7007 part I

U.S. Army Environmental Center

FORT DEVENS
FINAL REMEDIAL
INVESTIGATION FOR
GROUP 2 & 7 SITES

FINAL
REMEDIAL INVESTIGATION REPORT
AREA OF CONTAMINATION (AOC) 43G

VOLUME I OF II

CONTRACT DAAA-91-D-0008
DELIVERY ORDER NUMBER 005

U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MARYLAND

February 1996

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Prepared for:

U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland

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Prepared by:

ABB Environmental Services, Inc.
Portland, ME
Project No. 07053-15

February 1996

FINAL
REMEDIAL INVESTIGATION REPORT
AREA OF CONTAMINATION (AOC) 43G

TABLE OF CONTENTS

Section	Title	Page No.
PREFACE		x
EXECUTIVE SUMMARY		ES-1
1.0	INTRODUCTION	1-1
1.1	PURPOSE AND SCOPE	1-1
1.2	REPORT ORGANIZATION	1-2
1.3	PROJECT OBJECTIVES	1-3
1.4	PROJECT APPROACH	1-3
1.4.1	Project Operations Plan	1-4
1.4.2	Task Order Work Plan	1-5
2.0	INSTALLATION DESCRIPTION	2-1
2.1	HISTORY	2-1
2.2	PHYSICAL SETTING	2-4
2.2.1	Climate	2-4
2.2.2	Vegetation	2-5
2.2.3	Ecology	2-6
2.2.4	Physiography	2-7
2.2.5	Soils	2-8
2.2.6	Surficial Geology	2-11
2.2.7	Bedrock Geology	2-12
2.2.8	Regional Hydrogeology	2-14
3.0	ANALYTICAL PROGRAM	3-1
3.1	FIELD ANALYTICAL METHODS	3-1
3.1.1	Instrument Calibration	3-2
3.1.2	Sample Preparation and Analysis	3-3
3.1.3	Target Compound Concentrations Calculations	3-4

TABLE OF CONTENTS
(continued)

Section		Title	Page No.
	3.1.4	Field Documentation Procedures	3-4
	3.1.5	Field Analytical Quality Control	3-5
	3.1.6	Method Detection Limits and Data Qualifiers	3-7
3.2		OFF-SITE LABORATORY ANALYTICAL PARAMETERS	3-8
	3.2.1	Off-Site Laboratory Certification	3-9
	3.2.2	Off-Site Laboratory Methods Quality Control	3-10
	3.2.3	Data Reduction, Validation, and Reporting	3-10
	3.2.4	Data Reporting	3-11
	3.2.5	Field Quality Control Samples	3-12
	3.2.6	Off-Site Analytical Data Quality Evaluation	3-14
3.3		CHEMICAL DATA MANAGEMENT	3-14
	3.3.1	Sample Tracking System	3-15
	3.3.2	Installation Restoration Data Management Information System	3-16
4.0		IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS	4-1
4.1		CHEMICAL-SPECIFIC ARARS	4-2
	4.1.1	Groundwater	4-3
	4.1.2	Soil	4-3
	4.1.3	Massachusetts Contingency Plan	4-3
4.2		LOCATION-SPECIFIC ARARS	4-4
4.3		ACTION-SPECIFIC ARARS	4-5
4.4		BACKGROUND CONCENTRATIONS	4-5
5.0		AOC 43G REMEDIAL INVESTIGATION	5-1
5.1		BACKGROUND AND CONDITIONS	5-1
5.2		SUMMARY OF PREVIOUS REMOVAL ACTIONS	5-2
	5.2.1	Fort Devens 1990 Gasoline UST Removal	5-2

TABLE OF CONTENTS
(continued)

Section	Title	Page No.
	5.2.2 ATEC 1992 Waste Oil UST Removal	5-5
5.3	PREVIOUS ABB-ES INVESTIGATIONS	5-5
	5.3.1 Summary of 1992 Site Investigation	5-6
	5.3.2 Summary of Site Investigation Results and Observations	5-7
	5.3.3 Conclusions and Recommendations	5-8
	5.3.4 Summary of 1993 Supplemental Site Investigation	5-8
	5.3.5 Summary of Supplemental Site Investigation Results and Observations	5-12
	5.3.6 Conclusions and Recommendations	5-14
5.4	REMEDIAL INVESTIGATION PROGRAM OBJECTIVES	5-15
	5.4.1 Technical Objectives	5-15
	5.4.1.1 Soil Borings	5-15
	5.4.1.2 Monitoring Wells	5-15
	5.4.1.3 Field Laboratory Analysis	5-16
	5.4.1.4 Off-Site Analytical Sampling	5-16
	5.4.2 Data Quality Objectives	5-16
5.5	SUMMARY OF 1994 REMEDIAL INVESTIGATION PROGRAM	5-20
	5.5.1 Surficial Geophysical Survey	5-21
	5.5.2 Seismic Refraction Survey	5-21
	5.5.3 Soil Borings	5-22
	5.5.4 Monitoring Well/Piezometer Installation	5-23
	5.5.5 Well Development	5-23
	5.5.6 Pumping Test	5-23
	5.5.7 In-Situ Hydraulic Conductivity Testing	5-25
	5.5.8 Groundwater Sampling	5-25
	5.5.9 Soil Vapor Extraction/Bioventing Pilot Test	5-26
	5.5.9 Equipment Decontamination	5-27
	5.5.11 Investigation-Derived Waste	5-28
	5.5.12 Location and Elevation Survey	5-28

TABLE OF CONTENTS
(continued)

Section	Title	Page No.
6.0	SITE HYDROLOGY, GEOLOGY AND GROUNDWATER CHARACTERIZATION	6-1
6.1	SITE HYDROLOGY	6-1
6.2	SITE GEOLOGY	6-1
6.2.1	Surficial Soils and Fill Material	6-1
6.2.2	Subsurface Soils	6-2
6.2.3	Bedrock Geology	6-3
6.2.4	Summary and Interpretation of Seismic Survey Results	6-4
6.2.5	Site Geology Interpretation Summary	6-5
6.3	HYDROGEOLOGY	6-5
6.3.1	Site Hydrogeology	6-5
6.3.1.1	Aquifer Pumping Test Results XGM-94-06X (Overburden) Background and Atmospheric Trend	6-8
6.3.1.2	Aquifer Pumping Test Results XGM-94-04X (Bedrock)	6-11
6.3.2	Site Hydrogeology Interpretation Summary	6-14
7.0	NATURE AND DISTRIBUTION OF DETECTED SITE CONTAMINANTS	7-1
7.1	APPROACH TO CONTAMINATION ASSESSMENT	7-2
7.1.1	Tentatively Identified Compounds/Non-Project Analyte List Compounds	7-2
7.1.2	Potential Laboratory and Sampling Contaminants	7-5
7.2.1	Analytical Data Accuracy and Precision	7-7
7.2	CONTAMINATION ASSESSMENT	7-10
7.2.1	Soil	7-10
7.2.1.1	Field Analytical Soil Results	7-10

TABLE OF CONTENTS
(continued)

Section	Title	Page No.
	7.2.1.2 Off-Site Laboratory Analytical Soil Results	7-14
	7.2.1.3 Summary of Soil Impacts	7-17
	7.2.2 Groundwater	7-17
	7.2.2.1 Field Analytical Groundwater Results	7-17
	7.2.2.2 Off-Site Groundwater Laboratory Analytical Sample Results	7-18
	7.2.2.3 Summary of Groundwater Impacts	7-21
	7.2.3 Sediment	7-22
8.0	CONTAMINANT FATE AND TRANSPORT	8-1
8.1	COMPOUND PROPERTIES AND TRANSPORT PROCESSES	8-1
8.2	FATE AND TRANSPORT OF CONTAMINANTS DETECTED AT AOC 43G	8-7
8.3	SITE CONCEPTUAL MODEL	8-11
9.0	BASELINE HUMAN HEALTH RISK ASSESSMENT	9-1
9.1	OVERVIEW	9-1
9.2	SELECTION OF CHEMICALS OF POTENTIAL CONCERN	9-2
	9.2.1 Data Summary Procedures	9-3
	9.2.2 Data Screening Procedures	9-5
9.3	EXPOSURE ASSESSMENT	9-6
	9.3.1 Human Exposure Pathways	9-6
	9.3.2 Estimation of Exposure	9-8
9.4	TOXICITY ASSESSMENT	9-12
9.5	RISK CHARACTERIZATION	9-14
9.6	COMPARISON OF EPCS TO STANDARDS AND GUIDELINES	9-20
9.7	EVALUATION OF UNCERTAINTY	9-21
9.8	SUMMARY AND CONCLUSIONS	9-22

TABLE OF CONTENTS
(continued)

Section	Title	Page No.
10.0	CONCLUSIONS AND RECOMMENDATIONS	10-1
10.1	CONCLUSIONS	10-1
10.2	RECOMMENDATIONS	10-4

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

REFERENCES

APPENDICES

A		EXPLORATION LOGS
B		MONITORING WELL AND PIEZOMETER CONSTRUCTION DIAGRAMS
C		GEOPHYSICAL INVESTIGATION DATA AND ANALYSIS
D		QUALITY CONTROL RESULTS AND ASSESSMENT
E		WELL DEVELOPMENT RECORDS
F		WATER LEVEL DATA/AQUIFER PUMPING TESTS
G		HYDROGEOLOGIC DATA
	G-1	IN-SITU HYDRAULIC CONDUCTIVITY TESTING
	G-2	HYDRAULIC GRADIENT AND GROUNDWATER FLOW VELOCITY CALCULATIONS
H		FIELD SAMPLE DATA RECORDS (GROUNDWATER)
I		SURVEY DATA
J		GEOTECHNICAL DATA (GRAIN SIZE)
K		PROJECT ANALYTE LIST
L		CALCULATION OF BACKGROUND CONCENTRATIONS
M		ANALYTICAL DATA
	M-1	FIELD ANALYTICAL DATA
	M-2	OFF-SITE ANALYTICAL LABORATORY DATA

TABLE OF CONTENTS
(continued)

Section	Title	Page No.
N	HUMAN HEALTH RISK ASSESSMENT	
O	SOIL VAPOR EXTRACTION/BIOVENTING PILOT TEST	

LIST OF FIGURES

Figure	Title
ES-1	Site Map of AOC 43G
2-1	Location of Fort Devens
2-2	Location of AOC 43G
2-3	General Soils Map
2-4	Bedrock Geology
2-5	Regional Aquifer Transmissivities
2-6	Regional Overburden Groundwater Flow Map
2-7	Regional Bedrock Groundwater Flow Map
5-1	Location of AOC 43G
5-2	Site Map of AOC 43G
5-3	Previous Contractor Exploration Locations
5-4	Previous Contractor Sampling Location
5-5	SI Exploration Locations
5-6	SSI Exploration Locations
5-7	RI Exploration Locations
5-8	Location of SVE Bioventing Pilot Test Wells
6-1	Orientation of Geologic Cross-Sections A-A', B-B', and C-C'
6-2	Interpretive Geologic Cross-Section A-A'
6-3	Interpretive Geologic Cross-Section B-B'
6-4	Interpretive Geologic Cross-Section C-C'
6-5	Interpretive Bedrock Elevation Contours
6-6	Interpretive Water Table Elevation Contours
7-1	Location of Areas 1 Through 3
7-2	Distribution of Benzene in Groundwater - Concentration Above 5 μg/L
8-1	Conceptual Model Flow Diagram

LIST OF TABLES

Table	Title
3-1	1994 Analytical MDLs and PQLs for Target Compounds
4-1	Federal ARARs and TBC Guidance - Groundwater and Surface Water
4-2	State ARARs and TBC Guidance - Groundwater
4-3	ARARs and TBC Guidance - Soil and Sediment
4-4	Potential Location-Specific ARARs at Fort Devens
4-5	Potential Action-Specific Federal ARARs at Fort Devens
5-1	Summary of Investigation Activities
5-2	Summary of Field and Laboratory Analytical Program
5-3	Summary of Soil Borings
5-4	Summary of Monitoring Well Completion Data
6-1	Summary of Bedrock Elevation Data
6-2	Summary of Water Level Elevation Data
6-3	Summary of In-Situ Hydraulic Conductivity Test Results
6-4	Aquifer Pumping Test Transmissivity and Storativity Results
7-1	Summary of TICs and Unknown Compounds Detected in Soil Boring and Groundwater Samples
7-2	Summary of Analytes Detected in Method Blanks
7-3	Equipment Rinseate Summary
7-4	Trip Blank Summary
7-5	SI Field Analytical Subsurface Soil/Soil Gas Samples
7-6	SSI Field Analytical Subsurface Soil Samples
7-7	RI Soil Boring Field Analytical Results
7-8	Soil Boring Off-Site Laboratory Analytical Results
7-9	Screened Auger Results
7-10	Groundwater Off-Site Laboratory Analytical Results
7-11	Sediment Off-Site Laboratory Results
8-1	Chemical and Physical Properties of Compounds Detected
8-2	Mobilities of Inorganic Elements
9-1	Summary of Sample Locations Used in the Human Health Risk Assessment
9-2	Chemicals and Potential Concern
9-3	Summary of Potential Pathways for Human Health Risk Assessment

LIST OF TABLES
(continued)

Table	Title
9-4	Exposure Parameters
9-5	Soil Contaminant Release Analysis
9-6	Oral Dose/Response Information for Carcinogenic Effects
9-7	Oral Dose/Response Information for Non Carcinogenic Effects
9-8	Inhalation Dose/Response Information for Carcinogenic Effects
9-9	Inhalation Dose/Response Information for Non Carcinogenic Effects
9-10	Quantitative Risk Summary
9-11	Qualitative Evaluation of Contaminants in Sediment
9-12	Comparison of Source Area Groundwater Concentrations to Standards and Guidelines
9-13	Comparison of Downgradient Groundwater Concentrations to Standards and Guidelines
9-14	Potential Sources of Uncertainty

PREFACE

In 1991, the U.S. Department of the Army and U.S. Environmental Protection Agency signed a Federal Facility Agreement under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act for environmental investigations and remedial actions at Fort Devens. The agreement required that Site Investigations be undertaken at each Study Area to verify whether a release or potential release exists, to determine the nature of the associated risk to human health and the environment, and to determine whether further investigations or response actions may be required.

In 1991, Fort Devens was identified for closure, by July 1997, under Public Law 101-510, the Defense Base Closure and Realignment Act of 1990. This has resulted in accelerated schedules for the environmental investigations at Fort Devens.

In 1991, under contract DAAA15-91-D-0008, the U.S. Army Environmental Center (formerly U.S. Toxic and Hazardous Materials Agency) tasked ABB Environmental Services, Inc. to conduct site investigations at 13 Study Areas in Groups 2 and 7 and the Historic Gas Stations (19 sites), as described in the Fort Devens Master Environmental Plan (Biang et al., 1992). The findings of these site investigations are presented in the Final Site Investigation Report (ABB-ES, 1993a). Based on the results of the site investigations at these Study Areas, the Army decided to conduct Supplemental Site Investigations at 14 of the original 32 Study Areas. The findings of these supplemental site investigations are presented in the Supplemental Site Investigation Data Package Groups 2 and 7 (ABB-ES, 1994a). Upon completion of the Supplemental Data Package, it was recommended that three Study Areas (Study Area 41, 43G and 43J) should progress to the Remedial Investigation and Feasibility Study phase. The name designation for each of these Study Areas were administratively changed to Areas of Contamination and will be addressed as such in this Remedial Investigation Report and associated Feasibility Study Report. This report presents the findings from Area of Contamination 43G.

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EXECUTIVE SUMMARY

ABB Environmental Services, Inc. (ABB-ES) has prepared this Remedial Investigation (RI) Report on Area of Contamination (AOC) 43G at the Fort Devens U.S. Army Installation, Massachusetts (Fort Devens) to support Task Order 005 of Contract DAAA15-91-D-0008 with the U.S. Army Environmental Center (USAEC). This RI Report details the results of the RI and previous investigations completed at AOC 43G, which were completed in accordance with relevant U.S. Environmental Protection Agency (USEPA) and USAEC guidance. This report also summarizes the previous sampling and analyses completed during the site investigation and the supplemental site investigation at AOC 43G. Fort Devens is currently on the National Priorities List and AOC 43G is considered as a subsite to the entire installation.

The RI field investigation was conducted at AOC 43G during September and October 1994 and included seismic survey, installation of nine water table monitoring wells, subsurface soil sampling for field and off-site laboratory analyses, and two rounds of groundwater sampling from the new and existing monitoring wells for off-site laboratory analyses. The scope of work for this RI at AOC 43G was specified by the USAEC based on previous studies and investigations, and USEPA and Massachusetts Department of Environmental Protection (MADEP) comments on previous investigations and reports. For the purpose of this report, AOC 43G has been divided into three areas. Area 1 consists of the historic gas station, Area 2 encompasses the existing 10,000-gallon underground storage tanks (USTs), and Area 3 is made up of the former waste oil UST and existing sand and gas trap (Figure ES-1). USAEC directed this RI at AOC 43G to evaluate the nature and distribution of the contamination in groundwater downgradient and crossgradient of the Army Air Force Exchange Service gas station, and in soil at Areas 2 and 3. In general, the efforts associated with this RI have resulted in a conceptual model that identifies the source of the groundwater contamination to be the soil directly adjacent, and potentially below Area 2. The results of the RI also indicated that the highest concentrations of the site-related groundwater contamination (up to 2,000 micrograms per liter [μg/L] of benzene in the source area) are above the standards/guidelines established for the commercial/industrial risk scenario used to determine human health risks associated with this AOC.

The analytical data collected from subsurface soil samples from AOC 43G indicates that residual soil contamination was present at Areas 1 through 3. The results from the Supplemental Site Investigation (SSI) indicated that residual total petroleum hydrocarbon (TPHC) contamination was present in subsurface soil at Area 1. However, the maximum concentration of 2,000 micrograms per gram ($\mu g/g$) was below the human health preliminary risk evaluation benchmark concentration completed for this area of AOC 43G in the SSI Data Package (ABB-ES, 1994a). Because of this finding, Area 1 was recommended for no further action.

The analytical results for subsurface soil samples collected from Area 2 indicated that residual soil contamination was present directly adjacent to, and potentially below, the existing gasoline USTs. The results of the RI sampling and analysis showed that volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and TPHC contamination was predominantly confined to the soil at 20 to 28 feet below ground surface (bgs). The lateral distribution was not fully delineated.

Previous investigation results indicated that residual soil contamination was present in the soil below the former waste oil UST and sand and gas trap located behind Building 2008 (Area 3) (see Figure ES-1). Based on previous results, it appears that the contamination is present in the soil from 6 to 12 feet bgs and consists of VOCs, SVOCs, and TPHC.

The groundwater and soils analytical data from the RI indicated that the source of the fuel-related groundwater contamination (i.e., benzene, toluene, ethylbenzene, xylenes, and naphthalene) appears to be located in the soils and upper portion of the bedrock below and directly downgradient of Areas 2 and 3. The water table in Areas 2 and 3 occurs in the overburden soils but seasonally fluctuates below the bedrock surface. This groundwater fluctuation has caused the fuel-related contaminants to migrate into bedrock fractures and overburden soils downgradient of the site. The downgradient distribution of the groundwater contaminant plume has been delineated.

A key issue for the AOC 43G RI is related to the future use of groundwater in and around the AOC. AOC 43G is slated to remain within the proposed U.S. Army Reserve Enclave (BRAC, 1991). However, for the purposes of this RI, the

risk assessment used a commercial/industrial scenario for both soil and groundwater to assess the potential future risk to workers exposed to subsurface soil or consumption of groundwater. Two assessments were prepared. The first used the RI groundwater results from downgradient monitoring wells to assess the groundwater consumption risk in areas east-southeast of Areas 2 and 3. The second used the RI groundwater and soil results from source area monitoring wells and soil borings to assess the groundwater consumption risk and the dermal contact risk from contaminated soil from Areas 2 and 3.

Potential health risks associated with exposure to subsurface soil at Areas 2 and 3 of AOC 43G were evaluated. The primary contaminants of potential concern (CPCs) identified in soil were ethylbenzene, toluene, xylene, PAHs, and inorganic compounds. The exposure scenario evaluated was for a utility/maintenance worker. Estimated carcinogenic risks did not exceed the USEPA target risk range or MADEP MCP risk management level. Similarly, potential noncarcinogenic risks did not exceed the USEPA and MADEP MCP target level.

Risks associated with exposure to groundwater were evaluated for unfiltered groundwater representing the source area and for unfiltered groundwater identified as downgradient. The receptor evaluated was a future commercial/industrial worker. Estimated carcinogenic risks were at the upper end or exceeded the USEPA risk range of $1x10^{-4}$ to $1x10^{-6}$ for exposure to both mean and maximum concentrations of CPCs in source area groundwater ($1x10^{-4}$ and $6x10^{-4}$, respectively). Arsenic and benzene were the primary contributors to the excess risk in both cases. At maximum concentrations both arsenic and benzene produced individual risks above $1x10^{-4}$. In downgradient groundwater, only exposure to maximum concentrations produced a cancer risk exceeding the USEPA range. Arsenic contributed 94 percent of the risk of $2x10^{-4}$ for maximum concentrations.

Risks were estimated for commercial/industrial worker exposure to filtered groundwater assuming that concentrations of organic CPCs remain the same as in unfiltered groundwater. Estimated carcinogenic risks were at the upper end or exceeded the USEPA target risk range of $1x10^{-4}$ to $1x10^{-6}$ for exposure to both mean and maximum concentrations of CPCs in source area filtered groundwater ($1x10^{-4}$ and $4x10^{-4}$, respectively). Arsenic and benzene were the primary contributors to the excess risk in both cases. At maximum concentrations both

arsenic and benzene produced individual risks above $1x10^{-4}$. In downgradient filtered groundwater, exposure to both mean and maximum concentrations produced risks within the USEPA range ($5x10^{-5}$ and $9x10^{-5}$, respectively).

If the modified cancer slope factors (CSFs) for arsenic was used to estimate excess lifetime cancer risks, the cancer risks associated with exposure to both average and maximum concentrations of arsenic in filtered and unfiltered groundwater would fall below $1x10^{-4}$.

Estimated noncarcinogenic risks exceeded the USEPA target level of 1 for both source area and downgradient unfiltered groundwater at mean and maximum concentrations. Hazard index (HIs) for the source area are 36 and 98 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary risk contributors for source area groundwater. HIs for downgradient groundwater are 11 and 21 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual hazard quotients (HQs) for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of 1.

For filtered groundwater, estimated noncarcinogenic risks exceeded the USEPA target level of 1 for both source area and downgradient groundwater at mean and maximum concentrations. HIs for the source area are 36 and 98 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary contributors for source area groundwater. HIs for downgradient groundwater are 11 and 21 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual HQs for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of 1.

A comparison of detected concentrations of CPCs in source area and downgradient groundwater to federal and state drinking water standards and guidelines showed several exceedances. In source area groundwater, the following CPCs were detected at concentrations above a federal or state standard or guideline: xylenes, benzene, ethylbenzene arsenic, lead, nickel, aluminum, iron, manganese, and sodium. In downgradient groundwater, detected concentrations

of benzene, aluminum, iron, manganese and sodium exceed federal or state drinking water standards or guidelines.

Based on the results and interpretations of the RI and the human health risk assessment, ABB-ES recommends that a Feasibility Study be performed to evaluate alternatives to reduce potential human health risks associated with potential future exposure to groundwater at the source area directly downgradient of Areas 2 and 3. The Feasibility Study should also evaluate alternatives to mitigate the migration of source area contaminants to downgradient areas.

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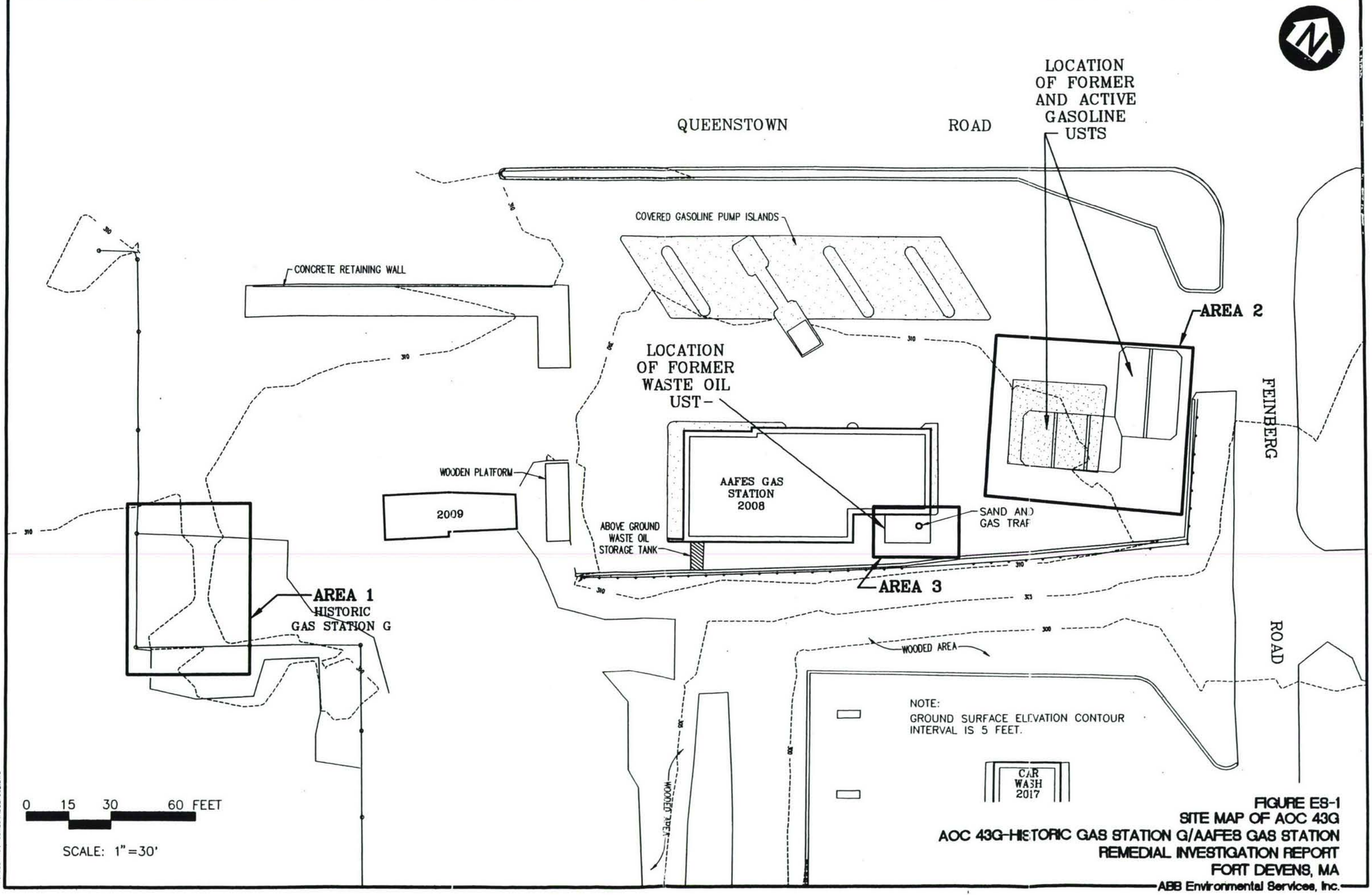


FIGURE ES-1
SITE MAP OF AOC 43G
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

1.0 INTRODUCTION

This Remedial Investigation (RI) Report (Data Item A009) for Area of Contamination (AOC) 43G at the Fort Devens U.S. Army Installation (Fort Devens), in north central Massachusetts was prepared by ABB Environmental Services, Inc. (ABB-ES) as a component of Task Order 005 of Contract DAAA15-91-D-0008 with the U.S. Army Environmental Center[1] (USAEC). This report details the results of the RI program at AOC 43G, which was completed in accordance with relevant USAEC and U.S. Environmental Protection Agency (USEPA) guidance.

1.1 PURPOSE AND SCOPE

The scope of work for the RI at AOC 43G was specified by the USAEC based on previous studies and investigations, and USEPA and Massachusetts Department of Environmental Protection (MADEP) comments on prior investigations conducted by ABB-ES at this AOC.

Prior investigations included Fort Devens underground storage tank (UST) removals, Site Investigation (SI) activities, Supplemental Site Investigation (SSI) activities, and RI activities. These activities, directed by USAEC, were undertaken to establish the nature and distribution of site-related contaminants in groundwater and subsurface soil at AOC 43G. Data were collected in order to provide a basis for evaluating and recommending remedial alternatives for potential site remediation, if necessary. The nature of the impacts has been estimated from individual soil and groundwater samples. The following activities were included in the SI, SSI, and RI investigations:

- soil borings and subsurface soil sampling for field and off-site laboratory analysis;

[1]In January 1993, the U.S. Army Toxic Hazardous Materials Agency (USATHAMA) became the U.S. Army Environmental Center (USAEC). Throughout the RI Report, "USATHAMA" will be used in reference to previous reports, etc., that predate this name change.

- installation of groundwater monitoring wells and the sampling of groundwater for laboratory analyses;
- sediment sampling;
- aquifer testing;
- geophysical survey;
- vertical and horizontal location surveys.

1.2 REPORT ORGANIZATION

Preparation of the RI Report consisted of characterizing the geologic and hydrogeologic conditions and assessing the distribution, migration, potential receptors, and potential effects of identified chemicals on human receptors. The content and presentation of the report relies heavily upon the figures and tables that present the data in the context of exploration locations on site maps. The text within the report supports the figures, and provides detail, interpretation, and analysis that cannot be presented in figures.

After acquiring and evaluating the field and off-site laboratory data and identifying chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), ABB-ES has prepared this RI Report for AOC 43G in accordance with USEPA and USAEC guidance. The report describes the field methods employed and summarizes and evaluates the relevant background information, results, and conclusions from previous investigations, presents the RI field and off-site laboratory data, and assesses the potential human health risks.

Section 2.0 of this report describes the history and physical setting of Fort Devens. Section 3.0 summarizes the site investigation program, including the field procedures, analytical program, QA and QC, and data management. Section 4.0 presents potential ARARs and background concentrations of inorganic analytes in soil and groundwater. Section 5.0 summarizes the AOC 43G background and physical conditions, previous investigations, technical objectives of the RI, and the RI sampling and investigatory techniques. Section 6.0 presents the geology and

hydrogeology for the site, and Section 7.0 outlines the nature and distribution of detected site contaminants. Section 8.0 evaluates the fate and transport of the detected site contaminants, and Section 9.0 presents the human health baseline risk assessment. Section 10.0 presents the summary of findings, the conclusions, and recommendations for AOC 43G. Figures and tables associated with each section are presented at the end of each section.

In accordance with the FFA, this RI report will be presented in a Draft version, and after regulatory review, a Final version.

1.3 PROJECT OBJECTIVES

The objective of the project at AOC 43G was to perform an RI in accordance with all relevant MADEP and USEPA guidance and in compliance with USAEC-approved field methods and procedures. The purpose of the RI conducted at AOC 43G was to further define the site contaminants detected in soil and groundwater during the previous UST removals, SI, and SSI conducted at this AOC, and to determine whether remediation of the site contaminants is warranted.

1.4 PROJECT APPROACH

In order to meet the project objectives, a significant amount of effort was focused on the production of RI planning documents. The planning documents were developed in compliance with the appropriate regulatory guidance for remedial investigations, and considered regulatory and USAEC comments and results of previous investigations.

The project plans were designed to answer data gaps identified from the previous investigations and gather additional data on the physical conditions of the AOC, the nature and distribution of site-related contaminants, and determine the potential impact on human receptors.

1.4.1 Project Operations Plan

The principal planning document was the ABB-ES Fort Devens Project Operations Plan (POP) (ABB-ES, 1992a, 1993c), which provides detailed descriptions and discussions of the elements essential to conducting field investigation activities. The Fort Devens POP was revised between the 1992 SI and 1993 SSI field investigation to include new sampling techniques. The purpose of this plan was to define responsibilities and authorities for data quality, and to define requirements for assuring that the field investigation activities undertaken by ABB-ES at Fort Devens were planned and executed in a manner consistent with USAEC quality assurance (QA) program objectives. The POP includes the specified elements of a Sampling and Analysis Plan (SAP) and Health and Safety Plan (HASP). The SAP includes the essential elements of the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP). USEPA has prepared guidance on the preparation of a POP in "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring" (OWRS QA-1: May 1984). The guidance was designed to eliminate the necessity for preparation of multiple, redundant documents.

Requirements of the POP were applied to ABB-ES and subcontractor activities related to the collection of environmental data at Fort Devens. The POP adheres to the requirements and guidelines contained in the "USAEC QA Program, January 1990" for collection and analysis of samples, and the USAEC "Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports, March 1987" for the installation of borings and monitoring wells, and for land survey location. In addition, the POP meets guidelines of USAEC chain-of-custody (COC) procedures.

The ABB-ES Fort Devens POP provides guidance and specifications to ensure that samples are obtained under controlled conditions using appropriate, documented procedures; and that samples are identified uniquely and controlled through sample tracking systems and COC protocols. The POP also includes specifications to ensure that field determinations and off-site laboratory analytical results are of known quality and are valid, consistent, and compatible with the USAEC chemical data base through the use of certified methods, preventive maintenance, calibration and analytical protocols, quality control (QC) measurements, review, correction of out-of-control situations, and audits. The

POP also specifies the methods and procedures to be used to ensure that calculations and evaluations are accurate, appropriate, and consistent throughout the projects; generated data are validated and their use in calculations is documented; and records are retained as documentary evidence of the quality of samples, applied processes, equipment, and results.

The HASP was prepared as an integral element of the POP in accordance with the same schedule and review requirements (ABB-ES, 1992a; 1993c, Appendix A). The HASP complies with EM 385-1-1, AMC-R-385-100, and Fort Devens safety requirements, as well as Occupational Safety and Health Administration (OSHA) Regulations 29 CFR 1910.120. The HASP development was based on appropriate information contained in previous investigation documents from Fort Devens. The HASP portion of the POP ensures that health and safety procedures are maintained by requiring inclusion of the health and safety staff function in the project organization.

1.4.2 Task Order Work Plan

The background, rationale, and specific scope for the RI are set forth in a second companion planning document, the Task Order Work Plan. The Revised Final Task Order Work Plan for AOC 43G was prepared under a modification to Contract DAAA15-91-D-0008 Task Order No. 005 (ABB-ES, 1994b). The Revised Final Task Order Work Plan was developed to comply with the Massachusetts Contingency Plan (MCP) (310 Code of Massachusetts Regulations [CMR] 40.000); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the corrective action provisions of the Hazardous and Solid Waste Amendments; and the Toxic Substances Control Act. Work conducted under the Revised Final Task Order Work Plan was performed in accordance with the provisions of the Federal Facility Agreement (FFA) (USEPA and Army, 1991) and USAEC guidelines.

The background information provided in the Revised Final Task Order Work Plan for AOC 43G was based largely on information in the Master Environmental Plan (MEP), review of installation documents, observations made during site visits, interviews with installation personnel, and previous investigations. Summaries of each of these activities and discussions of specific field activities to

be conducted under this modification to Task Order No. 005 were included in the Revised Final Task Order Work Plan. The discussions focused specifically on the objectives and scope of proposed RI activities.

2.0 INSTALLATION DESCRIPTION

Fort Devens is located in the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), approximately 35 miles northwest of Boston, Massachusetts. It lies within the Ayer, Shirley, and Clinton map quadrangles (7½-minute series). The installation occupies approximately 9,260 acres and is divided into the North Post, the Main Post, and the South Post (Figure 2-1).

Over 6,000 acres at Fort Devens are used for training and military maneuvers, and over 3,000 acres are developed for housing, buildings, and other facilities; the installation has been reported as the largest undeveloped land holding under a single owner in north-central Massachusetts (United States Fish and Wildlife Service [USFWS], 1992).

The South Post is located south of Massachusetts Route 2 and is largely undeveloped. The Main Post and North Post primarily contain developed lands, including recreational areas (e.g., a golf course and Mirror Lake), training areas, and an airfield. AOC 43G is located on Queenstown Road on the Main Post (Figure 2-2).

The following subsections describe the history and physical setting of Fort Devens.

2.1 HISTORY

Camp Devens was created as a temporary cantonment in 1917 for training soldiers from the New England area. It was named after Charles Devens -- a Massachusetts Brevet Major General in the Union Army during the Civil War who later became Attorney General under President Rutherford Hayes. Camp Devens served as a reception center for selectees, as a training facility, and, at the end of World War I, as a demobilization center (Marcoa Publishing Inc., 1990). At Camp Devens, the 1918 outbreak of Spanish influenza infected 14,000 people, killed 800, and caused the installation to be quarantined (McMaster et al., 1982). Peak military strength during World War I was 38,000. After World War II, Camp Devens became an installation of the U.S. Army Field Forces, CONARC in

1962 and the U.S. Army Forces Command (FORSCOM) in 1973 (Biang et al., 1992).

In 1921, Camp Devens was placed in caretaker status. During summers from 1922 to 1931, it was used as a training camp for National Guard troops, Reserve units, Reserve Officer Training Corps cadets, and the Civilian Military Training Corps. In 1929, Dr. Robert Goddard used Fort Devens to test his early liquid-fuel rockets, and there is a monument to him on Sheridan Road near Jackson Gate (Fort Devens Dispatch, 1992).

In 1931, troops were again garrisoned at Camp Devens. It was declared a permanent installation, and in 1932 it was formally dedicated as Fort Devens. During the 1930s, there was a limited building program, and beautification projects were conducted by the Works Progress Administration (WPA) and Civilian Conservation Corps.

In 1940, Fort Devens became a reception center for New England draftees. It expanded to more than 10,000 acres. Approximately 1,200 wooden buildings were constructed, and two 1,200-bed hospitals were built. In 1941, the Army Airfield was constructed by the WPA in a period of 113 days (Fort Devens Dispatch, 1992). In 1942, the Whittemore Service Command Base Shop for motor vehicle repair (Building 3713) was built, and at the time it was known as the largest garage in the world (U.S. Army, 1979). The installation's current wastewater treatment plant was also constructed in 1942 (Biang et al., 1992).

During World War II, more than 614,000 inductees were processed through Fort Devens. Fort Devens' population reached a peak of 65,000. Three Army divisions and the Fourth Women's Army Corps trained at Fort Devens, and it was the location of the Army's Chaplain School, the Cook & Baker School, and a basic training center for Army nurses. A prisoner of war camp for 5,000 German and Italian soldiers was operated from 1944 to 1946. At the end of the war, Fort Devens again became a demobilization center, and in 1946 it reverted to caretaker status.

Fort Devens was reactivated in July 1948 and again became a reception center during the Korean Conflict. It has been an active Army facility since that time.

Currently the missions at Fort Devens are to command and train its assigned duty units; operate the South Boston Support Activity in Boston, Massachusetts, Sudbury Training Annex and Hingham USAR Annex; and to support the 10th Special Forces Group (A), the U.S. Army Intelligence School, Fort Devens, the U.S. Army Reserves, Massachusetts Army National Guard, and Training Programs. No major industrial operations occur at Fort Devens, although several small-scale industrial operations are performed under the Directorate of Plans, Training, and Security; the Directorate of Logistics; and the Directorate of Engineering and Housing. The major waste-producing operations performed by these groups are photographic processing and maintenance of vehicles, aircraft, and small engines. Past artillery fire, mortar fire, and waste explosive disposal at Fort Devens are potential sources for explosives contamination (USAEC, 1993).

In 1985, Fort Devens applied for a Resource Conservation and Recovery Act (RCRA) Part B Permit for its hazardous waste storage facility. The submission included a list of Solid Waste Management Units (SWMUs) that showed potential for the release of hazardous materials to the environment. Under the FFA between the Army and the USEPA (USEPA and Army, 1991), these potential areas of contamination are referred to as Study Areas (SAs). In cooperation with the MADEP, USEPA Region I issued a draft permit and selected ten SAs for corrective action. In 1986, a final permit was issued along with a list of 40 SAs. At the request of Fort Devens, six additional SAs were added to the list, for a total of 46 SAs.

Argonne National Laboratory's (ANL) Environmental Assessment and Information Sciences Division conducted an environmental assessment of the 46 SAs in November 1988, as part of the environmental restoration of Fort Devens. The objective of the ANL assessment was to characterize on-site contamination and provide recommendations for potential response actions. In 1989, Fort Devens was placed on the National Priority List (NPL). During a subsequent site visit by ANL in 1990, eight more SAs were added, bringing the total to 54. Since that time, four more areas of potential contamination have been identified, for a current total of 58 SAs.

Results of ANL's assessment are reported in a document entitled the MEP for Fort Devens, Massachusetts (Biang et al., 1992). The MEP summarizes preliminary assessment activities conducted by ANL and provides an historical

summary of the installation, discusses the geologic and hydrologic setting, discusses the nature and distribution of contamination, and proposes response actions for each of the 58 SAs. The MEP provided the basis for much of the planning effort for the 1992 investigation of AOC 43G, then known as SA 43G. Based on results of the 1992 SI, additional investigation was conducted under a SSI in 1993. Results of the 1993 SSI indicated an RI was required to fully characterize the site. The RI field investigation was conducted during the Fall and Winter of 1994/1995.

Under Public Law 101-510, the Base Realignment and Closure Act (BRAC) 1990, Fort Devens has been identified for closure by July 1997, and 4,600 acres are to be retained to establish a Reserve Component enclave and regional training center.

2.2 PHYSICAL SETTING

The climate, vegetation, ecology, physiography, soils, surficial and bedrock geology, and regional hydrogeology of Fort Devens are described in the subsections that follow.

2.2.1 Climate

The climate of Fort Devens is typical of the northeastern United States, with long cold winters and short hot summers. Climatological data were reported for Fort Devens by U.S. Department of the Army (1979), based in part on a 16-year record from Moore Army Airfield (MAAF).

The mean daily minimum temperature in the coldest months (January and February) is 17 degrees Fahrenheit (°F), and the mean daily maximum temperature in the hottest month (July) is 83°F. The average annual temperature is 58°F. There are normally 12 days per year when the temperature reaches or exceeds 90°F and 134 days when it falls to or below freezing.

The average annual rainfall is 39 inches. Mean monthly precipitation varies from a low of 2.3 inches (in June) to a high of 5.5 inches (in September). The average

annual snowfall is 65 inches, and snowfall has been recorded in the months of September through May (falling most heavily from December through March).

Wind speed averages 5 miles per hour (mph), ranging from the highest monthly average of 7 mph (March-April) to the lowest monthly average of 4 mph (September).

Average daytime relative humidities range from 71 percent (January) to 91 percent (August), and average nighttime relative humidities range from 46 percent (April) to 60 percent (January).

2.2.2 Vegetation

The Main and North Posts at Fort Devens are primarily characterized by urban and developed cover types. Approximately 56 percent of the area is covered by developed lands, the golf course, the airfield, and the wastewater infiltration beds. Early successional forest cover types (primarily black cherry-aspen hardwoods) cover approximately 2 percent of the area, mixed oak-red maple hardwoods approximately 20 percent, and white pine-hardwood mixes approximately 11 percent. The rest of the North and Main Posts are characterized by various coniferous species, shrub habitat, and herbaceous cover types.

Much of the South Post is undeveloped forested land. The area includes approximately 8 percent early successional forest (black cherry, red birch, grey birch, quaking aspen, red maple); 26 percent mixed oak hardwoods; and 9 percent coniferous forest (white pine, pitch pine, red pine). Four percent of the area is comprised of a mixed shrub community. The 200-acre Turner Drop Zone is maintained as a grassland that represents a "prairie" habitat. Vegetative cover in the large "impact area" of the central South Post has not been mapped in detail. It is dominated by fire-tolerant species such as pitch pine and scrub oak.

Extensive sandy glaciofluvial soils are found in the Nashua River Valley, particularly in the South and North Post areas of Fort Devens. Extensive accumulations of these soils are unusual in Massachusetts outside of Cape Cod and adjacent areas of southeastern Massachusetts, and they account for some of the floral and faunal diversity at the installation.

2.2.3 Ecology

Fort Devens encompasses numerous terrestrial, wetland, and aquatic habitats in various successional stages. Floral and faunal diversity is strengthened by the installation's close proximity to the Nashua River; the amount, distribution, and nature of wetlands; and the undeveloped state and size of the South Post (USFWS, 1992). Much of Fort Devens was formerly agricultural land and included pastures, woodlots, orchards, and cropped fields. Existing habitat types reflect this agrarian history, ranging from abandoned agricultural land to secondary growth forested regions. Fort Devens is gradually reverting back to a forested state.

There are 1,313 acres of wetlands at Fort Devens. The wetlands are primarily palustrine, although riverine and lacustrine types are also found. Forested palustrine floodplain wetlands associated with the Nashua River and its tributary, Nonacoicus Brook, are located on Fort Devens' Main and North Posts. These include 191 acres of flooded areas, emergent marsh, and shrub wetlands. Also present are 245 acres of isolated regions of palustrine wetlands and lacustrine systems. On the South Post, there are 877 acres of wetlands, consisting of deciduous forested wetlands, deciduous shrub swamps, emergent marsh, open lacustrine waters in ponds, and open riverine waters.

Approximately half of Fort Devens' land area abuts the northern boundary of the Oxbow National Wildlife Refuge (NWR), a federal resource administered as part of the Great Meadows NWR (USFWS, 1992).

Fort Devens supports an abundance and diversity of wildlife. Identified taxa include 771 vascular plant species, 538 species of butterflies and moths, eight tiger beetle species, 30 vernal pool invertebrates, 15 amphibian species (six salamanders, two toads, seven frogs), 19 reptile species (seven turtles, 12 snakes), 152 bird species, and 42 mammal species. The status of fish populations in Fort Devens aquatic systems has not been fully defined.

Rare and endangered species at Fort Devens include the federally listed (endangered) bald eagle and peregrine falcon (both occasional transients); the state-listed (endangered) upland sandpiper, ovoid spike rush, and Houghton's flatsedge; the state-listed (threatened) Blanding's turtle, cattail sedge, pied-billed

grebe, and northern harrier; and the state-listed (special concern) blue-spotted salamander, grasshopper sparrow, spotted turtle, wood turtle, water shrew, blackpoll warbler, American bittern, Cooper's hawk, sharp-shinned hawk, and Mystic Valley amphipod. Also state listed as rare or endangered are three Lepidoptera (butterfly and moth) species identified at Fort Devens.

The Massachusetts Natural Heritage Program has developed Watch Lists of unprotected species that are uncommon or rare in Massachusetts. From the Watch Lists, 14 plant species, two amphibian species, and 15 bird species have been observed at Fort Devens.

2.2.4 Physiography

Fort Devens is in a transitional area between the coastal lowland and central upland regions of Massachusetts. All of the landforms are products of glacial erosion and deposition on a crystalline bedrock terrain. Glacial erosion was superimposed on ancient bedrock landforms that were developed by the erosional action of preglacial streams. Generally, what were bedrock hills and ridges before the onset of Pleistocene glaciation were only moderately modified by glacial action, and they remain bedrock hills and ridges today. Similarly, preglacial bedrock valleys are still bedrock valleys. In post-glacial time, streams have locally modified the surficial glacial landforms but generally have not affected bedrock.

The predominant physiographic (and hydrologic) feature in the Fort Devens area is the Nashua River (see Figure 2-1). It forms the eastern installation boundary on the South Post, where its valley varies from a relatively narrow channel (at Still River Gate), to an extensive floodplain with a meandering river course and numerous cutoff meanders (at Oxbow National Wildlife Sanctuary). The Nashua River forms the western boundary of much of the Main Post, and there its valley is deep and comparatively steep-sided with extensive bedrock outcroppings on the eastern bank. The river flows through the North Post in a well defined channel within a broad forested floodplain.

Terrain at Fort Devens falls generally into three types. The least common is bedrock terrain, where rocks that have been resistant to both glacial and fluvial erosion remain as topographic highs, sometimes thinly veneered by glacial deposits. Shepley's Hill on the Main Post is the most prominent example.

A similar but more common terrain at Fort Devens consists of materials (tills) deposited directly by glaciers as they advanced through the area or as the ice masses wasted (melted). These landforms often conform to the shape of the underlying bedrock surface. AOC 43G falls within this type of terrain. They range from areas of comparatively low topographic relief (such as near Lake George Street on the Main Post) to elongated hills (drumlins) whose orientations reflect the direction of glacier movement (such as Whittemore Hill on the South Post).

The third type of terrain was formed by sediment accumulations in glacial-meltwater streams and lakes (glaciofluvial and glaciolacustrine deposits). This is the most common terrain at Fort Devens, comprising most of the North and South Posts and much of the Main Post. Its form bears little or no relationship to the shape of the underlying bedrock surface. Landforms include extensive flat uplands such as the hills on which Moore Army Airfield and the wastewater infiltration beds are located on the North Post. Those are large remnants of what was once a continuous surface that was later incised and divided by downcutting of the Nashua River. Another prominent glacial meltwater feature is the area around Cranberry Pond and H-Range on the South Post. This is classic kame-and-kettle topography formed by sand and gravel deposition against and over large isolated ice blocks, followed by melting of the ice and collapse of the sediments. The consistent elevations of the tops of these ice-contact deposits are an indication of the glacial-lake stage with which they are associated. Mirror Lake and Little Mirror Lake on the Main Post occupy another conspicuous kettle.

2.2.5 Soils

Fort Devens lies within Worcester County and Middlesex County in Massachusetts (see Figure 2-1). The soils of Worcester County have been mapped by the Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) (SCS, 1985). Mapping of the soils of Middlesex County has not been completed. However, an interim report (SCS, 1991), field sheet #19 (SCS, 1989), and an unpublished general soil map (SCS, undated) are available.

Soil mapping units ("soil series") that occur together in intricate characteristic patterns in given geographic areas are grouped into soil "associations." Soils in the Worcester County portions of Fort Devens consist generally of three

associations. Three associations also have been mapped in the Middlesex County portions of Fort Devens. Although the mapped associations are not entirely the same on both sides of the county line, the differences reflect differences in definition and the interim status of Middlesex County mapping. The general distributions of the soil associations are shown in Figure 2-3, and descriptions of the soil series in those associations are provided below.

WORCESTER COUNTY (SCS, 1985)

Winooski-Limerick-Saco Association:

Winooski Series. Very deep; moderately well-drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Limerick Series. Very deep; poorly drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Saco Series. Very deep; very poorly drained; slopes 0 to 3 percent; occurs on floodplains; derived mainly from schist and gneiss.

Hinckley-Merrimac-Windsor Association:

Hinckley Series. Very deep; excessively drained; slopes 0 to 35 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Merrimac Series. Very deep; excessively drained; slopes 0 to 25 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Windsor Series. Very deep; moderately well-drained; slopes 0 to 3 percent; occurs on floodplains.

Paxton-Woodbridge-Canton Association:

Paxton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glacial till uplands; formed in friable till overlying firm till.

Woodbridge Series. Very deep; moderately well-drained; slopes 0 to 15 percent; occurs on glacial till uplands; formed in firm till.

Canton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glaciated uplands; formed in friable till derived mainly from gneiss and schist.

MIDDLESEX COUNTY (SCS, 1991)

Hinckley-Freetown-Windsor Association. The soils at AOC 43G are comprised of this soil type (see Figure 2-3). (This is a continuation of the Hinckley-Merrimac-Windsor Association mapped in Worcester County):

Hinckley Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash terraces, kames, and eskers; formed in gravelly and cobbley coarse textured glacial outwash.

Freetown Series. Deep; very poorly drained; nearly level, organic; occurs in depressions and on flat areas of uplands and glacial outwash plains.

Windsor Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, deltas, and escarpments; formed in sandy glacial outwash.

Quonset-Carver Association:

Quonset Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, eskers, and kames; formed in water-sorted sands derived principally from dark phyllite, shale, or slate.

Carver Series. Deep; excessively drained; nearly level to steep; occurs on glacial outwash plains, terraces, and deltas; formed in coarse, sandy, water-sorted material.

Winooski-Limerick-Saco Association. (This is a continuation of the same association mapped along the Nashua River floodplain in Worcester County).

2.2.6 Surficial Geology

Fort Devens lies in three topographic quadrangles: Ayer, Clinton, and Shirley. The surficial geology of Fort Devens has been mapped only in the Ayer quadrangle (Jahns, 1953) and Clinton quadrangle (Koteff, 1966); the Shirley quadrangle is unmapped.

Unconsolidated surficial deposits of glacial and postglacial origin comprise nearly all of the exposed geologic materials at Fort Devens. The glacial units consist of till, deltaic deposits of glacial Lake Nashua, and deposits of glacial meltwater streams.

The surficial geology at AOC 43G can be placed in the following geologic setting. The till ranges from unstratified gravel to silt, and it is characteristically bouldery. Jahns (1953) and Koteff (1966) recognize a deeper unit of dense, subglacial till, and an upper, looser material that is probably a slightly younger till of englacial or superglacial origin. Till is exposed in ground-moraine areas of the Main Post (such as in the area of Lake George Street) and on the South Post at and south of Whittemore Hill. It also underlies some of the water-laid deposits (Jahns, 1953). Till averages approximately 10 feet in thickness, but reaches 60 feet in drumlin areas (Koteff, 1966).

Most of the surficial glacial units in the Nashua Valley are associated with deposition in glacial Lake Nashua, which formed against the terminus of the Wisconsinan ice sheet as it retreated northward along the valley. Successively lower outlets were uncovered by the retreating glacier, and the lake level was correspondingly lowered. Koteff (1966) and Jahns (1953) recognize six lake levels (stages) in the Fort Devens area, distinguished generally by the elevations and distribution of their associated deposits. The stages are, in order of development: Clinton Stage; Pin Hill Stage; Old Mill Stage; Harvard Stage; Ayer Stage; and Groton Stage.

The glacial lake deposits consist chiefly of sand and gravelly sand. Coarser materials are found in topset beds of deltas built out into the lakes and in glacial stream beds graded to the lakes. Delta foreset beds are typically composed of medium to fine sand, silt, and clay. Lake-bottom deposits, which consist of fine sand, silt, and clay, are mostly covered by delta deposits and are seldom observed

in glacial Lake Nashua deposits. One of the few known exposures of glacial lake-bottom sediments in the region is on the South Post near A- and C-Ranges. There, a section of more than 14 feet of laminated clay was mined for brick-making in the early part of this century (Alden, 1925, pp. 70-71). The general physical characteristics of glacial lake deposits are the same regardless of the particular lake stage in which the deposits accumulated (Koteff, 1966; Jahns, 1953). Although glaciofluvial and glaciolacustrine sediments are typically well stratified, correlations between borings are difficult because of laterally abrupt changes characteristic of these generally high-energy depositional environments.

Postglacial deposits consist mostly of river-terrace sands and gravels; fine alluvial sands and silts beneath modern floodplains; and muck, peat, silt, and sand in swampy areas.

Jahns (1953) also observed a widespread veneer of windblown sand and ventifacts above the glacial materials (and probably derived from them in the brief interval between lake drainage and the establishment of vegetative cover).

2.2.7 Bedrock Geology

Fort Devens is underlain by low-grade metasedimentary rocks, gneisses, and granites. The rocks range in age from Late Ordovician to Early Devonian (approximately 450 million to 370 million years old). The installation is situated approximately 2 miles west of the Clinton-Newbury-Bloody Bluff fault zone, which developed when the ancestral European continental plate collided with and underthrust the ancestral North American plate. The continents reseparated in the Mesozoic to form the modern Atlantic Ocean. Fort Devens is located on the very eastern edge of the ancestral North American continental plate. A piece of the ancestral European continent (areas now east of the Bloody Bluff fault) broke off and remained attached to North America.

Preliminary bedrock maps (at scale 2,000 feet/inch) are available for the Clinton quadrangle (Peck, 1975 and 1976) and Shirley quadrangle (Russell and Allmendinger, 1975; Robinson, 1978). Bedrock information for the Ayer quadrangle is from the Massachusetts state bedrock map (at a regional scale of 4 miles/inch) (Zen, 1983) and in associated references (Robinson and Goldsmith, 1991; Wones and Goldsmith, 1991). Among these sources, there is some

disagreement about unit names and stratigraphic sequence; however, there is general agreement about the distribution of rock types.

In contrast to the high metamorphic grade and highly sheared rocks of the Clinton-Newbury zone, the rocks in the Fort Devens area are low grade metamorphics (generally below the biotite isograd) and typically exhibit less brittle deformation. Major faults have been mapped, however, including the Wekepeke fault exposed west of Fort Devens (in an outcrop 0.25 mile west of the old Howard Johnson rest stop on Route 2).

Figure 2-4 is a generalized summary of the bedrock geology of Fort Devens. It is compiled from Peck (1975), Robinson (1978), Russell and Allmendinger (1975), and Zen (1983), and it adopts the nomenclature of Zen (1983). Because of limited bedrock exposures, the locations of mapped contacts are considered approximate, and the mapped faults are inferred. Rock units strike generally northward to northeastward but vary locally. The bedrock units underlying Fort Devens are as follows:

DSw **WORCESTER FORMATION** (Lower Devonian and Silurian) Carbonaceous slate and phyllite, with minor metagraywacke to the west (Zen, 1983; Peck, 1975). Bedding is typically obscure due to a lack of compositional differences. It is relatively resistant to erosion and forms locally prominent outcrops. The abandoned Shaker slate quarry on the South Post is in rocks of the Worcester Formation. The unit corresponds to the "DSgs" and "DSs" units of Peck (1975) and the "e3" unit of Russell and Allmendinger (1975).

So **OAKDALE FORMATION** (Silurian) Metasiltstone and phyllite. It is fine-grained and consists of quartz and minor feldspar and ankerite, and it is commonly deformed by kink banding (Zen, 1983; Peck, 1975; Russell and Allmendinger, 1975). In outcrop it has alternating layers of brown siltstone and greenish phyllite. The Oakdale Formation crops out most visibly on Route 2 just east of the Jackson Gate exit. It corresponds to the "DSsp" unit of Peck (1975), the "e2" unit of Russell and Allmendinger (1975), and "ms" unit of Robinson (1978). The bedrock at AOC 43G is classified as part of this formation.

Sb **BERWICK FORMATION** (Silurian) Thin- to thick-bedded metamorphosed calcareous metasiltstone, biotitic metasiltstone, and fine-grained metasandstone, interbedded with quartz-muscovite-garnet schist and feldspathic quartzite (Zen, 1983; Robinson and Goldsmith, 1991). In areas northwest of Fort Devens, cataclastic zones have been observed (Robinson, 1978).

Dcgr **CHELMSFORD GRANITE** (Lower Devonian) Light-colored and gneissic, even and medium grained, quartz-microcline-plagioclase-muscovite-biotite, pervasive ductile deformation visible in elongate quartz grains aligned parallel to mica. It intrudes the Berwick Formation and Ayer granite (Wones and Goldsmith, 1991).

AYER GRANITE

Sacgr **Clinton facies** (Lower Silurian) Coarse-grained, porphyritic, foliated biotite granite with a nonporphyritic border phase; it intrudes the Oakdale and Berwick Formations and possibly the Devens-Long Pond Facies (Zen, 1983; Wones and Goldsmith, 1991).

SOad **Devens-Long Pond facies** (Upper Ordovician and Lower Silurian) Gneissic, equigranular to porphyoblastic biotite granite and granodiorite. Its contact relationship with the Clinton facies is unknown (Wones and Goldsmith, 1991). Observations of mapped exposures of this unit on Fort Devens indicate that it may not be intrusive.

Bedrock is typically unweathered to only slightly weathered at Fort Devens. Glaciers stripped away virtually all of the preglacially weathered materials, and there has been insufficient time for chemical weathering of rocks in the comparatively brief geologic interval since glacial retreat.

2.2.8 Regional Hydrogeology

Fort Devens is in the Nashua River drainage basin, and the Nashua River is the eventual discharge point for all surface water and groundwater flow at the installation.

The water of the Nashua River has been assigned to Class B under Commonwealth of Massachusetts regulations. Class B surface water is "designated for the uses of protection and propagation of fish, other aquatic life and wildlife, and for primary and secondary contact recreation" (314 CMR 4.03).

The principal tributaries of the north-flowing Nashua River at Fort Devens are Nonacoicus Brook and Walker Brook on the North Post; Cold Spring Brook (which is a tributary of Nonacoicus Brook) on the Main Post; and Spectacle Brook and Ponakin Brook (tributaries of the North Nashua River), Slate Rock Brook, and New Cranberry Pond Brook on the South Post (see Figure 2-5).

Glacial meltwater deposits constitute the primary aquifer at Fort Devens. In aquifer tests performed as part of the field investigations, measured hydraulic conductivities in meltwater deposits were comparatively high: typically 10^{-3} to 10^{-2} centimeters per second (cm/sec). In till and in clayey lake-bottom sediments, measured hydraulic conductivities were lower and ranged generally from 10^{-6} to 10^{-4} cm/sec. Groundwater also occurs in the underlying bedrock; however, flow is limited because the rocks have no primary porosity and water moves only in fractures and dissolution voids.

Groundwater in the surficial aquifer at Fort Devens has been assigned to Class I under Commonwealth of Massachusetts regulations. Class I consists of groundwaters that are "found in the saturated zone of unconsolidated deposits or consolidated rock and bedrock and are designated as a source of potable water supply" (314 CMR 6.03).

The transmissivity of an aquifer is the product of its hydraulic conductivity and saturated thickness, and as such it is a good measure of groundwater availability. Figure 2-5 shows aquifer transmissivities at Fort Devens, based on the regional work of Brackley and Hansen (1977). Transmissivities in the meltwater deposits range from 10 square feet per day (ft^2/day) to more than 4,000 ft^2/day. Aquifer transmissivities between 10 and 1,350 ft^2/day correspond to potential well yields generally between 10 and 100 gallons per minute (gpm); transmissivities from 1,350 to 4,000 ft^2/day typically yield from 100 to 300 gpm; and where transmissivities exceed 4,000 ft^2/day, well yields greater than 300 gpm can be expected. (Most domestic wells in the area are drilled 100 to 200 feet into

bedrock and yield less than 10 gpm. Higher yields are associated with deeper bedrock wells.)

In Figure 2-5, the zones of highest transmissivity are found in areas of thick glacial meltwater deposits on the North and Main Posts, and these encompass the Sheboken, Patton, and McPherson production wells and the largely inactive Grove Pond well field. The zones of lowest transmissivity are associated with exposed till and bedrock and are located on the Main Post surrounding Shepley's Hill and between Jackson Gate and the parade ground, and on the South Post at Whittemore Hill and isolated areas to the north and west.

A regional study of water resources in the Nashua River basin was reported by Brackley and Hansen (1977). A digital model of overburden and bedrock groundwater flow at Fort Devens is available in a draft final report by Engineering Technologies Associates, Inc. (ETA) (1992) (Figures 2-6 and 2-7).

According to ETA, in the absence of pumping or other disturbances, groundwater recharge occurs in upland areas (e.g., the high ground on the Main Post between Queenstown, Givry, and Lake George Streets (AOC 43G is located in this area of the Main Post), and on the South Post the area around Whittemore Hill). The groundwater flows generally from the topographic highs to topographic lows. It discharges in wetlands, ponds, streams, and directly into the Nashua River. Groundwater discharge maintains the dry-weather flow of the rivers and streams.

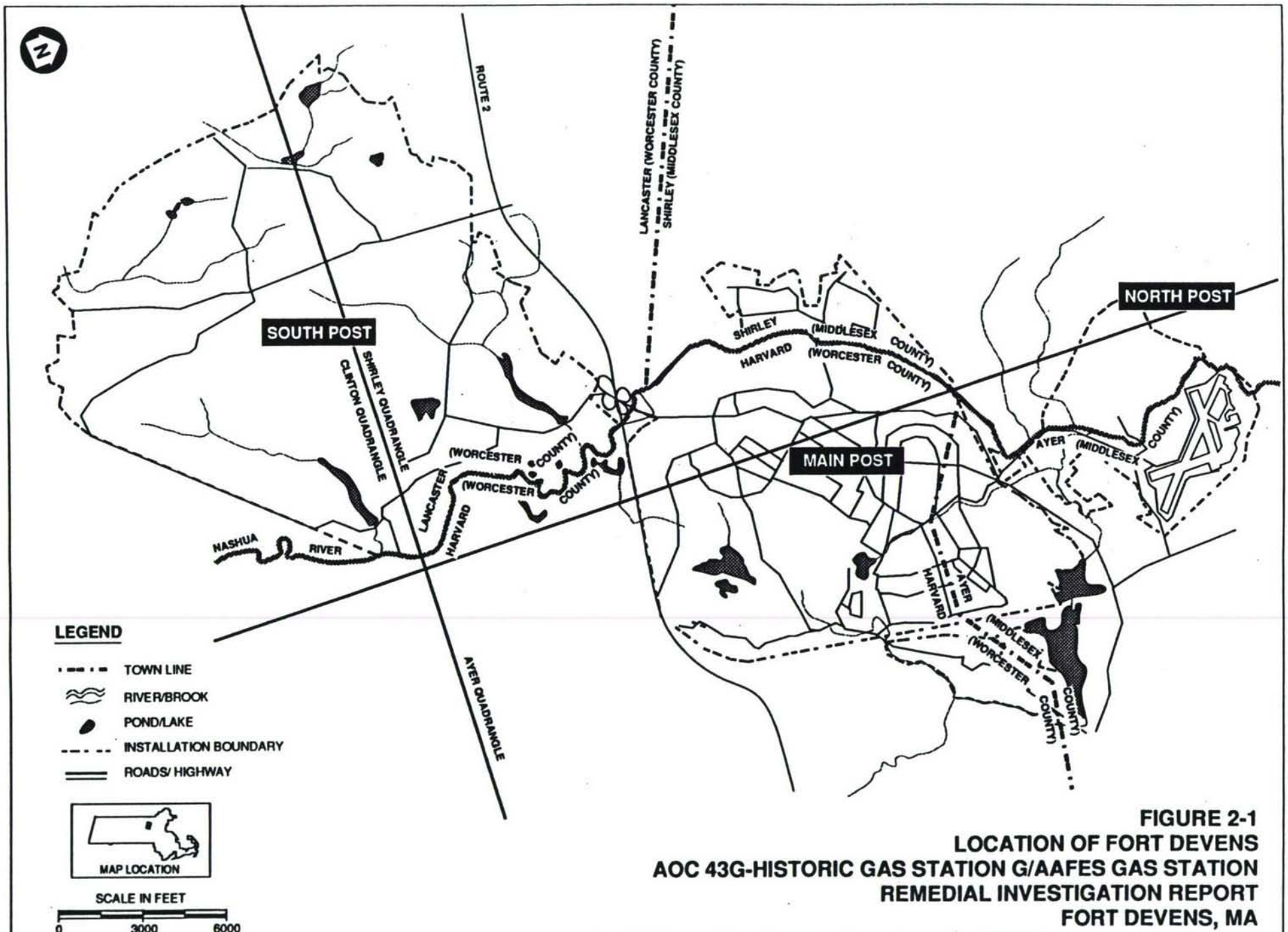


FIGURE 2-1
LOCATION OF FORT DEVENS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

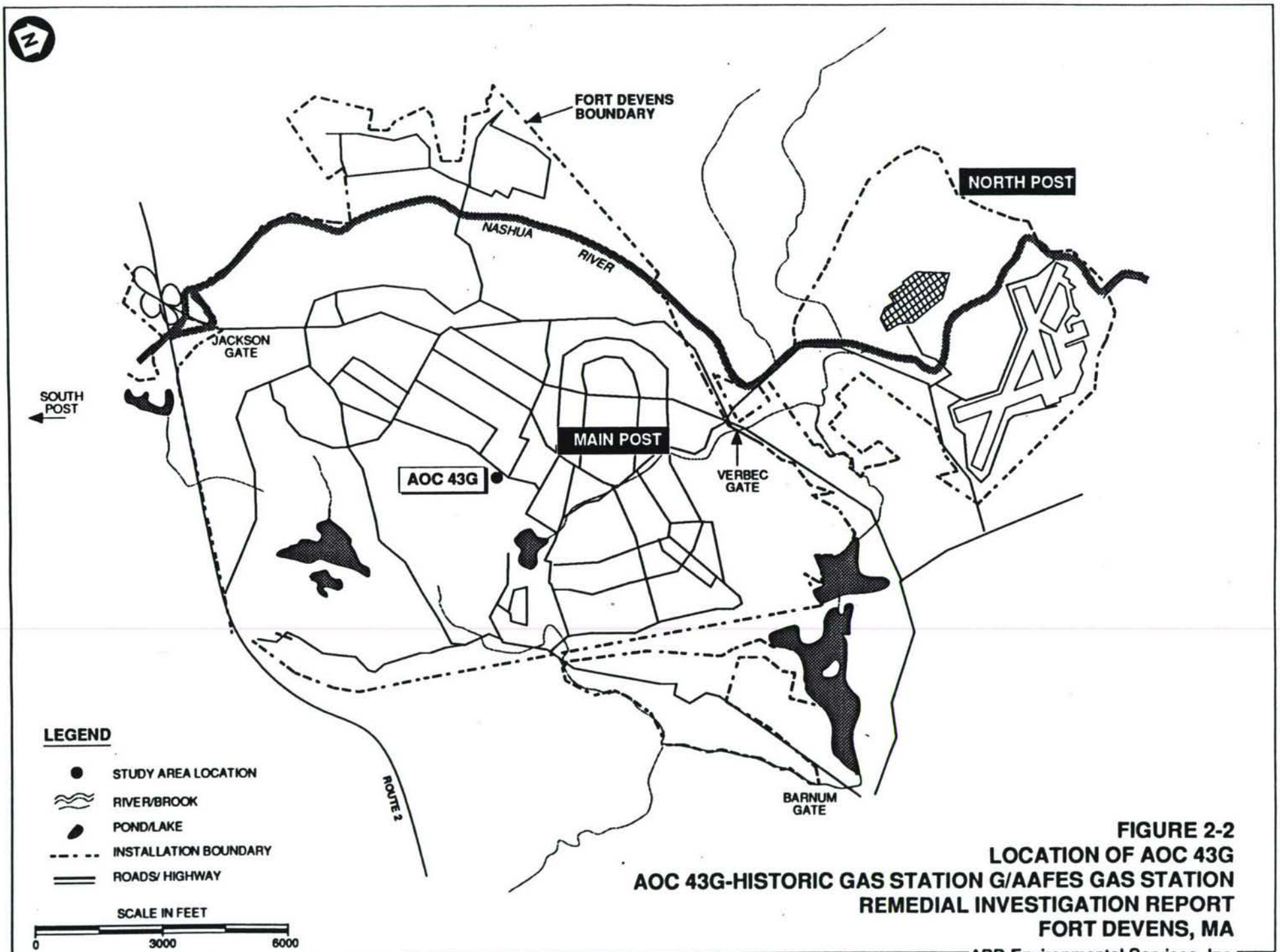


FIGURE 2-2
LOCATION OF AOC 43G
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ABB Environmental Services, Inc.

9505016D/(wm)6

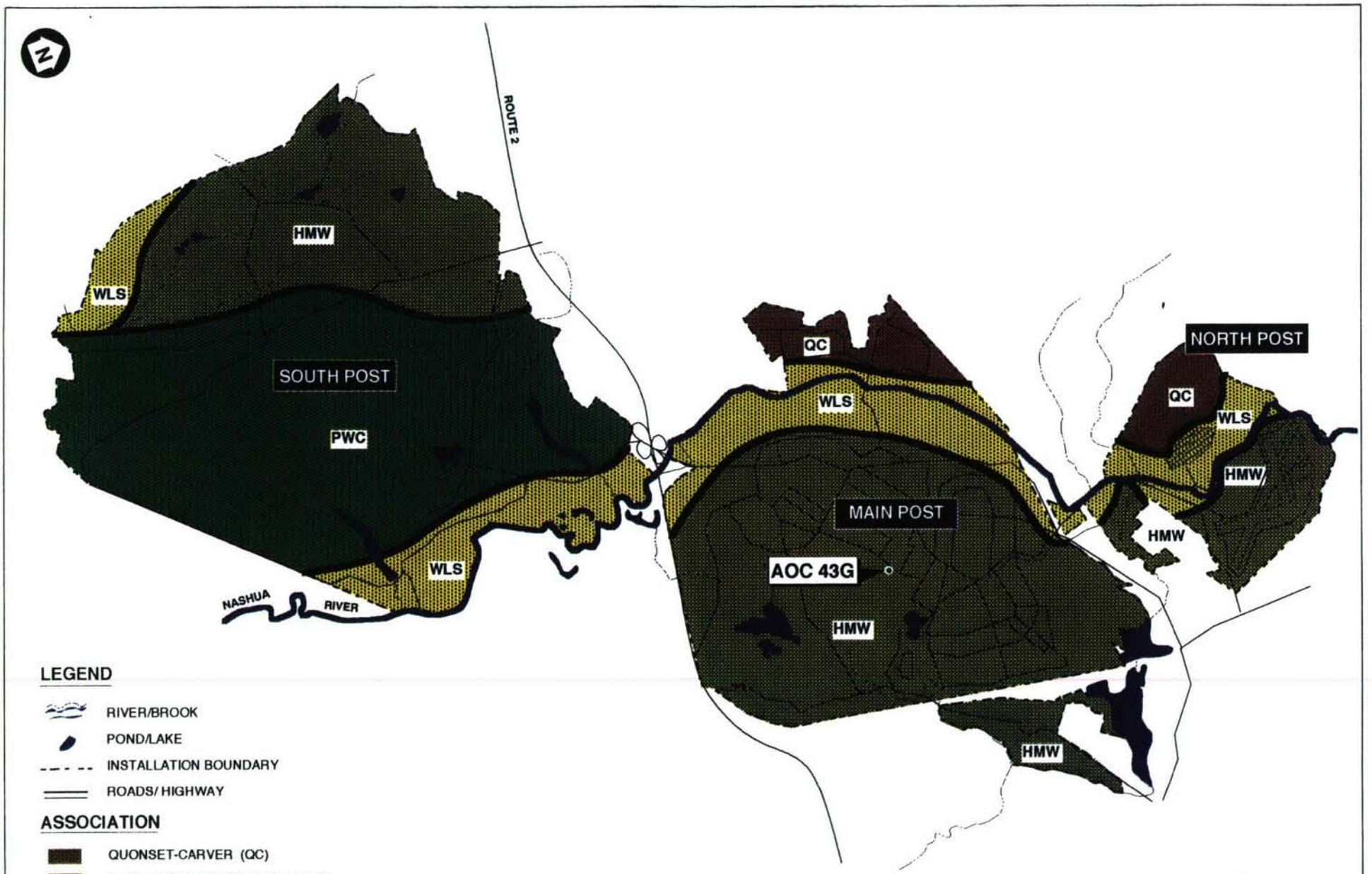


FIGURE 2-3
GENERAL SOILS MAP
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ABB Environmental Services, Inc.

9505016D/(wc)2,2b

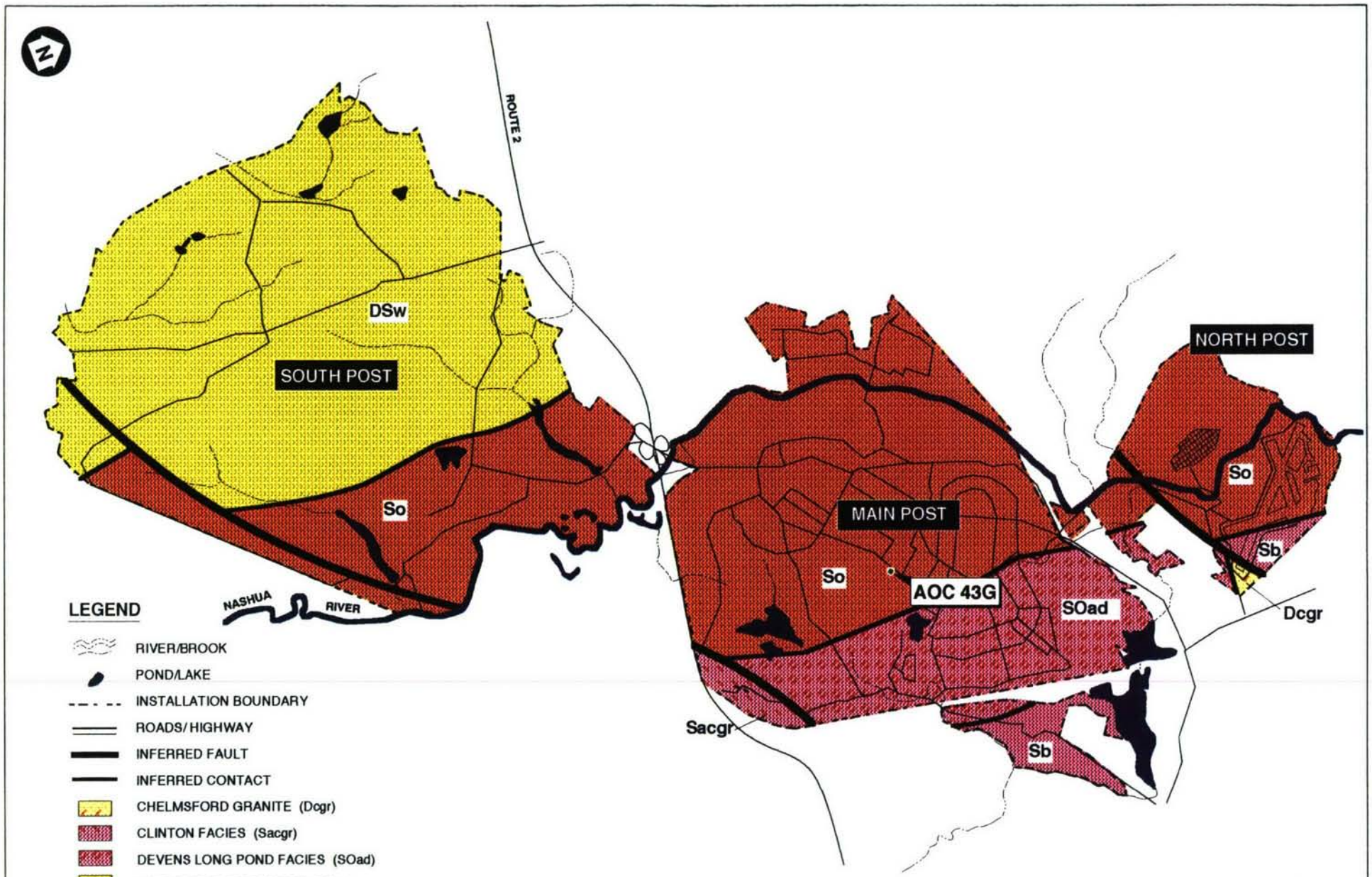


FIGURE 2-4
BEDROCK GEOLOGY
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

9505016D/(wc) A,A2

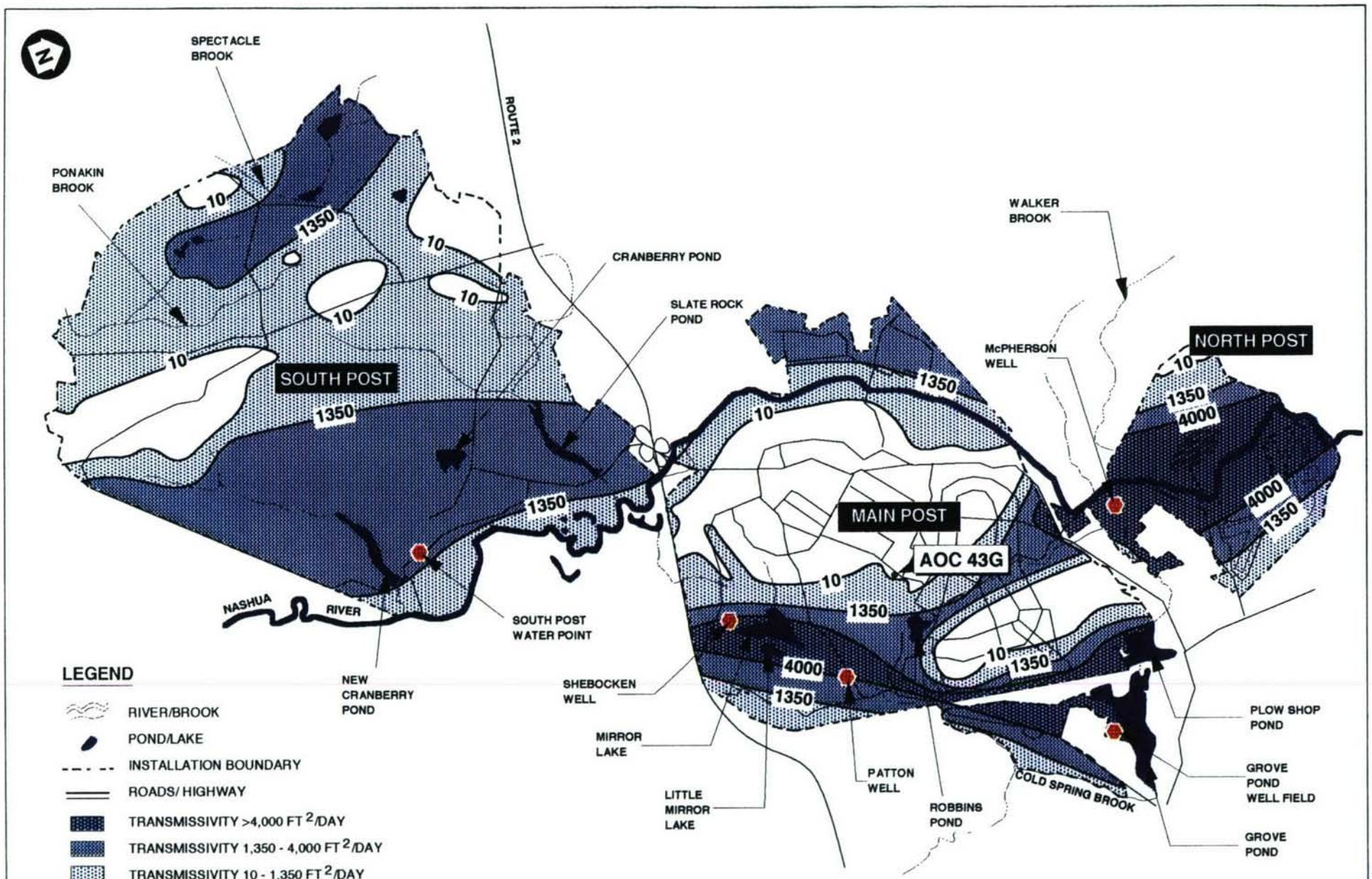
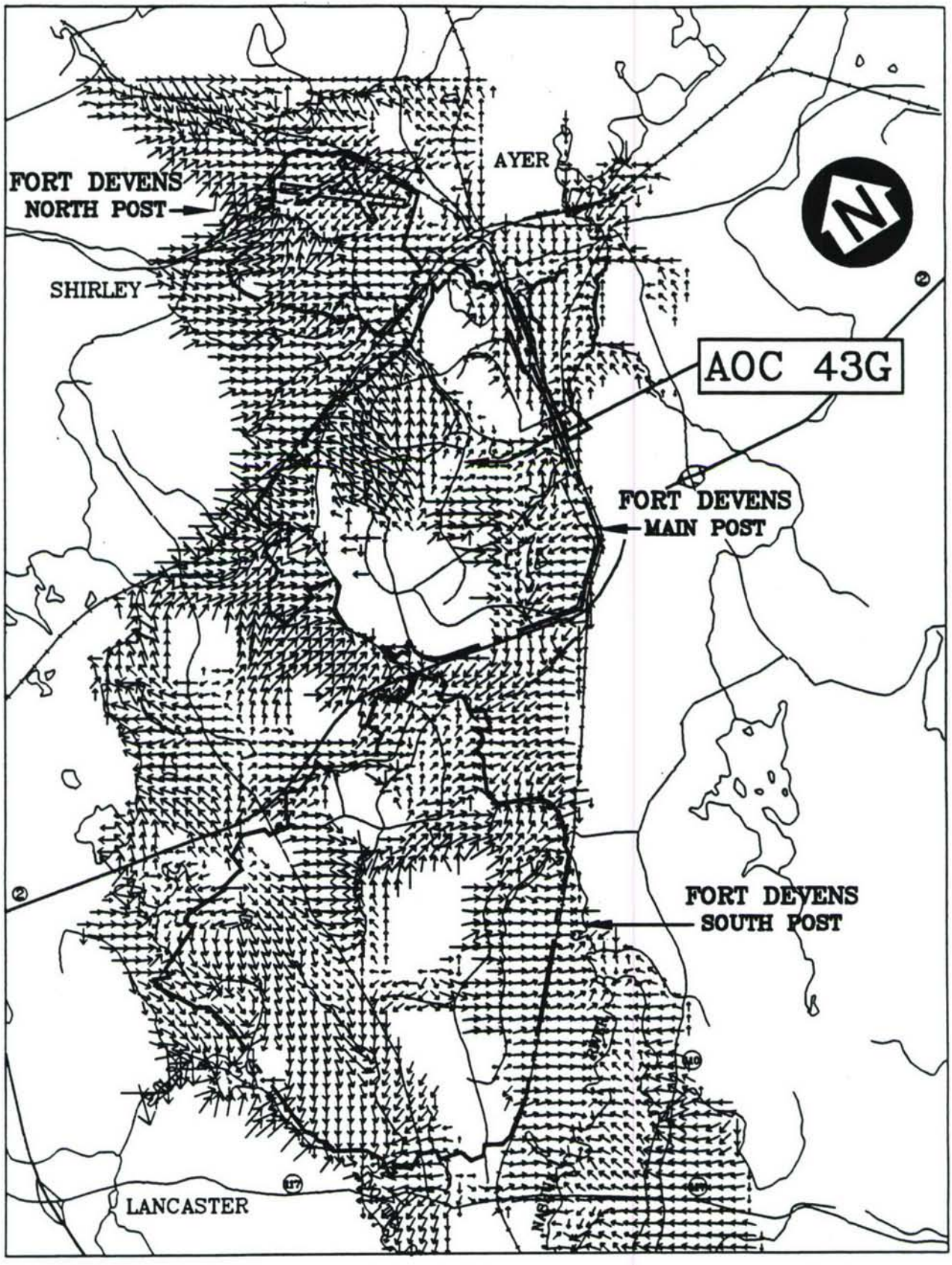


FIGURE 2-5
REGIONAL AQUIFER TRANSMISSIVITIES
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

9505016D/(wc) 3 6a B



SOURCE:
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA, ETA, INC. OCTOBER 30, 1992.

