Final

Site 1: Camp Allen Landfill (Operable Unit 01)

Site 3: Q-Area Drum Storage Yard (Operable Unit 03)

Site 18: Former Naval Magazine Waste Storage Area (Operable Unit 14)

Site 20: Building LP-20 (Operable Unit 04)

Record of Decision

Naval Station Norfolk

Norfolk, Virginia

Prepared by
Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

August 2010

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Contents

Appendices

Tables

Figures

Abbreviations and Acronyms

amsl	above mean sea level
AOC	Area of Concern
ARAR	applicable or relevant and appropriate requirement
AS/SVE	air sparge/soil vapor extraction
bgs	below ground surface
BTAG	Biological Technical Assistance Group
CALF	Camp Allen Landfill
CASY	Camp Allen Salvage Yard
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
DD	Decision Document
DCB	dichlorobenzene
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
DPVE	dual-phase vapor extraction
EE/CA	Engineering Evaluation/Cost Analysis
ERD	enhanced reductive dechlorination
ERA	Ecological Risk Assessment
ESI	Expanded Site Investigation
FFA	Federal Facilities Agreement
FS	Feasibility Study
IAS	Initial Assessment Study
IC	Institutional Controls
IRP	Installation Restoration Program
LTM	long-term monitoring
LUC	land use control
MCL	Maximum Contaminant Level
MIP	membrane interface probe
NAS	Naval Air Station
Navy	United States Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NM	Naval Magazine
NPL	National Priorities List

NSN	Naval Station Norfolk
NTCRA	Non-time-critical Removal Action
O&M	operation and maintenance
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
POL	petroleum, oils, and lubricants
QADSY	Q Area Drum Storage Yard
RAO	Remedial Action Objective
RBC	risk based concentration
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RFA	RCRA Facility Assessment
RI	Remedial Investigation
ROD	Record of Decision
RRR	Relative Risk Ranking
SARA	Superfund Amendments and Reauthorization Act of 1986
SMP	Site Management Plan
SVOC	semivolatile organic compound
TCA	trichlorothane
TCE	trichloroethene
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VC	vinyl chloride
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
WWTP	wastewater treatment plant
yd^3	cubic yards

SECTION 1
Declaration

1.1 Site Names and Location

Cleanup sites at Naval Station Norfolk (NSN), Norfolk, Virginia (identification number VA6170061463) addressed in this Record of Decision (ROD) include:

- Site 1: Camp Allen Landfill (Operable Unit (OU) 01)
- Site 3: Q-Area Drum Storage Yard (OU 03)
- Site 18: Former Naval Magazine Waste Storage Area (OU 14)
- Site 20: Building LP-20 (OU 04)

This ROD is issued jointly by the United States Department of the Navy (Navy) and the United States Environmental Protection Agency (USEPA) under a Federal Facilities Agreement (FFA) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

1.2 Statement of Basis and Purpose

This ROD documents the Selected Remedy for Site 18 at NSN, in Norfolk, Virginia. This ROD also affirms the remedy selections for Sites 1, 3, and 20 which were originally made by the Navy in Decision Documents (DDs) issued prior to NSN's listing on the National Priorities List (NPL). These DDs were issued pursuant to Navy's authority and obligations under the CERCLA, the NCP, and Executive Order 12580.

This ROD summarizes the work completed under the DDs for Sites 1, 3, and 20, documents changes in the cleanup goals for certain contaminants with respect to groundwater for Sites 3 and 20, and reflects recodifications made to the statutory citations for certain Commonwealth of Virginia statutory and regulatory programs. Except as discussed in Section 2.1.5 (Documentation of Significant Changes), the discussion of the DDs for Sites 1, 3, and 20 (including the changes to certain cleanup levels), and the Selected Remedy for Site 18, is consistent with the discussion of these sites that was set forth in the Proposed Plan that was issued for public review and comment between June 18, 2010 and July 18, 2010 (Proposed Plan).

The determinations in this ROD have been made in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the NCP. These decisions are based on information in the Administrative Record file for the site. Information not specifically summarized in this ROD or its references but contained in the Administrative Record, has been considered and is relevant to the changes in cleanup levels at Sites 3 and 20, and to the selection of the remedy for Site 18. Thus, the ROD is based upon and relies upon the entire Administrative Record file in making the decisions documented herein.

By way of background, as a result of the NPL listing and pursuant to CERCLA, the USEPA Region 3, the Virginia Department of Environmental Quality (VDEQ), and the Navy entered into a FFA for NSN in February 1999. The primary purpose of the FFA was to ensure that the environmental impacts associated with past and present activities at NSN are thoroughly investigated and that the appropriate remedial action is taken as necessary to protect the public health, welfare, and the environment. The Installation Restoration Program (IRP) is responsible for ensuring that appropriate CERCLA response alternatives are developed and implemented as necessary to protect public health, welfare, and the environment. No CERCLA enforcement activities have been recorded at Sites 1, 3, 18, or 20 outside of the work undertaken pursuant to the FFA.

The Navy is the lead agency and provides funding for site remediation at NSN. In this ROD EPA affirms the remedy selections presented in Navy's DDs for Sites 1, 3, and 20. Under the FFA and in accordance with Section 121(a) of CERCLA, USEPA Region 3 and the Navy, with the concurrence of VDEQ, jointly issue the Selected Remedy for Site 18 and changes modifying the cleanup levels for the DDs for Sites 3 and 20.

1.3 Assessment of the Site

The DD response actions for Sites 1, 3, and 20 have been in place and operational since 1998. The ongoing DD response actions for these sites (with the changes to cleanup levels documented herein) and the response action selected in this ROD for Site 18 are necessary to protect public health, welfare, and/or the environment from actual or threatened releases of contaminants that may present an imminent and substantial endangerment to public health or welfare.

If current or reasonably anticipated future land use is modified, additional evaluation would be required to ensure that potential risks are mitigated or addressed as part of the change; in this event the Navy would undertake the necessary actions to ensure continued protection of human health and the environment.

1.4 Description of the Selected Remedies

This section describes the remedies selected in the prior DDs for Sites 1, 3, and 20, as well as the selected remedy for Site 18, as documented by this ROD.

1.4.1 Decision Document Remedy Sites (1, 3, and 20)

The primary contaminants at Site 1 are chlorinated volatile organic compounds (VOCs) in groundwater. The selected remedy in the DD for Site 1 (**Appendix A**), Camp Allen Landfill (CALF), consisted of in situ treatment of soil and shallow groundwater using dual-phase vapor extraction (DPVE) in Area A; extraction and treatment of the water table and Yorktown aquifers groundwater in Areas A and B; and groundwater monitoring and institutional controls (ICs) (Baker, 1995).

The selected remedy in the DD for Site 3 (**Appendix B**), Q-Area Drum Storage Yard QADSY), consisted of remediation of the groundwater using air sparging/soil vapor extraction (AS/SVE) to reduce concentrations of VOCs and groundwater monitoring (ESE, 1996). This ROD documents changing the groundwater cleanup goals for Site 3 from the original, risk-based cleanup goals in the DD (which had been based upon the most likely exposure scenarios) to the federal Maximum Contaminant Levels (MCLs), where the MCL is more stringent.

The selected remedy in the DD for Site 20 (**Appendix C**), Building LP-20, included treatment of the groundwater to reduce concentrations of VOCs using AS/SVE, groundwater monitoring, and ICs (Baker, 1996a). This ROD documents the changing of groundwater cleanup goals for Site 20 from the original, risk-based clean up goals in the DD (which had been based upon the most likely exposure scenarios) to the more-stringent federal MCLs.

1.4.2 Selected Remedy Site

The selected remedy for Site 18, Former Naval Magazine Waste Storage Area, is continued enhanced bioremediation with groundwater monitoring to reduce concentrations of chlorinated VOCs and achieve the Remedial Action Objectives (RAOs) and Land Use Controls (LUCs) to restrict site use to prevent exposure to unacceptable risks in groundwater in the interim.

1.5 Statutory Determinations

In accordance with the NCP, each Selected Remedy for Sites 1, 3, 18, and 20 meets the statutory determinations. The Selected Remedies are protective of human health and the environment, cost-effective, and utilize permanent solutions to the maximum extent practicable. Because these remedies result in pollutants or contaminants remaining onsite in soil and groundwater above levels that allow for unlimited use and unrestricted exposure, statutory CERCLA Five-Year Reviews will be conducted (or continue to be conducted) to ensure that the remedies are protective of human health and the environment.

1.6 Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record files for each of these sites.

- Current and reasonably anticipated future land use assumptions (Section 2.7)
- Risks related to the contaminants of concern (COCs), their respective concentrations, and cleanup levels (Section 2.8)
- How source materials constituting principal threats will be addressed (Section 2.12)
- Estimated capital costs, annual operation and maintenance (O&M), and total present-worth costs, discount rate, and the number of years over which the remedy cost estimate is projected for Site 18 (Section 2.10 and **Table 2-3**)
- Key factors that led to selecting the remedy for Site 18 (Section 2.13)
- Potential land and groundwater use that will be appropriate for the site as a result of the Selected Remedy for Site 18 (Section 2.13)

1.7 Authorizing Signatures

USEPA and VDEQ affirm the Navy's adoption of the DD remedies (Sites 1, 3, and 20). In addition, the Navy and USEPA select this remedy for Site 18 with the concurrence of VDEQ.

Concur and recommend for immediate implementation:

Kelly M. Johnson — 8/12/10

Captain Kelly M. Johnson
Commanding Officer
Naval Station Norfolk
By direction of the Commander
Navy Region Mid-Atlantic

Date

Ronald J. Borsellino — 8/26/10

Ronald J. Borsellino, Director
Hazardous Site Cleanup Division
USEPA Region 3

Date

SECTION 2
Decision Summary

2.1 Site Name, Location, and Description

NSN encompasses 4,631 acres of land in the northwest corner of Norfolk, Virginia, adjacent to the Elizabeth River and Willoughby Bay near the mouth of the Chesapeake Bay (**Figure 2-1**). NSN operates in various capacities to provide support to vessels, aircraft, and other activities. NSN houses many tenants, each performing different operations involving the servicing and maintenance of vessels and aircraft. NSN is also used for recreational, commercial, and residential purposes. Land development surrounding the base is residential, commercial, and industrial.

2.1.1 Decision Document Remedy Sites

Site 1—Camp Allen Landfill

Site 1—CALF includes two distinct areas: Area A, the 45-acre landfill, and Area B, the 2-acre fire disposal area (**Figures 2-2 and 2-3**). The Area A landfill, which operated from the mid-1940s until approximately 1974, was used for the disposal of metal plating and parts cleaning sludge, paint-stripping residue, various chlorinated organic solvents, overage chemicals, pesticides, asbestos, incinerator ash, fly and bottom ash from the Base power plant, and miscellaneous debris. Wastes from a fire at Site 22—Camp Allen Salvage Yard (CASY), including drums containing various chemicals, were buried in trenches at Area B in 1971.

Contamination from prior disposal practices at CALF affected the surface and subsurface soil, sediment, surface water, and groundwater. The primary contaminants found in these media at the site are volatile organic compounds (VOCs). Areas of inorganic contamination of surface water and sediments in the surrounding drainage ditches and in the onsite pond also were detected. As detailed below, groundwater contamination was found in both the water-table aquifer and the deeper Yorktown Aquifer in Areas A and B. The presence of contamination in the Yorktown Aquifer is thought to be due to the breach of a confining layer between the two aquifers beneath much of the CALF area.

Currently, the Base brig facility and a heliport are located over a portion of the Area A landfill. The brig facility is being relocated to another facility, and future plans call for the demolition of the existing building. Area B was originally an unused, fenced area. Now, Area B has been covered with asphalt and currently serves as a parking lot supporting adjacent recreational fields. Area A is soil-covered and vegetated to minimize surface erosion to adjacent tidal drainage ditches that convey stormwater runoff to Willoughby Bay.

A Non-Time Critical Removal Action (NTCRA) to remove the primary source areas of contamination at Area B was initiated in May 1994 and completed in January 1995. A Remedial Investigation (RI)/Feasibility Study (FS) was completed in 1994 (Baker, 1994). In July 1995, a DD for both Areas A and B was signed, which required localized treatment of groundwater and soil using vacuum extraction, and implementation of ICs (Baker, 1995).

Because of the close proximity of Site 22 to Site 1, groundwater beneath the sites underlying Areas A and B, as well as the Site 22 (CASY) (which is located between Areas A and B) is being managed and addressed as a single unit. The groundwater hydrogeology for all the sites addressed in this ROD is discussed in more detail in Section 2.6.

The groundwater extraction and treatment system, which began continuous operation in November 1998, consists of a pump-and-treat system installed in Area A (for deep Yorktown groundwater in the western part of the area and for the water table groundwater in the northern part of the area) and in Area B (for both water table and Yorktown groundwater). At the same time, a DPVE system was completed and began operation in May 1998 to address a soil hot spot in Area A. In 2008, the DPVE system was turned off (but maintained in an operable condition). Currently, cleanup levels (MCLs) are being met in the groundwater outside of the waste material, and groundwater monitoring is being conducted to verify that cleanup goals are being met and contaminants are not migrating as result of the shutdown of the system. The LTM program for Site 1 is documented in an annual LTM report that prepared by the Navy that is reviewed by EPA and DEQ. The DPVE will be restarted if necessary.

Long-term monitoring (LTM) and remedial process optimization for Site 1 to determine the effectiveness of the DD remedy has been conducted annually since 1999, including the DPVE system. A Remedial Design (RD) to implement institutional controls (ICs)/ land use controls (LUCs) was finalized in 2007 and revised in 2008. The LUCs are currently being implemented at the site. In addition to LTM, the DD remedy has been evaluated as part of the Five-Year Review process in 2003 and 2008.

Site 3—Q-Area Drum Storage Yard

Site 3—QADSY (**Figure 2-4**) was previously a compound that occupied approximately 5 acres in the northwest corner of the NSN near the carrier piers. This area of the NSN was created by dredging operations in the early 1950s. QADSY was an open earthen yard that was used from the 1950s until the late 1980s to store tens of thousands of drums. Most of the drums contained new petroleum products, various chlorinated organic solvents, paint thinners, and pesticides. Previous investigations showed dark stains on the soil and oil-saturated soil throughout the storage yard, indicating past spills. The northern portion of the yard, which was used to store leaking or damaged drums and hazardous materials, was particularly stained. These drums have been removed, and the site is not currently used.

In 1986, Navy fire inspectors expressed concern with the oil-saturated soils at the northern end of the storage area (previously used to store damaged or leaking drums). On the basis of a potential fire hazard, in 1987 the top 6 inches of soil was excavated from an area of 4,240 square yards (yd^2) (totaling approximately 750 cubic yards [yd^3] of soil removed) in the northern section and disposed offsite. Following the removal action, this area of the storage yard was paved.

Previous investigation for this site revealed that outside of the area where the 1987 removal action was conducted, the soil was contaminated with total petroleum hydrocarbons (TPH), VOCs, and pesticides. In addition, VOC contamination was found in the groundwater beneath the site and outside the storage yard boundary. The shallow groundwater beneath the hazardous materials area and the northern portion of the petroleum products area was impacted the most. Low concentrations of VOCs were also identified in the deep monitoring wells at Site 3. This was determined to potentially be due to the lack of a confining layer between the water table aquifer and underlying Yorktown aquifer in this area. The general extent of the groundwater plume, which affected approximately 29 acres beneath the fleet parking area west of the storage yard, was defined with monitoring well and direct-push groundwater sampling. As a result of the delineation, QADSY was subdivided into Area of Concern (AOC) 1 and AOC 2 to reflect the two distinct plumes of high concentrations of VOCs.

A DD for Site 3 that called for remediation of groundwater using AS/SVE was signed in November 1996 (ESE, 1996b). The two AOCs (AOC 1 and AOC 2) were addressed at the site. The AS/SVE system installed for AOC 1 consisted of 30 AS wells and 14 SVE wells, and the system installed for AOC 2 consisted of 20 AS wells and 10 SVE wells. The remediation systems for both AOCs began operation in August 1998. Semiannual LTM and remedial process optimization for Site 3 to evaluate the effectiveness of the DD remedy has been undertaken since 1999. Because groundwater cleanup goals selected in the DD were being achieved in AOC 1, the system was shut down while groundwater monitoring continues. The system at AOC 2 continues to operate. The systems have reduced groundwater contaminant concentrations; only one monitoring well at AOC 1 and three monitoring wells at AOC 2 continue to show exceedances of the risk-based clean up goals documented by the DD.

A LUC RD for Site 3 was finalized in 2007. LUCs are currently being implemented at Site 3. In addition to LTM, the Site 3 DD remedy has been reevaluated as part of the Five-Year Review process in 2003 and 2008.

Site 20—Building LP-20

Site 20 — Building LP-20 is an industrial building within an industrial area of NSN that includes the areas and other buildings in close proximity to Building LP-20. It is located northwest of the Naval Air Station (NAS) main runway (**Figure 2-5**) in the former Naval Aviation Depot area of the facility. Currently, Building LP-20 houses the Transportation Department, where vehicle maintenance is performed, as well as utilized as office space. Historically, a portion of the building was used for aircraft engine overhaul and maintenance. Previous activities at the building included painting, X-ray operations, cleaning and blasting, and metal plating. Wastewater products generated from these activities were transferred to the industrial wastewater treatment plant (WWTP) via underground piping (**Figure 2-5**). A large fuel storage area, known as the LP Fuel Farm, is located south of the building and underground pipeline extends from it to buildings LP-78 and LP-176 located east of the site. Numerous spills or releases of wastewater and petroleum in the area of Building LP-20 have been documented from the 1940s through the 1990s. Significant releases were associated with damage to underground wastewater lines during construction activities and leakage of the underground petroleum pipeline.

Investigations at the site began in 1986 following a release of JP-5 fuel from the underground pipeline. Since 1986, approximately 10 separate investigations have been conducted to evaluate the extent of releases from underground fuel pipelines, the industrial wastewater line, and various underground storage tanks (USTs) at the site. These investigations determined that significant amounts of free product as well as chlorinated solvents were present in soil and groundwater. Specifically, chlorinated solvents were detected in the vicinity of LP-20 and LP-26. In addition, petroleum products were found in soils east of Building LP-22 and south of Building LP-179. The petroleum releases and associated RAs have been/continue to be addressed in the Petroleum, Oil, and Lubrication (POL) Regulatory Program at NSN.

A DD for Site 20 that required that groundwater at the site be treated to reduce the threat to human health and the environment was signed in November 1996 (Baker, 1996a). The goal of the remedial action was to treat the contaminant plume in the shallow aquifer using an AS/SVE system to prevent migration of the plume offsite and into the deep aquifer, and reduce the contaminant concentrations to established cleanup goals. The original DD provided for the protection of the deep aquifer by removing source material in the shallow aquifer. A remedy optimization is being implemented in 2010 that further address the deep aquifer by providing for additional source removal. In addition, ICs/LUCs restricting aquifer use (for both the shallow and the deep aquifers) were mandated to prevent the groundwater from being used as either a potable or nonpotable (industrial water) source.

The construction of the treatment system was completed, and it began operating on April 14, 1998. The shallow aquifer is treated by an AS/SVE system consisting of 53 AS wells and 27 SVE wells. The system was placed throughout the center and downgradient extent of the contaminant plume (**Figure 2-5**). Since 1999 LTM and remedial process optimization for Site 20 has been undertaken to determine the effectiveness of the DD remedy.

A LUC RD was finalized in 2007; the LUCs are currently enforced. In 2010, the USEPA and the Navy decided to optimize the AS/SVE system by adding a groundwater extraction well, which when completed, will enhance recovery of contaminated groundwater and provide further positive hydraulic control of the contaminated water. The extraction system is scheduled to be operational by August 2010. In addition to LTM, the DD remedy was evaluated as part of the Five-Year Review process in 2003 and 2008.

2.1.2 Selected Remedy Site

Site 18—Former Naval Magazine (NM) Storage Area, is located in the southeastern corner of NSN (**Figure 2-6**). The Site was used from 1975 to 1979 to store drums of hazardous waste consisting of waste oil, metal-plating solutions and sludges, chlorinated organic acids (including trichloroethene [TCE] and 1,1,1-trichloroethane [TCA]), and paint-stripping solutions. The storage area was an open, unpaved yard east of the metal storage buildings in the NM area (Taussig Can Area). Waste oil and hazardous wastes were spilled in this area, including an intentional spill in July 1979. As a result of this spill, a pit was excavated and an existing drainage ditch was widened and lengthened to channel the waste oil and contaminated runoff into an unlined pit. Oil and contaminated water were periodically pumped from the pit and transported to a WWTP. Soil in the area of the spill was sampled and found to be contaminated primarily with chromium and cadmium. However, the soil was classified nonhazardous based on USEPA Extraction Procedure toxicity testing.

A landfill permit was obtained in October 1980 from the Virginia Department of Solid Waste to address the contaminated soil at the site by grading and seeding it to establish a vegetative cover. The permit required continuous monitoring of the shallow groundwater and surface water to determine if contaminant migration was occurring (ESE, 1983). The monitoring program was conducted over 55 months. In October 1985, the Virginia State

Water Control Board agreed to discontinue the monitoring on the basis that no significant contamination was observed.

In 2000, the Navy, USEPA, and VDEQ agreed to reevaluate Site 18 soil by comparing the Phase I Relative Risk Ranking (RRR) soil data to risk-based screening criteria. On the basis of this review, the Navy, USEPA, and VDEQ agreed to undertake a groundwater investigation at the site. Additional investigation indicated the shallow groundwater was contaminated with VOCs and metals. The results of groundwater investigation at Site 18 were compiled in the *Final Site 18 Site Investigation Summary Report* (CH2M HILL, 2007). This report recommended that an Engineering Evaluation/Cost Analysis (EE/CA) be completed to evaluate NTCRA alternatives for the treatment of VOCs in groundwater.

An EE/CA setting forth the basis for a NTCRA for groundwater at Site 18 was finalized in March 2008 (CH2M HILL, 2008a). The Site 18 EE/CA was made available for public comment between January 25, 2008 and February 25, 2008. No comments were received from the public during this period. In April 2008, an Action Memorandum (CH2M HILL, 2008b) was completed to authorize the implementation of the NTCRA to address the potential human health risk from groundwater, which was completed in July 2008. The NTCRA provided for the injection of a substrate into the groundwater to promote enhanced reductive dechlorination (ERD) of the VOCs in groundwater. Performance monitoring was completed for 1 year following the substrate injection. The last round of performance monitoring indicated contamination levels that still exceeded cleanup goals in the shallow groundwater; therefore, the NSN Partnering Team agreed to reinject substrate into the shallow aquifer to encourage further ERD. This action was documented in a Removal Action Memorandum Addendum in April 2010 (CH2M HILL, 2010), and the supplemental injections were completed in May 2010.

2.2 Site History and Enforcement Activities

2.2.1 Basewide Investigations

Previous basewide investigations completed through the IRP include the Initial Assessment Study (IAS) (ESE, 1983), the IRP RI Interim Report (Malcolm Pirnie, 1988), a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) (A. T. Kearney, 1992), an Aerial Photographic Site Analysis (USEPA, 1994), a Phase I Relative Risk Ranking (RRR) System Data Collection Sampling and Analysis Report (RRR—Phase I) (Baker, 1996b), and an RRR System Data Collection Sampling and Analysis Report Phase II (RRR—Phase II) (Baker, 1996c). Specific details of the investigations at Sites, 1, 3, and 20 are found in the respective DD documents (see Appendices A- C) as well as information contained in other pertinent investigations and reports are in the Administrative Record (see Section 2.3).

No CERCLA enforcement activities have been recorded at Sites 1, 3, 18, or 20 aside from the response actions implemented to date within the IRP. The underground storage tank (UST) site adjacent to Site 20, however, has had actions conducted to date as part of the POL program at NSN.

2.2.2 Investigations Conducted at Site 1

Investigation of and supporting documentation for Site 1 leading to the 1995 DD consisted of the following:

- IAS, 1983 (Malcolm Pirnie, 1983)
- Site Suitability Assessment, 1984 (Malcolm Pirnie, 1984)
- Confirmation Study, 1987 (Malcolm Pirnie, 1987)
- Interim RI Report, 1988
- Interim RI, 1990–1991
- RI, 1992–1993 (Baker, 1994a)
- FS, 1994 (Baker, 1994b)

Based on the results from the RI, an EE/CA (Baker, 1993) for a NTCRA in Area B was performed to develop and evaluate alternatives for removal and disposal of contaminated subsurface soil and debris identified in former waste burial trenches at this location (considered the source area of contamination). The selected removal action alternative included:

- Excavation of the soil, debris, and buried drums from the trenches plus over excavation of visibly contaminated soil from the side walls and floor of the excavation

- Confirmation soil sampling and analysis, and additional excavation of material contaminated in excess of the removal action cleanup levels

- Disposal of excavated soil, debris, and drums at a RCRA-permitted hazardous waste disposal facility (landfill or incinerator)

The Area B removal action was initiated in the summer of 1994 and was completed prior to the 1995 DD. The objective of the removal action was to remove the primary sources of groundwater contamination within the Area B Landfill so that no further remedial actions would be required for the soils and debris associated with the Area B Landfill. Confirmation soil sampling and analysis, as outlined in the Remedial Action Closeout Report (OHM, 1995), verified that the soil cleanup levels were met as established in the Final EE/CA Report (Baker, 1993). Therefore, the primary sources of contamination at Area B have been eliminated.

LTM has been completed annually at Site 1 since the DD remedy has been in operation. The most recent monitoring event at Site 1 occurred in March 2010. Site inspections for LUCs occur at least quarterly.

As part of the 2008 Five-Year Review (CH2M HILL, 2008c), recommendations were made to evaluate potential risk to human health due to vapor intrusion in accordance with current standards. The field investigation is expected to begin in September 2010. The results of the investigation will determine whether an unacceptable current or future potential risk is present due to groundwater contamination volatilizing and impacting indoor air located within the Area B barracks building. In 1995, an indoor air investigation was conducted at a school located in the vicinity of Area B; no unacceptable indoor air risk was identified. The brig facility located in Area A was not recommended for evaluation because the facility is scheduled to be demolished in Fiscal Year 2011.

2.2.3 Investigations Conducted at Site 3

Investigation of and supporting documentation for Site 3 leading to the 1996 Decision Document consisted of the following:

- IAS, 1983
- Interim RI, 1983–1986 (LANTNAVFACENGCOM, 1988)
- RI, 1990–1996 (ESE, 1996a)
- FS, 1996 (ESE, 1996b)

Following the interim RI, in 1987 the Navy excavated 750 yd^3 of soil identified to be the most contaminated soil from the area as part of a military construction project that was scheduled for 1989. That portion of the QADSY is now paved and used for fleet parking.

LTM has been completed semiannually at Site 3 since the DD remedy has been in operation. The most recent monitoring event at Site 3 occurred in February 2010. Site inspections for LUCs occur at least quarterly. Five-year reviews were completed in 2003 and 2008.

2.2.4 Investigations Conducted at Site 20

Site 20 has been investigated since the mid-1980s as both an IRP site and as a UST site. The UST sampling and reporting have been completed and managed by the Commonwealth of Virginia UST regulatory program. Investigation of and supporting documentation for IRP Site 20 leading to the 1996 DD consisted of the following:

- Draft Interim RI Report, 1991 (ESE, 1991)
- RI, 1994–1996 (Baker, 1996d)
- FS, 1996 (Baker, 1996d)

LTM has been completed annually at Site 20 since the DD remedy has been in operation. The most recent regularly scheduled monitoring event at Site 20 occurred in March 2009. Additionally, a comprehensive groundwater sampling event was conducted as part of remedy optimization measures in October 2009 and February 2010, in response to additional site studies being conducted to support evaluation of alternatives that were to be used to enhance the existing AS/SVE remedy. This consisted of a comprehensive groundwater sampling event (and included wells that are not in the routine LTM) and the installation of nine additional monitoring wells. Based upon evaluation of the data obtained, the Navy, USEPA and VDEQ agreed that a groundwater extraction and treatment system should be installed to optimize the AS/SVE remedy by moving contaminated groundwater toward the AS/SVE, thereby removing contaminants from the extracted groundwater. Construction for the remedy enhancement is underway and is anticipated to be complete by August 2010.

As part of the 2008 Five-Year Review (CH2M HILL, 2008c), recommendations were made to evaluate potential risk to human health due to vapor intrusion. The field investigation is currently scheduled to begin in September 2010. The results of the investigation will determine whether an unacceptable current or future potential risk is present due to groundwater contamination volatilizing and impacting indoor air located within Building LP-20. A previous investigation of indoor air conducted by the USEPA in January 2010 did not identify of a significant pathway for vapor intrusion at Building LP-26 and LP-20 (USEPA, 2010).

2.2.5 Previous Investigations at Site 18

1980–1985 Landfill Monitoring

The landfill permit obtained from the Virginia Department of Solid Waste Management in October 1980 required continuous monitoring of the shallow groundwater (Columbia aquifer) and nearby surface water to determine if contaminant migration was occurring. In addition, from February 1980 to April 1982, monthly monitoring of the standing water in the pit and the nearby creek indicated the presence of cadmium, chromium, cyanide, and phenol (ESE, 1983). In October 1985, the Virginia Water Control Board eliminated monitoring requirements after a review of the data.

1995 Resource Conservation and Recovery Act Inspection

In 1995, a RCRA inspection was conducted and concluded that no signs of adverse impacts or threats to human health or the environment were observed; therefore, the site was no longer subject to RCRA inspections.

1995 Phase I Relative Risk Ranking Study

Site 18 was included in the Phase I RRR Study conducted at NSN in October 1995 (Baker, 1996b). Two surface soil samples were collected and analyzed for VOCs, semivolatile organic compounds (SVOCs), inorganics, and pesticides/polychlorinated biphenyls (PCBs). The soil data indicated the presence of several metals and SVOCs as well as two pesticides. Based on an evaluation of the site conditions (visual), potential pathways for exposures, potential for migration, and the analytical data, the study assigned moderate rankings for migration of contaminants and exposure routes (human and/or ecological receptors) for groundwater, soil, sediment, and surface water. Potential pathways were based on site conditions observed and the presence of SVOCs and metals in surface soil.

2001 Site Management Decision

During an October 2000 meeting, the Navy, USEPA, and VDEQ agreed to reevaluate Site 18 soil by comparing the Phase I RRR soil data to current USEPA Region 3 residential soil risk based concentrations (RBCs). Based on the comparison, the Navy, USEPA, and VDEQ agreed soil was no longer a medium of concern at Site 18. The Navy, USEPA, and VDEQ agreed to initiate a groundwater investigation at the site.

June 2001 Supplemental Investigation

A groundwater investigation was conducted at Site 18 in June 2001 (CH2M HILL, 2001). Three monitoring wells were installed within the estimated boundary of the site and sampled for VOCs, SVOCs, inorganics, and pesticides/PCBs. Several metals (arsenic, iron, manganese, antimony, and thallium), VOCs (cis-1,2-dichloroethene [cis-1,2-DCE], TCE, vinyl chloride (VC), and 1,4–dichlorobenzene [1,4-DCB]), and one SVOC (naphthalene) exceeded screening values. Further groundwater investigation was recommended.

February 2002 Additional Field Investigation

In February 2002 an investigation was conducted to further characterize the extent of groundwater contamination detected during previous investigations. Four additional monitoring wells were installed in the Columbia aquifer. Groundwater samples were collected from all monitoring wells and analyzed for VOCs and inorganics (CH2MHILL, 2002).

The February 2002 investigation indicated that VOCs were localized at the site (in the vicinity of MW03S), as no VOCs were detected in wells south, east, and north of the site. Additionally, the investigation concluded that metals detected during 2001 and 2002 were not related to historical site operations and were attributable to background conditions.

Due to the elevated concentrations of VOCs in well MW03S and metals throughout the site, an Expanded Site Investigation (ESI) was recommended to further evaluate soil, sediment, surface water, and groundwater media.

December 2002 Expanded Site Investigation

In December 2002, an ESI was performed to further define the nature and extent and mobility of VOCs and metals in all media at the site (CH2M HILL, 2007).

Soil, surface water, and sediment samples were collected. Only chromium and lead exceeded the established NSN soil background values. Because VOC concentrations were relatively consistent in the drainage channel both up- and down-gradient of the site, it was concluded that the chemicals were not site-related. Several metals exceeded the BTAG benchmarks for surface water in the total metals samples; however, in filtered samples, only iron exceeded the Biological Technical Assistance Group (BTAG) screening criteria.

Two new monitoring wells (MW03C and MW03D) were installed in the vicinity of well MW03S, where the highest concentrations of VOCs were previously detected. Well MW03C was screened just above the Yorktown Confining Unit, and well MW03D was screened in the Yorktown aquifer. All site wells were sampled for VOCs, inorganics, and natural attenuation parameters. The highest concentrations of VOCs occurred at wells MW03S and MW03C, indicating VOC contamination over the entire thickness of the surficial aquifer (i.e., Columbia aquifer) in this vicinity. In general, the highest concentrations of metals were found in upgradient well MW01S. The metals concentrations are likely associated with Site 2, the Naval Magazine Slag Pile, which is located immediately adjacent to (upgradient in groundwater) Site 18. Site 2 was addressed in a ROD (Navy, 2000), requiring the excavation of sediment, placement of soil and asphalt covers, stabilization of the west bank of the drainage channel, and LTM. The data from the sample collected from the monitoring well screened in the Yorktown aquifer showed no detections of site-related contaminants. A preliminary evaluation of natural attenuation of chlorinated solvents at the site determined that natural attenuation was likely occurring.

Preliminary ecological and human health risk evaluations were completed based on a qualitative assessment using conservative screening values. No unacceptable risk was identified for ecological receptors due to site-related contaminants above background levels. Potential human health risk was identified for exposure to groundwater. Therefore, it was recommended that an interim action be conducted to address the VOCs detected in groundwater at MW03S and MW03C. To further delineate the extent of VOCs detected in the MW03 well cluster and determine the existence of a plume or isolated hotspot, a membrane interface probe (MIP) survey and additional groundwater sampling was recommended.

December 2004 Additional Delineation

A December 2004 investigation was undertaken to further define the extent of VOCs detected in wells MW03S and MW03C and determine if there was an isolated hotspot of VOCs. Delineation was accomplished using an MIP survey. In situ grab samples of groundwater were collected at select locations based on the MIP survey results and analyzed for VOCs. Groundwater samples were also collected from monitoring wells MW03S and MW03C and analyzed for VOCs. Data were screened against USEPA Region 3 RBCs and MCLs.

Concentrations of TCE and cis-1,2-DCE exceeded MCLs at the northern and eastern site boundaries, but there were no exceedances at the southern and western boundaries. The maximum VOC concentrations were observed in wells MW03S and MW03C; in the in situ grab sample located just east of the MW03 well cluster; and in one in situ grab sample located west of the MW03 well cluster. The data showed that the VOC contamination in the surficial aquifer was isolated to the vicinity of the MW03 well cluster. Temporal VOC groundwater data showed similar or lower concentrations over time in the MW03 well cluster vicinity. Installation of additional monitoring wells was recommended to confirm the results of the MIP and in situ grab groundwater samples.

June 2006 Groundwater Sampling

The purpose of the June 2006 investigation was to confirm the results of the December 2004 MIP investigation, and to better define the apparent VOC hotspot in the vicinity of MW03. Three new monitoring wells (MW08S, MW09S, and MW10S) were installed where the December 2004 in situ grab samples (GW01S, GW02S, and GW06S) indicated constituent concentrations exceeded MCLs. The new monitoring wells and three existing monitoring wells (MW03S, MW03C, and MW05S) were sampled and analyzed for VOCs and natural attenuation parameters. Groundwater data for VOCs were compared to USEPA Region 3 RBCs and MCLs. Results were above these criteria; therefore, future action for groundwater was deemed to be necessary.

The potential for natural attenuation based on site conditions was evaluated by applying the USEPA screening procedure to the temporal data. The evaluation determined “limited evidence for biodegradation” in monitoring wells MW03C and MW10S and “adequate evidence for biodegradation” in monitoring wells MW03S and MW09S.

November 2007 Site Investigation Summary Report

In November 2007 a Site Investigation Summary Report (CH2M HILL, 2007) was prepared to comprehensively document the groundwater investigations conducted at Site 18 between 2001 and 2007. The report recommended that an EE/CA for a NTCRA be prepared for Site 18 to evaluate potential alternatives to address groundwater impacted by chlorinated VOCs at the site.

July 2007 Groundwater Sampling

Groundwater samples were collected from all site monitoring wells in July 2007 to provide a complete and current data set of VOC concentrations in groundwater in support of the EE/CA. These data were not provided in the 2007 Site Investigation Summary Report.

Engineering Evaluation/Cost Analysis and Non-Time-Critical Removal Action

An EE/CA, dated March 2008, developed three removal action alternatives to meet the removal action objective of implementing measures to mitigate potential unacceptable human health risk associated with exposure to VOCs in groundwater. The cleanup goals for the VOCs in groundwater were the MCLs. The removal action alternatives are the following:

- **Alternative 1—No Action.** The no action alternative assumed that no removal work would be done at this site.
- **Alternative 2—Monitored Natural Attenuation.** Reliance on the natural biodegradation of chlorinated VOCs in groundwater, as evaluated by groundwater monitoring.
- **Alternative 3—ERD.** Application of an electron donor to enhance the natural biological degradation of chlorinated VOCs in groundwater.

With the exception of Alternative 1 (No Action), each alternative evaluated required the implementation of LUCs to prevent unacceptable risk exposure until site cleanup levels are achieved. Site cleanup levels for VOCs in groundwater were established to be the MCLs. The EE/CA for Site 18 was made available for public comment from January 25, 2008 to February 25, 2008. No comments were received from the public during this period. An Action Memorandum was signed by the Navy on April 8, 2008, to implement the removal action. The removal action was completed July 2008 and performance monitoring was conducted for 1 year to evaluate the effectiveness of the removal action. At the completion of performance monitoring, chlorinated VOCs were detected in groundwater in exceedance of cleanup goals at only monitoring wells MW09S, MW03C, and MW03S.

Following the completion of performance monitoring, the Navy, USEPA, and VDEQ agreed that a subsequent injection was warranted to further encourage ERD in the shallow aquifer to reduce concentrations of chlorinated VOCs. A Removal Action Memorandum Addendum was issued to implement a supplemental injection to reduce concentrations of chlorinated VOCs (CH2M HILL, 2010). This supplemental injection was completed in May 2010. Monitoring will continue to be conducted to evaluate the groundwater concentrations and determine whether treatment of chlorinated VOCs is warranted.

2.3 Proposed Plan

In June 2010, the Proposed Plan describing the prior DD remedies (Sites 1, 3, and 20), modifying the clean up goals from risk-based values to the MCLs (Sites 3 and 20) (Section 2.9), and presenting the preferred alternative for Site 18 (continued enhanced bioremediation with groundwater monitoring and LUCs) was made available for the public to review and comment. A public meeting was held on June 23, 2010. Representatives from the Navy, USEPA, and VDEQ attended the meeting. No community members attended the meeting.

2.4 Community Participation

The Navy and USEPA provide information regarding the cleanup of NSN to the public through the community relations program, which includes a Restoration Advisory Board (RAB) that was formed in 1994; public meetings; the Administrative Record file; the information repository; and announcements published in the local newspapers. During the course of investigations at these sites, the RAB has been apprised of all environmental cleanup activities related to the site.

In accordance with Section 117(a) of CERCLA, the Navy provided a public comment period between June 18, 2010, and July 18, 2010, for the Sites 1, 3, 18, and 20 Proposed Plan. A public meeting held on June 23, 2010 at the Larchmont Public Library presented the preferred alternative for Site 18 (continued enhanced bioremediation with groundwater monitoring and LUCs), described the prior DD remedies (Sites 1, 3, and 20), and presented the modified cleanup goals of MCLs from risk-based values for Sites 3 and 20 (Section 2.9). Public notice of the meeting and availability of documents was placed in the *Virginian-Pilot* newspaper on June 16, 2010. Representatives from the Navy, USEPA, and VDEQ attended the meeting.

The Proposed Plan was available at the Norfolk Main Library during the public comment period. The Proposed Plan and previous investigation reports for each of these sites are available to the public in the Administrative Record. The Administrative Record is accessible to the public at:

Norfolk Main Library
235 East Plume Street
Norfolk, Virginia 23510
(757) 664-7323

The index is available online at: http://public.lantops-ir.org/sites/public/nsn/Site%20Files/AdminRecords.aspx.

No comments were submitted by the public during the public comment period. There were no attendees at the public meeting.

2.5 Scope and Role of Response Action

Sites 1, 3, 18, and 20 are four of the 18 sites in the IRP that are part of the comprehensive environmental investigation and cleanup currently being performed at NSN under the CERCLA program. The status of all the IRP sites at NSN can be found in the current version of the Site Management Plan (SMP)(for fiscal year 2010), which is located in the Administrative Record. This ROD documents the final remedial action for Sites 1, 3, 18, and 20 and does not include any other sites at the facility.

2.6 Site Characteristics

2.6.1 Site 1

Hydrogeology of Site 1

Two aquifer systems have been impacted by CALF: the water-table aquifer (Columbia aquifer) and the underlying Yorktown aquifer. The Columbia aquifer (shallow groundwater) is unconfined. The Yorktown aquifer (deep groundwater) is separated from the water-table aquifer by a confining clay unit. In the vicinity of the CALF, a breach and/or ineffective (poorly developed) portion of the confining clay unit allows downward migration of constituents from the Columbia aquifer to the Yorktown aquifer. Groundwater at the site is not used for any non-environmental purpose. Potable water used onsite and by the nearby community is supplied by the City of Norfolk.

According to the CALF/Site 1 DD (Baker, 1995), residential wells were present within Glenwood Park, located west of the Brig Facility, but were used only for nonpotable uses such as lawn watering, car washing, and swimming-pool filling. These wells reportedly are positioned to extract water from the Columbia aquifer. As a safety precaution, the residents in Glenwood Park were advised by the Navy to consider their private wells nonpotable. The deep groundwater (Yorktown aquifer) in the vicinity of the site has also been used for nonpotable purposes. At the time of publication of the 1995 DD, two nonpotable wells, located approximately 1 mile northwest of the site, reportedly pumped about 100,000 gallons per day from the Yorktown Aquifer for use as process water.

Nature and Extent of Contamination at Site 1

Contamination from prior disposal practices at Areas A and B of the CALF has been detected in subsurface soils, surface soils, sediment, surface water, and groundwater (Columbia and Yorktown aquifer systems). Although various organic and inorganic contaminants were detected in site media, the primary constituents of concern were VOCs. Additional detail is provided in the 1995 DD and the Administrative Record for Site 1.

The threat of contaminant migration from Area B soil has been essentially eliminated by the Area B removal action. The principal threat at Site 1 is posed by contaminated soil in the Area A Landfill, which provides a potential source of contamination to the underlying aquifers. Currently, potable water throughout Camp Allen and the surrounding area is supplied by the City of Norfolk. Residential wells in Glenwood Park, located west of Area A, have supplied water for nonpotable uses only. Although groundwater at the site currently is not used for any purpose, contaminated groundwater at the site could pose a human health risk if utilized as a drinking water source under a potential future residential use scenario.

Contaminant Fate and Transport at Site 1

Migration of contaminants from the surface water and sediments to groundwater was not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater). Source control measures that have been implemented at Area B (removal action) and Area A improved the quality of surface water and sediment in these areas over time. The combination of response actions for this site provided effective source control and substantially reduced the potential for migration of contamination, which reduced potential human health and environmental risks.

2.6.2 Site 3

Hydrogeology of Site 3

According to the 1996 DD, Site 3 (QADSY) is underlain by approximately 15 feet of fill, the edge of which is located approximately 2,500 feet south of the site. The water table is approximately 8 feet below ground surface (bgs), and water table elevations range from 2 to 5 feet above mean sea level (amsl). The Yorktown and Columbia aquifers are hydraulically connected at the site, producing an unconfined aquifer. Aquifer thickness was not determined at the site, but is reportedly between 90 to 100 feet thick in the vicinity of NSN (CH2M HILL, 2008c). Recharge by infiltration at the site and surrounding areas is limited to unpaved areas; extensive paved areas and manmade drains and culverts control much of the surface runoff. Groundwater discharge from the unconfined aquifer is primarily to the Elizabeth River to the west and Willoughby Bay to the east.

Nature and Extent of Contamination at Site 3

Contamination from prior activities at Site 3 has been detected in soils and groundwater (the upper 60 feet). According to the DD, the primary constituents detected in soil were petroleum compounds. VOCs were detected in soil, with one location an order of magnitude above the others for total VOC concentration. Groundwater indicated the primary contaminants of concern were chlorinated VOCs. Additional detail is provided in the 1996 DD as well as in the Administrative Record for Site 3.

Contaminant Fate and Transport at Site 3

The threat of contaminant migration from Site 3 was reduced by the asphalt cover (parking lot) that covers much of the site. Inorganic compounds were detected in sediment and surface water, but are not site-related. The chlorinated VOCs in groundwater were the primary contaminant of concern. Currently, potable water is supplied by the City of Norfolk. Although groundwater at the site currently is not used for any purpose, contaminated groundwater at the site could pose a human health risk if utilized as a drinking water source under a potential future residential use scenario. Additional detail is provided in the 1996 DD as well as in the Administrative Record for Site 3.

2.6.3 Site 20

Hydrogeology of Site 20

Site 20 is located in an area of fill created as a result of expansion by NSN in the early 1940s. Bousch Creek, which was historically a tidal creek connected to Willoughby Bay, was placed into a culvert that is presently approximately 3,900 feet long. The culvert is now located east of Site 20. The depth to groundwater beneath the site is typically 5 to 6 feet bgs. The Columbia and Yorktown aquifers are present across the site. Previous investigations suggest that the Yorktown confining unit may not be continuous over the entire area. The clay unit was encountered at relatively shallow depths (8 to 15 feet bgs) on the Western portion of the site; however, it was not detected in several of the wells installed in the vicinity of Buildings LP-20 and LP-26. The clay layer, where present, dips to the north from the fuel farm (located south of the site) to depths of approximately 30 feet bgs. Previous investigations have indicated that direction of groundwater flow in the shallow aquifer are radial towards the northeastern corner of Building LP-20; the direction of groundwater flow in the deep aquifer is northeast, towards Willoughby Bay. The Bousch Creek culvert is known to be influenced by tides in this area.

Nature and Extent of Contamination at Site 20

According to the 1996 DD, VOCs, SVOCs, and metals were detected in both the soils (surface and subsurface) and groundwater (shallow and deep) in the vicinity of Building LP-20. Data generated during the RI indicate that VOCs were the primary contaminants detected in the area. Two types of VOC contaminants were detected in the Building LP-20 area: chlorinated solvents in the vicinity of Buildings LP-20 and LP-26, and petroleum products east of Building LP-22 and south of Building LP- 179 (the petroleum products have been and continue to be addressed under a separate Virginia Underground Storage Tank Program). VOCs, SVOCs, and metals detected in the surface and subsurface soils collected during the RI indicated the soil had been impacted by organic and inorganic contaminants. However, all VOCs in shallow and deep soils were below risk-based screening criteria. The SVOCs were present primarily in shallow and deep samples obtained near Building V-147 and were addressed under the Virginia Underground Storage Tank Program. Arsenic, beryllium, and iron exceeded RBCs in the shallow soils with arsenic and beryllium exceeding RBCs in the deep soils.

The shallow groundwater in the vicinity of Building LP-20 has been impacted by past activities performed in the area; the primary VOCs found in the vicinity of Buildings LP-20 and LP-26 were vinyl chloride, 1-2-DCE (total), and TCE. At the time the RI was completed, the Yorktown was found to have been impacted by VOCs. Several total and dissolved inorganics also exceeded groundwater criteria in deep aquifer samples.

Contaminant Fate and Transport at Site 20

According to the 1996 DD, the physical nature of the contaminants (specific gravity) and the geologic conditions of the site (coarse sands and a confining clay layer) influenced the contaminant distribution patterns. The clay layer beneath the site, in conjunction with a medium- to coarse-grained sand zone, appeared to have created preferential pathways for the contaminants to migrate away from apparent source areas. Suspected scouring of the clay layer, which has created a "bowl" configuration, appears have caused VOCs to accumulate in the area north of Bellinger Boulevard, and is thought to potentially be inhibiting the contaminants from migrating farther north. A depression in the clay surface near former Building LP- 14 (east/northeast of Building LP-26) also appears to be providing a pathway for the plume to migrate eastward. In the area near former Buildings LP-13 and LP-14, both solvent and petroleum plumes are present. An evaluation of the vertical distribution of the contamination indicated that the dense non–aqueous phase liquid (DNAPL) contaminants have migrated toward the base of the shallow aquifer.

Sampling conducted as part of the LTM program as well as the remedy optimization studies in 2009 and 2010 have better defined the configuration of the clay confining unit as well as the migration of VOC contamination from the Columbia aquifer into the Yorktown aquifer.

2.6.4 Selected Remedy Site 18

Hydrogeology at Site 18

The Columbia Aquifer at Site 18 consists of fine to coarse-grained sands with minor amounts of silt, gravel layers, and shell hash. Depth to water is typically 3.5 to 7 feet bgs. The Yorktown Confining Unit is at 22 to 35 feet bgs throughout the site. The Yorktown aquifer below the confining unit consists of fine to coarse-grained sands with some interbedded shell hash and thin clay layers. Groundwater in the Columbia aquifer flows north-northeast through the site toward the drainage channel located immediately north of the site boundary (**Figure 2-6**). The hydraulic gradient is low across the site at less than 0.005 feet per foot (ft/ft). A drainage channel, located just north of the site, is the discharge point for the shallow groundwater flowing to the northeast from the site. A site conceptual model is provided as **Figure 2-7**.

Nature and Extent of Contamination at Site 18

Groundwater investigations conducted at Site 18 as part of the site investigation between 2001 and 2007 defined an area of chlorinated VOCs in groundwater around the MW03 monitoring well cluster. Samples were collected from 10 site monitoring wells and with direct-push technology to define both the lateral and vertical extent of groundwater contamination. The results of this delineation were combined with the monitoring well data to develop depth-specific targets for injection of a substrate to promote ERD through the NTCRA. Monitoring data for the NTCRA defined the current extent of groundwater contamination at the site.

Initial rounds of groundwater data indicated metals were present in groundwater. Because the highest metals concentrations in groundwater were upgradient of Site 18, additional delineation or investigation of metals in groundwater was not performed as part of investigations at Site 18. Metals contamination detected in the shallow groundwater at Site 18 is associated with Site 2, Naval Magazine Slag Pile. Site 2 was addressed in a ROD (Navy, 2000) that required the excavation of sediment, placement of soil and asphalt covers, stabilization of the west bank of the drainage channel, and LTM of groundwater. The metals in groundwater upgradient of Site 18 continue to be assessed as part of the Site 2 groundwater monitoring program and is documented and evaluated in LTM reports. Currently, the Site 2 groundwater monitoring program includes sampling in support of each Five-Year Review.

Surface water sampling of the creek during the expanded site investigation indicated that VOCs were present; however, they were deemed not likely to be site-related as discussed in Section 2.2.5.

Contaminant Fate and Transport at Site 18

The groundwater contamination appears to be limited in extent based upon data collected from the existing monitoring well network at the site. Up- and downgradient monitoring wells define the contamination. The primary mechanism for contaminant transport is the flow of groundwater, which flows north toward the creek located adjacent to the site. However, a downgradient monitoring well indicates contaminants are not migrating from the site. An assessment of the groundwater data indicated that natural attenuation was occurring prior to the NTCRA. The ongoing NTCRA promotes the breakdown of the VOCs through ERD.

2.7 Current and Potential Future Site and Resource Uses

Sites 1, 3, 18, and 20 are primarily used for industrial activities. Area B of Site 1 serves as a parking lot for the recreational areas immediately adjacent to the site. Site 3 is almost entirely covered by asphalt serving as a parking lot for Navy fleet operations. Site 20 is an industrial use area consisting of buildings and parking areas. The groundwater is not currently used as source of drinking water within NSN. Drinking water is provided by the City of Norfolk. Site 18 is an open grassy area adjacent to the naval magazine. This location precludes it from development without specific authority through the Navy's site approval process and essentially prevents it from ever being developed as long as the naval magazine storage area is present. Nonetheless, LUCs will be employed to restrict site use and use of the groundwater.

ICs (LUCs) have been enforced at Sites 1 and 20 in accordance with their respective DDs since the remedies have been in place and operating. In 2007, LUC RDs for Sites 1, 3, and 20 were formally documented, specifically providing for enforcement and notification measures. LUCs at Site 18 will restrict the use of the site as well as prevent potential exposure to groundwater until groundwater cleanup goals have been met. LUC requirements for Site 18 will be defined in a remedial action design document specifically addressing LUCs.

2.8 Summary of Risks

2.8.1 Risk Summary for Sites 1, 3, and 20

The summary of Site risks for Sites 1, 3, and 20 are presented in detail in their respective DDs. A summary of potential unacceptable risk to receptors is presented as **Table 2-1**.

Site risks for Areas A and B at Site 1 were evaluated for the following:

- surface and subsurface soil
- surface water and sediment
- indoor/outdoor air
- groundwater
- ecological risks

As documented by the Site 3 DD, no action was deemed necessary to address potential unacceptable risk to receptors from exposure to soil at Site 3 in part because QADSY is an ecologically limited environment in a highly industrial area and is mostly a paved parking lot.

The scope of the Site 20 DD was limited to groundwater remediation for several reasons:

- The concrete and asphalt surfaces in the area have already "capped" the area of contamination and limits the potential contaminant pathway
- Available information does not indicate a discrete source area
- The amount of unsaturated soils in the vadose zone is approximately 5 feet
- The highly industrialized nature of the site limits remediation alternatives

The prior DDs are attached in **Appendices A, B, and C**.

2.8.2 Human Health Risk Summary for Site 18

A preliminary human health risk evaluation was conducted in December 2002 (CH2M HILL, 2002) to identify the potential for human health risks associated with exposure to groundwater, soil, sediment, and surface water at the site. The human health risk evaluation consisted of a comparison of data collected during the ESI to human health screening values, and an exposure assessment to identify potential exposure pathways from contaminants found in the media at Site 18.

This evaluation was documented in the *Final Expanded Site Investigation Report, Site 18, Former NM Hazardous Waste Storage Area, Naval Station Norfolk, Norfolk, Virginia* (CH2M HILL, 2004).

Potential *current* human receptors at Site 18 include adolescent and adult trespassers visitors who may contact the soil. Assuming potential residential, recreational, industrial, or commercial future site use, potential future receptors include adult and child residents, site workers, construction workers, and adolescent and adult trespassers who may contact site soil. Current and future land use exposure routes include exposure to unvegetated surface soil, which could occur as a result of incidental ingestion; dermal contact; or inhalation of fugitive dust. Future receptors could also be exposed to the subsurface soil if future construction work results in disturbance of the soil column. Additionally, current/future adolescent and adult trespassers/visitors may contact the surface water and sediment in the drainage ditch adjacent to the Site. Exposure to surface water and sediment could occur through incidental ingestion and dermal contact. Groundwater is not currently used as a potable water supply at Site 18; however, the groundwater was considered for future residential potable use for the purposes of evaluating unrestricted land use. Residents could be exposed to groundwater through ingestion of potable water, dermal contact while bathing, and inhalation of VOCs while showering. It is also possible that construction workers may come in contact with the groundwater during construction or excavation activities. Construction workers could be exposed as a result of inhalation of volatiles and dermal contact with the groundwater.

The conclusion of the semiquantitative human health risk evaluation was based upon a semiquantitative assessment comparing site data to conservative human health risk-based screening values. Potential unacceptable human health risk was identified for exposure to groundwater. The following VOCs were determined to be contaminants of potential concern (COPCs) in groundwater at Site 18:

- TCE
- cis-1,2-dichloroethene (cis-1,2-DCE)
- VC
- 1,1-dichloroethene (1,1-DCE)

2.8.3 Ecological Risk Summary

A preliminary ecological risk evaluation was conducted to identify the potential for risks to ecological receptors based upon the contaminant concentrations and distribution in soil, sediment, and surface water. The evaluation consisted of the first step in the Ecological Risk Assessment (ERA) process. Following the preliminary problem formulation, validated soil, sediment, and surface water data collected during the ESI were compared to medium-specific ecological screening valuesBTAG benchmarks) to provide a preliminary ecological risk evaluation for direct exposures to these media.

Upper-trophic-level ecological receptors that may utilize the habitats on the site or the adjacent ditch include herbivorous mammals (such as meadow vole), insectivorous mammals (such as short-tailed shrew), omnivorous birds (such as American robin), carnivorous birds and mammals (such as red fox and American kestrel), omnivorous mammals (such as raccoon), and piscivorous birds (such as great blue heron and belted kingfisher). Various reptilian species may also be present on the site. Amphibians (such as frogs) may be present in the drainage ditch. Lower trophic level receptor species include terrestrial and wetland plant species, soil invertebrates, benthic and aquatic invertebrates, and fish.

Complete exposure pathways to surface soils may exist for terrestrial receptors that could utilize the habitats present on the site. Potentially complete exposure pathways to aquatic (e.g., benthic invertebrates and fish) and semiaquatic (e.g., herons) receptors utilizing the ditch adjacent to Site 18 also potentially exist. Direct contact is potentially a significant exposure route for lower trophic level receptors (e.g., plants and soil invertebrates) while exposure via food webs is likely to represent the only potentially significant exposure route for upper-trophic-level ecological receptors.

The conclusions of the ecological risk evaluation were based upon a qualitative assessment using conservative screening values. No unacceptable risk was identified for ecological receptors due to site-related contaminants above background levels.

2.8.4 Basis for Action

It is the current judgment of the Navy and USEPA, in conjunction with VDEQ, that the remedies selected in and implemented according to the pre-NPL DDs for Sites 1, 3, and 20 remain necessary to protect public health, welfare, and the environment from exposure to hazardous substances in surface and subsurface soil at Site 1 and groundwater at Sites 1, 3, and 20. In addition, this ROD documents several changes in cleanup goals for groundwater from risk-based values (previously developed in the DD based upon the most likely exposure scenarios) to the MCLs at Sites 3 and 20, where the MCLs are more stringent.

The Selected Remedy documented in this ROD for Site 18 is necessary to protect public health, welfare, and the environment from exposure to hazardous substances in the groundwater.

2.9 Remedial Action Objectives

The site-specific remedial action alternatives to meet the remedial action objectives (RAOs) for NSN Sites 1, 3, and 20 were presented in detail in their respective DDs (**Appendices A, B, and C**). The information provided below is a summary of the RAOs presented in the DD for each site. A detailed comparison of the remedial action alternatives RAOs for the Selected Remedy site, Site 18, is provided below.

2.9.1 Site 1

The previously selected remedy for Site 1 included in situ treatment of soil and shallow groundwater using DPVE in Area A; extraction and treatment of the Columbia (shallow) and Yorktown (deep) aquifers groundwater in Areas A and B; and LTM and ICs to meet the following RAOs to prevent potential unacceptable risk to human health and the environment:

- Prevent exposure to the contaminated groundwater, subsurface soil, debris, surface water, and sediment
- Prevent further migration of contaminated groundwater
- Remediate the Columbia (shallow) and Yorktown (deep) aquifers groundwater for future beneficial use
- Minimize the migration of contaminants from soil and debris in Area A to groundwater and surface water

In response to the 2003 Five Year Review (CH2M HILL, 2003), the Navy, USEPA, and VDEQ agreed to revise the groundwater cleanup goals from the risk-based values to more stringent MCLs (see **Table 2-2**) for the shallow aquifer..

2.9.2 Site 3

The previously selected remedy for Site 3 includes remediation of the groundwater using AS/SVE and LTM to meet the following RAO to prevent potential unacceptable risk to human health:

- Minimize the threat of exposure to the contaminated groundwater through inhalation of VOCs by a potential human receptor (site worker and resident) in future buildings.

The original and revised cleanup goals for Site 3 are shown in **Table 2-3**. This Record of Decision documents the revision of the groundwater cleanup goals from the original, risk-based clean up goals for groundwater to the more stringent MCLs. In addition, LUCs are enforced at the site to prevent exposure to groundwater.

2.9.3 Site 20

The previously selected remedy for Site 20 includes treatment of the groundwater using AS/SVE, LTM, and LUCs to meet the following RAOs to address potential unacceptable risk to human health:

- Prevent current and future exposure to human and ecological receptors to the contaminated Columbia and Yorktown aquifer groundwater
- Prevent further migration of contaminated shallow groundwater
- Reduce contaminant concentrations in the shallow and Yorktown aquifer to risk-based levels defined in the DD

The original and revised cleanup goals for Site 20 are shown in **Table 2-4**. This ROD documents the revision of the groundwater cleanup goals from the original, risk-based cleanup goals for groundwater to the more stringent MCLs.

2.9.4 Site 18

The site-specific RAO for Site 18 is to address potential unacceptable risk to human health:

- Eliminate potential unacceptable human health risk associated with exposure to chlorinated VOCs in groundwater.

Groundwater cleanup goals will be the federal MCLs for the COPCs in groundwater (**Table 2-5**). LUCs are proposed to prevent unacceptable exposure to groundwater.

2.10 Description of Alternatives for Site 18

Two alternatives were developed to achieve the RAO:

- Alternative 1—No action. No further action would be done at this site
- Alternative 2— Continued enhanced bioremediation (including additional substrate injections if necessary) with groundwater monitoring and LUCs

Alternative 2, continued enhanced bioremediation with groundwater monitoring and LUCs is the selected alternative for the site to reduce concentrations of chlorinated VOCs to achieve the RAO and restrict site use to prevent exposure to unacceptable risks in groundwater in the interim. **Table 2-6** provides the major components, details, and cost of Alternative 2 identified for Site 18.

2.11 Summary of Comparative Analysis of Alternatives for Site 18

Each remedial alternative for Site 18 was evaluated against the nine criteria listed below, as required by the NCP at 40 CFR 300.430(e)(9)(iii).

- **Protection of Human Health and the Environment**—addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls.

- **Compliance with ARARs**—Section 121(d) of CERCLA and the NCP at 40 CFR Section 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, which are collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4).
- **Long-Term Effectiveness and Permanence**—refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.
- **Reduction of Toxicity, Mobility, or Volume Through Treatment**—refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.
- **Short-Term Effectiveness**—addresses the period of time needed to implement the remedy and reduce any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.
- **Implementability**—addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.
- **Cost**—refers to the estimated capital and annual O&M costs, as well as present-worth cost. Present-worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
- **State Acceptance**—considers whether the state agrees with the analyses and recommendations.
- **Community Acceptance**—considers whether the local community agrees with the analyses and selected remedy.

2.11.1 Threshold Criteria

Overall Protection of Human Health and the Environment

Alternative 1, No Action, would not restrict, manage, or monitor site conditions to reduce exposure to contaminants that pose potential risks to human health. Alternative 2 is protective of human health and the environment because potentially unacceptable risk exposures to groundwater would be managed through continued enhanced bioremediation and the implementation and enforcement of LUCs. Groundwater-monitoring data would be used to assess the efficacy of the bioremediation occurring in groundwater, while LUCs would be implemented as long as contaminant concentrations exceed cleanup goals.

Compliance with ARARs

ARARs include any federal or more stringent state environmental or facility-siting standards, requirements, criteria, or limitations that are legally applicable or relevant and appropriate to a CERCLA site or action. No ARARs (apart from those already in effect in accordance with the NTCRA) would apply to Alternative 1 since no further action would be taken at Site 18. Alternative 2 would be compliant with ARARs set forth in the EE/CA for the continued enhanced bioremediation, including MCLs, management of investigative derived waste, underground injection management, etc. The complete list of ARARs for Alternative 2 is included in **Appendix D**.

2.11.2 Primary Balancing Criteria

Long-Term Effectiveness and Permanence

On the basis of an evaluation of chlorinated VOC and geochemical data collected during the performance monitoring for the initial injection, bio-enhancing substrates are continuing to provide an environment favorable to biodegradation of chlorinated VOCs at Site 18. Consequently, if No Action were implemented, groundwater quality would most likely continue to improve; however, no monitoring would take place to ensure that RAOs are met.

Alternative 2 would include monitoring of the ongoing treatment at Site 18 in accordance with the NTCRA and enforcement of LUCs to assure that RAOs are achieved. If the substrates injected into the groundwater during the 2008 and 2010 actions are expended prior to attainment of RAOs, Alternative 2 would provide for additional treatment ensuring that RAOs are achieved. Consequently, Alternative 2 has greater long-term effectiveness and is the more permanent solution.

Reduction in Toxicity, Mobility, or Volume through Treatment

Based on evaluation of chlorinated VOC and geochemical data collected during the performance monitoring for the initial injection, bio-enhancing substrates are continuing to provide an environment favorable to biodegradation of chlorinated VOCs at Site 18. Alternative 1 does not provide a means to measure reductions in the toxicity, mobility, or volume even though some degree of treatment of the groundwater contaminants in Site 18 groundwater may be occurring from the previously conducted removal action.

Alternative 2 would include monitoring of the ongoing treatment and assess reductions in toxicity and volume. Additionally, the alternative would allow for additional treatment to continue to reduce concentrations of contaminants, if warranted. Consequently, Alternative 2 has the greatest potential to reduce toxicity, mobility and volume of contaminants in order to achieve RAOs.

Short-Term Effectiveness

Treatment has already begun at Site 18 as a result of the NTCRA. There are no short-time human health risks to site workers and/or the community from implementation of additional treatments (e.g., injection of substrates) under Alternative 2 as long as work is conducted in accordance with a Site-specific Health and Safety Plan. The LTM component of Alternative 2 poses minimal risk to workers conducting monitoring, and any potential risks are addressed through use of personal protective equipment.

Implementability

No action would be implemented under Alternative 1. LUCs included in Alternative 2 would require consent from base command, which would be obtained. With Alternative 2, any additional substrate treatment injections would be implemented using well-established technologies already being used to implement the NTCRA, with conventional equipment and standard construction methods. Operations would consist of injection and LTM.

Alternative 2 would be easily monitored during Five-Year Reviews. In addition, monitoring under Alternative 2 would be used to evaluate groundwater quality.

Cost

In terms of net present worth, the No Action alternative has no cost. There would be minimal costs to implement Alternative 2 (**Table 2-7**). These costs would include preparation of a limited remedial action document, periodic inspections, long-term monitoring, and periodic reporting (including the Five-Year Review Report) to maintain the LUCs. These costs are assumed conservatively to occur for 10 years and are estimated to be $100,000. The actual duration will not be known until additional groundwater data is collected through the monitoring program. Likewise, while a future injection may be necessary to stimulate further ERD in the groundwater, an estimated cost to perform an additional injection is not likely to be accurate without additional data.

2.11.3 Modifying Criteria

State Acceptance

State involvement has been solicited throughout the CERCLA process, including during the publication period for the Proposed Plan. The Commonwealth of Virginia supports the Selected Remedy for Site 18. Additionally, the Commonwealth of Virginia supports the DD remedies for Sites 1, 3, and 20 along with the revision to the cleanup goals.

Community Acceptance

Community acceptance was solicited during the Proposed Plan comment period. No comments were received during the comment period or at the public meeting.

2.12 Principal Threat Wastes

Principal threat wastes are hazardous or highly toxic source materials that result in ongoing contamination to surrounding media, generally cannot be reliably contained, or present a significant risk to human health or the environment should exposure occur. There are no known principal threat wastes associated with Sites 1, 3, or 18. While concentrations of chlorinated solvents in groundwater data obtained at Site 20 have indicated that DNAPLs may be present in groundwater as a principal threat waste, DNAPLs have not been detected during site investigations.

2.13 Selected Remedy

The remedies for Sites 1, 3, and 20 were selected and documented in their respective DDs and this ROD. The USEPA, with concurrence from VDEQ, accept these selected remedies as final CERCLA remedial actions.

The DD sites were submitted for public comment and finalized as defined below:

- Site 1 public comment period was held from March 6, 1995 to April 6, 1995; comments received from the public were addressed in the DD. The DD was signed by the Navy on August 14, 1995
- Site 3 public comment period was held from July 15, 1996 to August 15, 1996; comments received from the public were addressed in the DD. The DD was signed by the Navy on November 19, 1996
- Site 20 public comment period was held from September 26, 1996 to October 25, 1996; comments received from the public were addressed in the DD. The DD was signed by the Navy on November 19, 1996

  The respective DDs for Site 1, 3, and 20 evaluated ARARs for each site's selected remedy. The DDs for Sites 1, 3, and 20 are provided as Appendix A, B, and C. In accordance with CERCLA, Five Year Reviews have been completed in 2003 and 2008 to verify the effectiveness of each remedy, including compliance with ARARs. **Appendix D** summarizes the ARARs applicable to each of the current remedies at the site (ARARs applicable to construction of the remedies are not included in Appendix D).

Notice of revision of the original risk-based cleanup goals for groundwater to the MCLs, where the MCLs are more stringent for Sites 3 and 20, is documented in this ROD.

The preferred alternative for Site 18 is Alternative 2, continued enhanced bioremediation with groundwater monitoring and LUCs.

2.13.1 Summary of the Rationale for the Selected Remedy

The Selected Remedy for Site 18 is continued enhanced bioremediation with groundwater monitoring and LUCs. The LUCs will be implemented to ensure that exposure to groundwater containing unacceptable levels of contaminants does not occur. The LUCs will be implemented and enforced until such time that monitoring data indicates that contaminants in groundwater have been reduced to the cleanup goals . If monitoring data indicates that the ERD initiated in the groundwater through the previously conducted NTCRA has not achieved the cleanup goals, additional injections will be performed to assure that cleanup goals are being met. This remedy is being selected because it will achieve substantial risk reduction and prevent exposure to contaminated media. Alternative 1, no action, was eliminated because it does not meet the RAOs and is not protective of human health and the environment.

