Massachusetts Military Reservation

PLUME RESPONSE PROGRAM

Final Record of Decision for Fuel Spill-12 Groundwater

September 2006

Prepared for:
AFCEE/MMR
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ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Environmental Excellence
ARAR	applicable or relevant and appropriate requirement
AS/SVE	air sparging/soil vapor extraction
AVGAS	aviation gasoline
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
COC	contaminant of concern
COPC	chemical of potential concern
DAD	dermally absorbed dose
DOD	U.S. Department of Defense
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ETR	extraction, treatment, reinjection
FFA	Federal Facility Agreement
FS	feasibility study
FS-#	Fuel Spill-#
ft msl	feet mean sea level
GAC	granular activated carbon
gpm	gallons per minute
HEAST	Health Effect Assessment Summary Table

ACRONYM AND ABBREVIATIONS

HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
IROD	Record of Decision for Interim Action
IRP	Installation Restoration Program
kg	kilograms
LUC	land use control
M	million
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
mg/kg-day	milligrams per kilogram per day
MMR	Massachusetts Military Reservation
MMCL	Massachusetts maximum contaminant level
MPP	Mashpee Pitted Plain
NCP	National Oil and Hazardous Substances Contingency Plan
NGB	National Guard Bureau
NPL	National Priorities List
O&M	operations and maintenance
OU	operable unit
PCE	tetrachloroethene
PCT	Plume Cleanup Team
PP	Proposed Plan
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act

ACRONYM AND ABBREVIATIONS

RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPM	remedial program manager
SF	slope factor
SI	site investigation
SPEIM	system performance and ecological impact monitoring
SWD	Sandwich Water District
USCG	U.S. Coast Guard
VOC	volatile organic compound
µg/L	micrograms per liter

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

The Massachusetts Military Reservation (MMR) on Cape Cod Massachusetts is located within the boundaries of the towns of Bourne, Mashpee, and Sandwich, and abuts the town of Falmouth. This site is listed on the National Priority List (NPL) as Otis Air National Guard/Camp Edwards in Falmouth, Massachusetts. This Record of Decision (ROD) addresses the groundwater at Fuel Spill-12 (FS-12). The Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) number for the MMR site is MA2570024487.

1.2 STATEMENT OF BASIS AND PURPOSE

This ROD presents the selected remedy for FS-12 groundwater, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendment and Reauthorization Act (SARA), and to the extent practicable, the National Oil and Hazardous Substances Contingency Plan (NCP). This decision is based on the Administrative Record for this site. Remediation of the source area was completed in 1998, and a post-closure source area sampling plan was implemented (AFCEE 2000b); therefore, this ROD will only address groundwater contamination.

The U.S. Department of Defense (DOD) (U.S. Air Force) is the lead agency for CERCLA remedial actions at the MMR. The U.S. Environmental Protection Agency (EPA), the U.S. Air Force, and the National Guard Bureau (NGB) are parties to the Federal Facility Agreement (FFA) (EPA et al. 2002) for this site. They, along with the Massachusetts Department of Environmental Protection (MassDEP), concur with the selected remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health and welfare and/or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The selected remedy for the FS-12 groundwater provides for continued active treatment of the FS-12 plume with the existing extraction, treatment, and reinjection (ETR) system. The objective of this remedy would be to continue to operate, maintain, and optimize the existing ETR system to expedite aquifer restoration and implement land use controls to prevent residential exposure to the FS-12 plume. The ETR system consists of extraction, treatment, and reinjection of groundwater following federal and state standards for the FS-12 contaminants of concern (COCs) as stipulated in the current Operation and Maintenance Plan. The remedy leaves open the possibility of modifying the treatment system to optimize the cleanup time frame. Most likely, modifications would be implemented using the existing extraction and reinjection wellfields, and could involve well packering (decreasing the effective length of the well screen through installation of a well packer), turning on or off existing extraction and reinjection wells, or adjusting flow rates. This remedy, however, does not exclude the possibility of adding system components, such as additional extraction wells, if deemed necessary. Modifications would be made for the purpose of improving treatment system operation and expediting plume cleanup. This remedy would also provide for chemical and hydraulic monitoring of the plume as long as active remediation continued. After active ETR becomes no longer effective at expediting plume cleanup, the Air Force Center for Environmental Excellence (AFCEE), with regulatory input, will cease operation of the ETR system and will continue to monitor the residual plume contamination until the remedial action objectives have been met. The monitoring of the plume would be conducted as part of the system performance and ecological impact monitoring (SPEIM) program. This remedy provides the flexibility of modifying the monitoring network as necessary to adequately monitor the FS-12 plume and optimize system performance. Land use

controls (LUCs) will prevent or reduce human exposure to contaminated groundwater. Five-year reviews will be performed to determine if the remedy is still appropriate and protective. A residual risk assessment and/or an evaluation of the technical and economic feasibility of additional remediation to approach background concentrations would be performed if deemed necessary.

1.5 STATUTORY DETERMINATIONS

The selected FS-12 groundwater remedy is protective of human health and the environment, complies with federal and Commonwealth of Massachusetts requirements that are applicable or relevant and appropriate requirements (ARARs) for the remedial action, utilizes permanent solutions to the maximum extent possible, and is cost-effective. The remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants, as a principal element through treatment). Because hazardous substances are expected to remain in the aquifer for a number of years above levels that allow for unlimited use and unrestricted exposure, five-year reviews will be conducted to ensure that the remedy continues to be protective of human health and the environment.

1.6 DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary (Section 2.0) section of this ROD. Additional information can be found in the Administrative Record for this site.

Contaminant of concern (COC) and its respective concentration.	Section 2.7.5
Baseline risk represented by the COC.	Section 2.7
Cleanup level established for the COC and the basis for this level.	Section 2.8
How source materials constituting principal threats will be addressed.	Section 2.2

Data Item	Location in Document
Current and reasonable anticipated future land use assumptions and current and potential future beneficial use of groundwater used in the baseline risk assessment and the ROD.	Section 2.6
Potential land and groundwater use that will be available at the site as a result of the selected remedy.	Section 2.8
Estimated annual and total present value costs, discount rate, and the number of years over which the remedy cost estimate is projected.	Tables 2-24 and 2-25 Section 2.11.3
Key factor(s) that led to selecting the remedy.	Sections 2.10.2, 2.12.3, 2.12.4

1.7 AUTHORIZING SIGNATURES

The foregoing represents the decision for remedial action for FS-12 groundwater by AFCEE and the EPA, with the concurrence of the MassDEP.

Approve and recommend for immediate implementation.

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

By: _____ Date: 15 Sept 2006

Paul A. Parker
Director

U.S. ENVIRONMENTAL PROTECTION AGENCY

By: _____ Date: 09/28/06

Susan Studlien
Director, Office of Site Remediation and Restoration

2.0 DECISION SUMMARY

The following sections describe the setting, potential risks, remedial action objectives, and alternative evaluation for remediation of the FS-12 groundwater.

2.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The MMR is listed on the NPL as Otis Air National Guard/Camp Edwards in Falmouth, Massachusetts. The CERCLIS number for the MMR site is MA2570024487. In accordance with Executive Order 12580, the DOD is the lead agency for remedial actions at the MMR. The MMR was formally added to the NPL in 1989. The FFA for the MMR site was signed in 1991 by the DOD, the EPA, and the U.S. Coast Guard (USCG)/Department of Transportation[1] (EPA et al. 2002). The Commonwealth of Massachusetts chose not to be a signatory to the FFA. In 1995, the FFA was amended to add the U.S. Air Force as the lead agent for the cleanup at MMR. The FFA, as amended, requires the U.S. Air Force to implement CERCLA requirements at the MMR (EPA et al. 2002).

The MMR occupies approximately 22,000 acres on Cape Cod (Figure 2-1) and consists of several operating command units: the Air National Guard, the Army National Guard, the Air Force, the USCG, and the Veterans Administration. Military training and maneuvers, military aircraft operations, and maintenance and support activities have resulted in past releases of hazardous materials at the MMR. FS-12 is located on the eastern side of the MMR (Figure 2-1 and Figure 2-2). The FS-12 groundwater plume was identified as Operable Unit (OU) ID01, GW Plumes/FS-12 in the EPA database.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Military use at the MMR began in 1911. The most intense periods of activity occurred from 1940 to 1946 and 1955 to 1970. Sources of contamination and chemical spills

[1] In 2000, the FFA was amended to remove the USCG/U.S. Department of Transportation as a signatory to the FFA.

resulting from a variety of military operations include motor pools, landfills, fire training areas, and drainage structures such as dry wells and drainage swales.

The MMR history consists of a series of complex interactions between various federal agencies and the Commonwealth of Massachusetts. In 1940, the U.S. Army signed a 99-year lease with the Commonwealth of Massachusetts for the use of the MMR. The Army transferred this lease to the Air Force in 1953 for the Otis Air Force Base portion of the military reservation, and the Army maintained a sublease for the 14,000-acre area on the base known as Camp Edwards. In 1974, the Air Force licensed the Massachusetts Air National Guard to use Otis Air Force Base, and in 1975, the U.S. Army licensed the Massachusetts Army National Guard to use and occupy Camp Edwards. On 05 March 2002, a law was enacted to designate the northern 15,000 acres of the MMR as protected conservation land dedicated for the purposes of water supply and wildlife habitat, at the same time allowing military training compatible with the environmental protection of the land. In 2003, the Commonwealth of Massachusetts extended the lease with the National Guard until 2052.

Activities resulting in CERCLA actions are summarized below. In 1982, the DOD initiated the Installation Restoration Program (IRP) at the Otis Air National Guard Base area of the MMR. The IRP at the MMR is funded by the Defense Environmental Restoration Account. The NGB was responsible for implementing the IRP at the MMR. In 1986, the IRP was expanded to include all potential hazardous waste sites at the MMR. In 1989, the MMR was formally added to the NPL. An FFA among the NGB, the EPA, and the USCG was signed in 1991 and has since been amended (EPA et al. 2002). The FFA provides a framework for EPA oversight and enforcement of the MMR investigations and cleanup activities and identifies a schedule for cleanup activities. A Community Relations plan is included as an attachment to the FFA. In 1996, the EPA Region I Administrator requested that the DOD provide a new management structure for the MMR IRP. In response to that request, the U.S. Air Force assumed the lead role in the execution of the IRP and assigned AFCEE to manage the program. Under Amendment 2, additional enforceable milestones and the Plume Response Decision

Criteria and Schedule were added to the FFA. More recently, the USCG has been removed from its status as a party to the FFA (Amendment 3 to the FFA). Amendment 4 added Section 7003 of the Resource Conservation and Recovery Act (RCRA) to the FFA in order to address contamination caused solely by petroleum releases that fall within the scope of the CERCLA "petroleum exclusion" described in the last sentence of CERCLA Section 101(14). In June 2002 Amendment 5 was signed and the CS-13 site was removed from the list of Study Areas and Areas of Contamination contained in Section 5.24 of the FFA. After investigation of the historical usage of the CS-13 site, it was removed based on a lack of evidence to indicate that any military component currently is or had been either an owner or operator of the site (i.e., real property comprising CS-13) as defined under CERCLA and the NCP.

The FS-12 groundwater plume originated from a break in a pipeline located along Greenway Road that occurred in 1972 (Figure 2-3). The operation of the pipeline was discontinued in 1973. The underground fuel line was clean-closed in place in 1997 in compliance with all State environmental laws and regulations.

In 1990 the plume was first detected when the Sandwich Water District performed some exploratory drilling for future municipal wells. In 1990 an expanded site investigation (SI) was conducted by Advanced Sciences, Inc. to characterize the nature and extent of the suspected groundwater contamination (ANG 1992). The expanded SI included installation of groundwater monitoring wells and a soil gas survey. Based on findings of possible significant risk, the Air National Guard expanded the SI to a remedial investigation (RI) and feasibility study (FS).

In January 1992 the FS-12 RI was initiated by Advanced Sciences, Inc. The RI reported that the Greenway Road pipeline was used to transport various aviation fuels. The pipeline extended approximately 11 miles from the south side of the Cape Cod Canal to the Otis Air National Guard Base flight line area. Part of this pipeline was constructed in the early 1960s by Standard Transmission Corporation and operated until 1973. As a

result of modeling conducted for the RI, the FS-12 spill was estimated to be about 70,000 gallons of aviation gasoline (AVGAS) (ANG 1995b).

During the RI, free product was found above the water table. The free product was identified as a diesel-like fuel, very likely Jet Propulsion Fuel-4 with traces of other components that are more characteristic of gasoline-based fuel. The free product contained xylenes, toluene, ethylbenzene, and benzene. No EDB was detected in the free product (ANG 1995b). Samples collected during the groundwater investigation contained high levels of EDB and benzene, as well as ethylbenzene, toluene, xylenes, naphthalene, and 2-methylnaphthalene. The highest concentrations detected during analysis for benzene and EDB were 1,600 µg/L and 597 µg/L, respectively. Chloroform and a variety of naturally occurring inorganic compounds were detected, but the distribution of these compounds did not match that of the fuel contamination (ANG 1995b).

The RI concluded that the break in the pipeline located along the on-base portion of Greenway Road was the source of the groundwater contaminants in the FS-12 plume. The FS-12 source area was defined as approximately 11 acres of contaminated soil, groundwater, and floating/free product. Fuel-related contaminants were detected in vadose zone soils to a depth of approximately 90 feet below ground surface in the source area. Groundwater contamination extended from the source area to approximately 5,000 feet downgradient.

On 28 June 1993 the FS-12 source area was subject to a time-critical removal action initiated by the NGB. In October 1995 construction began on a combined air sparging/soil vapor extraction (AS/SVE) system (AFCEE 2000b). The AS/SVE system consisted of compressed air supplied through 23 air sparging wells and withdrawn from 23 soil vapor extraction wells (Figure 2-3). An estimated total of 44,579 pounds of product was removed over a period of 29 months by the AS/SVE system. This total was approximately 11 percent of the estimated residual hydrocarbons. On 25 February 1998

the system was shut down because the remaining levels of contaminants in the source area could not be effectively addressed by the AS/SVE system (AFCEE 2000b).

The selected interim action for the FS-12 groundwater, documented in the Record of Decision for Interim Action (IROD) (ANG 1995a), consisted of extraction at the leading edge of the plume, treatment to remove volatile organic compounds (VOCs), and discharge of treated water back to the aquifer. The interim response action would also restrict groundwater use within impacted areas through imposition of institutional controls. The interim remedial action would intercept the FS-12 plume to prevent further downgradient movement.

The design for the interim response action for the FS-12 plume included 30 extraction wells and 30 reinjection wells to capture the FS-12 plume (ANG 1996). The contaminated groundwater would be treated by removing the VOCs and discharging the treated water to the aquifer through reinjection wells.

After review of the conceptual interim response action, it was determined that the remedy could not be implemented without a detrimental impact to the sensitive, affected ecosystems for the FS-12 plume, specifically Snake and Weeks ponds (TRET 1996). The approach to the plume containment strategy for FS-12 was revised as follows. The treatment system would include 25 extraction wells (AFCEE 1997). The groundwater would be extracted and transferred through double-walled high-density polyethylene pipe to a treatment plant. The facility's treatment process would consist of pH control; greensand filters to remove suspended solids, iron, and manganese; solids settling and collection facilities; an ultraviolet/oxidation system to remove a large portion of the organic compounds; and a granular activated carbon (GAC) filtration system to remove contaminants. The extraction wells would be arranged across the toe of the southern extent of the FS-12 plume and in an axial arrangement intercepting the central portion of the plume with the highest contaminant concentrations (Figure 2-3). After treatment, the

water would be returned through 23[2] reinjection wells. These reinjection wells would be placed downgradient of the extraction toe fence and west of the axial wells near the eastern shore of Snake Pond. The revised design was implemented and on 18 September 1997 the FS-12 treatment system began operation.