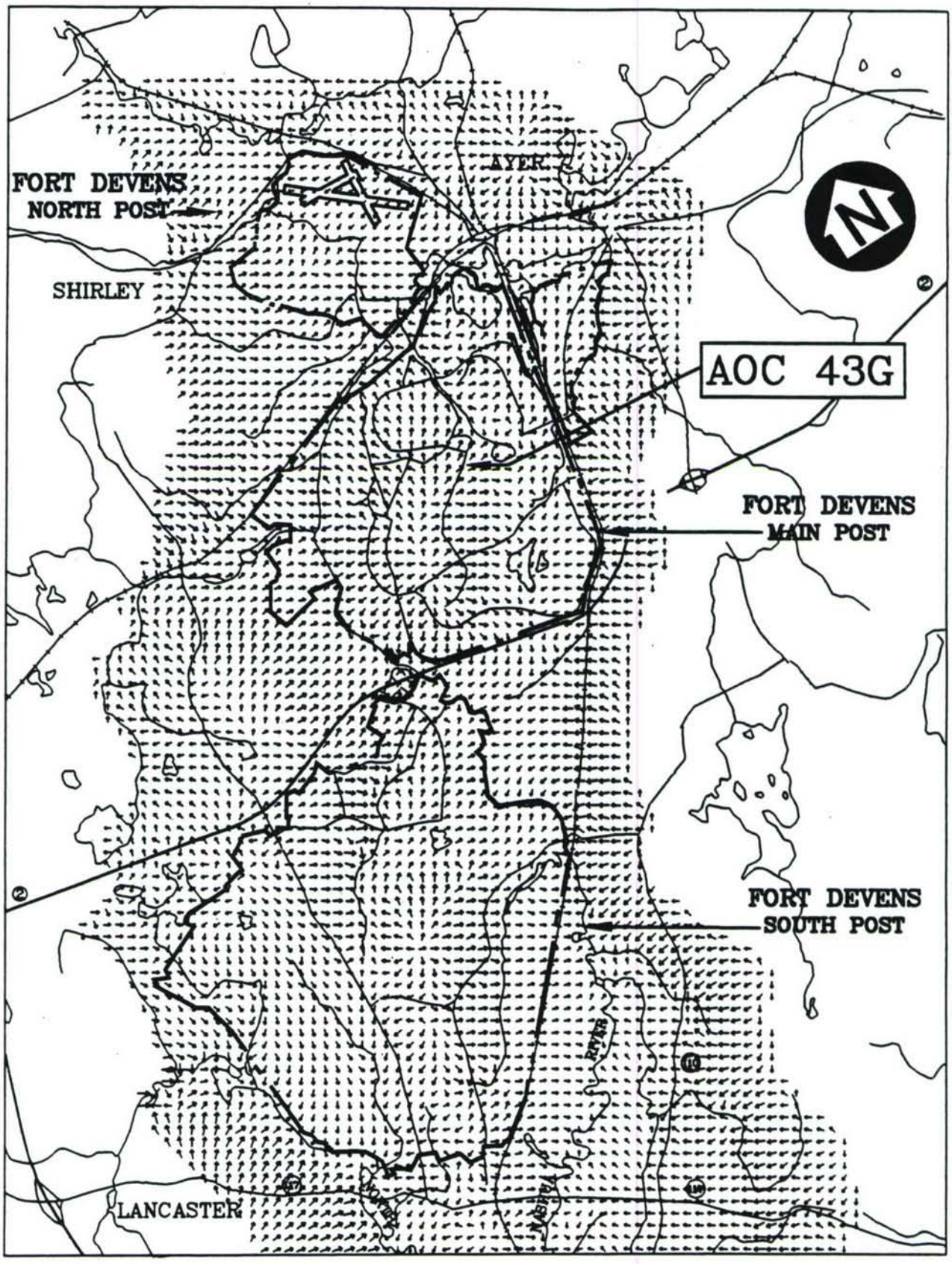
GROUNDWATER FLOW VECTORS

0 3000 6000 12000 FEET

SCALE: 1" =6000'

FIGURE 2-6
REGIONAL OVERBURDEN GROUNDWATER FLOW MAP
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

H:\7053-15\FIGURES\ETAF005.DWG



SOURCE:
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA, ETA, INC. OCTOBER 30, 1992.

GROUNDWATER FLOW VECTORS

0 3000 6000 12000 FEET

SCALE: 1" = 6000'

FIGURE 2-7
REGIONAL BEDROCK GROUNDWATER FLOW MAP
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

H:\7053-15\FIGURES\ETAF006.DWG

3.0 ANALYTICAL PROGRAM

Based on data obtained from previous investigations presented in the Final SI Report for Fort Devens Groups 2 and 7, Data Item A009 (ABB-ES, 1993a) and the Groups 2 and 7 SSI Data Package, (ABB-ES, 1994a), an analytical program was established to identify contaminants that were potentially present due to historic activities at AOC 43G. Contaminants previously identified with AOC 43G are primarily associated with fuel. The analytical program for AOC 43G included field analysis as well as off-site laboratory analyses for a predetermined set of organic and inorganic analytes. The specific analyses implemented for these investigations are discussed in Section 5.0 of this report and in the Revised Final Task Order Work Plan (ABB-ES, 1994b and the Fort Devens POP (ABB-ES, 1993c). The following subsections describe the field and off-site programs implemented for the 1992 through 1994 investigations completed by ABB-ES at AOC 43G.

3.1 FIELD ANALYTICAL METHODS

Samples were analyzed in the field during each phase of the investigation (SI, SSI, and RI) to provide real time chemical data. Soil and groundwater samples from AOC 43G were analyzed for volatile organic compounds (VOCs), and soil samples were also analyzed for total petroleum hydrocarbons (TPHC). Data were primarily used to delineate the distribution of fuel-related contamination in soil and groundwater at and downgradient of this AOC. Target compounds and detection limits for field analysis compounds are outlined in Table 3-1. Sample submitted for field analysis included groundwater from soil borings, and soil taken from TerraProbe℠ points and soil borings.

A Hewlett Packard 5890 Series II gas chromatograph (GC) in series with a Tekmar 3000 purge and trap concentrator was used to measure concentrations of VOCs in the different matrices. Several detectors were used in conjunction with the GC during the three field programs. Detectors included a flame ionization detector (FID), photoionization detector (PID), and electrolytic conductivity detector (ELCD). Target VOCs for AOC 43G measured on the FID and PID included benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene (BTEX).

During the 1994 RI, additional halocarbons were measured on the ELCD including vinyl chloride (VC), c-1,2-dichloroethene, t-1,2-dichloroethene, trichloroethene (TCE), tetrachloroethene (PCE), 1,2-dichlorobenzene, and 1,1,2,2,-tetrachloroethane (1,1,2,2-TCA). Only PCE was identified as target compounds at AOC 43G. The ability to detect these compounds provided additional chemical data about the site.

TPHC analyses for soils collected at AOC 43G during each field investigation were conducted using a Miran Fixed Filter Infrared Spectrophotometer (IR). This method is similar to USEPA Method 418.1. A soil microextraction sample preparation technique was developed for use in a field laboratory. The procedure followed for each program is presented in the following subsection and the Fort Devens POP (ABB-ES, 1995).

3.1.1 Instrument Calibration

For analysis of samples for target compounds using a GC, an initial calibration was established. The initial calibration was accomplished through the analysis of three to five different concentrations of working standards. The response of the instrument to each standard was plotted versus the concentrations of standards to establish a calibration curve. The range of standards used to create the calibration curve was determined by the anticipated range of VOC contamination. A standard that contained all of the ELCD target compounds except VC was used in concentrations of 2, 5, 10, 20 and 40 micrograms per liter (μg/L) to create a calibration curve. The calibration curve for vinyl chloride was created from standard runs of 10, 20, and 40 μg/L. A standard that contained all of the BTEX PID target compounds was used in concentrations of 2, 5, 10, 50, and 100 μg/L to create a calibration curve. Once all points were established on the calibration curve, the linearity was measured using linear regression. The r^2 value, which provided a measure of this linearity, was required to be a minimum of 0.990. No field samples were analyzed until this condition was satisfied.

Prior to analysis of samples, a continuing calibration check standard was analyzed each day to ensure that the response of the instrument had not changed from the initial calibration. The concentration of the check standard was at mid-level in the calibration curve. The initial calibration remained valid if concentrations obtained for the target analytes were no greater than 30% different from values

obtained from the initial calibration. The percent difference was allowed to be greater than 30% for one compound. If continuing calibrations did not meet this criterion, a new initial calibration was created.

The IR used for TPHC analysis was calibrated using seven concentrations of standards prepared from chlorobenzene, hexadecane, and 2,2,4-trimethylpentane as specified in USEPA Method 418.1. Before standards were run, the IR was zeroed with the extraction solvent (freon). A series of standards were run at concentrations covering the working range of the instrument. The instrument response of each standard was recorded. The response factor was calculated for each concentration. The average response factor from the initial calibration was used to convert infrared readings to TPHC concentrations. TPHC instrument response and concentrations were recorded in the instrument logbook and manually entered into the database daily.

3.1.2 Sample Preparation and Analysis

Sample preparation techniques for GC VOCs were adapted from protocols outlined in USEPA Method 5030 and Method 8010/8020 (USEPA, 1986). Soil samples were prepared for field analysis by the measurement of 5 grams into a soil sparger. For water samples, the amount used was 5 mL. Both soil and groundwater samples were loaded onto the purge and trap concentrator. Helium was purged through the sample to carry compounds onto a cold, compound-capturing silica/charcoal trap. The trap was heated to 235°C to liberate volatile compounds into a DB-624 capillary column which was installed in the GC. The capillary column served the purpose of separating out the various compounds. An FID detector was used during the 1992 and 1993 field investigations. For the 1994 RI field analytical program, PID, a Hall, and ELCD detectors were located in series at the end of the column. The amount of time spent in the capillary column (retention time) by each compound was determined by its molecular weight and the temperature program of the GC. A retention time window of +/- 3 percent was used for the identification of target compounds.

TPHC analyses were completed for soil samples during investigations at AOC 43G conducted during 1992, 1993, and 1994. The method used for determination of TPHC was modeled after that specified for USEPA Method 418.1. Soils were prepared for this ABB-ES field TPHC analysis by weighing out 2 grams of the

sample into a test tube. Roughly 2 grams of sodium sulfate were added to the test tube to remove water. After this step was completed, 10 mL of 1,1,2-trichloro-1,1,2-trifluoroethane (freon) was added as the solvent. The freon extracted fuel compounds from the soil. The freon/soil mix was vortexed to ensure mixing. The freon was decanted off and poured into another test tube that contained silica gel. The silica gel was used to remove plant and animal protein oils. Plant and animal protein oils left in the freon extract could have produced false positive readings. The freon/silica gel mix was vortexed to ensure mixing. Freon was decanted from the test tubes into a curvet for TPHC measurement in the IR.

3.1.3 Target Compound Concentrations Calculations

Target VOC concentrations were determined from comparisons of responses of compounds in samples versus responses from standards in the initial calibration curves described in Subsection 3.1.1. TPHC concentrations were obtained by comparison of sample extract responses to responses of various concentrations of standards. Soil and sediment compound concentrations were reported on a dry weight basis. The percent solid fraction of soil samples was determined by drying the samples in an oven. The dry weight of the sample divided by the wet weight provided a solid fraction value. Solid fraction data was used to calculate final VOC and TPHC concentrations. Dilutions performed on both water and soil samples also were used to calculate final VOC concentrations. Dilution factors were calculated for any analysis where sample amounts were modified due to high concentrations of chemicals present in the sample. Samples for VOC analysis were prepared based on procedures outlined in USEPA Method 5030 (USEPA, 1986). Final sample results were calculated by dividing original unadjusted sample results by the fraction of solid and multiplying any result by the dilution factor.

3.1.4 Field Documentation Procedures

Instrument logbooks were completed and maintained for each instrument used during the field analytical programs. A log of all chromatography runs were recorded in these logbooks. A separate logbook was maintained for GC and IR results. The logbooks recorded the concentrations for calibration standards used; instrument maintenance records, percent solid determination data, sample run

number, sample identification (ID), date, standard preparation records, sample volume or weight, and comments or observations of the field chemist. In addition, the results from each GC run were saved into a computerized database.

At the conclusion of field efforts for each investigation, raw data from the GC analyses and instrument logbooks were transferred for storage at ABB-ES's office. Raw data includes chromatograms, quantitation reports, and instrument and notebook records to document analyses.

3.1.5 Field Analytical Quality Control

A QC program for the field analytical results was established prior to commencement of each investigation. Field analysis using an on-site laboratory was conducted during the 1992, 1993, and 1994 field investigation. Each program was developed to ensure that the data generated at the field laboratory was of sufficient quality to be considered satisfactory for its intended use. The QC program for the 1994 RI field analytical program included initial and daily calibration check standard runs, an independent check standard evaluation, mid-level check standards after every ten samples, low-level and mid-level method blanks, cleaning blanks, matrix spikes and field or laboratory duplicates. The QC program that was implemented during the SI in 1992 and the 1993 SSI was identical to the QC program used during the RI field program except that matrix spike and duplicate samples were not analyzed and continuing calibration check standards were only run once per day. QC objectives for the on-site laboratory analyses are outlined in the Fort Devens POP (ABB-ES, 1993b) and Appendix M. QC sample results for the on-site laboratory are discussed in Appendix D.

Instruments were calibrated using initial calibration procedures outlined in Subsection 3.1.1. Daily calibration checks were completed to ensure that the response of the detectors on the GC did not change significantly enough to compromise reported concentrations. If the reported concentration was greater than 30 percent different from the actual concentration for all but one of the target compounds then a new calibration curve was established.

Beginning in the 1994 RI, an independent check standard was prepared from standards of the VOC target compounds obtained from a different chemical

supplier than those that were used to prepare working standards. The purpose of completing analysis of this standard was to determine the analytical precision of the method and to confirm that there was good precision in the preparation of the standards. A mid-level concentration of this standard was analyzed and compared to the calibration curve established using the working standard. The concentrations of the target compounds from the independent check standard were required to be within 30 percent of the mid-point concentration established using the working standard. Results from the independent check standard analysis are contained in Appendix D.

Method blanks were analyzed daily to document that the analytical system was free of contamination. Samples were not run if the there were any target compounds detected above the Practical Quantitation Limit (PQL) in the method blank. In addition to the low-level method blank, a mid-level method blank was run in instances where methanol extractions were necessary. One hundred microliters of methanol were added to deionized water and analyzed to ensure that it was free of contamination.

During VOC GC analyses, cleaning blanks were run at the beginning of each day to show that the analytical system was clean. They were also run after particularly heavily contaminated samples were run through the GC.

During the 1994 RI program, matrix spikes were analyzed to determine if the soil or water matrix had any influence in retarding or enhancing the concentrations of target compounds. A sample was first run to determine baseline values of the target compounds. A known concentration of a mix of the target compounds was added to a sample and analyzed as a regular sample. The reported concentrations were adjusted by subtracting the baseline concentration of a particular analyte that was measured in the sample before it was spiked. This result was then divided by the actual concentrations at which analytes were spiked and multiplied by 100 to calculate the percent recovery. Matrix spikes results for 1994 RI field analyses are presented in Appendix D.

For VOC analyses, a surrogate was added to every sample to determine if the matrix was having an effect on the recovery of the target compounds. The surrogate used for all field investigations was 4-Bromofluorobenzene. This surrogate was used because it is chemically similar to the target compounds and

responds well on the detectors selected for the field programs. Surrogate recoveries had to be from 30 percent to 170 percent to be considered acceptable. Samples for which the surrogate did not meet this criteria were reanalyzed.

Field duplicate samples were also analyzed to determine the precision of sampling and analytical techniques. Reported concentrations of target compounds for each sample and associated duplicate pair were compared by calculating the relative percent difference (RPD) of the results. RPDs were compared to criteria from USEPA Region 1 validation guidelines to evaluate the precision of measurements. Duplicate results for the 1994 RI are presented in Appendix M.

3.1.6 Method Detection Limits and Data Qualifiers

Method Detection Limits (MDLs) were established during the 1994 RI for both the ELCD and PID detector. MDLs were also established for the FID during the SSI completed in 1993. The MDL study was completed for all VOC target compounds to provide data to support the PQLs established for the various field programs. MDLs were calculated based on procedures published in CFR Appendix B Part 136, vol. 49, no. 209. The MDL study provides an estimation of the lower concentration limit of what the detectors were able to measure. The MDL is defined as the maximum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. They were determined by running seven consecutive runs of a premixed standard at a concentration believed to be near the threshold of detection. The concentration used for all target compounds in the MDL study was 2 μg/L.

Once the seven low concentration runs of the standard were completed, the mean and standard deviation were calculated for the area counts reported by the instrument. These values were inserted into the equation below to determine the MDL.

$$MDL = \frac{\textit{standard deviation of peak area } x \text{ 3.14 } (\textit{student t number for 7 runs})}{\textit{mean peak area}}$$

The MDLs obtained during the 1994 RI field analytical program are presented in Table 3-1.

MDLs were also established during the SSI completed in 1993 for benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene. The MDLs obtained in 1993 using the FID detector ranged from 0.08 to 0.09 μg/L.

PQLs were established to provide a margin of error from the MDL since the MDL identifies the threshold concentration of what the detector was capable of measuring. MDLs were conducted during the SSI and RI phases to provide a high level of data quality and defendability of field analytical results. PQLs were the same for the 1992, 1993, and 1994 programs (see Table 3-1). PQLs were used as reporting limits for field sample results during the 1994 RI. In the 1993 SSI, MDLs served as reporting limits.

In some instances, data qualifiers were used to address data quality issues associated with a particular sample. The following qualifiers were used during site and remedial investigations at Fort Devens:

E - Denotes target compound concentrations that exceeded the highest standard of the calibration curve.

U - Denotes sample concentrations that are less than PQLs or MDLs.

Results of the on-site sample analysis are presented in discussions of the nature and distribution of site contaminants presented in Section 7.0 of this report.

3.2 OFF-SITE LABORATORY ANALYTICAL PARAMETERS

Soil and groundwater samples collected from AOC 43G were analyzed at an off-site laboratory for chemical parameters on the Fort Devens Project Analyte List (PAL). Off-site laboratory analyses for PAL organics and inorganics were considered approximately equivalent to USEPA Level III quality data. The Fort Devens PAL and laboratory methods are presented in the Fort Devens POP (ABB-ES, 1993e) and Appendix K.

The laboratories performing the analytical work for all AOC 43G investigations used the 1990 USATHAMA (now USAEC) QA Program (USATHAMA, 1990). All method performance demonstration, data management, and oversight for previous USATHAMA analytical procedures are currently performed by the USAEC.

The off-site laboratory contracted to implement the analytical program for all phases of investigation at AOC 43G was Environmental Science and Engineering (ESE). This laboratory was approved to complete analyses using USATHAMA and USEPA methods. These analyses were completed while implementing the 1990 USATHAMA QA Program. Specific performance demonstration and QC components of the 1990 USATHAMA QA Plan are detailed in Subsection 3.2.3 of this report.

The following subsection describes the procedures implemented to achieve the objectives of the QA program and any additional quality control processes implemented during the SI, SSI and RI.

3.2.1 Off-Site Laboratory Certification

In accordance with the 1990 USATHAMA QA Program, laboratories were required to demonstrate competency by performance demonstration of the PAL analytical methods conducted in association with field investigations. The USAEC requires that a laboratory demonstrate proficiency in performing USAEC methods for specific analytes. Analytical methods are based on USEPA procedures (USEPA 1986; USEPA 1983). Laboratories demonstrate proficiency by submitting data from runs of USAEC pre-certification calibration standards. The true concentrations of the analytes in the performance samples are unknown by the laboratory. The data obtained from the analyses of these samples are then sent to the USAEC to determine the laboratory precision and accuracy. Qualifications to perform USAEC methods are awarded to laboratories based on this performance. Certified Reporting Limits are also determined through this process. A method code associated with each USAEC analysis and laboratory is then assigned and reported with the results.

For some methods such as alkalinity, total organic carbon (TOC), TPHC, and total suspended solids (TSS), there are no associated USAEC methods. The

USAEC recognizes standard USEPA protocols or internal laboratory methods for these analyses. Laboratories are required to submit information on procedures for analyzing samples using these methods to the USAEC Chemistry Branch before they are implemented.

3.2.2 Off-Site Laboratory Methods Quality Control

All field samples sent to ESE were organized into lots which were assigned a three digit code using letters of the alphabet. Each lot consisted of the maximum number of samples, including QC samples that can be processed through the rate limiting step of the method during a single time period (not exceeding 24 hours). Associated with each lot were laboratory control samples. Control samples were spikes of high and low concentrations of specific analytes that help monitor ESE's precision and accuracy. The recoveries of these spikes were plotted on control charts generated by the laboratory and submitted to the USAEC. Data generated during the performance demonstration process were used to calculate a mean of the recoveries. Control and warning limits were statistically generated by the USAEC Chemistry Branch to help measure laboratory data quality. Control charts are generated with each lot providing a continuous benchmark for trend evaluation of laboratory performance.

Method blanks were also analyzed at ESE to evaluate the potential for target analytes to be introduced during the processing and analysis of samples. One method blank was included with each analytical lot. Because analytical lots included samples from several areas, method blank results are presented and discussed by year of investigation for AOCs 43G in Appendix D. Only method blank data associated with samples from these AOCs were used for the QC report.

3.2.3 Data Reduction, Validation, and Reporting

Initial responsibility for accuracy and completeness of Fort Devens analytical data packages was with ESE. All data submissions to the USAEC first underwent a review process. This review included checks on the data quality which evaluated completeness of the ESE data, accuracy of reporting limits, compliance with QC limits and holding times, and correlation of ESE data to associated laboratory tests.

The following items were also validated by ESE before submission to the USAEC:

- chain of custody records;
- instrument printouts for agreement with handwritten results;
- calibration records to ensure a particular lot is associated with only one calibration;
- chromatograms and explanations for operator corrective actions (such as manual integrations);
- standard preparation and documentation of source;
- calculations on selected samples;
- notebooks and sheets of paper to ensure all pages were dated and initialed, and explanations of procedure changes;
- GC/MS library search of unknown compounds; and
- transfer files and records to ensure agreement with analysis results.

To document the data review and validation process, a data-review checklist was submitted as part of each data package.

3.2.4 Data Reporting

After review and validation by ESE, the data were encoded for transmission into the USAEC's Installation Restoration Data Management Information System (IRDMIS) as Level 1 data. IRDMIS, a computerized data management system used by the USAEC, is described in detail in Subsection 3.3. Once the data were entered into the system, a group and records check was completed. Data were then transferred to USAEC's data management contractor. During this phase, the data were elevated to Level 2. Another group and records check was performed and the data were reviewed by the USAEC Chemistry Branch. When errors

were identified, the data were returned to ESE for correction. Control charts were produced by ESE that plotted recoveries of high and low concentrations of laboratory control spikes of the target analytes. The control charts provided the USAEC with information about the accuracy of the analytical methods performed by ESE. Once data were reviewed by the USAEC Chemistry Branch, the determination was made on a lot-by-lot basis whether the data were acceptable. The data that were accepted were then elevated to Level 3 and made available to USAEC personnel and ABB-ES by modem to a main frame computer. Off-site results are presented in Section 7.0 and Appendix M.

3.2.5 Field Quality Control Samples

Field QC samples collected during various investigations conducted at AOC 43G included a field blank (source water), matrix spikes/matrix spike duplicates, field duplicate samples, rinse blanks and trip blanks.

Before field investigations were initiated at AOC 43G, a sample of water was collected from the source which was used for sampling equipment decontamination. The water source used for each field investigation at AOC 43G was the South Post Water Point (Well D-1). For the purpose of laboratory QC, this was identified as the field blank (source water sample). The field blank data were sent to the USAEC Chemistry Branch where approval was granted for the use of this water in decontamination procedures. The information gained from the analysis of the field blank provided data on the quality of the USAEC-approved water used in the decontamination of the sampling equipment. Field blank data were also used to explain the presence of certain analytes or compounds in rinse blanks. Several field blanks were collected from 1992 to 1994. All field blank data are discussed with the 1992 QC data in Appendix D.

As specified in the Fort Devens POP, (ABB-ES, 1993c), matrix spike/matrix spike duplicates (MS/MSDs) were spiked and analyzed for PAL inorganics, explosives, and pesticides/polychlorinated biphenyl (PCBs). ABB-ES personnel made the determination of which samples were to be designated as MS/MSDs. This was noted on the COC forms submitted to ESE. Samples designated as MS/MSDs were spiked at the laboratory with specified analytes to determine matrix effects based on USAEC and USEPA method guidelines. MS/MSD data were also used to assess the accuracy of the analyses used. MS/MSD samples were collected at a

rate of one set per 20 samples. During the Fort Devens field investigations, samples were collected from multiple SAs or AOCs. After the twentieth sample was collected, a sample from any SA may have been designated for MS/MSD analysis. The MS/MSD samples were collected and analyzed at the specified frequency program-wide and not for specific SAs or AOCs. Therefore, assessments of MS/MSD data contained in Appendix D were not made specifically for AOC 43G but are discussed by year for AOCs 43J, 43G, and 41 collectively.

Field duplicate samples were also collected at a rate of one per 20 field samples. The purpose of duplicate sample analysis was to assess the sampling and off-site laboratory precision for particular methods. Since several SAs or AOCs were investigated simultaneously during each field effort, designations for duplicate samples covered multiple SAs or AOCs. Duplicate data available for AOCs 43G, 43J, and 41 were assessed collectively by year of investigation. Duplicates submitted to ESE were analyzed for the same compounds as the corresponding field samples. Duplicate sample results are presented in Appendix D.

Rinsate blanks were collected and analyzed for PAL analytes. Rinsate blanks consisted of previously analyzed deionized water which was poured over sampling equipment. Analysis of this water provided information used to evaluate the potential for sample contamination during sample collection. The results were also used to assess decontamination of the sampling equipment. As specified in the Fort Devens POP (ABB-ES, 1993c), rinsate blanks were collected at a rate of one per 20 samples. Rinsate blank data associations were not made specifically for AOC 43G. Rinsate blanks which were shipped with any samples from AOCs 43G, 43J, or 41 were included in the data quality reports. Therefore, the discussions regarding rinsate blank contamination are relevant to all three AOCs rather than one specific AOC. Rinsate blank results were segregated by year of investigation and are presented in Appendix D.

For every shipment of VOC samples to ESE, there was an accompanying pair of trip blanks that traveled with the samples. The purpose of analyzing trip blanks was to determine if there was potential for VOC cross contamination during the shipment and handling of samples. The trip blanks consisted of previously analyzed deionized water that was bottled at ESE. Trip blanks were shipped in sealed containers to the job site. As needed, trip blanks were then included with

shipments of VOC field samples. Since many of these VOC field samples were taken from various AOCs there is no association of trip blank data specifically to AOC 43G. Data were included for trip blanks sent with any samples from AOCs 43G, 43J, and 41. Trip blank assessments were separated by the year of investigation. All trip blank data are presented in Appendix D.

3.2.6 Off-Site Analytical Data Quality Evaluation

Laboratory data collected during the three investigations at AOC 43G were evaluated for possible laboratory or sampling-related contamination. This evaluation did not include validation by USEPA guidelines. Sample results reported and discussed in this report were not adjusted for reported analytes that were also detected at similar concentrations in blanks associated with that sample; action levels were not established, and the 10X rule was not applied to compounds considered by the USEPA to be common laboratory contaminants. Examples of these contaminants include the VOCs acetone, methylene chloride, 2-butanone, and the SVOCs bis (2-ethylhexyl)phthalate (BEHP) and di-n-butylphthalate. Likewise, action levels for other analytes using the 5X rule application were not established. Analytes which would have been below these action levels were not removed from the data as they would have been in the USEPA validation process.

General trends relating to blank and sample contamination were examined. Comparison of blank data with results from the entire data set are discussed as a data assessment. Assessments are made based on analyte detection in blanks, the frequency of the detection and the concentrations of these analytes. A summary of blank contamination was completed and is presented in Subsection 7.1.2 of this report.

3.3 CHEMICAL DATA MANAGEMENT

Chemical data from the AOC was managed by ABB-ES' Sample Tracking System and the USAEC's IRDMIS. These systems are described in the following sections.

3.3.1 Sample Tracking System

ABB-ES employed its computerized Sample Management System to track environmental samples from field collection to shipment to the off-site laboratory. ABB-ES also tracked the status of analyses and reporting by the off-site laboratory.

Each day the field sampling teams carried computer-generated sample labels into the field that stated the sample control number, sample identification, size and type of container, sample preservation summary, analysis method code, and sample medium. The labels also provided space for sampling date, time, depth (if applicable), and the collector's initials to be added at the time of collection.

After collection in the field, the samples were stored on ice for transport to the ABB-ES field office. Samples were temporarily stored in the ABB-ES field office refrigerator. They were checked-in on the field office computer, and the collector's initials and the sampling date and time were entered. The system would then indicate the sample status as "COLLECTION IN PROGRESS."

When the samples were prepared for shipment, they were "RELEASED" by the sample management system. Upon request, the system printed an Analysis Request Form (ARF) and a COC, which were signed and included with the samples in the shipment. The system would then indicate the sample status as "SENT TO LAB."

This system substantially reduced the time required for preparation of sample tracking documentation, and it provided an automated record of sample status.

After shipment of samples to the off-site laboratory, ABB-ES continued to use the sample tracking system to track and record the status of the samples, including the date analyzed (to determine actual holding times), the date a transfer file was established by ESE, and the date the data were sent to IRDMIS (Subsection 3.3.2)

3.3.2 Installation Restoration Data Management Information System

IRDMIS is an integrated system for collection, validation, storage, retrieval, and presentation of data of the USAEC's Installation Restoration and Base Closure Program. It uses personal computers (PCs), a UNIX-based minicomputer, printers, plotters, and communications networks to link these devices.

For each sample lot, ABB-ES developed a "provisional" map file for the sample locations, which was entered into IRDMIS by Potomac Research, Inc. (PRI), USAEC's data management contractor.

Following analysis of the sample lot, ESE created chemical files using data codes provided by ABB-ES, and entered the analytical results (Level 1) on a PC in accordance with the User's Manual (PRI, 1993). For each sample lot, a hard copy was printed and was reviewed and checked by ESE's Laboratory Program Manager. ESE created a transfer file from accepted records which was sent to ABB-ES (Level 2). ABB-ES performed a group and record check and sent approved records in a chemical transfer file to PRI. PRI checked the data and, if accepted, entered it into the IRDMIS minicomputer (Level 3). Level 3 chemical data are the data used for evaluating site conditions and are the data used in this AOC 43G RI report and risk assessment.

TABLE 3-1
1994 FIELD ANALYTICAL MDLs and PQLs FOR TARGET COMPOUNDS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Compound	Year	MDL (ug/L)	PQL (ug/L; ug/kg)
Vinyl Chloride	1994	2.07	4.0
t-1,2-Dichloroethene	1994	0.19	2.0
c-1,2-Dichloroethene	1994	0.15	2.0
TCE	1994	0.19	2.0
PCE	1994	0.19	2.0
1,1,2,2-TCA	1994	2.1	4.0
1,2-Dichlorobenzene	1994	0.23	2.0
Benzene	1992-1994	0.22	2.0
Toluene	1992-1994	0.19	2.0
Ethylbenzene	1992-1994	0.16	2.0
m/p-Xylene	1992-1994	0.33	2.0
o-Xylene	1992-1994	0.18	2.0

4.0 IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

CERCLA was enacted by Congress in 1980, establishing the Superfund program. The regulations implementing this program are found in 40 CFR Part 300, also known as the National Contingency Plan (NCP). CERCLA was amended in 1986 by the SARA which mandated that the level or standard of control specified in a remedial action be "at least that of any ARAR standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent standard, requirement, criteria or limitation promulgated pursuant to a state environmental statute." SARA established that the requirements of the NCP apply to federal facilities.

The purpose of the RI was to determine the nature and distribution of site-related soil and groundwater contamination at AOC 43G. In order to evaluate whether there is a potential threat to human health and the environment, the preliminary ARARs are identified in this section and will then be compared to the site-specific data. ARARs are federal and state human health and environmental requirements used to (1) evaluate the distribution of site impacts and the appropriate extent of site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the final remedy.

Identification and evaluation of ARARs is an iterative task, necessary throughout the remedial response process. Therefore, the preliminary lists of requirements identified for AOC 43G and their relevance may change as more information is obtained, as the preferred alternative is chosen, and as the design and approach to remediation becomes more refined.

Applicable Requirements - Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site. An example of an applicable requirement is the use of the Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) drinking water standards for a site where groundwater impacts have affected a public water supply.

Relevant and Appropriate Requirements - Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site. For example, MCLs for drinking water would be relevant and appropriate requirements at a site where groundwater impacts could affect a potential, rather than actual, drinking water source. When a requirement is found to be relevant and appropriate, it is complied with to the same degree as if it were applicable.

To be Considered (TBC) Material - TBCs are non-promulgated advisories or guidance issued by the federal and state government, are not legally binding, and do not have the status of potential ARARs. However, in many circumstances, TBCs will be considered along with ARARs as part of the site risk assessment and may be used in determining the level of cleanup for protection of human health or the environment.

ARARs that pertain to the remedial response can be classified into three categories: chemical-, location-, and action-specific. The following subsections provide an overview of these ARARs.

4.1 CHEMICAL-SPECIFIC ARARS

Because of their site-specific nature, the identification of ARARs requires an evaluation of the federal, state, and local environmental regulations with respect to chemicals of concern and site characteristics.

Chemical-specific ARARs generally involve health- or risk-based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts. These values are used to develop action levels or cleanup concentrations.

4.1.1 Groundwater

Table 4-1 sets forth the federal chemical-specific ARARs and TBC information for groundwater. The USEPA SDWA MCLs are legally applicable to contaminants found in public water systems that have at least 15 service connections or serve an average of at least 25 people daily at least 60 days per year. Even when not legally applicable, MCLs may be relevant and appropriate to groundwater remediation. Maximum contaminant level goals (MCLGs) are non-enforceable, health-based goals at which no known or anticipated adverse effects on health will occur. Table 4-1 also includes the USEPA Region III risk-based concentrations (RBCs) which are commonly used as TBC information at CERCLA sites nationwide.

The groundwater/surface water criteria set forth in Table 4-1 will only be applicable if a discharge to surface water will be part of the groundwater remedial action (which is not expected).

Table 4-2 sets forth the state chemical-specific ARARs and TBC information for groundwater. The Commonwealth of Massachusetts has adopted drinking water standard and guidelines, expressed in terms of maximum levels of contaminants allowed in drinking water. Groundwater data from AOC 43G will be applied to Massachusetts Maximum Contaminant Levels (MMCLs), Massachusetts Class I groundwater quality standards, and/or USEPA Region III RBCs for tap water.

4.1.2 Soil

Table 4-3 sets forth the soil screening levels from the USEPA Region III RBC documents.

4.1.3 Massachusetts Contingency Plan

The NCP provides that CERCLA response actions must comply with environmental and public health laws and regulations to the extent they are substantive (i.e., pertain directly to actions or conditions in the environment), but do not need to comply with those that are administrative (i.e., mechanisms that facilitate the implementation of the substantive requirements).

The provisions of the MCP, 310 CMR 40.0000 (January 13, 1995) are mostly administrative in nature and, therefore do not have to be complied with in connection with the response action selected for AOC 43G. Further, the MCP contains a specific provision (310 CMR 40.0111) for deferring application of the MCP at CERCLA sites. As stated in the MCP, response actions at CERCLA sites are deemed adequately regulated for purposes of compliance with the MCP, provided the MADEP concurs in the CERCLA Record of Decision.

However, some provisions of the MCP contain substantive requirements that may be ARARs. Section 310 CMR 40.0940 sets forth three methods of risk characterization. Section 310 CMR 40.0942 provides that any of the three methods may be used, subject to certain specified limitations. MCP Method 1 establishes specific numerical standards for certain listed contaminants (see 310 CMR 40.0974-.0975). Because MCP Method 1 contains promulgated numerical standards, it may be an ARAR if this method is selected.

MCP Method 3 does not contain substantive numerical standards; rather it provides a risk characterization methodology to determine the appropriate cleanup level (see 310 CMR 40.0991-.0996). Because MCP Method 3 is a methodology and does not contain substantive standards, and because it defines protectiveness in a way that is inconsistent with the CERCLA NCP, Method 3 is not an ARAR which has to be met. Therefore, these standards of the MCP do not apply to the remedial response at AOC 43G.

4.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs represent restrictions placed on the concentration of hazardous substances or the conduct of activities because of the location or characteristics of a site. These ARARs set restrictions relative to special locations such as wetlands, floodplains, sensitive ecosystems, as well as historic or archeological sites, and provide a basis for assessing existing site conditions. Table 4-4 presents a preliminary overview of location-specific federal and state requirements.

Some of the location-specific ARARs for areas such as wetlands and floodplains may or may not be applicable, or relevant and appropriate, depending on the

remedial action selected, because the regulations do not apply unless some activity is conducted in a certain defined area.

4.3 ACTION-SPECIFIC ARARS

Action-specific ARARs involve design, implementation, and performance requirements that are generally technology- or activity-based. Action-specific ARARs, unlike location- and chemical-specific ARARs, are usually technology- or activity-based limitations that direct how remedial actions are conducted. After remedial alternatives are developed, the evaluation of action-specific ARARs is one criteria for assessing the feasibility and effectiveness of proposed remedial alternatives. The applicability of this set of requirements is directly related to the particular remedial activities selected for the site. Table 4-5 represents an overview of potential action-specific ARARs that may or may not ultimately be applicable to AOC 43G.

4.4 BACKGROUND CONCENTRATIONS

As a means to evaluate concentrations of inorganic analytes detected in samples collected during each phase of investigation, background concentrations were calculated for the Fort Devens installation. Background concentration calculations were based on analytical data results gathered from soil and groundwater samples collected throughout the Fort Devens installation, selected as representative of background (non-contaminated) conditions. Though most of the calculations include assumptions on both the distribution of chemical concentrations and on the selection of representative samples that are not statistically rigorous, the results are considered conservatively representative of actual background concentrations at Fort Devens.

For soil, chemical data gathered from 33 soil samples collected by Ecology & Environment, Inc. (E&E) as part of their Group 1A and 1B investigation activities were used. The samples were collected from the major soil associations throughout Fort Devens specifically to establish background concentrations of inorganic analytes in soil. The background soil samples were collected from

locations that were visually undisturbed, at least 50 feet from any road, and 300 feet from any known SA.

The calculations were performed on 22 of the 23 PAL inorganic analytes (no data were available for thallium). For analytes that were not detected in the majority of soil samples, the detection limit for that analyte was selected as the background concentration. Sample locations, data ranges, mean values, details of calculations, and calculated background concentrations are summarized in Appendix L.

For groundwater, ABB-ES selected 10 representative groundwater samples collected from the Round One groundwater sampling events, completed in 1992, for Groups 2, 3, 5, 6 and 7 for the purpose of calculating background inorganic analyte concentrations in groundwater. Representative groundwater samples were selected from specific monitoring wells located upgradient of a SA, exhibiting low total TSS and/or low aluminum concentrations. Aware that elevated TSS concentrations artificially elevate inorganic analyte concentrations, ABB-ES selected samples that exhibited TSS concentrations on the same order of magnitude as the South Post Water Point (Well D-1) (i.e., representative of typical TSS concentrations in potable groundwater). Because a close correlation between TSS concentrations and aluminum concentrations was observed in all the groundwater samples analyzed, the aluminum concentration was used as an alternate selection criterion in the absence of TSS data. The concentration values detected in the ten samples were calculated using the same assumptions on outliers and detection limits applied to the soils background concentration calculations. The statistical analysis calculations for groundwater inorganics, and the resulting background concentrations, data ranges, mean values, calculated background concentrations, and details of the calculations are provided in Appendix L.

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)[a]		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)[b]			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Volatile Organics						
acetone	-	-	-	-	-/-	3,700N
benzene	5	zero	0.66	40	5,300/-[2]	0.36C
carbon tetrachloride	5	zero	0.4	6.94	35,200/-[2]	0.16C
chloroform (THM)	100/80[3]	zero	0.19	15.7	28,900/1,240[2]	0.15C
ethylbenzene	700	700	1,400	3,280	32,000/-[2]	1,300N
styrene	100	100	-	-	-/-	1,600N
1,1,2,2-tetrachloroethane	-	-	0.17	10.7	-/2,400[2]	0.052C
tetrachloroethylene	5	zero	0.8	8.85	5,280/840[2]	1.10C
toluene	1,000	1,000	14,300	424,000	17,500/-[2]	750N
1,1,1-trichloroethane	200	200	18,400	1,030,000	-/-	1,300N
trichloroethylene	5	zero	2.7	80.7	45,000/21.900[2]	1.6C
trichlorofluoromethane	-	-	-	-	-/-	1,300N
xylenes (total)	10,000	10,000	-	-	-/-	12,000N

continued

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

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			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Semivolatile Organics						
acenaphthene	-	-	-	-	-/-	2,200N
anthracene	-	-	-	-	-/-	11,000N
bis(2-ethylhexyl)phthalate	6	zero	-	-	-/-	4.80C
benzo(a)anthracene	-	-	-	-	-/-	0.0092C
benzo(a)pyrene	2	zero	-	-	-/-	0.092C
benzo(b)fluoranthene	-	-	-	-	-/-	0.092C
benzo(g,h,i)perylene	-	-	-	-	-/-	-
benzo(k)fluoranthene	-	-	-	-	-/-	0.92C
benzyl alcohol	-	-	-	-	-	11,000N
carbazole	-	-	-	-	-/-	3.4C
chrysene	-	-	-	-	-/-	9.2C
dibenzofuran	-	-	-	-	-/-	150N
di-n-butyl phthalate	-	-	-	-	-	3,700N

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	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
fluoranthene	-	-	-	-	-/-	1,500N
fluorene	-	-	-	-	-/-	1,500N
indeno(1,2,3-c,d)pyrene	-	-	-	-	-/-	0.092C
2-methylnaphthalene	-	-	-	-	-/-	-
naphthalene	-	-	-	-	2,300/620[2]	1,500N
n-nitrosodiphenylamine	-	-	4.9	16.1	-/-	14C
phenanthrene	-	-	-	-	30/6.3[5]	-
pyrene	-	-	-	-	-/-	1,100N
Inorganics						
aluminum	-	50 to 200[8]			-/-	37,000N
antimony	6	6[5]	146	45,000	88/30[5]	15N
arsenic	50[1]	-	0.0022	0.0175	360/190[2,7]	11N/0.038C
barium	2,000	2,000	1,000		-/-	2,600
beryllium	4[4]	4	0.0037	0.0641	130/5.3[2]	0.016C

continued

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

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FORT DEVENS, MA

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	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
cadmium	5	5	10	-	3.9/1.1[4]	18N
calcium	-	-			-/-	-
chromium (total)	100	100	-	-	1,700/210[4,9]	180
cobalt	-		-	-	-/-	2,220
copper	TT[10]	1,300	-	-	18/12[4]	1,400N
iron	-	300[8]	300	-	-/1,000	-
lead	TT[11]	zero	50	-	83/3.2[4]	-
magnesium	-	-	-	-	-/-	-
manganese	-	50[8]	50	100	-/-	180N
mercury	2	2	0.144	0.146	2.4/0.012	11N
nickel	100[5]	100[5]	13.4	100	1,400/160[4]	730N
potassium	-		-	-	-/-	-
selenium	50	50	10	-	20/5	180N
silver	-	100[8]	50	-	4.1/0.12[4,6]	180N

continued

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
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			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
sodium	-		-	-	-/-	-
vanadium	-					260N
zinc	-	5,000[8]	-	-	12/110[4]	11,000N
Pesticide/PCBs						
DDT	-	-	.000024	.000024	1.1/0.001	0.2C
DDD	-	-	-	-	-/-	0.28C
DDE	-	-	-	-	1,050/-[2]	0.2C
endrin	2	2	1.0	-	0.18/.0023	11N
alpha chlordane	2[13]	zero[13]	0.00046[13]	0.00048[13]	2.4/0.0043[13]	0.052[13]
gamma chlordane	2[13]	zero[13]	0.00046[13]	0.00048[13]	2.4/0.0043[13]	0.052C[13]
heptachlor	0.4	zero	0.00028	0.00029	0.52/.0038	0.0023C
PCB 1248	0.5[14]	zero[14]	0.000079[14]	0.000079[14]	2.0/0.014[14]	0.0087C
PCB 1254	0.5[14]	zero[14]	0.000079[14]	0.000079[14]	2.0/0.014[14]	0.73N
PCB 1260	0.5[14]	zero[14]	0.000079[14]	0.000079[14]	2.0/0.014[14]	0.0087C[14]

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

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FORT DEVENS, MA

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			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Explosives						
cycloetramethylenetetranitramine (HMX)	-	-	-	-	-	-
cyclonite (RDX)	-	-	-	-	-	-
2,4-dinitrotoluene	-	-	-	-	-	73N
2,6-dinitrotoluene	-	-	-	-	-	37N
nitroglycerine	-	-	-	-	-	-
2,4,6-trinitrotoluene	-	-	-	-	-	2.2C
Cations/Anions						
chloride		250,000[8]	-	-	860K/230K	-
phosphate	-	-	-	-	-/-	-
sulfate	-	500,000[15]/250,000[8]	-	-	-/-	-
alkalinity	-	-	-	-	-/20,000	-

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FORT DEVENS, MA

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	Safe Drinking Water Act (SDWA)[a]		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)[b]			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Other						
nitrate/nitrite as N	10,000/1,000[12]	-	10,000/-			58,000N/3,100N
TPH	-	-				-

Notes:

(a) USEPA, "Drinking Water Standards and Health Advisories", Office of Water, Washington, D.C.; May 1995.
(b) USEPA, "Water Quality Criteria Summary", Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.; May 1, 1991; criteria shown for carcinogens present a one-in-a-million incremental risk.

CWA = Clean Water Act
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
TT = Treatment technique required.
µg/L = micrograms per liter
\- = No federal or state guidance criteria or standards exist.
N = Noncarcinogenic effects representing an HQ of 1.0.
C = Carcinogenic effects representing a cancer risk of 10^{-6}.

1 MCL for arsenic currently under review.
2 Insufficient data to develop criteria. Value presented is the Lowest Observed Effect Level (LOEL).
3 1994 Proposed rule for Disinfectants and Disinfection By-Products: Total for all THMs combined would not exceed the 80 ug/L level.
4 Hardness dependent criteria (100 mg/L $CaCO_3$ used).
5 Standard is being remanded.
6 Proposed level, freshwater acute - 0.92 µg/Ll.
7 Values presented are for trivalent species.
8 Non-enforceable secondary regulation based on aesthetics (e.g., color, odor, taste).
9 Values presented are for hexavalent chromium species.
10 Treatment technique action level 1,300 µg/L.
11 Treatment technique action level 15 µg/l; concentration measured at tap.
12 Nitrate or nitrite as nitrogen; standard total nitrate and nitrite is 10,000 µg/l.
13 Values reported for chlordane (CAS #57-74-9)
14 Values reported for total PCBs (CAS #1336-36-3)
15 Proposed criteria.

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER[A] (µG/L)	CLASS I GROUNDWATER[B] (µG/L)
Volatile Organics		
acetone	3000[2]	-
benzene	5	-
carbon tetrachloride	5	-
chloroform	5[2]	100[3]
ethylbenzene	700	-
styrene	100	-
1,1,2,2-tetrachloroethane	-	-
tetrachloroethylene	5	-
toluene	1000	-
1,1,1-trichloroethane	200	-
trichloroethylene	5	-
trichlorofluoromethane	-	-
xylenes (total)	10,000	-
Semivolatile Organics		
acenaphthylene	-	-
anthracene	-	-
bis(2-ethylhexyl)phthalate	6	-
benzo(a)anthracene	-	-
benzo(a)pyrene	0.2	-
benzo(b)fluoranthene	-	-
benzo(g,h,i)perylene	-	-
benzo(k)fluoranthene	-	-
benzyl alcohol	-	-
carbazole	-	-
chrysene	-	-
dibenzofuran	-	-
di-n-butyl phthalate		
fluoranthene	-	-
fluorene	-	-
indeno(1,2,3-c,d)pyrene	-	-
2-methylnaphthalene	-	-

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER[A] (µG/L)	CLASS I GROUNDWATER[B] (µG/L)
naphthalene	-	-
n-nitrosodiphenylamine	-	-
phenanthrene	-	-
pyrene	-	-
Inorganics		
aluminum	50 to 200[10]	-
antimony	6	-
arsenic	50	50
barium	2,000	1,000
beryllium	4	-
cadmium	5	10
calcium	-	-
chromium (total)	100	50
cobalt	-	-
copper	1,300	1,000
iron	300[10]	300
lead	15	50
magnesium	-	-
manganese	50[10]	50
mercury	2	2
nickel	100	-
potassium	-	-
selenium	50	10
silver	100[10]	50
sodium	20,000[2]	-
vanadium	-	-
zinc	5,000[10]	5,000
Pesticides/PCBs		
DDT	-	-
DDD	-	-
DDE	-	-
endrin	2[8]	0.2

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER[A] (µG/L)	CLASS I GROUNDWATER[B] (µG/L)
alpha chlordane	2[8]	-
gamma chlordane	2[8]	-
heptachlor	0.4	-
PCB 1248	0.5[9]	-
PCB 1254	0.5[9]	-
PCB 1260	0.5[9]	-
Explosives		
cyclotetramethylenetetranitramine (HMX)	-	-
cyclonite (RDX)	-	-
2,4-dinitrotoluene	-	-
2,6-dinitrotoluene	-	-
nitroglycerine	-	-
2,4,6-trinitrotoluene	-	-
Cations/Anions		
chloride	250,000[10]	-
phosphate	-	-
sulfate	250,000[10]	250,000
alkalinity	-	-
Other		
nitrate/nitrite (total)	10,000	10,000[8]
TPH	-	-

Notes:

(a) MADEP - Office of Research and Standards; Massachusetts Drinking Water Standards and Guidelines, (310 CMR 22.00) Massachusetts MCLs; Autumn 1994.
(b) MADEP - Division of Water Pollution Control; Massachusetts Surface Water Quality Standards, (314 CMR 6.06) Minimum GW Quality Criteria - Class I; promulgated December 31, 1986.
(c) MADEP - Division of Water Pollution Control; Massachusetts Surface Water Quality Standards, (314 CMR 4.05[b]) Class B criteria; promulgated July 20, 1990.
(d) MADEP; Massachusetts Drinking Water Standards; (310 CMR 22.05[8]) Maximum Microbiological Contaminant Levels; promulgated November 20, 1992.

DWS = Drinking Water Standards
MCLG = Maximum Contaminant Level Goal
MMCL = Massachusetts Maximum Contaminant Level
ORSG = Office of Research and Standards Guideline (Massachusetts)
µg/l = micrograms per liter
- = Standard not established.

(1) MMCL established for 1,4-dichlorobenzene isomer (more stringent than for 1,2- isomer). Reported values are totals (isomers not distinguished.)
(2) Value is an Office of Research and Standards guideline.
(3) Standard indicated is concentration of total trihalomethanes (i.e., the sum of concentrations of chloroform, bromodichloromethane, dibromochloromethane, and bromoform).

(4) Defers to EPA DWS; see federal MCLs/MCLGs.
(5) Mean value per any set of samples.
(6) Numerical standard does not exist. MMCL is based on presence or absence of coliform.
(7) Nitrate as nitrogen.
(8) Value reported for chlordane; CAS No. 57749.
(9) Value reported for PCBs; CAS No. 1336363.
(10) SMCL = Secondary Maximum Contaminant Levels.

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC[C] (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL[A] (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL[A] (MG/KG)		
Volatile Organics				
acetone	7,800N	200,000N	-	-
benzene	22C	200C	-	-
carbon tetrachloride	4.9C	44C	-	-
chloroform	100C	940C	-	-
ethylbenzene	7,800N	200,000N	-	-
styrene	16,000N	410,000N	-	-
tetrachloroethylene	12C	110C	-	-
toluene	16,000N	410,000N	-	-
1,1,1-trichloroethane	7,000N	180,000N	-	-
1,1,2,2-tetrachloroethane	3.2C	29C	-	-
trichloroethylene	58C	520C	-	-
trichlorofluoromethane	23,000N	610,000N	-	-
xylenes (total)	160,000N	1E+06N	-	-
Semivolatile Organics				
acenaphthene	-	-	-	-
anthracene	23,000N	610,000N	-	-
bis(2-ethylhexyl)phthalate	46C	410C	-	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC[C] (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL[A] (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL[A] (MG/KG)		
benzo(a)anthracene	0.88C	7.8C	-	1,317
benzo(a)pyrene	0.088C	0.78C	0.4	1,063
benzo(b)fluoranthene	0.88C	7.8C	-	-
benzo(g,h,i)perylene	-	-	-	-
benzo(k)fluoranthene	8.8C	78C	-	-
benzyl alcohol	23,000N	610,000N	-	-
carbazole	32C	290C	-	-
chrysene	88C	780C	0.4	-
dibenzofuran	310N	8200N	-	-
di-n-butyl phthalate	7,800N	200,000N	-	-
fluoranthene	3,100N	82,000N	0.6	1,883
fluorene	3,100N	82,000N	0.035	-
indeno(1,2,3-c,d)pyrene	0.88C	7.8C	-	-
2-methylnaphthalene	-	-	-	0.065
naphthalene	3,100N	82,000N	0.34	-
n-nitrosodiphenylamine	130C	1200C	-	-
phenanthrene	-	-	0.225	139
pyrene	2,300N	61,000N	0.35	1,311

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC[C] (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL[A] (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL[A] (MG/KG)		
total PAHs	-	-	4.0	-
Inorganics				
aluminum	78,000N	1E+06N	-	-
antimony	31N	820N	0.002	-
arsenic	0.37C/23N	3.3C/610N	0.033	-
barium	5,500N	140,000N	-	-
beryllium	0.15C	1.3C	-	-
cadmium	39N	1,000N	0.005	-
calcium	-	-	-	-
chromium	390N[1]	10,000N[1]	0.080	-
cobalt	4,700N	120,000N	-	-
copper	2,900N	76,000N	0.070	-
iron	-	-	-	-
lead	-	-	0.035	-
magnesium	-	-	-	-
manganese	390N	10,000N	-	-
mercury	23N	610N	0.00015	-
nickel	1,600N	41,000N	0.030	-
potassium	-	-	-	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC[C] (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL[A] (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL[A] (MG/KG)		
selenium	390N	10,000N	-	-
silver	390N	10,000N	0.001	-
sodium	-	-	-	-
vanadium	550N	14,000N	-	-
zinc	23,000N	610,000N	0.120	-
Pesticides/PCBs				
DDT	1.9C	17C	0.001	0.828
DDD	2.7C	24C	0.002	-
DDE	1.9C	17C	0.002	-
endrin	23N	610N	0.00002	.0332
alpha chlordane	0.49C[3]	4.4C[3]	0.0005[3]	-
gamma chlordane	0.49C[3]	4.4C[3]	.0005[3]	-
heptachlor	0.14C	1.3C	-	0.110
PCB 1248	0.083C[4]	0.74C[4]	0.05[4]	-
PCB 1254	1.6N	41N	0.05[4]	19.5
PCB 1260	0.083C[4]	0.74C[4]	0.05[4]	-
Explosives				
cycloetramethylenetetranitramine (HMX)	-	-	-	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC[C] (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL[A] (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL[A] (MG/KG)		
cyclonite (RDX)	-	-	-	-
2,6-dinitrotoluene	78N	2000N	-	-
2,4,6-trinitrotoluene	21C	190C	-	-
nitroglycerine	-	-	-	-
Other				
nitrate/nitrite	130,000N/7,800N	1E+06N/200,000N	-	-
TPH	-	-	-	-

Notes:

(1) Chromium IV values.
(2) Dry weight.
(3) Values reported for chlordane (CAS # 57-74-9).
(4) Values reported for total polychlorinated biphenyls (CAS # 1336-36-3).
(a) U.S. Environmental Protection Agency (USEPA) Region III, January 1995. Memorandum from Roy L. Smith to RBC (Risk-Based Concentration) Table Mailing List, Subject: Risk-Based Concentration Table.
(b) National Oceanic and Atmospheric Administration (NOAA), March 1990. "The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National States and Trends Program"; NOAA Technical Memorandum NOS OMA52. (Edward R. Long and Lee G. Morgan, authors)
(c) USEPA, May 1988. "Interim Sediment Quality Criteria Values for Nonpolar Hydrophobic Organic Contaminants".
(d) USEPA OSWER Directive 193554-02.

mg/kg = milligrams per kilogram
NOAA = National Oceanic and Atmospheric Administration
N = Non-carcinogenic effects representing an HQ of 1.0.
1E+06 = 1,000,000
SQC = Sediment Quality Criteria
- = No federal or state guidance criteria or standards exist.
C = Carcinogenic effects representing a cancer risk of 10^{-6}.

TABLE 4-4
POTENTIAL LOCATION-SPECIFIC ARARS AT FORT DEVENS
AOC 43G - HISTORIC GAS STATION / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Statutory, Regulatory Basis	Citation	Description
Resource Conservation and Recovery Act	40 CFR Sec. 264.18	Prohibits or restricts siting of hazardous waste management units in certain sensitive areas (100-year floodplain, active seismic area, wetlands).
Migratory Bird Treaty Act of 1972	16 USC Sec. 703-712 50 CFR Parts 10, 20, 21	If migratory birds are present, provides protection of almost all species of native birds in the U.S. from unregulated activities. Unregulated activities can include poisoning at hazardous waste sites.
Fish and Wildlife Conservation Act of 1980	16 USC Sec. 2901 50 CFR Part 83	Requires the submittal of conservation plans outlining provisions to conserve non-game fish and wildlife. Approved conservation plans are enforced by state agencies.
Federal Land Policy and Management Act	13 USC Sec. 1700 et seq.	Establishes requirements concerning utilization of public lands, particularly rights-of-way regulation, land use planning and land acquisition and appropriation of waters on public lands.
Fish and Wildlife Improvement Act	16 USC Sec. 661-666c	Provides for development, protection, rearing, and stocking of all species of wildlife, wildlife resources, and their habitat.
Endangered Species Act	16 USC 1531 et seq. 50 CFR Part 200 50 CFR Part 402	Provides for protection and conservation of various species of fish, wildlife, and plants.
Clean Water Act, Section 404	33 USC 1251 et seq. Sec. 404 40 CFR Part 230	Prohibits discharge of dredged or fill material into wetlands without a permit.

TABLE 4-4
POTENTIAL LOCATION-SPECIFIC ARARS AT FORT DEVENS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Statutory, Regulatory Basis	Citation	Description
Fish and Wildlife Improvement Act	33 CFR 320-330	Provides for management of dredged material; establish requirements for structures affecting navigable waterways; and provides for certain permitting requirements.
Archaeological and Historic Preservation Act	16 USC Sec. 469 40 CFR 6.301(c)	Establishes procedures for preservation of historical and archaeological resources when terrain is altered as a result of a federal or federally licensed construction activity.
National Historic Preservation Act	16 USC Sec. 470 40 CFR Sec. 6.301(b) 36 CFR Part 800	Provides for the protection of historic places.
Historic Sites, Buildings, and Antiquities Act	16 USC Sec. 461-467	Provides for the protection of natural landmarks.
Fish and Wildlife Coordination Act	16 USC 661-667 E	All agencies regulating activities that may have an effect on either fish or wildlife must notify and allow input by agencies overseeing fish and wildlife habitats in the area of the proposed activities.
Coastal Zone Management Act	16 USC 1451 et seq. 15 CFR Parts 923, 928, 932	Provides for the proper maintenance and upkeep of all coastal areas. Protects coastal resources.
Wetlands Protection	310 CMR 10.00-10.99	Establishes State of Massachusetts regulations for protection of coastal and inland wetlands, including compliance with the Massachusetts Environmental Policy Act.

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Solid Waste Disposal Act	42 USC Sec. 6901-6987	Resource Conservation and Recovery	
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby prohibit open dumps.	Not Applicable
Criteria for Municipal Solid Waste Disposal Facilities	40 CFR Part 258	Establishes minimum federal criteria for design, construction, operation, and permitting of municipal solid waste landfills.	Not Applicable
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous waste.	Applicable for defining whether or not hazardous waste is generated
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes standards for generators of hazardous waste	Applicable. If remedial action causes hazardous waste to be generated, these standards will apply
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S.	Applicable. If hazardous waste is transported off-site, these standards will apply

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Applicable for hazardous waste management activities during remediation
Standards for Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 CFR Part 266	Establishes requirements which apply to recyclable materials used in a manner constituting disposal or hazardous waste burned for energy recovery.	If hazardous wastes are recycled on or off-site, these standards are applicable
Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	40 CFR Part 267	Establishes minimum national standards that define acceptable management of hazardous waste land disposal facilities.	Applicable if hazardous waste is present
Land Disposal Restrictions (LDR) Program	40 CFR Part 268	Sets treatment standards for hazardous wastes based on the levels achievable by current technology; sets two-year national variances from the statutory effective dates due to insufficient treatment capacity.	Applicable for hazardous wastes destined for land disposal
Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)	40 CFR Part 280	Provides regulations pertaining to underground storage tanks.	Applicable if there is operation or removal of an UST

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Clean Water Act	33 USC Sec. 1251-1376		
EPA-Administered Permit Programs: The National Pollutant Discharge Elimination System	40 CFR Part 122	Requirements for the discharge of pollutants from any point source into waters of the U.S.	Applicable if remedial action requires outfall discharge
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR Part 125	Provides discharge criteria, chemical standards, and permit forms for existing industrial operations.	Applicable to remedial actions which cause discharge to waters of the U.S.
Occupational Safety and Health Act of 1970	29 USC Sec. 657 and 667		
Occupational Safety and Health Standards	29 CFR Part 1910	Sets standards for safety in the work environment.	Applicable to all remedial actions
Safety and Health Regulations for Construction	29 CFR Part 1926	Sets standards for safety in the construction work environment.	Applicable to all remedial actions
Safety and Health Standards for Federal Service Contracts	29 CFR Part 1925	States that safety and health standards are applicable to work performed under Federal Service Contracts.	Applicable to all remedial actions
Clean Air Act			

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
National Emissions Standards for Hazardous Air Pollutants	40 CFR Part 61	Establishes emissions standards for hazardous air pollutants that may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating illness.	Applicable to incineration, storage of petroleum liquids; and air stripping activities
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare.	Applicable if there are any air emissions during remediation
Safe Drinking Water Act	40 USC Sec. 300G		
Underground Injection Control Program	40 CFR Part 144	Provides for protection of underground sources of drinking water.	Applicable to underground injection of wastes/ contaminated water
Underground Injection Control Program: Criteria and Standards	46 CFR Part 146	Provides technical requirements for UIC programs.	Applicable to underground injection of wastes/ contaminated water
Department of Transportation - Hazardous Materials Regulations			
Shipping and Manifesting Requirements for Hazardous Waste	49 CFR Parts 171-179	Provides requirements for packaging, manifesting, and transportation of hazardous waste.	Applicable if offsite shipment of wastes occurs

5.0 AOC 43G REMEDIAL INVESTIGATION

5.1 BACKGROUND AND CONDITIONS

AOC 43G is located in the central portion of the Main Post on Queenstown Road (Figure 5-1). The AOC consists of the former Army Air Force Exchange Service (AAFES) gas station and historic gas station G (Figure 5-2).

The original Study Area (SA 43G) was Area 1 (historic gas station G) at AOC 43G, which was one of eighteen historic gas station sites, all of which are located in the Main Post area of Fort Devens. The station was used during World War II as a vehicle motor pool to support military operations. The motor pool operations were discontinued during the late 1940s or early 1950s. No records were available on the decommissioning of the motor pool and therefore, there was no evidence of the exact location of the historic gas station or that the station's UST had been removed. The reported location of the historic gas station was southwest of the former AAFES gasoline station (Building 2008) and southwest of Building 2009 (see Figure 5-2). The structures of this historic gas station consisted of a pump island and a small gasoline pumphouse. Reportedly, the gas station had one 5,000-gallon (or possibly 5,140-gallon) UST located between the gasoline pumphouse and the pump island.

AOC 43G was expanded to include the former AAFES gas station after the SI was completed. The gas station was added to further define the distribution of contamination detected during the past gasoline UST removals (completed in 1990), as well as the contaminants detected during a waste oil UST removal completed in 1992. The former AAFES gasoline station is located approximately 120 feet northeast of historic gas station G and is comprised of the service station (Building 2008) which houses three vehicle service bays and the former AAFES store, three existing 10,000-gallon USTs, and associated pump islands (see Figure 5-2). Information about these sites was obtained principally from the MEP (Biang et al., 1992), old plans of Fort Devens (Barbour, 1941; U.S. Engineer Office, 1948-1952), historic and recent aerial photographs (Detrick, 1991), reports of recent tank removals (Environmental Applications, Inc. [EA], 1990; Nobis Engineering, Inc. [Nobis], 1990; GZA Remediation, Inc. [GZAR], 1990; Kurz Associates, 1991; ATEC Environmental Consultants, Inc. [ATEC], 1992), from

additional data compiled by Fort Devens Environmental Management Office (EMO), and from previous SI and SSI activities. Presently, the gas station is closed and the AAFES management has been discontinued. The Fort Devens Reuse Plan (BRAC, 1991) has indicated that this gas station will stay within the Reserve Enclave. Recently, the decision was made by Fort Devens personnel to remove the three existing gasoline USTs.

5.2 SUMMARY OF PREVIOUS REMOVAL ACTIONS

The following subsections discuss previous removal actions performed at AOC 43G by Fort Devens subcontractors. A brief summary of analytical data is presented to demonstrate the need for subsequent investigations at the site. A complete assessment of the analytical data is presented in Section 7.0 of this RI report. The scope of investigation activities performed at AOC 43G is summarized chronologically in Table 5-1.

5.2.1 Fort Devens 1990 Gasoline UST Removal

Five gasoline USTs were removed from the north side of the former AAFES gas station by a Fort Devens subcontractor on October 15 through 19, 1990. The removal was overseen and a report of the removal activities was prepared by Nobis. The Nobis report stated that three 9,000- and two 10,000-gallon USTs were removed from the north side of the former AAFES gas station (Figure 5-3). The USTs, and associated piping, were inspected by Nobis personnel upon removal. Some surficial rusting and minor pitting was observed along the sides and bottom of the USTs, but no visual indication of holes or leaks were reported (Nobis, 1990).

A total of 54 soil samples were collected from the UST excavations by Nobis, and jar headspace screened in the field with a PID (see Table 5-2, Figure 5-3). Up to 10 soil samples were collected from each UST excavation. Concentrations of total VOCs ranged from non-detect to 5,290 parts per million (ppm) based on PID measurements. Based on these field screening results, Nobis collected two soil samples from each of the UST excavations for off-site laboratory analysis consisting of TPHC using USEPA Method 418.1. The results of the laboratory analysis indicated TPHC concentration ranging from 100 to 3,713 milligrams per

kilogram (mg/kg). These TPHC concentrations exceeded the MADEP soil standards (at the time) policy #WSC-400-89 for remediation of contaminated soil (Nobis, 1990) (Table 5-3). A detailed discussion of the Nobis data is presented in Section 7.0 of this report.

Because of the elevated TPHC concentrations detected during the UST removals, a soil removal, subsurface soil, and groundwater investigation was conducted by Nobis at the former AAFES gas station from October 24, 1990 through April 24, 1991. A report of the findings of these activities was prepared by Nobis (Nobis, 1991). The investigation was divided into three activities; (1) soil borings and soil sampling for field headspace analysis, (2) soil excavation and removal, and (3) groundwater monitoring well installation, and sampling (Nobis, 1991).

The first activity was comprised of drilling 15 soil borings and subsurface soil sampling for field screening of total VOCs, using a PID. The soil borings were located in and around the former gasoline USTs mentioned above (see Figure 5-3). The results of the PID field screening indicated total VOCs ranging from non-detect (ND) to 2,817 ppm. The total VOC concentrations reportedly increased with depth. The highest concentrations of total VOCs were detected in soil samples collected from soil borings (B-1, B-2, B-5, and B-11) located on the southeast side of the former gasoline USTs (Nobis, 1991) (Table 5-4). A summary of soil borings is presented in Table 5-5, and soil boring logs are presented in Appendix A.

The second activity completed was the removal of contaminated soil from the former UST graves. Based on the results of the soil samples collected during the UST removals and the soil boring program, the soil excavation activity began by removing soil from the northwest portion of the former UST area. The soil was removed, screened for total VOCs using a PID, and stockpiled on polyethylene sheeting in a vacant parcel of land southeast of Building 2008 (see Figure 5-3). Approximately 1,400 tons of soil were excavated from the former UST excavations. The removal excavation was extended vertically downward to approximately 20 feet (the extent of the excavator). The continuous total VOC PID field screening of soil removed from the excavation, showed concentrations ranging from ND to 120 ppm (Table 5-6). Reportedly, the highest concentrations were in the southwestern and northern portions of the excavation. Upon completion of the soil excavation, Nobis personnel collected 22 soil samples from

from the walls of the excavation. The soil samples were submitted for laboratory analysis consisting of TPHC using USEPA method 418.1. The results of the soil samples indicated that TPHC concentrations ranged from 39 to 569 mg/kg in the soil left in the excavation (Table 5-7).

The former UST excavation was backfilled with approximately 1,400 tons of "clean" soil on December 13, 1990. A total of seven soil samples were collected from the stockpiled soils and submitted for laboratory analysis consisting of TPHC and total VOCs. The results reportedly indicated that the stockpiled soil was below 1,800 ppm of TPHC. Based on these results the soil was removed from the site on November 19, 20 and 21, 1990 by Alky Enterprises, Inc. of Greenland, New Hampshire; and transported to Brox Paving Materials, Inc. in Hudson, New Hampshire. The manifests are presented in Appendix E of the Nobis report (Nobis, 1991).

The third phase of the investigation at the former AAFES gas station was the installation of seven groundwater monitoring wells (AAFES-1D through AAFES-7) (see Figure 5-3). One monitoring well (AAFES-3) was installed in an apparent upgradient location while the remaining six monitoring wells were installed to monitor downgradient groundwater quality. Monitoring well installation diagrams are presented in Appendix B and summarized in Table 5-8. The monitoring wells were sampled by Nobis on December 12, 1990. The groundwater samples were analyzed at a non-USAEC approved off-site laboratory for TPHC only, using USEPA method 418.1. TPHC concentrations ranged from 1.7 mg/L at AAFES-7 to 5.1 mg/L at AAFES-2. The results of the groundwater sampling did not exceed the MADEP action levels for remediation for low environmental impact areas (Nobis, 1991). A complete discussion of the Nobis groundwater data is presented in Section 7.0 of this report.

Based on the review of design drawings, it is believed that the existing tanks at AAFES gas station were installed in the spring of 1991. Drawings show that three 10,000-gallon tanks were installed within the footprint of the former three 9,000-gallon USTs. The tanks are double wall fiberglass-constructed and placed on an approximate 32-foot by 32-foot by 1-foot thick concrete pad. A similarly sized pad was installed at the ground surface over the tops of the tanks. Reportedly, the tanks were each furnished with a tank leak detector system, overspill protection,

double wall supply line piping, and vapor recovery piping (capped for future connection).

5.2.2 ATEC 1992 Waste Oil UST Removal

On May 27, 1992 ATEC, under contract to Fort Devens, removed a 500-gallon waste oil UST from behind Building 2008 (see Figure 5-3). The waste oil UST, and it's associated piping, were in "good condition" upon inspection by ATEC personnel (ATEC, 1992). Groundwater was not encountered in the UST excavation. The soil removed from the side walls and bottom of the UST excavation was reported as "visibly contaminated" and produced a "strong septic odor". Soil samples were collected from the excavation by ATEC personnel for field screening consisting of PID headspace and TPHC screening via non-dispersed infrared spectroscopy. The results of the PID field screening showed total VOCs ranging from 0.0 to 48.0 ppm and TPHC concentrations ranging from 6.3 to 28,745.5 ppm (Table 5-9). Soil excavated during the waste oil UST removal had similar total VOC and TPHC concentrations (ATEC, 1992).

One soil sample (LSS-1) was collected from the wall of the excavation and another soil sample (LSS-2) was collected from the bottom of the excavation, for laboratory analysis (Figure 5-4). The samples were analyzed for VOCs, SVOC, Priority Pollutant metals, and TPHC. The results of the off-site laboratory analyses indicated that chlorinated solvents (PCE, 1,1,1-trichloroethane, and methylene chloride) were present in the samples at a maximum concentration of 152 parts per billion (ppb). BEHP, xylene, and pyrene were also detected in the samples. TPHC was detected up to a concentration of 35,100 ppm (see Table 5-9). A complete discussion of ATEC's data is presented in Section 7.0 of this report.

5.3 Previous ABB-ES Investigations

The following subsections discuss investigations performed by ABB-ES at AOC 43G prior to the RI. A brief summary of analytical data is presented to demonstrate the need for subsequent investigations at the site. A complete assessment of the analytical data is presented in Section 7.0 of this RI Report.

The scope of investigation activities performed at AOC 43G is summarized in Table 5-1.

5.3.1 Summary of 1992 Site Investigation

The SI at AOC 43G was undertaken in August 1992, in accordance with the historic gas stations Final Task Order Work Plan (ABB-ES, 1992) and in conformance to the provisions of the Fort Devens POP (ABB-ES, 1993c). Table 5-1 summarizes the scope of investigations completed during the SI.

The SI at AOC 43G focused in and around the location of the former pumphouse and UST associated with the historic gas station (Figure 5-5). The activities consisted of the following:

- A geophysical program was conducted consisting of a metal detector and ground-penetrating radar (GPR) survey.
- A total of four TerraProbe points were completed with up to two soil samples per point collected for field analysis.
- A total of 10 TerraProbe℠ points were completed with one soil gas sample collected from each point for field analysis.
- One soil boring was completed and two subsurface soil samples were submitted for off-site laboratory analysis.
- A horizontal and vertical survey was completed for all SI explorations.

The field investigation was conducted in and around the historic gas station portion of AOC 43G to determine if the UST had been removed and if any residual soil contamination was present in the subsurface soil below the site. Field and off-site laboratory analytical samples collected and their associated parameters are summarized in Table 5-10. A full discussion of the field and laboratory analytical results are presented in Section 7.0.

Four TerraProbe℠ points were advanced in and around the former UST location (see Figure 5-5). Three soil samples were collected from 9 feet bgs to analyze the soil at or near the estimated bottom of the historic gas station UST. Four soil samples were collected from 11 feet bgs and 12 feet bgs, which was the depth of TerraProbe℠ refusal at this site. All of the subsurface soil samples collected with the TerraProbe℠ unit were analyzed in the field for BTEX and TPHC. The water table was not encountered in any of the TerraProbe℠ points prior to probe refusal. Because groundwater was not reached, ten soil-gas samples (TS-01 through TS-10) were collected from 8 feet (just above the estimated bottom of the UST excavation). The soil-gas samples were analyzed for BTEX only.

One soil boring (43G-92-01X) was drilled to the water table, so that subsurface soil samples could be collected for off-site laboratory analysis (see Figure 5-5). The samples were analyzed in the laboratory for VOCs, TPHC, and lead (see Table 5-10).

5.3.2 Summary of Site Investigation Results and Observations

The results of the geophysical surveys indicate that no abandoned UST was present at the historic gas station portion of AOC 43G. The results of the geophysical surveys are presented in Appendix C.

BTEX was not detected in any of the 9-foot samples; however, TPHC was detected in the 9-foot soil sample collected from TS-04 and TS-11 (830 and 130 ppm, respectively). BTEX was not detected in any of the samples collected from 11 to 12 feet bgs, but TPHC was detected in the 11-foot samples collected from TS-10 (130 ppm) and TS-11 (130 ppm, 10-feet; 190 ppm, 11 feet) (Table 5-11).

BTEX was not detected in any of the soil-gas samples collected from the historic gas station.

One soil boring, 43G-92-01X, was drilled to the water table adjacent to TS-04, which had the highest concentration of TPHC at 830 ppm, to determine if the TPHC contamination detected during the TerraProbe℠ survey had migrated to the water table. Analytical soil samples were collected from depths of 10 feet to 12 feet and 20 feet to 22 feet bgs. Groundwater was encountered at 18 feet bgs

and the boring was advanced to 22 feet bgs. The boring log for this location is presented in Appendix A.

No VOCs or TPHC were detected in either of the subsurface soil samples collected for off-site laboratory analysis, and lead was present in each sample below the Fort Devens background concentration. A complete discussion of the field and off-site laboratory results is presented in Section 7.0 of this report.

5.3.3 Conclusions and Recommendations

The objective of the SI field investigation at AOC 43G was to determine if the historic gas station activities had adversely impacted the soil or groundwater quality below that portion of AOC 43G. Based on the results of the subsurface soil sampling program and the field and off-site laboratory analysis, it appears that the past site activities had impacted the soil quality at this site, but it did not appear that the contamination detected in the unsaturated zone soils had migrated to the water table. However, it was concluded that the distribution of the contaminants detected in the soil on the southern side of historic gas station was unclear. Because of this it was recommended that additional TerraProbe℠ points be completed in that area.

Based on the results of the two UST removals, and subsequent soil and groundwater sample results, the AAFES gas station was added to AOC 43G after the SI field investigation had been completed. This decision was made to further define the potential soil and groundwater contamination previously detected. It was determined that additional subsurface soil and groundwater sampling and analysis was needed from the potential source areas at the AAFES gas station. To investigate the distribution of potential soil and groundwater contamination, USAEC recommended that an SSI be conducted at AOC 43G. The following subsections outline that program and its results.

5.3.4 Summary of 1993 Supplemental Site Investigation

The SSI at AOC 43G was performed in accordance with the Final SSI Task Order Work Plan (ABB-ES, 1993b) and in conformance to the provisions of the Fort Devens POP (ABB-ES, 1993c). The following paragraphs describe the field

activities completed at AOC 43G during the SSI. Table 5-1 summarizes the scope of the SSI.

The SSI at AOC 43G was conducted at the historic gas station as well as at the potential source areas at the AAFES gas station (Figure 5-6). The activities consisted of the following:

- A total of 39 TerraProbe℠ points (34 points were completed around the then-active gasoline USTs and the former waste oil UST, and five points were completed west of the historic gas station) were completed. Up to three soil samples were collected from each point and analyzed in the field for BTEX and TPHC.

- Seven soil borings were completed at apparent "hot spots" identified by the TerraProbe℠ survey at the historic gas station and the AAFES gas station.

- Two groundwater monitoring wells were installed at the AAFES gas station (one upgradient and one downgradient of the active gasoline USTs) to supplement the existing monitoring well network.

- Two round of groundwater samples were collected from the newly installed monitoring wells and existing monitoring wells.

- Aquifer permeability tests were conducted on the newly installed monitoring wells, only.

- A horizontal and vertical survey of all SSI explorations was completed.

Soil

To better define the distribution of contamination at AOC 43G, the site was subdivided in three areas. Area 1 was comprised of historic gas station G. Area 2 included the areas around the existing gasoline USTs, and Area 3 included the area in and around the former waste oil UST and sand and gas trap behind Building 2008 (see Figure 5-6). Field and off-site laboratory analytical samples

and their associated parameters are summarized in Table 5-10. Results of field and off-site laboratory analyses are presented at the end of this section.

Area 1. A total of five TerraProbe℠ points (TS-35 through TS-39) were advanced west of the TerraProbe℠ points completed at the historic gas station during the SI. These points were located to further define the horizontal distribution of contaminants detected during the SI. Up to two soil samples were collected from each TerraProbe℠ point. The samples were analyzed in the field for BTEX and TPHC (see Figure 5-6 and Table 5-10).

Based on the results of the supplemental TerraProbe℠ survey at historic gas station, one soil boring (XGB-93-09X) was advanced adjacent to the TerraProbe℠ point with the highest concentration of contamination (TS-39). A total of three soil samples were collected from this soil boring. The soil samples from this boring were submitted for off-site laboratory analyses consisting of PAL VOCs, SVOCs, inorganics, TPHC, and TOC. Additional soil samples were collected and analyzed in the field for BTEX and TPHC (see Figure 5-6 and Table 5-10).

Area 2. A total of 23 (TS-12 through TS-34) TerraProbe points were completed in Area 2. These points were concentrated around the then-active gasoline USTs to determine if residual soil contamination was present. Up to two soil samples were collected from each point and analyzed in the field for BTEX and TPHC (see Figure 5-6 and Table 5-10). Soil samples were not collected from TerraProbe points TS-12, TS-15, TS-16, TS-17, and TS-27 due to underground utilities.

The results of the TerraProbe survey at Area 2 were used to locate three soil borings (XGB-93-05X through XGB-93-07X) at "hot spots" in Area 2 (see Figure 5-6). Up to three soil samples were collected from each soil boring for off-site laboratory analysis. The soil samples from these borings were analyzed for PAL VOCs, SVOCs, inorganics, TPHC, and TOC. Additional soil samples were collected and analyzed in the field for BTEX and TPHC (see Table 5-10).

Area 3. A total of 10 TerraProbe℠ points (TS-01 through TS-10) were completed in Area 3. These points were concentrated in and around the former waste oil UST (see Figure 5-6). Up to two soil samples were collected from each point and

analyzed in the field for BTEX and TPHC (see Table 5-10). No soil samples were collected from TS-06 and TS-11 due to subsurface obstructions.

The results of the TerraProbe℠ survey at Area 3 were used to locate two soil borings (XGB-93-03X and XGB-93-04X) at "hot spots" in Area 3 (see Figure 5-6). Up to three soil samples were collected from each soil boring for laboratory analysis. The soil samples from these borings were analyzed for PAL VOCs, SVOCs, inorganics, TPHC, and TOC. Additional soil samples were collected and analyzed in the field for BTEX and TPHC (see Table 5-10).

An additional soil boring was advanced between Area 1 and the AAFES station to assess the soil quality in this area, per a regulatory request. Soil samples from this boring were submitted for off-site laboratory analyses consisting of PAL VOC, SVOC, inorganics and TOC. In addition, each soil sample was analyzed in the field for BTEX and TPHC (see Figure 5-6; Table 5-10).

Groundwater

Two groundwater monitoring wells (XGM-93-01X and XGM-93-02X) were installed around Areas 2 and 3 to supplement the existing groundwater monitoring well network. These monitoring wells were installed to monitor upgradient (XGM-93-01X) and downgradient (XGM-93-02X) groundwater quality (see Figure 5-6). Monitoring well XGM-93-02X was also installed to replace the existing monitoring well AAFES-4 which had been historically dry. The screen of both monitoring wells was placed so that it would intercept the water table to monitor for free product and allow for seasonal groundwater fluctuations. Due to the depth of the water table in this portion of the installation, the newly installed monitoring wells were installed across the bedrock/soil interface. Table 5-8 summarizes the construction of each new and existing groundwater monitoring well.

Two rounds (Round Three and Four) of groundwater samples were collected from the new and existing monitoring wells. Round Three groundwater samples were collected in October 1993, and Round Four groundwater sampling was completed in January 1994. These samples were submitted for off-site laboratory analysis consisting of PAL VOCs, SVOCs, inorganics (both filtered and unfiltered), TPHC, and TSS (see Table 5-10).

Sediment

One sediment sample was collected from the storm water outfall that drains the paved area around the AAFES gas station. The sample was analyzed for PAL VOCs, SVOCs, inorganics, TPHC, and TOC (see Table 5-10).

