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Feasibility Study Report

Site 57 - Building 292 TCE Contamination

Naval Support Facility, Indian Head

Indian Head, Maryland

VOLUME I - TEXT

Naval Facilities Engineering Command
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FEASIBILITY STUDY REPORT
SITE 57 - BUILDING 292 TCE CONTAMINATION

NAVAL SUPPORT FACILITY, INDIAN HEAD
INDIAN HEAD, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
AASHTO	American Association of State Highway and Transportation Officials
ARAR	Applicable or Relevant and Appropriate Requirements
AS	air sparging
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BOD	biochemical oxygen demand
B&R	Brown and Root
btoc	below top of casing
CAA	Clean Air Act
CAMU	corrective action management unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/sec	centimeter per second
COC	chemical of concern
COD	chemical oxygen demand
COMAR	Code of Maryland Regulations
COPC	chemical of potential concern
CP	cone penetrometer
CSF	cancer slope factor
CSM	Conceptual Site Model
CTO	Contract Task Order
CWA	Clean Water Act
DNAPL	dense non-aqueous-phase liquid
E.O.	Executive Order
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
°F	degrees Fahrenheit
FS	Feasibility Study
ft	feet, foot
GAC	granular activated carbon
gpm	gallons per minute
GIS	Geographic Information System
GRA	general response action

HI	Hazard Index
HRC®	Hydrogen Release Compound
IAS	Initial Assessment Study
IHDIV-NSWC	Indian Head Division, Naval Surface Warfare Center
ILCR	incremental lifetime cancer risk
iSOC	in-situ Submerged Oxygen Curtain
IW40	Industrial Wastewater Outfall 40
IW80	Induatrial Wastewater Outfall 80
kg	kilogram
K_h	horizontal hydraulic conductivity
LDR	land disposal restriction
LUC	land use control
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
msl	mean sea level
MW	monitoring well
NAAQS	National Ambient Air Quality Standards
NAD	North American Datum
NAVFAC	Naval Facilities Engineering Command
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSASP	Naval Support Activity, South Potomac
NSF-IH	Naval Support Facility, Indian Head
NSPS	New Source Performance Standards
O&M	operation and maintenance
ORC®	Oxygen Release Compound
OSWER	Office of Solid Waste and Emergency Response
PCB	polychlorinated biphenyl
P-CPT	piezoelectric cone penetration test
PRB	permeable reactive barrier
PRG	preliminary remediation goal
RAO	remedial action objective

RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
SB	soil boring
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TAL	Target Analyte List
TBC	to be considered
TCE	trichloroethene
TCL	Target Compound List
TOC	total organic carbon
TSD	treatment, storage, and disposal
TtNUS	Tetra Tech NUS, Inc.
TU	temporary unit
TW	temporary well
UIC	Underground Injection Control
USC	United States Code
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VOC	volatile organic compound

EXECUTIVE SUMMARY

This Feasibility Study (FS) Report for Naval Support Facility, Indian Head (NSF-IH), Indian Head, Maryland, was prepared by Tetra Tech NUS, Inc. in response to Contract Task Order (CTO) 007 of the Comprehensive Long-Term Environmental Action Navy (CLEAN), Contract Number N62472-03-D-0057. NSF-IH is a Naval Support Activity, South Potomac (NSASP) facility within the Naval District Washington Region. Until October 1, 2005, NSF-IH was referred to as Naval District Washington, Indian Head. The purpose of this FS Report is to develop and evaluate potential remedial alternatives to mitigate groundwater contamination at Site 57 [Building 292 Trichloroethene (TCE) Contamination]. Environmental studies of this site commenced in 1994. A Remedial Investigation (RI) Report prepared in July 2000 (TtNUS, 2000) presented the environmental data collected from the site and evaluated the data to determine the human health and environmental risks resulting from on-site contamination. Additional investigations conducted between August 2001 and October 2005 to fill data gaps and to collect data needed to evaluate potential remedial alternatives are discussed in this FS Report.

This FS develops remedial alternatives that address the risks from exposure to shallow groundwater identified in the RI Report. Soil contamination was addressed under a non-time-critical removal action. There are no unacceptable risks to human health and the environment associated with surface water and sediment. Risks to human health are associated with exposure to chlorinated volatile organic compounds (VOCs), primarily TCE, and diethyl ether in groundwater under a hypothetical future residential exposure scenario.

Alternative 1 is the no-action alternative, which is included to serve as a baseline against which other groundwater alternatives can be compared.

Alternative 2 would allow shallow groundwater contaminants to naturally attenuate. Monitoring would be conducted to evaluate the effectiveness of natural attenuation. Groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of potable water until clean-up goals were attained.

Alternative 3 provides for the injection of chemicals into the shallow groundwater to promote in-situ biological treatment (biodegradation). Monitoring would be conducted to evaluate the effectiveness of treatment. Short-term groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of potable water until clean-up goals were attained.

Alternative 4 provides for the installation of a permeable reactive barrier (PRB) that would remove contaminants as groundwater flows through the barrier. Monitoring would be conducted to evaluate the

effectiveness of the PRB. Groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of potable water until clean-up goals were attained.

Alternative 5 provides for the installation of extraction wells to remove contaminated groundwater. The groundwater would be treated using air stripping to remove contaminants, and treated groundwater would be discharged to Mattawoman Creek. Monitoring would be conducted to evaluate the effectiveness of extraction and treatment. Groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of potable water until clean-up goals were attained.

Table ES-1 summarizes the evaluation of groundwater alternatives and presents the costs for each alternative considered. The groundwater alternatives were developed and evaluated in accordance with the nine criteria required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

TABLE ES-1

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In-Situ Bioremediation
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Groundwater use restrictions and monitoring would reduce risks to human health and the environment.	Groundwater treatment and groundwater use restrictions would reduce risks to human health and the environment.
Compliance with ARARs			
Chemical-specific	Would not comply.	Would eventually comply.	Would comply.
Location-specific	Not applicable.	No ARARs.	No ARARs.
Action-specific	Not applicable.	Not applicable.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows uncontrolled risks to remain.	Groundwater use restrictions would reduce risks to human health. Monitoring and use restrictions would provide adequate and reliable controls. Removal of potential DNAPL could enhance effectiveness.	Treatment would be expected to be effective over the long term. Additional applications may be needed to completely degrade the chlorinated COCs. Removal of potential DNAPL and addition of proper bacteria could enhance effectiveness.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	In-situ biological treatment would reduce toxicity of hazardous substances in groundwater.

TABLE ES-1

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In-Situ Bioremediation
Primary Balancing Criteria (continued)			
Short-Term Effectiveness	Not applicable.	No impacts to community, workers, or environment. One month to implement. Approximately 70 years to attain clean-up goals. Potential DNAPL could increase time.	No impacts to community, workers, or environment. Short-term impacts on traffic during chemical injection. Two months to construct. May take several years to attain PRGs in Area 1, and could take longer to naturally attenuate Area 2. Potential DNAPL could increase time.
Implementability	Not applicable.	Groundwater use restrictions can be strictly enforced because site is located within a military facility.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.
Cost			
Capital	$0	$9,700	$541,000 (plus $182,000 for retreatment of Area 1 in Year 3)
Annual O&M	$0	$45,000 (plus $15,000 every 5 years)	$54,000 (Years 1 and 2), $53,000 (Years 3 to 6), $50,000 (Years 7 to 30) (plus $15,000 every 5 years)
Present worth	$0	$604,000	$1,358,000 (includes retreatment of Area 1 at 3 years)
Modifying Criteria			
State Acceptance	Not applicable.	To be determined.	To be determined.
Community Acceptance	Not applicable.	To be determined.	To be determined.

TABLE ES-1

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Threshold Criteria		
Overall Protection of Human Health and the Environment	Groundwater treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.	Groundwater extraction and treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs		
Chemical-specific	Would comply.	Would comply.
Location-specific	No ARARs.	No ARARs.
Action-specific	Can be designed to attain ARARs that apply.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions would provide adequate and reliable controls. Removal of potential DNAPL could enhance effectiveness.	Extraction and treatment would be effective over the long term. May be a point at which concentrations approach a constant value, and contaminant mass is no longer being removed at significant levels. Monitoring and use restrictions would provide adequate and reliable controls. Removal of potential DNAPL could enhance effectiveness.
Reduction of Toxicity, Mobility, or Volume through Treatment	Treatment using PRB would reduce toxicity of hazardous substances in groundwater.	Treatment using air stripping would reduce toxicity of hazardous substances prior to discharge to surface water.
Short-Term Effectiveness	No impacts to community, workers, or environment. Short-term impacts to traffic during PRB construction. Three months to construct. Need additional studies to evaluate time to achieve clean-up goals. Potential DNAPL could increase time.	No impacts to community, workers, or environment. Short-term impacts to traffic during installation of wells and piping. Five months to construct. Approximately 19 years to attain clean-up goals. Potential DNAPL could increase time.

TABLE ES-1

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Primary Balancing Criteria (continued)		
Implementability	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities. Requires NAVFAC Headquarters' approval.
Cost		
Capital	$782,000 (plus $334,000 in Year 15 for reactive medium replacement)	$470,000
Annual O&M	$31,500 (plus $15,000 every 5 years)	$79,000 (plus $15,000 every 5 years)
Present worth	$1,326,000 (includes barrier replacement at 15 years)	$1,308,000
Modifying Criteria		
State Acceptance	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.

ARARs Applicable or relevant and appropriate requirements.
COCs Chemicals of concern.
DNAPL Dense non-aqueous-phase liquid.
NAVFAC Naval Facilities Engineering Command.
O&M Operation and maintenance.
PRB Permeable reactive barrier.

1.0 INTRODUCTION

1.1 PURPOSE AND ORGANIZATION OF REPORT

This Feasibility Study (FS) Report has been prepared for Naval Facilities Engineering Command (NAVFAC) Washington by Tetra Tech NUS, Inc. (TtNUS) in response to Contract Task Order (CTO) 007 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62472-03-D-0057. The purpose of this FS is to develop and evaluate potential remedial alternatives to mitigate shallow groundwater contamination at Site 57, Building 292 Trichloroethene (TCE) Contamination, at the Naval Support Facility, Indian Head (NSF-IH), Indian Head, Maryland. NSF-IH is a Naval Support Activity, South Potomac (NSASP) facility within the Naval District Washington Region. Until October 1, 2005, NSF-IH was referred to as Naval District Washington, Indian Head. The FS Report summarizes information presented in the Remedial Investigation (RI) Report (TtNUS, 2000), presents and evaluates information collected after the RI Report was completed, and discusses the basis for remedial action that may be required at Site 57. In this report, remedial technologies and process options are evaluated and screened to select those that are most viable for the site conditions and contaminants. The technologies and process options that pass the screening are combined to form remedial alternatives to address site contamination. The remedial alternatives are also evaluated to distinguish positive and negative aspects of each alternative.

Section 1.0 summarizes background information, physical characteristics of the site, the nature and extent of contamination, the results of the human health and ecological risk assessments from the RI Report, and information collected after the RI Report was completed and provides the Conceptual Site Model (CSM). Section 2.0 presents the objectives and goals of remediation, including preliminary remediation goals (PRGs), chemicals of concern (COCs), and media of concern. Section 3.0 presents the identification and screening of technologies and process options. Section 4.0 presents the development and screening of alternatives. Section 5.0 presents the detailed analysis of alternatives. Section 6.0 presents the comparative analysis of alternatives.

1.2 FACILITY BACKGROUND

1.2.1 Location

NSF-IH is located in northwestern Charles County, Maryland. As shown on Figure 1-1, NSF-IH is located approximately 25 miles southwest of Washington, D.C. NSF-IH is a military facility consisting of the Main Area on the Cornwallis Neck Peninsula and the Annex on Stump Neck. The Main Area is bounded by the Potomac River to the northwest, west, and south, Mattawoman Creek to the south and east, and the

Town of Indian Head to the northeast (Figure 1-2). Stump Neck Annex is located across Mattawoman Creek and is not contiguous with the Main Area.

1.2.2 Mission

The primary mission of Indian Head Division, Naval Surface Warfare Center (IHDIV-NSWC), the main tenant at NSF-IH, is as follows:

- Provide services in energetics for all warfare centers through engineering, fleet, and operation support, manufacturing technology, limited production, and industrial base support.

- Provide research, development, testing, and evaluation of energetic materials, ordnance devices and components, and other related ordnance engineering standards including chemicals, propellants and their propulsion systems, explosives, pyrotechnics, warheads, and simulators.

- Provide support to all warfare centers, military departments, and the ordnance industry for special weapons, explosive safety, and ordnance environmental issues.

- Execute other responsibilities assigned by the Commander of the IHDIV-NSWC.

1.2.3 Meteorology

Indian Head experiences a modified, moist, humid, continental climate with warm and wet summers and cool winters. The Appalachian and Blue Ridge Mountain ranges to the west obstruct cold, continental air in the winter, and the Potomac River and Atlantic Ocean contribute to temperatures that are moderate and to high humidity. The mean temperature at Indian Head is 58 degrees Fahrenheit (°F) (NOAA, 1987). July is typically the warmest month, with an average temperature of 79°F. January is the coldest month, with an average temperature of 35°F. The area receives an average of approximately 39 inches of precipitation per year with approximately 17 inches of snow. Precipitation is uniformly distributed throughout the year.

1.2.4 Physiography and Topography

The Indian Head peninsula is located in the Atlantic Coastal Plain Physiographic Province, approximately 8 to 10 miles east of the Fall Line that marks the western extent of the physiographic province. Indian Head has gently rolling to undulating topography with elevations ranging from sea level to more than 100 feet above mean sea level (msl). The higher elevations are on the eastern portion of the facility, and the land surface generally slopes to the southwest and southeast. The portion of NSF-IH along the

Potomac River is characterized by 20- to 100-foot bluffs. The portion along Mattawoman Creek is more gently sloping.

1.2.5 Soils

The following is a brief description of the soil types in the Indian Head area, as classified by the United States Department of Agriculture (USDA) Soil Survey of Charles County, Maryland (USDA, 1974). The dominant soil series in this area are the Evesboro-Keyport-Elkton Association and the Beltsville-Gravelly Land-Bourne Association. The Evesboro-Keyport-Elkton Association consists of level to moderately sloping, excessively drained, sandy soils and moderately well-drained and poorly drained, level to gently sloping, loamy soils that have clayey subsoil. The Beltsville-Gravelly Land-Bourne Association consists of level or moderately sloping and moderately drained, deep, and dense loamy soils. Areas of cut-and-fill soils are also found. Cut-and-fill lands are areas where the native soils have been removed and graded or filled with other material or soil.

1.2.6 Geology

The geologic units underlying the Indian Head peninsula, in ascending stratigraphic order, are the Lower Cretaceous Potomac Group, the Tertiary-age Aquia Formation and Park Hall Formation, and several Quaternary fluvial and estuarine deposits (McCartan, 1989). Additional details on the geologic units are provided in Section 3.0 of the RI Report (TtNUS, 2000).

1.2.7 Hydrogeology

The Patapsco and Patuxent Formations of the Potomac Group are the main groundwater aquifers used for water supply purposes in the Indian Head area. Typical screen interval depths for supply wells vary from 150 to 500 feet below ground surface (bgs). The aquifers are separated by the Arundel Formation confining unit. Figure 1-3 presents a generalized cross-sectional view of the Indian Head area.

The three principal water-bearing zones within the Patapsco Formation are the Lower, Middle, and Upper Sands, all of which are under confined conditions. The Lower Sand crops out in Virginia, the Middle Sand crops out below the Potomac River and in Virginia, and the Upper Sand crops out beneath the Potomac River.

The water-bearing zones of the Patuxent Formation consist of laterally discontinuous sand lenses. The Patuxent Formation crops out in Virginia, where it is recharged by surface water.

Shallow, unconfined to semi-confined groundwater at the Indian Head peninsula occurs from near the ground surface to approximately 45 feet bgs, with water-table elevations ranging from sea level to approximately 65 feet above msl. Typically, shallow groundwater occurs in perched water-bearing zones and is recharged from infiltration. In some lowland areas, surface water intrusion may be an additional source of recharge of the shallow aquifer along the edge of water bodies and during periods of high tide. It is assumed that shallow groundwater flow follows topography and discharges into local water bodies.

The Lower and Middle Sands of the Patapsco Formation and the Patuxent Formation of the Potomac Group are the principal aquifers for domestic use at NSF-IH. The Upper Sands of the Patapsco Formation are poor producers of groundwater in the area and are not considered an important aquifer. The Upper Sands are considered a confining layer above the underlying Middle and Lower Sand aquifers in the area and below the shallow, small-scale, surficial water-bearing zones. The Middle Sand aquifer is believed to be hydraulically connected to the Potomac River where the river has eroded into the aquifer. Potomac River water may be partially recharging the aquifer in this area because of the heavy pumping of supply wells in the area (Hiortdahl, 1990).

1.2.8 Surface Water

The two principal waterways near the Indian Head peninsula are the Potomac River and Mattawoman Creek. The Potomac River is a tidally influenced estuary and is slightly brackish. Mattawoman Creek is a tributary to the Potomac River and is tidally influenced. Tidal marshes exist along Mattawoman Creek.

Wastewater from NSF-IH is discharged directly to the Potomac River or Mattawoman Creek and from outfalls to tributaries of the Potomac River or Mattawoman Creek. The wastewater consists of industrial, sanitary, and storm effluents or combinations thereof (Hart, 1983).

1.2.9 Population and Land Use

According to the Indian Head Division 2001 Year in Review Report, the population of NSF-IH is estimated as follows:

- Civilian employees - 2,217 (IHDIV - 1,756, tenants - 449)
- Military personnel - 517 (IHDIV - 23, tenants - 484)
- Contractors - 800 (IHDIV - 467, tenants - 333)
- Military and family members living in base housing - 548

Most of those living in base housing work at IHDIV-NSWC, but some do not.

Based on the 2000 United States Census, the population of the Town of Indian Head is 3,422, and the total population of Charles County is 120,546. The Town of Indian Head is primarily residential, with a business corridor located along Maryland Route 210. Tourism comprises a significant portion of the local commerce because Indian Head is located near some of the best fishing locations on Mattawoman Creek.

1.2.10 Ecology

The information in this section was extracted from the Initial Assessment Study (IAS) Report (Hart, 1983), except where noted.

1.2.10.1 Flora

Approximately 35 percent of NSF-IH is wooded. The forests consist of hardwoods, including oak and hickory, and loblolly and Virginia pines. The upland areas are characterized by older growths of pine and oaks, and the lower elevations are composed of sycamore, ash, elm, and sweet gum.

Approximately 53 percent of NSF-IH is open field and shrub vegetation. Loblolly pine, sweet gum, red cedar, and black locust are typical of these communities.

Along the shoreline and beaches of the Potomac River, black persimmon, false indigo, poison ivy, sea myrtle, grape, and Virginia creeper are present along with phlox, gama grass, panic grass, Bermuda grass, and/or finger grass. Marsh areas predominate along the shores of Mattawoman Creek. They are characterized by jewelweed, alger, marsh cattail, weedgrass, sedge, three square bulrush, wild rice, saltmarsh cordgrass, smartweed, and marsh mallow.

1.2.10.2 Wildlife

The ecosystem at NSF-IH supports a variety of animal life. White-tailed deer are abundant. Other common mammals include opossum, bats, squirrels, mice, raccoons, woodchucks, skunks, rabbits, and other burrowing rodents such as voles and shrews. The birds found within Charles County include grebes, herons, ducks, geese, hawks, kestrels, osprey, eagles, gulls, owls, and perching birds such as robins, warblers, and jays. Common reptiles and amphibians of Charles County include lizards, snakes, turtles, salamanders, frogs, and toads.

1.2.10.3 Aquatic Life

The area of the Potomac River adjacent to the facility is part of the spawning and nursery area for striped bass, white perch, herrings, and shad. Bay anchovies and three species of silversides also spawn and

nurse within this area. The area is the upstream limit of the nursery area for estuarine-dependent species, including the Atlantic menhaden and Atlantic croaker. Mattawoman Creek is a spawning area for blueback herring, white and yellow perch, and gizzard shad.

1.2.10.4 Threatened and Endangered Species

A rare, threatened, and endangered species and natural area survey was performed at NSF-IH by the Maryland Natural Heritage Program (MDNR, 1992). There are no known rare, threatened, or sensitive species or sensitive habitats at Site 57.

1.3 SITE 57 BACKGROUND

1.3.1 Site Location and Description

Site 57, Building 292 TCE Contamination, encompasses the area located south of Building 292 at the Main Area of NSF-IH (Figure 1-2). Previous operations from the mid-1960s until 1989 involved the use of TCE for vapor degreasing and general cleaning. During the 1970s and 1980s, spent TCE was transferred from a tank inside Building 292 into drums via a pipe that passed through the wall near the southern corner of the building. The spent TCE was determined to be United States Environmental Protection Agency (EPA) hazardous waste number F002. The drums were reportedly stored on a grass-covered area near manhole MH-1 south of the southern corner of Building 292 (Figure 1-4). It is believed that these operations have resulted in the contamination of soil and groundwater. The use of TCE at Building 292 stopped in 1989. Site 57 also includes Buildings 165 and 496, located approximately 150 feet southwest of Building 292, which were used to store ethyl ether.

1.3.2 Topography and Surface Features

The topography and surface features of the site area are shown on Figure 1-4. Building 292 is located in a valley approximately 1,300 feet north of Mattawoman Creek at an elevation of approximately 35 feet above msl. The valley trends approximately southeast toward Mattawoman Creek to approximately sea level. The valley slopes are much steeper east, north, and west of the site. A storm drain from Building 292 approximately follows the valley and discharges to Mattawoman Creek at Industrial Wastewater Outfall 80 (IW80). An unnamed stream also flows through the valley before discharging to Mattawoman Creek at Industrial Wastewater Outfall 40 (IW40). Portions of an abandoned railroad track are located in the valley.

1.3.3 Site Geology

Generally, the subsurface materials within the study area consist of fill material, alluvium, and Marlboro Clay. The fill material consists primarily of reworked natural gravel, sand, silt, and clay. At some locations, the fill material contains minor amounts of asphalt, concrete, brick, terra cotta, and slag fragments. In areas of construction, the natural soil and alluvium are cut by, or supplemented with, the fill material.

The alluvium is interpreted as being derived from erosion of adjacent upland areas. It generally consists of yellow-brown and gray, poorly sorted sand and gravel with minor amounts of silt and clay overlying greenish clayey, well-sorted, very fine-grained sand and silt. The contact between these two units is abrupt and ranges in elevation from approximately 10 feet below to 12 feet above msl. The green unit typically has a clayey upper surface, and the clay content generally diminishes downward. The clayey upper portion of this unit ranges in thickness from 0 to 17 feet. This green unit comes in contact abruptly with a distinct light brownish or bluish gray, friable clay and silt unit that is interpreted to be the Marlboro Clay. The upper surface elevation of the Marlboro Clay at Site 57 ranges from approximately sea level to 25 feet below msl. The Marlboro Clay thickness at Site 57 is unknown. Regionally, the unit ranges in thickness from 0 to 40 feet but is typically 10 to 20 feet thick (USGS, 1989). Soil borings completed at Site 57 did not completely penetrate the Marlboro Clay.

The subsurface materials encountered at the adjacent upland areas are believed to be Middle to Lower Pleistocene-age Chicamuxen Church Formation, consisting primarily of yellow brown sand and gravel, clay, and clayey sand.

Five geologic cross-sections (A-A′ to E-E′) were developed to better characterize the subsurface materials underlying Site 57 and areas downgradient from the site. Figure 1-5 shows the locations of the generalized geologic cross-sections. Cross-sections A-A' through E-E' are illustrated on Figures 1-6 through 1-10, respectively. The cross-sections were generated using soil boring logs and cone penetrometer test results. The cone penetrometer test uses direct-push techniques to infer soil types by measuring the stress applied to the point and side of a probe as the probe is being pushed into the ground by a very heavy truck. No visual description of the soil is prepared.

Cross-Section A-A'

Cross-section A-A' (Figure 1-6) is a northwest-to-southeast transect that depicts subsurface materials along the northern portion of the study area, including the Building 292 area. Fill material is encountered throughout the extent of this section. The fill is identified by traces of brick, terra cotta, and slag fragments in a gravel, sand, and clay matrix. At S57MW013, the bottom of the fill material is defined by a

layer of asphalt at 7 feet bgs. At well clusters S57MW001/MW002, S57MW007/MW008 and S57MW009/MW010, fill material is encountered at the ground surface to approximately 7, 8, and 12 feet bgs, respectively. The recovery rate at these locations during split-spoon sampling was very poor, and the material encountered was very loose. At S57MW003/MW004 and S57MW011, the fill material is 8 and 11 feet thick, respectively.

The yellow brown and gray sand unit is encountered below the fill material throughout the cross-section. At location S57MW012/MW013, the sand unit is approximately 36 feet thick, and it thins to approximately 8 feet to the south at S57MW009/MW010. At boring locations S57MW001, S57MW003, S57MW007, S57SB033, S57SB036, and S57SB045, moderately sorted, green, very fine-grained sand with varying amounts of silt and clay is encountered below the sand unit at approximately 22 to 27 feet bgs. Based on field observations, it is interpreted as an aquitard beneath Building 292. The thickness of this upper aquitard is approximately 6 to 12 feet, and the contact with the underlying green silty sand is gradational. The lateral extent is marked to the north by S57MW012 and to the south by S57SB037 where the unit consists primarily of silty sand and becomes clayey at S57MW009 at the southern end of the section. At locations S57MW012, S57SB033, and S57SB036, a lower aquitard consisting of a distinct light brownish or bluish gray, friable clay and silt is encountered at 43, 40, and 36 feet bgs, respectively. The Marlboro Clay is interpreted to extend the length of the cross-section.

Cross-Section B-B'

Cross-section B-B' (Figure 1-7) is a southern continuation of cross-section A-A'. It is a northwest-to-southeast transect that depicts subsurface materials along the southern portion of the study area in the vicinity of former Building 158 and extending beyond IW80 to Mattawoman Creek. Fill material is encountered at locations S57MW009/MW010 and S57MW020 from the ground surface to 11 and 9 feet bgs, respectively. The fill material at S57TW021 is interpreted to be the storm sewer bedding. The yellow-brown and gray sand unit is encountered below the fill material and at the surface when the fill is absent. The sand unit contains more gravel near the ground surface where it is exposed at the ground surface between S57MW010 and S57CP003. At S57CP003, an 8-foot-thick clay lens was encountered at approximately 4 feet bgs. It is interpreted that these shallow clay units are not part of the upper green fine sand, clay, and silt aquitard. The upper fine sand, clay, and silt aquitard encountered at S57MW007 on cross-section A–A' is encountered at location S57MW009 and extends nearly the length of the cross-section. However, at S57CP003 and S57SB042 (located outside the stream valley), the unit is absent, and at adjacent boring locations S57SB041 and S57SB043, the upper aquitard comes in contact with the Marlboro Clay. The upper aquitard (fine sand, clay, and silt) extends farther south and grades into a soft and more permeable clayey silt with peat at S57MW022 near Mattawoman Creek. The clayey sand underlying the peat unit at S57MW022 is a poor aquitard based on field observations. At locations S57MW026, S57MW028, and S57MW030, a distinct light brownish or bluish gray friable clay and silt unit

is encountered at 37, 34, and 34 feet bgs, respectively. The Marlboro Clay is interpreted to extend the length of the cross-section.

Cross-Section C-C'

Cross-section C-C' (Figure 1-8) is a north-to-south transect that depicts subsurface materials between the Building 292 area (lowland) and the uplands to the south toward Mattawoman Creek. Fill material is encountered at locations S57MW001/MW002 and S57TW016/TW017. The yellow brown and gray sand unit is encountered below the fill material and at the surface when the fill is absent. The sand unit contains more gravel near the ground surface and extends the entire length of the cross-section. The clayey sand and silt aquitard encountered at S57MW001/MW002 on cross-section A-A' extends to S57TW016/TW017. Further south, outside the lowland area at S57CP001, a clayey sand unit is encountered at 26 feet bgs. This unit is at least 17 feet thick. Based on field observations, this clayey sand unit has low permeability, extends the length of the section, and is interlayered with sandy clay lenses. The Marlboro Clay is interpreted to extend the length of the cross-section based on nearby boring logs.

Cross-Section D-D'

Cross-section D-D' (Figure 1-9) is a north-to-south transect that depicts subsurface materials between the southern portion of the study area in the vicinity of former Building 157 and Mattawoman Creek. At locations S57SB030 and S57MW026, silty sand and gravel were encountered at the ground surface and extended down approximately 10 to 12 feet bgs. The silty sand and gravel may be reworked natural material used for the development of roads and buildings in the immediate vicinity. The yellow brown and gray sand unit is encountered below the silty sand and gravel and extends to the south beyond S57CP007, where it grades into a clayey sand layer at 41MW03 and 41MW04. The green fine sand, clay, and silt unit (upper aquitard) was encountered beneath the yellow brown sand unit at soil boring S57SB030 and was penetrated at S57MW026 (where the unit is approximately 7 feet thick). Farther south, the fine sand, clay, and silt layer was found to be at least 14 feet thick at S57SB032 and extends the length of the section. However, in the central portion of the section in the upland area, it is absent at S57MW035 where the overlying sand comes in contact with the Marlboro Clay (lower aquitard). The Marlboro Clay was also encountered at S57MW026 and is interpreted to extend the entire length of the cross-section.

Cross-Section E-E'

Cross-section E-E' (Figure 1-10) is a west-to-east transect that depicts subsurface materials along Mattawoman Creek downgradient of the study area. Fill material is encountered across most of the

cross-section except at S57CP008. A clayey sand unit was encountered beneath the fill material at locations 41MW01, 41SB01, and 41MW04 and at the ground surface at S57CP008. At locations 41MW02 and S57CP008, a layer of sand underlies the fill material. The sand layer pinches out to the east at S57MW022. The greenish fine sand with varying amounts of clay and silt layer, which is 8 feet thick at 41MW02 and 2 feet thick at S57CP008, extends the entire length of the section. In the 41SB01 area, the green unit includes a significant amount of clay.

1.3.4 Site Hydrogeology

Groundwater exists in the fill, alluvium, and Marlboro Clay at Site 57. The surficial aquifer generally consists of yellow brown sand and gravel beneath the study area and displays the characteristics of an unconfined system. The static water-level elevations in completed wells ranged from 2.14 to 38.92 feet above msl. The water table mimics the surface topography. The olive gray fine sand, silt, and clay unit (upper aquitard) within the surficial aquifer would hinder the downward and lateral movement of groundwater within the surficial aquifer. However, as shown on the cross-sections, it would provide less hindrance to groundwater flow where the olive gray fine sand, silt, and clay aquitard becomes sandier or thinner. The olive gray fine sand, silt, and clay unit becomes sandier downward and comes in contact abruptly with the Marlboro Clay (lower aquitard). The Marlboro Clay thickness at Site 57 is unknown. Regionally, the unit ranges in thickness from 0 to 40 feet but is typically 10 to 20 feet thick (USGS, 1989). Based on field observations, the Marlboro Clay is a dry, very stiff and friable clay and silt and would provide a good barrier between the shallow aquifer and deeper aquifers.

The latest complete round of water-level measurements was taken from 33 monitoring wells on October 11, 2005. The synoptic groundwater-level measurements were performed to determine the groundwater flow pattern at the site. Measurements were taken with an electronic water-level indicator (M-scope) using the top of the well riser pipe at each well as the reference point for determining depths to water. Groundwater-level measurements were recorded to the nearest 0.01 foot. Table 1-1 provides a summary of the water-level data used to generate the potentiometric surface map (Figure 1-5).

Based on the potentiometric surface map, the shallow groundwater in the upper and lower portions of the surficial aquifer is flowing toward the unnamed stream and Mattawoman Creek. There is a slight downward flow component in the northern portion of the study area based on water levels measured at well cluster S57MW012/MW013. There is a very slight upward flow component in the southern portion of the study area based on water levels measured at well clusters S57MW005/MW006, S57MW026/MW027, and S57MW028/MW029. However, there is also a very slight downward flow component at well cluster S57MW020/MW030 in the southern portion of the study area. The upper surficial groundwater may be discharging to both the unnamed stream and Mattawoman Creek. The deeper groundwater in the surficial aquifer is most likely discharging to Mattawoman Creek. The surficial

aquifer is recharged by infiltration of precipitation through the vadose zone and by groundwater flowing from the adjacent upland areas located to the north, east, and west.

Based on slug test data, the geometric mean hydraulic conductivity was 3.6 feet per day for shallow monitoring wells, 1.4 feet per day for intermediate monitoring wells, and 1.0 foot per day for deep wells. The shallow wells are typically screened across the water table, intermediate wells are screened just above the upper aquitard (green fine-grained sand with silt and clay), and deep wells are screened just above the lower aquitard (Marlboro Clay). Table 1-2 provides a summary of the 2005 slug test results. The hydraulic gradient was estimated to be 0.028 in the northern portion of the study area including the Building 292 area. The hydraulic gradient estimated for the southern portion of the site was 0.017. Based on an estimated effective porosity of 0.25, the seepage velocity of the groundwater in the northern portion of the study area is estimated to be 0.40 feet per day. The seepage velocity of groundwater in the southern portion of the study area is estimated to be 0.25 feet per day.

1.4 PREVIOUS INVESTIGATIONS

This section provides a summary of the investigations conducted to date at Site 57, with a focus on groundwater. The results from all investigations are summarized; however, the main focus will be on the most recent data from 2005, which is most representative of current site conditions. In addition, a pilot study conducted in the source area near Building 292 in 2003 reduced some contaminant concentrations and may have altered the groundwater chemistry. Details from sampling and analysis of other media (soil, surface water, and sediment) can be found in the RI Report (TtNUS, 2000) and the Engineering Evaluation/Cost Analysis (EE/CA) Report (TtNUS, 2005) that was prepared to support a non-time-critical removal action for contaminated soil.

1.4.1 Sewer Sampling – 1994

In February 1994, sampling was conducted at IW80 (manhole MH-489 on Figure 1-4) in response to an odor. TCE was detected at a concentration of 53 micrograms per liter (µg/L). This manhole is located approximately 1,300 feet downstream of Building 292. A sample collected from the same location in May 1994 contained TCE at 60.2 µg/L. Additional sampling was conducted in July 1994 to determine the source of this chemical. TCE was detected at manhole MH-1 (62 µg/L) immediately downstream of Building 292 and at IW80 (47 µg/L) but was not detected upstream of the building. Additional details on this sampling can be found in the RI Report (TtNUS, 2000).

1.4.2 Soil-Gas Survey – 1995

A soil-gas survey was conducted in 1995 in and around the former drum storage area near manhole MH-1 (Figure 1-4). Elevated TCE concentrations were detected near where the drums were filled and stored. As a result, soil, groundwater, and sewer water samples were collected based on the results of the soil-gas survey. TCE was detected at a concentration of 370,000 µg/L in a groundwater sample collected near the southern corner of Building 292. Lower concentrations of other chlorinated solvents and TCE degradation products were also detected. Additional details on this sampling can be found in the RI Report (TtNUS, 2000).

1.4.3 Remedial Investigation – 1998 to 1999

The RI was conducted in October 1998 and January 1999 to delineate the nature and extent of contamination. The field investigation, analytical results, and human health and ecological risk assessments are fully described in the RI Report (TtNUS, 2000).

1.4.3.1 Field Investigation

The field investigation included the collection of 10 surface soil, 38 subsurface soil, 17 groundwater, 20 surface water, and 8 sediment samples. Monitoring wells were screened in the upper and lower portions of the surficial aquifer. All groundwater samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs) and diethyl ether. Selected groundwater samples were analyzed for TCL semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs), Target Analyte List (TAL) metals (unfiltered and filtered), cyanide, explosives, and miscellaneous water quality parameters.

1.4.3.2 Nature and Extent of Contamination

The following is a summary of the nature and extent of groundwater contamination as presented in the RI Report:

- Minimal organic contamination was present upgradient of Building 292.