2.13.2 Description of the Selected Remedy

Decision Document Sites

Affirmation of the DD remedies as described in Section 1.4.1 for Sites 1, 3, and 20 are being documented in this ROD. LUCs are in place and are currently enforced at Sites 1, 3, and 20. Establishing the cleanup goals at the most stringent MCLs for Sites 3 and 20 provides the maximum potential for reuse in the future.

Selected Remedy Site 18

The major components of Alternative 2, continued enhanced bioremediation, groundwater monitoring, and LUCs, are the following:

- Continued groundwater monitoring and reporting to assess the continuing effectiveness of the 2008 and 2010 injections and any future applications of bio-enhancing substrates determined to be necessary at Site 18. The Navy, USEPA, and VDEQ will evaluate monitoring reports to determine if additional injections are necessary. Monitoring will be conducted for a sufficient period of time to assure that RAOs have been achieved.
- Additional in situ injection or application of bio-enhancing substrates into the shallow groundwater at Site 18 if the Navy, USEPA, and VDEQ agree that, on the basis of groundwater-monitoring data, additional treatment is warranted to achieve RAOs.
- LUCs in the form of restrictions on potable use of groundwater at the site and annual inspections to ensure LUCs are maintained.

The objectives of the LUCs will be to protect against unacceptable exposure to groundwater:

- Prohibit digging into or disturbance of the site
- Prohibit the withdrawal of groundwater for purposes other than environmental monitoring

Navy will perform a trend evaluation of both contaminant concentrations and groundwater geochemical data on a yearly basis and submit the evaluation to USEPA and VDEQ for review. This evaluation may be included in the Annual Long-term Monitoring Report (beginning with the 2012 Report) for Naval Station Norfolk. If contaminant concentrations remain above cleanup goals and the evaluation concludes that ERD is not effectively occurring, the Navy will submit a plan which will provide for implementation of actions necessary to achieve cleanup goals at Site 18 in a reasonable time frame. The plan will be submitted within 60 days after approval of the Long-term Monitoring Report containing the Site 18 evaluation.

Site 18 will be inspected quarterly, and the Navy will evaluate the effectiveness of the LUCs. The Navy will maintain LUCs until site conditions allow for unlimited use and unrestricted exposure. Within 120 days of the ROD signature, the Navy shall prepare a Limited Remedial Action document for LUCs to implement the Selected Remedy and submit it to USEPA and VDEQ for review and concurrence. The LUC portion of the remedial action will provide for implementation and maintenance actions, including quarterly inspections and reporting. The limited Remedial Action document will also include provisions that would require a reevaluation of potential risks when the monitoring data indicate that cleanup goals have been met. The Navy will implement, maintain, monitor, record, review, report on, and enforce the LUCs in accordance with the limited Remedial Action document. Although the Navy may later transfer these responsibilities to another party by contract, property transfer agreement, or through other means, the Navy shall retain ultimate responsibility for remedy.

Cleanup goals for Site 18 were established to be MCLs. A detailed cost breakdown of the Selected Remedy for Site 18 is provided in **Table 2-7**.

2.13.3 Expected Outcome of the Selected Remedy for Site 18

Currently, Site 18 is an open, vegetated field adjacent to the naval magazine storage area that is not regularly accessed for purposes other than environmental monitoring or inspection. Current land use is expected to continue at Site 18. LUCs will be employed to prohibit the withdrawal of groundwater for any purpose other than environmental monitoring until the monitoring data indicate that cleanup goals have been met in groundwater.

2.14 Statutory Determinations for Site 18

In accordance with the NCP, the Selected Remedy for Site 18 meets the following statutory determinations.

2.14.1 Overall Protection of Human Health and the Environment

The Selected Remedy for Site 18 will prevent potential unacceptable human health risk from contact with groundwater, by means of continued ERD and LUCs. LUCs will be maintained to prevent the withdrawal of groundwater for purposes other than environmental monitoring.

2.14.2 Compliance with ARARs

The Selected Remedy for Site 18 will comply with ARARs as shown in **Appendix D**.

2.14.3 Cost Effectiveness

The Selected Remedy for Site 18 is cost effective and represents the most reasonable value. The cost incurred with continued enhanced bioremediation with groundwater monitoring and LUCs would be for the preparation of a limited remedial action document, implementation of the LUCs, periodic inspections, and periodic site monitoring and reporting (including the Five-Year Review Report) to enforce the LUCs and conduct groundwater monitoring. These costs are assumed to occur over a 10-year timeframe.

2.14.4 Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The Navy and USEPA, in partnership with the VDEQ, determined the Selected Remedy for Site 18 represents the optimization of current solutions and treatment technologies.

2.14.5 Preference for Treatment as a Principal Element

The Selected Remedy for Site 18 does satisfy the statutory preference for treatment as a principal element because there is remediation occurring as part on the ongoing bioremediation of groundwater. It also provides a means to assess the on-going effects of the removal action injection activities, and the potential to perform additional injections to promote ERD if monitoring data indicates additional stimulation is warranted.

2.14.6 Five-Year Review Requirements

The remedy will result in hazardous substances, pollutants or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure. Therefore, a statutory review will be conducted within five years of the initiation of the remedial action (and every five years thereafter) to evaluate continuing remedy effectiveness and to determine if the remedy continues to be protective of human health and the environment. Five Year Reviews will be conducted until groundwater cleanup levels have been achieved.

2.15 Documentation of Significant Changes

The Proposed Plan for Sites 1, 3, 18, and 20 was released for public comment June 18, 2010. No comments were received during the public meeting or comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate based upon input from the public.

The Proposed Plan, as released to the public, included revisions to certain cleanup goals at Site 3 and Site 20 that would have resulted in changing the goals for certain contaminants from risk-based values to MCLs that would have been less stringent. Based on further evaluation, the Navy, USEPA, and VDEQ agree that the risk-based cleanup goals for COCs with risk-based values lower than their respective MCLs should not be revised. Therefore, only the constituents whose MCLs are more stringent than the original, risk-based values are acceptable to be established as cleanup goals. The cleanup goals for Site 3 documented in this ROD are shown in **Table 2-3**.

Additionally, the purpose of the ROD was adjusted slightly to include documentation of ARARs applicable to current site remedies for Sites 1, 3, and 20. The DD ARARs are referenced in the individual site DD (**Appendices A, B, and C**). The revised listing of ARARs are documented in **Appendix D**.

Table 2-1: Sites 1, 3, and 20 Potential Unacceptable Risk

Site	Receptor	Risk Drivers
Site 1	Area A Future adult resident (soil, groundwater) Future child resident (soil, surface water, sediment, and groundwater) Ecological (surface water and sediment)	Area A Soil: Arsenic and cadmium Surface water: Aroclor-1254 Sediment: Arsenic, Aroclor-1254, and Aroclor-1260 Groundwater: 1,2-dichlorothene, vinyl chloride, and trichloroethene
	Area B Future adult resident (groundwater) Future child resident (soil, sediment, and groundwater) Ecological (surface water and sediment)	Area B Soil: Arsenic, cadmium, and manganese Sediment: Arsenic and cadmium Groundwater: 1,2-dichloroethene, benzene, vinyl chloride, trichloroethene, and arsenic
Site 3	Future Worker (indoor air) Future adult resident (indoor air) Future child resident (indoor air and soil) No unacceptable ecological risk identified	Groundwater (indoor air): Carbon tetrachloride, chloroform, 1,1-DCE, 1,1-DCA, 1,1,1-TCA, PCE, TCE, vinyl chloride Soil: thallium
Site 20	Current/Future Maintenance Worker (shallow groundwater and surface soil) Current/Future Industrial Worker (surface soil and shallow groundwater) Future Construction Worker (shallow groundwater, surface soil) Future adult resident (shallow and deep groundwater) Future child resident (shallow and deep groundwater, surface and subsurface soil) No unacceptable ecological risks were identified	Shallow Groundwater: Vinyl chloride, 1,1-DCE, 1,2-DCE, TCE, and benzene Deep Groundwater: Arsenic, vinyl chloride, benzene, and 1,2-DCE Surface Soil: arsenic, beryllium, and benzo(a)pyrene Subsurface soil: None

Table 2-2 - Cleanup Goals for Groundwater at Site 1

Contaminant of Concern	Deep Aquifer Cleanup Goals (μg/L)	Shallow Aquifer Original Cleanup Goals (μg/L)	Shallow Aquifer Revised Cleanup Goals (μg/L)[a]
	MCL	**Risk-based**	**MCL**
1,2-Dichloroethane	5	190	5
cis-1,2-Dichloroethene	70	15,000	70
1,1,1-Trichloroethane	200	13,500	200
Benzene	5	600	5
Ethylbenzene	700	150,000	700
Tetrachloroethene	5	340	5
Toluene	1,000	301,000	1,000
Trichloroethene	5	1,600	5
Vinyl Chloride	2	9	2
Xylenes	10,000	3,000,000	10,000

Notes:

[a] In November 2007, the NSN Tier 1 Partnering Team agreed to revise the groundwater cleanup goals from the risk-based values to MCLs for the shallow aquifer Non-Significant Differences Document.

Table 2-3 - Cleanup Goals for Groundwater at Site 3

Contaminant of Concern	Original Cleanup Goals (µg/L)	Revised Cleanup Goals (µg/L)[a]
	Risk-based	**MCL**
Carbon Tetrachloride	2.7	2.7
Chloroform	11	11
1,1-Dichloroethene	0.38	0.38
Tetrachloroethene	60	5
Trichloroethene	49	5
Vinyl chloride	0.08	0.08

Notes:

[a] Clean up goals are revised only for those contaminants which the MCL is more stringent.

Table 2-4 - Cleanup Goals for Groundwater at Site 20

Contaminant of Concern	Original, Risk-Based Cleanup Goals (μg/L)	Revised (MCL) Cleanup Goals (μg/L)
Trichloroethene	136	5
1,1-Dichloroethene	11	7
1,2-Dichloroethane[a]	172	5
1,2-Dichloroethene	306	70
Vinyl Chloride	6	2
Benzene	19	5

Notes:
[a] 1,2-Dichloroethane was not identified in the Decision Document, but was listed in the Long-term Monitoring Plan.

Table 2-5 - Cleanup Goals for Groundwater at Site 18

Contaminant of Potential Concern	Clean up Goal at MCLs (µg/L)
Trichloroethene	5
cis-1,2-Dichloroethene	70
Vinyl chloride	2
1,1-Dichloroethene	7

TABLE 2-6
Descriptions of Alternatives

Alternative	Components	Details	Cost	
1—No Action	Existing Site 18 Area	Not Applicable	Capital Cost Annual O&M Present-Worth Time Frame 10 years	$0 $0 $0
2 – Continued Enhanced Bioremediation with Groundwater Monitoring and Land Use Controls*	Land Use Controls (LUCs) to cover Site 18 Area	- Semiannual groundwater monitoring - Annual monitoring report - Five-Year Review report - Sign Installation - LUC document - Integrity Inspections - Statutory remedy 5-year reviews	Capital Cost Annual O&M Net Present-Worth Time Frame 10 years	$6,500 $8,904 $100,258

Notes

*Alternative 2 assumes that groundwater monitoring is required but no additional injections are conducted. If the Navy, USEPA, and VDEQ agree additional treatment via injection is required, additional cost will need to be considered.

TABLE 2-7
Alternative 2
Continued Enhanced Bioremediation

Site: Site 18
Location: Naval Station Norfolk, Former NM Storage Area
Phase: Record of Decision
Date: July 1, 2010

Description: Monitoring groundwater data to determine if bioremediation implemented through a removal action at the site is reducing groundwater contaminant concentrations to the MCL. Stimulate the bioremediation if necessary. Institute LUCs to prevent unacceptable exposure to groundwater.

CALCULATIONS

ASSUMPTIONS

1) Long Term Monitoring
* Quarterly inspection of site and annual reporting
* 5 Year review
* No long term groundwater or soil sampling will be conducted

2) LUCs for 10 year timeframe

CAPITAL COSTS

Description	Qty	Unit	Unit Cost	Total Cost	Notes
Preparation of LUC Remedial Design	1	EA	$5,000	$5,000	Engineer's Estimate
Purchase and Installation of Site Signs (Monitoring in Progress; LUCs in effect; Contact info, etc.)	1	EA	$1,500.00	$1,500	
TOTAL CAPITAL COST				**$6,500**	

OPERATION AND MAINTENANCE COSTS (Years 1-4 and 6-9)

Description	Qty	Unit	Unit Cost	Total Cost	Notes
Land Use Control Monitoring					
Quarterly site inspection and annual reporting	1	UNIT	$1,500.00	$1,500	Engineer's Estimate
SUBTOTAL					
Groundwater Monitoring					
Semi-annual groundwater monitoring/reporting (assumed)	2	EA	$2,750.00	$5,500	
SUBTOTAL				$7,000	
Contingency	20%			$1,400	
SUBTOTAL				$8,400	
Project Management	6%			$504	
TOTAL ANNUAL OPERATION AND MAINTENANCE COST (Years 1-4 and 6-9)				**$8,904**	

OPERATION AND MAINTENANCE COSTS (Years 5 and 10)

Description	Qty	Unit	Unit Cost	Total Cost	Notes
Five Year Reviews					
Inspection	1	UNIT	$500.00	$500	Engineer's Estimate
SUBTOTAL				$500	
Five year review report	1	UNIT	$2,000.00	$2,000	Engineer's Estimate
SUBTOTAL					
SUBTOTAL				$2,500	
Groundwater Monitoring					
Semi-annual groundwater monitoring/reporting (assumed)	2	EA	$2,750.00	$5,500	
SUBTOTAL				$8,000	
Contingency	20%			$500	Engineer's Estimate
SUBTOTAL				$16,500	
Project Management	6%			$990.00	
TOTAL ANNUAL OPERATION AND MAINTENANCE COST (Years 5 and 10)				$17,490	
TOTAL NET PRESENT WORTH (10 Years)				**$100,258**	

NOTES: 1. THE ESTIMATE SHOWN ABOVE IS CONSIDERED BUDGETARY-LEVEL COST ESTIMATING, SUITABLE FOR USE IN PROJECT EVALUATION AND PLANNING. ACTUAL CONSTRUCTION COSTS ARE EXPECTED TO VARY FROM THESE ESTIMATES DUE TO MARKET CONDITIONS, ACTUAL COSTS OF PURCHASED MATERIALS, QUANTITY VARIATIONS, REGULATORY REQUIREMENTS, AND OTHER FACTORS EXISTING AT THE TIME OF CONSTRUCTION.
2. COSTS REFLECT AN ASSUMPTION THAT GROUNDWATER MONITORING IS REQUIRED BUT NO ADDITIONAL INJECTIONS ARE REQUIRED. THE EFFICACY OF THE ORIGINAL ERD INJECTIONS WILL BE REVIEWED BY THE NAVY IN CONSULTATION WITH THE EPA AND VDEQ TO DETERMINE IF ADDITIONAL INJECTIONS ARE WARRANTED.

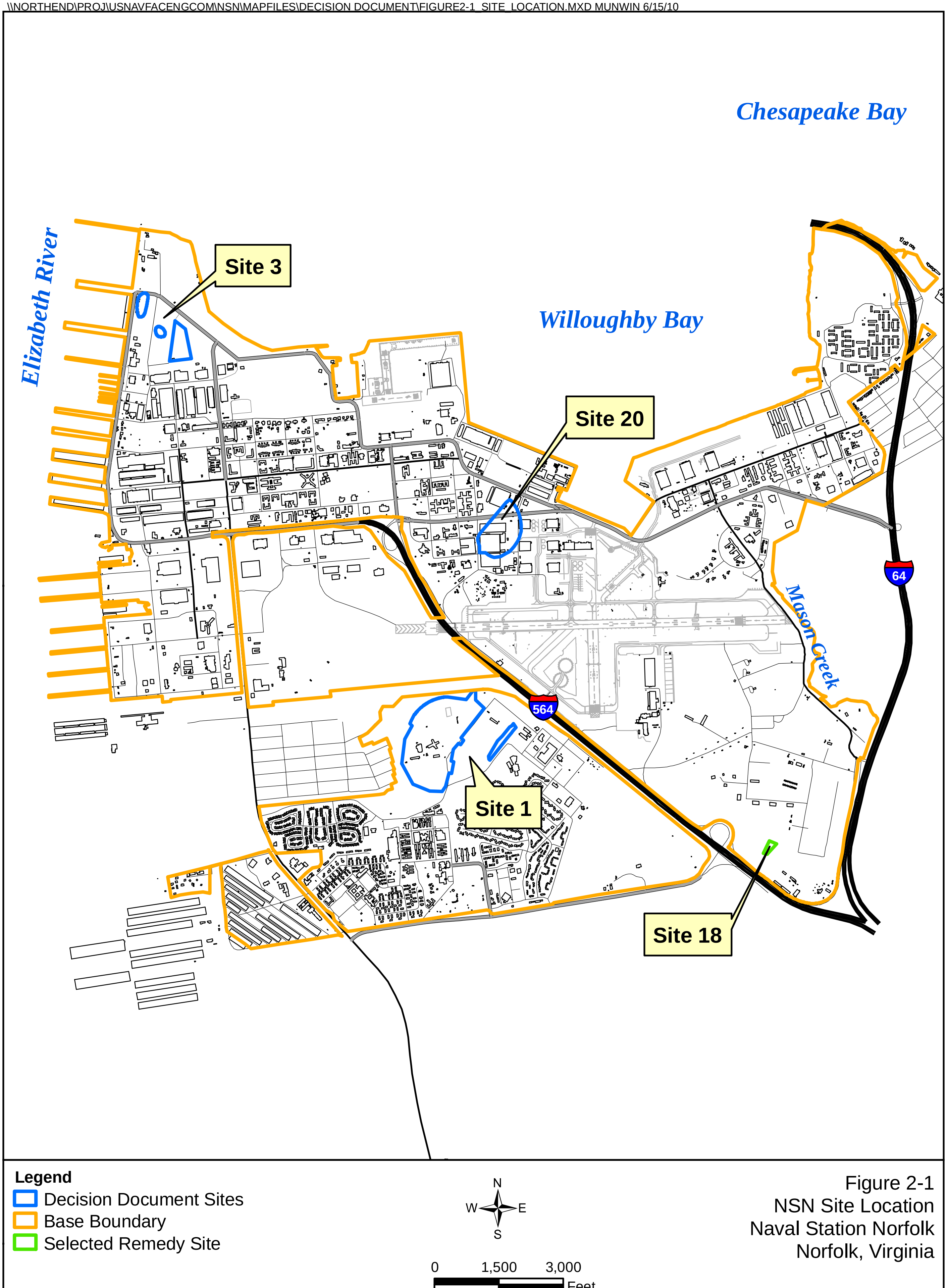

Figure 2-1
NSN Site Location
Naval Station Norfolk
Norfolk, Virginia

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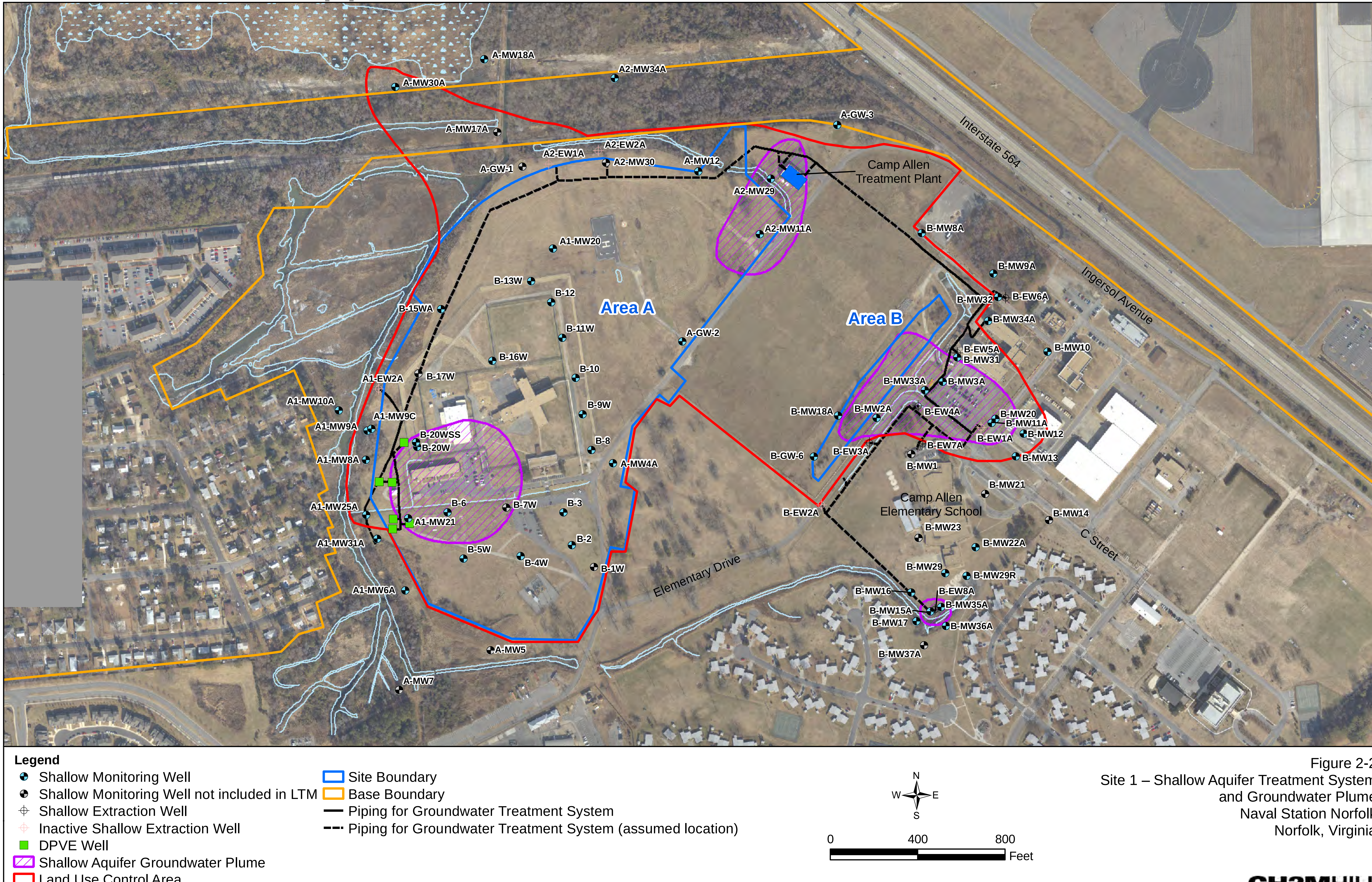

Figure 2-2
Site 1 – Shallow Aquifer Treatment System
and Groundwater Plume
Naval Station Norfolk
Norfolk, Virginia

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\\NORTHEND\PROJ\USNAVFACENGCOM\NSN\MAPFILES\DECISION DOCUMENT\FIGURE2-3_SITE1_DEEP.MXD MUNWIN 7/15/10

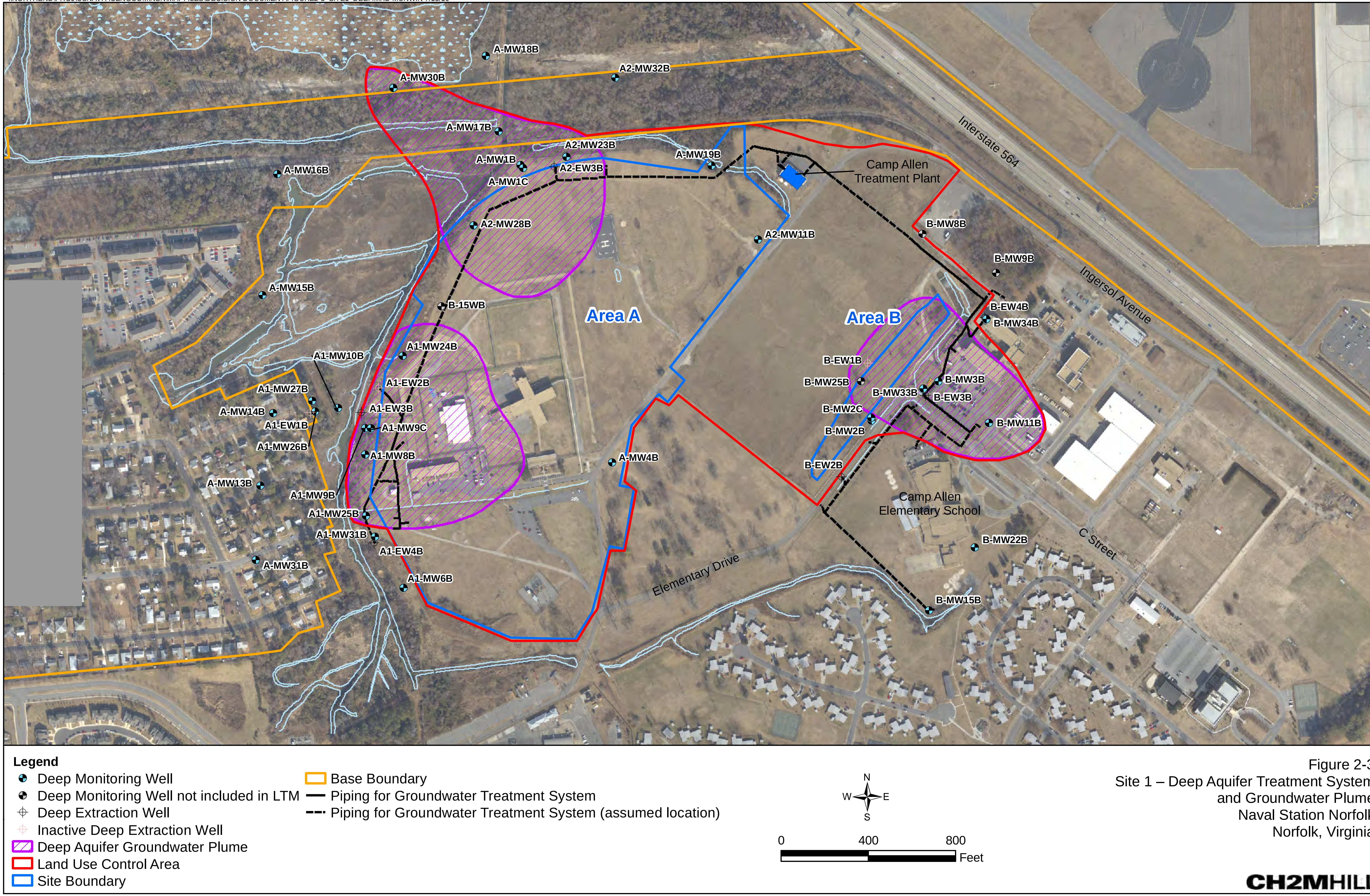

Figure 2-3
Site 1 – Deep Aquifer Treatment System
and Groundwater Plume
Naval Station Norfolk
Norfolk, Virginia

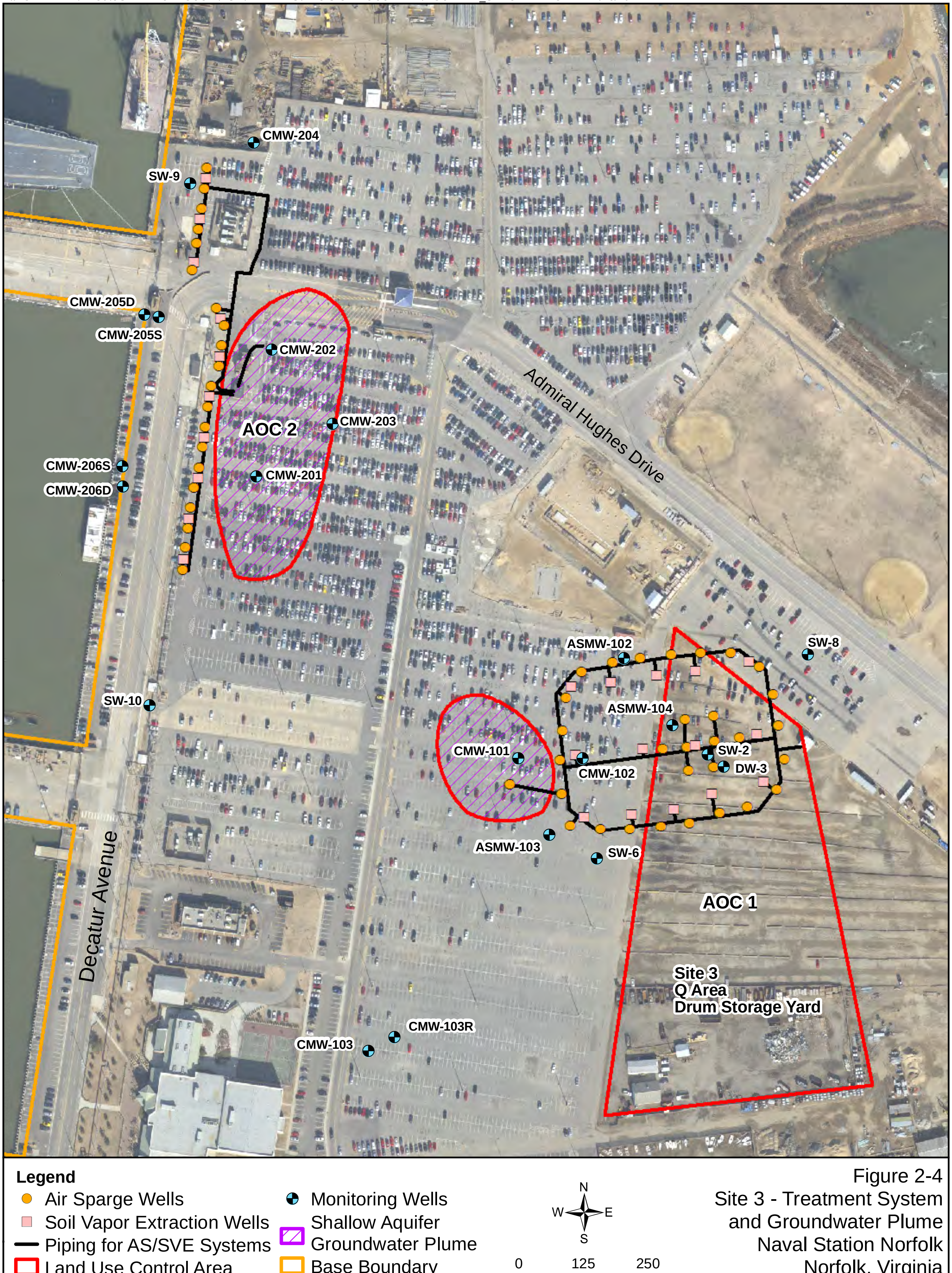

Figure 2-4
Site 3 - Treatment System and Groundwater Plume
Naval Station Norfolk
Norfolk, Virginia

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\\NORTHEND\PROJ\USNAVFACENGCOM\NSN\MAPFILES\DECISION DOCUMENT\FIGURE2-5_SITE20.MXD MUNWIN 7/15/10

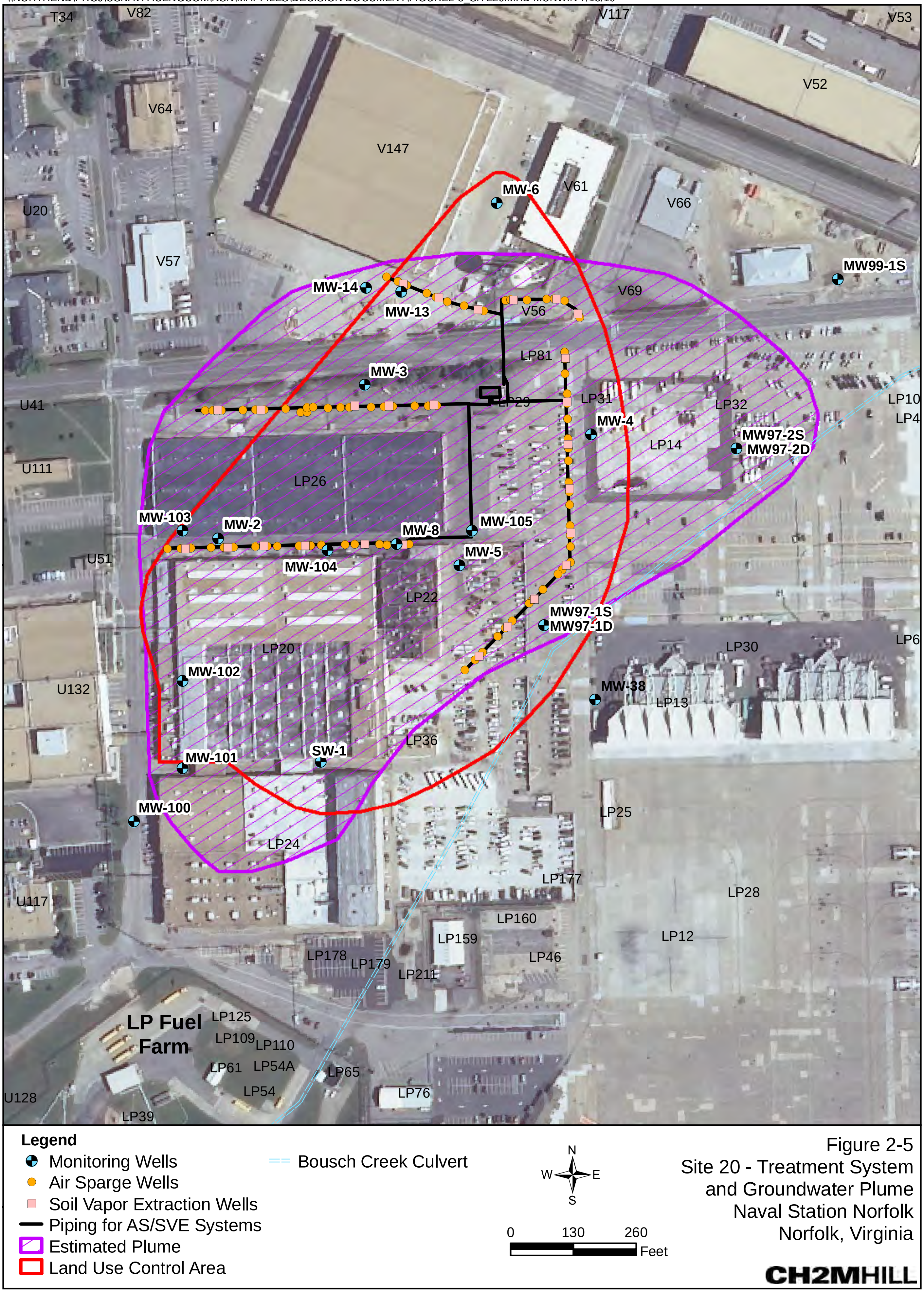

Figure 2-5
Site 20 - Treatment System and Groundwater Plume
Naval Station Norfolk
Norfolk, Virginia

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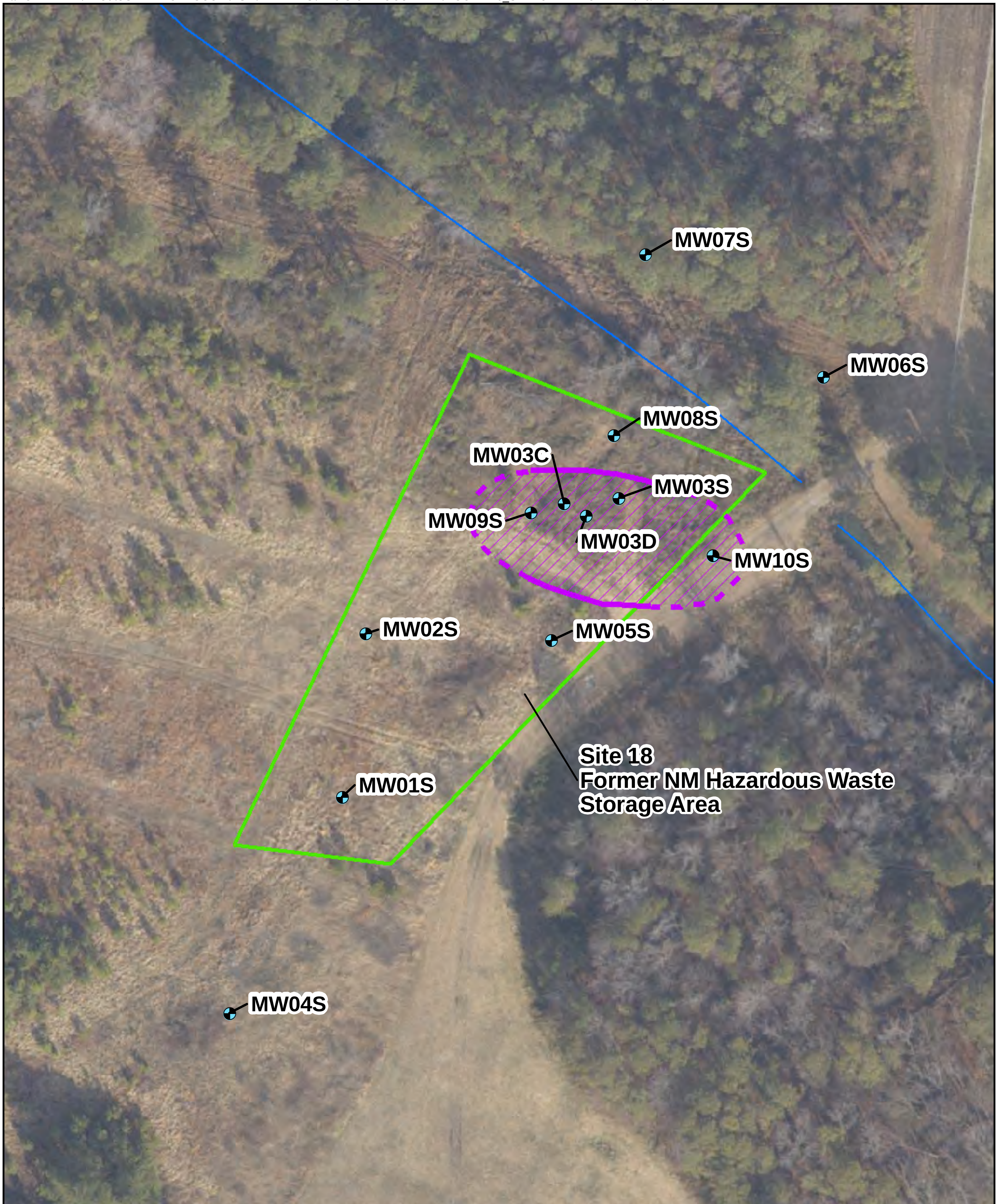

Legend

- Site Boundary
- Monitoring Wells
- Estimated VOC Plume (July 2009) (Dashed where inferred)

N W E S

0 40 80 Feet

Figure 2-6
Site 18 Layout
and Groundwater Plume
Naval Station Norfolk
Norfolk, Virginia

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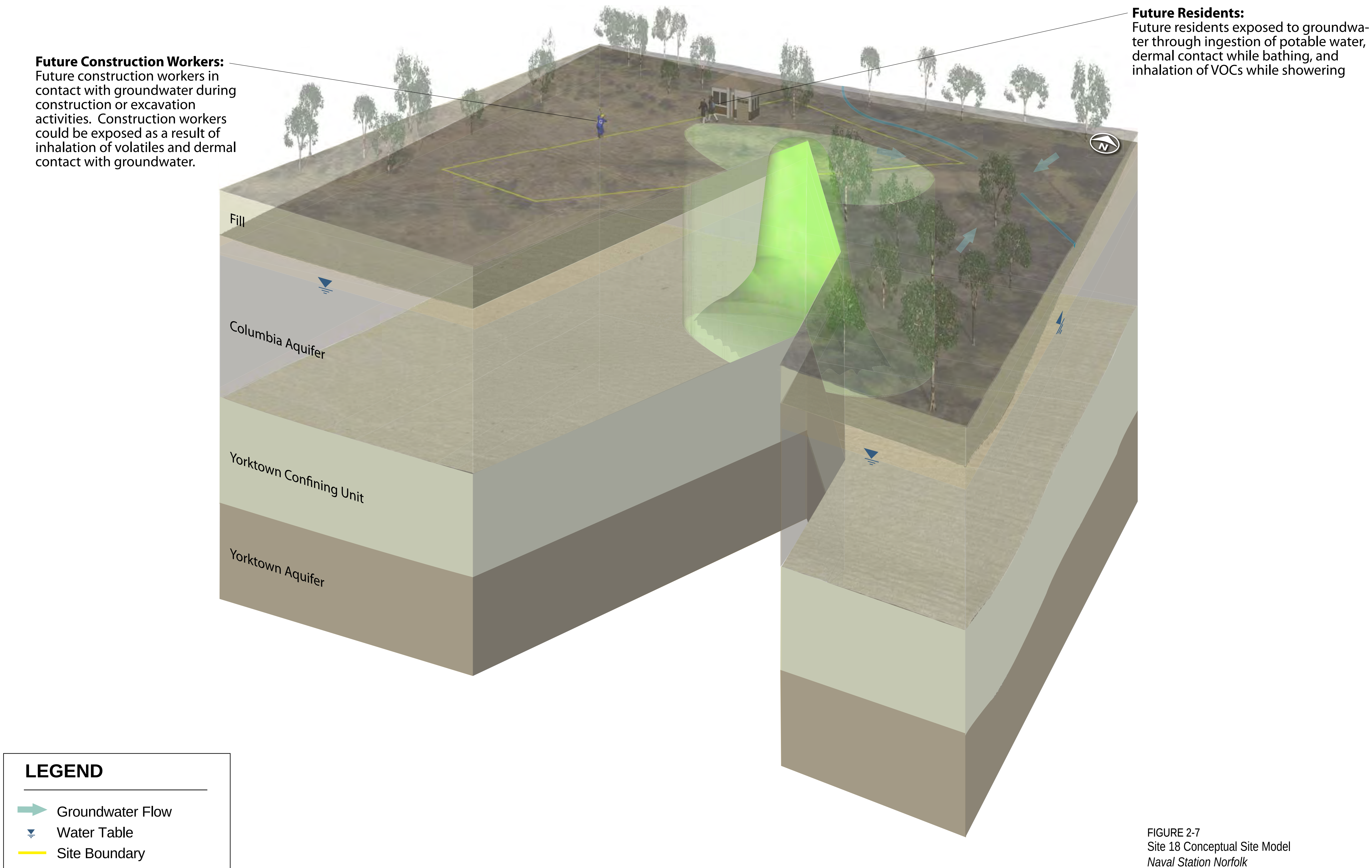

FIGURE 2-7
Site 18 Conceptual Site Model
Naval Station Norfolk
Norfolk, Virginia

SECTION 3

Responsiveness Summary

The participants in the public meeting included representatives of the Navy, USEPA, and VDEQ. No community members attended the meeting. No questions were received during the public meeting, and no additional written comments, concerns, or questions were received from community members during the public comment period.

SECTION 4

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Appendix A
Site 1 Decision Document

04.09-07/01/95-00599

FINAL

DECISION DOCUMENT

CAMP ALLEN LANDFILL
NAVAL BASE, NORFOLK, VIRGINIA

CONTRACT TASK ORDER 0084

JULY 17, 1995

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

THIS VOLUME IS THE PROPERTY OF:

COMNAVBASE, NORFOLK
1530 GILBERT STREET, SUITE 2200
NORFOLK VA, 23511-2797
ATTN: CODE N42B (D. BAILEY)
PHONE: 804-322-2900

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

Number

LIST OF FIGURES

Number

ACRONYMS AND ABBREVIATIONS

ARARs	applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DoN	Department of the Navy
DOT	Department of Transportation
DPVE	dual phase vacuum extraction
EE/CA	Engineering Evaluation/Cost Analysis
FS	Feasibility Study
gpm	gallons per minute
HI	Hazard Index
ICR	incremental cancer risks
IRP	Installation Restoration Program
MCLs	maximum contaminant levels
NCP	National Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
PEM	Palustrine Emergent Wetland
PRAP	Proposed Remedial Action Plan
PSS	Palustrine Scrub Shrub
RA	Risk Assessment
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SVOCs	semivolatile organic compounds
TBC	to be considered
USEPA	United States Environmental Protection Agency
USMC	United States Marine Corps
VADEQ	Virginia Department of Environmental Quality
VOCs	volatile organic compounds
VR	Virginia Regulations

DECLARATION

Site Name and Location

Camp Allen Landfill
Naval Base Norfolk
Norfolk, Virginia

Statement of Basis and Purposes

This Decision Document presents the selected remedial actions for the Camp Allen Landfill Site at Naval Base Norfolk in Norfolk, Virginia. The selected remedial actions were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Contingency Plan (NCP). This Decision Document is based on the Administrative Record for the site.

The Department of the Navy (DoN) has obtained concurrence from the Commonwealth of Virginia and the United States Environmental Protection Agency (USEPA) Region III on the selected remedies.

Assessment of the Site

Actual or threatened releases of hazardous substances from this site (consisting of Areas A and B), if not addressed by implementing the response actions selected in this Decision Document, may present a current or potential threat to public health, welfare, or the environment.

Description of the Selected Remedy

The proposed response actions (or preferred alternatives) identified herein address all contaminated media of concern at the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the preferred alternatives include contaminated soil, surface water/sediment, and groundwater in Areas A and B. Areas A and B of the Camp Allen Landfill Site are described in Section 1.0 and are illustrated in Figure 1-1.

The principal threat posed by conditions at the Camp Allen Landfill Site is that contaminated soil in the Area A Landfill provides a potential source of contamination, which threatens the underlying aquifers. Although groundwater at the site currently is not used for any purpose, contaminated groundwater at the site could pose a human health risk if utilized as a drinking water source under a potential future residential use scenario. The response actions for this site address the principal threat posed by the site via in situ treatment of Area A soils, extraction and treatment of groundwater in Areas A and B, institutional controls, and monitoring. A removal action has been successfully implemented for Area B soil/waste, which has eliminated the primary source of groundwater contamination in this area. The major components of the preferred alternatives for the various media are briefly described below. For a more detailed description and analysis of remedial alternatives, the reader is referred to Sections 7.0 and 8.0 of this document, and to the Camp Allen Landfill Site Final Feasibility Study (Baker, November 1994).

Area A Soil

- In situ treatment of soil and shallow groundwater in Area A1 by dual phase vacuum extraction (DPVE)

    - DPVE system is able to extract both soil and shallow groundwater (water table aquifer) contamination with a single system

    - Groundwater extracted by the DPVE system would be pumped to proposed on-site water treatment plant

- Institutional Controls (maintenance of fence and grass-cover and deed restrictions) for Areas A1 and A2

Area B Soil

- Institutional controls (fence maintenance and deed restrictions)

Areas A and B Surface Water/Sediment

- Institutional controls to restrict future land use
- Monitoring to track trends in contamination levels in these media
- Additional sampling/analysis of surface water/sediment to determine the full extent of ecological impacts to the area surrounding the Camp Allen Landfill

Area A Groundwater

- Protection of the Yorktown Aquifer for beneficial use through extraction and treatment (Area A1)
- Protection of the water table aquifer for beneficial use through extraction and treatment (Area A2)
  - Groundwater extracted through pumping wells would be pumped to an on-site water treatment system
- Groundwater monitoring (Areas A1 and A2)
- Institutional controls (Area A1 and A2)

Area B Groundwater

- Protection of both the water table aquifer and the Yorktown Aquifer for beneficial use through extraction and treatment

- Extracted groundwater from both aquifers would be pumped to an on-site water treatment system

- Groundwater monitoring

- Institutional controls

This combination of response actions is expected to significantly reduce potential human health and environmental risks associated with the site by providing effective source control at the site and substantially reducing the potential for migration of contamination.

Statutory Determinations

This remedial action is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedial action utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. Because this remedy will result in hazardous substances remaining on site (in the Area A Landfill) above health-based levels, a review will be conducted within five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Signature (Commander, Naval Base Norfolk) — 14 August 95 — Date

1.0 SITE LOCATION AND DESCRIPTION

The Camp Allen Landfill is located approximately one mile east of Hampton Boulevard and one mile south of Willoughby Bay at the Naval Base Norfolk, Norfolk, Virginia. The Camp Allen Landfill Site and surrounding areas are illustrated in Figure 1-1. Landfilling operations commenced at the Camp Allen Landfill in the early 1940s and continued until approximately 1974. As shown in Figure 1-1, the Camp Allen Landfill is comprised of Area A (approximately 45 acres) and Area B (approximately 3 acres). In addition, source areas identified within Area A are designated as Area A1 and Area A2, as shown in Figure 1-1.

The Camp Allen Salvage Yard operation (scheduled to close in 1995) is located between Camp Allen Landfill Areas A and B. The salvage yard stores and recycles scrap such as wood, metal, appliances, abandoned cars, drums of various materials, and other types of surplus material.

The Camp Allen Landfill Site is located in mixed-use, urban land. Military facilities are located atop and/or adjacent to the landfill areas. Area A incorporates the Navy Brig facility and a heliport, which were built over a portion of the landfill during the mid-1970s. Glenwood Park (an off-base residential area) is located to the west of Area A. The Camp Allen Elementary School is located to the south of Area B, and the Capehart Military Housing Area is located south of the Camp Allen Elementary School. Various military activities, including USMC Camp Elmore operations, are conducted throughout the Camp Allen area.

At present, most of Area A and Area B is soil-covered and vegetated to minimize surface erosion. The area is surrounded by drainage ditches, which convey surface water runoff to Willoughby Bay. These drainage ditches are remnants of Bousch Creek, the main drainage channel, which was completely filled and replaced by a network of ditches and channels during the development of Naval Base Norfolk.

1.1 Physical Geography/Regional Geology

The Camp Allen Landfill Site and surrounding area can be characterized as a former tidal flat associated with the Bousch Creek drainage channel. The area was developed from marine sediments whose major constituents include sands, silts, and clays with considerable amounts of shell material and gravel.

The uppermost geologic unit and youngest formation is the Columbia Group; its average thickness ranges from 20 to 50 feet. The unconsolidated sediments are characterized by light-colored clay, sand, and silt. Monitoring wells installed at Camp Allen and in the vicinity confirm the sand depth to an average of 23 to 25 feet and dark clays, silts, and sands from 25 to 30 feet below ground surface. These later elements extend to the top of the Yorktown Formation. Surficial soils are primarily silts and clays that quickly grade into the sands and silts of the Columbia Group.

The Yorktown Formation underlies the Columbia Group, and is characterized by coarse sand, gravel, and abundant shell fragments. Regionally, the Yorktown Formation ranges in thickness from 300 to 400 feet. In the vicinity of the site, the Yorktown was encountered between 37 and 63 feet below grade and extends to a depth of approximately 130 feet.

1.2 Natural Resources

1.2.1 Surface Water

Surface water at Area A of the Camp Allen Landfill Site is primarily accommodated by two drainage ditches, which are remnants of Bousch Creek. Surface water from the site is eventually conveyed to Willoughby Bay through a main drainage channel, which begins at the northwest corner of Area A. Due to the proximity of this area to Willoughby Bay and the low relief of the land surface, the remnant tributaries of Bousch Creek are tidal throughout the Base. Surface water from the Camp Allen Salvage Yard, located between Areas A and B, is directed via storm sewers to the drainage ditch north of Area A.

Surface drainage at the Camp Allen Landfill Site is relatively poor in places, especially at Area B, due to the flatness of the area and silty/clayey nature of site surficial soils, which tend to retard infiltration. Patterns of surface drainage can be observed in Figure 1-2.

1.2.2 Groundwater

Two aquifer systems are impacted by the Camp Allen Landfill: the water table aquifer (Columbia Group) and the underlying Yorktown Aquifer (Yorktown Formation). The water table aquifer (shallow groundwater) is unconfined. The Yorktown Aquifer (deep groundwater) is separated from the water table aquifer by a confining clay unit. In the Camp Allen Area, a breach and/or ineffective (poorly developed) portion of the confining clay unit allows downward migration of constituents from the water table aquifer to the Yorktown Aquifer. Figure 1-3 presents generalized groundwater flow patterns for both the water table and Yorktown aquifer systems.

Groundwater on site currently is not used for any purpose. Potable water used on site and by the nearby community is supplied by the City of Norfolk, which obtains its water from a number of interconnected surface water sources (i.e., lakes, reservoirs and rivers) and from several groundwater wells during drought conditions. The shallow (water table) aquifer in the vicinity of the site is generally not suitable for potable (drinking water) use because of high concentrations of iron, manganese and suspended solids, as well as low pH (less than 6). In addition, a City of Norfolk ordinance does not allow potable use of the shallow aquifer. The water table aquifer is considered a Class 3 aquifer (i.e., not a potential source of drinking water and of limited beneficial use). The deeper Yorktown Aquifer is generally suitable for potable uses, except near tidal waters, which can cause the water to be brackish in quality. The Yorktown Aquifer is considered a Class 2 aquifer (i.e., current and potential sources of drinking water and waters having other beneficial uses). However, neither the water table nor Yorktown aquifers are used as a potable source on site or in the vicinity of the site.

Residential wells are present within Glenwood Park, located west of the Brig Facility, but are used only for nonpotable uses such as lawn watering, car washing and filling swimming pools. These wells reportedly are screened within the shallow (water table) aquifer. As a safety precaution, the residents in Glenwood Park were advised by the Navy to consider their private wells nonpotable. The deep groundwater (Yorktown Aquifer) in the vicinity of the site is also used for nonpotable purposes. Two currently inactive nonpotable wells, located approximately 1 mile northwest of the site, reportedly pumped about 100,000 gallons per day from the Yorktown Aquifer for use as process water.

1.2.3 Wetlands

Several types of wetlands have been identified in the vicinity of the site. Wetlands are an important natural resource because of their well-documented abilities in flood and soil erosion control. Wetlands also provide suitable habitat and cover for a variety of birds, reptiles, mammals, fish, and plants. The wetlands identified in the area of the Camp Allen Site are described as mostly a Palustrine system with a subsystem classification of Palustrine Scrub Shrub (PSS), Palustrine Emergent Wetland (PEM), and a Riverine Intermittent system with a Riverine stream bed subsystem (R4SB). Figure 1-4 depicts the most recently identified wetland areas near the Camp Allen Site. Each of these wetland areas has been assigned numbers 1 through 4 for identification purposes.

SECTION 1.0 FIGURES

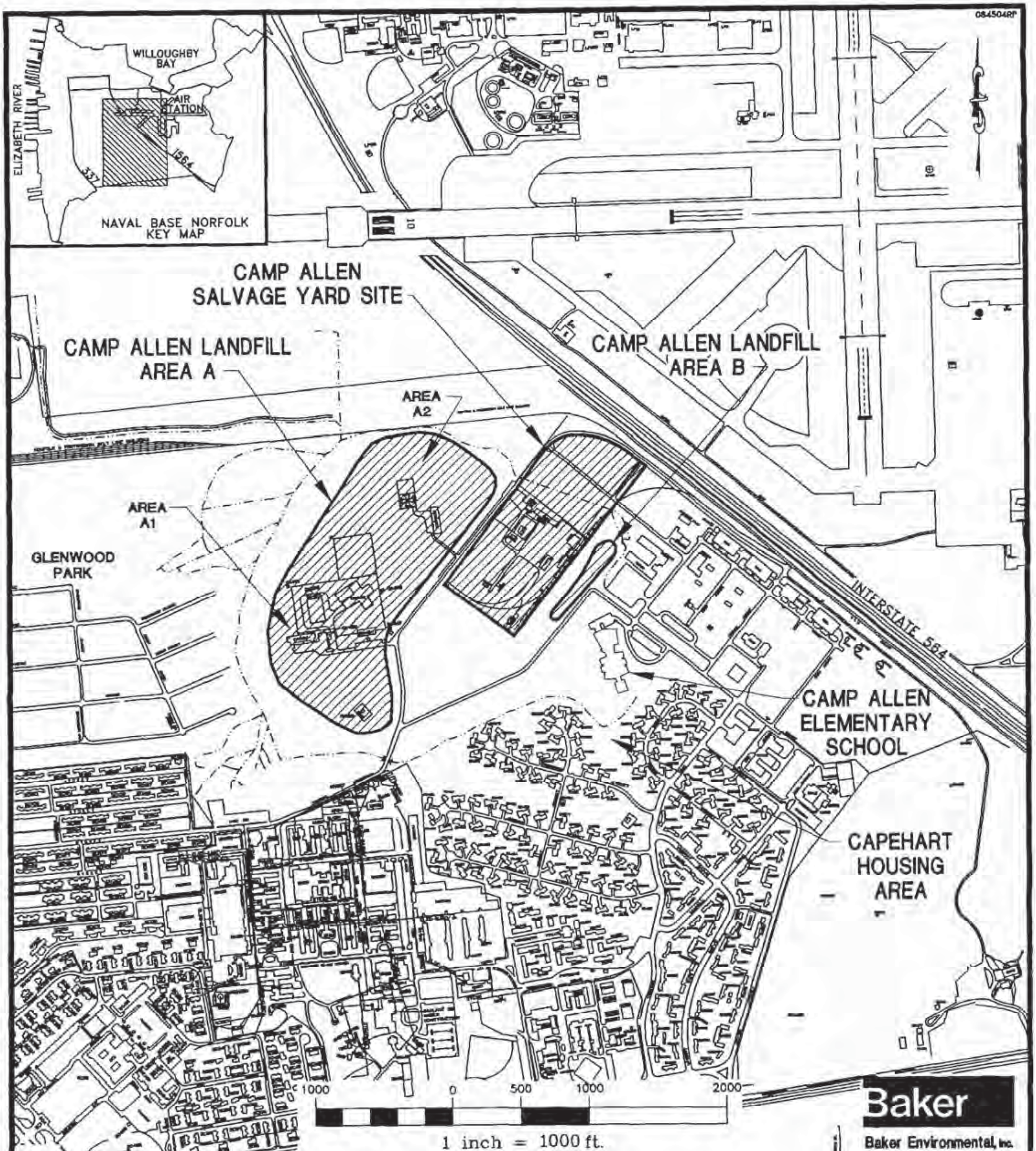
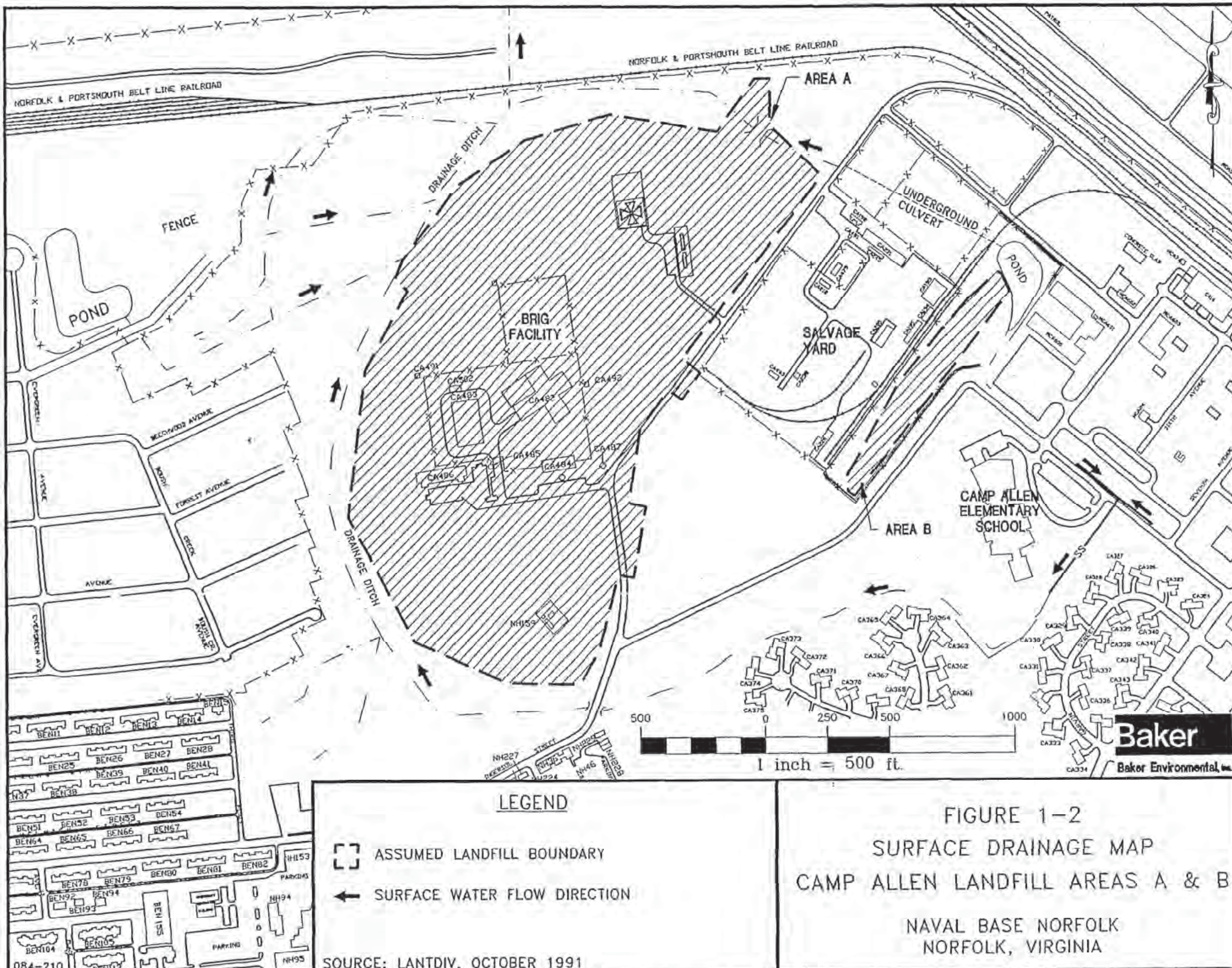


FIGURE 1-1
SITE MAP
CAMP ALLEN LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

SOURCE: LANTDIV, OCTOBER 1991



LEGEND

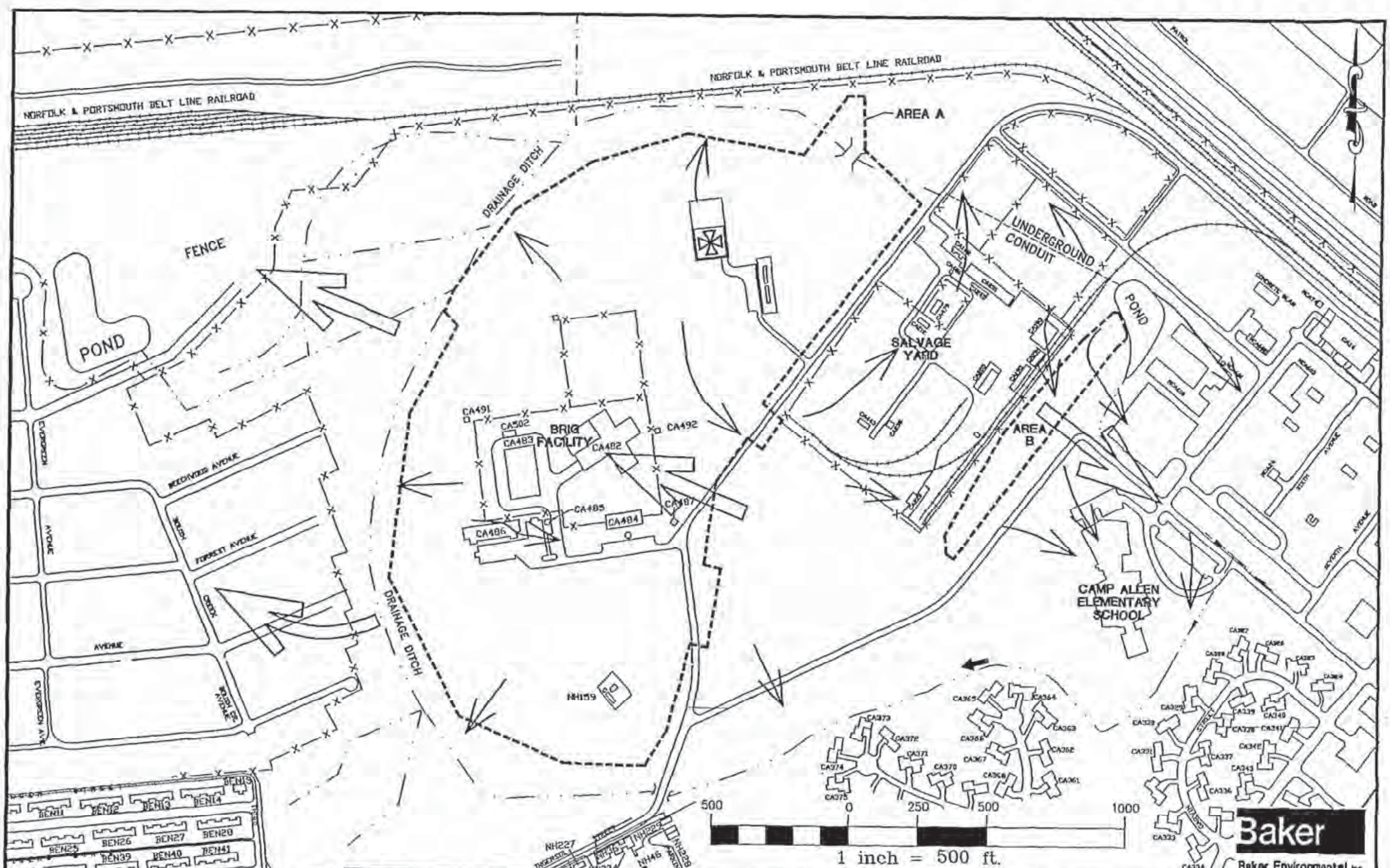
ASSUMED LANDFILL BOUNDARY

SURFACE WATER FLOW DIRECTION

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 1-2
SURFACE DRAINAGE MAP
CAMP ALLEN LANDFILL AREAS A & B

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

ASSUMED LANDFILL BOUNDARY

GENERAL DEEP GROUNDWATER FLOW DIRECTION (YORKTOWN AQUIFER)

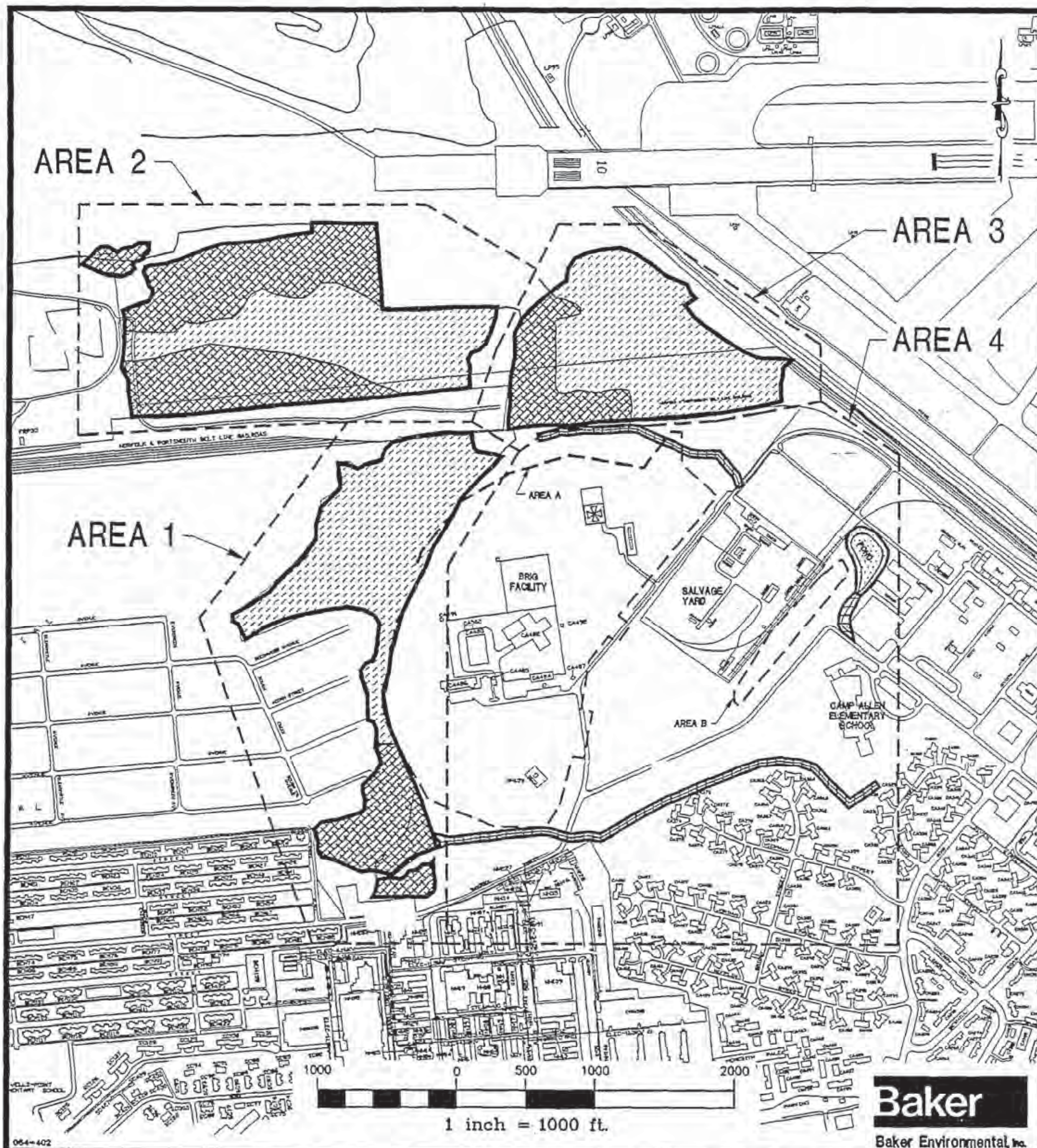
GENERAL SHALLOW GROUNDWATER FLOW DIRECTION (WATER TABLE AQUIFER)

NOTE: INFORMATION DEPICTED ON THIS FIGURE IS GENERALIZED AND DOES NOT INDICATE ACTUAL DEFINED PATTERNS.

