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Baltimore District

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FORT GEORGE G. MEADE
CLOSED SANITARY LANDFILL
Groundwater Remedial Investigation (RI)

FINAL DOCUMENT

AUGUST 2007

EM FEDERAL
CORPORATION
Innovations in Philanthropy and Engineering Services

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
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REPLY TO ATTENTION OF:

Directorate of Public Works

21 April 2008

Subject: Closed Sanitary Landfill, Groundwater Remedial Investigation

Mr. Robert Stroud
US Environmental Protection Agency
Environmental Science Center
701 Mapes Road
Fort Meade, Maryland 20755

Dear Mr. Stroud:

Please find enclosed two copies (one paper and one on compact disc) of the August 2007 *Fort George G. Meade Closed Sanitary Landfill, Groundwater Remedial Investigation* report.

If you have any questions, please feel free to contact me at (301) 677-9365, fax: (301) 677-9001, or paul.v.fluck@us.army.mil.

Sincerely,

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Encl
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Fort George G. Meade Administrative Record
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LIST OF ACRONYMS

11DCE 1,1-dichloroethene
ADI ..... Australia Defense Industries, Ltd.
ARAR ..... Applicable or Relevant and Appropriate Requirement
AREE ..... Area Requiring Environmental Evaluation
ASL ..... Active Sanitary Landfill
AWQC ..... Ambient Water Quality Criteria
bgs ..... below-ground-surface
BRA ..... Baseline Risk Assessment
BRAC ..... Base Realignment and Closure Act
CEQ ..... Council on Environmental Quality
CERCLA ..... Comprehensive Environmental Response, Compensation, and Liability Act
CFD ..... Clean Fill Dump
cis12DCE 1,2-dichloroethene
CSL ..... Closed Sanitary Landfillm
COC ..... Chain-of-Custody
COPC ..... Chemical of Potential Concern
CRL ..... Certified Reporting Limit
CSE ..... Chemical Sediment
CSO ..... Chemical Soil
CSW ..... Chemical Surface Water
DNAPL ..... Dense, Non-Aqueous Phase Liquid
DQO ..... Data Quality Objective
DRMO ..... Defense Reutilization and Management Office
EA ..... EA Engineering, Inc.
EM ..... Electro Magnetic
ERA ..... Ecological Risk Assessment
ER-L ..... Effects-Range-Low
ER-M ..... Effects-Range-Median
ESE ..... Environmental Science and Engineering, Inc.
F ..... Fahrenheit
FGGM ..... Fort George G. Meade
ft-msl ..... feet above mean sea level
FTA ..... Fire Training Area
GFD ..... Geotechnical Field Drilling File
GGS ..... Geotechnical Groundwater Stabilized File
GMA ..... Geotechnical Map File
gpm ..... gallons per minute
GWC ..... Geotechnical Well Construction File
HFA ..... Human Factors Applications
HHA ..... Helicopter Hanger Area
HASP ..... Health and Safety Plan
HHRA ..... Human Health Risk Assessment

ID ..... Identification
I.D. ..... Inner Diameter
IDM ..... Investigation Derived Media
LEL ..... Lowest-Effect-Level
LOC ..... Levels of Concern
MCL ..... Maximum Contaminant Limit
MDE ..... Maryland Department of the Environment
MDL ..... Method Detection Limit
MRD ..... Missouri River Division
NAD83 ..... National Vertical Datum of 1983
NAPL ..... Non-aqueous Phase Liquid
NEL ..... No-Effect-Level
NEPA ..... National Environmental Policy Act
NFG ..... National Functional Guideline
NGVD ..... National Geodetic Vertical Datum
NOAA ..... National Oceanic Atmospheric Administration
NPL ..... National Priorities List
O.D. ..... Outer Diameter
ODA ..... Ordnance Demolition Area
OHM ..... OH Materials, Inc.
PA ..... Preliminary Assessment
PAH ..... Polyaromatic hydrocarbon
PCB ..... Polychlorinated byphenyls
PCE ..... Tetrachloroethene
PID ..... Photoionization Detector
PPE ..... Personal Protective Equipment
PVC ..... polyvinyl chloride
PWRC ..... Patuxent Wildlife Research Center
QA ..... Quality Assurance
QAM ..... Quality Assurance Manual
QAPP ..... Quality Assurance and Project Plan
QC ..... Quality Control
QA/QC ..... Quality Assurance/Quality Control
RDL ..... Required Detection Level
RI ..... Remedial Investigation
RI/FS ..... Remedial Investigation/Feasibility Study
RPD ..... Relative Percent Difference
RTA ..... Range Training Area
SARA ..... Superfund Amendments and Reauthorization Act
SAV ..... Submerged Aquatic Vegetation
RBC ..... Risk Based Concentration
RCRA ..... Resource Conservation and Recovery Act
SDWA ..... Safe Drinking Water Act
SI ..... Site Investigation
SIA ..... Site Investigation Addendum

SOP ..... Standard Operating Procedure
SVOC..... Semivolatile Organic Compound
SQC..... Sediment Quality Criteria
SQL..... Sample Quantitation Limit
STP..... Sewage Treatment Plant
TAL..... Target Analyte List
TBC..... To-Be-Considered
TCE..... Trichloroethene
TCL..... Target Compound List
TCLP..... Toxicity Characteristic Leachate Procedure
TEL..... Threshold Effect Level
TOC..... Total Organic Compound
TSAP ..... Technical Sampling and Analysis Program
URL..... Upper Reporting Limit
USACE ..... U.S. Army Corps of Engineers
USAEC ..... U.S. Army Environmental Center
USAEHA..... U.S. Army Environmental Hygiene Agency
USCS..... Unified Soil Classification System
USEPA..... U.S. Environmental Protection Agency
UST..... Underground Storage Tank
UWS ..... Uncontrolled Waste Site
UXO..... Unexploded Ordnance
VOC..... Volatile Organic Compound
WP/SAP..... Work Plan/Sampling and Analysis Plan
WTP..... Water Treatment Plant

EXECUTIVE SUMMARY

EM Federal Engineering ("EM Federal") is contracted by the USACE, Baltimore District, for the Fort George G. Meade (FGGM) Environmental Management Office (EMO), to conduct a Groundwater Remedial Investigation at the Closed Sanitary Landfill (CSL), Anne Arundel County, MD.

The landfill began operation at FGGM in 1958, using the trench fill method, and was used for the disposal of "mixed residential, commercial, and nonhazardous industrial wastes." The trench fill method continued until 1976. Sanitary land filling continued altering the operation to area fill. The landfill was constructed as an unlined facility and was initially designated as the Active Sanitary Landfill. It was divided into two cells: Cell 1 and Cell 2. A third area which lacks topographic expression, has been informally referred to as Cell 3, but is not a defined disposal area. Historical aerial photographs from 1970, 1975 and 1986 show the progression of expansion and waste disposal in the CSL when it was active (**Figure 4-6**).

FGGM was issued a Refuse Disposal Permit (Permit No. 80-02-00-08-A) in 1980 by the Maryland Department of Health and Mental Hygiene (now MDE). A federal/state mandated detection monitoring program was initiated in March 1994 to identify potential deficiencies in the landfill operation. Based on the results of the detection monitoring, assessment monitoring was initiated for the upper aquifer in November 1994 and was initiated for the lower aquifer in June 2000. Under the monitoring program, groundwater and surface water samples are collected and analyzed on a semi-annual basis. In 1992, FGGM was issued a Disposal Permit by MDE (Permit No. WSF-0022-0). The landfill ceased operations in 1996, at which time it began to be referred to as the Closed Sanitary Landfill. Landfill Cell 1 was capped and closed during the period 1995 through 1997 and Landfill Cell 2 was capped and closed during the period 1997 through 1998. A flexible membrane liner was incorporated into the final cap system for both Landfill Cells 1 and 2. A landfill gas collection and treatment system operates along the eastern edge of the landfill cells to control air emissions from the site.

Analytical data from the semi-annual groundwater samples collected since December 2000 showed several wells with statistically significant increases in concentrations of monitored constituents. Fewer organic compounds were detected in the lower aquifer relative to the upper aquifer, and at generally lower concentrations

In a letter (Appendix K) dated April 4, 2001, Maryland Department of Environment (MDE) stated "the Army must characterize the nature and extent of contamination of the release by installing additional wells as necessary." MDE recommended, at a minimum, the installation of eight wells (three in the Upper Patapsco Aquifer and five in the Lower Patapsco) as a starting point in the delineation of groundwater contamination and the refinement of current understanding of groundwater flow. After a review of local topography, MDE concurred that the proposed shallow wells in the off-site Amtrak railroad maintenance area would not add value to the understanding of groundwater flow and contaminant migration downgradient of the CSLF.

In response to the MDE letter of April 4, 2001 and in accordance with 40 CFR 258.55(g), the Army designed an accelerated and phase-based groundwater investigation. The Army's goal was to ensure that MDE, USEPA Region III, and Anne Arundel County were involved in the scoping and implementation of all field efforts. The following are a few examples of the Army's commitment to achieving this goal:

- Substantially increased well installation and sampling efforts initially requested by MDE:
  - ⇒ Split sample of well MW-4DR on May 31, 2001 to confirm the presence of carbon tetrachloride in the Lower Patapsco;
  - ⇒ Increased the requested number of Lower Patapsco wells from 5 to 16;
  - ⇒ Increased the requested number of Upper Patapsco wells from 0 to 4;
  - ⇒ Collected 68 groundwater samples, in two rounds, from new and existing wells (including all RCRA monitoring wells);

- ⇒ Collected 13 Direct Push Technology (DPT) screening samples south and southeast of the CSLF to determine if contamination is extending down-gradient of MW-12S and MW-19;
- ⇒ Collected 10 DPT screening samples north of the CSLF to confirm that carbon tetrachloride is not present in the shallow aquifer and if so, is it migrating from a shallow source;
- ⇒ Collected 20 surface soil samples to quantify chemical levels for use in Human Health Risk Assessment;
- ⇒ Collected 18 shallow sub-surface samples in Cell 3 and the former Ammunition Storage Point (ASP) to assess potential soil contamination, characterize landfill material, and evaluate potential future risk;
- ⇒ Performed 6 twenty-five feet long characterization trenches in Cell 3 to identify potential sources for contamination found in shallow groundwater;
- ⇒ Collected 8 surface water and sediment samples to determine if contamination is leaving the CSL through the surface water migration pathway;

- Hosted an MDE site visit on August 28, 2001 to inspect the surrounding topography. MDE concurred that the proposed shallow well locations in the off-site Amtrak railroad maintenance area would not serve the purpose of monitoring shallow groundwater downgradient of the CSL.
- Discussed the progress and status of the CSL at the following FGGM Environmental Partnership meetings: February 2000, April 2000, August 2000, October 2000, November 2000, December 2000, January 2001, March 2001, April 2001, May 2001, July 2001, August 2001, March 2002, April 2002, May 2002, June 2002, July 2002, October 2002, November 2002, January 2003, March 2003, November 2003, December 2003, and March 2004.
- Met with USEPA and MDE at USEPA Region III office on April 25, 2003 to review and discuss the investigation design to ensure compliance with CERCLA prior to initiating field work.

Based on discussions held during the April 19, 2001 FGGM Environmental Partnership meeting, a phased sampling approach was considered to be the most effective in meeting the investigation objectives.

Field work was conducted from approximately May 2001 to March 2005. Groundwater sampling was performed to evaluate the potential impact of covered waste materials on water quality. Surface water and sediments were sampled to evaluate the impacts of runoff from the landfill areas. Soil borings were performed to characterize the depth and nature of the waste materials in the Cell 3 area. Surface soil samples were collected from the landfills to help assess potential exposure pathways.

The following tasks were performed to complete the RI:

- The CSL was investigated by collecting samples of groundwater, surface soils, subsurface soils, surface water, and sediments. Hydraulic head measurements in new and existing wells were taken to define ground water flow. Human health risk evaluations were performed.
- Twenty monitoring wells were installed as part of this investigation. Sixty-eight ground water samples were collected from these new wells and all 23 existing RCRA monitoring wells.
- Analytical and hydrogeologic results from previous studies were evaluated.
- Environmental samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, PAHs, explosives, perchlorates, and TAL inorganics.

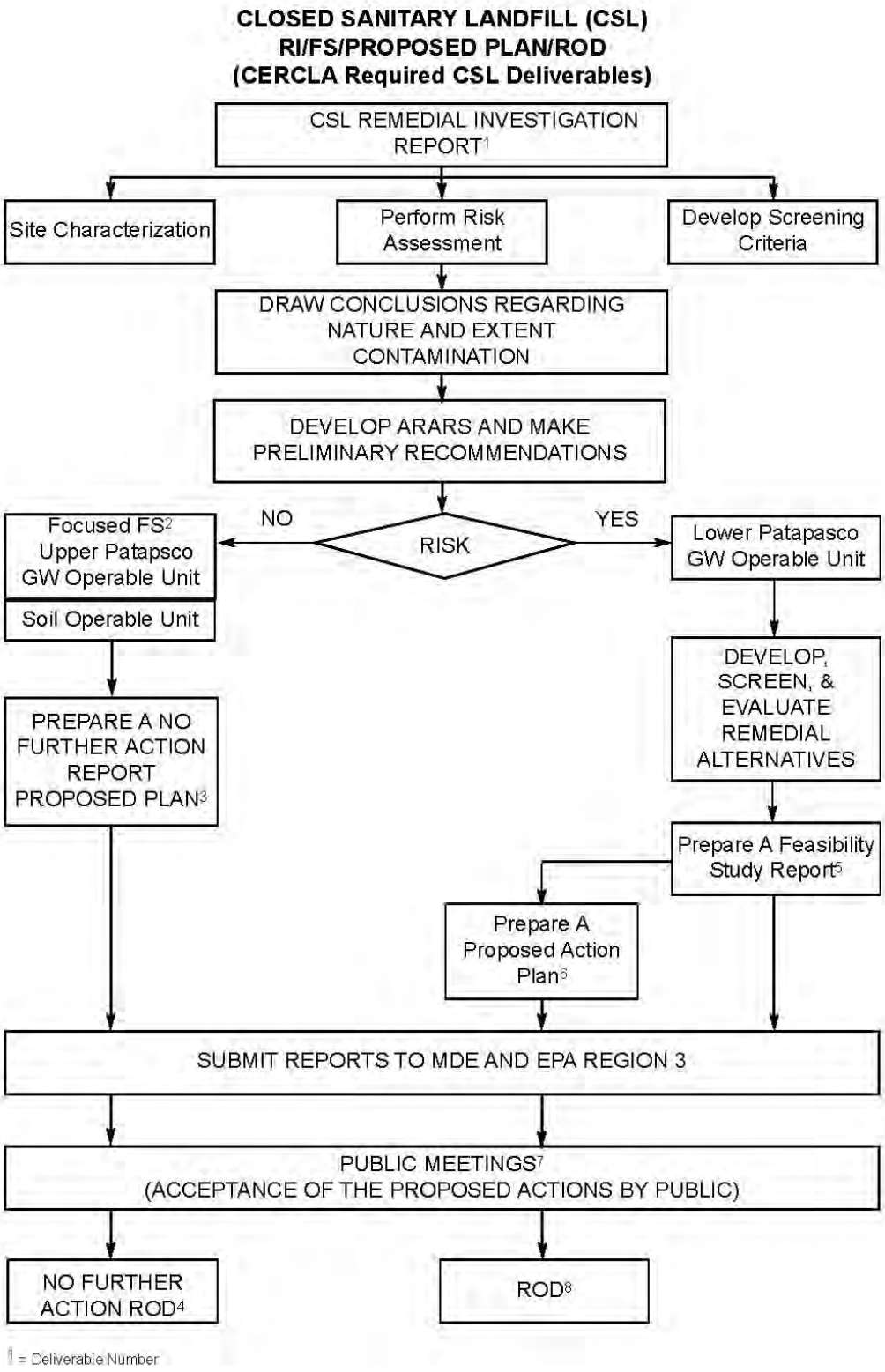
The major findings of the investigation are summarized below:

- In general, the analytical results from sampling were consistent with historical documentation indicating that disposal of "mixed residential, commercial, and non-hazardous industrial wastes" occurred at the CSL.
- Geologic, hydrogeologic, and hydraulic data indicates the Middle Patapsco clays are a thick and effective confining unit at the CSL. Likewise, data indicates the CSL is not the source of contamination found in the Lower Patapsco.
- Data indicates the Benzene MCL exceedances in the Upper Patapsco aquifer are bounded to the south by shallow wells MW-12s and MW-19. Shallow wells MW-12s and MW-19 monitor the Upper Patapsco Aquifer immediately south and east of the southernmost extent of CSL Cell 1. The screened interval of MW-12S is 18 to 28 feet bgs and the screened interval of MW-19 is 22 to 37 feet bgs. Benzene has been detected above the Tap Water RBC (0.5 μg/L) and/or MCL (5μg/L) in MW-12S and MW-19 in all RCRA semi-annual monitoring rounds since May 1995 at concentrations ranging between 2.9 and 25 μg/L. Based on the site topography, shallow groundwater in the vicinity of the southern end of Cell 1 near MW-12S and MW-19 would flow toward the lower elevations to the southwest toward a minor tributary of the Little Patuxent River. The off-post land surface directly to the south of the CSL is at approximately the same elevation as the base of the CSL and rises to the south **(see Figure 4-4 – Topographic Map)**. Likewise, data indicates Benzene is not migrating off-post above MCLs. This conclusion is supported by the fact that MW-20, south of MW-12s, has not detected Benzene (0.59 to 4.7μg/L) above MCLs in the history of the RCRA monitoring program. In fact, Benzene has been non-detect in MW-20 for the past five RCRA sampling rounds. Also, Benzene has not been detected in eastern off-post wells MW-105, MW-106, MW-107, MW-123, and MW-124.
- Data indicates the CSL is not the source of carbon tetrachloride, PCE and TCE present in the Lower Patapsco aquifer. Carbon tetrachloride has not been detected in the shallow aquifer. PCE and TCE were detected in the deep aquifer only for both the September 2002 and June 2004 sampling events. PCE and TCE have not been detected above MCLs in the shallow aquifer during RCRA monitoring.
- Potential exposures to on-Site soils, surface water, sediment, and vapors from groundwater by maintenance workers, adolescent trespassers, and recreational users were evaluated on the basis of current and future industrial/commercial and recreational land use scenarios at the CSL. Cumulative cancer risks for human receptors are below USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. Cumulative noncancer hazard indices for all receptors are less than 1, indicating that adverse noncarcinogenic effects are not likely to occur.
- Potential exposures to off-Post groundwater in the Upper Patapsco by construction workers and residents were evaluated on the basis of a future residential land use scenario. Cumulative cancer risks for human receptors are within or below USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. Cumulative noncancer hazard indices for the construction worker are less than 1. Cumulative noncancer hazard indices for the adult resident are equal to 1 when hazards are segregated by similar target organ and rounded to one significant figure. Cumulative noncancer hazard indices for the child resident are less than 1 when hazards are segregated by similar target organ. These results indicate that adverse noncarcinogenic effects are not likely to occur.
- Several new receptors were added to the report with quantitative evaluations. These receptors include: (1) An on-site construction worker that would build the golf course; (2) An on-site golfer; and (3) An on-site club house worker that would work in the "to be constructed" golf course club house. Cumulative cancer risks are within or below USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. Cumulative noncancer hazard indices are less than 1. In addition, with the guidance of EPA Region 3, unlikely and unrealistic future on-site residential exposures were evaluated quantitatively and added to

this report. Results are summarized in Appendix G and Section 6 of this report for informational purposes only.

- Geologic, hydrogeologic, and hydraulic data indicates the Middle Patapsco clays are a thick and effective confining unit at the CSL. Likewise, data indicates the CSL is not the source of contamination found in the Lower Patapsco. Nevertheless, Lower Patapsco data was collected and reviewed in order to provide a baseline understanding of risks associated with potential off-post exposures. Potential exposures to off-Post groundwater in the Lower Patapsco by residents were evaluated on the basis of a future residential land use scenario. Cumulative cancer risk for adult receptors is above USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. Cumulative noncancer hazard indices for adult and child receptors are above USEPA's target hazard index of 1. Cumulative cancer risk for child receptors is within USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. However, information presented in this RI supports the conclusion that these estimated future risks and hazards are not from chemical constituents in the CSL because the Middle Patapsco clay-rich confining unit precludes hydraulic communication between the Upper and Lower units (thereby preventing the migration of COPCs in the CSL to the Lower Patapsco) (see Section 4.4.3 for additional details).
- Most off-site residents are on public water and do not use private drinking water wells. Therefore, the use of off-Post monitoring well data (as discussed in the preceding bullet) overestimates future residential risks and hazards. In March 2005 the Anne Arundel County Health Department collected and analyzed water samples from thirteen off-Post private drinking water wells located adjacent to FGGM and downgradient from the CSL. The analytical results demonstrated that water in all the sampled wells met primary USEPA drinking water standards (MCLs). Although five of the homes had lead levels above the lead action level, the Department is working with the affected homeowners to make recommendations that can assist in effectively reducing the level of lead in their water, as the most common source of lead in home drinking water is household plumbing materials. As the measured concentrations of organics in the off-site domestic wells were below MCLs, actual (current) risks and hazards to off-Post residents are generally deemed acceptable. Although lead was a concern in five private wells, lead was not identified as a hazard driver in the CSL HHRA, and its presence in the private wells is most likely a result of leaching from household plumbing materials.
- The possibility of off-Post residents installing new private wells screened in the Upper Patapsco or the upper portion of the Lower Patapsco aquifers is extremely unlikely. Due to naturally elevated levels of radium in northern Anne Arundel County shallow groundwater, new or replacement drinking water wells must be installed to depths equal to or greater than approximately 250 to 500 feet bgs, and some may be required to be deeper than 600 feet bgs. As the depths to the Upper and Lower Patapsco aquifers are approximately 20 and 100 feet, respectively, this MDE-specific directive would generally only allow new or replacement wells in deeper portions of the Lower Patapsco aquifer where chlorinated hydrocarbon contaminants are unlikely to be present.

The attached RI/FS process flow diagram illustrates the CERCLA process and how the current investigation efforts will be used to support an evaluation of remedial alternatives. Should any remedial actions become necessary, the data and risk assessment will be used to identify ARARs and select the most appropriate action, if any.


CLOSED SANITARY LANDFILL (CSL)
RI/FS/PROPOSED PLAN/ROD
(CERCLA Required CSL Deliverables)
CSL REMEDIAL INVESTIGATION REPORT1
Site Characterization
Perform Risk Assessment
Develop Screening Criteria
DRAW CONCLUSIONS REGARDING NATURE AND EXTENT CONTAMINATION
DEVELOP ARARS AND MAKE PRELIMINARY RECOMMENDATIONS
NO
RISK
YES
Focused FS2 Upper Patapsco GW Operable Unit
Soil Operable Unit
Lower Patapasco GW Operable Unit
PREPARE A NO FURTHER ACTION REPORT PROPOSED PLAN3
DEVELOP, SCREEN, & EVALUATE REMEDIAL ALTERNATIVES
Prepare A Feasibility Study Report5
Prepare A Proposed Action Plan6
SUBMIT REPORTS TO MDE AND EPA REGION 3
PUBLIC MEETINGS7
(ACCEPTANCE OF THE PROPOSED ACTIONS BY PUBLIC)
NO FURTHER ACTION ROD4
ROD8
1 = Deliverable Number

1.0 INTRODUCTION

EM Federal Engineering ("EM Federal") is contracted by the USACE, Baltimore District, for the Fort George G. Meade (FGGM) Environmental Management Office (EMO), to conduct a Groundwater Remedial Investigation at the FGGM Closed Sanitary Landfill (CSL), Anne Arundel County, MD.

The CSL is located in the southeast corner of FGGM and was closed under the Resource Conservation and Recovery Act (RCRA) from 1995 through 1998. A groundwater monitoring program for the Upper Patapsco (water table) and Lower Patapsco (confined) Aquifers was initiated, as part of the RCRA closure to ensure that leachate from the landfill did not impact groundwater. Analytical data from semi-annual groundwater samples collected since December 2000 indicate that several wells have shown statistically significant increases in concentrations of monitored constituents. In addition, three volatile organic compounds [(VOCs), carbon tetrachloride, tetrachloroethene and benzene], have routinely exceeded Maximum Contaminant Levels (MCLs). Three metals (arsenic, beryllium and thallium), have also been detected at concentrations exceeding their respective MCLs.

FGGM was listed on the National Priority List (NPL) on July 22 1998. Likewise, the CSL field work and data evaluation followed U.S. Environmental Protection Agency (USEPA) guidance documents developed for activities performed under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). In addition, the RI/FS process was conducted in compliance with the National Environmental Policy Act of 1969 (NEPA); and the President's Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508). The procedures used in the study were consistent with the Department of the Army's environmental policy toward integrating the NEPA and CERCLA/SARA processes.

This study was performed under the purview of the U.S. Army, USEPA Region III, and the Maryland Department of the Environment (MDE). The overall objective of this task is to conduct a Groundwater RI/FS for the CSL. All field and sampling activities were conducted in accordance with the Specific Addendum to the Generic Field Sampling Plan (USACE, 2003a).

1.1 PURPOSE OF THIS REPORT

This RI report presents the results of field activities conducted between May 2001 and June 2004 and the results of the Baseline Risk Assessment (BRA). The objectives of the RI and the planned approach to meeting these objectives are as follows:

- Evaluate the general nature and extent of groundwater and associated media (surface water, sediments, surface soil and subsurface soil) contamination at the CSL, which may contribute to potential adverse environmental or unacceptable risks. Samples from monitoring wells, soil borings, surface soil, surface water, and sediment were collected to determine the nature and extent of contamination;
- Evaluate contaminant migration and transport within the study area. Fate and transport of contaminant constituents in environmental media were evaluated; and
- Evaluate the potential risks posed to human health and the environment within the CSL. A BRA was performed to evaluate the potential risks to human health and the environment to meet this objective.

1.2 REPORT ORGANIZATION

This report is divided into eight sections as follows:

Section 1.0 - Introduction: This section presents the purpose and organization of the report.

Section 2.0 - Site Background and Procedures: This section presents information on the site location, history, and physical setting at the site. This section also discuss the technical approach to field sampling procedures including subsurface soil sampling; groundwater sampling; and surface soil, surface water, and sediment sampling. Quality Assurance/Quality Control (QA/QC) and data management protocols are also discussed.

Section 3.0 - Identification of Screening Levels: This section presents the selection of screening levels based on Applicable or Relevant and Appropriate Requirements (ARARs) and the presentation of background samples collected for all media. The screening levels are used for comparison and evaluation of the sampling results which are presented in Section 4.0.

Section 4.0 - Nature and Extent of Contamination: This section describes the CSL area and presents a summary of the data collected during the RI and previous investigations. This section also summarizes monitoring well, soil boring, surface soil, surface water, and sediment sampling locations and rational; and presents the analytical results of the RI for each area.

Section 5.0 - Contaminant Fate and Transport: This section presents an assessment of potential routes of contaminant migration and persistence. The assessment focuses on contaminants that exceed screening levels in various environmental media.

Section 6.0 - Human Health and Risk Assessment: This section evaluates potential impacts to human health at the CSL. Chemicals of potential concern (COPCs) and receptor pathways are identified, and the level of risk associated with the contamination present at the site is evaluated.

Section 7.0 - Summary and Conclusions: This section presents a summary of the RI and BRA findings.

Section 8.0 - References

2.0 SITE BACKGROUND AND PROCEDURES

2.1 SITE DESCRIPTION

Fort Meade occupies 5,426 acres of land in the northwest corner of Anne Arundel County, MD. The installation is located along the Baltimore, Maryland-Washington, D.C. corridor, and is approximately equidistant from both cities. The base is located within the Coastal Plain Physiographic Province and is characterized by relatively flat land with rolling hills and incised stream valleys.

The CSL is located in the southeast corner of FGGM south of State Route 32 (See **Figures 2-1 and 2-6**). The CSL is bounded to the west by small arms training ranges and woodland areas (formerly part of FGGM) which are now part of the Department of Interior's Patuxent Research Refuge (PRR). Residential and light industrial areas of Odenton, MD are present to the east and north of the site. Neighboring properties include the National Railroad Passenger Corporation (Amtrak) maintenance yard and railroad right of way, a residential trailer park, residences and commercial business facilities. The Amtrack railroad borders the southeastern CSL/FGGM property line.

A former ammunition supply point (ASP) consisting of 12 concrete ammunition storage bunkers (magazines) and associated access roads was located in the area north of Cell 1 and west of Cell 2. The ASP was little used after the 1960s and was demolished and removed in 2001.

The FGGM DPW uses a portion of the northwest corner of the site for bulk storage of loose materials (gravel, sand, etc.). This is the only active operation at the site.

Currently, the largest site features are the two capped cells - Cell 1 (46 acres) and Cell 2 (24 acres). Other site features include engineered drainage features, including several small retention ponds, gravel access roads, and a perimeter security fence. A small stream roughly bisects the site from west to east. Wetland areas are present between Cell 1 and Cell 2, along the stream, and west of the CSL. Wooded areas buffer the site to the north, west, and southwest.

The landfill began operation at FGGM in 1958, using the trench fill method, and was used for the disposal of "mixed residential, commercial, and nonhazardous industrial wastes." The trench fill method continued until 1976. Sanitary land filling continued altering the operation to area fill. The landfill was constructed as an unlined facility and was initially designated as the Active Sanitary Landfill. It was divided into two cells: Cell 1 and Cell 2. A third area which lacks topographic expression, has been informally referred to as Cell 3, but is not a defined disposal area. Historical aerial photographs from 1970, 1975 and 1986 show the progression of expansion and waste disposal in the CSL when it was active (**Figure 4-6**).

A federal/state mandated detection monitoring program was initiated in March 1994 to identify potential deficiencies in the landfill operation. Based on the results of the detection monitoring, assessment monitoring was initiated for the upper aquifer in November 1994 and was initiated for the lower aquifer in June 2000. Under the monitoring program, groundwater and surface water samples are collected and analyzed on a semi-annual basis. The landfill ceased operations in 1996, at which time it began to be referred to as the Closed Sanitary Landfill. Landfill Cell 1 was capped and closed during the period 1995 through 1997 and Landfill Cell 2 was capped and closed during the period 1997 through 1998. A flexible membrane liner was incorporated into the final cap system for both Landfill Cells 1 and 2. A landfill gas collection and treatment system operates along the eastern edge of the landfill cells to control air emissions from the site.

2.2 PHYSICAL SETTING

2.2.1 Physiography and Topography

Fort Meade is located in the Coastal Plain Physiographic Province, which is characterized by low rolling uplands and low-gradient streams. The Coastal Plain is underlain by a wedge of unconsolidated alluvial sediments that dip and thicken toward the Atlantic Ocean. The igneous and metamorphic rocks of the Piedmont physiographic province (the easternmost portion of the Appalachian Plateau) are exposed near the Anne Arundel County line, about five miles west of Fort Meade. The demarcation between the

Piedmont and Coastal Plain Physiographic Provinces is termed the "Fall Line," after the falls and rapids found where streams cross this boundary.

The CSLF is characterized by two mounded cells, which rise approximately 30 feet above the surrounding terrain. The cells are sloped on all sides and have been revegetated since closure and capping. The elevations at the base of the cells range from 164 to 150 feet above mean sea level (AMSL) and reach 190 to 192 feet AMSL at the highest elevation of the landfill cells.

2.2.2 Land Use

The primary zoning classification in the Anne Arundel County Assessment District 4 (which includes FGGM) is residential, particularly low-density residential and agricultural/ residential. Commercial uses are permitted primarily in sections along Annapolis Road (Maryland Route 178), along the eastern edge of Robert Crain Highway, and in the Maryland City area west of the Baltimore-Washington Parkway.

The Base Realignment and Closure (BRAC) parcel is comprised of land management areas designated A-Z, most of these areas having multiple uses, with emphasis placed on wildlife, fisheries, timber, and hunting management. The BRAC parcel can be divided into three principal land use areas.

- The northeast corner of the BRAC parcel includes the ASL, small arms firing ranges, and stables.
- The majority of the BRAC parcel has been transferred to the U.S. Department of Interior and is now operated as the Patuxent Research Refuge (PRR), North Tract.
- Tipton Airfield, formerly known as Tipton Army Airfield, is located in the north-central portion of the BRAC parcel.

2.2.3 Climatology

The climate at FGGM is variable, influenced by the Chesapeake Bay and the Atlantic Ocean to the east and the Appalachian Mountains to the west. The winter weather in the FGGM area is characterized primarily by cold, dry, continental-polar winds from the west and northwest and less frequent maritime-tropical winds from the south and southwest, which brings warm, often humid air to the region. During the summer, the dominance of these two air masses is reversed and warm, humid weather dominates.

Local weather data is compiled by the National Oceanic and Atmospheric Administration's Climatic Data center for the Baltimore-Washington Airport weather station. Annual precipitation averages about 40 inches per year. The distribution of precipitation is essentially even throughout the year although slightly lower averages are posted for the summer months. Historical average precipitation ranges between 2.8 and 3.5 inches for all months. The annual mean daily temperature for the FGGM area is 61°F, with a daily annual maximum of 72°F and a minimum of 45°F. Annual temperature extremes vary from -6°F to 101°F.

2.2.4 Regional Geology

Fort Meade is located on the unconsolidated sands, clays, and silts of the Coastal Plain Physiographic Province, which were deposited from the Cretaceous to the Quaternary geologic periods. The Coastal Plain sediments begin at the Fall Line, where they overlie the bedrock of the Piedmont physiographic province, and dip and thicken to the east and southeast. A cross section of Anne Arundel County showing the hydrogeologic units underlying the Fort Meade area is presented as **Figure 2-3**. Unconsolidated deposits present at Fort Meade are from the lower Cretaceous age Potomac Group. This Group consists of, from youngest to oldest, the Patapsco Formation, Arundel Clay, and Patuxent Formation, which have a maximum total thickness of approximately 600 feet at Fort Meade. The formations were formed as fluvial and lacustrine deposits and consist of interbedded sand, silt, and clay layers. Because these formations dip toward the east, they are progressively exposed at the surface across Fort Meade. A geologic map of the site is presented in **Figure 2-4** and a conceptual site model is presented in **Figure 2-7**.

2.2.4.1 Soil Types

FGGM soils were originally covered with hardwood forests. However, due to development on the installation and the slow successional rates of more excessively drained uplands, they currently support a limited hardwood and conifer cover.

The general soil types found in the FGGM vicinity belong to two major associations. Most of the area is comprised of the loamy and clayey land of the Muirkirk-Evesboro soil association, and remaining soils are of the Evesboro-Rumford-Sassafras association, as discussed below.

- **Muirkirk-Evesboro:** These soils are primarily located within the BRAC parcel and comprise undeveloped forest land and some portions of the developed section. These soils are loamy and clayey, underlain by an unstable clay of low permeability. This association primarily supports a mixture of pine and hardwood vegetation.
- **Evesboro-Rumford-Sassafras:** These soils are found in the northern part of FGGM, where heavy development has taken place. These soils usually have an unstable and slowly drained substratum that seasonally enhances a high water table. The Evesboro series is characterized by coarse, loose, and drought soils with a clayey substratum of low permeability; the Rumford series is composed of loose loamy soils with a sandy loamy subsoil; and the Sassafras series consists of fine sandy loamy material overlain on sandy-clayey-loamy subsoil.

2.2.4.2 Quaternary Deposits

Quaternary alluvium and river terrace deposits are present in the vicinity of the Patuxent and Little Patuxent Rivers and their tributaries. The alluvium consists of interbedded sand and gravel with some silt, clay, and organic matter. These heterogeneous sediments underlie the river flood plains and may be present at thicknesses of up to 15 feet adjacent to the rivers.

2.2.4.3 The Patapsco Formation

The Patapsco Formation is divided into an upper, middle, and lower section. Based on site drilling logs, the upper section of the Patapsco Formation, which consists of mottled, medium-fine to silty sand, is present only at the extreme eastern portion of the facility. This unit has a maximum observed thickness of 40 feet at the CSLF and is the unit in which the shallow monitoring wells are screened.

The middle section of the Patapsco Formation is a thick, hard, highly plastic, mottled clay. At the CSLF, where this confining unit has been completely penetrated, the middle layer has an average thickness of 50 feet. Lenses of very fine silty sand, varying from two to 16 feet in thickness, are not uncommon in the middle section.

A transitional zone of alternating silty sands and silty clays is often observed between the middle and lower sections of the Patapsco Formation.

The lower section of the Patapsco Formation typically consists of silty sands that grades downward into coarser sands with silt. Colors observed in this layer include pale to dark yellowish orange, dark brown, and dark yellow. Reported thicknesses of this section range from 80 to 100 feet. The deeper monitoring wells associated with the CSLF are screened in this unit.

2.2.4.4 The Arundel Formation

The Arundel Formation is approximately 200 to 250 feet thick in the Fort Meade area and is located between the Patapsco and Patuxent Formations. This formation consists of massive beds of red, brown and gray clay with more permeable layers in some areas. The Arundel Formation acts as a regional confining layer between the Lower Patapsco and Patuxent aquifers and is characterized by low vertical permeability.

2.2.4.5 The Patuxent Formation

The Patuxent Formation, located below the Arundel Formation, is the oldest of the unconsolidated deposits and is composed of sand and gravel with some silty clay and clay. This

formation overlies bedrock and crops out between the western boundary of FGGM and the Fall Line. The Patuxent Formation, like the rest of the unconsolidated deposits of the coastal plain, slopes to the east or southeast. In the Tipton area, the top of the Patuxent Formation is located approximately 300 feet below ground surface (bgs).

2.2.4.6 Bedrock

The Patuxent Formation is underlain at Fort Meade by crystalline bedrock of the Piedmont Province. The bedrock, which is probably part of the Baltimore Mafic Complex, is Precambrian to early Cambrian in age and consists of metavolcanic rocks including amphibolite, schist, and serpentinite. Depths to bedrock on the eastern side of Fort Meade range from approximately 600 to 800 feet below ground surface (bgs).

2.2.5 Regional Hydrogeology

Groundwater availability in the Coastal Plain sediments is generally good, with three separate and distinct aquifers: the Upper Patapsco, the Lower Patapsco, and the Patuxent. The Arundel Formation and the middle confining layer of the Patapsco Formation act as confining layers separating each of the aquifers. The aquifers are confined on a regional scale but locally act as water table aquifers in areas where they crop out at the surface.

The regional groundwater flow is to the southeast, generally following the structural dip. However, due to small variations in the surface relief, stratigraphy, and recharge/discharge zones, local flow in the upper hydrostratigraphic unit, which generally mirrors the topography, can be to the east, south, or west. Although flow direction will vary with seasonal fluctuations in the water table, local shallow groundwater flow is controlled by the Patuxent River and Little Patuxent River.

In the vicinity of the CSL, the water table aquifer (Upper Patapsco Aquifer) is generally encountered between 5 and 20 feet bgs. The groundwater flow in this aquifer is influenced primarily by local topography and therefore multiple directions of shallow flow exist within the CSLF area. The Lower Patapsco Aquifer is separated from the upper aquifer by the Middle Patapsco clay sequences. Water level data from well pairs screened in the two aquifers suggest that the two units are hydraulically separated and that there is a strong downward gradient.

2.2.6 Surface Water Hydrology

Fort Meade is located within the Patuxent River watershed, which is one of the primary drainage systems in Anne Arundel County. This watershed encompasses approximately 932 square miles. The Patuxent River receives drainage from numerous intermittent streams. The Little Patuxent River, the major tributary of the Patuxent River, flows southeast across the middle of Fort Meade and receives drainage from the majority of the installation. Both rivers eventually drain into the Chesapeake Bay.

On the CSL the two cells are separated by a drainage swale which receives runoff from the inner flanks of the cells and from surface runoff from off-post areas to the southeast. Surface water follows the swale to the west and then enters a series of small retention ponds, which in turn empty into minor tributaries of the Little Patuxent River.

2.2.7 Groundwater and Surface Water Use

FGGM gets water from two sources: 1) surface water from the Little Patuxent River; and 2) eight deep facility production wells (PW-1 to PW-8) located west, northwest, and south of the CSL.

Maryland regulations (COMAR 26.08.02) designate the Little Patuxent River south of the Old Forge Bridge as a Use I waterway – designated as suitable for human water contact recreation, fishing, and the protection and propagation of aquatic life. The Little Patuxent River north (upstream) of the Old Forge Bridge is designated as Use I-P, which is additionally suitable for use as a public water supply.

The eight FGGM production wells are screened well below the Arundel Clay regional aquitard at depths between 500 and 800 feet bgs. Production wells PW-1 and PW-2 are located on FGGM cantonment area north of Route 32 and wells PW-3 to PW-8 which are located essentially along Range Road on the extreme eastern side of the BRAC parcel. Historical analyses of extracted groundwater by the installation Department of Public Works have not indicated any impacts from site-related activities.

2.3 FIELD PROGRAM PROCEDURES

2.3.1 Soil Boring/Logging Procedures

All boring operations were conducted in general accordance with American Society for Testing and Materials (ASTM) standards. Prior to drilling or direct-push, subsurface utilities and subsurface structures were identified and marked on the ground surface. Standard split-spoon soil samples were collected during drilling at the discretion of the Site Geologist, but were generally collected at five-foot intervals near the aquifer unit contacts and the proposed screened intervals. DPT soil samples were collected via a Geoprobe macrocore sampler.

During the advancement of borings for the purpose of monitoring well installation, the Site Geologist described all activities in the field boring/probing logs. The following data were recorded on the boring logs at the drill site:

- The name of the Site Geologist(s), project name, location.
- Sketch map of drill location.
- Depths in feet and fractions thereof (tenths of feet).
- Soil descriptions, in accordance with the Unified Soil Classification System (USCS) and prepared in the field by the attending Site Geologist, which include the following information.
  - Classification, USCS symbol, Secondary components and estimated percentages, color (using Munsell Soil Color Chart), plasticity, consistency (cohesive soil) or density noncohesive soil), moisture content, texture/fabric/bedding, lithologic boundaries.
  - Visual estimates of secondary soil constituents (If terms such as "trace," "some," or "several" are used, their quantitative meanings will be defined in a general legend).
  - Length of sample recovered for each sample interval for driven samples.
  - Estimated depth interval for each sample.
- Depth to water first encountered during drilling and the method of determination, if applicable (any distinct water-bearing zones below the first zone also will be noted).
- General description of the drilling equipment used, including the rod size, bit type, pump type, rig manufacturer, model, and drilling personnel.
- Drilling sequence, description of drilling materials used (i.e., bentonite) including the brand name and the quantity.
- Start and completion dates of all borings and a chronological time-sequence of all significant events.
- Volatile organic vapors in surface and subsurface soil samples, as measured using a Photo Ionization Detector (PID) calibrated, at a minimum, on a daily basis using a benzene equivalent isobutylene standard.
- Sketch map of drill location.
- Well installation information; and
- Boring completion information.

2.3.2 Monitoring Well Construction and Installation

A total of 16 deep wells were installed to monitor the Lower Patapsco Aquifer using a mud rotary rig. Well statistics are summarized in **Table 4-2**. A total of 11 new deep wells were installed and sampled as part of the carbon tetrachloride investigation. These are broken out into four groups:

- **Wells MW-113D, MW-114D, and MW-115D** were located at or near the installation boundary north of Cell 2 at locations downgradient or potentially downgradient of MW-4DR. MW-114D,

which was sited on the eastern (downgradient) edge of CSLF Cell 3 along the installation boundary was one of the wells requested by MDE. MW-114D was located on the northeast margin of Cell 3 and MW-115D was located east of MW-4DR on the installation boundary. These wells ranged from 185-205 feet depth.

- **Wells MW-117D, MW-118D, and MW-119D** were located upgradient of MW-4DR on the southeast side of Route 32. These 3 wells were located on a SW-NE line stretching from the CSLF entrance gate (MW-117D) to the DPW salt dome (MW-119D) to indicate the direction of the source of the carbon tetrachloride. These wells were 105-188 feet deep.
- **Wells MW-120D, MW-121D, and MW-122D** were installed in further upgradient locations north of Route 32 based on preliminary field screening results. The three wells were place on a line trending SSW from Route 175 (MW-120) to the south-southwest in order to bracket the historical source area and migration path of the carbon tetrachloride in the Lower Patapsco Aquifer. These wells ranged from 60-165 feet in depth.
- **Wells MW-125D and 126D** were located off-post east of Cell 2 to assess possible groundwater contamination migration. The wells ranged from 220 to 240 feet in depth.

Five new wells were installed at off-post locations southeast and downgradient of the CSLF at the request of MDE to assess potential off-post migration of contaminated groundwater from the CSLF in the Lower Patapsco Aquifer.

- **Wells MW-109D, MW-110D, MW-111D, and MW-116D** were located, in conjunction with existing well MW-108D, essentially parallel to the installation boundary along or in line with Old Waugh Chapel Road near the Amtrack Maintenance Yard about 400-600 feet downgradient from the CSLF. These wells ranged from 133-195 feet in depth.
- **Well MW-112D** was installed an additional 600-800 feet further east near the intersection of Route 170 and Old Waugh Chapel Road, essentially downgradient from existing well MW-108D. The well had a total depth of 198 feet.

2.3.2.1 Mud Rotary Drilling

A total of 16 (MW-109D through MW-122D, MW-125D and MW-126D) were installed within confined water bearing zones of the Lower Patapsco aquifer using mud rotary techniques. To protect against cross-contamination during drilling activities for the installation of mid-depth and deep wells, the water table aquifer was sealed off from the borehole by installation of double casing which extended from the surface into the confining unit to prevent potential downward migration of contaminants down the borehole. The water used for well drilling requirements was obtained from an un-chlorinated water source, FGGM production well PW-5.

Each well was drilled using the mud rotary drilling technique with a 12-inch drag bit to a minimum depth of three feet into the clay confining unit between the Upper and Lower Patapsco as determined by split-spoon sampling and drilling characteristics. Once drilling had progressed into the confining unit, the boring was flushed until clean. The drilling and sampling rods were then removed, and 10-inch I.D. carbon steel casing was installed in the entire length of the boring and pressure grouted to the surface. After outer casing installation was completed, the grout was allowed to set 24 hours. An 8-inch drag bit was then used to drill through the grouted annulus of the outer casing until the screened interval was reached.

Drilling mud was containerized in drums. Each drum was labeled with weatherproof marking showing the date, boring number, location, depth range, and contents and staged to a secure area.

2.3.2.2 Monitoring Well Design and Installation

Monitoring wells were installed using flush-threaded Schedule 40, 4-inch diameter PVC casing and screen. Each monitoring well screen was 20 feet in length, had factory 0.01-inch slot size, and a 6-inch solid bottom cap. The polyvinyl chloride (PVC) materials used for well construction conformed to National Sanitation Foundation Standard 14 for potable water usage or the ASTM equivalent. The

casing, screen, and bottom cap were screwed together using flush jointed threads. Threaded bottom plugs and well caps were also constructed of Schedule 40 PVC. No plastic solvents or glues were used on any of the well materials. The casing and screen were shipped certified clean in sealed plastic bags and were unwrapped shortly before well installation. Screens and casing were decontaminated prior to transportation to the drill site. Clean latex gloves were worn at all times during the handling of well screens and casing. Each well was installed into the completed mud rotary boring. The well screen and casing were assembled as it is lowered.

The filter pack in all wells consisted of #2 sand. This size is compatible with both the screen slot size and the aquifer materials. The sandpack extended from the bottom of the well to 3-5 feet above the top of the screen.

Filter pack installation was accomplished by the washing or pouring of sand through a tremie pipe placed two feet from the bottom of the boring. The tremie pipe was raised to remain one to two feet above the top of the sand, as the level of sand in the annular space increased. The height of the sand pack was verified with a weighted tape to ensure proper sand placement.

Three to five feet of bentonite slurry was placed in the annular space above the sand pack. The grout was allowed to hydrate for two hours before the remainder of annular space is filled with a cement/bentonite grout.

The grout used in well construction was composed of 20 parts Type II Portland cement to one part bentonite, with a maximum of eight gallons of approved water per 94-pound bag of cement. The bentonite was added after mixing of the cement and water. Grouting was performed in one continuous operation in the presence of the Site Geologist. Once the grout seal was complete and had set, the grout column was topped off as necessary and a protective steel casing was cemented into the borehole.

All 9 on-post wells and 2 of the 7 off-post wells were completed in the stick-up configuration. An 8-inch protective steel casing was installed over the top of the riser, which extended approximately 2.5 feet above ground surface and 2.5 feet below ground surface. The protective casing was grouted in place. The casing included a padlock and hinged cap. All wells were locked with the same-keyed padlocks provided by FGGM. An internal mortar collar was placed within the well/protective casing annulus from ground surface to 0.5 feet above ground surface. A 0.25-inch diameter drainage port was drilled in the protective casing, centered 1/8-inch above the level of the internal mortar collar. The base of the wells was covered 2x2-foot square concrete pad. Four steel bumper posts, placed two to three feet below ground and extending three feet above ground surface, were cemented into place at the corners of the protective concrete pad. The well outer casing was permanently marked with the well ID and the well permit tag.

Three off-post wells (MW-109, MW-112d, MW-116d, MW-125d, and 126d) were located on or immediately adjacent to roadways and were completed in a flush mount configuration. These wells were equipped with a water tight flush-mount, traffic-rated designed cover with a lockable water tight cap, set in concrete with slightly sloping sides to prevent water accumulation.

Well designations and state well tags were permanently affixed to the wellhead for later monitoring and/or sampling activities. A weather resistant well identification tag will be placed on the locking cap. The tag identifies the well designation, permit number, and the name of the company that installed the well.

2.3.3 Monitoring Well Development

The new wells were developed to remove fine-grained material from around the sand pack and to remove water lost during the drilling process. The purpose of well development is to ensure that the resulting groundwater is chemically and physically representative of the screened aquifer. Well development logs are included in **Appendix C**. Development of monitoring wells was initiated between two and seven days after well installation was completed. Monitoring wells were developed using a variable rate submersible pump.

For normal wells, a minimum of five times the standing water volume in the well plus any water lost during drilling/well installation was removed for development purposes, in accordance with the QAPP. This generally resulted in the removal of 500-800 gallons of water. Key indicator parameters, including

temperature, specific conductivity, and pH were measured, in order to determine when the wells reached equilibrium. Development proceeded until the development water achieved visual clarity or until field parameters stabilized. Field parameters pH, conductivity, and temperature, were monitored periodically during development and recorded until the water was clear and parameter stabilization was achieved. Stabilization was defined as successive readings in which the pH has changed by less than 0.1 pH units, and temperature has changed 1°F or less. Surging and swabbing (repeatedly raising and lowering the pump within the screen while pumping) were performed to ensure vigorous, back-and forth flow across the screen. Water was not added to the wells to aid in development, nor were air-lift techniques used. The pump was decontaminated and allowed to dry before use in each well.

Three wells (MW-112D, MW-113D, and MW-121D), which produced water at very low rates (much less than 1 gpm) and took excessive time to recover, were developed by pumping them dry three times.

Data recorded during well development included:

- Quantity of standing water in well;
- Specific conductivity, temperature, pH, and turbidity measurements taken and recorded at no greater than 15 minute intervals throughout the development process;
- Physical character of removed water, including changes during development in clarity, color, particulate, and odor;
- Quantity of water removed and removal time.

In addition to containerization of all media associated with well construction, all purge and development waters were drummed. All drums were labeled with the drum contents, location, originator, and date.

2.3.4 Well Location and Elevation Survey

The horizontal location of monitoring wells was within ±1.0 feet, while the elevations of the top of casing and ground surface was within ±0.01. The survey was performed by a Maryland licensed surveyor.

A groundwater level survey was conducted on all the newly installed and existing monitoring wells sampled. The data collected in this survey was used to better define the local groundwater contours and groundwater flow direction.

2.3.5 Monitoring Well Sampling

Groundwater samples were collected using the low-flow technique for both purging and sampling. This method ensures minimal physical disturbance of the water column (turbulence and aeration) and eliminates the need to filter metals analyses samples. The primary advantage of this procedure is the collection of low turbidity samples (i.e., samples with low concentrations of suspended particles) and the reduction of sample aeration, resulting in samples that are more representative of true aquifer conditions. Low flow sampling also, in most cases, reduces the volume of groundwater purged from the well and associated disposal issues.

This sampling procedure involves removing groundwater from a monitoring well using a variable speed stainless-steel electric-powered submersible pump placed at the center of screened interval. The pump intake was kept at least two feet above the bottom of the monitoring well to prevent mobilization of any sediment present in the bottom of the well. The depth to which the pump was lowered and the sample collected were recorded so that the pump could be placed in the same location during future sampling events.

Before pumping began, the water level in the monitoring well was measured. The water level was also measured every three to five minutes during pumping. Pumping rates were less than 500 mL per minute. Where possible, a pumping rate was maintained that resulted in a stabilized water level (less than 0.3 feet drawdown) in the monitoring well. Water quality parameters (i.e., pH, temperature, conductivity, DO, turbidity, and ORP) were measured on three to five minute intervals. Stabilization was

defined by the following variances between three successive readings: turbidity, DO, and ORP within ±10%; conductivity within ±3%; pH within ±5%; and temperature within ± 1°C. If the water quality parameters did not stabilize, pre-sample purging continued until one well volume was removed or a purge time of two hours was exceeded.

If drawdown in the monitoring well was greater than 0.3 feet, the pumping rate was reduced to match the recharge rate of the well, taking care to maintain pump suction and avoid air entrainment in the tubing. If drawdown continued despite reducing the pumping rate, the well was monitored until a stable groundwater level above the screened interval was achieved. Once the groundwater level in the well stabilized (i.e., well reaches steady-state), the pumping rate and the water level in the well remained constant, groundwater quality parameters were evaluated on three to five minute intervals for stabilization. At a minimum, three times the volume of the groundwater drawdown in the well was removed prior to groundwater sampling. The volume of groundwater drawdown in the well was calculated by subtracting the constant head level from the initial water level measured in the well prior to pump installation and multiplying the well drawdown length by 0.65 gallons, which is the amount of water contained in one foot of 4-inch I.D. PVC well casing.

Disposable sample tubing connected to the pump was used in collecting low-flow groundwater samples. The tubing was dedicated to each individual well and was disposed of after use. Sample bottles were filled in order of decreasing analyte volatility and preserved according to the aqueous preservation requirements. VOC samples were collected first. VOC samples were collected directly into pre-preserved sample containers. All containers were filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Samples were collected at the stabilized low flow flowrate. Sample labels and the chain-of-custody forms were completed following the collection of each sample as described in the Work Plan. The labels were placed on the bottle and the bottle placed immediately into a cooler. The cooler was iced and the samples kept at a temperature of approximately 4°C. The completed chain of custody was placed in a plastic zip-lock bag taped to the inside lid of the cooler with the sample.

Prior to the start of the sampling event and following the collection of samples, all downhole equipment were thoroughly decontaminated following procedures outlined in the Work Plan (IT, 2001b).

2.3.6 Direct-push Groundwater Sampling

Groundwater screening samples were collected using direct push technology (DPT) at 23 locations to help characterize the extent of groundwater contamination. DPT rig utilizing a temporary 4-foot, stainless steel, 0.02-inch slotted, screened Geoprobe groundwater sampler at each location. The direct-push drive point was hydraulically driven to the desired sampling depth and the rods were then raised approximately 1 to 2 feet, which disengages the drive point and allows the stainless steel screen to drop into the open interval. Disposable 3/8-inch tubing with a check valve on the end was then inserted into the screened interval. Purging was accomplished using an inertial displacement technique that releases and closes a mini check valve inside the tubing and forces water up through the tubing. Samples were collected directly from the tubing once three tubing volumes were evacuated. A groundwater sample was then collected for VOCs. DPT groundwater screening data are provided in **Appendix D**.

Prior to the start of the sampling event and following the completion of each point, all downhole equipment was thoroughly decontaminated following procedures outlined in the Work Plan.

2.3.7 Quality Assurance and Quality Control

This section presents the analytical methodology, approximate number of samples and general sample quality control (QC) procedures. The sample collection, handling, and custody procedures will be in compliance with detailed procedures outlined in the *Fort Meade Quality Assurance Project Plan* (USAEC, 1996b) and the Work Plan Addendum (IT, 2001b).

2.3.7.1 QA/QC Samples and Frequency

QC sampling was conducted as follows:

Matrix Spike/Matrix Spike Duplicate: For every twenty samples, the laboratory utilized excess sample volume to analyze one matrix spike and one matrix spike duplicate sample.

Duplicate Samples: Duplicate samples were collected at a rate of 10% of the total number of both quantitative and screening samples.

Rinse Blank: Four rinse blanks were collected for the quantitative groundwater sampling effort at a rate of 1 per 10 samples. The rinse blank samples were collected by pouring laboratory supplied analyte-free deionized ultra-filtered water over the sampling equipment directly into the sample containers.

Trip Blanks: One trip blank accompanied each cooler containing samples for VOC analysis.

2.3.7.2 Sample Containers and Preservation Methods

Sample containers, preservation methods, analytical methods and holding times were followed in accordance with the Work Plan Addendum (IT, 2001b) and the *Fort Meade Quality Assurance Project Plan* (USAEC, 1996). The chain of custody forms and sample container labels indicating the sample number, date, time, the individual collecting the sample, the parameters being analyzed, and the preservative used.

2.3.7.3 Sample Field IDs

The Field IDs for the direct-push groundwater screening samples was as follows: MDPGWxxx, where xxx= sequential sample number starting with 001.

The sample numbering system for monitoring well sampling was as follows: MWxxx, where xxx= Specific Fort Meade Well Number. New wells were assigned the numbers MW-109 through MW-128.

2.3.8 Data Validation

DPT groundwater samples analyzed for VOCs were collected as screening level data and these analytic data were not validated. An independent review of 100% of the data collected from monitoring wells was performed according to USEPA Region III Validation Level M-3 (organics) and IM-2 (inorganics) by Ecochem and Laboratory Data Consultants (LDC). Data validation was performed in accordance with a combination of method-specific criteria and laboratory SOPs. The *USEPA Region III Modifications to the National Functional Guidelines for Inorganic Data Review*, *USEPA Region III Modifications to the National Functional Guidelines for Organic Data Review*, and *USEPA Region III Innovative Approaches to Data Validation* were used to provide the validation qualification schemes.

Data packages were validated to ensure compliance with specified analytical and quality assurance/quality control (QA/QC) requirements; data reduction procedures; data reporting requirements; and required accuracy, precision, and completeness criteria. These included (as applicable), but are not limited to:

1. Sample preservation and holding times.
2. Instrument performance check.
3. Calibration (initial and continuing).
4. Blanks.
5. Matrix spike and spike duplicate recoveries.
6. Sample duplicate.
7. Surrogate spike recoveries.
8. Laboratory control samples.
9. Interference check sample (for metals).
10. Serial dilution (for metals).
11. Internal standards and retention times.
12. Quantitative verification.

Appropriate data qualifiers were added to the results as determined by the data validation reports. The most common data validation qualifiers are:

B[1] Estimated value. Value reported was greater than the method detection limit and less than the method reporting limit.
B[2] Analyte was detected in sample and associated blank at a concentration within 5 or 10 times the blank concentration.
J Estimated value.
K Estimated value, bias high.
L Estimated value, bias low.
D Sample diluted.
U Analyte non-detected.

2.3.9 Investigation-Derived Waste

Investigation-Derived Waste (IDW) generated during well installation and sampling activities at Fort Meade primarily consisted of about 600 drums of drilling fluids, soil cuttings, and decontamination water, development water, and sample purge water. Lesser amounts of personal protective equipment (PPE) and non-hazardous field supplies (e.g., plastic sheeting, miscellaneous trash) were also generated and drummed. All drums were affixed with non-hazardous waste labels indicating the type of waste, location (i.e., well ID) where the materials were generated, and the date(s) the wastes were generated. The drums were then consolidated at a staging area at the CSLF. Composite solid and liquid samples were collected and analyzed for Toxicity Characteristic Leaching Procedure (TCLP) parameters.

Based on the lack of indications of contamination (soil staining, odors, elevated PID readings, etc.) encountered during drilling and drumming of IDM, the minimal indications of contamination in the Lower Patapsco Aquifer groundwater samples collected from the wells, and the lack of contamination indicated by the TCLP sampling characterization, it was determined that IDM would be disposed on-site. Analytical detections for water were also compared to the National Pollutant Discharge Elimination System (NPDES) permit (No. 90-DP-2533) for the Fort Meade Water Treatment Plant and were found to be suitable for discharge to the sanitary sewer system. No IDM was classified as hazardous waste.

Soils, mud, and sediment-laden water were spread, leveled and seeded in a location at the CSLF designated by the Fort Meade Environmental Management Office. Clear (non-turbid) water IDM were discharged through the sanitary sewer system. Non-hazardous solid waste was disposed of as solid waste by Fort Meade. Drums were recycled at the Fort Meade Recycling center.

3.0 IDENTIFICATION OF SCREENING LEVELS

This section discusses the selection of screening levels for assessing the significance of environmental sample results obtained during the RI and identifying chemicals of potential concern (COPCs) for the human health risk assessment (HHRA). Screening levels used in the RI include chemical-specific ARARs, to-be-considered (TBC) guidance, and background sample results. Screening levels provide a means by which chemical results obtained during the RI can be evaluated to assess the nature and extent of contamination (see Section 4.0); however, comparison of screening levels to environmental sample results does not necessarily determine if an area poses unacceptable risk to human health or the environment. Further refinement of screening levels and statistical analysis of background concentrations is performed during the HHRA (see Sections 6.0). If the BRA determines that there is unacceptable risk posed by contamination at the CSL, the screening levels will be considered in the development of remedial action cleanup levels.

3.1 CHEMICAL-SPECIFIC ARARS AND GUIDANCE TO BE CONSIDERED

ARARs are defined as cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site. ARARs and TBC guidances do not determine whether remediation of a site should take place, but they do guide the manner in which the selected remedial alternative would be performed, should a remediation option be selected.

Environmental laws and regulations may be applicable, relevant, and appropriate, or TBC to the hazardous substances, pollutants, or contaminants at a site. "Applicable" requirements are those Federal and State requirements which are legally applicable, either directly or as incorporated by a Federally-authorized State program. An example of an applicable requirement would be Safe Drinking Water Act (SDWA) MCLs for sites which may contaminate public water supplies.

"Relevant and appropriate" requirements are Federal and State standards, criteria, or limitations which are not legally applicable to the site, but which address problems so similar that their application is appropriate. The determination that a requirement is relevant and appropriate involves the comparison of a number of site specific factors with those addressed in the regulatory requirements, including the physical circumstances of the site, hazardous substances present at the site, and characteristics of the remedial action. For example, while Resource Conservation and Recovery Act (RCRA) regulations are not applicable to closing undisturbed hazardous wastes disposed prior to November 1980, the RCRA regulations for closure by capping may be deemed relevant and appropriate.

TBC guidances are non-promulgated advisories or guidance issued by Federal or State governments that are not legally binding and do not have the status of ARARs. TBCs may be used in conjunction with ARARs to determine the necessary level of cleanup for protection of health and the environment. Examples of TBCs are the Risk-Based Concentrations (RBCs) developed by USEPA.

The regulatory agencies responsible for the site make the final determination on the applicability or relevance and appropriateness of a requirement based on such factors as the circumstances of the remedial action and physical characteristics of the site. The development and refinement of potential ARARs is continuous throughout the RI/FS process as additional site information is acquired.

For the purposes of this report, chemical-specific ARARs and TBC guidance values were selected for comparison to environmental sample results in Section 4.0, and for use in the BRA (Section 6.0) to select COPCs. Chemical-specific requirements set health- or risk-based concentration limits or ranges for specific hazardous substances in various environmental media.

The chemical-specific ARARs used in developing screening levels for the RI are listed in Table 3-1A. This table identifies the regulatory authority, a brief synopsis of the requirement, and whether the requirement is applicable, relevant and appropriate, or TBC. Table 3-1B presents a complete listing of the screening levels used for comparison to the RI analytical results which are discussed in Section 5.0. Table 3-1B includes USEPA Region III Industrial Soil RBCs (USEPA, 2005a) for surface and subsurface

soils; USEPA Region III Tap Water RBCs[1] (USEPA, 2005a) and Federal MCLs (USEPA, 2005b) or Maryland Water Quality Standards (COMAR 26.04.01) for groundwater; the more stringent of the Federal Ambient Water Quality Criteria (AWQCs)(USEPA, 2005a) and the Maryland Water Quality Standards for surface water (hereafter referred to as AWQCs); and the Sediment Quality Guidelines developed for the National Status and Trends Program (NOAA 1999), Effects Range-Low (ER-Ls)(hereafter referred to as ER-Ls) for sediment. The analytes listed in Table 3-1B do not necessarily represent the comprehensive list of analytes included in each reference document, but instead represent the list of target analytes for the RI.

3.2 BACKGROUND SAMPLE RESULTS

Per meeting and agreement with EPA Region 3's Toxicologist, RPM, and MDE on April 25, 2003, background levels established in the approved Final RI for Inactive Landfills (IAL) 1,2, 3 and Clean Fill Dump (August 1998) were used for background screening in this report.

Background surface soil, subsurface soil, groundwater, surface water, and sediment samples were collected to establish background concentrations for all chemical analyses performed for the RI. Chemical concentrations detected in background samples collected during the RI were compared to the concentrations detected from the same medium at site-wide locations to determine if site-related contaminants are present at concentrations that are greater than background levels. Background locations and sampling rationale are presented for each medium in the following sections.

3.2.1 Groundwater

A total of four wells were used to assist in the establishment of background levels for use in the RI. An effort was made to relate stratigraphic units and geologic formations with areas of investigation.

Aquifer/Formation	Background Wells	CSL Wells
Upper Patapsco	CFD-1 ODAMW-5	MW-2S, MW-4S, MW-5, MW-7S, MW-8, MW-10S, MW-12S, MW-13S, MW-14, MW-17, MW-18, MW-19, MW-20, MW-105, MW-106, MW-107, MW-123, MW-124, MW-127, MW-128
Lower Patapsco	MW-22S ODAMW-6D	MW-2D, MW-4DR, MW-7D, MW-10D, MW-12D, MW-13D, MW-101D, MW-108D, MW-109D, MW-110D, MW-111D, MW-112D, MW-113D, MW-114D, MW-115D, MW-116D, MW-117D, MW-118D, MW-119D, MW-120D, MW-121D, MW-122D, MW-125D, MW-126D

Background wells are located upgradient of all known disposal and training areas. The well locations were also chosen based on past facility operations. No indications of past soil disturbance have been identified at these locations based on examination of aerial photographs and review of site investigation reports.

Monitoring wells CFD-1 and ODAMW-5 were used to establish site background for samples collected from the Upper Patapsco aquifer. ODAMW-5 is screened in the first water-bearing zone of the Upper Patapsco at approximately 2 to 12 feet bgs. Monitoring well CFD-1 is located approximately 300 feet upgradient of the Clean Fill Dump. RI samples collected in the Upper Patapsco aquifer include shallow wells at the CSL. Both background groundwater samples were analyzed for TCL VOCs, SVOCs, explosive compounds, pesticides, PCBs, and TAL inorganics.

No VOCs, SVOCs, pesticides, PCBs, or explosives were detected in wells CFD-1 or ODAMW-5. Background levels of arsenic and beryllium were detected above conservative Tap Water RBCs in both wells but below MCLs.

[1] USEPA Region III Tap Water RBCs were used as a conservative means of screening groundwater data. However, under current and future industrial/commercial land use scenarios (see Section 6.0), Tap Water RBCs are inappropriate. USEPA does not provide RBCs for groundwater for industrial use scenarios.

Monitoring wells MW-22S and ODAMW-6D were used to establish site background for samples collected from the Lower Patapsco. MW-22S was installed as an upgradient well to the IAL1 during the SI and is screened from 15 to 25 feet bgs. ODAMW-6D is screened in the Lower Patapsco aquifer at approximately 80 to 120 feet bgs. Both background groundwater samples were analyzed for TCL VOCs, SVOCs, explosive compounds, pesticides, PCBs, and TAL inorganics.

No VOCs, SVOCs, pesticides, PCBs, or explosives were detected in wells MW-22S and ODAMW-6D. Background levels of arsenic and beryllium were detected above conservative Tap Water RBCs but below MCLs in both wells.

3.2.2 Subsurface Soil

Nine subsurface soil samples were collected from the first 10 feet of three soil borings drilled south of the Patuxent River in the PRR, Central Tract. Soil samples were collected at the 2-4, 4-6, and 8-10 foot depth intervals, resulting in a total of nine subsurface soil samples. Subsurface soil samples were analyzed for TCL VOCs and SVOCs, explosives, pesticides, PCBs, and TAL inorganics.

No VOCs, SVOCs, explosives, pesticides, or PCBs were detected in background subsurface soils. All TAL inorganics were well below Industrial RBCs.

3.2.3 Surface Soil

Five surface soil samples were collected from off-post areas to establish a range of background chemical concentrations. Samples were collected from the PRR, Central Tract, located south of the Patuxent River. These samples were collected from undisturbed areas that are similar in elevation and soil type to the surface soil samples collected on post.

Sample locations were selected so as not to be impacted by the landfill and laboratory drain field or other environmental conditions of concern existing on the PRR South Tract. Surface soil samples were analyzed for TCL VOCs and SVOCs, explosives, pesticides, PCBs, TAL inorganics, and hexavalent chromium.

No VOCs, SVOCs, explosives, pesticides, or PCBs were detected in background subsurface soils above Industrial RBCs. All TAL inorganics were well below Industrial RBCs.

3.2.4 Surface Water and Sediments

Background surface water and sediment samples were collected from upstream locations on the Patuxent River (two samples) and the Little Patuxent River (one sample). Two upgradient surface water sediment pairs collected by Analysas, Inc. were also used to establish upgradient conditions in the Little Patuxent between the STP and IAL1. These surface water and sediment samples were analyzed for TCL VOCs and SVOCs, explosives, pesticides, PCBs, TAL inorganics, TOC, and grain size.

4.0 NATURE AND EXTENT OF CONTAMINATION

Contamination exists whenever chemical constituents are present in the environment above designated screening and background levels deemed appropriate for each media. Their presence does not necessarily constitute a risk, but can provide an indication of the likely source of the release(s) and how the chemicals interact and migrate in the natural environment. The nature of the contamination is described by the chemical constituents that are present and by their associated concentrations. The extent of contamination is described by the distribution of these chemicals in various environmental media. This distribution can be based on a single point in time or on samples collected over some specified time frame.

This section provides the following information: a description of the physical setting and operational history of the CSL; a description of the topographic, geologic, and hydrogeologic conditions at the CSL and adjacent (downgradient) off-post areas to the southeast; a summary of historical sampling results; the investigation program summary; the analytical results; and a discussion of the nature and distribution of chemicals at the CSL.

4.1 SITE DESCRIPTION AND OPERATIONAL HISTORY

The CSL is located in the southeast corner of FGGM south of State Route 32 and encompasses approximately 130 acres of land (See **Figure 2-6**). The CSL is bounded to the west by small arms training ranges and woodland areas (formerly part of FGGM) which are now part of the Department of Interior's Patuxent Research Refuge (PRR). Residential and light industrial areas of Odenton, MD are present to the east and north of the site. Neighboring properties include the National Railroad Passenger Corporation (Amtrak) maintenance yard and railroad right of way, a residential trailer park, residences and commercial business facilities. The Amtrack railroad borders the southeastern CSL/FGGM property line.

A former ammunition supply point (ASP) consisting of 12 concrete ammunition storage bunkers (magazines) and associated access roads was located in the area north of Cell 1 and west of Cell 2. The ASP was little used after the 1960s and was demolished and removed in 2001.

The FGGM DPW uses a portion of the northwest corner of the site for bulk storage of loose materials (gravel, sand, etc.). This is the only active operation at the site.

Currently, the largest site features are the two capped cells - Cell 1 (155 acres) and Cell 2 (66 acres). Other site features include engineered drainage features, including several small retention ponds, gravel access roads, and a perimeter security fence. A small stream roughly bisects the site from west to east. Wetland areas are present between Cell 1 and Cell 2, along the stream, and west of the CSL. Wooded areas buffer the site to the north, west, and southwest.

The landfill began operation at FGGM in 1958, using the trench fill method, and was used for the disposal of "mixed residential, commercial, and nonhazardous industrial wastes." The trench fill method continued until 1976. Sanitary land filling continued altering the operation to area fill. The landfill was constructed as an unlined facility and was initially designated as the Active Sanitary Landfill. It was divided into two cells: Cell 1 and Cell 2. A third area which lacks topographic expression, has been informally referred to as Cell 3, but is not a defined disposal area. Historical aerial photographs from 1970, 1975 and 1986 show the progression of expansion and waste disposal in the CSL when it was active (**Figure 4-6**).

FGGM was issued a Refuse Disposal Permit (Permit No. 80-02-00-08-A) in 1980 by the Maryland Department of Health and Mental Hygiene (now MDE). A federal/state mandated detection monitoring program was initiated in March 1994 to identify potential deficiencies in the landfill operation. Based on the results of the detection monitoring, assessment monitoring was initiated for the upper aquifer in November 1994 and was initiated for the lower aquifer in June 2000. Under the monitoring program, groundwater and surface water samples are collected and analyzed on a semi-annual basis. In 1992, FGGM was issued a Disposal Permit by MDE (Permit No. WSF-0022-0). The landfill ceased operations in 1996, at which time it began to be referred to as the Closed Sanitary Landfill. Landfill Cell 1 was capped and closed during the period 1995 through 1997 and Landfill Cell 2 was capped and closed during the period 1997 through 1998. A flexible membrane liner was incorporated into the final cap

system for both Landfill Cells 1 and 2. A landfill gas collection and treatment system operates along the eastern edge of the landfill cells to control air emissions from the site.

4.2 PHYSIOGRAPHY, TOPOGRAPHY, AND DRAINAGE

FGGM is located in the Coastal Plain Physiographic Province, which is characterized by low rolling uplands and low-gradient streams. The Coastal Plain is underlain by a wedge of unconsolidated alluvial sediments that dip and thicken toward the Atlantic Ocean. The igneous and metamorphic rocks of the Piedmont physiographic province (the easternmost portion of the Appalachian Plateau) are exposed near the Anne Arundel County line, about five miles west of FGGM. The demarcation between the Piedmont and Coastal Plain Physiographic Provinces is termed the "Fall Line," after the falls and rapids found where streams cross this boundary.

FGGM is located within the Patuxent River watershed, which is one of the primary drainage systems in Anne Arundel County. This watershed encompasses approximately 932 square miles. The Patuxent River receives drainage from numerous intermittent streams. The Little Patuxent River, the major tributary of the Patuxent River, flows southeast across the middle of FGGM and receives drainage from the majority of the installation. Both rivers eventually drain into the Chesapeake Bay.

The CSL is dominated by two capped landfill cells, which rise approximately 30+ feet above the surrounding terrain (**Figure 4-4**). The cells are sloped on all sides and have been revegetated since closure and capping. The elevations at the base of the cells range from 164 to 150 feet above mean sea level (AMSL) and reach 190 to 192 feet AMSL at the highest elevation of the landfill cells. Surface water flow is radial from the cells, locally channeled by engineered drainages.

On the CSL the two cells are separated by a drainage swale which receives runoff from the inner (western) flanks of the cells and from surface runoff from adjacent areas to the north. Surface water follows the swale to the west and then enters a series of small engineered retention ponds, which in turn empty into minor tributaries of the Little Patuxent River.

Surface water from the eastern flanks of the cells flows eastward into a northeast-southwest trending drainage ditch located along the installation boundary and the adjacent elevated railroad bed. The railroad, currently operated by Amtrak, was originally located through a southwest trending topographic low in this area – which is generally about 160-170 feet AMSL along the FGGM boundary. The terrain generally rises eastward into Odenton onto a series of hills which crest at about 200-240 feet AMSL near State Road 170.

4.3 GEOLOGY

Geologic and hydrogeologic information for the Closed Sanitary Landfill (CSL) area was compiled from the Active Sanitary Landfill RI Report (EA Engineering,1992), the USACE (1999) Basic Data Report Site-Wide Groundwater Study, the USACE (2004) Southeast Area Conceptual Site Model, the CSL Groundwater Data Report (EM Federal, 2003), Mack and Achmad (1986), Wilson and Achmad (1995), CSL semi-annual RCRA Groundwater Monitoring Reports, and on-going CSL and adjacent area investigations. A geologic map and generalized cross section across the FGGM area showing the principal geologic formations and their relationships are presented in **Figures 2-3** and **2-4** along with a regional deep litho-electric log (**Figure 2-5**).

The following geologic discussion references the following local CSL figures: A Pseudo cross section showing all CSL deep wells projected onto a NW-SE line (**Figure 4-7)** and a fence diagram showing geologic variation across the CSL (**Figure 2-8**). A conceptual site model is presented in **Figure 2-7.**

The Patapsco Formation outcrops over FGGM except where locally overlain by Quaternary alluvial and river terrace deposits or fill materials. The Patapsco Formation is informally divided into an upper, middle, and lower section of unconsolidated alluvial deposits which overlay the Arundel Clay regional confining unit. In the vicinity of the CSL, the upper and lower sections of the Patapsco Formation, which are predominantly sand-rich and water bearing units, are separated by a (middle) clay-rich section which acts as a confining unit. These units dip and thicken to the southeast consistent with regional trends. The unlined CSL was constructed in/on the Upper Patapsco outcrop area.

At the CSL and in adjacent areas to the southeast, groundwater is present under unconfined conditions in the Upper Patapsco and under confined conditions in the Lower Patapsco. Note that in the central and western portions of FGGM (in the Lower Patapsco outcrop area), shallow groundwater is also present under unconfined conditions in the Lower Patapsco.

The upper section of the Patapsco Formation has an erosional (zero) edge near the eastern side of FGGM such that the recharge area of this unit at FGGM is essentially restricted to the CSL area and adjacent area north of State Route 32. This unit has a maximum observed thickness of about 40 feet at the CSL and continues to dip and thicken to the east to about 70 feet in the easternmost off-post well borings. It is generally comprised of mottled, medium-fine to silty sand. The CSL shallow monitoring wells, which monitor the water table aquifer are screened in this unit.

The middle section of the Patapsco Formation is mostly comprised of hard, highly plastic, mottled clay although lenses of fine silts and sand are not uncommon. The erosion (zero) edge of the middle Patapsco lies to the west of the CSL and the unit thickens and dips to the southeast. The middle Patapsco is about 35 feet thick on the west side of the CSL and about 50 feet thick on the east side of the CSL. Off-post borings penetrating the middle Patapsco downgradient of the CSL have generally encountered 85-100 feet of clay.

The deep CSL wells are screened in the Lower Portion of the Patapsco Formation (Lower Patapsco aquifer). In this area, the lower section of the Patapsco Formation typically consists of silty sands which grades generally coarser downward. No CSL area deep monitoring wells fully penetrate the Lower Patapsco aquifer (down to the Arundel Clay). During the DRMO plume investigation, the Lower Patapsco was observed to be up to about 200 feet thick in the area west and southwest of the CSL in the PRR.

4.4 HYDROGEOLOGY OF THE CSL

In addition to the investigation results, hydrogeologic information for the Closed Sanitary Landfill (CSL) area was compiled from the Active Sanitary Landfill RI Report (EA Engineering,1992), the USACE (1999) Basic Data Report Site-Wide Groundwater Study, the USACE (2004) Southeast Area Conceptual Site Model, the CSL Groundwater Data Report (EM Federal, 2003), Mack and Achmad (1986), Wilson and Achmad (1995), CSL semi-annual RCRA Groundwater Monitoring Reports, and on-going CSL and adjacent area investigations.

The operative units discussed in the following text are the Upper Patapsco Aquifer, which is the water table aquifer in the study area, the Middle Patapsco confining unit, and the Lower Patapsco Aquifer, which is confined in this area.

4.4.1 Hydrologic Data

Historical head measurements from the Upper Patapsco (water table) aquifer wells and Lower Patapsco (confined) wells at the CSL are tabulated in **Table 2-1** and are graphed in **Figure 4-9A** This data shows a head variation of approximately 2-4 feet in any given well due to a combination of seasonal effects and local precipitation events. The maximum heads were observed in the spring months and lower heads were observed in summer and fall months.

Hydrographs of the hydraulic heads from the CSL well nests show that wells screened in the unconfined aquifer have hydraulic heads of approximately 100 feet mean sea level (MSL) and that the mid-depth and deep wells screened in Upper Patapsco Aquifer have hydraulic heads of approximately 75 feet NGVD. MSL 25-foot head difference indicates that the Upper Portion of the Arundel Clay is an effective confining unit in this area. Downward vertical hydraulic gradients are observed between the upper (unconfined) and lower (confined) aquifers in well pairs and in the measured potentiometric surfaces of the upper and Lower Patapsco aquifers, with gradients generally increasing to the southeast. At the eastern CSL/facility boundary, the potentiometric surface of the Lower Patapsco aquifer is about 80-90 feet msl, about 50-60 feet below the unconfined surface of the Upper Patapsco aquifer (140-150 feet msl).

Hydraulic gradients in the Upper Patapso Aquifer are highly variable due to topographic variations on the order of 10^{-2} ft/ft. Mean hydraulic conductivity based on 8 slug tests was calculated as 2.44×10^{-4} cm/s (0.46 ft/day) (EA, 1992).

Local hydraulic gradients in the Lower Patapsco Aquifer are on the order of 3×10^{-3} ft/ft. Mean hydraulic conductivity based on three slug tests was calculated as 1.59×10^{-3} cm/s (EA, 1992).

4.4.2 Groundwater Flow in the Upper Patapsco Aquifer in the Vicinity of the CSL

Although shallow groundwater flow in the water table aquifer is regionally to the east-southeast, topographic highs in the vicinity of the CSL results in local deviations from regional trends (**Figure 4-1**). The significant topographic features are as follows:

- The man-made cells of the CSL with their impermeable RCRA caps form significant (>30 feet) topographic highs of about 170 feet AMSL which locally impose radial deflections of shallow groundwater. This can locally impart north or westerly flow of unconfined groundwater into the low lying area between CSL cells 1 and 2 and southerly flow south of Cell 1.
- The Amtrak Railroad and associated right-of way lie in a NE-SW trending topographic low which crosses the regional groundwater flow direction at a high angle, locally resulting in surface water seeps and southerly or southwesterly deflection of unconfined groundwater flow. This is reinforced by the presence of local topographic highs (200+ feet AMSL) in central Odenton located between the right-of-way and State Road 170.
- The local topography features, and the hydraulic head measurements from the shallow wells located on the south side of Cell 1 and the off-post wells to the east suggests that local groundwater flow immediately east of the CSL is to the south or southwest instead of to the southeast.
- Hydraulic gradients in the Upper Patapso Aquifer are highly variable due to topographic variations on the order of 10^{-2} ft/ft.
- Mean hydraulic conductivity based on 8 slug tests was calculated as 2.44×10^{-4} cm/s (0.46 ft/day) (EA, 1992).
- Calculated average linear flow velocities in the Upper Patapsco aquifer based on Darcy's equation for an assumed porosity of 25% show velocities ranging from about 3-20 feet/year (URS, 2005).

4.4.3 The Middle Patapsco as a Confining Unit at the CSL

The Middle Patapsco clays form a thick (35-100 feet), effective confining unit at the CSL. Regionally, this unit ranges from 0 to about 60 feet of fine sandy clay which may be heterogenous and laterally discontinuous; however, it is often comprised of massive beds of clay (such as here) with very low vertical permeabilities (Mack and Achmad, 1986 and Wilson and Achmad 1995). This is supported by:

- The observed thickness and homogeneity of the clays encountered during drilling in the vicinity of the CSL (about 35-50 feet on-post, thickening to 70+ feet in off-post downgradient areas);
- Semi-annual RCRA monitoring show downward vertical hydraulic gradients between the upper and lower aquifers, and statistically increasing concentrations of organic contaminants (as defined by the RCRA landfill monitoring requirements) in the upper aquifer which are not observed in the lower aquifer.
- The primary organic contaminants observed in the lower aquifer, carbon tetrachloride and tetrachloroethene (PCE), were also detected in upgradient deep wells (117D and 122D). This indicates a potential source upgradient from the CSL.
- The presence of carbon tetrachloride in the deep aquifer only.

- PCE and TCE were only detected in the deep aquifer for both the September 2002 and June 2004 sampling events.
- Benzene was only detected in the shallow aquifer for both September 2002 and June 2004 sampling events.
- Downward vertical hydraulic gradients are observed between the upper (unconfined) and lower (confined) aquifers in well pairs and in the measured potentiometric surfaces of the upper and Lower Patapsco aquifers, with gradients generally increasing to the southeast. At the eastern CSL/facility boundary, the potentiometric surface of the Lower Patapsco aquifer is about 80-90 feet msl, about 50-60 feet below the unconfined surface of the Upper Patapsco aquifer (140-150 feet msl). The persistent strong negative hydraulic gradients shows a good hydraulic separation between the aquifers is being maintained.
- The Upper and Lower Patapsco aquifers have different water chemistries. Charge balance calculations for major anions (calcium, magnesium, potassium, iron, sodium, and nitrate) and major cations (chloride, sulfate, and alkalinity) have been performed (EA,1992 and USACHPPM, 1994)[1]. Lower Patapsco groundwater samples showed significantly lower and more uniform microequivalent charge per liter for both cations (<1.5) and anions (<1.9) than were observed in the Upper Patapsco aquifer (0 to about 50 for both anions and cations). The % differences within individual samples did not show significant differences. This indicates Upper Patapsco groundwater is not mixing with the Lower Patapsco groundwater in the vicinity of the CSL.
- Calculation of permeabilities of 5 shelby tube samples (from 5 different borings) of the middle Patapsco clay ranged from 1.2×10^{-8} cm/sec to 1.9×10^{-7} cm/sec (EA,1992). These values are representative of confining layers.
- A short term (4-hour) pumping test was performed on deep CSL well MW-7D (EA,1992). Deep well MW-7D, screened in the Lower Patapsco aquifer drew down 32 feet. Adjacent shallow well MW-7S, screened in the Upper Patapsco aquifer, exhibited no drawdown. This data suggests that the middle Patapsco confining unit effectively blocked hydraulic communication between the upper and Lower Patapsco aquifers in the area of the CSL. No other pump tests have been performed in this area.

4.4.4 Groundwater Flow in the Lower Patapsco Aquifer in the Vicinity of the CSL

Local hydraulic gradients are on the order of 3×10^{-3} ft/ft. Mean hydraulic conductivity based on slug tests was calculated as 1.59×10^{-3} cm/s (EA, 1992).

Regional groundwater flow directions in the Lower Patapsco aquifer are to the southeast, as documented in the USACE (1999) Basic Data Report. The potentiometric surface of the Lower Patapsco aquifer, based on data from the deep CSL and adjacent area wells presented in **Figure 4-2,** is more east-southeast near the facility boundary downgradient from the CSL. Local hydraulic gradients are on the order of 3×10^{-3} ft/ft.

The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, and MW-122D and detections of tetrachloroethene in wells MW-114D, MW-116D, MW-117D, and MW-120D show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSL is to the east-southeast, which is consistent with the regional groundwater flow direction but is a little more easterly than predicted by the USACE groundwater model for FGGM. MW-4DR is cross-gradient from the Lower Patapsco aquifer below the CSL, not upgradient. Data indicates the carbon tetrachloride and tetrachloroethene present in the Lower Patapsco aquifer, on the north side of the CSL, aquifer are not related to the CSL.

Mean hydraulic conductivity based on 3 slug tests was calculated as 1.59×10^{-3} cm/s (EA, 1992).

[1] Outling data from former well MW-4D (which was abandoned and replaced by MW-4DR) was dropped.

Calculated average linear flow velocities in the Lower Patapsco aquifer based on Darcy's equation for an assumed porosity of 25% show velocities ranging from about 15-20 feet/year (URS, 2005).

4.5 SUMMARY OF PREVIOUS ANALYTICAL RESULTS

Previous analytical data for groundwater, surface water, and sediments collected at the CSL are discussed below for each sampled media.

Historical sampling results are dominated by the CSL RCRA groundwater and surface water detection and monitoring program which has been collecting and analyzing samples semiannually since 1994. Other sampling events or programs are as follows:

- Active Sanitary Landfill and Clean fill Dump Remedial Investigation Report (EA, 1992);
- Off-Post Drilling and Sampling Results and Surface Water Sampling Results, Fort Meade Feasibility Study and Remedial Investigation/Site Inspection (USAEC,1999);
- Atrazine Study (AD Little, 1999)
- Monitoring Well MW-4DR Resampling (IT, 2001)

4.5.1 Overview of Semi-Annual RCRA Assessment Monitoring

In support of the RCRA closure for the CSL, a semi-annual groundwater monitoring program was initiated in 1994. This program was intended to identify constituents that may be leaching from the capped landfills and impacting the groundwater. Semiannual assessment monitoring was performed on the upper (Patapsco) aquifer and surface water beginning in 1994. The program was expanded to include semiannual monitoring of the lower (Patapsco) aquifer in 1995. The CSL monitoring well network is depicted on **Figure 4-9**.

The groundwater detection and assessment monitoring well network has gradually expanded over time and currently consists of the following upper and lower aquifer monitoring wells:

Upper Aquifer: MW-2S, 4S, 5, 7S, 8, 10S, 12S, 13S, 14, 17, 18, 19, 20, 105, 106, and 107

Lower Aquifer: MW-2D, 4DR, 7D, 10D, 12D, 13D, 101D, 108D, 109D, and 110D

The groundwater samples, which are collected under the assessment monitoring program, are analyzed for Appendix I and II 40 CFR 258 inorganic and organic parameters plus an additional 19 inorganic analytes and water quality parameters required by the State and FGGM (URS, 2005).

The surface water assessment sampling network consists of three (SW1-SW-3) surface water sampling points. The surface water samples, which are collected for the detection monitoring program, are analyzed for Appendix I 40 CFR 258 inorganic and organic parameters plus an additional 19 inorganic analytes and water quality parameters required by the State and FGGM (URS, 2005).

Summary sampling results, statistical analyses, and conclusions from the March 2005 sampling event (URS, 2005) are summarized here.

4.5.1.1 Assessment Monitoring in Upper Patapsco Aquifer (URS, 2005)

Ten years and 21 rounds of sampling have been accomplished under the assessment monitoring in the Upper Patapsco aquifer. Twenty organic compounds including fuel, solvent, and pesticide constituents, and five metals have been selected from the Upper Patapsco results. The organic compounds include several that have been detected above MCL concentrations and others that are below screening levels but have been persistent over the 10 year assessment monitoring program. Those organic analytes that are reported infrequently and at low concentrations have generally not been included in this review, but two pesticides have been included to demonstrate the inconsistent nature of these detections. Five of the metals have exceeded their MCL (Action Level in the case of lead and SMCL in the case of iron) at some time during the 10 year period.

In general, the organic compounds have been reported at low concentrations, within an order of magnitude of the detection limit. Many of these constituents have persisted through the assessment

monitoring showing no trend toward decreased nor increased concentrations. These persistent compounds individually are of relatively little concern, are considered as a group in terms of potential effects upon human health and the environment in Section 6.0 – Human Health Risk Assessment. Some compounds including benzene and vinyl chloride have been detected during the assessment monitoring at concentrations above the MCLs. In the recent sampling event Benzene was detected at 11 µg/L in MW-19 compared to the MCL of 5 µg/L. Benzene has been detected above the MCL in MW-19 throughout the assessment program, but this constituent has demonstrated a systematic decrease from greater than the MCL to approximately 3 µg/L in MW-2S and MW-12. Similarly, vinyl chloride exceeded its MCL in several wells early in the assessment and has decreased to less than 1 µg/L where it is present. Arsenic, chromium, lead, and thallium each exceeded the screening criterion in at least one assessment monitoring round. Chromium, lead, and thallium detections have been variable in location and concentration whereas arsenic has been persistent and remains above the MCL in several wells. These metals are frequently found in Cretaceous age aquifers and are often related to turbidity remaining in the sample even after well development and in spite of low-flow sampling techniques aimed specifically at minimizing stress to the aquifer. Iron was frequently detected at concentrations of 10^5, far greater than the SMCL of 300 µg/L.

4.5.1.2 Assessment Monitoring in Lower Patapsco Aquifer (URS, 2005)

Since assessment monitoring was specified for the Lower Patapsco aquifer in June 2000 eleven rounds of sampling have been conducted. The ten organic compounds (1,1-Dichloroethane, 1,2-Dichloroethene, 1,4-Dichlorobenzene, benzene, carbon tetrachloride, chlorobenzene, chloroform, cis-1,2-dichloroethene, and tetrachloroethene) and iron are the persistent detections in the lower aquifer during the assessment program. As with the upper aquifer, constituents in the lower aquifer organics include both fuel-related and chlorinated compounds. Most of the compounds are present at low concentrations near the detection limit and show little variation between sampling rounds. Carbon tetrachloride in MW4DR has exceeded the MCL throughout the monitoring, but has been generally decreasing during the 5 year term. PCE and TCE in MW-108D both show an increase with time, and PCE exceeded the MCL of 5 µg/L in the March sample.

Iron has been detected at concentrations exceeding the SMCL of 300 µg/L in several wells including MW-10D, MW-12D, and MW-13D. The spatial and temporal distribution of iron is possibly tied to the aquifer's electro-chemical conditions near the wells. Iron was below the detection limit in upgradient well MW4DR, suggesting the background concentration of iron is low and the elevated concentrations are related to subsurface conditions.

4.5.1.3 Detection Monitoring of Surface Water (URS, 2005)

Three surface water sample locations are defined along the stream that crosses the site. Surface water sample location SW-1, the upgradient monitoring point, is in the ditch along the eastern boundary of the FGGM landfill. Surface water from offsite usually flows across the landfill boundary near the northeastern portion of Cell 1. Surface drainage from the landfill flows toward the retention pond at the center of the landfill, just downstream of which is surface water sampling location SW-2. Water from the retention pond then discharges to the head of a stream that flows northwest across the western boundary of the landfill, where surface water sampling point SW-3 is located.

The surface water samples were screened against MCLs and Tap Water RBCs. While MCLs and SMCLs are typically used to evaluate groundwater quality, they are useful to evaluate surface water because constituents in the shallow aquifer almost certainly affect the surface water quality near groundwater discharge points. Areas of groundwater discharge occur when the elevation of the water table intersects the land surface, which is the case through the wetlands, the retention ponds, and at downgradient surface water sample location SW3. No surface water analytes exceeded their MCLs. Iron, chloride, color, turbidity, total dissolved solids, and pH exceeded their SMCLs. Ammonia in SW3 was the only analyte to exceed an RBC.

Surface water was present at two of the three designated sampling locations in March 2005. No analytes exceeded their MCL in the surface water samples, Iron, color, and turbidity both surface water samples exceeded their SMCLs, and chloride, total dissolved solids, and pH each exceeded the SMCL in one sample.