In June 1998 an investigation was initiated to determine the nature and extent of contamination downgradient of the southern toe extraction fence and to evaluate the need for additional extraction wells downgradient of the toe fence (AFCEE 2000a). The investigation included installation of monitoring wells and a focused risk evaluation on the uncontrolled downgradient transport of FS-12 contamination. The results of the investigation concluded that the FS-12 plume front residuals presented no unacceptable risk to human health and additional extraction wells to capture this contamination were not necessary. Routine monitoring since then has shown that the groundwater downgradient of the toe fence no longer has detectable concentrations of EDB.

Operation of the FS-12 ETR system has been optimized during the years of operation. Optimization has included changes in flow rates, changes in operation of specific extraction wells and reinjection wells, packering of extraction wells, and conversion of a reinjection well to an extraction well. Currently 16 extraction wells and 20 reinjection wells are operating at a total flow rate of 680 gpm (Figure 2-3).

In support of reaching a final ROD for FS-12, a risk assessment was performed (AFCEE 2005b) using data collected from the ongoing SPEIM program to characterize the current plume and assess potential risks from exposure to the groundwater in the FS-12 plume area. Based on the risk assessment, remedial action objectives (RAOs) were established, which formed the basis of an FS. The FS evaluated a range of remedial alternatives, one of which was presented in the proposed plan and has been selected as the final remedy.

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[2] Reinjection wells 90RIW0001, 90RIW0002, 90RIW0003, and 90RIW0004 were designed to be placed north of Snake Pond, but this design was abandoned. Reinjection wells 90RIW0011 and 90RIW0012 were not installed because of the landowner's request. Reinjection well 90RIW0019 was not installed because its position on the toe fence was believed to interfere with the J. Braden Thompson plume.

2.3 COMMUNITY PARTICIPATION

The MMR IRP has a very robust community involvement program that provides many opportunities for the public to become involved in the investigation and decision-making process. Public meetings and poster board sessions are held, display ads are placed in newspapers to announce significant events and meetings, news releases are issued, tours of the sites and treatment facilities are conducted, neighborhood notices are distributed to notify people of events impacting their neighborhoods, and public notices of other kinds are issued.

In addition, several citizen teams advise the IRP and the regulatory agencies about the program. They include the Senior Management Board and the Plume Cleanup Team (PCT). These teams are made up of citizen volunteers and government representatives working together to resolve problems and complete the cleanup. All citizen team meetings are open to the public. Assumptions about reasonably anticipated future land use and potential beneficial uses of groundwater and surface water are regularly discussed by these teams.

The public has been kept up-to-date on the progress of the FS-12 site through various public and citizen team meetings and public notices. The following updates on the IROD to ROD process for sites addressed in this ROD were presented to the PCT:

- 11 September 2002: Overview of the *Draft Final Work Plan for the Process Leading to Final Groundwater Decisions for Eastern Briarwood, Western Aquafarm, Storm Drain-5, and Fuel Spill-12* (AFCEE 2002b).
- 12 November 2003: Overview of the FS-12 Risk Assessment and initial list of FS-12 Feasibility Study remedial alternatives.
- 10 December 2003: Overview of the list of FS-12 Feasibility Study remedial alternatives.
- 09 June 2004: Overview of the FS-12 Feasibility Study results.
- 14 September 2005: Proposed Plan for FS-12 (AFCEE 2005a).
- 12 October 2005: PCT input on Proposed Plan for FS-12 (AFCEE 2005a).

On 14 September 2005 a presentation of the FS-12 Proposed Plan (PP) was made to the PCT and on 12 October 2005 the team discussed their preferred alternative. On 27 October 2005, AFCEE held a public meeting at the Oak Cove Meeting Room Center to present the PP. From 28 October to 28 November 2005, AFCEE held a 30-day comment period to obtain public comments on the remedy presented in the PP for the FS-12 groundwater. Before the public comment period, the PP was mailed on 21 October 2005 to 1,500 residences in the area surrounding the FS-12 plume. On 17 November 2005, AFCEE held a public hearing at the Oak Cove Meeting Room to accept formal public comments on the PP. A transcript of the public hearing is provided in Appendix B. AFCEE's response to written comments received during the public comment period is included in the Responsiveness Summary, which is Section 3.0 of this ROD.

AFCEE published display advertisements for the public information meeting and public comment period (21 October 2005), and for the public hearing (11 November 2005) for the FS-12 PP in the *Falmouth, Mashpee, Bourne,* and *Sandwich Enterprises* and in the *Cape Cod Times*. AFCEE also circulated news releases for the public information meeting and public comment period (19 October 2005) and for the public hearing (08 November 2005). The PP was made available for public review at the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts and on the MMR website. The PP has also been made part of the Administrative Record available for public review at the AFCEE IRP office at the MMR and on the MMR website, http://www.mmr.org.

2.4 SCOPE AND ROLE OF OPERABLE UNIT

The FS-12 site was organized into separate OUs, focusing on source area and groundwater. The source area OU addresses the soil contamination. The FS-12 source area was remediated and a post-closure sampling plan for the source area was implemented (AFCEE 2000b). This ROD addresses the groundwater OU; and therefore, only the contamination in the groundwater is considered.

The FS-12 area is located along the eastern edge of the MMR where, through the IRP, AFCEE is responsible for the cleanup of contamination from past military practices. The NGB is actively investigating and remediating soil and groundwater contamination in the northern portion of the base (upgradient of the FS-12 site) as part of the Impact Area Groundwater Study Program.

2.5 SITE CHARACTERISTICS

As described in Section 2.2, environmental data have been collected from the FS-12 area since 1990. This overview of the site characteristics will focus on current site conditions.

The FS-12 site is located on a broad, flat, gently southward-sloping glacial outwash plain known as the Mashpee Pitted Plain (MPP) (Figure 2-1). The MPP consists of stratified outwash sand underlain by silty glaciolacustrine sediment. Some sections have remnants of gravel and basal till that overlie bedrock. The topography of the MPP gradually slopes from 140 feet mean sea level (ft msl) in the north to 70 ft msl in the south and is pocked with numerous kettle ponds. The elevation of the ground surface overlying the FS-12 plume ranges from 70 ft msl to 160 ft msl. Moraines bound the MMP to the west and north.

In the FS-12 plume area, there are silty deposits in the lower sections of the aquifer where hydraulic conductivities are lower and some plume contaminants are restrained. Several of these silty glaciolacustrine deposits have been identified in the location of the mapped bottom of the FS-12 plume. Below the silty lacustrine deposits, one generally finds bedrock. In some places, a poorly sorted glacial till can be found overlying the bedrock.

The single groundwater flow system that underlies western Cape Cod, including the MMR, is known as the Sagamore Lens. This sole-source aquifer is primarily unconfined and recharged by infiltration of precipitation. Groundwater flow is generally radial from the recharge area toward the ocean, which forms the lateral boundary of the aquifer on three sides; the Bass River in Yarmouth forms the eastern boundary of the Sagamore Lens. Flow direction within the aquifer is generally horizontal with stronger vertical

gradients near surface water bodies. Ponds are generally an expression of the water table and are hydraulically connected with the aquifer. Groundwater enters the upgradient portion of the pond, flows through the pond, and exits on the downgradient portion of the pond. Water table elevations fluctuate from 1 to 4 feet per year. The elevation of the water table is generally around 67 ft msl, and the aquifer thickness is approximately 210 feet thick in the FS-12 area.

2.5.1 Conceptual Site Model

The conceptual model for FS-12 is illustrated in Figure 2-4. The FS-12 plume originated at the source area. The leached contamination dissolved in the aquifer at the water table and was carried downgradient with the general groundwater flow in a south to southeasterly direction.

The FS-12 plume is defined by exceedances of the MMCL for EDB (MMCL = 0.02 µg/L). The EDB-contaminated portion of the FS-12 plume is fragmented into the following two zones, which have been delineated based on groundwater analytical data, evaluation of hydraulic data, groundwater modeling and discussions with the regulatory agencies: (1) a small area just south of the base boundary where EDB exceeds the MMCL at one monitoring well, and (2) the main plume (the large zone with the most mass, the axial extraction fence at its core, and bordered to the south by the southern toe extraction fence) (Figure 2-3).

The main body of the plume is 2,200 feet long, 1,400 feet wide, and up to 125 feet thick (AFCEE 2005c). The contamination is located from approximately 0 to -140 ft msl. The highest concentrations are located in the center of the plume (Figure 2-5). The highest EDB concentration in 2005 was 12.8 µg/L. The elevation of the small pod of above-MMCL contamination just south of the base boundary is from approximately 0 to –25 ft msl.

Benzene has historically been detected at concentrations above the MCL (benzene MCL = 5 µg/L), largely in the area between the source area and the northern extraction wells in the axial fence (Figure 2-6). The maximum benzene concentration in 2005 was 4.1 µg/L.

Total xylenes have historically been detected within the source area and occasionally within the plume. The maximum detected concentration was 2,900 µg/L (2001), which is below the MCL (total xylenes MCL = 10,000 µg/L). The total xylenes contamination is located at the water table and the concentrations fluctuate as the elevation of the water table fluctuates. The maximum concentration in recent sampling events has fluctuated from 490 µg/L (April 2005) to 2,219 µg/L (December 2005) to 1,128 µg/L (May 2006). The area of highest total xylenes concentrations is between Greenway Road and the MMR boundary.

Plume contaminants are dissolved in the groundwater and are transported downgradient with groundwater flow. In some areas, contamination is retained in low hydraulic conductivity units.

EDB is the predominant contaminant in the FS-12 plume and is predicted to persist at concentrations above the cleanup level longer than benzene or total xylenes. Since September 1997 the treatment system has been primarily responsible for the containment and attenuation of the FS-12 plume (Figure 2-5). The FS-12 ETR system was designed to provide total capture and prohibit further downgradient transport. If the FS-12 ETR system were to be turned off, the plume would likely continue to migrate downgradient and partially discharge into Mashpee-Wakeby Pond (Figure 2-2). Also, there may be some discharge of the plume to Snake Pond should operation of the treatment system be terminated.

2.5.2 Sampling Strategy

Groundwater samples have been collected in the FS-12 area at prescribed frequencies (minimum annual frequency) as part of the SPEIM program, which was initiated before the operation of the FS-12 ETR system in 1997. Over 100 monitoring wells have been

installed in support of monitoring the FS-12 plume, and over 2,400 samples have been collected since 1996. The sampling program was initiated as part of the interim remedy for FS-12 groundwater and, thus, is ongoing.

2.6 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

This section discusses the current and reasonably anticipated future land uses and current and potential beneficial groundwater uses in the vicinity of FS-12 contaminated groundwater, and presents the basis for future groundwater use assumptions.

2.6.1 Land Use

The on-base area of FS-12 groundwater contamination is undeveloped and not currently used for any military training purposes. The off-base area southeast of the MMR boundary in the FS-12 area is composed of undeveloped areas, a summer camp for children, residential areas, and a few commercial properties (Figure 2-2). It is anticipated that the land use in the FS-12 area will not significantly change over time.

2.6.2 Water Resource Use

There are no current groundwater uses at the FS-12 area. All of the residences in the area are connected to the municipal water supply. The aquifer throughout upper Cape Cod, also known as the Sagamore Lens, is generally highly transmissive and is a productive aquifer. The Sagamore Lens has been designated by the MassDEP as drinking water and by EPA as a sole source aquifer.

Surface water bodies, which are fed by groundwater, provide recreational use. Snake Pond is used for fishing, swimming, and boating.

AFCEE has developed a working relationship with the water commissioners of the four surrounding towns to ensure that future development of the groundwater resource is coordinated with groundwater monitoring and remediation at the MMR. The

groundwater may be utilized as a source of drinking water in approximately 25 to 45 years.

Southwest of the FS-12 plume area and west of Snake Pond, the Sandwich Water District (SWD) was operating a water supply well (Weeks Pond well, #5) (Figure 2-3). The SWD temporarily shut down the Weeks Pond well out of concern that continued operation might introduce FS-12 contamination into Snake Pond. The SWD may at some point in the future decide to add corrosion control and attempt to put the well back into service.

2.7 SUMMARY OF SITE RISKS

The risk assessment estimated the potential future risks posed by the present FS-12 groundwater contamination. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed. The technical approach of the risk assessment is detailed in the *Final Work Plan for the Process Leading to Final Groundwater Decisions for Eastern Briarwood, Western Aquafarm, Storm Drain-5, and Fuel Spill-12* (AFCEE 2002a). The risk assessment evaluated the human health risks from exposure to contaminated groundwater in the FS-12 area. An ecological baseline risk assessment was not conducted for FS-12 because of the lack of evidence of plume discharge to Snake Pond. Contaminated groundwater may discharge to surface water, but only a very small portion of the FS-12 plume could potentially discharge to Snake Pond. Extensive sampling over 10 years has not detected any FS-12 contaminants in the surface water because groundwater contamination upgradient of the pond is much lower than it was in the past. It is not expected that the discharge of FS-12 contamination would pose unacceptable risk to Snake Pond in the future even without the existing system. Although water that is presently located in the central portion of the FS-12 plume could plausibly discharge to Mashpee-Wakeby Pond in the future if the current FS-12 ETR system were shut down, modeling predicts the contamination would attenuate and water at the point of discharge is not expected to contain detectable levels of contamination.

This section of the ROD summarizes the results of the human health risk assessment and COC selection for FS-12 (AFCEE 2005b). A complete description of the methods and results of the baseline human health risk assessment for FS-12 is presented in Appendix A of the *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005b).

2.7.1 Identification of Chemicals of Potential Concern

The selection of chemicals of potential concern (COPCs) for inclusion in the quantitative human health risk calculations was typically based on three screening criteria:

- Frequency of detection,
- Compound concentration and toxicity, as compared to conservative risk and/or hazard-based concentrations,
- Essential nutrient status.

The concentration-toxicity screen was conducted by comparing site data with a series of federal and Massachusetts risk-based criteria. The maximum detected concentration was used in the concentration-toxicity screen.

For groundwater, the following screening criteria were used:

- EPA Region IX preliminary remediation goals (PRGs) for residential tap water (EPA 1999a),
- EPA MCLs,
- Massachusetts drinking water standards and guidelines.

PRGs for noncarcinogens were modified (PRG was multiplied by 0.1) such that the PRGs were based on a non-cancer hazard quotient (HQ) of 0.1 (EPA 1995). PRGs for carcinogens were based on a cancer risk level of 1×10^{-6} and were not modified for the screening. When more than one criterion was available for a chemical (PRGs, MCLs, state standards, and guidelines), the lowest of the available criteria was used in the concentration-toxicity screen.

Groundwater in the FS-12 risk assessment was evaluated in three separate subsets: on-base FS-12 groundwater, off-base groundwater within the FS-12 plume, and off-base groundwater outside the FS-12 plume. On-base groundwater was evaluated separately because it was anticipated that it would be helpful at the remedy selection point to understand the magnitude of risks posed by the relatively small area of FS-12 impacted groundwater that lies within the MMR boundary. The off-base groundwater within and outside the FS-12 plume was separated so that the risk from the groundwater outside the plume, with concentrations below the MCLs/MMCL, could be appropriately assessed. The tables presenting the screening process for identifying COPCs in each area are listed below:

- On-Base FS-12 Groundwater (Table 2-1)
- Off-Base Groundwater Within the FS-12 Plume (Table 2-2)
- Off-Base Groundwater Outside the FS-12 Plume (Table 2-3).

Table 2-1, Table 2-2, and Table 2-3 present the occurrence and distribution of compounds detected in FS-12 areas. For each detected chemical, these tables include the minimum and maximum detected concentration, the data qualifiers associated with these concentrations, the location of the maximum detected concentration, the frequency of detection, and the range of detection limits. The "J" qualifier indicates estimated concentrations.