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 1-3
GENERAL GROUNDWATER FLOW PATTERNS
CAMP ALLEN LANDFILL AREAS A & B

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

PALUSTRINE EMERGENT WETLAND (PEM)

PALUSTRINE SCRUB SHRUB (PSS)

RIVERINE STREAM BED SUBSYSTEM (R4SB)

PALUSTRINE UNCONSOLIDATED BOTTOM (PUB)

SOURCE: USFWS/NATIONAL RESOURCE MANAGEMENT STAFF, ATLANTIC DIVISION, NAVAL FACILITIES ENGINEERING COMMAND

FIGURE 1-4
WETLAND LOCATION MAP
CAMP ALLEN LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The regulatory basis of the site investigation, the land use history of the site, and the previous investigations which have been conducted at the site are briefly discussed below.

2.1 Installation Restoration Program

The Naval Base Norfolk currently is not on the National Priorities List (NPL), although it is expected to be placed on the NPL sometime in 1995. Therefore, there have been no enforcement activities at the site. The Camp Allen Landfill Site has been studied to date under the Installation Restoration Program (IRP).

The Camp Allen Landfill Site was identified during the IRP process as requiring investigation and evaluation of potentially hazardous materials. The following sections describe the history of the Camp Allen Landfill Site and summarize the results of previous investigations.

2.2 Site History

Area A of the Camp Allen Landfill is a 45-acre, grass-covered site that was used for the disposal of a variety of wastes. During the early 1940s, landfill operations commenced at the Camp Allen Landfill and continued until about 1974. Unknown various waste materials were disposed in Area A including demolition debris, sludges from metal plating processes, parts cleaning and paint stripping wastes, overage chemicals, various chlorinated organic solvents, acids, caustics, paints and paint thinners, pesticides, asbestos, and ash from an incinerator, which operated from the mid-1940s until the mid-1960s. Portions of the landfill now accommodate the Navy Brig Facility and a heliport.

Area B is a 3-acre landfill, which was used to dispose residue and debris resulting from a 1971 fire at the Camp Allen Salvage Yard.

2.3 Previous Investigations

Previous investigations of various hazardous waste sites at the Naval Base Norfolk (including the Camp Allen Landfill) were conducted and documented in an Initial Assessment. In addition, a Site Suitability Assessment, Confirmation Study, Interim Remedial Investigation Report, and an Interim Remedial Investigation have been conducted specifically for the Camp Allen Landfill Site. These investigations are briefly described below:

- Initial Assessment Study (IAS) (February 1983): In April 1982, an IAS was conducted at Sewell's Point Naval Complex at the Naval Base Norfolk. Based on review of historical records and general site reconnaissance, the Camp Allen Landfill was among the sites at the Naval Base Norfolk recommended for further study.

- Site Suitability Assessment (June 1984): Assessment activities were conducted for a proposed Brig Expansion from 1983 to 1984. The field investigation included a magnetometer survey, soil borings, and installation of 11 shallow groundwater monitoring wells and nine gas monitoring stations.

- Confirmation Study (April 1987): Six shallow and one deep groundwater monitoring wells were installed as part of the Confirmation Study. Existing wells were sampled, and surface water sampling was performed.

- Interim Remedial Investigation Report (March 1988): This interim report summarized Confirmation Study results for the Camp Allen Landfill. Additional field activities were not performed.

- Interim Remedial Investigation (1990-1991): A soil gas survey was performed in the vicinity of Area B. Nine shallow and six deep monitoring wells at Area A and eight shallow and three deep monitoring wells at Area B were installed. A week-long tidal study was performed in order to determine estimated influence on the groundwater regime. Groundwater was subsequently sampled from 26 new and 10 existing monitoring wells. A second round of samples was also collected from the nine deep wells. In addition, 55 residential wells in Glenwood Park were sampled for volatile organic compounds.

Surface water and sediment samples were collected and analyzed from adjacent drainage ditches at Area A and the pond at Area B.

- Remedial Investigation (1992-1993): A remedial investigation (RI) was performed to further assess the nature and extent of contamination at the Camp Allen Landfill Site. The following activities were performed:

  - Geophysical survey
  - Monitoring well installation and sampling
  - Surface soil sampling
  - Surface water and sediment sampling
  - Source characterization
  - Residential well sampling
  - Air monitoring of Navy Brig and Camp Allen Elementary School

  A summary of pertinent RI findings is presented in Section 5.1.

2.4 Removal and Remedial Actions

2.4.1 Area B Removal Action

Based on the RI findings, an Engineering Evaluation/Cost Analysis (EE/CA) (Baker, August 1993) for a non-time-critical removal action in Area B was performed to develop and evaluate alternatives for removal and disposal of contaminated subsurface soil and debris identified in former waste burial trenches at this location. The selected removal action alternative included:

- Excavation of the soil, debris, and buried drums from the trenches plus over-excavation of visibly-contaminated soil from the side walls and floor of the excavation;

- Confirmation soil sampling and analysis, and additional excavation of material contaminated in excess of the removal action cleanup levels;

- Disposal of excavated soil, debris, and drums at a RCRA-permitted hazardous waste disposal facility (landfill or incinerator).

The Area B removal action was initiated in the summer of 1994 and has been completed. The objective of the removal action was to remove the primary sources of groundwater contamination within the Area B Landfill so that no further remedial actions would be required for the soils and debris associated with the Area B Landfill. Confirmation soil sampling and analysis, as outlined in the Remedial Action Closeout Report (OHM, March 1995), verified that the soil cleanup levels were met as established in the Final EE/CA Report (Baker, August 1993). Therefore, the primary sources of contamination at Area B have been eliminated.

2.4.3 Remedial Design/Remedial Actions

In order to expedite the cleanup of contaminated soil and groundwater at the Camp Allen Landfill site, the DoN has proceeded with preliminary remedial design/remedial action (RD/RA) activities. Remedial design activities were initiated in the spring of 1994 and are expected to be completed in early 1995. The basis for the remedial design (groundwater and soil remediation) is summarized in the Final Basis of Design Report (Baker, May 1994). In addition, limited remedial action activities have been initiated at the site, including installation of groundwater extraction wells and performance of a DPVE pilot test in Areas A1 and A2 (OHM, December 1994).

Initially, DPVE was recommended for Areas A1 and A2 to provide source control in these "hot spot" areas of the Area A Landfill. As discussed herein, DPVE technology is no longer recommended for use in Area A2 based on the results of the DPVE pilot study. An alternative remediation approach, using submersible pumps to extract shallow groundwater, has been selected for Area A2. This approach, which was not initially proposed as an alternative in the FS, is now the preferred alternative for Area A2 groundwater. Therefore, an additional alternative (A2-GW4) has been added to accommodate the alternative remediation approach for Area A2 groundwater.

3.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The Final Remedial Investigation (RI) (Baker, July 1994), Risk Assessment (RA) (Baker, November 1994), and Feasibility Study (FS) (Baker, November 1994) reports, as well as the Final Proposed Remedial Action Plan (PRAP) (Baker, March 1995) for the Camp Allen Landfill Site have been released and made available to the public in the Administrative Record at the Kirn Memorial Branch of the Norfolk Public Library in Norfolk, Virginia and at information repositories maintained at the Larchmont and Mary Pretlow Branches of the Norfolk Public Library and the Naval Station Library (Building C-9).

The notice of availability of the aforementioned documents was published in the Virginian-Pilot and Ledger Star on March 6, 1995. A public comment period was held from March 6, 1995 to April 5, 1995. In addition, a Restoration Advisory Board (RAB) meeting, in which the public was invited to attend, was held in Norfolk, Virginia on March 22, 1995. At this meeting, representatives from DoN discussed the remedial action alternatives currently under consideration and addressed community concerns. Response to the comments received during the public comment period and additional background information on community involvement for this project are presented in Section 11.0 of this document.

This Decision Document presents the selected response actions for the Camp Allen Landfill Site at Naval Base Norfolk in Norfolk, Virginia, which were chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the NCP. The selected decision for the Camp Allen Landfill Site is based on the Administrative Record.

4.0 SCOPE AND ROLE OF THE RESPONSE ACTION

The proposed response actions identified in this Decision Document address all contaminated media of concern at the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the proposed response actions include contaminated soil, surface water/sediment, and groundwater in Areas A and B. The recommended response actions (or preferred alternatives) for the various media and the rationale for their selection are described in Sections 7.0 through 9.0.

The principal threat posed by conditions at the Camp Allen Landfill Site is that contaminated soil in the Area A Landfill provides a continuing source of contamination, which threatens the underlying aquifers. The combination of proposed response actions is expected to address the principal threat posed by the site by providing effective source control and substantially reducing the potential for migration of contamination. The goals of the selected remedy are: (1) to prevent current or future exposure to the contaminated groundwater, soil, and surface water/sediment; (2) prevent further migration of contaminated groundwater and to remediate groundwater contamination for future potential beneficial uses of the aquifers; and (3) to treat contaminated soils in the areas of concern.

The selected remedial action authorized by this Decision Document addresses contaminated groundwater (shallow and deep) originating from the site through extraction and treatment, and through institutional controls to restrict groundwater use on site. Groundwater currently is not used for any purpose at the site; however, the groundwater poses a potential threat to human health and the environment because of the risks of possible ingestion under a future use scenario and potential off-site migration.

Area A soil also poses a risk to surface water and groundwater due to leaching of contaminants to those media. The selected remedial action addresses contaminated soil in Area A through in situ treatment. Contaminated soil, debris, and drums in Area B have been addressed through a removal action (see Section 2.4). Contaminated soil at the site does not pose a potential human health threat under the current land use scenario; however, the contaminated soils pose a potential threat to human health and the environment because of the risks of exposure to site soils under a future use scenario. The remedial actions for Areas A and B include institutional controls, which include maintenance of the existing fencing and deed restrictions to limit the areas to non-residential land use.

The selected remedial action is expected to comply with applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC) requirements, which are federal and state environmental statutes that are either directly applicable or are considered in the development and evaluation of remedial alternatives at a particular site. Summaries of ARARs and TBCs for the Camp Allen Landfill Site are provided in Tables 10-1 and 10-2 in Section 10.0.

The selected remedial action proposes monitoring of surface water/sediment, but does not address contaminated surface water/sediment through removal or treatment for the following reasons:

- Relatively low levels of contaminants were detected in site surface water and sediments.

- Migration of contaminants from the surface water and sediments to groundwater is not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater).

- Results of the baseline risk assessment for Area A and Area B surface water and sediment indicate no exceedances of human health criteria associated with exposure (via ingestion and dermal contact) to surface water or sediment under the current land uses. Therefore, under the current land uses at Areas A and B, no unacceptable human health effects would be expected from exposure to surface water and sediment.

- Source control measures that have been implemented at Area B (removal action), and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment in these areas over time.

Additional sampling/analysis of surface water/sediment is planned in the immediate future to determine the full extent of ecological impacts to the area surrounding the Camp Allen Landfill.

5.0 SUMMARY OF SITE CHARACTERISTICS

This section presents an overview of the nature and extent of contamination at Camp Allen Landfill with respect to known or suspected sources of contamination, types of contamination, and affected media.

5.1 Contamination and Affected Media

Contamination from prior disposal practices at Areas A and B of the Camp Allen Landfill has been detected in subsurface soils, surface soils, sediment, surface water, and groundwater (water table and Yorktown aquifer systems). Although various organic and inorganic contaminants were detected in site media, the primary constituents of concern at the site are volatile organic compounds (VOCs). Table 5-1 lists primary areas of detected contamination by media and area. Summaries of contaminants of potential concern (COPCs) by environmental media for various areas of the site are presented in Tables 5-2, 5-3, and 5-4. Highlights include source areas of VOCs in subsurface soils identified at or near the top of the water table aquifer in Area A and Area B. In isolated locations, wastes were identified beneath the water table. The following section summarizes the nature and extent of contamination at the Camp Allen Landfill, as established in the Camp Allen Landfill Final RI Report (Baker, July 1994).

Area A

- Subsurface soil: VOCs were the predominant contaminants detected in the subsurface soils at Area A. In general, two primary source locations were indicated. The first area appears to be located in the western portion of the Brig Facility. The second area appears to be located in the northern/northeastern region of Area A (north of the Brig Facility, near the helipad).

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate isolated areas of VOCs and various inorganic constituent concentrations exceeding applicable standards/criteria.

- Sediment: Results indicate isolated areas of elevated levels of organic and inorganic constituent concentrations in small, sporadic areas of the drainage ditches surrounding the area.

- Groundwater: Two primary areas of VOC contamination were identified at Area A. The first area is located in the western portion of the Brig Facility (Area A1) and the second area is located along the north portion of the site near the helipad area (Area A2). Both shallow and deep groundwater contamination are present within these areas. Identified contaminants (primarily VOCs) appear to correspond to source areas mentioned above. Area A1 and Area A2 are shown in Figure 1-1.

- Residential well groundwater sampling: Analytical results indicate that site-related contaminants have not impacted the shallow (water table) groundwater in the Glenwood Park area. Shallow groundwater contamination appears to be limited to the western side of the Brig Facility (located east of Glenwood Park).

- Air sampling: No significant site-specific volatile air contaminants were detected.

Area B

- Subsurface soil: VOCs were the predominant contaminants detected in the subsurface soils at Area B. In general, the primary source area is located in the middle portion of the site within the landfill.

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate areas of VOCs and various inorganic constituent concentrations exceeding applicable standards/criteria primarily in the eastern and northern portion of the ponded area.

- Sediment: Results indicate isolated areas of elevated levels of organic and inorganic constituent concentrations, primarily in the ponded area northeast of the site.

- Groundwater: The primary area of VOC contamination is located south/southeast of Area B. Both shallow and deep groundwater contamination are present within this area. Identified contaminants (primarily VOCs) correspond to the source area within the Area B landfill mentioned above.

- Residential wells: No residential wells reportedly are located in the vicinity of Area B.

- Air sampling: No significant site-specific volatile air contaminants were detected.

5.2 Location of Contamination (Based on Pre-Design Investigation)

The nature and extent of contamination, as determined by the Camp Allen Landfill RI, is summarized in Section 5.1. Additional activities that have been conducted since the RI that impact or further define the location/extent of contamination include the removal action in Area B, described in Section 2.4.1, and a pre-design investigation, which is described below.

In October 1993, Baker initiated a pre-design investigation to further delineate areas of groundwater and soil contamination to support remedial design efforts. Related pre-design activities included: in situ groundwater sampling (hydraulic drive points) and analysis of shallow groundwater in suspected source areas within Area A; well installation (shallow and deep) and groundwater sampling/analysis in Areas A and B; and, test pits in suspected source areas within Area A. The contaminants detected in soil and groundwater were similar to those found during the RI. Detailed information on the pre-design investigation can be found in the Remedial Design Work Plan (Baker, May 1994). A summary of pre-design investigation conclusions is presented below.

The results of the October 1993 groundwater sampling are shown in Figures 5-1 through 5-6 for Areas A1, A2, and B. Based on the well sampling results, the estimated downgradient edges of groundwater contamination in the water table aquifer in Areas A2 and B, and the deep (Yorktown) aquifer in Areas A1, A2 and B were revised as shown in Figure 5-7. Shallow groundwater contamination extends to the base of the water table aquifer, which is located approximately 20 to 30 feet below grade. Contamination in the Yorktown Aquifer generally extends to a depth of approximately 60 to 70 feet below grade.

The test pit investigation results are shown in Figures 5-8 and 5-9 for Areas A1 and A2, respectively. Based on the test pit investigation results and the soil cleanup goals (see Section 9.2.1), two primary source areas were identified in Area A. The source areas were designated Areas A1 and A2, as shown in Figures 5-10 and 5-11, respectively. These figures indicate the estimated extent of soil contamination in Areas A1 and A2. Based on this test pit investigation, the total volume of contaminated soil was estimated to be approximately 12,800 cubic yards.

5.3 Potential Migration Pathways

The threat of contaminant migration from Area B soil has been essentially eliminated by the Area B removal action. The principal threat at the Camp Allen Landfill Site is posed by contaminated soil in the Area A Landfill, which provides a potential source of contamination to the underlying aquifers. Currently, potable water throughout Camp Allen and the surrounding area is supplied by the City of Norfolk. Residential wells in Glenwood Park, located west of Area A, supply water for nonpotable uses only. Although groundwater at the site currently is not used for any purpose, contaminated groundwater at the site could pose a human health risk if utilized as a drinking water source under a potential future residential use scenario.

Migration of contaminants from the surface water and sediments to groundwater is not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater). Source control measures that have been implemented at Area B (removal action), and that are planned for Area A, are expected to improve the quality of surface water and sediment in these areas over time.

The combination of proposed response actions for this site is expected to provide effective source control and substantially reduce the potential for migration of contamination, which will reduce potential human health and environmental risks.

SECTION 5.0 TABLES

TABLE 5-1

SUMMARY OF RI FINDINGS

Media	Area A	Area B
Subsurface Soil	VOCs • West of Brig Facility • North of Brig Facility	VOCs • Middle portion of Area B
Surface Soil	Nominal findings	Nominal findings
Sediment	VOCs • Northwest drainage ditch (Area B related)	VOCs • Ponded area
	Metals • Northeast drainage ditch (Area B related) (various constituents) • Northern drainage ditch (various constituents) • Northwestern drainage ditch (mercury plus others)	Metals • Ponded area (mercury plus others)
Surface Water	VOCs • Northwest drainage ditch (Area B related)	VOCs • Ponded area
	Metals • Throughout Area A (various constituents)	Metals • Ponded area • Throughout drainage ditches
Shallow Groundwater	VOCs • West of Brig Facility • North of Brig Facility	VOCs • South/southeast of Area B
Deep Groundwater	VOCs • West of Brig Facility • North of Brig Facility	VOCs • Underneath Area B

TABLE 5-2

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds: Benzene	--	--	310J	3J	--	--	--
Bromomethane	--	--	--	--	--	--	--
2-Butanone	--	--	4,300	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--
Chloroform	--	--	--	8	--	--	--
Chloromethane	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--	--	--	--
1,2-Dichloroethane	--	--	3J	38J	--	--	--
1,1-Dichloroethene	--	--	--	--	--	--	--
1,2-Dichloroethene	--	--	6,100	540	--	--	--
4-Methyl-2-pentanone	--	--	16,000	--	--	--	--
Methylene chloride	--	--	57J	--	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Volatile Organic Compounds (Continued): Tetrachloroethene	--	--	620	4	6J	--	--
Toluene	--	3,000,000	5,400	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--
Trichloroethene	--	--	1,800	100	20	--	--
1,2,4-Trimethylbenzene	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	--	--	--	--	--
Benzyl chloride	--	--	--	--	--	--	--
Vinyl chloride	--	--	3,300	100	6J	--	--
Total Xylenes	--	--	--	--	3J	--	--
Semivolatile Organic Compounds: Hexachlorobutadiene	--	--	--	--	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Semivolatile Organic Compounds: (Continued) 2-Methylphenol	--	--	1,800J	--	--	--	--
2,4-Dimethylphenol	--	--	1,400J	--	--	--	--
4-Methylphenol	--	--	21,000	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	13	--	3J	--	--
Bis(2-chloroethyl)ether	--	--	--	2J	--	--	--
Acenaphthene	--	--	--	--	--	--	4,100
Pesticides: Aldrin	--	--	0.026J	--	--	--	--
alpha-Chlordane	--	--	--	--	0.015J	--	--
delta-BHC	--	--	--	--	0.025J	--	--
gamma-BHC (Lindane)	--	--	--	--	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Pesticides (Continued): 4,4'-DDD	--	--	--	--	0.26L	--	--
4,4'-DDE	--	--	--	--	0.069J	110	85
4,4'-DDT	--	--	--	--	--	73L	--
Dieldrin	--	89K	--	--	0.027J	--	62
gamma-Chlordane	--	--	--	--	0.024J	--	--
Heptachlor epoxide	--	--	0.14L	0.0065J	0.006J	--	--
Polychlorinated Biphenyls: Aroclor-1254	--	1,600	--	--	0.44J	--	980
Aroclor-1260	420L	1,800	--	--	--	1,500	--
Metals (2): Aluminum	9,880	--	132,000 (-)	49,600 (-)	20,300J	--	--
Antimony	--	--	31 (-)	-- (-)	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Metals (Continued): Arsenic	70	--	309 (200L)	64.35L (4.9)	64.2	590	71
Barium	1,050J	--	7,270 (6,060)	(-)	409	--	--
Beryllium	--	--	10.6 (-)	-- (-)	--	--	--
Cadmium	88.9	--	45.9 (-)	6.5 (-)	--	160	180
Chromium	121	--	353 (-)	165.5 (-)	--	3,000	1,700
Copper	477	--	356 (-)	-- (-)	--	553J	--
Lead	683	--	381L (1.6)	44.2 (-)	800	1,000	540
Manganese	128	--	2,060J (2,630)	2,170 (284)	697	51.2	50.7
Mercury	--	--	(-)	(-)	3.9	3	1.1

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Nickel	--	--	352	-- (-)	--	--	--
Silver	--	--	-- (-)	-- (-)	12	110	49
Thallium	0.92	--	-- (-)	6L (-)	--	--	--
Vanadium	78.7	--	396 (-)	355.5 (-)	--	180	74
Zinc	--	--	-- (-)	-- (-)	1,860J	--	542K

Notes:

(1) Maximum detected concentrations are presented only for those constituents retained as COPCs in the Revised Final Human Health Risk Assessment.
(2) Maximum detected concentrations presented for metals in soils and sediments are in units of mg/kg.
-- Not retained as a COPC for the respective environmental medium in the Revised Final Human Health Risk Assessment.
() = Concentration or "--" in parentheses is for dissolved (filtered) constituent in groundwater.
J Value estimated
K Estimated value, biased high
L Estimated value, biased low

TABLE 5-3

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds:							
Benzene	--	--	410	12	12	--	--
Bromomethane	--	--	--	--	--	--	--
2-Butanone	--	--	48	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--
Chloroform	--	--	--	1J	24	--	--
Chloromethane	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	3J	--	--	--	--
1,2-Dichloroethane	--	--	180	450	8J	--	--
1,1-Dichloroethene	--	--	51	--	--	--	--
1,2-Dichloroethene	--	--	1,600	16	--	--	--
4-Methyl-2-pentanone	--	--	--	--	--	--	--
Methylene chloride	--	--	--	--	--	--	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds (Continued): Tetrachloroethene	--	--	10J	--	--	--	--
Toluene	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--
Trichloroethene	--	3,100	520	35	45	--	--
1,2,4-Trimethylbenzene	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	--	--	--	--	--
Benzyl chloride	--	--	--	--	--	--	--
Vinyl chloride	--	16	940J	3	22	60	10J
Total Xylenes	--	--	--	--	--	--	--
Semivolatile Organic Compounds: Hexachlorobutadiene	--	--	--	--	--	--	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Semivolatile Organic Compounds: (Continued) 2-Methylphenol	--	--	--	--	--	--	--
2,4-Dimethylphenol	--	--	--	--	--	--	--
4-Methylphenol	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	5J	--	9J	--	--
Bis(2-chloroethyl)ether	--	--	8J	--	--	--	--
Acenaphthene	--	--	--	--	--	--	--
Pesticides: Aldrin	--	--	--	--	--	--	--
alpha-Chlordane	--	--	--	--	--	--	--
delta-BHC	--	--	--	--	--	--	--
gamma-BHC (Lindane)	--	--	0.15	--	--	--	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Pesticides (Continued): 4,4'-DDD	--	3,800	--	--	--	4,200	--
4,4'-DDE	--	--	--	--	--	850	60L
4,4'-DDT	--	--	--	--	--	--	4,400
Dieldrin	--	1,500	0.043J	0.009J	--	86K	--
gamma-Chlordane	--	--	--	--	--	--	--
Heptachlor epoxide	--	--	0.006J	0.0105J	--	--	--
Polychlorinated Biphenyls: Aroclor-1254	--	9,500	--	--	--	7,600	--
Aroclor-1260	780L	--	--	--	--	--	--
Metals (2): Aluminum	--	15,500	192,000 (-)	146,000 (-)	690	--	--
Antimony	--	8L	28.7 (32.9)	25.2L (-)	--	16L	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Metals (Continued): Arsenic	11.6	60.5J	93.6 (16.4)	194L (1.3)	6.7	42.7	--
Barium	--	1,480	1,740 (-)	596 (-)	--	--	--
Beryllium	--	5.6	18.5 (-)	11.2 (-)	--	0.76	0.56
Cadmium	20.5	--	17.8 (-)	30.8 (-)	--	41.9	12
Chromium	44.3	--	774.5 (22.2)	542K (-)	--	--	--
Copper	--	--	380 (-)	225 (-)	--	298	--
Lead	--	--	1,020 (-)	183 (-)	15.8	497J	--
Manganese	102	63.5	4,880 (1,385)	4,740K (356)	272	246	69.6

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Mercury	--	--	3 (-)	-- (-)	--	0.35K	--
Nickel	--	--	433 (-)	203 (-)	--	--	--
Silver	--	--	-- (-)	-- (-)	--	14.7	--
Thallium	--	2	-- (-)	-- (-)	--	--	--
Vanadium	--	149	1,610 (29.9)	769K (-)	--	130	--
Zinc	--	--	1,550 (-)	-- (-)	202	1,020	--

Notes:

(1) Maximum detected concentrations are presented only for those constituents retained as COPCs in the Revised Final Human Health Risk Assessment.

(2) Maximum detected concentrations presented for metals in soils and sediments are in units of mg/kg.

-- Not retained as a COPC for the respective environmental medium in the Revised Final Human Health Risk Assessment.

() = Concentration or "--" in parentheses is for dissolved (filtered) constituent in groundwater.

J Value estimated

K Estimated value, biased high

L Estimated value, biased low

TABLE 5-4

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds: Benzene	--	--	410	12	--	--	--
Bromomethane	--	--	--	--	--	--	--
2-Butanone	--	--	48	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--
Chloroform	--	--	--	1J	--	--	--
Chloromethane	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	3J	--	--	--	--
1,2-Dichloroethane	--	--	180	450	--	--	--
1,1-Dichloroethene	--	--	51	--	--	--	--
1,2-Dichloroethene	--	--	1,600	16	--	--	--
4-Methyl-2-pentanone	--	--	--	--	--	--	--
Methylene chloride	--	--	--	--	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Volatile Organic Compounds (Continued): Tetrachloroethene	--	--	10J	--	--	--	--
Toluene	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--
Trichloroethene	--	3,100	520	35	--	--	--
1,2,4-Trimethylbenzene	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	--	--	--	--	--
Benzyl chloride	--	--	--	--	--	--	--
Vinyl chloride	--	16	940J	3	--	--	--
Total Xylenes	--	--	--	--	--	--	--
Semivolatile Organic Compounds: Hexachlorobutadiene	--	--	--	--	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Semivolatile Organic Compounds: (Continued)							
2-Methylphenol	--	--	--	--	--	--	--
2,4-Dimethylphenol	--	--	--	--	--	--	--
4-Methylphenol	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	5J	--	--	--	--
Bis(2-chloroethyl)ether	--	--	8J	--	--	--	--
Acenaphthene	--	--	--	--	--	--	--
Pesticides:							
Aldrin	--	--	--	--	--	--	--
alpha-Chlordane	--	--	--	--	--	--	--
delta-BHC	--	--	--	--	--	--	--
gamma-BHC (Lindane)	--	--	0.15	--	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Pesticides (Continued): 4,4'-DDD	--	3,800	--	--	0.038J	--	--
4,4'-DDE	--	--	--	--	--	--	--
4,4'-DDT	--	--	--	--	--	--	--
Dieldrin	--	1,500	0.043J	0.009J	--	--	--
gamma-Chlordane	--	--	--	--	--	--	--
Heptachlor epoxide	--	--	0.006J	0.0105J	--	--	--
Polychlorinated Biphenyls: Aroclor-1254	--	9,500	--	--	--	--	--
Aroclor-1260	--	--	--	--	--	--	--
Metals (2): Aluminum	--	15,500	192,000 (-)	146,000 (-)	--	--	--
Antimony	7.8L	8L	28.7 (32.9)	25.2L (-)	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Metals (Continued): Arsenic	25.1L	60.5J	93.6 (16.4)	194L (1.3)	11.5K	--	--
Barium	--	1,480	1,740 (-)	596 (-)	--	--	--
Beryllium	--	5.6	18.5 (-)	11.2 (-)	--	--	--
Cadmium	--	--	17.8 (-)	30.8 (-)	--	--	--
Chromium	869	--	774.5 (22.2)	542K (-)	--	--	--
Copper	--	--	380 (-)	225 (-)	--	--	--
Lead	--	--	1,020 (-)	183 (-)	53.6	--	310
Manganese	61.2	63.5	4,880 (1,385)	4,740K (1,356)	574	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Mercury	--	--	3 (-)	-- (-)	--	--	0.8
Nickel	--	--	433 (-)	203 (-)	--	--	--
Silver	--	--	-- (-)	-- (-)	--	--	--
Thallium	--	2	-- (-)	-- (-)	--	--	--
Vanadium	128	149	1,610 (29.9)	769K (-)	--	--	--
Zinc	--	--	1,550 (-)	-- (-)	199J	--	--

Notes:

(1) Maximum detected concentrations (based on RI sampling Rounds 2 and 3) are presented only for those constituents retained as COPCs in the Revised Final Human Health Risk Assessment (Baker, February 1995).

(2) Maximum detected concentrations presented for metals in soils and sediments are in units of mg/kg.

-- Not retained as a COPC for the respective environmental medium in the Revised Final Human Health Risk Assessment (Baker, February 1995).

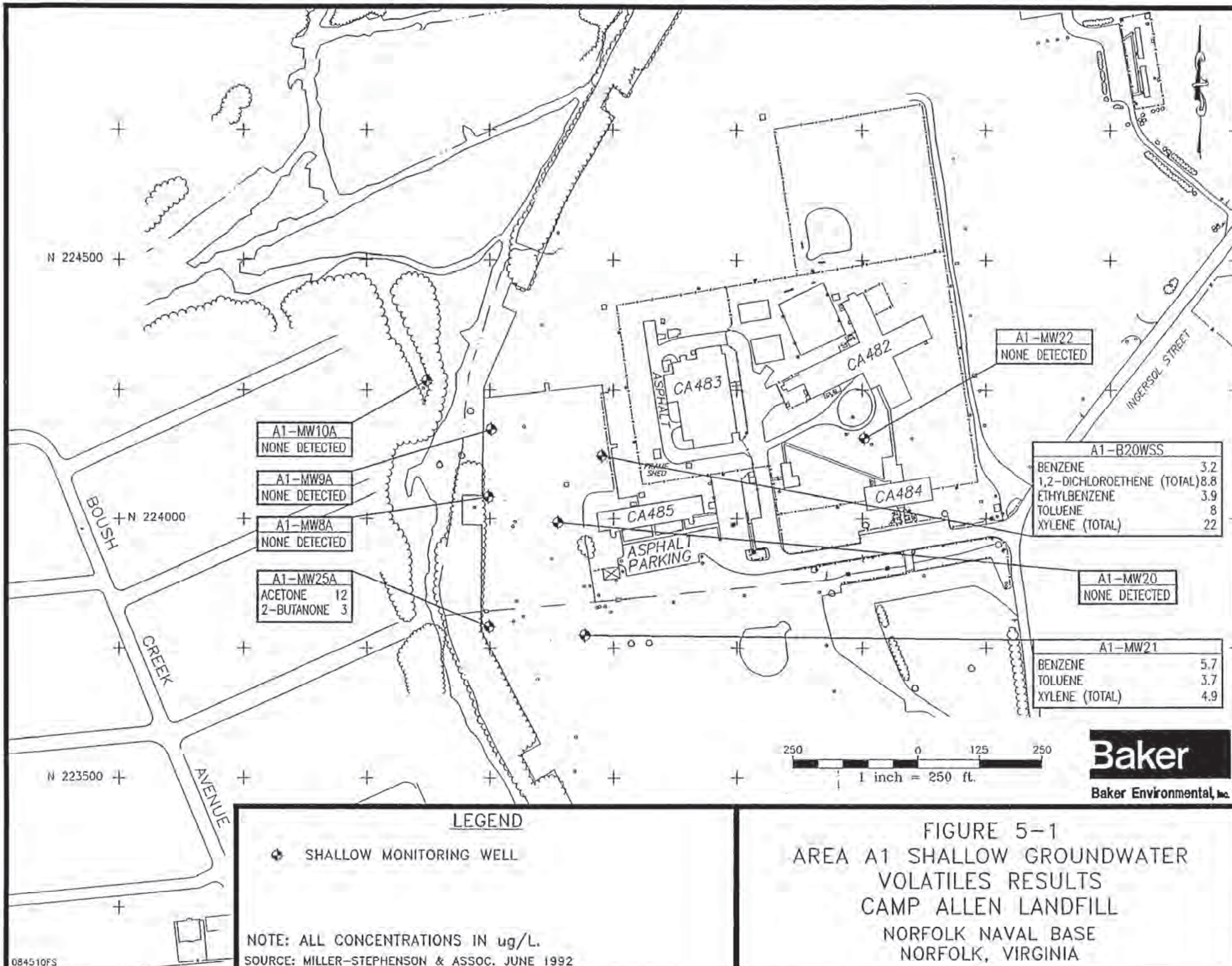
() = Concentration or "--" in parentheses is for dissolved (filtered) constituent in groundwater.

J Value estimated

K Estimated value, biased high

L Estimated value, biased low

SECTION 5.0 FIGURES



Baker

Baker Environmental, Inc.

LEGEND

- SHALLOW MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-1
AREA A1 SHALLOW GROUNDWATER VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

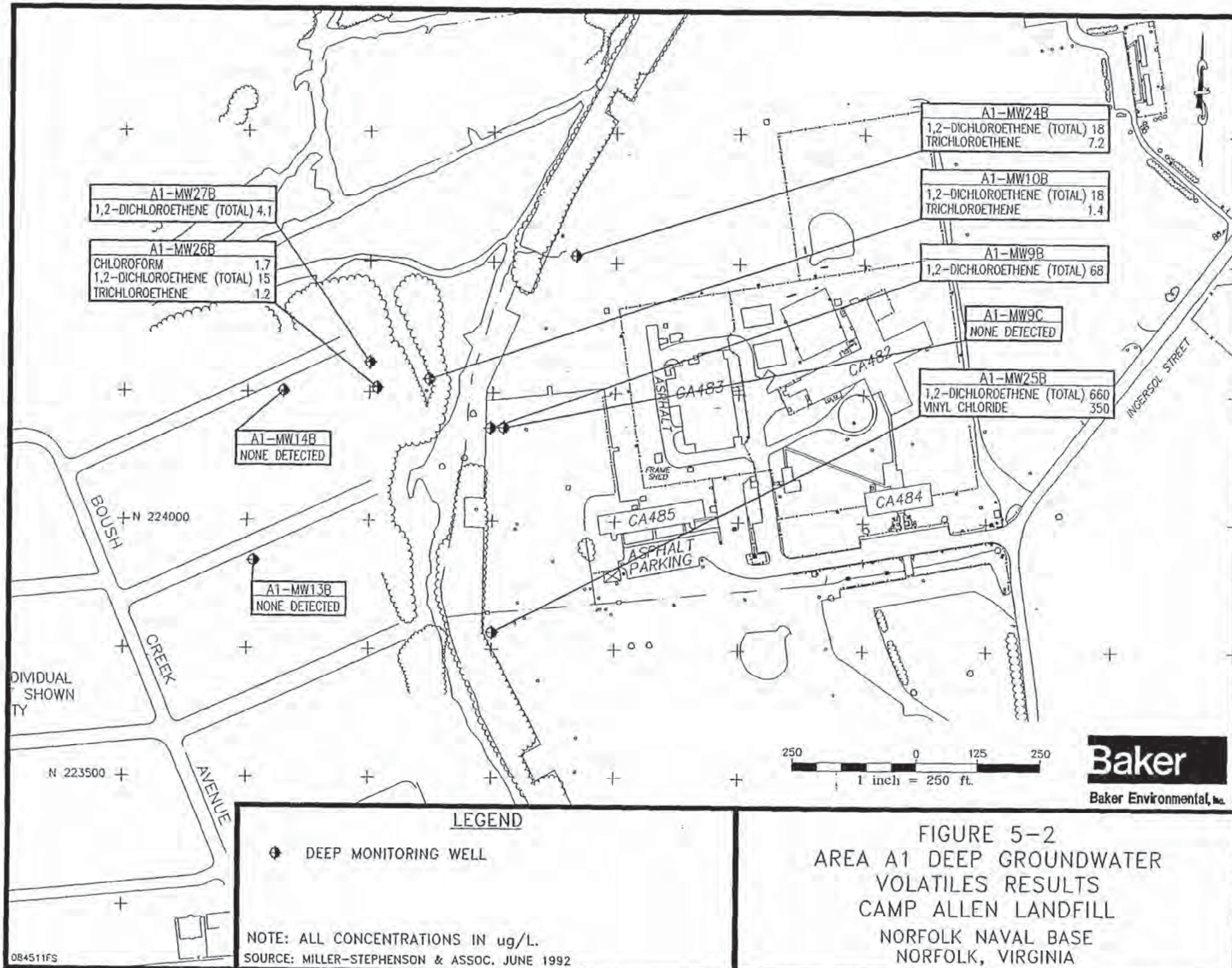
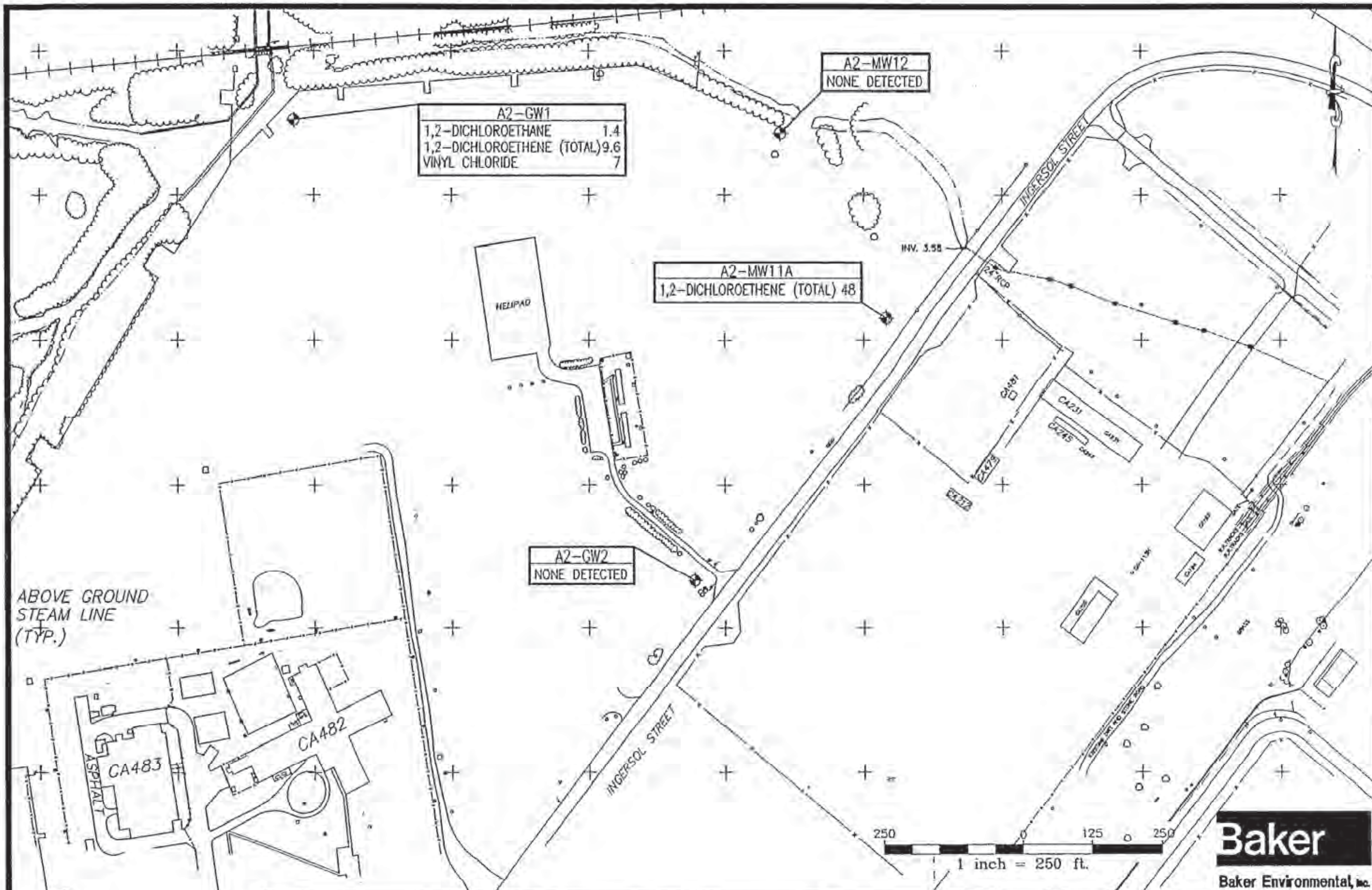


FIGURE 5-2
AREA A1 DEEP GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



Baker
Baker Environmental, Inc.

LEGEND

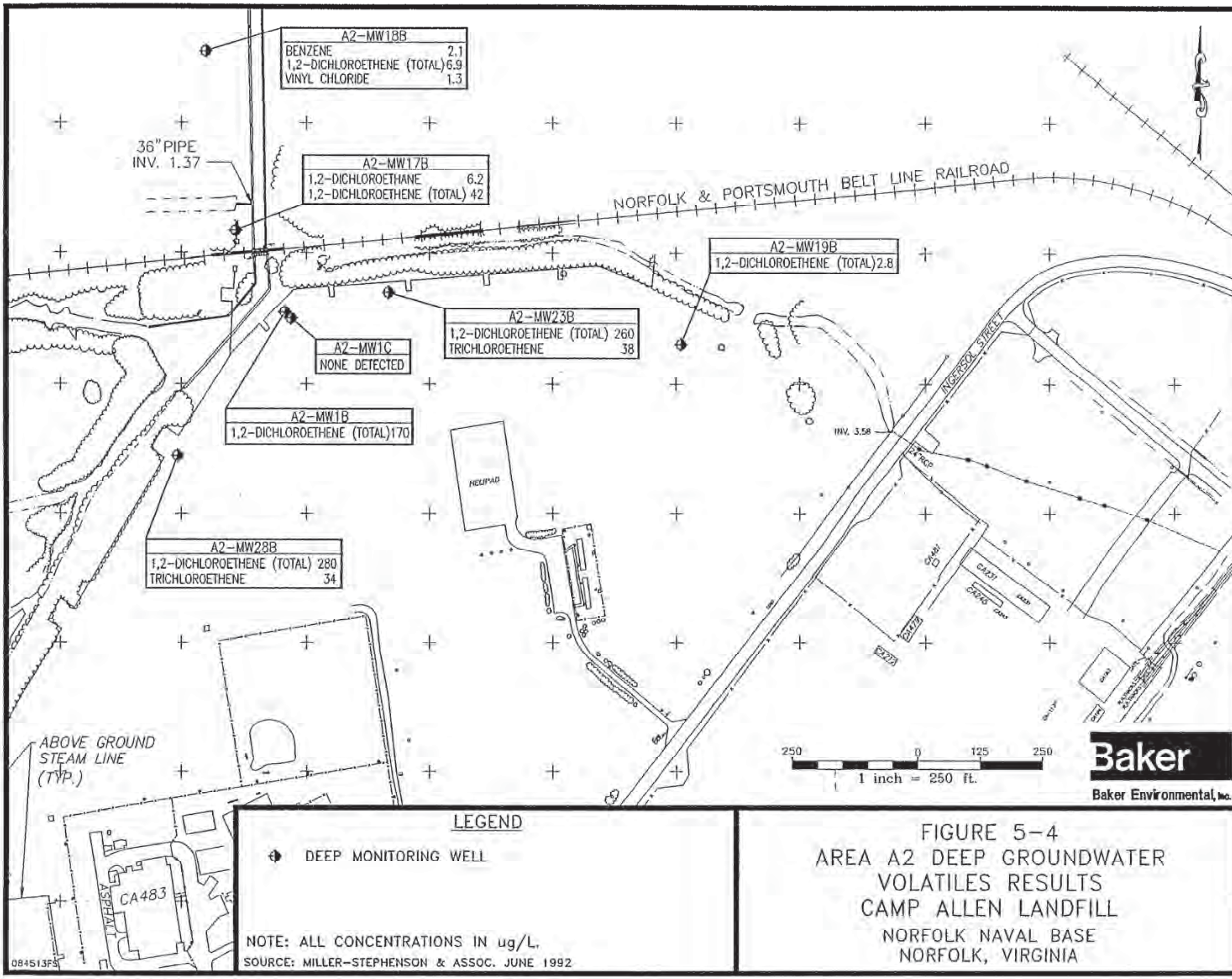
SHALLOW MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

084512FS

FIGURE 5-3
AREA A2 SHALLOW GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



Baker
Baker Environmental, Inc.

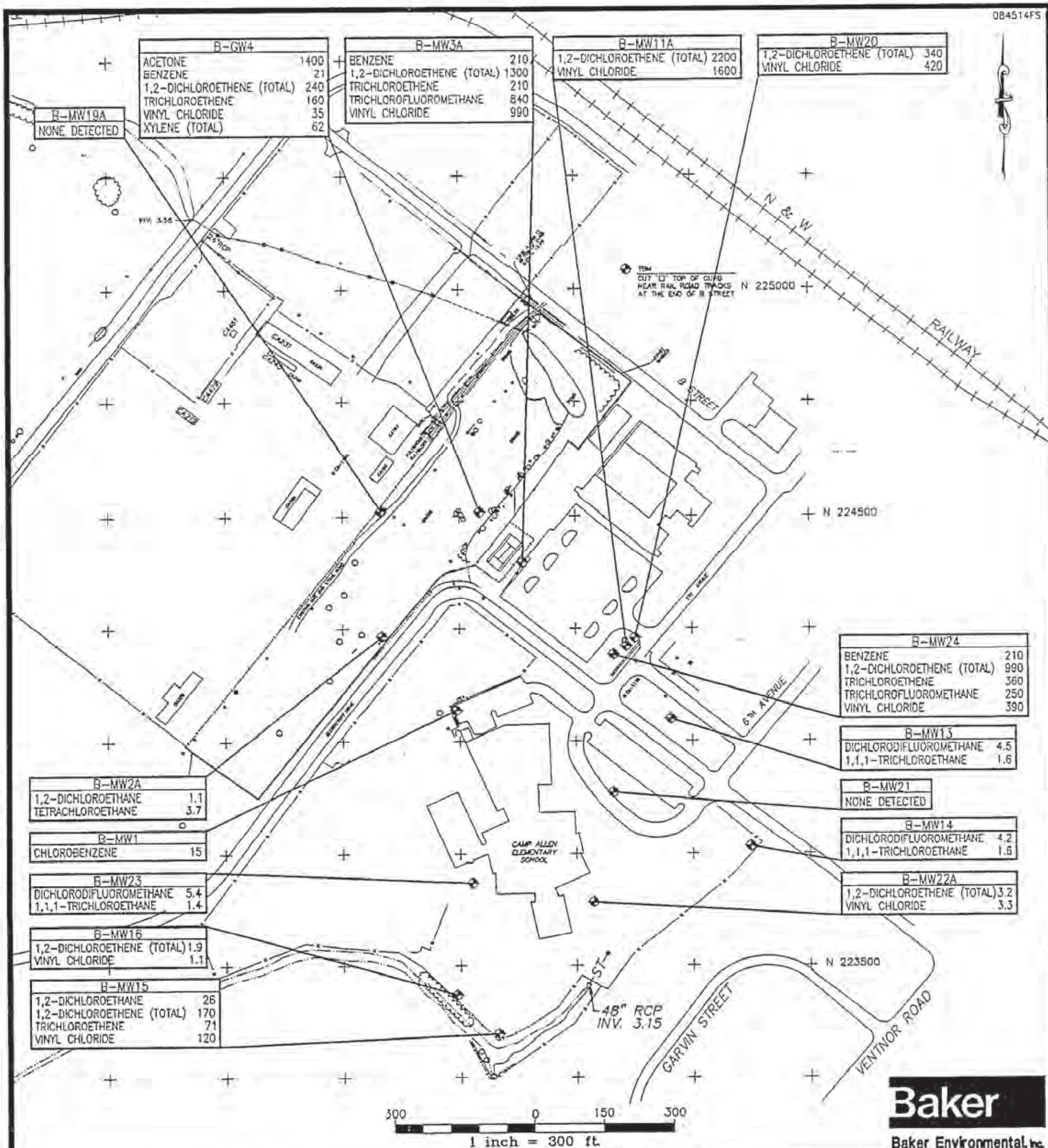
LEGEND

DEEP MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-4
AREA A2 DEEP GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



Baker
Baker Environmental, Inc.

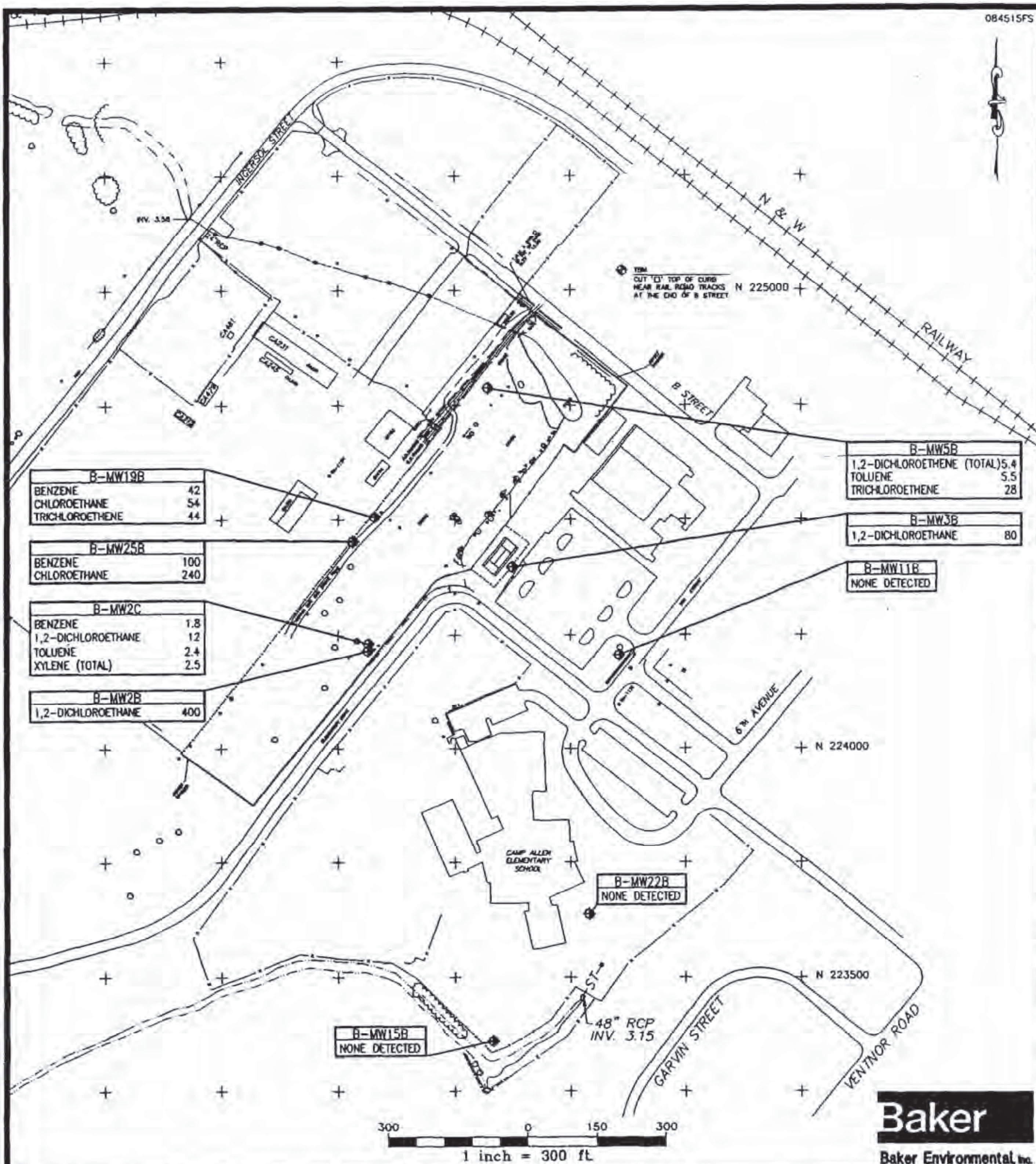
LEGEND

SHALLOW MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.
SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-5
AREA B SHALLOW GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



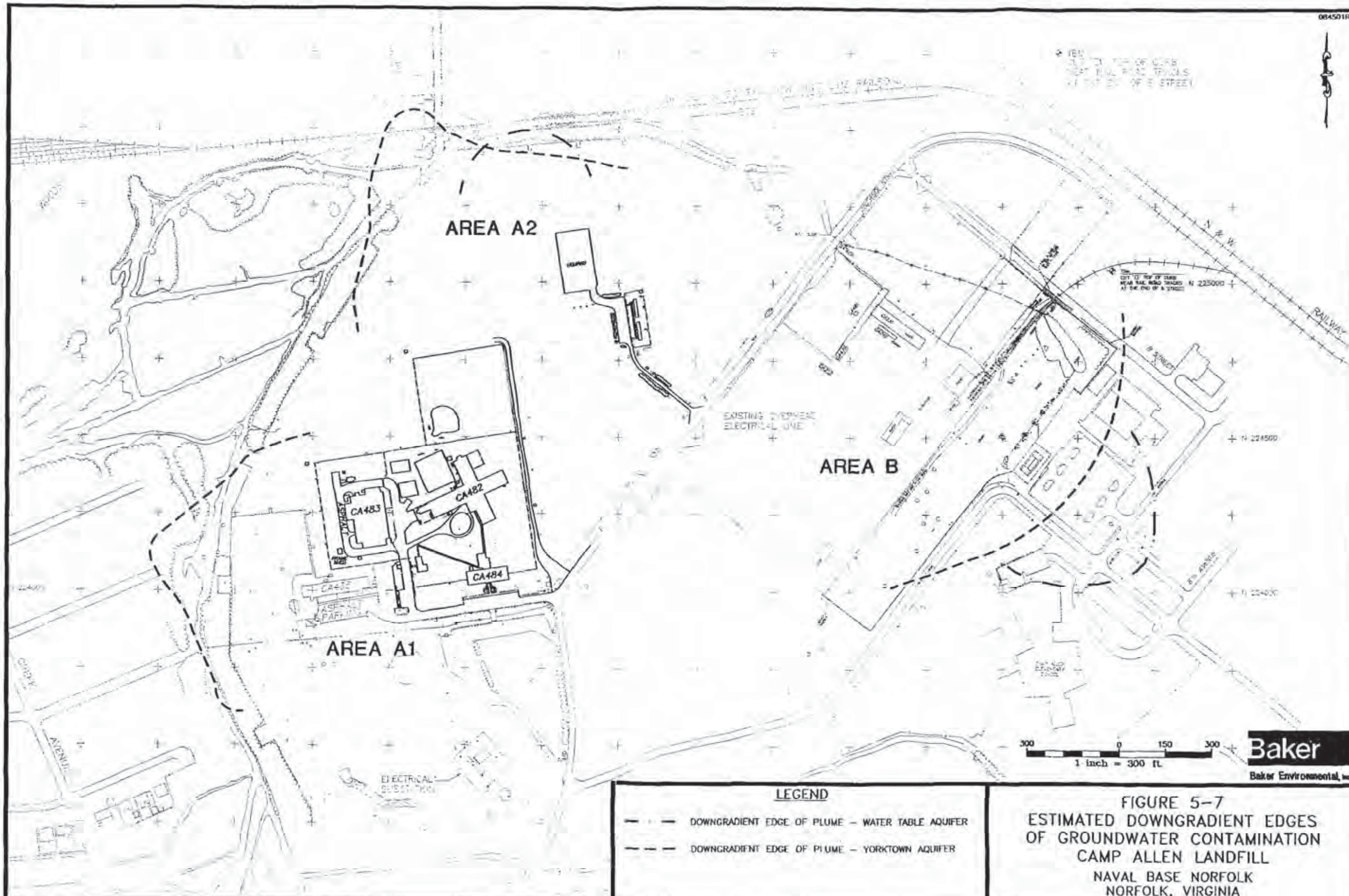
LEGEND

⊕ DEEP MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.
SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-6
AREA B DEEP GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

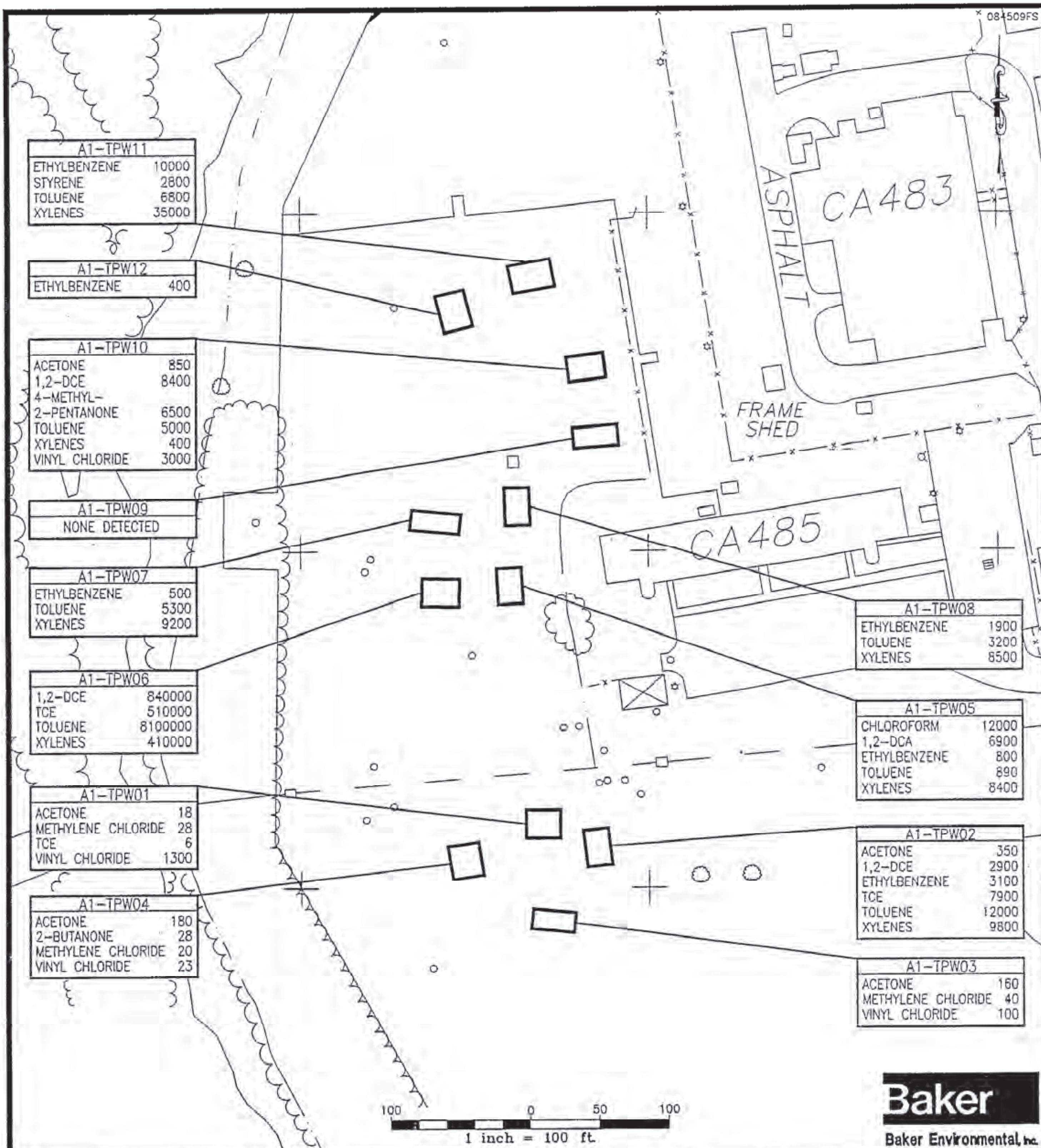


LEGEND

— · — DOWNGRADIENT EDGE OF PLUME – WATER TABLE AQUIFER

— — — DOWNGRADIENT EDGE OF PLUME – YORKTOWN AQUIFER

FIGURE 5–7
ESTIMATED DOWNGRADIENT EDGES OF GROUNDWATER CONTAMINATION
CAMP ALLEN LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



Baker

Baker Environmental, Inc.

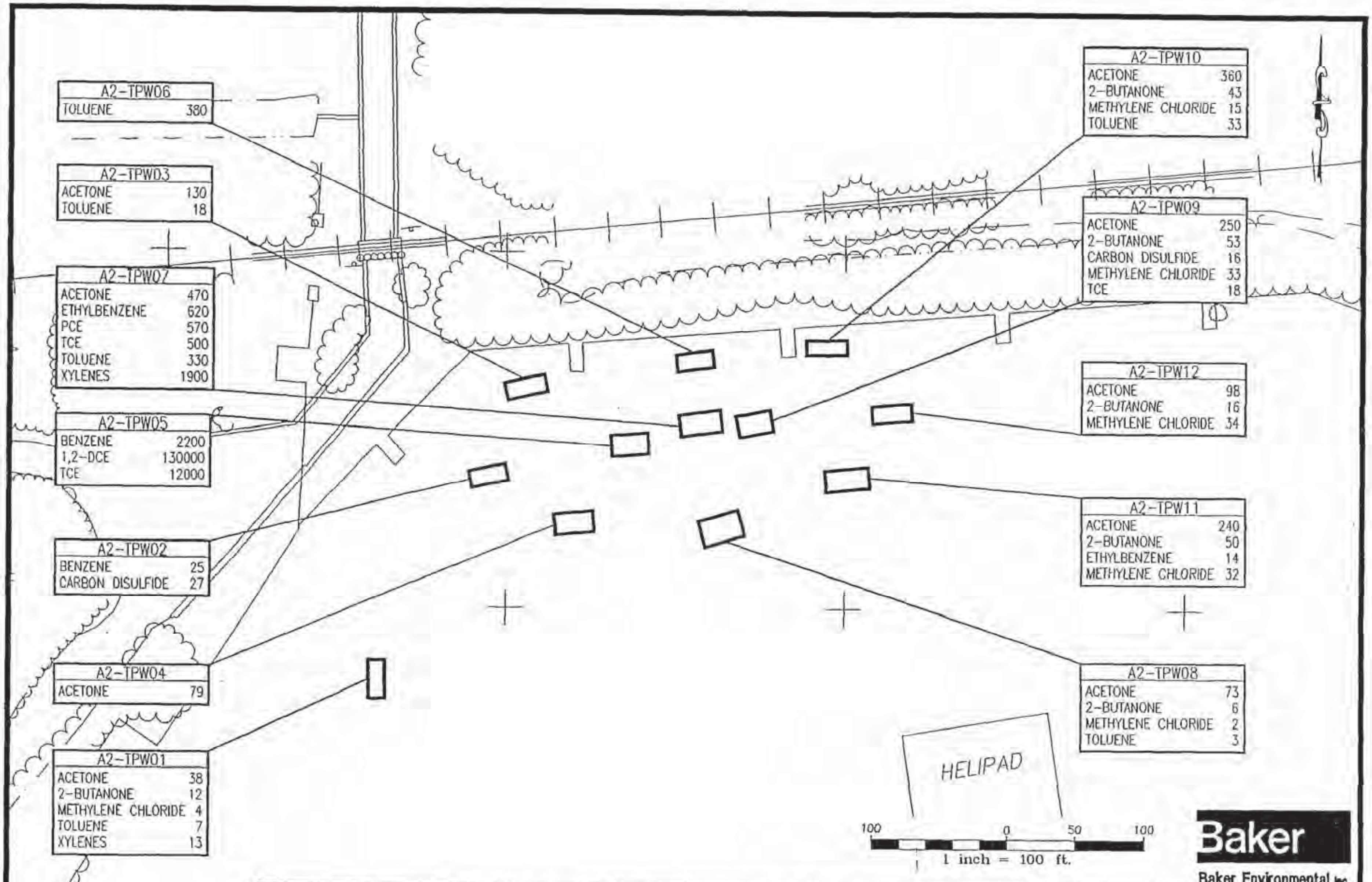
LEGEND

▭ TEST PIT

NOTE: ALL CONCENTRATIONS IN ug/kg.

FIGURE 5-8
AREA A1 TEST PIT LOCATIONS
AND VOLATILES RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



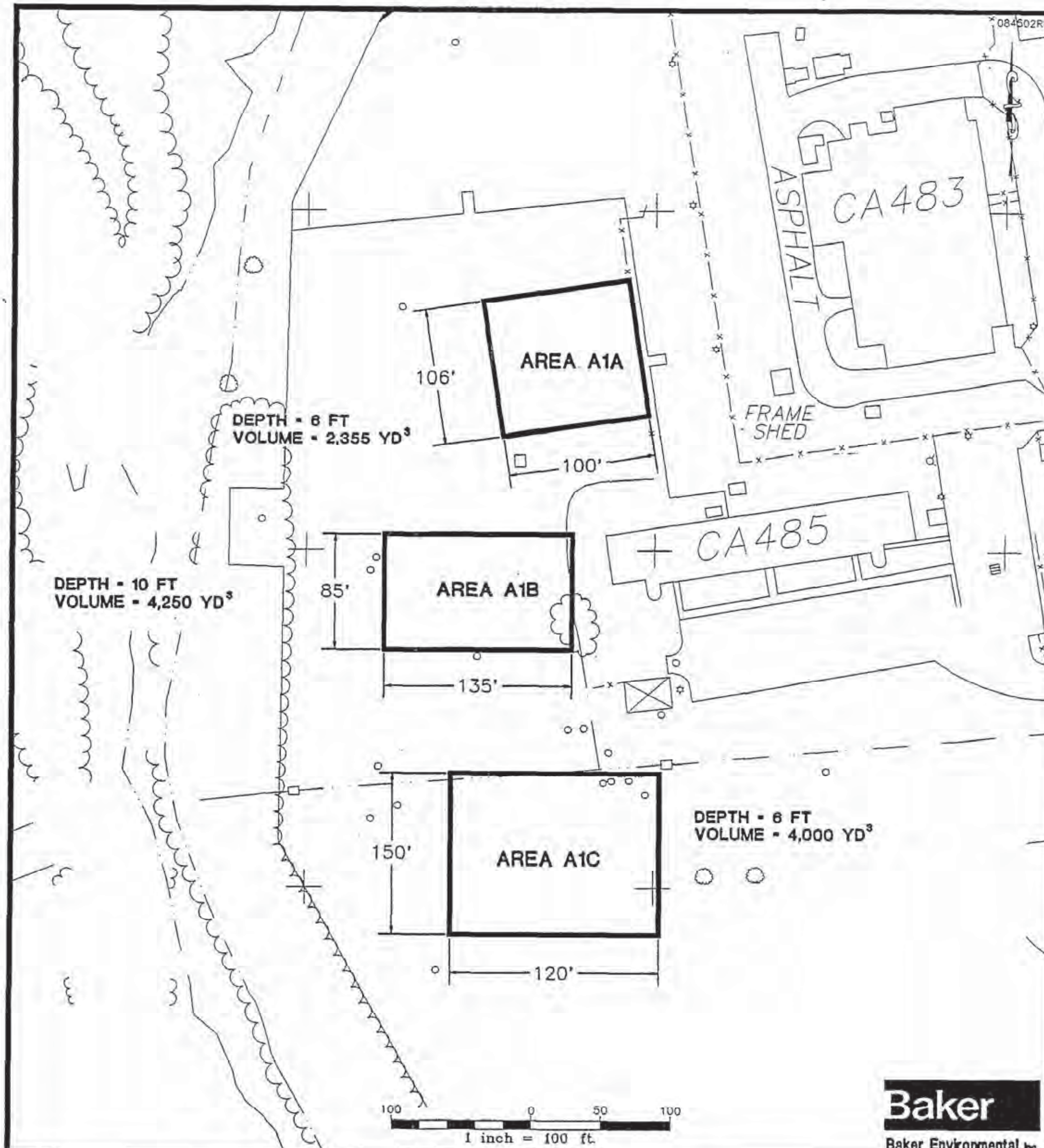
LEGEND

TEST PIT

NOTE: ALL CONCENTRATIONS IN ug/kg.

