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Massachusetts Military Reservation

RECORD OF DECISION
AREA OF CONTAMINATION FS-1

FINAL

April 2000

Prepared for:
AFCEE/MMR
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U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

RECORD OF DECISION
AREA OF CONTAMINATION FS-1

MASSACHUSETTS MILITARY RESERVATION
CAPE COD, MASSACHUSETTS

Final

April 2000

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ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services, Inc.
AFCEE	Air Force Center for Environmental Excellence
ANG	Air National Guard
AOC	Area of Contamination
ARAR	applicable or relevant and appropriate requirement
AVGOU	Ashumet Valley Groundwater Operable Unit
BAF	bioaccumulation factor
BBM	Buzzards Bay moraine
bgs	below ground surface
BTEX	benzene, toluene, ethylene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1 1980
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
CMR	Code of Massachusetts Regulations
COC	contaminant of concern
COPC	contaminant of potential concern
CRQL	Contract-required Quantitation Limit
CS	Chemical Spill
CSF	Cancer Slope Factor
CT	central tendency
DDT	dichlorodiphenyltrichloroethane
DOD	Department of Defense
DPH	Department of Public Health (Massachusetts)
EAT	Eastern Aircraft Turnaround
EDB	ethylene dibromide
EPC	exposure point concentration
FFA	Federal Facility Agreement
FS	Feasibility Study
FS-1	Fuel Spill No. 1
GAC	granulated activated carbon
GC	gas chromatograph
gpm	gallons per minute
HAZWRAP	Hazardous Waste Remedial Actions Program
HEC	hazard/risk equivalent concentration
HI	Hazard Index
HQ	Hazard Quotient

HSL	Hazardous Substances List
IEUBK	Integrated Uptake/Biokinetic (model)
IRP	Installation Restoration Program
K_{oc}	water organic-carbon partition coefficient
LOAEL	lowest observed adverse effects level
MADEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
MCP	Massachusetts Contingency Plan
μg/kg	microgram per kilogram
μg/L	microgram per liter
mgd	million gallons per day
MMCL	Massachusetts maximum contaminant level
MMR	Massachusetts Military Reservation
MPP	Mashpee pitted plain
MW	monitoring well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGB	National Guard Bureau
NOEC	no observed adverse effects concentration
NOAEL	no observed adverse effects level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	operation and maintenance
PAT	Process Action Team
PCB	polychlorinated biphenyl
ppb	parts per billion
ppm	part per million
PRA	Preliminary Risk Assessment
RAH	Risk Assessment Handbook
RAO	remedial action objective
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RME	reasonable maximum exposure
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SERGOU	Southeast Regional Groundwater Operable Unit
SI	site investigation
SM	Sandwich Moraine

SS	surface soil
STCL	soil target cleanup level
SVOC	semivolatile organic compound
TAL	Target Analyte List
TB	test boring
TPH	total petroleum hydrocarbons
UCL	upper confidence limit
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAT	Western Aircraft Turnaround

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1. DECLARATION

1.1 SITE NAME AND LOCATION

Area of Contamination
Fuel Spill No. 1 (FS-1)
Otis Air National Guard [U.S. Air Force (USAF)]
Mashpee, Massachusetts

1.2 STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedial actions for Area of Contamination (AOC) FS-1 at the Massachusetts Military Reservation (MMR) in Barnstable County, Mashpee, Massachusetts. The area of contamination includes both source area and groundwater associated with FS-1

These remedial actions were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), 42 U.S.C. §§ 9601 et seq., and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) at 40 CFR Part 300. The Director of the Air Force Center for Environmental Excellence (AFCEE), and the Director of the Office of Site Remediation and Restoration, U.S. Environmental Protection Agency (USEPA) New England have been delegated the authority to approve this ROD.

This ROD is based on the Administrative Record for AOC FS-1, which has been developed in accordance with Section 113(k) of CERCLA. The Administrative Record is available for public review at the AFCEE Installation Restoration Program (IRP) Office at MMR and at the Falmouth Public Library, Falmouth, Massachusetts.

The Commonwealth of Massachusetts concurs with the selected remedy (Alternative 3B) for AOC FS-1. Appendix E of this ROD contains a copy of the letter of concurrence.

1.3 ASSESSMENT OF AOC FS-1

Actual or threatened releases of hazardous substances from AOC FS-1, if not addressed by implementing the response action selected in this ROD, may present a current or potential threat to human health, welfare, or the environment.

1.4 DESCRIPTION OF THE SELECTED REMEDY (ALTERNATIVE 3B) FOR AOC FS-1

The selected response for AOC FS-1 is composed of multiple components. In the source area, no action will be taken for surface soils since there are no risks warranting action. For the

downgradient groundwater contamination, the selected remedy (Alternative 3B) is leading edge and axial extraction, treatment, and reinjection/discharge. Monitoring is selected for the source area groundwater.

The leading edge groundwater extraction, treatment, and reinjection/discharge pilot test system, and the groundwater and surface water monitoring for the pilot test system have already been put in place. This pilot test system began operating on April 1, 1999 to initiate extraction of EDB contaminated groundwater that was discharging to the surface waters in the Quashnet River cranberry bogs. The pilot system consists of one deep extraction well and shallow groundwater extraction well points with a current total flow rate of 650 gallons per minute, a treatment plant utilizing granulated activated carbon, and a reinjection trench and surface water discharge bubbler. The purpose of the pilot test system is to protect human health from exposure to EDB in groundwater and surface water and to accelerate restoration of the groundwater and Quashnet River. Currently, monitoring of the pilot test is ongoing and being conducted to evaluate the system's impacts to natural resources and removal of EDB from surface water and groundwater. Optimization of pilot test system will be conducted in response to monitoring results. With respect to the axial extraction and treatment portion of the selected remedy (Alternative 3B), remedial design including data gap investigations will be conducted subsequent to finalization of this ROD.

This remedy is an on-going response designed to address the principal threats at AOC FS-1. The contamination of downgradient groundwater and surface water by the organic compound ethylene dibromide (EDB) poses an unacceptable risk to human health. Source area groundwater contains toluene, lead, and thallium above maximum contaminant levels (MCLs) and Massachusetts maximum contaminant levels (MMCLs). The contaminants in source area groundwater are not mobile and do not present a present threat to human health or the environment. Source area surface and subsurface soils do not contain contaminants at levels that pose a threat to human health or the environment.

COCs Identified for Remediation at AOC FS-1

Downgradient Groundwater	Source Area Groundwater
EDB	Toluene
	Lead
	Thallium

The major components of the Selected remedy (Alternative 3B) include:

- Leading edge groundwater extraction, treatment, and reinjection/discharge (pilot test) which is already operational
- Data gap investigations and additional modeling for the axial extraction wells
- Axial groundwater extraction with approximately 17 extraction wells at approximately 400 gpm
- Property acquisition for additional axial extraction wells

- Site preparation (i.e., road construction, power line connections, etc)
- Treatment using granulated activated carbon (GAC) (650 gpm are currently being treated; additionally extracted groundwater will also be treated using GAC in a new or expanded treatment plant)
- Reinjection and/or discharge of treated groundwater (of the 650 gpm currently being extracted and treated, 120 gpm is reinjected and 530 gpm is discharged to the surface water using a bubbler); additional reinjection/discharge for groundwater extracted from the axial portion of plume
- Monitoring of source area groundwater
- Monitoring of surface water and groundwater to assess performance of the system and ensure that sensitive aquatic habitat is not impacted
- A round of fish sampling will be conducted for two consecutive years (2000 and 2001) to confirm that there are no environmental impacts to the fish and to evaluate potential human health risks posed by ingestion of fish.
- Periodic cranberry sampling to further verify that the remedy is performing as designed
- Operation and maintenance of the treatment system(s) including treatment plant(s) and extraction wells
- Institutional controls to reduce the risk of current and future exposure to contaminated groundwater until cleanup standards are attained.

The response addresses the principal threat (EDB) in downgradient contaminated groundwater and surface water by extraction, treatment, and reinjection/discharge. The EDB will be removed from groundwater. Over the course of remediation, surface water contamination will be eliminated because the groundwater source causing surface water contamination will be remediated. The response addresses the low level threats (toluene, lead, and thallium) contained in source area groundwater by monitoring source area groundwater to ensure that those contaminants do not migrate away from the source area. A groundwater monitoring and site visual inspection program will be implemented after the remedial action is complete. Extraction, treatment, and reinjection/discharge will reduce the toxicity, mobility, and volume of contaminated groundwater by extracting groundwater and treating that water to remove EDB.

1.5 STATUTORY DETERMINATIONS FOR AOC FS-1

The selected remedy (Alternative 3B) is consistent with CERCLA and, to the extent practicable, the NCP; is protective of human health and the environment; complies with federal and Commonwealth of Massachusetts requirements that are legally applicable or relevant and appropriate to the remedial action; and is cost-effective. The remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable. In addition, the remedy satisfies the statutory preference for treatment that reduces toxicity, mobility, or volume as a principal element. Because this remedy may result in hazardous substances, pollutants or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure and groundwater remediation will take more than five years, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. At the MMR site, pursuant to OSWER Directive 9355.7-02A (Supplemental Five-Year Review Guidance) and based upon the initiation

of remedial action at the CS-4 groundwater plume, the next five-year review is scheduled for the year 2002.

1.6 ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this Record of Decision. Additional information can be found in the Administrative Record file for this site.

- Chemicals of concern and their respective concentrations
- Baseline risk represented by the chemicals of concern
- Cleanup levels established for chemicals of concern and the basis for those levels
- How source materials constituting principal threats are addressed
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the risk assessment and ROD
- Potential land and groundwater use that will be available at the site as a result of the selected remedy
- Estimated capital, annual operation and maintenance (O&M), and the total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected
- Key factor(s) that led to selecting the remedy (i.e., describe how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision).

1.7 SIGNATURE AND SUPPORT AGENCY ACCEPTANCE

The foregoing represents the decision for remedial action at the AOC FS-1 Source Areas by AFCEE and USEPA with the concurrence of the Massachusetts Department of Environmental Protection (MADEP).

Concur and recommend for immediate implementation:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

GARY M. ERICKSON, P.E. Date 4 May 2000
Director

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

PATRICIA L. MEANEY Date 15 May 2000
Director, Office of Site Remediation and Restoration
U.S. Environmental Protection Agency, New England

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2. DECISION SUMMARY

Multiple figures included in this ROD have been extracted from the 1999 RI. Figures are numbered in order of appearance. The reference for the figures is included in Section 6. All the figures appear in Appendix A.

2.1 SITE NAME, LOCATION, AND DESCRIPTION

This ROD addresses past releases of contaminants at AOC FS-1 and contaminated groundwater associated with AOC FS-1 located at MMR in Mashpee, Massachusetts.

MMR is a National Priorities List (NPL) site under CERCLA. MMR's CERCLA identification number is MA2570024487 MMR is located on western Cape Cod in Barnstable County, Mashpee, Massachusetts, approximately 60 miles south of Boston and immediately southeast of the Cape Cod Canal. It occupies approximately 22,000 acres within the towns of Bourne, Falmouth, Mashpee, and Sandwich (Figure 2-1). MMR is organized into four functional areas: Range Maneuver and Impact Area, Cantonment Area, Massachusetts National Cemetery, and Cape Cod Air Force Station. AOC FS-1 source area occupies approximately 2 acres along taxiway E, which is located in the southeastern area of MMR (Figure 2-2). The FS-1 source area is located within the flight line area and includes the Eastern Aircraft Turnaround (EAT) and the Western Aircraft Turnaround (WAT). The EAT and WAT are constructed of concrete and asphalt and are located in an area once used as a source or borrow material. The area containing the EAT and WAT is sparsely vegetated, and the northern and southern boundaries of the borrow area are denoted by steep slopes capped by heavily vegetated forest.

For AOC FS-1, the lead agency is the Air Force Center for Environmental Excellence (AFCEE). AFCEE funding for AOC FS-1 work is derived from the Defense Environmental Restoration Account (DERA). Providing regulatory oversight, EPA and the Massachusetts Department of Environmental Protection (MADEP) are the support agencies.

AOC FS-1 contains two separate areas of groundwater contamination. In the source area, there is a small area of groundwater contamination that is limited to an area within 1,000 feet of the EAT and WAT. The other area of groundwater contamination is a detached plume beginning 2,000 feet downgradient from the suspected source area. At its trailing edge, this detached plume is deep within the aquifer, but then rises abruptly and discharges to surface water in the Quashnet River cranberry bogs.

The cranberry bog east of Johns Pond (Figure 2-2) is an important feature for this site. The Quashnet River is fed by a controlled head gate located on the northeast corner of Johns Pond. From there, the river flows through the large cranberry bog adjacent to Johns Pond and onward to Waquoit Bay. The upper reaches of the Quashnet River are fed by groundwater discharge.

The primary drinking water supply for MMR comes from a groundwater supply well located on the base and installed in glacial outwash. The adjacent towns of Bourne, Falmouth, Mashpee, and Sandwich also derive their drinking water from supply wells within the recharge area of this aquifer. Falmouth has a reservoir for storage of drinking water obtained from groundwater. The

water supply wells at MMR and surrounding towns range from 40 to 412 feet deep, with the majority of wells extending to depths of 50 to 100 feet bgs. In areas where public water supply lines are not available, residents use private wells for domestic water supplies (HAZWRAP 1994). The town of Mashpee has proposed installation of a public water supply well slightly east of the area of contaminated groundwater from AOC FS-1. For purposes of identification, that well is referred to as proposed Mashpee public supply well P-11 (Fig. 2-2).

A more complete description of MMR and AOC FS-1 can be found in *Phase I Records Search U.S. Air Force Installation Restoration Program, Phase I: Records Search, Air National Guard, Camp Edwards, U.S. Air Force, and Veterans Administration Facilities at Massachusetts Military Reservation, Task 6* (E. C. Jordan 1986); and in the final RI report, *Final Remedial Investigation Report, Area of Contamination FS-1* (HAZWRAP 1999). These reports are available for review at the main libraries in the towns of Bourne, Falmouth, Mashpee, and Sandwich and at the U.S. Coast Guard library at MMR.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

This section provides background information on the site's history and enforcement actions taken to date. Factors addressed include the land use and site history of activities, the history of site investigations (SIs), and the history of CERCLA enforcement activities.

2.2.1 Site History

Although military activity began at MMR as early as 1911, most operations occurred after 1935 and consisted of two general types: (1) mechanized Army training and maneuvers and (2) military aircraft operations, maintenance, and support. Intensive Army activity occurred with the onset of World War II and continued through demobilization following the war (1940–1946). Major aircraft operations were associated with surveillance and air defense aircraft and occurred from 1955 to 1970. Although aircraft operations continue today, the greatest potential for release of contaminants to the environment was between 1940 and 1970. Tenants at MMR include, or have included, the U.S. Coast Guard, Army National Guard (Camp Edwards), U.S. Air Force (USAF), Air National Guard (ANG) (Otis Air National Guard Base), Veterans Administration National Cemetery, U.S. Marine Corps, U.S. Department of Agriculture, and the Commonwealth of Massachusetts. The USAF managed MMR until 1973, when base management was transferred to the ANG.

Activities at MMR that had the potential to contaminate the environment included the storage, handling, and disposal of solvents and petroleum fuels as well as the leakage of these materials into storm water drainage systems and the sanitary sewer system. Landfill operations, firefighter training, coal and ash storage, and numerous chemical and fuel spills also resulted in environmental contamination.

AOC FS-1 was used by the 551st Airborne Early Warning and Control Wing to test fuel dump valves between 1955 and 1970. Both the EAT and WAT were investigated during the course of the site investigation (SI) and the remedial investigation (RI). Records searches indicate that EC-121 Super Constellation aircraft were parked at the EAT and WAT and fuel valves were tested. The valves were opened and the fuel allowed to drain. Initially, records suggest the fuel

was hosed off the concrete. Records also indicate that the fuel was collected in 55-gallon barrels. The exact quantity of fuels released onto the concrete is unknown.

2.2.2 History of Site Investigations

The following investigations related to AOC FS-1 were conducted.

- **1983** An IRP Phase I records search to identify potential sites at MMR indicated the need for further investigation at AOC FS-1.
- **1985** An initial environmental investigation (Phase II, Stage I study) was performed in the source area. Explorations included eight test pits and one water table well. No contamination was identified.
- **1989** An SI was performed in the source area. Explorations included 30 soil gas sampling points, 1 soil boring, and 3 monitoring wells. Fuel-related compounds were detected in groundwater above MCLs.
- **1990** An initial RI was performed in which FS-1 was differentiated into two operable units: FS-1B source area and FS-1B downgradient groundwater. Seven source area wells were installed and two source area soil borings were completed. Twelve downgradient wells were installed in two well fences. Four additional water table wells were installed to aid in determination of local groundwater flow. Source area wells contained fuel-related compounds. Of these, only toluene and lead were above MCLs. Downgradient wells did not contain levels of fuel-related compounds above the MCL. Because of the absence of fuel-related compounds, it was hypothesized that the fuel compounds had degraded.
- **1993** A basewide EDB study included collection and analyses of groundwater from seven FS-1 source area wells for EDB. EDB was not detected in the samples.
- **1995** A Geoprobe investigation was performed to track a potential path of fuel contamination from FS-1. Twenty multilevel locations were sampled for fuel constituents and indicator parameters of biodegradation. Additionally, three new wells were installed and five surface soil samples were collected in the source area. No contamination was identified.
- **1997–1998** Additional downgradient groundwater and surface water investigations were performed as a result of public comment concerning FS-1. Thirty-two downgradient wells were installed along a path that had not previously been investigated. Thirty-nine surface water samples were collected from the Quashnet River and the Quashnet River bogs. This investigation identified a plume of EDB-contaminated groundwater discharging into the Quashnet River bogs.

2.2.3 History of Enforcement Activities

On November 21, 1989, USEPA placed MMR on the NPL under CERCLA, as amended by SARA, to evaluate and implement response actions to clean up past releases of hazardous substances, pollutants, and contaminants. A Federal Facility Agreement (FFA) between the Department of Defense (DOD), Air National Guard (ANG), U.S. Coast Guard, and USEPA was signed in 1991 and subsequently amended. The FFA established a procedural framework for ensuring that appropriate response actions are implemented and required the ANG to take the lead in cleanup activities at MMR, including AOC FS-1. FS-1 is an operable unit within the entire installation. AFCEE is currently acting as lead agent for cleanup under the FFA at MMR.

In response to environmental contamination at MMR, DOD implemented its multiphase IRP at MMR to identify and evaluate problems associated with past releases of hazardous substances. The IRP parallels the USEPA CERCLA investigation and cleanup process. The NGB, and subsequently AFCEE, followed USEPA guidelines for most IRP investigations performed between 1986 and 1989 and for all investigations performed since 1989.

In 1986, an extensive records search and review of available soil and groundwater data identified 73 areas at MMR as having potential for contamination (E. C. Jordan 1986). Additional areas were later identified through anonymous sources and unrelated base construction projects, bringing the total to 80. The investigative history of AOC FS-1 addressed in this ROD is presented in the RI report (HAZWRAP 1999) and summarized in Section 2.2.2 of this ROD.

The Proposed Plan (AFCEE 1999) for remedial action of the contaminated groundwater associated with AOC FS-1 was issued in June 1999 for public comment. Technical comments presented during the public comment period are included in the Administrative Record. The Responsiveness Summary (Appendix C) contains a summary of these comments and AFCEE's responses and describes how these comments affected the remedial action decision for the AOC. All written comments received during the public comment period are included as an attachment to the Responsiveness Summary. A transcript of the Public Hearing is included in Appendix D. A letter of concurrence from the Commonwealth of Massachusetts is included in Appendix E.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The NGB and AFCEE have held regular informational meetings, issued fact sheets, and held public meetings to keep the community and other interested parties informed of the activities at AOC FS-1.

Throughout MMR's history, community concern and involvement have been high. The NGB, AFCEE, USEPA, and MADEP have kept the community and other interested parties apprised of site activities through informational meetings, fact sheets, news releases, public hearings, and Technical Environmental Affairs Committee (TEAC) meetings. TEAC was organized in 1986 by the NGB to provide a forum for public input on the MMR response activities. Membership in TEAC comprised USEPA, MADEP, and representatives from local, regional, and state groups. Beginning with the October 7, 1992, TEAC meeting, members of the public could attend these bimonthly meetings. TEAC ceased meeting in 1996 and is no longer in existence.

During May 1991, an MMR Community Involvement Plan was released that outlined a program to address community concerns and keep citizens informed and involved in the remediation process at MMR. In July 1994, and again in December 1996, an updated Community Involvement Plan (AFCEE 1996) was issued to incorporate concerns and feedback provided by the community and to document changes in AFCEE policy, such as the public attendance at TEAC meetings.

In October 1993, a senior management board was created to advise AFCEE on IRP activities. A Selectman from each of the four towns surrounding MMR is among the senior management board members, along with the regulatory agencies and the Adjutant General's Office of the Commonwealth of Massachusetts. Process Action Teams (PATs) were also created to address

specific issues at MMR; these issues include plume containment, long-range water supplies, innovative technologies, and public information. PATs have representation from the community, local business, regulatory agencies, and AFCEE.

AFCEE published a display ad for the Public Information Meeting for the FS-1 Proposed Plan in the *Falmouth* and *Mashpee Enterprises*, the *Cape Cod Times*, and the *Bourne* and *Sandwich Enterprises* on May 21, 1999. The announcement of the public hearing was contained in display ads run in the *Mashpee* and *Falmouth Enterprises* on June 1, 1999; in the *Sandwich* and *Bourne Enterprises* on June 4, 1999; and the *Cape Cod Times* on June 29, 1999. Before the start of the comment period, AFCEE made the RI reports, the FS, and Proposed Plan available for public review at the U.S. Coast Guard library at MMR and the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts. The Proposed Plan has also been made part of the Administrative Record available for public review at the AFCEE IRP office at MMR and at the Falmouth Public Library. From June 4, 1999, to July 3, 1999, AFCEE held a 30-day public comment period to accept public comments on the preferred alternatives presented for AOC FS-1 in the Proposed Plan. On June 3, 1999, AFCEE held a public meeting at the Mashpee Town Hall to present and discuss the Proposed Plan. On June 23, 1999, AFCEE held a public hearing at the Mashpee Town Hall to accept verbal comments on the Proposed Plan. A transcript of the June 23, 1999, hearing is included in Appendix D. These written comments were primarily concerned with the impact of the preferred alternative on the environment and questions regarding the distribution of EDB in the Quashnet River bogs.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

FS-1 is part of the Federal Facilities Agreement. This response action is designed to address the principal threat at AOC FS-1: contaminated groundwater and surface water that pose an unacceptable risk to human health. Source area soils do not present a risk to human health or the environment and are not included in the response action. This response addresses the principal threat through the extraction and treatment of EDB-contaminated downgradient groundwater. The low level threats to groundwater posed by toluene, lead, and thallium in source area groundwater are addressed through a long-term monitoring plan.

Groundwater contamination at MMR is problematic and involves multiple distinct plumes. The FS-1 groundwater plume is one of those plumes. AFCEE developed a strategy for restoration of groundwater that is presented in Strategic Plan, Massachusetts Military Reservation, Installation Restoration Program (AFCEE, 1997). Though FS-1 was not specifically included in the strategic plan, the objectives of the strategic plan are applicable to FS-1. The objectives of the strategic plan applicable to FS-1 are:

- remediate community ground-water resources;
- complete the MMR cleanup program; and
- protect human health and the environment from hazards of past practices.

Remedies for other groundwater plumes have been proposed/selected and are either in design, under construction, or operational. Most of those systems depend on extraction , treatment, and reinjection of treated water.

FS-1 groundwater contamination is addressed in this ROD. Ingestion of groundwater extracted from this aquifer, and exposure to surface water derived from the FS-1 plume, pose a current and potential risk to human health because EPA and/or MADEP acceptable risk range is exceeded. Contamination concentrations in FS-1 related groundwater exceed MCLs and MMCLs for drinking water. Remedial actions for FS-1 address the principal threat from the site through the extraction and treatment of EDB-contaminated downgradient groundwater. The low-level threat to groundwater posed by toluene, lead, and thallium in source area groundwater are addressed through the long term monitoring plan.

A pilot study began in April 1999 and is functioning in the area of the groundwater upwelling in the Quashnet River cranberry bogs. That pilot study includes:

- extraction of deep groundwater from a large diameter well,
- extraction of shallow groundwater from a system of manifolded shallow wellpoints,
- treatment of the extracted groundwater with granulated activated carbon,
- reintroduction of treated water to the aquifer by reinjection,
- reintroduction of treated water to surface water with an aeration system,
- construction and maintenance of berms to isolate areas of potential contaminated groundwater upwelling from other areas of the Quashnet River and Quashnet River cranberry bogs, and
- performance monitoring to evaluate the systems effectiveness, to ensure that ecological habitats are not negatively impacted.

2.5 SITE CHARACTERISTICS

The areas of contaminated groundwater and surface water associated with AOC FS-1 that are addressed in this ROD are the source area groundwater, downgradient groundwater, and surface water in the Quashnet River cranberry bogs.

2.5.1 Conceptual Site Model

A conceptual model of contamination was developed for FS-1. That model includes the areas of contamination, potential exposure pathways, and final receptors. The groundwater contamination is divided into source area groundwater contamination and the downgradient area of contamination.

The source area groundwater contamination is limited to an area within 1000 feet of the WAT and EAT. All the COCs in the source area are relatively immobile as indicated by the lack of movement of those COCs. Site activities that may have caused the contamination ceased 30 years ago and the COCs associated with the source area are still near the source area.

The only contaminant of concern in the downgradient area of contamination is EDB. The downgradient area of groundwater contamination extends from the most northern detection of EDB, approximately 2000 feet downgradient of the source area, to the discharge at the cranberry bog. The downgradient groundwater contamination is approximately 6,950 feet long, 600 to 1,200 feet wide, and 50 to 100 feet thick. After discharging to surface water in the Quashnet

River bogs, EDB-contaminated water moves downstream in the Quashnet River. EDB has been detected in the Quashnet River cranberry bogs and the Quashnet River. The most downstream detection of EDB in the Quashnet River was approximately 2 miles from the Quashnet River cranberry bogs.

Graphical Depiction 2-1 and Graphical Depiction 2-2 show the potential risk pathways by which humans and/or potential ecological receptors may be exposed to contamination associated with the downgradient area of contamination.

2.6 GEOLOGY

The regional geology of western Cape Cod is composed of glacial sediments deposited during the retreat of the Wisconsin stage of glaciation between 7,000 and 85,000 years ago. The regional geology is dominated by three extensive sedimentary units: Buzzards Bay moraine (BBM), Sandwich moraine (SM), and MPP. BBM and SM lie along the western and northern edges of western Cape Cod, respectively. MPP, which consists of poorly sorted, fine- to coarse-grained sands forming a broad outwash plain, lies between the two moraines. Underlying MPP are fine-grained, glaciolacustrine sediments and basal till at the base of the unconsolidated sediments. The BBM and SM are composed of ablation glacial till, which is unsorted material ranging from clay to boulder size that was deposited at the leading edge of two lobes of the Wisconsinian glacier at its farthest advance. These moraines form hummocky ridges.

The total thickness of unconsolidated sediments overlying bedrock varies from approximately 175 feet near the Cape Cod Canal in the northwest to approximately 325 feet at the thickest portion of the BBM; it decreases to about 250 feet near Nantucket Sound to the south. The portion of the overburden composed of MPP outwash sediments varies in thickness from approximately 225 feet near the moraines in the north to about 80 feet near the shore of Nantucket Sound. Glaciolacustrine sediments and till underlying MPP generally increase in thickness as the proportion of MPP sediments decreases. Bedrock, which has been mapped as a granodiorite, lies approximately 300 feet bgs.

2.6.1 Hydrogeology

A description of the overall hydrogeologic setting can be found in the Task 1-8 hydrogeologic summary report (E. C. Jordan 1989). A single groundwater flow system underlies western Cape Cod, including MMR. The aquifer system is unconfined (in equilibrium with atmospheric pressure) and is recharged by infiltration from precipitation. Surface water runoff at MMR is virtually nonexistent (except on extreme slopes) because of the highly permeable nature of the sands and gravel underlying the area. The high point of the water table occurs as a groundwater mound beneath the northern portion of MMR. Groundwater flow generally radiates outward from this mound. The aquifer is bounded by the ocean on three sides; groundwater discharges into Nantucket Sound on the south, Buzzards Bay on the west, and Cape Cod Bay on the north. The Bass River in Yarmouth forms the eastern lateral aquifer boundary.

The aquifer underlying AOC FS-1 is within the MPP and is designated as a sole-source aquifer by USEPA. Aquifer recharge occurs from precipitation. The aquifer is composed of unconsolidated sediments consisting of the MPP and finer-grained till and lacustrine sediments.

The industrialized area of MMR (including the flight line and AOC FS-1) is located on the southern and southeastern flanks of the groundwater mound. Groundwater contours depicting groundwater flow direction of the southeastern area of MMR that includes FS-1 are shown on Figure 2-3. Groundwater beneath AOC FS-1 flows from the north to the south and southeast. In general, groundwater flow paths at MMR appear to dip slightly into the aquifer.

MPP consists of coarse-grained sand and gravel outwash sediments underlain by finer-grained sediments. The hydraulic conductivity of the outwash sediments has been measured at up to 380 feet/day. Hydraulic conductivity of the fine-grained sediments was observed to be only 2 to 10% of the outwash. Therefore, the bulk of regional groundwater flow is transmitted through the upper outwash unit; horizontal flow velocities range from 1 to 3.4 feet/day. The hydraulic gradient across MMR ranges from about 0.0014 to 0.0018 feet/foot.

Based on data collected during previous investigations, the hydraulic gradient of the groundwater system beneath AOC FS-1 is approximately 0.002 feet/foot, the effective porosity of the aquifer material is approximately 0.3, and the hydraulic conductivity of the material ranges from 136 to 253 feet/day. Using these values, the seepage velocity is calculated using the following equation:

$$v = \frac{k \times i}{n}$$

where

v = seepage velocity,
k = hydraulic conductivity,
i = hydraulic gradient,
n = effective porosity.

The seepage velocity is calculated to range from 0.9 to 1.7 feet/day.

2.6.2 Surface Water

Surface water is present at MMR as intermittent streams in a few of the drainage swales and as ponds in kettle holes on MPP. The kettle hole ponds are depressions of land surface below the water table. On a regional scale, these kettle hole ponds and streams influence groundwater flow in a manner similar to that of large aquifer heterogeneities: the larger or deeper the pond or stream, the greater the effect on slope and direction of the regional water table near the pond. While horizontal groundwater flow is dominant in the aquifer system, vertical flow driven by piezometric head differences is important in areas near some of the ponds and streams.

The Quashnet River cranberry bogs (Figure 2-2) are an important feature for FS-1. The SERGOU study indicates cranberry bogs are important because (1) they receive groundwater discharge and cause some convergence of groundwater flowlines, (2) they store surface runoff and release this water slowly to adjoining streams and thereby diminish peak flows, (3) they receive herbicides and/or pesticides (most likely through application of a petroleum-based carrier), and (4) the abundance of natural organic matter in the shallow subsurface creates an acidic oxygen-deficient (reducing) environment that can filter and absorb both inorganics and

organic compounds. This reducing environment can cause some metals (e.g., arsenic, manganese, and iron) to become soluble.

The SERGOU study notes that the effect the cranberry bog has on groundwater flow is difficult to separate from the drain function of the river. The Quashnet River is fed by a controlled head gate located on the northeast corner of Johns Pond. From there the river flows through the large cranberry bog adjacent to Johns Pond and onward to Waquoit Bay. The upper reaches of the Quashnet River are fed by groundwater discharge (ABB-ES 1994). The SERGOU RI report suggests that 33 to 49% of the flow measured along the Quashnet River is contributed in the first 0.7 miles downstream of Johns Pond. This implies that groundwater discharge to the river is the main source of this flow.

The water budget presented by HAZWRAP indicated that the majority of flow in the Quashnet in the area immediately downgradient of Johns Pond was derived from groundwater discharging to the cranberry bogs. The calculations contained in the HAZWRAP water budget and the Quashnet River published in USGS reports (Barlow and Hess 1993) was confirmed by Jacobs measurements (Jacobs 1997) in August 1997. Surface water flow measurements were taken at weirs from two upstream locations, one midstream location, and at a single downstream outlet location. Stepwise increases in the volume of surface water along the Quashnet River at the midstream and outlet locations clearly demonstrate additions on the order of 2,000 to 2,500 gpm of water to the bogs from groundwater upwelling.

2.6.3 Sampling Strategy

AOC FS-1 source area and groundwater has been investigated in multiple phases between 1985 and 1999. Surface soils, subsurface soils, groundwater, surface water, and sediments have been sampled and analyzed. The turning point of the investigation was the detection of EDB in surface water in the Quashnet River cranberry bogs in August 1997. The extent of the downgradient detached EDB plume was characterized in 1997 and 1998. Table 2.5-1 presents a summary of sampling associated with FS-1. Organized in chronological order, the following subsections contain summaries of each investigation related to FS-1.

2.6.3.1 Phase II Study 1985

Initial investigations were performed during the 1985 Phase II Stage 1 study, *Phase II – Confirmation/Quantification, Stage 1* (R.F. Weston 1985). The initial investigations included eight test pits and one water table monitoring well. Four of the test pits were excavated adjacent to the WAT and the remaining four test pits were located in a swale approximately 1,600 feet southwest of the WAT. Monitoring well RFW-11 was installed approximately 200 feet south of the WAT (Figure 2-6). Fuel-related contamination was not detected in soil and groundwater samples submitted for laboratory analyses.

2.6.3.2 Site Inspection (1989)

An SI of MMR Priority I areas that included AOC FS-1 was conducted in 1989 [*Site Inspection Report Task 2-3A, Field Investigation Work Conducted Fall 1989* and *Site Inspection Report Task 2-3B, Field Investigation Work Conducted Spring-Summer 1988* (E. C. Jordan 1989 and 1990a)].

The SI program at AOC FS-1 included a soil gas survey and the installation of one soil boring (TB-3) and three monitoring wells (MW-1, MW-2, and MW-4). Thirty soil gas sampling points were located where fuel valve testing was suspected to have been conducted. Samples were analyzed for chlorinated hydrocarbons and fuel-related hydrocarbons (i.e., benzene, toluene, and xylene). Trace to low levels [i.e., generally less than 1 microgram per liter (μg/L)] of target compounds were detected in the soil gas probes located along the southern and western edges of the WAT. Maximum concentration of total target chlorinated hydrocarbons and fuel-related hydrocarbons recorded on-site were 2.2 μg/L and 1.6 μg/L, respectively. Overall, soil gas results suggested minimal near-surface residual contamination from previous fuel valve testing activities.

Soil and groundwater samples collected during the SI program were submitted for laboratory analysis. In monitoring well MW-1, low levels of xylene [i.e., 17 micrograms per kilogram (μg/kg)] were found in a soil sample collected near the water table. Fuel-related volatile organic compounds (VOCs) were not detected in soils collected from MW-2, TB-3, or MW-4. Lead and fuel-related compounds were found in groundwater samples collected from AOC FS-1. Lead was detected at 15 μg/L in MW-1, located adjacent to the northwestern edge of the WAT. Several fuel-related constituents were also detected in groundwater from MW-2 and MW-4, located downgradient from the WAT. Groundwater results from the SI are plotted on Figure 2-7. Additional explorations were recommended to delineate the extent of residual contamination in the vicinity, and downgradient, of the WAT.

2.6.3.3 Mashpee Groundwater Study, Task 5 (1990)

The Mashpee Groundwater Study, Task 5, was performed to determine the impact of MMR waste disposal activities on groundwater in the Mashpee Township adjacent to MMR [*Mashpee Groundwater Study, Task 5*, (E.C. Jordan 1990b)]. This program consisted of two stages. Stage I involved installation of 14 water table monitoring wells, completion of 3 deep borings to characterize the geologic conditions, establishment of survey markers, and collection of water level data from 35 existing observation wells. Water table wells were used to determine horizontal groundwater flow direction. Wells located crossgradient or downgradient of AOC FS-1 include WT-7, WT-8, WT-9, WT-10, WT-11, WT-12, WT-13, and WT-14 (Figure 2.6). Groundwater flow directions determined during this study are shown on Figure 3 of the Task 5 report (E. C. Jordan 1990b).

The second phase of the Mashpee Groundwater Study focused on installing and sampling multilevel well clusters for characterizing groundwater quality. Two of these well clusters, MW-516 and MW-517 were installed potentially downgradient of AOC FS-1. The MW-516 cluster contains 5 wells (screened depths below grade are shown in brackets [ ]): MW-516A [120–125 feet], MW-516B [100–105 feet], MW-516C [80–85 feet], and MW-516D [60–65 feet]. These wells were located next to the Phase I water table well, WT-11, which was redesignated as MW-516E [34–44 feet]. The MW-517 cluster include monitoring wells MW-517A [120–125 feet], MW-517B [100–105 feet], MW-517C [80–85 feet], MW-517D [60–65 feet], and MW-517E [43–48 feet].

During drilling activities for MW-516A, 20 soil samples were collected and screened in the field using a field gas chromatograph (GC). Two samples were submitted for analysis using Routine Analytical Services (RAS) Contract Laboratory Program (CLP) methods for Hazardous

Substance List (HSL) VOCs, semivolatile organic compounds (SVOCs), and inorganic metals. These samples were collected at 33–35 bgs and 103–105 feet bgs. Soil samples were collected during drilling for MW-517A at the 45–47 feet bgs and 125–127 feet bgs intervals and submitted for similar analyses.

Six rounds of groundwater samples were collected from each of the wells in the two well clusters. Round 1 sampling was conducted in May of 1987. These samples were submitted to a fixed-base laboratory for analysis of HSL VOCs and SVOCs and for elemental analysis by RAS CLP methods. Rounds 2, 3, and 4 were conducted in June, July, and August 1987, respectively; samples were submitted for RAS CLP analysis for VOCs only. Rounds 5 and 6 were conducted in December 1987 and February 1988, respectively. These samples were not analyzed by CLP methods. Analysis was specifically targeted toward trichloroethene, perchloroethene, toluene, and methyl ethyl ketone by a modified USEPA Method 8020.

2.6.3.4 Remedial Investigation

An RI was initiated at AOC FS-1 in 1990. *Remedial Investigation Report, AVGAS Fuel Valve Test Dump Site, FS-1 Study Area* (ABB-Environmental Services 1991), the RI for AOC FS-1, was partitioned into two operable units: (1) AOC FS-1A source area and (2) AOC FS-1B downgradient groundwater. At source area AOC FS-1A, seven monitoring wells (MW-6, MW-7, MW-8, MW-412, MW-413, MW-414, and MW-415) and two test borings (TB-5 and TB-411) were installed (Figure 2-6). Twelve subsurface soil samples from six of the borings were collected. Groundwater samples from all new and previously installed source area wells were also collected.

During the AOC FS-1B investigation, downgradient monitoring wells were installed using screened augers. A total of 53 groundwater screening samples were collected at various depths below grade and analyzed using a field GC. Analytical results were used to determine vertical screen placement in the permanent monitoring wells. The downgradient investigation involved the installation of two monitoring well fences and one touchpoint well. Monitoring well fence number 1 includes MW-4A, MW-9, MW-10A, MW-10B, MW-41, and MW-42. Existing well MW-4 was incorporated into fence number 1. These wells are located approximately 500 feet downgradient of the WAT. Installation of monitoring well fence number 2 includes MW-11, MW-12, MW-13, MW-112, and MW-121. Wells in this fence are located along the eastern MMR boundary (Figure 2-6). One touchpoint monitoring well, MW-14, was installed between the two well fences. Four water table monitoring wells were installed between AOC FS-1 and Route 130 in Mashpee. These wells are designated WT-15, WT-16, WT-17, and WT-18 (Figure 2-6). Groundwater samples were collected and analyzed from all downgradient monitoring wells except water table wells designated "WT." Hydraulic conductivity testing was performed in the following wells: MW-4, MW-4A, MW-10A, MW-10B, MW-11, MW-12, and MW-112.

In the Draft RI report, it was suggested that natural biodegradation of fuel-related compounds may explain the lack of contamination in downgradient monitoring wells. To evaluate this possibility, a biodegradation study was proposed; however, problems with this study prevented it from being performed.

2.6.3.5 Source Area EDB Study (1993)

A multisite EDB study, *Technical Memorandum, Ethylene Dibromide Study* (ABB-ES 1993), included collection of groundwater samples from AOC FS-1 source area wells. Groundwater samples from MW-2, MW-6, MW-7, MW-8, MW-11, RFW-11, and MW-42 were analyzed for EDB using EPA Method 504.

2.6.3.6 Geoprobe Investigation (1995)

Multidepth Geoprobe groundwater screening was conducted for the area downgradient of the AOC FS-1 source area to evaluate the presence or absence of fuel-related contamination (ASI 1995). Six Geoprobe fences were installed beginning at the AOC FS-1 source area and progressing downgradient to the cranberry bog adjacent to Johns Pond. Two additional Geoprobe borings were installed in the cranberry bog. Groundwater was collected at multiple depths in each boring beginning at the maximum depth achieved to the water table. These samples were analyzed in a field laboratory for benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbons (TPH). Based on the results from this investigation, screened auger borings were installed at three of the Geoprobe sites. During drilling, samples were submitted to a local laboratory for analysis of fuel-related compounds. Samples were also collected from monitoring wells MW-516B (100–105 feet bgs), MW-516C (80-85 feet bgs), MW-517B (100 - 105 feet bgs), and MW-517C (80 - 85 feet bgs). These samples were submitted to a local laboratory. Groundwater samples collected from monitoring wells MW-15, MW-16, and MW-17 were submitted for analysis of TPH and EDB using modified USEPA Method 8015 and Method 504.2 in accordance with USEPA CLP methods. Sample locations are show on Figure 2-6.

2.6.3.7 Supplemental Surface Soil Sampling (1995)

Supplemental surface soil sampling was conducted in September of 1995. The purpose of this sampling was to provide additional surface soil data for the risk assessment. Five surface soil samples were collected from the area surrounding the WAT and were submitted to a fixed-base laboratory for analysis of VOCs, SVOCs, pesticides and polychlorinated biphenyls (PCBs), and Target Analyte List (TAL) inorganics in accordance with USEPA CLP protocols. Sample locations are shown on Figure 2-6.

2.6.3.8 SERGOU Remedial Investigation

Work not performed specifically for AOC FS-1 but applicable to these discussions was conducted during the SERGOU RI. Monitoring wells MW-538A, MW-538B, MW-538C, MW-552A, MW-552B, MW-552C, MW-552D, MW-553A, MW-553D, MW-556A, MW-556B, MW-556C, and MW-557 were installed during the SERGOU RI and are located downgradient of AOC FS-1 (Figure 2.6). Samples collected from all of these wells were analyzed for EDB, VOCs, SVOCs, and inorganics in accordance with USEPA CLP protocols.

2.6.3.9 1997–1999 Supplemental Investigations

Additional downgradient investigations were initiated as the result of public comments concerning the AOC FS-1 RI and related reports. Varying groundwater flow directions have

been observed downgradient of AOC FS-1. The primary focus of pre1997 investigations was on groundwater that appeared to flow in a southerly direction. Other water level survey results indicated that groundwater might contain a more southeasterly flow component. Consequently, a water budget and particle tracking model were conducted for the AOC FS-1 area.

Results of the modeling indicated that water flowing along the more easterly flow lines would discharge to the cranberry bogs along the Quashnet as shown in Figure 2-8. No wells were positioned to intercept the easterly component predicted by the model. Because of the lack of wells intercepting the easterly component, the 1997–1998 Supplemental RI was initiated. In conjunction with the groundwater investigation, surface water and sediment sampling was also conducted at the Quashnet River cranberry bogs east of Johns Pond.

2.6.3.9.1 Groundwater

Groundwater investigations were conducted in two separate phases that moved in "fences" from downgradient areas near the Quashnet bogs upgradient toward the presumed AOC FS-1 source. The primary emphasis was on tracking the EDB plume identified in wells at the cranberry bog during the initial phase. The first phase occurred from August to October 1997 (13 locations, 16 wells, 2 piezometers); the second phase occurred in March and April 1998 (13 locations, 16 wells). A total of 26 screened auger borings were advanced to refusal or to a maximum depth of 250 feet. Screened auger groundwater samples were collected every 10 feet as the augers were advanced. Screened auger samples were submitted for rapid chemical analyses of selected VOCs (USEPA Method 502.2), EDB (USEPA Method 504), and metals (USEPA Method SW-486 Method 6010). Thirty-two permanent wells were installed based on the results of the screening analyses. Figure 2-9 shows wells installed during the 1997–1998 investigation.

2.6.3.9.2 Surface Water

Surface water sampling and laboratory analysis has occurred in three separate events at a number of locations in the eastern half of the Quashnet cranberry bogs. A total of 26 different locations were sampled by Jacobs Engineering. In August 1997, 22 locations were sampled; 10 locations were sampled in February 1998 (the bog was flooded during this event); 7 locations were sampled in May 1998. Laboratory analysis included EDB for each event and VOCs, SVOCs, and metals for the May 1998 event in accordance with USEPA CLP protocol. Locations and results for these events shown on Figures 2-10, 2-11, and 2-12.

2.6 3.9.3 Sediment

Sediment sampling and laboratory analysis was conducted by Jacobs Engineering in May 1998 at seven locations where surface water was also collected. Laboratory analysis of sediment samples included EDB, VOCs, SVOCs, and metals in accordance with USEPA CLP protocol. Locations and results for this event are shown on Figures 2-10, 2-11, and 2-12.

2.6.3.10 Confirmation Sampling

Selected source area wells were resampled in April 1999 to evaluate potential false positive detections of methylene chloride and provide additional data on lead. Source area wells which were resampled include MW002, MW004, MW007, MW008, MW009, MW010B, MW0412,

MW013, and MW0415. Well locations are shown on Figure 2-6. Groundwater from the wells was analyzed for VOCs, EDB, SVOCs, and metals.

2.6.4 Investigation Findings

2.6.4.1 Surface Soil

Surface soil samples were collected during the Task 2-3B Site Investigation performed in 1988 and in a supplemental sampling event conducted in September 1995. The purpose of the supplemental sampling event was to provide additional surface soil data for the risk. During the Task 2-3B investigation, one surface soil sample and a duplicate were collected at TB-4 (MW-4). These samples were submitted to a fixed-based laboratory for analysis of SVOCs, pesticides/PCBs, and inorganics. In September 1995, five surface soil samples and a duplicate were collected adjacent to the WAT and submitted for analysis at a fixed-based laboratory for VOCs, SVOCs, pesticides/PCBs, and inorganics. Figure 2-13 depicts surface soil sample locations and associated analytical results. A summary of laboratory detections is presented in Table 2.5-2.

Surface soil samples did not contain significant quantities of regulated compounds. Minimal levels of SVOCs and inorganics were quantified. Aluminum, barium, chromium, and manganese were detected at concentrations slightly above established arithmetic mean background concentrations. Concentrations of lead were detected from 1.3 to 114 mg/kg.

2.6.4.2 Subsurface Soils

At the AOC FS-1 source area, subsurface soil samples were collected during the Phase II, Stage I study (Weston 1985), SI (E. C. Jordan 1989a, 1990a), and RI (ABB-ES 1991). During the Phase II, Stage I investigation, soil samples were collected from four test pits excavated adjacent to the WAT. Test pits were also excavated in the swale located southwest of the WAT; however, samples were not obtained. During the Task 2-3A investigation of 1987, 10 subsurface soil samples were collected and submitted to a fixed-based laboratory for VOC, SVOC, pesticide/PCB, and inorganic analyses. During the Task 2-3B field effort, one soil sample was collected during drilling for MW-4 and submitted for laboratory analysis of SVOCs and inorganics. During RI field activities, 12 subsurface soil samples were collected from TB-5, MW-6, MW-7, and MW-8 adjacent to the WAT and from TB-411 and MW-413 adjacent to the EAT. Table 2.5-2 presents analytical results for soil.

Eight samples were collected from the water table/vadose zone interface. VOCs were not detected. The only SVOC detected was bis(2-ethylhexyl) phthalate, which was detected at a concentration of 2300 μg/kg in a sample from MW-8 adjacent to the WAT.

Lead was the only metal detected in subsurface soil samples. The maximum concentration of lead detected was 4.8 mg/kg in MW-7.

Methylene chloride was detected in samples collected above and below the water table/vadose zone interface. A maximum concentration of 140,000 μg/kg was detected in a sample collected 65 feet bgs at MW-7 adjacent to the WAT. Based on the following observations, methylene chloride is most likely a laboratory contaminant.

- There is no historical evidence of other chlorinated solvents (trichloroethene, tetrachloroethene, cis- or trans-1,2-dichloroethene, 1,1-dichloroethene, etc.) used at this fuel spill site. If methylene chloride was a site contaminant, one would expect to find other halogenated hydrocarbons at elevated levels.

- Following good laboratory practice, volatile samples determined to have high concentrations of hydrocarbons were screened using a GC before analysis. Because of the elevated hydrocarbons, a medium-level extraction that elevated the Sample Quantitation Limit (SQL) was performed. It is noted that the GC used for screening samples is often located in the organic extraction laboratory, where methylene chloride is the primary solvent. If volatile soil samples were opened in the extraction laboratory, they very easily could have been contaminated through ambient methylene chloride. If trace methylene chloride were present, the concentration would be amplified when multiplied by a dilution factor.

- This phenomenon was also noted in the same sample delivery group for samples collected from CS-10. These samples were screened and analyzed with samples from AOC FS-1 on the same day.

- When comparing field duplicate precision, sample 03BS010086xxx had no detectable methylene chloride when the duplicate sample 03BS010086xxD contained 110,000 μg/kg. If methylene chloride is a site contaminant, it should also be present in both samples.

The single detection of bis(2-ethylhexyl) phthalate (BEHP) suggests that the detection of that compound is anomalous. BEHP is common plasticizer found in latex gloves.

2.6.4.3 Groundwater

2.6.4.3.1 Pre 1997–1999 Data

A total of 63 monitoring wells were installed at the source area and downgradient of the source area. Monitoring wells were installed and groundwater samples collected and analyzed during the Phase II, Stage I work performed by Weston, SI activities performed by Jordan, RI activities performed by ABB-ES, and additional investigation activities performed by ASI. Monitoring well RFW-11 was the only monitoring well installed during the Phase II, Stage I field activities; monitoring wells MW-1 and MW-2 were installed during the Task 2-3A investigation at AOC FS-1. MW-4 was the only monitoring well installed during the Task 2-3B investigation. During the RI field activities, 7 monitoring wells (MW-6, MW-7, MW-8, MW-412, MW-413, MW-414, and MW-415) were installed at the source area; 12 wells (MW-4A, MW-9, MW-10A, MW-10B, MW-41, MW-42, MW-11, MW-12, MW-13, MW-112, MW-121, and MW-14) were installed downgradient of the source area.

The Mashpee Groundwater Study placed wells downgradient of the AOC FS-1 source area. Analytical results associated with samples collected from well clusters MW-516A-E and MW-517A-E will be discussed in this section. Although six sampling events were conducted at each well cluster, analytical results from sampling events conducted in December 1987 and February 1988 will not be discussed further because samples were not analyzed in accordance with CLP methods. Water table wells WT-7 through WT-14 were installed during the Mashpee

Groundwater Study; however, sampling was never conducted in these wells. Monitoring wells MW-538A, B, and C; MW-552A, B, C, and D; MW-553A and D; MW-556A, B, and C; MW-557; and MW-568 were installed during the SERGOU investigation activities.

ASI conducted additional groundwater investigation activities downgradient of the AOC FS-1 source area as a result of data gaps identified by USEPA and MADEP during review of the 1991 Draft RI report. During the Task 1 investigation of 1994, 27 Geoprobe borings and 2 permanent Geoprobe microwells (GMW-01 and GMW-02) were completed. Samples collected from the borings and Permascreen wells were not analyzed in accordance with CLP methods; therefore, analytical results will not be discussed in this section. During the Task 2 investigation, monitoring wells MW-15, MW-16, and MW-17 were installed. Samples collected from these wells were analyzed in accordance with CLP methods.

A total of 57 samples from source area and downgradient wells were analyzed for VOCs. Positive results from some of these samples are presented in Figures 2-14 through 2-18. The majority of the concentrations detected were below the promulgated and/or proposed state and federal MCLs. Only methylene chloride and toluene were detected above their respective MCLs. Methylene chloride concentrations ranged from 1 to 25 μg/L, and toluene concentrations ranged from 0.3 to 2,500 μg/L. The MCL for methylene chloride is 5 μg/L; the MCL for toluene is 1,000 μg/L. Concentrations that exceeded published MCLs were detected in MW-2 and MW-7, each a source area well. Based on information discussed in Section 4.1 of the RI, methylene chloride is most likely a laboratory contaminant.

2-Butanone was detected at concentrations up to 120,000 μg/L. 2-Butanone is not a site-specific contaminant; however, it most likely was introduced locally within certain wells as a result of chemicals used during equipment decontamination activities. The presence of 2-butanone in groundwater samples is attributable to the use and insufficient rinsing of a small volume of commercial-grade methyl hydrate that was used as a decontamination fluid for groundwater sampling equipment. During RI field activities, impure methyl hydrate contained a small percentage of 2-butanone by volume (ABB-ES 1992).

A total of 55 samples from source area and downgradient wells were analyzed for SVOCs. Positive results from some of these samples are presented in Figures 2-14 through 2-18. Only benzyl alcohol, 2-methylphenol, and bis(2-ethylhexyl)phthalate were detected. Concentrations were less than 26 μg/L, a value approximately two times greater than the reported CRQL.

A total of six samples from source area and downgradient wells were analyzed for pesticides/PCBs. 4,4'-DDT was detected in MW-15; however, the concentration was well below the reported CRQL. No other pesticides or PCBs were detected.

A total of 57 samples from source area and downgradient wells were analyzed for inorganics. Positive results from some of these samples are presented in Figures 2-14 through 2-18. Arsenic, calcium, iron, lead, manganese, sodium, aluminum, chromium, sodium, zinc, and cyanide were detected at concentrations greater than the reported CRQLs; however, only lead, manganese, iron, thallium, and aluminum were detected at concentrations greater than their respective MCLs. Lead was detected at concentrations ranging from 2 to 159 μg/L. The highest concentrations of lead were detected in monitoring well MW-2, which is located in the source area. The highest concentrations of manganese were detected in wells located in the source area and immediately

downgradient of the source area. Concentrations greater than SMCLs were also detected in monitoring wells located in the vicinity of Moody Pond, Johns Pond, and the cranberry bog. Concentrations of manganese detected in samples collected from MW-516 and MW-517 were 35 μg/L and 56 μg/L, respectively. These monitoring wells are located between the source area and downgradient surface water bodies. Iron was detected at concentrations that ranged from 323 to 22,100 μg/L. Similar to manganese, the highest concentrations of iron were detected in wells located in the source area, immediately downgradient of the source area, and near downgradient surface water bodies.

Aluminum was detected at concentrations that ranged from 57.1 to 4240 μg/L. The highest concentrations of aluminum also were detected in wells located in the source area and in the vicinity of downgradient surface water bodies. Although thallium was detected below the reported CRQL, detected concentrations slightly exceeded the MCL. Thallium was detected at concentrations ranging from 2.1 to 3.1 μg/L.

Traces of fuel-related contamination well below MCLs were detected along the track of a possible plume emanating from the source area. During additional investigation activities conducted by ASI in 1994–1995, sampling from temporary Geoprobe borings located along the track of a possible plume indicated slight detections of fuel-related contamination, mainly toluene, and evidence of low dissolved oxygen (DO) concentrations within the estimated plume location. This suggests that localized aerobic biodegradation of low levels of fuel-related contamination downgradient of the source area is currently occurring, or DO levels have not rebounded to background levels. Concentrations of fuel-related compounds detected downgradient of the source area are well below MCLs.

Low DO concentrations detected in the source area during the additional investigation activities suggest continuing aerobic biodegradation in the source area. Detected concentrations of toluene in the source area were less than three times the MCL of 1,000 μg/L. Minimal concentrations of fuel-related contamination detected in the groundwater beneath the source area and downgradient of the source area support the low concentrations of similar compounds that were detected in the source area surface and subsurface soils.

No EDB was quantified in source area water table wells during the EDB study (ABB-ES 1993). A summary of analytical detections is presented in Table 2.5-3.

2.6.4.3.2 1997–1999 Data

The 1997–1999 groundwater investigation was focused primarily toward determining the horizontal and vertical extent of the EDB plume that is upwelling in the Quashnet cranberry bogs east of Johns Pond. A series of well fences composed of three to seven wells each were used to track the EDB contamination upgradient along the groundwater flow path from the bogs toward the presumed AOC FS-1 source. Positive detections of VOCs and inorganic compounds from laboratory analysis of groundwater from the 32 monitoring wells installed in these fences are presented in Figures 2-19 and 2-10 which illustrate the results of screened auger sampling and local laboratory analysis and of laboratory analysis from well sampling. The results for EDB are presented in each section along with sampling intervals, topographical, and hydrogeological data. A plan view of the approximate width and extent of the EDB plume is shown in Figures 2-19 and 2-20, Appendix A, 1999 RI.

The groundwater data indicate that EDB is the only COC in downgradient groundwater. EDB is the only VOC to exceed MCLs and to consistently exceed the 0.02 μg/L MADEP MCL at many locations and depths both in completed wells and in auger screening samples. EDB plume concentrations detected in wells range from minimum values near the 0.01 μg/L detection limit to a maximum of 7.7 μg/L in MW-132B. EDB plume concentrations detected in screened auger samples range from minimum values near 0.01 μg/L to a maximum of 15.5 at the MW-132 location at a depth of 75 to 80 feet bgs. EDB concentrations from drive point groundwater samples from the Quashnet River bogs range from below the detection limit to 2.93 μg/L.

Based on source area groundwater sampling in April 1999, it was determined that source area groundwater COCs are toluene, thallium and lead.

All other inorganic compounds and VOCs occur well below their MCLs. The occurrence of trace to low concentrations of xylenes at many locations in the 1998 wells and not in the 1997 wells suggests the compound may be related to laboratory or field contamination. However these and other trace and low levels of VOCs detected in some wells are far below MCLs. Similarly, some inorganic compounds such as iron and manganese exceed MCLs. A summary of laboratory detections is presented in Tables 2.5-4 and 2.5-5.

The combined screening and CLP data indicate that the EDB occurs in a fairly coherent plume from its upwelling at the cranberry bogs upgradient to just beyond the 600 series fence. North of the 600 series fence, the plume appears to end. Superposition of the groundwater flow paths shown in Figures 2.4 and 2.5 with the known extent of the EDB plume up to the 600 series fence shows that if the plume followed the flow path further upgradient, it should have been detected by screening and monitoring well results at MW-653, MW-701, MW-702, and MW-703. The listed wells are positioned appropriately to intercept contamination. The longitudinal extent of the plume is bounded by the 650 and 700 series fences to the north and by the cranberry bog to the south. The lateral extent of the plume is bounded by wing wells in all fences. This extent is illustrated in Figures 2-19 and 2-10.

Additional groundwater samples were collected from drive points in the Quashnet River cranberry bogs by Jacobs Engineering. EDB was quantified in 12 of 24 groundwater samples collected from drive points in the bogs. The maximum detection of EDB was 5.45 μg/L (5 feet bgs) in drivepoint 36DP0022.

2.6.4.4 Surface Water

The results of surface water sampling for EDB at 26 locations in the Quashnet cranberry bogs are presented in Figure 2-10 and 2-11. Results for inorganic compounds are illustrated in Figure 2-12. Additional information is presented on Figure 4-18A contained in the FS-1 RI. Analyses were conducted in August 1997 and February 1998 for EDB only. Analysis in May 1998 included VOCs and SVOCs in addition to EDB. With the exception of EDB and chloroform, which may be attributable to laboratory contamination, no VOCs or SVOCs were detected. Positive detections of EDB in surface water ranged up to a maximum concentration of 1.43 μg/L at 36SW0017. The extent of the zone of upwelling of EDB contamination in the cranberry bogs is difficult to delineate because of the effect of surface water movement across the bog, which acts to commingle zones where EDB may upwell with areas of clean, active surface water movement. Upstream nondetect locations 36SW004 and 36SW0015, which were sampled in

August 1997, suggest that most of the EDB-contaminated surface water is entering the bog on the east side of the Quashnet River and its unnamed north-south tributary that enters the bog on the north side. Note that the February 1998 surface water sampling event occurred when the bogs where flooded. The nondetects at locations 36SW0026, 36SW0027, 36SW0028, and 36SW0029, therefore, may not be a representative indication of whether EDB is upwelling into this portion of the cranberry bogs. As with groundwater, the concentrations of inorganic compounds in surface water samples do not exceed MCLs, and exceedances of SMCLs apply to drinking water aesthetics. A summary of laboratory detections is presented in Table 2.5-6.

2.6.4.5 Sediment

The results of sediment sampling for EDB and inorganic compounds in the Quashnet cranberry bogs are presented in Figure 2-11. Sediment samples were analyzed for EDB during May 1998 at seven locations where surface water samples have been previously acquired (36SE002, 36SE007, 36SE0012, 36SE0016, 36SE0017, 36SE0018, and 36SE0020). EDB was detected at only one location, 36SE0018, at a concentration of 0.075 μg/L. A summary of laboratory detections is presented in Table 2.5-7.

2.6.5 Contamination Characteristics

The source area groundwater contamination is limited to an area within 1,000 feet of the WAT and EAT. All the COCs in the source area are relatively immobile as indicated by the lack of movement of those COCs. Site activities that may have caused the contamination ceased 30 years ago, and the COCs associated with the source area are still near the source area.

The downgradient area of groundwater contamination from the most northern detection to the discharge at the cranberry bogs is approximately 6,950 feet long, 600 to 1,200 feet wide, and 50 to 100 feet thick. The estimated volume of contaminated water contained in that plume is 121 million gallons. EDB has been detected in the Quashnet River cranberry bogs and the Quashnet River. The most downstream detection of EDB in the Quashnet River was approximately 2 miles from the Quashnet River cranberry bogs.

EDB is the only downgradient groundwater and surface water COC. Source area groundwater COCs identified for FS-1 are toluene, lead, and thallium. No COCs for soils or sediments were identified.

EDB may cause adverse noncarcinogenic and/or carcinogenic effects. Accidental ingestion and chronic inhalation or dermal exposures may result in neurological damage as well as moderate-to-severe liver and kidney damage. EDB is classified as a probable human carcinogen (Class B2) based on increased incidences of a variety of tumors in rats following oral and inhalation administration. EDB is soluble in water, poorly adsorbed to soils, and is not readily degraded. Consequently, it is highly mobile and persistent in groundwater systems. Because of the potential health impacts and high mobility in groundwater, EDB is a principal threat at FS-1.

Toluene may cause adverse noncarcinogenic effects. Accidental ingestion and chronic inhalation may cause neurological, kidney, liver, or reproductive damage. Toluene is not classifiable as to human carcinogenicity (Class D). Toluene is slightly soluble in water and readily biodegraded.

Consequently, toluene is not highly mobile in groundwater. Because of the potential health impacts and low mobility in groundwater, toluene is a low-level threat at FS-1.

Lead may cause adverse noncarcinogenic and/or carcinogenic effects. It can accumulate in bones and teeth of children and may be released to the bloodstream resulting in neurological damage in adulthood. It may also cause hypertension, immune and nervous system disorders, kidney failure, and damage to human reproductive systems. Lead is classified as a probable human carcinogen (Class B2) based on the development of kidney and central nervous system cancer in rats following laboratory administration. Lead is not soluble in water, but may be introduced to groundwater from fuels. Lead partitions readily to soils and may precipitate out of aqueous solutions. Consequently, it is not mobile or persistent in groundwater systems. Because of the potential health impacts and low mobility, lead is a low level-threat at FS-1.

Thallium may cause adverse noncarcinogenic effects. Accidental ingestion may cause neurological, kidney, liver, or heart damage. Thallium is not classifiable as to human carcinogenicity (Class D). Thallium is not soluble in water, but it may be released into groundwater by reduction of naturally occurring minerals. Thallium is found only in the immediate vicinity of the FS-1 source area, and because of this limited distribution, the empirical mobility is low. Because of the potential health impacts and low mobility, thallium is a low level threat at FS-1.

2.6.6 Contaminant Location and Migration

The AOCs associated with FS-1 as defined by the presence of COCs in groundwater and surface water are located in two distinct areas: the source area and the downgradient detached plume and upwelling area. The source area is characterized by the presence of the COCs, toluene, lead, and thallium. The downgradient detached plume and upwelling area are characterized by the presence of the COC EDB. EDB is not present in the source area, nor are toluene, lead, or thallium present in the downgradient detached plume and upwelling areas.

The source area groundwater contamination is limited to an area within 1,000 feet of the WAT and EAT. Site activities that may have caused the contamination ceased 30 years ago, and the COCs associated with the source area are still near the source area.

The downgradient area of groundwater contamination from the most northern detection to the discharge at the cranberry bogs is approximately 6,950 feet long, 600 to 1,200 feet wide, and 50 to 100 feet thick. The estimated volume of contaminated water contained in that plume is 121 million gallons. EDB has been detected in the Quashnet River cranberry bogs and the Quashnet River. The most downstream detection of EDB in the Quashnet River was approximately 2 miles from the Quashnet River cranberry bogs.

2.6.7 Current and Potential Future Site Resource Uses

Current land use of the source area is military use. The source area is within the flight area and is adjacent to a taxiway. Future source area use may be military or private. In either case, it is probable that source area will be used for aircraft.

Land use downgradient of the source area is mixed. A single dwelling and several lots are located on land above the EDB plume at the northern end of the plume. The area immediately downgradient of the area is under a 100-year lease to the USAF as the approach right-of-way to the East-West runway. The land downgradient of the lease and above the EDB is parceled into small woodlots. The lots are small and ownership is questionable. Many of the owners of record are deceased. Regardless of the ownership, the lots are small and may be too small for development. If this situation changes, it is possible that homes could be constructed in this area. The area from the woodlots to the Quashnet River cranberry bogs is owned by the Mashpee Conservation Commission. The commission has no current plans to allow development. The cranberry bogs are owned by the Mashpee Conservation Commission and leased for commercial cranberry production.

Land adjacent to the plume is either military property or private. The closest housing other than the home at the north end of the plume is 1,200 feet east of the eastern edge of the plume.

Regardless of the potential use of the land in the future, potential residents will not be impacted by the plume. The only potential impact of the plume is if residents consume contaminated water from private wells. The Mashpee Water District has issued a moratorium on installation of all wells in areas of groundwater contamination. This moratorium will prevent potential future residents from installing wells and consuming potentially contaminated groundwater.

The groundwater is a sole-source aquifer. It is probable that water in this area will be used for human consumption in the future. The Town of Mashpee has proposed installation of a public water supply well slightly east of the eastern edge of the plume. That well is referred to as proposed Mashpee public supply well P-11. The proposed location of the well is shown on Figure 2.2.

Surface water in the Quashnet River and Quashnet River cranberry bogs support recreation, farming, and fisheries. It is anticipated that such use will continue.

2.7 SUMMARY OF SITE RISKS

The risk assessment process for AOC FS-1 consists of a Preliminary Risk Assessment (PRA), which was conducted as part of the May 1999 RI. The PRA fulfills the CERCLA requirement that a baseline risk assessment be performed to establish whether remediation is necessary to protect human health and the environment.

The objective of the PRA was to provide an estimate of the baseline risks (i.e., risks in the absence of remediation—the No Action cleanup alternative) associated with soil, sediment, groundwater, and surface water at AOC FS-1. Baseline risks are estimated to determine whether a current or potential threat to human health or the environment exists that warrants remedial action (USEPA 1990). For risk assessment purposes, two subareas area were considered (1) the AOC FS-1 source area and (EAT and WAT) and (2) the groundwater upwelling area. Contaminated media include soil at AOC FS-1 source area and groundwater, sediment, and surface water at the groundwater plume upwelling area. The PRA was conducted in accordance with federal CERCLA human health and ecological risk assessment guidance, requirements set forth by the state of Massachusetts, and site-specific guidance.

Actual or threatened releases of hazardous substances from AOC FS-1, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

2.7.1 Human Health Preliminary Risk Assessment

For AOC FS-1, the human health PRA consisted of five primary components: identification of COCs, exposure assessment, toxicity assessment, risk characterization, and a summary of uncertainties.

2.7.1.1 Identification of Contaminants of Concern

The sources of sampling data used to conduct the PRA are listed in Table 2.6.1. The validated site characterization data were compared to background or reference concentrations, ARARs, and toxicity-based screening concentrations to determine which chemicals were carry through to the next step in the risk assessment. Selection of contaminants of potential concern (COPCs) to be retained in the risk assessment are presented in Table 2.6-2 through 2.6-5. A summary of constituents used in the screening for each media (including range of detection concentrations) is presented in Tables 2.6-6 through 2.6-9.

For COPCs retained through the screening process, a representative exposure point concentration (EPC) was computed. For soil and groundwater, the representative concentrations for the reasonable maximum exposure (RME) condition and the central tendency (CT) exposure condition are the maximum and arithmetic mean concentrations, respectively. For surface water and sediment, the representative concentrations for both RME and CT conditions is the 95% upper confidence limit (UCL) of the mean unless the 95% UCL of the mean exceeds the maximum concentration. If this is the case, then the RME EPC is the maximum concentration and the CT EPC is the arithmetic mean concentration. The 95% UCL of the mean is calculated on the arithmetic mean of the concentrations with or without log transformation depending on the underlying normal or lognormal distribution of the data. If the data are not distributed either normally or log normally, the EPCs for the RME and CT conditions are the maximum and arithmetic mean concentration, respectively. The 95% UCL is defined as "a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time" (USEPA 1992a). The COPCs are summarized in the following table and organized by chemical class and environmental media.

2.7.1.2 Exposure Assessment

The exposure assessment identified potential exposure pathways, developed exposure scenarios based on current and future land use, and quantified exposure using standard USEPA risk assessment methods. The current and potential future exposure pathways associated with AOC FS-1 are summarized in the Human Health Conceptual Exposure Model (Graphical Depiction 2-1). The exposure pathways and the parameters used to calculate intakes are presented in Tables 2.6-10 through 2.6-20.

Chemicals of Potential Concern for Human Health

Constituent	AOC Soil	Groundwater Plume	Surface Water	Sediment
Volatile Organics				
1,2-Dichloroethane		X		
4-Methyl-2-pentanone		X		
Chloroform		X	X	
Chloromethane		X		
1,2-Dibromoethane (EDB)		X	X	
Tetrachloroethene		X		
Toluene		X		
Pesticides/PCBs				
Alpha chlordane	X			
Endrin Ketone	X			
Inorganics				
Aluminum		X	X	
Arsenic		X		
Boron			X	
Cobalt		X		
Copper		X	X	
Iron		X	X	X
Lead		X	X	X
Manganese		X	X	
Silver		X		
Thallium		X		

The AOC area is within the flight line and designated as an industrial area; therefore, there are no potentially exposed residential populations at the site. The aircraft turnarounds are currently unused. It is possible that utility workers may be exposed at this site should excavation activities be required. For current land use, the utility worker exposure scenario is recommended for soils based on the AOC location within the flight line area (HAZWRAP 1994). The current utility worker is assumed to be present at the AOC for 42 days per year, and exposures to surface and subsurface soils (0 to 10 ft bgs) would occur during maintenance or alteration of existing facilities within the AOC. The exposure routes evaluated for the utility worker are ingestion, inhalation, and dermal absorption.