2.7.2 Exposure Assessment

The exposure assessment identified potential exposure routes for the site, the pathways by which humans may be exposed to site contamination. Soil exposure pathways were not considered primarily because the source areas (soils) have been addressed by the IRP program as a separate OU. In addition, soil in non-source areas is not impacted by groundwater contamination. The only contamination at these sites is related to the migration of contaminants from the military base in groundwater.

Currently, there is no exposure to contaminated groundwater in the FS-12 area. However, that aquifer has been designated by the MassDEP as drinking water and by EPA as a sole source aquifer, and potential future exposure to groundwater in the FS-12 area was evaluated since it was assumed that residential use of groundwater could occur in the future. Potential exposure routes for these individuals are ingestion and dermal contact. VOCs could also be inhaled during household use of water.

The human health conceptual exposure model for the FS-12 area is illustrated in Figure 2-7. After identifying which human receptors would be evaluated in the risk assessment, the exposure point concentrations (EPCs) for each receptor were determined. A representative EPC was calculated for each COPC.

For groundwater, the reasonable maximum exposure (RME) EPCs were the maximum detected concentrations. For metals that were selected based on both dissolved and total concentrations, the EPCs were selected as the higher of the total or dissolved concentration.

The EPCs for each area/media are presented in the tables listed below:

- On-Base FS-12 Groundwater (Table 2-4)
- Off-Base Groundwater Within the FS-12 Plume (Table 2-5)
- Off-Base Groundwater Outside the FS-12 Plume (Table 2-6).

To quantitatively assess the potential carcinogenic risks and health hazards, daily intakes of the COPCs were calculated based on receptor-specific, site-specific, and chemical-specific exposure parameters. These exposure parameters may vary depending on the time frame, exposure medium, exposure point, and receptor population and age. Exposure assumptions and other parameters used in the chronic daily intake (CDI) or dermally absorbed dose (DAD) algorithms are presented for each receptor and exposure medium in the tables listed below:

- Future Adult Resident, Groundwater (Table 2-7)
- Future Child Resident, Groundwater (Table 2-8).

All of the parameters used in the CDI and DAD equations are presented in these tables, except for some chemical-specific parameters (e.g., dermal absorption factors and other calculated parameters used in the dermally absorbed dose calculations), which are presented in Appendix A of the *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005b).

2.7.3 Toxicity Assessment

At the time each risk assessment was prepared, toxicity values were obtained from EPA's most current versions of the Integrated Risk Information System (IRIS) (EPA 2003a) or the Health Effects Assessment Summary Table (HEAST) (EPA 1997), which are databases containing toxicity values for use in quantitative risk assessment. Cancer and non-cancer toxicity factors for each of the COPCs evaluated in the FS-12 risk assessment are presented in the tables listed below:

- Oral/Dermal Non-Cancer Toxicity Factors (Table 2-9)
- Inhalation Non-Cancer Toxicity Factors (Table 2-10)
- Oral/Dermal Cancer Toxicity Factors (Table 2-11)
- Inhalation Cancer Toxicity Factors (Table 2-12).

2.7.4 Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$Risk = (CDI \text{ or } DAD) \times SF$$

Where

Risk = a unitless probability of an individual's developing cancer

CDI = chronic daily intake (milligrams per kilogram per day [mg/kg-day])

DAD = dermally absorbed dose (mg/kg-day)

SF = slope factor $(mg/kg\text{-}day)^{-1}$

Carcinogenic risks are probabilities that usually are expressed in scientific notation (e.g., 1E-06). An excess lifetime cancer risk of 1E-06 indicates that an individual experiencing the RME theoretically has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an excess lifetime cancer risk because it would be in addition to the risk of cancer an individual faces from other causes such as exposure to too much solar radiation or radon. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. EPA's target risk range for site-related exposures is E-04 to E-06 (EPA 1991b).

Separate assumptions were used to calculate doses for adult and child residents, and then cancer risks for the adult and child were combined to represent total risks to residents for a 30-year exposure period.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level to which an individual may be exposed that is not expected to cause any deleterious effect. The ratio of exposure to toxicity, which is called a hazard quotient (HQ), is calculated as follows:

Non-cancer HQ = (CDI or DAD) / (RfD)

Where

CDI = chronic daily intake (mg/kg-day)
DAD = dermally absorbed dose (mg/kg-day)
RfD = reference dose (mg/kg-day)

The hazard index (HI) is calculated by adding the HQs for all COCs that affect the same target organ (e.g., prostate) within a medium or across all media to which a given individual may reasonably be exposed. An HI less than 1 indicates that, based on all of the different contaminants and exposure routes, toxic noncarcinogenic effects are unlikely (EPA 1991b). An HI greater than 1 indicates that site-related exposures may present a hazard to human health.

The tables listed below are the tables from the risk assessments that summarize the cancer and non-cancer risks to each receptor under the RME exposure scenario. Cancer and non-cancer risks that appear in these tables are limited to those for the COPCs that produced cancer or non-cancer risks at or near regulatory thresholds. Risks associated with COPCs that produced excess lifetime cancer risks less than 1E-06 or HQs less than 0.1 do not appear in these tables.

- Future Adult Resident, On-Base FS-12 Groundwater (Table 2-13)
- Future Child Resident, On-Base FS-12 Groundwater (Table 2-14)
- Future Adult Resident, Off-Base Within the FS-12 Plume (Table 2-15)
- Future Child Resident, Off-Base Within the FS-12 Plume (Table 2-16)
- Future Adult Resident, Off-Base Outside the FS-12 Plume (Table 2-17)
- Future Child Resident, Off-Base Outside the FS-12 Plume (Table 2-18)

The cancer risk calculations indicated that future residential exposure to FS-12 groundwater on-base and FS-12 groundwater off-base within the plume may present an excess lifetime cancer risk greater than the acceptable federal range of E-04 to E-06. The potential RME carcinogenic risk levels for the future residential exposure pathways are 6E-04 for FS-12 on-base, and 3E-02 for FS-12 off-base within the plume, and 1E-04 for FS-12 off-base outside the plume. The non-cancer hazard calculations indicated that residential exposure to FS-12 groundwater on-base and off-base inside the plume may present an unacceptable non-cancer hazard (Table 2-13, Table 2-14, Table 2-15, and Table 2-16). Three chemicals in off-base groundwater outside of the FS-12 plume were found to increase human health risks (Table 2-16 and Table 2-17). However, the concentrations of those chemicals were consistent with background levels.

The response action selected in this ROD is necessary to protect the public health or welfare of the environment from actual or threatened releases of contaminants from this site which may present imminent and substantial endangerment to public health or welfare. The RAOs for the FS-12 plume were developed to protect public health or welfare of the environment from groundwater contamination characterized by EDB

concentrations greater than the MMCL (0.02 µg/L) and benzene concentrations greater than the MCL (5 µg/L).

2.7.5 Uncertainty Analysis and Human Health Risk Assessment Conclusions

There are uncertainties involved in the process of quantifying the risk for human receptors, and overall they make the risk assessment very conservative. Exposure assumptions, slope factors, and oral-to-dermal adjustment factors are all very conservative. In the RME groundwater assumptions, the maximum concentrations of contaminants detected in groundwater were conservatively assumed to be present in all groundwater throughout the area for the entire 30-year period (neglecting contaminant degradation or plume movement). The assumption was also made that human exposure remains constant over the lifetime of an individual, when in fact, lifestyle changes due to age and actual time in residence will alter the projected exposure duration. Even the assumption that the groundwater in these areas would be used for household purposes is a conservative assumption. In light of the conservatism that was built into many of the factors used in the risk assessment approach, the results should be considered to be significant overestimates of actual risk.

COPCs for which an RME was calculated to result in an excess lifetime cancer risk greater than one in a million or an HI greater than 1 are presented in Table 2-19. From this list, the COCs were identified based on a range of criteria. Several COPCs were eliminated from inclusion as COCs because they met one or more of the following criteria:

- The detection frequency of the COPC at the site is low.
- The COPC concentrations decreased in more recent sampling rounds at the site. Six rounds of sampling have been conducted since the risk assessment was conducted.
- The COPC is present at the site at concentrations similar to background concentrations.
- The COPC is present only at concentrations below state and federal drinking water standards.

- Site-specific exposure assumptions used in the risk assessment were overly conservative considering the predicted persistence of the COPC and reasonably anticipated future land use.

In consideration of these criteria, for FS-12 the groundwater COCs are EDB and benzene. The contaminant-specific evaluations are presented in the risk assessment (AFCEE 2005b). Some of the more significant COPCs associated with potential risks are discussed below.

The FS-12 risk assessment identified toluene as a potential health risk based on a concentration of 10,100 µg/L measured in May 2002. The highest toluene concentration in FS-12 groundwater in 2005 was 33 µg/L. The highest concentrations of EDB, benzene, and tetrachloroethene (PCE) used in the risk assessment calculations were 23 µg/L, 54 µg/L, and 5.6 µg/L, respectively. These concentrations equated to excess lifetime cancer risks of 3E-02, 1E-04, and 8E-05, respectively, for the future residents under the RME scenario. The highest concentration of xylenes (total) used in the risk assessment calculations was 2,900 µg/L, which equated to an HI of 32 for a future child resident under the RME scenario. The most current (April 2005) maximum EDB, benzene, PCE, and xylenes (total) concentrations in FS-12 groundwater are 12.8 µg/L, 4.1 µg/L, nondetect, and 490 µg/L respectively. Based on the risk assessment and the current distribution in FS-12 groundwater, toluene, PCE, and xylenes (total) are not COCs because the concentrations of these chemicals have dropped to very low levels. However, EDB and benzene are COCs in FS-12 groundwater because the current maximum concentrations could conceivably pose unacceptable human health risks to a future resident.

2.8 REMEDIAL ACTION OBJECTIVES

Results of the human health risk assessment for FS-12 groundwater were considered in conjunction with expected current and future use of the aquifer to develop RAOs for the FS-12 groundwater OU.

There is no risk to ecological receptors. Therefore, the following RAOs for the FS-12 groundwater FS were developed to evaluate the alternatives with respect to protecting human health:

- Prevent or reduce residential exposure to FS-12 groundwater with benzene concentrations greater than the MCL of 5 µg/L.
- Prevent or reduce residential exposure to FS-12 groundwater with EDB concentrations greater than the MMCL of 0.02 µg/L.
- Return useable groundwaters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site.

The groundwater cleanup levels as specified in the RAOs are the MCL for benzene (5 µg/L) and the MMCL for EDB (0.02 µg/L)[3].

2.8.1 Basis and Rationale for Remedial Action Objectives

For human health concerns, the only media/exposure pathway that presents a cancer risk and/or a non-cancer HI above the target values is the future potential residential exposure to groundwater. A summary of the human health total non-cancer HIs and cancer risks for the FS-12 study area indicates that EDB and benzene increase risk and hazards associated with exposure to groundwater.

2.8.2 Steps to Achieving Remedial Action Objectives

MMR groundwater plumes, including the FS-12 plume, 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 RAOs. This three-step process will be implemented in the following manner:

[3] The FS-12 groundwater proposed plan (AFCEE 2005a) also had RAOs to prevent or reduce exposure to toluene and xylenes (total) in FS-12 groundwater. Current concentrations are below the MCL and equate to a Hazard Index of 8, which is protective given the specific circumstances of the operable unit.

1. **During the period that treatment systems are remediating the aquifer to federal and state drinking water standards or other risk-based cleanup levels, AFCEE will monitor the plume in accordance with an approved system performance monitoring plan.** The performance monitoring program will collect data for evaluating (a) whether the system is performing as designed, (b) whether the system is impacting ecologically sensitive areas, (c) the potential for short-term health effects due to exposures during active remediation, and (d) when the selected remedy will attain the remediation goals in the ROD.

2. **In accordance with applicable EPA guidance, perform a residual risk assessment(s) 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 residual risk assessment(s), if deemed necessary, to determine whether the COCs remaining in the aquifer continue to pose unacceptable ecological and/or human health risks. This risk determination shall be made jointly by AFCEE and EPA, in consultation with the MassDEP, and may result in aquifer cleanup that is more protective than the NCP point-of-departure risk of 10^{-6} [40 Code of Federal Regulations (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 risk levels 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 modification cannot remediate to a level of no significant risk, or to levels that 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 that approach or achieve background justifies related costs unless

        i. the incremental cost for the remedy is substantial and disproportional to the increased reduction of risk, 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 MassDEP, have also agreed that in the event that implementation of this process 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 MassDEP in accordance with the criteria set forth in EPA's *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents*, OSWER 9200.1-23P (EPA 1999b). In this manner, such changes will be subject to regulatory review and stakeholder involvement through issuance of a new PP and/or conduct of a public comment period. In the event that a dispute arises regarding any of the determination to be jointly reached under the process outlined above, such dispute shall be resolved under the dispute resolution procedure of the MMR FFA.

2.9 DESCRIPTION OF FS-12 ALTERNATIVES

Three alternatives were considered for the FS-12 groundwater action: (1) No Action, (2) Land Use Controls and Long-Term Monitoring, and (3) Continue Operating and Optimizing the Existing ETR System with SPEIM and Land Use Controls.

A component common to Alternatives 2 and 3 is LUCs. Several LUCs protect area residents from exposure to FS-12 groundwater contamination. The safety of all public water supplies within Massachusetts is currently regulated by the Commonwealth. Residents and workers on the MMR receive their water from the base water supply system that has wellhead treatment. All off-base residences within the FS-12 plume are currently connected to town water. The off-base LUCs will involve the ordinance implemented by the Sandwich Board of Health, which precludes the construction of new

potable supply wells for new buildings where Sandwich Water District Service is available (Appendix C).

2.9.1 Alternative 1 – No Action

The no-action alternative is required by the NCP (40 CFR 300.430[e][6]) to provide a baseline condition if no remedial action is taken. Under this alternative, no monitoring would be performed to assess the predicted natural attenuation of the FS-12 plume. EDB and benzene concentrations would eventually reach the cleanup levels through natural attenuation processes, but there would be no monitoring data to confirm this attenuation. Human health would remain protected by virtue of existing LUCs to which they were heeded. AFCEE would not check the adherence to LUCs under Alternative 1.

2.9.2 Alternative 2 – Land Use Controls and Long-Term Monitoring

No active remediation would occur with this alternative. As with Alternative 1, active remediation of FS-12 would cease when the ROD is signed. However, unlike Alternative 1, this alternative would provide for continued chemical monitoring of the monitoring wells in the surrounding network and LUCs to limit exposure. Continued monitoring and reporting would provide for

- Tracking FS-12 plume movement and attenuation; and
- Determining when COC concentrations have decreased to below the cleanup levels.

Monitoring would involve periodic testing of groundwater for EDB and benzene to measure the natural attenuation of the plume. Based on the model prediction of plume migration under this alternative, it would be necessary to install additional monitoring wells downgradient of the extraction fence in order to follow the plume movement. Monitoring results would be periodically reported in technical update meetings and formal reports. Groundwater monitoring would continue after the cleanup levels were met to ensure the aquifer had been restored. For cost-estimating purposes, it has been assumed that groundwater monitoring would continue for five years after the cleanup levels are met.

Under this alternative, this plume would be subject to the basewide CERCLA five-year review through the lifetime of the alternative. A residual risk assessment and/or evaluation of the technical and economic feasibility of additional remediation to approach or achieve background concentrations would be conducted, if deemed necessary, and would likely include additional data collection and analysis.

2.9.3 Alternative 3 – Construction, Operation, Maintenance, and Monitoring of the Existing FS-12 ETR System

This alternative would provide for continued active treatment of the FS-12 plume with the current ETR system. This alternative also includes LUCs to reduce exposure to contaminated groundwater.

This alternative allows for the modification of pumping scenarios to improve the cleanup time frame. Modifications would most likely be made to the existing extraction and reinjection wellfields and could involve optimizing the extraction interval through the use of inflatable packers, turning on or off extraction or reinjection wells, or adjusting flow rates. However, Alternative 3 does not exclude the possibility of adding additional system components, if deemed necessary. Modifications would be made for the purpose of improving treatment system options and expediting the plume cleanup. The potential exists for adding new extraction or reinjection wells, if necessary.