FIGURE 5-9
AREA A2 TEST PIT LOCATIONS
AND VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

084508FS

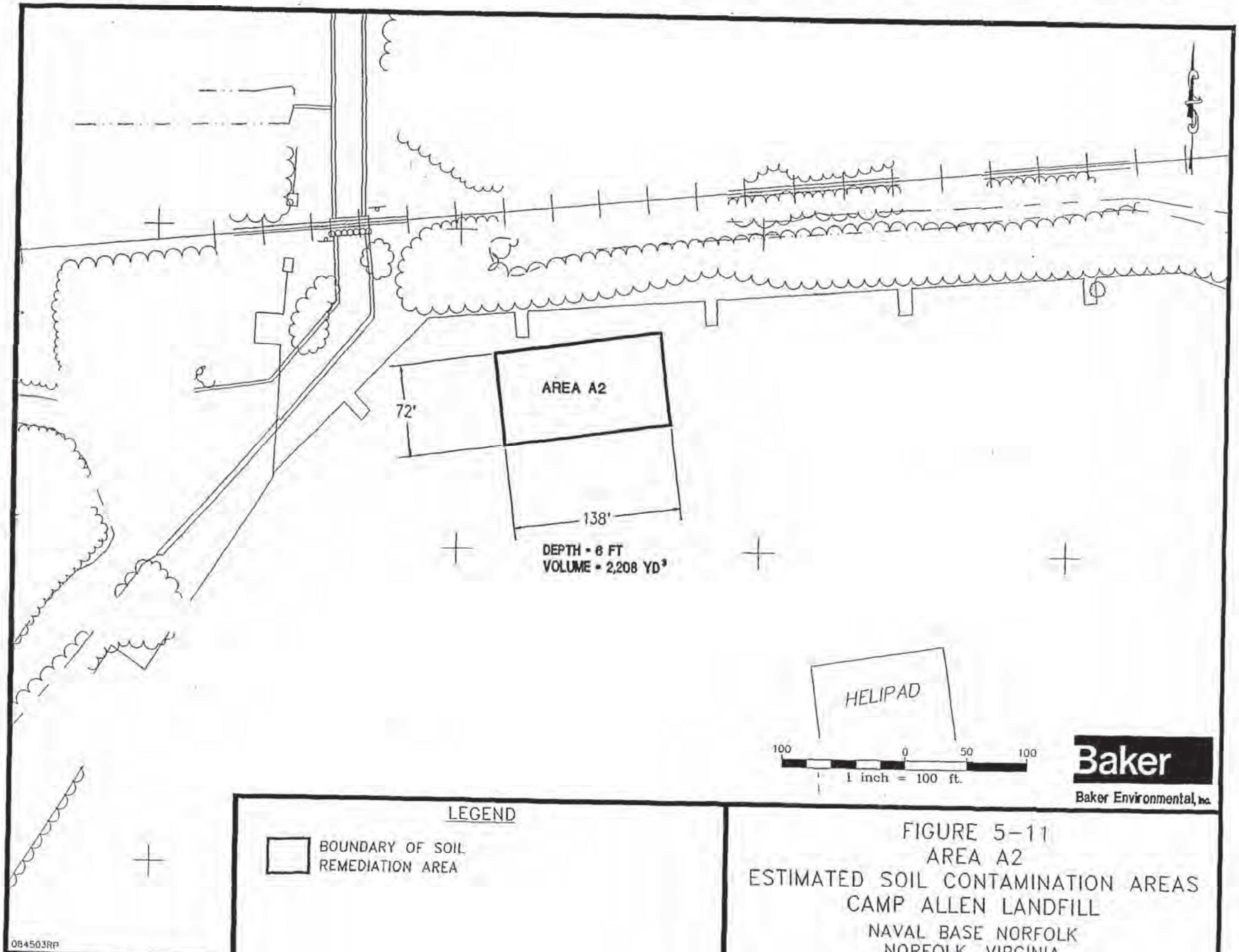


LEGEND

BOUNDARY OF SOIL REMEDIATION AREA

FIGURE 5-10
AREA A1
ESTIMATED SOIL CONTAMINATION AREAS
CAMP ALLEN LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

BOUNDARY OF SOIL REMEDIATION AREA

FIGURE 5-11
AREA A2
ESTIMATED SOIL CONTAMINATION AREAS
CAMP ALLEN LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

6.0 SUMMARY OF SITE RISKS

The potential human health risks associated with exposure to contaminated media within Areas A and B of the Camp Allen Landfill Site were evaluated under current use and potential future use scenarios in the baseline risk assessment. An ecological evaluation was also performed. The public health risks and ecological risks associated with the site are summarized below and are presented in detail in the Revised Final Baseline Risk Assessment (Baker, February, 1995).

6.1 Summary of Human Health Risks

The Human Health RA consisted of the following four components:

- Identification of Chemicals of Potential Concern
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

The results of these risk assessment components are summarized in the following sections.

6.1.1 Identification of Chemicals of Potential Concern

In the RI, chemicals detected in environmental media were discussed with respect to applicable Federal and Commonwealth of Virginia criteria and/or standards, and a preliminary account of chemicals of potential concern (COPCs) was presented. Chemicals detected in environmental media sampled during the RI were reevaluated to select COPCs for evaluation in the baseline RA. Chemicals selected as COPCs in the RA are presented in Tables 5-2 through 5-4 in Section 5.0 of this document.

COPC selection was based on the information provided in the USEPA Region III Technical Guidance on the Screening of Exposure Pathways and Selection of Contaminants of Concern, dated January 1993 (USEPA Region III, 1993) and USEPA's Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A), Interim Final, December 1989 (USEPA, 1989).

Both of these guidances provide a number of criteria by which chemical data can be evaluated. The primary criterion used in selecting a chemical as a COPC at the Camp Allen Landfill included comparison of maximum detected concentrations with USEPA Region III risk-based COPC screening concentrations, as derived in accordance with USEPA Region III Technical Guidance on the Screening of Exposure Pathways and Selection of Contaminants of Concern (USEPA Region III, January 1993), chemical prevalence, and site history.

6.1.2 Exposure Assessment

The exposure assessment addresses each current and future potential exposure pathway in groundwater, surface soil, surface water, sediment, and air. To determine whether human exposure could occur at the Camp Allen Landfill Site in the absence of remedial action, an exposure assessment was conducted as part of the RA, which identified potential exposure pathways and receptors. The following four elements were considered to determine whether a complete exposure pathway was present: a source and mechanism of chemical release; an environmental retention or transport medium; a point of potential human contact with the contaminated medium; and an exposure route (e.g., ingestion) at the contact point.

The exposure scenarios developed in the RA represent USEPA's Reasonable Maximum Exposure (RME). Relevant equations for assessing intakes and exposure factors were obtained from the Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation (RAGS) (USEPA, 1989), Exposure Factors Handbook (USEPA, 1989a), Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992), Superfund Exposure Assessment Manual (USEPA, 1988), and Standard Default Exposure Factors, Interim Final (USEPA, 1991).

Development of a conceptual site model of potential exposure is critical in evaluating all potential exposures for the aforementioned human receptors. The conceptual site model describes the area of concern in terms of suspected sources of contamination, the affected media, and all potential routes of migration of the contaminants present. Conceptual site models for Areas A and B are presented in Figures 6-1 and 6-2, respectively.

6.1.3 Toxicity Assessment

The potential health and environmental effects associated with potential exposure to the COPCs were identified during the toxicity assessment in the RA. The toxicological evaluation, which characterized the inherent toxicity of a compound, involved the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with potential exposure to the various chemicals. The end product of this evaluation was a collection of toxicological profiles for the COPCs. These toxicological profiles provided the qualitative weight-of-evidence (WOE) that demonstrated whether facility COPCs pose any actual or potential health and environmental effects.

An important component of the toxicity assessment process is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. Standard reference doses and/or carcinogenic slope factors have been developed for many of the COPCs, which are provided in Table 6-1. Brief descriptions of these parameters are provided below.

Cancer slope factors (CSFs) have been developed by EPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CSFs, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the CSF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer slope factors are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied.

Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur.

6.1.4 Risk Characterization Results

Incremental cancer risks (ICRs) and the potential to experience non-carcinogenic adverse effects (i.e., central nervous system effects, kidney effects, etc.), as measured by a hazard index (HI), were evaluated in this assessment. Estimated incremental cancer risks were compared to the target risk range of 10^{-4} to 10^{-6}, which the USEPA considers to be safe and protective of public health (USEPA, 1989). The calculated HI was compared to a threshold value of one; below this level, there is minimal potential to experience noncarcinogenic adverse health effects.

The risk assessment has shown that past practices at the Camp Allen Landfill Site have contaminated certain media to the extent that they pose a potential threat to human health only under certain potential future residential use scenarios. Although future residential use scenarios are unlikely at the site, they have been incorporated into the baseline comparisons. Table 6-2 summarizes potential health risk values associated with soil, surface water, sediment and air under current use and potential future use (residential) scenarios. Table 6-3 summarizes potential health risk values associated with groundwater under current use (nonpotable) and potential future use (residential) scenarios. Risk values presented for soil, sediment, surface water, air, shallow groundwater, and deep groundwater are considered to be "worst case," as they were derived by selecting those sampling locations with the most primary constituents of potential concern. Sample locations were also selected so as to not underestimate the resulting potential human health risks. Tables 6-4 and 6-5 present the total ICR and HI values for the current potential human receptors at Area A and Area B, respectively. Tables 6-6 and 6-7 present the total ICR and HI values for the future potential residential development of Area A and Area B, respectively.

A summary of human health risks for Areas A and B at the site, by media, is provided below.

Area A - Soil

Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to the surface soil at Area A under the current land use of the area as a Navy Brig (for either prisoners or Brig employees). Also, the risk assessment indicates that no unacceptable adverse human health effects would be expected from exposure to subsurface soils at Area A under a future use scenario for remedial construction workers. However, the HIs calculated for a child and an adult receptor under a future residential use scenario were 6.4 and 1.3, respectively, which exceed the acceptable HI of 1.0 under CERCLA. In addition, ICRs of 1.4×10^{-4} and 1.8×10^{-4} were estimated for a child and an adult receptor, respectively, under a future residential use scenario. These ICRs exceed USEPA's acceptable target risk range of 10^{-4} to 10^{-6}, which the USEPA considers to be safe and protective of public health. The chemicals found in Area A soil that contribute most predominantly to the risks are arsenic and cadmium.

Area B - Soil

Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to the surface soil at Area B under the current land use in the area (i.e., for either employees or children at the Camp Allen Elementary School). Also, the risk assessment indicates that no unacceptable adverse human health effects would be expected from exposure of remedial construction workers to subsurface soils at the Area B Landfill/Pond/School under a remediation (removal action) scenario. The HIs calculated for a child receptor under a future residential use scenario ranged from 1.6 at the Area B Landfill/Pond to 4.5 in the school area, which exceed the acceptable HI of 1.0; however, no unacceptable risks are indicated for an adult receptor under a future residential use scenario. Also, these risks were calculated at the Area B Landfill/Pond based on existing conditions prior to the removal action that has been implemented in this area. Therefore, the actual risks may be much lower in this area since the removal action has been successfully completed. The HI calculated for the Landfill/Pond area was mainly due to arsenic and cadmium in the soil, and the HI value for the Camp Allen Elementary School area was primarily the result of manganese in the soil.

Area A - Surface Water/Sediment

Results of the baseline risk assessment indicate that, under the current land use of this area as a Navy Brig, no unacceptable adverse human health effects would be expected from exposure (via ingestion and dermal contact) to surface water or sediment in Area A. Under a future residential land use scenario, the HIs calculated for a child receptor ranged from 4.0 to 4.8 for exposure (via ingestion and dermal contact) to shallow and deep sediments, respectively, which exceed the acceptable HI of 1.0. An ICR of 1.2×10^{-4} was estimated for a young child resident exposed to shallow sediments, which exceeds the target risk range of 10^{-4} to 10^{-6}. However, no unacceptable risks are indicated for an adult receptor for exposure to sediments under a future residential use scenario. Also, under a future residential land use scenario, the ICR for a child receptor associated with exposure (via ingestion and dermal contact) to surface water is 2.0×10^{-4}, which slightly exceeds the acceptable ICR of 1.0×10^{-4}. Under a future residential land use scenario, the ICR for an adult receptor associated with exposure (via ingestion and dermal contact) to surface water is 1.2×10^{-4}, which also slightly exceeds the acceptable ICR of 1.0×10^{-4}. The chemicals found in Area A sediment that contribute most predominantly to the risks are arsenic, Aroclor-1254, and Aroclor-1260. The chemical found in Area A surface water that contributes most predominantly to the risks is Aroclor-1254.

Area B - Surface Water/Sediment

Results of the baseline risk assessment indicate that, under the current land use of the Area B pond and school, no unacceptable human health effects would be expected from exposure (via ingestion and dermal contact) to the surface water and sediment in the vicinity of Area B. Under a future residential land use scenario, the HI calculated for a child receptor at the Area B Landfill and Pond, under a future residential scenario, was 2.0 for exposure (via ingestion and dermal contact) to shallow sediments. This exceeds the acceptable HI of 1.0. However, no unacceptable risks are indicated for a child receptor for exposure to surface water, and no unacceptable risks are indicated for an adult receptor for exposure to surface water or sediments under a future residential use scenario. The chemicals found in Area B sediment that contribute most predominantly to the risks are arsenic and cadmium.

Areas A and B - Indoor/Outdoor Air

As shown in Table 6-2, results of the baseline risk assessment indicate that, under the current use of Area A (i.e., employees and prisoners at the Navy Brig), no unacceptable human health effects would be expected from the indoor air exposure pathway. Similarly, under the current use exposure scenario for Area B (i.e., children attending Camp Allen Elementary School), no unacceptable human health effects would be expected from exposure to indoor air. With respect to exposure to outdoor (ambient) air, no unacceptable human health effects would be expected for both adult and child receptors under both current and future residential use scenarios.

Area A Groundwater

Results of the baseline risk assessment for Area A indicate that no unacceptable adverse human health effects would be expected from exposure (via incidental ingestion and dermal contact) to the shallow groundwater under the current land use in the area (i.e., nonpotable use of groundwater by Glenwood Park residents). Groundwater currently is not used for any purpose at the Navy Brig facility in Area A.

Under a potential future residential use scenario, the baseline risk assessment indicates that unacceptable risks for both children and adult receptors would be expected from exposures to COPCs in both the shallow and deep aquifers via ingestion, dermal contact, and inhalation under a potable use scenario. A summary of maximum incremental cancer risks and hazard indices for shallow (water table aquifer) and deep (Yorktown Aquifer) groundwater under potential current and future use scenarios is presented in Table 6-3. The chemicals found in Area A groundwater that contribute most predominantly to the risks are 1,2-dichloroethene, vinyl chloride, and trichloroethene.

Area B Groundwater

Results of the baseline risk assessment for Area B indicate that no unacceptable adverse human health effects would be expected from exposure to either deep or shallow groundwater under the current land use in the area since groundwater currently is not used for any purpose at Area B.

Under a potential future residential use scenario (potable use of shallow or deep groundwater), the baseline risk assessment indicates that unacceptable risks for both children and adult receptors would be expected from exposure via ingestion, dermal contact, and inhalation . A summary of maximum incremental cancer risks and hazard indices for shallow and deep groundwater under potential current and future use scenarios is presented in Table 6-3. The chemicals found in Area B groundwater that contribute most predominantly to the risks are 1,2-dichloroethene, benzene, vinyl chloride, trichloroethene, and arsenic.

6.2 Summary of Ecological Risks

The ecological evaluation focused upon three measures of environmental impact from the Camp Allen Landfill: exceedances of state and federal criteria for surface waters and sediments; the presence and distribution of benthic macroinvertebrates; and a qualitative assessment of terrestrial flora and fauna.

Surface water constituents exceeded federal criteria and/or Commonwealth of Virginia standards at sampled locations throughout Areas A and B. National Oceanic and Atmospheric Administration (NOAA) sediment criteria were also exceeded at various locations. These exceedances represent the potential for environmental impacts.

The endpoint of the ecological evaluation used to assess the aquatic and terrestrial environment is decreased integrity of the aquatic and terrestrial community. Exceedances of surface water and sediment quality measurement endpoints indicate a low to moderate potential for risk to aquatic life. The benthic community is characteristic of an aquatic ecosystem that has potential impacts from both contaminant exposure and natural conditions. In addition, this benthic community exhibited spatial variations within the range of natural population variation in similar environments. Based on this finite ecological risk assessment, the aquatic community may be impacted by releases from the Camp Allen Landfill. However, remedial measures are being implemented that provide both source removal and source containment, as well as treatment to control further contaminant migration into the drainage ditches. Therefore, post-remediation studies are warranted to evaluate the reduction of risks to the aquatic community as a result of site remediation activities.

The post-remediation ecological monitoring program will include: 1) surface water and sediment sampling along the drainage ditches adjacent to the Area A and B Landfills and at the Bousch Creek outfall on Willoughby Bay; 2) data analysis; 3) revisions to the Ecological Risk Assessment, as required; and, 4) development of a regional environmental perspective including point and non-point sources to the Bousch Creek and Willoughby Bay watersheds.

The terrestrial qualitative evaluation did not produce any significant indicators of risk to terrestrial receptors based on observations of diversity and productivity of the fauna and flora. Significant potential effects on terrestrial receptors resulting from Area A and B were not observed at any location. For an urban area, the terrestrial habitats appeared to be diverse and productive.

6.2.1 Threatened and Endangered Species

One endangered bird, the peregrine falcon (Falco peregrinus), had been observed at the Camp Allen Landfill during the RI field sampling effort. The falcon does not nest in the area and has been seen infrequently. Local ecologists believe that it was attracted to the site to feed on flocks of starlings and pigeons at the salvage yard.

Incomplete information is available on the levels of environmental contamination at the site (i.e., contaminant levels in site plants and animals), on bioaccumulation and bioavailability of contaminants, and on specific contaminant effects to peregrine falcons. Therefore, it is not possible to definitively assess risk to the falcons. However, the falcons are not present at the site regularly and the birds on which they do feed appear to be healthy.

SECTION 6.0 TABLES

TABLE 6-1

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSF $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
Volatile Organic Compounds: benzene	2.90E-02 (i)	2.90E-02 (i)	--	1.71E-03 (e)	A	Blood	Hematological impairment
benzyl chloride	1.70E-01 (i)	--	--	--	B2	--	--
bromomethane	--	--	1.40E-03 (i)	1.43E-03 (i)	D	Cells	Epithelial hyperplasia of the forestomach/nasal cavity
2-butanone	--	--	6.00E-01 (i)	2.86E-01 (i)	D	Fetus	Decreased birth rate
chlorobenzene	--	--	2.00E-02 (i)	5.71E-03 (a)	D	Liver	Histopathologic changes in liver
chloroform	6.10E-03 (i)	8.05E-02 (i)	1.00E-02 (i)	--	B2	Liver	Lesions
chloromethane	1.30E-02 (h)	6.30E-03 (h)	--	--	C	--	--
1,4-dichlorobenzene	2.40E-02 (h)	--	--	2.29E-01 (i)	C	Liver	Increased weight
1,1-dichloroethane	--	--	1.00E-01 (h)	1.43E-01 (a)	C	--	None observed
1,2-dichloroethane	9.10E-02 (i)	9.10E-02 (i)	--	2.86E-03 (e)	B2	--	--
1,1-dichloroethene	6.00E-01 (i)	1.75E-01 (i)	9.00E-03 (i)	--	C	Liver	Lesions
1,2-dichloroethene	--	--	9.00E-03 (h)	--	D	Liver	Lesions
4-methyl-2-pentanone (methyl isobutyl ketone)	--	--	8.00E-02 (h)	2.29E-02 (a)	--	Liver and Kidney	Increased weight
methylene chloride	7.50E-03 (i)	1.64E-03 (i)	6.00E-02 (i)	8.57E-01 (h)	B2	Liver	Liver toxicity

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF (mg/kg/day)$^{-1}$	Inhal. CSF (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
tetrachloroethene	5.20E-02 (e)	2.03E-03 (e)	1.00E-02 (i)	--	B2/C[(1)]	Liver	Hepatotoxicity
toluene	--	--	2.00E-01 (i)	1.14E-01 (i)	D	Liver and Kidney	Altered weight
1,1,1-trichloroethane	--	--	9.00E-02 (w)	2.86E-01 (w)	D	CNS/Whole Body	Hyperactivity/decreased weight
trichloroethene	1.10E-02 (w)	6.00E-03 (e)	6.00E-03 (e)	--	B2	--	--
1,2,4-trimethylbenzene	--	--	5.40E-04 (c)	--	--	--	--
1,3,5-trimethylbenzene	--	--	4.00E-04 (e)	--	--	--	--
vinyl chloride	1.90 (h)	3.00E-01 (h)	--	--	A	--	--
m-xylene	--	--	2.00 (h)	2.00E-01 (w)	D	CNS/Whole Body	Hyperactivity/decreased weight
o-xylene	--	--	2.00 (h)	2.00E-01 (w)	D	CNS/Whole Body	Hyperactivity/decreased weight
p-xylene	--	--	--	8.57E-02 (w)	D	CNS/Whole Body	Hyperactivity/decreased weight
xylenes (total)	--	--	2.00 (i)	--	D	CNS/Whole Body	Hyperactivity/decreased weight

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF (mg/kg/day)$^{-1}$	Inhal. CSF (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
Semivolatile Organic Compounds: acenaphthene	--	--	6.00E-02 (i)	--	--	Liver	Hepatotoxicity
bis(2-chloroethyl)ether	1.10 (i)	1.16 (i)	--	--	B2	--	--
bis(2-ethylhexyl)phthalate	1.40E-02 (i)	--	2.00E-02 (i)	--	B2	Liver	Increased weight
2,4-dimethylphenol	--	--	2.00E-02 (i)	--	--	CNS/Blood	Clinical signs/ hematological changes
hexachlorobutadiene	7.80E-02 (i)	7.70E-02 (i)	2.00E-04 (h)	--	C	Renal tubules (kidney)	Regeneration (increased weight)
2-methylphenol (o-cresol)	--	--	5.00E-02 (i)	--	C	Whole Body/CNS	Decreased body weight and neurotoxicity
4-methylphenol (p-cresol)	--	--	5.00E-03 (h)	--	C	Whole Body/ Respiratory Sys./ CNS	Maternal death/distress/ hyperactivity
Pesticides: aldrin	17.0 (i)	17.1 (i)	3.00E-05 (i)	--	B2	Liver	Liver toxicity
beta-BHC	1.80 (i)	1.79 (i)	--	--	C	--	--
gamma-BHC (Lindane)	1.30 (h)	--	3.00E-04 (i)	--	C	Liver and Kidney	Liver and kidney toxicity
alpha-chlordane[(2)]	1.30 (i)	1.29 (i)	6.00E-05 (i)	--	B2	Liver	Regional liver hypertrophy
4,4'-DDD	2.40E-01 (i)	--	--	--	B2	--	--

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF (mg/kg/day)$^{-1}$	Inhal. CSF (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
4,4'-DDE	3.40E-01 (i)	--	--	--	B2	--	--
4,4'-DDT	3.40E-01 (i)	3.40E-01 (i)	5.00E-04 (i)	--	B2	Liver	Lesions
dieldrin	16.0 (i)	16.1 (i)	5.00E-05 (i)	--	B2	Liver	Lesions
heptachlor epoxide	9.10 (i)	9.10 (i)	1.30E-05 (i)	--	B2	Liver	Increased weight
PCBs: Aroclor-1254[3]	7.70 (i)	--	--	--	B2	--	--
Aroclor-1260[3]	7.70 (i)	--	--	--	B2	--	--
Inorganics: aluminum	--	--	1.00E+00 (o)	--	--	--	--
antimony	--	--	4.00E-04 (i)	--	D	Whole Body/Blood	Increased mortality/ altered chemistry
arsenic	1.75 (i)	15.1 (i)	3.00E-04 (i)	--	A	Skin	Keratosis/hyperpigmentation
barium	--	--	7.00E-02 (i)	1.43E-04 (a)	D	Cardiovascular system	Increased blood pressure
beryllium	4.30 (i)	8.40 (i)	5.00E-03 (i)	--	B2	--	None observed
cadmium	--	6.30 (i)	5.00E-04 (i)	--	B1	Renal cortex	Significant proteinuria
chromium	--	42.0 (i)	5.00E-03 (i)	--	A	--	None observed

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF (mg/kg/day)$^{-1}$	Inhal. CSF (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
copper	--	--	3.71E-02 (h)	--	D	Gastrointestinal system	Irritation
lead	--	--	--	--	B2	--	--
manganese	--	--	5.00E-03 (i)	1.43E-05 (i)	D	CNS/lung	Effects
mercury (inorganic)	--	--	3.00E-04 (h)	8.57E-05 (h)	D	Kidney/ nervous system	Effects/neurotoxicity
nickel (refinery dusts)	--	8.40E-01 (i)	--	--	A	--	--
nickel (soluble salts)	--	--	2.00E-02 (i)	--	C	Whole body	Decreased body and organ weights
silver	--	--	5.00E-03 (i)	--	D	Skin	Argyria
thallium[4]	--	--	8.00E-05 (i)	--	D	Liver/Blood/Hair	Increased SGOT/Increased Serum LDH/Adopecia
vanadium	--	--	7.00E-03 (h)	--	D	--	--
zinc	--	--	3.00E-01 (i)	--	D	Blood	Decreased blood enzyme

Notes: (1) Under review
(2) Toxicity factors for chlordane used.
(3) Toxicity factor for polychlorinated biphenyls.
(4) Reference dose applies to thallium carbonate, chloride or sulfate.
i = Integrated Risk Information System (IRIS), 1994
e = Environmental Criteria and Assessment Office (ECAO) (as cited from 4th quarter USEPA, Region III RBC Tables)
h = Health Effects Assessment Summary Tables (HEAST), 1994
a = EAST Alternative Method, 1994
w = withdrawn from IRIS or HEAST
o = Other EPA Document (as cited from 4th quarter USEPA, Region III RBC tables)

CSF = cancer slope factor
RfD = reference dose
WOE = weight-of-evidence

USEPA WOE Classifications:
A = Carcinogen
B = Probable Carcinogen
C = Possible Carcinogen
D = not classified

TABLE 6-2

SUMMARY TABLE OF MAXIMUM INCREMENTAL CANCER RISKS (ICR) AND HAZARD INDICES (HI) FOR MEDIA OF INTEREST, AREAS A AND B CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	Area A				Area B - Pond/Landfill				Area B - School			
	Potential Current		Potential Future		Potential Current		Potential Future		Potential Current		Potential Future	
Medium	HI	ICR	HI[3]	ICR[3]	HI[1]	ICR[1]	HI[3]	ICR[3]	HI	ICR	HI[3]	ICR
Soils	0.82[2]	7.0×10^{-5}[1]	**6.4**	**1.8×10^{-4}[6]**	0.13	1.9×10^{-5}	**1.6**	4.5×10^{-5}[6]	0.73[5]	2.7×10^{-5}[1]	**4.5**	6.7×10^{-5}[6]
Sediments	0.38[4]	1.8×10^{-5}[4]	**4.0**	1.2×10^{-4}[3]	0.002	4.4×10^{-6}	**2.0**	7.1×10^{-5}[3]	[7]	[7]	0.014	[7]
Surface Waters	0.040[4]	4.2×10^{-5}[4]	0.64	**2.0×10^{-4}[3]**	0.074	2.1×10^{-6}	0.34	2.1×10^{-5}[3]	0.019[5]	3.1×10^{-6}[5]	0.03	6.3×10^{-6}[3]
Indoor Air	0.25[2]	1.3×10^{-6}[1]	NA	NA	NA	NA	NA	NA	0.094[5]	3.4×10^{-7}[5]	NA	NA
Outdor (Ambient) Air	0.60[1]	1.3×10^{-6}[1]	0.052[3]	1.2×10^{-7}[3]	0.13[1]	1.3×10^{-6}[1]	0.052[3]	1.2×10^{-7}[3]	0.021[5]	4.9×10^{-8}[5]	0.052[3]	1.2×10^{-7}[3]

Notes: Hazard indices exceeding 1 and Incremental Cancer Risks exceeding 1×10^{-4} are shown in bold face type.

(1) Industrial Use (Adults)
(2) Brig Prisoners
(3) Resident Young Child (1-6 yrs)
(4) Resident Older Child (6-15 yrs)
(5) School Children (6-12 yrs)
(6) Resident Adults.
(7) No contaminants of concern detected.
NA - Not applicable

Current - Current potential exposure
Future - Future potential (residential) exposure

TABLE 6-3

SUMMARY TABLE OF MAXIMUM INCREMENTAL CANCER RISKS (ICR) AND HAZARD INDICES (HI) FOR SHALLOW AND DEEP GROUNDWATER, AREAS A AND B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	Area A (and Glenwood Park Residential Area)							
	Potential Current				Potential Future			
	Child		Adult		Child		Adult	
Medium	HI	ICR	HI	ICR	HI	ICR	HI	ICR
Shallow	0.003	3.8×10^{-7}	0.001	6.4×10^{-7}	**620**	**1.8×10^{-1}**	**300**	**2.7×10^{-1}**
Deep Groundwater	NA	NA	NA	NA	**12**	**5.4×10^{-3}**	**7.5**	**8.9×10^{-3}**

	Area B							
	Potential Current				Potential Future			
	Child		Adult		Child		Adult	
Medium	HI	ICR	HI	ICR	HI	ICR	HI	ICR
Shallow	NA	NA	NA	NA	**30**	**1.4×10^{-2}**	**0.19**	**2.9×10^{-2}**
Deep Groundwater	NA	NA	NA	NA	**4.6**	3.8×10^{-5}	**2.8**	8.0×10^{-5}

Notes: Hazard indices exceeding 1 and Incremental Cancer Risks exceeding 1×10^{-4} are shown in bold face type.
Current Use - Potential nonpotable use of groundwater (child, swimming pools; adults, car washing).
Future Use - Potential residential potable use of groundwater.
NA - Scenario not applicable (i.e., groundwater in Area B currently not used for potable or nonpotable).

TABLE 6-4

TOTAL SITE ICR AND HI VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS, AREA A CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Local Adults[(1)]	5.9×10^{-02}	3.4×10^{-05}
Local Children[(2)]*	4.5×10^{-01}	6.0×10^{-05}
Brig Employees[(3)]	$1.3 \times 10^{+00}$	1.1×10^{-04}
Brig Prisoners[(4)]	$1.1 \times 10^{+00}$	8.1×10^{-06}

Notes: (1) Local adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of shallow groundwater, surface waters, and sediments, as well as inhalation of VOCs in outdoor air.

(2) Local children could potentially be exposed to surface waters, sediments, and shallow-groundwaters, as well as inhalation of VOCs in outdoor air. Total site risk values represent potential exposure to surface waters and sediments by older children and total site risk values for younger children potentially exposed to COPCs in residential area shallow groundwater.

(3) Brig employees (civilian) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as the inhalation of VOCs detected in indoor and outdoor air and fugitive dusts.

(4) Brig prisoners could potentially be exposed to COPCs through dermal contact and accidental ingestion of soils, as well as inhalation of VOCs detected in indoor and outdoor air. Prisoners do not generally gain access to the ditches.

* Total HI and ICR values derived by summing the HI and ICR values for younger children (ages 1 to 6 years) and older children (ages 7 to 15 years) potentially exposed to Area A ditch surface waters and sediments.

TABLE 6-5

TOTAL SITE ICR AND HI VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS, AREA B CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Adult Workers[1]	2.9×10^{-01}	2.7×10^{-05}
Elementary School Children[2]	8.6×10^{-01}	1.5×10^{-05}
Elementary School Workers[3]	4.4×10^{-01}	2.9×10^{-05}

Notes: (1) Adult workers (employees and prisoners) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs in outdoor air, in Area B Pond during maintenance activities.

(2) Elementary school children (6 to 12) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface water, and sediments, as well as the inhalation of fugitive dusts and VOCs in outdoor air, in Area B School.

(3) Elementary school workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as the inhalation of fugitive dusts and VOCs in outdoor air, in Area B School.

TABLE 6-6

TOTAL SITE ICR AND HI VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS, AREA A* CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Resident Adults[(1)]	$3.0 \times 10^{+02}$ ($2.9 \times 10^{+02}$)	2.7×10^{-01} (2.7×10^{-01})
Resident Children[(2)]	$6.4 \times 10^{+02}$ ($6.3 \times 10^{+02}$)	1.8×10^{-01} (1.8×10^{-01})
Construction Workers[(3)]	8.0×10^{-02}	1.3×10^{-06}

Notes: Values in parentheses represent risk values derived using dissolved inorganic constituent results for groundwaters.

(1) Future resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of VOCs detected in outdoor air. Potable use of shallow and deep groundwaters were also evaluated. Potential exposure pathways included ingestion, whole body dermal contact, and inhalation of VOCs while showering.

(2) Future resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of VOCs detected in outdoor air, and by the potable use of shallow and deep groundwaters.

(3) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, and the inhalation of fugitive dusts emanating from excavated subsurface soils.

* Total site ICR and HI values presented using shallow well location B-20W since this location was associated with the most elevated risks in Area A.

TABLE 6-7

TOTAL SITE ICR AND HI VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS, AREA B*
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Resident Adults[(1)]	$2.0 \times 10^{+01}$ ($1.1 \times 10^{+01}$)	2.9×10^{-02} (2.8×10^{-02})
Resident Children[(2)]	$3.5 \times 10^{+01}$ ($2.2 \times 10^{+01}$)	1.4×10^{-02} (1.4×10^{-02})
Construction Workers[(3)]	7.5×10^{-01}	7.2×10^{-06}

Notes: Values in parentheses represent risk values derived using dissolved inorganic constituent results for groundwaters.

(1) Future resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs detected in outdoor air. Potable use of shallow and deep groundwaters were also evaluated. Potential exposure pathways included ingestion, whole body dermal contact, and inhalation of VOCs while showering.

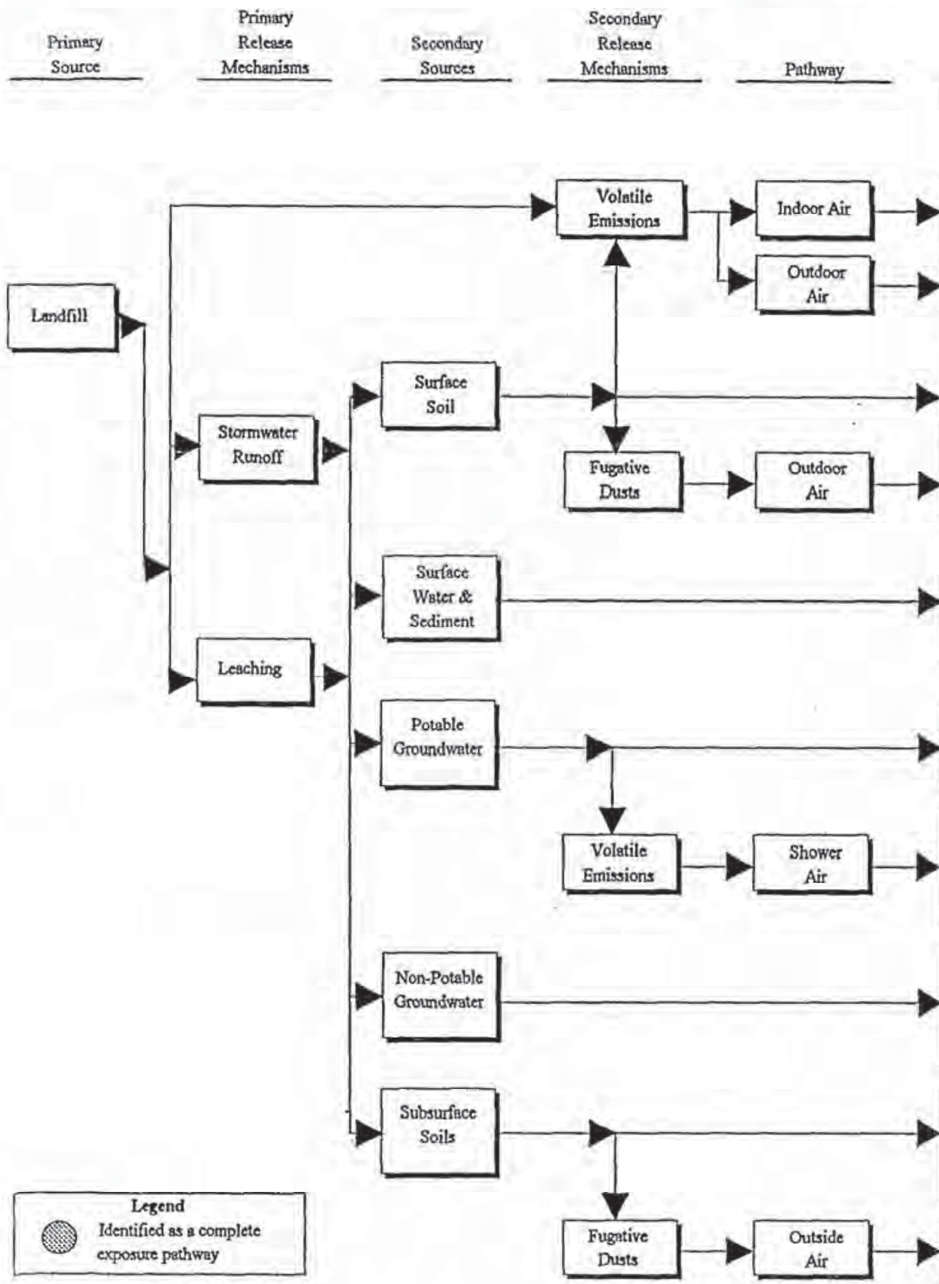
(2) Future resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs detected in outdoor air, and by the potable use of shallow and deep groundwaters.

(3) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, and the inhalation of fugitive dusts emanating from excavated subsurface soils.

* Total site ICR and HI values presented using shallow well location B-MW11A since this location was associated with the most elevated risks in Area B.

SECTION 6.0 FIGURES

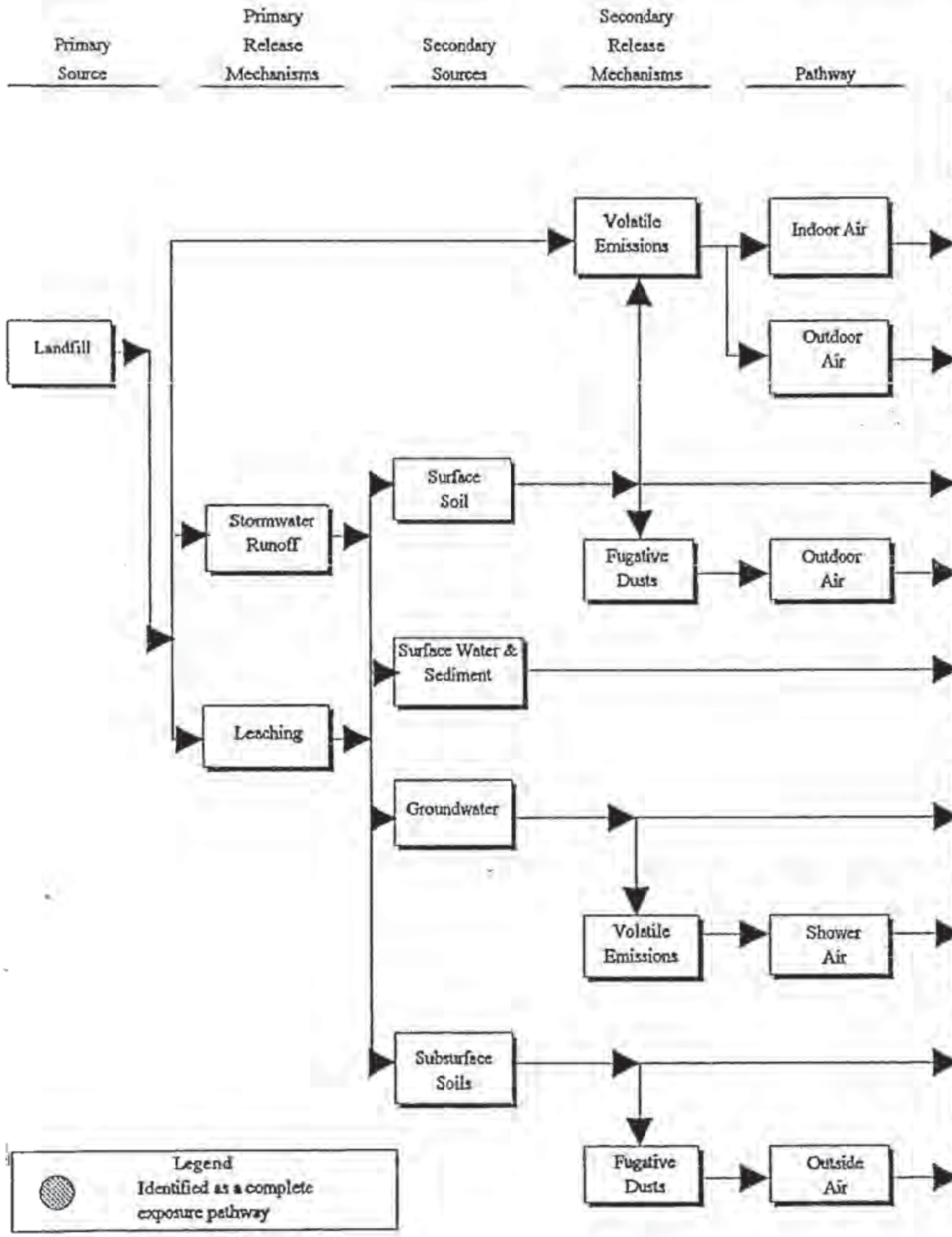
FIGURE 6-1
CONCEPTUAL SITE MODEL
CAMP ALLEN LANDFILL - AREA A
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA



Area A

Exposure Route	Brig Prisoners	Brig Employees	Future Residential Adults	Future Residential Children	Construction Workers	Local Residential Adult	Local Residential Children
Inhalation	●	●					
Inhalation	●	●	●	●		●	●
Ingestion	●	●	●	●			
Dermal Contact	●	●	●	●			
Inhalation	●	●					
Ingestion	●	●	●	●		●	●
Dermal Contact	●	●	●	●		●	●
Ingestion	●	●	●	●			
Inhalation	●		●	●			
Dermal Contact	●		●	●			
Ingestion						●	●
Dermal Contact						●	●
Ingestion					●		
Dermal Contact					●		
Inhalation					●		

FIGURE 6-2
CONCEPTUAL SITE MODEL
CAMP ALLEN LANDFILL - AREA B, AREA B POND, AREA B SCHOOL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA



	Area B Pond			Area B School				Area B
Exposure Route	Current Adult Workers	Future Residential Adults	Future Residential Children	School Employee	School Children	Future Residential Adult	Future Residential Child	Construction Worker
Inhalation					●	●		
Inhalation	●	●	●	●	●	●	●	
Ingestion	●	●	●	●	●	●	●	
Dermal Contact	●	●	●	●	●	●	●	
Inhalation	●	●	●	●	●	●	●	
Ingestion	●	●	●	●	●	●	●	
Dermal Contact	●	●	●	●	●	●	●	
Ingestion		●	●			●	●	
Inhalation		●	●			●	●	
Dermal Contact		●	●					
Ingestion								●
Dermal Contact								●
Inhalation								●

7.0 DESCRIPTION OF ALTERNATIVES

For the various contaminated media at the Camp Allen Landfill to be addressed by response actions (soils, surface water/sediment and groundwater), summaries of the remedial alternatives evaluated for each contaminated media are presented in Sections 7.1 through 7.3.

7.1 Soils

Primary contaminants of concern in Area A and Area B soils are VOCs consisting of chlorinated organics, such as trichloroethene, and fuel-related compounds, such as benzene, present in buried waste materials. The soils in Area A and Area B are addressed separately. Remedial alternatives for Area A and Area B are summarized in the following sections.

7.1.1 Area A Soils

The Area A contaminated soils provide a potential on-going source of groundwater contamination at the site. Based on the test pit investigation performed during the pre-design study and the soil cleanup goals (see Section 9.2.1), primary source areas were delineated and were designated Areas A1 and A2 as shown in Figures 5-10 and 5-11, respectively. The total volume of contaminated soil for Area A has been estimated to be approximately 12,800 cubic yards.

Seven potential remedial alternatives for the Area A soil were developed and evaluated in the Feasibility Study. They are:

- A-SO1 - No Action
- A-SO2 - Institutional Controls
- A-SO3 - Asphalt/Geosynthetic Cap Over Brig Area with Institutional Controls
- A-SO4 - Composite Cap Over Hot Spot Areas with Institutional Controls
- A-SO5 - In Situ Treatment of Hot Spot Area Soils and Shallow Groundwater Using Dual Phase Vacuum Extraction with Institutional Controls
- A-SO6 - Thermal Treatment of Hot Spot Area Soils with Institutional Controls
- A-SO7 - Disposal of Hot Spot Area Soils in Off-site Hazardous Waste Landfill with Institutional Controls

Except for A-SO1, the No Action alternative, all the alternatives for Area A soils have several common components including maintenance of the existing fence, maintenance of the existing soil cover over the entire Area A (approximately 45 acres), and control of site access and future land use through institutional controls. There are currently no plans to close Naval Base, Norfok or the Camp Allen area; however, in the event of base closure, institutional controls, such as deed restrictions, would limit the Camp Allen Landfill Area to non-residential land use.

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), are provided below:

- A-SO1 - No Action

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $20,000 (every five years)
  Estimated Present-Worth Cost: $55,600
  Estimated Implementation Timeframe: none

  No action would be taken to remediate Area A soils or to restrict site access using institutional controls. The estimated O & M cost of $20,000 is for five-year site reviews.

- A-SO2 - Institutional Controls

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $17,557 (annually)
  $37,557 (every five years)
  Estimated Present-Worth Cost: $325,500
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. In the event of base closure, deed restrictions would be implemented to limit the Area A Landfill to non-residential land use. Legal procedures associated with implementation of deed restrictions would require less than one year to complete. In addition, the existing fence, which separates Area A Landfill from Glenwood Park, would be maintained to limit site access, and the existing soil cover over Area A would be maintained. The estimated O&M costs are for fence maintenance, soil cover maintenance, and five-year site reviews. Costs for implementation of deed restrictions were not estimated.

- A-SO3 - Asphalt/Geosynthetic Cap Over Brig Area with Institutional Controls

  Estimated Capital Cost: $927,200
  Estimated Annual O & M Cost: $17,557 (annually)
  $95,653 (every five years)
  Estimated Present-Worth Cost: $1,877,900
  Estimated Implementation Timeframe: less than one year, once construction begins

  An impermeable asphalt/geosynthetic cap would be placed over the brig area and the area immediately west of the brig area (an area of approximately 12 acres) to cover the hot spot areas identified in Area A1 during the pre-design investigation. The cap would minimize infiltration of surface water, thus reducing leaching and transport of contaminants from the contaminated soil. In addition, the cap would prevent potential exposure to contaminated soil. The technologies for grading and cap installation are demonstrated and commercially available. Periodic inspection and maintenance of the cap would be required.

- A-SO4 - Composite Cap Over Hot Spot Areas with Institutional Controls

  Estimated Capital Cost: $465,300
  Estimated Annual O & M Cost: $19,395 (annually)
  $39,395 (every five years)
  Estimated Present-Worth Cost: $819,100
  Estimated Implementation Timeframe: less than one year, once construction begins

  An impermeable composite cap would be placed over the hot spot areas identified in Areas A1 and A2 during the pre-design investigation (a total area of approximately 1 acre). The cap would minimize infiltration of surface water, thus reducing leaching and transport of contaminants from the contaminated soil. In addition, the cap would prevent potential exposure to contaminated soil. The technologies for grading and cap installation are demonstrated and commercially available. Periodic inspection and maintenance of the cap would be required.

- A-SO5 - In Situ Treatment of Hot Spot Area Soils and Shallow Groundwater Using Dual Phase Vacuum Extraction with Institutional Controls

  Estimated Capital Cost: $490,700
  Estimated Annual O & M Cost: $108,066 (years 1 - 4)
  $139,022 (year 5)
  $17,557 (years 6 - 30)
  Estimated Present-Worth Cost: $1,216,700
  Estimated Implementation Timeframe: five years, or possibly longer

The contaminated soil in the hot spot areas identified during the pre-design investigation would be treated with a dual phase vacuum extraction (DPVE) system, removing contaminated soil gas and shallow groundwater for subsequent treatment. The estimated volume of soil to be treated is 12,800 cubic yards. DPVE is a method to remediate soil and shallow groundwater using a single extraction system. The system uses a high vacuum to strip the unsaturated zone of VOCs, while simultaneously removing groundwater (in liquid and vapor form) from the shallow aquifer. The dual phase vacuum extraction and treatment system would consist of several major components. The extraction system would include the extraction wells (approximately 5-10 wells) and below-grade interconnecting well piping. The treatment system would include a liquid ring vacuum pump system, an air/water separator system, a vapor phase carbon adsorption system, and a groundwater transfer pump. The liquid ring vacuum pump system would entrain vapor and liquid from the extraction wells. This two-phase stream would be entrained in the air/water separator and split into a liquid and vapor stream. The vapor phase would be treated with activated carbon, and the liquid would be sent to the on-site groundwater treatment plant, which is part of the proposed response action for groundwater at the site.

As noted in Section 2.4.3, a pilot test was conducted in Area A1 and Area A2 to determine the feasibility of the DPVE technology in each area. Test results indicated that DPVE treatment is well-suited for Area A1 but not appropriate for Area A2 due to the higher permeability soils.

DPVE technology is innovative, but is very similar to soil vapor extraction (SVE) technology, which has been used extensively. The equipment and technology for

DPVE systems are demonstrated and commercially available. The major operational requirements include periodic (e.g., monthly) replacement of the carbon canisters used to treat soil gas and on-site treatment of the water collected in the air/water separator. This alternative would be implemented in conjunction with a groundwater treatment alternative, and periodic monitoring of off-gas contaminant concentrations, water level checks in the air/water separator, and servicing of the air compressor would also need to be performed.

Since Area A is a landfill, the remedial action objective for the soils is groundwater protection rather than soil cleanup. Therefore, achievement of this objective would not necessarily be based on attainment of the developed soil cleanup goals (see Section 9.2.1) since they represent theoretical values calculated through modeling. In addition, the cleanup goals were developed using conservative assumptions and may not be representative of actual site conditions. Therefore, achievement of groundwater protection would be determined through development of treatment system performance curves and through evaluation of actual environmental monitoring results (i.e., via ongoing monitoring of contaminant levels in groundwater and in the extracted vapors from the in situ vacuum extraction system). Soil contaminant concentrations may eventually reach asymptotic levels below which contaminant levels cannot be reduced via in situ vacuum extraction. It is estimated that the asymptotic levels would be reached within a 5-year period. If treatment system performance curves indicate that the cleanup goals for some or all of the contaminants cannot be achieved, then the soil cleanup goals will be reevaluated. If the soil cleanup goals are achieved, then the levels of VOCs in the soils would be reduced by approximately two orders of magnitude. Contaminant trends would be analyzed using results from the groundwater monitoring program to assess whether any portion of the landfill is acting as a source of groundwater contamination over the long term.

- A-SO6 - Thermal Treatment of Hot Spot Area Soils with Institutional Controls

  Estimated Capital Cost: $6,141,500
  Estimated Annual O & M Cost: $17,557 (annually)
  $37,557 (every five years)
  Estimated Present-Worth Cost: $6,467,100
  Estimated Implementation Timeframe: less than one year, once construction begins

  The contaminated soil in the hot spot areas identified during the pre-design investigation would be treated on site using a low-temperature (i.e., 400-800°F) thermal desorption process. The treatment process involves separation of VOCs and, to a lesser degree, semi-volatile organic compounds (SVOCs) from soil by heating the waste in a desorption chamber. Desorbed organic vapors are subsequently condensed and recovered as liquid for subsequent disposal (i.e., off-site incineration). This process is expected to remove more than 99 percent of the VOCs and 80 to 99 percent of SVOCs (depending on their boiling points) from the soil. Thus, the levels of VOCs would be reduced well below the soil cleanup goals (i.e., reduced by more than two orders of magnitude). The treated soil would be backfilled on site, assuming that the established soil cleanup levels have been achieved.

  The technologies proposed for excavation, material handling, and thermal treatment are all demonstrated and commercially available. Excavation could be more difficult if the source area is located adjacent to a building or in an area containing many underground utilities. Material handling would also be more difficult if the contaminated soils contain a large amount of debris, such as glass, paper, metallic objects, or construction materials. Thermal treatment technologies are expected to be technically feasible and implementable. However, since a residential community is located adjacent to the base property, there could be public opposition to operation of a thermal treatment unit on site. An on-site trial burn with extensive stack and site perimeter air monitoring could be required to satisfy regulatory agency and/or public concerns.

- A-SO7 - Disposal of Hot Spot Area Soils in Off-site Hazardous Waste Landfill with Institutional Controls

  Estimated Capital Cost: $9,867,900
  Estimated Annual O & M Cost: $17,557 (annually)
  $37,557 (every five years)
  Estimated Present-Worth Cost: $10,193,500
  Estimated Implementation Timeframe: less than one year, once construction begins

  The contaminated soil in the hot spot areas identified during the pre-design investigation would be excavated and transported off site for disposal at a RCRA-permitted hazardous waste landfill. The excavation would be backfilled with clean soil from an off-site source.

  The technologies proposed for excavation, material handling, and off-site disposal are all demonstrated and commercially available. Material handling would also be more difficult in Area A2 where the contaminated soils contain some debris and construction materials (i.e., concrete). Adequate landfill capacity is not expected to be a concern. The nearest facility is located approximately 375 miles from the site.

7.1.2 Area B Soils

As discussed in Section 2.4.1, a removal action for the Area B Landfill was initiated in the summer of 1994 and has been completed. The removal action involved excavation of contaminated soil, debris, and drums in several hot spot areas and off-site disposal at a RCRA-permitted hazardous waste landfill or incinerator. The objective of the removal action was to remove the sources of groundwater contamination within the Area B Landfill so that no further remedial actions would be required for Area B soils. Therefore, source control alternatives (such as capping and treatment alternatives), which were developed for Area A soils, were not developed for Area B soils.

Two potential remedial alternatives for the Area B soil were developed and evaluated. They are:

- B-SO1 - No Action
- B-SO2 - Institutional Controls

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- B-SO1 - No Action

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $20,000 (every five years)
  Estimated Present-Worth Cost: $55,600
  Estimated Implementation Timeframe: none

  No action would be taken to remediate Area B soils or to restrict site access using institutional controls. The estimated O & M cost of $20,000 is for five-year site reviews.

- B-SO2 - Institutional Controls

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $600 (annually)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $63,200
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. In the event of base closure, deed restrictions would be implemented to limit the Area B Landfill to non-residential land use. Legal procedures associated with implementation of deed restrictions would require less than one year to complete. In addition, the existing perimeter fence would be maintained to limit site access. The estimated O&M costs are for fence maintenance and five-year site reviews. Costs for implementation of deed restrictions were not estimated.

7.2 Surface Water/Sediment (Areas A and B)

Sediment and surface water in the drainage channels surrounding Areas A and B were found to contain isolated areas of elevated organic and inorganic constituents. However, contamination levels do not suggest a need for active remediation of surface water/sediment for the following reasons:

- Relatively low levels of contaminants were detected in site surface water and sediments.

- Migration of contaminants from the surface water and sediments to groundwater is not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater).

- Results of the baseline risk assessment for Area A and Area B surface water and sediment indicate no exceedances of human health criteria associated with exposure (via ingestion and dermal contact) to surface water or sediment under the current land uses. Therefore, under the current land uses at Areas A and B, no unacceptable human health effects would be expected from exposure to surface water and sediment.

- Source control measures that have been implemented at Area B (removal action), and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment in these areas over time.

Two potential remedial alternatives for the Area A and B surface water/sediment were developed and evaluated. They are:

- SD1 - No Action
- SD2 - Institutional Controls with Monitoring

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring periods), are provided below;

- SD1 - No Action

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $20,000 (every five years)
  Estimated Present-Worth Cost: $55,600
  Estimated Implementation Timeframe: none

No action would be taken to remediate Area A or B surface water or sediments or to restrict site access using institutional controls. The estimated O & M cost of $20,000 is for five-year site reviews. Under the recommended soil alternative, the existing fence in Areas A and B would be maintained to limit site access, and the existing soil cover over Area A would be maintained. As previously discussed, the proposed remediation of the soil and groundwater in the area will most likely result in a decrease in contaminant levels in surface water/sediment over time.

- SD2 - Institutional Controls with Monitoring

Estimated Capital Cost: $0
Estimated Annual O & M Cost: $50,477 (annually)
$70,477 (every five years)
Estimated Present-Worth Cost: $831,600
Estimated Implementation Timeframe: less than one year

The current land use at the site is industrial/military. In the event of base closure, deed restrictions would be implemented to limit the area to non-residential land use. Legal procedures associated with implementation of deed restrictions would require less than one year to complete. Under the recommended soil alternative, the existing fence in Areas A and B would be maintained to limit site access, and the existing soil cover over Area A would be maintained.

In addition, a surface water and sediment monitoring program would be implemented (estimated annual cost $50,477) to track trends in surface water and sediment contamination levels. As previously discussed, the proposed remediation of the soil and groundwater in the area will most likely result in a decrease in contaminant levels in surface water and sediment over time. The monitoring program would provide information required to track trends in contaminant levels over time in these media.

7.3 Groundwater

Groundwater contamination is present both in the water table (shallow) aquifer and the upper Yorktown (deep) Aquifer at the site. The primary contaminants of concern in site groundwater are

VOCs, with trace amounts of other contaminants. Elevated levels of some inorganics were also detected, but are believed to be associated with total suspended solids rather than dissolved in the groundwater.

The groundwater in various areas of the site is addressed separately. Remedial alternatives evaluated for Area A1, Area A2 and Area B are summarized in the following sections.

7.3.1 Area A1 Groundwater

As will be discussed in Section 9.0 of this report, the recommended response action for contaminated soil in Area A1 is Alternative A-SO5, in situ treatment by dual phase vacuum extraction (DPVE). The DPVE system is able to extract both soil and shallow groundwater contamination with a single system. This benefit is especially valuable since it has been shown that the conventional pump and treat method would not be feasible for remediation of the water table aquifer in Area A1 due to its very low hydraulic conductivity. The shallow groundwater extracted by the DPVE system will be pumped to the proposed on-site treatment plant for contaminated groundwater. Since remediation of the water table aquifer in Area A1 will be addressed by the proposed DPVE system, remedial alternatives were not developed for the water table aquifer in this area.

Three potential remedial alternatives for Area A1 groundwater were developed and evaluated. They are:

- A1-GW1 - No Action with Monitoring
- A1-GW2 - Institutional Controls with Monitoring
- A1-GW3 - Protection of the Yorktown Aquifer for Beneficial Use through Extraction and Treatment, Institutional Controls, and Monitoring

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- A1-GW1 - No Action with Monitoring

Estimated Capital Cost: $0
Estimated Annual O & M Cost: $38,600 (years 1 - 10)
$19,600 (years 11 - 20)
$10,100 (years 21 - 30)
$20,000 (every five years)
Estimated Present-Worth Cost: $476,700
Estimated Implementation Timeframe: none

No action would be taken to actively remediate the upper Yorktown Aquifer in Area A1 or to restrict site access using institutional controls. However, since a primary source area and the water table aquifer within Area A1 will be remediated by DPVE (see Alternative A-SO5), contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be used to assess trends in groundwater quality over time, as discussed below.

Under this alternative, a groundwater monitoring program would be implemented in Area A1. Groundwater monitoring would be conducted on a quarterly basis until a stable or decreasing trend in contaminant levels is observed. Then the frequency of monitoring would be reduced to a semi-annual or annual basis. For cost estimating purposes, it was assumed quarterly monitoring would occur in years 1 to 10, semi-annual monitoring would occur in years 11 to 20, and annual monitoring would occur in years 21 to 30. Additionally, it was assumed that seven monitoring wells and three perimeter monitoring wells in Area A1 would be included in the monitoring program.

- A1-GW2 - Institutional Controls with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. Under this alternative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. There are currently no plans to close Naval Base, Norfolk or the Camp Allen area. However, if the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater. Legal procedures associated with implementation of deed restrictions would require less than one year to complete.

  Since a primary source area and the water table aquifer within Area A1 will be remediated by DPVE (see Alternative A-SO5), contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented, as described under Alternative A1-GW1, to assess trends in groundwater quality over time.

- A1-GW3 - Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

  Estimated Capital Cost: $6,108,500
  Estimated Annual O & M Cost: $187,300 (years 1 - 10)
  $168,300 (years 11 - 20)
  $158,800 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $8,870,200
  Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

  This alternative for groundwater in Area A1 would involve protection of the Yorktown Aquifer for beneficial use (i.e., potential drinking water source) through extraction and on-site treatment. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (e.g., three to six wells, approximately 65 feet deep) and would be pumped to an on-site treatment system. The pumping rate would be designed to contain the current extent of contamination. If possible, the system would be operated until groundwater cleanup goals (federal MCLs for Yorktown Aquifer) are achieved. An estimated groundwater pumping rate of 82 gallons per minute (gpm) would be required to contain the current extent of contamination in Area A1 as shown in Figure 5-7.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under this alternative has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the cost for this alternative includes the entire capital cost for construction of the groundwater treatment system for all three areas of the site.

Air stripping and carbon adsorption are commonly used for groundwater remediation for treatment of organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials in packed towers and clogging of air diffusers in diffused aeration strippers. The pretreatment system would remove suspended solids and any nuisance metals that may cause clogging. Construction of a permanent building would be required to house the treatment systems.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve. Also, MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed MCLs. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

With respect to initial risk associated with potable use of the Yorktown Aquifer, HI values of 12 and 7.5 and ICR values of 5.4×10^{-3} and 8.9×10^{-3} were calculated for child and adult receptors, respectively (Table 6-3). If the MCLs are ultimately achieved, then these initial risks would be reduced to acceptable levels (i.e., HI <1.0 and ICR $<1 \times 10^{-4}$).

Additionally, institutional controls and a groundwater monitoring program would be implemented, as described under Alternatives A1-GW1 and A1-GW2.

7.3.2 Area A2 Groundwater

Three potential remedial alternatives for Area A2 groundwater were developed and evaluated in the Feasibility Study. They are:

- A2-GW1 - No Action with Monitoring
- A2-GW2 - Institutional Controls with Monitoring
- A2-GW3 - Protection of the Yorktown Aquifer for Beneficial Use through Extraction and Treatment, Institutional Controls and Monitoring

When the Feasibility Study was prepared, it was believed that remediation of the water table aquifer in Area A2 could be addressed by the DPVE system. Therefore, an extraction and treatment remedial alternative was not developed for the water table aquifer in this area in the Feasibility Study.

Since completion of the Feasibility Study, a DPVE pilot test has been performed in Area A2. Based on the results of the pilot test, extraction of groundwater from the water table aquifer using conventional submersible pumps appears to be better suited for Area A2 than DPVE technology. Therefore, a fourth groundwater alternative, A2-GW4, was added to the Proposed Remedial Action Plan (PRAP) to address the water table aquifer in this area as follows:

- Alternative A2-GW4 - Protection of the Water Table Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring.

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- A2-GW1 - No Action with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: none

  No action would be taken to actively remediate the upper Yorktown Aquifer in Area A2 or to restrict site access using institutional controls. Contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be used to assess trends in groundwater quality over time, as discussed below.

  Under this alternative, a groundwater monitoring program would be implemented in Area A2. Groundwater monitoring would be conducted on a quarterly basis until a stable or decreasing trend in contaminant levels is observed. Then the frequency of monitoring would be reduced to a semi-annual or annual basis. For cost estimating purposes, it was assumed quarterly monitoring would occur in years 1 to 10, semi-annual monitoring would occur in years 11 to 20, and annual monitoring would occur in years 21 to 30. Additionally, it was assumed that seven monitoring wells and three perimeter monitoring wells in Area A2 would be included in the monitoring program.

- A2-GW2 - Institutional Controls with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. Under this alterative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. There are currently no plans to close Naval Base, Norfolk or the Camp Allen area. However, if the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater. Legal procedures associated with implementation of deed restrictions would require less than one year to complete.

  Contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented, as described under Alternative A2-GW1, to assess trends in groundwater quality over time.

- A2-GW3 - Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

  Estimated Capital Cost: $0 (capital cost for treatment system under Alternative A1-GW3)
  Estimated Annual O & M Cost: $59,400 (years 1 - 10)
  $40,400 (years 11 - 20)
  $30,900 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $796,000
  Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

  This alternative for groundwater in Area A2 would involve protection of the Yorktown Aquifer for beneficial use (i.e., potential drinking water source) through extraction and on-site treatment. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (e.g., three to six wells approximately 65 feet deep) and would be pumped to an on-site treatment system.

The pumping rate is designed to contain the current extent of contamination. If possible, the system would be operated until groundwater cleanup goals (federal MCLs for Yorktown Aquifer) are achieved. An estimated groundwater pumping rate of 82 gpm would be required to contain the current extent of contamination in Area A2 as shown in Figure 5-7.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under Alternative A1-GW3 has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the entire capital cost for construction of the groundwater treatment system for all three areas of the site is included under Alternative A1-GW3. Therefore, capital costs for the groundwater treatment system are not included in this alternative. Annual O&M costs for this alternative include the incremental treatment costs associated with treating the additional flow (82 gpm) from Area A2.

Air stripping and carbon adsorption are commonly used for groundwater remediation for treatment of organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials in packed towers and clogging of air diffusers in diffused aeration strippers. The pretreatment system would remove suspended solids and any nuisance metals that may cause clogging. Construction of a permanent building would be required to house the treatment system.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve. Also, MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed MCLs. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

With respect to initial risks associated with potable use of the Yorktown Aquifer, HI values of 12 and 7.5 and ICR values of 5.4×10^{-3} and 8.9×10^{-3} were calculated for child and adult receptors, respectively (Table 6-3). If the MCLs are ultimately achieved, then these initial risks would be reduced to acceptable levels (i.e., HI <1.0 and ICR $<1 \times 10^{-4}$).

Additionally, institutional controls and a groundwater monitoring program would be implemented, as described under Alternatives A2-GW1 and A2-GW2.

- A2-GW4 - Protection of the Water Table Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Estimated Capital Cost: $0 (capital cost for treatment system under Alternative A1-GW3)
Estimated Annual O & M Cost: $8,900 (years 1 - 10)
$6,200 (years 11 - 20)
$4,900 (years 21 - 30)
$20,000 (every five years)
Estimated Present-Worth Cost: $168,000
Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

This alternative for groundwater in Area A2 would involve protection of the water table aquifer for its beneficial use (i.e., nonpotable use) through extraction and on-site treatment. Groundwater in the water table aquifer would be extracted through a series of shallow pumping wells (e.g., two to three wells, approximately 25 feet deep). Extracted groundwater would be pumped to an on-site treatment system. The pumping rate is designed to contain the current extent of contamination. If possible, the system would be operated until groundwater cleanup goals (see Section 9.2.2) are achieved. An estimated groundwater pumping rate of 6 gpm would be required to contain the current extent of contamination in Area A2 as shown in Figure 5-7.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under Alternative A1-GW3 has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the entire capital cost for construction of the groundwater treatment system for all three areas of the site is included under Alternative A1-GW3. Therefore, capital costs for the groundwater treatment system are not included in this alternative. Annual O&M costs for this alternative include the incremental treatment costs associated with treating the additional flow (6 gpm) from Area A2.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve.

Since the groundwater cleanup goals for the water table aquifer were based on an ICR of 1×10^{-6} and a hazard quotient (HQ) of 1.0, achievement of these goals would ensure that remaining cumulative risks are within acceptable levels for nonpotable use (i.e., HI <1.0 and ICR <1×10^{-4}).

Institutional controls and a groundwater monitoring program would also be implemented under this alternative, as described under Alternatives A2-GW1 and A2-GW2.

7.3.3 Area B Groundwater

In situ treatment of soil and shallow groundwater is not proposed for Area B under Alternative A-SO5, as was done for Area A. Therefore, since remediation of the water table aquifer in Area B has not been addressed under another alternative, remedial alternatives for Area B groundwater include remediation of both the water table aquifer and the Yorktown Aquifer.

Three potential remedial alternatives for Area B groundwater were developed and evaluated. They are:

- B-GW1 - No Action with Monitoring
- B-GW2 - Institutional Controls with Monitoring
- B-GW3 - Protection of the Water Table and Yorktown Aquifers for Beneficial Use through Extraction and Treatment, Institutional Controls, and Monitoring

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- B-GW1 - No Action with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: none

  No action would be taken to actively remediate Area B groundwater or to restrict site access using institutional controls. However, since a primary source area within Area B has been permanently removed through a removal action (see Section 5.2.1), contaminant levels in groundwater in Area B should gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be used to assess trends in groundwater quality over time, as discussed below.

  Under this alternative, a groundwater monitoring program would be implemented in Area B. Groundwater monitoring would be conducted on a quarterly basis until a stable or decreasing trend in contaminant levels is observed. Then the frequency of monitoring would be reduced to a semi-annual or annual basis. For cost estimating purposes, it was assumed quarterly monitoring would occur in years 1 to 10, semi-annual monitoring would occur in years 11 to 20, and annual monitoring would occur in years 21 to 30. Additionally, it was assumed that ten monitoring wells in Area B would be included in the monitoring program.

- B-GW2 - Institutional Controls with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. Under this alterative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. There are currently no plans to close Naval Base, Norfolk or the Camp Allen area. However, if the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater. Legal procedures associated with implementation of deed restrictions would require less than one year to complete.

  Since a primary source area within Area B has been remediated through a removal action (see Section 5.2.1), contaminant levels in groundwater in Area B should gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented, as described under Alternative B-GW1, and would be used to assess trends in groundwater quality over time.

- B-GW3 - Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

  Estimated Capital Cost: $0 (capital cost for treatment system under Alternative A1-GW3)
  Estimated Annual O & M Cost: $62,400 (years 1 - 10)
  $43,400 (years 11 - 20)
  $34,000 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $842,500
  Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

  This alternative for groundwater in Area B would involve protection of the water table aquifer and Yorktown Aquifer for their respective beneficial uses (i.e., potential drinking water source for Yorktown Aquifer and nonpotable use for water table aquifer) through extraction and on-site treatment. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (e.g., three wells, approximately 65 feet deep). Groundwater in the water table aquifer would be extracted through a series of shallow pumping wells (e.g., five wells, approximately 25 feet deep). Extracted groundwater from both aquifers would be pumped to an on-site treatment system. The pumping rate is designed to contain the current extent of contamination as shown in Figure 5-7. If possible, the system would be operated until groundwater cleanup goals (see Section 9.2.2) are achieved. An estimated groundwater pumping rate of 42 gpm would be required to contain the current extent of contamination in Area B.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under Alternative A1-GW3 has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the entire capital cost for construction of the groundwater treatment system for all three areas of the site is included under Alternative A1-GW3. Therefore, capital costs for the groundwater treatment system are not included in this alternative. Annual O&M costs for this alternative include the incremental treatment costs associated with treating the additional flow (42 gpm) from Area B.