The downgradient detached groundwater plume and upwelling area consists of the Quashnet River Bogs and the Quashnet River system. The Quashnet River bog is an active cranberry bog. It is possible that cranberry workers may be exposed to contamination in the surface water and

sediments in the bog. The groundwater plume and upwelling area is not a residential area, nor is it heavily trafficked with recreational users; however, recreational activities do occur in this area. Fishing is permissible along the Quashnet, although there is a catch-and-release policy for parts of the system. It is possible that recreational youth and fisherman may be exposed to contamination in the surface water and sediment within the groundwater plume and upwelling area.

Four types of receptor populations are identified for the groundwater plume and upwelling area based on potential for exposure to groundwater, surface water, and sediment. These populations include:

- residents (adults) who use groundwater for household use,
- recreational youth who may play in the shallow Quashnet River and cranberry bogs, and
- recreational adults who may spend time wading in the Quashnet River and cranberry bogs during recreational pursuits and may ingest fish taken from the river and cranberry workers (adult) who work in the Quashnet River cranberry bogs.

Based on the identified current and potential future exposure pathways, the following exposure scenarios were evaluated in the exposure assessment.

- Utility Worker—ingestion, inhalation, and dermal absorption pathways for soil.
- Resident Adult—ingestion, inhalation, and dermal absorption pathways for groundwater.
- Recreational Youth—ingestion, inhalation, and dermal absorption pathways for surface water and sediment.
- Recreational Adult—ingestion, inhalation, and dermal absorption pathways for surface water sediment and ingestion of fish.

2.7.1.3 Toxicity Assessment

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

RfDs have been developed by USEPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have

been applied (e.g., to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur. Tables 2.6-21a through 2.6-22c present CSFs and RfDs used in the PRA at AOC FS-1.

2.7.1.4 Risk Characterization

The risk characterization combined dose estimates from the exposure assessment and toxicity information from the toxicity assessment to estimate chemical-specific and total pathway ELCRs (carcinogenic risk), noncarcinogenic Hazard Quotients (HQs), and total pathway Hazard Indices (HIs).

ELCRs are determined by multiplying the intake level with the cancer potency factor. These risks are probabilities that are generally expressed in scientific notation (e.g., 1×10^{-6} or 1E-06). An excess lifetime cancer risk of 1×10^{-6} indicates that as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site.

Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the HQ (the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's RfD). By adding the HQs for all contaminants within a medium or across all media to which a given population may reasonably be exposed, the HI can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

Results of the PRA indicated carcinogenic and noncarcinogenic risks associated with all areas, environmental media, and receptors evaluated in the RI are shown in Tables 2.6-23a through 2.6-26b. For groundwater for residential exposures, the results exceed both USEPA and MADEP risk management guidelines (carcinogenic risks within the USEPA target risk range of 10^{-4} to 10^{-6} and MADEP values of $1 \times 10^{-5}$and HQ/HI of less than 1.0) (Table 2.6-27). For all other receptors and associated media, the results indicate no exceedance of USEPA risk management guidelines. However, the cumulative risk for the recreational adult exceeded the Massachusetts Contingency Plan (MCP) carcinogenic risk management guideline of 1×10^{-5} (MCP 1994). The scenarios that exceeded the risk management guidelines are summarized as follows.

Current and Future Resident The RME risks to the hypothetical current and future resident using contaminated groundwater for household use are an ELCR of 2×10^{-2} and a total HI of 20. The RME cancer and noncancer risks are each higher than the USEPA and MADEP risk management criteria. Approximately 98% of the cancer risk is associated with EDB. The highest organ/tissue-specific HI was for sperm (13.9) (contributed by EDB) that accounted for 60% of the total HI. Other organ/tissue-specific HIs exceeding 1 were 1.4 for chloroform and 2.3 for toluene.

The CT risks to hypothetical current and future residents using contaminated groundwater for household use are an ELCR of 6×10^{-4} and a total HI of 3. The CT ELCR and HI are higher than the USEPA and MADEP risk management criteria. The CT cancer risk is due 98% to EDB.

The highest organ/tissue-specific HI of 2.1 for sperm was a result of EDB and accounted for 76% of the total HI. No other COPCs exceed 1 for the CT. No risks could be calculated for thallium in groundwater because there are no toxicity values for soluble salts of thallium. Thallium levels at one location in the plume exceed the MCL.

These risks were calculated for a hypothetical current or future resident in the groundwater plume and upwelling area exposed to current maximum or average concentrations of COPCs in groundwater. There is no known use of contaminated groundwater for residential purposes in this area; therefore, there is no known risk. However, there could be unacceptable risks to human health under current land use if residents use the groundwater that contains COPC concentrations that are equivalent to the maximum or average concentrations detected in the groundwater plume and upwelling area. The concentrations of COPCs were much lower than these concentrations in most of the monitoring wells within this area.

Current or Future Recreation Wader: Adult The RME risks to current or future adult wader (including fish ingestion) are an ELCR of 6×10^{-5} and a total HI of 0.2. No actual fish samples were collected and analyzed in time for the human health risk assessment. A model was used to estimate the amount of EDB in fish tissues given the EDB concentrations in surface water and bioaccumulation factors. The RME cancer risk is within the USEPA risk management criteria range and greater than the MADEP risk management criteria. The RME noncancer risk is below the USEPA and MADEP risk management criteria. One hundred percent of the cancer risk is associated with EDB in surface water and fish.

The RME risks to the current or future recreational fish ingestion exposure route for the Quashnet River are an ELCR of 6×10^{-5} and a total HI of 0.2. The RME cancer risk is within the USEPA risk management criteria range and greater than the MADEP risk management criteria. The RME noncancer risk is below the USEPA and MADEP risk management criteria. About 100% of the cancer risk is associated with EDB in surface water and fish. The bioaccumulation factor (BAF) used for EDB of 10 was obtained from USEPA Region I.

Risks Associated with Blood Lead Because there is no threshold for exposure to lead in the environment, virtually all the regulatory values involve risk management decisions that balance the potential health impacts with technical feasibility and cost consideration. The use of traditional methods for developing strictly health-based criteria or assessing risk is not currently an option in the case of lead for two reasons:

- there is no NOAEL used to derive an RfD or RfC, as is the usual basis for regulating chemicals with noncarcinogenic effects; and
- there is no CSF that is the usual basis for regulating chemicals considered to be carcinogenic.

In the absence of these values, USEPA has recommended that lead exposures at Superfund sites be evaluated using the Integrated Uptake/Biokinetic (IEUBK) model developed by USEPA's Air Quality Management Division (USEPA 1994) and by comparing the sample concentrations to the regulatory standards. The IEUBK model is a site-specific multimedia exposure method used for estimating the blood lead levels and the percentage of the child population with blood levels above the critical value (10 μg/dL). MADEP's Office of Research and Standards has determined that model outputs estimating 5% of the child population or greater above the 10 μg/dL cutoff value are unacceptable.

Lead concentrations found in surface soil and subsurface soil samples at AOC FS-1 and in groundwater, surface water, and sediment from the downgradient detached plume and upwelling area were compared to the USEPA standards for drinking water of 15 parts per billion (ppb), and the MADEP standard for soil of 300 parts per million (ppm). Both surface soil and subsurface soil lead concentrations were below the MADEP standards. The mean lead concentration found in groundwater (8.52 ppb) was below the drinking water standard; the maximum concentration (159.0 ppb) exceeded the USEPA standard of 15 ppb. The surface water and sediment lead maximum concentrations (2.02 ppb and 8.9 ppm, respectively) were below the USEPA standards.

The IEUBK model was run using the mean and maximum lead concentrations found in groundwater within the AOC FS-1 downgradient detached plume and upwelling area. The age range of children 0 through 6 years was used. Table 2.6-28 shows the results of the IEUBK model used to estimate blood lead levels in children. Default values were used for all other parameters (air, soil, and diet). Use of the mean lead concentration of 8.52 g/L resulted in an estimation that less than 5% of the children 0 through 6 years of age would have blood levels above 10 μg/dL. The 159-g/L maximum concentration resulted in an estimation that greater than 5% of the children would have a blood lead level above 10 μg/dL. This approach is based on developmental effects and therefore is not applicable to adult exposure.

2.7.1.5 Evaluation of Uncertainties

Uncertainties in Exposure Assessment Uncertainty in the exposure assessment is a function of the completeness of site data, assumptions that simplify and approximate actual current or future site conditions, and professional judgement used in developing and evaluating various parameters.

Exposure scenarios and health-protective exposure factors presented in this risk assessment are generally conservative and overestimate rather than underestimate exposure. Another assumption made in the exposure assessment is that COCs are uniformly distributed over the defined area, thus resulting in a uniform exposure level. Chemical analytical data were obtained from a directed sampling program. Sampling zones found to be free of contamination received less investigation. This type of sampling scheme tends to overestimate the overall chemical concentration at a site and, therefore, the resultant exposure and risk values. The BAF for EDB of 10 was used to estimate the EDB concentration in fish. The BAF could have a range as low as 1.0. The use of the USEPA-approved BAF of 10 could overestimate risks from fish ingestion.

Finally, the assumption is made that human exposure remains constant over the lifetime of an individual. In fact, lifestyle changes due to age and actual residence time will alter the projected exposure duration. Movement of individuals in and out of the potentially exposed community also affects exposure duration.

Factors Uncertainties in Toxicity Assessment Slopes developed by USEPA are generally conservative and represent the upper-bound limit (i.e., upper 95th percent confidence limit) of the probability of a cancer response. Thus, the actual carcinogenic risk as a result of exposure to selected chemicals is likely to be lower than the estimated risk. Furthermore, there is uncertainty in the carcinogenic potential of chemicals classified as B1, B2, or C carcinogens. Only chemicals classified as A carcinogens are proven human carcinogens, but risks were calculated

identically for all chemicals classified as A, B1, B2, or C carcinogens. Thus, it is possible for carcinogenic risk to be reported for chemicals that may not induce carcinogenesis.

RfDs and RfCs developed by the USEPA are generally considered to have uncertainty spanning an order of magnitude or more (a range of 10). Consequently, total HIs may be skewed by an order of magnitude or more. USEPA reports a "level of confidence" for each RfD and RfC. Low confidence suggests a high degree of uncertainty in the accuracy of the toxicity value and indicates that the value may change in the future as additional toxicity data become available. Conversely, high confidence by USEPA in a RfD or RfC indicates low uncertainty in the accuracy of the toxicity value.

There are numerous uncertainties concerning the adjustment of oral RfDs and slope factors to dermal RfDs and slope factors, based on intestinal absorption. Compared to oral exposures, dermal exposure routes could result in different patterns of distribution, metabolism, and excretion. Because these potential differences would be chemical specific, the use of oral toxicity factors could underestimate or overestimate risk, depending on the chemical. Most oral RfDs and slope factors are based on administered dose, whereas the dermal exposure assessment provides an estimate of an absorbed dose based on intestinal absorption. Intestinal absorption of all organic COCs was assumed to equal 100%.

The use of surrogate data in the toxicity assessment creates uncertainty. In many cases, oral RfDs served as inhalation RfDs. Because actual toxicity values may vary on the basis of exposure route, the use of surrogate pathway RfDs may underestimate or overestimate risk.

Uncertainties in Risk Estimation. USEPA indicates that carcinogenic risks and HIs resulting from various exposure scenarios that may or may not involve the same chemicals are additive (USEPA 1989a). However, this approach ignores the possible synergistic or antagonistic effects between chemicals and could overestimate or underestimate cancer risk or HIs for receptors.

For some chemicals (such as thallium), toxicological data were lacking; therefore, carcinogenic and noncarcinogenic risk associated with exposure to these chemicals could not be calculated. If these chemicals are toxic, the risks could be underestimated.

2.7.2 Ecological Risk Assessment Summary

The ecological risk assessment was conducted for the two subareas identified for AOC FS-1. The assessment included a screening level risk assessment that identified potentially impacted habitats, COPCs, exposure pathways, target receptors, and appropriate assessment/measurement endpoints. It also includes an in-depth baseline ecological risk assessment when screening-level assessment endpoints were exceeded.

2.7.2.1 Identification of Contaminants of Concern

COPCs were identified as chemicals that were detected in the surface soil, surface water, or sediment if the maximum detected concentration exceeded ecological hazard/risk equivalent concentrations (HECs), USEPA *Ecotox Thresholds* (USEPA 1996a), or background concentrations. HECs are concentrations of compounds or elements at which negative impacts to ecological receptors may occur. In addition, even those chemicals that did not exceed

background but did exceed other criteria were retained for further evaluation to assess their potential risk. Tables 2.6-29 through 2.6-31 summarize the toxicity data used to screen the COPCs as well as background data and frequency of detection for each chemical.

Baseline risks were calculated at the AOC area for terrestrial plants and terrestrial wildlife receptors that had HEC exceedances. Baseline risks were calculated at the groundwater plume and upwelling area for aquatic organisms and semiaquatic wildlife receptors that had HEC exceedances. The risk to terrestrial plants and aquatic organisms were estimated by dividing the maximum concentration in the media by the ecological benchmark for the selected COPCs to yield the ecological HQ. The HQ for each chemical was added to yield the resulting HI. The baseline risk was estimated for mean and maximum concentrations. Risk conclusions for populations were based on the HI values for mean concentrations, an evaluation of the uncertainty in the benchmark, and those chemicals exceeding their respective benchmarks. The realistic exposure concentrations for the receptor populations are the mean concentrations rather than the maximum concentrations, and an HI of 1 is protective of populations that have additional available habitat and recruitment outside the AOC FS-1 study area.

Risk conclusions for individuals of protected species were based on the HI values for maximum concentrations and an evaluation of the uncertainty in the benchmark and those chemicals exceeding their respective benchmarks because the individuals may experience maximum COPC concentrations and the goal is to protect individuals in addition to populations of such species.

2.7.2.2 Exposure Assessment

Environmental Setting and Contamination at the AOC FS-1 Study Area The AOC FS-1 ecological conceptual model (Graphical Depiction 2-2) illustrates the potential exposures to ecological receptors associated with the AOC site and the groundwater plume upwelling area.

AOC FS-1 is primarily industrial in use. The AOC area is a paved turnaround surrounded by sand with intermittent tufts of grass distributed sparsely. A pine-oak forest that surrounds the AOC is separated from the AOC by a clearing of several hundred yards. Although AOC FS-1 presents limited habitat for fauna under current conditions, some foraging activities may occur at the site. This area may provide suitable foraging habitat under future scenarios. There is no permanent aquatic habitat within AOC FS-1. No aquatic receptor species are evaluated because no suitable habitat for these species exists within AOC FS-1.

The groundwater upwelling area is primarily agricultural. It overlies groundwater impacted by the AOC FS-1 EDB plume. Within the vicinity of the groundwater plume and upwelling area, the habitats known to be present are active cranberry bogs (a special kind of wetland), abandoned cranberry bogs, scrub-shrub wetlands, and the Quashnet River system. The scrub-shrub wetland communities are drained by freshwater streams that flow in a southwesterly direction into the main channel of the Quashnet River. The Quashnet River originates from the northeastern corner of Johns Pond and drains generally in a southern direction into Waquoit Bay.

The groundwater plume and upwelling area is a sensitive habitat because it supports freshwater tributaries for spawning blue herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), and wild native brook and brown trout, all of which are listed a species of federal concern (HAZWRAP 1994). The spotted turtle (*Clemmys guttata*) and the eastern box turtle (*Terrapene*

carolina) have been sighted within the groundwater plume and upwelling area. The spotted turtle is listed as a threatened species, and the eastern box turtle is listed as a state species of special concern.

Potential Receptors Terrestrial plants were identified as an ecological receptor group at the AOC area and evaluated for phytotoxicity. Five species considered representative of those animals that may occur at AOC FS-1 currently (or in the future) were selected for evaluation because they represent various trophic levels including omnivorous mammals, herbivorous mammals, insectivorous mammals, omnivorous bird, and carnivorous bird.

- **Red fox** (*Vulpes vulpes*). This omnivorous mammal prefers open woodlands and grassy fields and is most active during the night and at dawn and dusk. It is an opportunistic predator and feeds on small mammals, birds, reptiles, amphibians, and invertebrates as well as berries and other fruits. The red fox has a home range of approximately 250 acres (HAZWRAP 1994).

- **White-footed mouse** (*Peromyscus leucopus*). This small, primarily herbivorous rodent can be found in a variety of habitats including deciduous and coniferous forests, open grasslands, and buildings. It forages for seeds, acorns, fruits, and green plants and may prey on insects. It is nocturnal, active in all seasons, and is common throughout New England (HAZWRAP 1994).

- **Short-tailed shrew** (*Blarina brevicamda*). This small insectivore can be found in forests, fields, and marshes. It feeds primarily on insects and other invertebrates. This shrew is active in all seasons (HAZWRAP 1994).

- **Cardinal** (*Cardinalis cardinalis*). This omnivorous finch forages on the ground and in trees and shrubs and feeds on beetles, ants, grasshoppers, and other insects as well as on fruits and seeds. It can be found at woodland edges and in urbanized areas throughout the eastern United States, and it occurs at MMR in all seasons (HAZWRAP 1994).

- **Grasshopper sparrow** (*Ammodranus savannarum*). This small carnivorous bird can be found in grasslands, hayfields, and prairies. It feeds primarily on invertebrates and prefers grasshoppers, spiders, myriapods, snails, earthworms, and other invertebrates.

Eight species considered representatives of aquatic and semiaquatic species that may occur within the groundwater plume upwelling area were selected for evaluation because they represent various trophic levels. The eight species include one amphibian, one reptile, one fish, two medium-size mammals, and three birds.

- **Bull frog** (*Rana catesbeiana*). This aquatic piscivore/insectivore inhabits lakes, ponds, bogs, and streams. Its diet includes consumption of fish, amphibians, crustaceans, mollusks, other aquatic animals, terrestrial insects, and other invertebrates (USEPA 1993b).

- **Eastern box turtle** (*Terrapene carolina*). This omnivore inhabits open fields, forest edge, marshes, and most freshwater bodies. When young, it is primarily carnivorous, but it becomes more herbivorous with age and slower growth. It consumes a wide variety of

animal material including earthworms, slugs, snails, insects and their larvae, crayfish, frogs, toads, snakes, and carrion. It also consumes vegetable matter, including leaves, grass, berries, fruits, and fungi (USEPA 1993).

- **Brook trout** *(Salvelinus fontinalis)*. This aquatic omnivore inhabits clear, cold-water streams and lakes and uses spawning sites of loose, clean gravel in shallow riffle or shoreline areas with a good supply of upwelling, oxygen-rich water. The fish thrive only in cold, clear lakes and streams where water temperatures remain below 66° F, dissolved oxygen levels are high, and siltation is practically nonexistent. Its diet consists of everything from mayflies to salamanders and virtually any animal or vegetable matter.

- **Muskrat** (*Ondatra zibethicus*). This aquatic herbivorous mammal can be found in the vicinity of marshes, shallow portions of lakes, vernal pools, and slow-moving streams. Its diet consists primarily of shoots, roots, and stems of cattails and other emergent vegetation (USEPA 1993b).

- **Raccoon** (*Procyon lotor*). This opportunistic omnivore inhabits woods, mixed woodlands, open areas, and swamps. It feeds primarily on fleshy fruits nuts, acorns, and corn, but it also eats grains, insects, frogs, crayfish, eggs, and virtually any animal and vegetable matter (USEPA 1993b).

- **Mallard** (*Anas platyrhynchos*). This aquatic omnivore inhabits marshes, lakes, and rivers and is particularly attracted to cattail wetlands. In New England, some mallards are year-round residents, while others may migrate in response to seasonal food availability. It prefers shallow surface waters for bottom feeding. Mallards prefer a diet of aquatic macrophytes and wetland vegetation, seeds, and acorns. They supplement their diet with animal material (e.g., earthworms and insects) during breeding periods (HAZWRAP 1994).

- **Black-crowned night heron** (*Nycticorax nycticorax*). This opportunistic omnivorous wading bird can inhabit a broad range of habitats including fresh, brackish, and saltwater areas. The night heron has a diverse diet that can include fish, crustaceans, mollusks, worms, insects, and amphibians. Because it feeds by wading slowly or standing and waiting for prey, the night heron favors shallow water bodies (HAZWRAP 1994).

- **Osprey** (*Pandion haliaetus*). This piscivorous bird is seldom far from large-surface water bodies that support an abundance of fish. Although the osprey nests along rivers and lakes, the greatest density of osprey occurs along coastal shores. Special habitat requirements include clean water with an adequate supply of fish and elevated nesting sites. Nesting sites include tall dead trees, sand dunes, and telephone pole crossarms. It prefers shallower surface water where fish are found close to the surface (HAZWRAP 1994).

Complete Exposure Pathways The following elements must all exist for a complete exposure pathway and for potential exposure of ecological receptors to a COPC:

- a source of the chemical and mechanism of release of the chemical,
- a transport or retention medium,
- a point of exposure or contact with the chemical, and

- an exposure route to the receptor. Tables 2.6-32 and 2.6-33 provide a general overview of the ecological exposure pathways considered in the PRA (for terrestrial and aquatic, respectively).

Terrestrial animals (i.e., birds, mammals, reptiles, and terrestrial invertebrates) at AOC FS-1 may be exposed to contamination via incidental ingestion and dermal absorption of chemicals in surface soil, ingestion of prey items that have bioaccumulated chemicals in their tissues, and inhalation of volatile constituents and airborne particles. However, only the direct ingestion and food chain pathways were modeled because the ingestion pathway is likely to be the most significant route of exposure to COPCs for most vertebrate receptors.

Aquatic and semiaquatic receptors (i.e., birds, mammals, reptiles, amphibians, and aquatic invertebrates) within the groundwater plume and upwelling area may be exposed to contamination via incidental ingestion and dermal absorption of chemicals in surface water and sediment, ingestion of prey items that have bioaccumulated chemicals in their tissues, and inhalation of volatile constituents and airborne particles. The ingestion pathway is likely to be the most significant route of exposure to COPCs for most vertebrate receptors.

Exposure Point Concentration Table 2.6-34 presents the summary statistics for terrestrial ecological COPCs in surface soils. Tables 2.6-8 and 2.6-9 present the summary statistics for the semiaquatic and aquatic ecological COPCs for surface water and sediment, respectively. The exposure point mean and maximum concentrations of COPCs detected in surface soil, surface water, and sediment samples were used to estimate exposure doses. Exposure point mean concentrations in surface soils at AOC FS-1 and in surface water and sediment within the groundwater upwelling area provide a realistic-case estimate of the contaminant concentration or dose to which ecological receptors may be exposed. The maximum concentration provides a worst-case estimate of contaminant exposure.

Food Chain Models Conducted To Establish Exposure A food chain model outlined in the Risk Assessment Handbook (RAH) was used to estimate the potential contaminant doses for three terrestrial receptor species at AOC FS-1 and four semiaquatic receptor species within the groundwater plume upwelling area. For terrestrial and semiaquatic risk, dermal and inhalation pathways were considered to be negligible, and, therefore, only the ingestion pathway was modeled for the terrestrial and semiaquatic receptors. The parameter values for each species are summarized in Tables 2.6-35 and 2.6-26. Chemical-specific parameters are presented in Table 2.6-37. The equations used to estimate the body-weight-normalized contaminant dose received by each model species for the three terrestrial receptors and for each of the four semiaquatic exposure pathways considered are presented in the AOC FS-1 RI (HAZWRAP 1999). Additional details regarding the food chain models, inputs, and exposure parameters for the semiaquatic receptors are included in Table 2.6-36.

The calculated exposure doses for the three terrestrial species and the four semiaquatic species are provided in Appendix H of the AOC FS-1 RI (HAZWRAP 1999). The COPC screening for terrestrial and semiaquatic receptors is shown in Tables 2.6-29 to 2.6-31. These tables show the comparison of HECs for each receptor to the maximum media concentration. Those receptors that had no HECs exceeded were eliminated from further evaluation (i.e. cardinal, mallard, and red fox). Only those COPCs that exceeded an HEC were further evaluated for the respective

receptor. The tables in Appendix H.2 AOC FS-1 RI present the baseline dose calculations. The doses are then compared to the adjusted benchmarks to calculate risk.

2.7.2.3 Ecological Affects Assessment

The ecological effects assessment identifies the potential adverse effects associated with exposure to COPCs. This assessment involves selecting applicable ecotoxicological benchmarks (i.e., a dose expected to be protective of receptor species exposed to COPCs in surface soil via direct contact, inhalation, ingestion, or food chain pathways). Adjusted benchmarks for the identified receptor plant and terrestrial animal species applicable to the exposure routes being evaluated at AOC FS-1 were obtained from current literature and presented in Tables 2.6-38 through 2.6-41. The adjusted toxicity values have been incorporated into the risk characterization provided in the AOC FS-1 RI. A summary of the risk characterization is provided below for each subarea.

2.7.2.4 Ecological Risk Characterization

The risk for each receptor that progressed through the screening is estimated in this section for those COPCs that exceed the receptor-specific HECs. The baseline risk estimate based on the mean and maximum concentrations are presented in Appendix H.2 of the AOC FS-1 RI.

The ecological HQ for each COPC is calculated by dividing the exposure concentration or dose by the adjusted benchmark concentration. Under an assumption of simple additivity of toxicity by different chemicals, the HQ for each COPC is added to calculate the ecological HI.

The risk results are presented in Table 2.6-42. For each receptor, the risks were calculated for maximum and mean concentrations of all chemicals that exceeded HECs, benchmarks, or background. Species of special concern in the study area include the native brook trout, the eastern box turtle, and the osprey.

Interpretation of Risks to Terrestrial Receptors. As shown by the results in Table 2.6-42, the total HIs calculated for the white-footed mouse, grasshopper sparrow, and short-tailed shrew indicate potential adverse effects to these species are not likely (HIs<1). No HECs were exceeded for the fox, mallard, and cardinal, which indicates potential adverse effects to these species are not likely.

Terrestrial plants were identified as an ecological receptor group at AOC FS-1 and evaluated for phytotoxicity. Table 2.6-43 presents the comparison of the phytotoxicity benchmark values to the maximum and mean surface soil concentrations. The maximum exposure scenario's HI was 1.41. The mean exposure scenario's HI was less than 1. The maximum value barely exceeded the benchmark value, which leads to the conclusion that adverse effects are not likely. The maximum concentration of lead contributed the most to the phytotoxicity risk, but no single compound exceeded an HQ of 1. Three inorganics exceeded the established background values. However the HI indicated that there were no significant risks from either site-related or background concentrations.

Interpretation of Risks to Semiaquatic and Aquatic Receptors. The total HIs calculated for the semiaquatic receptors indicate adverse effects to these species are not likely (HIs>1).

The total HIs to the nonmobile aquatic receptors (i.e., benthic invertebrates) indicate adverse effects could occur but are not likely. Maximum and average concentrations detected in the surface water and sediment within the groundwater plume and upwelling area were compared to aquatic benchmarks to determine if adverse effects to aquatic receptors (i.e., benthic invertebrates) were likely. The maximum HI for surface water was 18 and the mean HI was 8. The maximum HI indicates that the no observed adverse effects level (NOAEL) benchmark has been exceeded; however, the maximum concentration compared to the lowest observed adverse effects level (LOAEL) benchmark would barely exceed 1, and the average concentration would not exceed the LOAEL benchmark. The maximum concentrations of aluminum, barium, and iron contributed the most to the aquatic risk. Although these analytes are greater than the estimated background levels, they are not believed to be site related, and they could be indigenous to this type environment. Therefore, although comparison of media concentrations to NOAEL benchmarks suggests a potential effect, significant effects to the assessment endpoint (reproduction and population) are not expected. Table 2.6-44 presents the comparison of the aquatic benchmarks values to the maximum and mean sediment concentrations. The maximum and the mean HIs for aquatic sediment exposure were less than 1 (i.e., 0.56, 0.31, respectively), which led to the conclusion that adverse affects are not likely at site or background sediment concentrations.

Maximum and average concentrations detected in the surface water and sediment within the groundwater plume and upwelling area were compared to fish benchmarks from Suter and Mabrey (1994) to determine if adverse effects to fish and amphibians were likely. Table 2.6-45 presents the comparison of the fish benchmark values to the maximum and mean surface water concentrations. The maximum HI for surface water was 2 and the mean HI was 1. Only the comparison of the maximum concentration to the NOAEL benchmark is slightly above 1, which led to the conclusion that potential adverse affects are not likely. The maximum concentrations of aluminum, barium, and iron contributed the most to the aquatic risk. Table 2.6-46 presents the comparison of the aquatic benchmarks values to the maximum and mean sediment concentrations. The maximum and the mean HIs for fish sediment exposure were less than 1 (i.e., 0.56, 0.31, respectively). Thus, it is concluded that there is no significant MMR-related ecological impact to populations of mobile aquatic organisms (i.e., fish and amphibians) in the river/bog sediment.

2.7.2.5 Uncertainty Evaluation

This section discusses the uncertainties involved in the process of quantifying risk for ecological receptors. Uncertainties involved in the exposure assessment, toxicity assessment, and risk estimation are discussed separately.

Uncertainties in Exposure Assessment. Uncertainty in the exposure assessment is a function of the completeness of site data, assumptions that simplify and approximate actual current or future site conditions, and professional judgement used in developing and evaluating various parameters.

Exposure scenarios and exposure factors presented in this risk assessment are generally conservative and overestimate rather than underestimate exposure. Another assumption made in the exposure assessment is that chemicals of concern are uniformly distributed over the defined area, thus resulting in a uniform exposure level. Chemical analytical data were obtained from a

directed sampling program (i.e., sampling locations were generally selected on the basis of where contaminants were expected to be present). Sampling zones found to be free of contamination received less investigation. This type of sampling scheme tends to overestimate the overall chemical concentrations at a site and the resultant exposure and risk values.

A major source of uncertainty in this assessment is the BAF for COPCs in fish, benthic invertebrates, and plants. The BAFs for plants and invertebrates were those provided for terrestrial plants and invertebrates and may be higher or lower than the BAFs for aquatic plants and benthic invertebrates. The BAF for EDB used the derivation of the HECs was 14. No fish-eating species exceeded the HEC. Risks for fish ingestion may be overestimated. This is of little consequence because the risks for the turtle and raccoon were well below 1.0, and no other semiaquatic receptors exceeded the EDB HEC screening level. The aquatic benchmarks derived for EDB were based on actual data and, therefore, did not rely on a theoretical uptake factor.

Finally, the assumption is made that exposure remains constant over the seasonal exposure duration of an individual animal. In fact, the home range changes from one life stage to another, and actual residence or foraging time in site habitat will alter the projected exposure duration. Migration of individuals in and out of the potentially exposed community also affects exposure duration.

Uncertainties in Toxicity Assessment. The adjusted benchmarks for aquatic organisms and wildlife are highly conservative and represent no-effect concentrations (chronic no observed effect concentrations and NOAELs) in the test species. A conservative uncertainty factor of 10 is used to extrapolate to NOAELs for species of a phylogenetic class different from the target species (e.g., not to turtle). Thus, the actual risk due to exposure to selected chemicals may be higher or lower than the estimated risk. Furthermore, there is uncertainty in the toxicity of chemicals to those species that have not been tested. Thus, it is possible that toxicity is estimated for chemicals that may not actually be toxic to the target species.

There are numerous uncertainties concerning the adjustment of ecological benchmarks based on interspecific and interclass extrapolation, including different patterns of exposure (administered dose versus exposure dose), body-weight scaling, and differences in distribution, metabolism, and excretion of the chemicals. The adjustment of NOAELs in one species to benchmarks for different target species could underestimate or overestimate risk, depending on the similarity in chemical-specific sensitivity of the target species to the test species. Most of the test species NOAELs are based on administered dose rather than absorbed dose, and there is uncertainty in the degree of intestinal absorption of the COPCs by the target species. For this assessment, intestinal absorption of all COPCs was conservatively assumed to equal 100%.

Uncertainties in Risk Estimation. It is assumed in this assessment that the toxicity of individual COPCs is additive without regard to possible synergistic or antagonistic effects between chemicals and could overestimate or underestimate HIs for receptors.

Benchmark concentrations for aquatic organisms were not available for two chemicals that occurred at concentrations higher than background; therefore, the risks associated with exposure to these chemicals could not be calculated. These chemicals were selenium in river sediment and barium in pond sediments. The risks of these chemicals could be underestimated if these chemicals are toxic at the concentrations that occurred in sediments.

2.7.3 Risk Characterization Summary

The PRA was conducted for the AOC FS-1 according to the current federal and state guidance (HAZWRAP 1999). For the purposes of the PRA, the site was subdivided into two subareas: (1) the AOC source area and (2) the downgradient groundwater plume and upwelling area. Risks from exposure to soil at AOC FS-1 source area are below the USEPA target risk range and the MADEP target value.

The human health risk assessment concluded that there are exceedances of the USEPA target risk range (10^{-6} to 10^{-4}) and the MADEP target risk for future exposure scenarios for residents exposed to groundwater. HIs, a measure of noncarcinogenic effects, for future exposure exceeded 1.0. Risks associated with the source area COPCs are below applicable EPA and MADEP risk guidelines. All groundwater risk associated with FS-1 is associated with the downgradient area of contamination.

The human health risk assessment concluded that there are no exceedances of the generally accepted USEPA target risk range (1×10^{-6} to 1×10^{-4}) in current and future exposure scenarios for exposure to sediments and surface water. The values calculated in the human health risk assessment do fall within the target risk range. However, the MADEP target risk of 1×10^{-5} was exceeded for current and future recreational wader (adult) exposed to surface water, sediment, and fish ingestion. All HIs for current and future exposure are less than 1.0, which indicates that there are no noncancer human health risks.

Based on the ecological risk assessment COPC concentrations in soil, surface water, and sediments do not pose unacceptable risks.

2.8 REMEDIAL ACTION OBJECTIVES

Based on preliminary information relating to types of contaminants, environmental media of concern, and potential exposure pathways, remedial action objectives were developed to aid in the development and screening of remedial action alternatives. These remedial action objectives were developed to mitigate existing and future potential threats to human health and the environment. Specifically, the objectives include:

- prevent or reduce exposure to groundwater COCs exceeding cleanup standards in groundwater;
- restore the aquifer to beneficial uses within a reasonable time frame; and
- prevent or reduce worker, recreational youth, and adult wader contact with Quashnet River water containing unacceptable concentrations of EDB and ingestion of fish exposed to Quashnet River water containing unacceptable concentrations of EDB.

MMR groundwater plumes, including FS-1, are located within the Cape Cod sole-source aquifer. Therefore, AFCEE has agreed that for all active remedies selected, it will undertake a three-step process in achieving remedial action objectives. This three-step process, which was outlined in the Proposed Plan dated June 1999, will be implemented in the following manner:

1. **Remediate the aquifer to federal and state drinking water standards or other risk-based cleanup levels.** Restoration time frames and remedial costs estimated in this ROD were developed based on the expected time to attain federal and state drinking water standards (MCLs and MMCLs) or other risk-based cleanup levels. During the period that remedial systems are in operation, AFCEE will monitor the plume in accordance with the approved system performance monitoring plan. The plume will be considered to have reached MCLs, MMCLs, or other risk-based cleanup levels (for those contaminants for which no MCLs or MMCLs are promulgated) when there have been no detections exceeding those levels over a time period agreed to by AFCEE and EPA in consultation with DEP.

2. **When MCLs, MMCLs, or other risk-based cleanup levels are achieved and before the system is shut off, perform a risk assessment to determine if unacceptable ecological and/or human health risks are present; continue system operation and/or pursue additional measures as required to achieve acceptable risks.** AFCEE shall conduct a risk assessment once MCLs, MMCLs or other risk-based cleanup levels have been achieved (as defined in step 1, above) to determine whether the contaminants of concern (COPCs) remaining in the aquifer continue to pose unacceptable ecological and/or human health risks. This risk determination shall be made jointly among AFCEE and EPA in consultation with DEP and may result in aquifer cleanup which is more protective than the NCP point of departure risk level of 10-6 (40 CFR Part 300.430(e)(2)), if justified, based on the following site-specific factors: cumulative effects of multiple contaminants, the potential for exposure from other pathways of exposure at the site, population sensitivities, potential impacts on environmental receptors, and cross-media impacts (NCP Preamble page 8717).

3. **Once acceptable risks have been achieved, evaluate the technical and economic feasibility of additional remediation to approach or achieve background concentrations.** AFCEE shall proceed with a technical and economic feasibility analysis of approaching or achieving background concentrations in the aquifer. The feasibility of approaching or achieving background will be determined in accordance with the following criteria:

A. Technological - Not feasible if:

i. the existing technologies or modifications cannot remediate to a level of no significant risk, or to levels which approach or achieve background; or

ii. the reliability of the identified alternative has not been sufficiently proven and a substantial uncertainty exists as to whether it will effectively reduce risk; or

iii. the remedy does not or cannot be modified to meet other regulatory requirements.

B. Economic - The benefits of implementing a remedy and reducing the concentrations of contaminants in the environment to levels which approach or achieve background justifies related cost unless:

i. the incremental cost for the remedy is substantial and disproportional to the benefit of risk reduction, environmental restoration and monetary and non-monetary values; or

ii. the risk of harm to health/safety/public welfare/environment by the remedy cannot be adequately controlled.

AFCEE and EPA with input from DEP have also agreed that in the event that implementation of steps two and/or three above leads to a mutual decision to undertake additional cleanup and such decision results in a significant or fundamental change to the remedial approach, cleanup levels and/or costs documented in this final ROD, AFCEE will execute an Explanation of Significant Differences (with public comment) or ROD Amendment, as appropriate. Whether any such additional cleanup actions result in a significant or fundamental change to this final ROD shall be determined jointly by AFCEE and EPA in consultation with DEP in accordance with the criteria set forth in EPAs *A Guide to Preparing Superfund Proposed Plans, Records of Decision, And Other Remedy Selection Decision Documents,* OSWER 9200.1-23P (July 1999). In this manner, such changes will be subject to regulatory review and stakeholder involvement through issuance of a new Proposed Plan and/or conduct of a public comment period. In the event that a dispute arises regarding any of the determinations to be jointly reached under the three-step process outlined above, such dispute shall be resolved under the Dispute Resolution procedures of the MMR Federal Facility Agreement.

2.9 DEVELOPMENT AND SCREENING OF ALTERNATIVES

Under its legal authorities, AFCEE's primary responsibility at Superfund sites is to undertake remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences that include (1) a requirement that the remedial action, when complete, must comply with all applicable or relevant and appropriate federal and more stringent state environmental standards, requirements, criteria, or limitations, unless a waiver is invoked; (2) a requirement that a remedial action be cost-effective and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (3) a preference for remedies in which treatment permanently and significantly reduces the toxicity, mobility, or volume of hazardous substances as a principal element. Remedial action alternatives were developed to be consistent with these mandates.

CERCLA and the NCP set forth the process by which remedial action alternatives are evaluated and selected. In accordance with these requirements, the RI/FS developed a range of alternatives that included an alternative in which treatment that reduces the toxicity, mobility, or volume of the hazardous substances is a principal element and removes or destroys hazardous substances to the maximum extent feasible and thereby eliminating or minimizing (to the degree possible) the need for long-term management. This range also included alternatives that involve little or no treatment but provide protection through engineering or institutional controls and a No Action alternative.

As discussed in Section 7 of the FS, the RI/FS identified, assessed, and screened technologies based on implementability, effectiveness, and cost. The purpose of the initial screening was to narrow the number of potential remedial actions for further detailed analysis while preserving a

range of options. Section 8 of the FS presented the remedial alternatives identified in the screening process in the categories identified in Section 300.430(e)(3) of the NCP and evaluated these alternatives. Of the five identified technologies and process options, only one, Limited Action, was eliminated by the screening process. Alternative 2 included only institutional controls and no active treatment. The four alternatives that were retained are:

- Alternative 1 No Action
- Alternative 2B: Limited Action with Leading Edge Extraction, Treatment, and Reinjection/Discharge
- Alternative 3: Axial Well Extraction, Treatment, and Reinjection/Discharge
- Alternative 3B: Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge

All alternatives except the No Action alternative include source area groundwater monitoring. Actions in the source area are limited to monitoring only due to contaminant characteristics. The contaminants in source area groundwater, toluene, lead, and thallium, are immobile and will not migrate beyond the source area. Additionally, toluene, based on scientific literature, is known to be subject to natural degradation. Based on these characteristics, monitoring only in the source area is protective of human health and the environment.

2.10 DESCRIPTION OF ALTERNATIVES

The FS (HAZWRAP 1999) assessed how the four remedial alternatives whose application the NCP requires in the evaluation of remedial alternatives meet the nine evaluation criteria within the context of the remedial objectives. A fifth alternative, Limited Action, was eliminated from consideration during the FS because it did not meet the remedial action objectives. Alternative 2 included only institutional controls and no active treatment. Therefore, the alternatives assessed are:

- Alternative 1 No Action
- Alternative 2B: Limited Action with Leading Edge Extraction, Treatment, and Reinjection/Discharge
- Alternative 3: Axial Well Extraction, Treatment, and Reinjection/Discharge
- Alternative 3B: Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge

The remedial alternatives discussed in this section address source area groundwater, the downgradient detached plume and surface water in the Quashnet River and the Quashnet River cranberry bogs. All alternatives except the No Action alternative include source area groundwater monitoring. Actions in the source area are limited to monitoring only due to contaminant characteristics. The contaminants in source area groundwater, toluene, lead, and thallium, are immobile and will not migrate beyond the source area. Additionally, toluene, based on scientific literature, is known to be subject to natural degradation. Based on these characteristics, monitoring only in the source area is protective of human health and the environment.

2.10.1 Alternative 1: No Action

The No Action alternative was evaluated as a baseline with which to compare other alternatives. No remedial action, monitoring, further investigation, or 5-year site reviews would be performed as part of this alternative. A detailed discussion of the No Action alternative is provided in Section 8.1. of the FS (HAZWRAP 1999).

2.10.2 Alternative 2B: Limited Action with Leading Edge Extraction, Treatment, and Reinjection/Discharge

Alternative 2B includes extraction and treatment of groundwater at the leading edge of the plume and institutional controls to prevent usage of the aquifer during cleanup. During operation, this alternative minimizes risk to human receptors potentially exposed to surface water and groundwater. This alternative also includes long-term monitoring and/or site inspection in two areas, the source area groundwater, and the downgradient detached plume and surface water in the upwelling area.

Institutional controls for FS-1 involve on-base and off-base authorities. For source area groundwater, there is no immediate risk. Residents and workers on the base obtain drinking water from the base water supply system. Construction projects on MMR, including water supply wells, require written approval from the Base Civil Engineer. Construction of a new drinking water supply well for MMR would also require DEP permission. For downgradient groundwater, Mashpee has placed a moratorium on wells impacted by contaminated groundwater. AFCEE will coordinate with the Base Civil Engineer and the Town of Mashpee periodically (but not less than annually) to ensure that these entities are apprized of any changes to the plume configuration and/or contaminant concentrations.

The alternative meets remedial action objectives (RAOs), specifically protection of human health. Exposure to groundwater COCs exceeding cleanup standards is prevented through institutional controls. Restoration of the aquifer to beneficial use is accomplished by capturing and treating contaminated groundwater. Contact with Quashnet River water containing unacceptable contaminant levels is reduced by the active removal of EDB contaminated water prior to that water discharging to the Quashnet River.

The estimated time for restoration of the aquifer is 11 years. The estimate is derived from model run 17 contained in Appendix B. The model predicts that the leading edge extraction system effectively removes EDB from the aquifer and prevents discharge of EDB to the Quashnet River bogs. Immediate reductions in EDB surface water concentrations were observed after the startup of the Quashnet River Bogs Pilot Test, located in the areas of upwelling contaminated groundwater.

Elements of the operational Quashnet River Bogs Pilot Test comprise the initial configuration of the Leading Edge Extraction, Treatment and Reinjection/Discharge system. The pilot system consists of one deep extraction well and shallow groundwater extraction well points with a current total flow rate of 650 gallons per minute, a treatment plant utilizing granulated activated carbon, and a reinjection trench and surface water discharge bubbler. Exact configuration of the system is dynamic and the system will be modified as necessary.

This alternative includes the following remedial activities to cleanup groundwater and surface water contamination:

- leading edge extraction, treatment, and reinjection/discharge;
- groundwater monitoring in the source area and downgradient plume;
- surface water monitoring in the Quashnet River area bogs;
- institutional controls;
- operation and maintenance; and
- 5-year reviews.

The pilot system consists of one deep extraction well and shallow well groundwater extraction well points with a current total flow rate of 650 gallons per minute, a treatment plant utilizing granulated activated carbon, and a reinjection trench and surface water discharge bubbler. Exact configuration of the system is dynamic and the system will be modified as necessary.

The monitoring program will involve groundwater and surface water sampling for EDB by USEPA Method 504, VOCs by USEPA Method 524, and metals by USEPA Method methodologies. Site inspections and collection and analysis of samples will be performed quarterly for the first 2 years and annually thereafter for 9 years. The sampling, analysis, data validation, and preparation of a monitoring report would require approximately 12 weeks per sampling event. Treatment system operation is estimated to continue for 11 years.

Alternative 2B meets all identified ARARs. Those ARARs follow.

Chemical Specific

Groundwater It is expected that through capture and treatment at the leading edge of the plume, the groundwater at AOC FS-1 will meet MCLs, nonzero maximum contaminant level goals (MCLGs) and MMCLs within 11 years.

Location Specific

Wetlands and Floodplains Remedial actions will be performed in such a manner that wetland areas and floodplains will not be adversely impacted. All actions will comply with provisions and requirements contained in the federal and state ARARs which pertain to wetlands and floodplains. Identified federal ARARs are: Rivers and Harbors Act, Protection of Wetlands Executive Order, Clean Water Act Section 404, and Floodplain Management Executive Order. Identified state ARARs are: Massachusetts Wetlands Regulations. Additionally, fill material will not be discharged to wetlands. Engineering controls will be used to prevent such discharges.

Fish and Wildlife Before modification of the bogs, the U.S. Fish and Wildlife Service will be consulted. All actions will comply with provisions and requirements contained in the federal ARARs that pertain to fish and wildlife. Identified ARARs are: Federal Fish and Wildlife Coordination Code.

Endangered Wildlife Endangered or threatened species will be identified during design. Activities will be conducted in a fashion that will not adversely impact sensitive species.

Actions will comply with provisions and requirements contained in the state ARARs that pertain to endangered species. Identified ARARs are: Massachusetts Endangered Species Act.

Action Specific

Groundwater Multiple applicable or relevant and appropriate requirements (ARARs) related to groundwater have been identified. Identified ARARS include the federal Underground Injection Control Program, Massachusetts Groundwater Discharge Permits, and Massachusetts Underground Water Source Protection. In all instances, remedial actions will comply with those ARARS.

Surface Water Discharge of treated water into surface water will be in accordance with the National Pollutant Discharge Elimination System (NPDES).

Air Multiple ARARS associated with air have been identified. Identified air-related ARARS include RCRA Air Emission Standards for Process Vents, RCRA Air Emission Standards and Control of Emissions of Volatile Organic Compounds, and Massachusetts Air Pollution Control Requirements. Construction and on-site treatment activities will be performed to comply with identified ARARS.

Hazardous Waste Generators All operations related to the generation of hazardous waste and the hazardous waste generated will comply with state and federal RCRA requirements. Identified Federal ARARS include: RCRA Identification and Listing of Hazardous Wastes, Toxicity Characteristics; RCRA Subtitle C Standards for Owners and Operators of Hazardous Waste TSD Facilities, and RCRA Subtitle C Subpart F-releases from Solid Waste Management Units. Identified state ARARs include: Massachusetts Hazardous Waste Management Regulations (HWMR)-Requirements for Generators, and Massachusetts HWMR-Location Standards.

Food Tolerance Massachusetts Department of Public Health (DPH) food tolerance levels for EDB in food products are being considered in the selection and design of FS-1 remedial alternatives. Cranberry testing would be undertaken as an additional measure of the performance of the alternative in attaining the surface water RAO.

Alternative 2B is effective in the long term, reliable, and will achieve the RAOs for AOC FS-1. Modeling for this alternative estimates that the MMCL of 0.02 μg/L EDB in groundwater will be achieved within 11 years. Of the estimated total of 11 kg of EDB in the aquifer, modeling indicates that 68% will be extracted by the remediation system, 18% will escape the extraction system and discharge beyond the model boundaries, and 14% will remain dispersed through the aquifer. It is assumed that the portion of EDB that escapes extraction and is not retained in the aquifer discharges to surface water. If the EDB is not extracted, nor does it escape the boundaries of the plume, it is assumed to be immobile. The portion of EDB that is not extracted and does not escape the boundaries of the model is assumed to be either trapped in silts, in blind pores that are not connected to other pores that will allow transport, or is dissipated through the aquifer. It is anticipated that the surface water RAOs will be achieved within 1 year of system startup. The pilot system was put into operation in April 1999. It has and will continue to reduce human exposure to contaminants within the groundwater plume emanating from AOC FS-1 and surface water in the Quashnet River bogs.

Alternative 2B is reliable. All components of the remedial system are standard remedial action equipment. The equipment has a history of successful operation. Additionally, the system will be operated and maintained in a manner that ensures proper functioning. The Leading Edge Extraction and Reinjection/Discharge aspects of Alternative 2B are flexible and can be rapidly modified to address site conditions or to optimize performance. Additionally, because of the modular nature of this system, a catastrophic failure of the system is less likely than a system relying on a small number of high production wells. This versatility enhances the reliable protection of human health and the environment.

There are technical difficulties associated with Alternative 2B. Potential difficulties include construction of stable berms over unstable organic materials, fouling of small-diameter wells if high entrance velocities are used, construction of stable piping networks between wells in the bogs, metals precipitation in GAC filter canisters, channelization of the GAC filter canisters, and other problems. However, those problems can be overcome with good engineering and construction practices.

Several institutional controls protect area residents from exposure to FS-1 groundwater contaminants. The safety of all public water supplies within Massachusetts is regulated by the Commonwealth. Residents and workers on MMR receive their water from the base water supply system. The institutional controls presently in place adequately prevent residential exposure in all Mashpee households currently connected to the municipal water supply and all residents and workers on MMR.

At its July 29, 1999, meeting, the Mashpee Board of Health adopted a moratorium on groundwater wells to minimize the risk of exposure to groundwater contamination. These regulations prohibit the use of existing or future wells located in documented or anticipated areas of groundwater contamination for any purpose.

Institutional controls are already in place to prevent the drilling of private wells on MMR. A lengthy review process must be completed before a public water supply well can be drilled on the military base. This process includes DEP review and ensures that wells will not be located in or immediately downgradient of known groundwater contamination plumes. AFCEE will coordinate with the base Civil Engineer and the Town of Mashpee periodically (but not less than annually) to ensure the two entities know of any changes to the plume configurations and/or contaminant concentrations.

The principal capital cost components for this alternative are associated with the construction of the Leading Edge Extraction, Treatment, and Reinjection/Discharge system. Estimated capital costs are $3,952,000. The operation and maintenance (O&M) costs incurred by implementing this alternative will be for O&M of the remediation system, performing groundwater monitoring, and site inspections. Total O&M costs for the life of the project are estimated at $5,543,000. The total present worth for this alternative was calculated using an inflation of 5% annually, then calculating present worth based on a 7% annual discount rate. All calculations assume that O&M activities will extend for 11 years. This results in a present worth cost of $9,423,000. A summary of costs and assumptions for this alternative is presented in Appendix F.

2.10.3 Alternative 3: Axial Well Extraction, Treatment, and Reinjection/Discharge

Alternative 3 includes groundwater extraction from wells oriented axially down the center of the plume, treatment of the extracted groundwater, and institutional controls to prevent usage of the aquifer during cleanup. During operation, this alternative minimizes risk to human receptors potentially exposed to surface water and groundwater. This alternative also includes long-term monitoring and/or site inspection in two areas, the source area groundwater, and the downgradient detached plume and surface water in the upwelling area.

The alternative meets remedial action objectives (RAOs), specifically protection of human health. Exposure to groundwater COCs exceeding cleanup standards is prevented through institutional controls. Restoration of the aquifer to beneficial use is accomplished by capturing and treating contaminated groundwater. Contact with Quashnet River water containing unacceptable contaminant levels is reduced by the active removal of EDB contaminated water prior to that water discharging to the Quashnet River. During operation, this alternative minimizes risk to human receptors potentially exposed to surface water and groundwater.

Institutional controls for FS-1 involve on-base and off-base authorities. For source area groundwater, there is no immediate risk. Residents and workers on the base obtain drinking water from the base water supply system. Construction projects on MMR, including water supply wells, require written approval from the Base Civil Engineer. Construction of a new drinking water supply well for MMR would also require DEP permission. For downgradient groundwater, Mashpee has placed a moratorium on wells impacted by contaminated groundwater. AFCEE will coordinate with the Base Civil Engineer and the Town of Mashpee periodically (but not less than annually) to ensure that these entities area apprized of any changes to the plume configuration and/or contaminant concentrations.

This alternative includes the following remedial activities to clean up groundwater and surface water contamination:

- axial extraction, treatment, and reinjection/discharge of contaminated groundwater;
- groundwater monitoring in the source area and downgradient plume;
- surface water monitoring in the Quashnet River area bogs;
- institutional controls;
- operation and maintenance; and
- 5-year reviews.

Before construction of Alternative 3, additional modeling and design would be performed to optimize the extraction system. Property would be acquired on which the axial wells and utilities would be installed. Construction would include construction of approximately 2 miles of road to provide access to the axial wells as well as the installation of power lines, control wiring, and piping along the road to connect the wells to the treatment facility. Approximately 20 wells (200 feet deep) would be installed. Present modeling indicates the wells would pump at approximately 600 gpm. A treatment facility would be constructed and treatment equipment installed. For cost purposes, it is assumed that the treatment would be located adjacent to the Quashnet River bog. Nineteen reinjection wells capable of reinjecting 200 gpm would be

installed in the bogs, and a surface water discharge system capable of discharging 400 gpm to the bogs would be constructed.

Operation of the described system would continue for 7 years or longer, based on achievement of the RAOs. Institutional controls, in the form of zoning restrictions, would be placed to prevent use of groundwater. Those restrictions would continue until RAOs were met. Additionally, surface water and groundwater would be monitored for the life of the treatment system.

Implementation of this alternative at AOC FS-1 will take approximately 24 months to complete. Monitoring site conditions will involve collecting and analyzing groundwater and surface water samples for VOCs by USEPA Method 524, EDB by USEPA Method 504, and metals by USEPA Method 200.7/6010/7000. Source area groundwater will be resampled for metals and VOCs. These site inspections, and collection and analysis of groundwater samples, will be performed quarterly for the first 2 years and annually thereafter for 5 years.

Alternative 3 meets all identified ARARs. Those ARARs are:

Chemical Specific

Groundwater It is expected that through capture and treatment at the leading edge of the plume, the groundwater at AOC FS-1 will meet MCLs, nonzero maximum contaminant level goals (MCLGs) and MMCLs within 7 years.

Location Specific

Wetlands and Floodplains Remedial actions will be performed in such a manner that wetland areas and floodplains will not be adversely impacted. All actions will comply with provisions and requirements contained in the federal and state ARARs which pertain to wetlands and floodplains. Identified federal ARARs are: Rivers and Harbors Act, Protection of Wetlands Executive Order, Clean Water Act Section 404, and Floodplain Management Executive Order. Identified state ARARs are: Massachusetts Wetlands Regulations. Additionally, fill material will not be discharged to wetlands. Engineering controls will be used to prevent such discharges.

Fish and Wildlife Before modification of the bogs, the U.S. Fish and Wildlife Service will be consulted. All actions will comply with provisions and requirements contained in the federal ARARs that pertain to fish and wildlife. Identified ARARs are: Federal Fish and Wildlife Coordination Code.

Endangered Wildlife Endangered or threatened species will be identified during design. Activities will be conducted in a fashion that will not adversely impact sensitive species. Actions will comply with provisions and requirements contained in the state ARARs that pertain to endangered species. Identified ARARs are: Massachusetts Endangered Species Act.

Action Specific

Groundwater Multiple applicable or relevant and appropriate requirements (ARARs) related to groundwater have been identified. Identified ARARS include the federal Underground Injection

Control Program, Massachusetts Groundwater Discharge Permits, Massachusetts Underground Water Source Protection. In all instances, remedial actions will comply with those ARARS.

Surface water Discharge of treated water into surface water will be in accordance with the National Pollutant Discharge Elimination System (NPDES).

Air Multiple ARARS associated with air have been identified. Identified air-related ARARS include RCRA Air Emission Standards for Process Vents, RCRA Air Emission Standards and Control of Emissions of Volatile Organic Compounds, and Massachusetts Air Pollution Control Requirements. Construction and on-site treatment activities will be performed to comply with identified ARARS.

Hazardous Waste Generators All operations related to the generation of hazardous waste and the hazardous waste generated will comply with state and federal RCRA requirements. Identified federal ARARS include: RCRA Identification and Listing of Hazardous Wastes, Toxicity Characteristics; RCRA Subtitle C Standards for Owners and Operators of Hazardous Waste TSD Facilities, and RCRA Subtitle C Subpart F-releases from Solid Waste Management Units. Identified state ARARs include: Massachusetts Hazardous Waste Management Regulations (HWMR)-Requirements for Generators, and Massachusetts HWMR-Location Standards.

Food Tolerance Massachusetts Department of Public Health (DPH) food tolerance levels for EDB in food products are being considered in the selection and design of FS-1 remedial alternatives. Cranberry testing would be undertaken as an additional measure of the performance of the alternative in attaining the surface water RAO.

Alternative 3 is effective in the long term and reliable. Modeling for this alternative estimates that the MMCL of 0.02 μg/L EDB in groundwater will be achieved within 7 years. Of the estimated total of 11 kg of EDB in the aquifer, modeling indicates that 83% will be extracted by the remediation system, 11% will escape the extraction system and discharge beyond the model boundaries, and 6% will remain dispersed through the aquifer. It is assumed that that portion of EDB that escapes extraction and is not retained in the aquifer discharges to surface water. If the EDB is not extracted, and does it escape the boundaries of the plume, it is assumed to be immobile. The portion of EDB that is not extracted and does not escape the boundaries of the model is assumed to be either trapped in silts, in blind pores that are not connected to other pores that will allow transport, or is dissipated through the aquifer. Surface water RAOs will be achieved at the completion of the remedial activities. If the Quashnet River Bogs Pilot Test is shut down prior to the startup of Alternative 3, a small quantity of EDB could discharge to the Quashnet River bogs. If Alternative 3 is chosen, system startup should occur by the year 2000. The groundwater and surface water monitoring and site inspection programs will document the continued effectiveness of this alternative.

Alternative 3 is reliable. All components of the remedial system are standard remedial action equipment. The equipment has a history of successful operations. Additionally, the system will be operated and maintained in a manner that ensures proper functioning.

There are technical difficulties associated with Alternative 3. Potential difficulties include metals precipitation in GAC filter canisters, channelization of the GAC filter canisters, well

fouling, and other problems. However, those problems can be overcome with good engineering and construction practices. Implementation and supervision of the design, construction, and O&M of the alternative will require close coordination with local, state, and federal agencies.

Several institutional controls protect area residents from exposure to FS-1 groundwater contaminants. The safety of all public water supplies within Massachusetts is regulated by the Commonwealth. Residents and workers on MMR receive their water from the base water supply system. The institutional controls presently in place adequately prevent residential exposure in all Mashpee households currently connected to the municipal water supply and all residents and workers on MMR.

At its July 29, 1999, meeting, the Mashpee Board of Health adopted a moratorium on groundwater wells to minimize the risk of exposure to groundwater contamination. These regulations prohibit the use of existing or future wells located in documented or anticipated areas of groundwater contamination for any purpose.

Institutional controls are already in place to prevent the drilling of private wells on the MMR. A lengthy review process must be completed before a public water supply well can be drilled on the military base. This process includes DEP review and ensures that wells will not be located in or immediately downgradient of known groundwater contamination plumes. AFCEE will coordinate with the base Civil Engineer and the Town of Mashpee periodically (but not less than annually) to ensure the two entities know of any changes to the plume configurations and/or contaminant concentrations.

The principal capital cost components for this alternative will be associated with the construction of the extraction, treatment, and reinjection/discharge systems. Estimated capital costs are $4,626,000. The O&M costs incurred by implementing this alternative will be for O&M of the remediation system, performing groundwater monitoring, and site inspections. Total O&M costs for the life of the project are estimated at $4,041,000. The total present worth for this alternative was calculated using an inflation of 5% annually, then calculating present worth based on a 7% annual discount rate. All calculations assume that O&M activities will extend for a period of 7 years. This results in a present worth cost of $8,699,000. Alternative 3 does not include the pilot test system and therefore the costs of the system were not capitalized under the cost estimate for Alternative 3. Please note however, that since the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system. A summary of costs and assumptions for this alternative is presented in Appendix F.

2.10.4 Alternative 3B: Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge

Alternative 3B includes groundwater extraction and treatment of groundwater at the leading edge of the plume, groundwater extraction and treatment of groundwater along the axis of the plume, reinjection/discharge of treated water, and institutional controls to prevent usage of the aquifer during cleanup. During operation, this alternative minimizes risk to human receptors potentially exposed to surface water and groundwater. This alternative also includes long-term monitoring and/or site inspection in the source area and groundwater and surface water downgradient of the source area.

Alternative 3B will meet RAOs, specifically protection of human health. Exposure to groundwater COCs exceeding cleanup standards is prevented through institutional controls. Restoration of the aquifer to beneficial use is accomplished by capturing and treating contaminated groundwater. Contact with Quashnet River water containing unacceptable contaminant levels is reduced by the active removal of EDB contaminated water prior to that water discharging to the Quashnet River. During operation, this alternative minimizes risk to human receptors potentially exposed to surface water and groundwater.

Elements of the operational Quashnet River Bogs Pilot Test comprise part of the Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge. The pilot system consists of one deep extraction well and shallow groundwater extraction well points with a current total flow rate of 650 gallons per minute, a treatment plant utilizing granulated activated carbon, and a reinjection trench and surface water discharge bubbler. Exact configuration of the system is dynamic and the system will be modified as necessary.

The estimated time for restoration of the aquifer is 7 years. The leading edge extraction system effectively removes EDB from the aquifer and prevents discharge of EDB to the Quashnet River bogs. Addition of the axial wells removes EDB from the upgradient aquifer, thereby accelerating groundwater cleanup. Reductions in EDB concentrations in surface water have already occurred as a result of the operation of the pilot test. The system will be modified to optimize performance.

During operation, this alternative minimizes risk to human receptors potentially exposed to surface water and groundwater. This alternative also includes long-term monitoring and/or site inspection in the source area and groundwater and surface water downgradient of the source area.

This alternative includes the following remedial activities to cleanup groundwater and surface water contamination:

- axial and leading edge extraction, treatment, and reinjection/discharge;
- groundwater monitoring in the source area and downgradient plume;
- surface water monitoring in the Quashnet River area bogs;
- institutional controls;
- operation and maintenance; and
- 5-year reviews.

Before construction of Alternative 3B, additional modeling and design would be performed to optimize the extraction system. Property would be acquired on which the axial wells and utilities would be installed. Construction would include construction of approximately 2 miles of road to provide access to the axial wells and installation of power lines, control wiring, and piping along the road to connect the wells to the treatment facility.

The extraction system would be composed of a leading edge extraction system, an axial well extraction system, a treatment system, and a reinjection/discharge system. The leading edge extraction system is composed of one high-volume extraction well (EW-5), which would pump at approximately 200 gpm, and 135 shallow well points that would be pumped at approximately

400 to 450 gpm. The axial well extraction system would be composed of 17 wells along the central axis of the plume that would extract water at 400 gpm. All water from the extraction wells would be piped to a treatment facility, located adjacent to bogs, where the 1,000 gpm pumped from the wells would be treated by pumping the extracted water through GAC. After treatment, the water would be reinjected to the aquifer and discharged to surface water. Two hundred gallons per minute would be reinjected to the aquifer through approximately 19 wells. The remaining 800 gpm would be discharged to the surface water in the Quashnet River bogs. Additionally, water discharged to the bogs may be run through a bubbler before discharge to oxygenate the water. A berm would also be constructed to separate areas of potential contaminated groundwater upwelling from areas in which there is no potential contaminated groundwater upwelling.

Other elements of this alternative will include long-term monitoring, well drilling restrictions, and warning signs. These actions are commonly employed process options. However, the effectiveness of such institutional controls is dependent on local government for implementation and enforcement. The institutional controls for FS-1 involve on-base and off-base authorities.

For source area groundwater, there is no immediate risk. Residents and workers on the base obtain drinking water from the base water supply system. Construction projects on MMR, including water supply wells, require written approval from the Base Civil Engineer. Construction of a new drinking water supply well for MMR would also require DEP permission. For downgradient groundwater, the Town of Mashpee has placed a moratorium on wells impacted by contaminated groundwater. AFCEE will coordinate with the Base Civil Engineer and the Town of Mashpee periodically (but not less than annually) to ensure that these entities area apprized of any changes to the plume configuration and/or contaminant concentrations. Implementation of this alternative will require approval from the appropriate state and local authorities.

Implementation of the processes at AOC FS-1 will take approximately 24 months to complete. The Leading Edge Extraction, Treatment, Reinjection/Discharge portion of Alternative 3B are operational as the Quashnet River Bogs Pilot Test. The 24 months required for implementation are primarily related to the construction of the Axial Extraction portion of Alternative 3B. Monitoring site conditions will involve collecting and analyzing groundwater and surface water samples for VOCs by USEPA Method 524, EDB by USEPA Method 504, and metals by USEPA Method 200.7/6010/7000. Source area groundwater will be sampled for potential COCs. These site inspections, and collection and analysis of groundwater samples, will be performed quarterly for the first 2 years and annually thereafter for 5 years.

Alternative 3B meets all identified ARARs. Those ARARs are:

Chemical Specific

Groundwater It is expected that through capture and treatment axially and at the leading edge of the plume, the groundwater at AOC FS-1 will meet MCLs, nonzero maximum contaminant level goals (MCLGs) and MMCLs within 7 years.

Location Specific

Wetlands and Floodplains Remedial actions will be performed in such a manner that wetland areas and floodplains will not be adversely impacted. All actions will comply with provisions and requirements contained in the federal and state ARARs which pertain to wetlands and floodplains. Identified federal ARARs are: Rivers and Harbors Act, Protection of Wetlands Executive Order, Clean Water Act Section 404, and Floodplain Management Executive Order. Identified state ARARs are: Massachusetts Wetlands Regulations Additionally, fill material will not be discharged to wetlands. Engineering controls will be used to prevent such discharges.

Fish and Wildlife Before modification of the bogs, the U.S. Fish and Wildlife Service will be consulted. All actions will comply with provisions and requirements contained in the federal ARARs that pertain to fish and wildlife. Identified ARARs are: Federal Fish and Wildlife Coordination Code.

Endangered Wildlife Endangered or threatened species will be identified during design. Activities will be conducted in a fashion that will not adversely impact sensitive species. Actions will comply with provisions and requirements contained in the state ARARs that pertain to endangered species. Identified ARARs are: Massachusetts Endangered Species Act.

Action Specific

Groundwater Multiple applicable or relevant and appropriate requirements (ARARs) related to groundwater have been identified. Identified ARARS include the federal Underground Injection Control Program, Massachusetts Groundwater Discharge Permits, Underground Water Source Protection. In all instances, remedial actions will comply with those ARARS.

Surface water Discharge of treated water into surface water will be in accordance with the National Pollutant Discharge Elimination System (NPDES).

Air Multiple ARARS associated with air have been identified. Identified air-related ARARS include RCRA Air Emission Standards for Process Vents, RCRA Air Emission Standards and Control of Emissions of Volatile Organic Compounds, and Massachusetts Air Pollution Control Requirements. Construction and on-site treatment activities will be performed to comply with identified ARARS.

Hazardous Waste Generators All operations related to the generation of hazardous waste and the hazardous waste generated will comply with state and federal RCRA requirements. Identified Federal ARARS include: RCRA Identification and Listing of Hazardous Wastes, Toxicity Characteristics; RCRA Subtitle C Standards for Owners and Operators of Hazardous Waste TSD Facilities, and RCRA Subtitle C Subpart F-releases from Solid Waste Management Units. Identified state ARARs include: Massachusetts Hazardous Waste Management Regulations (HWMR)-Requirements for Generators, and Massachusetts HWMR-Location Standards.

Food Tolerance Massachusetts Department of Public Health (DPH) food tolerance levels for EDB in food products are being considered in the selection and design of FS-1 remedial

alternatives. Cranberry testing would be undertaken as an additional measure of the performance of the alternative in attaining the surface water RAO.

Alternative 3B is effective in the long term and reliable. Modeling for this alternative estimates that the MMCL of 0.02 μg/L EDB in groundwater will be achieved within 7 years. Of the estimated total of 11 kg of EDB in the aquifer, modeling indicates that 83% will be extracted by the remediation system, 11% will escape the extraction system and discharge beyond the model boundaries, and 6% will remain dispersed through the aquifer. It is assumed that that portion of EDB that escapes extraction and is not retained in the aquifer discharges to surface water. If the EDB is not extracted, and does not escape the boundaries of the plume, it is assumed to be immobile. The portion of EDB that is not extracted and does not escape the boundaries of the model is assumed to be either trapped in silts, in blind pores that are not connected to other pores that will allow transport, or is dissipated through the aquifer. It is anticipated that the surface water RAOs will be achieved within 1 year of system startup. The pilot system was put into operation in April 1999. It has and will continue to reduce human exposure to contaminants within the groundwater plume emanating from AOC FS-1 and surface water in the Quashnet River bogs. The groundwater and surface water monitoring and site inspection programs will document the continued effectiveness of this alternative.

Alternative 3B is reliable. All components of the remedial system are standard remedial action equipment. The equipment has a history of successful operations. Additionally, the system will be operated and maintained in a manner that ensures proper functioning. The Leading Edge Extraction and Reinjection/Discharge aspects of Alternative 3B are flexible and can be rapidly modified to address site conditions or to optimize performance. Additionally, because of the modular nature of this system, a catastrophic failure of the system is less likely than a system relying on a small number of high production wells. This versatility enhances the reliable protection of human health and the environment.

There are technical difficulties associated with Alternative 3B. Potential difficulties include construction of stable berms over unstable organic materials, fouling of small-diameter wells if high entrance velocities are used, construction of stable piping networks between wells in the bogs, metals precipitation in GAC filter canisters, channelization of the GAC filter canisters, and other problems. However, those problems can be overcome with good engineering and construction practices.

Implementation and supervision of the design, construction, and O&M of the alternative will require close coordination with local, state, and federal agencies. The implementation of institutional controls and access restrictions associated with this alternative will require administrative and regulatory support from local, state, and federal agencies.