This alternative would also provide for chemical and hydraulic monitoring of the plume as long as active remediation continued, and chemical monitoring for five years after the cleanup levels are met. Hydraulic monitoring would be in the form of periodic water level measurements. Chemical monitoring would include periodic groundwater analysis for EDB and benzene. Monitoring data would aid in ongoing optimization and could prompt additional action if COC concentrations did not decrease as expected. Monitoring results would also provide data to update plume contours and verify groundwater modeling predictions. Monitoring results would be periodically reported at technical update meetings and in formal reports. Groundwater monitoring could continue after the cleanup levels were met to establish spatial and temporal verification of the

restoration. For cost-estimating purposes, it is assumed that monitoring will continue for five years after the cleanup levels are met. As the plume collapses, it is anticipated that new monitoring wells would need to be installed to accurately and effectively monitor the plume footprint and its attenuation. For cost-estimating purposes, it is assumed that one new monitoring well will be added to the wellfield every two years during system operation until all cleanup levels are met (year 2030). It is also assumed that the overall monitoring program will reduce in size due to the expected fewer number of monitoring points needed as the plume collapses.

Under this alternative, this plume would be subject to the basewide CERCLA five-year review through the lifetime of the alternative. A residual risk assessment would be conducted, if deemed necessary, and would likely include additional data collection and analysis.

2.9.4 Common Elements and Distinguishing Features of Alternatives

Alternatives 1 and 2 do not actively treat the FS-12 plume. Under both Alternatives 1 and 2, cleanup levels of the FS-12 plume would be reached primarily through natural attenuation. Under Alternatives 2 and 3, COC concentrations within and surrounding the FS-12 plume would be routinely measured, allowing for a check on modeling assumptions and verification of natural attenuation. Alternative 3 would actively treat the FS-12 plume via the existing ETR system. Existing on-base and off-base LUCs would remain under all three alternatives, but under Alternative 1 AFCEE would not enforce or check the adherence to LUCs. The performance of the three alternatives with respect to the threshold and primary balancing criteria is summarized in Table 2-20.

ARAR waivers would not be required with any of the FS-12 plume alternatives. Refer to the *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005b) for a complete listing of ARARs for each alternative and how individual alternatives would comply with them. ARARs for the selected alternative are listed in Table 2-21, Table 2-22, and Table 2-23.

Alternatives 2 and 3 rely on techniques and technologies that have been proven and employed at the MMR since 1997. Significant residual risk would not remain with any of the alternatives.

For Alternative 3, it was assumed that the existing ETR system would operate until approximately 2030. Based on modeling predictions, contaminant concentrations would be reduced below the cleanup level by approximately 2051 under Alternatives 1 and 2 and by approximately 2030 under Alternative 3. The estimated costs for Alternatives 2 and 3 are presented in Table 2-24.

2.9.5 Expected Outcomes of the Alternatives

Groundwater modeling indicates that under Alternatives 1 and 2 the plume moves southeast at concentrations higher than the MMCL approximately 4600 feet downgradient of the FS-12 toe extraction fence under residential neighborhoods in Sandwich and Mashpee as it approaches Mashpee-Wakeby Pond. The plume eventually attenuates to below-MMCL levels by approximately 2051. Under Alternative 3 the main body of the plume will be contained by the extraction fence, and concentrations decrease to below-MMCL levels by approximately 2030. Based on current and reasonably anticipated future land use, human health risks are acceptable under all of the alternatives. The existing Sandwich Board of Health regulations prevent exposure of residents to contaminated groundwater. However, Alternatives 2 and 3 offer additional assurance that residents and workers will not be exposed to the FS-12 plume through the implementation and monitoring of LUCs.

2.10 COMPARATIVE ANALYSIS OF FS-12 ALTERNATIVES

The following sections summarize the comparative analysis of FS-12 groundwater Alternatives 1, 2, and 3 presented in the *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005b).

2.10.1 Criteria For Detailed Analysis of Alternatives

The NCP (40 CFR, Part 300) presents nine criteria for analyzing the acceptability of a given alternative. These nine criteria are categorized as threshold criteria, primary balancing criteria, and modifying criteria. The performance of the three alternatives with respect to the threshold and primary balancing criteria is summarized in Table 2-20.

2.10.1.1 Threshold Criteria

There are two threshold criteria: overall protection of human health and the environment, and compliance with ARARs. Threshold criteria represent the minimum requirements that each alternative must meet to be eligible for selection.

Overall Protection of Human Health and the Environment This criterion assesses the overall effectiveness of an alternative and focuses on whether that alternative achieves adequate protection and risk reduction, elimination, or control. The assessment of overall protection draws on assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs Each alternative is assessed to determine whether it complies with ARARs under federal and state laws. Section 121(d) of CERCLA requires that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, unless such ARARs are waived under CERCLA Section 121(d)(4). Appendix D of the *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005b) outlines ARARs for all the FS-12 alternatives. ARARs for the selected alternative are listed in Table 2-21, Table 2-22, and Table 2-23.

2.10.1.2 Primary Balancing Criteria

The five primary balancing criteria are (1) long-term effectiveness and permanence, (2) reduction of toxicity, mobility or volume through treatment, (3) short-term

effectiveness, (4) implementability, and (5) cost. Primary balancing criteria form the basis for comparing alternatives in light of site-specific conditions.

Long-Term Effectiveness and Permanence Each alternative is assessed for its long-term effectiveness and the permanence of the solution. This criterion assesses the destruction or removal of contaminants, the magnitude of residual risks remaining at the conclusion of remedial activities, and the adequacy and reliability of controls to be used to manage residual risk.

Reduction of Toxicity, Mobility, or Volume Through Treatment Section 121 (Cleanup Standards) of CERCLA states a preference for remedial actions that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of contaminants as the primary element of the action. This criterion addresses the capacity of the alternative to reduce the principle risks through destruction of contaminants, reduction in the total mass of contaminants, irreversible reduction in contaminant mobility, or reduction in the total volume of contaminated media.

Short-Term Effectiveness This criterion addresses the effects of the alternative during construction and operational phases until remedial objectives are met. Each alternative is evaluated with respect to its (potentially negative) effects on community health, worker safety, and environmental quality during the course of remedial actions. This criterion also addresses the time required by each alternative until remedial objectives are achieved.

Implementability The implementability criterion is used to assess the technical and administrative feasibility of implementing an alternative. Technical issues include the reliability of the technology under consideration, potential construction difficulties, and the availability of required services, materials, and equipment (preferably from multiple sources). Administrative issues include permitting and access for construction and monitoring.

Cost Costs associated with carrying out an alternative are based on current (present day) information escalated at a rate of 5 percent until year zero; after year zero, costs are discounted at a rate of 3.5 percent (per Office of Management and Budget Circular A-94 [OMB 2004]). Cost estimates included in this document are intended for comparative purposes only. The accuracy of the estimates are between –30 and +50 percent.

2.10.1.3 Modifying Criteria

There are two modifying criteria: state acceptance and community acceptance.

State Acceptance The MassDEP has expressed its support for Alternative 3.

Community Acceptance The PCT unanimously supports Alternative 3. All of the comments received during the public comment period favored Alternative 3.

2.10.2 Comparison of FS-12 Groundwater Plume Alternatives

Alternatives 1, 2, and 3 were evaluated against the nine NCP criteria. The following sections present the evaluation.

2.10.2.1 Overall Protection of Human Health and the Environment

Risk from groundwater exposure has been mitigated by a municipal water supply to all residences within the FS-12 plume area. Based on current and reasonably anticipated future land use, human health risks are acceptable under all of the alternatives. The existing Sandwich Board of Health regulations prevent exposure of residents to contaminated groundwater. However, Alternatives 2 and 3 offer additional assurance that residents and workers will not be exposed to the FS-12 plume through the implementation and monitoring of LUCs.

2.10.2.2 Compliance with ARARs

All the alternatives are compliant with ARARs. The point at which chemical-specific ARARs are met would not be known under Alternative 1 since monitoring would not be performed. Monitoring would be performed under Alternatives 2 and 3 to determine when cleanup goals have been met. All construction, treatment, and monitoring activities would be performed in accordance with location-specific and action-specific ARARs.

2.10.2.3 Long-Term Effectiveness and Permanence

Alternative 3 would actively and permanently reduce the toxicity, mobility, or volume of the contaminants, and restore the aquifer to its beneficial use approximately 21 years earlier than under Alternatives 1 or 2. Removal would be performed with proven technology.

2.10.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 3 satisfies EPA's preference that active treatment be a principle element in site remediation. The model predicts that a total of 1.1602 kilograms (kg) out of the original 1.1608 kg of EDB depicted in the plume shell is accounted for through removal and decay, for a total of 99.95 percent mass removal. Contaminants are permanently removed from the aquifer. Regeneration of the GAC ultimately destroys the contaminants. The plume volume would decrease due to extraction and the plume would be contained by the FS-12 extraction system. Alternatives 1 and 2 do not employ active treatment, and under these alternatives, the plume would move southeast, at concentrations higher than the MMCL, approximately 4,600 feet downgradient of the FS-12 toe extraction fence under residential neighborhoods as it approaches Mashpee-Wakeby Pond. The plume volume would expand for a few years and all contaminant concentrations would eventually decrease below the MCL/MMCL through natural attenuation.

2.10.2.5 Short-Term Effectiveness

Alternative 1 has the least impact on workers, the community, and the environment since it does not require any monitoring, construction, or maintenance activities. Alternative 2 has limited impact on workers, the community and environment because it entails groundwater monitoring and monitoring well construction over its lifetime. Even though additional monitoring wells would be required, the risks associated with that work is considered low and would be easily controlled through training, safety procedures, and medical monitoring.

Alternative 3 has the greatest impact since it involves the operation of the existing FS-12 ETR system, installation of potential new monitoring wells, and system optimization. However, this impact is not new because the system has been operating since 1997. Since monitoring is already being conducted under the SPEIM program, there would be no new risks posed to the community, the workers, or the environment as a result of this activity under Alternative 3. It is assumed that additional monitoring wells would be required; however, the risks associated with that work is considered low and would be easily controlled.

2.10.2.6 Implementability

Alternative 1 would require no action. Therefore, there are no technical or administrative implementability concerns for Alternative 1. Alternative 2 would have limited technical implementability concerns because it would entail monitoring of the current groundwater network and installation of new wells with proven technologies. Alternative 3 should have no technical implementability concerns since the operation of the existing ETR system relies on proven technologies, including extraction wells, GAC filtration, and reinjection wells and because the FS-12 treatment facility has been operating since 1997 without significant technical difficulties.

Administrative implementability concerns for Alternative 2 and 3 include coordination with other agencies for technical update meetings, remedial program manager (RPM) meetings, and active communication on all issues of concern. Long-term access

agreements with private landowners and permitting issues are an administrative implementability concern where monitoring wells are being constructed.

2.10.2.7 Cost

Alternative 1 is the baseline scenario and, thus, no costs are associated with it. Alternative 2 includes capital costs (monitoring well construction) and periodic costs (monitoring and reporting). It is assumed for Alternative 2 that two new monitoring wells would be installed every four years until COCs reach cleanup levels. It is also assumed that monitoring would continue for five years once the cleanup levels are met. Periodic CERCLA five-year reviews and a final risk assessment are included in Alternatives 2 and 3. Alternative 2 has a present value cost of $6.3 million (M). Alternative 3 includes capital costs (monitoring well construction), annual costs (operations and maintenance [O&M] of the ETR system), and periodic costs (monitoring and reporting). Costs related to the construction of monitoring wells would be incurred from project year 2 to year 24, based on the assumed frequency of installation (one new monitoring well every two years during system operation) for plume tracking. Costs related to monitoring well installation and maintenance, sample collection, and groundwater analysis would be incurred throughout the project lifetime (year 2005 to year 2035). O&M costs would be incurred only as long as the ETR system is operational. Alternative 3 continues the active treatment approach to the FS-12 plume and has a present value cost of $22.4 M.

2.10.2.8 State Acceptance

The MassDEP has expressed its support for Alternative 3.

2.10.2.9 Community Acceptance

The PCT unanimously supports Alternative 3. All of the comments received during the public comment period favored Alternative 3.

2.11 SELECTED REMEDY FOR THE FS-12 GROUNDWATER OPERABLE UNIT

Based on the Administrative Record for the FS-12 site and the evaluation of comments received by interested parties during the public comment period, AFCEE has selected Alternative 3 as the remedy for the FS-12 groundwater OU.

2.11.1 Summary of the Rationale for the Selected Remedy

The selected remedy is Alternative 3, which consists of continued operation and optimization of the existing ETR system, monitoring, and LUCs. A full description of the selected remedy is provided below. The selected remedy provides for treatment of the plume via the existing ETR system, is protective of human health through implementation of LUCs, complies with ARARs, does not have any significant implementability concerns, and has minor impacts on worker safety, the community, and the environment. The preferred remedy was selected over the other alternatives because it is expected to achieve the RAOs in a reasonable time frame (approximately 25 years) and is cost-effective.

2.11.2 Detailed Description of Selected Remedy

The selected remedy would provide for continued active treatment of the FS-12 plume with the current ETR system. The objective of this alternative would be to continue to expedite aquifer restoration through use of the existing ETR system. The ETR system consists of extraction, treatment, and reinjection of groundwater following federal and state standards for the FS-12 COCs as stipulated in the current O&M plan. The alternative leaves open the possibility of modifying the treatment system to optimize the cleanup time frame. Most likely, modifications would be implemented using the existing extraction and reinjection wellfields and could involve well packering, turning on or off existing extraction and reinjection wells, or adjusting flow rates. This alternative, however, does not exclude the possibility of adding system components, such as additional extraction wells, if deemed necessary. Modifications could be made for the purpose of improving treatment system operation and expediting plume cleanup. This

alternative would also provide for chemical and hydraulic monitoring of the plume as long as active remediation continued and for chemical monitoring until the RAOs are met. Monitoring data would aid in ongoing optimization and could prompt additional action if COC concentrations did not decrease as expected. Monitoring results will be periodically reported in formal reports. CERCLA five-year reviews will be performed to evaluate remedy appropriateness and site status for as long as hazardous substances remain above unrestricted use levels in the groundwater. A residual risk assessment would be conducted, if deemed necessary, and would likely include additional data collection and analysis.

Groundwater from the FS-12 plume currently poses an unacceptable risk to human health if used for household purposes (i.e., ingestion, dermal contact, and inhalation of vapors released during household use of water). The FS-12 plume is located in the eastern part of the MMR off Greenway Road, and a portion of the FS-12 plume has migrated past the MMR boundary into the neighboring town of Sandwich. Therefore, administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use, known as "land use controls" (LUCs), must be established for this area of concern to avoid the risk of exposure to groundwater from the FS-12 area. These LUCs are needed both on-base and off-base, within the town of Sandwich, until the groundwater from the FS-12 plume no longer poses an unacceptable risk.

The performance objectives of the LUCs are:

- Prevent access to or use of the groundwater from the FS-12 plume until the groundwater no longer poses an unacceptable risk;
- Maintain the integrity of the current or future remedial or monitoring system such as treatment systems and monitoring wells.

The LUCs will encompass the area including the FS-12 plume (Figure 2-8) and surrounding areas to prevent a risk from exposure to the plume. The on-base area of concern is controlled and operated by the U.S. Army, which leases this land from the Commonwealth of Massachusetts. It is expected that these entities will operate and own,

respectively, the area of concern and the surrounding area for the duration of this ROD. As a result, the Air Force will coordinate with the Commonwealth of Massachusetts as the Air Force fulfills its responsibility to establish, monitor, maintain, and report on the LUCs for this site.