These results are consistent with the semi-annual detection monitoring results since 1994 which do not indicate that contaminants related to the CSL are migrating from the CSL in surface water at concentrations above screening levels.

4.5.1.4 Summary of Recent RCRA Semi-annual Groundwater Monitoring Conclusions

In support of the RCRA closure for the CSL, a semi-annual groundwater monitoring program was established. This program was intended to identify constituents that may be leaching from the capped landfills and impacting the groundwater. Sampling data and statistical analyses discussed herein are taken from the 2000 through 2005 detection and assessment monitoring reports (CH2MHILL, 2001 and URS, 2001, 2002a, 2002b, 2003a, 2003b, 2004a, 2004b, 2005). The groundwater samples collected during the monitoring events were analyzed for Appendix II 40 CFR 258 parameters, and the assessment monitoring well network consists of the following upper and lower aquifer monitoring wells for the 2000-2002 sampling events:

Upper Aquifer: MW (2S, 4S, 5, 7S, 8, 10S, 12S, 13S, 14, 17, 18, 19, 20, 105, 106, and 107)

Lower Aquifer: MW (2D, 4DR, 7D, 12D, 13D, 101D, and 108D)

The conclusions sections from the Annual Detection and Assessment Monitoring Reports are recapped below.

June 2000 Detection Sampling Event: During the June 2000 semi-annual detection sampling event, statistically significant increases in VOCs and metals were noted in the groundwater samples. In addition, carbon tetrachloride, benzene, total PCBs, and three metals (arsenic, beryllium and thallium) were detected in groundwater at concentrations above their respective MCLs (CH2MHILL, 2001).

December 2000 Upper Aquifer Conclusions: Because the results of the December 2000 monitoring event are similar to those of previous events, the conclusions drawn from them are similar. As in June 2000, benzene exceeds the MCL in wells MW-12S and MW-19. Arsenic was also detected above the MCL in MW-12S. Iron found in upper-aquifer groundwater exceeds the Safe Drinking Water Standard in fourteen of the sixteen upper-aquifer wells. The results of the Cochran's Approximation to the Behrens-Fisher (CABF) t-test statistical comparisons made for the upgradient and downgradient upper-aquifer wells indicate that the CSL continues to impact the upper-aquifer groundwater. The statistical analysis showed the CSL was impacting the areas downgradient of Cell 1 and Cell 2. The t-Test analysis also indicated that the wells MW-7S and MW-17 were having significant increases in measured constituents when compared to the upgradient well MW-4S, indicating, based on the measured groundwater flow, a possible off-site upgradient source of contamination other than the CSL.

December 2000 Lower Aquifer Conclusions: The results of statistical comparisons made for the upgradient and downgradient lower aquifer wells indicate that seven Appendix I parameters have shown significant increases when compared to the upgradient well MW-7D. Four of the constituents are organics and have been detected in three wells. Carbon tetrachloride and chloroform are detected in MW-4DR, tetrachloroethene (PCE) and trichloroethene (TCE) in MW-108D, and PCE in MW-101D. The other three Appendix I parameters showing significant increase are the metals barium, chromium (total chromium), and thallium. Barium shows up as statistically significant increases in MW-4DR, MW-10D and MW-101D. Chromium continues to show significant increases in MW-12D and thallium has shown a significant increase for the first time in MW-4DR[2]. MCL were exceeded for carbon tetrachloride and thallium in MW-4DR, total PCBs in MW-101D, and beryllium MW-7D.

Small concentrations (0.74 μg/L) of benzene were again detected in the upgradient well MW-7D. The presence of low concentrations of benzene in upgradient well MW-7D continues a trend of benzene detections, which was first detected in the well in 1994. The presence of benzene in MW-7D is likely from an upgradient off-site source.

[2] Lower aquifer well MW-4D was abandoned in place and replaced with MW-4DR.

Carbon tetrachloride has been present in upgradient MW-4DR at well above MCL levels since it was first sampled during the December 1998 monitoring event. Chloroform has also been detected in MW-4DR in each monitoring event, although at levels well below the MCL of 100 μg/L. Additionally, carbon tetrachloride has not been detected in any other well and MW-4DR is upgradient of the CSL. This would indicate that the source of the contamination in MW-4DR is not from the landfill but rather from areas northwest and upgradient of the landfill.

PCE and TCE both showed significant increases in MW-108D over the upgradient MW-7D. Both compounds have been consistently detected in MW-108D during previous sampling events. Additionally, MW-101D the deep aquifer well closest and upgradient to MW-108D, also had PCE detections in the previous sampling events. No other deep aquifer wells have had notable detections of PCE and TCE, and only well MW-13S in the upper aquifer (east of Cell 2) had a significant detection of TCE or has shown significant increase in TCE. The contamination is not coming from an obvious source and may be from an off-site source.

PCBs were detected (in MW-101D) for the first time during the monitoring program in either of the monitoring aquifers. The value for PCBs is derived by totaling all detected aroclors (i.e., Aroclor 1016, 1221, 1232, 1242, 1248, 1254 and 1260). Three aroclors were detected at estimated values near the reporting limits and the addition of these values gave a total PCB value of 1.6 μg/L that exceeded the MCL of 0.5 μg/L. This result may be an anomaly.

June 2001 Upper Aquifer Conclusions: The results of the June 2001 groundwater monitoring program are consistent with the December 2000 results. Statistically significant detections of VOCs and semi-volatile organic compounds (SVOCs) were noted in wells MW-2S, MW-13S, MW-14S, and MW-19. All of these wells are located directly next to Cell 1, which is the likely source of these constituents. Pesticides and/or herbicides were detected in wells MW-5, MW-13S, MW-14, and MW-18. The source of these constituents in MW-13S, MW-14, and MW-18 is likely from Cell 1. However, in the case of MW-5 and MW-8, the location of the source is uncertain, and is not likely associated with either landfill cell. Metals were elevated in nine of 16 wells with iron being the most common. Significant detections of anions included chloride, nitrogen as nitrate, sulfate and nitrogen as ammonia. Sulfate was the most commonly elevated anion and was found in both on- and off-site wells to the southeast of Cell 1.

June 2001 Lower Aquifer Conclusions: As previously reported, carbon tetrachloride was elevated in well MW4DR. This compound was not detected in any other well. The pesticides beta-BHC and heptachlor, were both found in well MW-13D. The source of these compounds is unknown. PCBs were not detected. Several metals were elevated in deep aquifer wells MW-10D, MW-12D, and MW-13D; iron was elevated in all three wells. MW-10D and MW-12D are upgradient and downgradient, respectively, of the southwestern portion of Cell 1. Therefore, it is difficult to distinguish the effect, if any, the landfill is having on the water quality at these locations. Nitrate was elevated in all deep aquifer wells relative to upgradient MW-7D.

December 2001 Upper Aquifer Conclusions: The results of the December 2001 groundwater monitoring program are consistent with the June 2001 results. Statistically significant detections of VOCs and semi-volatile organic compounds (SVOCs) were noted in wells MW-2S, MW-13S, MW-14S, and MW-19. All of these wells are located directly next to Cell 1, which is the likely source of these constituents. Pesticides and/or herbicides were detected in wells MW-5, MW-8, MW-13S, MW-14, and MW-18 in the June 2001 samples but were absent in December 2001. The source of these constituents in MW-13S, MW-14, and MW-18 is likely from Cell 1. Metals were elevated in 11 of 16 wells with iron being the most common. Significant detections of anions included chloride, nitrogen as nitrate, sulfate and nitrogen as ammonia. Chloride was the most commonly elevated anion but was not elevated in any of the off-site wells.

December 2001 Lower Aquifer Conclusions: Carbon tetrachloride was elevated in well MW4DR. This compound was not detected in any other well. The pesticides beta-BHC and heptachlor, were both found in well MW-13D in June 2001 but were absent in December 2001. The source of these compounds is unknown. Several metals were elevated in deep aquifer wells MW-10D, MW-12D, and MW-13D; iron was elevated in all three wells. MW-10D and MW-12D

are upgradient and downgradient, respectively, of the southwestern portion of Cell 1. Therefore, it is difficult to distinguish the effect that the landfill is having on the water quality at these locations. Nitrate was elevated in all deep aquifer wells in June 2001 and in several deep wells in December 2001 relative to upgradient MW-7D

March 2002 Upper Aquifer Conclusions: The results of the March 2002 groundwater monitoring program are consistent previous sampling results. Both fuel- and solvent-related compounds continued to be detected with some variability in the specific compounds and concentrations reported. Constituents were primarily detected at relatively low levels in well located between the installation boundary and Cells 1 and 2. Very limited detections of SVOCs and pesticides were also reported. Of the detected inorganics, arsenic was above its MCL in two samples, iron was above its SMCL in all samples, and chloride was above its SMCL in two samples. RBCs were more frequently exceeded. A statistical analysis of the analytical detections indicated that numerous VOCs, a few SVOCs, one pesticide, 1 herbicide, and several metals were detected at statistically significant concentrations in the downgradient wells relative to the upgradient wells. Several metals were significant as well as four anions.

March 2002 Lower Aquifer Conclusions: Fewer fuel- and solvent-related compounds were detected in the lower aquifer relative to the upper aquifer, and at generally lower concentrations. The only notable exception remains carbon tetrachloride in upgradient well MW4DR, which was the only organic compound detected above its MCL. This compound has not been observed in any other monitored well at the CSL. The source of the carbon tetrachloride is unknown. Beryllium in MW-7D slightly exceed its MCL, while iron exceeded its SMCL in four wells. There were few RBC exceedances and very few statistically significant exceedances. Nitrogen (nitrate) and iron were most frequently found to be significant.

September 2002 Upper Aquifer Conclusions: Both fuel- and solvent-related compounds continued to be detected with some variability in the specific compounds and concentrations reported. Constituents were primarily detected at relatively low levels in well located between the installation boundary and Cells 1 and 2. Low levels of SVOCs and pesticides were also reported. Of the detected inorganics, arsenic was above its MCL in two samples. Secondary MCLs were exceeded for iron (most samples), chloride (2 samples), and sulfate (1 sample). RBCs were more frequently exceeded. A statistical analysis of the analytical detections indicated that numerous VOCs, a few SVOCs, several pesticides/herbicides, and several metals were detected at statistically significant concentrations in the downgradient wells relative to the upgradient wells.

September 2002 Lower Aquifer Conclusions: Fewer fuel- and solvent-related compounds were detected in the lower aquifer relative to the upper aquifer, and at lower concentrations. The only notable exception remains carbon tetrachloride in upgradient well MW4DR, which was the only organic compound detected above its MCL. This compound has not been observed in any other monitored well at the CSL. The source of the carbon tetrachloride is unknown. Iron exceeded its SMCL in three wells. There were few RBC exceedances and few statistically significant exceedances. Nitrate and iron were most frequently found to be significant.

Deep wells MW-109D, 110D, 111D, 112D, and 116D were added to the sampling program for 2003.

March 2003 Upper Aquifer Conclusions: The results of the March 2003 groundwater monitoring program are generally consistent previous sampling results. Both fuel- and solvent-related compounds continued to be detected with some variability in the specific compounds and concentrations reported. Constituents were primarily detected at relatively low levels in well located between the installation boundary and Cells 1 and 2. Very limited detections of SVOCs and pesticides were also reported. Of the detected inorganics, arsenic was above its MCL in two samples and iron was above its SMCL in all samples. RBCs were more frequently exceeded. A statistical analysis of the analytical detections indicated that numerous metals and VOCs, a few SVOCs, three pesticides and one herbicide were detected at statistically significant concentrations in one or more wells relative to the upgradient wells.

March 2003 Lower Aquifer Conclusions: Fewer fuel- and solvent-related compounds were detected in the lower aquifer relative to the upper aquifer, and at generally lower concentrations. The only notable exceptions are carbon tetrachloride in upgradient well MW-4DR and TCE in MW-108D, and bis(2-ethylhexyl)phthalate in MW-111D, which were the only organic compounds detected above MCLs. The source of these compounds is unknown. Iron exceeded its SMCL in seven lower aquifer wells. There were few RBC exceedances and very few detections determined to be statistically significant exceedances. Nitrogen (nitrate) and iron were most frequently found to be significant.

September 2003 Upper Aquifer Conclusions: Both fuel and solvent-related compounds continue to be detected with some variability in the specific compounds and concentrations reported. Constituents were primarily detected at relatively low levels in wells between the installation boundary and Cells 1and 2. Very limited detections of SVOCs and pesticides were also reported. Of the detected inorganics, arsenic was above its MCL in four samples for the September 2003 samples, iron was above its SMCL in nearly all of the samples, and chlorine was above its SMCL in one samples.

September 2003 Lower Aquifer Conclusions: Fewer fuel and solvent-related compounds were detected relative to the upper aquifer, and at generally lower concentrations. The only notable exceptions are carbon tetrachloride in upgradient well MW4DR, and TCE and PCE in MW108D which were the only organic compounds above MCLs. The source of carbon tetrachloride, TCE, and PCE is unknown. Bis (2-ethylhexyl) phthalate may be related to laboratory contamination. In September 2003, iron exceeded its SMCL in four of the onsite wells.

Deep wells MW-111D, 112D, and 116D were dropped from the sampling program for 2004.

March 2004 Upper Aquifer Conclusions: Both fuel and solvent-related compounds continue to be detected with some variability in the specific compounds and concentrations reported. Constituents were primarily detected at relatively low levels in wells between the installation boundary and Cells 1 and 2. Very limited detections of SVOCs and pesticides were also reported. Of the detected inorganics, arsenic was above its MCL in two samples, iron was above its SMCL in all samples, and chloride was above its SMCL in two samples.

March 2004 Lower Aquifer Conclusions: Fewer fuel and solvent-related compounds were detected relative to the upper aquifer, and at generally lower concentrations. The only notable exceptions are carbon tetrachloride in upgradient well MW4DR, and TCE in MW108D; the only organic compounds above MCLs. The source of carbon tetrachloride and TCE is unknown. Iron exceeded its SMCL in seven wells.

September 2004 Upper Aquifer Conclusions: The results of the September 2004 groundwater monitoring program are generally consistent previous sampling results. Both fuel- and solvent-related compounds continued to be detected with some variability in the specific compounds and concentrations reported. Constituents were primarily detected at relatively low levels in well located between the installation boundary and Cells 1 and 2. Very limited detections of SVOCs and pesticides were also reported. Of the detected inorganics, arsenic was above its MCL in five samples and iron was above its SMCL in 14 samples. RBCs were more frequently exceeded. A statistical analysis of the analytical detections indicated that numerous metals and VOCs, and several pesticides and herbicides were detected at statistically significant concentrations in one or more wells relative to the upgradient wells.

September 2004 Lower Aquifer Conclusions: Fewer fuel- and solvent-related compounds were detected in the lower aquifer relative to the upper aquifer, and at generally lower concentrations. The only notable exceptions are carbon tetrachloride in upgradient well MW4DR and PCE in MW-108D. These two detections equaled or exceeded the MCLs. The source of these compounds is unknown. Iron exceeded its SMCL in three lower aquifer wells. There were several RBC exceedances, one each of chloroform, TCE, and PCE, and very few detections determined to be statistically significant exceedances. Nitrogen (nitrate) and iron were most frequently found to be significant.

March 2005 Upper Aquifer Conclusions: The results of the March 2005 groundwater monitoring program are generally consistent previous sampling results. Both fuel- and solvent-related compounds continued to be detected with some variability in the specific compounds and concentrations reported. Constituents were primarily detected at relatively low levels in well located between the installation boundary and Cells 1 and 2. Very limited detections of SVOCs and pesticides were also reported. Of the detected inorganics, arsenic was above its MCL in four samples and iron was above its SMCL in 13 samples. RBCs were more frequently exceeded. A statistical analysis of the analytical detections indicated that numerous metals and VOCs, one explosive, and several pesticides and herbicides were detected at statistically significant concentrations in one or more wells relative to the upgradient wells.

March 2005 Lower Aquifer Conclusions: Fewer fuel- and solvent-related compounds were detected in the lower aquifer relative to the upper aquifer, and at generally lower concentrations. The only notable exceptions are carbon tetrachloride in upgradient well MW4DR and PCE and TCE in MW-108D. These three detections equaled or exceeded the MCLs. The source of these compounds is unknown. Iron exceeded its SMCL in 5 lower aquifer wells. There were several RBC exceedances, primarily PCE, and very few detections determined to be statistically significant exceedances. Nitrogen (nitrate) and iron were most frequently found to be significant.

4.5.2 Historical Groundwater Sampling

4.5.2.1 Atrazine Study and Extention of the Off-Post Public Water System

In the fall of 1994 USAEC sampled off-post private drinking water wells located near the CSL (AD Little, 1994). Atrazine, a herbicide, was detected in one well at 8.3 μg/L, above the MCL of 3 μg/L. As a result of the proximity of the residential wells to the CSL, USAEC determined that on-post samples would be collected to evaluate the CSL as a potential source area. Five surface water and sediment samples, 15 surface soil samples, and 27 groundwater samples from existing monitoring wells were collected in April-August 1995 and analyzed for atrazine. The soil samples were also analyzed for TAL metals. Atrazine was not detected in any sample (AD Little, 1999). No conclusions were drawn in the report. However, as a result of the absence of on-post detections of atrazine, no further investigation or actions related to atrazine was required for the CSL. Testing associated with the Atrazine Study and subsequent sampling related to the extension of the off-post public water system was due to off-site detections of atrazine. There was no known history of atrazine use or disposal on-site

MDE and Anne Arundel County (USEPA, 1997) also sampled private drinking water wells located near the CSL in the 1994-1995 time frame. The State and County reported that atrazine and VOCs were detected in off-post residential wells. Because little information is available on the locations, depths and construction of these wells and the data quality and validation status of the sampling results, further assessment of these results has not been included in this report.

We note that the public water system was extended into the areas of Odenton adjacent to the CSL at this time and residential users of groundwater in these areas were connected to the public water system, and the State recommended that any existing residential wells be abandoned.

4.5.2.2 Off-Post Drilling and Groundwater Sampling Results (1999)

An off-post drilling and sampling program (USACE, 1999) was performed in 1996 to obtain additional information of the geology, hydrogeology, and water quality conditions in the off-post area downgradient of the CSL. Four new monitoring wells, three shallow wells screened in the Upper Patapsco aquifer, and one deep well screened in the first water bearing zone of the Lower Patapsco aquifer were installed at locations selected jointly by FGGM, MDE, and Anne Arundel County. The wells were located offset from the FGGM boundary and were constructed as follows:

- MW-107 (screened 29-39 ft bgs) and MW-108D (155-165 ft) were installed as a well pair at the Piney Orchard water tower. MW-108D was drilled and sampled for lithology to a total depth of 220 feet bgs.
- MW-105 (49-59 ft) was located 0.5 miles north of the water tower on North Patuxent Road.

- MW-106 (21.5-31.5 ft) was located 0.6 miles south of the water tower on Old Waugh Chapel Road adjacent to the Amtrak maintenance yard.

The four new off-post wells were sampled in in 1996 and the samples were analyzed for TCL VOCs and SVOCs, filtered and unfiltered TAL metals, atrazine and select water quality parameters. The results were screened against MCLs and Tap Water RBCs as follows:

- No analytes were detected above MCLs.
- PCE (2.7 μg/L) and trichloroethene (2.9 μg/L) in deep well MW-108D were the only analytes detected above RBCs.
- No metals or SVOCs or atrazine were detected above RBCs. Atrazine was only detected in MW-107.

4.5.2.3 Monitoring Well MW-4DR Resampling for VOCs

At the April 2001 meeting, the FGGM Environmental Partnership Team agreed to have MW-4DR resampled with a split VOC fraction sent to a second laboratory to confirm the presence of carbon tetrachloride above MCLs. Rapid turnaround of the VOC results was performed so that the results could be reported at the May 31, 2001 partnering meeting (prior to the June groundwater and surface water monitoring event for the CSL). The samples were analyzed by off-site subcontract laboratories Severn Trent Laboratories, Inc. of Sparks, Maryland (STL) and Datachem Laboratories, Inc. of Salt Lake City, Utah (DCL).

As shown below, the May 2001 results are presented alongside results from sampling rounds on MW-4DR since January 1999. Carbon tetrachloride was present at 82 and 66 μg/L, well above the MCL of 5 μg/L, and consistent with previous sampling data. No other VOCs were detected in the May 2001 samples.

May 22, 2001 MW-4DR
VOC Detections in Deep Groundwater (μg/L)

	MCL	Historical Maximum Detected Concentration	Severn Trent Labs	Datachem Labs
Acetone	-	2.5	ND	ND
Benzene	5	ND	ND	ND
Carbon Tetrachloride	5	91	82	66
Chloroform	100	3.7	2.0	1.9
cis-1,2-Dichloroethene	70	0.37	ND	ND
Methylene Chloride	5	0.89	ND	ND
Trichloroethylene	5	0.31	ND	ND

ND- not detected above detection limit.

The results of the analysis were compared to the annual assessment and monitoring data for the CSL, and the levels of analytes detected are comparable to levels previously detected in samples from MW-4DR (IT, 2001).

4.5.3 Historical Soil Sampling

Minimal historical soil sampling data are available for the CSL. Three pre-cell closure surface soil samples (SS-29 to SS-31) were collected from the CSL in 1991 (EA, 1992). VOCs, SVOCs, pesticides,

and TAL inorganics were not detected above Industrial RBCs, although the detection limit for arsenic (2.5 mg/kg) was greater than the RBC. No post cell closure soil sampling data for the CSL is available.

Four surface and sixteen subsurface soil samples were collected during the 1996 off-post drilling program from borings for new wells MW-105, MW-106, MW-107, MW-108D (USACE,1999). These samples were analyzed for atrazine and TAL metals. Atrazine was not detected. All detected metals, with the exception of arsenic, did not exceed residential or Industrial RBCs for soil. Arsenic was detected at concentrations up to 12.3 mg/kg, exceeding the Industrial RBC and maximum background in 3 of 20 samples.

4.5.4 Historical Surface Water and Sediment Sampling

4.5.4.1 1991 CSL RI Sampling

Six surface water and sediment samples were collected in 1991 from five locations at the CSL (USATHAMA, 1992). Locations SW-2/SS-2 to SW-6/SS-6 were collected in the small streams which form the western drainages of the CSL. Samples SW-7/SS-7 were collected from a small ponded area between the east side of the CSL and the railroad tracks (near RCRA monitoring point SW-1). All samples were analyzed for TCL VOCs and SVOCs, perticides, PCBs, and TAL metals.

Surface Water Sampling Results: VOCs, SVOCs, and PCBs were not detected. DDT (0.009-0.0028 μg/L) was detected above the NWQC in samples SW-2 and SW-5. Multiple pesticides, for which no NWQCs have been promulgated were detected in each sample. Scattered NWQCs were exceeded for inorganic analytes arsenic, copper, lead, nickel, and silver in samples SS-2, SS-3, and SS-7.

Sediment Sampling Results: VOCs and PCBs were not detected. No organic analytes were detected above ER-Ls. Multiple pesticides, for which no ER-Ls have been promulgated, were detected in all samples. For inorganics, cyanide (6.48 ug/g) in SW-6 and lead (5.65 ug/g) in SW-2 were the only detected analytes exceeding NWQCs. We note that detection levels for multiple analytes exceeded current NWQCs,

4.5.4.2 Off-Post Drilling and Sampling Program (1996)

Surface water samples were collected from 5 on-post locations in 1996, during the off-post drilling and sampling program, and analyzed for atrazine (USACE,1999). These samples were located at the three established RCRA monitoring locations and at two additional locations within the former ASP area. Atrazine was not detected.

4.5.4.3 Detection Monitoring of Surface Water

The bulk of the historical surface water sampling has been conducted under the RCRA Detection Monitoring Program previously discussed in Section 4.5. Three surface water sample locations SW-1 to SW-3 have been sampled semiannually since 1994. Analytical detections screened against MCLs and Tap Water RBCs generally show that no surface water analytes exceed their MCLs although iron, chloride, color, turbidity, total dissolved solids, and pH may exceed SMCLs in specific samples. Tap water RBCs were rarely exceeded. These results do not indicate that contaminants related to the CSL are migrating from the CSL in surface water at concentrations above screening levels.

4.6 INVESTIGATION PROGRAM SUMMARY

The technical approach to the investigation is based on Maryland Department of the Environment (MDE) recommendations for additional sampling (MDE, 2001). The need for additional characterization was identified by the MDE based on groundwater samples collected as part of the semi-annual sampling program.

As outlined in the April 4, 2001 correspondence from MDE to FGGM, “the Army must characterize the nature and extent of contamination of the release by installing additional wells as necessary.” MDE recommended, at a minimum, the installation of eight wells (three in the Upper Patapsco Aquifer and five in the Lower Patapsco) as a starting point in the delineation of groundwater contamination and the refinement of current understanding of groundwater flow. However, in the case of the three shallow wells proposed by MDE to be installed in the off-site Amtrak railroad maintenance area,

the proposed locations did not seem appropriate for this investigation. Based on a site visit (August 28, 2001) and inspection of the surrounding topography, MDE concurred that the proposed shallow well locations would not serve the purpose of monitoring shallow groundwater downgradient of the CSLF.

Based on discussions held during the April 19, 2001 FGGM Environmental Partnership meeting, a phased sampling approach was considered to be the most effective in meeting the investigation objectives. The first phase was executed on May 31, 2001 and involved the re-sampling of monitoring well MW-4DR to confirm the presence of carbon tetrachloride. The second phase, included the 2002 installation and sampling of additional monitoring wells as identified in discussions with MDE and further groundwater delineation through the use of direct-push sampling. In 2004, a third investigation phase involved additional on-post and off-post well installations and groundwater sampling to address and characterize groundwater flow and water quality in upgradient and off-post downgradient areas.

A summary of the environmental sampling program is presented in **Table 4-1**. The locations of all monitoring wells and sampling locations are shown in **Figure 4-9**.

4.6.1.1 Groundwater Investigation

The groundwater investigation included the installation and sampling of additional shallow and deep wells in both on-post and off-post locations to ascertain the nature and extent of the presence of carbon tetrachloride in the Lower Patapsco Aquifer and monitor off-post locations downgradient from the CSLF at the request of MDE.

Groundwater screening samples were collected from 24 direct-push points in 2002. These grab samples were analyzed for TCL VOCs on a 24-hour turnaround basis.

Although carbon tetrachloride has not been detected in the Upper Patapsco Aquifer in CSL area, screening samples for VOCs were collected from shallow groundwater north of the CSL to be sure that contamination is not present in the shallow aquifer and migrating downward via a faulty well seal from former well MW-4D or MW-4DR. This sampling was also designed to further evaluate the CSL and properties to the north as potential sources. A total of 10 push-points were executed in the northern CSL.

Shallow wells MW-12s and MW-19 monitor the Upper Patapsco Aquifer immediately south and east of the southernmost extent of CSL Cell 1. The screened interval of MW-12S is 18 to 28 feet bgs and the screened interval of MW-19 is 22 to 37 feet bgs. Benzene has been detected above the Tap Water RBC (0.5 μg/L) and/or MCL (5μg/L) in MW-12S and MW-19 in all RCRA semi-annual monitoring rounds since May 1995 at concentrations ranging between 2.9 and 25 μg/L. Based on the site topography, shallow groundwater in the vicinity of the southern end of Cell 1 near MW-12S and MW-19 would flow toward the lower elevations to the southwest toward a minor tributary of the Little Patuxent River. The off-post land surface directly to the south of the CSL is at approximately the same elevation as the base of the CSL and rises to the south. As a result, it is unlikely that shallow groundwater contamination has migrated any significant distance off-post and to the south of the CSL. A ‘picket line” of twelve DPT sampling locations spaced 150-feet apart was established along the facility boundary across from Cell 1. Two additional DPT sampling points were performed south of Cell 1 between the “picket line” and the physical training course to the west. Fourteen new deep monitoring wells (MW-109D to MW-122D) were installed and sampled in 2002: 9 on-post wells located north of the CSLF related to the carbon tetrachloride investigation, and 5 off-post wells located downgradient of the CSLF. These wells were sampled for TCL VOCs, SVOCs, pesticides, herbicides, PCBs, and TAL metals. Five additional existing on-post shallow wells located south of Cell 1, which were not part of the RCRA semi-annual monitoring network, were sampled to assess whether the existing network coverage for the Upper Patapsco aquifer was adequate in this area.

An additional of 4 shallow wells screened in the Upper Patapsco aquifer (MW-123S-MW-124S and MW-127S-MW-128S) and 2 deep wells screened in the Lower Patapsco aquifer (MW-125D-MW-126D) were installed and sampled as part of the remedial investigation in 2004.

MW-125D and MW-126D were sampled in March 2004 for TCL VOCs, SVOCs, PAHs, explosives, perchlorate, pesticides, herbicides, PCBs, and TAL metals. These results are discussed with the June 2004 sampling round results.

The June 2004 sampling round consisted of 20 Upper Patapsco aquifer wells and 23 Lower Patapsco aquifer wells. All wells were sampled for TCL VOCs, SVOCs, PAHs, explosives, perchlorate, pesticides, herbicides, PCBs, and TAL metals.

Upper Patapsco Monitoring Wells:

- **Off-post Wells MW-123S and MW-124S** were located east of Cell 2 to monitor potential off-post migration of contaminants from the Cell 2/Cell 3 area.
- **On-post Wells MW-127S and MW-128S** were installed west of the CSL as additional upgradient wells to monitor groundwater and to help constrain the groundwater flow regime for the Upper Patapsco aquifer.

Lower Patapsco Monitoring Wells:

The following off-post deep wells were installed at the request of MDE, southeast of Cell 1 to help delineate the off-post extent of deep groundwater contamination detected in the CSL eastern boundary wells.

- **Off-post Wells MW-109D, MW-110D, MW-116D, and MW-111D** were located, in conjunction with existing well MW-108D, essentially parallel to the installation boundary along or in line with Waugh Chapel Road about 400-600 feet downgradient from the CSLF.
- **Off-post Well MW-112D** was installed an additional 600 feet further east near the intersection of Route 170 and Old Waugh Chapel Road, essentially downgradient from existing well MW-108d.

The following deep wells were installed as part of the investigation to delineate the nature and extent of carbon tetrachloride originally detected in MW-4DR:

- **On-post Wells MW-113D, MW-114D, and MW-115D** which were located at or near the installation boundary north of Cell 1 at locations downgradient or potentially downgradient of MW-4DR.
- **On-post Wells MW-117D, MW-118D, and MW-119D** were located upgradient of MW-4DR on the southeast side of Route 32.
- **On-post Wells MW-120D, MW-121D, and MW-122D** which were installed in further upgradient locations north of Route 32, based on preliminary field screening results, to assess if the location of a source area or areas could be determined.

The following deep wells were installed in off-post locations to assess the nature and extent of contamination potentially leaving the installation from the north side of the CSL:

- **Off-Post Well MW-125D and MW-126D** were located east of Cell 2 to monitor potential off-post migration of contaminants from the Cell 2/Cell 3 area as well as carbon tetrachloride.

CSL Monitoring Wells		
Monitoring Well Network	**Shallow Wells** **Upper Patapsco** **(Screen Interval BGS)**	**Deep Wells** **Lower Patapsco** **(Screen Interval BGS)**
RCRA Monitoring Well Network	MW- 2S (24-29 ft) MW-4S (7-12 ft) MW-5 (8-28 ft) MW-7S (5.5-25.5 ft) MW-8 (8-23 ft) MW-10S (8-18 ft) MW-12S (13-23 ft) MW-13S (19-34 ft) MW-14 (20-30 ft) MW-17 (20-35 ft) MW-18 (20-35 ft) MW-19 (22.5-37.5 ft) MW-20 (21-31 ft) MW-105 (49-59 ft) MW-106 (21.5-31.5 ft) MW-107 (29-39 ft)	MW-2D (76.5-86.5 ft) MW-4DR (129-149 ft) MW-7D (98-108 ft) MW-12D (121-131 ft) MW-13D (100-120 ft) MW-101D(133-143 ft) MW-108D (155-165 ft)
Other On-Post Wells	MW-11 (9.5-19.5 ft) MW-12S (18-28 ft) MW-19 (22.5-37.5 ft) MW-20 (21-31 ft) MW-21 6-21 ft)	
RI Wells Installed	MW-123S (35-45 ft) MW-124S (45-55 ft) MW-127S (55-65 ft) MW-128S (33-43 ft)	MW-109D (133.5-153.5 ft) MW-110D (140-160 ft) MW-111D (175-195 ft) MW-112D (175-195 ft) MW-113D (160-180 ft) MW-114D(185-205 ft) MW-115D (160-180 ft) MW-116D (166-186 ft) MW-117D (127-147 ft) MW-118D (105-125ft) MW-119D (168-188 ft) MW-120D (85-105 ft) MW-121D (145-165 ft) MW-122D (60-80 ft) MW-125D (204.5-224.5 ft) MW-126D (220-240 ft)

Well construction details for the CSL monitoring wells are presented in **Table 4-2**.

Supporting data for the hydrogeologic investigations are appendicized as follows:

- Appendix A: Boring Logs
- Appendix B: Well Construction Diagrams
- Appendix C: Well Development Logs

- Appendis H: Anne Arundel County Well Permits
- Appendix I: Well Survey Data

4.6.1.2 Soils Investigation

Six trenches were performed. A total of 20 surface soil and 18 subsurface soil samples (excluding QA/QC samples) were collected. All soil samples were analyzed for TCL VOCs and SVOCs, explosives, pesticides, herbicides, PCBs, and TAL metals.

A total of six 25-ft long characterization trenches were performed in the Cell 3 area in order to assist in the determination of whether wastes were buried in this area and to characterize the physical nature of the waste materials, if present. One surface soil and two subsurface soil samples were collected from each trench. The subsurface soil samples were collected from the base of the fill materials.

One surface and one shallow subsurface soil samples were collected from each of six former magazine locations in the former ASP area to assess the potential for soil contamination due to spills or leaks.

Eight random surface soil samples were collected from the cover materials in the cap of Cell 1 (SS-1 to SS-4) and Cell 2 (SS-5 to SS-8) to quantify chemical levels for use in risk assessment.

4.6.1.3 Surface Water and Sediment Investigation

A total of seven surface water and six sediment samples were collected at the CSL and downstream areas. Samples were collected from each of the 3 RCRA surface water detection monitoring locations, as well as from 3 locations futher downstream to the west. The surface water and sediment samples were analyzed for TCL VOCs and SVOCs, explosives, pesticides, herbicides, PCBs, and TAL Inorganics.

4.7 NATURE AND DISTRIBUTION OF CHEMICALS AT THE CSL

Surface and subsurface soil, shallow and deep groundwater, surface water, and sediment samples were collected from the CSL area to assess the nature and distribution of potential chemical contaminants related to the CSL.

4.7.1 Groundwater Screening Results

Groundwater screening samples were attempted at 23 locations (MDP-1 through MDP-23) from the water table (Upper Patapsco) aquifer (approximately 12 to 30 feet bgs) using direct-push technology (DPT) groundwater sampling. Groundwater screening samples were collected using a check-valve and dedicated Teflon tubing from within a retractable Geoprobe-type groundwater sampler. All samples were analyzed for TCL VOCs on a 24-hour turnaround basis. The analytic exceedances of Tap Water RBCs and MCLs are presented on **Figures 4-10 and 4-11**.

4.7.1.1 Northern CSL DPT Groundwater Screening Results for VOCs

Although carbon tetrachloride has not been detected in the Upper Patapsco Aquifer, screening samples for VOCs were collected from shallow groundwater north of the CSL to be sure that contamination is not present in the shallow aquifer and migrating downward via a faulty well seal from former well MW-4D or MW-4DR. This sampling was also designed to further evaluate the CSL and properties to the north as potential sources.

A total of 10 DPT points were performed on the north side of the CSL (See **Figure 4-10**). DPT points (MDP-15, MDP-16, MDP-17, and MDP-23) were located along the northern boundary of the CSL upgradient from MD-4DR to help identify if shallow contamination originates from off-site areas or from areas of FGGM to the northeast of the CSL. Three DPT points (MDP-12, MDP-13, and MDP-14) were located surrounding MW-4DR to determine if shallow contamination exists near the well, which might indicate that contamination is entering MW-4DR via a faulty well seal. Three points (MDP-18, MDP-19, and MDP-20) were located south (downdradient) of MW-4DR on the north side of the CSL. Since the direction of groundwater flow in the shallow aquifer generally follows the local topography, these samples would help to determine if shallow groundwater contamination is flowing off the northern flank of CSL Cell

2 toward MW-4DR. Of these points, MDP-20 was dry at three attempted locations and was abandoned without sampling.

Carbon tetrachloride was not detected in any sample. No VOCs were detected above MCLs. Chloroform (0.49-2.3 μg/L) was detected above the Tap Water RBC at the three points around MW-4DR. Acetone was also detected above the Tap Water RBC at two locations due to decontamination of the Geoprobe sampler. No other VOCs were detected above Tap Water RBCs.

Groundwater screening data for VOCs in the shallow aquifer north of the CSL shows that carbon tetrachloride is not present in the Upper Patapsco Aquifer and that shallow groundwater is not the source of carbon tetrachloride found in the confined aquifer. The screened areas are also upgradient from the CSL.

4.7.1.2 Southern CSL DPT Groundwater Screening Results for VOCs

Shallow wells MW-12s and MW-19 monitor the Upper Patapsco Aquifer immediately south and east of the southernmost extent of CSL Cell 1. The screened interval of MW-12S is 18 to 28 feet bgs and the screened interval of MW-19 is 22 to 37 feet bgs. Benzene has been detected above the Tap Water RBC (0.5 μg/L) and/or MCL (5μg/L) in MW-12S and MW-19 in all RCRA semi-annual monitoring rounds since May 1995 at concentrations ranging between 2.9 and 25 μg/L.

Based on the site topography shallow groundwater in the vicinity of the southern end of Cell 1 near MW-12S and MW-19 would flow toward the lower elevations to the southwest toward a minor tributary of the Little Patuxent River. The off-post land surface directly to the south of the CSL is at approximately the same elevation as the base of the CSL and rises to the south. As a result, it is unlikely that shallow groundwater contamination has migrated any significant distance off-post and to the south of the CSL.

Based on this information, the DPT sampling effort was designed to attempt to define the extent of shallow groundwater contamination of VOCs in areas located on-post to the south, southwest and west of MW-12S and MW-19 (See **Figure 4-11)**. A ‘picket line” of DPT sampling locations (MDP-1 through MDP-11) spaced 150-feet apart was established along the facility boundary across from Cell 1. Two additional DPT sampling points (MDP-21 and MDP-22) were performed south of Cell 1 between the “picket line” and the physical training course to the west.

Benzene was detected above the MCL of 5 μg/L in three adjacent sampling points located near the southernmost tip of cell 1: MDP-6 (12 μg/L), MDP-7 (9.1 μg/L), and MDP-8 (5.1μg/L). No other VOCs were detected above an MCL. Benzene was detected above the Tap Water RBC in 9 of the other 10 sampling points (0.45 – 4.4 μg/L) with the concentrations generally decreasing to the south and west.

Chloroform (up to 3.4 μg/L), 1,2-dichloroethane (up to 0.93 μg/L), 1,2-dichloropropane (up to 2 μg/L), trichloroethene (up to 0.64 μg/L), and vinyl chloride (up to 1.2 μg/L) were sporadically detected above Tap Water RBCs. Carbon tetrachloride was not detected.

The highest VOC concentrations were detected immediately southeast from the elevated topography of the south tip of Cell 1. Shallow groundwater is flowing south-southeast from Cell 1, transporting VOCs at levels above Tap Water RBCs and benzene above the MCL near the facility boundary.

Based on the site and surrounding topography, shallow groundwater in the vicinity of the southern end of Cell 1 is locally influence by radial flow to the south or southwest.

4.7.2 Groundwater Sampling Results

Groundwater samples were collected in September 2002 from 5 existing shallow wells screened in the Upper Patapsco (water table) aquifer located south of Cell 1 and from 9 new deep wells screened in the (confined) Lower Patapsco aquifer. The shallow wells were sampled and analyzed for TCL VOCs. The deep wells were sampled and analyzed for TCL VOCs and SVOCs, explosives, pesticides, herbicides, PCBs, and TAL Inorganics.

Groundwater samples were also collected in June 2004 from 27 shallow wells screened in the Upper Patapsco (water table) aquifer and 27 deep wells screened in the (confined) Lower Patapsco aquifer. All samples were analyzed for TCL VOCs and SVOCs, explosives, pesticides, herbicides, PCBs, TAL Inorganics, and perchlorate.

Complete analytical results are presented in **Appendix F**.

4.7.2.1 2002 Upper Patapsco Aquifer Groundwater Sampling Results

Because of the persistent benzene MCL exceedances during RCRA monitoring of shallow wells MW-19 and MW-12S located immediately downgradient of the southern tip of Cell 1, all existing shallow wells located on FGGM property south of MW-12S and MS-19 were sampled for TCL VOCs to assess the whether additional wells need to be added to the semi-annual monitoring well network. A total of eight shallow wells (MW-1, MW-11, MW-12S, MW-16, MW-19, MW-20, MW-21, and MW-104) were planned to be sampled (See **Figure 4-12**). Of these wells MW-1, MW-11, MW-16, MW-19, MW-21, and MW-104 are not part of the semi-annual monitoring well network.

Wells MW-1, MW-16, and MW-104 were not sampled because they were dry at the time of sample collection in September 2002.

Analytical results of shallow groundwater samples collected at CSL from the 5 shallow monitoring well sampled are presented in **Table 4-3**.

The TCL VOC detections above Tap Water RBCs or MCLs are summarized as follows:

- No VOCs were detected above MCLs.
- Benzene (1.8-3.1 μg/L) was detected above the Tap Water RBC in MW-11, MW-12S, MW-19, and MW-20. 1,2-Dichloropropane (0.26-0.39 μg/L) was detected above the Tap Water RBC in MW-11 and MW-20. Chloroform (0.28 μg/L) exceeded the Tap Water RBC in MW-21.

Based on this data, it was determined, in consultation with the FGGM Environmental Partnership, that no additional shallow monitoring wells were required in this area of the CSL for the semi-annual monitoring program.

4.7.2.2 2004 Upper Patapsco Aquifer Groundwater Sampling Results

Analytical results of shallow groundwater samples collected at CSL from the 20 shallow monitoring well sampled are presented in **Table 4-3**. Detections exceeding screening criteria for inorganic analytes are plotted in **Figure 4-15** and detections exceeding the screening criteria for organic analytes are plotted on **Figure 4-16**.

Western Shallow Groundwater Wells: Monitoring wells MW-4S, MW-5, MW-7S, MW-8, and MW-10S are sited along the western margin of the CSL. These wells monitor upgradient conditions (MW-4S) and localized westward flow of shallow groundwater due to the local topography of Cell 1 and Cell 2. The detections above Tap Water RBCs or MCLs and maximum background levels are summarized as follows:

TCL VOCs

- No VOCs were detected above MCLs.
- Benzene (0.88 μg/L) in MW-10s was the only VOC detected above Tap Water RBCs.

TCL SVOCs and PAHs

- SVOCs were not detected above Tap Water RBCs.
- PAHs were not detected.

Explosives and Perchlorate

- No explosives or perchlorate were detected

Pesticides, Herbicides, and PCBs

- Pesticides and herbicides were not detected.
- PCBs were not detected.

TAL Inorganics

- Lead (16.3 μg/L) exceeded the MCL of 15 μg/L in MW-5. No other inorganic analyte was detected above MCLs.
- Several metals were detected above Tap Water RBCs.

Lead, in MW-5, was the only detection above MCLs. Only one organic analyte, benzene in MW-10S, was detected above Tap Water RBCs. The only other RBC exceedances were scatted detections of arsenic, aluminum, iron, and manganese. Groundwater sampling results show that little contamination is migrating westward from the CSL and that the upgradient wells are in upgradient locations relative to the CSL waste disposal areas.

Eastern Boundary Shallow Groundwater Wells: Monitoring wells MW-2S, MW-12S, MW-13, MW-14, MW-17, MW-18, MW-19, and MW-20 are sited along the installation boundary along the eastern margin of the CSL. These wells monitor the flow of shallow groundwater off the topographic highs of Cell 1 and Cell 2 downgradient toward lower elevations along the railroad line to the east. The detections above Tap Water RBCs or MCLs are summarized as follows:

TCL VOCs

- Benzene (10.4 μg/L) in MW-19 was the only VOCs detected above MCLs.
- Benzene (0.4– 2.4 μg/L) in MW-17, MW-13S, MW- 18, MW-2S, MW-14 and MW-19, and 1,4-Dichlorobenzene (1.2-6.1 μg/L) in MW-13S, MW-2S, MW-14, MW-18, MW-12S, and MW-19 were the only VOCs detected above Tap Water RBCs.

TCL SVOCs and PAHs

- Bis(2-Ethylhexyl) phthalate (11.3-102 μg/L) in MW-13S and MW-14 was the only SVOC detected above Tap Water RBCs.
- PAHs were not detected above Tap Water RBCs.

Explosives and Perchlorate

- No explosives were detected above Tap Water RBCs.

Pesticides and PCBs

- Pesticides and PCBs were not detected.

TAL Inorganics

- Arsenic (39.8-51.2 μg/L) was detected above MCLs in MW-19 and MW-12s
- Cadmium (5.1-6.3 μg/L) was detected above MCLs in MW-17, MW-13S, and MW-18.
- Thallium was detected above MCLs in MW17.
- Several other metals were detected above Tap Water RBCs

Off-Post Shallow Groundwater Wells: Monitoring wells MW-105, MW-106, MW-107, MW-123S, and MW-124S are sited in Odenton, between the CSL and State Road 170. With the exception of MW-106, these shallow wells are located on slightly higher topographically locations than the eastern CSL boundary wells. The detections above Tap Water RBCs or MCLs are summarized as follows:

TCL VOCs

- No VOCs were detected above MCLs.

- Chloroform (1.4-4 μg/L) in MW-106 and MW-107 and MTBE (7.6-49.3 μg/L) in MW-105 and MW-106 were the only VOCs detected above Tap Water RBCs.

TCL SVOCs and PAHs

- SVOCs and PAHs were not detected.

Explosives and Perchlorate

- Explosives were not detected above Tap Water RBCs.

Pesticides, Herbicides, and PCBs

- Pesticides, herbicides and PCBs were not detected.

TAL Inorganics

- No inorganic analytes were detected above MCLs or Tap Water RBCs.
- No analytes were detected above MCLs. Chloroform and MTBE, exceeded the Tap Water RBC in two samples each.
- Benzene was not detected.
- Samples from off-post shallow monitoring wells MW123S and MW-124S, located east of Cell 2, do not indicate that contamination from the CSL is migrating to this area in the Upper Patapsco aquifer.

New Upgradient Shallow Groundwater Wells: Monitoring wells MW-127S and MW-128S are sited along the western margin of the CSL. These wells monitor upgradient conditions (MW-4S) and localized westward flow of shallow groundwater due to the local topography of Cell 1 and Cell 2. The detections above Tap Water RBCs or MCLs are summarized as follows:

TCL VOCs

- No VOCs were detected above MCLs or Tap Water RBCs.

TCL SVOCs and PAHs

- SVOCs were not detected above Tap Water RBCs.
- PAHs were not detected.

Explosives and Perchlorate

- Explosives were not detected above Tap Water RBCs

Pesticides, Herbicides, and PCBs

- Pesticides, herbicides and PCBs were not detected.

TAL Inorganics

- Beryllium (40.2 μg/L) was detected above the MCL of 4 μg/L in MW-127S. This detection is within background levels and may be naturally occurring.
- Vanadium was detected above the Tap Water RBCs in MW-128S.

4.7.2.3 2002 Lower Patapsco Aquifer Groundwater Sampling Results

Additional deep wells were installed and sampled in both on-post and off-post locations to ascertain the nature and extent of the presence of carbon tetrachloride in the Lower Patapsco Aquifer and monitor off-post locations downgradient from the CSL at the request of the Maryland Department of the Environment. A total of 14 new deep monitoring wells were installed – 9 on-post wells located north of the CSL related to the carbon tetrachloride investigation, and 5 off-post wells located downgradient of the CSL CELL1. All new wells were analyzed for the full assessment suite of TCL VOCs, TCL SVOCs, pesticides, herbicides, PCBs, TAL metals (including cyanide, mercury and sulfide). Analytical detections,

which were screened against Tap Water RBCs and MCLs, are presented in **Table 4-4**. Complete analytical results are presented in **Appendix F**. Detections exceeding screening criteria for organics are shown in **Figure 4-13.** Detections exceeding the screening criteria for inorganics are shown in **Figure 4-14.**

New Northern On-Post Lower Patapsco Aquifer Wells:

Carbon tetrachloride has been consistently detected in well MW-4DR at concentrations ranging from 66-91 μg/L in multiple sampling rounds since 1999, but has not been detected in any other CSL well. MW-4DR was screened from 129 to 149 feet bgs in the confined Lower Patapsco aquifer. It was included in the semi-annual monitoring program as an upgradient well for the CSL. It has not been known if the source of the carbon tetrachloride originated on FGGM property, or from some off-site source to the north of the CSL. This investigation was designed to determine if the CSL is the source of contamination, and if not, to determine if the contamination source(s) is on-post or off-post and to attempt to delineate the extent of contamination.

Analytical detections for the groundwater samples from the 9 new northern CSL deep wells (MW-113D to MW-122D) are tabulated in **Table 4-4**. It is noted that the samples for wells MW-115D and MW-122D were turbid, i.e. contained suspended solids which may have caused elevated concentrations of metals. Analytical detections, with emphasis on exceedances of MCLs and Tap Water RBCs are as follows:

TCL VOCs

- Carbon tetrachloride was detected in MW-114D (26μg/L) above the MCL of 5 μg/L and also in wells MW-115D (1.5 μg/L), and MW-122D (4.7 μg/L) above the Tap Water RBC of 0.16 μg/L. It was not detected in any other of the sampled wells.
- The only (other) VOC detected above an MCL was tetrachloroethene, which was detected above the MCL of 5 μg/L in wells MW-114D (9.9 μg/L) and MW-117D (14 μg/L).
- Several other VOCs were detected in one or more wells at concentrations above Tap Water RBCs as follows: chloroform (0.79-5 μg/L) in 7 wells; tetrachloroethene (0.22-2.2) in three wells; and trichloroethene (0.21-2.8 μg/L) in 6 wells.

SVOCs

- Bis(2-ethyl-hexyl) phthalate, a plasticiser which is a common laboratory and field cross-contaminant, was detected above the Tap Water RBC of 4.8 μg/L at concentrations ranging from 5-19 μg/L in 6 of the 9 wells sampled. No other SVOCs were detected.

Pesticides/Herbicides/PCBs

- No pesticides were detected above MCLs or Tap Water RBCs.
- Herbicides were not detected.
- PCBs were only detected in MW-115D, where Arochlor 1232 (0.27μg/L), the only PCB detected, was detected above the MCL of 0.033 μg/L.

TAL Metals

- Beryllium in wells MW-115D (7.2 μg/L) and MW-120D (6.9 μg/L) was detected above the MCL of 4 μg/L, which in this case is lower than the RBC of 7.3 μg/L. Chromium (143 μg/L), lead (30.2 μg/L) and nickel (121 μg/L) were also detected above MCLs in MW-115D.
- Several metals were detected above Tap Water RBCs for in one or more wells: – aluminum (7,870-24,200 μg/L) in two wells, arsenic (3.1-9.9 μg/L) in two wells, iron (1,150-35,800 μg/L) in 4 wells, manganese (118-369 μg/L) in 4 wells, nickel (78-108 μg/L) in two wells, and sodium (116 μg/L) in one well. A majority of the RBC

exceedances were from the samples for two wells - MW-115D and MW-122D. The highest concentrations for nearly all metals were from MW-115D.

A total of 9 new deep wells (MW-113D to MW-1115D and MW-117D to MW-122D) were installed and sampled as part of the carbon tetrachloride investigation to determine if the CSL is the source of carbon tetrachloride contamination, and if not, to determine if the contamination source is on-post or off-post and to attempt to delineate the extent of contamination. Summary results for the installation and sampling of these wells are as follows:

- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, and MW-122D show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSL is to the east-southeast, which is consistent with the regional groundwater flow direction but is more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR is essentially cross-gradient from the CSLF, not upgradient.
- Data indicates the CSL is not the source of the carbon tetrachloride. Upgradient well (MW-122D) data suggests the source is to the northwest.
- The CSL proper, aside from MW-4DR and perhaps the northeastern most corner of the CSL, is downgradient from the carbon tetrachloride source.
- Carbon tetrachloride is present at a concentration above the MCL at in MW-114D (26 μg/L) and is migrating in an east-southeasterly direction.
- PCE was also detected above the MCL or Tap Water RBC in northern (from the CSL) wells MW-117D, MW-120, MW-122D and northern CSL wells MW-114 and MW-115.
- PCE was detected above the MCL of 5 μg/L in wells MW-114D (9.9 μg/L) and MW-117D (14 μg/L).
- PCE (0.22-2.2 μg/L) was detected above the Tap Water RBCs in Well MW-115D, MW-120D, and MW-122D.
- Detections of PCE show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSL is to the east-southeast, which is consistent with that observed for the spatial distribution of carbon tetrachloride detections.
- Data suggests the source of the PCE detected above screening criteria, is crossgradient and upgradient from the CSL.

Other VOCs were detected in one or more wells at concentrations above Tap Water RBCs as follows: chloroform (0.79-5 μg/L) in 6 wells and trichloroethene (0.24-2.8 μg/L) in 5 wells.

New Southern CSL Off-Post Lower Patapsco Aquifer Wells:

Five new wells were installed at off-post locations southeast and downgradient of the CSL at the request of MDE to assess potential off-post migration of contaminated groundwater from the CSL in the Lower Patapsco Aquifer in conjunction with existing deep well MW-108D. These are wells MW-109D, MW-110D, MW-111D, MW-112D, and MW-116D.

Analytical detections for the groundwater samples from the new Southern CSLF deep wells are tabulated in **Table 4-4**. Analytical detections, with emphasis on exceedances of MCLs and Tap Water RBCs are as follows:

VOCs

- No VOCs were detected above MCLs.
- Tetrachloroethene was detected above the Tap Water RBC of 0.1μg/L in both samples from well MW-109D (1.6/2.2 μg/L) and in MW-116D (0.35 μg/L). No other VOCs were detected above a Tap Water RBC. Trichloroethene was not detected.

SVOCs

- No SVOCs were detected above MCLs. Bis(2-ethyl-hexyl) phthalate, a plasticiser which is a common laboratory and field cross-contaminant, was detected above the Tap Water RBC of 4.8 μg/L in MW-111D (7.8 μg/L) and MW-112D (6.9 μg/L).

Pesticides/Herbicides/PCBs

- No pesticides were detected above MCLs or Tap Water RBCs.
- Herbicides and PCBs were not detected.

TAL Metals

- No metals were detected above MCLs.
- Arsenic (2.7 μg/L) was detected above the Tap Water RBC (0.04 μg/L) in one sample.

General sampling results for this sampling round are as follows:

- Fewer organic analytes were detected, and at generally lower concentrations, than samples from on-post wells located proximal to the CSL.
- No analytes were detected above MCLs.
- Tetrachloroethene, bis(2-ethylhexyl)phthalate and scattered metals were detected at concentrations above Tap Water RBCs.

4.7.2.4 2004 Lower Patapsco Aquifer Groundwater Sampling Results

The June 2004 sampling round consisted of 23 Lower Patapsco aquifer wells. All wells were sampled for TCL VOCs, SVOCs, PAHs, explosives, perchlorate, pesticides, herbicides, PCBs, and TAL metals. Analytical detections for the groundwater samples from the new Southern CSLF deep wells are tabulated in **Table 4-6**. Well locations, with exceedances of MCLs and Tap Water RBCs annotated, are shown in **Figures 4-17** for inorganic analytes and **Figure 4-18** for organic analytes.

New deep wells MW-125D and MW-126D were initially sampled in June 2004 and analyzed for TCL VOCs, SVOCs, PAHs, explosives, perchlorate, pesticides, herbicides, PCBs, and TAL metals. These wells were re-sampled in March 2005 and analyzed for VOCs only. These results are discussed with the June 2004 sampling round results.

Discussion of the analytical detections screened against MCLs and Tap Water RBCs are as follows:

Northern CSL On-Post Lower Patapsco Aquifer Wells:

The on-post northern CSL deep wells (MW-4DR and MW-113D to MW-122D) are located upgradient or cross gradient from the CSL, except for MW-114D and MW-115D which are located in the extreme northeast corner of the CSL. Analytical detections for the groundwater samples from the) screened against MCLs and Tap Water RBCs are as follows:

TCL VOCs

- Carbon tetrachloride was detected above the MCL in MW-4DR (11.6 μg/L) and MW-114D (61.3-61.5 μg/L). Tetrachloroethene (9.3-9.5 μg/L) in MW-114D and 19.2 in MW-117D were the only other VOC detected above an MCL.
- VOCs detected above Tap Water RBCs were as follows:
- Carbon tetrachloride (1.8-3.7 μg/L) in MW-115D and MW-122D
- Chloroform (0.81-7.8 μg/L) in MW-4DR, 114D, 115D, 118D, 119D, 120D, 121D and 122D
- Tetrachloroethene (0.74-2.6 μg/L) in MW-116D, MW-120D, and MW-122D

- Trichloroethene (0.64-3 μg/L) in 2 wells.

SVOCs and PAHs

- SVOCs and PAHs were not detected above MCLs or Tap Water RBCs.

Explosives and Perchlorate

- Explosives and perchlorate were not detected above MCLs or Tap Water RBCs.

Pesticides/Herbicides/PCBs

- No pesticides and herbicides were not detected.
- PCBs were not detected.

TAL Metals

- Three metals were detected above MCLs: Antimony (11.3 μg/L) exceeded the MCL of 6 μg/L in MW-113D. Beryllium (27 μg/L) exceeded the MCL of 4 μg/L and lead (44.3 μg/L) exceeded the MCL of 15 μg/L in MW-115D.
- A majority of the MCL and Tap Water RBC exceedances and the highest concentrations for nearly all metals were from MW-115D.

Summary results for the sampling of the northern CSL deep wells are as follows:

- Carbon tetrachloride and tetrachloroethene are present above MCLs and Tap Water RBCs in multiple wells across the northern CSL area, including wells upgradient and/or cross gradient from the CSL.
- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, and MW-122D and tetrachloroethene in wells MW-114D, MW-117D, and MW-120D show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSLF is to the east-southeast. This is consistent with the regional groundwater flow direction but is more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR is cross-gradient from the CSLF, not up-gradient.
- The CSL proper, aside from MW-4DR and perhaps the northeastern most corner of the CSL, is downgradient from the carbon tetrachloride source.
- Data indicates the carbon tetrachloride in the Lower Patapsco Aquifer is not related to the CSL.
- Carbon tetrachloride is present at a concentration above the MCL at in MW-114D (61.5/61.3 μg/L) and MW-4DR (11.6 μg/L) and is migrating in an east-southeasterly direction.
- Upgradient well (MW-122D) data suggests the source is northwest of the CSL.

Northern CSL Off-Post Lower Patapsco Aquifer Wells (June 2004):

Analytical detections for the groundwater samples from the off-post northern CSL deep wells (MW-MW-125D to MW-126D) screened against MCLs and Tap Water RBCs are as follows:

TCL VOCs

- Carbon tetrachloride (21.3 μg/L) was detected in MW-125D and tetrachloroethene (12.4 μg/L) was detected in MW-126D above the MCL of 5 μg/L.
- Chloroform (0.43-0.85 μg/L) and trichloroethene (0.54-3.5 μg/L) were detected above Tap Water RBCs in both wells. Tetrachloroethene (2.8 μg/L) was detected above Tap

Water RBCs in MW-125D. Carbon tetrachloride (4.1 μg/L) also exceeded the Tap Water RBC in MW-126D.

SVOCs and PAHs

- SVOCs were not detected above the screening criteria.
- PAHs were not detected.

Explosives and Perchlorate

- Explosives and perchlorate were not detected.

Pesticides/Herbicides/PCBs

- Pesticides and herbicides were not detected.
- PCBs were not detected.

TAL Metals

- Thallium (6.9 μg/L) and lead (16.2 μg/L) in MW-125D was the only metals to exceed an MCL.
- Tap Water RBCs were also exceed for iron (11,000-27,000 μg/L) in both wells and for vanadium (60.3 μg/L) in MW-125D.

Northern CSL Off-Post Lower Patapsco Aquifer Wells (March 2005 – Re-sampling Event):

Off-post wells MW-125D and MW-126D were re-sampled in March 2005 to confirm MCL exceedances for VOCs. Analytical detections were screened against MCLs and Tap Water RBCs are as follows:

TCL VOCs

- Carbon tetrachloride was detected in MW-125D (20 μg/L) and tetrachloroethene (6.5 μg/L) was detected in MW-126D above the MCL of 5 μg/L. No other VOCs were detected above an MCL.
- Chloroform (0.29-0.8 μg/L) and trichloroethene (0.28-2.4 μg/L) were detected above Tap Water RBCs in both wells. Tetrachloroethene (1.2 μg/L) was detected above Tap Water RBCs in MW-125D. No other VOCs exceeded tap Water RBCs.

Southern CSL On-Post Lower Patapsco Aquifer Wells

Analytical detections for the groundwater samples from the southern on-post CSL deep wells, upgradient well MW-7D, and CSL boundary wells (MW-2D, MW-12D, and MW-101D) were screened against MCLs and Tap Water RBCs are as follows:

Upgradient Well MW-7D: No organic analytes were detected. No inorganic analytes were detected above MCLs or Tap Water RBCs.

TCL VOCs

- VOCs were not detected above screening levels. Toluene in one sample was the only VOC detected.

SVOCs and PAHs

- SVOCs were not detected above screening levels. Bis(2-ethylhexly)phthalate in one sample was the only SVOC detected
- PAHs were not detected.

Explosives and Perchlorate

- Explosives were not detected.

- Perchlorate was not detected above the Tap Water RBC.

Pesticides/Herbicides/PCBs

- Pesticides and herbicides were not detected.
- PCBs were not detected.

TAL Metals

- No metals were detected above MCLs or Tap Water RBCs.

In the on-post CSL area (excluding the northeast corner of Cell 2 and Cell 3), deep groundwater in the Lower Patapsco aquifer is not contaminated above screening levels. No analytes were detected above MCLs or Tap Water RBCs. Carbon tetrachloride, PCE, TCE, benzene, and their breakdown products were not detected in these on-post southern wells.

Southern CSL Off-Post Lower Patapsco Aquifer Wells

Analytical detections for the groundwater samples from the southern off-post CSL deep wells – wells MW-108D, MW-109D, MW-110D, MW-111D, MW-112D and MW-116D - screened against MCLs and Tap Water RBCs are as follows:

TCL VOCs

- VOCs were not detected above MCLs.
- Tetrachloroethene (0.74-0.77 μg/L) in MW-116D, was the only VOC detected above tap Water RBCs.

SVOCs and PAHs

- SVOCs were not detected above MCLs.
- Bis(2-ethylhexyl)phthalate (8.8 μg/L) in MW-111D was the only SVOC detected above Tap Water RBCs.
- PAHs were not detected.

Explosives and Perchlorate

- Explosives were not detected.
- Perchlorate was not detected above the Tap Water RBC.

Pesticides/Herbicides/PCBs

- Pesticides and herbicides were not detected.
- PCBs were not detected.

TAL Metals

- No metals were detected above MCLs
- Vanadium (49.2 μg/L) in MW-111D was the only inorganic to exceed a Tap Water RBC.

In the off-post CSL area east and downgradient of Cell 1, deep groundwater in the Lower Patapsco aquifer is not significantly impacted above screening levels. No analytes were detected above MCLs. Low-levels of tetrachloroethene, bis(2-ethylhexyl)phthalate and vanadium exceeded Tap Water RBCs. Carbon tetrachloride, TCE, benzene and their breakdown products were not detected.

4.7.3 Soil Investigation Results

A total of 20 surface soil and 18 shallow subsurface soil/waste samples (excluding QA/QC samples) were collected at CSL to assess potential soil contamination, characterize landfill material, and evaluate potential future risk. Trenching and soil sample locations are shown on **Figure 4-20**. All soil samples were analyzed for TCL VOCs and SVOCs, PAHs, explosives, pesticides, herbicides, PCBs, and

TAL Inorganics. Analytical detections, screened against Industrial RBCs for Soil are discussed in the following sections. Complete analytical results are presented in **Appendix F**.

4.7.3.1 Cell 3 Trenching

Historical aerial photos **Figure 4-6** have shown consistent ground scarring and activity in this area since the inception of the CSL. Subtle linear features were visible in the otherwise flat field, which could be consistent with the surface expression of historical trenches. A total of six 25-ft long characterization trenches were performed in order to; 1) assess in the determination of whether wastes were buried in this area; 2) characterize the physical nature of the waste materials if present; and 3) provide access for collection of subsurface soil samples for chemical characterization (**Figure 4-20**).

Trench depths ranged from 4-7 feet below ground surface to approximately 6 feet in depth or to when undisturbed soils were encountered below the fill. Groundwater infiltration was noted in several of the trenches at approximately 6 feet below ground surface. Because wastes are not typically landfilled below the water table, it is assumed that this would have been the approximate practical limit of historical excavation for waste disposal.

CSL Cell 3 Trenching Summary			
Trench	**Dimensions**	**Fill Materials Encountered**	**Figure**
TR-1	4x2x25-ft (N-S)	Approx. 4-ft (depth) of wood debris, plastic bottles, cans, styrofoam, paper labels in sand/silt matrix.	**4-21**
TR-2	5x2x25-ft (N-S)	Approx. 3-ft of sanitary fill consisting of bricks, wood, construction debris, plastic, 1966 newspapers in sand/silt matrix.	**4-22**
TR-3	6x2x25-ft (N-S)	Approx. 5-ft of misc. sanitary fill – soda cans, milk cartons, 1968 newspapers, plywood, carpet fragments, misc. plastic debris in sand/silt matrix.	**4-23**
TR-4	7x2x25-ft (N-S)	Approx. 6-ft of construction debris in sand/silt matrix.	**4-24**
TR-5	6x2x25-ft (WNW-ESE)	No buried debris/waste was encountered.	**4-25**
TR-6	6x2x25-ft (N-S)	Approx. 6-ft of sanitary fill similar to that found in trenches TR-2 and TR-3.	**4-26**

Trenching characterization of the Cell 3 area showed the presence of saniitary wastes and construction debris consistent with the “mixed residential, commercial, and nonhazardous industrial wastes” reported as being disposed of in Cells 2 and 3. Dates on newspapers recovered ranged from 1966-1968 which is likely contemporaneous with their disposal.

4.7.3.2 Cell 3 Trench Sampling Results

One surface soil and two subsurface soil samples were collected from each trench. The subsurface soil samples were collected from the base of the fill materials. Exceedances of surface soil sampling criteria are shown in **Figure 4-19**. Exceedances of subsurface soil sampling criteria are shown in **Figure 4-20**.

Surface Soil (0 - 0.5 feet): Analytical detections from the six surface soil locations (SS-CELL3-1 to SS-CELL3-6) are presented in **Table 4-9**. The detections above Industrial RBCs for soil are summarized as follows:

TCL VOCs

- None were detected.

SVOCs, PAHs, Explosives

- SVOCs were not detected above Industrial RBCs. Bis(2-ethylhexyl)phthalate was the only non-PAH detected.
- PAHs were not detected above Industrial RBCs.
- Explosives were not detected.

Pesticides, Herbicides, and PCBs

- Pesticides were not detected above Industrial RBCs.
- Herbicides were not detected.
- PCBs were only detected in one sample and were not detected above Industrial RBCs.

TAL Inorganics

- Arsenic was the only inorganic analyte detected above Industrial RBCs. Arsenic was detected at or above the RBC (1.9 mg/kg) in 5 of 6 samples but only exceeded the maximum background concentration for arsenic at SS-CELL3-5 (3.6 mg/kg).

Subsurface Soil (3 – 7.5 feet): Analytical detections of twelve CSL Cell 3 trench surface soil locations (TR1A and B through TR6A and B) are presented in **Table 4-10**. The detections above Industrial RBCs are summarized as follows:

TCL VOCs

- VOCs were detected in samples from trenches TR-4 and TR-6, but no VOCs were detected above Industrial RBCs.

SVOCs and PAHs

- SVOCs were not detected above RBCs.
- PAHs were detected in all samples, but no PAH exceeded its Industrial RBC.

Pesticides, Herbicides and Explosives

- Pesticides and herbicides were not detected.
- Explosives were not detected.

PCBs

- Pesticides were detected above in 10 of 12 samples. Arochlor 1221 (6.39 mg/kg) and Arochlor 1242 (1.94 mg/kg) in TR-3B were the only PCBs detected above Industrial RBCs.

TAL Inorganics

- Arsenic was the only inorganic analyte detected above Industrial RBCs. Arsenic was detected at or above the RBC (1.9 mg/kg) and maximum background in 9 of 12 samples at concentrations ranging from 2.1 to 5.5 mg/kg.

Surface and subsurface soil sampling results from the Cell 3 characterization trenches do not show distribution of chemical contamination above Industrial RBCs for soil. Arochlor 1221 (6.39 mg/kg) and Arochlor 1242 (1.94 mg/kg) in subsurface soil sample TR-3B were the only organic analytes detected above Industrial RBCs. Arsenic, the only inorganic analyte detected above Industrial RBCs, was detected above the RBC in a majority of the samples. However, the maximum background concentration for arsenic in surface soil (2.79 mg/kg) which is greater than the RBC, was exceeded in only one sample.

4.7.3.3 Former ASP Soil Sampling Results

One surface and one shallow subsurface soil samples were collected from six former magazine locations to assess the potential for soil contamination due to spills or leaks. Exceedances of surface

soil sampling criteria are shown in **Figure 4-19**. Exceedances of subsurface soil sampling criteria are shown in **Figure 4-20**.

Surface Soil (0 - 0.5 feet): Analytical detections of sample analyses from the six ASP surface soil locations (SS-ASP-1 to SS-ASP-6) are presented in **Table 4-7**. The detections above Industrial RBCs for soil and maximum background levels are summarized as follows:

TCL VOCs, SVOCs, PAHs, Pesticides, and PCBs

- VOCs were not detected above Industrial RBCs.
- SVOCs were not detected above Industrial RBCs. Bis(2-ethylhexyl)phthalate was the only non-PAH detected.
- PAHs were not detected above Industrial RBCs.
- Pesticides were not detected above Industrial RBCs.
- PCBs were only detected in one sample and were not detected above Industrial RBCs.

Herbicides and Explosives

- Explosives were not detected.
- Herbicides were not detected.

TAL Inorganics

- Arsenic was the only inorganic analyte detected above Industrial RBCs. Arsenic was detected at or above the RBC (1.9 mg/kg) in all 6 samples, and exceeded the maximum background concentration at concentration ranging from 2.4-2.8 mg/kg in 5 of the 6 samples. All arsenic analytical results in this lot were “L” flagged indicating that the result may be biased low.

Subsurface Soil (0.5 - 5 feet): Analytical results from the 9 ASP sub-surface soil samples are presented in **Table 4-10**. The detections above Industrial RBCs are summarized as follows:

TCL VOCs, Explosives, and PCBs

- VOCs, explosives, and PCBs were not detected.

SVOCs and PAHs

- SVOCs were not detected above Industrial RBCs. Bis(2-ethylhexyl)phthalate was the only SVOC detected.
- PAHs were not detected above Industrial RBCs.

Pesticides and Herbicides.

- Pesticides were only detected in SS-ASP-6 and did not exceed Industrial RBCs.
- Herbicides were not detected.

TAL Inorganics

- Arsenic was the only inorganic analyte detected above Industrial RBCs. Arsenic was detected at or above the RBC (1.9 mg/kg) in 6 of 9 samples at concentrations ranging from 2 to 3.3 mg/kg.

Surface and subsurface soil sampling from the former locations of magazines does not show the presence of contamination above Industrial RBCs. Explosives were not detected. No organic analytes were detected above Industrial RBCs. No inorganic analytes other than arsenic were detected above Industrial RBCs. Arsenic was detected above the RBC (1.9 mg/kg) in 9 of 15 samples collected at concentrations up 3.3 mg/kg.

4.7.3.4 Cell 1 and Cell 2 Cover Surface Soil Sampling Results

Surface soil samples were collected from the cover materials in the cap of Cell 1 (SS-1 to SS-4) and Cell 2 (SS-5 to SS-8) to quantify chemical levels for use in risk assessment. Exceedances of surface soil sampling criteria are shown on **Figure 4-19.**

Surface Soil (0 - 0.5 feet): Analytical results from the eight surface soil locations are presented in **Table 4-9**. The detections above Industrial RBCs and maximum background levels are summarized as follows:

TCL VOCs

- None were detected.

SVOCs and PAHs,

- SVOCs were not detected above Industrial RBCs. Bis(2-ethylhexyl)phthalate was the only SVOC detected.
- PAHs were not detected above Industrial RBCs.

Pesticides, Herbicides, and PCBs

- Pesticides were not detected above Industrial RBCs.
- Herbicides were not detected.
- PCBs were not detected above Industrial RBCs.

Explosives

- Explosives were not detected above Industrial RBCs. Explosives, primarily dinitrotoluenes and 2,4,6-TNT were detected in samples SS-1 through SS-5.

TAL Inorganics

- Arsenic was the only inorganic analyte detected above RBCs. Arsenic was detected at or above the Industrial RBC (1.9 mg/kg) and the maximum background concentration in all samples at concentration ranging from 2.4-8.6 mg/kg.

Surface soil sampling results from the Cell 1 and Cell 2 cover materials does not show the presence of contamination above the screening criteria.

4.7.3.5 Surface Water and Sediments

A total of seven surface water and six sediment samples were collected at the CSL from locations shown on **Figure 4-18A** as SW1 to SW6 (surface water) and SED1 to SED6 (sediment). All samples were collected at times when the stream flow or surface water runoff was not directly influenced from precipitation events. The surface water and sediment samples were analyzed for TCL VOCs and SVOCs, explosives, pesticides, herbicides, PCBs, and TAL Inorganics. Analytical results of the surface water samples are presented in **Table 4-7**. Analytical results of the sediment samples are presented in **Table 4-8.** Analytes detected above AWQCs or tap Water RBCs values for surface water or ER-Ls for sediment are discussed in the following paragraphs. Complete analytical results are presented in **Appendix F**.

Surface Water and Sediment Samples on the Eastern FGGM Boundary: Surface water runoff from the eastern side of the CSL is channeled via ditches along the post boundary/AMTRACK railbed. Samples SW1/SED1 were collected from shallow ponded water adjacent to the culvert which connects to the Odenton stormwater management system. The location is approximately the same as the semi-annual RCRA monitoring location SW-1. Analytical results and detections exceeding the screening criteria are summarized as follows:

TCL VOCs

- VOCs were not detected in surface water or sediment above the screening criteria.

- Low levels of ethylbenzene (0.0016 mg/kg) and toluene (0.0123 mg/kg), for which no ER-L exist, were detected in sediment.
- Acetone (8.1 μg/L), for which AWQCs and MCLs have not been promulgated, was the only VOC detected in surface water.

TCL SVOCs, and PAHs

- No SVOCs were detected in surface water.
- No SVOCs were detected above ER-Ls in sediment. Bis(2-ethylhexyl) phthalate was the only non-PAH SVOC detected.
- PAHs were not detected above ER-Ls in sediment. Low levels (< 0.007 mg/kg) of 12 PAHs were detected.

Explosives and PCBs

- Explosives and PCBs were not detected in either surface water or sediment.

Pesticides and Herbicides

- Pesticides were not detected in surface water.
- No pesticides were detected above ER-Ls in sediment. 4,4'-DDT (0.0027 mg/kg) which does not have an ER-L, was the only pesticide detected.
- Herbicides were not detected in either surface water or sediment.

TAL Inorganics

- No inorganic analytes were detected above the screening criteria in either surface water or sediment.

Surface water and sediment leaving the site to the east were not at concentrations above the screening criteria. These results are consistent with the RCRA detection monitoring results for this location.

Surface Water and Sediment Samples From Interior CSL Drainages: Surface water runoff from the western sides of Cell 1 and Cell 2 is channeled via engineered drainages and retention ponds northwestward through the former ASP area. Samples SW2/SED2 were collected from the approximate location of semi-annual RCRA monitoring point SW-2. Analytical results and detections exceeding the screening criteria are summarized as follows:

TCL VOCs

- VOCs were not detected in surface water or sediment.

TCL SVOCs, PCBs, and Explosives

- None were detected in either surface water or sediment.

Pesticides and Herbicides

- Pesticides were not detected in surface water.
- No pesticides were detected above ER-Ls in sediment. 4,4'-DDT (0.0029 mg/kg) which does not have an ER-L, was the only pesticide detected.
- Herbicides were not detected in either surface water or sediment.

TAL Inorganics

- No inorganic analytes were detected above the screening criteria in either surface water or sediment.

Surface water and sediment from the interior CSL drainage were not at concentrations above the screening criteria. These results are consistent with the RCRA detection monitoring results for this location.

Surface Water and Sediment Samples from Near Western Drainages: The interior and western areas of the CSL are drained by a generally westward flowing unnamed perennial stream. Surface water and sediment samples were collected to assess the nature and extent of any contamination Sample SW4/SED4 was collected from the stream where it exits the former ASP area. This is approximately the same location as RCRA surface water monitoring point SW3. Sample SW3/SED3 was collected approximately 250 feet further downstream (to the west) from a pond/wetlands area adjoining Range Road. All samples were collected at times when the area was not directly influenced from precipitation events. Analytical results and detections exceeding the screening criteria are summarized as follows:

TCL VOCs

- VOCs were not detected in surface water.
- VOCs were not detected above the screening criteria in sediment. Low levels of acetone (0.0302-0.0359 mg/kg), 2-butanone (0.0123 mg/kg), and toluene (0.0068 mg/kg), for which no ER-Ls exist, were detected.

TCL SVOCs, PAHs, and Explosives

- No SVOCs (other than PAHs) were detected in surface water or sediment.
- PAHs were not detected in surface water.
- PAHs were not detected above ER-Ls in either sediment sample. Twelve 12 PAHs were detected in SED3 but no PAHs were detected in SED4 which located closer to the CSL.
- Explosives were not detected in either surface water or sediment.

Pesticides, Herbicides, and PCBs

- Pesticides were not detected in surface water.
- No pesticides were detected above ER-Ls in sediment. 4,4'-DDD (0.0914-0.372 mg/kg), 4,4'-DDT (0.0326-0.0847 mg/kg), and 4,4'-DDT (0.0081-0.0235 mg/kg) which do not have ER-Ls, were the only pesticides detected.
- Herbicides were not detected in either surface water or sediment.
- PCBs were not detected in surface water.
- PCBs were detected above ER-Ls in sediment. Arochlor 1260 (0.0956) mg/kg) which does not have an ER-L, was the only PCB.

TAL Inorganics

- No inorganic analytes were detected above the screening criteria in either surface water or sediment.

Surface water and sediment leaving the CSL to the west along the unnamed stream were not at concentrations above the screening criteria. The surface water results for SW-4 are consistent with the RCRA detection monitoring results for this (SW3) location.

Surface Water and Sediment Samples from Far Western Drainages: The interior and western areas of the CSL are drained by a generally westward flowing unnamed perennial stream. Two distal surface water and sediment samples were collected from the unnamed stream in the PRR to assess if any contamination was migrating from the CSL. Sample SW5/SED5 was collected from the stream approximately 2000 feet downstream from SW3/SED3. Sample SW6/SED6 was collected approximately 1000 feet further downstream. All samples were collected at times when

the area was not directly influenced from precipitation events. Analytical results and detections exceeding the screening criteria are summarized as follows:

TCL VOCs

- VOCs were not detected in surface water or sediment.

TCL SVOCs and PAHs

- No SVOCs were detected in either surface water or sediment.
- PAHs were not detected in surface water.
- PAHs were not detected in SED6.
- In SED5, benzo(a)pyrene (7.45 mg/kg), fluoranthene (10.9 mg/kg), and fluorene(4.89 mg/kg) were detected above the ER-Ls. Three other PAHs - benzo(b)fluoranthene (1.9), benzo(g,h,i) fluoranthene (4.89) and indeno(1,2,3-cd)pyrene - for which no ER-Ls exist - were also detected.

Pesticides, Herbicides, PCBs, and Explosives

- Pesticides and herbicides were not detected in either surface water or sediment.
- PCBs were not detected in either surface water or sediment.
- Explosives were not detected in either surface water or sediment.

TAL Inorganics

- No inorganic analytes were detected above the screening criteria in either surface water or sediment.

Surface water and sediments downstream from the CSL to the west were not at concentrations CSL above screening criteria. Except for the detections of PAHs above ER-Ls in one distal downstream sample, the CSL is not contributing to downstream contamination of sediments above the screening criteria. Since PAHs were not detected in SED2 or SED4, the samples collected proximal to the CSL, it seems unlikely to attribute PAH exceedances in SED5 to the CSL.

Nature and extent screening in this section used RBCs with a Hazard Quotient of 1. Risk screening in **Section 6** used a Hazard Quotient of 0.1 for RBCs, therefore, additional chemicals may be identified as contaminants of potential concern in the more conservative risk assessment.

4.8 GEOLOGY AND HYDROGEOLOGY CONCLUSIONS

4.8.1 Upper Patapsco Aquifer

Although shallow groundwater flow in the Upper Patapsco water table aquifer is regionally to the east-southeast, topographic highs in the vicinity of the CSL results in local deviations from regional trends (**Figure 4-4**). The significant topographic features are as follows:

- The man-made cells of the CSL with their impermeable RCRA caps form significant (>30 feet) topographic highs of about 170 feet AMSL which locally impose radial deflections of shallow groundwater. This can locally impart north or westerly flow of unconfined groundwater into the low lying area between CSL cells 1 and 2 and southerly flow south of Cell 1.
- The Amtrak Railroad and associated right-of way lie in a NE-SW trending topographic low which crosses the regional groundwater flow direction at a high angle, locally resulting in surface water seeps and southerly or southwesterly deflection of unconfined groundwater flow. This is reinforced by the presence of local topographic highs (200+ feet AMSL) in central Odenton located between the right-of-way and State Road 170.
- The local topography features, and the hydraulic head measurements from the shallow wells located on the south side of Cell 1 and the off-post wells to the east suggests that

local groundwater flow immediately east of the CSL is to the south or southwest instead of to the southeast.

- Hydraulic gradients are highly variable due to topographic variations on the order of 10^{-2} ft/ft. Mean hydraulic conductivity based on 8 slug tests was calculated as 2.44×10^{-4} cm/s (0.46 ft/day) (EA, 1992).

4.8.2 Middle Patapsco Confining Unit

The Middle Patapsco clays form a thick (35-100 feet), effective confining unit at the CSL. Regionally, this unit ranges from 0 to about 60 feet of fine sandy clay which may be heterogeneous and laterally discontinuous; however, it is often comprised of massive beds of clay (such as here) with very low vertical permeabilities (Mack and Achmad, 1986 and Wilson and Achmad 1995). This is supported by:

- The observed thickness and homogeneity of the clays encountered during drilling in the vicinity of the CSL (about 35-50 feet on-post, thickening to 70+ feet in off-post downgradient areas);
- Semi-annual RCRA monitoring show downward vertical hydraulic gradients between the upper and lower aquifers, and statistically increasing concentrations of organic contaminants (as defined by the RCRA landfill monitoring requirements) in the upper aquifer which are not observed in the lower aquifer.
- The primary organic contaminants observed in the lower aquifer, carbon tetrachloride and tetrachloroethene (PCE), were also detected in upgradient deep wells (117D and 122D). This indicates a potential source upgradient from the CSL.
- The presence of carbon tetrachloride in the deep aquifer only.
- PCE and TCE were only detected in the deep aquifer for both September 2002 and June 2004 sampling events.
- Benzene was only detected in the shallow aquifer for both September 2002 and June 2004 sampling events.
- Downward vertical hydraulic gradients are observed between the upper (unconfined) and lower (confined) aquifers in well pairs and in the measured potentiometric surfaces of the upper and lower Patapsco aquifers, with gradients generally increasing to the southeast. At the eastern CSL/facility boundary, the potentiometric surface of the lower Patapsco aquifer is about 80-90 feet msl, about 50-60 feet below the unconfined surface of the upper Patapsco aquifer (140-150 feet msl). The persistent strong negative hydraulic gradients indicate that good hydraulic separation between the aquifers is being maintained.
- The upper and lower Patapsco aquifers have different water chemistries. Charge balance calculations for major anions (calcium, magnesium, potassium, iron, sodium, and nitrate) and major cations (chloride, sulfate, and alkalinity) have been performed (EA,1992 and USACHPPM, 1994)[3]. Lower Patapsco groundwater samples showed significantly lower and more uniform microequivalent charge per liter for both cations (<1.5) and anions (<1.9) than were observed in the upper Patapsco aquifer (0 to about 50 for both anions and cations). The % differences within individual samples did not show significant differences. This indicates Upper Patapsco groundwater is not mixing with the Lower Patapsco groundwater in the vicinity of the CSL.
- Calculation of permeabilities of 5 shelby tube samples (from 5 different borings) of the middle Patapsco clay ranged from 1.2×10^{-8} cm/sec to 1.9×10^{-7} cm/sec (EA,1992). These values are representative of confining layers.

[3] Outlying data from former well MW-4D (which was abandoned and replaced by MW-4DR) was dropped.

- A short term (4-hour) pumping test was performed on deep CSL well MW-7D (EA,1992). Deep well MW-7D, screened in the lower Patapsco aquifer drew down 32 feet. Adjacent shallow well MW-7S, screened in the upper Patapsco aquifer, exhibited no drawdown. This data suggests that the middle Patapsco confining unit effectively blocked hydraulic communication between the upper and lower Patapsco aquifers in the area of the CSL. No other pump tests have been performed in this area.

4.8.3 Lower Patapsco Aquifer

Regional groundwater flow directions in the lower Patapsco aquifer are to the southeast, as documented in the USACE (1999) Basic Data Report. The potentiometric surface of the lower Patapsco aquifer, based on data from the deep CSL and adjacent area wells presented in **Figure 4-2**, is more east-southeast near the facility boundary downgradient from the CSL.

- Local hydraulic gradients are on the order of $3x10^{-3}$ ft/ft. Mean hydraulic conductivity based on slug tests was calculated as $1.59x10^{-3}$ cm/s (EA, 1992).
- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, MW-122D, 125D and 126D detections of tetrachloroethene in wells MW-114D, MW-117D, MW-120D, MW-122D, MW-125D, and MW-126D indicates the groundwater flow direction in the lower Patapsco aquifer north of the CSL is to the east-southeast, which is consistent with the regional groundwater flow direction but is a little more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR is cross-gradient from the Lower Patapsco aquifer below the CSL, not upgradient. Data indicates the carbon tetrachloride and tetrachloroethene present in the Lower Patapsco aquifer, on the north side of the CSL, aquifer are not related to the CSL.

4.9 GROUNDWATER CONCLUSIONS

4.9.1 2002 Upper Patapsco Direct Push Groundwater Screening Conclusions

Northern CSL DPT Groundwater Screening Results for VOCs

Groundwater screening for VOCs was performed at 10 DPR points in the shallow aquifer north of the CSL in and around the area of MW-4DR to be sure that contamination is not present in the shallow aquifer and migrating downward via a faulty well seal from former well MW-4D or MW-4DR and to further evaluate the CSL and properties to the north as potential sources.

- Carbon tetrachloride was not detected in any sample.
- Shallow groundwater in this area is not the source of carbon tetrachloride found in the confined aquifer.
- The screened areas are cross-gradient or up-gradient from the CSL.
- Shallow groundwater in this area is not significantly impacted by VOCs (above screening levels) which might be related to the CSLF.

Southern CSL DPT Groundwater Screening Results for VOCs

Shallow wells MW-12s and MW-19 monitor the Upper Patapsco Aquifer immediately south and east of the southernmost extent of CSL Cell 1. Benzene has been detected above the Tap Water RBC (0.5 μg/L) and/or MCL (5μg/L) in MW-12S and MW-19 in all RCRA semi-annual monitoring rounds since May 1995 at concentrations ranging between 2.9 and 25 μg/L. The 13 point DPT sampling effort was designed to attempt to define the extent of shallow groundwater contamination of VOCs in areas located on-post to the south, southwest and west of MW-12S and MW-19.

- Benzene was detected above the MCL of 5 μg/L in three adjacent sampling points located near the southernmost tip of cell 1: MDP-6 (12 μg/L), MDP-7 (9.1 μg/L), and MDP-8 (5.1μg/L). No other VOCs were detected above an MCL. Benzene was detected

above the Tap Water RBC in 9 of the other 10 sampling points (0.45 – 4.4 μg/L) with the concentrations generally decreasing to the south and west.

- Chloroethane (4.2 μg/L), Chloroform (up to 3.4 μg/L), 1,2-dichloroethane (up to 0.93 μg/L), 1,2-dichloropropane (up to 2 μg/L), trichloroethene (up to 0.64 μg/L), vinyl chloride (up to 1.2 μg/L) and total xylenes (24 μg/L) were sporadically detected above Tap Water RBCs.
- Carbon tetrachloride was not detected.
- The highest VOC concentrations were detected immediately southeast of the south tip of Cell 1.
- The lateral extent of VOC contamination, as indicated by the presence of benzene at concentrations above the MCL in shallow groundwater screening samples, is about 600 feet. MW-12S and MW-19 essentially bound the area of benzene MCL exceedances.
- Shallow groundwater is generally flowing south-southeast from the elevated topography of Cell 1. However, based on the site and surrounding topography shallow groundwater in the vicinity of the southern end of Cell 1 is locally influenced by radial flow to the south and southwest.

4.9.2 2002 Upper Patapsco Groundwater Sampling Conclusions

Because of the persistent benzene MCL exceedances during RCRA monitoring of shallow wells MW-19 and MW-12S located immediately downgradient of the southern tip of Cell 1, all existing shallow wells located on FGGM property south of MW-12S and MS-19 were sampled for TCL VOCs to assess the whether additional wells need to be added to the semi-annual monitoring well network.

The TCL VOC detections above Tap Water RBCs or MCLs are summarized as follows:

- No VOCs were detected above MCLs.
- Benzene (1.8-3.1 μg/L) was detected above the Tap Water RBC in MW-11, MW-12S, MW-19, and MW-20, with the highest detection in MW-12S. 1,2-Dichloropropane (0.26-0.39 μg/L) was detected above the Tap Water RBC in MW-11 and MW-20. Chloroform (0.28 μg/L) exceeded the Tap Water RBC in MW-21.
- Chloroform (0.28 μg/L) in MW-21 was the only other VOCs to exceed a Tap Water RBC.
- Based on this data, it was determined, in consultation with the FGGM Environmental Partnership, that no additional shallow monitoring wells were required in this area of the CSL for the semi-annual monitoring program.

4.9.3 2004 Upper Patapsco Groundwater Sampling Conclusions

Western Shallow Groundwater Wells: Monitoring wells MW-4S, MW-5, MW-7S, MW-8, and MW-10S are sited along the western margin of the CSL. These wells monitor upgradient conditions (MW-4S) and localized westward flow of shallow groundwater due to the local topography of Cell 1 and Cell 2.

- Lead, in MW-5, was the only detection above MCLs.
- Sporadic detections of inorganics exceeded Tap Water RBCs.
- Groundwater sampling results show that little contamination is migrating westward from the CSL and that the upgradient wells are in upgradient locations relative to the CSL waste disposal areas.

Eastern Boundary Shallow Groundwater Wells: Monitoring wells MW-2S, MW-12S, MW-13, MW-14, MW-17, MW-18, MW-19, and MW-20 are sited along the installation boundary along the eastern margin of the CSL. These wells monitor the flow of shallow groundwater off the

topographic highs of Cell 1 and Cell 2 downgradient toward lower elevations along the railroad line to the east.

- Benzene (10.4 μg/L) in MW-19 was the only VOCs detected above MCLs.
- Arsenic, Cadmium and Thallium were detected above MCLs.

Off-Post Shallow Groundwater Wells: Samples from off-post shallow monitoring wells MW-105 to MW-107, located east of Cell 1 and the Amtrack Maintenance Yard show low-levels of contamination in the Upper Patapsco aquifer.

- No analytes were detected above MCLs. MTBE exceeded the Tap Water RBCs in off-post wells MW-105 and MW-106. Chloroform and bis-2-Ethylhexyl)phthalate exceeded Tap Water RBCs in MW-106 and MW-123s.
- Benzene was not detected in off-post shallow wells.
- The lack of benzene detections and the limited detections above Tap Water RBCs in the Upper Patapsco aquifer suggests that CSL-related contamination is migrating to the southwest rather than the southeast.

Samples from off-post shallow monitoring wells MW123S and MW-124S, located east of Cell 2, suggests that contamination from the CSL is not migrating to this area in the Upper Patapsco aquifer. No analytes were detected above MCLs.

New Upgradient Shallow Groundwater Well:

- Beryllium (40.2 μg/L) was detected above the MCL of 4 μg/L in MW-127S. This detection is within background levels and may be naturally occurring.
- Vanadium was detected above the Tap Water RBCs in MW-128S.

4.9.4 2002 Lower Patapsco Groundwater Sampling Conclusions

New On-Post Northern CSL Lower Patapsco Well Sampling

Carbon tetrachloride has been consistently detected in well MW-4DR (in the Lower Patapsco aquifer) at concentrations above the MCL ranging from 66-91 μg/L in multiple sampling rounds since 1999, but had previously not been detected in any other CSLF well. MW-4DR, screened from 129 to 149 feet bgs in the confined Lower Patapsco aquifer, was included in the semi-annual monitoring program as an upgradient well for the CSL. A total of 9 new deep wells (MW-113D to MW-1115D and MW-117D to MW-122D) were installed and sampled as part of the carbon tetrachloride investigation to determine if the CSL is the source of contamination, and if not, to determine if the contamination source is on-post or off-post and to attempt to delineate the extent of contamination. Summary results for the installation and sampling of these wells are as follows:

- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, and MW-122D indicates the groundwater flow direction in the Lower Patapsco Aquifer north of the CSL is to the east-southeast, which is consistent with the regional groundwater flow direction but is more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR (in the Lower Patapsco aquifer) is cross-gradient from the CSLF, not upgradient.
- Data indicates the CSL is not the source of the carbon tetrachloride. Upgradient well (MW-122D) suggests the source is northwest of the CSL.
- The CSL proper, aside from MW-4DR (in the Lower Patapsco aquifer) and perhaps the northeastern most corner of the CSL, is downgradient from the carbon tetrachloride source.
- Carbon tetrachloride is present at a concentration above the MCL at in MW-114D (26 μg/L) and is migrating in an east-southeasterly direction.