Several institutional controls protect area residents from exposure to FS-1 groundwater contaminants. The safety of all public water supplies within Massachusetts is regulated by the Commonwealth. Residents and workers on MMR receive their water from the base water supply system. The institutional controls presently in place adequately prevent residential exposure in all Mashpee households currently connected to the municipal water supply and all residents and workers on MMR.

At its July 29, 1999, meeting, the Mashpee Board of Health adopted a moratorium on groundwater wells to minimize the risk of exposure to groundwater contamination. These regulations prohibit the use of existing or future wells located in documented or anticipated areas of groundwater contamination for any purpose.

Institutional controls are already in place to prevent the drilling of private wells on the MMR. A lengthy review process must be completed before a public water supply well can be drilled on the military base. This process includes DEP review and ensures that wells will not be located in or immediately downgradient of known groundwater contamination plumes. AFCEE will coordinate with the base Civil Engineer and the Town of Mashpee periodically (but not less than annually) to ensure the two entities know of any changes to the plume configurations and/or contaminant concentrations.

The principal capital cost components for this alternative will be associated with the construction of the extraction, treatment, and reinjection systems. Estimated capital costs are $6,385,00. The O&M costs incurred by implementing this alternative will be for O&M of the remediation system, performing groundwater monitoring, and site inspections. Total O&M costs for the life of the project are estimated at $4,149,000. The total present worth for this alternative was calculated using an inflation of 5% annually, then calculating present worth based on a 7% annual discount rate. All calculations assume that O&M activities will extend for a period of 7 years. This results in a present worth cost of $10,561,000. A summary of costs and assumptions for this alternative is presented in Appendix F.

Alternative 3B includes the pilot test system and therefore the costs of the system were capitalized under the cost estimate for Alternative 3B. Because the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.

2.11 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

2.11.1 Alternative Evaluation Criteria

Section 121(b)(1) of CERCLA presents several factors that, at a minimum, AFCEE is required to consider in its assessment of remedial action alternatives. Building upon these specific statutory mandates, the NCP specifies nine evaluation criteria that are categorized into three levels (threshold, balancing, and modifying) that are to be used in assessing the individual remedial alternatives. The nine criteria are used to compare the alternatives and select a remedy that meets the goals of protecting human health and the environment, maintaining protection over time, and minimizing untreated waste. Definitions of the nine criteria are provided below.

2.11.1.1 Threshold Criteria

Each of the two threshold criteria described below must be met for an alternative to be eligible for selection in accordance with the NCP. These are considered threshold criteria because they establish the minimum requirements that a remedial alternative must achieve.

- **Overall protection of human health and the environment.** This criterion assesses whether a remedy will protect human health and the environment and includes an assessment of how human health and environmental risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- **Compliance with applicable or relevant and appropriate requirements.** This criterion assesses whether a remedy complies with all federal and state environmental and facility-siting laws and requirements that apply or are relevant and appropriate to the conditions and cleanup options at a specific site. If an alternative cannot meet an ARAR, the analysis of the alternative must provide the rationale for invoking a statutory waiver.

2.11.1.2 Primary Balancing Criteria

The following five criteria are used to compare and evaluate the alternatives that meet the threshold criteria. The effectiveness of a remedial action in achieving these criteria may sway favor toward one alternative or another. These criteria provide a preliminary evaluation of the extent to which the alternative employs permanent solutions and treatment in a cost-effective manner to achieve the site remedial action objective.

- **Long-term effectiveness and permanence.** This criterion assesses the effectiveness of the alternative in protecting human health and the environment after response objectives have been met. In addition, it includes consideration of the magnitude of residual risks and the adequacy and reliability of controls.

- **Reduction of toxicity, mobility, or volume through treatment.** This criterion evaluates the effectiveness of treatment processes used to reduce toxicity, mobility, or volume of hazardous substances. It also considers the degree to which treatment is irreversible and the type and quantity of residuals remaining after treatment. SARA emphasizes that, whenever possible, a remedy should be selected that uses treatment to permanently reduce the toxicity of contaminants at the site, the spread of contaminants away from the source of contamination, and the volume or amount of contamination at the site.

- **Short-term effectiveness.** This criterion evaluates the effectiveness of the alternative in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met. It considers the protection of the community, workers, and the environment during implementation of remedial actions.

- **Implementability.** This criterion assesses the technical and administrative feasibility of an alternative and availability of required goods and services. Technical feasibility considers the ability to construct and operate a technology and its reliability, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of a remedy. Administrative feasibility considers the ability to obtain approvals from other parties or agencies and the extent of required coordination with other parties or agencies.

- **Cost.** This criterion evaluates the capital and O&M costs of each alternative.

2.11.1.3 Modifying Criteria

The modifying criteria are used in the final evaluation of remedial alternatives, generally after AFCEE has received public comments on the FS and Proposed Plan.

- **State acceptance.** This criterion considers the state's preferences among or concerns about the alternatives, including comments on ARARs or the proposed use of waivers.
- **Community acceptance.** This criterion considers the community's preferences among, or concerns about, the alternatives.

Following the detailed analysis of each individual alternative, AFCEE performed a comparative analysis focusing on the relative performance of each alternative with respect to the nine evaluation criteria. The purpose of the comparative analysis was to identify the advantages and disadvantages of the alternatives relative to one another and to aid in the eventual selection of a remedial alternative for soil at each AOC. A detailed analysis of the alternatives using the evaluation criteria is provided in the FS (HAZWRAP 1998). Section 2.9.2 of this ROD summarizes the comparative analysis of alternatives for AOC FS-1.

2.11.2 Comparative Analysis of Alternatives

The following sections summarize the comparative analysis of alternatives performed in the FS for AOC FS-1.

Table 2.9-1 presents a comparative analysis of alternatives for AOC FS-1.

2.11.2.1 Overall Protection of Human Health and the Environment

All the alternatives except Alternative 1 (No Action) provide adequate protection of human health and the environment. Although the reduction in risk was not calculated, groundwater is restored to drinking water standards (MCLs and MMCLs). At the time that MCLs and MMCLs are achieved, a risk assessment will be performed to determine are posed by any residual contaminants remaining at or blow these levels posed by MCLs. If residual risk remains after achieving MCLs, additional or other remedial actions may be taken. Surface water is protected by the alternatives through the extraction of groundwater. Alternatives 2B, 3, and 3B prevent further migration of contaminated groundwater by extracting and treating the plume to health-based ARARs. Human health is protected during implementation of Alternatives 2B, 3, and 3B by restricting the use of groundwater, and active removal of EDB-contaminated water prior to that water discharging to the Quashnet River.

Alternative 3B is considered the most protective of human health because it incorporates the currently operating Quashnet River Bogs Pilot Test, thereby reducing or eliminating the migration of EDB into the surface water by approximately April 2000. Alternative 3 provides less overall protection because the axial pump and treat system will not be operational until late 2000.

Alternative 2B is less effective because it does not remove as much mass of EDB from the aquifer.

Alternative 3B is considered the most protective of human health because of the combined utilization of leading edge extraction and axial extraction. The advantage of Alternative 3B over Alternative 2B is the use of axial wells. Aquifer cleanup is more rapid using an axial well component and will extract a higher percentage of contamination. Alternative 3B is more protective than Alternative 3 because Alternative 3B incorporates leading edge extraction. Leading edge extraction is flexible and can be rapidly modified to address site conditions or to optimize performance. Additionally, because of the modular nature of leading edge extraction, a catastrophic failure of this system is less likely than a system proposed under Alternative 3 which relies exclusively on deep high-production axial extraction wells. Portions of the leading edge extraction system can fail without seriously impacting the overall effectiveness of the extraction. Further more, the leading edge extraction system will act as a "safety net" since it is likely to capture any contamination that may escape the axial extraction system. Repair and maintenance of the leading edge extraction system is easier and quicker than repair of deep axial wells The versatility of Alternative 3B enhances the protection of human health and the environment. Alternative 3B is the most reliable of evaluated alternatives.

2.11.2.2 Compliance with ARARs

The evaluation of the ability of the alternatives to comply with ARARs included a review of chemical-specific, action-specific, and location-specific ARARs that was presented earlier in this report. Under Alternatives 3 and 3B, chemical-specific ARARs will be met in approximately 7 years. Chemical specific ARARs will be achieved with Alternative 2B in 11 years. With respect to action-specific and location-specific ARARs, all the alternatives, except the No Action alternative, will meet all the respective ARARs.

2.11.2.3 Long-term Effectiveness and Permanence

Alternatives 2B, 3, and 3B provide good long-term effectiveness and permanence because all three alternatives use treatment technologies to reduce hazards posed by contaminants in groundwater and surface water. Alternative 1 does not provide long-term effectiveness and permanence.

Alternative 3B relies on the extraction of groundwater along the axis of the plume and at the toe of the plume. This configuration results in shorter flowpaths to the extraction system than does Alternative 2B. Note that the effectiveness of a system is dependent on the startup date. The model assumes that the extraction system is currently operating. If system startup of 3B is delayed, the amount of EDB captured by the system will decrease. A portion of Alternative 3B, the extraction at the toe of the plume, is currently operational as the Quashnet River Bogs Pilot Test. It is extracting EDB. The model indicates that the Alternative 3B extraction and treatment system will extract 83% of EDB contained in the aquifer. Eleven percent of the EDB will escape the extraction system according to model calculations. Review of the groundwater flow patterns indicates that the EDB escapes to the Quashnet River. Six percent of the EDB will be retained in the aquifer and be trapped in either silts or blind pores. The model also indicates that minimal additional reduction of EDB concentrations is achieved through additional operation of the extraction system after 7 years. The risks associated with the EDB that escapes the extraction system or is retained in the aquifer is minimal. If the EDB discharges to the Quashnet River, the EDB that discharges will no longer be a risk in groundwater. A ratio analysis of risk indicates that the surface water RME cancer risk from the EDB that escapes to the Quashnet River will be

6.6×10^{-6} and the central tendency exposure (CTE) will be 7×10^{-7}. The portion of EDB that remains in the aquifer is immobile and does not cause a risk to human health or the environment.

Alternative 3 relies on the extraction of groundwater along the axis of the plume. This configuration results in shorter flowpaths to the extraction system than does Alternative 2B. Note that the effectiveness of the system is dependent on the startup date. The model assumes that the extraction system is currently operating. If system startup is delayed, the amount of EDB captured by the system will decrease. No portion of Alternative 3 is presently extracting contaminated groundwater. The model indicates that the Alternative 3 extraction and treatment system will extract 83% of the EDB contained in the aquifer. Eleven percent of the EDB will escape the extraction system according to model calculations. Review of the groundwater flow patterns indicates that the EDB escapes to the Quashnet River. Six percent of the EDB will be retained in the aquifer and be trapped in either silts or blind pores. The model also indicates that minimal additional reduction of EDB concentrations is achieved through additional operation of the extraction system after 7 years. The risks associated with the EDB that escapes the extraction system or is retained in the aquifer are minimal. If the EDB discharges to the Quashnet River, the EDB that discharges will no longer be a risk in groundwater. A ratio analysis of risk indicates that the surface water RME cancer risk from the EDB that escapes to the Quashnet River will be 6.6×10^{-6} and the CTE will be 7×10^{-7}. The portion of EDB that remains in the aquifer is immobile and does not cause a risk to human health or the environment.

Alternative 2B relies on the extraction of groundwater at the toe of the plume and is consequently dependent on the natural flow of groundwater to the extraction system. An initial configuration of Alternative 2B is currently operational as the Quashnet River Bogs Pilot Test. Also note that the effectiveness of the system is dependent on the startup date. The model assumes that the extraction system is currently operating. The model indicates that the extraction and treatment system will extract 68% of the EDB contained in the aquifer. Eighteen percent of the EDB will escape the extraction system. Review of the groundwater flow patterns indicates that the EDB escapes to the Quashnet River. Fourteen percent of the EDB will be retained in the aquifer and be trapped in either silts or blind pores. Based on modeling results, minimal additional reduction of EDB concentrations will be achieved through additional operation of the extraction system after 11 years. The risks associated with the EDB that escapes the extraction system or is retained in the aquifer is minimal. If the EDB discharges to the Quashnet River, the EDB that discharges will no longer be a risk in groundwater. A ratio analysis of risk indicates that the surface water RME cancer risk from the EDB that escapes to the Quashnet River will be 1.1×10^{-5} and the CTE will be 7×10^{-7}. The portion of EDB that remains in the aquifer is immobile and does not cause a risk to human health or the environment.

2.11.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 2B, 3, and 3B would reduce contaminant mobility, toxicity, and/or volume. Alternative 3B maximizes reduction of contaminant mobility, toxicity, and/or volume. Alternative 3 does not reduce contaminant mobility, toxicity, and/or volume as well as does Alternative 3B because the leading edge extraction, treatment and reinjection/discharge aspect of Alternative 3B is already extracting contaminants and Alternative 3 will not extract contaminants until some future date. Consequently, some contamination captured by Alternative 3B will escape Alternative 3. Alternative 2B reduces contaminant toxicity, mobility, and/or volume less than Alternative 3 or Alternative 3B because that system removes less contamination from the

aquifer based on modeling results. Alternative 1 would not reduce toxicity, mobility, and/or volume and availability through treatment. Alternatives 2B, 3, and 3B satisfy the preference for treatment. Alternative 1 does not.

2.11.2.5 Short–term Effectiveness

Alternatives 2B, 3, and 3B would be short-term effective. All three alternatives would protect human health and the environment during implementation of the alternative. Workers constructing or operating the remedial system could be exposed to the contamination during construction and implementation of the remedial actions. Also, there is the potential for contaminants to be released into the environment during construction. However, exposure of workers to contaminants and releases of contaminants to the environment could be controlled, thereby reducing such problems. Alternative 1 would not have any adverse impacts to the community or workers during implementation since no action would be taken.

2.11.2.6 Implementability

Alternative 3B is the most difficult to implement. Alternative 3 would be less difficult than 3B, and 2B would be less difficult than 3 or 3B. This variation in difficulty is directly related to the amount of construction required for each option. However, all such activities are common groundwater cleanup components and do not present any unusual implementation issues. Alternative 1 is easily implemented.

Construction in a wetland area requires that permits be obtained as appropriate and there be close coordination with the state and local authorities. For the leading edge component of alternatives 2B and 3B, construction was conducted under the General Permit requirements and local wetland issues have been coordinated and are being managed by an Order of Conditions issued by the Mashpee Conservation Commission

2.11.2.7 Cost

Cost includes the capital (up front) cost of implementing an alternative and the long-term cost of operating and maintaining the alternative. Capital and O&M costs for each alternative were calculated with an estimated accuracy of -30% to +50%. In general, the alternative with the lowest capital cost is that which includes the least amount of construction, the No Action alternative. Alternative 3B has the highest capital cost.

Alternative 3B is the most expensive alternative ($10,561,000 present worth cost for 7 years), followed by Alternative 3 ($8,699,000 present worth cost for 7 years), Alternative 2B ($9,423,000 present worth cost for 11 years), and Alternative 1 at $0.

Alternative 3B includes the pilot test system and therefore the costs of the system were capitalized under the cost estimate for Alternative 3B. Because the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.

Alternative 3 does not include the pilot test system and therefore the costs of the system were not capitalized under the cost estimate for Alternative 3. Please note however, that since the pilot

system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.

2.11.2.8 State Acceptance

The Commonwealth of Massachusetts has reviewed the RI and FS reports and the Proposed Plan and concurs with AFCEE's selected remedy (Alternative 3B).

2.11.2.9 Community Acceptance

AFCEE received no verbal comments during the public hearing held June 23,1999. AFCEE received no written comments from the general public during the public comment period. Comments were provided by the Joint Process Action Team (JPAT), the Massachusetts Military Reservation Natural Resources Trustee Council, the National Oceanic and Atmospheric Administration, and the Massachusetts Division of Fisheries and Wildlife.

Organizations that provided comments were primarily interested in the impact of the remediation system on the Quashnet River bogs and fisheries; the focus of the proposed cleanup; potential impact on public water supplies; and potential health impacts if EDB continues to upwell in the bogs. Organizations approved of the chosen alternative.

A Responsiveness Summary that addresses all comments received at the Public Hearing and that were provided during the public comment period is provided as Appendix C. All correspondence received from the public is included as Attachment A to the Responsiveness Summary. Appendix D is the transcript of the Public Hearing.

2.12 THE SELECTED REMEDY (ALTERNATIVE 3B)

The chosen alternative is Alternative 3B, Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge. Alternative 3B includes:

- Additional modeling to optimize the extraction system.
- Sampling and analysis to verify the boundaries of contamination that exceeds the MCLs. Additional bounding wells will be installed.
- Acquisition of property necessary to the extraction wells will be acquired. Acquisition may be through lease or purchase.
- Site preparation by constructing road(s) along the proposed path of extraction wells. For cost purposes, it is assumed that 3 miles of gravel road will be created.
- Installation of power and well controls wiring along the roadway(s).
- Installation of 17 deep axial extraction wells pumping at approximately 400 gpm.
- Installation of one deep extraction well pumping at approximately 200 gpm.
- Installation of 135 shallow well points pumping a total of 400 gpm.
- Installation of 19 reinjection wells capable of injecting 200 gpm.
- Construction of a surface water discharge system capable of discharging 800 gpm to the bog area.

- Construction of berms to separate areas of upwelling contaminated groundwater from areas in the bog at which contaminated groundwater does not upwell.
- Construction of additional treatment facility capacity using activated carbon adsorption to create a treatment facility capable of treating 1,000 gpm.
- Operation and maintenance of the system for 7 years.
- Performance of an ecological sampling program to ensure that groundwater extraction, treatment and reinjection/discharge does not impact sensitive aquatic habitat.
- AFCEE will conduct a round of fish sampling in 2000 and 2001 as a measure of meeting the remedial action objective related to surface water. Identified objectives include evaluation of the fish ingestion pathway and determination of environmental impact on the fish in the surface water of the Quashnet River cranberry bog complex.

Construction activities associated with the Quashnet River Bogs Pilot Test are complete. Implementation of the axial well extraction system and enlargement of the treatment facility and discharge systems will begin within 15 months of signature of the final ROD.

Monitoring site conditions will involve collecting and analyzing groundwater and surface water samples. These site inspections, and the collection and analysis of groundwater and surface water samples, will be performed quarterly for the first 2 years and annually thereafter for 5 years. The sampling, analysis, data validation, and preparation of a monitoring report will require approximately 12 weeks per sampling event. Monitoring wells adequate for such monitoring exist at the AOC. Surface water will also be monitored. Additionally, wells in the source area will be resampled for metals and VOCs to verify the presence of VOCs and metals above background and MCLs. The monitoring program will involve groundwater and surface water sampling for EDB by USEPA Method 504, VOCs by USEPA Method 524, and metals by USEPA Method 200.7/6010/7000 .

Institutional controls will be employed that include placing of zoning restrictions on the AOC to limit site activities. Identified restrictions include restrictions preventing use of impacted groundwater for 7 years. The leading edge extraction system is operational as the Quashnet River Bogs Pilot Test, and it is expected that surface contamination will be significantly reduced by April 2000. The authority for institutional controls for FS-1 involves on-base and off-base authorities. For source area groundwater, there is no immediate risk. Residents and workers on the base obtain drinking water from the base water supply system. Construction projects on MMR, including water supply wells, require written approval from the Base Civil Engineer. Construction of a new drinking water supply well for MMR would also require DEP permission. For downgradient groundwater, institutional controls have been enacted by the Town of Mashpee. Mashpee has placed a moratorium on wells impacted by contaminated groundwater.

2.12.1 Summary of the Rationale for the Selected Remedy (Alternative 3B)

Alternative 3B, Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge was selected as the remedy because that alternative best satisfies the threshold criteria, overall protection of Human Health and the Environment. A component of that alternative, "Leading Edge Extraction, Treatment and reinjection Discharge" is presently operating as the Quashnet River Bogs Pilot Test. Therefore, that system is already protecting human health by reducing releases of EDB into surface water.

Alternative 3B is considered the most protective of human health because of the combined utilization of leading edge extraction and axial extraction. The advantage of alternative 3B over Alternative 2B is the use of axial wells. Aquifer cleanup is more rapid using an axial well component and will extract a higher percentage of contamination. Alternative 3B is more protective than Alternative 3 because Alternative 3B incorporates leading edge extraction. Leading edge extraction is flexible and can be rapidly modified to address site conditions or to optimize performance. Additionally, because of the modular nature of leading edge extraction, a catastrophic failure of this system is less likely than a system proposed under Alternative 3 which relies exclusively on deep, high-production axial extraction wells. Portions of the leading edge extraction system can fail without seriously impacting the overall effectiveness of the extraction. Further more, the leading edge extraction system will act as a "safety net" since it is likely to capture any contamination that may escape the axial extraction system. Repair and maintenance of the leading edge extraction system is easier and quicker than repair of deep axial wells. The versatility of Alternative 3B enhances the protection of human health and the environment. Alternative 3B is the most reliable of evaluated alternatives.

All alternatives include monitoring of source area groundwater. This remedy is appropriate for the source area, because the contaminants contained in source area groundwater are not mobile and do not present a current threat to humans or the environment.

2.12.2 Summary of Estimated Remedy Costs

The principal capital cost components for this alternative will be associated with the construction of the extraction, treatment, and reinjection systems. Estimated capital costs are $6,385,00. The O&M costs incurred by implementing this alternative will be for O&M of the remediation system, performing groundwater monitoring, and site inspections. Total O&M costs for the life of the project are estimated at $4,149,000. The total present worth for this alternative was calculated using an inflation of 5% annually, then calculating present worth based on a 7% annual discount rate. All calculations assume that O&M activities will extend for a period of 7 years. This results in a present worth cost of $10,561,000. A summary of costs and assumptions for this alternative is presented in Appendix E.

Alternative 3B includes the pilot test system and therefore the costs of the system were capitalized under the cost estimate for Alternative 3B. Because the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.

2.12.3 Expected Outcomes of the Selected Remedy (Alternative 3B)

The selected remedy (Alternative 3B) will have minor impacts on land use. At the completion of remedial actions, all land and bog areas will be available for unrestricted use. Additionally, fish habitat will be improved in certain areas and the Quashnet River cranberry bogs will be returned to marketable condition.

Groundwater uses will be unrestricted upon achieving remediation goals. The current goals for completion of remediation are contingent on residual risk calculations. The initial target for EDB cleanup is the Massachusetts MCL (MMCLs) of 0.02 μg/L. It is estimated that the Selected remedy (Alternative 3B) could reach the EDB MMCL of 0.02 μg/L in 7 years for the

downgradient detached plume. However, prior to shutdown, risk assessments will be performed to evaluate residual risks. If residual risks are unacceptable, the remedial system will continue operation. In addition, once residual risks are acceptable, the technical and economic feasibility of continuing remediation to approach or achieve background concentrations will be evaluated. If additional cleanup is warranted pursuant to such analyses, any estimates regarding the time to attain more stringent cleanup levels would be presented in ESD or ROD Amendment.

Surface water uses will be unrestricted upon achieving groundwater remediation goals or sooner if surface water contamination is reduced to acceptable levels before achieving groundwater remediation goals. It is estimated that surface water use will be unrestricted within 1 year of system startup because contaminated groundwater will be prevented from discharging to surface water.

The low level threat compounds toluene, lead, and thallium, which will be monitored in the source area as part of the selected remedy (Alternative 3B), will not impact land or groundwater use. These compounds are constrained within the base boundary.

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3. STATUTORY DETERMINATION

The selected remedy (Alternative 3B) for AOC FS-1 is consistent with CERCLA and, to the extent practicable, the NCP. The selected remedy (Alternative 3B) is protective of human health and the environment, attains ARARs, and is cost-effective. The statutory preference for treatment that permanently and significantly reduces the toxicity, mobility, or volume of hazardous substances as a principal element is satisfied.

3.1 THE SELECTED REMEDY (ALTERNATIVE 3B) IS PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy (Alternative 3B) protects human health and the environment by extracting groundwater contaminated with EDB that poses an unacceptable risk, removes the EDB from groundwater with activated carbon treatment and reintroduces clean water into the aquifer and surface water. Moreover, by April 2000, the selected remedy (Alternative 3B) is expected to significantly reduce or eliminate discharge of EDB to the Quashnet River and thereby attain the surface water RAO. In addition to addressing potential future risks in groundwater and surface water through extraction and treatment, the selected remedy (Alternative 3B) addresses risks from exposure to surface water since contaminated water, if unchecked, discharges to surface water. After completion of remedial actions, EDB levels in the aquifer will meet or be less than MMCLs. AFCEE will employ the three step process outlined in Section 2.8 to evaluate cleanup completion.

A long-term monitoring program for groundwater and surface water will be implemented to ensure that the remedy is protective. For the source area groundwater, toluene, lead, and thallium will be monitored to ensure that toluene is degrading, and all three contaminants remain immobile. In the downgradient EDB groundwater plume, both groundwater and surface water will be monitored. As a measure of meeting the remedial action objective related to surface water, a round of fish sampling will be conducted in 2000 and 2001. Identified objectives include evaluation of the fish ingestion pathway and determination of environmental impact on the fish in the surface water of the Quashnet River cranberry bog complex.

There are no short-term threats associated with the selected remedy (Alternative 3B) that cannot be readily controlled using the health and safety measures planned for the remedial action and the access restrictions that will be in place. Institutional controls will be maintained until cleanup standards are attained.

3.2 THE SELECTED REMEDY (ALTERNATIVE 3B) ATTAINS APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The selected remedy (Alternative 3B) will attain all federal and state ARARs. No waivers are required. ARARs for AOC FS-1 were identified and discussed in the FS (HAZWRAP 1999). The ARARs and method of attainment are:

Chemical Specific

Groundwater It is expected that through capture and treatment at the leading edge and along the axis of the plume, the groundwater at AOC FS-1 will meet MCLs, nonzero maximum contaminant level goals (MCLGs) and MMCLs within 7years.

Location Specific

Wetlands and Floodplains Remedial actions will be performed in such a manner that wetland areas and floodplains will not be adversely impacted. All actions will comply with provisions and requirements contained in the federal and state ARARs which pertain to wetlands and floodplains. Identified federal ARARs are: Rivers and Harbors Act, Protection of Wetlands Executive Order, Clean Water Act Section 404, and Floodplain Management Executive Order. Identified state ARARs are: Massachusetts Wetlands Regulations Additionally, fill material will not be discharged to wetlands. Engineering controls will be used to prevent such discharges.

Fish and Wildlife Before modification of the bogs, the U.S. Fish and Wildlife Service will be consulted. All actions will comply with provisions and requirements contained in the federal ARARs that pertain to fish and wildlife. Identified ARARs are: Federal Fish and Wildlife Coordination Code.

Endangered Wildlife Endangered or threatened species will be identified during design. Activities will be conducted in a fashion that will not adversely impact sensitive species. Actions will comply with provisions and requirements contained in the state ARARs that pertain to endangered species. Identified ARARs are: Massachusetts Endangered Species Act

Action Specific

Groundwater Multiple applicable or relevant and appropriate requirements (ARARs) related to groundwater have been identified. Identified ARARS include the federal Underground Injection Control Program, Massachusetts Groundwater Discharge Permits, and Massachusetts Underground Water Source Protection. In all instances, remedial actions will comply with these ARARS.

Surface water Discharge of treated water into surface water will be in accordance with the National Pollutant Discharge Elimination System (NPDES).

Air Multiple ARARS associated with air have been identified. Identified air-related ARARS include RCRA Air Emission Standards for Process Vents, RCRA Air Emission Standards and Control of Emissions of Volatile Organic Compounds, and Massachusetts Air Pollution Control Requirements. Construction and on-site treatment activities will be performed to comply with identified ARARS.

Hazardous Waste Generators All operations related to the generation hazardous waste and the hazardous waste generated will comply with state and federal RCRA requirements. Identified federal ARARS include: RCRA Identification and Listing of Hazardous Wastes, Toxicity Characteristics; RCRA Subtitle C Standards for Owners and Operators of Hazardous Waste TSD Facilities, and RCRA Subtitle C Subpart F-releases from Solid Waste Management Units.

Identified state ARARs include: Massachusetts Hazardous Waste Management Regulations (HWMR)-Requirements for Generators, and Massachusetts HWMR-Location Standards.

Food Tolerance: Massachusetts Department of Public Health (DPH) food tolerance levels for EDB in food products are being considered in the selection and design of FS-1 remedial alternatives. Cranberry testing will be undertaken as an additional measure of the performance of the alternative in attaining the surface water RAO.

Table 3.2-1 summarizes the ARARs applicable to the selected remedy.

3.3 THE SELECTED REMEDY (ALTERNATIVE 3B) IS COST-EFFECTIVE

In AFCEE's judgment, the selected remedy (Alternative 3B) is cost-effective (i.e., the remedy affords overall effectiveness proportional to its costs). In selecting this remedy (and after AFCEE identified alternatives that are protective of human health and the environment and attain, or, as appropriate, waive ARARs), AFCEE evaluated the overall effectiveness of each alternative according to the relevant three criteria: (1) long-term effectiveness and permanence; (2) reduction in toxicity, mobility, or volume through treatment; and (3) short-term effectiveness, in combination. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs.

The costs of this remedial alternative are:

Estimated capital cost	$6,385,000
Estimated operation and maintenance cost	$4,149,000
Estimated total cost (present worth*)	$10,561,000

Alternative 3B includes the pilot test system and therefore the costs of the system were capitalized under the cost estimate for Alternative 3B. Because the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.

3.4 THE SELECTED REMEDY (ALTERNATIVE 3B) USES PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT OR RESOURCE RECOVERY TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE

AFCEE has determined that the selected remedy (Alternative 3B) represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for the contaminant source areas at AOC FS-1. Of those alternatives that are protective of human health and the environment and comply with ARARs, AFCEE has determined that this selected remedy (Alternative 3B) provides the best balance of tradeoffs among long-term effectiveness and permanence; reduction in toxicity, mobility, or volume achieved through treatment; short-term effectiveness; implementability; and cost. This alternative also considers the statutory preference for treatment as a principal element and considering state and community acceptance.

The selected remedy (Alternative 3B) provides optimum long-term effectiveness and permanence. Of the evaluated alternatives, Axial and Leading Edge Extraction/Treatment, and Reinjection/Discharge ensures that the maximum amount of groundwater possible is permanently treated and remediated. Relative to the other alternatives, this process provides the most permanent solution with the maximum treatment recovery possible and reduces the ecological risks at the AOC to levels equal to those of the other remedies.

The selected remedy (Alternative 3B) offers short-term effectiveness equivalent to other alternatives. Measures to control potential exposures during construction and operation of the treatment system through engineering and site access controls is identified and implemented as part of the Health and Safety Plan.

Only the selected remedy (Alternative 3B) provides maximum reduction in toxicity and mobility through treatment. The reduction in toxicity and mobility will be attained by extracting and treating groundwater. The maximization of the reduction of toxicity and mobility is a result of the present operation of the leading edge extraction system and operation of the axial system in the body of the plume. This alternative satisfies CERCLA's statutory preference for treatment as a principal component of a remedial action. With respect to implementability, the selected alternative is the most difficult because of the additional effort required to construct and maintain the remedial system, but it affords a more permanent and treatment-oriented solution.

Of the alternatives evaluated, the selected remedy (Alternative 3B), although not the least expensive alternative, is the most effective alternative involving treatment; and by use of treatment, it offers the greatest permanence.

Alternative 3B, Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge was selected as the remedy because that alternative best satisfies the threshold criteria, overall protection of Human Health and the Environment. A component of that alternative, "Leading Edge Extraction, Treatment and reinjection Discharge" is presently operating as the Pilot Study. The advantage of Alternative 3B over Alternative 2B is the use of axial wells. Aquifer cleanup is more rapid using an axial well component and will extract a higher percentage of contamination. Alternative 3B is more protective than Alternative 3 because Alternative 3B incorporates leading edge extraction. Leading edge extraction is flexible and can be rapidly modified to address site conditions or to optimize performance. Additionally, because of the modular nature of leading edge extraction, a catastrophic failure of this system is less likely than a system proposed under Alternative 3 which relies exclusively on deep, high-production axial extraction wells. Portions of the leading edge extraction system can fail without seriously impacting the overall effectiveness of the extraction. Also, the leading edge extraction system is likely to capture contamination that might escape axial wells if for some reason that contamination is not captured by the axial extraction system. Repair and maintenance of the leading edge extraction system is easier and quicker than repair of deep axial wells. The versatility of Alternative 3B enhances the reliable protection of human health and the environment. Alternative 3B is the most certain of evaluated alternatives.

3.5 THE SELECTED REMEDY (ALTERNATIVE 3B) SATISFIES THE PREFERENCE FOR TREATMENT THAT PERMANENTLY AND SIGNIFICANTLY REDUCES THE TOXICITY, MOBILITY, OR VOLUME OF HAZARDOUS SUBSTANCES AS A PRINCIPAL ELEMENT

The principal elements of the selected remedy (Alternative 3B) for AOC FS-1 are extraction and treatment of contaminated groundwater with reinjection/discharge of treated water. This remedy is a remedial action designed to address the principal threat at AOC FS-1: the organic compounds and EDB contamination in groundwater and surface water at concentrations that pose an unacceptable risk to human health. The selected remedy (Alternative 3B) permanently reduces the toxicity, mobility, and volume of contaminated groundwater.

3.6 FIVE YEAR REVIEW REQUIREMENTS

Because this remedy will result in hazardous substances, pollutants or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after the initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

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4. DOCUMENTATION OF NO SIGNIFICANT CHANGES

AFCEE presented a Proposed Plan (preferred alternative) for remedial action at AOC FS-1 source areas and groundwater at a public information meeting held on June 3, 1999, at the Mashpee Town Hall and at a Public Hearing held on June 23, 1999, at the Mashpee Town Hall. No significant changes have been made to the Axial and Leading Edge Extraction/ Treatment, and Reinjection/Discharge preferred alternative presented in the Proposed Plan.

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5. STATE ROLE

The Commonwealth of Massachusetts has reviewed the SI, RI, and FS reports and the Proposed Plan and concurs with the proposed remedial action decisions. The Commonwealth has also reviewed these documents to determine if the decision complies with applicable or relevant and appropriate laws and regulations of the Commonwealth. A copy of the letter of concurrence from the Commonwealth of Massachusetts is attached as Appendix E to this ROD.

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Appendix A

APPENDIX A
FIGURES

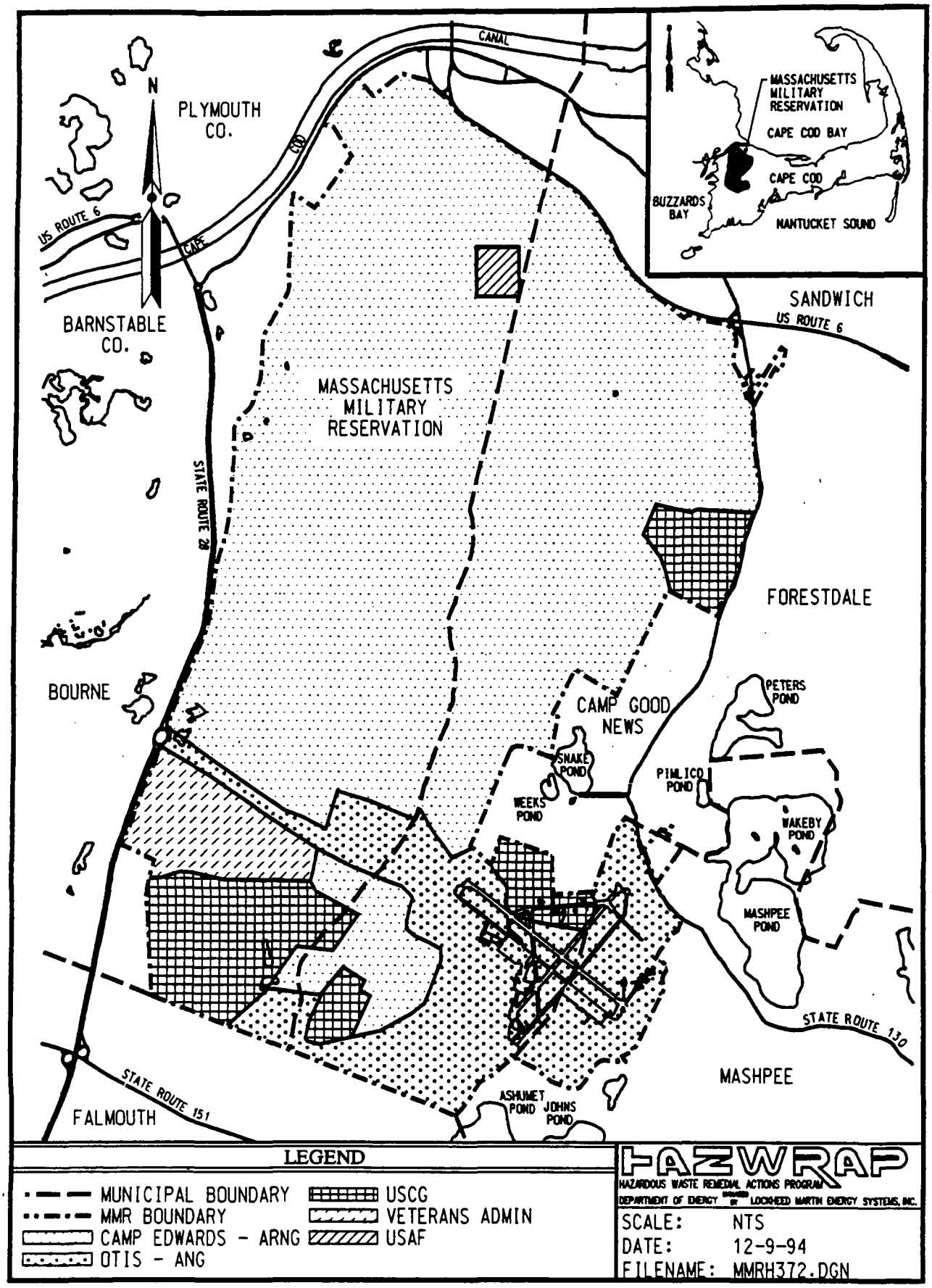


Figure 2-1. Regional location map of the MMR area.

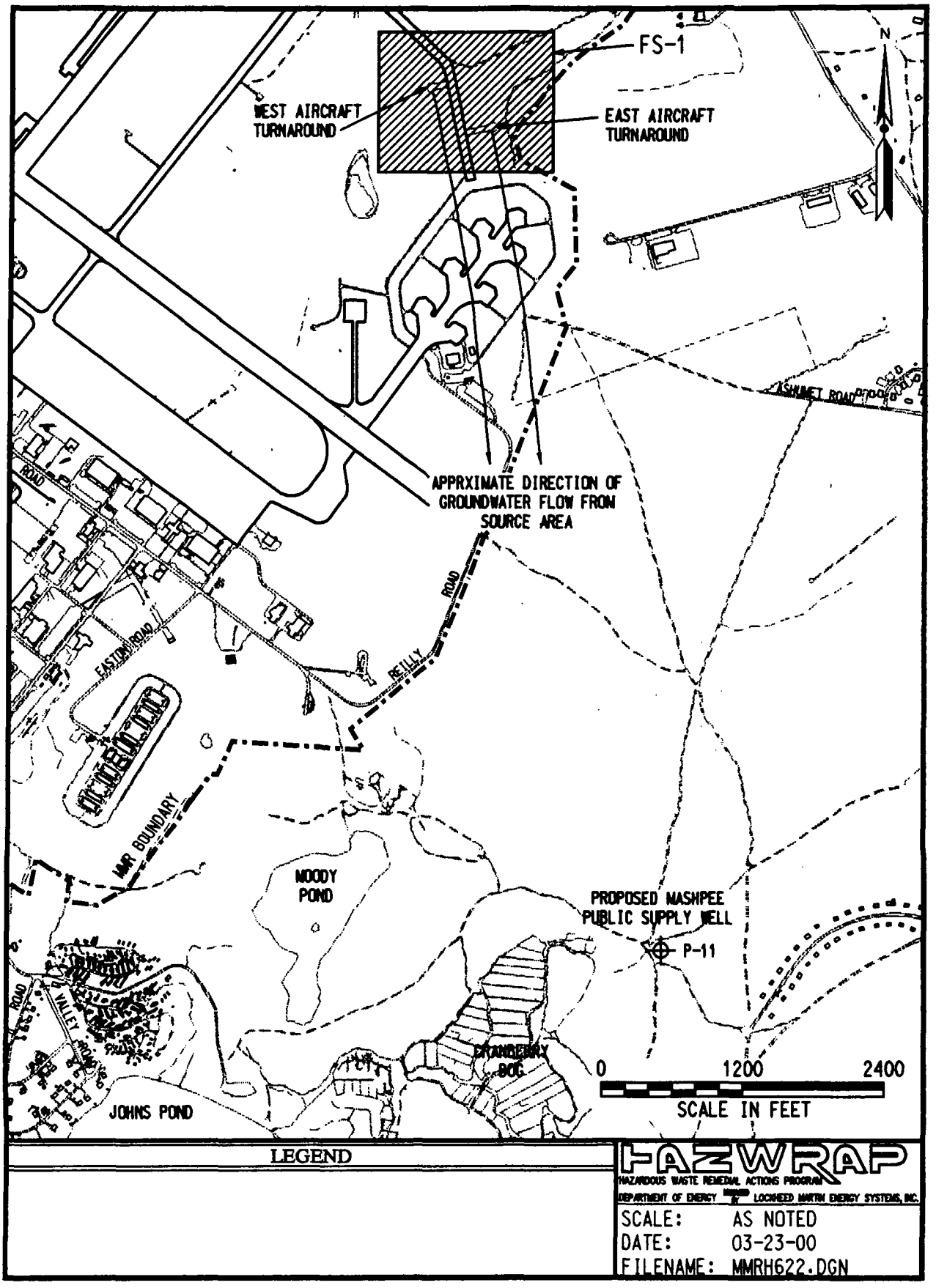


Fig. 2-2. AOC FS-1 Study Area Site Map.

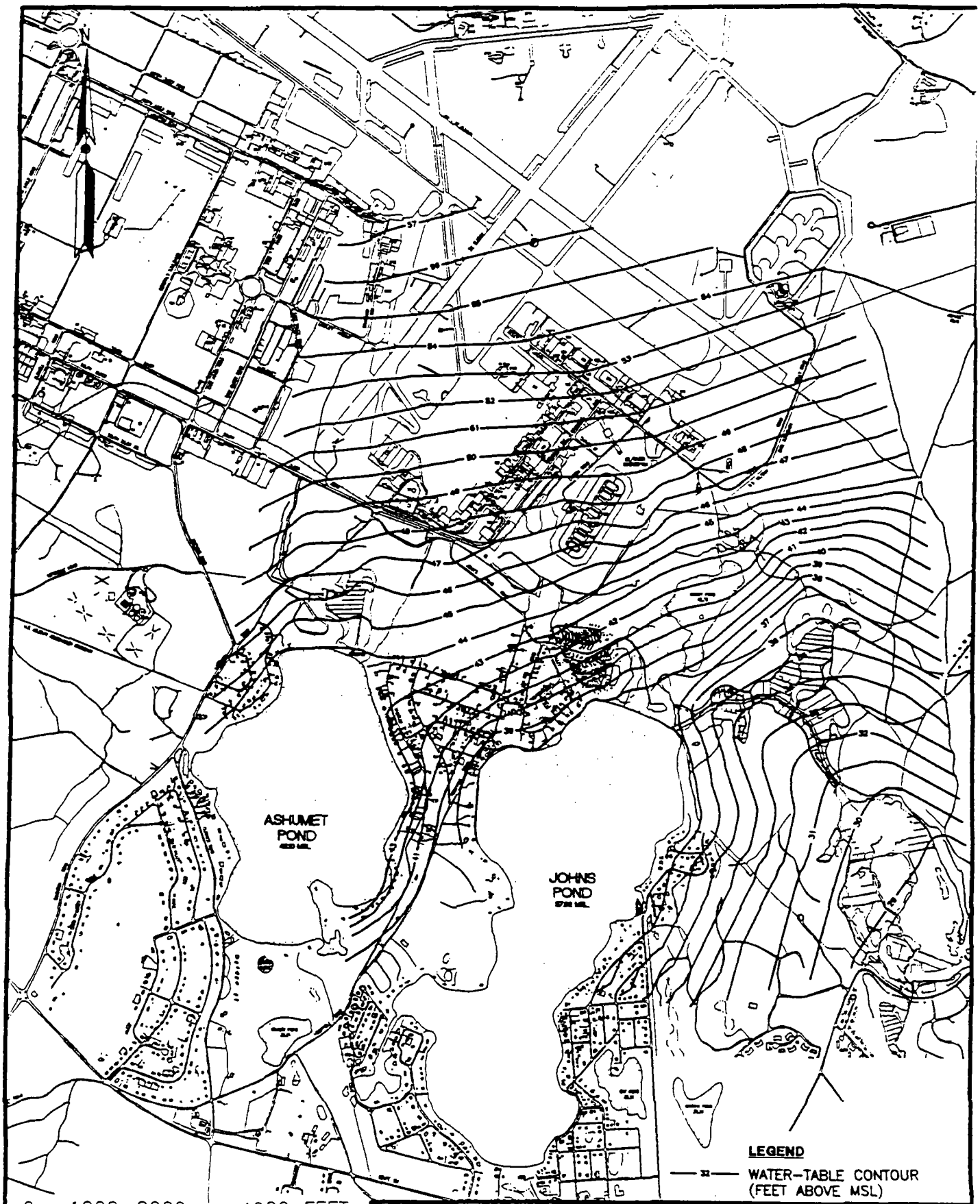


ABB Environmental Services Inc.

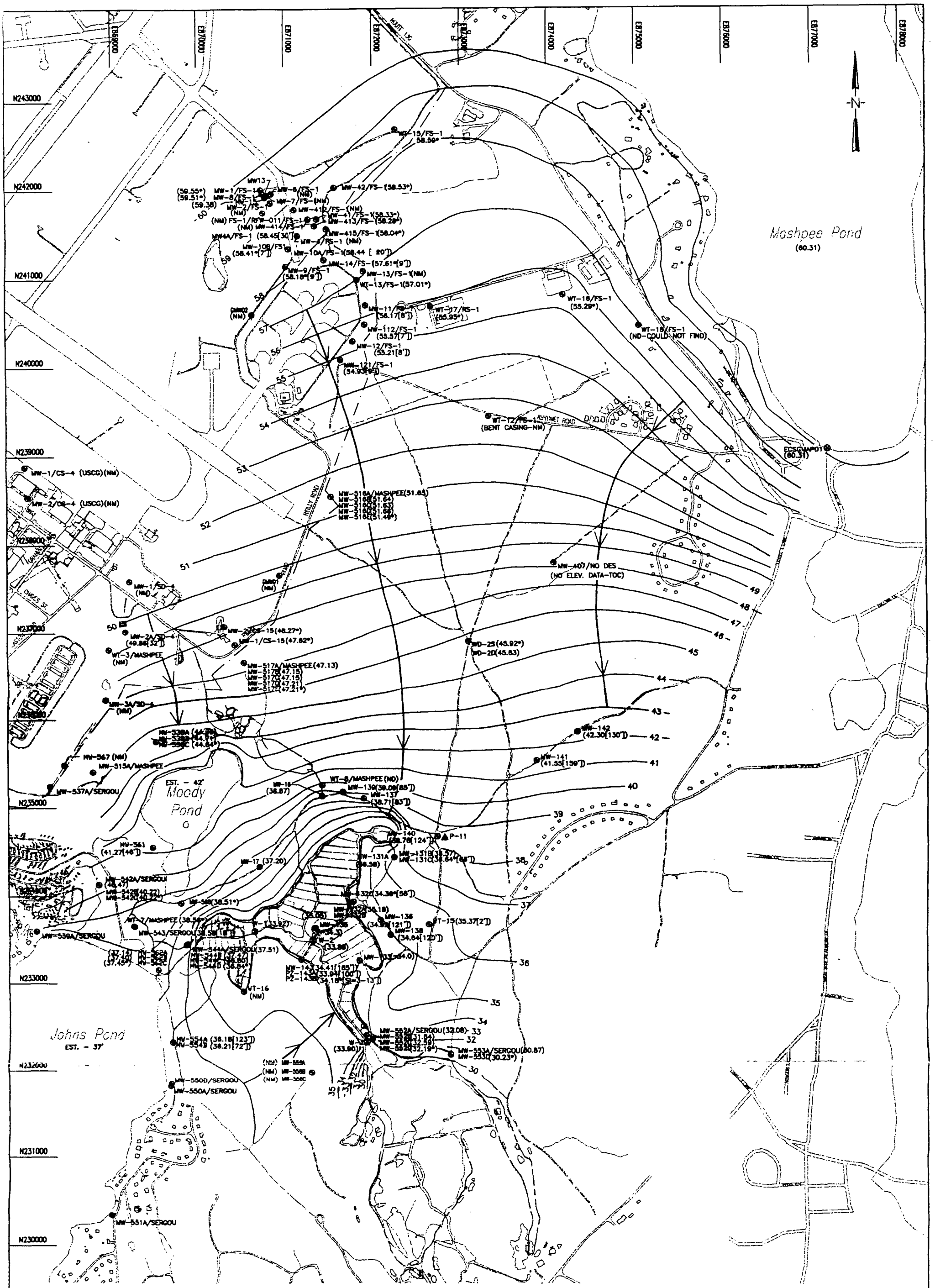
SERGOU
WATER-TABLE CONTOUR MAP
DECEMBER 1993

INSTALLATION RESTORATION PROGRAM
MASSACHUSETTS MILITARY RESERVATION

SERGOU
RI

FIGURE 2-3

H:\MM\7837-DA\(C)-8



LEGEND

- ▲ EXISTING PUMP TEST WELL
- ● WELL LOCATION
- —— GROUNDWATER CONTOURS
- ⊗ STAFF GAGE
- • INDICATES VALUES USED IN CONTOURING
- → GROUNDWATER FLOW

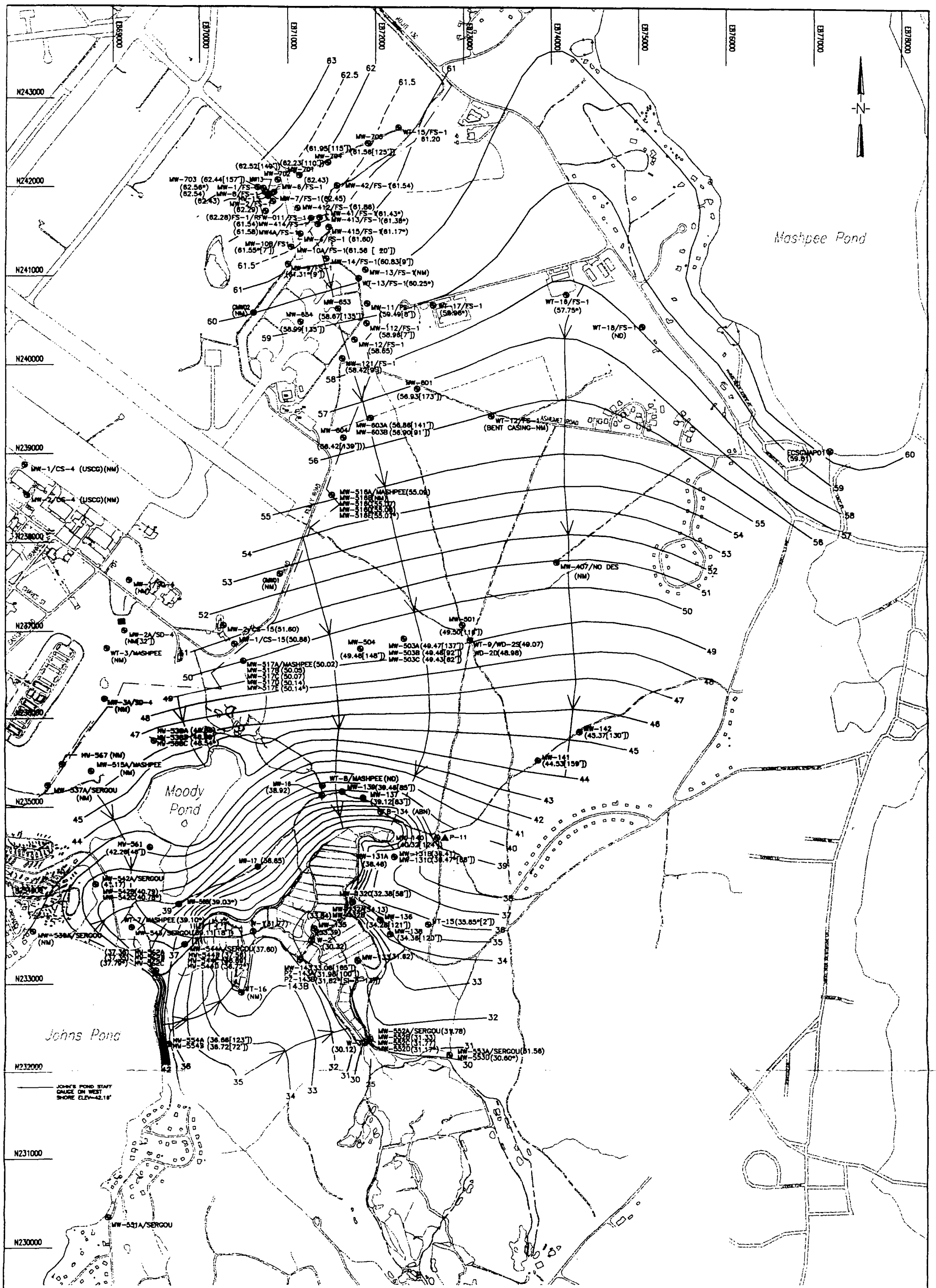
● MW-141 — WELL NUMBER
(41.55[159']) — GROUNDWATER ELEVATION; DISTANCE FROM WATER LEVEL TO TOP OF SCREEN

COMMODORE ADVANCED SCIENCES, INC.

SCALE IN FEET
1000 500 0 500 1000

FIGURE 2-4
WATER TABLE CONTOUR MAP
JANUARY 28 AND 29, 1998
AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

SCALE: 1"=1000'	DWN BY: KVP
DATE: 2-10-99	FILENAME: MMRM198.DWG



LEGEND

- ▲ EXISTING PUMP TEST WELL
- ⊕ WELL LOCATION
- — GROUNDWATER CONTOURS
- ⊗ STAFF GAGE
- • INDICATES VALUES USED IN CONTOURING
- → GROUNDWATER FLOW

WELL NUMBER

⊕ MW-141
(41.55[159'])

GROUNDWATER ELEVATION — DISTANCE FROM WATER LEVEL TO TOP OF SCREEN

COMMODORE ADVANCED SCIENCES, INC.

SCALE IN FEET

1000 500 0 500 1000

FIGURE 2-5
WATER TABLE CONTOUR MAP
APRIL 16 AND 17, 1998

AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

SCALE: 1"=1000'	DWN BY: KVP
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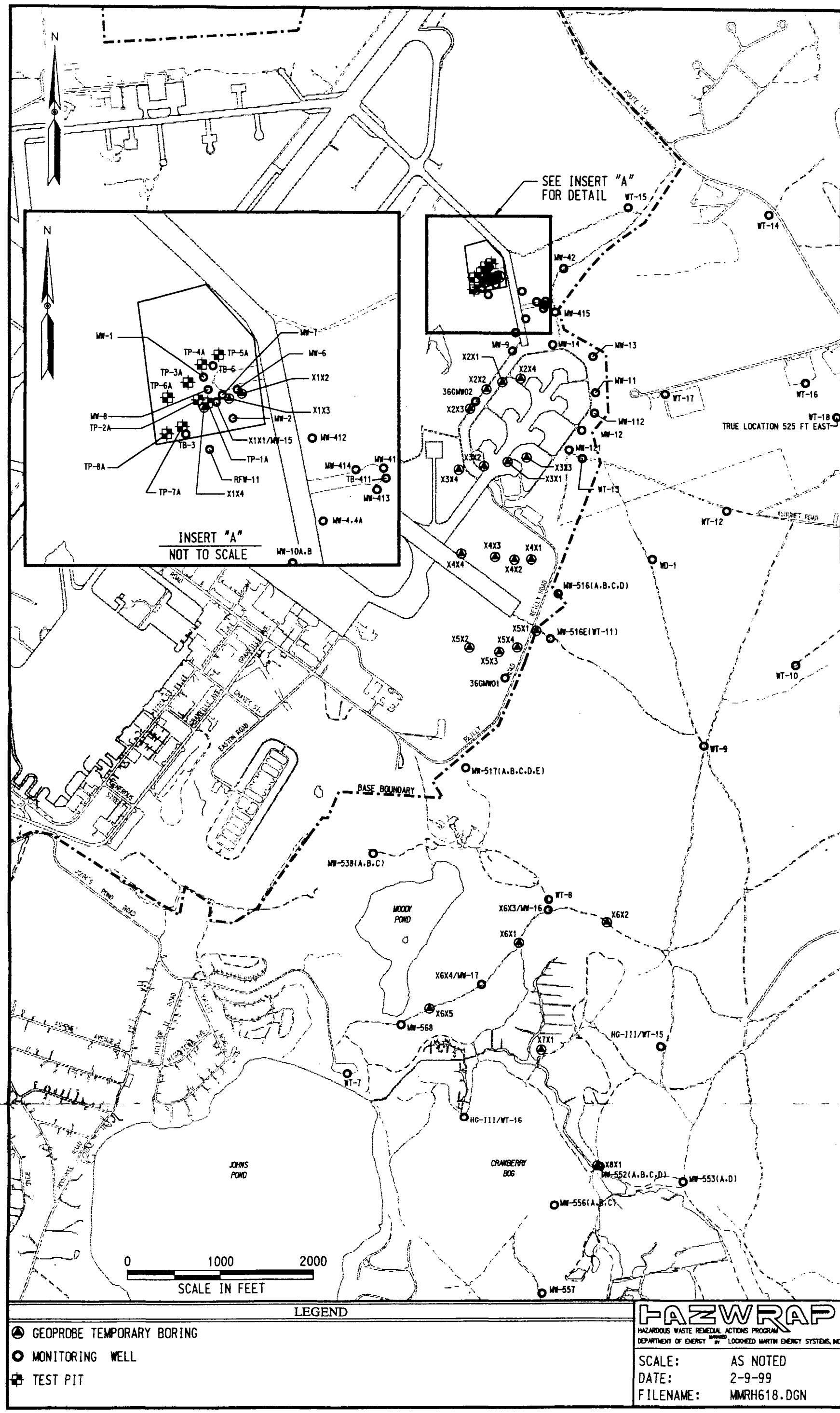


Figure 2-6. Monitoring well, temporary geoprobe boring and test pit locations prior to 1997/1998 investigation.

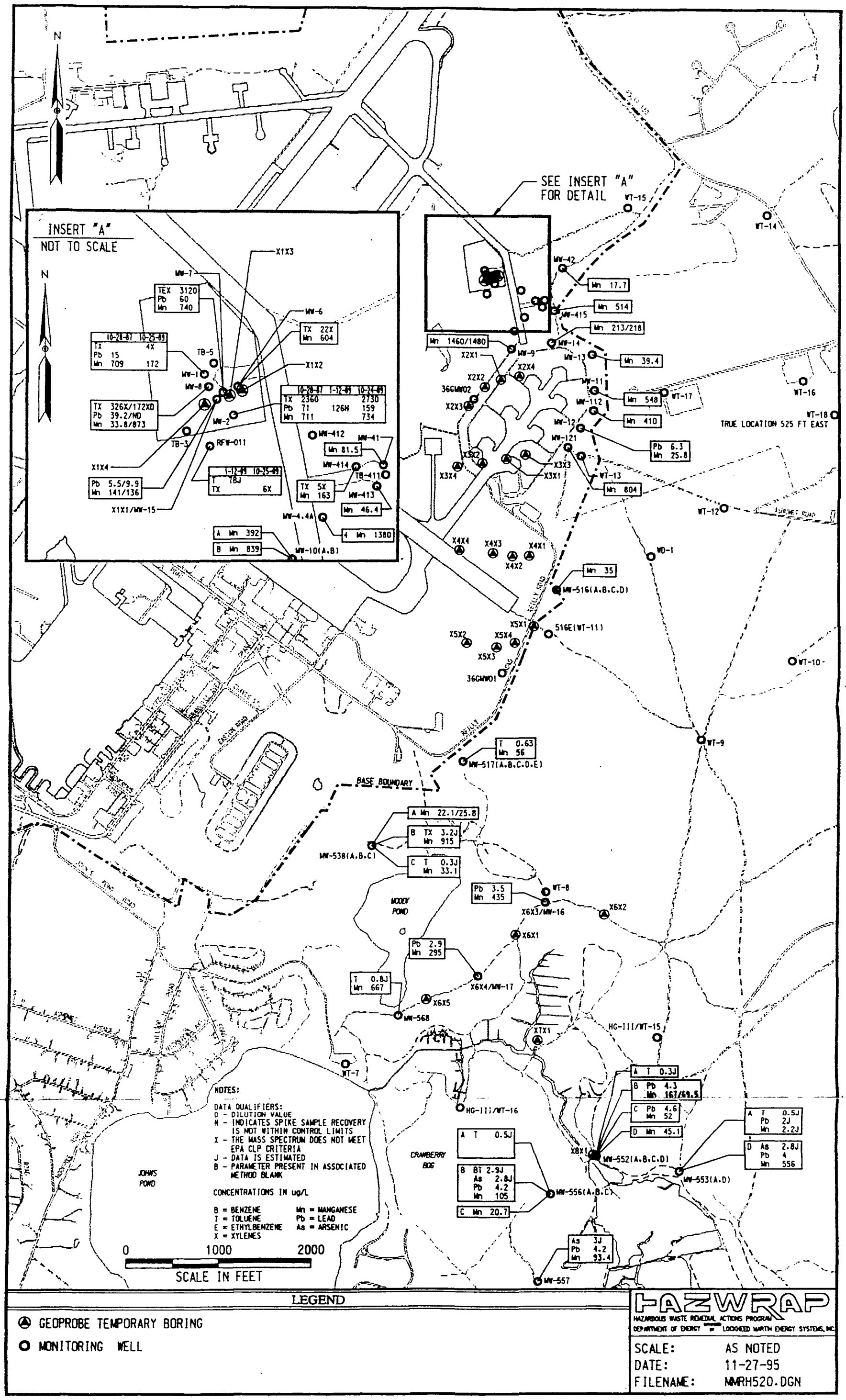


Figure 2-7. Summary of detected concentrations of BTEX, lead, arsenic, and manganese in groundwater prior to 1997/1998.

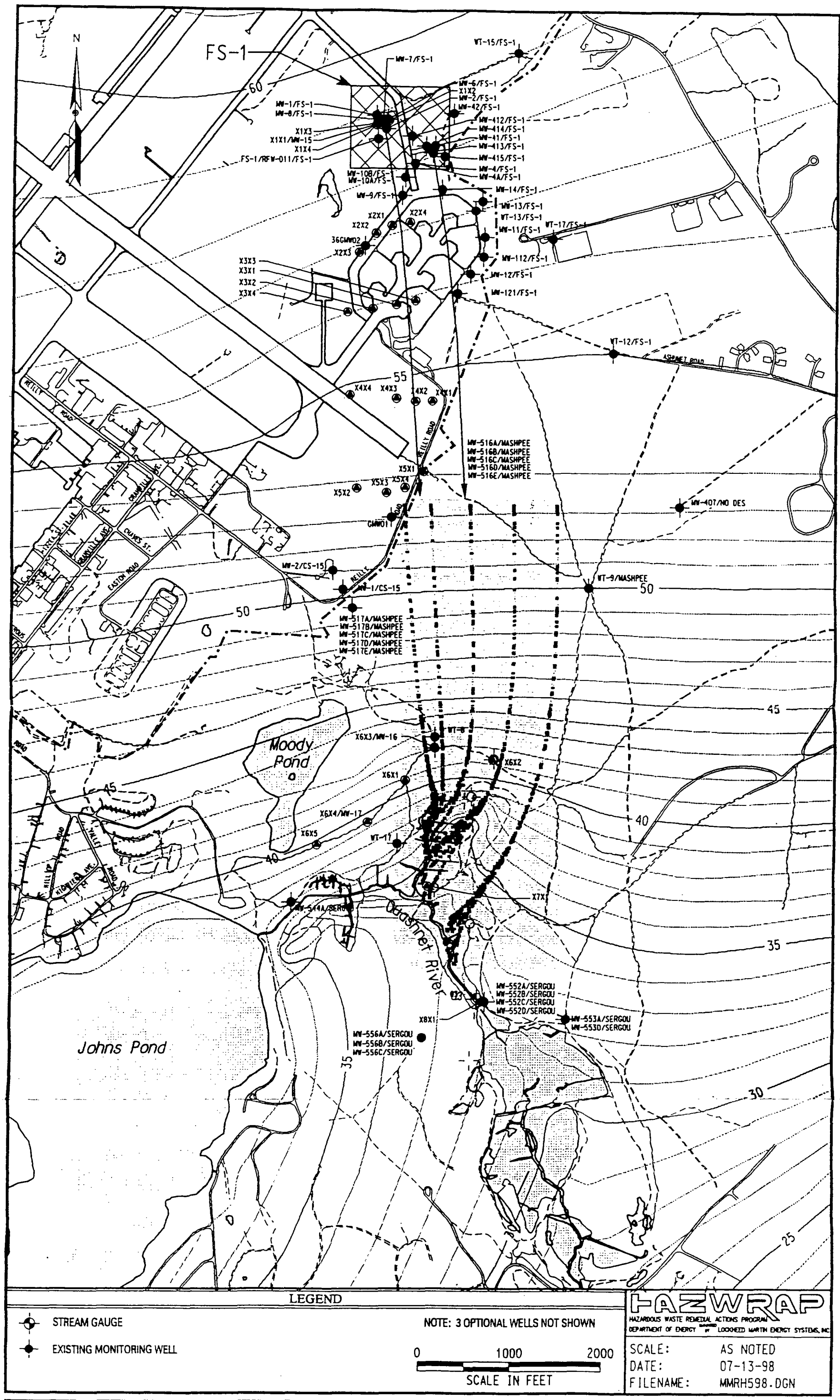
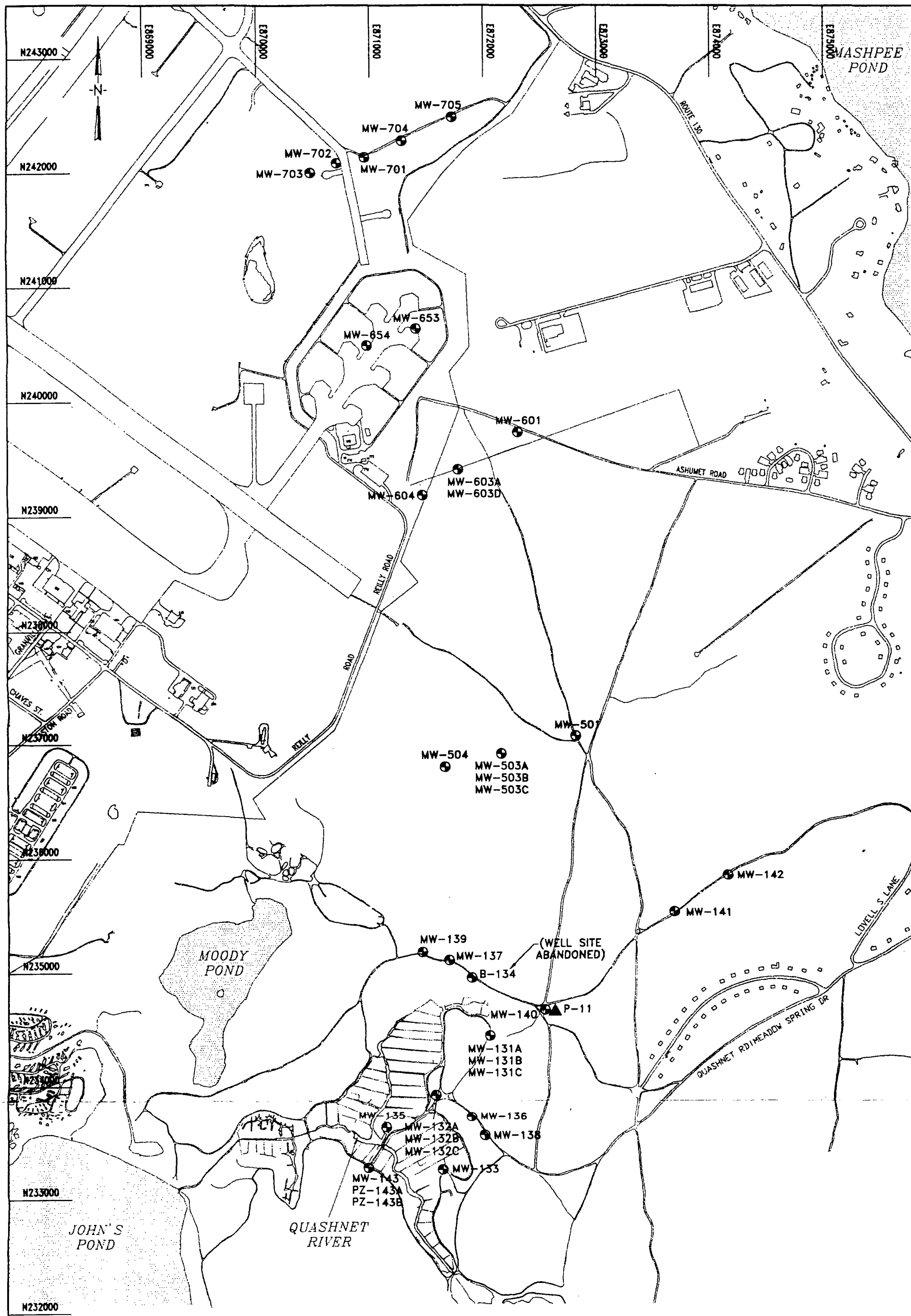


Fig. 2-8. HAZWRAP particle tracking model results.



LEGEND

- 1997/1998 MONITORING WELL
- EXISTING PUMP TEST WELL

COMMODORE ADVANCED SCIENCES, INC.