Each LUC will be maintained until either (1) the concentrations of EDB and benzene in the groundwater are at such a level to allow unrestricted use and exposure, or (2) the Air Force, with the prior approval of the EPA and MassDEP, modifies or terminates the LUC in question.

The Air Force is responsible for ensuring that the following two LUCs are established, monitored, maintained, and reported on as part of this final remedy to ensure protection of human health and the environment in accordance with CERCLA and the NCP for the duration of the final remedy selected in this ROD. The Commonwealth of Massachusetts only has enforcement authority regarding the second LUC. In the event that the Town of Sandwich fails to promptly enforce the first LUC or the Commonwealth of Massachusetts fails to promptly enforce the second LUC, the Air Force will act in accordance with the third to last paragraph in this section. For purposes of the preceding sentence, "promptly enforce" means if the violation or potential violation is imminent or on-going, enforce to prevent or terminate the violation within 10 days from the enforcing agency's (i.e. the Town or the Commonwealth) discovery of the violation or potential violation; otherwise, enforce as soon as possible.

1. To better protect the public health and welfare of its citizens, the Town of Sandwich Board of Health amended its private well regulations on 11 April 2005 to prohibit the construction of potable water supply wells for new buildings. For existing buildings, the Board of Health will not approve any new well to be used for human consumption until its water has been tested and the Board of Health has determined that the water is potable. The regulation, which is reproduced in Appendix C, covers documented and anticipated areas of contamination from the FS-12 plume. To assist the Town of Sandwich in the implementation of this LUC, the Air Force will meet with the Board of Health on an annual basis, or more frequently if needed, to provide and discuss plume maps that document the current and projected location of the FS-12 plume within the Town of Sandwich. While Figure 2-8 shows the current area of LUCs in the town, the Sandwich Board of Health may modify the areas where well use is

excluded, and this LUC will apply to such areas even if they differ from the area shown in Figure 2-8.

2. In addition to the Board of Health regulation, which generally applies to small water supply wells, existing LUCs also prevent the possible creation of a large potable water supply well. The MassDEP administers a permitting process for any new drinking water supply wells in Massachusetts that propose to service more than 25 customers or exceed a withdrawal rate of 100,000 gallons per day. This permitting process, which serves to regulate the use of the FS-12 plume for any withdrawals of groundwater for drinking water purposes, constitutes an additional LUC for this final remedy. This LUC applies to both on-base and off-base portions of FS-12.

Additionally, the Air Force is responsible for ensuring that the following LUCs are established, monitored, maintained, reported on, and enforced as part of this final remedy to ensure protection of human health and the environment in accordance with CERCLA and the NCP for the duration of this final remedy selected in this ROD.

1. For the on-base area of concern, a prohibition on new drinking water wells serving 25 or fewer customers has been established and placed on file with the planning and facilities offices for the Massachusetts Air and Army National Guard and United States Coast Guard (major tenants at the MMR). The prohibition will be applied to future land use planning per Air National Guard Instruction (ANGI) 32-1003, Facilities Board, Army National Guard Regulation 210-20, Real Property Development Planning for the Army National Guard, and Commandant Instruction Manual 11010.14, Shore Facility Project Development Manual.
2. For the on-base area of concern, the Air National Guard has administrative processes and procedures that require approval for all projects involving construction or digging/subsurface soil disturbance, currently set forth in ANGI 32-1001, Operations Management. This procedure is a requirement of the Army National Guard and the United States Coast Guard by the Air National Guard through Installation Support Agreements. The Air National Guard requires a completed AF Form 103, Base Civil Engineer Work Clearance Request (also known as the base digging permit), prior to allowing any construction, digging or subsurface soil disturbance activity. All such permits are forwarded to the Installation Restoration Program for concurrence before issuance. An AF Form 103 will not be processed without a Dig Safe permit number (see next paragraph).
3. The Dig Safe program implemented in Massachusetts provides an added layer of protection to prevent the installation of water supply wells in the FS-12 area and to protect monitoring wells and the treatment system's infrastructure. This program requires, by law, anyone conducting digging activities (e.g., well drilling) to request clearance through the Dig Safe network. The Air Force at the MMR is a member utility of Dig Safe. The FS-12 plume is encompassed by a geographical area identified by the Air Force as a notification region within the Dig Safe program.

Through the Dig Safe process, the Air Force will be electronically notified at least 72 hours prior to any digging within this area. The notification will include the name of the party contemplating, and the nature of, the digging activity. The Air Force will review each notification and if the digging activity is intended to provide a well, which has not been approved via the procedures above, the Air Force will immediately notify the project sponsor (of the well drilling), the EPA, the Sandwich Board of Health and the MassDEP, in order to curtail the digging activity. If the Dig Safe notification indicates proposed work near monitoring wells or treatment system infrastructure, the Air Force will mark its components to prevent damage due to excavation. This LUC applies to both on-base and off-base portions of FS-12. The extent of the Air Force's enforcement of this LUC does not address off-base parties failing to file a Dig Safe request nor Dig Safe improperly processing a notification, but if such incidents do occur, the Air Force is responsible for ensuring remedy integrity and, if necessary, repairing damage caused by third parties to the remedial system infrastructure or monitoring wells.

Monitoring of the environmental use restrictions and controls will be conducted annually by the Air Force. The monitoring results will be included in a separate report or as a section of another environmental report, if appropriate, and provided to the EPA and MassDEP for informational purposes. The annual monitoring reports will be used in preparation of the five-year review to evaluate the effectiveness of the final remedy.

The annual monitoring report, submitted to the regulatory agencies by the Air Force, will evaluate the status of the LUCs and how any LUC deficiencies or inconsistent uses have been addressed. The annual evaluation will address (i) whether the use restrictions and controls referenced above were effectively communicated, (ii) whether the operator, owner and state and local agencies were notified of the use restrictions and controls affecting the property, and (iii) whether use of the property has conformed with such restrictions and controls and, in the event of any violations, summarize what actions have been taken to address the violations.

The Air Force shall notify the EPA and MassDEP 45 days in advance of any proposed land changes that would be inconsistent with the LUC objectives or the final remedy. If the Air Force discovers a proposed or ongoing activity that would be or is inconsistent with the LUC objectives or use restrictions, or any other action (or failure to act) that may interfere with the effectiveness of the LUCs, it will address this activity or action as soon

as practicable, but in no case will the process be initiated later than 10 days after the Air Force becomes aware of this breach. The Air Force will notify the EPA and MassDEP as soon as practicable, but no later than 10 days after the discovery of any activity that is inconsistent with the LUC objectives or use restrictions, or any other action that may interfere with the effectiveness of the LUCs. The Air Force will notify the EPA and MassDEP regarding how the Air Force has addressed or will address the breach within 10 days of sending the EPA and MassDEP notification of the breach.

For the LUCs identified and selected for this ROD, the Air Force will provide notice to the EPA and MassDEP at least six months prior to relinquishing the lease to the FS-12 area so the EPA and MassDEP can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective LUCs. If it is not possible for the Air Force to notify the EPA and MassDEP at least six months prior to any transfer or sale, then the Air Force will notify the EPA and MassDEP as soon as possible, but no later than 60 days prior to the transfer or sale of any property, subject to LUCs.

The Air Force shall not modify or terminate LUCs, implementation actions, or modify land use without approval by the EPA and MassDEP. The Air Force, in coordination with other agencies using or controlling the FS-12 area, shall seek prior concurrence before taking any anticipated action that may disrupt the effectiveness of the LUCs or any action that may alter or negate the need for LUCs.

2.11.3 Cost Estimate for the Selected Remedy

The cost estimate for Alternative 3 is provided in Table 2-24 and Table 2-25. The information for the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements may occur based on alterations in operation of the FS-12 ETR system and the monitoring program. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30 percent of the actual project cost. The cost comes from the operations and

maintenance of the FS-12 ETR system, the SPEIM program, periodic CERCLA reporting, and the residual risk assessment.

O&M costs would be incurred for the operation of the FS-12 treatment plant from the date the ROD is signed[4] to 2030, when cleanup levels are expected to be met. O&M costs have been estimated using actual costs realized for the previous operation of the existing FS-12 treatment system. Previous costs have been adjusted for the expected future reductions in total pumping rate and influent concentrations under the future operating conditions assumed for the purposes of this ROD.

Costs related to monitoring well maintenance, hydraulic measurement, sample collection, and groundwater analysis also would be incurred during this time. Groundwater monitoring could continue after the cleanup levels are met to ensure the aquifer had been restored. It is assumed (for cost-estimating purposes) that monitoring would continue for the entire plume for five years after the cleanup levels are met, making the total lifetime of this alternative 30 years. Although a new monitoring well is estimated to be added every other year, it is assumed that the number of monitoring points and frequency of testing would both continue to decrease with plume collapse, as has been the case under most SPEIM programs at the MMR to date. Monitoring costs include periodic reporting of results in technical update meetings and in formal reports.

Costs related to the construction of monitoring wells would be incurred from project year 2 to year 24, based on the assumed frequency of installation (one new monitoring well every two years during system operation) for plume tracking. Costs related to monitoring well installation and maintenance, sample collection, and groundwater analysis would be incurred throughout the project lifetime (year 2005 to year 2035).

Costs did not include those associated with potential LUCs because they were not determined until after the FS was completed. Additionally, no costs were included for

[4] When cost estimates were prepared, the ROD was scheduled to be signed in September 2005.

negotiating and compensating for legal access to off-base property (for new monitoring wells). These omissions are anticipated to have a small impact on the overall net present value.

Costs associated with CERCLA reporting and a final risk assessment are also included in this alternative. The present value of this alternative is estimated to be $22.4 M.

Capital, annual and periodic costs generated in the cost estimates and used in the present value calculations have been escalated from the time the cost estimate was prepared (February 2004) to the start of the base year (September 2005); thus, an escalation of 1.5 years at a rate of 5 percent has been used. A discount rate of 3.5 percent was used for all present value calculations per EPA guidance (EPA 2000) and Office of Management and Budget Circular A-94, revised February 2004 (OMB 2004).

2.11.4 Expected Outcomes of the Selected Remedy

Alternative 3 provides for protection of human health through implementation of LUCs. The groundwater model indicates that cleanup levels will be met by approximately 2030, at which time the groundwater will be useable as a source of drinking water.

2.12 STATUTORY DETERMINATIONS

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with ARARs (unless a waiver is justified), be cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element. The following sections discuss how the selected remedy meets these statutory requirements.

2.12.1 Protection of Human Health and the Environment

The selected remedy will protect human health and the environment through LUCs and monitoring of the groundwater plume to ensure contaminant concentrations are dissipating to below cleanup levels, as predicted by the groundwater model. Monitoring and LUCs will prevent residential exposure to the FS-12 plume. There are no short-term threats associated with the selected remedy that cannot be readily controlled.

2.12.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy of continuing operation of the existing FS-12 ETR system to remediate the FS-12 plume complies with all chemical-, location-, and action-specific ARARs. Refer to Table 2-21, Table 2-22, and Table 2-23 for a listing of these ARARs.

2.12.3 Cost-Effectiveness

In AFCEE's judgment, the selected remedy for FS-12 groundwater is cost-effective. The overall effectiveness of the selected remedy was determined to be proportional to its costs and, hence, to represent a reasonable value for the money to be spent.

The cost-effectiveness for the FS-12 remedy was evaluated based on the data currently available for the FS-12 plume and the following considerations: (1) cleanup levels will be met by approximately 2030, (2) approximately 1.2 kg of EDB (approximately 100 percent of the EDB mass) will be accounted through removal and decay, (3) contaminants are permanently destroyed, (4) risks to workers, the community, and the environment would be easily controlled, (5) there is a high degree of confidence that the existing controls can adequately handle potential problems.

2.12.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy for the FS-12 plume provides the best balance of trade-offs among the alternatives considered in the FS. Alternative 3 represents the maximum extent to which permanent solutions and treatment can be practicably utilized at the site because

long-term monitoring (Alternative 2) would not expedite aquifer restoration and the plume would migrate to the southeast and under residential neighborhoods in Sandwich and Mashpee as it approaches Mashpee-Wakeby Pond. Based on the evaluation criteria and the statutory mandates, AFCEE finds Alternative 3 to be the most appropriate solution for the FS-12 plume. The treatment, monitoring, and controls included in Alternative 3 will demonstrate compliance with ARARs and protectiveness of human health and the environment. The contaminants removed from the aquifer are destroyed through active treatment and contamination remaining in the aquifer is reduced to acceptable levels through natural attenuation. The selected remedy does not present any significant short-term risks. There are no special implementability issues that make the selected remedy unacceptable.

2.12.5 Preference for Treatment as a Principal Element

The selected remedy treats the contamination present in the FS-12 plume. The contaminated groundwater is removed from the aquifer through extraction wells and piped to the treatment plant. Contaminants are removed from the groundwater through GAC filtration. The treated groundwater is returned to the aquifer via reinjection wells.

2.12.6 Five-Year Review Requirements

Five-year statutory reviews will be performed for the FS-12 plume, according to Section 121(c) of CERCLA and NCP Section 300.430(f)(4)(ii), which requires such reviews in those instances where the remedy results in any hazardous substances, pollutants, or contaminants remaining at the site in excess of levels that allow for unlimited use and unrestricted exposure. The purpose of the five-year reviews is to revisit the appropriateness of the remedy in providing adequate protection of human health and the environment. The five-year reviews for the FS-12 groundwater OU will be part of the five-year reviews conducted for the CERCLA IRP sites on the MMR.

2.13 DOCUMENTATION OF NO SIGNIFICANT CHANGES

The Proposed Plan for the Groundwater at Fuel Spill-12 was released for public comment in October 2005. The PP identified Alternative 3 as AFCEE's preferred alternative.

AFCEE, the EPA, and the MassDEP reviewed all written and verbal comments submitted during the public comment period. Upon review of these comments, it was determined that no significant changes to the remedy, as it was originally identified in the PP, were necessary.

3.0 RESPONSIVENESS SUMMARY

The Responsiveness Summary is on the following pages.

COMMENTS RESPONSES

Comments from the Plume Cleanup Team:	Responses:
The team (PCT), by consensus, recommends Alternative 3: continued operation and optimization of the existing ETR system with on-going monitoring until cleanup levels throughout the plume are met. The team also offers the following comments:	
• Please list additional metrics for treatment success beyond pounds of contaminants captured. The public cannot translate "X pounds" of contaminant "Y" into any meaningful understanding since the metric does not take into account risk, percent of contaminants remaining, and other factors.	• In future plume cleanup updates, AFCEE will use additional metrics such as volume reduction and concentration trends to characterize system effectiveness.
• Please note that the Town of Sandwich discovered FS-12 when drilling for a new public water supply well on Camp Good News. Thus, it's important to note the plume has adversely affected Sandwich Water District's ability to deliver sufficient clean water to residents.	• The FS-12 plume has limited the Sandwich Water District's ability to develop a new supply service in this area. Current Sandwich Water District's sources are able to meet the needs of the residents. An objective of the FS-12 remedy is to restore the groundwater in the FS-12 area to beneficial uses.