5.3.5 Summary of Supplemental Site Investigation Results and Observations

The soil encountered at AOC 43G ranged from silty sand (fill) to a sandy silt with fine to medium gravel (glacial till). The depth of bedrock ranged from 20.5 to 34.5 feet bgs. Rock core samples were collected from the two monitoring well borings (XGM-93-01X and XGM-93-02X). The bedrock was classified as a metasiltstone or phyllite and part of the Oakdale Formation. The water table was encountered at 27 to 30 feet bgs. Elevated PID measurements were recorded for the drilling water and development water from XGM-93-02X, and from the development water from AAFES-1D, AAFES-2, and AAFES-6 (see Figure 5-6). The boring logs are presented in Appendix A and the monitoring well diagrams are presented in Appendix B. A detailed discussion of the geologic setting at AOC 43G is presented in Section 6.1 of this report.

TerraProbe℠ Soil Results. The results of the field analysis for soil samples collected from Area 1 indicated that residual TPHC contamination was present in the soil at this site to a depth of 10 feet bgs. The results from the two soil samples collected from TS-39 showed TPHC concentrations at 740 ppm at 10 feet and 2,000 ppm at 11 feet. TPHC was also detected in the 10-foot samples from TS-35, TS-37 and TS-38 at concentrations ranging from 190 to 400 ppm (Table 5-12). No BTEX was detected in the soil samples collected from Area 1.

Xylene (the only VOC detected) was detected at 6.3 ppb in only one (TS-13 at 10 feet) of the 23 soil samples collected from TerraProbe℠ points located in Area 2. TPHC concentrations ranged from below the detection limit to 5,800 ppm in the 9-foot soil sample at TS-31. The concentrations were highest in the soil samples collected from the north and east/downgradient of the active gasoline USTs (i.e., TS-31 and TS-32) (see Table 5-12).

Concentrations of toluene, ethylbenzene and xylene (TEX) contamination appeared to be confined in and around the former waste oil UST and the sand

and gas trap in Area 3. Total BTEX ranged from below the detection limit to 32,930 ppb at TS-08. TPHC concentrations ranged from below the detection limit to 8,500 ppm at TS-02 (see Table 5-12).

Off-Site Laboratory Soil Results. No contaminants of concern were detected in any of the off-site laboratory soil samples collected from the soil boring (XGB-93-09X) drilled in Area 1. All TPHC concentrations were below the detection limit in these soil samples (Table 5-13).

The results of the off-site laboratory analyses for soil samples collected from Area 2 showed low concentrations of VOCs (acetone and/or trichlorofluoromethane (freon), common laboratory contaminants). SVOCs, consisting of predominantly polynuclear aromatic hydrocarbons (PAHs) were detected in the 8-foot soil sample collected from XGB-93-05X. The remaining SVOCs were BEHP and di-n-butyl phthalate, which are common laboratory contaminants. TPHC was detected at 185 micrograms per gram (μg/g) in the 8-foot sample from XGB-93-05X and at 158 μg/g in the 12-foot sample at XGB-93-06X (see Table 5-13).

The results of the off-site laboratory analyses in Area 3 indicated some low concentrations of VOCs from samples collected from soil borings XGB-93-03X and XGB-93-04X. These borings were drilled in or adjacent to the former waste oil UST and the existing sand and gas trap. BEHP and di-n-butyl phthalate (common laboratory contaminants) were the only SVOCs detected in Area 3. TPHC concentrations ranged from <52 to 1,020 ppm in the soil samples collected from 8 feet bgs at XGB-93-04X (see Table 5-12). Inorganic analytes were detected above Fort Devens background in the 8-foot and 10-foot soil samples collected from XGB-93-04X (adjacent to former waste oil UST) (Table 5-14).

One soil boring (XGB-93-08X) was drilled between the AAFES gas station and historic gas station to determine if contaminants from either area had impacted the subsurface soil quality at this location. No contaminants of concern were detected in any of the subsurface soil samples collected from this boring (see Table 5-13). Inorganic analytes were detected above the Fort Devens background concentration in each of the soil samples collected from XGB-93-08X (see Table 5-10 and 5-14). A complete discussion of the SSI soil results is presented in Section 7.0 of this report.

Off-Site Laboratory Groundwater Results. The results of the off-site laboratory analyses for the Round Three and Four groundwater samples showed the presence of several VOCs (including acetone, benzene, ethylbenzene, toluene, xylenes, PCE, and 1,2-dichloroethane) in the groundwater samples collected from the downgradient and crossgradient monitoring wells (AAFES-1D, AAFES-2, AAFES-5, AAFES-6, AAFES-7 and XGM-93-02X). TPHC was detected in the downgradient groundwater samples and the sample collected from the upgradient monitoring well AAFES-3. No VOCs, SVOCs or TPHC were detected in the samples collected from the upgradient monitoring wells (XGM-93-01X) installed during the SSI. Several inorganic analytes were detected above the Fort Devens groundwater background concentrations in both the unfiltered and the filtered samples. Approximately 0.10 feet of free product was measured in AAFES-2 prior to the Round Three groundwater sampling. No free product was measured in AAFES-2 prior to the Round Four sampling (Table 5-15).

Off-Site Laboratory Sediment Results. One sediment sample was collected from the outfall of the storm drain which drains the paved area at the AAFES gas station. No VOCs or SVOCs were detected in this sample. Several inorganic analytes were detected at notable concentrations. TPHC was detected at 448 $\mu g/g$. A surface water sample was not collected due to insufficient surface water volume during sampling (Table 5-16).

5.3.6 Conclusions and Recommendations

It appeared that past leaks and spills from former USTs had impacted soil quality at Areas 2 and 3 and that contaminants detected in the soil were a continuing source of contamination to the groundwater. It also appeared that the contaminants were moving downgradient with the groundwater flow direction. The replacement of the active gasoline USTs in 1990 and the subsequent removal of the waste oil UST did not appear to have stopped the source of contaminants detected in the groundwater. It appears that the soil directly adjacent to and potentially below the active USTs, the soil below former waste oil UST location and the soil around and potentially below the existing sand and gas trap for Building 2008, contain contaminants which continue to adversely impact groundwater quality below the AAFES gas station.

The additional TPHC contamination detected at Area 1 did not appear to have impacted the groundwater quality below the historic gas station G.

Elevated TPHC was detected in the sediment sample collected from below the outfall for the storm drainage system that drains the parking/refueling area at the AAFES gas station. The elevated TPHC concentration (448 μg/g) appears to be caused by runoff of small fuel spills associated with the AAFES gas station and Queenstown Road activities. Based on the TPHC concentration and lack of any associated VOCs, SVOCs, or elevated lead concentration, it appeared that the sediment in this area has been moderately impacted by this storm drain system.

An RI was recommended for Areas 2 and 3 to further assess the soil and groundwater contamination detected at the AAFES gas stations. Based on the results of the SI, the SSI, and the revised human health Preliminary Risk Evaluation (PRE) associated with the SSI, no further action was recommended for Area 1 (historic gas station G) and the storm drain outfall area. The following subsections summarize the activities conducted during the 1994 RI.

5.4 Remedial Investigation Program Objectives

5.4.1 Technical Objectives

The following subsections present the technical objectives of the field analytical and off-site laboratory analytical programs for the AOC 43G RI.

5.4.1.1 Soil Borings. The technical objective of the soil boring program was to obtain representative soil samples for geologic classification and for conducting field analytical, off-site laboratory analyses, and grain size distribution. In addition, the borings were intended to yield sufficient data to evaluate the nature and concentration of fuel-related contaminants below the existing gasoline USTs and pump islands at AOC 43G.

5.4.1.2 Monitoring Wells. The technical objective of the monitoring well installation program was to install monitoring wells in geologic strata (both overburden and bedrock) such that the local groundwater flow system and contaminant distribution could be adequately characterized. This included

collecting water level and pumping test data to establish flow directions as well as horizontal gradients; and estimating the hydraulic conductivity of the geologic strata.

5.4.1.3 Field Laboratory Analysis. The technical objective of the field analytical program was to relatively quickly generate USEPA Level II analytical data for previously identified site-related compounds (specifically BTEX and TPHC) that allowed for supplemental identification of their distribution. This field analytical data was used to support the results and findings of the contaminant assessment and human health risk assessments. The field analytical techniques employed as part of this RI are discussed in detail in Subsection 3.1 of this report. The results of the field analyses are discussed in detail in Section 7.0 of this report.

5.4.1.4 Off-Site Analytical Sampling. The technical objective of the off-site laboratory analytical program was to enhance the analytical data base for subsurface soil and groundwater at AOC 43G. This data base was used as the foundation for the contamination assessment, the fate and transport discussion, and human health risk assessments. The laboratory analytical methods employed as part of this RI are discussed in detail in Subsection 3.2 of this report. The results of the analytical data are discussed in detail in Section 7.0 of this report.

5.4.2 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative or quantitative statements developed by the data user to specify the quality of data needed from a particular activity to support specific decisions. The DQOs are the starting point in the design of the remedial investigation. The DQO development process matches sampling and analytical capabilities to the data targeted for specific uses and ensures that the quality of the data does not underestimate project requirements.

The procedures of the QA Objectives presented in Section 3.0 of Volume I of the Fort Devens POP were followed during the RI field program at AOC 43G (ABB-ES, 1993c). These DQOs reflect the pre-1993 USEPA data quality levels rather than the existing data quality levels (USEPA, 1993). This subsection includes a general scope of work, DQOs, and the QA/QC approach.

Analyses were conducted on samples collected from AOC 43G to evaluate the nature and distribution of the contaminants detected in the previous investigations. On-site field analysis conformed with the guidelines presented in Subsection 4.6 of Volume I of the Fort Devens POP. Off-site laboratory analytical procedures are presented Section 7.0 of Volume I of the POP, and the Laboratory QA Plan and the USAEC Certified Analytical Methods procedures are presented in Appendices B and C, respectively, in Volume II of the Fort Devens POP (ABB-ES, 1993c).

The USEPA has identified five general levels of analytical data quality as being potentially applicable to field investigations conducted at potential hazardous waste sites under CERCLA. These levels are summarized as follows:

- Level I - Field Screening. This level is characterized by the use of portable instruments which can provide real time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.

- Level II - Field Analysis. This level is characterized by the on-site use of portable analytical instruments and mobile laboratories which can render qualitative and quantitative data.

- Level III - Off-site laboratory analysis using methods other than the Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily in support of engineering studies using standard USEPA-approved procedures. Some procedures may be equivalent to the USEPA RAS, without the CLP requirements for documentation.

- Level IV - CLP RAS. This level is characterized by rigorous QA/QC protocols and documentation, that provide qualitative and quantitative analytical data.

- Level V - Non-standard methods. This level includes analyses which may require modification and/or development. CLP Special Analytical Services (SAS) are considered Level V.

For AOC 43G RI efforts, field measurements such as pH, temperature, conductivity, and readings from a PID and O_2/Explosimeter constituted Level I field analytical data. Field GC and IR analysis constituted Level II field analytical data. Off-site laboratory analyses of soil, groundwater, and sediments for organics, inorganics, TOC, TPHC, and TSS were considered approximately equivalent to USEPA analytical support Level III. The sampling approaches and analytical procedures described in the Fort Devens POP have been selected to meet the Level III data quality.

DQOs were established to support the level of detail required for RI activities. Data generated during the field and off-site laboratory tasks were used to characterize AOC 43G conditions and to perform baseline risk assessments.

DQOs and quality control for field measurements and off-site laboratory analyses conform to USAEC and USEPA requirements (as specified in the USAEC Quality Assurance Manual, 1990 and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, 1988).

USAEC requirements and analytical processes are discussed in Section 3.0 of this report. They focus on the use of off-site laboratory control spikes in associated data lots to measure the performance of the off-site laboratory in the use of USAEC methods. Many of the USAEC methods are identical to standard USEPA methods. The certification process, required by laboratories performing USAEC work, is discussed in Section 3.2.1. The data review and evaluation process are described in Section 3.2.3.

Off-site laboratory data were evaluated for precision, accuracy, representativeness, completeness and comparability (PARCC) in order to meet USEPA Level III requirements. This was accomplished through the collection of field quality control blanks such as field blanks, trip blanks, and equipment rinsates, and through the evaluation of off-site laboratory blanks such as method blanks. The specific purpose of collecting each of these is discussed in Section 3.2.5 of this report. Off-site laboratory control spikes are run in the certification process to

generate control charts that help to establish control limits that are used to ensure accuracy of the results. This process is described in Section 3.2.6 of this report. MS/MSD were also analyzed to meet PARCC DQOs. These are broken down by group and are presented in Appendix D.

The precision of the data is a measurement of the ability to reproduce a value under certain conditions. It is a quantitative measurement based on the differences of two values. Precision was evaluated using the RPD of MS/MSD sample pairs and field duplicate sample pairs. Evaluations of the precision of the data are found in Appendix D.

Accuracy measurements identify the performance of a measurement system based on tests with known values. The laboratory, sampling, and media effects on accuracy were assessed by reviewing the percent recoveries of spiked analytes for MS/MSDs, laboratory control samples, and surrogate compounds.

Representativeness refers to the extent to which a measurement accurately and precisely represents a given population within the accepted variation of laboratory and sampling measurements. Collection techniques that obtained samples characteristic of the matrix and location being evaluated were chosen. Historic information was used to identify sample locations. Representativeness was also evaluated using method blanks and field QC sample data. By evaluating method blank and field QC samples, false positive results should be identified. Representativeness was also measured by evaluating field duplicate pair precision.

Completeness refers to the percentage of usable, valid values obtained through data evaluation. Completeness was determined by the success rate in meeting holding time criteria and acceptance of sample lots by USAEC.

Comparability is a qualitative assessment describing the confidence with which one data set may be compared with another. Comparability was assured using standard operating procedures for sampling, and by reporting analytical results in standard units.

5.5 SUMMARY OF 1994 REMEDIAL INVESTIGATION PROGRAM

The RI techniques were conducted in conformance with the Revised Final Task Order Work Plans for AOC 41, AOC 43G, and AOC 43J (ABB-ES, 1994b) and the Fort Devens POP (ABB-ES, 1993c).

The RI program for AOC 43G consisted of:

- A geophysical survey using GPR to clear exploration locations and a seismic refraction survey.
- Field analysis of soil samples from soil borings using a GC and IR, and groundwater using a GC.
- Six soil borings were completed adjacent to the existing USTs in Area 2.
- Eight water table monitoring wells were installed downgradient and crossgradient of Areas 2 and 3 to supplement the existing monitoring well network.
- Seven piezometers were installed to support the aquifer pumping tests.
- Two rounds of groundwater samples were collected from the newly installed and existing monitoring wells.
- Aquifer permeability testing was completed on the newly installed monitoring wells, and two aquifer pumping tests were completed.
- Horizontal and vertical survey of all RI explorations was completed.

ABB-ES established a project field office in Building 201 on Fort Devens' Main Post. The field office was used for equipment storage and maintenance, sample management, shipping and receiving, staff meetings, and communications. A telephone was maintained in the field office, and each field crew was issued a hand-held cellular phone. A central equipment decontamination pad was

constructed near the field office. ABB-ES and subcontractor staff were briefed about the nature of AOC 43G, health and safety information, Fort Devens traffic regulations, and key technical requirements.

ABB-ES began implementation of the AOC 43G field program in September 1994 with equipment mobilization and a geophysical survey.

The subcontractors used by ABB-ES in conducting the RI program were as follows:

- D.L. Maher, North Reading, MA - Drilling and monitoring well installation.
- ESE, Gainesville, FL - Chemical analysis of environmental samples.
- Martinage Engineering Assoc., Inc., Reading, MA - Surveying of site explorations.

All field activities were conducted in accordance with the ABB-ES' Fort Devens POP and USAEC's Geotechnical Guidelines (USAEC, 1987). The following subsections describe the field activities for the RI at AOC 43G.

5.5.1 Surficial Geophysical Survey

A surficial geophysical survey was conducted to locate safe drilling locations for the intrusive explorations completed during the RI. Surficial geophysical survey procedures are outlined in Subsection 4.4.3 of Volume I of the Fort Devens POP (ABB-ES, 1993c).

5.5.2 Seismic Refraction Survey

A seismic refraction survey was conducted in December 1994 by Geophysics GPR International, Inc. (GPRI) of Needham Heights, MA to further define the bedrock surface of AOC 43G. One seismic line (line SL-4) was completed at the base of the hill east of AOC 43G (see Figure 5-7). A summary of the technique and procedures employed is presented below; the complete report GPRI is presented in Appendix C.

A 24-channel EG&G Smartseis S24 digital seismograph was employed during this investigation. Amplification of the signals from the geophones was accomplished using integrated floating point technology, which allows maximum trace size throughout the record. Each seismogram was recorded digitally on the seismograph hard drive, transferred to floppy disk, and printed on-site.

The major energy source was electrical percussion detonated by a shotbox. The shotbox delivered a 67.5 volt, 2 amp electric impulse via the blasting cable to each charge. When a shot was fired, an impulse from the shotbox was sent to the shot instant recording galvanometer which marks the zero time on the first trace of each seismogram.

Three to five shotpoints were used for each spread of geophones. These shotpoints provide information on the acoustic velocity of the overburden and permit an estimate of the velocity and depth to rock. In-line offset shots were fired beyond the end of each spread in the forward and reverse directions. The offset distance was such that the first arrivals at each geophone were refracted from the bedrock. Offset shotpoints provide detailed information on the topographic profile and velocity of the bedrock.

5.5.3 Soil Borings

A total of six soil borings (XGB-94-10X through XGB-94-15X) were completed during the RI (see Figure 5-7 and see Table 5-1). Soil samples were collected at 5-foot intervals from each boring. All of the soil borings were drilled using 4.25-inch inside diameter (ID) hollow-stem augers (HSAs). The boring logs are presented in Appendix A. Sample results are discussed in Section 7.0 of this report.

Soil borings were completed in accordance with procedures presented in Section 4.4.6.1 of Volume I of the Fort Devens POP (ABB-ES, 1993c).

One groundwater sample was collected from four monitoring well soil borings (XGM-94-06X, XGM-94-07X, XGM-94-09X, and XGM-94-10X) for field analysis using a GC. These samples were collected to better define the horizontal distribution of site contaminants for optimum downgradient and crossgradient

monitoring well location. Each sample was analyzed for BTEX and selected chlorinated solvents.

5.5.4 Monitoring Well/Piezometer Installation

Based on the results of the previous investigations and the soil borings, a total of eight new water table monitoring wells (XGM-94-03X through XGM-94-10X) and seven piezometers (XGP-94-01X through XGP-94-07X) were installed during the RI (see Figure 5-7 and Table 5-1). Each of the monitoring wells, with the exception of XGM-94-06X, were screened in the bedrock or across the bedrock soil interface. Monitoring well XGM-94-06X was screened completely in overburden soils. Four of the piezometers (XGP-94-01X and XGP-94-05X through XGP-94-07X) were installed in the bedrock or across the bedrock soil interface; and the remaining three piezometers (XGP-94-02X through XGP-94-04X) were installed completely in the overburden soils. Monitoring well construction was completed in accordance with USAEC requirements. Monitoring well and piezometer completion diagrams are presented in Appendix B, and a summary of each monitoring well installation is presented in Table 5-8. Monitoring wells were installed following procedures presented in Section 4.4.6.4 of Volume I of the Fort Devens POP (ABB-ES, 1993c).

5.5.5 Well Development

Each of the newly installed RI monitoring wells was developed using the pump and surge method, to remove any water added to the boring during drilling and/or well installation, and to remove sediment from the monitoring well screen prior to groundwater sampling. The procedures for well development are presented in Subsection 4.4.6.5 of Volume I of the Fort Devens POP (ABB-ES, 1993c).

5.5.6 Pumping Test

Aquifer pumping tests were performed at AOC 43G to provide information on the hydrogeologic characteristics of the overburden and bedrock aquifers as well as to gather data required to support the FS. A chronology of events and quantitative discussion of the aquifer pumping test results are provided in Appendix F.

Pumping tests were performed on the overburden monitoring well XGM-94-06X and the bedrock monitoring well XGM-94-04X. These monitoring wells were chosen to represent potential source control at XGM-94-04X and potential downgradient contaminant plume containment at XGM-94-06X. Monitoring well XGM-94-04X was chosen as the representative source area well because other monitoring wells with higher concentrations of site-related contaminants (i.e., AAFES-2 or XGM-94-03X) did not have sufficient permeability to support an aquifer pumping test. A Grundfos 2-inch submersible pump with a Redi-Flo voltage regulator and 5/8-inch discharge line was used for all tests. Power was supplied by a 220 volt gas powered generator. Discharge rate was monitored with an in-line Badger totalizing flow meter and an in-line, instant read, Blue White flow meter with a 0 to 1.0 gpm range.

Monitoring wells and piezometers were instrumented with In-Situ pressure transducers (10 to 50 pounds per square inch [psi] range) and In-Situ Hermit data loggers to monitor and record groundwater levels. Barometric pressure was monitored with an In-Situ barometric probe. All water generated during the aquifer tests was containerized in polyethylene tanks and disposed of at a U.S. Army Corps of Engineers-run water treatment facility located on Fort Devens.

Variable-rate step-drawdown tests were performed at XGM-94-04X and XGM-94-06X prior to the constant rate discharge tests to ascertain the maximum sustainable yield for each well. Pumping rates for the initial step were estimated from well development records. The optimum pumping rate as determined from the step-drawdown tests was 0.4 gpm for both XGM-94-04X and XGM-94-06X. Refer to Appendix F for a detailed discussion of the step-drawdown test procedures.

Monitoring wells XGM-94-07X and XGM-94-08X were instrumented with in-situ Well Sentinel data loggers and pressure transducers six days prior to the start of the constant-discharge aquifer tests. XGM-93-01X was also used as a background well for the XGM-94-04X aquifer pumping test. Data from these wells were used to determine antecedent trends affecting groundwater levels during the test and to monitor recharge effects.

The pumping phase of the XGM-94-06X constant-rate discharge test lasted for 48 hours. Recovery was monitored for 37.5 hours. Water levels were monitored in

the piezometers XGP-94-02X, XGP-94-03X, and XGP-94-04X, in addition to monitoring well XGM-94-06X, throughout the pumping and recovery phases of the test.

The pumping phase of the constant-rate discharge test conducted at XGM-94-04X lasted for 87 hours. Recovery was monitored for three days. Pumping influences were observed in XGP-94-01X, XGP-94-05X, XGP-94-06X, XGP-94-07X, AAFES-6, XGM-93-02X and XGM-94-10X. For a more detailed discussion of the aquifer testing procedures refer to Appendix F.

5.5.7 In-Situ Hydraulic Conductivity Testing and Water Level Measurement

Hydraulic conductivity tests were performed on each of the newly installed RI monitoring wells to further define the hydraulic conductivity of the geologic units at AOC 43G. Appendix G presents data and analysis of the hydraulic conductivity testing. These tests generally consisted of falling and rising head tests within a given monitoring well. Falling head test data was analyzed for monitoring wells with static water levels above the top of the well screen. Rising head tests were performed on all monitoring wells except XGM-94-05X, due to very slow (>2 hours) water level recovery. The rate of water level recovery back to static conditions within the well casing was monitored using a pressure transducer and data logger. The elevation of the water level (for falling head tests) and depression (for rising head tests) was accomplished with a solid cylindrical PVC slug using the techniques discussed in Subsection 4.8.2 of Volume I of the Fort Devens POP (1993e).

The data from all in-situ hydraulic conductivity tests were analyzed using the Method of Bouwer and Rice 1976 with the Aqtesolv computer program. In addition, data were analyzed by the Hvorslev (1951) method. Discussion of the results of the in-situ hydraulic conductivity testing are presented in Section 6.0 of this RI Report.

5.5.8 Groundwater Sampling

Two rounds of groundwater samples (Rounds Five and Six) were collected from the eight new and eight existing monitoring wells (see Figure 5-7 and Table 5-1). Round Five samples were collected in January 1995 and Round Six were collected

in March 1995. The groundwater samples for these two rounds were submitted for off-site laboratory analysis consisting of PAL VOCs, SVOCs, inorganics (both filtered and unfiltered), water quality parameters, and TSS (see Table 5-10). Groundwater sampling procedures are presented in Subsection 4.5.2.2 of Volume I of the Fort Devens POP (ABB-ES, 1993c). Sample results are discussed in Section 7.0 of this report.

5.5.9 Soil Vapor Extraction/Bioventing Pilot Test

A Soil Vapor Extraction (SVE)/bioventing pilot test was conducted near the three active 10,000-gallon gasoline USTs at AAFES during the RI. The pilot test system consisted of a vent well, four vapor monitoring probes, a blower, vapor-phase carbon (for off-gas treatment), piping, and monitoring equipment. Details of the system are described in the Draft SVE/Bioventing Report located in Appendix O.

System Description: The well and probes that were installed as part of the RI for the pilot test consisted of one 2-inch diameter SVE well (29 feet deep, 10-foot screen) and three 1-inch diameter monitoring probes (26 to 29 feet deep, 5-foot screens). The SVE well was installed in soil boring XGB-94-12X and the monitoring probes were installed in soil borings XGB-94-10X, XGB-94-11X and XGB-94-13X (Figure 5-8). Monitoring well AAFES-4, an existing 2-inch diameter PVC well, was also used as a monitoring probe. AAFES-4 was installed in November 1990 by Nobis as part of the soil and groundwater investigation. This monitoring well was dry at the time of the SVE pilot study. Details of the well and probe construction are presented in Appendix O.

The distances from the vapor extraction well to the probe locations range from approximately 8 feet to 30 feet. The vapor extraction well was located as near to the USTs as possible and in an area where contaminant concentrations were likely to be highest, based on SSI data (ABB-ES, 1994a). The screen of the vapor extraction well (XGB-94-12X) was located at the soil zone located below the original tank excavation and extending to the bedrock surface (approximately 20 feet to 30 feet bgs).

Procedures: The SVE/bioventing pilot test was performed in two parts; a permeability (SVE) test and a respiration (bioventing) test.

The permeability test consisted of operating the vacuum exhauster which was connected to XGB-94-12X and measuring the resulting vacuum pressures at each of the four monitoring probes at discrete time intervals over a 48-hour time period. At these same time intervals, PID measurements were taken at a sampling port on the pressure line from the blower and from the effluent of both granular-activated carbon (GAC) drums. Soil gas off-site laboratory samples were collected from the SVE well upon startup, and at 4, 12, 36 and 48 hours during the test. Oxygen, carbon dioxide, and methane levels were also measured at the monitoring probes during the permeability test to evaluate how much time was necessary to vent (aerate) the soil to achieve ambient gas levels (20.9 percent O_2, 0 percent CO_2, and 0 percent CH_4).

The respiration test commenced immediately upon completion of the permeability test. Upon turning off the SVE blower, levels of oxygen, carbon dioxide, methane and volatile carbon were measured in monitoring probes and the vent well at discrete time points over an approximate 50-hour time period.

Pilot test results and conclusions are discussed in Appendix O.

5.5.10 Equipment Decontamination

Several different sampling and analytical procedures were used during the AOC 43G RI field program, which lead to a variety of decontamination procedures. To document the effectiveness of decontamination procedures, periodic equipment rinsate blanks were collected and submitted for chemical analyses. Analytical results for the rinsate blanks are presented in Appendix D. Decontamination procedures followed during the RI are presented in Section 4.3 of Volume I of the Fort Devens POP (ABB-ES, 1993c).

One central decontamination pad was constructed and maintained by D.L. Maher, Inc (drilling subcontractor). The pad was constructed at ABB-ES's field office located at Building T-201 for the decontamination (via steam cleaning) of the drill rig and other equipment, including but not limited to drill rods, well materials, split spoons, augers, drill bits and vehicles. This decontamination pad was approximately 10 feet long and 10 feet wide and was built with three low sides and a floor that sloped to the southwest to collect liquid residuals. The bottom was lined with high density plastic sheeting and plywood sheeting.

5.5.11 Investigation-Derived Waste

During the field program at the AOC 43G a variety of investigation-derived waste (IDW) was produced including: purge water, soil cuttings, and well development water, decontamination fluids from the decontamination pad, grout and personnel protective equipment. As the IDW was produced, it was screened in the field with a PID. As soil cuttings were generated from the drilling process they were segregated into piles (5 feet of drilling depth per pile) on plastic sheeting as the cuttings came off of the auger fights. The IDW collection, handling, and disposal procedures followed during the RI are presented in Section 4.10 of Volume I of the Fort Devens POP (ABB-ES, 1993c).

5.5.12 Location and Elevation Survey

Upon completion of the field program at the AOC 43G, a location and elevation survey was conducted to accurately locate the new explorations including: new and existing monitoring wells, TerraProbe points, piezometers, and soil borings. A topographic survey was also conducted at the AOC to better define the topographic features at the site.

The survey was conducted by Martinage Engineering, Inc. of Reading, MA. Horizontal control was established with a Leitz Sokkia II Total Station Vernier reading to one second accuracy. Vertical control was established using a Topcon Auto Level accurate to 0.001 of a foot. Both units were calibrated in December 1993 by North American Survey Supply, authorized dealer and service representative for Leitz and Topcon.

Monitoring wells were surveyed for horizontal control, and vertical control of the ground surface, top of the protective casing, and the top of the PVC well riser. Test pits and the geophysical grid were surveyed for horizontal control and vertical control. Survey procedures and accuracy followed during the RI are presented in Section 4.9 of Volume I of the Fort Devens POP (ABB-ES, 1993c). Appendix I presents a summary of the survey data for AOC 43G.

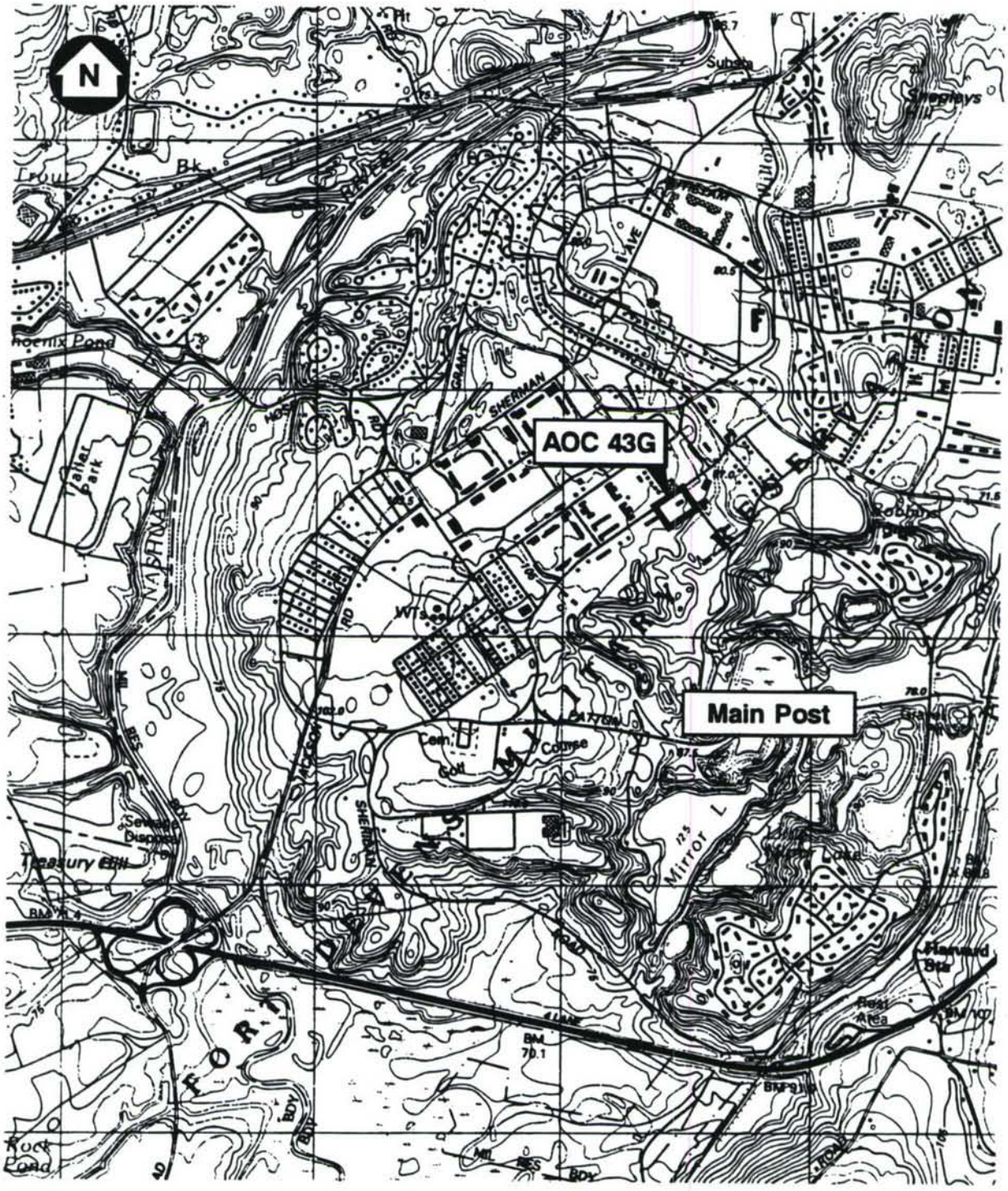


FIGURE 5-1
LOCATION OF AOC 43G
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ABB Environmental Services, Inc.

W9505016D(a)

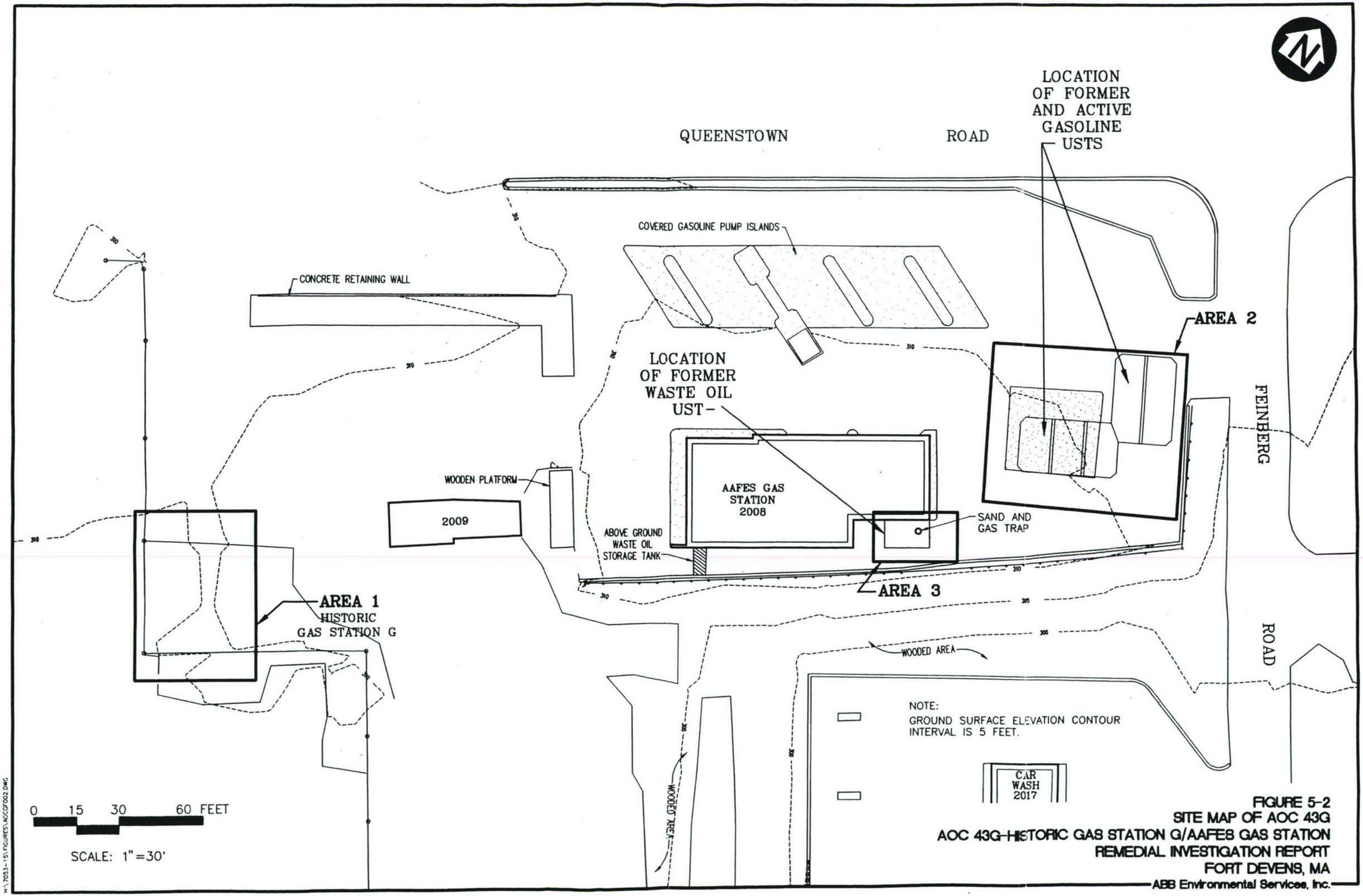


FIGURE 5-2
SITE MAP OF AOC 43G
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

LEGEND

- AAFES-1 — MONITORING WELL
- B-1 — SOIL BORING
- T-5 W — SOIL SAMPLE (NOBIS) (EXCAVATION)

NOTE:
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

48 SOIL SAMPLES COLLECTED BY NOBIS (DEC 1990 – APR 1991)

QUEENSTOWN ROAD

LOCATION OF FORMER AND ACTIVE GASOLINE USTS

54 SOIL SAMPLES COLLECTED BY NOBIS (OCT 1990) FROM TANK EXCAVATIONS

AAFES-3

B-15

CONCRETE RETAINING WALL

COVERED GASOLINE PUMP ISLANDS

B-12

B-10

B-13

B-4

T-4 W

T-5 W

B-14

LOCATION OF FORMER WASTE OIL UST

12 SOIL SAMPLES (SS-1 – SS-10 AND LSS-1, LSS-2) COLLECTED FROM TANK EXCAVATIONS, MAY 1992 BY ATEC

B-6

T-2 W

T-3 NW

T-3 W

T-5 N

B-8

AREA 2

FEINBERG ROAD

GRASSED AREA

T-4 W

B-7

T-1 S

B-3

T-1/T-2 E

T-3 E

T-1 E

B-2

T-2 E

B-1

T-5 E

T-4/T-5 E

T-4 E

B-11

WOODEN PLATFORM

2009

AAFES GAS STATION 2008

ABOVE GROUND WASTE OIL STORAGE TANK

SAND AND GAS TRAP B-5

AAFES-4

AREA 1

AREA 3

AAFES-5

AAFES-2

WOODED AREA

AAFES-6

AAFES-1D

B-9

CONTAMINATED SOIL STOCKPILE AREA

CAR WASH 2017

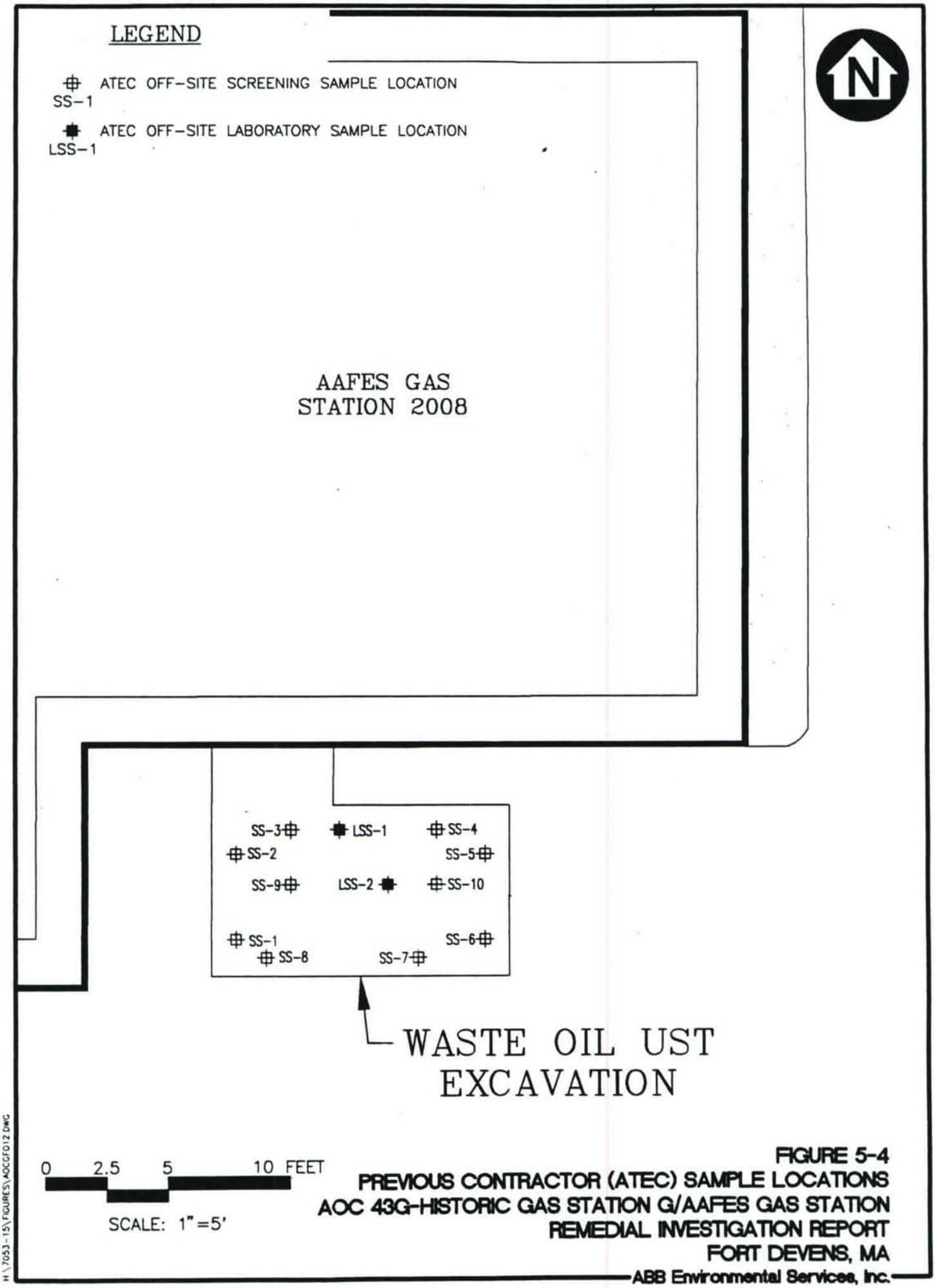
AAFES-7 IS LOCATED APPROXIMATELY 530' EAST OF AAFES-5

0 15 30 60 FEET

SCALE: 1"=30'

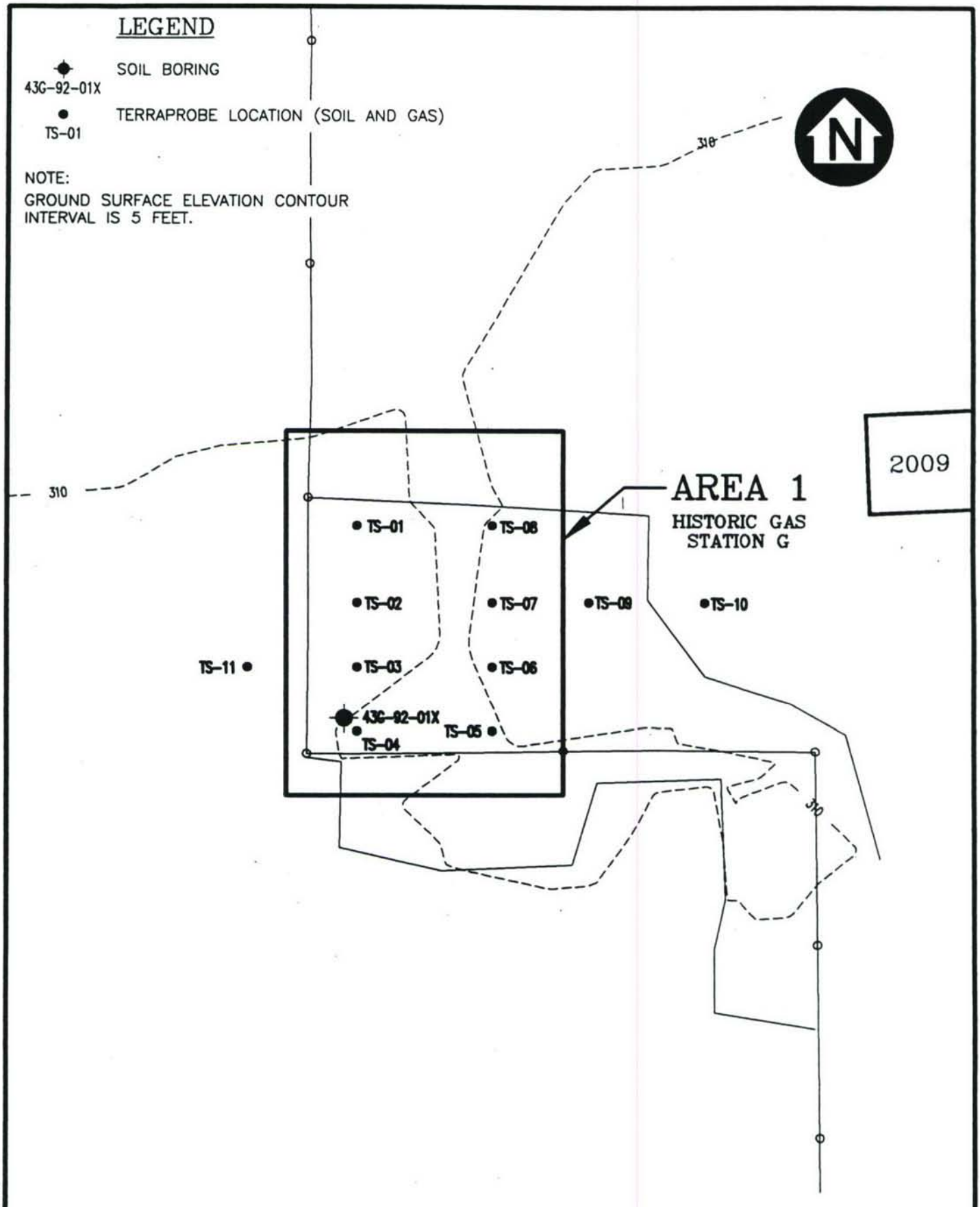
FIGURE 5-3
PREVIOUS CONTRACTOR EXPLORATIONS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ABB Environmental Services, Inc.



H:\7053-15\FIGURES\AOCGF012.DWG

FIGURE 5-4
PREVIOUS CONTRACTOR (ATEC) SAMPLE LOCATIONS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.



H:\7053-15\FIGURES\AOCGF013.DWG

FIGURE 5-5
SI EXPLORATION LOCATIONS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

LEGEND

- ⊕ AAFES-1 — MONITORING WELL
- • TS-90 — TERRAPROBE POINT (SOIL ONLY)
- ◆ XGB-93-05X — SOIL BORING
- ◆ XGD-93-02X — SEDIMENT SAMPLE

NOTE:
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

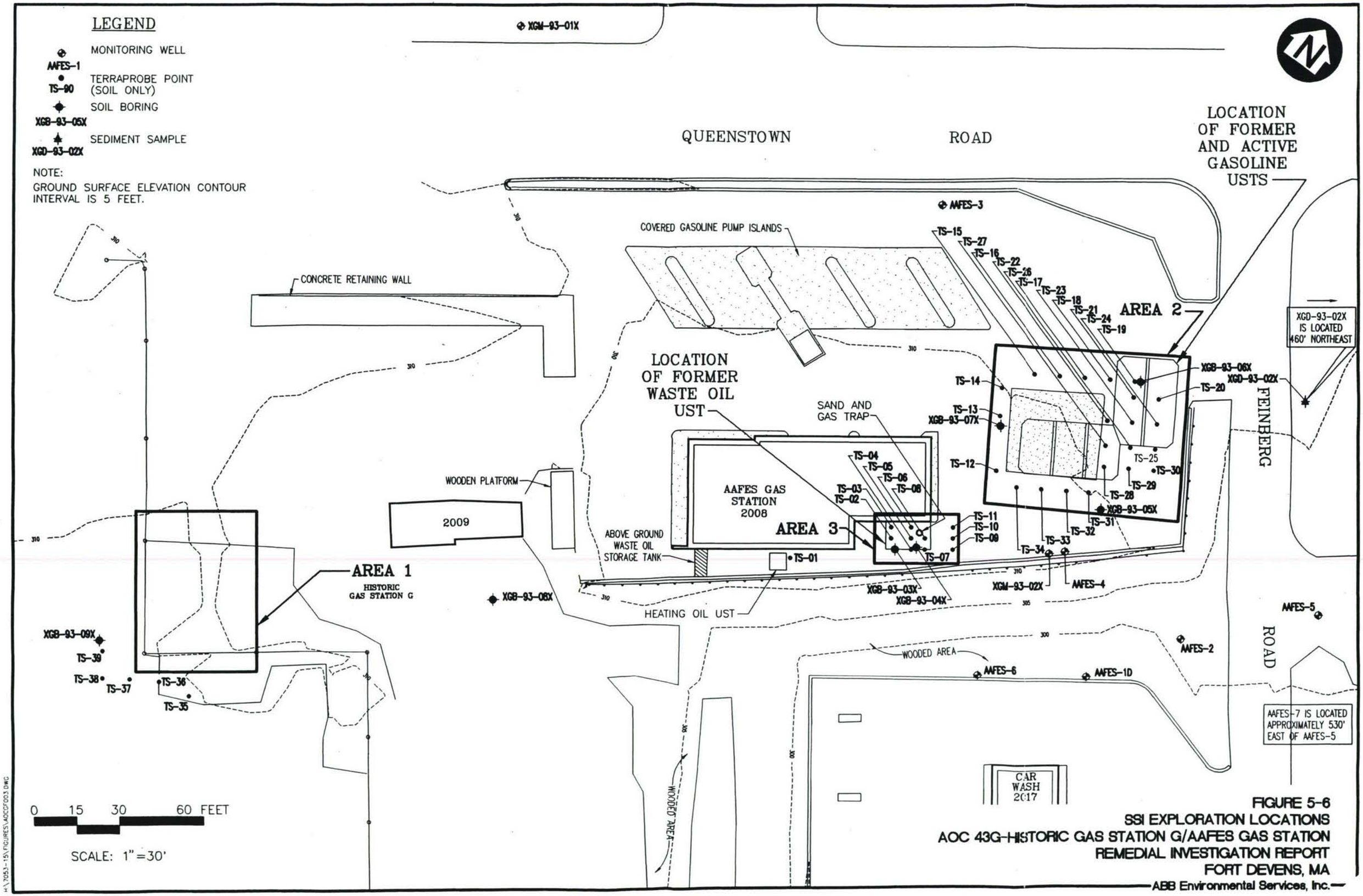


FIGURE 5-6
SSI EXPLORATION LOCATIONS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

H:\7053-15\FIGURES\AOCGF003.DWG

LEGEND

XGB-94-10X — SOIL BORING/VAPOR EXTRACTION WELL

XGB-94-14X — SOIL BORING

XGP-94-06X — PIEZOMETER

XGM-94-05X — MONITORING WELL

NOTE:
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

LOCATION OF EXISTING GASOLINE USTS

LOCATION OF FORMER WASTE OIL UST

ROAD

QUEENSTOWN

AREA 2

AREA 3

AREA 1

GRASSED AREA

XGB-94-11X

XGB-94-12X

XGB-94-10X

XGB-94-13X

AAFES-3

XGB-94-15X

XGM-93-01X

COVERED GASOLINE PUMP ISLANDS

XGB-94-14X

AAFES-4

XGM-93-02X

AAFES-5

XGM-94-05X

AAFES-2

XGM-94-03X

AAFES-1D

FEINBERG

XGM-94-07X

2012
ONE-STORY BUILDING

ABOVE GROUND WASTE OIL STORAGE TANK

AAFES GAS STATION 2008

CONCRETE RETAINING WALL

ABOVE GROUND WASTE OIL STORAGE TANK

WOODEN PLATFORM

2009

WOODED AREA

AAFES-6

XGM-94-04X

XGP-94-07X

XGP-94-05X

XGP-94-06X

XGP-94-01X

CAR WASH 2017

AAFES-7 AND SEISMIC LINE ARE LOCATED 180' SOUTHEAST

AAFES-7

XGM-94-09X

XGM-94-08X

ROAD

STORAGE SHED

REMAINS OF CONCRETE FOUNDATION

XGP-94-04X

XGM-94-06X

XGP-94-02X

XGP-94-03X

BLDG. 3653

BIT. CONC. PAVEMENT

GRAVEL

XGM-94-10X

WOODED AREA

SMALL TREES & BRUSH

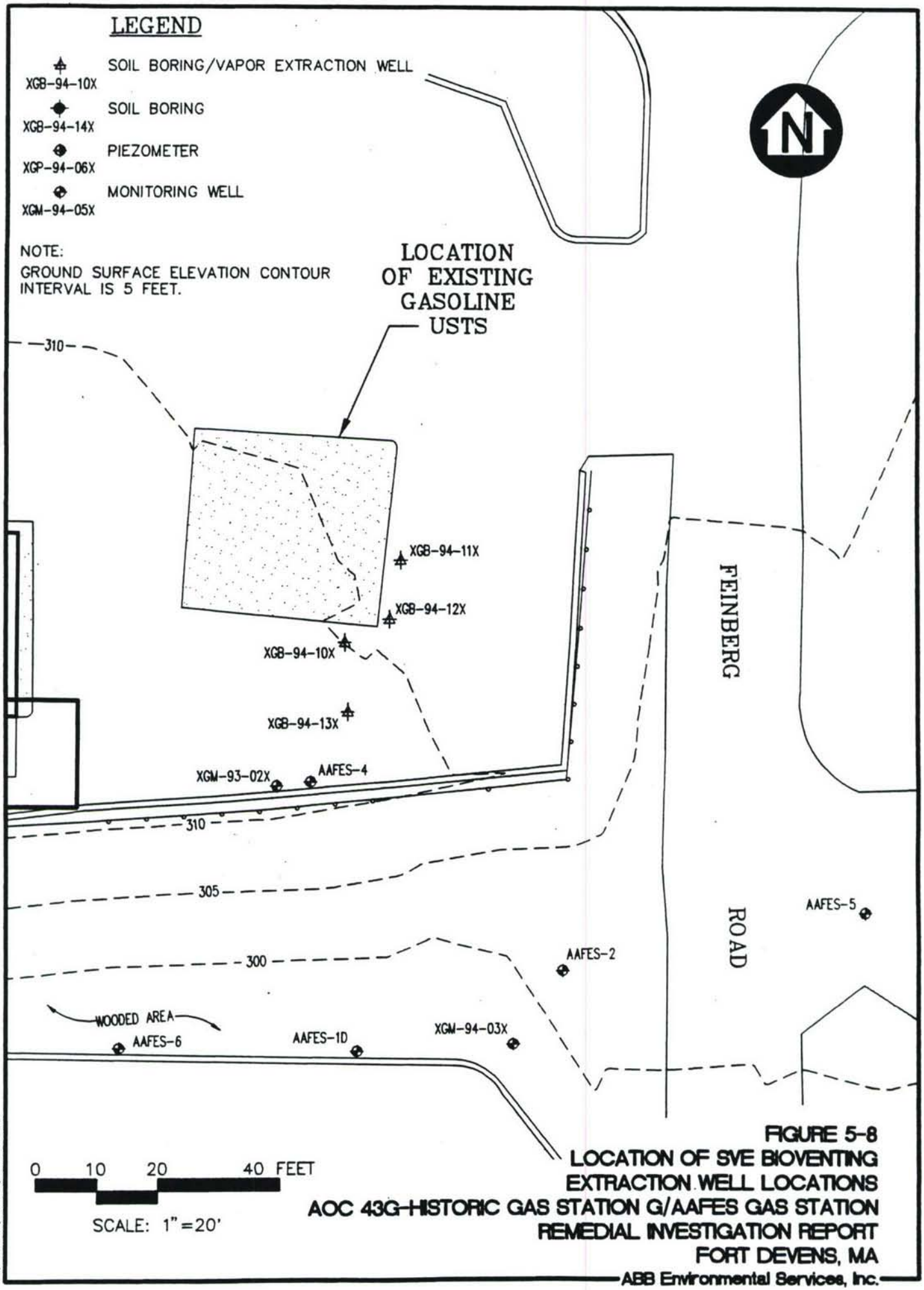
GRASSED AREA

0 25 50 100 FEET

SCALE: 1"=50'

H:\7053-15\FIGURES\AOCGF004.DWG

FIGURE 5-7
RI EXPLORATION LOCATIONS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.



H:\7053-15\FIGURES\AOCGF010.DWG

FIGURE 5-8
LOCATION OF SVE BIOVENTING EXTRACTION WELL LOCATIONS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

TABLE 5-1
SUMMARY OF INVESTIGATION ACTIVITIES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION/SAMPLE IDENTIFICATION	PURPOSE OF ACTIVITY
PREVIOUS CONTRATOR INVESTIGATIONS					
OCTOBER 1990	REMOVAL OF THREE 9,000 AND TWO 10,000-GAL GASOLINE USTs (AREA 2)	NOBIS	5 USTS	NORTH OF AAFES GAS STATION	REMOVE USTS AS PART OF POST-WIDE PROGRAM
	SOIL SAMPLING (AREA 2)	NOBIS	54 SAMPLES	S-1 TO S-13 AT TANK #1 S-1 TO S-10 AT TANK #2 S-1 TO S-10 AT TANK #3 S-1 TO S-11 AT TANK #4 S-1 TO S-10 AT TANK #5	FIELD SCREENING SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST EXCAVATION PRIOR TO REMEDIATION
			10 SAMPLES	S-1 AND S-2 AT EACH TANK LOCATION	LAB ANALYTICAL SAMPLE TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST EXCAVATION PRIOR TO REMEDIATION
OCTOBER 1990	SOIL BORINGS (AREA 2)	NOBIS	15 BORINGS	B-1 TO B-15	FIELD SCREENING SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST
NOVEMBER 1990	SOIL REMOVAL (AREA 2)	NOBIS	NA	NORTH OF AAFES GAS STATION	REMOVE CONTAMINATED SOILS ASSOCIATED WITH THE GASOLINE UST REMOVALS
	SOIL SAMPLING (AREA 2)	NOBIS	22 SAMPLES	SUITE T-1 TO SUITE T-5	FIELD SCREENING AND LABORATORY ANALYTICAL SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST
	SOIL BORINGS/MONITORING WELL INSTALLATION	NOBIS	8 BORINGS/WELLS	MW-1D, MW-1 TO MW-7 (SUBSEQUENTLY RENAMED AAFES-1D, AAFES-1 TO AAFES-7)	FIELD SCREENING AND LABORATORY ANALYTICAL SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST
DECEMBER 1990	GROUNDWATER SAMPLING	NOBIS	7 MONITORING WELLS	MW-1D TO MW-7	MONITOR GROUNDWATER QUALITY AND ASSESS HYDROGEOLOGIC CONDITIONS
	SOIL SAMPLING	NOBIS	39 SAMPLES	PUMP ISLANDS AND ASSOCIATED PIPING	FIELD SCREENING SAMPLES TO ASSESS IMPACT TO NEAR SURFACE AND SUBSURFACE SOIL FROM PUMP ISLANDS AND PRODUCT LINE
APRIL 1991	SOIL SAMPLING	NOBIS	9 SAMPLES	PUMP ISLANDS AND ASSOCIATED PIPING	FIELD SCREENING SAMPLES TO FURTHER ASSESS IMPACT TO SURFACE AND SUBSURFACE SOIL FROM PUMP ISLANDS AND PRODUCT LINE
MAY 1992	REMOVAL OF ONE 500-GAL WASTE OIL UST (AREA 3)	ATEC	1 UST	BEHIND AAFES GAS STATION	REMOVE UST AS PART OF POST-WIDE PROGRAM
	SOIL SAMPLING (AREA 3)	ATEC	10 SAMPLES	SS-1 TO SS-10	FIELD SCREENING SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM WASTE OIL UST REMOVAL
				LSS-1 AND LSS-2	LAB ANALYTICAL SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM WASTE OIL UST REMOVAL

TABLE 5-1
SUMMARY OF INVESTIGATION ACTIVITIES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
PORT DEVENS, MA

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION/SAMPLE IDENTIFICATION	PURPOSE OF ACTIVITY
SITE INVESTIGATION					
AUGUST 1992	GEOPHYSYICS SURVEY	ABB-ES	NA	HISTORIC GAS STATION G	DETERMINE IF UST HAD BEEN REMOVED AND PROVIDE UTILITY CLEARANCE FOR SUBSURFACE EXPLORATIONS
	TERRAPROBE POINTS (AREA 1)	ABB-ES	10 POINTS	TS-01 TO TS-10	COLLECT SOIL GAS SAMPLES FOR FIELD ANALYSIS AROUND HISTORIC GAS STATION
	TERRAPROBE POINTS (AREA 1)	ABB-ES	4 POINTS	TS-04, TS-09 to TS-11	COLLECT SOIL SAMPLES FOR FIELD ANALYSIS AROUND HISTORIC GAS STATION
SEPTEMBER 1992	SOIL BORING (AREA 1)	ABB-ES	1 BORING	43G-92-01X	COLLECT SUBSURFACE SOIL SAMPLES NEAR FORMER GASOLINE UST FOR LABORATORY ANALYSIS
SUPPLEMENTARY SITE INVESTIGATION					
AUGUST 1993	TERRAPROBE POINTS (AREAS 1, 2, AND 3)	ABB-ES	26 POINTS	TS-1 TO TS-5,7,8,10,13,14, TS-18 TO TS-26, AND TS-28 TO TS-35 AND TS-55 TO TS-39	COLLECT SOIL SAMPLES AT AAFES GAS STATION FOR FIELD ANALYSIS
			5 POINTS		COLLECT SOIL SAMPLES WEST OF HISTORIC GAS STATION FOR FIELD ANALYSIS
	SOIL BORINGS AND MONITORING WELL INSTALLATION	ABB-ES	2 WELLS	XGM-93-01X AND XGM-93-02X	COLLECT SUBSURFACE SOIL SAMPLES FOR ANALYSIS AND INSTALL MONITORING WELLS TO ASSESS IMPACT TO GROUNDWATER FROM FORMER USTS
SEPTEMBER 1993	SOIL BORINGS (AREA 2 and 3)	ABB-ES	6 BORINGS	XGB-93-03X TO XGB-94-08X	COLLECT SOIL SAMPLES AT AAFES GAS STATION FOR OFF-SITE LABORATORY ANALYSIS
	(AREA 1)		1 BORING	XGB-93-09X	COLLECT SOIL SAMPLES NEAR HISTORIC GAS STATION FOR OFF-SITE LABORATORY ANALYSIS
OCTOBER 1993	GROUNDWATER SAMPLING	ABB-ES	8 WELLS	AAFES-1D TO AAFES-7, XGM-93-01X,-02X	GROUNDWATER SAMPLING TO ASSESS IMPACT TO GROUNDWATER FROM FORMER USTS
OCTOBER 1993	IN-SITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	2 WELLS	XGM-93-01X AND XGM-93-02X	PERMEABILITY TESTING TO ESTIMATE AQUIFER HYDRAULIC CONDUCTIVITIES
JANUARY 1994	GROUNDWATER SAMPLING	ABB-ES	8 WELLS	AAFES-1D TO AAFES-7, XGM-93-01X,-02X	GROUNDWATER SAMPLING TO ASSESS IMPACT TO GROUNDWATER FROM FORMER USTS
REMEDIAL INVESTIGATION					
SEPTEMBER 1994	SOIL BORINGS AND SVE POINTS (AREA 2)	ABB-ES	6 BORINGS	XGB-94-10X TO XGB-94-15X	COLLECT SOIL SAMPLES AT AAFES GAS STATION FOR OFF-SITE LABORATORY ANALYSIS AND INSTALL POINTS FOR SVE PILOT STUDY
SEPTEMBER AND OCTOBER 1994	MONITORING WELLS	ABB-ES	8 WELLS	XGM-94-03X TO XGM-94-10X	INSTALL MONITORING WELLS TO ASSESS IMPACT TO DOWNGRADIENT GROUNDWATER FROM FORMER USTS
OCTOBER AND NOVEMBER 1994	PIEZOMETER INSTALLATION	ABB-ES	7 PIEZOMETERS	XGP-94-01X TO XGP-94-07X	INSTALL PIEZOMETERS TO MONITOR GROUNDWATER LEVELS DURING AQUIFER PUMPING TESTS
NOVEMBER 1994	SVE PILOT STUDY (AREA 2)	ABB-ES	NA	NORTHEAST CORNER OF AFFES GAS STATION USTS	SOIL VAPOR EXTRACTION PILOT TEST TO EVALUATE THE EFFECTIVENESS OF THE TECHNOLOGY AS AN OPTION FOR SOIL REMEDIATION
NOVEMBER AND DECEMBER 1994	GROUNDWATER SAMPLING	ABB-ES	16 WELLS	AAFES-1D TO AAFES-7, XGM-93-01X TO XGM-94-10X	GROUNDWATER SAMPLING TO ASSESS IMPACT TO GROUNDWATER FROM FORMER USTS
	AQUIFER PUMPING TESTS	ABB-ES	2 CONSTANT RATE TESTS	XGM-94-04X AND XGM-94-06X	CONSTANT RATE DISCHARGE AQUIFER TESTS TO ASSESS THE HYDROGEOLOGIC PROPERTIES OF THE OVERBURDEN AND BEDROCK AQUIFERS AND OBTAIN TREATABILITY DATA
DECEMBER 1994	SEISMIC REFRACTION SURVEY	ABB-ES	NA	NEAR AAFES-7, SOUTHEAST OF SITE	SEISMIC SURVEY TO ESTIMATE DEPTH TO BEDROCK SOUTHEAST OF THE AOC
FEBRUARY AND MARCH 1995	IN-SITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	21 WELLS/ PIEZOMETERS	AAFES-1D TO AAFES-7, XGM-94-03X TO XGM-94-10X AND XGP-94-01X TO XGP-94-07X	PERMEABILITY TESTING TO ESTIMATE AQUIFER HYDRAULIC CONDUCTIVITIES
MARCH 1995	GROUNDWATER SAMPLING	ABB-ES	16 WELLS	AAFES-1D TO AAFES-7, XGM-93-01X TO XGM-94-10X	GROUNDWATER SAMPLING TO ASSESS IMPACT TO GROUNDWATER FROM FORMER USTS

TABLE 5-2
SUMMARY OF NOBIS FIELD SCREENING RESULTS
UST EXCAVATION SAMPLES
AOC 43G – HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NUMBER	DEPTH	PID MEASUREMENT	SAMPLE NUMBER	DEPTH	PID MEASUREMENT
TEST PIT TP-1			TEST PIT TP-4		
S-1	STOCK PILE	128	S-1	8-10	12
S-2	STOCK PILE	160	S-2	6-8	475
S-3	STOCK PILE	181	S-3	12-13	ND
S-4	STOCK PILE	55	S-4	8	1233
S-5	8	26.2	S-5	8	26
S-6	7-8	44.7	S-6	8-10	22
S-7	8	ND	S-7	8-10	ND
S-8	8-9	ND	S-8	10-11	5290
S-9	9-10	843	S-9	11-12	5096
S-10	10-11	1128	S-10	11-12	108
S-11	12-13	149	S-11	11-12	1675
S-12	13-14	4			
S-13	14	509	TEST PIT TP-5		
			S-1	7-9	2227
TEST PIT TP-2			S-2	6-8	2490
S-1	6-8	2643	S-3	7-9	2651
S-2	8-10	362	S-4	7-9	88
S-3	8-10	312	S-5	8-10	8
S-4	8-10	599	S-6	7-9	2
S-5	10-12	101	S-7	7-9	16
S-6	8-10	678	S-8	10-12	12
S-7	12-13	449	S-9	11-12	13
S-8	6-8	2079	S-10	11-12	1207
S-9	5-6	1046			
S-10	12-13	370			

TABLE 5-2
SUMMARY OF NOBIS FIELD SCREENING RESULTS
UST EXCAVATION SAMPLES
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NUMBER	DEPTH	PID MEASUREMENT	SAMPLE NUMBER	DEPTH	PID MEASUREMENT
TEST PIT TP-3					
S-1	2-4	31			
S-2	13	97			
S-3	6	ND			
S-4	10-12	2385			
S-5	10-12	2746			
S-6	12-13	186			
S-7	12-13	42			
S-8	10-11	4.9			
S-9	11-12	1641			
S-10	13-14	32			

Notes:
ND - Non-detect

TABLE 5–3
SUMMARY OF NOBIS LABORATORY SOIL RESULTS
UST EXCAVATION SAMPLES
AOC 43G – HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NUMBER	TOTAL PETROLEUM HYDROCARBONS (mg/kg)	SAMPLE NUMBER	TOTAL PETROLEUM HYDROCARBONS (mg/kg)
TEST PIT TP–1		TEST PIT TP–4	
S–1	182	S–1	3122
S–2	1761	S–2	3713
TEST PIT TP–2		TEST PIT TP–5	
S–1	635	S–1	164
S–2	100	S–2	3708
TEST PIT TP–3			
S–1	2225	LAB BLANK	< 5
S–2	132		

Notes:

1. Total petroleum hydrocarbons (TPH) concentrations reported in milligrams per kilogram (mg/kg).
2. Soil samples collected by Nobis Engineering, Inc. personnel from tank excavations on October 18 and 19, 1990.
3. TPH analysis performed by AMRO Environmental Laboratories Co., of Merrimack, NH using USEPA Method 418.1.

TABLE 5–4
SUMMARY OF NOBIS FIELD SCREENING RESULTS
SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NUMBER	DEPTH	PID MEASUREMENT	SAMPLE NUMBER	DEPTH	PID MEASUREMENT
B–1			B–5		
S–1	0.2–1.7	ND	S–1	0.2–1.7	9.1
S–2	4.5–6	ND	S–2	4.5–6	1.9
S–3	9.5–11	1.5	S–3	9.5–11	ND
S–4	14.5–16	1.9	S–4	14.5–16	4.9
S–5	19.5–21	20	S–5	19.5–21	98
B–2			S–6	24.5–26	8.1
S–1	0.2–1.7	ND	B–6		
S–2	4.5–6	ND	S–1	0.3–1.8	ND
S–3	9.5–11	41	S–2	4.5–6	ND
S–4	14.5–16	5.2	S–3	9.5–11	0.4
S–5	19.5–21	2077	S–4	14.5–16	0.2
S–6	24.5–26	147	S–5	19.5–21	5.1
B–3			S–6	24.5–26	6.8
S–1	14.5–16	2049	B–7		
S–2	19.5–21	1281	S–1	0.2–1.7	0.4
S–3	24.5–26	2817	S–2	4.5–6	ND
B–4			S–3	9.5–11	0.8
S–1	0.2–1.7	ND	S–4	14.5–16	1.2
S–2	4.5–6	12.7	B–8		
S–3	9.5–11	15.9	S–1	0.3–1.8	0.3
S–4	14.5–16	0.9	S–2	4.5–6	0.2
S–5	19.5–21	ND	S–3	9.5–11	0.2
			S–4	14.5–16	ND
			S–5	19.5–21	0.9
			S–6	24.5–25.2	3.9

TABLE 5-4
SUMMARY OF NOBIS FIELD SCREENING RESULTS
SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NUMBER	DEPTH	PID MEASUREMENT	SAMPLE NUMBER	DEPTH	PID MEASUREMENT
B-9			B-13		
S-1	0-1.5	ND	S-1	0.2-1.7	ND
S-2	4.5-6	ND	S-2	4.5-6	ND
S-3	9.5-11	ND	S-3	9.5-11	ND
S-4	14.5-16	6.5	S-4	14.5-16	ND
S-5	19.5-20.2	12.1	S-5	19.5-21	ND
B-10			B-14		
S-1	0.2-1.7	ND	S-1	0.2-1.7	1.5
S-2	4.5-6	ND	S-2	4.5-6	20
S-3	9.5-11	ND	S-3	9.5-11	7
S-4	14.5-16	ND	S-4	14.5-16	7
S-5	19.5-21	ND	B-15		
B-11			S-1	0.2-1.7	ND
S-1	0.2-1.7	ND	S-2	4.5-6	ND
S-2	4.5-6	ND	S-3	9.5-11	ND
S-3	9.5-11	ND	S-4	14.5-16	ND
S-4	14.5-16	1	S-5	19.5-21	ND
S-5	19.5-21	32	S-6	24.5-26	9
S-6	24.5-26	2			
B-12					
S-1	0.2-1.7	ND			
S-2	4.5-6	ND			
S-3	9.5-11	ND			
S-4	14.5-16	ND			
S-5	19.5-21	ND			

Notes: ND – Non-detect

TABLE 5-5
SUMMARY OF SOIL BORINGS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)[1]	TOTAL VOCs BY PID (PPM)	COMMENTS
PREVIOUS CONTRACTOR						
B-1	21	0.2-1.7	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW	1.5	
		14.5-16	NA	SW	1.9	
		19.5-21	NA	SP	20	
B-2	26	0.2-1.7	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW	41	
		14.5-16	NA	SW	5.2	
		19.5-21	NA	ML	2077	
		24.5-26	NA	SW	147	
B-3	26	14.5-16	NA	GW	2049	Nobis
(AREA 2)		19.5-21	NA	SW/PHYL	1281	
		24.5-26	NA	SW	2817	
B-4	21	0.2-1.7	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SP	12.7	
		9.5-11	NA	SW	15.9	
		14.5-16	NA	ML	0.9	
		19.5-21	NA	ML	BKG	
B-5	26	0.2-1.7	NA	SW	9.1	Nobis
(AREA 2)		4.5-6	NA	SW	1.9	
		9.5-11	NA	SW	BKG	
		14.5-16	NA	SW	4.9	
		19.5-21	NA	SP	98	
		24.5-26	NA	GW	8.1	
B-6	26	0.3-1.8	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW	0.4	
		14.5-16	NA	GW	0.2	
		19.5-21	NA	PHYL	5.1	
		24.5-26	NA	PHYL	6.8	
B-7	19.5	0.2-1.7	NA	SW	0.4	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW	0.8	
		14.5-16	NA	SW/PHYL	1.2	
B-8	25.3	0.2-1.7	NA	SW	0.3	Nobis
(AREA 2)		4.5-6	NA	SW	0.2	
		9.5-11	NA	GW	0.2	
		14.5-16	NA	ML	BKG	
		19.5-21	NA	SP	0.9	
		24.5-25.3	NA	PHYL	3.9	
B-9	20.3	0-1.5	NA	SW	BKG	Nobis
(AREA 2,3)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SP	BKG	
		14.5-16	NA	PHYL	6.5	
		19.5-20.3	NA	PHYL	12.1	
B-10	20.3	0.2-1.7	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	GW	BKG	
		14.5-16	NA	ML	BKG	
		17.3-18.8	NA	SP	BKG	
		18.8-20.3	NA	SP	BKG	

TABLE 5-5
SUMMARY OF SOIL BORINGS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)[1]	TOTAL VOCs BY PID (PPM)	COMMENTS
B-11	26	0.2-1.7	NA	GW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW	BKG	
		14.5-16	NA	SW	1	
		19.5-21	NA	SP	32	
		24.5-26	NA	SW	2	
B-12	21	0.2-1.7	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW	BKG	
		14.5-16	NA	SW	BKG	
		19.5-21	NA	SW	BKG	
B-13	21	0.2-1.7	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW	BKG	
		14.5-16	NA	SW	BKG	
		19.5-21	NA	SW/PHYL	BKG	
B-14	14.9	0.2-1.7	NA	SW	1.5	Nobis
(AREA 2)		4.5-6	NA	SW	20	
		9.5-11	NA	SW	7	
		14.5-16	NA	SW	7	
B-15	26	0-1.5	NA	SW	BKG	Nobis
(AREA 2)		4.5-6	NA	SW	BKG	
		9.5-11	NA	SW/PHYL	BKG	
		14.5-16	NA	SM	BKG	
		19.5-21	NA	SM	BKG	
		24.5-26	NA	SW/PHYL	9	
AAFES-ID	29.7	8-9.5	8-9.5	SP	49.1	Nobis
		9.5-11	9.5-11	SP	10.9	
		14.5-16	14.5-16	BDR	10.3	Bedrock Fragments in Sampler
		19.5-20.2		BDR	80.1	Bedrock Fragments in Sampler
AAFES-2	34.6	0-1.5		SP	2.3	Nobis
		4.5-6		SW	2.6	
		9.5-11		GW	4.9	
		14.5-16		SP	8.8	
		19.5-21	19.5-21	SW	39	
		24.5-24.7		BDR		Boring Completed to 34.6 feet
AAFES-3	26.3	1-2.5		SW	< 1	Nobis
		4.5-6		SW	BKG	
		9.5-11		SW	BKG	
		14.5-16	14.5-16	SP	< 1	
		19.5-21	19.5-21	SP	< 1	
		24.5-25.4		BDR	< 1	Boring Completed to 26.3 feet
AAFES-4	27.8	0.5-2	NA	SW	< 1	Nobis
		4.5-6	NA	SW	< 1	
		9.5-11	NA	SW	< 1	
		14.5-16	NA	SW	58	
		19.5-21	NA	ML	208	
		24.5-26	NA	ML	147	Boring Completed to 27.8 feet
AAFES-5	30.8	0.5-2	NA	SW	< 1	Nobis
		4.5-6	NA	GW	< 1	
		9.5-11	NA	GW	< 1	
		14.5-16	NA	SP	< 1	
		9.5-21	NA	SP	< 1	
		24.5-26	NA	SW	4	
		30.5-30.8	NA	BDR	4.3	Refusal at 30.8 feet

TABLE 5-5
SUMMARY OF SOIL BORINGS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)[1]	TOTAL VOCs BY PID (PPM)	COMMENTS
AAFES-6	24.9	0-1.5	NA	SP	< 1	Nobis
		4.5-6	NA	SW	< 1	
		9.5-11	NA	SW	< 1	
		14.5-16	NA		9.3	Boulder Fragment in Sampler
		19.5-21	NA	SP	87	
		24.5-24.9	NA	BDR	9.5	Refusal at 24.9 feet
AAFES-7	16	0.-1.5	NA	SW	< 1	Nobis
		4.5-6	NA	SW	< 1	
		9.5-11	NA	SW	< 1	
		14.5-16	NA	SW	1.8	Boring Completed to 16.0 feet
SITE INVESTIGATION						
43G-92-01X	22	5-7		SW	BKG	ABB-ES
(AREA 1)		10-12	10-12	SW	BKG	
		15-17		SW	BKG	
		20-22	20-22	SM	BKG	Boring Completed to 22 feet
SUPPLEMENTAL SITE INVESTIGATION						
XGB-93-03X	25	1-3		GP	BKG	ABB-ES
(AREA 3)		5-7		SP	BKG	
		8-10	8-10	GP	8	
		12-14	12-14	SP	25.2	
		15-17		SW	BKG	
		20-22		SM-ML	488	Total VOCs measured in headspace
		25-27		SM-ML	245.7	Total VOCs measured in headspace
XGB-93-04X	25	1-3		GP	BKG	ABB-ES
(AREA 3)		5-7		SP	BKG	
		8-10	8-10	SP	220.1	
		12-14	12-14	SP	BKG	
		15-17		SW	15.1	Total VOCs measured in headspace
		20-22				No Recovery
		25-26	25-26	SM-ML	3.3	Refusal at 26 feet
XGB-93-05X	28	0-2		SW	BKG	ABB-ES
(AREA 2)		5-7		SW	BKG	
		8-10	8-10	SP	BKG	
		12-14	12-14	SP	BKG	
		15-17		SW	BKG	
		20-22	20-22	SM	BKG	
		25-27	25-27	SM	BKG	Refusal at 28 feet
XGB-93-06X	25.5	0-2		SP	BKG	ABB-ES
(AREA 2)		5-7		SP	BKG	
		8-10	8-10	SP	BKG	
		12-14	12-14	SP	BKG	
		15-17		SW-SM	BKG	Fill material from 0 to 15 feet
		20-22		SW-SM	BKG	
		25-25.5		SW-SM	BKG	Refusal on phylite at 25.5 feet
XGB-93-07X	20.5	1-3		SP-SM	BKG	ABB-ES
(AREA 2)		5-7		SP-SM	BKG	
		8-10		SW-GW	BKG	Insufficient recovery for analytical
		10-12	10-12	SW-GW	BKG	
		12-14		SW-GW	8.4	Chunk of asphalt caught in spoon
		15-17		SW	BKG	
		20-20.5		SM	BKG	Refusal at 20.5 feet
XGB-93-08X	27.5	1-3		SP	BKG	ABB-ES
(AREA 1)		5-7		SW	BKG	
		8-10	8-10	SW	BKG	
		10-12		SW-SM	BKG	
		12-14	12-14	SW-SM	BKG	
		15-17		SW-SM	BKG	
		17-19	17-19	SW-SM	BKG	
		19-21	19-21	SM	BKG	
		25-27		SM	BKG	Refusal at 27.5 feet

TABLE 5-5
SUMMARY OF SOIL BORINGS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)[1]	TOTAL VOCs BY PID (PPM)	COMMENTS
XGB-93-09X	29.7	1-3		SW	BKG	ABB-ES
(AREA 1)		5-7		SW	BKG	
		8-10	8-10	SP	BKG	
			12-14	GW-SW	BKG	
		15-17		SP-SM	BKG	
		20-22	20-22	SM	BKG	
		25-26.2		SM-PHYL	BKG	Refusal at 29.5 feet
XGM-93-01X	34	0-2		SP-FILL	BKG	ABB-ES
		4-6		SW-SM	BKG	
		9-11		SW	BKG	
		14-16		SM	BKG	
			19-21	ML-PHYL	BKG	
		24-26		SM-PHYL	BKG	
		29-30		ML-PHYL	BKG	Phylite reamed w/ rollerbit to 34 feet
XGM-93-02X	38	0-2		SP	BKG	ABB-ES
		4-6		SP	BKG	
		9-11		SW	BKG	
		14-16		SP-SW	BKG	
		19-21		SW	BKG	
			24-26	SM	BKG	
		29-31		SM	BKG	PID = 8 ppm at mouth of borehole
		34-34.5		SM-PHYL	8.2	Phylite bedrock at 34.5 feet
REMEDIAL INVESTIGATION						
XGB-94-10X	28	0-2		SP	BKG	ABB-ES
(AREA 2)		5-7		SP/GP	BKG	
		10-12		SP	BKG	
		15-17		SP/GP	BKG	
		20-22	20-22	ML	972	
		25-27	25-27	GM	1014	Boring Completed at 28 feet
XGB-94-11X	29	0-2		SP	BKG	ABB-ES
(AREA 2)		5-7		GP	BKG	
		10-12		GP/SP	BKG	
		15-17	15-17	SP	2.4	
		20-22		GM	1038	
		25-27		GM	821	
		27-29	27-28	PHYL	342	Boring Completed at 28 feet
XGB-94-12X	30.5	0-2		SP	BKG	ABB-ES
(AREA 2)		5-7		SP	28	
		10-12		SP/GP	1.6	
		15-17	15-17	GP/SP	BKG	
		20-22		ML/GM	658	
		25-27		GM/SM	678	
		27-29	27-29	ML	661	
		30-30.5		PHYL	50.7	Phyllite Bedrock at 30.8 feet
XGB-94-13X	30.3	0.5-2.5		SP	BKG	ABB-ES
(AREA 2)		5-7		SP	BKG	
		10-12		SP/SM	BKG	
		15-17	15-17	SP	BKG	
		20-22		ML	BKG	
		25-27	25-27	ML	BKG	
		30-30.2		PHYL	41.5	Phyllite Bedrock at 30.3 feet

TABLE 5-5
SUMMARY OF SOIL BORINGS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)[1]	TOTAL VOCs BY PID (PPM)	COMMENTS
XGB-94-14X	28.5	0-2		SW	BKG	ABB-ES
(AREA 2)		5-7		SW	BKG	
		10-12		SP	BKG	
		15-17	15-17	ML	BKG	
		20-22		GM	BKG	
		25-27	25-27	GM/SM	0.4	Phyllite Bedrock at 28.5 feet
XGB-94-15X	28.7	0.5-2.5		SP	BKG	ABB-ES
(AREA 2)		5-7		SP	BKG	
		10-12		SW	BKG	
		15-17	15-17	SM/ML	BKG	
		20-22		SM/ML	BKG	
		25-27	25-27	SM/ML	BKG	
		27-28.7		PHYL	BKG	Phyllite Bedrock at 28.7 feet
XGM-94-03X	30.1	0-2	NA	SP	BKG	ABB-ES
		5-7	NA	SP	BKG	
		10-12	NA	ML	BKG	
		15-17	NA	ML	BKG	
		20-22	NA	ML	121	Boring completed into bedrock, 30.1 feet
XGM-94-04X	29.8	0-2	NA	SM-SP	BKG	ABB-ES
		5-7	NA	SP	BKG	
		10-12	NA	ML-GM	BKG	
		15-17	NA	ML-GM	BKG	Boring completed into bedrock, 29.8 feet
XGM-94-05X	36.5	0-2	NA	SP	BKG	ABB-ES
		5-7	NA	SW	BKG	
		10-12	NA	SP	BKG	
		15-17	NA	SM	BKG	
		20-22	NA	SM	BKG	
		25-27	NA	GM	BKG	Boring completed into bedrock, 36.5 feet
XGM-94-06X	27.5	5-7	NA	SM	BKG	ABB-ES
		10-12	NA	SM	BKG	
		15-17	NA	SM-ML	BKG	
		20-22	NA	SM-ML	BKG	
		25-27	NA	SM-ML	266	Boring completed into bedrock, 27.5 feet
XGM-94-07X	20.5?	0-2	NA	SP	BKG	ABB-ES
		5-7	NA	SW	BKG	
		10-12	NA	ML	BKG	
		15-17	NA	GM-ML	BKG	
		20-20.5	NA	PHYL	BKG	Boring completed into bedrock, 20.5 feet
XGM-94-08X	36.2	0-2	NA	SP	BKG	ABB-ES
		5-7	NA	SP	BKG	
		10-12	NA	SP	BKG	
		15-17	NA	SP	BKG	
		20-22	NA	GW	BKG	
		25-27	NA	PHYL	BKG	Boring completed into bedrock, 36.2 feet
XGM-94-09X	33.2	5-7	NA	SW	BKG	ABB-ES
		10-12	NA	SM	BKG	
		15-17	NA	SM	BKG	
		20-22	NA	MML	BKG	
		25-27	NA	ML	BKG	
		30-30.8	NA	PHYL	BKG	Boring completed into bedrock, 33.2 feet

TABLE 5-5
SUMMARY OF SOIL BORINGS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)[1]	TOTAL VOCs BY PID (PPM)	COMMENTS
XGM-94-10X	32.5	5-7	NA	SP-SM	BKG	ABB-ES
		10-12	NA	SP-SM	BKG	
		15-17	NA	SP-SM	BKG	No surface soil sample collected.
		20-22	NA		BKG	No recovery, cobble in sampler.
		25-25.6	NA		BKG	No recovery, cobble in sampler.
		30-30.5	NA		BKG	Boring completed into bedrock, 33.2 feet
XGP-94-01X	31.4	5-7	NA	SP	BKG	ABB-ES
		10-12	NA	SP	BKG	
		15-17	NA	SM	BKG	
		20-22	NA	PHYL FRAG	BKG	No surface soil sample collected.
		25-27	NA	GM-SM	8.4	Boring completed into bedrock, 31.4 feet
XGP-94-02X	27	0-2	NA	SW	BKG	ABB-ES
		4-6	NA	SW	BKG	
		9-11	NA	SM	BKG	
		14-16	NA	SM	BKG	
		19-21	NA	SM	BKG	
		24-24.9	NA	SM	BKG	Boring completed into bedrock, 27 feet
XGP-94-03X	27	0-2	NA	SW	BKG	ABB-ES
		4-6	NA	SW	BKG	
		9-11	NA	SW	BKG	
		14-16	NA	ML	BKG	
		19-21	NA	ML	BKG	
		24-25.1	NA	ML	BKG	Boring completed into bedrock, 27 feet
XGP-94-04X	27	0-2	NA	SW	BKG	ABB-ES
		4-6	NA	SW	BKG	
		9-11	NA	SW	BKG	
		14-16	NA	ML	BKG	
		19-21	NA	ML	BKG	
		24-26	NA	ML	BKG	Boring completed into bedrock, 27 feet
XGP-94-05X	27.8	14-15.8	NA	ML	BKG	ABB-ES
			NA			No regular samples collected, only to confirm the presence of refusal.
XGP-94-06X	31.5	14-16	NA	ML	BKG	ABB-ES
		19-19.4	NA	PHYL	BKG	No regular samples collected, only to confirm the presence of refusal.
XGP-94-07X	30	19-19.4	NA	PHYL	BKG	ABB-ES
			NA			No regular samples collected, only to confirm the presence of refusal.