SCALE IN FEET

800 400 0 400 800

FIGURE 2-9.
NEW MONITORING WELLS INSTALLED IN 1997/1998

AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

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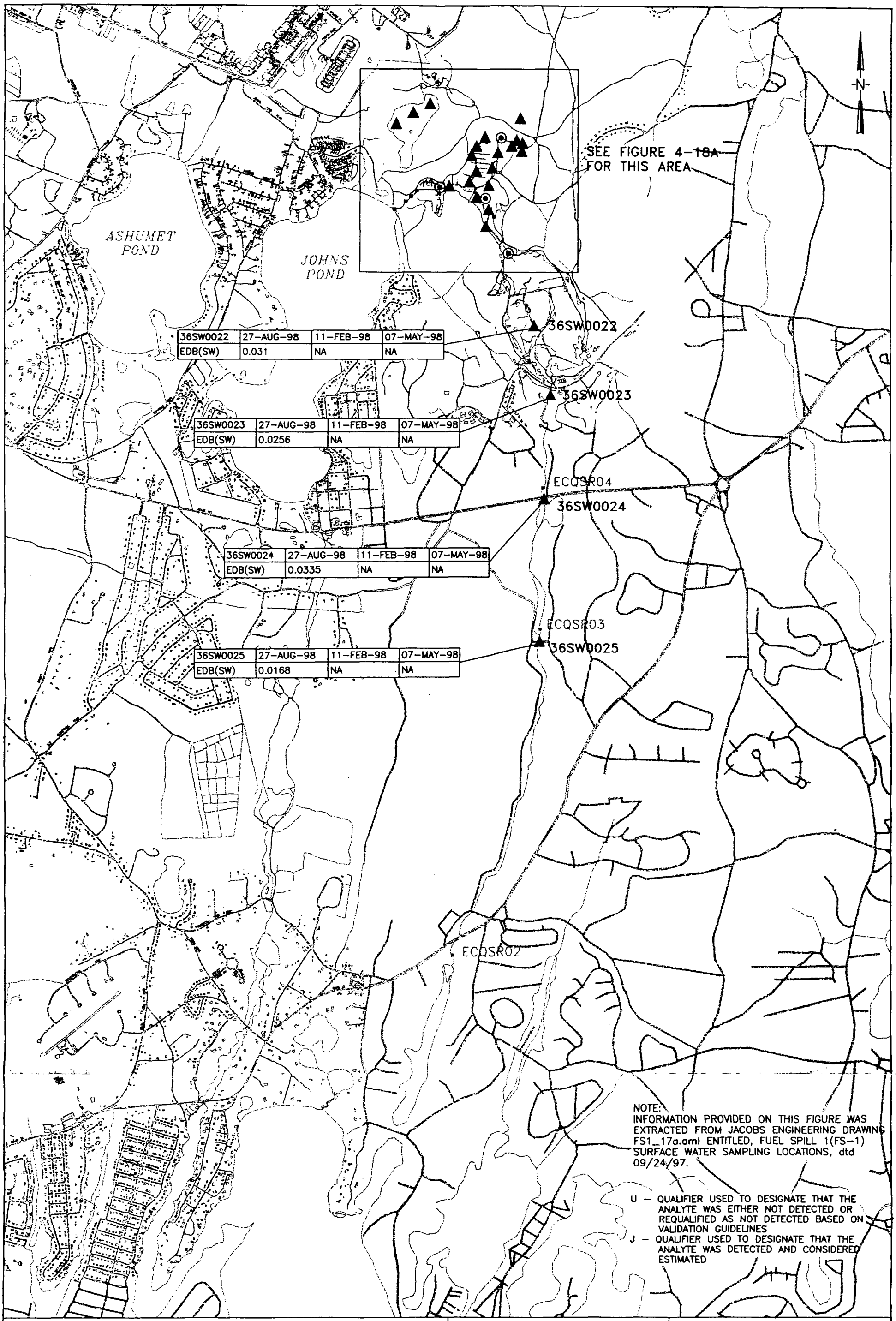

LEGEND

- ▲ SURFACE WATER SAMPLING LOCATION
- ⊙ SURFACE WATER SAMPLING LOCATION AND DISCHARGE MEASUREMENT POINT
- ▪ ECOLOGICAL STUDY SURFACE WATER SAMPLING LOCATION

ND - NON DETECT
NA - NOT ANALYZED
SED - SEDIMENT (µg/kg)
SW - SURFACE WATER (µg/L)

COMMODORE ADVANCED SCIENCES, INC.

SCALE IN FEET
2000 1000 0 1000 2000

FIGURE 2-10.
ANALYTICAL RESULTS FOR QUASHNET RIVER SURFACE WATER SAMPLES (EDB)
AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

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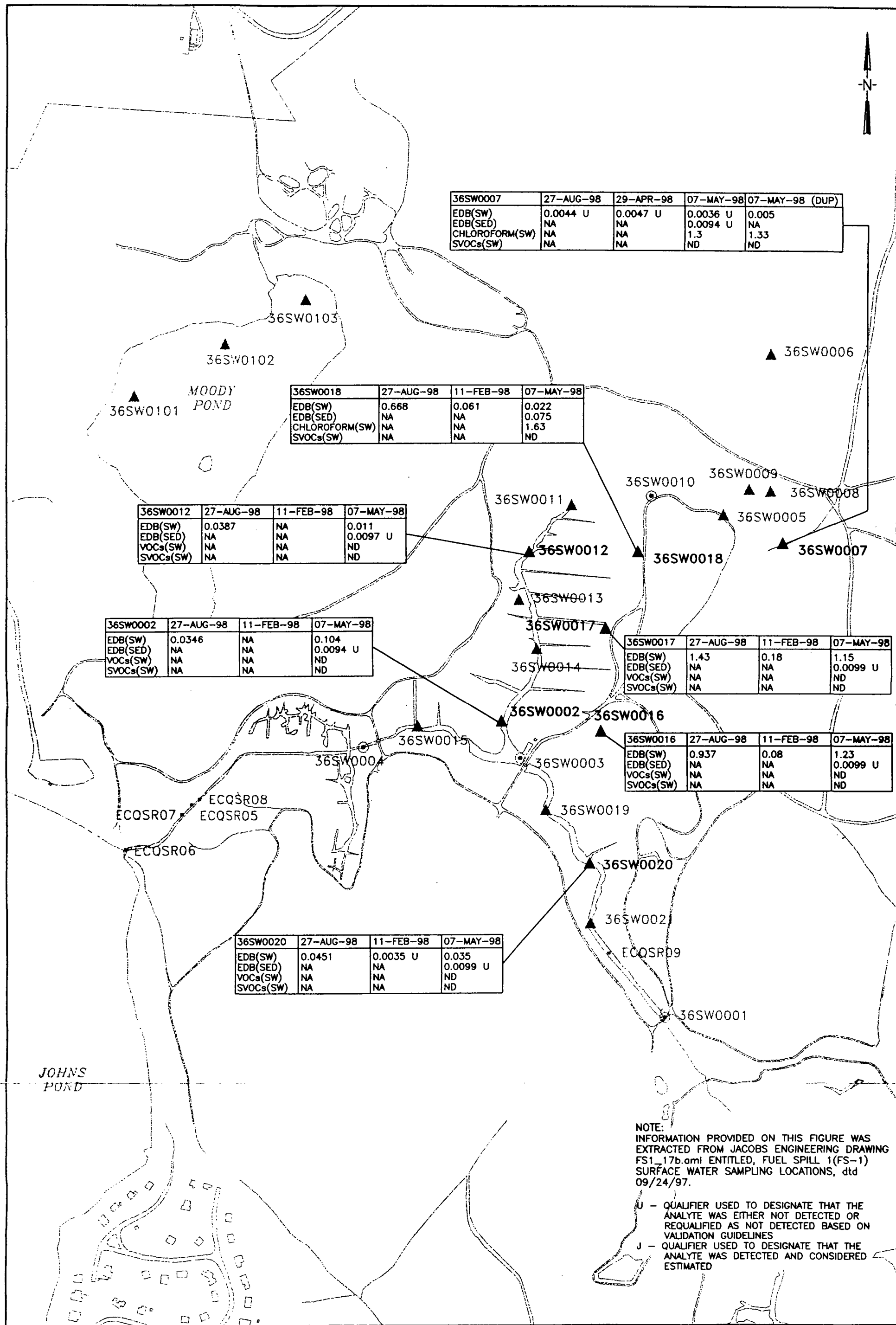

NOTE:
INFORMATION PROVIDED ON THIS FIGURE WAS EXTRACTED FROM JACOBS ENGINEERING DRAWING FS1_17b.aml ENTITLED, FUEL SPILL 1(FS-1) SURFACE WATER SAMPLING LOCATIONS, dtd 09/24/97.

U – QUALIFIER USED TO DESIGNATE THAT THE ANALYTE WAS EITHER NOT DETECTED OR REQUALIFIED AS NOT DETECTED BASED ON VALIDATION GUIDELINES

J – QUALIFIER USED TO DESIGNATE THAT THE ANALYTE WAS DETECTED AND CONSIDERED ESTIMATED

LEGEND

▲ SURFACE WATER SAMPLING LOCATION

⊙ SURFACE WATER SAMPLING LOCATION AND DISCHARGE MEASUREMENT POINT

• ECOLOGICAL STUDY SURFACE WATER SAMPLING LOCATION

ND – NON DETECT
NA – NOT ANALYZED
SED – SEDIMENT (µg/kg)
SW – SURFACE WATER (µg/L)

COMMODORE ADVANCED SCIENCES, INC.

SCALE IN FEET
400 200 0 200 400

FIGURE 2-11. (SHT 1 OF 2)
ANALYTICAL RESULTS FOR QUASHNET RIVER/ CRANBERRY BOG SURFACE WATER AND SEDIMENT SAMPLES (ORGANICS)
AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

SCALE: 1"=400'	DWN BY: KVP
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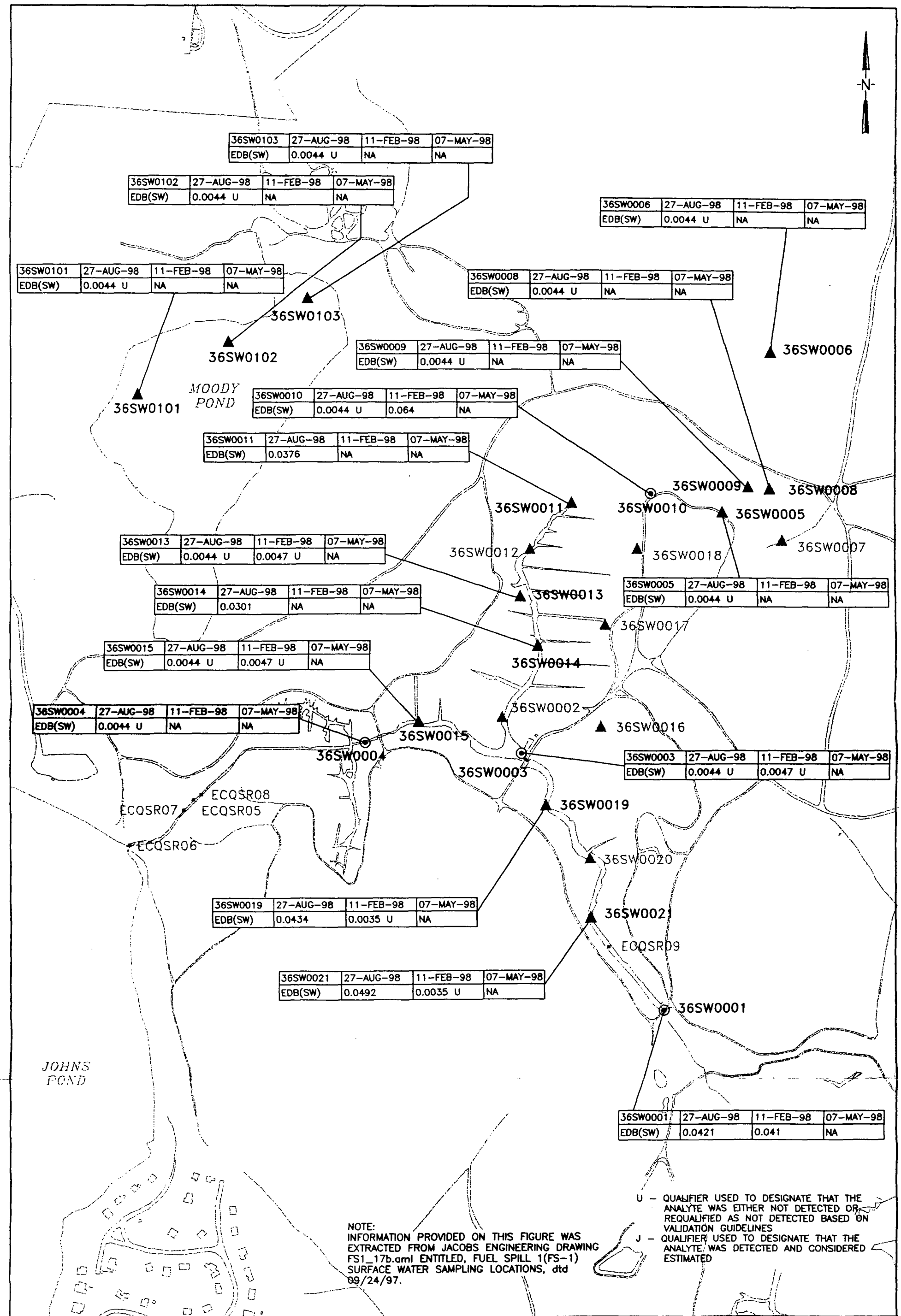


U – QUALIFIER USED TO DESIGNATE THAT THE ANALYTE WAS EITHER NOT DETECTED OR REQUALIFIED AS NOT DETECTED BASED ON VALIDATION GUIDELINES

J – QUALIFIER USED TO DESIGNATE THAT THE ANALYTE WAS DETECTED AND CONSIDERED ESTIMATED

NOTE:
INFORMATION PROVIDED ON THIS FIGURE WAS EXTRACTED FROM JACOBS ENGINEERING DRAWING FS1_17b.aml ENTITLED, FUEL SPILL 1(FS-1) SURFACE WATER SAMPLING LOCATIONS, dtd 09/24/97.

LEGEND

- ▲ SURFACE WATER SAMPLING LOCATION
- ⊙ SURFACE WATER SAMPLING LOCATION AND DISCHARGE MEASUREMENT POINT
- • ECOLOGICAL STUDY SURFACE WATER SAMPLING LOCATION

ND – NON DETECT
NA – NOT ANALYZED
SED – SEDIMENT (µg/kg)
SW – SURFACE WATER (µg/L)

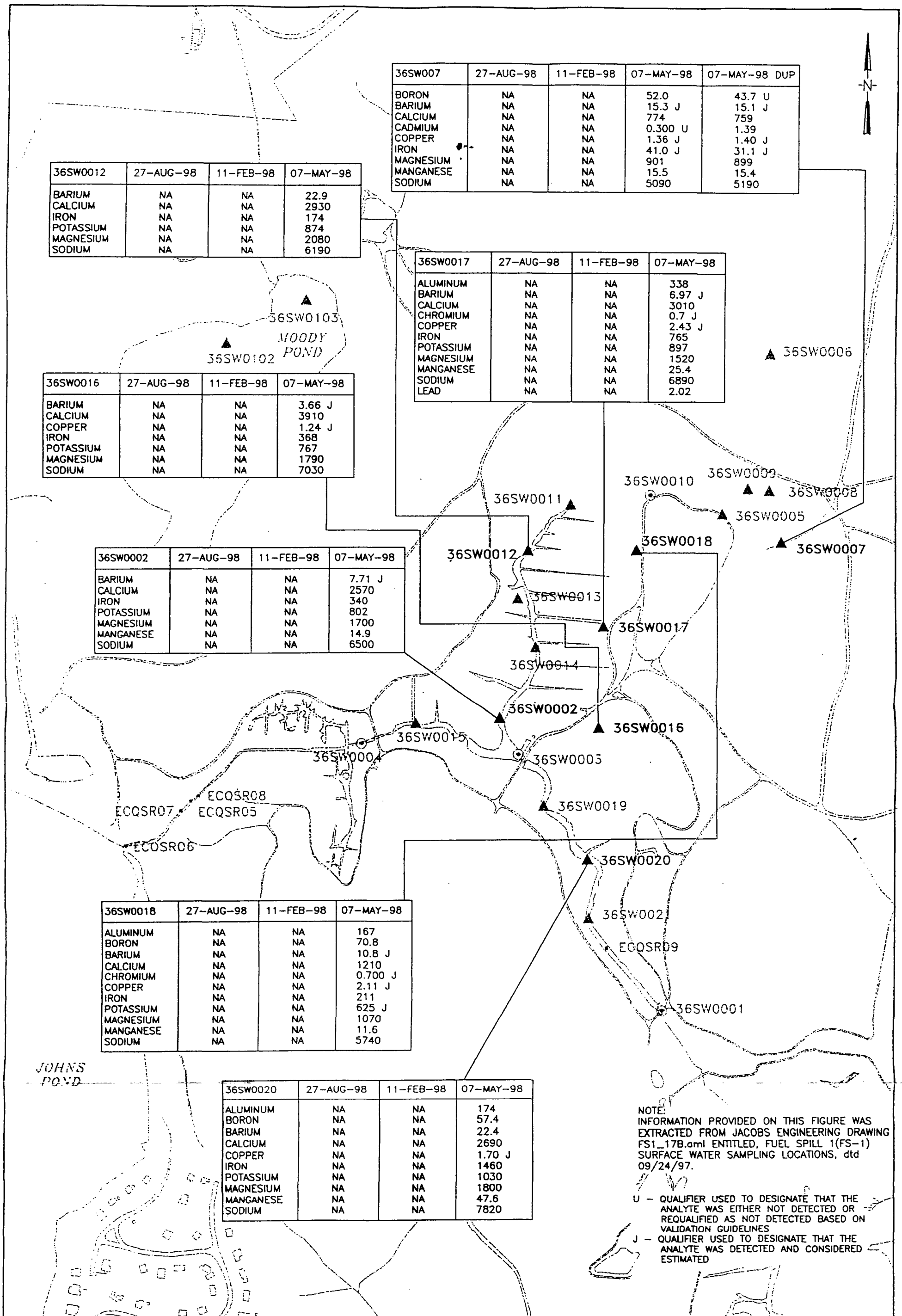
COMMODORE ADVANCED SCIENCES, INC.

SCALE IN FEET
400 200 0 200 400

FIGURE 2-11. (SHT 2 OF 2)
ANALYTICAL RESULTS FOR QUASHNET RIVER/ CRANBERRY BOG SURFACE WATER AND SEDIMENT SAMPLES (ORGANICS)

AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

SCALE: 1"=400'	DWN BY: KVP
DATE: 5-17-99	FILENAME: MMRSWSDB1.DWG



LEGEND

- ▲ SURFACE WATER SAMPLING LOCATION
- ⊙ SURFACE WATER SAMPLING LOCATION AND DISCHARGE MEASUREMENT POINT
- • ECOLOGICAL STUDY SURFACE WATER SAMPLING LOCATION

ND - NON DETECT
NA - NAT ANALYZED
SED - SEDIMENT
SW - SURFACE WATER

COMMODORE ADVANCED SCIENCES, INC.

SCALE IN FEET
400 200 0 200 400

FIGURE 2-12.
ANALYTICAL RESULTS FOR QUASHNET RIVER/ CRANBERRY BOG SURFACE WATER SAMPLES (INORGANICS)
AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

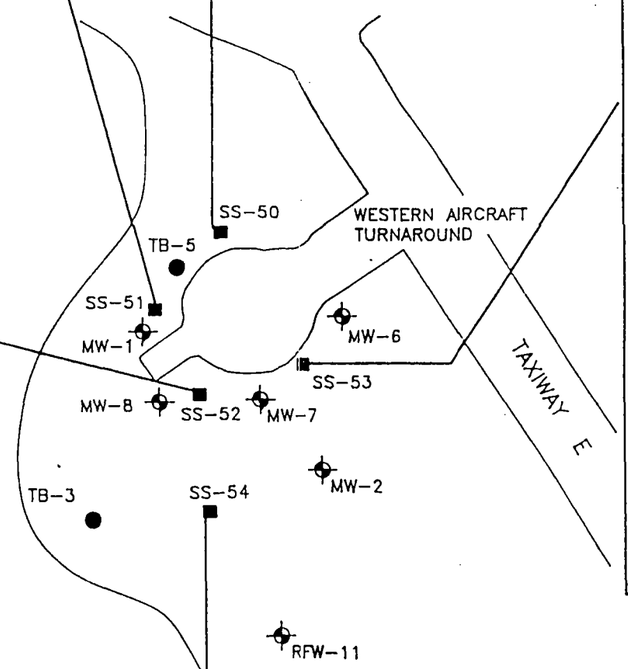
SCALE: 1"=400'	DWN BY: KVP
DATE: 7-11-98	FILENAME: MMRSWS00.DWG

SS-51	Conc.
SVOCs	ug/kg
Phenanthrene	100
Anthracene	ND
Fluoranthene	180
Pyrene	270
Benzo(a)anthracene	90
Chrysene	ND
Benzo(b)fluoranthene	210
Benzo(k)fluoranthene	190
Benzo(a)pyrene	100
Indeno(1,2,3-cd)pyrene	49
Benzo(g,h,i)perylene	44
Acenaphthlene	ND
PESTICIDES	ug/kg
alpha-BHC	ND
Aldrin	ND
Heptachlor epoxide	0.29
Endosulfan I	0.6
Dieldrin	1.5
4,4'-DDE	ND
Endrin	0.92
Endosufan II	1.4
4,4'-DDD	ND
4,4'-DDT	0.24
Methoxychlor	ND
Endrin ketone	ND
alpha-Chlodane	0.16
gamma-Chlordane	ND
METALS	mg/Kg
Aluminum	931
Antimony	ND
Arsenic	ND
Barium	11.5 J
Chromium	2.4
Cobalt	0.98
Iron	1770
Lead	8.4
Magnesium	225
Manganese	42.4
Nickel	1.9
Potassium	98.7 J
Sodium	272 J
Vanadium	2.9
MISCELLANEOUS	mg/Kg
TOC	NA

SS-52	Conc.	DUP
SVOCs	ug/kg	ug/kg
Phenanthrene	76	56
Anthracene	ND	12
Fluoranthene	140	130
Pyrene	230	210
Benzo(a)anthracene	130	110
Chrysene	180	170
Benzo(b)fluoranthene	370	270
Benzo(k)fluoranthene	330	250
Benzo(a)pyrene	190	190
Indeno(1,2,3-cd)pyrene	ND	130
Benzo(g,h,i)perylene	ND	150
Acenaphthlene	50	ND
PESTICIDES	ug/kg	ug/kg
alpha-BHC	ND	ND
Aldrin	ND	0.16
Heptachlor epoxide	ND	ND
Endosulfan I	0.74	ND
Dieldrin	1.8	1.6
4,4'-DDE	0.28	0.24
Endrin	0.87	0.76
Endosufan II	0.97	ND
4,4'-DDD	ND	ND
4,4'-DDT	0.81	1
Methoxychlor	ND	ND
Endrin ketone	ND	0.34
alpha-Chlodane	0.24	0.19
gamma-Chlordane	ND	ND
METALS	mg/Kg	mg/Kg
Aluminum	1790	1800
Antimony	ND	ND
Arsenic	0.93	1.2
Barium	5.1 J	5.1 J
Chromium	3.5	3.2
Cobalt	0.99	1
Iron	3370	3220
Lead	41.4	36.6
Magnesium	387	393
Manganese	31.5	29.7
Nickel	2	1.9
Potassium	161	176 J
Sodium	253	258 J
Vanadium	5.6	5.3
MISCELLANEOUS	mg/Kg	mg/Kg
TOC	50	NA

NOTES:

- J = Estimated
- NA = Not Analyzed
- ND = Non Detect
- TOC = Total Organic Carbon
- Conc. = Concentrations
- * = Indicates duplicate analysis is not within control limits.



SS-53	Conc.
SVOCs	ug/kg
Phenanthrene	150
Anthracene	ND
Fluoranthene	140
Pyrene	220
Benzo(a)anthracene	53
Chrysene	240
Benzo(b)fluoranthene	360
Benzo(k)fluoranthene	320
Benzo(a)pyrene	140
Indeno(1,2,3-cd)pyrene	79
Benzo(g,h,i)perylene	ND
Acenaphthlene	54
PESTICIDES	ug/kg
alpha-BHC	0.23
Aldrin	ND
Heptachlor epoxide	0.48
Endosulfan I	0.59
Dieldrin	13
4,4'-DDE	1
Endrin	1.7
Endosufan II	1.5
4,4'-DDD	3
4,4'-DDT	3.2
Methoxychlor	0.72
Endrin ketone	ND
alpha-Chlodane	0.35
gamma-Chlordane	0.15
METALS	mg/Kg
Aluminum	2690
Antimony	0.63 J
Arsenic	1.2
Barium	4.6 J
Chromium	7.4
Cobalt	0.87
Iron	3740
Lead	114
Magnesium	404
Manganese	24.9
Nickel	2.7
Potassium	165 J
Sodium	255 J
Vanadium	8.2
MISCELLANEOUS	mg/Kg
TOC	NA

SS-50	Conc.
SVOCs	ug/kg
Phenanthrene	61
Anthracene	ND
Fluoranthene	75
Pyrene	110
Benzo(a)anthracene	52
Chrysene	72
Benzo(b)fluoranthene	110
Benzo(k)fluoranthene	100
Benzo(a)pyrene	59
Indeno(1,2,3-cd)pyrene	ND
Benzo(g,h,i)perylene	ND
Acenaphthlene	ND
PESTICIDES	ug/kg
alpha-BHC	ND
Aldrin	ND
Heptachlor epoxide	0.15
Endosulfan I	ND
Dieldrin	1.9
4,4'-DDE	2.1
Endrin	0.47
Endosufan II	1
4,4'-DDD	ND
4,4'-DDT	5
Methoxychlor	ND
Endrin ketone	0.53
alpha-Chlodane	0.24
gamma-Chlordane	ND
METALS	mg/Kg
Aluminum	1590
Antimony	ND
Arsenic	0.67
Barium	64.8 J
Chromium	3
Cobalt	0.69
Iron	2370
Lead	23.6
Magnesium	290
Manganese	23.6
Nickel	1.6
Potassium	107 J
Sodium	259 J
Vanadium	3.7
MISCELLANEOUS	mg/Kg
TOC	50

TB-4	Conc.	DUP
VOCs	ug/kg	ug/kg
Chlorothone	ND	ND
Acetone	ND	ND
Methylene Chloride	ND	ND
Metals	mg/kg	mg/kg
Aluminum	982 *	1310 *
Chromium	ND	2.8
Iron	1600 *	2500 *
Lead	1.3	1.9
Manganese	49	91
Zinc	7.1 *	7.6 *

MW-4/TB-4
MW-4A

SS-54	Conc.
SVOCs	ug/kg
Phenanthrene	ND
Anthracene	ND
Fluoranthene	ND
Pyrene	ND
Benzo(a)anthracene	ND
Chrysene	ND
Benzo(b)fluoranthene	ND
Benzo(k)fluoranthene	ND
Benzo(a)pyrene	ND
Indeno(1,2,3-cd)pyrene	ND
Benzo(g,h,i)perylene	ND
Acenaphthlene	ND

PESTICIDES	ug/kg
alpha-BHC	ND
Aldrin	ND
Heptachlor epoxide	ND
Endosulfan I	ND
Dieldrin	0.22
4,4'-DDE	ND
Endrin	ND
Endosufan II	ND
4,4'-DDD	ND
4,4'-DDT	ND
Methoxychlor	ND
Endrin ketone	ND
alpha-Chlodane	ND
gamma-Chlordane	ND

METALS	mg/Kg
Aluminum	911
Antimony	ND
Arsenic	ND
Barium	2.7 J
Chromium	1.8
Cobalt	0.7
Iron	2250
Lead	2.2 J
Magnesium	234
Manganese	30.6
Nickel	1.4
Potassium	86.3 J
Sodium	235 J
Vanadium	3.5
MISCELLANEOUS	mg/Kg
TOC	50

LEGEND

- Monitoring Well
- Soil Boring
- Surface Soil Sample Locations

0 100 200 FEET

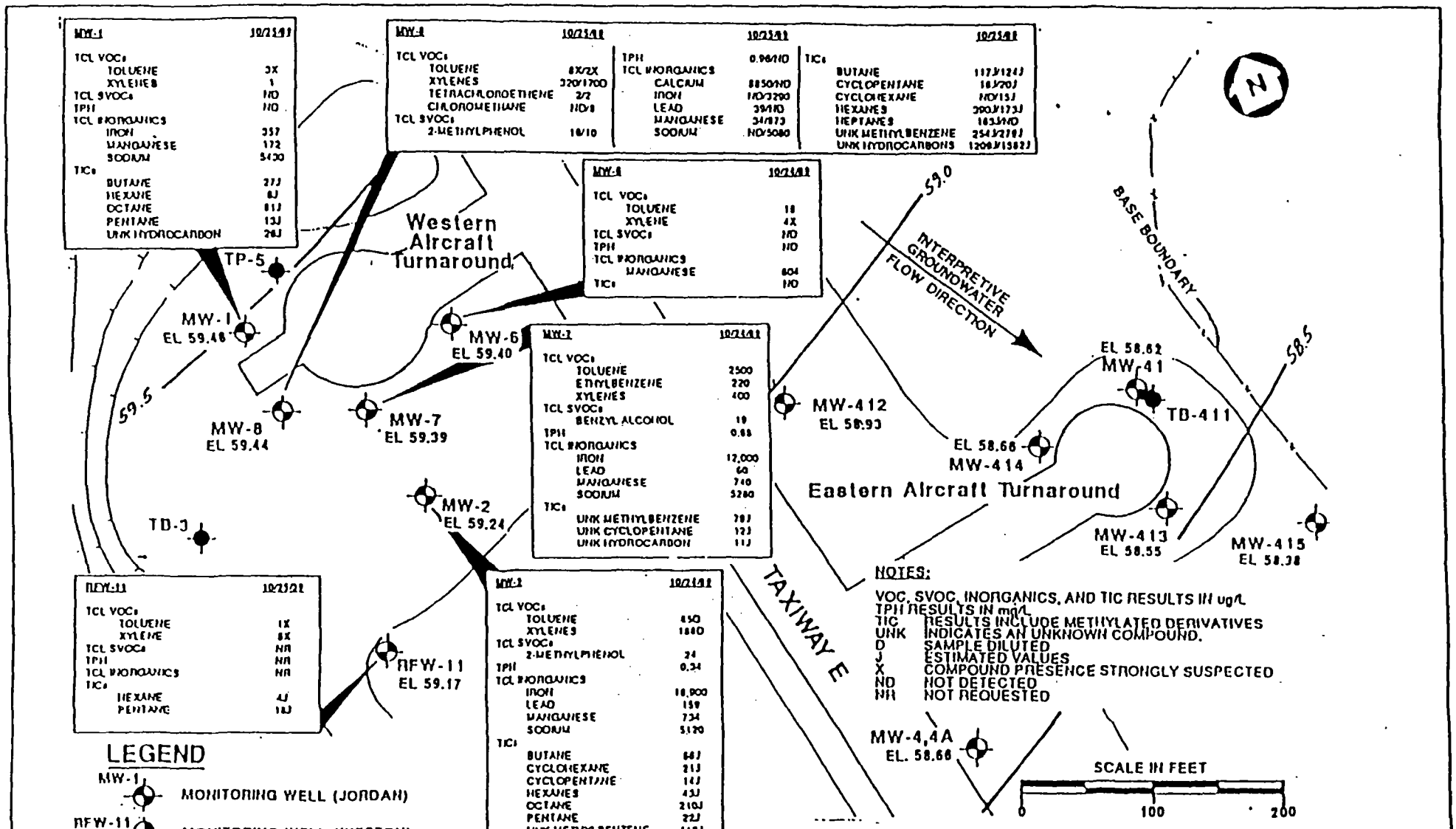
ADVANCED SCIENCES, INC.

INTERPRETIVE SURFACE SOIL ANALYTICAL RESULTS FOR AOC FS-1

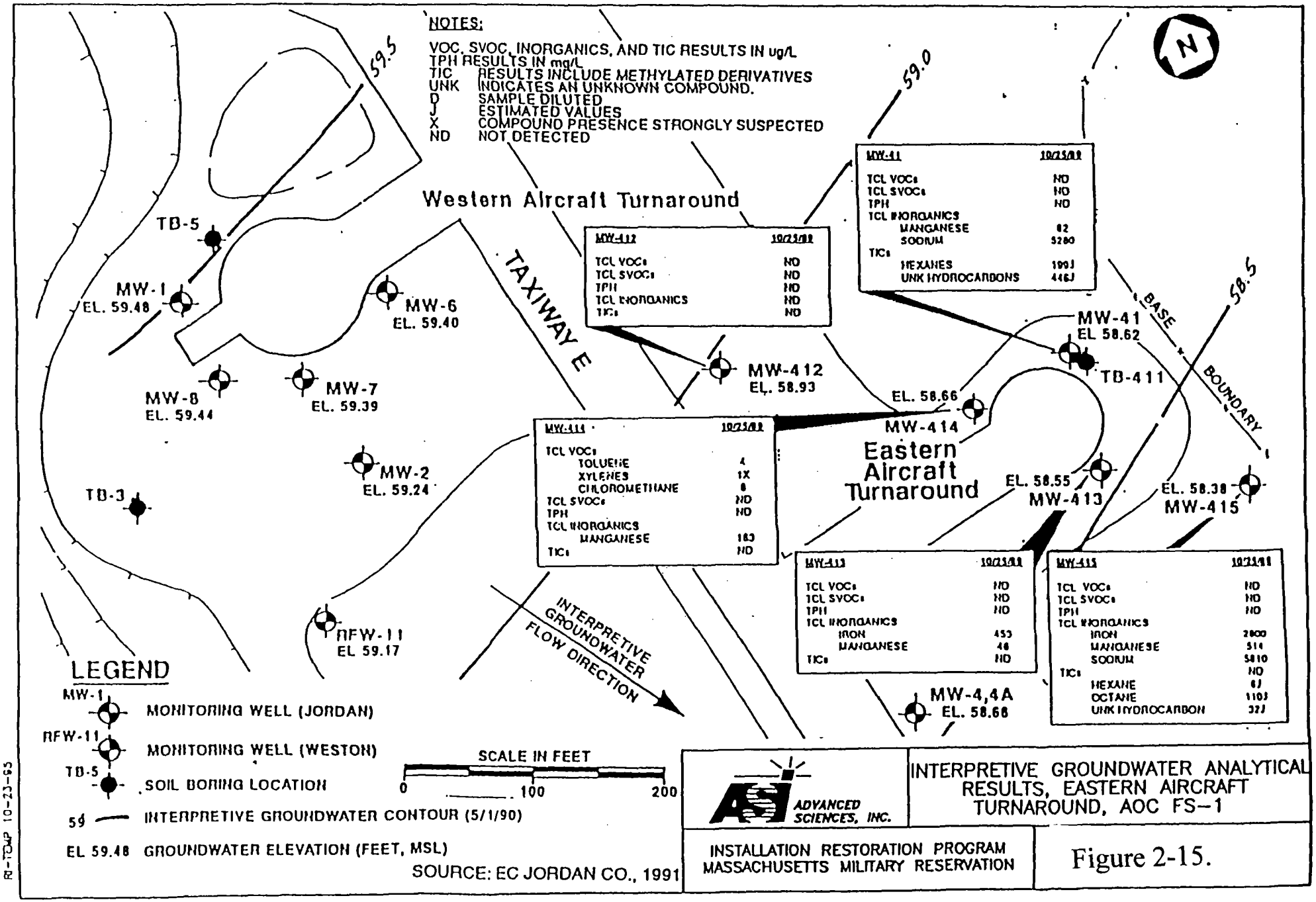
INSTALLATION RESTORATION PROGRAM
MASSACHUSETTS MILITARY RESERVATION

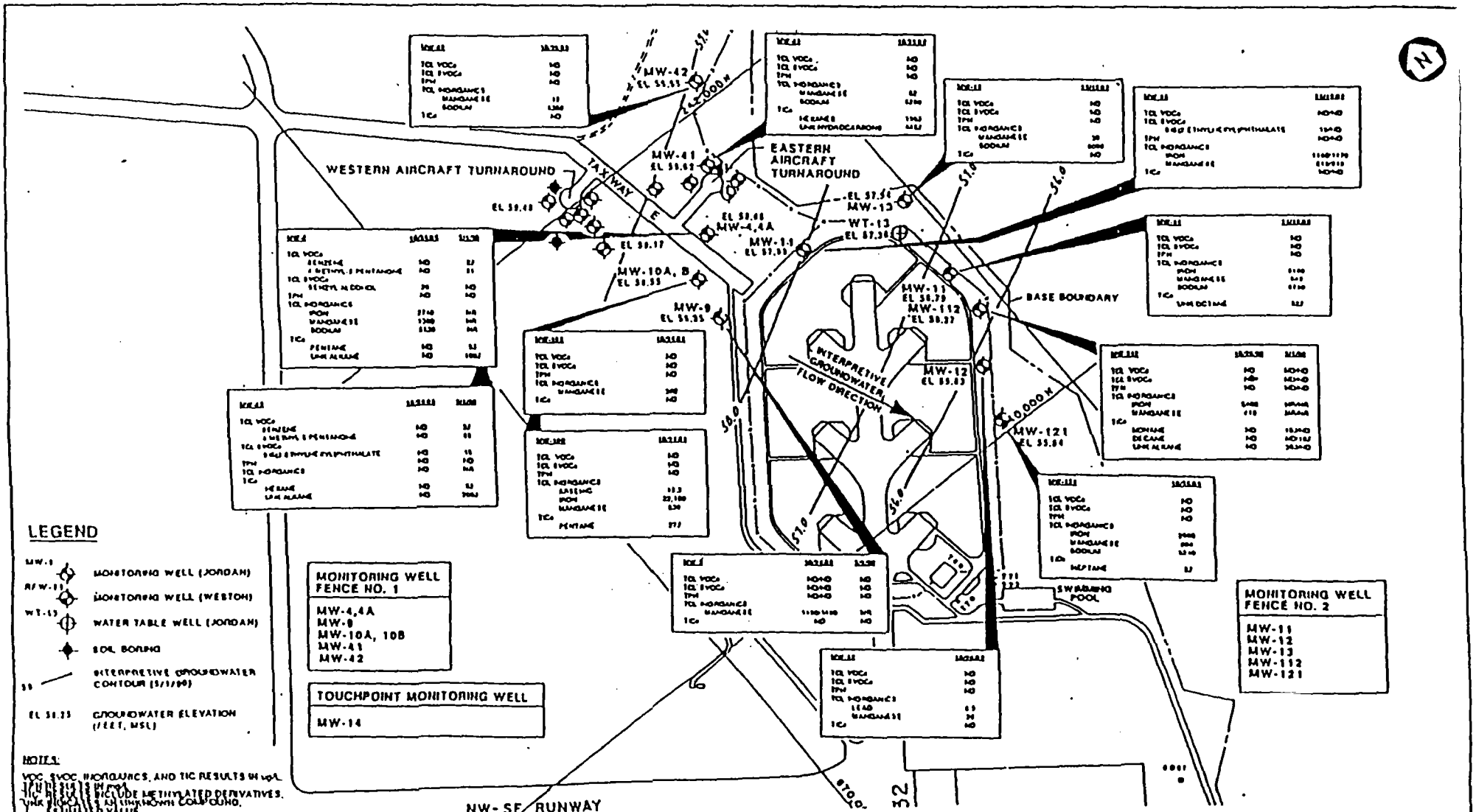
Figure 2-13.

FS2ARI 10/25/95



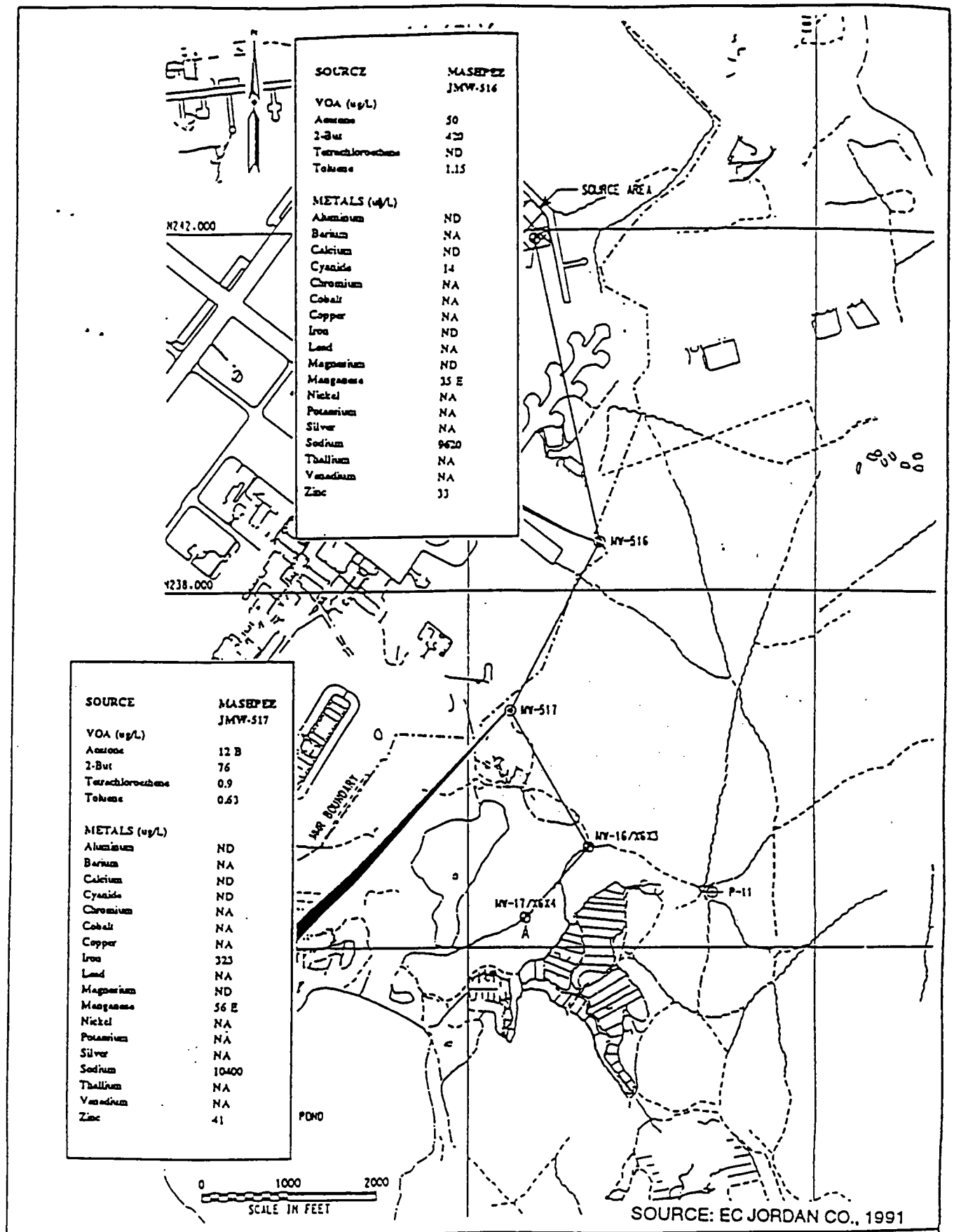
RI-TDMP 10-23-95


NOTES:
VOC, SVOC, INORGANICS, AND TIC RESULTS IN ug/L
TPH RESULTS IN mg/L
TIC RESULTS INCLUDE METHYLATED DERIVATIVES
UNK INDICATES AN UNKNOWN COMPOUND.
D SAMPLE DILUTED
J ESTIMATED VALUES
X COMPOUND PRESENCE STRONGLY SUSPECTED
ND NOT DETECTED
Western Aircraft Turnaround
TAXIWAY E
Eastern Aircraft Turnaround
BASE BOUNDARY
INTERPRETIVE GROUNDWATER FLOW DIRECTION
59.5
59.0
58.5
TB-5
MW-1
EL. 59.48
MW-6
EL. 59.40
MW-8
EL. 59.44
MW-7
EL. 59.39
MW-2
EL. 59.24
TB-3
RFW-11
EL 59.17
MW-412
EL. 58.93
MW-41
EL 58.62
TB-411
EL. 58.66
MW-414
EL. 58.55
MW-413
EL. 58.38
MW-415
MW-4,4A
EL. 58.66
MW-41 10/25/88
TCL VOCs ND
TCL SVOCs ND
TPH ND
TCL INORGANICS
MANGANESE 82
SODIUM 5280
TICs
HEXANES 199J
UNK HYDROCARBONS 446J
MW-412 10/25/88
TCL VOCs ND
TCL SVOCs ND
TPH ND
TCL INORGANICS ND
TICs ND
MW-414 10/25/88
TCL VOCs
TOLUENE 4
XYLENES 1X
CHLOROMETHANE 8
TCL SVOCs ND
TPH ND
TCL INORGANICS
MANGANESE 183
TICs ND
MW-413 10/25/88
TCL VOCs ND
TCL SVOCs ND
TPH ND
TCL INORGANICS
IRON 453
MANGANESE 48
TICs ND
MW-415 10/25/88
TCL VOCs ND
TCL SVOCs ND
TPH ND
TCL INORGANICS
IRON 2800
MANGANESE 514
SODIUM 5810
TICs ND
HEXANE 6J
OCTANE 110J
UNK HYDROCARBON 32J
LEGEND
MW-1 MONITORING WELL (JORDAN)
RFW-11 MONITORING WELL (WESTON)
TB-5 SOIL BORING LOCATION
59 INTERPRETIVE GROUNDWATER CONTOUR (5/1/90)
EL 59.48 GROUNDWATER ELEVATION (FEET, MSL)
SCALE IN FEET
0 100 200
SOURCE: EC JORDAN CO., 1991
ADVANCED SCIENCES, INC.
INTERPRETIVE GROUNDWATER ANALYTICAL RESULTS, EASTERN AIRCRAFT TURNAROUND, AOC FS-1
INSTALLATION RESTORATION PROGRAM
MASSACHUSETTS MILITARY RESERVATION
Figure 2-15.
RI-TOMP 10-23-93



SOURCE: EC JORDAN CO., 1991

Figure 2-16.



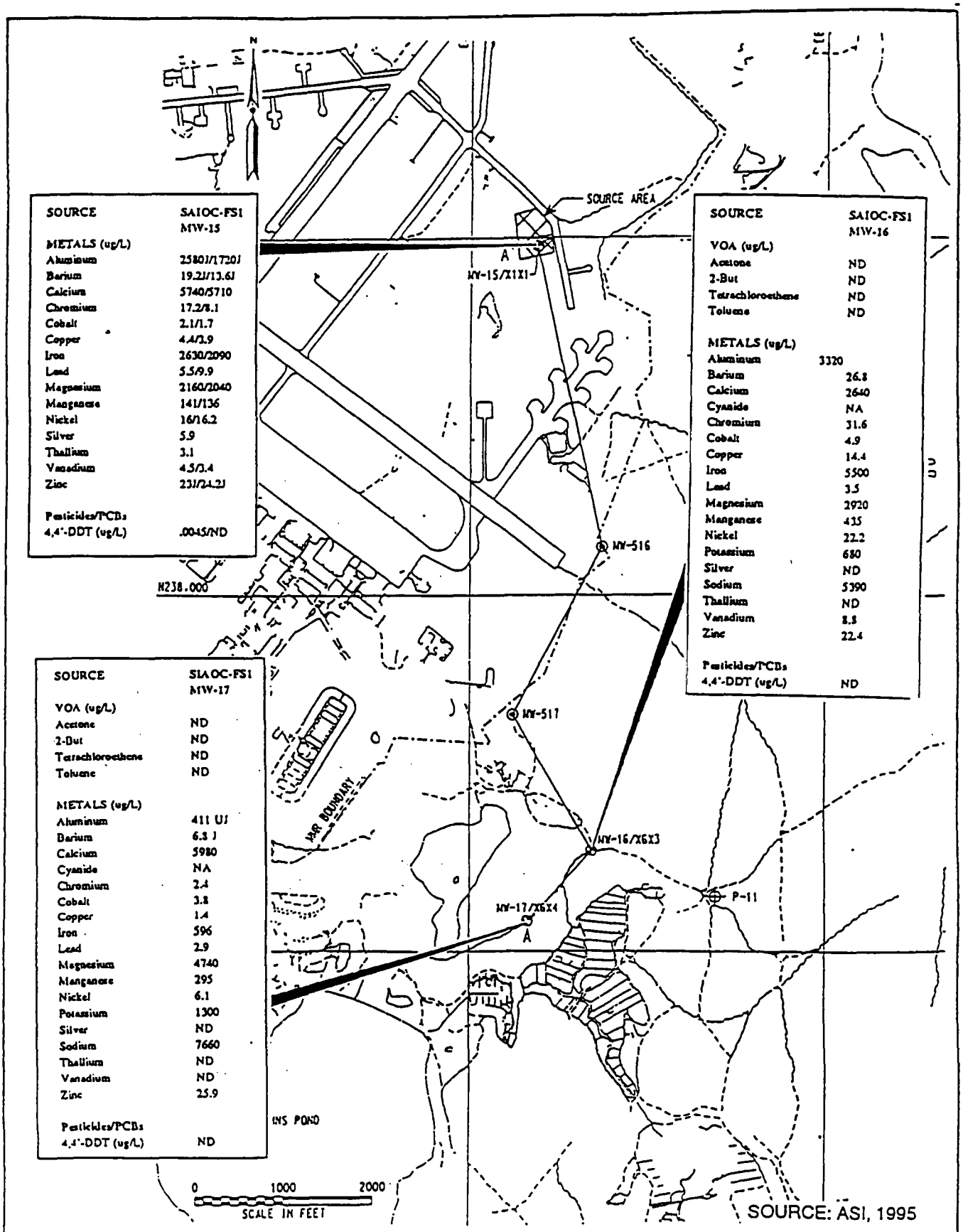
⊗ SCREENED AUGER BORING/MONITORING WELL
⊙ EXISTING MONITORING WELL
PROPOSED MUNICIPAL PRODUCTION WELL

ADVANCED SCIENCES, INC.

INTERPRETIVE DOWNGRADIENT GROUNDWATER ANALYTICAL RESULTS (MASHPEE STUDY), AOC FS-1

INSTALLATION RESTORATION PROGRAM
MASSACHUSETTS MILITARY RESERVATION

Figure 2-17.



SOURCE	SAIOC-FS1 MW-15
METALS (ug/L)	
Aluminum	2580J/1720J
Barium	19.2J/13.6J
Calcium	5740/5710
Chromium	17.2/8.1
Cobalt	2.1/1.7
Copper	4.4/3.9
Iron	2630/2090
Lead	5.5/9.9
Magnesium	2160/2040
Manganese	141/136
Nickel	16/16.2
Silver	5.9
Thallium	3.1
Vanadium	4.5/3.4
Zinc	23J/24.2J
Pesticides/PCBs	
4,4'-DDT (ug/L)	.0045/ND

SOURCE	SAIOC-FS1 MW-16
VOA (ug/L)	
Acetone	ND
2-But	ND
Tetrachloroethene	ND
Toluene	ND
METALS (ug/L)	
Aluminum	3320
Barium	26.8
Calcium	2640
Cyanide	NA
Chromium	31.6
Cobalt	4.9
Copper	14.4
Iron	5500
Lead	3.5
Magnesium	2920
Manganese	435
Nickel	22.2
Potassium	680
Silver	ND
Sodium	5390
Thallium	ND
Vanadium	8.8
Zinc	22.4
Pesticides/PCBs	
4,4'-DDT (ug/L)	ND

SOURCE	SIAOC-FS1 MW-17
VOA (ug/L)	
Acetone	ND
2-But	ND
Tetrachloroethene	ND
Toluene	ND
METALS (ug/L)	
Aluminum	411 UJ
Barium	6.3 J
Calcium	5980
Cyanide	NA
Chromium	2.4
Cobalt	3.8
Copper	1.4
Iron	596
Lead	2.9
Magnesium	4740
Manganese	295
Nickel	6.1
Potassium	1300
Silver	ND
Sodium	7660
Thallium	ND
Vanadium	ND
Zinc	25.9
Pesticides/PCBs	
4,4'-DDT (ug/L)	ND

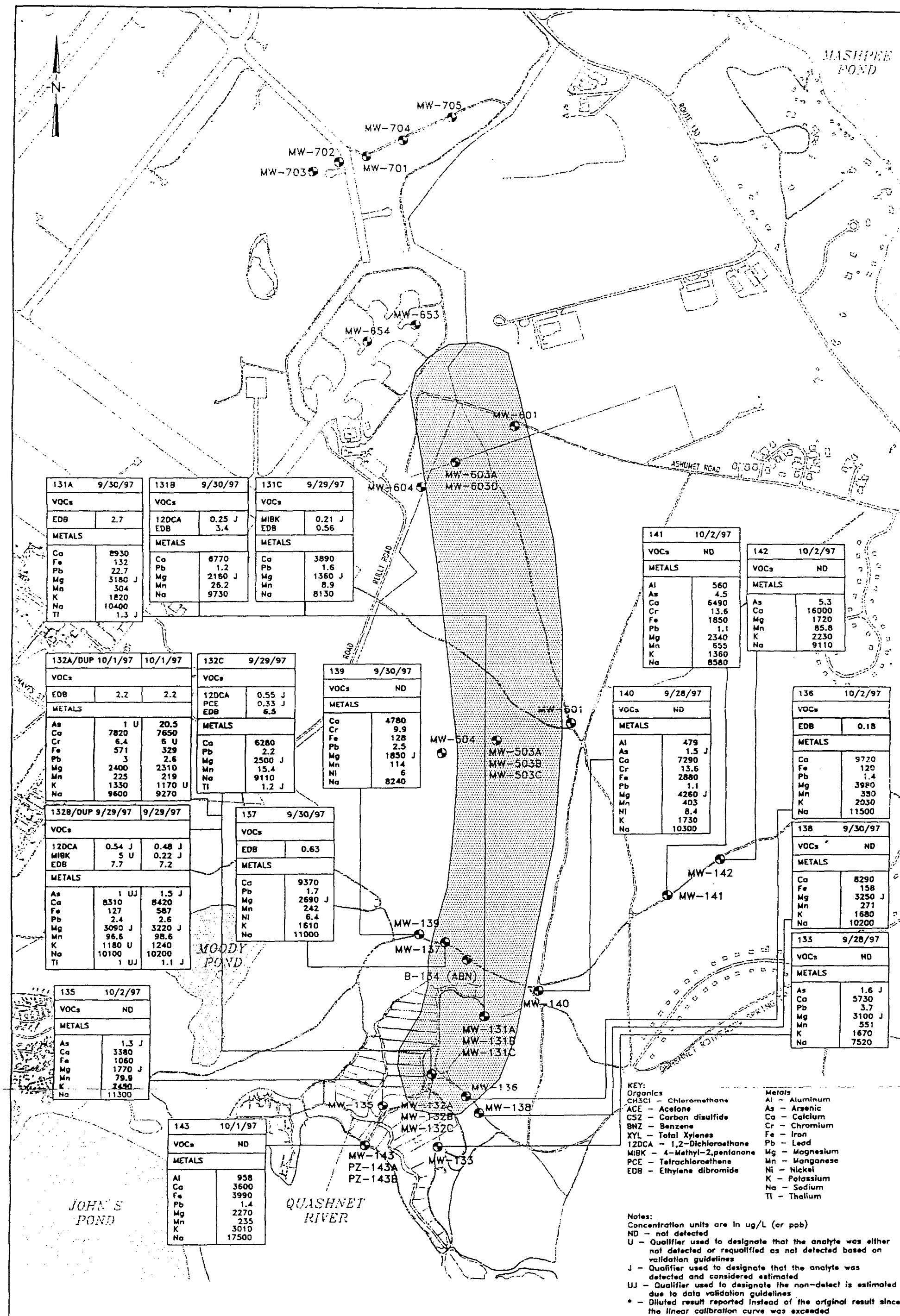
⊗ SCREENED AUGER BORING/MONITORING WELL
⊙ EXISTING MONITORING WELL
⊕ PROPOSED MUNICIPAL PRODUCTION WELL

ADVANCED SCIENCES, INC.

INTERPRETIVE GROUNDWATER ANALYTICAL RESULTS (1995 DATA), AOC FS-1

INSTALLATION RESTORATION PROGRAM
MASSACHUSETTS MILITARY RESERVATION

Figure 2-18.



131A	9/30/97
VOCs	
EDB	2.7
METALS	
Ca	8930
Fe	132
Pb	22.7
Mg	3180 J
Mn	304
K	1820
Na	10400
Tl	1.3 J

131B	9/30/97
VOCs	
12DCA	0.25 J
EDB	3.4
METALS	
Ca	6770
Pb	1.2
Mg	2160 J
Mn	26.2
Na	9730

131C	9/29/97
VOCs	
MIBK	0.21 J
EDB	0.56
METALS	
Ca	3890
Pb	1.6
Mg	1360 J
Mn	8.9
Na	8130

141	10/2/97
VOCs	ND
METALS	
Al	560
As	4.5
Ca	6490
Cr	13.6
Fe	1850
Pb	1.1
Mg	2340
Mn	655
K	1360
Na	8580

142	10/2/97
VOCs	ND
METALS	
As	5.3
Ca	16000
Mg	1720
Mn	85.8
K	2230
Na	9110

132A/DUP	10/1/97	10/1/97
VOCs		
EDB	2.2	2.2
METALS		
As	1 U	20.5
Ca	7820	7650
Cr	6.4	6 U
Fe	571	329
Pb	3	2.6
Mg	2400	2310
Mn	225	219
K	1330	1170 U
Na	9600	9270

132C	9/29/97
VOCs	
12DCA	0.55 J
PCE	0.33 J
EDB	6.5
METALS	
Ca	6280
Pb	2.2
Mg	2500 J
Mn	15.4
Na	9110
Tl	1.2 J

139	9/30/97
VOCs	ND
METALS	
Ca	4780
Cr	9.9
Fe	128
Pb	2.5
Mg	1850 J
Mn	114
Ni	6
Na	8240

140	9/28/97
VOCs	ND
METALS	
Al	479
As	1.5 J
Ca	7290
Cr	13.6
Fe	2880
Pb	1.1
Mg	4260 J
Mn	403
Ni	8.4
K	1730
Na	10300

136	10/2/97
VOCs	
EDB	0.18
METALS	
Ca	9720
Fe	120
Pb	1.4
Mg	3980
Mn	390
K	2030
Na	11500

132B/DUP	9/29/97	9/29/97
VOCs		
12DCA	0.54 J	0.48 J
MIBK	5 U	0.22 J
EDB	7.7	7.2
METALS		
As	1 UJ	1.5 J
Ca	8310	8420
Fe	127	587
Pb	2.4	2.6
Mg	3090 J	3220 J
Mn	96.6	98.6
K	1180 U	1240
Na	10100	10200
Tl	1 UJ	1.1 J

137	9/30/97
VOCs	
EDB	0.63
METALS	
Ca	9370
Pb	1.7
Mg	2690 J
Mn	242
Ni	6.4
K	1610
Na	11000

138	9/30/97
VOCs	ND
METALS	
Ca	8290
Fe	158
Mg	3250 J
Mn	271
K	1680
Na	10200

133	9/28/97
VOCs	ND
METALS	
As	1.6 J
Ca	5730
Pb	3.7
Mg	3100 J
Mn	551
K	1670
Na	7520

135	10/2/97
VOCs	ND
METALS	
As	1.3 J
Ca	3380
Fe	1060
Mg	1770 J
Mn	79.9
K	7450
Na	11300

143	10/1/97
VOCs	ND
METALS	
Al	958
Ca	3600
Fe	3990
Pb	1.4
Mg	2270
Mn	235
K	3010
Na	17500

KEY:

Organics
- CH3Cl – Chloromethane
- ACE – Acetone
- CS2 – Carbon disulfide
- BNZ – Benzene
- XYL – Total Xylenes
- 12DCA – 1,2-Dichloroethane
- MIBK – 4-Methyl-2,pentanone
- PCE – Tetrachloroethene
- EDB – Ethylene dibromide

Metals
- Al – Aluminum
- As – Arsenic
- Ca – Calcium
- Cr – Chromium
- Fe – Iron
- Pb – Lead
- Mg – Magnesium
- Mn – Manganese
- Ni – Nickel
- K – Potassium
- Na – Sodium
- Tl – Thallium

Notes:
Concentration units are in ug/L (or ppb)
- ND – not detected
- U – Qualifier used to designate that the analyte was either not detected or requalified as not detected based on validation guidelines
- J – Qualifier used to designate that the analyte was detected and considered estimated
- UJ – Qualifier used to designate the non-detect is estimated due to data validation guidelines
- * – Diluted result reported instead of the original result since the linear calibration curve was exceeded

LEGEND

- 1997/1998 MONITORING WELL
- APPROXIMATE EDB PLUME

COMMODORE ADVANCED SCIENCES, INC.

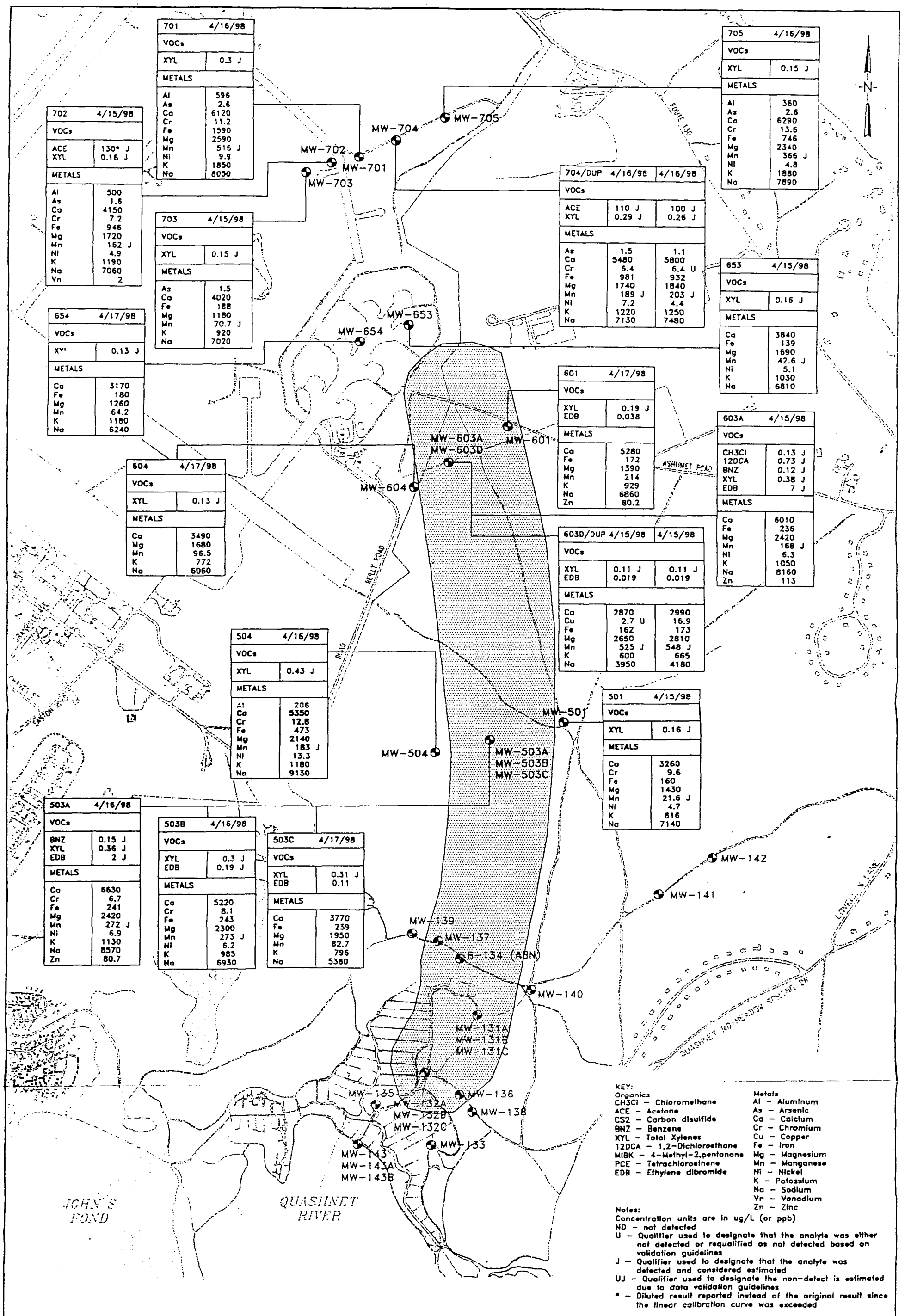
SCALE IN FEET

800 400 0 400 800

FIGURE 2-19.
ANALYSIS RESULTS FOR 1997 INSTALLED WELLS

AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

SCALE: 1"=800'	DWN BY: KVP
DATE: 7-9-98	FILENAME: MWR97AM.DWG



KEY:

Organics
- CH3Cl – Chloromethane
- ACE – Acetone
- CS2 – Carbon disulfide
- BNZ – Benzene
- XYL – Total Xylenes
- 12DCA – 1,2-Dichloroethane
- MIBK – 4-Methyl-2,pentanone
- PCE – Tetrachloroethene
- EDB – Ethylene dibromide

Metals
- Al – Aluminum
- As – Arsenic
- Ca – Calcium
- Cr – Chromium
- Cu – Copper
- Fe – Iron
- Mg – Magnesium
- Mn – Manganese
- Ni – Nickel
- K – Potassium
- Na – Sodium
- Vn – Vanadium
- Zn – Zinc

Notes:
Concentration units are in ug/L (or ppb)
ND – not detected
U – Qualifier used to designate that the analyte was either not detected or requalified as not detected based on validation guidelines
J – Qualifier used to designate that the analyte was detected and considered estimated
UJ – Qualifier used to designate the non-detect is estimated due to data validation guidelines
* – Diluted result reported instead of the original result since the linear calibration curve was exceeded

LEGEND

1997/1998 MONITORING WELL

APPROXIMATE EDB PLUME

COMMODORE ADVANCED SCIENCES, INC.