Air stripping and carbon adsorption are commonly used for groundwater remediation for treatment of organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials in packed towers and clogging of air diffusers in diffused aeration strippers. The pretreatment system would remove suspended solids and any nuisance metals that may cause clogging. Construction of a permanent building would be required to house the treatment systems.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve. Also, MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed MCLs. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

With respect to initial risks associated with potable use of the Yorktown Aquifer in Area B, HI values of 4.6 and 2.8 and ICR values of 3.8×10^{-5} and 8.0×10^{-5} were calculated for child and adult receptors, respectively (Table 6-3). Although the ICR is currently within acceptable levels, contaminants were detected in several Yorktown Aquifer monitoring wells at concentrations significantly in excess of the MCLs. Therefore, achievement of the MCLs, if possible, would reduce the HI to less than 1.0 and would also ensure that the cumulative ICR is below the acceptable 1×10^{-4}.

Since the groundwater cleanup goals for the water table aquifer were based on an ICR of 1×10^{-6} and a hazard quotient (HQ) of 1.0, achievement of these goals would ensure that remaining cumulative risks are within acceptable levels for nonpotable use (i.e., HI <1.0 and ICR $<1 \times 10^{-4}$).

Additionally, institutional controls and a groundwater monitoring program would be implemented, as described under Alternatives B-GW1 and B-GW2.

8.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, alternatives for soil, surface water/sediment, and groundwater are evaluated against nine evaluation criteria to assess their relative performance and to highlight key differences among the alternatives. The nine evaluation criteria have been determined by the USEPA and are presented in the publication, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (USEPA, 1988). A summary and descriptions of the nine evaluation criteria are presented in Table 8-1.

Summaries of the performance of remedial alternatives for Area A and Area B soils, Areas A and B surface water/sediment, Area A1 groundwater, Area A2 groundwater, and Area B groundwater with respect to seven of the nine evaluation criteria are presented in Tables 8-2 through 8-7.

The two remaining criteria are state acceptance and community acceptance. With respect to state acceptance, both the USEPA and VADEQ (the state) concur with the selected remedies as presented in Section 9.0. The community acceptance criteria will be assessed in the Responsiveness Summary (Section 11.0 of this document) following a review of public comments on the RI/FS Reports and the Proposed Remedial Action Plan (PRAP).

Soil, surface water/sediment, and groundwater alternatives are compared against each other using the seven evaluation criteria in the following sections:

- 8.1 Comparison of Soil Alternatives
- 8.2 Comparison of Surface Water/Sediment Alternatives
- 8.3 Comparison of Groundwater Alternatives

8.1 <u>Comparison of Soil Alternatives</u>

8.1.1 Comparison of Area A Soil Alternatives

A side-by-side comparison of the alternatives for addressing contaminants in Area A soils, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-2. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: With respect to surface soils, all alternatives would essentially provide a similar level of protection to human health and the environment since little contamination was detected in the surface soils, and potential risks to human health are within acceptable levels. With respect to potential contamination in subsurface soils, Alternative A-SO1 would not provide any additional protection to human health than that currently provided by existing site fencing. Alternative A-SO2 would provide a higher degree of protection through institutional controls and maintenance of the existing landfill soil cover.

Alternatives A-SO1 and A-SO2 would not provide any additional protection of groundwater than that provided by existing pavement and buildings. Alternatives A-SO3 and A-SO4 would provide partial protection of groundwater through capping. The caps would only be partially effective because the landfill is unlined, and wastes are present near, or below, the water table in some areas. The caps would also provide protection against direct contact with potential soil contaminants. Of the seven alternatives, Alternative A-SO6 would provide the maximum level of protection of human health and the environment through removal and active treatment of the hot spots. Alternative A-SO7 would also permanently remove the "hot spot" areas from the site but would not provide any treatment. Alternative A-SO5 would treat the soil and shallow groundwater in the "hot spot" areas in situ, but would not achieve the same degree of contaminant removal from soil as Alternative A-SO6. Additionally, based on the results of a DPVE pilot study, Alternative A-SO5 is no longer recommended for Area A2.

Compliance with ARARs: There are no contaminant-specific ARARs available for soil. Cap designs under Alternatives A-S03 and A-S04 would comply with applicable RCRA and state regulations. Air emissions generated under Alternatives A-SO5, A-SO6, and A-SO7 would be treated to comply with state and federal air standards. Any hazardous wastes generated during implementation of Alternatives A-SO5, A-SO6, and A-SO7 would be handled, containerized, transported, and disposed in accordance with RCRA and state hazardous waste regulations.

Long-term Effectiveness and Permanence: Estimated risk levels for exposure to surface soils are currently within acceptable levels. Therefore, all alternatives would be protective of human health with respect to surface soils. Alternative A-SO2 would provide a greater degree of protection against possible exposures to subsurface contamination through deed restrictions. lternatives A-SO1 and A-SO2 would not provide a permanent solution in the sense that the "hot spots" would continue to provide sources of groundwater contamination. Alternatives A-SO3 and A-SO4 would provide partial protection of groundwater through capping. Under Alternatives A-SO5, A-SO6, and A-SO7, "hot spot" areas would be permanently removed and/or treated. Based on results of a DPVE pilot study, Alternative A-SO5 is no longer recommended for Area A2.

Reduction of Toxicity, Mobility, or Volume: Alternatives A-SO1 and A-SO2 would not actively reduce the toxicity, mobility, or volume of contaminants in the soils through remedial actions. Some reduction may be achieved under these alternatives through natural processes, such as dispersion, volatilization, and biodegradation. Alternatives A-SO3 and A-SO4 also would not reduce the toxicity, mobility, or volume of contaminants in the soils through treatment. Alternatives A-SO5 and A-SO6 would reduce the toxicity and volume of contaminants in the soils through in situ vacuum extraction and ex situ thermal treatment, respectively. Alternative A-S05 would also reduce the toxicity and volume of contaminants in shallow groundwater through treatment. Alternative A-SO6, thermal treatment, would provide a higher degree of contaminant removal from soil than would vacuum extraction under Alternative A-SO5. Alternative A-SO7 would permanently remove the source areas from the site but would not provide any reduction in toxicity, mobility, or volume through treatment.

Short-term Effectiveness: Alternatives A-SO1 through A-SO4 would not pose potential risks to human health or the environment during implementation. Alternatives A-SO5 and A-SO6 could pose potential risks to these receptors through air emissions; however, treatment and monitoring of air emissions would be used to minimize such potential risks. Implementation of Alternative A-SO7 could pose potential risks to human health and the environment from dust emissions during excavation; however, dust controls would be used minimize such risks. It is estimated that Alternative A-SO5 would require several years to achieve soil cleanup levels that are protective of groundwater, whereas, thermal treatment of the soil under Alternative A-SO6 could be completed within approximately six months once on-site work begins. Alternative A-SO7 could be completed within approximately two months once on-site work begins.

Implementability: There are no implementability considerations under Alternatives A-SO1 and A-S02. Alternative A-SO4 would be easier to implement than Alternative A-SO3 since the cap would cover only limited "hot spot" areas (e.g., 1.0 acre) as opposed to the entire Brig Facility area (approximately 12 acres). Alternative A-SO5 would be easier to implement than Alternatives A-

SO6 and A-SO7 in the sense that excavation and handling of contaminated soils would not be required. In addition, demonstration of compliance with air pollution standards for Alternative A-SO5 could be less complex than those for Alternative A-SO6. There may also be fewer public concerns associated with implementation of Alternative A-SO5 than with Alternative A-SO6. With respect to operation and maintenance requirements, on-site thermal treatment under Alternative A-SO6 would be more complex to operate and monitor than would in situ vacuum extraction under Alternative A-SO5. However, the duration of on-site operation would be less than one year for on-site thermal treatment (assuming extensive trial runs are not needed), compared to potentially several years of operation for Alternative A-SO5. For Alternative A-SO7, off-site disposal capacity is not expected to be a concern.

Cost: The 30-year net present worth costs for the six Area A soil alternatives are summarized below:

- Alternative A-SO1: $55,600
- Alternative A-SO2: $325,500
- Alternative A-SO3: $1,877,900
- Alternative A-SO4: $819,100
- Alternative A-SO5: $1,216,700
- Alternative A-SO6: $6,467,100
- Alternative A-SO7: $10,193,500

With respect to the capping alternatives, A-SO3 and A-SO4, the estimated cost of capping the "hot spot" areas (A-S04) is approximately one-half the cost of capping the entire Brig Facility area (A-S03). With respect to the treatment alternatives, A-SO5 and A-SO6, the estimated cost of treating the "hot spot" area via vacuum extraction ($1,216,700) is approximately one-fifth the cost of thermal treatment ($6,467,100), based on the estimated volume of contamination (i.e., 12,800 cubic yards) and assumed duration of operation (i.e., 5 years for vacuum extraction). Based on the estimated volume of contamination, the estimated cost of disposing the contaminated material off site ($10,193,500) is almost double the cost of treating the "hot spot" area via on-site thermal treatment ($6,467,100).

8.1.2 Comparison of Area B Soil Alternatives

A side-by-side comparison of the alternatives for addressing Area B soils, based on the seven evaluation criteria used in previous sections, is presented in Table 8-3. A summary of the alternative comparison based on the seven criteria is provided below.

Overall Protection: With respect to Area B soils, Alternative B-SO1 would not provide any additional protection to human health than that currently provided by existing site fencing. Alternative B-SO2 would provide a higher degree of protection through institutional controls.

Compliance with ARARs: There are no contaminant-specific ARARs available for soils. In addition, there are no location- or action-specific ARARs associated with either alternative.

Long-term Effectiveness and Permanence: Risks associated with exposure to the surface soils are currently within acceptable levels established under CERCLA under both industrial and residential use scenarios. A removal action has been implemented to remove the sources of groundwater contamination within the Area B landfill. Therefore, both alternatives would provide the same level of groundwater protection following the removal action. Alternative B-SO2 would provide a slightly greater degree of protection against possible exposures to any remaining contamination in the landfill through institutional controls.

Reduction of Toxicity, Mobility, or Volume: Alternatives B-SO1 and B-SO2 would not reduce the toxicity, mobility, or volume of contaminants in the soils through treatment. However, a removal action has been completed for the source areas within the Area B Landfill. Some additional reduction may be achieved under these alternatives through natural processes such as dispersion, volatilization, and biodegradation.

Short-term Effectiveness: Alternatives B-SO1 and B-SO2 would not pose potential risks to human health or the environment during implementation.

Implementability: There are no implementability considerations under Alternative B-SO1 or Alternative B-SO2.

Cost: The estimated 30-year net present worth cost of Alternative B-SO1 is $55,600, which is the cost of performing site reviews every 5 years. The estimated 30-year net present worth cost of Alternative B-SO2 is $63,200 to maintain the existing fencing as well as to conduct 5-year site reviews.

8.2 Comparison of Surface Water/Sediment Alternatives

A side-by-side comparison of the alternatives for addressing site surface water and sediment (Areas A and B), based on the seven evaluation criteria used in previous sections, is presented in Table 8-4. A summary of the alternative comparison based on the seven criteria is provided below.

Overall Protection: There are no unacceptable human health risks associated with exposure to site surface water/sediment. With respect to surface water/sediments, Alternative SD1 would not provide any additional protection to human health than that currently provided by existing site fencing. Alternative SD2 would provide a higher degree of protection through institutional controls. In addition, a surface water and sediment monitoring program would be implemented under Alternative SD2 to track trends in contaminant levels over time in these media.

Compliance with ARARs: There are no contaminant-specific ARARs available for sediments. Although there were sporadic minor exceedances of federal Ambient Water Quality Criteria and Virginia Water Quality Standards, there were no gross exceedances and no clear pattern of exceedances that would suggest a significant problem with site surface water. There are no location- or action-specific ARARs associated with either alternative.

Long-term Effectiveness and Permanence: Under Alternative SD1, there would be no remedial action taken. The human health risks associated with exposure to surface water and sediment would remain the same as in the baseline human health risk assessment (no unacceptable risk). Alternative SD2 would provide a greater degree of protection against possible exposures to potential contamination in surface water and sediments through institutional controls. For both alternatives, source control measures that have been implemented at Area B (removal action), and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment over time.

Reduction of Toxicity, Mobility, or Volume: Alternatives SD1 and SD2 would not reduce the toxicity, mobility, or volume of contaminants in the sediments through treatment. There may be a reduction in toxicity, mobility, or volume of contaminants in the long term through natural attenuation processes.

Short-term Effectiveness: Alternatives SD1 and SD2 would not pose potential risks to human health or the environment during implementation.

Implementability: There are no implementability considerations under Alternative SD1 or Alternative SD2.

Cost: The estimated 30-year net present worth cost of Alternative SD1 is $55,600 for performing site reviews every 5 years. The estimated 30-year net present worth cost of Alternative SD2 is $831,600 for maintaining existing fencing, implementing a five-year surface water and sediment monitoring program, and conducting five-year site reviews.

8.3 Comparison of Groundwater Alternatives

8.3.1 Comparison of Area A1 Groundwater Alternatives

A side-by-side comparison of the alternatives for addressing contamination in Area A1 groundwater, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-5. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: Alternatives A1-GW1 and A1-GW2 would not contain or treat contaminated groundwater. Alternative A1-GW3 would achieve protection of the Yorktown Aquifer for beneficial use through groundwater extraction and treatment.

Compliance with ARARs: Alternatives A1-GW1 and A1-GW2 would not treat or contain groundwater contaminated above federal MCLs. However, groundwater on-site and in the vicinity of the site currently is not used for drinking water purposes. Alternative A1-GW3 would comply with these ARARs by containing and potentially restoring contaminated groundwater within the

Yorktown Aquifer to federal MCLs. Under Alternative A1-GW3, treated groundwater and associated air emissions would comply with all local, state, and federal ARARs.

Long-term Effectiveness and Permanence: All alternatives currently provide on-site protection of human health since groundwater is not currently used on site. All alternatives, except Alternative A1-GW1, would provide on-site protection of human health through institutional controls.

Under Alternatives A1-GW1 and A1-GW2, risks would exceed acceptable levels if the groundwater were to be used for potable use. Under Alternative A1-GW3, risks associated with potable use of groundwater would be within acceptable levels following groundwater restoration. Thus, Alternative A1-GW3 would ultimately provide the greatest degree of long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume: Alternatives A1-GW1 and A1-GW2 would not reduce the toxicity, mobility, or volume of contaminants in the groundwater through treatment. Alternative A1-GW3 would reduce the toxicity and volume of contaminants to the established cleanup goals through treatment and would reduce contaminant mobility through extraction.

Short-term Effectiveness: There would be no risks to human health or the environment associated with implementation of Alternatives A1-GW1 and A1-GW2. Under Alternative A1-GW3, air emissions would be regularly monitored to ensure compliance with state and federal air quality standards.

Implementability: Alternative A1-GW3 would be more difficult to implement than would Alternatives A1-GW1 and A1-GW2 since it involves groundwater extraction and treatment. The treatment system components are demonstrated and commercially available.

Cost: The 30-year net present worth costs for the Area A1 groundwater alternatives are summarized below:

- Alternative A1-GW1: $476,700
- Alternative A1-GW2: $476,700
- Alternative A1-GW3: $8,870,200 (includes extraction and treatment system capital cost)

8.3.2 Comparison of Area A2 Groundwater Alternatives

A side-by-side comparison of the alternatives for addressing contamination in Area A2 groundwater, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-6. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: Alternatives A2-GW1 and A2-GW2 would not contain or treat contaminated groundwater. Alternatives A2-GW3 and A2-GW4 would achieve protection of the water table and Yorktown Aquifers for their beneficial uses through groundwater extraction and treatment.

Compliance with ARARs: Alternatives A2-GW1 and A2-GW2 would not treat or contain groundwater contaminated above federal MCLs. However, groundwater on-site and in the vicinity of the site currently is not used for drinking water purposes. Alternative A2-GW3 would comply with these ARARs by containing and potentially restoring contaminated groundwater within the Yorktown Aquifer to federal MCLs. Under Alternative A2-GW4, groundwater within the water table aquifer would be contained and potentially restored to cleanup levels based on nonpotable use. Under Alternatives A2-GW3 and A2-GW4, treated groundwater and associated air emissions would comply with all local, state, and federal ARARs.

Long-term Effectiveness and Permanence: All alternatives currently provide on-site protection of human health since groundwater is not currently used on site. All alternatives, except Alternative A2-GW1, would provide off-site protection of human health, if necessary, through institutional controls.

Under Alternatives A2-GW1 and A2-GW2, risks would exceed acceptable levels if the groundwater were to be used for potable use. Under Alternatives A2-GW3 and A2-GW4, risks associated with potable and nonpotable use of groundwater, respectively, would be within acceptable levels following groundwater restoration. Thus, Alternatives A2-GW3 and A2-GW4 would ultimately provide the greatest degree of long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume: Alternatives A2-GW1 and A2-GW2 would not reduce the toxicity, mobility, or volume of contaminants in the groundwater through treatment.

Alternatives A2-GW3 and A2-GW4 would reduce the toxicity and volume of contaminants to the established cleanup goals through treatment and would reduce contaminant mobility through extraction.

Short-term Effectiveness: There would be no risks to human health or the environment associated with implementation of Alternatives A2-GW1 and A2-GW2. Under Alternatives A2-GW3 and A2-GW4, air emissions would be regularly monitored to ensure compliance with state and federal air quality standards.

Implementability: Alternatives A2-GW3 and A2-GW4 would be more difficult to implement than would Alternatives A2-GW1 and A2-GW2 since they involve groundwater extraction and treatment. The treatment system components are demonstrated and commercially available.

Cost: The 30-year net present worth costs for the Area A2 groundwater alternatives are summarized below:

- Alternative A2-GW1: $476,700
- Alternative A2-GW2: $476,700
- Alternative A2-GW3: $796,000 (includes only O&M costs for Area A2)
- Alternative A2-GW4: $168,000 (includes only O&M costs for Area A2)

8.3.3 Comparison of Area B Groundwater Alternatives

A side-by-side comparison of the Area B groundwater alternatives, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-7. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: Alternatives B-GW1 and B-GW2 would not contain or treat contaminated groundwater. Alternative B-GW3 would achieve protection of the water table and Yorktown aquifers for their beneficial uses through groundwater extraction and treatment.

Compliance with ARARs: Alternatives B-GW1 and B-GW2 would not treat or contain groundwater contaminated above federal MCLs. However, groundwater on-site and in the vicinity of the site currently is not used for drinking water purposes. Alternative B-GW3 would comply with these ARARs by containing and potentially restoring contaminated groundwater within the Yorktown Aquifer to federal MCLs. Groundwater within the water table aquifer would be contained and potentially restored to cleanup levels based on nonpotable use. Under Alternative B-GW3, treated groundwater and associated air emissions would comply with all local, state, and federal ARARs.

Long-term Effectiveness and Permanence: All alternatives currently provide on-site protection of human health since groundwater is not currently used on site. All alternatives, except Alternative B-GW1, would provide on-site protection of human health through institutional controls.

Under Alternatives B-GW1 and B-GW2, risks would exceed acceptable levels if the groundwater were to be used for potable use. Under Alternative B-GW3, risks associated with potable use of groundwater would be within acceptable levels following groundwater restoration. Thus, Alternative B-GW3 would ultimately provide the greatest degree of long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume: Alternatives B-GW1 and B-GW2 would not reduce the toxicity, mobility, or volume of contaminants in the groundwater through treatment. Alternative B-GW3 would reduce the toxicity and volume of contaminants to the established cleanup goals through treatment and would reduce contaminant mobility through extraction.

Short-term Effectiveness: There would be no risks to human health or the environment associated with implementation of Alternatives B-GW1 and B-GW2. Under Alternative B-GW3, air emissions would be regularly monitored to ensure compliance with state and federal air quality standards.

Implementability: Alternative B-GW3 would be more difficult to implement than would Alternatives B-GW1 and B-GW2 since it involves groundwater extraction and treatment. The treatment system components are demonstrated and commercially available.

Cost: The 30-year net present worth costs for the Area B groundwater alternatives are summarized below:

- Alternative E-GW1: $476,700
- Alternative E-GW2: $476,700
- Alternative E-GW3: $842,500 (includes only O&M costs for Area B)

SECTION 8.0 TABLES

TABLE 8-1

SUMMARY OF EVALUATION CRITERIA

Threshold Criteria

- **Overall Protection of Human Health and Environment** - addresses whether or not an alternative provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- **Compliance with ARARs** - addresses whether or not an alternative will meet all of the applicable or relevant and appropriate requirements (ARARs) or other federal and state environmental statutes and/or provide grounds for invoking a waiver.

Primary Balancing Criteria

- **Long-Term Effectiveness and Permanence** - refers to the magnitude of residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time once cleanup goals have been met.

- **Reduction of Toxicity, Mobility, or Volume through Treatment** - is the anticipated performance of the treatment options that may be employed in an alternative.

- **Short-Term Effectiveness** - refers to the speed with which the alternative achieves protection, as well as the remedy's potential to create adverse impacts on human health and the environment during the construction and implementation period.

- **Implementability** - is the technical and administrative feasibility of an alternative, including the availability of materials and services needed to implement the chosen solution.

- **Cost**- includes capital and operation and maintenance costs, and for comparative purposes, net present worth values.

Modifying Criteria

- **USEPA/State Acceptance** - indicates whether, based on review of the RI and FS reports and the PRAP, the USEPA and state concur with, oppose, or have no comments on the preferred alternative.

- **Community Acceptance** - will be addressed in this Decision Document following a review of the public comments received on the RI and FS reports and the PRAP.

TABLE 8-2

COMPARISON OF AREA A SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A-SO1 NO ACTION	ALTERNATIVE A-SO2 INSTITUTIONAL CONTROLS	ALTERNATIVE A-SO3 ASPHALT/GEOSYNTHETIC CAP OVER BRIG AREA(1)	ALTERNATIVE A-SO4 COMPOSITE CAP OVER HOT SPOT AREAS(1)	ALTERNATIVE A-SO5 DUAL PHASE VACUUM EXTRACTION OF HOT SPOT AREAS(1)	ALTERNATIVE A-SO6 THERMAL TREATMENT OF HOT SPOT AREAS(1)	ALTERNATIVE A-SO7 OFF-SITE DISPOSAL OF HOT SPOT AREAS(1)
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT						
No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. No additional protection from direct contact with potential soil contamination. No additional protection of groundwater.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. No additional protection of groundwater.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls and cap. Partial protection of groundwater provided by cap over Brig area.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls and cap. Partial protection of groundwater provided by cap over hot spot area(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater provided by in situ treatment of source area(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater provided by ex situ treatment of source(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater by off-site disposal of source area(s).
COMPLIANCE WITH ARARS						
No contaminant-, location-, or action-specific ARARs.	No contaminant-, location- or action-specific ARARs.	No contaminant-specific ARARs. Cap designed in accordance with RCRA and state solid waste regulations.	No contaminant-specific ARARs. Cap designed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/ disposed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/disposed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/disposed in accordance with RCRA and state hazardous waste regulations.
LONG-TERM EFFECTIVENESS AND PERMANENCE						
No remedial action would be taken. No reduction in risk levels; however, risks are acceptable under current use, and site is not used for residential use. No additional protection of groundwater.	Institutional actions would administratively limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Maintenance of landfill soil cover effective in limiting surface water infiltration and erosion.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Partial long-term protection of groundwater provided by cap over potential source areas in vicinity of Brig.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Partial long-term protection of groundwater provided by cap over hot spot area(s).	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by in situ treatment.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by ex situ treatment.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by off-site disposal.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT						
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes. Partial reduction in mobility through capping.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes. Partial reduction in mobility through capping.	Reduction in TMV through in situ vacuum extraction/treatment. Effective removal of VOCs, partial removal of SVOCs.	Reduction in TMV through ex situ thermal treatment. Very effective removal of VOCs and effective removal of SVOCs.	No reduction in TMV through treatment. Reduction in mobility via disposal in secure off-site landfill.

TABLE 8-2 (Continued)

COMPARISON OF AREA A SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A-SO1 *NO ACTION*	ALTERNATIVE A-SO2 *INSTITUTIONAL CONTROLS*	ALTERNATIVE A-SO3 *ASPHALT/GEOSYNTHETIC CAP OVER BRIG AREA*[(1)]	ALTERNATIVE A-SO4 *COMPOSITE CAP OVER HOT SPOT AREAS*[(1)]	ALTERNATIVE A-SO5 *DUAL PHASE VACUUM EXTRACTION OF HOT SPOT AREAS*[(1)]	ALTERNATIVE A-SO6 *THERMAL TREATMENT OF HOT SPOT AREAS*[(1)]	ALTERNATIVE A-S07 *OFF-SITE DISPOSAL OF HOT SPOT AREAS*[(1)]
SHORT-TERM EFFECTIVENESS						
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Potential risks to human health and environment during operation would be controlled by air emission treatment/ monitoring. Several years required to achieve cleanup levels.	Potential risks to human health and environment during operation would be controlled by air emission treatment/ monitoring. Approx. 6 months required to complete remediation.	Potential risks to human health and environment during excavation would be controlled by dust controls. Approx. 2 months required to complete remediation.
IMPLEMENTABILITY						
Readily implementable.	Straight-forward installation of fencing. Periodic inspection and maintenance of fenced required. Legal/administrative requirements for institutional controls.	Legal/administrative requirements for institutional controls. Capping technologies demonstrated and commercially available. Periodic inspection and maintenance of cap required.	Legal administrative requirements for institutional controls. Capping technologies demonstrated and commercially available. Periodic inspection and maintenance of cap required.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available. Approx. 5-year operation of treatment system.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available. Trial runs may be required. Potential public opposition. Approx. 6-month operation of treatment system.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available.
COST						
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $17,557 (annually); $20,000 (every 5 years) NPW: $325,500	Capital: $927,200 O&M: $17,557 (annually); $95,653 (every 5 years) NPW: $1,877,900	Capital: $465,300 O&M: $19,395 (annually); $39,395 (every 5 years) NPW: $819,100	Capital: $490,700 O&M: $108,066 (years 1-4) $139,022 (year 5) $17,557 (years 6-30) NPW: $1,216,700	Capital: $6,141,500 O&M: $17,557 (annually); $37,557 (every 5 years) NPW: $6,467,100	Capital: $9,867,900 O&M: $17,557 (annually); $37,557 (every 5 years) NPW: $10,193,500

[(1)] Alternative includes Institutional Controls
O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 8-3

COMPARISON OF AREA B SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-SO1 NO ACTION	ALTERNATIVE B-SO2 INSTITUTIONAL CONTROLS
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT	
No unacceptable risks from surface soils for current land uses, marginal risks for future residential use. Provides no additional protection from direct contact, no additional protection of groundwater. However, the removal action of sources at Area B will provide protection.	No unacceptable risks from surface soils for current land uses, marginal risks for future residential use. Provides some additional protection from direct contact by institutional controls, no additional protection of groundwater. However, the removal action of sources at Area B will provide protection.
COMPLIANCE WITH ARARS	
No contaminant-, location-, or action-specific ARARs.	No contaminant-, location- or action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
No remedial action; however, the removal action will provide effective and permanent source removal.	Institutional controls would limit future land use to non-residential. The removal action will provide effective and permanent source control.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT	
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.
SHORT-TERM EFFECTIVENESS	
No risks to human health or environment during implementation.	No risks to human health or environment during implementation.
IMPLEMENTABILITY	
No action; therefore, no implementability concerns.	Periodic inspection and maintenance of fenced required. Legal/administrative requirements for institutional controls.
COST	
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $600 (annually); $20,000 (every 5 years) NPW: $63,200

O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 8-4

COMPARISON OF SURFACE WATER/SEDIMENT ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE SD-1 NO ACTION	ALTERNATIVE SD-2 INSTITUTIONAL CONTROLS WITH MONITORING
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT	
No unacceptable human health risks associated with exposure to Area A or Area B surface water/sediment. No unacceptable risks associated with elementary school in Area B. Marginal risks for future residential use. Low levels of contaminants. Migration of contaminants to groundwater not considered to be a pathway. Provides no additional protection.	No unacceptable human health risks associated with exposure to Area A or Area B surface water/sediment. No unacceptable risks associated with elementary school in Area B. Marginal risks for future residential use. Low levels of contaminants. Migration of contaminants to groundwater not considered to be a pathway. Provides some additionai protection through institutional controls.
COMPLIANCE WITH ARARS	
Minor exceedances of federal and state standards for surface water. No action- or location-specific ARARs.	Minor exceedances of federal and state standards for surface water. No action- or location-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
No remedial action -- risks same as in baseline risk assessment. However, source control actions in Areas A and B are expected to improve surface water/sediment quality over time.	Institutional controls would limit future land use to non-residential. Monitoring would provide information to track contaminant levels in these media.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT	
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.
SHORT-TERM EFFECTIVENESS	
No risks to human health during implementation.	No risks to human health during implementation.
IMPLEMENTABILITY	
No action; therefore, no implementability concerns.	Legal/administrative requirements for institutional controls. Monitoring easily implemented.
COST	
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $50,477 (annually); $70,477 (every 5 years) NPW: $831,600

O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 8-5

COMPARISON OF AREA A1 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A1-GW1 NO ACTION[1]	ALTERNATIVE A1-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE A1-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT[2]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site.	Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater in the Yorktown Aquifer to established cleanup goals. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore Yorktown Aquifer to federal MCLs. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.

TABLE 8-5 (CONTINUED)

COMPARISON OF AREA A1 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A1-GW1 NO ACTION[(1)]	ALTERNATIVE A1-GW2 INSTITUTIONAL CONTROLS[(1)]	ALTERNATIVE A1-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT[(2)]
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $6,108,500 O&M: $187,300 (yrs 1-10) $168,300 (yrs 11-20) $158,800 (yrs 21-30) $20,000 (every 5 yrs) NPW: $8,870,200

(1) Alternative includes groundwater monitoring.
(2) Alternative cost includes extraction and treatment system capital cost.
O&M: Operation and maintenance.
NPW: Net present worth.

TABLE 8-6

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION[1]	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVES A2-GW3 AND A2-GW4 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination may continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site.	Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination may continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater to established cleanup goals. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore the water table and Yorktown Aquifers to their respective cleanup goals. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.

TABLE 8-6 (Continued)

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION[1]	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVES A2-GW3 AND A2-GW4 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.

TABLE 8-6 (Continued)

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION[1]	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVES A2-GW3 AND A2-GW4 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	A2-GW3 / A2-GW4 Capital: $0 / $0 O&M: $59,400 / $8,900 (yrs 1-10) $40,400 / $6,200 (yrs 11-20) $30,900 / $4,900 (yrs 21-30) $20,000 / $20,000 (every 5 yrs) NPW: $796,000 / $168,000

(1) Alternative includes groundwater monitoring.
(2) Alternative cost includes only additional O&M costs for Area A2 groundwater treatment.
O&M: Operation and maintenance.
NPW: Net present worth.

TABLE 8-7

COMPARISON OF AREA B GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-GW1 NO ACTION[1]	ALTERNATIVE B-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE B-GW3 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater, however, groundwater on site and immediately downgradient of contamination is not currently used for any purpose.	Would not contain or treat contaminated groundwater, however, groundwater on site and immediately downgradient of contamination is not currently used for any purpose. Institutional controls would prevent future potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater to established cleanup goals. Contamination below cleanup goals would continue to migrate off site. Groundwater on site and immediately downgradient of contamination is not currently used for any purpose. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore the water table and Yorktown Aquifers to their respective cleanup goals. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Under current conditions, risks would exceed acceptable levels if shallow or deep aquifers were used for potable use on site. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow or deep aquifers were used for potable use on site. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.

TABLE 8-7 (Continued)

COMPARISON OF AREA B GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-GW1 NO ACTION[1]	ALTERNATIVE B-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE B-GW3 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be treated and monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,1000 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $62,400 (years 1-10) $43,400 (years 11-20) $34,000 (years 21-30) $20,000 (every 5 years) NPW: $842,500

[1] Alternative includes groundwater monitoring.
[2] Alternative cost includes only additional O&M costs for Area B groundwater treatment.
O&M: Operation and maintenance.
NPW: Net present worth.

9.0 THE SELECTED REMEDY

9.1 Site Remediation Goals

Based on RI findings and the results of the baseline risk assessment, three media of concern have been identified at the Camp Allen Landfill Site as follows:

- Soils
- Surface Water/Sediments
- Groundwater

Site remediation goals were developed for each medium of concern considering the contaminants of concern, potential receptors, and exposure scenarios. Given the removal action at Area B, site remediation goals differ slightly for soil between Areas A and B of the Camp Allen Landfill Site. Site remediation goals for each area are listed as follows:

- Soil
  - Prevent exposure to subsurface soil and debris.
  - Minimize migration of contaminants to groundwater and surface water (Area A only since removal action at Area B has been successfully implemented).

- Surface Water/Sediment
  - Prevent exposure to potential contaminants in surface water and sediments.
  - Address indirectly through the development of soil and groundwater alternatives.

- Groundwater
  - Prevent exposure to contaminated groundwater.
  - Prevent further migration of contaminated groundwater.
  - Restore contaminated aquifers.

9.2 Cleanup Goal Development

The three media of concern that have been identified at the site are: soils, groundwater and surface water/sediments. Cleanup goals are developed in the following sections for soils and groundwater. Cleanup goals have not been established for surface water/sediments because removal and/or treatment alternatives were not evaluated for site surface water/sediments, as discussed in Section 7.2.

9.2.1 Soil Cleanup Goals

Soil analytical data obtained during the Camp Allen Landfill pre-design investigation indicate the presence of VOCs in subsurface soils in Areas A1 and A2. Under the influence of infiltrating precipitation, these VOCs may migrate through the unsaturated zone soils to the water table aquifer. Thus, under current conditions, the contaminated subsurface soils in Areas A1 and A2 could potentially act as sources of continuing contamination to underlying groundwater. The objective of soil cleanup goal development was to determine subsurface soil cleanup goals based on the potential for the VOCs to migrate (i.e., leach) to the water table aquifer in Areas A1 and A2 at the Camp Allen Landfill.

A spreadsheet-based transport model described by Summers was developed to determine the potential soil cleanup goals. The Summers Model is a one-dimensional advective transport model that estimates the potential contaminant concentration in leachate (emanating from the source area) at the top of the water table aquifer. The general input data for the spreadsheet model include contaminant characteristics, unsaturated zone characteristics, hydrogeological properties of the water table aquifer, and annual precipitation data. Site-specific data were obtained from the pre-design investigation as well as from previous field investigations. A more detailed description of the Summers Model, as well as the specific modeling inputs and their sources used in the spreadsheet calculation of soil cleanup goals, are provided in the Final Camp Allen Landfill Feasibility Study.

The soil cleanup goals developed using the Summers Model for the contaminants of concern in Areas A1 and A2 are provided in Table 9-1. The soil cleanup goals shown in Table 9-1 were based on attainment of federal MCLs in shallow groundwater immediately below the source area as a conservative measure in order to protect the underlying Yorktown Aquifer to its potential future beneficial use (i.e., drinking water supply). Since the MCLs for the contaminants of concern are less than the Federal Ambient Water Quality Criteria and Virginia Water Quality Standards, soil cleanup goals are also protective of surface water.

The soil cleanup goals were used to estimate remediation areas and the volume of contaminated soil in Area A. It should be noted that, since Area A is a landfill, the primary remediation goal for the soils is groundwater protection rather than soil cleanup. Therefore, achievement of this goal will be determined through evaluation of actual environmental monitoring results (i.e., via on-going monitoring of contaminant levels in groundwater), and will not necessarily be based on attainment of the developed soil cleanup goals since they represent theoretical values calculated through modeling.

9.2.2 Groundwater Cleanup Goals

Cleanup goals for each aquifer have been developed based on the potential beneficial use of the aquifer. For the Yorktown Aquifer, the groundwater cleanup goals were based on attainment of federal MCLs in order to protect the aquifer for its potential future beneficial use (i.e., potential future drinking water supply). The cleanup goals for the Yorktown Aquifer are shown in Table 9-2.

It is recognized that MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed MCLs. Performance curves will be periodically (e.g., annually) developed to monitor groundwater contaminant levels. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

Unlike the Yorktown Aquifer, the beneficial use of the water table aquifer is nonpotable use. Therefore, nonpotable use cleanup goals were developed for the water table aquifer, which were based on a 1×10^{-6} cancer risk level and a hazard quotient of 1.0 for children and the exposure pathways of incidental ingestion and dermal absorption of contaminants during outdoor activities, such as car washing and lawn watering. Cleanup goals for the water table aquifer are also presented in Table 9-2.

As a point of comparison, Federal Ambient Water Quality Criteria (AWQC) were included in Table 9-2 (there are no State AWQC for contaminants of potential concern). These surface water criteria would apply to groundwater as it discharges into surface water. The Yorktown Aquifer cleanup goals (based on Federal MCLs) are less than the Federal AWQC for all contaminants. The water table aquifer cleanup goals are less than the Federal AWQC for all contaminants except toluene. However, the maximum concentration of toluene detected in groundwater (567 µg/L) is less than the Federal AWQC for toluene (5,000 µg/L). Therefore, these groundwater cleanup levels are also protective of surface water.

9.3 Selected Remedy Description

The selected remedy for each medium of concern for Areas A and B is identified below:

Area A1 Soil

Alternative A-SO5: In Situ Treatment by Dual Phase Vacuum Extraction with Institutional Controls

Area A2 Soil

Alternative A-SO2: Institutional Controls

Area B Soil

Alternative B-SO2: Institutional Controls

Surface Water/Sediment (Areas A and B)

Alternative SD-2: Institutional Controls with Monitoring

Area A1 Groundwater

Alternative A1-GW3: Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Area A2 Shallow Groundwater (Water Table Aquifer)

Alternative A2-GW4: Protection of the Water Table Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Area A2 Deep Groundwater (Yorktown Aquifer)

Alternative A2-GW2: Institutional Controls with Monitoring.

Area B Groundwater

Alternative B-GW3: Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

9.3.1 Rationale for Selected Remedies

Based on available information and the current understanding of site conditions, each alternative appears to provide the best balance of trade-offs with respect to the nine CERCLA evaluation criteria. In addition, the selected alternatives are anticipated to meet the following statutory requirements:

- Protection of human health and the environment
- Compliance with ARARs (or justification of a waiver)
- Cost-effectiveness
- Utilization of permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable

The proposed response actions (or selected remedies) identified herein address all contaminated media of concern at the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the selected remedies include contaminated soil, surface water/sediment, and groundwater in Areas A and B. The selected remedies for the various media are briefly described below.

Soil Alternatives

Area A1

The preferred alternative for contaminated soil in Area A1 is Alternative A-SO5, In Situ Treatment by Dual Phase Vacuum Extraction (DPVE) with institutional controls. The DPVE system offers a significant advantage over other treatment alternatives in that it is able to extract both soil and shallow groundwater (water table aquifer) contamination with a single system. This benefit is especially valuable since it has been shown that the conventional pump and treat method would not be feasible for remediation of the water table aquifer in Area A1 due to its very low hydraulic conductivity. The groundwater extracted by the DPVE system would be pumped to the proposed on-site treatment plant for contaminated groundwater, which would be constructed as part of Alternatives A1-GW3 and B-GW3. Institutional controls would include maintenance of the existing fencing and soil cover in Area A1 and deed restrictions to limit the area to non-residential land use.

Area A2

The preferred alternative for Area A2 soils is A-SO2 - Institutional Controls. In contrast to Area A1, the DPVE pilot test performed in Area A2 yielded no identifiable contaminants in either the extracted groundwater or soil vapors, indicating that the extent of soil contamination in Area A2 is very limited. The test results also showed that the DPVE technology is not well suited for the shallow groundwater in Area A2, and that conventional submersible pumps are more appropriate for this area. Any contamination that may migrate from the soil to the shallow groundwater would be captured by the shallow groundwater extraction system proposed for Area A2. Similarly to Area A1, institutional controls would include maintenance of the existing fencing and soil cover in Area A2 and deed restrictions to limit the area to non-residential land use.

Area B

Since the primary source of groundwater contamination in Area B appeared to be concentrated in a relatively small volume of contaminated soil, a removal action was performed for the Area B contaminated soil. The removal action involved excavation of contaminated soil and debris in hot spot areas within Area B and off-site disposal of the excavated material at a RCRA-permitted hazardous waste management facility (landfill or incinerator). Since it is expected that this removal action has permanently removed the primary sources of contamination in Area B, the preferred alternative for Area B soils is Alternative B-SO2, Institutional Controls (fence maintenance and deed restrictions).

Surface Water/Sediment Alternative

The preferred alternative for surface water/sediment in Areas A and B is Alternative SD-2, Institutional Controls and Monitoring. The proposed remediation of the soil and groundwater in the Camp Allen Landfill Area is expected to result in a decrease in contaminant levels in surface water/sediment over time. Therefore, a post-remediation surface water/sediment monitoring program would be used to track trends in contamination levels over time in these media in the surrounding drainage channels. Additional sampling/analysis of surface water/sediment is proposed in the immediate future to establish baseline conditions of surface water/sediment in the vicinity of the Camp Allen Landfill Site for the proposed monitoring program.

Groundwater Alternatives

Area A1

The preferred alternative for groundwater in Area A1 is Alternative A1-GW3, Protection of the Yorktown Aquifer for Beneficial use Through Extraction and Treatment, Institutional Controls, and Monitoring. The water table aquifer in Area A1 will be addressed by the DPVE system that is proposed for Area A1 soils. Although there are no downgradient residential receptors for groundwater in this area, extraction and treatment of groundwater in the Yorktown Aquifer is recommended in Area A1, since the contaminant plume could migrate off of Navy property in this area. Groundwater in the Yorktown Aquifer would be extracted through a series of mid-depth (approximately 65 feet) pumping wells and would be pumped to an on-site treatment system. The treatment system, which would include metals removal via clarification/filtration, and removal of volatile organics via air stripping and carbon adsorption, would be sized to accommodate groundwater flows from Areas A1, A2, and B. A groundwater monitoring program would be implemented to assess trends in groundwater quality over time and to evaluate the effectiveness of the groundwater extraction and treatment system. Additionally, deed restrictions would be implemented to limit the area to non-residential land uses.

Area A2

The preferred alternative for the water table aquifer in Area A2 is A2-GW4 - Protection of the Water Table Aquifer for Beneficial Use through Extraction and Treatment, Institutional Controls, and Monitoring. This alternative was not included in the Feasibility Study because shallow groundwater remediation was addressed by the DPVE alternative developed for Area A2 soils. However, results of the DPVE pilot test indicate that the DPVE technology is not well-suited for the shallow groundwater in Area A2, and that conventional submersible pumps are more appropriate for this area. Therefore, Alternative A2-GW4 is proposed to contain shallow groundwater contamination in Area A2, which could migrate horizontally, or vertically to the Yorktown Aquifer. Implementation of this alternative would be very similar to Alternatives A1-GW3 and B-GW3. Groundwater in the water table aquifer would be extracted through shallow extraction wells (approximately 25 feet deep). Extracted groundwater would be pumped to the on-site groundwater treatment system proposed for Alternatives A1-GW3 and B-GW3.

At this time, the preferred alternative for the Yorktown Aquifer in Area A2 is Alternative A2-GW2, Institutional Controls with Monitoring. Since there are no receptors for groundwater immediately downgradient of Area A2, and the contaminant plume is not expected to migrate off Navy property in this area, extraction and treatment of groundwater in the Yorktown Aquifer is not recommended in Area A2. Since the water table aquifer within Area A2 will be remediated under Alternative A2-GW4, contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented to assess trends in groundwater quality over time. As previously noted, the on-site treatment system would be sized to treat flows from Areas A1, A2 and B. In the event that extraction and treatment of the Yorktown Aquifer in Area A2 becomes necessary, treatment capacity would be available. Additionally, deed restrictions would be implemented to limit the area to non-residential land uses.

Area B

The preferred alternative for groundwater in Area B is Alternative B-GW3, Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring. Extraction and treatment of both aquifers in Area B is recommended because, in general, the levels of contaminants in Area B groundwater are higher than in Areas A1 and A2. Additionally, although there are no groundwater users downgradient of Area B, extraction and treatment of groundwater in both aquifers is recommended in this area to contain the contaminant plume. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (approximately 65 feet deep). Groundwater in the water table aquifer would be extracted through a series of shallow pumping wells (approximately 25 feet deep). Extracted groundwater from both aquifers would be pumped to an on-site treatment system. The treatment system, which would include metals removal via clarification/filtration, and removal of organics via air stripping and carbon adsorption, would be sized to accommodate groundwater flows from Areas A1, A2, and B.

A groundwater monitoring program would be implemented to assess trends in groundwater quality over time and to evaluate the effectiveness of the groundwater extraction and treatment system. Additionally, existing fencing in Area B would be maintained, and deed restrictions would be implemented to limit the area to non-residential land uses.

This combination of response actions is expected to provide effective source control at the site, to substantially reduce the potential for migration of contamination, and to significantly reduce potential human health and environmental risks associated with the site. For a more detailed analysis and evaluation of remedial alternatives, the reader is referred to the Camp Allen Landfill Site Final Feasibility Study.

SECTION 9.0 TABLES

TABLE 9-1

SOIL CLEANUP GOALS
CAMP ALLEN LANDFILL SITE, NORFOLK, VIRGINIA

CONTAMINANTS OF CONCERN	GROUNDWATER GOAL* (ppm)	SOIL CLEANUP GOAL (ppm)
1,2-Dichloroethane	0.005	0.05
1,2-Dichloroethene (cis)	0.070	3.1
1,1,1-Trichloroethane	0.200	21.3
Benzene	0.005	0.2
Ethylbenzene[(1)]	0.700	500
Tetrachloroethene	0.005	1.4
Toluene	1.000	220.7
Trichloroethene	0.005	0.5
Vinyl Chloride	0.002	0.01
Xylenes[(1)]	10.00	7,000

* Soil cleanup goals are derived from groundwater goals, which are based on Federal Safe Drinking Water Act Maximum Contaminant Levels (MCLs), USEPA, May 1993.

(1) Monte Carlo analyses not performed for these compounds.

TABLE 9-2

GROUNDWATER CLEANUP GOALS (μg/L)
CAMP ALLEN LANDFILL SITE, NORFOLK, VIRGINIA

Contaminants of Concern	Yorktown Aquifer[1] Cleanup Goals (μg/L)	Water Table Aquifer[2] Cleanup Goals (μg/L)	Federal AWQC[4]		Maximum Concentration Detected in Groundwater[5]
			Freshwater Chronic	Marine Chronic	
1,2-Dichloroethane	5	190	20,000	--	600
1,2-Dichloroethene (cis)	70	15,000	--	--	3,807
1,1,1-Trichloroethane	200	13,500	--	--	ND
Benzene	5	600	--	700	600
Ethylbenzene	700	150,000	--	--	ND
Tetrachloroethene	5	340	840	450	354
Toluene	1,000	301,000	--	5,000	567
Trichloroethene	5	1,600	21,900	--	699
Vinyl Chloride	2	9	--	--	ND
Xylenes	10,000	3,000,000	--	--	672

(1) Based on federal Safe Drinking Water Act Maximum Contaminant Levels (MCLs), USEPA, May 1994.
(2) Based on incidental ingestion under a nonpotable use scenario and an incremental cancer risk of 1×10^{-6} and a hazard quotient (HQ) of 1.0 for children.
(3) Cleanup goals are based on contaminants found in soil and groundwater during the pre-design investigation.
(4) Ambient water quality criteria (AWQC) are included to present a comparison between groundwater cleanup goals and surface water quality criteria. AWQC standards are based on Federal Water Quality Criteria (USEPA Water Quality Criteria, May 1, 1991).
(5) Maximum concentration detected in groundwater during the pre-design investigation.
ND = Not detected
-- = Criteria not available

10.0 STATUTORY DETERMINATIONS

A selected remedy must satisfy the statutory requirements of CERCLA Section 121, which include:

- Protection of human health and the environment
- Compliance with ARARs (or justification of a waiver)
- Cost-effectiveness
- Utilization of permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable.
- Preference for treatment that reduces toxicity, mobility, or volume as a principal element, or explanation as to why this preference is not satisfied.

The evaluation of how the selected remedy for the Camp Allen Landfill Site satisfies these requirements is presented below.

10.1 Protection of Human Health and the Environment

The selected remedy provides protection to human health and the environment through extraction and treatment of groundwater in Areas A and B, in situ treatment of soil in Area A (Area B soil has been excavated and disposed off site through a removal action), monitoring of groundwater and surface water/sediments, and institutional controls, as described below.

Groundwater is not used for any purpose at the site or in the immediate vicinity of the site. Public water in the area is provided by the City of Norfolk. Nonetheless, the Yorktown Aquifer is the primary source of potable water in the region. The selected remedy provides for extraction and treatment of groundwater in the Yorktown Aquifer in Areas A1 and B. The extraction and treatment system is designed to prevent migration of contaminated groundwater off site. The selected remedy does not provide for extraction and treatment of the Yorktown Aquifer in Area A2, since there are no downgradient receptors and the plume is not expected to migrate off Navy property in this area. In Area A2 and B, the water table aquifer will also be extracted and treated. In Area A1, the water table aquifer is not amenable to extraction due to its low hydraulic conductivity. Therefore, the water table aquifer in Area A1 will be addressed by the dual phase vacuum extraction (DPVE) and treatment, which is proposed for Area A1 soils.

In Areas A1 and B, the selected remedy will prevent exposure (i.e., ingestion, inhalation, dermal contact) to groundwater exceeding drinking water standards (i.e., MCLs) in the Yorktown Aquifer through extraction and treatment, which will prevent further migration of contaminated groundwater and gradually reduce contaminant levels. In Area A2, this exposure pathway will be controlled through use of institutional controls, which will prevent consumption of contaminated groundwater in this area. If groundwater is eventually restored to the MCLs, then site risks associated with potable use of groundwater will be reduced to within the 1×10^{-4} to 1×10^{-6} range for the carcinogenic contaminants, and hazard indices will be reduced to less than one for noncarcinogenic contaminants. Implementation of the selected remedy for the Yorktown Aquifer should pose no unacceptable short-term risks to human health or the environment nor cause any cross-media adverse impacts.

In Areas A1, A2, and B, the selected remedy will prevent exposure (i.e., ingestion, inhalation, dermal contact) to groundwater exceeding nonpotable-use cleanup goals in the water table aquifer through extraction and treatment, which will prevent further migration of contaminated groundwater and gradually reduce contaminant levels. Exposure pathways will also be controlled through use of institutional controls to prevent consumption of contaminated groundwater. If groundwater is eventually restored to the cleanup goals, then site risks associated with nonpotable use of groundwater will be reduced to within the 1×10^{-4} to 1×10^{-6} range for the carcinogenic contaminants, and hazard indices will be reduced to less than one for noncarcinogenic contaminants. Implementation of the selected remedy for the water table aquifer should pose no unacceptable short-term risks to human health or the environment nor cause any cross-media adverse impacts.

The contaminated soil and shallow groundwater in Area A1 will be treated in situ via a dual phase vacuum extraction (DPVE) system, which removes contaminated soil gas and shallow groundwater for subsequent treatment. Treatment of the Area A1 soil will protect the underlying groundwater by reducing contamination and subsequent leaching of contaminants into the groundwater. Thus, the selected soil remedy will help to achieve the groundwater restoration objectives and associated risk reductions. Risks associated with exposure to potential contaminants within the landfills through direct contact (e.g., ingestion, dermal contact) will be mitigated through use of institutional controls to prevent residential use of the area. Implementation of the selected remedy for the soils should pose no unacceptable short-term risks to human health or the environment nor cause any adverse cross-media impacts.

The selected remedy includes monitoring of groundwater and surface water/sediments. A groundwater monitoring program will be implemented to assess trends in groundwater quality over time and to evaluate the effectiveness of the groundwater extraction and treatment system. A surface water/sediment monitoring program will be implemented to track trends in the surface water/sediment quality at the site. Source controls that are being implemented at Area A and B are expected to improve the quality of surface water and sediments at the site over time.

The institutional controls to be implemented at the site would include aquifer use restrictions and deed restrictions limiting the area to non-residential land use.

10.2 Compliance With Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with applicable or relevant and appropriate requirements (ARARs). No ARAR waivers are anticipated. Some of the key ARARs are discussed below. Compliance with the remaining state and federal ARARs is outlined in Table 10-1. Federal and state TBC requirements are provided in Table 10-2.

Specifically, groundwater cleanup goals for the Yorktown Aquifer comply with Safe Drinking Water Act maximum contaminant levels (Federal MCLS). Groundwater cleanup goals for the water table aquifer are risk-based levels for nonpotable use. Groundwater recovered by the extraction system would be treated at the on-site groundwater treatment plant and would be discharged in accordance with the Virginia Pollution Discharge Elimination System (VPDES) (VR 680-14-01) Regulations and the Virginia Water Protection Permit Regulations (VR 680-15-01). Under these regulations, effluent limits are established based on the Virginia Water Quality Standards (VR 680-21-00) for surface water. At the Camp Allen Landfill Site, the only contaminant in groundwater that exceeds the appropriate Virginia surface water standard is trichloroethene (TCE). Therefore, the DoN has proposed a discharge limit to the VADEQ for only this contaminant. The proposed discharge limit for TCE is 807 μg/L, as shown in Table 10-1.

For the DPVE system in Area A1, air emissions would be treated and/or monitored to comply with the Virginia Air Emissions Standards as set forth in Virginia Regulations for the Control and Abatement of Air Pollution (VR 120-01). Recovered solvents generated by the extraction system would be disposed or treated in accordance with applicable RCRA regulations. Air emission calculations provided in Appendix E of the Final Feasibility Study indicate that air stripper emissions should qualify for a permit exemption determination under the Virginia Regulations for the Control and Abatement of Air Pollution.

In addition, the selected remedy will comply with the appropriate portions of RCRA, Virginia Solid and Hazardous Waste Management Regulations, the Department of Transportation (DOT) Rules for Hazardous Materials Transport and the Protection of Wetlands Order.

10.3 Cost-Effectiveness

The selected remedy provides overall cost-effectiveness (benefits proportional to cost). With respect to groundwater, the selected remedy is the most cost-effective alternative that complies with ARARs and protects the Yorktown Aquifer and water table aquifer for their respective potential beneficial uses. With respect to Area A1 soil, in situ treatment is the most cost-effective of the treatment alternatives. Since Area A is a relatively large landfill (45 acres), treatment that would require excavation or removal of the landfill would not be cost-effective. With respect to surface water/sediment, monitoring is the most cost-effective remedy, since these media are expected to improve in quality over time due to the source control actions that are being implemented at the site.

10.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy utilizes permanent solutions and treatment technologies to the maximum extent practicable. The selected remedy utilizes groundwater extraction and treatment technologies in all areas of the site except for the Yorktown Aquifer in Area A2. Groundwater extraction and treatment in this area was determined not to be practicable at this time because the extent of contamination is limited, and contaminated groundwater does not appear to be migrating off Navy property. However, the selected remedy includes construction of a groundwater treatment system with sufficient capacity to treat additional groundwater from Area A2 if necessary in the future.

The selected remedy provides the best balance of tradeoffs among the alternatives with respect to the evaluation criteria, especially the five balancing criteria. The criteria that were most critical in the selection decision are overall protection, long-term effectiveness and permanence, and reduction in toxicity, mobility, and volume of contamination through treatment. These three criteria all relate the ability of the alternatives to attain of the remedial action objectives, which include preventing exposure to contaminated groundwater, preventing further migration of contaminated groundwater, and restoring groundwater to the cleanup levels.

With respect to the key tradeoffs that were involved in the remedy selection process, cost and implementability factors were balanced against overall protection, long-term effectiveness, and reduction in toxicity, mobility, and volume of contamination. Except for Area A2, the selected remedy for groundwater is the most costly and most difficult alternative to implement; however, it will provide the highest degree of protection and long-term risk reduction. In contrast, for the Yorktown Aquifer in Area A2, institutional controls and monitoring can be implemented at a much lower cost than groundwater extraction and treatment; however, these actions may not achieve as high a level of protection as groundwater treatment. With respect to the soil alternatives, the selected remedy will not achieve the same degree of contaminant removal as would the thermal treatment or off-site disposal alternatives; however, it can be implemented at a significantly lower cost and will achieve the main objective of preventing migration of contaminants from soil to groundwater.

The State and community acceptance criteria were factored into the decision making process as part of the public comment period for the PRAP. Several comments on the PRAP were received from the Commonwealth of Virginia, which are addressed in the Responsiveness Summary. However, no State comments were received that affected the selected remedy outlined in the PRAP. In addition, one comment was received from a community representative.

10.5 Preference for Treatment as a Principal Element

Treatment, the selected remedy, addresses the principal threats posed by both groundwater and soil contamination. With respect to groundwater, the selected remedy utilizes groundwater treatment technologies including metals pretreatment, air stripping, and carbon adsorption. With respect to Area A1 soil, the selected remedy utilizes dual phase vapor extraction with treatment of the recovered groundwater (treatment described above) and treatment of the soil gas (if required) via vapor phase carbon adsorption.

SECTION 10.0 TABLES

TABLE 10-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	ARAR Determination	Comments
FEDERAL/CONTAMINANT-SPECIFIC			
Safe Drinking Water Act (42 USC 300(f)) a. Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16 b. Maximum Contaminant Level Goals (MCLGs) 40 CFR 141.50-141.51	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibility of removing a contaminant; MCLGs do not consider the technical feasibility of contaminant removal. For a given contaminant, the more stringent of MCLs or MCLGs is applicable unless the MCLG is zero, in which case the MCL applies.	Relevant and appropriate in developing cleanup goals for contaminated groundwater and surface water that may potentially be used as a potable water supply.	MCLs were used in developing cleanup goals for the Yorktown Aquifer (see Table 9-2 in Section 9.0).
FEDERAL/LOCATION-SPECIFIC			
Executive Order 11988 (related to Floodplain Management)	Regulates activities located in a floodplain. Federal activities in floodplains must reduce the risk of flood loss, minimize the impact of floods on human safety, health and welfare, and preserve the natural and beneficial values served by floodplains.	Applicable for remedial actions involving activities with a floodplain. Site is located within a 100-year floodplain.	Activities during construction will comply with requirements.
FEDERAL/ACTION-SPECIFIC			
DOT Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171.1-500)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Applicable for any action requiring off-site transportation of hazardous materials.	Remedial actions may include off-site treatment and disposal (e.g., off-site regeneration of activated carbon).
Resource Conservation and Recovery Act (RCRA) Subtitle C	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable to remedial actions involving treatment, storage, or disposal of hazardous waste.	Remediation may involve treatment, storage, or disposal of hazardous waste.
Identification and Listing of Hazardous Waste (40 CFR Part 261)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Applicable in determining waste classification.	Some site contaminants are considered listed wastes.
Treatment, Storage, and Disposal (TSD) of Hazardous Waste (40 CFR Parts 262-265, 266)	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable in the event that wastes on site are classified as hazardous.	TSD activities related to hazardous waste will comply with regulations.
Manifest Systems, Recordkeeping, and Reporting (40 CFR Part 264, Subpart E)	Regulates manifest systems related to hazardous waste treatment, storage, and disposal.	Applicable to remedial actions where hazardous waste is generated or transported.	Remedial actions may include off-site disposal or treatment.
Releases from Solid Waste Management Unites (40 CFR Part 264, Subpart F)	Regulates releases from solid waste management units.	All solid waste management units on site shall comply with requirements.	Groundwater protection standards apply to solid waste management units.

TABLE 10-1 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	ARAR Determination	Comments
Use and Management of Containers (40 CFR Part 264, Subpart I)	Regulates use and management of containers being stored at all hazardous waste facilities.	Applicable to containers stored on site.	Remedial actions may generate containerized waste. Investigation-derived waste (IDW) is containerized.
Resource Conservation and Recovery Act (RCRA) Subtitle D	Regulates the treatment, storage, and disposal of solid waste.	Applicable to remedial actions involving treatment, storage, or disposal of materials classified as solid waste.	Remediation may include treatment, storage, or disposal of solid waste.
STATE/CONTAMINANT-SPECIFIC			
Virginia Water Quality Standards (VR 680-21-00)	Surface water quality standards based on water use and criteria class of surface water.	Applicable to remedial actions requiring discharge to surface water.	Will be used to determine the discharge limit from the treatment facility. The Navy has proposed a discharge limit of 807 µg/L for trichloroethene to the VADEQ, based on the Virginia Water Quality Standard.
Virginia Emission Standards for Toxic Pollutants (VR 120-01)	Establishes acceptable limits for toxic pollutants by applying a 1/40 correction factor to the occupational standard Threshold Limit Value-Ceiling (TLV-Ceiling). Also provides rules for making an exemption determination based on quantities of pollutants emitted.	These standards are applicable requirements for remedial actions requiring discharge to the atmosphere. Air calculations are provided in Appendix E of the Final Feasibility Study that demonstrate that air stripper emissions should qualify for an exemption from the air emission standards.	To be used during the remedial action to determine whether air emissions from the treatment facility will exceed air emission standards.
Virginia Pollution Discharge Elimination System (VPDES) (VR 680-14-01) Regulation and Virginia Water Protection Permit Regulations (VR 680-15-01)	Regulated point-source discharges through the VPDES permitting program. Permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	Applicable to discharge of treated water to surface water.	Substantive requirements of VPDES permit will be used to determine the discharge limits for the discharge of the treated water to surface water on site. Monitoring requirements are associated with VPDES regulations. The VADEQ is currently reviewing the discharge limits proposed by the Navy.
STATE/ACTION-SPECIFIC			
Virginia Solid Waste Management Regulations (VR 672-20-10)	Regulates the disposal of solid wastes.	Applicable for solid (nonhazardous) waste.	Remedial actions could include off-site disposal of nonhazardous waste.
Virginia Hazardous Waste Management Regulations (VR 672-10-1, Parts VI and VII) Regulations Governing the Transportation of Hazardous Materials (VR 672-30-1)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Applicable for any action requiring off-site transportation of hazardous materials.	Remedial actions may include off-site treatment and disposal (e.g., off-site regeneration of activated carbon).

TABLE 10-1 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	ARAR Determination	Comments
STATE/ACTION-SPECIFIC			
Virginia Hazardous Waste Management Regulations (VR 672-10-1)	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable to remedial actions involving treatment, storage, or disposal of hazardous waste.	Remediation may include treatment, storage, or disposal of hazardous waste.
Identification and Listing of Hazardous Waste (VR 672-10-1, Part III)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Applicable in determining waste classification.	Some site contaminants are considered listed wastes.
Manifest Systems, Recordkeeping, and Reporting (VR 672-10-1, Part IX, Section 9.4)	Regulates manifest systems related to hazardous waste treatment, storage, and disposal.	Applicable to remedial actions where hazardous waste is generated or transported.	Remedial actions may include off-site disposal or treatment.
Use and Management of Containers (VR 672-10, Part X, Section 9.8)	Regulates use and management of containers being stored at all hazardous waste facilities.	Applicable to containers stored on site.	Remedial actions may generate containerized waste. Investigation-derived waste (IDW) is containerized.
Landfills - Post Closure Requirements (VR 672-10, Part IX, Section 9.13)	Regulates post-closure requirements for hazardous waste landfills.	Relevant and appropriate for post-closure groundwater monitoring.	Remedial activities will incorporate post-closure groundwater monitoring.
Virginia Stormwater Management Regulations (VR 215-02-00) and Virginia Erosion and Sediment Control Regulations (VR 625-02-00)	Regulates stormwater management and erosion/ sedimentation control practices that must be followed during land disturbing activities.	Applicable for remedial actions involving land disturbing activities.	Activities during construction will comply with the Virginia Storm Water Management Program. A sediment and erosion control plan will be submitted to LANTDIV for approval.
Virginia Wetlands Regulations (VR 450-01-0051)	Regulates activities that impact tidal wetlands.	Relevant and appropriate to activities that could impact site wetlands.	VADEQ has been notified that remedial activities could impact adjacent wetlands. No comments from VADEQ have been received.
Chesapeake Bay Preservation Area Designation and Management Regulations (VR 173-02-01)	Sets limitations in certain tidal and wetland areas for land-disturbing activities, removal of vegetation, use of impervious cover, E&S control, stormwater management, etc.	Potentially relevant and appropriate if site is within jurisdiction.	If required, plans will be submitted to the appropriate agency for approval.

TABLE 10-2

TO BE CONSIDERED (TBC) REQUIREMENTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	TBC Determination	Comments
FEDERAL/CONTAMINANT-SPECIFIC			
Reference Doses (RfDs), EPA Office of Research and Development	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to characterize risks due to exposure to contaminants.	To be considered (TBC) requirement in the public health assessment.	Will be used in evaluating human health risks at the site.
Carcinogenic Potency Factors, EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to compute the individual incremental cancer risk resulting from exposure to carcinogens.	TBC requirement in the public health assessment.	Will be used in evaluating human health risks at the site.
Health Advisories, EPA Office of Drinking Water	Non-enforceable guidelines for chemicals that may intermittently be encountered in public water supply systems. Available for short- or long-term exposure for a child and/or adult.	TBC requirement in the public health assessment.	Will be used in evaluating human health risks at the site.
FEDERAL/LOCATION-SPECIFIC			
RCRA Subtitle C Landfills (40 CFR Part 264, Subpart N)	Regulates owners and operators of facilities that dispose hazardous wastes in landfills.	TBC to evaluate compliance of off-site landfills.	TBC for remedial actions that involve off-site landfill of hazardous waste (sludge or IDW).
Groundwater Protection Strategy	EPA policy to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater: Class 1 - Special Ground Waters Class 2 - Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses Class 3 - Groundwater Not a Potential Source of Drinking Water and of Limited Beneficial Use	TBC requirement.	Groundwater in the Yorktown Aquifer is considered a Class 2 given its historical, current, and expected future use. Groundwater in the surficial (water table) aquifer is considered a Class 3.

TABLE 10-2 (Continued)

TO BE CONSIDERED (TBC) REQUIREMENTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	TBC Determination	Comments
FEDERAL/ACTION-SPECIFIC			
Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Directive 9355.0-28)	Guidance that establishes criteria as to whether air emission controls are necessary for air strippers. A maximum 3 lbs/hr or 15 lbs/day or 10 tons/yr of VOC emissions is allowable; air pollution controls are recommended for any emissions in excess of these quantities.	TBC requirement.	TBC as remedial action includes air stripping.
STATE/LOCATION-SPECIFIC			
RCRA Subtitle C Landfills (VR 672-10, Part X, Section 10.13)	Regulates owners and operators of facilities that dispose hazardous wastes in landfills.	TBC to evaluate compliance of off-site landfills.	TBC for remedial actions that involve off-site landfill of hazardous waste (sludge or IDW).

11.0 RESPONSIVE SUMMARY

11.1 Background on Community Involvement

A record review of the Naval Base Norfolk files indicates an active community involvement program. The primary communities for the Camp Allen Landfill investigation include the adjacent Glenwood Park neighborhood, the Camp Allen Elementary School, and the Navy housing area of Capehart.

Community relations activities to date for the Camp Allen Landfill site are summarized below:

- Conducted community relations interviews with base personnel, local officials, residents, and civic and environmental groups. A total of 15 persons were interviewed.

- Prepared a Community Relations Plan, dated May 27, 1993. Plan was based on community interviews and historic community involvement.

- Established three local information repositories.

- Established the Administrative Record for all of the sites under investigation at the base.

- Sampled the Glenwood Park residential wells, at the request of the residents. All Glenwood Park residents are on public water, which is supplied by the City of Norfolk; however, some have domestic wells which they use for garden/lawn watering. Analytical results of the water testing were provided to the residents.

- Canvassed the primary communities and distributed numerous Fact Sheets during the investigation.

- Briefed neighbors on monitoring well installation in Glenwood Park.

- Participated and attended many Glenwood Park Civic League meetings.

- Provided frequent briefings, to the Camp Allen Elementary School, especially during the field investigation stage.

- Released the Final PRAP for public review and comment in the information repositories on March 6, 1995.

- Released public notice announcing public comment period and document availability of the PRAP on March 6, 1995.

- Held a Restoration Advisory Board (formerly Technical Review Committee) meeting, in which the public was invited to attend, on March 22, 1995 to review the PRAP and solicit comments.

11.2 Summary of Public Comments

This section addresses written comments received during the public comment period and the public comments received from those attending the public meeting. Please note that comments were received from the Virginia Department of Environmental Quality (VADEQ). In addition, one question was posed from a Restoration Advisory Board member during the March 22, 1995 meeting. Comments and responses are presented below.

11.2.1 Response to VADEQ Comments on Final PRAP

1. *Page 2-5, Section 2.3.2: This section refers to surface soil as nominally impacted. Please clarify this statement as there were several contaminants that exceed risk-based concentrations in surface soil. Table 2-1 uses a similar description.*

   RESPONSE: As described in the Final RI Report, dated July 1994, no contaminants of potential concern were found in surface soils. Also, the Revised Final Risk Assessment, dated February 24, 1995, indicates that there are no unacceptable risks associated with surface soils. Please note that the Area A landfill is covered with a cover soil material and is vegetated with a heavy grass cover that is regularly maintained to prevent erosion. Therefore, the waste material is covered and is not exposed at the surface of the landfill.