- TCE and several other chlorinated hydrocarbons were detected in downgradient groundwater samples. TCE and 1,2-dichloroethene (a TCE degradation product) were typically detected with the greatest frequency and at the greatest concentrations. The maximum concentrations of TCE and several other chlorinated hydrocarbons in upper surficial groundwater were associated with a monitoring well located at the southern corner of Building 292. The maximum concentrations of all detected chlorinated hydrocarbons (except vinyl chloride) in lower surficial groundwater were

associated with a well located approximately 450 feet downgradient of the building. However, definitive patterns (i.e., from upgradient to downgradient or from upper surficial to lower surficial) of chlorinated hydrocarbon contamination could not be established.

- Diethyl ether was frequently detected in upper and lower surficial groundwater. The greatest concentrations of diethyl ether were found within 300 feet of Building 496, a vault formerly used for ether storage. The maximum concentration was detected approximately 100 feet south of Building 292. In general, concentrations decreased downgradient of this detection.

- No SVOCs were detected in upper surficial groundwater. Bis(2-ethylhexyl)phthalate was detected in one sample from lower surficial groundwater. No pesticides or PCBs were detected in upper or lower surficial groundwater. No explosives were detected in upper surficial groundwater. Nitrocellulose was detected in one sample from the lower surficial groundwater.

- Metals were detected in groundwater. In general, the detected concentrations did not appear to vary greatly between upgradient and downgradient or upper surficial and lower surficial samples.

The analytical results indicate that organic chemicals have migrated from the source area to downgradient groundwater. The key chemicals detected were TCE, its degradation products, and diethyl ether. The TCE degradation products detected included dichloroethenes and vinyl chloride. TCE was detected in 11 of 14 groundwater samples. Cis-1,2-dichloroethene was found in 12 of 14 samples. Other detected degradation products included 1,1-dichloroethene (seven samples), trans-1,2-dichloroethene (14 samples), and vinyl chloride (14 samples). In addition, technical-grade TCE contains 1,1,1-trichloroethane, which was detected in eight samples. 1,1-Dichloroethane, a degradation product of 1,1,1-trichloroethane, was detected in eight samples.

1.4.3.3 Human Health Risk Assessment Summary

A baseline risk assessment was developed in the RI Report. There were no unacceptable risks to human health from exposure to chemicals detected in surface water or sediment. Unacceptable risks from exposure to surface and subsurface soil were identified. However, contaminated soil was addressed under a non-time-critical removal action. The following discussion is a summary of risks from exposure to groundwater. Details on the risk assessment for groundwater and other site media are presented in the RI Report (TtNUS, 2000).

The risk assessment estimated potential risks for full-time employees, adolescent trespassers, construction workers, and hypothetical future residents. However, only construction workers and hypothetical residents have the potential to be exposed to shallow groundwater. There were no

unacceptable risks to construction workers; however, the use of shallow groundwater as a source of potable water could result in unacceptable risks to hypothetical residents. An unacceptable risk is defined as an incremental lifetime cancer risk (ILCR) greater than 1.0E-04 or a Hazard Index (HI) greater than 1.0. The risk drivers for the unacceptable cancer risk were TCE and vinyl chloride. The risk drivers for the unacceptable noncancer risk were cis-1,2-dichloroethene, TCE, and diethyl ether.

COCs were determined are based on protection of human health and/or exceedances of regulatory standards (e.g., drinking water standards). Based on the findings from the RI, groundwater COCs include 1,1-dichloroethene, cis-1,2-dichloroethene, diethyl ether, tetrachloroethene, TCE, and vinyl chloride.

1.4.4 Pre-Feasibility Study Investigation - 2001

A field investigation was conducted in August 2001 to fill data gaps, to refine the nature and extent of soil and groundwater contamination, and to provide additional information on subsurface characteristics. Field activities included the installation of soil borings and temporary and permanent monitoring wells, soil and groundwater sampling, cone penetrometer testing, and aquifer testing. The results of the investigation with respect to groundwater and aquifer characteristics are discussed below. The results for soil are contained in the EE/CA (TtNUS, 2005) prepared to support a non-time critical removal action. Field forms including boring logs, well construction sheets, well completion reports, well development sheets, sample log sheets, chain-of-custody forms, water-level measurements, and survey data are included in Appendix A. The laboratory analytical data are included in Appendix B. Data validation memoranda are included in Appendix C. Aquifer test measurements and calculations are included in Appendix D. The cone penetration testing report is included in Appendix E.

1.4.4.1 Groundwater Sampling

Ten new monitoring wells were installed in the upper and lower portions of the surficial aquifer to collect groundwater samples to better define the extent of groundwater contamination and to gather information to allow for an evaluation of natural attenuation processes. The wells were temporary wells S57TW014 through S57TW019 and S57TW021 and permanent wells S57MW020, S57MW022, and S57MW023. Samples were collected from new and existing monitoring wells. Table 1-3 provides a summary of monitoring well construction details for the new and existing wells. All groundwater samples were analyzed for TCL VOCs and ethyl ether (diethyl ether). Many of the samples were also analyzed for water chemistry parameters and parameters that would allow for an evaluation of natural attenuation. A summary of analytical results or parameters detected at least once in groundwater samples is provided in Table 1-4. Monitoring well locations are shown on Figure 1-5.

Based on different hydrogeologic characteristics and chemical concentrations, groundwater at Site 57 was divided into five areas including the upgradient area, source area, mid-plume area, downgradient area, and an area between the mid-plume and downgradient areas where little or no contamination was detected.

The upgradient area is northeast of Building 292 and includes well clusters S57MW012/MW013 and S57TW014/TW015. With the exception of 1,1-dichloroethene (74 µg/L) at location S57MW013 and diethyl ether (920 µg/L) and tetrachloroethene (7.1 µg/L) at location S57TW015, concentrations of chlorinated VOCs were generally less than 5 µg/L.

The source area begins near Building 292 near well cluster S57MW001/MW002 and extends approximately 400 feet down the valley to well clusters S57MW007/MW008 and S57TW018/TW019. The results of the 2001 pre-FS sampling are similar to those from the 1999 RI sampling. The chemicals detected most frequently and at the highest concentrations were TCE, cis-1,2-dichloroethene, and diethyl ether. TCE concentrations ranged from not detected at wells S57MW001, S57MW008, and S57TW016 to a maximum concentration of 12,000 µg/L at well S57MW004. Well S57MW004, which is screened in the upper portion of the surficial aquifer, is located near Building 292 where drums of spent TCE were stored. The sample from well S57MW004 also had the maximum concentration of cis-1,2-dichloroethene (620 µg/L). The sample for well S57MW003, which is the deeper well at this location, had 365 µg/L of TCE and 30 µg/L of cis-1,2-dichloroethene. The concentrations of cis-1,2-dichloroethene in other wells ranged from not detected at locations S57MW001, S57MW008, S57TW016, and S57TW017 to 66 µg/L at well S57TW018. The concentrations of diethyl ether ranged from 2.1 µg/L at well S57TW018 to 4,800 µg/L at well S57TW017. Well S57TW017 is located near Ether Vault No. 4 (Building 496). Other chemicals detected less frequently and at lesser concentrations were 1,1-dichloroethene, tetrachloroethene, and vinyl chloride.

The mid-plume area is southeast of the source area and includes well clusters S57MW005/MW006 and S57MW009/MW010. This area extends approximately 500 feet down the valley. The chemicals detected in this area are similar to those detected in the source area but generally at lower concentrations. However, the concentrations of 1,1-dichloroethene were slightly higher than in the source area. TCE concentrations ranged from not detected at well S57MW005 to 480 µg/L at location S57MW009. The concentrations of cis-1,2-dichloroethene ranged from not detected at well S57MW005 to 150 µg/L at well S57MW010. Diethyl ether was only detected at well S57MW005 at a concentration of 570 µg/L.

Farther southeast of the mid-plume area is a zone where minimal groundwater contamination was detected. This area includes shallow wells S57MW020 and S57TW021 and extends approximately 600 feet down the valley from the mid-plume area. Chlorinated VOCs were not detected in either of these

wells. Diethyl ether was detected at well S57MW020 at a concentration of 18 µg/L. No wells were installed in the deeper portion of the surficial aquifer in this area; however, groundwater contamination was detected downgradient of this area, as discussed below. This created uncertainty in defining the overall extent of groundwater contamination.

The downgradient area is near shallow wells S57TW003 (installed and removed in 1999) and S57MW022. This area also includes cone penetrometer location S57CP005, which extended into the deeper portion of the aquifer. The contamination in this area is not as well defined as in the source area and mid-plume area. TCE and diethyl ether were not detected in the shallow wells but were detected at concentrations of 11 µg/L and 800 µg/L, respectively, at S57CP005. Well S57MW002 exhibited the greatest concentrations of cis-1,2-dichloroethene (1,400 µg/L) and vinyl chloride (1,500 µg/L).

The presence of TCE degradation products in a large number of groundwater samples and their occurrence at relatively significant concentrations at the most downgradient location suggested that natural attenuation of TCE in the groundwater may be taking place.

Well S57MW023 was installed in the surficial aquifer near potable well PW-07 where TCE was detected in a sample collected in 1997 (but not in 1999). Benzene (900 µg/L), o-xylene (28 µg/L), and TCE (30 µg/L) were detected in the groundwater sample from well S57MW023. Benzene and o-xylene have never been detected in any of the other groundwater samples associated with Site 57. This provides further evidence that Site 57 is not the source of TCE previously detected in potable well PW-07.

1.4.4.2 Cone Penetrometer Tests

Piezoelectric cone penetration tests (P-CPTs) were conducted at 10 locations as part of the pre-FS field investigation. The purpose of the P-CPTs was to better characterize the geology and extent of groundwater contamination at the site. Typically, two tests (penetrations) were conducted at each location. The first test was a P-CPT to generate a geologic profile, and the second was conducted to collect a groundwater sample at a specific depth based on the preliminary findings of the first penetration. The resulting geological profiles from the P-CPTs were used in combination with soil boring logs to generate generalized geological cross-sections to illustrate subsurface materials at the site. Dissipation tests were also conducted during the P-CPTs that provided information about the permeability, depth to the water table, and compressibility of the formation.

Well points were installed at 7 of the 10 P-CPT locations. Three of the well points were dry, and four were sampled for VOC analysis. The groundwater samples were collected using a stainless-steel bailer. At 3 of the 10 P-CPT locations, well points were not installed because the P-CPT parameters indicated

that the sandy silt and clay unit was more than 10 feet thick and the well points would be expected to be dry.

1.4.4.3 Aquifer Testing

Slug tests were completed at 16 permanent wells and 7 temporary wells to estimate the horizontal hydraulic conductivity (k_h) of the aquifer. Rising head slug tests were performed at the permanent wells. The changes in water levels at the permanent wells were induced by withdrawing two bailers (each with a volume of 1 liter) simultaneously. Rising head slug tests were performed at four temporary wells using a solid (1/2 inch in diameter by 6 feet long) galvanized steel slug to induce the water-level change. Falling head slug tests were also performed at the temporary wells by introducing a 1-liter slug of deionized water into the well. Before a slug test was initiated, the static water level in the monitoring well was measured using an electronic water-level indicator. Water levels were recorded during the tests with a pressure transducer at logarithmic intervals of time using a programmed electronic data logger as the head returned to the original static water level. The time and the rate of change required for the water level to return to the original static water level are functions of the transmissivity of the aquifer.

1.4.4.4 Surveying

The monitoring well (temporary and permanent), P-CPT, and soil borings locations were surveyed, and existing base control points within NSF-IH were used as reference points. The horizontal locations of all sampling locations were surveyed to within 0.5 foot. Vertical elevations were referenced to the National Geodetic Vertical Datum (NGVD) of 1929, and horizontal positioning was referenced to 1983 North America Datum (NAD) and the Maryland State Plane Coordinate System. The top of riser pipe and ground surface elevations were surveyed to within 0.01 foot for the monitoring well locations. At the temporary well and CPT locations, only the ground surface was surveyed.

1.4.4.5 Geotechnical Soil Sampling

Fifteen subsurface soil samples were collected using split-spoon samplers and submitted for geotechnical analysis that included Unified Soil Classification System (USCS) and American Association of State Highway and Transportation Officials (AASHTO) classification, particle size distribution, specific gravity, porosity, and moisture content. Table 1-5 provides a summary of the classification and particle size distribution results. All geotechnical results are provided in Appendix B.2.

1.4.5 HRC® Pilot Study – 2003

A field-scale pilot study was conducted in 2003 to evaluate in-situ bioremediation of the TCE and other VOCs detected in groundwater. During the pilot study, Regenisis Hydrogen Release Compound (HRC®)

was injected into the subsurface in the TCE source area south of Building 292 between S57MW003/MW004 and S57MW024 (see Figures 1-4 and 1-5) to establish anaerobic conditions suitable for reducing contaminant concentrations through reductive dechlorination. The objective of the pilot study was to determine whether the application of HRC® would result in reduced TCE concentrations in groundwater. Field activities included installation of soil borings and monitoring wells, soil and groundwater sampling, HRC® injection, and aquifer testing. All field forms, field data, and laboratory data are included in the pilot study report (TtNUS, 2004a).

1.4.5.1 Subsurface Soil Investigation

Subsurface soil samples were collected from four depths at each of two soil boring locations (S57SB027 and S57SB028) downgradient of the HRC® injection area. The subsurface soil samples were analyzed for chlorinated VOCs, ethyl ether, and arsenic. The results from the soil sampling were used in the EE/CA (TtNUS, 2005) to refine the horizontal and vertical extent of the source area.

1.4.5.2 Monitoring Well Installation and Baseline Groundwater Sampling

Two new monitoring wells (S57MW024 and S57MW025) were installed downgradient of the HRC® injection points to monitor changes in contaminant concentrations. The initial round of groundwater sampling was completed prior to HRC® injection. Groundwater samples collected from the new wells and existing wells S57MW003, S57MW004, and S57MW011 were analyzed for chlorinated VOCs, ethyl ether, field parameters, biological activity indicators, HRC®-based electron donors, and end-product dissolved gases. Table 1-3 provides a summary of monitoring well construction details.

1.4.5.3 HRC® Injection

The treatment area was approximately 30 feet by 10 feet and consisted of 12 HRC® injection points. The HRC® injection points were installed with approximately 5 feet between each of three rows and with approximately 8 feet between the points within each row. The HRC® was injected at a rate of approximately 0.6 gallon (6.6 pounds) per vertical foot, starting at a depth of 20 feet bgs and continuing upward to 6 feet bgs.

1.4.5.4 Groundwater Sampling

Groundwater samples were collected at 1, 2, 4, and 6 months following HRC® injection. Samples were collected from wells S57MW003, S57MW004, S57MW011, S57MW024, and S57MW025 and analyzed for the same parameters as the baseline samples.

1.4.5.5 Water-Level Measurements, Aquifer Tests, and Surveying

One complete round of water-level measurements was collected from the 16 existing and two newly installed wells at Site 57 and three existing wells located at Site 41 (near Site 57). The synoptic groundwater-level measurements were performed to determine groundwater flow patterns.

Slug tests were complete at five monitoring wells to better estimate the horizontal hydraulic conductivity of the aquifer within the pilot study area.

The two new monitoring wells and HRC® injection points were surveyed using existing reference points.

1.4.5.6 Summary

The pilot study report provided data evaluations for primary, secondary, and other indicators of reductive dechlorination. Primary indicators were the concentrations of TCE and its daughter products (e.g., cis-1,2-dichloroethene and vinyl chloride). Secondary indicators included dissolved oxygen, oxidation-reduction potential, nitrate/nitrite, manganese, iron, sulfate/sulfide, phosphate, and methane. Other indicators included carbon dioxide, alkalinity, chloride, and breakdown products of HRC® (volatile fatty acids). The following is a summary of the pilot study results. Details are provided in the pilot study report (TtNUS, 2004a).

The primary indicators showed definite evidence of reductive dechlorination, especially in downgradient wells S57MW024 and S57MW025. Over the 6-month pilot study duration, TCE concentrations decreased by as much as 98 percent, cis-1,2-dichloroethene concentrations exhibited expected increases followed by decreases, and vinyl chloride concentrations increased.

The secondary indicators generally supported the conclusion that reductive dechlorination was ongoing during the pilot study. Particularly in S57MW024 and S57MW025, oxygen was depleted, ferrous iron was generated, sulfate was reduced while sulfides were generated, and methane was generated. All of these are indicators of moderately to strongly reducing conditions favorable for reductive dechlorination.

The other indicators were not as conclusive. Although carbon dioxide concentrations increased, alkalinity and chloride concentrations showed little change. The presence of volatile fatty acids indicated that conditions continued to be suitable for reductive dechlorination. The generation of these acids was favorable, and their accumulation indicated that there was significant hydrogen in the system for dechlorination at the conclusion of the pilot study.

The HRC® was not effective for ethyl ether; there was essentially no change in concentrations over the duration of the pilot study.

The pilot study report recommended that one or two additional sampling rounds be conducted. Under favorable conditions, HRC® can support microbial activity and hydrogen release for up to 18 months. Therefore, reductive dechlorination could have continued for several months beyond the end of the pilot study.

1.4.6 Comprehensive Groundwater Sampling – 2004 and 2005

Groundwater sampling was conducted in March and April 2004 and September and October 2005 to further evaluate contaminant concentration trends. Another purpose was to collect comprehensive rounds of samples from all permanent monitoring wells to support this FS. The previous comprehensive sampling was conducted during the 2001 pre-FS investigation, and conditions could have changed upgradient and downgradient of the 2003 pilot study area. The 2005 field work also included an evaluation of the confining unit encountered beneath the site during previous investigations. This confining unit is described as the upper aquitard (green fine sand with silt and clay) in Section 1.3.3. Testing to determine whether dense non-aqueous phase liquid (DNAPL) was present was also conducted. Field activities included the installation of soil borings and temporary and permanent monitoring wells, groundwater sampling, IW80 sampling, field testing for DNAPL, aquifer testing, and video inspection of a portion of the IW80 sewer pipe. Field forms including boring logs, well construction sheets, well completion reports, well development sheets, sample log sheets, chain-of-custody forms, water-level measurements, and survey information are included in Appendix A. The laboratory analytical data are included in Appendix B. Data validation memoranda are included in Appendix C. Aquifer test measurements and calculations are included in Appendix D. The video inspection is included in Appendix F.

1.4.6.1 Soil Boring Installation

Borings S57SB033 to S57SB035, S57SB037, S57SB041 to S57SB043, and S57SB045 were installed during the 2005 investigation to investigate and evaluate the confining unit (upper aquitard). At four boring locations in the source area (S57SB033 to S57SB036), ribbon samplers were installed to determine whether DNAPL was present. DNAPL was not detected at any locations; therefore, based on the work plan, no soil samples were collected. The remaining soil borings were used for installation of permanent monitoring wells. Soil boring and monitoring well locations are shown on Figure 1-5.

1.4.6.2 Groundwater Sampling

No new wells were installed during the 2004 sampling event. Samples were collected from the 17 permanent monitoring wells in existence at Site 57 at the time and from one permanent monitoring well (S57MW023) previously installed near potable well PW-07. All Site 57 groundwater samples were analyzed for TCL VOCs, diethyl ether, total and dissolved TAL metals, total suspended solids, total dissolved solids, total inorganic carbon, and total organic carbon. Groundwater from selected Site 57 monitoring wells in the vicinity of the 2003 pilot study area were also analyzed for alkalinity, dissolved gases, miscellaneous anions, and metabolic acids. The water from IW80 was analyzed for TCL VOCs, diethyl ether, total and dissolved TAL metals, and metabolic acids. Groundwater from the well near PW-07 was analyzed for TCL VOCs, diethyl ether, and total and dissolved TAL metals. A summary of analytical results is provided in Table 1-6.

Twelve permanent and three temporary monitoring wells were installed during the 2005 sampling event. Samples were collected from these wells and all other permanent monitoring wells previously installed at Site 57. Samples were also collected from three monitoring wells from UXO 32 (also known as Site 41), which is adjacent to Mattawoman Creek. These wells were sampled to determine whether UXO 32 was contributing to the groundwater contamination detected in the downgradient area near Mattawoman Creek. Table 1-3 provides a summary of monitoring well construction details for the new and existing wells. All samples collected in 2005 were analyzed for TCL VOCs and diethyl ether. A summary of analytical results is provided in Table 1-7.

Results from the 2004 and 2005 sampling generally indicated the same five groundwater areas identified during the 2001 sampling event. These include the upgradient area, source area, mid-plume area, downgradient area, and an area between the mid-plume and downgradient areas where little or no contamination was detected. Results for groundwater COCs are shown on Figure 1-11.

<u>Upgradient Area</u>

The upgradient area is northeast of Building 292 and includes well cluster S57MW012/MW013. With the exception of 1,1-dichloroethene (62 to 75 µg/L) at location S57MW013, the concentrations of chlorinated VOCs were less than 5 µg/L. Diethyl ether was detected at S57MW012 (5 to 14 µg/L) but was not detected at S57MW013.

<u>Source Area</u>

Based on the 2001 data, the source area begins near Building 292, near well cluster S57MW001/MW002, and extends approximately 400 feet down the valley to well cluster S57MW007/MW008. The chemicals

detected most frequently and at the greatest concentrations were TCE, cis-1,2-dichloroethene, and diethyl ether, which is consistent with the 2001 sampling event. In addition, vinyl chloride was detected more often and at greater concentrations than in 2001 as a result of the HRC® injection and the reductive dechlorination of TCE.

At location S57MW001, which is approximately 150 feet upgradient of the HRC® pilot study location, concentrations of chlorinated VOCs were similar to those observed in 2001; however, concentrations decreased at S57MW002, the shallow well at this location. The diethyl ether concentration deceased from 450 to 100 µg/L at S57MW001 but increased from 930 to 1,600 µg/L at location S57MW002.

In 2005, a temporary well point was installed at location S57SB035, which is upgradient of the pilot study area. A groundwater sample was collected from 10 to 14 feet bgs, where a chemical odor was observed during drilling. The sample was mixed with Oil Red O dye to evaluate the presence of DNAPL, which was not observed. High concentrations of TCE (32,000 to 36,000 µg/L), cis-1,2-dichloroethene (41,000 to 46,000 µg/L), and vinyl chloride (3,900 to 4,400 µg/L) were detected. Diethyl ether was not detected. Although the test for DNAPL was negative, the TCE concentrations were high enough that the presence of DNAPL could be inferred.

At location S57MW003/MW004, which is immediately upgradient of the pilot study area, the TCE concentration was similar in the lower portion of the surficial aquifer (S57MW003) to that observed in 2001. The TCE concentration decreased from 12,000 µg/L in 2001 to 595 µg/L in 2004 in the upper portion (S57MW004); in 2005 the concentration increased somewhat to 950 µg/L. The concentrations of cis-1,2-dichloroethene and diethyl ether decreased slightly from the 2001 levels at S57MW003. The concentration of diethyl ether at S57MW004 decreased slightly from the 2001 level. However, the concentrations of cis-1,2-dichloroethene and vinyl chloride, which increased during the 2003 pilot study, began to decline.

In 2005, a temporary well point was installed at location S57SB033, which is within the pilot study area. A groundwater sample collected from of 21 to 25 feet bgs was mixed with Oil Red O dye to evaluate the presence of DNAPL, which was not observed. The concentrations of TCE (78 µg/L), cis-1,2-dichloroethene (27 µg/L), and vinyl chloride (4 µg/L) were somewhat lower than detected at S57MW003, which is screened at a similar interval. Diethyl ether was not detected.

At location S57MW024, which is immediately downgradient of the pilot study area, the TCE concentration decreased from 8,600 µg/L before the pilot study to 350 µg/L in 2004, but increased to 580 µg/L in 2005. The concentrations of cis-1,2-dichloroethene and vinyl chloride increased by 2004 because of reductive

dechlorination but began to decline by 2005. The concentration of diethyl ether decreased from 270 µg/L in 2001 to 58 µg/L in 2005; however, this reduction is probably not a result of the HRC® injection.

At location S57MW025, which is approximately 25 feet downgradient of the pilot study area, TCE concentrations decreased from 9,100 µg/L before the pilot study to 67 µg/L in 2004 and 70.5 µg/L (average) in 2005. Concentrations of cis-1,2-dichloroethene increased from 12,000 µg/L at the beginning of the pilot study to 49,000 µg/L in 2004. The concentration decreased to 9,450 µg/L (average) in 2005. Concentrations of vinyl chloride increased from 2,300 µg/L before the pilot study to 10,400 µg/L in 2004 and 23,500 µg/L (average) in 2005. The concentration trends are evidence that TCE was being removed by reductive dechlorination. The diethyl ether concentrations increased during the pilot study and then decreased in 2004 and 2005; however, this reduction is probably not a result of the HRC® injection.

At location S57MW011, which is approximately 50 feet downgradient of the pilot study area, TCE concentrations, which increased to 600 µg/L during the pilot study, decreased to 91 µg/L in 2004 and 27 µg/L in 2005. Concentrations of cis-1,2-dichloroethene, which increased slightly during the pilot study, decreased to 18 µg/L in 2004 and 2005. Concentrations of diethyl ether, which decreased before the pilot study, increased then decreased during the pilot study. The concentrations detected in 2004 (2,100 µg/L) and 2005 (2,000 µg/L average) were similar to those detected before the pilot study.

In 2005, a temporary well point was installed at location S57SB036, which is approximately 150 feet south of the pilot study area. A groundwater sample collected from 16 to 20 feet bgs was mixed with Oil Red O dye to evaluate the presence of DNAPL, which was not detected. TCE and its degradation products were not detected. Diethyl ether was detected at a concentration of 4,200 µg/L.

Location S57MW007/MW008, which is approximately 200 feet south of the pilot study area, was at the southern end of the source area plume based on the 2001 data. However, in the lower portion of the aquifer (S57MW007), TCE concentrations decreased from 280 µg/L in 2001 to 0.2 µg/L in 2004, and TCE was not detected in 2005. However, the TCE concentration in 1999 was 2.2 µg/L. It is not known if this variation was caused by natural conditions or from downgradient effects of HRC® injection. Cis-1,2-dichloroethene and vinyl chloride were not detected in 2004 or 2005. TCE and its degradation products were not detected in the upper portion of the aquifer (S57MW008) in 2005. The diethyl ether concentrations at both locations continued to decline from the levels detected in 2001.

Mid-Plume Area

Based on the 2001 data, the mid-plume area is southeast of the source area and includes well clusters S57MW009/MW010 and S57MW005/MW006. Well cluster S57MW026/MW027 was installed farther downgradient in 2005. The chemicals detected in this area are similar to those detected in the source

area but generally at much lower concentrations. However, the concentrations of 1,1-dichloroethene were slightly higher than in the source area.

At locations S57MW009/MW010 and S57MW005/006, chemical concentrations detected in 2004 and 2005 decreased slightly or showed little change from previous sampling rounds. In 2005, TCE concentration ranged from not detected at S57MW026 to 330 µg/L at S57MW009. The concentrations of cis-1,2-dichloroethene ranged from not detected at S57MW026 to 59 µg/L at S57MW010. Vinyl chloride was only detected at S57MW006 (6 µg/L) and S57MW010 (2 µg/L). In 2004 and 2005, the maximum concentration of diethyl ether was 2 µg/L.

Downgradient Area

Based on the 2001 data, this area was farther southeast of the mid-plume area in an area were minimal groundwater contamination was detected. Prior to 2005, the only permanent well in this area was S57MW022. TCE has never been detected at this location; however, cis-1,2-dichloroethene, vinyl chloride, and diethyl ether have been detected. Concentrations of cis-1,2-dichloroethene decreased from 1,400 µg/L in 2001 to approximately 200 µg/L in 2004 and 2005. Concentrations of vinyl chloride decreased from 1,500 µg/L in 2001 to 850 µg/L in 2004 and 400 µg/L in 2005. Diethyl ether was not detected in 2001, but was detected at concentrations of 130 µg/L in 2004 and 160 µg/L in 2005.

Additional wells were installed in and around this area in 2005; however, additional contamination was not detected. Well cluster S57MW028/MW029 was installed approximately 700 feet northwest of S57MW022 and 100 feet southeast of S57MW026/MW027, which was the farthest downgradient detection of TCE based on the 2005 sampling results. Well S57MW030 was installed to form a well cluster with S57MW020, located approximately 100 feet downgradient of S57MW028/MW029. Well S57MW037 was installed approximately 100 feet farther downgradient. Wells S57MW031 through S57MW034 and S557MW036 were installed at various distances around S57MW022 to determine the extent of cis-1,2-dichloroethene and vinyl chloride contamination; however, these chemicals were not detected. Low concentrations (4 to 27 µg/L) of diethyl ether were detected; there was no pattern to the detections. TCE (5 µg/L) and diethyl ether (49 µg/L) were detected at S57MW034; however, based on the detections in other wells and the groundwater flow direction, this detection does not appear to be related to Site 57.

UXO 32 (also known as Site 41 – Scrap Yard) is located west of the downgradient area, and TCE was detected in groundwater during the Site 41 RI. Several existing wells downgradient of the Scrap Yard were sampled in 2005, and well S57MW035 was installed upgradient of the site. TCE was detected at a concentration of 28 µg/L at S57MW035 and was detected at downgradient locations S41MW001 (17 µg/L) and S41MW004 (33 µg/L). TCE was not detected at S57MW036, which was installed between the Scrap Yard and S57MW022. Based on the pattern of TCE detections and the groundwater flow direction,

the Scrap Yard does not appear to be the source of the cis-1,2-dichloroethene and vinyl chloride detected at S57MW022.

In 2001, S57MW023 was installed in the surficial aquifer near potable well PW-07 where TCE was detected in a sample collected in 1997 (but not in 1999). Benzene, o-xylene, and TCE, which were detected at S57MW023 in 2001, were also detected in 2004 and 2005. Consistent with the 2001 sampling, benzene and o-xylene have never been detected in any of the groundwater samples associated with Site 57. In addition, methyl tert-butyl ether was detected in 2004 and 2005. This chemical is not associated with Site 57. This supports the previous evidence that Site 57 is not the source of TCE that was previously detected in PW-07.

1.4.6.3 Aquifer Testing

Slug tests were completed at nine permanent wells to estimate the horizontal hydraulic conductivity (k_h) of the surficial aquifer. Rising head slug tests were performed at the permanent wells. The changes in water levels at the permanent wells were induced by withdrawing two bailers (each having a volume of 1 liter) simultaneously. Before a slug test was initiated, the static water level in the monitoring well was measured using an electronic water-level indicator. Water levels were recorded during the tests with a pressure transducer at logarithmic intervals of time via a programmed electronic data logger as the head returned to the original static water level. The time and the rate of change required for the water level to return to the original static water level are functions of the transmissivity of the aquifer.

1.4.6.4 Surveying

The new monitoring well and soil boring locations were surveyed, and existing base control points were used as reference points. The horizontal locations were surveyed to within 0.5 foot and were referenced to the 1983 NAD and the Maryland State Plane Coordinate System. The top of riser pipe (wells only) and ground surface elevations were surveyed to within 0.01 foot and were referenced to the NGVD of 1929.

1.4.6.5 Video Sewer Inspection

Much of the storm sewer line that discharges through IW80 has been relined. This did not include the section of sewer between manhole MH-497, which is located north of Building 406, and Mattawoman Creek. During the scoping of the 2005 investigation, it was determined that damage to this section of sewer could cause a preferential pathway for contaminant migration via infiltration and/or exfiltration. Therefore, an attempt was made to inspect the sewer using a video camera. The survey began at manhole MH-497 and extended approximately 168 feet downstream. The sewer could not be inspected farther downstream because of an obstruction. The remaining section of the sewer could not be

inspected upstream from Mattawoman Creek because of access restrictions and the water level in the creek.

The sewer pipe is severely damaged immediately upstream of Building 406, is in reasonably good condition under the building, and has a severe longitudinal crack along the crown of the pipe as it passes under the railroad tracks. Infiltration was observed at several locations. Exfiltration is possible but could not be observed or evaluated. Based on samples collected from wells installed in 2005, the groundwater in this area is not contaminated. Therefore, infiltration into this section of pipe should not cause downstream contamination, and potential exfiltration is not contributing to groundwater contamination.

1.5 CONCEPTUAL SITE MODEL

The CSM summarizes site conditions and provides a conceptual framework for establishing remedial action objectives (RAOs), evaluating remedial alternatives, and identifying data gaps that may need to be filled during the remedial design of the selected remedy. Most of the information in this section is a summary of the information provided previously in Section 1.0.

1.5.1 History

At Building 292, TCE was used for vapor degreasing and general cleaning from the mid-1960s until 1989. During the 1970s and 1980s, spent TCE (EPA hazardous waste number F002) was transferred from a tank inside the building into drums through a pipe that passed through the wall near the southern corner of the building. The drums were stored on a grass-covered area near the building, and releases from the drums are suspected to have occurred.

1.5.2 Site Features, Geology, and Hydrogeology

Building 292 is located in a valley approximately 1,300 feet due north of Mattawoman Creek at an elevation of approximately 35 feet above msl. The valley trends approximately southeast towards the creek to an elevation of approximately sea level. A storm sewer from the building area approximately follows the valley and discharges to Mattawoman Creek. An unnamed stream also flows through the valley before discharging to Mattawoman Creek. The distance from the building to the creek measured southeast down the valley is approximately 2,000 feet.

Subsurface materials at the site consist of fill, alluvium, and Marlboro Clay. The fill generally consists of reworked natural material of gravel, sand, silt, and clay. At some locations, the fill material contains minor amounts of asphalt, concrete, brick, terra cotta, and slag fragments. In areas of construction, the natural soil and alluvium are cut by, or supplemented with, the fill material. The alluvium is derived from erosion

of adjacent upland areas. It generally consists of yellow brown and gray, poorly sorted sand and gravel with minor amounts of silt and clay overlying a greenish clayey, well-sorted, very fine-grained sand and silt. The green unit typically has a clayey upper surface, and the clay content generally decreases as depth increases. Based on field observations, the green unit is interpreted as an aquitard (upper aquitard). This green unit comes into contact with a distinct clay and silt unit that is interpreted to be the Marlboro Clay (lower aquitard). The Marlboro Clay is encountered at approximately 35 to 40 feet bgs. The thickness at Site 57 is unknown. Regionally, the unit is typically 10 to 20 feet thick.

Groundwater exists in the fill, alluvium, and Marlboro Clay. The surficial aquifer generally consists of yellow-brown sand and gravel and displays the characteristics of an unconfined system. The water table mimics the surface topography. The upper aquitard within the surficial aquifer is expected to hinder the downward and lateral movement of groundwater within the surficial aquifer. However, it would provide less hindrance where the aquitard becomes sandier or thinner. The Marlboro Clay (lower aquitard) is expected to significantly limit migration between the shallow aquifer and deeper aquifers. The shallow groundwater in the upper and lower portions of the surficial aquifer generally flows southeast down the valley toward the unnamed stream and Mattawoman Creek. There is a slight downward flow component in the northern portion of the valley and a very slight upward flow component in the southern portion of the valley. The upper surficial groundwater may be discharging to both the unnamed stream and Mattawoman Creek. The deeper groundwater in the surficial aquifer is most likely discharging to Mattawoman Creek.

1.5.3 Contaminant Sources, Release Mechanisms, and Migration Pathways

Drum filling and spillage of spent TCE onto soil are the likely sources of contamination. Surface soil contaminants could migrate to downgradient areas and surface water and sediment in the unnamed stream via surface runoff. Surface soil contaminants could also migrate vertically to subsurface soil and shallow groundwater. Groundwater contaminants could migrate to surface water and sediment in the unnamed stream and Mattawoman Creek, which are the assumed groundwater discharge points. Groundwater contaminants could also infiltrate into the storm sewer that discharges to Mattawoman Creek.

The analytical data collected during previous investigations indicate that organic chemicals, particularly TCE and its degradation products dichloroethenes and vinyl chloride, have migrated from the source area to downgradient soil, groundwater, surface water, and sediment. Concentrations of inorganics were typically within background levels and similar in upgradient and downgradient samples. Consequently, inorganics do not appear to be migrating from the source area. VOCs were detected in surface and subsurface soil in the former drum storage area. The VOC concentrations were greater in the subsurface soil than in the surface soil. VOCs were also detected in groundwater samples, indicating that chemicals

have migrated from soil to groundwater. VOCs were detected in surface water samples collected from the unnamed stream, which indicates that contaminated groundwater may be discharging to the stream. Several VOCs were detected in groundwater samples and storm sewer water samples, which suggests that contaminated groundwater may be infiltrating into the storm sewer. However, some VOCs were only detected in storm sewer water, which suggests another source may be present. The presence of TCE degradation products suggests that natural attenuation of TCE in groundwater is most likely occurring. Although field testing did not identify the presence of DNAPL in soil and groundwater samples, TCE concentrations in a few soil and groundwater samples were great enough to infer that DNAPL may be present in the source area near the building and where drums were stored. The DNAPL would be a potential ongoing source of groundwater contamination. The amount of potential DNAPL that may be present is not known.