NOTES:

bgs = below ground surface
VOCs = Volatile Organic Compounds
USCS = Unified Soil Classification System
NA = Not Analyzed
PID = Photoionization Detector
PPM = parts per million
PHYL = PHYLLITE
BKG = Background levels of total VOCs, measured with a PID in the field

[1] USCS type determined from field sample by on-site geologist during sampling. Soil classification made from grain size distribution analyses may vary from field classification.

TABLE 5-6
SUMMARY OF NOBIS FIELD SCREENING RESULTS
SOIL REMOVAL SAMPLES
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NUMBER	DEPTH	TOTAL PETROLEUM HYDROCARBONS (PPM)	SAMPLE NUMBER	DEPTH	TOTAL PETROLEUM HYDROCARBONS (PPM)
T-1, SOUTH	16-18	3.1	T-4, WEST	13-16	26.2
T-1, WEST	16-18	2	T-4, WEST	16-18	78
T-1, EAST	10-13	11	T-4, EAST	17-20	4.1
T-1/T-2, EAST	12-16	11.5	T-4, EAST	8-12	15
			T-4/T-5, EAST	15-18	<1
T-2, WEST	16-19	15.9	T-4/T-5, EAST	9-12	<1
T-2, EAST	17-20	120			
T-2, EAST	10-13	6.1	T-5,WEST	16-18	15.7
T-2, EAST	6-8	ND	T-5, NORTH	16-18	13.7
			T-5, EAST	15-18	11.7
T-3, WEST	16-19	5.9			
T-3, NORTHEWEST	16-18	12.9			
T-3, EAST	17-19	109			
T-3, EAST	15-18	45			
T-3, EAST	8-12	7.5			

Notes:

1. ND - Non-detect

TABLE 5-7
SUMMARY OF NOBIS LABORATORY RESULTS
SOIL REMOVAL SAMPLES
AOC 43G – HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NUMBER	DEPTH	TOTAL PETROLEUM HYDROCARBONS (PPM)	SAMPLE NUMBER	DEPTH	TOTAL PETROLEUM HYDROCARBONS (PPM)
T-1, SOUTH	16-18	47	T-4, WEST	13-16	46
T-1, WEST	16-18	39	T-4, WEST	16-18	41
T-1, EAST	10-13	112	T-4, EAST	17-20	90
T-1/T-2, EAST	12-16	62	T-4, EAST	8-12	170
			T-4/T-5, EAST	15-18	85
T-2, WEST	16-19	41	T-4/T-5, EAST	9-12	569
T-2, EAST	17-20	109			
T-2, EAST	10-13	132	T-5,WEST	16-18	72
T-2, EAST	6-8	63	T-5, NORTH	16-18	33
			T-5, EAST	15-18	92
T-3, WEST	16-19	38			
T-3, NORTHEWEST	16-18	372			
T-3, EAST	17-19	174			
T-3, EAST	15-18	109			
T-3, EAST	8-12	86			

Notes:

1. TPH concentrations reported in milligrams per kilogram (mg/kg).
2. Soil samples collected by Nobis Engineering, Inc. personnel from tank excavation on October 18 and 19, 1990.
3. TPH analysis performed by AMRO Environmental Laboratories Co. of Merrimack, NH usinf USEPA method 418.1.

TABLE 5-8
SUMMARY OF MONITORING WELL COMPLETION DETAILS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

WELL IDENTIFICATION	SOIL DRILLING METHOD	BEDROCK DRILLING MEHTOD	MEDIA SCREENED	WELL SCREEN DEPTH (Feet bgs)	WELL SCREEN ELEVATION (Feet MSL)	COMPLETION DEPTH (Feet bgs)	WELL CONSTRUCTION MATERIAL
PREVIOUS INVESTIGATIONS							
AAFES-1D	HSA	ROCK CORE	BEDROCK/SOIL	13.9-28.9	282.6 – 267.6	29.7	2" ID PVC
AAFES-2	HSA	ROCK CORE	BEDROCK/SOIL	16.2-31.2	284.5 – 269.5	34.6	2" ID PVC
AAFES-3	HSA	NA	SOIL	16.0-26.0	293.0 – 283.0	26.3	2" ID PVC
AAFES-4	HSA	NA	SOIL	12.8-27.8	297.8 – 282.8	27.8	2" ID PVC
AAFES-5	HSA	NA	SOIL	15.5-30.5	287.7 – 270.7	30.8	2" ID PVC
AAFES-6	HSA	NA	SOIL	14.5-24.5	283.0 – 273.0	24.5	2" ID PVC
AAFES-7	HSA	NA	SOIL	4.5-14.5	252.4 – 242.4	14.5	2" ID PVC
SUPPLEMENTAL SITE INVESTIGATION							
XGM-93-01X	HSA/D&W	ROLLER CONE	BEDROCK/SOIL	23.0-33.0	288.5 – 278.5	34.0	4" ID PVC
XGM-93-02X	HSA/D&W	NA	BEDROCK/SOIL	28.0-38.0	282.6 – 272.6	38.2	4" ID PVC
REMEDIAL INVESTIGATION							
XGM-94-03X	HSA	ROCK CORE/ OVER REAM	BEDROCK/SOIL	19.0-29.0	279.2 – 269.2	30.1	4" ID PVC
XGM-94-04X	HSA	ROCK CORE/ OVER REAM	BEDROCK	18.2-28.2	280.9 – 270.9	29.8	4" ID PVC
XGM-94-05X	HSA	ROCK CORE/ OVER REAM	BEDROCK/SOIL	26.0-36.0	273.3 – 263.3	36.5	4" ID PVC
XGM-94-06X	HSA	NA	SOIL	17.0-27.0	265.2 – 255.2	27.5	4" ID PVC
XGM-94-07X	HSA	ROCK CORE/ OVER REAM	BEDROCK/SOIL	17.0-27.0	276.0 – 266.0	28.2	4" ID PVC
XGM-94-08X	HSA	ROCK CORE/ OVER REAM	BEDROCK/SOIL	23.5-33.5	273.7 – 263.7	36.2	4" ID PVC
XGM-94-09X	HSA	ROLLER CORE	SOIL	23.0-33.0	285.4 – 275.4	33.2	4" ID PVC
XGM-94-10X	HSA	NA	SOIL	21.5-31.5	278.9 – 268.9	32.5	4" ID PVC
XGP-94-01X	HSA/D&W	NA	BEDROCK/SOIL	20.5-30.5	284.2 – 274.2	31.4	4" ID PVC
XGP-94-02X	HSA	NA	SOIL	16.5-26.5	265.2 – 255.2	27.0	1.5" ID PVC
XGP-94-03X	HSA	NA	SOIL	17.0-27.0	265.2 – 255.2	27.0	1.5" ID PVC
XGP-94-04X	HSA	NA	SOIL	17.0-27.0	265.2 – 255.2	27.0	1.5" ID PVC
XGP-94-05X	HSA/D&W	ROCK CORE	BEDROCK	19.6-27.6	280.2 – 272.2	27.8	1.5" ID PVC
XGP-94-06X	HSA/D&W	ROCK CORE	BEDROCK	21.4-31.4	279.9 – 267.9	31.5	1.5" ID PVC
XGP-94-07X	HSA/D&W	ROCK CORE	BEDROCK	19.0-29.0	279.9 – 269.6	30.0	1.5" ID PVC

NOTES:

bgs = below ground surface
HSA = Hollow Stem Auger
NA = Not Applicable
ID = Inside Diameter
MSL = Mean Sea Level
PVC = Polyvinyl Chloride

HSA/D&W = Boring advanced to refusal with hollow stem auger. 6-inch casing is then driven to or beyond refusal depth. Boring is cleaned out with 5 7/8-inch roller cone and advanced into bedrock if so noted.
Rock Core/Oven Ream = Boring was advanced through bedrock by first coring with HQ 14-inch OD core barrel and then reaming out bedrock borehole with 5 7/8-inch OD roller cone to desired depth for installation of 4-inch monitoring well.

TABLE 5-9
ATEC FIELD SCREENING/LABORATORY RESULTS
AOC 43G - HISTORIC GAS STATIONS G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SAMPLE NO.	FIELD SCREENING		LABORATORY	
	PID (ppm)	NDIR (ppm)	VOC* (ppm)	TPH (ppm)
SS-1	ND	41.5	N/A	N/A
SS-2	11.0	28,215.6	N/A	N/A
SS-3	48	28,745.5	N/A	N/A
SS-4	13.4	16,741.3	N/A	N/A
SS-5	4.9	2,649.7	N/A	N/A
SS-6	3.4	8,520.5	N/A	N/A
SS-7	0.6	20.8	N/A	N/A
SS-8	0.2	6.3	N/A	N/A
SS-9	2.0	27,000.0	N/A	N/A
SS-10	6.9	17,260.3	N/A	N/A
STOCK-1	8.5	15,040.7	N/A	N/A
STOCK-2	48	29,940.5	N/A	N/A
LSS-1	N/A	N/A	188	35,100
LSS-2	N/A	N/A	101	23,200

NOTES:
* = total VOCs detected
SS = ATEC Field Screening Sample
LSS = ATEC Laboratory Soil Sample
Stock = Soil Stock Pile Sample
ND = Non-detect
N/A = Not applicable

TABLE 5-10
SUMMARY OF FIELD AND LABORATORY ANALYTICAL PROGRAM
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION	DEPTH	ROUND	PARAMETERS										
						OFF-SITE LABORATORY- PAL ANALYSES								FIELD ANALYTICAL		
						VOA	SVOA	INOR-tot	INOR-diss	TPHC	TSS	TOC	H20 QUAL	BTEX	CHLOR	TPHC/IR
SI	Soil	Boring	43G-92-01X	10-12		X		X		X						
				20-22		X		X		X						
SI	Gas	T-Probe	TS-01	8-9										X		
SI			TS-02	8-9										X		
SI			TS-03	8-9										X		
SI			TS-04	8-9										X		
SI			TS-05	8-9										X		
SI			TS-06	8-9										X		
SI			TS-07	8-9										X		
SI			TS-08	8-9										X		
SI			TS-09	8-9										X		
SI			TS-10	8-9										X		
SI	Soil		TS-04	9-10										X		X
SI			TS-04	12-13										X		X
SI			TS-09	9-10										X		X
SI			TS-09	12-13										X		X
SI			TS-10	11-12										X		X
SI			TS-11	9-10										X		X
SI			TS-11	12-13										X		X
SSI	Soil	T-Probe	TS-01	10-12										X		X
SSI			TS-02	9-10										X		X
SSI			TS-02	10-11										X		X
SSI			TS-02	11-12										X		X
SSI			TS-03	9-10										X		X
SSI			TS-03	10-11										X		X
SSI			TS-04	9-10										X		X
SSI			TS-04	10-11										X		X
SSI			TS-04	12-13										X		X
SSI			TS-05	9-10										X		X
SSI			TS-05	10-11										X		X
SSI			TS-07	10-11										X		X
SSI			TS-08	10-11										X		X
SSI			TS-09	9-10										X		X
SSI			TS-09	12-13										X		X
SSI			TS-10	10-11										X		X
SSI			TS-10	11-12										X		X
SSI			TS-11	9-10										X		X

TABLE 5-10
SUMMARY OF FIELD AND LABORATORY ANALYTICAL PROGRAM
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION	DEPTH	ROUND	PARAMETERS										
						OFF-SITE LABORATORY- PAL ANALYSES								FIELD ANALYTICAL		
						VOA	SVOA	INOR-tot	INOR-diss	TPHC	TSS	TOC	H20 QUAL	BTEX	CHLOR	TPHC/IR
SSI	Soil	T-Probe	TS-11	12-13										X		X
SSI			TS-13	10-11										X		X
SSI			TS-14	10-11										X		X
SSI			TS-18	9-10										X		X
SSI			TS-19	9-10										X		X
SSI			TS-19	10-11										X		X
SSI			TS-20	9-10										X		X
SSI			TS-20	11-12										X		X
SSI			TS-21	9-10										X		X
SSI			TS-22	13-14										X		X
SSI			TS-23	9-10										X		X
SSI			TS-24	9-10										X		X
SSI			TS-25	9-10										X		X
SSI			TS-26	9-10										X		X
SSI			TS-26	11-12										X		X
SSI			TS-28	11-12										X		X
SSI			TS-29	9-10										X		X
SSI			TS-30	9-10										X		X
SSI			TS-30	10-11										X		X
SSI			TS-31	9-10										X		X
SSI			TS-32	9-10										X		X
SSI			TS-33	9-10										X		X
SSI			TS-34	9-10										X		X
SSI			TS-35	10-11										X		X
SSI			TS-35	11-12										X		X
SSI			TS-36	10-11										X		X
SSI			TS-36	11-12										X		X
SSI			TS-37	10-11										X		X
SSI			TS-37	11-12										X		X
SSI			TS-38	10-11										X		X
SSI			TS-38	11-12										X		X
SSI			TS-39	10-11										X		X
SSI			TS-39	11-12										X		X

TABLE 5-10
SUMMARY OF FIELD AND LABORATORY ANALYTICAL PROGRAM
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION	DEPTH	ROUND	PARAMETERS										
						OFF-SITE LABORATORY- PAL ANALYSES								FIELD ANALYTICAL		
						VOA	SVOA	INOR-tot	INOR-diss	TPHC	TSS	TOC	H20 QUAL	BTEX	CHLOR	TPHC/IR
SSI	Soil	Boring	XGB-93-03X	1-3										X		X
SSI			XGB-93-03X	5-7										X		X
SSI			XGB-93-03X	8-10		X	X	X		X		X				
SSI			XGB-93-03X	12-14		X	X	X		X		X				
SSI			XGB-93-03X	15-17										X		X
SSI			XGB-93-03X	20-22		X	X	X		X		X				
SSI			XGB-93-03X	20-22										X		X
SSI			XGB-93-03X	25-27										X		X
SSI			XGB-93-04X	1-3										X		X
SSI			XGB-93-04X	5-7										X		X
SSI			XGB-93-04X	8-10		X	X	X		X		X				
SSI			XGB-93-04X	12-14		X	X	X		X		X				
SSI			XGB-93-04X	15-17										X		X
SSI			XGB-93-04X	25-27		X	X	X		X		X				
SSI			XGB-93-05X	0-2										X		X
SSI			XGB-93-05X	5-7										X		X
SSI			XGB-93-05X	8-10		X	X	X		X		X		X		X
SSI			XGB-93-05X	12-14		X	X	X		X		X		X		X
SSI			XGB-93-05X	15-17										X		X
SSI			XGB-93-05X	20-22										X		X
SSI			XGB-93-05X	25-27		X	X	X		X		X		X		X
SSI			XGB-93-06X	8-10		X	X	X		X		X				
SSI			XGB-93-06X	12-14		X	X	X		X		X				
SSI			XGB-93-07X	1-3										X		X
SSI			XGB-93-07X	5-7										X		X
SSI			XGB-93-07X	8-10										X		X
SSI			XGB-93-07X	10-12		X	X	X		X		X		X		X
SSI			XGB-93-07X	15-17										X		X
SSI			XGB-93-07X	20-22										X		X
SSI			XGB-93-08X	1-3										X		X
SSI			XGB-93-08X	5-7										X		X
SSI			XGB-93-08X	8-10		X	X	X		X		X		X		X
SSI			XGB-93-08X	10-12										X		X
SSI			XGB-93-08X	12-14		X	X	X		X		X		X		X
SSI			XGB-93-08X	15-17										X		X
SSI			XGB-93-08X	17-19		X	X	X		X		X		X		X

TABLE 5-10
SUMMARY OF FIELD AND LABORATORY ANALYTICAL PROGRAM
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION	DEPTH	ROUND	PARAMETERS										
						OFF-SITE LABORATORY - PAL ANALYSES								FIELD ANALYTICAL		
						VOA	SVOA	INOR-tot	INOR-diss	TPHC	TSS	TOC	H20 QUAL	BTEX	CHLOR	TPHC/IR
SSI			XGB-93-08X	19-21										X		X
SSI			XGB-93-08X	25-27										X		X
SSI			XGB-93-09X	1-3										X		X
SSI	Soil	Boring	XGB-93-09X	5-7										X		X
SSI			XGB-93-09X	8-10		X	X	X		X		X		X		X
SSI			XGB-93-09X	12-14		X	X	X		X		X				
SSI			XGB-93-09X	15-17										X		X
SSI			XGB-93-09X	20-22		X	X	X		X		X		X		X
SSI			XGB-93-09X	25-27										X		X
SSI	Water	Groundwater	AAFES-1D		3	X	X	X	X	X	X					
SSI			AAFES-1D		4	X	X	X	X	X	X					
SSI			AAFES-2		3	X	X	X	X	X	X					
SSI			AAFES-2		4	X	X	X	X	X	X					
SSI			AAFES-3		3	X	X	X	X	X	X					
SSI			AAFES-3		4	X	X	X	X	X	X					
SSI			AAFES-5		3	X	X	X	X	X	X					
SSI			AAFES-5		4	X	X	X	X	X	X					
SSI			AAFES-6		3	X	X	X	X	X	X					
SSI			AAFES-6		4	X	X	X	X	X	X					
SSI			AAFES-7		3	X	X	X	X	X	X					
SSI			AAFES-7		4	X	X	X	X	X	X					
SSI	Water	Groundwater	XGM-93-01X		3	X	X	X	X	X	X					
SSI			XGM-93-01X		4	X	X	X	X	X	X					
SSI			XGM-93-02X		3	X	X	X	X	X	X					
SSI			XGM-93-02X		4	X	X	X	X	X	X					
SSI	Sediment		XGD-93-02X			X	X	X		X		X				
RI	Water	Screened Auger	XGM-94-01X	17-22										X	X	
RI			XGM-94-02X	20-25										X	X	
RI			XGM-94-04X	22-27										X	X	
RI			XGM-94-06X	20-25										X	X	
RI			XGM-94-06X	27-32										X	X	
RI			XGM-94-09X	29-34										X	X	
RI			XGM-94-09X	30-35										X	X	
RI			XGM-94-10X	30-35										X	X	
RI	Soil	Boring	XGM-94-06X	5-7										X	X	X
RI			XGM-94-06X	10-12										X	X*	X

TABLE 5-10
SUMMARY OF FIELD AND LABORATORY ANALYTICAL PROGRAM
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION	DEPTH	ROUND	PARAMETERS										
						OFF-SITE LABORATORY- PAL ANALYSES								FIELD ANALYTICAL		
						VOA	SVOA	INOR-tot	INOR-diss	TPHC	TSS	TOC	H20 QUAL	BTEX	CHLOR	TPHC/IR
RI			XGM-94-06X	11-13										X	X	X
RI			XGM-94-06X	15-17										X	X*	X
RI			XGM-94-06X	20-22										X	X*	X
RI	Soil	Boring	XGM-94-06X	25-27										X	X	X
RI			XGM-94-09X	5-7										X	X	X
RI			XGM-94-09X	10-12										X	X	X
RI			XGM-94-09X	15-17										X	X	X
RI			XGM-94-09X	20-22										X	X	X
RI			XGM-94-09X	25-27										X	X	X
RI			XGB-94-09X	30-32										X	X	X
RI			XGB-94-10X	20-22										X	X	X
RI			XGB-94-10X	20-22		X	X	X		X		X		X	X	X
RI			XGB-94-10X	25-27		X	X	X		X		X		X	X	X
RI			XGB-94-11X	15-17		X	X	X		X		X		X	X	X
RI			XGB-94-11X	25-27		X	X	X		X		X		X	X	X
RI			XGB-94-11X	27-29										X	X	X
RI			XGB-94-12X	15-17		X	X	X		X		X		X	X	X
RI			XGB-94-12X	20-22										X	X	X
RI			XGB-94-12X	25-27										X	X	X
RI			XGB-94-12X	27-29		X	X	X		X		X		X	X	X
RI			XGB-94-13X	10-12										X	X	X
RI			XGB-94-13X	15-17		X	X	X		X		X		X	X	X
RI			XGB-94-13X	20-22										X	X	X
RI			XGB-94-13X	25-27		X	X	X		X		X				
RI			XGB-94-13X	30-32										X	X	X
RI			XGB-94-14X	15-17		X	X	X		X		X		X	X	X
RI			XGB-94-14X	20-22										X	X	X
RI			XGB-94-14X	25-27		X	X	X		X		X		X	X	X
RI			XGB-94-15X	15-17		X	X	X		X		X		X	X	X
RI			XGB-94-15X	20-22										X	X	X
RI			XGB-94-15X	25-27										X	X	X
RI			XGB-94-15X	27-29		X	X	X		X		X		X	X	X
RI	Water	Groundwater	AAFES-1D		5	X	X	X	X		X		X			
RI			AAFES-1D		6	X	X	X	X		X		X			
RI			AAFES-2		5	X	X	X	X		X		X			
RI			AAFES-2		6	X	X	X	X		X		X			

TABLE 5-10
SUMMARY OF FIELD AND LABORATORY ANALYTICAL PROGRAM
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION	DEPTH	ROUND	PARAMETERS										
						OFF-SITE LABORATORY- PAL ANALYSES								FIELD ANALYTICAL		
						VOA	SVOA	INOR-tot	INOR-diss	TPHC	TSS	TOC	H20 QUAL	BTEX	CHLOR	TPHC/IR
RI	Water	Groundwater	AAFES-3		5	X	X	X	X		X		X			
RI			AAFES-3		6	X	X	X	X		X		X			
RI			AAFES-5		5	X	X	X	X		X		X			
RI			AAFES-5		6	X	X	X	X		X		X			
RI			AAFES-6		5	X	X	X	X		X		X			
RI			AAFES-6		6	X	X	X	X		X		X			
RI			AAFES-7		5	X	X	X	X		X		X			
RI			AAFES-7		6	X	X	X	X		X		X			
RI			XGM-93-01X		5	X	X	X	X				X			
RI			XGM-93-01X		6	X	X	X	X				X			
RI			XGM-93-02X		5	X	X	X	X				X			
RI			XGM-93-02X		6	X	X	X	X				X			
RI			XGM-94-03X		5	X	X	X	X				X			
RI			XGM-94-03X		6	X	X	X	X				X			
RI			XGM-94-04X		5	X	X	X	X				X			
RI			XGM-94-04X		6	X	X	X	X				X			
RI			XGM-94-05X		5	X	X	X	X				X			
RI			XGM-94-05X		6	X	X	X	X				X			
RI			XGM-94-06X		5	X	X	X	X				X			
RI			XGM-94-06X		6	X	X	X	X				X			
RI			XGM-94-07X		5	X	X	X	X				X			
			XGM-94-07X		6	X	X	X	X				X			
RI			XGM-94-08X		5	X	X	X	X				X			
RI			XGM-94-08X		6	X	X	X	X				X			
RI			XGM-94-09X		5	X	X	X	X				X			
RI			XGM-94-09X		6	X	X	X	X				X			
RI			XGM-94-10X		5	X	X	X	X				X			
RI			XGM-94-10X		6	X	X	X	X				X			

Notes:

VOA = Volatile Organic Analysis
SVOA = Semivolatile Organic Analysis
Inorg. = Inorganics
TOC = Total Organic Carbon
TSS = Total Suspended Solids
TPHC=Total Petroleum Hydrocarbons
H20 QUAL=Sulfate, Alkalinity, Phosphate, Nitrite as Nitrogen,Total Kjeldhal Nitrogen, Lead
BTEX=Benzene,Toluene,ethylbenzene,M/P/O-Xylenes
CHLOR=Chlorinated VOCs
TPHC/IR=Total Petroleum Hydrocarbons by Infared Spectrophotometry

TABLE 5-11
SI FIELD ANALYTICAL RESULTS SUBSURFACE SOIL/SOIL GAS SAMPLES
AOC 43G – HISTORIC GAS STATIONS G

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE – SOIL (ppb)	TP-04	TP-04	TP-09	TP-09	TP-10	TP-11	TP-11
DEPTH	**10 FT**	**9 FT**	**10 FT**	**11 FT**	**9 FT**	**10 FT**	**10 FT**
BENZENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TOLUENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
ETHYLBENZENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
m/p-XYLENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
o-XYLENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
OTHER (ppm)							
TOTAL PETROLEUM HYDROCARBONS	830	< 54	< 54	< 54	130	130	190

ANALYTE – SOIL GAS (ppb)	TP-01	TP-02	TP-03	TP-04	TP-05	TP-06	TP-07	TP-08	TP-09	TP-10
DEPTH	**8 FT**	**8 FT**	**8 FT**	**8 FT**	**8 FT**	**8 FT**	**8 FT**	**8 FT**	**8 FT**	**8 FT**
BENZENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TOLUENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
ETHYLBENZENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
m/p-XYLENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
o-XYLENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Notes:

< = Less than detection limit.

TABLE 5-12
SSI FIELD ANALYTICAL RESULTS FOR SUBSURFACE SOIL SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 3								
ANALYTE	TS-01 10 FT	TS-02 9 FT	TS-02 10 FT	TS-02 11 FT	TS-03 9 FT	TS-03 10 FT	TS-04 10 FT	TS-05 10 FT	TS-07 10 FT
ORGANICS (mg/kg)	TSG0110F	TSG0209F	TSG0210F	TSG0211F	TSG0309F	TSG0310F	TSG0410F	TSG0510F	TSG0710F
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	0.00016	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0049	< 0.0001
ETHYLBENZENE	< 0.0001	0.0044	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0013	0.0013	< 0.0001
m/p-XYLENE	< 0.0001	0.0088	0.0003	< 0.0001	< 0.0001	< 0.0001	0.0034	0.12	< 0.0001
o-XYLENE	< 0.0001	0.012	< 0.0001	< 0.0001	< 0.0001	0.0008	0.0024	0.058	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	< 52	8500	210	120	960	NA	110	110	< 51

TABLE 5-12
SSI FIELD ANALYTICAL RESULTS FOR SUBSURFACE SOIL SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 3		AREA 2						
ANALYTE	TS-08 10 FT	TS-10 10 FT	TS-13 10 FT	TS-14 10 FT	TS-18 9 FT	TS-19 9 FT	TS-19 10 FT	TS-20 9 FT	TS-20 11 FT
ORGANICS (mg/kg)	TSG0810F	TSG1010F	TSG1310F	TSG1410F	TSG1809F	TSG1909F	TSG1910F	TSG2009F	TSG2011F
BENZENE	0.14	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	0.29	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	14	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	13	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	5.5	< 0.0001	0.0063	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	3300	< 54	74	500	140	200	2300	< 52	560

TABLE 5-12
SSI FIELD ANALYTICAL RESULTS FOR SUBSURFACE SOIL SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 2								
ANALYTE	TS-21 9 FT	TS-22 13 FT	TS-23 9 FT	TS-24 9 FT	TS-25 9 FT	TS-26 9 FT	TS-26 11 FT	TS-28 11 FT	TS-29 9 FT
ORGANICS (mg/kg)	**TSG2109F**	**TSG2213F**	**TSG2309F**	**TSG2409F**	**TSG2509F**	**TSG2609F**	**TSG2611F**	**TSG2811F**	**TSG2909F**
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	NA	160	64	130	< 53	< 53	< 53	< 53	950

TABLE 5-12
SSI FIELD ANALYTICAL RESULTS FOR SUBSURFACE SOIL SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 2						AREA 1		
ANALYTE	TS-30 9 FT	TS-30 10 FT	TS-31 9 FT	TS-32 9 FT	TS-33 9 FT	TS-34 9 FT	TS-35 10 FT	TS-35 11 FT	TS-36 10 FT
ORGANICS (mg/kg)	TSG3009F	TSG3010F	TSG3109F	TSG3209F	TSG3309F	TSG3409F	TSG3510F	TSG3511F	TSG3610F
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	< 0.0001	0.0013	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	< 0.0001	< 0.0001	0.0009	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	< 0.0001	< 0.0001	0.001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	460	120	5800	230	< 54	< 54	400	< 53	< 52

TABLE 5-12
SSI FIELD ANALYTICAL RESULTS FOR SUBSURFACE SOIL SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 1						
ANALYTE	TS-36 11 FT	TS-37 10 FT	TS-37 11 FT	TS-38 10 FT	TS-38 11 FT	TS-39 10 FT	TS-39 11 FT
ORGANICS (mg/kg)	**TSG3611F**	**TSG3710F**	**TSG3711F**	**TSG3810F**	**TSG3811F**	**TSG3910F**	**TSG3911F**
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER							
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	< 52	270	54	190	52	740	2000

Notes:

< = Less than detection limit.

mg/kg = milligram per kilogram

TABLE 5-13
ORGANIC ANALYTES IN SUBSURFACE SOIL
AOC 43G - HISTORIC GAS STATIONS G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SSI						
	XGB-93-03X	XGB-93-03X	XGB-93-03X	XGB-93-04X	XGB-93-04X	XGB-93-04X	XGB-93-05X
ORGANICS (ug/g)	**8 FT**	**12 FT**	**20 FT**	**8 FT**	**12 FT**	**25 FT**	**8 FT**
ACETONE	< 0.017	< 0.017	< 0.017	< 0.08	< 0.017	0.024	0.047
ETHYLBENZENE	< 0.002	< 0.002	0.002	0.03	< 0.002	< 0.002	< 0.002
TOLUENE	< 0.001	< 0.001	< 0.001	0.02	< 0.001	< 0.001	< 0.001
TRICHLOROFLUOROMETHANE	< 0.006	< 0.006	0.006	0.03	< 0.006	< 0.006	0.01
XYLENES	0.008	< 0.002	0.019	0.6	< 0.002	< 0.002	< 0.002
2-METHYLNAPHTHALENE	< 0.5	< 0.049	0.17	0.72	< 0.049	< 0.049	< 0.5
ACENAPHTHYLENE	< 0.3	< 0.033	< 0.033	< 0.3	< 0.033	< 0.033	5
ANTHRACENE	< 0.3	< 0.033	< 0.033	< 0.3	< 0.033	< 0.033	4
BENZO [A] ANTHRACENE	< 2	< 0.17	< 0.17	< 2	< 0.17	< 0.17	7
BENZO [A] PYRENE	< 2	< 0.25	< 0.25	< 2	< 0.25	< 0.25	10
BENZO [B] FLUORANTHENE	< 2	< 0.21	< 0.21	< 2	< 0.21	< 0.21	30
BENZO [G,H,I] PERYLENE	< 2	< 0.25	< 0.25	< 2	< 0.25	< 0.25	3
BENZO [K] FLUORANTHENE	< 0.7	< 0.066	< 0.066	< 0.7	< 0.066	< 0.066	6
BIS (2-ETHYLHEXYL) PHTHALATE	< 6	< 0.62	0.96	< 6	< 0.62	< 0.62	< 6
CHRYSENE	< 1	< 0.12	< 0.12	< 1	< 0.12	< 0.12	10
DI-N-BUTYL PHTHALATE	< 0.6	0.48	0.76	< 0.061	0.45	0.36	< 0.6
FLUORANTHENE	< 0.7	< 0.068	< 0.068	< 0.7	< 0.068	< 0.068	20
FLUORENE	< 0.3	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	1
INDENO [1,2,3-C,D] PYRENE	< 3	< 0.29	< 0.29	< 3	< 0.29	< 0.29	4
NAPHTHALENE	< 0.4	< 0.037	< 0.037	0.46	< 0.037	< 0.037	0.5
PHENANTHRENE	< 0.3	< 0.033	< 0.033	< 0.3	< 0.033	< 0.033	10
PYRENE	< 0.3	< 0.033	< 0.033	< 0.3	< 0.033	< 0.033	10
OTHER (ug/g)							
TOTAL ORGANIC CARBON	NA	NA	1590	NA	NA	845	27400
TOTAL PETROLEUM HYDROCARBONS	359	59.2	62.6	1020	213	40.8	185

Notes:
< = Less than detection limit.

TABLE 5-13
ORGANIC ANALYTES IN SUBSURFACE SOIL
AOC 43G - HISTORIC GAS STATIONS G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SSI						
	XGB-93-05X	XGB-93-05X	XGB-93-06X	XGB-93-06X	XGB-93-07X	XGB-93-08X	XGB-93-08X
ORGANICS (ug/g)	12 FT	25 FT	8 FT	12 FT	10 FT	8 FT	12 FT
ACETONE	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.0177
ETHYLBENZENE	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
TOLUENE	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
TRICHLOROFLUOROMETHANE	< 0.006	< 0.006	< 0.006	0.006	0.007	0.009	0.01
XYLENES	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
2-METHYLNAPHTHALENE	< 0.049	< 0.049	< 0.049	< 0.2	< 0.049	< 0.049	< 0.049
ACENAPHTHYLENE	< 0.033	< 0.033	< 0.033	< 0.2	< 0.033	< 0.033	< 0.033
ANTHRACENE	< 0.033	< 0.033	< 0.033	< 0.2	< 0.033	< 0.033	< 0.033
BENZO [A] ANTHRACENE	< 0.17	< 0.17	< 0.17	< 0.8	< 0.17	< 0.17	< 0.17
BENZO [A] PYRENE	< 0.25	< 0.25	< 0.25	< 1	< 0.25	< 0.25	< 0.25
BENZO [B] FLUORANTHENE	< 0.21	< 0.21	< 0.21	< 1	< 0.21	< 0.21	< 0.21
BENZO [G,H,I] PERYLENE	< 0.25	< 0.25	< 0.25	< 1	< 0.25	< 0.25	< 0.25
BENZO [K] FLUORANTHENE	< 0.066	< 0.066	< 0.066	< 0.3	< 0.066	< 0.066	< 0.066
BIS (2-ETHYLHEXYL) PHTHALATE	< 0.62	< 0.62	< 0.62	< 3	< 0.62	< 0.62	< 0.62
CHRYSENE	< 0.12	< 0.12	< 0.12	< 0.6	< 0.12	< 0.12	< 0.12
DI-N-BUTYL PHTHALATE	0.43	0.56	0.52	0.6	< 0.061	0.25	0.15
FLUORANTHENE	< 0.068	< 0.068	< 0.068	< 0.3	< 0.068	< 0.068	< 0.068
FLUORENE	< 0.033	< 0.033	< 0.033	< 0.2	< 0.033	< 0.033	< 0.033
INDENO [1,2,3-C,D] PYRENE	< 0.29	< 0.29	< 0.29	< 1	< 0.29	< 0.29	< 0.29
NAPHTHALENE	< 0.037	< 0.037	< 0.037	< 0.2	< 0.037	< 0.037	< 0.037
PHENANTHRENE	< 0.033	< 0.033	< 0.033	< 0.2	< 0.033	< 0.033	< 0.033
PYRENE	< 0.033	< 0.033	< 0.033	< 0.2	< 0.033	< 0.033	< 0.033
OTHER (ug/g)							
TOTAL ORGANIC CARBON	NA	NA	NA	NA	NA	NA	NA
TOTAL PETROLEUM HYDROCARBONS	< 28.7	< 28.7	< 28.5	158	< 28.8	< 28.7	< 28.8

Notes:
< = Less than detection limit.

TABLE 5-13
ORGANIC ANALYTES IN SUBSURFACE SOIL
AOC 43G - HISTORIC GAS STATIONS G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	SSI						SI	
ANALYTE	XGB-93-08X	XGB-93-09X	XGB-93-09X	XGB-93-09X	XGM-93-01X	XGM-93-02X	43G-92-01X	43G-92-01X
ORGANICS (ug/g)	17 FT	8 FT	12 FT	20 FT	19 FT	24 FT	10 FT	20 FT
ACETONE	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
ETHYLBENZENE	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
TOLUENE	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
TRICHLOROFLUOROMETHANE	< 0.006	0.006	0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
XYLENES	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
2-METHYLNAPHTHALENE	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.5	< 0.5
ACENAPHTHYLENE	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.3	< 0.3
ANTHRACENE	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.3	< 0.3
BENZO [A] ANTHRACENE	< 0.17	< 0.17	< 0.17	< 0.17	< 0.17	< 0.17	< 0.17	< 0.17
BENZO [A] PYRENE	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
BENZO [B] FLUORANTHENE	< 0.21	< 0.21	< 0.21	< 0.21	< 0.21	< 0.21	< 0.21	< 0.21
BENZO [G,H,I] PERYLENE	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
BENZO [K] FLUORANTHENE	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066
BIS (2-ETHYLHEXYL) PHTHALATE	< 0.62	< 0.62	< 0.62	< 0.62	< 0.62	< 0.62	< 0.62	< 0.62
CHRYSENE	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12
DI-N-BUTYL PHTHALATE	0.18	0.27	0.27	0.49	0.88	< 0.061	< 0.061	< 0.061
FLUORANTHENE	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068
FLUORENE	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
INDENO [1,2,3-C,D] PYRENE	< 0.29	< 0.29	< 0.29	< 0.29	< 0.29	< 0.29	< 0.29	< 0.29
NAPHTHALENE	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
PHENANTHRENE	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
PYRENE	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
OTHER (ug/g)								
TOTAL ORGANIC CARBON	1250	NA	NA	687	2490	576	NA	436
TOTAL PETROLEUM HYDROCARBONS	< 28.7	< 28.7	< 28.7	< 28.7	< 28.8	< 28.8	< 27.7	< 27.9

Notes:
< = Less than detection limit.

TABLE 5-14
INORGANIC ANALYTES IN SUBSURFACE SOIL
AOC 43G - HISTORIC GAS STATIONS G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

		SSI					SSI				
ANALYTE	BACKGROUND	XGB-93-03X	XGB-93-03X	XGB-93-03X	XGB-93-04X	XGB-93-04X	XGB-93-04X	XGB-93-05X	XGB-93-05X	XGB-93-05X	XGB-93-06X
INORGANIC (ug/g)		8 FT	12 FT	20 FT	8 FT	12 FT	25 FT	8 FT	12 FT	25 FT	8 FT
ALUMINUM	15000.0	11200	5100	7520	10000	9040	9270	5340	12200	5550	3770
ANTIMONY	0.5	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09
ARSENIC	21.0	17	31	19	51	28	14	16	21	8.53	8.21
BARIUM	42.5	23.5	14.6	23.3	53.3	29.2	25	22.9	56.5	20	21.5
BERYLLIUM	0.347	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.964	1.38	1.25	0.996
CADMIUM	2.0	< 0.7	< 0.7	< 0.7	2.61	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
CALCIUM	1400.0	1130	405	554	1570	1000	1930	1190	660	614	651
CHROMIUM	31.0	21.2	17.4	19.2	46	36.8	23.1	32	37.4	11.7	8.89
COBALT	NA	5.26	6.99	11	3.56	9.93	7.03	4.56	9.94	6.1	1.67
COPPER	8.39	10.2	9.09	27.1	29.2	17.3	15.3	14.4	11.3	9.66	6.54
IRON	15000.0	11300	9660	21700	10400	19300	17600	10700	15300	12100	9460
LEAD	36.9	14	5.12	8.6	11	57	8.5	50	8.8	5.29	3.8
MAGNESIUM	5600.0	2250	2550	3330	4760	6100	3910	2850	5570	1900	1590
MANGANESE	300.0	229	239	501	86.6	267	194	130	324	280	81.7
NICKEL	14.0	19.5	22.4	40.8	20.4	38.3	24.1	20.3	33.4	21.2	6.08
POTASSIUM	1700	568	774	995	1180	1340	1110	702	2580	760	1440
SODIUM	131.0	296	287	254	342	419	373	283	267	268	306
VANADIUM	28.7	15.1	8.24	8.18	18.3	19.9	12.8	14.3	26.3	8.73	11.6
ZINC	35.3	24.1	21.3	33.8	87.6	36.6	31.6	208	33.9	24.1	18.2

Notes:
< = Less than detection limit.
Shaded values exceed background limit.

TABLE 5-14
INORGANIC ANALYTES IN SUBSURFACE SOIL
AOC 43G - HISTORIC GAS STATIONS G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

		SSI					SSI						SI	
ANALYTE	BACKGROUND	XGB-93-06X	XGB-93-07X	XGB-93-08X	XGB-93-08X	XGB-93-08X	XGB-93-09X	XGB-93-09X	XGB-93-09X	XGM-93-01X	XGM-93-02X		43G-92-01X	43G-92-01X
INORGANIC (ug/g)		12 FT	10 FT	8 FT	12 FT	17 FT	8 FT	12 FT	20 FT	19 FT	24 FT		10 FT	20 FT
ALUMINUM	15000.0	4220	8410	12000	2440	11600	4010	26600	8700	3380	7870		NA	NA
ANTIMONY	0.5	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	4.01	1.51	< 1.09	< 1.09		NA	NA
ARSENIC	21.0	7.15	8.07	52	49	45	37	41	32	34	13		NA	NA
BARIUM	42.5	22.5	66.5	34.4	7.16	42.6	10.2	89.3	28.1	22.6	28.2		NA	NA
BERYLLIUM	0.347	1.08	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		NA	NA
CADMIUM	2.0	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7		NA	NA
CALCIUM	1400.0	867	2000	895	304	1330	456	5190	1030	13000	698		NA	NA
CHROMIUM	31.0	12.8	28	45.5	9.86	60.2	13	93.7	21.2	9.63	19.3		NA	NA
COBALT	NA	< 1.42	7.71	13.2	3.5	12.6	4.43	18.7	16.6	11.3	6.75		NA	NA
COPPER	8.39	7.98	10.8	20.7	4.16	31.8	8.76	37.5	27.9	17.8	11.1		NA	NA
IRON	15000.0	11400	14600	21200	5250	22200	7910	34000	30300	25900	16100		NA	NA
LEAD	36.9	4.44	3.58	20	12	12	5.73	13	15	12	6.26		8.8	8.19
MAGNESIUM	5600.0	1760	5670	8870	1840	8960	2470	13700	3860	2780	3280		NA	NA
MANGANESE	300.0	89.5	264	372	121	407	138	632	621	880	331		NA	NA
NICKEL	14.0	6.25	21.2	53.9	12.7	55.7	18.9	87	69.6	50.3	24.1		NA	NA
POTASSIUM	1700	1420	4290	2470	576	3060	621	6170	1160	612	1240		NA	NA
SODIUM	131.0	292	330	290	489	291	285	1280	345	338	390		NA	NA
VANADIUM	28.7	14	24.1	25.1	5.49	22.6	6.86	51	11.8	5.78	11.8		NA	NA
ZINC	35.3	21.5	35.7	45.6	12.1	48.4	17.4	68	62.3	53.8	34		NA	NA

Notes:
< = Less than detection limit.
Shaded values exceed background limit.

TABLE 5-15
ANALYTES IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 3 AAFES-1D 09/29/93 26 MXAF01X1		ROUND 4 AAFES-1D 01/25/94 26 MXAF01X2		ROUND 3 AAFES-2 09/30/93 28 MXAF02X1		ROUND 4 AAFES-2 01/25/94 28 MXAF02X2		ROUND 3 AAFES-3 09/30/93 24 MXAF03X1		ROUND 4 AAFES-3 02/02/94 24 MXAF03X2	
PAL CATIONS/ANIONS (µg/L)													
Chloride		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phosphate		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Sulfate		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL METALS (µg/L)													
Aluminum	6870	5270	< 141 F	5710	< 141 F	15100	< 141 F	5030	< 141 F	49400	< 141 F	< 141	
Antimony	3.03	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	6.79	< 3.03 F	6.34	< 3.03 F	< 3.03	
Arsenic	10.5	19.1	10.3 F	12.3	9.28 F	73.1	13.5 F	21.9	28.3 F	210	< 2.54 F	< 2.54	
Barium	39.6	45.2	15 F	47.5	15.7 F	154	33.4 F	131	44.5 F	161	6.63 F	< 5	
Calcium	14700	88100	80800 F	81400	76300 F	79800	74000 F	76500	66000 F	77100	64400 F	40900	
Chromium	14.7	11.1	< 6.02 F	14.3	< 6.02 F	97.2	< 6.02 F	32.1	< 6.02 F	219	< 6.02 F	< 6.02	
Cobalt	25.0	< 25	< 25 F	< 25	< 25 F	81.8	< 25 F	122	< 25 F	160	< 25 F	< 25	
Copper	8.09	14.1	< 8.09 F	13.9	< 8.09 F	43.8	< 8.09 F	42.7	< 8.09 F	151	< 8.09 F	< 8.09	
Iron	9100	27400	10200 F	23700	12800 F	96400	21900 F	95700	60900 F	198000	< 38.8 F	236	
Lead	4.25	11.8	< 1.26 F	11.7	< 1.26 F	58.8	11 F	87.6	2.93 F	82.1	< 1.26 F	< 1.26	
Magnesium	3480	27700	24600 F	25600	22200 F	24600	22500 F	16500	14200 F	33900	9540 F	6420	
Manganese	291	11200	7350 F	9460	8010 F	24400	10800 F	35200	14200 F	8630	76 F	26.3	
Mercury	0.243	< 0.243	< .243 F	< 0.243	.255 F	< 0.243	< .243 F	0.28	< .243 F	< 0.243	< .243 F	< 0.243	
Nickel	34.3	88.7	< 34.3 F	82	< 34.3 F	336	< 34.3 F	393	< 34.3 F	598	< 34.3 F	< 34.3	
Potassium	2370	3300	1930 F	3810	1670 F	6980	2120 F	3420	2250 F	9930	2270 F	2030	
Sodium	10800	57100	51200 F	53500	51700 F	67700	67500 F	64700	63400 F	110000	107000 F	70900	
Vanadium	11.0	< 11	< 11 F	< 11	< 11 F	28.3	< 11 F	< 11	< 11 F	59.3	< 11 F	< 11	
Zinc	21.1	42.4	< 21.1 F	46	< 21.1 F	131	< 21.1 F	58.6	< 21.1 F	507	< 21.1 F	< 21.1	
PAL SEMIVOLATILE ORGANICS (µg/L)													
2-methylnaphthalene		< 30	NA	17	NA	5000	NA	2000	NA	< 1.7	NA	< 1.7	
Bis (2-ethylhexyl) Phthalate		< 4.8	NA	< 4.8	NA	< 4000	NA	< 50	NA	< 4.8	NA	< 4.8	
Naphthalene		90	NA	30	NA	4000	NA	2000	NA	< 0.5	NA	< 0.5	
Phenanthrene		< 0.5	NA	< 0.5	NA	80	NA	20	NA	< 0.5	NA	< 0.5	
PAL VOLATILE ORGANICS (µg/L)													
*xylenes		2000	NA	900	NA	9000	NA	9000	NA	< 0.84	NA	< 0.84	
1,2-dichloroethane		< 10	NA	< 5	NA	< 20	NA	< 50	NA	< 0.5	NA	< 0.5	
Acetone		< 300	NA	100	NA	< 600	NA	< 1000	NA	< 13	NA	< 13	
Benzene		1000	NA	600	NA	1000	NA	2000	NA	< 0.5	NA	< 0.5	
Carbon Disulfide		< 10	NA	< 5	NA	< 20	NA	< 50	NA	< 0.5	NA	< 0.5	
Chloroform		< 10	NA	< 5	NA	< 20	NA	< 50	NA	< 0.5	NA	0.56	
Ethylbenzene		200	NA	200	NA	1000	NA	1000	NA	< 0.5	NA	< 0.5	
Methylene Chloride		< 60	NA	< 20	NA	< 100	NA	< 200	NA	< 2.3	NA	< 2.3	
Methyl isobutyl ketone/Isopropylacetone		< 80	NA	< 30	NA	< 200	NA	< 300	NA	< 3	NA	< 3	
Tetrachloroethylene / Tetrachloroethene		< 40	NA	< 20	NA	< 80	NA	< 200	NA	< 1.6	NA	< 1.6	
Toluene		70	NA	40	NA	500	NA	400	NA	< 0.5	NA	< 0.5	
Trichloroethylene / Trichloroethene		< 10	NA	< 5	NA	< 20	NA	< 50	NA	< 0.5	NA	< 0.5	
Trichlorofluoromethane		< 40	NA	< 10	NA	< 70	NA	< 100	NA	< 1.4	NA	2.1	
PAL WATER QUALITY PARAMETERS (µg/L)													
Alkalinity		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Nitrite, Nitrate-non Specific		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Nitrogen By Kjeldahl Method		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total Dissolved Solids		NA	NA	480000	NA	NA	NA	480000	NA	NA	NA	NA	
Total Hardness		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total Suspended Solids		1320000	NA	280000	NA	1670000	NA	2900000	NA	3210000	NA	19000	
OTHER (µg/L)													
Total Petroleum Hydrocarbons		925	NA	1200	NA	44000	NA	120000	NA	5170	NA	190	

TABLE 5-15
ANALYTES IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 4		ROUND 3		ROUND 4		ROUND 3		ROUND 4		ROUND 3	
		AAFES-3 02/02/94 24 MXAF03X2		AAFES-5 09/29/93 25 MXAF05X1	AAFES-5 09/29/93 25 MXAF05X1	AAFES-5 01/25/94 25 MXAF05X2	AAFES-5 01/25/94 25 MXAF05X2	AAFES-6 09/30/93 22 MXAF06X1	AAFES-6 09/30/93 22 MXAF06X1	AAFES-6 01/25/94 22 MXAF06X2	AAFES-6 01/25/94 22 MXAF06X2	AAFES-7 09/30/93 12 MXAF07X1	AAFES-7 09/30/93 12 MXAF07X1
PAL CATIONS/ANIONS (µg/L)													
Chloride		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL METALS (µg/L)													
Aluminum	6870	< 141	F	71700	< 141 F	67400	< 141 F	35900	< 141 F	27800	< 141 F	15600	< 141 F
Antimony	3.03	< 3.03	F	2.95	< 3.03 F	6.96	< 3.03 F	3.93	< 3.03 F	.5	< 3.03 F	< 3.03	< 3.03 F
Arsenic	10.5	< 2.54	F	45.7	< 2.54 F	11.9	< 2.54 F	94	10.3 F	140	33.7 F	51.7	< 2.54 F
Barium	39.6	< 5	F	538	18.4 F	567	19.8 F	149	14.4 F	147	11.3 F	61.8	< 5 F
Calcium	14700	37500	F	56800	46000 F	50200	37100 F	72700	56300 F	54800	44600 F	14300	11800 F
Chromium	14.7	< 6.02	F	296	< 6.02 F	261	< 6.02 F	106	< 6.02 F	85.4	< 6.02 F	49.9	< 6.02 F
Cobalt	25.0	< 25	F	222	< 25 F	190	< 25 F	85.6	< 25 F	86.1	< 25 F	< 25	< 25 F
Copper	8.09	< 8.09	F	376	< 8.09 F	296	< 8.09 F	91.5	< 8.09 F	66.9	< 8.09 F	34.9	< 8.09 F
Iron	9100	< 38.8	F	406000	< 38.8 F	316000	43.1 F	106000	8060 F	83600	13100 F	35600	63 F
Lead	4.25	< 1.26	F	89	< 1.26 F	170	< 1.26 F	32.9	< 1.26 F	27.4	< 1.26 F	19.5	< 1.26 F
Magnesium	3480	5890	F	29900	7880 F	25000	5820 F	28700	9660 F	21000	7480 F	9280	1860 F
Manganese	291	9.36	F	8380	2690 F	8190	761 F	8400	5970 F	6390	4950 F	1540	374 F
Mercury	0.243	< .243	F	0.303	< .243 F	0.399	< .243 F	0.424	< .243 F	0.692	< .243 F	< 0.243	< .243 F
Nickel	34.3	< 34.3	F	1140	< 34.3 F	901	< 34.3 F	333	62.2 F	306	< 34.3 F	86.4	< 34.3 F
Potassium	2370	1990	F	21500	2440 F	24500	2200 F	8590	2350 F	8930	2450 F	5130	1150 F
Sodium	10800	67100	F	88400	85600 F	87100	83900 F	63700	64200 F	63400	59900 F	15400	14600 F
Vanadium	11.0	< 11	F	119	< 11 F	111	< 11 F	39.2	< 11 F	32.5	< 11 F	24.8	< 11 F
Zinc	21.1	< 21.1	F	944	< 21.1 F	923	< 21.1 F	229	< 21.1 F	252	< 21.1 F	72.7	< 21.1 F
PAL SEMIVOLATILE ORGANICS (µg/L)													
2-methylnaphthalene		NA		< 1.7	NA	< 1.7	NA	6.3	NA	< 1.7	NA	< 1.7	NA
Bis (2-ethylhexyl) Phthalate		NA		< 4.8	NA	< 4.8	NA	< 4.8	NA	< 4.8	NA	6.3	NA
Naphthalene		NA		< 0.5	NA	< 0.5	NA	2.5	NA	1.7	NA	< 0.5	NA
Phenanthrene		NA		< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA
PAL VOLATILE ORGANICS (µg/L)													
*xylenes		NA		< .84	NA	< 0.84	NA	2.8	NA	< 8	NA	0.86	NA
1,2-dichloroethane		NA		< .5	NA	< 0.5	NA	2.6	NA	< 5	NA	< 0.5	NA
Acetone		NA		< 13	NA	< 13	NA	51	NA	< 100	NA	< 13	NA
Benzene		NA		< .5	NA	< 0.5	NA	13	NA	70	NA	< 0.5	NA
Carbon Disulfide		NA		< .5	NA	< 0.5	NA	< 0.5	NA	< 5	NA	< 0.5	NA
Chloroform		NA		< .5	NA	< 0.5	NA	< 0.5	NA	< 5	NA	< 0.5	NA
Ethylbenzene		NA		< .5	NA	< 0.5	NA	34	NA	90	NA	< 0.5	NA
Methylene Chloride		NA		< 2.3	NA	< 2.3	NA	< 2.3	NA	< 20	NA	< 2.3	NA
Methyl isobutyl ketone/Isopropylacetone		NA		< 3	NA	< 3	NA	< 3	NA	< 30	NA	< 3	NA
Tetrachloroethylene / Tetrachloroethene		NA		3.8	NA	7	NA	< 1.6	NA	< 20	NA	< 1.6	NA
Toluene		NA		< .5	NA	< 0.5	NA	0.63	NA	< 5	NA	< 0.5	NA
Trichloroethylene / Trichloroethene		NA		< .5	NA	0.52	NA	< 0.5	NA	< 5	NA	< 0.5	NA
Trichlorofluoromethane		NA		< 1.4	NA	< 1.4	NA	< 1.4	NA	< 10	NA	< 1.4	NA
PAL WATER QUALITY PARAMETERS (µg/L)													
Alkalinity		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite, Nitrate-non Specific		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids		NA		NA	NA	330000	NA	NA	NA	310000	NA	NA	NA
Total Hardness		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Suspended Solids		NA		6620000	NA	7400000	NA	2240000	NA	2000000	NA	538000	NA
OTHER (µg/L)													
Total Petroleum Hydrocarbons		NA		< 190	NA	1000	NA	274	NA	640	NA	< 192	NA

TABLE 5-15
ANALYTES IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 4			ROUND 3			ROUND 4			ROUND 3			ROUND 4		
		AAFES-7 02/01/94 12 MXAF07X2			XGM-93-01X 09/28/93 28 MXXG01X1			XGM-93-01X 01/25/94 28 MXXG01X2			XGM-93-02X 09/29/93 33 MXXG02X1			XGM-93-02X 02/01/94 33 MXXG02X2		
		AAFES-7 02/01/94 12 MXAF07X2			XGM-93-01X 09/28/93 28 MXXG01X1			XGM-93-01X 01/25/94 28 MXXG01X2			XGM-93-02X 09/29/93 33 MXXG02X1			XGM-93-02X 02/01/94 33 MXXG02X2		
PAL CATIONS/ANIONS (µg/L)																
Chloride		NA			NA			NA			NA			NA		
Phosphate		NA			NA			NA			NA			NA		
Sulfate		NA			NA			NA			NA			NA		
PAL METALS (µg/L)																
Aluminum	6870	6420	<	141 F	2290	<	141 F	9830	<	141 F	23800	<	141 F	33200	<	141 F
Antimony	3.03	< 3.03		2.86 F	< 3.03		3.93 F	2.86		3.84 F	< 3.03	<	3.03 F	4.46	<	3.03 F
Arsenic	10.5	24.5	<	2.54 F	11.7	<	2.54 F	32.8	<	2.54 F	57.7		4.05 F	70.1		8.1 F
Barium	39.6	38.1		11.9 F	20		11.9 F	54.5		7.34 F	124		34.1 F	154		31.1 F
Calcium	14700	26600		24300 F	52300		61400 F	55800		51800 F	107000		82700 F	109000		75800 F
Chromium	14.7	25.8	<	6.02 F	7.92	<	6.02 F	22.8	<	6.02 F	63.4	<	6.02 F	96.4	<	6.02 F
Cobalt	25.0	< 25	<	25 F	< 25	<	25 F	< 25	<	25 F	68.1	<	25 F	86.2	<	25 F
Copper	8.09	14.7	<	8.09 F	< 8.09	<	8.09 F	26.2	<	8.09 F	67.6	<	8.09 F	96.5	<	8.09 F
Iron	9100	15800		47.1 F	5600	<	38.8 F	24200		56.2 F	80000		5700 F	120000		27700 F
Lead	4.25	7.16	<	1.26 F	8.68	<	1.26 F	24	<	1.26 F	36.9		2.06 F	56.6	<	1.26 F
Magnesium	3480	7210		3960 F	10100		13500 F	12600		10400 F	35000		21300 F	37400		19600 F
Manganese	291	2200		85.3 F	137		46.4 F	428		51.4 F	12300		11100 F	11200		8790 F
Mercury	0.243	< 0.243	<	.243 F	< 0.243	<	.243 F	< 0.243	<	.243 F	< 0.243	<	.243 F	< 0.243	<	.243 F
Nickel	34.3	< 34.3	<	34.3 F	< 34.3	<	34.3 F	55	<	34.3 F	213	<	34.3 F	290		41.2 F
Potassium	2370	5070		3960 F	680		3420 F	5350		3360 F	10100		6220 F	10200		7120 F
Sodium	10800	80900		89900 F	600		29800 F	33400		31300 F	74300		72900 F	70200		68800 F
Vanadium	11.0	< 11	<	11 F	< 1	<	11 F	13.9	<	11 F	28.5	<	11 F	39.6	<	11 F
Zinc	21.1	29.4	<	21.1 F	22.7	<	21.1 F	90.7	<	21.1 F	150	<	21.1 F	413	<	21.1 F
PAL SEMIVOLATILE ORGANICS (µg/L)																
2-methylnaphthalene		< 1.7		NA	< 1.7		NA	< 1.7		NA	100		NA	40		NA
Bis (2-ethylhexyl) Phthalate		< 4.8		NA	< 4.8		NA	5		NA	< 4.8		NA	< 4.8		NA
Naphthalene		< 0.5		NA	< 0.5		NA	< 0.5		NA	300		NA	200		NA
Phenanthrene		< 0.5		NA	< 0.5		NA	< 0.5		NA	< 0.5		NA	< 0.5		NA
PAL VOLATILE ORGANICS (µg/L)																
*xylenes		< 0.84		NA	< 0.84		NA	< 0.84		NA	6000		NA	1000		NA
1,2-dichloroethane		< 0.5		NA	< 0.5		NA	< 0.5		NA	< 100		NA	< 20		NA
Acetone		< 13		NA	< 13		NA	< 13		NA	< 3000		NA	< 600		NA
Benzene		< 0.5		NA	< 0.5		NA	< 0.5		NA	2000		NA	300		NA
Carbon Disulfide		< 0.5		NA	< 0.5		NA	< 0.5		NA	< 100		NA	< 20		NA
Chloroform		< 0.5		NA	< 0.5		NA	< 0.5		NA	< 100		NA	< 20		NA
Ethylbenzene		< 0.5		NA	< 0.5		NA	< 0.5		NA	< 100		NA	100		NA
Methylene Chloride		< 2.3		NA	< 2.3		NA	2.9		NA	< 500		NA	300		NA
Methyl isobutyl ketone/Isopropylacetone		< 3		NA	< 3		NA	< 3		NA	< 600		NA	< 200		NA
Tetrachloroethylene / Tetrachloroethene		< 1.6		NA	< 1.6		NA	< 1.6		NA	< 300		NA	< 80		NA
Toluene		< 0.5		NA	< 0.5		NA	< 0.5		NA	800		NA	40		NA
Trichloroethylene / Trichloroethene		< 0.5		NA	< 0.5		NA	< 0.5		NA	< 100		NA	< 20		NA
Trichlorofluoromethane		1.6		NA	< 1.4		NA	< 1.4		NA	< 300		NA	< 70		NA
PAL WATER QUALITY PARAMETERS (µg/L)																
Alkalinity		NA		NA	NA		NA	NA		NA	NA		NA	NA		NA
Nitrite, Nitrate-non Specific		NA		NA	NA		NA	NA		NA	NA		NA	NA		NA
Nitrogen By Kjeldahl Method		NA		NA	NA		NA	NA		NA	NA		NA	NA		NA
Total Dissolved Solids		NA		NA	NA		NA	270000		NA	NA		NA	NA		NA
Total Hardness		NA		NA	NA		NA	NA		NA	NA		NA	NA		NA
Total Suspended Solids		430000		NA	149000		NA	380000		NA	2180000		NA	1400000		NA
OTHER (µg/L)																
Total Petroleum Hydrocarbons		230		NA	< 184		NA	< 190		NA	2750		NA	2300		NA

TABLE 5-16
ANALYTES IN SEDIMENT
AOC 43G – HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALTYE / SITE ID:	XGD-93-02X
INORGANICS (ug/g)	
ALUMINUM	3710
ARSENIC	7.5
BARIUM	17.2
CALCIUM	1610
CHROMIUM	13.3
COBALT	2.63
COPPER	15.3
IRON	11400
LEAD	24
MAGNESIUM	1840
MANGANESE	119
NICKEL	9.87
POTASSIUM	697
SODIUM	298
VANADIUM	9.84
ZINC	70.7
OTHER (ug/g)	
TOTAL ORGANIC CARBON	8970
TOTAL PETROLEUM HYDROCARBONS	448

6.0 SITE HYDROLOGY, GEOLOGY AND GROUNDWATER CHARACTERIZATION

6.1 SITE HYDROLOGY

Surface water drainage at AOC 43G is controlled by pavement, topography, and a storm water collection system. The unpaved areas of AOC 43G are well-drained with no indication of seasonal ponding or wetlands environment. Precipitation runoff apparently follows topography which slopes away to the southeast (Figure 6-1). The outfall of the storm water collection system is located 600 feet northeast of the AAFES gas station along the southern side of Queenstown Road. A drainage ditch runs southeast away from the outfall. Seasonal ponding has been observed in the outfall's drainage ditch southeast of AOC 43G in the vicinity of AAFES-7. A small northeasterly flowing stream exists 1,000 feet southeast of the AAFES gas station. The stream drains the Ammunition Storage Area and flows into Robbins Pond 1,500 feet east of the AAFES gas station (see Figure 5-1).

6.2 SITE GEOLOGY

This subsection presents descriptions of the geologic formations encountered at AOC 43G. Figure 6-1 shows the orientations of the geologic cross-sections. Figures 6-2, 6-3, and 6-4 present geologic cross sections A-A', B-B', and C-C', respectively. Interpretive bedrock surface elevation contours are shown in Figure 6-5.

6.2.1 Surficial Soils and Fill Material

Surficial soil at AOC 43G is classified by the SCS as the Hinckley-Merrimac (Freetown)-Windsor Association (see Figure 2-3). The soil is described as being deep; excessively drained; nearly level to very steep (see Subsection 2.2.5). Soils from this association were likely excavated and refilled to level ground surfaces at AOC 43G during construction of the AAFES gas station, car wash, and Auto Crafts Shop (Building 2012).

Observations indicate that surficial soils consist of well-graded sand fill and construction debris. This fill was used to level the ground surface immediately southeast of the Auto Crafts Shop and in the vicinity of Building 3553 (see Figure 6-1). Soil borings were not installed through the fill but it is presumed that the fill is 6 to 8 feet thick.

6.2.2 Subsurface Soils

This subsection describes native subsurface soils at AOC 43G. Boring logs are provided in Appendix A and results of grain-size analysis are presented in Appendix J.

Subsurface soil samples collected at AOC 43G indicate that subsurface soils consist of sand and gravel, a continuation of the Hinckley-Merrimac (Freetown)-Windsor Association, overlying basal till. Observed overburden thickness ranges from 34.5 feet at XGM-93-02X to 17 feet at XGP-94-05X. The sand and gravel layer overlying the till consists primarily of poorly to well-graded fine to coarse sand with sub-rounded to sub-angular gravel. These soils are predominately dense to medium dense and range in color from light tan to dark brown. Occasional fine sand lenses, approximately 0.1 feet thick, were encountered in several borings. The observed thickness of the sand and gravel layer ranges between 7 and 17 feet, with an average thickness of 10 to 12 feet. The minimum thickness of the layer, 7 feet, was observed in XGM-94-03X and XGM-94-04X located along the base of the hill between the AAFES gas station and the Car Wash (Building 2017). Observations of topography and the hillside suggest that the sand layer in this area was excavated to level the ground surface during construction of the Car Wash. It is likely that the excavated soils were used as fill on the southern side of the Car Wash. The maximum observed thickness of the sand and gravel layer, 17 feet, was observed along the top of the slope immediately south and east of the AAFES gas station near the existing gasoline USTs. Nobis reported encountering fine to coarse sand and gravel to 26 feet bgs at AAFES-5 (see Figures 6-2 through 6-4 and Table 5-5).

Till underlies the sand and gravel layer and consists of well graded silty sand, sandy silt, and silt with highly weathered phyllite gravel and cobbles. Gravel content generally increases with depth approaching the highly weathered bedrock surface. The till is primarily dense to medium dense and ranges in color from

light brown to dark olive brown. Minimum observed till thickness is 0.5 feet at XGB-93-07X adjacent to the former and active gasoline USTs. Maximum observed till thickness, 16 feet, was observed at XGM-93-01X located northwest of the AAFES gas station (see Figures 6-2 through 6-4 and Table 5-5).

6.2.3 Bedrock Geology

Bedrock in the vicinity of AOC 43G is classified as the Oakdale Formation (Zen, 1983). The formation is described as fine-grained metasiltstone and phyllite, consisting of quartz and minor feldspar and ankerite. The metasiltstone and phyllite are commonly deformed by kink banding. Measured depths to bedrock from soil borings indicate that the bedrock surface slopes to the southeast mimicking surficial topography (see Figure 6-4 and 6-5). Bedrock beneath the AAFES gas station and the area to the northwest appears to be relatively flat with a localized high beneath the western side of the former and active gasoline USTs (Table 6-1). The maximum observed bedrock elevation at AOC 43G, 289.3 feet MSL, was at the soil boring XGB-93-07X located along the western side of the former and active gasoline USTs (see Figure 6-4). The lowest measured bedrock elevation, 254.7 feet MSL, was encountered in XGM-94-06X and XGP-94-02X both located 65 feet northwest of Building 3553 (see Figure 6-1). The bedrock surface in the vicinity of AOC 43G is highly weathered, resulting in a gradational change from overburden till to bedrock. For purposes of this report, the bedrock surface was defined as the point at which HSAs and split-spoons met refusal.

Bedrock coring was performed at 10 monitoring well borings at AOC 43G: AAFES-1D, AAFES-2, XGM-94-03X, XGM-94-04X, XGM-94-05X, XGM-94-07X, XGM-94-08X, XGP-94-05X, XGP-94-06X, and XGP-94-07X. The rock core samples collected are light gray to rust brown phyllite. The bedding is comprised of thin laminae that are severely deformed via banding and folding. Existing fractures occur primarily along bedding planes, although both natural and mechanical fractures were noted perpendicular to bedding. As all samples were collected via rock core, it was not possible to directionally orient the fractures. Fracture dips ranged between 0 and 50 degrees with the majority dipping at approximately 45 degrees. Secondary quartzite and calcite replacement was noted along fractures. Secondary mineralization has resulted in numerous healed fractures. Iron staining was observed in some of the fractures along with secondary sulfides (pyrite) and less prevalent greenish staining possibly indicating

secondary chlorides (XGM-94-05X only). Evidence of mud seams and heavily fractured (rubble) zones were noted in XGM-94-04X, XGM-94-07X, XGM-94-08X, XGP-94-05X, XGP-94-06X, and XGP-94-07X. Small, iron stained solution cavities, 0.05 to 0.1 feet in diameter were also observed in XGP-94-06X. Rock core logs are presented in Appendix A.

6.2.4 Summary and Interpretation of Seismic Survey Results

The objective of the seismic refraction survey performed by GPRI at AOC 43G was to further define the bedrock surface. This subsection presents a summary of the findings of the survey. Complete details of the methodology and results of the survey, including interpretive profiles of depth to bedrock, are presented in Appendix C.

The following information was derived by GPRI from the results of the seismic refraction survey:

- The surface of the bedrock could be distinguished on all of the refraction records.
- The seismic refraction survey showed that the overburden at the site is partially saturated beginning at approximately 9 feet bgs. The uppermost material has a velocity range of 1,500 to 1,700 feet per second, representative of partially saturated silty sand.
- The bedrock surface was shown to have moderately uniform slopes. The depth to bedrock ranges from 10 to 12 feet.
- Moderately competent to sound bedrock was detected on all profiles. The velocities of the bedrock, 16,000 feet per second, are indicative of a sound phyllitic bedrock, which is consistent with boring logs.

In general, the depths to bedrock determined from the seismic survey are in relatively close ($\pm$5 feet) agreement with physical data obtained from borings at AOC 43G.

6.2.5 Site Geology Interpretation Summary

The geology of AOC 43G is comprised of a gravelly sand to sandy gravel layer overlying till which in turn overlies phyllite bedrock. The sand and gravel layer, which ranges in thickness from 7 and 17 feet, is comprised primarily of poorly to well-graded fine to coarse sand with sub-rounded to sub-angular gravel. Occasional fine sand lenses, 0.1 feet thick, were encountered in several borings. The till consists of well-graded silty sand, sandy silt, and silt with highly weathered phyllite gravel and cobbles. Gravel content generally increases with depth approaching the highly weathered bedrock surface. The till ranges in thickness from 0.5 and 16 feet. Bedrock encountered beneath AOC 43G is moderately to highly weathered fine-grained phyllite that slopes to the southeast mimicking topography. Depths to bedrock ranged from 34 feet bgs near the AAFES gas station to 17 feet in the southeastern corner of the site. Numerous fractures, primarily along bedding planes and dipping 45 degrees, were observed in rock core samples. Secondary quartzite and calcite were prevalent along fracture zones and voids.

6.3 HYDROGEOLOGY

This subsection presents data and interpretations of hydrogeologic conditions at AOC 43G. Groundwater levels used in this subsection are provided in Table 6-2 and interpretive water table elevation contours are presented in Figure 6-6. Water level elevations were measured on January 31, 1995. An additional water level round was collected on May 9, 1995. The groundwater flow direction calculated from these elevations was similar to the January 31, 1995 elevations (see Table 6-2). In-situ hydraulic conductivity results are provided in Table 6-3 and Appendix G, and results of the aquifer pumping tests are summarized in Table 6-4.

6.3.1 Site Hydrogeology

As a result of the type of contaminants (primarily fuel compounds) identified in groundwater at AOC 43G, all monitoring wells have been installed as water table wells (i.e., their screened interval, including sandpack, spans the water table). Because of the proximity of the water table to the bedrock surface, it was

necessary to install monitoring wells and piezometers in both overburden and bedrock, and/or across the overburden-bedrock interface as conditions dictated (see Figures 6-2, 6-3, and 6-4, and Table 5-8). A total of 11 monitoring wells and/or piezometers (AAFES-3, AAFES-4, AAFES-5, AAFES-6, AAFES-7, XGM-94-06X, XGM-94-09X, XGM-94-10X, XGP-94-02X, XGP-94-03X, and XGP-94-04X) were installed entirely in overburden. Nine monitoring wells and/or piezometers (AAFES-1D, AAFES-2, XGM-93-01X, XGM-93-02X, XGM-94-03X, XGM-94-05X, XGM-94-07X, XGM-94-08X, and XGP-94-01X) were installed across the soil-bedrock interface, while the final four (XGM-94-04X, XGP-94-05X, XGP-94-06X, and XGP-94-07X) were constructed in bedrock.

The water table generally occurs in the overburden till across AOC 43G, with the exception of the area west of the Car Wash near XGM-94-04X where the water table occurs in the bedrock (see Figure 6-3). Figure 6-6 presents a water table elevation contour map for AOC 43G. Groundwater elevations presented on the figure are from water level measurements collected January 31, 1995. Based on this data set, groundwater flows east-southeast across the site. This flow direction is consistent with the overburden and bedrock flow directions as calculated by the basewide flow model (see Figures 2-6 and 2-7) (ETA, 1992). Additional groundwater elevation data collected on May 9, 1995 supports these flow directions.

Comparison of the January 31, 1995 water level measurements with measurements collected on December 5 and 8, 1994 prior to the aquifer pumping tests indicates a rise in all of the water levels. Increases for the majority of the site ranged between 0.81 feet at XGM-93-02X and 2.84 feet at XGM-94-08X. Much larger increases, between 6.05 feet and 7.06 feet, were observed in the overburden monitoring well XGM-94-06X and the surrounding piezometers XGP-94-02X, XGP-94-03X, and XGP-94-04X located southeast and downslope of the site (see Figure 6-1). These increases are consistent with the fact that this area is largely unpaved and therefore more susceptible to recharge. The variance in recharge does not appear to effect flow directions, but did decrease local horizontal gradients at AOC 43G. Horizontal gradients were calculated between XGM-93-02X and XGM-94-06X using water level data collected on December 5, 1994, January 31, 1995, and May 9, 1995. These monitoring wells were used because they are roughly along the axis of the contaminant plume, and

interpretive water table elevation contours indicate that they share a common flow path. Water levels collected on December 5, 1994 yield a horizontal gradient of 0.052 feet/foot. The increased water levels observed in January 1995 give a gradient of 0.036 feet/foot while May 9, 1995 water level data yields horizontal gradients of 0.041 feet/foot. The comparatively large increases and decreases in water levels observed in the vicinity of XGM-94-06X appear to govern the magnitude of the gradients. This effect appears to be localized in the southeastern corner of the site and does not severely impact gradients across the rest of the site.

There is no evidence to indicate the presence or absence of vertical gradients across the bedrock-overburden interface in the area of the AAFES gas station and the Car Wash. The fact that the water table at AOC 43G intermittently exists both in the overburden and bedrock suggests that there is little differentiation between the overburden and bedrock aquifers.

In-situ Hydraulic Conductivity Results. In-situ hydraulic conductivity test results presented in Table 6-3 indicate that estimates of hydraulic conductivity (Hvorslev method) range between 5.9×10^{-3} cm/sec and 4.0×10^{-6} cm/sec at AAFES-6 and AAFES-1D, respectively. The geometric mean of hydraulic conductivities of the wells and piezometers screened entirely in overburden, 5.3×10^{-4} cm/sec, is approximately an order of magnitude greater than the geometric mean of hydraulic conductivities estimated for wells and piezometers screened entirely within the bedrock, 1.7×10^{-5} cm/sec. A presentation of all the hydraulic conductivity test results is presented in Appendix G.

Groundwater Velocity Analyses. Flow velocities were estimated between XGM-93-02X and XGM-94-06X using maximum and minimum observed hydraulic conductivities and gradients. The maximum calculated flow velocity was 2.9 feet per day or 1,060 feet/year. The minimum calculated flow velocity was 0.0014 feet/day or 0.51 feet/year.

The following subsections qualitatively discuss the results of the aquifer pumping tests performed at AOC 43G. A complete quantitative discussion including chronology and procedures is provided in Appendix G.

6.3.1.1 Aquifer Pumping Test Results XGM-94-06X (Overburden) Background and Atmospheric Trend. Background water level trends were monitored in XGM-94-08X and XGM-94-07X, both outside the influence of pumping. XGM-94-07X showed a steady increase in water levels of 0.00007 feet per minute (ft/min) throughout the test. Monitored water levels in XGM-94-08X rose at 0.00006 ft/min for the first 900 minutes of the test and then increased to a rate of 0.00015 ft/min for the remainder of the pumping and recovery phases. This increase appears to be related to a precipitation event and snow melt. Efforts were made to correct the drawdown water levels for the observed rising background trends. However, applying these trends generated hydrographs that did not display reasonable drawdown curves. Rates of water level increase observed in XGM-94-06X, XGP-94-02X, XGP-94-03X, and XGP-94-04X range between 0.0002 and 0.0003 ft/min. Sampling of the monitoring well and piezometer borings indicate that the sand and gravel extends to between 11 and 15 feet bgs. The sandpack for XGM-94-06X and the piezometers extend upward into the sand and gravel layer although the screened intervals are all in the till (see Appendix B for monitoring well/piezometer installation detail). The combination of the sandpack acting as a conduit for recharge through the till and the lack of pavement in the area of XGM-94-06X explain the higher rate of recharge. The increased heads observed during the quarterly water level surveys helps to further substantiate using a larger trend correction factor then that which was observed in the background wells.

Atmospheric pressure was monitored and recorded prior to, during, and after the pumping test. Comparison of the atmospheric pressure data with the water level data indicates that barometric pressure has no measurable influence on the aquifer. This is consistent with the unconfined nature of the overburden aquifer.

Aquifer pumping tests at XGM-94-06X consisted of a variable-rate step-drawdown test and a constant-rate discharge test.

XGM-94-06X is screened in the overburden (well-graded sand overlying till) as are the surrounding piezometers XGP-94-02X, XGP-94-03X, and XGP-94-04X (see Figure 6-1). Bedrock is at approximately 27 feet bgs and, at the time of the test, groundwater was approximately 22 feet bgs.

Variable Rate Test. The objective of the step-drawdown test was to ascertain the maximum sustainable pumping rate to be used during the constant-rate discharge test. The step-drawdown test at XGM-94-06X was initiated at 0.52 gpm. The initial depth to water was 25.35 feet with a total well depth of 30 feet. The pump intake was set at approximately 29.2 feet, resulting in an available drawdown of 3.85 feet. After 125 minutes of pumping, the water level had dropped to the top of the pump and the decision was made to step the test to a lower rate before the well was dewatered. The flow rate was adjusted down to 0.42 gpm and after 55 minutes of pumping the drawdown appeared to stabilize at 2.35 feet. Based on this information, the optimum rate for the constant-rate discharge test was estimated to be 0.4 gpm.

Constant Rate Test. The purpose of the constant-rate discharge test performed at XGM-94-06X was to assess hydrogeologic conditions and provide data for a potential groundwater containment system downgradient of AOC 43G. Specific data to be determined include transmissivity, storativity, and zone of influence. Unless otherwise noted, pumping test results discussed in this subsection are limited to data that has been corrected for water level trend. Appendix F provides a quantitative discussion of data reduction and manipulation, water level data, hydrographs, and calculations.

XGM-94-06X was pumped at 0.38 gpm for 48 hours at which point the pump was turned off. Recovery was then monitored for 38 hours. Water levels were monitored in the pumping well and piezometers XGP-94-02X, XGP-94-03X, and XGP-94-04X. The maximum observed drawdown in the pumping well, 0.33 feet (uncorrected), was measured 5.5 hours after the start of the test. All monitored water levels then began to rise and continued to do so, with small scale variation, for the remainder of the test. The rising water levels are attributed to a 1.5-inch precipitation event coupled with snow melt on the first day of the test.

Stabilized corrected drawdown, 0.39 feet, was achieved in the pumping well 24 hours into the test. This drawdown was maintained, with small scale fluctuation (0.42 feet at 28 hours), for the remainder of the test. Pumping effects were noted in all of the piezometers. XGP-94-02X, located 7.5 feet southeast of XGM-94-06X, experienced maximum drawdown, 0.4 feet, approximately 25 hours into the test. Water levels then began to slowly rise until termination of the test. The additional 0.01 feet of drawdown observed in XGP-94-02X may be attributed

to small scale variations introduced during trend correction or to the pressure transducers experiencing electrical interference from the pump power cable. After 24 hours, 0.3 feet of drawdown was observed in XGP-94-03X, which is located 15 feet southwest of the pumping well, and XGP-94-04X, 25 feet northeast, experienced 0.2 feet of drawdown 18 hours into the test.

Aquifer Test Analysis. A variety of methods of analysis were applied to the corrected data. The results of the analyses are provided in Table 6-4. Refer to Appendix F for a discussion of the methodologies. The method of Jenkins and Prentice (1982) was applied to both the drawdown and recovery data to determine the presence or absence of linear flow in the vicinity of the pumped well. The Cooper and Jacob method (1946)(commonly known as the Jacob straight-line method), the Sen method (1988), the Cooper leaky aquifer analysis (1963), and a distance drawdown analysis (Driscoll, 1986) were all applied to the drawdown data. Recovery data were analyzed as residual recovery versus t/t' in accordance with the methods outlined in Driscoll (1986).

The method of Jenkins and Prentice indicated that flow in the vicinity of XGM-94-06X and the surrounding piezometers was non-linear.

Calculated transmissivity values range from 27 to 134 feet^2/day. The highest transmissivity was calculated from XGP-94-03X drawdown data using the Jacob straight-line method. The lowest calculated transmissivity was also from XGP-94-03X but was derived using recovery data and the residual drawdown method. Assuming an aquifer thickness of 8 feet, these values are within the typical range for silty sand and glacial till (Freeze, 1979). The calculated transmissivities and saturated overburden thickness are in agreement with the hydraulic conductivities estimated from in-situ permeability testing.