2. *Page 2-7, Section 2.4: This section refers to the Remedial Action Closeout Report for the Area B Landfill removal action. Note that this report was only recently received by this office and will be reviewed to verify that remedial actions are not required for Area B soils.*

RESPONSE: Comment noted.

3. *Table 3-1: Note that the ARARs comments submitted by the state (February 3, 1995 letter from Erica Dameron to Nina Johnson) have not been incorporated into the final document. The comments are as follow:*

   a) The identification of VPDES as an ARAR may require some revision to indicate that this is a permitted activity. Also, the comments for the VPDES regulations should indicate that there are monitoring requirements associated with the discharge regulations.

   b) The citation to the "Virginia Hazardous Waste Regulations", as used to identify requirements for the transport of hazardous materials, should be changed to "Virginia Hazardous Waste Management Regulations (VR 672-10-1, Parts VI and VII) and Regulations Governing the Transportation of Hazardous Materials (VR 672-30-1)".

   c) Some specific sections of Part X of the Virginia Hazardous Waste Management Regulations (VHWMR) are identified as subparts under the general citation. Part IX of VHWMR should be referenced in place of Part X because Part IX is applicable to unpermitted units. Also, VHWMR Section 9.13, Landfills, should be included in this section of the table.

Note that VHWMR Section 9.13.D addresses the requirements for landfill closure and post-closure care. The questions raised by EPA in the third paragraph of comment #12 (letter from Stacie Morekas Driscoll to Dave Forsythe dated February 23, 1995) regarding state *closure requirements should be addressed in relation to this section. Also note that the date of closure, as stated in LANTDIV's response to EPA comments (letter to Stacie Driscoll from Nina Johnson dated March 20, 1995), does not affect the determination of whether this section is relevant and appropriate to the proposed remedial action.*

It should be noted that 9.13.D. does require a final cover. However, if it can be shown that the proposed remedial action would be as protective as the cover described in this section, then the requirement for the cover may not necessarily be considered relevant and appropriate. In addition, it must be shown that the landfill would not be an eyesore if it were not covered in order to comply with Part IV of the Virginia Solid Waste Management Regulations.

All groundwater monitoring requirements must be met. If groundwater monitoring indicates that cleanup goals cannot be met, the decision not to cover the landfill as part of the final remedy will have to be reevaluated.

RESPONSE: The ARAR tables presented in the Decision Document have been revised in accordance with VADEQ comments.

As previously stated, the Area A Landfill has a vegetated soil cover that is well-maintained. The landfill area certainly would not be described as an eyesore - it is a relatively flat, open area that is covered with grass which is mowed on a regular basis. The Navy Brig facility and a heliport are located on top of the Area A Landfill.

There is no data available at this time to evaluate the permeability of the existing landfill cover. The absence of a confining layer, combined with a high water table, would limit the effectiveness of a cap. Furthermore, placement of an impermeable cover over the landfill may actually be counterproductive in light of the selected remedial action (groundwater extraction and treatment). The current cover material allows some infiltration, which flushes contaminants within the landfill into the water table aquifer where they can be extracted and treated.

Virginia post-closure groundwater monitoring requirements will be met by the long-term monitoring program to be implemented under the selected remedy.

4. *Section 4.1: The summary of site risks for each medium should also mention the contaminants that are driving any unacceptable risks.*

RESPONSE: The chemicals contributing most predominantly to site risks have been added to the Decision Document and are listed below, by environmental medium:

AREA A

Shallow and Deep Groundwater
- 1,2-Dichloroethene
- Vinyl chloride
- Trichloroethene

Soils
- Arsenic
- Cadmium

Surface Water
- Aroclor-1254

Sediment
- Arsenic
- Aroclor-1254
- Aroclor-1260

AREA B

Shallow and Deep Groundwater
- 1,2-Dichloroethene
- Benzene
- Vinyl chloride
- Trichloroethene
- Arsenic

Sediments
- Arsenic
- Cadmium

The contaminants of concern are indicated in Section 2.5 of the PRAP. The above-listed risk-drivers will be added to the Decision Document.

5. *Page 4-7, Section 4.3.1: This section states that achievement of the remediation goals for soil will be based on monitoring of contaminant levels in groundwater. Does this imply that there will not be any confirmation sampling in soil during and after the remedial action? Confirmatory soil sampling should be performed to insure that there is no unacceptable risk due to soil contact, particularly if there will not be a final cover on the landfill.*

RESPONSE: There will be no confirmatory sampling of soils (i.e., landfill materials) following remediation. As stated in the PRAP, achievement of soil remediation goals will be based on monitoring of contaminant levels in groundwater. Since the area is a landfill, the primary goal of the remediation is protection of the underlying groundwater rather than soil cleanup (soil cleanup levels were based on groundwater protection rather than direct contact risk). This concept was clearly stated in the Feasibility Study, which was reviewed and approved by VADEQ. The landfill cover, which provides a barrier to direct contact with landfill waste material, has been described in previous responses.

6. *Page 4-7, Section 4.3.2 states that the cleanup goals for each aquifer have been developed based on the potential beneficial use. Therefore, the cleanup goals for the shallow aquifer are based on nonpotable use. However, in Appendix B of the Final Feasibility Study (FS) it appears that soil cleanup levels are being set to achieve Maximum Contaminant Levels (MCLs) in the shallow aquifer. Please clarify this apparent discrepancy.*

RESPONSE: Soil cleanup goals were based on MCLs as a conservative measure since they were derived from various assumptions associated with the Summers leaching model. This point has been clarified in the Decision Document.

7. *Although it has been stated that the shallow aquifer is not currently used as a potable source, there is no statement confirming that the shallow aquifer cannot be used as a potable source in the future. If the cleanup levels for the shallow aquifer are based on nonpotable use, the document should include a definitive statement that the water will not be used as a potable source. (As discussed at the RAB meeting on March 22, 1995, the City of Norfolk does not allow potable use of the upper aquifer. A citation of this city ordinance would help to justify the use of nonpotable cleanup goals. If there are physical properties of the aquifer that make it unacceptable for drinking, these should be mentioned as well.)*

RESPONSE: The Decision Document includes a statement indicating that the shallow aquifer cannot be used as a potable water source due to a City of Norfolk ordinance that does not allow potable use of the shallow aquifer. In addition, the shallow aquifer in the vicinity of the site is generally not suitable for potable use due to high concentrations of iron, manganese and suspended solids, as well as low pH (less than 6).

8. *Appendix B of the FS uses Monte Carlo simulation to set soil cleanup levels. However, the model inputs are given as discreet values rather than distributions in Attachment II. Please explain how Monte Carlo simulation was used in setting cleanup levels. Also, results at different percentiles in addition to the expected value should be shown and discussed.*

RESPONSE: Three variable parameters were designated for Monte-Carlo simulations of the Summers model. These variables included depth to the water table, organic carbon fraction and vertical hydraulic conductivity. The uncertainties associated with the value range inputs of these parameters were defined by triangular distributions described by minimum, mean and maximum values.

A detailed distributional analysis, a rather involved statistical process, would be necessary to estimate percentile levels with a higher degree of certainty than those based on input ranges described by triangular distributions. As previously noted, the soil cleanup levels were based on MCLs as a conservative measure to account for uncertainties associated with the modeling effort. Statistical efforts were deemed unnecessary for the purpose of defining cleanup goals in the FS.

9. *The shallow aquifer cleanup levels have been set to achieve a hazard quotient of one for individual contaminants. The cleanup levels should be set to achieve a hazard index of one for multiple contaminants unless it can be shown that the effects of the contaminants would not be additive.*

RESPONSE: Use of a target hazard quotient (THQ) of unity in the Final Risk Assessment Report was approved by both the State and EPA.

10. *Table 6-5: The evaluation of long-term effectiveness and permanence states that risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on-site under alternative A1-GW3. However, if the Yorktown Aquifer is treated to the proposed cleanup levels, potable use would be within acceptable risk levels (except as noted above for HIs). This statement should be clarified. Similar statements are made on Tables 6-6 and 6-7.*

RESPONSE: The Decision Document clarifys that under current conditions, risks exceed acceptable levels for both the shallow and deep aquifers for potable use; however, after remediation, the Yorktown Aquifer would be within the acceptable range.

11. *The Yorktown Aquifer cleanup levels have been set to achieve MCLs for individual contaminants. For the carcinogenic contaminants, the estimated risk at the cleanup levels (rounded to one significant figure) would be 1×10^{-4} and would, therefore, be considered acceptable. However, for the noncarcinogenic contaminants, the hazard index at the cleanup levels exceeds unity. As noted above, the cleanup levels should be set to achieve a hazard index of one for multiple contaminants unless it can be shown that the effects of the contaminants would not be additive.*

RESPONSE: See response to Comment 9.

11.2.2 Response to Restoration Advisory Board Member Comment

1. *Mr. Nathaniel Riggins: What was the depth of the shallow wells in Glenwood Park?*

RESPONSE: Fifty-five shallow (non-potable) wells averaging 20 feet in depth were sampled. The Yorktown Aquifer at the site is approximately 40 feet below ground surface.

12.0 REFERENCES

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Camp Allen Landfill Area B Removal Action Closeout Report. Prepared for the Department of the Navy. Atlantic Division Naval Facilities Engineering Command. OHM Remediation Services Corp., March 1995.

Camp Allen Landfill Engineering Evaluation/Cost Analysis. Final. Prepared for the Department of the Navy, Atlantic Division Naval Facilities Engineering Command, Baker Environmental, Inc., August 1993.

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Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D. C. March 25, 1991. OSWER Directive 9285.6-03.

Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening. Region III, Philadelphia, Pennsylvania. January 1993. EPA/903/R-93-001.

Site Suitability Assessment, Proposed Brig Expansion, (P-977) Naval Station, Norfolk, Virginia. Malcolm Pirnie, June 1984.

Appendix B
Site 3 Decision Document

04.09 - 11/19/96-00934

FINAL
Document Decision (DD) for Q-Area Drum Storage Yard Norfolk Naval Base Norfolk, Virginia

Prepared for:
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Contract No. N62470-90-R-7661
Delivery Order 0006

Prepared by:
Environmental Science & Engineering, Inc.
Herndon, Virginia

November 1996

ESE Project No. 4921150-0900-2100

Declaration
Selected Remedial Alternative for the QADSY

Site Name and Location

This Document Decision (DD) has been prepared for the Q Area Drum Storage Yard (QADSY) located at the Norfolk Naval Base in Norfolk, Virginia. The QADSY is located in the northwest corner of the complex, within 1200 feet of both the Elizabeth River (to the west) and Willoughby Bay (to the northeast). Tens of thousands of drums containing solvents, oils, lubricants, paint thinners, pesticides, and acids have been stored at the QADSY. The site has not been used for drum storage since 1987.

Statement and Basis of Purpose

This DD presents the selected response actions for the QADSY that were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This DD explains the factual and legal basis for selecting the response actions for the QADSY. The information supporting this remedial action decision is contained in the Administrative Record for the QADSY.

The content of this DD is based on recommendations in the US Environmental Protection Agency (USEPA)'s Interim Final Guidance on Preparing Superfund Decision Documents (USEPA, 1989).

Assessment of the Site

The investigations addressed in this DD began with an initial assessment study (IAS) in 1982 and ended with the comprehensive Remedial Investigation/Feasibility Study (RI/FS) performed in 1996.

During the IAS, recommendations were made to install and sample (quarterly) three monitor wells for oil and grease, volatile organic compounds (VOCs), pesticides, and polychlorinated biphenyls (PCBs). The IAS report published by Naval Energy and Environmental Support Activity (NEESA, February 1983) suggested that the wells be located downgradient of the QADSY, with specific attention to the leaking drum area.

Subsequent to the IAS, the Navy Assessment and Control of Installation Pollutants (NACIP) Program was redesigned as the Installation Restoration Program (IRP). The terminology and structure of the IRP were changed to conform to that of SARA. The RI Interim Report (LANTNAVFACENGCOM, March 1988) was designed to verify the existence of contamination, satisfying the site investigation requirements of SARA, but it does not meet the full requirements of an RI. The objective was to incorporate the RI Interim Report into a completed RI/FS document at a later date.

The initial site investigation for the interim RI was conducted in November and December of 1983. Four monitor wells were installed at that time, and 12 soil samples were analyzed from four hand borings. A second round of groundwater sampling was performed in August 1984. Groundwater samples from the existing wells and 21 soil samples from seven locations were analyzed as part of the third round of sampling, performed in April 1986. The Navy analyzed eight soil samples in April 1986 following the groundwater event; this effort resulted in plans to remove the most contaminated soil as part of a 1989 military construction project. Finally, a fourth round of groundwater sampling occurred in June 1986.

Following the interim RI, the Navy excavated 750 cubic yards of soil in 1987. That portion of the QADSY is presently paved and used for fleet parking.

A RI/FS was conducted from 1990 to 1995. The RI Field Investigation included soil, groundwater, surface water, and sediment sampling, aquifer testing, groundwater modeling, and a quantitative risk assessment.

The results of the Risk Assessment (RA) in Section 6 of the RI concluded that conditions at the QADSY do not pose an unacceptable potential risk to human health and the environment for the current worker. There is a potential risk to human health and the environment for the future worker and residential scenario because of inhalation if a building is constructed onsite.

The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans, although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY (refer to Section 4.0 of this document for a description of this RA). This RA showed that under a worker exposure scenario, potential risks to human health are within the acceptable range. The future commercial scenario will be used to determine the preferred alternative selection.

Additionally, potential ecological risks associated with exposure due to ingestion of fish are all less than 1, suggesting that there is low potential for adverse effects to the terrestrial animals due to site-related chemicals in fish caught near the site. The ecotoxicity quotients (EQs) for water- and sediment-dwelling aquatic organisms at QADSY are all below the EQ of less than 1, indicating that there is low potential for adverse effects to these aquatic organisms.

Description of the Selected Remedy

This DD addresses the final remedy for QADSY. The following remedial actions are determined to be necessary at the QADSY:

- No action for soil is necessary at the QADSY because:
  - Inorganic compounds (IOC) contamination appears to be inherited from the dredged material
  - The QADSY is not conducive to an ecological environment because it is in a highly industrial area and is mostly a paved parking lot
  - The present plans are for the unpaved area to be paved, which will subsequently eliminate this ecologic risk pathway
- Air sparging/soil vapor extraction (AS/SVE) remedial action is determined to be necessary for groundwater

- Groundwater monitoring
- A 5-year review to assess site conditions

Statutory Determinations

The selected remedy for the QADSY is protective of human health and the environment, complies with federal and state environmental requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy uses permanent solutions to the maximum extent practicable for the QADSY. No further remedial action is determined to be necessary for the soil. AS/SVE remedial action is determined to be necessary for groundwater.

Remedial action objectives include protecting the groundwater and preventing inhalation of VOCs from impacted groundwater. The studies undertaken at the QADSY have shown that future worker potential for human health and environmental risks are associated with the groundwater.

Based on the careful consideration of the technical, environmental, institutional, public health, and cost criteria as presented in Section 6.0, and in keeping with the overall response strategy, the recommended remedial action for the QADSY at Norfolk Naval Base is AS/SVE.

Commander, Naval Base, Norfolk

11-19-96
Date

Table of Contents

Table of Contents (continued)

List of Tables

List of Figures

List of Appendices

Table of Contents (continued)

List of Acronyms and Abbreviations

ARARs	applicable or relevant and appropriate requirements
AS	air sparging
AWQC	ambient water quality criteria
AWS	air-water separator
BDL	below detection limit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeters
cm/sec	centimeters per second
COCs	chemicals of concern
COPCs	chemicals of potential concern
CSF	carcinogenic slope factor
CTV	critical toxicity value
cy	cubic yard
DCA	1,2-Dichloroethane
DCE	1,2-Dichloroethene
EQ	ecotoxicity quotient
ERA	Ecological Risk Assessment
ESE	Environmental Science & Engineering, Inc.
FS	Feasibility Study
HI	hazard index
HRA	Human Risk Assessment
IAS	Initial Assessment Study
IOCs	inorganic compounds
IRP	Installation Restoration Program
IWTP	Industrial Waste Treatment Plant
LOAEL	lowest-observed-adverse-effect level
mg/kg	milligrams per kilogram
mg/kg/day	milligram per kilogram day
mg/L	milligrams per liter
mm	millimeter
msl	mean sea level
MTV	mobility, toxicity, and volume
NACIP	Navy Assessment and Control of Installation Pollutants
NCP	National Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effect level
NPDES	National Pollutant Discharge Elimination Stream
NPL	National Priorities List
NWR	National Wildlife Refuge
NWRSA	National Wildlife Refuge System Act
O&M	operation and maintenance

Table of Contents (continued)

List of Acronyms (continued)

OSHA	Occupational Safety and Health Administration
PAHs	Polynuclear Aromatic Halogens
PCA	1,1,2,2-Tetrachloroethane
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene
ppm	parts per million
PRAP	Proposed Remedial Action Plan
PQL	Practical Quantitation Limit
QADSY	Q-Area Drum Storage Yard
RA	Risk Assessment
RAE	reasonable average exposure
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RGOs	remedial goal objectives
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RME	reasonable maximum exposure
SARA	Superfund Amendments and Reauthorization Act
SF	slope factors
sq ft	square foot
SVE	soil vapor extraction
SVOCs	semi-volatiles organic compounds
TBC	To be considered
TCE	trichloroethene
TCLP	toxic characteristic leachate procedure
TPH	Total Petroleum Hydrocarbon
TRV	toxicity reference value
μg/l	micrograms per liter
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
VDEQ	Virginia Department of Environmental Quality
VOCs	volatile organic compounds
WQSs	Water Quality Standards

1.0 Site Name, Location, and Description

The QADSY is located on the Norfolk Naval Base and is part of the Sewells Point Naval Complex (Figure 1). It is located in the northwest corner of the complex, within 1200 feet of both the Elizabeth River (to the west) and Willoughby Bay (to the northeast). The site is currently a relatively flat fenced area, paved with crushed gravel, and bounded by asphalt parking lots to the north and west.

The QADSY was created by a fill operation in the early 1950s and was used as a disposal area for the dredged materials from Willoughby Bay. Tens of thousands of drums containing solvents, oils, lubricants, paint thinners, pesticides, and acids have been stored at the QADSY. The site has not been used for drum storage since 1987.

Since 1982, a number of investigations and reports have been conducted and prepared under various Navy programs to assess the nature and extent of contamination and contaminant migration.

1.1 Topography

The topography of the area is relatively uniform, characterized by flat sloping areas. The QADSY is located in the northernmost portion of the Norfolk Naval Base (Figure 1). The surrounding terrain is flat and even, characteristic of the whole region. The southern portion of the site (south of well SW-3) slopes gently from north to south. The average elevation of the site is about 10 feet above mean sea level (msl).

Two large water bodies are located adjacent to the QADSY. Elizabeth River borders the western boundary of the site; Willoughby Bay borders the northern and eastern boundary of the site.

Drainage of the site and surrounding area is controlled by man-made structures and features. Much of the area is paved, and surface runoff is directed into numerous open storm drains that presumably lead directly to the open waters of the Elizabeth River to the west or to Willoughby Bay to the north. No natural drainage features (creeks, marshes, etc.) were found on or near the site.

1.2 Geology/Hydrology

The QADSY is located in the outer Coastal Plain Physiographic Province, characterized by low elevations and relief, sloping gently eastward. The Coastal Plain is defined to the east by the Atlantic Ocean and to the west by the Fall Line near Emporia, Virginia (Frye, 1986). The Coastal Plain is characterized by unconsolidated sediments of Cretaceous, Tertiary, and Quaternary ages that dip gently eastward and rest on pre-Cretaceous aged bedrock at a depth of approximately 2200 feet. The Coastal Plain of Virginia consists of an eastward thickening sedimentary wedge composed principally of unconsolidated gravels, sands, silts, and clays with variable amounts of shells. Coastal Plain deposits cover the length of the Virginia coastline, extending westward to the "fall line," where the pre-Cretaceous basement complex reaches the surface approximately 80 miles westward (Meng and Harsh, 1988).

QADSY is underlain by approximately 15 feet of fill. The edge of the fill is located approximately 2500 feet south of the site (Barker and Bjorken, 1978). Below the fill, the QADSY is underlain by the Upper Pleistocene Lynnhaven Member within the Tabb Formation. The strata consist of fine to coarse sand grading upward to sandy and clayey silt. Locally, the base of the unit includes cross-bedded sand and clayey silt containing plant material. The member constitutes surficial deposits of broad swales and extensive lowlands. The average thickness of the Lynnhaven Member is 20 feet (Mixon, et al., 1989).

The QADSY is underlain by yellow-brown, gray, and black silty sand with shell fragments indicative of the fill material that created the site; brown to black clay lenses are rare from 20 to 30 feet below ground surface. The water table is approximately 8 feet below ground surface, and water table elevations range from 2 to 5 feet above msl.

Throughout the Coastal Plain, groundwater occurs in the unconsolidated, layered sediments. The depositional strata encountered at the site are part of the undifferentiated quaternary sediments of the Columbia aquifer. These sediments are primarily Pleistocene and Holocene in age, but also include sandy Pliocene sediments along the contact with the underlying Yorktown confining unit. The Columbia aquifer is generally unconfined; however, clayey sediments within the aquifer may produce local confined or semi-confined conditions. The sediments composing the Columbia aquifer consist mostly of a series of formations resulting from Pleistocene marine transgressions (Meng and Harsh, 1988).

According to Siudyla, et al. (1981), the aquifer can be used only for lawn watering and other similar uses due to water quality limitations. The groundwater commonly has a low pH and a high iron content. Regionally, the aquifer has typically been contaminated by:

- Waste lagoons
- Landfills
- Septic tanks below the water table
- Municipal sludge application sites

The City of Norfolk Health Department prohibits the use of the water table aquifer for public or private potable water supplies under law ordinance Chapter 46.1, Reference 46.1-5. All potable water in the City of Norfolk is supplied by the City of Norfolk.

The Yorktown Formation underlies the Tabb Formation and is Miocene in age. The unit is characterized by coarse sand and gravel beds, and abundant, thick shell beds; the formation thickness ranges from 300 to 400 feet.

The Yorktown aquifer is generally encountered under confined (artesian) conditions; the major water-bearing zones are found at depths from 50 to 150 feet (Siudyla, et al., 1981). The aquifer is generally separated from the overlying water table aquifer by 20- to 40-foot thick confining beds of silt, clay, and sandy clay. Leaky confined conditions are encountered in places, and Yorktown recharge commonly occurs through downward leakage from the water table aquifer.

Domestic, public, commercial, and industrial supply wells tap the Yorktown aquifer throughout the region; the water quality is generally suitable for potable and most other uses. However, high iron concentrations are occasionally noted, and brackish water problems (i.e., high chloride content) have also occurred locally. No drinking water wells are used in the vicinity of the site. The Yorktown aquifer at the site adjacent to the Elizabeth River and/or Willoughby Bay is brackish and not used for potable water (Siudyla, et al., 1981). The Yorktown aquifer discharges into the Elizabeth River and Willoughby Bay. The Elizabeth River and Willoughby Bay water is not used for domestic, public, commercial, or industrial supply because the surface water is brackish.

Available water supplies at the QADSY site and surrounding area consist of that stored in the pore space of the underlying sediments. As mentioned earlier, literature confirms the presence of two major aquifer systems in the area. The lower system (Yorktown Formation) is not confined at the QADSY. Clay was intercepted at the base (20 feet) at boring SW-4 but not in any of the deeper borings, including wells DW-1 through DW-8 (Figure 2). The confining bed between the Columbia and Yorktown aquifers does not exist at the site; it appears to be eroded from channelization and meandering of the Elizabeth River. The Yorktown aquifer is not hydraulically separated from the Columbia aquifer at the site.

The Yorktown aquifer in the area of the site is only used for lawn irrigation. The discharge flows to either the Elizabeth River or Willoughby Bay. This aquifer is not used for public water supply because the downgradient surface waters (Willoughby Bay and Elizabeth River) are brackish and contain high metal concentrations.

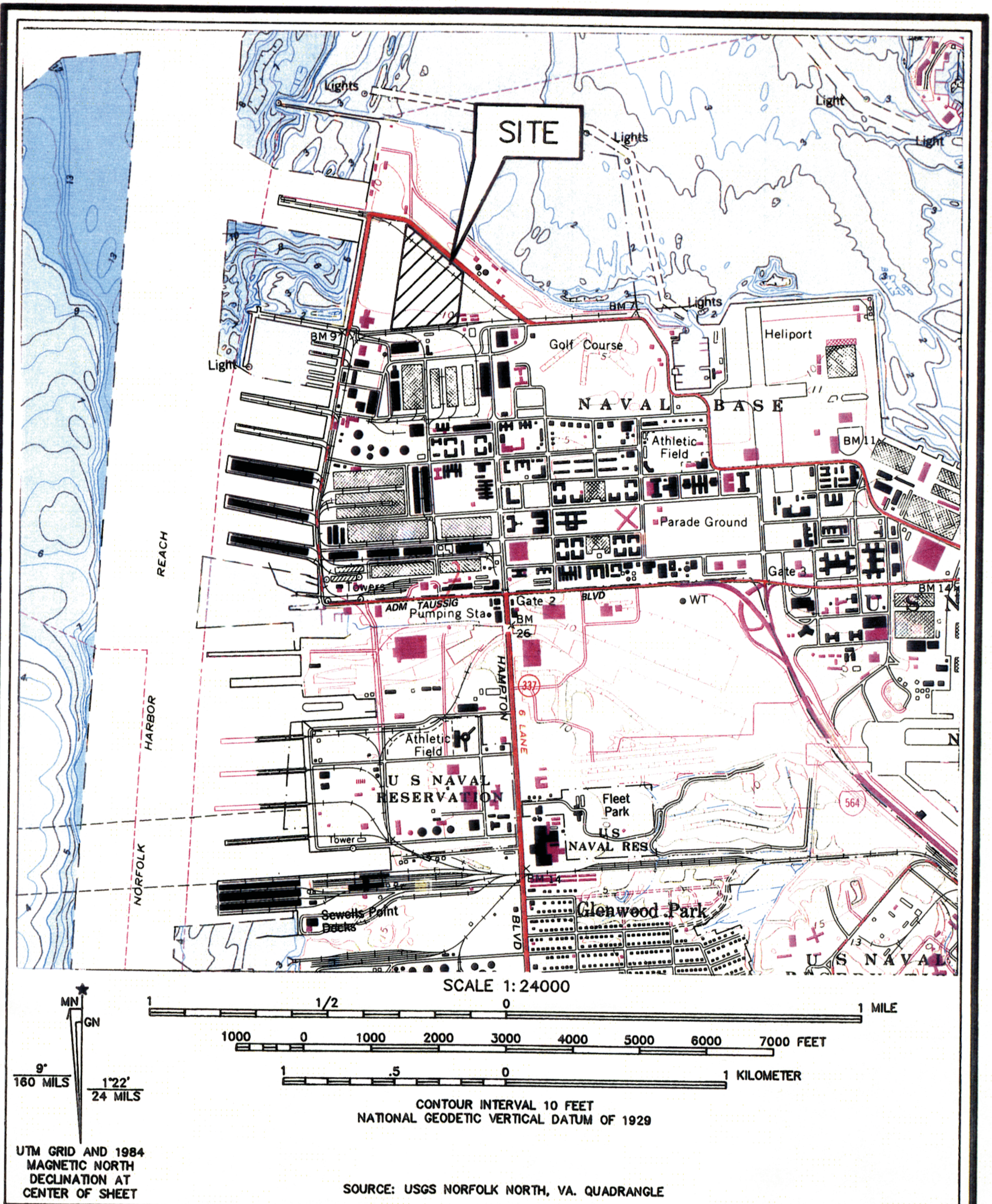
The Yorktown and Columbia aquifers are hydraulically connected at the site, producing an unconfined aquifer. Aquifer thickness has not been determined at the site, but appears to be between 85 to 140 feet by incorporating the fill (15 to 20 feet), Tabb (20 feet), and Yorktown (50 to 100 feet) formations (Meng and Harsh, 1988).

Groundwater in the study area is sustained by precipitation, which infiltrates the land surface, and by regional flow. Broadly speaking, the unconfined aquifer is recharged by infiltration.

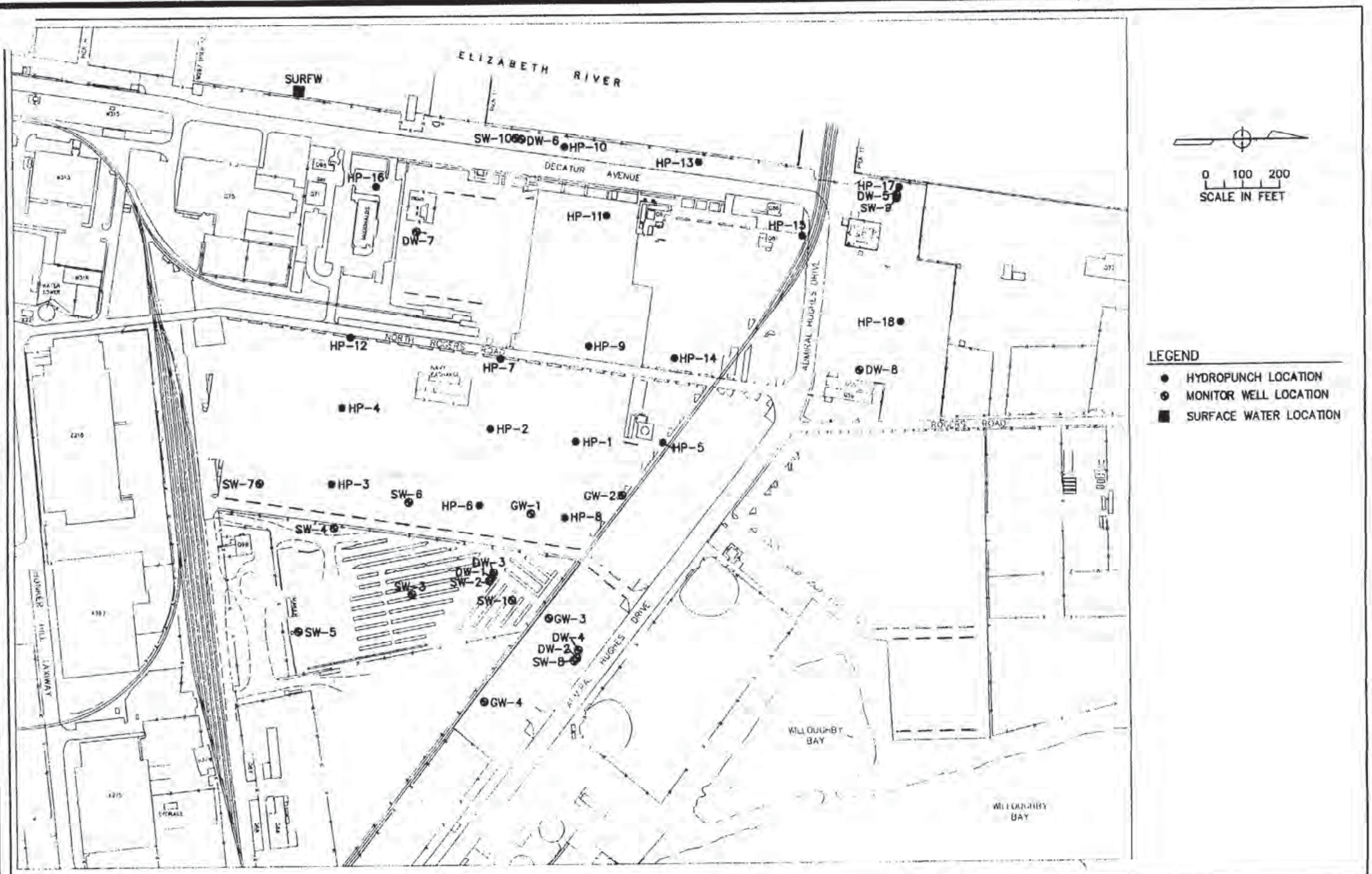
Recharge by infiltration at the site and surrounding areas is limited to unpaved areas; extensive paved areas and man-made drains and culverts control much of the surface runoff. The construction and placement of the drainage network may also have profound effects on the localized flow in the area: they may be partially permeable and intercept the groundwater surface.

Annual precipitation averages 47 inches; however, much may be lost as runoff to man-made drainage ways. Additionally, evapotranspiration may result in a significant loss, despite the lack of vegetation at the site. The annual recharge to the water table aquifer is not precisely known, but is estimated to be between 12 and 20 inches.

Groundwater discharge from the unconfined aquifer is thought to be primarily into Elizabeth River to the west and Willoughby Bay to the east. However, significant control on groundwater discharge and flow patterns may be exercised by man-made drainage culverts that may intercept the water table.



ESE Environmental Science & Engineering	DATE 6-3-91	SCALE SHOWN	TITLE Site Location Map — Q Area Drum Storage Yard — Norfolk Naval Base — Norfolk, Virginia	
	DRAWN BY LAF	APPROVED BY		
	JOB NO. 4901107	DWG. NO./ REV. NO. 1 –	CLIENT NAVFAC LANTDIV – Q AREA	FIGURE 1



ESE Environmental Science & Engineering
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DATE	SCALE	TITLE
3-16-94	SHOWN	MONITOR WELL, HYDROPUNCH, AND WATER LOCATIONS Q AREA DRUM STORAGE YARD NORFOLK, VIRGINIA
DRAWN BY LAL/DN	APPROVED BY	
JOB NO. 4921150	DWG. NO./ REV. NO. QDB / -	CLIENT NAVFAC - Q AREA

FIGURE 2

2.0 Site History and Enforcement Activities

The QADSY has been in use since its creation in the 1950s, and tens of thousands of drums have been stored at the site since that time (LANTNAVFACENGCOM, 1988). A variety of materials were stored in 55-gallon steel drums, including petroleum products (such as oil lubricants), various organic solvents, paint thinners, some pesticides, formaldehyde, and acids. Throughout the site's history, the northern portion of the yard was used to store damaged and leaking drums. The site has not been used for drum storage since 1987.

Since 1982, a number of investigations and reports have been conducted and prepared under various Navy programs to assess the nature and extent of contamination and contaminant migration.

The investigations addressed in this Proposed Plan began with an IAS in 1982 and ended with the comprehensive RI/FS performed in 1996.

During the IAS, evidence of considerable liquid leakage and spillage was noted throughout the site. In particular, the northern portion of the site was used to store damaged and leaking drums. Recommendations were made to install and sample (quarterly) three monitor wells; recommended analytes included oil and grease, VOCs, pesticides, and PCBs. The IAS report (NEESA, February 1983) suggested that the wells be located downgradient of the QADSY, with specific attention to the leaking drum area.

Subsequent to the IAS, the NACIP Program was redesigned as the IRP. The terminology and structure of the IRP were changed to conform to that of SARA. The RI Interim Report (LANTNAVFACENGCOM, March 1988) was designed to verify the existence of contamination, satisfying the site investigation requirement of SARA, but it does not meet the full requirements of an RI. The objective was to incorporate the RI Interim Report into a completed RI/FS document at a later date.

The initial site investigation for the interim RI was conducted in November and December of 1983. Four monitor wells were installed at that time, and 12 soil samples were analyzed from four hand borings. A second round of groundwater sampling was performed in August 1984. Groundwater samples from the existing wells and 21 soil samples from seven locations were analyzed as part of the third round of sampling, performed in April 1986. The Navy analyzed eight soil samples in April 1986 following the groundwater event; this effort resulted in plans to remove the most contaminated soil as part of a 1989 military construction project. Finally, a fourth round of groundwater sampling occurred in June 1986.

Following the interim RI, the Navy excavated 750 cubic yards of soil in 1987 as shown in Figure 1-5 of the RI (ESE, 1996). That portion of the QADSY is now paved and used for fleet parking.

3.0 Highlights of Community Participation

The RI/FS and Proposed Remedial Action Plan (PRAP) Reports for the QADSY were released to the public in May and June 1996. These two document are available to the public as part of the Administrative Record and in the information repositories maintained at the following location:

Kirn Library City of Norfolk Main Library 301 City Hall Avenue Norfolk, VA	(757) 664-7323
Larchmont Public Library 6525 Hampton Blvd. Norfolk, VA	(804) 441-5335
Mary Pretlow Public Library 9640 Granby Street Norfolk, VA	(804) 441-1750
Naval Station Library Building C-9, Bacon Street Naval Station Norfolk, VA 23511	(804) 445-2740 (804) 444-2880

The notice of availability of these documents was published in the 15 July 1996 Virginia Pilot newspaper. A public comment period was held between 15 July and 15 August 1996. In addition, a public availability session and meeting was held on 14 August 1996. At this meeting, representatives from the Navy, USEPA, City of Norfolk, Elizabeth River Project, and Virginia Department of Environmental Quality (VDEQ) addressed questions and received comments about the remedial alternatives under consideration.

This DD presents the selected remedial action for the QADSY. The selected remedy presented in this DD was chosen in accordance with CERCLA, as amended by SARA, and the NCP. The decision for this site is based on the QADSY Administrative Record.

4.0 Scope and Role of the Response Action

This DD addresses the selected remedy for the QADSY, the construction and operation of an AS/SVE system. This remedial action was determined to be necessary due to the identified potential human health risks to the future worker at the QADSY. Studies undertaken at the QADSY identified these potential human health risks being associated with the volatilization of the VOC-impacted groundwater at the site into a future building located above the contaminate plume. The remedial objective of the QADSY is to minimize any threat of these potential human health risks from the VOC-impacted groundwater.

Incorporated into the design of this system is the positioning of AS and SVE wells along the downgradient edge of the contaminate plume that parallels the waterfront. This well arrangement will provide a remediation zone prior to groundwater discharge to the Elizabeth River. Semi-annual groundwater monitoring and a 5-year review to assess site conditions will also be conducted.

5.0 Summary of Site Characteristics

The objective of the RI was to determine the nature and extent of contamination at the site, as well as locate and characterize the groundwater contamination both onsite and offsite. The complete results of the RI are presented in this document.

The RI field investigation was performed in two stages: (1) a 1990 groundwater and soil sampling event; and (2) 1992-1993 groundwater, 1992 soil, 1992 surface water, 1993 sediment, and 1995 soil and groundwater sampling events (Figure 2).

To fulfill the objectives of the RI, ESE performed the following tasks:

- A total of 18 monitor wells were installed. Ten of the wells comprise four well clusters. Each cluster consists of two or three wells that monitor the shallow and deep portions of the aquifer beneath the site. Subsurface soil samples were collected from wells SW-1 through SW-5.

- Surface soil samples were collected from 36 locations from the four study areas during the 1990 sampling event. Samples were collected from two intervals in 24 of the borings: 0 to 18 inches and 18 to 36 inches. A composite sample was taken from 0 to 36 inches in the remaining 12 borings.

- Subsurface samples were collected from eight locations during the 1992 sampling event to further delineate the extent of total petroleum hydrocarbon (TPH) contamination. Samples were collected from two intervals in the borings: 3 to 5 feet and 5 to 7 feet.

- During the May 1995 sampling event, surface soil samples were collected at 19 locations. Fifteen of these were analyzed to further delineate the extent of TPH contamination. The remaining four were analyzed for VOCs, semi-volatile organic compounds (SVOCs), pesticides, PCBs, IOCs, and cyanide.

- Two sediment samples were collected from onsite storm drains.

- During the 1990 sampling event, groundwater samples were collected from the ten new wells and from three existing wells installed as part of the IAS. During the 1992-1993 sampling event, groundwater was collected from five of the wells installed in 1990 and from the eight new wells installed in 1992. Groundwater samples were collected from the eight new wells in May 1995.

- Collection of 66 groundwater samples from 18 locations was completed using the hydropunch sampling technique in December 1992. The samples were analyzed for Trichloroethene (TCE), Tetrachloroethene (PCE), and 1,2-Dichloroethane (DCA) using a Photovac field gas chromatograph. At least two hydropunch samples were collected at each location. Groundwater samples were collected at 10-foot intervals beginning at 15 feet below ground surface. Hydropunch samples were collected until the contamination was below detection limits (BDL) or two consecutive samples were detected at or below 5 micrograms per liter (μg/l).

- One surface water sample was collected from the Elizabeth River adjacent to the piers.
- Rising and falling head slug tests were used to determine the hydraulic conductivity of the aquifer. Continuous water level monitoring was conducted on one shallow and one deep well to determine tidal and recharge influences on the aquifer.
- The vertical flow regime between the aquifer and the Elizabeth River was determined by installing a piezometer at the end of one of the piers.
- A 72-hour drawdown test was performed to evaluate aquifer characteristics including specific capacity, transmissivity, storativity, and area of influence.
- Following the 1992 field investigation, MODFLOW®, a three-dimensional groundwater flow model, was used to determine groundwater flow lines at the site.
- Monitor well locations were surveyed to determine the elevation of each well; additional surveys were performed to develop accurate site maps.
- Two AS/SVE pilot studies were performed in May 1995 to test the feasibility of a remediation system.

5.1 RI Results

A variety of contaminants have been identified at the site. A list of compounds of concern (target compounds) was created from the contaminants identified and is located in Section 4 of the RI report.

The following factors were considered when identifying the target compounds:

- Relation to known or suspected site activity
- Frequency of detection above background levels and/or relevant standards/criteria
- Frequency of detection above those mandated by NEESA Level C Protocols
- Compound presence in laboratory or field blanks

Several compounds identified at the site are recognized laboratory contaminants. These compounds are not the focus of the FS and therefore are not relevant. In addition, the treatment proposed for PCE and TCE will also eliminate these compounds if they are present at low levels.

A brief summary follows of the sample results from each media investigated during the RI. Figures 2-1 and 2-2 of the RI report show the locations sampled during the investigation. Media included groundwater, surface soils, subsurface soils, sediment, and surface water. Figures 5-6 through 5-38 of the RI report show the location of the monitor wells and interpreted contaminant plumes. Additional details regarding the site can be found in Sections 3.0 through 8.0 of the RI Report.

Surface Soils:

- Fifty percent of the 0- to 3-foot samples from the QADSY were contaminated by petroleum hydrocarbons above the 100 parts per million (ppm) of VDEQ action level. Two-thirds of the samples exceeded the 50 ppm VDEQ guideline for disposal of the soil as clean fill. Concentrations ranged from not detected to 4400 ppm. A hydrocarbon that closely matched the reference standard for compressor oil was the most common; other oils were less common. All of the 3- to 7-foot samples were below the 50 ppm VDEQ guideline.

- Soil VOC contamination is limited. Only the sample from location HM-9-2, at 32,000 micrograms per kilogram (μg/kg) PCE, exceeded the range for all other samples of 1000 μg/kg total VOCs. Other VOCs detected at much lower levels included: acetone, xylenes, 1,1-DCA, toluene, methylene chloride, 1,2-Dichloroethene (DCE), 1,1,1-Trichloroethane (TCA), TCE, 4-methyl-2-pentanone, and 1,1,2,2-Tetrachloroethane (PCA).

- All detected toxic characteristic leachate procedure (TCLP) organics and IOCs were well below federal standards.

- Many of the compounds detected in the surface soils were also detected in the groundwater samples, including VOCs, TPH, and IOCs.

Groundwater:

- The contaminants present in the saturated zone were comparable to those observed in the soils and are typical of the type of contaminants stored at the site except for TPH.

- Contamination appears to affect the upper 60 feet of the aquifer.

- The main groundwater contaminants of concern are the following chlorinated organics: PCE, TCE, 1,1,1-TCA, 1,1,-DCA, 1,1-DCE, 1,2-DCE, and acetone. Locally, some IOC concentrations were elevated (e.g., cadmium).

6.0 Summary of Risks

6.1 Human Health Risks

6.1.1 Identification of Constituents of Concern

A Risk Assessment is a procedure that uses a combination of facts and assumptions to estimate the potential for adverse effects on human health and the environment from exposure to chemicals found at a site. The RA process for the QADSY involved consideration of chemicals of concern (COCs) in air, soil, sediment, surface water, and groundwater and how humans and animals can be exposed to these COCs.

In the RA, potential carcinogenic risks and non-carcinogenic health risks were calculated using EPA standards, protocols, and specific EPA Region III guidelines. Conservative assumptions were used in calculating potential risks that weigh in favor of protecting human health and the environment.

Potential risks to human health and the environment were then evaluated with respect to carcinogenic and non-carcinogenic effects. USEPA's acceptable increased cancer risk range is $1.0x10^{-4}$ to $1.0x10^{-6}$ (one individual in 10,000 to one individual in 1,000,000) as established in the NCP. The number $1.0x10^{-4}$ corresponds to a probability of one additional individual in 10,000 developing cancer from a lifetime (70 years) of exposure to chemicals on the installation.

A hazard index (HI) is used to determine whether individuals in a population could be adversely affected by non-carcinogenic chemicals. An HI exceeding 1.0 indicates a potential unacceptable risk and a possible concern for potential toxic effects.

The ecological RA was conducted to determine if there were any potential/current or future adverse effects on plants and animals due to the presence of chemicals at the study areas. Potential risks were determined by evaluating the toxicity of the study area COCs and the potential exposure to those COCs.

The Risk Assessment was generated in accordance with EPA Risk Assessment Guidance (RAGS) for Superfund and Region III guidance to assess the potential current and future human and ecological health risks associated with potential onsite exposures at the QADSY, assuming no remedial action is implemented at the site. The risk results are then used to develop remedial goal objectives (RGOs), goals that remedial alternatives strive to achieve considering other factors such as feasibility and achievability.

The RA identified the primary site-related chemicals of potential concern (COPCs) at the QADSY. Based on past operations at the site, the COPCs evaluated in the Human RA (HRA) and Ecological RA (ERA) include a subset of VOCs and IOCs. The data used in the RA are taken from ESE sampling events (1990-1993) and sampling events from different contractors (Malcolm Pirnie, 1983-1986 and Baker Environmental, 1995). The most recent and/or reliable data are used in the calculation of the exposure concentrations for the RA. The number of chemicals to be evaluated in the RAs was reduced using 1) EPA Region III methodology for risk-based concentration screening, 2) comparison of site and background soil concentrations, and 3) a screening for nutritionally essential chemicals.

TPH was also detected at the site. Although this group of chemicals is useful for determining the extent of petroleum-based contamination, a quantitative risk evaluation was not performed, as TPH represents a large group of chemicals, typically composed of long, straight-chain hydrocarbons of relatively low toxicity. However, to provide a conservative risk evaluation, the carcinogenic polynuclear aromatic halogens (PAHs) were used as a surrogate to evaluate TPH.

Potential human health risks were characterized based on the detected constituents of concern present in the relevant medium at the QADSY. Based on the results of the RA, the constituents of concern that pose the greatest potential risk to human health were identified. The constituents of concern are VOCs in the soil and groundwater.

6.1.2 Human Health Exposure Assessment

The exposure assessment identifies significant human and ecological exposure pathways and population(s) based on the environmental fate/transport analysis; determines the exposure concentrations to potential receptors; and estimates the magnitude, duration, and frequency of exposure for each receptor (or receptor group). The primary exposure pathways evaluated in the HRA and ERA are as follows:

<u>Human Exposure Pathways</u>

Current Worker -- incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air

Future Worker -- incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air

Future Residential -- incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air

Domestic groundwater consumption is an incomplete human exposure pathway as the water below the QADSY site is not potable due to the high salinity of the water. Thus, this pathway, under the guidance of state and federal regulatory agencies, is not further evaluated in the RA. However, due to the presence of VOCs in groundwater beneath the site, inhalation of VOCs volatilized from groundwater into indoor air is evaluated.

The primary sources of toxicological data were from EPA-verified references. When an appropriate toxicological constant was not identified, current literature was reviewed to find appropriate toxicological data, which were used to calculate dose-response values using the methodologies outlined in EPA guidance documents.

For each human exposure pathway evaluated, carcinogenic and non-carcinogenic health risks were characterized for the reasonable maximum exposure (RME), and the reasonable average exposure (RAE) scenarios. The standard and default exposure assumptions recommended by RAG's were used, as well as conservative assumptions and professional judgement. The methods and assumptions used in the exposure assessment are presented in Section 6.0 of the RI/FS Report (ESE, 1996).

6.1.3 Human Health Toxicity Assessment

Available toxicity factors of carcinogenic and noncarcinogenic COPCs are discussed and presented in Section 5.0 of the RI/FS Report (ESE, 1996). The COPCs selected for the RA for the site have a wide range of carcinogenic and noncarcinogenic effects associated with them. The reference dose (RfD) values and slope factors (SF) were key dose-response variables used in the RA. The RfD, expressed in units of milligrams per kilogram per day (mg/kg/day), for a specific chemical is an estimated daily intake rate that appears to pose no risk over a lifetime of exposure. The RfD value is used to assess noncarcinogenic effects. The SF, expressed in units of $(mg/kg/day)^{-1}$, provides a conservative estimate of the probability of cancer development from a lifetime of exposure to a particular level of a potential carcinogen. Brief toxicity summaries of the COPCs that may present the greatest carcinogenic risks and are present at the highest concentrations at the site are presented in Section 6.0 of the RI Report.

6.1.4 Human Health Risk Characterization

Potential excess carcinogenic risks were calculated for individual constituents by multiplying exposure levels of each constituent by the appropriate carcinogenic slope factor (CSF). The total combined potential health risks were also evaluated for each pathway by summing estimates derived for each constituent of concern for that pathway. The additive approach is in accordance with USEPA guidelines (USEPA, 1989) on chemical mixtures in which potential risks associated with carcinogens are considered additive. Risks from inhalation, skin absorption, and oral exposures can be added to estimate total overall potential risk to human receptors.

The site-specific potential carcinogenic risk estimates were based on the RME and RAE scenarios. The potential cancer risks associated with the known or suspected carcinogens detected at the QADSY were compared to the USEPA acceptable cancer risk range of 1.0E-4 to 1.0E-06.

The potential for noncarcinogenic effects was evaluated by comparing an exposure level over a specified time period (e.g., the daily dose in mg/kg/day for a long period up to a lifetime) with an RfD derived for a similar period (USEPA, 1989a). This ratio of exposure to toxicity is called a noncarcinogenic HI. The noncarcinogenic HI assumes that there is a level of exposure below which it is unlikely for even sensitive populations to experience adverse health effects (USEPA, 1989). If the exposure level exceeds the threshold level (i.e., if the HI exceeds unity), there may be concern for potential noncarcinogenic effects. Total pathway HIs were calculated by summing estimates derived for each constituent of concern. This additive approach assumes that multiple subthreshold-exposures could result in an adverse effect and that the magnitude of the effect is proportional to the sum of the ratios of the exposure to acceptable exposures. The possible effects of multimedia exposures were evaluated by summing the HI values for the relevant exposure routes.

The results of the HRA indicate that the following scenarios exceed either a cumulative risk of 10^{-4} or an HI of 1:

Human Health Exposure Summary Table

Exposure Scenario	Medium	Exceedance	COCs	Risk/ HI Values
Future Worker	Indoor air	Risk $>1x10^{-4}$	carbon tetrachloride,	$4.4x10^{-5}$
			chloroform,	$5.4x10^{-6}$
			1,1-dichloroethene,	$3.7x10^{-4}$
			tetrachloroethene,	$2.6x10^{-6}$
			trichloroethene,	$2.8x10^{-5}$
			and vinyl chloride	$4.4x10^{-4}$
		HI >1	carbon tetrachloride	4.1
Future Residential (Lifetime)	Indoor air	Risk $>1x10^{-4}$	carbon tetrachloride,	$6.6x10^{-5}$
			chloroform,	$8.1x10^{-6}$
			1,1-dichloroethane,	$5.5x10^{-4}$
			1,1-dichloroethene,	$1.3x10^{-4}$
			tetrachloroethene,	$4.0x10^{-6}$
			1,1,1-trichloroethane,	$6.4x10^{-5}$
			trichloroethene,	$4.2x10^{-5}$
			vinyl chloride	$6.6x10^{-4}$
(Child)	Indoor air	HI >1	carbon tetrachloride,	21
			1,1-dichloroethane,	0.10
			1,1,1-trichloroethane	0.29
	Soil	HI >1	thallium	2.2

6.2 Ecological Risk Summary

6.2.1 Identification of Constituents of Concern

Constituents at the QADSY were identified from soil, groundwater, surface water, and sediment samples. In addition, constituents were also identified through small mammal trapping and tissue sample collection conducted at the QADSY. Over 40 constituents (including volatile organics, semi-volatile organics, and inorganics) were detected in these media.

Potential ecological risks were characterized based on the detected constituents of concern present in the relevant medium at the QADSY. Information about the specific constituents of concern detected at each site and in each medium is presented in Section 5.0 of this DD.

6.2.2 Ecological Exposure Assessment

The exposure assessment in the RA identified potential receptors and complete exposure pathways, and estimated chemical intakes for potentially exposed populations. Terrestrial, aquatic, and vegetative ecological receptor groups were evaluated for quantitative evaluation in the RA.

Exposures to potential ecological receptors, including a number of terrestrial, aquatic, and vegetative receptors, were evaluated for soil, groundwater, surface water, and sediment. The groundwater pathway was evaluated in the ecological RA in terms of potential groundwater discharge to surface water causing potential risks to aquatic species through exposure to affected surface water and sediment. The food chain (bioaccumulation) pathway was also evaluated for ecological receptors. Future ecological exposure scenarios are expected to remain unchanged from the current scenarios at the QADSY.

Current ecological exposure scenarios at the QADSY sites included a number of terrestrial and aquatic receptors. Because of the large number of different species of wildlife that are known or suspected of inhabiting the QADSY sites, it was not possible to evaluate all ecological receptors. The ecological receptors were screened based on the analysis of the ecological setting and site characteristics, and a determination of those communities/species critical to the ecological RA. A detailed analysis of the ecological receptors is presented in Section 6.0 of the RI/FS (ESE, 1996). After the analysis of the ecological receptors was conducted, indicator species were selected. These indicator species were chosen from the list of potential ecological receptors and are those species that appeared to be at greatest risk from exposure to potential constituents of concern.

The QADSY is located in an industrial area with limited vegetative cover, which would provide habitat for terrestrial wildlife. Potential exposure of terrestrial animals to contaminated surficial soils was evaluated in Section 6.3.3.1 of the RI/FS (ESE, 1996) and, due to the lack of exposed soil, was found to be incomplete. Therefore, no terrestrial receptors are considered applicable at the QADSY.

To evaluate potential bioaccumulative effects of site contaminants on surface water organisms, one species of wading bird, the great blue heron, is found in Mid-Atlantic habitats and was chosen as the indicator avian species for this ERA. The great blue heron (*Ardea herodias*) is the only species of wading bird that is found during the winter in the northern parts of the Atlantic coast [US Fish and Wildlife Service (USFWS, 1984)]. The great blue heron is one of the larger wading birds, eating fish as small as minnows or as large as 20 to 25 centimeters (cm) in length. Other items in the great blue heron's diet include crayfish, snails, frogs, lizards, and snakes (USFWS, 1984). The potential for bioaccumulation of IOCs into fish in the Elizabeth River and the subsequent ingestion of these fish by the heron is evaluated in the RA.

The selected representative ecological receptors are the following:

Ecological Exposure Pathways

Terrestrial -- ingestion of contaminated fish by great blue heron

Aquatic -- exposure to surrounding surface water and sediment by aquatic and benthic organisms

6.2.3 Ecological Toxicity Assessment

The toxicities of the constituents of concern were assessed for effects on vegetation, aquatic life, and terrestrial wildlife, including birds. Risks to ecological receptors are quantitatively evaluated by comparing the chemical intake (for terrestrial receptors) to a toxicity reference value (TRV) for that chemical in the specific receptor.

Selected ecotoxicity benchmarks for the surface water COPCs at QADSY were obtained from the available literature and are presented in Table 6-17 in the RI (ESE, 1996). Ecotoxicity benchmarks were chosen based on the following considerations:

- Including acute and chronic effects
- Choosing results of tests using organisms as closely related taxonomically to representative receptors as possible
- Choosing tests with ecologically relevant endpoints
- Choosing tests conducted with an ecologically relevant exposure pathway

The preferred value sought was a chronic no-observed-adverse-effect level (NOAEL) in the indicator species or related organism. For chemicals with no available chronic NOAEL, other values [e.g., a lowest-observed-adverse-effect level (LOAEL) or the dose/concentration lethal to 50 percent of a study population (LD_{50}/LC_{50})] were used to derive a TRV. In the absence of US Navy guidance on the evaluation of ecotoxicity data, the ecotoxicity benchmarks were adjusted to account for extrapolation uncertainties according to guidance provided by the US Army (USA, 1994). The Army's methodology for applying uncertainty factors to ecotoxicity benchmark values is presented in Figure 6-1 in the RI (ESE, 1996).

As discussed in Section 5.3.2, the great blue heron (*Ardea herodias*) was evaluated for ingestion of fish that may bioconcentrate contaminants from surface water. Potential ecotoxicity for this species is evaluated by comparing the intake of biota-borne chemicals during feeding to the species-specific TRVs presented in Tables 6-17 in the RI (ESE, 1996).

Due to few toxicity studies conducted on the heron, ecotoxicity benchmarks for the mouse and rat were predominantly used for the COPCs modeled into Elizabeth River surface water at QADSY. The following avian values were used for the surface water COPCs: an acute LD_{50} for arsenic and a chronic LD for selenium in mallard ducks (*Anas platyrhyncos*); an acute NOAEL for chromium in the black duck (*Anas rubripes*); an unknown chronic value for lead in the American kestrel (*Falco sparverius*); a chronic LOEL for cadmium and an acute LD_{50} for mercury in Japanese quail (*Coturnix coturnix japonica*); an acute LC_{50} for copper in an unknown species of pheasant; acute LC_{50}s for acetone in Japanese quail (*Coturnix coturnix japonica*) and ring-necked pheasant (*Phasianus colchicus*); and acute LC_{50}s for thallium in unspecified birds.

Aquatic receptors are continually in contact with the contaminated medium. Groundwater contaminants are assumed to be discharging to surface water adjacent to the site, resulting in potential bioaccumulation of certain contaminants in fish tissue and potential exposure to aquatic organisms. Instead of using receptor-specific TRVs, modeled surface water contaminant concentrations were compared to chronic federal and state ambient water quality criteria. Also, measured onsite groundwater concentrations were compared to acute water quality criteria to evaluate a worst-case scenario of toxicological effects at the groundwater-surface water interface. The level of contamination at the point of discharge is assumed to be equivalent to the level of contamination found in onsite groundwater. This assumption is considered very conservative, as it does not consider physical processes such as dilution, attenuation, or volatilization.

Similar to surface water receptors, organisms living in sediment are continually in contact with the contaminated medium. Instead of using receptor-specific TRVs, potential impacts to organisms inhabiting river sediments near the site were evaluated using the National Oceanic and Atmospheric Administration (NOAA) sediment benchmarks for LOAELs in marine organisms (1990). Sediment concentrations modelled from the groundwater concentrations at the groundwater-surface water interface were compared to the NOAA values.

The results of the RA indicated that, for the future commercial use scenario, groundwater at the QADSY poses an elevated carcinogenic (risk is 9E-04) and non-carcinogenic risks (HI of 4). The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans, although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY (refer to Section 4.0 of this document for a description of this RA). This RA showed that under a worker exposure scenario, potential risks to human health are within the acceptable range. The QADSY will use the future commercial scenario for its preferred alternative selection.

6.2.4 Ecological Risk Characterization

The objective of this risk characterization is to integrate information developed in the RI report (ESE, 1996) exposure assessment (Section 5.3.2) and the toxicity assessment (Section 5.3.3) into a complete evaluation of the potential worst-case ecological health risks associated with contaminants at QADSY. The ERA evaluates the nature and degree of risk to potential receptor populations described in Section 6.3.3. Wherever possible, risk estimates are derived for individual source areas as well as for the total contaminant contribution from the site to aid in developing priorities for remedial action planning.

The evaluation of potential health risks posed to wildlife is performed in a similar manner as the evaluation of health risks to humans. The main difference between evaluating ecological versus human health risks is that intra-species differences may significantly affect the amount that an animal ingests per body weight or the sensitivity of a species to adverse health effects. To evaluate potential risks to terrestrial receptors, the chemical intakes for a particular indicator species are compared to chemical-specific TRVs derived for that species. The ratio of chemical intake to TRV is calculated as the EQ.

Chemical intakes and TRVs are expressed in the same units. EQs less than 1 suggest that the benchmark effect is unlikely to occur in the individual; EQs greater than or equal to 1 require further evaluation. Although these EQs may indicate some potential for adverse effects to individuals, at this point, the potential for adverse effects to populations or ecosystems is qualified. Although the EQ method does not provide an estimate of uncertainty and is not an estimation of risk, it is commonly used for screening the potential for ecological effects from exposure to hazardous chemicals (EPA, 1988b).

Great Blue Heron--Diluted surface water concentrations were used to estimate the concentration of contaminants in fish. Health risks to a great blue heron ingesting fish from the river are estimated by comparing estimated chemical intakes (from fish ingestion) to TRVs to produce an EQ. An EQ equal to or exceeding unity (≥ 1) suggests that the potential for adverse health effects may exist and indicates that further evaluation of the ecological exposure scenario should be performed. An EQ less than 1 indicates that it is unlikely for even sensitive populations to experience adverse health effects.

Surface Water Receptors--Groundwater contaminants are assumed to be discharging to surface water adjacent to the site, resulting in potential bioaccumulation of certain contaminants in fish tissue and potential exposure to aquatic organisms. Exposure of potential surface water receptors to site contaminants was evaluated using two methods. First, onsite groundwater concentrations were compared to acute federal Ambient Water Quality Criteria (AWQCs) and Commonwealth of Virginia Water Quality Standards (WQSs) to evaluate a worst-case scenario of toxicological effects at the groundwater-surface water interface. The level of contamination at the point of discharge is assumed to be equivalent to the level of contamination found in onsite groundwater. This assumption is considered very conservative, as it does not consider physical processes such as dilution, attenuation, or volatilization. A ratio greater than 1 indicates that the potential may exist for adverse effects to occur in an organism exposed to chemical concentrations at the groundwater-surface water interface.

Second, surface water contaminant concentrations that may be found in the open river were modeled from onsite groundwater concentrations using a dilution factor. These modeled concentrations were compared to chronic federal AWQCs and state WQSs to evaluate the potential exposure of aquatic organisms in the area. A ratio greater than 1 indicates that the potential may exist for adverse effects to occur in an organism exposed to diluted chemical concentrations in the river.

Benthic Organisms--Potential impacts to organisms inhabiting river sediments near the site are evaluated using the NOAA (1990) sediment benchmarks for LOAELs in aquatic organisms. Sediment concentrations modelled from the groundwater concentrations at the groundwater-surface water interface were compared to the NOAA values. A ratio greater than 1 indicates that the potential may exist for adverse effects in organisms exposed to sediments with the modelled chemical concentration.

Great Blue Heron

A summary of the potential risks associated with exposure of great blue heron to site contaminants due to ingestion of fish is presented in Table 6-18 in the RI (ESE, 1996). The EQs for this exposure pathway are less than 1 for all potential surface water contaminants, suggesting that there is low potential for adverse effects to the great blue heron due to site-related chemicals in fish caught near the site.

Aquatic Receptors

Surface Water Organisms--A comparison of modeled surface water concentrations to federal and state ambient water quality criteria is presented in Table 6-19 in the RI (ESE, 1996). Acute surface water concentrations (i.e., groundwater concentrations assumed to be present at the groundwater-surface water interface) exceed federal AWQCs and/or Commonwealth of Virginia WQSs for arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc. Diluted surface water concentrations are less than the chronic federal AWQCs and Virginia WQSs for all chemicals evaluated. As groundwater chemical concentrations will be quickly diluted upon confluence with the Elizabeth River, acute impacts to surface water organisms in the river are not anticipated.

Benthic Organisms--A comparison of modeled sediment concentrations to NOAA sediment values is presented in Table 6-20 in the RI (ESE, 1996). Sediment IOC concentrations (i.e., concentrations modeled from site groundwater and present at the groundwater-sediment interface) exceed NOAA sediment benchmark values for antimony, arsenic, chromium, lead, and silver. Due to the industrialized nature of the site vicinity and the size of the Elizabeth River, the presence of significant benthic organisms and exposure of sediment organisms to significant amounts of site groundwater chemicals is not expected.

Terrestrial--The EQs associated with exposure of great blue heron to site contaminants due to ingestion of fish are all less than 1, suggesting that there is low potential for adverse effects to the great blue heron due to site-related chemicals in fish caught near the site.

Aquatic--The EQs for water- and sediment-dwelling aquatic organisms at QADSY are all less than 1, indicating that there is low potential for adverse effects to these aquatic organisms.

7.0 Description of Alternatives

No action for soil is necessary at the QADSY because:

- IOCs contamination appear to be inherited from the dredged material
- The QADSY is not conducive to an ecological environment because it is in a highly industrial area and is mostly a paved parking lot
- The present plans are for the unpaved area to be paved, which will subsequently eliminate this ecologic risk pathway

In the RA, potential carcinogenic risks and non-carcinogenic health risks were calculated. Conservative assumptions were used in calculating potential risks that weigh in favor of protecting human health and the environment.

Five alternatives were analyzed in the FS for their ability to protect human health and the environment, comply with legal requirements, and be cost effective.

The evaluations of capital costs, operation and maintenance (O&M) costs, net present worth costs, and implementation times presented below are estimates. Each alternative, except the No Action alternative, will include a provision for land use controls at the QADSY whether remedial activities take place or not. Implementation of land use controls will reduce the potential for future exposure to the remaining affected soil and restrict the construction of drinking water wells in the QADSY.

Under Alternatives 2 through 5, groundwater at the QADSY will be remediated to RGOs developed in the RA. Under Alternatives 2 through 5, groundwater monitoring will occur at the QADSY quarterly the first year, semi-annually the second and third years, annually the fourth and fifth years, then every 5 years thereafter until year 30. Monitoring well samples will be analyzed for VOCs.

7.1 Alternative 1 - No Action

The No Action alternative leaves the QADSY in its current condition. No remedial actions that result in the treatment, containment, or removal of affected soil are implemented under Alternative 1. The NCP requires the consideration of a No Action alternative. The No Action alternative is also used as a baseline for comparison with other remedial alternatives. This no remedial action alternative consists of implementing monitoring to determine access and exposure to contaminated groundwater. No remedial actions that result in the treatment, containment, or removal of the contaminated media will be implemented under this alternative. In addition, this alternative would require continuation of current water use restrictions.

The elements necessary to implement the no-action alternative follow:

- Installing two shallow and three deep monitor wells
- Collecting groundwater samples at 11 wells

- Additional contaminant transport modeling
- Periodically evaluating public health

Capital Costs	$ 35,000
Present Worth O&M	$ 28,500
Total Present Worth Costs	$884,200
Time to Construct	2 Months

7.2 Alternative 2 - Groundwater Collection, Treatment, and Onsite Discharge

Alternative 2 consists of the following elements:

- Locating and installing 33 extraction wells
- Constructing and operating a groundwater treatment system
- Locating and installing pressurized conveyance piping
- Locating a discharge point for treated water into Willoughby Bay
- Groundwater monitoring
- A detailed review of site conditions every 5 years

Capital Costs	$ 411,500
Present Worth O&M Costs	$ 136,250
Total Present Worth	$2,902,250
Time to Construct	6 months

7.3 Alternative 3 - Groundwater Collection, Pretreatment, and Offsite Treatment

Alternative 3 consists of the following elements:

- Locating and installing 33 extraction wells
- Constructing and operating a groundwater treatment system
- Locating and installing pressurized conveyance piping
- Pretreated by VOC volatilization by air stripping
- Effluent can be discharged to an Industrial Waste Treatment Plant (IWTP)
- Groundwater monitoring
- A detailed review of site conditions every 5 years

Capital Costs	$ 411,500
Present Worth O&M Costs	$ 318,400
Total Present Worth	$5,936,300
Time to Construct	9 months

This alternative consists of the same groundwater recovery and treatment system as Alternative 2. The contaminated groundwater will be pretreated by VOC volatilization by air stripping so that the effluent can be discharged to an IWTP, such as the Norfolk Naval Base Industrial IWTP, via pipeline. This alternative, therefore, eliminates the need for direct discharge to Willoughby Bay.

The contamination would be treated over a 3- to 12-year period, depending on the groundwater extraction rates. This estimate can vary significantly due to factors such as volume and velocity of groundwater flow, and extent and degree of contamination.

7.4 Alternative 4 - Collection/Onsite Treatment/Onsite Discharge/In-Situ Treatment

Alternative 4 consists of the following elements:

- Locating and installing 33 extraction wells
- Constructing and operating a groundwater treatment system
- Locating and installing pressurized conveyance piping
- Pretreated by VOC volatilization by air stripping
- Effluent can be discharged to an infiltration gallery
- Groundwater monitoring
- A detailed review of site conditions every 5 years

This alternative consists of the same groundwater recovery system (i.e., air stripping) as Alternative 2, but includes additional in-situ treatment by biological degradation to decrease remediation time. In addition to the recovery and treatment equipment outlined under Alternative 2, Alternative 4 will require installing and operating biologic nutrient and catalyst control units, infiltration gallery, and manifolds. As part of the design effort, a Biofeasibility study will be required. All treated water will be discharged into the surficial aquifer so that no water discharge to Willoughby Bay or Elizabeth River will occur.