COMMENTS	RESPONSES
PCT comments (continued): • Please continue to work with the Town of Sandwich and Camp Good News to ensure smooth, on-going coordination and to minimize adverse impacts of the cleanup on existing businesses and Snake Pond public activities.	**Responses (continued)** • AFCEE will continue to work with the Town of Sandwich, Camp Good News and other stakeholders to ensure the remedy has minimal adverse impacts on the public.
Comment from David Dow (Sierra Club): We favor Alternative 3. This option will allow plume containment, active remediation of EDB in the groundwater, and monitoring of ecological impacts on Snake Pond. This alternative may require an adaptive management response program if the SPEIM program detects impacts. In addition, the Impact Area Groundwater Study Program needs to use the FS-12 treatment and/or extraction well system for treating J-Range contaminants, then some alterations may be required to the optimized ETR system described under Alternative 3.	**Response:** AFCEE agrees that Alternative 3 is the preferred alternative for the FS-12 plume. For clarification, although the J-3 plume treatment system is housed within the FS-12 treatment plant building, the J-3 groundwater ETR system would be able to operate even if the FS-12 ETR system were shut down.
Comments from Hans Keijser (Citizen from Sandwich): After reading the compiled information it is clear to me the responsibility we have as residents to speak up and voice our opinions, concerns and provide you with a clear direction in which to proceed regarding the final clean-up plan for our neighborhood. It is clear to me that the Alternative 3 is the preferred one because: 1. It is by far the shortest time period in which an acceptable clean-up can be established. 2. The alternative 3 has verifiable performance-measures built in, regarding chemical and hydraulic monitoring which will help with convincing the general public that the clean-up effort is done properly.	**Responses:** Community involvement is important to the success of the MMR groundwater cleanup program. This comment notes a variety of reasons that Alternative 3 is the most appropriate remedy for the FS-12 plume, including some that were not mentioned in the Proposed Plan. AFCEE agrees that Alternative 3 provides the best balance of all of the various criteria used in the remedy selection process.

COMMENTS	RESPONSES
Comments from Hans Keijser (continued): 3. The Air Force is actively doing something about a contamination caused by the organization. 4. The costs are high but not unreasonable for the effort and will be able to be managed properly under current staffing levels and will make full, longer and better use of the current facility- and infrastructure-investment. 5. It will provide a positive image toward the Air Force and the Massachusetts Military Reservation for taking care of their responsibility and not dropping the ball halfway through. 6. It will provide property owners in the area a guaranteed and final date in the near-future and an announcement that the clean-up is finalized and closure to the contamination issue of FS 12.	**Responses (continued):**
7. The reality is that the Forestdale section of Sandwich does have a higher cancer rate than the rest of the Town and this has to be caused by something. See articles in the Cape Cod Times this summer. The potential cancer risk levels are not clearly explained in the flyer. The longer the contamination is allowed to stay in the groundwater and in the soils under our collective properties in the area the more suspicious the public will get. I think it is imperative to deal with the contamination issue in a most expedient way possible.	Regarding point No. 7, AFCEE acknowledges that the Proposed Plan provided only a brief overview of the human health risk assessment that was conducted for the FS-12 plume. The entire risk assessment is presented in Appendix A of the *Final Fuel Spill-12 Groundwater Feasibility Study*, which is document number 18079 in the Administrative Record, available at www.mmr.org. For clarification, the fuel spill has not contaminated the soils on private properties that overlie the plume.
8. Under the other 2 alternatives the plume would actually move, become bigger and would start to contaminate a greater area of Forestdale according your flyer under the EDB contamination consequences (page 12) before eventually dissipating. I do think these 2 options are really non-starters, contrary to the whole intent and purpose of the AFCEE and bordering on a criminal neglect-approach to the issue.	Regarding point No. 8, “No Action” is required to be evaluated by Superfund law. Although not required for evaluation, long-term monitoring has historically been included in the MMR IRP evaluation process.

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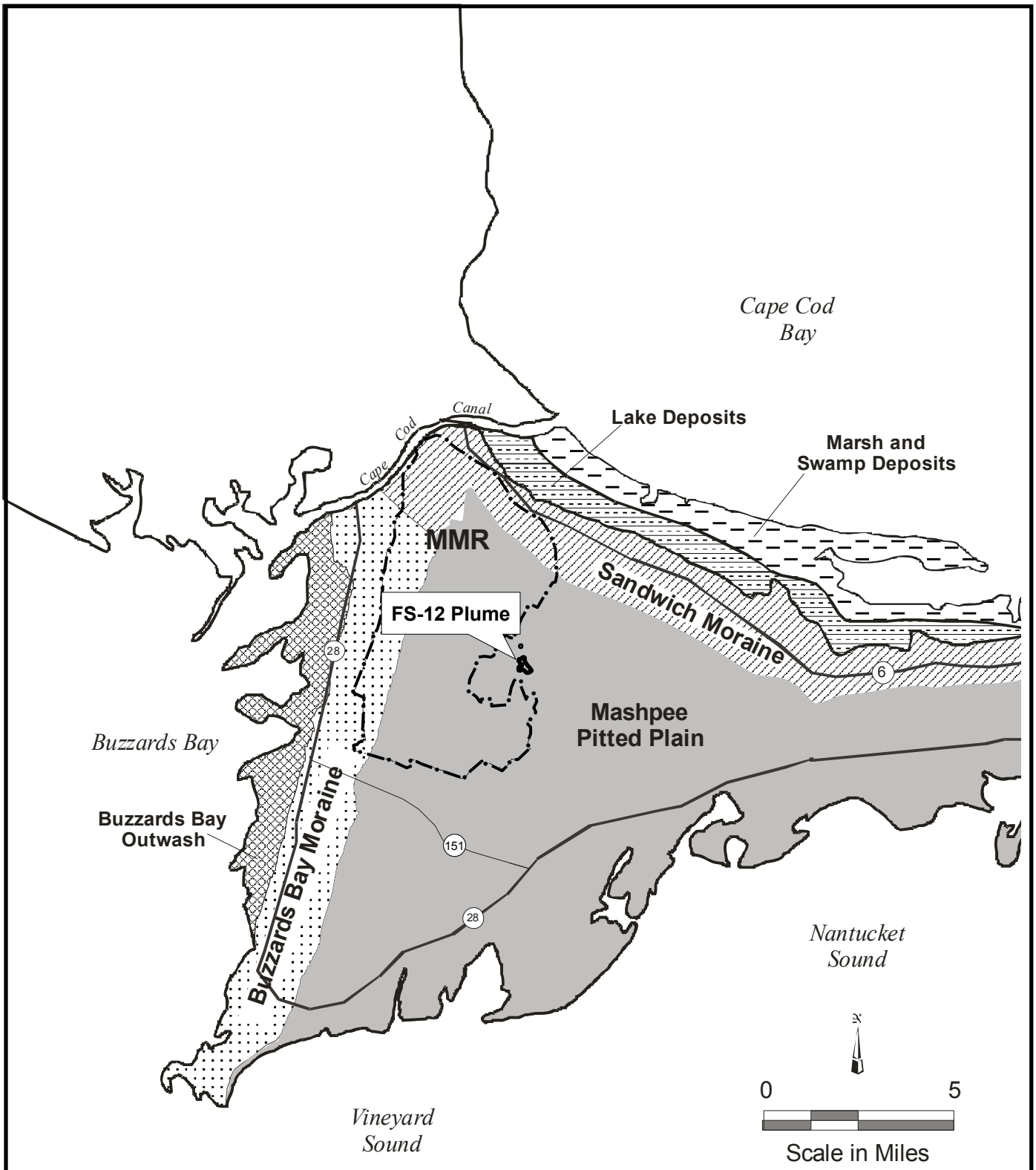


JACOBS

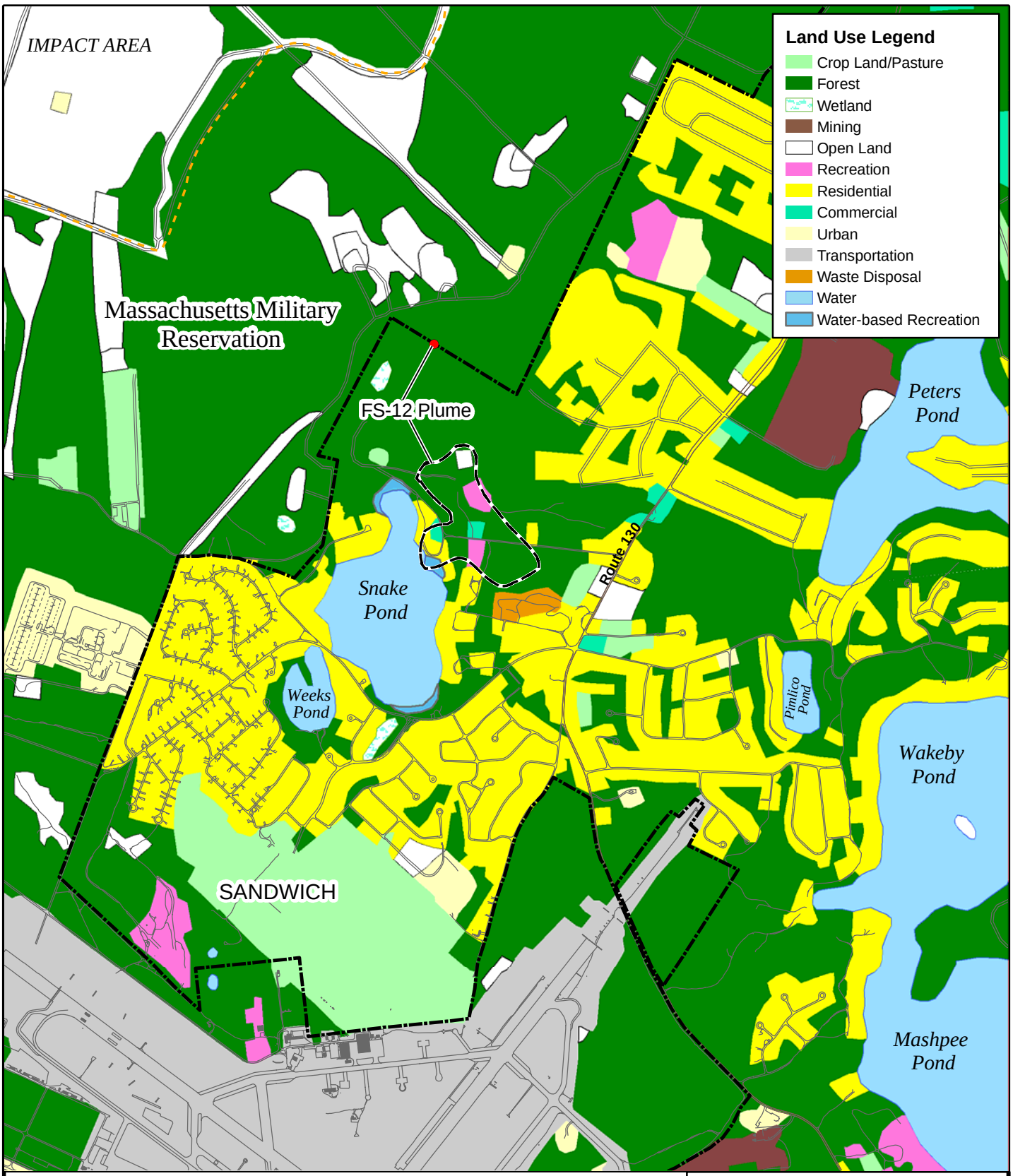
Regional Surficial Geology Map and the Massachusetts Military Reservation

Massachusetts Military Reservation
Cape Cod, Massachusetts

NAME: csr DATE: 1/6/2006

Figure 2-1

Y:\GIS\projects\352048\02\20060110\ArcGIS\Geology_MMR3.mxd



Legend

- Plume Contour (EDB MMCL = 0.02 µg/L)
- EDB Detection > MMCL
- MMR Boundary
- Impact Area

N

0 1,000 2,000 Feet

Scale 1:24,000

Source: 1999 Land Use layer provided by MASS GIS November, 2005.

JACOBS

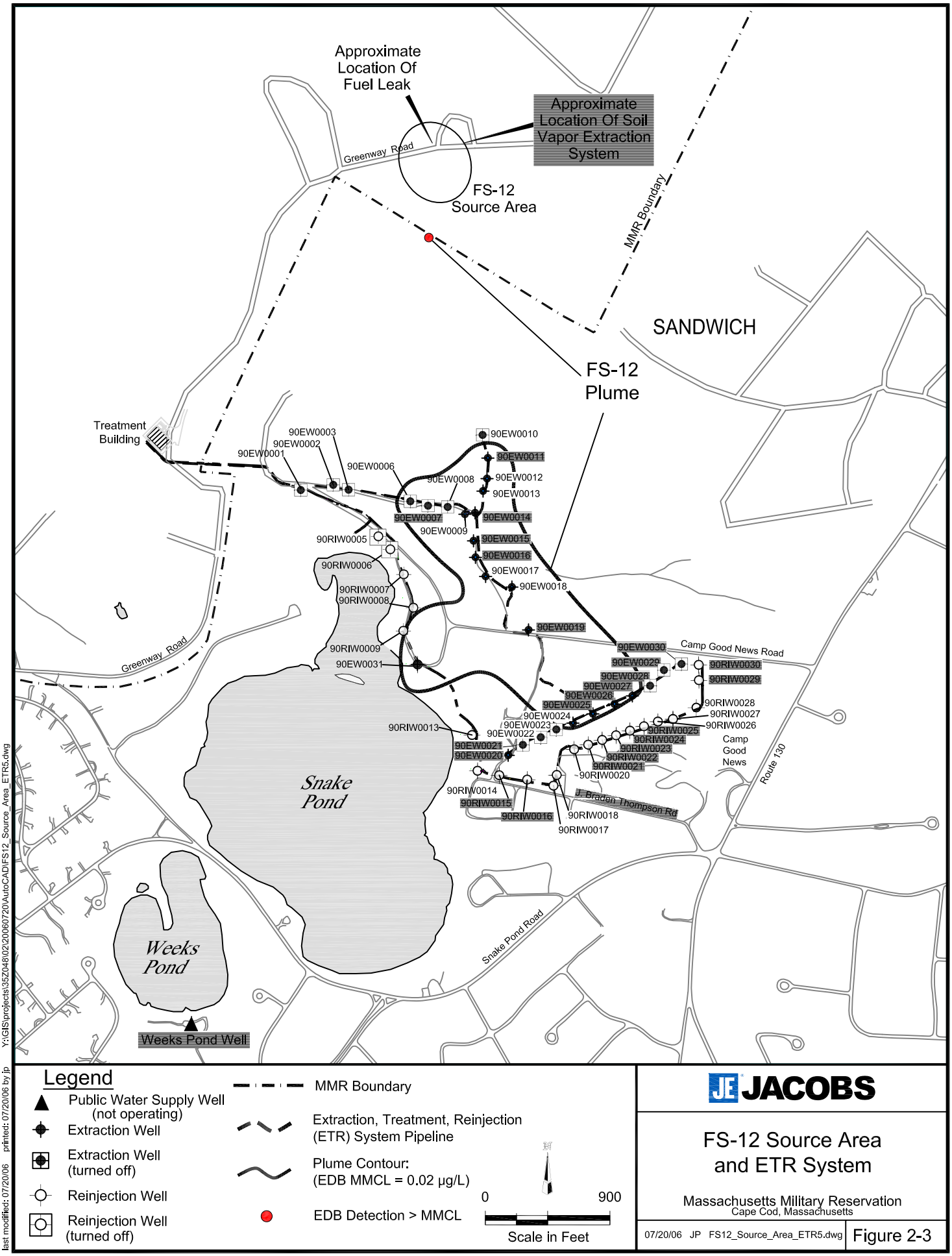
FS-12 Area Land Use

Massachusetts Military Reservation
Cape Cod, Massachusetts

NAME: csr DATE: 1/10/2006

Figure 2-2

Y:\GIS\projects\35Z048\02\2006110\ArcGIS\FS12_Landuse4.mxd



JACOBS

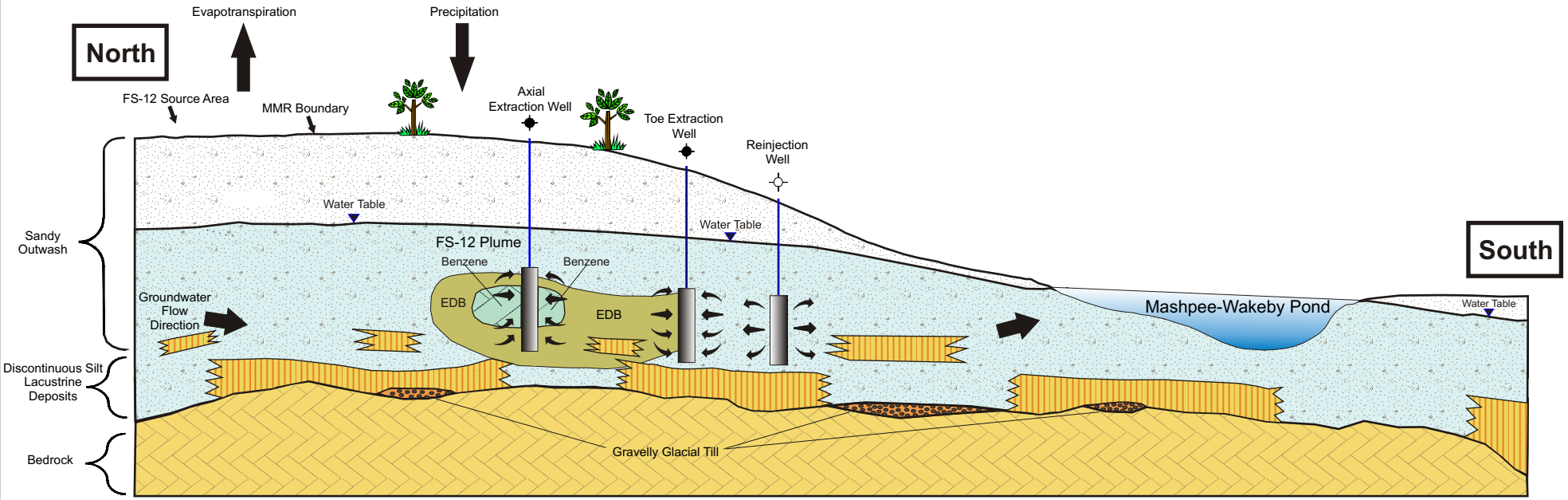
FS-12 Source Area and ETR System

Massachusetts Military Reservation
Cape Cod, Massachusetts

07/20/06 JP FS12_Source_Area_ETR5.dwg

Figure 2-3

last modified: 07/20/06 printed: 07/20/06 by: jp Y:\GIS\projects\35Z048\02\20060720\AutoCAD\FS12_Source_Area_ETR5.dwg