The storativity values calculated from the aquifer test data range from 0.16 to 0.001. The lowest storativity was calculated using the Jacob straight-line method and drawdown data from XGP-94-03X. The highest storativity was calculated using the same method and drawdown data from XGP-94-02X. All calculated storativities except the lowest (0.001) are within the typical range for unconfined aquifers (Driscoll, 1986).

6.3.1.2 Aquifer Pumping Test Results XGM-94-04X (Bedrock). Aquifer pumping tests at XGM-94-04X consisted of a variable-rate step-drawdown test and a constant-rate discharge test.

Background and Atmospheric Trend. Monitoring wells XGM-94-07X, XGM-94-08X, and XGM-93-01X were instrumented with In-Situ Well Sentinel data loggers and pressure transducers prior to the constant-rate discharge test to monitor background water level trends. These wells were chosen because they are located outside the influence of pumping. Background water level trends for XGM-94-08X and XGM-93-01X were observed to be rising at 0.00012 ft/min and 0.00014 ft/min, respectively. Trends observed in these wells were relatively constant throughout the test except for a slight decrease in the rate of water level rise during the recovery phase (approximately 133.3 hours after the start of pumping). Background data collected from XGM-94-07X showed that water levels were rising at 0.0001 ft/min until 3,600 minutes after the start of pumping. At this point the rate of rise decreased to approximately 0.00004 ft/min for the duration of monitoring.

Efforts were made to correct the drawdown water levels for the observed rising background water level trends. However, applying these trends generated overcorrected hydrographs that did not display reasonable drawdown curves. Experimentation showed that applying a correction factor of 0.00008 ft/min best corrected the majority of observation wells and pumping well as approximately matching all of the observed background trend data. Applying this trend correction to XGP-94-01X, XGM-94-10X, and XGM-93-02X overcorrected the drawdown and recovery curves. A two part trend correction of 0.00008 ft/min from 0 to 3,600 minutes and 0.00004 ft/min for 3,600 minutes until the end of monitoring, as was observed in XGM-94-07X, was applied to these observation wells.

Atmospheric pressure was monitored and recorded prior to, during, and after the pumping test. Comparison of the atmospheric pressure data with the water level data indicated that barometric pressure had no measurable influence on the aquifer. This is consistent with an unconfined aquifer.

Variable Rate Test. The objective of the step-drawdown test was to ascertain the maximum sustainable pumping rate to be used during the constant-rate discharge

test. The depth to water prior to the step-drawdown test was 23.59 feet (top of PVC) with a total well depth of 31 feet (top of PVC). The pump intake was set at 30.2 feet (top of PVC) resulting in an available drawdown of 6.6 feet. The step-drawdown test at XGM-94-04X was initiated at 0.5 gpm and, after 225 minutes of pumping, the water level in XGM-94-04X had dropped to 25.2 feet (top of PVC). The decision was made to step the test to 1.0 gpm. After 55 minutes of pumping at 1.0 gpm, the water level had dropped to 30.1 feet (top of PVC) and pumping was stopped before the well was dewatered. The water level was allowed to recover to approximately 25.3 feet (top of PVC) before pumping was resumed, this time at 0.7 gpm. After approximately 170 minutes of pumping the well was again dewatered and the test was terminated. Rates of drawdown and recovery were most rapid from 30.2 to 28 feet (top of PVC) indicating that this portion of the bedrock is either fairly competent and/or has a lower hydraulic conductivity than the upper portion of the bedrock. The rock core log from XGM-94-04X (see Appendix A) indicates the presence of a highly fractured zone from 27.5 to 28 feet (top of PVC). Based on the drawdown data obtained during the step-test the optimum rate for the constant-rate discharge test was estimated to be 0.4 gpm.

Constant Rate Test. The purpose of the constant-rate discharge test performed at XGM-94-04X was to assess hydrogeologic conditions and to emulate a potential source control extraction well in this portion of the AOC. Appendix F provides a qualitative discussion of data reduction and manipulation. Corrected water level data, hydrographs, and calculations are also presented.

A total of 12 monitoring wells and piezometers were instrumented with In-Situ pressure transducers for the constant-rate discharge test. XGM-94-04X is screened in the moderately to highly weathered meta-siltstone (phyllite) bedrock, as are the surrounding piezometers XGP-94-05X, XGP-94-06X, and XGP-94-07X. AAFES-6, XGM-94-09X, and XGM-94-10X are screened in the overburden and were instrumented and monitored during the pumping test. AAFES-1D, AAFES-2, XGM-93-02X, XGM-94-03X, and XGP-94-01X are screened across the bedrock overburden interface and were also instrumented and monitored during the test. Bedrock at XGM-94-04X is approximately 30 feet (top of PVC) and groundwater was at 22.99 feet (top of PVC) prior to the start of the test. XGM-94-04X was pumped at 0.4 gpm for 87 hours. The maximum observed drawdown, 0.78 feet (uncorrected), occurred approximately 1,080 minutes into the

test. Water levels then began to rise in response to the background water level trend.

Effects of pumping were observed in XGP-94-01X, XGP-94-05X, XGP-94-06X, XGP-94-07X, XGM-94-10X, XGM-94-03X, XGM-94-02X, AAFES-6, and AAFES-1D. Corrected hydrographs are supplied in Appendix F.

Aquifer Test Analysis. The same methods applied to the XGM-94-06X pumping test data were used to analyze the XGM-94-04X drawdown and recovery data. The results of the analyses are provided in Table 6-4. Refer to Appendix F for a discussion of the methodologies. The inability to create the same magnitude of drawdown in XGM-94-04X as seen during the step test may be due to the presence of a large fracture observed in the rock core from 22.7 to 23.0 feet (top of PVC). The water level prior to the constant-rate discharge test was 22.99 feet, while the water level prior to the step-test was 23.59 feet. It is possible that the pumping rate of 0.4 gpm was insufficient to completely dewater this previously dry fracture.

The method of Jenkins and Prentice indicated that in the immediate vicinity of XGM-94-04X, groundwater flow has linear tendencies. Evidence of linear flow was exhibited in drawdown and recovery data from XGM-94-04X, XGP-94-05X, XGP-94-06X, and XGP-94-07X. The recovery data sets provided clearer evidence of linear flow due to the absence of fluctuations caused by small scale pumping rate variation. The presence of linear flow characteristics indicates that flow between the monitored wells is controlled by one or more major fractures that behave as extended wells. In a true linear flow system, the magnitude of drawdown experienced in an observation well is not dependent on the radial distance from the pumped well but instead upon the perpendicular distance from the extended well (i.e., pumped well and associated fracture[s]). Fractures noted during rock coring of the XGM-94-04X boring and in the borings for the surrounding piezometers may be behaving as extended wells.

The maximum transmissivity was 340 feet^2/day at XGP-94-01X as calculated by the residual drawdown method outlined in Driscoll (1986). This value is three times as high as the next highest calculated transmissivity and is considered aberrant. The lowest calculated transmissivity, 27 feet^2/day, was derived from XGP-94-05X drawdown data using the Jacob straight-line method. Bedrock

aquifer thickness is unknown. Because of the observed nature of fractures and the highly weathered overburden/bedrock interface, it may be assumed that the effective aquifer thickness is between 10 and 15 feet. The transmissivity values are in good agreement with the values derived from the overburden aquifer test performed at XGM-94-06X. This further indicates that there is little hydrogeologic distinction between the overburden and bedrock aquifers.

Storativity values calculated from the aquifer test data range from 0.001 to 0.07. The lowest storativity was obtained from XGP-94-06X drawdown data using the Cooper leaky aquifer method. The highest storativity was calculated from XGP-94-05X drawdown data using the Jacob straight-line method. Estimated storativities are slightly lower than the overburden values. One would expect to see lower values not necessarily due to confining situations but because of the limited water supply in storage characteristic of fractured rock.

6.3.2 Site Hydrogeology Interpretation Summary

Groundwater at AOC 43G occurs in overburden till and the meta-siltstone (phyllite) bedrock. The predominant groundwater flow direction at the site is to the east-southeast with an average horizontal gradient of 0.034 feet/foot across the site. Water level data indicate that the area surrounding XGM-94-06X is particularly sensitive to recharge. In-situ hydraulic conductivity estimates yield an average value of 7.2×10^{-4} cm/sec for wells in the overburden and 2.5×10^{-5} cm/sec for wells screened entirely in the bedrock. Results of water level surveys and aquifer pumping tests indicate that there is little differentiation between the overburden and bedrock aquifers.

The overburden aquifer pumping tests conducted at XGM-94-06X yielded transmissivity values ranging between 27 and 134 feet^2/day. These values are consistent with the in-situ hydraulic conductivity estimates. Storativity values ranged between 0.16 and 0.001. Transmissivity and storativity values are consistent with observed geology and unconfined situations. A zone of influence of 80 feet was calculated by distance drawdown analysis for XGM-94-06X at 0.4 gpm.

The bedrock aquifer pumping test conducted at XGM-94-04X yielded transmissivity values ranging between 340 and 27 feet^2/day. These values are

commensurate with the transmissivities calculated for the XGM-94-06X test. Storativity ranged between 0.001 and 0.07 which is slightly lower than the storativities estimated from the XGM-94-06X. This is to be expected due to the limited water supply in storage characteristic of fractured rock. Evidence of linear flow was noted during the XGM-94-04X pumping test at locations XGM-94-04X, XGP-94-05X, XGP-94-06X, and XGP-94-07X. The linear flow is believed to be caused by major fractures behaving as extended wells. Flow characteristics within the bedrock aquifer in the vicinity of XGM-94-04X was shown to be dependent on water level.

The results of the bedrock aquifer pumping tests at XGM-94-04X indicated that the bedrock at this location does have sufficient hydraulic characteristics to support a groundwater extraction system. Similar hydraulic characteristics were measured in AAFES-6. However, it appears that these characteristics are not shared by the other monitoring wells located directly downgradient of Areas 2 and 3, based upon the in-situ hydraulic conductivity results from monitoring wells AAFES-1D, AAFES-2, XGM-93-02X, and XGM-94-03X.

The results of the overburden aquifer tests at XGM-94-06X also indicated that the hydraulic characteristics of the soils at this location could support a groundwater containment system.

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LEGEND

- XGB-94-10X — SOIL VAPOR EXTRACTION
- XGP-94-06X — PIEZOMETER
- AAFES-1D — MONITORING WELL
- XGB-94-15X — SOIL BORING
- A A' — CROSS SECTION ORIENTATION

NOTE:
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

LOCATION OF FORMER AND ACTIVE GASOLINE USTS

LOCATION OF FORMER WASTE OIL UST

ROAD

QUEENSTOWN

GRASSED AREA

AAFES-3

XGB-93-06

XGB-94-15X

XGM-93-01X

XGB-94-11X

XGB-94-12X

XGB-93-05

XGB-93-07

XGB-94-13X

XGB-94-10X

AAFES-4

XGM-93-02X

XGB-94-14X

AAFES-5

XGM-94-05X

AAFES-2

XGM-94-03X

XGB-93-04

XGB-93-03

AAFES-1D

FEINBERG

XGM-94-07X

2012
ONE-STORY BUILDING

ABOVE GROUND WASTE OIL STORAGE TANK

COVERED GASOLINE PUMP ISLANDS

CONCRETE RETAINING WALL

AAFES GAS STATION 2008

WOODED AREA

AAFES-6

ABOVE GROUND WASTE OIL STORAGE TANK

XGP-94-05X

XGM-94-04X

XGP-94-07X

XGP-94-06X

CAR WASH 2017

AAFES-7 IS LOCATED 180' SOUTHEAST

AAFES-7

XGP-94-01X

WOODEN PLATFORM

2009

XGB-93-08

B B'

XGM-94-09X

WOODED AREA

XGM-94-08X

ROAD

STORAGE SHED

REMAINS OF CONCRETE FOUNDATION

XGP-94-04X

XGM-94-06X

XGP-94-02X

XGP-94-03X

A' C C'

BIT. CONC. PAVEMENT

BLDG 3553

GRAVEL

XGM-94-10X

SMALL TREES & BRUSH

GRASSED AREA

0 25 50 100 FEET

SCALE: 1"=50'

H:\7053-15\FIGURES\AOCGF006.DWG

FIGURE 6-1
ORIENTATION OF GEOLOGIC CROSS SECTIONS A-A', B-B', AND C-C'
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

NORTHWEST
A

SOUTHEAST
A'

XGM-93-01X

QUEENSTOWN ROAD

FUEL ISLAND

CONCRETE PAD

XGB-94-14X
OFFSET 30' N

AAFES GAS STATION
BUILDING 2008

BLDG FOUNDATION

XGM-94-04X
OFFSET 32' S

AAFES-6
OFFSET 13' N

CAR WASH
BUILDING 2017

CAR WASH FOUNDATION

XGM-94-08X
OFFSET 47' S

ROAD

XGM-94-06X

SAND AND GRAVEL

TILL

PHYLLITE BEDROCK

BOE

310
300
290
280
270
260
250

ELEVATION (FEET, MSL)

CROSS SECTION A - A'

0 25 50 100 FEET

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=10'
VERTICAL EXAGGERATION: 5:1

LEGEND

XGB-94-14X
OFFSET 30' N

EXPLORATION AND OFFSET

GROUND SUFACE AT OFFSET LOCATION

GROUND SURFACE

BENTONITE SEAL

GROUT

FILTER SAND

WATER LEVEL (1/31/95)

GEOLOGIC CONTACT

SCREENED INTERVAL

BOE

BOTTOM OF EXPLORATION

PHYLLITE BEDROCK

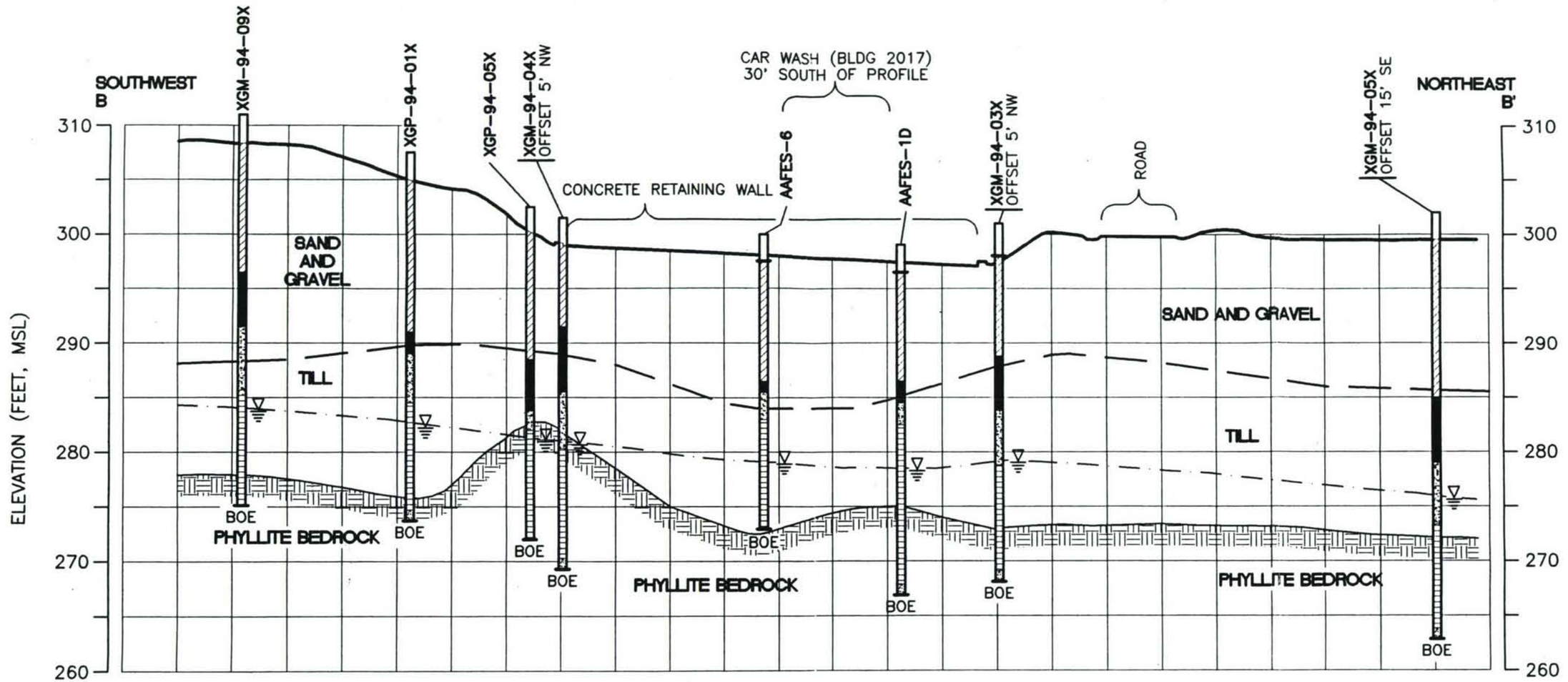
BEDROCK SURFACE

NOTES:

1. FOR ORIENTATION OF CROSS SECTION, SEE FIGURE 6-1.
2. DUE TO ITS HIGHLY WEATHERED NATURE, THE BEDROCK SURFACE WAS DEFINED BY SPLIT-SPOON/AUGER REFUSAL.
3. GEOLOGIC CONDITIONS BETWEEN WELLS ARE AN INTERPRETATION OF AVAILABLE DATA. ACTUAL CONDITIONS MAY VARY.

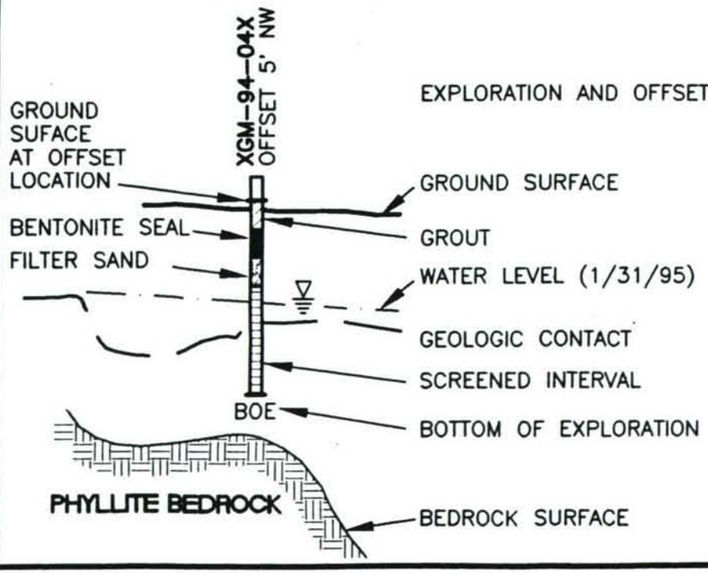
FIGURE 6-2
INTERPRETIVE GEOLOGIC CROSS SECTION A-A'
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

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CROSS SECTION B - B'

LEGEND



NOTES:

1. FOR ORIENTATION OF CROSS SECTION, SEE FIGURE 6-1.
2. DUE TO ITS HIGHLY WEATHERED NATURE, THE BEDROCK SURFACE WAS DEFINED BY SPLIT-SPOON/AUGER REFUSAL.
3. GEOLOGIC CONDITIONS BETWEEN WELLS ARE AN INTERPRETATION OF AVAILABLE DATA. ACTUAL CONDITIONS MAY VARY.

0 15 30 60 FEET

HORIZONTAL SCALE: 1"=30'
VERTICAL SCALE: 1"=10'
VERTICAL EXAGGERATION: 3:1

FIGURE 6-3
INTERPRETIVE GEOLOGIC CROSS SECTION B-B'
AOC 43G-HISTORIC GAS STATION Q/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

H:\7053-15\7053F4.PS

NORTHWEST C

SOUTHEAST C'

QUEENSTOWN ROAD

AAFES–3

CONCRETE PAD FOR GASOLINE UST's

UST

XGB–94–10X

XGB–94–13X OFFSET 4' S

XGM–94–03X (BEND IN PROFILE)

XGM–94–07X OFFSET 25' N

XGM–94–06X OFFSET 15' S

SAND AND GRAVEL

TILL

PHYLLITE BEDROCK

BOE

ELEVATION (FEET, MSL)

310
300
290
280
270
260
250

LEGEND

XGB–94–13X OFFSET 4' S — EXPLORATION AND OFFSET

GROUND SUFACE AT OFFSET LOCATION — GROUND SURFACE

BENTONITE SEAL — GROUT

FILTER SAND — WATER LEVEL (1/31/95)

GEOLOGIC CONTACT

SCREENED INTERVAL

BOE — BOTTOM OF EXPLORATION

PHYLLITE BEDROCK — BEDROCK SURFACE

CROSS SECTION C - C'

0 20 40 80 FEET

HORIZONTAL SCALE: 1"=40'
VERTICAL SCALE: 1"=10'
VERTICAL EXAGGERATION: 4:1

NOTES:

1. FOR ORIENTATION OF CROSS SECTION, SEE FIGURE 6–1.
2. DUE TO ITS HIGHLY WEATHERED NATURE, THE BEDROCK SURFACE WAS DEFINED BY SPLIT–SPOON/AUGER REFUSAL.
3. GEOLOGIC CONDITIONS BETWEEN WELLS ARE AN INTERPRETATION OF AVAILABLE DATA. ACTUAL CONDITIONS MAY VARY.

H:\7053-15\7053X43C

FIGURE 6-4
INTERPRETIVE GEOLOGIC CROSS SECTION C-C'
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

LEGEND

- XGB-94-03X — SOIL BORING/VAPOR EXTRACTION WELL
- XGP-94-06X — PIEZOMETER
- XGM-94-05X — MONITORING WELL
- XGB-93-03X — SOIL BORING
- 280.8 — ELEVATION OF TOP OF BEDROCK (FEET, MSL)
- NE — BEDROCK NOT ENCOUNTERED
- 255 — INTERPRETIVE BEDROCK CONTOUR

NOTE:
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

LOCATION OF FORMER AND ACTIVE GASOLINE USTS

LOCATION OF FORMER WASTE OIL UST

QUEENSTOWN ROAD

FEINBERG ROAD

GRASSED AREA

XGB-94-11X 281.7
XGB-94-12X 279.4
XGB-94-10X 282
XGB-94-13X 280
XGB-93-06 282.3
XGB-93-05X 281.8
AAFES-3 282.8
AAFES-5 270.7
XGM-94-05X 272.3
XGB-94-15X 280.8
XGM-93-01X 281.5
XGB-93-07 289.3
COVERED GASOLINE PUMP ISLANDS
XGB-94-14X 281.9
AAFES-4
AAFES-2 275.5
XGM-93-02X 276.1
XGM-94-03X 273.2
XGB-93-04X 284.3
AAFES-1D 275.0
XGM-94-07X 272.5
AAFES GAS STATION 2008
XGB-93-03X NE
WOODED AREA
AAFES-6 272.5
XGM-94-04X 281.1
XGP-94-05X 282.8
XGP-94-07X 278.6
XGP-94-06X 277.3
XGP-94-01X 275.7
CONCRETE RETAINING WALL
ABOVE GROUND WASTE OIL STORAGE TANK
WOODEN PLATFORM
2009
XGB-93-08 281.1
XGM-94-09X 277.9
CAR WASH 2017
2012 ONE-STORY BUILDING
ABOVE GROUND WASTE OIL STORAGE TANK
AAFES-7 IS LOCATED 180' SOUTHEAST
AAFES-7 NE
XGM-94-08X 270.2
XGM-94-10X 269.8
43C-92-01X NE
XGB-93-09 278.3
WOODED AREA
SMALL TREES & BRUSH
GRASSED AREA
STORAGE SHED
REMAINS OF CONCRETE FOUNDATION
XGP-94-04X NE
XGM-94-06X 254.7
XGP-94-02X 254.7
XGP-94-03X NE
GRAVEL
BIT. CONC. PAVEMENT
BLDG 3653

280 275 270 265 260 255

0 25 50 100 FEET

SCALE: 1"=50'

FIGURE 6-5
INTERPRETIVE BEDROCK ELEVATION CONTOURS
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

TABLE 6-1
SUMMARY OF BEDROCK ELEVATION DATA
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION TYPE	EXPLORATION ID	GROUND ELEVATION (FEET MSL)	DEPTH TO BEDROCK (FEET bgs)	BEDROCK ELEV. (FEET MSL)
SOIL BORINGS	43G-92-01X	309.8	NE	
	XGB-93-03X	310.4	NE	
	XGB-93-04X	310.3	26	284.3
	XGB-93-05X	309.8	28	281.8
	XGB-93-06X	308.7	25.5	283.2
	XGB-93-07X	309.8	20.5	289.3
	XGB-93-08X	308.6	27.5	281.1
	XGB-93-09X	308	29.7	278.3
	XGB-94-10X	310	28	282
	XGB-94-11X	309.7	28	281.7
	XGB-94-12X	309.9	30.5	279.4
	XGB-94-13X	310.3	30.3	280
	XGB-94-14X	310.4	28.5	281.9
	XGB-94-15X	309.5	28.7	280.8
MONITORING WELLS	XGM-93-01X	311.5	30	281.5
	XGM-93-02X	310.6	34.5	276.1
	XGM-94-03X	298.2	25	273.2
	XGM-94-04X	299.1	18	281.1
	XGM-94-05X	299.3	27	272.3
	XGM-94-06X	282.2	27.5	254.7
	XGM-94-07X	293	20.5	272.5
	XGM-94-08X	297.2	27	270.2
	XGM-94-09X	308.4	30.5	277.9
	XGM-94-10X	300.4	30.6	269.8
	AAFES-1D	296.5	21.5	275
	AAFES-2	300.7	25	275.7
	AAFES-3	309	26.25	282.75
	AAFES-5	301.2	30.5	270.7
	AAFES-6	297.5	25	272.5
	AAFES-7	256.9	NE	
PIEZOMETER	XGP-94-01X	304.7	29	275.7
	XGP-94-02X	281.7	27	254.7
	XGP-94-03X	282.2	NE	
	XGP-94-04X	282	NE	
	XGP-94-05X	299.8	17	282.8
	XGP-94-06X	299.3	22	277.3
	XGP-94-07X	298.6	20	278.6

NOTES:
Top of bedrock defined by split-spoon and auger refusal
bgs = below ground surface
MSL = Mean Sea Level
NE = not encountered

TABLE 6–2
SUMMARY OF WATER LEVEL ELEVATION DATA
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

WELL/PIEZOMETER ID	REF. POINT	ELEV. OF REF POINT (FEET MSL)	OCTOBER 4, 1994		JANUARY 31, 1995		MAY 9, 1995	
			DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)
AAFES–1D	PVC	298.83	21.65	277.18	20.4	278.43	21.52	277.31
AAFES–2	PVC	302.80	25.8	277	24.6	278.2	25.68	277.12
AAFES–3	PVC	308.61	23.37	285.24	21.9	286.71	23.33	285.28
AAFES–4	PVC	310.00	Dry	Dry	Dry	Dry	Dry	Dry
AAFES–5	PVC	300.92	24.04	276.88	23.1	277.82	24.1	276.82
AAFES–6	PVC	300.10	23.96	276.14	21.1	279	22.07	278.03
AAFES–7	PVC	259.51	Not Measured	Not Measured	7.7	251.81	9.19	250.32
XGM–93–01X	PVC	313.62	27.97	285.65	26	287.62	27.96	285.66
XGM–93–02X	PVC	309.9	30.61	279.29	30	279.9	31.62	278.28
XGM–94–03X	PVC	300.57	Not Installed	Not Installed	21.4	279.17	23.64	276.93
XGM–94–04X	PVC	301.49	Not Installed	Not Installed	20.6	280.89	22.72	278.77
XGM–94–05X	PVC	301.65	Not Installed	Not Installed	26	275.65	26.89	274.76
XGM–94–06X	PVC	284.87	Not Installed	Not Installed	18.1	266.77	21.88	262.99
XGM–94–07X	PVC	295.62	Not Installed	Not Installed	20.9	274.72	21.42	274.2
XGM–94–08X	PVC	299.78	Not Installed	Not Installed	25.5	274.28	27.69	272.09
XGM–94–09X	PVC	310.73	Not Installed	Not Installed	26.8	283.93	27.69	283.04
XGM–94–10X	PVC	302.76	Not Installed	Not Installed	24.48	278.28	26.25	276.51
XGP–94–01X	PVC	306.99	Not Installed	Not Installed	24.6	282.39	25.28	281.71
XGP–94–02X	PVC	284.26	Not Installed	Not Installed	17	267.26	21.85	262.41
XGP–94–03X	PVC	284.89	Not Installed	Not Installed	17.8	267.09	22.14	262.75
XGP–94–04X	PVC	284.74	Not Installed	Not Installed	20.2	264.54	23.86	260.88
XGP–94–05X	PVC	302.06	Not Installed	Not Installed	21	281.06	23.23	278.83
XGP–94–06X	PVC	301.89	Not Installed	Not Installed	21.1	280.79	22.93	278.96
XGP–94–07X	PVC	298.33	Not Installed	Not Installed	18.6	279.73	20.27	278.06

NOTES:
ELEV. = Elevation
MSL = Mean Sea Level
PVC = Top of Polyvinyl Chloride well riser

TABLE 6-3
SUMMARY OF IN-SITU HYDRAULIC CONDUCTIVITY TEST RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

WELL	TYPE OF WELL	TYPE OF TEST	HYDRAULIC CONDUCTIVITY	
			HVORSLEV (cm/sec)	BOUWER AND RICE (cm/sec)
REMEDIAL INVESTIGATION				
XGM-94-03X	BEDROCK/OVERBURDEN	RISING HEAD	2.20E-05	9.20E-05
XGM-94-04X	BEDROCK/OVERBURDEN	RISING HEAD	1.10E-04	4.30E-04
XGM-94-06X	OVERBURDEN	RISING HEAD	8.40E-04	2.90E-03
XGM-94-07X	BEDROCK/OVERBURDEN	RISING HEAD	1.50E-05	5.00E-05
XGM-94-08X	BEDROCK/OVERBURDEN	RISING HEAD	9.00E-04	1.50E-03
XGM-94-09X	OVERBURDEN	RISING HEAD	1.40E-03	2.30E-03
XGM-94-10X	OVERBURDEN	RISING HEAD	5.70E-05	7.30E-05
AAFES-1D	BEDROCK/OVERBURDEN	RISING HEAD	4.00E-06	1.10E-05
AAFES-2	BEDROCK/OVERBURDEN	RISING HEAD	2.60E-05	1.70E-04
AAFES-3	OVERBURDEN	RISING HEAD	4.10E-04	6.20E-04
AAFES-5	OVERBURDEN	RISING HEAD	2.70E-05	4.90E-05
AAFES-6	OVERBURDEN	RISING HEAD	5.00E-03	5.90E-03
AAFES-7	OVERBURDEN	FALLING HEAD	5.30E-04	2.00E-03
AAFES-7	OVERBURDEN	RISING HEAD	5.40E-04	2.20E-03
XGP-94-01X	BEDROCK/OVERBURDEN	RISING HEAD	2.20E-05	2.70E-05
XGP-94-02X	OVERBURDEN	RISING HEAD	5.00E-04	9.10E-04
XGP-94-03X	OVERBURDEN	RISING HEAD	1.60E-04	6.70E-04
XGP-94-04X	OVERBURDEN	RISING HEAD	1.40E-04	2.70E-04
XGP-94-05X	BEDROCK	RISING HEAD	1.40E-05	3.60E-05
XGP-94-06X	BEDROCK	FALLING HEAD	4.10E-06	2.00E-05
XGP-94-06X	BEDROCK	RISING HEAD	4.10E-06	1.90E-05
XGP-94-07X	BEDROCK	RISING HEAD	4.50E-05	5.00E-05

Notes:
cm/sec = centimeters/second

TABLE 6–4
AQUIFER PUMPING TEST TRANSMISSIVITY AND STORATIVITY RESULTS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

MONITORING WELL ID	JENKINS AND PRENTICE (1982)	COOPER AND JACOB METHOD (1946)		SEN DIMENSIONLESS ANALYSIS (1988)	COOPER LEAKY AQUIFER ANALYSIS (1963)		RESIDUAL DRAWDOWN ANALYSIS (DRISCOLL, 1986)
	LIN/NON–LIN	T (FT^2/DAY)	S	SLOPE OVER 1 LOG CYCLE	T (FT^2/DAY)	S	T (FT^2/DAY)
XGM–94–06X CONSTANT–RATE DISCHARGE TEST							
XGM–94–06X	NON–LIN	NA	NA	NA	NO MATCH	NO MATCH	77
XGP–94–02X	NON–LIN	36	0.16	2.3	39	0.08	30
XGP–94–03X	NON–LIN	134	0.001	2.35	41	0.016	27
XGP–94–04X	NON–LIN	74	0.016	2.16	65	0.012	61
DISTANCE–DRAWDOWN ANALYSIS AT t = 1 DAY, Q = 0.38 GPM: T = 69 FT^2/DAY, S = 0.02 (DRISCOLL, 1986)							
XGM–94–04X CONSTANT–RATE DISCHARGE TEST							
XGM–94–04X	LIN	NA	NA	NA	NO MATCH	NO MATCH	55
XGP–94–01X	NON–LIN	NA	NA	NA	NO MATCH	NO MATCH	340
XGP–94–05X	LIN	27	0.07	2.5	34	0.004	48
XGP–94–06X	LIN	36	0.006	2.1	28	0.001	43
XGP–94–07X	LIN	37	0.006	2.2	34	0.002	36
XGM–93–02X	NON–LIN	NA	NA	NA	NO MATCH	NO MATCH	71
XGM–94–10X	NON–LIN	NA	NA	NA	NO MATCH	NO MATCH	94
AAFES–6	NON–LIN	NA	NA	NA	NO MATCH	NO MATCH	59
AAFES–1D	NON–LIN	NA	NA	NA	NO MATCH	NO MATCH	74
XGM–94–03X	NON–LIN	NA	NA	NA	NO MATCH	NO MATCH	71

NOTES:
NA indicates that the dimensionless time factor exceeds 0.05, Theis condition not satisfied
"NO MATCH" indicates that the log–log curve did not sufficiently match the Theis type curve
LIN/NON–LIN = Linear/Non–linear

7.0 NATURE AND DISTRIBUTION OF DETECTED SITE CONTAMINANTS

The following subsections address the nature and distribution of analytes detected in soil and groundwater collected from AOC 43G during the 1992 SI, the 1993 SSI, and the 1994 RI. In addition to data from these efforts, historical data contained in the USAEC's IRDMIS has been used to assess analytes detected in soil. Fort Devens background soil and groundwater data are also presented to aid in the assessment of the site-related data. Analytes detected in QC blanks are presented to assess potential contamination of analytical samples introduced during sample preparation and analysis. A complete discussion of the laboratory QC samples results is presented in Subsection 3.2 and Appendix D.

In addition to data obtained from off-site analytical laboratory analysis, field analytical data are presented and discussed. During implementation of field programs, field screening results were used to direct placement of soil borings, test pits, and monitoring wells used to define the vertical and/or horizontal distribution of contaminants. Screening results were also used to select off-site laboratory samples. Samples were collected from hot zones to gather information on the nature and concentrations of contaminants, and samples were collected from clean areas for off-site confirmation. Field analytical data are used in the following subsections to complement off-site analytical laboratory data in the assessment of the nature and distribution of detected analytes. A review of field laboratory quality control sample analyses from the RI program is presented in Appendix D.

This assessment of site-related contaminants relies on the use of tables and figures to present field and off-site laboratory results. Figures and hits-only data tables (containing detected analytes and concentrations for samples within a given media) are presented at the end of this section. The text within the assessment provides detail, interpretation, and analysis that cannot be presented in the figures.

7.1 APPROACH TO CONTAMINATION ASSESSMENT

Off-site laboratory analytical results and field analytical data are the primary data used to assess impacts at the site from suspected past site activities. Where applicable, pre-1994 analytical data have been used to assess AOC 43G. All pre-1994 data were obtained by ABB-ES during the SI and SSI phases of investigation. A summary of pre-1994 and 1994 analyses performed on samples from all media is presented in Table 5-10.

Detected analytes and concentrations in field analytical and off-site laboratory analytical data have been displayed on figures to aid the reader. Field analytical and off-site laboratory hits-only data are presented in tables at the end of the section. A complete data set of field and off-site analytical data is presented in Appendix M. Off-site laboratory results that showed no detections for an entire analytical method (i.e., VOA) are not listed in the hits-only tables. In addition, tentatively identified compounds (TICs) are discussed in Subsection 7.1.1 and presented in separate data tables (Tables 7-1 through 7-4). Fort Devens calculated background inorganic concentrations for analytes detected in soil and groundwater are presented in each hits-only table. A discussion of the Fort Devens background concentrations is presented in Subsection 4.4 of the report and in Appendix L.

A blank contamination evaluation was performed as described in Subsection 7.1.2. This evaluation resulted in the identification of probable laboratory-related contaminants. All data presented in the tables are uncorrected for blank contamination, although a "*" has been added to indicate a probable blank contaminant. Discussions in the contamination assessment evaluate uncertainty regarding potential false positives due to sampling and laboratory contaminants.

7.1.1 Tentatively Identified Compounds/Non-Project Analyte List Compounds

Volatile and semivolatile TICs and unknown compounds were detected in several soil and groundwater samples collected from AOC 43G. These compounds are differentiated from target analytes in IRDMIS with an "S" flag in the flagging code field. All TICs associated with AOC 43G are summarized and presented in Table 7-1.

Compounds were tentatively identified by comparing the GC/MS spectra to those contained in the National Bureau of Standards mass spectral library. Once the tentative identification was made, the appropriate USAEC code name was assigned for that compound. Reported concentrations are not based on calibration standards and are considered estimated. If no compound identification was possible, the compound became listed as an unknown with an assigned number. The assigned number which accompanies the prefix "UNK" is determined by the relative retention time to the internal standard.

For example, if the relative retention time of the compound to 1,4 difluorobenzene is 1.42, the compound would be assigned the number "UNK142" in IRDMIS.

The requirements for making tentative identification of compounds are listed in the Fort Devens POP (ABB-ES, 1993c) as follows:

1. Relative intensities of major ions in the reference spectrum (ions > 10 percent of the most abundant ion) should be present in the sample spectrum.

2. The relative intensities of the major ions must agree within 20 percent.

3. Molecular ions present in reference spectrum should be present in sample spectrum.

4. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of co-eluting compounds.

5. Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or co-eluting compounds. Data system library reduction programs can sometimes create these discrepancies.

6. If, in the technical judgement of the mass spectral interpretation specialist, no valid tentative identification can be made, the compound should be reported as unknown.

VOC and SVOC TICs were detected in field samples associated with AOC 43G. Semivolatile TICs included heavyweight alkanes such as decane, pentadecane, hendecane, pentadecane, hexadecane, nonane, and tridecane. Concentrations of individual compounds ranged from 0.32 to 6,000 μg/g. These compounds are likely associated with fuel contamination. Samples associated with detections of heavy weight alkanes include BXXG0308, BXXG0312, BXXG0320, BXXG0408, BXXG0425, BXXG1020, BXXG1025, BXXG1125, and BXXG1227. A particularly high concentration (6,000 μg/g) of nonane was noted for the sample BXXG1227.

Alkyl-substituted benzenes were detected in samples associated with AOC 43G. Examples of these types of compounds include 1,2,3-trimethylbenzene; 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene; and 1-ethyl-3-ethylbenzene. These compounds were detected in concentrations ranging from 0.32 to 10 μg/g. Samples associated with detections of substituted benzene include BXXG1020 and BXXG1415. The detection of these compounds is generally consistent with gasoline contamination.

Other compounds detected in samples collected from AOC 43G include 2-methylheptane; 2,3,4-trimethylpentane; 2,3-dimethylpentane; 2-methylhexane; 3-methylhexane; 2-methylpentane; and 1-methylnaphthalene. Concentrations of these compounds ranged from 1.1 μg/g for 1-methylnaphthalene to 20,000 μg/g for 3-methylhexane. Samples with detections of these TICs include BXXG1020, BXXG1025, and BXXG1227. The presence of these compounds is also associated with gasoline contamination.

AOC 43G samples had concentrations of unknown compounds ranging from 0.4 to 20,000 μg/g. Specific samples with detections of unknowns include BXXG1020, BXXG1025, BXXG1125, and BXXG1227. It is likely that many of the unknown compounds that were detected for these samples are fuel-related.

It is important to note that in addition to the GC/MS method used to identify and report the alkanes and aromatics identified as TICs, USEPA Method 418.1

was used during the field and off-site analysis of soil and water samples to quantify hydrocarbons within these chemical classes. Field analyses were conducted on many samples during the 1992, 1993, and 1994 field programs using a modified version of USEPA Method 418.1. The field analytical method was designed to provide data on the distribution of these fuel hydrocarbons. On-site results were used to direct field exploration programs and provide supporting data for the off-site sample results. The off-site laboratory USEPA Method 418.1 results are the primary data used to make quantitative evaluations of these chemicals as TPHC.

7.1.2 Potential Laboratory and Sampling Contaminants

An evaluation of results from rinsate, trip, and laboratory method blank analyses was conducted to determine possible target analyte contaminant contributions originating from non-site-related sources. Blank data associated with AOCs 43G, 43J, and 41 for the Fort Devens SI, SSI, and RI were used for this evaluation. Potential sources of contamination include materials used during borehole advancement and monitoring well installation, field sampling procedures, field equipment decontamination, sample shipment, laboratory storage, and laboratory processing. Detailed discussions of blank contamination for the RI, SI and SSI are contained in Section D.2.0 of Appendix D.

Since the majority of off-site analytical data was generated using USAEC methods, USEPA data validation guidelines related to the evaluation of blank contamination were not implemented. In addition, action levels were not established. The following approach is taken in the report regarding laboratory method blank and field QC sample blank contamination:

Organic analytes.

Common organic laboratory contaminants identified by the USEPA Draft National Functional Guidelines for Organic Data Review (USEPA, 1991) are not considered contaminants of concern. The common organic laboratory contaminants identified in this document include:

- Siloxanes, diethyl ether, 1,1,2-trichloro-1,2,2-trifluoroethane, fluorotrichloromethane, and phthalates at levels less than 100 μg/L or 4 μg/g.

- Solvent preservatives such as cyclohexane, and related by-products including cyclohexanone, cyclohexenone, cyclohexanol, cyclohexenol, chlorocyclohexene, and chlorohexanol.

- Aldol condensation products of acetone including 4-hydroxy-4-methyl-2-pentanone, 4-methyl-2-penten-2-one, and 5,5-dimethyl-2(5H)-furanone.

- Additional TICs were detected in blanks. The additional TICs detected in SVOA blanks include 1,2-epoxycyclohexene, mesityl oxide, 2-ethyl-1-hexanol, and hexanedioc acid dioctylester. These compounds have been identified as contaminants in contaminant assessments presented in this document.

For organic target compounds trends in method and field blanks were evaluated for each sampling program. Several target compounds have been identified by USEPA as common laboratory contaminants including:

- phthalates

- Methylene chloride, acetone, toluene, and methyl ethyl ketone (2-butanone) at concentrations comparable to concentrations observed in blanks.

Organic analytes detected in QC blanks are presented in Table 7-2 through 7-4. Organic compounds detected in samples at similar concentration ranges as those in blanks are discussed qualitatively in the contamination assessment, but may not be carried through the risk assessment calculations. In addition, the spatial distribution and relative concentration of common organic laboratory contaminants, and rationale for elimination of data from consideration as site-related contaminants, are presented in the contamination assessment in Section 7.2.

Inorganic Analytes Inorganics present in rinsate blanks and method blanks are presented in Table 7-2 through 7-4. Sample data as reported in the figures, data tables, and risk assessment tables are uncorrected. The risk assessments carry all inorganic detections through the calculations. QC blank data is qualitatively evaluated for inorganics exceeding risk thresholds.

During the SSI and RI programs samples were analyzed for a variety of water quality indicators to generate data to support the development of alternatives during the FS process. Low concentrations of method blank contamination was reported for TSS ($\leq$ 8,000 μg/L), hardness ($\leq$ 16,000 μg/L), and TDS ($\leq$ 12,000 μg/L). It is possible that similar concentrations reported in samples may be related to laboratory contamination. Laboratory contamination in these methods at the above concentrations does not impact the contamination and risk assessments presented in the document.

Tables 7-2 through 7-4 present a summary of analytes detected in method blanks, rinsate blanks, and trip blanks. The data contained in these tables are representative of detected analytes in AOCs 43G, 43J, and 41 for the Fort Devens SI, SSI, and RI. Inorganic detections in the soil method blanks are not included in Table 7-2 because the elements detected do not represent laboratory contamination as discussed in Appendix D, Section D.2.0. The elements have been detected at consistent concentrations in these blanks throughout several investigations.

7.2.1 Analytical Data Accuracy and Precision

Analytical data accuracy and precision was evaluated using results of matrix spikes (MS) and field duplicate analyses for the majority of off-site analytical methods conducted to support the Devens field programs. Surrogate recoveries were reviewed to evaluate the accuracy of VOA and SVOA measurements. Detailed discussions and presentation of these results are included in Appendix D.

Matrix spike, field duplicate, and surrogate results for the majority of the methods and target analytes evaluated during the SI, SSI, and RI indicate the accuracy and precision of results were within project goal outlined in the Fort Devens POP (ABB-ES, 1992) and USEPA control limits (USEPA,1988; USEPA, 1989). Trends were reviewed for each set of QC sample data from each field event to

determine if qualification of the accuracy of results was needed. Some analytes in groundwater and soil analyses have been identified as estimated with potential biases included. The following items summarize the qualification of results:

1. Based on MS recoveries from the SI and RI analyses, concentrations of antimony and selenium in groundwater are potentially biased low. Selenium was not detected in any groundwater samples collected during the SI, SSI, or RI, and selenium is not interpreted to be important at any of the study areas.

2. Based on MS recoveries for unfiltered groundwater samples during the SI, concentrations reported for arsenic, chromium, copper, lead, nickel, thallium, and zinc are potentially biased low. Similar trends were not observed for the filtered sample analyses associated with the SI field program. These sample locations were recollected during subsequent field programs and similar matrix effects trends were not apparent.

3. Based on MS recoveries for soils from the SI analyses, magnesium and selenium results are potentially biased low. Selenium low recoveries were also reported in the RI MS analyses. No selenium was reported in any soil samples and selenium is not interpreted to be important at the Devens sites.

4. Based on MS recoveries for soils from the SSI analyses, arsenic results are potentially biased high. Arsenic concentrations in all samples were below risk levels so the effect of high biased results do not affect risk interpretations.

5. Based on MS recoveries for soils from the RI analyses, results for aluminum, arsenic, iron, magnesium, and manganese are considered estimated values. MS recoveries were reported both above and below project recovery goals and no specific bias is identified.

6. Based on differences observed in field duplicate sample results for target PAHs in sediments and soil samples analyzed during the SSI and RI, PAH in soils and sediments are considered estimated values.

7. Based on differences observed in field duplicate results for TOC and TPHC in soil and sediments collected during the RI, TOC and TPHC results are considered to be estimated.

8. Based on differences observed in field duplicate soil results for the VOC 1,1,2,2-tetrachloroethane during the RI, results for this compound in soil are considered estimated.

9. Based on differences observed in field duplicate groundwater results for TKN during the RI, TKN results are considered estimated. TKN was collected for use in designing remedial options for groundwater and this parameter is not used in the contamination or risk assessments.

10. VOA Surrogate Recovery Evaluations:

    - No qualification of VOA samples occurred for the SI and SSI samples.

    - Based on high surrogate recoveries for one or two surrogates in RI soil samples BXXG1025 and BXXG1227, reported BTEX concentrations in these samples are considered estimated and possibly biased high.

    - Based on high recoveries of surrogate 1,2-dichloroethane-D4 reported in a RI water samples MXXG06X3, MXXG07X3, MXXG08X3, MXXG08X4, MDXG07X3, MXXG10X3, MDXG04X4, MXAF01X3, MXAF01X4, MXAF02X3, MXAF02X4, MXAF05X3, MXAF06X3, MXAF06X4, MXXG02X3, MXXG03X3, MXXG04X3, and MXXG04X4, concentrations of detected target compounds in these samples are considered estimated and possibly biased high.

    - Based on low recoveries of 4-bromofluorobenzene and/or toluene-D8 reported in samples MXXG09X4, MXXG03X4, and MXAF03X3, concentrations reported for detected target compounds and CRLs for non-detected target compounds are considered

estimated and possibly biased low. A large bias is not suspected based on recoveries observed for the other surrogates.

11. SVOA Surrogate Recovery Evaluations:

- No qualification of SVOA samples occurred for SI, SSI, and RI samples.

7.2 CONTAMINATION ASSESSMENT

The following subsections assess compounds and analytes detected in samples collected from subsurface soil and groundwater samples collected during each of the field investigations at AOC 43G. The AOC has been divided into three areas (Areas 1 through 3) in an effort to focus in on the portions of the AOC that posed the greatest threat to human health. Area 1 consists of the historic gas station G, Area 2 is located around the three existing 10,000-gallon gasoline USTs and the location of the five former gasoline USTs, and Area 3 is the area around the former waste oil UST. Figure 7-1 presents the location of the three areas.

7.2.1 Soil

The following subsections present field and off-site laboratory analytical results for the soil samples collected at AOC 43G.

7.2.1.1 Field Analytical Soil Results. Soil samples were collected for field analysis from the TerraProbe℠ points and soil borings during all phases of investigation. The field analytical samples were collected in an attempt to define the nature and distribution of the site-related contaminants at Areas 1, 2 and 3 (Table 7-5, 7-6, and 7-7). A discussion of the results for each area of this AOC and for each exploration type is presented below.

Area 1

TerraProbe Sample Results. The soil samples were collected from the TerraProbe℠ points completed during the SI and the SSI field programs, and analyzed for BTEX and TPHC.

The TerraProbe℠ survey completed during the SI was confined to Area 1 of AOC 43G. Soil samples were collected from four TerraProbe℠ points (TS-04, TS-09, TS-10, and TS-11) at depths of 9, 11, and 12 feet bgs (see Figure 5-5). The results of the field analysis for the TerraProbe℠ soil samples indicated that the presence of TPHC contamination ranging from below the detection limit (<54 ppm) to 830 ppm in the 9-foot soil sample from TS-04 (see Table 7-5). No BTEX were detected in any of the TerraProbe℠ soil samples collected. Because groundwater was not reached during the TerraProbe℠ survey, a soil gas survey was completed to aid in determining if residual soil contamination was present. A total of 10 soil gas samples, TS-01 through TS-10, were collected from 8 feet bgs (see Figure 5-2). This depth was chosen because it was at or near the estimated bottom of the former UST. The soil gas samples were analyzed for BTEX, only. The results of the soil gas survey show no evidence of residual BTEX contamination in the soils at or near 8 feet bgs (see Table 7-5).

Due to the concentration of TPHC detected in the 9-foot soil sample collected from TS-04 during the SI, a total of five TerraProbe℠ points (TS-35 through TS-39) were completed during the SSI west of the TerraProbe℠ points completed at Area 1 during the SI (see Figure 5-5). These points were located to further define the horizontal and vertical distribution of contaminants detected at TS-04 during the SI. Two soil samples were collected from each TerraProbe℠ point at 10 and 11 feet bgs. The samples were analyzed in the field for BTEX and TPHC.

The results of the SSI field analysis indicated that residual TPHC contamination was present in the soil at this site to a depth of 11 feet bgs. The results from the two soil samples collected from TS-39 showed TPHC concentrations at 740 ppm at 10 feet and 2,000 ppm at 11 feet. TPHC was also detected in the 10-foot samples from TS-35, TS-37 and TS-38 at concentrations ranging from 190 to 400 ppm, and in the 11-foot samples from TS-37 and TS-38 at 54 and 52 ppm, respectively. No BTEX was detected in the soil samples collected from Area 1 (see Table 7-6).

No TerraProbe℠ samples were collected from Area 1 during the RI field investigation.

Area 2

TerraProbe Sample Results. No field analytical soil samples were collected from Area 2 during the SI field investigation. During the SSI field investigation, 23 soil samples were collected from 19 TerraProbe℠ points (TS-13 through TS-34) located around the then-active gasoline USTs. Sample depths ranged between 9 and 13 feet bgs and were analyzed in the field for BTEX and TPHC (see Table 7-6 and Figure 5-6).

TPHC was detected in 14 of the 22 samples collected. TPHC concentrations ranged from below the detection limit (<52 ppm) to 5,800 ppm in the 9-foot sample from TS-31. TPHC contamination was found in the deepest sample collected at 13 feet (160 ppm at TS-22). The concentrations were highest in the soil samples collected from the points located south and east of the active gasoline USTs (i.e., TS-30, TS-31 and TS-32). The high TPHC values detected south and east of the active gasoline USTs may be attributed to the former gasoline USTs that were removed from this area (Nobis, 1991). Toluene was detected at a concentration of 0.0013 ppm in the 9-foot sample from TS-31. Xylene was detected as well in this sample at 0.0009 ppm (meta/para) and 0.001 ppm (ortho). The only other VOC detected was o-xylene at 0.0063 ppm in the 10-foot sample from TS-13.

No TerraProbe℠ samples were collected from Area 2 during the 1994 RI field investigation.

Soil Boring Field Analytical Sample Results. Four soil borings (XGB-94-10X through XGB-94-13X) were completed during the RI at Area 2 (see Figure 5-7). This area was chosen because of the elevated TPHC concentrations detected in the TerraProbe℠ samples and soil borings completed during the SSI. Two additional soil borings (XGB-94-14X and XGB-94-15X) were completed near the existing pump island to assess if residual soil contamination was present in this area (see Figure 5-7).

Field analytical soil samples collected from each of the soil borings were analyzed for BTEX, TPHC, and selected chlorinated solvents. Soil sampling for field and/or off-site laboratory analysis began at or below 10 feet bgs in each soil

boring to assess the nature and concentration of contaminants in soil directly adjacent to the active USTs. Results of field analyses are provided in Table 7-7.

Field analytical sampling showed that soil contamination from toluene, ethylbenzene and xylenes (TEX) was present beginning at approximately 16 feet bgs and continuing to the top of bedrock between 27 and 30 feet bgs in XGB-94-10X, XGB-94-11X, and XGB-94-12X (see Figure 5-7). Benzene was detected as well in the 27-foot sample from XGB-94-11X at a concentration of 0.018 ppm. Benzene was likely present in the other samples containing TEX but due to the dilutions necessary to perform the analysis the detection limits for benzene ranged between 0.55 and 2.8 ppm. BTEX was not detected in any of the four samples (10, 15, 20, and 30 feet bgs) collected from XGB-94-13X. Individual minimum and maximum TEX detections range between 0.02 ppm of toluene (XGB-94-11X, 27 feet) to 210 ppm of m/p xylene (XGB-94-12X, 25 feet). Detection of TPHC was generally coincident with the detection of TEX in each of the soil boring samples in Area 2 except for the 15 foot sample from XGB-94-11X and all of the samples from XGB-94-13X. TPHC concentrations ranged from 340 ppm (XGB-94-12X, 15 feet) to 3,800 ppm (XGB-94-12X, 20 feet). No other site-related contaminants were detected in any of the other Area 2 field screening soil boring samples (see Table 7-7).

No detectable concentrations of VOCs or TPHC were identified in the field analytical soil samples collected from XGB-94-14X or XGB-94-15X (see Table 7-7).

Based on the subsurface soil data collected during the RI, it is apparent that the majority of the fuel-related contaminants were present in soil boring XGB-94-10X through XGB-94-12X.

Area 3

TerraProbe℠ Sample Results. No field analytical soil samples were collected from Area 3 during the SI or RI field investigations. During the SSI field investigation, 11 soil samples were collected from eight TerraProbe℠ points (TS-01 through TS-05 and TS-07, TS-08, and TS-10) located in and around the former waste oil USTs and the existing sand and gas trap located behind the AAFES gas station (see Table 7-6 and Figure 5-6).

TEX contamination were detected in six of the 11 soil samples from around the former waste oil UST and a sand and gas trap in Area 3. Benzene was detected at 0.14 ppm in only one sample, TS-08 at 10 feet. Total BTEX ranged from below the detection limit to 32.9 ppm in the 10 to 11-foot sample from TS-08. Individual minimum and maximum detected concentrations range from 0.0003 ppm of m/p xylene (TS-02, 10 feet) to 14.0 ppm of ethylbenzene (TS-08, 10 feet). Area 3 VOC contamination appears to be confined to the area of the former waste oil UST excavation and existing sand and gas trap. Detection of TPHC was generally coincident with detection of TEX compounds. TPHC concentrations ranged from below the detection limit (<54 ppm) to 8,500 ppm in the 9-foot sample from TP-02 (see Table 7-6).

7.2.1.2 Off-Site Laboratory Analytical Soil Results.

Area 1

Soil Borings Results. Based on the SI TerraProbe℠ survey soil sample results, one soil boring (43G-92-01X) was completed adjacent to TS-04 (see Figure 5-2). Analytical soil samples were collected from depths of 8 to 10 feet bgs and 18 to 20 feet bgs (depth of the water table). The samples were submitted for off-site laboratory analysis (see Table 5-10). No VOCs or TPHC were detected in either sample, and lead was present below the Fort Devens background concentration in each soil sample collected (Table 7-8).

The results of the SSI TerraProbe℠ survey completed at Area 1 were used to locate one additional soil boring (XGB-93-09X). The boring was located adjacent to TerraProbe℠ point TS-39 which had the highest concentrations of TPHC (see Table 7-6). A total of three soil samples were collected from this soil boring at depths of 8 to 10, 12 to 14, and 20 to 22 feet bgs. The soil samples from this boring were submitted for off-site laboratory analysis (see Table 5-10). Subsurface soil samples were collected from similar shallow depths as those collected during the TerraProbe℠ survey. No VOCs or SVOCs were detected in any of the soil samples collected from this soil boring. Trichlorofluoromethane (freon) and Di-n-butyl phthalate were detected in the 8- to 10-foot and 12- to 14-foot samples at concentrations of 0.006 μg/g. These compounds appear to be laboratory contaminants based on the results of the off-site laboratory QC program. TPHC concentrations were below the detection limit (<28.7 μg/g) in

each of these soil samples. The TOC concentration in the 20- to 22-foot sample was 687 μg/g (see Table 7-8).

Several inorganic analytes were detected above their Fort Devens background concentrations in each soil sample collected from XGB-93-09X (see Table 7-8).

Area 2

Soil Boring Results. No subsurface soil samples were collected from Area 2 during the SI. The off-site laboratory results for the six soil samples collected from the three soil borings drilled in Area 2 (XGB-93-05X, XGB-93-06X and XGB-93-07X) during the SSI showed low concentrations (below 1.0 μg/g) of VOCs (acetone and/or freon and SVOCs consisting of predominantly PAHs. The acetone and freon appear to be laboratory contaminants based on the results of the off-site laboratory QC program. A majority of the PAHs were detected in the 8-foot soil samples collected from XGB-93-05X. The remaining SVOCs were BEHP and di-n-butyl phthalate, which are common laboratory contaminants. TPHC was detected in the 6- to 8-foot sample at 185 μg/g in XGB-93-05X and in the 10- to 12-foot sample at 158 μg/g in XGB-93-06X (located on the southeast and east sides of Area 2). Each of these soil borings were advanced to refusal on apparent bedrock (28.0, 25.5 and 25.0 feet bgs, respectively) (see Table 7-8).

Several inorganic analytes were detected above their Fort Devens background concentrations in the subsurface soil sample collected from the SSI borings (see Table 7-8).

The off-site laboratory results for the soil samples collected from Area 2 borings (XGB-94-10X through XGB-94-15X) during the RI field program, indicated that BTEX was present in soil directly adjacent to the then-active gasoline USTs. Total BTEX concentrations (which are predominantly total xylenes) ranged from 372 μg/g in the 25- to 27-foot sample from XGB-94-10X to 0.0037 μg/g of xylenes in the 25- to 27-foot sample from XGB-94-13X. Low concentrations of benzene (0.0027 μg/g) and total xylenes (0.0051 μg/g) were detected in the 15- to 17-foot samples from XGB-94-14X. No other VOCs were detected in the soil samples collected from XGB-94-14X or XGB-94-15X (see Table 7-8).

SVOCs were also detected in soil samples collected from the soil boring completed directly adjacent to the then-active gasoline USTs (XGB-94-10X through XGB-94-13X). A majority of the SVOCs detected were PAHs (see Table 7-8). A majority of the PAHs were detected in the soil samples collected from XGB-94-10X and XGB-94-11X. Additional PAHs were also detected in the 27- to 29-foot sample from XGB-94-12X. BEHP was detected in several samples but the presence of this compound appears to be attributable to laboratory contamination based on the results of the off-site laboratory QC program.

TPHC was detected in 11 of the 12 soil samples collected from Area 2 during the RI. Concentrations in soil borings XGB-94-10X through XGB-94-13X ranged from 40.5 μg/g in the 25- to 27-foot sample from XGB-94-13X, to 1,730 μg/g in the 27- to 29-foot sample from XGB-94-12X. Concentrations of TPHC ranged from below the detection limit (<28 μg/g) to 41.5 μg/g in the soil samples collected from XGB-94-14X and XGB-94-15X (see Table 7-8).

Several inorganic analytes were detected above their Fort Devens background concentrations in each of the soil samples collected during the RI (see Table 7-8).

Area 3

Soil Boring Results. The results of the laboratory analyses for soil samples collected in Area 3 during the SSI indicated low concentrations of VOCs (TEX) from soil samples collected from both soil borings (XGB-93-03X and XGB-93-04X). These borings were drilled in or adjacent to the former waste oil UST and the existing sand and gas trap. One SVOC (2-methylnaphthalene) was detected in the 20-foot soil sample (0.17 μg/g) and the 8-foot soil sample (0.72 μg/g) in XGB-93-03X and XGB-93-04X, respectively. BEHP and di-n-butyl phthalate were also detected in Area 3, however, these compounds appear to be laboratory contaminants based on the off-site laboratory QC program. TPHC concentrations ranged from 40.8 μg/g in the 25- to 27-foot soil sample from XGB-93-04X to 1,020 μg/g in the soil samples collected from the 6- to 8-foot sample from XGB-93-04X. These soil borings were advanced to refusal on apparent bedrock at 25.0 and 26.5 feet bgs, respectively (see Table 7-8).

Several inorganic analytes were detected above their Fort Devens background concentrations in the subsurface soil samples collected from the SSI borings (see Table 7-8).

No contaminants of concern were detected in any of the subsurface soil samples collected from the boring (XGB-93-08X) drilled between the AAFES gas station and historic gas station G during the 1993 SSI. Inorganic analytes were detected above the Fort Devens background concentration in each of the soil samples collected from AOC 43G (see Table 7-8).

7.2.1.3 Summary of Soil Impacts. Analytes detected in soil samples collected from AOC 43G are consistent with the historical use of this area as a gas station (see Section 2.0). The BTEX and TPHC concentrations detected in Areas 2 and 3 indicated that residual soil contamination is still present in these areas from leaks and spills associated with the former gasoline and waste oil USTs. The results of the soil sampling in Area 2 shows that residual fuel-related soil contamination appears to be present in the soil at the southeastern corner and directly adjacent to the existing gasoline USTs from approximately 20 to 28 feet bgs. The results of the soil sampling at Area 3 indicate that residual soil contamination is present in the shallow soils (approximately 6 to 8 feet bgs) below the former waste oil UST and around the existing sand and gas trap.

7.2.2 Groundwater

The following discussion presents field analytical results and results of four rounds (Round Three through Six) of groundwater sampling completed at AOC 43G. However, the focus will be on the RI sampling results (Round Five and Six) because these rounds include each of the new and existing monitoring wells.

7.2.2.1 Field Analytical Groundwater Results. Groundwater samples were collected for field analysis during the RI field program. Field analysis of groundwater samples consisted of collection and analysis of groundwater samples from monitoring well borings to determine monitoring well locations outside the area of groundwater contamination.

One groundwater sample was collected from the soil borings for XGM-94-06X, XGM-94-07X, XGM-94-09X, and XGM-94-10X. These samples were analyzed in the field for BTEX and selected chlorinated solvents (Table 7-9).

Based upon the results of the field analysis the locations of each of the above mentioned monitoring wells was confirmed or moved so that an optimum position for that monitoring well was achieved.

7.2.2.2 Off-Site Groundwater Laboratory Analytical Sample Results. Two rounds of off-site laboratory analytical samples were collected during both the SSI (Round Three and Four) and RI (Round Five and Six) field investigations conducted at AOC 43G. Table 5-10 presents the samples collected, the field program, and the analyses requested. Table 7-10 presents the hits-only table of analytes detected in SSI and RI groundwater samples. The following discussion will focus quantitatively on 1994 data, and use pre-1994 data in a qualitative fashion. Inorganic analyte concentrations will be compared to the established Fort Devens background concentrations.

Previous Investigation Groundwater Results. As part of the 1991 gasoline UST removal program, a total of seven groundwater monitoring wells (AAFES-1D through AAFES-7) were installed by Nobis (see Figure 7-2). One of these monitoring wells (AAFES-3) was installed in an apparent upgradient location, while the remaining six monitoring wells were installed to monitor downgradient groundwater quality. The monitoring wells were sampled by Nobis, and samples were submitted to a non-USAEC-approved laboratory for chemical analysis consisting of TPHC, only. Therefore, this data will be considered USEPA Level II data quality. TPHC concentrations ranged from 1.7 to 5.1 mg/L. The results of the groundwater sampling did not exceed the MADEP action levels at the time for remediation for low environmental impact areas (Nobis, 1991).

SSI Groundwater Results. Under the SSI field investigation, ABB-ES installed two groundwater monitoring wells (XGM-93-01X and XGM-93-02X) at the AAFES gas station (one upgradient [XGM-93-01X] and one downgradient [XGM-93-02X] of the active gasoline USTs) to supplement the existing monitoring well network around Areas 2 and 3 (Figure 7-2).

These new monitoring wells were installed to monitor upgradient and downgradient groundwater quality. The screen of both monitoring wells was placed across the water table to monitor for free product and allow for seasonal groundwater fluctuations. Due to the location of the water table in this portion of the installation, the SSI and the majority of the existing AAFES monitoring wells were screened across the bedrock/soil interface. Elevated PID measurements were recorded on the drilling water and development water from the XGM-93-02X, and from the development water from the existing downgradient monitoring wells (AAFES-ID, AAFES-2, and AAFES-6).

Two rounds of groundwater samples (Rounds Three and Four) were collected from the new and existing monitoring wells during the SSI. Round Three groundwater samples were collected in October 1993 and Round Four samples were collected in January 1994. Each round of samples was submitted for off-site laboratory analysis (see Table 5-10).

The results of the Round Three and Four laboratory analysis showed the presence of several VOCs and SVOCs (including BTEX, PCE, naphthalene, and 1,2-dichloroethane [1,2-DCA]) in the groundwater samples collected from the downgradient and crossgradient monitoring wells. Benzene, ethylbenzene, and naphthalene were the only compounds detected above maximum drinking water standards/guidelines in monitoring wells directly downgradient of Areas 2 and 3 (XGM-93-02X, AAFES-1D, AAFES-2, and AAFES-6). Concentrations of benzene ranged from 13 μg/L at AAFES-6 to 2,000 μg/L in XGM-93-02X. Ethylbenzene concentrations ranged from 34 μg/L in AAFES-6 to 2,000 μg/L in AAFES-2. Concentrations of naphthalene ranged from 1.7 μg/L in AAFES-6 to 4,000 μg/L in AAFES-2 (see Table 7-10). Acetone was also detected, however, this compound appears to be a laboratory contaminant based on the off-site laboratory QC program.

TPHC was detected in Round Three and Four groundwater samples collected from the existing upgradient monitoring well, AAFES-3 (5,170 and 190 μg/L, respectively). No VOCs or SVOCs were detected in either SSI round collected from AAFES-3. No VOCs, SVOCs or TPHC were detected in the samples collected upgradient of the monitoring well, XGM-93-01X. The monitoring wells directly downgradient of Areas 2 and 3 (XGM-93-02X, AAFES-1D, AAFES-2 and

AAFES-6), had TPHC concentrations that ranged from 274 μg/L at AAFES-6 to 120,000 μg/L at AAFES-2 (see Table 7-10).

Both filtered and unfiltered inorganic groundwater samples were collected during the SSI. Several inorganic analytes were detected above the Fort Devens groundwater background concentrations in the unfiltered groundwater samples. Calcium, magnesium, manganese, potassium, and sodium were the only inorganic analytes detected above the Fort Devens background in the filtered groundwater samples collected during Rounds Three and Four (see Table 7-10).

Approximately 0.10 feet of free product was measured in AAFES-2 prior to the Round Three groundwater sampling round. Free product was not detected during Round Four.

RI Groundwater Results. As part of the RI field investigation, ABB-ES installed eight additional groundwater monitoring wells (XGM-94-03X through XGM-94-10X) downgradient and crossgradient of Areas 2 and 3 to supplement the existing monitoring well network (see Figure 7-2). Two rounds of groundwater sampling (Round Five and Six) were collected from each of the new and existing monitoring wells.

The results of the Round Five and Six laboratory analysis showed the presence of several VOCs and SVOCs (including BTEX, PCE, 2,4-dimethylphenol, 4-methylphenol, 2-methylnaphthalene, acenaphthene, anthracene, fluorene, naphthalene, phenanthrene, carbon disulfide, methylene chloride, and methyl isobutyl ketone), in monitoring wells located downgradient and crossgradient of Areas 2 and 3. The highest levels of site-related contaminants (BTEX, naphthalene, and 2-methylnaphthalene) were detected in the monitoring well directly downgradient of Areas 2 and 3 (AAFES-1D, AAFES-2, AAFES-6, XGM-93-02X, XGM-93-03X, and XGM-94-04X). Analysis of samples from XGM-94-06X, XGM-94-07X, XGM-94-08X, and XGM-94-10X (located further downgradient) showed lower levels of these site-related contaminants. PCE was detected in XGM-94-05X (2.4 μg/L in Round Six), XGM-94-07X (3.8 μg/L in Round Five and 3.3 μg/L in Round Five duplicate) and AAFES-5 (2.1 μg/L in Round Five). These wells are located downgradient and crossgradient of Areas 2 and 3. BEHP, acetone, and freon were detected in a number of samples, however, these compounds appear to be laboratory contaminants based on the off-site laboratory QC program.

Concentrations of benzene ranged from 0.56 μg/L at XGM-94-10X (Round Six) to 2,000 μg/L at AAFES-2 and XGM-93-02X (both Round Five). Toluene was detected at concentrations ranging from 0.51 μg/L in XGM-94-06X (Round Five) to a maximum of 300 μg/L at AAFES-2 (Round Five). Ethylbenzene concentrations ranged from 0.95 μg/L in XGM-94-09X (Round Six) to 2,000 μg/L in AAFES-2 (Round Five). Xylenes were detected at concentrations ranging from 1.3 μg/L in AAFES-6 (Round Six) to 20,000 μg/L in AAFES-2 (Round Five). Based on these results, the highest concentration of contamination is apparently in the groundwater in the vicinity of AAFES-2.

Several inorganic analytes were detected above the Fort Devens groundwater background concentrations in the unfiltered samples. Antimony, arsenic, barium, calcium, copper, iron, magnesium, manganese, nickel, potassium, and sodium were the only inorganic analytes detected above background in the filtered groundwater samples collected during Rounds Five and Six.

7.2.2.3 Summary of Groundwater Impacts. Distribution and concentrations of VOCs (primarily BTEX) and SVOCs detected in 1994 groundwater samples are in agreement with pre-1994 data. The distribution of the groundwater contamination appears to confirm that the groundwater contaminant source is the apparent residual soil contamination below the existing gasoline USTs in Area 2, and potentially the residual soil contamination detected in Area 3.

The highest concentrations of BTEX and PAHs were detected in the monitoring wells directly downgradient of Areas 2 and 3 (AAFES-1D, AAFES-2, AAFES-6, XGM-93-02X, XGM-94-03X, and XGM-94-04X). Concentrations were highest in groundwater samples collected from AAFES-2 (see Table 7-10).

BTEX was detected in several downgradient (XGM-94-06X, XGM-94-08X and XGM-94-10X) and crossgradient (XGM-94-03X and XGM-94-09X) monitoring wells. Concentrations were in exceedance of drinking water standards in XGM-94-10X, XGM-94-08X, and XGM-94-07X (see Table 7-10). Figure 7-2 shows the distribution of groundwater contamination using benzene concentrations above 5 μg/L.

The RI groundwater results indicate that the highest concentrations of groundwater contamination appear to be in the groundwater at the base of the

slope directly south (downgradient) of Areas 2 and 3. The groundwater contamination concentrations decrease with distance (in the downgradient and crossgradient directions) from this area.

Although concentrations of inorganic analytes generally exceed Fort Devens background concentrations in unfiltered samples, this appears to be a result of TSS in the unfiltered sample rather then dissolved site-related contamination. In addition, the distribution of detected inorganic analytes do not indicate that their presence is related to past activities at AOC 43G.

7.2.3 Sediment

One sediment sample (XGD-93-02X) was collected from the storm water collection outfall located east of AOC 43G during the SSI. A surface water sample was not collected from this location because there was insufficient surface water volume available at the time of sample collection.

No VOCs or SVOCs were detected in XGD-93-02X. TPHC was detected at 448 μg/g. Several inorganic analytes were detected and the TOC concentration was 8,970 μg/g (Table 7-11).

N

LOCATION OF FORMER AND ACTIVE GASOLINE USTS

QUEENSTOWN ROAD

COVERED GASOLINE PUMP ISLANDS

CONCRETE RETAINING WALL

AREA 2

LOCATION OF FORMER WASTE OIL UST

FEINBERG ROAD

WOODEN PLATFORM

2009

AAFES GAS STATION 2008

SAND AND GAS TRAP

ABOVE GROUND WASTE OIL STORAGE TANK

AREA 3

AREA 1
HISTORIC
GAS STATION G

WOODED AREA

NOTE:
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

CAR WASH 2017

0 15 30 60 FEET

SCALE: 1"=30'

H:\7053-15\FIGURES\AOC43F09.DWG

FIGURE 7-1
LOCATION OF AREAS 1 THROUGH 3
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

LEGEND

XGB-94-10X — SOIL BORING/VAPOR EXTRACTION WELL

XGB-94-14X — SOIL BORING

XGP-94-06X — PIEZOMETER

XGM-94-05X — MONITORING WELL

NOTE:
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

LOCATION OF EXISTING GASOLINE USTS

LOCATION OF FORMER WASTE OIL UST

ROAD

QUEENSTOWN

AREA 1

AREA 2

AREA 3

GRASSED AREA

XGB-94-11X
XGB-94-12X
XGB-94-10X
XGB-94-13X

AAFES-3
XGB-94-15X
XGM-93-01X
AAFES-5
XGM-94-05X
XGB-94-14X
AAFES-4
XGM-93-02X
AAFES-2
XGM-94-03X
AAFES-1D
AAFES-6
XGM-94-07X

COVERED GASOLINE PUMP ISLANDS

AAFES GAS STATION 2008

FEINBERG

2012
ONE-STORY BUILDING

ABOVE GROUND WASTE OIL STORAGE TANK

CONCRETE RETAINING WALL

ABOVE GROUND WASTE OIL STORAGE TANK

WOODED AREA

XGM-94-04X
XGP-94-07X
XGP-94-05X
XGP-94-06X
XGP-94-01X

CAR WASH 2017

WOODEN PLATFORM

2009

XGM-94-09X

AAFES-7 IS LOCATED 180' SOUTHEAST

AAFES-7

REMAINS OF CONCRETE FOUNDATION

STORAGE SHED

ROAD

XGM-94-08X

XGP-94-04X
XGM-94-06X
XGP-94-02X
XGP-94-03X

BLDG 3553

BIT. CONC. PAVEMENT

GRAVEL

XGM-94-10X

SMALL TREES & BRUSH

GRASSED AREA

0 25 50 100 FEET

SCALE: 1" = 50'

FIGURE 7-2
DISTRIBUTION OF GROUNDWATER BENZENE CONCENTRATION ABOVE 5ug/L
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ABB Environmental Services, Inc.