Capital Costs	$ 503,750
Present Worth O&M Costs	$ 136,250
Total Present Worth	$2,963,700
Time to Construct	6 months

7.5 Alternative 5 - Air Sparging/Soil Vapor Extraction

Alternative 5 consists of the following elements:

- Locating and installing 30 AS wells
- Locating and installing 19 SVE wells
- Locating and installing pressurized conveyance piping
- Pretreated by VOC volatilization from the SVE wells to an air-water separator (AWS) (vapor removal) and then through an activated carbon vessel by air stripping
- Condensed water vapor removed by the AWS will be piped through an air stripper and an activated carbon vessel before it is discharged to a surface storm drain
- Groundwater monitoring
- A detailed review of site conditions every 5 years

An alternative discussed with LANTDIV will position the AS and SVE wells on the downgradient edge of the plume paralleling the waterfront. This arrangement will provide a remediation zone prior to groundwater discharge to the Elizabeth River. The system at the FP would consist of approximately 22 AS wells and 13 SVE wells. A total of 30 AS and 19 SVE wells will be required to effectively remediate the two existing plumes.

Capital Costs	\$1,269,500
Present Worth O&M Costs	\$ 264,400
Total Present Worth	\$6,401,118
Time to Construct	6 months

8.0 Summary of the Comparative Analysis of Alternatives

In accordance with the provisions set forth in CERCLA, SARA, and the NCP, each of the alternatives was evaluated against nine established criteria. Overall protection of human health and the environment and attainment of applicable or relevant and appropriate requirements (ARARs) are threshold criteria and the primary objectives of a remedial action. In addition, the selected remedial alternative must reflect the best balance among criteria such as reduction of nitroaromatic compounds; short- and long-term effectiveness; implementability; and cost. Support agency and community acceptance are also considered during the evaluation. These nine criteria are as follows:

Threshold Criteria

- **Overall Protection of Human Health and the Environment** determines whether an alternative eliminates, reduces, or controls threats to human health and the environment.

- **Compliance with ARARs** evaluates whether the alternative meets federal and state environmental laws pertaining to the site.

Balancing Criteria

- **Long-term Effectiveness and Permanence** considers the ability of an alternative to protect human health and the environment over time.

- **Reduction of Toxicity, Mobility, or Volume Through Treatment** evaluates an alternative's use of treatment to reduce the harmful nature of contaminants, their ability to move in the environment, and the amount of contamination present.

- **Short-term Effectiveness** considers the length of time needed to implement an alternative and the risks it poses for workers, residents, and the environment during implementation.

- **Implementability** considers the technical and administrative feasibility of implementing an alternative.

- **Cost** evaluates estimated capital and O&M costs, as well as present-worth costs.

Modifying Criteria

- **State Acceptance** considers whether the state agrees with the recommendations as presented in the RI/FS and the Proposed Plan.

- **Community Acceptance** considers the public's response to the alternatives described in the FS and the Proposed Plan. Specific responses to public comments are contained in the Responsiveness Summary attached to this DD.

The five alternatives for groundwater are compared under the various evaluation criteria, profiling the performance of the alternatives against the nine criteria. A summary of this comparison is provided in Table 1.

8.1 Overall Protection of Human Health and the Environment

Alternatives 2, 3, 4, and 5 will provide adequate protection to human health and the environment following contaminated groundwater treatment. Once treatment is completed, the risk to human health will be the same as the risk associated with background levels that currently exist at the site. Contaminants will be completely destroyed, providing overall protection to the environment.

Alternative 1 will provide protection to human health by eliminating exposure to groundwater; however, the alternative will not be protective of the environment because contaminants will remain in place.

8.2 Compliance with ARARs

Alternatives 2 through 5 will all meet chemical-specific ARARs following completion of the treatment phase. Alternative 1, however, will not meet ARARs because no remediation of the contaminants will occur and VDEQ exceedances will still exist in the upper aquifer. Treated groundwater under Alternative 2 will be discharged into Willoughby Bay at levels below chemical-specific ARARs.

Action-specific ARARs will also be met by Alternatives 2 through 5. Alternatives 2 through 4 are not expected to exceed action-specific ARARs for air emissions from the air stripping towers. Alternative 5 is not expected to exceed action-specific ARARs for air emissions from the VES. Alternative 2 will meet ARARs for surface water discharges, and Alternative 4 should meet ARARs for treated groundwater infiltration.

8.3 Long-Term Effectiveness

The alternatives, except the no-action alternative, remove contaminants from the site and do not leave any untreated waste or residuals that require managing to ensure an adequate level of protection.

The no-action alternative will effectively reduce the potential for exposure to contaminants but will not eliminate exposure over the long term. This alternative leaves the contaminants in place and requires management beyond the implementation phase.

8.4 Reduction of Mobility, Toxicity, and Volume Through Treatment

Alternative 4 will provide the greatest degree of contaminant destruction and therefore the greatest degree of mobility, toxicity, and volume reduction. Alternatives 2 and 3 will also provide a similar reduction. However, Alternative 4 provides a greater degree of volume and mobility reduction due to the additional in-situ treatment of the VOCs in the area influenced by the extraction wells.

Alternatives 2 through 4 provide hydraulic control of the Aquifer.

Alternative 5, through the removal of contaminants, vapors, and extraction of air will provide a quick reduction in contaminant volume and therefore provide control of mobility, toxicity, and volume of contaminated groundwater.

Alternative 1 does not consist of any containment, collection, or treatment actions and will not reduce the mobility, toxicity, or volume of contaminants in the groundwater.

8.5 Short-Term Effectiveness

Alternatives 2 through 5 are more effective in reducing aquifer contamination than the no remedial action alternative. In alternatives 2 through 4, this is because contaminated groundwater is extracted from the surficial aquifer, treated, and discharged by three different means: surface water, WTP, and infiltration gallery. Alternative 5 effectively treats the contamination from the groundwater prior to discharge to the atmosphere. However, the no-action alternative may be equally effective in reducing exposure to contaminants if current water and land use restrictions are maintained.

Alternatives 2 through 4 will have onsite emissions from air stripping and/or onsite discharge of treated water. Alternative 5 will have onsite emissions from vapor extractions. Alternative 1 will not affect the current exposure to workers and the community because no contaminated groundwater extraction will occur.

Alternative 4 will achieve remedial objectives quicker than Alternatives 2 and 3. The relative remedial rates cannot be determined until the completion of a Bioremediation/biological degradation/biological feasibility study is conducted.

Alternative 5 does not include extraction of groundwater and has the least likelihood of uncontrolled contaminant release.

Alternative 1 will not meet the remedial response objectives over time.

8.6 Implementation

All of the remediation alternatives for groundwater are technically feasible. Each alternative can be constructed and operated on reliable technologies that are both effective and proven. Alternatives 2 through 4 involve standard extraction and wastewater treatment processes with monitored discharge or disposal. The exception is Alternative 4, infiltration gallery with microbial degradation. However, until a biological treatability study is performed, the actual degradation rate and system parameters are unknown. Further, the operational permit process for the infiltration gallery is not well defined.

The no-action alternative for groundwater is easiest to implement because water and land use restrictions are already in place, and long-term groundwater monitoring and surface water runoff monitoring are easy to put in operation.

Implementation of the remediation alternatives from an administrative standpoint is not estimated to be a major concern because the QADSY is on Navy property. It is also surrounded by Navy property so rights-of-way and easements should not be a problem. Permits from the Virginia regulatory agencies will be required for any air emissions from stripping towers.

8.7 Cost

Present worth cost is provided in Table 12-3 in the FS (ESE, 1996). Alternative 5 has the highest capital cost and the highest present worth.

The present worth costs were calculated by considering the replacement of the capital expenditure items at half the performance period for those alternatives that have performance periods greater than one year. Alternative 5 demonstrates the greatest sensitivity to the replacement cost because the capital expenditures are a greater portion of the alternative's present worth cost. There are no additional costs associated with implementing No Further Action. Alternatives 1 is the least costly of the alternatives. However, Alternative 1 provides no active remediation processes.

Active remedial processes associated with Alternative 2 consist of groundwater pumping and treating of VOCs and discharging to the storm drain. Alternative 3 and 4 discharges the treated water to IWTP and a infiltration gallery, respectively. Of the remaining alternatives that do provide for active remediation processes (Alternatives 2 through 4), Alternatives 2 and 4 are similar in cost ranging from $2.9 million for Alternative 2 and $2.96 million for Alternative 4. Alternative 3 is the most costly of the alternatives at $5.9 million.

Each of the Alternatives 2 through 4 meet the criteria for protection of human health and the environment, and are accepted by the state as viable treatment alternatives. In addition, each of these alternatives also meet the requirements for compliance with ARARs; long- and short-term effectiveness; implementability; and the reduction of mobility, toxicity, and volume (MTV) for the VOCs. Based on this evaluation, Alternative 5 is the most cost effective of the alternatives that meet the seven threshold criteria.

8.8 State Acceptance

USEPA and VDEQ concur with the implementation of AS/SVE of groundwater at the QADSY.

8.9 Community Acceptance

The community concurs with the implementation of AS/SVE of groundwater at the QADSY.

Table 1. Remedial Alternative Evaluation Summary

	No Further Action 1	Groundwater Collection, Treatment, and Onsite Discharge 2	Groundwater Collection, Pretreatment, and Offsite Treatment 3	Groundwater Collection/ Offsite Treatment, Onsite Discharge, In-Situ Treatment 4	Air Sparging/Soil Vapor Extraction 5
Protective of Human Health and Environment			✓	✓	✓
Complies with ARARs			✓	✓	✓
Long-Term Effectiveness			✓	✓	✓
Reduction of Mobility			✓	✓	✓
Reduction of Toxicity			✓	✓	✓
Reduction of Volume			✓	✓	✓
Short-Term Effectiveness		✓	✓	✓	✓
Implementability	✓	✓	✓	✓	✓
Cost ($M)	0.8	2.9	5.9	2.95	6.4
Public Acceptance		✓	✓	✓	✓
State Acceptance			✓	✓	✓

9.0 Selected Remedy

Based on careful consideration of the technical, environmental, institutional, public health, and cost criteria, and in keeping with the overall response strategy, the preferred alternative is Alternative 5. Alternative 5 consists of implementing an AS/SVE system, performing periodic groundwater monitoring, and a review of site conditions every 5 years.

9.1 Remediation Goals

SARA requires that remedial actions attain a degree of contaminant cleanup that ensures protection of public health and the environment. Thus, the risk characterization results are used to identify whether site COPCs need to be reduced to acceptable health-based levels. The acceptable health-based levels are referred to as RGOs, which are chemical-specific concentration goals for individual chemicals for specific medium and reasonable land use combinations.

Based on the results of the risk characterization, future worker exposure to indoor air and future residential exposure to indoor air and soil resulted in a cumulative risk exceeding 10^{-4} and/or an HI exceeding 1. However, to provide a complete site analysis, RGOs are developed for all chemicals contributing an individual risk of at least 10^{-6} to a total of greater than 10^{-4} or on HI of at least 0.1 to a total HI of greater than 1. Ecological risk characterization results indicated that several IOCs in soil produced an excess EQ in mice and raccoon; therefore, RGOs were developed for these IOCs in soil based on these two receptors. In summary, RGOs are developed for the following chemicals to provide risk managers with the maximum risk-related media level options on which to develop remediation aspects of the FS:

	RGOs
Medium Scenario	
RGO	COCs
Groundwater	
Future Worker	
Carbon tetrachloride	2.7 µg/l
chloroform	11.1 µg/l
1,1-dichloroethene	0.38 µg/l
tetrachloroethene	59.6 µg/l
trichloroethene	48.9 µg/l
vinyl chloride	0.08 µg/l
Future Resident	
Carbon tetrachloride	1.8 µg/l
chloroform	7.4 µg/l
1,1-dichloroethane	540 µg/l
1,1-dichloroethene	0.26 µg/l
tetrachloroethene	38.9 µg/l
1,1,1-trichloroethane	3790 µg/l
trichloroethene	32.6 µg/l
vinyl chloride	0.05 µg/l
Soil	
Future Resident	
Thallium	12.5 mg/kg

The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY.

9.2 Detailed Description of the Selected Remedy

AS/SVE address VOC-impacted groundwater via in-situ remediation. AS acts as a subsurface air stripper to volatilized dissolved VOCs in the groundwater. The AS system include AS wells and an air compressor. The SVE will collect the vapors as they migrate to the vadose zone. A minimal amount of groundwater is entrained and collected with the vapor. The collected water and vapor will be separated and treated via carbon adsorption technology. The primary components of the SVE system will include SVE wells, an AWS, a liquid-phase carbon unit, and a vacuum pump. A building may be required to house the various mechanical/electrical components of the system.

9.2.1 AS

The AS process involves injection of air into the water table (Columbia) aquifer to create a subsurface air stripper that will volatilize the dissolved impacted groundwater. The natural aerobic biodegradation process will be enhanced by the AS process due to the addition of air and oxygen to the aquifer.

The AS system will utilize a network of air injection points constructed of horizontal and/or vertical wells installed below the impacted groundwater. The AS wells will be spaced to have overlapping zones of influence. Air will be injected in the wells and exits through the well screen, moving outward and upward through the saturated zone. The AS wells will be connected to a compressor or blower that will supply the air.

9.2.2 SVE

SVE involves a vacuum applied to soil extraction wells that are installed in the vadose zone. The vacuum creates a pressure gradient that induces volatile contaminants in the vadose zone to be volatilized and transported through the soil to the SVE wells. SVE also promotes in-situ biodegradation of contaminants.

Groundwater monitoring will be conducted using 20 monitor wells on the following schedule: quarterly during the first year, semiannually during the second and third years, annually during the fourth and fifth years, and every fifth year thereafter.

The estimated capital cost of the selected remedy is $1,269,500. The estimated present worth O&M cost is $4,278,890, and the estimated net present worth cost is $6,401,118. These costs are detailed in Table 2.

9.3 Rationale for Selection

After careful consideration of the technical, environmental, institutional, public health, and cost criteria, the recommended remedial action alternative for the QADSY is Alternative 5 (AS/SVE). Implementation of Alternative 5 will achieve the remedial action objective for the QADSY by minimizing the potential human health and ecological risks associated with site contaminants present in the groundwater above remediation goals.

All of the remediation alternatives for groundwater are technically feasible. The actual degradation rate and system parameters are unknown until a biologic treatability study is performed for Alternatives 4 and 5.

AS and SVE wells will be placed on the downgradient edge of the plume paralleling the waterfront. This arrangement will provide a remediation zone prior to groundwater discharge to the Elizabeth River. A small-scale pilot test will be conducted to develop design parameters for a full-scale AS/SVE system.

Given the installation-specific conditions discussed above, AS/SVE will be protective of human health and the environment. Therefore, AS/SVE is the recommended remedial alternative for the QADSY.

Although not the least costly alternative, Alternative 5 provides sufficient protection of public health and the environment and substantially complies with federal and state environmental statutes. This alternative provides for active treatment of affected groundwater. This alternative also provides comparable environmental and public health protection as the other alternatives considered through elimination of potential risks associated with direct contact by humans and animals. This alternative meets USEPA's statutory preference for treatment, and is also acceptable to VDEQ.

CERCLA Section 120(h)(3)(B) requires that, if the property is sold or transferred, each deed contain language stating that action to protect human health and the environment has been taken before the date of property transfer.

Table 2. Estimated Costs of Selected Remedy - Alternative 5

	Estimated Cost
Treatment Component	
Mobilization	$30,000
AS/SVE Well Installation	$240,000
Treatment System	$930,700
Indirect Costs (e.g., Survey, Well Locating)	$8,800
Subtotal Capital Costs	$1,209,500
Engineering	$60,000
Total Capital Cost	$1,269,500
Operations and Maintenance Costs	
Groundwater monitoring (quarterly first year, through third year, biannually fourth and fifth year, annually after five years thereafter)	$17,800
Treatment System Maintenance	$4,278,890
Contingency	$834,928
Total Costs	**$6,401,118**
Net present worth using a 5 percent discount value for 30 years	$6,081,062

10.0 Statutory Determinations

To comply with the requirements of Section 121 of CERCLA, as amended by SARA, the selected remedy must satisfy the following statutory requirements:

- Protect human health and the environment
- Comply with ARARs
- Be cost effective
- Utilize permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment as a principal element, or provide an explanation as to why this preference is not satisfied

The implementation of Alternative 5 satisfies the requirements of CERCLA, as amended by SARA, as detailed below.

10.1 Overall Protection of Human Health and the Environment

Implementation of Alternative 5 will provide for the overall protection of human health and the environment at the QADSY. The results of the RA indicated that, for the future commercial use scenario, groundwater at the QADSY poses an elevated carcinogenic (risk is 9E-04) and non-carcinogenic risks (HI of 4). The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY (refer to Section 4.0 of this document for a description of this RA). This RA showed that under a worker exposure scenario, potential risks to human health are within the acceptable range. The QADSY will use the future commercial scenario for its preferred alternative selection.

Of those complete exposure pathways evaluated in the RA (ESE, 1996), groundwater treatment will eliminate the human exposure pathways of inhalation from a future building located at the QADSY. Therefore, by remediating groundwater above remediation goals, any potential unacceptable risks from the affected groundwater to human health and the environment will be mitigated, thus attaining the protective benchmarks of 1.0E-06 and HI/ERI < 1.

10.2 Compliance with ARARs

The selected alternative will comply with federal and state ARARs. A listing of ARARs associated with the selected alternative is found in Appendix O of the RI/FS (ESE, 1996). The following ARARs will be attained.

Chemical-specific--Shallow groundwater at the QADSY is not currently used for drinking water nor will it be used in the foreseeable future because of a City of Norfolk Ordinance that prohibits water table wells for potable water.

Location-specific--The Endangered Species Act and Migratory Bird Treaty will be met under this alternative by implementing proper procedures to protect wildlife during remediation of groundwater. Efforts will be made during excavation and construction of the soil staging area to minimize any adverse effects on potential wetlands to comply with Executive Order 11990-Protection of Wetlands and Section 404 of the Clean Water Act. This alternative will be compatible with the major purposes for which the refuge was established under the National Wildlife Refuge System Act (NWRSA) including development and disposition consistent with the needs of agriculture, industry, recreation, and wildlife conservation.

Action-specific--Active remediation of groundwater will be implemented through AS/SVE to RGOs calculated in the RA. This alternative will be designed to fulfill action-specific ARARs for the site and for the future worker.

10.3 Cost Effectiveness

Although not the least costly alternative, Alternative 5 provides sufficient protection of public health and the environment and substantially complies with federal and state environmental statutes. This alternative provides comparable environmental and public health protection as the other alternatives considered through elimination of potential risks associated potential future plans for a building. The risks are from incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air.

10.4 Use of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

Alternative 5 represents the maximum extent to which permanent solutions can be utilized at the QADSY and still remain cost effective. Although Alternatives 2 through 4 each are protective of human health and the environment and comply with ARARs, Alternative 5 was selected as the remedy that will provide the greater balance of long-term effectiveness; implementability; reduction of toxicity, mobility, or volume; and cost.

An AS/SVE pilot study will be conducted during the initial installation of the system. The AS/SVE pilot study will calculate the actual zone of influence for AS/SVE well placement.

10.5 Preference for Treatment as a Principal Element

AS/SVE is considered a reliable treatment method to remediate VOC-impacted groundwater. In-situ air stripping by AS/SVE of VOCs under Alternative 5 meets the statutory requirement for treatment as a principal element.

In summary, the selected remedy for the QADSY is protective of human health and the environment, complies with federal and state environmental requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy uses permanent solutions, to the maximum extent practicable. The statutory preference for treatment as a principal element of the remedy will be met. Because the remedy will result in hazardous substances remaining onsite, a review will be conducted within 5 years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

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Appendix A

Glossary of Terms

GLOSSARY OF TERMS

Administrative Record: A file that contains the information used to make a decision on the selection of a response action under CERCLA. The file is established at or near a site and is available for public review.

Ambient Water Quality Criteria (AWQC): USEPA designated limits for toxic chemicals in surface waters. The levels are set to protect plant, fish, and animal habitats in the areas surrounding the surface waters.

Applicable or Relevant and Appropriate Requirements (ARARs): Any state or federal law or regulation that pertains to the protection of human health and the environment in addressing certain site conditions or using a particular cleanup technology at a site.

Background Concentrations: Naturally occurring chemicals present in air, water, or soil in concentrations which would normally be expected.

Base/Neutral Acid Extractable Compounds (BNAs): Chemicals detected using a laboratory procedure designed to determine the concentration of semi-volatile organic compounds.

Berm: An earthen, concrete, or other man-made barrier used to keep liquids from flowing into or out of an enclosure.

Bioaccumulation: The build-up of toxic chemicals in living things.

Carcinogenic: Term used to describe chemicals or substances that are known or suspected to cause cancer in humans based on observed health effects in humans or existing data from animal laboratory tests.

Characteristically Hazardous Waste: A waste material that exhibits certain potentially hazardous characteristics such as flammability, toxicity, corrosivity, and reactivity or contains levels of certain chemicals, as designated by federal regulations.

Constituents of Concern or Contaminants of Concern: Site-related chemicals that pose critical health concerns to human or environmental receptors because of their toxicity and potential for exposure. Although many chemicals at a site may pose a potential risk to human health and the environment, constituents of concern represent those chemicals that contribute the majority of potential risk.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): A federal law enacted in 1980 and subsequently modified by the Superfund Amendments and Reauthorization Act of 1986 (SARA). This act resulted in the creation of a trust fund, commonly known as "Superfund," which provides money to investigate and clean up abandoned or uncontrolled hazardous waste sites.

Critical Toxicity Values (CTVs): A term used to describe the level of toxicity to ecological receptors in terms of acceptable daily intake.

Detection Limits: The lowest concentration of a chemical that laboratory instruments or methods can detect.

Dose-Response: The concept in that the physiological affect (the response) is directly related to the level of chemical intake (the dose) by a living thing.

Ecological Risk Index (ERI): A calculated value used to quantify potential risks to plants and animals due to the presence of constituents of concern. The index value is calculated by dividing the estimated chemical exposure concentrations with the critical toxicity values (CTV). An ERI greater than 1.0 is considered to represent an potential unacceptable risk.

Exposure Pathways: The routes by which chemicals reach receptors. These routes may include (for example) drinking groundwater or inhaling windblown dust.

Feasibility Study (FS): A study that selects a remedial action at a site. through a series of evaluation steps. The FS identifies, develops, and evaluates several alternatives for addressing contamination.

Groundwater: Water that is present in the open spaces between soil particles (silt, sand, gravel) and/or rock fractures below the ground surface.

Hazard Index (HI): An indicator of the potential for a hazardous substance to cause noncancerous health effects in humans. The HI is calculated by dividing estimated human exposure concentrations by exposure levels that USEPA has determined to be acceptable. Any result of this calculation that is greater than 1.0 is considered to represent a potential unacceptable risk.

Hydrogeology: The study of groundwater and aquifers.

Indicator Species: Those species from the list of potential ecological receptors that appear to be at greatest risk from exposure to potential constituents of concern.

Information Repository: A location where documents and data related to a site investigation and response actions are maintained to allow the public access to this material.

Land Use Controls: Management of a property in a manner that minimizes the potential exposure of hazardous substances to the public. For example, placing restrictions on the use of groundwater at a site.

Lowest-Observed-Effect Level (LOEL): The lowest concentration of a constituent of concern at which an adverse effect is observable.

Milligrams per Kilogram (mg/kg): A unit of measure used to show concentrations of chemicals in dry materials such as soil, sediment, or sludge. This unit (mg/kg) is equal to parts per million. As a conceptual example, 1 mg/kg is equivalent to one dollar in a stack of one million dollars.

Milligrams per Liter (mg/L): A unit of measure used to show concentrations of chemicals in liquid materials such as groundwater and surface water.

Mobility, Toxicity, and Volume (MTV): Three indicators of chemical presence and movement in the environment. These indicators are used to assess the current and future concentrations of chemicals in the environment and determine how harmful these chemicals may be to human health and the environment.

Monitoring Well: A well installed for the purpose of collecting samples of groundwater to be analyzed for chemicals. A monitoring well is a permanent structure that can be sampled repeatedly over an extended period to track chemical concentrations.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP): A federal regulation that outlines the procedures that must be followed under the Superfund Program. The NCP was most recently revised in 1990.

National Priorities List (NPL): USEPA's list of the most serious uncontrolled or abandoned waste sites identified for possible long-term remedial response actions.

Non-carcinogenic: The term used to describe chemicals or substances that are not known or suspected to cause cancer in humans. This term generally refers to chemicals that may not cause cancer, but potentially produce other unwanted health effects.

No-Observed-Effect Level (NOEL): The concentration of a constituent of concern that results in no observable effect on an ecological system.

Organic Constituents: Chemical compounds composed primarily of carbon, including materials such as solvents, oils, and pesticides.

Polychlorinated Biphenyls (PCBs): A group of organic compounds related by their basic chemical structure. They are highly resistant to degradation, but have a tendency to be retained in body tissue. Due to their efficient electrical conductivity properties, they were widely used in capacitors, transformers, and other products in the U.S. before 1980.

Practical Quantitation Limits (PQLs): A value equal to 10 times the detection limit that reflects the value above which a chemical can be quantified with acceptable confidence.

Preferred Alternative: The remedial alternative initially proposed for implementation as a result of the screening process conducted during the FS.

Present Worth Cost: An economic term used to describe today's cost for a Superfund cleanup and reflect the discounted value of future costs. A present value cost estimate includes construction and future operation and maintenance costs.

Receptor: A human, animal, or plant that could potentially receive exposure to chemicals migrating from or present at hazardous waste sites.

Record of Decision (ROD): A legal document that describes in detail the remedy selected for an entire NPL site or a particular operable unit. The DD summarizes the results of the RI/FS and includes a formal response to comments supplied by the public.

Reference Dose (RfD): The daily acceptable level of constituents of concern intake. This number is used to estimate potential for non-carcinogenic effects.

Remediation Goals: Remedial action objectives and remediation goals are the target cleanup levels for chemicals at a contaminated site.

Remedial Investigation (RI): A study that supports the selection of a remedial action at a Superfund site. The RI identifies the nature, magnitude and extent of contamination associated with a Superfund site.

Resource Conservation and Recovery Act of 1976 (RCRA): The federal law that establishes a regulatory system that governs procedures to be used in generating, storing, transporting, treating, and disposing of hazardous waste.

Responsiveness Summary: Comments presented during the public meeting and received during the public comment period that are considered and addressed by the lead agency.

Risk Assessment (RA): The process whereby risks to human health and the environment are quantitatively evaluated. This information is used to determine whether remedial actions are necessary. The BRA is conducted during the Remedial Investigation/Feasibility Study.

Risk Assessment Guidance for Superfund (RAGS): A document produced by the USEPA as a guide for conducting risk assessments under Superfund.

Sediment: Soil and other material that settles to the bottom of a stream, creek, or lake.

Semi-Volatile Organic Compounds (VOCs): Semi-VOCs are organic chemicals that vaporize less readily than VOCs. These compounds include many polynuclear aromatic hydrocarbons and pesticides.

Slope Factor (SF): A number used to estimate the probability of potential carcinogenic effects.

Superfund Amendments and Reauthorization Act of 1986 (SARA): This act modified specific provisions in CERCLA.

Surface Water: Water on the earth's surface such as streams, ponds, and lakes.

To Be Considered (TBC) Value - State advisories, guidance, non-binding guidelines, or other standards that are not legally binding that may be considered when fashioning a protective remedy for a site.

Toxicity Characteristic Leaching Procedure (TCLP): USEPA approved laboratory procedure used to determine if a waste material is characteristically hazardous.

Toxicity Value: Used to indicate the level of toxicity of the constituents of concern at the site.

Uncertainty Factor: A measure of the uncertainty inherent in assumptions made in risk assessments.

Volatile Organic Compounds (VOCs): Organic liquids that readily evaporate under atmospheric conditions and exhibit varying degrees of solubility in water. Examples of VOCs include benzene and xylenes.

Appendix C
Site 20 Decision Document

11/1/96-01161

FINAL

DECISION DOCUMENT

BUILDING LP-20 SITE
NAVAL BASE NORFOLK, VIRGINIA

CONTRACT TASK ORDER 0269

NOVEMBER 1, 1996

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
ATEC	ATEC Environmental Consultants, Inc.
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Contaminant of Potential Concern
cu. yd.	cubic yard
DD	Decision Document
DCE	Dichloroethene
DoN	Department of the Navy
ESE	Environmental Science and Engineering
FS	Feasibility Study
FWE	Foster Wheeler Enviresponse, Inc.
GAC	Granular Activated Carbon
gpm	Gallons Per Minute
HI	Hazard Index
HLA	Harding Lawson Associates
ILCR	Incremental Lifetime Cancer Risk
IRP	Installation Restoration Program
IWS	Industrial Waste Sewer
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
MCLs	Maximum Contaminant Levels
mg/kg	milligram per kilogram
mg/L	milligram per liter
NADEP	Naval Aviation Depot
NAS	Naval Air Station
NCP	National Contingency Plan
NPW	Net Present Worth
O&G	O'Brien & Gere
O&M	Operation and Maintenance
ppb	part per billion
PRAP	Proposed Remedial Action Plan

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

RA	Risk Assessment
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RBCs	Risk Based Concentrations
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SVE	Soil Vapor Extraction
SVOCs	Semivolatile Organic Compounds
TBC	To Be Considered
TCE	Trichloroethene
TPH	Total Petroleum Hydrocarbon
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VADEQ	Virginia Department of Environmental Quality
VOCs	Volatile Organic Compounds
μg/l	micrograms per liter

DECLARATION

Site Name and Location

Building LP-20 Site
Naval Aviation Depot
Naval Base Norfolk
Norfolk, Virginia

Statement of Basis and Purpose

This Decision Document (DD) presents the selected remedial actions for the Building LP-20 site at Naval Base Norfolk in Norfolk, Virginia. The selected remedial actions were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and to the extent practicable, the National Contingency Plan (NCP).

The Department of the Navy (DoN) has obtained concurrence from the Commonwealth of Virginia and the United States Environmental Protection Agency (USEPA) Region III on the selected remedies.

Assessment of the Site

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response actions selected in this DD, may present a current or potential threat to public health, welfare, or the environment.

Description of the Selected Remedy

The proposed response actions (or preferred alternatives) identified herein address contaminated groundwater at the site and comprise the overall cleanup strategy for the site. The preferred alternatives address contaminated groundwater in the shallow aquifer and contaminated groundwater in the underlying Yorktown Aquifer.

Contaminated groundwater in the shallow (i.e., water table) aquifer poses a current risk to construction workers and a potential risk to environmental receptors in Willoughby Bay. Although groundwater at the site is not currently used for any purpose, contaminated groundwater from both the water table and the Yorktown Aquifers pose a risk to future receptors that may use the groundwater under a non-potable or industrial use scenario.

The response actions for this site address the principal threat posed by contaminated groundwater in the shallow and deep aquifers. The selected remediation alternative includes the treatment of groundwater, institutional controls, and monitoring. The major components of the preferred alternatives for the water table and Yorktown Aquifers are briefly listed below. For a more detailed description and analysis of remedial alternatives, the reader is referred to Sections 7.0 and 8.0 of this document, and to the Building LP-20 site Final Feasibility Study (Baker, September 1996).

Water Table Aquifer

- Institutional Controls

    - Aquifer use restrictions.
    - Installation of one additional monitoring well.
    - Monitoring of nine monitoring wells on a semi-annual frequency.

- Air Sparging and Soil Vapor Extraction
    - Installation of air injection wells (31 estimated).
    - Installation of vapor extraction wells (21 estimated).
    - Vapors will be treated at an on-site treatment facility constructed specifically for the remediation alternative.

Yorktown Aquifer

- Institutional Controls
    - Aquifer use restrictions.
    - Monitoring of six monitoring wells on a semi-annual frequency.

This combination of response actions is expected to significantly reduce potential human health and environmental risks associated with the site by providing effective reduction of contaminants and substantially reducing the potential for migration of contamination.

Statutory Determinations

This remedial action is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedial action utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. Because this remedy will result in hazardous substances remaining on site (in the Yorktown Aquifer) above health-based levels, a review will be conducted within five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

R. T. Brewer (signature) — 11-19-96

Signature (Commander, Naval Base Norfolk) — Date

1.0 LOCATION AND DESCRIPTION

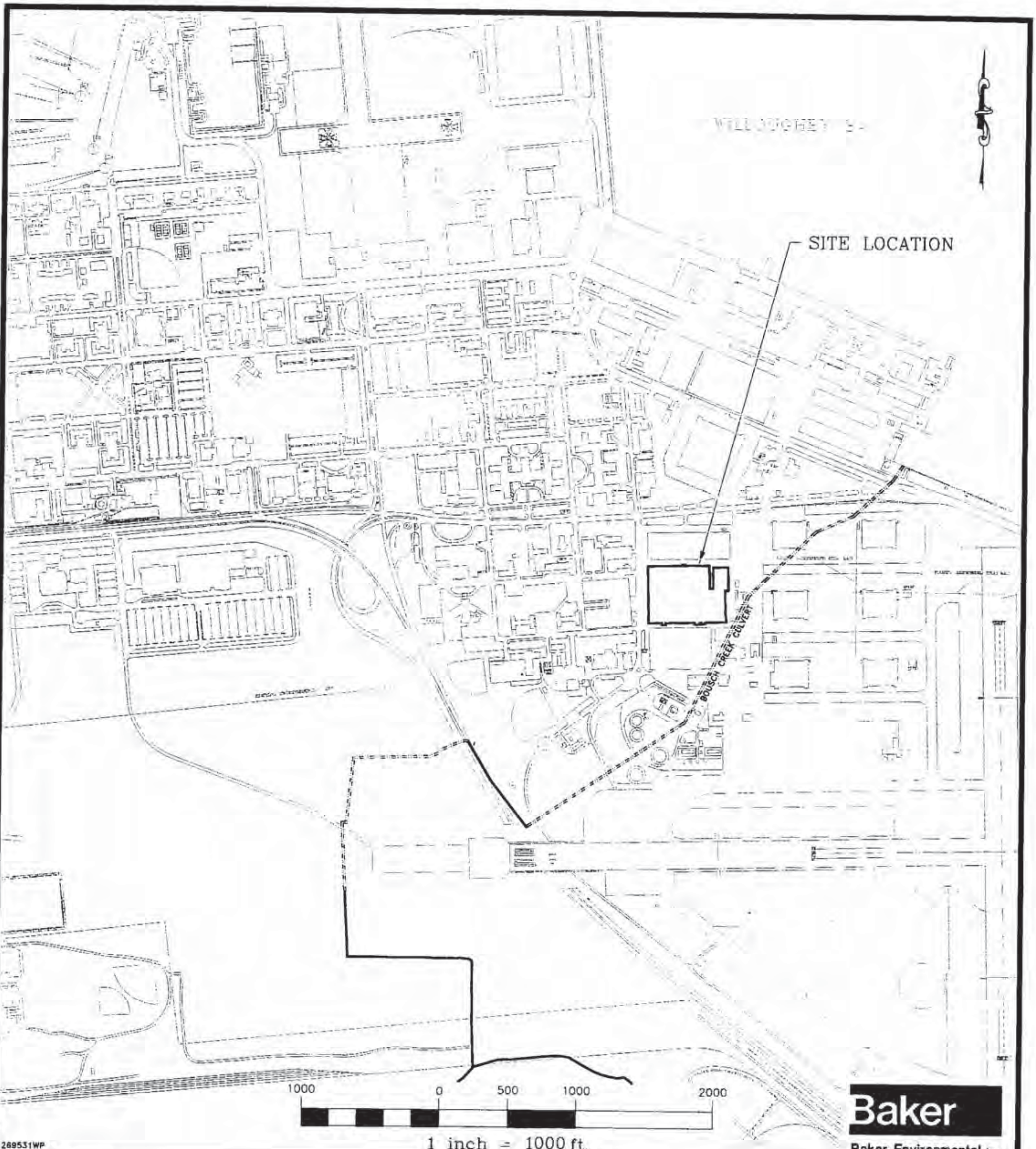
The Building LP-20 site is located within the Naval Aviation Depot (NADEP) area of the Naval Base Norfolk. As shown in Figure 1-1, the site is located approximately 1,400 feet southwest of where Bousch Creek discharges into Willoughby Bay.

The mission of NADEP is to perform maintenance and repair activities for military aircraft. To support these activities, services provided by NADEP include engine repair, fuselage overhauling, storage and distribution of aircraft fuels, and the disposal/treatment of industrial wastes

In general, the NADEP area is highly developed and industrialized. The entire area is relatively flat and paved with either asphalt or concrete. The only vegetation present in the area is in the landscaped zones located along roadways or parking areas.

The LP-20 site actually includes Building LP-20 and the surrounding area. Other buildings located within the site area include Buildings LP-22, LP-24, LP-26, LP-78, LP-176, V-147 and other smaller buildings in the area. Several of these buildings have a history of utilizing, or are currently using, petroleum or chemical products. The locations of these buildings are provided in Figure 1-2.

SECTION 1.0 FIGURES



LEGEND

CULVERT BELOW GRADE

SURFACE DRAINAGE CHANNEL

FIGURE 1-1
SITE LOCATION MAP
BUILDING LP-20 SITE

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

SOURCE: INITIAL ASSESSMENT STUDY, DEC. 1994

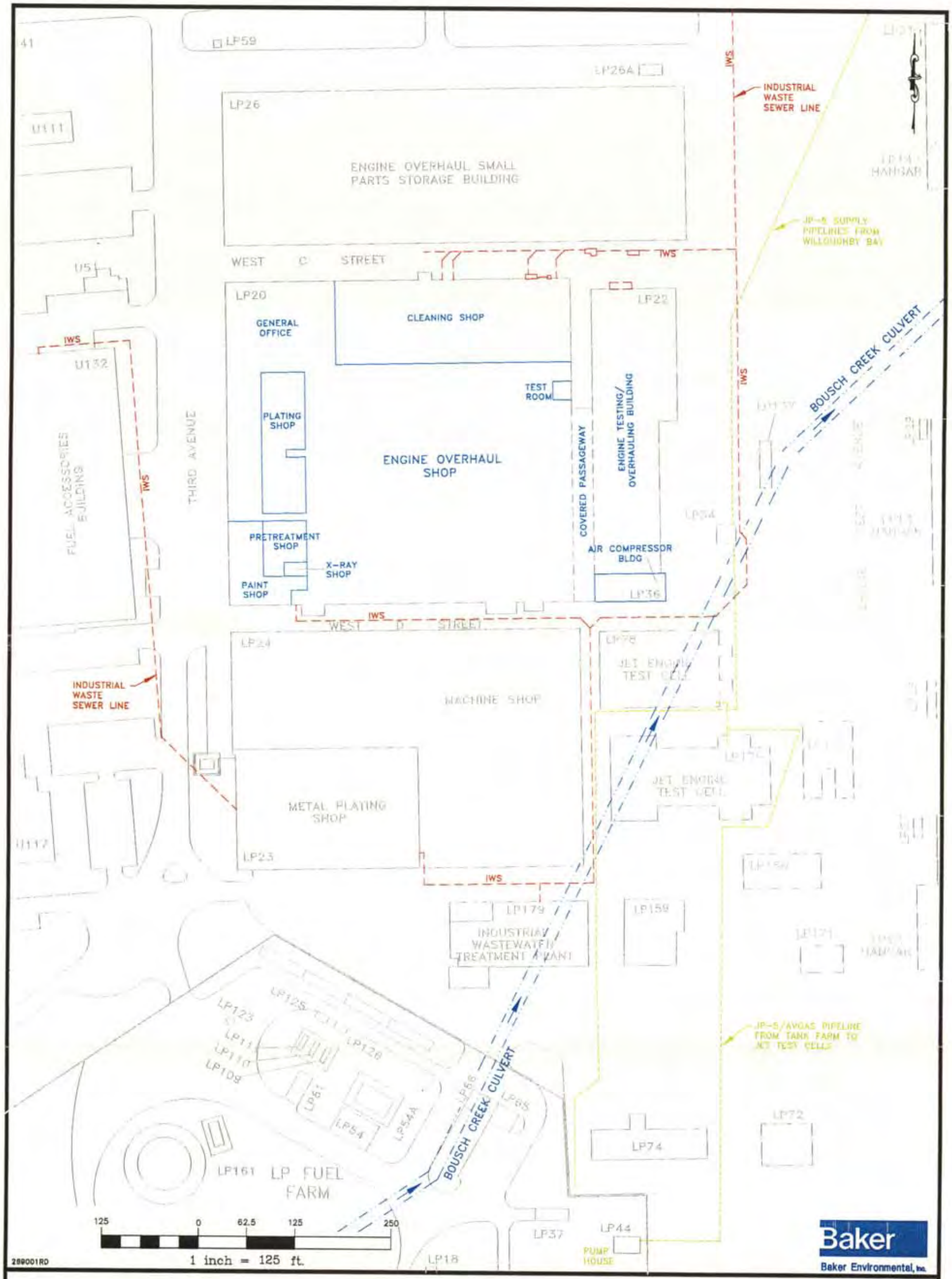


FIGURE 1-2
SITE PLAN
BUILDING LP-20 SITE

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

SOURCE: LANTDIV, FEB. 1992

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2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

This section of the DD provides background information of the history of the Building LP-20 site and enforcement actions taken to date. Specifically, the land use history of the site and the previous investigations which have been conducted are briefly discussed below.

2.1 Site History

Building LP-20 was constructed in the early 1940s. Prior to the development of this area in the 1930's, the portion of the NADEP area in the vicinity of Building LP-20 was a marshlands associated with Bousch Creek. As this portion of the Base was developed, Bousch Creek was entirely encased in a subsurface culvert from the area south of the Naval Air Station (NAS) to Willoughby Bay. The surrounding areas were filled with soils and brought to their present elevations. The present location of the Bousch Creek culvert in the immediate vicinity of Building LP-20 is shown in Figure 1-2.

NAS drawings from 1942 indicate that Building LP-20 was originally constructed at half of the present day size shown in Figure 1-2. The north-south length of the building was approximately 250 feet instead of the 390 feet today. It is believed that the building was expanded in the late 1940's when construction activities were completed on other NADEP buildings.

Building LP-20 is used for the reconditioning, repair, and testing of turbine engines. Several of the shop operations currently performed within the building, which utilize chemical compounds, include the pretreatment shop, paint shop, x-ray shop, and the cleaning and blasting shop. A metal plating shop formerly was operated within the building until 1987.

Over the years, numerous spills or releases of wastewater, petroleum products, and other chemicals in the area have been documented. These incidents have resulted in chemical releases ranging from less than five gallons of chromic acid to approximately 4,600 gallons of industrial wastewater.

Petroleum releases of over 100,000 gallons have also occurred in the area. The petroleum release is associated with a pipeline that extends from the LP Fuel Farm to Buildings LP-78 and LP-176. The locations of the pipeline and fuel farm are shown in Figure 1-2.

2.2 Previous Investigations

Due to the amount of petroleum and chemical usage and storage in the area, several releases have occurred which have required investigations. The investigations that have been performed for both the Underground Storage Tank (UST) Program and the Installation Restoration Program (IRP) are discussed in the following sections.

2.2.1 UST Program Investigation Activities

The majority of the previous investigations performed in the area have been primarily directed at characterizing petroleum contamination suspected of originating from both the LP Fuel Farm and USTs in the vicinity. The known petroleum investigations that have been performed to date in this area include:

- Harding Lawson Associates (HLA): "Leak Characterization Study, Naval Air Station, Norfolk, Virginia"; 1986. HLA performed the first environmental assessment in this portion of the NADEP area in September 1986. The investigation was intended to evaluate the 1984 petroleum release from the LP Fuel Farm pipeline. The HLA investigation indicated that a significant area, east of Buildings LP-78 and LP-176 had been impacted by JP-5 contamination (18 of the 23 monitoring wells installed had measurable free product ranging in thickness from 0.07 feet to 4.65 feet). The investigation did not, however, delineate the extent of groundwater contamination.

- O'Brien and Gere (O&G): "Contaminated Ground Water Study NAS Bousch Creek Area": O&G installed monitoring wells in the areas north of the LP Fuel Farm and the parking lot located east of Building LP-22 in June 1988 to further define the extent of free product associated with the LP Fuel Farm pipeline release. Two areas of free product, west of Building LP-12 and north of Building LP-177, were defined.

  O&G installed additional monitoring wells to further evaluate petroleum (free product) contamination at the LP Fuel Farm in February 1989. These shallow monitoring wells were primarily located south of the Building LP-20 site in the vicinity of the LP Fuel Farm.

- O&G; "Corrective Action Plan - Contaminated Groundwater Study, Building U-132 Site": In April 1990, an estimated 500 to 750 gallons of calibration fluid was released at Building U-132 when an UST overflowed. Later in 1990, during an UST replacement, a petroleum substance was detected within the tank excavations. Petroleum fluid was also detected on the south side of Building U-132 during a road construction project. In response, O&G performed a site characterization in the vicinity of Building U-132. Two wells installed during this investigation were located west of Building LP-20. These wells were detected to have trichloroethene (TCE) concentrations of 19,000 parts per billion (ppb) and 54,000 ppb, respectively.

- ATEC Environmental Consultants, Inc. (ATEC); "Site Check Investigation Report - Sewells Point Complex, Building LP-22 Underground Storage Tank": ATEC completed a site check of the two USTs located within Building LP-22. Total petroleum hydrocarbon (TPH) concentrations above the Commonwealth of Virginia groundwater standard of 1.0 milligram per liter (mg/L) and soil "action level" of 100 milligrams per kilogram (mg/kg) were detected.

- Foster Wheeler Enviresponse, Inc. (FWE); "Site Characterization Report for the Former UST System, Building LP-22": In October and November 1991, FWE completed a site characterization for three removed USTs east of Building LP-22. Five soil samples had TPH concentrations that exceeded the Virginia "action level" of 100 mg/kg. Volatile organic compounds (VOCs) were also detected in the groundwater samples.

- Environmental Science and Engineering (ESE); "Final Site Characterization/ Environmental Assessment Report, Building LP-179": On January 25, 1991, the underground industrial waste sewer (IWS) line from Building LP-23 to LP-179 was damaged during excavation activities. Approximately 160 gallons of chromic acid were released into the soil. On July 24, 1991, a cyanide IWS line was damaged by excavation activities in the same area as the earlier chromic acid release. In response, Base personnel excavated contaminated subsurface soils. Approximately 100 drums and 20 cubic yards (cu. yd.) of soil were removed by these activities.

ESE subsequently performed a site characterization and environmental assessment of the area and submitted the final report in November 1992. The only soil contaminant at this site that was found to exceed Federal guidelines for corrective action on a site-wide basis was beryllium. The investigation also indicated that groundwater was impacted by iron and manganese, but that their concentrations may be typical of the indigenous shallow groundwater quality in the area and unrelated to the spills.

- Baker Environmental, Inc. (Baker): "Site Characterization Report, UST System U-117-1, Building U-117": In September 1991, Baker completed a site characterization of a 2,500 diesel UST at Building U-117, southwest of Building LP-20. The amount of soil and groundwater contamination detected at the site was limited to the immediate vicinity of the UST.

- ESE: "Draft Monitor Well Sampling Report, Bousch Creek Culvert": ESE performed additional groundwater sampling of the existing monitoring wells located in the vicinity of Building LP-20 (29 wells) and the LP Fuel Farm (20 wells) in March and April, 1994. At this time, this field program provided the most extensive analytical data available for this area. The analyses indicated that groundwater contaminants were concentrated in the central portion of the Bousch Creek culvert area. Another isolated area of contamination also existed further north. ESE concluded that groundwater was impacted by several different sources within the Bousch Creek culvert area. These sources were former USTs located in the area and the JP-5 pipeline. The LP Fuel Farm was not indicated as a contaminant source.

More detailed discussions of the UST investigations and findings for the Building LP-20 area are provided in the Final RI Report (Baker, 1996).

2.2.2 Installation Restoration Program Investigations

Two investigations have been performed under the IRP. Both of these investigations focussed on the release of hazardous materials in the vicinity of Building LP-20. These investigations are briefly described below:

- ESE; "Draft Interim Remedial Investigation Report LP-20 Aircraft Engine Maintenance Facility NAS": ESE installed six shallow monitoring wells during February and March 1991 as part of an interim remedial investigation (RI) for Building LP-20. Based on the results of the field activities and analytical data, three potential sources of TCE contamination in the groundwater were identified including: 1) north of Building LP-20; 2) south of Building LP-20; and, 3) in the vicinity of Building LP-48 (located east of Building LP-22). The investigation also suggested that groundwater beneath the site had been impacted by metals (chromium, lead, and zinc).

- Baker; Remedial Investigation - Building LP-20 Site: A RI was performed to further assess the nature and extent of VOC contamination associated with Building LP-20. This investigation evaluated soil and groundwater conditions in both the shallow water table aquifer and the underlying Yorktown Aquifer. The field activities for this investigation were performed between December 1994 and October 1995.

  In summary, VOCs, semivolatile organic compounds (SVOCs), and metals were confirmed in soils (surface and subsurface) and groundwater (water table and Yorktown Aquifers) in the Building LP-20 area. A number of contaminants in both aquifers exceeded applicable Federal and/or State standards and guidelines. This contamination was attributed to several sources:

  - Past storage and distribution systems for a variety of petroleum products, such as gasoline, waste oils, and aviation fuels (JP-5), are known to have leaked at various locations.

- Past storage and disposal areas for chemical solvents used in cleaning, painting, and metal plating operations performed in the Building LP-20 area where poor storage and handling practices or accidents resulted in leaks or spills.

- Accidental releases of waste fluids via breaks in the IWS caused during construction activities in the area.

The results of the RI are discussed in further detail in Section 5.0. Complete details of the IRP investigations are provided in the Final RI Report (Baker, 1996).

2.3 Enforcement Activities

The following sections describe the history of remediation efforts performed in the vicinity of Building LP-20.

2.3.1 UST Program Removal and Remedial Actions

The UST Program has performed petroleum recovery efforts to remediate aviation fuel released in the NADEP area. Prior to 1986, it was estimated that over one hundred thousand gallons of fuel was released from the pipeline located between the jet engine test cells in Buildings LP-78 and LP-176 and the LP Fuel Farm located south of Building LP-24. As a result, two groundwater recovery/treatment systems were installed in the areas south and southeast of Building LP-22.

The two product recovery systems were constructed between 1986 and 1989. Both systems utilized four recovery wells with various types of pneumatic pumping systems. Fluids collected by the systems passed to an oil/water separator before being discharged to a subsurface drain which was connected to the Bousch Creek culvert.

Activity personnel indicate that neither recovery system performed as anticipated. The systems were seldom in operation due to various mechanical problems; operations were terminated in December 1994. Both recovery systems were dismantled during the Spring of 1996.

The UST Program has other petroleum remediation efforts scheduled for the NADEP area. Two well clusters consisting of three recovery wells each have been installed in the area near the jet engine testing area (Buildings LP-78 and LP-176). A mobile recovery system utilizing groundwater depression and product recovery pumps will alternate every six months between the well clusters. Recovered fluids will pass through an oil/water separator prior to eventually discharging to the Bousch Creek culvert. Although the mobile recovery system has been constructed, it is not yet operational due to concerns by the Virginia Department of Environmental Quality (VADEQ) associated with the discharge permit. It is anticipated that the mobile system will be in operation by the Spring of 1997.

A final remediation effort planned by the UST Program involves four to five wells installed in the area east of Building LP-22. Two solar powered product skimming pumps are alternated between the wells. Product is temporarily stored on-site until the fluids are transported to a recycling facility.

2.3.2 Accidental Releases and Spill Response Measures

Over the years there have been numerous documented releases of industrial wastewater and other chemicals at Building LP-20 and other buildings in the area. The dates, volumes, and response measures which have occurred at Building LP-20, LP-22, and LP-24 are provided in Tables 2-1, 2-2, and 2-3, respectively.

2.3.3 Installation Restoration Program Remedial Actions

To date, no remediation activities have been performed under the IRP.

SECTION 2.0 TABLES

TABLE 2-1

SUMMARY OF RELEASES AT BUILDING LP-20
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Date of Release	Material Released	Estimated Volume of Release (gallons)	Additional Comments
December 1985	Wastewater	Not Specified	Pipe between Bldgs. LP-20 and LP-24 was damaged by a backhoe. Fluid filled the trench to a depth of four feet. The fluid was pumped to the IWTP. No soil removal or other types of remediation was performed.
May 1986	Industrial Wastewater	4600	Pump failure caused release of industrial wastewater in the alley between Bldgs. LP-20 and LP-26.
August 1986	Chromic Acid	2-3	Spill occurred on western loading dock of Bldg. LP-20. Spill was immediately contained and removed, however an undetermined volume of fluid reached the storm sewer system.
August 1986	Industrial Wastewater	50	Wastewater was released onto the machine shop and plating shop floor. Spill was contained and remediated without contact to the environment.
November 1990	Hydraulic Fluid	5-10	Hydraulic line on fork-lift broke and released fluid. No documentation of cleanup or impact to the environment.
February 1991	Industrial Wastewater	40	Seal failed on IWS piping system. No other information available.
March 1991	Industrial Wastewater	100	Both pumps failed at the industrial waste pump station. The failure resulted in the station overflowing. No other information concerning environmental impact or remediation is available.
March 1991	Industrial Wastewater	100	Occurred in LP-20 area. No other information available.
March 1991	Industrial Wastewater	50	Occurred between Bldgs. LP-20 and LP-26. No other information available.
May 1991	Industrial Wastewater	10-50	Spill caused by short in pump motor. Reportedly 10-50 gallons of spill entered storm sewer system.
July 1991	Industrial Wastewater	500	Occurred in LP-20 area. No other information available.

Note: IWS - Industrial Waste Sewer
Source: ICF Kaiser, NADEP Environmental Baseline Survey, 1994.

TABLE 2-1 (Continued)

SUMMARY OF RELEASES AT BUILDING LP-20
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Date of Release	Material Released	Estimated Volume of Release (gallons)	Additional Comments
December 1991	Industrial Wastewater	2000	Four separate releases totaling over 2,000 gallons, resulted when the IWS lines were damaged during construction activities. The bulk of the fluid was pumped out of the excavation. The remainder entered the soils. No indication that additional remediation activities were performed.
March 1992	Industrial Wastewater	2000	Pumps in the lift station located on the northern side of Building LP-20 failed. Some of the released fluid reached the storm sewer system.
June 1992	Industrial Wastewater	35	Release occurred in alley between Bldgs. LP-20 and LP-22. Spill was remediated by a NADEP hazardous waste crew.
May 1993	Industrial Wastewater	200	Spill occurred on the northern side of Bldg. LP-20. Reportedly 20 gallons of fluid entered the stormwater sewer.
January 1994	Industrial Wastewater	200	Release occurred from an aboveground section of the IWS. Spill logs also indicate small-quantity spills of solvents, oils, and process solutions onto the building floor were cleaned by a NADEP hazardous waste crew.

Note: IWS - Industrial Waste Sewer
Source: ICF Kaiser, NADEP Environmental Baseline Survey, 1994.

TABLE 2-2

SUMMARY OF RELEASES AT BUILDING LP-22
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Date of Release	Material Released	Estimated Volume of Release (gallons)	Additional Comments
July 1985	Mercury	Unknown	Mercury gauges were broken during demolition of the control room for Test Cells 7 and 8. The bulk of the spill was remediated and procedures were initiated to clean the residual mercury.
February 1987	Mercury	Unknown	Mercury spill reported. No other information available.
March 1987	Mercury	Unknown	Mercury spill reported. No other information available.
1989	JP-5	900	Elbow in fuel filter line ruptured. No other information available.
1990	Ethylene Glycol	670	Release occurs from an anti-freeze tank. The spill reportedly reached a storm drain.
March 1991	JP-5	5200	Release occurred due to the rupture of a fitting on a filter casing for the fuel supply line. Release apparently entered the Bousch Creek culvert, but was contained by the floating boom at Outfall 80.
1994	Ethylene Glycol	Unknown	The removal of a pipe from the heat exchanger located on the roof of Building LP-20, resulted in the release of an anti-freeze/water solution. The release covered approximately 100 square feet of the roof. An unknown volume of the solution reaches the roof drain which empties to Willoughby Bay.

Source: ICF Kaiser, NADEP Environmental Baseline Survey, 1994.

TABLE 2-3

SUMMARY OF RELEASES AT BUILDING LP-24
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Date of Release	Material Released	Estimated Volume of Release (gallons)	Additional Comments
January 1991	Chromic Acid	160	The IWS line broke during the pumping of a chromic acid solution. The fluid contaminated soils in the area. Soil remediation involved the removal of 100 drums of soil and 20 cubic yards of concrete.
July 1991	Cyanide Liquid	Unknown	The cyanide fluid was sighted flowing out of an expansion joint on the south side of the building. A portion of this fluid entered the excavation made by January 1991 chromic acid spill. The cause of the release was from the new cyanide line from Bldg. LP-24 connected to an old cyanide line from Building LP-20. The old line had shifted and broke causing the Building LP-24 waste to backflow and enter the soil.
August 1991	Industrial Rinse Water	2	Operator error resulted in an overflow of a pump station. The release was cleaned by waste handlers.
December 1992	Industrial Wastewater	Unknown	The IWS line beneath the southern side of Building LP-24 broke. An unknown amount of fluid entered the storm sewer line. The soils removed during excavation activities were determined to be non-hazardous and were placed back into the excavation.
March 1994	Acid	8	The drum was found to be leaking in an outside storage area. The spill was cleaned without impact to the environment.

Note: IWS - Industrial Waste Sewer
Source: ICF Kaiser, NADEP Environmental Baseline Survey, 1994.

3.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The Final Remedial Investigation/Feasibility Study (RI/FS) (Baker, September 1996), as well as the Final Proposed Remedial Action Plan (PRAP) (Baker, November 1996) for the Building LP-20 site have been released and made available to the public in the Administrative Record at the Kirn Memorial Branch of the Norfolk Public Library in Norfolk, Virginia and at information repositories maintained at the Larchmont and Mary Pretlow Branches of the Norfolk Public Library and the Naval Station Library (Building C-9).

The notice of availability of the aforementioned documents was published in the Virginian-Pilot and Ledger Star on September 26, 1996. A public comment period was scheduled from September 26, 1996 to October 25, 1996. In addition, a Restoration Advisory Board (RAB) meeting, in which the public was invited to attend, was held in Norfolk, Virginia on October 24, 1996. At this meeting, representatives from the DoN discussed the remedial action alternatives currently under consideration and addressed community concerns. Response to comments received during the public comment period and additional background information on community involvement for this project are presented in Section 11.0 of this document.

This DD presents the selected response actions for the Building LP-20 site at Naval Base Norfolk in Norfolk, Virginia, which were chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the NCP. The selected decision for the Building LP-20 site is based on the Administrative Record.

4.0 SCOPE AND ROLE OF THE RESPONSE ACTION

The proposed response actions identified in this DD address contaminated groundwater in the shallow aquifer and the Yorktown Aquifer beneath the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the proposed response actions include contaminated groundwater in the water table aquifer and the Yorktown Aquifer. The recommended response actions (or preferred alternatives) for the various media and the rationale for their selection are described in Sections 7.0 through 9.0.

The principal threat posed by conditions at the Building LP-20 site is that contaminated groundwater in the shallow aquifer may pose a risk to human and ecological receptors. In addition, this shallow groundwater contamination provides a continuing source of contamination which threatens the underlying Yorktown Aquifer. The combination of proposed response actions is expected to address the principal threat posed by the site by providing effective control of the contaminant migration and substantially reducing the contaminant concentrations.

The goals of the selected remedy are to: (1) prevent current or future exposure to the contaminated groundwater and (2) prevent further migration of contaminated groundwater and to remediate groundwater contamination for future potential beneficial uses of the aquifers.

The selected remedial action authorized by this DD addresses contaminated groundwater (shallow and deep) originating from the site through treatment and through institutional controls to restrict groundwater use on site. Groundwater currently is not used for any purpose at the site; however, the groundwater poses a potential threat to human health and the environment because of the risks of possible human receptor pathways and potential off-site migration.

The selected remedial action is expected to comply with applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC) requirements, which are federal and state environmental statutes that are either directly applicable or are considered in the development and evaluation of remedial alternatives at a particular site. Summaries of ARARs and TBCs for the Building LP-20 site are provided in Section 10.0.

The proposed response actions identified in this DD address only the contaminated shallow and deep aquifers beneath the site but do not address contaminated soils. The scope of this DD is limited to groundwater remediation only, as explained below:

- The unacceptable risk to the construction worker is the result of dermal contact to metals and SVOCs. The slight risk levels at which construction workers may be exposed can be eliminated by implementing health and safety procedures.

- Since the entire area is covered by buildings or pavement, any contaminated soils in the unsaturated zone are, in effect, "capped", by low-permeability materials that minimize rainwater infiltration and subsequent leaching of contaminants.

- Available data do not indicate a major, discrete source area that would lend itself to remediation. Since the water table is high (5 to 6 feet below the ground surface), any residual soil contamination in the vadose zone would be limited.

Results of the RI determined the presence of free product in areas east of Building LP-22. However, the remediation of the free product is to be performed by the Naval Facilities Engineering Command, Atlantic Division (LANTDIV) UST Department and is not intended to be addressed by this DD.

5.0 SUMMARY OF SITE CHARACTERISTICS

As stated earlier, VOCs, SVOCs, and metals were detected in both the soils (surface and subsurface) and groundwater (shallow and deep) in the vicinity of Building LP-20. The following sections present a brief overview of the nature and extent of contamination at the Building LP-20 site with respect to known sources of contamination, types of contamination, and affected media.

5.1 Extent of Contamination

Data generated during the RI indicate that VOCs are the primary contaminants detected in the area. Two types of VOC contaminants were detected in the Building LP-20 area: chlorinated solvents occur in the vicinity of Buildings LP-20 and LP-26, and petroleum products occur east of Building LP-22 and south of Building LP-179.

5.2 Surface and Subsurface Soils

VOCs, SVOCs, and metals detected in the surface and subsurface soils collected during the RI indicate the soils have been impacted by organic and inorganic contaminants. However, all VOCs in shallow and deep soils were below risk based concentrations (RBCs). SVOCs primarily were present in shallow and deep samples obtained near Building V-147 and may not be related to past activities at the LP-20 site. Arsenic, beryllium, and iron exceeded RBCs in the shallow soils with arsenic and beryllium exceeding RBCs in the deep soils.

5.3 Shallow Aquifer

The shallow groundwater in the vicinity of Building LP-20 has been impacted by past activities performed in the area. The primary VOCs found in the vicinity of Buildings LP-20 and LP-26 and their maximum concentrations are shown below:

- Vinyl chloride - 15,000 micrograms per liter (μg/L)
- 1,2-Dichloroethene (DCE) (total) - 28,000 μg/L
- TCE - 23,000 μg/L

In the area near Buildings LP-13 and LP-14, the primary VOCs detected include:

- Benzene - 860 µg/L
- Vinyl chloride - 3,700 µg/L
- 1,2-DCE (total) - 15,000 µg/L
- TCE - 2,700 µg/L

In general, VOCs were present in shallow groundwater across the site in concentrations well above the Federal Maximum Contaminant Levels (MCLs) for drinking water. However, the shallow aquifer is not suitable for drinking water purposes. The organic compounds (VOCs and SVOCs) detected in the shallow aquifer are shown in Figure 5-1.

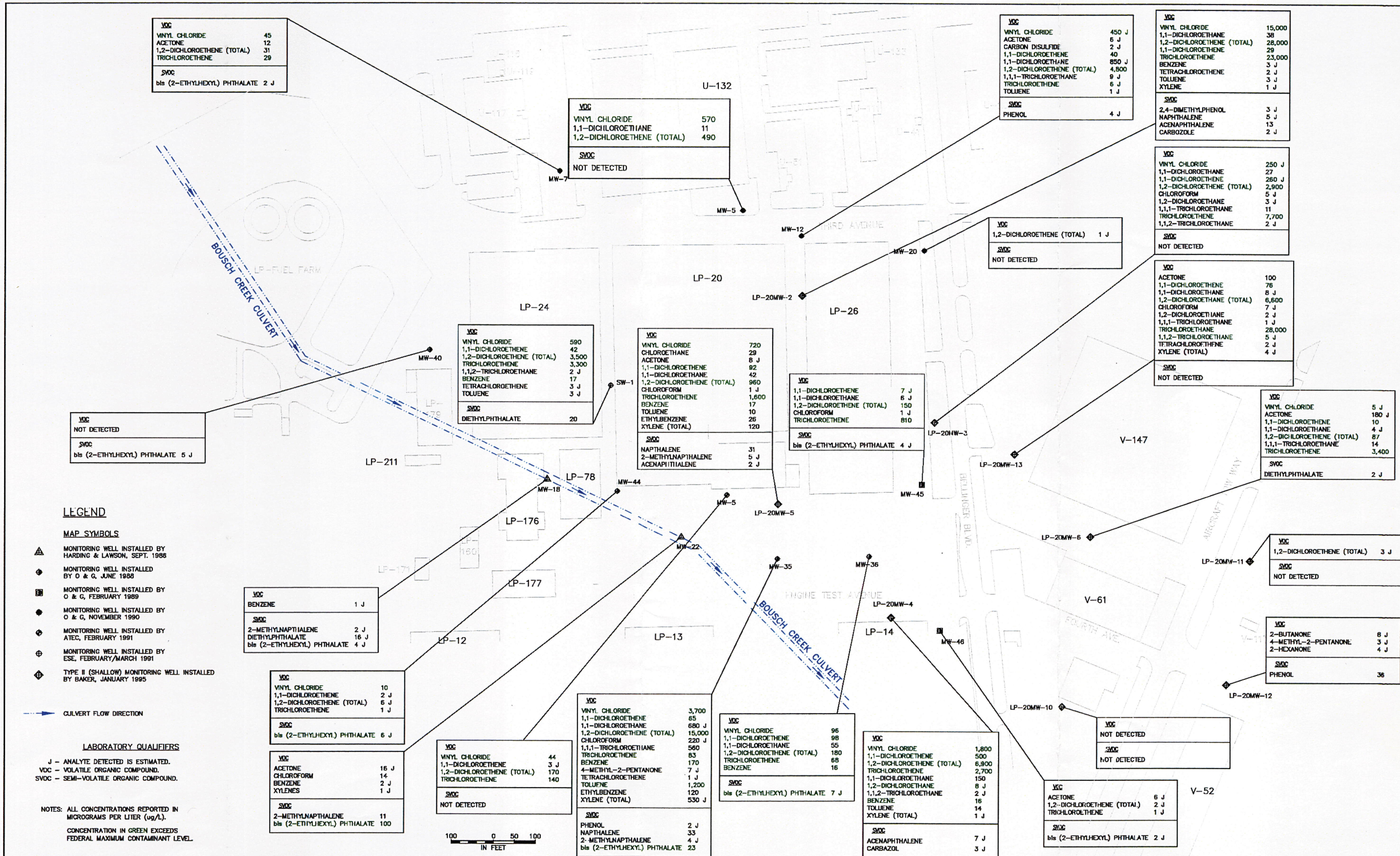
5.4 Yorktown Aquifer

Although the level of contamination is significantly lower than detected in the shallow water table aquifer, it appears that the Yorktown Aquifer has been impacted by VOC and SVOC contaminants. The primary VOCs detected include:

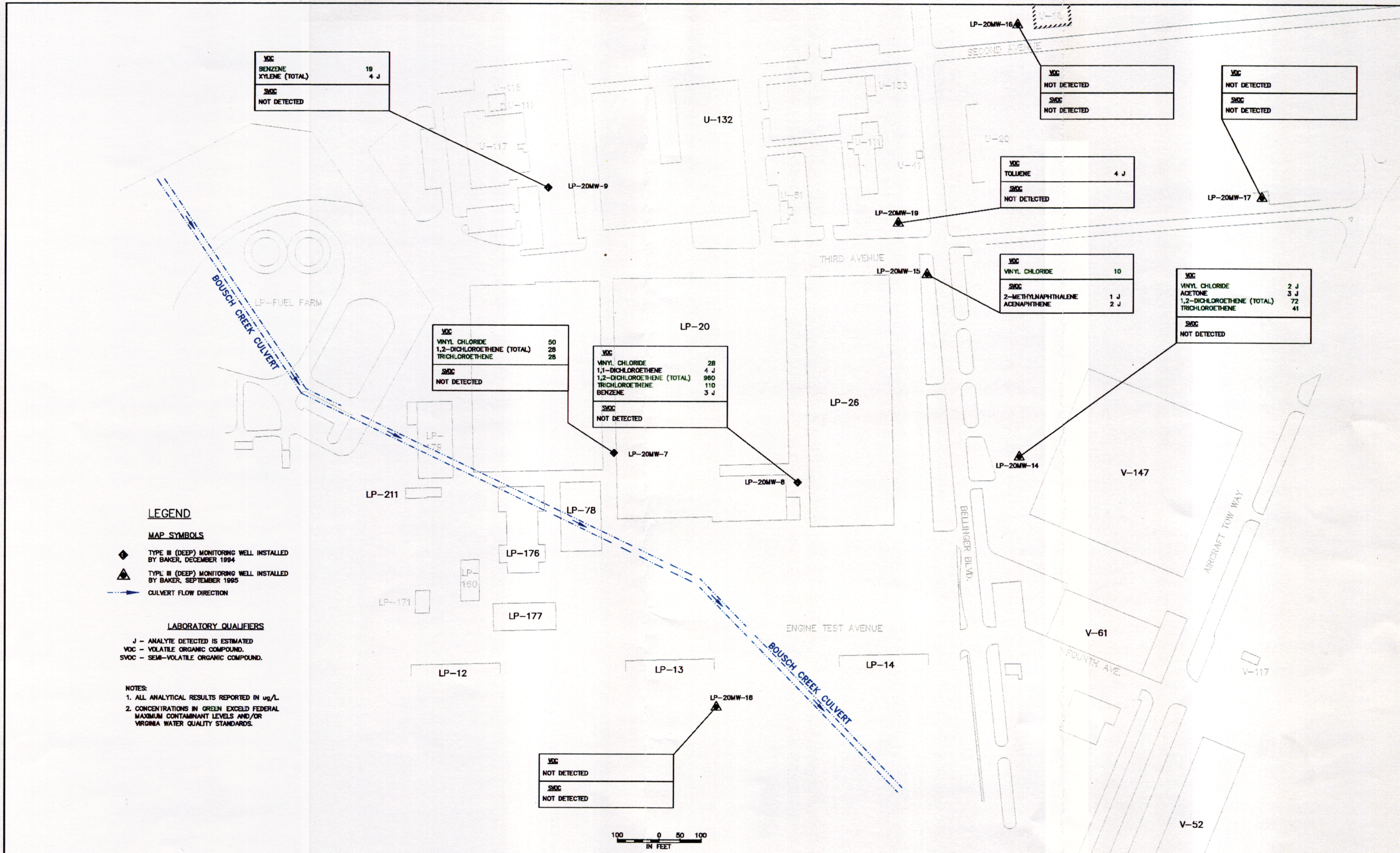
- Vinyl chloride - 50 µg/L
- 1,2-DCE (total) - 960 µg/L
- TCE - 110 µg/L
- Benzene - 19 mg/L

The organic compounds (VOCs and SVOCs) detected in the Yorktown Aquifer are shown in Figure 5-2. The extent of contamination in the Yorktown Aquifer is much less than the shallow aquifer.