1.5.4 Risk Assessment Summary

A risk assessment was conducted based on data collected during the RI. The following potential receptors were identified under current and future land use conditions:

- Full-time employees may be exposed to surface soil while performing maintenance activities (e.g., mowing, landscaping), site inspections, or daily duties. Employees are not typically exposed to subsurface soil and would not be exposed to shallow groundwater because it is not used as a potable water supply under current conditions and is not anticipated to be used as a potable water supply in the future. Exposure to surface water and sediment is expected to be minimal for these receptors.

- Construction workers were evaluated for exposure to surface soil, subsurface soil, surface water, and sediment. It was also assumed that construction workers could contact surface water and sediment in the storm sewer. Dermal exposure to shallow groundwater or inhalation of organics volatilizing from groundwater is also possible if excavation occurs below the water table.

- Hypothetical on-site residents were assumed to be exposed to soil and groundwater on a daily basis and to surface water and sediment less frequently. A future residential scenario is not considered to be likely as long as the property is a military facility. However, this scenario was evaluated to determine whether land use restrictions may be needed. Potential risks to off-site residents were not evaluated because Site 57 is isolated from current residential areas by creeks, rivers, and NSF-IH access restrictions. Off-site resident exposure to contamination is highly unlikely.

Potential risks to adolescent trespassers were not evaluated because Site 57 is located in a restricted area of NSF-IH.

There were no unacceptable risks to human health or ecological receptors from exposure to surface water or sediment. Mattawoman Creek has not been affected by releases from the site. There were unacceptable risks to construction workers and hypothetical residents from exposure to soil; however, contaminated soil above the water table was removed under a non-time-critical removal action completed in June 2006. The contaminated soil was also a potential source of groundwater contamination. There were no unacceptable risks to constructions workers exposed to contaminated groundwater. However, use of shallow groundwater as a source of potable water could result in unacceptable risks to hypothetical residents. Therefore, the remainder of this section only discusses groundwater because it is the only medium at the site that needs to be addressed by the remedial action.

1.5.5 Groundwater Contaminant Distribution

Three areas of groundwater contamination have been defined at Site 57 that have different COCs at different concentrations. This discussion will focus on TCE and its degradation products (i.e., cis-1,2-dichloroethene and vinyl chloride) because these are the COCs detected most often at the greatest concentrations.

The source area is near Building 292 and exhibits the greatest contaminant concentrations. This is the area where contaminated soil was removed. The length of the plume in the source area is approximately 300 feet. Monitoring wells are screened across the water table and above the upper confining unit. The principal COCs are TCE, cis-1,2-dichloroethene, and vinyl chloride. Chemical concentrations are greater in the upper portion of the aquifer. The average concentration of TCE is greater than 7,000 µg/L in the upper portion and less than 60 µg/L in the lower portion. The average concentration of cis-1,2-dichloroethene is greater than 10,000 µg/L in the upper portion and approximately 10 µg/L in the lower portion. The average concentration of vinyl chloride is greater than 5,000 µg/L in the upper portion and less than 1 µg/L in the lower portion. The concentrations of TCE, cis-1,2-dichloroethene, and vinyl chloride have been affected by the HRC® pilot study. This reduced the concentrations of TCE, but resulted in greater concentrations of TCE degradation products.

The next downgradient area (mid-plume area) of groundwater contamination is approximately halfway between Building 292 and Mattawoman Creek. The principal COC is TCE. Chemical concentrations are much lower than in the source area and do not change significantly between the upper and lower portions of the aquifer. The average concentration of TCE is approximately 200 µg/L in the upper portion and approximately 150 µg/L in the lower portion. The average concentration of cis-1,2-dichloroethene is approximately 50 µg/L in the upper portion and approximately 25 µg/L in the lower portion. The average concentration of vinyl chloride is less than 5 µg/L in the upper portion, and vinyl chloride was not detected in the lower portion.

The other area of groundwater contamination is near Mattawoman Creek. There is a relatively large area (approximately 700 feet) of uncontaminated groundwater between this area and the area discussed above. The principal COCs are cis-1,2-dichloroethene and vinyl chloride. The concentrations of these chemicals are decreasing. The concentration of 1,2-dichloroethene was 1,400 µg/L in 2001 and 210 µg/L in 2005. The concentration of vinyl chloride was 1,500 µg/L in 2001 and 400 µg/L in 2005.

TABLE 1-1

GROUNDWATER LEVEL SUMMARY - OCTOBER 2005
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Well Identification	Depth to Water (feet btoc)	Top of Reference Point Elevation (feet above msl)	Water Level Elevation (feet above msl)
S57MW001	6.95	37.09	30.14
S57MW002	5.51	37.58	32.07
S57MW003	8.60	35.82	27.22
S57MW004	8.57	35.72	27.15
S57MW005	5.34	18.54	13.20
S57MW006	5.45	18.57	13.12
S57MW007	8.47	30.58	22.11
S57MW008	6.44	30.26	23.82
S57MW009	8.45	25.75	17.30
S57MW010	8.45	25.82	17.37
S57MW011	8.68	33.49	24.81
S57MW012	5.35	43.82	38.47
S57MW013	5.06	43.98	38.92
S57MW020	5.39	13.31	7.92
S57MW022	7.95	10.09	2.14
S57MW023	14.18	40.54	26.36
S57MW024	6.41	32.50	26.09
S57MW025	6.79	32.43	25.64
S57MW026	6.11	17.05	10.94
S57MW027	6.60	17.28	10.68
S57MW028	4.65	14.11	9.46
S57MW029	5.35	14.39	9.04
S57MW030	5.00	12.74	7.74
S57MW031	5.84	14.61	8.77
S57MW032	5.18	10.05	4.87
S57MW033	5.74	10.96	5.22
S57MW034	5.06	10.76	5.70
S57MW035	20.73	31.55	10.82
S57MW036	7.16	10.58	3.42
S57MW037	4.31	11.57	7.26
41MW01	6.75	14.97	8.22
41MW02	5.08	9.33	4.25
41MW04	4.14	8.20	4.06

btoc - Below top of casing.
msl - Mean sea level.

TABLE 1-2

SLUG TEST HYDRAULIC CONDUCTIVITY RESULTS
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Monitored Interval	Well Identification	Slug Test Results - 2001 and 2005			
		Falling Head Test (feet/day)	Rising Head Test (feet/day)	Average[1] (feet/day)	Average[1] (cm/sec)
Shallow	S57MW002	--	1.10	1.10	3.9E-04
	S57MW004	--	15.20	15.20	5.4E-03
	S57MW006	--	14.90	14.90	5.3E-03
	S57MW008	--	9.33	9.33	3.3E-03
	S57MW010	--	2.95	2.95	1.0E-03
	S57MW013	--	2.37	2.37	8.4E-04
	S57TW016	0.53	--	0.53	1.9E-04
	S57TW018	0.17	--	0.17	6.0E-05
	S57MW020	3.2	1.30	2.25	7.9E-04
	S57MW022	--	3.30	3.30	1.2E-03
	S57MW023	--	12.80	12.80	4.5E-03
	S57MW032	--	9.39	9.39	3.3E-03
	S57MW033	--	4.56	4.56	1.6E-03
	S57MW034	--	1.88	1.88	6.6E-04
	S57MW036	--	21.50	21.50	7.6E-03
			Geometric Mean =	**3.6**	**1.3E-03**
Intermediate	S57MW001	--	0.743	0.74	2.6E-04
	S57MW003	--	3.18	3.18	1.1E-03
	S57MW005	--	18.4	18.40	6.5E-03
	S57MW007	--	0.57	0.57	2.0E-04
	S57MW009	--	1.5	1.50	5.3E-04
	S57MW011	--	0.50	0.50	1.7E-04
	S57TW015	--	0.4	0.40	1.4E-04
	S57TW017	3.6	5.2	4.40	1.6E-03
	S57TW019	1.22	2.1	1.66	5.9E-04
	S57TW021	0.54	0.98	0.76	2.7E-04
	S57MW027	--	0.855	0.86	3.0E-04
	S57MW031	--	1.57	1.57	5.5E-04
			Geometric Mean =	**1.4**	**4.9E-04**
Deep	S57MW012	--	17.94	17.94	6.3E-03
	S57MW028	--	0.0192	0.02	6.8E-06
	S57MW030	--	0.38	0.4	1.3E-04
	S57MW035	--	7.98	7.98	2.8E-03
			Geometric Mean =	**1.0**	**3.6E-04**

1 Arithmetic average of falling head and rising head tests.
-- Test not performed.

cm/sec - Centimeters per second.
MW - Monitoring well.
TW - Temporary well.

TABLE 1-3

MONITORING WELL CONSTRUCTION SUMMARY
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Well Number	Northing	Easting	Ground Elevation (ft above msl)	Top of Riser Elevation (ft above msl)	Total Depth (ft bgs)	Screen Interval (ft bgs)	Screen Length (ft)	Top of Screen Elevation (ft above msl)	Bottom of Screen Elevation (ft above msl)	Total Depth (below top of riser)	Monitored Interval	Completion Type	Date Installed	Abandonment Date
	NAD 1983 Datum													
41MW01	334,130.33	1,263,811.38	12.69	14.97	18.5	8.5 - 19	10	4.19	-5.81	20.3	shallow	stick-up	9/1/1992	NA
41MW02	333,984.15	1,264,245.77	6.87	9.33	18.5	8.5 - 19	10	-1.63	-11.63	20.22	Intermediate	stick-up	9/1/1992	NA
41MW03	334,124.36	1,264,054.95	8.54	11.18	18.5	8.5 - 19	10	0.04	-9.96	20.1	Intermediate	stick-up	9/2/1992	1998
41MW04	334,035.83	1,264,056.62	8.47	8.20	15.5	5 - 15	10	3.47	-6.53	14.73	shallow	flush	10/8/1998	NA
S57CP001	335,041.75	1,263,378.61	75.96	na	43.2	14 - 16	2	61.96	59.96	na	deep	temporary	8/30/2001	8/30/2001
S57CP002	334,733.23	1,263,591.09	39	na	53.3	na - na	na	na	na	na	deep	temporary	8/30/2001	8/30/2001
S57CP003	334,820.26	1,264,059.09	34.42	na	52.7	43 - 45	2	-8.58	-10.58	na	deep	temporary	8/30/2001	8/30/2001
S57CP004	334,365.84	1,264,190.00	20.41	na	23	21 - 23	2	-0.59	-2.59	na	deep	temporary	8/28/2001	8/28/2001
S57CP005	334,071.68	1,264,896.71	8.25	na	20.5	17 - 19	2	-8.75	-10.75	na	deep	temporary	8/29/2001	8/29/2001
S57CP006	333,968.89	1,264,640.78	6.78	na	31.5	25 - 27	2	-18.22	-20.22	na	deep	temporary	8/29/2001	8/29/2001
S57CP007	334,278.06	1,264,026.24	29.14	na	43	na - na	na	na	na	na	deep	temporary	8/30/2001	8/30/2001
S57CP008	334,208.41	1,263,509.08	28.52	na	32.7	27 - 29	2	1.52	-0.48	na	deep	temporary	8/29/2001	8/29/2001
S57CP009	334,378.55	1,263,452.66	38.35	na	55.3	na - na	na	na	na	na	deep	temporary	8/29/2001	8/29/2001
S57CP010	335,292.06	1,263,606.29	34.98	na	49.2	38 - 40	2	-2.52	-4.52	na	deep	temporary	8/28/2001	8/28/2001
S57MW001	335,394.46	1,263,650.94	35.57	37.09	26	14 - 24	10	21.57	11.57	26.25	Intermediate	stick-up	1/6/1999	NA
S57MW002	335,397.69	1,263,649.26	35.72	37.58	13.5	3 - 13	10	32.72	22.72	14.32	shallow	stick-up	1/6/1999	NA
S57MW003	335,285.64	1,263,748.26	33.83	35.82	22.5	17 - 22	5	16.83	11.83	24.35	Intermediate	stick-up	1/22/1999	NA
S57MW004	335,289.36	1,263,746.88	33.91	35.72	16.5	6 - 16	10	27.91	17.91	16.15	shallow	stick-up	1/7/1999	NA
S57MW005	334,578.38	1,264,177.60	16.18	18.54	20	13 - 18	5	3.18	-1.82	19.8	Intermediate	stick-up	1/11/1999	NA
S57MW006	334,576.70	1,264,181.97	16.57	18.57	12.5	2 - 12	10	14.57	4.57	14.2	shallow	stick-up	1/11/1999	NA
S57MW007	335,082.26	1,263,768.13	28.17	30.58	30	16 - 26	10	12.17	2.17	28.6	Intermediate	stick-up	1/10/1999	NA
S57MW008	335,084.77	1,263,765.00	28.09	30.26	15.5	5 - 15	10	23.09	13.09	15.5	shallow	stick-up	1/10/1999	NA
S57MW009	334,897.38	1,263,862.13	23.9	25.75	20	14 - 19	5	9.9	4.9	20	Intermediate	stick-up	1/12/1999	NA
S57MW010	334,894.06	1,263,861.24	23.34	25.82	14.5	4 - 14	10	19.34	9.34	16	shallow	stick-up	1/11/1999	NA
S57MW011	335,222.16	1,263,751.17	31.61	33.49	20	9 - 19	10	22.61	12.61	19.69	Intermediate	stick-up	1/7/1999	NA
S57MW012	335,575.45	1,263,497.42	41.74	43.82	43.5	33 - 43	10	8.74	-1.26	44.3	deep	stick-up	1/9/1999	NA
S57MW013	335,577.33	1,263,500.08	41.9	43.98	16.5	6 - 16	10	35.9	25.9	17.95	shallow	stick-up	1/12/1999	NA
S57MW020	334,440.46	1,264,429.15	10.39	13.31	14	4 - 14	10	6.39	-3.61	17.58	shallow	stick-up	8/22/2001	NA
S57MW022	334,065.57	1,264,908.66	8.11	10.09	14	4 - 14	10	4.11	-5.89	17.45	shallow	stick-up	8/22/2001	NA
S57MW023	334,392.01	1,263,440.68	37.44	40.54	20	10 - 20	10	27.44	17.44	23.1	shallow	stick-up	8/22/2001	NA
S57MW024	335,262.44	1,263,748.03	32.86	32.50	14.5	4 - 14	10	28.86	18.86	12.35	shallow	flush	5/14/2003	NA
S57MW025	335,244.82	1,263,758.45	32.6	32.43	14.5	4 - 14	10	28.6	18.6	13.7	shallow	flush	5/14/2003	NA
S57MW026	334,535.75	1,264,255.39	14.87	17.05	38	27 - 37	10	-12.13	-22.13	39.52	deep	stick-up	9/21/2005	NA

TABLE 1-3

MONITORING WELL CONSTRUCTION SUMMARY
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Well Number	Northing	Easting	Ground Elevation (ft above msl)	Top of Riser Elevation (ft above msl)	Total Depth (ft bgs)	Screen Interval (ft bgs)	Screen Length (ft)	Top of Screen Elevation (ft above msl)	Bottom of Screen Elevation (ft above msl)	Total Depth (below top of riser)	Monitored Interval	Completion Type	Date Installed	Abandonment Date
	NAD 1983 Datum													
S57MW027	334,532.80	1,264,259.46	14.8	17.28	20	10 - 20	10	4.8	-5.2	22.73	Intermediate	stick-up	9/16/2005	NA
S57MW028	334,474.20	1,264,348.86	11.96	14.11	34	24 - 24	10	-12.04	-12.04	36.66	deep	stick-up	9/22/2005	NA
S57MW029	334,478.13	1,264,351.37	12.09	14.39	14	4 - 14	10	8.09	-1.91	17.14	Intermediate	stick-up	9/16/2005	NA
S57MW030	334,436.10	1,264,438.78	10.36	12.74	34	24 - 34	10	-13.64	-23.64	36.74	deep	stick-up	9/23/2005	NA
S57MW031	334,406.92	1,264,662.02	12.46	14.61	20	10 - 20	10	2.46	-7.54	22.26	Intermediate	stick-up	9/15/2005	NA
S57MW032	334,211.39	1,264,723.47	7.71	10.05	16	5 - 15	10	2.71	-7.29	17.95	shallow	stick-up	9/15/2005	NA
S57MW033	334,149.50	1,264,941.64	8.41	10.96	16	6 - 16	10	2.41	-7.59	18.72	shallow	stick-up	9/15/2005	NA
S57MW034	334,313.11	1,265,094.18	8.21	10.76	14	4 - 14	10	4.21	-5.79	17.37	shallow	stick-up	9/15/2005	NA
S57MW035	334,280.46	1,264,030.55	29.05	31.55	32	22 - 32	10	7.05	-2.95	35.16	deep	stick-up	9/19/2005	NA
S57MW036	334,010.39	1,264,692.48	7.91	10.58	10	5 - 10	5	2.91	-2.09	12.71	shallow	stick-up	9/15/2005	NA
S57MW037	334,367.48	1,264,506.12	8.92	11.57	15	10 - 15	5	-1.08	-6.08	15.1	Intermediate	stick-up	9/14/2005	NA
S57TW001	334,862.81	1,263,841.35	22.77	24.78	12	2 - 12	10	20.77	10.77	14.01	shallow	temporary	1/19/1999	1/28/1999
S57TW002	334,440.19	1,264,429.70	10.09	11.94	12	3 - 8	5	7.09	2.09	9.85	shallow	temporary	1/19/1999	1/28/1999
S57TW003	334,055.20	1,264,862.80	6.63	7.12	12	4.5 - 9.5	5	2.13	-2.87	9.99	shallow	temporary	1/19/1999	1/28/1999
S57TW014	335,445.15	1,263,459.21	42.51	44.54	10	4 - 9	5	38.51	33.51	11.7	shallow	temporary	8/22/2001	10/24/2001
S57TW015	335,449.71	1,263,455.01	42.71	45.92	30	25 - 30	5	17.71	12.71	32.9	Intermediate	temporary	8/24/2001	10/24/2001
S57TW016	335,291.18	1,263,603.59	34.83	35.68	10	5 - 10	5	29.83	24.83	11.92	shallow	temporary	8/17/2001	10/24/2001
S57TW017	335,289.40	1,263,606.71	34.78	35.48	24	13 - 23	10	21.78	11.78	25	Intermediate	temporary	8/16/2001	10/24/2001
S57TW018	335,080.92	1,263,895.89	30.71	31.16	15	9.5 - 15	5	21.21	16.21	15	shallow	temporary	8/20/2001	10/24/2001
S57TW019	335,078.62	1,263,897.69	30.64	31.64	24	19 - 24	5	11.64	6.64	25	Intermediate	temporary	8/17/2001	10/24/2001
S57TW021	334,173.08	1,264,593.47	9.84	10.49	25	9 - 14	5	0.84	-4.16	14.65	Intermediate	temporary	8/21/2001	10/24/2001

All elevations are referenced to National Geodetic Datum of 1929.

bgs - Below ground surface.
CP - Cone penetrometer.
ft - Feet.
msl - Mean sea level.
MW - Monitoring well.
NA - Not abandoned.
na - Not applicable.
NAD - North American Datum.
TW - Temporary well.

TABLE 1-4

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2001
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57CP004	S57CP005	S57CP005-D	S57CP006	S57CP010	S57MW001	S57MW002	S57MW003	S57MW003-D
Acetone									
Benzene									
cis-1,2-Dichloroethene							2.6	47	14
1,1-Dichloroethane									
1,2-Dichloroethane									
1,1-Dichloroethene									
Diethyl ether		800				450	930	440	320
Methlyene chloride									
o-Xylene									
Tetrachloroethene									
trans-1,2-Dichloroethene									
1,1,1-Trichloroethane									
Trichloroethene		11	9.4			2.6	43	450	280
Vinyl chloride									

TABLE 1-4

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2001
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57MW004	S57MW005	S57MW006	S57MW007	S57MW007-D	S57MW008	S57MW009	S57MW010
Acetone								
Benzene								
cis-1,2-Dichloroethene	620		46	47			85	150
1,1-Dichloroethane				1.7			4	4.3
1,2-Dichloroethane								
1,1-Dichloroethene			6.7	11			28	13
Diethyl ether	320	570			750	1300		
Methlyene chloride								
o-Xylene								
Tetrachloroethene	6.3							
trans-1,2-Dichloroethene	3.7							
1,1,1-Trichloroethane	20		4.6					
Trichloroethene	12000		250	280	0.6		480	330
Vinyl chloride	26							5.5

TABLE 1-4

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2001
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57MW011	S57MW012	S57MW013	S57TW014	S57TW015	S57TW016	S57TW017	S57TW018
Acetone				70				
Benzene								
cis-1,2-Dichloroethene	30	1.9						64
1,1-Dichloroethane		5.3						2.2
1,2-Dichloroethane			4.8					
1,1-Dichloroethene		2	74					3.7
Diethyl ether	1700			740	920	5.4	4800	2.1
Methlyene chloride								1.3
o-Xylene								
Tetrachloroethene					7.1		1.6	
trans-1,2-Dichloroethene								
1,1,1-Trichloroethane								
Trichloroethene	94	1.6			2.3	1.1		210
Vinyl chloride								

TABLE 1-4

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2001
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57TW018-D	S57TW019	S57MW020	S57TW021	S57MW022	S57MW023
Acetone						
Benzene						900
cis-1,2-Dichloroethene	68	5.5			1400	
1,1-Dichloroethane	1.9					
1,2-Dichloroethane						
1,1-Dichloroethene	2.5					
Diethyl ether		77	18			
Methlyene chloride		1.9				
o-Xylene						28
Tetrachloroethene						
trans-1,2-Dichloroethene						
1,1,1-Trichloroethane						
Trichloroethene	210	62				30
Vinyl chloride					1500	

Blank space indicates chemical was not detected.
All concentrations in units of µg/L.
CP - Cone penetrometer.
D - Duplicate sample.
MW - Monitoring well.
TW - Temporary well.

TABLE 1-5

SUMMARY OF GRAIN SIZE DISTRIBUTION IN SUBSURFACE SOIL SAMPLES
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Sample No.	Sample Depth (feet)	Hydraulic Unit	USCS Symbol	Soil Description
57SB0160103	4 - 5	Vadose	SM	Sand with some clay, gravel, and silt.
57SB0160303	18 - 20	Lower Surficial Aquifer	SW/SM	Well-graded sand with trace silt and clay.
57SB0180103	4 - 5	Vadose	SM	Clayey sand with some gravel and silt.
57SB0180303	16 - 18	Lower Surficial Aquifer	SM	Sand with some clay and trace silt.
57SB0210103	4 - 5	Vadose	ML	Sandy clay with some silt trace gravel.
57SB0210303	14 - 16	Lower Surficial Aquifer	SP/SM	Poorly graded sand with trace silt and clay.
57SB0220103	4 - 5	Vadose	SM	Sand with some gravel and clay and trace silt.
57SB0220303	12 - 14	Lower Surficial Aquifer	SP/SM	Poorly graded gravelly sand with trace silt and clay.
57SB0240103	4 - 5	Vadose	ML	Sandy silt with some clay trace gravel.
57SB0300203	8 - 10	Surficial Aquifer	SM	Sand with some clay and silt trace gravel.
57SB0300403	22 - 24	Aquitard	ML	Clay with some silt and sand.
57SB0310203	8 - 10	Surficial Aquifer	SM	Sand with some silt and clay trace gravel.
57SB0310403	18 - 20	Aquitard	SM	Sand with some silt and clay.
57SB0320203	8 - 10	Aquitard	ML	Clay with some silt, sand, and gravel.
57SB0320403	18 - 20	Aquitard	ML	Clay with some silt, sand, and gravel.

ML - Inorganic silts and very fine sands, silty or clayey fine sands or clayey silts.
SM - Silty sands, sand-silt mixtures.
SP - Poorly-graded sands, gravelly sands, little or no fines.
SW - Well-graded sands, gravelly sands, little or no fines.
USCS - Unified Soil Classification System.

TABLE 1-6

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2004
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57MW001	S57MW002	S57MW003	S57MW004	S57MW004-D	S57MW005	S57MW006	S57MW007	S57MW008
1,1,1-Trichloroethane		0.3			0.7	4	3		
1,1,2-Trichloroethane					0.2	0.2	0.2		
1,1-Dichloroethane	1	2			0.8	1	1		
1,1-Dichloroethene	0.2			3	3	9	8		
1,2-Dichloroethane									
Acetone									
Benzene									
Carbon tetrachloride							0.2		
Chloroform	0.2						0.1		
cis-1,2-Dichloroethene		0.7	8	520	560	33	38		0.2
Cyclohexane									
Diethyl ether	420	1200	8	96	120	0.7	1	580	330
Methyl tert-butyl ether									
Tetrachloroethene	0.3								
Toluene	0.2	0.2							
Total xylenes									
trans-1,2-Dichloroethene				3	5				
Trichloroethene	2	10	400	590	600	240	240	0.2	0.3
Vinyl chloride				14	15	0.4	0.6		

TABLE 1-6

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2004
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57MW009	S57MW010	S57MW011	S57MW012	S57MW013	S57MW020	S57MW022	S57MW023	S57MW024
1,1,1-Trichloroethane	4	2		0.4	8				
1,1,2-Trichloroethane	0.4	0.2							
1,1-Dichloroethane	3	2	0.3	4	0.7		4	0.5	
1,1-Dichloroethene	20	8	0.6	2	75				8
1,2-Dichloroethane		0.2			2				
Acetone								7900	
Benzene								1200	
Carbon tetrachloride				0.3					
Chloroform	0.5	0.4		0.3	2				
cis-1,2-Dichloroethene	51	43	18	1	0.3		200		4600
Cyclohexane								12	
Diethyl ether	2	1	2100	5		220	130		77
Methyl tert-butyl ether								1700	
Tetrachloroethene			0.4	0.2	0.7			0.4	
Toluene		0.1		0.2	0.1		0.4	0.3	
Total xylenes								38	
trans-1,2-Dichloroethene			0.4				2		15
Trichloroethene	360	200	91	1	0.4	0.2		40	350
Vinyl chloride		2	0.7				850		1300

TABLE 1-6

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2004
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57MW025	S57MW025-D	IW80
1,1,1-Trichloroethane			
1,1,2-Trichloroethane			
1,1-Dichloroethane			
1,1-Dichloroethene	78		
1,2-Dichloroethane			
Acetone			
Benzene			0.2
Carbon tetrachloride			
Chloroform			
cis-1,2-Dichloroethene	58000	40000	6
Cyclohexane			
Diethyl ether	130	120	41
Methyl tert-butyl ether			0.4
Tetrachloroethene			
Toluene			0.2
Total xylenes			
trans-1,2-Dichloroethene	260	230	
Trichloroethene	72	62	3
Vinyl chloride	11000	9800	1

Blank space indicates chemical was not detected.
All concentrations in units of µgL.
IW80 - Industrial Wastewater Outfall 80.
MW - Monitoring well.

TABLE 1-7

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2005
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S41MW001	S41MW002	S41MW004	S57MW001	S57MW002	S57MW003	S57MW003-D	S57MW004	S57MW005
1,1,1-TRICHLOROETHANE								2	2
1,1,2-TRICHLOROETHANE									
1,1-DICHLOROETHANE				2					1
1,1-DICHLOROETHENE						1	1	4	6
1,2-DICHLOROETHANE									
2-BUTANONE									
2-HEXANONE									
BENZENE	260								
CHLOROFORM									
CHLOROMETHANE	8								
CIS-1,2-DICHLOROETHENE						7	7	72	36
DIETHYL ETHER				100	1600	140	160	120	
ISOPROPYLBENZENE	1								
METHYL TERT-BUTYL ETHER	510		51						
O-XYLENE									
TETRACHLOROETHENE									
TOLUENE									
TOTAL 1,2-DICHLOROETHENE						7	7	72	36
TOTAL XYLENES									
TRANS-1,2-DICHLOROETHENE									
TRICHLOROETHENE	17		33	3	5	200	150	950	230
VINYL CHLORIDE								13	

TABLE 1-7

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2005
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57MW006	S57MW007	S57MW008	S57MW009	S57MW010	S57MW011	S57MW012	S57MW013	S57MW020
1,1,1-TRICHLOROETHANE	3			3	2			5	
1,1,2-TRICHLOROETHANE									
1,1-DICHLOROETHANE	1			3	2		6		
1,1-DICHLOROETHENE	7			20	9		2	62	
1,2-DICHLOROETHANE								3	
2-BUTANONE									
2-HEXANONE									
BENZENE									
CHLOROFORM								2	
CHLOROMETHANE									
CIS-1,2-DICHLOROETHENE	38			50	59	18	1		
DIETHYL ETHER		410	320	1		2000	14		260
ISOPROPYLBENZENE									
METHYL TERT-BUTYL ETHER									
O-XYLENE									
TETRACHLOROETHENE									
TOLUENE									
TOTAL 1,2-DICHLOROETHENE	38			50	59	18	1		
TOTAL XYLENES									
TRANS-1,2-DICHLOROETHENE									
TRICHLOROETHENE	230			330	160	27	2		
VINYL CHLORIDE	6				2				

TABLE 1-7

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2005
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Analyte	S57MW022	S57MW023	S57MW024	S57MW025	S57MW025-D	S57MW026	S57MW027	S57MW027-D
1,1,1-TRICHLOROETHANE								
1,1,2-TRICHLOROETHANE								
1,1-DICHLOROETHANE	4		1	5	6			
1,1-DICHLOROETHENE			4	12	12			1
1,2-DICHLOROETHANE								
2-BUTANONE				49	47			
2-HEXANONE		2						
BENZENE		1400						
CHLOROFORM								
CHLOROMETHANE		37						
CIS-1,2-DICHLOROETHENE	210	5	820	10000	8900		5	5
DIETHYL ETHER	160		58	23	25			
ISOPROPYLBENZENE		5						
METHYL TERT-BUTYL ETHER		1400						
O-XYLENE		19						
TETRACHLOROETHENE								
TOLUENE								
TOTAL 1,2-DICHLOROETHENE	260	5	820	10000	8900		5	5
TOTAL XYLENES		19						
TRANS-1,2-DICHLOROETHENE			6	160	160			
TRICHLOROETHENE		79	580	72	71		28	33
VINYL CHLORIDE	400		250	25000	22000			

TABLE 1-7

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2005
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

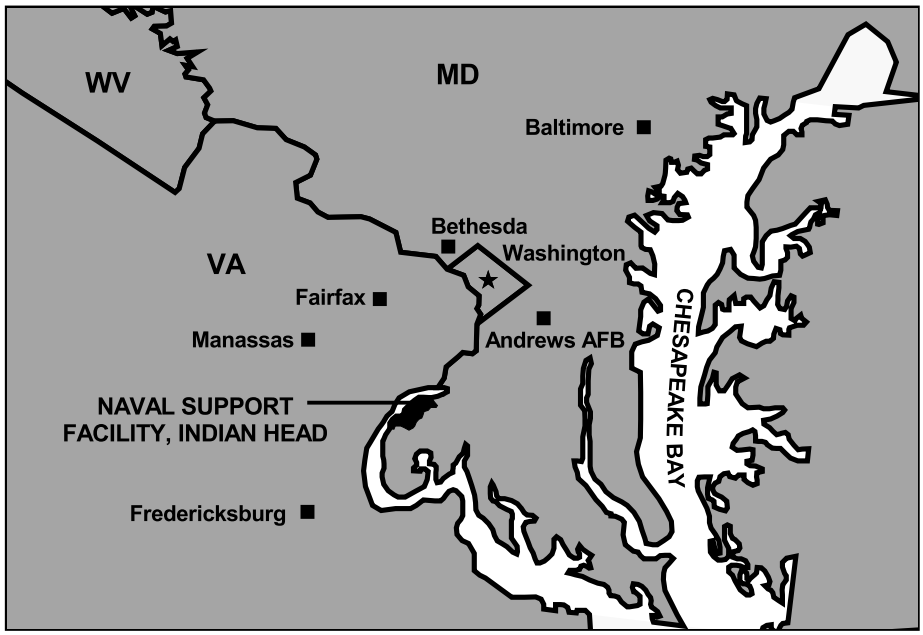
Analyte	S57MW028	S57MW029	S57MW030	S57MW031	S57MW031-D	S57MW032	S57MW033	S57MW034	S57MW035
1,1,1-TRICHLOROETHANE									
1,1,2-TRICHLOROETHANE									
1,1-DICHLOROETHANE									
1,1-DICHLOROETHENE									
1,2-DICHLOROETHANE									
2-BUTANONE									
2-HEXANONE									
BENZENE									1
CHLOROFORM									
CHLOROMETHANE									
CIS-1,2-DICHLOROETHENE									
DIETHYL ETHER		1		27	27	5	4	49	
ISOPROPYLBENZENE									
METHYL TERT-BUTYL ETHER									36
O-XYLENE									
TETRACHLOROETHENE									
TOLUENE									
TOTAL 1,2-DICHLOROETHENE									
TOTAL XYLENES									
TRANS-1,2-DICHLOROETHENE									
TRICHLOROETHENE								5	28
VINYL CHLORIDE									

TABLE 1-7

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER - 2005
SITE 57 - BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

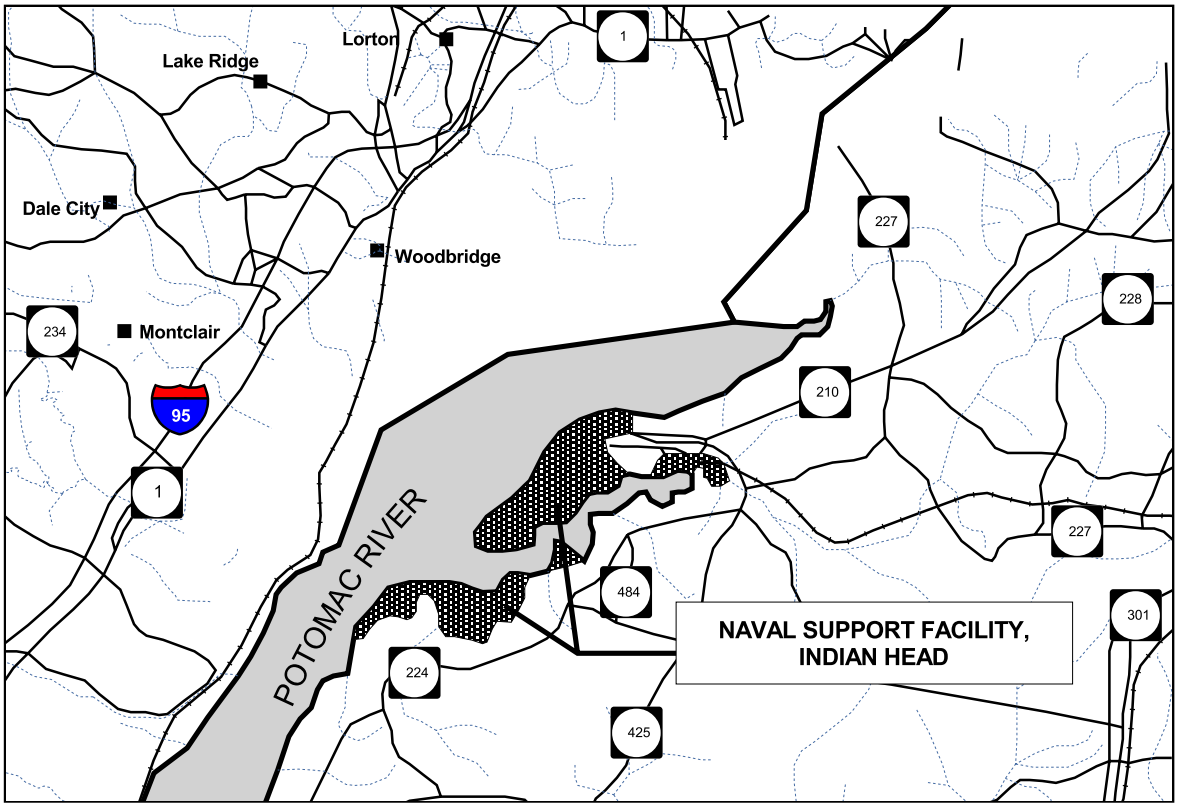
Analyte	S57MW036	S57MW037	S57SB033	S57SB035	S57SB035-D	S57SB036
1,1,1-TRICHLOROETHANE						
1,1,2-TRICHLOROETHANE				4	4	
1,1-DICHLOROETHANE				18	22	
1,1-DICHLOROETHENE				120	110	
1,2-DICHLOROETHANE						
2-BUTANONE						
2-HEXANONE						
BENZENE						
CHLOROFORM						
CHLOROMETHANE						2
CIS-1,2-DICHLOROETHENE			27	46000	41000	
DIETHYL ETHER	44					4200
ISOPROPYLBENZENE						
METHYL TERT-BUTYL ETHER						
O-XYLENE						
TETRACHLOROETHENE				3	3	
TOLUENE				2	2	
TOTAL 1,2-DICHLOROETHENE			27	46000	41000	
TOTAL XYLENES						
TRANS-1,2-DICHLOROETHENE						
TRICHLOROETHENE			78	36000	32000	
VINYL CHLORIDE			4	4400	3900	

Blank space indicates chemical was not detected.
All concentrations in units of µg/L.
MW - Monitoring well.
SB - Temporary well installed in soil boring.