- PCE was also detected above the MCL or Tap Water RBC in northern (from the CSL) wells MW-117D, MW-120, MW-122D and northern CSL wells MW-114 and MW-115.
- PCE was detected above the MCL of 5 μg/L in wells MW-114D (9.9 μg/L) and MW-117D (14 μg/L).
- PCE (0.22-2.2 μg/L) was detected above the Tap Water RBCs in Well MW-115D, MW-120D, and MW-122D.
- Detections of PCE show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSL is to the east-southeast, which is consistent with that observed for the spatial distribution of carbon tetrachloride detections.
- Data indicates the source of the PCE detected above screening criteria, is crossgradient and upgradient from the CSL.

Other VOCs were detected in one or more wells at concentrations above Tap Water RBCs as follows: chloroform (0.79-5 μg/L) in 7 wells and trichloroethene (0.21-2.8 μg/L) in 6 wells.

New Off-Post Downgradient CSL Lower Patapsco Well Sampling

Five new wells (MW-109D to MW-112D, and MW-116D) were installed at off-post locations between the Amtrak Maintenance Yard and Route 175 at the request of MDE to monitor the Lower Patapsco Aquifer downgradient of the CSL. Summary results for the installation and sampling of these wells are as follows:.

- Fewer organic analytes were detected, and at generally lower concentrations, than samples from on-post wells located proximal to the CSLF.
- No analytes were detected above MCLs.
- PCE in two wells, bis(2-ethylhexyl)phthalate, and scattered metals were detected at concentrations above Tap Water RBCs.

4.9.5 2004 Lower Patapsco Groundwater Sampling Conclusions

Northern CSL On-Post Lower Patapsco Aquifer Wells:

Summary results for the sampling of the northern CSL deep wells (MW-4DR and MW-113D to MW-115, and MW-117 to MW-122D) are as follows:

- Carbon tetrachloride and tetrachloroethene are present above MCLs and Tap Water RBCs in multiple wells across the northern CSL area, including wells upgradient and/or cross gradient from the CSL.
- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, and MW-122D and tetrachloroethene in wells MW-114D, MW-117D, and MW-120D show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSLF is to the east-southeast. This is consistent with the regional groundwater flow direction but is more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR is cross-gradient from the CSLF, not upgradient.
- The CSL proper, aside from MW-4DR and perhaps the northeastern most corner of the CSL, is downgradient from the carbon tetrachloride source. Data indicates the carbon tetrachloride in the Lower Patapsco Aquifer is not related to the CSL.
- Carbon tetrachloride is present at a concentration above the MCL in MW-114D (61.5/61.3 μg/L) and MW-4DR (11.6 μg/L) and is migrating in an east-southeasterly direction.
- Upgradient well (MW-122D) data suggests the source is northwest of the CSL.

Northern CSL Off-Post Lower Patapsco Aquifer Wells (June 2004 and March 2005):

For off-post wells MW-125D and MW-126D:

- Carbon tetrachloride and PCE were detected above MCLs in each well.
- Chloroform and trichloroethene were also detected in both wells above Tap Water RBCs.
- Lead and Thallium were detected above MCLs in 125d.

Southern CSL On-Post Lower Patapsco Aquifer Wells

In the on-post CSL area containing wells MW-2D, MW-7D, MW-12D, and MW-101D (excluding the northeast corner of Cell 2 and Cell 3), deep groundwater in the Lower Patapsco aquifer is not contaminated above screening levels.

- No analytes were detected above MCLs or Tap Water RBCs.
- Carbon tetrachloride, PCE, TCE, and benzene and their breakdown products were not detected.
- The Lower Patapsco aquifer is not contaminated above screening levels in the southern on-post area.. No analytes were detected above MCLs or Tap Water RBCs. Carbon tetrachloride, PCE, TCE, benzene, and their breakdown products were not detected in these on-post southern wells.

Southern CSL Off-Post Lower Patapsco Aquifer Wells:

In the off-post CSL area east and downgradient of Cell 1, deep groundwater in the Lower Patapsco aquifer is not significantly contaminated above screening levels.

- No analytes were detected above MCLs.
- Tetrachloroethene and bis(2-ethylhexyl)phthalate and vanadium exceeded Tap Water RBCs in only one sample each.
- Carbon tetrachloride, TCE, benzene and their breakdown products were not detected.

4.10 SOIL SAMPLING CONCLUSIONS

Cell 3 Trenching and Soil Sampling Conclusions

- Sanitary waste and construction debris were found in 5 of 6 characterization trenches performed in Cell 3.
- Surface and subsurface soil sampling results from the Cell 3 characterization trenches do not show distribution of chemical contamination above Industrial RBCs for soil.
- Arochlor 1221 (6.39 mg/kg) and Arochlor 1242 (1.94 mg/kg) in subsurface soil sample TR-3B were the only organic analytes detected above Industrial RBCs.
- Arsenic, the only inorganic analyte detected above Industrial RBCs, was detected above the RBC in a majority of the samples. However, the maximum background concentration for arsenic in surface soil (2.79 mg/kg) which is greater than the RBC, was exceeded in only one surface soil sample.

Former ASP Soil Sampling Conclusions

- Surface and subsurface soil sampling from the former locations of ammunition storage magazines does not indicate the presence of soil contamination above Industrial RBCs.
- Explosives were not detected.
- No organic analytes were detected above Industrial RBCs.

- No inorganic analytes other than arsenic were detected above Industrial RBCs. Arsenic was detected above the RBC (1.9 mg/kg) and maximum background in 9 of 15 samples collected at concentrations up 3.3 mg/kg.

Cell 1 and Cell 2 Cover Soil Sampling Conclusions

- Surface soil sampling results from the Cell 1 and Cell 2 cover materials does not indicate the presence of contamination above Industrial RBCs.
- Explosives were not detected above Industrial RBCs. Explosives, primarily dinitrotoluenes and 2,4,6-TNT were detected in samples SS-1 through SS-5. This material was brought in as clean fill for the Cell 1 and Cell 2 caps.

4.11 SURFACE WATER AND SEDIMENT SAMPLING CONCLUSIONS

- MCLs or AWQCs were not exceeded in any of the six surface water samples.
- ER-Ls were only exceeded for three PAHs in sediment sample SED5, located several thousand feet downstream of the CSL to the west.
- Surface water and sediment leaving the site to the east are not showing site-related impacts.
- Surface water downstream from the CSL to the west are not showing site-related impacts. Except for the detections of PAHs above ER-Ls in one distal downstream sample, the CSL is not contributing to downstream contamination of sediments above the screening criteria. Since PAHs were not detected in SED2 or SED4, the samples collected proximal to the CSL, it seems unlikely to attribute PAH exceedances in SED5 to the CSL.
- These surface water sampling results are consistent with the RCRA surface water detection monitoring sampling results.

5.0 FATE AND TRANSPORT

An analysis of the fate of chemicals in the subsurface environment involves an understanding of their physical, chemical, and biological interactions and transformations that are likely to take place. The transport of a chemical constituent through the subsurface environment involves the tendency of the chemical to migrate in the vapor, dissolved, or free liquid phase through advective, dispersive, or diffusive mechanisms toward potential receptors. A clear understanding of the nature of the chemical, its distribution in the subsurface, its interaction with other chemicals that are present, and the nature of potential migration pathways is essential to an appreciation of fate and transport mechanisms that may be at work at any particular site.

The discussion that follows is based on preliminary screening of the media against RBCs[1]. The rationale for this screening is discussed in Section 3.0. The Baseline Risk Assessment (BRA) (Section 6.0) selects chemicals of potential concern and identifies potential receptors, exposure pathways, and future land use considerations.

Although there were scattered detections of chemical constituents above applicable screening criteria, these detections were not concentrated in a definable area of contamination. The following discussion of fate can be applied to these detections. RBCs used to screen data in this section used a Hazard Quotient of 1 and RBCs at an HQ of 0.1 were used in the Human Health Risk Assessment (HHRA). Therefore, additional chemicals may be COPCs in the more conservative HHRA.

5.1 CLOSED SANITARY LANDFILL

Chemicals and compounds discussed in this section were selected because they were detected in one or more media at the CSL at concentrations that exceeded the relevant screening levels, and because they occur in the groundwater in a definite plume. As discussed above, RBCs used to screen data in this section used a Hazard Quotient of 1 and RBCs at an HQ of 0.1 were used in the HHRA. Therefore, additional chemicals may be COPCs in the more conservative HHRA.

5.1.1 Soils

Surface and subsurface soil sampling results do not show distribution of chemical contamination above Industrial RBCs for soil. Arochlor 1221 (6.39 mg/kg) and Arochlor 1242 (1.94 mg/kg) in subsurface soil sample TR-3B were the only organic analytes detected above Industrial RBCs. Arsenic, the only inorganic analyte detected above Industrial RBCs, was detected above the RBC in a majority of the samples. However, the maximum background concentration for arsenic in surface soil (2.79 mg/kg) which is greater than the RBC, was exceeded in only one sample.

5.1.2 Surface Water and Sediments

Surface water and sediment leaving the CSL were not at concentrations above the screening criteria. The surface water results are consistent with the RCRA assessment monitoring results.

5.1.3 Groundwater

All inorganics were retained for evaluation in the HHRA. It is likely that the concentrations of the chemical constituents exceeding the RBCs represent both dissolved and particulate matter in the groundwater.

Thirty-one wells at the CSL contained at least one chemical constituent that exceeded the Tap Water RBCs or MCL. Carbontetrachloride, Benzene, and Tetrachloroethylene (PCE) were the only VOCs with MCL exceedances. Antimony, cadmium, and lead were the only inorganics with MCL exceedances. Also, the risk assessment is not limited by the background comparison.

The contaminants of potential concern and the environmental media in which they were detected above screening criteria are summarized in the following table.

1. _____

[1] The HHRA in Section 6 uses RBCs with a hazard quotient (HQ) of 0.1 to screen values.

Contaminants of Potential Concern	Environmental Media
Metals	
Antimony	Groundwater
Aluminum	Groundwater
Arsenic	Groundwater, soils
Beryllium	Groundwater
Cadmium	Groundwater
Iron	Groundwater
Lead	Groundwater
Manganese	Groundwater
Thallium	Groundwater
Vanadium	Groundwater
Volatile Organic Compounds	
Tetrachloroethene	Groundwater
Trichloroethene	Groundwater
Benzene	Groundwater
Carbon Tetrachloride	Groundwater
1,4-Dichlorobenzene	Groundwater
Chloroethane	Groundwater
Chloroform	Groundwater
MTBE	Groundwater
Semi-Volatile Organic Compounds	
Bis(2-ethylhexyl) phthalate	Groundwater
Pesticides	
Benzo(a)pyrene	Sediments
Benzo(b)fluoranthene	Sediments
Benzo(g,h,i)perylene	Sediments
Dibenzo(a,h)anthracene	Sediments
Fluoranthene	Sediments
Indeno(1,2,3-cd)pyrene	Sediments
Arochlor 1242 (PCB)	Soils

Note: As discussed with EPA R3, additional COPCs may be evaluated in the HHRA (Section 6.0), since a hazardous quotient ("HQ") of 0.1 was used.

5.1.4 Chemical Fate

The fate and persistence of chemical compounds are influenced by a variety of chemical, physical, and biological processes in the environment. Fate processes are those that occur because of the chemical or physical interaction between the contaminant and its immediate environment. The interactions are chemical-specific and depend, to a great extent, on the physical properties of each individual chemical and interactions between chemical groups. Although the physical characteristics of

the aquifer, such as clay content or surface area of particles, come into play, they do not dominate the transformations that take place.

The primary fate processes that may be found in the aquifer include sorption, complexation, ion exchange, redox reactions, volatilization, biotic degradation and abiotic degradation. These processes help to define what phase and transformations the chemical constituents will undergo. Chemical constituents can be transported with little attenuation or retardation due to these processes, or they can be delayed or transformed so that little migration occurs. Some of these processes, such as sorption, apply to both organic and inorganic species.

The table below summarizes the major properties of the volatile organic chemical constituents and can be used to provide an indication of the transformations that these chemicals are likely to undergo at the CSL.

Physical and Chemical Properties of Potential Contaminants of Concern in Groundwater

		Water Solubility (mg/L @ 20-25°C)	Vapor Pressure (mm Hg @ 20-25°C)	Henry's Law Constant (atm-m³/mole @ 25°C)	Organic Carbon Partition Coefficient (log K_{oc})	Octanol/ Water Partition Coefficient (log K_{ow})	Absolute Viscosity (@20°C)
Property:	**Specific Gravity**						
What It Measures:	Sink or Float	Tendency to dissolve in Water	Volatility	Volatility from aqueous solutions	Tendency to sorb onto organic particles	Tendency to dissolve in a solvent	Tendency to flow like a liquid
Typical Ranges:	Floats:<1 Sinks:>1	Low:<1	Low:<0.001	Low:<0.00001	Low:<2.5	Low:<10	Low:<
		High: >1000	High:>1	High:>0.001	High:>3.2	High:>10	High:>
Chloroform	1.5	8000	160	0.0032	1.6	1.9	0.56
1,1-Dichloroethene	1.2	2250	500	0.0015	3.4	69	
Trichloroethene	1.5	1100	58	0.0091	2.1	2.5	0.57
Tetrachloroethene	1.6	150	14	0.015	2.4	2.6	0.89
Carbon Tetrachloride	1.59	1200	91.3	0.0304	1.85	2.62-2.83	0.612
Benzene	0.87	1750	74.6	0.0055	1.8 - 1.9	2.13	0.744

The fate of inorganics in the surface and subsurface environment depends, to a great extent, on their species. There are six categories of species that apply to inorganics:

1. free ions;
2. insoluble species;
3. metal/ligand complexes;
4. adsorbed species;
5. ion exchanges; and
6. differing oxidation states.

Each one of these species states will define the ability of the inorganic element to migrate within the environment.

5.1.4.1 Sorption

Sorption and desorption are two major mechanisms affecting the transport of contaminants in the subsurface. Adsorption is defined as the accumulation occurring at an interface, absorption as the partitioning between two phases, and sorption as the generic term for both adsorption and absorption (Knox, 1993). The degree to which a chemical in soil leaches into the groundwater is controlled by the sorptive properties of the chemical and the clay and organic carbon content of the soils. A compound which is strongly adsorbed onto the soil matrix will be relatively immobile and will not leach into the groundwater to be transported any distance from the contaminant source. A compound which has a low potential for sorption will not be bound to the soil matrix and is available to be transported with both advective and dispersive flow.

For metals, sorption is the coordinated bonding of metal anions to specific sites on the soil matrix. This becomes an important factor in the subsurface environment due to the large surface area of the aquifer matrix. The ability of a metal to sorb onto a soil particle is dependent on its concentration and the pH of the aquifer. Arsenic and lead are strongly adsorbed onto soil particles (clays, metal oxides, and organic materials). Nickel and zinc are not strongly sorbed and are more likely to migrate from the source area. The degree of sorption is limited by the pH and Eh (redox potential) of the ground or surface water and is insignificant at low pH.

The octanol/water partitioning coefficient (K_{ow}) is one measure of a chemical's adsorption tendency and solubility (ability to be dissolved in a solvent). Chemicals with low K_{ow} (i.e., less than 10 L/kg) are considered relatively hydrophilic and tend to have high water solubilities and small adsorptive coefficients. Conversely, hydrophobic compounds typically have K_{ow} values greater than 10^{-4} L/kg (Lyman et al., 1990). Therefore, a hydrophobic compound will be adsorbed onto soil particles while a hydrophilic compound will leach to ground or surface water.

When no sorption or retardation of a chemical occurs, the contaminant in the groundwater moves at the same rate as the groundwater itself. In this case, the contaminant is termed "conservative" or "non-reactive". The velocity of the contaminant front can be substantially different from that of the groundwater for solutes that are adsorbed onto the soil matrix. The retardation factor (R) is defined as the ratio of the groundwater flow velocity to that of the contaminant front. The retardation factor indicates the extent to which sorption is a factor at the site. If R = 1, the contaminant is said to be conservative and no retardation is taking place due to sorption. If R = 10, this means that the contaminant front is moving at one-tenth the velocity of groundwater advective flow.

5.1.4.2 Complexation

Complexation occurs when a metal forms a water-soluble ligand. The more complexation that occurs, the fewer metals are absorbed or precipitate from solution due to the reduction of free ions. Complexation is significant for some mineral species.

5.1.4.3 Ion Exchange

Ion exchange occurs when surfaces of the aquifer matrix have a fixed charge and ions are held there by electrostatic forces. The next result is similar to sorption in that metals become unavailable for migration is ion exchange is significant. The degree to which ion exchange is operating at a site varies with the amount of ion present and the nature of the aquifer matrix. It is significant when there is clay present. It may be a significant process in the lower portions of the aquifer where clay layers and lenses are encountered.

5.1.4.4 Redox Reactions

Oxidation-reduction reactions (redox) involve a change in oxidation state of an element. Redox can affect contaminant transport For example, Fe(III) precipitates as a highly adsorptive solid (ferric hydroxide), whereas Fe(II), the reduced state, is very soluble and does not retain other metals. As Fe(III) is reduced to Fe(II), not only if iron released to the groundwater, but all of the contaminants that were adsorbed to the iron will also be released and available to migrate. Although the oxidation state of the metals in the groundwater at the CSL were not measured during this investigation, it is likely that a portion of the high concentrations of iron detected in the groundwater are the result of redox reactions.

5.1.4.5 Volatilization

Volatilization is a process whereby the compounds are transferred from soil or water into the atmosphere. Compounds that do not absorb onto soil/sediments or dissolve in the water have the greatest tendency to volatilize. An indicator of volatility is the Henry's Law constant. This constant can be considered the partition coefficient of the contaminant between the aqueous phase and the gas phase. A Henry's Law constant greater than 0.001 atm-m^3/mole indicates a high volatility and a constant of less than 0.00001 atm-m^3/mole indicates a low volatility.

Environmental factors such as the depth of the aquifer and the geology of the unsaturated zone also influence the rate of volatilization. The majority of the organic chemical constituents above the screening criteria at the CSL are volatile, as most have a Henry's Law constant greater than 1 atm-m^3/mole. Volatilization at the surface of the water table may be significant and will tend to reduce the concentrations in the upper saturated zone. No volatile organic compounds were detected in the surface water, indicating either that the surface water did not receive any volatile organics, or that volatilization has removed them all.

5.1.4.6 Abiotic Degradation

Abiotic degradation is the chemical degradation of compounds without the assistance of biological activity. In the natural environment, the most common abiotic processes are hydrolysis and hydroxyl radical reactions. Other abiotic degradation processes include direct photolysis, dehalogenation, and oxidation.

Hydrolysis is a chemical reaction in which compounds react with water molecules in the environment, resulting in the introduction of a hydroxyl group (-OH) and the loss of a leaving group (-X), typically a halide, usually at a point of unbalanced charge distribution (Cherry, 1983). Halogenated aliphatic compounds, such as those found at the CSL, are susceptible to hydrolysis, with reactions proceeding most rapidly for monohalogenated compounds, and much more slowly as the number of halogen ions increases. The majority of chemical constituents above RBCs in groundwater at CSL are polychlorinated aliphatics, resulting in a slow rate of hydrolysis.

Hydroxyl radical reactions are reactions with the hydroxyl radicals photochemically generated from sunlight. These reactions occur mostly in the atmosphere and to a lesser degree in surface water. Because the contamination at the CSL occurs in the groundwater, hydroxyl radical reactions are not significant. The same is true for direct photolysis, which requires the chemical to absorb sunlight.

Dehalogenation is a degradation reaction that can occur in groundwater when a halide disassociates and then is replaced by hydrogen. Dehalogenation may occur in an anaerobic (oxygen-poor) or aerobic (oxygen-rich) environment. One indication that dehalogenation is occurring is the presence of halogenated aliphatic daughter products in association with polychlorinated compounds. This is especially true if the daughter products are found further downgradient from the source than their parents, or if changes in the ratio of parent to daughter concentrations indicates an increase in daughters with a decrease in parents. **Figure 5-1** illustrates some typical dehalogenation pathways and shows the typical parent/daughter relationship.

Oxidation is the chemical reaction that occurs when an atom loses an electron and increases its valence. This reaction occurs in water or air in an oxygen-rich environment. Dissolved oxygen measurements in the groundwater at the CSL, which ranged from 2.69 to 19.16 μg/L, indicate that oxidation may be a significant process at work there.

5.1.4.7 Biotic Degradation

Biodegradation is the process by which the degradation of a chemical is assisted by soil microorganisms (e.g., fungi and bacteria). Reactions include oxidation, reduction, hydrolysis, and sometimes rearrangement of the molecule. Though biodegradation may occur very slowly for some compounds, the eventual mineralization of almost all organic compounds in the terrestrial and aquatic environment can be attributed to biodegradation (Alexander, 1978). **Figure 5-2** illustrates the carbon tetrachloride degradation pathway.

Complete biodegradation of organic chemicals by microorganisms, utilizing enzymes to facilitate degradation, ultimately produces microbial cells, water, and carbon dioxide, which eventually leads to the mineralization of the compound. Whether or not a chemical is transformed by enzymes depends on the configuration alignment of the enzyme with the organic chemical during the reaction. If an ideal configuration occurs, the reaction will occur. Persistent chemicals have less favorable alignments, and non-reacting or recalcitrant chemicals fail to bond or produce any favorable alignments. In addition, for biodegradation to occur, there must be microorganisms capable of metabolizing the chemicals that are present. Sampling and microbial profiling is one way to establish this. It is possible for biodegradation to be a significant process at work at the CSL, as the chemical constituents above Tap Water RBCs are susceptible to biodegradation and it is likely that suitable microbes exist there.

An anaerobic reaction is one that occurs in the absence of oxygen. Anaerobic reactions can occurs in the deeper portions of an aquifer where dissolved oxygen values are low. Transformations in this zone may include dehalogenation or reductive reactions. **Figure 5-1** illustrated some of these anaerobic transformations for halogenated compounds. Dissolved oxygen measurements in the groundwater at the CSL indicate that the aquifer contains dissolved oxygen, but the redox potential shows it is marginally aerobic.

5.1.5 Contaminant Transport

Contaminant transport moves the contaminant from one position in the aquifer to another as a function of time. Transport mechanisms are the only way that a chemical can leave a source area and reach a receptor, so their understanding is fundamental to the identification of the risk they may pose. Transport can take place through any environmental media and with a chemical in any physical state (solid, liquid, and vapor). However, due to the distribution and fate of the chemical constituents above the screening criteria at the CSL, only free phase, dissolved phase, and vapor phase transport will be considered.

5.1.5.1 Free Phase Transport

The USEPA has formulated a ranking system to identify those sites that are likely to contain non-aqueous phase liquids (NAPL). Because all of the organic chemical constituents above Tap Water RBCs at the CSL have a specific gravity greater than one, they are considered “sinkers” and are termed dense, non-aqueous phase liquids (DNAPLs). The ranking system takes into account certain chemical and physical parameters to judge whether it is likely that the site contains DNAPLs. This is significant in that DNAPLs migrate so differently than the dissolved phase, it requires a specifically designed investigative program to confirm that they exist on the site.

One of the critical criteria in determining whether DNAPLs should be considered a problem at a site is the solubilities of the chemical constituents and the concentrations of their dissolved phase. The maximum concentration of any organic chemical constituent at the CSL is 61.5 μg/L of carbon tetrachloride (well MW-114D), whose solubility is 1,200,000 μg/L. The concentration found in the well is well below the concentration that one would expect if DNAPLs were present. Therefore, it is concluded that free phase migration is not a factor at the CSL.

5.1.5.2 Vapor Phase Transport

The transport of vapors occurs when volatilized chemical constituents leave the surface of a stream or the soil pore spaces or surface of the groundwater and travel through the air-filled interstitial spaces in the vadose zone under the influence of a concentration gradient. Moisture content, vapor permeability, temperature, relative humidity, wind speed, and various other factors can influence both the rate and pathways of this migration. Vapor transport may be significant if volatilization off of the water table is occurring, even with the relatively thin vadose zone that exists. No soil gas measurements were made at the site, so the extent to which this process is on-going is not known. However, vapor migration through the vadose zone is a likely mechanism of transport. In addition to distributing the vapors, vapor transport can contribute to groundwater contamination when the vapors condense, due to temperature differences, and re-enter the saturated zone as a liquid in area that were previously uncontaminated.

5.1.5.3 Sorbed Particle Transport

Although probably not a significant mechanism in the groundwater throughout most of the saturated zone at the CSL, chemicals sorbed onto soil particles can be transported through the pore spaces in the soil matrix. Due to the limited size openings in the matrix, it is presumed that this only occurs through openings that are sufficiently coarse to allow the passage of particles, such as in sand and gravel lenses. The pesticides/PCBs found downstream but not in immediately leaving the CSL suggests the widespread use of pesticides may be a more explanation for the distribution of these constituents in sediments than sorbed particle transport.

5.1.5.4 Dissolved Phase Transport

Once the chemical constituents are dissolved in surface or groundwater, there are three ways in which they can migrate in the subsurface – advection, dispersion, and diffusion. Advection is migration with groundwater flow from one point to another. It is the major means of chemical transport in a dynamic groundwater system and is probably the primary mechanism at work at the CSL.

The second means of chemical transport occurs through dispersion. Dispersion is the spreading of a contaminant plume due to local and pore-scale heterogeneities in the porous medium or turbulence in surface water. Dispersion can occur both in the longitudinal and transverse directions, causing the plume to spread wider or deeper than the original source. The limitation of the groundwater plume to the upper portion of the saturated zone, and the narrow width of the plume downgradient of the source area show that dispersion is not significant on a large scale.

Diffusion is transport of a chemical constituent by means of a concentration gradient, with chemicals moving from higher to lower concentrations. It is generally less of a factor than advection or dispersion. Diffusive transport also works on a smaller scale than advection of dispersion. Due to the relatively low concentrations found at the CSL, diffusion is not thought to be a significant transport mechanism at the site.

5.1.6 Conclusions

The fate of chemical constituents above the screening criteria in environmental media at the CSL may be dependent on a number of different process that retard or transform the chemicals. The most likely processes that have an significant impact on the chemicals detected there are volatilization at the saturated zone/vadose zone interface, abiotic and biotic dehalogenization that cause polychlorinated compounds to break down, and advective transport that moves the chemical constituents with the groundwater flow. The distribution of chemical constituents in groundwater has been limited to the upper portions of the saturated zone.

6.0 HUMAN HEALTH RISK ASSESSMENT

6.1 INTRODUCTION

This section presents the Human Health Risk Assessment (HHRA), which evaluates the probability and magnitude of adverse effects on human health associated with actual or potential exposure to site-related chemicals associated with the Closed Sanitary Landfill (CSL).

FGGM occupies 5,426 acres of land in the northwest corner of Anne Arundel County, Maryland, along the Baltimore - Washington, DC, corridor. The Patuxent River parallels the southern installation boundary. The National Railroad Passenger Corporation, Amtrak railroad track right-of-way, and State Route 175 form the southeast and northeast FGGM boundaries, respectively. The Federal government commandeered 4,000 acres of land in 1917 for troop training during World War I. The installation was named Camp Meade in 1917 in honor of Major General George G. Meade. During the 1940s, the facility underwent widespread growth to accommodate several regiments that moved their base of operations to FGGM, and additional training areas were added, expanding the post to its present size of 13,596 acres. In 1988, approximately 9,000 acres were identified for closure or realignment under BRAC. The BRAC parcel occupies the portion of FGGM located south of MD State Routes 198 and 32. In 1991, the U.S. Army transferred 8,100 of the 9,000 acres to the Department of the Interior's Patuxent Research Refuge (PRR).

The CSL site is located in the southeast corner of the base. An area map for the CSL is provided in **Figure 2-1**. As discussed in Section 2.1, the landfill was constructed as an unlined facility and was divided into two cells (1 and 2) and was initially designated as the Active Sanitary Landfill. The landfill began operation at Fort Meade in 1958 and was used for the disposal of “mixed residential, commercial, and nonhazardous industrial wastes.” Operations at the CSL ended in 1996. Landfill Cell 1 was capped and closed during the period 1995 through 1997 and landfill Cell 2 was capped and closed during the period 1997 through 1998. A flexible membrane liner was incorporated into the final cap system for both Landfill Cells 1 and 2. The CSL is characterized by two mounded cells, which rise approximately 30 feet above the surrounding terrain. The cells are sloped on all sides and have been revegetated since closure and capping.

Residential and light industrial areas are present to the east and north of the site. Neighboring properties include the National Railroad Passenger Corporation (Amtrak) maintenance yard, a residential trailer park, residences and commercial business facilities (Fergeson Trenching).

This HHRA is based on groundwater, surface soil, subsurface soil, surface water, and sediment samples collected and analyzed during the RI. This HHRA is consistent with Subpart E, Section 300.430(d)(4) of the National Contingency Plan (NCP), which directs that a Baseline Risk Assessment (BRA) be conducted “to characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to groundwater or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain.” This section of the NCP was applied to the HHRA in which human health effects associated with site-related chemicals in environmental media of the CSL within FGGM were evaluated. This HHRA is consistent with USEPA guidance and standards (USEPA, 1986a,b; 1989; 1991a,b; 1992a,b,c; 1995a,b; 1997a,b; 2001; 2002a; 2004a; 2005a,b; 2006; 2007a). In addition, MDE risk assessment guidance (2001) was applied, as appropriate.

The HHRA is organized as follows:

- **Data Summary (Section 6.2):** This section describes the process used to summarize the data based on USEPA (1989). The data are summarized by presenting the frequency of detection and the range of detected concentrations in site-related samples and the range of concentrations in background samples.
- **Chemicals of Potential Concern for Human Health (Section 6.3):** Chemicals of potential concern (COPCs) are identified for quantitative evaluation in the HHRA.
- **Human Health Exposure Assessment (Section 6.4):** The potential pathways by which individuals may be exposed to COPCs are discussed. The chemical concentrations at the

points of potential exposure are presented for each complete exposure pathway. Standard exposure factors and health-protective assumptions are used to assess the magnitude, frequency, and duration of exposure for each pathway and potential exposures (intakes) are then estimated.

- **Human Health Toxicity Assessment (Section 6.5):** The potential toxicity of chemicals to humans and the chemical-specific health effects criteria to be used in the quantitative assessment are presented.
- **Human Health Risk Characterization (Section 6.6):** Quantitative risk estimates are calculated for each complete exposure pathway by combining the toxicity criteria with estimated intakes of potentially exposed individuals.
- **Uncertainties in the Human Health Risk Assessment (Section 6.7):** Major sources of uncertainty in the HHRA are discussed.
- **Summary and Conclusions (Section 6.8):** The HHRA is summarized and conclusions are presented.

USEPA's *Risk Assessment Guidance Superfund, Part D* (USEPA, 2001) prescribes a standard format for presenting the risk assessment assumptions, calculations, and results. The required tables are presented in Appendix G-1.

6.2 DATA SUMMARY

The first step of the HHRA process was to summarize the analytical data collected during the RI for CSL. Detailed discussions of sampling approaches and results are presented in the Section 4.0, and the quality assurance and control activities implemented during the collection of the data are provided in the Specific Addendum to the Generic Field Sampling Plan (USACE, 2003a).

The following steps, which are in accordance with USEPA (1989) guidance, were used to summarize the analytical data for this HHRA:

- The RI data were summarized by environmental medium (i.e., groundwater, surface soil, subsurface soil, sediment, and surface water). In addition, the RI samples were divided into groups that describe conditions relevant to potential exposure by receptors or pertinent to site environmental factors (e.g., contamination patterns, hydrology). The sample groupings used in the HHRA are described by environmental medium in Section 6.3.
- The data were qualified by the analytical laboratory and validated by Ecochem Inc. and Laboratory Data Consultants, Inc. (see **Appendix E**). The qualification and validation of the analytical data included a comparison of the site data to corresponding blank (laboratory, field, and trip) data. If the detected concentration in a site sample was less than 10 times (for common laboratory contaminants) or five times (for all other compounds) the concentration in the corresponding blank sample, the sample was qualified with a "B." In accordance with USEPA Region III, B-qualified data were excluded from HHRA calculations (USEPA, 2000a). Other qualifiers and validation codes were identified in the analytical data. Data that were rejected by the validation process (R-qualified) were not used in the HHRA. Data that were considered estimated values (e.g., J-qualified) were used in the HHRA without modification.
- Arithmetic mean chemical concentrations were calculated by averaging the detected concentrations with one-half the detection limit of nondetects. One-half the detection limit is typically used in assessments (USEPA, 1989) when averaging non-detect concentrations, because the actual value can be between zero and a value less than the detection limit. In accordance with USEPA Region III guidance, this procedure was also used, even when the nondetect sample quantitation limit was two or more times higher than the maximum detected concentration in that medium. The uncertainties associated with this methodology are discussed in the Uncertainty Section.
- Data from duplicate samples were averaged together and treated as one result. If a chemical was detected in only one of two duplicate samples, the detected value was

averaged with one-half the detection limit of the non-detect sample, and the result was counted as one "detect" sample.

- Frequency of detection was calculated as the number of samples in which the chemical was detected over the total number of samples analyzed. The frequency of detection was determined after the exclusion of R- and B-qualified data, and after the treatment of duplicate sample data. Since samples were sometimes analyzed for different sets of analytes, the frequencies of detection varied by analyte.
- Groundwater chemicals were not eliminated as COPCs if they are known breakdown products of detected chemicals. Breakdown products were retained even if the concentrations of their precursors are not above the screen values.

6.3 SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HUMAN HEALTH

Once the sampling data for the CSL were grouped and summarized, COPCs for the HHRA were identified. The purpose of identifying COPCs is to select those chemicals that are present as a result of past activities at the site and most likely to be of concern to human health. The screening process eliminates from the HHRA: (1) those chemicals present at concentrations less than levels of concern (represented by risk-based concentrations [RBCs]); and (2) those chemicals that are essential human nutrients and unlikely to pose risks to human health.

6.3.1 Methodology for Identification of Chemicals of Potential Concern

The following methodology was used to eliminate from the list of COPCs chemicals detected at concentrations less than their RBCs and essential human nutrients.

6.3.1.1 Risk-based Concentrations

The maximum concentrations of detected chemicals were compared to RBCs (USEPA, 2005a) in accordance with USEPA Region III guidance. RBCs are health-protective chemical concentrations that are back-calculated using toxicity criteria, a $1x10^{-6}$ target risk level or a 0.1 hazard index (HI), and conservative exposure parameters. A HI of 0.1, instead of 1.0, was used to add a ten-fold measure of safety, thereby ensuring that compounds that could combine to result in a hazard index greater than 1.0 were not eliminated from the assessment. If the maximum detected on-site chemical concentration was less than the RBC, the probability of developing cancer from complete exposure pathways would be less than one-in-one-million, and adverse noncarcinogenic effects would not be expected to occur. As a result, only chemicals detected at levels greater than RBCs were retained for evaluation. A complete list of RBCs and other screening values used for this comparison are presented in **Table 6-1**. The potential exposure pathways associated with each of these media are presented in Appendix G-1, **Tables 1.1, 1.2 and 1.3**. A more detailed discussion of the exposure setting and associated potential human exposure pathways are presented in Section 6.4.

Surface Soil and Total Soil (Industrial Land Use): Current land-uses at CSL are industrial in nature (see Section 6.4) thus industrial soil RBCs were used to identify COPCs for ingestion and dermal exposure pathway evaluations. Therefore, analytical results from surface soil and total soil were screened against the USEPA Region III RBCs for industrial soil corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the hazard index (HI) for noncarcinogenic effects (USEPA, 2005a). No RBC is available for comparison to lead, thus USEPA's 400 mg/kg screening level (based on residential exposures) for lead was used (USEPA, 1994a).

Surface Soil and Total Soil (Recreational/Residential Land Use): Future land-uses at CSL include a golf course (see Section 6.4), therefore, residential soil RBCs were conservatively used to identify COPCs for ingestion and dermal exposure pathway evaluations Although residential development of CSL is highly unlikely, there are no formal institutional land use controls currently in place. Therefore, future residential land use was evaluated (see Section 6.4). Because this HHRA has been amended to include on-site recreational and residential exposures, analytical results from surface soil and total soil were screened against updated USEPA Region III RBCs for residential soil corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the hazard index

(HI) for noncarcinogenic effects (USEPA, 2006). No RBC is available for comparison to lead, thus USEPA's 400 mg/kg screening level (based on residential exposures to young children) for lead was used (USEPA, 1994a).

Sediment: Because RBCs are not available for sediment, chemicals present in sediment were compared with USEPA Region III RBCs for residential soil corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2005a). The residential soil RBCs were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for this medium. The USEPA soil screening value for lead (400 mg/kg) (USEPA, 1994a) were used for comparison to chemical concentrations detected in sediment samples.

Surface Water: Because RBCs are not available for surface water, chemicals present in surface water were compared to USEPA Region III RBCs for tap water corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2005a). The tap water RBCs were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for this medium. Lead in surface water was compared to the federal action level for lead of 0.015 mg/L (USEPA, 1996a).

Groundwater: The analytical results from groundwater were screened against USEPA Region III RBCs for tap water corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2005a). Since there is no tap water RBC available for lead, lead in groundwater was compared to the federal action level for lead of 0.015 mg/L (USEPA, 1996a).

6.3.1.2 Essential Nutrients

Essential human nutrients (i.e., calcium, magnesium, sodium, and potassium) were eliminated from the evaluation.

6.3.1.3 Breakdown Products

Chemicals were not eliminated as COPCs if they are known breakdown or degradation products of detected chemicals. Breakdown products (BDPs) were retained even if the concentrations of their precursors are not above the screening values. For example, in selecting COPCs for groundwater exposure, vinyl chloride is a known breakdown product of trichloroethylene (TCE) and tetrachloroethylene (PCE), thus in this example vinyl chloride (VC) would be retained as a COPC regardless of its detected concentration or FOD, because its concentration and FOD could be expected to increase in the future due to TCE's and PCE's environmental fate characteristics. Four important anaerobic chemical and biological transformation pathways for chlorinated solvents in groundwater are presented below (from McCarty, 1996):

PCE → TCE → 1,2-DCE → VC

TCA → 1,1-DCA →Chloroethane

TCA → 1,1-DCE → VC

CCl_4 → Chloroform → Methylene chloride → Chloromethane

Further breakdown products such as ethene, ethane, acetic acid, carbon dioxide, and water are not presented above as these products are not considered especially toxic.

6.3.1.4 Background

For each medium, comparisons between detected site concentrations and background concentrations were also conducted in HHRA for information purposes only. An EPA-approved list of background monitoring wells was used for background concentrations of inorganics in the upper and lower Patapsco Aquifers. These background wells were ODAMW-5 and CFD-1 for the Upper Patapsco and ODAMW-6D and MW-22S for the Lower Patapsco Aquifer (ICF Kaiser, 1998). Inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were noted as

being within background levels, but were still carried through the HHRA. These inorganic chemicals were included in the risk calculations, in addition to being qualitatively addressed in the uncertainty section of the HHRA (Section 6.7.5).

In addition, upgradient concentrations of some organics, measured in monitoring well 122D that is situated hydraulically upgradient from the site, were used to potentially identify organics (primarily chlorinated hydrocarbons) in Lower Patapsco groundwater that may not be site related. This is discussed further in the uncertainty section of the HHRA (Section 6.7.5)

6.3.2 Data Groups

The following sections define the basis for grouping the data within a medium, and present the COPCs identified within each group. Data summary tables present the chemical data by medium and data group and contain parameters such as the minimum and maximum concentration detected, location of maximum detected concentration, frequency of detection, range of detection limits, and the screening concentrations. Compounds determined to be COPCs are also identified on the summary tables.

6.3.2.1 Surface Soil

Surface soil samples (i.e., samples collected from the 0 to 2 ft soil interval) included in the HHRA for evaluation are shown in Table 6**-2**. A total of 29 (including 3 duplicates) surface soil samples collected in November 2003 at the CSL were evaluated in the HHRA. Surface soil samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, and MTBE. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in the surface soil evaluated in the HHRA are presented in Appendix G-1,Tables 2.1 and 2.2.

Surface soil COPCs were selected by comparing maximum concentrations of detected chemicals to industrial soil RBCs; essential nutrients were not selected as COPCs. As shown in Appendix G-1, Table 2-1, 22 inorganics were detected in surface soil at the CSL. Two inorganics (arsenic and iron) were detected at a concentration above industrial soil RBCs, or other screening criteria, and were selected as COPCs. Twenty-eight organic compounds were detected at the CSL. No organics were detected at concentrations above industrial soil RBCs, or other screening criteria, where available.

Surface soil COPCs for residential land use were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs; essential nutrients were not selected as COPCs. As shown in Appendix G-1 Table 2-2, 22 inorganics were detected in surface soil at the CSL. Seven inorganics (aluminum, arsenic, chromium, cobalt, iron, thallium, and vanadium) were selected as COPCs. Twenty-eight organic compounds were detected at the CSL. One organic (benzo(a)pyrene) was detected at concentrations above residential soil RBCs, or other screening criteria, where available.

6.3.2.2 Mixed Surface and Subsurface Soils (i.e., Total Soil)

Total soil samples (i.e., surface soil and subsurface soil samples collected from the 0 to 7.5 ft soil interval) included in the HHRA for evaluation are shown in Table 6-2. A total of 29 (including 3 duplicates) surface and 15 (including one duplicate) subsurface soil samples collected November 2003 at the CSL were evaluated in the HHRA. Surface and subsurface soil samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, and MTBE. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in total soil evaluated in the HHRA are presented in Appendix G-1, Tables 2.3 and 2.4.

Total soil COPCs for industrial land use were selected by comparing maximum concentrations of detected chemicals to industrial soil RBCs; essential nutrients were not selected as COPCs. As shown in Appendix G-1, Table 2.3, 22 inorganics were detected in total soil at the CSL. Two inorganics (arsenic and iron) were detected at a concentration above industrial soil RBCs, or other screening criteria, and were selected as COPCs. Forty-seven organic compounds were detected at the CSL. One PCB (Aroclor-1242) was detected at a concentration above the industrial soil RBC and was selected as a COPC.

Total soil COPCs for recreational and residential land use were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs; essential nutrients were not selected as COPCs. As shown in Appendix G-1, Table 2-4, 22 inorganics were detected in total soil at the CSL. Eight inorganics (aluminum, arsenic, chromium, cobalt, iron, manganese, thallium, and vanadium) were detected at a concentration above residential soil RBCs, or other screening criteria, and were selected as COPCs. Forty-seven organic compounds were detected at the CSL. Eight organics (Aroclor 1221, Aroclor 1242, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, dibenzofuran, and di-n-octylphthalate) were detected at a concentration above the residential soil RBC and was selected as a COPC.

6.3.2.3 Sediment

On-Site Sediment

On-site sediment samples included in the HHRA for evaluation are shown in Table 6-2. A total of four sediment samples collected November 2003 at the CSL were evaluated in the HHRA. Sediment samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, and MTBE. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in on-site sediment evaluated in the HHRA are presented in Appendix G-1, Table 2.5.

Sediment COPCs were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs adjusted upward by a factor of 10; essential nutrients were not selected as COPCs.

As shown in Appendix G-1, Table 2.5, 20 inorganics were detected in on-site sediment at the CSL. One inorganic (arsenic) was detected at a concentration above residential soil RBCs and was selected as COPCs. Twenty-four organic compounds were detected at the CSL. No organics were detected at concentrations above the adjusted residential soil RBCs.

Down-Gradient Sediment

Down-gradient sediment samples included in the HHRA for evaluation are shown in **Table 6-2**. These samples were collected down-gradient of the site and were used to indicate whether COPCs were migrating from the site. They were not included in the data set for the quantitative HHRA because these samples were essentially clean and their use would have biased the on-site sediment exposure point concentrations. A total of two sediment samples collected in May 20005 near the CSL were evaluated in the HHRA. Sediment samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, and MTBE. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in down-gradient sediment evaluated in the HHRA are presented in Appendix G-1, Table 2.6.

Sediment COPCs were selected by comparing maximum concentrations of detected chemicals to adjusted residential soil RBCs; essential nutrients were not selected as COPCs.

As shown in Appendix G-1, Table 2.6, 10 inorganics were detected in down-gradient sediment at the CSL. No inorganics were detected at a concentration above residential soil RBCs and none were selected as COPCs. Six organic compounds were detected at the CSL. No organics were detected at concentrations above the adjusted residential soil RBCs.

6.3.2.4 Surface Water

On-Site Surface Water

On-site surface water samples included in the HHRA for evaluation are shown in Table 6-2. A total of five (including one duplicate) surface water samples collected in November 2003 at the CSL were evaluated in the HHRA. Surface water samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, and MTBE. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in surface water evaluated in the HHRA are presented in Appendix G-1, Table 2.7.

Surface water COPCs were selected by comparing maximum concentrations of detected chemicals to adjusted tap water RBCs; essential nutrients were not selected as COPCs.

As shown in Appendix G-1, Table 2.7, 15 inorganics were detected in on-site surface water at the CSL. Three inorganics (aluminum, iron, and manganese) were detected at a concentration above the adjusted tab water RBCs and ARARs and were selected as COPCs. One organic compound was detected in on-site surface water at the CSL, but was not detected at a concentration above the adjusted tab water RBC.

Down-Gradient Surface Water

Down-gradient surface water samples included in the HHRA for evaluation are shown in **Table 6-2**. These samples were collected down-gradient of the site and were used to indicate whether COPCs were migrating from the site. They were not included in the data set for the quantitative HHRA because these samples were essentially clean and their use would have biased the on-site surface water exposure point concentrations. A total of two surface samples collected in May 2005 near the CSL were evaluated in the HHRA. Surface water samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, and MTBE. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in total soil evaluated in the HHRA are presented in Appendix G-1, Table 2.8.

Surface water COPCs were selected by comparing maximum concentrations of detected chemicals to adjusted tap water RBCs; essential nutrients were not selected as COPCs.

As shown in Appendix G-1, Table 2.8, six inorganics were detected in down-gradient surface water at the CSL. No inorganics were detected at a concentration above the adjusted tap water RBCs and none were selected as COPCs. No organic compounds were detected in down-gradient surface water at the CSL.

6.3.2.5 Groundwater

On-Site Groundwater (Upper Patapsco)

On-site groundwater (Upper Patapsco) samples included in the HHRA for evaluation are shown in Table 6-2. A total of 14 groundwater samples collected June 2004 at the CSL were evaluated in the HHRA. Groundwater samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, MTBE, and perchlorate. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in on-site groundwater water (Upper Patapsco) evaluated in the HHRA are presented in Appendix G-1, Table 2.9.

Groundwater COPCs were selected by comparing maximum concentrations of detected chemicals to tap water RBCs; essential nutrients were not selected as COPCs. As shown in Appendix G-1, Table 2.9, 19 inorganics were detected in on-site groundwater at the CSL. Thirteen inorganics were detected at a concentration above tap water RBCs and were selected as COPCs. These included aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, iron, lead, manganese, nickel, thallium, and vanadium. Chromium was determined to be within background. As discussed in Section 6.3.1.4, inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were carried through the quantitative risk assessment and addressed in the risk characterization, if applicable (Section 6.6). Twenty-two organic compounds were detected at the CSL. Nine organics were detected at a concentration above the tap water RBCs and were selected as COPCs. These included 1,4-dichlorobenzene; 3&4-methylphenol; benzene; bis(2-ethylhexyl)phthalate; chlorobenzene; chloroethane; MTBE; naphthalene; and phenol. Chloroethane was selected as a COPC because it is a breakdown product (Section 6.3.1.3).

On-Site Groundwater (Lower Patapsco)

On-site groundwater (Lower Patapsco) samples included in the HHRA for evaluation are shown in Table 6-2. A total of seven (including two duplicates) groundwater samples collected in June 2004 at the CSL were evaluated in the HHRA. Groundwater samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, MTBE, and perchlorate. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in on-site groundwater (Lower Patapsco) evaluated in the HHRA are presented in Appendix G-1, Table 2.10.

Groundwater COPCs were selected by comparing maximum concentrations of detected chemicals to tap water RBCs; essential nutrients were not selected as COPCs. As shown in Appendix G-1, Table 2.10, 18 inorganics were detected in on-site groundwater at the CSL. Eleven inorganics were detected at a concentration above tap water RBCs and were selected as COPCs. These included aluminum, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, and vanadium. Eleven organic compounds were detected at the CSL. Four organics were detected at a concentration above the tab water RBCs and were selected as COPCs. These included carbon tetrachloride, chloroform, PCE, and TCE.

Off-Site Groundwater (Upper Patapsco)

Off-site groundwater (Upper Patapsco) samples included in the HHRA for evaluation are shown in Table 6-2. A total of five groundwater samples collected June 2004at the CSL were evaluated in the HHRA. Groundwater samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, MTBE, and perchlorate. Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in off-site groundwater (Upper Patapsco) evaluated in the HHRA are presented in Appendix G-1, Table 2.11.

Groundwater COPCs were selected by comparing maximum concentrations of detected chemicals to tap water RBCs; essential nutrients were not selected as COPCs.

As shown in Appendix G-1, Table 2.11, 15 inorganics were detected in on-site groundwater at the CSL. Five inorganics were detected at a concentration above tap water RBCs and were selected as COPCs. These included aluminum, chromium, iron, manganese, and vanadium. Chromium, iron, and vanadium were determined to be within background. As discussed in Section 6.3.1.4, inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were carried through the quantitative risk assessment and addressed in the risk characterization, if applicable (Section 6.6). Five organic compounds were detected at the CSL. Three organics (bis(2-ethylhexyl)phthalate, chloroform, and MTBE) were detected at a concentration above the tap water RBCs and were selected as COPCs.

Off-Site Groundwater (Lower Patapsco)

Off-site groundwater (Lower Patapsco) samples included in the HHRA for evaluation are shown in Table 6-2. A total of 11 (including one duplicate) groundwater samples collected June 2004 at the CSL were evaluated in the HHRA. Groundwater samples were analyzed for VOCs, SVOCs, PAHs, TAL metals, PCBs, pesticides, herbicides, explosives, MTBE, and perchlorate.

Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in off-site groundwater (Lower Patapsco) evaluated in the HHRA are presented in Appendix G-1, Table 2.12.

Groundwater COPCs were selected by comparing maximum concentrations of detected chemicals to tap water RBCs; essential nutrients were not selected as COPCs.

As shown in Appendix G-1, Table 2.12, 18 inorganics were detected in off-site groundwater at the CSL. Eight inorganics were detected at a concentration above tap water RBCs and were selected as COPCs. These included aluminum, barium, chromium, iron, lead, manganese, thallium, and vanadium. Thirteen organic compounds were detected at the CSL. Six organics were detected at a concentration above the tap water RBCs and were selected as COPCs. These included bis(2-ethylhexyl)phthalate; carbon tetrachloride; chloroform; cis-1,2-DCE; PCE; and TCE.

Nine monitoring wells (MW-113D, MW-117D, MW-119D, MW-119X, MW-120, MW -121D, MW-122D, MW4DR and MW4S) were not used in the risk assessment because they were all located on-post hydraulically upgradient of the CSL.

6.3.2.6 Summary of Chemicals of Potential Concern

Table 6-3 summarizes the COPCs in all potential exposure media at the CSL. Contamination at this site is primarily due inorganics in surface soil, sediment, and surface water; PCBs and inorganics in total soil; VOCs, SVOCs, and inorganics in groundwater.

6.4 HUMAN HEALTH EXPOSURE ASSESSMENT

In this section, the potential pathways by which individuals may be exposed to the COPCs in each environmental medium are identified and exposures are quantified. A discussion of current and future exposure pathways through which populations could be exposed to chemicals at or originating from the CSL is presented in Section 6.4.1. For each pathway selected for quantitative evaluation, the chemical concentrations at the points of exposure are estimated (Section 6.4.2), and the methodology and parameters for calculating potential chemical intakes are presented (Section 6.4.3).

6.4.1 Potential Human Exposure Pathways

An exposure pathway describes the course a chemical takes from the source to the exposed individual, and is defined by four elements: (1) a source and mechanism of chemical release to the environment; (2) an environmental transport medium for the released chemical (e.g., groundwater); (3) a point of potential contact with the contaminated medium (referred to as the exposure point); and (4) an exposure route at the contact point (e.g., ingestion). An exposure pathway is considered complete when all four elements are present. In risk assessments, only complete exposure pathways are quantitatively evaluated.

When conducting an exposure assessment, USEPA (1989, 1991a) guidance requires that plausible exposures under both current and future land-use scenarios be evaluated in a HHRA. Accordingly, potential human exposure pathways are identified for current and potential future land-use conditions at the CSL in the following sections. The current land-use scenario assumes conditions, as they currently exist, while the future land-use scenario evaluates potential risks that may be associated with plausible changes in site use, assuming no remedial action occurs.

6.4.1.1 Potential Exposure Pathways Under Current Land-Use Conditions

The potential exposure pathways through which humans could currently be exposed to contamination resulting from past activities at the CSL are discussed below. Appendix G-1 Table 1-1 presented an exposure pathway analysis, indicating the exposure medium, exposure points, receptor population, and exposure routes. This table also indicates whether the pathway is potentially complete, and identifies those pathways that are quantitatively evaluated.

Receptor Characterization: The CSL is located in the southeast corner of the base and encompasses approximately 130 acres of land. As discussed in Section 1.1, the site consists of an inactive landfill. The landfill's two cells were closed and capped by the end of 1998. A flexible membrane liner was incorporated into the final cap system for both Landfill Cells 1 and 2. The site is not currently used and is fenced. There is currently no digging or construction activities taking place on the CSL; therefore, no direct exposure to subsurface soil or groundwater is anticipated. No residences or base housing are located at the CSL. Potential receptors at the CSL include an on-site worker, such as a maintenance worker, and a youth trespasser.

Exposure Pathway Identification: The exposure pathways associated with current receptors at the CSL were identified based on consideration of the sources and releases of chemicals. The exposure pathways considered for evaluation under current land-use conditions are described below.

On-Site Surface Soil. Human exposures to chemicals in surface soil could occur by direct contact and subsequent dermal absorption and/or incidental ingestion of COPCs. As a result, on-site worker and trespasser exposures to COPCs in surface soil via incidental ingestion and dermal absorption were evaluated under current land-use conditions for CSL. Airborne releases of COPCs from surface soil can occur via the wind entrainment of chemicals on dust particles. Therefore, on-site workers and trespassers could potentially be exposed to airborne chemicals released from surface soil at CSL. As a result, exposures via inhalation of particulates were evaluated. (As discussed in Section 6.3.2.1, no VOCs were identified as COPCs in surface soil; therefore, inhalation of VOCs via volatilization was not evaluated.)

On-Site Total Soil. Because ground-intrusive or construction/excavation activities are not currently taking place at the CSL, potential excavation worker exposures to chemicals in surface and subsurface soil (i.e., total soil) would not occur. In addition, it is not likely that on-site workers and trespassers would

have the opportunity to be exposed to total soil when on-site; thus, direct contact exposures (i.e., incidental ingestion and dermal contact) to chemicals in total soil were not evaluated under current land-use conditions. Airborne releases of COPCs from total soil can occur via volatilization of chemicals into ambient air. As a result, exposure via inhalation of VOCs in ambient air by on-site workers and trespassers were evaluated. However, as discussed in Section 6.3.2.2, no VOCs were identified as COPCs in total soil; therefore, inhalation of VOCs via volatilization into ambient air was not quantified.

On-Site Sediment. It is possible that trespassers could contact sediment in the on-site drainage swale at the CSL while wading. Therefore, dermal absorption of chemicals in sediments by trespassers was quantitatively evaluated. Although incidental ingestion of sediment could occur, it was assumed exposures would likely be negligible and were not quantified.

On-Site Surface Water. The two landfill cells at the CSL are separated by a drainage swale which receives runoff from the inner flanks of the cells and from surface runoff from off-post areas to the east. It is possible that trespassers may have incidental contact with surface water while wading. However, it is not reasonable to expect incidental ingestion of surface water to be a complete pathway because the drainage swale is shallow when flowing and is not suitable to swimming. Dermal exposures to surface water, however, could occur. Therefore, potential dermal absorption exposures to trespassers to surface water in the CSL drainage swale were quantitatively evaluated.

On-Site Groundwater. As discussed in Section 6.3.2.5, an upper aquifer (Upper Patapsco) and a lower aquifer (Lower Patapsco) lie beneath the CSL and were evaluated in the RI. Although groundwater wells exist at FGGM, groundwater is not currently used as a source of drinking water or for other purposes at the CSL. As a result, potential direct contact exposure pathways (i.e., ingestion and dermal contact) to chemicals in groundwater at the CSL are not complete, and were not quantitatively evaluated. However, airborne releases of COPCs from groundwater can occur via volatilization of chemicals into ambient air. As a result, exposures to contaminants in groundwater via inhalation of VOCs in ambient air by on-site workers and trespassers were evaluated. Only inhalation of COPCs from the Upper Patapsco groundwater was evaluated. Due to the depth of the Lower Patapsco groundwater below ground surface, airborne releases of COPCs were assumed to be negligible. In addition, any VOCs migrating from the Lower aquifer would potentially intercept the Upper aquifer; therefore, only the Upper aquifer needs to be assessed for the off-gassing of *in situ* vapors.

Off-Site Groundwater. There is a possibility that under current conditions VOCs from *in-situ* off-site Upper aquifer groundwater may be migrating into the indoor air of residential homes. This uncertainty is evaluated in the uncertainty section on the HHRA (Section 6.7.7).

Summary of Pathways Evaluated Under Current Land-Use Conditions

- Incidental ingestion, dermal absorption, and inhalation of particulates of chemicals in surface soil by on-site workers (e.g., maintenance workers) and trespassers;
- Dermal absorption of chemicals in surface water by on-site trespassers;
- Dermal absorption of chemicals in sediment by on-site trespassers; and
- Inhalation of VOCs in ambient air from on-site groundwater (Upper Patapsco) by on-site workers and trespassers.

6.4.1.2 Potential Exposure Pathways Under Future Land-Use Conditions

According to USEPA (1995a), a risk assessment evaluating potential future exposures should reflect the most reasonably anticipated future land-uses. The potential future exposure pathways through which humans could be exposed to environmental media at the CSL are discussed in the following sections. Appendix G-1 Tables 1-2 and 1-3 present an exposure pathway analysis for potential future land-use conditions, indicating the media, exposure points, potential receptors, and exposure routes. These tables also indicate whether the pathway is potentially complete, and identifies those pathways that are quantitatively evaluated. The exposure pathways that were quantitatively evaluated under current land-use conditions are assumed to be the same for future exposures.

Receptor Characterization: Because there are plans to convert the site to a golf course, future recreational and construction worker exposures have been added to this HHRA. The recreational receptors would potentially be exposed to surface soil across the site. Future construction workers are not expected to be exposed to subsurface soils at Cells No. 1 and 2. It is highly unlikely that landfill contents under the capped areas would be disturbed, due to the critical concern of exposing waste material. It is anticipated, however, that subsurface soil at Cell No. 3 would be disturbed. Therefore, the construction worker scenario addressed potential exposure to total soil, which consisted of all surface soil at the site and subsurface soil at Cell No. 3).

The nature of the current land use at the CSL makes it extremely unlikely that in the future this area will be developed for residential purposes in the future. It is also unlikely that excavation activities would occur because the site is a closed and inactive landfill. A hypothetical residential scenario was added, however, to evaluate the need for potential land controls.

Potential on-site workers under future land-use scenarios, therefore, include on-site construction workers. On-site recreational receptors include golf course groundskeepers, club house workers, and golfers. Residential receptors include on-site adult and child residents. Because of the potential for contaminants in groundwater to migrate beyond the boundaries of FGGM, off-site receptors were also evaluated for this media. Likely off-site receptors include construction workers and adult and child residents.

Exposure Pathway Identification: The exposure pathways associated with potential future receptors at the CSL were identified based on consideration of the sources and releases of chemicals. Appendix G-1, **Tables** 1.2 and 1.3 present the pathways considered under the future land-use conditions, summarized as follows:

On-Site Surface Soil. Human exposures to chemicals in surface soil could occur by direct contact and subsequent dermal absorption and/or incidental ingestion of COPCs. As a result, golf course groundskeeper and golfer exposure to COPCs in surface soil via incidental ingestion and dermal absorption were evaluated under future land-use conditions for CSL. Airborne releases of COPCs from surface soil can occur via the wind entrainment of chemicals on dust particles. Therefore, golf course groundskeepers and golfers, could potentially be exposed to airborne chemicals released from surface soil at CSL. As a result, exposures via inhalation of particulates were evaluated. (As discussed in Section 6.3.2.1, no VOCs were identified as COPCs in surface soil; therefore, inhalation of VOCs via volatilization was not evaluated.)

On-Site Total Soil. Human exposures to chemicals in total soil could occur by direct contact and subsequent dermal absorption and/or incidental ingestion of COPCs. As a result, on-site construction worker, and resident exposures to COPCs in total soil via incidental ingestion and dermal absorption were evaluated under future land-use conditions for CSL. Airborne releases of COPCs from total soil can occur via the wind entrainment of chemicals on dust particles. Therefore, on-site construction workers, and adult and child residents could potentially be exposed to airborne chemicals released from total soil at CSL. As a result, exposures via inhalation of particulates were evaluated. (As discussed in Section 6.3.2.1, no VOCs were identified as COPCs in total soil; therefore, inhalation of VOCs via volatilization was not evaluated.)

On-Site Sediment. It is possible that on-site receptors could contact sediment in the on-site drainage swale at the CSL while wading. Therefore, dermal absorption of chemicals in sediments by construction workers, golf course groundskeepers, golfers, and child residents was quantitatively evaluated. Although incidental ingestion of sediment could occur, it was assumed exposures would likely be negligible and were not quantified.

On-Site Surface Water. The two landfill cells at the CSL are separated by a drainage swale which receives runoff from the inner flanks of the cells and from surface runoff from off-post areas to the east. It is possible that on-site receptors may have incidental contact with surface water while wading. However, it is not reasonable to expect incidental ingestion of surface water to be a complete pathway because the drainage swale is shallow when flowing and is not suitable to swimming. Dermal exposures to surface water, however, could occur. Therefore, potential dermal absorption exposures to construction

workers, golf course groundskeepers, golfers, and child residents to surface water in the CSL drainage swale were quantitatively evaluated.

On-Site Groundwater. As discussed in Section 6.3.2.5, an upper aquifer (Upper Patapsco) and a lower aquifer (Lower Patapsco) lie beneath the CSL and were evaluated in the RI. Although groundwater wells exist at FGGM, groundwater is not currently used as a source of drinking water or for other purposes at the CSL. To assess potential closure requirements, however, a future hypothetical residential scenario was evaluated for exposures to COPCs in groundwater during household use. Potential direct contact exposure pathways included ingestion, dermal contact, and inhalation of volatile COPCs during showering. Because the average depth of the groundwater on site is 15 ft, the construction worker was also evaluated for potential dermal exposure to groundwater during construction or excavation activities. It was assumed that exposures due to incidental ingestion would be negligible.

In addition, airborne releases of COPCs in groundwater can occur via volatilization of VOCs. It is possible that on-site receptors could be exposed to VOCs in groundwater, as follows:

- Golf course groundskeepers and golfer exposures to VOCs in ambient air;
- Club house worker exposure to VOCs in indoor air via vapor intrusion, into the clubhouse;
- Construction worker exposure to VOCs in a construction or utility trench;
- Adult resident exposure to airborne VOCs while showering; and
- Adult and child resident exposures to VOCs in indoor air via vapor intrusion into residences.

For the inhalation pathway (except for showering exposure), only inhalation of COPCs from the on-site Upper Patapsco groundwater was evaluated. Due to the depth of the on-site Lower Patapsco groundwater below ground surface, airborne releases of COPCs were assumed to be negligible. In addition, any VOCs migrating from the lower aquifer would potentially intercept the upper aquifer; therefore, only the upper aquifer was assessed for the off-gassing of *in situ* vapors.

Off-Site Groundwater. Under future land-use conditions, it is assumed that residents (adult and child) will be exposed to off-site groundwater (both Upper and Lower Patapsco groundwater) via household use, including ingestion, dermal contact, and inhalation during showering. It is possible that off-site residents could be exposed to VOCs in groundwater via vapor intrusion into indoor air of a residence. In addition, off-site exposures of construction/utility workers to VOCs in groundwater via vapors migrating into a trench or pit could occur. For the inhalation pathway (except for showering exposure), only the off –site Upper Patapsco groundwater was evaluated in the HHRA. Due to the depth of the off-site Lower Patapsco groundwater below ground surface, airborne releases of COPCs were assumed to be negligible. In addition, any VOCs migrating from the lower aquifer would potentially intercept the Upper aquifer; therefore, only the Upper aquifer needs to be assessed for the off-gassing of *in situ* vapors.

Future Migration of On-Site Groundwater Off the Site. Hypothetical future off-site exposure to constituent concentrations on-site that have migrated off-site with no attenuation, is discussed in the Uncertainty Section (**Section 6.7**).

Summary of Pathways Evaluated Under Future Land-Use Conditions

- Incidental ingestion, dermal absorption, and inhalation of particulates of chemicals in on-site surface soil by on-site golf course groundskeepers and golfers;
- Incidental ingestion, dermal absorption, and inhalation of particulates of chemicals in on-site total soil by on-site construction workers and adult and child residents;
- Inhalation of VOCs in ambient air from on-site groundwater (Upper Patapsco) by on-site golf course groundskeepers and golfers;

- Inhalation of VOCs in indoor air from on-site groundwater (Upper Patapsco) by on-site club house workers;
- Dermal absorption of chemicals in on-site surface water by on-site construction workers, golf course groundskeepers, golfers, and child residents;
- Dermal absorption of chemicals in on-site sediment by on-site construction workers, golf course groundskeepers, golfers, and child residents;
- Ingestion and dermal absorption of chemicals from on-site groundwater (Upper Patapsco) by on-site residents (adult and child);
- Inhalation of VOCs from on-site groundwater (Upper Patapsco) by on-site residents (adults only) while showering;
- Inhalation of VOCs in indoor air from on-site groundwater (Upper Patapsco) by on-site residents (adults and child);
- Inhalation of VOCs in trench air from on-site groundwater (Upper Patapsco) by on-site construction workers;
- Ingestion and dermal absorption of chemicals from on-site groundwater (Lower Patapsco) by on-site residents (adult and child).
- Inhalation of VOCs from on-site groundwater (Lower Patapsco) by on-site residents (adults only) while showering.
- Ingestion and dermal absorption of chemicals from off-site groundwater (Upper Patapsco) by off-site residents (adult and child);
- Inhalation of VOCs from off-site groundwater (Upper Patapsco) by off-site residents (adults only) while showering;
- Inhalation of VOCs in indoor air from off-site groundwater (Upper Patapsco) by off-site residents (adults and child);
- Inhalation of VOCs in trench air from off-site groundwater (Upper Patapsco) by off-site construction workers;
- Ingestion and dermal absorption of chemicals from off-site groundwater (Lower Patapsco) by off-site residents (adult and child); and
- Inhalation of VOCs from off-site groundwater (Lower Patapsco) by off-site residents (adults only) while showering.

6.4.2 Exposure Point Concentrations

To evaluate the magnitude of exposures and risks that may be experienced by an individual, the concentration of the COPCs in the exposure medium must be known or estimated. This concentration is referred to as an exposure point concentration (EPC). The EPCs used in the HHRA are based on the data summarized in Section 6.3.2, and were determined for all selected COPCs.

The approach used to estimate exposure point concentrations (EPCs) follows that recommended by USEPA (1989, 1992c, 2002b) guidance. According to this guidance, the most appropriate measurement of central tendency for exposure to environmental chemical concentrations is the arithmetic mean. To account for uncertainty associated with this value, USEPA guidance requires the use of the 95% upper confidence limit (UCL) on the arithmetic mean concentration, unless the 95% UCL is greater than the maximum detected value. When the 95% UCL is greater than the maximum detected concentration, USEPA (1989) directs that the maximum detected value be used as the exposure point concentration. USEPA recently released the software package, ProUCL (Version 3.0, USEPA, 2004b), which enables the simultaneous calculation of 95% UCLs using a variety of statistical calculations. The ProUCL program then selects the most appropriate 95% UCL statistic based on criteria established in the package. This value is used as the exposure point concentration. Exposure point concentrations for soil,

sediment, surface water, and groundwater COPCs are presented in Appendix G-1, Tables 3.1 through 3.19. Output from the ProUCL software package is presented in Appendix G-2.

EPCs Associated with Ambient Air (Groundwater). For this scenario, the volatilization model outlined in ASTM Risk-Based Corrective Action (RBCA) Guidance (ASTM, 1995) for volatilization from groundwater to ambient air was used. The model, outlined in ASTM (1995), is based on the Superfund Exposure Assessment Manual EPA/540/1-88/001. This model calculates a representative concentration in outdoor air based on the assumptions that there is a constant dissolved concentration in groundwater, a steady-state vapor and liquid phase, and no biodegradation. The model considers wind speed, mixing height, depth to groundwater, and diffusion coefficients in air and water. The following equation is used to calculation the volatilization factor to ambient air:

$$VF_{wamb} = (H / 1 + (U_a d_{air} L_{GW} / WD_{effws}))\ X\, 10^3\, L / m^3$$

where:

VF_{wamb} = Volatilization factor (mg/m^3 air per mg/L water) – calculated
H = Henry's Law Constant (cm^3-water per cm^3-air) – chemical specific
U_a = Wind speed above ground surface (cm/sec) – 411 (NOAA, 1991)
d_{air} = Ambient air mixing zone height (cm) – 200 (ASTM, 1995)
L_{GW} = Depth to groundwater (cm) – 457 cm (site-specific)
W = Width of source area perpendicular to wind flow direction (cm) - 121,920 cm (site specific)
D_{effws} = Effective diffusion coefficient between ground water and soil surface (cm^2/sec; calculated)

The effective diffusion coefficient between ground water and soil surface is calculated as follows:

$$D_{effws} = \left(h_{cap+}\ h_v\right)\left[\frac{h_{cap}}{D_{effcap}} + \frac{h_v}{D_{effs}}\right]^{-1}$$

where:

D_{effws} = Effective diffusion coefficient between ground water and soil surface (cm^2/sec)
h_{cap} = Thickness of capillary fringe (5 cm)
h_v = Thickness of vadose zone (295 cm)
D_{effcap} = Effective diffusion coefficient through capillary fringe (cm^2/sec; calculated)
D_{effs} = Effective diffusion coefficient in soil based on vapor phase concentration (cm^2/sec; calculated)

The effective diffusion coefficient through the capillary fringe is calculated as follows:

$$D_{effcap} = D^{air}\ \frac{\theta_{acap}^{3.33}}{\theta_T^2} + D^{wat}\ \frac{1}{H}\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$$

where:

D_{effcap} = Effective diffusion coefficient through capillary fringe (cm^2/sec)
D_{air} = Diffusion coefficient in air (cm^2/sec; chemical-specific)
D_{wat} = Diffusion coefficient in water (cm^2/sec; chemical-specific)

θ_{acap} = Volumetric air content in capillary fringe soils (0.038 cm^3 – air/cm^3 – soil)

θ_{wcap} = Volumetric water content in capillary fringe soils (0.342 cm^3 – H_2O/cm^3 – soil)

θ_T = Total soil porosity (0.38 cm^3/cm^3 – soil)

The effective diffusion coefficient in soil based on vapor-phase concentration is calculated as follows:

$$D_{effs} = D^{air} \frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

where:

D_{effs} = Effective diffusion coefficient in soil based on vapor phase concentration (cm^2/sec)

D^{air} = Diffusion coefficient in air (cm^2/sec; chemical-specific)

D^{wat} = Diffusion coefficient in water (cm^2/sec; chemical-specific)

θ_{as} = Volumetric air content in vadose zone soils (0.26 cm^3 – air/cm^3 – soil)

θ_{ws} = Volumetric water content in vadose zone soils (0.12 cm^3 – water/cm^3 – soil)

H = Henry's Law Constant (cm^3 – water/cm^3 – air; chemical-specific)

θ_T = Total soil porosity (0.38 cm^3 – soil)

Chemical-specific values for the ASTM equation are listed in Table 6-4. The concentration of the COPC in ambient air is calculated using the following equation:

$$C_{air} = C_{GW} \times VF_{wamb}$$

where:

C_{air} = Concentration of chemical in ambient air (mg/m^3)

C_{GW} = Concentration of chemical in groundwater (mg/L)

VF_{wamb} = Volatilization factor (mg/m^3 per mg/L water) - calculated

A summary of the groundwater EPCs in ambient air for the current and future on-site worker, trespasser, and recreational scenarios are presented in Appendix G-1, Table 3.11.

EPCs Associated with Volatilization in a Construction Trench. The average depth to groundwater on site at CSL is 15 ft bgs. In the event that a construction/utility worker encounters groundwater the worker may be exposed to volatile emissions from groundwater pooling at the bottom of the trench. While USEPA does not have a standardized model for estimating concentrations of airborne VOCs in a trench or a pit, the VDEQ provides such a model on their VRP web site (VDEQ, 2006. VDEQ (2000a) assumes that the trench would only intercept the groundwater for a few inches. The trench depth is set at 15 ft and approximates the contaminated groundwater depth at CSL.

Because the nature of construction activities at CSL is hypothetical, a default value for the time spent in the trench by a construction/utility worker was used to calculate the EPC.

Airborne concentrations of a contaminant in a trench are estimated using the equation below (VDEQ, 2000a):

$$C_{trench} = C_{GW} \times VF$$

where:

C_{trench} = concentration of contaminant in the trench ($\mu g/m^3$);

C_{GW} = concentration of contaminant in groundwater ($\mu g/L$); and

VF = volatilization factor (L/m^3).

Groundwater concentrations beneath the trench were conservatively assumed to be equal to the 95% UCL on the arithmetic mean concentrations. The volatilization factor (VF) is estimated using the equation below (VDEQ, 2000a) and the specific input values in Appendix G-1, Table 3.12:

$$VF = (K_i \times A \times F \times 10^{-3} \times 10^4 \times 3600) / (ACH \times V)$$

where:

K_i = overall mass transfer coefficient of contaminant i (cm/sec);

A = area of the trench (m^2);

F = fraction of floor through which contaminant can enter (unitless);

ACH = air changes per hour (h^{-1});

V = volume of trench (m^3);

10^{-3} = conversion factor (L/cm^3);

10^4 = conversion factor (cm^2/m^2); and

3600 = conversion factor (sec/hr).

The default value for air changes per hour (ACH) of 2/hr is used for the risk assessment. The overall mass transfer coefficient of contaminant is calculated using the equation below (VDEQ, 2000a):

$$K_i = 1 / \{(1/K_{iL}) + [(R\ T) / H_i\ K_{iG})]\}$$

where:

K_{iL} = liquid-phase mass transfer coefficient of contaminant i (cm/sec);

R = ideal gas constant ($atm\text{-}m^3/mole\text{-}K$);

T = average system absolute temperature (K);

H_i = Henry's Law constant of contaminant i ($atm\text{-}m^3/mol$); and

K_{iG} = gas-phase mass transfer coefficient of contaminant i (cm/sec).

The value for R is 8.2×10^{-5} $atm\text{-}m^3/mol\text{-}K$. The average annual temperature for CSL was set at 12.5°C (54.5°F or 286K). The values for H_i for each COPC are presented in Appendix G-1, Table 3.11. The liquid-phase mass transfer coefficient is calculated using the following equation (VDEQ, 2000a):

$$K_{iL} = (MW_{02}/MW_i)^{0.5} \times (T/298) \times K_L, O_2$$

where:

K_{iL} = liquid-phase mass transfer coefficient of contaminant i (cm/sec);

MW_{02} = molecular weight of O_2 (g/mol);

MW_i = molecular weight of contaminant i (g/mol); and

K_L, O_2 = liquid-phase mass transfer coefficient of oxygen at 25°C (cm/sec).

The value of K_L, O_2 is 0.002 cm/sec (VDEQ, 2000a). The gas-phase mass transfer coefficient of contaminant is calculated using the equation below:

$$K_{iG} = (MW_{H_2O}/MW_i)^{0.335} \times (T/298)^{1.005} \times K_G, H_2O$$

where:

K_{iG} = gas-phase mass transfer coefficient of contaminant i (cm/sec);

MW_{H_2O} = molecular weight of water (g/mol);

MW_i = molecular weight of contaminant i (g/mol); and

K_G, H_2O = gas-phase mass transfer coefficient of water at 25°C (cm/sec).

The value of K_G, H_2O is 0.833 cm/sec (VDEQ, 2000a).

If the construction/utility worker encounters groundwater in the trench at the site, the worker could have direct exposure to the groundwater. The EPCs for groundwater for direct-contact exposures are assumed to be the 95% UCL on the arithmetic mean concentrations of COPCs in CSL groundwater. The EPCs for groundwater COPCs, the trench model input values, and the trench air concentrations for the construction/utility worker scenario are presented in Appendix G-1, Table 3.11.

In the event that construction/ utility work is performed off-site, the worker may be exposed to volatile emissions from groundwater below the bottom of the trench. Given the average depth to Upper Patapsco groundwater off-post is 37 feet, VDEQ's model intended for depths greater than 15 feet was used for this HHRA.

Airborne concentrations of a contaminant in a trench are estimated using the equation below (VDEQ, 2006):

$$C_{trench} = C_{GW} \times VF$$

where:

C_{trench} = concentration of contaminant in the trench ($\mu g/m^3$);

C_{GW} = concentration of contaminant in groundwater ($\mu g/L$); and,

VF = volatilization factor (L/m^3).

The EPC for each COPC was used to represent the groundwater concentration beneath the trench. The VF is estimated using the equation below (VDEQ, 2005):

$$VF = \frac{(H_i \times D_{air} \times AC_{vad}^{3.33} \times A \times F \times 10^{-3} \times 10^{4} \times 3600)}{(R \times T \times L_d \times ACH \times V \times Por_{vad}^{2})}$$

H_i	=	Henry's Law constant for contaminant	atm^3/mol
D_{air}	=	diffusion coefficient in air	cm^2/s
AC_{vad}	=	volumetric air content in vadose zone soil	cm^3/cm^3
A	=	area of trench	m^2
F	=	fraction of floor through which contaminant can enter	Unitless
R	=	ideal gas constant	$atm\text{-}m^3/mole\text{-}°K$
T	=	average system absolute temperature	°K
L_d	=	distance between trench bottom and groundwater	cm
ACH	=	air changes per hour	h^{-1}
V	=	volume of trench	m^3
Por_{vad}	=	total soil porosity in vadose zone	cm^3/cm^3
10^{-3}	=	conversion factor	L/cm^3
10^{-4}	=	conversion factor	cm^3/m^2
3600	=	conversion factor	s/hr

The value for R is 8.2×10^{-5} $atm\text{-}m^3/mole\text{-}°K$. A value of 286°K, which was based on the average temperature for shallow groundwater (USEPA, 2003a), was used for the average system absolute temperature.

Studies of urban canyons suggest that if the ratio of trench width – relative to wind direction – to trench depth or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of air exchange with atmosphere. In consultation with USEPA Region III, VDEQ has assumed an ACH in this case of 2/hr – based upon ventilation rates of buildings.

The trench model input values and the trench air concentrations (i.e., EPCs) for the off-site construction/utility worker scenario are presented in Appendix G-1, Table 3.13.

EPCs Associated with Vapor Intrusion. The Johnson and Ettinger model (1991; USEPA, 2003a) is used to estimate indoor air concentrations of volatiles migrating from Upper Patapsco groundwater through the soil and into a structure. Spreadsheets for this model are provided by USEPA (USEPA, 2003a); these spreadsheets were used to estimate air concentrations of VOCs in residences for this HHRA.

Site-specific values were used in the model in lieu of model defaults (USEPA, 2003a), where appropriate. It was conservatively assumed that on-site and off-site residential buildings would be constructed with a basement. The EPCs for Upper Patapsco groundwater were used in the model (see Tables 3-14 and 3-15).

The values used in the model to estimate indoor air concentrations of volatiles for future on-site and off-site exposures are described below:

- Average soil/groundwater temperature (Ts) is set at 55°F or 12.5°C, based on the average temperature of shallow groundwater for the vicinity of FGGM, as indicated in Figure 8 from the User's Guide for the Johnson & Ettinger Model (USEPA, 2003a).
- Depth below grade to bottom of enclosed space floor (LF) is set at the default value of 200 cm because building construction is likely to include a basement.
- Depth below grade to water table (Lwt) is set at 457 cm (15 ft) for on-site groundwater, conservatively based on the average depth of groundwater measured in on-post wells. The value for Lwt is set at 1,128 cm (37 ft), conservatively based on the average depth of groundwater measured in off-post wells.
- The soil type in the vadose zone both on-site and off-site was modeled as loamy sand (LS). This is based on boring logs for monitoring wells MW-123S and MW-124S that show vadose zone soil types of silt, silt with sand, clay, and silty sand. As the Johnson and Ettinger model (1991) has the following 12 soil types available for modeling (ranked from highest hydraulic conductivity to lowest), loamy sand was selected as a conservative default, as soil vapor permeability is directly related to hydraulic conductivity:

SCS Soil Type	Hydraulic Conductivity (cm/hr)	SCS Soil Type	Hydraulic Conductivity (cm/hr)
Sand	26.78	Sandy clay loam	0.55
Loamy sand	4.38	Loam	0.50
Silt	1.82	Sandy clay	0.47
Sandy loam	1.60	Silty clay loam	0.46
Silt loam	0.76	Silty clay	0.40
Clay	0.61	Clay loam	0.34

- The thickness and properties of the capillary zone are calculated by the model based on the LS soil type.
- The vadose zone soil total porosity is set at 0.39, based on the "lookup" soil parameter in the model for loamy sand (USEPA, 2003a).
- The vadose zone soil water-filled porosity is set at 0.076 cm^3/cm^3, based on the "lookup" soil parameter in the model for loamy sand (USEPA, 2003a).
- The vadose zone soil dry bulk density (pb) is set at the "lookup" soil parameter of 1.62 g/cm^3 for loamy sand in the model (USEPA, 2003a).
- The calculated concentration of each COPC in building air ($C_{building}$) served as the EPC in the intake calculations for inhalation.

The Johnson and Ettinger model input values and model results for groundwater COPCs are presented in Appendix G-3. A summary of the groundwater EPCs in indoor air for the on-site upper aquifer (benzene, chlorobenzene, chloroethane, 1,4-dichlorobenzene, MTBE, and naphthalene) is presented in Appendix G-1, Table 3.14. A summary of the groundwater EPCs in indoor air for the off-site upper aquifer (chloroform and MTBE) is presented in Appendix G-1, Table 3.15.

EPCs in Shower Room Air. EPCs of VOCs in air due to volatilization from groundwater were estimated for a showering scenario, applicable to the adult resident, using the Foster-Chrostowski (1987) shower room model. Although VOCs may gain access to ambient air from most typical household uses of groundwater, showering likely represents the upper–bound for exposure, because the warm water temperature of a shower facilitates volatilization, and the VOCs released and the receptor are confined together in a relatively small space. In addition, showering and the characteristics of a typical shower room have been studied sufficiently to permit estimating shower room air concentrations of the VOCs.

The Foster-Chrostowski model estimates the liquid-film and gas-film mass transfer coefficients as follows:

$$k_l = 20 \cdot (44 / MW)^{0.5}$$

where:

k_l	=	liquid-film mass transfer coefficient (centimeters per hour [cm/hour])
20	=	liquid-film mass transfer coefficient for carbon dioxide (cm/hour)
44	=	conversion factor
MW	=	molecular weight (chemical-specific)

and

$$k_g = 3000 \cdot (18 / MW)^{0.5}$$

where:

k_g	=	gas-film mass transfer coefficient (cm/hour)
3000	=	gas-film mass transfer coefficient for water(cm/hour)
18	=	conversion factor
MW	=	molecular weight (chemical-specific).

The overall mass transfer coefficient is estimated as follows:

$$K_L = \left(\frac{1}{k_l} + \frac{R \cdot T}{H \cdot k_g} \right)^{-1}$$

where:

K_L	=	overall mass transfer coefficient (cm/hour)
k_l	=	liquid-film mass transfer coefficient (cm/hour)
R	=	gas constant (8.2E-5 atm-m^3/mole-°K)
T	=	room temperature (293 °K, Foster-Chrostowski, 1987)
H	=	Henry's Law constant (chemical-specific, atm-m^3/mole)
k_g	=	gas-film mass transfer coefficient (cm/hour).

The overall mass transfer coefficient is adjusted to the shower water temperature as follows:

$$K_{aL} = K_L \cdot \left(\frac{T_1 \cdot u_s}{T_s \cdot u_l} \right)^{-0.5}$$

where:

K_{aL} = adjusted overall mass transfer coefficient (cm/hour)
K_L = overall mass transfer coefficient (cm/hour)
T_1 = calibration (room) temperature (293 °K, Foster-Chrostowski, 1987)
u_s = water viscosity at temperature T_s (0.596 centipoise [cp], Foster-Chrostowski, 1987)
T_s = shower water temperature (318 °K, Foster-Chrostowski, 1987)
u_l = water viscosity at temperature T (1.002 cp, Foster-Chrostowski, 1987).

The contribution of VOCs to ambient air is estimated as the concentration leaving the shower droplet as described by:

$$C_{wd} = C_w \cdot \left(1 - \exp\left[\frac{-K_{aL} \cdot t_s}{60 \cdot d}\right]\right)$$

where:

C_{wd} = concentration leaving shower droplet after time t_s (µg/L)
C_w = concentration in shower water (µg/L)
K_{aL} = adjusted overall mass transfer coefficient (cm/hour)
t_s = shower droplet drop time (2 seconds, Foster-Chrostowski, 1987)
60 = conversion factor
d = shower droplet diameter (1 millimeter, Foster-Chrostowski, 1987).

Applying the shower water flow rate and the shower room air volume to the concentration leaving the shower droplet allows estimating the VOCs in air generation rate as follows:

$$S = \frac{C_{wd} \cdot FR}{SV}$$

where:

S = VOCs in air generation rate (µg/m^3-min)
C_{wd} = concentration leaving shower droplet after time t_s (µg/L)
FR = shower water flow rate (13 L/minute, EPA, 1997a)
SV = shower room air volume (6 m^3, Foster-Chrostowski, 1987).

For cases in which the shower duration is less than total time spent in the shower room, the concentration of VOCs in the shower room air is estimated as follows:

$$C_{wa} = \left(\frac{S}{R_a \bullet t \bullet CF}\right) \bullet \left[D_s + \frac{e^{(-Ra \bullet t)}}{R_a} - \frac{e^{Ra(Ds-t)}}{R_a}\right]$$

where:

C_{wa} = VOC concentration in shower room air (mg/m^3)
S = VOCs in air generation rate (µg/m^3-minute)
R_a = shower room air exchange rate (0.01667 per minute, Foster-Chrostowski, 1987)
D_s = shower duration (35 minutes, USEPA, 2004a, 2005d)
t = total time in shower room (65 minutes, USEPA, 2004a, 2005d)
CF = conversion factor (1000 µg/mg).

The chemical-specific Foster-Chrostowski shower model input values are shown in Table 6-5. The resulting EPCs for the on-site Upper Patapsco groundwater and Lower Patapsco groundwater are shown in Appendix G-1**,** Tables 3.16 and 3.17, respectively. The resulting EPCs for the off-site Upper Patapsco groundwater and Lower Patapsco groundwater are shown in Appendix G-1, Tables 3.18 and 3.19, respectively.

6.4.3 Quantification Of Exposure

This section describes the development of the exposure estimates (chemical doses) that serve as the basis of the risk estimates in Section 6.6. To estimate doses, exposure point concentrations for each COPC are used in conjunction with the Reasonable Maximum Exposure (RME) parameters describing the extent, frequency, and duration of exposure for each potential receptor of concern.

This section defines the parameters used to develop the RME for each receptor and presents an overview of the approaches and equations used in quantifying doses and specific details relevant to each selected exposure pathway. The approaches used to quantify doses due to chemical exposures are consistent with guidance provided by USEPA (1989; 1992a,b).

6.4.3.1 Methodology For Deriving Dose Estimates

For the exposure pathways that involve ingestion or dermal contact, quantification of exposure involves the estimation of an average daily dose, expressed in units of mg chemical/kg body weight per day (mg/kg-day). Dose can be defined as an exposure rate or as an exposure to a chemical determined over an exposure period per unit body weight. It is calculated similarly for both ingestion and dermal absorption pathways; however, there are significant differences in the meaning and terms used to describe dose for the ingestion and dermal pathways. For the ingestion exposure pathways, the doses calculated in this assessment are referred to as "potential doses." The potential dose is the amount of chemical ingested and available for uptake in the body, and is analogous to the administered dose in a dose-response toxicity experiment. For the dermal absorption pathways, the estimated dose is referred to as an "internal dose," and reflects the amount of chemical that has been absorbed into the body and is available for interaction with biologically important tissues.

ADDs are estimated differently for chemicals exhibiting noncarcinogenic and carcinogenic effects, because different toxicity criteria are available for carcinogenic effects and noncarcinogenic effects of chemicals (see *Section 6.5*, Human Health Toxicity Assessment). ADDs for noncarcinogens are averaged over the duration of exposure and, following USEPA (1992c) guidance, are given the acronym ADD for average daily doses. ADDs for carcinogens are averaged over a lifetime, and are given the acronym LADD for lifetime average daily doses.

The ADDs and LADDs are estimated using EPCs of chemicals together with exposure parameters that specifically describe the exposure pathway. ADDs and LADDs for each pathway were derived by combining the selected EPC (based on the maximum or on the 95% UCL on the mean concentration) of each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA, 1989; 1992c; 2004a, 2005a).

The following sections present the equations and exposure parameters used in the HHRA to estimate potential doses ($ADDs_{pot}$ and $LADDs_{pot}$) for ingestion exposures, internal doses ($ADDs_{int}$ and $LADDs_{int}$) for dermal absorption exposures, and ($ADDs_{pot}$ and $LADDs_{pot}$) for inhalation exposures. It was assumed that the chemical concentrations in the media evaluated would remain constant over the exposure period.

The particulate emission factor (PEF) for wind erosion used to calculate the particulate inhalation ADDs and LADDs was calculated based on an equation provided by USEPA (1996d), and is shown below. It should be noted that one of the inputs for calculating the PEF is the Q/C value which represents both local climatic conditions and the size of the contaminated area. Q/C values are provided by USEPA (1996d) for 29 different cities in the United States and for contaminated areas ranging from 0.5 to 30 acres. A conservative Q/C value of 46.59 g/m^2-s per kg/m^3, corresponding to climatic conditions in Philadelphia, Pennsylvania and a 30-acre site was selected for use in the HHRA.

The variable for vegetative cover used to calculate the PEF accounts for the percentage of ground cover (e.g., pavement, gravel, or vegetation) that potentially inhibits the release of VOCs and particulate matter from soil into ambient air. Although the majority of the site is currently covered, the fraction of the vegetative cover was conservatively assumed to be 50 percent to allow for potential changes to site conditions in the future. USEPA's default value was used to represent the mean annual wind speed [4.69 meters/second (m/s)].

Using the following equation and the assumptions described above, a PEF of 6.75x10^8 m^3/kg was calculated.

$$PEF = \frac{\frac{Q}{C} * (3600 \frac{sec}{hr})}{0.036 * (1 - V) * \left(\frac{U_m}{U_t}\right)^3 * F(x)}$$

where:

PEF	=	particulate emission factor (m^3/kg)
Q/C	=	inverse of the mean concentration of the center of a 30-acre source (equal to 46.59 g/m^2 per kg/m^3 for Climatic Zone VIII, Philadelphia, PA [USEPA, 1996d])
V	=	fraction of vegetative cover (assumed to be 50 percent)
U_m	=	mean annual wind speed (m/sec)
U_t	=	equivalent threshold value of wind speed a 7 m (11.32 m/sec) (default)
F(x)	=	function dependent on U_m/U_t derived using Cowherd et al. (as cited in USEPA, 1996d)

The particulate emission factor (PEF) for the construction worker used to calculate the particulate inhalation ADDs and LADDs was calculated based on an equation provided by USEPA (2002a), and is shown below. Under a construction scenario, fugitive dusts may be generated from surface soil by wind erosion, construction vehicle traffic on temporary unpaved roads, and other construction activities. Due to the potential for increased dust exposure from truck traffic on unpaved roads during construction, USEPA recommends that fugitive dusts associated with the construction scenario be evaluated for semivolatile compounds (SVOCs) and for all metals (USEPA, 2002a).

The methodology for calculating a PEF for road emissions (PEFsc) is described in USEPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002a). The equation for the PEF_{sc} requires estimates of parameters that represent the movement of vehicular traffic across the site, such as number of days with at least 0.01 inch of rainfall, the mean vehicle weight, and the sum of fleet vehicle distance traveled during construction. Because future plans for construction at

the Ft. Meade sites have not been defined, a range of conservative values was used in the sample calculations. The equations and exposure parameters are described in the following sections.

The subchronic dispersion factor for dust generated by unpaved road traffic (Q/C_{sr}) was first calculated for each site as follows (USEPA, 2002a):

$$Q/C_{sr} = A\ x \exp\left[\frac{(\ln A_s - B)^2}{C}\right]$$

where: Q/C_{sr} = inverse of the ratio of 1-hour geometric mean air concentration to the emission flux along a straight road segment bisecting a square site (g/m^2-s) per kg/m^3)
A = constant (12.9351; unitless)
A_s = area extent of site surface soil contamination (130 acres); site-specific (**Section 6.4.1.1**)
B = constant (5.7383; unitless)
C = constant (71.7711; unitless)

As noted in the guidance (USEPA, 2002a), the Q/C_{sr} for the construction worker scenario can only be modified to reflect different site sizes; it cannot be modified for climatic zone like the Q/C values for other scenarios. It was assumed that the surface area of the site was 130 acres.