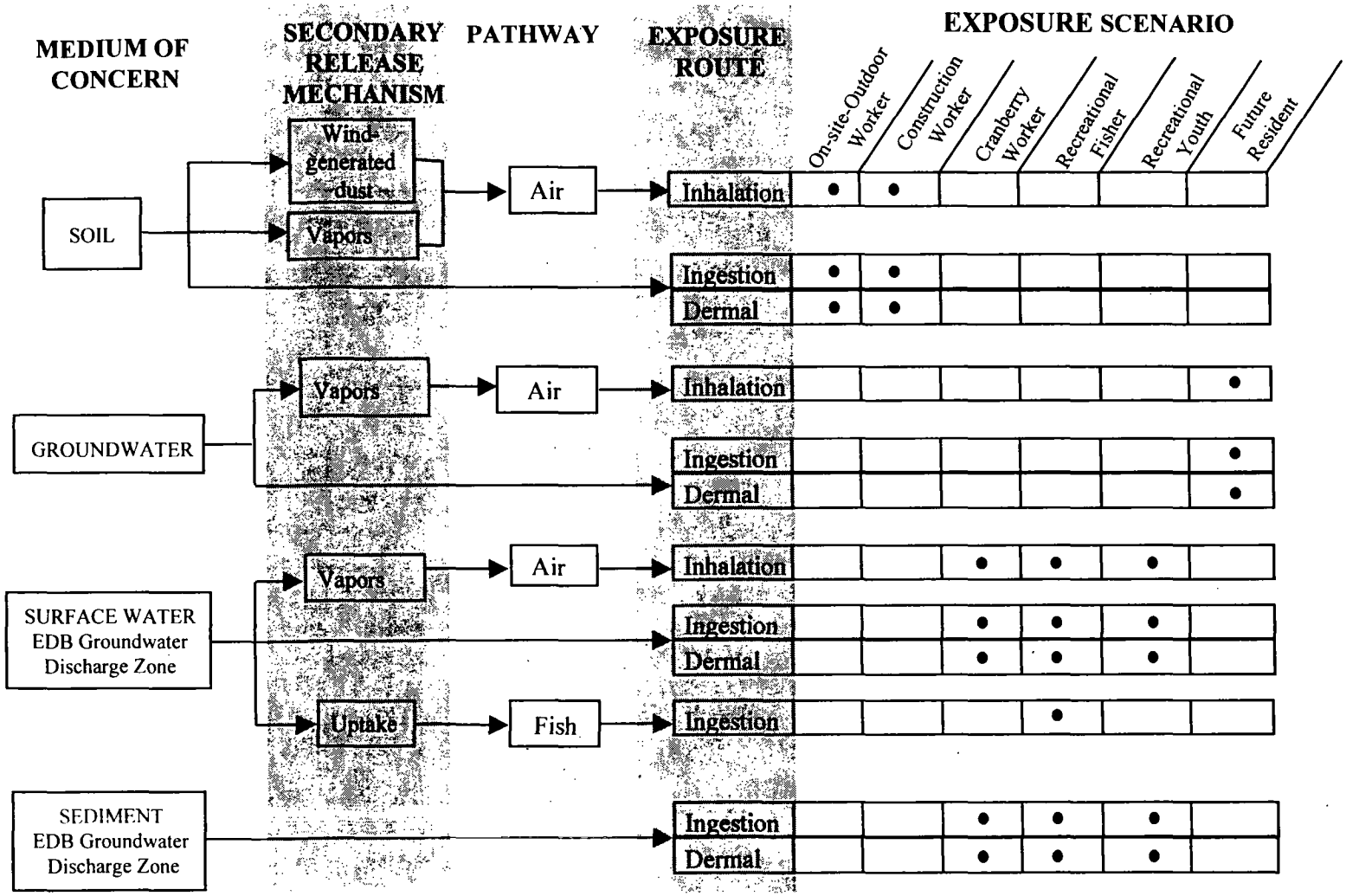
SCALE IN FEET

800 400 0 400 800

FIGURE 2-20.
ANALYSIS RESULTS FOR 1998 WELLS

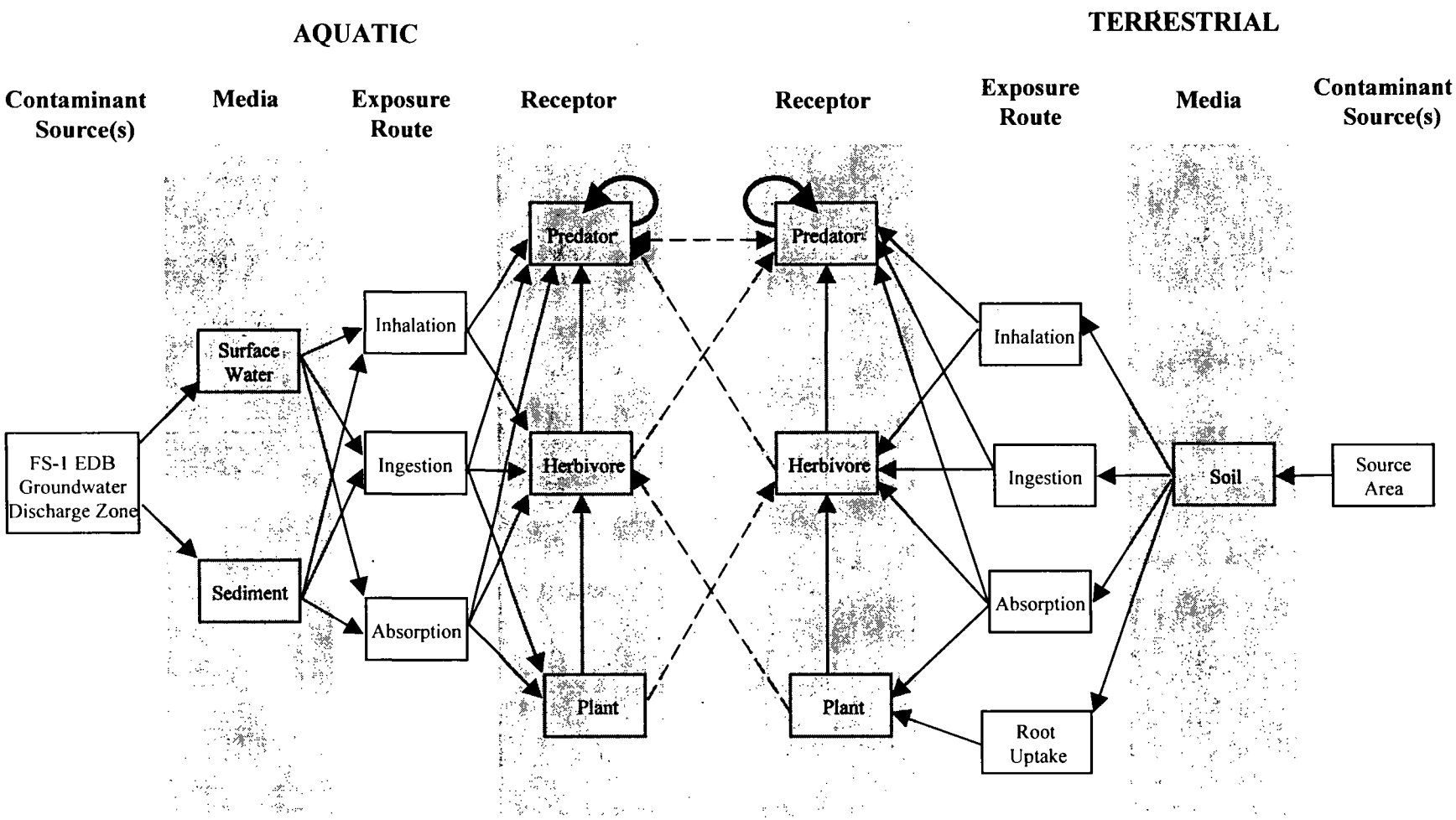
AOC FS-1 Supplemental Remedial Investigation
Massachusetts Military Reservation

SCALE: 1"=800'	DWN BY: KVP
DATE: 7-9-98	FILENAME: MWR98AN.DWG



● Potential pathway

AIMTech Advanced Infrastructure Management Technologies	
Human Health Conceptual Exposure Model FS-1 Installation Restoration Program, Massachusetts Military Reservation	
File: HCSMSRI.PPT	Graphical Depiction 2-1



AIMTech Advanced Infrastructure Management Technologies	
Ecological Conceptual Exposure Model FS-1 Installation Restoration Program, Massachusetts Military Reservation	
File: ECSMSRI.PPT	Graphical Depiction 2-2

Appendix B

APPENDIX B
TABLES

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Table 2.5-1
Summary of Exploration Activities and Associated Analytical Programs

SITE	EXPLORATION ID	INSTALLED DURING (EFFORT)	EXPLORATION TYPE	SAMPLE TYPE	MATRIX	QUANTITY	ANALYTES
FS-1	TP-1A	(1) PH.II, STG.I	TP	CLP	SOIL	1	V,S,P,I
FS-1	TP-2A	(1) PH.II, STG.I	TP	CLP	SOIL	1	V,S,P,I
FS-1	TP-3A	(1) PH.II, STG.I	TP	CLP	SOIL	1	V,S,P,I
FS-1	TP-4A	(1) PH.II, STG.I	TP	CLP	SOIL	1	V,S,P,I
FS-1	TP-5A	(1) PH.II, STG.I	TP	NONE	NONE	0	NONE
FS-1	TP-6A	(1) PH.II, STG.I	TP	NONE	NONE	0	NONE
FS-1	TP-7A	(1) PH.II, STG.I	TP	NONE	NONE	0	NONE
FS-1	TP-8A	(1) PH.II, STG.I	TP	NONE	NONE	0	NONE
FS-1	FS-1-1	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-2	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-3	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-4	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-5	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-6	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-7	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-8	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-9	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-10	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-11	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-12	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-13	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-14	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-15	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-16	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-17	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-18	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-19	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-20	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-21	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-22	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-23	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-24	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-25	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-26	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-27	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-28	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-29	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	FS-1-30	(3) TASK 2-3B	SG	SCREENING	SOIL GAS	1	SEL. VOCs
FS-1	X1X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	22	SEL. VOCs,TPH
FS-1	X1X2	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X1X3	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X1X4	(7) FS1 TM	GP	SCREENING	GROUNDWATER	10	SEL. VOCs,TPH
FS-1	X2X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	6	SEL. VOCs,TPH
FS-1	X2X2	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X2X3	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X2X4	(7) FS1 TM	GP	SCREENING	GROUNDWATER	7	SEL. VOCs,TPH
FS-1	X3X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X3X2	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X3X3	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X3X4	(7) FS1 TM	GP	SCREENING	GROUNDWATER	7	SEL. VOCs,TPH
FS-1	X4X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	6	SEL. VOCs,TPH
FS-1	X4X2	(7) FS1 TM	GP	SCREENING	GROUNDWATER	4	SEL. VOCs,TPH
FS-1	X4X3	(7) FS1 TM	GP	SCREENING	GROUNDWATER	4	SEL. VOCs,TPH
FS-1	X4X4	(7) FS1 TM	GP	SCREENING	GROUNDWATER	5	SEL. VOCs,TPH
FS-1	X5X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X5X2	(7) FS1 TM	GP	SCREENING	GROUNDWATER	5	SEL. VOCs,TPH
FS-1	X5X3	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X5X4	(7) FS1 TM	GP	SCREENING	GROUNDWATER	6	SEL. VOCs,TPH
FS-1	X6X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	9	SEL. VOCs,TPH
FS-1	X6X2	(7) FS1 TM	GP	SCREENING	GROUNDWATER	9	SEL. VOCs,TPH
FS-1	X6X3	(7) FS1 TM	GP	SCREENING	GROUNDWATER	7	SEL. VOCs,TPH
FS-1	X6X4	(7) FS1 TM	GP	SCREENING	GROUNDWATER	4	SEL. VOCs,TPH
FS-1	X6X5	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X7X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH
FS-1	X8X1	(7) FS1 TM	GP	SCREENING	GROUNDWATER	8	SEL. VOCs,TPH

Table 2.5-1
Summary of Exploration Activities and Associated Analytical Programs

SITE	EXPLORATION ID	INSTALLED DURING (EFFORT)	EXPLORATION TYPE	SAMPLE TYPE	MATRIX	QUANTITY	ANALYTES
FS-1	TB-3	(2) TASK 2-3A	SB	SCREENING	SOIL	7	SEL. VOCs
				CLP	SOIL	3	V,S,P,I
				SCREENING	GROUNDWATER	NA	SEL. VOCs
				CLP	GROUNDWATER	NA	V,S,P,I
FS-1	TB-5	(4) TASK 2-5 RI	SB	SCREENING	SOIL	11	SEL. VOCs
				CLP	SOIL	2	V,S,P,I
				SCREENING	GROUNDWATER	NA	SEL. VOCs
				CLP	GROUNDWATER	NA	V,S,P,I
FS-1	TB-411	(4) TASK 2-5 RI	SB	CLP	SOIL	1	V,S,P,I
				SCREENING	GROUNDWATER	NA	SEL. VOCs
				CLP	GROUNDWATER	NA	V,S,P,I
FS-1	RFW-011	(1) PH.II, STG.I	MW	SCREENING	GROUNDWATER	1	SEL. VOCs
				CLP	GROUNDWATER	3	V,S,P,I
FS-1	MW-1	(2) TASK 2-3A	MW	SCREENING	SOIL	13	SEL. VOCs
				CLP	GROUNDWATER	3	V,S,I
FS-1	MW-2	(2) TASK 2-3A	MW	SCREENING	SOIL	18	SEL. VOCs
				CLP	SOIL	4	V,S,I
				SCREENING	GROUNDWATER	2	SEL. VOCs
				CLP	GROUNDWATER	3	V,S,I
FS-1	MW-4	(3) TASK 2-3B	MW	SCREENING	SOIL	12	SEL. VOCs
				CLP	SOIL	2	S,P,I
				CLP	GROUNDWATER	3	V,S,LEAD
MASHPEE	WT-7	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-8	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-9	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-10	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-11	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-12	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-13	(4) TASK 5	MW	SCREENING	GROUNDWATER	1	SEL. VOCs
MASHPEE	WT-14	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-15	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-16	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-17	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	WT-18	(4) TASK 5	MW	NONE	NONE	0	NONE
MASHPEE	MW-516A	(4) TASK 5	MW	SCREENING	SOIL	20	SEL. VOCs
				CLP	SOIL	2	V,S,I
				CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-516B	(7) FS1 TM	MW	SCREENING	GROUNDWATER	1	SEL. VOCs,TPH,A
MASHPEE	MW-516B	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-516C	(7) FS1 TM	MW	SCREENING	GROUNDWATER	1	SEL. VOCs,TPH,A
MASHPEE	MW-516C	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-516D	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-516E	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-517A	(4) TASK 5	MW	SCREENING	SOIL	17	SEL. VOCs
				CLP	SOIL	2	V,S,I
				CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-517B	(7) FS1 TM	MW	SCREENING	GROUNDWATER	1	SEL. VOCs,TPH,A
MASHPEE	MW-517B	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-517C	(7) FS1 TM	MW	SCREENING	GROUNDWATER	1	SEL. VOCs,TPH,A
MASHPEE	MW-517C	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-517D	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
MASHPEE	MW-517E	(4) TASK 5	MW	CLP	GROUNDWATER	6	*SEE NOTE
FS-1	MW-4A	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	7	SEL. VOCs
				CLP	GROUNDWATER	2	V,S,I, TPH
FS-1	MW-6	(5) TASK 2-5 RI	MW	SCREENING	SOIL	8	SEL. VOCs
				CLP	SOIL	2	V,S,I, TPH
				SCREENING	GROUNDWATER	1	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-7	(5) TASK 2-5 RI	MW	SCREENING	SOIL	15	SEL. VOCs
				CLP	SOIL	3	V,S,I, TPH
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-8	(5) TASK 2-5 RI	MW	SCREENING	SOIL	17	SEL. VOCs

Table 2.5-1
Summary of Exploration Activities and Associated Analytical Programs

SITE	EXPLORATION ID	INSTALLED DURING (EFFORT)	EXPLORATION TYPE	SAMPLE TYPE	MATRIX	QUANTITY	ANALYTES
				CLP	SOIL	3	V,S,I, TPH
				CLP	GROUNDWATER	2	V,S,I, TPH
FS-1	MW-9	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	5	SEL. VOCs
				CLP	GROUNDWATER	3	V,S,I, TPH
FS-1	MW-10A	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	4	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-10B	(5) TASK 2-5 RI	MW	CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-11	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	7	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-112	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	3	SEL. VOCs
				CLP	GROUNDWATER	3	V,S,I, TPH
FS-1	MW-12	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	5	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-121	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	6	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-13	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	4	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-14	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	4	SEL. VOCs
				CLP	GROUNDWATER	2	V,S,I, TPH
FS-1	MW-41	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	5	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-412	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	1	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-413	(5) TASK 2-5 RI	MW	CLP	SOIL	1	V,S,I, TPH
				CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-414	(5) TASK 2-5 RI	MW	CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-415	(5) TASK 2-5 RI	MW	CLP	GROUNDWATER	1	V,S,I, TPH
FS-1	MW-42	(5) TASK 2-5 RI	MW	SCREENING	GROUNDWATER	4	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,I, TPH
SERGOU	MW-538A	(6) TASK 2-5C PH II	MW	SCREENING	GROUNDWATER	17	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
SERGOU	MW-538B	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
SERGOU	MW-538C	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-552A	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-552B	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-552C	(6) TASK 2-5C PH II	MW	SCREENING	GROUNDWATER	22	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-552D	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-553A	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-553D	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-556A	(6) TASK 2-5C PH II	MW	SCREENING	GROUNDWATER	16	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-556B	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-556C	(6) TASK 2-5C PH II	MW	CLP	GROUNDWATER	1	V,S,P,I
REGION III	MW-557	(6) TASK 2-5C PH II	MW	SCREENING	GROUNDWATER	23	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
SERGOU	MW-568	(6) TASK 2-5C PH II	MW	SCREENING	GROUNDWATER	17	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
FS-1	MW-15	(7) FS1 TM	MW	SCREENING	GROUNDWATER	16	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
FS-1	MW-16	(7) FS1 TM	MW	SCREENING	GROUNDWATER	8	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
FS-1	MW-17	(7) FS1 TM	MW	SCREENING	GROUNDWATER	12	SEL. VOCs
				CLP	GROUNDWATER	1	V,S,P,I
FS-1	#GMW-01	(7) FS1 TM	MW	SCREENING	GROUNDWATER	2	SEL. VOCs,TPH
FS-1	#GMW-02	(7) FS1 TM	MW	SCREENING	GROUNDWATER	2	SEL. VOCs,TPH
FS-1	MW-131A	1997	MW	SCREENING	GROUNDWATER	18	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-131B	1997	MW	CLP	GROUNDWATER	1	V, I
FS-1	MW-131C	1997	MW	CLP	GROUNDWATER	1	V, I
FS-1	MW-132A	1997	MW	CLP	GROUNDWATER	1	V, I
FS-1	MW-132B	1997	MW	CLP	GROUNDWATER	1	V, I
FS-1	MW-132C	1997	MW	SCREENING	GROUNDWATER	15	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-133	1997	MW	SCREENING	GROUNDWATER	19	V, I

Table 2.5-1
Summary of Exploration Activities and Associated Analytical Programs

SITE	EXPLORATION ID	INSTALLED DURING (EFFORT)	EXPLORATION TYPE	SAMPLE TYPE	MATRIX	QUANTITY	ANALYTES
				CLP	GROUNDWATER	1	V, I
FS-1	BW-134	1997	MW (abandoned)	SCREENING	GROUNDWATER	7	V, I
FS-1	MW-135	1997	MW	SCREENING	GROUNDWATER	19	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-136	1997	MW	SCREENING	GROUNDWATER	13	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-137	1997	MW	SCREENING	GROUNDWATER	15	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-138	1997	MW	SCREENING	GROUNDWATER	13	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-139	1997	MW	SCREENING	GROUNDWATER	13	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-140	1997	MW	SCREENING	GROUNDWATER	6	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-141	1997	MW	SCREENING	GROUNDWATER	18	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-142	1997	MW	SCREENING	GROUNDWATER	11	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-143	1997	MW	SCREENING	GROUNDWATER	14	V, I
				CLP	GROUNDWATER	1	V, I
FS-1	MW-501	1998	MW	SCREENING	GROUNDWATER	11	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-503A	1998	MW	SCREENING	GROUNDWATER	14	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-503B	1998	MW	CLP	GROUNDWATER	1	V, I
FS-1	MW-503C	1998	MW	CLP	GROUNDWATER	1	V, I
FS-1	MW-504	1998	MW	SCREENING	GROUNDWATER	17	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-601	1998	MW	SCREENING	GROUNDWATER	14	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-603A	1998	MW	SCREENING	GROUNDWATER	17	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-603D	1998	MW	CLP	GROUNDWATER	1	V, I
FS-1	MW-604	1998	MW	SCREENING	GROUNDWATER	14	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-653	1998	MW	SCREENING	GROUNDWATER	16	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-654	1998	MW	SCREENING	GROUNDWATER	11	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-701	1998	MW	SCREENING	GROUNDWATER	12	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-702	1998	MW	SCREENING	GROUNDWATER	16	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-703	1998	MW	SCREENING	GROUNDWATER	16	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-704	1998	MW	SCREENING	GROUNDWATER	11	V
				CLP	GROUNDWATER	1	V, I
FS-1	MW-705	1998	MW	SCREENING	GROUNDWATER	12	V
				CLP	GROUNDWATER	1	V, I
FS-1/bogs	SW-01	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-02	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-03	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-04	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-05	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-06	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-07	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-08	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-09	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-10	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-11	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-12	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-13	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-14	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-15	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS

Table 2.5-1
Summary of Exploration Activities and Associated Analytical Programs

SITE	EXPLORATION ID	INSTALLED DURING (EFFORT)	EXPLORATION TYPE	SAMPLE TYPE	MATRIX	QUANTITY	ANALYTES
	SW-16	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-17	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-18	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-19	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-20	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-21	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-22	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-23	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-24	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-25	1997	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-26	1998	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-26	1998	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-28	1998	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-29	1998	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS
	SW-30	1998	SW	DEFINIITVE	SURFACE WATER	1	EDB,METALS

Notes:

Sample numbers are for total samples collected over all field efforts (i.e., MW-1 has been sampled during 2-3A, 2-3B, and the RI field effort [2, 3, and 5 below]

1" Stainless Steel Geoprobe Permascreen Wells

SG = Soil Gas, SB = Soil Boring, TP = Test Pit, MW = Monitoring Well, GP = Geoprobe, NA = Not Available

SEL VOCs = Selected VOCs, V = VOCs, S = SVOCs, P = Pesticides/PCBs, I = Inorganics, TPH = Total Petroleum Hydrocarbons, A = Arsenic

* May 1987 CLP V,S,I - June, July, August, 1987 CLP V - Dec.,1987 Non CLP Selected VOCs - Feb., 1988 Non CLP Selected VOCs

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(1) R.F. Weston, Inc., 1985, Installation Restoration Program, Phase II-Confirmation/Quantification, Stage I, Otis Air National Guard Base, Massachusetts and Air National Guard Support Center, Andrews AFB, MD, September 1985.

(2) E.C. Jordan, Co., 1989a, "Site Inspection Report Task 2-3A, Field Investigation Work Conducted Fall 1987", Installation Restoration Program, Massachusetts Military Reservation, (Final).

(3) E.C. Jordan, Co., 1990a, "Site Inspection Report Task 2-3B, Field Investigation Work Conducted Spring-Summer 1988" Installation Restoration Program, Massachusetts Military Reservation, (Final).

(4) E.C. Jordan, Co., 1990b, "Mashpee Groundwater Study, Task 5", Installation Restoration Program, Massachusetts Military Reservation, (Final).

(5) ABB-Environmental Services, 1991, "Remedial Investigation Report, AVGAS Fuel Valve Test Dump Site, FS-1 Study Area", Installation Restoration Program, Massachusetts Military Reservation, (Draft with Appendix I added July 1992).

(6) ABB-Environmental Services, 1994, "Southeast Region Groundwater Operable Unit Remedial Investigation Report (Including Region III)", Installation Restoration Program, Massachusetts Military Reservation, (?????).

(7) Advanced Sciences Inc., 1995, "Technical Memorandum, Site Investigation for Area of Contamination Fuel Spill 1 and Downgradient Areas", Installation Restoration Program, Massachusetts Military Reservation, (Revised Draft).

Table 2.5-2
Analytical Results from Soil Collected at Fuel Spill Site 1
Pre-1997

Source:		E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1991
Sample Location:		36BS005048	36BS005054	36MS006015	36MS006048	36MS007030	36MS007048	36MS007065	36MS008047	36MS008047D	36MS008060
Sample Depth:		48ft	54ft	15ft	48ft	30ft	48ft	65ft	47ft	47ft	60ft
Date Sampled:		7/31/89	7/31/89	7/31/89	7/31/89	8/1/89	8/1/89	8/1/89	8/2/89	8/2/89	8/2/89
Chemical	CRQL/CRDL										
Volatiles (ug/Kg)											
Methylene Chloride	5	ND	ND	ND	ND	110000	ND	140000	ND	ND	70000
Acetone	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Semivolatiles (ug/Kg)											
bis(2-Ethylhexyl)phthalate	330	ND	ND	ND	ND	ND	ND	ND	2300	ND	ND
Phenanthrene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthlene	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides (ug/Kg)											
alpha-BHC	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan I	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DD	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metals(mg/Kg)											
Aluminum	200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	3	ND	2.1	1.3	1.7	1.1	4.8	ND	3	3	1.9
Magnesium	5000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	5000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	5000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous(mg/Kg)											
TOC	50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TPH	0.2	ND	ND	ND	ND	ND	55.8	ND	63.3	234	ND

Table 2.5-2
Analytical Results of Soil Collected at Fuel Spill Site 1
Pre-1997 (continued)

Source:		E.C. Jordan 1991	E.C. Jordan 1991	E.C. Jordan 1989	E.C. Jordan 1989	E.C. Jordan 1990	HAZWRAP 1995	HAZWRAP 1995	HAZWRAP 1995	HAZWRAP 1995	HAZWRAP 1995	HAZWRAP 1995
Sample Location:		36BS411054	36MS413055	FS1-TB2	FS1-TB3	FS-1 TB-4	36SS50	36SS51	36SS52	36SS52D	36SS53	36SS54
Sample Depth:		54ft	55ft				0.5-1.5ft	0.5-1.5ft	0.5-1.5ft	0.5-1.5ft	0.5-1.5ft	0.5-1.5ft
Date Sampled:		9/27/89	10/3/89	10/1/87	10/1/87	4/24/88	9/28/95	9/28/95	9/28/95	9/28/95	9/28/95	9/28/95
Chemical	CRQL/CRDL											
Volatiles (ug/Kg)												
Methylene Chloride	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	10	ND	13	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	10	ND	ND	ND	20 JB	ND	ND	ND	ND	ND	ND	ND
Semivolatiles (ug/Kg)												
bis(2-Ethylhexyl)phthalate	330	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	330	ND	ND	ND	ND	ND	81	100	78	56	150	ND
Anthracene	330	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND
Fluoranthene	330	ND	ND	ND	ND	ND	75	180	140	130	140	ND
Pyrene	330	ND	ND	ND	ND	ND	110	270	230	210	220	ND
Benzo(a)anthracene	330	ND	ND	ND	ND	ND	52	90	130	110	53	ND
Chrysene	330	ND	ND	ND	ND	ND	ND	ND	180	170	240	ND
Benzo(b)fluoranthene	330	ND	ND	ND	ND	ND	ND	210	370	270	360	ND
Benzo(k)fluoranthene	330	ND	ND	ND	ND	ND	ND	190	330	250	320	ND
Benzo(a)pyrene	330	ND	ND	ND	ND	ND	ND	100	190	190	140	ND
Indeno(1,2,3-cd)pyrene	330	ND	ND	ND	ND	ND	ND	49	ND	130	79	ND
Benzo(g,h,i)perylene	330	ND	ND	ND	ND	ND	ND	44	ND	150	ND	ND
Acenaphthlene	330	ND	ND	ND	ND	ND	ND	ND	50	ND	54	ND
Pesticides (ug/Kg)												
alpha-BHC	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.23	ND
Aldrin	1.7	ND	ND	ND	ND	ND	ND	ND	ND	0.16	ND	ND
Heptachlor epoxide	1.7	ND	ND	ND	ND	ND	0.15	0.29	ND	ND	0.48	ND
Endosulfan I	1.7	ND	ND	ND	ND	ND	ND	0.6	0.74	ND	0.59	ND
Dieldrin	3.3	ND	ND	ND	ND	ND	1.9	1.5	1.8	1.6	13	0.22
4,4'-DDE	3.3	ND	ND	ND	ND	ND	2.1	ND	0.28	0.24	1	ND
Endrin	3.3	ND	ND	ND	ND	ND	0.47	0.92	0.87	0.78	1.7	ND
Endosulfan II	3.3	ND	ND	ND	ND	ND	1	1.4	0.97	ND	1.5	ND
4,4'-DDD	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND
4,4'-DDT	3.3	ND	ND	ND	ND	ND	5	0.24	0.81	1	3.2	ND
Methoxychlor	17	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.72	ND
Endrin ketone	3.3	ND	ND	ND	ND	ND	0.53	ND	ND	0.34	ND	ND
alpha-Chlordane	1.7	ND	ND	ND	ND	ND	0.24	0.16	0.24	0.19	0.35	ND
gamma-Chlordane	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.15	ND
Metals(mg/Kg)												
Aluminum	200	NA	NA	1090	471	400	1590	931	1790	1800	2690	911
Antimony	60	NA	NA	ND	ND	ND	ND	ND	ND	ND	0.63	ND
Arsenic	10	NA	NA	ND	ND	ND	0.67	ND	0.93	1.2	1.2	ND
Barium	200	NA	NA	ND	ND	ND	64.8 J	11.5 J	5.1 J	5.1 J	4.6 J	2.7 J
Chromium	10	NA	NA	ND	ND	ND	3	2.4	3.5	3.2	7.4	1.8
Cobalt	50	NA	NA	ND	ND	ND	0.69	0.98	0.99	1	0.87	0.7
Iron	100	NA	NA	1430	749	990	2370	1770	3370	3220	3740	2250
Lead	3	ND	ND	1.8	ND	ND	23.6	6.4	41.4	36.6	114	2.2 J
Magnesium	5000	NA	NA	ND	ND	ND	290	225	387	393	404	234
Manganese	15	NA	NA	32	21	7.8	23.6	42.4	31.5	29.7	24.9	30.6
Nickel	40	NA	NA	ND	ND	ND	1.6	1.9	2	1.9	2.7	1.4
Potassium	5000	NA	NA	ND	ND	ND	107 J	98.7 J	161	176 J	165 J	86.3 J
Sodium	5000	NA	NA	ND	ND	ND	259 J	272 J	253	258 J	255 J	235 J
Vanadium	50	NA	NA	ND	ND	ND	3.7	2.9	5.6	5.3	8.2	3.5
Zinc	20	NA	NA	8	6.1	5.7	ND	ND	ND	ND	ND	ND
Miscellaneous(mg/Kg)												
TOC	50	NA	NA	NA	NA	NA	50	NA	50	NA	NA	50
TPH	0.2	ND	15.4	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 2.5-2
Analytical Results from Soil Collected at Fuel Spill Site 1
Pre-1997 (continued)

Notes:

ND = Not Detected
CRQL/CRDL = Contract Required Quantitation Limit/Contract Required Detection Limit
TPH = Total Petroleum Hydrocarbons
TOC = Total Organic Carbon
NA = Not Analyzed
J = Estimated Value
B = Parameter was present in the associated method blank.
* Excludes Weston 1985 Test Pit Data

Subsurface Soil Samples Collected in the Following Borings
At the Indicated Depths Did Not Contain Contaminant
Concentrations In Exceedance of the CRQL/CRDLs.
FS-1 TB-1 (13-15 Ft.), FS-1 TB-1 (48-50 Ft.), FS-1 TB-1 (58-60 Ft.)
FS-1 TB-2 (24-26 Ft.), FS-1 TB-2 (49-51 Ft.), FS-1 TB-3 (48-50 Ft),
FS-1 TB-3 (53-55 Ft), FS-1 TB-4 (69-71 Ft.)

Table 2.5-3
Analytical Results Groundwater FS-1
Pre 1997

Source		1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI
Sample Location:		36MW1	36MW2	36MW4	36MW4A	36MW6	36MW7	36MW8	36MW8D	36MW9	36MW9D	36MW10A	36MW10B	36MW414
Date Sampled		10/25/89	10/24/89	10/24/95	10/24/89	10/24/89	10/24/89	10/25/89	10/25/89	10/24/89	10/24/89	10/24/89	10/24/89	10/25/89
VOA (ug/L)	CRQL													
Chloromethane	1	ND	ND	ND	ND	ND	ND	ND	8	ND	ND	ND	ND	8
Methylene Chloride	2	2	ND	ND	ND	ND	ND	1	1	ND	ND	ND	ND	1
Acetone	5	49	210	ND	8	5	ND	8	13	ND	ND	ND	ND	9
2-Butanone	5	620 D	ND	ND	ND	180	ND	ND	ND	120000	101000	ND	ND	ND
4-Methyl-2-Pentanone	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1	ND	ND	ND	ND	ND	ND	2	2	ND	ND	ND	ND	ND
Toluene	1	3 X	85 D	ND	ND	18	2500	6 X	2 X	ND	ND	ND	ND	4
Ethylbenzene	1	ND	ND	ND	ND	ND	220	ND	ND	ND	ND	ND	ND	ND
Xylene	1	1	188 D	ND	ND	4 X	400	320	170 D	ND	ND	ND	ND	1 X
Trichloroethene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SVOA (ug/L)	CRQL													
Benzyl Alcohol	10	ND	ND	26	ND	ND	19	ND	ND	ND	ND	ND	ND	ND
2-Methylphenol	10	ND	24	ND	ND	ND	ND	16	10	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Miscellaneous (mg/L)	RL													
TPH	0.2	ND	0.34	ND	ND	ND	0.68	0.96	ND	ND	ND	ND	ND	ND
Pesticides/PCBs (ug/L)	CRQL													
4,4'-DDT	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Metals (ug/L)	CRDL													
Aluminum	200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12.3	ND
Barium	200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	5000	ND	ND	ND	ND	ND	ND	8850	ND	ND	ND	ND	ND	ND
Cyanide	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	100	357	16900	2740	ND	ND	12000	ND	3290	ND	ND	ND	22100	ND
Lead	5	ND	159	ND	ND	ND	60	39.2	ND	ND	ND	ND	ND	ND
Magnesium	5000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	15	172	734	1380	ND	604	740	33.8	873	1460	1480	392	839	163
Nickel	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	5000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	5000	5430	5120	5520	ND	ND	5280	ND	5080	ND	ND	ND	ND	ND
Thallium	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

KEY
D Dilution
J=Data estimated
E Outside linear range
ND=Nondetect
N=Not Analyzed
X=Mass Spectrum outside criteria, compound present
B=Analyte detected in blank
Dup=duplicate sample result

Table 2.5-3
Analytical Results Groundwater FS-1
Pre 1997

Source		1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI	1991RI
Sample Location:		36MWRFW11	36MW12	36MW41	36MW42	36MW112	36MW121	36MW412	36MW413	36MW415	36MW14	36MW14D	36MW11	36MW13
Date Sampled		10/25/89	10/26/89	10/25/89	10/26/89	10/26/89	10/26/89	10/25/89	10/25/89	10/25/89	11/19/89	11/19/89	11/19/89	11/19/89
VOA (ug/L)	CRQL													
Chloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	2	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	5	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	5	190	ND	ND	1500	53000	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1	1 X	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene	1	5 X	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SVOA (ug/L)	CRQL													
Benzyl Alcohol	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylphenol	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	ND
Miscellaneous (mg/L)	RL													
TPH	0.2	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides/PCBs (ug/L)	CRQL													
4,4'-DDT	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Metals (ug/L)	CRDL													
Aluminum	200	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	10	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	200	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	5000	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cyanide	10	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	10	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	50	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	25	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	100	NA	ND	ND	ND	5400	2960	ND	453	2800	1470	1160	6160	ND
Lead	5	NA	6.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Magnesium	5000	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	15	NA	25.8	81.5	17.7	410	804	ND	46.4	514	213	218	548	39.4
Nickel	40	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	5000	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	10	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	5000	NA	ND	5280	5350	ND	5240	ND	ND	5810	ND	ND	8750	6090
Thallium	10	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	50	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	40	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

KEY
D Dilution
J=Data estimated
E Outside linear range
ND=Nondetect
N=Not Analyzed
X=Mass Spectrum outside criteria, compound present
B=Analyte detected in blank
Dup=duplicate sample result

Table 2.5-3
Analytical Results Groundwater FS-1
Pre 1997

Source		1991RI	1991RI	1991RI	1991RI	1991RI	SIAOC-FS1	SIAOC-FS1	SIAOC-FS1	SIAOC-FS1	GW Mashpee	GW Mashpee
Sample Location:		MW-112	MW-112D	MW-4	MW-4A	FS1MW9	36MWX15131	36MWX15131D	36MWX16X66	36MWX17105	JMW516	JMW517
Date Sampled		2/1/90	2/1/90	2/1/90	2/1/90	3/2/90	12/6/94	12/6/94	12/5/94	12/6/94	5/13/87	5/13/87
VOA (ug/L)	CRQL											
Chloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	50	12 B
2-Butanone	5	250 D	96	46000 D	55000DEJ	24000 X	ND	ND	ND	ND	420	76
4-Methyl-2-Pentanone	5	ND	ND	51	85	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0 9
Toluene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.15	0.63
Ethylbenzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SVOA (ug/L)	CRQL											
Benzyl Alcohol	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2-Methylphenol	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
bis(2-Ethylhexyl)phthalate	10	ND	ND	ND	18	ND	2 J	ND	ND	ND	NA	NA
Miscellaneous (mg/L)	RL											
TPH	0.2	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
Pesticides/PCBs (ug/L)	CRQL											
4,4'-DDT	0.1	NA	NA	NA	NA	NA	0.0045 J	ND	ND	ND	ND	ND
Metals (ug/L)	CRDL											
Aluminum	200	NA	NA	NA	NA	NA	2580 J	1720	3320	ND	ND	ND
Arsenic	10	NA	NA	NA	NA	NA	ND	ND	ND	ND	NA	NA
Barium	200	NA	NA	NA	NA	NA	19.2 J	13.6	26 8	6.8	NA	NA
Calcium	5000	NA	NA	NA	NA	NA	5740	5710	2640	5980	ND	ND
Cyanide	10	NA	NA	NA	NA	NA	NA	NA	NA	NA	14	ND
Chromium	10	NA	NA	NA	NA	NA	17.2	8.1	31.6	2.4	NA	NA
Cobalt	50	NA	NA	NA	NA	NA	2.1	1.7	4.9	3 8	NA	NA
Copper	25	NA	NA	NA	NA	NA	4.4	3.9	14.4	1.4	NA	NA
Iron	100	NA	NA	NA	NA	NA	2630	2090	5500	596	ND	323
Lead	5	ND	ND	ND	ND	ND	5.5	9.9	3.5	2.9	NA	NA
Magnesium	5000	NA	NA	NA	NA	NA	2160	2040	2920	4740	ND	ND
Manganese	15	NA	NA	NA	NA	NA	141	136	435	295	35	56
Nickel	40	NA	NA	NA	NA	NA	16	16 2	22.2	6.1	NA	NA
Potassium	5000	NA	NA	NA	NA	NA	1970	1770	1680	1300	NA	NA
Silver	10	NA	NA	NA	NA	NA	ND	5.9	ND	ND	NA	NA
Sodium	5000	NA	NA	NA	NA	NA	16000	13400	5390	7660	9620	10400
Thallium	10	NA	NA	NA	NA	NA	3.1	ND	ND	ND	NA	NA
Vanadium	50	NA	NA	NA	NA	NA	4.5	3.4	8 8	ND	NA	NA
Zinc	40	NA	NA	NA	NA	NA	23 J	24.2 J	22.4 J	25.9 J	33	41
Cadmium	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

KEY
D Dilution
J=Data estimated
E Outside linear range
ND=Nondetect
N=Not Analyzed
X=Mass Spectrum outside criteria, compound present
B=Analyte detected in blank
Dup=duplicate sample result

Table 2.5-3
Analytical Results Groundwater FS-1
Pre 1997

Source		2-3A	2-3A	2-3B	**2-3B	2-3B	2-3B	2-5C PHII	2-5C PHII	2-5C PHII	2-5C PHII	2-5C PHII	2-5C PHII	2-5C PHII
Sample Location:		MW-1	MW-2	RFW-011	MW-1	MW-2	MW-4	MW-552A	MW-552B	MW-552C	MW-552D	MW-553A	MW-553D	MW-568
Date Sampled		10/28/87	10/07/88	01/12/89	01/12/89	01/12/89	01/12/89	11/19/93	11/19/93	11/19/93	11/19/93	11/19/93	11/19/93	12/06/93
VOA (ug/L)	CRQL													
Chloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	2	ND	25 JB- DUP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	5	ND	ND	ND	3 BJ	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1	ND	1900	7 8J	ND	ND	ND	0.3J	ND	ND	ND	0.5J	ND	0.8J
Ethylbenzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene	1	ND	460	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	1	ND	ND	ND	ND	ND	ND	ND	0.4J	1J	ND	ND	ND	ND
Chloroform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	2	3	0.3J
1,1,1-Trichloroethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SVOA (ug/L)	CRQL													
Benzyl Alcohol	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylphenol	10	ND	ND	ND	ND	24	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	10	ND	ND	ND	ND	ND	2J	2J	ND	ND	ND	ND	ND	ND
Miscellaneous (mg/L)	RL													
TPH	0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ug/L)	CRQL													
4,4'-DDT	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Metals (ug/L)	CRDL													
Aluminum	200	ND	ND	NA	NA	NA	NA	ND	447 / 150 J	230	57.2 J	ND	1210	57.1 J
Arsenic	10	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	2.8 J	ND
Barium	200	ND	ND	NA	NA	NA	NA	ND	5.8 J / 3.2 J	2.5 J	14.5 J	ND	22.7 J	12.4 J
Calcium	5000	ND	ND	NA	NA	NA	NA	2560 J	3020 J / 2890 J	2840 J	ND	ND	1350 J	1340 J
Cyanide	10	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND
Chromium	10	ND	ND	NA	NA	NA	NA	ND	8.4 J	ND	ND	ND	6 6 J	ND
Cobalt	50	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	3.4 J	ND
Copper	25	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND
Iron	100	ND	16400	NA	NA	NA	NA	ND	931 / 390	551	ND	ND	2300	ND
Lead	5	15	71	ND	ND	126 N	ND	ND	4.3	4.6	ND	2 J	4	ND
Magnesium	5000	ND	ND	NA	NA	NA	NA	1330 J	1680 J / 1520 J	1590 J	1340 J	664 J	1440 J	1360 J
Manganese	15	709	711	NA	NA	NA	NA	ND	167 / 69 5	52	45.1	2.2 J	556	667
Nickel	40	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND
Potassium	5000	ND	ND	NA	NA	NA	NA	733 J	963 J / 990 J	937 J	673 J	485 J	669 J	1020 J
Silver	10	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND
Sodium	5000	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND
Thallium	10	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND
Vanadium	50	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	4 1 J	ND
Zinc	40	ND	23-DUP	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND
Cadmium	5	ND	ND	NA	NA	NA	NA	ND	ND	3.1 J	ND	ND	ND	ND
Selenium	5	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND

KEY
D Dilution
J=Data estimated
E Outside linear range
ND=Nondetect
N=Not Analyzed
X=Mass Spectrum outside criteria, compound present
B=Analyte detected in blank
Dup=duplicate sample result

Table 2.5-3
Analytical Results Groundwater FS-1
Pre 1997

Source		2-5C PHII	2-5C PHII	2-5C PHII	2-5C PHII	SERGOU	SERGOU	SERGOU
Sample Location:		MW-556A	MW-556B	MW-556C	MW-557	MW-538A	MW-538B	MW-538C
Date Sampled		12/07/93	12/07/93	12/07/93	11/19/93	12/08/93	12/08/93	12/08/93
VOA (ug/L)	CRQL							
Chloromethane	1	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	2	ND	ND	ND	ND	ND	ND	ND
Acetone	5	ND	ND	ND	ND	ND	ND	ND
2-Butanone	5	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	5	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	1	ND	ND	ND	ND	ND / 0.4 J	0.3 J	ND
Toluene	1	0.5J	2	ND	ND	ND	3	0.3 J
Ethylbenzene	1	ND	ND	ND	ND	ND	ND	ND
Xylene	1	ND	ND	ND	ND	ND	0.2 J	ND
Trichloroethene	1	ND	ND	ND	ND	ND	1 J	ND
Chloroform	1	0.3J	3	ND	ND	ND	0.3 J	4 J
1,1,1-Trichloroethane	1	ND	0.8 J	ND	ND	ND	0.4 J	ND
Bromodichloromethane	1	ND	0.2 J	ND	ND	ND	0.4 J	ND
Dibromochloromethane	1	ND	0.5 J	ND	ND	ND	0.8 J	ND
Bromoform	1	ND	0.4 J	ND	ND	ND	0.7 J	ND
Benzene	1	ND	0.9 J	ND	ND	ND	ND	ND
SVOA (ug/L)	CRQL							
Benzyl Alcohol	10	ND	ND	ND	ND	ND	ND	ND
2-Methylphenol	10	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	10	ND	ND	ND	ND	ND	ND	ND
Miscellaneous (mg/L)	RL							
TPH	0.2	NA	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ug/L)	CRQL							
4,4'-DDT	0.1	NA	NA	NA	NA	NA	NA	NA
Metals (ug/L)	CRDL							
Aluminum	200	70.4 J	4240	136 J	3590	161 J /231	ND	ND
Arsenic	10	ND	2.8 J	ND	3 J	ND	ND	ND
Barium	200	3 J	46.2 J	24.8 J	19 J	ND	26.1 J	19.4 J
Calcium	5000	4350 J	1650 J	1990 J	6040	3950 J / 4040 J	2620 J	ND
Cyanide	10	ND	ND	ND	ND	ND	ND	ND
Chromium	10	ND	41.3	ND	16.4 J	ND	ND	ND
Cobalt	50	ND	5.4 J	ND	3.3 J	ND	ND	ND
Copper	25	ND	10.2 J	ND	ND	ND	ND	ND
Iron	100	ND	9680	ND	8610	ND / 448 J	ND	ND
Lead	5	ND	4.2 J	ND	4.2	ND	ND	ND
Magnesium	5000	1790 J	2580 J	2590 J	2660 J	2070 J / 2130 J	2050 J	1920 J
Manganese	15	ND	105	20.7	93.4	22.1 / 25.8	915	33.1
Nickel	40	ND	23.2 J	ND	ND	ND	ND	ND
Potassium	5000	757 J	1730 J	640 J	1410 J	737 J / 712 J	1330 J	749 J
Silver	10	ND	ND	ND	ND	ND	ND	ND
Sodium	5000	ND	ND	ND	ND	ND	ND	ND
Thallium	10	ND	ND	ND	2.1 J	ND	ND	ND
Vanadium	50	ND	14.3 J	ND	13 J	ND	ND	ND
Zinc	40	ND	ND	ND	ND	ND	ND	ND
Cadmium	5	ND	ND	ND	ND	ND	ND	ND
Selenium	5	ND	ND	ND	ND	ND / 2.4 J	ND	ND

KEY
D Dilution
J=Data estimated
E Outside linear range
ND=Nondetect
N=Not Analyzed
X=Mass Spectrum outside criteria, compound present
B=Analyte detected in blank
Dup=duplicate sample result

Table 2 5-4
Analytical Results from Groundwater Collected at Fuel Spill Site 1,
February 1997, October 1997, and April 1998

Monitoring Well	MW18	MW18Dup	MW17	MW131A	MW131B	MW131C	MW132A	MW132ADup	MW132B	MW132BDup	MW132C	MW133	MW135
Volatile Organics (ug/L)													
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	0.25 J	ND	ND	ND	0.54 J	0.48 J	0.55 J	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	0.21 J	ND	ND	ND	0.22 J	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.33 J	ND	ND
Benzene	ND	ND	0.14 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	0.16 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	ND	ND	ND	2.7	3.4	0.56	2.2	2.2	7.7	7.2	6.5	ND	ND
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Metals (ug/L)													
Aluminum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND	ND	ND	20.5	ND	1.5 J	ND	1.6 J	1.3 J
Barium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	2130 J	2070 J	4810 J	8930	6770	3890	7820	7650	8310	8420	6280	5730	3380
Chromium	ND	ND	ND	ND	ND	ND	6.4	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	207	169	120	132	ND	ND	571	329	127	587	ND	ND	1060
Lead	1.7 J	1.4 J	ND	22.7	1.2	1.6	3	2.6	2.4	2.6	2.2	3.7	ND
Magnesium	2280 J	3180 J	3180 J	3180 J	2160 J	1380 J	2400	2310	3090 J	3220 J	2500 J	3100 J	1770 J
Manganese	14.9 J	304	304	304	26.2	8.9	225	219	96.6	98.6	15.4	551	79.9
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	562 J	598 J	1820 J	1820	ND	ND	1330	ND	ND	1240	ND	1670	2450
Sodium	5950 J	5860	6250	10400	9730	6130	9600	9270	10100	10200	9110	7520	11300
Thallium	1.3 J	1.3 J	1.3 J	1.3 J	ND	ND	ND	ND	ND	1.1 J	1.2 J	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
* 1,2-Dibromoethane (EDB or ethylene dibromide) was analyzed reported from the Method 504 result
J = Data is estimated.
ND = Nondetect
NA = Not analyzed
Dup = Concentration from duplicate sample
ug/L = micrograms per liter

Table 2 5-4
Analytical Results from Groundwater Collected at Fuel Spill Site 1,
February 1997, October 1997, and April 1998

Monitoring Well	MW136	MW137	MW138	MW139	MW140	MW141	MW142	MW143	MW501	MW503A	MW503B	MW503C	MW504
Volatile Organics (ug/L)													
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.15 J	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	0.18	0.63	ND	ND	ND	ND	ND	ND	ND	2 J	0.19 J	0.11	ND
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	0.16 J	0.36 J	0.3 J	0.31 J	0.43 J
Total Metals (ug/L)													
Aluminum	ND	ND	ND	ND	479	560	ND	958	ND	ND	ND	ND	206
Arsenic	ND	ND	ND	ND	1.5 J	4.5	5.3	5.3	ND	ND	ND	ND	ND
Barium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	9720	9370	8290	4780	7290	6490	16000	3600	3260	6630	5220	3770	5350
Chromium	ND	ND	ND	9.9	13.6	13.6	ND	ND	9.6	6.7	8.1	ND	12.8
Copper	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	120	ND	158	128	2880	1850	ND	3990	160	241	243	239	473
Lead	1.4	1.7	1.7	2.5	1.1	1.1	ND	1.4	ND	ND	ND	ND	ND
Magnesium	3980	2890 J	3250 J	1850 J	4260 J	2340	1720	2270	1430	2420	2300	1950	2140
Manganese	380	242	271	114	403	655	85.8	235	21.6 J	272 J	273 J	82.7	183 J
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	6.4	6.4	6	8.4	ND	ND	ND	4.7	6.9	6.2	ND	13.3
Potassium	2030	1610	1680	ND	1730	1360	2230	3010	816	1130	985	798	1180
Sodium	11500	11000	10200	8240	10300	8580	9110	17500	7140	6570	6930	5380	9130
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND	80.7	ND	ND	ND

Notes:
* 1,2-Dibromoethane (EDB or ethylene dibromide) was analyzed reported from the Method 504 result
J = Data is estimated
ND = Nondetect
NA = Not analyzed
Dup = Concentration from duplicate sample
ug/L = micrograms per liter

Table 2.5-4
Analytical Results from Groundwater Collected at Fuel Spill Site 1,
February 1997, October 1997, and April 1998

Monitoring Well	MW516A	MW516B	MW516BDup	MW516C	MW516E	MW552A	MW552B	MW552C	MW552D	MW601	MW603A	MW603D	MW603DDup
Volatile Organics (ug/L)													
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.13 J	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.73 J	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.12 J	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	0.22 J	0.44 J	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.038	7 J	0.019	0.019
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.19 J	0.38 J	0.11 J	0.11 J
Total Metals (ug/L)	ug/L												
Aluminum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	25.2 J	ND	ND	ND	29.8 J	ND	ND	ND	25.2	ND	ND	ND	ND
Calcium	1290 J	3010 J	3060 J	2450 J	3920 J	2960 J	3060 J	3000 J	1140 J	5280	6010	2870	2990
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16.9
Iron	ND	ND	ND	ND	ND	ND	ND	ND	ND	172	236	162	173
Lead	ND	ND	ND	ND	3.7	ND	2.7 J	ND	1.7 J	ND	ND	ND	ND
Magnesium	1930 J	2580 J	2600 J	2950 J	525 J	1630 J	1650 J	1650 J	1720 J	1390	2420	2650	2810
Manganese	ND	ND	ND	ND	44.9	ND	8.7 J	ND	45.9	214	168 J	525 J	546 J
Mercury	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	4.9 J	ND	6.3	ND	ND
Potassium	398 J	511 J	476 J	650 J	614 J	669 J	729 J	701 J	1000 J	929	1050	800	885
Sodium	5630	3810 J	3900 J	4030 J	10100 J	10500 J	9180 J	8550 J	7820 J	6860	8160	3950	4180
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.6
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND	80.2	113	ND	ND

Notes:
* 1,2-Dibromoethane (EDB or ethylene dibromide) was analyzed reported from the Method 504 result
J = Data is estimated.
ND = Nondetect
NA = Not analyzed
Dup = Concentration from duplicate sample
ug/L = micrograms per liter

Table 2 5-4
Analytical Results from Groundwater Collected at Fuel Spill Site 1,
February 1997, October 1997, and April 1998

Monitoring Well	MW604	MW653	MW654	MW701	MW702	MW703	MW704	MW704Dup	MW705
Volatile Organics (ug/L)									
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	130 J	ND	110 J	100 J	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes (total)	0.13 J	0.16 J	0.13 J	0.3 J	0.16 J	0.15 J	0.29 J	0.26 J	0.15 J
Total Metals (ug/L)		ug/L							
Aluminum	ND	ND	ND	598	500	ND	ND	ND	360
Arsenic	ND	ND	ND	2.6	1.6	1.5	1.5	1.1	2.6
Barium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	3490	3640	3170	6120	4150	4020	5480	5800	6290
Chromium	ND	ND	ND	11.2	7.2	ND	6.4	ND	13.6
Copper	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	ND	139	180	1590	946	188	981	932	746
Lead	ND	ND	ND	ND	ND	ND		ND	ND
Magnesium	1680	1690	1260	2590	1720	1180	1740	1840	2340
Manganese	96.5	42.6 J	64.2	516 J	182 J	70.7 J	189 J	203 J	366 J
Mercury	ND	ND	ND		ND	ND	ND	ND	ND
Nickel	ND	5.1	ND	9.9	4.9	ND	7.2	4.4	4.8
Potassium	772	1030	1180	1850	1190	920	1220	1250	1680
Sodium	6060	6810	6240	8050	7060	7020	7130	7480	7690
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	2	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
* 1,2-Dibromoethane (EDB or ethylene dibromide) was analyzed reported from the Method 504 result
J = Data is estimated.
ND = Nondetect
NA = Not analyzed
Dup = Concentration from duplicate sample
ug/L = micrograms per liter

Table 2.5-5
Groundwater Results 1999 Source Area Samping

Well #	36MW002	36MW004	36MW007	36MW008	36MW009	36MW010B	36MW0412	36MW0413	36MW0413D	36MW0415
Date Sampled	4/22/99	4/22/99	4/22/99	4/22/99	4/22/99	4/22/99	4/22/99	4/23/99	4/23/99	4/23/99
VOC (ug/L)										
Tetrachloroethylene	ND	ND	ND	1.5J	ND	ND	ND	ND	ND	ND
Toluene	2800	ND	76	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	200	ND	160	58	ND	ND	ND	ND	ND	ND
Xylene	1300	ND	900	130	ND	ND	ND	ND	ND	ND
Chloroform	ND	0.97J	ND	6	7.6	0.55J	ND	ND	ND	ND
SVOA (ug/L)										
Napthalene	1.2J	ND	1.2J	ND	ND	ND	ND	ND	2.0J	ND
bis(2-Ethylhexyl)phthalate	ND	ND	1.6J	ND	ND	ND	ND	ND	ND	ND
Metals (ug/L)										
Aluminum	47.2J	42.1J	35.7J	43J	52J	74.4J	60J	58.6J	43.1J	44.4J
Antimony	6.1	ND	ND	3.5J	7.1	ND	ND	ND	4.6J	ND
Arsenic	4.5J	ND	2.2J	ND	ND	22.7	ND	ND	ND	ND
Barium	20.2	22.5	42.2	57.5	38	21.2	11J	20	20.9	21.2
Calcium	1630	1430	2860	2070	2580	1110	1340	1230	971	968
Chromium	ND	ND	ND	ND	ND	ND	1.6J	ND	ND	ND
Cobalt	2.8J	8.99	2.4J	3.6J	1.J	12.2	ND	1.1J	1.2J	1J
Copper	2.5J	ND	ND	ND	1J	ND	ND	ND	ND	ND
Iron	6860	ND	5920	2060	32.5J	22100	ND	158	624	503
Lead	3.5	ND	39.2	16.6	ND	ND	ND	ND	ND	ND
Magnesium	864	1700	768	1070	1660	882	623	798	778	774
Manganese	238	638	254	68.9	331	664	5.5J	47.4	6.9J	7J
Nickel	ND	1.7J	2.2J	6J	ND	3J	2.8J	1.8J	ND	ND
Potassium	763J	901J	1290J	ND	1220J	1500	ND	753J	1230J	1100J
Silver	10	1.2J	ND	ND	ND	ND	ND	2J	ND	ND
Sodium	4340	6180	6160	4890	6770	4170	6060	4620	4860	ND
Thallium	7.7J	4.3J	ND	3.5J	4J	ND	8.4J	3.5J	6J	2.9J
Vanadium	1.1J	ND	ND	ND	ND	1.2J	ND	ND	ND	ND
Zinc	34.6	7.4J	13.9J	42.2	30.1	14.6J	11.7J	14.2J	10J	10.9J

Table 2.5-6
Analytical Results from Surface Water Collected Downgradient of Fuel Spill Site 1, August 1997 through May 1998

August-September 1997 Event

Location:	36SW0001	36SW0002	36SW003	36SW004	36SW005	36SW006	36SW007	36SW008	36SW009	36SW010	36SW011	36SW012
Sample No:	36SW0001-01	36SW0002-01	36SW003-01	36SW004-01	36SW005-01	36SW006-01	36SW007-01	36SW008-01	36SW009-01	36SW010-01	36SW011-01	36SW012-01
Sample Date:	8/26/97	8/26/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97
Compoupd:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
ETHYLENE DIBROMIDE	0.0421	0.0346	ND	ND	ND	ND	ND	ND	ND	ND	0.0376	0.0387

February-April 1998 Event

Location:	36SW0001		36SW0003				36SW0007			36SW010		
Sample No:	36SW0001-02		36SW0003-02				36SW0007-02			36SW010-02		
Sample Date:	4/29/98		4/29/98				4/29/98			4/29/98		
Compound.	ug/L		ug/L				ug/L					
ETHYLENE DIBROMIDE	0.041	NA	ND	NA	NA	NA	ND	NA	NA	0.064	NA	NA

May 1998 Event

Location:		36SW0002					36SW0007					36SW012
Sample No:		36SW0002-02					36SW0007-03					36SW012-02
Sample Date:		5/7/98					5/7/98					5/7/98
Compound:		ug/L					ug/L					ug/L
ETHYLENE DIBROMIDE	NA	0.104	NA	NA	NA	NA	ND	NA	NA	NA	NA	0.011
Analyte:												
ALUMINUM	NA	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	ND
BORON	NA	ND	NA	NA	NA	NA	52.0	NA	NA	NA	NA	ND
BARIUM	NA	7.71 J	NA	NA	NA	NA	15.3 J	NA	NA	NA	NA	22.9
CALCIUM	NA	2570	NA	NA	NA	NA	774.	NA	NA	NA	NA	2930
CADMIUM	NA	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	ND
CHROMIUM	NA	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	ND
COPPER	NA	ND	NA	NA	NA	NA	1.38 J	NA	NA	NA	NA	ND
IRON	NA	340.	NA	NA	NA	NA	41.0 J	NA	NA	NA	NA	174
POTASSIUM	NA	802	NA	NA	NA	NA	ND	NA	NA	NA	NA	874
MAGNESIUM	NA	1700	NA	NA	NA	NA	901.	NA	NA	NA	NA	2080
MANGANESE	NA	14.9	NA	NA	NA	NA	15.5	NA	NA	NA	NA	ND
SODIUM	NA	6500	NA	NA	NA	NA	5090	NA	NA	NA	NA	6190
LEAD	NA	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	ND

Notes:
NA - not analyzed
ND - not detected
ug/L - micrograms per liter
J - estimated result

Table 2.5-6
Analytical Results from Surface Water Collected Downgradient of Fuel Spill Site 1, August 1997 through May 1998

August-September 1997 Event

Location:	36SW013	36SW0014	36SW0015	36SW0016	36SW0017	36SW0018	36SW0019	36SW0020	36SW0021	36SW0022	36SW0023
Sample No:	36SW013-01	36SW0014-01	36SW0015-01	36SW0016-01	36SW0017-01	36SW0018-01	36SW0019-01	36SW0020-01	36SW0021-01	36SW0022-01	36SW0023-01
Sample Date:	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/27/97	8/26/97	8/26/97
Compound:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
ETHYLENE DIBROMIDE	ND	0.0301	ND	0.937	1.43	0.668	0.0434	0.0451	0.0492	0.031	0.0256

February-April 1998 Event

Location:	36SW013		36SW0015	36SW0016	36SW0017	36SW0018	36SW0019	36SW0020	36SW0021		
Sample No:	36SW013-02		36SW0015-02	38SW0016-02	36SW0017-02	36SW0018-02	36SW0019-02	36SW0020-02	36SW0021-02		
Sample Date:	4/29/98		4/29/98	2/11/98	2/11/98	2/11/98	2/11/98	2/11/98	2/11/98		
Compound:	ug/L		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L		
ETHYLENE DIBROMIDE	ND	NA	ND	0.08	0.18	0.061	ND	ND	ND	NA	NA

May 1998 Event

Location:				36SW0016	36SW0017	36SW0018		36SW0020			
Sample No.				36SW0016-03	36SW0017-03	36SW0018-03		36SW0020-03			
Sample Date.				5/7/98	5/7/98	5/7/98		5/7/98			
Compound:				ug/L	ug/L	ug/L		ug/L			
ETHYLENE DIBROMIDE	NA	NA	NA	1.23	1.15	0.022	NA	0.035	NA	NA	NA
Analyte:											
ALUMINUM	NA	NA	NA	ND	338.	167.	NA	174.	NA	NA	NA
BORON	NA	NA	NA	ND	ND	70.8	NA	57.4	NA	NA	NA
BARIUM	NA	NA	NA	3.68 J	6.97 J	10.8 J	NA	22.4	NA	NA	NA
CALCIUM	NA	NA	NA	3910	3010	1210	NA	2690	NA	NA	NA
CADMIUM	NA	NA	NA	ND	ND	ND	NA	ND	NA	NA	NA
CHROMIUM	NA	NA	NA	ND	0.700 J	0.700 J	NA	ND	NA	NA	NA
COPPER	NA	NA	NA	1.24 J	2.43 J	2.11 J	NA	1.70 J	NA	NA	NA
IRON	NA	NA	NA	368.	765	211.	NA	1460	NA	NA	NA
POTASSIUM	NA	NA	NA	767.	897.	625. J	NA	1030	NA	NA	NA
MAGNESIUM	NA	NA	NA	1790	1520	1070	NA	1800	NA	NA	NA
MANGANESE	NA	NA	NA	ND	25.4	11.6	NA	47.6	NA	NA	NA
SODIUM	NA	NA	NA	7030	6890	5740	NA	7820	NA	NA	NA
LEAD	NA	NA	NA	ND	2.02	ND	NA	ND	NA	NA	NA

Notes:
NA - not analyzed
ND - not detected
ug/L - micrograms per liter
J - estimated result

Table 2.5-6
Analytical Results from Surface Water Collected Downgradient of Fuel Spill Site 1, August 1997 through May 1998

August-September 1997 Event

Location:	36SW0024	36SW0025						36SW0101	36SW0102	36SW0103
Sample No:	36SW0024-01	36SW0025-01						36SW0101-01	36SW0102-01	36SW0103-01
Sample Date:	9/4/97	9/4/97						9/4/97	9/4/97	9/4/97
Compound:	ug/L	ug/L						ug/L	ug/L	ug/L
ETHYLENE DIBROMIDE	0 0335	0.0168	NA	NA	NA	NA	NA	ND	ND	ND

February-April 1998 Event

Location:			36SW0026	36SW0027	36SW0028	36SW0029	36SW0036			
Sample No.			36SW0026-01	36SW0027-01	36SW0028-01	36SW0029-01	36SW0036-01			
Sample Date:			2/11/98	2/11/98	2/11/98	2/11/98	4/29/98			
Compound:			ug/L	ug/L	ug/L	ug/L	ug/L			
ETHYLENE DIBROMIDE	NA	NA	0.025	ND	ND	ND	ND	NA	NA	NA

May 1998 Event

Location:										
Sample No:										
Sample Date:										
Compound.										
ETHYLENE DIBROMIDE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Analyte:										
ALUMINUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BORON	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BARIUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CALCIUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CADMIUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CHROMIUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
COPPER	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IRON	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POTASSIUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MAGNESIUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MANGANESE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SODIUM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LEAD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
NA - not analyzed
ND - not detected
ug/L - micrograms per liter
J - estimated result

Table 2.5-7
Analytical Results for Sediment Collected Downgradient of Fuel Spill Site 1,
May 1998

Location:	36SW002	36SW007	36SW007	36SW012	36SW016	36SW017	36SW018	36SW020
Sample No:	36SE002-02	36SE007-03	36SE007-03FD	36SE012-02	36SE016-03	36SE017-03	36SE018-03	36SEW020-03
Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
Sample Date:	07-May-98	07-May-98	07-May-98	07-May-98	07-May-98	07-May-98	07-May-98	07-May-98
Volatile Organics (ug/kg)								
ETHYLENE DIBROMIDE	ND	ND	ND	ND	ND	ND	0.075	ND
Metals (mg/Kg):								
ALUMINUM	693	466 J	3090 J	1120	1200	691	503	729 J
ARSENIC	ND	ND	0.433 J	ND	ND	ND	ND	0.684 J
BARIUM	2.04 J	1.74 J	2.12 J	3.78 J	3.61 J	3.73 J	3.02 J	2.96 J
BERYLLIUM	0.0674 J	0.0812 J	0.0847 J	0.0561 J	ND	0.0848 J	0.0406 J	0.0686 J
CALCIUM	ND	74.6 J	500 J	88.6 J	500 J	123 J	331 J	68 J
COBALT	0.204 J	ND	1.16 J	0.226 J	ND	ND	ND	0.47 J
CHROMIUM	1.37 J	2.9	2.67	1.71 J	1.79 J	2.18 J	4.74	1.57 J
COPPER	1.02 J	0.456 J	0.881 J	ND	4.14 J	1.28 J	0.505 J	ND
IRON	1550	1470 J	7020 J	1310	1920	2080	1060	2090
POTASSIUM	ND	ND	ND	ND	ND	ND	ND	139 J
MAGNESIUM	163 J	76.4 J	1290	173 J	177 J	111 J	112 J	196 J
MANGANESE	17	7.58 J	83.4 J	8.11	21.4	9.21	8.1	15.8
SODIUM	90.7 J	126 J	112 J	257 J	101 J	72.5 J	103 J	84.3 J
NICKEL	0.486 J	ND	0.6 J	0.491 J	0.225 J	0.384 J	0.462 J	0.432 J
LEAD	ND	2.59	1.9	3.38	8.9	4.57	3.71	2.1
SELENIUM	ND	ND	0.318 J	ND	ND	ND	ND	ND
VANADIUM	2.29 J	2.77 J	10.2	2.63 J	3.59 J	4.1 J	ND	4.11 J
ZINC	2.47 J	1.55 J	8.09	3.86	3.56 J	2.57 J	1.45 J	4.09

Notes:
ND - not detected
ug/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
J - estimated result

Table 2.6-1. Summary of Samples Used for Human Health and Ecological Risk Assessment
Massachusetts Military Reservation
Fuel Spill 1

Sample #	Media Sampled	Analysis	Year Sampled
WM1	**Groundwater**	VOC, SVOC, INORGANICS	1987
WM1	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
WM10A	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
WM10B	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW11	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW112	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW112 & dup	Groundwater	VOC, SVOC, TPH, INORGANICS	1990
MW12	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW121	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW131A	Groundwater	VOC, EDB, INORGANICS	1997
MW131B	Groundwater	VOC, EDB, INORGANICS	1997
MW131C	Groundwater	VOC, EDB, INORGANICS	1997
MW132A & dup	Groundwater	VOC, EDB, INORGANICS	1997
MW132B & dup	Groundwater	VOC, EDB, INORGANICS	1997
MW132C	Groundwater	VOC, EDB, INORGANICS	1997
MW136	Groundwater	VOC, EDB, INORGANICS	1997
MW137	Groundwater	VOC, EDB, INORGANICS	1997
MW14 & dup	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW140	Groundwater	VOC, EDB, INORGANICS	1997
MW15131 & dup	Groundwater	VOC, SVOC, TPH, PEST, INORGANICS	1994
MW17	Groundwater	VOC, EDB, INORGANICS	1997
MW2	Groundwater	VOC, SVOC, INORGANICS	1988
MW2	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW4	Groundwater	VOC, SVOC, TPH, INORGANICS	1989; 1990
MW4A	Groundwater	VOC, SVOC, TPH, INORGANICS	1989; 1990
MW41	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW412	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW413	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW414	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW415	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW42	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW501	Groundwater	VOC, EDB, INORGANICS	1998
MW503A	Groundwater	VOC, EDB, INORGANICS	1998
MW503B	Groundwater	VOC, EDB, INORGANICS	1998
MW503C	Groundwater	VOC, EDB, INORGANICS	1998
MW504	Groundwater	VOC, EDB, INORGANICS	1998
MW516	Groundwater	VOC, PEST, INORGANICS	1987
MW517	Groundwater	VOC, PEST, INORGANICS	1987
MW538A & dup	Groundwater	VOC, SVOC, INORGANICS	1993
MW538B	Groundwater	VOC, SVOC, INORGANICS	1993
MW538C	Groundwater	VOC, SVOC, INORGANICS	1993
MW552A	Groundwater	VOC, SVOC, INORGANICS	1993
MW552B	Groundwater	VOC, EDB, INORGANICS	1997

Table 2.6-1. Summary of Samples Used for Human Health and Ecological Risk Assessment
Massachusetts Military Reservation
Fuel Spill 1 (continued)

Sample #	Media Sampled	Analysis	Year Sampled
MW552B & dup	Groundwater	VOC, SVOC, INORGANICS	1993
MW552C	Groundwater	VOC, SVOC, INORGANICS	1993
MW552C	Groundwater	VOC, EDB, INORGANICS	1997
MW552D	Groundwater	VOC, SVOC, INORGANICS	1993
MW553A	Groundwater	VOC, SVOC, INORGANICS	1993
MW553D	Groundwater	VOC, SVOC, INORGANICS	1993
MW556A	Groundwater	VOC, SVOC, INORGANICS	1993
MW556B	Groundwater	VOC, SVOC, INORGANICS	1993
MW568	Groundwater	VOC, SVOC, INORGANICS	1993
MW6	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW601	Groundwater	VOC, EDB, INORGANICS	1998
MW603A	Groundwater	VOC, EDB, INORGANICS	1998
MW603D & dup	Groundwater	VOC, EDB, INORGANICS	1998
NW604	Groundwater	VOC, EDB, INORGANICS	1998
MW653	Groundwater	VOC, EDB, INORGANICS	1998
MW654	Groundwater	VOC, EDB, INORGANICS	1998
MW7	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW701	Groundwater	VOC, EDB, INORGANICS	1998
MW702	Groundwater	VOC, EDB, INORGANICS	1998
MW703	Groundwater	VOC, EDB, INORGANICS	1998
MW704 & dup	Groundwater	VOC, EDB, INORGANICS	1998
MW705	Groundwater	VOC, EDB, INORGANICS	1998
MW8 & dup	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MW9	Groundwater	VOC, SVOC, TPH, INORGANICS	1990
MW9 & dup	Groundwater	VOC, SVOC, TPH, INORGANICS	1989
MWRFW11	Groundwater	VOC, SVOC, INORGANICS	1989
RFW011	Groundwater	VOC, SVOC	1989
36SW0001	**Surface Water**	EDB	1997; 1998
36SW0003	Surface Water	EDB	1997; 1998
36SW0014	Surface Water	EDB	1997; 1998
36SW0015	Surface Water	EDB	1997; 1998
36SW0019	Surface Water	EDB	1997; 1998
36SW002	Surface Water	VOC, SVOC, EDB, METALS	1997; 1998
36SW0021	Surface Water	EDB	1997; 1998
36SW0022	Surface Water	EDB	1997; 1998
36SW0023	Surface Water	EDB	1997; 1998
36SW0024	Surface Water	EDB	1997; 1998
36SW0025	Surface Water	EDB	1997; 1998
36SW0026	Surface Water	EDB	1997; 1998
36SW0027	Surface Water	EDB	1997; 1998
36SW0028	Surface Water	EDB	1997; 1998
36SW0029	Surface Water	EDB	1997; 1998
36SW003	Surface Water	EDB	1997; 1998
36SW0036	Surface Water	EDB	1997; 1998

Table 2.6-1. Summary of Samples Used for Human Health and Ecological Risk Assessment
Massachusetts Military Reservation
Fuel Spill 1 (continued)

Sample #	Media Sampled	Analysis	Year Sampled
36SW004	Surface Water	EDB	1997; 1998
36SW005	Surface Water	EDB	1997; 1998
36SW006	Surface Water	EDB	1997; 1998
36SW007 & dup	Surface Water	EDB	1997; 1998
36SW008	Surface Water	EDB	1997; 1998
36SW009	Surface Water	EDB	1997; 1998
36SW010	Surface Water	EDB	1997; 1998
36SW011	Surface Water	EDB	1997; 1998
36SW012	Surface Water	VOC, SVOC, EDB, METALS	1997; 1998
36SW013	Surface Water	EDB	1997; 1998
36SW016	Surface Water	VOC, SVOC, EDB, METALS	1997; 1998
36SW017	Surface Water	VOC, SVOC, EDB, METALS	1997; 1998
36SW018	Surface Water	VOC, SVOC, EDB, METALS	1997; 1998
36SW020	Surface Water	VOC, SVOC, EDB, METALS	1997; 1998
36SW0002	**Sediment**	VOC, SVOC, EDB, METALS	1998
36SW0012	Sediment	VOC, SVOC, EDB, METALS	1998
36SW0016	Sediment	VOC, SVOC, EDB, METALS	1998
36SW0017	Sediment	VOC, SVOC, EDB, METALS	1998
36SW0018	Sediment	VOC, SVOC, EDB, METALS	1998
36SW0020	Sediment	VOC, SVOC, EDB, METALS	1998
36DP01	**Surface Soil (0-2 ft)**	SVOC, PEST, METALS	1995
36SS50	Surface Soil (0-2 ft)	SVOC, PEST, METALS	1995
36SS51	Surface Soil (0-2 ft)	SVOC, PEST, METALS	1995
36SS52	Surface Soil (0-2 ft)	SVOC, PEST, METALS	1995
36SS53	Surface Soil (0-2 ft)	SVOC, PEST, METALS	1995
36SS54	Surface Soil (0-2 ft)	PEST, METALS	1995
FS1-TB4	Surface Soil (0-2 ft)	METALS	1988
FS1-TB4D	Surface Soil (0-2 ft)	METALS	1998
FS1-TB2	**Surface Soil (2-10 ft)**	VOC, METALS	1988
TS1-TB3	Surface Soil (2-10 ft)	VOC, METALS	1988

KEY:

MW = Monitoring Wells
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound
TPH = Total Petroleum Hydrocarbons
PEST = Pesticides
EDB = Ethylene dibromide

Table 2.6-2. Comparison of Soil Contaminant Concentrations (0-10 ft) to
Human Health Hazard Equivalent Concentrations (HECs)
Massachusetts Military Reservation
Fuel Spill 1