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID	43G-92-01X	43G-92-01X	XGB-93-03X	XGB-93-03X	XGB-93-03X	XGB-93-04X	XGB-93-04X
DEPTH	10 ft	20 ft	8 ft	12 ft	20 ft	8 ft	12 ft
ANALYTE / FIELD SAMPLE NUMBER	BX433110	BX43H109	BXXG0308	BXXG0312	BXXG0320	BXXG0408	BXXG0412
PAL SEMIVOLATILE ORGANICS (µg/g)							
1-methylnaphthalene							
123tmb							
124tmb							
135tmb							
3mund							
Bepyr							
C9							
C13			10 S	.32 S			
Et3mbz							
Et4mbz							
Isodur							
Indan							
Pcymen							
Decane			3 S				
Diacetone Alcohol / 4-hydroxy-4-methyl-2-pentanon				.32 S			
Hendecane				.32 S	3.3 S	200 S	
C17					2.2 S		
Hexadecane			3 S		3.3 S	10 S	
Pentadecane							
Tetradecane			10 S	.53 S	8.9 S		.44 S
1e2mb							
PAL VOLATILE ORGANICS (µg/g)							
2-methylheptane / Isooctane							
234tmp							
23dmc5							
2mc6							
Mecype							
Heptane							
Hexane	.0042 S	.0056 S					
3mc6							
PAL PESTICIDES/PCBS (µg/g)							
2-methylpentane							

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID	43G-92-01X	43G-92-01X	XGB-93-03X	XGB-93-03X	XGB-93-03X	XGB-93-04X	XGB-93-04X
DEPTH	10 ft	20 ft	8 ft	12 ft	20 ft	8 ft	12 ft
ANALYTE / FIELD SAMPLE NUMBER	BX433110	BX43H109	BXXG0308	BXXG0312	BXXG0320	BXXG0408	BXXG0412
UNKNOWN GC/MS TIC (µg/g)							
Unk094							
Unk106						.006 S	
Unk116					.006 S		
Unk128							
Unk160						.5 S	
Unk161					.03 S		
Unk200							
Unk201							
Unk202							
Unk203							
Unk207							
Unk211							
Unk212							
Unk220							
Unk221							
Unk227							
Unk228							
Unk235							
Unk237							
Unk238							
Unk248							
Unk521							
Unk522							
Unk530							
Unk542							
Unk546							
Unk547							
Unk548						40 S	
Unk549							
Unk551							
Unk552							
Unk553			3 S			20 S	
Unk554						20 S	
Unk555			3 S			40 S	
Unk556			10 S			20 S	
Unk557							
Unk558			2 S			10 S	
Unk559			4 S			20 S	
Unk560			3 S			20 S	

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SITE ID / DEPTH / FIELD SAMPLE NUMBER	43G-92-01X 10 ft BX433110		43G-92-01X 20 ft BX43H109		XGB-93-03X 8 ft BXXG0308		XGB-93-03X 12 ft BXXG0312		XGB-93-03X 20 ft BXXG0320		XGB-93-04X 8 ft BXXG0408		XGB-93-04X 12 ft BXXG0412	
Unk561						3	S			.7	S	30	S		
Unk562						2	S					20	S		
Unk563						3	S					30	S		
Unk564						2	S					20	S		
Unk565						3	S			.9	S	20	S		
Unk566															
Unk567															
Unk568						2	S			.8	S	10	S		
Unk569						2	S			2	S	20	S		
Unk570						4	S								
Unk573															
Unk574										.8	S				
Unk575						3	S			.9	S				
Unk576										.8	S				
Unk577										1	S	70	S		
Unk578										.9	S				
Unk579										1	S				
Unk580						4	S								
Unk581										1	S	20	S		
Unk582										3	S				
Unk586										1	S				
Unk607															
Unk624								1	S						
Unk629														50	S
Unk658															
Unk672															

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE / SITE ID / DEPTH / FIELD SAMPLE NUMBER	XGB-93-04X 25 ft BXXG0425		XGB-93-05X 8 ft BXXG0508		XGB-94-10X 20 ft BXXG1020		XGB-94-10X 25 ft BXXG1025		XGB-94-11X 15 ft BXXG1115		XGB-94-11X 25 ft BXXG1125	
PAL SEMIVOLATILE ORGANICS (µg/g)												
1-methylnaphthalene					1.1	S	2.2	S			1.1	S
123tmb					1.1	S						
124tmb					4.5	S						
135tmb					1.1	S						
3mund											.32	S
Bepyr			4	S								
C9												
C13	.33	S			.78	S	2.2	S			1.1	S
Et3mbz					3.3	S						
Et4mbz												
Isodur					1.1	S	.98	S				
Indan												
Pcymen												
Decane	.55	S										
Diacetone Alcohol / 4-hydroxy-4-methyl-2-pentanon												
Hendecane					1.1	S						
C17												
Hexadecane	.22	S										
Pentadecane	.33	S										
Tetradecane	.33	S					2.2	S			.65	S
1e2mb												
PAL VOLATILE ORGANICS (µg/g)												
2-methylheptane / Isooctane					10000	S	10000	S				
234tmp					6000	S						
23dmc5					10000	S						
2mc6					10000	S						
Mecype					6000	S						
Heptane												
Hexane												
3mc6					20000	S	8000	S				
PAL PESTICIDES/PCBS (µg/g)												
2-methylpentane					6000	S						

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID	XGB-93-04X	XGB-93-05X	XGB-94-10X		XGB-94-10X		XGB-94-11X		XGB-94-11X	
DEPTH	25 ft	8 ft	20 ft		25 ft		15 ft		25 ft	
ANALYTE / FIELD SAMPLE NUMBER	BXXG0425	BXXG0508	BXXG1020		BXXG1025		BXXG1115		BXXG1125	
UNKNOWN GC/MS TIC (µg/g)										
Unk094			20000	S						
Unk106										
Unk116										
Unk128			20000	S	20000	S			5000	S
Unk160										
Unk161										
Unk200					10000	S			10000	S
Unk201										
Unk202					8000	S			5000	S
Unk203										
Unk207					5000	S			4000	S
Unk211					10000	S			10000	S
Unk212			6000	S						
Unk220					5000	S				
Unk221									4000	S
Unk227										
Unk228					5000	S			4000	S
Unk235										
Unk237					5000	S			4000	S
Unk238										
Unk248									3000	S
Unk521			1	S						
Unk522							2	S	3	S
Unk530			1	S						
Unk542					2	S				
Unk546			2	S						
Unk547			1	S						
Unk548			2	S						
Unk549			.9	S						
Unk551			.6	S						
Unk552			1	S	.7	S			.4	S
Unk553									.5	S
Unk554			1	S						
Unk555			2	S	1	S			.8	S
Unk556					.9	S			.4	S
Unk557					1	S			.8	S
Unk558					.9	S				
Unk559			.7	S	.8	S			.3	S
Unk560					.8	S			.5	S

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SITE ID DEPTH FIELD SAMPLE NUMBER	XGB-93-04X 25 ft BXXG0425	XGB-93-05X 8 ft BXXG0508	XGB-94-10X 20 ft BXXG1020	XGB-94-10X 25 ft BXXG1025	XGB-94-11X 15 ft BXXG1115	XGB-94-11X 25 ft BXXG1125
Unk561							.3 S
Unk562				.7 S	.8 S		.8 S
Unk563				.6 S	.7 S		.3 S
Unk564					.7 S		.8 S
Unk565					1 S		.5 S
Unk566					1 S		.8 S
Unk567					.9 S		
Unk568							.3 S
Unk569							
Unk570							
Unk573				.7 S			
Unk574							
Unk575					2 S		.6 S
Unk576					2 S		.8 S
Unk577					1 S		.4 S
Unk578							
Unk579							
Unk580							
Unk581							
Unk582							
Unk586							
Unk607			4 S				
Unk624							
Unk629							
Unk658							
Unk672							

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID	XGB-94-12X		XGB-94-13X	XGB-94-14X		XGB-94-14X	XGB-94-15X	XGB-94-15X
DEPTH	27 ft		15 ft	15 ft		25 ft	15 ft	27 ft
ANALYTE / FIELD SAMPLE NUMBER	BXXG1227		BXXG1315	BXXG1415		BXXG1425	BXXG1515	BXXG1527
PAL SEMIVOLATILE ORGANICS (µg/g)								
1-methylnaphthalene	1	S						
123tmb								
124tmb				.033	S			
135tmb								
3mund								
Bepyr								
C9	6000	S						
C13	.78	S						
Et3mbz								
Et4mbz				.011	S			
Isodur	.89	S		.022	S			
Indan				.011	S			
Pcymen				.011	S			
Decane								
Diacetone Alcohol / 4-hydroxy-4-methyl-2-pentanon								
Hendecane	3.3	S						
C17								
Hexadecane								
Pentadecane								
Tetradecane	3.3	S						
1e2mb				.011	S			
PAL VOLATILE ORGANICS (µg/g)								
2-methylheptane / Isooctane	10000	S						
234tmp								
23dmc5								
2mc6	6000	S						
Mecype								
Heptane	6000	S						
Hexane								
3mc6								
PAL PESTICIDES/PCBS (µg/g)								
2-methylpentane								

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE / SITE ID / DEPTH / FIELD SAMPLE NUMBER	XGB-94-12X 27 ft BXXG1227		XGB-94-13X 15 ft BXXG1315		XGB-94-14X 15 ft BXXG1415		XGB-94-14X 25 ft BXXG1425		XGB-94-15X 15 ft BXXG1515		XGB-94-15X 27 ft BXXG1527	
UNKNOWN GC/MS TIC (µg/g)												
Unk094												
Unk106												
Unk116												
Unk128	20000	S										
Unk160												
Unk161												
Unk200												
Unk201	10000	S										
Unk202												
Unk203	7000	S										
Unk207												
Unk211												
Unk212	10000	S										
Unk220												
Unk221												
Unk227	6000	S			.01	S						
Unk228												
Unk235									.009	S		
Unk237												
Unk238	6000	S										
Unk248												
Unk521											.7	S
Unk522			2	S	2	S	2	S	3	S		
Unk530												
Unk542	6	S										
Unk546												
Unk547	4	S										
Unk548	4	S										
Unk549	4	S										
Unk551												
Unk552	.4	S										
Unk553	.8	S										
Unk554												
Unk555	1	S										
Unk556	.6	S										
Unk557	1	S										
Unk558	.6	S										
Unk559	.6	S										
Unk560	.6	S										

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS
DETECTED IN SOIL BORING SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SITE ID / DEPTH / FIELD SAMPLE NUMBER	XGB-94-12X 27 ft BXXG1227	XGB-94-13X 15 ft BXXG1315	XGB-94-14X 15 ft BXXG1415	XGB-94-14X 25 ft BXXG1425	XGB-94-15X 15 ft BXXG1515	XGB-94-15X 27 ft BXXG1527
Unk561							
Unk562		.8 S					
Unk563							
Unk564		.7 S					
Unk565							
Unk566		.4 S					
Unk567							
Unk568							
Unk569							
Unk570							
Unk573							
Unk574							
Unk575		2 S					
Unk576							
Unk577		2 S					
Unk578							
Unk579							
Unk580							
Unk581							
Unk582							
Unk586							
Unk607							
Unk624							
Unk629							
Unk658							
Unk672							.9 S

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

ANALYTE	Site ID:	AAFES-1D	AAFES-1D	AAFES-1D	AAFES-1D	AAFES-2	AAFES-2	AAFES-2	AAFES-2	AAFES-3	AAFES-3	AAFES-3	AAFES-3
	Sample Date:	09/29/93	01/25/94	11/30/94	03/14/95	09/30/93	01/25/94	12/01/94	03/14/95	09/30/93	02/02/94	12/02/94	03/15/95
	Depth:	26	26	26	26	28	28	28	28	24	24	24	24
	Field Sample Number:	MXAF01X1	MXAF01X2	MXAF01X3	MXAF01X4	MXAF02X1	MXAF02X2	MXAF02X3	MXAF02X4	MXAF03X1	MXAF03X2	MXAF03X3	MXAF03X4
PAL SEMIVOLATILE ORGANICS (µg/L)													
1234mb													
1,2,3-trimethylbenzene							5000 S						
12dmb	300 S	200 S				4000 S	5000 S						
135tmb													
13deb													
1,3-dimethylbenzene / M-xylene	300 S	100 S					8000 S						
14dmb	200 S	200 S											
1e2mb													
1-methylnaphthalene													
23dhio				8 S									
3pt													
C20													
Et3mbz							10000 S						
Et4mbz							10000 S						
Etc6h5	200 S	80 S											
Indan	100 S	90 S	200 S	100 S	4000 S				600 S				
Isodur							4000 S						
Isopbz													
Mec6h5													
Pcymen													
Prc6h5	70 S				4000 S		5000 S						
Trimbz							20000 S						
N-nitroso Dimethylamine													
PAL VOLATILE ORGANICS (µg/L)													
224tmp													
234tmp				100 S									
23dmc4													
23dmc5			200 S	100 S									
24dmc5													
2m2c3l													
2mc3													
2mc4	200 S	200 S	200 S										
2-methylpentane													
3mepen	100 S												
Amylen													
C4													
Mecype	200 S	100 S		100 S	400 S								
Naphthalene													
Pentan													
UNKNOWN GC/MS TIC (µg/L)													
Unk047													
Unk094			200 S					8000 S					
Unk098													
Unk122			200 S										
Unk134													
Unk200								20000 S					
Unk201													
Unk203								8000 S					
Unk207			200 S						600 S				
Unk211			200 S					20000 S					
Unk212													
Unk221													
Unk232													
Unk238													
Unk515													
Unk516													
Unk521													
Unk530													

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

ANALYTE	Site ID:	AAFES-1D	AAFES-1D	AAFES-1D	AAFES-1D	AAFES-2	AAFES-2	AAFES-2	AAFES-2	AAFES-3	AAFES-3	AAFES-3	AAFES-3
	Sample Date:	09/29/93	01/25/94	11/30/94	03/14/95	09/30/93	01/25/94	12/01/94	03/14/95	09/30/93	02/02/94	12/02/94	03/15/95
	Depth:	26	26	26	26	28	28	28	28	24	24	24	24
	Field Sample Number:	MXAF01X1	MXAF01X2	MXAF01X3	MXAF01X4	MXAF02X1	MXAF02X2	MXAF02X3	MXAF02X4	MXAF03X1	MXAF03X2	MXAF03X3	MXAF03X4
Unk531													
Unk535													
Unk536							10000 S						
Unk537					10 S								
Unk540					7 S								
Unk541						4000 S							
Unk542						4000 S							
Unk544			80 S										
Unk546		100 S	100 S				10000 S		60 S				
Unk547		200 S	200 S			4000 S	5000 S						
Unk548		200 S			3000 S	20000 S				4 S			
Unk549		300 S	70 S										
Unk550		90 S				4000 S							
Unk551									50000 S				
Unk552		70 S	50 S				7000 S						
Unk553		70 S	40 S	10000 S		4000 S	10000 S	300000 S					
Unk554		200 S	100 S			8000 S	5000 S						
Unk555		60 S	40 S			4000 S	8000 S						
Unk556			20 S			8000 S							
Unk557			20 S										
Unk558		40 S	30 S			2000 S							
Unk559		40 S	20 S			2000 S							
Unk560			20 S			2000 S	5000 S		6 S				
Unk561		70 S	40 S		10 S	3000 S							
Unk562						2000 S							
Unk564													
Unk565													
Unk566													
Unk567													
Unk570													
Unk571													
Unk572													
Unk573									30 S				
Unk574				8 S									
Unk576									5 S				
Unk577					7 S								
Unk578		50 S											
Unk579													
Unk581													
Unk582								60 S					
Unk585													
Unk606													
Unk607										8 S	4 S		
Unk608													
Unk609												50 S	30 S
Unk610													
Unk613													
Unk614													
Unk615													
Unk616													
Unk617													
Unk618													
Unk619													
Unk620													
Unk621													
Unk622													
Unk624													
Unk645													
Unk647								5000 S					

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

Site ID:	AAFES-5	AAFES-5	AAFES-5	AAFES-5	AAFES-6	AAFES-6	AAFES-6	AAFES-6	XGM-93-01X	XGM-93-01X	XGM-93-02X	XGM-93-02X
Sample Date:	09/29/93	01/25/94	12/01/94	03/13/95	09/30/93	01/25/94	11/30/94	03/14/95	01/25/94	12/05/94	09/29/93	02/01/94
Depth:	25	25	25	25	22	22	22	22	28	0	33	33
ANALYTE Field Sample Number:	MXAF05X1	MXAF05X2	MXAF05X3	MXAF05X4	MXAF06X1	MXAF06X2	MXAF06X3	MXAF06X4	MXXG01X2	MXXG01X3	MXXG02X1	MXXG02X2
PAL SEMIVOLATILE ORGANICS (µg/L)												
1234mb												
1,2,3-trimethylbenzene												400 S
12dmb											2000 S	800 S
135tmb												400 S
13deb												100 S
1,3-dimethylbenzene / M-xylene												1000 S
14dmb											2000 S	
1e2mb												
1-methylnaphthalene											30 S	
23dhio												
3pt							10 S					
C20												
Et3mbz												
Et4mbz							60 S	30 S				
Etc6h5					20 S	20 S	4 S				700 S	300 S
Indan					30 S	10 S	20 S				600 S	300 S
Isodur							20 S	6 S				70 S
Isopbz												
Mec6h5											600 S	200 S
Pcymen							30 S					
Prc6h5					20 S		6 S					
Trimbz												800 S
N-nitroso Dimethylamine									2ND R		2ND R	2ND R
PAL VOLATILE ORGANICS (µg/L)												
224tmp												
234tmp								50 S				
23dmc4					100 S		80 S					
23dmc5					200 S	50 S	100 S	30 S				
24dmc5												
2m2c3l												
2mc3												
2mc4					100 S	200 S	200 S	40 S				
2-methylpentane							100 S					
3mepen					200 S	50 S	100 S					
Amylen												
C4												
Mecype					70 S	70 S		30 S				
Naphthalene												
Pentan												
UNKNOWN GC/MS TIC (µg/L)												
Unk047												
Unk094							90 S					
Unk098					200 S	40 S						
Unk122												
Unk134										5 S		
Unk200												
Unk201												
Unk203												
Unk207							90 S	20 S				
Unk211												
Unk212												
Unk221												
Unk232												
Unk238												
Unk515												
Unk516							7 S					
Unk521						7 S						
Unk530												

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

ANALYTE	Site ID:	AAFES-5	AAFES-5	AAFES-5	AAFES-5	AAFES-6	AAFES-6	AAFES-6	AAFES-6	XGM-93-01X	XGM-93-01X	XGM-93-02X	XGM-93-02X
	Sample Date:	09/29/93	01/25/94	12/01/94	03/13/95	09/30/93	01/25/94	11/30/94	03/14/95	01/25/94	12/05/94	09/29/93	02/01/94
	Depth:	25	25	25	25	22	22	22	22	28	0	33	33
	Field Sample Number:	MXAF05X1	MXAF05X2	MXAF05X3	MXAF05X4	MXAF06X1	MXAF06X2	MXAF06X3	MXAF06X4	MXXG01X2	MXXG01X3	MXXG02X1	MXXG02X2
Unk531													
Unk535													
Unk536				6 S				10 S					
Unk537													
Unk540			10 S				10 S						
Unk541		5 S											
Unk542													
Unk544													600 S
Unk546						80 S		5 S				500 S	
Unk547							40 S					700 S	100 S
Unk548												600 S	
Unk549								40 S				1000 S	
Unk550										6 S		700 S	
Unk551								40 S					
Unk552						70 S	20 S	20 S					100 S
Unk553						40 S	7 S					200 S	300 S
Unk554						100 S	10 S		10 S			500 S	100 S
Unk555						40 S	8 S	30 S				200 S	100 S
Unk556						50 S	10 S						30 S
Unk557						30 S	7 S	4 S					50 S
Unk558		4 S				10 S	10 S	9 S				20 S	
Unk559		9 S				40 S	20 S	10 S				40 S	
Unk560		5 S				30 S	5 S	8 S				40 S	100 S
Unk561						10 S	5 S	7 S				70 S	
Unk562						20 S	20 S	4 S					
Unk564								10 S					
Unk565								4 S					
Unk566						10 S		5 S					
Unk567								4 S					
Unk570												30 S	
Unk571													
Unk572													
Unk573													
Unk574													
Unk576													
Unk577													
Unk578													
Unk579													
Unk581								4 S					
Unk582													
Unk585													
Unk606													
Unk607		5 S	30 S										
Unk608													
Unk609				20 S									
Unk610					9 S								
Unk613										5 S			
Unk614													
Unk615													
Unk616													
Unk617													
Unk618													
Unk619													
Unk620													
Unk621													
Unk622													
Unk624													
Unk645													
Unk647													

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

Site ID:	XGM-93-02X		XGM-93-02X		XGM-94-03X		XGM-94-03X		XGM-94-03X		XGM-94-04X		XGM-94-04X		XGM-94-04X		XGM-94-05X		XGM-94-05X		XGM-94-06X	
Sample Date:	12/02/94		03/15/95		11/30/94		11/30/94		03/14/95		03/14/95		12/02/94		03/14/95		12/01/94		03/14/95		03/15/95	
Depth:	37.5		37.5		29		33		29		29		29		29		34.5		34.5		28	
ANALYTE Field Sample Number:	MXXG02X3		MXXG02X4		MXXG03X3		MXXG03X3		MXXG03X4		MDXG04X4		MXXG04X3		MXXG04X4		MXXG05X3		MXXG05X4		MXXG06X4	
PAL SEMIVOLATILE ORGANICS (µg/L)																						
1234mb											10	SD										
1,2,3-trimethylbenzene	600	S	400	S			30	S					90	S								
12dmb	2000	S	900	S			80	S	100	S	10	SD	100	S	10	S						
135tmb	600	S	400	S			20	S					100	S								
13deb	70	S											30	S								
1,3-dimethylbenzene / M-xylene	1000	S	400	S			50	S	100	S	50	SD	200	S	60	S						
14dmb	1000	S	800	S			60	S					200	S								
1e2mb	600	S	300	S			40	S					100	S								
1-methylnaphthalene	30	S																				
23dhio	60	S							7	S												
3pt							4	S														
C20							9	S														
Et3mbz	500	S	400	S									100	S								
Et4mbz							30	S														
Etc6h5	300	S	90	S			20	S	20	S	20	SD	90	S	20	S						
Indan	400	S	300	S	100	S	30	S	60	S	10	SD			10	S						
Isodur	40	S	90	S			4	S							10	S						
Isopbz																						
Mec6h5	100	S					10	S					100	S								
Pcymen			200	S			6	S														
Prc6h5											6	SD			8	S						
Trimbz	2000	S	1000	S			60	S	50	S	30	SD	300	S	30	S						
N-nitroso Dimethylamine	3	S	2ND	R			2ND	R	2ND	R	2ND	RD	2ND	R	2ND	R	2ND	R	2ND	R		
PAL VOLATILE ORGANICS (µg/L)																						
224tmp																					30	S
234tmp											60	S			50	S					10	S
23dmc4																						
23dmc5																					6	S
24dmc5																						
2m2c3l																						
2mc3																						
2mc4	300	S			100	S					200	S	1000	S	200	S						
2-methylpentane											100	S	400	S	100	S						
3mepen											50	S			50	S						
Amylen					40	S																
C4													300	S								
Mecype	300	S			50	S					90	S	300	S	80	S						
Naphthalene	200	S																				
Pentan													300	S								
UNKNOWN GC/MS TIC (µg/L)																						
Unk047																						
Unk094																						
Unk098																						
Unk122																						
Unk134																						
Unk200					100	S							200	S								
Unk201	800	S																				
Unk203	500	S			50	S							200	S								
Unk207	500	S			100	S			40	S			200	S								
Unk211					200	S							600	S								
Unk212	1000	S																				
Unk221	500	S			50	S																
Unk232																	7	S				
Unk238	200	S																				
Unk515																						
Unk516																						
Unk521																						
Unk530																						

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

ANALYTE	Site ID:	XGM-93-02X	XGM-93-02X	XGM-94-03X	XGM-94-03X	XGM-94-03X	XGM-94-04X	XGM-94-04X	XGM-94-04X	XGM-94-05X	XGM-94-05X	XGM-94-06X
	Sample Date:	12/02/94	03/15/95	11/30/94	11/30/94	03/14/95	03/14/95	12/02/94	03/14/95	12/01/94	03/14/95	03/15/95
	Depth:	37.5	37.5	29	33	29	29	29	29	34.5	34.5	28
	Field Sample Number:	MXXG02X3	MXXG02X4	MXXG03X3	MXXG03X3	MXXG03X4	MDXG04X4	MXXG04X3	MXXG04X4	MXXG05X3	MXXG05X4	MXXG06X4
Unk531												
Unk535												
Unk536												
Unk537									4 S			
Unk540		700 S				6 S		100 S				
Unk541					20 S							
Unk542			400 S									
Unk544												
Unk546												
Unk547		500 S										
Unk548			80 S					40 S				
Unk549			200 S		5 S							
Unk550		900 S						200 S				
Unk551					10 S							
Unk552												
Unk553												
Unk554			70 S			30 S			10 S			
Unk555		80 S			5 S			30 S				
Unk556			70 S									
Unk557		100 S	100 S		4 S							
Unk558		200 S			8 S			20 S				
Unk559												
Unk560												
Unk561												
Unk562		60 S										
Unk564												
Unk565		60 S										
Unk566												
Unk567						4 S						
Unk570												
Unk571												
Unk572		40 S										
Unk573		80 S										
Unk574												
Unk576												
Unk577												
Unk578		60 S										
Unk579						7 S					30 S	
Unk581												
Unk582												
Unk585												
Unk606					7 S							
Unk607												
Unk608					6 S							
Unk609												
Unk610												
Unk613					5 S							
Unk614					4 S							
Unk615					4 S							
Unk616					10 S							
Unk617					6 S							
Unk618					10 S							
Unk619					7 S							
Unk620					9 S							
Unk621					900 S							
Unk622					5 S							
Unk624					5 S							
Unk645					300 S							
Unk647												

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

Site ID:	XGM-94-06X		XGM-94-07X		XGM-94-07X		XGM-94-07X		XGM-94-08X		XGM-94-08X		XGM-94-09X		XGM-94-09X		XGM-94-10X		XGM-94-10X	
Sample Date:	11/30/94		11/29/94		11/29/94		03/14/95		11/29/94		03/13/95		12/02/94		03/16/95		11/30/94		03/15/95	
Depth:	28		27		27		27		35		35		33.5		33.5		31.5		31.5	
ANALYTE Field Sample Number:	MXXH06X3		MDXG07X3		MXXG07X3		MXXG07X4		MXXG08X3		MXXG08X4		MXXG09X3		MXXG09X4		MXXG10X3		MXXG10X4	
PAL SEMIVOLATILE ORGANICS (µg/L)																				
1234mb																				
1,2,3-trimethylbenzene																				
12dmb							10	S												
135tmb							20	S					20	S	4	S				
13deb									6	S			4	S						
1,3-dimethylbenzene / M-xylene							20	S												
14dmb																				
1e2mb							10	S	20	S			20	S					9	S
1-methylnaphthalene																				
23dhio																				
3pt																				
C20																				
Et3mbz																				
Et4mbz											9	S								
Etc6h5									10	S										
Indan	4	S					10	S	7	S	5	S								
Isodur													3	S						
Isopbz															4	S				
Mec6h5																				
Pcymen																				
Prc6h5																				
Trimbz							7	S	20	S			40	S						
N-nitroso Dimethylamine																				
PAL VOLATILE ORGANICS (µg/L)																				
224tmp	100	S									70	S							40	S
234tmp	60	S	7	SD	9	S	20	S			40	S							20	S
23dmc4	20	S			6	S							60	S	9	S	100	S		
23dmc5	70	S			5	S	20	S	40	S	20	S	60	S	6	S			30	S
24dmc5	40	S									20	S								
2m2c3l	20	S							40	S										
2mc3									40	S										
2mc4	20	S	9	SD	10	S	20	S	300	S	20	S	200	S	40	S	900	S	20	S
2-methylpentane													80	S			300	S		
3mepen									70	S			70	S	10	S	200	S	30	S
Amylen																				
C4									70	S							100	S		
Mecype									50	S			60	S	5	S	200	S		
Naphthalene																				
Pentan													50	S	8	S	300	S		
UNKNOWN GC/MS TIC (µg/L)																				
Unk047									50	S										
Unk094			10	SD	20	S			40	S										
Unk098																				
Unk122	80	S	10	SD																
Unk134																				
Unk200																				
Unk201																				
Unk203																				
Unk207											9	S	40	S			100	S	8	S
Unk211													90	S			200	S		
Unk212																				
Unk221																				
Unk232																				
Unk238																				
Unk515	6	S																		
Unk516	8	S																		
Unk521																				
Unk530													7	S						

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 43G - HISTORIC GAS STATION G/AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA.

Site ID:	XGM-94-06X	XGM-94-07X	XGM-94-07X	XGM-94-07X	XGM-94-08X	XGM-94-08X	XGM-94-09X	XGM-94-09X	XGM-94-10X	XGM-94-10X
Sample Date:	11/30/94	11/29/94	11/29/94	03/14/95	11/29/94	03/13/95	12/02/94	03/16/95	11/30/94	03/15/95
Depth:	28	27	27	27	35	35	33.5	33.5	31.5	31.5
ANALYTE / Field Sample Number:	MXXH06X3	MDXG07X3	MXXG07X3	MXXG07X4	MXXG08X3	MXXG08X4	MXXG09X3	MXXG09X4	MXXG10X3	MXXG10X4
Unk531		10 SD	10 S							
Unk535										
Unk536		5 SD	4 S		7 S					
Unk537		5 SD	5 S		10 S					
Unk540							20 S			
Unk541										
Unk542	4 S									
Unk544										
Unk546							9 S			
Unk547										
Unk548										
Unk549	5 S									
Unk550	8 S				20 S		30 S			
Unk551										
Unk552										
Unk553										
Unk554	7 S		4 S	8 S		6 S	4 S			4 S
Unk555					4 S		6 S			
Unk556		10 SD	10 S				7 S			
Unk557					3 S		3 S			6 S
Unk558					4 S		10 S			
Unk559										
Unk560										
Unk561										
Unk562										
Unk564										
Unk565										
Unk566										
Unk567										
Unk570										
Unk571		5 SD	6 S							
Unk572										
Unk573										
Unk574										
Unk576							4 S			
Unk577										
Unk578										
Unk579										
Unk581										
Unk582										
Unk585		7 SD	7 S							
Unk606										
Unk607										
Unk608										
Unk609		30 SD	30 S							
Unk610				9 S						
Unk613										
Unk614										
Unk615										
Unk616										
Unk617										
Unk618										
Unk619										
Unk620										
Unk621										
Unk622										
Unk624										
Unk645										
Unk647										

TABLE 7–2
SUMMARY OF ANALYTES DETECTED IN METHOD BLANKS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Analyte	Frequency of Detection	Minimum Detection	Maximum Detection
Soil (µg/g)			
VOCs			
Toluene	1:27	0.00095	0.00095
Trifluorochloromethane	5:27	0.0063	0.01
Xylene	2:27	0.0019	0.014
Acetone	1:27	0.027	0.027
Chloroform	2:27	0.001	0.002
SVOCs			
Bis(2–ethylhexyl)phthalate	2:18	0.64	2.2
4–Methyl–3–penten–2–one	2:11	0.5	0.5
Di–n–butyl Phthalate	5:18	0.09	40
Pesticides/PCBs			
a–Chlordane	1:5	0.006	0.006
g–Chlordane	1:5	0.041	0.041
Heptachlor	1:5	0.032	0.032
Aqueous (µg/L)			
VOCs			
Toluene	1:32	0.51	0.51
Methylene Chloride	4:32	4.6	9.1
Chloroform	3:32	0.91	1.1
Acetone	3:32	16	53
Methyl Ethyl Ketone	1:32	9.5	9.5
SVOCs			
Bis(2–ethylhexyl)phthalate	5:19	5.6	200
1,2–Epoxycyclohexane	4:19	1.0	4.0
2–Cyclohexen–1–ol	1:19	3.0	3.0
2–Cyclohexen–1–one	1:19	4.0	4.0
Mesityl Oxide	1:19	2.0	2.0
Inorganics			
Iron	1:15	56	56
Lead	1:15	3.2	3.2
Miscellaneous			
Hardness	2:6	1200	1600
TDS	2:6	11000	12000
TSS	4:14	4000	7000

Notes:
VOC = volatile organic compound
SVOC = semivolatile organic compound
PCB = polychlorinated biphenyl
µg/g = micrograms per gram
TDS = Total Dissolved Solids
TSS = Total Suspended Solids
µg/L = micrograms per liter

TABLE 7–3
EQUIPMENT RINSATE SUMMARY
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Analyses	Frequency of Detection	Minimum Detection	Maximum Detection
VOCs (µg/L)			
1,1,1–Trichloroethane	4:6	1.8	6.8
Acetone	1:6	18	18
Methylene Chloride	2:6	2.8	4.0
Chloroform	1:6	1.3	1.3
SVOCs (µg/L)			
Di–n–butyl Phthalate	2:3	9.1	13
Inorganics			
Lead	3:7	1.52	3.4
Aluminum	1:5	499	499
Iron	2:5	48	1120
Manganese	2:5	3.5	30.2
Arsenic	1:5	3.8	3.8
Calcium	1:5	4790	4790
Potassium	1:5	488	488
Miscellaneous (µg/L)			
TOC	1:3	1340	1340

Notes:

VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound
TOC = total organic carbon
µg/L = micrograms per liter

TABLE 7–4
TRIP BLANK SUMMARY
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Analyses	Frequency of Detection	Minimum Detection	Maximum Detection
VOCs (µg/L)			
Total Xylenes	1:42	1.9	1.9
Acetone	1:42	29	29
Methylene Chloride	8:42	2.6	17
Chloroform	1:42	0.81	0.81

Notes:

VOC = Volatile Organic Compound
µg/L = micrograms per liter

TABLE 7-5
SI FIELD ANALYTICAL SUBSURFACE SOIL/SOIL GAS SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 1 SOIL						
ANALYTE	TS-04 9 FT	TS-04 12 FT	TS-09 9 FT	TS-09 12 FT	TS-10 11 FT	TS-11 9 FT	TS-11 11 FT
ORGANICS (µg/g)	43TSG04XX901XF	43TSG04X1201SF	43TSG09XX901XF	43TSG09X1201XF	43TSG10X1101XF	43TSG11XX901XF	43TSG11X1201XF
BENZENE	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND
m/p-XYLENE	ND	ND	ND	ND	ND	ND	ND
o-XYLENE	ND	ND	ND	ND	ND	ND	ND
OTHER							
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	830	< 54	< 54	< 54	130	130	190

Notes:

NA = Not analyzed
ND = Non-detect
mg/kg = milligram per kilogram
µg/g = microgram per gram

TABLE 7–5
SI FIELD ANALYTICAL SUBSURFACE SOIL/SOIL GAS SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 1 SOIL GAS						
ANALYTE	TS–01 8 FT	TS–02 8 FT	TS–03 8 FT	TS–04 8 FT	TS–05 8 FT	TS–06 8 FT	TS–07 8 FT
ORGANICS (µg/g)	43TGG01XX801XF	43TGG02XX801XF	43TGG03XX801XF	43TGG04XX801XF	43TGG05XX801XF	43TGG06XX801XF	43TGG07XX801XF
BENZENE	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND
m/p–XYLENE	ND	ND	ND	ND	ND	ND	ND
o–XYLENE	ND	ND	ND	ND	ND	ND	ND
OTHER							
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	NA	NA	NA	NA	NA	NA	NA

Notes:

NA = Not analyzed
ND = Non–detect
mg/kg = milligram per kilogram
µg/g = microgram per gram

TABLE 7–5
SI FIELD ANALYTICAL SUBSURFACE SOIL/SOIL GAS SAMPLES
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 1 SOIL GAS		
	TS–08	TS–09	TS–10
ANALYTE	8 FT	8 FT	8 FT
ORGANICS (µg/g)	43TGG08XX801XF	43TGG09XX801XF	43TGG10XX801XF
BENZENE	ND	ND	ND
TOLUENE	ND	ND	ND
ETHYLBENZENE	ND	ND	ND
m/p–XYLENE	ND	ND	ND
o–XYLENE	ND	ND	ND
OTHER			
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	NA	NA	NA

Notes:

NA = Not analyzed
ND = Non–detect
mg/kg = milligram per kilogram
µg/g = microgram per gram

TABLE 7-6
SSI FIELD ANALYTICAL SUBSURFACE SOIL SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 3								
ANALYTE	TS-01 10 FT	TS-02 9 FT	TS-02 10 FT	TS-02 11 FT	TS-03 9 FT	TS-03 10 FT	TS-04 10 FT	TS-05 10 FT	TS-07 10 FT
ORGANICS (mg/kg)	**TSG0110F**	**TSG0209F**	**TSG0210F**	**TSG0211F**	**TSG0309F**	**TSG0310F**	**TSG0410F**	**TSG0510F**	**TSG0710F**
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	0.00016	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0049	< 0.0001
ETHYLBENZENE	< 0.0001	0.0044	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0013	0.0013	< 0.0001
m/p-XYLENE	< 0.0001	0.0088	0.0003	< 0.0001	< 0.0001	< 0.0001	0.0034	0.12	< 0.0001
o-XYLENE	< 0.0001	0.012	< 0.0001	< 0.0001	< 0.0001	0.0008	0.0024	0.058	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	< 52	8500	210	120	960	NA	110	110	< 51

TABLE 7-6
SSI FIELD ANALYTICAL SUBSURFACE SOIL SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 3		AREA 2						
ANALYTE	TS-08 10 FT	TS-10 10 FT	TS-13 10 FT	TS-14 10 FT	TS-18 9 FT	TS-19 9 FT	TS-19 10 FT	TS-20 9 FT	TS-20 11 FT
ORGANICS (mg/kg)	TSG0810F	TSG1010F	TSG1310F	TSG1410F	TSG1809F	TSG1909F	TSG1910F	TSG2009F	TSG2011F
BENZENE	0.14	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	0.29	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	14	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	13	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	5.5	< 0.0001	0.0063	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	3300	< 54	74	500	140	200	2300	< 52	560

TABLE 7-6
SSI FIELD ANALYTICAL SUBSURFACE SOIL SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 2								
ANALYTE	TS-21 9 FT	TS-22 13 FT	TS-23 9 FT	TS-24 9 FT	TS-25 9 FT	TS-26 9 FT	TS-26 11 FT	TS-28 11 FT	TS-29 9 FT
ORGANICS (mg/kg)	TSG2109F	TSG2213F	TSG2309F	TSG2409F	TSG2509F	TSG2609F	TSG2611F	TSG2811F	TSG2909F
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	NA	160	64	130	< 53	< 53	< 53	< 53	950

TABLE 7-6
SSI FIELD ANALYTICAL SUBSURFACE SOIL SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 2						AREA 1		
ANALYTE	TS-30 9 FT	TS-30 10 FT	TS-31 9 FT	TS-32 9 FT	TS-33 9 FT	TS-34 9 FT	TS-35 10 FT	TS-35 11 FT	TS-36 10 FT
ORGANICS (mg/kg)	TSG3009F	TSG3010F	TSG3109F	TSG3209F	TSG3309F	TSG3409F	TSG3510F	TSG3511F	TSG3610F
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	< 0.0001	0.0013	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	< 0.0001	< 0.0001	0.0009	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	< 0.0001	< 0.0001	0.001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER									
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	460	120	5800	230	< 54	< 54	400	< 53	< 52

TABLE 7-6
SSI FIELD ANALYTICAL SUBSURFACE SOIL SAMPLES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	AREA 1						
ANALYTE	TS-36 11 FT	TS-37 10 FT	TS-37 11 FT	TS-38 10 FT	TS-38 11 FT	TS-39 10 FT	TS-39 11 FT
ORGANICS (mg/kg)	**TSG3611F**	**TSG3710F**	**TSG3711F**	**TSG3810F**	**TSG3811F**	**TSG3910F**	**TSG3911F**
BENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
TOLUENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
ETHYLBENZENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m/p-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
o-XYLENE	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
OTHER							
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	< 52	270	54	190	52	740	2000

Notes:
< = Less than detection limit.
mg/kg = milligram per kilogram

TABLE 7-7
RI SOIL BORING FIELD ANALYTICAL RESULTS
AOC 43G - HISTORY GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

DETAIL	XGB-94-10X 20 ft SBG1020F	XGB-94-10X 25 ft SBG1025F	XGB-94-11X 15 ft SBG1115F	XGB-94-11X 25 ft SBG1125F	XGB-94-11X 27 ft SBG1127F	XGB-94-12X 15 ft SBG1215F	XGB-94-12X 20 ft SBG1220F	XGB-94-12X 25 ft SBG1225F	XGB-94-12X 27 ft SBG1227F	XGB-94-13X 10 ft SBG1310F
VOCs (µg/g)										
VINYL CHLORIDE	<2300	<2200	<4.2	<1100	<23	<4.2	<1100	<2300	<5700	<4.6
t-1,2-DCE	<1100	<1100	<2.1	<550	<11	<2.1	<560	<1100	<2800	<2.3
c-1,2-DCE	<1100	<1100	<2.1	<550	<11	<2.1	<560	<1100	<2800	<2.3
BENZENE	<1100	<1100	<2.1	<550	18	<2.1	<560	<1100	<2800	<2.3
TCE	<1100	<1100	<2.1	<550	<11	<2.1	<560	<1100	<2800	<2.3
TOLUENE	26000	25000	<2.1	<550	20	<2.1	25000	24000	3200	<2.3
PCE	<1100	<1100	<2.1	<550	<11	<2.1	<560	<1100	<2800	<2.3
ETHYLBENZENE	19000	22000	<2.1	4000	120	<2.1	15000	43000	15000	<2.3
m/p-XYLENE	150000E	170000E	<4.2	33000	820	<4.2	98000E	210000E	100000	<4.6
o-XYLENE	72000E	85000E	<2.1	19000	390	<2.1	47000E	100000E	35000	<2.3
1,1,2,2-TCA	<2300	<2200	<4.2	<1100	<23	<4.2	<1100	<2300	<5700	<4.6
1,2-DICHLOROBENZENE	<1100	<1100	<2.1	<550	<11	<2.1	<560	<1100	<2800	<2.3
TPH (mg/kg)	2400	1800	<53	1400	360	340	3800	2800	2700	<57

NOTES:
mg/kg = milligram per kilogram
PCE = tetrachloroethene
TCE = trichloroethene
VOC = volatile organic compound
µg/g = microgram per gram

TABLE 7-7
RI SOIL BORING FIELD ANALYTICAL RESULTS
AOC 43G - HISTORY GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

DETAIL	XGB-94-13X 15 ft SBG1315F	XGB-94-13X 20 ft SBG1320F	XGB-94-13X 30 ft SBG1330F	XGB-94-14X 15 ft SBG1415F	XGB-94-14X 20 ft SBG1420F	XGB-94-14X 25 ft SBG1425F	XGB-94-15X 15 ft SBG1520F	XGB-94-15X 20 ft SBG1520F	XGB-94-15X 25 ft SBG1525F	XGB-94-15X 27 ft SBG1527F
VOCs (µg/g)										
VINYL CHLORIDE	<4.2	<4.2	<4.3	<4.5	<4.5	<4.7	<4.5	<4.5	<4.6	<4.6
t-1,2-DCE	<2.1	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
c-1,2-DCE	<2.1	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
BENZENE	<2.0	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
TCE	<2.1	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
TOLUENE	<2.0	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
PCE	<2.0	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
ETHYLBENZENE	<2.0	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
m/p-XYLENE	<4.0	<4.2	<4.3	<4.5	<4.5	<4.7	<4.5	<4.5	<4.6	<4.6
o-XYLENE	<2.0	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
1,1,2,2-TCA	<4.2	<4.2	<4.3	<4.5	<4.5	<4.7	<4.5	<4.5	<4.6	<4.6
1,2-DICHLOROBENZENE	<2.1	<2.1	<2.2	<2.2	<2.2	<2.3	<2.3	<2.3	<2.3	<2.3
TPH (mg/kg)	<50	<52	<54	<56	<56	<59	<57	<57	<58	<57

NOTES:
mg/kg = milligram per kilogram
PCE = tetrachloroethene
TCE = trichloroethene
VOC = volatile organic compound
µg/g = microgram per gram

TABLE 7-8
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G /AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

			SI		SSI			
ANALYTES	FORT DEVENS BACKGROUND CONCENTRATIONS	Site ID: Depth Field Sample Number:	43G-92-01X 10 ft BX433110	43G-92-01X 20 ft BX43H109	XGB-93-03X 8 ft BXXG0308	XGB-93-03X 12 ft BXXG0312	XGB-93-03X 20 ft BXXG0320	XGB-93-04X 8 ft BXXG0408
PAL METALS (µg/g)								
Aluminum	18000		NA	NA	11200	5100	7520	10000
Antimony	0.5		NA	NA	<1.09	<1.09	<1.09	<1.09
Arsenic	19		NA	NA	17	31	19	51
Barium	54		NA	NA	23.5	14.6	23.3	53.3
Beryllium	0.81		NA	NA	<.5	<.5	<.5	<.5
Cadmium	1.28		NA	NA	<.7	<.7	<.7	2.61
Calcium	810		NA	NA	1130	405	554	1570
Chromium	33		NA	NA	21.2	17.4	19.2	46
Cobalt	4.7		NA	NA	5.26	6.99	11	3.56
Copper	13.5		NA	NA	10.2	9.09	27.1	29.2
Iron	18000		NA	NA	11300	9660	21700	10400
Lead	48		8.8	8.19	14	5.12	8.6	11
Magnesium	5500		NA	NA	2250	2550	3330	4760
Manganese	380		NA	NA	229	239	501	86.6
Nickel	14.6		NA	NA	19.5	22.4	40.8	20.4
Potassium	2400		NA	NA	568	774	995	1180
Sodium	234		NA	NA	296	287	254	342
Vanadium	32.3		NA	NA	15.1	8.24	8.18	18.3
Zinc	43.9		NA	NA	24.1	21.3	33.8	87.6
PAL SEMIVOLATILE ORGANICS (µg/g)								
2-methylnaphthalene			NA	NA	<.5	<.049	.17	.72
Acenaphthylene			NA	NA	<.3	<.033	<.033	<.3
Anthracene			NA	NA	<.3	<.033	<.033	<.3
Benzo [a] Anthracene			NA	NA	<2	<.17	<.17	<2
Benzo [a] Pyrene			NA	NA	<2	<.25	<.25	<2
Benzo [b] Fluoranthene			NA	NA	<2	<.21	<.21	<2
Benzo [g,h,i] Perylene			NA	NA	<2	<.25	<.25	<2
Benzo [k] Fluoranthene			NA	NA	<.7	<.066	<.066	<.7
*Bis (2-ethylhexyl) Phthalate			NA	NA	<6	<.62	.96	<6
Chrysene			NA	NA	<1	<.12	<.12	<1
*Di-n-butyl Phthalate			NA	NA	<.6	.48 B	.76 B	<.061
Fluoranthene			NA	NA	<.7	<.068	<.068	<.7
Fluorene			NA	NA	<.3	<.033	<.033	<.033
Indeno [1,2,3-c,d] Pyrene			NA	NA	<3	<.29	<.29	<3
Naphthalene			NA	NA	<.4	<.037	<.037	.46
Phenanthrene			NA	NA	<.3	<.033	<.033	<.3
Pyrene			NA	NA	<.3	<.033	<.033	<.3
PAL VOLATILE ORGANICS (µg/g)								
Toluene			<.00078	<.00078	<.00078	<.00078	<.00078	.02
Ethylbenzene			<.0017	<.0017	<.0017	<.0017	.0024	.03
xylenes			<.0015	<.0015	.0084	<.0015	.019	.6
*Acetone			<.017	<.017	<.017	<.017	<.017	<.08
Benzene			<.0015	<.0015	<.0015	<.0015	<.0015	<.008
*Trichlorofluoromethane			<.0059	<.0059	<.0059	<.0059	.006	.03
OTHER (µg/g)								
Total Organic Carbon			NA	436	NA	NA	1590	NA
Total Petroleum Hydrocarbons			<27.7	<27.9	359	59.2	62.6	1020

TABLE 7-8
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G /AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

			SSI					
ANALYTES	FORT DEVENS BACKGROUND CONCENTRATIONS	Site ID: Depth Field Sample Number:	XGB-93-04X 12 ft BXXG0412	XGB-93-04X 25 ft BXXG0425	XGB-93-05X 8 ft BXXG0508	XGB-93-05X 12 ft BXXG0512	XGB-93-05X 25 ft BXXG0525	XGB-93-06X 8 ft BXXG0608
PAL METALS (µg/g)								
Aluminum	18000		9040	9270	5340	12200	5550	3770
Antimony	0.5		<1.09	<1.09	<1.09	<1.09	<1.09	<1.09
Arsenic	19		28	14	16	21	8.53	8.21
Barium	54		29.2	25	22.9	56.5	20	21.5
Beryllium	0.81		<.5	<.5	.964	1.38	1.25	.996
Cadmium	1.28		<.7	<.7	<.7	<.7	<.7	<.7
Calcium	810		1000	1930	1190	660	614	651
Chromium	33		36.8	23.1	32	37.4	11.7	8.89
Cobalt	4.7		9.93	7.08	4.56	9.94	6.1	1.67
Copper	13.5		17.3	15.3	14.4	11.3	9.66	6.54
Iron	18000		19300	17600	10700	15300	12100	9460
Lead	48		57	8.5	50	8.8	5.29	3.8
Magnesium	5500		6100	3910	2850	5570	1900	1590
Manganese	380		267	194	130	324	280	81.7
Nickel	14.6		38.3	24.1	20.3	33.4	21.2	6.08
Potassium	2400		1340	1110	702	2580	760	1440
Sodium	234		419	373	283	267	268	306
Vanadium	32.3		19.9	12.8	14.3	26.3	8.73	11.6
Zinc	43.9		36.6	31.6	208	33.9	24.1	18.2
PAL SEMIVOLATILE ORGANICS (µg/g)								
2-methylnaphthalene			<.049	<.049	<.5	<.049	<.049	<.049
Acenaphthylene			<.033	<.033	5	<.033	<.033	<.033
Anthracene			<.033	<.033	4	<.033	<.033	<.033
Benzo [a] Anthracene			<.17	<.17	7	<.17	<.17	<.17
Benzo [a] Pyrene			<.25	<.25	10	<.25	<.25	<.25
Benzo [b] Fluoranthene			<.21	<.21	30	<.21	<.21	<.21
Benzo [g,h,i] Perylene			<.25	<.25	3	<.25	<.25	<.25
Benzo [k] Fluoranthene			<.066	<.066	6	<.066	<.066	<.066
*Bis (2-ethylhexyl) Phthalate			<.62	<.62	<6	<.62	<.62	<.62
Chrysene			<.12	<.12	10	<.12	<.12	<.12
*Di-n-butyl Phthalate			.45 B	.36 B	<.6	.43	.56	.52
Fluoranthene			<.068	<.068	20	<.068	<.068	<.068
Fluorene			<.033	<.033	1	<.033	<.033	<.033
Indeno [1,2,3-c,d] Pyrene			<.29	<.29	4	<.29	<.29	<.29
Naphthalene			<.037	<.037	.5	<.037	<.037	<.037
Phenanthrene			<.033	<.033	10	<.033	<.033	<.033
Pyrene			<.033	<.033	10	<.033	<.033	<.033
PAL VOLATILE ORGANICS (µg/g)								
Toluene			<.00078	<.00078	<.00078	<.00078	<.00078	<.00078
Ethylbenzene			<.0017	<.0017	<.0017	<.0017	<.0017	<.0017
xylenes			<.0015	<.0015	<.0015	<.0015	<.0015	<.0015
*Acetone			<.017	.024	.047	<.017	<.017	<.017
Benzene			<.0015	<.0015	<.0015	<.0015	<.0015	<.0015
*Trichlorofluoromethane			<.0059	<.0059	.01	<.0059	<.0059	<.0059
OTHER (µg/g)								
Total Organic Carbon			NA	845	27400	NA	NA	NA
Total Petroleum Hydrocarbons			213	40.8	185	<28.7	<28.7	<28.5

TABLE 7-8
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G /AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

			SSI					
ANALYTES	FORT DEVENS BACKGROUND CONCENTRATIONS	Site ID: Depth Field Sample Number:	XGB-93-06X 12 ft BXXG0612	XGB-93-07X 10 ft BXXG0710	XGB-93-08X 8 ft BXXG0808	XGB-93-08X 12 ft BXXG0812	XGB-93-08X 17 ft BXXG0817	XGB-93-09X 8 ft BXXG0908
PAL METALS (µg/g)								
Aluminum	18000		4220	8410	12000	2440	11600	4010
Antimony	0.5		<1.09	<1.09	<1.09	<1.09	<1.09	<1.09
Arsenic	19		7.15	8.07	52	49	45	37
Barium	54		22.5	66.5	34.4	7.16	42.6	10.2
Beryllium	0.81		1.08	<.5	<.5	<.5	<.5	<.5
Cadmium	1.28		<.7	<.7	<.7	<.7	<.7	<.7
Calcium	810		867	2000	895	304	1330	456
Chromium	33		12.8	28	45.5	9.86	60.2	13
Cobalt	4.7		<1.42	7.71	13.2	3.5	12.6	4.43
Copper	13.5		7.98	10.8	20.7	4.16	31.8	8.76
Iron	18000		11400	14600	21200	5250	22200	7910
Lead	48		4.44	3.58	20	12	12	5.73
Magnesium	5500		1760	5670	8870	1840	8960	2470
Manganese	380		89.5	264	372	121	407	138
Nickel	14.6		6.25	21.2	53.9	12.7	55.7	18.9
Potassium	2400		1420	4290	2470	576	3060	621
Sodium	234		292	330	290	489	291	285
Vanadium	32.3		14	24.1	25.1	5.49	22.6	6.86
Zinc	43.9		21.5	35.7	45.6	12.1	48.4	17.4
PAL SEMIVOLATILE ORGANICS (µg/g)								
2-methylnaphthalene			<.2	<.049	<.049	<.049	<.049	<.049
Acenaphthylene			<.2	<.033	<.033	<.033	<.033	<.033
Anthracene			<.2	<.033	<.033	<.033	<.033	<.033
Benzo [a] Anthracene			<.8	<.17	<.17	<.17	<.17	<.17
Benzo [a] Pyrene			<1	<.25	<.25	<.25	<.25	<.25
Benzo [b] Fluoranthene			<1	<.21	<.21	<.21	<.21	<.21
Benzo [g,h,i] Perylene			<1	<.25	<.25	<.25	<.25	<.25
Benzo [k] Fluoranthene			<.3	<.066	<.066	<.066	<.066	<.066
*Bis (2-ethylhexyl) Phthalate			<3	<.62	<.62	<.62	<.62	<.62
Chrysene			<.6	<.12	<.12	<.12	<.12	<.12
*Di-n-butyl Phthalate			.6	<.061	.25	.15	.18	.27
Fluoranthene			<.3	<.068	<.068	<.068	<.068	<.068
Fluorene			<.2	<.033	<.033	<.033	<.033	<.033
Indeno [1,2,3-c,d] Pyrene			<1	<.29	<.29	<.29	<.29	<.29
Naphthalene			<.2	<.037	<.037	<.037	<.037	<.037
Phenanthrene			<.2	<.033	<.033	<.033	<.033	<.033
Pyrene			<.2	<.033	<.033	<.033	<.033	<.033
PAL VOLATILE ORGANICS (µg/g)								
Toluene			<.00078	<.00078	<.00078	<.00078	<.00078	<.00078
Ethylbenzene			<.0017	<.0017	<.0017	<.0017	<.0017	<.0017
xylenes			<.0015	<.0015	<.0015	<.0015	<.0015	<.0015
*Acetone			<.017	<.017	<.017	<.017	<.017	<.017
Benzene			<.0015	<.0015	<.0015	<.0015	<.0015	<.0015
*Trichlorofluoromethane			.0057	.0071	.009	.01	<.0059	.0056
OTHER (µg/g)								
Total Organic Carbon			NA	NA	NA	NA	1250	NA
Total Petroleum Hydrocarbons			158	<28.8	<28.7	<28.8	<28.7	<28.7

TABLE 7-8
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G /AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

			SSI		RI			
ANALYTES	FORT DEVENS BACKGROUND CONCENTRATIONS	Site ID: Depth Field Sample Number:	XGB-93-09X 12 ft BXXG0912	XGB-93-09X 20 ft BXXG0920	XGB-94-10X 20 ft BXXG1020	XGB-94-10X 25 ft BXXG1025	XGB-94-11X 15 ft BXXG1115	XGB-94-11X 25 ft BXXG1125
PAL METALS (µg/g)								
Aluminum	18000		26600	8700	8580	4760	7330	2330
Antimony	0.5		4.01	1.51	<1.09	<1.09	<1.09	<1.09
Arsenic	19		41	32	15	11	10.9	14
Barium	54		89.3	28.1	22.5	15.6	31	14.5
Beryllium	0.81		<.5	<.5	<.5	.728	<.5	<.5
Cadmium	1.28		<.7	<.7	<.7	<.7	<.7	<.7
Calcium	810		5190	1030	448	462	1060	9680
Chromium	33		93.7	21.2	22	11	29.1	8.66
Cobalt	4.7		18.7	16.6	7.71	4.79	5.23	15.7
Copper	13.5		37.5	27.9	13.7	18.1	9.63	24.7
Iron	18000		34000	30300	14600	11600	10600	25500
Lead	48		13	15	8.66	6.72	5.57	9
Magnesium	5500		13700	3860	4090	1880	4720	4160
Manganese	380		632	621	472	197	175	565
Nickel	14.6		87	69.6	31.1	24.1	22.3	78.3
Potassium	2400		6170	1160	1040	496	1780	459
Sodium	234		1280	345	403	358	368	367
Vanadium	32.3		51	11.8	12.1	8.09	19.5	4.83
Zinc	43.9		68	62.3	38	29.9	35.1	57
PAL SEMIVOLATILE ORGANICS (µg/g)								
2-methylnaphthalene			<.049	<.049	2.6	7.8	<.049	3
Acenaphthylene			<.033	<.033	<.033	<.033	.069	<.033
Anthracene			<.033	<.033	<.033	.049	.1	<.033
Benzo [a] Anthracene			<.17	<.17	<.17	<.17	.25	<.17
Benzo [a] Pyrene			<.25	<.25	<.25	<.25	<.25	<.25
Benzo [b] Fluoranthene			<.21	<.21	<.21	<.21	<.21	<.21
Benzo [g,h,i] Perylene			<.25	<.25	<.25	<.25	<.25	<.25
Benzo [k] Fluoranthene			<.066	<.066	<.066	<.066	.14	<.066
*Bis (2-ethylhexyl) Phthalate			<.62	<.62	.79	<.62	9.1	.87
Chrysene			<.12	<.12	<.12	<.12	.36	<.12
*Di-n-butyl Phthalate			.27	.49	<.061	<.061	<.061	<.061
Fluoranthene			<.068	<.068	<.068	<.068	.62	<.068
Fluorene			<.033	<.033	.16	.38	.088	.22
Indeno [1,2,3-c,d] Pyrene			<.29	<.29	<.29	<.29	<.29	<.29
Naphthalene			<.037	<.037	1.6	2.8	<.037	1.1
Phenanthrene			<.033	<.033	.092	.24	.52	.12
Pyrene			<.033	<.033	<.033	.091	.73	.073
PAL VOLATILE ORGANICS (µg/g)								
Toluene			<.00078	<.00078	30	50	.00083	1
Ethylbenzene			<.0017	<.0017	9	20	<.0017	4
xylenes			<.0015	<.0015	100	300	<.0015	40
*Acetone			<.017	<.017	<.8	<2	<.017	<.8
Benzene			<.0015	<.0015	2	2	<.0015	<.08
*Trichlorofluoromethane			.0057	<.0059	<.3	<.6	<.0059	<.3
OTHER (µg/g)								
Total Organic Carbon			NA	687	2680	1620	NA	NA
Total Petroleum Hydrocarbons			<28.7	<28.7	442	892	357	287

TABLE 7-8
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G /AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

			RI					
ANALYTES	FORT DEVENS BACKGROUND CONCENTRATIONS	Site ID: Depth Field Sample Number:	XGB-94-12X 15 ft BXXG1215	XGB-94-12X 27 ft BXXG1227	XGB-94-13X 15 ft BXXG1315	XGB-94-13X 25 ft BXXG1325	XGB-94-14X 15 ft BXXG1415	XGB-94-14X 25 ft BXXG1425
PAL METALS (µg/g)								
Aluminum	18000		8970	<2.35	13500	6090	7050	5750
Antimony	0.5		<1.09	<1.09	<1.09	<1.09	<1.09	1.91
Arsenic	19		29	15	30	15	19	38
Barium	54		44	<5.18	54.3	18	31.2	9.98
Beryllium	0.81		<.5	<.5	.629	<.5	<.5	<.5
Cadmium	1.28		<.7	<.7	<.7	<.7	<.7	<.7
Calcium	810		1010	<100	891	668	339	2400
Chromium	33		40.2	<4.05	48.3	12.9	11.7	15.4
Cobalt	4.7		6.78	<1.42	10.6	5.13	4.46	14.5
Copper	13.5		16.7	<.965	16.6	8.72	9.25	21.7
Iron	18000		15100	11.5	19000	11600	9590	19800
Lead	48		10.3	7.61	9.6	6.87	6.72	9.97
Magnesium	5500		6070	<100	9530	2480	2030	3490
Manganese	380		225	<2.05	373	222	218	1130
Nickel	14.6		36.8	<1.71	44.9	21.9	18.8	57.8
Potassium	2400		1910	<100	4190	691	821	446
Sodium	234		462	<100	350	343	534	403
Vanadium	32.3		21.3	<3.39	29.5	8.4	7.46	7.03
Zinc	43.9		37.4	<8.03	48.1	27.6	27.6	54.3
PAL SEMIVOLATILE ORGANICS (µg/g)								
2-methylnaphthalene			<.2	10	<.049	<.049	<.049	<.049
Acenaphthylene			<.2	<.033	<.033	<.033	<.033	<.033
Anthracene			<.2	.051	<.033	<.033	<.033	<.033
Benzo [a] Anthracene			<.8	<.17	<.17	<.17	<.17	<.17
Benzo [a] Pyrene			<1	<.25	<.25	<.25	<.25	<.25
Benzo [b] Fluoranthene			<1	<.21	<.21	<.21	<.21	<.21
Benzo [g,h,i] Perylene			<1	<.25	<.25	<.25	<.25	<.25
Benzo [k] Fluoranthene			<.3	<.066	<.066	<.066	<.066	<.066
*Bis (2-ethylhexyl) Phthalate			<3	<.62	<.62	<.62	<.62	<.62
Chrysene			<.6	<.12	<.12	<.12	<.12	<.12
*Di-n-butyl Phthalate			<.3	<.061	<.061	<.061	<.061	<.061
Fluoranthene			<.3	<.068	<.068	<.068	<.068	<.068
Fluorene			<.2	.96	<.033	<.033	<.033	<.033
Indeno [1,2,3-c,d] Pyrene			<1	<.29	<.29	<.29	<.29	<.29
Naphthalene			<.2	6	<.037	<.037	<.037	<.037
Phenanthrene			<.2	.3	<.033	<.033	<.033	<.033
Pyrene			<.2	.12	<.033	<.033	<.033	<.033
PAL VOLATILE ORGANICS (µg/g)								
Toluene			<.00078	3	<.00078	<.00078	<.00078	<.00078
Ethylbenzene			<.0017	20	<.0017	<.0017	<.0017	<.0017
xylenes			.0019	200	.0042	.0037	.0051	<.0015
*Acetone			<.017	3	<.017	<.017	<.017	<.017
Benzene			<.0015	.2	<.0015	<.0015	.0027	<.0015
*Trichlorofluoromethane			.025	<.6	.013	.024	.0089	<.0059
OTHER (µg/g)								
Total Organic Carbon			3490	NA	NA	829	NA	NA
Total Petroleum Hydrocarbons			304	1730	47.5	40.5	41	41.2

TABLE 7–8
SOIL BORING OFF–SITE LABORATORY ANALYTICAL RESULTS
AOC 43G – HISTORIC GAS STATION G /AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

			RI		SSI		RI	
ANALYTES	FORT DEVENS BACKGROUND CONCENTRATIONS	Site ID: Depth Field Sample Number:	XGB–94–15X 15 ft BXXG1515	XGB–94–15X 27 ft BXXG1527	XGM–93–01X 19 ft BXXG0119	XGM–93–02X 24 ft BXXG0224	XGM–94–06X 20 ft BXXG0620	XGM–94–09X 25 ft BXXGO925
PAL METALS (µg/g)								
Aluminum	18000		9720	4880	3380	7870	NA	NA
Antimony	0.5		<1.09	1.64	<1.09	<1.09	NA	NA
Arsenic	19		14	25	34	13	NA	NA
Barium	54		29.3	9.59	22.6	28.2	NA	NA
Beryllium	0.81		<.5	<.5	<.5	<.5	NA	NA
Cadmium	1.28		<.7	<.7	<.7	<.7	NA	NA
Calcium	810		458	1400	13000	698	NA	NA
Chromium	33		26.1	16	9.63 I	19.3 I	NA	NA
Cobalt	4.7		8.05	15.3	11.3	6.75	NA	NA
Copper	13.5		13.6	18	17.8	11.1	NA	NA
Iron	18000		17500	21000	25900	16100	NA	NA
Lead	48		7.34	7.1	12 I	6.26 I	NA	NA
Magnesium	5500		3800	3100	2780	3280	NA	NA
Manganese	380		487	578	880	331	NA	NA
Nickel	14.6		35.7	79.6	50.3	24.1	NA	NA
Potassium	2400		1120	333	612	1240	NA	NA
Sodium	234		485	386	338	390	NA	NA
Vanadium	32.3		11.6	6.11	5.78	11.8	NA	NA
Zinc	43.9		36.7	53.9	53.8	34	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/g)								
2–methylnaphthalene			<.049	<.049	<.049	<.049	NA	NA
Acenaphthylene			<.033	<.033	<.033	<.033	NA	NA
Anthracene			<.033	<.033	<.033	<.033	NA	NA
Benzo [a] Anthracene			<.17	<.17	<.17	<.17	NA	NA
Benzo [a] Pyrene			<.25	<.25	<.25	<.25	NA	NA
Benzo [b] Fluoranthene			<.21	<.21	<.21	<.21	NA	NA
Benzo [g,h,i] Perylene			<.25	<.25	<.25	<.25	NA	NA
Benzo [k] Fluoranthene			<.066	<.066	<.066	<.066	NA	NA
*Bis (2–ethylhexyl) Phthalate			.76	<.62	<.62	<.62	NA	NA
Chrysene			<.12	<.12	<.12	<.12	NA	NA
*Di–n–butyl Phthalate			<.061	<.061	.88	<.061	NA	NA
Fluoranthene			<.068	<.068	<.068	<.068	NA	NA
Fluorene			<.033	<.033	<.033	<.033	NA	NA
Indeno [1,2,3–c,d] Pyrene			<.29	<.29	<.29	<.29	NA	NA
Naphthalene			<.037	<.037	<.037	<.037	NA	NA
Phenanthrene			<.033	<.033	<.033	<.033	NA	NA
Pyrene			<.033	<.033	<.033	<.033	NA	NA
PAL VOLATILE ORGANICS (µg/g)								
Toluene			<.00078	<.00078	<.00078	<.00078	NA	NA
Ethylbenzene			<.0017	<.0017	<.0017	<.0017	NA	NA
xylenes			<.0015	<.0015	<.0015	<.0015	NA	NA
*Acetone			<.017	<.017	<.017	<.017	NA	NA
Benzene			<.0015	<.0015	<.0015	<.0015	NA	NA
*Trichlorofluoromethane			<.0059	<.0059	<.0059	<.0059	NA	NA
OTHER (µg/g)								
Total Organic Carbon			844	NA	2490	576	3650	3530
Total Petroleum Hydrocarbons			<28	41.5	<28.8	<28.8		

Notes:
< – Less than the detection limit
NA = Not analyzed
* – Probable Laboratory Contaminant
Shaded values exceed background concentrations.
1 – Source for background concentration data is RI Report for Functional Area II, Fort Devens, MA, August 1994 by Ecology and Environment, Inc. for the U.S. Army Environmental Center. The value presented for background is the maximum of the range of concentrations.

TABLE 7–9
SCREENED AUGER RESULTS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

DETAIL	SAG01 17 ft SAG0117W	SAG02 20 ft SAG0220W	XGM–94–06X 20 ft SAG0620W	XGM–94–06X 27 ft SAG0627W	XGP–94–09X 29 ft SAG0929W	XGM–94–09X 30 ft SAG0930W	XGM–94–10X 30 ft SAG1030W
VOCs (µg/L)							
VINYL CHLORIDE	<4.0	<4.0	<4.0	<4.0	<20	<4.0	<4.0
t–1,2–DCE	<2.0	<2.0	<2.0	<2.0	<10	<2.0	<2.0
c–1,2–DCE	<2.0	<2.0	<2.0	<2.0	<10	<2.0	<2.0
BENZENE	<2.0	23	4.8	9.2	39	3.3	<2.0
TCE	<2.0	<2.0	<2.0	<2.0	<10	<2.0	<2.0
TOLUENE	<2.0	3.6	<2.0	<2.0	42	<2.0	<2.0
PCE	3.2	4.7	<2.0	<2.0	<10	<2.0	<2.0
ETHYLBENZENE	<2.0	5.4	<2.0	<2.0	57	<2.0	3.6
m/p–XYLENE	<4.0	5.6	<4.0	<4.0	78	<4.0	<4.0
o–XYLENE	<2.0	<2.0	<2.0	<2.0	50	<2.0	<2.0
1,1,2,2–TCA	<4.0	<4.0	<4.0	<4.0	<20	<4.0	<4.0
1,2–DICHLOROBENZENE	<2.0	<2.0	<2.0	<2.0	<10	<2.0	<2.0

NOTES:

PCE = tetrachloroethene
TCE = Trichloroethene
VOC = volatile organic compound
µg/L = microgram per liter

TABLE 7 - 10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 3 AAFES-1D 09/29/93 26 MXAF01X1		ROUND 3 AAFES-1D 09/29/93 26 MXAF01X1		ROUND 4 AAFES-1D 01/25/94 26 MXAF01X2		ROUND 4 AAFES-1D 01/25/94 26 MXAF01X2		ROUND 5 AAFES-1D 11/30/94 26 MXAF01X3		ROUND 5 AAFES-1D 11/30/94 26 MXAF01X3		ROUND6 AAFES-1D 03/14/95 26 MXAF01X4		ROUND6 AAFES-1D 03/14/95 26 MXAF01X4		ROUND 3 AAFES-2 09/30/93 28 MXAF02X1		ROUND 3 AAFES-2 09/30/93 28 MXAF02X1		ROUND 4 AAFES-2 01/25/94 28 MXAF02X2	
PAL CATIONS/ANIONS (µg/L)																							
Chloride		NA		NA		NA		NA		160000		NA		160000		NA		NA		NA		NA	
Phosphate		NA		NA		NA		NA		13.3		NA		238		NA		NA		NA		NA	
Sulfate		NA		NA		NA		NA	<	10000		NA	<	10000		NA		NA		NA		NA	
PAL METALS (µg/L)																							
Aluminum	6870	5270	<	141	F	5710	<	141	F	278	<	141	F	215	<	141	F	15100	<	141	F	5030	
Antimony	3.03	< 3.03	<	3.03	F	< 3.03	<	3.03	F	< 3.03		4.02	F	< 3.03	<	3.03	F	< 3.03	<	3.03	F	6.79	
Arsenic	10.5	19.1		10.3	F	12.3		9.28	F	11.4		10.9	F	13.6		10.9	F	73.1		13.5	F	21.9	
Barium	39.6	45.2		15	F	47.5		15.7	F	18.6		15.8	F	17.2		16.8	F	154		33.4	F	131	
Calcium	14700	88100		80800	F	81400		76300	F	86700		89800	F	84900		83400	F	79800		74000	F	76500	
Chromium	14.7	11.1	<	6.02	F	14.3	<	6.02	F	< 6.02	<	6.02	F	< 6.02	<	6.02	F	97.2	<	6.02	F	32.1	
Cobalt	25.0	< 25	<	25	F	< 25	<	25	F	< 25	<	25	F	< 25	<	25	F	81.8	<	25	F	122	
Copper	8.09	14.1	<	8.09	F	13.9	<	8.09	F	< 8.09	<	8.09	F	< 8.09	<	8.09	F	43.8	<	8.09	F	42.7	
Iron	9100	27400		10200	F	23700		12800	F	14300		11300	F	14900		14900	F	96400		21900	F	95700	
Lead	4.25	11.8	<	1.26	F	11.7	<	1.26	F	1.74	<	1.26	F	2.6		2.71	F	58.8		11	F	87.6	
Magnesium	3480	27700		24600	F	25600		22200	F	26500		27300	F	25300		24600	F	24600		22500	F	16500	
Manganese	291	11200		7350	F	9460		8010	F	7940		7790	F	6930		7300	F	24400		10800	F	35200	
Mercury	0.243	< .243	<	.243	F	< .243		.255	F	< .243	<	.243	F	< .243	<	.243	F	< .243	<	.243	F	.28	
Nickel	34.3	88.7	<	34.3	F	82	<	34.3	F	< 34.3	<	34.3	F	< 34.3	<	34.3	F	336	<	34.3	F	393	
Potassium	2370	3380		1930	F	3810		1670	F	2170		1870	F	2000		1410	F	6980		2120	F	3420	
Sodium	10800	57100		51200	F	53500		51700	F	63500		65500	F	59200		60300	F	67700		67500	F	64700	
Vanadium	11.0	< 11	<	11	F	< 11	<	11	F	< 11	<	11	F	< 11	<	11	F	28.3	<	11	F	< 11	
Zinc	21.1	42.4	<	21.1	F	46	<	21.1	F	< 21.1	<	21.1	F	< 21.1	<	21.1	F	131	<	21.1	F	58.6	
PAL SEMIVOLATILE ORGANICS (µg/L)																							
2,4-dimethylphenol		< 5.8		NA		< 5.8		NA	<	5.8		NA	<	5.8		NA	<	200		NA	<	60	
2-methylnaphthalene		< 30		NA		17		NA		13		NA		9.2		NA		5000		NA		2000	
4-methylphenol / 4-cresol		< 0.52		NA	<	0.52		NA	<	0.52		NA	<	0.52		NA	<	20		NA	<	5	
Acenaphthene		< 1.7		NA	<	1.7		NA	<	1.7		NA	<	1.7		NA	<	70		NA	<	20	
Anthracene		< .5		NA	<	.5		NA	<	.5		NA	<	.5		NA	<	20		NA	<	5	
Bis (2-ethylhexyl) Phthalate		< 4.8		NA	<	4.8		NA		38		NA		8.1		NA	<	4000		NA	<	50	
Fluorene		< 3.7		NA	<	3.7		NA	<	3.7		NA	<	3.7		NA	<	100		NA	<	40	
Naphthalene		90		NA		30		NA		50		NA		30		NA		4000		NA		2000	
Phenanthrene		< .5		NA	<	.5		NA		.56		NA	<	.5		NA		80		NA		20	
PAL VOLATILE ORGANICS (µg/L)																							
*xylenes		2000		NA		900		NA		800		NA		400		NA		9000		NA		9000	
1,2-dichloroethane		< 10		NA	<	5		NA	<	2		NA	<	2		NA	<	20		NA	<	50	
Acetone		< 300		NA		100		NA	<	60		NA	<	60		NA	<	600		NA	<	1000	
Benzene		1000		NA		600		NA		600		NA		300		NA		1000		NA		2000	
Carbon Disulfide		< 10		NA	<	5		NA	<	2		NA	<	2		NA	<	20		NA	<	50	
Chloroform		< 10		NA	<	5		NA	<	2		NA	<	2		NA	<	20		NA	<	50	
Ethylbenzene		200		NA		200		NA		100		NA		100		NA		1000		NA		1000	
Methylene Chloride		< 60		NA	<	20		NA	<	10		NA		20		NA	<	100		NA	<	200	
Methyl isobutyl ketone/Isopropylacetone		< 80		NA	<	30		NA	<	20		NA	<	20		NA	<	200		NA	<	300	
Tetrachloroethylene / Tetrachloroethene		< 40		NA	<	20		NA	<	8		NA	<	8		NA	<	80		NA	<	200	
Toluene		70		NA		40		NA		40		NA		10		NA		500		NA		400	
Trichloroethylene / Trichloroethene		< 10		NA	<	5		NA	<	2		NA	<	2		NA	<	20		NA	<	50	
Trichlorofluoromethane		< 40		NA	<	10		NA	<	7		NA	<	7		NA	<	70		NA	<	100	
PAL WATER QUALITY PARAMETERS																							
Alkalinity		NA		NA		NA		NA		265000		NA		236000		NA		NA		NA		NA	
Nitrite, Nitrate-non Specific		NA		NA		NA		NA	<	10		NA	<	10		NA		NA		NA		NA	
Nitrogen By Kjeldahl Method		NA		NA		NA		NA		362		NA		724		NA		NA		NA		NA	
Total Dissolved Solids		NA		NA		480000		NA		NA		NA		NA		NA		NA		NA		480000	
Total Hardness		NA		NA		NA		NA		344000		NA		383000		NA		NA		NA		NA	
Total Suspended Solids		1320000		NA		280000		NA		32000		NA		808000		NA		1670000		NA		2900000	
OTHER (µg/L)																							
Total Petroleum Hydrocarbons		925		NA		1200		NA		NA		NA		NA		NA		44000		NA		120000	

TABLE 7 - 10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 4	ROUND 5		ROUND 6		ROUND 3		ROUND 4		ROUND 5	
		AAFES-2 01/25/94 28 MXAF02X2	AAFES-2 12/01/94 28 MXAF02X3	AAFES-2 12/01/94 28 MXAF02X3	AAFES-2 03/14/95 28 MXAF02X4	AAFES-2 03/14/95 28 MXAF02X4	AAFES-3 09/30/93 24 MXAF03X1	AAFES-3 09/30/93 24 MXAF03X1	AAFES-3 02/02/94 24 MXAF03X2	AAFES-3 02/02/94 24 MXAF03X2	AAFES-3 12/02/94 24 MXAF03X3	AAFES-3 12/02/94 24 MXAF03X3
PAL CATIONS/ANIONS (µg/L)												
Chloride		NA	150000	NA	210000	NA	NA	NA	NA	NA	220000	NA
Phosphate		NA	119	NA	670	NA	NA	NA	NA	NA	860	NA
Sulfate		NA	< 10000	NA	< 10000	NA	NA	NA	NA	NA	28000	NA
PAL METALS (µg/L)												
Aluminum	6870	< 141 F	818	< 141 F	< 141	< 141 F	49400	< 141 F	< 141	< 141 F	5820	< 141 F
Antimony	3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	6.34	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F
Arsenic	10.5	28.3 F	19.7	24.1 F	< 2.54	20.9 F	210	< 2.54 F	< 2.54	< 2.54 F	11.9	< 2.54 F
Barium	39.6	44.5 F	47.8	42.1 F	50.4	48.5 F	161	6.63 F	< 5	< 5 F	25.8	6.16 F
Calcium	14700	66000 F	80600	82200 F	72200	69400 F	77100	64400 F	40900	37580 F	74800	74200 F
Chromium	14.7	< 6.02 F	< 6.02	< 6.02 F	< 6.02	< 6.02 F	219	< 6.02 F	< 6.02	< 6.02 F	26.6	< 6.02 F
Cobalt	25.0	< 25 F	< 25	< 25 F	< 25	< 25 F	160	< 25 F	< 25	< 25 F	< 25	< 25 F
Copper	8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09	< 8.09 F	151	< 8.09 F	< 8.09	< 8.09 F	13.9	< 8.09 F
Iron	9100	60900 F	41000	37400 F	57500	54100 F	198000	< 38.8 F	236	< 38.8 F	22000	< 38.8 F
Lead	4.25	2.93 F	13.9	3.04 F	49.1	1.41 F	82.1	< 1.26 F	< 1.26	< 1.26 F	18.1	< 1.26 F
Magnesium	3480	14200 F	21800	22100 F	15100	14400 F	33900	9540 F	6420	5890 F	13600	11000 F
Manganese	291	14200 F	11500	11000 F	13300	12700 F	8630	76 F	26.3	9.36 F	912	44.9 F
Mercury	0.243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F
Nickel	34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 F	598	< 34.3 F	< 34.3	< 34.3 F	66.6	< 34.3 F
Potassium	2370	2250 F	3110	2470 F	2550	2470 F	9930	2270 F	2030	1990 F	3860	3080 F
Sodium	10800	63400 F	73500	74900 F	94200	91000 F	110000	107000 F	70900	67100 F	108000	108000 F
Vanadium	11.0	< 11 F	< 11	< 11 F	< 11	< 11 F	59.3	< 11 F	< 11	< 11 F	< 11	< 11 F
Zinc	21.1	< 21.1 F	< 21.1	< 21.1 F	< 21.1	< 21.1 F	507	< 21.1 F	< 21.1	< 21.1 F	57	< 21.1 F
PAL SEMIVOLATILE ORGANICS (µg/L)												
2,4-dimethylphenol		NA	< 60	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA
2-methylnaphthalene		NA	2000	NA	900	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA
4-methylphenol / 4-cresol		NA	< 5	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA
Acenaphthene		NA	< 20	NA	3.2	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA
Anthracene		NA	< 5	NA	1.4	NA	< .5	NA	< .5	NA	< .5	NA
Bis (2-ethylhexyl) Phthalate		NA	200	NA	69	NA	< 4.8	NA	< 4.8	NA	5.1	NA
Fluorene		NA	40	NA	20	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA
Naphthalene		NA	1000	NA	500	NA	< .5	NA	< .5	NA	< .5	NA
Phenanthrene		NA	20	NA	7.5	NA	< .5	NA	< .5	NA	< .5	NA
PAL VOLATILE ORGANICS (µg/L)												
*xylenes		NA	20000	NA	8000	NA	< .84	NA	< .84	NA	< .84	NA
1,2-dichloroethane		NA	< 100	NA	< 50	NA	< .5	NA	< .5	NA	< .5	NA
Acetone		NA	< 3000	NA	< 1000	NA	< 13	NA	< 13	NA	< 13	NA
Benzene		NA	2000	NA	1000	NA	< .5	NA	< .5	NA	< .5	NA
Carbon Disulfide		NA	< 100	NA	< 50	NA	< .5	NA	< .5	NA	< .5	NA
Chloroform		NA	< 100	NA	< 50	NA	< .5	NA	.56	NA	< .5	NA
Ethylbenzene		NA	2000	NA	1000	NA	< .5	NA	< .5	NA	< .5	NA
Methylene Chloride		NA	< 600	NA	< 200	NA	< 2.3	NA	< 2.3	NA	< 2.3	NA
Methyl isobutyl ketone/Isopropylacetone		NA	< 800	NA	< 300	NA	< 3	NA	< 3	NA	< 3	NA
Tetrachloroethylene / Tetrachloroethene		NA	< 400	NA	< 200	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA
Toluene		NA	300	NA	200	NA	< .5	NA	< .5	NA	< .5	NA
Trichloroethylene / Trichloroethene		NA	< 100	NA	< 50	NA	< .5	NA	< .5	NA	< .5	NA
Trichlorofluoromethane		NA	< 400	NA	< 100	NA	< 1.4	NA	2.1	NA	< 1.4	NA
PAL WATER QUALITY PARAMETERS												
Alkalinity		NA	254000	NA	171000	NA	NA	NA	NA	NA	117000	NA
Nitrite, Nitrate-non Specific		NA	19.7	NA	38.4	NA	NA	NA	NA	NA	6600	NA
Nitrogen By Kjeldahl Method		NA	533	NA	876	NA	NA	NA	NA	NA	1050	NA
Total Dissolved Solids		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness		NA	314000	NA	249000	NA	NA	NA	NA	NA	246000	NA
Total Suspended Solids		NA	247000	NA	1060000	NA	3210000	NA	19000	NA	770000	NA
OTHER (µg/L)												
Total Petroleum Hydrocarbons		NA		NA	NA	NA	5170	NA	190	NA	NA	NA

TABLE 7 - 10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 6 AAFES-3 03/15/95 24 MXAF03X4	ROUND 6 AAFES-3 03/15/95 24 MXAF03X4	ROUND 3 AAFES-5 09/29/93 25 MXAF05X1	ROUND 3 AAFES-5 09/29/93 25 MXAF05X1	ROUND 4 AAFES-5 01/25/94 25 MXAF05X2	ROUND 4 AAFES-5 01/25/94 25 MXAF05X2	ROUND 5 AAFES-5 12/01/94 25 MXAF05X3	ROUND 5 AAFES-5 12/01/94 25 MXAF07X3	ROUND 6 AAFES-5 03/13/95 25 MXAF05X4	ROUND 6 AAFES-5 03/13/95 25 MXAF05X4	ROUND 3 AAFES-6 09/30/93 22 MXAF06X1
PAL CATIONS/ANIONS (µg/L)												
Chloride		240000	NA	NA	NA	NA	NA	230000	NA	460000 ?	NA	NA
Phosphate		990	NA	NA	NA	NA	NA	2300	NA	1400	NA	NA
Sulfate		26000	NA	NA	NA	NA	NA	25000	NA	19000 ?	NA	NA
PAL METALS (µg/L)												
Aluminum	6870	10200	< 141 F	71700	< 141 F	67400	< 141 F	4150	< 141 F	11700	< 141 F	35900
Antimony	3.03	3.04	< 3.03 F	2.95	< 3.03 F	6.96	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	3.93
Arsenic	10.5	82.5	< 2.54 F	45.7	< 2.54 F	11.9	< 2.54 F	3.09	< 2.54 F	7.57	< 2.54 F	94
Barium	39.6	57.2	5.29 F	538	18.4 F	567	19.8 F	65.8	27 F	369	138 F	149
Calcium	14700	66000	59900 F	56800	46000 F	50200	37100 F	58100	55100 F	57300	57200 F	72700
Chromium	14.7	48.1	< 6.02 F	296	< 6.02 F	261	< 6.02 F	17.2	< 6.02 F	37.3	< 6.02 F	106
Cobalt	25.0	35.3	< 25 F	222	< 25 F	190	< 25 F	< 25	< 25 F	51.3	< 25 F	85.6
Copper	8.09	32.7	< 8.09 F	376	< 8.09 F	296	< 8.09 F	18.8	< 8.09 F	49.5	< 8.09 F	91.5
Iron	9100	31800	< 38.8 F	406000	< 38.8 F	316000	43.1 F	21000	< 38.8 F	45000	< 38.8 F	106000
Lead	4.25	51.2	< 1.26 F	89	< 1.26 F	170	< 1.26 F	13.9	< 1.26 F	49.7	< 1.26 F	32.9
Magnesium	3480	13300	9500 F	29900	7880 F	25000	5820 F	10500	9300 F	9180	6850 F	28700
Manganese	291	1870	10.1 F	8380	2690 F	8190	761 F	3550	3030 F	2720	526 F	8400
Mercury	0.243	< .243	< .243 F	.303	< .243 F	.399	< .243 F	< .243	< .243 F	< .243	< .243 F	.424
Nickel	34.3	152	< 34.3 F	1140	< 34.3 F	901	< 34.3 F	98.4	< 34.3 F	172	< 34.3 F	333
Potassium	2370	4630	1790 F	21500	2440 F	24500	2200 F	5290	2780 F	8500	4030 F	8590
Sodium	10800	115000	115000 F	88400	85600 F	87100	83900 F	115000	109000 F	206000	225000 F	63700
Vanadium	11.0	< 11	< 11 F	119	< 11 F	111	< 11 F	< 11	< 11 F	< 11	< 11 F	39.2
Zinc	21.1	91.7	< 21.1 F	944	< 21.1 F	923	< 21.1 F	64.2	< 21.1 F	111	< 21.1 F	229
PAL SEMIVOLATILE ORGANICS (µg/L)												
2,4-dimethylphenol		< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8
2-methylnaphthalene		< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	6.3
4-methylphenol / 4-cresol		< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52
Acenaphthene		< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7
Anthracene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Bis (2-ethylhexyl) Phthalate		5.7	NA	< 4.8	NA	< 4.8	NA	17	NA	8.4	NA	< 4.8
Fluorene		< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7
Naphthalene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	2.5
Phenanthrene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
PAL VOLATILE ORGANICS (µg/L)												
*xylenes		< .84	NA	< .84	NA	< .84	NA	< .84	NA	< .84	NA	2.8
1,2-dichloroethane		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	2.6
Acetone		< 13	NA	< 13	NA	< 13	NA	< 13	NA	< 13	NA	51
Benzene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	13
Carbon Disulfide		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Chloroform		.76	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Ethylbenzene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	34
Methylene Chloride		< 2.3	NA	< 2.3	NA	< 2.3	NA	< 2.3	NA	< 2.3	NA	< 2.3
Methyl isobutyl ketone/Isopropylacetone		< 3	NA	< 3	NA	< 3	NA	< 3	NA	< 3	NA	< 3
Tetrachloroethylene / Tetrachloroethene		< 1.6	NA	3.8	NA	7	NA	2.1	NA	< 1.6	NA	< 1.6
Toluene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	.63
Trichloroethylene / Trichloroethene		< .5	NA	< .5	NA	.52	NA	< .5	NA	< .5	NA	< .5
Trichlorofluoromethane		< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4
PAL WATER QUALITY PARAMETERS												
Alkalinity		85000	NA	NA	NA	NA	NA	86000	NA	26000	NA	NA
Nitrite, Nitrate-non Specific		5700	NA	NA	NA	NA	NA	3300	NA	1100	NA	NA
Nitrogen By Kjeldahl Method		1240	NA	NA	NA	NA	NA	1900	NA	848	NA	NA
Total Dissolved Solids		NA	NA	NA	NA	330000	NA	NA	NA	NA	NA	NA
Total Hardness		214000	NA	NA	NA	NA	NA	194000	NA	204000	NA	NA
Total Suspended Solids		3190000	NA	6620000	NA	7400000	NA	2120000	NA	4110000	NA	2240000
OTHER (µg/L)												
Total Petroleum Hydrocarbons		NA	NA	< 190	NA	1000	NA	NA	NA	NA	NA	274

TABLE 7 - 10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 3 AAFES-6 09/30/93 22 MXAF06X1	ROUND 4 AAFES-6 01/25/94 22 MXAF06X2	ROUND 4 AAFES-6 01/25/94 22 MXAF06X2	ROUND 5 AAFES-6 11/30/94 22 MXAF06X3	ROUND 5 AAFES-6 11/30/94 22 MXAF06X3	ROUND 6 AAFES-6 03/14/95 22 MXAF06X4	ROUND 6 AAFES-6 03/14/95 22 MXAF06X4	ROUND 3 AAFES-7 09/30/93 12 MXAF07X1	ROUND 3 AAFES-7 09/30/93 12 MXAF07X1	ROUND 4 AAFES-7 02/01/94 12 MXAF07X2	ROUND 4 AAFES-7 02/01/94 12 MXAF07X2
PAL CATIONS/ANIONS (µg/L)												
Chloride		NA	NA	NA	120000	NA	160000	NA	NA	NA	NA	NA
Phosphate		NA	NA	NA	306	NA	215	NA	NA	NA	NA	NA
Sulfate		NA	NA	NA	11000	NA	25000	NA	NA	NA	NA	NA
PAL METALS (µg/L)												
Aluminum	6870	< 141 F	27800	< 141 F	9500	< 141 F	< 141	< 141 F	15600	< 141 F	6420	< 141 F
Antimony	3.03	< 3.03 F	5	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	2.86 F
Arsenic	10.5	10.3 F	140	33.7 F	57.7	8.85 F	18.9	19.9 F	51.7	< 2.54 F	24.5	< 2.54 F
Barium	39.6	14.4 F	147	11.3 F	52.1	15.6 F	19.4	19.4 F	61.8	< 5 F	38.1	11.9 F
Calcium	14700	56300 F	54800	44600 F	61600	57900 F	55200	55400 F	14300	11800 F	26600	24300 F
Chromium	14.7	< 6.02 F	85.4	< 6.02 F	25	< 6.02 F	< 6.02	< 6.02 F	49.9	< 6.02 F	25.8	< 6.02 F
Cobalt	25.0	< 25 F	86.1	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F
Copper	8.09	< 8.09 F	66.9	< 8.09 F	19.9	< 8.09 F	< 8.09	< 8.09 F	34.9	< 8.09 F	14.7	< 8.09 F
Iron	9100	8060 F	83600	13100 F	30100	7220 F	14000	14200 F	35600	63 F	15800	47.1 F
Lead	4.25	< 1.26 F	27.4	< 1.26 F	3.8	< 1.26 F	< 1.26	< 1.26 F	19.5	< 1.26 F	7.16	< 1.26 F
Magnesium	3480	9660 F	21000	7480 F	14900	10100 F	9020	9060 F	9280	1860 F	7210	3960 F
Manganese	291	5970 F	6390	4950 F	6330	6180 F	5360	5390 F	1540	374 F	2200	85.3 F
Mercury	0.243	< .243 F	.692	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F
Nickel	34.3	62.2 F	306	< 34.3 F	88.4	< 34.3 F	< 34.3	< 34.3 F	86.4	< 34.3 F	< 34.3	< 34.3 F
Potassium	2370	2550 F	8930	2450 F	3700	2830 F	2280	2500 F	5130	1150 F	5070	3960 F
Sodium	10800	64200 F	63400	59900 F	65600	67900 F	80200	80400 F	15400	14600 F	80900	89900 F
Vanadium	11.0	< 11 F	32.5	< 11 F	< 11	< 11 F	< 11	< 11 F	24.8	< 11 F	< 11	< 11 F
Zinc	21.1	< 21.1 F	252	< 21.1 F	101	< 21.1 F	< 21.1	< 21.1 F	72.7	< 21.1 F	29.4	< 21.1 F
PAL SEMIVOLATILE ORGANICS (µg/L)												
2,4-dimethylphenol		NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA
2-methylnaphthalene		NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA
4-methylphenol / 4-cresol		NA	< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA
Acenaphthene		NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA
Anthracene		NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA
Bis (2-ethylhexyl) Phthalate		NA	< 4.8	NA	14	NA	36	NA	6.3	NA	< 4.8	NA
Fluorene		NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA
Naphthalene		NA	1.7	NA	.85	NA	< .5	NA	< .5	NA	< .5	NA
Phenanthrene		NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA
PAL VOLATILE ORGANICS (µg/L)												
*xylenes		NA	< 8	NA	3.3	NA	1.3	NA	.86	NA	< .84	NA
1,2-dichloroethane		NA	< 5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA
Acetone		NA	< 100	NA	< 13	NA	< 13	NA	< 13	NA	< 13	NA
Benzene		NA	70	NA	2.1	NA	37	NA	< .5	NA	< .5	NA
Carbon Disulfide		NA	< 5	NA	.88	NA	< .5	NA	< .5	NA	< .5	NA
Chloroform		NA	< 5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA
Ethylbenzene		NA	90	NA	19	NA	19	NA	< .5	NA	< .5	NA
Methylene Chloride		NA	< 20	NA	< 2.3	NA	2.7	NA	< 2.3	NA	< 2.3	NA
Methyl isobutyl ketone/Isopropylacetone		NA	< 30	NA	< 3	NA	< 3	NA	< 3	NA	< 3	NA
Tetrachloroethylene / Tetrachloroethene		NA	< 20	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA
Toluene		NA	< 5	NA	1.5	NA	< .5	NA	< .5	NA	< .5	NA
Trichloroethylene / Trichloroethene		NA	< 5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA
Trichlorofluoromethane		NA	< 10	NA	< 1.4	NA	< 1.4	NA	< 1.4	NA	1.6	NA
PAL WATER QUALITY PARAMETERS												
Alkalinity		NA	NA	NA	172000	NA	117000	NA	NA	NA	NA	NA
Nitrite, Nitrate-non Specific		NA	NA	NA	< 10	NA	< 10	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method		NA	NA	NA	724	NA	638	NA	NA	NA	NA	NA
Total Dissolved Solids		NA	310000	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness		NA	NA	NA	230000	NA	208000	NA	NA	NA	NA	NA
Total Suspended Solids		NA	2000000	NA	1100000	NA	316000	NA	538000	NA	430000	NA
OTHER (µg/L)												
Total Petroleum Hydrocarbons		NA	640	NA	NA	NA	NA	NA	< 192	NA	230	NA