Using a combination of default and site-specific values, the PEF_{sc} was calculated as follows (USEPA, 2002a):

$$PEF_{sc} = Q/C_{sr}\ x\ \frac{1}{F_D}\ x \left[\frac{T\ x\ A_R}{556\ x\ (W/3)^{0.4}\ x\ \frac{365\ day/yr - p)}{365\ day/yr}\ x \sum VKT}\right]$$

Where: PEF_{sc} = subchronic road particulate emission factor (m^3/kg)
Q/C_{sr} = inverse of the ratio of 1-hour geometric mean air concentration to the emission flux along a straight road segment bisecting a square site (calculated 19.76 g/m^2-s) per kg/m^3); site-specific
F_D = dispersion correction factor (0.19; unitless; calculated following Appendix E, USEPA, 2002a) to estimate subchronic average air concentrations (e.g., 3-, 8- and 24-hour durations) instead of 1-hour concentrations
T = total time over which construction occurs (7,488,000 sec); based on 1 year
A_R = surface area of contaminated road segment (4,421.9 m^2);
W = mean vehicle weight (8 tons)
p = number of days with at least 0.01 inch of precipitation (140 days/year);
$\sum$VKT = sum of fleet vehicle kilometers traveled during the exposure duration (5,657.6 km); site-specific

The number of days with at least 0.01 inch of rainfall (140 days/year) was estimated using Exhibit 5-2 of the Supplemental SSL Guidance (USEPA, 2002a). Mean vehicle weight (W) was estimated by assuming the numbers and weights of different types of vehicles. For the worst-case scenario, following the example provided by USEPA (2002a), it was assumed that the daily unpaved road traffic consists of twenty 2-ton cars and ten 20-ton trucks. The calculated mean vehicle weight was:

W = [(20 cars x 2 tons/car) + (10 trucks x 20 tons/truck)]/30 vehicles = 8 tons

The sum of the fleet vehicle km traveled during construction ($\sum$VKT) was estimated based on the size of the area of the site, assuming the configuration of the unpaved road and the amount of vehicle

traffic on the road. For example, the area of soil contamination in acres or square meters (m^2) was assumed to be configured as a square, with the unpaved road segment dividing the square evenly. The road length is equal to the square root of m^2 in units of meters (m) or km. Assuming that each vehicle travels the length of the road once per day, 5 days per week, for a total of 12 months (consistent with the construction worker's exposure duration of 1 year), the total fleet vehicle km traveled for the CSL would be:

$$\sum VKT = 30 \text{ vehicles} \times 0.725 \text{ km/day} \times (52 \text{ weeks}) \times 5 \text{ days/week} = 5{,}655 \text{ km}$$

The calculated PEF for the construction worker scenario at the CSL was 8.03×10^5 m^3/kg.

Appendix G-1, Tables 4.1 through 4.23 provide the values used to calculate the doses for each of the exposure pathways that were quantitatively evaluated in this HHRA.

Current On-Site Maintenance Worker Dose Equations and Exposure Parameters for Soil and Groundwater. Under current land-use conditions, on-site workers could be exposed to COPCs in surface soil and on-site Upper Patapsco Groundwater. As previously noted, the site is the location of a closed and capped landfill. Exposures to subsurface soil and groundwater through direct contact are not likely because there are no digging/construction activities currently taking place. However, exposure to VOCs in groundwater released to ambient air is possible. It should be noted that exposures to VOCs in total soil released to ambient air is also possible; however, there were no volatile COPCs detected in total soil. The potential chemical doses for current on-site worker exposures to surface soil and groundwater at the CSL were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.4.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in Appendix G-1.

Incidental Ingestion of Soil by On-Site Maintenance Workers. The exposure for incidental ingestion of COPCs in soil by workers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.1. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (> 18 years of age).

Workers were assumed to be exposed to soil 50 days/year, based on the assumption that maintenance/inspection activities are conducted 1 day/week based on a 5-day work week for 50 weeks/year (workers were assumed to spend 2 weeks a year on vacation). Duration of exposure for workers was assumed to be 25 years, a USEPA (2002a) upper-bound default estimate of the time spent working in one location. The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for workers was assumed to be 100 mg/day, a standard USEPA (2002a) default value for exposure to adults in the workplace. It was conservatively assumed that soil ingested during the workday by workers would originate in the sampled areas; however, most maintenance workers would likely visit other portions of the Installation. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by On-Site Maintenance Workers. The internal dose due to dermal absorption of COPCs in soil by workers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.1. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. It was assumed that a worker's head, hands and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data

from USEPA (1997a), and averaging across gender and age, it was estimated that the exposed skin surface area for workers would be 3,300 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a; 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. For a chemical to be absorbed through the skin from soil, it must be released from the soil matrix, pass through the layers of the skin, and enter into the systemic circulation. This series of events is dependent on a number of factors including the characteristics of the chemical, the concentration in the applied dose, the site of exposure, inter-individual variability, and characteristics of soil (e.g., particle size and organic carbon content). Data regarding the amount of specific chemicals that may be absorbed through the skin under conditions normally encountered in the environment (and assumed to occur for this assessment) are lacking. While a number of approaches have been developed to estimate absorption of compounds from the soil matrix, the resulting dose estimates are highly uncertain (USEPA, 1992b, 2004a). Chemical-specific dermal absorption factors were used to estimate absorption of COPCs from soil (USEPA, 2004a). If chemical-specific information was not available, class-specific dermal absorption values were applied (USEPA, 1995b, 2003b). The dermal absorption factors include arsenic (3.0 percent) and other inorganics (1 percent).

Inhalation of Particulates from Soil by Maintenance Workers. The exposure for inhalation of COPCs in soil by maintenance workers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.2. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a maintenance worker.

The inhalation rate of 2.5 m^3 per hour for maintenance workers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day (USEPA, 2002a). It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas; however, it is unlikely that a worker would spend the entire day at just one location on the Installation every day.

Inhalation of VOCs from Groundwater by Maintenance Workers. The exposure for inhalation of COPCs in groundwater by maintenance workers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.3. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a maintenance worker.

The inhalation rate of 2.5 m^3 per hour for maintenance workers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day (USEPA, 2002a). It was conservatively assumed that VOCs inhaled during the visit would originate in the sampled areas; however, it is unlikely that a worker would spend the entire day at just one location on the Installation every day.

Current On-Site Trespasser Dose Equations and Exposure Parameters for Soil. Under current land-use conditions, trespassers could potentially be exposed to COPCs in surface soil, on-site Upper Patapsco Groundwater, surface water, and sediment. As noted previously, a drainage ditch separates the two landfill cells on-site. Exposures to surface water and sediment while wading were considered possible for the trespasser. The potential chemical doses for current on-site trespasser exposures to surface soil and groundwater at the CSL were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.3.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in Appendix G-1.

Incidental Ingestion of Soil by Trespassers. The exposure for incidental ingestion of COPCs in soil by trespassers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.1. Standard parameters were used to characterize exposures by children between 7 and 16 years of age.

Trespassers were assumed to be exposed to soil 48 days/year, assuming that the trespasser would visit the site approximately 3 days/week during the summer months and 1 day/month during the rest of the year. Duration of exposure was assumed to be 10 years, based on the age group being

evaluated (USEPA, 1991a). The body weight value used for trespassers was 45 kg (derived from USEPA, 1997a). An averaging time of 70 years was used for carcinogenic COPCs, while 10 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for trespassers was assumed to be 100 mg/day (USEPA, 1991a). It was conservatively assumed that all soil ingested by trespassers would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Trespassers. The internal dose due to dermal absorption of COPCs in soil by trespassers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.1. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a trespasser.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a trespasser's hands, forearms, lower legs, and feet would be exposed to soil. Using data from USEPA (1997a, 2004a) and averaging across gender and age, it was estimated that the exposed skin surface area for adolescent trespassers would be 4,080 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event (USEPA, 1997a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003b, 2004a) were used to estimate absorption of COPCs from soil.

Inhalation of Particulates from Soil by Trespassers. The exposure for inhalation of COPCs in soil by trespassers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.2. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a trespasser.

The inhalation rate of 0.83 m^3 per hour for trespassers was derived by dividing a daily rate of 20 m^3/day (USEPA, 1991a) by 24 hours per day. The exposure time is 7 hours per day (USEPA, 1997a). It was conservatively assumed that all soil inhaled at the site would originate in the sampled areas.

Inhalation of VOCs from Groundwater by Trespassers. The exposure for inhalation of COPCs in groundwater by trespassers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.3. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a trespasser.

The inhalation rate of 0.83 m^3 per hour for trespassers was derived by dividing a daily rate of 20 m^3/day (USEPA, 1991a) by 24 hours per day. The exposure time is 7 hours per day (USEPA, 1997a). It was conservatively assumed that all inhaled VOCs at the site would originate in the sampled areas.

Dermal Absorption of Chemicals in Surface Water by Trespassers. The internal dose due to dermal absorption of COPCs in surface water by trespassers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.4. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a trespasser.

It was assumed that the trespasser would contact surface water once per day for a period of two hours. The skin surface area available for contact is 4,080 cm^2 (USEPA, 1997a, 2004a) based on the assumption that the trespasser's hands, forearms, lower legs, and feet are exposed to surface water. This value represents an average of the 50th percentile values for male and female children (Exhibit C-1, USEPA, 2004a).

The DA_{event} is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin (K_p), and exposure time (ET). DA_{event} is calculated in the same manner for both carcinogenic and noncarcinogenic effects; however, it is calculated differently, depending

on whether a steady-state (e.g., for inorganic chemicals) or a non-steady state (e.g., for organic chemicals) approach is used. The non-steady state approach is recommended by the USEPA to account for the total amount of chemical crossing the exposed (outside) skin surface rather than the amount that has traversed the skin and entered the blood during the exposure period (e.g., under a steady-state condition). Therefore, the non-steady state approach more accurately reflects normal exposure conditions (under which a steady state often may not occur) and accounts for the dose that may enter the circulatory system after the exposure event due to the storage of chemicals in skin lipids (USEPA, 2004a).

Only inorganics were identified as COPCs in surface water. When calculating the absorbed dose for inorganics assuming steady-state conditions, it is assumed that the concentration gradient across all of the skin layers is constant and the rate that a chemical enters the skin equals the rate that it exits. Under these conditions, DA can be estimated using the following steady-state equation:

$$DA = C_w * CF_1 * CF_2 * PC * ET$$

where:

DA = dose absorbed per unit area per event (mg/cm^2-event);
C_w = chemical concentration in water (µg/L);
CF_1 = volumetric conversion factor for water (1 liter/1000 cm^3);
CF_2 = concentration conversion factor (1 mg/1000 µg);
PC = chemical-specific dermal permeability coefficient (cm/hr); and
ET = exposure time (hours/event).

The permeability coefficient is defined as a flux value, normalized for concentrations, that represents the rate at which a chemical penetrates the skin (in units of cm/hr). The default permeability coefficient for inorganics was used for all evaluated inorganics (i.e., 10^{-3} cm/hr [USEPA, 2004a]).

Organic COPCs were identified in groundwater. The absorbed dose for organics is calculated assuming non-steady state conditions. The equations applied to derive the DA_{event} values under the non-steady state assumption were dependent on the length of assumed t_{event} in relation to the time required after initial contact of a chemical with the skin for steady-state to be achieved (t*). The term t* is dependent on chemical-specific properties, and the appropriate equation to derive t* for a chemical is dependent on a dimensionless constant reflecting the partitioning properties of that chemical (USEPA, 2004a). This constant, termed B, can be derived from the dermal permeability coefficient K_p values, as follows:

$$B = K_p \frac{\sqrt{MW}}{2.6}$$

where:

B = Ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless)
Kp = Chemical-specific dermal permeability coefficient in water (cm/hr); compiled from USEPA (2004a)
MW = Chemical-specific molecular weight (g/mole)

Once B was derived, t* can be calculated using the appropriate equation below (USEPA, 2004a):

- For B ≤ 0.6:

$$t^* = 2.4 \times \tau$$

where τ = lag time (hr).

- For B > 0.6:

$$t^* = 6(b - \sqrt{b^2 - c^2}) \times \tau$$

where:

$$b = \frac{2}{\pi}(1+B)^2 - c \quad \text{and} \quad c = \frac{1+3B+3B^2}{3(1+B)}$$

The lag time (τ) is defined for the stratum corneum, the outermost layer of the skin, which is thought to provide the major resistance to the absorption into the circulatory system of chemicals deposited on the skin (USEPA, 2004a). The τ values can be derived from the following equation (USEPA, 2004a):

$$\tau = \frac{l_{sc}^2}{6D_{sc}} = 0.105 \times 10^{(0.0056 \times MW)}$$

where:

Lsc = Thickness of stratum corneum (10^{-3} cm); and,
Dsc = Diffusivity of a chemical within the stratum corneum (cm^2/hr).

The diffusivity of a chemical within the stratum corneum (D_{sc}) can be estimated from the thickness of the stratum corneum (l_{sc}) and the molecular weight (MW) of the chemical, using the following equation (USEPA, 2004a):

$$\text{Log}\frac{D_{sc}}{l_{sc}} = -2.80 - (0.0056 \times MW)$$

Once the time until steady-state (t*) has been derived, it can be compared to the assumed exposure time (t_{event}) in order to select the appropriate equation to derive the DA_{event}. If the exposure time was less than or equal to the time until steady-state (i.e., if $t_{event} \leq t^*$), the following equation was used (USEPA, 2004a):

$$DA_{event} = 2FA \times K_p \times C\sqrt{\frac{6 \times \tau \times t_{event}}{\pi}}$$

where:

FA = Chemical-specific fraction absorbed (dimensionless); compiled from USEPA (2004a).

The other variables have been previously described.

If the exposure time was greater than the time until steady-state (i.e., if $t_{event} > t^*$), then the following equation was used (USEPA, 2004a):

$$DA_{event} = FA \times C \times K_p \times \left[\frac{t_{event}}{1+B} + (2 \times \tau \times \frac{1+3B+3B^2}{(1+B)^2}) \right]$$

Each of the variables has been previously described. Parameters used to calculate DA_{event} for COPCs in this HHRA are presented in Table 6-6.

Dermal Absorption of Chemicals in Sediment by Trespassers. The internal dose due to dermal absorption of COPCs in sediment by trespassers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.5. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a trespasser.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a trespasser's hands, forearms, lower legs, and feet would be exposed to sediment, based on the likelihood that trespassers at the site will often wear shirts and shorts. Using data from USEPA (1997a, 2004a), and averaging across gender and age, it was estimated that the exposed skin surface area for trespassers would be 4,080 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a, 2004a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003b, 2004a) were used to estimate absorption of COPCs from sediment.

Future On-Site Golf Course Groundskeeper Dose Equations and Exposure Parameters. Under future land-use conditions, on-site groundskeepers at the golf course could be exposed to COPCs in surface soil, surface water, sediment, and on-site Upper Patapsco Groundwater. As previously noted, a golf course is to be constructed at the CSL. Exposures to subsurface soil and groundwater through direct contact are not likely because the groundskeepers will not be involved in digging/construction activities. However, exposure to VOCs in groundwater released to ambient air is possible. It should be noted that exposures to VOCs in total soil released to ambient air is also possible; however, there were no volatile COPCs detected in total soil. The potential chemical doses for future on-site groundskeeper exposures to surface soil and groundwater at the CSL were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.4.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for groundskeepers in Appendix G-1.

Incidental Ingestion of Soil by On-Site Golf Course Groundskeepers. The exposure for incidental ingestion of COPCs in soil by groundskeepers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.6. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (> 18 years of age).

Groundskeepers were assumed to be exposed to soil 195 days/year, based on the assumption that maintenance/inspection activities are conducted 8 hours/day for 5 days/week with the primarily from March through November (USEPA, 2007b). Duration of exposure for workers was assumed to be 25 years, a USEPA (2002a) upper-bound default estimate of the time spent working in one location. The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for workers was assumed to be 100 mg/day, a standard USEPA (2002a) default value for exposure to adults in the workplace. It was conservatively assumed that soil

ingested during the workday by groundskeepers would originate in the sampled areas; however, most workers would likely visit other areas of the golf course not near the Site. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by On-Site Golf Course Groundskeepers. The internal dose due to dermal absorption of COPCs in soil by workers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.6. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. It was assumed that a worker's head, hands and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (1997a), and averaging across gender and age, it was estimated that the exposed skin surface area for groundskeepers would be 3,300 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a; 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for the maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003b, 2004a) were used to estimate absorption of COPCs from soil.

Inhalation of Particulates from Soil by Golf Course Groundskeepers. The exposure for inhalation of COPCs in soil by groundskeepers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.7. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a maintenance worker.

The inhalation rate of 2.5 m^3 per hour for groundskeepers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day (USEPA, 2002a). It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas; however, it is unlikely that a groundskeeper would spend the entire day at just one location on the Installation every day.

Inhalation of VOCs from Groundwater by Golf Course Groundskeepers. The exposure for inhalation of COPCs in groundwater by groundskeepers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.8. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a groundskeeper.

The inhalation rate of 2.5 m^3 per hour for groundskeepers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day (USEPA, 2002a). It was conservatively assumed that VOCs inhaled during the visit would originate in the sampled areas; however, it is unlikely that a groundskeeper would spend the entire day at just one location on the golf course every day.

Dermal Absorption of Chemicals in Surface Water by On-Site Golf Course Groundskeepers. The internal dose due to dermal absorption of COPCs in surface water by groundskeepers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.9. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a groundskeeper.

It was assumed that the groundskeeper would contact surface water once per day for a period of two hours. The skin surface area available for contact is 3,300 cm^2 (USEPA, 1997a, 2004a) based on the assumption that the groundskeeper's head, hands, and forearms are exposed to surface water.

Dermal Absorption of Chemicals in Sediment by On-Site Golf Course Groundskeepers. The internal dose due to dermal absorption of COPCs in sediment by groundskeepers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.10. The parameters

describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a groundskeeper.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a groundskeeper's head, hands, and forearms would be exposed to sediment, based on the likelihood that groundskeepers at the site will often wear short-sleeve shirts and long pants. Using data from USEPA (1997a, 2004a), and averaging across gender and age, it was estimated that the exposed skin surface area for groundskeepers would be 3,300 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a, 2004a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003b, 2004a) were used to estimate absorption of COPCs from sediment.

Future On-Site Golfer Dose Equations and Exposure Parameters. Under future land-use conditions, on-site golfers could be exposed to COPCs in surface soil, surface water, sediment, and on-site Upper Patapsco Groundwater. As previously noted, a golf course is to be constructed at CSL. Exposures to subsurface soil and groundwater through direct contact are not likely because golfers will not be involved in digging/construction activities. However, exposure to VOCs in groundwater released to ambient air is possible. It should be noted that exposures to VOCs in total soil released to ambient air is also possible; however, there were no volatile COPCs detected in total soil. The potential chemical doses for future on-site golfer exposures to surface soil and groundwater at the CSL were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.4.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in Appendix G-1.

Incidental Ingestion of Soil by On-Site Golfers. The exposure for incidental ingestion of COPCs in soil by golfers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.6. Where relevant, standard adult parameters were used to characterize golfer exposures, because it is assumed that most golfers at the site will be adults (> 18 years of age).

Golfers were assumed to be exposed to soil 50 days/year, based on the assumption that they would play golf for an average of 2 days/week during the summer months, 1 day/week during spring and fall, and would take one week vacation in summer, thereby missing 2 days. Duration of exposure for golfers was assumed to be 25 years, a USEPA (2002a). The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for golfers was assumed to be 100 mg/day, a standard USEPA (2002a) default value for exposure to adults in the workplace. It was conservatively assumed that soil ingested by golfers would originate in the sampled areas; however, most golfers would likely visit other portions of the golf course. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by On-Site Golfers. The internal dose due to dermal absorption of COPCs in soil by golfers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.6. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a golfer.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. It was assumed that a golfer's head, hands, forearms, and lower legs would be exposed to soil, based on the likelihood that workers at the site may wear long pants and short-sleeve shirts and shorts. Using data from USEPA (1997a), and averaging across gender and age, it was estimated that the

exposed skin surface area for golfers would be 6,160 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a; 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed does is described in the previous section for the maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003b, 2004b) were used to estimate absorption of COPCs from soil.

Inhalation of Particulates from Soil by Golfers. The exposure for inhalation of COPCs in soil by golfers was calculated using the equation and the exposure parameters presented in Appendix G-1,Table 4.7. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a golfer.

The inhalation rate of 2.5 m^3 per hour for golfers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour day. The exposure time is 8 hours per day (USEPA, 2002a). It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas; however, it is unlikely that a golfer would spend the entire day at just one location on the golf course every day.

Dermal Absorption of Chemicals in Surface Water by On-Site Golfers. The internal dose due to dermal absorption of COPCs in surface water by golfers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.9. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a golfer.

It was assumed that the golfer would contact surface water once per day for a period of two hours. The skin surface area available for contact is 5,672 cm^2 (USEPA, 1997a, 2004a) based on the assumption that the golfer's hands, forearms, lower legs, and feet are exposed to surface water.

Dermal Absorption of Chemicals in Sediment by On-Site Golfers. The internal dose due to dermal absorption of COPCs in sediment by golfers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.10. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a golfer.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a golfer's hands, forearms, lower legs, and feet would be exposed to sediment, based on the likelihood that golfers at the site may wear short-sleeve shirts and shorts. Using data from USEPA (1997a, 2004a), and averaging across gender and age, it was estimated that the exposed skin surface area for groundskeepers would be 5,672 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a, 2004a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003b, 2004a) were used to estimate absorption of COPCs from sediment.

Future On-Site Club House Worker Dose Equations and Exposure Parameters.

Inhalation of COPCs in Groundwater via Vapor Intrusion by a club house worker. ADDs due to inhalation of VOC COPCs in groundwater that could migrate into a club house were calculated for adult workers (aged 18 through 70) using the equations and exposure parameters presented in Appendix G-1, Table 4.11. The concentration of COPCs in indoor air was calculated by using the Johnson and Ettinger (USEPA, 2003a) Vapor Intrusion Model, as discussed in Section 6.4.2. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater by an adult worker. The inhalation rate was estimated to be

0.83 m^3/hour, which was determined by dividing the adult daily inhalation rate of 20 m^3/day (USEPA, 1991a) by 24 hours/day. It was assumed that the ET was 8 hours/day.

Although it is also possible that COPCs in soil could migrate into the club house, there were no volatile COPCs in total soil.

Future On-Site and Off-Site Construction Worker Dose Equations and Exposure Parameters. Under both future land-use conditions, construction workers could be exposed to COPCs in total soil, surface water, sediment, and on-site Upper Patapsco Groundwater. As previously noted, the site is the location of a closed and capped landfill, however, a golf course is to be constructed at CSL. Exposures to surface soil across the entire site, subsurface soil from Cell No. 3, surface water, sediment, and groundwater through direct contact could occur during future digging/construction activities. In addition, exposure to VOCs in groundwater released into an excavation or utility trench is possible. It should be noted that exposures to VOCs in total soil is also possible; however, there were no volatile COPCs detected in total soil. The potential chemical doses for future on-site construction worker exposures to total soil, surface water, sediment, and groundwater at the CSL were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.4.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in Appendix G-1.

Incidental Ingestion of Soil by Construction Workers. The exposure for incidental ingestion of COPCs in soil by construction workers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.12. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (> 18 years of age).

Construction workers were assumed to be exposed to soil 125 days/year. Duration of exposure for construction workers was assumed to be 1 year. The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 1 year was used for noncarcinogenic COPCs.

The daily soil ingestion rate for construction workers was assumed to be 330 mg/day, a standard USEPA (2002a) default value for exposure during construction activities. It was conservatively assumed that soil ingested during the workday by construction workers would originate in the sampled areas; however, most construction workers would likely visit other portions of the CSL. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Construction Workers. The internal dose due to dermal absorption of COPCs in soil by construction workers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.12. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. It was assumed that a construction worker's head, hands and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (1997a), and averaging across gender and age, it was estimated that the exposed skin surface area for workers would be 3,300 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a; 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for the maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003b, 2004a) were used to estimate absorption of COPCs from soil. The dermal absorption factors for total soil include arsenic (3 percent), other inorganics (1 percent), and PCBs (14 percent).

Inhalation of Particulates from Soil by Construction Workers. The exposure for inhalation of COPCs in soil by construction workers was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.13. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a construction worker.

The inhalation rate of 2.5 m^3 per hour for construction workers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day (USEPA, 2002a). It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas; however, it is unlikely that a construction worker would spend the entire day at just one location on the CSL every day.

Dermal Absorption of Chemicals in Surface Water by Construction Workers. The internal dose due to dermal absorption of COPCs in surface water by construction workers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.9. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a construction worker.

It was assumed that the construction worker would contact surface water once per day for a period of two hours. The skin surface area available for contact is 3,300 cm^2 (USEPA, 1997a, 2004a) based on the assumption that the worker's head, hands, and forearms are exposed to surface water.

Dermal Absorption of Chemicals in Sediment by Construction Workers. The internal dose due to dermal absorption of COPCs in sediment by construction workers was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.10. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a construction worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a construction worker's head, hands, and forearms would be exposed to sediment, based on the likelihood that construction workers at the site will often wear short-sleeve shirts and long pants. Using data from USEPA (1997a, 2004a), and averaging across gender and age, it was estimated that the exposed skin surface area for construction workers would be 3,300 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997a, 2004a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003b, 2004a) were used to estimate absorption of COPCs from sediment.

Dermal Absorption of COPCs in Groundwater by Construction Workers. ADDs due to dermal absorption of COPCs in groundwater by construction workers during work in an excavation or utility trench were calculated using the equations and exposure parameters presented in Appendix G-1, Table 4.14. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of soil by a construction worker.

It was assumed that the event time would be 2 hours/day. The skin surface area available for contact is 3,300 cm^2, which is based on the assumption that the head, hands, and forearms are exposed to groundwater during work in the trench. This value represents an average of the 50th percentile surface area values for adult males and females (USEPA, 2004a). The absorbed dose was calculated using the method presented earlier (USEPA, 2004a) to evaluate dermal absorption of COPCs in surface water by trespassers. The chemical/physical properties used in the calculation of DA event are listed in **Table 6-6.**

Inhalation of COPCs in Groundwater by a Construction/Utility Worker. ADDs due to inhalation of VOC COPCs in groundwater by construction/utility workers due to vapors generated during work in a trench or a pit were calculated using the equations and exposure parameters presented in Appendix G-1,

Table 4.15. The concentrations of COPCs in a trench or pit were calculated using the trench model, as discussed in Section 6.4.2.

Workers were assumed to be exposed to groundwater 125 days/year. Duration of exposure for workers was assumed to be 1 year. The body weight value used for workers was 70 kg, the standard USEPA (1991a, 2002a) default value for adult body weight. It was assumed that the exposure time was 2 hours/day. The inhalation rate was estimated to be 2.5 m^3/hour, which was determined by dividing the adult daily inhalation rate of 20 m^3/day (USEPA, 1997a) by 8 hours/day.

Future On-Site Adult Resident Dose Equations and Exposure Parameters. Under future land-use conditions, on-site adult residents could potentially be exposed to COPCs in on-site total soil and Upper Patapsco groundwater and Lower Patapsco groundwater through household use or vapor intrusion into residences. The potential chemical doses for future adult resident exposures to groundwater were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.3.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in Appendix G-1.

Incidental Ingestion of Soil by Adult Residents. The exposure for incidental ingestion of COPCs in total soil by adult residents was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.16. Standard parameters were used to characterize adult exposures (> 18 years of age).

Adult residents were assumed to be exposed to total soil 350 days/year, a standard USEPA (1991a) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for residents was assumed to be 30 years, a USEPA (1991a) upper-bound default estimate of the time spent residing in one location. The body weight value used for adult residents was 70 kg, the standard USEPA (1991a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 30 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for adult residents was assumed to be 100 mg/day, a standard USEPA (1991a) default value for exposure to soil for the residential scenario. It was conservatively assumed that soil ingested during time at home by residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Adult Residents. The internal dose due to dermal absorption of COPCs in total soil by adult residents was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.16. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an adult resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a resident's head, hands, arms, and lower legs would be exposed to soil. Using data from USEPA (Tables 6-2 and 6-3; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for adult residents would be 5,700 cm^2. The soil-to-skin adherence factor was assumed to be 0.07 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997b; 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from total soil, as described for construction worker exposures.

Inhalation of Particulates from Soil by Adult Residents**.** The exposure for inhalation of COPCs in total soil by adult residents was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.17. The parameters describing the frequency of exposure, duration of exposure,

body weight, and averaging time are identical to those used for estimating the ingestion of soil by an adult resident.

The inhalation rate of 0.83 m^3 per hour for adult residents was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by 24 hours per day. Based on best professional judgment, an exposure time of 8 hours per day was used. It was conservatively assumed that soil inhaled at the residence would originate in the sampled areas.

Ingestion of COPCs in Groundwater by an Adult Resident. ADDs due to ingestion of chemicals in groundwater during household use by residents were calculated using the equations and exposure parameters presented in Appendix G-1, Table 4.18. Residents were assumed to be exposed to groundwater 350 days/year, assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation away from home). Duration of exposure for residents was assumed to be 30 years (USEPA, 1991a, 2003b). The body weight value used for adults was 70 kg, the standard USEPA (1991a, 2003c) default value for adult body weight. The water ingestion rate used for an adult resident was 2 L/day (USEPA, 1991a, 2003b).

Dermal Absorption of COPCs in Groundwater by an Adult Resident. ADDs due to dermal absorption of COPCs in groundwater by adult residents during bathing or showering were calculated using the equations and exposure parameters presented in Appendix G-1, Table 4.18. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of groundwater by an adult resident.

It was assumed that one shower would be taken per day (i.e., event frequency equals one) (USEPA, 2004a). The skin surface area available for contact is 18,000 cm^2, which is based on the assumption that the total body area is exposed to groundwater while bathing or showering. This value represents an average of the 50th percentile surface area values for adult males and females (USEPA, 2004a). The absorbed dose was calculated using the method presented earlier (USEPA, 2004a) to evaluate dermal absorption of COPCs in surface water by trespassers.

Inhalation of COPCs in Groundwater during Shower by an Adult Resident. Potential doses due to inhalation of chemicals in groundwater due to vapors generated during showering were calculated for adult residents. The concentrations of COPCs in shower room air were calculated using the Foster and Chrostowski (1987) Shower Inhalation Model, as discussed in Section 6.4.2. The dose equation and exposure parameters are presented in Appendix G-1, Table 4.19. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater by an adult resident.

The inhalation rate was estimated to be 0.83 m^3/hour, which was determined by dividing the adult daily inhalation rate of 20 m^3/day (USEPA, 1991a) by 24 hours/day. It was assumed that the ET was 65 minutes/day (1.08 hours/day), which assumes 35 minutes is spent showering (based on the 95th percentile value for overall showering time) and an additional 30 minutes is spent in the shower room (USEPA, 2004a).

Inhalation of COPCs in Groundwater via Vapor Intrusion by an Adult Resident. ADDs due to inhalation of VOC COPCs in groundwater that could migrate into future residences were calculated for adult residents (aged 18 through 70) using the equations and exposure parameters presented in Appendix G-1, Table 4.19. The concentration of COPCs in indoor air was calculated by using the Johnson and Ettinger (USEPA, 2003a) Vapor Intrusion Model, as discussed in Section 6.4.2. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater by an adult resident. The inhalation rate was estimated to be 0.83 m^3/hour, which was determined by dividing the adult daily inhalation rate of 20 m^3/day (USEPA, 1991a) by 24 hours/day. It was assumed that the ET was 24 hours/day (Johnson and Ettinger, 1991).

Future On-Site Child Resident Dose Equations and Exposure Parameters. Under future land-use conditions, on-site child residents could potentially be exposed to COPCs in on-site in total soil, surface water, sediment, and Upper Patapsco groundwater and Lower Patapsco groundwater through household use or vapor intrusion into residences. The potential chemical doses for future child resident exposures to

groundwater were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.3.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables in Appendix G-1.

Incidental Ingestion of Soil by Child Residents. The exposure for incidental ingestion of COPCs in total soil by child residents was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.16. Standard parameters were used to characterize exposures by children of 6 years of age or less.

Child residents were assumed to be exposed to total soil 350 days/year, a standard USEPA (1991a) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for children was assumed to be 6 years (USEPA, 1991a). The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for a child's body weight averaged over 0 to 6 years of age. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for child residents was assumed to be 200 mg/day, a standard USEPA (1991a) default value for exposure to soil for the children of 6 years of age and under. It was conservatively assumed that soil ingested during time at home by child residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Child Residents. The internal dose due to dermal absorption of COPCs in total soil by child residents was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.16. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a child resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a child's head, hands, forearms, lower legs, and feet would be exposed to soil. Using data from USEPA (USEPA Tables 6-6, 6-7, 6-8; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for child residents would be 2,800 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997b, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from soil.

Inhalation of Particulates from Soil by Child Residents. The exposure for inhalation of COPCs in total soil by child residents was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.17. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a child resident.

The inhalation rate of 0.5 m^3 per hour for child residents was based the recommended value for light activities (USEPA Table 5-23; USEPA, 1997b). Based on best professional judgment, an exposure time of 8 hours per day was used. It was assumed that children under the age of 6 years year old are likely to be accompanied or supervised by an adult during their time spent outdoors. Therefore, the exposure time was assumed to be equivalent to that of the adult resident. It was conservatively assumed that soil inhaled at the residence would originate in the sampled areas.

Incidental Ingestion of Sediment by Child Residents. It was assumed that exposure to sediment in the drainage ways via ingestion is expected to be negligible while wading. Therefore, the ingestion pathway was not quantitatively evaluated for this pathway.

Dermal Absorption of Chemicals in Sediment by Child Residents. The internal dose due to COPCs in sediment by child residents was calculated using the equation and the exposure parameters presented in Appendix G-1, Table 4.10. Standard parameters were used to characterize exposures by children of 6 years of age or less.

Child residents were assumed to be exposed to sediment for 48 days/year, assuming that a child under 6 years of age would be accompanied by an adult while wading. Duration of exposure for children was assumed to be 6 years (USEPA, 1991a). The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for a child's body weight averaged over 0 to 6 years of age. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of sediment adhering to the skin, and the amount of chemical absorbed through the skin from sediment. It was assumed that a child's head, face, hands, forearms, lower legs, and feet would be exposed to sediment. Using data from USEPA (USEPA Tables 6-6, 6-7, 6-8; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for child residents would be 2,800 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from sediment.

Incidental Ingestion of Surface Water by Child Residents. It was assumed that exposure to surface water in the drainage ways via ingestion is expected to be negligible while wading. Therefore, the ingestion pathway was not quantitatively evaluated for this receptor.

Dermal Absorption of Chemicals in Surface Water by Child Residents**.** The internal dose due to dermal absorption of COPCs in surface water by child residents was estimated using the equation and the exposure parameters presented in Appendix G-1, Table 4.9. Where relevant, standard parameters were used to characterize child exposures (> 6 years of age).

Child residents were assumed to be exposed to surface water for 48 days/year, based on the assumption that the child under 6 years of age would be accompanied by an adult while wading and, therefore, would have an exposure frequency similar to an adult resident. The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for child body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

It was assumed that the child resident would contact surface water once per day for a period of two hours. The skin surface area available for contact with surface water is 2,800 cm^2 (USEPA, 1997b) based on the assumption that the head, hands, forearms, lower legs, and feet are exposed to surface water while wading. This value represents an average of the 50th percentile values for males and females (Tables 6-6 and 6-7, USEPA, 1997b).

Ingestion of COPCs in Groundwater by a Child Resident. ADDs due to ingestion of chemicals in groundwater during household use by children were calculated using the equations and exposure parameters presented in Appendix G-1, Table 4.18. Children were assumed to be exposed to groundwater 350 days/year, assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation away from home). Duration of exposure for children was assumed to be 6 years (USEPA, 1991a, 2003c), representing the age period of concern (6 years total). The body weight value used for children was 15 kg, the standard USEPA (1991a, 2003c) default value for a child's body weight averaged over ages 0 to 6. The water ingestion rate used for a child resident was 1 L/day, as recommended by USEPA (2003c).

Dermal Absorption of COPCs in Groundwater by a Child Resident. ADDs due to dermal absorption of COPCs in groundwater by child residents during bathing were calculated using the

equations and exposure parameters presented in Appendix G-1, Table 4.18. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of groundwater by a child resident.

It was assumed that one bath would be taken per day (i.e., event frequency equals one) (USEPA, 2004a) for an exposure time of 60 minutes (1.0 hour) (USEPA, 2004a). The skin surface area available for contact is 6,600 cm^2 based on the assumption that the total body area is exposed to groundwater while bathing. This value represents an average of the 50th percentile surface area values for males and females up to 6 years of age (USEPA, 2004a). The absorbed dose was calculated using the method presented earlier (USEPA, 2004a) to evaluate dermal absorption of COPCs in surface water by trespassers.

Inhalation of COPCs in Groundwater via Vapor Intrusion by a Child Resident. ADDs due to inhalation of VOC COPCs in groundwater that could migrate into future residences were calculated for child residents (aged 0 through 6 years) using the equations and exposure parameters presented in Appendix G-1, Table 4.19. The concentrations of COPCs in indoor air were calculated by using the Johnson and Ettinger (USEPA, 2003a) Vapor Intrusion Model, as discussed in Section 6.4.2. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater for a child resident.

The inhalation rate was estimated to be 0.5 m^3/hour, which was determined by dividing the child's daily inhalation rate of 12 m^3/day (USEPA, 2003c) by 24 hours/day. It was assumed that the ET was 24 hours/day (Johnson and Ettinger, 1991).

Future Off-Site Adult Resident Dose Equations and Exposure Parameters for Groundwater. Under future land-use conditions, off-site adult residents could potentially be exposed to COPCs in off-site Upper Patapsco groundwater and Lower Patapsco groundwater through household use or vapor intrusion into residences. The potential chemical doses for future off-site adult resident exposures to groundwater were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.3.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in Appendix G-1.

Ingestion of COPCs in Groundwater by an Adult Resident. ADDs due to ingestion of chemicals in groundwater during household use by residents were calculated using the equations and exposure parameters presented in Appendix G-1 Table 4.20. Residents were assumed to be exposed to groundwater 350 days/year, assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation away from home). Duration of exposure for residents was assumed to be 30 years (USEPA, 1991a, 2003b). The body weight value used for adults was 70 kg, the standard USEPA (1991a, 2003c) default value for adult body weight. The water ingestion rate used for an adult resident was 2 L/day (USEPA, 1991a, 2003b).

Dermal Absorption of COPCs in Groundwater by an Adult Resident. ADDs due to dermal absorption of COPCs in groundwater by adult residents during bathing or showering were calculated using the equations and exposure parameters presented in Appendix G-1 Table 4.20. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of groundwater by an adult resident.

It was assumed that one shower would be taken per day (i.e., event frequency equals one) (USEPA, 2004a). The skin surface area available for contact is 18,000 cm^2, which is based on the assumption that the total body area is exposed to groundwater while bathing or showering. This value represents an average of the 50th percentile surface area values for adult males and females (USEPA, 2004a). The absorbed dose was calculated using the method presented earlier (USEPA, 2004a) to evaluate dermal absorption of COPCs in surface water by trespassers.

Inhalation of COPCs in Groundwater during Shower by an Adult Resident. Potential doses due to inhalation of chemicals in groundwater due to vapors generated during showering were calculated for adult residents. The concentrations of COPCs in shower room air were calculated using the Foster and

Chrostowski (1987) Shower Inhalation Model, as discussed in Section 6.4.2. The dose equation and exposure parameters are presented in Appendix G-1 Table 4.21. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater by an adult resident.

The inhalation rate was estimated to be 0.83 m^3/hour, which was determined by dividing the adult daily inhalation rate of 20 m^3/day (USEPA, 1991a) by 24 hours/day. It was assumed that the ET was 65 minutes/day (1.08 hours/day), which assumes 35 minutes is spent showering (based on the 95th percentile value for overall showering time) and an additional 30 minutes is spent in the shower room (USEPA, 2004a).

Inhalation of COPCs in Groundwater via Vapor Intrusion by an Adult Resident. ADDs due to inhalation of VOC COPCs in groundwater that could migrate into future residences were calculated for adult residents (aged 18 through 70) using the equations and exposure parameters presented in Appendix G-1 Table 4.21. The concentration of COPCs in indoor air was calculated by using the Johnson and Ettinger (USEPA, 2003a) Vapor Intrusion Model, as discussed in Section 6.4.2. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater by an adult resident. The inhalation rate was estimated to be 0.83 m^3/hour, which was determined by dividing the adult daily inhalation rate of 20 m^3/day (USEPA, 1991a) by 24 hours/day. It was assumed that the ET was 24 hours/day (Johnson and Ettinger, 1991).

Future Off-Site Child Resident Dose Equations and Exposure Parameters for Groundwater. Under future land-use conditions, off-site child residents could potentially be exposed to COPCs in off-site Upper Patapsco groundwater and Lower Patapsco groundwater through household use or vapor intrusion into residences. The potential chemical doses for future off-site child resident exposures to groundwater were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.3.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables in Appendix G-1.

Ingestion of COPCs in Groundwater by a Child Resident. ADDs due to ingestion of chemicals in groundwater during household use by children were calculated using the equations and exposure parameters presented in Appendix G-1 Table 4.20. Children were assumed to be exposed to groundwater 350 days/year, assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation away from home). Duration of exposure for children was assumed to be 6 years (USEPA, 1991a, 2003c), representing the age period of concern (6 years total). The body weight value used for children was 15 kg, the standard USEPA (1991a, 2003c) default value for a child's body weight averaged over ages 0 to 6. The water ingestion rate used for a child resident was 1 L/day, as recommended by USEPA (2003c).

Dermal Absorption of COPCs in Groundwater by a Child Resident. ADDs due to dermal absorption of COPCs in groundwater by child residents during bathing were calculated using the equations and exposure parameters presented in Appendix G-1 Table 4.20. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of groundwater by a child resident.

It was assumed that one bath would be taken per day (i.e., event frequency equals one) (USEPA, 2004a) for an exposure time of 60 minutes (1.0 hour) (USEPA, 2004a). The skin surface area available for contact is 6,600 cm^2 based on the assumption that the total body area is exposed to groundwater while bathing. This value represents an average of the 50th percentile surface area values for males and females up to 6 years of age (USEPA, 2004a). The absorbed dose was calculated using the method presented earlier (USEPA, 2004a) to evaluate dermal absorption of COPCs in surface water by trespassers.

Inhalation of COPCs in Groundwater via Vapor Intrusion by a Child Resident. ADDs due to inhalation of VOC COPCs in groundwater that could migrate into future residences were calculated for child residents (aged 0 through 6 years) using the equations and exposure parameters presented in

Appendix G-1 Table 4.21. The concentrations of COPCs in indoor air were calculated by using the Johnson and Ettinger (USEPA, 2003a) Vapor Intrusion Model, as discussed in Section 6.4.2. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater for a child resident.

The inhalation rate was estimated to be 0.5 m^3/hour, which was determined by dividing the child's daily inhalation rate of 12 m^3/day (USEPA, 2003c) by 24 hours/day. It was assumed that the ET was 24 hours/day (Johnson and Ettinger, 1991).

Future Off-Site Construction Worker Dose Equations and Exposure Parameters for Groundwater. Under future land-use conditions, off-site construction/utility workers could potentially be exposed to COPCs in off-site Upper Patapsco Groundwater. As mentioned previously, direct contact with groundwater is unlikely due to its depth. However, exposure to VOCs in groundwater released to trench air is possible. The potential chemical doses for future off-site construction worker exposures to groundwater were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in Section 6.4.2, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in Appendix G-1.

Inhalation of COPCs in Groundwater by a Construction/Utility Worker. ADDs due to inhalation of VOC COPCs in groundwater by construction/utility workers due to vapors generated during work in a trench or a pit were calculated using the equations and exposure parameters presented in Appendix G-1 Table 4.21. The concentrations of COPCs in a trench or pit were calculated using the trench model, as discussed in Section 6.4.2.

Workers were assumed to be exposed to groundwater 125 days/year (VDEQ, 2006). Duration of exposure for workers was assumed to be 1 year (VDEQ, 2006). The body weight value used for workers was 70 kg, the standard USEPA (1991a, 2002a) default value for adult body weight. It was assumed that the exposure time was 4 hours/day (VDEQ, 2006). The inhalation rate was estimated to be 2.5 m^3/hour, which was determined by dividing the adult daily inhalation rate of 20 m^3/day (USEPA, 1997a) by 8 hours/day.

6.5 HUMAN HEALTH TOXICITY ASSESSMENT

The general methodology for the classification of health effects and the development of health effects criteria is described in Section 6.5.1 to provide the analytical framework for the characterization of human health risks. In Section 6.5.2, the health effects criteria, or toxicity values, used to derive estimates of risk are presented. These values are combined with dose information for each complete exposure pathway quantitatively evaluated to characterize risks associated with exposures to COPCs in environmental media at the CSL (Section 6.6).

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA (1986a,b; 1989; 1997b; 2003d; 2004c). The health effects analysis considers chronic (long-term) exposures. While some sources were used to obtain toxicity values for the soil and groundwater HHRAs, USEPA published the following hierarchy for these sources in 2003 (USEPA, 2003d):

- Tier 1 – Integrated Risk Information System (IRIS) (USEPA, 2005c, 2007a).
- Tier 2 – Provisional Peer Reviewed Toxicity Values (PPRTVs) – as developed on a chemical-specific basis by the Office of Research and Development/National Center for Environmental Assessment (NCEA)/Superfund Health Risk Technical Support Center (USEPA, 2003d). Because access to PPRTV is limited (USEPA, 2004c), these values were obtained directly from USEPA Region III's RBC table (USEPA, 2005a; 2006).
- Tier 3 – Other Toxicity Values – including additional USEPA and non-USEPA sources of toxicity information. This tier includes the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b).

6.5.1 Health Effects Classification And Criteria Development

According to USEPA's science policy, there are two primary approaches to developing toxicity values or health criteria. The non-threshold approach is based on USEPA's scientific policy position that a small number of molecular events can evoke changes in a single cell, or a small number of cells. This is described as a non-threshold initiator mechanism, because there is essentially no level of exposure (i.e., a threshold) to a constituent that will not result in some finite possibility of causing an adverse effect. Another assumption stemming from USEPA's science policy is that the dose-response curve is linear at low doses. For most carcinogens, toxicity values are based on the non-threshold approach.

The threshold approach is based on the assumption that organisms have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the adverse effect is manifested. For example, an organ can have a large number of cells performing the same or similar functions that must be significantly depleted before the effect on the organ is realized. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects. Toxicity values for noncarcinogenic effects are based on the threshold approach. Furthermore, as additional information regarding the mechanisms of toxicity becomes available, the threshold approach does apply to some carcinogens (e.g., chloroform).

6.5.1.1 Health Effects Criteria for Potential Carcinogens

For carcinogens, USEPA estimates the excess lifetime cancer risks associated with various levels of exposure by developing cancer slope factors (CSFs) and unit risks. CSFs are expressed in terms of reciprocal dose, as units of (mg chemical/kg body weight-day)$^{-1}$, which describes the upper-bound increase in an individual's risk of developing cancer over a 70-year lifetime per unit of exposure. Unit risks are expressed either as a reciprocal air concentration, in units of (µg/m^3)$^{-1}$, or as a reciprocal drinking water concentration, in units of (µg/L)$^{-1}$. Similarly, they are defined as the excess probability of an individual developing cancer over a 70-year lifetime as a result of exposure to one unit of concentration in air or water. Because regulatory efforts are geared to be protective of public health, including even the most sensitive members of the population, the CSFs are derived using conservative assumptions.

CSFs and unit risks are derived from the results of human epidemiological studies or chronic animal bioassays. The animal studies usually must be conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed to doses lower than those used in the animal studies, the potential cancer risks at lower doses are estimated by using mathematical models. The data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response relationship. In general, after the data are fit to the dose-response model, the 95% UCL of the slope of the resulting dose-response relationship at low doses is calculated. This upper-bound limit is subjected to various adjustments, and an interspecies scaling factor is applied to derive the slope factor or unit risk for humans. Thus, the actual risks associated with a given intake of a potential carcinogen quantitatively evaluated based on animal data are generally regarded as not likely to exceed the risks estimated using these CSFs or unit risks, and they may be as low as zero (USEPA, 1986a). Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves. These models provide rough, but plausible, estimates of the upper limits on lifetime risk. CSFs and unit risks based on human epidemiological data are derived using conservative assumptions and, as such, they too are unlikely to underestimate risks for a given level of exposure.

Weight-of-evidence categories represent an assessment of the amount and quality of the data, which support the finding that specific chemicals and elements can cause cancer in humans. Although USEPA's guidelines for carcinogen risk assessment (USEPA, 1996b, 1999, 2005b) propose a weight-of-evidence narrative, IRIS currently uses the original alphanumeric classification. Under the existing guidelines (USEPA, 1986a), chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A includes those substances for which high-quality studies have demonstrated a relationship between the exposure to the substance in question and the development of cancer in human populations. Groups B1, B2, and C represent chemicals with limited (B1) or insufficient (B2) human evidence of carcinogenicity, and sufficient (B1, B2) or insufficient (C) animal data. Group D substances are those for which there is insufficient or no evidence of carcinogenicity in humans or

animals, while Group E substances are those for which no evidence of carcinogenicity is available in adequate human or animal studies.

6.5.1.2 Health Effects Criteria for Noncarcinogens

Health effects criteria for chemicals exhibiting noncarcinogenic effects are generally developed using verified risk reference doses (RfDs) and reference concentrations (RfCs). These are developed by USEPA and listed in IRIS (USEPA, 2005c), or can be obtained from HEAST (USEPA, 1997b) and supplements. The RfD is expressed in units of dose (mg chemical/kg body weight-day) and is usually derived either from human studies involving workplace exposures or from animal studies. The RfDs are estimates (with uncertainty spanning perhaps several orders of magnitude) of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is used as a reference point for gauging the potential effects of exposures. Usually, exposures (as chemical intakes or doses) that are less than the RfD are not likely to be associated with adverse health effects. As the frequency and/or magnitude of the exposures exceeding the RfD increase, the probability of adverse effects in a human population increases.

RfDs are developed for both chronic and subchronic exposures. Chronic RfDs are presented in IRIS or HEAST and are intended for use in evaluating exposures of durations greater than seven years. Subchronic RfDs are developed by USEPA's NCEA and are used to characterize the potential for the occurrence of noncarcinogenic effects associated with short-term exposures [two weeks to seven years as defined by USEPA (1989)]. The subchronic RfDs are developed similarly to chronic RfDs, and are typically equal to chronic RfDs or are one order of magnitude greater (less stringent). The subchronic RfDs are presented in HEAST, but they are no longer being reviewed and updated in the same manner as IRIS. Because there is greater uncertainty associated with the subchronic RfDs, chronic RfDs have conservatively been used in this HHRA.

The RfDs are derived using uncertainty factors that reflect scientific judgment regarding the various types of data used to estimate the RfD. RfDs are typically estimated from no observable adverse effect levels (NOAELs) or lowest observable adverse effect levels (LOAELs) in human or animal studies. Uncertainty factors, generally 10-fold factors, are intended to account for:

- The variation in sensitivity among members of the human population;
- The uncertainty in extrapolating animal data to the case of humans;
- The uncertainty in extrapolating from data obtained in a study that is less-than-lifetime exposure;
- The uncertainty in using LOAEL data, when necessary, rather than NOAEL data; and,
- The inability of a single study to adequately address every possible adverse outcome in humans.

To derive RfDs, NOAELs or LOAELs are divided by one or more uncertainty factors, as appropriate. When taken together, these uncertainty factors may confer an extra margin of safety of up to a factor of 10,000 below an LOAEL. In some cases, modifying factors are also applied to RfDs to take into account other uncertainties in the toxicity database and reflect the professional judgment of those reviewing the database. The net result is that RfDs are generally considered to provide a conservative estimate of the likelihood of adverse noncarcinogenic effects.

6.5.2 Health Effects Criteria For Individual COPCs

Health effects criteria for chronic exposures to COPCs in soil, surface water, sediment, and groundwater via the oral route of exposure are presented in Appendix G-1 Tables 5-1 and 6-1. Health effects criteria for chronic exposures to COPCs in groundwater and soil, respectively, via the inhalation of VOCs and particulate matter are presented in Appendix G-1 Tables 5-2 and 6-2. For those chemicals that were added to this HHRA for the recreational and residential scenarios, toxicity criteria were obtained from the most current sources of toxicity values (EPA, 2006; EPA, 2007a). Toxicity criteria from the original HHRA were also updated in response to USEPA review comments (USEPA, 2005e). All other toxicity criteria in the original HHRA were obtained from sources in 2005. Chemical-specific guidance was also used, if applicable, for individual COPCs. The following chemical-specific guidance was also used.

Chromium. The toxic effects associated with chromium are dependent upon its valence state (USEPA, 1998). Two common forms of chromium are trivalent chromium (chromium III) and hexavalent chromium (chromium VI). Chromium III is the predominant form of chromium in nature and is the less toxic of the two forms. Hexavalent chromium is the more toxic form of chromium and is considered to be a Class A carcinogen via the route of inhalation. The speciation of hexavalent chromium (Cr VI) is not routinely performed during a sampling program due to the very short holding time and the unique stability issues associated with hexavalent chromium (i.e., it tends to change valence states very easily after sample collection). Unless there is convincing evidence that hexavalent chromium may be present at a site (such as its for control of scale in non-contact cooling water piping for a power plant or a chromium plating operation), it is generally not included in an analytical program. For the CSL, hexavalent chromium analyses were not performed for the environmental media samples. To be conservative, it was assumed that the majority of the chromium that was detected at the site would be in the hexavalent form.

***Iron*.** A “margin of exposure” evaluation was performed in cases where iron concentrations in soil or water resulted in an HQ greater than 0.5. Hazards associated with exposures to iron were characterized by comparing the estimated iron intake with the RDA and concentrations known to cause adverse effects in children (USEPA, 1996c).

Lead. Quantitative oral toxicity criteria were available from IRIS (USEPA, 2005c), HEAST (USEPA, 1997b), or USEPA's NCEA for the majority of the COPCs, with the exception of lead, which was selected as a COPC in groundwater at or downgradient from the CSL. The potential risks associated with residential exposures to lead are addressed using the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model for Windows®, Version 1.0, Build 261 (USEPA, 1994b, 2002c, 2004d). The IEUBK model was designed to provide predictions of the probability of elevated blood lead levels for children. This model addresses three components of environmental risk assessments: the multimedia nature of exposures to lead, lead pharmacokinetics, and significant variability in exposure and risk, through estimation of probability distributions of blood lead levels for children exposed to similar environmental concentrations. The arithmetic mean of the lead concentration in groundwater and the default lead concentration in soil were used in conjunction with the default input parameters to represent site-specific exposures to lead. The predicted geometric mean blood lead level and the percent of the population potentially experiencing concentrations above 10 μg/dl (below which adverse manifestations are not expected) are provided in Section 6.6 and Tables 6-7, 6-8, and 6-9. Percentages below 5 percent are considered to be protective of human health. The corresponding input parameters and the distribution probability plot from the model are included with the table.

6.5.2.1 Adjusted Oral Toxicity Criteria

Toxicity criteria have not been developed by USEPA specifically for the dermal absorption route of exposure; instead, oral health effects criteria are adjusted to assess this pathway. In order to have a meaningful comparison between the dermal absorption dose estimates, which represent internal (or absorbed) doses, and oral toxicity criteria, which typically represent potential (or administered) doses, toxicity criteria are modified to represent absorbed doses. The method for modifying toxicity criteria involves determination of an absolute oral absorption factor for each chemical and use of this value to increase the chemical's CSF or to decrease the chemical's RfD, as shown in the following equations:

$$(\text{CSF}) / (\text{Absolute oral absorption factor}) = \text{Adjusted Dermal CSF}$$
$$(\text{RfD}) \times (\text{Absolute oral absorption factor}) = \text{Adjusted Dermal RfD}$$

The absolute oral absorption factors that are applied should reflect the specific conditions under which the toxicological study was conducted (e.g., method of administration such as gavage, water or diet, and vehicle of administration such as solvent or solution). The absolute oral absorption factors and adjusted toxicity criteria for the COPCs used when evaluating dermal absorption are also presented in Appendix G-1 Tables 5-1 and 6-1. The adjusted CSFs and RfDs presented in these tables were used to evaluate potential risks associated with dermal absorption exposures.

6.6 HUMAN HEALTH RISK CHARACTERIZATION

In this section, the potential human health cancer risks and noncancer hazards associated with selected human exposure pathways are calculated and detailed results are provided in Appendix G-1 Tables 7.1 through 7.11b for non-cancer hazards and in Tables 8.1 through 8.11b for cancer risks. To quantitatively assess risks at the CSL, the average daily doses (LADDs and ADDs) calculated in the exposure section are combined with the health effects criteria presented in the toxicity section. USEPA has developed guidance for assessing the potential risks to individuals from exposure to carcinogenic and noncarcinogenic chemicals, and uses separate methodologies for estimating the risks from these two different classes of compounds.

For exposures to potential carcinogens, the individual upper-bound excess lifetime cancer risk was calculated by multiplying the estimated LADD by the upper-bound CSF. Upper-bound is a term used by USEPA to describe CSFs, meaning that actual risks are unlikely to be higher than the risks predicted using the upper-bound CSFs. Using this approach, a risk level of $1x10^{-6}$, for example, represents an upper-bound increase in the lifetime probability of 1 in 1,000,000 that an individual could develop cancer as a result of exposure.

The approach of calculating carcinogenic risks by multiplying the LADD by the CSF assumes that the increased risk of cancer resulting from exposure to a constituent is linearly proportional to the amount of chemical intake averaged over a lifetime. According to USEPA (1989) risk assessment guidance, this approach is appropriate when the estimated carcinogenic risks calculated are less than 10^{-2} (i.e., one excess cancer case per 100 people exposed). If the estimated risks are above 10^{-2}, the assumption of linearity is not valid. In such cases, the carcinogenic risks should be calculated using the following equation, per USEPA risk assessment guidance (USEPA, 1989):

$$\text{Risk} = 1 - e^{(-\text{LADD} * \text{CSF})}$$

It is important to note that although the upper-bound cancer risk estimates provide plausible estimates of the upper limits of risk, the actual risk could be considerably lower.

In order to assess the upper-bound individual excess lifetime cancer risks associated with simultaneous exposure to COPCs, the risks derived from the individual chemicals were summed within each exposure pathway. This approach is consistent with the USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA, 1986b, 1989).

Potential adverse health effects for noncarcinogens were calculated by means of an HI technique as recommended by USEPA (1989). The ratio of the ADD to the reference dose (ADD:RfD) was derived for each chemical. Values of these ratios, called HQs, which are greater than 1 are indicative of the potential for adverse health effects. The effects from simultaneous exposures to COPCs were computed by summing the individual ratios (HQs) within each exposure pathway. This sum, known as the HI, serves the same function for the mixture as the HQ does for the individual compound. In general, HIs that are less than 1 are not likely to be associated with health risks and are, therefore, less likely to be of regulatory concern than HIs greater than 1. If an HI is greater than 1, the COPCs are subdivided into categories based on target organ affected by exposure (e.g., liver, kidney) in accordance with USEPA (1989) guidance. HIs are then recalculated for these categories to better identify whether noncarcinogenic effects to specific target organs or endpoints might occur.

The upper-bound excess lifetime cancer risks derived in this report can be compared to USEPA's target risk range for health protectiveness at Superfund sites of $1x10^{-6}$ to $1x10^{-4}$ (USEPA, 1990). In addition, USEPA's Office of Solid Waste and Emergency Response (USEPA, 1991b) has issued a directive clarifying the role of HHRA in the Superfund process. The directive states that, where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than $1x10^{-4}$, and the noncarcinogenic HI is less than 1, action generally is not warranted unless there could be adverse environmental effects.

6.6.1 Risk Estimates for On-Site Workers under Current Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site worker exposures to surface soil, total soil, and groundwater at the CSL under current land-use

conditions are provided in Appendix G-1, Table 9.1. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since on-site workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.1 and discussed below.

***Surface Soil*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface soil by an on-site worker was $4.6x10^{-7}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface soil by an on-site worker (HI = 0.013) was less than 1.

***Total Soil*.** There were no VOCs identified as COPCs in total soil.

***On-Site Upper Patapsco Groundwater*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater by an on-site worker was $1.4x10^{-8}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an on-site worker (HI = 0.00041) was less than 1.

***Cumulative Risk and Hazard*.** The potential cumulative risk for on-site workers exposed to surface soil, total soil, and groundwater at the CSL under current and future land-use conditions was $4.7x10^{-7}$, which is below the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for on-site workers (HI = 0.013) was less than 1.

6.6.2 Risk Estimates for On-Site Trespassers under Current Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site trespasser exposures to surface soil, total soil, sediment, surface water, and groundwater at the CSL under current land-use conditions are provided in Appendix G-1, Table 9.2. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since on-site trespassers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.2 and discussed below.

***Surface Soil*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface soil by an on-site trespasser was $2.9x10^{-7}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface soil by an on-site trespasser (HI = 0.020) was less than 1.

***Total Soil*.** There were no VOCs identified as COPCs in total soil.

***Sediment*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment by an on-site trespasser was $7.7x10^{-8}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment soil by an on-site trespasser (HI = 0.0012) was less than 1.

Surface Water. There were no carcinogenic COPCs in surface water; therefore, an excess lifetime cancer risk was not calculated. The HI associated with exposures to noncarcinogenic COPCs in surface water by an on-site trespasser (HI = 0.0096) was less than 1.

***On-Site Upper Patapsco Groundwater*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater by an on-site trespasser was $4.8x10^{-10}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an on-site trespasser (HI = 0.000036) was less than 1.

***Cumulative Risk and Hazard*.** The potential cumulative risk for on-site trespassers exposed to surface soil, total soil, sediment, surface water, and groundwater at the CSL under current land-use conditions was $3.6x10^{-7}$, which is below the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health

protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for on-site trespassers (HI = 0.031) was less than 1.

6.6.3 Risk Estimates for On-Site Construction Workers under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site construction worker exposures to total soil, sediment, surface water, and on-site groundwater at the CSL under future land-use conditions are provided in Appendix G-1, Table 9.3. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since on-site construction workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.3 and discussed below.

Total Soil. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in total soil by an on-site construction worker was $2.5x10^{-7}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in total soil by an on-site construction worker (HI = 0.087) was less than 1.

Sediment. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment by an on-site construction worker was $1.0x10^{-8}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment soil by an on-site construction worker (HI = 0.0016) was less than 1.

Surface Water. There were no carcinogenic COPCs in surface water; therefore, an excess lifetime cancer risk was not calculated. The HI associated with exposures to noncarcinogenic COPCs in surface water by an on-site construction worker (HI = 0.0013) was less than 1.

On-Site Upper Patapsco Groundwater. The total upper-bound excess lifetime cancer risk associated with dermal exposures to COPCs in groundwater by an on-site construction worker was $1.0x10^{-6}$, which is equal to the lower limit of the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an on-site construction worker (HI = 1.5) was greater than 1.

Cumulative Risk and Hazard. The potential cumulative risk for on-site construction workers exposed to surface soil, total soil, sediment, surface water, and groundwater at the CSL under future land-use conditions was $1.3x10^{-6}$, which is within the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for on-site trespassers (HI =1.6) was less greater 1. When re-calculated by target organ, the HI for nasal effects was equal to 1.

6.6.4 Risk Estimates for On-Site Golf Course Groundskeepers Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site golf course groundskeeper exposures to surface soil, total soil, sediment, surface water, and on-site groundwater at the CSL under future land-use conditions are provided in Appendix G-1, Table 9.4. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since on-site groundskeepers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.4 and discussed below.

Surface Soil. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface soil by an on-site groundskeeper was $2.6x10^{-6}$, which is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$, primarily due to arsenic via ingestion The HI associated with exposures to noncarcinogenic COPCs in surface soil by an on-site groundskeeper (HI = 0.16) was less than 1.

Total Soil. There were no VOCs identified as COPCs in total soil.

***Sediment*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment by an on-site groundskeeper was $4.0x10^{-7}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment by an on-site groundskeeper (HI = 0.0025) was less than 1.

Surface Water. There were no carcinogenic COPCs in surface water; therefore, an excess lifetime cancer risk was not calculated. The HI associated with exposures to noncarcinogenic COPCs in surface water by an on-site groundskeeper (HI = 0.02) was less than 1.

***On-Site Upper Patapsco Groundwater*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater by an on-site groundskeeper was $1.1x10^{-8}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an on-site groundskeeper (HI = 0.00032) was less than 1.

***Cumulative Risk and Hazard*.** The potential cumulative risk for on-site groundskeepers exposed to surface soil, total soil, sediment, surface water, and groundwater at the CSL under future land-use conditions was $2.4x10^{-6}$, which is within the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for on-site groundskeepers (HI = 0.18) was less than 1.

6.6.5 Risk Estimates for On-Site Golfers under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site golfer exposures to surface soil, total soil, sediment, surface water, and on-site groundwater at the CSL under future land-use conditions are provided in Appendix G-1, Table 9.5. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since on-site golfers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix A, Table 9-5 and discussed below.

***Surface Soil*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface soil by an on-site golfer was $5.9x10^{-7}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface soil by an on-site golfer (HI = 0.058) was less than 1.

***Total Soil*.** There were no VOCs identified as COPCs in total soil.

***Sediment*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment by an on-site golfer was $1.8x10^{-7}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment by an on-site golfer (HI = 0.0011) was less than 1.

Surface Water. There were no carcinogenic COPCs in surface water; therefore, an excess lifetime cancer risk was not calculated. The HI associated with exposures to noncarcinogenic COPCs in surface water by an on-site golfer (HI = 0.0089) was less than 1.

***On-Site Upper Patapsco Groundwater*.** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater by an on-site golfer was $2.8x10^{-9}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an on-site golfer (HI = 0.000083) was less than 1.

***Cumulative Risk and Hazard*.** The potential cumulative risk for on-site golfers exposed to surface soil, total soil, sediment, surface water, and groundwater at the CSL under future land-use conditions was $7.7x10^{-7}$, which is below the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for on-site golfers (HI = 0.068) was less than 1.

6.6.6 Risk Estimates for On-Site Club House Workers under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site club house worker exposures to on-site groundwater under future land-use conditions are provided in

Appendix G-1, Table 9.6. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. As noted previously, the club house workers exposures were only evaluated for inhalation.

On-Site Upper Patapsco Groundwater. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater by an on-site club house worker was $1.8x10^{-6}$, which is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$, primarily due to benzene. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an on-site club house worker (HI = 0.032) was less than 1.

6.6.7 Risk Estimates for On-Site Adult Residents under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site adult resident exposures to groundwater under future land-use conditions are provided in Appendix G-1, Table 9.7. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since the on-site adult resident may be exposed at one time by a combination of pathways (e.g., incidental ingestion, dermal absorption, and inhalation), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.7 and discussed below.

Total Soil. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in total soil by an on-site adult resident was $9.0x10^{-6}$, which is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The primary contributors were Aroclor 1221, Aroclor 1242, and arsenic by ingestion. The HI associated with exposures to noncarcinogenic COPCs in total soil by an on-site adult resident (HI = 0.22) was less than 1.

On-Site Upper Patapsco Groundwater. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in Upper Patapsco groundwater by an on-site adult resident were $7.1x10^{-4}$ for ingestion, $2.7x10^{-5}$ for dermal absorption, and $2.7x10^{-5}$ for inhalation. The primary contributors were benzene (ingestion and inhalation), bis(2-ethylhexyl)phthalate (ingestion and dermal absorption), 1,4-dichlorobenzene (ingestion and inhalation), and arsenic (ingestion and dermal absorption). These values are above the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in Upper Patapsco groundwater by an on-site adult resident (HI = 46) was above 1, primarily due to arsenic (ingestion), iron (ingestion), manganese (ingestion), thallium (ingestion), benzene (inhalation), chlorobenzene (inhalation), and naphthalene (inhalation) exposures to chloroform that had an estimated hazard of 1.2. The HIs for ingestion (HI = 0.98) and dermal absorption (HI = 0.15) were less than 1.

As described in Section 6.5.2, a margin of exposure evaluation was performed because the HI for iron (8.4) exceeded a value of 0.5. The calculated intake of iron was 2.5 mg/kg-day via the route of ingestion. This value was conservatively compared to amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996a). The intake calculated for on-site groundwater (Upper Patapsco) is above the allowable range.

Lead was also evaluated as a COPC in on-site Upper Patapsco groundwater. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Site-specific lead exposures were evaluated for residential exposures using the IEUBK model. Although this model is based on children's exposure to lead, IEUBK was used to evaluate residential exposures per USEPA guidance (USEPA, 1992d; 1994a,b; 2002c; 2004d). This calculation was based on the site-specific arithmetic mean concentration of lead detected in groundwater (3.94 µg/L). The average detected concentration of lead in soil (17.2 mg/kg) was used as the input value for lead soil concentrations. The results of the model are presented in Table 6-7 The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level for the young child was 1.73 µg/dl, with 0.009 percent of the population potentially experiencing concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that the percent of the exposed population with a blood lead level exceeding 10 µg/dl (0.009 percent) would be below the 5 percent level of exceedance considered to be protective of human health by USEPA.

On-Site Lower Patapsco Groundwater. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in Lower Patapsco groundwater by an on-site adult resident were $1.3x10^{-4}$ for ingestion, $4.5x10^{-5}$ for dermal absorption, and $6.7x10-^{05}$ for inhalation. The primary contributors to ingestion and dermal absorption risks were carbon tetrachloride, PCE, and TCE. The primary contributors to inhalation risks were carbon tetrachloride, chloroform, PCE, and TCE. The dermal absorption inhalation risk values are within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The ingestion risk value is above the upper-bound target risk range value of $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in Lower Patapsco groundwater by an on-site adult resident was above 1 for ingestion (HI = 10) primarily due to carbon tetrachloride, iron, manganese, and vanadium. The HIs for inhalation and dermal absorption were both 1.4. None of the inhalation or dermal HIs for individual COPCs exceeded 1.

As described in Section 6.5.2, a margin of exposure evaluation was performed because the HI for iron (3.0) exceeded a value of 0.5. The calculated intake of iron was 0.9 mg/kg-day via the route of ingestion. This value was conservatively compared to amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996a). The intake calculated for on-site groundwater (Lower Patapsco) is within the allowable range.

Lead was also evaluated as a COPC in on-site Lower Patapsco groundwater. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Site-specific lead exposures were evaluated for residential exposures using the IEUBK model. Although this model is based on children's exposure to lead, IEUBK was used to evaluate residential exposures per USEPA guidance (USEPA, 1992d; 1994a,b; 2002c; 2004d). This calculation was based on the site-specific arithmetic mean concentration of lead detected in groundwater (7.74 µg/L). The average detected concentration of lead in soil (17.2 mg/kg) was used as the input value for lead soil concentrations. The results of the model are presented in Table 6-8. The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level for the young child was 2.03 µg/dl, with 0.035 percent of the population potentially experiencing concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that the percent of the exposed population with a blood lead level exceeding 10 µg/dl (0.035 percent) would be below the 5 percent level of exceedance considered to be protective of human health by USEPA.

Cumulative Risk and Hazard. Since on-site Upper Patapsco groundwater represents the more highly contaminated portion of groundwater, cumulative risk and hazard estimates are conservatively based on this data grouping. The potential cumulative risk for on-site adult residents exposed to groundwater via future land-use conditions was $7.7x10^{-1}$, which is above the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for on-site adult residents (HI = 46) was above 1, primarily due to arsenic, iron, manganese, thallium, vanadium, benzene, chlorobenzene, and naphthalene. When recalculated by target organ, the following target organs exceeded 1: skin (3.6), vascular effects (3.6), liver (HI = 15), blood (HI = 15), kidney (HI = 5.5), GI Irritation (HI = 8.5), CNS (HI = 1.9), hair (HI = 2.3), immune system (4.6), and nasal effects (19). It should be noted that no inhalation target organ has been identified for carbon tetrachloride (HI = 0.74).

Because there is no toxicity value for lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative hazard calculation. However, the results of the IEUBK model are described in the previous section. These results indicate that lead concentrations in on-site Lower Patapsco groundwater are below the criterion for blood lead levels in exposed populations.

6.6.8 Risk Estimates for On-Site Child Residents under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with on-site child resident exposures to groundwater under future land-use conditions are provided in Appendix G-1, Table 9.8. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since on-site child residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion, dermal absorption, and inhalation), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.8 and discussed below.

Total Soil. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in total soil by an on-site child resident was $1.5x10^{-5}$, which is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in total soil by an on-site child resident (HI = 1.8) was greater than 1. However, none of the His for individual COPCs exceeded 1.

Sediment. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment by an on-site child resident was $9.5X10^{-8}$, which is below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment soil by an on-site child resident (HI = 0.0025) was less than 1.

Surface Water. There were no carcinogenic COPCs in surface water; therefore, an excess lifetime cancer risk was not calculated. The HI associated with exposures to noncarcinogenic COPCs in surface water by an on-site child resident (HI = 0.02) was less than 1.

On-Site Upper Patapsco Groundwater. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in Upper Patapsco groundwater by an on-site child resident was $3.3x10^{-4}$ for ingestion, due to benzene, bis(2-ethylhexyl)phthalate, and arsenic. This risk value is above the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimates for dermal absorption ($9.2X10^{-6}$) and inhalation ($1.0x10^{-6}$) were within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in Upper Patapsco groundwater by an on-site child resident (HI = 43) was above 1 for ingestion, primarily due to arsenic, iron, manganese, thallium, and vanadium. The HIs for dermal absorption (HI = 0.92) and inhalation (HI = 0.089) were less than 1.

As described in Section 6.5.2, a margin of exposure evaluation was performed because the HI for the Upper Patapsco (20), exceeded a value of 0.5. The calculated intake of iron was 5.9 mg/kg-day via the route of ingestion for the Upper Patapsco. This value was compared to amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996c). The intake value calculated for on-site Upper Patapsco groundwater is above the recommended range.

Lead was also evaluated as a COPC in on-site Upper Patapsco groundwater. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 1992d; 1994a,b; 2002c; 2004d), site-specific lead exposures were evaluated for residential exposures using the IEUBK model. This calculation was based on the site-specific arithmetic mean concentration of lead detected in groundwater (3.94 µg/L). The average detected concentration of lead in soil (17.2 mg/kg) was used as the input value for lead soil concentrations. The results of the model are presented in Table 6-7. The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level for the young child was 1.73 µg/dl, with 0.009 percent of the population potentially experiencing concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that the percent of the exposed population with a blood lead level exceeding 10 µg/dl (0.009 percent) would be below the 5 percent level of exceedance considered to be protective of human health by USEPA.

On-Site Lower Patapsco Groundwater. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in Lower Patapsco groundwater by an on-site child resident were $6.0x10^{-5}$ for ingestion and $2.2x10^{-5}$ for dermal absorption. (As noted previously, the inhalation pathways associated with Lower Patapsco groundwater was not evaluated for the child resident. The child resident is assumed to bathe rather than shower and due to the depth of the Lower Patapsco groundwater, VOCs migrating into indoor air from *in-situ* groundwater are considered to be negligible.) The primary contributors to ingestion and dermal absorption risks were carbon tetrachloride, PCE, and TCE. These risk values were within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in Lower Patapsco groundwater by an on-site child resident was above 1 for ingestion (HI = 23) and dermal absorption (HI = 4.4), primarily due to carbon tetrachloride, beryllium, chromium, iron, manganese, and vanadium.

As described in Section 6.5.2, a margin of exposure evaluation was performed because the HI for the Lower Patapsco (7.1), exceeded a value of 0.5. The calculated intake of iron was 2.1 mg/kg for the

Lower Patapsco. This value was compared to amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996c). The intake value calculated for on-site Lower Patapsco groundwater is above the recommended range.

Lead was also evaluated as a COPC in off-site Lower Patapsco groundwater. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 1992d; 1994a,b; 2002c; 2004d), site-specific lead exposures were evaluated for residential exposures using the IEUBK model. This calculation was based on the site-specific arithmetic mean concentration of lead detected in groundwater (7.74 µg/L). The average detected concentration of lead in soil (17.2 mg/kg) was used as the input value for lead soil concentrations. The results of the model are presented in Table 6-8. The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level for the young child was 2.03 µg/dl, with 0.035 percent of the population potentially experiencing concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that the percent of the exposed population with a blood lead level exceeding 10 µg/dl (0.035 percent) would be below the 5 percent level of exceedance considered to be protective of human health by USEPA.

Cumulative Risk and Hazard. Since on-site Upper Patapsco groundwater represents the more highly contaminated portion of groundwater, cumulative risk and hazard estimates are conservatively based on this data grouping. The potential cumulative risk for on-site child residents exposed to groundwater via future land-use conditions was 3.6×10^{-4}, which is above the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for on-site child residents (HI = 45) was above 1, primarily due to carbon tetrachloride, beryllium, chromium, iron, manganese, and vanadium. When recalculated by target organ, the following target organs exceeded 1: skin (HI = 8.6), vascular effects (HI = 8.6), liver (HI = 26), blood (HI = 26), kidney (HI = 3.1), GI Irritation (HI = 20.3), CNS (HI = 4.2), and hair (HI = 5.4). It should be noted that no target organ has been identified for chromium (HI = 1.4); its RfD is based on NOAEL.

Because there is no toxicity value for lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative hazard calculation. However, the results of the IEUBK model are described in the previous section. These results indicate that lead concentrations in on-site Upper and Lower Patapsco groundwater are below the criterion for blood lead levels in exposed populations.

6.6.8 Risk Estimates for Off-Site Construction Workers under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with off-site construction worker exposures to groundwater beyond the boundary of the CSL under future land-use conditions are provided in Appendix G-1, Table 9.9. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above 1×10^{-6} or HIs above 1 are identified in the text below. As noted previously, the off-site construction worker exposures were only evaluated for inhalation.

Off-Site Upper Patapsco Groundwater. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater by an off-site construction worker was 1.1×10^{-9}, which is below the target risk range of 1×10^{-6} to 1×10^{-4}. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an off-site construction worker (HI = 0.00007) was less than 1.

6.6.9 Risk Estimates for Off-Site Adult Residents under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with off-site adult resident exposures to groundwater beyond the boundary of the CSL under future land-use conditions are provided in Appendix G-1, Table 9.10. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above 1×10^{-6} or HIs above 1 are identified in the text below. Since the off-site adult resident may be exposed at one time by a combination of pathways (e.g., incidental ingestion, dermal absorption, and inhalation), the cumulative pathway risks

for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.10 and discussed below.

Off-Site Upper Patapsco Groundwater. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in Upper Patapsco groundwater by an off-site adult resident were $4.1x10^{-6}$ for ingestion, $3.3x10^{-6}$ for dermal absorption, and $2.6x10^{-5}$ for inhalation. The primary contributors were bis(2-ethylhexyl)phthalate (ingestion and dermal absorption), MTBE (ingestion), and chloroform (inhalation). These values are within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in Upper Patapsco groundwater by an off-site adult resident (HI = 1.4) was slightly above 1, primarily due to inhalation exposure to chloroform that had an estimated hazard of 1.2. The HIs for ingestion (HI = 0.98) and dermal absorption (HI = 0.15) were less than 1.

Off-Site Lower Patapsco Groundwater. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in Lower Patapsco groundwater by an off-site adult resident were $1.0x10^{-4}$ for ingestion, $4.9x10^{-5}$ for dermal absorption, and $1.6x10^{-4}$ for inhalation. The primary contributors to ingestion and dermal absorption risks were bis(2-ethylhexyl)phthalate, carbon tetrachloride, PCE, and TCE. The primary contributors to inhalation risks were carbon tetrachloride, chloroform, PCE, and TCE. The dermal absorption risk value is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The ingestion risk value is equal to the upper-bound target risk range value of $1x10^{-4}$, while the inhalation risk value exceeds the target risk range. The HI associated with exposures to noncarcinogenic COPCs in Lower Patapsco groundwater by an off-site adult resident was above 1 for ingestion (HI = 7.7) and inhalation (HI = 3.0), primarily due to iron, thallium, and vanadium for ingestion and carbon tetrachloride and TCE for inhalation. The HI for dermal absorption (HI = 0.62) were less than 1.

As described in Section 6.5.2, a margin of exposure evaluation was performed because the HI for iron (2.5) exceeded a value of 0.5. The calculated intake of iron was 0.74 mg/kg-day via the route of ingestion. This value was compared to amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996a). The intake calculated for off-site groundwater (Lower Patapsco) is within the allowable range.

Lead was also evaluated as a COPC in off-site Lower Patapsco groundwater. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Site-specific lead exposures were evaluated using the IEUBK model. Although this model is based on children's exposure to lead, IEUBK was used to evaluate residential exposures per USEPA guidance (USEPA, 1992d; 1994a,b; 2002c; 2004d). This calculation was based on the site-specific arithmetic mean concentration of lead detected in groundwater (6.51 µg/L). Because off-site soil samples were not collected, the default input value for lead soil concentrations (200 mg/kg) was used. The results of the model are presented in Table 6-9. The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level for the young child was 3.59 µg/dl, with 1.47 percent of the population potentially experiencing concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that the percent of the exposed population with a blood lead level exceeding 10 µg/dl (1.47 percent) would be below the 5 percent level of exceedance considered to be protective of human health by USEPA.

Cumulative Risk and Hazard. Since off-site Lower Patapsco groundwater represents the more highly contaminated portion of groundwater, cumulative risk and hazard estimates are conservatively based on this data grouping. The potential cumulative risk for off-site adult residents exposed to groundwater via future land-use conditions was $3.2x10^{-4}$, which is above the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for off-site adult residents (HI = 11) was above 1, primarily due to iron, thallium, vanadium, carbon tetrachloride, and TCE. When recalculated by target organ, the following target organs exceeded 1: liver (HI = 7.4), blood (HI = 4.7), kidney (HI = 2.2), GI Irritation (HI = 2.5), CNS (HI = 1.2), and hair (HI = 2.3). It should be noted that no inhalation target organ has been identified for carbon tetrachloride (HI = 1.3).

Because there is no toxicity value for lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative hazard calculation. However, the results of the IEUBK model are described in the previous section. These results indicate that lead concentrations in off-site Lower Patapsco groundwater are below the criterion for blood lead levels in exposed populations.

6.6.10 Risk Estimates for Off-Site Child Residents under Future Land-Use Conditions at CSL

A summary of the upper-bound excess lifetime cancer risks and HIs associated with off-site child resident exposures to groundwater beyond the boundary of the CSL under future land-use conditions are provided in Appendix G-1, Table 9.11. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since off-site child residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion, dermal absorption, and inhalation), the cumulative pathway risks for plausible multiple pathway exposures are also provided in Appendix G-1, Table 9.11 and discussed below.

Off-Site Upper Patapsco Groundwater. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in Upper Patapsco groundwater by an off-site child resident was $1.5x10^{-6}$ for dermal absorption, due to bis(2-ethylhexyl)phthalate. This value is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimates for ingestion (1.9×10^{-6}) and inhalation (8.8×10^{-8}) were within and below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in Upper Patapsco groundwater by an off-site child resident (HI = 2.7) was above 1 for ingestion. No individual chemical HQ or target organ specific HI was equal to or greater than 1. The HIs for dermal absorption (HI = 0.43) and inhalation (HI = 0.00095) were less than 1.

Off-Site Lower Patapsco Groundwater. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in Lower Patapsco groundwater by an off-site child resident were $4.8x10^{-5}$ for ingestion and $2.2x10^{-5}$ for dermal absorption. (As noted previously, the inhalation pathways associated with Lower Patapsco groundwater was not evaluated for the child resident. The child resident is assumed to bathe rather than shower and due to the depth of the Lower Patapsco groundwater, VOCs migrating into indoor air from *in-situ* groundwater are considered to be negligible.) The primary contributors to ingestion and dermal absorption risks were bis(2-ethylhexyl)phthalate, carbon tetrachloride, PCE, and TCE. These values were within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in Lower Patapsco groundwater by an off-site child resident was above 1 for ingestion (HI = 18) and dermal absorption (HI = 1.7), primarily due to carbon tetrachloride, chromium, iron, thallium, and vanadium.

As described in Section 6.5.2, a margin of exposure evaluation was performed because the HI for iron (5.8) exceeded a value of 0.5. The calculated intake of iron was 1.7 mg/kg-day via the route of ingestion. This value was compared to amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996c). The intake calculated for off-site groundwater (Lower Patapsco) is above the recommended range.

Lead was also evaluated as a COPC in off-site Lower Patapsco groundwater. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 1992d; 1994a,b; 2002c; 2004d), site-specific lead exposures were evaluated for residential exposures using the IEUBK model. This calculation was based on the site-specific arithmetic mean concentration of lead detected in groundwater (6.51 µg/L). Because off-site soil samples were not collected, the default input value for lead soil concentrations (200 mg/kg) was used. The results of the model are presented in Table 6-91. The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level for the young child was 3.59 µg/dl, with 1.47 percent of the population potentially experiencing concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that the percent of the exposed population with a blood lead level exceeding 10 µg/dl (1.47 percent) would be below the 5 percent level of exceedance considered to be protective of human health by USEPA.

Cumulative Risk and Hazard. Since off-site Lower Patapsco groundwater represents the more highly contaminated portion of groundwater, cumulative risk and hazard estimates are conservatively based on this data grouping. The potential cumulative risk for off-site child residents exposed to groundwater via future land-use conditions was $7.1x10^{-5}$, which is within the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for off-site child residents (HI = 20) was above 1, primarily due to carbon tetrachloride, chromium, iron, thallium, and vanadium. When recalculated by target organ, the following target organs exceeded 1: liver

(HI = 14), blood (HI = 11), kidney (HI = 4.1), GI Irritation (HI = 5.8), and hair (HI = 5.3). It should be noted that no target organ has been identified for chromium (HI = 1.4); its RfD is based on NOAEL.

Because there is no toxicity value for lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative hazard calculation. However, the results of the IEUBK model are described in the previous section. These results indicate that lead concentrations in off-site Lower Patapsco groundwater are below the criterion for blood lead levels in exposed populations

6.6.11 Summary of Predominant COPCs at or Downgradient from the CSL

This section summarizes the predominant COPCs associated with potential risks and hazards at the CSL. For the purposes of the HHRA, predominant COPCs are defined as chemicals contributing to exposure route total cancer risks (i.e., based on the sum of every route evaluated) greater than or equal to $1x10^{-6}$ or exposure route total HIs greater than or equal to one. The predominant COPCs are summarized by receptor, media, and exposure route, in Appendix G-1, Tables 10.1 through 10.11. The predominant COPCs are discussed according to exposure medium in the text below.

***On-Site Surface Soil*.** As shown in Appendix G-1, Tables 10.1, 10.2, 10.4, and 10.5, , there were no predominant COPCs representing cancer risk for current and future exposures to on-site surface soil at the CSL. The total cancer risk estimates for surface soil exposures were below the USEPA target risk range for health protectiveness. There are no predominant COPCs representing non-carcinogenic hazard. The HIs for current and future exposures to surface soil were less than 1.

***On-Site Total Soil*.** As shown in Appendix G-1, Tables 10.3, 10.7, and 10.8, predominant COPCs representing cancer were Aroclor 1221, Aroclor 1242, and arsenic. The total cancer risk estimates for exposures for the on-site construction worker were below the USEPA target risk range for health protectiveness. The total cancer risk estimates for exposures for the on-site adult resident and child resident were within the USEPA target risk range for health protectiveness. The HIs for future exposures to total soil were less than 1 for individual COPCs. Furthermore, there were no COPCs identified for the exposure pathway determined to be complete (i.e., inhalation of VOCs released from total soil into ambient air).

***On-Site* Sediment.** As shown in Appendix G-1, Tables 10.2, 10.3, 10.4, 10.5, ,and 10.8, there were no predominant COPCs representing cancer risk for current and future exposures to on-site sediment at the CSL. The total cancer risk estimates for sediment exposures were below the USEPA target risk range for health protectiveness. There are no predominant COPCs representing non-carcinogenic hazard. The HIs for current and future exposures to sediment were less than 1.

***On-Site* Surface Water.** As shown in Appendix G-1, Tables 10.2, 10.3, 10.4, 10.5, ,and 10.8, there were no COPCs representing cancer risk for current and future exposures identified in on-site surface water at the CSL. There are no predominant COPCs representing non-carcinogenic hazard. The HIs for current and future exposures to surface water were less than 1.

On-Site Upper Patapsco Groundwater*.** As shown in Appendix G-1,Tables 10.1 through 10.8, the predominant COPCs representing cancer risk for current and future exposures to on-site Upper Patapsco groundwater at the CSL included benzene, bis(2-ethylhexyl)phthalate, 1,4-dichlorobenzene, and arsenic. The total cancer risk estimates for groundwater exposures by on-site workers, on-site trespassers, on-site construction workers, on-site golf course groundskeepers, and on-site golfers were below the USEPA target risk range for health protectiveness. The total cancer risk estimates for groundwater exposures by on-site club house workers was within the USEPA target risk range for health protectiveness. The total cancer risk estimates for groundwater exposures by on-site adult and child residents were above the USEPA target risk range for health protectiveness. The predominant COPCs representing noncarcinogenic hazard included arsenic, iron, manganese, thallium, vanadium, benzene, 1,4-dichlorobenzene, and naphthalene. The HIs for current and future exposures to groundwater by on-site workers, on-site trespassers, on-site golf course groundskeepers, and on-site golfers were less than 1. There were no noncarcinogenic COPCs evaluated in indoor air for the club house worker. The HI for future exposures to groundwater by on-site construction workers was equal to 1. The HIs for future exposures to groundwater by on-site adult and child residents were above 1.On-Site Lower Patapsco Groundwater*.** As shown in Appendix G-1, Tables 10.7 and 10.8, the predominant COPCs representing

cancer risks were carbon tetrachloride, chloroform, PCE, and TCE. The total cancer risk estimates for groundwater exposures by on-site child residents were within the USEPA target risk range for health protectiveness. The total cancer risk estimates for groundwater exposures by on-site adult residents were above the USEPA target risk range for health protectiveness. The predominant COPCs representing carcinogenic hazards were carbon tetrachloride, beryllium, chromium, iron, manganese, and vanadium. The HIs for future exposures to groundwater by on-site adult and child residents were above 1.

***Off-Site Upper Patapsco Groundwater*.** As shown in Appendix G-1,Tables 10.9 through 10.11, the predominant COPCs representing cancer risk for off-site Upper Patapsco groundwater are bis(2-ethylhexyl)phthalate, MTBE, and chloroform. The total cancer risk estimates for exposures for the off-site construction worker were below the USEPA target risk range for health protectiveness. The total cancer risk estimates for exposures for the off-site adult resident and child resident were within the USEPA target risk range for health protectiveness. The predominant COPC representing non-carcinogenic hazard for off-site Upper Patapsco groundwater is chloroform. The HI for off-site Upper Patapsco groundwater was less than 1 for the off-site construction worker and the off-site child resident. The HIs for off-site Upper Patapsco groundwater were greater than 1 for the off-site adult resident.

***Off-Site Lower Patapsco Groundwater*.** As shown in Appendix G-1,Tables 10.10 and 10.11, the predominant COPCs representing cancer risk for off-site Lower Patapsco groundwater are bis(2-ethylhexyl)phthalate, carbon tetrachloride, chloroform, PCE, and TCE. The total cancer risk estimates for exposures for the off-site adult resident were above the USEPA target risk range for health protectiveness, while the child resident cancer risk estimates were within the target range. The predominant COPCs representing non-carcinogenic hazard for off-site Lower Patapsco groundwater are carbon tetrachloride, TCE, chromium, iron, thallium, and vanadium. Based on a “margin-of-exposure” evaluation, the intake of iron was above the recommended range. The HIs for off-site Lower Patapsco groundwater were greater than 1 for both receptors (i.e., adult and child residents).

6.7 UNCERTAINTIES IN THE HUMAN HEALTH RISK ASSESSMENT

All risk assessments involve the use of assumptions, judgments, and incomplete data to varying degrees that contribute to the uncertainty of the final estimates of risk. Uncertainties result from the use of assumptions or models in lieu of actual data and from the error inherent in the estimation of risk-related parameters, and may cause risk to be overestimated or underestimated. Based on the uncertainties described below, this risk assessment should not be construed as presenting an absolute estimate of risk to persons potentially exposed to chemicals at the CSL.

Consideration of the uncertainty attached to various aspects of the risk assessment process allows one to better interpret the risk assessment results and understand the potential adverse effects on human health. In general, the primary sources of uncertainty are associated with environmental sampling and analysis, selection of chemicals for evaluation, toxicological data, exposure assessment, and risk characterization. The effects of these uncertainties on the risk estimates are discussed below.

6.7.1 Environmental Sampling and Analysis

Uncertainty in environmental chemical analysis can stem from several sources including errors inherent in the sampling or analytical procedures. Analytical accuracy errors or sampling errors can result in rejection of data, which decreases the available data for use in the HHRA, or in the qualification of data, which increases the uncertainty in the detected chemical concentrations. There is uncertainty associated with chemicals reported in samples at concentrations below the reported detection limit, but still included in data analysis, and with those chemicals qualified with the letter J, K, or L indicating that the concentrations are estimated. In addition, B-qualified data were eliminated from the data set per USEPA Region III guidance (1995c).

6.7.2 Selection of Chemicals for Evaluation

A comparison of maximum detected chemical concentrations to USEPA Region III RBCs was conducted for each medium. Chemicals whose maximum concentrations were below their respective RBCs were not carried through the assessment. It is unlikely that this risk-based screening would have excluded chemicals that would be of concern, based on the conservative exposure assumptions and

conservatively derived toxicity criteria that are the basis of the RBCs. Although following this methodology does not provide a quantitative risk estimate for all chemicals, it focuses the assessment on the chemicals accounting for the greatest risks (i.e., chemicals whose maximum concentrations exceeded their respective RBCs). The overall cumulative risk estimates would not be expected to be significantly (if at all) greater. It is noted that there are no medium-specific RBCs for sediment and surface water. These media were compared to adjusted residential soil RBCs and adjusted tap water RBCs, respectively.

6.7.3 Exposure Assessment

There are several sources of uncertainty in the exposure assessment, including the determination of the exposure point concentrations, the selection of input parameters used to estimate chemical intakes ([L]ADDs), and other assumptions used in the exposure models. The uncertainties associated with these various sources are discussed below.

When calculating exposure point concentrations from sampling data, ½ of the reported sample quantitation limit was used for non-detected concentrations in the calculation of the 95% UCL. Any approach dealing with non-detected chemical concentrations is associated with some uncertainty. This is because chemicals that were not detected at the specified sample quantitation limit may be absent from the medium or may be present at any concentration below the sample quantitation limit. The uncertainty in the exposure point concentration will increase as the number of non-detects in a data set increases.

The 95% UCL was the preferable exposure point concentration used for each medium. USEPA's ProUCL software program was used to estimate 95% UCLs, including UCLs calculated for normal, lognormal, gamma, and undefined data distributions. For some COPCs with undefined data distributions, the ProUCL software recommended the use of a 95% UCL estimated via the 95%, 97.5%, or 99% Chebyshev statistical technique. In these instances the 95% UCL was quite elevated and may have overestimated the upper-bound exposure point concentration. If the 95% UCL exceeded the maximum detected value, the maximum was conservatively used as a default for the exposure point concentration. Using a value that is based on one sampling location (i.e., the maximum) is associated with some uncertainty, and adds a great deal of conservatism to the assessment. Due to sample sizes less than or equal to 5, the maximum detected concentration was used for surface water, sediment, the off-site Upper Patapsco aquifer, and beryllium and chromium in the on-site Upper Patapsco aquifer to calculate risks, resulting in an overestimate of risk for pathways associated with exposures to these media (and COPCs).