Chemical	Maximum Soil Conc. (mg/kg)	Background Conc. (mg/kg)	Does Conc. Exceed Background? (Y or N)	Is Frequency of Detection >5%? (a)	Tier I Cancer Risk/Hazard Equivalent Conc. (mg/kg)	Tier I Cancer Does Conc. Exceed Criterion? (Y or N)	Tier I Non Cancer Risk/Hazard Equivalent Conc. (mg/kg)	Tier I Non Cancer Does Conc. Exceed Criterion? (Y or N)	Is Contaminant A COC?	Reason for Exclusion or Inclusion
Volatiles										
Chloroethane	0.02	NA	NA	NA	1.10E+00	N	-	-	N	< HEC
Semivolatiles										
Phenanthrene	0.15	NA	NA	NA	-	-	2.33E+03	N	N	< HEC
Anthracene	0.01	NA	NA	NA	-	-	1.75E+05	N	N	< HEC
Fluoranthene	0.18	NA	NA	NA	-	-	2.33E+04	N	N	< HEC
Pyrene	0.27	NA	NA	NA	-	-	1.75E+04	N	N	< HEC
Benzo(a)anthracene	0.13	NA	NA	NA	2.79E+01	N	-	-	N	< HEC
Chrysene	0.24	NA	NA	NA	2.76E+03	N	-	-	N	< HEC
Benzo(b)fluoranthene	0.37	NA	NA	NA	2.79E+01	N	-	-	N	< HEC
Benzo(k)fluoranthene	0.33	NA	NA	NA	2.79E+02	N	-	-	N	< HEC
Benzo(a)pyrene	0.19	NA	NA	NA	2.79E+00	N	-	-	N	< HEC
Indeno(1,2,3-cd)pyrene	0.13	NA	NA	NA	2.79E+01	N	-	-	N	< HEC
Benzo(g,h,i)perylene	0.15	NA	NA	NA	-	-	2.33E+03	N	N	< HEC
Acenaphthylene	0.05	NA	NA	NA	-	-	2.33E+03	N	N	< HEC
Pesticides/PCB										
alpha-BHC	0.0002	NA	NA	NA	1.08E+01	N		-	N	< HEC
Aldrin	0.0002	NA	NA	NA	3.99E+00	N	5.82E+00	N	N	< HEC
Heptachlor epoxide	0.0005	NA	NA	NA	7.46E+00	N	2.52E+00	N	N	< HEC
Endosulfan I	0.0007	NA	NA	NA	-	-	1.16E+03	N	N	< HEC
Dieldrin	0.0130	NA	NA	NA	4.24E+00	N	9.70E+00	N	N	< HEC
4,4'-DDE	0.0021	NA	NA	NA	2.00E+02	N	1.36E+02	N	N	< HEC
Endrin	0.0017	NA	NA	NA	-	-	5.82E+01	N	N	< HEC
Endosulfan II	0.0015	NA	NA	NA	-	-	1.20E+04	N	N	< HEC

Table 2.6-2. Comparison of Soil Contaminant Concentrations (0-10 ft) to Human Health Hazard Equivalent Concentrations (HECs)
Massachusetts Military Reservation
Fuel Spill 1

Chemical	Maximum Soil Conc. (mg/kg)	Background Conc. (mg/kg)	Does Conc. Exceed Background? (Y or N)	Is Frequency of Detection >5%? (a)	Tier I Cancer Risk/Hazard Equivalent Conc. (mg/kg)	Tier I Cancer Does Conc. Exceed Criterion? (Y or N)	Tier I Non Cancer Risk/Hazard Equivalent Conc. (mg/kg)	Tier I Non Cancer Does Conc. Exceed Criterion? (Y or N)	Is Contaminant A COC?	Reason for Exclusion or Inclusion
Pesticides/PCB continued										
4,4'-DDD	0.0030	NA	NA	NA	2.83E+02	N	5.82E+02	N	N	< HEC
4,4'-DDT	0.0050	NA	NA	NA	2.00E+02	N	9.70E+01	N	N	< HEC
Methoxychlor	0.0007	NA	NA	NA	-	-	9.70E+02	N	N	< HEC
Endrin ketone	0.0005	NA	NA	NA	-	-	-	-	Y	No HEC
alpha-Chlordane	0.0004	NA	NA	NA	1.60E+01	N	-	-	N	< HEC
gamma-Chlordane	0.0002	NA	NA	NA	5.22E+01	N	1.16E+01	N	N	< HEC
Metals										
Aluminum	2690.00	8930.00	N	NA	-	-	5.82E+04	N	N	< HEC
Antimony	0.63	17.50	N	NA	-	-	2.33E+01	N	N	< HEC
Arsenic	1.20	3.60	N	NA	1.16E+01	N	1.75E+01	N	N	< HEC
Barium	64.80	10.40	Y	NA	-	-	4.07E+03	N	N	< HEC
Chromium	7.40	6.80	Y	NA	3.77E+04	N	1.16E+03	N	N	< HEC
Cobalt	1.00	4.10	N	NA	-	-	1.20E+05	N	N	< HEC
Iron	3740.00	12400.00	N	NA	-	-	6.10E+05	-	N	< HEC
Lead	114.00	12.50	Y	NA	-	-	1.00E+03	N	N	< HEC
Magnesium	404.00	794.50	N	NA	-	-	-	-	N	Essential Nutrient
Manganese	91.00	108.00	N	NA	-	-	8.14E+03	N	N	< HEC
Nickel	2.70	5.20	N	NA	1.84E+06	N	1.16E+03	N	N	< HEC
Potassium	176.00	551.00	N	NA	-	-	-	-	N	Essential Nutrient
Sodium	272.00	386.00	N	NA	-	-	-	-	N	Essential Nutrient
Vanadium	8.20	15.20	N	NA	-	-	4.07E+02	N	N	< HEC
Zinc	8.00	16.00	N	NA	-	-	1.75E+04	N	N	< HEC

Table 2.6-2. Comparison of Soil Contaminant Concentrations (0-10 ft) to Human Health Hazard Equivalent Concentrations (HECs)
Massachusetts Military Reservation
Fuel Spill 1

Chemical	Maximum Soil Conc. (mg/kg)	Background Conc. (mg/kg)	Does Conc. Exceed Background? (Y or N)	Is Frequency of Detection >5%? (a)	Tier I Cancer Risk/Hazard Equivalent Conc. (mg/kg)	Tier I Cancer Does Conc. Exceed Criterion? (Y or N)	Tier I Non Cancer Risk/Hazard Equivalent Conc. (mg/kg)	Tier I Non Cancer Does Conc. Exceed Criterion? (Y or N)	Is Contaminant A COC?	Reason for Exclusion or Inclusion
Miscellaneous										
TOC (mg/g)	50.00	NA	-	NA	-	-	-	NA	NA	NA

NA = Not Applicable
Source: HAZWRAP 1994
Boxed areas denote COCs
(a) Less then 20 samples in data set
Source for RbCs for alpha-chlordane, Endosulfan II, cobalt, iron, and chloroethane is EPA Region III RBC Table, October 1998 update.
COC = contaminant of concern
conc = concentration
kg = kilogram
mg = milligram

TABLE 2.6-3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HUMAN HEALTH

Scenario Timeframe: Current & Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (µg/L)	Background (2) Value (µg/L)	Screening Toxicity Value (HEC) (µg/L) (3)	Potential ARAR/TBC Value (µg/L)	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
000071-55-6	1,1,1-Trichloroethane	0.40	J	0.80	J	ug/L	MW556B	2 out of 75	1	0.80	--	NA	200	MCL	No	Less than 5% detection
000095-50-1	1,2-Dichlorobenzene	0.47	J	0.47	J	ug/L	MW17	1 out of 28	1	0.47	--	NA	--	--	No	Less than 5% detection
000107-06-2	1,2-Dichloroethane	0.25	J	0.73	J	ug/L	MW603A	4 out of 28	1	0.73	--	0.196	5	MCL	Yes	--
000078-93-3	2-Butanone	78.00	--	120,000.00	--	ug/L	MW9	12 out of 47	5	120,000.00	--	NA	--	--	No	Lab Contaminant
000108-10-1	4-Methyl-2-pentanone	0.21	J	85.00	J	ug/L	MW4A	4 out of 75	5	85.00	--	--	--	--	Yes	--
000067-64-1	Acetone	5.00	--	210.00	--	ug/L	MW2	11 out of 49	5	210.00	--	NA	--	--	No	Lab Contaminant
000071-43-2	Benzene	0.12	J	0.90	J	ug/L	MW556B	3 out of 75	1	0.90	--	NA	5	MCL	No	Less than 5% detection
000074-97-5	Bromochloromethane	0.20	J	0.40	J	ug/L	MW538B	2 out of 75	1	0.40	--	NA	--	--	No	Less than 5% detection
000075-25-2	Bromoform	0.40	J	0.70	J	ug/L	MW538B	2 out of 75	1	0.70	--	NA	--	--	No	Less than 5% detection
000067-66-3	Chloroform	0.30	J	4.00	J	ug/L	MW538C	8 out of 75	1	4.00	--	0.275	--	--	Yes	--
000074-87-3	Chloromethane	0.13	J	8.00	--	ug/L	MW414, MW8D	4 out of 75	1	8.00	--	2.32	--	--	Yes	--
000124-48-1	Dibromochloromethane	0.50	J	0.80	J	ug/L	MW538B	2 out of 75	1	0.80	--	NA	--	--	No	Less than 5% detection
000100-41-4	Ethylbenzene	220.00	--	220.00	--	ug/L	MW7	1 out of 75	1	220.00	--	NA	700	MCL	No	Less than 5% detection
000075-09-2	Methylene chloride	1.00	--	25.00	JB	ug/L	MW2	5 put of 75	2	25.00	--	NA	5	MCL	No	Lab Contaminant
000127-18-4	Tetrachloroethene	0.30	J	2.00	--	ug/L	MW8, MW8D	5 out of 75	1	2.00	--	--	5	MCL	Yes	--
000108-88-3	Toluene	0.30	J	2,500.00	--	ug/L	MW7	18 out of 75	1	2,500.00	--	191	1000	MCL	Yes	--
000079-01-6	Trichloroethene	0.18	J	1.00	J	ug/L	W552C, MW53	8 out of 75	1	1.00	--	2.49	5	MCL	No	Less than Hazard Equivalent Concentration
001330-20-7	Total Xylenes	0.11	J	460.00	--	ug/L	MW2	16 out of 75	1	460.00	--	12900	10,000	MCL	No	Less than Hazard Equivalent Concentration
	SEMI-VOLATILES															
000100-51-6	Benzyl Alcohol	19.00	--	26.00	--	ug/L	MW4	2 out of 45	10	26.00	--	NA	--	--	No	Less than 5% detection

TABLE 2 6-3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HUMAN HEALTH

Scenario Timeframe: Current & Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (µg/L)	Background (2) Value (µg/L)	Screening Toxicity Value (HEC) (µg/L) (3)	Potential ARAR/TBC Value (µg/L)	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
000095-48-7	2-Methylphenol	10.00	--	24.00	--	ug/L	MW2	3 out of 45	10	24.00	--	351	--	--	No	Less than Hazard Equivalent Concentration
000117-01-7	bis(2-Ethylhexyl)phthalate	2.00	J	19.00	--	ug/L	MW14	5 out of 45	10	19.00	--	NA	6	MCL	No	Lab Contaminant
	Miscellaneous															
--	TPH	0.34	--	0.96	--	ug/L	MW8	3 out of 26	0.2	0.96	--	--	--	--	Yes	--
	Pesticides/PCBs															
000050-29-3	4,4'-DDT	0.00	J	0.00	J	ug/L	MWX15131	1 out of 3	0.1	0.00	--	0.21	--	--	No	Less than Hazard Equivalent Concentration
	EDB															
000106-93-4	EDB	0.02	--	7.70	--	ug/L	MW132B	10 out of 28	0.02	7.70	--	0.000935	0.05	MCL	Yes	--
	Metals															
007429-90-5	Aluminum	57.10	J	4,240.00	--	ug/L	MW556B	12 out of 66	200	4,240.00	484.44	NA	50	SMCL	Yes	--
007440-38-2	Arsenic	1.50	J	20.50	--	ug/L	MW132A DUP	6 out of 64	10	20.50	2.30	0.0487	50	MCL	Yes	--
007440-39-3	Barium	2.50	J	46.20	J	ug/L	MW556B	9 out of 64	200	46.20	13.00	511	2000	MCL	No	Less than Hazard Equivalent Concentration
007440-43-9	Cadmium	3.10	J	3.10	J	ug/L	MW552C	1 out of 70	5	3.10	1.37	NA	5	MCL	No	Less than 5% detection
007440-70-2	Calcium	1340.00	J	9,720.00	--	ug/L	MW136	30 out of 66	5000	9,720.00	4438.16	NA	--	--	No	Essential Nutrient
018540-29-9	Chromium	6.40	--	41.30	--	ug/L	MW556B	8 out of 64	10	41.30	6.74	NA	100	MCL	Yes	--
007440-48-4	Cobalt	1.70	--	5.40	J	ug/L	MW556B	3 out of 64	50	5.40	4.70	--	--	--	Yes	--
007440-50-8	Copper	3.90	--	16.90	--	ug/L	MW603D DUP	4 out of 64	25	16.90	3.87	--	1300	MCL	Yes	--
000057-12-5	Cyanide	14.00	--	14.00	--	ug/L	MW516	1 out of 37	10	14.00	5.00	NA	200	MCL	No	Less than 5% Detection
007439-89-6	Iron	120.00	--	22,100.00	--	ug/L	MW10B	33 out of 66	100	22,100.00	1176.07	NA	300	SMCL	Yes	--
007439-92-1	Lead	1.10	--	159.00	--	ug/L	MW2	23 out of 72	5	159.00	1.72	15	15	MCL	Yes	--
007439-95-4	Magnesium	664.00	J	4,980.00	J	ug/L	MW17	32 out of 66	5000	4,980.00	2384.74	NA	--	--	No	Essential Nutrient

TABLE 2.6-3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HUMAN HEALTH

Scenario Timeframe: Current & Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (µg/L)	Background Value (2) (µg/L)	Screening Toxicity Value (HEC) (3) (µg/L)	Potential ARAR/TBC Value (µg/L)	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
007439-96-5	Manganese	2 25	--	1,480.00	--	ug/L	MW9D	48 out of 66	15	1,480.00	155 99	NA	50	SMCL	Yes	--
07440-02-0	Nickel	4.70	--	23.20	J	ug/L	MW556B	9 out of 64	40	23.20	6 59	148	100	MCL	No	Less than Hazard Equivalent Concentration
007440-90-7	Potassium	480 00	J	2,030.00	--	ug/L	MW138	29 out of 64	5000	2,030.00	1301.92	NA	--	--	No	Essential Nutrient
007782-49-2	Selenium	2 40	J	2.40	J	ug/L	MW538A	1 out of 71	5	2 40	1 22	NA	50	MCL	No	Less than 5% detection
007440-22-4	Silver	5 90	--	5.90	--	ug/L	MW15131DUP	1 out of 64	10	5 90	2.38	NA	100	SMCL	No	Less than 5% detection
007440-23-5	Sodium	3950 00	--	16,000.00	--	ug/L	MWX15131	32 out of 66	5000	16,000.00	7591.05	NA	--	--	No	Essential Nutrient
007440-28-0	Thallium	1.10	J	3.10	--	ug/L	MWX15131	5 out of 64	10	3.10	1.52	0.584	2	MCL	Yes	--
007440-62-2	Vanadium	2 00	--	14.30	J	ug/L	MW556B	4 out of 64	50	14.30	5.81	51 1	--	--	No	Less than Hazard Equivalent Concentration
007440-66-6	Zinc	23 00	J	113.00	--	ug/L	MW603A	5 out of 66	40	113 00	10 27	2190	5	SMCL	No	Less than Hazard Equivalent Concentration

(1) Minimum/maximum detected concentration.
(2) NA - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.
(3) Provide reference for screening toxicity value.
(4) Rationale Codes Selection Reason: Infrequent Detection but Associated Historically (HIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)
Deletion Reason Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions:
NA = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic
TPH = Total Petroleum Hydrocarbons
Dup = Duplicate
-- = Data not available
HEC = Hazard Equivalent Concentration

TABLE 2.6-4
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR HUMAN HEALTH
MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA (SURFACE WATER)

Scenario Timeframe: Current & Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Surface Water

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	95% UCL of Mean (ug/L)	Max or UCL Concentration (Used for Screening) µg/L	Background (2) Value (location 36SW 007) in µg/L	µg/L Screening (3) Toxicity Value * (HEC: HAZ-WRAP 1994)	Potential ARAR/TBC Value µg/L	Potential ARAR/TBC Source	COPC Flag	Rationale for (4) Contaminant Deletion or Selection
000106-93-4	1,2-Dibromoethane (EDB) Meth 504	0.01100	--	1.43	--	ug/L	36SW017	27 out of 45	0.01	0.43	0.43	NA	5.41E-03	--	--	Yes	--
007429-90-5	Aluminum (Total)	174.00	--	338.00	--	ug/L	36SW017	3 out of 6	108	4369.55	338.00	86.6	1.72E+04	--	--	No	Below Hazard Equivalent Concentration
007440-39-3	Barium (Total)	3.66	J	22.90	--	ug/L	36SW012	6 out of 6	20	33.09	22.90	15.2	3.00E+03	--	--	No	Below Hazard Equivalent Concentration
007440-42-8	Boron (Total)	57.40	--	70.80	--	ug/L	36SW018	2 out of 6	50.5	68.63	68.63	47.85	--	--	--	Yes	--
007440-43-9	Cadmium (Total)	ND	--	ND	--	ug/L	--	0 out of 6	1	0.15	0.15	0.845	NA	N	--	No	Not Detected
007440-70-2	Calcium (Total)	1210.00	--	3,910.00	--	ug/L	36SW016	6 out of 6	500	4170.16	3910.00	766.5	--	--	--	No	Essential Nutrient
000067-66-3	Chloroform	1.63	--	1.63	--	ug/L	36SW018	1 out of 6	1	1.81	1.63	1.315	7.44E+01	5.7	AWQC	No	Below Hazard Equivalent Concentration
018540-29-9	Chromium (Total)	0.70	J	0.70	J	ug/L	36SW017	2 out of 6	5	0.68	0.68	0.7	4.32E+00	--	--	No	Below Background
007440-50-8	Copper (Total)	1.24	J	2.43	J	ug/L	36SW017	4 out of 6	5	3.16	2.43	1.38	--	--	--	Yes	--
007439-89-6	Iron (Total)	174.00	--	1,460.00	--	ug/L	36SW020	6 out of 6	100	1779.88	1460.00	36.05	--	--	--	Yes	--
007439-92-1	Lead (Total)	2.02	--	2.02	--	ug/L	36SW017	1 out of 6	2	1.75	1.75	1.145	--	N	--	Yes	--
007439-95-4	Magnesium (Total)	1070.00	--	2,080.00	--	ug/L	36SW012	6 out of 6	500	2047.48	2047.48	900	--	--	--	No	Essential Nutrient
007439-96-5	Manganese (Total)	11.60	--	47.60	--	ug/L	36SW020	4 out of 6	10	302.86	47.60	15.45	2.47E-03	--	--	Yes	--
007440-90-7	Potassium (Total)	625.00	J	1,030.00	--	ug/L	36SW020	6 out of 6	750	970.29	970.29	593	--	--	--	No	Essential Nutrient
007440-23-5	Sodium (Total)	5740.00	--	7,820.00	--	ug/L	36SW020	6 out of 6	500	not log norma	7820.00	5140	--	--	--	No	Essential Nutrient

-- = Data Not Available
NA = Not Applicable; excluded for other reason
UCL = Upper Confidence Limit
HEC = Hazard Equivalent Concentration
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemicals of Potential Concern
ND = Not Detected
J = Laboratory Qualifier

TABLE 2 6-5
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SEDIMENT FOR HUMAN HEALTH
MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA (SEDIMENT)

Scenario Timeframe: Current & Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Sediment

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits mg/kg	Concentration Used for Screening mg/kg	Background Value (2) mg/kg	Screening Toxicity Value (3) mg/kg	Potential ARAR/TBC Value mg/kg	Potential ARAR/TBC Source	COPC Flag	Rationale for (4) Contaminant Deletion or Selection
000106-93-4	1,2-Dibromoethane (EDB)	0 000075	--	0 000075	--	mg/kg	36SW0018	1 out of 6	.0000094-.000009	7.50E-05	NA	1.00E+00	--	--	No	Below Hazard-Equivalent Conc.
007429-90-5	Aluminum	503	--	1200	--	mg/kg	36SW0018	6 out of 6	--	1.13E+03	1.78E+03	7.30E+06	--	--	No	Below Hazard-Equivalent Conc
007440-39-2	Arsenic	0 684	J	0 684	J	mg/kg	36SW0020	1 out of 6	1 93-2.36	6 84E-01	7.37E-01	4.87E+01	--	--	No	Below Background
007440-39-3	Barium	2.04	J	3.78	J	mg/kg	36SW0012	6 out of 6	--	3.78E+00	1.93E+00	5.11E+05	--	--	No	Below Hazard-Equivalent Conc.
007440-41-7	Beryllium	0.0406	J	0.0848	J	mg/kg	36SW0017	5 out of 6	1.02	8.48E-02	8.30E-02	1 98E+01	--	--	No	Below Background
007440-70-2	Calcium	68	J	500	J	mg/kg	36SW0016	5 out of 6	20 8	5.00E+02	2 87E+02	0.00E+00	--	--	No	Essential Nutrient
018540-29-9	Chromium	1 37	J	4.74	--	mg/kg	36SW0018	6 out of 6	--	3.51E+00	2.79E+00	3.65E+04	--	--	No	Below Hazard-Equivalent Conc.
007440-48-4	Cobalt	0.204	J	0.47	J	mg/kg	36SW0020	3 out of 6	--	4 70E-01	3.18E+00	NA	--	--	No	Below Background
007440-50-8	Copper	0.505	J	4.14	J	mg/kg	36SW0016	4 out of 6	1.18	4.14E+00	6.69E-01	0 00E+00	--	--	No	Below Background
007439-89-6	Iron	1060	--	2090	--	mg/kg	36SW0020	6 out of 6	--	2 09E+03	4.25E+03	NA	--	--	Yes	--
007439-92-1	Lead	2.1	--	8.9	--	mg/kg	36SW0016	5 out of 6	--	8 90E+00	2 25E+00	NA	--	--	Yes	--
007439-95-4	Magnesium	111	J	196	J	mg/kg	36SW0020	6 out of 6	--	1.96E+02	6 83E+02	0.00E+00	--	--	No	Essential Nutrient
007439-96-5	Manganese	8.1	--	21.4	--	mg/kg	36SW0016	6 out of 6	--	2 08E+01	4.55E+01	0 00E+00	--	--	No	Below Background
007440-02-0	Nickel	0 225	J	0 491	J	mg/kg	36SW0012	6 out of 6	--	4.91E-01	2 38E+00	0.00E+00	--	--	No	Below Background
007440-90-7	Potassium	139	J	139	J	mg/kg	36SW0020	1 out of 6	89 3-115	1.02E+02	5.36E+01	0 00E+00	--	--	No	Below Background
007782-49-2	Selenium	ND	--	ND	--	mg/kg	--	0 out of 6	903-1.18	ND	4.19E-01	0 00E+00	--	--	No	ND
007440-23-5	Sodium	72 5	J	257	J	mg/kg	36SW0012	6 out of 6	--	1 94E+02	1.19E+02	0.00E+00	--	--	No	Essential Nutrient
007440-62-2	Vanadium	2.29	J	4.11	J	mg/kg	36SW0020	5 out of 6	1.43	4 11E+00	6 49E+00	0.00E+00	--	--	No	Below Background
007440-66-6	Zinc	1.45	J	4.09	--	mg/kg	36SW0020	6 out of 6	--	4 09E+00	4.82E+00	2.19E+06	--	--	No	Below Hazard-Equivalent Conc.

Selection Reason:	Infrequent Detection but Associated Historically (HIST)
	Frequent Detection (FD)
	Toxicity Information Available (TX)
	Above Screening Levels (ASL)
Deletion Reason:	Infrequent Detection (IFD)
	Background Levels (BKG)
	No Toxicity Information (NTX)
	Essential Nutrient (NUT)
	Below Screening Level (BSL)

Definitions:

NA = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic
ND = Not Detected
-- = Data not available

Table 2.6-6. Data Summary, Human Health COCs - Soil (0-10 ft)
Massachusetts Military Reservation
Fuel Spill 1

Chemical	Mean	Frequency of Detection	Maximum	Minimum	Background
Volatiles (µg/kg)					
Chloroethane	6.88	1 of 8	20.00	20.00	NA
Semivolatiles (µg/kg)					
Acenaphthylene*	54.00	2 of 8	54.00	50.00	NA
Anthracene*	12.00	1 of 8	12.00	12.00	NA
Benzo(a)anthracene	121.88	4 of 8	130.00	52.00	NA
	207.50	4 of 8	370.00	110.00	NA
Benzo(k)fluoranthene	195.00	4 of 8	330.00	100.00	NA
Benzo(g,h,i)perylene	148.94	2 of 8	150.00	44.00	NA
Benzo(a)pyrene	143.63	4 of 8	190.00	59.00	NA
Chrysene	164.00	3 of 8	240.00	72.00	NA
Fluoranthene	148.75	4 of 8	180.00	75.00	NA
Indeno(1,2,3-cd)pyrene*	130.00	3 of 8	130.00	49.00	NA
Phenanthrene	129.63	4 of 8	150.00	56.00	NA
Pyrene	185.00	4 of 8	270.00	110.00	NA
Pesticides (µg/kg)					
Aldrin*	0.16	1 of 6	0.16	0.16	NA
alpha-BHC*	0.23	1 of 6	0.23	0.23	NA
alpha-Chlordane*	0.35	4 of 6	0.35	0.16	NA
4,4'-DDE*	2.10	3 of 6	2.10	0.24	NA
4,4'-DDD	2.93	1 of 6	3.00	3.00	NA
4,4'-DDT	3.17	4 of 6	5.00	0.24	NA
Dieldrin	4.39	5 of 6	13.00	0.22	NA
Endosulfan I*	0.74	3 of 6	0.74	0.59	NA
Endosulfan II*	1.50	4 of 6	1.50	0.97	NA
Endrin*	1.70	4 of 6	1.70	0.47	NA
Endrin ketone*	0.53	2 of 6	0.53	0.34	NA
gamma-Chlordane*	0.15	1 of 6	0.15	0.15	NA
Heptachlor epoxide*	0.48	3 of 6	0.48	0.15	NA
Methoxychlor*	0.72	1 of 6	0.72	0.72	NA

Table 2.6-6 (continued)

Chemical	Mean	Frequency of Detection	Maximum	Minimum	Background
Metals (mg/kg)					
Aluminum	1328.00	8 of 8	2690.00	471.00	8930.00
Antimony*	0.63	1 of 8	0.63	0.63	17.50
Arsenic*	1.20	3 of 8	1.20	0.67	3.60
Barium	18.59	5 of 8	64.80	2.70	10.40
Chromium	2.73	6 of 8	7.40	1.80	6.80
Cobalt*	1.00	5 of 8	1.00	0.69	4.10
Iron	2206.75	8 of 8	3740.00	749.00	12400.00
Lead	23.86	7 of 8	114.00	1.30	12.50
Magnesium	380.38	5 of 8	404.00	225.00	794.50
Manganese	34.39	8 of 8	91.00	21.00	108.00
Nickel*	2.69	5 of 8	2.70	1.40	5.20
Potassium*	176.00	5 of 8	176.00	86.30	551.00
Sodium*	272.00	5 of 8	272.00	235.00	386.00
Vanadium	4.84	5 of 8	8.20	2.90	15.20
Zinc*	8.00	3 of 8	8.00	6.10	16.00
Miscellaneous					
Total Organic Carbon	50.00	3 of 3	50.00	50.00	NA

NA = Not Applicable

* The calculated mean value exceeds the maximum value, therefore, the mean value listed is equal to the maximum detected value.

Table 2.6-7. Data Summary for Groundwater

Chemical	Mean (µg/L)	Max (µg/L)	Min (µg/L)	Background (µg/L)
VOLATILES				
1,1,1-Trichloroethane	0.50	0.8	0.4	--
1,2-Dichlorobenzene	0.50	0.47	0.47	--
1,2-Dichloroethane	0.50	0.73	0.25	--
2-Butanone	6207.37	120000	76	--
4-Methyl-2-pentanone	4.20	85	0.21	--
Acetone	14.08	210	5	--
Benzene	0.49	0.9	0.12	--
Bromochloromethane	0.49	0.4	0.2	--
Bromoform	0.50	0.7	0.4	--
Chloroform	0.63	4	0.3	--
Chloromethane	0.64	8	0.13	--
Dibromochloromethane	0.50	0.8	0.5	--
EDB	1.18	7.7	0.019	--
Ethylbenzene	3.43	220	220	--
Methylene chloride	1.32	25	1	--
Tetrachloroethene	0.52	2	0.3	--
Toluene	60.83	2500	0.3	--
Trichloroethene	0.50	1	0.16	--
Total Xylenes	16.64	460	0.11	--
SEMIVOLATILES				
Benzyl Alcohol	5.78	26	19	--
2-Methylphenol	6.02	24	10	--
bis(2-Ethylhexyl)phthalate	5.28	19	2	--
MISCELLANEOUS				
TPH	0.15	0.96	0.34	--

Table 2.6-7. Data Summary for Groundwater

Chemical	Mean (µg/L)	Max (µg/L)	Min (µg/L)	Background (µg/L)
PESTICIDES				
4,4'-DDT	0.04	0.0045	0.0045	--
METALS				
Aluminum	218.83	4240	57.1	484.44
Arsenic	3.39	20.5	1.5	2.30
Barium	43.96	46.2	2.5	13.00
Cadmium	1.84	3.1	3.1	1.37
Calcium	3872.73	9720	1340	4,438.16
Chromium	5.96	41.3	6.4	6.74
Cobalt	14.15	5.4	1.7	4.70
Copper	7.56	16.9	3.9	3.87
Cyanide	5.24	14	14	5.00
Iron	1807.08	22100	120	1,176.07
Lead	8.52	159	1.1	1.72
Magnesium	2262.33	4980	664	2,384.74
Manganese	287.09	1480	2.25	155.99
Nickel	13.15	23.2	4.7	6.59
Potassium	1563.21	2030	480	1,301.92
Selenium	1.73	2.4	2.4	1.22
Silver	3.48	5.9	5.9	2.38
Sodium	5745.08	16000	3950	7,591.05
Thallium	3.16	3.1	1.1	1.52
Vanadium	13.69	14.3	2	5.81
Zinc	19.23	113	23	10.27

Table 2.6-8. Data Summary for Surface Water

CHEMICAL	Mean (µg/L)	Max (µg/L)	Min (µg/L)	95% UCL of mean (µg/L)	Background (µg/L)
VOLATILES					
1,2-Dibromoethane (EDB) Meth 504	0.141	1.43	0.011	0.43	--
METALS					
Aluminum (Total)	125.675	338	174	4369.55	86.6
Barium (Total)	12.407	22.9	3.66	33.09	15.2
Boron (Total)	37.692	70.8	57.4	68.63	47.85
Cadmium (Total)	0.150	ND	ND	0.15	0.845
Calcium (Total)	2720.000	3910	1210	4170.16	766.5
Chloroform	0.393	1.63	1.63	1.81	1.315
Chromium (Total)	0.467	0.7	0.7	0.68	0.7
Copper (Total)	1.447	2.43	1.24	3.16	1.38
Iron (Total)	553.000	1460	174	1779.88	36.05
Lead (Total)	0.878	2.02	2.02	1.75	1.145
Magnesium (Total)	1660.000	2080	1070	2047.48	900
Manganese (Total)	17.339	47.6	11.6	302.86	15.45
Potassium (Total)	832.500	1030	625	970.29	593
Sodium (Total)	6695.000	7820	5740	not log normal	5140

Table 2.6-9. Data Summary for Sediment

CHEMICAL	Mean (mg/kg)	Max (mg/kg)	Min (mg/kg)	95% UCL of mean (mg/kg)	Background (mg/kg)
VOLATILES					
1,2-Dibromoethane (EDB)	0.000017	0.000075	0.000075	0.000091	--
METALS					
Aluminum	822.67	1200.00	503.00	1134.68	1778.00
Arsenic	0.98	0.68	0.68	1.16	0.74
Barium	3.19	3.78	2.04	3.95	1.93
Beryllium	0.14	0.08	0.04	0.52	0.08
Calcium	186.83	500.00	68.00	3966.16	287.30
Chromium	2.23	4.74	1.37	3.51	2.79
Cobalt	2.83	0.47	0.20	375.46	3.18
Copper	1.34	4.14	0.51	4.18	0.67
Iron	1668.33	2090.00	1060.00	2187.61	4245.00
Lead	3.88	8.90	2.10	17.55	2.25
Magnesium	155.33	196.00	111.00	197.37	683.20
Manganese	13.27	21.40	8.10	20.81	45.49
Nickel	0.41	0.49	0.23	0.55	2.38
Potassium	67.53	139.00	139.00	102.06	53.55
Selenium	0.51	ND	ND	ND	0.42
Sodium	118.08	257.00	72.50	193.76	119.00
Vanadium	2.91	4.11	2.29	7.45	6.49
Zinc	3.00	4.09	1.45	4.55	4.82

ND = Not Detected
mg = milligram
kg = kilogram

TABLE 2.6-10

SELECTION OF EXPOSURE PATHWAYS

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Groundwater	Groundwater	Tap Water	Resident	Adult	Dermal	Off-site	Quantitative	Possible residential groundwater use
						Ingestion	Off-site	Quantitative	Possible residential groundwater use
		Air	Vapor from Water Use	Resident	Adult	Inhalation	Off-site	Quantitative	Possible residential groundwater use
Current & Future	Surface Water	Surface Water	Surface Water	Recreational Youth	Youth 7-12	Dermal	Off-site	Quantitative	Youth may play in bogs and river and come into contact with water
						Ingestion	Off-site	Quantitative	Youth may play in bogs and river and come into contact with water
		Air	Vapor from Water Use	Recreational Youth	Youth 7-12	Inhalation	Off-site	Quantitative	Youth may play in bogs and river and come into contact with vapors emanating from bog
				Adult Wader	Adult	Dermal	Off-site	Quantitative	Person fishing may fish in river and come into contact with water
						Ingestion	Off-site	Quantitative	Person fishing may fish in river and come into contact with water
		Air	Vapor from Water Use	Adult Wader	Adult	Inhalation	Off-site	Quantitative	Person fishing may come into contact with vapors from water
				Cranberry Worker	Adult	Dermal	Off-site	Quantitative	Cranberry worker may come into contact with surface water
						Ingestion	Off-site	Quantitative	Cranberry worker may come into contact with surface water
		Air	Vapor from Water Use	Cranberry Worker	Adult	Inhalation	Off-site	Quantitative	Person fishing may come into contact with vapors from water
Current & Future	Sediment	Sediment	Sediment	Recreational Youth	Youth 7-12	Dermal	Off-site	Quantitative	Youth may come into contact with sediment
						Ingestion	Off-site	Quantitative	Youth may come into contact with sediment
				Adult Wader	Adult	Dermal	Off-site	Quantitative	Person may come into contact with sediment while fishing
						Ingestion	Off-site	Quantitative	Person may come into contact with sediment while fishing
				Cranberry Worker	Adult	Dermal	Off-site	Quantitative	Cranberry worker may come into contact with sediment
						Ingestion	Off-site	Quantitative	Cranberry worker may come into contact with sediment
Current & Future	Edible Biota	Edible Biota	Fish	Adult Wader	Adult	Ingestion	Off-site	Quantitative	People catching fish in river may consume their catch and be exposed to chemicals potentially in the fish

Table 2.6-11. Human Health Risk Assessment Exposure Parameters - Soil
Massachusetts Military Reservation
Fuel Spill 1 - AOC

Parameters	Values	Units	Source
Soil - Ingestion and Dermal Absorption for Utility Worker - Current Use			
Soil Ingestion Rate	480	mg/day	HAZWRAP 1994
Soil Adherence Factor	1	mg/cm^2	HAZWRAP 1994
Surface Area Exposed	3120	cm^2/day	HAZWRAP 1994
Fraction Ingested	100%	--	Assumption
Dermal Absorption Factor	Compound Specific	--	HAZWRAP 1994
Ingestion Absorption Factor	Compound Specific	--	HAZWRAP 1994
Exposure Frequency	42	days/year	HAZWRAP 1994
Exposure Duration	1	year	HAZWRAP 1994
Body Weight	70	kg	HAZWRAP 1994
Average Time:			
Cancer	70	years	HAZWRAP 1994
Noncancer	1	year	Site Specific
Soil - Inhalation for Utility Worker - Current Use			
Inhalation Rate	20	m^3/day	HAZWRAP 1994
Exposure Duration	1	year	HAZWRAP 1994
Exposure Frequency	42	days/year	HAZWRAP 1994
Particulate Emission Factor	4.63E+09	m^3/kg	HAZWRAP 1994
Soil-to-Air Volatilization Factor*	Compound Specific	kg/m^3	HAZWRAP 1994
Body Weight	70	kg	HAZWRAP 1994
Average Time:			
Cancer	70	years	HAZWRAP 1994
Noncancer	1	year	Site Specific

* The volatilization factor is applied only to those compounds likely to volatilize.

Table 2.6-12. Human Health Risk Parameters and Equations for Ingestion of Groundwater - Future Use
Massachusetts Military Reservation
Fuel Spill 1

Parameter	Symbol	Value Resident Adult (age 7 yrs - adult)	Units	Source
Water concentration - CTE	C_{gw}	Mean concentration	mg/L	Site-specific
Water concentration - RME	C_{gw}	Max concentration	mg/L	Site-specific
Groundwater ingestion rate - CTE	IR_{gw}	1.4	L/day	EPA 1989b, 50th percentile
Groundwater ingestion rate - RME	IR_{gw}	2	L/day	EPA 1989b, 90th percentile
Exposure Frequency (days/year)	EF	350	days/year	Site-specific
Exposure duration (years) - CTE	ED	9	years	EPA 1989b, national medial time, 50th percentile at one residence
Exposure duration (years) - RME	ED	30	years	EPA 1989b, national medial time, 90th percentile at one residence
Body weight (kg)	BW	70	kg	EPA 1989b
Carcinogen averaging time (days)	AT	25550	days	EPA 1989b, equivalent to 70 year lifetime exposure at 365 days/year
Noncarcinogen averaging time - Ave	AT	3285	days	EPA 1989b, avg exposure duration x 365 days/year
Noncarcinogen averaging time - RME	AT	10950	days	EPA 1989b, max exposure duration x 365 days/year

Intake - ingestion (mg/kg*day) = $\frac{C_{gw} \times IR_{gw} \times EF \times ED}{BW \times AT}$

avg = average
EPA = U.S. Environmental Protection Agency
kg = kilogram
L = liter
mg = milligram
NA = Not applicable
RME = Reasonable maximum exposure
UCL = Upper confidence limit

US EPA 1989b. *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual*. USEPA 600/8/89/043.

Table 2.6-13. Human Health Risk Parameters and Equations for Dermal Absorption of Groundwater While Showering - Future Use

Fuel Spill 1

Parameter	Symbol	Resident Adult - Age 7 yrs +	Units	Source
Water Concentration - Avg.	C_{gw}	Mean conc.	mg/L	Site-specific
Water Concentration - RME	C_{gw}	Max Conc.	mg/L	Site-specific
Dose absorbed per unit area per event	DA_{event}	chem.-specific	mg/cm^2-event	EPA 1992
Events	EV	1	event/day	Site-specific
Skin Surface Area - CT	SA	20,000	cm^2	EPA 1992, based on 50th percentile adult male
Skin Surface Area - RME	SA	23,000	cm^2	EPA 1992, based on 50th percentile adult male
Exposure Frequency	EF	350	days/ year	Site-specific
Exposure duration - CTE	ED	9	years	EPA 1989b, based on 50th percentile at one residence
Exposure duration - RME	ED	30	years	EPA 1989b, based on 90th percentile at one residence
Body weight	BW	70	kg	EPA 1989b
Carcinogen averaging time	AT	25550	days	EPA 1989b, 70 year lifetime exposure at 365 days/ year
Noncarcinogen averaging time - CTE	AT	3285	days	EPA 1989b, a average exposure duration x 365 days/year
Noncarcinogen averaging time - RME	AT	10950	days	EPA 1989b, max exposure duration x 365 days/year
Permeability Constant (estimated)	K_p	chem.-specific	cm/hr	Chem.-specific
Lag Time	τ	chem.-specific	hr	Chem.-specific
Event time	tevent	1	hr	EPA 1992
Calculated absorption time	t*	chem.-specific	hr	EPA 1992
Partitioning Properties Constant	B	chem.-specific	unitless	EPA 1992
Volumetric Conversion Factor	CF	1.00E-03	$L/1000\ cm^3$	EPA 1989b

Equation for dermal contact with chemicals in water:

Dermal absorbed dose (mg/kg*day) = $\frac{DA_{event} * EV * ED * EF * SA}{BW \times AT}$

DA_{event} for Inorganics:

$DA_{event} = K_p * C_w * CF * t_{event}$

DA_{event} for Organics IF $t_{event} < t^*$

$$DA_{event} = 2K_p * C_w * CF \sqrt{\frac{6 * \tau * t_{event}}{\pi}}$$

DA_{event} for Organics IF $t_{event} > t^*$

$$DA_{event} = K_p * C_w * CF \left[\frac{tevent}{1+B} + 2\tau \left[\frac{1+3B}{1+B} \right] \right]$$

avg = average
chem. = chemical
cm = centimeter
conc. = concentration
EPA = U.S. Environmental Protection Agency
kg = kilogram
L = liter
mg = milligram
UCL = Upper confidence limit
NA = not applicable
RME = Reasonable maximum exposure

EPA 1989b. *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual*. USEPA/600/8-89/043.
EPA 1992. *Dermal Exposure Assessment: Principles and Applications, Interim Report*. EPA/600/8-91/011B.

Table 2.6-14. Human Health Risk Parameters and Equations for Inhalation of Volatiles from Household Water Use, Future Use
Massachusetts Military Reservation, FS-1

Parameter	Symbol	Value: Adult Resident	Units	Source
Water Concentration - CTE	C_w	Mean concentration	mg/L	Site-specific
Water Concentration - RME	C_w	Max concentration	mg/L	Site-specific
Inhalation rate	IR	15	m^3/day	US EPA 1996a
Volatilization Factor*	VF	0.5	L/ m^3	US EPA 1991b
Exposure frequency	EF	350	days/year	Site-specific
Exposure duration - CTE	ED	9	years	EPA 1991a, 50th percentile at one residence
Exposure duration - RME	ED	30	years	EPA 1991a, 90th percentile at one residence
Body weight	BW	70	kg	EPA 1989a, EPA 1991a, combined mean of male and female body weights
Noncarcinogen averaging time - CTE	AT_n	3,285	days	EPA 1989b, Average exposure duration x 365 days per year
Noncarcinogen averaging time - RME	AT_n	10,950	days	EPA 1989b, Maximum exposure duration x 365 days per year
Carcinogen averaging time	AT_c	25,550	days	EPA 1989b

$$\text{Chronic Daily Intake (mg/kg*day)} = \frac{C_w \times IR \times VF \times EF \times ED}{BW \times AT_{n,c}}$$

*EDB Volatilization Factor set at 0.2 (Jacobs, 1998)

avg = average
cm = centimeter
CT = Central Tendency
EPA = U.S. Environmental Protection Agency
kg = kilogram
L = liter
m = meter
mg = milligram
RME = Reasonable Maximum Exposure

EPA 1989a. *Risk Assessment Guidance for Superfund. Vol 1 Human Health Evaluation Manual (Part A)*. EPA/540/1-898/002.
EPA 1989b. *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual*. USEPA/600/8-89/043.
EPA 1991a. *Risk Assessment Guidance for Superfund Vol. I. Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final* OSWER Directive 9285.6-03
EPA 1991b. *Risk Assessment Guidance for Superfund Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*. OSWER Publ. 9285.7-01B
EPA 1996a. *Exposure Factors Handbook* - DRAFT. EPA/600/P-95/002B. Office of Research and Development.
Jacobs, 1998. *Southwest Operable Unit (SWOU) Remedial Investigation for Massachusetts Military Reservation*.

Table 2.6-15. Human Health Risk Parameters and Equations for Incidental Surface Water Ingestion While Wading, Current and Future Use
Massachusetts Military Reservation
Fuel Spill 1

Parameter	Symbol	Value			Units	Source
		Recreational Youth	Adult Wader	Cranberry Worker[1]		
Chemical Concentration in Water - CT	C_{sw}	95% UCL or Mean	95% UCL or Mean	95% UCL or Mean	mg/L	Site-specific, if 95% UCL of mean is higher than the max concentration, the mean is used to calculate dose
Chemical Concentration in Water - RME	C_{sw}	95% UCL or Max	95% UCL or Max	95% UCL or Max	mg/L	Site-specific, if 95% UCL of mean is higher than the max concentration, the max is used to calculate dose
Surface water ingestion rate - CTE	IR	0.05	0.05	0.05	L/day	USEPA Region I; Bob Lim, EPA 1998
Surface water ingestion rate - RME	IR	0.05	0.05	0.05	L/day	USEPA Region I; Bob Lim, EPA 1998
Exposure Frequency - CTE	EF	7	7	12	days/yr	Site - specific assumption
Exposure Frequency - RME	EF	104	104	18	days/yr	Site - specific assumption
CT Exposure Duration	ED	6	9	6.6	years	EPA 1990, based on age classification
RME Exposure Duration	ED	6	24	25	years	Site-specific assumption
Body Weight	BW	36.2	70	70	kg	EPA 1989b
Carcinogen Averaging Time	AT	25,550	25,550	25,550	days	EPA 1989b, EPA 1989a, equivalent to 70 year lifetime exposure at 365 days/year
CT Noncarcinogen Averaging Time	AT	2,190	3,285	2,409	days	EPA 1989b, EPA 1989a, exposure duration x 365 days/year
RME Noncarcinogen Averaging Time	AT	2,190	8,760	9,125	days	EPA 1989b, EPA 1989a, exposure duration x 365 days/year

Equation for ingestion of chemicals in surface water (EPA 1989):

$$\text{Intake (mg/kg*day)} = \frac{C_{sw} \times IR \times EF \times ED}{BW \times AT}$$

[1] = Memo dated June 4, 1998 from Richard Sugatt to Tom Szymoniak

avg = average
cm = centimeter
conc. = concentration
CT = Central Tendency
EPA = U.S. Environmental Protection Agency
kg = kilogram
L = liter
mg = milligram
NA = not applicable
RME = Reasonable maximum exposure
UCL = Upper confidence limit
yr = year

Table 2.6-16. Human Health Risk Parameters and Equations for Sediment Ingestion, Current and Future Use
Massachusetts Military Reservation, FS-1

Parameter	Symbol	Value			Units	Source
		Recreational Youth 7-12 yrs	Adult Wader	Cranberry Worker [1]		
Chemical Conc. in Sediment - CT	C_s	95 % UCL or Mean	95 % UCL or Mean	95 % UCL or Mean	mg/kg	Site-specific, if 95% UCL of mean is higher than the max concentration, the mean is used to calculate dose
Chemical Conc. in Sediment - RME	C_s	95 % UCL or Max	95 % UCL or Max	95 % UCL or Max	mg/kg	Site-specific, if 95% UCL of mean is higher than the max concentration, the max is used to calculate dose
Sediment Ingestion Rate - CTE	Ir_s	100	50	100	mg/day	EPA 1991a
Sediment Ingestion Rate - RME	Ir_s	200	100	200	mg/day	EPA 1991a
Fraction Ingested from contaminated source	FI	1	1	1	unitless	Site-specific assumption, EPA 1989a
Exposure Frequency - CTE	EF	7	7	12	days/year	Site-specific assumption
Exposure Frequency - RME	EF	104	104	18	days/year	Site-specific assumption
CT Exposure Duration	ED	6	9	6.6	years	Site-specific assumption, EPA 1989a
RME Exposure Duration	ED	6	24	25	years	Site-specific assumption, EPA 1989a
Body Weight	BW	36.2	70	70	kg	EPA 1989a, ASG 1994
Carcinogen Averaging Time	AT	25,550	25,550	25,550	days	EPA 1989a, equivalent to 70 year lifetime exposure at 365 days/year
CT Noncarcinogen Averaging Time	AT	2,190	3,285	2,409	days	EPA 1989a, exposure duration x 365 days/year
RME Noncarcinogen Averaging Time	AT	2,190	8,760	9,125	days	EPA 1989a, exposure duration x 365 days/year
Conversion Factor	CF	1.00E-06	1.00E-06	1.00E-06	10^{-6} kg/mg	EPA 1989a

Equation for ingestion of chemicals in sediment (EPA 1989a):

$$\text{Intake (mg/kg*day)} = \frac{C_s \times IR_s \times CF \times FI \times EF \times ED}{BW \times AT}$$

avg = average
cm = centimeter
conc = concentration
CT = Central Tendency
EPA = U.S. Environmental Protection Agency
kg = kilogram
L = liter
Max = maximum
mg = milligram
NA = not applicable
RME = Reasonable maximum exposure
UCL = Upper confidence limit
[1] = Memo dated June 4, 1998, from Richard Sugatt to Tom Szymoniak

EPA 1989a. *Risk Assessment Guidance for Superfund. Vol 1 Human Health Evaluation Manual (Part A)*. EPA/540/1-898/002.
EPA 1989b. *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual*. USEPA/600/8-89/043.
EPA 1992. *Dermal Exposure Assessment: Principles and Applications, Interim Report*. EPA/600/8-91/011B.
EPA 1996a. *Exposure Factors Handbook* - DRAFT. EPA/600/P-95/002B. Office of Research and Development.
EPA 1997. *Risk Assessment Guidance for Superfund. Vol I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance*. (June 19, 1997)
EPA Region I. Memo from Bob Lim, EPA to B. Hoda, B. Johnston, and T. Rottero, dated 10/30/98.

Table 2.6-17. Human Health Risk Parameters and Equations for Dermal Absorption of Surface Water - Future Use
Massachusetts Military Reservation, FS-1, Groundwater Plume and Upwelling Area

Parameter	Symbol	Youth	Adult Wader	Cranberry Worker	Units	Source
Water Concentration - CT	C_{sw}	95% UCL or Mean	95% UCL or Mean	95% UCL or Mean	mg/L	Site-specific
Water Concentration - RME	C_{sw}	95% UCL or Max	95% UCL or Max	95% UCL or Max	mg/L	Site-specific
Dose absorbed per unit area per event	DA_{event}	chem.-specific	chem.-specific	chem.-specific	mg/cm^2-event	EPA 1992
Events	EV	1	1	1	event/day	Site-Specific assumption
Skin Surface Area - CT	SA	3,075	5,700	5,700	cm^2	EPA Region I, EPA 1992
Skin Surface Area - RME	SA	3,825	6,600	6,600	cm^2	EPA Region I, EPA 1992
Exposure Frequency CT	EF	7	7	12	days/ year	Site-specific
Exposure Frequency RME	EF	104	104	18	days/ year	Site-specific
Exposure duration - CT	ED	6	9	6.6	years	1989a
Exposure duration - RME	ED	6	24	25	years	1989a
Body weight	BW	36	70	70	kg	EPA 1989b
Carcinogen averaging time	AT	25550	25550	25550	days	EPA 1989b, equivalent to 70 year lifetime exposure at 365 days/ year
Noncarcinogen averaging time - CT	AT	2190	3285	2409	days	EPA 1989b, a average exposure duration x 365 days/year
Noncarcinogen averaging time - RME	AT	2190	8760	9125	days	EPA 1989b, max exposure duration x 365 days/year
Permeability Constant (estimated)	K_p	chem.-specific	chem.-specific	chem.-specific	cm/hr	EPA 1992
Lag Time	τ	chem.-specific	chem.-specific	chem.-specific	hr	Chem.-specific
Event time	tevent	1	1	8	hr	EPA 1992
Calculated Absorption time	t*	chem.-specific	chem.-specific	chem.-specific	hr	EPA 1992
Partitioning Properties Constant	B	chem.-specific	chem.-specific	chem.-specific	unitless	EPA 1992
Volumetric Conversion Factor	CF	1.00E-03	1.00E-03	1.00E-03	L/1000 cm^3	EPA 1989b

Equation for dermal contact with chemicals in water:

Dermal absorbed dose (mg/kg*day) =

$$\frac{DA_{event} * EV * ED * EF * SA}{BW \times AT}$$

DA_{event} for Organics IF $t_{event} < t^*$

$$DA_{event} = 2K_p{}^*C_w{}^*CF \sqrt{\frac{6^*\tau^*t_{event}}{\pi}}$$

DA_{event} for Inorganics:

$$DA_{event} = K_p{}^*C_w{}^*CF^*t_{event}$$

DA_{event} for Organics IF $t_{event} > t^*$

$$DA_{event} = K_p{}^*C_w{}^*CF \left[\frac{tevent}{1+B} + 2\tau \left[\frac{1+3B}{1+B} \right] \right]$$

avg = average
chem. = chemical
cm = centimeter
conc. = concentration
CT = Central Tendency
EPA = U.S. Environmental Protection Agency
kg = kilogram
L = liter
mg = milligram
RME = Reasonable Maximum Exposure
UCL = Upper confidence limit
NA = not applicable
RME = Reasonable maximum exposure

EPA 1989a *Risk Assessment Guidance for Superfund Vol 1 Human Health Evaluation Manual (Part A)*. EPA/540/1-89/002.
EPA 1989b. *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual.* OSEPA/600/8-89/043.
EPA 1992. *Dermal Exposure Assessment: Principles and Applications, Interim Report.* EPA/600/8-91/011B.
EPA Region I. Memo from Bob Lim, EPA to B. Hoda, B. Johnston, and T. Rottero, dated 10/30/98.

Table 2.6-18. Human Health Risk Parameters and Equations for Dermal Contact with Sediment, Current and Future Use
Massachusetts Military Reservation
Fuel Spill 1

Parameter	Symbol	Value			Units	Source
		Recreational Youth Age 7-12	Adult Wader	Cranberry Worker		
Chemical Concentration in Sediment CT	C_S	95% UCL or Mean	95% UCL or Mean	95% UCL or Mean	mg/kg	Site-specific, if 95% UCL of mean is higher than the max concentration, the mean is used to calculate dose
Chemical Concentration in Sediment RME	C_S	95% UCL or Max	95% UCL or Max	95% UCL or Max	mg/kg	Site-specific, if 95% UCL of mean is higher than the max concentration, the max is used to calculate dose
Adherence Factor - CTE	AF	0.3	0.14	0.14	mg/cm^2	EPA Region I
Adherence Factor - RME	AF	1	0.14	0.14	mg/cm^2	EPA Region I
Absorption Factor	ABS	Compound-specific	Compound-specific	Compound-specific	unitless	EPA 1997
Skin surface area for contact - CTE	SA	3075	5700	5700	cm^2	EPA 1996, EPA Region I
Skin surface area for contact - RME	SA	3825	6600	6600	cm^2	EPA 1996, EPA Region I
Exposure Frequency - CTE	EF	7	7	12	days/yr	Site-specific assumption
Exposure Frequency - RME	EF	104	104	18	days/yr	Site-specific assumption
Exposure Duration - CT	ED	6	9	6.6	years	Site-specific assumption, EPA Region 1
Exposure Duration - RME	ED	6	24	25	years	Site-specific assumption, EPA Region 1
Body Weight	BW	36.2	70	70	kg	EPA 1989b, ASG 1994
Carcinogen Averaging Time	AT	25,550	25,550	25,550	days	EPA 1989b, equal to 70 year life exposure at 365 days/yr
Noncarcinogen Averaging Time CT	AT	2,190	3,285	2,409	days	EPA 1989b, avg exposure * 365 days/yr
Noncarcinogen Averaging Time RME	AT	2,190	8,760	9,125	days	EPA 1989b, RME exposure * 365 days/yr
Conversion Factor	CF	1.00E-06	1.00E-06	1.00E-06	kg/mg	EPA 1989a

Equation for dermal contact with chemicals in sediment (EPA 1992):

Absorbed dose per event (DAevent) = Cs * CF*AF*ABS

Dermal absorbed dose (mg/kg*day) = $\frac{DA_{event} * EF * ED * SA}{BW \times AT}$

avg = average
cm = centimeter
kg = kilogram
L = liter
mg = milligram
CT = Central Tendency

NA = not applicable
RME = Reasonable maximum exposure
yr = year
UCL = Upper confidence limit
EPA = U.S. Environmental Protection Agency
Max = maximum

EPA 1989a. *Risk Assessment Guidance for Superfund. Vol 1 Human Health Evaluation Manual (Part A)*. EPA/540/1-898/002.
EPA 1989b. *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual*. USEPA/600/8-89/043.
EPA 1992. *Dermal Exposure Assessment: Principles and Applications, Interim Report*. EPA/600/8-91/011B.
EPA 1996a. *Exposure Factors Handbook* - DRAFT. EPA/600/P-95/002B. Office of Research and Development.
EPA 1997. *Risk Assessment Guidance for Superfund. Vol I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance*. (June 19, 1997)
EPA Region I. Memo from Bob Lim, EPA to B. Hoda, B. Johnston, and T. Rottero, dated 10/30/98.

Table 2.6-19. Human Health Risk Parameters and Equations for Inhalation of Volatiles from Surface Water, Current and Future Use
Massachusetts Military Reservation
Fuel Spill 1

Parameter	Symbol	Value			Units	Source
		Recreational Youth	Adult Wader	Cranberry Worker[1]		
Chemical Concentration in Water - CT	C_{sw}	95% UCL or Mean	95% UCL or Mean	95% UCL or Mean	mg/L	Site-specific, if 95% UCL of mean is higher than the max concentration, the mean is used to calculate dose
Chemical Concentration in Water - RME	C_{sw}	95% UCL or Max	95% UCL or Max	95% UCL or Max	mg/L	Site-specific, if 95% UCL of mean is higher than the max concentration, the max is used to calculate dose
Inhalation Rate - CT	IR	1	1	1.3	m^3/hr	EPA 1996a, EPA Region I
Inhalation Rate - RME	IR	1.2	1.6	3.3	m^3/hr	EPA Region I
Volatilization Factor for EDB	VF	0.2	0.2	0.2	L/m^3	Jacobs, 1998
Exposure Time	ET	1	1	8	hours/day	Site-specific assumption
Exposure Frequency - CT	EF	7	7	12	days/year	Site-specific assumption
Exposure Frequency - RME	EF	104	104	18	days/year	Site-specific assumption
Exposure Duration - CT	ED	6	9	6.6	years	EPA 1989a, EPA 1990, EPA Region I
Exposure Duration - RME	ED	6	24	25	years	EPA Region I
Body Weight	BW	36.2	70	70	kg	EPA 1989b
Averaging Time - Carcinogen	AT_c	25,550	25,550	25,550	days	EPA 1989b
CT Averaging Time - Non-Carcinogen	AT_n	2,190	3,285	2,409	days	EPA 1989b
RME Averaging Time - Non-Carcinogen	AT_n	2,190	8,760	9,125	days	EPA 1989b

Equation for inhalation of volatiles from surface water:

$$\text{Chronic Intake (mg/kg*day)} = \frac{C_{sw} \times VF \times IR \times ET \times EF \times ED}{BW \times AT}$$

avg = average
cm = centimeter
EPA = U.S. Environmental Protection Agency
kg = kilogram
L = liter
mg = milligram
NA = not applicable
RME = Reasonable maximum exposure
yr = year
UCL = Upper confidence limit
CT = Central Tendency

Automated Sciences Group, Inc. (ASG) 1994. *Risk Assessment Handbook, Massachusetts Military Reservation, Cape Cod, Massachusetts*.
EPA 1989a. *Risk Assessment Guidance for Superfund. Vol 1 Human Health Evaluation Manual (Part A)*. EPA/540/1-898/002.
EPA 1989b. *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual*. USEPA/600/8-89/043.
EPA 1991b. *Risk Assessment Guidance for Superfund Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*. OSWER Publ. 9285.7-01B
EPA 1996a. *Exposure Factors Handbook* - DRAFT. EPA/600/P-95/002B. Office of Research and Development.
EPA Region I. Memo from Bob Lim, EPA to B. Hoda, B. Johnston, and T. Rottero, dated 10/30/98.
Jacobs, 1998. *Southwest Operable Unit (SWOU) Remedial Investigation for Massachussetts Military Reservation.*

Table 2.6-20. Human Health Risk Parameters and Equations for Ingestion of Fish
Current and Future Use

Parameter	Symbol	Value: Adult Wader	Units	Source
Chemical concentration in Surface Water - CT	C_{sw}	95% UCL or Max	mg/L	Site- and chemical-specific
Chemical concentration in Surface Water -RME	C_{sw}	95% UCL or Mean	mg/L	Site- and chemical-specific
Bioaccumulation Factor	BAF	Chemical-specific	L/kg	Chemical-specific
CT Ingestion Rate	IR	6.4	g/day	
RME Ingestion Rate	IR	26	g/day	
Fraction Ingested	FI	1	unitless	
Conversion Factor	CF	0.001	kg/g	--
Exposure Frequency	EF	350	days/year	Site-specific
CT Exposure Duration	ED	9	years	EPA 1991a, 50th percentile at one residence
RME Exposure Duration	ED	30	years	EPA 1991a, 90th percentile at one residence
Body Weight	BW	70	kg	EPA 1989a
Averaging Time, carcinogen	AT	25,550	days	EPA 1989b, exposure duration x 365 days/year
CT Averaging Time, non-cancer	AT	3,285	days	EPA 1989b, exposure duration x 365 days/year
RME Averaging Time, non-cancer	AT	10,950	days	EPA 1989b, exposure duration x 365 days/year

$$\text{Chronic Daily Intake} = \frac{C_{sw}*BAF*IR*FI*CF*EF*ED}{BW*AT}$$

avg = average
cm = centimeter
EPA = U.S. Environmental Protection Agency
g = gram
kg = kilogram
L = liter
m = meter
mg = milligram
RME = Reasonable Maximum Exposure
CT = Central Tendency

TABLE 2.6-21a
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
HUMAN HEALTH, MASSACHUSETTS MILITARY RESERVATION, FUEL SPILL 1, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
1,2-Dichloroethane	NA	--	NA	NA	NA	NA	---	NA	---	---
4-Methyl-2-pentanone	NA	--	NA	NA	NA	NA	--	NA	---	---
Chloroform	CHRONIC	1.00E-02	mg/kg-day	NA	NA	NA	Liver	1000	IRIS, HEAST	12/11/98, 7/31/97
Chloromethane	NA	--	NA	NA	NA	NA	---	NA	---	1/0/00
Tetrachloroethene	CHRONIC	1.00E-02	mg/kg-day	NA	NA	NA	Liver	1000	IRIS, HEAST	12/11/98, 7/31/97
Toluene	CHRONIC	2.00E-01	mg/kg-day	NA	NA	NA	liver, kidney	1000	IRIS	12/11/98
TPH	NA	--	NA	NA	NA	NA	---	NA	---	---
EDB	NA	--	NA	NA	NA	NA	---	NA	---	---
Metals										
Aluminum	CHRONIC	1.00E+00	mg/kg-day	NA	NA	NA	---	100	---	1/0/00
Arsenic	CHRONIC	3.00E-04	mg/kg-day	NA	NA	NA	Skin, vasc. Sys.	3	IRIS, HEAST	12/11/98, 7/31/97
Boron	CHRONIC	9.00E-02	mg/kg-day	NA	NA	NA	Gonads	NA	IRIS	12/11/98
Chromium	CHRONIC	3.00E-03	mg/kg-day	NA	NA	NA	Health effects	500	IRIS	12/11/98
Cobalt	CHRONIC	6.00E-02	mg/kg-day	NA	NA	NA	--	NA	---	1/0/00
Copper		4.00E-02	mg/kg-day	NA	NA	NA	Gastrointestinal	NA	HEAST	7/31/97
Iron	CHRONIC	3.00E-01	mg/kg-day	NA	NA	NA	--	NA	---	1/0/00
Lead	NA	--	NA	NA	NA	NA	--	NA	---	1/0/00
Manganese	CHRONIC	1.40E-01	mg/kg-day	NA	NA	NA	CNS	1	IRIS, HEAST	12/11/98, 7/31/97

TABLE 2.6-21a
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
HUMAN HEALTH, MASSACHUSETTS MILITARY RESERVATION, FUEL SPILL 1, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
Thallium	NA	--	NA	NA	NA	NA	Blood	NA	IRIS	6/8/98

NA = Not Applicable
(1) Refer to RAGS, Part A
(2) Provide equation used for derivation.
(3) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of the article provided by NCEA.

TABLE 2.6-21b

NON-CANCER TOXICITY DATA -- INHALATION

MASSACHUSETTS MILITARY RESERVATION, FUEL SPILL 1, HUMAN HEALTH, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD (1)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (2) (MM/DD/YY)
1,2-Dichloroethane	NA	--	NA	--	NA	--	NA	--	--
4-Methyl-2-pentanone	NA	--	NA	--	NA	--	NA	--	--
Chloroform	NA	1.05E-03	NA	3.00E-04	mg/kg-day	Nasal tissue	NA	NCEA	12/1/97
Chloromethane	NA	--	NA	--	NA	--	NA	--	--
Tetrachloroethene	NA	--	NA	--	NA	--	NA	--	--
Toluene	CHRONIC	3.99E-01	mg/m^3	1.14E-01	mg/kg-day	--	300	--	--
TPH	NA	--	NA	--	NA	--	NA	--	--
EDB	CHRONIC	2.00E-04	mg/m^3	5.71E-05	mg/kg-day	Sperm	NA	HEAST	7/31/97
Metals									
Aluminum	NA	--	NA	--	NA	--	NA	--	--
Arsenic	NA	--	NA	NA	NA	--	NA	--	--
Boron	CHRONIC	2.00E-02	mg/m^3	5.71E-03	mg/kg-day	--	NA	--	--
Chromium	NA	9.98E-05	NA	2.85E-05	mg/kg-day	--	NA	--	--
Cobalt	NA	--	NA	--	NA	--	NA	--	--
Copper	NA	--	NA	--	NA	--	NA	--	--

TABLE 2.6-21b

NON-CANCER TOXICITY DATA -- INHALATION

MASSACHUSETTS MILITARY RESERVATION, FUEL SPILL 1, HUMAN HEALTH, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD (1)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (2) (MM/DD/YY)
Iron	NA	--	NA	--	NA	--	NA	--	--
Lead	NA	--	NA	--	NA	--	NA	--	--
Manganese	CHRONIC	5.01E-05	mg/m^3	1.43E-05	mg/kg-day	--	1000	--	--
Thallium	NA	--	NA	--	NA	--	NA	--	--

(1) Provide equation used for derivation in text.

(2) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of the article provided by NCEA.

TABLE 2.6-21c

NON-CANCER TOXICITY DATA -- SPECIAL CASE CHEMICALS

Massachusetts Military Reservation, Fuel Spill 1, Groundwater Plume and Upwelling Area

Chemical of Potential Concern	Chronic/ Subchronic	Value	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of Primary Target Organ	Date (MM/DD/YY)
NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2.6-22a
CANCER TOXICITY DATA -- ORAL/DERMAL
MASSACHUSETTS MILITARY RESERVATION, FS-1, HUMAN HEALTH, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source Target Organ	Date (2) (MM/DD/YY)
1,2-Dichloroethane	9.10E-02	--	--	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1998
4-Methyl-2-pentanone	--	--	NA	NA	NA	NA	NA
Chloroform	6.10E-03	--	--	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1998
Chloromethane	1.30E-02	--	--	$(mg/kg\text{-}day)^{-1}$	C	HEAST	1998
Tetrachloroethene	5.20E-02	--	--	$(mg/kg\text{-}day)^{-1}$	--	--	--
Toluene	--	--	--	--	--	--	--
TPH	--	NA	NA	NA	NA	NA	NA
EDB	8.50E+01	--	--	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1998
Metals							
Aluminum	--	NA	NA	NA	NA	NA	NA
Arsenic	1.50E+00	--	--	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1998
Boron	--	--	--	--	--	--	--
Chromium	--	NA	NA	NA	NA	NA	NA

TABLE 2.6-22a
CANCER TOXICITY DATA -- ORAL/DERMAL
MASSACHUSETTS MILITARY RESERVATION, FS-1, HUMAN HEALTH, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source Target Organ	Date (2) (MM/DD/YY)
Cobalt	--	NA	NA	NA	NA	NA	NA
Copper	--	NA	NA	NA	NA	NA	NA
Iron	--	NA	NA	NA	NA	NA	NA
Lead	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--
Thallium	--	NA	NA	NA	NA	NA	NA

IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables

(1) Provide equation for derivation in text.
(2) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of article provided by NCEA.

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

Weight of Evidence:
Known/Likely
Cannot be Determined
Not Likely

TABLE 2.6-22b
CANCER TOXICITY DATA -- INHALATION
MASSACHUSETTS MILITARY RESERVATION, FS-1, HUMAN HEALTH, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Unit Risk	Units	Adjustment	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (1) (MM/DD/YY)
1,2-Dichloroethane	2.60E-05	$(ug/m^3)^{-1}$	NA	9.10E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1998
4-Methyl-2-pentanone	NA	NA	NA	--	NA	NA	--	NA
Chloroform	2.30E-05	$(ug/m^3)^{-1}$	NA	8.10E-02	$(mg/kg\text{-}day)^{-1}$	B2	HEAST	1998
Chloromethane	1.80E-06	$(ug/m^3)^{-1}$	NA	6.30E-03	$(mg/kg\text{-}day)^{-1}$	C	HEAST	1998
Tetrachloroethene	5.80E-05	$(ug/m^3)^{-1}$	NA	2.00E-03	$(mg/kg\text{-}day)^{-1}$	C	EAOC	1998
Toluene	NA	NA	NA	--	NA	NA	NA	NA
TPH	NA	NA	NA	--	NA	NA	NA	NA
EDB	2.20E-04	$(ug/m^3)^{-1}$	NA	7.60E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1998
Metals								
Aluminum	NA	NA	NA	--	NA	NA	NA	NA
Arsenic	4.30E-03	$(ug/m^3)^{-1}$	NA	5.00E+01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1998
Boron	NA	NA	NA	--	NA	NA	NA	NA
Chromium	1.20E-02	$(ug/m^3)^{-1}$	NA	4.10E+01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1998
Cobalt	NA	NA	NA	--	NA	NA	NA	NA

TABLE 2.6-22b
CANCER TOXICITY DATA -- INHALATION
MASSACHUSETTS MILITARY RESERVATION, FS-1, HUMAN HEALTH, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Unit Risk	Units	Adjustment	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (1) (MM/DD/YY)
Copper	NA	NA	NA	--	NA	NA	NA	NA
Iron	NA	NA	NA	--	NA	NA	NA	NA
Lead	NA	NA	NA	--	NA	NA	NA	NA
Manganese	NA	NA	NA	--	NA	NA	NA	NA
Thallium	NA	NA	NA	--	NA	NA	NA	NA

IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables

Weight of Evidence:
Known/Likely
Cannot be Determined
Not Likely

(1) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of the article provided by NCEA.
(W)

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

TABLE 2.6-22c

CANCER TOXICITY DATA -- SPECIAL CASE CHEMICALS

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Chemical of Potential Concern	Value	Units	Source	Date (1) MM/DD/YY
NA	NA	NA	NA	NA

(1) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of the article provided by NCEA.