TABLE 7 - 10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 5 AAFES-7 12/02/94 12 MXAF07X3	ROUND 5 AAFES-7 12/02/94 12 MXAF07X3	ROUND 6 AAFES-7 03/15/95 12 MXAF07X4	ROUND 6 AAFES-7 03/15/95 12 MXAF07X4	ROUND 3 XGM-93-01X 09/28/93 28 MXXG01X1	ROUND 3 XGM-93-01X 09/28/93 28 MXXG01X1	ROUND 4 XGM-93-01X 01/25/94 28 MXXG01X2	ROUND 4 XGM-93-01X 01/25/94 28 MXXG01X2	ROUND 5 XGM-93-01X 12/05/94 33 MXXG01X3	ROUND 5 XGM-93-01X 12/05/94 33 MXXG01X3	ROUND 6 XGM-93-01X 03/15/95 33 MXXG01X4
PAL CATIONS/ANIONS (µg/L)												
Chloride		37000	NA	33000	NA	NA	NA	NA	NA	66000	NA	66000
Phosphate		1000	NA	171	NA	NA	NA	NA	NA	187	NA	126
Sulfate		14000	NA	14000	NA	NA	NA	NA	NA	31000	NA	30000
PAL METALS (µg/L)												
Aluminum	6870	22300	< 141 F	2730	< 141 F	2290	< 141 F	9830	< 141 F	2220	< 141 F	2530
Antimony	3.03	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	3.93 F	2.86	3.84 F	< 3.03	5.27 F	< 3.03
Arsenic	10.5	40.1	< 2.54 F	3.62	< 2.54 F	11.7	< 2.54 F	32.8	< 2.54 F	9.38	2.98 F	3.62
Barium	39.6	75.6	< 5 F	13.2	< 5 F	20	11.9 F	54.5	7.34 F	17.5	6.7 F	18.8
Calcium	14700	19400	16700 F	15700	13600 F	52300	61400 F	55800	51800 F	64600	59600 F	57000
Chromium	14.7	76.4	< 6.02 F	9.39	< 6.02 F	7.92	< 6.02 F	22.8	< 6.02 F	< 6.02	< 6.02 F	< 6.02
Cobalt	25.0	31.9	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25
Copper	8.09	47.2	< 8.09 F	< 8.09	< 8.09 F	< 8.09	< 8.09 F	26.2	< 8.09 F	< 8.09	13.2 F	9.35
Iron	9100	58500	< 38.8 F	5600	< 38.8 F	5600	< 38.8 F	24200	56.2 F	5140	< 38.8 F	7520
Lead	4.25	30.9	< 1.26 F	3.15	< 1.26 F	8.68	< 1.26 F	24	< 1.26 F	6.51	< 1.26 F	10.3
Magnesium	3480	14000	2600 F	3680	2180 F	10100	13500 F	12600	10400 F	11900	10500 F	11700
Manganese	291	2770	873 F	188	8.88 F	137	46.4 F	428	51.4 F	150	21.1 F	248
Mercury	0.243	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243
Nickel	34.3	124	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 F	55	< 34.3 F	< 34.3	< 34.3 F	< 34.3
Potassium	2370	5980	1990 F	2120	1260 F	3680	3420 F	5350	3360 F	3280	2750 F	2950
Sodium	10800	26700	28000 F	21700	20100 F	30600	29800 F	33400	31300 F	42000	38700 F	36800
Vanadium	11.0	29.2	< 11 F	< 11	< 11 F	< 11	< 11 F	13.9	< 11 F	< 11	< 11 F	< 11
Zinc	21.1	226	< 21.1 F	< 21.1	< 21.1 F	22.7	< 21.1 F	90.7	< 21.1 F	< 21.1	< 21.1 F	25.8
PAL SEMIVOLATILE ORGANICS (µg/L)												
2,4-dimethylphenol		< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8
2-methylnaphthalene		< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7
4-methylphenol / 4-cresol		< 0.52	NA	< 0.52	NA	< .52	NA	< .52	NA	< .52	NA	< .52
Acenaphthene		< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7
Anthracene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Bis (2-ethylhexyl) Phthalate		6.8	NA	< 4.8	NA	< 4.8	NA	5	NA	8.5	NA	< 4.8
Fluorene		< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7
Naphthalene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Phenanthrene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
PAL VOLATILE ORGANICS (µg/L)												
*xylenes		< .84	NA	< .84	NA	< .84	NA	< .84	NA	< .84	NA	< .84
1,2-dichloroethane		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Acetone		< 13	NA	< 13	NA	< 13	NA	< 13	NA	< 13	NA	< 13
Benzene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Carbon Disulfide		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Chloroform		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Ethylbenzene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Methylene Chloride		< 2.3	NA	< 2.3	NA	< 2.3	NA	2.9	NA	< 2.3	NA	< 2.3
Methyl isobutyl ketone/Isopropylacetone		< 3	NA	< 3	NA	< 3	NA	< 3	NA	< 3	NA	< 3
Tetrachloroethylene / Tetrachloroethene		< 1.6	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA	< 1.6
Toluene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	.62	NA	< .5
Trichloroethylene / Trichloroethene		< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Trichlorofluoromethane		< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4
PAL WATER QUALITY PARAMETERS												
Alkalinity		40000	NA	26000	NA	NA	NA	NA	NA	128000	NA	115000
Nitrite, Nitrate-non Specific		1200	NA	2100	NA	NA	NA	NA	NA	2300	NA	4100
Nitrogen By Kjeldahl Method		448	NA	333	NA	NA	NA	NA	NA	371	NA	419
Total Dissolved Solids		NA	NA	NA	NA	NA	NA	270000	NA	NA	NA	
Total Hardness		63600	NA	48800	NA	NA	NA	NA	NA	192000	NA	172000
Total Suspended Solids		1620000	NA	183000	NA	149000	NA	380000	NA	142000	NA	245000
OTHER (µg/L)												
Total Petroleum Hydrocarbons		NA	NA	NA	NA	< 184	NA	< 190	NA		NA	

TABLE 7 - 10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 6 XGM-93-01X 03/15/95 33 MXXG01X4		ROUND 3 XGM-93-02X 09/29/93 33 MXXG02X1		ROUND 3 XGM-93-02X 09/29/93 33 MXXG02X1		ROUND 4 XGM-93-02X 02/01/94 33 MXXG02X2		ROUND 4 XGM-93-02X 02/01/94 33 MXXG02X2		ROUND 5 XGM-93-02X 12/02/94 37.5 MXXG02X3		ROUND 5 XGM-93-02X 12/02/94 37.5 MXXG02X3		ROUND 6 XGM-93-02X 03/15/95 37.5 MXXG02X4		ROUND 6 XGM-93-02X 03/15/95 37.5 MXXG02X4		ROUND 5 XGM-94-03X 11/30/94 29 MXXG03X3	
PAL CATIONS/ANIONS (µg/L)																					
Chloride		NA		NA		NA		NA		NA		180000		NA		270000		NA		110000	
Phosphate		NA		NA		NA		NA		NA		205		NA		212		NA		19	
Sulfate		NA		NA		NA		NA		NA	<	10000		NA	<	10000		NA		13000	
PAL METALS (µg/L)																					
Aluminum	6870	< 141	F	23800	<	141	F	33200	<	141	F	2020	<	141	F	10700	<	141	F	147	
Antimony	3.03	< 3.03	F	< 3.03	<	3.03	F	4.46	<	3.03	F	< 3.03		2.77	F	< 3.03	<	3.03	F	< 3.03	
Arsenic	10.5	< 2.54	F	57.7		4.05	F	70.1		8.1	F	9.17		7.57	F	8.53		6.18	F	8	
Barium	39.6	5.41	F	124		34.1	F	154		31.1	F	45.8		36.9	F	81.6		40.9	F	14.3	
Calcium	14700	55000	F	107000		82700	F	109000		75800	F	90700		91100	F	112000		101000	F	79300	
Chromium	14.7	< 6.02	F	63.4	<	6.02	F	96.4	<	6.02	F	6.89	<	6.02	F	29.2	<	6.02	F	< 6.02	
Cobalt	25.0	< 25	F	68.1	<	25	F	86.2	<	25	F	34	<	25	F	46	<	25	F	< 25	
Copper	8.09	< 8.09	F	67.6	<	8.09	F	96.5	<	8.09	F	< 8.09	<	8.09	F	40.2	<	8.09	F	< 8.09	
Iron	9100	< 38.8	F	80000		5700	F	120000		27700	F	22000		10400	F	87200		46300	F	3050	
Lead	4.25	< 1.26	F	36.9		2.06	F	56.6	<	1.26	F	3.8		1.41	F	21.4	<	1.26	F	< 1.26	
Magnesium	3480	9520	F	35000		21300	F	37400		19600	F	24100		22200	F	29600		24700	F	28300	
Manganese	291	20	F	12300		11100	F	11200		8790	F	5400		5170	F	7130		5580	F	6290	
Mercury	0.243	< .243	F	< .243	<	.243	F	< .243	<	.243	F	< .243	<	.243	F	< .243	<	.243	F	< .243	
Nickel	34.3	< 34.3	F	213	<	34.3	F	290		41.2	F	209		180	F	124	<	34.3	F	< 34.3	
Potassium	2370	3080	F	10100		6220	F	10200		7120	F	5780		4590	F	7820		6660	F	2520	
Sodium	10800	38600	F	74300		72900	F	70200		68800	F	83900		83000	F	98600		105000	F	67000	
Vanadium	11.0	< 11	F	28.5	<	11	F	39.6	<	11	F	< 11	<	11	F	12.2	<	11	F	< 11	
Zinc	21.1	< 21.1	F	150	<	21.1	F	413	<	21.1	F	30.3	<	21.1	F	91.3	<	21.1	F	27.6	
PAL SEMIVOLATILE ORGANICS (µg/L)																					
2,4-dimethylphenol		NA		< 5.8		NA		14		NA		16		NA	<	5.8		NA		< 5.8	
2-methylnaphthalene		NA		100		NA		40		NA		70		NA		40		NA		2.1	
4-methylphenol / 4-cresol		NA		< .52		NA		2.4		NA		3.3		NA	<	.52		NA		< .52	
Acenaphthene		NA		< 1.7		NA	<	1.7		NA	<	1.7		NA	<	1.7		NA	<	1.7	
Anthracene		NA		< .5		NA	<	.5		NA	<	.5		NA	<	.5		NA	<	.5	
Bis (2-ethylhexyl) Phthalate		NA		< 4.8		NA	<	4.8		NA		6.8		NA		9.1		NA		200	
Fluorene		NA		< 3.7		NA	<	3.7		NA	<	3.7		NA	<	3.7		NA	<	3.7	
Naphthalene		NA		300		NA		200		NA		300		NA		200		NA		17	
Phenanthrene		NA		< .5		NA	<	.5		NA	<	.5		NA	<	.5		NA	<	.5	
PAL VOLATILE ORGANICS (µg/L)																					
*xylenes		NA		6000		NA		1000		NA		5000		NA		4000		NA		600	
1,2-dichloroethane		NA		< 100		NA	<	20		NA	<	.5		NA	<	20		NA	<	2	
Acetone		NA		< 3000		NA	<	600		NA	<	13		NA	<	600		NA	<	60	
Benzene		NA		2000		NA		300		NA		2000		NA		900		NA		300	
Carbon Disulfide		NA		< 100		NA	<	20		NA	<	.5		NA	<	20		NA	<	2	
Chloroform		NA		< 100		NA	<	20		NA	<	.5		NA	<	20		NA	<	2	
Ethylbenzene		NA		< 100		NA		100		NA		600		NA		800		NA		100	
Methylene Chloride		NA		< 500		NA		300		NA	<	2.3		NA	<	100		NA	<	10	
Methyl isobutyl ketone/Isopropylacetone		NA		< 600		NA	<	200		NA		19		NA	<	200		NA	<	20	
Tetrachloroethylene / Tetrachloroethene		NA		< 300		NA	<	80		NA	<	1.6		NA	<	80		NA	<	8	
Toluene		NA		800		NA		40		NA		200		NA		80		NA		40	
Trichloroethylene / Trichloroethene		NA		< 100		NA	<	20		NA	<	0.5		NA	<	20		NA	<	2	
Trichlorofluoromethane		NA		< 300		NA	<	70		NA	<	1.4		NA	<	70		NA	<	7	
PAL WATER QUALITY PARAMETERS																					
Alkalinity		NA		NA		NA		NA		NA		257000		NA		231000		NA		254000	
Nitrite, Nitrate-non Specific		NA		NA		NA		NA		NA	<	10		NA	<	10		NA	<	10	
Nitrogen By Kjeldahl Method		NA		NA		NA		NA		NA		448		NA		610		NA		410	
Total Dissolved Solids		NA		NA		NA		NA		NA		NA		NA		NA		NA		NA	
Total Hardness		NA		NA		NA		NA		NA		338000		NA		398000		NA		334000	
Total Suspended Solids		NA		2180000		NA		1400000		NA		182000		NA		2950000		NA		32000	
OTHER (µg/L)																					
Total Petroleum Hydrocarbons		NA		2750		NA		2300		NA		NA		NA		NA		NA		NA	

TABLE 7-10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 5						ROUND 6		ROUND 5	
		XGM-94-06X 11/30/94 28 MXXH06X3	XGM-94-06X 11/30/94 28 MXXG06X3	XGM-94-06X 12/06/94 28 MXXG06P1	XGM-94-06X 12/06/94 28 MXXG06P1	XGM-94-06X 12/07/94 28 MXXG06P2	XGM-94-06X 12/07/94 28 MXXG06P2	XGM-94-06X 03/15/95 28 MXXG06X4	XGM-94-06X 03/15/95 28 MXXG06X4	XGM-94-07X 11/29/94 27 MXXG07X3	XGM-94-07X 11/29/94 27 MDXG07X3
PAL CATIONS/ANIONS (µg/L)											
Chloride		110000	NA	99000	NA	99000	NA	140000	NA	190000	190000 D
Phosphate		81.1	NA	NA	NA	NA	NA	105	NA	25	25.4 D
Sulfate		13000	NA	17000	NA	18000	NA	18000	NA	22000	22000 D
PAL METALS (µg/L)											
Aluminum	6870	1260	< 141 F	< 141	< 141 F	< 141	451 F	< 141	< 141 F	< 141	< 141 D
Antimony	3.03	< 3.03	< 3.03 F	< 3.03	3.3 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 D
Arsenic	10.5	10.7	7.78 F	12.6	14.8 F	11.7	13.4 F	< 2.54	< 2.54 F	< 2.54	< 2.54 D
Barium	39.6	24.5	18.1 F	18.3	17.5 F	16.6	17.1 F	13.1	14.4 F	20.6	18.8 D
Calcium	14700	50400	52300 F	46500	44500 F	42800	41400 F	57200	59700 F	49800	48200 D
Chromium	14.7	< 6.02	< 6.02 F	< 6.02	< 6.02 F	< 6.02	< 6.02 F	< 6.02	< 6.02 F	< 6.02	< 6.02 D
Cobalt	25.0	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25	< 25 D
Copper	8.09	< 8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09	15.4 F	< 8.09	< 8.09 F	< 8.09	< 8.09 D
Iron	9100	9740	4350 F	7850	7420 F	7220	6780 F	1480	1500 F	405	190 D
Lead	4.25	1.95	< 1.26 F	< 1.26	< 1.26 F	< 1.26	< 1.26 F	< 1.26	< 1.26 F	< 1.26	< 1.26 D
Magnesium	3480	10100	9720 F	8330	8040 F	7650	7330 F	8540	8910 F	9630	9120 D
Manganese	291	6760	6840 F	6280 J	6010 FJ	5780 J	5600 FJ	1710	1860 F	5640	5220 D
Mercury	0.243	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 D
Nickel	34.3	< 34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 D
Potassium	2370	3790	2710 F	2170	2120 F	2260	2300 F	1490	1900 F	2660	2660 D
Sodium	10800	51400	52400 F	49500	46800 F	46600	45900 F	57100	59100 F	95000	88600 D
Vanadium	11.0	< 11	< 11 F	< 11	< 11 F	< 11	< 11 F	< 11	< 11 F	< 11	< 11 D
Zinc	21.1	24.9	< 21.1 F	< 21.1	< 21.1 F	< 21.1	< 21.1 F	< 21.1	< 21.1 F	< 21.1	< 21.1 D
PAL SEMIVOLATILE ORGANICS (µg/L)											
2,4-dimethylphenol		< 5.8	NA	NA	NA	NA	NA	< 5.8	NA	< 5.8	< 5.8 D
2-methylnaphthalene		< 1.7	NA	NA	NA	NA	NA	< 1.7	NA	< 1.7	< 1.7 D
4-methylphenol / 4-cresol		< 0.52	NA	NA	NA	NA	NA	< 0.52	NA	< 0.52	< 0.52 D
Acenaphthene		< 1.7	NA	NA	NA	NA	NA	< 1.7	NA	< 1.7	< 1.7 D
Anthracene		< 0.5	NA	NA	NA	NA	NA	< 0.5	NA	< 0.5	< 0.5 D
Bis (2-ethylhexyl) Phthalate		64	NA	NA	NA	NA	NA	4.6	NA	< 4.8	< 4.8 D
Fluorene		< 3.7	NA	NA	NA	NA	NA	< 3.7	NA	< 3.7	< 3.7 D
Naphthalene		< .5	NA	NA	NA	NA	NA	< .5	NA	< .5	< .5 D
Phenanthrene		< 0.5	NA	NA	NA	NA	NA	< 0.5	NA	< 0.5	< 0.5 D
PAL VOLATILE ORGANICS (µg/L)											
*xylenes		< 84	NA	NA	NA	NA	NA	< .84	NA	2.6	2.5 D
1,2-dichloroethane		< .5	NA	NA	NA	NA	NA	< .5	NA	< .5	< .5 D
Acetone		< 13	NA	NA	NA	NA	NA	< 13	NA	< 13	< 13 D
Benzene		2.3	NA	NA	NA	NA	NA	< .5	NA	< .5	< .5 D
Carbon Disulfide		< .5	NA	NA	NA	NA	NA	< .5	NA	< .5	< .5 D
Chloroform		< .5	NA	NA	NA	NA	NA	< .5	NA	< .5	< .5 D
Ethylbenzene		< .5	NA	NA	NA	NA	NA	< .5	NA	< .5	< .5 D
Methylene Chloride		< 2.3	NA	NA	NA	NA	NA	< 2.3	NA	< 2.3	< 2.3 D
Methyl isobutyl ketone/Isopropylacetone		< 3	NA	NA	NA	NA	NA	< 3	NA	< 3	< 3 D
Tetrachloroethylene / Tetrachloroethene		< 1.6	NA	NA	NA	NA	NA	< 1.6	NA	3.8	3.3 D
Toluene		51	NA	NA	NA	NA	NA	< .5	NA	.54	.65 D
Trichloroethylene / Trichloroethene		< 0.5	NA	NA	NA	NA	NA	< .5	NA	< .5	< .5 D
Trichlorofluoromethane		< 1.4	NA	NA	NA	NA	NA	< 1.4	NA	< 1.4	< 1.4 D
PAL WATER QUALITY PARAMETERS											
Alkalinity		128000	NA	108000	NA	104000	NA	109000	NA	85000	86000 D
Nitrite, Nitrate-non Specific		< 10	NA	NA	NA	NA	NA	260	NA	2500	2100 D
Nitrogen By Kjeldahl Method		324	NA	NA	NA	NA	NA	486	NA	267	371 D
Total Dissolved Solids		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness		178000	NA	141	NA	139	NA	204000	NA	188000	172000 D
Total Suspended Solids		131000	NA	12000	NA	6000	NA	178000	NA	7000	5000 D
OTHER (µg/L)											
Total Petroleum Hydrocarbons		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	ROUND 5		ROUND 6		ROUND 5		ROUND 6		ROUND 5		ROUND 6
		XGM-94-07X 11/29/94 27 MXXG07X3	XGM-94-07X 11/29/94 27 MDXG07X3	XGM-94-07X 03/14/95 27 MXXG07X4	XGM-94-07X 03/14/95 27 MXXG07X4	XGM-94-08X 11/29/94 35 MXXG08X3	XGM-94-08X 11/29/94 35 MXXG08X3	XGM-94-08X 03/13/95 35 MXXG08X4	XGM-94-08X 03/13/95 35 MXXG08X4	XGM-94-09X 12/02/94 33.5 MXXG09X3	XGM-94-09X 12/02/94 33.5 MXXG09X3	XGM-94-09X 03/16/95 33.5 MXXG09X4
PAL CATIONS/ANIONS (µg/L)												
Chloride		NA	NA	240000	NA	88000	NA	120000	NA	99000	NA	110000
Phosphate		NA	NA	22.2	NA	15.9	NA	27.1	NA	38.1	NA	15.9
Sulfate		NA	NA	12000	NA	20000	NA	21000	NA	25000	NA	27000
PAL METALS (µg/L)												
Aluminum	6870	< 141 F	< 141 FD	353	< 141 F	< 141	< 141 F	459	< 141 F	< 141	< 141 F	< 141
Antimony	3.03	< 3.03 F	< 3.03 FD	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03
Arsenic	10.5	< 2.54 F	< 2.54 FD	< 2.54	< 2.54 F	14.7	14.1 F	18.9	12.3 F	3.52	< 2.54 F	< 2.54
Barium	39.6	20.2 F	20.1 FD	27.6	23.7 F	13.9	13.3 F	22.5	21.4 F	7.01	12.2 F	4.63
Calcium	14700	49500 F	47900 FD	64700	66000 F	45500	44200 F	55000	57200 F	66500	71000 F	49600
Chromium	14.7	< 6.02 F	< 6.02 FD	< 6.02	< 6.02 F	< 6.02	< 6.02 F	< 6.02	< 6.02 F	< 6.02	< 6.02 F	< 6.02
Cobalt	25.0	< 25 F	< 25 FD	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25	< 25 F	< 25
Copper	8.09	< 8.09 F	< 8.09 FD	< 8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09
Iron	9100	60.2 F	145 FD	4520	459 F	5750	5450 F	12400	9840 F	317	38.8 F	86.1
Lead	4.25	< 1.26 F	< 1.26 FD	< 1.26	< 1.26 F	< 1.26	< 1.26 F	2.28	< 1.26 F	2.39	< 1.26 F	< 1.26
Magnesium	3480	9380 F	8920 FD	11900	11800 F	8370	8090 F	9680	9700 F	11300	14200 F	8050
Manganese	291	5630 F	5560 FD	5900	6150 F	6650	6380 F	8630	8820 F	1600	1110 F	246
Mercury	0.243	< .243 F	< .243 FD	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243	< .243 F	< .243
Nickel	34.3	< 34.3 F	< 34.3 FD	< 34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3
Potassium	2370	2630 F	2710 FD	2440	2530 F	2040	1440 F	1860	1650 F	3130	3340 F	2130
Sodium	10800	92600 F	90900 FD	104000	110000 F	41500	39800 F	57200	58200 F	53000	53200 F	54600
Vanadium	11.0	< 11 F	< 11 FD	< 11	< 11 F	< 11	< 11 F	< 11	< 11 F	< 11	< 11 F	< 11
Zinc	21.1	< 21.1 F	< 21.1 FD	< 21.1	< 21.1 F	< 21.1	< 21.1 F	< 21.1	< 21.1 F	< 21.1	< 21.1 F	< 21.1
PAL SEMIVOLATILE ORGANICS (µg/L)												
2,4-dimethylphenol		NA	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8	NA	< 5.8
2-methylnaphthalene		NA	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7
4-methylphenol / 4-cresol		NA	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52	NA	< 0.52
Acenaphthene		NA	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7	NA	< 1.7
Anthracene		NA	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5
Bis (2-ethylhexyl) Phthalate		NA	NA	33	NA	< 4.8	NA	< 4.8	NA	< 4.8	NA	< 4.8
Fluorene		NA	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7	NA	< 3.7
Naphthalene		NA	NA	4.1	NA	3	NA	< .5	NA	.95	NA	< .5
Phenanthrene		NA	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5
PAL VOLATILE ORGANICS (µg/L)												
*xylenes		NA	NA	52	NA	1.8	NA	< .84	NA	21	NA	3.3
1,2-dichloroethane		NA	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Acetone		NA	NA	< 13	NA	< 13	NA	< 13	NA	< 13	NA	19
Benzene		NA	NA	79	NA	37	NA	1.5	NA	< .5	NA	< .5
Carbon Disulfide		NA	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Chloroform		NA	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Ethylbenzene		NA	NA	15	NA	17	NA	< .5	NA	3.7	NA	.95
Methylene Chloride		NA	NA	< 2.3	NA	< 2.3	NA	< 2.3	NA	< 2.3	NA	< 2.3
Methyl isobutyl ketone/Isopropylacetone		NA	NA	< 3	NA	< 3	NA	< 3	NA	< 3	NA	< 3
Tetrachloroethylene / Tetrachloroethene		NA	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA	< 1.6
Toluene		NA	NA	4.4	NA	2.2	NA	< .5	NA	.78	NA	2.2
Trichloroethylene / Trichloroethene		NA	NA	< .5	NA	< .5	NA	< .5	NA	< .5	NA	< .5
Trichlorofluoromethane		NA	NA	< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4	NA	< 1.4
PAL WATER QUALITY PARAMETERS												
Alkalinity		NA	NA	111000	NA	117000	NA	131000	NA	162000	NA	93000
Nitrite, Nitrate-non Specific		NA	NA	105	NA	39.1	NA	28.2	NA	730	NA	4600
Nitrogen By Kjeldahl Method		NA	NA	286	NA	267	NA	352	NA	276	NA	324
Total Dissolved Solids		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness		NA	NA	226000	NA	162000	NA	216000	NA	218000	NA	157000
Total Suspended Solids		NA	NA	13000	NA	13000	NA	40000	NA	17000	NA	21000
OTHER (µg/L)												
Total Petroleum Hydrocarbons		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
GROUNDWATER OFF-SITE LABORATORY ANALYTIC
AOC 43G - HISTORIC GAS STATION G / AAFES GAS

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

		ROUND 6	ROUND 5		ROUND 6	
ANALYTE	FORT DEVENS BACKGROUND CONCENTRATIONS	XGM-94-09X 03/16/95 53.5 MXXG09X4	XGM-94-10X 11/30/94 31.5 MXXG10X3	XGM-94-10X 11/30/94 31.5 MXXG10X3	XGM-94-10X 03/15/95 31.5 MXXG10X4	XGM-94-10X 03/15/95 31.5 MXXG10X4
PAL CATIONS/ANIONS (µg/L)						
Chloride		NA	77000	NA	71000	NA
Phosphate		NA	180	NA	930	NA
Sulfate		NA	24000	NA	37000	NA
PAL METALS (µg/L)						
Aluminum	6870	< 141 F	1490	< 141 F	1860	< 141 F
Antimony	3.03	< 3.03 F	< 3.03	< 3.03 F	< 3.03	< 3.03 F
Arsenic	10.5	< 2.54 F	23.6	8.21 F	21.4	13.2 F
Barium	39.6	< 5 F	16.7	11.7 F	20.6	12.2 F
Calcium	14700	50100 F	60900	59500 F	58500	57400 F
Chromium	14.7	< 6.02 F	< 6.02	< 6.02 F	< 6.02	< 6.02 F
Cobalt	25.0	< 25 F	< 25	< 25 F	< 25	< 25 F
Copper	8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09	< 8.09 F
Iron	9100	85 F	5760	1180 F	4730	635 F
Lead	4.25	< 1.26 F	3.47	< 1.26 F	1.84	< 1.26 F
Magnesium	3480	8140 F	13600	12800 F	12400	11300 F
Manganese	291	269 F	3550	3330 F	2980	3200 F
Mercury	0.243	< .243 F	< .243	< .243 F	< .243	< .243 F
Nickel	34.3	< 34.3 F	< 34.3	< 34.3 F	< 34.3	< 34.3 F
Potassium	2370	1960 F	3160	2910 F	2990	2330 F
Sodium	10800	53500 F	41600	42300 F	40100	39300 F
Vanadium	11.0	< 11 F	< 11	< 11 F	< 11	< 11 F
Zinc	21.1	< 21.1 F	< 21.1	68.9 F	< 21.1	< 21.1 F
PAL SEMIVOLATILE ORGANICS (µg/L)						
2,4-dimethylphenol		NA	< 5.8	NA	< 5.8	NA
2-methylnaphthalene		NA	2.2	NA	< 1.7	NA
4-methylphenol / 4-cresol		NA	< 0.52	NA	< 0.52	NA
Acenaphthene		NA	< 1.7	NA	< 1.7	NA
Anthracene		NA	< 0.5	NA	< 0.5	NA
Bis (2-ethylhexyl) Phthalate		NA	< 4.8	NA	15	NA
Fluorene		NA	< 3.7	NA	< 3.7	NA
Naphthalene		NA	6.2	NA	< .5	NA
Phenanthrene		NA	< 0.5	NA	< 0.5	NA
PAL VOLATILE ORGANICS (µg/L)						
*xylenes		NA	47	NA	< .84	NA
1,2-dichloroethane		NA	< .5	NA	< .5	NA
Acetone		NA	< 13	NA	< 13	NA
Benzene		NA	7.7	NA	.56	NA
Carbon Disulfide		NA	< .5	NA	< .5	NA
Chloroform		NA	< .5	NA	< .5	NA
Ethylbenzene		NA	29	NA	< .5	NA
Methylene Chloride		NA	< 2.3	NA	2.2	NA
Methyl isobutyl ketone/Isopropylacetone		NA	< 3	NA	< 3	NA
Tetrachloroethylene / Tetrachloroethene		NA	< 1.6	NA	< 1.6	NA
Toluene		NA	4.3	NA	< .5	NA
Trichloroethylene / Trichloroethene		NA	< .5	NA	< .5	NA
Trichlorofluoromethane		NA	< 1.4	NA	< 1.4	NA
PAL WATER QUALITY PARAMETERS						
Alkalinity		NA	NA	NA	145000	NA
Nitrite, Nitrate-non Specific		NA	NA	NA	440	NA
Nitrogen By Kjeldahl Method		NA	381	NA	1050	NA
Total Dissolved Solids		NA	NA	NA	NA	NA
Total Hardness		NA	NA	NA	225000	NA
Total Suspended Solids		NA	NA	NA	378000	NA
OTHER (µg/L)						
Total Petroleum Hydrocarbons		NA	NA	NA	NA	NA

TABLE 7–11
SEDIMENT OFF–SITE LABORATORY RESULTS
AOC 43 G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE SITE ID:	XGD–93–02X
INORGANICS (µg/g)	
Aluminum	3710
Arsenic	7.5
Barium	17.2
Calcium	1610
Chromium	13.3
Cobalt	2.63
Copper	15.3
Iron	11400
Lead	24
Magnesium	1840
Manganese	119
Nickel	9.87
Potassium	697
Sodium	298
Vanadium	9.84
Zinc	70.7
OTHER (µg/g)	
Total Organic Carbon	8970
Total Petroleum Hydrocarbons	448

8.0 CONTAMINANT FATE AND TRANSPORT

This subsection discusses the migration potential and probable environmental fate of general contaminant groups identified at AOC 43G. Compounds and analytes detected include VOCs, SVOCs, inorganics, and TPHC. The observed distribution of these contaminants in different environmental media (soil, sediment, and groundwater) is the result of the release pattern and of their physical and chemical properties. For organic chemicals, these properties include specific gravity, solubility, volatility, and organic carbon partition coefficient (K_{oc}). For inorganic constituents, the physical and chemical properties include oxidation state of the analyte, pH, and specific solute species. Site-specific conditions governing fate and transport (e.g., persistence and migration) of analytes include contaminant concentration, topography, meteorological conditions, and in the case of groundwater, hydrogeology.

8.1 COMPOUND PROPERTIES AND TRANSPORT PROCESSES

The primary contaminants detected in soil at AOC 43G are fuel-related VOCs, SVOCs, and TPHC. In addition, some VOCs and SVOCs may have been introduced as laboratory contamination.

The persistence of compounds in soil is determined by chemical properties, source configurations and releases, geochemical and biochemical reactions, and soil and meteorological conditions. Factors and processes that control the persistence of chemicals in water-bearing units, in addition to the aforementioned factors, are water-bearing unit characteristics, advection, and hydrodynamic dispersion. Compounds may exist in the surface and subsurface in gaseous, aqueous, or solid phases. The fate of these compounds is controlled by a combination of all of these factors.

The following subsections discuss general physical and chemical properties, and how these properties affect transport and general attenuation processes.

8.1.1 Physical and Chemical Properties Significant to Fate and Transport

This subsection discusses the physical and chemical properties which affect the fate and transport of contaminants in the environment. Physical and chemical properties of organic contaminants of concern detected at AOC 43G are presented in Table 8-1. Table 8-2 summarizes the relative mobilities of selected inorganic elements in different chemical environments.

Most physical and chemical properties of Target Compound List (TCL) analytes are described in "Basics of Pump-and-Treat Groundwater Remediation Technology" (USEPA, 1990b) including specific gravities, K_{oc}, relative solubility, and relative volatility. This reference document does not include inorganics, because analyses conducted measure the total amount of a particular constituent in the sample rather than the actual chemical form or metal oxidation state. The distribution of specific solute species, pH, and oxidation are important factors in establishing the total solubility or mobility of a given inorganic element.

Specific gravity is the ratio of the mass of a given volume of a liquid substance to the mass of an equal volume of water. Liquids with specific gravities greater than 1 are termed "heavier" than water.

Solubility measures the partitioning between the aqueous phase and solid form of a chemical, and the tendency of a material to dissolve in water. Substances with lower solubilities are more likely to remain in a separate phase when in contact with water; substances with higher solubilities will dissolve into, and move with, water.

Volatility measures the tendency of a chemical to partition into the gaseous phase. Volatility can be predicted by an analyte's vapor pressure and Henry's Law Constant value (H). Volatility of a compound increases with increasing vapor pressure. Compounds with H values less than $1.0x10^{-5}$ have a low degree of volatility, and those with H values below $3.0x10^{-7}$ are considered non-volatile. H values between $1.0x10^{-5}$ and $1.0x10^{-3}$ (e.g., anthracene, naphthalene, PCBs) are moderately volatile, while those with values exceeding $1.0x10^{-3}$ (e.g., VOCs) are considered highly volatile.

K_{oc} measures the extent that an organic chemical partitions between a solid phase and a liquid phase, and is used to predict to what extent a chemical could be adsorbed to soil organic carbon. Chemicals with a K_{oc} greater than 10,000 will adsorb strongly to soil organic carbon. Chemicals with a K_{oc} ranging from 1,000 to 10,000 will moderately adsorb, and move slowly in the soil profile. Chemicals with a K_{oc} of less than 1,000 weakly adsorb to soil organic carbon and tend to be more mobile. Examples of weakly adsorbed compounds include many VOCs such as benzene and xylene.

8.1.2 General Transport and Attenuation Processes

Migration and persistence are controlled by various transport and attenuation processes. Processes that tend to disperse contaminants include surface water and groundwater movement (which includes the movement of dissolved and suspended contaminants), facilitated transport, leaching by dissolution or desorption, and surface erosion.

The solubility of a compound in water is considered to be the most important transport factor, because it determines the maximum concentration dissolved in water. Knowledge of the solubility of a chemical provides considerable insight into the fate and transport of that chemical. In general, highly soluble compounds are less likely to partition into soil or sediment, or to volatilize from water, and are more likely to biodegrade (Montgomery, 1991).

Dissolved phase transport can occur via two processes: advection or dispersion. Advection involves transport with flowing groundwater and migrating with the mean velocity of the solvent (groundwater plus dissolved compounds). When compounds move through the ground by advection, they are subject to spreading within the ground, which allows compounds with little or no affinity for soils to migrate faster than the groundwater velocity. This spreading is the result of a process known as dispersion. Hydrodynamic dispersion has two components: molecular diffusion and mechanical dispersion (USEPA, 1989a). Diffusion is the process by which ionic or molecular constituents move under the influence of concentration gradients. Mechanical dispersion occurs as the groundwater flows through the media, and compounds spread out through the tortuous pathways of the soil matrix, and mix with clean water. The result is a dilution of the compound by a process known as dispersion (Fetter, 1988). At very low

groundwater velocities, diffusion is the dominant process; at higher velocities, dispersion is the dominant process. Dispersivity is dependent on vertical and horizontal permeability variations, increasing with the degree of heterogeneity and anisotropy, and is dependent on whether flow is principally through porous media or nonporous media (e.g., fractured bedrock) (Walton, 1988).

The rate a compound migrates can be influenced by facilitated transport, which is the combined effects of physical, chemical, and/or biological phenomena that act to increase mobility. Examples of facilitated transport include particle transport, cosolvation, and phase shifting (Keely, 1989).

Particle transport involves the movement of small, solid-phase particles (such as inorganic and organic colloids), macromolecules, or emulsions to which compounds have adhered by sorption, ion exchange, or other means. High molecular weight organic compounds such as PAHs, pesticides, and heavy metals, have a high affinity for mobile subsurface particles, and this affinity increases their mobility (Huling, 1989). Small particles, especially mobile organic carbon phase particles such as biocolloids and macromolecules (e.g., humic substances) are transported in the aqueous phase and may act as mobile sorbents. PAHs, pesticides, and heavy metals are not site-related contaminants at AOC 43G.

Cosolvation is the process by which the solubility and mobility of one compound is increased by the presence of another (Keely, 1989). Naturally occurring organic compounds (e.g., humic acids) can undergo complexation reactions with metals and pesticides. Complexation reactions can increase the solubility of metals (including iron, aluminum, copper, nickel, and lead) and pesticides (e.g., DDT). In a cosolvent system, as the fraction of a water-miscible cosolvent increases, the solubilities of the metals or pesticides increase. However, the cosolvent concentration normally needs to be high to ensure a substantial increase in solute velocity. Therefore, cosolvation is important primarily near sources of groundwater impact (USEPA, 1989a). High concentrations of water-miscible phases (e.g., ketones) were not detected at AOC 43G.

Chemical phase shifts involve changes in pH and/or the redox potential of the groundwater. These shifts can increase solubilities and mobilities by ionizing neutral organics, solubilizing precipitated metals, forming complexes, or limiting biological activity (Keely, 1989). These processes are particularly important in

determining the mobility of heavy metals. Inorganics and heavy metals are not site-related contaminants at AOC 43G.

Processes that tend to attenuate migration of impacted groundwater include retardation resulting from sorption, volatilization, degradation, and precipitation. The sorption properties of individual solutes are dependent on soil and groundwater characteristics. In general, the relative amount of sorption by soil or sediment materials that do not contain organic matter is as follows: clay > silt > sand > gravel (Walton, 1988). The till beneath AOC 43G is a sandy silt. Sorption would be expected to exert a significant influence in retarding the migration of fuel-related VOCs and SVOCs in the till. Sorption would be expected to be less significant in the underlying bedrock.

The tendency of organic chemicals to be sorbed is also dependent on the organic content of the soil and the degree of hydrophobicity (lack of affinity for water) of the solute. The rate of travel for each chemical depends on the groundwater seepage velocity and the degree of sorption. If an organic chemical is extensively adsorbed by particles, it will be rendered relatively immobile. The rates and degree of volatilization, photolysis, hydrolysis, and biodegradation are directly dependent on the extent of adsorption (Montgomery, 1991). The vadose zone typically contains greater amounts of organic material and metal oxides (which may also act as sorbents) than the saturated zone, which may make the rate of movement in the vadose zone substantially less than that in the saturated zone (USEPA, 1989a).

The soil/sediment partition or sorption coefficient (K_{oc}) is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous solute concentration. The coefficient indicates the tendency of a compound to adsorb to organic carbon (degree of retardation) and, therefore, provides a means for estimation of the relative mobility of solutes (Montgomery, 1991). Mobility is a function of the relative rate of transport of a chemical versus the rate of groundwater flow. Chemicals that have relatively low mobilities (i.e., high retardation or sorption) move slowly compared to the velocity of the groundwater. Chemicals that have relatively high mobilities (i.e., low retardation or sorption) move at a rate closer to groundwater velocity. VOCs detected at AOC 43G have relatively high mobility potential, while SVOCs have moderate to high mobility potential (see Table 8-1).

Volatilization is the transport of a compound from the liquid to the vapor phase and, ultimately, into the atmosphere. Volatilization rates are affected by soil properties, vapor pressure, temperature, and sorption. VOCs partition between the aqueous and gaseous phase in unsaturated soils. This process will occur most readily for compounds with a high vapor pressure and a high H. These compounds tend to partition off into the gas phase and occupy the available soil pore space. In addition, VOCs in the saturated zone or in surface water will partition to the gaseous phase, particularly those with lower solubility (e.g., xylenes). VOCs with greater aqueous solubility tend to remain in solution.

Volatilization is an important process in shallow soils and surface water. In recharge areas composed of sandy or gravelly soil, volatilization may be an important process, especially for compounds with moderate to high volatility (Montgomery, 1991). The effectiveness of volatilization normally decreases with depth in the soil column.

Chemicals released to the environment are susceptible to several degradation pathways, including chemical degradation (e.g., oxidation and reduction); photolysis or photochemical degradation; and biodegradation. Compounds formed by these processes may be more or less toxic and/or more or less mobile than the parent compound.

Oxidation typically involves the loss of electrons during a chemical reaction. In general, substituted aromatic compounds such as ethylbenzene and naphthalene can be oxidized. Oxidation rates for aromatic compounds are typically an order of magnitude faster than for chlorinated aliphatic compounds (e.g., 1,2-DCA). Overall, abiotic (without biological life) oxidation of organic compounds in groundwater systems is extremely limited.

Photochemical breakdown processes involve structural changes in a molecule induced by radiation in the ultraviolet-visible light range. This process is unlikely to occur at AOC 43G due to contamination being confined to the subsurface environment.

Biodegradation may be defined as the breakdown of organic compounds by microorganisms through metabolic processes. Variables affecting the rate of biodegradation include:

- number of microorganisms (most are within 14 centimeters of the ground surface)
- chemical properties, concentrations, and distribution
- presence of food and nutrients
- temperature
- pH
- moisture and oxygen content

The rate of biodegradation tends to be higher for low molecular weight compounds. Naturally occurring soil and aquatic microorganisms capable of degrading aromatic hydrocarbons (e.g., BTEX) have been studied, and a relationship between dissolved oxygen and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized by dissolution from soil or sediment, they are likely to be rapidly degraded as long as microorganisms and dissolved oxygen are available.

8.2 Fate and Transport of Contaminants Detected at AOC 43G

This subsection discusses the potential fate and transport of contaminants, by chemical class, detected at AOC 43G.

VOCs. Soil samples collected at or below the water table at AOC 43G contained the fuel-related VOCs BTEX (see Table 7-5). Fuel-related VOC TICs such as heptane and octane were also present in the soil samples (see Table 7-1). BTEX are the primary VOCs detected in groundwater samples from AOC 43G (see Table 7-10). 1,2-DCA and PCE were also detected in downgradient and crossgradient monitoring wells (XGM-94-07X and AAFES-5). Fuel-related VOC TICs tentatively identified in groundwater include butane, isobutane, 2-methyl-1-butene, 2-methyl-2-butene, cyclohexane, isopentane, pentane, methlycyclopentane, and 3-methylpentane.

VOCs detected at AOC 43G can be classified as aromatic hydrocarbons (e.g., BTEX) and halogenated hydrocarbons (e.g., 1,2-DCA). Processes and forces that will control the fate of these VOCs include volatilization, advection/dispersion, and biodegradation.

Gravity drainage of VOCs from soil was an important transport mechanism at AOC 43G. Percolation of free-phase fuel and waste oils from leaking USTs and/or associated subsurface piping through soils was likely the initial transport mechanism for VOCs to groundwater. Factors affecting VOC percolation to groundwater are density and volatility. Compounds with higher density and low volatility are most likely to be transported to groundwater.

Dissolution of VOCs from unsaturated zone soil via infiltrating precipitation is not likely to be a dominant transport mechanism at AOC 43G due to the extensive asphalt cover of the parking lot.

Volatilization is believed to be the most significant transport mechanism for VOCs in the unsaturated soils at AOC 43G. The fuel-related VOCs at AOC 43G are likely partitioning between the aqueous and gaseous phases in the source area unsaturated soils beneath the existing gasoline USTs. This process occurs most readily for compounds with a high vapor pressure and a high H (e.g., benzene and toluene). In addition, VOCs in the saturated zone will partition to the gaseous phase, particularly those with lower solubility (e.g., toluene, xylene, and ethylbenzene). As groundwater transports the fuel-related VOCs away from the source areas, the VOCs with lower solubility will partition to some extent into the gas phase and occupy the available soil pore space above the water table in the unsaturated zone. Headspace readings from unsaturated zone soils up to 150 feet from the source area confirm this partitioning. VOCs with greater aqueous solubility tend to partition more strongly to the aqueous phase (e.g., benzene).

Dissolved phase transport of VOCs in groundwater is also a significant transport mechanism at AOC 43G. Factors affecting partitioning of VOCs from soil to groundwater include solubility and K_{oc}. VOCs with high solubilities and low K_{oc}s, such as benzene, will partition to groundwater from the saturated zone soils. Results of saturated zone soil samples and groundwater samples indicates this to be the case, as benzene was detected in groundwater, but not in soil. Toluene, ethylbenzene, and xylene were detected in saturated zone soils and groundwater, which is probably a

result of the moderate K_{oc}s and solubilities (see Table 8-1). Processes that tend to attenuate migration of impacted groundwater at AOC 43G include retardation resulting from sorption, volatilization, and degradation.

Biodegradation reactions act to reduce the total mass of VOCs. Naturally occurring soil microorganisms capable of degrading aromatic hydrocarbons have been studied, and a relationship between dissolved oxygen and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized by dissolution from the soil or sediment, they are likely to be rapidly degraded as long as dissolved oxygen and sufficient microorganisms are available.

Fuel-related VOC contaminants at AOC 43G are expected to be reduced through volatilization, biodegradation, and/or dilution and dispersion.

SVOCs. Soil samples collected at or below the water table at AOC 43G contained the fuel-related SVOCs (see Table 7-1). Fuel-related SVOC TICs such as heavyweight alkanes pentadecane, hendecane, and pentacosane were also present in the soil samples (see Table 7-1). 1-methylnaphthalene, naphthalene, and phenanthrene, are the primary SVOCs detected in groundwater samples from AOC 43G. Fuel-related SVOC TICs in groundwater include 1,3-diethylbenzene; 1-ethyl-3-methylbenzene; trimethylbenzenes; 1,2,3,4-tetramethylbenzene; propylbenzene; 3-methylcyclohexene; cumene; isodurene; indan; hexadecanoic acid butyl ester; nonadecane; and cyclopentanone (see Table 7-1).

SVOCs detected at AOC 43G can be classified as monocyclic aromatic hydrocarbons (e.g., o-cresol, and p-cresol) and PAHs (e.g., 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene). Processes that will control the fate of these SVOCs include volatilization, sorption, advection/dispersion, and biodegradation.

Gravity drainage of SVOCs from soil was an important transport mechanism at AOC 43G. Percolation of free-phase fuel and waste oils from leaking USTs and/or associated subsurface piping through soils was likely the initial transport mechanism for SVOCs to groundwater. Factors affecting SVOC percolation to groundwater are density and volatility. Compounds with higher density and low volatility are most likely to be transported to groundwater.

Dissolution of SVOCs from unsaturated zone soil via infiltrating precipitation is not likely to be a dominant transport mechanism at AOC 43G due to the extensive asphalt cover of the parking lot.

Volatilization is a minor transport mechanism for SVOCs in the soils and groundwater at AOC 43G. The fuel-related SVOCs at AOC 43G, such as naphthalene and phenanthrene, are considered moderately volatile, and therefore volatilization is not as significant a transport mechanism as it is for VOCs.

Dissolved phase transport of SVOCs in groundwater is a significant transport mechanism at AOC 43G. Factors affecting partitioning of SVOCs from soil to groundwater include solubility and K_{oc}. SVOCs are generally regarded as immobile because of strong adsorption to the organic carbon fraction of soil predicted through higher K_{oc}s and low solubilities (Tinsley, 1979; Kenaga and Goring, 1978). SVOCs with moderate solubilities and moderate to high K_{oc}s, such as pyrene and 1-methylnaphthalene, will partition slightly to groundwater from the saturated zone soils (see Table 8-1). Results of saturated zone soil samples and groundwater samples indicate this to be the case, as the SVOCs were detected at much higher concentrations in soil than in groundwater. Processes that tend to attenuate migration of impacted groundwater at AOC 43G include retardation resulting from sorption, volatilization, and degradation.

Biodegradation reactions act to reduce the total mass of lower molecular weight PAHs (e.g., naphthalene). Naturally occurring soil microorganisms capable of degrading aromatic hydrocarbons have been studied, and a relationship between dissolved oxygen and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized from the soil by groundwater movement, they are likely to be degraded as long as dissolved oxygen and sufficient microorganisms are available.

The fate of fuel-related SVOC contaminants at AOC 43G is expected to be reduction through volatilization, biodegradation, and/or dilution and dispersion. The SVOCs would be expected to eventually partition out of the aqueous phase to the soil phase and remain present in the soils. The slow rate of migration (due to partitioning to soil) for the PAHs allows for significant degradation, even if degradation rates are small, before they can travel significant distances. The fuel-related PAHs also tend to be more persistent with increasing molecular weight.

Inorganics. Inorganics detected at AOC 43G include metals (aluminum and lead), transition metals (iron, manganese, vanadium, chromium, cobalt, cadmium, mercury, nickel, silver, zinc, and copper), alkaline earth metals (calcium, magnesium, and barium), alkali metals (sodium and potassium), and nonmetallic elements (arsenic). It should be noted that the detection of these inorganics could not be correlated with the presence of fuel-related organic compounds (see Section 7.0 of this report). Discussion of the fate and transport of inorganics, presented below, is therefore limited.

The mobility of inorganics in soil-water systems is strongly affected by compound solubility, pH, soil cation exchange capacity, soil type, oxidation-reduction potential, adsorption processes, major ion concentrations, and salinity. The distribution of inorganics would most likely be controlled by adsorption processes. Once adsorbed to soil, the inorganics may migrate with the soil by mechanical transport of particles. The migration of dissolved inorganics is dependent upon their individual adsorption characteristics (Oak Ridge National Laboratories, 1989). Mobilities of inorganic elements relative to the redox state of the environment are presented in Table 8-2.

8.3 SITE CONCEPTUAL MODEL

The site conceptual model is designed to present a simplified model encompassing the essential features of AOC 43G. Figure 8-1 presents a site conceptual model flow chart showing the potential source and transport mechanisms for the contaminants detected at AOC 43G. The model reflects the current understanding of the site with respect to sources of contamination, the distribution of contamination, and the potential migration pathways.

Based on the results of the previous investigations the primary site-related contaminants at AOC 43G are fuel-related contaminants in soil and groundwater. VOCs were detected in the subsurface soil in two of the three areas investigated during each investigation, while TPHC was detected in all three areas. Benzene and ethylbenzene were detected above the federal MCL in groundwater samples collected directly downgradient of the AAFES gas station. Several inorganics were also detected above their action limits in the unfiltered samples collected during each round of groundwater sampling. The inorganic results for the filtered groundwater samples collected during Rounds Three and Four were either slightly above or below

federal MCLs, indicating that the inorganic concentrations in the unfiltered samples were a result of elevated TSS, and were not site-related contaminants.

Figure 8-1 presents a site conceptual model flow chart showing the potential source and transport mechanisms for the contaminants detected at the AAFES gas station. Based on the results of each field investigation, it appears that the former gasoline USTs (removed and replaced in 1991), the former waste oil UST and the gas station's sand and gas trap are the primary sources of soil and groundwater contamination.

The primary release mechanism appears to be leaks from the former gasoline USTs, waste oil UST, and their associated piping, and leaks from the existing sand and gas trap.

Potential secondary source of groundwater contamination is the contaminated soil below the existing gasoline USTs, the subsurface soil below the former waste oil UST, and the soil around and below the sand and gas trap. The groundwater table below the station is located in the bedrock below the existing gasoline USTs and contaminants from the soil have migrated into the bedrock.

The secondary release mechanism appears to be gravity drainage/infiltration and/or percolation of the contaminants through the subsurface soil and to the water table. A layer of free product was detected in one monitoring well (AAFES-2). The distribution of this free product layer is unknown. Also, if the contaminated soil was excavated there could be release of contaminants into the air in the form of dust.

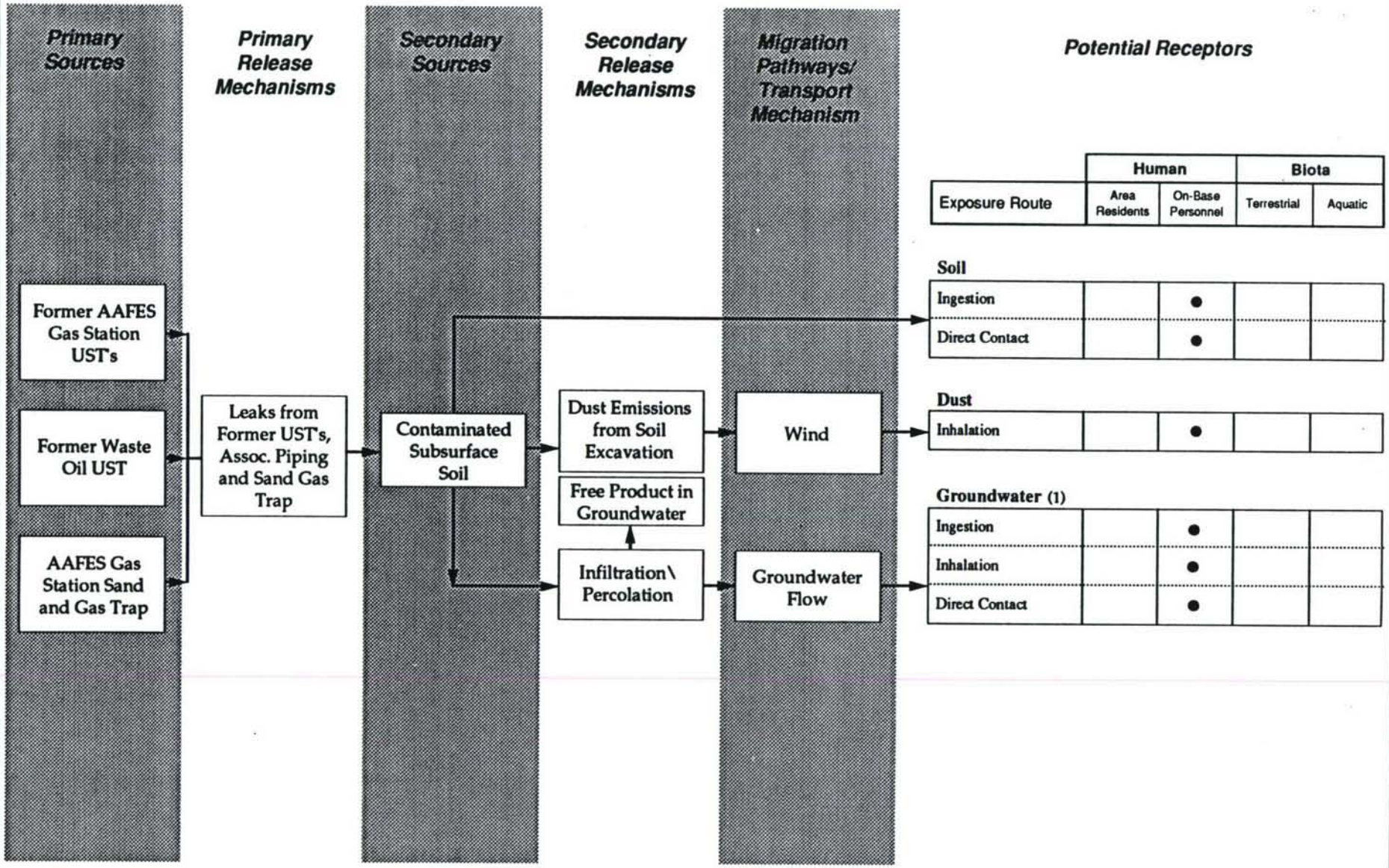
The migration pathways/transport mechanisms appear to be groundwater flow of dissolved contaminants and wind for contaminants adhering to soil.

AOC 43G is within the northeastern edge of the proposed Army Reserve Enclave. Because of this, the human health exposure scenario shows that on-base personnel could be effected by the fuel-related contaminants through ingestion, direct contact and inhalation of volatilized contaminants from groundwater migrating from the site. However, it is highly unlikely that this exposure pathway exists due to the fact that the planned reuse of this area, and the areas downgradient of this AOC, precludes the installation of a potable water supply well at or near this AOC. On-post personnel could be exposed to contaminated subsurface soil through accidental

ingestion and direct contact. Both area residents and on-post personnel could be exposed to contaminated subsurface soil dust via inhalation.

Based upon the depth of the soil and groundwater contamination detected at AOC 43G, it appears that there is no potential future risks to ecological receptors.

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NOTE

(1) = Assumes drinking water wells will be installed at the site in the future.

FIGURE 8-1
CONCEPTUAL MODEL FLOW DIAGRAM
AOC 43G-HISTORIC GAS STATION G/AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

TABLE 8-1
CHEMICAL AND PHYSICAL PROPERTIES OF COMPOUNDS DETECTED[1]
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

CONTAMINANT	MOLECULAR WEIGHT	DENSITY (g/cm3)	WATER SOLUBILITY (mg/L)	VAPOR PRESSURE (mm Hg)	HENRY'S CONSTANT, H_c (atm m3 mol-1)	ORGANIC CARBON PARTITION COEFFICIENT K_{oc} (mL/g)
VOLATILE ORGANIC COMPOUNDS						
1,2-DICHLOROETHANE	98.98	1.28	8.52E+03	6.40E+01	9.78E-04	1.40E+01
BENZENE	78.12	1.87	1.75E+05	9.52E+01	5.59E-03	8.30E+01
CARBON TETRACHLORIDE	153.82	1.58	7.57E+02	9.00E+01	2.41E-02	4.39E+02
ETHYLBENZENE	106.16	0.87	1.52E+02	7.00E+00	6.43E-03	1.10E+03
TETRACHLOROETHENE	165.8	1.47	1.50E+02	1.78E+01	2.59E-02	3.64E+02
TOLUENE	92.13	0.86	5.35E+02	2.81E+01	6.37E-03	3.00E+02
TRICHLOROETHENE	131.4	1.47	1.10E+03	5.79E+01	9.10E-01	1.26E+02
XYLENES[2]	106.16	0.88	1.75E+02	6.60E+00	5.10E-03	8.30E+02
SEMIVOLATILE ORGANIC COMPOUNDS						
ACENAPHTHENE	152	0.9	3.93E+00	2.50E+03	1.48E+03	2.50E+03
ANTHRACENE	178.2	1.24	4.50E-02	1.95E-04	1.02E-03	1.40E+04
FLUORENE	116.2	1.2	1.69E+00	7.10E-04	6.42E-05	7.30E+03
o-CRESOL	108.14	1.03	2.50E+04	2.43E-01	1.50E-06	NA
P-CRESOL	108.14	1.01	NA	1.14E-01	NA	NA
2-METHYLNAPHTHALENE	142.2	1.02	2.54E+01	NA	NA	8.50E+03
1,2-DICHLOROBENZENE	1.4701	1.3	1.00E+02	1.00E+00	1.70E-03	1.70E+03
NAPHTHALENE	128.2	0.98	3.17E+01	2.30E-01	1.15E-03	1.30E+03
PHENANTHRENE	178.2	1.03	1.00E+00	6.80E-04	1.59E-04	1.40E+04
PYRENE	202.3	1.27	1.30E-01	2.50E-06	5.04E-06	3.80E+04

Notes:

1. Primary Source: USEPA, 1990. "Basics of Pump-and-Treat Ground-Water Remediation Technology." Robert S. Kerr, Environmental Research Laboratory, Ada, OK. EPA/600/8-90/003.

2. Data presented is for o-xylene.

Aubrey, D.C., 1993. "Encyclopedia of Chemical Technology," Fourth Edition. John Wiley and Sons, New York, NY.

Verschueren, Karel, 1983. "Handbook of Environmental Data on Organic Chemicals." Van Nostrand Reinhold Company, Inc.

Howard, Philip, 1990. "Handbook of Environmental Fate and Exposure Data for Organic Chemicals; Volume II, Solvents." Lewis Publishers, Inc.

atm m3 mol-1 = cubic atmospheres per molecule
g/cm3 = gram per cubic centimeter
K_{oc} =
mg/L = miligram per liter
mL/g =
mm Hg =
NA = Not available

TABLE 8-2
MOBILITIES OF INORGANIC ELEMENTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Relative Mobility	Environment		
	Oxidizing (pH 5 to 8)	Oxidizing (pH <4)	Reducing
Highly mobile	Anions, B, Mo	Anions, B	Anions
Moderately mobile	Ca, Na, Mg, Sb, As, V, Zn, Be	Ca, Na, Mg, Pb, Zn, Cu, Hg, Co, Ni, V, As, Mn, Cd, Sb	Ca, Na, Mg, Ba, Mn
Slightly mobile	K, Ba, Mn, Pb, Cu, Cd, Ni	K, Ba, Cr	K, Fe^{2+}
Immobile	Fe, Al, Cr, Hg	Fe, Al	Fe^{3+}, Al, Cu, Zn, Pb, Cr, V, Ni, As*, Sb, Cd, Hg, Ba

*Mobile in slightly reducing conditions.

As = Arsenic
Al = Aluminum
B = Boron
Ba = Barium
Be = Beryllium
Ca = Calcium
Cd = Cadmium
Co = Cobalt
Cr = Chromium
Cu = Copper
Fe = Iron
Hg = Mercury
K = Potassium
Mg = Magnesium
Mn = Manganese
Mo = Molybdenum
Nd = Sodium
Ni = Nickel
Pb = Lead
Sb = Antimony
V = Vanadium
Z = Zinc

Source:

Rose, A.W., H.E. Hawkes, and J.S. Webb, 1979. Geochemistry in Mineral Exploration. Academic Press.

9.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

9.1 OVERVIEW

A human health risk assessment has been conducted to evaluate potential health risks to individuals under current or foreseeable future site conditions at AOC 43G. The risk assessment is consistent with relevant guidance and standards developed by USEPA (USEPA, 1989b; 1991b,c; 1992a,b,c) and incorporates data from the scientific literature used in conjunction with professional judgment. Due to the urbanized nature of this site and the lack of exposure pathways, an ecological risk assessment was not conducted.

The assessment for AOC 43G consists of the following components:

- Selection of Chemicals of Potential Concern (CPCs)
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Evaluation
- Summary and Conclusions

As a result of the SI (ABB-ES, 1993a) and SSI (ABB-ES, 1994a) conducted at AOC 43G, three areas of potential concern were delineated at AOC 43G to better define the distribution of contaminants. Area 1, the historic gas station consisted of a pump island and a small gasoline pumphouse. Reportedly, the gas station had one 5,000-gallon UST, located between the gasoline pumphouse and the pump island. The station was used during World War II as a vehicle motor pool to support military operations until the late 1940s or early 1950s. Based on the results of the SI, the SSI, and the Human Health PRE conducted in the SSI Data Package (ABB-ES, 1994a), no further action has been recommended for Area 1 (Historic Gas Station G). The PRE for Area 1 is included as Appendix M in this document to support the recommendation of no further action.

After the SI was completed, the study area was expanded to include the active AAFES gas station (Building 2008) which is located approximately 200 feet north of Historic Gas Station G. The area around the existing gasoline USTs at the

AAFES gas station is referred to as Area 2. AOC 43G now also includes the area around a former 500-gallon waste oil UST that was located behind Building 2008 but has been removed, and a sand and gas trap also located behind Building 2008. This area around the former waste oil UST is known as Area 3.

Because Area 1 has been recommended for no further action, the focus of the baseline risk assessment for AOC 43G will be Area 2 (the existing AAFES gasoline USTs) and Area 3 (the former waste oil UST and sand and gas trap).

9.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

The first step in the risk assessment was to collect, summarize, and analyze site data to identify those chemicals present in environmental media as a result of potential sources at Areas 2 and 3 of AOC 43G. Site-related chemicals that were selected for risk evaluation are referred to as CPCs and represent those chemicals present as a result of past activities at AOC 43G.

Contaminants associated with AOC 43G are present in sediment, groundwater, and subsurface soil. Sample locations are presented in Figure 6-1. Surface soil contamination is not present because either parts of AOC 43G are paved or surface soil was removed as part of the UST removals during previous activities and replaced with clean fill.

Two sediment samples were collected from a stormwater drain associated with the paved areas around AOC 43G - one as part of the AREE 70 study conducted by Arthur D. Little, Inc. (ADL, 1994) and one during the SSI. Because a quantitative risk assessment does not appear warranted based on two samples and the limited exposure potential to the stormwater drain, sediment will be qualitatively evaluated in Subsection 9.5 of this report.

Groundwater is separated into a data set of wells associated with the source area and a set of wells downgradient of the source area. Analytical data from filtered and unfiltered samples in Rounds Five and Six are used for the evaluation.

For subsurface soils, Areas 2 and 3 will be evaluated separately. Table 9-1 lists the sample locations providing data for subsurface soil and sediment analyses. All

available data taken above 15 feet bgs from Areas 2 and 3 are included in the evaluation. The procedures used to evaluate and summarize data and to screen data for the selection of CPCs are discussed below.

In addition to the subsurface soil data collected during the SSI and the RI (see Table 9-1), additional subsurface data were collected by ATEC during the tank removal of Area 3 in 1992. Soil samples were collected from the tank excavation by ATEC personnel for field screening consisting of PID headspace and TPHC screening using non-dispersive infrared (NDIR). The results of the PID field screening indicated that VOCs were present in the soil at concentrations up to 48 mg/kg, and TPHC concentrations were as high as 28,000 mg/kg.

ATEC collected two soil samples for laboratory analysis: one from the wall of the excavation and one from the bottom of the excavation. Sample LSS-1, collected at the northwest wall of the excavation, showed the presence of methylene chloride (36 micrograms per kilogram [μg/kg]), PCE (152 μg/kg), BEHP (2,640 μg/kg), pyrene (2,840 μg/kg) and TPHC (35,100 mg/kg). Sample LSS-2, obtained from the bottom of the excavation, showed the presence of methylene chloride (23 μg/kg), PCE (31 μg/kg), 1,1,1-trichloroethane (11 μg/kg), total xylenes (69 μg/kg), BEHP (4,170 μg/kg), pyrene (2,670 μg/kg), and TPHC (23,200 mg/kg).

Although not used in the quantitative risk assessment for subsurface soil, the ATEC data will be used as supportive data and will be considered qualitatively in the risk assessment.

9.2.1 Data Summary Procedures

Prior to selecting CPCs, the analytical data were grouped into the data sets defined on Table 9-1 and summarized. The SSI sampling program is described in Subsection 5.3.5. Samples were analyzed as discussed in Subsection 5.3.6. The following steps, which are in accordance with USEPA (USEPA, 1989b) guidance, were used to summarize the analytical data for this risk assessment:

- Data were summarized by environmental medium (for example, subsurface soil). All chemicals detected in at least one sample were identified.

- Frequency of detection was calculated as the number of samples in which the chemical was detected, divided by the total number of samples collected. Duplicate samples were considered as one data point for determining frequency of detection.

- The maximum detected concentration for each chemical was reported. For this determination, any duplicate samples were considered individually to ensure that the reported maximum concentration was an actual measured concentration, and not the average of two samples.

- For the purpose of calculating the arithmetic mean, duplicate samples were averaged together and the averaged value was used to represent the concentration for that location.

- The arithmetic mean was calculated for each chemical using the detected concentration(s), or using one-half the sample quantitation limit (SQL) for the nondetect sample(s). Duplicate samples for a given sampling point were also averaged in this manner if a chemical was detected in only one sample of a duplicate pair.

- Because all the data sets for AOC 43G consist of 12 samples or fewer, a 95 percent upper confidence limit (UCL) on the arithmetic mean was not calculated. "Supplemental Guidance to RAGS: Calculating the Concentration Term" (USEPA, 1992b) states that data sets with fewer than 10 samples provide poor estimates of the true mean, with the UCL frequently being greater than the highest measured concentration.

Summary sampling data for Areas 2 and 3 subsurface soil data sets and the source and downgradient groundwater data sets are presented in Table 9-2. The data screening procedures described in the following subsection were applied to the summary data to select CPCs.

9.2.2 Data Screening Procedures

The procedures used for selection of CPCs, based on USEPA (1989b) guidance are described below. The results are indicated in Table 9-2.

- If a chemical was determined to be an artifact, either due to laboratory or field cross-contamination in Subsection 7.1.1 or 7.1.2, then it was eliminated as a CPC.

- The summary data were also screened to eliminate naturally occurring inorganic analytes present at levels within Fort Devens background concentrations. The development of the background data sets is described in Subsection 4.3 of this report.

  If all detected concentrations of an inorganic analyte in soil or groundwater samples were within the range of the Fort Devens basewide background concentrations for that medium, then that chemical was assumed to be present at naturally occurring levels and was eliminated as a CPC. If, however, the maximum concentration of an inorganic exceeded the maximum basewide background concentration, then that chemical was selected as a CPC and carried through the risk assessment. It should be noted that this is a conservative, non-statistical approach, and it does not indicate whether there is a statistically significant difference between the site and Fort Devens background concentration distributions.

- An assessment of essential nutrients was also performed to eliminate from the risk assessments those chemicals unlikely to result in adverse effects at low concentrations. Chemicals considered to be essential human nutrients include calcium, magnesium, potassium, and sodium.

CPCs retained in the selection process for AOC 43G are presented in Table 9-2. In addition, chemicals not selected for quantitative evaluation are noted, along with the reason for their elimination.

9.3 EXPOSURE ASSESSMENT

The following subsections describe the exposure pathways evaluation for human health risk assessment at AOC 43G.

9.3.1 Human Exposure Pathways

An exposure assessment was conducted to identify the potential pathways by which human populations may be exposed to chemicals at AOC 43G and to provide quantitative evaluations of those exposures.

An exposure pathway (i.e., the sequence of events leading to contact with a chemical) generally consists of four elements:

(1) A source and mechanism of chemical release to the environment;

(2) A retention or transport medium for the released chemical;

(3) A point of potential human contact with the impacted medium (i.e., the exposure point); and

(4) A route of exposure (ingestion or dermal contact, for example) for a potential receptor.

When all four of these elements are present, an exposure pathway is considered "complete." In the risk assessment, only complete exposure pathways are evaluated. The exposure assessment is performed to identify complete pathways at AOC 43G, and it draws on information regarding the source, fate and transport of chemicals, and information on human populations potentially exposed to chemicals in environmental media.

In evaluating potential human exposure pathways, exposures under both current and potential future site uses and surrounding land use conditions were evaluated. Current land use conditions were evaluated to consider actual or possible exposures. Future site land use conditions were considered to address exposures that may occur as a result of any future activities or land use changes.

The future use of AOC 43G is expected to be the same as its current use. AOC 43G will continue to be used as a gas station. AOC 43G is located on a portion of the Main Post to be retained by the Department of Defense after the closure of Fort Devens in 1995. It will be part of the Army Reserve Enclave that will provide facilities support to the Army Reserve organization at Fort Devens. The Enclave will also contain facilities for the active Army component remaining on Fort Devens to support the reserve training activities (Vanasse Hangen Brustlin, Inc., 1994).

No construction is anticipated at AOC 43G in the foreseeable future. However it is possible that the USTs or utility lines in the area may need repair at some time in the future.

Although AOC 43G is designated to remain within the Army Reserve Enclave, it cannot be ruled out that the site might be developed for commercial or industrial use in the future. According to the Devens Reuse Plan (Vanasse Hangen Brustlin, Inc., 1994), development of certain tracts of land at Fort Devens will occur in various phases. In this risk assessment, certain exposure scenarios (such as the groundwater exposure pathway) have been developed to address the possibility of commercial/industrial use of AOC 43G.

Possible exposure pathways encompassing both current and future conditions are presented in Table 9-3, and are discussed below.

Soil Pathway. There is no current contact with contaminated subsurface soil. In the future, contact with contaminated subsurface soil could occur if excavation activities (i.e., repair of utility lines or USTs) were to take place. The receptor chosen for evaluation is a utility/maintenance worker engaged in periodic repair activities. The two principal routes by which workers could be exposed to chemicals in soil are ingestion and dermal contact. Following USEPA Region I guidance, the dermal route will not be evaluated quantitatively due to a lack of adequate dermal absorption information for the CPCs at the site. This approach will likely underestimate the risks associated with the VOCs and SVOCs detected in subsurface soil. However, the effects from inorganics would be expected to be negligible due to the poor absorption of inorganics through the skin. An additional exposure route, the inhalation of volatile compounds or soil particles entrained in air (dust), is discussed under the Air Pathway below.

Surface Water/Sediment Pathway. Two sediment samples were collected from the outfall of a storm drain at AOC 43G. The storm drain collects runoff from the paved area of the gas station and empties into a riprap-filled ditch in a field about 200 feet east of AOC 43G. Surface water is present at the outfall only during storm events and was not sampled due to insufficient quantity. Some transitory exposure to sediment by workers or reserve personnel passing through the area is possible, but would be extremely limited in frequency and duration. For this reason, as well as the small sample size, the evaluation of this pathway will be done qualitatively.

Groundwater Pathway. There is no current use of groundwater at AOC 43G. AOC 43G is to be retained within the proposed Army Reserve Enclave in the central portion of the Main Post, which is one of several areas that will be retained by the Army after base closure (Vanasse Hangen Brustlin, Inc., 1994). There are existing supplies of water on the base and it is unlikely that the groundwater at the site would be developed. However, because future use of the groundwater cannot be ruled out, a future commercial/industrial worker using groundwater at the site as a drinking water source was selected as a receptor. Ingestion of groundwater as drinking water is the exposure route evaluated.

Air Pathway. Air could be a contact medium if VOCs present in the soil or groundwater volatilize into the ambient air or if airborne particulates containing chemicals are generated from the soil. Any persons present at or near areas of release could be exposed via inhalation. Inhalation of volatiles from soil will be evaluated quantitatively for the utility/maintenance worker. While dust could be generated during soil excavation, it is not considered to represent a significant source compared to inhalation of volatiles and will not be evaluated. (Dust would be of concern if a large-scale construction project were anticipated.) Because the depth to groundwater at AOC 43G is 15 to 29 feet bgs, the presence of VOCs in groundwater would not be expected to pose a significant risk to a utility/maintenance worker, nor would it be likely to migrate into building foundations.

9.3.2 Estimation of Exposure

To quantitatively estimate the magnitude of exposures and thus, the risks that may be experienced by an individual, the concentration of the CPC in the contact

medium must be known or estimated. This concentration is referred to as an exposure point concentration (EPC). To estimate exposures, the EPC is combined with assumptions on the rate and magnitude of chemical contact. The determination of EPCs for each pathway is described below.

USEPA Region I has adopted the approach developed in "Supplemental Guidance to RAGS: Calculating the Concentration Term" (USEPA, 1992b) which recommends using the 95 percent UCL on the arithmetic mean concentration as the EPC (USEPA, 1994a). However, the guidance points out that data sets with fewer than 10 samples per exposure area provide poor estimates of the true mean concentration, often exceeding the maximum concentration. For this reason, the maximum detected concentration and the arithmetic mean of all samples were used for AOC 43G as EPCs for estimating reasonable maximum and central tendency exposures, respectively.

Quantitative exposure estimates were derived by combining the EPCs with information describing the extent, frequency, and duration of exposure for the specific receptor. An overview of the approaches used to quantify exposures is given below, followed by specific details for potential exposure pathways. The approaches described in the following paragraphs to quantify exposures are consistent with guidance provided by USEPA (1989a,b; 1991b; 1992a,c).

In cases where a 95 percent UCL can be calculated, current USEPA Region I guidance requires the use of the 95 percent UCL combined with central tendency exposure parameters and with reasonable maximum exposure (RME) parameters (USEPA, 1994a). Because two concentration terms are being used in this risk assessment instead of a 95 percent UCL, exposures were quantified by estimating RME parameters in accordance with USEPA risk assessment guidance (USEPA 1989a, 1991b).

The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA 1989b). The RME is intended to place a conservative upper-bound on the potential risks, meaning that the risk estimate is unlikely to be underestimated but it may very well be overestimated. The likelihood that this RME scenario may actually occur is small, due to the combination of conservative assumptions incorporated into the scenario. The RME estimate for a given pathway is derived by combining the maximum EPC of each chemical with

reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA 1989b). The central tendency estimate combines the same exposure parameters with the arithmetic mean exposure point concentration. Many of the exposure parameter values used in this assessment have been defined by USEPA (1989b,d, 1991b) for the RME case.

The general equation for calculating chemical intake is as follows:

$$Intake = \frac{(C \times CR \times RAF \times EF \times ED)}{BW \times AT \times CF}$$

where:

Intake	=	daily intake averaged over the exposure period
C	=	concentration of the chemical in the exposure medium
CR	=	contact rate for the medium of concern
RAF	=	relative absorption factor
EF	=	exposure frequency
ED	=	exposure duration
BW	=	body weight of the hypothetically exposed individual
AT	=	averaging time (for carcinogens, AT = 70 years; for noncarcinogens, AT = ED)
CF	=	units conversion factor (365 days/yr)

Specific equations for each exposure scenario are provided in the risk calculation spreadsheets in Appendix N. Standard parameters from USEPA guidance were used where appropriate in the intake equations. Table 9-4 delineates the parameters used in the scenario and lists a source for each. The parameters are discussed briefly below.

The contact rate reflects the amount of the medium contacted per unit of time or event. For incidental ingestion of soil, the contact rate is 480 mg soil per day for the utility worker (USEPA, 1991c). A fraction-ingested variable can be used to account for the amount of soil ingested daily that is assumed to come from the area of concern. It was conservatively assumed that all soil ingested daily would originate at AOC 43G. The contact rate for inhalation exposure is 4.8 m^3 of air

per hour or 38.4 m^3 per workday for the utility/maintenance worker based on a heavy activity rate (USEPA, 1989c). The contact rate for ingestion of groundwater is one liter per day, assuming half an individual's daily water intake occurs at work (USEPA, 1991b).

The relative oral absorption factor represents the ratio of a chemical's bioavailability (i.e., ability to be absorbed and potentially exert an effect) when in an environmental matrix to its bioavailability when administered in the experimental dose-response study from which the toxicity criterion for that chemical was derived. The relative oral bioavailability factor is applied to account for the potentially reduced bioavailability of a chemical when ingested in a soil matrix, compared to when experimentally administered in a food mash, water, or a solvent medium. In keeping with the conservative nature of this assessment, a relative oral bioavailability of 100 percent (or 1.0) was assumed for all chemicals.

The EPCs for volatiles released from soil into the air were calculated by applying a soil-to-air volatilization factor to the maximum and mean soil EPCs. The soil-to-air volatilization factor was developed using the equation presented in USEPA, 1991c and revised in USEPA, 1992d. Table 9-5 presents the calculation of volatilization factors for CPCs at Areas 2 and 3.

The body weight used for the utility/maintenance and the commercial/industrial worker is 70 kg, the standard default value for adult body weight.

An exposure frequency and duration of 10 days per year (two work-weeks) for five years was assumed for the utility/maintenance worker. The standard default values for exposure frequency and duration were used for commercial/industrial groundwater exposure (250 days per year for 25 years) (USEPA, 1991b).

The averaging time for lifetime exposure, used for developing intake to evaluate carcinogenic risk was 70 years. Averaging time for noncarcinogenic risk was the actual exposure duration.

9.4 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to define the relationship between the dose of a substance and the likelihood that a toxic effect, either carcinogenic or noncarcinogenic, will result from exposure to that substance. Dose-response values were identified and used to estimate the likelihood of adverse effects as a function of human exposure to an agent. Dose-response summaries are presented in Tables 9-6 through 9-9.

There are two types of dose-response values used in this risk assessment: cancer slope factors (CSFs) and reference dose (RfDs). USEPA has derived CSFs and RfDs to evaluate carcinogenic risks and noncarcinogenic (systemic) effects, respectively. The definitions of CSFs and RfDs, as stated in USEPA guidance are:

- Cancer Slope Factor - a plausible upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The CSF is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen (USEPA Class A or B carcinogens) (USEPA, 1989b).

- Subchronic Reference Dose - an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a portion of a lifetime (e.g., as a Superfund program guideline, two weeks to seven years) (USEPA, 1989b).

In addition, because the toxicity and/or carcinogenicity of a compound can depend on the route of exposure (e.g., oral or inhalation), unique dose-response values (e.g., CSFs and RfDs) have been developed for the oral and inhalation exposure routes. The utility/maintenance worker was evaluated for subchronic exposure (five years), while the commercial/industrial worker (25 years) was evaluated as a chronic exposure.

The primary source for identifying dose-response values is the USEPA Integrated Risk Information System (IRIS) (USEPA, 1995a). If no information is found in

IRIS, the USEPA Health Effects Assessment Summary Tables (HEAST) (USEPA, 1994c) are used. If appropriate dose-response values are not available from either of these two sources, other USEPA sources are consulted (e.g., the USEPA Environmental Criteria and Assessment Office [ECAO]).

Several carcinogenic PAHs were detected at Area 2. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene are classified as carcinogenic PAHs by USEPA. Among the carcinogenic PAHs, the only one for which a CSF has been developed by USEPA is benzo(a)pyrene. To characterize risks associated with exposures to the other carcinogenic PAHs selected as CPCs, a CSF was derived for each of these chemicals by adjusting the toxicity value for benzo(a)pyrene with an estimated relative potency factor (RPF). The RPF used for each carcinogenic PAH is based on that compound's relative potency compared to the potency of benzo(a)pyrene. The RPFs used in this assessment are presented in "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," (USEPA, 1993a). Specifically, the RPFs used for each carcinogenic PAH are as follows:

Carcinogenic PAH	RPF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-c,d)pyrene	0.1

RfDs have been published for only a few of the PAHs. For noncarcinogenic PAHs without published values and for all of the carcinogenic PAHs, the RfD for naphthalene is used as a surrogate value. This is a conservative assumption because, thus far, no PAH has been assigned a lower RfD.

No dose-response values are available for some of the CPCs. Therefore, risks associated with these chemicals could not be quantitatively evaluated although they are retained as CPCs. Chemicals not quantitatively evaluated for the AOC

43G Areas include lead and TPHC. These chemicals will be evaluated qualitatively in the risk characterization section.