LEGEND

- City
- Highway
- Railroad
- River



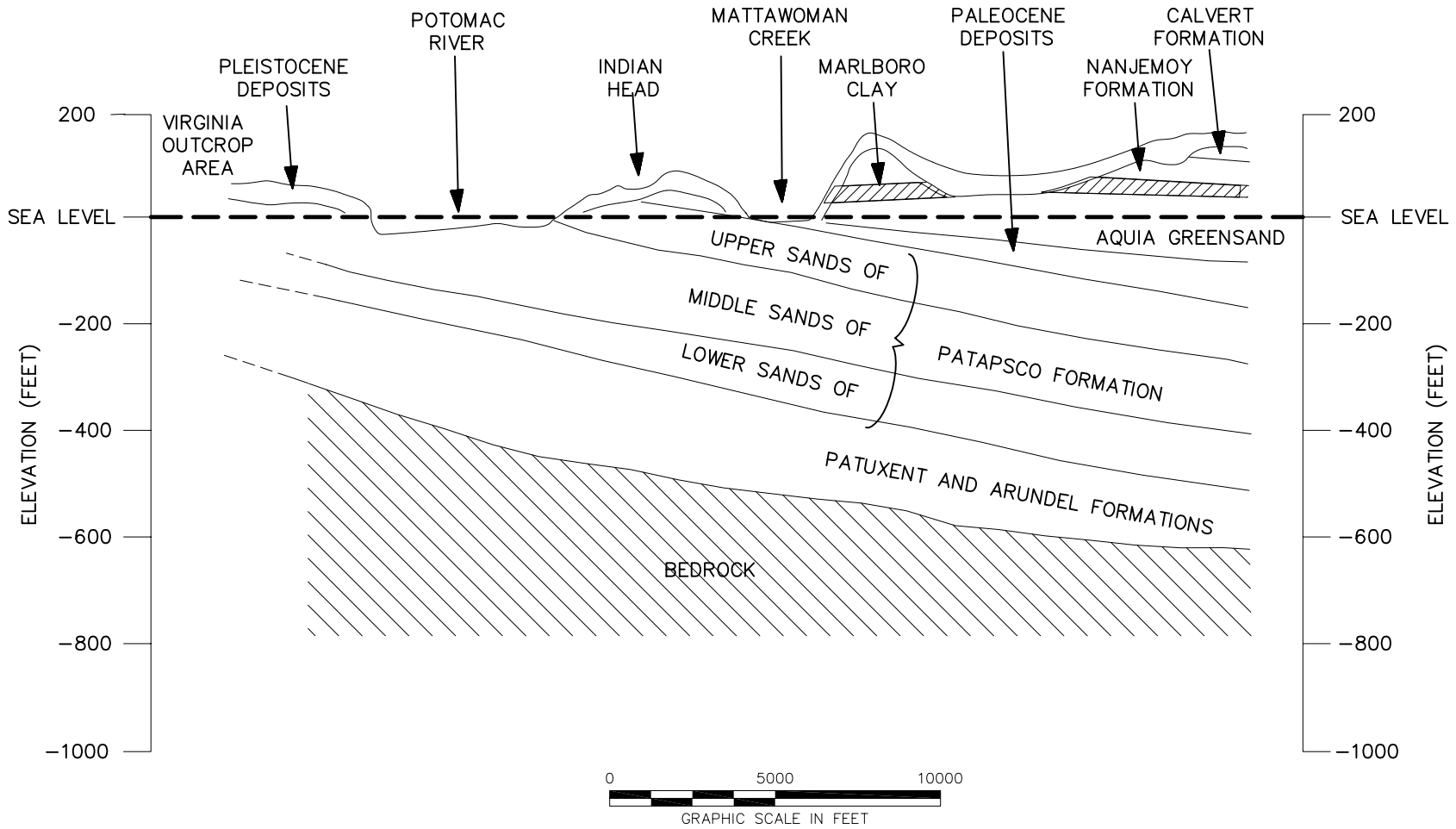
DRAWN BY K. PEILA — DATE 3/17/05	Tetra Tech NUS, Inc.	CONTRACT NUMBER 2194	OWNER NO. 007
CHECKED BY G. LATULIPPE — DATE 3/17/05	FACILITY LOCATION MAP NAVAL SUPPORT FACILITY, INDIAN HEAD INDIAN HEAD, MARYLAND	APPROVED BY KCT — DATE 10/25/05	
COST/SCHEDULE-AREA		APPROVED BY — — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1 - 1	REV 0

P:\GIS\NSWC_INDIAN_HEAD\SITE57_PILOTSTUDY_SITELOCATION:APR FACILITY LOCATION MAP 3/1/06 KMP

P:\GIS\INDIANHEAD_NSWC\APR\COMMUNITYRELATIONSPLAN.APR SITE 57 WORK PLAN 3/1/06 KMP

DRAWN BY K. PEILA	DATE 3/17/05	Tetra Tech NUS, Inc.	CONTRACT NUMBER 2194 / OWNER NUMBER 007
CHECKED BY GJL	DATE 3/17/05	SITE LOCATION MAP SITE 57 - BUILDING 292 TCE CONTAMINATION NAVAL SUPPORT FACILITY, INDIAN HEAD INDIAN HEAD, MARYLAND	APPROVED BY GJL / DATE 3/17/05
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-2 / REV 0

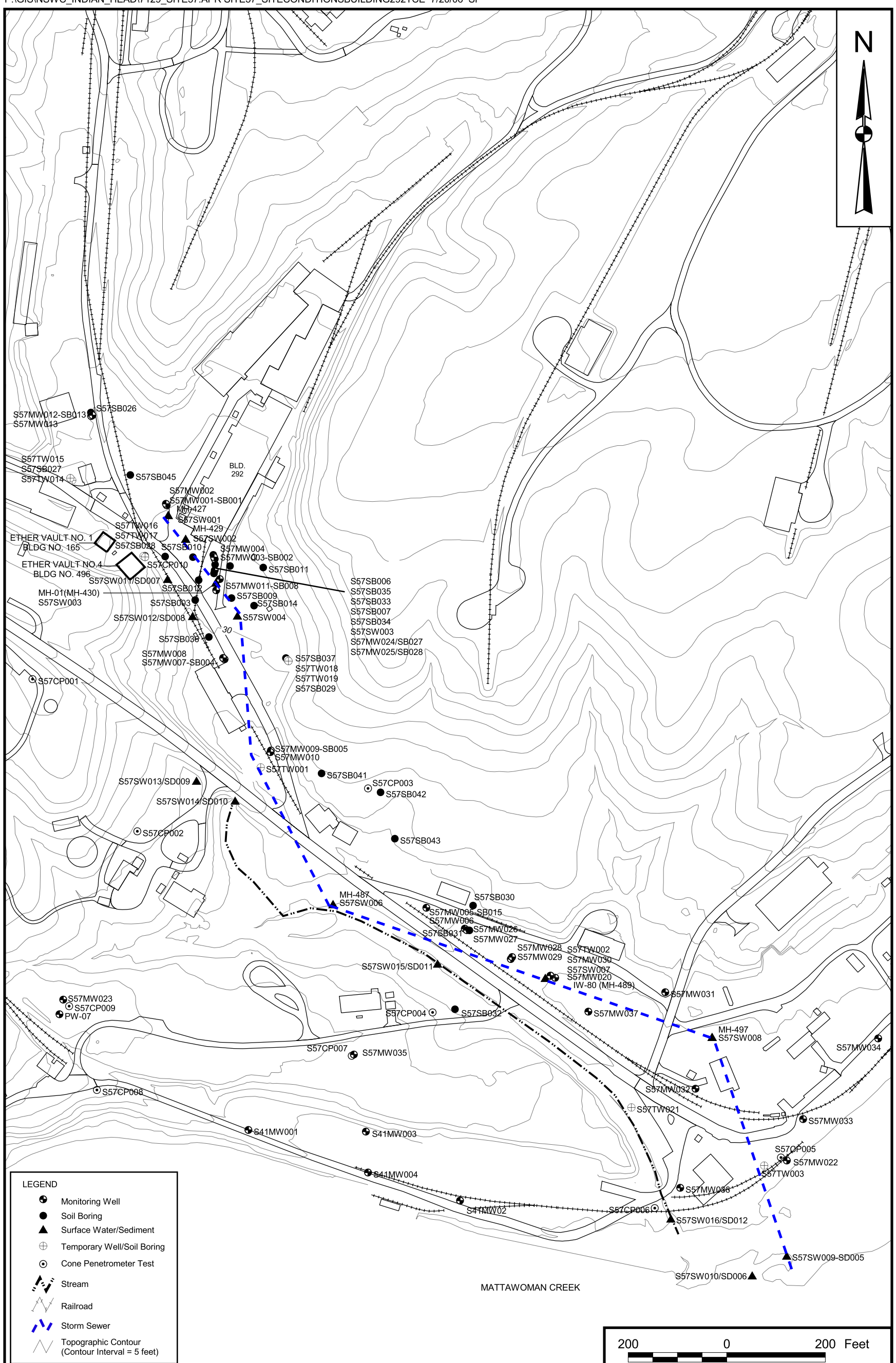
ACAD: 2194GX06.dwg 02/23/06 MF PIT



DRAWN BY MF DATE 2/23/06	Tetra Tech NUS, Inc.	GENERALIZED CROSS SECTION OF THE REGION NAVAL SUPPORT FACILITY, INDIAN HEAD INDIAN HEAD, MARYLAND	CONTRACT NO. 2194
CHECKED BY KCT DATE 2/23/06			OWNER NO. 007
REVISED BY DATE			APPROVED BY KCT DATE 2/24/06
SCALE AS NOTED			DRAWING NO. FIGURE 1-3 REV. 0

FORM CADD NO. TTNUS-AH.DWG - REV 1 -9/10/98

P:\GIS\NSWC_INDIAN_HEAD\7129_SITE57.APR SITE57_SITECONDITIONSBUILDING292TCE 7/20/06 SP



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NUMBER
K. PEILA	2/28/06		2194	007
CHECKED BY	DATE	SITE CONDITIONS MAP	APPROVED BY	DATE
K. TURNBULL	7/20/06	SITE 57 - BUILDING 292 TCE CONTAMINATION	K. TURNBULL	7/20/06
COST/SCHEDULE-AREA		NAVAL SUPPORT FACILITY, INDIAN HEAD	APPROVED BY	DATE
			—	—
SCALE		INDIAN HEAD, MARYLAND	DRAWING NO.	REV
AS NOTED			FIGURE 1-4	0

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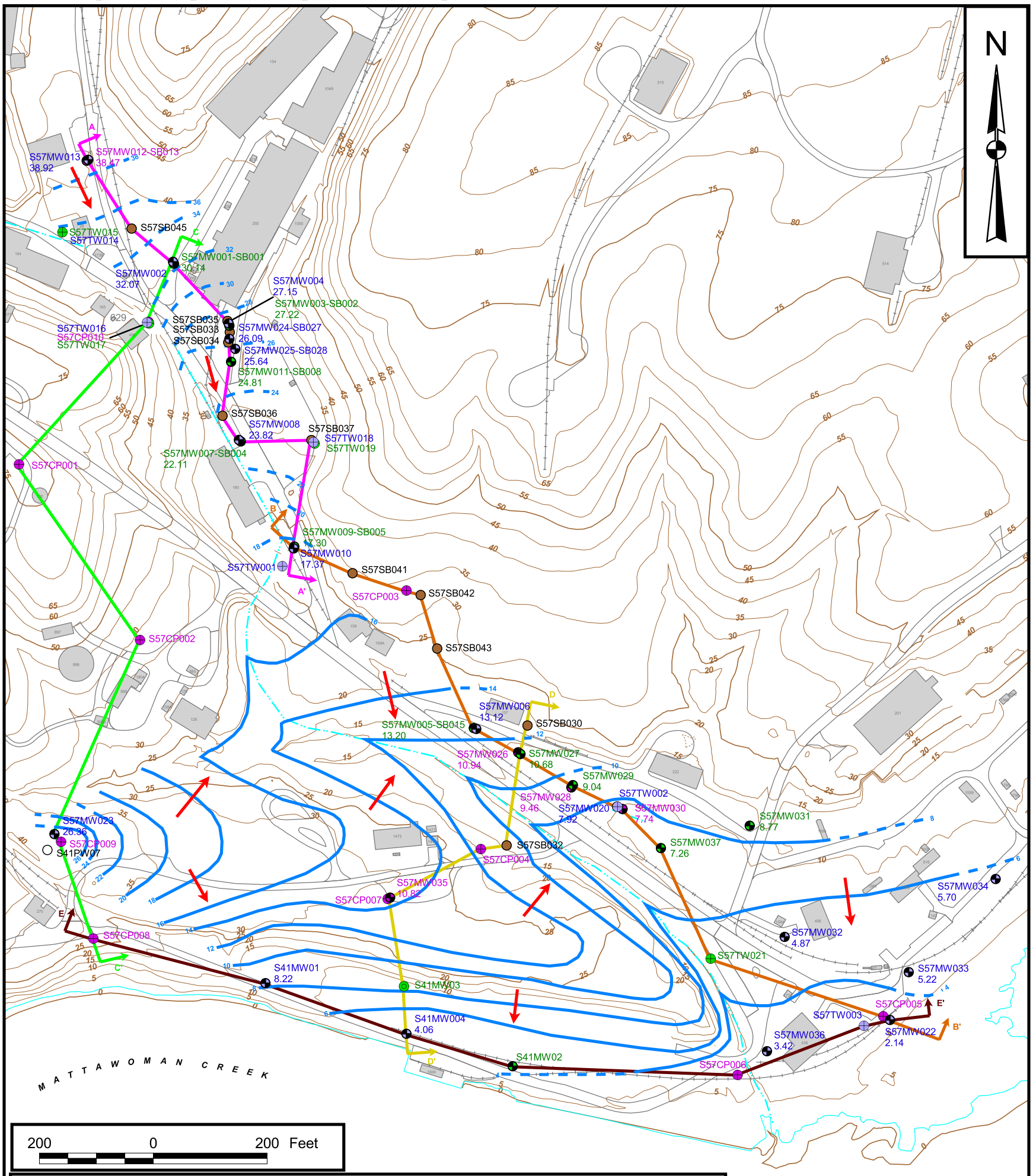


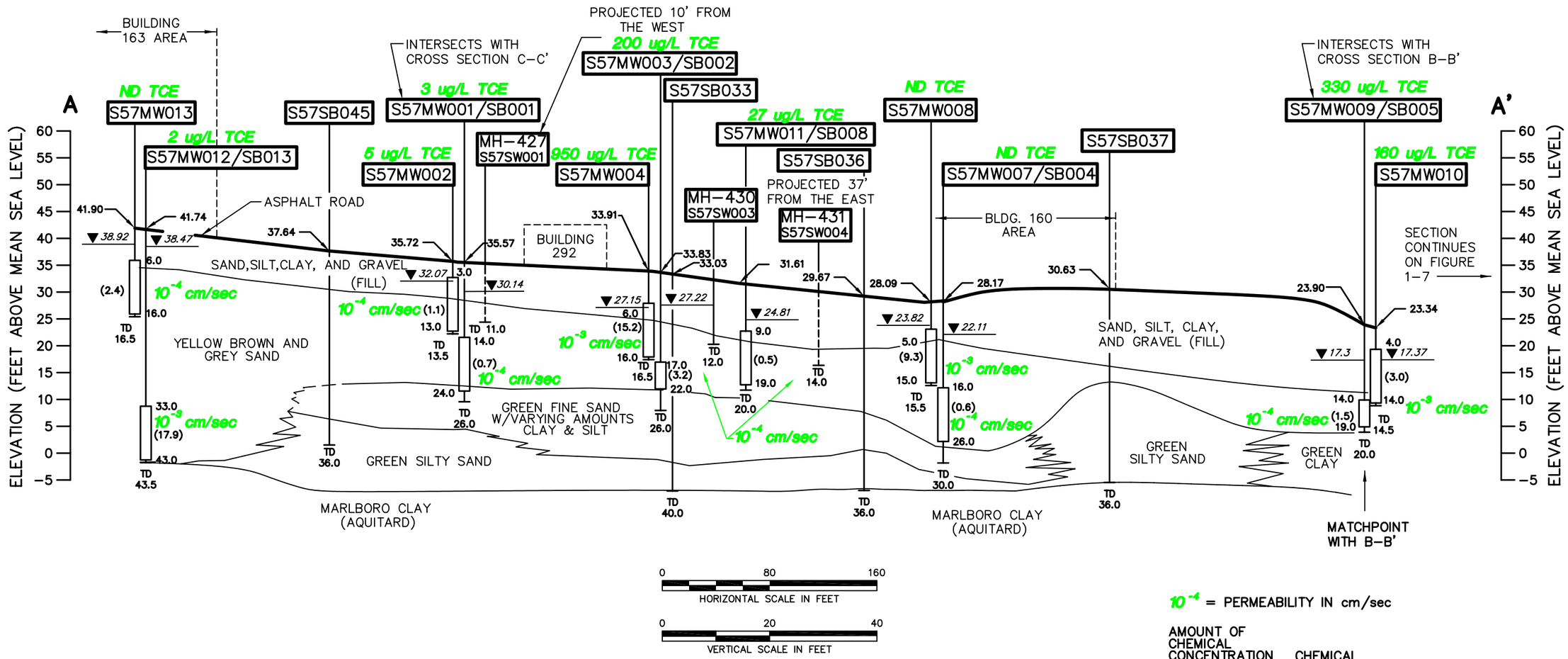
LEGEND

S57MW022 2.14	Shallow Monitoring Well with Potentiometric Surface Elevation
S57TW003	Previously Installed Shallow Temporary Well or Cone Penetrometer
S57MW037 7.26	Intermediate Monitoring Well with Potentiometric Surface Elevation
S57TW019	Previously Installed Intermediate Temporary Well or Cone Penetrometer
S41MW03	Abandoned Intermediate Monitoring Well
S57MW028 9.46	Deep Monitoring Well with Potentiometric Surface Elevation
S57CP001	Previously Installed Deep Temporary Well or Cone Penetrometer
S41PW07	Supply Well
S57SB042	Soil Boring
	Building
	Road
	Railroad
	Stream
	Shoreline
	Topographic Contour Contour Interval = 5 feet
A A'	Hydrogeologic Cross Section Location
	Groundwater Flow Direction
	Potentiometric Contour as of October 11, 2005 (Dashed Where Inferred)

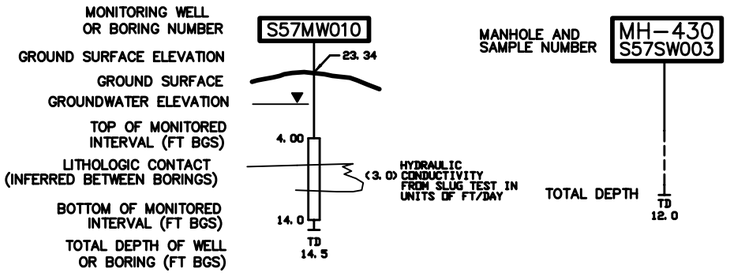
Note: Shallow and intermediate potentiometric surface data were used to develop this map.

DRAWN BY K. PEILA DATE 2/28/06	Tetra Tech NUS, Inc.	CONTRACT NUMBER 2194	OWNER NUMBER 007
CHECKED BY K. TURNBULL DATE 7/13/06	DATA POINTS, HYDROGEOLOGIC CROSS SECTIONS, AND POTENTIOMETRIC SURFACE CONTOURS SITE 57 - BUILDING 292 TCE CONTAMINATION NAVAL SUPPORT FACILITY, INDIAN HEAD INDIAN HEAD, MARYLAND	APPROVED BY —	DATE —
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 1-5	REV 0

ACAD:2194GX01.dwg 07/17/06 MF PIT



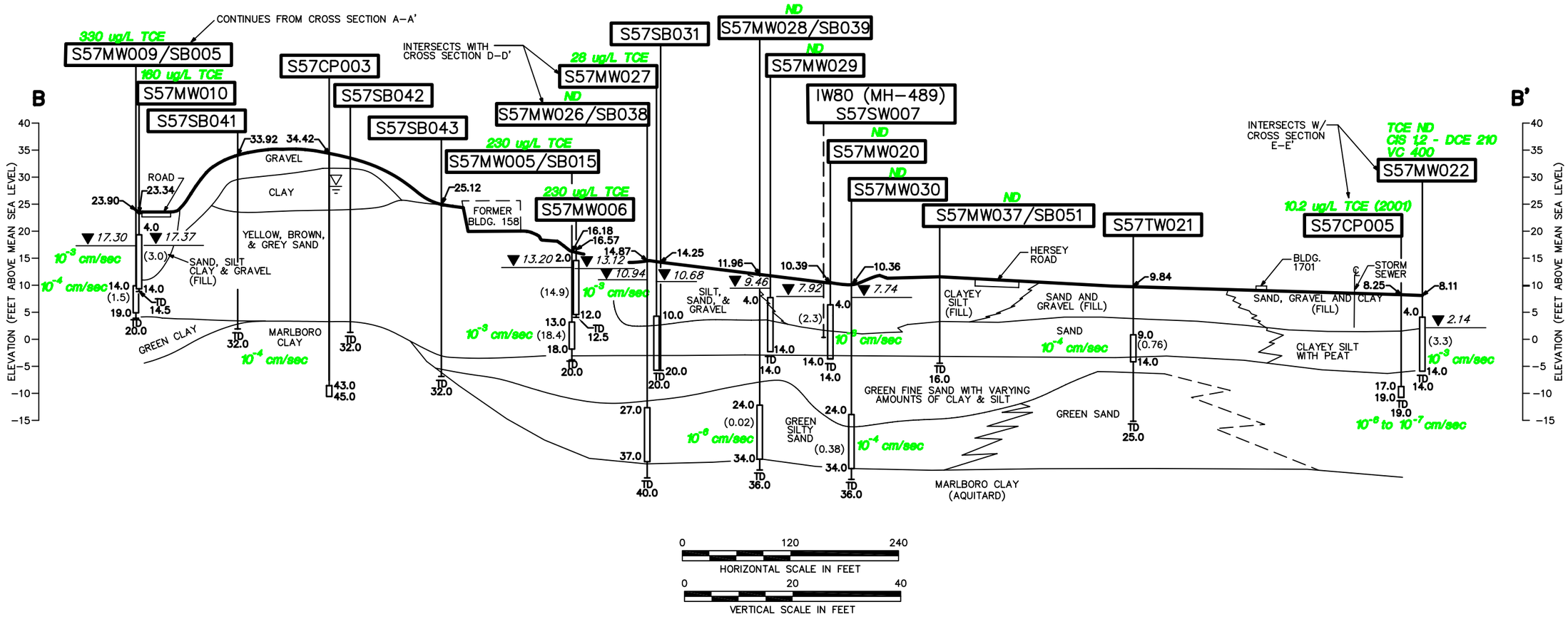
LEGEND:



DRAWN BY MF	DATE 2/23/06	Tetra Tech NUS, Inc.	CROSS SECTION A-A' SITE 57 - BUILDING 292 TCE CONTAMINATION NSF-IH, INDIAN HEAD, MARYLAND	CONTRACT NO. 2194	
CHECKED BY GJL	DATE 2/23/06			OWNER NO. 007	
REVISED BY	DATE			APPROVED BY KT	DATE 2/24/06
SCALE AS NOTED				DRAWING NO. FIGURE 1-6	REV. 0

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

ACAD: 2194GX02.dwg 07/17/06 MF PIT



LEGEND:

MANHOLE AND SAMPLE NUMBER — MH–489 / S57SW007

TOTAL DEPTH

MONITORING WELL OR BORING NUMBER — S57MW009

GROUND SURFACE ELEVATION — 23.90

GROUND SURFACE

GROUNDWATER ELEVATION

ESTIMATED POTENTIOMETRIC SURFACE

TOP OF MONITORED INTERVAL (FT BGS) — 14.0

LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)

HYDRAULIC CONDUCTIVITY FROM SLUG TEST IN UNITS OF FT/DAY — (1.5)

BOTTOM OF MONITORED INTERVAL (FT BGS) — 19.0

TOTAL DEPTH OF WELL OR BORING (FT BGS) — TD 20.0

10^{-4} = PERMEABILITY IN cm/sec

AMOUNT OF CHEMICAL CONCENTRATION — 10 ug/L TCE — CHEMICAL

UNIT MEASUREMENT: MICROGRAM/LITER

DATE MEASURED: OCTOBER 2005 UNLESS OTHERWISE NOTED

ND NOT DETECTED

DRAWN BY MF	DATE 2/23/06	Tetra Tech NUS, Inc.	CROSS SECTION B-B' SITE 57 - BUILDING 292 TCE CONTAMINATION NSF-IH, INDIAN HEAD, MARYLAND
CHECKED BY GJL	DATE 2/23/06		
REVISED BY	DATE		
SCALE AS NOTED			

CONTRACT NO. 2194	
OWNER NO. 007	
APPROVED BY KT	DATE 2/24/06
DRAWING NO. FIGURE 1-7	REV. 0

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

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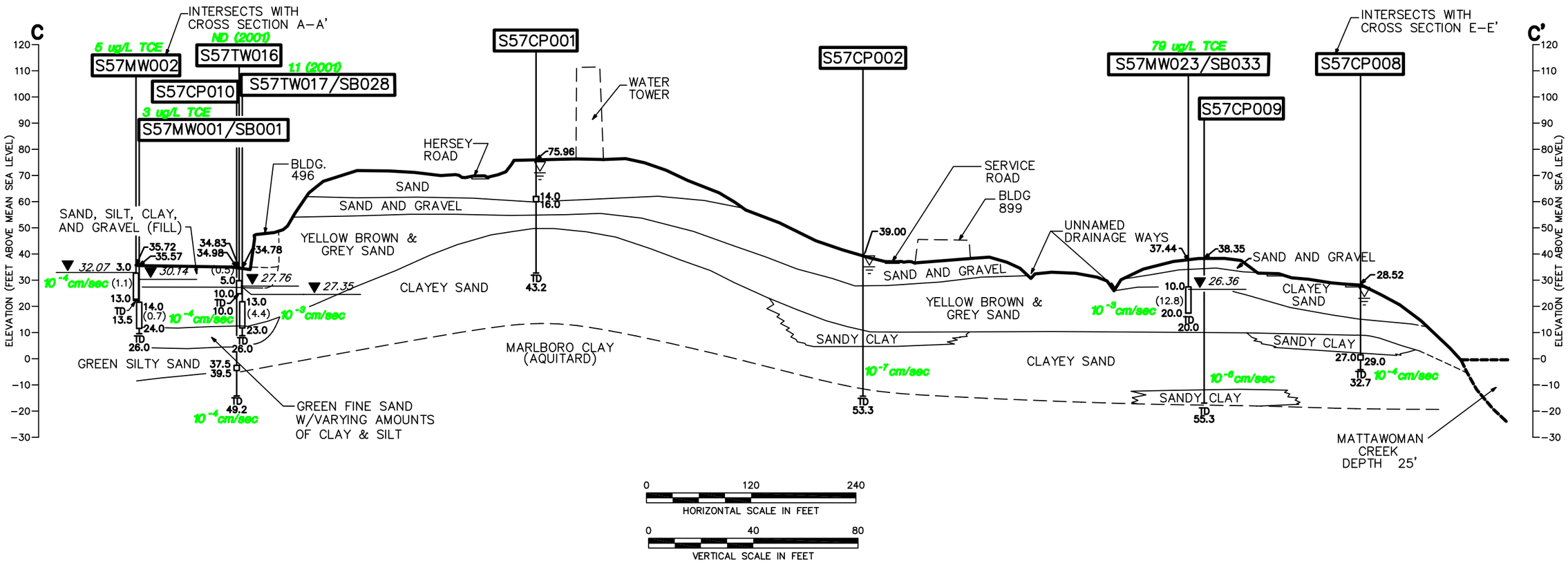

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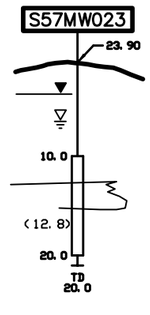

- MONITORING WELL OR BORING NUMBER
- GROUND SURFACE ELEVATION
- GROUND SURFACE
- GROUNDWATER ELEVATION
- ESTIMATED POTENTIOMETRIC SURFACE
- TOP OF MONITORED INTERVAL (FT BGS)
- LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)
- HYDRAULIC CONDUCTIVITY FROM SLUG TEST IN UNITS OF FT/DAY
- BOTTOM OF MONITORED INTERVAL (FT BGS)
- TOTAL DEPTH OF WELL OR BORING (FT BGS)

10^{-4} = PERMEABILITY IN cm/sec

AMOUNT OF CHEMICAL CONCENTRATION → 10 ug/L TCE ← CHEMICAL

UNIT MEASUREMENT: MICROGRAM/LITER

DATE MEASURED: OCTOBER 2005 UNLESS OTHERWISE NOTED

ND NOT DETECTED

DRAWN BY DM	DATE 7/25/05	Tetra Tech NUS, Inc.	CROSS SECTION C-C' SITE 57 - BUILDING 292 TCE CONTAMINATION NSF-IH, INDIAN HEAD, MARYLAND
CHECKED BY MF	DATE 2/23/06		
REVISED BY	DATE		
SCALE AS NOTED			

CONTRACT NO. 2194	
OWNER NO. 007	
APPROVED BY KT	DATE 2/24/06
DRAWING NO. FIGURE 1-8	REV. 0

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

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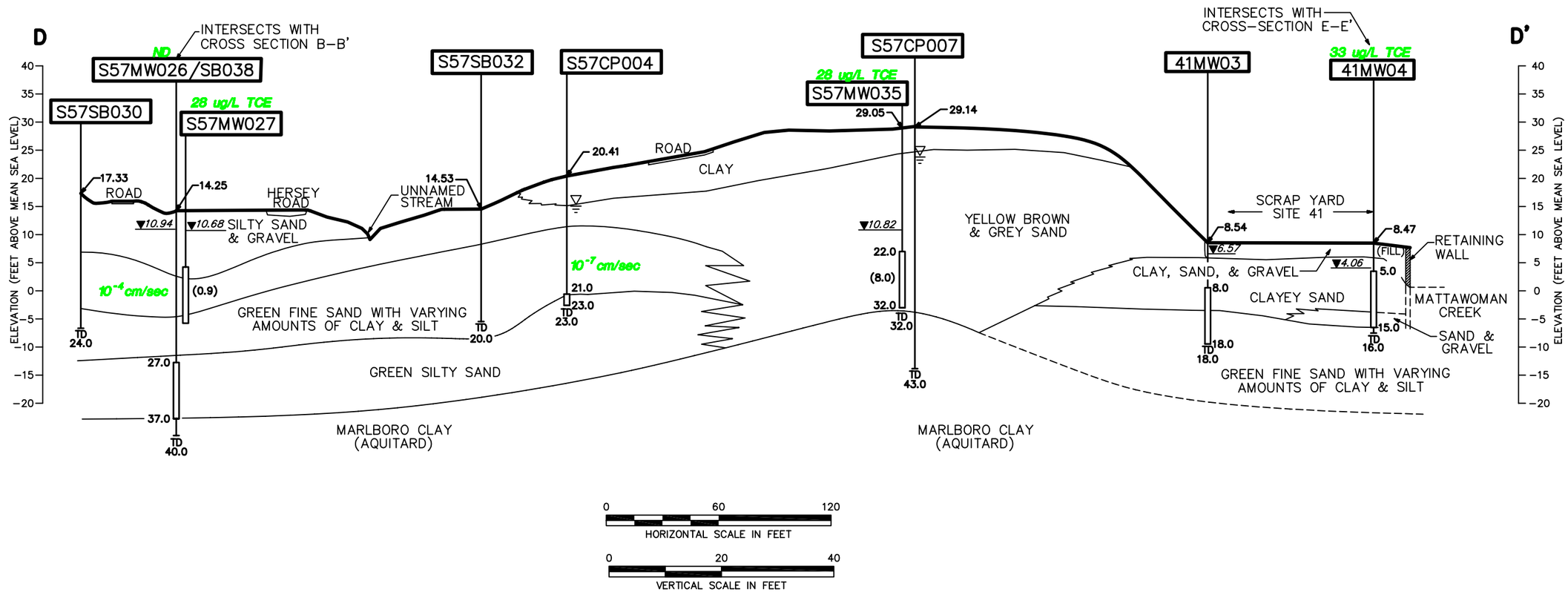

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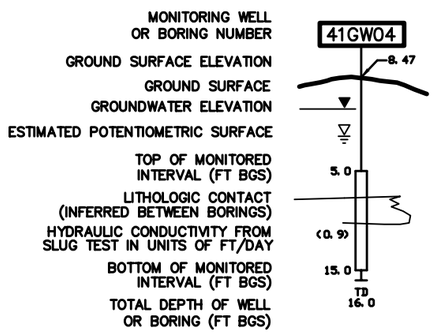

10^{-4} = PERMEABILITY IN cm/sec

AMOUNT OF CHEMICAL CONCENTRATION

CHEMICAL

21 ug/L TCE ← DATE MEASURED: OCTOBER 2005 UNLESS OTHERWISE NOTED

UNIT MEASUREMENT: MICROGRAM/LITER

ND NOT DETECTED

DRAWN BY MF DATE 2/23/06	Tetra Tech NUS, Inc.	CROSS SECTION D-D' SITE 57 - BUILDING 292 TCE CONTAMINATION NSF-IH, INDIAN HEAD, MARYLAND	CONTRACT NO. 2194
CHECKED BY GJL DATE 2/23/06			OWNER NO. 007
REVISED BY DATE			APPROVED BY KT DATE 2/24/06
SCALE AS NOTED			DRAWING NO. FIGURE 1-9 REV. 0