TABLE 2 6-23a

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	Tetrachloroethene	6.66E-08	NA	1.20E-07	1[illegible]07	Arsenic	SK/BL	2.17E-01	NA	3.10E-03	2.20E-01
			EDB	2.47E-04	NA	3.64E-04	6.11E-04	Manganese	CNS	3.84E-02	NA	5.48E-04	3.89E-02
			Arsenic	1.25E-05	NA	1.79E-07	1.27E-05						
			TOTAL	**2.60E-04**	**0.00E+00**	**3.64E-04**	**6.24E-04**	**TOTAL**	--	**2.55E-01**	--	**3.64E-03**	**2.59E-01**
	AIR	Water Vapors in Shower	EDB	NA	1.19E-05	NA	1.19E-05	EDB	--	NA	2.12E+00	NA	2.12E+00
			TOTAL	--	**1.19E-05**	--	**1.19E-05**	**TOTAL**	--	--	**2.12E+00**	--	**2.12E+00**
						Total Risk Across All Media and All Exposure Routes	6.36E-04					Total Hazard Index Across All Media and All Exposure Routes	2.38E+00

SK/BL = Skin/Blood
CNS = Central Nervous System
-- = Data Not Available
CT = Central Tendency
NA = Not Applicable

Total [CNS] HI =	3.89E-02
Total [SK/BL] HI =	2.20E-01
Total [Organ] HI =	--

TABLE 2.6-23b

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	Chloromethane	1.22E-06	--	8.02E-08	1.30E-06	Arsenic	SK/BL	1.87E+00	--	2.15E-02	1.89E+00
			Tetrachloroethene	1.22E-06	--	1.77E-06	2.99E-06	Iron	--	2.02E+00	--	2.32E-02	2.04E+00
			EDB	7.68E-03	--	9.10E-03	1.68E-02						
			Arsenic	3.61E-04	--	4.15E-06	3.65E-04						
			TOTAL	**8.05E-03**	**0.00E+00**	**9.10E-03**	**1.72E-02**	**TOTAL**	--	**3.89E+00**	**0.00E+00**	**4.47E-02**	**3.94E+00**
	AIR	Water Vapors in Shower	Chloroform	--	1.43E-05	--	1.43E-05	Chloroform	Nasal Tissue	--	1.37E+00	--	1.37E+00
			1,2-Dichloroethane	--	2.93E-06	--	2.93E-06	Toluene	L/K	--	2.25E+00	--	2.25E+00
			EDB	--	2.58E-04	--	2.58E-04	EDB	--	--	1.39E+01	--	1.39E+01
			Chloromethane	--	2.22E-06	--	2.22E-06						
			TOTAL	--	**2.77E-04**	**0.00E+00**	**2.77E-04**	**TOTAL**	--	--	**1.61E+01**	--	**1.61E+01**
						Total Risk Across All Media and All Exposure Routes	1.74E-02					Total Hazard Index Across All Media and All Exposure Routes	2.00E+01

SK/BL = Skin/Blood

L/K = Liver/Kidney

-- = Data Not Available

RME = Reasonable Maximum Exposure

Total [SK/BL] HI =	1.89E+00
Total [L/K] HI =	2.25E+00
Total [Nasal Tissue] HI =	1.4E+00

TABLE 2.6-24a

RISK ASSESSMENT SUMMARY

CENTRAL TENDENCY EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe: Current & Future
Receptor Population: Recreational Youth
Receptor Age: Youth

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	EDB (Meth 504)	8.30E-08	2.97E-09	5.10E-08	1.37E-07	EDB (Meth 504)	Sperm	NA	7.98E-04	NA	7.98E-04
			TOTAL	**8.30E-08**	**2.97E-09**	**5.10E-08**	**1.37E-07**	**TOTAL**	**--**	**0.00E+00**	**7.98E-04**	**0.00E+00**	**7.98E-04**
Sediment	Sediment	Sediment	--	--	--	--	0.00E+00	Iron	--	2.95E-04	--	2.72E-05	3.22E-04
			TOTAL	**--**	**--**	**--**	**0.00E+00**	**TOTAL**	**--**	**2.95E-04**	**--**	**2.72E-05**	**3.22E-04**
						Total Risk Across All Media and All Exposure Routes	1.37E-07					Total Hazard Index Across All Media and All Exposure Routes	1.12E-03

-- = Data Not Available

CT = Central Tendency

Total [Sperm] HI =	7.98E-04
Total [Organ] HI =	--
Total [Organ] HI =	--

TABLE 2.6-24b

RISK ASSESSMENT SUMMARY

REASONABLE MAXIMUM EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe: Current & Future
Receptor Population: Recreational Youth
Receptor Age: Youth

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	EDB (Meth 504)	1.23E-06	5.29E-08	9.42E-07	2.23E-06	EDB (Meth 504)	Sperm	NA	1.42E-02	NA	1.42E-02
			TOTAL	**1.23E-06**	**5.29E-08**	**9.42E-07**	**2.23E-06**	**TOTAL**	–	**0.00E+00**	**1.42E-02**	**0.00E+00**	**1.42E-02**
Sediment	Sediment	Sediment	--	--	--	--	--	Iron	--	1.10E-02	--	2.10E-03	1.31E-02
			--	--	--	--	--	--	--	--	--	--	--
			TOTAL	–	–	–	**0.00E+00**	**TOTAL**	–	**1.10E-02**	–	**2.10E-03**	**1.31E-02**
						Total Risk Across All Media and All Exposure Routes	2.23E-06					Total Hazard Index Across All Media and All Exposure Routes	2.73E-02

-- = Data Not Available

RME = Reasonable Maximum Exposure

Total [Sperm] HI =	1.42E-02
Total [Organ] HI =	--
Total [Organ] HI =	--

TABLE 2.6-25a

RISK ASSESSMENT SUMMARY

CENTRAL TENDENCY EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe: Current & Future
Receptor Population: Adult Wader
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	EDB (Meth 504)	6.44E-08	2.30E-09	7.33E-08	1.40E-07	EDB (Meth 504)	Sperm	NA	4.13E-04	NA	4.13E-04
			TOTAL	**6.44E-08**	**2.30E-09**	**7.33E-08**	**1.40E-07**	**TOTAL**	--	**0.00E+00**	**4.13E-04**	**0.00E+00**	**4.13E-04**
Sediment	Sediment	Sediment	--	--	--	--	--	Iron	--	7.62E-05	--	1.22E-05	8.83E-05
			TOTAL	--	--	--	**0.00E+00**	**TOTAL**	--	**7.62E-05**	--	**1.22E-05**	**8.83E-05**
Fish Ingestion	Fish Ingestion	Fish Ingestion	EDB (Meth 504)	4.12E-06	--	--	4.12E-06	Iron	--	1.62E-02	--	--	1.62E-02
								Manganese	CNS	4.34E-03	--	--	4.34E-03
			TOTAL	**4.12E-06**	**0.00E+00**	**0.00E+00**	**4.12E-06**	**TOTAL**		**2.05E-02**	**0.00E+00**	**0.00E+00**	**2.05E-02**
						Total Risk Across All Media and All Exposure Routes	4.26E-06					Total Hazard Index Across All Media and All Exposure Routes	2.10E-02

-- = Data Not Available

CT = Central Tendency

NA = Not Applicable

Total [CNS] HI =	4.34E-03
Total [Sperm] HI =	4.13E-04
Total [Organ] HI =	--

TABLE 2.6-25b

RISK ASSESSMENT SUMMARY

REASONABLE MAXIMUM EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe Current & Future
Receptor Population: Adult Wader
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	EDB (Meth 504)	2.55E-06	1.46E-07	3.36E-06	6.06E-06	EDB (Meth 504)	Sperm	NA	9.81E-03	NA	9.81E-03
			TOTAL	**2.55E-06**	**1.46E-07**	**3.36E-06**	**6.06E-06**	**TOTAL**	**0.00E+00**	**0.00E+00**	**9.81E-03**	**0.00E+00**	**9.81E-03**
Sediment	*Sediment*	*Sediment*	NA	--	--	--	0.00E+00	*Iron*	--	2.84E-03	--	2.62E-04	3.10E-03
			TOTAL	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**TOTAL**	**0.00E+00**	**2.84E-03**	**0.00E+00**	**2.62E-04**	**3.10E-03**
Fish Ingestion	Fish Ingestion	Fish Ingestion	EDB (Meth 504)	5.58E-05	NA	NA	5.58E-05	Iron		1.73E-01	NA	NA	1.73E-01
								Manganese	CNS	4.84E-02	NA	NA	4.84E-02
			TOTAL	**5.58E-05**	**0.00E+00**	**0.00E+00**	**5.58E-05**	**TOTAL**	**0.00E+00**	**2.22E-01**	**0.00E+00**	**0.00E+00**	**2.22E-01**
						Total Risk Across All Media and All Exposure Routes	6.19E-05					Total Hazard Index Across All Media and All Exposure Routes	2.35E-01

-- = Data Not Available

RME = Reasonable Maximum Exposure

CNS = Central Nervous System

NA = Not Applicable

Total [CNS] HI =	4.84E-02
Total [Sperm] HI =	9.81E-03
Total [Organ] HI =	--

TABLE 2.6-26a

RISK ASSESSMENT SUMMARY

CENTRAL TENDENCY EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe: Current & Future
Receptor Population: Cranberry Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	EDB (Meth 504)	8.09E-08	3.01E-08	3.16E-07	4.27E-07	EDB (Meth 504)	Sperm	NA	7.36E-03	NA	7.36E-03
			TOTAL	**8.09E-08**	**3.01E-08**	**3.16E-07**	**4.27E-07**	--	--	**0.00E+00**	**7.36E-03**	**0.00E+00**	**7.36E-03**
Sediment	Sediment	Sediment	--	--	--	--	--	Iron	--	2.61E-04	--	2.08E-05	2.82E-04
			TOTAL	--	--	--	**0.00E+00**	**TOTAL**	--	**2.61E-04**	--	**2.08E-05**	**2.82E-04**
						Total Risk Across All Media and All Exposure Routes	4.27E-07			Total Hazard Index Across All Media and All Exposure Routes			7.64E-03

-- = Data Not Available

CT = Central Tendency

NA = Not Applicable

Total [Sperm] HI =	7.36E-03
Total [Organ] HI =	--
Total [Organ] HI =	--

TABLE 2.6-26b

RISK ASSESSMENT SUMMARY

REASONABLE MAXIMUM EXPOSURE FOR HUMAN HEALTH

MASSACHUSETTS MILITARY RESERVATION, FS-1, GROUNDWATER PLUME AND UPWELLING AREA

Scenario Timeframe: Current & Future
Receptor Population: Cranberry Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	EDB (Meth 504)	4.60E-07	4.34E-07	2.08E-06	2.97E-06	EDB (Meth 504)	Sperm	NA	2.80E-02	NA	2.80E-02
			TOTAL	**4.60E-07**	**4.34E-07**	**2.08E-06**	**2.97E-06**	**TOTAL**	--	**0.00E+00**	**2.80E-02**	**0.00E+00**	**2.80E-02**
Sediment	Sediment	Sediment	--	--	--	--	--	Iron	--	9.82E-04	--	4.54E-05	1.03E-03
			TOTAL	--	--	--	**0.00E+00**	**TOTAL**	--	**9.82E-04**	--	**4.54E-05**	**1.03E-03**
						Total Risk Across All Media and All Exposure Routes	2.97E-06					Total Hazard Index Across All Media and All Exposure Routes	2.90E-02

-- = Data Not Available

NA = Not Applicable

RME = Reasonable Maximum Exposure

Total [Sperm] HI =	2.80E-02
Total [Organ] HI =	--
Total [Organ] HI =	--

Table 2.6-27. Human Health Risk Summary for the AOC and Groundwater Plume and Upwelling Area Massachusetts Military Reservation

EXPOSURE PATHWAY		MEAN/CT		MAX/RME	
		Total Cancer	Total HI	Total Cancer	Total HI
FS-1 ACO					
Future/Current - Soil					
	Ingestion	N/A	N/A	N/A	N/A
	Inhalation	N/A	N/A	N/A	N/A
	Dermal	N/A	N/A	N/A	N/A
	Total (Utility Worker)	N/A	N/A	N/A	N/A
FS-1 DOWNGRADIENT IMPACT AREA					
Future/Current - Groundwater					
	Ingestion	3.E-04	4.E-01	8.E-03	5.E+00
	Inhalation	1.E-05	2.E+00	3.E-04	2.E+01
	Dermal	4.E-04	1.E-02	9.E-03	4.E-01
	Total (Resident Adult)	6.E-04	3.E+00	2.E-02	2.E+01
Current / Future - Cranberry Worker					
Surface Water	Ingestion	8.E-08	6.E-05	5.E-07	2.E-04
	Inhalation	3.E-08	7.E-03	4.E-07	3.E-02
	Dermal	3.E-07	6.E-05	2.E-06	1.E-04
	Total	4.E-07	7.E-03	3.E-06	3.E-02
Sediment	Ingestion	0.E+00	3.E-04	0.E+00	1.E-03
	Dermal	0.E+00	2.E-05	0.E+00	5.E-05
	Total	0.E+00	3.E-04	0.E+00	1.E-03
	Overall Risk to Cranberry Worker	4.E-07	8.E-03	3.E-06	3.E-02
Current / Future - Youth					
Surface Water	Ingestion	8.E-08	7.E-05	1.E-06	2.E-03
	Inhalation	3.E-09	8.E-04	5.E-08	1.E-02
	Dermal	5.E-08	5.E-06	9.E-07	8.E-05
	Total	1.E-07	9.E-04	2.E-06	2.E-02
Sediment	Ingestion	0.E+00	3.E-04	0.E+00	1.E-02
	Dermal	0.E+00	3.E-05	0.E+00	2.E-03
	Total	0.E+00	3.E-04	0.E+00	1.E-02
	Overall Risk to Youth	1.E-07	1.E-03	2.E-06	3.E-02
Current / Future - Adult Wader					
Surface Water	Ingestion	6.E-08	4.E-05	3.E-06	1.E-03
	Inhalation	2.E-09	4.E-04	1.E-07	1.E-02
	Dermal	7.E-08	4.E-06	3.E-06	7.E-05
	Total	1.E-07	5.E-04	6.E-06	1.E-02
Sediment	Ingestion	0.E+00	8.E-05	0.E+00	3.E-03
	Dermal	0.E+00	1.E-05	0.E+00	3.E-04
	Total	0.E+00	9.E-05	0.E+00	3.E-03
Fish Ingestion	Ingestion	4.E-06	2.E-02	6.E-05	2.E-01
	Overall Risk to Adult Wader	4.E-06	2.E-02	6.E-05	2.E-01

CT = Central Tendency
RME = Reasonable Maximum Exposure

Table 2.6-28. Uptake/Biokinetic Lead Model
Massachusetts Military Reservation
FS-1 AOC

Environmental Media: Lead Concentration	Age Range		Model Output (Cutoff Level = 10 µg/dL)		
			G.Mean	% Above	% Below
Groundwater: Maximum 0.159 mg/L	0-6 years	Air, Diet = Default Soil = 114 mg/kg	12.9	66.92	33.08
Groundwater: Mean 0.0085 mg/L	0-6 years	Air, Diet = Default Soil = 31.47 mg/kg	4.2	0.035	96.95

Model inputs for groundwater are in µg/L.

Soil values are actual amounts detected in soil samples at MMR FS-1.

Table 2.6-29. Comparison of AOC FS-1 Surface Soil Contaminant Concentrations to Ecological Hazard Equivalent Concentrations (HECs) Massachusetts Military Reservation

Chemical	Maximum Surface Soil Conc. (mg/kg)	Back-ground Conc. (mg/kg)	Does Conc. Exceed Back-ground? (Y or N)	Is Frequency of Detection >5%? (a)	HEC Values from RAII Table F-2					Are Any HECs Exceeded? (Y or N)	Is Contam-inant a COC?	For Which Species are HECs Exceeded?	Reason for Exclusion/ Inclusion
					Mouse	Shrew	Fox	Sparrow	Cardinal				
Semivolatiles (mg/kg)													
Phenanthrene	1.50E-01	NA	NA	NA	5.68E+01	6.80E+00	8.39E+00	1.99E+00	7.47E+00	N	N	NA	< HEC
Anthracene	1.20E-02	NA	NA	NA	5.53E+03	6.78E+02	7.97E+04	1.98E+02	7.44E+02	N	N	NA	< HEC
Fluoranthene	1.80E-01	NA	NA	NA	8.67E+02	8.50E+01	1.70E+03	2.49E+01	1.05E+02	N	N	NA	< HEC
Pyrene	2.70E-01	NA	NA	NA	5.62E+02	5.10E+01	1.64E+04	1.49E+01	6.57E+01	N	N	NA	< HEC
Benzo(a)anthracene	1.30E-01	NA	NA	NA	7.67E+01	6.80E+00	3.03E+03	1.99E+00	8.86E+00	N	N	NA	< HEC
Chrysene	2.40E-01	NA	NA	NA	7.67E+01	6.80E+00	3.03E+03	1.99E+00	8.86E+00	N	N	NA	< HEC
Benzo(b)fluoranthene	3.70E-01	NA	NA	NA	7.73E+01	6.80E+00	3.83E+03	1.99E+00	8.90E+00	N	N	NA	< HEC
Benzo(k)fluoranthene	3.30E-01	NA	NA	NA	7.73E+01	6.80E+00	3.83E+03	1.99E+00	8.90E+00	N	N	NA	< HEC
Benzo(a)pyrene	1.90E-01	NA	NA	NA	7.13E+01	6.80E+00	6.37E+02	1.99E+00	8.52E+00	N	N	NA	< HEC
Indeno(1,2,3-cd)pyrene	1.30E-01	NA	NA	NA	7.75E+01	6.80E+00	4.58E+03	1.99E+00	8.91E+00	N	N	NA	< HEC
Benzo(g,h,i)perylene	1.50E-01	NA	NA	NA	7.75E+01	6.80E+00	4.58E+03	1.99E+00	8.91E+00	N	N	NA	< HEC
Acenaphthylene	5.40E-02	NA	NA	NA	4.14E+01	6.80E+00	5.85E+02	1.99E+00	6.09E+00	N	N	NA	< HEC
Pesticides/PCB													
alpha-BHC	2.30E-04	NA	NA	NA	1.02E+01	2.21E+00	3.50E+01	6.47E-01	1.63E+00	N	N	NA	< HEC
Aldrin	1.60E-04	NA	NA	NA	3.76E-01	3.40E-02	4.01E+00	9.96E-01	4.39E+00	N	N	NA	< HEC
Heptachlor epoxide	4.80E-04	NA	NA	NA	6.00E+01	5.44E+00	4.90E+02	1.59E+00	7.00E+00	N	N	NA	< HEC
Endosulfan I	7.40E-04	NA	NA	NA	5.07E+01	1.36E+01	6.54E+02	6.97E-01	1.49E+00	N	N	NA	< HEC
Dieldrin	1.30E-02	NA	NA	NA	4.40E-01	3.40E-01	5.40E+00	1.12E-01	4.63E-01	N	N	NA	< HEC
4,4'-DDE	2.10E-03	NA	NA	NA	1.28E+02	1.29E+01	1.29E+02	1.19E+00	4.95E+00	N	N	NA	< HEC
Endrin	1.70E-03	NA	NA	NA	1.14E+00	6.80E-01	1.53E+02	4.98E-02	2.20E-01	N	N	NA	< HEC
Endosulfan II	1.50E-03	NA	NA	NA	-	-	-	-	-	-	Y	All Species	No HEC
4,4'-DDD	3.00E-03	NA	NA	NA	9.35E+01	8.22E+00	3.58E+03	7.69E+00	3.44E+01	N	N	NA	< HEC
4,4'-DDT	5.00E-03	NA	NA	NA	7.58E+02	6.80E+00	7.10E+02	7.97E-01	3.52E+00	N	N	NA	< HEC
Methoxychlor	7.20E-04	NA	NA	NA	2.04E+02	2.04E+01	3.76E+03	3.98E+01	1.66E+02	N	N	NA	< HEC

Table 2.6-29 (continued)

Chemical	Maximum Surface Soil Conc. (mg/kg)	Back-ground Conc. (mg/kg)	Does Conc. Exceed Back-ground? (Y or N)	Is Frequency of Detection >5%? (a)	HEC Values from RAII Table F-2					Are Any HECs Exceeded? (Y or N)	Is Contam-inant a COC?	For Which Species are HECs Exceeded?	Reason for Exclusion/ Inclusion
					Mouse	Shrew	Fox	Sparrow	Cardinal				
Pesticides/PCB (cont'd)													
Endrin ketone	5.30E-04	NA	NA	NA	-	-	-	-	-	-	Y	All Species	No HEC
alpha-Chlordane	3.50E-04	NA	NA	NA	-	-	-	-	-	-	Y	All Species	No HEC
gamma-Chlordane	1.50E-04	NA	NA	NA	2.55E+00	2.28E-01	7.20E+01	2.79E-01	1.23E+00	N	N	NA	< HEC
Metals													
Aluminum	2.69E+03	8.93E+03	N	NA	2.64E+04	4.00E+04	3.17E+05	2.70E+08	3.35E+05	N	N	NA	< HEC
Antimony	6.30E-01	1.75E+01	N	NA	2.06E+01	1.75E+01	1.39E+02	1.34E+09	1.00E+01	N	N	NA	< HEC
Arsenic	1.20E+00	3.60E+00	N	NA	2.57E+01	3.12E-01	7.62E+02	7.55E+00	3.37E+01	Y	Y	Shrew	> HEC
Barium	6.48E+01	1.04E+01	Y	NA	1.39E+04	9.20E+03	7.30E+04	5.14E+07	1.05E+04	N	N	NA	< HEC
Chromium	7.40E+00	6.80E+00	Y	NA	7.28E+00	7.00E-01	1.85E+02	1.61E+02	7.12E+02	Y	Y	Mouse, Shrew	> HEC
Cobalt	1.00E+00	4.10E+00	N	NA	5.95E+02	3.33E+02	2.64E+03	1.18E+05	8.19E+02	N	N	NA	< HEC
Iron	3.74E+03	1.24E+04	N	NA	-	-	-	-	-	-	N	NA	Essential Nutrient
Lead	1.14E+02	1.25E+01	Y	NA	1.73E+02	3.67E+01	6.61E+04	5.04E+01	2.25E+02	Y	Y	Shrew, Sparrow	> HEC
Magnesium	4.04E+02	7.95E+02	N	NA	-	-	-	-	-	-	N	NA	Essential Nutrient
Manganese	9.10E+01	1.08E+02	N	NA	7.87E+02	1.67E+03	1.32E+04	2.08E+08	2.98E+02	N	N	NA	< HEC
Nickel	2.70E+00	5.20E+00	N	NA	2.72E+03	1.67E+04	1.32E+05	5.14E+07	9.55E+02	N	N	NA	< HEC
Potassium	1.76E+02	5.51E+02	N	NA	-	-	-	-	-	-	N	NA	Essential Nutrient
Sodium	2.72E+02	3.86E+02	N	NA	-	-	-	-	-	-	N	NA	Essential Nutrient
Vanadium	8.20E+00	1.52E+01	N	NA	2.75E+01	1.40E+01	1.11E+02	3.02E+07	8.03E+01	N	N	NA	< HEC
Zinc	7.60E+00	1.60E+01	N	NA	4.02E+01	5.13E+00	7.72E+03	1.27E+01	4.50E+01	Y	Y	Shrew	>HEC
Miscellaneous													
TOC (mg/g)	5.00E+01	NA	NA	NA	5.00E+01	-	-	-	-	NA	N	NA	< HEC

NA = Not Applicable

Source: HAZWRAP 1994

Box denotes COC.

(a) Data set contained less than 20 samples.

Table 2.6-30. Comparison of FS-1 Groundwater Plume Upwelling Surface Water Contamination Concentrations to Ecological Hazard Equivalent Concentrations (HECs), Massachusetts Military Reservation

COPC Unit - µg/L	Surface water Max conc. (µg/L)	Site-Specific Back-ground (µg/L)	Aquatic Bench-mark Value (a) (µg/L)	HEC Values from RAII Table F-4: Eastern Box Turtle (µg/L)	Rac-coon (µg/L)	Muskrat (µg/L)	Mallard (µg/L)	Heron (µg/L)	Osprey (µg/L)	Are HECs or Aquatic Bench-marks Exceeded? Y/N	Is Back-ground Exceeded ? Y/N	Contam-inant of Aquatic Ecological Concern? Y/N	For Which Species?	Rationale for Inclusion/ Exclusion
Volatile Organics														
1,2-Dibromoethane	1.43E+00	NA	3.40E+01	NE	NE	5.72E+03	4.07E+02	3.50E+02	1.68E+02	N	NA	Y	Turtle, Raccoon	No HEC
Chloroform	1.63E+00	NA	NE	NE	NE	2.80E+04	2.02E+03	6.79E+03	3.92E+03	N	NA	Y	Turtle, Raccoon	No HEC
Inorganics														
Aluminum	3.38E+02	8.76E+01	8.70E+01	NE	NE	1.75E+05	1.46E+04	9.23E+03	4.70E+03	Y	Y	Y	Aquatic, Turtle, Raccoon	> Benchmark , No HEC
Boron	7.10E+01	4.79E+01	NE	NE	NE	NE	NE	NE	NE	NA	Y	Y	Aquatic, Turtle, Raccoon, Heron, Osprey	No HEC
Barium	2.29E+01	1.52E+01	3.90E+00	NE	NE	1.27E+05	1.06E+04	4.09E+03	2.70E+03	Y	Y	Y	Aquatic, Turtle, Raccoon	>Benchmark, No HEC
Calcium	3.91E+03	7.61E+02	NA	NA	NA	NA	NA	NA	NA	N	N	N		essential nutrient
Cadmium	1.50E-01	7.70E-01	1.10E+00	NE	NE	9.22E+02	1.46E+03	4.90E+01	4.90E-01	N	N	Y	Turtle, Raccoon	No HEC
Chromium	7.00E-01	3.50E-01	1.00E+01	NE	NE	3.23E+02	2.07E+04	2.55E+02	1.05E+02	N	Y	Y	Turtle, Raccoon	No HEC
Copper	2.43E+00	1.38E+00	1.10E+01	NE	NE	3.87E+03	3.23E+02	7.48E-02	3.05E-02	Y	Y	Y	Turtle, Raccoon, Osprey, Heron	No HEC, >HEC
Iron	1.46E+03	3.61E+01	1.00E+03	NE	NE	NA	NA	NA	NA	Y	Y	Y	Aquatic, Turtle, Raccoon	>Benchmark, No HEC
Potassium	1.03E+03	5.93E+02	NA	NA	NA	NA	NA	NA	NA	NA	Y	N		essential nutrient
Magnesium	2.08E+03	9.00E+02	NA	NA	NA	NA	NA	NA	NA	NA	Y	N		essential nutrient
Manganese	4.76E+01	1.55E+01	8.00E+01	NE	NE	1.20E+04	1.00E+03	1.37E-02	5.60E-03	Y	N	Y	Turtle, Raccoon, Osprey, Heron	No HEC, >HEC
Sodium	7.82E+03	5.14E+03	NA	NA	NA	NA	NA	NA	NA	NA	Y	N		essential nutrient
Lead	2.02E+00	9.20E-01	2.50E+00	NA	NA	1.38E+00	4.54E+04	6.66E+01	2.72E+01	N	N	Y	Muskrat,Turtle, Raccoon	No HEC, > HEC

Notes:

(a) All values obtained from USEPA Ecotox model 1996 with the exception of aluminum. Values for aluminum are from federal Ambient Water Quality Criteria (AWQC) and Guidelines (USEPA, 1992). Aluminum is pH dependent criterion: a pH of 7.8 was assumed. Cadmium, copper, lead, nickel, and zinc assumed water hardness value of 100 mg CaCO3/L and used AWQC hardness equation to derive the benchmark value.

HI - Hazard Index

NA - Not Available

NE - Not Evaluated. Compound detected in surface water, but could not be evaluated in terms of potential adverse impacts to aquatic receptors because no value for the compound is presented in Table O-2 of MMR Handbook. Calcium, sodium, potassium, and magnesium were not evaluated because they are nutritional requirements and have low toxicity.

ND - Not detected/not determined

Table 2.6-31. Comparison of FS-1 Groundwater Plume Upwelling Sediment Contamination Concentrations to Ecological Hazard Equivalent Concentrations (HECs)

Massachusetts Military Reservation

COPC Unit - µ/L	Sediment Max conc. (mg/kg)	Site-Specific Background	Sediment Bench-mark Value (a) (mg/kg)	HEC Values from RAH Table F-5: Eastern Box Turtle (mg/kg)	Raccoon (mg/kg)	Muskrat (mg/kg)	Mallard (mg/kg)	Heron (mg/kg)	Are HEC or Sediment Benchmark exceeded? Y/N	Is Back-ground Exceeded? Y/N	Contam-inant of Aquatic Ecological Concern? Y/N	For Which Species?	Rationale for Inclusion/Exclusion
Volatile Organics													
1,2-Dibromoethane	1.70E-05	NA	3.00E-02	NE	NE	5.72E+03	4.07E+02	3.50E+02	N	NA	Y	Turtle, Raccoon	No HEC
Inorganics													
Aluminum	1.20E+03	1.78E+03	NA	NE	NE	1.71E+04	2.85E+03	3.07E+03	N	N	Y	Turtle, Raccoon	No HEC
Arsenic	1.18E+00	7.37E-01	8.20E+00	NE	NE	2.49E+01	8.27E+01	1.12E+01	N	Y	Y	Turtle, Raccoon	No HEC
Barium	3.78E+00	1.93E+00	NE	NE	NE	2.63E+03	4.21E+02	7.07E+02	N	Y	Y	Turtle, Raccoon	No HEC
Beryllium	5.10E-01	8.30E-02	NA	NE	NE	2.42E+04	4.00E+03	1.59E+03	N	Y	Y	Turtle, Raccoon	No HEC
Calcium	5.00E+02	2.87E+02	NA	NE	NE	NA	NA	NA	N	Y	N		essential nutrient
Chromium	4.74E+00	2.79E+00	8.10E+01	NE	NE	6.71E+00	1.27E+03	2.07E+02	N	Y	Y	Turtle, Raccoon	No HEC
Cobalt	5.90E+00	3.18E+00	NA	NE	NE	3.19E+02	5.25E+01	2.56E+01	N	Y	Y	Turtle, Raccoon	No HEC
Copper	4.14E+00	6.69E-01	3.40E+01	NE	NE	3.40E+01	5.43E+00	4.51E+01	N	Y	Y	Turtle, Raccoon	No HEC
Iron	2.09E+03	4.25E+03	NA	NE	NE	NA	NA	NA	N	N	N		essential nutrient
Lead	8.90E+00	2.25E+00	4.70E+01	NE	NE	4.95E-03	5.30E+02	7.43E+01	N	Y	Y	Muskrat, Turtle, Raccoon	>HEC, No HEC
Magnesium	1.96E+02	6.83E+02	NA	NE	NE	NA	NA	NA	NA	N	N		essential nutrient
Manganese	2.14E+01	4.55E+01	NA	NE	NE	1.61E+02	2.57E+01	1.28E+02	N	N	Y	Turtle, Raccoon	No HEC
Nickel	4.91E-01	2.30E+00	2.10E+01	NE	NE	1.85E+03	3.00E+02	1.28E+03	N	N	Y	Turtle, Raccoon	No HEC
Potassium	1.39E+02	5.36E+01	NA	NE	NE	NA	NA	NA	NA	Y	N		essential nutrient
Selenium	5.90E-01	4.19E-01	NA	NE	NE	9.95E+00	1.63E+00	8.71E-01	N	Y	Y	Turtle, Raccoon	No HEC
Sodium	2.57E+02	1.19E+02	NA	NE	NE	NA	NA	NA	NA	Y	N		essential nutrient
Vanadium	4.11E+00	6.49E+00	NA	NE	NE	1.82E+01	3.03E+00	1.08E+00	Y	N	Y	Turtle, Raccoon, Mallard, Heron	>HEC
Zinc	4.09E+00	4.82E+00	1.50E+02	NE	NE	2.65E+01	4.41E+01	1.88E+01	N	N	Y	Turtle, Raccoon	No HEC

Notes:

(a) All values obtained from USEPA Ecotox model 1996
ND - Not detected/not determined
NA - Not Available
NE - Not Evaluated. Compound detected in surface water, but could not be evaluated in terms of potential adverse impacts to aquatic receptors because no value for the compound is presented in Table O-2 of MMR Handbook. Calcium, sodium, potassium, and magnesium were not evaluated because they are nutritional requirements and have low toxicity.

Table 2.6-32. Selection of Potential Ecological Exposure Pathways - Terrestrial
Massachusetts Military Reservation
FS-1 AOC

CONTAMINATED MEDIA TRANSPORT MEDIA	EXPOSURE TYPE	EXPOSURE ROUTE	RECEPTOR GROUPS
Soil	Direct	Absorption	Plants, Fossorial Organisms, and Ground-Nesting Birds
Soil	Direct	Ingestion	Terrestrial Invertebrates and Ground-Foraging Vertebrates
Soil	Indirect	Food Chain	Terrestrial Predators, Terrestrial Vertebrates
Soil: Fugitive Dust, Volatilized Organics	Direct	Inhalation	Surface-Dwelling, Terrestrial Vertebrates

Notes:

[a] From RAH, Table 3-7 (ASG 1994).

Table 2.6-33. Selection of Potential Ecological Exposure Pathways - Aquatic/Semiaquatic
Massachusetts Military Reservation
FS-1 Groundwater Plume and Upwelling Area

CONTAMINATED MEDIA TRANSPORT MEDIA	EXPOSURE TYPE	EXPOSURE ROUTE	RECEPTOR GROUPS
Surface Water	Direct	Absorption	Aquatic Invertebrates, Vertebrates, and Plants
Surface Water	Direct	Ingestion	Mammals, Birds, and Reptiles
Surface Water	Indirect	Food Chain	Terrestrial Piscivores and Aquatic Predators
Surface Water	Direct	Inhalation	Aquatic Mammals and Birds
Sediment	Direct	Absorption	Benthos and Bottom Dwelling Invertebrates and Vertebrates
Sediment	Direct	Ingestion	Bottom Feeding Vertebrates, Invertebrates, Benthos and Birds
Sediment	Indirect	Food Chain	Aquatic Predators

Source:
From RAH, Table 3-7 (HAZWRAP 1994)

Table 2.6-34. Data Summary of Potential Ecological COCs - Surface Soil (0-2 ft)
Massachusetts Military Reservation
Fuel Spill 1

Chemical	Mean	Frequency of Detection	Maximum	Minimum	Background
Semivolatiles (µg/kg)					
Acenaphthylene*	54.00	2 of 6	54.00	50.00	NA
Anthracene*	12.00	1 of 6	12.00	12.00	NA
Benzo(a)anthracene	107.50	4 of 6	130.00	52.00	NA
Benzo(b)fluoranthene	221.67	4 of 6	370.00	110.00	NA
Benzo(k)fluoranthene	205.00	4 of 6	330.00	100.00	NA
Benzo(g,h,i)perylene	143.58	2 of 6	150.00	44.00	NA
Benzo(a)pyrene	136.50	4 of 6	190.00	59.00	NA
Chrysene	163.67	3 of 6	240.00	72.00	NA
Fluoranthene	143.33	4 of 6	180.00	75.00	NA
Indeno(1,2,3-cd)pyrene	128.42	3 of 6	130.00	49.00	NA
Phenanthrene	117.83	4 of 6	150.00	56.00	NA
Pyrene	191.67	4 of 6	270.00	110.00	NA
Pesticides (µg/kg)					
Aldrin*	0.16	1 of 6	0.16	0.16	NA
alpha-BHC*	0.23	1 of 6	0.23	0.23	NA
alpha-Chlordane*	0.35	4 of 6	0.35	0.16	NA
4,4'-DDE*	2.10	3 of 6	2.10	0.24	NA
4,4'-DDD	2.93	1 of 6	3.00	3.00	NA
4,4'-DDT	3.17	4 of 6	5.00	0.24	NA
Dieldrin	4.39	5 of 6	13.00	0.22	NA
Endosulfan I*	0.74	3 of 6	0.74	0.59	NA
Endosufan II*	1.50	4 of 6	1.50	0.97	NA
Endrin*	1.70	4 of 6	1.70	0.47	NA
Endrin ketone*	0.53	2 of 6	0.53	0.34	NA
gamma-Chlordane*	0.15	1 of 6	0.15	0.15	NA
Heptachlor epoxide*	0.48	3 of 6	0.48	0.15	NA
Methoxychlor*	0.72	1 of 6	0.72	0.72	NA

Table 2.6-34 (continued)

Chemical	Mean	Frequency of Detection	Maximum	Minimum	Background
Metals (mg/kg)					
Aluminum	1510.50	6 of 6	2690.00	911.00	8930.00
Antimony*	0.63	1 of 6	0.63	0.39	17.50
Arsenic	1.20	3 of 6	1.20	0.67	3.60
Barium	18.12	5 of 6	64.80	2.70	10.40
Chromium	3.31	6 of 6	7.40	1.80	6.80
Cobalt*	1.00	5 of 6	1.00	0.69	4.10
Iron	2579.17	6 of 6	3740.00	1600.00	12400.00
Lead	31.47	6 of 6	114.00	1.30	12.50
Magnesium	340.50	5 of 6	404.00	225.00	794.50
Manganese	37.02	6 of 6	91.00	23.60	108.00
Nickel	2.26	5 of 6	2.70	1.40	5.20
Potassium*	176.00	5 of 6	176.00	86.30	551.00
Sodium*	272.00	5 of 6	272.00	235.00	386.00
Vanadium	4.79	5 of 6	8.20	2.90	15.20
Zinc*	7.60	1 of 6	7.60	7.10	16.00
Miscellaneous					
Total Organic Carbon	50.00	3 of 3	50.00	50.00	NA

NA = Not Applicable

* The calculated mean value exceeds the maximum value, therefore, the mean value listed is equal to the maximum detected value.

Table 2.6-35. Exposure Parameters for Terrestrial Receptors
Massachusetts Military Reservation, FS-1 AOC

Species	Parameter	Value	Units	Source
White-footed Mouse	Home range factor	0.5	unitless	Site specific
		0.80		
	Diet: plants, invertebrates	0.17		USEPA, 1993
	Feeding rate	4.2	g/d	USEPA, 1993
	Water ingestion rate	0.035	L/day	USEPA, 1993
	Sediment ingestion rate	0.03		USEPA, 1993
	Body Weight	25	g	USEPA, 1993
	Exposure Duration	12	months	USEPA, 1993
Short-tailed Shrew	Home range factor	0.5	unitless	Site specific
		0.80		
	Diet: plants invertebrate	0.17		USEPA, 1993
	Feeding rate	7.95	g/d	USEPA, 1993
	Water ingestion rate	0.035	L/day	USEPA, 1993
	Sediment ingestion rate	0.03		USEPA, 1993
	Body Weight	0.25	kg	USEPA, 1993
	Exposure Duration	12	months	USEPA, 1993
Grasshopper Sparrow	Home range factor	0.5	unitless	Site specific
	Diet: invertebrate	1		HAZWRAP, 1994
	Feeding rate	3.6	g/d	HAZWRAP, 1994
	Water ingestion rate	0.036	L/day	HAZWRAP, 1994
	Sediment ingestion rate	0		HAZWRAP, 1994
	Body Weight	0.014	kg	HAZWRAP, 1994
	Exposure Duration	12	months	HAZWRAP, 1994

g = grams
d = day
L = liters
kg = kilograms

Table 2.6-36. Exposure Parameters for Semiaquatic Receptors
Massachusetts Military Reservation, FS-1 Groundwater Plume Upwelling Area

Species	Parameter	Value	Units	Source
Eastern Box Turtle	Home range factor	1	unitless	USEPA, 1993
		0.85		
	Diet: plants invertebrate	0.12	%	USEPA, 1993
	Feeding rate	4.32	g/d	USEPA, 1993
	Water ingestion rate	0.0022	L/day	USEPA, 1993
	Sediment ingestion rate	0.03	%	USEPA, 1993
	Body Weight	0.3	kg	USEPA, 1993
	Exposure Duration	7	months	USEPA, 1993
Raccoon	Home range factor	0.004	unitless	Site Specific
		0.85		
	Diet: plants invertebrate	0.12	%	USEPA, 1993
	Feeding rate	673.5	g/d	USEPA, 1993
	Water ingestion rate	0.369	L/day	USEPA, 1993
	Sediment ingestion rate	0.03	%	USEPA, 1993
	Body Weight	9	kg	USEPA, 1993
	Exposure Duration	8	months	USEPA, 1993
Muskrat	Home range factor	1	unitless	Site Specific
		0.85		
	Diet: plants invertebrate	0.12	%	USEPA, 1993
	Feeding rate	425	g/d	USEPA, 1993
	Water ingestion rate	0.109	L/day	USEPA, 1993
	Sediment ingestion rate	0.03	%	USEPA, 1993
	Body Weight	1.3	kg	USEPA, 1993
	Exposure Duration	12	months	USEPA, 1993
Mallard Duck	Home range factor	0.017	unitless	Site Specific
		0.90		
	Diet: plants invertebrate	0.07	%	USEPA, 1993
	Feeding rate	199	g/d	USEPA, 1993
	Water ingestion rate	0.13	L/day	USEPA, 1993
	Sediment ingestion rate	0.03	%	USEPA, 1993
	Body Weight	1.225	kg	USEPA, 1993
	Exposure Duration	12	months	USEPA, 1993

Table 2.6-36. Exposure Parameters for Semiaquatic Receptors
Massachusetts Military Reservation, FS-1 Groundwater Plume Upwelling Area

Species	Parameter	Value	Units	Source
Black-crowned Night Heron	Home range factor	0.36	unitless	Site Specific
		0.4*		
	Diet: fish invertebrate	0.17	%	USEPA, 1993
	Feeding rate	6.6	g/d	USEPA, 1993
	Water ingestion rate	0.066	L/day	USEPA, 1993
	Sediment ingestion rate	0.03	%	USEPA, 1993
	Body Weight	1.014	kg	USEPA, 1993
	Exposure Duration	9	months	USEPA, 1993
Osprey	Home range factor	0.4	unitless	Site Specific
	Diet: fish	100	%	USEPA, 1993
	Feeding rate	80	g/d	USEPA, 1993
	Water ingestion rate	NA	L/day	USEPA, 1993
	Sediment ingestion rate	NA	%	USEPA; 1993
	Body Weight	1.586	kg	USEPA, 1993
	Exposure Duration	6	months	USEPA, 1993

* assumes only half of the fish diet comes from groundwater plume upwelling area.

g = grams
d = day
L = liters
kg = kilograms

Table 2.6-37 Chemical-Specific Parameters for Constituents of Potential Concern

Constituent	Permeability Constants (cm/hr)	Dermal Absorption Factor (unitless)	Soil -Plant Uptake Factor	BAF_{fish} (L/kg)	$BAF_{invertebrate}$
Volatile Organics					
1,2-Dichloroethane	4.30e-03	-	6.58e+00	7.00e+00	3.10e-01
4-Methyl-2-pentanone	3.30e-03	-	9.80e+00	-	3.10e-01
Chloroform	6.90e-03	-	3.38e+00	6.00e+00	3.10e-01
Chloromethane	4.20e-03	-	1.15e+01	4.00e+00	3.10e-01
1,2-Dibromoethane (EDB)	3.30e-03	-	-	1.00e+01	-
Tetrachloroethene	3.30e-03	-	1.52e+00	4.40e+01	3.10e-01
Toluene	4.50e-02	-	1.33e+00	-	3.10e-01
Pesticides/PCBs					
Alpha chlordane	-	-	1.90e-02	1.40e+06	-
Endosulfan II	-	-	3.20e-02	-	-
Endrin Ketone	-	-	1.80e-02	2.60e+03	-
Inorganics					
Aluminum	1.00e-03	1.00e-02	3.20e-03	1.00e+01	4.30e-02
Arsenic	1.00e-03	3.00e-02	3.80e-02	2.80e+02	2.40e-01
Barium	1.00e-03	1.00e-02	2.10e-01	4.00e+00	9.10e-02
Beryllium	1.00e-03	-	1.00e-02	2.00e+00	4.50e-02
Boron	1.00e-03	-	5.00e+00	2.20e-01	-
Cadmium	1.00e-03	-	5.90e-01	5.00e+01	1.40e+01
Chromium	1.00e-03	-	6.50e-02	2.00e+02	3.00e-01
Cobalt	1.00e-03	-	1.20e-02	3.00e+02	1.20e-01
Copper	1.00e-03	-	1.20e-01	2.10e+02	5.20e-01
Iron	1.00e-03	-	7.60e-03	1.00e+02	3.60e-02
Lead	1.00e-03	-	3.90e-02	3.00e+02	2.70e-01
Manganese	1.00e-03	-	1.10e-01	4.00e+02	5.40e-02
Nickel	1.00e-03	-	1.80e-02	1.00e+02	1.06e+00
Selenium	1.00e-03	-	6.70e-01	8.00e+00	1.70e+00
Silver	1.00e-03	-	1.60e-02	2.00e+00	2.04e+00

Table 2.6-37 Continued

Constituent	Permeability Constants (cm/hr)	Dermal Absorption Factor (unitless)	Soil -Plant Uptake Factor	BAF_{fish} (L/kg)	$BAF_{invertebrate}$
Thallium	1.00e-03	-	4.00e-03	1.00e+04	-
Vanadium	1.00e-03	-	5.00e-03	1.00e-02	4.20e-02
Zinc	1.00e-03	-	3.70e-01	1.00e+03	3.80e+00

Table 2.6-38. Adjusted Benchmarks for Terrestrial Ecological Receptors - Avian

Compounds	Test Species	Test Species NOAEL[a] (mg/kg-d)	Endpoint Assessed	Reference Study	Adjusted Benchmarks (mg/kg-d)[b] Grasshopper Sparrow
Pesticides/PCBS					
Endosulfan II	gray partridge	10 a	reproduction	Abiola 1992	10
Endrin ketone	mallard duck	0.3 a	reproduction	Spann et al. 1986	0.3
alpha-Chlordane	redwinged blackbird	2.1 a	mortality	Stickel et al. 1983	2.1
Inorganics					
Arsenic	brown head cowbird	2.5 a	mortality	USFWS 1969	2.5
Chromium	black duck	1 a	reproduction	Haseltine et al. unpublished data	1
Lead	American kestrel	3.85 a	reproduction	Edens et al. 1976	3.85
Zinc	white leghorn hen	14.5 a	reproduction	Stahl et al. 1990	14.5

a NOAELs are taken from Suter et al. 1996.
b Benchmarks are adjusted using equations and methods in Suter et al. 1996.
NOAEL = No observable adverse effect level
mg = milligrams
kg = kilograms
d = day

Table 2.6-39. Adjusted Benchmarks for Terrestrial Ecological Receptors - Mammals and Reptiles

Compounds	Test Species	Test Species NOAEL (mg/kg-d)		Test Species Body Wt (kg)	Endpoint Assessed	Reference Study	Target Species BW (kg)		Adjusted Benchmark (mg/kg-d)[b]	
							White-footed mouse	Northern Short-tailed Shrew	White-footed mouse	Northern Shorttailed Shrew
Pesticides/PCBs										
Endosulfan II	rat	0.15	a	0.35	reproduction, blood chemistry	Dikshith et al. 1984	0.025	0.025	3.58E-01	3.58E-01
Endrin ketone	mouse	0.092	a	0.03	reproduction	Good and Ware 1969	0.025	0.025	9.77E-02	9.77E-02
alpha-Chlordane	mouse	4.6	a	0.03	reproduction	WHO 1984	0.025	0.025	4.89E+00	4.89E+00
Inorganics										
Arsenic	mouse	0.126	a	0.03	reproduction	Schroeder and Mitchner 1971	0.025	0.025	1.34E-01	1.34E-01
Chromium	rat	2737	a	0.35	body weight, food consumption	Mackenzie et al. 1958	0.025	0.025	6.54E+03	6.54E+03
Lead	rat	8	a	0.35	reproduction	Azar et al. 1973	0.025	0.025	1.91E+01	1.91E+01
Zinc	rat	160	a	0.35	reproduction	Schlicker and Cox 1968	0.025	0.025	3.82E+02	3.82E+02

a NOAELs are taken from Suter et al. 1998
b Benchmarks are adjusted using equations and methods in Suter et al. 1998.

NOAEL = No observable adverse effect level
mg = milligrams
kg = kilograms
d = day

Table 2.6-40. Adjusted Benchmarks for Semiaquatic Ecological Receptors - Avian

Compounds	Test Species	Test Species NOAEL (mg/kg-d)	Endpoint Assessed	Reference Study	Adjusted Benchmarks (mg/kg-d)[c]		
					Mallard Duck	Night Heron	Osprey
Volatiles							
Chloroform	rat	15 a	reproduction	Thompson et al. 1974	15	15	15
EDB	rat	30 a	reproduction	Teramoto et al. 1980	30	30	30
Inorganics							
Aluminum	ringed dove	109.7 b	reproduction	Carriere et al. 1986	109.7	109.7	109.7
Arsenic	brown head cowbir	2.5 b	mortality	USFWS 1969	2.5	2.5	2.5
Barium	1-day-old chick	20.8 b	mortality	Johnson et al. 1960	20.8	20.8	20.8
Beryllium	rat	0.66 b	longevity, weight loss	Schroeder and Mitchner 1975	0.66	0.66	0.66
Boron	mallard duck	28.8 b	reproduction	Smith and Anders 1989	28.8	28.8	28.8
Cadmium	mallard duck	1.45 b	reproduction	White and Finley 1978	1.45	1.45	1.45
Chromium	black duck	1 b	reproduction	Haseltine et al., unpublished data	1	1	1
Cobalt	rat	5 a	reproduction	Nation et al. 1983	5	5	5
Copper	1-day-old-chick	47 b	mortality	Mehring et al. 1960	47	47	47
Iron							
Lead	American kestrel	3.85 b	reproduction	Edens et al. 1976	3.85	3.85	3.85
Manganese	Japanese quail	997 b	growth, aggressive behavior	Laskey and Edens 1985	997	997	997
Nickel	mallard duck	77.4 b	mortality, growth, behavior	Cain and Pafford 1981	77.4	77.4	77.4
Vanadium	mallard duck	11.4 b	mortality, body weight, blood chemistry	White and Dieter 1978	11.4	11.4	11.4
Zinc	white leghorn hen	14.5 b	reproduction	Stahl et al. 1990	14.5	14.5	14.5

a NOAELs are taken from Massachusetts Military Reservation Risk Assessment Handbook 1994

b NOAELs are taken from Suter et al. 1996.

c Benchmarks are adjusted using equations and methods in Suter et al. 1996.

NOAEL = No observable adverse effect level

mg = milligrams

kg = kilograms

d = day

Table 2.6-41. Adjusted Benchmarks for Semiaquatic Ecological Receptors - Mammals and Reptiles

Compounds	Test Species	Test Species NOAEL (mg/kg-d)	Test Species Body Wt (kg)	Endpoint Assessed	Reference Study	Target Species BW (kg)			Adjusted Benchmark (mg/kg-d)[c]		
						Muskrat	Raccoon	Turtle	Muskrat	Raccoon	Turtle
Volatiles											
Chloroform	rat	15 a	0.35	reproduction	Thompson et al. 1974	1.25	9	0.3	9.85E+00	5.14E+00	1.58E+01
EDB	rat	30 a	0.35	reproduction	Teramoto et al. 1980	1.25	9	0.3	1.97E+01	1.03E+01	3.16E+01
Inorganics											
Aluminum	mouse	1.93 b	0.03	reproduction	Ondreicka et al. 1966	1.25	9	0.3	5.64E-01	2.94E-01	9.03E-01
Arsenic	mouse	0.126 b	0.03	reproduction	Schroeder and Mitchner 1971	1.25	9	0.3	3.68E-02	1.92E-02	5.89E-02
Barium	rat	5.1 b	0.35	growth, hypertension	Perry et al. 1983	1.25	9	0.3	3.35E+00	1.75E+00	5.37E+00
Beryllium	rat	0.66 b	0.35	longevity, weight loss	Schroeder and Mitchner 1975	1.25	9	0.3	4.34E-01	2.26E-01	6.94E-01
Boron	rat	28 b	0.35	reproduction	Weir and Fisher 1972	1.25	9	0.3	1.84E+01	9.59E+00	2.95E+01
Cadmium	rat	1 b	0.35	reproduction	Sutou et al. 1980b	1.25	9	0.3	6.57E-01	3.42E-01	1.05E+00
Chromium	rat	2737 b	0.35	body weight, food consumption	Mackenzie et al. 1958	1.25	9	0.3	1.80E+03	9.37E+02	2.88E+03
Cobalt	rat	5 a	0.35	reproduction	Nation et al. 1983	1.25	9	0.3	3.28E+00	1.71E+00	5.26E+00
Copper	mink	11.7 b	1	reproduction	Aulerich et al. 1982	1.25	9	0.3	1.09E+01	5.67E+00	1.74E+01
Iron											
Lead	rat	8 b	0.35	reproduction	Azar et al. 1973	1.25	9	0.3	5.26E+00	2.74E+00	8.42E+00
Manganese	rat	88 b	0.35	reproduction	Laskey et al. 1982	1.25	9	0.3	5.78E+01	3.01E+01	9.26E+01
Nickel	rat	5 b	0.35	reproduction	Ambrose et al. 1976	1.25	9	0.3	3.28E+00	1.71E+00	5.26E+00
Vanadium	rat	0.21 b	0.35	reproduction	Domingo et al. 1986	1.25	9	0.3	1.38E-01	7.19E-02	2.21E-01
Zinc	rat	160 b	0.35	reproduction	Schlicker and Cox 1968	1.25	9	0.3	1.05E+02	5.48E+01	1.68E+02

a NOAELs are taken from Massachusetts Military Reservation Risk Assessment Handbook 1994

b NOAELs are taken from Suter et al. 1998

c Benchmarks are adjusted using equations and methods in Suter et al 1998.

NOAEL = No observable adverse effect level

mg = milligrams

kg = kilograms

d = day

Table 2.6-42. Summary of Ecological Risk for AOC FS-1 and the Groundwater Plume Upwelling Area

Receptor	Media	Maximum Hazard Index	Mean Hazard Index
AOC - Terrestrial			
White-footed Mouse	surface soil	0.001	0.003
Northern Short-tailed Shrew	surface soil	0.08	0.05
Red fox	surface soil	NA	NA
Grasshopper Sparrow	surface soil	1	0.3
Cardinal	surface soil	NA	NA
Downgradient Impact Area Semiaquatic			
Bull Frog[a]	surface water/sediment	2	1
Eastern box turtle	surface water/sediment	0.8	0.5
Brook Trout[a]	surface water/sediment	2	1
Muskrat	surface water/sediment	0.037	0.016
Raccoon	surface water/sediment	0.09	0.06
Mallard	surface water/sediment	NA	NA
Black-crowned night heron	surface water/sediment	0.02	0.01
Osprey[b]	surface water	0.8	0.3

a - Bull Frog and trout risks are calculated by comparing appropriate surface water and sediment benchmarks to site surface water and sediment concentrations, respectively.

b - Calculations for Osprey risk consider surface water exposure through fish ingestion only.

NA - not applicable. During screening, no HECs were exceeded and no COPC were identified for this receptor.

Table 2.6-43. Estimation of Phytotoxicity Risk
Surface Soils (0-2 ft bgs)
Massachusetts Military Reservation
Fuel Spill 1

Chemicals [a] (mg/kg)	Frequency of Detection	Maximum Conc. (mg/kg)	Exposure Point Mean [b] (mg/kg)	Phytotoxicity Benchmark Value [c] (mg/kg)	Maximum Hazard Quotient [d]	Mean Hazard Quotient [d]
PESTICIDES/PCBs						
Endosulfan II	4 of 6	0.0015	0.0015	N/A	--	--
Endrin Ketone	2 of 6	0.00053	0.00053	N/A	--	--
alpha-Chlordane [e]	4 of 6	0.00035	0.00035	38.95	0.00	0.00
METALS						
Arsenic	3 of 6	1.2	1.2	20	0.06	0.06
Chromium	6 of 6	7.4	3.31	75	0.10	0.04
Iron	6 of 6	3740	2579.2	N/A	--	--
Lead	6 of 6	114	31.47	100	1.14	0.32
Zinc	1 of 6	7.6	7.6	70	0.11	0.11
			HAZARD INDEX [f]		1.41	0.53

Notes:

[a] Chemicals in COCs, as selected in Table 6.1.

[b] Lesser of maximum detected concentration and mean concentration.

[c] Phytotoxicity critical soil concentration (RAH Appendix O, Tables O-3, lower end of range for inorganics).

[d] Hazard Quotient = concentration divided by benchmark.

[e] Phytotoxicity critical soil concentration for Chlordane used.

[f] Hazard Index = sum of HQs.

-- = Not applicable
HQ = Hazard quotient
NA = No phytotoxicity data available
SVOC = Semivolatile organic compound
COC = Contaminant of concern
RAH = Risk Assessment Handbook

Table 2.6-44
Aquatic Risk Characterization
Sediment
at
FS-1 Groundwater Plume Upwelling Area
Massachusetts Military Reservation

	Background Range (mg/kg)	Sediment Concentration Maximum (mg/kg)	Sediment Concentration Mean (mg/kg)	Sediment Ecotox Thresholds (a) (mg/kg)	Maximum HQ	Mean HQ
Volatile Organics						
1,2-Dibromoethane	--	7.50E-05	1.70E-05	0.03 c	2.5E-03	5.7E-04
Inorganics					--	--
Aluminum	1198 - 1778	1.20E+03	8.23E+02	--	--	--
Arsenic	0.43 - 6.2	1.18E+00	9.81E-01	8.2 b	1.4E-01	1.2E-01
Barium	1.9 - 5.9	3.78E+00	3.19E+00	--	--	--
Beryllium	0.083 - 0.2	5.10E-01	1.38E-01	--	--	--
Calcium	173 - 287	5.00E+02	1.87E+02	NA	--	--
Chromium	1.2 - 3.1	4.74E+00	2.23E+00	81	5.9E-02	2.8E-02
Cobalt	1.2 - 2.8	5.90E+00	2.83E+00	--	--	--
Copper	0.67 - 4.2	4.14E+00	1.34E+00	34 b	1.2E-01	3.9E-02
Iron	1520 - 6155	2.09E+03	1.67E+03	--	--	--
Lead	2.2 - 9.6	8.90E+00	3.88E+00	47 b	1.9E-01	8.3E-02
Magnesium	306 - 683	1.96E+02	1.55E+00	--	--	--
Manganese	15 - 46	2.14E+01	1.33E+01	--	--	--
Nickel	0.6 - 2	4.91E-01	4.13E-01	21 b	2.3E-02	2.0E-02
Potassium	--	1.39E+02	6.75E+01	NA	--	--
Selenium	0.32 - 1.4	5.90E-01	5.08E-01	--	--	--
Sodium	119 - 196	2.57E+02	1.18E+02	NA	--	--
Vanadium	3.1 - 6.5	4.11E+00	2.91E+00	--	--	--
Zinc	4.8 - 9.9	4.09E+00	3.00E+00	150 b	2.7E-02	2.0E-02
				HI =	5.6E-01	3.1E-01

(a) All values are sediment quality benchmarks (SQBs) by equilibrium partitioning obtained from EcoTox Update (EPA-540/F-95/038 January 1996). Arsenic, chromium, and mercury values are for all chemical forms.
(b) Effects Range Low (USEPA 1996)
(c) ORNL EDB Benchmark Study, 1998
NA = Not available
-- = Not evaluated

Table 2.6-45
Fish and Amphibian Risk Characterization for Surface Water
at
FS-1 Groundwater Plume Upwelling Area
Massachusetts Military Reservation

COC	Background Range (µg/L)	Surface Water Concentration Maximum (µg/L)	Surface Water Concentration Mean (µg/L)	Surface Water Conventional Benchmarks (a) (µg/L)	HQ Maximum	HQ Mean
Volatile Organics						
1,2-Dibromoethane	--	1.43E+00	1.41E-01	3.40E+01 b	4.21E-02	4.15E-03
Chloroform	--	1.63E+00	3.90E-01	--	--	--
Inorganics						
Aluminum	37- 49	3.38E+02	1.26E+02	3.29E+03	1.0E-01	3.83E-02
Boron	52	7.10E+01	3.78E+01	--	--	--
Barium	9 - 15.3	2.30E+01	1.24E+01	8.92E+02	2.6E-02	1.39E-02
Calcium	774 - 2829	3.91E+03	2.72E+03		--	--
Cadmium	--	1.50E-01	1.50E-01	1.70E+00	8.8E-02	8.82E-02
Chromium	0.9	7.00E-01	4.67E-01	6.90E+01	1.0E-02	6.77E-03
Copper	1.36 - 2.1	2.43E+00	1.45E+00	3.80E+00	6.4E-01	3.82E-01
Iron	41 - 396	1.46E+03	5.53E+02	1.30E+03	1.1E+00	4.25E-01
Potassium	780 - 901	1.63E+03	8.33E+02	NA	--	--
Magnesium	15.5 - 115	2.08E+03	1.60E+03	NA	--	--
Manganese	3.4	4.76E+01	1.73E+01	1.77E+03	2.7E-02	9.77E-03
Sodium	5090 - 9760	7.82E+03	6.70E+03	NA	--	--
Lead	1.9 - 3.4	2.02E+00	8.78E-01	1.90E+01	1.1E-01	4.62E-02
				HI=	2	1

(a) All values are from Suter and Mabrey, 1994, unless otherwise noted.
(b) ORNL EDB Benchmark Study 1998.
NA = Not applicable
-- = Not Evaluated

Table 2.6-46
Fish and Amphibian Risk Characterization for Sediment at FS-1 Groundwater Upwelling Area Massachusetts Military Reservation

	Background Range (mg/kg)	Sediment Concentration Maximum (mg/kg)	Sediment Concentration Mean (mg/kg)	Sediment Benchmarks Thresholds (a) (mg/kg)	Maximum HQ	Mean HQ
Volatile Organics						
1,2-Dibromoethane	--	7.50E-05	1.70E-05	0.03 d	2.5E-03	5.7E-04
Inorganics						
Aluminum	1198 - 1778	1.20E+03	8.23E+02	73160 b	1.6E-02	1.1E-02
Arsenic	0.43 - 6.2	1.18E+00	9.81E-01	8.2 c	1.4E-01	1.2E-01
Barium	1.9 - 5.9	3.78E+00	3.19E+00	--	--	--
Beryllium	0.083 - 0.2	5.10E-01	1.38E-01	--	--	--
Calcium	173 - 287	5.00E+02	1.87E+02	NA	--	--
Chromium	1.2 - 3.1	4.74E+00	2.23E+00	81	5.9E-02	2.8E-02
Cobalt	1.2 - 2.8	5.90E+00	2.83E+00	--	--	--
Copper	0.67 - 4.2	4.14E+00	1.34E+00	34 c	1.2E-01	3.9E-02
Iron	1520 - 6155	2.09E+03	1.67E+03	--	--	--
Lead	2.2 - 9.6	8.90E+00	3.88E+00	47 c	1.9E-01	8.3E-02
Magnesium	306 - 683	1.96E+02	1.55E+00	--	--	--
Manganese	15 - 46	2.14E+01	1.33E+01	460 b	4.7E-02	2.9E-02
Nickel	0.6 - 2	4.91E-01	4.13E-01	21 c	2.3E-02	2.0E-02
Potassium	--	1.39E+02	6.75E+01	NA	--	--
Selenium	0.32 - 1.4	5.90E-01	5.08E-01	--	--	--
Sodium	119 - 196	2.57E+02	1.18E+02	NA	--	--
Vanadium	3.1 - 6.5	4.11E+00	2.91E+00	--	--	--
Zinc	4.8 - 9.9	4.09E+00	3.00E+00	150 c	2.7E-02	2.0E-02
				HI =	0.6	0.3

(a) All values are sediment quality benchmarks (SQBs) by equilibrium partitioning obtained from EcoTox Update (EPA-540/F-95/038 January 1996). Arsenic, chromium, and mercury values are for all chemical forms.
(b) Jones et al. 1997, Table 4
(c) Effects Range Low (USEPA 1996)
(d) ORNL EDB Benchmark Study, 1998
NA = Not available
-- = Not evaluated

Table 2.9-1. Comparative Analysis of Alternatives for FS-1 Feasibility Study

General Response Action Criteria	Alternative I No Action	Alternative 2b Limited Action with Leading Edge Extraction, Treatment and Reinjection/Discharge	Alternative 3 Axial Well Extraction, Treatment, and Reinjection/Discharge	Alternative 3B Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge
Overall Protection of Human Health and the Environment	Least protective; will not achieve RAOs for 11 years. Does not protect human health or the environment during that 11 years.	Moderately protective; uses institutional actions to protect until remedial action restores groundwater and surface water to acceptable standards. Surface water RAOs will be achieved within 1 year. Groundwater RAOs achieved in 11 years.	More protective; uses institutional actions to protect until remedial action restores groundwater and surface water to acceptable standards. Surface water RAOs will be achieved within 1 year. Groundwater RAOs achieved in 7 years.	Most protective; uses institutional actions to protect until remedial action restores groundwater and surface water to acceptable standards. Surface water RAOs will be achieved within 1 year. Groundwater RAOs achieved in 7 years.
Compliance with ARARS	Complies with ARARS.	Complies with ARARS Will achieve chemical-specific ARARS in 11 years	Complies with ARARS. Will achieve chemical-specific ARARS in 7 years.	Complies with ARARS. Will achieve chemical-specific ARARS in 7 years.
Long-term Effectiveness and Permanence	Will achieve RAOs; is effective and is permanent.	Good long-term effectiveness; will achieve RAOs in 11 years. No risk after implementation complete. At 11 years: 68% EDB extracted by treatment system 18% EDB escapes extraction and discharges 14% EDB remains in aquifer retained on silts and in dead end pores. P-11 not impacted by system	Good long-term effectiveness; will achieve RAOs in 7 years. No risk after implementation complete. At 7 years: 83% EDB extracted by treatment system 11% EDB escapes extraction and discharges 6% EDB remains in aquifer retained on silts and in dead end pores P-11 not impacted by system	Good long-term effectiveness; will achieve RAOs in 7 years. No risk after implementation complete. At 7 years: 83% EDB extracted by treatment system 11% EDB escapes extraction and discharges 6% EDB remains in aquifer retained on silts and in dead end pores. P-11 not impacted by system.
Reduction of Toxicity, Mobility, and/or Volume Through Treatment	No reduction in toxicity, mobility, and/or volume; does not satisfy preference for treatment.	Reduces toxicity, mobility, and volume through treatment. EDB MCL of 0.02 μg/L achieved. Achieves reduction after startup. Bog separation aspect is operational.	Better reduction of toxicity, mobility, and/or volume through treatment. EDB MCL of 0.02 μg/L achieved. Achieves reduction after system startup. System cannot be started before 2000.	Maximizes reduction of toxicity, mobility, and/or volume through treatment. EDB MCL of 0.02 μg/L achieved. Achieves reduction after startup. Bog separation aspect is operational.
Short-term Effectiveness	Does not decrease short-term risk. Community and environment not protected. No risk to workers. RAOs achieved in 11 years	Good short-term effectiveness. Protects human health and the environment. Construction and treatment plant workers may be exposed to contamination. Community protected during implementation. Environmental impacts mitigated through engineering practices and environment protected by extraction of groundwater. RAOs achieved in 11 years.	Good short-term effectiveness. Protects human health and the environment. Construction and treatment plant workers may be exposed to contamination. Community protected during implementation. Environmental impacts mitigated through engineering practices and environment protected by extraction of groundwater. RAOs achieved in 7 years.	Good short-term effectiveness. Protects human health and the environment. Construction and treatment plant workers may be exposed to contamination. Community protected during implementation. Environmental impacts mitigated through engineering practices and environment protected by extraction of groundwater. RAOs achieved in 7 years.
Implementability	Most easily implemented and will not interfere with future remedial actions.	Difficult to implement; however, similar activities are common groundwater cleanup activities. Technology is reliable. Future remedial activities not impacted by alternative.	More difficult to implement; however, similar activities are common groundwater cleanup activities. Technology is reliable. Future remedial activities not impacted by alternative.	Most difficult to implement; however, similar activities are common groundwater cleanup activities. Technology is reliable. Future remedial activities not impacted by alternative.
Cost				
Capital cost	$0	$3,952,000	$4,626,000	$6,385,000
Annual O&M Costs	$0	$394,000	$480,000	$514,000
Present Worth	$0	$9,423,000	$8,699,000	$10,561,000

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Chemical-specific Requirements Federal			
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) [40 *Code of Federal Regulations* (CFR) 141.11–141.16]	Relevant and Appropriate	MCLs have been promulgated for several common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies; they may also be considered relevant and appropriate for groundwater aquifers used for drinking water.	**Alternative 1**: No action will be taken. Plume is expected to attain MCLs in 11 years **Alternative 2B:** The groundwater will be extracted, treated, and reinjected/discharged. The plume is expected to attain MCLs within 11 years. **Alternative 3 and 3B**: The groundwater will be extracted, treated, and reinjected/discharged. The plume is expected to attain MCLs within 7 years.
Cancer slope factors (CSFs) (1997)	To Be Considered	CSFs are accepted input values to risk assessments that represent current cancer risks of compounds and elements.	**Alternatives 1, 2B, 3, and 3B**: CSFs were used in the risk assessment to develop remediation goals.
Integrated Exposure Uptake Biokinetic model for lead in children. U.S. Environmental Protection Agency (USEPA) publication 92857.7–15.2	To Be Considered	This model is used to assess the chronic, noncancer exposure of children to lead.	**Alternatives 1 2B, 3, and 3B**. The model was used in the risk assessment to develop the cleanup standard for lead.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Chemical-specific Requirements (continued) State			
Massachusetts Drinking Water Standards [310 *Code of Massachusetts Regulations* (CMR) 22.00]	Relevant and Appropriate	These regulations establish state drinking water standards (MMCLs for public water systems. The state level for ethylene dibromide (EDB) [0.02 part per billion (ppb)] is more stringent than the federal level (0.05 ppb).	**Alternative1**: No action will be taken; plume is expected to attain MMCLs in 11 years **Alternative 2B**: The groundwater will be extracted, treated, and reinjected/discharged. The plume is expected to attain MMCLs within 11 years. **Alternative 3 and 3B**: The groundwater will be extracted, treated, and reinjected/discharged. The plume is expected to attain MMCLs within 7 years.
Massachusetts Groundwater Quality Standards (314 CMR 6.00)	Applicable	These standards limit the concentration of certain materials allowed in classified Massachusetts waters. The groundwater beneath and in the vicinity of MMR has been classified as Class I water (fresh groundwater found in the saturated zone of unconsolidated deposits) and is designated as a source of potable water supply	**Alternative 1**: No action taken. No water reinjected into the aquifer **Alternatives 2B, 3, and 3B**: The ETR systems will be designed and operated to treat extracted water to obtain groundwater quality standards prior to reinjection.
Massachusetts Surface Water Quality Standards (314 CMR 4.00)	Applicable	These standards mandate protection of surface water and regulate discharges to surface water. The Quashnet river bogs are Class B (habitat for fish, other aquatic life, and wildlife, and for primary and secondary recreation and are suitable for public water supply)	**Alternative 1**: No action taken. No water discharged to surface water **Alternatives 2B, 3, and 3B**: The ETR systems will be designed and operated to treat extracted water prior to discharge to surface water such that surface water quality standards are met.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Location-specific Requirements Federal			
Rivers and Harbors Act of 1899 (33 USC 403; 33 CFR Parts 320-323	Applicable	Section 10 of the Rivers and Harbors Act of 1899 requires authorization from the Secretary of the Army, acting through the Corps of Engineers, for the construction of any structure in or over any "navigable water of the U.S.". It also requires such authorization for the excavation from or deposition of material in such waters, or any obstruction or alteration in such waters	**Alternative 1**: Not applicable **Alternatives 2B, 3, and 3B**: All actions within navigable waters will be coordinated with the Army Corps of Engineers
Protection of Wetlands Executive Order (EO) 11990 (40 CFR Part 6, Appendix A)	Applicable	Appendix A of 40 CFR 6 sets forth USEPA policy for carrying out the provisions of the Wetlands EO (11990). Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance natural and beneficial values of wetlands. Appendix A requires that no remedial alternatives adversely impact a wetland if another practicable alternative is available. If no alternative is available, effects from implementing the chosen alternative must be mitigated	**Alternative 1**: No actions will be performed that may impact the wetland. **Alternatives 2B, 3, and 3B**: Remedial actions will be performed in such a manner that wetland areas are not adversely impacted. Altered areas will be repaired or restored.
Clean Water Act (CWA) Section 404; 40 CFR Part 230; 33 CFR Parts 320-323; 33 USC 1344	Applicable	No activity that adversely effects a wetland shall be permitted if a practicable alternative with less effects is available. If no practicable alternative exists, impacts must be mitigated.	**Alternative 1**: No actions will be performed that may impact the wetland. **Alternatives 2B, 3, and 3B**: Design, installation and operation of the treatment and discharge systems are being undertaken to minimize impacts to wetlands. All impacts will be mitigated.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Location-specific Requirements Federal (continued) Fish and Wildlife Coordination Act (16 United States Code 661; 40 CFR 6.302)	Applicable	This act requires that any federal agency proposing to modify a body of water must consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies to develop measures to prevent, mitigate or compensate to project-related losses to fish and wildlife. Such action should be viewed in the context of obtaining maximum overall project benefits such as cleaning up the site. The requirements to comply with this Act are contained in EPA's NPDES permit regulations (40 CFR 122.49)	**Alternative 1**: No actions will be performed that involve the body of water. **Alternatives 2B, 3, and 3B:** Actions will be taken to develop measures to prevent, mitigate, or compensate for project-related impacts to fish and wildlife. Relevant agencies will be contacted to help analyze the impact on fish and wildlife from installing treatment systems, and discharging treated water to the Quashnet River.
Floodplain Management EO 11988 (40 CFR Part 6, Appendix A).	Applicable	This order requires federal agencies to minimize potential harm to or within floodplains an avoid floodplain development wherever there is a practicable alternative.	**Alternative 1**: No actions will be taken that impact floodplains. **Alternatives 2B, 3, and 3B**: Remedial Actions in and around the Quashnet River will be performed so that floodplains are not adversely impacted.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
State			
Massachusetts Wetlands Regulations (310 CMR 10.00)	Applicable	These regulations protect inland and coastal wetlands as well as a 100-ft buffer zone from activities that may alter the resource area. Some wetlands receive additional protection of wildlife. The protected habitats are defined by the presence of particular plant or animal communities and/or hydrologic characteristics. The regulations specifically prohibit the loss of over 5,000 square feet of bordering vegetated wetlands. The loss may be permitted with replication of the lost area within two growing seasons	**Alternative 1**: No actions will be performed that may impact the protected wetland. **Alternatives 2B, 3, and 3B**all activities within the wetland area and buffer zones will be conducted to meet all requirements. If remedial actions alter more that 5,000 square feet, the affected area will be restored within two growing seasons.
Massachusetts Endangered Species Act (321 CMR 10.00)	Applicable	The Commonwealth of Massachusetts has authority to research, list, and protect any species deemed endangered, threatened, or of special concern. These species are listed as either endangered, threatened, or species of special concern in the regulations. The Massachusetts list may differ from the federal lists of endangered species. Actions must e conducted in a manner that minimizes the effect on Massachusetts-listed endangered species and species listed by the Massachusetts Natural Heritage Program.	**Alternative 1**: No actions will be performed that may impact these protected species. **Alternatives 2B, 3, and 3B** Several state-listed species have been identified in the vicinity of MM. Areas in which work is to be conducted will be evaluated for the presence of habitat for endangered of threatened species. Activities will be designed to meet the requirements of these regulations.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Action-specific Requirements Federal			
Underground Injection Control Program (40 CFR 144, 146,147, 1000)	Applicable	These regulations outline minimum program and performance standards for underground injection programs	**Alternative 1**: No remedial actions would occur to trigger these regulations. **Alternatives 2B, 3, and 3B**: Extracted groundwater will be treated to levels at or below federal and state drinking water standards to ensure that discharges to infiltration galleries will not cause any violation of drinking water standards in the receiving aquifer..
National Pollutant Discharge Elimination System (NPDES) (40 CFR 122-125 and 131)	Applicable	Establishes discharge limitations, monitoring requirements, and best management practices for any direct discharge from a point source into surface water.	**Alternative** 1: No remedial actions would occur to trigger this requirement. **Alternatives 2B, 3, and 3B**: Discharge of treated water into the Quashnet River or cranberry bogs will meet these standards.
Resource Conservation and Recovery Act (RCRA) – Identification and Listing of Hazardous Wastes; Toxicity Characteristics (40 CFR Part 261.24)	Relevant and Appropriate	These requirements identify the maximum concentrations of contaminants for which the waste would be a RCRA characteristic waste for toxicity. The analytical test given in Appendix II is referred to as the TCLP	**Alternative 1**: Not applicable **Alternatives 2B, 3, and 3B**: Drill cuttings, spent activated carbon, and sludge sent offsite for disposal (not including regeneration) will be analyzed according to TCLP. If TCL results exceed standards in 40 FR 261.24, the material will be disposed of offsite in a RCRA-permitted treatment, storage, and disposal facility.
RCRA Air Emission Standards for Process Vents (40 CFR 264, Subpart AA)	Relevant and Appropriate	These regulations establish requirements for controlling emissions from process vents associated with treatment processes that manage hazardous wastes with organic concentrations of 10 ppm or more.	**Alternative 1:** Not applicable. **Alternatives 2B, 3, and 3B**: If thresholds are met, emissions from process vents will be controlled in accordance with these requirements.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Action-specific Requirements (continued) Federal (continued)			
Standards for Control of Emissions of Volatile Organic Compounds (VOCs), RCRA (40 CFR 264, Subpart BB)	Relevant and Appropriate	Contains air pollutant emissions standards for equipment leaks at hazardous waste treatment, storage, and disposal (TSD) facilities. Contains design specifications and requirements for monitoring for leak detection. It is applicable to equipment that contains hazardous wastes with organic concentrations of at least 10% by weight.	**Alternative 1**: No remedial actions would occur that would trigger these standards. **Alternatives 2B, 3, and 3B**: If treatment involves groundwater with organic concentration of at least 10% by weight, equipment will meet the design specifications and will be monitored for leaks.
RCRA Subtitle C (40 CFR 264), Standards for Owners and Operators of Hazardous Waste TSD Facilities.	Relevant and Appropriate	These standards, which regulate the operation of facilities that treat, store, or dispose of hazardous waste, take effect through authorized state RCRA programs cited below	**Alternative 1:** Not applicable **Alternatives 2B, 3, and 3B:** See Massachusetts hazardous waste regulations cited below
RCRA Subtitle C Subpart F – releases from Solid Waste Management Units.	Relevant and Appropriate	These regulations establish groundwater protection requirements, including monitoring	**Alternative 1**: Not applicable **Alternatives 2B, 3, and 3B**: The groundwater at and emanating from the FS-1 source area will be monitored in accordance w1th these standards
State			
Massachusetts Department of Public Health Food Tolerance Action Levels (105 CMR 515.00)	To Be Considered	Establishes food tolerance action levels for EDB	**Alternative 1**: No actions will be taken. **Alternatives 2B, 3, and 3B:** The FS-1 treatment system and additional actions to be taken at the cranberry bogs will minimize the possibility that concentration of EDB exceeding the food tolerance action levels are present in the cranberry crop. Cranberries will be sampled and analyzed as an additional measure of the performance of the alternative.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Action-specific Requirements (continued) State (continued)			
Massachusetts Underground Water Source Protection (310 CMR 27)	Applicable	Under these regulations, "No underground injection shall be allowed where a Class V well causes or allows movement of fluid containing any pollutant into underground sources of drinking water and the presence of such a pollutant causes or is likely to cause a violation of any Massachusetts Drinking Water Regulation...or...adversely affects or is likely to adversely affect the health of persons.". Class V wells are defined to include, "wells used to replenish the water in an aquifer.".	**Alternative 1**: No actions will occur that will trigger these requirements. **Alternatives 2B, 3, and 3B:** Extracted groundwater will be treated to levels at or below federal and state drinking water standards to ensure that discharges to the aquifer will not cause any violation of drinking water standards in the receiving aquifer.
Massachusetts Groundwater Discharge Permits (314 CMR 5.00)	Applicable	Establishes permit system for permitting of discharges to groundwater.	**Alternative 1**: No actions will occur that will trigger these requirements. **Alternatives 2B, 3, and 3B**: Injection wells will be designed to meet the substantive standards of these permitting requirements.
Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	These regulations set emission limits necessary to attain ambient air quality standards.	**Alternative 1**: No actions will occur that trigger these requirements. **Alternatives 2B, 3, and 3B**: Construction activities and on-site treatments will be performed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition compounds (310 CMR 7.09); noise (310 CMR 7.10) and VOCs (310 CMR 7.18). If standards are exceeded, emissions will be managed through engineering controls.
Massachusetts Hazardous Waste Management Regulations (HWMR) - Requirements for Generators (310 CMR 30.300-30.371)	Relevant and Appropriate	This requirement sets standards for generators of hazardous waste that address (1) accumulating waste, (2) preparing waste for shipment, and (30 preparing the hazardous waste manifest. Massachusetts specifies requirements for very small quantity generators as well as small and large quantity generators.	**Alternative 1**: No actions will occur to trigger these rules. **Alternatives 2B, 3, and 3B:** If RCRA-characteristic wastes are generated, the material will be managed in accordance with these requirements .