With respect to determining exposure point concentrations, it was assumed that the concentrations of chemicals in the media evaluated would remain constant over time. Depending on the properties of the chemicals and the media in which they were detected, this assumption could overestimate risks to a low or high degree, since it is possible that chemicals could degrade or be transported to other media. In addition, risks could be underestimated if chemicals were to degrade into forms that were more toxic than those that were detected at the site. Therefore in this HHRA, groundwater chemicals were not eliminated as COPCs if they are known breakdown or degradation products of detected chemicals. Breakdown products were retained even if the concentrations of their precursors are not above the screening values.

An underlying assumption in the HHRA is that individuals at the site would engage in certain activities that would result in exposures via each selected pathway. For example, it was assumed that receptors would engage in regular activities under current and future land-use conditions that would result in exposures to COPCs. This assumption is conservative, in that it is more likely that the activity patterns assumed to occur in this analysis would likely occur occasionally.

The parameter values used to describe the extent, frequency, and duration of exposure are associated with some uncertainty. Actual risks for certain individuals within an exposed population may vary from those predicted depending upon their actual intake rates (e.g., soil ingestion rates), nutritional status, or body weights. The exposure assumptions were selected to produce an upper-bound estimate of exposure in accordance with USEPA guidelines regarding evaluation of potential exposures at Superfund sites (e.g., exposures were assumed to occur for 25 years for workers). In addition, many USEPA (1991a) default exposure parameters are highly conservative and are based on risk management interpretations of limited data. An example is soil ingestion rates. Although current USEPA guidance

recommends default soil ingestion rates of 100 mg/day for individuals over 6 years of age, other studies, such as Calabrese et al. (1990), have shown that the USEPA default soil ingestion rate of 100 mg/day is likely to greatly overestimate adult exposures and risks. In addition, chemicals in soil were assumed to be 100% bioavailable; this assumes that ingested chemicals present in a soil matrix are completely absorbed through the gastrointestinal tract, which is unlikely due to their affinity to the soil particles. Therefore, based on the conservative exposure assumptions used in the HHRA, exposures and estimated potential risks are likely to be overestimated for the ingestion of soil pathways.

As discussed in Section 6.2.3, the PEF is used to calculate the particulate inhalation ADDs and LADDs. One of the inputs for calculating the PEF is the Q/C value, which represents both local climatic conditions and the size of the contaminated area. The sampling and analysis program for the CSL was designed to characterize the 130-acre site. The Q/C values from the *Soil Screening Level* (SSL) guidance (USEPA, 1996b) are presented by source area, city, and climatic zone. Thus, the 130-acre area was considered to be the source area for purposes of the PEF calculation. Based on a size of greater than 30acres, a Q/C value of 47.24 was selected to represent the study area and a PEF of 6.75×10^{8} m^3/kg was calculated.

Because the source area (i.e., CSL) is larger than a size of 0.5 acres used to represent a residential lot and there are no plans for residential development, the sampling program was not designed to address 0.5-acre subareas or to define exposures areas for residential lots (as described in Section 4.1.4 of the SSL guidance). Inhalation risk and hazard estimates are typically lower when using a PEF based on a 0.5-acre subarea versus estimates using a PEF calculated for a larger area. For the CSL, however, the difference in the PEF would not have changed the conclusions of the HHRA.

The development of exposure assumptions for the construction worker PEF calculations is highly uncertain because the future details for construction at the CSL are not known. The default value from the Supplemental SSL Guidance (1 year or 12 months) was conservatively used for the exposure duration. This exposure duration was selected because it is consistent with the value used for other construction worker exposure pathways at the CSL. Conservative assumptions regarding exposure duration, the configuration of the construction area, and the amount of vehicle traffic are likely to result in an overestimation of risk and hazard at the CSL. For example, it is assumed that fugitive dust emissions are generated, in part, by construction vehicle traffic on unpaved roads. Because much of the surface area of the CSL is comprised of capped landfill, it is unlikely that the straight road segment described in the assumptions could be constructed at the CSL. Although risks calculated using the construction worker PEF are likely overestimated, the resulting cancer risk for this pathway was 8.9×10^{-8}, which is below the risk range of 1.0×10^{-6} to 1.0×10^{-4}. An HI was not calculated because there are no inhalation RfDs available for Aroclor 1242 and arsenic.

Evaluation of the dermal absorption exposure pathway is affected by uncertainties in exposure parameters specific to dermal contact. For example, there is uncertainty associated with the exposed skin surface areas used, since the choice of exposed body parts could slightly over- or underestimate risks. More significant uncertainties are associated with the selection and use of dermal absorption factors. There was no specific dermal absorption factor for iron. The default dermal absorption factor for inorganics is 1 percent (USEPA, 1995b, 2003b). However, USEPA's *RAGS, Part E* (USEPA 2004a), states that the speciation of the compound is critical to the dermal absorption of inorganics and there are too little data to extrapolate a reasonable default value. Therefore, the impact of using the dermal absorption factors to evaluate dermal absorption exposures is not known.

The EPCs for both the vapor intrusion model and the trench model were based on a variety of parameters. The parameters for chemical/physical properties and environmental conditions were provided by VDEQ for the trench model (VDEQ, 2006). Site-specific information was applied, if possible. Uncertainties associated with the Johnson and Ettinger model (USEPA, 2003a) used for the evaluation of vapor intrusion include:

- Depth to groundwater was based on the average depth and may not be representative of the entire exposure area.

The Johnson and Ettinger model was developed for use as a screening level model and is based on a number of simplifying assumptions. Because most of the inputs to the model are not collected

during a typical site characterization, conservative inputs have to be estimated or inferred from available data and other non-site-specific sources of information. Limitations and assumptions associated with the Johnson and Ettinger model are described in the user's guide (USEPA, 2003a). These include:

- Contaminant vapors enter the structure primarily through cracks and openings in the walls and foundation.
- Convective transport occurs primarily within the building zone of influence and vapor velocities decrease rapidly with increasing distance from the structure.
- Diffusion dominates vapor transport between the source of contamination and the building zone of influence.
- All vapors originating from below the building will enter the building unless the floors and walls are perfect vapor barriers.
- All soil properties in any horizontal plane are homogeneous.
- The contaminant is homogeneously distributed within the zone of contamination.
- The areal extent of the contamination is greater than that of the building floor in contact with the soil.
- Vapor transport occurs in the absence of convective water movement within the soil column (i.e., evaporation or infiltration), and in the absence of mechanical dispersion.
- The model does not account for transformation processes (e.g., biodegradation, hydrolysis).
- The soil layer is in contact with the structure floor and walls are isotropic with respect to permeability.
- Both the building ventilation rate and the difference in dynamic pressure between the interior of the structure and the soil surface are constant values.

It is also noted in the Johnson and Ettinger model user's guide (USEPA, 2003a) that use of measured soil gas concentrations directly beneath a building floor instead of calculated concentrations would reduce uncertainty in the estimation of indoor air concentrations.

6.7.4 Toxicological Data

The assessment of risks relied on USEPA-derived dose-response criteria. These health effects criteria are conservative and are designed to be protective of sensitive subpopulations. The health criteria used to evaluate long-term exposures, such as RfDs or CSFs, are based on concepts and assumptions that bias an evaluation in the direction of overestimation of health risk. As USEPA notes in its Guidelines for Carcinogenic Risk Assessment (USEPA, 1986a): "There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns and other cultural factors."

These uncertainties are compensated for by using upper-bound 95% UCLs for CSFs for carcinogens, and safety factors for RfDs for noncarcinogens. The assumptions used here provide a rough but plausible estimate of the upper limit of risk; in other words, it is not likely that the true risk would be much more than the estimated risk, but it could very well be considerably lower, even approaching zero. More refined modeling in the area of dose-response calculation (e.g., using maximum likelihood dose-response values rather than the 95% UCL) would be expected to substantially lower the final risk.

Because chromium was analyzed and reported as total chromium, there is uncertainty regarding the species of chromium that exists at the CSL. As discussed in Section 6.5.2, the toxicity values for chromium IV were used in this HHRA. Chromium III is the predominant form of chromium in nature, therefore, risks and hazard estimates could be over-estimated.

For dermal absorption exposure pathways, the absence of dermal toxicity criteria necessitated the use of oral toxicity data. In order to calculate risk estimates for the dermal absorption pathway, absorbed dermal absorption doses were combined with oral toxicity values. As described in Section 6.5.2.1, oral toxicity values, which are typically expressed in terms of potential (or administered) doses, should be adjusted when assessing dermal absorption doses, which are expressed as internal (or absorbed) doses. In this assessment, absolute oral absorption factors that reflect the toxicity study conditions were used to modify the oral toxicity criteria. For chemicals for which sufficient information is lacking (i.e., iron and aluminum), a default oral absorption factor of 1.0 was used, as recommended by USEPA. The risk estimates for the dermal absorption pathways may be over- or underestimated depending on how closely the values used in the HHRA reflect the difference between the oral and dermal routes.

For chemicals without IRIS toxicity criteria, provisional toxicity criteria, i.e., PPRTVs, were used if available (Appendix G-1, Tables 5.1, 5.2, 6.1, and 6.2**)**. For example, the toxicity values for cis-1,2-dichloroethene are PPRTVs. The PPRTVs present a source of uncertainty, since USEPA has evaluated the compound, but consensus has not been established on the toxicity criteria. For this assessment, use of provisional toxicity criteria was preferable to not evaluating the chemical in order to limit data gaps. However, because the toxicity criteria have not been formally accepted by USEPA, there is uncertainty with these values and, therefore, with the risks calculated using these toxicity criteria. Another source of uncertainty is values obtained from HEAST. These values have not been updated since 1997.

There are no verified toxicity criteria available for aluminum, cobalt, dibenzofuran, and di-n-octyl phthalate (Appendix G-1, Tables 5.1, 5.2, 6.1, and 6.2) because these values were retired by NCEA (2005a, 2006a). Although lack of published toxicity data would result in an underestimation of risk, this uncertainty is likely to be balanced by the conservative nature of the verified toxicity values that were available for use.

Due to the exposure duration of one year for the construction worker, subchronic toxicity criteria are more appropriate for evaluating this scenario. Although subchronic values for some chemicals are included in USEPA's database of Provisional Peer-Reviewed Toxicity Values (USEPA, 2003, 2005), this web site cannot be accessed without authorization. However, the Virginia Department of Environmental Quality (VDEQ) compiles subchronic toxicity values. Although the web site for the VDEQ Voluntary Remediation Program was consulted as a Tier 3 source for subchronic values (VDEQ, 2006), subchronic reference concentrations (RfC) and/or reference doses (RfD) were not available for cadmium, iron, manganese, thallium, vanadium, Aroclor 1242, benzene, bis(2-ethylhexyl)phthalate, chlorobenzene, naphthalene, and phenol. Because there were no subchronic values available for the COPCs at CSL, chronic toxicity values were used in the calculations. For the oral RfDs for arsenic and nickel and the inhalation RfDs for chloroethane, MTBE, and 4-methylphenol, there was no difference between the values listed in the tables for the chronic and subchronic toxicity criteria. There were differences between the chronic and subchronic oral RfDs for beryllium and chromium and the inhalation RfD for 1,4-dichlorobenzene. Because chronic toxicity values were used for all COPCs, the calculated risks and hazards are likely to be overestimated. Typically, subchronic toxicity values are 10-fold greater than chronic toxicity values. The overall lack of subchronic toxicity values for the COPCs at these sites contributes to the uncertainty of the cancer risk estimates and the hazard indices, however, the differences in these values would not impact the conclusions of this HHRA.

In addition, there are no toxicity criteria for lead. Residential exposures to lead were evaluated using the IEUBK model (USEPA, 1994b, 2002c, 2004d). Because the non-carcinogenic effects from lead are evaluated separately, these effects are not represented in the cumulative HI

6.7.5 Background and Up-Gradient COPCs

As discussed in Section 6.3.1.4, approved background concentrations for inorganics were used to identify inorganics in soil, groundwater, surface water, and sediment that are expected to be related to background and not to the site. Background-related COPCs that screened in on Tables Appendix G-1, 2.1 through 2.12 are designated with "Yes (B)" in the COPC Flag column on these tables, indicating that these inorganics had maximum concentrations that were below the background screening values. Background-related inorganics were limited to chromium in off-site Upper Patapsco groundwater, and

chromium, iron and vanadium in on-site Upper Patapsco groundwater. None of these inorganics were determined to be risk or hazard drivers based on results of the HHRA.

Upgradient concentrations of some organics, measured in monitoring well 122D that is situated hydraulically upgradient from the site, were used to potentially identify organics (primarily chlorinated hydrocarbons) in Lower Patapsco groundwater that were not site related. However, although several organics were detected in up-gradient groundwater (Appendix G-1, Tables 2.10 and 2.12; BEHP, carbon tetrachloride, PCE, TCE, and chloroform), none of the on-site or offsite maximum detected concentrations were lower than the up-gradient concentrations. Therefore, it cannot be definitively stated that these five organics are not site-related; however, these findings do suggest that an up-gradient source does exist for the risk drivers carbon tetrachloride, PCE, TCE, and chloroform.

6.7.6 Current Off-Site Residential Exposure to VOCs in Indoor Air

There is a possibility that under current conditions VOCs from *in-situ* off-site Upper aquifer groundwater may be migrating into the indoor air of residential homes. Although this situation is unlikely to result in biologically significant indoor air risks and hazards, it is a potential concern addressed in this uncertainty section.

Estimated indoor air residential adult and child risks were estimated to be 1.4E-6 and 8.8E-8 (Appendix G-1, Table 8.10a and 8.11a, respectively). Estimated indoor air residential adult and child hazards were estimated to be 0.003 and 0.00095 (Appendix G-1, Table 7.10a and 7.11a, respectively). As these estimated risks and hazards are below or equal to the lower end of the target risk range (when rounded to one significant figure), current off-site indoor air risks and hazard are expected to be acceptable,

6.7.7 Off-Site Residential Exposure to Groundwater

Off-site residential exposure, and subsequent risks and hazards, associated with off-post groundwater, was estimated using measured concentrations of COPCs in both Upper and Lower Patapsco groundwater monitoring wells. However, most off-site residents are on public water and do not use private drinking water wells (Anne Arundel County Health Department, 2005). Therefore, the use of off-site monitoring well data in the HHRA overestimates residential risks and hazards.

In March 2005 the Anne Arundel County Health Department collected and analyzed water samples from thirteen off-site private drinking water wells located adjacent to Ft. Meade directly downgradient from the CSL site (Anne Arundel County Health Department, 2005). Although nineteen homes were identified by the County as having private wells and not being on public water (located on Baliol Road, Front Street, Galloway Road, Old Waugh Chapel Road, Robey lane, and Tolbert Drive), only thirteen homeowners allowed samples to be collected (Gruver, 2005).

The analytical results, reported by both Department of Health and EPA laboratories, demonstrated that water in all the sampled wells met primary USEPA drinking water standards (MCLs), although a variety of organic compounds were detected above analytical detection limits (Appendix G-4). Five of the homes had lead levels above the lead action level of 15 ug/L. The Department is working with the affected homeowners to make recommendations that can assist in effectively reducing the level of lead in their water, as the most common source of lead in home drinking water is household plumbing materials. As a follow-up to the well sampling initiative, the Department of Health plans to resample the residential wells and is also resampling a subset of the wells to confirm the lead results.

It should be noted that the depth of the private wells was unknown in many cases, however, of the nineteen identified private wells, one is screened in the Lower Patapsco and six are screened in the Upper Patapsco aquifer. It should also be noted that all but one of the sampled private wells are located generally south of the most impacted off-site monitoring wells (MW-125D and MW-126D) at a distance of approximately 0.6 to 1.1 miles. One private well, on Baliol Road, is located east of MW-125D and MW-126D (Appendix G) at a distance of approximately 0.8 miles.

As the measured concentrations of organics in the off-site domestic wells were below MCLs, actual risks and hazards to off-site residents are generally deemed acceptable. It should be noted that

MCLs are not strictly associated with a target cancer risk of 1E-6 or a target hazard quotient of 1. Although lead was a concern in several private wells, lead was not identified as a hazard driver in the HHRA (Sections 6.6.4 and 6.6.5), and its presence in the private wells is most likely a result of leaching from household plumbing materials.

The possibility of off-site residents installing new private wells screened in the Upper Patapsco or the upper portion of the Lower Patapsco aquifers is extremely unlikely. Due to naturally elevated levels of radium in northern Anne Arundel County shallow groundwater, new or replacement drinking water wells must be installed to depths equal to or greater than approximately 250 to 500 feet bgs, and some may be required to be deeper than 600 feet bgs (Maryland Regulations 2005, 26:4:4:9:D:5; Gruver, 2005).

6.7.8 CSL as Source of COPCs in Lower Patapsco Groundwater

There is considerable uncertainty associated with the source of COPCs in the Lower Patapsco aquifer. Several lines of evidence strongly suggest that the Middle Patapsco clay-rich confining unit precludes hydraulic communication between the Upper and Lower units (Section 4.0), preventing the migration of COPCs in CSL soils from migrating to the Lower Patapsco. In addition, as shown in Table 6-10, none of the chlorinated hydrocarbon risk drivers detected in Lower Patapsco groundwater monitoring wells (PCE, TCE, chloroform, and carbon tetrachloride) are found in soil, sediment, or surface water samples collected from the CSL and used in this HHRA, and only chloroform is detected in the Upper Patapsco groundwater. In addition, all of these risk drivers have been detected in the up-gradient monitoring well MW-122D. This available information suggests that the CSL is not acting as the source of contamination to the Lower Patapsco aquifer.

6.7.9 Future Migration of On-Site Groundwater Off the Site.

Hypothetical future off-site exposure to constituent concentrations on-site that have migrated off-site with no attenuation is possible, however very unlikely. This is because COPC concentrations in the aquifer decline as they migrate along the groundwater flow path. This reduction is shown by comparing on-site and off-site risks and hazards, for similar receptors, based on measured groundwater COPC concentrations. Hypothetical future off-site residential exposure to constituent concentrations on-site that have migrated off-site with no attenuation would be represented by future on-site residential risk and hazard results.

6.8 HHRA SUMMARY

This HHRA was performed to evaluate the potential human health effects associated with chemical contamination from past operations at the CSL. For the purposes of the HHRA, surface soil, total soil, sediment, surface water, and groundwater were evaluated.

The HHRA was performed for both current and future land-use conditions. Under current land-use conditions, on-site worker and trespasser exposures to surface soil, total soil, and on-site groundwater were evaluated. On-site sediment and surface water exposures were also evaluated for the trespasser.

Under future conditions, on-site worker and trespasser exposures were assumed to be the same under future land-use conditions as those under current land-use conditions. In addition, off-site construction workers, adult resident, and child resident exposures to off-site groundwater were evaluated. Future recreational exposures are assessed in Section 6.7.6.

Upper-bound excess lifetime cancer risks and non-cancer HIs were estimated for the exposure pathways and data groupings described above. Estimations of excess lifetime cancer risks and non-cancer HIs for on-site and off-site receptor exposures evaluated in the HHRA are presented in Appendix G-1, Tables 7.1 through 7.11b (noncancer) and Tables 8.1 through 8.11b (cancer). Summaries of upper-bound excess lifetime cancer risks and non-cancer HIs for exposures evaluated in the HHRA are presented in Appendix G-1, Tables 9.1 through 9.11; the predominant exposure pathways and COPCs are shown in Appendix G-1, Tables 10.1 through 10.11. The following results are also summarized for each current receptor group in Table 6-11 and each future receptor group in Table 6-12.

On-site Maintenance Worker. For the current and future on-site worker, the risk characterization results showed total cancer risk associated with exposures to surface soil ($4.6x10^{-7}$) was below the target risk range. The total HI (HI = 0.013) was less than 1.

The risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($1.4x10^{-8}$) was below the target risk range. The total HI (HI = 0.00041) was less than 1.

On-site Trespasser. For the current and future on-site trespasser, the risk characterization results showed total cancer risk associated with exposures to surface soil ($2.9x10^{-7}$) was below the target risk range. The total HI (HI = 0.020) was less than 1.

The risk characterization results showed total cancer risk associated with on-site sediment ($7.7x10^{-8}$) was below the target risk range. The total HI (HI = 0.0012) was less than 1.

There were no carcinogenic COPCs in surface water. The total HI associated with on-site surface water (HI = 0.0096) was less than 1.

The risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($4.8x10^{-10}$) was below the target risk range. The total HI (HI = 0.000036) was less than 1.

On-site Construction Worker. For the future on-site construction worker, the risk characterization results showed total cancer risk associated with exposures to surface soil ($2.5x10^{-7}$) was below the target risk range. The total HI (HI = 0.087) was less than 1.

The risk characterization results showed total cancer risk associated with on-site sediment ($1.0x10^{-8}$) was below the target risk range. The total HI (HI = 0.0016) was less than 1.

There were no carcinogenic COPCs in surface water. The total HI associated with on-site surface water (HI = 0.013) was less than 1.

The risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($1.0X10^{-6}$) was equal to the lower limit of the target risk range. The total HI (HI = 1.5) was greater than 1.

On-site Golf Course Groundskeeper. For the future on-site golf course groundskeeper, the risk characterization results showed total cancer risk associated with exposures to surface soil ($2.0x10^{-6}$) was within the target risk range. The total HI (HI = 0.16) was less than 1.

The risk characterization results showed total cancer risk associated with on-site sediment ($4.0x10^{-7}$) was below the target risk range. The total HI (HI = 0.0025) was less than 1.

There were no carcinogenic COPCs in surface water. The total HI associated with on-site surface water (HI = 0.02) was less than 1.

The risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($1.1x10^{-8}$) was below the target risk range. The total HI (HI = 0.00032) was less than 1.

On-site Golfer. For the future on-site golfer, the risk characterization results showed total cancer risk associated with exposures to surface soil ($5.9x10^{-7}$) was below the target risk range. The total HI (HI = 0.058) was less than 1.

The risk characterization results showed total cancer risk associated with on-site sediment ($1.8x10^{-7}$) was below the target risk range. The total HI (HI = 0.0011) was less than 1.

There were no carcinogenic COPCs in surface water. The total HI associated with on-site surface water (HI = 0.0089) was less than 1.

The risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($2.8x10^{-9}$) was below the target risk range. The total HI (HI = 0.000083) was less than 1.

On-site Club House Worker. The risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($1.8x10^{-6}$) was within the target risk range. The total HI (HI = 0.032) was less than 1.

On-Site Adult Resident. For the future on-site adult resident, the risk characterization results showed total cancer risk associated with exposures to total soil ($9.0x10^{-6}$) was within the target risk range. The total HI (HI = 0.22) was less than 1.

For the future adult resident, the risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($7.6x10^{-4}$) were within the target risk range, primarily due to benzene, bis(2-ethylhexyl)phthalate, 1,4-dichlorobenzene, and arsenic. The total HI (HI = 46) was above 1, primarily due to arsenic, iron, manganese, thallium, vanadium, benzene, chlorobenzene, and naphthalene. When recalculated by target organ the following target organs exceeded 1: skin (HI = 3.6), vascular effects (HI = 3.6), liver (HI = 15), blood (HI = 15), kidney (HI = 5.4), GI irritation (HI = 8.5), CNS (HI = 1.9), hair (HI = 2.3), immune system (HI = 4.6), and nasal effects (HI = 19).

The risk characterization results showed total cancer risk associated with on-site Lower Patapsco groundwater ($2.4x10^{-4}$) was above the target risk range, primarily due to carbon tetrachloride, chloroform, PCE, and TCE. The total HI (HI = 11) was above 1, primarily due to carbon tetrachloride, iron, manganese, and vanadium. The margin-of-exposure evaluation indicated that the intake of iron was above the allowable range.

On-Site Child Resident. For the future on-site child resident, the risk characterization results showed total cancer risk associated with exposures to total soil ($1.5x10^{-5}$) was within the target risk range. The total HI (HI = 1.8) was greater than 1.

The risk characterization results showed total cancer risk associated with on-site sediment ($9.5x10^{-8}$) was below the target risk range. The total HI (HI = 0.0025) was less than 1.

There were no carcinogenic COPCs in surface water. The total HI associated with on-site surface water (HI = 0.020) was less than 1.

For the future child resident, the risk characterization results showed total cancer risk associated with on-site Upper Patapsco groundwater ($3.4x10^{-4}$) were above the target risk range, primarily due to benzene, bis(2-ethylhexyl)phthalate, and arsenic. The total HI (HI = 43) was above 1, primarily due to arsenic, iron, manganese, thallium, and vanadium.

The risk characterization results showed total cancer risk associated with on-site Lower Patapsco groundwater ($8.3x10^{-5}$) was above the target risk range, primarily due to carbon tetrachloride, PCE, and TCE. The total HI (HI = 28) was above 1, primarily due to carbon tetrachloride, beryllium, chromium, iron, manganese, and vanadium. The margin-of-exposure evaluation indicated that the intake of iron was within the allowable range.

Off-Site Construction Worker. For the future off-site construction worker, the risk characterization results showed total cancer risk associated with off-site Upper Patapsco groundwater ($1.1x10^{-9}$) was below the target risk range. The total HI (HI = 0.000070) was less than 1.

Off-Site Adult Resident. For the future adult resident, the risk characterization results showed total cancer risk associated with off-site Upper Patapsco groundwater ($3.5x10^{-5}$) were within the target risk range, primarily due to bis(2-ethylhexyl)phthalate, MTBE, and chloroform. The total HI (HI = 2.5) was above 1, primarily due to chloroform, however, when segregated by target organ, all HIs were less than or equal to 1 when rounded to one significant figure.

The risk characterization results showed total cancer risk associated with off-site Lower Patapsco groundwater ($3.2x10^{-4}$) was above the target risk range, primarily due to bis(2-ethylhexyl)phthalate, carbon tetrachloride, chloroform, PCE, and TCE. The total HI (HI = 11) was above 1, primarily due to carbon tetrachloride, TCE, iron, thallium, and vanadium. The margin-of-exposure evaluation indicated that the intake of iron was within the allowable range.

It is important to note that these groundwater risk and hazard estimates assume groundwater is actually used by off-site residential adults. This is generally not the case, as most residents are on public water. In addition, sampling of off-site domestic wells by the County Health Department determined no organics in well water were above applicable groundwater standards (MCLs; Section 6.7.8). Finally, current off-site indoor air risks and hazard, from vapors migrating from *in-situ* groundwater to indoor air, are expected to be acceptable (Section 6.7.7).

Off-Site Child Resident. For the future child resident, the risk characterization results showed total cancer risk associated with off-site Upper Patapsco groundwater ($3.5x10^{-6}$) was within the target risk range, primarily due to bis(2-ethylhexyl)phthalate and MTBE. The total HI (HI = 2.7) was above 1; no individual chemical target organ HQ exceeded 1.

The risk characterization results showed total cancer risk associated with off-site Lower Patapsco groundwater ($7.1x10^{-5}$) were within the target risk range, primarily due to bis(2-ethylhexyl)phthalate, carbon tetrachloride, PCE, and TCE. The total HI (HI = 20) was above 1, primarily due to carbon tetrachloride, chromium, iron, thallium, and vanadium. Individual target organ HQs also exceeded 1. The margin-of-exposure evaluation indicated that the intake of iron was above the allowable range.

It is important to note that these groundwater risk and hazard estimates assume groundwater is actually used by off-site residential children. This is generally not the case, as most residents are on public water. In addition, sampling of off-site domestic wells by the County Health Department determined no organics in well water were above applicable groundwater standards (MCLs; Section 6.7.8). Finally, current off-site indoor air risks and hazard, from vapors migrating from *in-situ* groundwater to indoor air, are expected to be acceptable (Section 6.7.7).

7.0 SUMMARY AND CONCLUSIONS

General conclusions regarding the investigation are presented in Section 7.1. Sections 7.2 to Section 7.5 present more detailed conclusions for the CSL.

7.1 GENERAL CONCLUSIONS

- In general, the analytical results from sampling were consistent with historical documentation indicating that disposal of "mixed residential, commercial, and non-hazardous industrial wastes" occurred at the CSL.
- Geologic, hydrogeologic, and hydraulic data indicates the Middle Patapsco clays are a thick and effective confining unit at the CSL. Likewise, data indicates the CSL is not the source of contamination found in the Lower Patapsco.
- Data indicates the Benzene MCL exceedances in the Upper Patapsco aquifer are bounded to the south by shallow wells MW-12s and MW-19. Shallow wells MW-12s and MW-19 monitor the Upper Patapsco Aquifer immediately south and east of the southernmost extent of CSL Cell 1. The screened interval of MW-12S is 18 to 28 feet bgs and the screened interval of MW-19 is 22 to 37 feet bgs. Benzene has been detected above the Tap Water RBC (0.5 μg/L) and/or MCL (5μg/L) in MW-12S and MW-19 in all RCRA semi-annual monitoring rounds since May 1995 at concentrations ranging between 2.9 and 25 μg/L. Based on the site topography, shallow groundwater in the vicinity of the southern end of Cell 1 near MW-12S and MW-19 would flow toward the lower elevations to the southwest toward a minor tributary of the Little Patuxent River. The off-post land surface directly to the south of the CSL is at approximately the same elevation as the base of the CSL and rises to the south **(see Figure 4-4 – Topographic Map)**. Likewise, data indicates Benzene is not migrating off-post above MCLs. This conclusion is supported by the fact that MW-20, south of MW-12s, has not detected Benzene (0.59 to 4.7μg/L) above MCLs in the history of the RCRA monitoring program. In fact, Benzene has been non-detect in MW-20 for the past five RCRA sampling rounds. Also, Benzene has not been detected in eastern off-post wells MW-105, MW-106, MW-107, MW-123, and MW-124.
- Data indicates the CSL is not the source of carbon tetrachloride, PCE and TCE present in the Lower Patapsco aquifer. Carbon tetrachloride has not been detected in the shallow aquifer. PCE and TCE were detected in the deep aquifer only for both the September 2002 and June 2004 sampling events. PCE and TCE have not been detected above MCLs in the shallow aquifer during RCRA monitoring.
- Potential exposures to on-Site soils, surface water, sediment, and vapors from groundwater by maintenance workers, adolescent trespassers, and recreational users were evaluated on the basis of current and future industrial/commercial and recreational land use scenarios at the CSL. Cumulative cancer risks for human receptors are below USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. Cumulative noncancer hazard indices for all receptors are less than 1, indicating that adverse noncarcinogenic effects are not likely to occur.
- Potential exposures to off-Post groundwater in the Upper Patapsco by construction workers and residents were evaluated on the basis of a future residential land use scenario. Cumulative cancer risks for human receptors are within or below USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. Cumulative noncancer hazard indices for the construction worker are less than 1. Cumulative noncancer hazard indices for the adult resident are equal to 1 when hazards are segregated by similar target organ and rounded to one significant figure. Cumulative noncancer hazard indices for the child resident are less than 1 when hazards are segregated by similar target organ. These results indicate that adverse noncarcinogenic effects are not likely to occur.
- Geologic, hydrogeologic, and hydraulic data indicates the Middle Patapsco clays are a thick and effective confining unit at the CSL. Likewise, data indicates the CSL is not the source of

contamination found in the Lower Patapsco. Nevertheless, Lower Patapsco data was collected and reviewed in order to provide a baseline understanding of risks associated with potential off-post exposures. Potential exposures to off-Post groundwater in the Lower Patapsco by residents were evaluated on the basis of a future residential land use scenario. Cumulative cancer risk for adult receptors is above USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. Cumulative noncancer hazard indices for adult and child receptors are above USEPA's target hazard index of 1. Cumulative cancer risk for child receptors is within USEPA's acceptable target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness. However, information presented in this RI supports the conclusion that these estimated future risks and hazards are not from chemical constituents in the CSL because the Middle Patapsco clay-rich confining unit precludes hydraulic communication between the Upper and Lower units (thereby preventing the migration of COPCs in the CSL to the Lower Patapsco) (see Section 4.4.3 for additional details).

- Most off-site residents are on public water and do not use private drinking water wells. Therefore, the use of off-Post monitoring well data (as discussed in the preceding bullet) overestimates future residential risks and hazards. In March 2005 the Anne Arundel County Health Department collected and analyzed water samples from thirteen off-Post private drinking water wells located adjacent to FGGM and downgradient from the CSL. The analytical results demonstrated that water in all the sampled wells met primary USEPA drinking water standards (MCLs). Although five of the homes had lead levels above the lead action level, the Department is working with the affected homeowners to make recommendations that can assist in effectively reducing the level of lead in their water, as the most common source of lead in home drinking water is household plumbing materials. As the measured concentrations of organics in the off-site domestic wells were below MCLs, actual (current) risks and hazards to off-Post residents are generally deemed acceptable. Although lead was a concern in five private wells, lead was not identified as a hazard driver in the CSL HHRA, and its presence in the private wells is most likely a result of leaching from household plumbing materials.
- The possibility of off-Post residents installing new private wells screened in the Upper Patapsco or the upper portion of the Lower Patapsco aquifers is extremely unlikely. Due to naturally elevated levels of radium in northern Anne Arundel County shallow groundwater, new or replacement drinking water wells must be installed to depths equal to or greater than approximately 250 to 500 feet bgs, and some may be required to be deeper than 600 feet bgs. As the depths to the Upper and Lower Patapsco aquifers are approximately 20 and 100 feet, respectively, this MDE-specific directive would generally only allow new or replacement wells in deeper portions of the Lower Patapsco aquifer where chlorinated hydrocarbon contaminants are unlikely to be present.

7.2 GEOLOGY AND HYDROGEOLOGY CONCLUSIONS

7.2.1 Upper Patapsco Aquifer

Although shallow groundwater flow in the Upper Patapsco water table aquifer is regionally to the east-southeast, topographic highs in the vicinity of the CSL results in local deviations from regional trends (**Figure 4-4**). The significant topographic features are as follows:

- The man-made cells of the CSL with their impermeable RCRA caps form significant (>30 feet) topographic highs of about 170 feet AMSL which locally impose radial deflections of shallow groundwater. This can locally impart north or westerly flow of unconfined groundwater into the low lying area between CSL cells 1 and 2 and southerly flow south of Cell 1.
- The Amtrak Railroad and associated right-of way lie in a NE-SW trending topographic low which crosses the regional groundwater flow direction at a high angle, locally resulting in surface water seeps and southerly or southwesterly deflection of unconfined groundwater flow. This is reinforced by the presence of local topographic highs (200+ feet AMSL) in central Odenton located between the right-of-way and State Road 170.

- The local topography features, and the hydraulic head measurements from the shallow wells located on the south side of Cell 1 and the off-post wells to the east suggests that local groundwater flow immediately east of the CSL is to the south or southwest instead of to the southeast.
- Hydraulic gradients in the Upper Patapso Aquifer are highly variable due to topographic variations on the order of 10^{-2} ft/ft. Mean hydraulic conductivity based on 8 slug tests was calculated as 2.44×10^{-4} cm/s (0.46 ft/day) (EA, 1992).

7.2.2 Middle Patapsco Confining Unit

The Middle Patapsco clays form a thick (35-100 feet), effective confining unit at the CSL. Regionally, this unit ranges from 0 to about 60 feet of fine sandy clay which may be heterogeneous and laterally discontinuous; however, it is often comprised of massive beds of clay (such as here) with very low vertical permeabilities (Mack and Achmad, 1986 and Wilson and Achmad 1995). This is supported by:

- The observed thickness and homogeneity of the clays encountered during drilling in the vicinity of the CSL (about 35-50 feet on-post, thickening to 70+ feet in off-post downgradient areas);
- Semi-annual RCRA monitoring show downward vertical hydraulic gradients between the upper and lower aquifers, and statistically increasing concentrations of organic contaminants (as defined by the RCRA landfill monitoring requirements) in the upper aquifer which are not observed in the lower aquifer.
- The primary organic contaminants observed in the lower aquifer, carbon tetrachloride and tetrachloroethene (PCE), were also detected in upgradient deep wells (117D and 122D). This indicates a potential source upgradient from the CSL.
- The presence of carbon tetrachloride in the deep aquifer only.
- PCE and TCE were only detected in the deep aquifer for both September 2002 and June 2004 sampling events.
- Benzene was only detected in the shallow aquifer for both September 2002 and June 2004 sampling events.
- Downward vertical hydraulic gradients are observed between the upper (unconfined) and lower (confined) aquifers in well pairs and in the measured potentiometric surfaces of the upper and lower Patapsco aquifers, with gradients generally increasing to the southeast. At the eastern CSL/facility boundary, the potentiometric surface of the lower Patapsco aquifer is about 80-90 feet msl, about 50-60 feet below the unconfined surface of the upper Patapsco aquifer (140-150 feet msl). The persistent strong negative hydraulic gradients indicate that good hydraulic separation between the aquifers is being maintained.
- The upper and lower Patapsco aquifers have different water chemistries. Charge balance calculations for major anions (calcium, magnesium, potassium, iron, sodium, and nitrate) and major cations (chloride, sulfate, and alkalinity) have been performed (EA,1992 and USACHPPM, 1994)[1]. Lower Patapsco groundwater samples showed significantly lower and more uniform microequivalent charge per liter for both cations (<1.5) and anions (<1.9) than were observed in the upper Patapsco aquifer (0 to about 50 for both anions and cations). The % differences within individual samples did not show significant differences. This indicates Upper Patapsco groundwater is not mixing with the Lower Patapsco groundwater in the vicinity of the CSL.

[1] Outling data from former well MW-4D (which was abandoned and replaced by MW-4DR) was dropped.

- Calculation of permeabilities of 5 shelby tube samples (from 5 different borings) of the middle Patapsco clay ranged from $1.2x10^{-8}$ cm/sec to $1.9x10^{-7}$ cm/sec (EA,1992). These values are representative of confining layers.
- A short term (4-hour) pumping test was performed on deep CSL well MW-7D (EA,1992). Shallow well MW-7D, screened in the lower Patapsco aquifer drew down 32 feet. Adjacent shallow well MW-7S, screened in the upper Patapsco aquifer, exhibited no drawdown. This data suggests that the middle Patapsco confining unit effectively blocked hydraulic communication between the upper and lower Patapsco aquifers in the area of the CSL. No other pump tests have been performed in this area.

7.2.3 Lower Patapsco Aquifer

Regional groundwater flow directions in the lower Patapsco aquifer are to the southeast, as documented in the USACE (1999) Basic Data Report. The potentiometric surface of the lower Patapsco aquifer, based on data from the deep CSL and adjacent area wells presented in **Figure 4-2**, is more east-southeast near the facility boundary downgradient from the CSL.

- Local hydraulic gradients are on the order of $3x10^{-3}$ ft/ft. Mean hydraulic conductivity based on slug tests was calculated as $1.59x10^{-3}$ cm/s (EA, 1992).
- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, MW-122D, 125D and 126D detections of tetrachloroethene in wells MW-114D, MW-117D, MW-120D, MW-122D, MW-125D, and MW-126D indicates the groundwater flow direction in the lower Patapsco aquifer north of the CSL is to the east-southeast, which is consistent with the regional groundwater flow direction but is a little more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR is cross-gradient from the Lower Patapsco aquifer below the CSL, not upgradient. Data indicates the carbon tetrachloride and tetrachloroethene present in the Lower Patapsco aquifer, on the north side of the CSL, aquifer are not related to the CSL.

7.3 GROUNDWATER CONCLUSIONS

7.3.1 2002 Upper Patapsco Direct Push Groundwater Screening Conclusions

Northern CSL DPT Groundwater Screening Results for VOCs

Groundwater screening for VOCs was performed at 10 DPR points in the shallow aquifer north of the CSL in and around the area of MW-4DR to be sure that contamination is not present in the shallow aquifer and migrating downward via a faulty well seal from former well MW-4D or MW-4DR and to further evaluate the CSL and properties to the north as potential sources.

- Carbon tetrachloride was not detected in any sample.
- Shallow groundwater in this area is not the source of carbon tetrachloride found in the confined aquifer.
- The screened areas are crossgradient or upgradient from the CSL.
- Shallow groundwater in this area is not significantly impacted by VOCs (above screening levels) which might be related to the CSLF.

Southern CSL DPT Groundwater Screening Results for VOCs

Shallow wells MW-12s and MW-19 monitor the Upper Patapsco Aquifer immediately south and east of the southernmost extent of CSL Cell 1. Benzene has been detected above the Tap Water RBC (0.5 μg/L) and/or MCL (5μg/L) in MW-12S and MW-19 in all RCRA semi-annual monitoring rounds since May 1995 at concentrations ranging between 2.9 and 25 μg/L. The 13 point DPT sampling effort was designed to attempt to define the extent of shallow groundwater contamination of VOCs in areas located on-post to the south, southwest and west of MW-12S and MW-19.

- Benzene was detected above the MCL of 5 μg/L in three adjacent sampling points located near the southernmost tip of cell 1: MDP-6 (12 μg/L), MDP-7 (9.1 μg/L), and MDP-8 (5.1μg/L). No other VOCs were detected above an MCL. Benzene was detected above the Tap Water RBC in 9 of the other 10 sampling points (0.45 – 4.4 μg/L) with the concentrations generally decreasing to the south and west.
- Chloroethane (4.2 μg/L), Chloroform (up to 3.4 μg/L), 1,2-dichloroethane (up to 0.93 μg/L), 1,2-dichloropropane (up to 2 μg/L), trichloroethene (up to 0.64 μg/L), vinyl chloride (up to 1.2 μg/L) and total xylenes (24 μg/L) were sporadically detected above Tap Water RBCs.
- Carbon tetrachloride was not detected.
- The highest VOC concentrations were detected immediately southeast of the south tip of Cell 1.
- The lateral extent of VOC contamination, as indicated by the presence of benzene at concentrations above the MCL in shallow groundwater screening samples, is about 600 feet. MW-12S and MW-19 essentially bound the area of benzene MCL exceedances.
- Shallow groundwater is generally flowing south-southeast from the elevated topography of Cell 1. However, based on the site and surrounding topography shallow groundwater in the vicinity of the southern end of Cell 1 is locally influenced by radial flow to the south and southwest.

7.3.2 2002 Upper Patapsco Groundwater Sampling Conclusions

Because of the persistent benzene MCL exceedances during RCRA monitoring of shallow wells MW-19 and MW-12S located immediately downgradient of the southern tip of Cell 1, all existing shallow wells located on FGGM property south of MW-12S and MS-19 were sampled for TCL VOCs to assess the whether additional wells need to be added to the semi-annual monitoring well network.

The TCL VOC detections above Tap Water RBCs or MCLs are summarized as follows:

- No VOCs were detected above MCLs.
- Benzene (1.8-3.1 μg/L) was detected above the Tap Water RBC in MW-11, MW-12S, MW-19, and MW-20, with the highest detection in MW-12S. 1,2-Dichloropropane (0.26-0.39 μg/L) was detected above the Tap Water RBC in MW-11 and MW-20. Chloroform (0.28 μg/L) exceeded the Tap Water RBC in MW-21.
- Chloroform (0.28 μg/L) in MW-21 was the only other VOCs to exceed a Tap Water RBC.
- Based on this data, it was determined, in consultation with the FGGM Environmental Partnership, that no additional shallow monitoring wells were required in this area of the CSL for the semi-annual monitoring program.

7.3.3 2004 Upper Patapsco Groundwater Sampling Conclusions

Western Shallow Groundwater Wells: Monitoring wells MW-4S, MW-5, MW-7S, MW-8, and MW-10S are sited along the western margin of the CSL. These wells monitor upgradient conditions (MW-4S) and localized westward flow of shallow groundwater due to the local topography of Cell 1 and Cell 2.

- Lead, in MW-5, was the only detection above MCLs.
- Sporadic detections of inorganics exceeded Tap Water RBCs.
- Groundwater sampling results show that little contamination is migrating westward from the CSL and that the upgradient wells are in upgradient locations relative to the CSL waste disposal areas.

Eastern Boundary Shallow Groundwater Wells: Monitoring wells MW-2S, MW-12S, MW-13, MW-14, MW-17, MW-18, MW-19, and MW-20 are sited along the installation boundary along the eastern margin of the CSL. These wells monitor the flow of shallow groundwater off the topographic highs of Cell 1 and Cell 2 downgradient toward lower elevations along the railroad line to the east.

- Benzene (10.4 μg/L) in MW-19 was the only VOCs detected above MCLs.
- Arsenic, Cadmium and Thallium were detected above MCLs.

Off-Post Shallow Groundwater Wells: Samples from off-post shallow monitoring wells MW-105 to MW-107, located east of Cell 1 and the Amtrack Maintenance Yard show low-levels of contamination in the Upper Patapsco aquifer.

- No analytes were detected above MCLs. MTBE exceeded the Tap Water RBCs in off-post wells MW-105 and MW-106. Chloroform and bis-2-Ethylhexyl)phthalate exceeded Tap Water RBCs in MW-106 and MW-123s.
- Benzene was not detected in off-post shallow wells.
- The lack of benzene detections and the limited detections above Tap Water RBCs in the Upper Patapsco aquifer suggests that CSL-related contamination is migrating to the southwest rather than the southeast.

Samples from off-post shallow monitoring wells MW123S and MW-124S, located east of Cell 2, suggests that contamination from the CSL is not migrating to this area in the Upper Patapsco aquifer. No analytes were detected above MCLs.

New Upgradient Shallow Groundwater Well:

- Beryllium (40.2 μg/L) was detected above the MCL of 4 μg/L in MW-127S. This detection is within background levels and may be naturally occurring.
- Vanadium was detected above the Tap Water RBCs in MW-128S.

7.3.4 2002 Lower Patapsco Groundwater Sampling Conclusions

New On-Post Northern CSL Lower Patapsco Well Sampling

Carbon tetrachloride has been consistently detected in well MW-4DR at concentrations above the MCL ranging from 66-91 μg/L in multiple sampling rounds since 1999, but had previously not been detected in any other CSLF well. MW-4DR, screened from 129 to 149 feet bgs in the confined Lower Patapsco aquifer, was included in the semi-annual monitoring program as an upgradient well for the CSL. A total of 9 new deep wells (MW-113D to MW-1115D and MW-117D to MW-122D) were installed and sampled as part of the carbon tetrachloride investigation to determine if the CSL is the source of contamination, and if not, to determine if the contamination source is on-post or off-post and to attempt to delineate the extent of contamination. Summary results for the installation and sampling of these wells are as follows:

- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, and MW-122D indicates the groundwater flow direction in the Lower Patapsco Aquifer north of the CSL is to the east-southeast, which is consistent with the regional groundwater flow direction but is more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR is cross-gradient from the CSLF, not upgradient.
- Data indicates the CSL is not the source of the carbon tetrachloride. Upgradient well (MW-122D) suggests the source is northwest of the CSL.
- The CSL proper, aside from MW-4DR and perhaps the northeastern most corner of the CSL, is downgradient from the carbon tetrachloride source.

- Carbon tetrachloride is present at a concentration above the MCL at in MW-114D (26 μg/L) and is migrating in an east-southeasterly direction.
- PCE was also detected above the MCL or Tap Water RBC in northern (from the CSL) wells MW-117D, MW-120, MW-122D and northern CSL wells MW-114 and MW-115.
- PCE was detected above the MCL of 5 μg/L in wells MW-114D (9.9 μg/L) and MW-117D (14 μg/L).
- PCE (0.22-2.2 μg/L) was detected above the Tap Water RBCs in Well MW-115D, MW-120D, and MW-122D.
- Detections of PCE show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSL is to the east-southeast, which is consistent with that observed for the spatial distribution of carbon tetrachloride detections.
- Data indicates the source of the PCE detected above screening criteria, is crossgradient and upgradient from the CSL.

Other VOCs were detected in one or more wells at concentrations above Tap Water RBCs as follows: chloroform (0.79-5 μg/L) in 7 wells and trichloroethene (0.21-2.8 μg/L) in 6 wells.

New Off-Post Downgradient CSL Lower Patapsco Well Sampling

Five new wells (MW-109D to MW-112D, and MW-116D) were installed at off-post locations between the Amtrak Maintenance Yard and Route 175 at the request of MDE to monitor the Lower Patapsco Aquifer downgradient of the CSL. Summary results for the installation and sampling of these wells are as follows:.

- Fewer organic analytes were detected, and at generally lower concentrations, than samples from on-post wells located proximal to the CSLF.
- No analytes were detected above MCLs.
- PCE in two wells, bis(2-ethylhexyl)phthalate, and scattered metals were detected at concentrations above Tap Water RBCs.

7.3.5 2004 Lower Patapsco Groundwater Sampling Conclusions

Northern CSL On-Post Lower Patapsco Aquifer Wells:

Summary results for the sampling of the northern CSL deep wells (MW-4DR and MW-113D to MW-115, and MW-117 to MW-122D) are as follows:

- Carbon tetrachloride and tetrachloroethene are present above MCLs and Tap Water RBCs in multiple wells across the northern CSL area, including wells upgradient and/or cross gradient from the CSL.
- The spatial distribution of detections of carbon tetrachloride in wells MW-4DR, MW-114D, MW-115D, and MW-122D and tetrachloroethene in wells MW-114D, MW-117D, and MW-120D show the groundwater flow direction in the Lower Patapsco Aquifer north of the CSLF is to the east-southeast. This is consistent with the regional groundwater flow direction but is more easterly than predicted by the USACE groundwater model for FGGM.
- MW-4DR is cross-gradient from the CSLF, not up-gradient.
- The CSL proper, aside from MW-4DR and perhaps the northeastern most corner of the CSL, is downgradient from the carbon tetrachloride source. Data indicates the carbon tetrachloride in the Lower Patapsco Aquifer is not related to the CSL.
- Carbon tetrachloride is present at a concentration above the MCL in MW-114D (61.5/61.3 μg/L) and MW-4DR (11.6 μg/L) and is migrating in an east-southeasterly direction.

- Upgradient well (MW-122D) data suggests the source is northwest of the CSL.

Northern CSL Off-Post Lower Patapsco Aquifer Wells (June 2004 and March 2005):

For off-post wells MW-125D and MW-126D:

- Carbon tetrachloride and PCE were detected above MCLs in each well.
- Chloroform and trichloroethene were also detected in both wells above Tap Water RBCs.
- Lead and Thallium were detected above MCLs in 125d.

Southern CSL On-Post Lower Patapsco Aquifer Wells

In the on-post CSL area containing wells MW-2D, MW-7D, MW-12D, and MW-101D (excluding the northeast corner of Cell 2 and Cell 3), deep groundwater in the Lower Patapsco aquifer is not contaminated above screening levels.

- No analytes were detected above MCLs or Tap Water RBCs.
- Carbon tetrachloride, PCE, TCE, and benzene and their breakdown products were not detected.
- The Lower Patapsco aquifer is not contaminated above screening levels in the southern on-post area.. No analytes were detected above MCLs or Tap Water RBCs. Carbon tetrachloride, PCE, TCE, benzene, and their breakdown products were not detected in these on-post southern wells.

Southern CSL Off-Post Lower Patapsco Aquifer Wells:

In the off-post CSL area east and downgradient of Cell 1, deep groundwater in the Lower Patapsco aquifer is not significantly contaminated above screening levels.

- No analytes were detected above MCLs.
- Tetrachloroethene and bis(2-ethylhexyl)phthalate and vanadium exceeded Tap Water RBCs in only one sample each.
- Carbon tetrachloride, TCE, benzene and their breakdown products were not detected.

7.4 SOIL SAMPLING CONCLUSIONS

Cell 3 Trenching and Soil Sampling Conclusions

- Sanitary waste and construction debris were found in 5 of 6 characterization trenches performed in Cell 3.
- Surface and subsurface soil sampling results from the Cell 3 characterization trenches do not show distribution of chemical contamination above Industrial RBCs for soil.
- Arochlor 1221 (6.39 mg/kg) and Arochlor 1242 (1.94 mg/kg) in subsurface soil sample TR-3B were the only organic analytes detected above Industrial RBCs.
- Arsenic, the only inorganic analyte detected above Industrial RBCs, was detected above the RBC in a majority of the samples. However, the maximum background concentration for arsenic in surface soil (2.79 mg/kg) which is greater than the RBC, was exceeded in only one surface soil sample.

Former ASP Soil Sampling Conclusions

- Surface and subsurface soil sampling from the former locations of ammunition storage magazines does not indicate the presence of soil contamination above Industrial RBCs.
- Explosives were not detected.
- No organic analytes were detected above Industrial RBCs.

- No inorganic analytes other than arsenic were detected above Industrial RBCs. Arsenic was detected above the RBC (1.9 mg/kg) and maximum background in 9 of 15 samples collected at concentrations up 3.3 mg/kg.

Cell 1 and Cell 2 Cover Soil Sampling Conclusions

- Surface soil sampling results from the Cell 1 and Cell 2 cover materials does not indicate the presence of contamination above Industrial RBCs.
- Explosives were not detected above Industrial RBCs. Explosives, primarily dinitrotoluenes and 2,4,6-TNT were detected in samples SS-1 through SS-5.

7.5 SURFACE WATER AND SEDIMENT SAMPLING CONCLUSIONS

- MCLs or AWQCs were not exceeded in any of the six surface water samples.
- ER-Ls were only exceeded for three PAHs in sediment sample SED5, located several thousand feet downstream of the CSL to the west.
- Surface water and sediment leaving the site to the east are not showing site-related impacts.
- Surface water downstream from the CSL to the west are not showing site-related impacts. Except for the detections of PAHs above ER-Ls in one distal downstream sample, the CSL is not contributing to downstream contamination of sediments above the screening criteria. Since PAHs were not detected in SED2 or SED4, the samples collected proximal to the CSL, it seems unlikely to attribute PAH exceedances in SED5 to the CSL.
- These surface water sampling results are consistent with the RCRA surface water detection monitoring sampling results.

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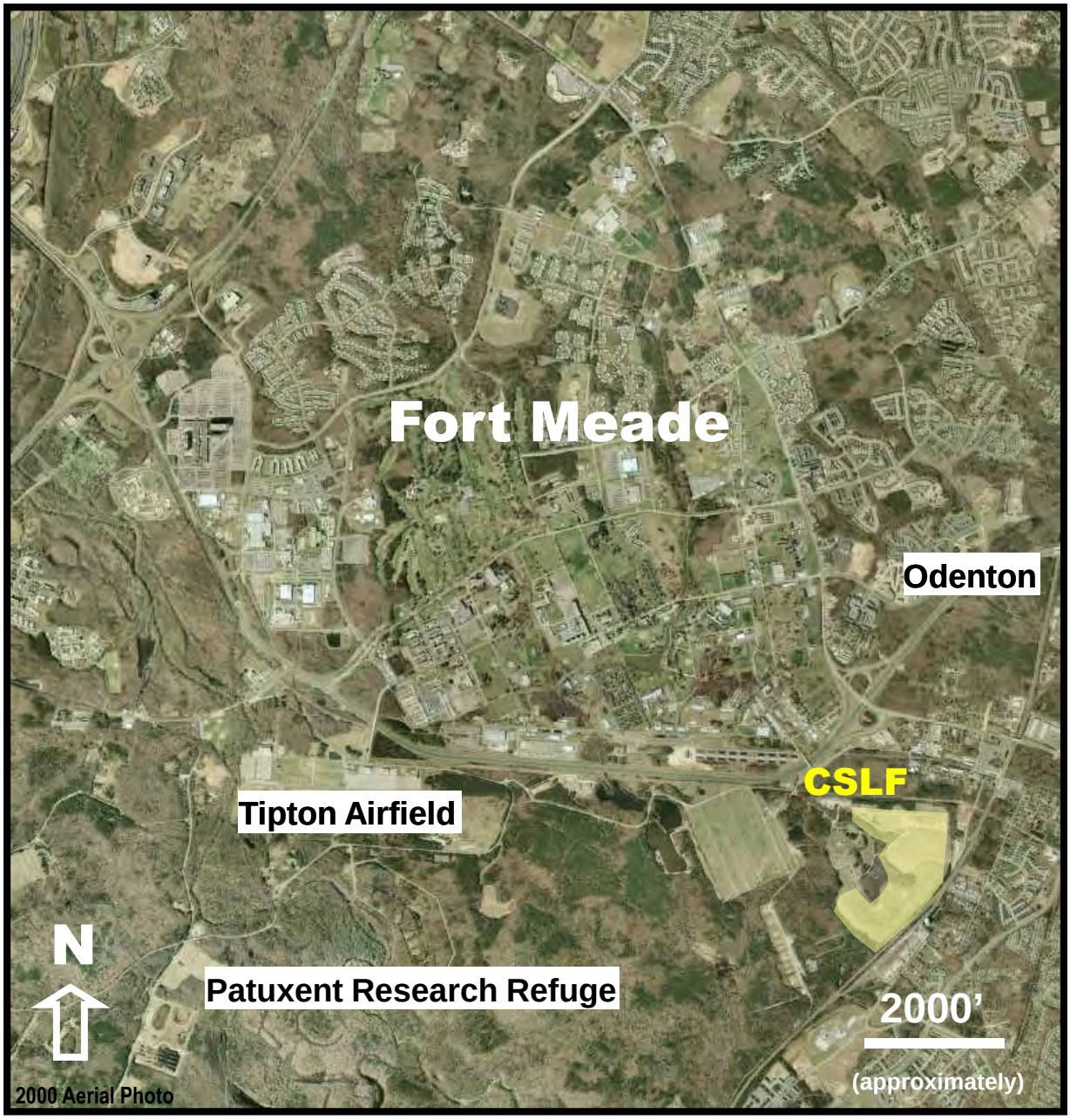
FIGURE 2-1



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EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	KB 6/16/05 FM-AP	Fort Meade Closed Sanitary Landfill	**Figure 2-1** **Fort Meade Regional Location Map**

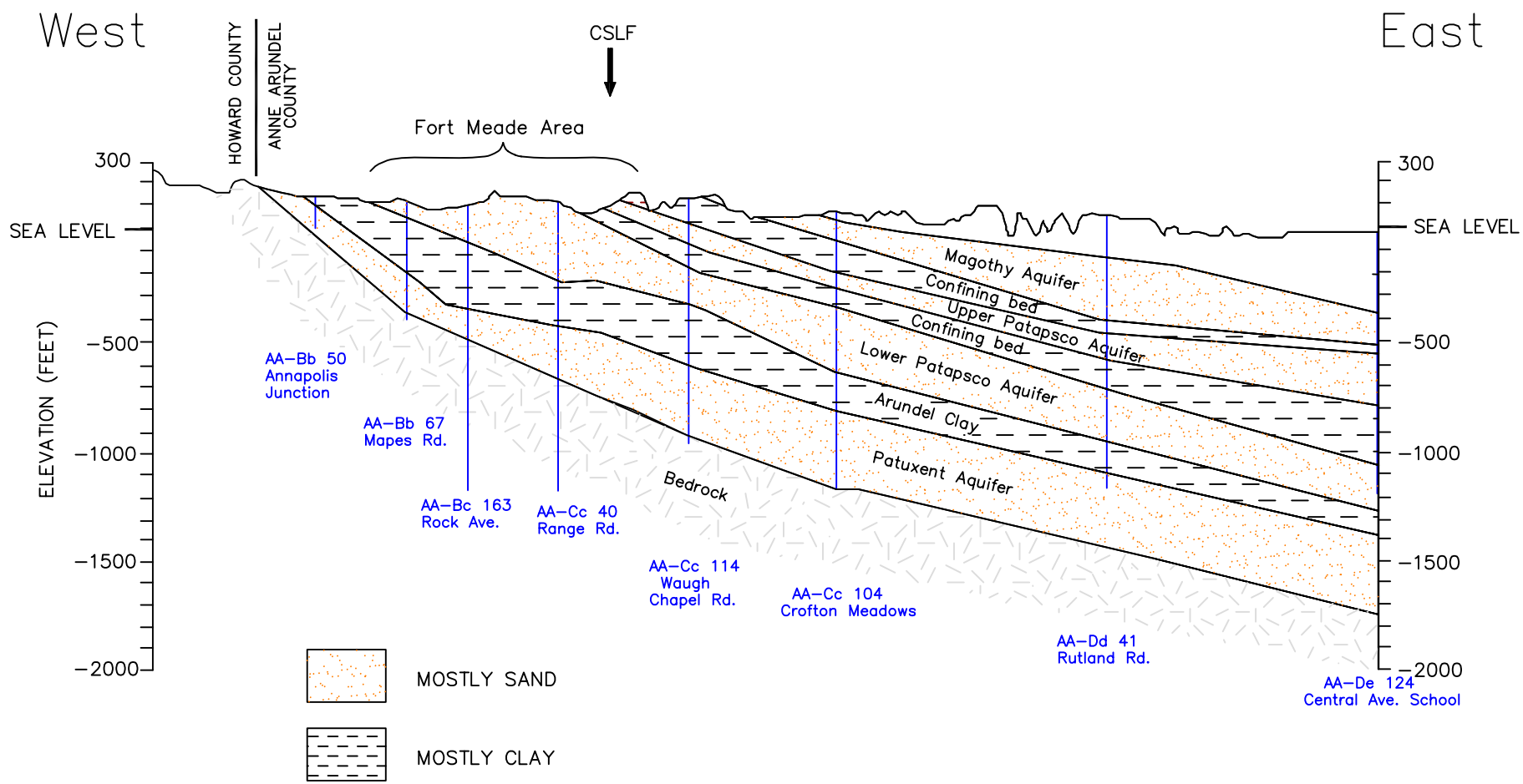
FIGURE 2-2

DRAFT

1999 Aerial Photograph

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	JR 6/21/05 CSL-Site	Fort Meade Closed Sanitary Landfill	**Figure 2 2** **Closed Sanitary Landfill Site Map**

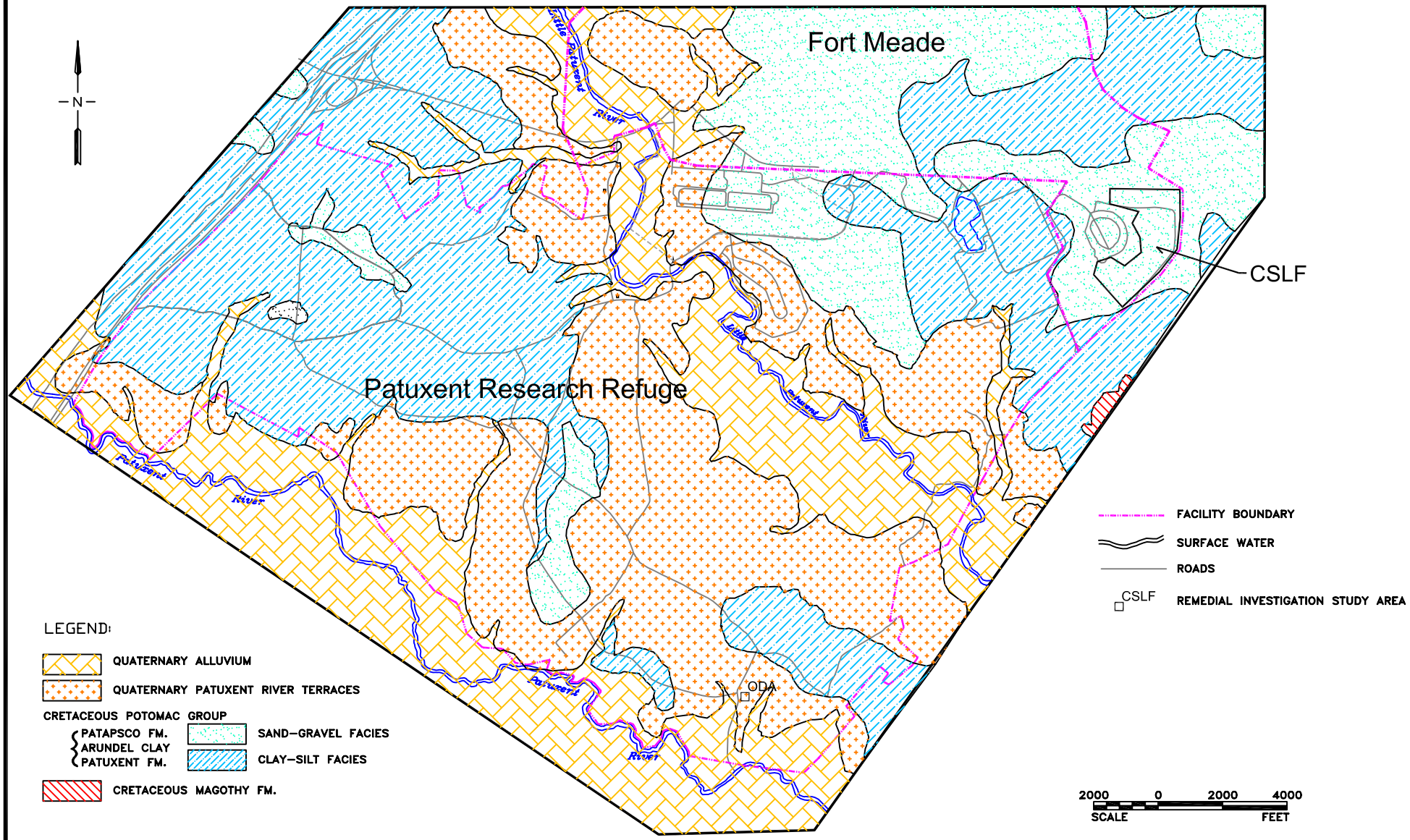
FIGURE 2-3



SOURCE: MDGS-REPORT OF INVESTIGATIONS NO. 46 (1986)

EM FEDERAL CORPORATION	**DRAFT**	JR 6/16/05 FM-XS-CSL	Fort Meade Closed Sanitary Landfill	Figure 2-3 Generalized Geologic Cross Section Across Anne Arundel County

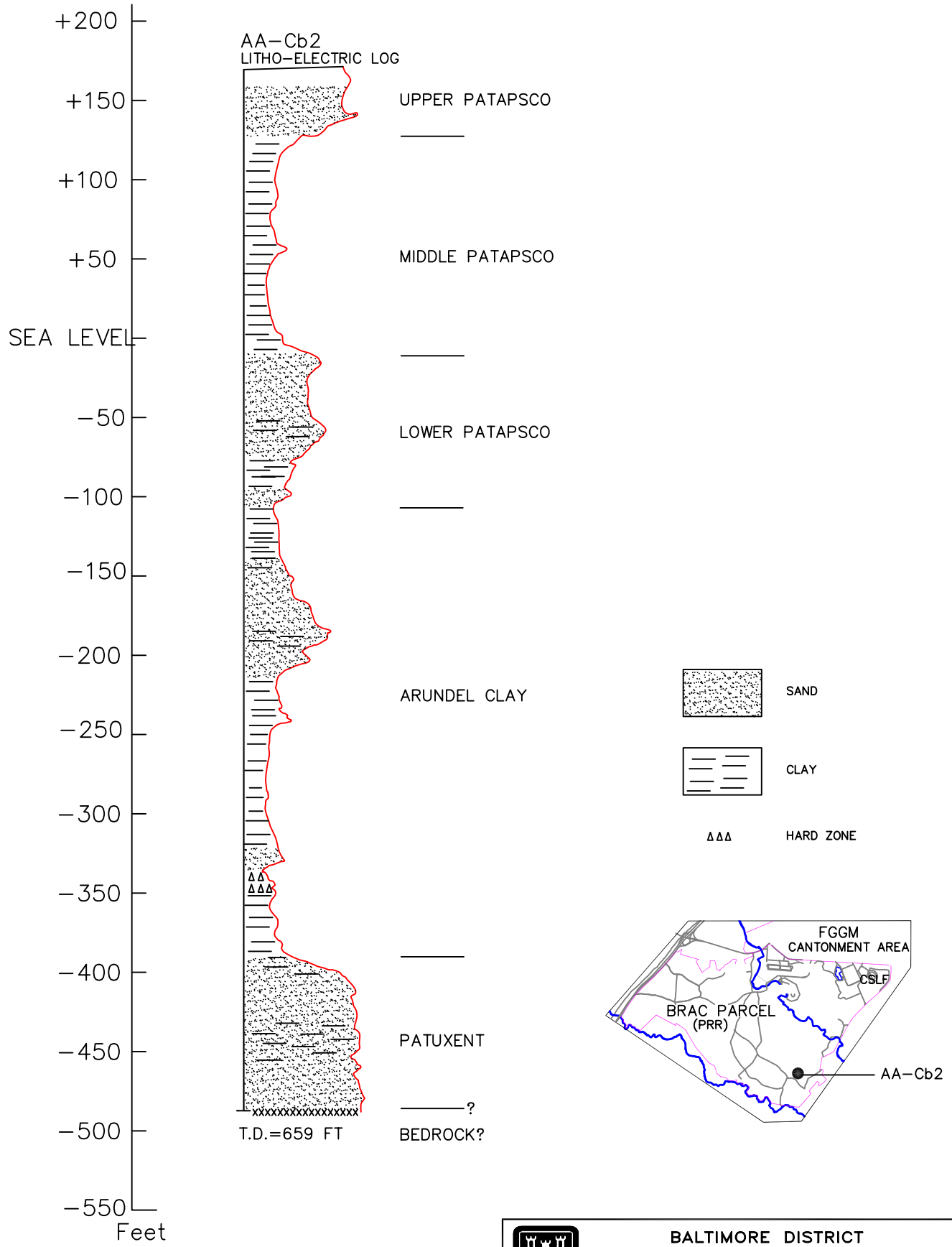
FIGURE 2-4



SOURCE: GLASER (1976) GEOLOGIC MAP OF ANNE ARUNDEL COUNTY

EM FEDERAL CORPORATION	DRAFT	JR 6/16/05 FM-GEO	Fort Meade Closed Sanitary Landfill	Figure 2-4 Geologic Map of Fort Meade Area

FIGURE 2–5



SOURCE: HANSEN (1968)

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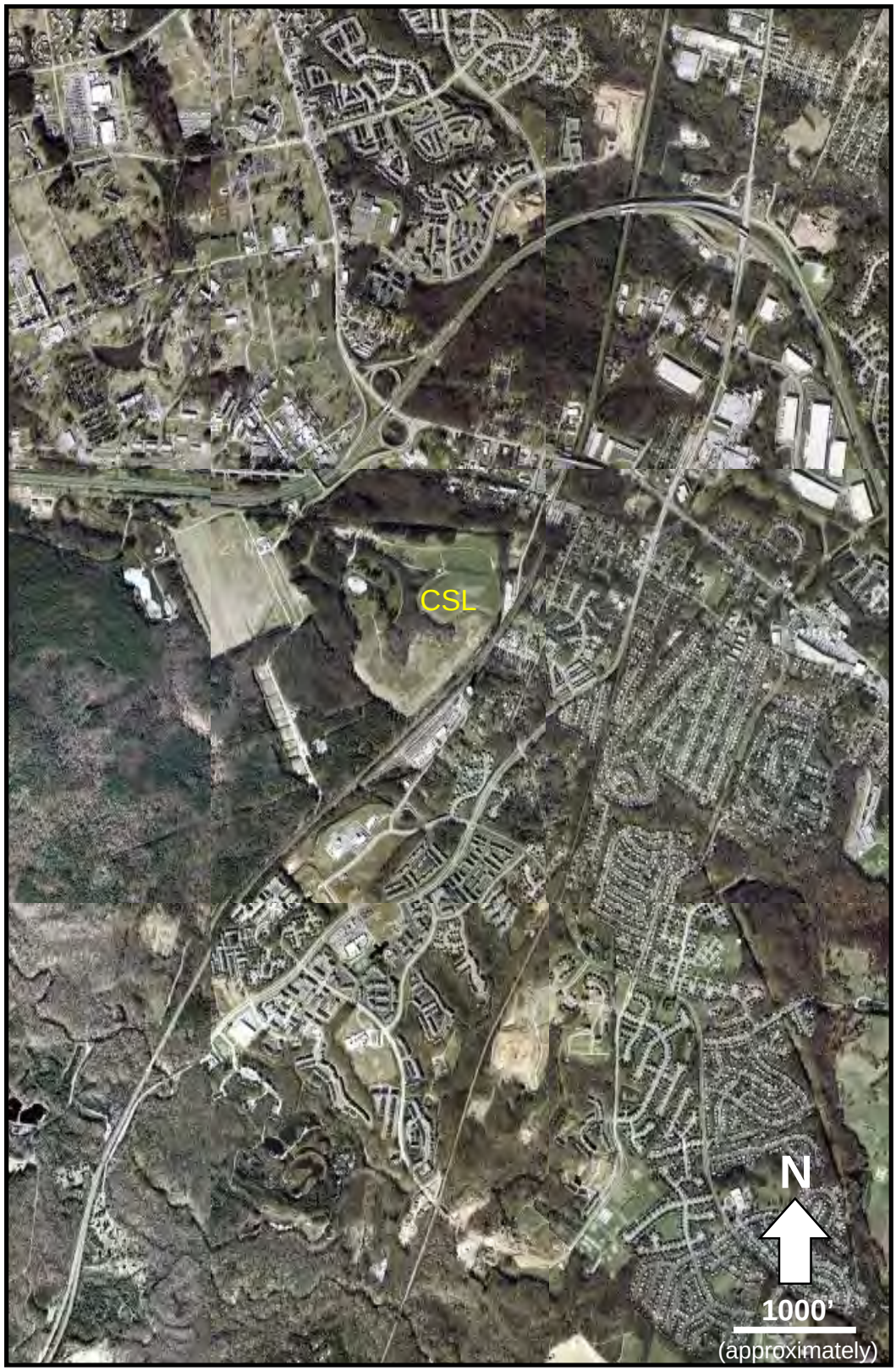
RLH 6/21/05
PM APPROVAL DATE

FM–LOG
16–JUN–05

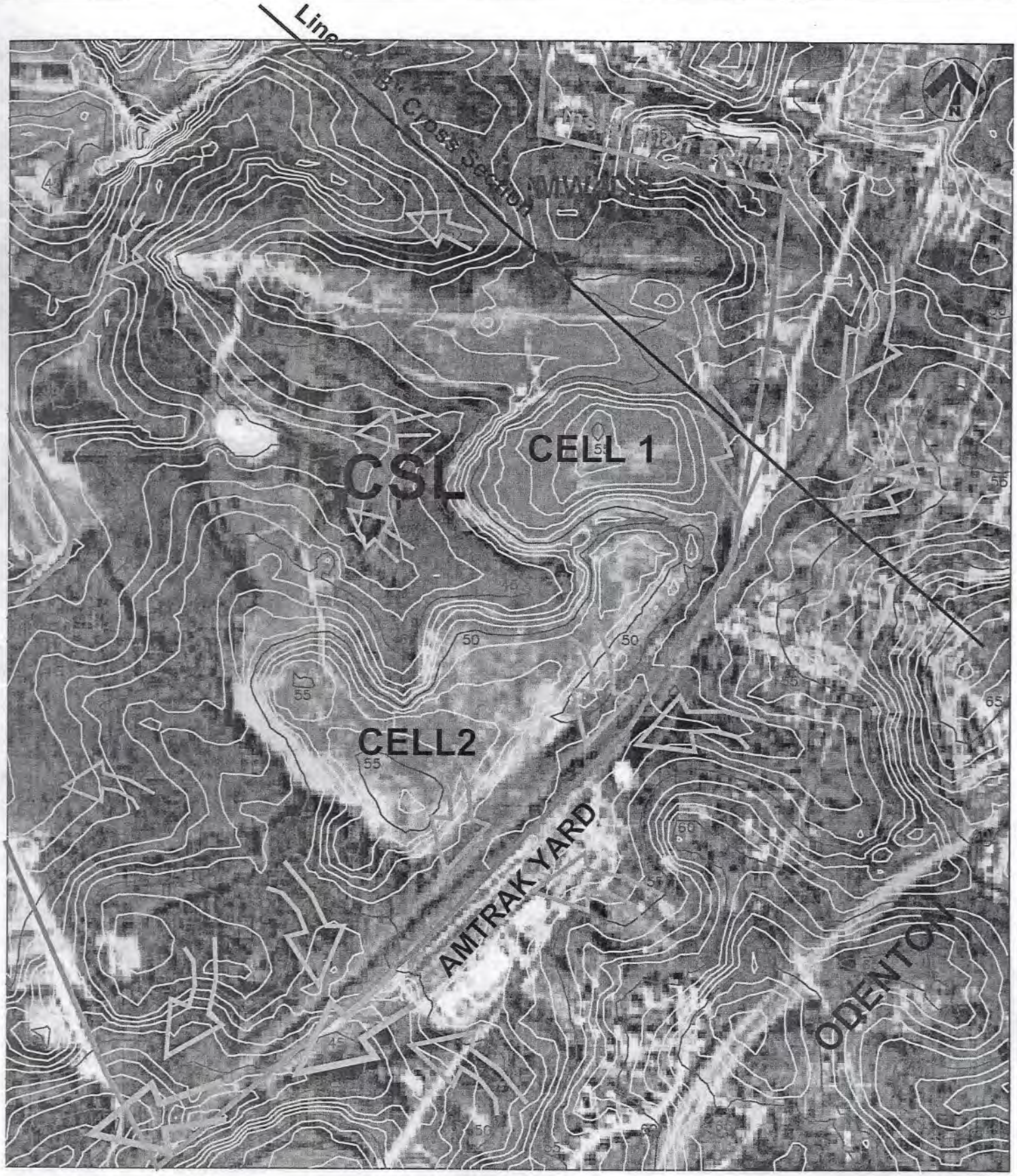
FIGURE 2–5
FORT GEORGE G. MEADE

LITHO–ELECTRIC LOG OF STRATIGRAPHY AT FORT MEADE

FIGURE 2-6



EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	**DRAFT**	JR 6/18/05 FM-AERIAL	Fort Meade Closed Sanitary Landfill	Figure 2-6 Aerial Photograph of the CSL and Surrounding Areas



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KB 8/9/07 B-CSL-CSM	Fort Meade Closed Sanitary Landfill	Figure 2-7 Closed Sanitary Landfill Conceptual Site Mode

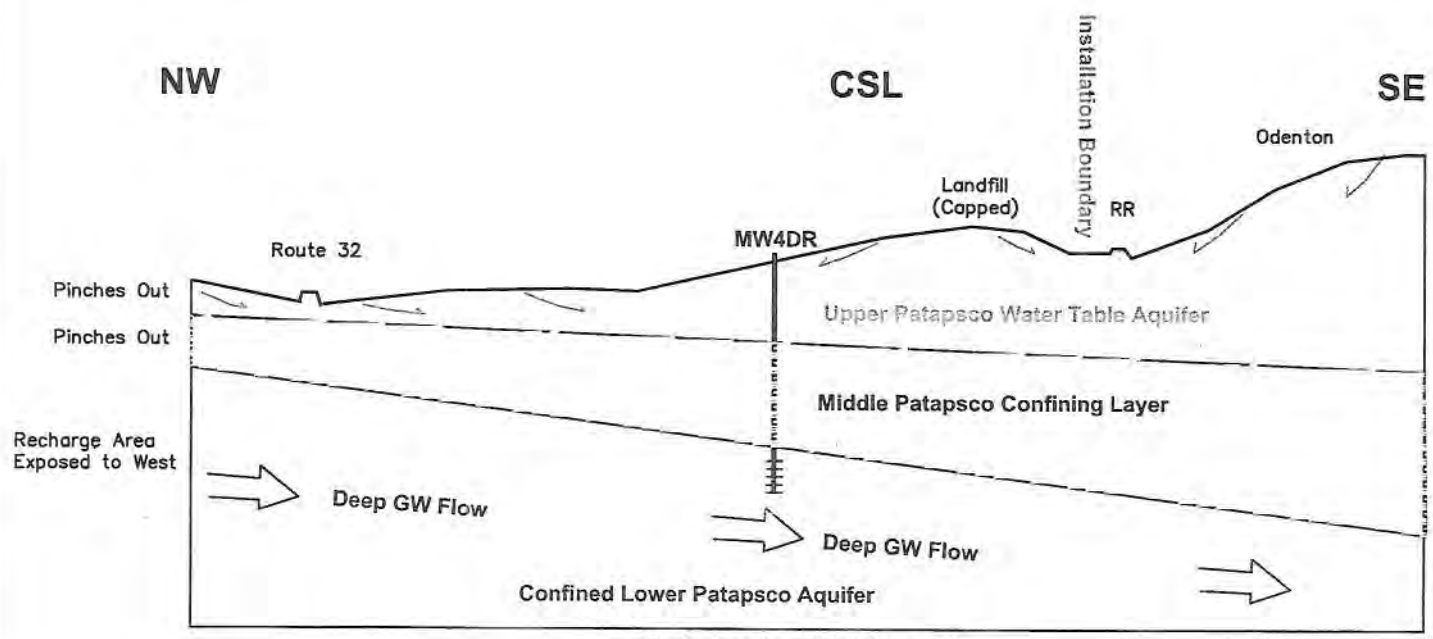
A. Shallow (unconfined) groundwater flow at the CSL is controlled by topography.