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

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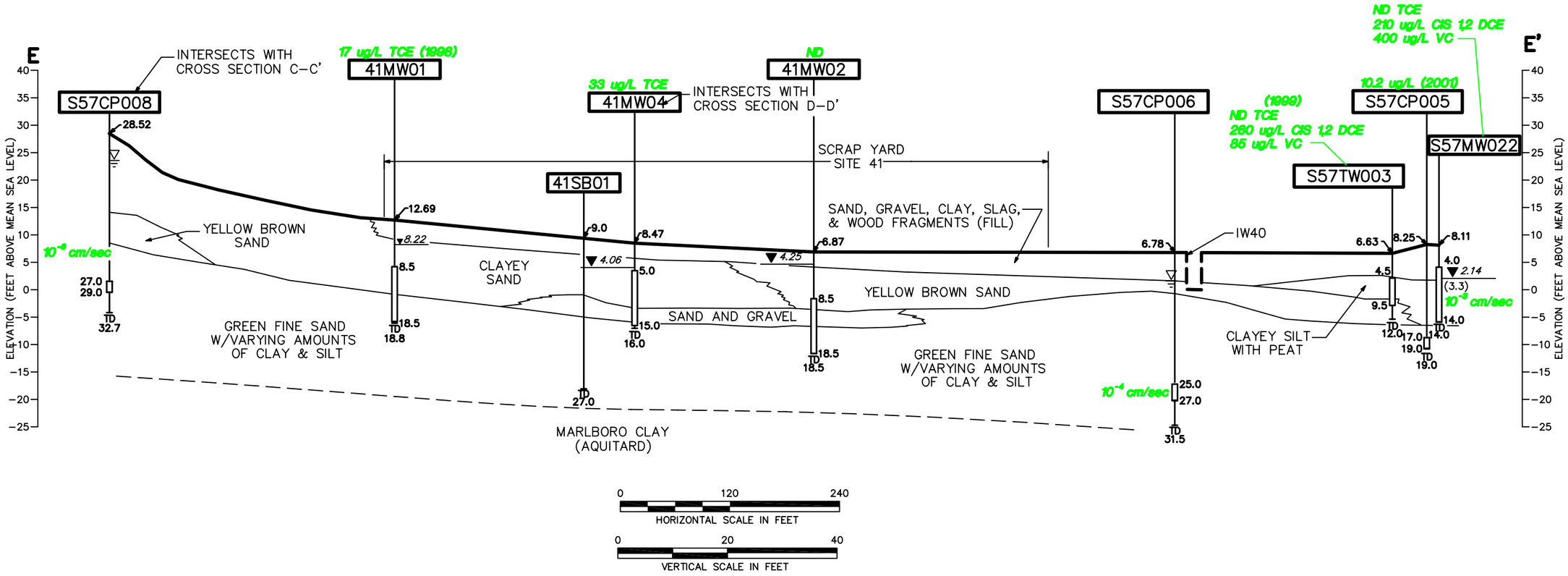

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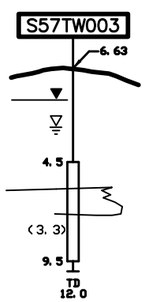


- MONITORING WELL OR BORING NUMBER
- GROUND SURFACE ELEVATION
- GROUND SURFACE
- GROUNDWATER ELEVATION
- ESTIMATED POTENTIOMETRIC SURFACE
- TOP OF MONITORED INTERVAL (FT BGS)
- LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)
- HYDRAULIC CONDUCTIVITY FROM SLUG TEST IN UNITS OF FT/DAY
- BOTTOM OF MONITORED INTERVAL (FT BGS)
- TOTAL DEPTH OF WELL OR BORING (FT BGS)

10^{-4} = PERMEABILITY IN cm/sec

AMOUNT OF CHEMICAL CONCENTRATION CHEMICAL

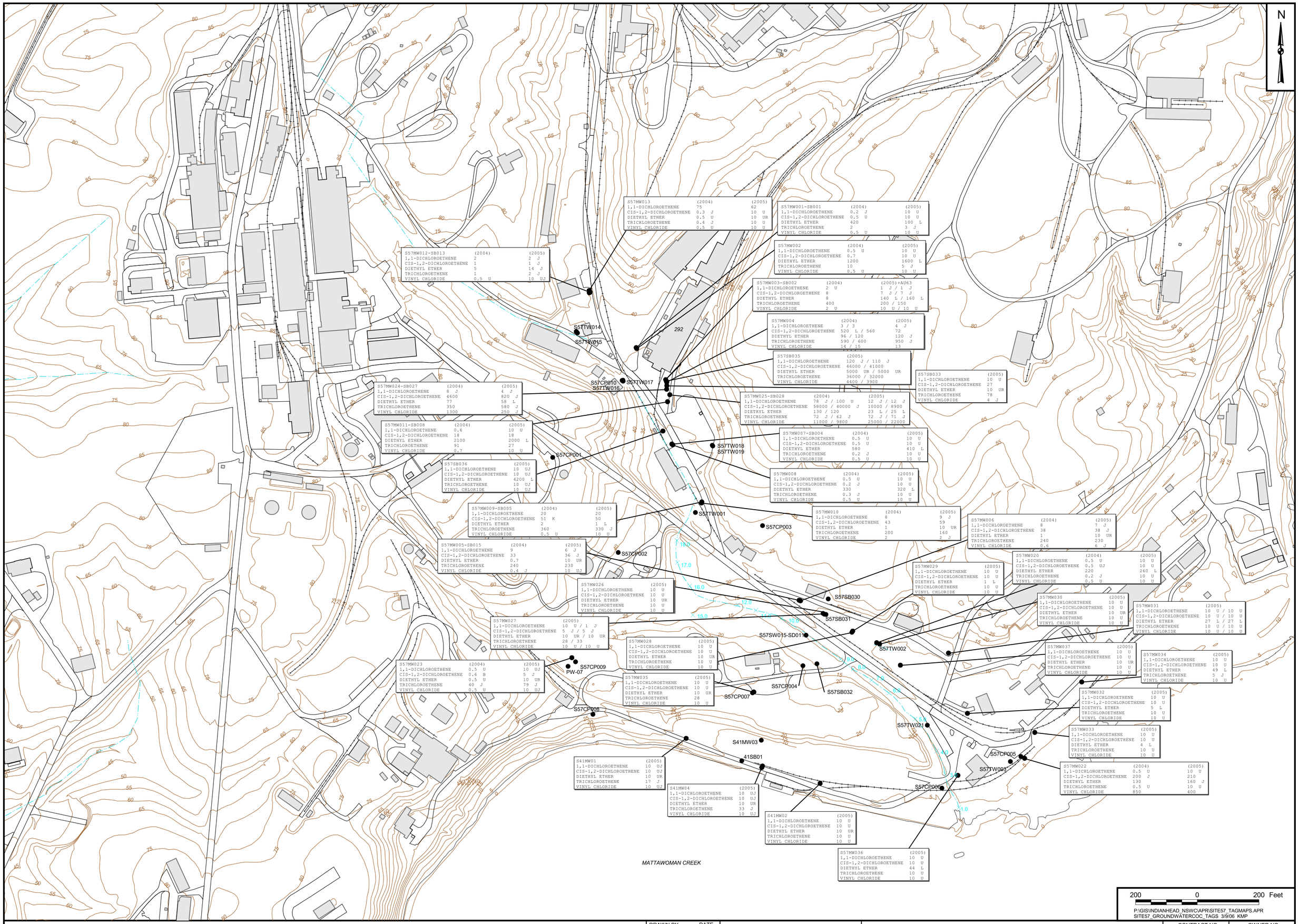
21 ug/L TCE ← DATE MEASURED: OCTOBER 2005 UNLESS OTHERWISE NOTED

UNIT MEASUREMENT: MICROGRAM/LITER

ND NOT DETECTED

DRAWN BY MF DATE 2/23/05	Tetra Tech NUS, Inc.	CROSS SECTION E-E' SITE 57 - BUILDING 292 TCE CONTAMINATION NSF-IH, INDIAN HEAD, MARYLAND	CONTRACT NO. 2194
CHECKED BY MF DATE 2/23/05			OWNER NO. 007
REVISED BY DATE			APPROVED BY KT DATE 2/24/05
SCALE AS NOTED			DRAWING NO. FIGURE 1-10 REV. 0

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98



LEGEND

- Sample Location
- Stream
- Railroad
- Road
- Building
- Topographic Contour
  Contour Interval = 5 feet

DRAWN BY	DATE
K. PEILA	3/1/06
CHECKED BY	DATE
K. TURNBULL	3/1/06
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

GROUNDWATER CHEMICALS OF CONCERN - 2004 AND 2005
SITE 57 - BUILDING 292 TCE CONTAMINATION
NAVAL SUPPORT FACILITY, INDIAN HEAD
INDIAN HEAD, MARYLAND

CONTRACT NO.	OWNER NO.
2194	007
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 1-11	0

2.0 REMEDIAL ACTIONS AND OBJECTIVES

2.1 INTRODUCTION

This section presents the objectives for remedial action and the factors used to develop remedial actions. These factors are the PRGs that propose clean-up goals and regulatory requirements and guidance [Applicable or Relevant and Appropriate Requirements (ARARs)] that may potentially govern remedial actions. In addition, this section presents the COCs and the conceptual pathways through which these chemicals may adversely affect human health and the environment.

This FS addresses shallow groundwater. Contaminated soil was removed under a non-time-critical removal action. There were no unacceptable risks to human health from exposure to surface water or sediment. The only potential risks to ecological receptors were associated with Mattawoman Creek. The chemicals that pose unacceptable ecological risks were not site related as determined in the Mattawoman Creek watershed study (TtNUS, 2004b).

2.2 REMEDIAL ACTION OBJECTIVES

Based on the potential pathways, receptors of concern, and current and potential future land use scenarios, the RAOs are as follows:

- Prevent exposure to groundwater contaminated at concentrations greater than PRGs
- Prevent or minimize further migration of the groundwater contaminant plume (plume containment)
- Restore groundwater to its expected beneficial use (aquifer restoration)

These RAOs were developed following guidance provided in Land Use in the CERCLA Remedy Selection Process (EPA, 1995). According to this guidance, RAOs developed during the RI/FS should reflect the reasonably anticipated future land use or uses. RAOs for groundwater were developed following guidance provided in Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites (EPA, 1988a). According to this guidance, the goal of Superfund remediation is to protect human health and the environment by restoring groundwater to its beneficial uses within a reasonable time frame, given the particular site circumstances.

2.3 COMPLIANCE WITH ARARs

One of the primary concerns during the development of remedial action alternatives under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is the degree of human health and environmental protection afforded by a given remedy. Section 121 of CERCLA

requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental regulations. On-site actions need only comply with substantive requirements (e.g., design standards). Off-site actions must comply with substantive and administrative requirements (e.g., permits and recordkeeping). The term "on site" means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action.

ARARs consist of the following:

- Any standard, requirement, criterion, or limitation under federal environmental law.
- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility siting law that is more stringent than the associated federal standard, requirement, criterion, or limitation.

Definitions of the two types of ARARs and to be considered (TBC) criteria are as follows:

- Applicable Requirements includes those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and Appropriate Requirements includes those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, although not applicable, address problems or situations sufficiently similar (relevant) to those encountered at the CERCLA site that their use is well suited (appropriate) to the particular site.

- TBC Criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing remedial action alternatives and for determining action levels that are protective of human health or the environment.

Section 121(d)(4) of CERCLA allows the selection of a remedial alternative that will not attain ARARs if any of six conditions for a waiver of ARARs exist. These conditions are as follows: the remedial action is an interim measure, and the final remedy will attain the ARAR upon completion; compliance will result in greater risk to human health and the environment than other options; compliance is technically impracticable; an alternative remedial action will attain the equivalent of the ARAR; for state

requirements, the state has not consistently applied the requirement in similar circumstances; and compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of funds. The last condition only applies to Superfund-financed actions.

ARARs fall into three categories based on the manner in which they are applied. Many requirements are combinations of the three types of ARARs. The categories are as follows:

- Chemical Specific: Health- or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Chemical-specific ARARs govern the extent of site cleanup.

- Location Specific: Restrictions based on the concentrations of hazardous substances or the conduct of activities in specific locations. Some examples of specific locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. These ARARs may restrict or preclude certain remedial actions and may apply only to certain portions of the site.

- Action Specific: Technology- or activity-based controls or restrictions on activities related to management of hazardous substances. Action-specific ARARs pertain to implementing a given remedy.

2.3.1 Chemical-Specific ARARs and TBC Criteria

This section presents a summary of federal and state chemical-specific ARARs and TBC criteria that provide medium-specific guidance on acceptable or permissible concentrations of contaminants. Table 2-1 presents a summary of these ARARs and TBC criteria.

2.3.1.1 Federal

The Safe Drinking Water Act (SDWA) [42 United States Code (USC) 300f et seq.] promulgated National Primary Drinking Water Standard Maximum Contaminant Levels (MCLs) [40 Code of Federal Regulations (CFR) 141]. MCLs are enforceable standards for contaminants in a public drinking water supply system. They consider not only health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. EPA has also promulgated Maximum Contaminant Level Goals (MCLGs) for several organic and inorganic contaminants in drinking water. MCLGs are non-enforceable guidelines that do not consider the technical feasibility of contaminant removal. Secondary MCLs (SMCLs) (40 CFR 143) are not enforceable but are intended as guidelines for contaminants that may adversely affect the aesthetic qualities of drinking water, including taste, odor, color, and appearance,

which may deter public acceptance of drinking water provided by public water systems. MCLs may be relevant and appropriate for developing groundwater remediation goals. MCLGs and SMCLs may be TBC criteria for developing such goals.

EPA Health Advisories are non-enforceable guidelines developed by the Office of Drinking Water for chemicals that may be intermittently encountered in public water systems. Health advisories are available for short-term, long-term, and lifetime exposures for a 10-kilogram (kg) child and a 70-kg adult. Health advisories may be pertinent TBC criteria for developing groundwater remediation goals, especially for chemicals that are not regulated under the SDWA.

EPA Ambient Water Quality Criteria (AWQC) are non-enforceable guidelines that were developed pursuant to Section 304(a) of the Clean Water Act (CWA) for pollutants in surface water. Although AWQC are not legally enforceable, they have been used by some states to develop enforceable water-quality standards. These guidelines should be considered as potential ARARs, as specified by CERCLA. AWQC are available for the protection of human health from exposure from both drinking water and consuming aquatic organisms (primarily fish) and from consumption of organisms alone. AWQC are also available for the protection of freshwater and saltwater aquatic life. AWQC can be used to establish groundwater clean-up goals that are protective of surface water. AWQC may also be considered for actions that involve groundwater treatment and discharge to surface water.

EPA Reference Doses (RfDs) are estimates (with uncertainty spanning perhaps an order of magnitude) of the amount of a chemical to which humans (including sensitive receptors) can be subjected on a daily basis for a lifetime without appreciable risk of adverse health effects. Although not strictly TBC criteria to be met by remedial alternatives, RfDs can be used to develop remediation goals and to determine areas of a site that pose an unacceptable risk to human health.

EPA Cancer Slope Factors (CSFs) are used to estimate the lifetime probability of humans developing cancer from exposure to known or suspected carcinogens. Although not strictly TBC criteria to be met by remedial alternatives, CSFs can be used to develop remediation goals and to determine areas of a site that pose an unacceptable risk to human health.

2.3.1.2 State

Maryland Drinking Water Regulations [Code of Maryland Regulations (COMAR) 26.04.01] include MCLs for inorganic and organic chemicals in drinking water. These standards may be relevant and appropriate for alternatives that involve groundwater cleanup.

Maryland Surface Water Quality Criteria (COMAR 26.08.02.03) establish minimum standards for surface water quality for each designated use. Standards are available for protection of human health and protection of aquatic life. These standards may be applicable for alternatives that involve or affect surface water.

2.3.2 Location-Specific ARARs and TBC Criteria

This section presents a summary of federal and state location-specific ARARs and TBC criteria that provide restrictions on activities at specific locations. Table 2-2 presents a summary of these ARARs and TBC criteria.

2.3.2.1 Federal

The Endangered Species Act of 1978 (16 USC 1531 et seq. and 50 CFR 402) provides for consideration of the impacts on endangered and threatened species and their critical habitats. The act requires federal agencies, in consultation with the Secretary of the Interior, to ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat. There are no known endangered or threatened species or their critical habitats at Site 57.

The Fish and Wildlife Coordination Act (16 USC 661 et seq.) provides for consideration of the impacts on wetlands and protected habitats. The acts require that federal agencies, before issuing a permit or undertaking a federal action for the modification of any body of water, consult with the appropriate state agency exercising jurisdiction over wildlife resources to conserve those resources.

Federal Protection of Wetlands Executive Order (E.O. 11990) provides for the consideration of wetlands during remedial actions. E.O. 11990 requires federal agencies, in carrying out their responsibilities, to take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. 40 CFR 6, Appendix A contains EPA policy for implementing the provisions of E.O. 11990. Mitigation of adverse effects to wetlands must be implemented if the wetlands will be disturbed by remedial activities. There are no wetlands at Site 57.

Federal Floodplain Management Executive Order (E.O. 11988) provides for consideration of floodplains during remedial actions. E.O. 11988 requires federal agencies, in carrying out their responsibilities, to take action to avoid adverse effects, minimize potential harm, and restore and preserve the natural and beneficial values of floodplains. 40 CFR 6, Appendix A contains EPA policy for implementing the provisions of E.O. 11988. Site 57 is not located within a floodplain.

The Archeological and Historic Preservation Act (16 USC 470 et seq.) provides for the preservation of historical and archeological data that might otherwise be lost because of alterations of the terrain. If activities in connection with any federal construction project or federally approved project may cause irreparable loss to significant scientific, historic, or archeological data, the agency undertaking the project must preserve the data or request that the Department of Interior do so. There are no known historical or archeological areas at Site 57.

EPA Groundwater Protection Strategy and Classification Guidelines (1986) provides guidance in determining the potential beneficial uses of contaminated groundwater. The various groundwater classes are described as follows:

- Special groundwater (Class I) is highly vulnerable to contamination and is either an irreplaceable or ecologically vital source of drinking water.

- Current and potential sources of drinking water and water having other beneficial uses include all other groundwater that is currently used (Class IIA) or is potentially available (Class IIB) for drinking water, agriculture, or other beneficial use.

- Groundwater not considered a potential source of drinking water and of limited beneficial use (Class III) is saline or is otherwise contaminated by naturally occurring constituents or human activity that is not associated with a particular waste disposal activity or another site beyond levels that allow remediation using methods reasonably employed in public water treatment systems. Class III also includes groundwater that is not available in sufficient quantity at any depth to meet the needs of an average household.

The groundwater at Site 57 would be classified as Class IIB.

2.3.2.2 State

Maryland Threatened and Endangered Species Regulations (COMAR 08.03.08) provide for consideration of the impacts on endangered, threatened, and rare species and their critical habitats. There are no known endangered, threatened, or rare species or their critical habitats at Site 57.

Maryland Regulations on Construction on Nontidal Waters and Floodplains (COMAR 26.17.04) are designed to govern construction, reconstruction, repair, alteration of a dam, reservoir, or water obstruction, or any change of the course, current, or cross-section of a stream or body of water. This includes changes to the 100-year floodplain of free-flowing waters. Remedial alternatives for Site 57 are not expected to impact surface water bodies. Site 57 is not located within a floodplain.

Maryland Nontidal Wetland Regulations (COMAR 26.23) contain permit requirements for activities in nontidal wetlands. The intent of the requirements is to avoid adverse impacts and minimize losses of nontidal wetlands. There are no nontidal wetlands at, or that could be affected by remedial activities at, Site 57.

Maryland Tidal Wetland Regulations (COMAR 26.24) contain permit requirements for activities in tidal wetlands. The intent of the requirements is to avoid adverse impacts and minimize losses of tidal wetlands. There are no tidal wetlands at, or that could be affected by remedial activities at, Site 57.

2.3.3 Action-Specific ARARs and TBC Criteria

This section presents a summary of federal and state action-specific ARARs and TBC that may pertain to implementation of a remedial activity. Table 2-3 presents a summary of these ARARs and TBC criteria.

2.3.3.1 Federal

The Clean Air Act (CAA) (42 USC 7401 et seq.) consists of programs or requirements that may be ARARs, depending on the nature of the remedial action and the amount and types of air emissions that may be discharged. These programs include National Ambient Air Quality Standards (NAAQS) (40 CFR 50), National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR 61 and 63), and New Source Performance Standards (NSPS) (40 CFR 60).

EPA requires the attainment and maintenance of primary and secondary NAAQS to protect public health and welfare, respectively. NAAQS are available for six criteria pollutants (carbon monoxide, lead, nitrogen oxides, ozone, sulfur dioxide, and airborne particulates). These standards are not source specific but are national limitations on ambient air quality. States are responsible for assuring compliance with NAAQS. Requirements in an EPA-approved State Implementation Plan for the implementation, maintenance, and enforcement of NAAQS are potential ARARs. NAAQS might be relevant and appropriate for emissions from groundwater treatment processes.

NESHAPs are emissions standards for source types (i.e., industrial categories) that emit hazardous air pollutants and include significant sources of beryllium, vinyl chloride, benzene, asbestos, and other hazardous substances. NESHAPs might be relevant and appropriate for emissions of hazardous air pollutants from treatment of contaminated groundwater.

NSPS are established for new sources of air emissions to ensure that new stationary sources minimize emissions. These standards are for categories of stationary sources that cause or contribute to air

pollution that might endanger public health or welfare. Standards are based on the best-demonstrated available technology. NSPS may be relevant and appropriate for treatment of contaminated groundwater if the pollutant(s) emitted and the technology used during the clean-up action are sufficiently similar to the pollutant and source category regulated by the NSPS and are well suited to the circumstances at the site.

Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites [Office of Solid Waste and Emergency Response (OSWER) Directive 9344.0-28] is a TBC that guides the control of air emissions from air strippers. For sites located in areas that are not attaining NAAQS for ozone, add-on emissions controls are required for an air stripper with an actual emission rate in excess of 3 pounds per hour, an actual emission rate in excess of 15 pounds per day, or a potential emission rate of 10 tons per year of total VOCs. Generally, the guidelines are suitable for VOC air emissions from other vented extraction techniques (e.g., soil vapor extraction) but not from area sources (e.g., soil excavation). Charles County, Maryland is in a nonattainment area for ozone.

Resource Conservation and Recovery Act (RCRA) Subtitle C (42 USC 6921 et seq.) regulates the treatment, storage, and disposal of hazardous waste from its generation to its ultimate disposal. In general, RCRA Subtitle C requirements will be applicable if either of the following apply:

- The waste is a listed or characteristic hazardous waste and was treated, stored, or disposed after the effective date of the RCRA requirements under consideration.

- The activity at a CERCLA site constitutes current treatment, storage, or disposal of hazardous waste as defined by RCRA.

RCRA Subtitle C requirements may be relevant and appropriate when the waste is sufficiently similar to a hazardous waste or the on-site remedial action includes treatment, storage, or disposal. In addition, the particular RCRA requirement should be well suited to the circumstances of the contaminant release and site.

The spent TCE associated with operations at Building 292 at Site 57 is a listed RCRA hazardous waste. The following requirements of RCRA Subtitle C may pertain to remedial actions at Site 57:

- Identification and listing of hazardous waste (40 CFR 261).
- Hazardous waste generator requirements (40 CFR 262).
- Transportation requirements (40 CFR 263).
- Standards for treatment, storage, and disposal (TSD) facilities (40 CFR 264), including corrective action management units (CAMUs) and temporary units (TUs).

- Land disposal restrictions (LDRs) (40 CFR 268).

Identification and Listing of Hazardous Waste (40 CFR 261) defines characteristic and listed hazardous wastes that are subject to RCRA Subtitle C.

Standards Applicable to Generators of Hazardous Waste (40 CFR 262) include manifest, pre-transport (i.e., packaging, labeling, placarding), recordkeeping, and reporting requirements.

Standards for Transporters of Hazardous Waste (40 CFR 263) are applicable to off-site transport of hazardous waste. These regulations include requirements for compliance with the manifest and recordkeeping systems and requirements for immediate action and cleanup of spills during transport.

Standards for Owners and Operators of Hazardous Waste TSD Facilities (40 CFR 264) are potentially applicable to remedial actions involving hazardous waste. Standards for TSD facilities include requirements for releases from solid waste management units (SWMUs), closure and post-closure care, use and management of containers, and design and operating standards for tank systems, surface impoundments, waste piles, landfills, incinerators, and miscellaneous units. When a site, or portion thereof, receives a CAMU designation, the designated area qualifies for certain exemptions from RCRA Subtitle C requirements. A TU or staging pile that will only be used for a short time during remediation also qualifies for certain exemptions.

LDR Requirements (40 CFR 268) restrict certain hazardous wastes from being placed or disposed on the land unless they meet specific treatment standards. Removal and treatment of a RCRA hazardous waste or movement outside a CAMU, thereby constituting disposal, may trigger LDR requirements. LDRs are not triggered when hazardous remediation waste is placed in a CAMU, when remediation wastes generated at a facility outside a CAMU are consolidated into a CAMU, and when remediation wastes are moved between two or more CAMUs. In addition, remediation wastes can be excavated from a CAMU, treated in a separate unit, and redeposited in the CAMU without triggering LDRs.

The CWA (33 USC 1251 et seq.) governs point-source discharges to surface water through the National Pollutant Discharge Elimination System (NPDES) and spills of oil and hazardous substances to surface water. NPDES requirements (40 CFR 122) are potentially applicable if the direct discharge of pollutants into surface water is part of the remedial action. This includes the discharge of stormwater from certain construction and other industrial activities.

Underground Injection Control (UIC) Program (40 CFR 144 to 148) contains provisions for control and prevention of pollutant injection into groundwater. Class IV wells are used to inject hazardous waste into

or above a formation that, within ¼ mile of the well, contains an underground source of drinking water. Operation or construction of Class IV wells is prohibited and allowed only for the reinjection of treated groundwater as part of a CERCLA or RCRA cleanup. The regulations are potentially applicable if groundwater is removed, treated, and reinjected into the formation from which it was withdrawn.

2.3.3.2 State

Maryland Ambient Air Quality Standards (COMAR 26.11.04) establish ambient standards for particulate matter, sulfur oxides, carbon monoxide, ozone, sulfur compounds, nitrogen dioxide, lead, and fluoride. These standards may be applicable for emissions of criteria pollutants that may be generated during groundwater treatment.

Maryland General Emission Standards, Prohibitions, and Restrictions (COMAR 26.11.06) establish emission standards for visible emissions, particulate matter, carbon monoxide, sulfur compounds, VOCs, and fluoride. These regulations also control NSPS sources by reference to federal regulations (40 CFR 60). These standards may be applicable for emissions of regulated pollutants that may be generated during groundwater treatment.

Maryland Regulations for Toxic Air Pollutants (COMAR 26.11.15 and 26.11.16) are standards for industries that emit toxic air pollutants, including sources regulated under NESHAPs (40 CFR 61 and 63). These standards might be relevant and appropriate for emissions of toxic or hazardous air pollutants from treatment of contaminated groundwater.

Maryland Regulations for Disposal of Controlled Hazardous Substances (COMAR 26.13) are similar to the federal RCRA Subtitle C hazardous waste regulations. The regulations include identification and listing of hazardous wastes and standards for generators, transporters, and TSD facilities. These regulations would be potentially applicable for any hazardous waste generated during remedial activities and would be potentially relevant and appropriate for handling of nonhazardous waste.

Maryland Water Pollution Permit Regulations (COMAR 26.08.04) contain requirements for discharges to surface water, including general discharge permits for certain classes of stormwater discharges from construction and other industrial activities. These requirements are potentially applicable for discharges to surface water.

Maryland Well Construction Regulations (COMAR 26.04.04) establish design standards and procedures applicable to construction of wells, including monitoring wells. The regulations contain construction and abandonment standards applicable to remedial activities that include groundwater extraction or monitoring.

Maryland UIC Regulations (COMAR 26.08.07) incorporates the EPA UIC program regulations by reference (40 CFR 124, 144, and 146), with certain exceptions.

2.4 PRELIMINARY REMEDIATION GOALS

Groundwater at Site 57 is not a source of potable water. However, the goal of Superfund remediation is to return usable groundwaters to their beneficial uses wherever practicable. In addition, the selected remedy for a site must also attain ARARs, unless a waiver is justified. Table 2-4 lists the chemicals of potential concern (COPCs) for groundwater identified in the human health risk assessment conducted for the RI Report (TtNUS, 2000). This table also compares maximum COPC concentrations to potential ARARs (MCLs). The maximum concentrations of cis-1,2-dichloroethene, 1,1-dichloroethene, trans-1,2-dichloroethene, TCE, and vinyl chloride detected in the most recent (2005) sampling event exceed ARARs. There are no ARARs for diethyl ether; therefore, a risk-based PRG was calculated. The PRG for diethyl ether, a noncarcinogen, is based on an HI that also accounts for the HI contribution from the PRGs for the other COPCs that had concentrations greater than ARARs. Based on the RI Report risk assessment, the HI based on the PRGs for these chemicals is 0.59. Therefore, the PRG for diethyl ether is based on an HI of 0.41, resulting in a total HI of 1.0 for the child resident, the most sensitive receptor. The calculated PRG for diethyl ether is 1,246 µg/L. Calculations are provided in Appendix G. Appendix G also contains calculations that show that the cancer risk based on the PRGs (ARARs) is within the EPA acceptable risk range (1E-04 to 1E-06). A summary of the groundwater PRGs is as follows:

- cis-1,2-Dichloroethene – 70 µg/L (MCL)
- 1,1-Dichloroethene – 7 µg/L (MCL)
- Diethyl ether – 1,246 µg/L (risk-based)
- trans-1,2-Dichloroethene – 100 µg/L (MCL)
- TCE – 5 µg/L (MCL)
- Vinyl chloride – 2 µg/L (MCL)

The risk calculations are based on the human health risk assessment portion of the RI Report. During the risk assessment, tetrachloroethene was identified as a COC because the exposure point concentration based on the RI data was greater than the MCL; however, there was no unacceptable carcinogenic or noncarcinogenic risk from exposure to tetrachloroethene. Based on the 2005 data, the maximum concentration is less than the MCL; therefore, tetrachloroethene is no longer a COC.

Also, trans-1,2-dichloroethene was not identified as a COPC during the RI risk assessment because the exposure point concentration was less than the COPC screening level. However, based on the 2005

data, the maximum concentration is greater than the screening level and the MCL. A statistical analysis was not conducted to determine the exposure point concentration; however, trans-1,2-dichloroethene was only detected at two locations during the 2005 sampling, and only one location had a concentration greater than the screening level and MCL. The concentration at the other location was less than the screening level and significantly less than the MCL.

The exposure point concentrations of most COCs are assumed to have changed since the RI risk assessment was prepared based on the following: natural conditions, contaminated soil that was the assumed source of groundwater contamination was not removed until June 2006, the effects of the HRC® pilot study, and the collection of additional samples within the source area where TCE was released. The risk calculations and statistical analyses were not repeated after the 2001, 2003, 2004, and 2005 sampling rounds because an obvious risk is still present from use of groundwater as a source of potable water. The PRGs developed in this section are sufficient to develop conceptual designs and to evaluate remedial alternatives. However, for the reasons stated above, it may be advisable to re-evaluate the COCs, exposure point concentrations, and the PRGs before the full-scale design of the selected remedy is completed.

2.5 CONTAMINANTS AND MEDIA OF CONCERN

There are no COCs for surface water or sediment because there are no unacceptable risks to human health or the environment from exposure to these media.

Contaminated soil was addressed under a non-time-critical removal action.

Groundwater COCs were identified based on the information provided in Section 2.4. Groundwater COCs based on ARARs (i.e., MCLs) are cis-1,2-dichloroethene, 1,1-dichloroethene, trans-1,2-dichloroethene, TCE, and vinyl chloride. The groundwater COC based on noncarcinogenic risks is diethyl ether.

2.6 VOLUME OR AREA OF CONTAMINATED MEDIA

Figure 2-1 shows the groundwater sampling locations where VOCs were detected at concentrations greater than PRGs. The locations where groundwater concentrations exceed PRGs, based on samples collected in 2005, are summarized in Table 2-5.

There are three areas of groundwater where COC concentrations are greater than PRGs. The first area is near Building 292 and extends from well cluster S57MW001/MW002 to S57SB036. The length of this plume is approximately 300 feet. No COCs were detected at concentrations greater than PRGs at

S57MW007/MW008, the next downgradient well cluster. The plume width is difficult to estimate because most of the wells have been installed near the center of the valley, and few sidegradient wells have been installed. Based on the topography and geologic cross-sections, the width of the plume is estimated to be 160 feet. Based on an average aquifer thickness of 25 feet and a porosity of 0.25, the volume of contaminated groundwater in this area is 2.24 million gallons.

The second area extends from well cluster S57MW009/MW010 to S57MW026/MW027. The length of the plume is approximately 500 feet. No COCs were detected at concentrations greater than PRGs at S57MW007/MW008, the next upgradient well cluster, or S57MW028/MW029, the next downgradient well cluster. The plume width is difficult to estimate for the reasons stated above. Based on the topography and geologic cross-sections, the width of the plume is estimated to be 80 feet. Based on an average aquifer thickness of 14 feet and a porosity of 0.25, the volume of contaminated groundwater in this area is 1.05 million gallons.

The third area is near well S57MW022 where TCE was not detected but concentrations of cis-1,2-dichloroethene and vinyl chloride were greater than PRGs. No COCs were detected in wells installed around this location in 2005. The nearest well is approximately 100 feet away, and the area of contamination is assumed to extend 50 feet from S57MW022. Based on an aquifer thickness of 8 feet and a porosity of 0.25, the volume of contaminated groundwater in this area is estimated to be 0.15 million gallons.

TABLE 2-1

CHEMICAL-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 –BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
Federal					
Safe Drinking Water Act	Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	40 CFR 141	Establishes enforceable standards (MCLs) and non-enforceable goals (MCLGs) for public water systems for contaminants that have been determined to adversely affect human health.	Relevant and appropriate (MCLs) and to be considered (MCLGs)	Considered for determining groundwater remediation goals.
	National Secondary Drinking Water Regulations (SMCLs)	40 CFR 143	Establishes welfare-based standards for public water systems for contaminants that may affect the aesthetic qualities of drinking water.	To be considered	Considered for determining groundwater remediation goals.
EPA Office of Drinking Water	Health Advisories	NA	Establishes short-term, long-term, and lifetime exposure limits for children and adults.	To be considered	Considered for determining groundwater remediation goals.
Clean Water Act	Ambient Water Quality Criteria	40 CFR 131.36	Non-enforceable guidelines for pollutants in surface water.	To be considered	Considered for determining discharge limits to surface water.
Risk Assessment Guidance	Reference Doses and Cancer Slope Factors	NA	Used to estimate risks and can be used to develop risk-based clean-up goals.	To be considered	Considered for determining areas of a site that pose an unacceptable risk.

TABLE 2-1

CHEMICAL-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 –BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
State					
Water, Ice, and Sanitary Facilities (Environment Article, Title 9)	Drinking Water Quality	COMAR 26.04.01	Establishes drinking water standards for public water systems.	Relevant and appropriate	Considered for determining groundwater remediation goals.
Water, Ice, and Sanitary Facilities (Environment Article, Title 9)	Surface Water Quality Criteria	COMAR 26.08.02.03	Establishes minimum standards for surface water quality.	Potentially applicable	Considered for determining discharge limits to surface water.

ARARs Applicable or Relevant and Appropriate Requirements.
CFR Code of Federal Regulations.
COMAR Code of Maryland Regulations.
EPA United States Environmental Protection Agency.
FS Feasibilty Study.
NA Not available/not applicable.
TBC To be considered.

TABLE 2-2

LOCATION-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
Federal					
Endangered Species Act	Protection of Endangered Species	16 USC 1531 et seq and 50 CFR 402	This act and associated regulations require federal agencies to act to avoid jeopardizing the continued existence of federally listed endangered or threatened species.	Not applicable	There are no endangered or threatened species or critical habitats at Site 57.
Fish and Wildlife Coordination Act	Impacts on Fish and Wildlife	16 USC 661	Requires federal agencies to consult appropriate state agencies before structural modification of any body of water, including wetlands. Requires action to be taken to protect fish and wildlife from projects affecting the water body and provides for consideration of impacts on wetlands and protected habitats.	Not applicable	Remedial actions are not expected to impact surface water or wetlands.
Protection of Wetlands	Activities in Wetlands	E.O. 11990 and 40 CFR 6, Appendix A	If no practicable alternative exists to a remedial activity that may adversely affect a wetland, impacts from implementing the chosen alternative must be mitigated.	Not applicable	There are no wetlands at, or that could be affected by remedial activities at, Site 57.
Floodplain Management	Activities in Floodplains	E.O. 11988 and 40 CFR 6, Appendix A	If no practicable alternative exists to performing cleanup in a floodplain, potential harm must be mitigated and actions taken to preserve the beneficial values of the floodplain.	Not applicable	Site 57 is not located within a floodplain.