SECTION 5.0 FIGURES



REVISIONS	DRAWN WAC REVIEWED DJM S.O.# 62470-269-0000-05100 CADD# 269002RD	NORTH		BUILDING LP-20 SITE NAVAL BASE, NORFOLK NORFOLK, VIRGINIA BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	ORGANIC COMPOUNDS IN THE SHALLOW AQUIFER SCALE DATE APRIL 1995	FIGURE NO. 5-1



REVISIONS

DRAWN WAC
REVIEWED DJM
S.O.# 62470-269-0000-05100
CADD# 269003RD

NORTH

BUILDING LP-20 SITE
NAVAL BASE, NORFOLK
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

ORGANIC COMPOUNDS IN THE YORKTOWN AQUIFER

SCALE

DATE NOVEMBER 1995

FIGURE NO.
5-2

6.0 SUMMARY OF SITE RISKS

Various dermal, inhalation, and ingestion exposure pathways associated with soil and groundwater contamination were developed as part of the RA evaluation. The RA was based on the VOCs, SVOCs, and inorganic analytical results from surface soils, subsurface soils, and shallow and deep groundwater samples obtained during the completion of the RI. The potential receptors evaluated were: current/future maintenance and industrial workers; future construction workers; and future adult and child (ages 1-6 years) military residents.

Exposure pathways for the current/future maintenance and industrial workers were based on exposure which would occur during excavation or installing/repairing underground utilities. Exposure pathways for the future adult and child military residents were based on exposure to groundwater under a non-potable use scenario (lawn watering, car washing, etc.) and various exposure pathways associated with soils. The future military resident exposure scenario is rather conservative given the unlikely possibility that this portion of the Naval Base will be converted into a housing area. Also, with the present quality of the groundwater (brackish) and City of Norfolk ordinances, it is unlikely that the groundwater in this area would be used, even as a non-potable supply.

Results of the RA indicate that exposure of current/future maintenance and industrial workers to shallow groundwater exceeded USEPA's target risk range of 1×10^{-6} to 1×10^{-4} for an incremental lifetime cancer risk (ILCR). Also for this scenario, the hazard index (HI) exceeded unity (1.0). An exceedence of unity indicates that the potential exists for the occurrence of adverse noncarcinogenic effects in individuals exposed to contaminants of potential concerns (COPCs) in a particular medium. Unacceptable risks were estimated for receptors in contact with surface soils and deep groundwater. The ILCR values for these exposure pathways are 1.4×10^{-4} and 1.1×10^{-4}, respectively.

Future construction workers were evaluated for potential risks associated with accidental ingestion and dermal contact with shallow groundwater and surface and subsurface soils. Potential exposure to deep groundwater was not evaluated due to a lack of a complete exposure pathway. The future construction worker exposed to shallow groundwater exhibited a total ILCR of 7.0×10^{-4} (which is not within the USEPA's target cancer risk range) and a HI of 27 (indicating noncarcinogenic effects may occur). Exposure to surface soils under this scenario exhibited a total HI of 1.1, which slightly exceeds unity.

Risks associated with shallow and deep groundwater exposure for future adult military residents were evaluated based on potable and non-potable use (e.g., car washing, lawn watering) scenarios. Future child receptors (ages 1-6 years) were only evaluated for potable use of the shallow and deep groundwater, since they are not likely to engage in non-potable use activities.

Future adult and child residents were determined to be at risk due to exposure to both shallow and deep groundwater via a potable use scenario. The future adult receptors were also found to be at risk from exposure to non-potable shallow and deep groundwater.

Future resident children were determined to be at risk due to exposure to surface and subsurface soils.

Based on evaluation of the aforementioned receptor and exposure pathways, the COPCs that were the predominant risk contributors, by medium include:

- Shallow Groundwater
  Vinyl chloride
  1,1-DCE
  1,2-DCE
  TCE
  Benzene
- Deep Groundwater
  Arsenic
  Vinyl chloride
  Benzene
  1,2-DCE
- Surface Soil
  Arsenic
  Beryllium
  Benzo(a)pyrene
- Subsurface Soil
  None

Because the site is approximately 1,400 feet from Willoughby Bay, there is a concern that contaminants may impact ecological receptors. Although investigation activities indicate that the plume does not extend to Willoughby Bay, the Bousch Creek culvert, which extends through the site, may provide a migration pathway to the bay. However, the investigation results indicate that the contaminants which originated from the vicinity of Building LP-20 may not significantly impact the surface water quality within the culvert. As the contaminants migrate toward the culvert, the physical nature of the chlorinated solvents cause the contaminants to migrate vertically within the shallow aquifer. Therefore, the contaminants are detected in higher concentrations at the base of the aquifer (30 to 50 feet below ground surface) than at the top of water table. The highest concentrations of the contaminants appear to migrate below the base of the culvert (an estimated depth of 12 to 15 feet below ground surface).

Ecological risks were not evaluated in the baseline risk assessment. This evaluation was not initially performed due to concerns of the ability to distinguish contaminants associated with the Building LP-20 site, and those which may have originated from other portions of the Bousch Creek drainage area or may have migrated via tidal flow from Willoughby Bay. An ecological evaluation of Bousch Creek, which includes sampling locations upstream and downstream of the Building LP-20 site, has been scheduled. The results of this ecological evaluation will be used to evaluate potential impacts the site may have on ecologic receptors.

7.0 DESCRIPTIONS OF ALTERNATIVES

Remedial alternatives were evaluated for both the shallow aquifer and the Yorktown Aquifer, summaries of the remedial alternatives evaluated for each aquifer are presented in Sections 7.1 and 7.2, respectively. To distinguish the shallow aquifer remediation alternatives from the Yorktown Aquifer alternatives, the shallow aquifer alternatives have been designated by the letter "S", while the Yorktown Aquifer alternatives are designated by the letter "Y".

7.1 Shallow Aquifer

The following potential remedial action alternatives have been developed for the shallow aquifer:

- Alternative 1S - No Action
- Alternative 2S - Aquifer Use Restrictions and Monitoring
- Alternative 3S - Air Sparging and Soil Vapor Extraction
- Alternative 4S - In-Well Aeration
- Alternative 5S - Groundwater Extraction and Treatment

A brief description of each alternative, as well as the estimated costs and timeframe to implement the remedial alternative, are provided below.

7.1.1 Alternative 1S: No Action

Description: Under this alternative, no action will be taken to contain, treat, monitor, or restrict access to contaminated groundwater in the shallow aquifer at the LP-20 Site. Contaminated groundwater will be allowed to migrate under the natural hydrogeologic conditions of the shallow aquifer.

Costs: There are no costs associated with this alternative, therefore, the net present worth (NPW) is $0.

Timeframe: Not applicable. Contaminant concentrations in the groundwater may decrease over time through natural attenuation processes such as subsurface volatilization, dilution, dispersion, and biodegradation

7.1.2 Alternative 2S : Aquifer Use Restrictions and Monitoring

Description: This alternative involves the use of institutional controls (aquifer use restrictions and a long-term groundwater monitoring program) to monitor and restrict access to contaminated groundwater in the aquifer. However, no action would be taken under this alternative to contain or treat the contaminated groundwater in the shallow aquifer. Contaminated groundwater will be allowed to migrate under the natural hydrogeologic conditions of the shallow aquifer.

To complete the alternative, one additional monitoring well would be installed to the base of the shallow aquifer (near Building LP-14). Monitoring would occur within nine selected wells. The wells would be sampled on a semi-annual frequency with samples analyzed for organics, and total and dissolved inorganics.

Costs: Capital Cost - $2,500
Annual Operation and Maintenance (O&M) - $31,000
NPW - $479,000

Timeframe: Institutional controls would be implemented within one year of the notice to proceed. The duration of the alternative is estimated at 30 years.

7.1.3 Alternative 3S: Air Sparging and Soil Vapor Extraction

Description: Alternative 3S includes implementation of the following major elements: an air sparging and soil vapor extraction (SVE) and off-gas treatment system, aquifer use restrictions, and a long-term groundwater monitoring program. The proposed aquifer use restrictions and long-term groundwater monitoring program are the same as described under Alternative 2S.

A total of 31 air injection wells and 21 SVE wells are included in the system. The proposed locations of the remediation wells are shown in Figure 7-1. The locations of the wells are intended to reduce contaminants is areas of highest concentrations, "hot spots," and to prevent the migration of contaminants off site by placing wells on the downgradient edge of the plume. The air sparging wells and the SVE wells are connected by manifold piping to a treatment system which includes air compressors, blowers, air-water separators, pumps, tanks, and liquid-phase and vapor-phase granular activated carbon (GAC) adsorption units. It is proposed that this equipment will be housed in a concrete block building for protection. The proposed location for the building is the parking area located south of Bellinger Boulevard (Figure 7-1).

Costs: Capital Cost - $1,105,000
Annual O&M - $94,000
NPW - $2,084,000

Timeframe: Institutional controls and system construction would be initiated within one year of the notice to proceed. Given the level of contaminants detected and the proposed remediation goals, it is estimated that 10-15 years will be required to complete remediation.

7.1.4 Alternative 4S: In-Well Aeration

Description: Alternative 4S includes the following major elements: an in-well aeration treatment system, aquifer use restrictions, and a long-term groundwater monitoring program. The proposed aquifer use restrictions and long-term groundwater monitoring program are the same as described under Alternative 2S.

A total of 23 in-well aeration wells comprise the system. As with Alternative 3S, the wells would be located in hot spot areas and along the downgradient edge of the plume. The wells shall be connected by manifold piping to a treatment system which includes blowers, air-water separators, pumps, tanks, and a vapor-phase GAC adsorption unit. This equipment will be housed in a concrete block building for protection.

Costs: Capital Cost - $1,631,000
Annual O&M - $91,000
NPW - $2,577,000

Timeframe: Institutional controls and system construction would be initiated within one year of the notice to proceed. Given the level of contaminants detected and the proposed remediation goals, it is estimated that 10-15 years will be required to complete remediation.

7.1.5 Alternative 5S: Groundwater Extraction and Treatment

Alternative 5S includes the following major elements: a groundwater extraction and treatment system, aquifer use restrictions, and a long-term groundwater monitoring program. The proposed aquifer use restrictions and long-term groundwater monitoring program are the same as described under Alternative 2S.

The extraction system will consist of four vertical wells installed to the base of the shallow aquifer. The test well installed during the RI field program may be incorporated into the system requiring the installation of only three wells. As with Alternative 3S, the wells would be located in hot spot areas and along the downgradient edge of the plume. Each well will operate at a pumping rate of 45 gallons per minute (gpm) for a total system pumping rate of 180 gpm. The wells will be connected by manifold piping to an on-site groundwater treatment system.

The primary components of the groundwater treatment system will consist of air stripping and carbon adsorption for removal of organic contaminants. It is assumed that off-gas treatment of VOCs from air stripping operations is not required. However, pretreatment for the removal of metals/suspended solids will be required. Treatability studies conducted during the RI field program concluded that precipitation is the most cost-effective metals removal method. Treated water will be discharged to the Bousch Creek Culvert.

Costs: Capital Cost - $2,585,000
Annual O&M - $166,00
NPW - $5,141,000

Timeframe: Institutional controls and system construction would be initiated within one year of the notice to proceed. Given the level of contaminants detected and the proposed remediation goals, it is estimated that 30 years will be required to complete remediation.

7.2 Yorktown Aquifer

The following potential remedial action alternatives have been developed for the Yorktown Aquifer:

- Alternative 1Y - No Action
- Alternative 2Y - Aquifer Use Restrictions and Monitoring
- Alternative 3Y - In-Well Aeration
- Alternative 4Y - Groundwater Extraction and Treatment

A brief description of each alternative, as well as the estimated costs and timeframe to implement the remedial alternative, are provided below.

7.2.1 Alternative 1Y: No Action

Description: Under this alternative, no action will be taken to contain, treat, monitor, or restrict access to contaminated groundwater in the Yorktown Aquifer beneath the LP-20 Site. Contaminated groundwater will be allowed to migrate under the natural hydrogeologic conditions of the Yorktown Aquifer.

Costs: There are no costs associated with this alternative, therefore, the NPW is $0.

Timeframe: Not applicable. Contaminant concentrations in the groundwater may decrease over time through natural attenuation processes such as dilution, dispersion, and biodegradation.

7.2.2 Alternative 2Y: Aquifer Use Restrictions and Monitoring

Description: This alternative involves the use of institutional controls (aquifer use restrictions and a long-term groundwater monitoring program) to monitor and restrict access to contaminated groundwater in the aquifer. However, no action would be taken under this alternative to contain or treat the contaminated groundwater in the Yorktown Aquifer. Contaminated groundwater will be allowed to migrate under the natural hydrogeologic conditions of the Yorktown Aquifer.

To complete the alternative, monitoring would occur within six selected wells. The wells would be sampled on a semi-annual frequency with samples analyzed for organics, and total and dissolved inorganics.

Costs: Capital Cost - $0
Annual O&M - $29,600
NPW - $455,000

Timeframe: Institutional controls would be implemented within one year of the notice to proceed. The duration of the alternative is estimated at 30 years.

7.2.3 Alternative 3Y: In-Well Aeration

Description: Alternative 3Y includes the following major elements: an in-well aeration treatment system, aquifer use restrictions, and a long-term groundwater monitoring program. The proposed aquifer use restrictions and long-term groundwater monitoring program are the same as described under Alternative 2Y.

A total of six in-well aeration wells comprise the system. The wells would be located in areas of highest contamination and along the estimated downgradient edge of the contaminant plume. The estimated locations of the in-well aeration wells are shown in Figure 7-2. The wells shall be connected by manifold piping to a treatment system which includes blowers, air-water separators, pumps, tanks, and a vapor-phase GAC adsorption unit. This equipment will be housed in a concrete block building for protection.

Costs: Capital Cost - $897,000
Annual O&M - $70,900
NPW - $1,629,000

Timeframe: Institutional controls and system construction would be initiated within one year of the notice to proceed. Given the level of contaminants detected and the proposed remediation goals, it is estimated that 10-15 years will be required to complete remediation.

7.2.4 Alternative 4Y: Groundwater Extraction and Treatment

Alternative 4Y includes the following major elements: a groundwater extraction and treatment system, aquifer use restrictions, and a long-term groundwater monitoring program. The proposed aquifer use restrictions and long-term groundwater monitoring program are the same as described under Alternative 2Y.

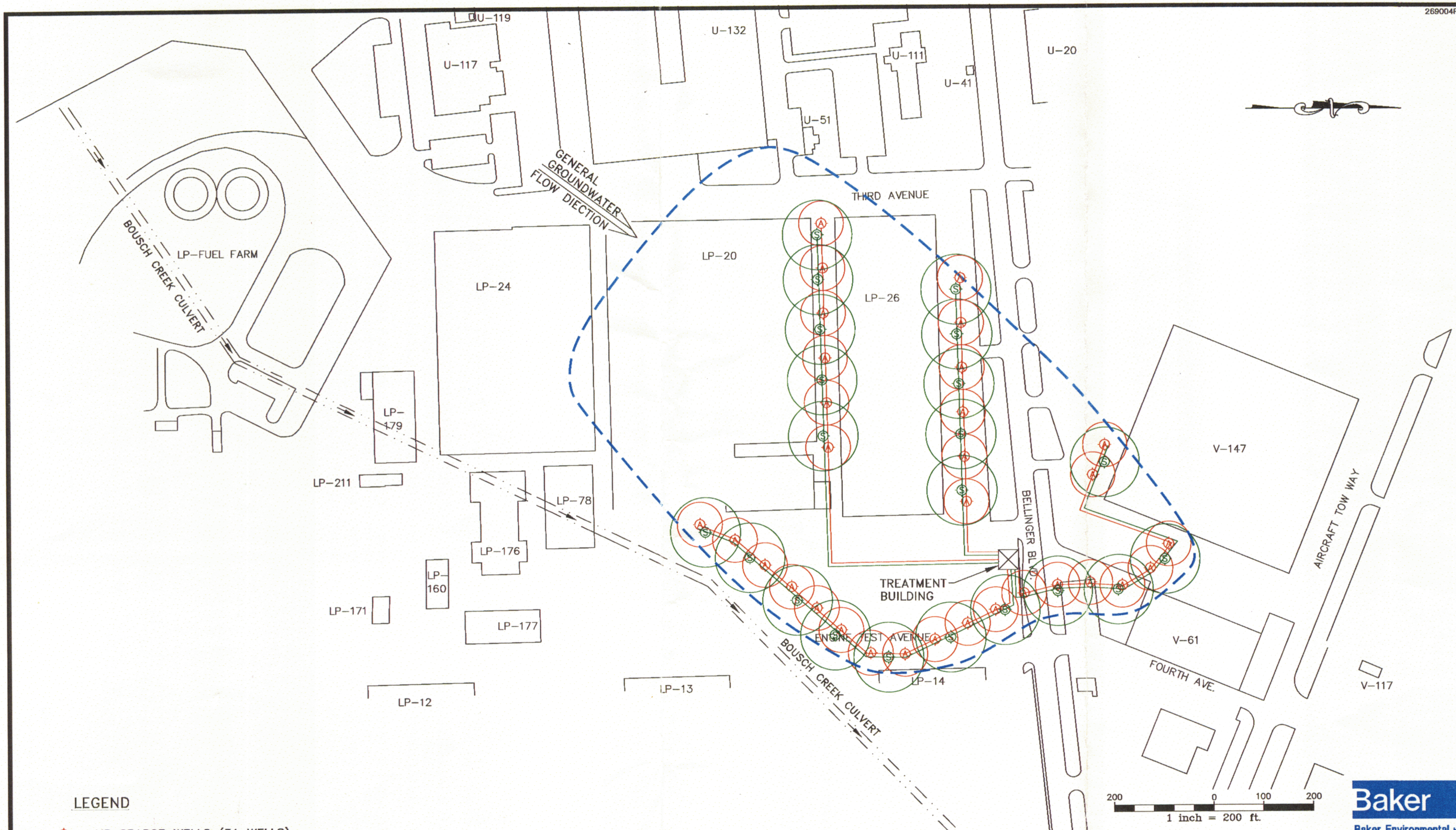
The extraction system will consist of three vertical wells screened in the upper 40 feet of the Yorktown Aquifer. The wells would be located in areas of highest contamination and along the estimated downgradient edge of the contaminant plume. Each well will operate at a pumping rate of 10 gpm for a total system pumping rate of 30 gpm. The wells will be connected by manifold piping to an on-site groundwater treatment system.

The primary components of the groundwater treatment system will consist of air stripping and carbon adsorption for removal of organic contaminants. It is assumed that off-gas treatment of VOCs from air stripping operations is not required. However, pretreatment for the removal of metals/suspended solids will be required. Treatability studies conducted during the RI field program concluded that precipitation is the most cost-effective metals removal method. Treated water will be discharged to the Bousch Creek Culvert.

Costs: Capital Cost - $1,131,000
Annual O&M - $109,00
NPW - $2,809,000

Timeframe: Institutional controls and system construction would be initiated within one year of the notice to proceed. Given the level of contaminants detected and the proposed remediation goals, it is estimated that 30 years will be required to complete remediation.

SECTION 7.0 FIGURES



LEGEND

Ⓐ AIR SPARGE WELLS (31 WELLS) (RADIUS OF INFLUENECE = 45')

Ⓢ SVE WELLS (21 WELLS) (RADIUS OF INFLUENCE = 70')

— — AREA OF CONCERN

Baker
Baker Environmental, Inc.

FIGURE 7-1
ALTERNATIVE 3S-
AIR SPARGING AND SOIL VAPOR EXTRACTION

BUILDING LP-20 SITE
NAVAL BASE, NORFOLK — NORFOLK, VIRGINIA

01161AB3Y

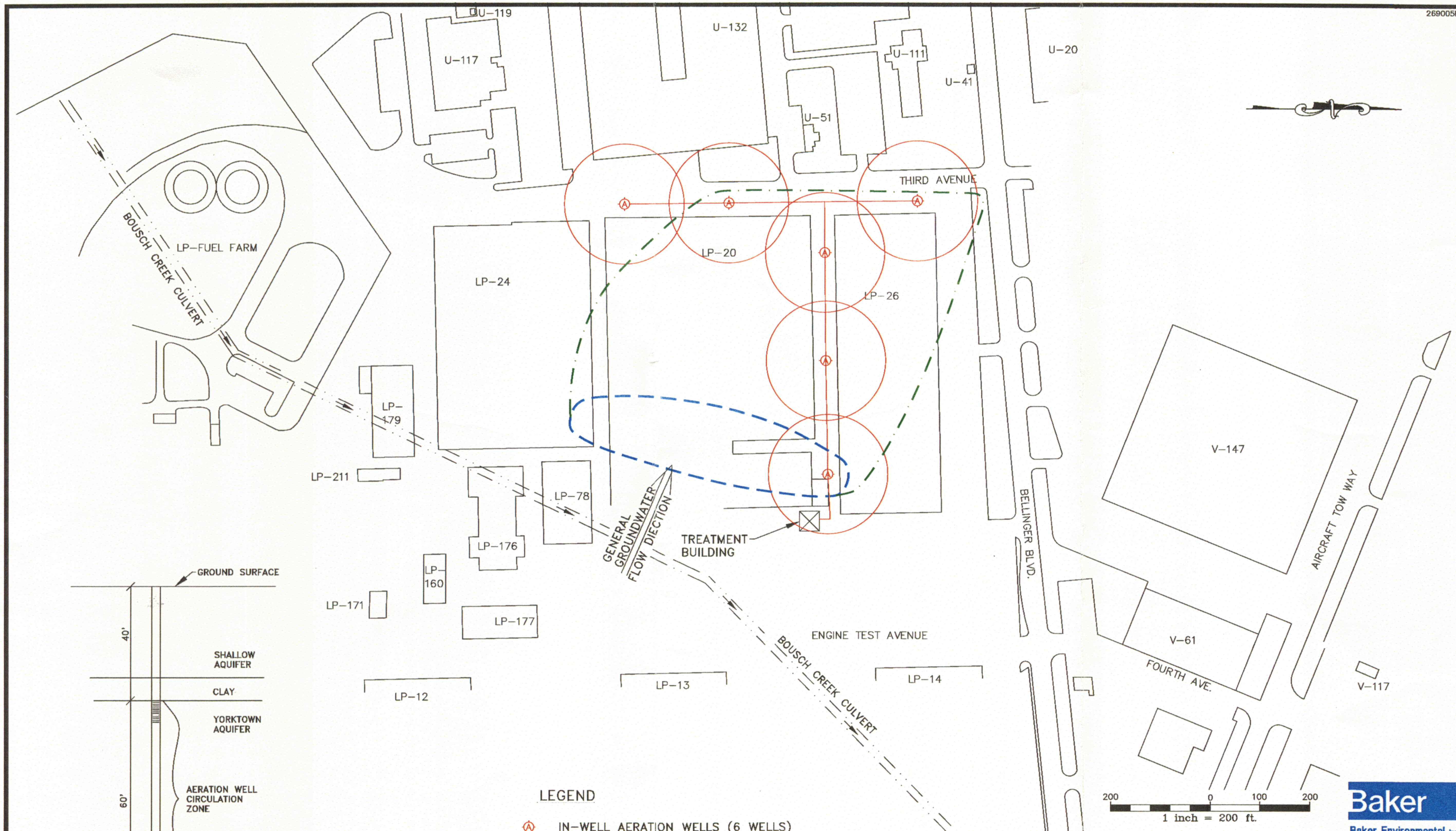


FIGURE 7-2
ALTERNATIVE 3Y–
IN-WELL AERATION
BUILDING LP-20 SITE

NAVAL BASE, NORFOLK NORFOLK, VIRGINIA

8.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, alternatives for remediation of the shallow and Yorktown Aquifer are evaluated against nine criteria to determine the preferred alternative. The preferred alternatives are discussed in Section 7.0. The nine criteria have been determined by the USEPA and are presented in the publication, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (USEPA, 1988). A summary and descriptions of the nine evaluation criteria are presented in Table 8-1. Summaries of the performance of remedial alternatives for the shallow aquifer and the Yorktown Aquifer with respect to seven of the nine evaluation criteria are presented in Tables 8-2 and 8-3, respectively.

The two remaining criteria are regulatory acceptance and community acceptance. The USEPA and VADEQ have had an opportunity to review the Final RI/FS (September 1996) and the Draft Final PRAP submitted on September 27, 1996. Both agencies have indicated that groundwater contaminants in the shallow aquifer must be reduced using an aggressive remediation alternative such as those proposed in Alternatives 3S, 4S, or 5S. The selection of Alternative 3S (Air Sparging/Vacuum Extraction) has been accepted primarily due to the ability to reduce chlorinated solvents and petroleum contaminants more efficiently than either Alternative 4S or 5S.

The USEPA and VADEQ also acknowledge that by reducing the contaminant levels in the shallow aquifer, contaminant concentrations within the Yorktown Aquifer will eventually decline. If exposure to the Yorktown Aquifer is restricted through institutional controls, remediation of the Yorktown Aquifer is not required at this time. Therefore, Alternative 2Y (Aquifer Use Restrictions and Monitoring) is acceptable.

SECTION 8.0 TABLES

TABLE 8-1

SUMMARY OF EVALUATION CRITERIA
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

- **Overall Protection of Human Health and Environment** - addresses whether or not an alternative provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.
- **Compliance with ARARs** - addresses whether or not an alternative will meet all of the applicable or relevant and appropriate requirements (ARARs) or other federal and state environmental statutes and/or provide grounds for invoking a waiver.
- **Long-Term Effectiveness and Permanence** - refers to the magnitude of residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time once cleanup goals have been met.
- **Reduction of Toxicity, Mobility, or Volume through Treatment** - is the anticipated performance of the treatment options that may be employed in an alternative.
- **Short-Term Effectiveness** - refers to the speed with which the alternative achieves protection, as well as the remedy's potential to create adverse impacts on human health and the environment during the construction and implementation period.
- **Implementability** - is the technical and administrative feasibility of an alternative, including the availability of materials and services needed to implement the chosen solution.
- **Cost** - includes capital and operation and maintenance costs, and for comparative purposes, net present worth values.
- **USEPA/State Acceptance** - indicates whether, based on review of the RI and FS reports and the PRAP, the USEPA and state concur with, oppose, or have no comments on the preferred alternative.
- **Community Acceptance** - will be addressed in the Decision Document following a review of the public comments received on the RI and FS reports and the PRAP.

TABLE 8-2

COMPARISON OF SHALLOW AQUIFER REMEDIATION ALTERNATIVES
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Alternative 1S No Action	Alternative 2S Aquifer Use Restrictions and Monitoring	Alternative 3S Air Sparging and Soil Vapor Extraction	Alternative 4S In-Well Aeration	Alternative 5S Groundwater Extraction and Treatment
Overall Protection of Human Health and the Environment				
Protective of public health under current land use. Alternative would not be protective if aquifer is used for non-potable use in the future. Not protective of the environment by allowing degradation of the Yorktown Aquifer and potential migration to Willoughby Bay.	Protective of public health under current land use. Alternative would be protective in the future by preventing aquifer usage. Not protective of the environment by allowing degradation of the Yorktown Aquifer and potential migration to Willoughby Bay.	Protective of public health under current land use. Alternative would be protective in the future by preventing aquifer usage. Would also be protective of the environment by reducing further degradation of the Yorktown Aquifer and potential contaminant migration to Willoughby Bay.	Protective of public health under current land use. Alternative would be protective in the future by preventing aquifer usage. Would also be protective of the environment by reducing further degradation of the Yorktown Aquifer and potential contaminant migration to Willoughby Bay.	Protective of public health under current land use. Alternative would be protective in the future by preventing aquifer usage. Would also be protective of the environment by reducing further degradation of the Yorktown Aquifer and potential contaminant migration to Willoughby Bay.
Compliance With ARARs(1)				
Would not satisfy Virginia Antidegradation Policy for groundwater. No action-specific or location-specific ARARs apply.	Would not satisfy Virginia Antidegradation Policy for groundwater. No action-specific or location-specific ARARs apply.	Alternative would comply with Virginia Antidegradation Policy. Can be designed to meet applicable action-specific and location-specific ARARs.	Alternative would comply with Virginia Antidegradation Policy. Can be designed to meet applicable action-specific and location-specific ARARs.	Alternative would comply with Virginia Antidegradation Policy. Can be designed to meet applicable action-specific and location-specific ARARs.
Long-Term Effectiveness and Permanence				
Long-term effectiveness depends upon natural attenuation processes.	Long-term effectiveness depends upon natural attenuation processes.	Long-term effectiveness depends on the success of alternative achieving remediation goal. Will be effective in removing solvent and hydrocarbon plumes.	Long-term effectiveness depends on the success of alternative achieving remediation goal. Will be effective in removing solvent plume. Not as effective in removing the hydrocarbon plume.	Long-term effectiveness depends on the success of alternative achieving remediation goal. Will be effective in removing groundwater from the aquifer, but not completely effective in removing DNAPLs.

TABLE 8-2 (Continued)

COMPARISON OF SHALLOW AQUIFER REMEDIATION ALTERNATIVES
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Alternative 1S No Action	Alternative 2S Aquifer Use Restrictions and Monitoring	Alternative 3S Air Sparging and Soil Vapor Extraction	Alternative 4S In-Well Aeration	Alternative 5S Groundwater Extraction and Treatment
Reduction of Toxicity, Mobility, or Volume Through Treatment				
Does not provide treatment to reduce toxicity, mobility, or volume of contamination.	Does not provide treatment to reduce toxicity, mobility, or volume of contamination.	Anticipated to reduce the toxicity, mobility, and volume of contaminants.	Anticipated to reduce the toxicity, mobility, and volume of contaminants.	Anticipated to reduce the toxicity, mobility, and volume of contaminants.
Short-Term Effectiveness				
With no remedial action performed, potential risks to the community or on-site remedial workers will not occur. No additional environmental impacts anticipated.	With no remedial action performed, potential risks to the community or on-site remedial workers will not occur. No additional environmental impacts anticipated.	Minor short-term risks to the on-site workers or the community may exist from construction hazards. No additional environmental impacts anticipated.	Minor short-term risks to the on-site workers or the community may exist from construction hazards. No additional environmental impacts anticipated.	Minor short-term risks to the on-site workers or the community may exist from construction hazards. No additional environmental impacts anticipated.
Implementability				
No implementability requirements with this alternative.	Aquifer restrictions and monitoring activities are easily implemented.	Pilot study required to demonstrate feasibility and design parameters. Installation of system will be difficult due to the development of the area and land use considerations.	Pilot study required to demonstrate feasibility and design parameters. Installation of system will be difficult due to the development of the area and land use considerations.	Installation of system will be difficult due to the development of the area and land use considerations.
Cost				
Capital: $0 O&M(2): $0 NPW(3): $0	Capital: $2,500 O&M: $31,000 NPW: $479,000	Capital: $1,105,100 O&M: $94,000 NPW: $2,084,000	Capital: $1,631,000 O&M: $91,000 NPW: $2,577,000	Capital: $2,585,000 O&M: $166,000 NPW: $5,141,000

Notes:

(1) ARAR = Applicable or Relevant and Appropriate Requirement
(2) O&M = Operation and Maintenance
(3) NPW = Net Present Worth

TABLE 8-3

COMPARISON OF YORKTOWN AQUIFER REMEDIATION ALTERNATIVES
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Alternative 1Y No Action	Alternative 2Y Aquifer Use Restrictions and Monitoring	Alternative 3Y In-Well Aeration	Alternative 4Y Groundwater Extraction and Treatment
Overall Protection of Human Health and the Environment			
Protective of public health under current land use. Alternative would not be protective if aquifer is used for non-potable or industrial usage use in the future.	Protective of public health under current land use. Alternative would be protective in the future by preventing future aquifer usage.	Protective of public health under current land use. Alternative would be protective in the future by preventing aquifer usage.	Protective of public health under current land use. Alternative would be protective in the future by preventing aquifer usage.
Compliance With ARARs(1)			
Would not satisfy Virginia Antidegradation Policy for groundwater. No action-specific or location-specific ARARs apply.	May satisfy Virginia Antidegradation Policy for groundwater by natural attenuation. No action-specific or location-specific ARARs apply.	Alternative would comply with Virginia Antidegradation Policy. Can be designed to meet applicable action-specific and location-specific ARARs.	Alternative would comply with Virginia Antidegradation Policy. Can be designed to meet applicable action-specific and location-specific ARARs.
Long-Term Effectiveness and Permanence			
Long-term effectiveness depends upon natural attenuation processes.	Long-term effectiveness depends upon natural attenuation processes.	Long-term effectiveness depends on the success of alternative achieving remediation goal. Will be effective in removing solvent plume.	Long-term effectiveness depends on the success of alternative achieving remediation goal. Will be effective in removing groundwater from the aquifer, but not completely effective in removing DNAPLs.
Reduction of Toxicity, Mobility, or Volume Through Treatment			
Does not provide treatment to reduce toxicity, mobility, or volume of contamination.	Does not provide treatment to reduce toxicity, mobility, or volume of contamination.	Anticipated to reduce the toxicity, mobility, and volume of contaminants.	Anticipated to reduce the toxicity, mobility, and volume of contaminants.
Short-Term Effectiveness			
With no remedial action performed, potential risks to the community or on-site remedial workers will not occur. No additional environmental impacts anticipated.	With no remedial action performed, potential risks to the community or on-site remedial workers will not occur. No additional environmental impacts anticipated.	Minor short-term risks to the on-site workers or the community may exist from construction hazards. No additional environmental impacts anticipated.	Minor short-term risks to the on-site workers or the community may exist from construction hazards. No additional environmental impacts anticipated.

TABLE 8-3 (Continued)

COMPARISON OF YORKTOWN AQUIFER REMEDIATION ALTERNATIVES
BUILDING LP-20 SITE
NAVAL BASE, NORFOLK, VIRGINIA
CONTRACT TASK ORDER 0269

Alternative 1Y No Action	Alternative 2Y Aquifer Use Restrictions and Monitoring	Alternative 3Y In-Well Aeration	Alternative 4Y Groundwater Extraction and Treatment
Implementability			
No implementability requirements with this alternative.	Aquifer restrictions and monitoring activities are easily implemented.	Pilot study required to demonstrate feasibility and design parameters. Installation of system will be difficult due to the development of the area and land use considerations.	Installation of system will be difficult due to the development of the area and land use considerations.
Cost			
Capital: $0 O&M(2): $0 NPW(3): $0	Capital: $0 O&M: $29,600 NPW: $455,000	Capital: $897,000 O&M: $70,900 NPW: 1,629,000	Capital: $1,131,000 O&M: $109,000 NPW: $2,809,000

Notes:

(1) ARAR = Applicable or Relevant and Appropriate Requirement
(2) O&M = Operation and Maintenance
(3) NPW = Net Present Worth

9.0 THE SELECTED REMEDY

9.1 Site Remediation Goals

Based on RI findings and the results of the baseline risk assessment, two media of concern have been identified at the Building LP-20 site as follows:

- Groundwater within the shallow water table
- Groundwater within the Yorktown Aquifer

Site remediation goals were developed for each medium of concern considering the contaminants of concern, potential receptors, and exposure scenarios. Site remediation goals for the aquifers are listed as follows:

- Shallow Aquifer
  - Prevent exposure of human and ecological receptors to contaminated groundwater.
  - Prevent further migration of contaminated groundwater.
  - Reduce contaminant concentrations to risk-based levels.

- Yorktown Aquifer
  - Prevent exposure of human and ecological receptors to contaminated groundwater.
  - Reduce contaminant concentrations to risk-based levels.

9.2 Cleanup Goal Development

The media of concern that have been identified at the site are the groundwater in both the water table aquifer and the Yorktown Aquifer. Cleanup goals are developed in the following sections for both the shallow and deep aquifers. Cleanup goals have not been established for soils. There are several reasons for limiting the remediation efforts to groundwater only, including:

- Available information does not indicate a source area.

- The amount of unsaturated soils in the vadose zone is approximately five feet.
- The highly industrialized nature of the site limits remediation alternatives.
- The concrete and asphalt surfaces in the area have already "capped" the area of contamination.

9.2.1 Groundwater Cleanup Goals

Groundwater remediation goals for the shallow aquifer were developed based on current and future maintenance and industrial workers who may be exposed to shallow groundwater by performing excavations, installing/repairing underground utilities, or by using the water for non-potable industrial use. These human health risk-based remediation goals for the shallow aquifer, which are presented in Table 9-1, were developed based on an ILCR of 1×10^{-5} for individual contaminants (carcinogens) to achieve a cumulative ILCR of less than 1×10^{-4}. For noncarcinogens, the cleanup goals were based on a HI of 0.1 for individual contaminants in order to achieve a cumulative HI of less than 1.0 for adults. Currently, contamination in the shallow aquifer exceeds these health risk-based cleanup goals for TCE, 1,1-DCE, 1,2-DCE, vinyl chloride, and benzene.

To be conservative, groundwater remediation goals developed for the shallow aquifer were also used for the Yorktown Aquifer. Currently, contamination in the Yorktown Aquifer exceeds these health risk-based goals for 1,2-DCE and vinyl chloride.

It is recognized that remediation goals may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed the specified goals. Performance curves will be periodically (e.g., annually) developed to monitor groundwater contaminant levels. If the performance curves indicate that asymptotic levels have been reached that exceed the cleanup goals for some contaminants, then the cleanup goals may be reevaluated at that time.

As a point of comparison, Federal Ambient Water Quality Criteria (AWQC) and Virginia Surface Water Standards were included in Table 9-1. These surface water criteria would apply to groundwater as it discharges into surface water. The cleanup goals established for the shallow and Yorktown Aquifers are less than the Federal AWQC and Virginia Surface Water Standards for all contaminants. Therefore, these groundwater cleanup levels are also protective of surface water.

9.3 Selected Remedy Description

The selected remedy for both aquifers located beneath the site is identified below:

Shallow Water Table Aquifer

Alternative 3S - Air Sparging and Soil Vapor Extraction: Protection of the water table aquifer for beneficial use through treatment, institutional controls, and monitoring

Yorktown Aquifer

Alternative 2Y - Aquifer Use Restrictions and Monitoring: Protection of the Yorktown Aquifer for beneficial use through institutional controls and monitoring

9.3.1 Rationale for Selected Remedies

Based on available information and the current understanding of site conditions, each alternative appears to provide the best balance of trade-offs with respect to the nine CERCLA evaluation criteria. In addition, the selected alternatives are anticipated to meet the following statutory requirements:

- Protection of human health and the environment
- Compliance with ARARs (or justification of a waiver)
- Cost-effectiveness
- Utilization of permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable

The proposed response actions (or selected remedies) identified herein address the contaminated media of concern at the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the selected remedies are focussed on the shallow water table and Yorktown Aquifers. The selected remedies for the various media are briefly described below.

9.3.1.1 Shallow Water Table Aquifer

The preferred alternative for the remediation of the shallow groundwater in Building LP-20 area is Alternative 3S. This alternative includes protection of the water table aquifer for beneficial use through treatment, institutional controls, and monitoring. The contaminant levels within the water table aquifer will be addressed by an air sparging/SVE system. The system will be installed in areas of highest detected contamination and near the downgradient edge of the contaminant plume. Although there are no downgradient receptors for groundwater in this area, treatment of groundwater in the shallow aquifer is recommended for several reasons:

- The contaminant plume could migrate to Willoughby Bay.
- The contaminants do present an unacceptable risk to current construction workers.
- The contaminants present an unacceptable risk to future military residents and construction/industrial workers.

The shallow aquifer would be treated by an air sparging/SVE system consisting of approximately 31 air injection wells and 21 SVE wells. The air sparging wells and the SVE wells would be connected by manifold piping to a treatment system which includes air compressors, blowers, air-water separators, pumps, tanks, and liquid-phase and vapor-phase GAC adsorption units. This equipment will be housed in a concrete block building designed specifically to protect the remediation equipment.

The air sparging/SVE system would also provide two additional benefits:

- The SVE portion of the system would reduce volatile contaminants that may be present in the soils.
- The biological effect that the overall system would produce would also reduce petroleum contaminants that may be in the area of remediation.

The other active remediation alternatives (4S and 5S) would not be capable of providing such additional benefits.

A groundwater monitoring program would be implemented to assess trends in groundwater quality over time and to evaluate the effectiveness of the groundwater treatment system. Additionally, aquifer use restrictions would be implemented to limit the usage of groundwater in this area.

9.3.1.2 Yorktown Aquifer

The preferred alternative for the Yorktown Aquifer in the vicinity of Building LP-20 area is Alternative 2Y. This alternative includes protection of the Yorktown Aquifer for beneficial use through institutional controls and monitoring. Since there are no receptors for groundwater in the vicinity of the site or immediately downgradient of Building LP-20, and the contaminant plume is not expected to migrate off Navy property in this area, extraction and treatment of groundwater in the Yorktown Aquifer is not recommended. Since the water table aquifer within the Building LP-20 area will be remediated under Alternative 3S, contaminant levels in groundwater in the Yorktown Aquifer should gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented to assess trends in groundwater quality over time. Additionally, aquifer use restrictions would be implemented to limit the usage of groundwater from the Yorktown Aquifer in this area.

SECTION 9.0 TABLES

TABLE 9-1

RISK BASED CLEANUP GOALS - SHALLOW AND YORKTOWN AQUIFERS BUILDING LP-20 SITE NAVAL BASE, NORFOLK, VIRGINIA CONTRACT TASK ORDER 0269

Contaminant	Maximum Concentration Detected in Shallow Aquifer	Maximum Concentration Detected in Yorktown Aquifer	Federal AWQC[1] (Marine Acute)	Virginia Surface Water Standards[2]	Risk-Based Cleanup Goal[3]
Trichloroethene	23,000	130	2,000	807	136 (N)
1,1-Dichloroethene	3,600	ND	224,000	-	11 (C)
1,2-Dichloroethene	28,000	960	224,000	-	306 (N)
Vinyl Chloride	15,000	50	-	5,250	6 (C)
Benzene	860	19	5,100	710	19 (C)

Notes:

(1) Federal Ambient Water Quality Criteria (AWQC) for marine acute conditions (USEPA Water Quality Criteria, May 1,1991). AWQC for marine chronic conditions are only available for benzene (700 μg/L).

(2) Virginia Surface Water Standards based on human health for surface water other than public water supplies (effective May 20, 1992).

(3) Health risk-based levels based on potential future non-potable, industrial use of groundwater using an incremental lifetime cancer risk of 1×10^{-5} for individual carcinogens (C) and a hazard index of 0.1 for individual noncarcinogens (N). The risk-based cleanup goals presented are the most health conservative values resulting from the carcinogenic and noncarcinogenic risk calculation.

ND = Not Detected above MCL

All concentrations are expressed as micrograms per liter (μg/L).

10.0 STATUTORY DETERMINATIONS

The selected remedy must satisfy the statutory requirements of CERCLA Section 121 which includes: (1) to be protective of human health and the environment, (2) comply with ARARs (or justify noncompliance), (3) be cost effective, (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable, and (5) satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element, or provide an explanation as to why this preference is not satisfied. The evaluation of how the selected remedy for the Building LP-20 site satisfies these requirements is presented below.

10.1 Protection of Human Health and the Environment

The selected alternative provides overall protection of human health and the environment by performing the following remediation functions:

- Reducing VOC contamination in the shallow aquifer by active treatment and in the Yorktown Aquifer by natural attenuation.

- Monitoring the groundwater for plume migration and natural attenuation of the groundwater contaminants.

- Placing restrictions on the use of the shallow and deep aquifers.

10.2 Compliance with ARARs

Since neither the shallow aquifer nor the Yorktown Aquifer are suitable as potable water sources in the vicinity of the LP-20 Site, federal MCLs and Virginia Groundwater Standards (VR 680-21-04.3) are not considered applicable or relevant and appropriate requirements (ARARs) for the site. However, the Virginia Antidegradation Policy for groundwater would be considered an ARAR for the site. The intent of this policy is to ensure that protective measures are taken to preserve and protect present and anticipated future uses of groundwater (VR 680-212-04.1,2). In order to comply with the general requirements of this policy, the goal of groundwater remediation efforts should focus on restoration of groundwater to levels that would permit groundwater in this area to be used as a non-potable water source. The selected alternatives will comply with the intent of this policy through active treatment in the shallow aquifer and natural attenuation in the Yorktown Aquifer.

10.3 Cost Effectiveness

The selected alternative for the water table aquifer is the lowest cost alternative, exclusive of the no-action (1S) and monitoring (2S) alternatives, primarily because of the low capital costs associated with the remediation equipment and the estimated duration of system operation. Hence, the selected alternative is the most cost-effective of the "treatment" alternatives. Also, because the system will enhance aerobic biodegradation in both the unsaturated soils and the groundwater, this alternative will also reduce the concentrations of petroleum contamination within the area. This would provide an additional benefit for the overall remediation efforts performed in the area.

Alternative 2Y is the lowest of the action alternatives evaluated for the Yorktown Aquifer, primarily because of the lack of capital costs associated with the remediation equipment and system operation in Alternatives 3Y and 4Y. Monitoring of the Yorktown Aquifer would also assist in evaluating the effectiveness of remediation efforts in the shallow water table.

10.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy for the water table aquifer represents a permanent solution with respect to the principal threats posed by the groundwater contamination. Therefore, this remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. The groundwater treatment represents a permanent solution by removing the VOCs.

Within the Yorktown Aquifer, the selected alternative also represents a permanent solution. Reduction of VOCs within the water table aquifer will essentially eliminate the source of contamination to the Yorktown Aquifer. VOCs which have already migrated into the lower aquifer will be reduced by natural attenuation.

10.5 Preference for Treatment as a Principal Element

By treating the shallow groundwater, the selected remedy addresses the principal threat (exposure by construction/maintenance workers) through the use of treatment technologies. Therefore, the statutory preference for remedies that employ treatment as a principal element is satisfied.

11.0 RESPONSIVENESS SUMMARY

11.1 Background on Community Involvement

The Building LP-20 site and the associated contaminated groundwater plume is located within the boundaries of the Naval Base Norfolk. Therefore, involvement from nearby communities was limited compared to other sites. A record review of the Naval Base Norfolk files indicates an active community involvement program.

Community relations activities to date for the Building LP-20 site are summarized below:

- Established three local information repositories.
- Established the Administrative Record for all of the sites under investigation at the Base.
- Distributed Fact Sheets during the investigation.
- Released the Draft Final PRAP for public review and comment in the information repositories on September 27, 1996.
- Released public notice announcing public comment period and document availability of the PRAP on September 26, 1996.
- Held a RAB (formerly Technical Review Committee) meeting on October 24, 1996, in which the public was invited to attend, to review the Draft Final PRAP and solicit comments.

11.2 Summary of Public Comments

The public did not provide comments during the September 26, 1996 through October 25, 1996 comment period. Comments were provided during the October 24, 1996 RAB meeting (Section 11.2.2). The low number of comments is an indication that the public accepts the proposed remediation alternatives for the site.

11.2.1 Response to VADEQ Comments on Final PRAP

The VADEQ has indicated that comments regarding the proposed remedation alternative will not be provided. This is an indication that the proposed remedation alternatives recommended for the Building LP-20 site are acceptable to the VADEQ.

11.2.2 Response to Restoration Advisory Board Member Comments

Several questions regarding the Building LP-20 site and proposed remediation alternatives were presented by the public during the RAB meeting held October 24, 1996. These comments and associated responses are provided below.

Question: Will there be any smell in the buildings during the process?

Response: No volatile organic compound (VOC) readings were recorded inside the building during the system pilot test conducted in June of this year. The air inside the building will be monitored during the remediation process.

Question: How are the plating tanks and equipment pits in LP-20 effected by this system?

Response: The plating shop area of LP-20 is in the process of a Resource Conservation and Recovery Act (RCRA) closure. The open pits created when equipment was removed are in the process of being backfilled and capped with concrete.

Mr. Devlin Harris (VADEQ), gave information and a point of contact at VADEQ to obtain current status of the LP-20 plating shop RCRA closure.

Question: Will the LP-20 system address the petroleum products?

Response: No, the petroleum products are being addressed under the UST programs. Two skimmers have been installed in the area behind LP-20 as part of the recovery effort.

Question: Was the well or pump installed behind LP-78 in the late 1980s part of or related to this system?

Response: No, the pump was installed as part of the UST program.

Question: What will the system look like when in full operation?

Response: All the wells and pipeline are underground and capped with concrete. Only the system's mechanical building, or buildings depending on the final design, will be present in the parking lot. The buildings will house the carbon treatment system, pumps, and other systems devices.

12.0 REFERENCES

ATEC Environmental Consultants, Inc. Site Check Investigation Report - Sewells Point Complex, Building LP-22 Underground Storage Tank, Naval Air Station, Norfolk, Virginia. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command. February 28, 1991.

Baker Environmental, Inc. Corrective Action Plan, Former UST System, Building LP-22, Norfolk Naval Air Station, Norfolk, Virginia. Final. Prepared for the Naval Facilities Engineering Command Atlantic Division, August 3, 1993.

Baker Environmental, Inc. Site Characterization Report, UST System U-117-1 Building U-117. Final prepared for the Naval Facilities Engineering Command Atlantic Division. March 11, 1993.

Baker Environmental, Inc. Final Remedial Investigation/Feasibility Study, Building LP-20 Site, Naval Base, Norfolk, Virginia, September 1996.

Baker Environmental, Inc. Proposed Remedial Action Plan. Final Prepared for the Naval Facilities Engineering Command Atlantic Division. November 1, 1996.

Environmental Science and Engineering, Inc. Draft Monitor Well Sampling Report, Bousch Creek Culvert, Norfolk Naval Air Station (NAS), Norfolk, Virginia. May 1994.

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Environmental Science and Engineering. Draft Interim Remedial Investigation Report, LP-20 Aircraft Engine Maintenance Facility, Naval Air Station, Norfolk, Virginia. August 1991.

Exposure Factors Handbook. Office of Health and Environmental Assessment. Washington, D. C. July 1989. EPA/600/8-89/043.

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O'Brien and Gere Engineers, Inc. Corrective Action Plan, Contaminated Groundwater Study, Naval Air Station, Building U-132 Site, Norfolk, Virginia. July 1991.

O'Brien and Gere Engineers, Inc. Final Report, Contaminated Ground Water Study, Naval Air Station, Bousch Creek Area, Norfolk, Virginia. January 1989.

Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D. C. March 25, 1991. OSWER Directive 9285.6-03.

Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D. C. December 1989. EPA/540/1-89-002.

Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening. Region III, Philadelphia, Pennsylvania. January 1993. EPA/903/R-93-001.

Appendix D
Site 18 ARARs

TABLE D-1
Acronyms and Abbreviations
Site 18 Record of Decision
Naval Station Norfolk
Norfolk, Virginia
Acronyms and Abbreviations

ARAR	Applicable or relevant and appropriate requirement
BTAG	Biological Technical Assistance Group
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
DCR	Virginia Department of Conservation and Recreation
DNH	Division of Natural Heritage
IDW	Investigation Derived Waste
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NAAQS	National Ambient Air Quality Standards
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NSDWRs	National Secondary Drinking Water Regulations
NSPS	New Source Performance Standards
OSWER	Office of Solid Waste and Emergency Response
PCB	Polychlorinated biphenyls
PMCL	Primary Maximum Contaminant Level
POTW	Publicly Owned Treatment Works
ppm	Parts per Million
RAO	Remedial Action Objective
RBC	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substance Control Act
UIC	Underground Injection Control
USACE	US Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
UU/UE	Unlimited Use/Unrestricted Exposure
VAC	Virginia Administrative Code
VMRC	Virginia Marine Resource Commission
VPA	Virginia Pollutant Abatement
VPDES	Virginia Pollutant Discharge Elimination System

Notes
ARARs cited within this Appendix are applicable to the non-time-critical removal action (NTCRA) conducted at the site to implement enhanced reductive dechlorination of volatile organic compounds.

References

Commonwealth of Virginia, 2004. Preliminary Identification, Applicable or Relevant and Appropriate Requirements.
USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Interim Final* . Office of Emergency and Remedial Response. EPA/540/G-89/006.
USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes.* Office of Emergency and Remedial Response.
USEPA, 1998. RCRA, Superfund & EPCRA Hotline Training Manual. Introduction to Applicable or Relevant and Appropriate Requirements. EPA540-R-98-020.

Table D-2
Federal Chemical-Specific ARARs
Site 18 Record of Decision
Naval Station Norfolk, Norfolk, Virginia

Media	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Safe Drinking Water Act						
Groundwater	SDWA standards serve to protect public water systems. Primary drinking water standards consist of federally enforceable MCLs. MCLs are the highest level of a contaminant that is allowed in drinking water.	Impact to public water systems that have at least 15 service connections or serve at least 25 year-round residents. May also be cleanup standards for on-site ground or surface waters that are current or potential sources of drinking water.	40 CFR 141.11 to 141.16 and 141.61 to 141.66	1 - No Further Action	Applicable	No action does not provide a means to assess whether or not groundwater concentrations are reducing to the MCLs. However, the aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply.
				2 - Continued Enhanced Bioremediation with LUCs	Applicable	The monitoring component provides data assesment to determine if groundwater concentrations have reached the MCL. However, the aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply.

Table D-3
Virginia Chemical-Specific ARARs
Site 18 Record of Decision
Naval Station Norfolk, Norfolk, Virginia

Media	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
State Water Control Law [VA Code Ann. §§ 62.1-44.2 to 62.1-44.34:28 (2003)]						
Groundwater	Establishes groundwater quality standards to protect the public health or welfare and enhance the quality of water.	Standards are used when no MCL is available.	*Groundwater Quality Standards*, 9 VAC 25-**280** Sections 10, 20, 30, 40, and 50 Waterworks Regulations: 12 VAC 5-590-10, 390, and 440	1 - No Further Action	Relevant	MCLs are used as cleanup goals. There are no surrogates listed in 9VAC 25-280 for other VOCs detected in Site 18 groundwater. Alternative 1 does not provide a means to assess groundwater contaminant concentrations ro compare to groundwater standards.
				2 - Continued Enhanced Bioremediation with LUCs	Relevant	
Virginia Waste Management Act [VA Code Ann. §§ 10.1-1400 to 1457 (2004)]						
Waste/Soil/Water	Wastes to be managed must be sampled for TCLP analyses to determine the appropriate waste characterization. TCLP regulatory levels and definition of RCRA hazardous waste.	Management of wastes.	H*azardous Waste Regulations*, 9 VAC 20-60-261	1 - No Further Action	Relevant	No Action will not generate waste (e.g, purge water).
				2 - Continued Enhanced Bioremediation with LUCs	Applicable	The groundwater monitoring will generate purge water which will be characterized for off site disposal at an appropriately licensed facility. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.
Waste/Soil/Water	Hazardous wastes shall not be disposed or managed in solid waste disposal facilities.	Management of solid waste.	Solid Waste Management Regulations, 9 VAC 20-80-240**c** **©**	1 - No Action	Relevant	No Action will not generate waste (e.g, purge water).
				2 - Continued Enhanced Bioremediation with LUCs	Relevant and Appropriate	The groundwater monitoring will generate purge water which will be characterized for off site disposal at an appropriately licensed facility. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.

Table D-4
Federal Action-Specific ARARs
Site 18 Record of Decision
Naval Station Norfolk, Norfolk, Virginia

Action	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Safe Drinking Water Act						
Underground injection	Regulates the subsurface emplacement of liquids through the Underground Injection Control program, which governs the design and operation of five classes of injection wells in order to prevent contamination of underground sources of drinking water.	Any dug hole or well that is deeper than it's largest surface dimension, where the principal function of the hole is in placement of fluids.	40 CFR 144.1(g)(1),144.3, 144.6,144.11,144.12(a), 144.24(a),144.80(e), 144.82, 144.83, 146.8, 146.10(c)	1 - No Further Action	Not Applicable	
				2 - Continued Enhanced Bioremediation with LUCs	Applicable	In the event groundwater monitoring data indicates that contaminant concentrations are not reducing or not likely to reach the MCLS, additional food-grade substrate injection may be completed to further the breakdown of contaminants in groundwater. The remedy will comply with the substantive requirements of the regulation. This ARAR is applicable because the temporary injections wells (via direct push application) could be considered class V groundwater wells and fluids will be injected into the ground.
Resource Conservation and Recovery Act Subtitle C						
Off-site disposal of hazardous wastes	Administrative standards for hazardous wastes sent off-site for further management. Administrative RCRA standards include the obligation to obtain permits and keep various records at all hazardous waste treatment, storage, and disposal facilities; and the requirement to include a hazardous waste manifest when sending hazardous wastes off-site.	Off-site disposal of hazardous wastes.	40 CFR 240 to 282	1 - No Further Action	Not Applicable	
				2 - Continued Enhanced Bioremediation with LUCs	Relevant and Appropriate	The groundwater monitoring component will generate waste (e.g., purge water) which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.

Table D-5
Virginia Action-Specific ARARs
Site 18 Record of Decision
Naval Station Norfolk, Norfolk, Virginia

Action	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Virginia Waste Management Act [VA Code Ann. §§ 10.1-1400 to 1457 (2004)]						
Handling, storage, treatment, disposal, and/or transportation of hazardous waste IDW	Provides for the control of all hazardous wastes that are generated within, or transported to, the Commonwealth for the purposes of storage, treatment, or disposal or for the purposes of resource conservation or recovery. Any disposal facility must be properly permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Management of wastes that meet the definition of hazardous waste.	*Hazardous Waste Regulations*, 9 VAC 20-60-261.3	1 - No Further Action	Applicable	
				2 - Continued Enhanced Bioremediation with LUCs	Applicable	The groundwater monitoring component will generate waste (e.g., purge water) which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.
Handling, storage, treatment, disposal, and/or transportation of hazardous waste IDW	Provides for the control of all hazardous wastes that are generated within, or transported to, the Commonwealth for the purposes of storage, treatment, or disposal or for the purposes of resource conservation or recovery. Any disposal facility must be properly permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Management of wastes that meet the definition of hazardous waste.	*Hazardous Waste Regulations*, 9 VAC 20-60-12 to 1505; *Regulations Governing the Transportation of Hazardous Materials*, 9 VAC 20-110-10 to 130	1 - No Further Action	Relevant and Appropriate	
				2 - Continued Enhanced Bioremediation with LUCs	Relevant and Appropriate	The groundwater monitoring component will generate waste (e.g., purge water) which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.
Handling, storage, treatment, disposal, and/or transportation of solid waste IDW	Establishes standards and procedures pertaining to the management of solid wastes, and siting, design, construction, operation, maintenance, closure, and post-closure care of solid waste management facilities in this Commonwealth in order to protect the public health, public safety, the environment, and natural resources. Provides the means for identification of open dumping of solid waste and provides the means for prevention or elimination of open dumping of solid waste to protect the public health and safety and enhance the environment. Sets forth the requirements for undertaking corrective actions at solid waste management facilities. Any disposal facility must be properly permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Management of wastes that meet the definition of solid waste.	*Solid Waste Management Regulations*, 9 VAC 20-80-10 to 790	1 - No Further Action	Relevant and Appropriate	
				2 - Continued Enhanced Bioremediation with LUCs	Relevant and Appropriate	The groundwater monitoring component will generate waste (e.g., purge water) which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.

Appendix E
Sites 1, 3, and 20 ARARs

TABLE E-1
Acronyms and Abbreviations
Sites 1, 3, and 20 Record of Decision
Naval Station Norfolk
Norfolk, Virginia

ARAR	Applicable or relevant and appropriate requirement
BTAG	Biological Technical Assistance Group
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
DCR	Virginia Department of Conservation and Recreation
DNH	Division of Natural Heritage
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NAAQS	National Ambient Air Quality Standards
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NSDWRs	National Secondary Drinking Water Regulations
NSPS	New Source Performance Standards
OSWER	Office of Solid Waste and Emergency Response
PCB	Polychlorinated biphenyls
PMCL	Primary Maximum Contaminant Level
POTW	Publicly Owned Treatment Works
ppm	Parts per Million
RBC	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substance Control Act
UIC	Underground Injection Control
USACE	US Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
VAC	Virginia Administrative Code
VMRC	Virginia Marine Resource Commission
VPA	Virginia Pollutant Abatement
VPDES	Virginia Pollutant Discharge Elimination System

Notes:

Listing the statutes, policies, and citations for the ARARs does not indicate that the Navy accepts the entire statues or policies as potential ARARs; only substantive requirements of the specific citations are considered potential ARARs.

Red text indicates a revision from the original ARARs documented in the DDs; revisions include current citations and changes documented in the ROD.

The ARARs documented by the ROD are inclusive of current remedies (ARARs applicable to construction of remedies are not included in this evaluation).

References

Commonwealth of Virginia, 2004. Preliminary Identification, Applicable or Relevant and Appropriate Requirements.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Interim Final* . Office of Emergency and Remedial Response. EPA/540/G-89/006.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes.* Office of Emergency and Remedial Response. EPA/540/G-89/009.

USEPA, 1998. RCRA, Superfund & EPCRA Hotline Training Manual. Introduction to Applicable or Relevant and Appropriate Requirements. EPA540-R-98-020.

TABLE E-2
Federal Chemical-Specific ARARs
Sites 1, 3, and 20
Naval Station Norfolk
Norfolk, Virginia

Media	Requirement	Citation	Site	ARAR Determination	Comment
Decision Document: Clean Water Act (CWA) 33 USC 1251 et seq					
Surface Water	Water quality criteria	33 USC 1313 and 57 Federal Register 60920-60921	Sites 1 and 20	Applicable	Federal water quality standards would be applicable for any discharges to surface water (from contaminated groundwater or surface runoff).
Surface Water	Water quality criteria	33 USC 1314(a) and 42 USC 9621(d)(2)	Sites 1 and 20	Applicable	Federal water quality standards may be relevant and appropriate for any discharges to surface water (from contaminated groundwater or surface runoff).
Decision Document: Safe Drinking Water Act					
Groundwater	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibiliity of removing a contaminant; MCLGs do not consider the technical feasibility of contaminant removal. For a given contaminant, the more strigent of MCLs or MCLGs is applicable unless the MCLG is zero, in which case the MCL applies.	a. MCLs 40 CFR 141.11-141.16 b. MCLGs 40 CFR 141.50-141.51	Sites 1, 3, and 20	Revelant and appropriate in developing cleanup goals for contaminated groundwater and surface water that may potentially be used as a potable water supply.	MCLs were used in developing cleanup goals for the Yortown Aquifer for Site 20. Site 1 cleanup goals were revised from risk-based concentrations to MCLs vis a NSD in 2008. Site 3 cleanup goals were revised from risk-based concentrations to MCLs for contaminants whose MCL is more stringent. Site 20 cleanup goals were revised from risk-based concentrations to MCLs for the shallow aquifer. Revised citation: 40 CFR 141.11 to 141.16 and 141.61 to 141.66

TABLE E-3
Virginia Chemical-Specific ARARs
Sites 1, 3, and 20
Naval Station Norfolk
Norfolk, Virginia

Media	Requirement	Site	Citation	ARAR Determination	Comment
Decision Document: Virginia Water Quality Standards					
Surface Water	Water quality standards based on water use and class of surface water	Sites 1 and 20	VR 680-21-01.14	Applicable	Water quality standards would be applicable for any discharges to surface water (from contaminated groundwater to surface water) Revised Citation: 9 VAC 25-260 Sections 10, 20, 30, 50, 140, 310, and 410
Decision Document: Virginia Emission Standards for Toxic Pollutants					
Air	Established acceptable limits for toxic pollutants by applying a 1/40 correction factor to the occupational standard Threshold Limit Value-Ceiling (TLV-Ceiling).	Sites 1, 3, and 20	VR 120-01	Applicable to discharge of treated water to the atmosphere	Remedial design will determine air emissions from the treatment technology will not exceed emissions standards. 9 VAC 5-60-Sections 300, 310, 320, 330, and 350
Decision Document: Virginia Pollution Discharge Elimination System Regulation					
Surface Water	Development of a discharge limit/clean-up level depending on the characteristic of receiving stream	Sites 1 and 20	VR 680-14-01	Applicable	Discharge limit/clean-up level would be applicable for any point source discharge of treated groundwater Revised Citation:9 VAC 25-31-10 et seq.
Department of Health's Waterworks Regulations					
Groundwater	Development of Maximum Contaminant Levels and secondary maximum contaminant levels for drinking water.	Sites 1, 3, and 20	12 VAC 5-590-Sections 10, 390, and 440	Applicable	The clean up goals for groundwater at Sites 1, 3, and 20 are maximum contaminant levels when the MCL is more stringent than risk-based calculated clean-up goals (Site 3).

TABLE E-4
Federal Action-Specific ARARs
Sites 1, 3, and 20
Naval Station Norfolk
Norfolk, Virginia

Action	Requirement	Citation	Site	ARAR Determination	Comment
Decision Document: DOT Rules for Hazardous Materials Transport					
Offsite Transport of any media	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding	49 CFR Parts 107 and 171.1-500	Sites 1, 3, and 20	Applicable for any action requiring offsite transportation of hazardous materials	Remedial actions may include off-site treatment and disposal (e.g. off-site regeneration of activiated carbon)
Decision Document: RCRA Subtitle C					
Hazardous Waste Handling	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing	40 CFR 240 to 282	Sites 1, 3, and 20	Relevant and appropriate	State regulations for treatment and disposal of wate take precedence
Decision Document: National Emissions Standards for Hazardous Air Pollutants (NESHAPs)					
Air	Standards promulgated under the Clean Air Act for significant sources of hazardous pollutants, such as vinyl chloride, benzene, TCE, dichlorobenzene, asbestos, and other hazardous substances. Considered for any source that has the potential to emit 10 tons of any hazardous air pollutant or 25 tons of a combination of hazardous air pollutants per year.	40 CFR Part 61	Sites 1, 3, and 20	Applicable to potential releases of hazardous pollutants. Remedial actions (e.g. air stripping) may result in releasing hazardous air pollutants. Treatment design will include air emissions control equipment as required to comply with NESHAPs	Air emissions from the treatment facility will not exceed air emission standards during the remedial design.

TABLE E-5
Virginia Action-Specific ARARs
Sites 1, 3, and 20
Naval Station Norfolk
Norfolk, Virginia

Action	Requirement	Citation	Site	ARAR Determination	Comment
Decision Document: Virginia Air Pollution Regulations					
Toxic pollutants	Toxic pollutants may not be discharged to the atmosphere at amounts in excess of standards	VR 120-05	Sites 1, 3, and 20	Applicable	Applicable to air discharges from groundwater treatment system Revised Citation: 9 VAC 5-60-Sections 300, 310, 320, 330, and 350.
Decision Document: Virginia Pollutant Discharge Elimination System (VPDES) and Water Permit Regulations					
Discharge to surface water	Regulated point-source discharges through VPDES permitting program; permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records. The Water Permit Regulations apply to activities such as dredging, filling, or discharging into or adjacent to surface waters (including wetlands); or any physical, chemical, or biological surface water impact	VR 680-14-01 and VR 680-15-01	Sites 1 and 20	Applicable	Substantive requirements of VPDES permit will be used to determine the discharge limits for the discharge of the treated water to surface water on site. Site 1 treated effluent is discharged to the Upper Reaches of Bousch Creek which contains wetlands in it's watershed. The Site 20 effluent is discharged into a drop inlet of the Bousch Creek culvert; no downgradient wetlands are present. Revised Citation: 9 VAC 25-210-80
Revised					
Closure of landfill	Closure and post-closure care requirement for hazardous waste landfill	VR 672-10-01, Part X, Section 10.13.K	Site 1	Relevant and Appropriate	Relevant and appropriate Revised citation: 9 VAC 20-80-Sections 140, 150, 210, 220, 230, 240, and 270
Handling, storage, treatment, disposal, and/or transportation of hazardous waste	Hazardous materials must be packaged, marked, labeled, placarded, and transported in the manner required	VR 672-10-01, Parts VI and VII	Sites 1, 3, and 20	Applicable	Applicable for offsite transportation of materials classified as hazardous Revised citation: Hazardous Waste Regulations, VAC 20-60-261.3, 262,263 Revised citation: Regulations Governing the Transportation of Hazardous Materials, 9 VAC 20-110-10 to 130
Handling, storage, treatment, disposal, and/or transportation of hazardous waste	Hazardous materials must be packaged, marked, labeled, placarded, and transported in the manner required	VR 672-30-1	Sites 1, 3, and 20	Applicable	Applicable for off-site transportation of materials classified as hazardous Hazardous Waste Regulations, 9 VAC 20-60-261.3, 262,263 Regulations Governing the Transportation of Hazardous Materials, 9 VAC 20-110-10 to 130