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement
Massachusetts HWMR – Location Standards (310 CMR 30.700-30.707)	Relevant and Appropriate	Under these standards, a new facility man not be located in an area subject of flooding; within the watershed of a Class A or Class SA segment of the surface water body unless it is determined that there is no feasible alternative; on land overlying an actual, planned, or potential public of private drinking water source; or in the flow path of groundwater supplying water to an existing well. In addition, there shall be a minimum of 300 feet from the active portion of the facility to the facility property line	**Alternative 1**: No actions will occur to trigger these rules **Alternatives 2B, 3, and 3B**: Any treatment facility will be located and operated to fulfill these regulations unless there is no feasible alternative. A waiver may be requested for the distance from the treatment facility to the property line.

See notes on following page.

Table 3.2.1. Applicable or Relevant and Appropriate Requirements, Criteria, Advisories, and Guidance for AOC FS-1 Feasibility Study, Massachusetts Military Reservation

ARAR	applicable or relevant and appropriate requirement
CFR	*Code of Federal Regulations*
CMR	*Code of Massachusetts Regulations*
CSF	cancer slope factor
CWA	Clean Water Act
EDB	ethylene dibromide
EO	Executive Order
IDW	investigation-derived waste
MCL	maximum contaminant level
OSWER	Office of Solid Waste and Emergency Response (USEPA)
ppb	part per billion
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
TSD	treatment, storage, and disposal
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

Appendix C

APPENDIX C
RESPONSIVENESS SUMMARY

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RESPONSIVENESS SUMMARY

RECORD OF DECISION
AREA OF CONTAMINATION FS-1

MASSACHUSETTS MILITARY RESERVATION
CAPE COD, MASSACHUSETTS

Final

April 2000

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RESPONSIVENESS SUMMARY
MASSACHUSETTS MILITARY RESERVATION
CAPE COD, MASSACHUSETTS

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PREFACE

This Responsiveness Summary has been prepared to meet the requirements of Sections 113(k)(2)(B)(iv) and 117(b) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), which requires response to "... significant comments, criticisms, and new data submitted in written or oral presentations" on a Proposed Plan for remedial action. The purpose of this Responsiveness Summary is to document the Air Force Center for Environmental Excellence (AFCEE's) responses to questions and comments expressed during the comment period by the public, potentially responsible parties, and governmental bodies in written and oral comments regarding the *Proposed Plan for Cleanup Related to FS- 1.*

AFCEE published a display ad for the Public Information Meeting for the FS-1 Proposed Plan in the *Falmouth* and *Mashpee Enterprises*, the *Cape Cod Times*, and the *Bourne* and *Sandwich Enterprises* on May 21, 1999. The announcement of the public hearing was contained in display ads run in the *Mashpee* and *Falmouth Enterprises* on June 1, 1999; in the *Sandwich* and *Bourne Enterprises* on June 4, 1999; and the *Cape Cod Times* on June 29, 1999. Before the start of the comment period, AFCEE made the RI reports, the FS, and Proposed Plan available for public review at the U.S. Coast Guard library at MMR and the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts. The Proposed Plan has also been made part of the Administrative Record available for public review at the AFCEE IRP office at MMR and at the Falmouth Public Library.

From June 4, 1999, to July 3, 1999, AFCEE held a 30-day comment period to accept public comments on the preferred alternatives presented for the AOC in this Proposed Plan. On June 3, 1999, AFCEE held a public meeting at Mashpee Town Hall to present and discuss the Proposed Plan. On June 23, 1999, AFCEE held a public hearing at Mashpee Town Hall to accept verbal comments on the Proposed Plan. A transcript of the public hearing is provided in Appendix D. Several residents and local officials attended the hearing. There were no verbal comments provided at the public hearing. A transcript of the public hearing is provided in Appendix D. Written comments were received by AFCEE from several community groups. Those comments were primarily concerned with the impact of the preferred alternative on the environment and questions regarding the distribution of EDB in the Quashnet River bogs. AFCEE's responses to the comments received at the hearing and during the public comment period are included in Section 3 of this Responsiveness Summary. This Responsiveness Summary is organized into the following sections:

1 "Overview of Remedial Alternatives Considered in the Feasibility Study Including the Selected remedy (Alternative 3B)." This section briefly outlines the remedial alternatives evaluated in detail in the Feasibility Study and presented in the Proposed Plan, including AFCEE's selected remedy (Alternative 3B).
2 "Background on Community Involvement." This section provides a brief history of community involvement and AFCEE's initiatives to inform the community of site activities.
3 "Summary of Comments Received During the Public Comment Period and AFCEE Responses." This section provides AFCEE's responses to verbal and written comments received from the public and not formally responded to during the public comment period. Copies of the comment letters are included in Attachment A of this Responsiveness

Summary. A transcript of the September 23, 1999, public hearing is included in Appendix D of the Record of Decision.

1. OVERVIEW OF REMEDIAL ALTERNATIVES CONSIDERED IN THE FEASIBILITY STUDY INCLUDING THE SELECTED REMEDY (ALTERNATIVE 3B)

1.1 DESCRIPTION OF EVALUATED ALTERNATIVES FOR AOC FS-1

The Feasibility Study assessed how well the following four alternatives would meet the evaluation criteria of the National Oil and Hazardous Substances Contingency Plan while controlling migration of contaminants from surface soils to groundwater at AOC FS-1.

- Alternative 1 No Action
- Alternative 2B: Limited Action with Leading Edge Extraction, Treatment, and Reinjection/Discharge
- Alternative 3: Axial Well Extraction, Treatment, and Reinjection/Discharge
- Alternative 3B: Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge

1.1.1 Alternative 1: No Action

The No Action alternative was evaluated as a baseline with which to compare other alternatives. No remedial action, monitoring, further investigation, or 5-year site reviews would be performed as part of this alternative. No action would be taken to maintain site access restrictions (security fencing and military guard posts) that currently limit potential human exposure to site contaminants.

1.1.2 Alternative 2B: Limited Action with Leading Edge Extraction, Treatment, and Reinjection/Discharge

The major features of this alternative include preliminary sampling and analysis, general site preparation, installation of a groundwater extraction system at the leading edge of the plume, treatment of extracted groundwater by granulated activated carbon treatment, reinjection/discharge of the treated groundwater, institutional controls, long-term groundwater and surface water monitoring program, and a visual inspection program.

The leading edge extraction, treatment, and reinjection/discharge system removes contaminated groundwater, treats that water to remove contamination, and reintroduces the clean water into the aquifer and surface water. This option will reduce groundwater and surface water contamination until that groundwater and surface water no longer pose a risk to human health or the environment. Components of the leading edge extraction, treatment, and reinjection/discharge system are operational as the Quashnet River Bogs Pilot Test.

1.1.3 Alternative 3: Axial Well Extraction, Treatment, and Reinjection/Discharge

The major features of this alternative include preliminary sampling and analysis, general site preparation, installation of a groundwater extraction system along the axis of the plume, treatment of extracted groundwater by granulated activated carbon treatment, reinjection/discharge of the treated groundwater, institutional controls, long-term groundwater and surface water monitoring program, and a visual inspection program.

The axial extraction, treatment, and reinjection/discharge removes contaminated groundwater, treats that water to remove contamination, and reintroduces the clean water into the aquifer and surface water. This option will reduce groundwater and surface water contamination until that groundwater and surface water no longer pose a risk to human health or the environment.

1.1.4 Alternative 3B: Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge

The major features of this alternative include preliminary sampling and analysis, general site preparation, installation of a groundwater extraction system at the leading edge and along the axis of the plume, treatment of extracted groundwater by granulated activated carbon treatment, reinjection/discharge of the treated groundwater, institutional controls, long-term groundwater and surface water monitoring program, and a visual inspection program. The leading edge extraction, treatment and reinjection/discharge system that is operating as the Quashnet River Bogs Pilot Test would be discontinued at the start up of Alternative 3

The axial and leading edge extraction, treatment, and reinjection/discharge system removes contaminated groundwater, treats that water to remove contamination, and reintroduces the clean water into the aquifer and surface water. This option will reduce groundwater and surface water contamination until that groundwater and surface water no longer pose a risk to human health or the environment.

1.1.5 Selected remedy (Alternative 3B)

The selected remedy (Alternative 3B) for FS-1 is Axial and Leading Edge Extraction, Treatment, and Reinjection, Discharge. This selected remedy (Alternative 3B) provides treatment of contaminated groundwater to remove site-related contaminants and return of groundwater and surface water to safe, beneficial use.

2. BACKGROUND ON COMMUNITY INVOLVEMENT

The National Guard Bureau (NGB) and AFCEE have held regular informational meetings, issued fact sheets, and held public meetings to keep the community and other interested parties informed of activities at this AOC. The NGB was responsible for the IRP at MMR until 1996, when AFCEE assumed this responsibility.

Throughout MMR's history, community concern and involvement have been high. The NGB, AFCEE, U.S. Environmental Protection Agency (USEPA), and Massachusetts Department of Environmental Protection (MADEP) have kept the community and other interested parties apprised of site activities through informational meetings, fact sheets, news releases, public hearings, and Technical Environmental Affairs Committee (TEAC) meetings. TEAC was organized in 1986 by NGB to provide a forum for public input on the MMR response activities. Membership in TEAC comprised USEPA, MADEP, and representatives from local, regional, and state groups. Beginning with the October 7, 1992, TEAC meeting, members of the public could attend these bimonthly meetings. TEAC is no longer in existence.

During May 1991, an MMR Community Involvement Plan was released that outlined a program to address community concerns and keep citizens informed and involved in the remediation process at MMR. In July 1994, and again in December 1996, an updated draft Community Involvement Plan was issued to incorporate concerns and feedback provided by the community and to document changes in AFCEE policy, such as the public attendance at TEAC meetings.

In October 1993, a Senior Management Board was created to advise AFCEE on IRP activities. A Selectman from each of the four towns surrounding MMR is among the senior management board members, along with the regulatory agencies and the Adjunct General's Office of the Commonwealth of Massachusetts. Process Action Teams (PATs) were also created to address specific issues at MMR; these issues include plume containment, long-range water supplies, innovative technologies, and public information. PATs have representation from the community, local business, regulatory agencies, and AFCEE.

AFCEE published a display ad for the Public Information Meeting for the FS-1 Proposed Plan in the *Falmouth* and *Mashpee Enterprises*, the *Cape Cod Times*, and the *Bourne* and *Sandwich Enterprises* on May 21, 1999. The announcement of the public hearing was contained in display ads run in the *Mashpee and Falmouth Enterprise* on June 1, 1999; in the Sandwich and Bourne Enterprise on June 4, 1999; and the *Cape Cod Times* on June 29, 1999. Before the start of the comment period, AFCEE made the RI reports, the FS, and Proposed Plan available for public review at the U.S. Coast Guard library at MMR and the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts. The Proposed Plan has also been made part of the Administrative Record available for public review at the AFCEE IRP office at MMR and at the Falmouth Public Library. From June 4, 1999, to July 3, 1999, AFCEE held a 30-day public comment period to accept public comments on the preferred alternatives presented for AOC FS-1 in the Proposed Plan. On June 3, 1999, AFCEE held a public meeting at the Mashpee Town Hall to present and discuss the Proposed Plan. On June 23, 1999, AFCEE held a public hearing at the Mashpee Town Hall to accept verbal comments on the Proposed Plan. A transcript of the June 23, 1999, hearing is included in Appendix D. AFCEE's responses to the comments received at the hearing and during the public comment period are included in

Attachment A. These written and verbal comments were primarily concerned with the impact of the preferred alternative on the environment and questions regarding the distribution of EDB in the Quashnet River bogs.

3. SUMMARY OF COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND AFCEE RESPONSES

AFCEE received no verbal comments during the public hearing on June 23, 1999. AFCEE received no written comments from the general public. Comments were provided by the Joint Process Action Team (JPAT), the Natural Resources Trustee Council, the National Oceanic and Atmospheric Administration, and the Massachusetts Department of Fisheries and Wildlife.

The comments and responses follow.

JPAT Recommendation, Comments and Questions on the Proposed Plan for Cleanup Related to FS-1 From JPAT Meetings held in February through June 1999

Conditional on Alternative 2B's (the FS-1 pilot test's) not causing ecological harm, JPAT recommends Alternative 3B because of its maximum mass capture and speed of cleanup.

As the alternative is further refined, the JPAT would like the IRP to consider modular treatment plants with reinjection on or near the extraction locations, to carefully analyze reinjection strategies so as to minimize ecological harm and hydrological balance, and to refine the pilot test to also minimize harm. The performance of 2B, now being installed, should be monitored very closely in the coming year, and the final remedial design for FS-1 should be modified accordingly, as needed.

Finally, the design goal of 3B should also be to render the pilot test unnecessary (up stream capture having been effective) so that the unsightly above ground piping and other hardware can be removed from the area of the cranberry bogs as soon as possible.

Response
AFCEE appreciates the comments of the JPAT and concurs with the JPAT that Alternative 3B is the best alternative. It was recognized in the proposed plan and feasibility study that design modifications to Alternative 3B could result in improvements. It was determined during the feasibility study that additional modeling and design modification would be performed.

The performance of 2B is and will be monitored closely. The issue of removing the above ground piping and hardware as soon as possible will be considered. The operation of the remedial system is a dynamic process. After the system is installed, and operated, the effectiveness of the system will be reviewed on a continuing basis and appropriate modifications will be made.

COMMENTS

Comment
1. All residents over and near the FS-1 plume need to be identified and contacted regarding key public meetings and public involvement activities.

Response
All key public meetings have been announced in several local papers. In addition, a mailing list specific to the FS-1 area was created and all notices of meetings, fact sheets and the proposed plan were mailed to area residents on that mailing list. Additionally, news releases were issued announcing meetings and updates on the project. Community outreach activities will continue through the design, construction and operation of the selected alternative

Comment
2. JPAT encourages the program to learn from past investigation efforts in regard to fuel spills.

Response
Comment noted. The MMR IRP program will continuously learn from past experiences by careful evaluation and incorporation of changes into the program.

Comment
3. JPAT believes that the cleanup goals should focus more on resident and ecological safety and public water supply protection than on cranberry bog restoration.

Response
The cleanup goals are focused on public health and the environment. The Remedial Action Objectives for FS-1 as stated in the ROD are:

1. Remediate the aquifer to federal and state drinking water standards or other risk-based cleanup levels. Restoration timeframes and remedial costs estimated in this ROD were developed based on the expected time to attain federal and state drinking water standards (MCLs and MMCLs) or other risk-based cleanup levels. During the period that remedial systems are in operation, AFCEE will monitor the plume in accordance with the approved system performance monitoring plan. The plume will be considered to have reached MCLs, MMCLs or other risk-based cleanup levels (for those contaminants for which no MCLs or MMCLs are promulgated) when there have been no detections exceeding those levels over a time period agreed to by AFCEE and EPA in consultation with DEP.

2. When MCLs, MMCLs or other risk-based cleanup levels are achieved and before the system is shut off, perform a risk assessment to determine if unacceptable ecological and/or human health risks are present; continue system operation and/or pursue additional measures as required to achieve acceptable risks. AFCEE shall conduct a risk assessment once MCLs, MMCLs or other risk-based cleanup levels have been achieved (as defined in step 1, above) to determine whether the contaminants of concern (COPCs) remaining in the aquifer continue to pose unacceptable ecological and/or human health risks. This risk determination shall be made jointly among AFCEE and EPA in consultation with DEP and may result in aquifer cleanup which is more protective than the NCP point of departure risk level of 10-6 (40 CFR Part 300.430(e)(2)), if justified, based on the following site specific factors: cumulative effects of multiple contaminants , the potential for exposure from other pathways of exposure at the site, population sensitivities, potential impacts on environmental receptors, and cross-media impacts (NCP Preamble page 8717).

3. Once acceptable risks have been achieved, evaluate the technical and economic feasibility of additional remediation to approach or achieve background concentrations. AFCEE shall

proceed with a technical and economic feasibility analysis of approaching or achieving background concentrations in the aquifer. The feasibility of approaching or achieving background will be determined in accordance with the following criteria:

A. Technological - Not feasible if:

i. The existing technologies or modifications cannot remediate to a level of no significant risk, or to levels which approach or achieve background; or

ii. The reliability of the identified alternative has not been sufficiently proven and a substantial uncertainty exists as to whether it will effectively reduce risk; or

iii. The remedy does not or cannot be modified to meet other regulatory requirements.

B. Economic - The benefits of implementing a remedy and reducing the concentrations of contaminants in the environment to levels which approach or achieve background justifies related cost unless:

i. The incremental cost for the remedy is substantial and disproportional to the benefit of risk reduction, environmental restoration and monetary and non-monetary values; or

ii. The risk of harm to health/safety/public welfare/environment by the remedy cannot be adequately controlled.

Since active remediation has been chosen for the FS-1 plume, three step process for achieving RAOs (outlined directly above) will be applied. Additionally, there is on-going ecological evaluation of the impact of the remedial system on the ecology of the cranberry bogs and adjacent waters and habitat of the Quashnet River.

Comment

4. JPAT is concerned about the economic impacts of this effort. Despite the expenditure of effort and money to separate the active cranberry bogs from EDB-contaminated waters, what if Ocean Spray continues to not buy the berries in the future, either because of actual contamination or market perception? Will the federal government then compensate the town of Mashpee and the grower and for how long, further increasing the cost of the pilot test? If the bog cannot be an active cranberry bog, will the federal government be responsible for managing the transition from an active to inactive bog system, including its associated costs? This kind of transition can be expensive.

Response

It is not possible to provide definitive statements regarding the economic impacts of this effort at this time. AFCEE/MMR cannot predict what Ocean Spray will do. However, AFCEE/MMR will continue to facilitate agreements between growers and the town of Mashpee, Ocean Spray, and Congress regarding the cranberry issues. The Air Force is committed to complete remediation as technically and economically feasible, including any future modification or changes in the remedy that may be necessary.

Comment

5. JPAT wants to ensure that there is a detailed trout habitat mitigation plan in place for any alternative that is selected. The manipulation of a sensitive ecological system by habitat alterations, groundwater drawdowns, surface water discharges and siltation during construction has in the past and may in the future impact wild brook trout and other fisheries. The town, cranberry growers, and the IRP must coordinate efforts to ensure that brook trout and other fisheries habitat in the Quashnet River is protected.

Response

AFCEE/MMR has already initiated ecological studies directed toward the fisheries. Such efforts will continue and, if needed, additional measures will be considered. Previous actions have improved the ecological condition of the Quashnet River compared to pre-existing conditions

Comment

6. The JPAT is very concerned about the possible failure of the berms. It is our understanding that the peat in the bog beneath the newly constructed berms is subsiding. This potential failure of the berms may have significant adverse impacts on fish habitat and health. The JPAT recommends that the current and potential future subsidence be monitored very carefully and contingency plans be developed if the new berms continue to subside and adversely affect both the bog/river separation and the trout fishery.

Response

AFCEE/MMR is monitoring and will continue to monitor berm subsidence. AFCEE/MMR is also engaged in an on-going ecological evaluation of the impact of the entire FS-1 remedial system. These two efforts are complimentary. AFCEE/MMR will respond appropriately to berm subsidence and will make all reasonable attempts to ensure the continued viability of the fisheries.

Comment

7. The JPAT is concerned about the potential impacts of the plume and the remedial alternatives on the potential public water supply well, P-11. The JPAT understands from a presentation by John Masterson of USGS that, under certain conditions, the proposed P-11 well could pull in a portion of the FS-1 plume. The P-11 well site should at least be considered "threatened" at this time. The JPAT requests to see further modeling runs to further clarify this issue prior to any IRP decision on the final remedial design. Ideally, the Air Force would compensate the town for the loss of this well and also help to put adjacent private well users on Town water. The entire underdeveloped area over, near, or threatened by FS-1 should be considered a potential public water supply source.

Response

The area is considered a potential public water supply source, classified as such by the Commonwealth of Massachusetts. Additional modeling will be performed, and will include impacts to the potential P-11 well site. The study done by the Standing Water ASUpply Group (SWSG) classifies P-11 as pristine. AFCEE/MMR cannot comment on compensation to the town of Mashpee for a potential loss of the P-11 well. Such issues will be addressed if and when they occur. There are no private wells threatened by the FS-1 plume. Consequently, it is not necessary to provide public potable water to private homes.

Comment

8. The lifecycle costs of alternatives should be consistent with how long they are expected to be in operation. Some systems are expected to clean up faster than others do, thus their lifecycle costs may be less.

Response

The total costs for the various options were estimated in the FS and presented in the PP. The lifecycle costs were based on how long each alternative was expected to be in operation.

Comment

9. JPAT has a concern about the quantity and quality of surface water discharged from the treatment system and its potential impacts on the ecological and hydrology of the area. Various options for surface discharge, reinjection, and location of reinjection should be considered and analyzed, including the impacts of different discharge options on the natural hydrological fluctuations in the area.

Response

As stated in the FS (Section 8.4, page 63, 1st bullet after 3rd paragraph) and the PP (page 8 "Alternative 3B, line 15), additional modeling will be performed to optimize the remedial system. This will include various options for surface discharge, reinjection. and extraction well placement.

Comment

10. JPAT would like the IRP to consider various treatment options, including modular treatment plants with reinjection on or near the extraction locations. The JPAT requests to review the treatment options, including their expected location, developed by the IRP as part of the final remedial design.

Response

Modular treatment plants are not typically used for plumes such as FS-1 because of the anticipated number of extraction wells, the length of the plume, and anticipated pumping rates. Alternative reinjection schemes will be evaluated during the design phase. However, modeling conducted for the FS suggested that injection in the vicinity of extraction wells would have negative impacts on system efficiencies. Injection along the flanks of the plume may be included during system design if such injection is considered appropriate and efficient.

QUESTIONS

Question

1. Are there concentrations of contaminants that do not upwell into the bogs, but flow under and move past the bogs, resulting in contamination further downgradient?

Response

All investigations to date indicate that no contamination flows under and past the bogs.

Question

2. Why is the human cancer risk estimated to be higher than the fish cancer risk, given the EDB concentrations are the same and human cancer risks are based on animal studies?

Response
Within the human health risk assessment, one of the exposure scenarios evaluated consisted of the recreational fisher who would become exposed to EDB through ingestion of contaminated fish. The reasonable maximum exposure to the current or future recreational fish ingestion exposure route for the Quashnet River are an excess lifetime cancer risks of 6 x 10-5 and a total Hazard Index of 0.2. This calculated cancer risk is within EPA's risk management criteria but greater than MADEP's risk management criteria. 100% of the cancer risk would be associated with EDB in surface water and fish based upon a estimated bioaccumulation factor of 10. EDB is identified as a probable human carcinogen which indicates there is sufficient evidence in animals and inadequate or no evidence in humans. Therefore, the response of the laboratory animals are used when making comparisons to humans. The current literature suggests that EDB does not bioaccumulate and therefore the bioaccumulation factor of 10 is a conservative estimate.

In contrast, within the ecological risk assessment, not much toxicological data exists on the effects to fish resulting from dermal exposure to EDB in surface water. The data that did exist identified EDB concentrations that were an order of magnitude higher that could be responsible for tumor induction in fish. In order to better predict the surface water concentrations that could be responsible for chronic effects such as a decrease in growth or reproduction, site-specific laboratory studies conducted during this time period allowed for the development of a surface water benchmark that would be protective of fish.

Overall, the methodology in evaluating the cancer risk to humans and fish is different. Typically, the toxicological data for evaluating potential adverse effects to the fish is based on laboratory studies that determine endpoints for survival, growth and reproduction not subchronic endpoints such as cancer. On the other hand, the toxicological data for evaluating the cancer risks to human was based on animal laboratory studies. Therefore, the conclusions could be different.

Question
3. The JPAT is concerned about the concentrations of EDB that will continue to upwell in the bogs despite the active treatment system. What will be the concentration of EDB that will continue to upwell into the bogs and/or river system? What will be the impacts of surface water discharges of EDB on humans, fish, and cranberries, in terms of potential chronic and acute affects?

Response
The remedial system is designed to eliminate upwelling of EDB in the Bogs. Initial data indicate a sharp reduction in the EDB levels in surface water and the system will operate until upwelling of contaminated water is contained and eliminated Because EDB levels in the bogs have been showing a reduction, AFCEE does not see any potential chronic or acute health impacts to humans or fish. should lessen significantly ,potential health impacts to humans, fish, and cranberries should diminish. If cranberry marketability is impacted, AFCEE will work with the town and the cranberry grower to seek reimbursement for lost revenue.

Question
4. Given that EDB will continue to upwell in the bogs, the JPAT is concerned about potential air-borne concentrations of EDB and potential human health impacts. What are the likely ambient air concentrations of EDB? Will there be air monitoring as part of the system-monitoring plan?

Response
Previous air quality tests were done and characterized the worst case scenario before any treatment system was in place. The results showed no unacceptable risk to human health. The leading edge portion of the remedial alternative was installed and is significantly reducing levels of EDB in surface water. Since EDB levels are declining, AFCEE does not believe that additional air quality monitoring is necessary.

Question
5. What is the effect on the concentrations of EDB in various parts of the bog as the pilot test wells are turned on and off? Will EDB concentrations in any of the pilot test monitoring wells increase in concentration over time rather than decrease, as desired?

Response
Turning wells on and off in the bog is primarily directed to optimize the extraction system to capture as much EDB as possible. EDB levels in small areas of the bogs may temporarily increase during the system optimization. Once the system is optimized and fully operational, the system will significantly prevent EDB from entering the bogs, EDB concentrations in the pilot test monitoring wells should decrease.

Natural Resource Trustee Council

Dear Mr. Snyder

The Massachusetts Military Reservation Natural Resource Trustee Council (the council) is pleased to submit these comments on the Proposed Plan for Clean-Up Related to FS-1 dated June 1999. The Trustees are submitting these comments per their Memorandum of Agreement Section II: Objective D-"Work to coordinate and integrate their activities with the ongoing IRP as appropriate and feasible"

The comments provided in this letter and the attached report are not intended to be part of any natural resource damage assessment or restoration plan for MMR, and the Council is not binding itself to these comments for future assessment and restoration planning purposes. Rather, these comments are submitted in satisfaction of the second of the Council's dual goals, that of providing timely input to the IRP and the community on ongoing remedy selection and other issues based on currently available information.

Comment
Based on our limited review of available information, the council believes that Alternative 3B is the best of the alternatives considered by the Air Force in their Feasibility Study. Given that this design is conceptual in nature only, the Council does reserve final judgement until the Council reviews the finalized design. The Council notes that the FS-1 pilot test, which is a component of Alternative 3B, does enhance natural resources by separating stream habitat from active cranberry agricultural operations. Please note that given the time and information available, the Council was not able to determine if the FS-1 pilot test best balances the natural resource impacts of construction, contamination removal, and operations.

Response
Your comment supporting Alternative 3B is noted. AFCEE also recommends this alternative because it restores the aquifer in a shorter time frame than other alternatives.

More specifically, the Council recommends the following:

Comment
1. The Council is particularly concerned about the trade-offs inherent in the destruction of upland woodland to create compensatory cranberry bog. Such a replacement project may pose unintended but significant natural resource impact. The Council recommends that the Air Force MMR IRP conduct the appropriate level of environmental analysis for the new bog area including alternative siting and consideration of trade-offs, including any additional field work necessary to conduct this analysis.

Response
The Order of Conditions issued by the Mashpee Conservation Commission for the construction and operation of the Quashnet River and Bogs Pilot Test included a condition that an Amended Order of Conditions must be obtained for creation of a new bog area if the plume treatment is to go on beyond three years. The construction of the pilot project resulted in the loss of some wetland acreage. The new bog was to compensate for that lost acreage.

Presently, because of the EDB detected in the K6 bog, plans for construction of the new bog area have been suspended. If a decision is made that the new bog area is still required, AFCEE will evaluate the impacts and trade-offs associated with the proposed construction and will work closely with the Mashpee Conservation Commission and other appropriate agencies to prepare a plan for implementation that will result in an acceptable balance between natural resource impacts and cleanup objectives.

Comment
2. For any construction that remains to be done or will be carried out over the life of the remedial system, the Air Force MMR IRP program should incorporate best management practices (BMP) during construction and operation. For example, the potential impacts of ETR construction, including the axial well fence, piping, access roads, and utility corridors, can be minimized through limiting clearing and grading. In addition, proper erosion and sedimentation barriers should be maintained (silt fences and haybales).

Response
Comment noted. As in the construction of the replacement bogs, appropriate environmental analysis will be conducted as suggested in your first bullet to evaluate the impact of construction before the design is finalized. During construction, the potential impacts will be minimized by employing the best management practices, as you suggested.

Comment
3. Upon completion of the Pilot Test, the Air Force MMR IRP program should carefully evaluate the impacts of the Pilot Test discharge system (i.e., a bubbler system) on the trout fishery in close consultation with the EPA, DEP, and the Commonwealth's Department of Fisheries and Wildlife. At this time, the IR and appropriate regulatory agencies should

consider and alternative discharge system would better protect and or enhance the trout fishery

Response
We will evaluate this recommendation in consultation with appropriate environmental agencies and conservation agencies.

Comment
4. The Air Force MMR IRP program should continue the monitoring program designed to maintain the aquatic habitat of the bog ditches beyond the one year pilot test for a period of three to five additional years. The extension of monitoring would provide a more comprehensive understanding of the optimum water levels and developing stream habitats.

Response
If the pilot test is successful and incorporated as part of the long-term remedial action, the ecological resources will be monitored throughout the life of system to ensure that resources are not adversely impacted.

Comment
5. The IRP should carefully evaluate the impacts of a power failure on the discharge of groundwater to surface water to ensure that the trout fishery would not be adversely affected. If a power failure occurred, there could be a lag time between treated water discharge and natural water upwelling. Currently, either the natural upwelling or treated water discharge provide lower temperatures and higher dissolved oxygen in the K1 bog. If a potential power failure will result in adverse impacts to the trout fishery, then appropriate contingency measures, such as a back-up power source for the treatment system, should be put in place.

Response
AFCEE has provided adequate power to the remedial system and will ensure that the power is maintained in such a manner, that the fishery is not adversely impacted.

Comment
6. The IRP should provide for streamside plantings with woody vegetation along the newly created "edge" between the berms and the bog ditch in the K2 bog to provide shade and cover for aquatic biota and fisheries, consistent with the Mashpee Conservation Commission requirements. The action of boulders, log flow deflectors, and excavation of silt and organic sediments would further improve the stream habitat.

Response
AFCEE is committed to implement all Mashpee Conservation Commission requirements as specified in their order of conditions.

Comment
7. While the following activities may or may not fall within the purviews of appropriate CERCLA-funded remediation activities, the Council recommends consideration be given to the following natural resource enhancements.

Streamside planting with woody vegetation below the current remediation effort along the Quashnet River to provide shade and cover for aquatic biota and fisheries.

Streamside plantings with woody vegetation above the current remediation effort along the Quashnet River to provide shade and cover for aquatic biota and fisheries.

Replacing and/or improving the Johns Pond fish ladder to improve fisheries habitat.

Response
Other natural resource enhancements suggested should be considered by the Natural Resources Trustee Council as mitigative measures if damage to natural resources is assessed.

National Oceanic and Atmospheric Administration

Comment
Thank you for the Proposed Plans for site remediation related to the FS-1 groundwater plume and source area, MMR Superfund site, dated June 1999. NOAA is in general agreement with the preferred alternative that includes extraction, treatment and reinjection/discharge of the contaminated groundwater and surface water that is presently operating in the Quashnet River cranberry bogs

As discussed in NOAA's review of the Remedial Investigation (RI), the FS-1 plume flows south and discharges to the Quashnet cranberry bogs east of Johns Pond. The Quashnet River flows into Waquoit Bay National Estuary Research Reserve Program, which encompasses some 1,000 hectares of open waters, barrier beaches, marshlands, and uplands. Natural resources of interest to NOAA (NOAA trust resources) are found in Waquoit Bay and include alewife, American eel, Bluebook herring, cunner, tautog, tomcod, winter founder, bay scallop, blue crab, quahog, and softshell clam. In additional to land use within the Reserve, the Reserve also manages a 140-hectare tract of land along the banks of the Quashnet River, a restored trout stream. Parts of the Reserve are included in the newly designated Mashpee National Wildlife Refuge.

The results of the RI for FS-1, indicated that an EDB groundwater plume extends from the site to the Quashnet River, but only very low concentrations of EDB are found in the river. These results also indicate that risks to aquatic receptors within the Quashnet River are likely very low. From this information, it may also be inferred that risks to NOAA trust resources found in Waquoit Bay due to exposure to site-related contaminants are also very low. This is further confirmed by the letter from the Massachusetts Department of Public Health that indicated that clams collected from Waquoit Bay did not have detectable concentrations of EDB. However, in 1997, the Massachusetts Department of Public Health collected fish from the Quashnet River. Brook trout and white sucker were collected and their tissues analyzed for EDB. Test results indicated EDB in brook trout at 0.12 mg/kg and 0.13 mg/kg in white sucker from the Quashnet River

Response
Thank you for your comments. We agree with you that the EDB contamination found in the Quashnet River presents a very low risk to aquatic receptors. In addition, the remedial system already constructed has started reducing the contamination even further. Given that the

contamination in surface water is starting to show a decline. AFCEE agrees to performing sampling and analysis of fish tissue during 2000 and 2001.

Massachusetts Division of Fisheries and Wildlife

Comment

The Massachusetts Division of Fisheries and Wildlife remains concerned about the proposed plan for the cleanup of the ethylene dibromide from Fuel Spill 1. The alteration of groundwater hydrology and surface water discharge of treated water to a sensitive ecological area, (i.e., wild brook trout habitat) continues to remain a concern. These concerns have been heightened by problems with the Quashnet River Pilot test including construction siltation, the March 5 fish kill and the early June stream bed rising due to berm construction and other potential (i.e., system failure during a stressful environmental period)

The groundwater flow to the upper Quashnet River (which also contains EDB) was the key factor that allowed wild brook trout spawning to occur despite the negative impacts of cranberry bog operations on brook trout habitat. AFCEE is now altering this key factor in order to the EDB contamination of the surface waters of the Quashnet River. Mitigation for alteration of this vital habitat component must include habitat improvements to other physical factors in the existing environment to improve the long term habitat for brook trout.

This is one of the most sensitive ecological environment that the cleanup of contamination from the Massachusetts Military Reservation will impact. Appropriate funds to protect the ecological integrity of this area must be devoted to protecting and improving the fisheries habitat of the Quashnet River.

We remain concerned about future impacts of this project on the wild brook trout population of the river. Maintenance of the berms and attention to protection of the fisheries resources must have continued throughout the length of this project. Protection of the sensitive ecological resources of the Quashnet River fisheries must be a priority with AFCEE and its contractors, i.e., Jacobs Engineering. This project requires overview by personnel with ecological insight as well as a strictly engineering approach.

Response

Thank you for your comments. AFCEE is committed to bringing top-level experts to construct the remedial system while maintaining the ecological resources of the Quashnet River. Although a few unavoidable incidences you mentioned did temporarily impact the ecological resources, AFCEE has taken a number of actions in close coordination with you that have improved the ecological condition of the Quashnet River in the bog area over and above what was prevailing in what, historically, has been a heavily managed agricultural area.

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ATTACHMENT A
WRITTEN COMMENTS RECEIVED DURING PUBLIC COMMENT PERIOD

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WRITTEN COMMENTS RECEIVED DURING PUBLIC COMMENT PERIOD

From: Patrick Field [mailto:pfield@igc.org]
Sent: Monday, June 21, 1999 7:05 PM
To: jim.snyder@mmr.brooks.af.mil
Cc: abrand@CH2M.com; vanessa.musgrave@mmr.brooks.af.mil
Subject: JPAT FS-1 Proposed Plan Comments

MR. JIM SNYDER
RPM
MMR IRP

Please find below and as an attachment in Word for Windows the comments developed by the Joint Process Action Team on the FS-1 Proposed Plan.

These comments were developed at the 24 February, 10 March, and 9 June JPAT meetings. Preliminary comments were submitted to the SMB on 16 March by Tom Cambereri. The comments from all these meetings were summarized by Patrick Field, one of the JPAT facilitators, after the June 9 meeting. As agreed in the 9 June meeting, these comments were circulated to JPAT members with email and corrections and additions were received and incorporated. The JPAT members who finalized these comments were Susan Walker, Joel Feigenbaum, Tom Cambereri, and Steve Hurley.

If you should have any questions, please do not hesitate to call me at (617) 492-1414 x18 or speak directly to any of the JPAT members mentioned above.

PATRICK FIELD
Consensus Building Institute
JPAT Facilitator

JPAT Recommendation, Comments and Questions on the Proposed Plan for Cleanup Related to FS-1
From JPAT Meetings held in February through June, 1999

GENERAL RECOMMENDATION

Conditional on Alternative 2B (the FS-1 pilot test) not causing ecological harm, the JPAT recommends Alternative 3b because of its maximum mass capture and speed of clean-up.

As the alternative is further refined, the JPAT would like the IRP to consider modular treatment plants with reinjection on or near the

extraction locations, to carefully analyze reinjection strategies so as to minimize ecological harm and hydrological balance, and to refine the pilot test to also minimize harm. The performance of 2B, now being installed, should be monitored very closely in the coming year and the final remedial design for FS-1 should be modified accordingly, as needed.

Finally, the design goal of 3b should also be to render the pilot test unnecessary (up stream capture having been effective) so that the unsightly above ground piping and other hardware can be removed from the area of the cranberry bogs as soon as possible.

COMMENTS

Comment

1. All residents over and near the FS-1 plume need to be identified and contacted regarding key public meetings and public involvement activities.

2. The JPAT encourages the program to learn from past investigation efforts in regard to fuel spills.

3. The JPAT believes that the clean-up goals should focus more on resident and ecological safety and public water supply protection than on cranberry bog restoration.

4. The JPAT is concerned about the economic impacts of this effort. Despite the expenditure of effort and money to separate the active cranberry bogs from EDB-contaminated waters, what if Ocean Spray continues to not buy the berries in the future, either because of actual contamination or market perception? Will the federal government then compensate the town of Mashpee and the grower, and for how long, further increasing the cost of the pilot test? If the bog cannot be an active cranberry bog, will the federal government be responsible for managing the transition from an active to inactive bog system, including its associated costs? This kind of transition can be expensive.

5. The JPAT wants to ensure that there is a detailed trout habitat mitigation plan in place for any alternative that is selected. The manipulation of a sensitive ecological system by habitat alterations, groundwater drawdowns, surface water discharges and siltation during construction has in the past and may in the future impact wild brook trout and other fisheries. The town, cranberry growers, and the IRP must coordinate efforts to ensure that brook trout and other fisheries habitat in the Quashnet River is protected.

6. The JPAT is very concerned about the possible failure of the berms. It is our understanding that the peat in the bog beneath the newly constructed berms is subsiding. This potential failure of the berms may

have significant adverse impacts on fish habitat and health. The JPAT recommends that the current and potential future subsidence be monitored very carefully and contingency plans be developed if the new berms continue to subside and adversely affect both the bog/river separation and the trout fishery.

7. The JPAT is concerned about the potential impacts of the plume and the remedial alternatives on the potential public water supply well, P11. The JPAT understands from a presentation by John Masterson of USGS that, under certain conditions, the proposed P11 well could pull in a portion of the FS-1 plume. The P11 well site should at least be considered "threatened" at this time. The JPAT requests to see further modeling runs to further clarify this issue prior to any IRP decision on the final remedial design. Ideally, the Air Force would compensate the town for the loss of this well and also help to put adjacent private well users on Town water. The entire underdeveloped area over, near, or threatened by FS-1 should be considered a potential public water supply source.

8. The lifecycle costs of alternatives should be consistent with how long they are expected to be in operation. Some systems are expected to clean-up faster than others, thus their lifecycle costs may be less.

9. JPAT has a concern about the quantity and quality of surface water discharged from the treatment system and its potential impacts on the ecological and hydrology of the area. Various options for surface discharge, reinjection and location of reinjection should be considered and analyzed, including the impacts of different discharge options on the natural hydrological fluctuations in the area.

10. JPAT would like the IRP to consider various treatment options, including modular treatment plants with reinjection on or near the extraction locations. The JPAT requests to review the treatment options, including their expected location, developed by the IRP as part of the final remedial design.

QUESTIONS

1. Are there concentrations of contaminants that do not upwell into the bogs, but flow under and move past the bogs, resulting in contamination further downgradient?

2. Why is the human cancer risk estimated to be higher than the fish cancer risk, given the EDB concentrations are the same and human cancer risks are based on animal studies?

3. The JPAT is concerned about the concentrations of EDB that will continue to upwell in the bogs despite the active treatment system. What

will be the concentration of EDB that will continue to upwell into the bogs and/or river system? What will be the impacts of surface water discharges of EDB on humans, fish, and cranberries, in terms of potential chronic and acute affects?

4. Given that EDB will continue to upwell in the bogs, the JPAT is concerned about potential air-borne concentrations of EDB and potential human health impacts. What are the likely ambient air concentrations of EDB? Will there be air monitoring as part of the system monitoring plan?

5. What is the effect on the concentrations of EDB in various parts of the bog as the pilot test wells are turned on and off? Will EDB concentrations in any of the pilot test monitoring wells increase in concentration over time rather than decrease, as desired?

0 July 1999
Mr. Jim Snyder
Remedial Program Manager
HQ AFCEE/MMR
322 East Inner Road
Otis ANGB, MA 02542

Dear Mr. Snyder

The Massachusetts Military Reservation Natural Resource Trustee Council (the council) is pleased to submit these comments on the Proposed Plan for Clean-Up Related to FS-1 dated June 1999. The Trustees are submitting these comments per their Memorandum of Agreement Section II: Objective D-"Work to coordinate and integrate their activities with the ongoing IRP as appropriate and feasible"

The comments provided in this letter and the attached report are not intended to be part of any natural resource damage assessment or restoration plan for MMR, and the Council is not binding itself to these comments for future assessment and restoration planning purposes. Rather, these comments are submitted in satisfaction of the second of the Council's dual goals, that of providing timely input to the IRP and the community on ongoing remedy selection and other issues based on currently available information

Based on our limited review of available information, the council believes that Alternative 3B is the best of the alternatives considered by the Air Force in their Feasibility Study. Given that this design is conceptual in nature only, the Council does reserve final judgement until the Council reviews the finalized design. The Council notes that the FS-1 pilot test, which is a component of Alternative 3B, does enhance natural resources by separating stream habitat from active cranberry agricultural operations. Please not that given the time and information available, the Council was not able to determine if the FS-1 pilot test best balances the natural resource impacts of construction, contamination removal, and operations.

More specifically, the Council recommends the following:

The Council is particularly concerned about the trade-offs inherent in the destruction of upland woodland to create compensatory cranberry bog. Such a replacement project may pose unintended but significant natural resource impact. The Council recommends that the Air Force MMR IRP conduct the appropriate level of environmental analysis for the new bog area including alternative siting and consideration of trade-offs, including any additional field work necessary t conduct the analysis.

For any construction that remains to be done or will be carried out over the life of the remedial system, the Air Force MMR IRP program should incorporate best management practices (BMP) during construction and operation. For example, the potential impacts of ETR construction, including the axial well fence, piping, access roads, and utility corridors, can be minimized

through limiting clearing and grading. In addition, proper erosion and sedimentation barriers should be maintained (silt fences ad haybales)

Upon completion of the Pilot Test, the Air Force MMR IRP program should carefully evaluate the impacts of the Pilot Test discharge system (i.e., a bubbler system) on the trout fishery in close consultation with the EPA, DEP, and the Commonwealth's Department of Fisheries and Wildlife. At this time, the IR and appropriate regulatory agencies should consider and alternative discharge system would better protect and or enhance the trout fishery

The Air Force MMR IRP program should continue the monitoring program designed to maintain the aquatic habitat of the bog ditches beyond the one year pilot test for a period of three to five additional years. The extension of monitoring would provide a more comprehensive understanding of the optimum water levels and developing stream habitats.

The IRP should carefully evaluate the impacts of a power failure on the discharge of groundwater to surface water to ensure that the trout fishery would not be adversely affected. If a power failure occurred, there could be a lag time between treated water discharge and natural water upwelling. Currently, either the natural upwelling or treated water discharge provide lower temperatures and higher dissolved oxygen in the K1 bog. If a potential power failure will result in adverse impacts to the trout fishery, then appropriate contingency measures, such as a back-up power source for the treatment system, should be put in place.

The IRP should provide for streamside plantings with woody vegetation along the newly created "edge" between the berms and the bog ditch in the K2 bog to provide shade and cover for aquatic biota and fisheries, consistent with the Mashpee Conservation Commission requirements. The action of boulders, log flow deflectors, and excavation of silt and organic sediments would further improve the stream habitat

While the following activities may or may not fall within the purviews of appropriate CERCLA-funded remediation activities, the Council recommends consideration be given to the following natural resource enhancements.

Streamside planting with woody vegetation below the current remediation effort along the Quashnet River to provide shade and cover for aquatic biota and fisheries.

Streamside plantings with woody vegetation above the current remediation effort along the Quashnet River to provide shade and cover for aquatic biota and fisheries.

Replacing and/or improving the Johns Pond fish ladder to improve fisheries habitat

Should you have any questions regarding these comments, please contact either Bruce Leighton at (210) 536-3907, or Dale Young at (617) 727-9800 x261.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Admin.
National Ocean Service
Office of Response a[illegible]
c/o EPA Office of S[illegible] Remedi[illegible]ion an[illegible]toration (HIO)
1 Congress Stre[illegible]
Boston, MA 02[illegible]
4 June 1999

RECEIVED

HQ AFCEE/MMR
Attn: FS-1
322 East Inner Road
Otis ANGB, MA 02542-5028

Dear Sir/Madam:

Thank-you for the Proposed Plan for site remediation related to the FS-1 groundwater plume and source area, MMR Superfund site, dated June 1999. NOAA is in general agreement with the preferred alternative that includes extraction, treatment and reinjection/discharge of the contaminated ground and surface water that is presently operating in the Quashnet River cranberry bogs.

As discussed in NOAA's review of the Remedial Investigation (RI), the FS-1 plume flows south and discharges to the Quashnet cranberry bogs east of Johns Pond. The Quashnet River flows into Waquoit Bay, approximately 8 km south of Johns Pond. Waquoit Bay is within the Waquoit Bay National Estuary Research Reserve Program, which encompasses some 1,000 hectares of open waters, barrier beaches, marshlands, and uplands. Natural resources of interest to NOAA (NOAA trust resources) are found in Waquoit Bay and include alewife, American eel, blueback herring, cunner, tautog, tomcod, winter flounder, bay scallop, blue crab, quahog, and softshell clam. In addition to land within the Reserve, the Reserve also manages a 140-hectare tract of land along the banks of the Quashnet River, a restored trout stream. Parts of the Reserve are included in the newly designed Mashpee National Wildlife Refuge.

The results of the RI for FS-1 indicated that an EDB groundwater plume extends from the site to the Quashnet River, but only very low concentrations of EDB are found in the river. These results also indicate that risks to aquatic receptors within the Quashnet River are likely very low. From this information, it may also be inferred that risks to NOAA trust resources found in Waquoit Bay due to exposure to site-related contaminants are also very low. This is further confirmed by the letter report from the Massachusetts Department of Public Health that indicated that clams collected from Waquoit Bay did not have detectable concentrations of EDB. However, in 1997, the Massachusetts Department of Public Health collected fish from the Quashnet Rivers. Brook trout and white sucker were collected and their tissues analyzed for EDB. Test results indicated EDB in brook trout at 0.12 mg/kg and 0.13 mg/kg in white sucker from the Quashnet River.

Division of Fisheries & Wildlife

Louis S. Hambly, Jr., *Manager*

June 25, 1999

Jim F. Snyder
Remediation Program Manager
HQ AFCEE/MMR
322 East Inner Road, Box 41
Otis ANGB, MA 02542-5028

RECEIVED

Re: Proposed plan for cleanup related to FS-1

Dear Mr. Snyder:

The Massachusetts Division of Fisheries and Wildlife remains concerned about the proposed plan for the cleanup of the ethylene dibromide from Fuel Spill 1. The alteration of groundwater hydrology and surface water discharge of treated water to a sensitive ecological area, (i.e. wild brook trout habitat) continues to remain a concern. These concerns have been heightened by problems with the Quashnet River pilot test including construction siltation, the March 5 fish kill and the early June stream bed raising due to berm construction and other potential future problems (i.e. system failure during a stressful environmental period).

The groundwater flow to the upper Quashnet River (which also contains the EDB) was the key factor that allowed wild brook trout spawning to occur despite the negative impacts of cranberry bog operations on brook trout habitat. AFCEE is now altering this key factor in order to control the EDB contamination of the surface waters of the Quashnet River. Mitigation for alteration of this vital habitat component must include habitat improvements to other physical factors in the existing environment to improve the long term habitat for brook trout.

This is one of the most sensitive ecological environments that the cleanup of contamination from the Massachusetts Military Reservation will impact. Appropriate funds to protect the ecological integrity of this area must be devoted to protecting and improving the fisheries habitat of the Quashnet River.

We remain concerned about future impacts of this project on the wild brook trout population of the river. Maintenance of the berms and attention to protection of the fisheries resources must be continued throughout the length of this project. Protection of the sensitive ecological resource of the Quashnet River fisheries resources must be a priority with AFCEE and its contractors, i.e. Jacobs Engineering. This protection has been inconsistent in the past. This project requires overview by personnel with ecological insight as well as a strictly engineering approach.

Sincerely,

Steve Hurley

Steve Hurley
Southeast District Fisheries Manager

Southeast Wildlife District
195 Bournedale Road, Buzzards Bay, Massachusetts 02532 (508) 759-3406
An Agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement

Because EDB was found in Quashnet River fish, albeit at low concentrations, NOAA urges that the Air Force include fish tissue analyses to the future long-term monitoring program. Such a monitoring plan is not included in this proposed plan; NOAA would appreciate reviewing this document when it comes available.

Please contact me if you have any questions.

Sincerely,

Kenneth Finkelstein, Ph.D.

cc: Mr. Michael Jasinski (EPA)
Mr. Robert Lim (EPA)

Appendix D

APPENDIX D
TRANSCRIPT OF PUBLIC HEARING

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1 MASSACHUSETTS MILITARY RESERVATION

2 INSTALLATION RESTORATION PROGRAM

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5 ----------x
In Re: FS-1 Proposed Plan :
6 :
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10 Mashpee Town Hall
16 Great Neck Road
11 Mashpee, MA 02649
Wednesday June 23, 1999
12 6:55 p.m.

13

HEARING OFFICER:

14

Douglas Karson

15

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18

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21

22

23 MARY E. PHILLIPS
Registered Professional Reporter
P.O. Box 160
24 Sagamore Beach, MA 02652
(508) 888-6717

25

1 ATTENDEES:
(Partial list)
2
3
4 Douglas Karson
5
6 Jim Snyder
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8 Bill Jonnston
9
10 Bud Hoda
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1 P R O C E E D I N G S

2 MR. KARSON: We are now starting the public
3 hearing portion of the meeting. And the official
4 record is now open.
5 My name is Douglas Karson. I'll be the
6 hearing officer for the Fuel Spill 1 Proposed Plan
7 tonight.
8 The purpose of this hearing is to accept
9 all comments on the Proposed Plan of Fuel Spill 1
10 groundwater plume.
11 At this time I would like to ask if anyone
12 here in attendance would like to provide oral
13 comments on the proposed plan.
14 (No response.)
15 Again, I would ask if anyone wishes to
16 offer oral comments on the Proposed Plan Fuel Spill 1
17 groundwater plume.
18 (No response.)
19 MR. KARSON: If there are no further
20 comments to be made then I shall now close the
21 official record for oral testimony. The record is
22 now closed.
23 (Whereupon the hearing concluded
24 at 6:56 p.m.)
25

C E R T I F I C A T E

I, MARY E. PHILLIPS, Registered Professional Reporter, do hereby certify that the foregoing transcript, pages 2 through 4 inclusive, was taken by me stenographically and thereafter under my direction was reduced to typewriting and is a true record of the testimony of the proceedings to the best of my ability.

Dated at Bourne, Massachusetts, this 30th day of June, 1999.

MARY E. PHILLIPS, RPR

Appendix E

APPENDIX E
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION LETTER OF CONCURRENCE

(Available at time of distribution of Final Record of Decision)

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
20 RIVERSIDE DRIVE, LAKEVILLE, MA 02347 508-946-2700

ARGEO PAUL CELLUCCI
Governor

JANE SWIFT
Lieutenant Governor

BOB DURAND
Secretary

LAUREN A. LISS
Commissioner

May 15, 2000

Gary M. Erickson, P.E., Director
HQ AFCEE/CC
3207 North Road
Brooks Air Force Base
San Antonio, TX 78235

RE: BOURNE--BWSC-4-0037
Massachusetts Military Reservation,
Final Record of Decision
Area of Contamination FS-1,
Concurrence

Patricia L. Meaney, Director
Office of Site Remediation
U.S. EPA Region I
JFK Federal Building
Boston, MA 02203

Dear Mr. Erickson and Ms. Meaney:

The Department of Environmental Protection (the "Department") has reviewed the "**FINAL RECORD OF DECISION AREA OF CONTAMINATION FS-1**" at the Massachusetts Military Reservation ("MMR") dated April 2000 and prepared by Hazardous Waste Remedial Actions Program for the Air Force Center for Environmental Excellence (AFCEE).

The Record of Decision (ROD) describes remedial actions to be taken by the Installation Restoration Program (IRP) to address groundwater and surface water contamination associated with the FS-1 plume.

The FS-1 source area is located within the flight line area of the Otis Air National Guard Base and includes the Eastern Aircraft Turnaround (EAT) and the Western Aircraft Turnaround (WAT) in the southeastern portion of the MMR. The area was used to test aircraft fuel dump valves between 1955 and 1970. The FS-1 plume extends south from approximately 2,000 feet downgradient of the source area to an upwelling point at the Quashnet River where groundwater discharges to surface water. Results from the remedial investigation indicate that the source area groundwater is contaminated with toluene, thallium and lead. The downgradient groundwater and surface water is contaminated with ethylene dibromide (EDB) at concentrations that pose a risk to human health. Soil and sediment at the FS-1 source area do not contain contaminants at levels that pose a risk to human health or the environment. Therefore, no further action is necessary for surface soils at the FS-1 source area.

The AFCEE plans to conduct the following remedial actions:

- Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge (ETR/D); and
- Source Area Groundwater Monitoring.

The remedial action includes long term monitoring of the source area groundwater, groundwater extraction and treatment at the leading edge and along the axis of the plume, and institutional controls to prevent the usage of the contaminated portion of the aquifer during cleanup. The remedial action is intended to aggressively capture the FS-1 plume through axial extraction and continued operation of the pilot test ETD at the leading edge which intercepts the plume before it discharges to the Quashnet River and bogs. The remedial action is one aspect of the overall cleanup strategy for MMR which encompasses the following goals:

- 100% capture of the plume if feasible, where a plume is defined as groundwater contaminated above maximum contaminant levels (MCLs) as defined by multiple samples from multiple wells. In the absence of MCLs, a risk based level will be established; and
- treatment of contaminants and cleanup of the plume to background levels, if technically and economically feasible.

The following three-step process has been agreed to for groundwater cleanup at the MMR due to the unique circumstances presented by the location of the FS-1 plume within the sole-source aquifer on Upper Cape Cod. The AFCEE has agreed that for the active remedy at the FS-1 plume, the following steps will be taken:

1. Remediate the aquifer to federal and state drinking water standards or other risk-based cleanup levels;
2. When maximum contaminant levels (MCLs), Massachusetts MCLs (MMCLs) or other risk-based cleanup levels are achieved and before the system is shut off, perform a risk assessment to determine if unacceptable ecological and/or human health risks are present; continue system operation and/or pursue additional measures as required to achieve acceptable risks; and
3. Once acceptable risks have been achieved, evaluate the technical and economic feasibility of additional remediation to approach or achieve background concentrations.

The Department concurs with the Record of Decision. The Department's concurrence is based upon representations made to the Department by the AFCEE and assumes that all information provided is substantially complete and accurate. Without limitation, if the Department determines that any material omissions or misstatements exist, if new information becomes available, or if conditions at the Study Area change, resulting in potential or actual human exposure or threats to the environment, the Department reserves its authority under M.G.L. c. 21E, and the Massachusetts Contingency Plan, 310 CMR 40.0000 et seq., and any other applicable law or regulation to require further response actions.

Please incorporate this letter into the Administrative Record for FS-1. The Department looks forward to working with you to expedite the cleanup at the MMR. If you have any questions regarding these comments, please contact Leonard J. Pinaud at (508) 946-2871.

Sincerely,

Paul A. Taurasi, P.E.
Regional Director

P/MCK/mw
Fs1rodconcur.ltr

Cc: DEP-SERO
ATTN: Millie Garcia-Surette, Deputy Regional Director
Leonard J. Pinaud, Chief, Federal Facilities Remediation Section

Distributions:
SERO
SMB
Plume Containment Team
Public Information Team
Long Range Water Supply PAT
Boards of Selectmen
Boards of Health

Appendix F

APPENDIX F
COST ANALYSIS

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ESTIMATED COST
FS-1 FEASIBILITY STUDY
ALTERNATIVE 2B
LEADING EDGE EXTRACTION, TREATMENT, AND REINJECTION/DISCHARGE

Direct Cost of Limited Action with Bog Seperation Activities.			
A: Administrative Costs, Institutional Controls			$250,000
B: Capital Costs			
1. Treatment Facility Construction	$2,355,000		
2. Extraction/ Injection System	$587,000		
3. Berms	$1,010,000		
Total			$3,952,000
C: Well Sampling, Source Area			$15,000
Operating and Maintenance Costs 1- 11 (includes 5% annual inflation)			
A: Treatment Facility O&M: Years 1- 11	$4,731,000		
B: Longterm Groundwater Monitoring: Years 1 - 11	$615,000		
C: System Effectivenss Monitoring: Years 1 - 11	$142,000		
D: Five Year Reviews: 5, 10 years	$55,000		
Total O&M costs Years 1 - 11		$5,543,000	
Present Worth O&M @ 7%			$5,206,000
Alternative 2B: Present Value Cost			$9,423,000

Note: Alternative 2B includes the pilot test system and therefore the costs of the system were capitalized under the cost estimate for Alternative 2B. Because the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.

ESTIMATED COST
FS-1 FEASIBILITY STUDY
ALTERNATIVE 3
AXIAL WELL EXTRACTION/TREATMENT/REINJECTION

Direct Cost of Extraction/Treatment/Reinjection			
A: Administrative Costs, Institutional Controls			$250,000
B: Capital Costs			
1. Property Acquisition	$340,000.00		
1. Treatment Facility Construction	$2,355,000.00		
2. Extraction/ Injection System	$1,681,000.00		
Total			$4,626,000
C: Well Sampling, Source Area			$15,000
Operating and Maintenance Costs (includes 5% annual inflation)			
A: Treatment Facility O&M: Years 1-7	$3,420,000.00		
B: Longterm Groundwater Monitoring: Years 1 -7	$353,000.00		
C: System Effectivenss Monitoring: Years 1 - 7	$81,000.00		
D: Five Year Reviews: 5 year	$24,000.00		
Total O&M costs Years 1 - 7		$4,041,000	
Present Worth O&M @ 7%			3,808,000
Alternative 3: Present Value Cost			$8,699,000

Note: Alternative 3 does not include the pilot test system and therefore the costs of the system were not capitalized under the cost estimate for Alternative 3. Please note however, that since the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.

ESTIMATED COST
FS-1 FEASIBILITY STUDY
ALTERNATIVE 3B
AXIAL AND LEADING EDGE EXTRACTION, TREATMENT AND REINJECTION/DISCHARGE

Direct Cost of Extraction/Treatment/Reinjection			
A: Administrative Costs, Institutional Controls			$250,000
B: Capital Costs			
1. Property Acquisition	$340,000		
2. Treatment Facility Construction	$3,260,000		
3. Extraction/ Injection System	$1,525,000		
4. Berms	$1,010,000		
Total			$6,385,000
C: Well Sampling, Source Area			$15,000
Operating and Maintenance Costs (includes 5% annual inflation)			
A: Treatment Facility O&M: Years 1- 7	$3,691,000		
B: Longterm Groundwater Monitoring: Years 1 - 7	$353,000		
C: System Effectivenss Monitoring: Years 1 - 7	$81,000		
D: Five Year Reviews: 5 year	$24,000		
Total O&M costs Years 1 - 7		$4,149,000	
Present Worth O&M @ 7%			$3,911,000
Alternative 3B: Present Value Cost			$10,561,000

Note: Alternative 3B includes the pilot test system and therefore the costs of the system were capitalized under the cost estimate for Alternative 3B. Because the pilot system has already been constructed and is operating, it should be understood that an estimated $1,597,000 in cost have already been expended by AFCEE on this system.