TABLE 2-2

LOCATION-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
Federal					
Archeological and Historical Preservation Act of 1974	Historic Areas	16 USC 470 et seq. and 36 CFR 65	Establishes requirements relating to potential loss or destruction of significant scientific, historical, or archeological data as a result of a proposed remedy.	Not applicable	There are no historic or archeological areas at Site 57.
EPA Groundwater Protection Strategy	Groundwater Classification	NA	Provides guidance in determining the potential beneficial uses of contaminated groundwater.	To be considered	Groundwater at Site 57 is Class IIB, potentially available for drinking water, agriculture, or other beneficial uses.
State					
Endangered Species	Threatened and Endangered Species	COMAR 08.03.08	Provides for consideration of the impacts on endangered, threatened, and rare species and their critical habitats.	Not applicable	There are no endangered, threatened, or rare species or critical habitats at Site 57.
Water Resources (Environment Article, Title 5)	Construction on Nontidal Waters and Floodplains	COMAR 26.17.04	Governs water obstructions or changes to a stream or body of water.	Not applicable	Remedial alternatives for Site 57 are not expected to impact surface water bodies. Site 57 is not located in a floodplain.
	Nontidal Wetland Regulations	COMAR 26.23	Establishes requirements for activities in nontidal wetlands.	Not applicable	There are no nontidal wetlands at, or that could be affected by remedial activities at, Site 57.
Wetlands and Riparian Rights (Environment Article, Title 16)	Tidal Wetland Regulations	COMAR 26.24	Establishes requirements for activities in tidal wetlands.	Not applicable	There are no tidal wetlands at, or that could be affected by remedial activities at, Site 57.

ARARs Applicable or Relevant and Appropriate Requirements.
COMAR Code of Maryland Regulations.
CFR Code of Federal Regulations.
E.O. Executive Order.
EPA United States Environmental Protection Agency.
FS Feasibility Study.
NA Not applicable/not available.
TBC To be considered.
USC United States Code.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Federal					
Clean Air Act	National Ambient Air Quality Standards (NAAQS)	40 CFR 50	Estabishes primary (health-based) and secondary (welfare-based) air quality standards for carbon monoxide, lead, nitrogen oxides, particulate matter, ozone, and sulfur oxides emitted from a major source of emissions.	Potentially relevant and appropriate	Criteria pollutants may be generated during groundwater treatment.
	New Source Performance Standards (NSPS)	40 CFR 60	Establishes source-specific emission standards.	Potentially relevant and appropriate	Air pollutants may be discharged during groundwater treatment activities.
	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 61 and 40 CFR 63	Establishes emission standards for particular air contaminants from specific sources.	Potentially relevant and appropriate	Hazardous air pollutants may be discharged during groundwater treatment activities.
EPA Superfund Guidance	Control of Air Emissions from Air Strippers	OSWER Directive 9344.0-28	Emission controls are required for an air stripper if actual or potential VOC emission rates are exceeded in an ozone nonattainment area.	To be considered	Charles County, Maryland is in a nonattainment area for ozone. An air stripper could be used for groundwater treatment.
Resource Conservation and Recovery Act (Subtitle C)	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies those solid wastes that are subject to regulation as a hazardous waste.	Potentially applicable	Spent TCE from Building 292 operations is a listed hazardous waste.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Federal (continued)					
Resource Conservation and Recovery Act (Subtitle C)	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes standards for generators of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards for transportation of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards for Owners and Operators of Hazardous Waste TSD Facilitites	40 CFR 264	Establishes minimum national standards for acceptable management of hazardous waste.	Potentially applicable or relevant and appropriate	These standards would be applicable for on-site treatment or disposal of hazardous waste and relevant and appropriate for nonhazardous waste.
	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes that are restricted from land disposal and waste analysis requirements.	Potentially applicable	These restrictions would apply for hazardous wastes shipped off site for land disposal.
Clean Water Act	National Pollutant Discharge Elimination System (NPDES)	40 CFR 122	NPDES permits are required for any discharges to surface waters.	Potentially applicable	Any alternative that includes discharges into surface water would comply with the substantive permit requirements.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Federal (continued)					
Safe Drinking Water Act	Underground Injection Control Program	40 CFR 144 to 148	Contains provisions for control and prevention of pollutant injection into groundwater.	Potentially applicable	These requirements would be applicable if groundwater is removed, treated, and reinjected into the formation from which it was withdrawn.
State					
Ambient Air Quality Control (Environment Article, Title 2)	Ambient Air Quality Standards	COMAR 26.11.04	Establishes ambient standards for particulate matter, sulfur oxides, carbon monoxide, ozone, nitrogen oxides, lead, and fluoride.	Potentially applicable	Criteria pollutants may be generated during groundwater treatment.
	General Emission Standards, Prohibitions, and Restrictions	COMAR 26.11.06	Establishes emission standards for visible emissions, particulate matter, carbon monoxide, sulfur compounds, VOCs, and fluoride and control of NSPS sources.	Potentially applicable	Criteria pollutants may be generated during groundwater treatment.
	Toxic Air Pollutants	COMAR 26.11.15 and 26.11.16	Establishes standards for industries that emit toxic air pollutants, including sources regulated by NESHAPs.	Potentially relevant and appropriate	Hazardous air pollutants may be discharged during groundwater treatment activities.
Hazardous Materials and Hazardous Substances (Environment Article, Title 7)	Identification and Listing of Hazardous Waste	COMAR 26.13.02	Identifies those solid wastes that are subject to regulation as a hazardous waste.	Potentially applicable	Spent TCE from Building 292 operations is a listed hazardous waste.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
State (continued)					
Hazardous Materials and Hazardous Substances (Environment Article, Title 7)	Standards Applicable to Generators of Hazardous Waste	COMAR 26.13.03	Establishes standards for generators of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards Applicable to Transprorters of Hazardous Waste	COMAR 26.13.04	Establishes standards for transportation of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards for Owners and Operators of Hazardous Waste TSD Facilitites	COMAR 26.13.05	Establishes minimum standards for acceptable management of hazardous waste.	Potentially applicable or relevant and appropriate	These standards would be applicable for on-site treatment or disposal of hazardous waste and relevant and appropriate for nonhazardous waste.
Regulation of Water Supply, Sewage Disposal, and Solid Wastes (Environment Article, Title 9)	Water Pollution Permit Regulations	COMAR 26.08.04	Contains requirements for discharges to surface water	Potentially applicable	Any alternative that includes a discharge to surface water would comply with these requirements.
	Well Construction Regulations	COMAR 26.04.04	Contains design standards and procedures for construction of wells.	Potentially applicable	The requirements would apply to remedial activities that include groundwater monitoring.
Environment Article, Title 7 and Title 9	Underground Injection Control	COMAR 26.08.07	References federal regulations for control and prevention of pollutant injection into groundwater.	Potentially applicable	These requirements would be applicable if groundwater is removed, treated, and reinjected into the formation from which it was withdrawn.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBC CRITERIA
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD MARYLAND

ARARs	Applicable or Relevant and Appropriate Requirements.
CFR	Code of Federal Regulations.
COMAR	Code of Maryland Regulations.
EPA	United States Environmental Protection Agency.
FS	Feasibility Study.
OSWER	Office of Solid Waste and Emergency Response.
TBC	To be considered.
TSD	Treatment, storage, and disposal.
VOC	Volatile organic compound.

TABLE 2-4

COMPARISON OF GROUNDWATER CONCENTRATIONS TO ARARs
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Groundwater COPC from RI Report	Maximum Concentration (2005)	MCL	Comments
Acetone	ND	NA	Less than criterion
cis-1,2-Dichloroethene	46,000	70	Greater than criterion
1,1-Dichloroethane	22	NA	Less than criterion
1,2-Dichloroethane	3.0	5	Less than criterion
1,1-Dichloroethene	120	7	Greater than criterion
Diethyl ether	4,200	NA	No criterion
Methylene chloride	ND	5	Less than criterion
Tetrachloroethene	3.0	5	Less than criterion
trans-1,2-Dichloroethene	160	100	Greater than criterion
1,1,1-Trichloroethane	5	200	Less than criterion
Trichloroethene	36,000	5	Greater than criterion
Vinyl chloride	25,000	2	Greater than criterion

All concentrations presented in units of µg/L.
ARARs Applicable or Relevant and Appropriate Requirements.
COPC Chemical of potential concern.
MCL Maximum Contaminant Level.
NA Not available.
ND Not detected.
RI Remedial Investigation.

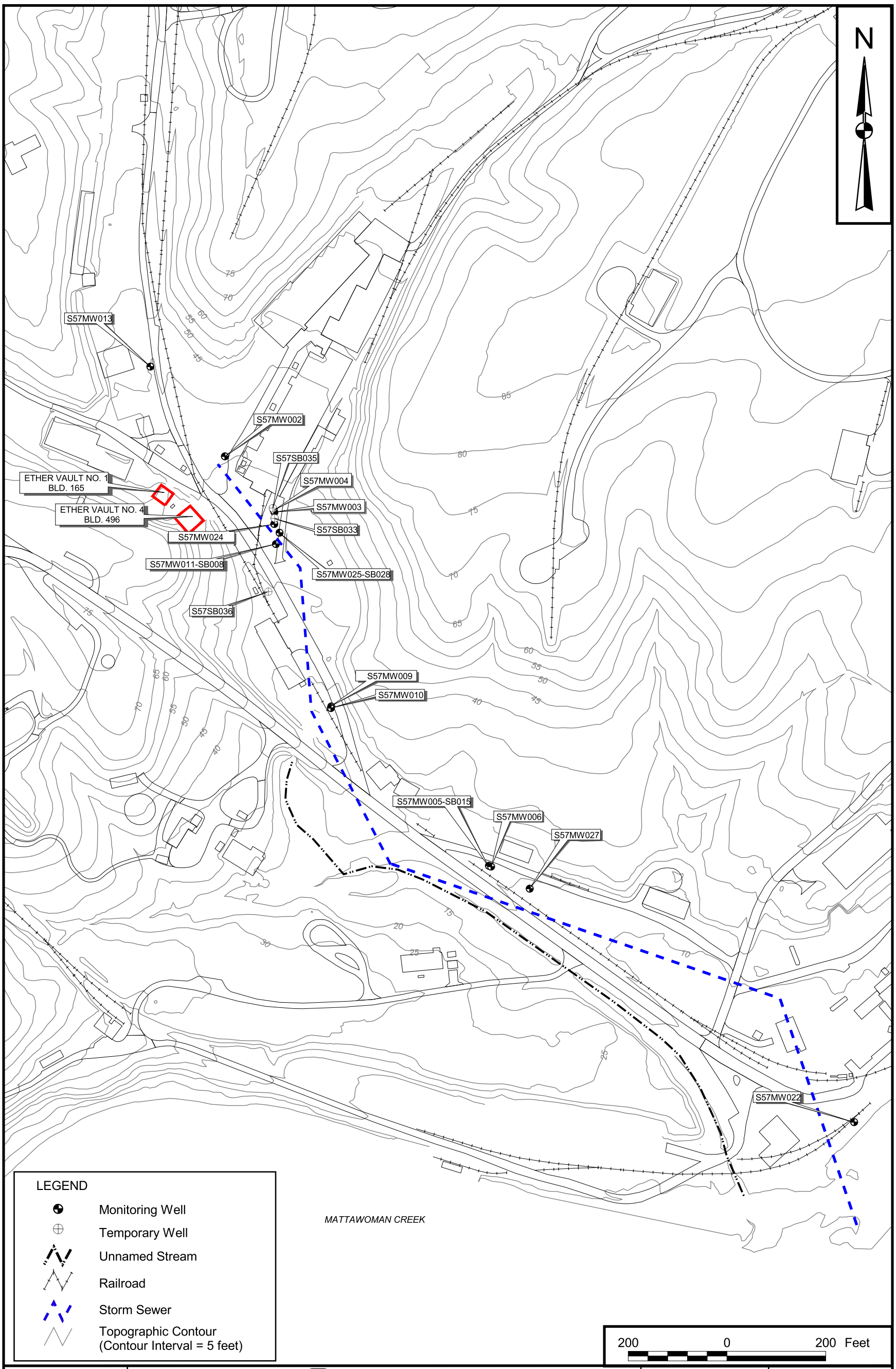
TABLE 2-5

SUMMARY OF EXCEEDANCES OF GROUNDWATER PRGs – 2005
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Location and Screened Interval	COC	Concentration (µg/L)	Comments
S57MW002 (shallow)	Diethyl ether	1,600	Source area
S57MW003 (intermediate)	Trichloroethene	200/150[(1)]	Source area
S57MW004 (shallow)	cis-1,2-Dichloroethene	72	Source area
	Trichloroethene	950	
	Vinyl chloride	13	
S57MW005 (intermediate)	Trichloroethene	230	Mid-plume area
S57MW006 (shallow)	Trichloroethene	250	Mid-plume area
	Vinyl chloride	6	
S57MW009 (intermediate)	1,1-Dichloroethene	9	Mid-plume area
	Trichloroethene	330	
S57MW010 (shallow)	1,1-Dichloroethene	9	Mid-plume area
	Trichloroethene	160	
S57MW011 (intermediate)	Diethyl ether	2,000	Source area
	Trichloroethene	27	
S57MW013 (shallow)	1,1-Dichloroethene	62	Upgradient area
S57MW022 (shallow)	cis-1,2-Dichloroethene	210	Downgradient area
	Vinyl chloride	400	
S57MW024 (shallow)	cis-1,2-Dichloroethene	820	Source area
	Trichloroethene	580	
	Vinyl chloride	250	
S57MW025 (shallow)	1,1-Dichloroethene	12/12	Source area
	cis-1,2-Dichloroethene	10,000/8,900	
	trans-1,2-Dichloroethene	160/160	
	Trichloroethene	72/71	
	Vinyl chloride	25,000/22,000	
S57MW027 (intermediate)	Trichloroethene	28/33	Mid-plume area
S57GB033 (intermediate)	Trichloroethene	78	Source area
	Vinyl chloride	4	
S57GB35 (shallow)	1,1-Dichloroethene	120/110	Source area
	cis-1,2-Dichloroethene	46,000/41,000	
	Trichloroethene	36,000/32,000	
	Vinyl chloride	4,400/3,900	
S57GB036 (intermediate)	Diethyl ether	4,200	Source area

1 Duplicate sample results.
COC Chemical of concern.
GB Grab sample from temporary well installed in soil boring.
MW Monitoring well.

P:\GIS\NSWC_INDIAN_HEAD\7129_SITE57.APR\PRG EXCEEDANCE_BUILDING292 3/9/06 KMP



DRAWN BY K. PEILA	DATE 4/30/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 2194 / OWNER NUMBER 007
CHECKED BY	DATE	PRG EXCEEDANCE - GROUNDWATER (2005) SITE 57 - BUILDING 292 TCE CONTAMINATION NAVAL SUPPORT FACILITY, INDIAN HEAD INDIAN HEAD, MARYLAND	APPROVED BY / DATE
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2 - 1 / REV 0

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section categorizes, identifies, and evaluates technologies that can be applied to the remediation of Site 57 groundwater.

3.1 INTRODUCTION

Identification, screening, and evaluation of potentially applicable technologies and process options are important steps in the FS process. The primary objective of this phase of the FS is to develop an appropriate range of remedial technologies and process options that can be combined into remedial alternatives. The basis for technology identification and screening began in Section 2.0 with a series of discussions that included the following:

- Development of RAOs
- Identification of ARARs
- Development of PRGs
- Identification of COCs and media of concern
- Identification of volumes and areas of interest

Technology screening is completed and technology evaluation is performed in this section with the following steps:

- Identification of general response actions (GRAs)
- Identification and screening of remedial technologies and process options
- Evaluation of technologies and selection of representative process options

3.2 GENERAL RESPONSE ACTIONS

GRAs describe categories of actions that could be implemented to satisfy or address a component of an RAO for a site. Typically, the formation of remedial alternatives represents combining GRAs to fully address RAOs. When implemented, the combined GRAs are capable of achieving the RAOs that have been developed for each medium of interest at the site. As discussed in Section 2.0, the media of concern for Site 57 are soil and surficial aquifer groundwater. Contaminated soil was addressed under a non-time-critical removal action.

The following GRAs are to be considered for Site 57:

- No action
- Institutional Actions
- Containment
- Removal
- Treatment
- Disposal

3.2.1 No Action

The no-action response is retained throughout the FS process as required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The no-action response provides a comparative baseline against which other alternatives can be evaluated. Under this response, no remedial action is taken. The contaminated media are left as is without the implementation of any monitoring, land use controls (LUC), containment, removal, treatment, or other mitigating actions.

3.2.2 Institutional Actions

Institutional actions include various site access controls or land use restrictions to reduce or eliminate direct contact pathways of exposure. These controls could involve the use of monitoring, groundwater use restrictions, and access controls. The toxicity, mobility, and volume of the contaminants are not reduced through the implementation of LUC.

3.2.3 Containment

Another method of reducing risk to human health and the environment is through containment that involves the use of physical measures to reduce the potential for exposure and contaminant migration. To reduce the migration of contaminants, the contaminated media must be isolated from the primary transport mechanisms such as wind, erosion, surface water, and groundwater. For example, installing surface or subsurface barriers or pumping groundwater for gradient control can be used to isolate contaminated groundwater.

3.2.4 Removal

Technologies in this category are used to move a contaminated medium from its current location to be treated or disposed elsewhere. Removal process options are combined with treatment or disposal actions.

3.2.5 Treatment

This response action includes both in-situ and ex-situ treatment processes and could include physical, chemical, biological, or thermal treatment techniques. Treatment processes are designed to reduce the toxicity, mobility, or volume of the contaminated medium. Ex-situ treatment processes are combined with removal and disposal actions to develop alternatives.

3.2.6 Disposal

For groundwater, disposal includes transfer of treated materials to another environmental medium (e.g., discharge of treated groundwater to surface water). Disposal actions are combined with removal or treatment actions. The toxicity, mobility, and volume of the contaminants are not reduced through the singular application of disposal.

3.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

In this section, a variety of technologies and process options are identified under each GRA and screened. The screening is first conducted at a preliminary level to focus on relevant technologies and process options based on site conditions, the medium of concern, and COCs. A more detailed evaluation is then conducted in Section 3.4, and process options are selected to represent technologies that have passed the detailed evaluation. The selected process options are combined to form remedial alternatives in Section 4.0. Some of the treatment technologies are based on presumptive remedies (preferred technologies) the EPA recommends for common categories of sites (e.g., VOCs in groundwater). Other treatment processes are emerging technologies that have been identified by the Navy.

Table 3-1 summarizes the preliminary screening of technologies and process options for groundwater. The table lists the GRA, identifies the technologies and process options, and provides a brief description of the process options and screening comments. All technologies and process options that are not eliminated are evaluated in Section 3.4.

3.4 EVALUATION OF TECHNOLOGIES AND SELECTION OF REPRESENTATIVE PROCESS OPTIONS

3.4.1 Evaluation Criteria

The evaluation criteria for detailed screening of technologies and process options retained after the preliminary screening in Section 3.3 are effectiveness, implementability, and cost.

The effectiveness evaluation focuses on the following: potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs, the potential impacts to human health and the environment during the construction and implementation phase, and how proven and reliable the process is with respect to the contaminants and conditions at the site.

Implementability encompasses both the technical and administrative feasibility of implementing a technology process. Technical implementability was used in the preliminary screening in Section 3.3 to eliminate those processes that are clearly ineffective or unworkable at the site. Therefore, this subsequent, more detailed evaluation places greater emphasis on the institutional aspects of implementability. This includes the ability to obtain necessary permits for off-site actions, the availability of treatment and disposal services, and the availability of necessary equipment and skilled workers to implement the technology.

Cost plays a limited role in the screening of process options. Relative capital and operation and maintenance (O&M) costs are used rather than detailed estimates. At this stage in the process, the cost analysis is made on engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type.

All the factors listed above may not directly apply to each process options and are only addressed as appropriate. Screening evaluations generally focus on effectiveness and implementability, with less emphasis on cost evaluations. Process options that would be precluded by waste or chemical characteristics and inapplicability to site conditions are screened and eliminated from further consideration. At this stage, no process options are eliminated based on cost. A process option within a technology category, however, may not be carried through to the alternative development stage if an equally effective process option is available at a lower cost.

3.4.2 Evaluation of Technologies and Process Options for Groundwater

The final screening of technologies and process options is based on the evaluation criteria presented in Section 3.4.1. The following table presents the technologies and process options for groundwater that remain for final screening.

General Response Action	Remedial Technology	Process Option
No Action	None	Not applicable
Institutional Actions	Monitoring	Groundwater monitoring
	Access/use restrictions	Groundwater use restrictions

General Response Action	Remedial Technology	Process Option
Containment	Vertical barriers	Slurry wall, grout curtain, and sheet piling
		Hydraulic barrier
Removal	Groundwater extraction	Extraction wells
		Collection trench
In-Situ Treatment	Physical/biological	Air sparging/soil vapor extraction
	Physical/chemical	Permeable reactive barriers
		Chemical oxidation
	Natural attenuation	Monitored natural attenuation
	Biological	Enhanced biodegradation
Ex-Situ Treatment	Physical/chemical	Air stripping
		Adsorption
		Chemical oxidation
Discharge/Disposal	Surface discharge	Direct discharge
	Subsurface discharge	Reinjection

3.4.2.1 No Action

No action consists of implementing no activities to address contaminated groundwater. No action is retained as required by the NCP; therefore, no evaluation is conducted.

3.4.2.2 Institutional Actions

Institutional actions remaining after preliminary screening consist of groundwater use restrictions and monitoring. Identifying restrictions in the Geographic Information System (GIS) maintained by NSF-IH can be used to prevent future groundwater use from posing a risk to human health. Monitoring may include the collection of groundwater samples followed by analysis for target contaminants.

Effectiveness

Groundwater use restrictions can be effective, depending on the administration of the controls. Sampling and analysis are not effective in controlling risks to human health or the environment, but they can be used to determine the effectiveness of a remedial action or the need for additional remedial action.

Implementability

Groundwater use restrictions and monitoring are readily implementable.

Cost

Costs of groundwater use restrictions are low. Costs associated with sampling and analysis are low to moderate depending on the nature of the monitoring program.

Conclusion

Groundwater use restrictions and groundwater monitoring are retained for further consideration.

3.4.2.3 Containment

The technologies being considered for containment are low-permeability vertical barriers and hydraulic barriers. Containment of groundwater can be performed using hydraulic controls such as extraction wells and collection trenches, or passive controls such as low-permeability vertical barriers. Extraction wells, collection trenches, and low-permeability vertical barriers can be used to contain a contaminant plume by restricting lateral migration of the groundwater. Passive barriers are evaluated in this section. Hydraulic controls are discussed in Section 3.4.2.4.

Low-permeability vertical barriers include slurry walls, grout curtains, and sheet piles that are used to minimize the horizontal migration of contaminants, especially in the saturated zone. These barriers are placed around wastes or contaminated areas. Low-permeability vertical barriers extend from the ground surface to at least the bottom depth of the contamination or to the confining layer of the aquifer. The type of barrier selected depends on site-specific conditions.

Effectiveness

The use of low-permeability vertical barriers may be considered if horizontal migration of contaminants from groundwater is a concern. Slurry walls are more commonly used than grout curtains and sheet piling and may be more effective in controlling contaminant migration in coarser soils. If the barrier cannot be installed into a confining layer, it may be less effective.

Implementability

The use of low-permeability vertical barriers could cause an increase in groundwater elevations upgradient of the barrier. Maintenance of the integrity of low-permeability vertical barriers is difficult over the long term, and groundwater monitoring may be required to ensure that the barrier remains effective. An excessive depth to the confining layer may cause problems with constructability. The depth to the confining layer at Site 57 is not excessive and is approximately 35 feet near Building 292 and generally decreases with downgradient distance.

Cost

The costs for low-permeability vertical barriers are moderate for slurry walls and sheet piling and high for grout curtains.

Conclusion

Low-permeability vertical barriers (slurry walls) to minimize the horizontal migration of groundwater and contaminants in the saturated zone are eliminated from further consideration. The area of contaminated groundwater at Site 57 is too large to be effectively contained using a low-permeability vertical barrier. The TCE plume is over 1,000 feet long and is estimated to be 80 to 160 feet wide. There is no confining layer present near Mattawoman Creek where cis-1,2-dichloroethene and vinyl chloride are the COCs. Control of groundwater migration at this site would be more effective using extraction wells or collection trenches to create a hydraulic barrier (see Section 3.4.2.4).

3.4.2.4 Removal

Remediation and containment of groundwater may be achieved by removal of contaminated groundwater from the aquifer. The process options for groundwater removal that are evaluated in this section are extraction wells and collection trenches.

Extraction wells are used to contain or remove a contaminated groundwater plume or to adjust groundwater levels to prevent formation of a plume. The selection of the appropriate well system depends on the depth of contamination and the hydrogeologic and geologic characteristics of the aquifer. Well systems are very versatile and can be used to contain, remove, divert, or prevent development of plumes under a variety of site conditions.

Collection trenches are used to collect and convey groundwater by gravity flow. They function like a continuous line of extraction wells. A collection trench is formed by first excavating to the desired depth. Collection pipes, pumps, and filter fabric are placed in the trench to allow for water removal. The trench is then backfilled with permeable material such as gravel or crushed rock. Collection trenches can be used to contain or remove groundwater or to prevent contact of water with a contaminated material. They offer the advantage of collecting groundwater in situations where the groundwater recharge rate is insufficient to sustain extraction well pumping. They are, however, less effective than extraction wells at lowering the water table.

Effectiveness

Groundwater pumping systems are the most versatile and flexible of the groundwater control techniques. They are effective under a variety of geologic and hydrogeologic conditions, including those found at Site 57. Extraction of contaminated groundwater through appropriately located wells would reduce contaminant concentrations in the subsurface. However, as groundwater extraction continues over time, there may be a point at which contaminant concentrations approach a constant value, and contaminant mass is no longer being removed at significant levels. Extracted groundwater would then require treatment and disposal.

The effectiveness of collection trenches depends on their depth. Collection trenches are used for relatively shallow aquifers. They are most effective for aquifers that have low hydraulic conductivities and shallow gradients. Limitations include the presence of viscous or reactive chemicals that could clog the filter fabric and drains. Such chemicals were not detected in Site 57 groundwater. Conditions that favor the formation of iron, manganese, and calcium carbonate deposits may also limit the use of trenches. Although these limitations also apply to extraction wells, the adverse effects are more pronounced and less easily repaired for collection trenches.

Implementability

Installation of a groundwater pumping system is technically feasible. Contractors qualified to drill and install wells are readily available. Pumps, casings, and screens must be maintained to ensure a constant, reliable flow of water from the well. Well maintenance is especially important in plume management because the loss of a well could result in the migration of contaminants. The causes of well yield loss and failure are typically encrustation of the well screen, corrosion, and pump failure. Any plans to install new pump-and-treat systems on Navy installations requires approval from NAVFAC Headquarters.

Collection trenches are readily implementable for aquifers with a shallow confining layer, and equipment and resources are readily available. Collection trenches may be difficult to implement at Site 57 because of the presence of underground utilities and a shallow water table. This would require excessive excavation and construction below the water table to the depth of the confining layer (approximately 35 feet at Building 292).

Cost

Costs of well systems for plume management vary greatly from site to site and depend on site geology, groundwater characteristics, contaminant characteristics, extent of contamination, and period and duration of pumping. Typically, capital and O&M costs are moderate.

Costs of collection trenches depend on the depth of excavation, soil stability, and groundwater flow rates. Capital costs are generally moderate to high, and O&M costs are low.

Conclusion

Extraction wells are retained for further consideration. Collection trenches are removed from further consideration. The presence of underground utilities and a shallow water table and the depth to a confining layer (approximately 35 feet) make extraction wells the more effective and implementable process option for groundwater containment or removal.

3.4.2.5 In-Situ Treatment

The process options considered under in-situ treatment are air sparging (AS)/soil vapor extraction (SVE), permeable reactive barriers, chemical oxidation, monitored natural attenuation, and enhanced biodegradation.

AS/SVE is a process in which pressurized air is injected into a contaminated aquifer. Air streams traverse horizontally and vertically through the aquifer and remove contaminants by volatilization. The air carries contaminants to a vapor extraction system that removes the generated vapor-phase contamination. In addition, the increased dissolved oxygen level in the aquifer would enhance aerobic biodegradation of contaminants. Optimizing the AS flow rate to emphasize biodegradation in comparison to volatilization is sometimes called biosparging.

Permeable reactive barriers (PRBs) consist of trenches placed in the path of a dissolved contaminant plume. The trench is filled with reactive material such as granular iron to dechlorinate halogenated organics, granular activated carbon to adsorb organics, or other treatment media. As the groundwater passes through the treatment barrier, the contaminants react with the media.

Chemical oxidation involves injecting chemical oxidants into groundwater to oxidize contaminants. Common oxidants are hydrogen peroxide-based Fenton's reagent and potassium permanganate. Ozone can also oxidize organic contaminants in situ, but ozone is not commonly used. Fenton's reagent is produced on site by adding iron catalyst to a hydrogen peroxide solution.

Monitored natural attenuation refers to inherent processes that affect the rates of migration and the concentrations of contaminants in groundwater. The most important processes are biodegradation, advection, hydrodynamic dispersion, dilution from recharge, sorption, and volatilization. Consideration of this option requires modeling and evaluation of contaminant degradation rates and pathways.

Enhanced biodegradation refers to the addition of nutrients and/or chemicals to enhance the natural biodegradation of organic compounds.

Effectiveness

AS/SVE is used primarily to treat compounds with high vapor pressure and low solubility, such as halogenated and nonhalogenated VOCs. Subsurface heterogeneity can interfere with uniform air distribution. The process is less effective in low-permeability soil and aquifers. AS/SVE can simultaneously remove VOCs from soil in the vadose zone and from soil and groundwater in the saturated zone. A previous pilot study concluded that the SVE portion of this process would not be effective at Site 57 (B&R Environmental, 1997).

PRBs have mainly been used in the field to degrade chlorinated solvents using zero-valent granular iron. The mechanism of chlorinated solvent degradation with zero-valent iron has been the most widely studied and reported to date. Impermeable funnel wings or walls on either side of the treatment trench can be used to enhance effectiveness by directing the plume toward the treatment area. The reactive material cell wall may have to be flushed or the reactive medium replaced periodically if precipitates build up to the point that reactivity or hydraulic performance is affected. This can potentially be overcome by incorporation of sufficient safety factors in the design.

In-situ chemical oxidation is most effective for sites contaminated with halogenated VOCs and DNAPL in saturated soil and groundwater. The effectiveness for diethyl ether is not known. This emerging process can be applied to highly contaminated sites or source areas to reduce contaminant concentrations. It is not generally cost effective for large plumes with lower contaminant concentrations. The contaminant plume at Site 57 covers an area of more than 2.5 acres. Residual levels of potassium permanganate, which is purple, can result in discoloration of the groundwater. The reaction of Fenton's reagent with VOCs can generate heat. This could cause a violent exothermic reaction if not applied carefully. This reaction could also cause volatilization of VOCs and subsequent migration through preferential pathways such as sewers and could cause VOCs to enter buildings and other confined spaces.

Monitored natural attenuation is effective if the rate of biodegradation, aided by sorption and dilution, is rapid enough to prevent significant contaminant migration by advection and dispersion. Natural attenuation has proven to be effective for chlorinated solvents and fuel-related compounds. The detection of degradation products of TCE downgradient of the source area is evidence that natural attenuation is occurring at Site 57. The effectiveness for diethyl ether is not known.

Enhanced biodegradation is effective in accelerating in-situ biodegradation rates and has been proven to be effective for chlorinated solvents. The 2003 pilot study concluded that enhanced biodegradation using HRC® is not effective for diethyl ether.

Treatability studies or evaluations would be required to verify the effectiveness of all in situ treatment processes, except HRC®.

Implementability

AS/SVE is a readily available technology. Air pollution controls may be required, depending on state and local air pollution control regulations.

The use of PRBs is an innovative technology, but the barriers are constructed of readily available materials. Because there are no above-ground structures associated with PRBs, the affected area can be put to productive use while it is being cleaned up. The soil excavated from the trench would need to be properly disposed based on chemical concentrations. PRBs can be designed so that they do not cause an increase in groundwater elevations upgradient of the treatment zone. This can be accomplished by adding a permeable material such as sand to the treatment barrier so that its permeability is greater than that of the surrounding lithology.

In-situ chemical oxidation is an emerging process that is being refined and tested by the Navy. The equipment and chemicals required are readily available. Subsurface heterogeneity can cause non-uniform distribution of the oxidant.

Natural attenuation would be readily implementable. A monitoring program can be accomplished without any major implementability concerns.

Enhanced biodegradation would be readily implementable. However, subsurface heterogeneity can cause non-uniform distribution of the additives necessary to stimulate biological activity.

Cost

The cost of AS/SVE is low to moderate. The costs for PRBs are proportional to the size of the treatment trench. The need for impermeable walls to direct the plume would add to the cost. The costs of in-situ chemical oxidation are expected to be higher than for AS/SVE and dependent on the amount of chemicals required. Chemical oxidation is generally not cost effective for residual contaminant concentrations. The costs of monitored natural attenuation would be expected to be lower than for AS/SVE. The costs are proportional to the monitoring program needed to confirm the effectiveness of

natural attenuation. The costs of enhanced biodegradation are dependent on the amount of additives needed to stimulate biological activity.

Conclusion

AS/SVE for treatment of VOCs is eliminated from further consideration because of effectiveness concerns with the SVE portion of this process. Chemical oxidation is eliminated because of effectiveness and cost concerns for large, low-concentration groundwater plumes. PRBs, monitored natural attenuation, and enhanced biodegradation for treatment of VOCs in the saturated zone are retained.

3.4.2.6 Ex-Situ Treatment

The process options considered under ex-situ treatment are air stripping, adsorption, and chemical oxidation.

Air stripping involves the mass transfer of volatile contaminants from water to air. For groundwater remediation, this process is typically conducted in a packed tower or low-profile aeration system. The typical packed tower air stripper includes a spray nozzle at the top of the tower to distribute contaminated water over the packing in the column, a fan to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect treated water. Low-profile air strippers are available in horizontal tray or vertical box designs. Baffles are used to route contaminated water two or more times along the length of the tray or height of the box. Air sparged through the bottom of the tray or through a vent pipe in the bottom of the box passes up through the water to strip out volatile compounds. Off-gas treatment may be required to comply with air pollution control regulations.

Granular activated carbon (GAC) adsorption is the most common adsorption process for groundwater treatment. Liquid-phase GAC treatment is performed by pumping groundwater through one or more vessels containing activated carbon, which removes contaminants from the water by sorption until available active sites are occupied. Carbon is “activated” by being processed to create porous particles with large internal surface areas that attract and adsorb organic molecules. As the available surface sites become occupied, the contaminant concentrations in the effluent increase. When contaminant concentrations in the effluent exceed a specified action level, the carbon can be regenerated in place, removed and regenerated at an off-site facility, or removed for disposal.

Chemical oxidation uses chemical oxidizing agents (e.g., ozone, hydrogen peroxide) to destroy toxic organic chemicals. Ultraviolet light is often used in conjunction with the oxidizing agent to promote faster and more complete destruction of organic compounds. Complete oxidation decomposes hydrocarbons into carbon dioxide and water, although chlorinated organics may also yield chlorine ions. If oxidation is

incomplete, toxic constituents may remain or toxic degradation products can be formed. Chemical oxidation is carried out in batch or continuous reactors. Oxidants are generally added to contaminated groundwater in a mixing tank prior to introduction into the reactor. Ultraviolet lamps, if used, are typically enclosed in quartz tubes submerged inside the reaction vessel. The tubes are subject to fouling or scaling from compounds such as iron oxide or calcium carbonate.

Effectiveness

Air stripping is a well-proven, reliable technology for the removal of VOCs in groundwater. Theoretically, removal efficiencies greater than 99 percent can be achieved. Because air stripping only removes contaminants from water and transfers them to air, the air may need to be treated depending on contaminant concentrations, air flow rates, and applicable discharge standards. Types of off-gas treatment include thermal oxidation, catalytic oxidation, and carbon adsorption. The type of off-gas treatment is primarily a matter of economics and is dependent on the air volume, contaminant, and contaminant concentration.