In addition, no inhalation reference doses are available for volatile CPCs. HEAST lists reference concentrations for some of these VOCs. Risks for these VOCs were evaluated by developing an average daily air concentration instead of an inhalation dose. The equation for the average daily air concentration is given on the spreadsheets in Appendix N-2.

9.5 Risk Characterization

In this final step of the risk assessment process, the exposure and toxicity information are integrated to develop both quantitative and qualitative evaluations of risk. To quantitatively assess risks associated with CPCs in an environmental medium, the average daily intakes calculated in the Exposure Assessment are combined with the dose-response criteria presented in the Toxicity Assessment. The methodology used to quantitatively assess risks is described below.

USEPA (1989b, 1992b) has developed guidance for assessing the potential risks to individuals from exposure to carcinogenic and noncarcinogenic chemicals. For exposures to a chemical exhibiting carcinogenic effects, an individual upper bound excess lifetime cancer risk is calculated by multiplying the estimated daily intake by the relevant CSF. The resulting risk estimate is an estimate of the probability of contracting, not dying from, cancer as a result of exposure to the potential carcinogen over a 70-year lifetime under the specified exposure conditions. A risk level of $1x10^{-6}$, for example, represents an upper bound probability of one in one million that an individual will contract cancer. The upper bound cancer risk estimates provide estimates of the upper limits of risk, and the risk estimates produced are likely to be greater than the 99th percentile of risks faced by actual receptors (USEPA 1992b). To assess the upper bound individual excess lifetime cancer risks associated with simultaneous exposure to all carcinogenic chemicals of concern, the risks derived from the individual chemicals are summed within each exposure pathway. This approach is consistent with the USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA 1989b). It will

overestimate risk if maximum concentrations occur in different locations and they are used as EPCs.

The relative significance of carcinogenic risk estimates was evaluated by comparison to a target risk range of $1x10^{-4}$ to $1x10^{-6}$ established by USEPA (USEPA, 1989b). USEPA's guidelines state that when the total incremental carcinogenic risk for an individual resulting from exposure at a hazardous waste site is within the range $1x10^{-4}$ to $1x10^{-6}$, a decision about whether to take action or not is a site-specific decision. An additional criterion used for comparison is the MADEP MCP target cancer risk level of $1x10^{-5}$. Although the MADEP MCP is not an ARAR for AOC 43G, risk estimates for exposure to mean site concentrations are compared to the MADEP MCP target risk level.

Unlike carcinogenic effects, noncarcinogenic effects are not expressed as incidence probabilities. Rather, potential noncarcinogenic impacts were evaluated by means of a hazard quotient/hazard index technique as recommended by USEPA (1989b). To assess impacts associated with noncarcinogenic exposures, the ratio of the daily intake to the reference dose is calculated for each noncarcinogenic chemical to derive a hazard quotient (HQ). In general, HQs that are less than 1 indicate that the associated exposure is not likely to result in any adverse health effects, while hazard quotients greater than 1 indicate that adverse health effects may occur. The effects from simultaneous exposures to all CPCs were computed by summing the individual HQs within each exposure pathway. This sum, known as the hazard index (HI), serves the same function for exposures to a mixture as the HQ does for exposure to an individual compound.

HIs for both mean and maximum site concentrations are compared to a target level of 1, established by USEPA; HIs for exposure to mean site concentrations are compared to a MADEP MCP target level of 1. HIs greater than 1 indicate the potential for the occurrence of adverse health effects. A conclusion should not be categorically drawn, however, that all HIs greater than 1 are unacceptable; this is because of the multiple conservative assumptions built into the exposure estimates and toxicity characterization. In cases where an HI is greater than 1, the CPCs are segregated into categories based on target organ/critical effect (e.g., liver, skin, etc.) in accordance with USEPA guidance (USEPA 1989b).

The risk calculations for Areas 2 and 3 are presented in Appendix N-2. The risk estimates are summarized in Table 9-10 and are discussed below.

Subsurface Soil. Potential health risks associated with future exposures to subsurface soil by utility/maintenance workers were quantified. At Area 2, the total cancer risk assuming exposure to mean concentrations is $6x10^{-7}$, which is below the USEPA risk range and the MADEP MCP target level. The estimated risk for exposure to maximum concentrations is $2x10^{-6}$, which is within the USEPA risk range. At Area 3, the total cancer risk assuming exposure to mean concentrations is $7x10^{-7}$, which is below the USEPA risk range and the MADEP MCP target level. The estimated risk for exposure to maximum concentrations is $1x10^{-6}$, which is at the lower limit of the USEPA risk range.

Estimated noncarcinogenic hazards for exposure to mean concentrations of soil contaminants for Areas 2 and 3 are 0.008 and 0.03, respectively; both are well below both the USEPA and MADEP MCP target level of 1. At maximum concentrations, HIs for Areas 2 and 3 are 0.01 and 0.05, again below the USEPA target level.

The ATEC sampling data discussed in Subsection 9.2 were not included in the quantitative risk estimated reported in Table 9-7. ATEC field screening and off-site laboratory results are presented in Table 5-8. Soil samples were collected from 2 to 6 feet bgs. The concentrations of VOCs and SVOCs reported in the ATEC sampling data ranged from 0.011 to 4.170 mg/kg. The risks reported in Table 9-7 are those associated with exposure to chemicals detected in either the SSI or the RI. If, however, the risks associated with exposure (by incidental ingestion) to the contaminants detected in the ATEC soil samples (as analyzed by the laboratory) were added to the quantitative risk estimates reported in Table 9-7, the total cancer risk and total HI do not change. The contribution to the total cancer risk associated with the maximum detected concentrations of carcinogens in the ATEC data set (excluding TPHC which does not have a toxicity value) would be approximately $9x10^{-10}$. The contribution to the total HI from the maximum concentrations of noncarcinogens detected in the ATEC data set would be approximately 0.00006. The concentrations of VOCs in the range of 0.011 to 0.152 mg/kg in soil would be expected to contribute significantly to potential inhalation risks.

Because lead does not have a published dose-response value, it is evaluated by comparison to the USEPA screening level of 400 mg/kg for lead in residential soil (USEPA, 1994b). Maximum concentrations of lead at Areas 2 and 3 are 50 mg/kg and 57 mg/kg, respectively. Neither concentration exceeds the USEPA screening level.

Toxicity values are also unavailable for TPHC, although the toxicity of some TPHC compounds (such as benzene and PAHs) has been evaluated. TPHC will be evaluated by comparing concentrations to MADEP MCP Method 1 S-2 soil standards TPHC. MCP soil standards are developed to consider both the potential risk from direct exposure to the contaminant in the soil and potential impact of the contaminant on groundwater at the site. The lowest identified standard will be used for comparison. Maximum concentrations for TPHC in subsurface soil at Areas 2 and 3 are 185 mg/kg and 1,020 mg/kg, respectively. Both are below the MADEP MCP standard of 2,500 mg/kg, which applies to all three groundwater categories associated with category S-2 soil.

However, the concentrations of TPHC reported by ATEC as part of the tank excavation (for the two soil samples collected from the bottom and northwest wall of the excavation) exceed the MADEP MCP S-2 standard. TPHC was reported at 35,100 and 23,200 mg/kg in these samples.

Sediment. Potential health risks associated with current or future exposure to sediment was qualitatively evaluated by comparing concentrations of chemicals in sediment to USEPA Region III industrial/commercial soil concentrations (USEPA, 1995b) and MADEP Method 1 S-2 soil standards (MADEP, 1995). This comparison is detailed in Table 9-11. Only arsenic exceeds a guideline; in this case, both detected concentrations of arsenic exceed the USEPA Region III Industrial Soil concentration. However, it should be noted that the Fort Devens background concentration of arsenic in sediment, 26 mg/kg, also exceeds the Region III concentration. Neither detected concentration of arsenic exceeds the Fort Devens background concentration.

Groundwater. Potential risks associated with use of site groundwater as a potable water source in the future was evaluated for both unfiltered and filtered data sets for source area wells and downgradient wells. Filtered groundwater was analyzed for inorganics only, but potential risks for the filtered data were estimated

assuming that all organic CPCs detected in unfiltered groundwater were present in filtered groundwater. For unfiltered source area groundwater, the estimated cancer risk assuming exposures to mean concentrations is $1x10^{-4}$, which is at the upper limit of the USEPA target risk range and above the MADEP MCP target level. Contribution to the risk is shared equally by arsenic (49 percent) and benzene (51 percent). The individual cancer risk for each compound, $6x10^{-5}$, is within the USEPA range. The estimated risk assuming exposure to maximum concentrations is $6x10^{-4}$, a level exceeding the USEPA risk range. Arsenic (64 percent) and benzene (36 percent) are the major risk contributors. In this case, the individual risk for each compound (arsenic at $4x10^{-4}$ and benzene at $2x10^{-4}$) also exceeds the USEPA risk range.

Estimated cancer risk for exposure to mean concentrations of filtered groundwater at the source area is $1x10^{-4}$, which is at the upper limit of the USEPA target risk range and is above the MADEP MCP target level. Contribution to the risk is shared by arsenic (53 percent) and benzene (47 percent). The individual cancer risk for each compound ($7x10^{-5}$ for arsenic and $6x10^{-5}$ for benzene) is within the USEPA range. The estimated risk assuming exposure to maximum concentrations is $4x10^{-4}$, a level exceeding the USEPA target risk range. Arsenic (42 percent) and benzene (58 percent) are the major risk contributors. The individual risk for each compound ($2x10^{-4}$ - the percentages differ due to rounding) also exceeds the USEPA target risk range.

Noncarcinogenic risk for unfiltered source area groundwater is estimated with an HI of 37, assuming exposures to mean concentrations, and 99 for exposures to maximum concentrations. The cumulative HI in both cases exceeds the USEPA level of 1. Based on mean concentrations, the primary contributors to the noncarcinogenic risk are manganese at 41 percent and benzene at 55 percent. For maximum concentrations, the contributors to noncarcinogenic risk are arsenic at 2 percent, iron at 3 percent, manganese at 28 percent, and benzene at 66 percent.

Noncarcinogenic risk for filtered source area groundwater is estimated with an HI of 36, assuming exposures to mean concentrations, and 98 for exposures to maximum concentrations. The cumulative HI in both cases exceeds the USEPA level of 1. The primary contributors to the noncarcinogenic risk based on mean concentrations are manganese at 41 percent with an HQ of 15 and benzene at 56

percent with an HQ of 20. For maximum concentrations, the contributors to noncarcinogenic risk are iron at 2 percent with an HQ of 2, manganese at 30 percent with an HQ of 30, and benzene at 67 percent with an HQ of 65.

For the source area filtered and unfiltered groundwater, segregation of the cumulative HI based on differences in mechanisms of action, toxic endpoint or target organ affected by exposure to each of the contributors is possible because each produces effects in distinct organ systems. However, this segregation still results in individual HQs greater than 1 for both the average and the RME scenarios.

Estimated cancer risk for unfiltered downgradient groundwater is $6x10^{-5}$, assuming exposure to mean concentrations of CPCs. The risk is within the USEPA risk range and exceeds the MADEP MCP target level. Arsenic contributes 97 percent of the risk in this case and is the only CPC with an individual cancer risk exceeding $1x10^{-5}$. For exposure to maximum CPC concentrations in downgradient groundwater, the total cancer risk is $2x10^{-4}$, which exceeds the USEPA risk range. Arsenic contributes 94 percent of the risk and is the only CPC with a cancer risk exceeding $1x10^{-4}$.

For filtered downgradient groundwater, estimated cancer risk is $5x10^{-5}$ for exposure to mean concentrations of CPCs. The risk is within the USEPA risk range and exceeds the MADEP MCP target level. Arsenic contributes 95 percent of the risk in this case and is the only CPC with an individual cancer risk exceeding $1x10^{-5}$. For exposure to maximum CPC concentrations in filtered downgradient groundwater, the total cancer risk is $9x10^{-5}$, which is within the USEPA risk range. Arsenic contributes 91 percent of the risk.

For unfiltered downgradient groundwater, noncarcinogenic risk assuming exposure to mean concentrations is 11, exceeding the USEPA and the MADEP MCP target levels of 1. Manganese contributes 90 percent of the risk with an HQ of 10. For exposure to maximum concentrations, the HI is estimated to be 21, exceeding the USEPA target level. In this case, manganese contributes 82 percent of the risk with an HQ of 17 and benzene adds 12 percent with an HQ of 3.

Noncarcinogenic risk assuming exposure to mean concentrations of filtered downgradient groundwater is estimated with an HI of 11, exceeding the USEPA

and the MADEP MCP target level of 1. Manganese contributes 92 percent of the risk with an HQ of 10. For exposure to maximum concentrations, the HI is estimated to be 21, exceeding the USEPA target level. In this case, manganese contributes 84 percent of the risk with an HQ of 17 and benzene adds 12 percent with an HQ of 3.

For unfiltered and filtered downgradient groundwater, segregation of the cumulative HI based on differences in mechanisms of action, toxic endpoint or target organ affected by exposure to each of the contributors is possible because each produces effects in distinct organ systems. However, this segregation still results in individual HQs greater than 1 for both the average and the RME scenarios.

9.6 Comparison of EPCs to Standards and Guidelines

Federal and state drinking water standards and guidelines exist for many of the CPCs detected in source area and downgradient groundwater. Tables 9-12 and 9-13 contain comparisons of source area and downgradient groundwater EPCs to drinking water standards and guidelines, respectively.

As seen in Table 9-12, detected concentrations of the following CPCs in the source area filtered and unfiltered groundwater exceed either a federal MCL, a USEPA drinking water guidelines, a Massachusetts MCL, or a Massachusetts drinking water guideline: xylenes, benzene, ethylbenzene, arsenic, lead, and nickel. In addition, detected concentrations of aluminum, iron, manganese, and sodium exceed their respective federal or state Secondary MCLs (SMCLs) - standards set not for health reasons but for economic or aesthetic reasons.

In downgradient groundwater, as shown in Table 9-13, detected concentrations of benzene in the unfiltered groundwater exceed one or more drinking water standards or guidelines. In addition, detected concentrations of aluminum, iron, manganese, and sodium in unfiltered groundwater and iron, manganese, and sodium in filtered groundwater exceed their respective SMCLs.

9.7 EVALUATION OF UNCERTAINTY

The interpretation of risk estimates is subject to a number of uncertainties as a result of conservative assumptions inherent in risk assessment. All quantitative estimates of risk are based on numerous assumptions, most intended to be protective of human health (i.e., conservative). As such, risk estimates are not truly probabilistic estimates of risk, but rather conditional estimates given a series of conservative assumptions about exposure and toxicity.

In general, sources of uncertainty are categorized into site-specific factors (e.g., variability in analytical data, modeling results, and exposure parameter assumptions) and toxicity factors. Toxicity information for many chemicals is very limited, leading to varying degrees of uncertainty associated with calculated toxicity values. Sources of uncertainty for calculating toxicity factors include extrapolation from short-term to long-term exposures, amount of data (e.g., number of studies) supporting the toxicity factors, consistency of different studies for the same chemical, and responses of various species to equivalent doses. Major sources of uncertainty and their potential effects (e.g., to over- or under-estimate risks) for AOC 43G are presented in Table 9-14.

Arsenic is a CPC detected in groundwater and subsurface soil at AOC 43G. Use of the CSF for arsenic to estimate excess lifetime cancer risks is thought by many to overestimate the true risk. The oral CSF for inorganic arsenic is based on dose/response data for skin cancer incidence obtained by Tseng et al. (1968). Individuals in this study were exposed to high levels of inorganic arsenic in drinking water (170 micrograms per milliliter [μg/ml]). Arsenic exposure was approximated based on estimates of water intake. Other exposure pathways contributing to total exposure, such as ingestion of fish, livestock, and plants were not assessed, potentially resulting in an underestimate of arsenic exposure. The oral slope factor was calculated using a model that assumes the dose/response curve is linear at low doses. Recent evidence suggests that arsenic, at low doses, may be largely detoxified by methylation, producing a non-linear dose/response curve (Goyer, 1991). In the study of Tseng et al. (1968), the overwhelming of the normal detoxification pathways, coupled with an underestimate of exposure, may have resulted in an overestimate of cancer risk.

The uncertainties summarized above have resulted in the USEPA IRIS file for inorganic arsenic reporting that, "The uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards as much as an order of magnitude, relative to risk estimates associated with most other carcinogens" (IRIS, December 1993).

The noncancer risks associated with manganese in drinking water may also be overestimated in this risk assessment. The manganese drinking water RfD of 5.00E-03 mg/kg-day is based on a single epidemiological study conducted in Greece (Kondakis et al., 1989). Limitations with study design coupled with the lack of supporting studies may have resulted in a significant overestimate of the risks associated with drinking water ingestion of manganese. The critical study assessed neurological function in an adequate number of individuals residing in three geographically distinct areas of Greece, each area with significantly different levels of manganese endemic to the local water supply. The study failed to investigate and quantitate other dietary sources of manganese in the study groups. The levels of manganese in locally grown produce and livestock can be presumed to reflect the local concentration of manganese in the water supply (i.e., the high manganese area would also have local food with higher levels of manganese than the areas with lower concentrations of manganese in water). This study flaw may have resulted in the establishment of a drinking water RfD that is artificially low (i.e., overly protective). Additionally, the study assessed neurological function only in individuals older than 50 years of age. The neurological degeneration documented to be produced by high chronic manganese consumption is non-specific in nature and may in fact be produced by a number of other neurological diseases, such as Parkinson's Disease and Alzheimer's Disease, which increase in prevalence with age. The failure of this study to control for the presence of other neurological diseases or for patients with a family history of neurological disease lends uncertainty to the cause-and-effect relationship of manganese to the toxic endpoint assessed.

9.8 SUMMARY AND CONCLUSIONS

Potential health risks associated with exposure to subsurface soil at Areas 2 and 3 of AOC 43G were evaluated. The primary CPCs identified in soil were ethylbenzene, toluene, xylene, PAHs, and inorganic compounds. The exposure

scenario evaluated was for a utility/maintenance worker. Estimated carcinogenic risks did not exceed the USEPA target risk range or MADEP MCP risk management level. Similarly, potential noncarcinogenic risks did not exceed the USEPA and MADEP MCP target level.

Risks associated with exposure to groundwater were evaluated for unfiltered groundwater representing the source area and for unfiltered groundwater identified as downgradient. The receptor evaluated was a future commercial/industrial worker. Estimated carcinogenic risks were at the upper end or exceeded the USEPA risk range of $1x10^{-4}$ to $1x10^{-6}$ for exposure to both mean and maximum concentrations of CPCs in source area groundwater ($1x10^{-4}$ and $6x10^{-4}$, respectively). Arsenic and benzene were the primary contributors to the excess risk in both cases. At maximum concentrations both arsenic and benzene produced individual risks above $1x10^{-4}$. In downgradient groundwater, only exposure to maximum concentrations produced a cancer risk exceeding the USEPA range. Arsenic contributed 94 percent of the risk of $2x10^{-4}$ for maximum concentrations.

Risks were estimated for commercial/industrial worker exposure to filtered groundwater assuming that concentrations of organic CPCs remain the same as in unfiltered groundwater. Estimated carcinogenic risks were at the upper end or exceeded the USEPA target risk range of $1x10^{-4}$ to $1x10^{-6}$ for exposure to both mean and maximum concentrations of CPCs in source area filtered groundwater ($1x10^{-4}$ and $4x10^{-4}$, respectively). Arsenic and benzene were the primary contributors to the excess risk in both cases. At maximum concentrations both arsenic and benzene produced individual risks above $1x10^{-4}$. In downgradient filtered groundwater, exposure to both mean and maximum concentrations produced risks within the USEPA range ($5x10^{-5}$ and $9x10^{-5}$, respectively).

If the modified CSFs for arsenic was used to estimate excess lifetime cancer risks, the cancer risks associated with exposure to both average and maximum concentrations of arsenic in filtered and unfiltered groundwater would fall below $1x10^{-4}$.

Estimated noncarcinogenic risks exceeded the USEPA target level of 1 for both source area and downgradient unfiltered groundwater at mean and maximum concentrations. HIs for the source area are 36 and 98 for exposure to mean and

maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary risk contributors for source area groundwater. HIs for downgradient groundwater are 11 and 21 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual HQs for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of 1.

For filtered groundwater, estimated noncarcinogenic risks exceeded the USEPA target level of 1 for both source area and downgradient groundwater at mean and maximum concentrations. HIs for the source area are 36 and 98 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary contributors for source area groundwater. HIs for downgradient groundwater are 11 and 21 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual HQs for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of 1.

A comparison of detected concentrations of CPCs in source area and downgradient groundwater to federal and state drinking water standards and guidelines showed several exceedances. In source area groundwater, the following CPCs were detected at concentrations above a federal or state standard or guideline: xylenes, benzene, ethylbenzene, arsenic, lead, nickel, aluminum, iron, manganese, and sodium. In downgradient groundwater, detected concentrations of benzene, aluminum, iron, manganese and sodium exceed federal or state drinking water standards or guidelines.

TABLE 9-1
SUMMARY OF SAMPLE LOCATIONS USED IN THE HUMAN HEALTH RISK ASSESSMENT
AOC 43G - HISTORIC GAS STATION G /AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

MEDIA	AREA	EXPLORATION	SAMPLE LOCATION	DEPTH (feet bgs)
Subsurface Soil[1]	Area 2	Supplemental Site Investigation	XGB-93-05X	8-10
				12-14
			XGB-93-06X	8-10
				12-14
			XGB-93-07X	10-12
	Area 3	Supplemental Site Investigation	XGB-93-03X	8-10
				12-14
		Remedial Investigation	XGB-94-04X	8-10
				12-14
Sediment	Stormdrain Outfall	Supplemental Site Investigation	XGD-93-02X	NA
		AREE 70	SSD-93-39A	
Groundwater[2]	Source Area	Remedial Investigation Rounds 5 and 6	AAFES-1D	NA
			AAFES-2	
			AAFES-6	
			XGM-93-02X	
			XGM-94-03X	
			XGM-94-04X	
	Downgradient Area	Remedial Investigation Rounds 5 and 6	XGM-94-06X	
			XGM-94-07X	
			XGM-94-08X	
			XGM-94-10X	

Notes:
[1] Subsurface soil is defined as soil between 1 and 15 feet bgs
[2]Unfiltered and filtered data from each sample location are used to develop separate data sets
bgs = below ground surface
NA = not applicable

TABLE 9-2
CHEMICALS OF POTENTIAL CONCERN
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	Range of SQLs	Frequency of Detection	Detected Concentrations Minimum	Detected Concentrations Maximum	Mean of all Samples	Back-Ground	CPC?	Notes
AREA 2 SUBSURFACE SOIL (1 - 15 feet bgs)[a] (mg/kg)								
PAL METALS								
Aluminum	N/A	5/5	3770	12200	6788	18000	No	Background[1]
Arsenic	N/A	5/5	7.15	21	12.1	19	Yes	
Barium	N/A	5/5	21.5	66.5	38.0	54	Yes	
Beryllium	0.5 - 0.5	4/5	0.964	1.38	0.9	0.81	Yes	
Calcium	N/A	5/5	651	2000	1073.6	810	No	Essential Nutrient[2]
Chromium	N/A	5/5	8.89	37.4	23.8	33	Yes	
Cobalt	1.42 - 1.42	4/5	1.67	9.94	4.9	4.7	Yes	
Copper	N/A	5/5	6.54	14.4	10.2	13.5	Yes	
Iron	N/A	5/5	9460	15300	12292	18000	No	Background[1]
Lead	N/A	5/5	3.58	50	14.1	48	Yes	Toxicity Value[3]
Magnesium	N/A	5/5	1590	5670	3488	5500	No	Essential Nutrient[2]
Manganese	N/A	5/5	81.7	324	177.8	380	No	Background[1]
Nickel	N/A	5/5	6.08	33.4	17.4	14.6	Yes	
Potassium	N/A	5/5	702	4290	2086.4	2400	No	Essential Nutrient[2]
Sodium	N/A	5/5	267	330	295.6	234	No	Essential Nutrient[2]
Vanadium	N/A	5/5	11.6	26.3	18.1	32.3	No	Background[1]
Zinc	N/A	5/5	18.2	208	63.5	43.9	Yes	
PAL SEMIVOLATILE ORGANICS								
Acenaphthylene	0.033 - 0.2	1/5	5	5	1.0	NDB	Yes	
Anthracene	0.033 - 0.2	1/5	4	4	0.8	NDB	Yes	
Benzo [a] Anthracene	0.17 - 0.8	1/5	7	7	1.5	NDB	Yes	
Benzo [a] Pyrene	0.25 - 1	1/5	10	10	2.2	NDB	Yes	
Benzo [b] Fluoranthene	0.21 - 1	1/5	30	30	6.2	NDB	Yes	
Benzo [g,h,i] Perylene	0.25 - 1	1/5	3	3	0.8	NDB	Yes	
Benzo [k] Fluoranthene	0.066 - 0.3	1/5	6	6	1.2	NDB	Yes	
Chrysene	0.12 - 0.6	1/5	10	10	2.1	NDB	Yes	
Di-n-butyl Phthalate	0.061 - 0.6	3/5	0.43	0.6	0.4	NDB	No	Blank[4]
Fluoranthene	0.068 - 0.3	1/5	20	20	4.1	NDB	Yes	
Fluorene	0.033 - 0.2	1/5	1	1	0.2	NDB	Yes	
Indeno [1,2,3-c,d] Pyrene	0.29 - 1	1/5	4	4	1.0	NDB	Yes	
Naphthalene	0.037 - 0.2	1/5	0.5	0.5	0.1	NDB	Yes	
Phenanthrene	0.033 - 0.2	1/5	10	10	2.0	NDB	Yes	
Pyrene	0.033 - 0.2	1/5	10	10	2.0	NDB	Yes	
PAL VOLATILE ORGANICS								
Acetone	0.017 - 0.017	1/5	0.047	0.047	0.02	NDB	No	Blank[4]
Trichlorofluoromethane	0.006 - 0.006	3/5	0.0057	0.01	0.01	NDB	No	Blank[4]
OTHER								
Total Petroleum Hydrocarbon	28.5 - 28.8	2/5	158	185	77.2	NDB	Yes	Toxicity Value[3]

TABLE 9-2
CHEMICALS OF POTENTIAL CONCERN
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	Range of SQLs	Frequency of Detection	Detected Concentrations Minimum	Detected Concentrations Maximum	Mean of all Samples	Back-Ground	CPC?	Notes
AREA 3 SUBSURFACE SOIL (1 - 15 feet bgs)[b] (mg/kg)								
PAL METALS								
Aluminum	N/A	4/4	5100	11200	8835	18000	No	Background[1]
Arsenic	N/A	4/4	17	51	31.8	19	Yes	
Barium	N/A	4/4	14.6	53.3	30.2	54	No	Background[1]
Cadmium	0.7 - 0.7	1/4	2.61	2.61	0.9	1.28	Yes	
Calcium	N/A	4/4	405	1570	1026.3	810	No	Essential Nutrient[2]
Chromium	N/A	4/4	17.4	46	30.4	33	Yes	
Cobalt	1.42 - 1.42	1/4	3.56	9.93	6.4	4.7	Yes	
Copper	N/A	4/4	9.09	29.2	16.4	13.5	Yes	
Iron	N/A	4/4	9660	19300	12665	18000	Yes	
Lead	N/A	4/4	5.12	57	21.8	48	Yes	
Magnesium	N/A	4/4	2250	6100	3915.0	5500	No	Essential Nutrient[2]
Manganese	N/A	4/4	86.6	267	205.4	380	No	Background[1]
Nickel	N/A	4/4	19.5	38.3	25.2	14.6	Yes	
Potassium	N/A	4/4	568	1340	965.5	2400	No	Essential Nutrient[2]
Sodium	N/A	4/4	287	419	336	234	No	Essential Nutrient[2]
Vanadium	N/A	4/4	8.24	19.9	15.4	32.3	No	Background[1]
Zinc	N/A	4/4	21.3	87.6	42.4	43.9	Yes	
PAL SEMIVOLATILE ORGANICS								
2-Methylnaphthalene	0.049 - 0.5	1/4	0.72	0.72	0.3	NDB	Yes	
Naphthalene	0.037 - 0.4	1/4	0.46	0.46	0.2	NDB	Yes	
PAL VOLATILE ORGANICS								
Toluene	0.001 - 0.001	1/4	0.02	0.02	0.005	NDB	Yes	
Ethylbenzene	0.002 - 0.002	1/4	0.03	0.03	0.008	NDB	Yes	
Xylenes	0.002 - 0.002	1/4	0.6	0.6	0.2	NDB	Yes	
Trichlorofluoromethane	0.006 - 0.006	1/4	0.03	0.03	0.01	NDB	No	Blank[4]
OTHER								
Total Petroleum Hydrocarbons	N/A	4/4	59.2	1020	412.8	NDB	Yes	Toxicity Value[3]

TABLE 9-2
CHEMICALS OF POTENTIAL CONCERN
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	Range of SQLs	Frequency of Detection	Detected Concentrations Minimum	Detected Concentrations Maximum	Mean of all Samples	Back-Ground	CPC?	Notes
SOURCE AREA GROUNDWATER c (mg/L) - UNFILTERED								
PAL METALS								
Aluminum	0.141 - 0.141	8/12	0.147	10.7	2.20	6.87	Yes	
Arsenic	0.003 - 0.003	11/12	0.0033	0.0577	0.01	0.0105	Yes	
Barium	NA	12/12	0.0078	0.0816	0.03	0.0396	Yes	
Calcium	NA	12/12	51.2	112	74.53	14.7	No	Essential Nutrient2
Chromium	0.006 - 0.006	3/12	0.0069	0.0292	0.007	0.0147	Yes	
Cobalt	0.025 - 0.025	2/12	0.034	0.046	0.02	0.025	Yes	
Copper	0.008 - 0.008	2/12	0.0199	0.0402	0.008	0.0081	Yes	
Iron	NA	12/12	1.46	87.2	25.89	9.1	Yes	
Lead	0.001 - 0.001	8/12	0.0017	0.0491	0.009	0.0043	Yes	
Magnesium	NA	12/12	8.84	29.6	18.9	3.48	No	Essential Nutrient2
Manganese	NA	12/12	2.88	14.3	7.6	0.291	Yes	
Nickel	0.034 - 0.034	4/12	0.0812	0.209	0.05	0.0343	Yes	
Potassium	NA	12/12	1.36	7.82	3.2	2.37	No	Essential Nutrient2
Sodium	NA	12/12	40.5	98.6	70.6	10.8	No	Essential Nutrient2
Vanadium	0.011 - 0.011	2/12	0.0122	0.0122	0.006	0.011	Yes	
Zinc	0.021 - 0.021	5/12	0.0276	0.101	0.03	0.0211	Yes	
PAL SEMIVOLATILE ORGANICS								
2,4-Dimethylphenol	0.006 - 0.06	2/12	0.016	0.021	0.01	NDB	Yes	
2-Methylnaphthalene	0.002 - 0.002	10/12	0.0021	2	0.3	NDB	Yes	
4-Methylphenol / 4-Cresol	0.001 - 0.005	1/12	0.0033	0.0033	0.0007	NDB	Yes	
Acenaphthene	0.002 - 0.02	1/12	0.0032	0.0032	0.002	NDB	Yes	
Anthracene	0.001 - 0.005	1/12	0.0014	0.0014	0.0005	NDB	Yes	
Bis (2-ethylhexyl) Phthalate	NA	12/12	0.0045	0.2	0.05	NDB	No	Blank4
Fluorene	0.004 - 0.004	2/12	0.02	0.04	0.007	NDB	Yes	
Naphthalene	0.001 - 0.001	11/12	0.0009	1	0.2	NDB	Yes	
Phenanthrene	0.001 - 0.001	3/12	0.0006	0.02	0.003	NDB	Yes	
PAL VOLATILE ORGANICS								
Xylenes	NA	12/12	0.0013	20	3.36	NDB	Yes	
Benzene	NA	12/12	0.0021	2	0.62	NDB	Yes	
Carbon Disulfide	0.001 - 0.1	1/12	0.0009	0.0009	0.01	NDB	Yes	
Ethylbenzene	NA	12/12	0.019	2	0.43	NDB	Yes	
Methylene Chloride	0.002 - 0.6	3/12	0.0027	0.02	0.04	NDB	No	Blank4
Methyl isobutyl ketone	0.003 - 0.8	1/12	0.019	0.019	0.06	NDB	No	Blank4
Toluene	0.001 - 0.001	11/12	0.0015	0.3	0.09	NDB	Yes	
SOURCE AREA GROUNDWATER c (mg/L) - FILTERED								
PAL METALS								
Aluminum	0.141 - 0.141	1/12	0.3	0.3	0.09	6.87	No	Background1
Antimony	0.003 - 0.003	2/12	0.0028	0.004	0.002	0.003	Yes	
Arsenic	NA	12/12	0.0047	0.0241	0.01	0.0105	Yes	
Barium	NA	12/12	0.0081	0.0485	0.02	0.0396	Yes	
Calcium	NA	12/12	53.1	101	72.4	14.7	No	Essential Nutrient2
Iron	NA	12/12	2.19	54.1	18.50	9.1	Yes	
Lead	0.001 - 0.001	4/12	0.0014	0.003	0.001	0.0043	No	Background1
Magnesium	NA	12/12	9.06	27.3	17.6	3.48	No	Essential Nutrient2
Manganese	NA	12/12	3.12	15.2	7.5	0.291	Yes	
Nickel	0.034 - 0.034	2/12	0.0651	0.18	0.03	0.0343	Yes	
Potassium	NA	12/12	1.41	6.66	2.7	2.37	No	Essential Nutrient2
Sodium	NA	12/12	42	105	70.9	10.8	No	Essential Nutrient2

TABLE 9-2
CHEMICALS OF POTENTIAL CONCERN
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	Range of SQLs	Frequency of Detection	Detected Concentrations Minimum	Detected Concentrations Maximum	Mean of all Samples	Back-Ground	CPC?	Notes
DOWNGRADIENT GROUNDWATER[d] (mg/L) - UNFILTERED								
PAL METALS								
Aluminum	0.141 - 0.141	5/8	0.459	1.86	0.7	6.87	No	Background5
Arsenic	0.003 - 0.003	5/8	0.0107	0.0236	0.01	0.0105	Yes	
Barium	NA	8/8	0.0131	0.0276	0.02	0.0396	No	Background5
Calcium	NA	8/8	45.5	64.7	55.2	14.7	No	Essential Nutrient2
Iron	NA	8/8	0.19	12.4	5.6	9.1	Yes	
Lead	0.001 - 0.001	4/8	0.0018	0.0035	0.002	0.0043	No	Background5
Magnesium	NA	8/8	8.37	13.6	10.5	3.48	No	Essential Nutrient2
Manganese	NA	8/8	1.71	8.63	5.2	0.291	Yes	
Potassium	NA	8/8	1.48	3.79	2.6	2.37	No	Essential Nutrient2
Sodium	NA	8/8	40.1	104	60.6	10.8	No	Essential Nutrient2
Zinc	0.021 - 0.021	1/8	0.0249	0.0249	0.01	0.0211	Yes	
PAL SEMIVOLATILE ORGANICS								
2-Methylnaphthalene	0.002 - 0.002	1/8	0.0022	0.0022	0.001	NDB	Yes	
Bis (2-ethylhexyl) Phthalate	0.005 - 0.005	4/8	0.0046	0.064	0.02	NDB	No	Blank4
Naphthalene	0.001 - 0.001	3/8	0.003	0.0062	0.002	NDB	Yes	
PAL VOLATILE ORGANICS								
Xylenes	0.001 - 0.001	4/8	0.0018	0.047	0.01	NDB	Yes	
Benzene	0.001 - 0.001	6/8	0.0015	0.079	0.02	NDB	Yes	
Ethylbenzene	0.001 - 0.001	3/8	0.015	0.029	0.008	NDB	Yes	
Methylene Chloride	0.002 - 0.002	1/8	0.0022	0.0022	0.001	NDB	No	Blank4
Tetrachloroethylene	0.002 - 0.002	2/8	0.0033	0.0038	0.001	NDB	Yes	
Toluene	0.001 - 0.001	5/8	0.0005	0.0044	0.002	NDB	Yes	
DOWNGRADIENT GROUNDWATER[d] (mg/L) - FILTERED								
PAL METALS								
Arsenic	0.003 - 0.003	5/8	0.0078	0.0141	0.007	0.0105	Yes	
Barium	NA	8/8	0.0117	0.0237	0.02	0.0396	No	Background1
Calcium	NA	8/8	44.2	66	55.6	14.7	No	Essential Nutrient2
Iron	NA	8/8	0.0602	9.84	2.9	9.1	Yes	
Magnesium	NA	8/8	8.09	12.8	10.2	3.48	No	Essential Nutrient2
Manganese	NA	8/8	1.86	8.82	5.3	0.291	Yes	
Potassium	NA	8/8	1.44	2.91	2.3	2.37	No	Essential Nutrient2
Sodium	NA	8/8	39.3	110	61.6	10.8	No	Essential Nutrient2
Zinc	0.021 - 0.021	1/8	0.0689	0.0689	0.02	0.0211	Yes	

NOTES:
[a] Based on samples XGB-93-05X, XGB-93-06X, and XGB-93-07X
[b] Based on samples XGB-93-03X and XGB-94-04X
[c] Based on samples XGM-94-03X to -04X, XGM-93-02X, AAFES-1D, -2, -6
[d] Based on samples XGM-94-06X to -08X, -10X

Background1 - Sample concentrations detected are below background concentrations.
Essential Nutrient2 - Analyte is an essential human nutrient (magnesium, calcium, potassium, sodium) and is not considered a CPC.
Toxicity Value3 - Compound cannot be evaluated quantitatively because toxicity values are not available.
Blank4 - Compound was detected in field and/or laboratory blanks.
Background5 - Maximum detected concentration of analyte was less than site-specific background concentrations.

SQL - Sample Quantitation Limit
NDB - not detected in background
N/A - not applicable
mg - milligram
L - liter
kg - kilogram
bgs - below ground surface
CPC - chemical of potential concern

TABLE 9–3
SUMMARY OF POTENTIAL PATHWAYS FOR HUMAN HEALTH RISK ASSESSMENT
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

POTENTIALLY EXPOSED POPULATION	EXPOSURE ROUTE, MEDIUM, AND POINT	EVALUATED?	REASON FOR SELECTION OR EXCLUSION
CURRENT AND FUTURE LAND USE			
Utility/Maintenance Worker	Incidental ingestion of subsurface soil	Yes	Performing repairs to utility lines or USTs may expose future workers to contaminated subsurface soil through ingestion route
	Dermal contact with subsurface soil	No	Dermal absorption values not available for CPCs
	Inhalation of particulates from subsurface soil	No	Considered to be insignificant for excavation scenario
	Inhalation of VOCs from subsurface soil	Yes	Excavation may expose future workers to VOCs in subsurface soil through inhalation route
Base Worker	Incidental ingestion of sediment	No	Evaluated qualitatively because of low exposure frequency and intensity potential
FUTURE LAND USE			
Commercial/Industrial Worker	Ingestion of drinking water	Yes	Future use of site may be commercial/industrial facility
	Inhalation of VOCs migrating into basement from groundwater	No	Depth to groundwater is 15 to 29 feet – vapor migration not a significant transport route at these depths

Notes:
VOC – Volatile Organic Compound
UST – Underground Storage Tank
CPC – Chemical of Potential Concern

TABLE 9-4
EXPOSURE PARAMETERS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

PARAMETER	CURRENT AND FUTURE UTILITY/MAINTENANCE WORKER	UNITS	SOURCE[1]
Soil Ingestion Rate	480	mg/day	USEPA, 1991c
Fraction Ingested From Site	100%		Assumption
Relative Absorption Factor	100%		Assumption
Inhalation Rate[2]	4.8	m^3/hour	USEPA, 1989c
Exposure Time	8	hours/day	Assumption
Exposure Frequency[3]	10	days/year	Assumption
Exposure Duration	5	years	Assumption
Body Weight	70	kg	USEPA, 1991c
Averaging Time			
Cancer	70	years	USEPA, 1989b
Noncancer[4]	5	years	Assumption
Soil-to-Air Volatilization Factor	See Table 9-5	m^3/kg	USEPA, 1991b

PARAMETER	FUTURE COMMERCIAL/INDUSTRIAL WORKER	UNITS	SOURCE[1]
Drinking Water Ingestion Rate	1	liters/day	USEPA, 1991c
Body Weight	70	kg	USEPA, 1991c
Exposure Frequency	250	days/year	USEPA, 1991c
Exposure Duration	25	years	USEPA, 1991c
Averaging Time			
Cancer	70	years	USEPA, 1991c
Noncancer[4]	25	years	USEPA, 1991c
Relative Absorption Factor	100%		Assumption

Notes:
[1] - Exposure variables with source listed as "assumption" are site specific; the remainder are default values.
[2] - Inhalation rate based on the heavy activity rate listed in the Exposure Factors Handbook (USEPA, 1989c)
[3] - 5 days per week for 2 weeks
[4] - The AT for noncarcinogenic effects is equal to the exposure duration.

mg - milligrams
m^3 - cubic meters
kg - kilograms
L - liter

TABLE 9–5
SOIL CONTAMINANT RELEASE ANALYSIS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

CALCULATION OF SOIL–TO–AIR VOLATILIZATION FACTOR (VF)

$$VF = \frac{(LS \times V \times DH)}{A} \times \frac{(3.14 \times AD \times T)^{0.5}}{(2 \times D_{ei} \times P_a \times K_{as} \times CF)}$$

Where:

$$AD = \frac{D_{ei} \times P_a}{P_a + (P_s)(1-P_a)/K_{as}} \qquad D_{ei} = D_i \times P_a^{3.33}/P_t^2$$

$$K_{as} = \frac{H \times 41}{K_d} \qquad P_a = P_t - (O \times B) \qquad P_t = 1 - (B/P_s) \qquad K_d = K_{oc} \times OC$$

and where:

VF =	volatilization factor (m^3/kg)
LS =	length of side of contaminated area (m)
V =	wind speed in mixing zone (m/s)
DH =	diffusion height (m)
A =	area of contamination (cm^2)
AD =	adjusted diffusivity (cm^2/s)
D_{ei} =	effective diffusivity (cm^2/s)
P_a =	air filled soil porosity (unitless)
P_t =	total soil porosity (unitless)
O =	soil moisture content (cm^3–water/g–soil)
B =	soil bulk density (g/cm^3)
K_{as} =	soil/air partition coefficient (g soil/cm^3 air)
P_s =	true soil density (g/cm^3)
T =	exposure interval (s)
OC =	organic carbon content of soil (fraction)
D_i =	diffusivity in air (cm^2/s)
H =	Henry's law constant (atm–m^3/mol)
K_d =	soil–water partition coefficient (cm^3/g)
K_{oc} =	Organic carbon partition coefficient (cm^3/g)
CF =	conversion factor (kg/mg)

PARAMETER	VALUE	UNITS	SOURCE
LS	45	m	USEPA,1991b
V	2.25	m/s	USEPA,1991b
DH	2	m	USEPA,1991b
A	2.03E+07	cm^2	USEPA,1991b
Ps	2.65	g/cm^3	USEPA,1991b
T	7.90E+08	s	USEPA,1991b
OC	0.02	fraction	USEPA,1991b
O	0.1	cm^3–water/g–soil	USEPA,1991b
B	1.5	g/cm^3	USEPA,1991b
CF	0.001	kg/g	

TABLE 9-5
SOIL CONTAMINANT RELEASE ANALYSIS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT

FORT DEVENS, MA

COMPOUND	D_i (cm^2/sec)	H (atm-m^3/mol)	K_{oc} (cm^3/g)	K_d (cm^3/g)	D_{ei} (cm^2/s)	P_a	P_t	K_{as} (g soil/ cm^3 air)	AD (cm^2/s)	VF (m^3/kg)
Acetone	1.15E-01 (1)	3.67E-05 (3)	2.2 (1)	4.40E-02	0.0092	0.28	0.43	3.42E-02	4.70E-05	1.90E+04
Trichlorofluoromethane	9.34E-02 (1)	5.83E-02 (2)	159 (6)	3.18E+00	0.0075	0.28	0.43	7.52E-01	7.58E-04	4.29E+03
Toluene	7.83E-02 (2)	6.60E-03 (4)	120 (7)	2.40E+00	0.0063	0.28	0.43	1.13E-01	1.04E-04	1.26E+04
Ethylbenzene	6.67E-02 (2)	8.43E-03 (5)	220 (7)	4.40E+00	0.0054	0.28	0.43	7.86E-02	6.22E-05	1.64E+04
Xylenes*	7.16E-02 (2)	6.90E-03 (5)	238 (1)	4.76E+00	0.0057	0.28	0.43	5.94E-02	5.07E-05	1.83E+04

Notes:
* Values for m-xylene used for mixed xylenes

Sources:
(1) Lyman et al., 1982
(2) Shen, 1982
(3) Rathburn and Tai, 1982
(4) Mackay and Shiu, 1981
(5) Mackay et al., 1979
(6) Mabey et al., 1982
(7) Hodson and Williams, 1988

TABLE 9-6
ORAL DOSE/RESPONSE INFORMATION FOR CARCINOGENIC EFFECTS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Compound	Weight of Evidence	Oral Slope Factor $(mg/kg/day)^{-1}$	Test Species	Study Type	Tumor Type	Source
2,4-Dimethylphenol	ND					IRIS
2-Methylnaphthalene	ND					IRIS
4-Methylphenol	C	ND				IRIS
Acenaphthene	ND					IRIS
Acenaphthylene	D					IRIS
Aluminum	ND					HEAST
Anthracene	D					IRIS
Arsenic	A	1.75E+00 *R	Human	DW	Skin tumors	IRIS
Barium	ND					IRIS
Benzene	A	2.9E-02	Human	Occupational	Leukemia	IRIS
Benzo(a)anthracene	B2	ND **				IRIS
Benzo(a)pyrene	B2	7.3E+00	Mouse	Oral-diet	Stomach tumors	IRIS
Benzo(b)fluoranthene	B2	ND **				IRIS
Benzo(g,h,i)perylene	D					IRIS
Benzo(k)fluoranthene	B2	ND **				IRIS
Beryllium	B2	4.3E+00	Rat	DW	Total tumors	IRIS
Cadmium	B1	NA				IRIS
Carbon Disulfide	ND					IRIS
Chromium VI	A	NA				IRIS
Chrysene	B2	NA **				IRIS
Cobalt	ND					IRIS
Copper	D					IRIS
Di-n-butyl Phthalate	D					IRIS
Ethylbenzene	D					IRIS
Fluoranthene	D					IRIS
Fluorene	D					IRIS
Indeno(1,2,3-cd)pyrene	B2	ND **				IRIS
Iron	Not Listed					
Lead	B2	ND				IRIS
Manganese	D					IRIS
Naphthalene	D					IRIS
Nickel	ND					IRIS
Phenanthrene	D					IRIS
Pyrene	D					IRIS
Tetrachloroethene	B2	5.2E-02 W	Mouse	Oral-gavage	Liver tumors	ECAO, 1992
Toluene	D					IRIS
Trichlorofluoromethane	ND					IRIS
Vanadium	ND					HEAST
Xylenes (total)	D					IRIS
Zinc	D					IRIS

W – Value withdrawn from IRIS
NA – Not Applicable to oral route
ND – Not Determined
P – IRIS input pending
R – Under review on IRIS
DW – Drinking water
mg – milligram
kg – kilogram
IRIS – Integrated Risk Information System
PAH – Polycyclic Aromatic Hydrocarbon
HEAST – Health Effects Assessment Summary Tables
ECAO – Environmental Criteria and Assessment Office

* – calculated from unit risk of 5E-5 ug/L
** – Slope Factor for Benzo(a)Pyrene used for other carcinogenic PAHs, adjusted by Relative Potency Factors of 1.0 [benzo(a)pyrene, dibenz(a,h)anthracene]; 0.1 [benzo(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-c,d)pyrene]; 0.01 [benzo(k)fluoranthene]; 0.001 [chrysene].

Shaded line indicated CPC evaluated as a carcinogen

SOURCES:
IRIS as of 5/95
HEAST, 1994 (including July and November updates)
ECAO, 1992

Weight of Evidence: A – Human carcinogen
B – Probable human carcinogen (B1 – limited evidence
B2 – sufficient evidence of carcinogenicity in animals wi
of evidence in humans)
C – Possible human carcinogen
D – Not classifiable as to human carcinogenicity
E – Evidence of lack of carcinogenicity to humans

TABLE 9-7
ORAL DOSE/RESPONSE INFORMATION FOR NONCARCINOGENIC EFFECTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
PORT DEVENS, MA

COMPOUND	CHRONIC ORAL RfD[1] (mg/kg-day)	SUBCHRONIC ORAL RfD[1] (mg/kg-day)	STUDY TYPE	CONFIDENCE LEVEL	CRITICAL EFFECT	TEST ANIMAL	UNCERTAINTY FACTOR	SOURCE
2,4-Dimethylphenol	2E-02	2E-01	Oral-gavage	Low	Clinical signs and hematological changes	Mouse	3,000 H,A,D	IRIS
2-Methylnaphthalene	ND *	ND*						
4-Methylphenol (p-Cresol)	5E-03	5E-03	Oral-gavage		Maternal death; respiratory distress; CNS hypoactivity	Rabbit	1,000	HEAST
Acenaphthene	6E-02	6E-01	Oral-gavage	Low	Hepatoxicity	Mouse	3,000 H,A,S,D	IRIS
Acenaphthylene	ND *P	ND						IRIS
Aluminum	1E+00 R	ND						ECAO, 1994a
Anthracene	3E-01	3E+00	Oral-gavage	Low	No effects	Mouse	3,000 H,A,S	IRIS
Arsenic	3E-04 P	3E-04	Oral-diet	Medium	Keratosis and hyperpigmentation	Human	3 H	IRIS
Barium	7E-02	7E-02	Oral-DW	Medium	Increased blood pressure	Human	3 H	IRIS
Benzene	3E-04 P	ND						ECAO, 1994b
Benzo(a)anthracene	ND *	ND *						IRIS
Benzo(a)pyrene	ND *	ND *						IRIS
Benzo(b)fluoranthene	ND *	ND *						IRIS
Benzo(g,h,i)perylene	ND *	ND *						IRIS
Benzo(k)fluoranthene	ND *	ND *						IRIS
Beryllium	5E-03	5E-03	DW	Low	None observed	Rat	100 H,A	IRIS
Cadmium (food)	1E-03	None	Oral-diet	High	Significant proteinuria	Human	10 H	IRIS
Cadmium (water)	5E-04	None	Oral-DW	High	Significant proteinuria	Human	10 H	IRIS
Carbon Disulfide	1E-01 R	1E-01	Inhalation	Medium	Fetal toxicity/malformation	Rabbit	100 H,A	IRIS
Chromium VI	5E-03	2E-02	Oral-DW	Low	No effects reported	Rat	500 H,A,S	IRIS
Chrysene	ND *	ND *			Data inadequate for risk assessment			HEAST
Cobalt (adult)	1.8E-01	1.8E-01 +						ECAO, 1994c
Copper	3.7E-02 ~ ~	3.7E-02	Oral		Gastrointestinal irritation	Human		HEAST
Ethylbenzene	1E-01	1E-01 +	Oral-diet	Low	Liver and kidney toxicity	Rat	1,000 H,A,S	IRIS
Fluoranthene	4E-02	4E-01	Oral-gavage	Medium	Increased liver weights, hematologic changes	Mouse	3,000 H,A,S	IRIS
Fluorene	4E-02	4E-01	Oral-gavage	Low	Hematologic changes, decreased RBC	Mouse	3,000 H,A,S	IRIS
Indeno(1,2,3-cd)pyrene	ND *	ND *						IRIS
Iron	3E-01	3E-01 +						ECAO, 1994d
Lead	ND	ND						IRIS
Manganese (food)	1.4E-01	1.4E-01	Oral-diet	Medium	CNS effects	Human	1	IRIS
Manganese (water)	5E-03	5E-03	Oral-diet	Medium	CNS effects	Human	1	IRIS
Naphthalene	4E-02 WH	4E-02						ECAO, 1994e
Nickel	2E-02	2E-02	Oral-diet	Medium	Decreased body and organ weights	Rat	300 H,A,D	IRIS
Phenanthrene	ND *	ND *						IRIS
Pyrene	3E-02	3E-01	Oral-gavage	Low	Kidney effects, renal tubular pathology	Mouse	3,000 H,A,S	IRIS
Tetrachloroethene	1E-02	1E-01	Oral-gavage	Medium	Hepatotoxicity	Mouse	1,000 H,A,S	IRIS
Toluene	2E-01	2E+00	Oral-gavage	Medium	Weight change in liver and kidneys	Rat	1,000 H,A,S	IRIS
Vanadium	7E-03 P	7E-03	Oral-DW		None observed	Rat	100	HEAST
Xylenes (total)	2E+00	2E+00 +	Oral-gavage	Medium	Hyperactivity, decreased body weight	Rat	100 H,A	IRIS
Zinc	3E-01	3E-01	Oral-diet	Medium	Decreased erythrocyte superoxide dimutase	Human	3 L	IRIS

ND - No data available
mg - milligram
kg - kilogram
DW - Drinking Water
IRIS - Integrated Risk Information System
HEAST - Health Effects Assessment Summary Tables
USEPA - United States Environmental Protection Agency
ECAO - Environmental Criteria and Assessment Office
NOAEL - No Observed Adverse Effect Level
LOAEL - Lowest Observed Adverse Effect Level
NOEL - No Observed Effect Level

[1] - Source for all subchronic RfDs is HEAST, 1994
*RfD for naphthalene is used as surrogate for PAHs without assigned RfD
+ Subchronic RfD not available; chronic RfD used

SOURCES:
IRIS as of 5/95
ECAO, 1994a,b,c,d,e
HEAST, 1994 (including July and November updates)

Uncertainty factors:
H - variation in human sensitivity
A - animal to human extrapolation
S - extrapolation from subchronic to chronic NOAEL
L - extrapolation from LOAEL to NOAEL
N - NOEL not attained
D - Lack of supporting data
Additional uncertainty factors or modifying factors (MF) of 1 to 10 may be added to account for other uncertainties such as inadequacies in the database or the severity of the effect.

TABLE 9-8
INHALATION DOSE/RESPONSE INFORMATION FOR CARCINOGENIC EFFECTS
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Compound	Weight of Evidence	Inhalation Slope Factor* $(mg/kg/day)^{-1}$	Unit Risk $(\mu g/m^3)^{-1}$	Test Species	Study Type	Tumor Type	Source
2-Methylnaphthalene	ND						IRIS
2,4-Dimethylphenol	ND						IRIS
4-Cresol	C		ND				IRIS
Acenaphthylene	D						IRIS
Acenapthene	D						IRIS
Aluminum	Not Listed						
Anthracene	D						IRIS
Arsenic	A	5.0E+01	4.3E-03	Human	Occupational	Respiratory tract	IRIS
Barium	ND						IRIS
Benzene	A	2.9E-02	8.3E-06	Human	Occupational	Leukemia	IRIS
Benzo(a)anthracene	B2		ND				IRIS
Benzo(a)pyrene	B2	W					IRIS
Benzo(b)fluoranthene	B2		ND				IRIS
Benzo(g,h,i)perylene	D						IRIS
Benzo(k)fluoranthene	B2		ND				IRIS
Beryllium	B2	8.4E+00	2.4E-03	Human	Occupational	Lung tumors	IRIS
Cadmium	B1	ND	1.8E-03	Human	Occupational	Respiratory tract	IRIS
Carbon Disulfide	ND						IRIS
Chromium VI	A	4.1E+01	1.2E-02	Human	Occupational	Lung tumors	IRIS
Chrysene	B2		ND				IRIS
Cobalt	ND						IRIS
Copper	D						IRIS
Ethylbenzene	D						IRIS
Fluoranthene	D						IRIS
Fluorene	D						IRIS
Indeno(1,2,3-cd)pyrene	B2		ND				IRIS
Iron	Not Listed						
Lead	B2		ND				IRIS
Manganese	D						IRIS
Naphthalene	D						IRIS
Nickel	ND						IRIS
Phenanthrene	D						IRIS
Pyrene	D						IRIS
Tetrachloroethene	ND						IRIS
Toluene	D						IRIS
Vanadium	ND						HEAST
Xylenes (total)	D						IRIS
Zinc	D						IRIS

ND - Not Determined
W - Withdrawn from IRIS
mg - milligram
kg - kilogram
μg - microgram
m^3 - cubic meter
IRIS - Integrated Risk Information System
HEAST - Health Effects Assessment Summary Tables

* - Source of slope factor is HEAST, 1994 unless otherwise noted.
Shaded line indicates CPC evaluated as a carcinogen

Sources:
USEPA IRIS as of 5/95
USEPA HEAST, 1994 (including July and November updates)

Weight of Evidence: A - Human carcinogen
B - Probable human carcinogen (B1 - limited evidence in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
C - Possible human carcinogen
D - Not classifiable as to human carcinogenicity
E - Evidence of lack of carcinogenicity to humans

TABLE 9–9
INHALATION DOSE/RESPONSE INFORMATION FOR NONCARCINOGENIC EFFECTS
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

COMPOUND	CHRONIC INHALATION RfC (mg/m^3)	SUBCHRONIC[1] INHALATION RfC (mg/m^3)	STUDY TYPE	CONFIDENCE LEVEL	CRITICAL EFFECT	TEST ANIMAL	UNCERTAINTY FACTOR	SOURCE
2,4–Dimethylphenol	ND							IRIS
2–Methylnaphthalene	Not Listed	Not Listed						
Acenaphthene	ND							IRIS
Acenaphthylene	ND	ND						IRIS
Acetone	ND	ND						IRIS
Aluminum	ND							HEAST
Anthracene	ND	ND						IRIS
Arsenic	ND	ND						IRIS
Barium	5E–03	5E–03	Inhalation		Fetotoxicity	Rat	1,000	HEAST[3]
Benzene	ND							IRIS
Benzo(a)anthracene	ND	ND						IRIS
Benzo(a)pyrene	ND	ND						IRIS
Benzo(b)fluoranthene	ND	ND						IRIS
Benzo(g,h,i)perylene	ND	ND						IRIS
Benzo(k)fluoranthene	ND	ND						IRIS
Beryllium	ND	ND						IRIS
Cadmium (food)	ND	ND						IRIS
Carbon Disulfide	2.9E–03	2.9E–03	Inhalation		Fetal toxicity	Rat	1,000	HEAST
Chromium VI	ND	ND						IRIS
Chrysene	ND	ND						IRIS
Cobalt	ND	ND						IRIS
Copper	ND	ND						IRIS
Ethylbenzene	1E+00	1E+00 +	Inhalation	Low	Developmental toxicity	Rat/Rabbit	300 H,A,D	IRIS
Fluoranthene	ND	ND						IRIS
Fluorene	ND	ND						IRIS
Indeno(1,2,3–cd)pyrene	ND	ND						IRIS
Iron	Not Listed	Not Listed						
Lead	ND[4]	ND[4]						IRIS
Manganese	1.4E–05	1.4E–05 +	Occupational	Medium	Impaired neurobehavioral function	Human	1,000 H,L,D	IRIS
Manganese	ND							IRIS
Naphthalene	ND	ND						IRIS
Nickel	ND	ND						IRIS
Phenanthrene	ND	ND						IRIS
Pyrene	ND	ND						IRIS
Tetrachloroethylene	ND							IRIS
Toluene	1.14e–01	1.14e–01 +	Inhalation	Medium	Neurological effects	Human	300 H,L,D	IRIS
Vanadium	ND							IRIS
Xylenes (total)	ND	ND						IRIS
Zinc	ND	ND						IRIS

ND – No data available
mg – milligram
m^3 – cubic meter
IRIS – Integrated Risk Information System
HEAST – Health Effects Assessment Summary Tables
USEPA – United States Environmental Protection Agency
NOAEL – No Observed Adverse Effect Level
LOAEL – Lowest Observed Adverse Effect Level
NOEL – No Observed Effect Level
SOURCES:
USEPA IRIS as of 5/95
USEPA HEAST, 1994 (including July and November updates)

[1] – Source for all subchronic RfCs is HEAST, 1994
[2] – HEAST Table 2: Alternate Methods;
RfC values were derived from methodology not current with interim methodology used by RfD/RfC Work Group
[3] – HEAST Table 1: Subchronic and Chronic Toxicity
[4] – There is a National Ambient Air Quality Standard for lead of 1.5 ug/m^3 averaged over three months
+ – Subchronic value not available; chronic value used

Uncertainty factors:
H – variation in human sensitivity
A – animal to human extrapolation
S – extrapolation from subchronic to chronic NOAEL
L – extrapolation from LOAEL to NOAEL
N – NOEL not attained
D – Lack of supporting data
Additional uncertainty factors or modifying factors (MF) of 1 to 10 may be added to account for other uncertainties such as inadequacies in the database or the severity of the effect.

TABLE 9–10
QUANTITATIVE RISK SUMMARY
AOC 43G – HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	MEAN EPC		MAXIMUM EPC	
	Total Cancer Risk	Total Hazard Index	Total Cancer Risk	Total Hazard Index
CURRENT AND FUTURE LAND USE				
SUBSURFACE SOIL (1 – 15 feet bgs) at AREA 2				
Incidental Ingestion of Subsurface Soil: Utility/Maintenance Worker	6E–07	0.008	2E–06	0.01
Inhalation of Volatiles from Soil: Utility/Maintenance Worker	ND	ND	ND	ND
TOTAL: UTILITY/MAINTENANCE WORKER	**6E–07**	**0.008**	**2E–06**	**0.01**
SUBSURFACE SOIL (1 – 15 feet bgs) at AREA 3				
Incidental Ingestion of Subsurface Soil: Utility Worker	7E–07	0.03	1E–06	0.05
Inhalation of Volatiles from Soil: Utility Worker	NC	4E–08	NC	2E–07
TOTAL: UTILITY/MAINTENANCE WORKER	**7E–07**	**0.03**	**1E–06**	**0.05**
FUTURE LAND USE				
SOURCE AREA GROUNDWATER – UNFILTERED				
Ingestion of Groundwater: Future Commercial/Industrial Worker	1E–04	37	6E–04	99
TOTAL: FUTURE COMMERCIAL/ INDUSTRIAL WORKER	**1E–04**	**37**	**6E–04**	**99**
SOURCE AREA GROUNDWATER – FILTERED				
Ingestion of Groundwater: Future Commercial/Industrial Worker	1E–04	36	4E–04	98
TOTAL: FUTURE COMMERCIAL/ INDUSTRIAL WORKER	**1E–04**	**36**	**4E–04**	**98**
DOWNGRADIENT GROUNDWATER – UNFILTERED				
Ingestion of Groundwater: Future Commercial/Industrial Worker	6E–05	11	2E–04	21
TOTAL: FUTURE COMMERCIAL/ INDUSTRIAL WORKER	**6E–05**	**11**	**2E–04**	**21**
DOWNGRADIENT GROUNDWATER – FILTERED				
Ingestion of Groundwater: Future Commercial/Industrial Worker	5E–05	11	9E–05	21
TOTAL: FUTURE COMMERCIAL/ INDUSTRIAL WORKER	**5E–05**	**11**	**9E–05**	**21**

Notes:
EPC – exposure point concentration
ND – No volatiles detected
NC – No carcinogenic volatiles detected

TABLE 9-11
QUALITATIVE EVALUATION OF CONTAMINANTS IN SEDIMENT
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	Frequency of Detection	Detected Concentrations [1] Minimum	Maximum	Back-ground Conc.[2]	Maximum Exceeds Background?	Region III Industrial Soil Conc.[3]	MCP S-2 Soil Conc.[4]	Maximum Exceeds Guidelines?
SEMIVOLATILE ORGANIC COMPOUNDS (mg/kg)								
bis(2-Ethylhexyl)phthalate	1/2	3	3	NDB	-	410	100	No
Di-n-butylphthalate	1/2	2.6	2.6	NDB	-	200000	ND	No
Acenaphthalene	1/2	0.097	0.097	NDB	-	ND	100	No
Fluoranthene	1/2	0.28	0.28	NDB	-	82000	600	No
Phenanthrene	1/2	0.3	0.3	NDB	-	ND	100	No
Pyrene	1/2	0.39	0.39	NDB	-	61000	500	No
INORGANICS (mg/kg)								
Aluminum	2/2	3710	8370	10500	No	1E+06	ND	No
Arsenic	2/2	3.77	7.5	26	No	3.3	30	Yes[5]
Barium	2/2	17.2	32.2	26.2	Yes	140000	2500	No
Beryllium	1/2	0.621	0.621	0.5	Yes	1.3	0.8	No
Calcium	2/2	1470	1610	1100	Yes	ND	ND	-
Chromium	2/2	13.3	30.2	15.9	Yes	10000	600	No
Cobalt	2/2	2.63	4.34	7.2	No	120000	ND	No
Copper	2/2	15.3	30.1	14.3	Yes	76000	ND	No
Iron	2/2	11400	17200	7900	Yes	ND	ND	-
Lead	2/2	24	99	12.5	Yes	ND	600	No
Magnesium	2/2	1840	3280	3100	Yes	ND	ND	-
Manganese	2/2	119	237	600	No	10000	ND	No
Nickel	2/2	9.87	18.5	18.6	No	41000	700	No
Potassium	2/2	697	1430	292	Yes	ND	ND	-
Sodium	2/2	113	298	289	Yes	ND	ND	-
Vanadium	2/2	9.84	25.3	13.3	Yes	14000	2000	No
Zinc	2/2	70.7	136	55.6	Yes	610000	2500	No
OTHER (mg/kg)								
Total Petroleum Hydrocarbons	2/2	448	1200	NDB	-	ND	2500	No

[1] Based on sample XGD-93-02X from the SSI and sample SSD-93-39A from the AREE 70 Report
[2] Sediment background values were extracted from Appendix K of Remedial Investigations Report Functional Area II, Volume IV of IV Appendices, prepared by Ecology and Environment, Inc., (1994)
[3] Industrial soil concentrations developed in USEPA Region III Risk-Based Concentration Table (USEPA, 1995b).
[4] The lowest of the MCP Method I S-2/GW-1, S-2/GW-2, and S-2/GW-3 soil standards.
[5] Maximum concentration exceed Region III Industrial Soil Concentration

Conc. = concentration
- = not applicable

TABLE 9-12
COMPARISON OF SOURCE AREA GROUNDWATER CONCENTRATIONS TO STANDARDS AND GUIDELINES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

COMPOUNDS	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (mg/L)	ARITHMETIC AVERAGE CONCENTRATION (mg/L)	FEDERAL MCLs (mg/L)	MASS. MCLs (mg/L)	MASS. GUIDELINES (mg/L)
UNFILTERED SAMPLES						
Volatile Organics						
Xylenes	12/12	20	3.36	10	10	ND
Benzene	12/12	2	0.62	0.005	0.005	ND
Carbon disulfide	1/12	0.00088	0.01	ND	ND	ND
Ethylbenzene	12/12	2	0.43	0.7	0.7	ND
Toluene	11/12	0.3	0.09	1	1	ND
Semivolatile Organics						
2,4-Dimethylphenol	2/12	0.021	0.01	ND	ND	ND
2-Methylnaphthalene	10/12	2	0.3	ND	ND	ND
4-Methylphenol/4-Cresol	1/12	0.0033	0.0007	ND	ND	ND
Acenaphthene	1/12	0.0032	0.002	ND	ND	ND
Anthracene	1/12	0.0014	0.0005	ND	ND	ND
Fluorene	2/12	0.04	0.007	ND	ND	ND
Naphthalene	11/12	1	0.2	ND	ND	ND
Phenanthrene	3/12	0.02	0.003	ND	ND	ND
Inorganics						
Aluminum	8/12	10.7	2.2	0.05 - 0.2 (2)	0.05 - 0.2 (2)	ND
Arsenic	11/12	0.0577	0.01	0.05	0.05	ND
Barium	12/12	0.0816	0.03	2	2	ND
Calcium	12/12	112	74.53	ND	ND	ND
Chromium	3/12	0.0292	0.007	0.1	0.1	ND
Cobalt	2/12	0.046	0.02	ND	ND	ND
Copper	2/12	0.0402	0.008	1.3 (3)	1.3	ND
Iron	12/12	87.2	25.89	0.3 (2)	0.3 (2)	ND
Lead	8/12	0.0491	0.009	0.015 (3)	0.015	ND
Magnesium	12/12	29.6	18.9	ND	ND	ND
Manganese	12/12	14.3	7.6	0.05 (2)	0.05 (2)	ND
Nickel	4/12	0.209	0.05	0.1	0.1	ND
Potassium	12/12	7.82	3.2	ND	ND	ND
Sodium	12/12	98.6	70.6	20 (4)	ND	20
Vanadium	2/12	0.0122	0.006	ND	ND	ND
Zinc	5/12	0.101	0.03	2 (1)/5 (2)	5 (2)	ND

TABLE 9-12
COMPARISON OF SOURCE AREA GROUNDWATER CONCENTRATIONS TO STANDARDS AND GUIDELINES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

COMPOUNDS	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (mg/L)	ARITHMETIC AVERAGE CONCENTRATION (mg/L)	FEDERAL MCLs (mg/L)	MASS. MCLs (mg/L)	MASS. GUIDELINES (mg/L)
FILTERED SAMPLES						
Aluminum	1/12	0.3	0.09	0.05-0.2 (2)	0.05-0.2 (2)	ND
Antimony	2/12	0.00402	0.002	0.006	0.006	ND
Arsenic	12/12	0.0241	0.01	0.05	0.05	ND
Barium	12/12	0.0485	0.02	2	2	ND
Calcium	12/12	101	72.4	ND	ND	ND
Iron	12/12	54.1	18.5	0.3 (2)	0.3 (2)	ND
Lead	4/12	0.00304	0.001	0.015 (3)	0.015	ND
Magnesium	12/12	27.3	17.6	ND	ND	ND
Manganese	12/12	15.2	7.5	0.05 (2)	0.05 (2)	ND
Nickel	2/12	0.18	0.03	0.1	0.1	ND
Potassium	12/12	6.66	2.7	ND	ND	ND
Sodium	12/12	105	70.9	20 (4)	ND	20

Shaded line denotes either average or maximum (or both) concentration(s) of analyte exceeds at least one of the ARARs

NA = Not applicable ND = No value available MCL = Maximum Contaminant Level

(1) USEPA lifetime health advisory

(2) Secondary MCL

(3) USEPA action level

(4) USEPA drinking water equivalency level (DWEL) - A lifetime exposure concentration protective of adverse, non-cancer health effects that assumes all exposure is from a drinking water source

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TABLE 9-13
COMPARISON OF DOWNGRADIENT GROUNDWATER CONCENTRATIONS TO STANDARDS AND GUIDELINES
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

COMPOUNDS	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (mg/L)	ARITHMETIC AVERAGE CONCENTRATION (mg/L)	FEDERAL MCLs (mg/L)	MASS. MCLs (mg/L)	MASS. GUIDELINES (mg/L)
UNFILTERED SAMPLES						
Volatile Organics						
Xylenes	4/8	0.047	0.01	10	10	ND
Benzene	6/8	0.079	0.02	0.005	0.005	ND
Ethylbenzene	3/8	0.029	0.008	0.7	0.7	ND
Tetrachloroethylene	2/8	0.0038	0.001	0.005	0.005	ND
Toluene	5/8	0.0044	0.002	1	1	ND
Semivolatile Organics						
2-Methylnaphthalene	1/8	0.0022	0.001	ND	ND	ND
Naphthalene	3/8	0.0062	0.002	ND	ND	ND
Inorganics						
Aluminum	5/8	1.86	0.7	0.05 - 0.2 (2)	0.05 - 0.2 (2)	ND
Arsenic	5/8	0.0236	0.01	0.05	0.05	ND
Barium	8/8	0.0276	0.02	2	2	ND
Calcium	8/8	64.7	55.2	ND	ND	ND
Iron	8/8	12.4	5.6	0.3 (2)	0.3 (2)	ND
Lead	4/8	0.00347	0.002	0.015 (3)	0.015	ND
Magnesium	8/8	13.6	10.5	ND	ND	ND
Manganese	8/8	8.63	5.2	0.05 (2)	0.05 (2)	ND
Potassium	8/8	3.79	2.6	ND	ND	ND
Sodium	8/8	104	60.6	20 (4)	ND	20
Zinc	1/8	0.0249	0.01	2 (1)/5 (2)	5 (2)	ND
FILTERED SAMPLES						
Arsenic	5/8	0.0141	0.007	0.05	0.05	ND
Barium	8/8	0.0237	0.02	2	2	ND
Calcium	8/8	66	55.6	ND	ND	ND
Iron	8/8	9.84	2.9	0.3 (2)	0.3 (2)	ND
Magnesium	8/8	12.8	10.2	ND	ND	ND
Manganese	8/8	8.82	5.3	0.05 (2)	0.05 (2)	ND
Potassium	8/8	2.91	2.3	ND	ND	ND
Sodium	8/8	110	61.6	20 (4)	ND	20
Zinc	1/8	0.0689	0.02	2(1)/5(2)	5(2)	ND

Shaded line denotes either average or maximum (or both) concentration(s) of analyte exceeds at least one of the ARARs

NA = Not applicable ND = No value available MCL = Maximum Contaminant Level

(1) USEPA lifetime health advisory

(2) Secondary MCL

(3) USEPA action level

(4) USEPA drinking water equivalency level (DWEL) - A lifetime exposure concentration protective of adverse, non-cancer health effects that assumes all exposure is from a drinking water source

References:

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TABLE 9-14
POTENTIAL SOURCES OF UNCERTAINTY
AOC 43G - HISTORIC GAS STATION G / AAFES GAS STATION

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

UNCERTAINTY	EFFECT	JUSTIFICATION
Likelihood of exposure pathways	Overestimate	Future pathways may not actually occur
Exposure assumptions (e.g., frequency, duration)	Overestimate	Parameters selected are conservative estimates of exposure.
Degradation of chemicals not considered	Overestimate	Risk estimates are based on recent chemical concentrations. Concentrations will tend to decrease over time as a result of degradation, so future exposures may be to lower concentrations.
Extrapolation of animal toxicity data to humans	Unknown, probably overestimate	Animals and humans differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the difference will vary with each chemical. Animal studies typically involve high-dose exposures, whereas humans are exposed to low doses in the environment.
Use of linearized, multistage model to derive cancer slope factors	Overestimate	Model assumes a non-threshold, linear-at-low-dose relationship for carcinogens. Many compounds induce cancer by non-genotoxic mechanisms. Model results in a 95% upper confidence limit of the cancer risk. The true risk is unlikely to be higher and may be as low as zero.
Summation of effects (cancer risks and hazard indices) from multiple substances	Unknown	The assumption that effects are additive ignores potential synergistic and/or antagnonistic effects. Assumes similarity in mechanism of action, which is not the case for many substances. Compounds may induce tumors or other toxic effects in different organs or systems.
Uses of uncertainty factors in the derivation of reference doses.	Unknown	Ten-fold uncertainty factors are incorporated to account for various sources of uncertainty. Although some data seem to support the ten-fold factor, its selection is somewhat arbitrary.
Application of the RfD for naphthalene to all PAHs without RfDs and assumption that their effects are additive.	Overestimate	Naphthalene is the most toxic representative of noncarcinogenic PAHs and will bias estimates of risk high.
Exclusion of analytes from quantitative evaluation because no toxicity information is available.	Underestimate	The exclusion of analytes without toxicity values from quantitative evaluation may bias estimates of risk low.
A single detection of an inorganic analyte above background concentrations results in including this analyte as a CPC.	Overestimate	The selection of an inorganic as a CPC due to one concentration above background can bias risk and may not be representative of site conditions. The average may be more representative of site condiditons.
The use of an oral absorption factor of 1	Overestimate	The assumption of 100% gastrointestinal absorption of chemicals on soil is conservative.
Dermal exposure to soil not evaluated because of lack of dermal absorption factors.	Underestimate	Dermal contact with soils may produce some incremental risk and the inability to quantify the risk may bias the total risk estimate low.
Data set too small to allow calculation of the 95% UCL to evaluate central tendency risk. Arithmetic mean used instead.	Unknown, probably underestimate	The 95% UCL is intended to provide reasonable confidence that the true site average is not underestimated. The arithmetic mean may underestimate the true site average.

10.0 CONCLUSIONS AND RECOMMENDATIONS

RI activities were conducted by ABB-ES personnel at AOC 43G to evaluate the nature and distribution of the groundwater and soil contamination detected during previous investigations. A summary of the RI findings is presented in the following subsections.

10.1 CONCLUSIONS

The following conclusions are based on interpretation of data collected from each phase of investigation (SI, SSI and RI) completed at AOC 43G.

- The geologic setting at AOC 43G includes a soil fill layer underlain by glacial till above a meta-siltstone phyllite.

- The hydrogeologic condition at AOC 43G includes an unconfined aquifer. The water table is predominantly found in the overburden soil, but the piezometric surface does seasonally fluctuate down below the surface of the bedrock. The groundwater flows, locally and regionally, to the east-northeast.

- Soil contamination was detected in all three areas at AOC 43G. TPHC contamination in Area 1 was found to be below human-health-risk-based standards. Because of this, Area 1 requires no further action. Soil contamination detected in Areas 2 and 3 appears to be concentrated below the existing gasoline USTs, the sand and gas trap, and the former waste oil UST. Due to the depth and the concentrations of the detected contamination, the commercial/industrial risk scenario found no unacceptable risks associated with this medium. However, it does appear that the soil contamination detected in Area 2, and to a lesser extent at Area 3, is the source of the groundwater contamination detected downgradient of Areas 2 and 3.

- Sediment from a storm water outfall system that drains the paved area of the AAFES gas station was sampled during previous investigations. The concentrations of TPHC in the samples collected from the outfall were evaluated in a human health risk assessment. The findings of the risk assessment were that the concentrations of TPHC did not pose a risk to human health.

- Potential health risks associated with exposure to subsurface soil at Areas 2 and 3 of AOC 43G were evaluated. The primary CPCs identified in soil were ethylbenzene, toluene, xylene, PAHs, and inorganic compounds. The exposure scenario evaluated was for a utility/maintenance worker. Estimated carcinogenic risks did not exceed the USEPA target risk range or MADEP MCP risk management level. Similarly, potential noncarcinogenic risks did not exceed the USEPA and MADEP MCP target level.

- Risks associated with exposure to groundwater were evaluated for unfiltered groundwater representing the source area and for unfiltered groundwater identified as downgradient. The receptor evaluated was a future commercial/industrial worker. Estimated carcinogenic risks were at the upper end or exceeded the USEPA risk range of $1x10^{-4}$ to $1x10^{-6}$ for exposure to both mean and maximum concentrations of CPCs in source area groundwater ($1x10^{-4}$ and $6x10^{-4}$, respectively). Arsenic and benzene were the primary contributors to the excess risk in both cases. At maximum concentrations both arsenic and benzene produced individual risks above $1x10^{-4}$. In downgradient groundwater, only exposure to maximum concentrations produced a cancer risk exceeding the USEPA range. Arsenic contributed 94 percent of the risk of $2x10^{-4}$ for maximum concentrations. The HIs for the source area are 36 and 98 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary risk contributors for source area groundwater. HIs for downgradient groundwater are 11 and 21 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual HQs for the primary

contributors in both source area and downgradient groundwater all exceed the USEPA target level of 1.

- Risks were estimated for commercial/industrial worker exposure to filtered groundwater assuming that concentrations of organic CPCs remain the same as in unfiltered groundwater. Estimated carcinogenic risks were at the upper end or exceeded the USEPA target risk range of $1x10^{-4}$ to $1x10^{-6}$ for exposure to both mean and maximum concentrations of CPCs in source area filtered groundwater ($1x10^{-4}$ and $4x10^{-4}$, respectively). Arsenic and benzene were the primary contributors to the excess risk in both cases. At maximum concentrations both arsenic and benzene produced individual risks above $1x10^{-4}$. In downgradient filtered groundwater, exposure to both mean and maximum concentrations produced risks within the USEPA range ($5x10^{-5}$ and $9x10^{-5}$, respectively). The HIs for the source area are 36 and 98 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary contributors for source area groundwater. HIs for downgradient groundwater are 11 and 21 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual HQs for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of 1.

- If the modified CSFs for arsenic was used to estimate excess lifetime cancer risks, the cancer risks associated with exposure to both average and maximum concentrations of arsenic in filtered and unfiltered groundwater would fall below $1x10^{-4}$.

- A comparison of detected concentrations of CPCs in source area and downgradient groundwater to federal and state drinking water standards and guidelines showed several exceedances. In source area groundwater, the following CPCs were detected at concentrations above a federal or state standard or guideline: xylenes, benzene, ethylbenzene arsenic, lead, nickel, aluminum, iron, manganese, and sodium. In downgradient groundwater, detected

concentrations of benzene, aluminum, iron, manganese and sodium exceed federal or state drinking water standards or guidelines.

10.2 RECOMMENDATIONS

Based on the results and interpretation of the physical and chemical data and taking into account the future use of this AOC, which is expected to be vehicle storage and maintenance, ABB-ES recommends the following action for the groundwater:

- Perform an FS to evaluate alternatives to reduce potential human health risks associated with potential future commercial/industrial exposure to groundwater at the source area directly downgradient of Areas 2 and 3.

- Evaluate alternatives to prevent potential future migration of contaminants to downgradient areas.

AAFES	Army Air Force Exchange Service
ABB-ES	ABB Environmental Services, Inc.
ADL	Arthur D. Little, Inc.
ANL	Argonne National Laboratory
AOC	Area of Contamination
ARF	Analysis Request Form
ARAR	applicable or relevant and appropriate requirements
ATEC	ATEC Environmental Consultants, Inc.
AWQC	Ambient Water Quality Criteria
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylenes
cm/sec.	centimeters per second
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
CMR	Code of Massachusetts Regulations
COC	chain-of-custody
CPC	chemical of potential concern
CSF	cancer slope factor
CWA	Clean Water Act
1,2-DCA	1,2-dichloroethane
DDT	dichlorodiphenyl trichloroethane
DOT	Department of Transportation
DQO	Data Quality Objective
EA	Environmental Applications, Inc.
ECAO	Environmental Criteria Assessment Office
E&E	Ecology & Environment, Inc.
ELCD	electrolytic conductivity detector
EMO	Environmental Management Office
EPC	exposure point concentration
ETA	Engineering Technologies Associates

ft/min	feet per minute
ft^2/day	square feet per day
FFA	Federal Facilities Agreement
FID	flame ionization detector
FORSCOM	U.S. Army Forces Command
FS	Feasibility Study
FSP	Field Sampling Plan
GAC	granular activated carbon
GC	gas chromatograph
gpm	gallons per minute
GPR	ground-penetrating radar
GZAR	GZA Remediation, Inc.
H	Henry's Law Constant
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HQ	hazard quotient
HSA	hollow-stem augers
ID	identification
ID	inside diameter
IDW	investigation-derived waste
IR	infrared spectrophotometer
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
K_{oc}	organic carbon partition coefficient
MADEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goals
MCP	Massachusetts Contingency Plan

MDL	Method Detection Limits
MEP	Master Environmental Plan
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MMCL	Massachusetts Maximum Contaminant Level
mph	miles per hour
MS/MSD	matrix spike/matrix spike duplicate
NCP	National Contingency Plan
NDIR	non-dispersed infrared
NGVD	National Geodetic Vertical Datum
NPL	National Priorities List
NTU	nephelometric turbidity unit
NWR	National Wildlife Refuge
°F	degrees fahrenheit
OSHA	Occupational Safety and Health Administration
OD	outside diameter
PAH	polynuclear aromatic hydrocarbon
PAL	Project Analyte List
PARCC	precision, accuracy, representativeness, completeness, and comparability
PC	personal computer
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
POP	Project Operations Plan
ppb	parts per billion
ppm	parts per million
PQL	Practical Quantitation Limit
PRE	preliminary risk evaluation
PRI	Potomoc Research, Inc.
psi	pounds per square inch
PVC	polyvinyl chloride

QA	quality assurance
QAPP	Quality assurance Project Plan
QC	quality control
RAS	Routine Analytical Services
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
RPD	relative percent difference
RPF	relative potency factor
SA	Study Area
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SAS	Special Analytical Services
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SI	Site Investigation
SMCL	Secondary Maximum Contaminant Level
SQL	sample quantitation limit
SWMU	Solid Waste Management Unit
SSI	Supplemental Site Investigation
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TBC	to be considered
1,1,2,2-TCA	1,1,2,2-trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TEX	toluene, ethylbenzene and xylenes
TIC	tentatively identified compounds
TPHC	Total Petroleum Hydrocarbons
TOC	Total Organic Carbon
TSS	total suspended solids

µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per Liter
µg/ml	micrograms per milliliter
UCL	upper confidence limit
USAEC	U.S. Army Environmental Center
USAR	U.S. Army Reserve
USATHAMA	U.S. Army Toxic Hazardous Materials Agency
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UST	underground storage tank
VC	vinyl chloride
VOC	volatile organic compound
WPA	Works Progress Administration

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