——— 5m topographic contour

1m topographic contour

Radial, shallow groundwater flow direction

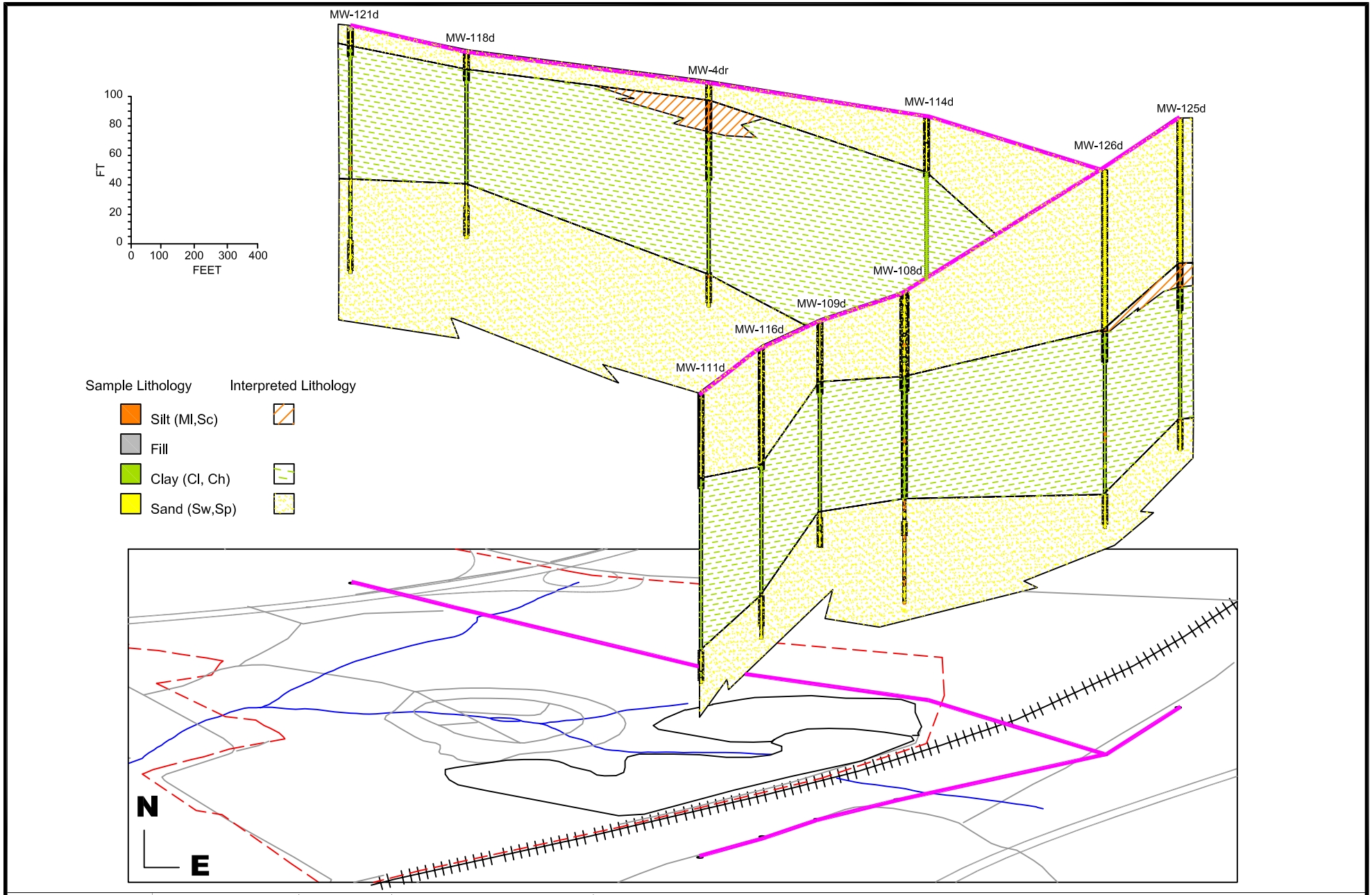
B. Deep (confined) groundwater flows under the CSL to the southeast



Schematic - Not to scale

odel

FIGURE 2-8



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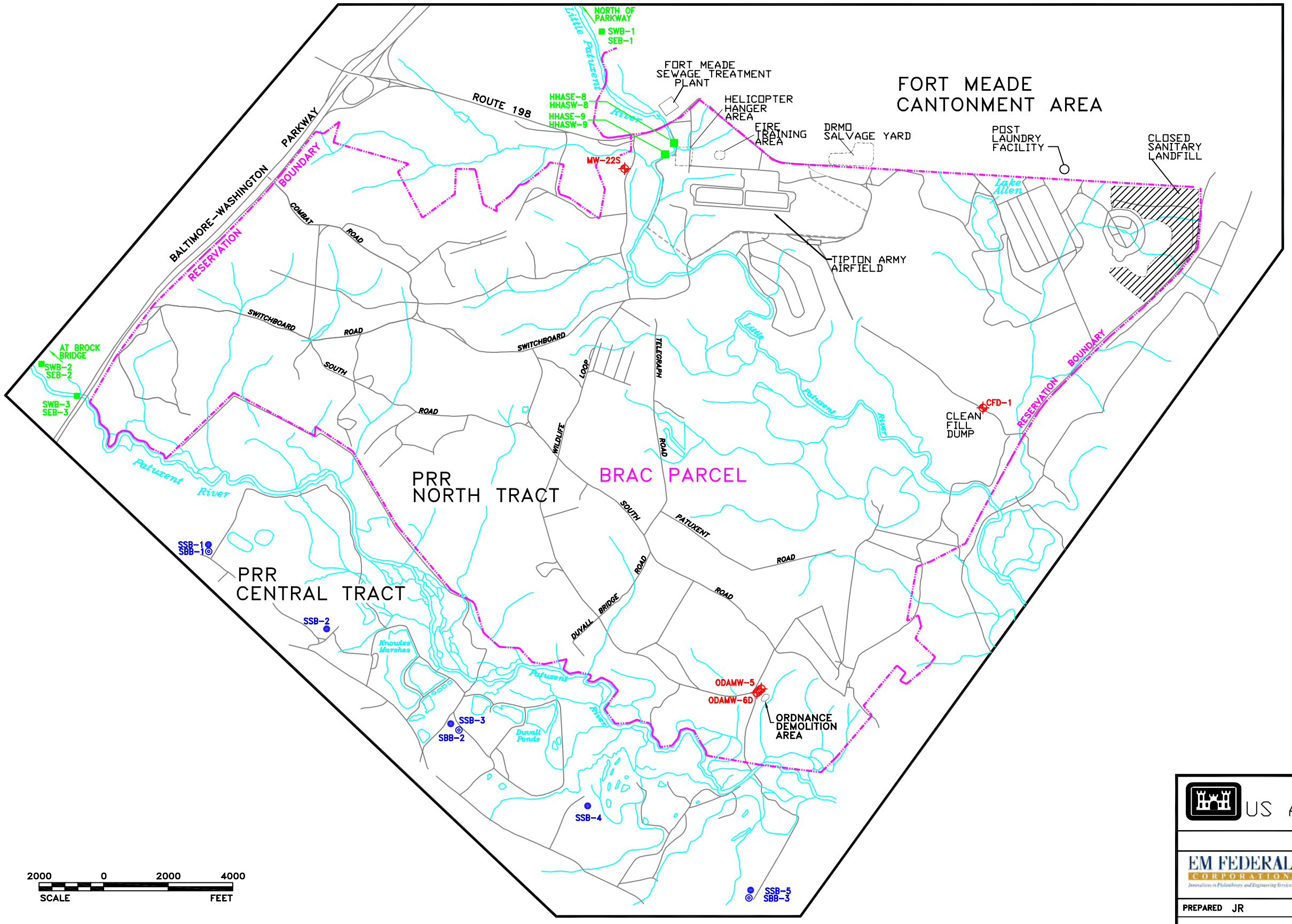
Fort Meade
Closed Sanitary Landfill

Figure 2-8
Fence Diagram of CSL Area

FIGURE 3–1



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LEGEND:

- MWB–1 SHALLOW MONITORING WELL
- MWB–6 DEEP MONITORING WELL
- SSB–5 SURFACE SOIL SAMPLE
- SBB–3 SOIL BORING
- SWB–2 SEB–2 SURFACE WATER/SEDIMENT SAMPLE
- SURFACE WATER
- ROADS
- REMEDIAL INVESTIGATION STUDY AREA

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FIGURE 3–1
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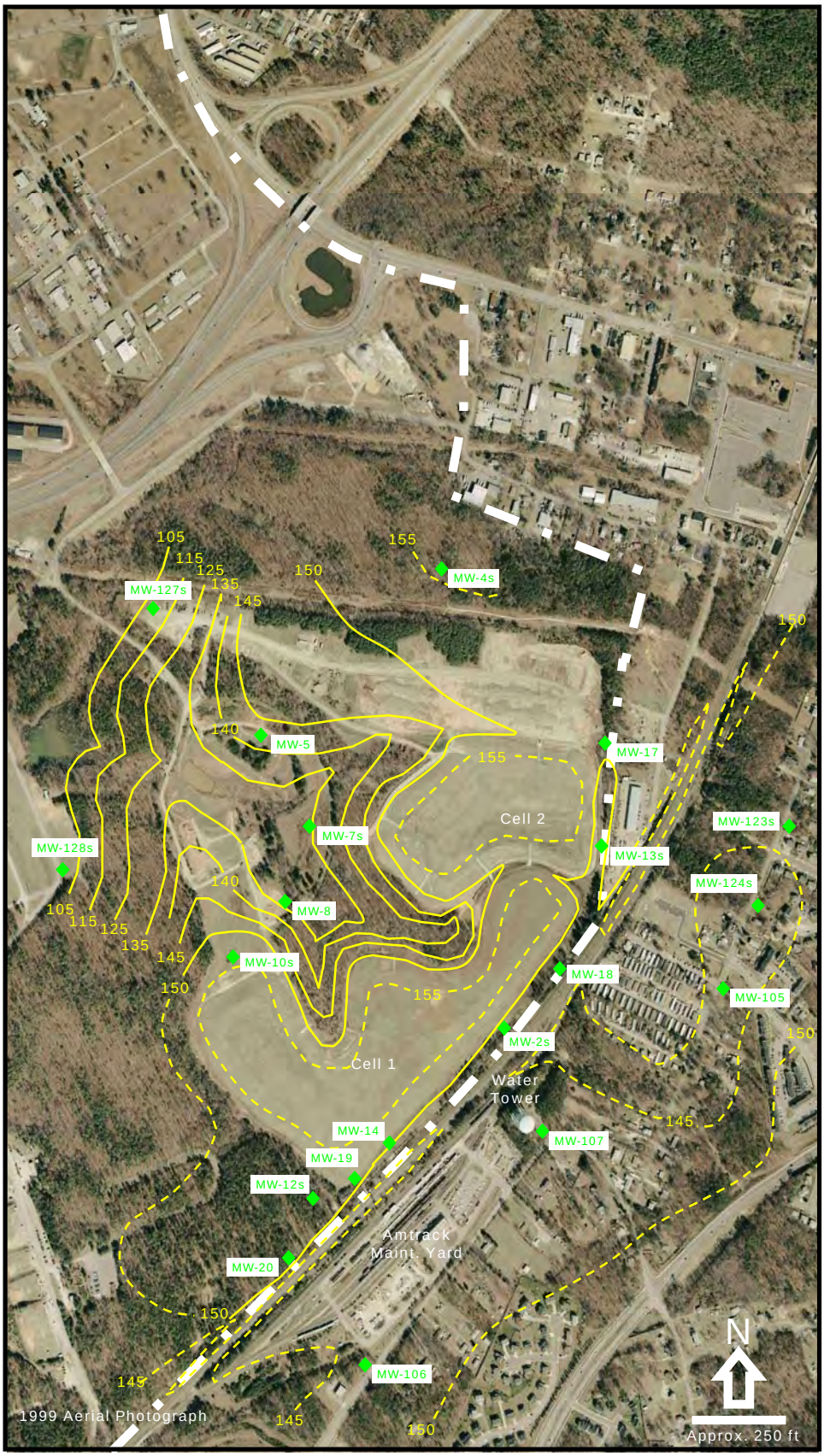
LOCATION OF BACKGROUND SAMPLES

FIGURE 4-1



Water Levels Measured during June 2004 Sampling Event in ft-msl

Shallow (Upper Patapsco aquifer) Groundwater Contour (contours are dashed where inferred)

MW-20 Shallow (Upper Patapsco aquifer) Groundwater Monitoring Well

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FIGURE 4-2

Water Levels Measured during June 2004 Sampling Event in ft-msl

Deep (Lower Patapsco Aquifer) Groundwater (contours are dashed where inferred)

MW-111d Deep (Lower Patapsco Aquifer) Monitoring Well

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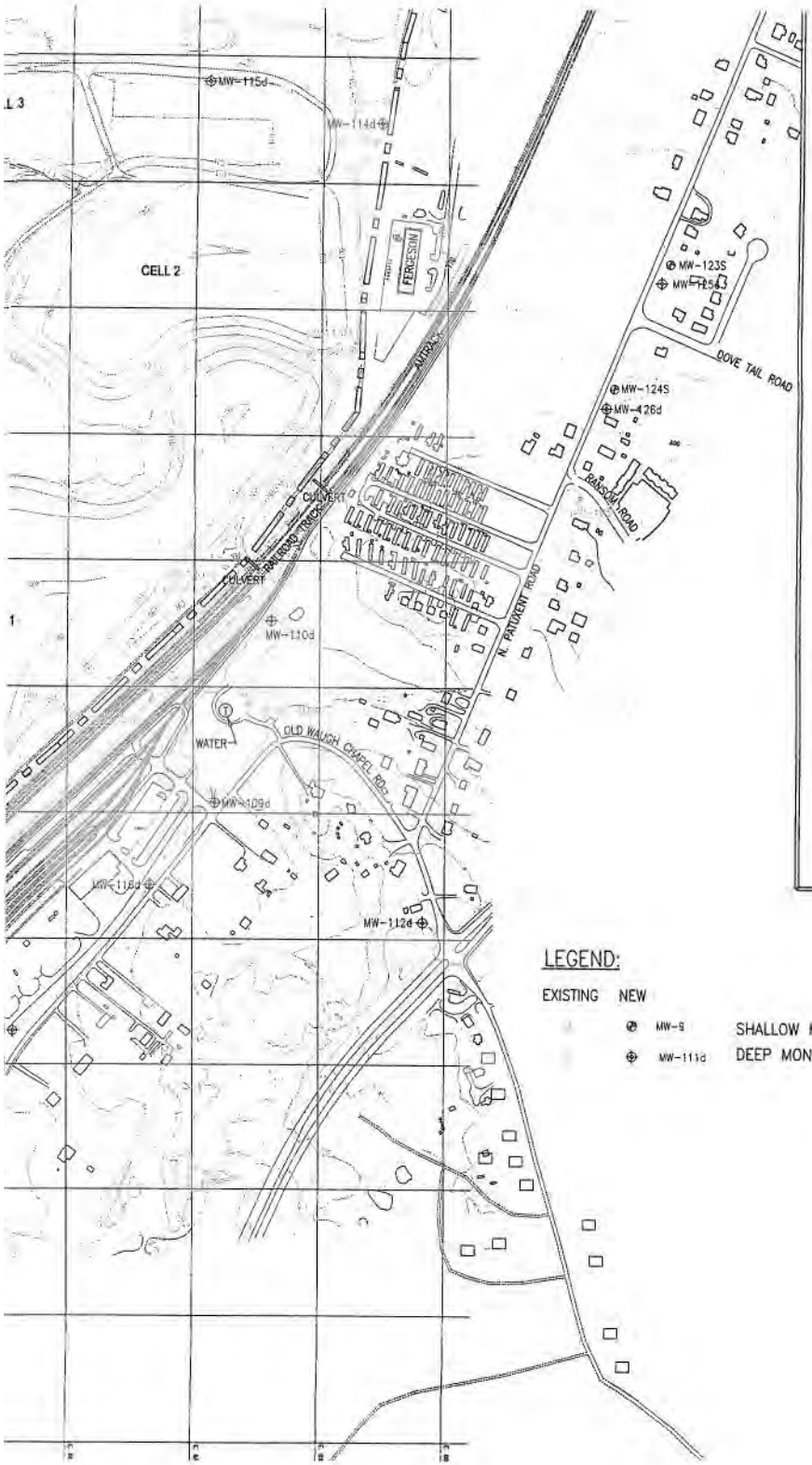
FIGURE 4-3

Water Levels Measured during June 2004 Sampling Event in ft-msl

Deep (Lower Patapsco Aquifer) Groundwater (contours are dashed where inferred)

Shallow (Upper Patapsco Aquifer) Groundwater (contours are dashed where inferred)

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	**DRAFT**	JR 6/16/05 UL-Contour	Fort Meade Closed Sanitary Landfill	**Figure 4-3** **Upper and Lower Aquifer Potentiometric Surface Map**



LEGEND:

EXISTING	NEW	
	MW-9	SHALLOW MONITORING WELL LOCATION
	MW-111d	DEEP MONITORING WELL LOCATION

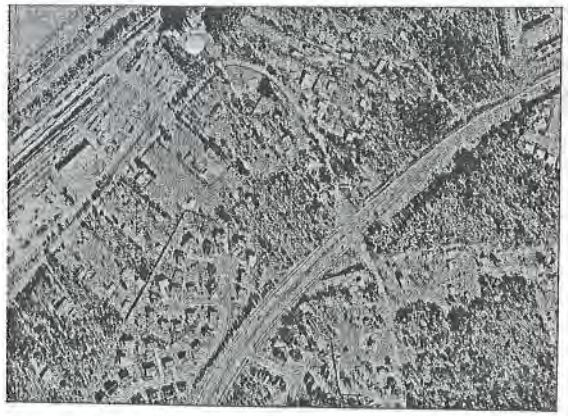


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FIGURE 4-4
FORT GEORGE G. MEADE

CLOSED SANITARY LANDFILL TOPOGRAPHY WITH NEW AND EXISTING WELLS

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FIGURE 4-5

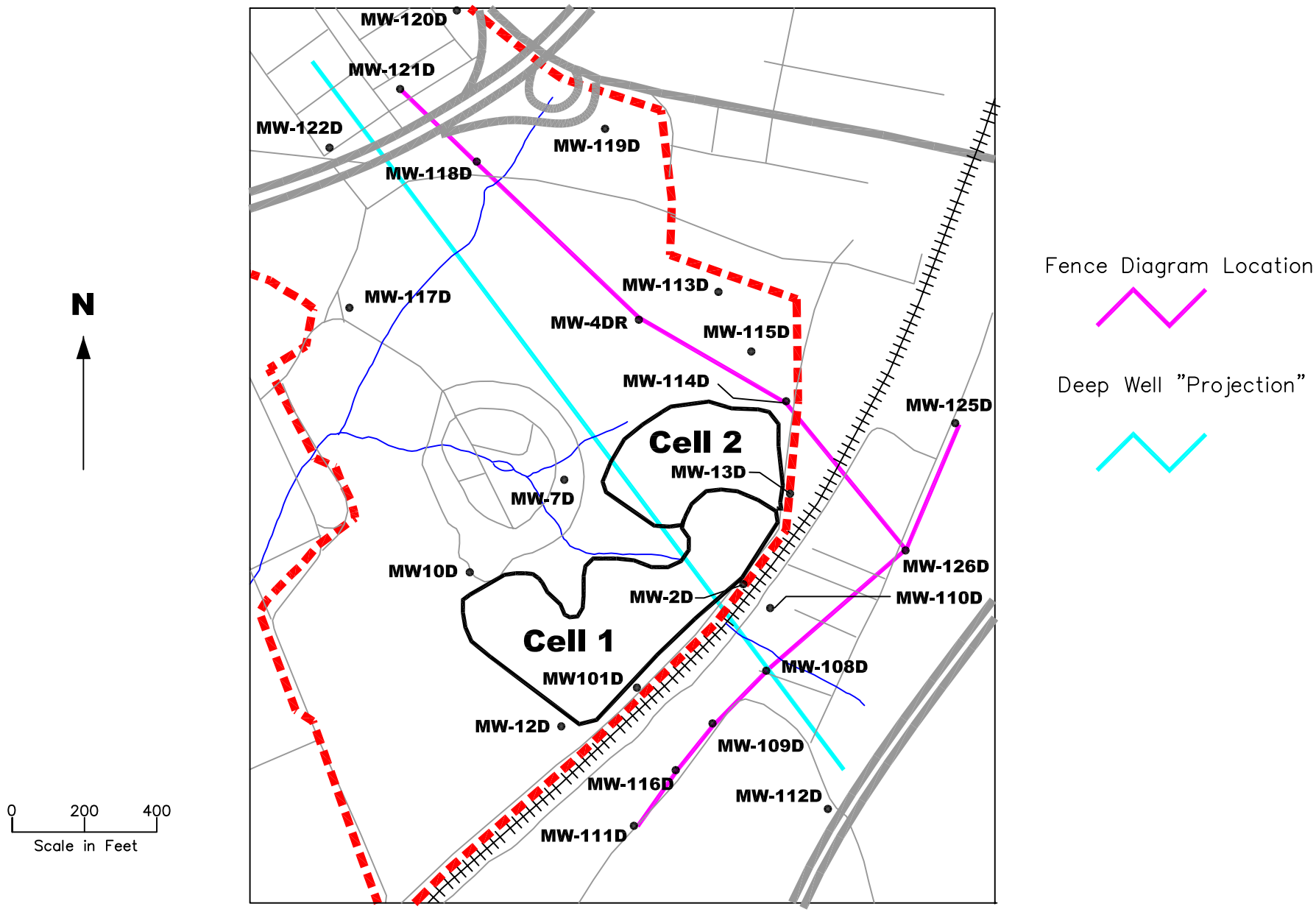

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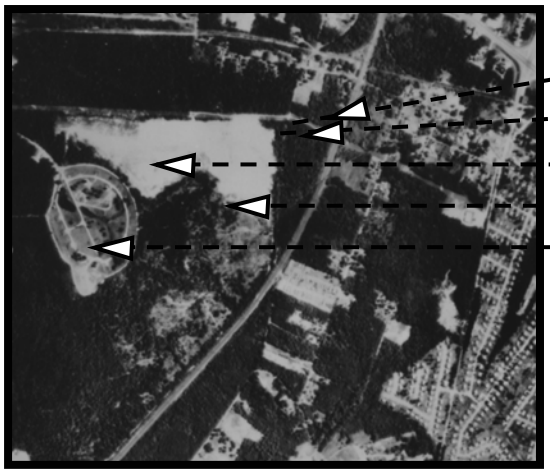
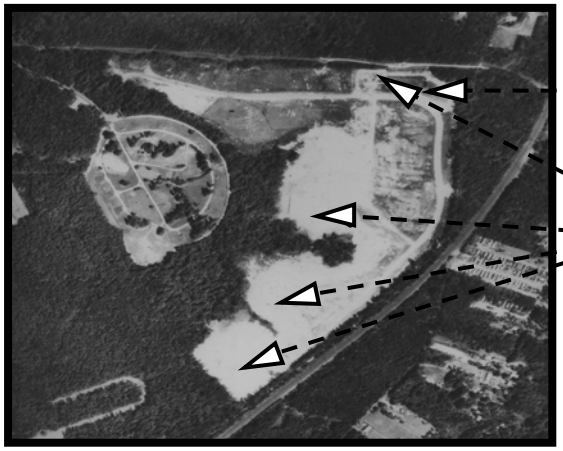
Figure 4-5
Location of CSL Fence Diagram and Cross Sections

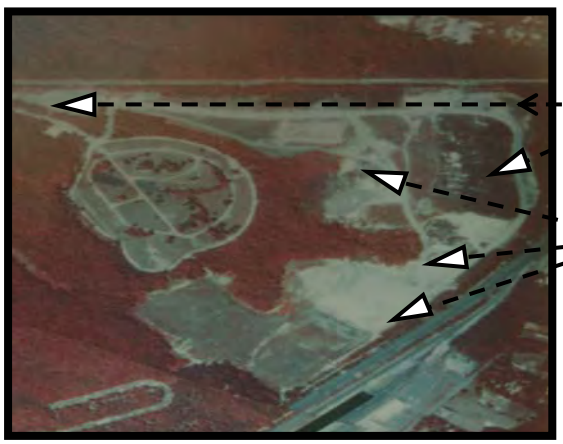
FIGURE 4-6



1970



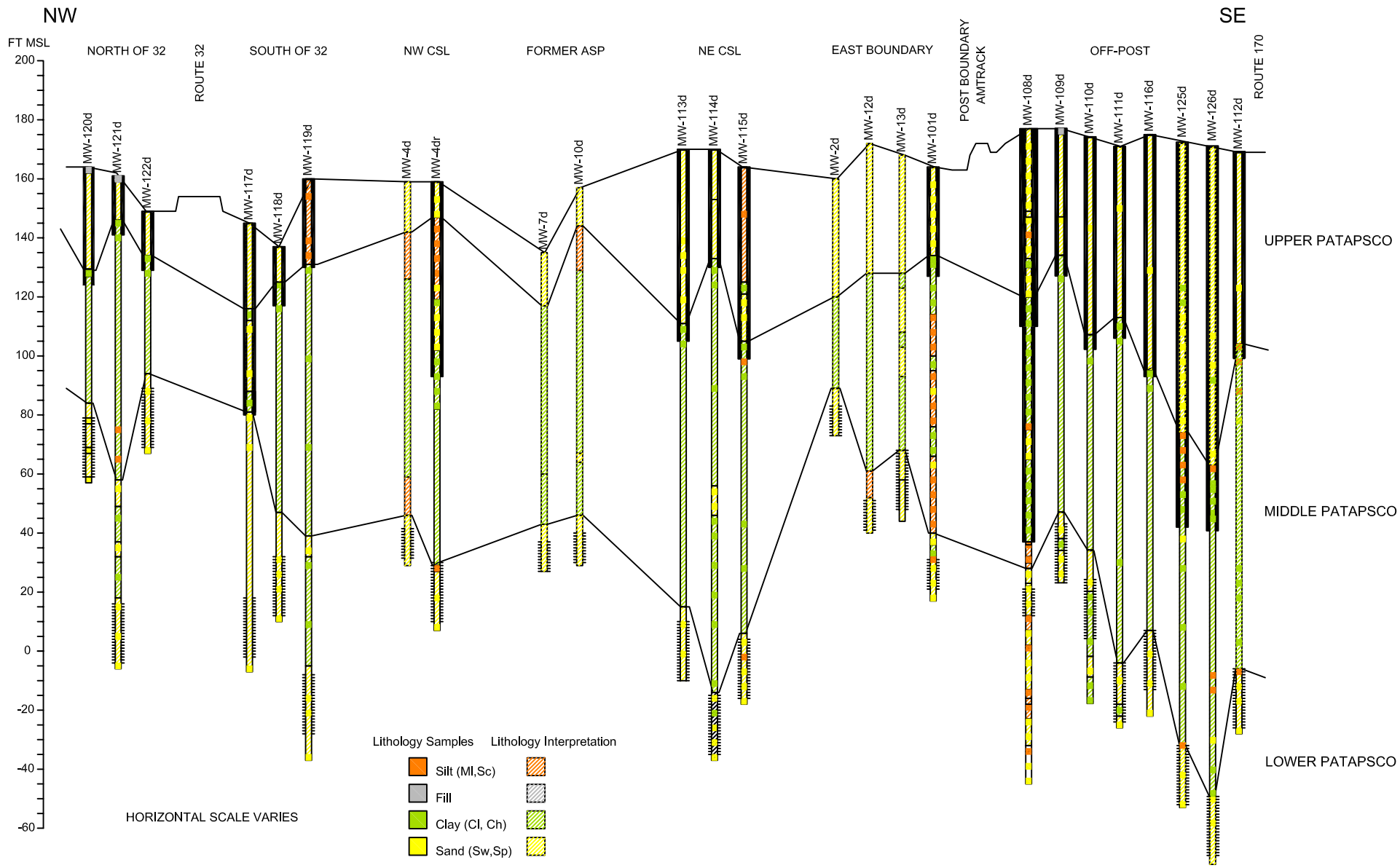
1975



1986

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	**DRAFT**	JR 6/17/05 Hist-Aerial	Fort Meade Closed Sanitary Landfill	Figure 4-6 Historical Aerial Photographs – 1970, 1975, 1986

FIGURE 4-7



EM FEDERAL CORPORATION
Innovations in Philanthropy and Engineering Services

DRAFT

KB
6/28/05
FM-DW-CSL

Fort Meade
Closed Sanitary Landfill

Figure 4-7
CSL Area Deep Wells Approximately Projected to a NW-SE Cross Section Line

There is no Figure 4-8

FIGURE 4-9

◆ **Deep Monitoring Well***

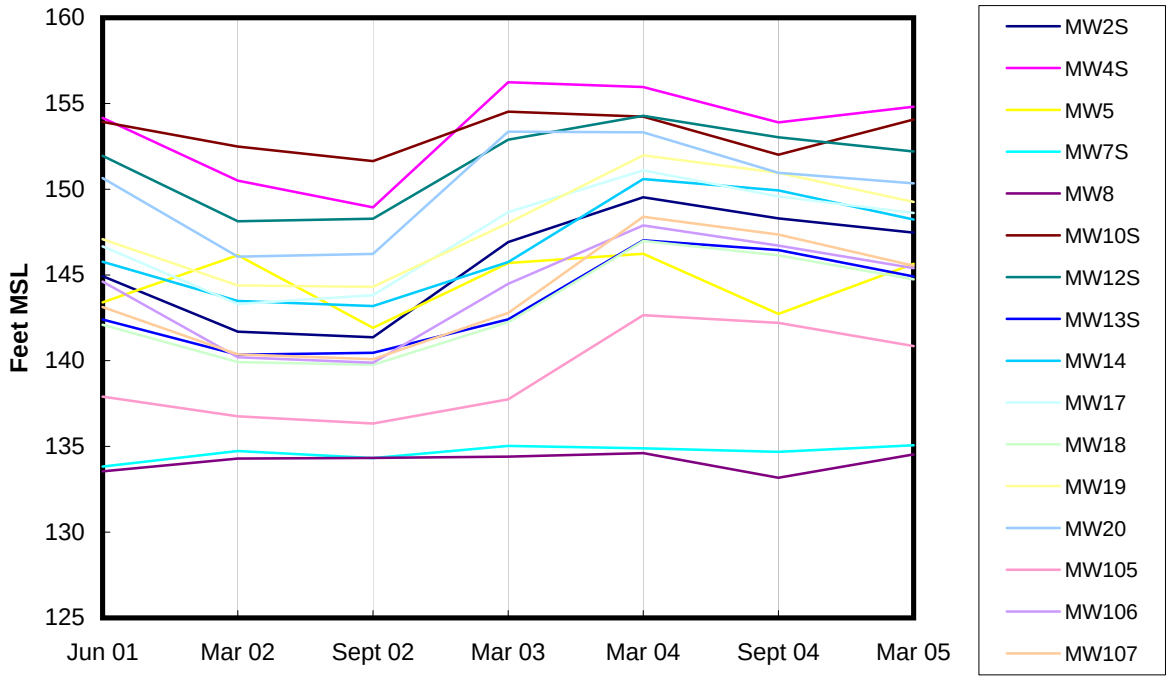
● **Shallow Monitoring Well***

***Green indicates RCRA program monitoring well**

***Blue indicates other program monitoring well**

EM FEDERAL CORPORATION *Innovations in Philanthropy and Engineering Services*	**DRAFT**	JR 6/10/05 WL-NTWK	Fort Meade Closed Sanitary Landfill	**Figure 4-9** **CSL Monitoring Well Network**

Figure 4-9A. CSL Historical Head Measurements
Shallow Wells



CSL Well Nests

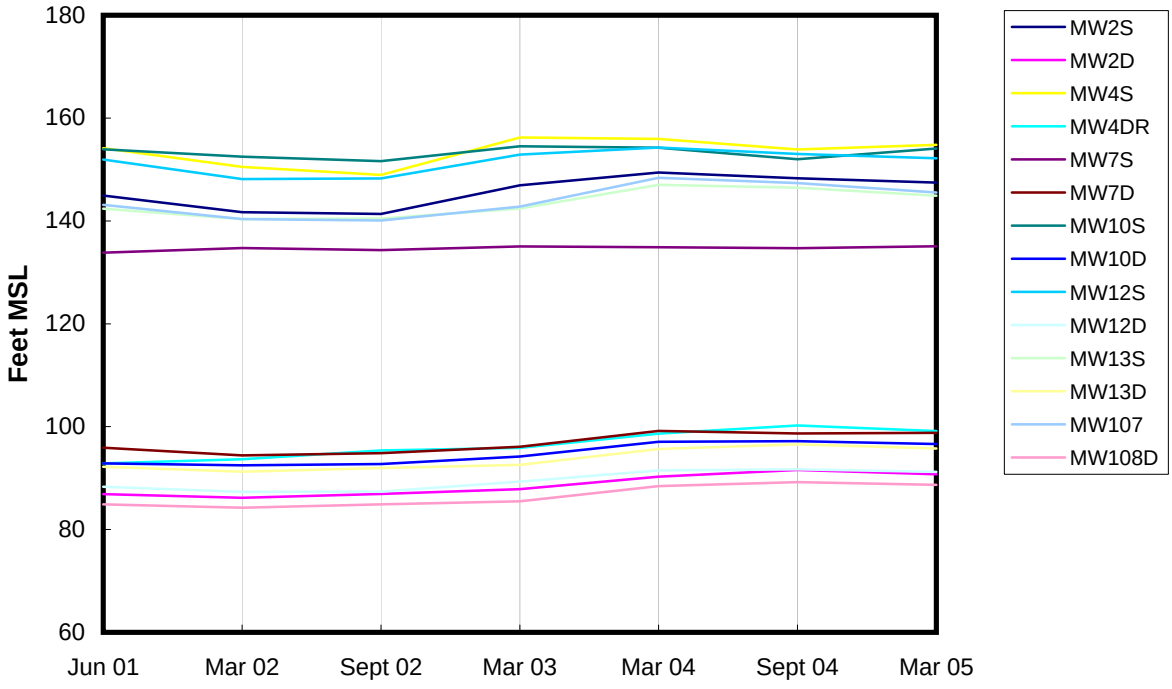


Figure 4-10

Deep Well MW-4DR DPT Groundwater Screening Point

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	DRAFT	KB 6/17/03 DPT-N	Fort Meade Closed Sanitary Landfill	**Figure 4 0** **2002 DPT Groundwater Screening Points- North**

FIGURE 4-11

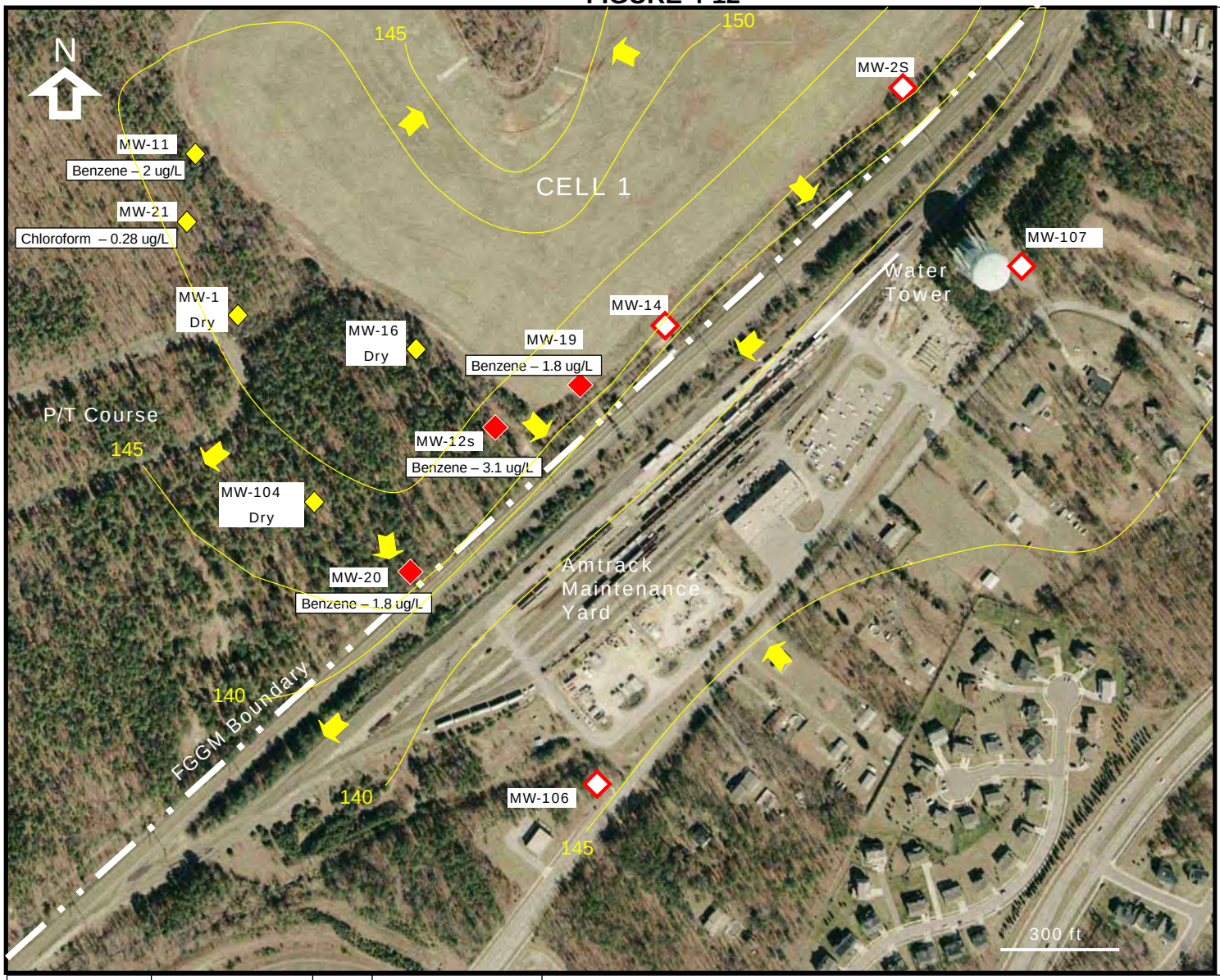
DPT Groundwater Screening Point

Shallow Monitored Well

Other Shallow Well

EM FEDERAL CORPORATION *Innovations in Philanthropy and Engineering Services*	DRAFT	KB 6/17/03 DPT-S	Fort Meade Closed Sanitary Landfill	**Figure 4 1** **2002 DPT Groundwater Screening Points- South**

FIGURE 4-12



Legend

South CSLF – Upper Patapsco Monitoring Wells

- Monitored Shallow Well - Sampled
- Other Monitored Shallow Well - Not Sampled
- Other Shallow Well Sampled

VOC Sampling Results (Sept 02)

MCL Exceedances - None

Tap Water RBC Exceedances

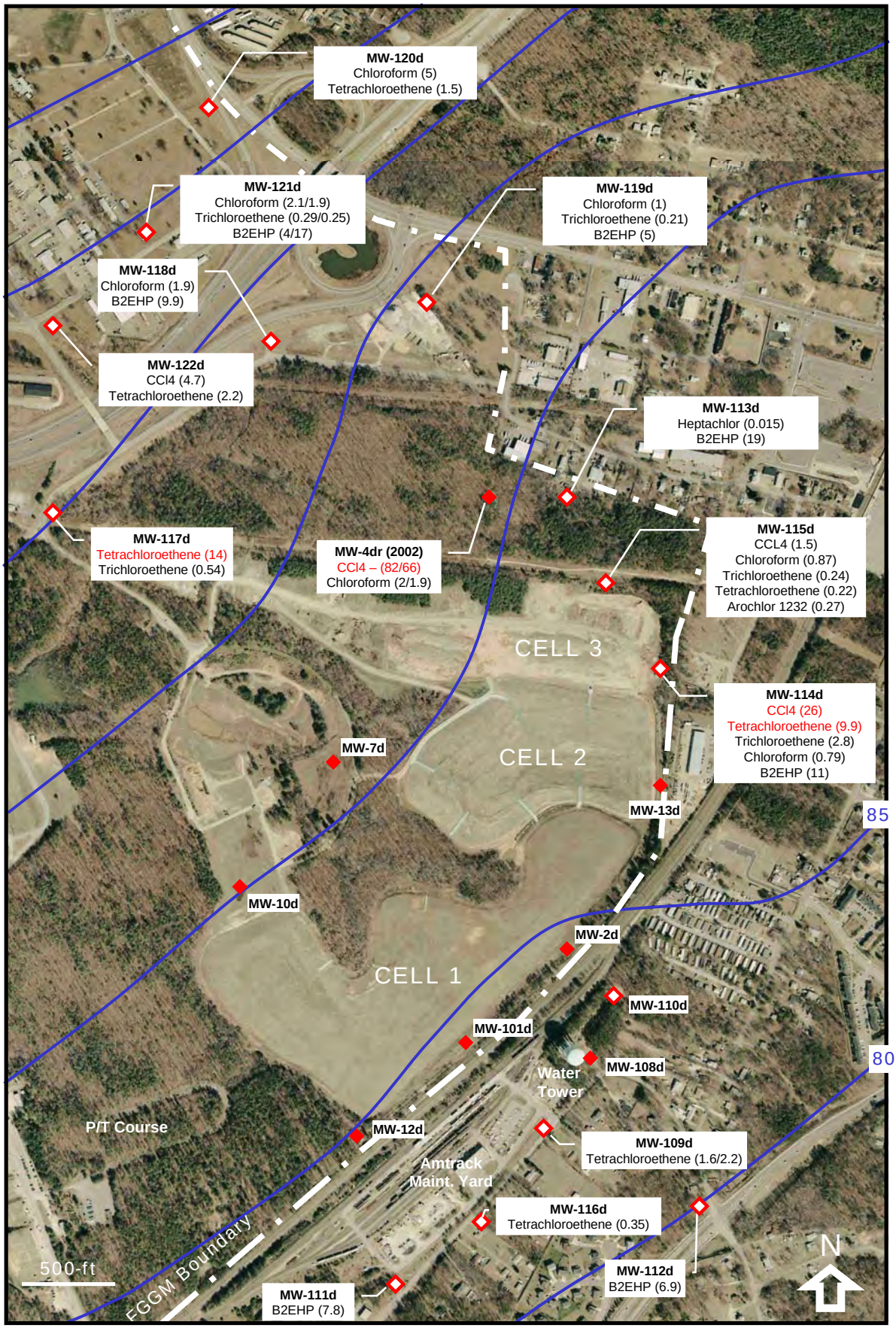
Benzene – 1.8 ug/L

Upper Patapsco Potentiometric Surface (Sept 02)

- 140 Feet MSL
- Groundwater Flow Direction

EM FEDERAL CORPORATION	DRAFT	JR 6/16/05 S-ORG 2002	Fort Meade Closed Sanitary Landfill	**Figure 4-12** **2002 Upper Patapsco Sample Locations - Organics**

FIGURE 4-13



Monitored Deep Well (Not Sampled)

New Deep Well (Sampled)

Sampling Results (Sept 02) in ug/L

CCl4 (26) MCL Exceedance

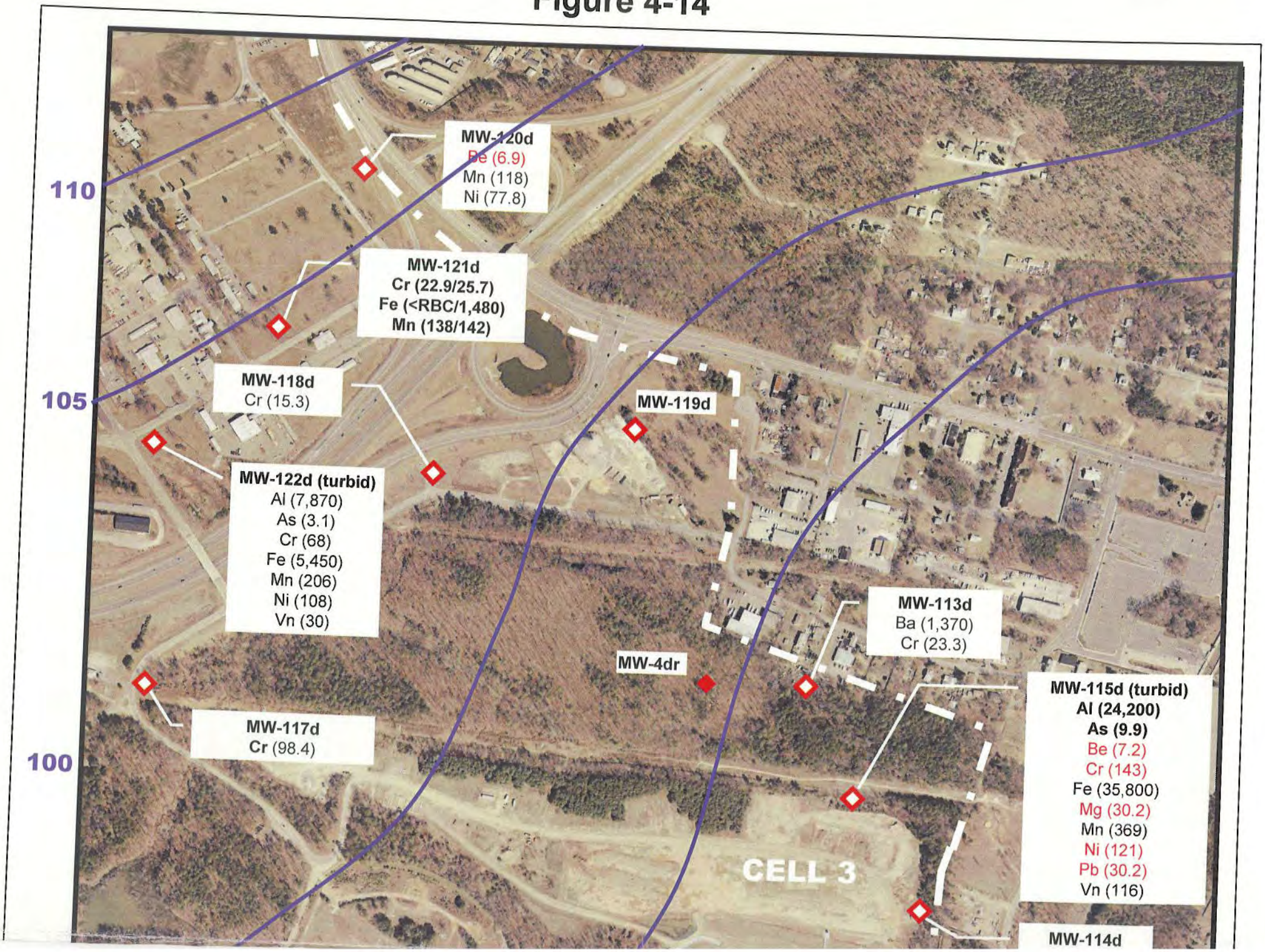
B2EHP (7.8) Tap Water RBC Exceedance

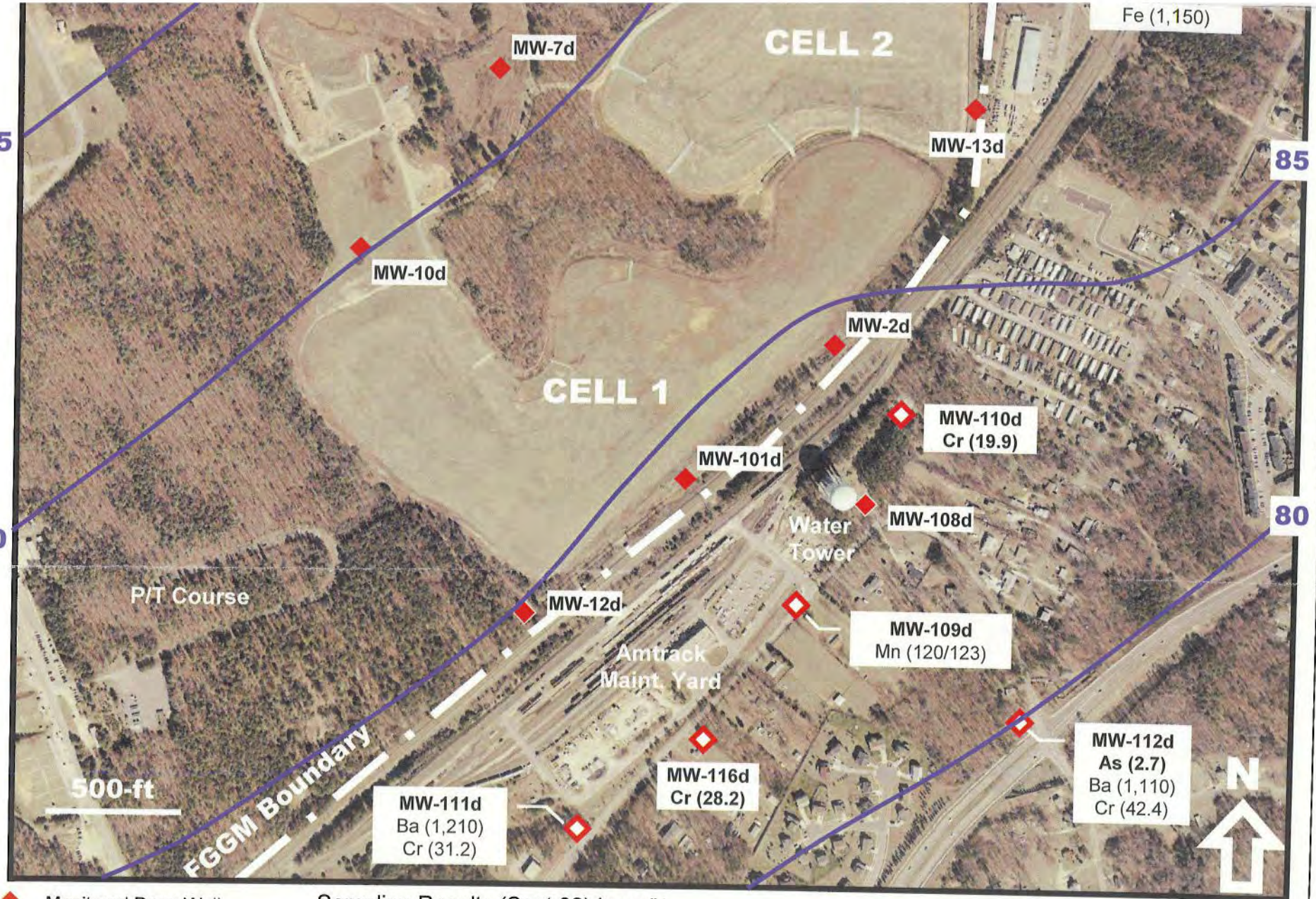
Lower Patapsco Potentiometric Surface (Sept 02)

90 Feet MSL

EM FEDERAL CORPORATION	DRAFT	KB 6/23/03 D-ORG	Fort Meade Closed Sanitary Landfill	**Figure 4-13** **2002 Lower Patapsco Sample Locations - Organics**

Figure 4-14


110
105
100
MW-120d
Be (6.9)
Mn (118)
Ni (77.8)
MW-121d
Cr (22.9/25.7)
Fe (<RBC/1,480)
Mn (138/142)
MW-118d
Cr (15.3)
MW-119d
MW-122d (turbid)
Al (7,870)
As (3.1)
Cr (68)
Fe (5,450)
Mn (206)
Ni (108)
Vn (30)
MW-113d
Ba (1,370)
Cr (23.3)
MW-4dr
MW-115d (turbid)
Al (24,200)
As (9.9)
Be (7.2)
Cr (143)
Fe (35,800)
Mg (30.2)
Mn (369)
Ni (121)
Pb (30.2)
Vn (116)
MW-117d
Cr (98.4)
CELL 3
MW-114d



Monitored Deep Well (Not Sampled)

New Deep Well (Sampled)

Sampling Results (Sept 02) in ug/L

Be (7.2) MCL Exceedance

Cr (8.2) Tap Water RBC Exceedance

Lower Patapsco Potentiometric Surface (Sept 02)

90 Feet MSL

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	**FINAL**	KB 6/23/03 D-INORG 2002	Fort Meade Closed Sanitary Landfill	**Figure 4-14** **2002 Lower Patapsco Sample Locations - Inorganic**

FIGURE 4-15

◆ Sampled Shallow Well

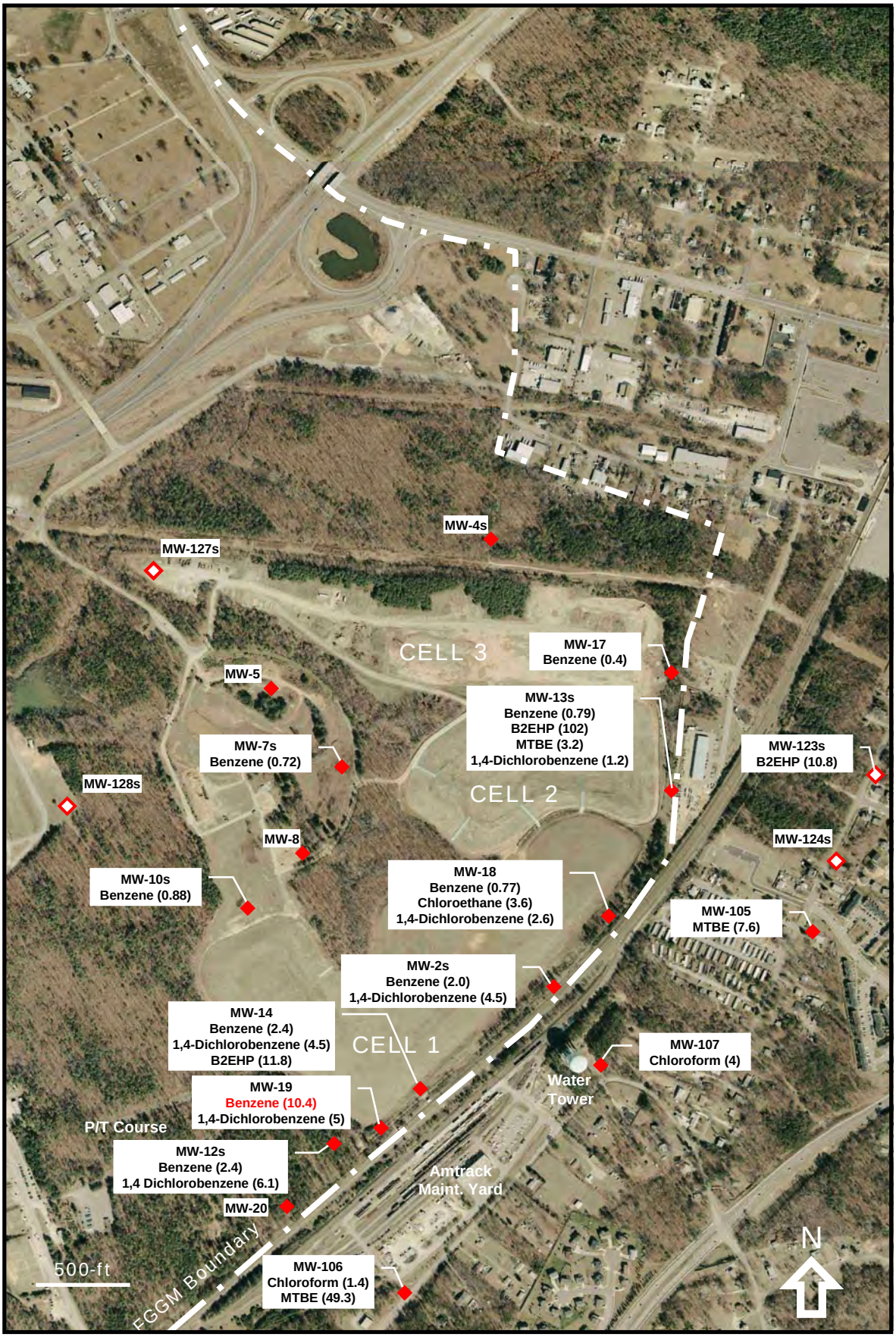
◇ New Shallow Well (Sampled)

Sampling Results in ug/L

As (51.2)	MCL Exceedance
Fe (98000)	Tap Water RBC Exceedance

EM FEDERAL CORPORATION *Innovations in Philanthropy and Engineering Services*	DRAFT	JR 5/24/05 S-INORG	Fort Meade Closed Sanitary Landfill	**Figure 4-15** **2004 Upper Patapsco Groundwater Chemistry - Inorganic**

FIGURE 4-16



Sampled Shallow Well

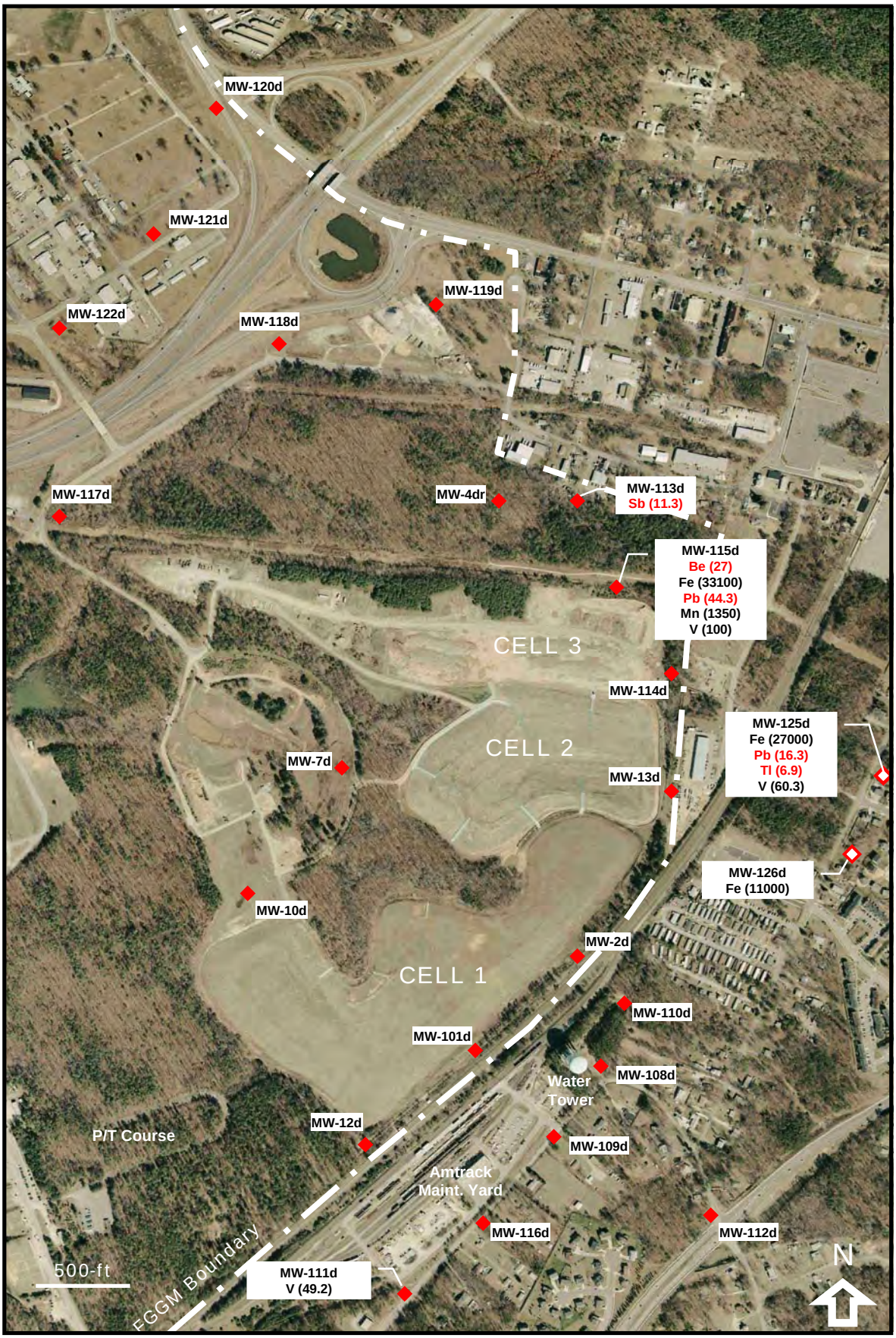
New Shallow Well (Sampled)

Sampling Results in ug/L

Benzene (1.8)	MCL Exceedance
MTBE (49.3)	Tap Water RBC Exceedance

EM FEDERAL CORPORATION	DRAFT	JR 5/24/05 S-ORG	Fort Meade Closed Sanitary Landfill	**Figure 4-16** **2004 Upper Patapsco Groundwater Chemistry - Organic**

FIGURE 4-17



Monitored Deep Well

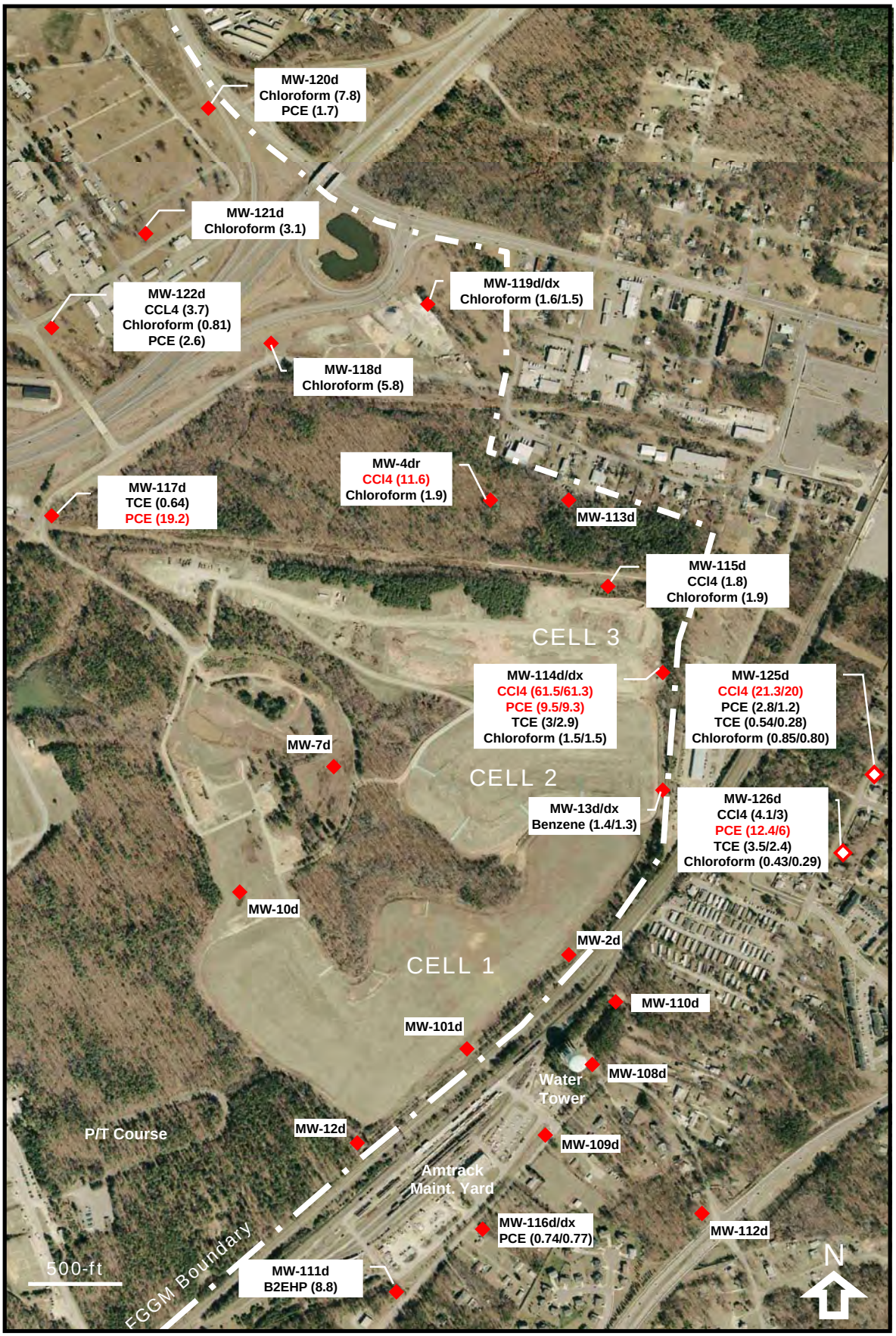
New Deep Well (Sampled)

Sampling Results in ug/L

Pb (44.3)	MCL Exceedance
Fe (33100)	Tap Water RBC Exceedance

EM FEDERAL CORPORATION *Innovations in Philanthropy and Engineering Services*	DRAFT	JR 5/24/05 D-INORG	Fort Meade Closed Sanitary Landfill	**Figure 4-17** **2004 Lower Patapsco Groundwater Chemistry - Inorganic**

FIGURE 4-18



Monitored Deep Well

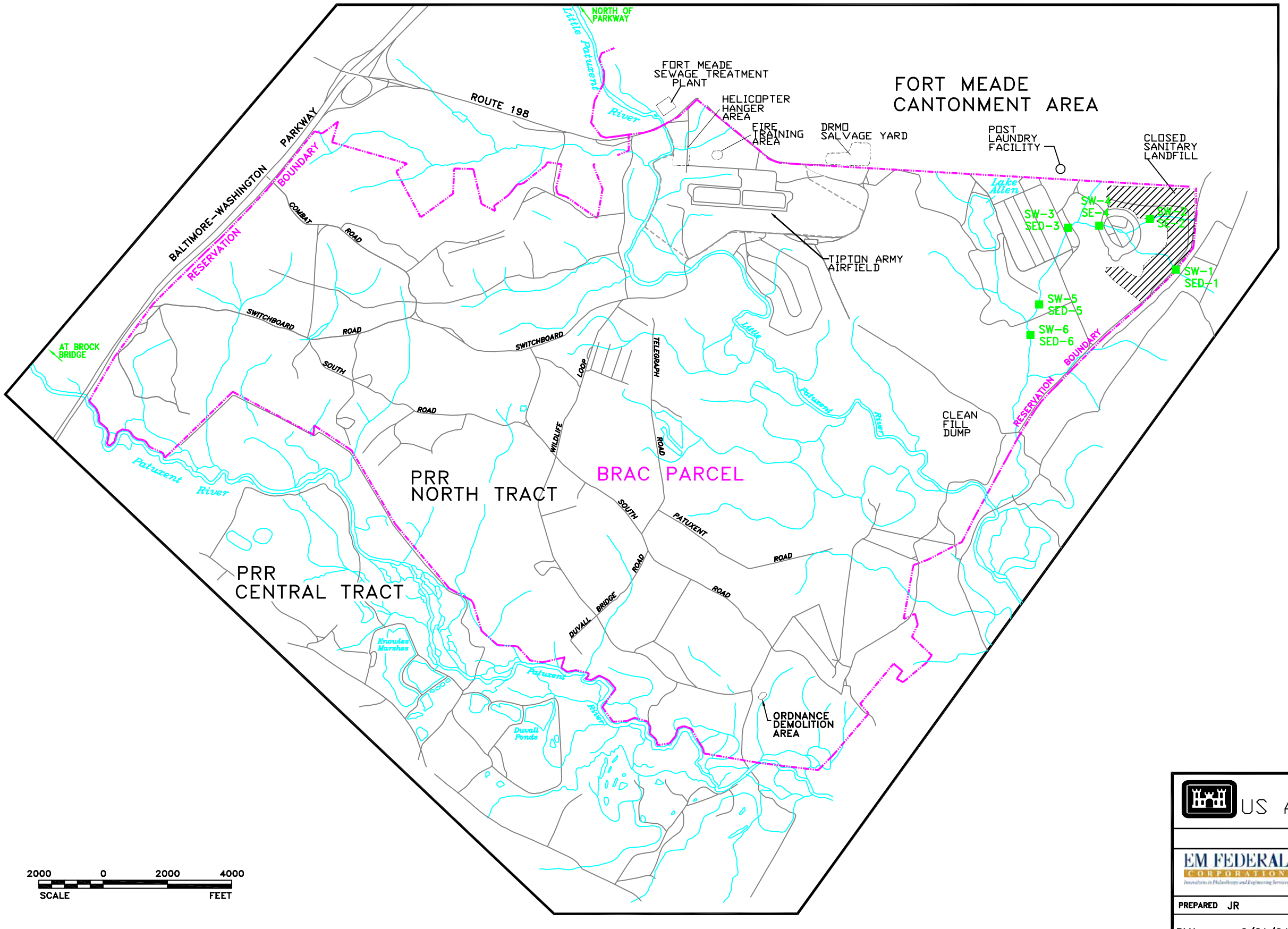
New Deep Well (Sampled)

Sampling Results in ug/L

CCl4 (11.6)	MCL Exceedance
B2EHP (8.8)	Tap Water RBC Exceedance

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	DRAFT	JR 5/24/05 D-ORG	Fort Meade Closed Sanitary Landfill	**Figure 4-18** **2004 Lower Patapsco Groundwater Chemistry - Organic**

FIGURE 4–18A



BALTIMORE DISTRICT
US Army Corps of Engineers

EM FEDERAL CORPORATION
Innovations in Philanthropy and Engineering Services
1212 New York Avenue
Washington, DC 20005
(202) 682-0909

FIGURE 4–18A
FORT GEORGE G. MEADE

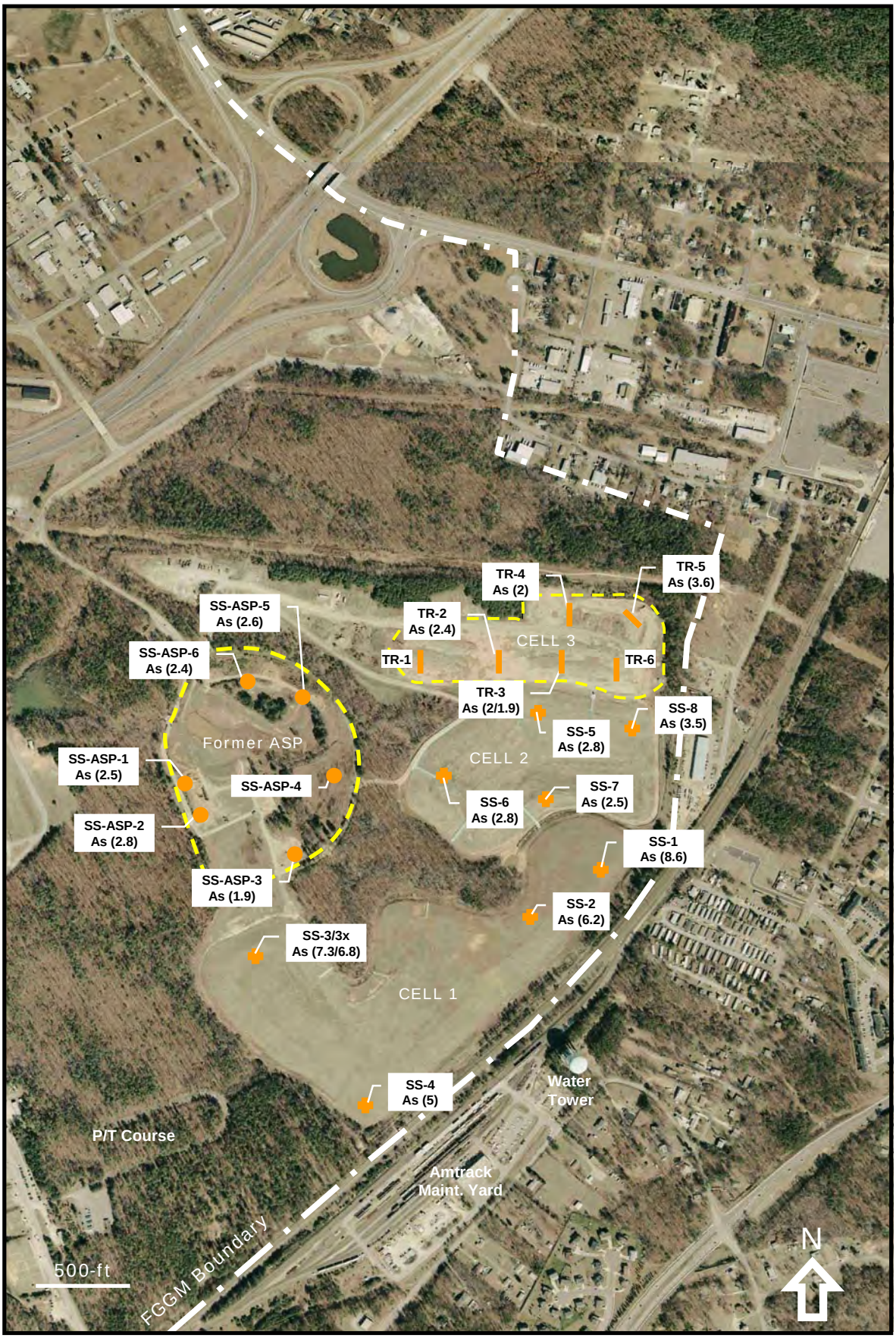
CSL SURFACE WATER AND SEDIMENT LOCATIONS

PREPARED JR

RLH 6/21/04
PM APPROVAL DATE

SW–SED
16–JUN–05

FIGURE 4-19



Trench Location

Surface Soil Location

Soil Boring Location

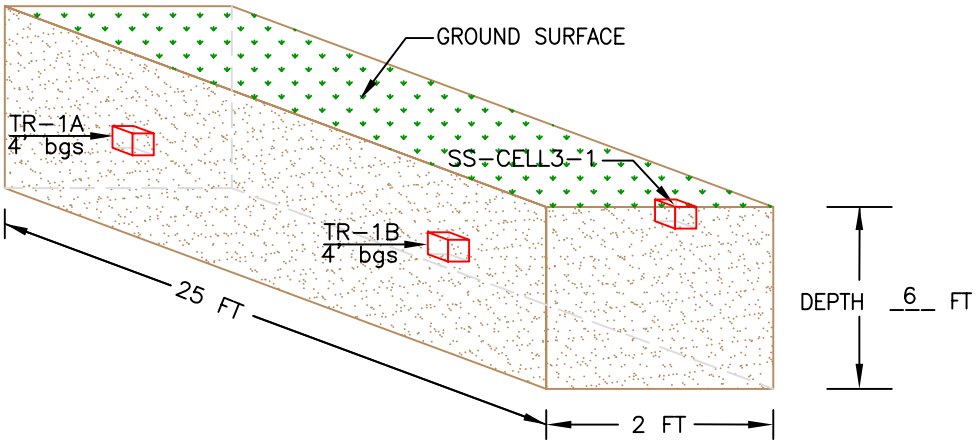
Sampling Results in mg/kg

As (2.5) Industrial RBC Exceedance

EM FEDERAL CORPORATION	DRAFT	JR 5/24/05 SS-INORG	Fort Meade Closed Sanitary Landfill	**Figure 4-19** **2004 Surface Soil Chemistry – CSL Trenches and ASP**

FIGURE 4–21

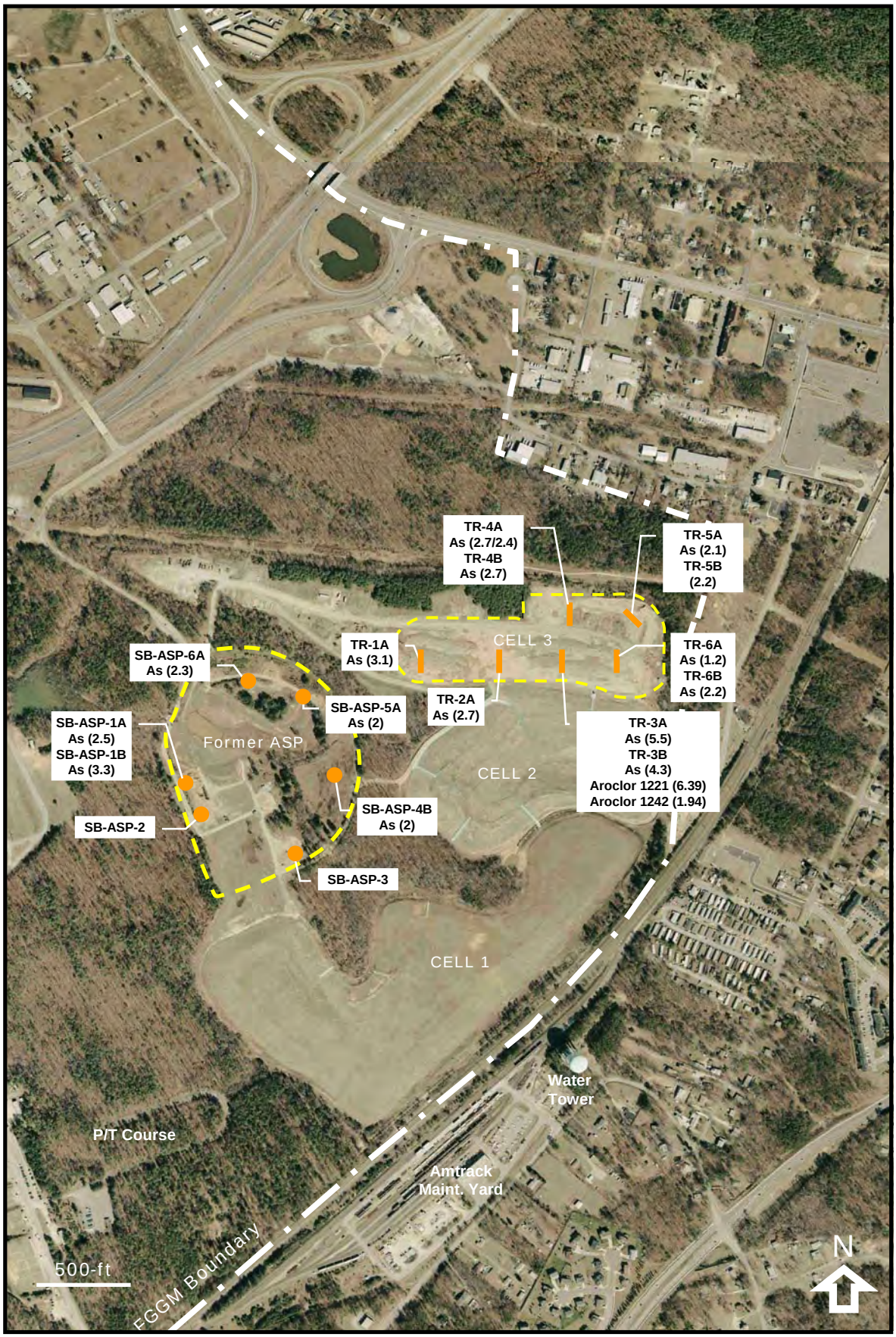
DEBRIS FROM TRENCH 1



Sample Location

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	JR 6/10/05 Trench1	FORT MEADE CLOSED SANITARY LANDFILL	FIGURE 4–21 PHOTOGRAPH AND DIAGRAM OF CSL TRENCH 1

FIGURE 4-20



Trench Location

Surface Soil Location

Soil Boring Location

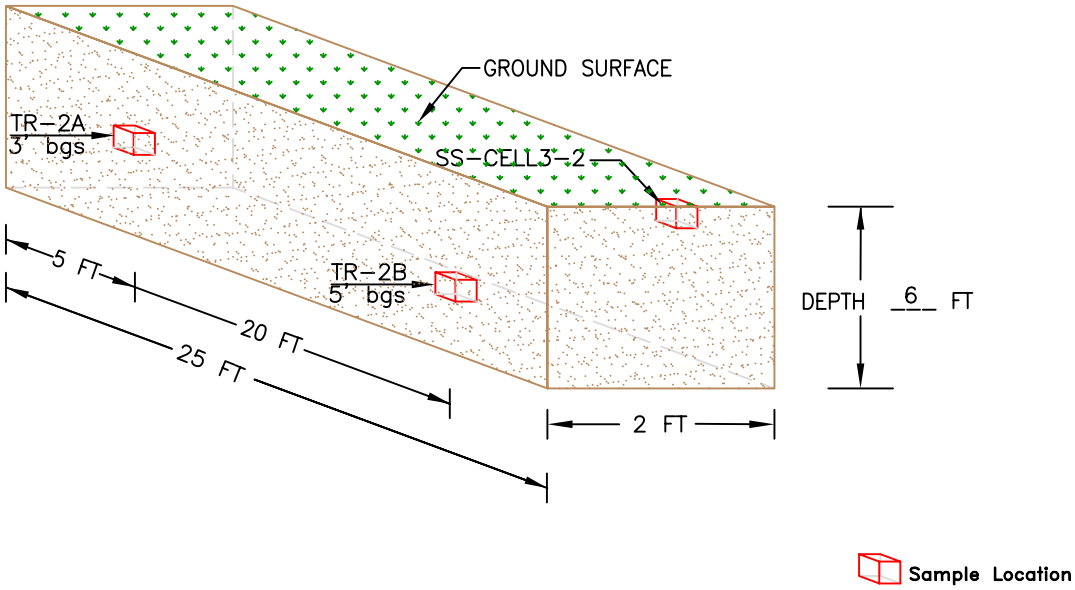
Sampling Results in mg/kg

As (2.5) Industrial RBC Exceedance

EM FEDERAL CORPORATION *Innovations in Philanthropy and Engineering Services*	DRAFT	JR 5/24/05 SUB-INORG	Fort Meade Closed Sanitary Landfill	**Figure 4-20** **2004 Subsurface Soil Chemistry – CSL Trenches and ASP**

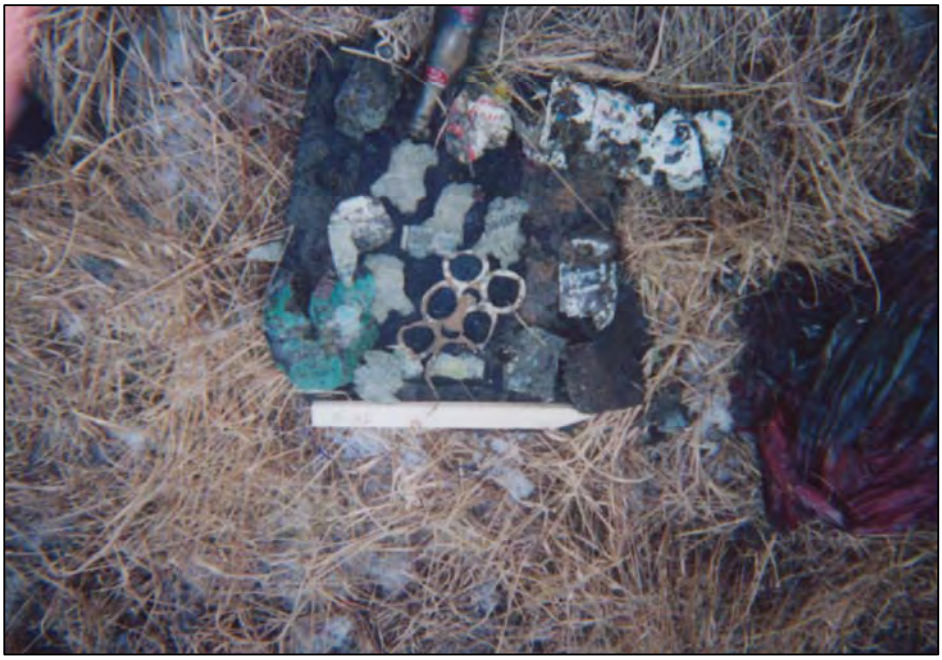
FIGURE 4–22

DEBRIS FROM TRENCH 2

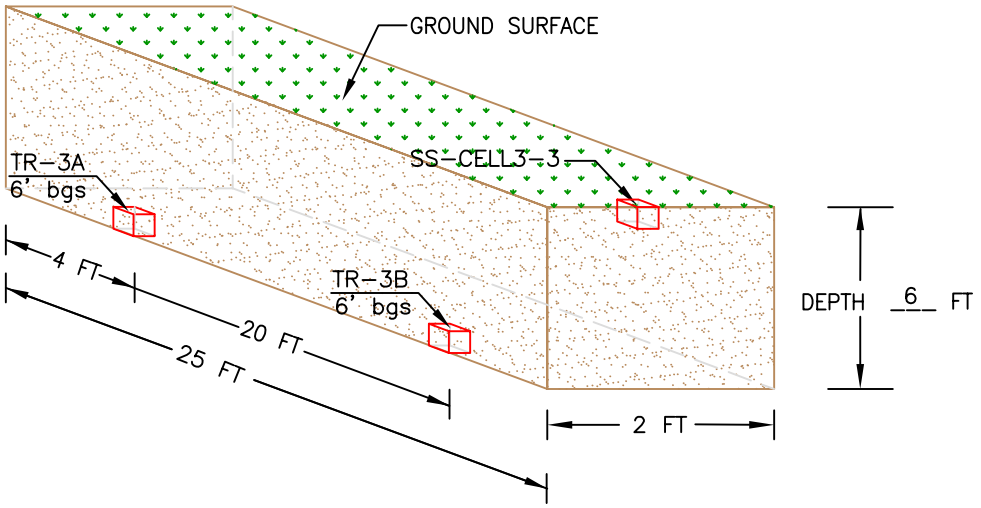


EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	JR 6/10/05 Trench2	FORT MEADE CLOSED SANITARY LANDFILL	FIGURE 4–22 PHOTOGRAPH AND DIAGRAM OF CSL TRENCH 2

FIGURE 4–23



DEBRIS FROM TRENCH 3

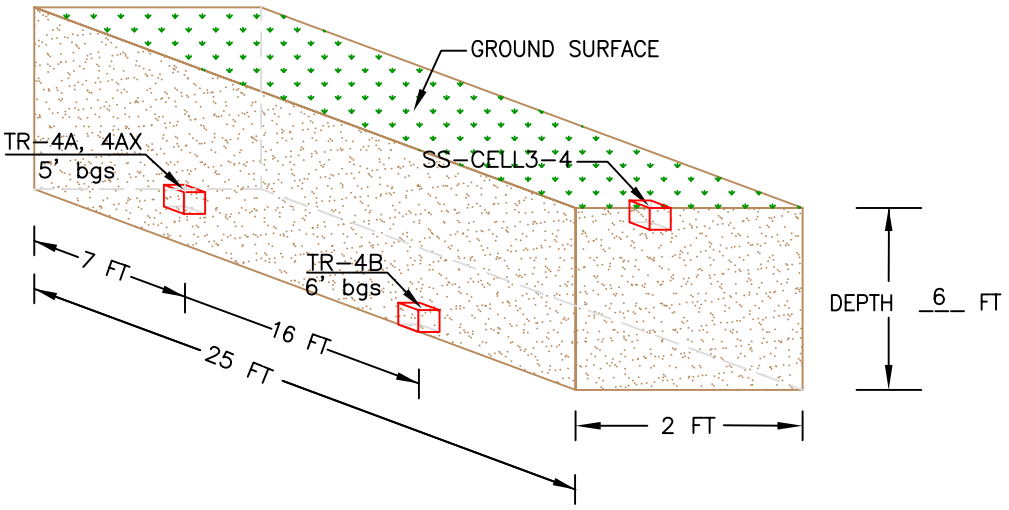


Sample Location

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	JR 6/10/05 Trench3	FORT MEADE CLOSED SANITARY LANDFILL	FIGURE 4–23 PHOTOGRAPH AND DIAGRAM OF CSL TRENCH 3

FIGURE 4–24

DEBRIS FROM TRENCH 4

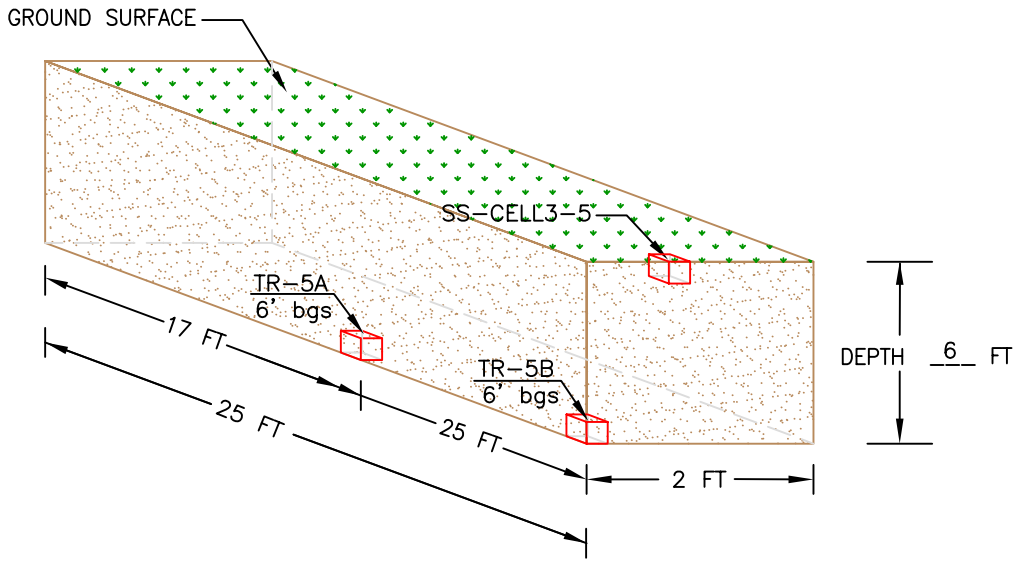


Sample Location

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	JR 6/10/05 Trench4	FORT MEADE CLOSED SANITARY LANDFILL	FIGURE 4–24 PHOTOGRAPH AND DIAGRAM OF CSL TRENCH 4

FIGURE 4–25

NO DEBRIS FOUND IN TRENCH 5

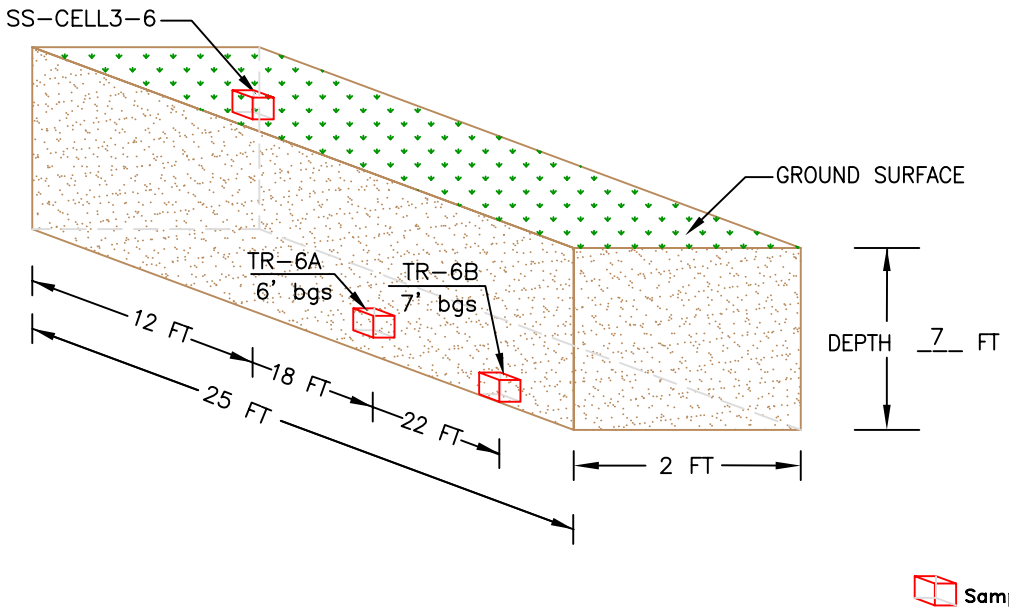


Sample Location

EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	JR 6/10/05 Trench5	FORT MEADE CLOSED SANITARY LANDFILL	FIGURE 4–25 PHOTOGRAPH AND DIAGRAM OF CSL TRENCH 5

FIGURE 4–26

DEBRIS FROM TRENCH 6



EM FEDERAL CORPORATION Innovations in Philanthropy and Engineering Services	JR 6/10/05 Trench6	FORT MEADE CLOSED SANITARY LANDFILL	FIGURE 4–26 PHOTOGRAPH AND DIAGRAM OF CSL TRENCH 6

Figure 5-1 Dehalogenation Flow Chart for PCE-Related Compounds

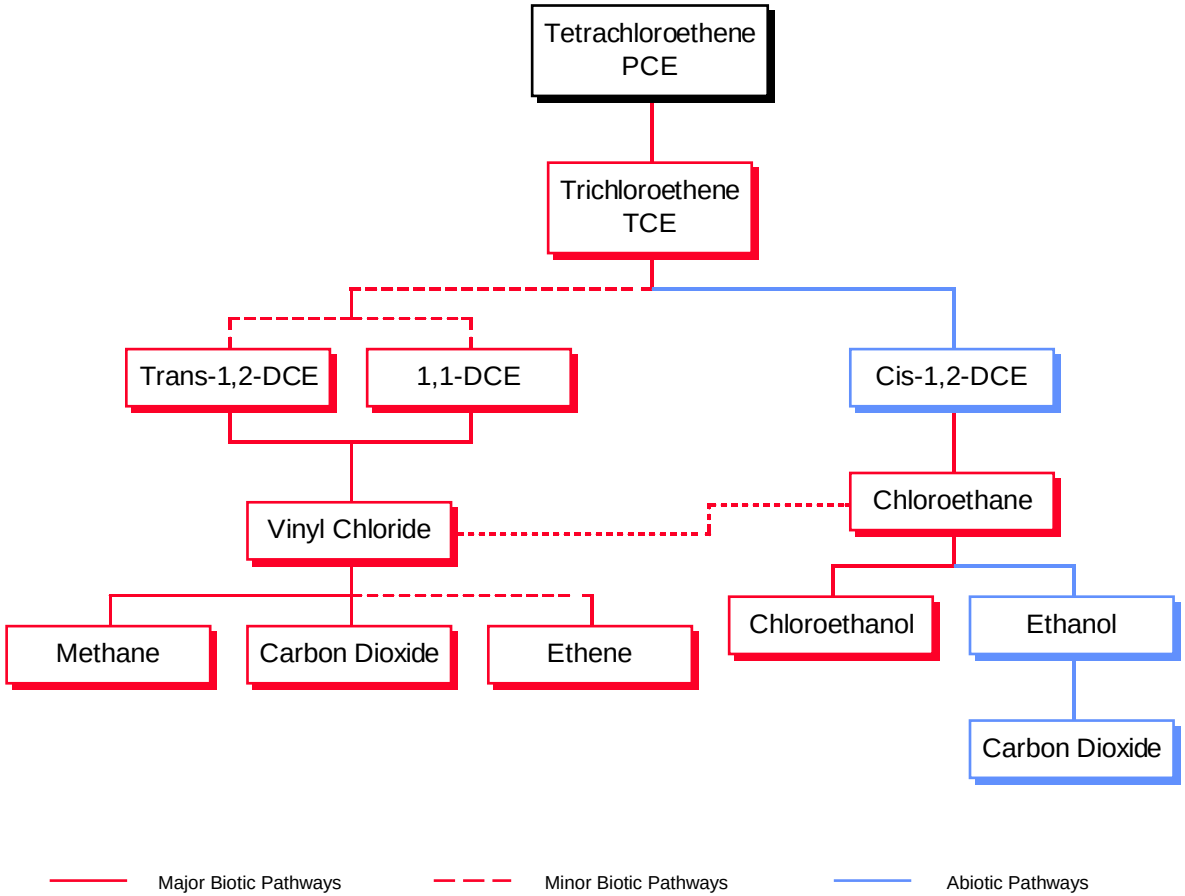


FIGURE 5-2 - CARBON TETRACHLORIDE DEGRADATION PATHWAY

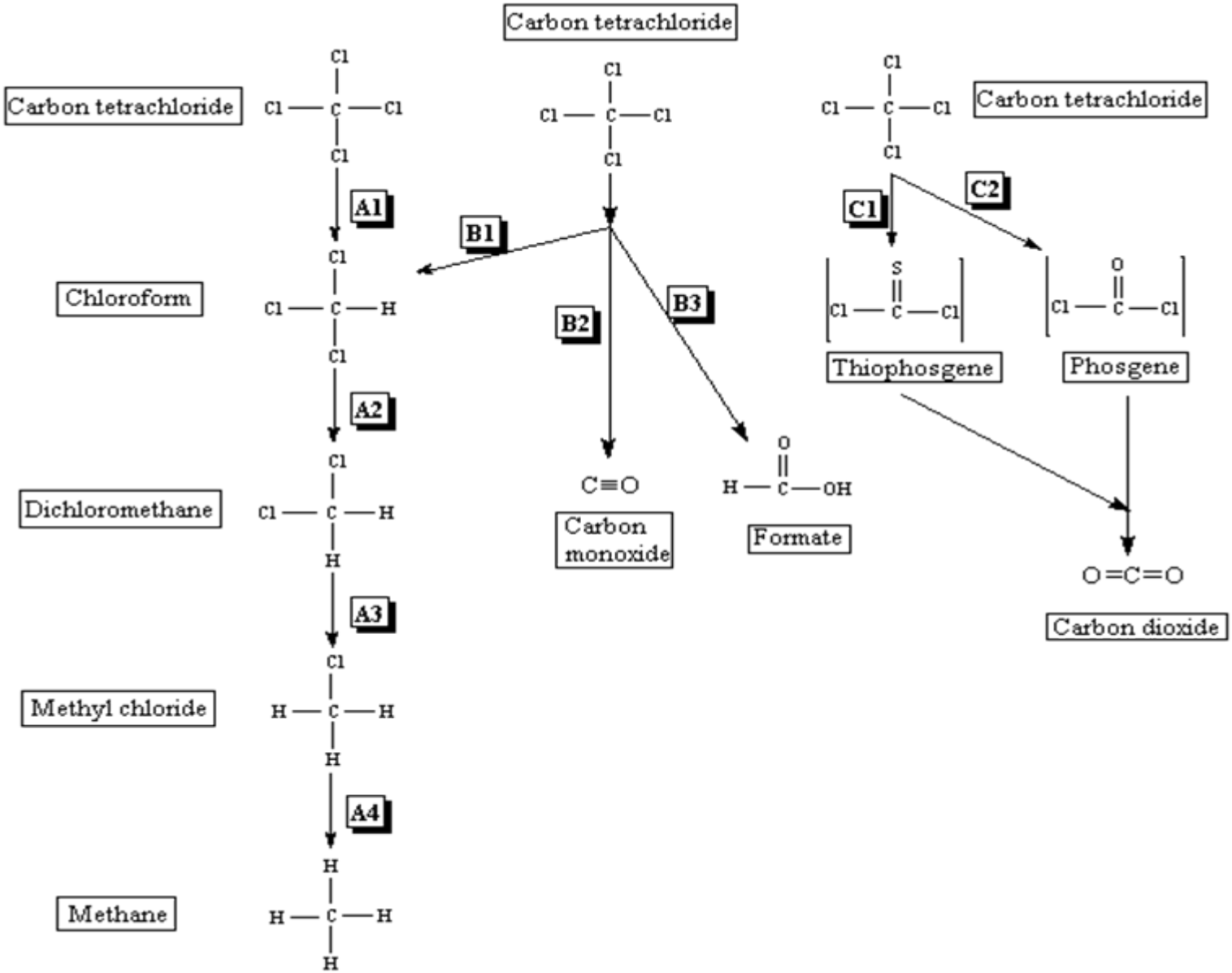


TABLE 2-1
HISTORICAL HEAD MEASUREMENTS

Well ID	Well Type	Top of Casing (ft msl)	Jun-01		Mar-02		Sep-02		Mar-03		Mar-04		Sep-04		Mar-05	
			Depth to Water (ft btoc)	Water Level (ft msl)	Depth to Water (ft btoc)	Water Level (ft msl)	Depth to Water (ft btoc)	Water Level (ft msl)	Depth to Water (ft btoc)	Water Level (ft msl)	Depth to Water (ft btoc)	Water Level (ft msl)	Depth to Water (ft btoc)	Water Level (ft msl)	Depth to Water (ft btoc)	Water Level (ft msl)
MW2S	upper	163.93	19.00	144.93	22.24	141.69	22.56	141.37	17.01	146.92	14.40	149.53	15.63	148.30	16.46	147.47
MW2D	lower	162.27	75.40	86.87	76.10	86.17	75.35	86.92	74.42	87.85	71.99	90.28	70.70	91.57	71.52	90.75
MW4S	upper	161.88	7.72	154.16	11.38	150.50	12.94	148.94	5.64	156.24	5.92	155.96	7.98	153.90	7.07	154.81
MW4DR	lower	167.76	74.89	92.87	74.10	93.66	72.39	95.37	71.89	95.87	69.13	98.63	67.52	100.24	68.61	99.15
MW5	upper	148.50	5.10	143.40	2.35	146.15	6.58	141.92	2.80	145.70	2.26	146.24	5.77	142.73	2.85	145.65
MW7S	upper	137.99	4.16	133.83	3.26	134.73	3.67	134.32	2.96	135.03	3.10	134.89	3.30	134.69	2.92	135.07
MW7D	lower	137.37	41.48	95.89	42.97	94.40	42.51	94.86	41.29	96.08	38.21	99.16	38.70	98.67	38.57	98.8
MW8	upper	141.76	8.21	133.55	7.47	134.29	7.43	134.33	7.35	134.41	7.15	134.61	8.59	133.17	7.22	134.54
MW10S	upper	159.39	5.46	153.93	6.90	152.49	7.75	151.64	4.87	154.52	5.16	154.23	7.38	152.01	5.32	154.07
MW10D	lower	159.62	66.78	92.84	67.14	92.48	66.88	92.74	65.42	94.20	62.55	97.07	62.44	97.18	63.01	96.61
MW12S	upper	174.44	22.49	151.95	26.30	148.13	26.16	148.28	21.55	152.89	20.16	154.28	21.41	153.03	22.24	152.2
MW12D	lower	174.52	86.20	88.32	87.21	87.31	87.14	87.38	85.22	89.30	83.02	91.50	82.83	91.69	83.31	91.21
MW13S	upper	169.16	26.76	142.40	28.81	140.35	28.70	140.46	26.75	142.41	22.14	147.02	22.71	146.45	24.25	144.91
MW13D	lower	168.05	75.85	92.20	76.82	91.23	76.11	91.94	75.49	92.56	72.38	95.67	71.50	96.55	72.3	95.75
MW14	upper	165.68	19.91	145.77	22.20	143.48	22.49	143.19	19.93	145.75	15.09	150.59	15.75	149.93	17.45	148.23
MW17	upper	171.81	25.14	146.67	28.50	143.31	27.99	143.82	23.15	148.66	20.71	151.10	22.23	149.58	23.19	148.62
MW18	upper	167.84	25.75	142.09	27.92	139.92	28.08	139.76	25.60	142.24	20.86	146.98	21.70	146.14	23.1	144.74
MW19	upper	170.01	22.92	147.09	25.62	144.39	25.70	144.31	21.98	148.03	18.03	151.98	19.05	150.96	20.75	149.26
MW20	upper	171.70	21.05	150.65	25.63	146.07	25.47	146.23	18.34	153.36	18.38	153.32	20.74	150.96	21.36	150.34
MW101D	lower	161.17	77.61	83.56	77.41	83.76	76.96	84.21	75.65	85.52	73.15	88.02	72.65	88.52	73.15	88.02
MW105	upper	192.70	54.80	137.90	55.94	136.76	56.36	136.34	54.95	137.75	50.05	142.65	50.49	142.21	51.85	140.85
MW106	upper	171.41	26.80	144.61	31.21	140.20	31.53	139.88	26.93	144.48	23.52	147.89	24.70	146.71	26.01	145.4
MW107	upper	179.91	36.78	143.13	39.54	140.37	39.82	140.09	37.13	142.78	31.52	148.39	32.55	147.36	34.37	145.54
MW108D	lower	179.55	94.65	84.90	95.31	84.24	94.65	84.90	94.08	85.47	91.11	88.44	90.34	89.21	90.88	88.67
MW109D	lower	*	*	*	*	*	*	*	86.08	*	83.42	*	83.13	*	83.64	87.62
MW110D	lower	*	*	*	*	*	*	*	82.44	*	79.41	*	79.40	*	79.12	88.79
MW111D	lower	*	*	*	*	*	*	*	85.63	*	*	*	*	*	*	*
MW112D	lower	*	*	*	*	*	*	*	122.12	*	*	*	*	*	*	*
MW116D	lower	*	*	*	*	*	*	*	88.65	*	*	*	*	*	*	*

TABLE 3-1A
CHEMICAL-SPECIFIC ARARs AND TO-BE-CONSIDERED GUIDANCE USED TO DEVELOP SCREENING LEVELS

Authority	Requirement	Status	Requirement Synopsis
Federal Regulatory Requirement	Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR 141.11 - 141.16)	Relevant and Appropriate	MCLs regulate the concentration of common organic and inorganic contaminants in public drinking water supplies based on health effects and technical capabilities. MCLs may also be considered relevant and appropriate for groundwater aquifers potentially used for drinking water.
State Regulatory Requirement	Numerical Criteria for Toxic Substances in Surface Waters (1996). Maximum Contaminant Levels. (COMAR 26.08.02.03)	Relevant and Appropriate	The State of Maryland regulates inorganic and organic contaminants in surface water for the protection of aquatic life and human health. Levels based on potential adverse health effects resulting from long term exposure to the contaminant in drinking water.
Federal Criteria, Advisories, and Guidance	USEPA Risk-Based Concentration (RBC) Table	To-Be-Considered	The RBC table provides screening levels corresponding to fixed levels of risk in tap water, soil, air, and fish tissue.
	Clean Water Act (33 U.S.C. 1314), USEPA Office of Water, Federal Ambient Water Quality Criteria (AWQC)	To-Be-Considered	Federal AWQCs are surface water criteria developed for protection of human health, and freshwater and marine aquatic life. These standards also apply to any stormwater or applied water that flows from the regulated unit to the land surface.
	USEPA Carcinogen Assessment Group Slope Factors (GSFs)	To-Be-Considered	Carcinogen slope factors are used in the baseline risk assessment to compute the individual incremental cancer risk resulting from exposure to site contaminants.
	USEPA Risk Reference Doses (RfDs)	To-Be-Considered	RfDs are dose levels developed by USEPA for non-carcinogenic effects. RfDs are used in the baseline risk assessment to characterize risks due to exposure to non-carcinogenic contaminants of concern.
	Sediment Quality Guidelines developed for the National Status and Trends Program (NOAA 1999)	To-Be-Considered	Outlines Effects Range Low (ERL) concentration levels below which adverse effects rarely occur.