GAC adsorption has a long history of use in treating municipal, industrial, and hazardous wastewaters. Liquid-phase GAC can be used to remove VOCs and other organic chemicals. Removal efficiencies greater than 99 percent can be achieved for some contaminants. Limited effectiveness may be achieved for some halogenated VOCs such as vinyl chloride and dichloroethenes. These VOCs are weakly sorbed, causing low GAC capacity. Because GAC adsorption only concentrates contaminants, the spent carbon would have to be regenerated or disposed.

Chemical oxidation is a proven and effective process for the removal of most, but not all, organics. It is generally more effective for alkenes than alkanes. The process is generally effective for concentrations less than 500 µg/L. Ultraviolet light can enhance the oxidation of compounds that are resistant to chemical oxidation alone. Destruction efficiencies of 99 percent or more may be expected for some organics.

Implementability

Air stripping is a conventional process that would be readily implementable at the site. A sufficient number of vendors provide air stripping equipment. If activated carbon is used to treat the off-gas, subsequent regeneration or disposal must be provided. One maintenance consideration for air stripping is channeling of flow resulting from clogging of the packing material. Common causes of clogging are suspended solids, oxidized manganese, and oxidized iron.

GAC adsorption is a conventional process that would be readily implementable. There are a sufficient number of vendors providing this process. Implementation factors include planning for disposal or regeneration of exhausted carbon. Pretreatment may be required prior to the adsorption process to prevent clogging and excessive pressure drop in the treatment unit.

Chemical oxidation should be implementable, and several vendors offer this process. Site-specific treatability studies are generally recommended for chemical oxidation systems. Pretreatment may be required to condition groundwater for effective oxidation. If ultraviolet lamps are used, the studies must evaluate the potential for fouling or scaling of the quartz tubes. If fouling occurs, oxidation rates are drastically reduced. The use of ozone as the oxidizing agent requires an on-site ozone generator and an ozone decomposition unit or other emission control device. The use of hydrogen peroxide requires storage tanks and special handling procedures to ensure operator safety.

Cost

Capital costs for air stripping are low, and O&M costs are low to moderate, depending on the need for off-gas treatment. Capital costs for GAC adsorption are moderate, and O&M costs are low to moderate and are dependent on the carbon usage rate. Capital costs for chemical oxidation are high, and O&M costs are moderate to high and depend on the chemical usage rate.

Conclusion

Air stripping is retained for further consideration because VOCs are the only COCs for groundwater. GAC adsorption is eliminated from further consideration because of potential effectiveness concerns for the some of the VOCs of concern (e.g., vinyl chloride and dichloroethenes). Although chemical oxidation may be effective and implementable, air stripping is equally or more effective for the narrow range of VOCs of concern present at the site, is more readily available, and is less expensive.

3.4.2.7 Discharge/Disposal

The process options considered under discharge/disposal are direct discharge to surface water and reinjection into the shallow aquifer.

Direct discharge to surface water would involve discharging treated groundwater to Mattawoman Creek through a new pipeline, to the existing storm sewer that discharges to Mattawoman Creek (IW80), or to the unnamed stream that flows to Mattawoman Creek (IW40).

Reinjection would involve pumping treated groundwater into the shallow aquifer from which it was extracted.

Effectiveness

The discharge of treated groundwater to Mattawoman Creek through a new pipeline, the existing storm sewer, or the unnamed stream would be effective if groundwater is treated to the necessary levels. Compliance with NPDES discharge limits to be established by the Maryland Department of the Environment (MDE) would achieve RAOs.

The reinjection of treated groundwater into the shallow aquifer would be effective if groundwater is treated to the necessary levels (i.e., PRGs for groundwater). Reinjection can reduce the time required to remediate an aquifer using conventional pump-and-treat methods. The clean, reinjected groundwater is expected to leach additional contaminants from soil in the saturated zone. However, the source area of groundwater contamination at Site 57 is limited to a relatively small area near Building 292, and contaminated soil was addressed under a non-time-critical removal action.

Implementability

Discharge to Mattawoman Creek through a new pipeline, existing sewer, or the unnamed stream is readily implementable. The existing NSF-IH NPDES permit would need to be modified, and MDE would need to establish appropriate discharge limits.

Reinjection is normally implementable and would require equipment and materials similar to extraction wells. The presence of multiple structures and underground utilities in the upgradient plume area could cause some implementability concerns.

Cost

Costs for discharge to the existing sewer and the unnamed stream would be lower than for construction of a new pipeline from the site to Mattawoman Creek. Costs for reinjection would be higher because additional equipment (injection pumps) would be required.

Conclusion

Discharge to the existing sewer, a new pipeline, and the unnamed stream is retained for further consideration. Reinjection is eliminated from further consideration because of implementability issues.

3.4.4 Selection of Representative Process Options

Table 3-2 summarizes the retained technologies and representative process options for groundwater. Representative process options are chosen from each technology to assemble an adequate variety of effective and implementable alternatives and to evaluate the alternatives in sufficient detail to aid in the final selection process. The specific process options selected for the remedial action will be determined during the remedial design or during bid evaluation and selection of the remedial contractor.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not applicable	No activities conducted to address contamination.	Required by NCP. Retain for baseline comparison.
Institutional Actions	Monitoring	Monitoring	Periodic sampling and analysis to track the spread of contamination.	Retain to assess migration of contaminants from site and to evaluate remedial actions.
	Access/Use Restrictions	Physical barriers	Fencing, markers, and warning signs to restrict site access.	Eliminate. Not applicable to groundwater.
		Groundwater use restrictions	Administrative action used to restrict future site activities and use.	Retain to limit human exposure to contaminated groundwater.
Containment	Vertical Barriers	Slurry wall, grout curtain, and sheet piling	Low-permeability barriers to restrict horizontal migration of groundwater.	Retain to reduce migration of groundwater contaminants.
		Hydraulic barrier	Use of extraction wells or collection trenches to restrict horizontal migration of groundwater.	Retain to reduce migration of groundwater contaminants.
	Horizontal Barriers	Physical barrier	Injection of bottom sealing slurry beneath or into an aquifer to minimize vertical migration of groundwater.	Eliminate because a confining layer is already present beneath site and because of implementability concerns.
Removal	Groundwater Extraction	Extraction wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain to remove contaminated groundwater.
		Collection trench	Permeable trench used to intercept and collect contaminated groundwater.	Retain to remove contaminated groundwater.
In-Situ Treatment	Physical/ Biological	Air sparging/soil vapor extraction	Volatilization and enhancement of biodegradation by supply of air and extraction of volatile gases.	Retain to remove VOCs from groundwater.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
In-Situ Treatment (cont.)	Physical/ Chemical	Multi-phase extraction	Use of vacuum and pumping to volatilize and remove contaminants from above and below the water table at the same location.	Eliminate because the area of groundwater contamination is much larger than the former area of soil contamination and soil was addressed under a separate removal action.
		Permeable reactive barriers	Passive in-situ treatment zone of reactive material that degrades or immobilizes contaminants as groundwater flows through it.	Retain to remove VOCs from groundwater.
		Lasagna™ process	Uses electric current to move contaminants in soil pore water (i.e., below the water table) into treatment zones where contaminants can be captured or decomposed.	Eliminate because this process is experimental and has only been used on relatively small areas.
		Chemical oxidation	Involves injecting chemical oxidants into groundwater to oxidize contaminants.	Retain to remove VOCs from groundwater.
	Natural Attenuation	Monitored natural attenuation	Use of natural processes that affect the rate of migration and concentrations of contaminants in groundwater.	Retain to treat contaminated groundwater.
	Biological	Enhanced biodegradation	Addition of chemicals and/or nutrients to enhance biodegradation of VOCs such as TCE.	Retain to treat contaminated groundwater.
Ex-Situ Treatment	Physical/ Chemical	Solids dewatering	Mechanical removal of free water from wastes using equipment such as a filter press or vacuum filter.	Not applicable. Removal of VOCs would not generate solids.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (cont.)	Physical/ Chemical (cont.)	Filtration	Separation of suspended solids from water via entrapment in a bed of granular material or on a membrane.	Not applicable. Removal of VOCs would not generate suspended solids. May be needed as a pretreatment step for VOC removal processes if high suspended solids are present.
		Reverse osmosis	Use of high pressure and membranes to separate dissolved metals from water.	Not applicable. Metals are not COCs for groundwater.
		Air stripping	Contact of water with air to removal volatile organics.	Retain to remove VOCs from extracted groundwater.
		Adsorption	Separation of dissolved contaminants via adsorption onto activated carbon, resins, or activated alumina.	Retain to remove VOCs from extracted groundwater.
		Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the COCs.	Eliminate because it is not applicable for low concentrations of contaminants.
		Distillation	Vaporization of liquid followed by condensation of the vapors to concentrate various constituents.	Eliminate because it is not applicable for low concentrations of contaminants.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (cont.)	Physical/ Chemical (cont.)	Sedimentation	Separation of solids from water via gravity settling.	Not applicable. Metals are not COCs for groundwater. Treatment of VOCs would not generate solids. May be needed as a pretreatment step for VOC removal processes if high suspended solids are present.
		Ion exchange	Process in which ions on a resin surface are exchanged for ions of similar charge.	Not applicable. Metals are not COCs for groundwater.
		Chemical oxidation	Use of oxidizers such as air, ozone, peroxide, chlorine, or permanganate to chemically increase the oxidation state of organic and inorganic compounds.	Retain for removal of organic contaminants.
		Reduction	Use of reducers such as sulfur dioxide, sulfite compounds, or ferrous iron compounds to decrease the oxidation state of organic and inorganic compounds.	Eliminate because it is not applicable to the COCs found in site groundwater.
		Chemical precipitation	Use of reagents to convert soluble constituents into insoluble constituents.	Eliminate because it is not applicable to the COCs found in site groundwater.
		Coagulation/ flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Eliminate because it is not applicable to the COCs found in site groundwater.
		Neutralization/pH adjustment	Use of acids and bases to counteract excess pH.	Eliminate because it is not applicable to the COCs found in site groundwater.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Discharge/ Disposal	Surface Discharge	Direct discharge	Discharge to surface water.	Retain for discharge of treated groundwater.
		Indirect discharge	Discharge to an existing sewage or industrial wastewater treatment plant.	Eliminate because no on-site facility is available.
		Off-site treatment facility	Treatment and disposal at an off-site treatment facility.	Eliminate because expected volumes are too large for off-site transport.
	Subsurface Discharge	Reinjection	Use of injection wells, spray irrigation, or infiltration to discharge treated groundwater underground.	Retain for discharge of treated groundwater.

COCs Chemicals of concern.
NCP National Oil and Hazardous Substances Pollution Contingency Plan.
VOCs Volatile organic compounds.

TABLE 3-2

SUMMARY OF RETAINED TECHNOLOGIES AND PROCESS OPTIONS
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

General Response Action	Remedial Technology	Representative Process Option
No Action	None	Not applicable
Institutional Actions	Monitoring	Groundwater monitoring
	Access/use restrictions	Groundwater use restrictions
Removal	Groundwater extraction	Extraction wells
In-Situ Treatment	Physical/chemical	Permeable reactive barriers
	Natural attenuation	Monitored natural attenuation
	Biological	Enhanced biodegradation
Ex-Situ Treatment	Physical/chemical	Air stripping
Discharge/Disposal	Surface discharge	Direct discharge

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

4.1 INTRODUCTION

This section presents the rationale for and the development of the remedial alternatives evaluated in the FS. These alternatives were developed from the combinations of technologies and process options evaluated in Section 3.0.

4.2 RATIONALE FOR ALTERNATIVE DEVELOPMENT

The purpose of the FS is to evaluate the information provided in the RI and subsequent investigations and studies that assess site conditions and to develop an appropriate range of alternatives to allow remedy selection. The development of alternatives should reflect the scope and complexity of the site problems being addressed. The number and types of alternatives should also be based on the site characteristics and the complexity of the site concerns. Development of alternatives for Site 57 is based on the following:

- Technologies and process options remaining after the screening evaluations in Section 3.0
- Reasonably anticipated land use scenarios
- Exposure scenarios
- RAOs
- ARARs

4.2.1 Technologies and Process Options

GRAs and representative process options have been developed for shallow groundwater at Site 57. Process options for groundwater also address saturated zone soil. The GRAs and process options that have been retained for assembly into alternatives are as follows:

General Response Action	Process Options
No Action	Not applicable
Institutional Actions	Groundwater monitoring
	Groundwater use restrictions

General Response Action	Process Options
Removal	Extraction
In-Situ Treatment	Permeable reactive barriers Monitored natural attenuation Enhanced bioremediation
Ex-Situ Treatment	Air stripping
Disposal	Direct discharge

These process options will be used individually or in combination, as appropriate, to form remedial alternatives, as described in Section 4.3.

4.2.2 Land Use Scenarios

Potential exposure to environmental media is evaluated in the context of current land use and future land use. Under current land use, Site 57 and operations at Building 292 are used to actively fulfill the NSF-IH mission. Under future land use, Site 57 could be released to the public or remain under the control of the Navy. While under the control of the Navy, land use is expected to continue as is.

4.2.3 Exposure Scenarios

Assumptions for the land use scenarios and receptors used for alternative development are consistent with the Site 57 risk assessment (TtNUS, 2000).

Under the current land use scenario, Site 57 is assumed to remain as it currently exists. Existing current land use at and near the site is such that human receptors most likely to be exposed to contaminants at the site and migrating from the site are full-time employees. No adverse health effects are expected for full-time employees. In addition, there are no unacceptable risks to ecological receptors.

Under potential future land use scenarios, potential receptors include on-site residents. Possible adverse effects could be expected for hypothetical future child and adult residents exposed to groundwater. Potential risks to ecological receptors would not be expected.

4.2.4 Accommodation of Clean-Up Goals and ARARs

In general, it is desirable to develop remedial alternatives that achieve compliance with all clean-up goals and ARARs. Groundwater contaminants are present at concentrations that exceed ARARs (i.e., MCLs) and risk-based levels.

4.3 REMEDIAL ALTERNATIVE DEVELOPMENT FOR GROUNDWATER

This section develops the remedial alternatives for groundwater considering the information provided in Section 4.2. The following alternatives have been developed:

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation
- Alternative 3 – In-Situ Bioremediation
- Alternative 4 – Permeable Reactive Barrier
- Alternative 5 – Extraction and Treatment

4.3.1 Alternative 1 – No Action

No action is required for Alternative 1. This alternative is required by the NCP and is used as a baseline for comparison with other alternatives.

4.3.2 Alternative 2 – Monitored Natural Attenuation

Alternative 2 includes natural attenuation, groundwater use restrictions, monitoring, and 5-year reviews. Natural attenuation refers to inherent processes that affect the rates of migration and concentrations of contaminants in groundwater. The most important processes are biodegradation, advection, hydrodynamic dispersion, dilution from recharge, sorption, and volatilization. A screening evaluation for natural attenuation was conducted after the 2001 investigation (Appendix H.1). The evaluation concluded that, with the exception of one downgradient location (S57MW022), groundwater conditions at the site are not favorable to or show limited possibilities for the natural attenuation of chlorinated VOCs. However, the presence of TCE degradation products (e.g., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of potable water until COC concentrations attain PRGs. The groundwater use restrictions would consist of maintaining records of the restrictions in the NSF-IH GIS. The information in the GIS

would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

Monitoring would include periodic sampling and analysis of groundwater. The objectives of the monitoring would be to determine the effectiveness of natural attenuation and to confirm that contaminants are not migrating off site at unacceptable levels.

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, to evaluate the site status (i.e., the site's use at that time and plans for future use), to review environmental laws and regulations in effect at the time of the review, and to provide direction for further action, if deemed necessary. Site reviews are required because this alternative would allow contaminants to remain at the site in excess of levels that allow for unlimited use and unrestricted exposure.

4.3.3 Alternative 3 – In-Situ Bioremediation

Alternative 3 includes in-situ bioremediation, natural attenuation, groundwater use restrictions, monitoring, and 5-year reviews. Under Alternative 3, an electron donor chemical (e.g., HRC®) would be injected into the TCE plume to accelerate in-situ biodegradation rates. HRC® would be metabolized by naturally occurring microorganisms, resulting in the creation of anaerobic conditions and the production of hydrogen. Naturally occurring microorganisms capable of reductive chlorination then use the hydrogen to progressively remove chlorine atoms, thereby converting TCE to dichloroethene and vinyl chloride to ethene. The use of HRC® has been assumed for the FS conceptual design and costing; other electron donor chemicals or materials may also be effective.

An electron acceptor chemical (e.g., Oxygen Release Compound, or ORC®) would be injected into the area near well S57MW022, which is contaminated with cis-1,2-dichloroethene and vinyl chloride. ORC® is used to provide oxygen. The release of dissolved oxygen supports a number of biological oxidation pathways that are expected to result in the complete breakdown of these contaminants. The use of ORC® has been assumed for the FS conceptual design and costing; other electron acceptor chemicals, such as an in-situ Submerged Oxygen Curtain (iSOC™) to provide oxygen, may also be effective.

A screening evaluation of the potential applicability of reductive anaerobic in-situ bioremediation was conducted after the 2001 investigation (Appendix H.2). The evaluation concluded that conditions at some well locations were favorable, and conditions at a few wells were unfavorable. The presence of TCE degradation products (e.g., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring that could possibly be enhanced.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of potable water until groundwater PRGs are attained. The groundwater use restrictions would consist of maintaining records of the restrictions in the NSF-IH GIS. The information in the GIS would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

Monitoring would include periodic sampling and analysis of groundwater. The objectives of the monitoring would be to determine the effectiveness of bioremediation and to confirm that contaminants are not migrating off site at unacceptable concentrations.

A 5-year site review would be conducted to evaluate the analytical results from monitoring samples, to evaluate the site status (i.e., the site's use at that time and plans for future use), to review environmental laws and regulations in effect at the time of the review, and to provide direction for further action, if deemed necessary. Site reviews would be required because this alternative would allow contaminants to remain at the site in excess of levels that allow for unlimited use and unrestricted exposure.

4.3.4 Alternative 4 – Permeable Reactive Barrier

Alternative 4 includes a PRB, natural attenuation, groundwater use restrictions, monitoring, and 5-year review. Under Alternative 4, a PRB would be installed in the downgradient portion of the TCE plume. The PRB would consist of a zone of reactive material installed in the path of the TCE plume. The most commonly used media are zero-valent metals, particularly granular iron. As groundwater flows through the reactive zone, COCs come in contact with the reactive medium and are degraded to potentially nontoxic dehalogenated organic compounds and inorganic chloride. As the zero-valent metal in the reactive cell corrodes, the resulting electron activity causes the reduction of chlorinated compounds. PRBs may be installed as a continuous reactive barrier or as a funnel-and-gate system. A continuous reactive barrier consists of a reactive cell containing the reactive medium. A funnel-and-gate system has an impermeable section (or funnel) that directs the captured groundwater toward the permeable section (or gate). The use of PRBs is an emerging technology that has shown to be effective for removal of chlorinated VOCs from groundwater.

Groundwater contaminated with cis-1,2-dichloroethene and vinyl chloride near well S57MW022 would be allowed to naturally attenuate, as described in Section 4.3.2 for Alternative 2.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of potable water until COC concentrations attain PRGs. The groundwater use restrictions would consist of maintaining records of the restrictions in the NSF-IH GIS. The information in the GIS

would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

Monitoring would include periodic sampling and analysis of groundwater. The objectives of monitoring would be to determine the effectiveness of the PRB; to confirm that contaminants are not migrating off site at unacceptable levels, and to ensure that the contaminants near well S57MW002 are naturally attenuating.

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, to evaluate the site status (i.e., the site's use at that time and plans for future use), to review environmental laws and regulations in effect at the time of the review, and to provide direction for further action, if deemed necessary. Site reviews would be required because this alternative would allow contaminants to remain at the site in excess of levels that allow for unlimited use and unrestricted exposure.

4.3.5 Alternative 5 – Extraction and Treatment

Alternative 5 includes groundwater extraction and treatment, groundwater use restrictions, monitoring, and 5-year reviews. Under Alternative 5, a groundwater extraction system would be installed to contain and remove contaminants in groundwater. Contaminated groundwater from within the TCE plume and the area of contamination near well S57MW022 would be pumped to an air stripper for removal of VOCs. The treated groundwater would be discharged to Mattawoman Creek. Any plans to install new pump-and-treat systems on Navy installations require approval from NAVFAC Headquarters. If the pump-and-treat system reaches a point of ineffectiveness before the PRGs are attained, another remedial approach may be required. Obtaining NAVFAC Headquarters approval will require a plan for addressing the remaining contamination if this situation occurs.

Monitoring would include periodic sampling and analysis of groundwater. Sampling and analysis of the air stripper influent and effluent would also be conducted. The objectives of monitoring would be to determine the effectiveness of the extraction and treatment systems and to determine whether contaminants are migrating off site at unacceptable levels.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of potable water until COC concentrations attain PRGs. The groundwater use restrictions would consist of maintaining records of the restrictions in the NSF-IH GIS. The information in the GIS would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, to evaluate the site status (i.e., the site's use at that time and plans for future use), to review environmental laws and regulations in effect at the time of the review, and to provide direction for further action, if deemed necessary. Site reviews would be required because this alternative would allow contaminants to remain at the site in excess of levels that allow for unlimited use and unrestricted exposure.

4.4 SCREENING OF ALTERNATIVES

Alternatives are sometimes screened to decrease the number of alternatives carried forward for detailed analysis. This step in the FS is conducted, when appropriate, to eliminate alternatives that do not achieve protection of human health and the environment. Alternatives should be eliminated if they are significantly less effective than other more promising alternatives, are not technically or administratively implementable, or have significantly higher costs.

The alternatives developed and described for Site 57 are considered to represent an appropriate range of alternatives. All alternatives are considered effective and implementable. Therefore, all of the alternatives will be carried forward for detailed analysis.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 INTRODUCTION

In this section, each remedial alternative developed in Section 4.0 is described and analyzed in detail. The detailed analysis is conducted in accordance with the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA, 1988b) and the NCP. The detailed analysis of remedial alternatives provides information for the comparison of alternatives in Section 6.0 and the final selection of a remedial alternative. The following criteria are used for the detailed analysis of each remedial alternative:

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with ARARs and TBCs

Primary Balancing Criteria

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

Modifying Criteria

- State acceptance
- Community acceptance

The first two criteria are threshold criteria in that each alternative must meet them. The next five criteria are grouped together because they represent the primary criteria upon which the analysis is based. The alternative that best matches the five primary balancing criteria is proposed to EPA, the state, and the community as the preferred remedy. The final two criteria, state and community acceptance, will be evaluated following comments on the FS and the Proposed Plan and will be addressed after a final decision is made and the Record of Decision (ROD) is being prepared. The following is a description of each of the nine evaluation criteria.

Overall Protection of Human Health and the Environment - The primary requirement for CERCLA remedial actions is that they are protective of human health and the environment. A remedy is protective if it adequately eliminates, reduces, or controls all current and potential risks. All pathways of exposure must be considered when evaluating the remedial alternative. If hazardous substances remain without engineering or land use controls after the remedy is implemented, the evaluation must consider unrestricted land use and unlimited exposure for human and environmental receptors. For those sites where hazardous substances remain and unrestricted use and unlimited access are not allowable, engineering controls, LUC, or some combination of the two must be implemented to control exposure and ensure reliable protection over time. In addition, implementation of a remedy cannot result in unacceptable short-term risks to or cross-medium impacts on human health and the environment.

Compliance with ARARs and TBCs - Compliance with ARARs and TBCs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the FS process to ensure that they will meet all their respective ARARs or that these is a good rationale for waiving an ARAR. Alternatives may be refined to ensure compliance with these requirements.

Long-Term Effectiveness and Permanence - This criterion reflects the CERCLA emphasis on implementing remedies that will ensure protection of human health and the environment in the future, as well as in the near term. In evaluation of alternatives for long-term effectiveness and the degree of permanence they afford, the analysis should focus on the residual risks that will remain at the site after completion of the remedial action. The analysis should include consideration of the following:

- Degree of threat posed by the hazardous substances remaining at the site.
- Adequacy of any controls (e.g., engineering and land use controls) used to manage the hazardous substances remaining at the site.
- Reliability of those controls.
- Potential impacts on human health and the environment if the remedy fails, based on assumptions included in the reasonable maximum exposure scenario.

Reduction of Toxicity, Mobility, or Volume through Treatment - This criterion addresses the statutory preference for remedies that employ treatment as a principle element by ensuring that the relative performance of the various treatment alternatives in reducing toxicity, mobility, or volume will be assessed. Specifically, the analysis should examine the magnitude, significance, and irreversibility of reductions.

Short-Term Effectiveness - This criterion examines the short-term impacts of the alternatives (i.e., impacts of the implementation) on the neighboring community, workers, and surrounding environment. This includes the potential threats to human health and the environment associated with excavation, treatment, and transportation of hazardous substances. The potential cross-medium impacts of the remedy and the time to achieve protection of human health and the environment should also be analyzed.

Implementability - Implementability considerations include the technical and administrative feasibility of the alternative. Implementability also considers the availability of goods and services (e.g., treatment, storage, or disposal capacity) on which the viability of the alternative depends. Implementation considerations often affect the timing of the various remedial alternatives (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material-handling steps that must be followed, the need to obtain permits for off-site activities, and the need to secure technical services).

Cost - Cost includes all capital and O&M costs incurred over the life of the project. The focus of the detailed analysis is on the net present values of these costs. Costs are used to select the least expensive or more cost-effective alternative that will achieve the RAOs. A 30-year maintenance life and a 7 percent annual discount factor are used to calculate the present worth of the capital and O&M costs.

State Acceptance - This criterion, which is an ongoing consideration throughout the remediation process, reflects the statutory requirement to provide substantial and meaningful state involvement.

Community Acceptance - This criterion refers to community comments on the remedial alternatives under consideration. Community is broadly defined to include all interested parties. These comments are taken into account throughout the FS process; however, only preliminary assessment of community acceptance can be conducted during development of the FS. Formal public comment will not be received until after the public comment period for the preferred alternative is held.

5.2 DESCRIPTION AND ANALYSIS OF GROUNDWATER ALTERNATIVES

5.2.1 Alternative 1 – No Action

5.2.1.1 Detailed Description

This alternative would be a “walk-away” alternative that is required under CERCLA to establish a basis for comparison with other alternatives. For this alternative, any existing remedial activities, monitoring

programs, or groundwater use restrictions would be discontinued, and the groundwater would be available for unrestricted use because no LUC would be implemented.

5.2.1.2 Overall Protection of Human Health and the Environment

Alternative 1 would not be protective of human health and the environment. Contaminated groundwater could pose a potential future threat under the residential exposure scenario.

5.2.1.3 Compliance with ARARs and TBCs

Alternative 1 would not comply with ARARs and TBCs, including MCLs and risk-based concentrations.

5.2.1.4 Long-Term Effectiveness and Permanence

The current and future threats to human health and the environment would remain. There would be no long-term management controls; therefore, the adequacy and reliability of controls would not be applicable. There would be no long-term monitoring program to confirm that contaminant migration from the site is not occurring.

5.2.1.5 Reduction of Toxicity, Mobility, or Volume

Alternative 1 would not include treatment to reduce the toxicity, mobility, or volume of hazardous substances in the groundwater.

5.2.1.6 Short-Term Effectiveness

Alternative 1 would not pose any short-term risks to the local community or on-site workers during implementation because no actions would occur. There would be no environmental risks from implementation.

5.2.1.7 Implementability

There would be no remedial actions to implement under Alternative 1.

5.2.1.8 Costs

There would be no costs associated with the no-action alternative.

5.2.1.9 State Acceptance

The no-action alternative would not be recommended because it does not meet the threshold criteria. Therefore, there would be no opportunity for state review, comments, or acceptance.

5.2.1.10 Community Acceptance

The no-action alternative would not be recommended because it does not meet the threshold criteria. Therefore, there would be no opportunity for community review, comments, or acceptance.

5.2.2 Alternative 2 – Monitored Natural Attenuation

5.2.2.1 Detailed Description

Under Alternative 2, groundwater contamination would be allowed to naturally attenuate. Monitoring would be performed to ensure the effectiveness of natural attenuation. Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of potable water.

Natural Attenuation

Natural attenuation refers to inherent processes that affect the rates of migration and concentrations of contaminants in groundwater. The most important processes are biodegradation, advection, hydrodynamic dispersion, dilution from recharge, sorption, and volatilization.

Advection and dispersion are the dominant mechanisms responsible for transporting contaminants in groundwater. These processes cause contaminants to spread and mix with uncontaminated groundwater and become diluted with increased travel distance. Dilution from recharge occurs as upgradient groundwater flows into and mixes with contaminated groundwater, causing a reduction in contaminant concentrations. Sorption slows the migration of contaminants relative to the rate of groundwater movement. Volatilization results in the transfer of contaminants to soil gas in the unsaturated zone above the aquifer. Biodegradation is the only mechanism that can transform some contaminants into innocuous by-products. Biodegradation occurs when indigenous microorganisms reduce the total mass of contamination without the addition of nutrients.

Natural attenuation is effective if the rate of biodegradation, aided by sorption, is rapid enough to prevent significant contamination migration by advection and dispersion. The screening evaluation for monitored natural attenuation (Appendix H.1) concluded that, with the exception of one downgradient location (SS7MW022), conditions in groundwater at the site are not favorable to or show limited possibilities for the natural attenuation of chlorinated VOCs. However, the presence of TCE degradation products (i.e.,

dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring. Additional long-term monitoring data would be needed to determine the rate and success of complete degradation to nontoxic end products.

Groundwater Use Restrictions

Groundwater use restrictions would be implemented to eliminate or reduce exposure pathways. Groundwater use restrictions would consist of maintaining records of the restrictions in the NSF-IH GIS. The information in the GIS would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development. Use of shallow groundwater as a source of potable water would not be permitted until PRGs are achieved. A LUC Remedial Design would need to be prepared to document the restrictions.

Monitoring

Monitoring of groundwater would be conducted to evaluate the effectiveness of natural attenuation and to confirm that groundwater contaminant migration is not occurring at unacceptable levels. It is assumed that all 28 existing permanent monitoring wells would be sampled annually and analyzed for TCL VOCs, diethyl ether, and natural attenuation parameters [ferrous iron, total organic carbon (TOC), alkalinity, nitrate, nitrite, sulfate, sulfide, chloride, carbon dioxide, methane, ethane, and ethane]. Based on initial sampling results, the number of analytes and/or sampling locations could be reduced. A long-term monitoring plan would need to be developed with EPA and MDE concurrence.

Site Review

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, to evaluate the site status, and to determine whether further action is necessary. The site reviews would be required because this alternative would allow contaminants to remain at the site in excess of levels that allow for unlimited use and unrestricted exposure.

5.2.2.2 Overall Protection of Human Health and the Environment

Alternative 2 would be protective of human health by implementing groundwater use restrictions. This would reduce the potential for human exposure to groundwater contaminants through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of this remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.2.2.3 Compliance with ARARs and TBCs

Groundwater contaminant concentrations would exceed chemical-specific ARARs and TBCs until biodegradation, dispersion, dilution, and other natural attenuation factors eventually reduce their concentrations. There are no location- or action-specific ARARs or TBCs associated with this alternative.

5.2.2.4 Long-Term Effectiveness and Permanence

Contaminants would remain in the groundwater; however, groundwater use restrictions would reduce the potential health hazard. Groundwater contaminants could migrate further; however, monitoring would be conducted to determine whether this is occurring at unacceptable levels.

The groundwater use restrictions would be protective over the long term. A 5-year periodic review of the site would be conducted as long as contaminants remain in excess of levels that allow for unrestricted groundwater use. Any private ownership of the land in the future would need to be controlled under a deed restriction to control groundwater use until PRGs are attained.

5.2.2.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 does not include active treatment to reduce the toxicity, mobility, or volume of the hazardous substances in groundwater.

5.2.2.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment.

It is expected that the RAOs could be achieved within 1 month because groundwater restrictions can be implemented within this time frame. Groundwater modeling conducted after the 2001 investigation (Appendix H.3) indicated that TCE concentrations would be reduced to PRGs in approximately 70 years if the source of contamination is removed or controlled. Any potential DNAPL in the source area could act as a continuing source of groundwater contamination that may increase the time to attain PRGs.

5.2.2.7 Implementability

Alternative 2 would be implementable. Groundwater use restrictions can be strictly enforced because the site is located within a military facility.

5.2.2.8 Cost

The estimated costs of Alternative 2 are as follows:

- Capital ($): 9,700
- O&M ($ per year): 45,000 (plus $15,000 every 5 years)
- Present worth ($): 604,000

The present-worth cost estimate is based on a 30-year monitoring period. Conceptual design calculations are provided in Appendix I, and details of the cost estimates are provided in Appendix J.

5.2.2.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS and Proposed Plan.

5.2.2.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.2.3 Alternative 3 – In-Situ Bioremediation

5.2.3.1 Detailed Description

Alternative 3 would consist of treating contaminated groundwater using in-situ bioremediation and natural attenuation. Monitoring would be conducted to confirm the effectiveness of the remedy and to ensure that contaminant migration is not occurring at unacceptable levels. Groundwater use restrictions would be implemented until contaminant concentrations attain PRGs. Conceptual design calculations are provided in Appendix I.

In-Situ Bioremediation and Natural Attenuation

For purposes of this FS, it was assumed that HRC® (electron donor) would be used to treat the most contaminated portion of the TCE plume at the source area near Building 292 where DNAPL may be present. Natural attenuation would be used for the remaining portion of the TCE plume, and ORC® (electron acceptor) would be used to treat the area near S57MW022 where only cis-1,2-dichloroethene and vinyl chloride were detected. The use of other bioremediation chemicals or methods may be feasible. The screening evaluation for in-situ biological treatment (Appendix H.2) concluded that site groundwater conditions may be favorable for treatment of chlorinated VOCs. The presence of TCE

degradation products (i.e., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring. Additional data would be needed to determine the rate and success of complete degradation to nontoxic end products. For purposes of this FS, it was assumed that two applications of HRC® and a single application of ORC® would be needed. The area with the greatest COC concentrations was already treated during the 2003 HRC® pilot study. Subsequent application(s) are needed to attain PRGs.

The TCE plume was separated into two areas (Areas 1 and 2) for conceptual design purposes based on the distribution and concentrations of COCs. The chemical concentrations detected in 2005 are assumed to be the most representative of current site conditions. Area 1 (source area) begins near Building 292 and extends down the valley to S57SB036, where a temporary well was sampled in 2005 (see Figures 1-4 and 1-5). The main COCs in this area are cis-1,2-dichloroethene, TCE, and vinyl chloride. This area has greater COC concentrations than Area 2. Area 2 (mid-plume area) begins near well cluster S57MW009/MW010 and extends down the valley to well cluster S57MW026/MW027. The main COC in this area is TCE. This area has lower COC concentrations than Area 2. There is an area between S57SB036 and S57MW009/010 (near well cluster S57MW007/MW008) where COC concentrations are no longer greater than the PRGs.

Area 1 would be treated using HRC®, which is a moderately flowable material that can be injected under pressure into an aquifer using various direct-push technologies. It can maintain dechlorinating conditions in the aquifer for up to a year or more depending on site conditions. HRC® can be injected in a grid pattern or as a treatment barrier. A series of treatment barriers can be used for large plumes. These treatment barriers would be installed perpendicular to the groundwater flow direction (e.g., across the valley) at regular intervals throughout the entire length of the plume in Area 1. HRC® would be injected in rows of delivery points to form each treatment barrier, thereby creating an anaerobic treatment zone oriented to intercept the downgradient migration of contaminants. The spacing between each treatment barrier was based on a 1-year groundwater travel time. The design parameters were based on software provided by the HRC® vendor. The grid spacing and HRC® dose are based on the width of the plume, aquifer characteristics (depth to contaminated zone, thickness of contaminated zone, hydraulic conductivity, hydraulic gradient, and seepage velocity), and groundwater chemistry (average concentrations). The length of each treatment barrier was estimated to be 160 feet, which is the approximate width of the valley in this area or the area between the valley wall and a structure (e.g., Building 292). Treatment barriers would not be installed beneath structures. Each treatment barrier would contain two rows of injection points on 10-foot centers. The spacing between each row would be 5 feet. The total amount of HRC® is estimated to be 3,210 pounds for each treatment barrier for each injection application. Based on the estimated length of the plume and the average seepage velocity, two HRC® treatment barriers would be installed in Area 1. The conceptual design includes injection events at Year 0 and Year 3.