Legend

- EDB MMCL = 0.02 µg/L
- Benzene MCL = 5.0 µg/L

Arrows
(Indicate Flow Direction)

Extraction Well

Reinjection Well

Note: Model is not to scale, vertical dimension is exaggerated.

JACOBS

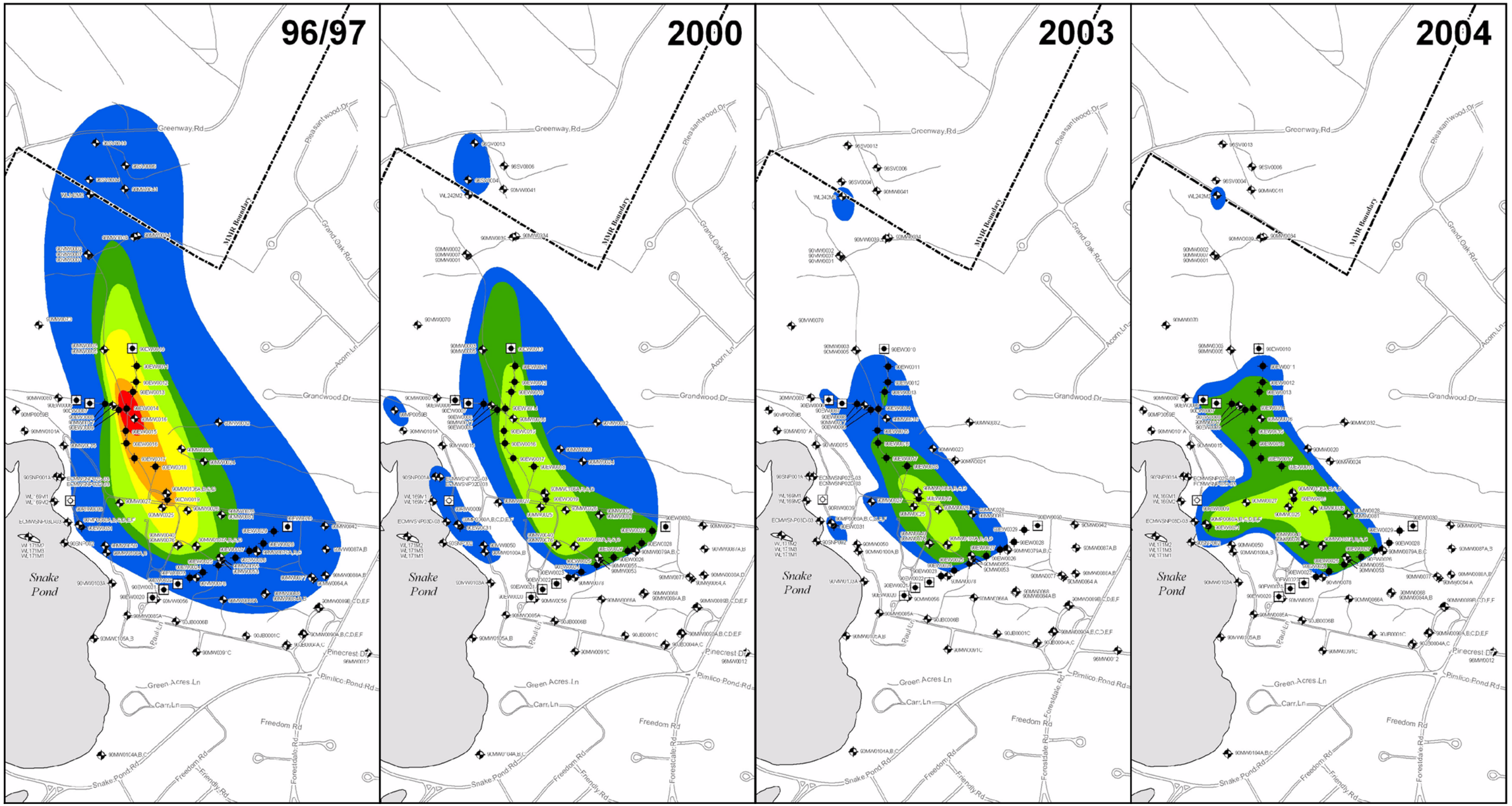
FS-12 Site
Conceptual Model

Massachusetts Military Reservation
Cape Cod, Massachusetts

1/6/06 jp

Figure 2-4

Y:\GIS\projects\35Z048\02\20060106\Corel\FS12_4ROD_Fig2-4.cdr



Note: Plume map inserts provided by CH2M Hill.

Legend

- Monitoring Well
- Extraction Well
- Extraction Well (turned off)
- Reinjection Well (turned off)
- MMR Boundary

Isocontour Color Key (µg/L)

0.02	=	EDB < 1.0
1.0	=	EDB < 10
10	=	EDB < 100
100	=	EDB < 300
300	=	EDB < 500
	=	500

Note: The well network in each figure represents wells that were included in the 2003 SPEIM chemical network. These wells are shown for point-of-reference and do not represent pre-2003 monitoring network configurations.

N

0 500 1,000 Feet

JACOBS

Temporal Change of EDB Concentrations at FS-12

Massachusetts Military Reservation
Cape Cod, Massachusetts

NZehms 11/30/05

Figure 2-5

Y:/GIS/projects/35Z048/02/20051129/ArcGIS/FS12_Plume_Change.mxd

96/97

2000

2001

2002

FS-12 Source Area

Snake Pond

Camp Good News Rd

J Braden Thompson Rd

Legend

Note: Plume map inserts provided by CH2M Hill.

- Monitoring Well
- Extraction Well
- Piezometer
- Reinjection Well (Non-operable, sampled)

Isocontour Color Key (µg/L)

- > 5
- > 25
- > 100
- > 500
- > 1000
- > 2000

Note:
1). The well network in each figure represents wells that were included in the 2002 SPEIM network. These wells are shown for point-of-reference and do not represent pre-2002 monitoring network configurations.
2). Dashed isocontours in 2002 panel are simulated and represent areas likely to contain Benzene above 5 µg/L based on 2002 plume shell.
3). Benzene concentrations in 2005 were below 5 µg/L.

0 750 Feet

JACOBS

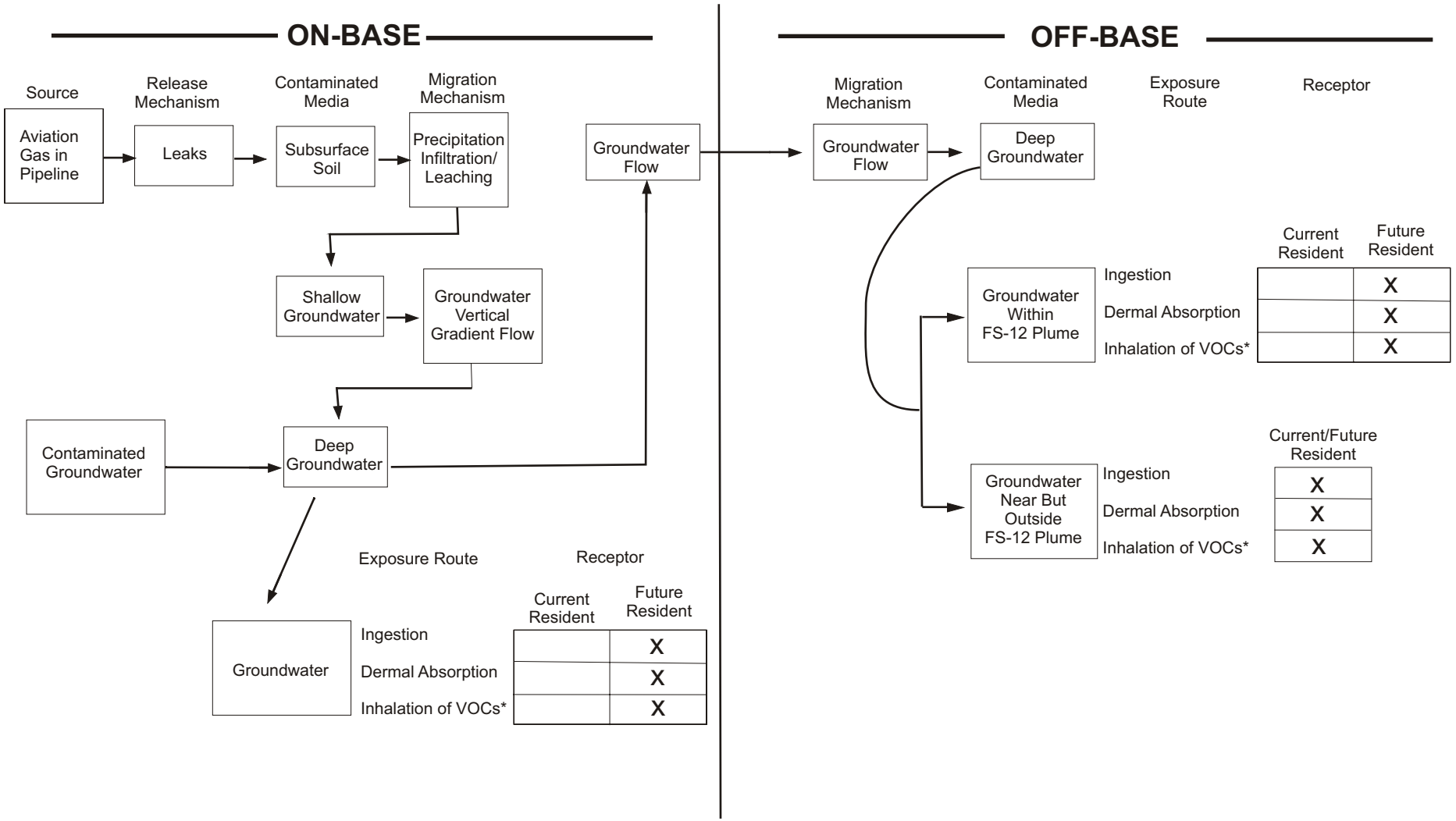
Temporal Change of Benzene Concentrations at FS-12

Massachusetts Military Reservation
Cape Cod, Massachusetts

04/06/06 JP fs12_benzene_change_fig2_6.dwg

Figure 2-6

last modified: 04/06/06 printed: 04/06/06 by jp
Y:\GIS\projects\352048\02\20060406\AutoCAD\fs12_benzene_change_fig2_6.dwg



Legend

VOC volatile organic compound
(* released from water during household use)

JACOBS

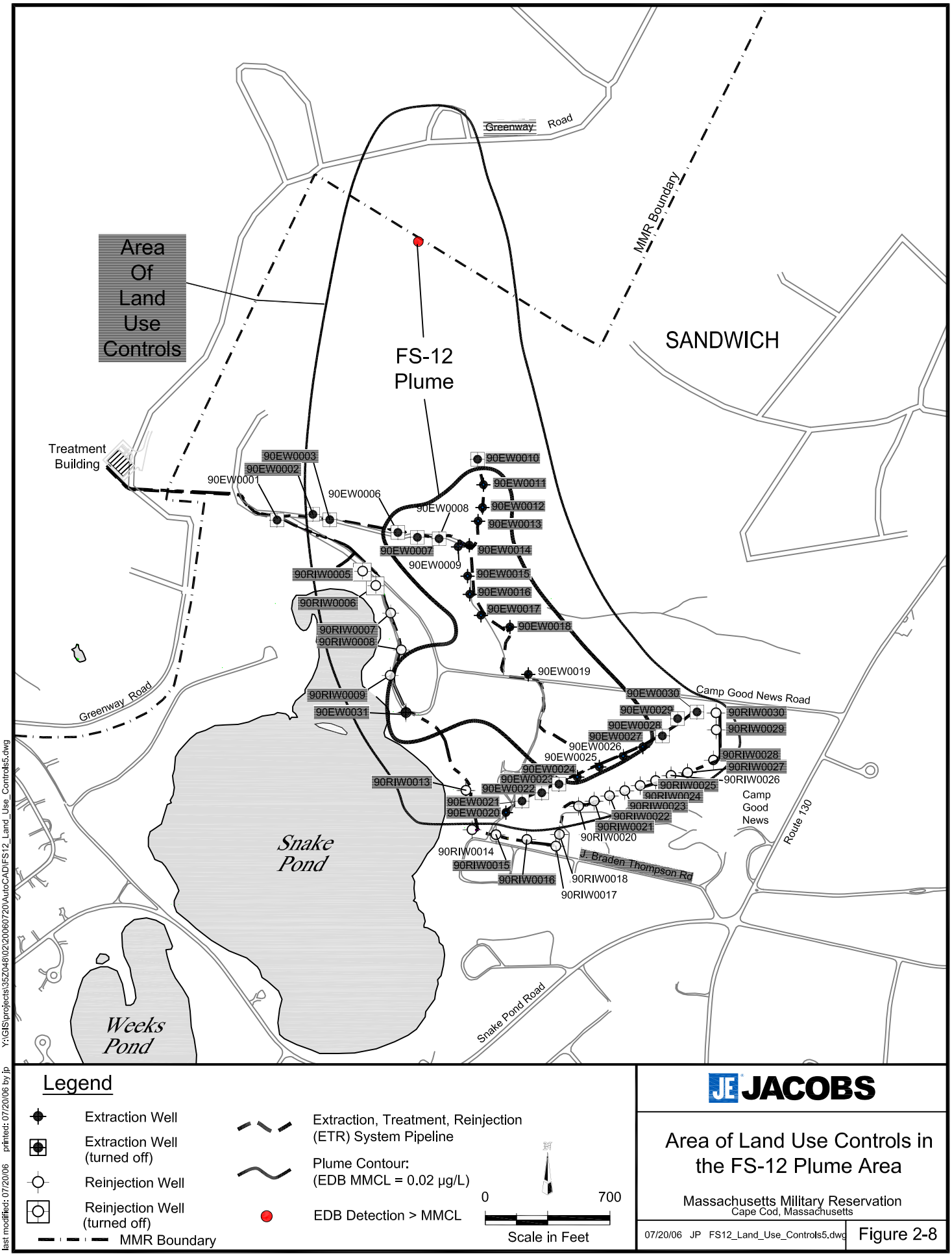
Human Health
Conceptual Exposure Model
FS-12