TABLE 3-1B
SCREENING LEVELS USED IN THE RI

Parameter	Tap Water µg/L			Industrial RBC µg/g			MCL µg/L			AWQC or MWQS (Chronic) µg/L			Sediment Guidance Values (µg/g) NOAA ER-L
METALS													
Aluminum		36500	N		1.02E+06	N		NA		NA			NA
Antimony		14.6	N		408.8	N		6		NA			NA
Arsenic		0.045	C		1.907	C		10	a	150			8.2
Barium		2555	N		71540	N		2000		NA			NA
Beryllium		73	N		2044	N		4		NA			NA
Cadmium		18.25	N		511	N		5		0.25			NA
Calcium		NA			NA			NA		NA			NA
Chromium		110	N		3066	N		100		11			81
Cobalt		730	N		20440	N		NA		NA			NA
Copper		1460	N		40880	N		1300		9			34.0
Cyanide		730	N		41000	N		200		5.2			NA
Iron		10950	N		306600	N		NA		NA			NA
Lead		NA			NA			15		2.5			46.7
Magnesium		NA			NA			NA		NA			NA
Manganese		730	N		20440	N		NA		NA			NA
Mercury		11	N		NA	N		2		0.77			0.15
Nickel		730	N		20440	N		100		52			20.9
Potassium		NA			NA			NA		NA			NA
Selenium		182.5	N		5110	N		50		NA			NA
Silver		182.5	N		5110	N		50		NA			1
Sodium		NA			NA			NA		NA			NA
Thallium		2.55	N		71.54	N		2		NA			NA
Vanadium		36.5	N		10.22	N		NA		NA			NA
Zinc		10950	N		306600	N		NA		120			150
VOLATILES													
1,1,1-Trichloroethane		790	N		286160	N		200		NA			NA
1,1,2,2-Tetrachloroethane		0.052	C		14.308	C		NA		NA			NA
1,1,2-Trichloroethane		0.19	C		50.2	C		5		NA			NA
1,1-Dichloroethane		896	N		204400	N		NA		NA			NA
1,1-Dichloroethylene		0.044	C		51100	N		7		NA			NA
1,2-Dichloroethane		0.12	C		31.44	C		5		NA			NA
1,2-Dichloropropane		0.16	C		42.08	C		5		NA			NA
2-Hexanone		NA			NA			NA		NA			NA
Acetone		5475	N		919800	N		NA		NA			NA

TABLE 3-1B
SCREENING LEVELS USED IN THE RI

Parameter	Tap Water µg/L		Industrial RBC µg/g		MCL µg/L	AWQC or MWQS (Chronic) µg/L	Sediment Guidance Values (µg/g) NOAA ER-L
Benzene	0.34	C	52.09	C	5	NA	NA
Bromodichloromethane	0.17	C	46.15	C	NA	NA	NA
Bromoform	8.4	C	362.22	C	NA	NA	NA
Bromomethane	8.51	N	1430.8	N	NA	NA	NA
Carbon disulfide	1042	N	102200	N	NA	NA	NA
Carbon tetrachloride	0.16	C	22.01	C	5	NA	NA
Chlorobenzene	106.08	N	20440	N	100	NA	NA
Chloroethane	8600	N	986.75	N	NA	NA	NA
Chloroform	0.15	C	10220	C	NA	NA	NA
Chloromethane	189.8	C	NA	C	NA	NA	NA
cis-1,2-Dichloroethene	61	N	10220	N	70	NA	NA
cis-1,3-Dichloropropylene	NA		NA		NA	NA	NA
Dibromochloromethane	0.13	C	34.06	C	NA	NA	NA
Ethylbenzene	1339	N	102200	N	700	NA	NA
Methyl ethyl ketone	6968	N	613200	N	NA	NA	NA
Methyl isobutyl ketone	6278	N	NA		NA	NA	NA
Methylene chloride	4.1	C	381.54	C	NA	NA	NA
Styrene	1623	N	204400	N	100	NA	NA
Tetrachloroethylene	0.1	C	5.29	C	5	NA	NA
Toluene	747	N	204400	N	1000	NA	NA
trans-1,2-Dichloroethylene	106	N	20440	N	100	NA	NA
trans-1,3-Dichloropropylene	NA		NA		NA	NA	NA
Trichloroethylene	0.026	C	7.154	C	5	NA	NA
Vinyl chloride	0.015	C	3.97	C	2	NA	NA
Xylene	212	N	2.04E+05	N	10000	NA	NA
SEMIVOLATILES							
1,2,4-Trichlorobenzene	7.15	N	102200	N	70	NA	NA
1,2-Dichlorobenzene	268	N	91980	N	NA	NA	NA
1,3-Dichlorobenzene	18.25	N	3066	N	NA	NA	NA
1,4-Dichlorobenzene	0.47	C	119	C	NA	NA	NA
2,2'-Oxybis(1-chloropropane)	NA		NA		NA	NA	NA
2,4,5-Trichlorophenol	3650	N	102200	N	NA	NA	NA
2,4,6-Trichlorophenol	6.09	C	260.15	C	NA	NA	NA
2,4-Dichlorophenol	109.5	N	3066	N	NA	NA	NA
2,4-Dimethylphenol	730	N	20440	N	NA	NA	NA

TABLE 3-1B
SCREENING LEVELS USED IN THE RI

Parameter	Tap Water µg/L		Industrial RBC µg/g		MCL µg/L	AWQC or MWQS (Chronic) µg/L	Sediment Guidance Values (µg/g) NOAA ER-L
2,4-Dinitrophenol	73	N	2044	N	NA	NA	NA
2,4-Dinitrotoluene	73	N	2044	N	NA	NA	NA
2,6-Dinitrotoluene	36.5	N	1022	N	NA	NA	NA
2-Chloronaphthalene	NA		NA		NA	NA	NA
2-Chlorophenol	30.41	N	5110	N	NA	NA	NA
2-Methylphenol	1825	N	51100	N	NA	NA	NA
2-Nitroaniline	109.5	N	3066	N	NA	NA	NA
2-Nitrophenol	NA		NA		NA	NA	NA
3,3'-Dichlorobenzidine	0.15	C	6.36	C	NA	NA	NA
3-Nitroaniline	3.3	C	143.08	N	NA	NA	NA
4,6-Dinitro-2-methylphenol	3.65	N	102.2	N	NA	NA	NA
4-Bromophenyl-phenylether	NA		NA		NA	NA	NA
4-Chloro-3-methylphenol	NA		NA		NA	NA	NA
4-Chloroaniline	1.24	C	52.99	N	NA	NA	NA
4-Chlorophenyl-phenylether	NA		NA		NA	NA	NA
4-Methylphenol	182.5	N	5110	N	NA	NA	NA
4-Nitroaniline	3.34	C	143.08	N	NA	NA	NA
4-Nitrophenol	NA		NA		NA	NA	NA
Benzoic acid	146000	N	4088000	N	NA	NA	NA
Bis(2-chloroethoxy)methane	NA		NA		NA	NA	NA
Bis(2-chloroethyl)ether	0.0096	C	2.601	C	NA	NA	NA
Bis(2-ethylhexyl)phthalate	4.78	C	204.4	C	6	NA	NA
Butylbenzylphthalate	35.2	C	1506	N	NA	NA	NA
Carbazole	3.34	C	143.08		NA	NA	NA
Di-n-butylphthalate	3650	N	102200	N	NA	NA	NA
Di-n-octylphthalate	1460	N	40880	N	NA	NA	NA
Dibenzofuran	12.16	N	2044	N	NA	NA	NA
Diethylphthalate	29200	N	8.18E+05	N	NA	NA	NA
Dimethylphthalate	365000	N	1.02E+07	N	NA	NA	NA
Hexachlorobenzene	0.042	C	1.78	C	1	NA	NA
Hexachlorobutadiene	0.858	C	36.68	C	NA	NA	NA
Hexachlorocyclopentadiene	219	N	6132	N	50	NA	NA
Hexachloroethane	4.78	C	204.4	C	NA	NA	NA
Isophorone	70.49	C	3012.21	C	NA	NA	NA
N-Nitroso-di-n-propylamine	0.0096	C	0.82	C	NA	NA	NA

TABLE 3-1B
SCREENING LEVELS USED IN THE RI

Parameter	Tap Water µg/L		Industrial RBC µg/g		MCL µg/L		AWQC or MWQS (Chronic) µg/L		Sediment Guidance Values (µg/g) NOAA ER-L
N-Nitrosodiphenylamine	13.66	C	0.4088	C	NA		NA		NA
Nitrobenzene	3.53	N	511	N	NA		NA		NA
Pentachlorophenol	0.558	C	23.84	C	1		NA		NA
Phenol	10950	N	306600	N	NA		NA		NA
POLYNUCLEAR AROMATIC HYDROCARBONS									
2-Methylnaphthalene	24.3	N	4088		NA		NA		70
Acenaphthene	365	N	61320	N	NA		NA		16
Acenaphthylene	NA		NA		NA		NA		44
Anthracene	1825	N	306600	N	NA		NA		85.3
Benzo(a)anthracene	0.092	C	3.92	C	NA		NA		261
Benzo(a)pyrene	0.0092	C	0.392	C	0.2		NA		430
Benzo(b)fluoranthene	0.092	C	3.92	C	NA		NA		NA
Benzo(g,h,i)perylene	NA		NA		NA		NA		NA
Benzo(k)fluoranthene	0.92	C	39.2	C	NA		NA		NA
Chrysene	9.2	C	392	C	NA		NA		384
Dibenzo(a,h)anthracene	0.0092	C	0.392	C	NA		NA		63.4
Fluoranthene	1460	N	0.392	N	NA		NA		600
Fluorene	243	N	40880	N	NA		NA		19
Indeno(1,2,3-cd)pyrene	0.092	C	3.92	C	NA		NA		NA
Naphthalene	6.511	N	20440	N	NA		NA		NA
Phenanthrene	NA		NA		NA		NA		240
Pyrene	182.5	N	30660	N	NA		NA		665
PESTICIDES									
Aldrin	0.004	C	0.16	C	NA		NA		NA
alpha-BHC	NA		NA		NA		NA		NA
alpha-Chlordane	NA		NA		2		NA		NA
beta-BHC	NA		NA		NA		NA		NA
Chlordane	0.19	C	8.176	C	2		0.0043		NA
DDD	0.28	C	11.92	C	NA		NA		NA
DDE	0.2	C	8.41	C	NA		NA		NA
DDT	0.2	C	8.41	C	NA		0.001		NA
delta-BHC	NA		NA		NA		2.2		NA
Dieldrin	0.0042	C	0.17	C	NA		0.056		NA
Endosulfan I	NA		NA		NA		NA		NA
Endosulfan II	NA		NA		NA		NA		NA

TABLE 3-1B
SCREENING LEVELS USED IN THE RI

Parameter	Tap Water µg/L		Industrial RBC µg/g		MCL µg/L		AWQC or MWQS (Chronic) µg/L		Sediment Guidance Values (µg/g) NOAA ER-L
Endosulfan sulfate	NA		NA		NA		NA		NA
Endrin	10.95	N	306.6	N	2		0.036		NA
Endrin aldehyde	NA		NA		NA		NA		NA
Endrin ketone	NA		NA		NA		NA		NA
gamma-BHC (Lindane)	0.052	C	2.2	C	0.2		NA		NA
gamma-Chlordane	NA		NA		NA		NA		NA
Heptachlor	0.015	C	0.63	C	0.4		0.0038		NA
Heptachlor epoxide	0.007	C	0.31	C	0.2		0.0038		NA
Methoxychlor	182.5	N	5110	N	40		NA		NA
Toxaphene	0.061	C	2.6	C	3		0.0002		NA
POLYCHLORINATED BIPHENYLS									
Aroclor-1016	0.96	C	40.88	C	0.5		0.014		22.7
Aroclor-1221	0.033	C	1.43	C	0.5		0.014		22.7
Aroclor-1232	0.033	C	1.43	C	0.5		0.014		22.7
Aroclor-1242	0.033	C	1.43	C	0.5		0.014		22.7
Aroclor-1248	0.033	C	1.43	C	0.5		0.014		22.7
Aroclor-1254	0.033	C	1.43	C	0.5		0.014		22.7
Aroclor-1260	0.033	C	1.43	C	0.5		0.014		22.7
EXPLOSIVES COMPOUNDS									
1,3-Dinitrobenzene	3.65	N	102.2	N	NA		NA		NA
2,4-Dinitrotoluene	73	N	2044	N	NA		NA		NA
2,6-Dinitrotoluene	36.5	N	1022	N	NA		NA		NA
HMX	1825	N	51100	N	NA		NA		NA
Nitrobenzene	3.5	N	511	N	NA		NA		NA
2-Nitrotoluene	NA		NA		NA		NA		NA
3-Nitrotoluene	NA		NA		NA		NA		NA
4-Nitrotoluene	NA		NA		NA		NA		NA
RDX	0.61	C	26.01	C	NA		NA		NA
Tetryl	146	N	4088	N	NA		NA		NA
1,3,5-Trinitrobenzene	1095	N	30660	N	NA		NA		NA
2,4,6-Trinitrotoluene	2.2	C	95.38	C	NA		NA		NA
2-amino-4,6-Dinitrotoluene	2.2	N	120	N	NA		NA		NA
4-amino-2,6-Dinitrotoluene	2.2	N	120	N	NA		NA		NA

TABLE 3-1B
SCREENING LEVELS USED IN THE RI

Parameter	Tap Water µg/L			Industrial RBC µg/g			MCL µg/L			AWQC or MWQS (Chronic) µg/L			Sediment Guidance Values (µg/g) NOAA ER-L
MUSTARD BREAKDOWN PRODUCTS													
1,4-Dithiane		365	N		10220	N		NA		NA			NA
1,4-Oxathiane		NA			NA			NA		NA			NA
Thiodiglycol		NA			NA			NA		NA			NA

a - value as of 1/23/06

TABLE 3-2
SUMMARY OF BACKGROUND SURFACE SOIL CHEMISTRY

Sample Location Identification	Screening Criteria		SSB-1	SSB-2	SSB-3	SSB-4	SSB-4	SSB-5
Field Sample ID			SSB-1	SSB-2	SSB-3	SSB-4	SSB-4X	SSB-5
Site Type			SURF	SURF	SURF	SURF	SURF	SURF
Start Depth (ft bgs)			0	0	0	0	0	0
End Depth (ft bgs)			0.5	0.5	0.5	0.5	0.5	0.5
Media			CSO	CSO	CSO	CSO	CSO	CSO
Collection Date	Maximum Background	Industrial	8/28/1996	8/28/1996	8/28/1996	8/28/1996	8/28/1996	8/29/1996
Solids	(mg/g)	Soil RBC (mg/g)	89.2	86.1	80.4	96	94.4	93.4
Metals (µg/g)								
Aluminum	7010	1000000	7010	5630	2460	1760	1830	3030
Arsenic	2.79	3.8	1.03 BL	2.79 L	1.05 BL	1.21 BL	1.29 BL	1.32 BL
Beryllium	0.634	1.3	0.378 K	0.634 K	0.106 K	0.174 K	0.122 K	0.165 K
Calcium	828	- -	828	771	- -	- -	- -	- -
Chromium	14.1	10000	14.1 K	9.35 K	6.03 K	6.39 K	7.01 K	12.1 K
Cobalt	4.43	120000	4.3	4.43	- -	- -	- -	2.72
Copper	8.15	82000	8.15	4.59	3.22	4.57	4.21	6.64
Iron	12400	610000	12400	7710	5100	7720	8910	12000
Lead	16	400	14.3	15.7	- -	9.75	11	16
Magnesium	1220	- -	1220	839	209	113	118	309
Manganese	149	47000	117	149	20	24.8	24.8	30.1
Nickel	9.38	41000	9.38	6.25	4	3.93	4.39	7.9
Potassium	503	- -	503	346	128	120	- -	206
Sodium	397	- -	352	370	397	329	328	330
Vanadium	24	14000	24	15.6	11.3	14.2	15.7	20.1
Zinc	22.6	610000	22.6	22.4	7.36	12.3	12.6	16.5
Volatiles (µg/g)								
Acetone	0.01	200000	- -	0.0116 B	- -	- -	- -	- -
Semivolatiles (µg/g)								
Benzoic acid	0.734	1000000	- -	- -	0.734	0.375	0.424	- -
Bis(2-ethylhexyl)phthalate	2.22	410	0.751 B	- -	- -	- -	2.22	- -

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
RBC - Risk-Based Concentration
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
X - Duplicate Sample
CSO - Chemical Soils

EPA Region III Data Qualifiers:
B - Not detected substantially above the level reported in the laboratory or field blanks.
J - Analyte present. Reported value may not be accurate or precise.
K - Analyte present. Reported value may be biased high. Actual value is expected to be lower.
L - Analyte Present. Reported value may be biased low. Actual value is expected to be higher.

TABLE 3-3
BACKGROUND SURFACE SOIL CHEMISTRY STATISTICS

	Surface Soil Screening Levels		Exceedance Frequencies				Detection Frequency	Minimum	Maximum	Location of Maximum	Average	Standard Deviation
			Positive Results		Not Detected Results							
	BKG	RBC	BKG	RBC	BKG	RBC						
Metals (µg/g)												
Aluminum	7010	1000000	0 / 2	0 / 2	0 / 4	0 / 4	2 / 6	5630	7010	SSB-1	6320	976
Arsenic	2.79	3.8	0 / 1	0 / 1	0 / 5	0 / 5	1 / 6	2.79	2.79	SSB-2	2.79	
Beryllium	0.634	1.3	0 / 6	0 / 6			6 / 6	0.106	0.634	SSB-2	0.263	0.206
Chromium	14.1	10000	0 / 6	0 / 6			6 / 6	6.03	14.1	SSB-1	9.16	3.32
Cobalt	4.43	120000	0 / 3	0 / 3	0 / 3	0 / 3	3 / 6	2.72	4.43	SSB-2	3.82	0.952
Copper	8.15	82000	0 / 2	0 / 2	0 / 4	0 / 4	2 / 6	6.64	8.15	SSB-1	7.4	1.1
Iron	12400	610000	0 / 5	0 / 5	0 / 1	0 / 1	5 / 6	7710	12400	SSB-1	9750	2300
Lead	16	400	0 / 5	0 / 5	0 / 1	0 / 1	5 / 6	9.75	16	SSB-5	13.4	2.83
Magnesium	1220	- -	0 / 1		0 / 5		1 / 6	1220	1220	SSB-1	1220	
Nickel	9.38	41000	0 / 6	0 / 6			6 / 6	3.93	9.38	SSB-1	5.975	2.279
Sodium	397	- -	0 / 6				6 / 6	328	397	SSB-3	351	28
Vanadium	24	14000	0 / 6	0 / 6			6 / 6	11.3	24	SSB-1	16.8	4.53
Zinc	22.6	610000	0 / 6	0 / 6			6 / 6	7.36	22.6	SSB-1	15.6	6.06
Semivolatiles (µg/g)												
Benzoic acid	0.734	1000000	0 / 3	0 / 3	0 / 3	0 / 3	3 / 6	0.375	0.734	SSB-3	0.511	0.195
Bis(2-ethylhexyl)phthalate	2.22	410	0 / 1	0 / 1	0 / 5	0 / 5	1 / 6	2.22	2.22	SSB-4	2.22	

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
BKG - Background levels (µg/g). Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
RBC - Industrial Soil Risk-Based Concentration (µg/g)
CRL - Certified Reporting Limit.
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists.

TABLE 3-4
SUMMARY OF BACKGROUND SUBSURFACE SOIL CHEMISTRY

Sample Location Identification	Screening Criteria		SBB-1A	SBB-1B	SBB-1C	SBB-2A	SBB-2B	SBB-2C	SBB-3A	SBB-3B	SBB-3B	SBB-3C
Field Sample ID			SBB-1A	SBB-1B	SBB-1C	SBB-2A	SBB-2B	SBB-2C	SBB-3A	SBB-3B	SBB-3BX	SBB-3C
Site Type			BORE	BORE	BORE	BORE	BORE	BORE	BORE	BORE	BORE	BORE
Start Depth (ft bgs)			0	4	6.5	0	2	3	0	4	4	8
End Depth (ft bgs)			4	8	10.5	4	6	7	4	8	8	12
Media	Maximum Background (mg/g)	Industrial Soil RBC (mg/g)	CSO	CSO	CSO	CSO	CSO	CSO	CSO	CSO	CSO	CSO
Collection Date			8/28/1996	8/28/1996	8/28/1996	8/28/1996	8/28/1996	8/28/1996	8/29/1996	8/29/1996	8/29/1996	8/29/1996
Solids			86.7	89.6	93.2	92.3	96.2	95.4	93.9	97.2	97.5	96.4
Metals (µg/g)												
Aluminum	6920	1000000	6920	3000	2000	2860	2150	1180	6460	1500	1700	2290
Arsenic	0.25	3.8	1.44 BL	0.676 BL	- -	0.714 BL	0.97 BL	0.736 BL	0.991 BL	0.684 BL	0.775 BL	0.636 BL
Beryllium	0.543	1.3	0.543 K	0.111 K	0.0453 K	0.224 K	0.212 K	0.165 K	0.518 K	0.468 K	0.436 K	0.502 K
Calcium	606	- -	606	154	141	- -	- -	- -	- -	- -	- -	- -
Chromium	16.1	10000	13.7 K	10.1 K	5.87 K	6.5 K	6.31 K	6.53 K	14.3 K	15.4 K	16.1 K	13.8 K
Cobalt	20.7	120000	3.85	- -	- -	- -	- -	- -	7.05	9.87	12.1	20.7
Copper	12.1	82000	6.66	2.13	1.35	3.94	5.04	3.64	8.91	11.3	12.1	11.1
Iron	20800	610000	13000	5420	2640	5620	6140	3880	15000	18800	20800	15600
Lead	10.3	400	10.3	- -	- -	- -	- -	- -	- -	- -	- -	- -
Magnesium	939	- -	939	123	75.2	286	225	95.2	667	169	229	680
Manganese	445	47000	87	8.36	- -	15.8	12.9	10.3	62.5	78.8	100	445
Nickel	8.2	41000	5.25	- -	- -	2.6	- -	- -	8.2	6.47	6.41	6.75
Potassium	494	- -	465	134	121	143	182	109	358	191	191	494
Sodium	404	- -	354	404	369	347	313	308	342	306	302	353
Vanadium	35.3	14000	23.9	14.2	7.62	10.6	9.86	7.78	26.2	30.3	35.3	20.5
Zinc	24.9	610000	16.6	- -	- -	7.56	6.51	- -	24.9	20.4	21.6	17.9
Volatiles (µg/g)												
Acetone	0.01	200000	- -	- -	0.0107 B	- -	- -	- -	- -	- -	- -	- -
Pesticides (µg/g)												
Dieldrin	0.003	0.36	0.00369 B	- -	- -	- -	- -	- -	- -	- -	- -	- -

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
RBC - Risk-Based Concentration
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
X - Duplicate Sample
CSO - Chemical Soils

EPA Region III Data Qualifiers:
B - Not detected substantially above the level reported in the laboratory or field blanks.
J - Analyte present. Reported value may not be accurate or precise.
K - Analyte present. Reported value may be biased high. Actual value is expected to be lower.
L - Analyte Present. Reported value may be biased low. Actual value is expected to be higher.

TABLE 3-5
BACKGROUND SUBSURFACE SOIL CHEMISTRY STATISTICS

	Subsurface Soil Screening Levels		Exceedance Frequencies				Detection Frequency	Minimum	Maximum	Location of Maximum	Average	Standard Deviation
			Positive Results		Not Detected Results							
	BKG	RBC	BKG	RBC	BKG	RBC						
Metals (µg/g)												
Aluminum	6920	1000000	0 / 2	0 / 2	0 / 8	0 / 8	2 / 10	6460	6920	SBB-1A	6690	325
Beryllium	0.543	1.3	0 / 10	0 / 10			10 / 10	0.0453	0.543	SBB-1A	0.322	0.189
Chromium	16.1	10000	0 / 10	0 / 10			10 / 10	5.87	16.1	SBB-3B	10.9	4.22
Cobalt	20.7	120000	0 / 5	0 / 5	0 / 5	0 / 5	5 / 10	3.85	20.7	SBB-3C	10.7	6.38
Copper	12.1	82000	0 / 4	0 / 4	0 / 6	0 / 6	4 / 10	8.91	12.1	SBB-3B	10.9	1.37
Iron	20800	610000	0 / 7	0 / 7	0 / 3	0 / 3	7 / 10	5620	20800	SBB-3B	13600	5840
Lead	10.3	400	0 / 1	0 / 1	0 / 9	0 / 9	1 / 10	10.3	10.3	SBB-1A	10.3	
Manganese	445	47000	0 / 1	0 / 1	0 / 9	0 / 9	1 / 10	445	445	SBB-3C	445	
Nickel	8.2	41000	0 / 6	0 / 6	0 / 4	0 / 4	6 / 10	2.6	8.2	SBB-3A	5.9	1.9
Sodium	404		0 / 10				10 / 10	302	404	SBB-1B	340	33
Vanadium	35.3	14000	0 / 10	0 / 10			10 / 10	7.62	35.3	SBB-3B	18.6	10
Zinc	24.9	610000	0 / 7	0 / 7	0 / 3	0 / 3	7 / 10	6.51	24.9	SBB-3A	16.5	6.99

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
BKG - Background levels (ug/g). Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
RBC - Industrial Soil Risk-Based Concentration (ug/g)
CRL - Certified Reporting Limit.
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists.

TABLE 3-6
SUMMARY OF BACKGROUND SURFACE WATER CHEMISTRY

Sample Location Identification Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection Date	Screening Criteria		SWB-1 SWB-1 STRM 0 0 CSW 11/20/1996	SWB-1 SWB-1X STRM 0 0 CSW 11/20/1996	HHASW-8 HHASW-8 STRM 0 0 CSW 4/22/1996	HHASW-9 HHASW-9 STRM 0 0 CSW 4/22/1996
	Maximum Background (µg/L)	AWQC or Tier II Value (freshwater, chronic) (µg/L)				
Metals (µg/L)						
Aluminum	197	87	139 K	104 K	197	140
Barium	48.1	4	47.2	48.1	47.4	46.6
Calcium	27400	- -	21700	22300	27400	24700
Iron	378	1000	334 J	298 J	378	327
Magnesium	6210	- -	5930	6080	6180	6210
Manganese	68.1	120	68.1	66	48.4	48.9
Potassium	3180	- -	2770	2760	3180	2910
Sodium	21000	- -	12700 K	13000 K	21000	20800
Zinc	17.5	- -	- -	- -	15.7	17.5
Semivolatiles (µg/L)						
Bis(2-ethylhexyl)phthalate	2	160	- -	- -	- -	- -
Pesticides (µg/L)						
alpha-BHC	0.02	2.2	0.02	0.0086	- -	- -
Endosulfan sulfate	0.036	0.056	0.036	0.025	- -	- -

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
AWQC - Federal Ambient Water Quality Criteria or Maryland Drinking Water Standards (COMAR).
Tier II Value (freshwater, chronic) - Suter and Tsao (1996), USEPA (1996).
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., AWQC) exists or that the analyte is present below the detection limits.
X - Duplicate Sample
STRM - Stream
CSW - Chemical Surface Water

EPA Region III Data Qualifiers:
B - Not detected substantially above the level reported in t field blanks.
J - Analyte present. Reported value may not be accurate
K - Analyte present. Reported value may be biased high. expected to be lower.
L - Analyte Present. Reported value may be biased low. expected to be higher.

TABLE 3-7
BACKGROUND SURFACE WATER CHEMISTRY STATISTICS

	Surface Water Screening Levels		Exceedance Frequencies				Detection	Minimum	Maximum	Location of	Average	Standard
			Positive Results		Not Detected Results							
	BKG	AWQC	BKG	AWQC	BKG	AWQC	Frequency			Maximum		Deviation
Metals (µg/L)												
Aluminum	197	87	0 / 4	4 / 4			4 / 4	104	197	HHASW-8	145	38.5
Barium	48.1	4	0 / 4	4 / 4			4 / 4	46.6	48.1	SWB-1	47.6	0.47
Calcium	27400	- -	0 / 4				4 / 4	21700	27400	HHASW-8	24025	2596
Iron	378	1000	0 / 4	0 / 4			4 / 4	298	378	HHASW-8	334	33
Magnesium	6210	- -	0 / 4				4 / 4	5930	6210	HHASW-9	6100	126
Manganese	68.1	120	0 / 4	0 / 4			4 / 4	48.4	68.1	SWB-1	57.8	10.7
Potassium	3180	- -	0 / 4				4 / 4	2760	3180	HHASW-8	2905	196
Sodium	21000	- -	0 / 4				4 / 4	12700	21000	HHASW-8	16875	4650
Zinc	17.5	- -	0 / 2		0 / 2	0 / 2	2 / 4	15.7	17.5	HHASW-9	16.6	1.3
Pesticides (µg/L)												
alpha-BHC	0.02	2.2	0 / 2	0 / 2	0 / 2	0 / 2	2 / 4	0.0086	0.02	SWB-1	0.014	0.008
Endosulfan sulfate	0.036	0.056	0 / 2	0 / 2	0 / 2	0 / 2	2 / 4	0.025	0.036	SWB-1	0.031	0.0078

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
BKG - Background levels (µg/L). Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
AWQC - Ambient Water Quality Criteria (µg/L) or Tier II value (freshwater, chronic - Suter and Tsao (1996), USEPA (1996)) (µg/L).
CRL - Certified Reporting Limit.
Dashes (- -) indicate that no screening level standard (e.g., AWQC) exists.

TABLE 3-8
SUMMARY OF BACKGROUND SEDIMENT CHEMISTRY

Sample Location Identification Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection Date Solids	Screening Criteria		SEB-1 SEB-1 STRM 0 0.5 CSE 11/20/1996 79.8	SEB-1 SEB-1X STRM 0 0.5 CSE 11/20/1996 81.6	HHASE-8 HHASE-8 STRM 0 0.5 CSE 4/22/1996	HHASE-9 HHASE-9 STRM 0 0.5 CSE 4/22/1996
	Maximum Background (mg/g)	ER-L (freshwater) (mg/g)				
Metals (µg/g)						
Aluminum	6600	- -	1500	1730	6600	3750
Arsenic	4.19	5.9	0.619 L	0.567 L	4.19	- -
Beryllium	0.354	- -	- -	0.354	- -	- -
Calcium	1200	- -	318	326	1200	766
Chromium	22	37.3	6.08	5.33	22	11.9
Cobalt	5.47	- -	2.72	3.66	5.24	5.47
Copper	14.7	35.7	2.38	3.13	14.7	5.75
Iron	10600	20000	3830	4600	10600	8450
Magnesium	1380	- -	570	734	1270	1380
Manganese	297	460	173	216	174	297
Nickel	7.11	18	2.58 K	3.38 K	6.29	7.11
Potassium	1780	- -	460	515	1250	1780
Silver	0.56	1	0.106	0.56	- -	- -
Sodium	252	- -	252	245	240	118
Vanadium	24	- -	5.69	7.01	24	15.5
Zinc	1490	123	12.3	14	1490	34.9
Organics (µg/g)						
Acetone	0.009	0.0698	- -	- -	0.009	- -
Bis(2-ethylhexyl)phthalate	1.64	7108.28	0.514 B	- -	1.64	0.137
Benzo(a)pyrene	0.085	0.0319	- -	- -	0.0851	- -
Fluoranthene	0.116	0.111	- -	- -	0.116	- -
Benzo(b)fluoranthene	0.0699	0.24	- -	- -	- -	0.0699
Phenanthrene	0.11	0.0419	- -	- -	0.0806	0.11
Pyrene	0.0955	0.053	- -	- -	0.0955	0.0918
Arochlor 1248	0.119	0.03	- -	- -	0.119	- -
DDE	0.0045	0.00142	- -	- -	0.0045	- -
DDT	0.0057	0.008	° 0.0123 B	- -	0.0057	- -

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
ER-L (freshwater) - Effects Range-Low (Long and Morgan 1990).
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., ER-L) exists or that the analyte is present below the detection limits.
X - Duplicate Sample
CSE - Chemical Sediment
STRM - Stream

EPA Region III Data Qualifiers:
B - Not detected substantially above the level reported in the laboratory or field blanks.
J - Analyte present. Reported value may not be accurate or precise.
K - Analyte present. Reported value may be biased high. Actual value is expected to be lower.
L - Analyte Present. Reported value may be biased low. Actual value is expected to be higher.

TABLE 3-9
BACKGROUND SEDIMENT CHEMISTRY STATISTICS

	Sediment Screening Levels		Exceedance Frequencies				Detection Frequency	Minimum	Maximum	Location of Maximum	Average	Standard Deviation
			Positive Results		Not Detected Results							
	BKG	ER-L	BKG	ER-L	BKG	ER-L						
Metals (µg/g)												
Aluminum	6600	- -	0 / 4	0 / 4			4 / 4	1500	6600	HHASE-8	3395	2360
Arsenic	4.19	5.9	0 / 3	0 / 3	0 / 1	0 / 1	3 / 4	0.567	4.19	HHASE-8	1.79	2.07
Beryllium	0.354	- -	0 / 1	0 / 1	0 / 3	0 / 3	1 / 4	0.354	0.354	SEB-1	0.354	
Chromium	22	37.3	0 / 4	0 / 4			4 / 4	5.33	22	HHASE-8	11.3	7.7
Cobalt	5.47	- -	0 / 2	0 / 2	0 / 2	0 / 2	2 / 4	2.72	5.47	HHASE-9	4.27	1.31
Copper	14.7	35.7	0 / 4	0 / 4			4 / 4	2.38	14.7	HHASE-8	6.49	5.66
Iron	10600	20000	0 / 4	0 / 4			4 / 4	3830	10600	HHASE-8	6870	3204
Magnesium	1380	- -	0 / 4	0 / 4			4 / 4	570	1380	HHASE-9	988	397
Manganese	297	460	0 / 4	0 / 4			4 / 4	173	297	HHASE-9	215	58.2
Nickel	7.11	18	0 / 4	0 / 4			4 / 4	2.58	7.11	HHASE-9	4.84	2.2
Potassium	1780	- -	0 / 4	0 / 4			4 / 4	460	1780	HHASE-9	1001	632
Silver	0.56	1	0 / 2	0 / 2	0 / 2	0 / 2	2 / 4	0.106	0.56	SEB-1	0.333	0.321
Sodium	252	- -	0 / 2	0 / 2	0 / 2	0 / 2	2 / 4	118	252	SEB-1	213	64
Vanadium	24	- -	0 / 4	0 / 4			4 / 4	5.69	24	HHASE-8	13.05	8.5
Zinc	1490	- -	0 / 4	0 / 4			4 / 4	12.3	1490	HHASE-8	388	735
Organics (µg/g)												
Acetone	0.009	0.0698	0 / 1	0 / 1	0 / 3	0 / 3	1 / 4	- -	0.009	HHASE-8		
Bis(2-ethylhexyl)phthalate	1.64	7108.28	0 / 2	0 / 2	0 / 2	0 / 2	2 / 4	0.137	1.64	HHASE-8	0.763	0.782
Benzo(a)pyrene	0.085	0.0319	0 / 1	1 / 1	0 / 3	0 / 3	1 / 4	- -	0.085	HHASE-8		
Fluoranthene	0.116	0.111	0 / 1	1 / 1	0 / 3	0 / 3	1 / 4	- -	0.116	HHASE-8		
Benzo(b)fluoranthene	0.0699	0.24	0 / 1	0 / 1	0 / 3	0 / 3	1 / 4	- -	0.0699	HHASE-9		
Phenanthrene	0.11	0.0419	0 / 2	2 / 2	0 / 2	0 / 2	2 / 4	0.0806	0.11	HHASE-8	0.095	0.021
Pyrene	0.0955	0.053	0 / 2	2 / 2	0 / 2	0 / 2	2 / 4	0.0918	0.0955	HHASE-8	0.093	0.003
Arochlor 1248	0.119	0.03	0 / 1	1 / 1	0 / 3	0 / 3	1 / 4	- -	0.119	HHASE-8		
DDE	0.0045	0.00142	0 / 1	0 / 1	0 / 3	0 / 3	1 / 4	- -	0.0045	HHASE-8		
DDT	0.0057	0.008	0 / 1	1 / 1	0 / 3	0 / 3	1 / 4	- -	0.0057	HHASE-8		

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
BKG - Background levels (µg/g). Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
ER-L (freshwater) - Effects Range-Low (µg/g) (Long and Morgan 1990).
CRL - Certified Reporting Limit.
Dashes (- -) indicate that no screening level standard (e.g., ER-L) exists.

TABLE 3-10
SUMMARY OF BACKGROUND GROUNDWATER CHEMISTRY (UPPER PATAPSCO)

Sample Location Identification Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection Date	Screening Criteria			ODAMW-5 ODAMW-5 WELL 2 12 CGW 5/30/1996	CFD-1 CFD-1 WELL 40 50 CGW 10/14/1996
	Maximum Background (µg/L)	Tap Water RBC (µg/L)	MCL or MWQS (µg/L)		
Field Quality Parameters					
pH				5.4	5.17
Conductivity (umhos/cm2)				0.063	0.029
Temperature (C)				13.3	22.8
Turbidity (NTU)				- -	186
Metals (µg/L)					
Aluminum	1260	37000	- -	473	1260
Arsenic	35.7	0.045	50	1.5	35.7
Barium	33.8	2600	2000	33.8	27.4
Beryllium	0.529	0.016	4	0.12	0.529
Cadmium	0.111	18	5	- -	0.111
Calcium	7890	- -	- -	7890	1460
Chromium	67	180	50	- -	67
Copper	10.4	1500	1300	4.7	10.4
Iron	5840	11000	- -	733	5840
Lead	14	- -	15	3.8	14
Magnesium	1270	- -	- -	1270	871 K
Manganese	154	840	- -	154	21.3
Nickel	57.1	730	100	- -	57.1
Potassium	1570	- -	- -	1570	1410
Sodium	2460	- -	- -	2220	2460 K
Vanadium	17.2	260	- -	- -	17.2
Zinc	51.5	11000	- -	36.4	51.5

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
MWQS - Maryland Water Quality Standard
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
X - Duplicate Sample
CGW - Chemical Groundwater

EPA Region III Data Qualifiers:
B - Not detected substantially above the level reported in the laboratory field blanks.
J - Analyte present. Reported value may not be accurate or precise.
K - Analyte present. Reported value may be biased high. Actual value expected to be lower.
L - Analyte Present. Reported value may be biased low. Actual value expected to be higher.

TABLE 3-10
SUMMARY OF BACKGROUND GROUNDWATER CHEMISTRY (UPPER PATAPSCO)

Sample Location Identification Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection Date	Screening Crite	
	Maximum Background (µg/L)	Tap Water RBC (µg/L)
Field Quality Parameters		
pH		
Conductivity (umhos/cm2)		
Temperature (C)		
Turbidity (NTU)		
Metals (µg/L)		
Aluminum	1260	37000
Arsenic	35.7	0.045
Barium	33.8	2600
Beryllium	0.529	0.016
Cadmium	0.111	18
Calcium	7890	- -
Chromium	67	180
Copper	10.4	1500
Iron	5840	11000
Lead	14	- -
Magnesium	1270	- -
Manganese	154	840
Nickel	57.1	730
Potassium	1570	- -
Sodium	2460	- -
Vanadium	17.2	260
Zinc	51.5	11000

NOTES:
Only detected analytes are included on this table. For full data set, s or
Background levels are either the CRL for not detected results or the concentration for positive results.
RBC - Risk-Based Concentration is
MCL - Maximum Contaminant Level
MWQS - Maryland Water Quality Standard is
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exi below the detection limits.
X - Duplicate Sample
CGW - Chemical Groundwater

TABLE 3-11
SUMMARY OF BACKGROUND GROUNDWATER STATISTICS (UPPER PATAPSCO)

	Groundwater Screening Levels			Exceedance Frequencies						Detection Frequency	Minimum	Maximum	Location of Maimum	Average	Standard Deviation
				Positive Results			Not Detected Results								
	BKG	TAP	MCL	BKG	TAP	MCL	BKG	TAP	MCL						
Field Quality Parameters															
pH															
Conductivity (ughos/cm2)															
Temperature (C)															
Turbidity (NTU)															
Metals (µg/L)															
Aluminum	1260	37000	- -	0 / 2	0 / 2					2 / 2	473	1260	CFD-1	866.5	556.5
Arsenic	35.7	0.045	50	0 / 2	2 / 2	0 / 2				2 / 2	1.5	35.7	CFD-1	18.6	24.2
Barium	27.4	2600	2000	0 / 2	0 / 2	0 / 2				2 / 2	27.4	33.8	ODAMW-5	30.6	4.5
Beryllium	0.529	0.016	4	0 / 2	2 / 2	0 / 2				2 / 2	0.12	0.529	CFD-1	0.3245	0.3
Cadmium	0.111	18	5	0 / 1	0 / 1	0 / 1		0 / 1	0 / 1	1 / 2	0.111	0.111	CFD-1	0.111	
Calcium	1460	- -	- -	0 / 2						2 / 2	1460	7890	ODAMW-5	4675	4546.7
Chromium	67	180	50	0 / 1	0 / 1	1 / 1		0 / 1	0 / 1	1 / 2	67	67	CFD-1	67	
Copper	10.4	1500	1300	0 / 2	0 / 2	0 / 2				2 / 2	4.7	10.4	CFD-1	7.55	4.0
Iron	5840	11000	- -	0 / 2	0 / 2					2 / 2	733	5840	CFD-1	3286.5	3611.2
Lead	14	- -	15	0 / 2		0 / 2				2 / 2	3.8	14	CFD-1	8.9	7.2
Magnesium	871	- -	- -	0 / 2						2 / 2	871	1270	ODAMW-5	1070.5	282.1
Manganese	21.3	840	- -	0 / 2	0 / 2					2 / 2	21.3	154	ODAMW-5	87.65	93.8
Nickel	57.1	730	100	0 / 1	0 / 1	0 / 1		0 / 1	0 / 1	1 / 2	57.1	57.1	CFD-1	57.1	
Potassium	1410	- -	- -	0 / 2						2 / 2	1410	1570	ODAMW-5	1490	113.1
Sodium	2460	- -	- -	0 / 2						2 / 2	2220	2460	CFD-1	2340	169.7
Vanadium	17.2	260	- -	0 / 1	0 / 1			0 / 1		1 / 2	17.2	17.2	CFD-1	17.2	
Zinc	51.5	11000	- -	0 / 2	0 / 2					2 / 2	36.4	51.5	CFD-1	43.95	10.7

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
BKG - Background levels (µg/L). Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
TAP - Tap Water Risk-Based Concentration (µg/L).
MCL - Maximum Contaminant Level (µg/L).
CRL - Certified Reporting Limit.
Dashes (- -) indicate that no screening level standard (e.g., MCL) exists.

TABLE 3-12
SUMMARY OF BACKGROUND GROUNDWATER CHEMISTRY (LOWER PATAPSCO)

Sample Location Identification Field sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection Date	Screening Criteria			ODAMW-6D ODAMW6D WELL 80 120 CGW 5/30/1996	MW-22S MW-22S WELL 15 25 CGW 10/29/1996
	Maximum Background (µg/L)	Tap Water RBC (µg/L)	MCL or MWQS (µg/L)		
Field Quality Parameters					
pH				5.9	4.83
Conductivity (umhos/cm)				0.49	0.037
Temperature (C)				11.1	19.72
Turbidity (NTU)				830	7.5
Metals (µg/L)					
Aluminum	759	37000	- -	759	- -
Arsenic	2	0.045	50	2	- -
Barium	19.1	2600	2000	19.1	- -
Beryllium	0.1	0.016	4	0.1	- -
Calcium	5890	- -	- -	5430	5890
Chromium	10.1	180	50	10.1	- -
Cobalt	18.4	2200	- -	18.4	- -
Copper	7.8	1500	1300	14.6	7.8
Iron	264	11000	- -	264	- -
Lead	10.6	- -	15	10.6	2.34
Magnesium	1770	- -	- -	627	1770
Manganese	45.1	840	- -	45.1	- -
Nickel	16.2	730	100	13.6	16.2
Potassium	3840	- -	- -	3840	1170
Sodium	4670	- -	- -	2910	4670 K
Vanadium	7	260	- -	7	- -
Zinc	66.1	11000	- -	66.1	- -

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
MWQS - Maryland Water Quality Standard
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
X - Duplicate Sample
CGW - Chemical Groundwater

EPA Region III Data Qualifiers:
B - Not detected substantially above the level reported in the laboratory or field blanks.
J - Analyte present. Reported value may not be accurate or precise.
K - Analyte present. Reported value may be biased high. Actual value is expected to be lower.
L - Analyte Present. Reported value may be biased low. Actual value is expected to be higher.

TABLE 3-12
SUMMARY OF BACKGROUND GROUNDWATER CHEMISTRY (LOWER PATAPSCO)

Sample Location Identification Field sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection Date	Screening Crite	
	Maximum Background (µg/L)	Tap Water RBC (µg/L)
Field Quality Parameters		
pH		
Conductivity (umhos/cm)		
Temperature (C)		
Turbidity (NTU)		
Metals (µg/L)		
Aluminum	759	37000
Arsenic	2	0.045
Barium	19.1	2600
Beryllium	0.1	0.016
Calcium	5890	- -
Chromium	10.1	180
Cobalt	18.4	2200
Copper	7.8	1500
Iron	264	11000
Lead	10.6	- -
Magnesium	1770	- -
Manganese	45.1	840
Nickel	16.2	730
Potassium	3840	- -
Sodium	4670	- -
Vanadium	7	260
Zinc	66.1	11000

NOTES:
Only detected analytes are included on this table. For full data set,
Background levels are either the CRL for not detected results or the concentration for positive results.
RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
MWQS - Maryland Water Quality Standard
CRL - Certified Reporting Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) ex below the detection limits.
X - Duplicate Sample
CGW - Chemical Groundwater

TABLE 3-13
SUMMARY OF BACKGROUND GROUNDWATER STATISTICS (LOWER PATAPSCO)

	Groundwater Screening Levels			Exceedance Frequencies											
				Positive Results			Not Detected Results			Detection			Location of		Standard
	BKG	TAP	MCL	BKG	TAP	MCL	BKG	TAP	MCL	Frequency	Minimum	Maximum	Maimum	Average	Deviation
Field Quality Parameters															
pH															
Conductivity (ughos/cm2)															
Temperature (C)															
Turbidity (NTU)															
Metals (µg/L)															
Aluminum	759	37000	- -	0 / 1	0 / 1		0 / 1	0 / 1		1 / 2	759	759	ODAMW-6D	759	
Arsenic	2	0.045	50	0 / 1	1 / 1	0 / 1	0 / 1	0 / 1	0 / 1	1 / 2	2	2	ODAMW-6D	2	
Barium	19.1	2600	2000	0 / 1	0 / 1	0 / 1	0 / 1	0 / 1	0 / 1	1 / 2	19.1	19.1	ODAMW-6D	19.1	
Beryllium	0.1	0.016	4	0 / 1	1 / 1	0 / 1	0 / 1	0 / 1	0 / 1	1 / 2	0.1	0.1	ODAMW-6D	0.1	
Calcium	5890	- -	- -	0 / 2						1 / 2	5430	5890	MW-22S	5660	325.3
Chromium	10.1	180	50	0 / 1	0 / 1	0 / 1	0 / 1	0 / 1	0 / 1	1 / 2	10.1	10.1	ODAMW-6D	10.1	
Cobalt	18.4	2200	- -	0 / 1	0 / 1		0 / 1	0 / 1		1 / 2	18.4	18.4	ODAMW-6D	18.4	
Copper	7.8	1500	1300	0 / 2	0 / 2	0 / 2				2 / 2	7.8	14.6	ODAMW-6D	11.2	4.8
Iron	264	11000	- -	0 / 1	0 / 1		0 / 1	0 / 1		1 / 2	264	264	ODAMW-6D	264	
Lead	10.6	- -	15	0 / 2		0 / 2				2 / 2	2.34	10.6	ODAMW-6D	6.47	5.8
Magnesium	1770	- -	- -	0 / 2						2 / 2	627	1770	MW-22S	1198.5	808.2
Manganese	45.1	840	- -	0 / 1	0 / 1		0 / 1	0 / 1		1 / 2	45.1	45.1	ODAMW-6D	45.1	
Nickel	16.2	730	100	0 / 2	0 / 2	0 / 2				2 / 2	13.6	16.2	MW-22S	14.9	1.8
Potassium	1170	- -	- -	0 / 2						2 / 2	1170	3840	ODAMW-6D	2505	1888.0
Sodium	4670	- -	- -	0 / 2						2 / 2	2910	4670	MW-22S	3790	1244.5
Vanadium	7	260	- -	0 / 1	0 / 1		0 / 1	0 / 1		1 / 2	7	7	ODAMW-6D	7	
Zinc	66.1	11000	- -	0 / 1	0 / 1		0 / 1	0 / 1		1 / 2	66.1	66.1	ODAMW-6D	66.1	

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
BKG - Background levels (µg/L). Background levels are either the CRL for not detected results or the maximum background concentration for positive results.
TAP - Tap Water Risk-Based Concentration (µg/L).
MCL - Maximum Contaminant Level (µg/L).
CRL - Certified Reporting Limit.
Dashes (- -) indicate that no screening level standard (e.g., MCL) exists.

TABLE 4-1
ENVIRONMENTAL SAMPLING SUMMARY
(PAGE 1 OF 4)

MATRIX	SAMPLE NO.	CHEMICAL ANALYSES									PHYSICAL	
		VOCs: 40 mL aqueous; 125 mL soil	SVOCs: 1L aqueous; 250 mL soil	PAH	Pesticides: 1-L aqueous; 250 mL soil	PCBs: 1-L aqueous; 250 mL soil	Herbicides	Explosives: 2-1 L aqueous; 250mL soil	TAL Metals\Cyn: 1 L-aqueous; 250 mL soil	Perchlorate	Atterberg Limits	Grain Size
Shallow Groundwater	MW-2S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-4S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-5	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-7S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-8	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-10S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-12S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-13S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-14	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-17	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-18	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-19	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-20	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-105	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-106	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-107	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-123S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-124S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-127S	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-128S	✓	✓	✓	✓	✓	✓	✓	✓	✓		

TABLE 4-1
ENVIRONMENTAL SAMPLING SUMMARY
(PAGE 2 OF 4)

MATRIX	SAMPLE NO.	CHEMICAL ANALYSES									PHYSICAL	
		VOCs: 40 mL aqueous; 125 mL soil	SVOCs: 1L aqueous; 250 mL soil	PAH	Pesticides: 1-L aqueous; 250 mL soil	PCBs: 1-L aqueous; 250 mL soil	Herbicides	Explosives: 2-1 L aqueous; 250mL soil	TAL Metals\Cyn: 1 L-aqueous; 250 mL soil	Perchlorate	Atterberg Limits	Grain Size
Deep Groundwater	MW-2D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-4DR	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-7D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-12D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-13D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-13DX	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-101D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-108D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-109D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-110D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-111D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-112D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-113D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-114D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-114DX	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-115D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-116D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-116DX	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-117D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-118D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-119D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-119DX	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-120D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-121D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-122D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-125D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	MW-126D	✓	✓	✓	✓	✓	✓	✓	✓	✓		

TABLE 4-1
ENVIRONMENTAL SAMPLING SUMMARY
(PAGE 3 OF 4)

MATRIX	SAMPLE NO.	CHEMICAL ANALYSES									PHYSICAL	
		VOCs: 40 mL aqueous; 125 mL soil	SVOCs: 1L aqueous; 250 mL soil	PAH	Pesticides: 1-L aqueous; 250 mL soil	PCBs: 1-L aqueous; 250 mL soil	Herbicides	Explosives: 2-1 L aqueous; 250mL soil	TAL Metals\Cyn: 1 L-aqueous; 250 mL soil	Perchlorate	Atterberg Limits	Grain Size
Surface Water	SW-1	✓	✓	✓	✓	✓	✓	✓	✓			
	SW-2	✓	✓	✓	✓	✓	✓	✓	✓			
	SW-3	✓	✓	✓	✓	✓	✓	✓	✓			
	SW-4	✓	✓	✓	✓	✓	✓	✓	✓			
	SW-4X	✓	✓	✓	✓	✓	✓	✓	✓			
	SW-5	✓	✓	✓	✓	✓	✓	✓	✓			
	SW-6	✓	✓	✓	✓	✓	✓	✓	✓			
Sediment	Sed-1	✓	✓	✓	✓	✓	✓	✓	✓			✓
	Sed-2	✓	✓	✓	✓	✓	✓	✓	✓			✓
	Sed-3	✓	✓	✓	✓	✓	✓	✓	✓			✓
	Sed-4	✓	✓	✓	✓	✓	✓	✓	✓			✓
	Sed-5	✓	✓	✓	✓	✓	✓	✓	✓			✓
	Sed-6	✓	✓	✓	✓	✓	✓	✓	✓			✓
Surface Soil	SS-1	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-2	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-3	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
	SS-3X	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-4	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-5	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
	SS-6	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-7	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-8	✓	✓	✓	✓	✓	✓	✓	✓			
Cell 3	SS3-1	✓	✓	✓	✓	✓	✓	✓	✓			
	SS3-2	✓	✓	✓	✓	✓	✓	✓	✓			
	SS3-3	✓	✓	✓	✓	✓	✓	✓	✓			
	SS3-4	✓	✓	✓	✓	✓	✓	✓	✓			
	SS3-5	✓	✓	✓	✓	✓	✓	✓	✓			
	SS3-6	✓	✓	✓	✓	✓	✓	✓	✓			
Former ASP	SS-ASP-1	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
	SS-ASP-2	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-ASP-3	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-ASP-4	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-ASP-5	✓	✓	✓	✓	✓	✓	✓	✓			
	SS-ASP-6	✓	✓	✓	✓	✓	✓	✓	✓			

TABLE 4-1
ENVIRONMENTAL SAMPLING SUMMARY
(PAGE 4 OF 4)

MATRIX	SAMPLE NO.	CHEMICAL ANALYSES									PHYSICAL	
		VOCs: 40 mL aqueous; 125 mL soil	SVOCs: 1L aqueous; 250 mL soil	PAH	Pesticides: 1-L aqueous; 250 mL soil	PCBs: 1-L aqueous; 250 mL soil	Herbicides	Explosives: 2-1 L aqueous; 250mL soil	TAL Metals\Cyn: 1 L-aqueous; 250 mL soil	Perchlorate	Atterberg Limits	Grain Size
Subsurface Soil	TR-1A	✓	✓	✓		✓		✓	✓			
	TR-1B	✓	✓	✓		✓		✓	✓			
	TR-2A	✓	✓	✓		✓		✓	✓			
Cell 3 - Trenches	TR-2B	✓	✓	✓		✓		✓	✓			
	TR-3A	✓	✓	✓		✓		✓	✓			
	TR-3B	✓	✓	✓		✓		✓	✓			
	TR-4A	✓	✓	✓		✓		✓	✓			
	TR-4B	✓	✓	✓		✓		✓	✓			
	TR-5A	✓	✓	✓		✓		✓	✓			
	TR-5B	✓	✓	✓		✓		✓	✓			
	TR-6A	✓	✓	✓		✓		✓	✓			
	TR-6B	✓	✓	✓		✓		✓	✓			
Former ASP-Borings	SB-ASP-1A	✓	✓	✓		✓		✓	✓			
	SB-ASP-1B	✓	✓	✓		✓		✓	✓			
	SB-ASP-2A	✓	✓	✓		✓		✓	✓			
	SB-ASP-2B	✓	✓	✓		✓		✓	✓			
	SB-ASP-3A	✓	✓	✓		✓		✓	✓			
	SB-ASP-3B	✓	✓	✓		✓		✓	✓			
	SB-ASP-4A	✓	✓	✓		✓		✓	✓			
	SB-ASP-4B	✓	✓	✓		✓		✓	✓			
	SB-ASP-5A	✓	✓	✓		✓		✓	✓			
	SB-ASP-5B	✓	✓	✓		✓		✓	✓			
	SB-ASP-6A	✓	✓	✓		✓		✓	✓			
	SB-ASP-6B	✓	✓	✓		✓		✓	✓			

TABLE 4-2
WELL CONSTRUCTION SUMMARY

Well	MD ID	Total Depth	Screen	Elevation ground surface	Elevation top of casing	Water Level	Water Level	Construction
		feet	feet	ft-msl	ft-msl	ft-bgs	ft-msl	
Upper Patapsco								
MW-2S	AA-74-0920	29	24-29	161.00	163.93	11.42	149.58	4-in, SC
MW-4S	AA-74-0922	27	7-12	159.00	161.88	3.74	155.26	4-in, SC
MW-5	AA-88-2498	30	8-28	147.40	148.50	3.06	144.34	4-in, SC
MW-7s	AA-88-2493	30	5.5-25.5	136.20	137.99	1.67	134.53	4-in, SC
MW-8	AA-88-2496	25	8-23	140.60	141.76	6.44	134.16	4-in, SC
MW-10s	AA-88-2501	20	8-18	157.90	159.39	3.81	154.09	4-in, SC
MW-12s	N/A	29	18-28	172.90	174.44	18.8	154.10	4-in, SC
MW-13s	AA-88-2500	35	19-34	167.40	169.16	20.36	147.04	4-in, SC
MW-14	AA-88-2490	31	20-30	163.50	165.68	12.63	150.87	4-in, SC
MW-17	AA-88-4762	36	20-35	170.00	171.81	18.49	151.51	4-in, SC
MW-18	AA-88-4761	35.5	20-35	166.30	167.83	19.35	146.95	4-in, SC
MW-19	AA-88-4760	37.5	22.5-37.5	166.90	168.46	14.65	152.25	4-in, SC
MW-20	AA-88-4759	31	21-31	169.00	171.70	16.01	152.99	4-in, SC
MW-105	AA-93-1400	60	49-59	193.06	192.70	50.25	142.81	4-in, SC, flush
MW-106	AA-93-655	32	21.5-31.5	169.20	171.41	21.04	148.16	4-in, SC
MW-107	AA-93-653	42	29.23	177.50	179.91	29.23	148.27	4-in, SC
MW-123s	AA-94-9543	45	35-45	182.43	182.09	36.92	145.51	4-in, SC, flush
MW-124s	AA-94-9542	55	45-55	188.27	188.06	45.79	142.48	4-in, SC, flush
MW-127s	AA-94-9647	65	55-65	149.94	152.05	45.8	104.14	4-in, SC
MW-128s	AA-94-9648	43	33-43	122.82	122.89	20.34	102.48	4-in, SC, flush
Lower Patapsco								
MW-2D	AA-88-3447	88	76.5-86.5	160.70	162.67	68.54	92.16	4-in, SC
MW-4DR	AA-94-3495	149	129-149	159.00	161.71	65.46	93.54	4-in, DC
MW-7D	AA-88-2499	110	98-108	135.40	137.37	35.17	100.23	4-in, SC
MW-12D	AA-88-3448	132	121-131	172.40	174.52	80.27	92.13	4-in, SC
MW-13D	AA-88-4758	120	100-120	166.30	168.05	69.84	96.46	4-in, SC
MW-101D	AA-88-9140	145	133-143	161.20	161.17	72.23	88.97	4-in, DC, flush
MW-108D	AA-93-654	220	155-165	177.50	179.55	93.00	84.50	4-in, SC
MW-109D	AA-94-7985	153.5	133.5-153.5	171.61	171.26	83.33	88.28	4-in, DC, flush
MW-110D	AA-94-7987	190	140-160	166.34	167.91	76.69	89.65	4-in, DC
MW-111D	AA-94-7986	195	175-195	167.58	170.04	80.37	87.21	4-in, DC
MW-112D	AA-94-8001	198	175-195	204.15	203.86	119.60	84.55	4-in, DC, flush
MW113D	AA-94-7982	180	160-180	167.22	169.90	68.97	98.25	4-in, DC
MW-114D	AA-94-8004	205	185-205	168.08	168.67	74.83	93.25	4-in, DC
MW-115D	AA-94-8005	180	160-180	165.72	166.03	69.20	96.52	4-in, DC
MW-116D	AA-94-8003	186	166-186	174.47	173.61	87.13	87.34	4-in, DC, flush
MW-117D	AA-94-7983	150	127-147	147.17	148.45	40.21	106.96	4-in, DC
MW-118D	AA-94-7984	125	105-125	136.24	137.13	31.10	105.14	4-in, DC
MW-119D	AA-94-7989	188	168-188	154.96	154.56	52.93	102.03	4-in, DC, flush
MW-120D	AA-94-8002	105	85-105	166.14	167.58	56.84	109.30	4-in, DC
MW-121D	AA-94-8345	165	145-165	160.29	160.94	61.21	99.08	4-in, DC
MW-122D	AA-94-8346	80	60-80	149.20	150.34	40.48	108.72	4-in, DC
MW-123s	AA-94-9543	45	35-45	182.43	182.09	36.92	145.51	4-in, SC, flush
MW-124s	AA-94-9542	55	45-55	188.27	188.06	45.79	142.48	4-in, SC, flush
MW-125D	AA-94-9541	224.5	204.5-224.5	182.00	181.96	96.04	85.96	2-in, DC, flush
MW-126D	AA-94-9540	240	220-240	188.62	188.20	101.24	87.38	4-in, DC, flush
MW-127s	AA-94-9647	65	55-65	149.94	152.05	45.8	104.14	4-in, SC
MW-128s	AA-94-9648	43	33-43	122.82	122.89	20.34	102.48	4-in, SC, flush

Table 4-3
Previous Groundwater Detections at the CSL -
(Upper Patapsco - 2002)

Sample Location Field Sample ID Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW011 MW011 9.5 19.5 Groundwater 9/26/2002	MW012s MW012s 18 28 Groundwater 9/26/2002	MW019 MW019 22.5 37.5 Groundwater 9/26/2002	MW020 MW020 21 31 Groundwater 9/25/2002	MW021 MW021 6 21 Groundwater 9/26/2002
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)					
VOCs (ug/L)								
1,1-Dichloroethane	1	--	896	--	--	--	0.3	--
1,2-Dichloropropane	1	5	0.16	**0.26**	--	--	**0.39**	--
2-Butanone	5	--	--	--	--	--	--	--
Acetone	10	--	5475	--	--	--	--	--
Benzene	1	5	0.34	**2**	**3.1**	**1.8**	**1.8**	--
Carbon tetrachloride	1	5	0.16	--	--	--	--	--
Chlorobenzene	1	100	106	0.23	1.2	0.37	--	--
Chloroethane	2	--	8600	0.8	2 J	0.39 J	0.7	--
Chloroform	1	80	0.15	--	--	--	--	**0.28**
cis-1,2-Dichloroethene	1	70	61	0.74	--	--	0.47	--
Ethylbenzene	1	700	1339	--	0.75	3.5	--	--
Methylene chloride	2	5	4.1	0.21	--	--	--	--
Tetrachloroethene	1	5	0.1	--	--	--	--	--
Toluene	1	1,000	747	0.21	--	--	--	--
Trichloroethene	1	5	0.026	--	--	--	--	--
Xylenes (total)	3	10,000	212	0.34	--	0.52	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

DL - Detection Limit
RBC - Risk-Based Concentration HI=0.1.
MCL - Maximum Contaminant Level
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Bolded results indicate that the analyte is present above the RBC screening level and maximum background level.
Shaded cells indicate that the analyte is present above the MCL screening level and maximum background level.

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L - Analyte Present. Reported value may be biased low. Actual value is expected to be higher.
DUP - Duplicate Sample

Table 4-4
Previous Groundwater Detections at the CSL (Lower Patapsco - 2002)

Sample Location	Screening Criteria			MW-109d		MW-110d	MW-111d	MW-112d	MW-116d
Field Sample ID				MW109	MW109DUP	MW110	MW111	MW112	MW116
Start Depth (ft bgs)				133.5	133.5	140	175	175	166
End Depth (ft bgs)				153.5	153.5	160	195	195	186
Media	Maximum Background	Maximum Contaminant Level	Tap Water	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Collection date	or DL (ug/L)	or MWQS (ug/L)	RBC (ug/L)	9/25/2002	9/25/2002	9/24/2002	9/24/2002	9/24/2002	9/25/2002
Metals (ug/L)									
Aluminum	759	--	36,500	253	244	1,010 K	709 K	1,520 K	1,140
Arsenic	2	10	0.045	--	--	--	--	**2.7** K	--
Barium	19.1	2000	2555	89.3	84.1	19.4	1,210	1,110	229
Beryllium	0.1	4	73	--	--	--	--	--	--
Cadmium	5	5	18.3	--	0.4	0.31	--	--	--
Calcium	5890	--	--	10,900	9,450	4,080	663,000	319,000	139,000
Chromium	10.1	100	110	7.8	4.9	19.9	31.2	42.4	28.2
Cobalt	18.4	--	730	31.3	31.9	9	1.8	6.6	--
Copper	7.8	1300	1,460	11.2 L	10.8 L	--	--	31.7	3.5 L
Cyanide, Total	3	200	730	--	--	--	--	--	--
Iron	264	--	1,095	35.2 L	--	1,010	631	311	89.2 L
Lead	10.6	15	--	--	--	2.5 L	4.7 L	--	--
Magnesium	1770	--	--	2,660	2,770	491	31.4 L	5,000 L	193
Manganese	45.1	--	730	**120**	**123**	27.3	3.3	1	--
Nickel	16.2	100	730	55	54	23	17.6	17	--
Potassium	1770	--	--	4,720	3,650	6,020	69,300	271,000	50,800
Selenium	5	50	182.5	--	--	--	--	4	3.9 K
Silver	5	50	182.5	--	--	--	--	--	--
Sodium	4670	--	--	21,000	20,700	4,150	68,200	210,000	23,600
Vanadium	7	--	36.6	--	--	4.2	7.4	19.6	33
Zinc	66.1	--	10,950	78.7	71.7	31.8	14.6	9.9	12.8
VOCs (ug/L)									
1,1-Dichloroethane	1	--	896	--	--	--	--	--	--
1,2-Dichloropropane	1	5	0.16	--	--	--	--	--	--
2-Butanone	5	--	--	--	--	--	--	2 J	--
Acetone	10	--	5475	--	--	--	7.8	16	--
Benzene	1	5	0.34	--	--	--	--	--	--
Carbon tetrachloride	1	5	0.16	--	--	--	--	--	--
Chlorobenzene	1	100	106	--	--	--	--	--	--
Chloroethane	2	--	8600	--	--	--	--	--	--
Chloroform	1	80	0.15	--	--	--	--	--	--
cis-1,2-Dichloroethene	1	70	61	--	--	--	--	--	--
Ethylbenzene	1	700	1339	--	--	--	--	--	--
Methylene chloride	2	5	4.1	--	--	--	--	--	--
Tetrachloroethene	1	5	0.1	**1.6**	**2.2**	--	--	--	**0.35**
Toluene	1	1,000	747	--	--	0.32	0.7	0.3	--
Trichloroethene	1	5	0.026	--	--	--	--	--	--
Xylenes (total)	3	10,000	212	--	--	--	--	--	--
Pesticides (ug/L)									
Endosulfan II	0.05	--	220	--	--	0.0092 J	--		--
Heptachlor	0.05	0.4	0.015	--	--	--	--	0.0086 J	--
Endrin aldehyde	0.05	--	--	--	--	--	--	--	--
SVOCs (ug/L)									
bis(2-Ethylhexyl) phthalate	9.4	--	4.78	--	--	1.8	**7.8**	**6.9**	--
Phenol	9.7	--	10,950	10 J	5.9 J	--	--	--	--
PCBs (ug/L)									
Aroclor 1232 (ug/L)	1	0.5	0.033	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
RBC - Risk-Based Concentration HI=0.1. MCL - Maximum Contaminant Level
DL- Detection Limit DUP - Duplicate Sample
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Bolded results indicate that the analyte is present above the RBC screening level and maximum background level.
Shaded cells indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the (metals) analyte is present above the RBC screening level but below the maximum background level.

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Table 4-4
Previous Groundwater Detections at the CSL (Lower Patapsco - 2002)

Sample Location Field Sample ID Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW-113d MW113 160 180 Groundwater 9/20/2002	MW-114d MW114 185 205 Groundwater 9/23/2002	MW-115d MW115 160 180 Groundwater 9/23/2002	MW-117d MW117 127 147 Groundwater 9/20/2002	MW-118d MW118 105 125 Groundwater 9/19/2002	MW-119d MW119 168 188 Groundwater 9/19/2002
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MCL (ug/L)	Tap Water RBC (ug/L)						
Metals (ug/L)									
Aluminum	759	--	3,650	653	991	**24,200**	--	208	736
Arsenic	2	10	0.04	--	--	**9.9**	--	--	--
Barium	19.1	2000	255.5	**1,370**	61.3	230	123	46.5	640
Beryllium	0.1	4	7.3	--	--	7.2 K	--	--	--
Cadmium	5	5	1.83	--	0.49	--	--	--	--
Calcium	5890	--	--	592,000	8,970	15,400	79,600	4,930	479,000
Chromium	10.1	100	11	**23.3**	**13.6**	**143**	**98.4**	**15.3**	8 K
Cobalt	18.4	--	73	3.2	40	50	3.7	27.1	13.8
Copper	7.8	1300	146	37.3 L	--	76.6	--	18.6	6
Cyanide, Total	3	200	73	--	--	--	--	--	--
Iron	264	--	1,095	613	**1,150**	**35,800**	--	156 L	315
Lead	10.6	15	15	9.9	--	**30.2**	--	--	3.5 L
Magnesium	1770	--	--	--	2,790	5,900	1,070	1,940	1,870
Manganese	45.1	--	73	2.5	64.9	**369**	15.1	30.7	29
Nickel	16.2	100	73	29.2	67.8	**121**	6.7	40.5	18.5
Potassium	1770	--	--	403,000	2,750	10,400	42,700	1,820	60,100
Selenium	5	50	18.25	--	--	4.1 K	3.2 K	--	--
Silver	5	50	180	--	--	--	--	--	--
Sodium	4670	--	--	292,000	15,300	18,500	41,900	9,570	132,000
Vanadium	7	--	25.55	5.1	2.5	**116**	11.4	--	7
Zinc	66.1	--	1,095	30	118	196	7.6	84.7	20.5
VOCs (ug/L)									
1,1-Dichloroethane	1	--	80	--	--	--	--	--	--
1,2-Dichloroethene	1	5	--	--	--	--	--	--	--
2-Butanone	5	--	--	3.5 J	--	--	--	--	--
Acetone	10	--	61	25	--	--	3.8	--	--
Benzene	1	5	0.34	--	--	--	--	--	--
Carbon tetrachloride	1	5	0.16	--	**26**	**1.5**	--	--	--
Chlorobenzene	1	100	11	--		--	--	--	--
Chloroethane	2	--	3.6	--	--	--	--	--	--
Chloroform	1	80	0.15	--	**0.79**	**0.87**		**1.9**	**1**
cis-1,2-Dichloroethene	1	70	6.1	--	--	--	0.81	0.48	--
Ethylbenzene	1	700	130	--	--	--	--	--	--
Methylene chloride	2	5	4.1	--	--	--	--	--	--
Tetrachloroethene	1	5	0.1		**9.9**	0.22	**14**	--	--
Toluene	1	1,000	75	0.37	--	--	0.45	--	--
Trichloroethene	1	5	0.026	--	**2.8** J	**0.24** J	**0.54** J	--	**0.21**
Xylenes (total)	3	10,000	21	--	--	--		--	--
Pesticides (ug/L)									
Endosulfan II	0.05	--	220	--	--	--	--	--	--
Heptachlor	0.05	0.4	0.015	0.015	--	--	0.0082 J	--	--
Endrin aldehyde	0.05	--	100	--	--	--		--	--
SVOCs (ug/L)									
bis(2-Ethylhexyl) phthalate	9.4	--	4.8	**19**	**11**	4.4	1.6	**9.9**	**5**
Phenol	9.7	--	11,000	--	--	--	--	--	--
PCBs (ug/L)									
Aroclor 1232 (ug/L)	1	0.5	0.033	--	--	**0.27**	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
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DL- Detection Limit DUP - Duplicate Sample
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Bolded results indicate that the analyte is present above the RBC screening level and maximum background level.
Shaded cells indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the (metals) analyte is present above the RBC screening level but below the maximum background level.

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Table 4-4
Previous Groundwater Detections at the CSL (Lower Patapsco - 2002)

Sample Location	Screening Criteria			MW-120d	MW-121d		MW-122d
Field Sample ID				MW120	MW121	MW121DUP	MW122
Start Depth (ft bgs)				85	145	145	60
End Depth (ft bgs)				105	165	165	80
Media	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MCL (ug/L)	Tap Water RBC (ug/L)	Groundwater	Groundwater	Groundwater	Groundwater
Collection date				9/18/2002	9/19/2002	9/19/2002	9/18/2002
Metals (ug/L)							
Aluminum	759	--	36,500	217	552	727	**7,870**
Arsenic	2	10	0.045	--	--	--	**3.1**
Barium	19.1	2,000	2555	107	43.3	45	188
Beryllium	0.1	4	73	6.9 K	--	--	--
Cadmium	5	5	18.3	0.75	--	--	1.3
Calcium	5890	--	--	12,600	4,560	4,650	25,800
Chromium	10.1	100	110	6.4 K	**22.9**	**25.7**	**68**
Cobalt	18.4	--	730	58.2	14.3	14.8	54.7
Copper	7.8	1,300	1,460	25.1	10.4	10.1	40
Cyanide, Total	3	200	730	24	--	--	--
Iron	264	--	1,095	--	1,080	**1,480**	**5,450**
Lead	10.6	15	--	2.8 L	6.5	4.6 L	12
Magnesium	1770	--	--	3,720	1,140	1,160	5,600
Manganese	45.1	--	730	**118**	**138**	**142**	**206**
Nickel	16.2	100	730	**77.8**	31.6	32.6	**108**
Potassium	1770	--	--	5,210	3,710	3,840	6,180
Selenium	5	50	182.5	--	--	--	--
Silver	5	50	182.5	--	--	--	--
Sodium	4670	--	--	20,900	6,500	6,610	60,300
Vanadium	7	--	36.6	--	3.2	3	**30**
Zinc	66.1	--	10,950	172	124	114	287
VOCs (ug/L)							
1,1-Dichloroethane	1	--	896	--	--	--	--
1,2-Dichloroethene	1	5	0.12	--	--	--	--
2-Butanone	5	--	--	--	--	--	--
Acetone	10	--	5475	--	--	--	--
Benzene	1	5	0.34	--	--	--	--
Carbon tetrachloride	1	5	0.16	--	--	--	**4.7**
Chlorobenzene	1	100	106	--	--	--	--
Chloroethane	2	--	8600	--	--	--	--
Chloroform	1	80	0.15	**5**	**2.1**	**1.9**	--
cis-1,2-Dichloroethene	1	70	61	--	0.55	0.58	--
Ethylbenzene	1	700	1339	--	--	--	--
Methylene chloride	2	5	4.1	--	--	--	--
Tetrachloroethene	1	5	0.1	**1.5**	--	--	**2.2**
Toluene	1	1,000	747	--	--	--	--
Trichloroethene	1	5	0.026	--	**0.29**	**0.25**	--
Xylenes (total)	3	10,000	212	--	--	--	--
Pesticides (ug/L)							
Endosulfan II	0.05	--	220	0.012 J	0.052 J	--	--
Heptachlor	0.05	0.4	0.015	--	--	--	--
Endrin aldehyde	0.05	--	--	--	0.048 J	--	--
SVOCs (ug/L)							
bis(2-Ethylhexyl) phthalate	9.4	--	4.78	1.6 B	4 J	**17** J	--
Phenol	9.7	--	10,950	--	--	--	--
PCBs (ug/L)							
Aroclor 1232 (ug/L)	1	0.5	0.033	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.
RBC - Risk-Based Concentration HI=0.1. MCL - Maximum Contaminant Level
DL- Detection Limit DUP - Duplicate Sample
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Bolded results indicate that the analyte is present above the RBC screening level and maximum background level.
Shaded cells indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the (metals) analyte is present above the RBC screening level but below the maximum background level.

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TABLE 4-5
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (UPPER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW2S MW2S Well 24 29 Groundwater 6/18/2004	MW4S MW4S Well 7 12 Groundwater 6/16/2004	MW5 MW5 Well 8 28 Groundwater 6/16/2004	MW7S MW7S Well 11.5 25.5 Groundwater 6/30/2004	MW8 MW8 Well 8 23 Groundwater 6/16/2004	MW10S MW10S Well 8 18 Groundwater 6/16/2004
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)						
Metals (ug/L)									
Aluminum	1260	--	36,500	985	2170	363	--	455	--
Antimony	1.5	6	14.6	--	--	--	--	--	--
Arsenic	35.7	10	0.045	--	--	--	*9.5	--	--
Barium	27.4	2000	2555	57.1	69.1	19.5	115	44.8	57.4
Beryllium	0.529	4	73	--	--	--	--	--	--
Cadmium	0.111	5	18.25	--	--	--	--	--	
Calcium	1460	--	--	10800	3460	2010	31200	6650	13900
Chromium	67	100	110		4.8	25.6	1	6.5	1.6
Cobalt	0.5	--	730		6.9	8.6	37.3	32.9	32.5
Copper	10.4	1300	1,460	27.6	24.6	130	--	--	--
Iron	5840	--	10,950	°13200	2950	740	°69100	7960	°30300
Lead	14	15	--	3.3	--	*16.3	--	--	--
Magnesium	871	--	--	3530	1630	1370	15500	2630	3640
Manganese	21.3	--	730	93.8	54.4	247	°987	385	530
Mercury	0.022	2	--	--	--	--	--	--	--
Nickel	57.1	--	730	5.3	10.2	39.9	4.2	27.6	24.9
Potassium	1410	--	--	4110	992	811	6350	1450	3080
Selenium	2	50	182.5	--	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--
Sodium	2460	--	--	43400	2420 L	5210 L	92200	5030 L	5970 L
Thallium	1.5	2	2.56	--	--	--	--	--	--
Vanadium	17.2	--	36.5	5.2	--	--	2.1	--	--
Zinc	51.5	--	10,950	25.8	56.3	47.8	--	42.1	41.4
VOCs (ug/L)									
Acetone	5	--	5475	--	--	--	--	--	--
Benzene	0.5	5	0.34	°2	--	--	--	--	°0.88 J
Carbon Tetrachloride	0.5	5	0.16	--	--	--	--	--	--
Chlorobenzene	0.5	100	106	10.7	--	--	0.95 J	--	--
Chloroform	0.5	80	0.15	--	--	--	--	--	--
Chloroethane	1	--	3.64	1.9	--	--	--	--	--
1,2-Dichlorobenzene	0.5	--	268	--	--	--	--	--	--
1,4-Dichlorobenzene	0.5	--	0.47	°4.5	--	--	--	--	--
1,1-Dichloroethane	0.5	--	897	0.99 J	--	--	0.6 J	--	1.6
cis-1,2-Dichloroethene	0.5	70	60.8	0.55 J	--	--	--	--	0.84 J
Ethylbenzene	0.5	700	1340	0.48 J	--	--	--	--	--
trans-1,2-Dichloroethene	0.5	--	106	--	--	--	--	--	--
Methyl Tert Butyl Ether	0.5	--	2.6	--	--	--	--	--	--
Toluene	0.5	1000	747	0.72 J	--	0.43 J	--	2.3	--
Xylene (total)	1	10000	213	--	--	--	--	--	--
SVOCs (ug/L)									
2,4-Dimethylphenol	0.92	--	730	--	--	--	--	--	--
3&4-Methylphenol	0.62	--	182.5	--	--	--	--	4.9 J	--
bis(2-Ethylhexyl)phthalate	0.43	--	4.78	--	--	2 J	--	--	3.1
Diethyl phthalate	0.31	--	29200	--	--	--	--	--	1.8 J
Phenol	0.32	--	10950	--	--	--	--	--	--
PAH (ug/L)									
Naphthalene	0.25	--	6.511	--	--	--	--	--	--
Explosives									
Perchlorate	--	--	25.55	2.3	--	--	--	--	--
Hebicides (ug/L)									
2,4-D	0.5	--	365	--	--	--	--	--	--
2,4,5-TP (Silvex)	0.15	--	--	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL - Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.
Xs (X) indicate that the analyte is present above the MCL screening level but below the DL or maximum background level.

TABLE 4-5
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (UPPER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW12S MW12S Well 18 28 Groundwater 6/22/2004	MW13S MW13S Well 19 34 Groundwater 6/17/2004	MW14 MW14 Well 20 30 Groundwater 6/21/2004	MW17 MW17 Well 20 35 Groundwater 6/17/2004	MW18 MW18 Well 20 35 Groundwater 6/18/2004	MW19 MW19 Well 22.5 37.5 Groundwater 6/21/2004
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)						
Metals (ug/L)									
Aluminum	1260	--	36,500	--	--	--	644	--	--
Antimony	1.5	6	14.6	--	--	--	--	--	--
Arsenic	35.7	10	0.045	+°51.2	*6.1	‹*31.5	*7.1	*6.6	+°39.8
Barium	27.4	2000	2555	122	167	106	66	22.1	557
Beryllium	0.529	4	73	--	--	--	--	--	--
Cadmium	0.111	5	18.25	3.9 B	+5.1	2.8	‹6.3	‹5.6	
Calcium	1460	--	--	52200	79100	70500	18900	12000	124000
Chromium	67	100	110	3.8 B	6.3	7	--	--	9.3
Cobalt	0.5	--	730	--	5.2	1.9	1.8	--	4.1
Copper	10.4	1300	1,460	--	--	--	19.4	--	8.1
Iron	5840	--	10,950	°98000	°141000	°79800	°173000	°164000	°75200
Lead	14	15	--	--	--	--	3.9	--	--
Magnesium	871	--	--	12700	24000	35900	1860	2450	66900
Manganese	21.3	--	730	366	°3330	173	°1500	369	231
Mercury	0.022	2	--	--	--	--	--	--	--
Nickel	57.1	--	730	--	3.3	4.3	2.8	--	25.8
Potassium	1410	--	--	9050	4490	20600	1810	1640	71500
Selenium	2	50	182.5	--	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--
Sodium	2460	--	--	7100	15500	64200	--	3590	311000
Thallium	1.5	2	2.56	--	--	--	+°8.8	--	--
Vanadium	17.2	--	36.5	9.2	13	10.8	13.5	14.4	17.9
Zinc	51.5	--	10,950	12.1 B	6.5 B	10.5	--	17.2	7.9
VOCs (ug/L)									
Acetone	5	--	5475	--	--	--	--	4.7 J	21.4
Benzene	0.5	5	0.34	°2.4 B	°0.79 B	°2.4	--	°0.77 J	+°10.4
Carbon Tetrachloride	0.5	5	0.16	--	--	--	--	--	--
Chlorobenzene	0.5	100	106	3.3	2.4	16.1	0.74 J	--	2.4
Chloroform	0.5	80	0.15	--	--	--	--	--	--
Chloroethane	1	--	3.64	1.9	2.7	2.1	--	3.6	--
1,2-Dichlorobenzene	0.5	--	268	--	--	--	--	--	1.3 J
1,4-Dichlorobenzene	0.5	--	0.47	°6.1	°1.2 J	°4.5	--	°2.6	°5
1,1-Dichloroethane	0.5	--	897	--	--	--	--	--	1.4
cis-1,2-Dichloroethene	0.5	70	60.8	0.6 J	0.59 J	--	--	--	0.85 J
Ethylbenzene	0.5	700	1340	--	--	0.72 J	--	--	6.9
trans-1,2-Dichloroethene	0.5	--	106	0.63 J	--	--	--	--	--
Methyl Tert Butyl Ether	0.5	--	2.6	1 B	°3.2	0.67 J	--	--	2.2
Toluene	0.5	1000	747	0.25 B	--	0.71 J	--	0.35 J	1.1
Xylene (total)	1	10000	213	--	--	2	--	--	2.6
SVOCs (ug/L)									
2,4-Dimethylphenol	0.92	--	730	--	--	--	--	--	4.2 J
3&4-Methylphenol	0.62	--	182.5	2.7 J	6.9	--	--	25.6	--
bis(2-Ethylhexyl)phthalate	0.43	--	4.78	--	°102	°11.8	--	--	--
Diethyl phthalate	0.31	--	29200	--	--	2 J	--	--	20.2
Phenol	0.32	--	10950	--	--	--	--	--	--
PAH (ug/L)									
Naphthalene	0.25	--	6.511	0.35	--	4	--	--	5.9
Explosives (ug/L)									
Perchlorate	--	--	25.55	--	--	--	--	1.3	--
Hebicides (ug/L)									
2,4-D	0.5	--	365	--	--	0.72	--	--	--
2,4,5-TP (Silvex)	0.15	--	--	--	--	--	--	--	0.6

NOTES:
Only detected analytes are included on this table.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL- Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.
Xs (*) indicate that the analyte is present above the MCL screening level but below the DL or maximum background level.

TABLE 4-5
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (UPPER PATAPSCO 2004)

Sample Location	Screening Criteria			MW20	MW105	MW106	MW107	MW123	MW124
Field Sample ID				MW20	MW105	MW106	MW107	MW123S	MW124S
Site Type				Well	Well	Well	Well	Well	Well
Start Depth (ft bgs)				21	49	21.5	31.5	35	45
End Depth (ft bgs)	Maximum	Maximum	Tap	31	59	31.5	41.5	45	55
Media	Background	Contaminant Level	Water	Groundwater	roundwater	Groundwater	Groundwater	Groundwater	Groundwater
Collection date	or DL (ug/L)	or MWQS (ug/L)	RBC (ug/L)	6/21/2004	6/9/2004	6/3/2004	6/4/2004	6/10/2004	6/10/2004
Metals (ug/L)									
Aluminum	1260	--	36,500	236	95.1	1920	--	2430	7910
Antimony	1.5	6	14.6	--	--	--	--	--	--
Arsenic	35.7	10	0.045	--	--	--	--	--	--
Barium	27.4	2000	2555	93.6	80	148	22.8	77.7	121
Beryllium	0.529	4	73	--	--	--	--	--	--
Cadmium	0.111	5	18.25	--	--	--	--	--	--
Calcium	1460	--	--	4500	6580	6520	7830	9130	12700
Chromium	67	100	110	--	14.1	1.3	3.7	27.3	19.8
Cobalt	0.5	--	730	8.3	7	66.2	--	31.5	6.6
Copper	10.4	1300	1,460	11.6	33.5	37.5	--	20.2	9.5
Iron	5840	--	10,950	183	--	--	--	268	687
Lead	14	15	--	--	2.9	2.7	--	--	3.9
Magnesium	871	--	--	3040	5800	7390	1260	2300	4740
Manganese	21.3	--	730	171	30.8	141	--	26.1	47.5
Mercury	0.022	2	--	--	--	--	--	--	--
Nickel	57.1	--	730	8.6	18.4	69.7	3.6	55.3	13.7
Potassium	1410	--	--	1460	2370	1550	1720	2180	6050
Selenium	2	50	182.5	--	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--
Sodium	2460	--	--	2630	60400 L	34500 K	--	11300	27500
Thallium	1.5	2	2.56	--	--	--	--	--	--
Vanadium	17.2	--	36.5	--	--	--	--	--	8.4
Zinc	51.5	--	10,950	60.3	33.7	99.7	14	53.9	--
VOCs (ug/L)									
Acetone	5	--	5475	--	--	--	--	--	--
Benzene	0.5	5	0.34	--	--	--	--	--	--
Carbon Tetrachloride	0.5	5	0.16	--	--	--	--	--	--
Chlorobenzene	0.5	100	106	--	--	--	--	--	--
Chloroform	0.5	80	0.15	--	--	°1.4	°4	--	--
Chloroethane	1	--	3.64	--	--	--	--	--	--
1,2-Dichlorobenzene	0.5	--	268	--	--	--	--	--	--
1,4-Dichlorobenzene	0.5	--	0.47	--	--	--	--	--	--
1,1-Dichloroethane	0.5	--	897	--	--	--	--	--	--
cis-1,2-Dichloroethene	0.5	70	60.8	--	--	--	--	--	--
Ethylbenzene	0.5	700	1340	--	--	--	--	--	--
trans-1,2-Dichloroethene	0.5		106	--	--	--	--	--	--
Methyl Tert Butyl Ether	0.5	--	2.6	--	°7.6	°49.3	--	--	--
Toluene	0.5	1000	747	--	0.26 J	--	--	--	--
Xylene (total)	1	10000	213	--	--	--	--	--	--
SVOCs (ug/L)									
2,4-Dimethylphenol	0.92	--	730	--	--	--	--	--	--
3&4-Methylphenol	0.62	--	182.5	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	0.43	--	4.78	1.3 J	--	--	--	10.8 J	--
Diethyl phthalate	0.31	--	29200	--	--	--	--	--	--
Phenol	0.32	--	10950	--	--	--	--	--	--
PAH (ug/L)									
Naphthalene	0.25	--	6.511	--	--	--	--	--	--
Explosives									
Perchlorate	--	--	25.55	--	0.61 L	--	--	--	--
Hebicides (ug/L)									
2,4-D	0.5	--	365	--	--	--	--	--	--
2,4,5-TP (Silvex)	0.15	--	--	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL- Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.
Xs (X) indicate that the analyte is present above the MCL screening level but below the DL or maximum background level.

TABLE 4-5
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (UPPER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW127 MW127S Well 55 65 Groundwater 6/29/2004	MW128 MW128S Well 33 43 Groundwater 6/23/2004
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)		
Metals (ug/L)					
Aluminum	1260	--	36,500	14000	3800
Antimony	1.5	6	14.6	--	--
Arsenic	35.7	10	0.045	*6.1	--
Barium	27.4	2000	2555	38.3	817
Beryllium	0.529	4	73	+40.2	--
Cadmium	0.111	5	18.25	--	--
Calcium	1460	--	--	26000	253000
Chromium	67	100	110	10.4	--
Cobalt	0.5	--	730	106	3.3
Copper	10.4	1300	1,460	65.8	23.4
Iron	5840	--	10,950	°31000	--
Lead	14	15	--	14.4	3.7
Magnesium	871	--	--	9000	12.6
Manganese	21.3	--	730	310	--
Mercury	0.022	2	--	--	--
Nickel	57.1	--	730	206	16.9
Potassium	1410	--	--	6120	94300
Selenium	2	50	182.5	--	--
Silver	0.55	--	182.5	--	--
Sodium	2460	--	--	22900	111000
Thallium	1.5	2	2.56	--	--
Vanadium	17.2	--	36.5	29.2	°95
Zinc	51.5	--	10,950	541	12.1
VOCs (ug/L)					
Acetone	5	--	5475	--	32.8
Benzene	0.5	5	0.34	--	--
Carbon Tetrachloride	0.5	5	0.16	--	--
Chlorobenzene	0.5	100	106	--	--
Chloroform	0.5	80	0.15	--	--
Chloroethane	1	--	3.64	--	--
1,2-Dichlorobenzene	0.5	--	268	--	--
1,4-Dichlorobenzene	0.5	--	0.47	--	--
1,1-Dichloroethane	0.5	--	897	--	--
cis-1,2-Dichloroethene	0.5	70	60.8	--	--
Ethylbenzene	0.5	700	1340	--	--
trans-1,2-Dichloroethene	0.5		106	--	--
Methyl Tert Butyl Ether	0.5	--	2.6	--	1.6
Toluene	0.5	1000	747	--	1.2
Xylene (total)	1	10000	213	--	--
SVOCs (ug/L)					
2,4-Dimethylphenol	0.92	--	730	--	--
3&4-Methylphenol	0.62	--	182.5	--	--
bis(2-Ethylhexyl)phthalate	0.43	--	4.78	--	--
Diethyl phthalate	0.31	--	29200	--	--
Phenol	0.32	--	10950	27.3	1790
PAH (ug/L)					
Naphthalene	0.25	--	6.511	--	--
Explosives					
Perchlorate	--	--	25.55	1.2 L	--
Hebicides (ug/L)					
2,4-D	0.5	--	365	--	--
2,4,5-TP (Silvex)	0.15	--	--	--	--

NOTES:
Only detected analytes are included on this table.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL- Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.
Xs (X) indicate that the analyte is present above the MCL screening level but below the DL or maximum background level.