Area 2 would be allowed to naturally attenuate. Natural attenuation is effective if the rate of biodegradation, aided by sorption, is rapid enough to prevent significant contaminant migration by advection and dispersion. The screening evaluation for monitored natural attenuation (Appendix H.1) concluded that conditions in this area show limited possibilities for or are not favorable to the natural attenuation of chlorinated VOCs. However, the presence of TCE degradation products (i.e., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring. Chemical concentrations in this area have continued to decline with time and downgradient distance.

The area of contamination near S57MW022 (Area 3) (see Figures 1-4 and 1-5) would be treated using ORC®, which is a proprietary formulation of intercalated magnesium peroxide that releases oxygen slowly when hydrated. ORC® provides the timed release of oxygen to support in-situ aerobic (or oxidative) biodegradation. Grid-based designs are typically recommended for small- to medium-sized contaminant plumes such as Area 3. The design parameters for the grid were based on software provided by the ORC® vendor. The grid spacing and ORC® dose are based on the width and length of the plume, aquifer characteristics (depth to contaminated zone, thickness of contaminated zone, hydraulic conductivity, hydraulic gradient, and seepage velocity), and groundwater chemistry. Several assumptions had to be made for Area 3 because there is only one permanent monitoring well in this area. The size of the plume in Area 3 was assumed to be 100 feet by 100 feet. The spacing between injection points would be 10 feet, for a total of 225 injection points. The total amount of ORC® is estimated to be 3,600 pounds. The conceptual design includes one injection event.

Groundwater Use Restrictions

The groundwater use restrictions would be the same as for Alternative 2, except they would only need to be enforced until treatment attains the PRGs.

Monitoring

Monitoring of groundwater would be conducted to evaluate the effectiveness of the remedy and to confirm that groundwater contamination migration is not occurring at unacceptable levels. It is assumed that a total of four new monitoring wells would be installed upgradient and downgradient of each HRC® barrier in Area 1 and the ORC® grid in Area 3. It is also assumed that all new (4) and existing (28) monitoring wells would be sampled annually and analyzed for TCL VOCs and diethyl ether. Samples from wells in Area 1 would also be analyzed for ferrous iron, dissolved iron, dissolved manganese, TOC, alkalinity, nitrate, nitrite, sulfate, sulfide, chloride, carbon dioxide, methane, ethane, and ethene. Samples from wells in Area 3 would also be analyzed for ferrous iron, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). Samples for all other wells would also be analyzed for natural attenuation parameters

(ferrous iron, TOC, alkalinity, nitrate, nitrite, sulfate, sulfide, chloride, carbon dioxide, methane, ethane, and ethene). A long-term monitoring plan would need to be developed with EPA and MDE concurrence.

Site Review

The 5-year reviews would be the same as described for Alternative 2.

5.2.3.2 Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health and the environment by using in-situ biological treatment and natural attenuation to reduce COC concentrations and by implementing groundwater use restrictions until PRGs are attained. This would reduce the potential for human exposure to groundwater contaminants through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of this remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.2.3.3 Compliance with ARARs and TBCs

This alternative would comply with chemical-specific ARARs and TBCs, including the MCLs for chlorinated organic COCs. The 2003 pilot study indicated that HRC® was not effective for diethyl ether. However, based on the most recent (2005) sampling results, diethyl ether concentrations only exceeded the PRG in samples collected in the source area from permanent wells S57MW002 and S57MW011 and in a grab sample collected from a temporary well point installed at boring S57SB036. The average concentration is less than the PRG. This alternative would also comply with action-specific ARARs and TBCs. There are no location-specific ARARs or TBCs associated with this alternative.

5.2.3.4 Long-Term Effectiveness and Permanence

This alternative would be expected to be effective over the long term with respect to chlorinated organics. The 2003 pilot study results indicated large reductions in TCE concentrations; however, TCE and its degradation products cis-1,2-dichloroethene and vinyl chloride remain at concentrations greater than PRGs. It is anticipated that implementation of this alternative would remove the remaining TCE and possibly the TCE degradation products. The contaminated soil that was a source of groundwater contamination was still present during the pilot study and continued releases to groundwater may have affected the pilot study results. The groundwater use restrictions would be effective in preventing exposure to contaminated groundwater until remedial goals are attained.

The recent removal of contaminated soil near Building 292, a source of ongoing releases to groundwater, would enhance the long-term effectiveness of this alternative. This action may also have removed some

DNAPL. Any DNAPL potentially present at the site could act as a continuing source of groundwater contamination. An additional investigation to determine the amount of DNAPL present, with subsequent treatment or removal, if necessary, could enhance the effectiveness of this alternate. The addition of the proper bacteria to enhance the removal of the TCE degradation products could also enhance the effectiveness.

5.2.3.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 includes in-situ biological treatment to reduce the toxicity of hazardous substances in groundwater.

5.2.3.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment. There could be short-term impacts to traffic because some of the injection points would need to be located on a parking area or road.

It is expected that this alternative could be implemented within 3 months. The HRC® would be injected at Year 0 and at Year 3, and it could take several years following the second application to attain PRGs. Additional applications, if needed, would increase the time to attain PRGs. It could take longer for natural attenuation in Area 2 to attain PRGs. Treatment or removal of any DNAPL remaining in the source area following the soil removal action and the addition of bacteria to enhance biodegradation could decrease the time to attain PRGs.

5.2.3.7 Implementability

Alternative 3 would be implementable. Equipment and services necessary to inject the HRC® and ORC® are available. However, care would need to be taken during injection because there are multiple underground utilities in the site area, especially near Building 292. The substantive requirements of a UIC permit would have to be met for the injection of HRC® and ORC®.

5.2.3.8 Cost

The estimated costs for Alternative 3 would be as follows:

- Capital ($): 541,000 (plus $182,000 for retreatment of Area 1 in Year 3)
- O&M ($ per year): 54,000 (Years 1 and 2), 53,000 (Years 3 to 6), 50,000 (Years 7 to 30) (plus $15,000 every 5 years)

- Present worth ($): 1,358,000

The present-worth cost estimate is based on a 30-year monitoring period, two applications of HRC®, and a single application of ORC®. The need for additional applications would increase the cost. Costs for investigation and removal of DNAPL and costs for adding bacteria to enhance biodegradation are not included. Details of the cost estimates are provided in Appendix J.

5.2.3.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS and Proposed Plan.

5.2.3.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.2.4 Alternative 4 – Permeable Reactive Barrier

5.2.4.1 Detailed Description

Alternative 4 would treat contaminated groundwater using a PRB and natural attenuation. Monitoring would be conducted to confirm the effectiveness of the remedy and to ensure that contaminant migration is not occurring at unacceptable levels. Groundwater use restrictions would be implemented until contaminant concentrations attain PRGs. Conceptual design calculations are provided in Appendix I.

Permeable Reactive Barrier

The 2001 investigation assumed that a PRB using iron as the reactive medium would be installed where soil borings S57SB030 through S57SB032 were installed. This area is near the most downgradient area where TCE was detected at a concentration greater than the PRG. For purposes of this FS, it is assumed that the PRB would extend approximately 210 feet across the valley from location S57SB030 to S57SB032 (see Figures 1-4 and 1-5). This would include a reactive zone gate (70 feet) and a slurry wall funnel on each side of the reactive zone (70 feet each). However, pre-design investigations would need to be conducted to ensure that this location is perpendicular to the groundwater flow direction and to determine whether a slurry wall funnel is necessary. The groundwater flow direction in this area (see Figure 1-5) is based on a limited number of water-level measurements perpendicular to the valley. Treatability studies could also be conducted to evaluate types of reactive material other than iron.

The depth to the confining unit near the proposed PRB is 15 feet, and the depth to groundwater is approximately 4 feet. Therefore, the height of the PRB would be approximately 11 feet.

The thickness of the reactive zone is based on the groundwater velocity and the required residence time to attain PRGs. The groundwater velocity was estimated based on slug test data from upgradient (well cluster S57MW005/MW006) and downgradient (well S57MW020) of the proposed PRB location. The residence time was estimated using literature-based half-life values for TCE (Battelle, 2000). The half-life values range over an order of magnitude. The actual half-life may vary depending on the iron source and site-specific groundwater chemistry. A treatability study would be required to determine the half-life to be used for the final design. Based on the average groundwater velocity near the PRB location, the average TCE half-life, and various correction factors, the thickness of the reactive zone was estimated to be 3.5 feet. Correction factors are recommended to account for changes in the bulk density of the reactive medium between the laboratory and the field, seasonal variations in groundwater flow, potential loss of reactivity over time, and any other field uncertainties. For purposes of this FS, it is assumed that the reactive medium would need to be replaced after 15 years of operation.

A conceptual plan view and cross-section of the PRB are shown on Figure 5-1.

Natural Attenuation

Groundwater contaminated with cis-1,2-dichoroethene and vinyl chloride near well S57MW022 would be allowed to naturally attenuate. The screening evaluation for monitored natural attenuation (Appendix H.1) indicated that conditions in this area are favorable for natural attenuation of chlorinated VOCs. Chemical concentrations at this location have continued to decline.

Groundwater Use Restrictions

Groundwater use restrictions would be the same as described for Alternative 2.

Monitoring

The groundwater would be monitored to evaluate the effectiveness of the PRB on the TCE plume and of natural attenuation near well S57MW022. Monitoring would also be used to confirm that contaminant migration is not occurring at unacceptable levels. It is assumed that all 28 existing monitoring wells would be sampled annually and analyzed for TCL VOCs and diethyl ether. Based on initial sampling results, the numbers of analytes and/or sampling locations could be reduced. A long-term monitoring plan would need to be developed with EPA and MDE concurrence.

Site Reviews

The 5-year reviews would be the same as described for Alternative 2.

5.2.4.2 Overall Protection of Human Health and the Environment

Alternative 4 would be protective of human health and the environment by using a PRB to reduce COC concentrations and by implementing groundwater use restrictions until PRGs are attained. This would reduce the potential for human exposure to groundwater contaminants through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of the remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.2.4.3 Compliance with ARARs and TBCs

This alternative would comply with ARARs and TBCs, including MCLs for the chlorinated organic COCs. Treatability studies would be needed to determine whether the risk-based PRG for diethyl ether would be attained. However, based on the most recent (2005) sampling results, diethyl ether concentrations only exceeded the PRG in samples collected in the source area from permanent wells S57MW002 and S57MW011 and in a grab sample collected from a temporary well point installed at boring S57SB036. The average concentration is less than the PRG. There are no location-specific ARARs or TBCs associated with this alternative.

5.2.4.4 Long-Term Effectiveness and Permanence

One significant uncertainty with this technology is the longevity of the reactive medium, a term that refers to the time during which the PRB retains the desired reactive and hydraulic performance. Because existing PRBs have not been operational for many years, and because most geochemical assessment tools have been primarily qualitative rather than quantitative or predictive, it is unclear how long a PRB may be expected to retain its performance (Battelle, 2000). The reactive medium may need to be replaced or regenerated in the future.

Contaminants would remain in groundwater until the entire TCE plume passes through the treatment zone. However, groundwater use restrictions would reduce the potential health hazard. Groundwater contaminants could migrate further; however, monitoring would be conducted to determine whether this is occurring at unacceptable levels. The recent removal of contaminated soil near Building 292, a source of ongoing releases to groundwater, is expected to enhance the long-term effectiveness of this alternative. This action may also have removed some DNAPL. Any DNAPL potentially present could act as a continuing source of groundwater contamination. An additional investigation to determine the amount of

DNAPL present, with subsequent treatment or removal, if necessary, could enhance the effectiveness of this alternative.

The groundwater use restrictions would be protective over the long term. A 5-year periodic review of the site would be conducted as long as contaminants remain at the site in excess of levels that allow for unrestricted groundwater use. Any private ownership of the land in the future would need to be controlled by a deed restriction to control groundwater use until PRGs are attained. The deed restriction would also include the location of the PRB.

5.2.4.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 4 uses a PRB to reduce the toxicity of hazardous substances in groundwater.

5.2.4.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment. There could be short-term impacts to traffic because the PRB would be located beneath a road.

It is expected that this alternative could be implemented within 3 months. The time to attain PRGs cannot be estimated at this time without additional studies (treatability testing and additional groundwater modeling). Any DNAPL remaining following the soil removal action could be an ongoing source of groundwater contamination that could affect the time needed to attain PRGs.

5.2.4.7 Implementability

Alternative 4 would be implementable. Equipment and services necessary to construct the PRB, including the slurry walls and reactive zone, are available. However, care would need to be taken during installation because existing sewers and the unnamed stream are present in the proposed PRB location. Groundwater use restrictions can be strictly enforced because the site is located within a military facility.

5.2.4.8 Cost

The estimated costs for Alternative 4 would be as follows:

- Capital ($): 782,000 (plus $334,000 in Year 15 for reactive medium replacement)
- O&M ($ per year): 31,500 (plus $15,000 every 5 years)
- Present worth ($): 1,326,000

The present-worth cost estimate is based on a 30-year monitoring period and assumes that the reactive medium would be replaced after 15 years. Details of the cost estimates are provided in Appendix J. Key assumptions for the cost estimates are the required thickness of the reactive medium, the dimensions of the reactive area gate and slurry wall funnel, and the longevity of the reactive medium. Treatability testing, additional site characterization in the area of the proposed PRB, and groundwater modeling would be needed to refine the cost estimate prior to installation. Costs for investigation and removal of potential DNAPL are not included.

5.2.4.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS and Proposed Plan.

5.2.4.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.2.5 Alternative 5 – Extraction and Treatment

5.2.5.1 Detailed Description

Alternative 5 would include extracting groundwater using pumping wells, air stripping to remove COCs, and discharging the treated groundwater to Mattawoman Creek. Monitoring would be conducted to confirm the effectiveness of the remedy and treatment system and to ensure that contaminant migration is not occurring at unacceptable levels. Groundwater use restrictions would be implemented until contaminant concentrations attain PRGs. Conceptual design calculations are provided in Appendix I.

Groundwater Extraction, Treatment, and Discharge

The groundwater extraction system would consist of five wells located within the TCE plumes and one well located near location S57MW022, which is contaminated with cis-1,2-dichloroethene and vinyl chloride. The individual extraction rates range from 5 to 20 gallons per minute (gpm), with a combined pumping rate of approximately 75 gpm. The well locations and pumping rates are based on the groundwater modeling presented in Appendix H.3. The wells would extend from the ground surface to approximately 15 to 30 feet bgs, depending on the location. The wells would be screened such that groundwater in the shallow and intermediate portions of the surficial aquifer (i.e., above the upper confining unit) would be removed. The combined flows from the extraction wells would be treated using air stripping. The air stripper was designed based on the flow-weighted average concentrations from the extraction wells and assuming that groundwater would be treated to attain PRGs prior to discharge to

Mattawoman Creek. The allowable discharge limits may be higher and would need to be determined by MDE. Monthly sampling of the influent and effluent would be conducted to monitor treatment efficiency and to ensure that discharge limits are being met. Based on the anticipated influent concentrations and flow rate, treatment of air emissions from the air stripper would not be required. Groundwater extraction would continue until the PRG for each of the COCs in the groundwater is achieved. The approximate locations of the extraction wells, transfer piping, treatment system, and discharge piping are shown on Figure 5-2.

Groundwater Use Restrictions

The groundwater use restrictions would be the same as described for Alternative 2.

Monitoring

Monitoring of groundwater would be conducted to evaluate the effectiveness of the groundwater extraction system in reducing COC concentrations. Monitoring would also be used to confirm that contaminant migration is not occurring at unacceptable levels. It is assumed that all 28 existing monitoring wells would be sampled annually and analyzed for TCL VOCs and diethyl ether. Based on initial sampling results, the numbers of analytes and/or sampling locations could be reduced. A long-term monitoring plan would need to be developed with EPA and MDE concurrence. It is assumed that the treatment system influent and effluent would be sampled monthly and analyzed for TCL VOCs.

Site Reviews

The 5-year reviews would be the same as described for Alternative 2.

5.2.5.2 Overall Protection of Human Health and the Environment

Alternative 5 would protect human health by removing contaminated groundwater. Groundwater use restrictions would be implemented until PRGs are attained. This would reduce the potential for human exposure to groundwater contaminants through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of this remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.2.5.3 Compliance with ARARs and TBCs

This alternative would comply with ARARs and TBCs, including MCLs and risk-based concentrations. The discharge of treated groundwater would comply with state water pollution permit regulations and surface water quality standards. The discharge to the atmosphere from the air stripper would comply with

state air pollution control regulations. There are no location-specific ARARs or TBCs associated with this alternative.

5.2.5.4 Long-Term Effectiveness and Permanence

Extraction of contaminated groundwater would permanently reduce contaminant concentrations. However, there may be a point at which contaminant concentrations approach a constant value, and contaminant mass is no longer being removed at significant levels. The groundwater use restrictions would be effective in preventing exposure to contaminated groundwater until PRGs are attained. A 5-year periodic review of the site would be conducted as long as contaminants remain in excess of levels that allow for unrestricted groundwater use. Any private ownership of the land in the future would need to be controlled under a deed restriction to control groundwater use until PRGs are attained. The recent removal of contaminated soil near Building 292, a source of ongoing releases to groundwater, would be expected to enhance the long-term effectiveness of this alternative. This action may have removed some DNAPL. Any DNAPL potentially present could act as a continuing source of groundwater contamination. An additional investigation to determine the amount of DNAPL present, with subsequent treatment or removal, if necessary, could enhance the effectiveness of this alternative.

5.2.5.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 5 uses air stripping to reduce the toxicity of hazardous substances in groundwater prior to discharge to Mattawoman Creek.

5.2.5.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment.

It is expected that this alternative could be implemented within 5 months. Groundwater modeling conducted as part of this FS (Appendix H.3) indicated that TCE concentrations would be reduced to attain ARARs in approximately 19 years if the source of contamination is removed. The potential presence of DNAPL remaining following the soil removal action could be an ongoing source of groundwater contamination that could affect the time needed to attain PRGs.

5.2.5.7 Implementability

Alternative 5 would be implementable. Equipment and services necessary to construct the extraction and treatment systems are available. However, care would need to be taken during pipe installation because piping would cross existing sewers and other underground utilities in the site area. Groundwater use

restrictions can be strictly enforced because the site is located within a military facility. The substantive requirements of an NPDES permit would have to be met for discharge of treated groundwater to Mattawoman Creek. Any plans to install new pump-and-treat systems require approval from NAVFAC Headquarters. If the system reaches a point of ineffectiveness before PRGs are attained, another remedial approach may be required. Obtaining NAVFAC Headquarters approval would require a plan for addressing the remaining contamination if this situation occurs.

5.2.5.8 Cost

The estimated costs of Alternative 5 are as follows:

- Capital ($): 470,000
- O&M ($ per year): 79,000 (plus $15,000 every 5 years)
- Present worth ($): 1,308,000

The present-worth cost estimate is based on a 19-year O&M period. Details of the cost estimates are provided in Appendix J. Costs for investigation and removal of potential DNAPL are not included.

5.2.5.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS and Proposed Plan.

5.2.5.10 Community Acceptance

Community acceptance will be addressed in the ROD following the pubic comment period on the FS and Proposed Plan.

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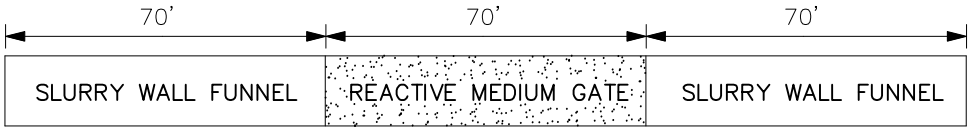

PLAN VIEW
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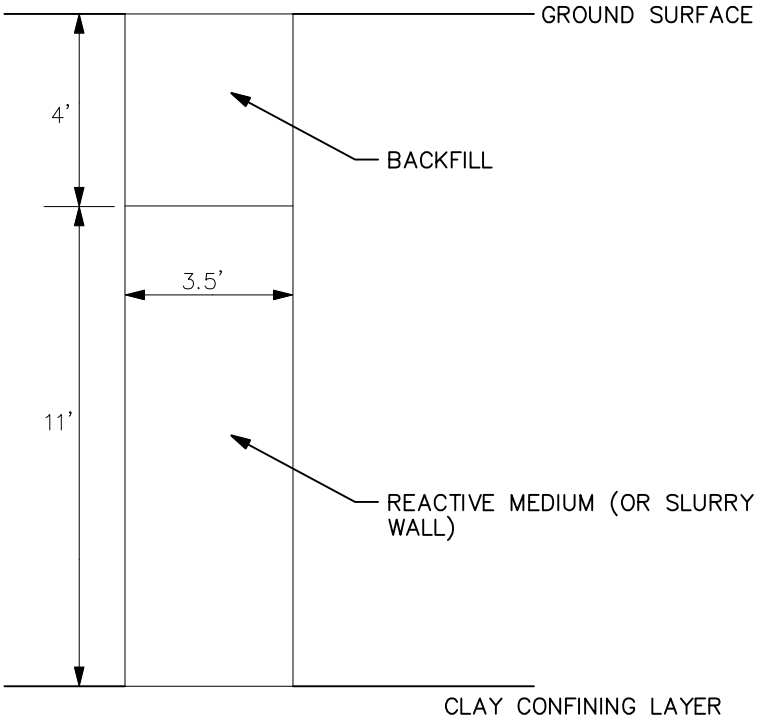

CROSS SECTION

DRAWN BY MF DATE 3/1/06	Tetra Tech NUS, Inc.	GROUNDWATER ALTERNATIVE 4 PERMEABLE REACTIVE BARRIER SITE 57 BUILDING 292 TCE CONTAMINATION NSF-IF, INDIAN HEAD, MARYLAND	CONTRACT NO. 2194
CHECKED BY DATE			OWNER NO. 007
REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 5-1 REV. 0

FORM CADD NO. TTNUS-AV.DWG - REV 1 -9/10/98

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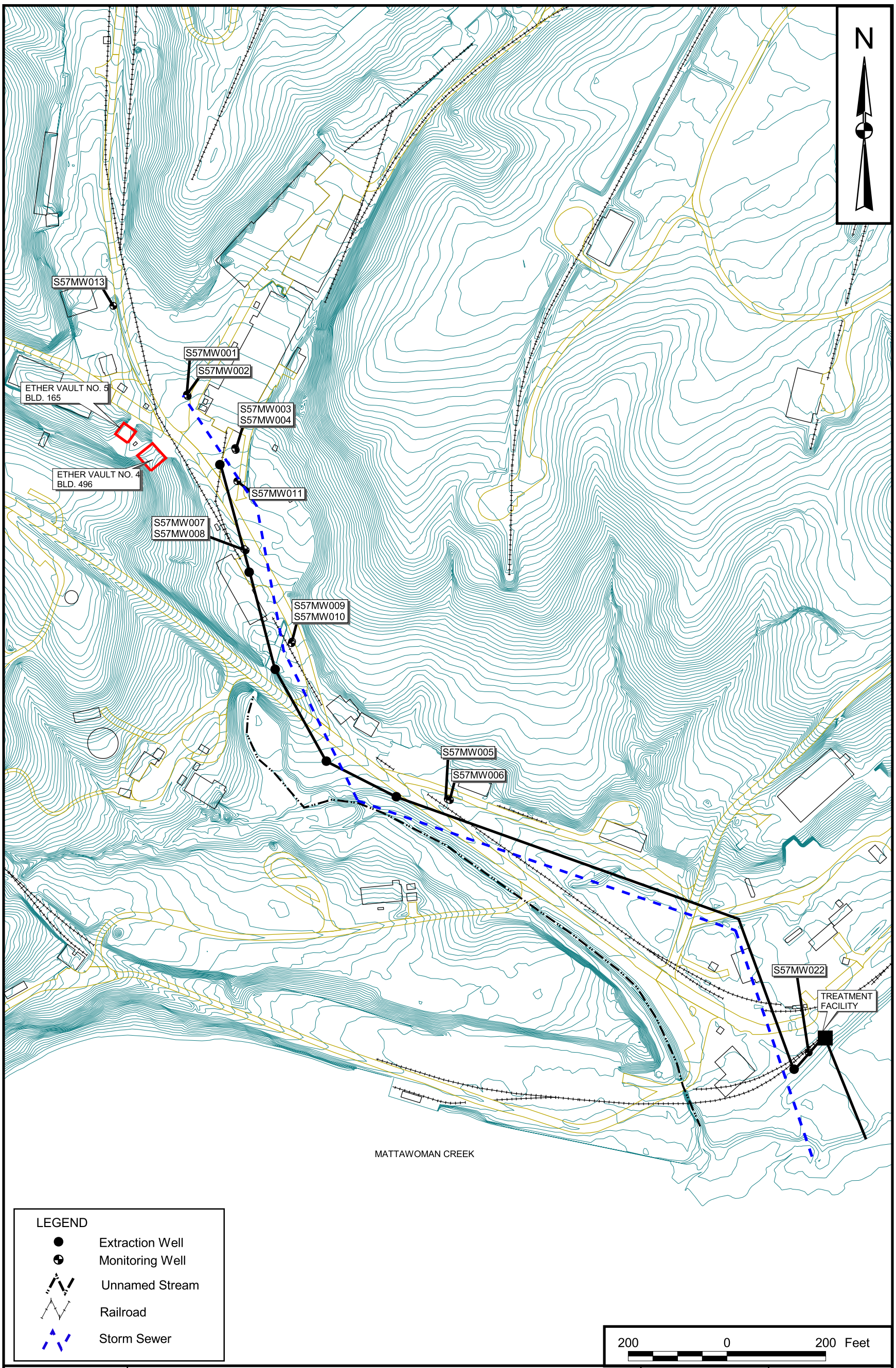

DRAWN BY K. PEILA DATE 4/30/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 2194	OWNER NUMBER 007
CHECKED BY K. TURNBULL DATE 4/30/02	GROUNDWATER ALTERNATE 5 - EXTRACTION AND TREATMENT SITE 57 - BUILDING 292 TCE CONTAMINATION NAVAL SUPPORT FACILITY, INDIAN HEAD INDIAN HEAD, MARYLAND	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 5-2	REV 0

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, the alternatives are evaluated in relation to one another with respect to each of the evaluation criteria. The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative.

Table 6-1 summarizes the comparative analysis of groundwater alternatives for Site 57.

6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

All of the groundwater alternatives, except Alternative 1 (No Action) would provide adequate protection of human health and the environment.

Alternative 3 (In-Situ Bioremediation) and Alternative 4 (PRB) would protect human health by treating contaminated groundwater in situ. Alternative 5 (Extraction and Treatment) would protect human health by removing contaminated groundwater. Groundwater contamination would be allowed to naturally attenuate under Alternative 2. Restrictions on the use of shallow groundwater as a source of potable water would be imposed for these alternatives until PRGs are attained.

Alternatives 2, 3, 4, and 5 would include groundwater monitoring to ensure protection of the environment.

6.2 COMPLIANCE WITH ARARs AND TBCs

Alternative 1 would not comply with ARARs and TBCs, including MCLs and risk-based concentrations.

Alternatives 2, 3, 4, and 5 would eventually comply with ARARs and TBCs.

6.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Because Alternatives 2, 3, 4, and 5 involve some form of active or passive groundwater remediation, they are expected to be effective at decreasing groundwater contaminant levels over the long term. The recent removal of contaminated soil that was an ongoing source of groundwater contamination would be expected to enhance the effectiveness of all alternatives. This action may have also removed some DNAPL. Any DNAPL potentially present could act as a continuing source of groundwater contamination. An additional investigation to determine the amount of DNAPL remaining, with subsequent treatment or removal, could enhance the effectiveness of all alternatives.

For Alternative 3, the 2003 pilot study showed reductions in concentrations of TCE with increases in concentrations of cis-1,2-dichloroethene and vinyl chloride. It is not known if complete dechlorination would occur with additional treatment, whether other chemicals would be needed, or if ongoing releases from contaminated soil affected the pilot study results. The addition of the proper bacteria to enhance the removal of TCE degradation products could enhance the effectiveness of Alternative 3.

A treatability study would be needed for Alternative 4 to confirm the long-term effectiveness with respect to chlorinated organics and to determine the effectiveness for diethyl ether.

Monitoring would be needed to confirm the effectiveness of Alternative 2 with respect to chlorinated organics and diethyl ether. Effectiveness for removal of diethyl ether is a minor concern because it was detected at a concentration greater than the PRG at only a few locations, and the average concentration was less than the PRG.

For Alternative 5, there may be a point at which concentrations approach a constant value, and contaminant mass is no longer being removed at significant levels. If a point of ineffectiveness is reached before PRGs are attained, another remedial approach may be required.

Alternatives 2, 3, 4, and 5 provide continued monitoring in accordance with a long-term monitoring plan and groundwater use restrictions that are adequate and reliable controls. Groundwater use restrictions could be removed after contaminant concentrations have decreased to PRGs. Any private ownership of the land in the future would need to be controlled under a deed restriction until PRGs have been attained.

A 5-year period review of the site would be conducted for Alternatives 2, 3, 4, and 5 as long as groundwater contaminants remain in excess of levels that allow for unrestricted use.

Alternative 1 would not be effective in the long term.

6.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternatives 3 and 4 include in-situ biological treatment and a PRB, respectively, to reduce the toxicity of hazardous substances in groundwater. Alternative 5 includes air stripping to reduce the toxicity of hazardous substances in groundwater prior to discharge to surface water.

Alternatives 1 and 2 do not include active treatment to reduce the toxicity, mobility, or volume of hazardous substances in groundwater.

6.5 SHORT-TERM EFFECTIVENESS

No risks to the community, on-site workers, or the environment are anticipated for any of the groundwater alternatives. However, activities associated with injection of HRC® and ORC®, construction of the PRB, and installation of groundwater extraction wells and associated piping under Alternatives 3, 4, and 5, respectively, would have short-term impacts on traffic.

Alternative 2 could be implemented within 1 month. The estimated construction durations for Alternatives 3 and 4 are 2 months and 3 months, respectively. The estimated construction duration for Alternative 5 is 5 months. The RAOs would also be achieved within these timeframes.

For Alternative 2, groundwater modeling indicated that TCE concentrations would be reduced to PRGs in approximately 70 years. For Alternative 3, HRC® would be injected at Year 0 and Year 3, and it could take several years following the second application to attain PRGs. The addition of bacteria to enhance biodegradation could decrease the time to attain PRGs. It may take additional time to attain PRGs for Area 2 via natural attenuation. The time to attain PRGs under Alternative 4 cannot be estimated without additional studies. For Alternative 5, groundwater modeling indicated that TCE concentrations would be reduced to PRGs in approximately 19 years. Any DNAPL potentially present following the soil removal action could be an ongoing source of groundwater contamination could affect the time needed to attain PRGs for all alternatives.

6.6 IMPLEMENTABILITY

All of the remedial alternatives are implementable. Equipment and services needed to implement the alternatives are available. The groundwater use restrictions under Alternatives 2, 3, 4, and 5 can be strictly enforced because the site is located within a military facility.

Alternative 5 would require approval from NAVFAC Headquarters. If the system reaches a point of ineffectiveness before PRGs are attained, another remedial approach may be required. Obtaining NAVFAC Headquarters' approval would require a plan for addressing the remaining contamination if this situation occurs.

Care would need to be taken during implementation of Alternatives 3, 4, and 5 because there are underground utilities present, especially near Building 292.

The state would need to develop effluent limits for the discharge of treated groundwater to Mattawoman Creek under Alternative 5.

6.7 COST

The present-worth costs of the groundwater alternatives are estimated as follows:

- Alternative 1: $0
- Alternative 2: $604,000
- Alternative 3: $1,358,000
- Alternative 4: $1,326,000
- Alternative 5: $1,308,000

Costs for investigation and removal of potential DNAPL are not included.

6.8 STATE ACCEPTANCE

State acceptance will be addressed following receipt of comments on the FS and Proposed Plan.

6.9 COMMUNITY ACCEPTANCE

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

TABLE 6-1

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In-Situ Bioremediation
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Groundwater use restrictions and monitoring would reduce risks to human health and the environment.	Groundwater treatment and groundwater use restrictions would reduce risks to human health and the environment.
Compliance with ARARs			
Chemical-specific	Would not comply.	Would eventually comply.	Would comply.
Location-specific	Not applicable.	No ARARs.	No ARARs.
Action-specific	Not applicable.	Not applicable.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows uncontrolled risks to remain.	Groundwater use restrictions would reduce risks to human health. Monitoring and use restrictions would provide adequate and reliable controls. Removal of potential DNAPL could enhance effectiveness.	Treatment would be expected to be effective over the long term. Additional applications may be needed to completely degrade the chlorinated COCs. Removal of potential DNAPL and addition of proper bacteria could enhance effectiveness.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	In-situ biological treatment would reduce toxicity of hazardous substances in groundwater.

TABLE 6-1

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In-Situ Bioremediation
Primary Balancing Criteria (continued)			
Short-Term Effectiveness	Not applicable.	No impacts to community, workers, or environment. One month to implement. Approximately 70 years to attain PRGs. Potential DNAPL could increase time.	No impacts to community, workers, or environment. Short-term impacts on traffic during HRC® and ORC® injection. Two months to construct. May take several years to attain PRGs in Area 1, and could take longer to naturally attenuate Area 2. Potential DNAPL could increase time.
Implementability	Not applicable.	Groundwater use restrictions can be strictly enforced because site is located within a military facility.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.
Cost			
Capital	$0	$9,700	$541,000 (plus $182,000 for retreatment of Area 1 in Year 3)
Annual O&M	$0	$45,000 (plus $15,000 every 5 years)	$54,000 (Years 1 and 2), $53,000 (Years 3 to 6), $50,000 (Years 7 to 30) (plus $15,000 every 5 years)
Present worth	$0	$604,000	$1,358,000 (includes retreatment of Area 1 at 3 years)
Modifying Criteria			
State Acceptance	Not applicable.	To be determined.	To be determined.
Community Acceptance	Not applicable.	To be determined.	To be determined.

TABLE 6-1

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Threshold Criteria		
Overall Protection of Human Health and the Environment	Groundwater treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.	Groundwater extraction and treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs		
Chemical-specific	Would comply.	Would comply.
Location-specific	No ARARs.	No ARARs.
Action-specific	Can be designed to attain ARARs that apply.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions would provide adequate and reliable controls. Removal of potential DNAPL could enhance effectiveness.	Extraction and treatment would be effective over the long term. May be a point at which concentrations approach a constant value and contaminant mass is no longer being removed at significant levels. Monitoring and use restrictions would provide adequate and reliable controls. Removal of potential DNAPL could enhance effectiveness.
Reduction of Toxicity, Mobility, or Volume through Treatment	Treatment using PRB would reduce toxicity of hazardous substances in groundwater.	Treatment using air stripping would reduce toxicity of hazardous substances prior to discharge to surface water.
Short-Term Effectiveness	No impacts to community, workers, or environment. Short-term impacts to traffic during PRB construction. Three months to construct. Need additional studies to evaluate time to achieve clean-up goals. Potential DNAPL could increase time.	No impacts to community, workers, or environment. Short-term impacts to traffic during installation of wells and piping. Five months to construct. Approximately 19 years to attain PRGs. Potential DNAPL could increase time.

TABLE 6-1

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
SITE 57 – BUILDING 292 TCE CONTAMINATION
NSF-IH, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Primary Balancing Criteria (continued)		
Implementability	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities. Requires NAVFAC Headquarters' approval.
Cost		
Capital	$782,000 (plus $334,000 in Year 15 for reactive medium replacement)	$470,000
Annual O&M	$31,500 (plus $15,000 every 5 years)	$79,000 (plus $15,000 every 5 years)
Present worth	$1,326,000 (includes barrier replacement at 15 years)	$1,308,000
Modifying Criteria		
State Acceptance	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.

ARARs Applicable or Relevant and Appropriate Requirements.
COCs Chemicals of concern.
DNAPL Dense non-aqueous-phase liquid.
NAVFAC Naval Facilities Engineering Command.
O&M Operation and maintenance.
PRB Permeable reactive barrier.

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