TABLE 4-6
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (LOWER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW113 MW113D Well 160 180 Groundwater 6/15/2004	MW114 MW114D Well 185 205 Groundwater 6/23/2004	MW114 MW114DX Well 185 205 Groundwater 6/23/2004	MW115 MW115D Well 160 180 Groundwater 6/23/2004	MW116 MW116D Well 166 186 Groundwater 6/4/2004	MW116 MW116DX Well 166 186 Groundwater 6/4/2004
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)						
Metals (ug/L)									
Aluminum	487	--	36,500	210	227	181	4680	318	379
Antimony	1.5	6	14.6	+11.3	--	--	--	--	--
Arsenic	2	10	0.045	--	--	--	--	--	--
Barium	100	2000	2555	1760	76.4	74.3	298	33.3	31.6
Beryllium	0.1	4	73	--	--	--	+27	--	--
Cadmium	0.26	5	18.25	--	--	--	4.4	--	--
Calcium	15900	--	--	801000	6920	6570	42200	9540	10100
Chromium	9.6	100	110	49.9	--	--	34.8	17.3	15.6
Cobalt	22	--	730	--	52.7	49.7	130	12.5	13.2
Copper	17.9	1300	1,460	67.2	23	21.6	231	6	7.9
Iron	283	--	10,950	--	474	397	°33100	256	274
Lead	10.6	15	--	12.9	3.2	--	+44.3	--	--
Magnesium	4260	--	--	--	3000	2840	6780	946	999
Manganese	121	--	730	--	48.5	45.7	°1350	45	47.8
Mercury	0.022	2	--	--	--		0.36	--	--
Nickel	36.5	--	730	9.8	68.3	65.2	202	31.1	30.3
Potassium	2360	--	--	119000	2340	2220	4210	2120	2160
Selenium	2	50	182.5	5.1	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--
Sodium	51400	--	--	113000 L	17500	16500	9000	4060 K	3990 K
Thallium	1.5	2	2.56	--	--	--	--	--	--
Vanadium	7	--	36.5	--	2.6	2.2	°100	--	--
Zinc	83.4	--	10,950	61.9	70.8	66.5	580	42.3	47.4
VOCs (ug/L)									
1,1-Dichloroethane	0.5	--	897	--	--	--	--	--	--
2-Butanone	2.5	--	6968	--	--	--	--	--	--
Acetone	5	--	5475	26.3	--	--	--	--	--
Benzene	0.5	5	0.34	--	--	--	--	--	--
Carbon Disulfide	1	--	1043	--	--	--	--	--	--
Carbon tetrachloride	3.7	5	0.16	--	+°61.5	+°61.3	°1.8	--	--
Chlorobenzene	0.5	100	106.1	--	--	--	--	--	--
Chloroethane	1	--	3.64	--	--	--	--	--	--
Chloroform	0.81	80	0.15	--	°1.5	°1.5	°1.9	--	--
cis-1,2-Dichloroethene	0.5	70	60.8	--	--	--	0.79 J	--	--
Ethylbenzene	0.5	700	1340	--	--	--	--	--	--
Methylene chloride	1	5	4.1	--	--	--	--	--	--
Methyl Tert Butyl Ether	0.85	--	2.6	0.43 J	--	--	--	--	--
Tetrachloroethene	2.6	5	0.1	--	+°9.5	+°9.3	--	*0.74 J	*0.77 J
Toluene	0.5	1,000	747	0.61 J	0.3 J	0.29 J	--	--	0.44 J
Trichloroethene	0.5	5	0.026	--	°3	°2.9	--	--	--
Xylenes (total)	1	10,000	213	--	--	--	--	--	--
SVOCs (ug/L)									
bis(2-Ethylhexyl)phthalate	3.2	--	4.78	2.9	--	--	3	--	--
Diethyl phthalate	0.31	--	29200	--	--	--	--	--	--
Phenol	0.32	--	10950	477	--	--	--	--	--
PAH (ug/L)									
Naphthalene	0.25	--	6.511	--	--	--	--	--	--
Explosives (ug/L)									
Perchlorate	--	--	25.55	--	--	--	--	0.4	--
RDX	0.75	--	0.6	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL - Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
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Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-6
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (LOWER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW117 MW117D Well 127 147 Groundwater 6/23/2004	MW118 MW118D Well 105 125 Groundwater 6/14/2004	MW119 MW119D Well 168 188 Groundwater 6/15/2004	MW119 MW119DX Well 168 188 Groundwater 6/15/2004	MW120 MW120D Well 85 105 Groundwater 6/14/2004	MW121 MW121D Well 145 165 Groundwater 6/14/2004
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)						
Metals (ug/L)									
Aluminum	487	--	36,500	95.4	--	1330	1330	537	93.4
Antimony	1.5	6	14.6	--	--	--	5.2	--	--
Arsenic	2	10	0.045	--	--	--	--	--	--
Barium	100	2000	2555	79.5	43.6	130	128	90.3	63.7
Beryllium	0.1	4	73	--	--	--	--	3.7	--
Cadmium	0.26	5	18.25	--	--	--	--	--	--
Calcium	15900	--	--	29900	4350	370000	359000	5030	5160
Chromium	9.6	100	110	11.7	7	9.1	8.9	20.3	12.3
Cobalt	22	--	730	28	9.3	3.2	3.5	31.5	19.3
Copper	17.9	1300	1,460	2.8	--	--	--	36.6	14.6
Iron	283	--	10,950	--	--	320	326	456	344
Lead	10.6	15	--	--	--	--	--	3.6	--
Magnesium	4260	--	--	4620	2100	1290	1330	3790	1850
Manganese	121	--	730	112	21.9	9.8	10.3	78	112
Mercury	0.022	2	--	--	--	--	--	--	--
Nickel	36.5	--	730	21.7	19.7	8.6	8.2	71.4	43.5
Potassium	2360	--	--	2860	1730	9450	9370	2090	12200
Selenium	2	50	182.5	--	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--
Sodium	51400	--	--	20400	8540 L	34800 L	34000 L	19900 L	11700 L
Thallium	1.5	2	2.55	--	--	--	--	--	--
Vanadium	7	--	36.5	2.5	--	7.1	7.6	--	--
Zinc	83.4	--	10,950	40.3	26.7	80.1	83.6	85	91.3
VOCs (ug/L)									
1,1-Dichloroethane	0.5	--	1339	--	--	--	--	--	--
2-Butanone	2.5	--	6968	--	--	--	--	--	--
Acetone	5	--	5475	--	--	6.5 J	6.6 J	--	--
Benzene	0.5	5	0.34	--	--	--	--	--	--
Carbon Disulfide	1	--	1042	--	--	--	--	--	--
Carbon tetrachloride	3.7	5	0.16	--	--	--	--	--	--
Chlorobenzene	0.5	100	106.1	--	--	--	--	--	--
Chloroethane	1	--	3.63	--	--	--	--	--	--
Chloroform	0.81	80	0.15	--	°5.8	°1.6	°1.5	°7.8	°3.1
cis-1,2-Dichloroethene	0.5	70	60.8	1.4	1.2	--	--	--	0.52 J
Ethylbenzene	0.5	700	1339	--	--	--	--	--	--
Methylene chloride	1	5	4.1	--	--	--	--	--	--
Methyl Tert Butyl Ether	0.85	--	2.6	--	--	--	--	--	--
Tetrachloroethene	2.6	5	0.1	+°19.2	--	--	--	°1.7	--
Toluene	0.5	1,000	747	--	0.51 J	0.35 J	0.34 J	0.28 J	0.47 J
Trichloroethene	0.5	5	0.026	°0.64 J	--	--	--	--	--
Xylenes (total)	1	10,000	212.0	--	--	--	--	--	--
SVOCs (ug/L)									
bis(2-Ethylhexyl)phthalate	3.2	--	4.78	--	0.92 J	1.1 J	0.88 J	2.2	3.6
Diethyl phthalate	0.31	--	29200	--	--	--	--	--	--
Phenol	0.32	--	10950	--	--	6.2	7.4	--	--
PAH (ug/L)									
Naphthalene	0.25	--	6.511	--	--	--	--	--	0.23
Explosives (ug/L)									
Perchlorate	--	--	25.55	4.2	--	--	--	--	--
RDX	0.75	--	0.6	--	0.13 J	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL- Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-6
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (LOWER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW122 MW122D Well 60 80 Groundwater 6/14/2004	MW125 MW125D Well 204.5 224.5 Groundwater 6/11/2004	MW126 MW126D Well 220 240 Groundwater 6/11/2004	MW125 MW125D-0305 Well 204.5 224.5 Groundwater 3/4/2005	MW126 MW126D-0305 Well 220 240 Groundwater 3/4/2005
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)					
Metals (ug/L)								
Aluminum	487	--	36,500	487	10600	3860	--	--
Antimony	1.5	6	14.6	--	--	--	--	--
Arsenic	2	10	0.045	--	--	--	--	--
Barium	100	2000	2555	100	115	81.6	--	--
Beryllium	0.1	4	73	--	--	1.1	--	--
Cadmium	0.26	5	18.25	--	--	--	--	--
Calcium	15900	--	--	15900	62500	19100	--	--
Chromium	9.6	100	110	9.6	40.5	67.7	--	--
Cobalt	22	--	730	22	29.9	5.3	--	--
Copper	17.9	1300	1,460	17.9	80.6	66.9	--	--
Iron	283	--	10,950	283	°27000	°11000	--	--
Lead	10.6	15	--	--	+16.3	14.4	--	--
Magnesium	4260	--	--	4260	3670	1890	--	--
Manganese	121	--	730	121	165	74.8	--	--
Mercury	0.022	2	--	--	--	--	--	--
Nickel	36.5	--	730	36.5	50.9	47.3	--	--
Potassium	2360	--	--	2360	4990	21900	--	--
Selenium	2	50	182.5	--	8.6	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--
Sodium	51400	--	--	51400 L	10300 L	14800 L	--	--
Thallium	1.5	2	2.55	--	+°6.9	--	--	--
Vanadium	7	--	36.5	--	°60.3	30.6	--	--
Zinc	83.4	--	10,950	83.4	119	59.7	--	--
VOCs (ug/L)								
1,1-Dichloroethane	0.5	--	1339	--	--	--	--	--
2-Butanone	2.5	--	6968	--	--	--	2	--
Acetone	5	--	5475	--	49.2	--	120	--
Benzene	0.5	5	0.34	--	--	--	--	--
Carbon Disulfide	1	--	1042	--	--	--	--	--
Carbon tetrachloride	3.7	5	0.16	°3.7	+°21.3	°4.1	+°20	°3
Chlorobenzene	0.5	100	106.1	--	--	--	--	--
Chloroethane	1	--	3.63	--	--	--	--	--
Chloroform	0.81	80	0.15	°0.81 J	°0.85 J	°0.43 J	°0.8	°0.29
cis-1,2-Dichloroethene	0.5	70	60.8	--	--	0.42 J	--	2.3
Ethylbenzene	0.5	700	1339	--	--	--	--	--
Methylene chloride	1	5	4.1	--	--	--	--	--
Methyl Tert Butyl Ether	0.85	--	2.6	0.85 J	--	--	--	--
Tetrachloroethene	2.6	5	0.1	°2.6	°2.8	+°12.4	°1.2	+°6.5
Toluene	0.5	1,000	747	--	0.36 J	0.5 J	1.8	--
Trichloroethene	0.5	5	0.026	--	°0.54 J	°3.5	°0.28	°2.4
Xylenes (total)	1	10,000	212.0	--	--	--	--	--
SVOCs (ug/L)								
bis(2-Ethylhexyl)phthalate	3.2	--	4.78	3.2	1.4 J	2.4	--	--
Diethyl phthalate	0.31	--	29200	--	--	--	--	--
Phenol	0.32	--	10950	--	--	--	--	--
PAH (ug/L)								
Naphthalene	0.25	--	6.511	--	--	--	--	--
Explosives (ug/L)								
Perchlorate	--	--	25.55	--	--	--	--	--
RDX	0.75	--	0.6	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL- Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-6
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (LOWER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW101D MW101D Well 133 143 Groundwater 6/21/2004	MW108D MW108D Well 155 165 Groundwater 6/9/2004	MW109 MW109D Well 133.5 153.5 Groundwater 6/10/2004	MW110 MW110D Well 140 160 Groundwater 6/10/2004	MW111 MW111D Well 175 195 Groundwater 6/3/2004	MW112 MW112D Well 175 195 Groundwater 6/4/2004
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)						
Metals (ug/L)									
Aluminum	487	--	36,500	104	330	281	994	4690	709
Antimony	1.5	6	14.6	--	--	--	--	--	--
Arsenic	2	10	0.045	--	--	--	--	--	--
Barium	100	2000	2555	64.7	28.4	71.9	25.3	107	1380
Beryllium	0.1	4	73	--	--	--	--	--	--
Cadmium	0.26	5	18.25	--	--	--	--	--	--
Calcium	15900	--	--	10100	3690	11500	2810	173000	675000
Chromium	9.6	100	110	--	8.8	4.6	15.2	73.3	55.9
Cobalt	22	--	730	17	27.6	34.4	8.4	9.7	3.3
Copper	17.9	1300	1,460	9.1	25.3	11.2	25.1	58.4	14.6
Iron	283	--	10,950	--	110	--	642	11800	--
Lead	10.6	15	--	--	--	--	--	9.1	6.3
Magnesium	4260	--	--	1830	1350	3480	517	1560	--
Manganese	121	--	730	150	89.2	186	19	51.8	2.4
Mercury	0.022	2	--	--	--	--	--	--	--
Nickel	36.5	--	730	28.5	54.7	60.4	19.9	22.2	9.4
Potassium	2360	--	--	2360	1430	1800	11700	5480	33500
Selenium	2	50	182.5	--	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--
Sodium	51400	--	--	16200	11200 L	18800 L	7500	5340 K	33900 K
Thallium	1.5	2	2.55	--	--	--	--	--	--
Vanadium	7	--	36.5	--	--	--	2.9	°49.2	8.7
Zinc	83.4	--	10,950	90.6	92.6	70	35.7	60.5	--
VOCs (ug/L)									
1,1-Dichloroethane	0.5	--	1339	--	--	--	--	--	--
2-Butanone	2.5	--	6968	--	--	--	--	--	--
Acetone	5	--	5475	--	--	--	--	--	--
Benzene	0.5	5	0.34	--	--	--	--	--	--
Carbon Disulfide	1	--	1042						
Carbon Tetrachloride	3.7	5	0.16	--	--	--	--	--	--
Chlorobenzene	0.5	100	106.1	--	--	--	--	--	20.4
Chloroethane	1	--	3.63	--	--			--	0.57 J
Chloroform	0.81	80	0.15	--	--	--	--	--	--
cis-1,2-Dichloroethene	0.5	70	60.8	--	--	--	--	--	--
Ethylbenzene	0.5	700	1339	--	--	--	--	--	--
Methylene Chloride	1	5	4.1						
Methyl Tert Butyl Ether	0.85	--	2.6	--	--	--	--	--	0.36 J
Tetrachloroethene	2.6	5	0.1						
Toluene	0.5	1,000	747	0.36 J	--	--	--	--	0.76 J
Trichloroethene	0.5	5	0.026						
Xylene (total)	1	10,000	212.0	--	--	--	--	--	--
SVOCs (ug/L)									
bis(2-Ethylhexyl)phthalate	3.2	--	4.78	0.77 J	--	--	--	°8.8	0.93 J
Diethyl phthalate	0.31	--	29200	--	--	--	--	--	--
Phenol	0.32	--	10950	--	--	--	--	2.9 J	133 J
PAH (ug/L)									
Naphthalene	0.25	--	6.511	--	--	--	--	--	--
Explosives									
Perchlorate	--	--	25.55	--	--	--	--	--	1.4
RDX	0.75	--	0.6	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL - Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-6
SUMMARY OF DETECTIONS IN GROUNDWATER AT THE CSL (LOWER PATAPSCO 2004)

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			MW2D MW2D Well 76.5 86.5 Groundwater 6/18/2004	MW4DR MW4DR Well 117 127 Groundwater 6/29/2004	MW7D MW7D Well 98 108 Groundwater 6/30/2004	MW12D MW12D Well 121 131 Groundwater 6/22/2004	MW13D MW13D Well 100 120 Groundwater 6/17/2004	MW13D MW13DX Well 100 120 Groundwater 6/17/2004
	Maximum Background or DL (ug/L)	Maximum Contaminant Level or MWQS (ug/L)	Tap Water RBC (ug/L)						
Metals (ug/L)									
Aluminum	487	--	36,500	--	206	529	--	--	--
Antimony	1.5	--	14.6	--	--	--	--	--	--
Arsenic	2	10	0.045	--	--	--	--	--	--
Barium	100	2000	2555	7.7	64.6	147	58.4	47.9	44.7
Beryllium	0.1	4	73	--	--	3.6	--	--	--
Cadmium	0.26	5	18.25	--	--	--	--	--	--
Calcium	15900	--	--	982	3880	34600	33000	10300	10300
Chromium	9.6	100	110	--	3.4	1.5	--	--	--
Cobalt	22	--	730	3.1	37.4	41.4	6	16	16.5
Copper	17.9	1300	1,460	15	20.8	11.4	3.8	9.5	8.7
Iron	283	--	10,950	--	277	--	423	3010	3020
Lead	10.6	15	--	--	--	--	--	--	--
Magnesium	4260	--	--	218	2210	2980	942	2240	2230
Manganese	121	--	730	--	66.8	143	104	22.6	22.3
Mercury	0.022	--	--	--	--	--	--	--	--
Nickel	36.5	--	730	5.1	32.7	72.7	10.4	19	19.8
Potassium	2360	--	--	743	1900	2650	1400	1730	1710
Selenium	2	50	182.5	--	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--
Sodium	51400	--	--	--	13900	26400	1990	12300	13500
Thallium	1.5	2	2.55	--	--	--	--	--	--
Vanadium	7	--	36.5	--	--	--	--	--	--
Zinc	83.4	--	10,950	26.5	53.4	--	--	58.7	59.4
VOCs (ug/L)									
1,1-Dichloroethane	0.5	--	1339	--	--	--	--	--	0.49 J
2-Butanone	2.5	--	6968	--	--	--	--	--	--
Acetone	5	--	5475	--	--	--	--	--	--
Benzene	0.5	5	0.34	--	--	--	--	--	--
Carbon Disulfide	1	--	1042					--	--
Carbon Tetrachloride	3.7	5	0.16	--	°11.6	--	--	--	--
Chlorobenzene	0.5	100	106.1	--	--	--	--	0.64 J	0.63 J
Chloroethane	1	--	3.63	--	--	--	--	--	--
Chloroform	0.81	80	0.15	--	°1.9	--	--	--	--
cis-1,2-Dichloroethene	0.5	70	60.8	--	--	--	--	0.8 J	0.77 J
Ethylbenzene	0.5	700	1339	--	--	--	--	--	--
Methylene Chloride	1	5	4.1	--	--	--	--	--	--
Methyl Tert Butyl Ether	0.85	--	2.6	--	--	--	--	--	--
Tetrachloroethene	2.6	5	0.1	--	--	--	--	--	--
Toluene	0.5	1,000	747	--	--	--	--	--	--
Trichloroethene	0.5	5	0.026	--	--	--	--	--	--
Xylene (total)	1	10,000	212.0	--	--	--	--	--	--
SVOCs (ug/L)									
bis(2-Ethylhexyl)phthalate	3.2	--	4.78	--	--	--	--	--	--
Diethyl phthalate	0.31	--	29200	--	--	--	--	7.3	7.8
Phenol	0.32	--	10950	--	--	--	--	--	--
PAH (ug/L)									
Naphthalene	0.25	--	6.511	--	--	--	--	--	--
Explosives									
Perchlorate	--	--	25.55	0.69	0.62 L	--	1.5	--	--
	0.75		0.6	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL - Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-7
SUMMARY OF DETECTIONS IN SURFACE WATER AT THE CSL

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria			SW1 SW1 Surface Water -- -- Water 11/5/2003	SW2 SW2 Surface Water -- -- Water 11/5/2004	SW3 SW3 Surface Water -- -- Water 11/6/2004	SW4 SW4 Surface Water -- -- Water 11/6/2004	SW4 SW4X Surface Water -- -- Water 11/6/2004	SW5 SW5 Surface Water -- -- Water 5/5/2005	SW6 SW6 Surface Water -- -- Water 5/6/2005
	Maximum Background or DL (ug/L)	Maximum Contaminant Level MCL (ug/L)	Tap Water RBC (ug/L)							
Metals (ug/L)										
Aluminum	197	--	36,500	1060	571	275	497	456	170	110
Antimony	1.5	6	14.6	5.9	--	--	--	--	--	--
Arsenic	2.8	10	0.045	--	--	--	--	--	--	--
Barium	48.1	2000	2555	42	34.4	--	--	--	36.7	34.8
Beryllium	0.26	4	73	--	--	--	--	--	--	--
Cadmium	0.26	0.25	18.25	--	--	--	--	--	--	--
Calcium	27400	--	--	42700	36500	30000	37500	37100	30500	29300
Chromium	0.43	11	110	3.2	1.5	0.94	1.4	1.2	--	--
Cobalt	0.5	--	730	1.7	--	--	--	--	--	--
Copper	0.44	9	1,460	--	--	--	--	--	1.7	2.6
Cyanide	--	5.2	73	--	--	--	--	--	--	0.0055
Iron	378	--	10,950	3500	980	1530	2010	1910	2280	2260
Lead	1.2	15	--	6.3	--	--	--	--	--	2.8
Magnesium	6210	--	--	3550	6430	5590	6850	6760	5060	4880
Manganese	68.1	--	730	312	53.6	69.6	126	139	81.7	91.9
Mercury	0.022	0.77	--	--	--	--	--	--	--	--
Nickel	1.1	52	730	4.3	--	--	--	--	--	--
Potassium	3180	--	--	5700	--	4950	5610	5620	2890	2300
Selenium	2	5	182.5	--	--	--	--	--	--	--
Silver	0.55	--	182.5	--	--	--	--	--	--	--
Sodium	21000	--	--	6730	5100	45200	9480	9380	58400	53000
Thallium	1.5	2	2.55	--	--	--	--	--	--	--
Vanadium	0.47	--	36.5	6.7	--	1.6	2.1	1.8	--	--
Zinc	17.5	120	10,950	61.2	16.9	--	--	--	26.4	12.2
VOC										
Acetone	5	--	5,475.0	8.1 J	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
MCL - Maximum Contaminant Level
DL - Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-8
SUMMARY OF DETECTIONS IN SEDIMENT AT THE CSL

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria Maximum Background or DL (mg/kg)	Screening Criteria Effects Range Low (ER-L) (mg/kg)	SED1 SED1 CREK 0 0.5 CSE 11/5/2003	SED2 SED2 CREK 0 0.5 CSE 11/5/2003	SED3 SED3 CREK 0 0.5 CSE 11/6/2003	SED4 SED4 CREK 0 0.5 CSE 11/6/2003	SED5 SED5 CREK 0 0.5 CSE 5/5/2005	SED6 SED6 CREK 0 0.5 CSE 5/6/2005
Metals (mg/kg)								
Aluminum	6600	--	5930	7200	6480	6080	2750	1350
Antimony	150	--	--	--	--	--	--	--
Arsenic	4	8.2	5	2.4	3.5	2.6	1.5	1.1
Barium	50	--	29.5	54.8	31.9	31	19.8	7.8
Beryllium	0.354	--	--	--	--	0.47	0.19	0.12
Cadmium	30	1	--	--	--	--	--	--
Calcium	1200	--	1100	1710	902	1190	1230	360
Chromium	22	81	15.6	10.1	14.3	12	4.7	3.8
Cobalt	5	--	2.1	1.5	4.7	4	2.1	1.5
Copper	15	34	13	9.4	20.5	13.4	8.2	9.6
Cyanide	--	--	0.13 L	0.18 L		--	--	0.063
Iron	10600	--	11700 L	6430 L	12500 L	7550 L	3580	3380
Lead	120	47	10.8	17	46	14.8	27.6	38.1
Magnesium	1380	--	892	552	872	539	508	285
Manganese	297	--	43.3	58.7	73.9	43.5	57.5	31
Mercury	80	0.15	--	0.088	--	--	--	
Nickel	7	21	7.2	4.6	9.7	6.8	3.8	2.5
Potassium	1780	--	490	373	368	387	168	104
Selenium	20	--	--	--	--	--	--	--
Silver	1	1	--	0.26	--	--	--	--
Sodium	252	--	96.1	--	124	--	--	--
Thallium	150	--	--	--	--	--	--	--
Vanadium	24	--	29	17.3	23.7	23.2	7.3	5.4
Zinc	1490	150	46.1	22.4	52.5	47.6	22.5	21.1
VOCs (mg/kg)								
Acetone	0.009	--	--	--	0.0359	0.0302	--	--
2-Butanone	0.002	--	--	--	--	0.0123	--	--
Benzene	0.002	--	--	--	--	--	--	--
Chlorobenzene	0.002	--	--	--	--	--	--	--
Ethylbenzene	0.002	--	0.0016	--	--	--	--	--
Toluene	0.002	--	0.0123	--	0.0068	--	--	--
Xylene (total)	0.0045	--	--	--	--	--	--	--
SVOCs (mg/kg)								
bis(2-Ethylhexyl)phthalate	1.64	--	0.0503 J	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

DL- Detection Limit

Laboratory Data Qualifiers:
L - Indicates reported value may be biased low
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., ERL) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the ERL screening level and maximum background level.

TABLE 4-8
SUMMARY OF DETECTIONS IN SEDIMENT AT THE CSL

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria Maximum Background or DL (mg/kg)	Screening Criteria Effect Range Low (ER-L) (mg/kg)	SED1 SED1 CREK 0 0.5 CSE 11/5/2003	SED2 SED2 CREK 0 0.5 CSE 11/5/2003	SED3 SED3 CREK 0 0.5 CSE 11/6/2003	SED4 SED4 CREK 0 0.5 CSE 11/6/2003	SED5 SED5 CREK 0 0.5 CSE 5/5/2005	SED6 SED6 CREK 0 0.5 CSE 5/6/2005
PAH (mg/kg)								
Acenaphthene	0.067	0.016	--	--	--	--	--	--
Anthracene	0.033	0.0853	0.00177	--	0.00131	--	--	--
Benzo(a)anthracene	0.013	0.261	0.00469	--	0.0032	--	--	--
Benzo(a)pyrene	0.085	0.43	0.00423	--	0.00339	--	0.00745	--
Benzo(b)fluoranthene	0.0699	--	0.00766	--	0.00624	--	0.0109	--
Benzo(g,h,i)perylene	0.013	--	0.00448	--	0.0034	--	0.00489	--
Benzo(k)fluoranthene	0.013	--	0.0036	--	0.0017	--	--	--
Chrysene	0.013	0.384	0.00559	--	0.00466	--	--	--
Dibenzo(a,h)anthracene	0.013	0.0634	0.0014	--	--	--	0.00245	--
Fluoranthene	0.116	0.6	0.00621	--	0.00575	--	0.0116	--
Fluorene	0.033	0.019	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	0.013	--	0.00417	--	0.00271	--	0.00508	--
2-Methylnaphthalene	0.033	0.07	--	--	--	--	--	--
Naphthalene	0.033	0.16	--	--	0.00151	--	--	--
Phenanthrene	0.11	0.24	0.00163	--	0.0043	--	--	--
Pyrene	0.119	0.665	0.0055	--	0.00632	--	--	--
PCBs (mg/kg)								
Aroclor 1260	0.0083	--	--	--	0.0956 J	--	--	--
Pesticides (mg/kg)								
4,4'-DDD	0.00066	--	--	--	0.0914 J	0.372 J	--	--
4,4'-DDE	0.0045	--	--	--	0.0326 J	0.0847 J	--	--
4,4'-DDT	0.0057	--	0.0027 J	0.0029 J	0.0235	0.0081 J	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

DL - Detection Limit

Data Qualifiers:
L - Indicates reported value may be biased low
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., ERL) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the ERL screening level and maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 1 SS-CELL3-1 SURF 0 0.5 CSO 1/22/2004	Trench 2 SS-CELL3-2 SURF 0 0.5 CSO 1/22/2004	Trench 3 SS-CELL3-3 SURF 0 0.5 CSO 1/22/2004	Trench 3 SS-CELL3-3X SURF 0 0.5 CSO 1/22/2004	Trench 4 SS-CELL3-4 SURF 0 0.5 CSO 1/22/2004	Trench 5 SS-CELL3-5 SURF 0 0.5 CSO 1/22/2004
	Maximum Background or DL (mg/kg)	Industrial RBC (mg//kg)						
Metals (mg/kg)								
Aluminum	7010	1022000	2760	9960	4420	4440	7180	3040
Antimony	0.15	408.8	--	--	--	--	--	--
Arsenic	2.79	1.9	1.3	*2.4	*2	*1.9	*2	°3.6
Barium	0.05	71540	16.3	31.3	110	11.6	76.4	14.1
Beryllium	0.634	2044.0	--	--	--	--	0.89	--
Cadmium	0.03	--	--	--	--	--	0.54	--
Calcium	828	--	754	4180	315	324	22200	942
Chromium	14.1	3066	11.9	21	7.9	7.2	25.6	11.8
Cobalt	4.43	20440	1.6	7	1.9	1.9	5.1	1.3
Copper	8.15	40880	15.4	12.4	10.5	8.8	19.4	9.2
Cyanide	--	20440	0.07	--	--	0.15	--	--
Iron	12400	306600	4000	15800	7170	6280	18600	8200
Lead	16	--	15.6	9.7	2.4	2.3	26.2	6.4
Magnesium	1220	--	327	1780	325	331	5000	544
Manganese	149	20440	35.4	204	29.9	27.3	964	30.8
Mercury	0.08	--	0.081	0.032 K	--	--	0.063 K	0.012 K
Nickel	9.38	20440	3.1	9.1	3.9	4	7.6	2.2
Potassium	503	--	195	474	264	264	481	--
Selenium	0.2	5110	--	--	--	--	--	--
Silver	0.06	5110	3.1	--	--	--	1.6	--
Sodium	397	--	--	--	--	--	128	--
Thallium	0.15	72	--	--	--	--	--	--
Vanadium	24	1022	10.2	29.2	14	13	73.9	22.2
Zinc	23	306600	22	22.9	7.1	6.9	38.1	12.6
VOCs (mg/kg)								
Acetone	0.01	919,800	--	--	--	--	--	--
SVOCs (mg/kg)								
bis(2-Ethylhexyl)phthalate	2.22	204	--	--	--	--	0.0498 J	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL - Detection Limit

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 1 SS-CELL3-1 SURF 0 0.5 CSO 1/22/2004	Trench 2 SS-CELL3-2 SURF 0 0.5 CSO 1/22/2004	Trench 3 SS-CELL3-3 SURF 0 0.5 CSO 1/22/2004	Trench 3 SS-CELL3-3X SURF 0 0.5 CSO 1/22/2004	Trench 4 SS-CELL3-4 SURF 0 0.5 CSO 1/22/2004	Trench 5 SS-CELL3-5 SURF 0 0.5 CSO 1/22/2004
	Maximum Background or DL (mg/kg)	Industrial RBC (mg/kg)						
PAH (mg/kg)								
Acenaphthene	0.067	61,320	--	--	--	--	--	--
Anthracene	0.033	306,600	--	--	--	--	--	--
Benzo(a)anthracene	0.013	--	0.0183	--	--	--	0.0354	--
Benzo(a)pyrene	0.013	392	0.0205	--	--	--	0.0373	--
Benzo(b)fluoranthene	0.013	3.92	0.0292	--	--	--	0.0703	--
Benzo(g,h,i)perylene	0.013	--	0.0133	--	--	--	0.0156	--
Benzo(k)fluoranthene	0.013	39.2	0.0153	--	--	--	0.0213	--
Chrysene	0.013	392	0.0213	--	--	--	0.0408	--
Dibenzo(a,h)anthracene	0.013	--	--	--	--	--	--	--
Fluoranthene	0.033	40,880	0.0264	--	--	--	0.0515	--
Fluorene	0.033	40,880	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	0.013	20,440	0.0122	--	--	--	0.0149	--
2-Methylnaphthalene	0.033	4,088	--	--	--	--	--	--
Naphthalene	0.033	20,440	--	--	--	--	0.0399	--
Phenanthrene	0.033	--	0.0122	--	--	--	0.0231	--
Pyrene	0.033	30,660	0.0265	0.0075	--	--	0.0486	--
PCBs (mg/kg)								
Aroclor 1260	0.0083	1.43	0.105	--	--	--	--	--
Pesticides (mg/kg)								
alpha-Chlordane	0.00066	--	--	--	--	--	0.003	0.001
gamma-Chlordane	0.00066	--	--	--	--	--	--	0.001
4,4'-DDD	0.00066	--	0.0031 J	0.0022	--	--	0.0074 J	0.0018
4,4'-DDE	0.00066	8	0.0061	0.0011	--	--	0.0055	0.0011
4,4'-DDT	0.00066	8	0.0057 J	--	--	--	--	0.0026 J
Dieldrin	0.00066	0.17	--	--	--	--	0.0014	--
Methoxychlor	0.0013	5,110	--	--	--	0.0018	0.0042 J	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL - Detection Limit

Data Qualifiers:
B - Indicates the compound or element was analyzed for but not detected substantially above the level reported in the laboratory or field blank.
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 6 SS-CELL3-6 SURF 0 0.5 CSO 1/23/2004	SS-ASP-1 SS-ASP-1 SURF 0 0.5 CSO 12/16/2003	SS-ASP-2 SS-ASP-2 SURF 0 0.5 CSO 12/16/2003	SS-ASP-3 SS-ASP-3 SURF 0 0.5 CSO 12/16/2003	SS-ASP-4 SS-ASP-4 SURF 0 0.5 CSO 12/16/2003	SS-ASP-5 SS-ASP-5 SURF 0 0.5 CSO 12/17/2003
	Maximum Background or DL (mg/kg)	Industrial RBC (mg/kg)						
Metals (mg/kg)								
Aluminum	7010	1022000	1540	5200	7350	4620	4550	6150 L
Antimony	0.15	408.8	--	--	--	--	--	--
Arsenic	2.79	1.9	1.2	*2.5 L	*2.8 L	*1.9 L	1.1 L	*2.6 L
Barium	0.05	71540	5.2	26.6	37.5	18.6	15.5	23.4 L
Beryllium	0.634	2044.0	0.03	--	0.4	--	--	--
Cadmium	0.03	--	--	--	0.42	--	--	0.21 L
Calcium	828	--	206	1670	1350	5370	488	299 L
Chromium	14.1	3066	6.9	17.7	20.3	15	7.8	10 L
Cobalt	4.43	20440	0.23	3	4.3	4.7	1.1	3.5 L
Copper	8.15	40880	8.6	16.3	19.1	10.3	8.8	8.3
Cyanide	--	20440	--	--	--	0.077	--	--
Iron	12400	306600	6530	7300	9710	4600	6360	10300 L
Lead	16	--	1.9	32	40.9	12.6	11.1	6 L
Magnesium	1220	--	62.3	747	986	2380	318	445 L
Manganese	149	20440	3.7	61.1	73.2	96.2	22	65.6 L
Mercury	0.08	--	--	0.06	0.048	0.03	0.028	0.016
Nickel	9.38	20440	--	6.4	8.7	5.4	2.3	5 L
Potassium	503	--	255	435	566	405	231	436 L
Selenium	0.2	5110	--	--	--	--	--	--
Silver	0.06	5110	--	--	--	--	--	--
Sodium	397	--	--	--	51.6	--	--	--
Thallium	0.15	72	--	--	--	--	--	1 L
Vanadium	24	1022	11.6	18.9	23.9	17.4	15.5	24.3 L
Zinc	23	306600	2.6 J	50.5	61.1	26.7	17.4	28.1
VOCs (mg/kg)								
Acetone	0.01	919,800	--	--	--	--	0.0156	--
SVOCs (mg/kg)								
bis(2-Ethylhexyl)phthalate	2.22	204	--	0.133	--	--	--	0.0443 J

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL - Detection Limit

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 6 SS-CELL3-6 SURF 0 0.5 CSO 1/23/2004	SS-ASP-1 SS-ASP-1 SURF 0 0.5 CSO 12/16/2003	SS-ASP-2 SS-ASP-2 SURF 0 0.5 CSO 12/16/2003	SS-ASP-3 SS-ASP-3 SURF 0 0.5 CSO 12/16/2003	SS-ASP-4 SS-ASP-4 SURF 0 0.5 CSO 12/16/2003	SS-ASP-5 SS-ASP-5 SURF 0 0.5 CSO 12/17/2003
	Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)						
PAH (mg/kg)								
Acenaphthene	0.067	61,320	--	--	--	--	--	--
Anthracene	0.033	306,600	--	--	--	--	--	--
Benzo(a)anthracene	0.013	--	--	0.03	--	--	--	--
Benzo(a)pyrene	0.013	392	--	0.0314	--	--	--	--
Benzo(b)fluoranthene	0.013	3.92	--	0.0419	0.0123	--	--	0.0082
Benzo(g,h,i)perylene	0.013	--	--	0.0204	--	--	--	--
Benzo(k)fluoranthene	0.013	39.2	--	0.0166	--	--	--	--
Chrysene	0.013	392	--	0.0355	0.0081	--	--	--
Dibenzo(a,h)anthracene	0.013	--	--	0.0079	--	--	--	--
Fluoranthene	0.033	40,880	--	0.0594	0.01	--	--	--
Fluorene	0.033	40,880	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	0.013	20,440	--	0.0177	--	--	--	--
2-Methylnaphthalene	0.033	4,088	--	--	--	--	--	--
Naphthalene	0.033	20,440	--	--	--	--	--	--
Phenanthrene	0.033	--	--	0.0211	--	--	--	--
Pyrene	0.033	30,660	--	0.0535	0.0099	--	--	--
PCBs (mg/kg)								
Aroclor 1260	0.0083	1.43	--	--	--	--	--	--
Pesticides (mg/kg)								
alpha-Chlordane	0.00066	--	--	0.0011 J	0.00098 J	--	--	--
gamma-Chlordane	0.00066	--	--	0.0014	0.0012	--	--	--
4,4'-DDD	0.00066	--	--	0.0059	0.0062	0.0038	--	--
4,4'-DDE	0.00066	8	--	0.0024 J	0.0028 J	0.0017 J	--	--
4,4'-DDT	0.00066	8	--	0.0035	0.0045 J	0.0037	--	--
Dieldrin	0.00066	0.17	--	0.004	--	--	--	--
Methoxychlor	0.0013	5,110	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
B - Indicates the compound or element was analyzed for but not detected substantially above the level reported in the laboratory or field blank.
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		SS-ASP-6 SS-ASP-6 SURF 0 0.5 CSO 12/17/2003	SS-1 SS-1 SURF 0 0.5 CSO 4/15/2005	SS-2 SS-2 SURF 0 0.5 CSO 4/15/2005	SS-3 SS-3 SURF 0 0.5 CSO 4/15/2005	SS-3x SS-3x SURF 0 0.5 CSO 4/15/2005	SS-4 SS-4 SURF 0 0.5 CSO 4/15/2005
	Maximum Background or DL (mg/kg)	Industrial RBC (mg/kg)						
Metals (mg/kg)								
Aluminum	7010	1022000	5850 L	10000	7270	11100	10800	7830
Antimony	0.15	408.8	--	--	--	--	--	--
Arsenic	2.79	1.9	*2.4 L	°8.6	°6.2	°7.3	°6.8	°5
Barium	0.05	71540	31.9 L	38.8	25.6	47.7	46	27.4
Beryllium	0.634	2044.0	--	1.2	0.55	0.8	0.8	0.53
Cadmium	0.03	--	0.44 L	0.33	0.11	0.26	--	0.18
Calcium	828	--	1630 L	1870	759	1360	1330	854
Chromium	14.1	3066	20.9 L	56.5	26.7	43.9	40.8	28.3
Cobalt	4.43	20440	3.4 L	3.4	2.2	4.2	4.3	2.7
Copper	8.15	40880	17.5	7.9	7.2	8.5	7.8	7.8
Cyanide	--	20440	--	0.057	--	0.021	0.039	--
Iron	12400	306600	8140	34700	16100	25200	25100	15500
Lead	16	--	40 L	11.4	7.1	18	15.1	11.1
Magnesium	1220	--	984 L	2080	970	1710	1670	1040
Manganese	149	20440	54.3 L	143	75.2	179	203	105
Mercury	0.08	--	--	--	--	0.41	0.03	--
Nickel	9.38	20440	7.1 L	6.7	3.9	8.6	8.6	4.9
Potassium	503	--	479 L	3760	1410	2510	2450	1540
Selenium	0.2	5110	--	72.2	--	--	--	--
Silver	0.06	5110	--	--	--	--	--	--
Sodium	397	--	67.9 B	--	--	--	--	--
Thallium	0.15	72	--	--	--	--	--	--
Vanadium	24	1022	21.4 L	46.4	28.5	37.4	38.9	29.3
Zinc	23	306600	60.5	33.4	13.8	32	31.6	22.5
VOCs (mg/kg)								
Acetone	0.01	919,800	--	--	--	--	--	--
SVOCs (mg/kg)								
bis(2-Ethylhexyl)phthalate	2.22	204	0.0473 J	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)	SS-ASP-6 SS-ASP-6 SURF 0 0.5 CSO 12/17/2003	SS-1 SS-1 SURF 0 0.5 CSO 4/15/2005	SS-2 SS-2 SURF 0 0.5 CSO 4/15/2005	SS-3 SS-3 SURF 0 0.5 CSO 4/15/2005	SS-3x SS-3x SURF 0 0.5 CSO 4/15/2005	SS-4 SS-4 SURF 0 0.5 CSO 4/15/2005
PAH (mg/kg)								
Acenaphthene	0.067	61,320	--	--	--	--	--	--
Anthracene	0.033	306,600	--	--	--	--	--	--
Benzo(a)anthracene	0.013	--	0.0114	0.0228	--	--	--	--
Benzo(a)pyrene	0.013	392	0.0149	0.0217	--	--	--	--
Benzo(b)fluoranthene	0.013	3.92	0.0247	0.0268	--	0.0269	21.2	--
Benzo(g,h,i)perylene	0.013	--	0.0086	--	--	--	--	--
Benzo(k)fluoranthene	0.013	39.2	0.008	--	--	--	--	--
Chrysene	0.013	392	0.0161	0.0224	--	--	--	--
Dibenzo(a,h)anthracene	0.013	--	--	--	--	--	--	--
Fluoranthene	0.033	40,880	0.0188	0.038	--	0.0201	24.7	--
Fluorene	0.033	40,880	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	0.013	20,440	0.0075	--	--	--	--	--
2-Methylnaphthalene	0.033	4,088	--	--	--	--	--	--
Naphthalene	0.033	20,440	--	--	--	--	--	--
Phenanthrene	0.033	--	0.0108	--	--	--	--	--
Pyrene	0.033	30,660	0.0194	--	--	--	--	--
PCBs (mg/kg)								
Aroclor 1260	0.0083	1.43	0.0239	--	--	--	--	--
Pesticides (mg/kg)								
alpha-Chlordane	0.00066	--	0.0019	0.0079	--	--	--	--
gamma-Chlordane	0.00066	--	0.0023	0.0087	--	--	--	--
4,4'-DDD	0.00066	--	0.0129	--	--	--	--	--
4,4'-DDE	0.00066	8	0.005	--	--	--	--	--
4,4'-DDT	0.00066	8	0.0039	--	--	--	--	--
Dieldrin	0.00066	0.17	0.0025 J	--	--	--	--	--
Methoxychlor	0.0013	5,110	--	--	--	--	--	--
Explosives								
1,3-Dinitrobenzene	--	102	--	--	--	--	0.11	--
2-amino-4,6-Dinitrotoluene	--	4.2	--	0.233	0.223	0.549	0.482	0.336
4-amino-2,6-Dinitrotoluene	--	4.2	--	0.265	0.2	0.475	0.366	0.27
2,4,6-Trinitrotoluene	--	95.3	--	0.301	0.26	0.409	0.33	0.92

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
B - Indicates the compound or element was analyzed for but not detected substantially above the level reported in the laboratory or field blank.
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		SS-5 SS-5 SURF 0 0.5 CSO 4/15/2005	SS-6 SS-6 SURF 0 0.5 CSO 4/15/2005	SS-7 SS-7 SURF 0 0.5 CSO 4/15/2005	SS-8 SS-8 SURF 0 0.5 CSO 4/15/2005
	Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)				
Metals (mg/kg)						
Aluminum	7010	1022000	13400	5590	5340	25600
Antimony	0.15	408.8	--	--	--	--
Arsenic	2.79	1.9	°2.8	°2.8	°2.5	°3.5
Barium	0.05	71540	46	31.1	27.4	187
Beryllium	1	2044.0	0.68	0.48	0.38	1.5
Cadmium	0.03	--	0.19	0.34	0.24	0.15
Calcium	828	--	13400	2340	2430	988
Chromium	14.1	3066	18.9	24.5	19.5	27.5
Cobalt	4.43	20440	6.4	3.7	3.3	14.7
Copper	8.15	40880	14.4	19.4	14.8	21.4
Cyanide	--	20440	0.028	0.043	0.036	0.066
Iron	12400	306600	16900	10300	8860	25700
Lead	16	--	17.6	38.8	28.1	16.1
Magnesium	1220	--	2600	1180	1100	4490
Manganese	149	20440	225	76.4	71.6	524
Mercury	0.08	--	0.22	0.043	0.038	--
Nickel	9.38	20440	9	8	7.2	21
Potassium	503	--	790	449	377	3420
Selenium	0.2	5110	--	--	--	--
Silver	0.06	5110	--	--	--	--
Sodium	397	--	73.4	55	48	66.7
Thallium	0.15	72	--	--	--	--
Vanadium	24	1022	30.5	20	18.9	41.3
Zinc	23	306600	34.8	60.3	46.5	57.9
VOCs (mg/kg)						
Acetone	0.01	919,800	--	--	--	--
SVOCs (mg/kg)						
bis(2-Ethylhexyl)phthalate	2.22	204		0.154	129	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-9
SUMMARY OF DETECTIONS IN SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		SS-5 SS-5 SURF 0 0.5 CSO 4/15/2005	SS-6 SS-6 SURF 0 0.5 CSO 4/15/2005	SS-7 SS-7 SURF 0 0.5 CSO 4/15/2005	SS-8 SS-8 SURF 0 0.5 CSO 4/15/2005
	Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)				
PAH (mg/kg)						
Acenaphthene	0.067	61,320	--	--	--	--
Anthracene	0.033	306,600	--	--	--	--
Benzo(a)anthracene	0.013	--	0.0227	0.0241	--	--
Benzo(a)pyrene	0.013	392	0.0227	0.0271	--	--
Benzo(b)fluoranthene	0.013	3.92	0.0311	0.0425	--	--
Benzo(g,h,i)perylene	0.013	--	--	--	--	--
Benzo(k)fluoranthene	0.013	39.2	--	--	--	--
Chrysene	0.013	392	--	0.0306	--	--
Dibenzo(a,h)anthracene	0.013	--	--	--	--	--
Fluoranthene	0.033	40,880	0.0291	0.048	0.0318	--
Fluorene	0.033	40,880	--	--	--	--
Hexachlorobenzene		--	--	0.0902	--	--
Indeno(1,2,3-cd)pyrene	0.013	20,440	--	--	--	--
2-Methylnaphthalene	0.033	4,088	--	--	--	--
Naphthalene	0.033	20,440	--	--	--	--
Phenanthrene	0.033	--	--	0.0221	--	--
Pyrene	0.033	30,660	--	0.0437	--	--
PCBs (mg/kg)						
Aroclor 1260	0.0083	1.43		0.0443	0.0405	--
Pesticides (mg/kg)						
alpha-Chlordane	0.00066	--		0.0027	0.0017	--
gamma-Chlordane	0.00066	--		0.0028	0.002	--
4,4'-DDD	0.00066	--	0.003	0.0152	0.0136	--
4,4'-DDE	0.00066	8	0.0033	0.0088	0.0061	--
4,4'-DDT	0.00066	8	0.0057	0.0227	0.0078	--
Dieldrin	0.00066	0.17				
Methoxychlor	0.0013	5,110				
Explosives						
1,3-Dinitrobenzene	--	102	--	--	--	--
2-amino-4,6-Dinitrotoluene	--	4.2	0.207	--	--	--
4-amino-2,6-Dinitrotoluene	--	4.2	0.187	--	--	--
2,4,6-Trinitrotoluene	--	95.3	0.228	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 1 TR1A SUBSURF 4 4.5 CSO 1/22/2004	Trench 1 TR1B SUBSURF 4 4.5 CSO 1/22/2004	Trench 2 TR2A SUBSURF 3 3.5 CSO 1/22/2004	Trench 2 TR2B SUBSURF 5 5.5 CSO 1/22/2004	Trench 3 TR3A SUBSURF 6 6.5 CSO 1/22/2004	Trench 3 TR3B SUBSURF 6 6.5 CSO 1/22/2004
	Maximum Background or DL (mg/kg)	Industrial RBC (mg/kg)						
Metals (mg/kg)								
Aluminum	6920	1022000	2820	3390	5140	5020	3630	3640
Antimony	0.15	408.8	--	--	--	--	--	--
Arsenic	0.25	1.9	°3.1	1.5	°2.7	1.8	°5.5	°4.3
Barium	0.05	71540	14.8	--	67.5	40.5	65.4	47.2
Beryllium	0.543	2044.0	--	--	--	--	0.45	--
Cadmium	0.03	--	--	--	--	--	--	0.56
Calcium	606	--	523	785	2020	1330	1650	1540
Chromium	16.1	3066	17.2	6.7	10.3	11.1	7.9	14.1
Cobalt	20.7	20440	2.1	1.7	3.9	3.6	7.6	2.7
Copper	12.1	40880	14.1	8.1	15.3	13.9	73.5	14
Cyanide	--	20440	--	--	--	--	--	--
Iron	20800	306600	7120	4040	9650	8100	18000	13400
Lead	10.3	--	22.1	10.9	49.9	29.5	23.9	44.7
Magnesium	939	--	267	318	654	746	312	367
Manganese	445	20440	31.7	29.5	56.4	70.6	214	84.6
Mercury	0.08	--	0.033 K	0.032 K	0.058 K	0.055 K	0.046 K	0.3 K
Nickel	8.2	20440	4.3	2.9	7.5	5.4	11.7	5.8
Potassium	494	--	234	166	327	428	248	223
Selenium	0.2	5110	1.4	--	--	--	--	--
Silver	0.06	5110	0.4	0.61	--	0.96	0.33	0.4
Sodium	404	--	--	--	--	--	56.2	--
Thallium	0.15	72	--	--	--	--	--	--
Vanadium	35.3	1022	12.3	9.6	22.1	17.9	14.7	13.2
Zinc	24.9	306600	30.7	15.8	55.1	37.2	69.9	138
VOCs (mg/kg)								
Acetone	0.01	919,800	--	--	--	--	--	--
2-Butanone	0.002	613,200	--	--	--	--	--	--
Benzene	0.002	52	--	--	--	--	--	--
Chlorobenzene	0.002	20,440	--	--	--	--	--	
Ethylbenzene	0.002	1,022,000	--	--	--	--	--	--
Toluene	0.002	204,400	--	--	--	--	--	--
Xylene (total)	0.0045	204,400	--	--	--	--	--	--
SVOCs (mg/kg)								
Butyl benzyl phthalate	0.083	1,506	--	--	--	--	--	0.11
Carbazole	0.033	143	--	--	--	--	--	--
1,4-Dichlorobenzene	0.005	119	0.0717 J	--	--	--	--	0.0882
Di-n-butyl phthalate	0.083	--	--	--	--	--	--	0.0497 J
Di-n-octyl phthalate	0.17	--	--	--	--	--	--	--
Dibenzofuran	0.033	12	0.0333 J	--	--	--	--	0.0501 J
Diethyl phthalate	0.083	817,600	--	--	--	--	--	0.067 J
bis(2-Ethylhexyl)phthalate	0.17	204	0.328	--	--	--	0.139	0.837
3&4-Methylphenol	0.066	5,110	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL - Detection Limit

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)	Trench 1 TR1A SUBSURF 4 4.5 CSO 1/22/2004	Trench 1 TR1B SUBSURF 4 4.5 CSO 1/22/2004	Trench 2 TR2A SUBSURF 3 3.5 CSO 1/22/2004	Trench 2 TR2B SUBSURF 5 5.5 CSO 1/22/2004	Trench 3 TR3A SUBSURF 6 6.5 CSO 1/22/2004	Trench 3 TR3B SUBSURF 6 6.5 CSO 1/22/2004
PAH (mg/kg)								
Acenaphthene	0.067	61,320	--	--	0.0253	--	--	0.0558
Anthracene	0.033	306,600	--	--	0.0289	--	0.0109	0.0176
Benzo(a)anthracene	0.013	--	0.0125	0.0097	0.0658	0.0214	0.0294	0.0247
Benzo(a)pyrene	0.013	392	0.0124	0.0094	0.0683	0.0226	0.0239	0.0169
Benzo(b)fluoranthene	0.013	3.92	--	0.0118	0.106	0.0257	0.0424	0.0413
Benzo(g,h,i)perylene	0.013	--	--	--	0.0466	0.014	0.0114	0.0115
Benzo(k)fluoranthene	0.013	39.2	--	0.0078	0.0845	0.0154	0.0104	--
Chrysene	0.013	392	0.0213	0.0104	0.0698	0.0244	0.0532	0.0378
Dibenzo(a,h)anthracene	0.013	0	--	--	0.0154	--	--	--
Fluoranthene	0.033	40,880	0.0204	0.0185	0.124	0.0316	0.0253	0.0372
Fluorene	0.033	40,880	0.0633	--	0.0324	--	0.0186	0.0597
Indeno(1,2,3-cd)pyrene	0.013	20,440	--	--	0.0513	0.012	--	0.0101
2-Methylnaphthalene	0.033	4,088	--	--	--	--	--	--
Naphthalene	0.033	20,440	0.0297	--	0.0153	0.0158	0.0624	0.323
Phenanthrene	0.033	--	0.0765	0.0103	0.098	0.0233	0.089	0.13
Pyrene	0.033	30,660	0.024	0.0173	0.103	0.0346	0.0329	0.0584
PCBs (mg/kg)								
Aroclor 1221	0.013	1.43	--	--	--	--	--	°6.39
Aroclor 1242	0.0083	1.43	--	--	--	0.691	0.155	°1.94
Aroclor 1248	0.0083	1.43	0.0632	0.0329	0.0927	--	--	--
Aroclor 1254	0.0083	1.43	--	--	--	--	--	--
Aroclor 1260	0.0083	1.43	0.032	0.022	0.0316	0.0224	0.0333	0.0576 K
Pesticides (mg/kg)								
alpha-Chlordane	0.00066	--	--	--	--	--	--	--
gamma-Chlordane	0.00066	--	--	--	--	--	--	--
4,4'-DDD	0.00066	--	--	--	--	--	--	--
4,4'-DDE	0.00066	8	--	--	--	--	--	--
4,4'-DDT	0.00066	8	--	--	--	--	--	--
Dieldrin	0.003	0.17	--	--	--	--	--	--
Methoxychlor	0.0013	5,110	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL - Detection Limit

Data Qualifiers:
B - Indicates the compound or element was analyzed for but not detected substantially above the level reported in the laboratory or field blank.
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 4 TR4A SUBSURF 5 5.5 CSO 1/22/2004	Trench 4 TR4AX SUBSURF 5 5.5 CSO 1/22/2004	Trench 4 TR4B SUBSURF 6 6.5 CSO 1/22/2004	Trench 5 TR5A SUBSURF 6 6.5 CSO 1/22/2004	Trench 5 TR5B SUBSURF 6 6.5 CSO 1/22/2004	Trench 6 TR6A SUBSURF 6 6.5 CSO 1/23/2004
	Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)						
Metals (mg/kg)								
Aluminum	6920	1022000	2080	3340	2630	3550	3700	1550
Antimony	0.15	408.8	--	--	--	--	--	--
Arsenic	0.25	1.9	°2.7	°2.4	°2.7	°2.1	°2.2	1.2
Barium	0.05	71540	32	61.6	33	12.7	14.6	8.1
Beryllium	0.543	2044.0	--	--	--	--	--	0.039
Cadmium	0.03	--	--	--	--	--	--	0.053
Calcium	606	--	1110	2170	2170	865	1360	172
Chromium	16.1	3066	7.2	5.9	9	6.5	7.7	4.1
Cobalt	20.7	20440	1.5	1.9	1.6	1.3	1.3	0.54
Copper	12.1	40880	11.9	12.7	13	7.2	7.8	4.7
Cyanide	--	20440	--	--	--		0.06	--
Iron	20800	306600	8360	6140	5450	5040	5340	3120
Lead	10.3	--	19.2	17.8	23.2	4.7	6.9	3.2
Magnesium	939	--	297	371	518	490	567	116
Manganese	445	20440	32.8	40.3	49.5	25.4	29.3	13.4
Mercury	0.08	--	0.054 K	0.14 K	0.046 K	0.018 K	0.02 K	0.017 K
Nickel	8.2	20440	3.2	3.9	3.7	2.5	2.9	0.92
Potassium	494	--	206	241	236	232	249	115
Selenium	0.2	5110	--		--	--	--	--
Silver	0.06	5110	0.2	0.21	0.77	--	--	--
Sodium	404	--	--	58.1	--	--	--	28.4
Thallium	0.15	72	--	--	--	--	--	--
Vanadium	35.3	1022	10.7	10.3	12.4	11.2	11.9	6.7
Zinc	24.9	306600	23.4	26	26.6	8.9	12.4	11.9 J
VOCs (mg/kg)								
Acetone	0.01	919,800	0.0108 J	--	--	--	--	
2-Butanone	0.002	613,200	--	--	--	--	--	--
Benzene	0.002	52	0.00059 J	0.00069 J	--	--	--	--
Chlorobenzene	0.002	20,440	0.0026 J	0.0024 J	0.0016 J	--	--	--
Ethylbenzene	0.002	1,022,000	--	--	--	--	--	0.00083 J
Toluene	0.002	204,400	--	--	--	--	--	--
Xylene (total)	0.0045	204,400	0.0026	0.0031	0.00089	--	--	0.00091 J
SVOCs (mg/kg)								
Butyl benzyl phthalate	0.083	1,506	--	--	--	--	--	0.596
Carbazole	0.033	143	--	0.204	--	--	--	--
1,4-Dichlorobenzene	0.005	119	0.0732	0.0698 J	0.12	--	--	--
Di-n-butyl phthalate	0.083	--	--	--	--	--	--	0.126
Di-n-octyl phthalate	0.17	--	--	--	--	--	--	0.66
Dibenzofuran	0.033	12	--	0.113	--	--	--	--
Diethyl phthalate	0.083	817,600	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	0.17	204	0.121	0.061 J	0.0542 J	--	--	1.55
3&4-Methylphenol	0.066	5,110	--	--	--	--	--	0.213

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL - Detection Limit

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 4 TR4A SUBSURF 5 5.5 CSO 1/22/2004	Trench 4 TR4AX SUBSURF 5 5.5 CSO 1/22/2004	Trench 4 TR4B SUBSURF 6 6.5 CSO 1/22/2004	Trench 5 TR5A SUBSURF 6 6.5 CSO 1/22/2004	Trench 5 TR5B SUBSURF 6 6.5 CSO 1/22/2004	Trench 6 TR6A SUBSURF 6 6.5 CSO 1/23/2004
	Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)						
PAH (ug/kg)								
Acenaphthene	0.067	61,320	0.0075	0.106	--	--	--	--
Anthracene	0.033	306,600	0.0117	0.366	--	--	--	0.0128
Benzo(a)anthracene	0.013	--	0.0327	0.674	0.0144	--	0.0098	0.0204
Benzo(a)pyrene	0.013	392	0.0264	0.336	0.0141	--	0.0104	0.0147
Benzo(b)fluoranthene	0.013	3.92	0.0316	0.5	0.0241	0.0076	0.012	0.0205
Benzo(g,h,i)perylene	0.013	--	0.0176	0.123	0.0109	--	0.009	0.0104
Benzo(k)fluoranthene	0.013	39.2	0.024	0.176	0.0086	--	0.009	0.0101
Chrysene	0.013	392	0.0394	0.476	0.0192	0.0073	0.0112	0.018
Dibenzo(a,h)anthracene	0.013	0	--	0.0524	--	--	--	--
Fluoranthene	0.033	40,880	0.0399	1.66	0.0263	0.0093	0.015	0.0506
Fluorene	0.033	40,880	0.0115	0.201	--	--	--	0.0112
Indeno(1,2,3-cd)pyrene	0.013	20,440	0.0136	0.13	0.0092	--	0.0071 J	0.0095
2-Methylnaphthalene	0.033	4,088	--	0.0505 J	0.016 J	--	--	--
Naphthalene	0.033	20,440	0.0393	0.0447	0.049	--	--	0.032
Phenanthrene	0.033	--	0.0602	1.68	0.0258	--	--	0.0526
Pyrene	0.033	30,660	0.039	1.2	0.0207	0.0103	0.0157	0.0359
PCBs (ug/kg)								
Aroclor 1221	0.013	1.43	--	--	--	--	--	--
Aroclor 1242	0.0083	1.43	0.138	0.15	0.516	--	--	0.0337
Aroclor 1248	0.0083	1.43	--	--	--	--	--	--
Aroclor 1254	0.0083	1.43	--	--	0.103	--	--	--
Aroclor 1260	0.0083	1.43	0.021	0.0188	0.0448	--	--	--
Pesticides (ug/kg)								
alpha-Chlordane	0.00066	--	--	--	--	--	--	--
gamma-Chlordane	0.00066	--	--	--	--	--	--	--
4,4'-DDD	0.00066	--	--	--	--	--	--	--
4,4'-DDE	0.00066	8	--	--	--	--	--	--
4,4'-DDT	0.00066	8	--	--	--	--	--	--
Dieldrin	0.003	0.17	--	--	--	--	--	--
Methoxychlor	0.0013	5,110	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		Trench 6 TR6B SUBSURF 7 7.5 CSO 1/23/2004	SS-ASP-1 SB-ASP-1A SUBSURF 0.5 2 CSO 12/16/2003	SS-ASP-1 SB-ASP-1B SUBSURF 3.5 5 CSO 12/16/2003	SS-ASP-2 SB-ASP-2A SUBSURF 0.5 2.5 CSO 12/16/2003	SS-ASP-3 SB-ASP-3A SUBSURF 0.5 2 CSO 12/16/2003	SS-ASP-3 SB-ASP-3AX SUBSURF 0.5 2 CSO 12/16/2003
	Maximum Background or DL (mg/kg)	Industrial RBC (mg/kg)						
Metals (mg/kg)								
Aluminum	6920	1022000	2590	4920	5760	966	4580	5060
Antimony	0.15	408.8	--	--	--	--	--	--
Arsenic	0.25	1.9	2.2	2.5 L	3.3 L	--	1.6 L	1.6 L
Barium	0.05	71540	12.5	23.8	20.3	11.5	16.1	19.1
Beryllium	0.543	2044.0	0.081	0.29	0.3	0.079	--	--
Cadmium	0.03	--	0.13	0.26	0.24	--	--	--
Calcium	606	--	369	1000	98.5	339	4160	3910
Chromium	16.1	3066	11.6	11.8	17	2.4	12.2	13.3
Cobalt	20.7	20440	1.1	2.3	1.7	0.56	5.7	10.6
Copper	12.1	40880	9.3	12.4	11.3	3.7	9.3	10.5
Cyanide	--	20440	--	--	--	--	--	--
Iron	20800	306600	5580	6680	16200	1080	10700	11100
Lead	10.3	--	17.7	22.4	5.3	4.3	6.8	11.1
Magnesium	939	--	225	506	190	90.3	2120	1640
Manganese	445	20440	21.2	35.4	7.1	6.8	158	143
Murcury	0.08	--	0.044 K	0.029	0.017	0.011	0.011	0.014
Nickel	8.2	20440	3.1	4.8	3.6	0.81	8.7	5.7
Potassium	494	--	256	364	435	94.8	356	423
Selenium	0.2	5110		--	--	--	--	--
Silver	0.06	5110		--	--	--	--	--
Sodium	404	--	57.5	--	--	--	--	--
Thallium	0.15	72		--	--	--	--	--
Vanadium	35.3	1022	17.3	17	36.7	2.7	14.9	17
Zinc	24.9	306600	62.4 J	35.7	9.3	8.3	22.5	27.3
VOCs (mg/kg)								
Acetone	0.01	919,800	--	--	--	--	--	--
2-Butanone	0.002	613,200	--	--	--	--	--	--
Benzene	0.002	52	--	--	--	--	--	--
Chlorobenzene	0.002	20,440	--	--	--	--	--	--
Ethylbenzene	0.002	1,022,000	0.001 J	--	--	--	--	--
Toluene	0.002	204,400	--	--	--	--	--	--
Xylene (total)	0.0045	204,400	0.0023	--	--	--	--	--
SVOCs (mg/kg)								
Butyl benzyl phthalate	0.083	1,506	0.282	--	--	--	--	--
Carbazole	0.033	143	0.0453 J	--	--	--	--	--
1,4-Dichlorobenzene	0.005	119	--	--	--	--	--	--
Di-n-butyl phthalate	0.083	--	0.237	--	--	--	--	--
Di-n-octyl phthalate	0.17	--	--	--	--	--	--	--
Dibenzofuran	0.033	12	0.0231 J	--	--	--	--	--
Diethyl phthalate	0.083	817,600	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	0.17	204	0.657	--	--	0.12	--	0.17
3&4-Methylphenol	0.066	5,110	0.0712 J	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
B - Indicates the compound or element was analyzed for but not detected substantially above the level reported in the laboratory or field blank.
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Pluses (+) indicate that the analyte is present above the MCL screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria Maximum Background or DL (ug/kg)	Industrial RBC (mg/kg)	Trench 6 TR6B SUBSURF 7 7.5 CSO 1/23/2004	SS-ASP-1 SB-ASP-1A SUBSURF 0.5 2 CSO 12/16/2003	SS-ASP-1 SB-ASP-1B SUBSURF 3.5 5 CSO 12/16/2003	SS-ASP-2 SB-ASP-2A SUBSURF 0.5 2.5 CSO 12/16/2003	SS-ASP-3 SB-ASP-3A SUBSURF 0.5 2 CSO 12/16/2003	SS-ASP-3 SS-ASP-3AX SUBSURF 0.5 2 CSO 12/16/2003
PAH (mg/kg)								
Acenaphthene	0.067	61,320	0.011	--	--	--	--	--
Anthracene	0.033	306,600	--	--	--	--	--	--
Benzo(a)anthracene	0.013	--	0.0104	--	--	--	--	--
Benzo(a)pyrene	0.013	392	0.0099	0.0087	--	--	--	--
Benzo(b)fluoranthene	0.013	3.92	0.015	0.0183	--	--	--	0.0106
Benzo(g,h,i)perylene	0.013	--	--	--	--	--	--	--
Benzo(k)fluoranthene	0.013	39.2	--	--	--	--	--	--
Chrysene	0.013	392	0.0106	0.009	--	--	--	--
Dibenzo(a,h)anthracene	0.013	0	--	--	--	--	--	--
Fluoranthene	0.033	40,880	0.0205	0.01	--	--	--	0.009
Fluorene	0.033	40,880	0.0115	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	0.013	20,440	--	--	--	--	--	--
2-Methylnaphthalene	0.033	4,088	--	--	--	--	--	--
Naphthalene	0.033	20,440	0.101	--	--	--	--	--
Phenanthrene	0.033	--	0.0266	--	--	--	--	--
Pyrene	0.033	30,660	0.0159	0.0111	--	--	--	0.0083
PCBs (mg/kg)								
Aroclor 1221	0.013	1.43	--	--	--	--	--	--
Aroclor 1242	0.0083	1.43	--	--	--	--	--	--
Aroclor 1248	0.0083	1.43	--	--	--	--	--	--
Aroclor 1254	0.0083	1.43	--	--	--	--	--	--
Aroclor 1260	0.0083	1.43	--				--	--
Pesticides (mg/kg)								
alpha-Chlordane	0.00066	--	--	--	--	--	--	--
gamma-Chlordane	0.00066	--	--	--	--	--	--	--
4,4'-DDD	0.00066	--	--	--	--	--	--	--
4,4'-DDE	0.00066	8	--	--	--	--	--	--
4,4'-DDT	0.00066	8	--	--	--	--	--	--
Dieldrin	0.003	0.17	--	--	--	--	--	--
Methoxychlor	0.0013	5,110	--	--	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria Maximum Background or DL (ug/kg)	Screening Criteria Industrial RBC (mg/kg)	SS-ASP-4 SS-ASP-4A SUBSURF 0.5 2 CSO 12/16/2003	SS-ASP-4 SS-ASP-4B SUBSURF 3.5 5 CSO 12/16/2003	SS-ASP-5 SS-ASP-5A SUBSURF 0.5 2 CSO 12/17/2003	SS-ASP-6 SS-ASP-6A SUBSURF 0.5 2 CSO 12/17/2003
Metals (mg/kg)						
Aluminum	6920	1022000	6640	4650	5940 L	5630 L
Antimony	0.15	408.8	--	--	--	--
Arsenic	0.25	1.9	1.1 L	°2 L	°2 L	°2.3 L
Barium	0.05	71540	17.3	10.4	16.4 L	28 L
Beryllium	0.543	2044.0	--	0.17	--	--
Cadmium	0.03	--	--	--	0.24 L	0.36 L
Calcium	606	--	88.3	57.4	216 L	960 L
Chromium	16.1	3066	8.3	12.7	10.7 L	15.6 L
Cobalt	20.7	20440	1.6	0.85	2.2 L	3.3 L
Copper	12.1	40880	7.5	12	10.5	15.5
Cyanide	--	20440	--	--	--	0.27 K
Iron	20800	306600	6320	8750	11300 L	7650 L
Lead	10.3	--	3.6	2.8	5.3 L	27 L
Magnesium	939	--	445	212	323 L	663 L
Manganese	445	20440	18.7	8.5	33.9 L	61 L
Mercury	0.08	--	0.0087		0.019	0.03
Nickel	8.2	20440	3.5	3.3	4.5 L	6.7 L
Potassium	494	--	251	286	324 L	447 L
Selenium	0.2	5110	--	--	--	--
Silver	0.06	5110	--	--	--	--
Sodium	404	--	--	--	--	--
Thallium	0.15	72	--	--	--	--
Vanadium	35.3	1022	14.1	19	20.9 L	19.2 L
Zinc	24.9	306600	9.3	6.9	18	44.7
VOCs (mg/kg)						
Acetone	0.01	919,800	--	--	--	--
2-Butanone	0.002	613,200	--	--	--	--
Benzene	0.002	52	--	--	--	--
Chlorobenzene	0.002	20,440	--	--	--	--
Ethylbenzene	0.002	1,022,000	--	--	--	--
Toluene	0.002	204,400	--	--	--	--
Xylene (total)	0.0045	204,400	--	--	--	--
SVOCs (mg/kg)						
Butyl benzyl phthalate	0.083	1,506	--	--	--	--
Carbazole	0.033	143	--	--	--	--
1,4-Dichlorobenzene	0.005	119	--	--	--	--
Di-n-butyl phthalate	0.083	--	--	--	--	--
Di-n-octyl phthalate	0.17	--	--	--	--	--
Dibenzofuran	0.033	12	--	--	--	--
Diethyl phthalate	0.083	817,600	--	--	--	--
bis(2-Ethylhexyl)phthalate	0.17	204	0.218	0.163	--	0.0519 J
3&4-Methylphenol	0.066	5,110	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL- Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

TABLE 4-10
SUMMARY OF DETECTIONS IN SUB-SURFACE SOIL AT THE CSL AND ASP

Sample Location Field Sample ID Site Type Start Depth (ft bgs) End Depth (ft bgs) Media Collection date	Screening Criteria		SS-ASP-4 SS-ASP-4A SUBSURF 0.5 2 CSO 12/16/2003	SS-ASP-4 SS-ASP-4B SUBSURF 3.5 5 CSO 12/16/2003	SS-ASP-5 SS-ASP-5A SUBSURF 0.5 2 CSO 12/17/2003	SS-ASP-6 SS-ASP-6A SUBSURF 0.5 2 CSO 12/17/2003
	Maximum Background or DL (mg/kg)	Industrial RBC (mg/kg)				
PAH (mg/kg)						
Acenaphthene	0.067	61,320	--	--	--	--
Anthracene	0.033	306,600	--	--	--	--
Benzo(a)anthracene	0.013	--	--	--	0.0249	--
Benzo(a)pyrene	0.013	392	--	--	0.0363	--
Benzo(b)fluoranthene	0.013	3.92	--	--	0.0512	--
Benzo(g,h,i)perylene	0.013	--	--	--	0.0205	--
Benzo(k)fluoranthene	0.013	39.2	--	--	0.0217	--
Chrysene	0.013	392	--	--	0.0356	--
Dibenzo(a,h)anthracene	0.013	0	--	--	--	--
Fluoranthene	0.033	40,880	--	--	0.0454	--
Fluorene	0.033	40,880	--	--	--	--
Indeno(1,2,3-cd)pyrene	0.013	20,440	--	--	0.0195	--
2-Methylnaphthalene	0.033	4,088	--	--	--	--
Naphthalene	0.033	20,440	--	--	--	--
Phenanthrene	0.033	--	--	--	0.0094	--
Pyrene	0.033	30,660	--	--	0.0354	--
PCBs (mg/kg)						
Aroclor 1221	0.013	1.43	--	--	--	--
Aroclor 1242	0.0083	1.43	--	--	--	--
Aroclor 1248	0.0083	1.43	--	--	--	--
Aroclor 1254	0.0083	1.43	--	--	--	--
Aroclor 1260	0.0083	1.43	--	--	--	--
Pesticides (mg/kg)						
alpha-Chlordane	0.00066	--	--	--	--	--
gamma-Chlordane	0.00066	--	--	--	--	--
4,4'-DDD	0.00066	--	--	--	--	0.0072 J
4,4'-DDE	0.00066	8	--	--	--	0.0027 J
4,4'-DDT	0.00066	8	--	--	--	--
Dieldrin	0.003	0.17	--	--	--	0.0013 J
Methoxychlor	0.0013	5,110	--	--	--	--

NOTES:
Only detected analytes are included on this table. For full data set, see the appropriate appendix.

RBC - Risk-Based Concentration
DL - Detection Limit
Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.

Data Qualifiers:
L - Indicates reported value may be biased low
K - Indicates the reported value may be biased high.
J - Indicates an estimated value

Dashes (- -) indicate that no screening level standard (e.g., RBC) exists or that the analyte is present below the detection limits.
Circles (°) indicate that the analyte is present above the RBC screening level and maximum background level.
Asterisks (*) indicate that the analyte is present above the RBC screening level but below the DL or maximum background level.

Table 6-1
USEPA Region III RBCs for Chemicals Detected at Ft. Meade, CSLF Site

Chemical	USEPA Region III RBC				
	Industrial Soil (a) (organics - mg/kg; inorganics - mg/kg)	Residential Soil (b) (organics - mg/kg; inorganics - mg/kg	Sediment (c) (organics - mg/kg; inorganics - mg/kg	Tap Water (d) (µg/L)	Tap Water (e) (µg/L)
Organics					
Acenaphthene	6.1E+03	4.7E+02	4.7E+03	---	---
Acenaphthylene (f)	---	---	2.3E+03	---	---
Acetone	9.2E+04	7.0E+03	7.0E+04	5.5E+02	5.5E+03
Anthracene	3.1E+04	2.3E+03	2.3E+04	---	---
Aroclor 1221	1.4E+00	3.2E-01	3.2E-01	---	---
Aroclor 1242	1.4E+00	3.2E-01	3.2E+00	---	---
Aroclor 1248	1.4E+00	3.2E-01	---	---	---
Aroclor 1254	1.4E+00	1.6E-01	---	---	---
Aroclor 1260	1.4E+00	3.2E-01	3.2E+00	---	---
Benzene	5.2E+01	---	---	3.4E-01	---
Benzo(a)anthracene	3.9E+00	8.7E-01 (2.2E-01)	8.7 E+00 (2.2E+00)	---	---
Benzo(a)pyrene	3.9E-01	8.7E-02 (2.2E-02)	8.7E-01 (2.2E-01)	---	---
Benzo(b)fluoranthene	3.9E+00	8.7E-01 (2.2E-01)	8.7E+00 (2.2E+00)	---	---
Benzo(g,h,i)perylene (f)	3.1E+03	3.3E+02	2.4E+03	---	---
Benzo(k)fluoranthene	3.9E+01	8.7E+01 (2.2E+00)	8.7E+01 (2.2E+01)	---	---
bis(2-Ethylhexyl)phthalate	2.0E+02	4.6E+01	4.6E+02	4.8E+00	---
2-Butanone	---	4.7E+03	4.7E+04	7.0E+02	---
Butyl benzyl phthalate	1.5E+03	1.6E+03	---	---	---
Di-n-butyl phthalate	1.0E+04	7.8E+03	---	---	---
Carbazole	1.4E+02	3.2E+01	---	---	---
Carbon disulfide	---	---	---	1.0E+02	---
Carbon tetrachloride	---	---	---	1.6E-01	---
alpha-Chlordane (g)	8.2E+00	1.8E+00	---	---	---
gamma-Chlordane (g)	8.2E+00	1.8E+00	---	---	---
Clorobenzene	2.0E+03	1.6E+02	---	1.1E+01	---
Chloroethane	---	---	---	3.6E+00	---
Chloroform	---	---	---	1.5E-01	---
Chrysene	3.9E+02	8.7E+01 (2.2E+01)	8.7E+02 (2.2E+02)	---	---
2,4-D	---	---	---	3.7E+01	---
4,4'-DDD	1.2E+01	2.7E+00	2.7E+01	---	---
4,4'-DDE	8.4E+00	1.9E+00	1.9E+01	---	---
4,4'-DDT	8.4E+00	1.9E+00	1.9E+01	---	---
Dibenz(a,h)anthracene	3.9E-01	8.7E-02 (2.2E-02)	8.7E-01 (2.2E-01)	---	---
Dibenzofuran	2.0E+02	(NRA)	(NRA)	---	---
1,2-Dichlorobenzene	---	---	---	2.7E+01	---
1,4-Dichlorobenzene	1.2E+02	2.7E+01	---	4.7E-01	---
1,1-Dichloroethane	---	---	---	9.0E+01	---
cis-1,2-Dichloroethene	---	---	---	6.1E+00	---
trans-1,2-Dichloroethene	---	---	---	1.1E+01	---
Dieldrin	1.8E-01	4.0E-02	---	4.2E-02	---
Diethyl phthalate	8.2E+04	6.3E+03	---	2.9E+03	---
2,4-Dimethylphenol	---	---	---	7.3E+01	---
1,3-Dinitrobenzene	1.0E+01	7.8E-01	---	---	---
2-amino-4,6-Dinitrotoluene (h)	2.0E+02	1.6E+01	---	---	---
4-amino-2,6-Dinitrotoluene (h)	2.0E+02	1.6E+01	---	---	---
Ethylbenzene	1.0E+04	7.8E+02	7.8E+03	1.3E+02	---
Fluoranthene	4.1E+03	3.1E+02	3.1E+03	---	---
Fluorene	4.1E+03	3.1E+02	---	---	---
Hexachlorobenzene	1.8E+00	4.0E-01	---	---	---
Indeno(1,2,3-c,d)pyrene	3.9E+00	8.7E-01 (2.2E-01)	8.7E+00 (2.2E+00)	---	---
Methoxychlor	5.1E+02	3.9E+01	---	---	---
2-Methylnaphthalene	4.1E+02	3.1E+01	3.1E+02	2.4E+01	---
3&4-Methylphenol	5.1E+02	3.9E+01	---	1.8E+01	---
Methyl tert-butyl ether	---	---	---	2.6E+00	---
Naphthalene	2.0E+03	1.6E+02	1.6E+03	6.5E-01	---
di-n-Octyl phthalate	4.1E+03	(NRA)	---	---	---
Perchlorate	---	---	---	2.6E+00	---
Phenanthrene (f)	3.1E+03	2.3E+02	2.3E+03	1.8E+02	---
Phenol	4.7E+03	2.3E+03	2.3E+04	1.1E+03	---
Pyrene	3.1E+03	2.3E+02	2.3E+03	---	---
Tetrachloroethene	---	---	---	1.0E-01	---
Toluene	---	6.3E+02	1.6E+04 (6.3E+03)	7.5E+01 (2.3E+02)	---
2,4,5-TP	---	---	---	2.9E+01	---
Trichloroethene	---	---	---	2.6E-02	---
2,4,6-Trinitrotoluene	9.5E+01	3.9E+00	---	---	---
Xylenes (total)	2.0E+04	1.6E+03	---	2.1E+01	---
Inorganics					
Aluminum	1.0E+05	(NRA)	7.8E+04 (NRA)	3.7E+03	3.7E+04
Antimony	---	---	---	---	1.5E+01

Table 6-1
USEPA Region III RBCs for Chemicals Detected at Ft. Meade, CSLF Site

Chemical	USEPA Region III RBC				
	Industrial Soil (a) (organics - mg/kg; inorganics - mg/kg)	Residential Soil (b) (organics - mg/kg; inorganics - mg/kg	Sediment (c) (organics - mg/kg; inorganics - mg/kg	Tap Water (d) (µg/L)	Tap Water (e) (µg/L)
Arsenic	1.9E+00	4.3E-01	4.3E+00	4.5E-02	---
Barium	2.0E+04	1.6E+03	5.5E+03 (1.6E+04)	2.6E+02 (7.3E+02)	2.6E+03 (7.3E+03)
Beryllium	2.0E+02	1.6E+01	1.6E+02	7.3E+00	---
Cadmium (i)	1.0E+02	7.8E+00	---	1.8E+00	---
Calcium	NRA	NRA	NRA	NRA	NRA
Chromium (j)	3.1E+02	2.3E+01	2.3E+02	1.1E+01	1.0E+02
Cobalt	2.0E+03	(NRA)	1.6E+03 (NRA)	7.3E+01	7.3E+02
Copper	4.1E+03	3.1E+02	3.1E+03	1.5E+02	---
Cyanide	2.0E+03	1.6E+02	1.6E+03	7.3E+01	---
Iron	3.1E+04	2.3E+03	2.3E+04	1.1E+03	3.0E+02
Lead (k)	4.0E+02	4.0E+02	4.0E+02	1.5E+01	1.5E+01
Magnesium	NRA	NRA	NRA	NRA	NRA
Manganese (l)	2.0E+03	1.6E+02	1.6E+03	7.3E+01	7.3E+02
Mercury (m)	3.1E+01	2.3E+00	7.8E+00	1.1E+00	---
Nickel	2.0E+03	1.6E+02	1.6E+03	7.3E+01	7.3E+02
Potassium	NRA	NRA	NRA	NRA	NRA
Selenium	---	---	---	1.8E+01	---
Silver	5.1E+02	3.9E+01	3.9E+02	1.8E+02	1.8E+02
Sodium	NRA	NRA	NRA	NRA	NRA
Thallium	7.2E+00	5.5E-01	5.5E+00	2.6E-01	---
Vanadium	1.0E+02	7.8E+00	7.8E+01	3.7E+00	3.7E+01
Zinc	3.1E+04	2.3E+03	2.3E+04	1.1E+03	1.1E+04

(a) USEPA Region III industrial soil RBCs are used as screening values for soil (USEPA, 2005a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1, following USEPA Region III guidance.

(b) USEPA Region III residential soil RBCs are used as screening values for soil (USEPA, 2006). RBCs for carcinogenic chemicals are conservatively based on a hazard quotient of 1. Value in parentheses indicates October 2006 residential value, if different from the 2005 value.

(c) USEPA Region III residential soil RBCs are used as screening values for sediment (USEPA, 2005a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1 and carcinogenic chemicals are based on a risk of $1x10^{-6}$, following USEPA Region III guidance. The RBCs for noncarcinogenics were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for sediment. Value in parentheses indicates October 2006 residential value, if different from the 2005 value.

(d) USEPA Region III tap water RBCs are used as screening values for ground water (USEPA, 2005a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1.

(e) USEPA Region III tap water RBCs are used as screening values for surface water (USEPA, 2005a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1 and a carcinogenic risk of $1x10^{-6}$, following USEPA Region III guidance. The RBCs for noncarcinogens were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for surface water.

(f) The RBC for pyrene was used for non-carcinogenic polynuclear aromatic hydrocarbons (PAHs) lacking RBCs.

(g) The RBC for chlordane was used.

(h) The RBC for aminodinitrotoluenes was used.

(i) For soil, the RBC for water was used because it is a more conservative value. For groundwater, the tap water RBC for water was used.

(j) The RBC for chromium VI was used as the screening criterion, although not all of the chromium at the site will be in this form.

(k) Because lead does not have an RBC, the 400 mg/kg residential screening level (USEPA, 1994a) was used for soil. The drinking water action level (15 ug/L) was used as the screening criterion for water (USEPA, 1996d).

(l) The RBC for non-food was used.

(m) For soil, the RBC for mercury chloride was used. For sediment, the RBC for methylmercury was used.

NRA = No RBC Available.

--- = The chemical was either not tested for or not detected in this media.

Table 6-2
CSLF Sample Groupings

ON-SITE SURFACE SOIL			
CSLF	SB-ASP-1A	SS-3X	SS-ASP-5
	SB-ASP-2A	SS-4	SS-ASP-6
	SB-ASP-3A	SS-5	SS-CELL 3-1
	SB-ASP-3AX	SS-6	SS-CELL 3-2
	SB-ASP-4A	SS-7	SS-CELL 3-3
	SB-ASP-5A	SS-8	SS-CELL 3-3X
	SB-ASP-6A	SS-ASP-1	SS-CELL 3-4
	SS-1	SS-ASP-2	SS-CELL 3-5
	SS-2	SS-ASP-3	SS-CELL3-6
	SS-3	SS-ASP-4	
ON-SITE SUBSURFACE SOIL			
CSLF	SB-ASP-1B	TR-2B	TR-4B
	SB-ASP-4B	TR-3A	TR-5A
	TR-1A	TR-3B	TR-5B
	TR-1B	TR-4A	TR-6A
	TR-2A	TR-4AX	TR-6B
ON-SITE SEDIMENT			
CSLF	SED-1	SED-3	
	SED-2	SED-4	
ON-SITE DOWNGRADIENT SEDIMENT			
CSLF	SED-5		
	SED-6		
ON-SITE SURFACE WATER			
CSLF	SW-1	SW-3	SW-4X
	SW-2	SW-4	
ON-SITE DOWNGRADIENT SURFACE WATER			
CSLF	SW-5		
	SW-6		
ON-SITE GROUNDWATER			
CSLF (Upper Patapsco)	MW-10S	MW-14	MW-2S
	MW-127S	MW-17	MW-5
	MW-128S	MW-18	MW-7S
	MW-12S	MW-19	MW-8
	MW-13S	MW-20	
CSLF (Lower Patapsco)	MW-101D	MW-115D	MW-13DX
	MW-114D	MW-12D	MW-2D
	MW-114DX	MW-13D	MW-7D
OFF-SITE GROUNDWATER			
CSLF (Upper Patapsco)	MW-105	MW-107	MW-124S
	MW-106	MW-123S	
CSLF (Lower Patapsco)	MW-108D	MW-112D	MW-125d-0305
	MW-109D	MW-116D	MW-126D
	MW-110D	MW-116DX	MW-126d-0305
	MW-111D	MW-125D	

Table 6-3
Summary of Chemicals of Potential Concern at the CSLF

Chemical (a)	Surface Soil - Industrial screen	Total Soil - Industrial screen	Surface Soil - Residential screen	Total Soil - Residential screen	On-Site Sediment	Down-Gradient Sediment[b]	On-Site Surface Water	Down-Gradient Surface Water[b]	On-Site Groundwater (Upper Patapsco)	On-Site Groundwater (Lower Patapsco)	Off-Site Groundwater (Upper Patapsco)	Off-Site Groundwater (Lower Patapsco)
Organics												
Acenaphthene												
Acenaphthylene												
Acetone												
Anthracene												
Aroclor 1221				X								
Aroclor 1242		X		X								
Aroclor 1248												
Aroclor 1254												
Aroclor 1260												
Benzene									X			
Benzo(a)anthracene				X								
Benzo(a)pyrene			X	X								
Benzo(b)fluoranthene				X								
Benzo(g,h,i)perylene												
Benzo(k)fluoranthene												
bis(2-Ethylhexyl)phthalate									X		X	X
2-Butanone												
Butyl benzyl phthalate												
Di-n-butyl phthalate												
Carbazole												
Carbon disulfide												
Carbon tetrachloride										X		X
alpha-Chlordane												
gamma-Chlordane												
Clorobenzene									X			
Chloroethane									X			
Chloroform										X	X	X
Chrysene												
2,4-D												
4,4'-DDD												
4,4'-DDE												
4,4'-DDT												
Dibenz(a,h)anthracene				X								
Dibenzofuran				X								
1,4-Dichlorobenzene									X			
1,1-Dichloroethane												
cis-1,2-Dichloroethene												X
trans-1,2-Dichloroethene												
Dieldrin												
Diethyl phthalate												
2,4-Dimethylphenol												
1,3-Dinitrobenzene												
2-amino-4,6-Dinitrotoluene												
4-amino-2,6-Dinitrotoluene												
Di-n-Octyl phthalate				X								
Endosulfan I												
Ethylbenzene												
Fluoranthene												
Fluorene												
Hexachlorobenzene												
Indeno(1,2,3-c,d)pyrene												
Methoxychlor												
2-Methylnaphthalene												

Table 6-3
Summary of Chemicals of Potential Concern at the CSLF

Chemical (a)	Surface Soil - Industrial screen	Total Soil - Industrial screen	Surface Soil - Residential screen	Total Soil - Residential screen	On-Site Sediment	Down-Gradient Sediment[b]	On-Site Surface Water	Down-Gradient Surface Water[b]	On-Site Groundwater (Upper Patapsco)	On-Site Groundwater (Lower Patapsco)	Off-Site Groundwater (Upper Patapsco)	Off-Site Groundwater (Lower Patapsco)
3&4-Methylphenol									X			
Methyl tert-butyl ether									X		X	
Naphthalene									X			
Perchlorate												
Phenanthrene												
Phenol									X			
Pyrene												
Tetrachloroethene										X		X
Toluene												
2,4,5-TP												
Trichloroethene										X		X
2,4,6-Trinitrotoluene												
Xylenes (total)												
Inorganics												
Aluminum			X	X			X		X	X	X	X
Antimony												
Arsenic	X	X	X	X	X				X			
Barium									X			X
Beryllium									X	X		
Cadmium									X	X		
Calcium												
Chromium			X	X					X	X	X	X
Cobalt			X	X					X	X		
Copper										X		
Cyanide												
Iron	X	X	X	X			X		X	X	X	X
Lead									X	X		X
Magnesium												
Manganese				X			X		X	X	X	X
Mercury												
Nickel									X	X		
Potassium												
Selenium												
Silver												
Sodium												
Thallium			X	X					X			X
Vanadium			X	X					X	X	X	X
Zinc												

(a) Chemicals detected in all media at the CSLF.
(b) No COPCs were identified for this medium.
Shaded cells indicate that the chemical lacks toxicity criteria and cannot be quantitatively evaluated.
X = Selected as a COPC.

Table 6-4

Chemical/Physical Parameters Used for Ambient Air Model[a]

Chemical of Potential Concern	Henry's Law Constant[b]	Effective Diffusivity Coefficient from Groundwater to Soil[c]	Effective Diffusivity Coefficient in Capillary Fringe[c]	Effective Diffusivity Coefficient in Soil[c]	Diffusion Coefficient in Air[b]	Diffusion Coefficient in H_2O[b]	Volatilization Factor[c]
Symbol:	(H)	(Deffws)	(Deffcap)	(Deffs)	(Dair)	(Dwat)	(VFamb)
Units:	$\frac{cm^3\text{-}H2O}{cm^3\text{-}Air}$	(cm^2/sec)	(cm^2/sec)	(cm^2/sec)	cm^2/sec	cm^2/sec	$\frac{mg/m^3\text{-}Air}{mg/L\text{-}H2O}$
Benzene	2.30E-01	0.001	0.000020	0.0069	8.80E-02	9.80E-06	7.53E-04
Chlorobenzene	1.50E-01	0.001	0.000021	0.0057	7.30E-02	8.70E-06	4.98E-04
Chloroethane	4.50E-01	0.001	0.000018	0.0078	1.00E-01	1.20E-05	1.40E-03
1,4 Dichlorobenzene	1.00E-01	0.0012	0.000024	0.0054	6.90E-02	7.90E-06	3.73E-04
MTBE	2.40E-02	0.0029	0.0001	0.0062	8.00E-02	1.00E-05	2.29E-04
Naphthalene	2.00E-02	0.0024	0.000081	0.0046	5.90E-02	7.50E-06	1.54E-04

(a) Based on ASTM method for estimating outdoor air vapor concentration from groundwater (ASTM, 1994).

(b) Based on chemical-specific data given in the "Intercalc tables" for physical and chemical properties. USEPA Region IX Preliminary Remediation Goal (PRG) tables (USEPA, 2004).

(c) Calculated value.

Table 6-5
Chemical/Physical Parameters Used for the Shower Model[a]

Chemical of Potential Concern	Molecular Weight[b] g/mol)	Henry's Law Constant[b] (atm-m^3/mol)
Benzene	78.1	5.56E-03
Carbon Tetrachloride	153.80	3.05E-02
Chlorobenzene	110.0	3.73E-03
Chloroethane	65.0	1.10E-02
Chloroform	119.40	3.66E-03
1,4-Dichlorobenzene	150.0	2.40E-03
cis-1,2-Dichloroethene	96.94	4.07E-03
Methyl tert-butyl ether	88.15	5.87E-04
Naphthalene	128.0	4.83E-04
Tetrachloroethene	165.85	1.84E-02
Trichloroethene	131.29	1.03E-02

(a) Values were used to estimate shower room concentrations of VOCs (Foster and Chrostowski, 1987).

(b) Based on chemical-specific data given in the "Intercalc tables" for physical and chemical properties. USEPA Region IX Preliminary Remediation Goal (PRG) tables (USEPA, 2004).

Table 6-6
Chemical/Physical Parameters Used for the Dermal Pathway for Surface Water and Groundwater Exposures

Chemical	Dermal Permeability Coefficient (Kp) (a) (cm/hr)	Molecular Weight (g/mol)	log K_{ow} (---)	Tau (hr)	t* (hr)	B (---)	Dsc (cm^2/hr)	Fraction Absorbed FA
Organics:								
Benzene	1.5E-02	78.1	2.13	2.90E-01	7.00E-01	1.00E-01	6.36E-07	1.0E+00
Bis(2-ethylhexyl)phthalate	2.5E-02	391	5.11	1.62E+01	3.90E+01	1.84E-01	7.85E-09	8.0E-01
Carbon tetrachloride	1.6E-02	153.8	2.83	7.63E-01	1.83E+00	7.67E-02	2.20E-07	1.0E+00
Chlorobenzene	2.8E-02	112.6	2.84	4.60E-01	1.09E+00	1.00E-01	3.92E-07	1.0E+00
Chloroethane	6.1E-03	64.5	1.43	2.40E-01	5.90E-01	0.00E+00	7.70E-07	1.0E+00
Chloroform	6.8E-03	119.4	1.97	4.90E-01	1.18E+00	2.85E-02	3.56E-07	1.0E+00
1,4-Dichlorobenzene	4.2E-02	147	3.39	7.10E-01	1.71E+00	2.00E-01	2.42E-07	1.0E+00
cis-1,2-Dichloroethene	7.7E-03	96.9	1.86	3.66E-01	8.79E-01	2.91E-02	4.89E-07	1.0E+00
3&4 Methylphenol (b)	7.6E-03	108.1	1.95	4.30E-01	1.03E+00	0.00E+00	4.17E-07	1.0E+00
Methyl tert-butyl ether	2.1E-03	88.5	0.94	3.29E-01	7.89E-01	7.64E-03	5.50E-07	1.0E+00
Naphthalene	4.7E-02	128.2	3.3	5.60E-01	1.34E+00	2.00E-01	3.15E-07	1.0E+00
Phenol	4.3E-03	94.11	1.46	3.60E-01	8.60E-01	0.00E+00	5.08E-07	1.0E+00
Tetrachloroethene	3.3E-02	165.8	3.4	8.91E-01	2.14E+00	1.62E-01	1.86E-07	1.0E+00
Trichloroethene	1.2E-02	131.4	2.42	5.72E-01	1.37E+00	5.08E-02	3.01E-07	1.0E+00
Inorganics:								
Aluminum	1.0E-03	NU	NU	NU	NU	NU	NU	NU
Barium	1.0E-03	NU	NU	NU	NU	NU	NU	NU
Beryllium	1.0E-03	NU	NU	NU	NU	NU	NU	NU
Cadmium	1.0E-03	NU	NU	NU	NU	NU	NU	NU
Chromium VI	2.0E-03	NU	NU	NU	NU	NU	NU	NU
Cobalt	4.0E-04	NU	NU	NU	NU	NU	NU	NU
Iron	1.0E-03	NU	NU	NU	NU	NU	NU	NU
Lead	1.0E-04	NU	NU	NU	NU	NU	NU	NU
Manganese	1.0E-03	NU	NU	NU	NU	NU	NU	NU
Nickel	2.0E-04	NU	NU	NU	NU	NU	NU	NU
Thallium	1.0E-03	NU	NU	NU	NU	NU	NU	NU
Vanadium	1.0E-03	NU	NU	NU	NU	NU	NU	NU

(a) Permeability coefficients were used to evaluate dermal exposures to water. For organics, Kp, Tau, t*, B, and DSC were estimated using molecular weights and log K_{ow}s presented in this table (USEPA, 2004a). Permeability coefficients for inorganics were default values obtained from USEPA (2004a).
(b) Kp value is based on 4-Methylphenol
NU = Not used.

TABLE 6-7
RAGS D IEUBK LEAD WORKSHEET
CSLF, Fort Meade
Child (Age 0 – 84 Months), Exposure to On-Site Soil and Groundwater (Upper Patapsco)

1. Lead Screening Questions

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	17.2	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level
Water	3.94	ug/L	Average Detected Value	15	ug/L	Recommended Drinking Water Action Level

2. Lead Model Questions

Question	Response for Residential Lead Model
What lead model (version and date was used?	Lead Model for Windows, Version 1.0 Build 263
Where are the input values located in the risk assessment report?	Located in IEUBKwin OUTPUT (Attached)
What range of media concentrations were used for the model?	3.3 – 16.3 ug/L (groundwater)
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Arithmetic Mean Concentrations; Data are Located in OUTPUT
Was soil sample taken from top 2 cm? If not, why?	Soil samples represent surface and subsurface soil (i.e., total soil).
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	N/A
What was the point of exposure/location?	On-Site Groundwater (Upper Patapsco)
Where are the output values located in the risk assessment report?	IEUBKwin OUTPUT (Attached)
Was the model run using default values only?	No – Assumed site-specific arithmetic mean concentrations of lead in soil and water.
Was the default soil bioavailability used?	Yes -- Default is 30%
Was the default soil ingestion rate used?	Yes -- Default values for 7 age groups are 85, 135, 135, 100, 090, and 85 mg/day
If non-default values were used, where is the rationale for the values located in the risk assessment report?	Located in Section 6.5

3. Final Result

Medium	Result	Comment/PRG [1]
Groundwater	Input value of 3.94 ug/L in water results in 0.009% of children above a blood lead level of 10 ug/dL. Geometric mean blood lead = 1.73 ug/dL. This is below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 ug/dL blood lead.	PRG not calculated.

1. Attach the IEUBK text output file and graph upon which the PRG was based as an appendix. For additional information, see www.epa.gov/superfund/programs/lead