Massachusetts Military Reservation
Cape Cod, Massachusetts

5/2/03 JP: flow_FS12a.cdr

Figure 2-7

L:\4-REPORTS/E-Briarwood\Work_plan\Corel\flow_FS12a.cdr



JACOBS

Area of Land Use Controls in the FS-12 Plume Area

Massachusetts Military Reservation
Cape Cod, Massachusetts

07/20/06 JP FS12_Land_Use_Controls5.dwg

Figure 2-8

last modified: 07/20/06 printed: 07/20/06 by jp Y:\GIS\projects\35Z048\02\20060720\AutoCAD\FS12_Land_Use_Controls5.dwg

Table 2-1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
FS-12 On-Base

Scenario Time Frame:	current/ future
Medium:	groundwater
Exposure Medium:	groundwater
Exposure Point:	FS-12, On-base

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	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
71-43-2	Benzene	1.2	J	54	J	µg/L	96SV0004	10/38	0.11 - 55	54		0.34	C	5	MCL	YES	ASL
67-66-3	Chloroform	0.16	J	1.3	-	µg/L	90WT0006	12/38	0.08 - 40	1.3		0.62	N/C	80	MCL	YES	ASL
100-41-4	Ethylbenzene	1.01	-	695	-	µg/L	96SV0004	27/38	0.1 - 50	695		2.9	C	700	MCL	YES	ASL
127-18-4	Tetrachloroethene (PCE)	5.6	J	5.6	J	µg/L	WL45S	1/38	0.11 - 55	5.6		0.66	C	5	MCL	YES	ASL, IFD
108-88-3	Toluene	1.4	-	10500	-	µg/L	96SV0004	26/38	0.09 - 120	10500		72	N	1000	MCL	YES	ASL
100-42-5	Styrene	22	J	22	J	µg/L	96SV0004	1/38	0.12 - 60	22		160	N	100	MCL	NO	BSL,IFD
	M,P-xylene	2.56	-	2040	-	µg/L	96SV0004	7/9	0.525 - 52.5	2040		21	N	10000	MCL	YES	ASL
95-47-6	O-xylene	0.96	J	797	J	µg/L	96SV0004	7/9	0.142 - 14.2	797		21	N	10000	MCL	YES	ASL
1330-20-7	Xylenes (total)	0.51	J	2900	-	µg/L	96SV0004	21/29	0.11 - 240	2900		21	N	10000	MCL	YES	ASL
106-93-4	Ethylene Dibromide (EDB)	0.009	J	0.115	-	µg/L	96SV0004	9/33	0.0022 - 0.0054	0.115		0.00076	C	0.02	MMCL	YES	ASL
96-12-8	1,2-Dibromo-3-chloropropane	0.015	-	0.029	-	µg/L	96SV0005	2/27	0.0051 - 0.0061	0.029		0.035	N	0.2	MCL	NO	BSL
106-44-5	4-Methylphenol (p-Cresol)	3	J	3	J	µg/L	WL45S	1/20	2.7 - 5	3		18	N	NA	NA	NO	BSL, IFD
7440-36-0	Antimony (total)	3.7	J	3.7	J	µg/L	WL45M1	1/25	2.2 - 4.9	3.7		1.5	N	6	MCL	NO	ASL, IFD
7440-38-2	Arsenic (total)	3	J	9	J	µg/L	WL45S	4/22	1 - 3.6	9		0.045	C	10	MCL	YES	ASL
7440-39-3	Barium (total)	5.3	J	19	-	µg/L	WL30	9/19	1.8 - 12	19		260	N	2000	MCL	NO	BSL
7440-41-7	Beryllium (total)	0.13	J	0.13	J	µg/L	90WT0013	1/25	0.1 - 1	0.13		7.3	N	4	MCL	NO	BSL, IFD
7440-42-8	Boron (total)	5.9	J	5.9	J	µg/L	WL45M2	1/12	1.3 - 12.7	5.9		730	N	NA	NA	NO	BSL
7440-70-2	Calcium (total)	1,260	-	1890	-	µg/L	90WT0013	5/5	105.1 - 105.1	1890		NA		NA	NA	NO	NUT, NSL
7440-47-3	Chromium (total)	0.87	J	7.4	J	µg/L	90MW0029B	5/25	0.7 - 1.2	7.4		11	N	100	MCL	NO	BSL
7440-48-4	Cobalt (total)	1.9	J	10	-	µg/L	90WT0013	6/20	1.5 - 3.3	10		73	N	NA	NA	NO	BSL
7440-50-8	Copper (total)	1.5	J	11.8	-	µg/L	90WT0013	8/25	0.9 - 2.3	11.8		150	N	1000	SMCL	NO	BSL
7439-89-6	Iron (total)	44.1	J	8770	-	µg/L	90WT0013	5/18	5.3 - 25.6	8770		1100	N	300	SMCL	NO	NUT
7439-92-1	Lead (total)	1.3	J	19.1	-	µg/L	90WT0013	6/25	0.8 - 2	19.1		NA		15	AL	YES	AAL
7439-95-4	Magnesium (total)	911	-	1670	-	µg/L	90WT0013	5/6	59.1 - 144	1670		NA		NA	NA	NO	NUT, NSL
7439-96-5	Manganese (total)	0.55	J	472	-	µg/L	90WT0013	8/9	0.3 - 1.3	472		88	N	50	SMCL	YES	ASL
7439-97-6	Mercury (total)	0.11	J	0.41	-	µg/L	90WT0013	2/24	0.1 - 0.1	0.41		1.1	N	2	MCL	NO	BSL
7439-98-7	Molybdenum (total)	1.6	J	4.4	J	µg/L	90MW0029B	3/18	1.1 - 1.5	4.4		18	N	NA	NA	NO	BSL
7440-02-0	Nickel (total)	2.4	J	14.8	J	µg/L	90WT0013	7/24	1.4 - 4.7	14.8		73	N	100	ORSG	NO	BSL
7440-09-7	Potassium (total)	497	J	1240		µg/L	90WT0013	7/8	33.7 - 504	1240		NA		NA	NA	NO	NUT, NSL
7440-21-3	Silicon (total)	6840	-	6840	-	µg/L	90WT0013	1/1	7.9 - 7.9	6840		NA		NA	NA	NO	CC,NSL
7440-22-4	Silver (total)	1.1	J	1.1	J	µg/L	WL45S	1/25	0.9 - 2.1	1.1		18	N	100	SMCL	NO	BSL, IFD
7440-23-5	Sodium (total)	5540	-	10200	-	µg/L	90WT0013	6/6	37.8 - 606.2	10200		NA		NA	NA	NO	NUT, NSL
7440-28-0	Thallium (total)	3	J	3	J	µg/L	WL45S	1/25	1 - 6.3	3		0.24	N	2	MCL	YES	ASL, IFD
7440-66-6	Zinc (total)	1.7	J	4.8	J	µg/L	WL45M1	6/21	0.8 - 3.8	4.8		1100	N	5000	SMCL	NO	BSL

Data Source: AFCEE, 14 March 2003, AFCEE-MMR Data Warehouse.

Table 2-1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
FS-12 On-Base

(1) Minimum/maximum detected concentration.

(2) N/A - Refer to *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005).

(3) MCL = maximum contaminant level

N = one-tenth of the EPA Region IX PRG based on non-carcinogenic effects

N/C = one-tenth of the EPA Region IX PRG based on non-carcinogenic effects (also protective of carcinogenic effects)

C = EPA Region IX PRG based on carcinogenic effects (at a risk of 1E-06)

(4) Rationale Codes:

Infrequent Detection (IFD)

Common Cation (CC)

Above Screening Levels (ASL)

No Screening Level (NSL)

Above Action Levels (AAL)

Essential Nutrient (NUT)

Below Screening Level (BSL)

Definitions:

AL = Action Level

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

C = Carcinogenic

CAS = Chemical Abstracts Service

COPC = Chemical of Potential Concern

EPA = U.S. Environmental Protection Agency

J = Estimated Value

MCL = Maximum Contaminant Level

N = Non-Carcinogenic

N/A = Not Applicable

NA = Not Available

ORSG = Office of Research and Standards Guidelines

PRG = Preliminary Remediation Goal

SMCL = Secondary Maximum Contaminant Level

µg/L = micrograms per liter

Table 2-2
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
FS-12 Off-Base Within the Plume

Scenario Time Frame:	current/ future
Medium:	groundwater
Exposure Medium:	groundwater
Exposure Point:	FS-12, Off-base, Within the Plume

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	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
71-43-2	Benzene	0.19	J	25	-	µg/L	90MW0020	16/80	0.11 - 0.22	25		0.34	C	5	MCL	YES	ASL
67-66-3	Chloroform	0.24	J	3	-	µg/L	90MW0081	48/74	0.08 - 0.336	3		0.62	N/C	80	MCL	YES	ASL
100-41-4	Ethylbenzene	0.52	J	6.9	-	µg/L	90MW0001	4/80	0.1 - 0.229	6.9		2.9	C	700	MCL	NO	ASL, IFD
127-18-4	Tetrachloroethlene (PCE)	2.2	-	5.6	J	µg/L	90MW0053	2/80	0.11 - 0.22	5.6		0.66	C	5	MCL	YES	ASL, IFD
108-88-3	Toluene	0.24	J	1.5	-	µg/L	90MW0001	7/80	0.09 - 0.185	1.5		72	N	1000	MCL	NO	BSL
1330-20-7	Xylenes (total)	0.77	J	1	-	µg/L	90MW0001	2/46	0.11 - 0.47	1		21	N	10000	MCL	NO	BSL, IFD
107-06-2	1,2-Dichloroethane	0.12	J	1.7	-	µg/L	90MW0040	4/74	0.09 - 0.382	1.7		0.12	C	5	MCL	YES	ASL
91-57-6	2-Methylnaphthalene*	5	J	24	J	µg/L	90MW0016	2/5	1 - 1.177	24		0.62	N	140	ORSG	YES	ASL
117-81-7	BEHP[Bis(2-ethylhexyl)phthalate]	2	J	2	J	µg/L	90MW0003	1/6	1 - 1.32	2		4.8	C	6	MCL	NO	BSL
91-20-3	Naphthalene	4	J	58	J	µg/L	90MW0016	3/5	1 - 1.33	58		0.62	N	140	ORSG	YES	ASL
108-95-2	Phenol	2	J	2	J	µg/L	90MW0003	1/6	0.73 - 1	2		2200	N	NA	NA	NO	BSL
106-93-4	Ethlyene Dibromide	0.01	J	27	J	µg/L	90MW0040	47/94	0.002 - 0.51	27		0.00076	C	0.02	MMCL	YES	ASL
7429-90-5	Aluminum (total)	200	-	241	-	µg/L	90MW0003	2/39	10.1 - 250	241		3600	N	50 to 200	SMCL	NO	BSL
7440-36-0	Antimony (total)	10.6	J	10.6	J	µg/L	90MP0060F	1/36	2.6 - 5.7	10.6		1.5	N	6	MCL	YES	ASL, IFD
7440-38-2	Arsenic (total)	3.4	J	6.2	J	µg/L	90MW0040	4/39	2.5 - 7.3	6.2		0.045	C	10	MCL	YES	ASL
7440-39-3	Barium (total)	1.4	J	5.4	J	µg/L	90MW0081	20/39	0.2 - 6.4	5.4		260	N	2000	MCL	NO	BSL
7440-42-8	Boron (total)	5.8	J	7.9	J	µg/L	90MW0020	2/2	1.3 - 3.1	7.9		730	N	NA	NA	NO	BSL
7440-70-2	Calcium (total)	1,130	J	4140	J	µg/L	90MW0003	39/39	7.2 - 71.9	4140		NA		NA	NA	NO	NUT, NSL
7440-47-3	Chromium (total)	0.8	J	10	-	µg/L	90MP0060D	15/39	0.29 - 6.4	10		11	N	100	MCL	NO	BSL
7440-48-4	Cobalt (total)	2.4	J	12.3	J	µg/L	90MW0020	10/39	0.41 - 4	12.3		73	N	NA	NA	NO	BSL
7440-50-8	Copper (total)	0.87	J	4.1	J	µg/L	90MP0060D	6/39	0.6 - 6.1	4.1		150	N	1000	SMCL	NO	BSL
7439-89-6	Iron (total)	49.1	J	1390	-	µg/L	90MW0003	23/39	11.2 - 159	1390		1100	N	300	SMCL	NO	NUT
7439-95-4	Magnesium (total)	718	J	2580	J	µg/L	90MW0003	39/39	5.2 - 72.8	2580		NA		NA	NA	NO	NUT, NSL
7439-96-5	Manganese (total)	13.8	J	336	-	µg/L	90MW0005	19/39	0.34 - 18	336		88	N	50	SMCL	YES	ASL
7440-02-0	Nickel (total)	1.5	J	328	-	µg/L	90MP0060D	14/39	0.9 - 5.6	328		73	N	100	ORSG	YES	ASL
7440-09-7	Potassium (total)	499	J	1320	J	µg/L	90MW0055	19/39	21 - 1750	1320		NA		NA	NA	NO	NUT, NSL
7782-49-2	Selenium (total)	1.5	J	1.9	J	µg/L	90MW0020	2/39	1.4-4.9	1.9		18	N	50	MCL	NO	BSL
7440-21-3	Silicon (total)	4450	-	5130	-	µg/L	90MP0060D	2/2	5.7 - 5.7	5130		NA		NA	NA	NO	CC, NSL
7440-23-5	Sodium (total)	5740	-	13300	-	µg/L	90MP0060F	38/38	88.2 - 464	13300		NA		NA	NA	NO	NUT, NSL
7440-66-6	Zinc (total)	6.2	J	14.6	J	µg/L	90MW0003	2/38	0.4 - 12.6	14.6		1100	N	5000	SMCL	NO	BSL

Data Source: AFCEE, 14 and 30 March 2003, AFCEE-MMR Data Warehouse.

Table 2-2
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
FS-12 Off-Base Within the Plume

* Used naphthalene as a surrogate for 2-methylnaphthalene

(1) Minimum/maximum detected concentration.

(2) N/A = Refer to the *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005).

(3) MCL = maximum contaminant level
N = one-tenth of the EPA Region IX PRG based on non-carcinogenic effects
N/C = one-tenth of the EPA Region IX PRG based on non-carcinogenic effects (also protective of carcinogenic effects)
C = EPA Region IX PRG based on carcinogenic effects (at a risk of 1E-06)

(4) Rationale Codes:
Infrequent Detection (IFD)
Common Cation (CC)
Above Screening Levels (ASL)
No Screening Level (NSL)
Above Action Levels (AAL)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions:
AL = Action Level
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
C = Carcinogenic
CAS = Chemical Abstracts Service
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
J = Estimated Value
MCL = Maximum Contaminant Level
N = Non-Carcinogenic
N/A = Not Applicable
NA = Not Available
ORSG = Office of Research and Standards Guidelines
PRG = Preliminary Remediation Goal
SMCL = Secondary Maximum Contaminant Level
µg/L = micrograms per liter

Table 2-3
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
FS-12 Off-Base Outside the Plume

Scenario Time Frame:	current/future
Medium:	groundwater
Exposure Medium:	groundwater
Exposure Point:	FS-12, Off-base, outside plume

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	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
71-43-2	Benzene	0.18	J	0.58	J	µg/L	90MW0034	3/86	0.11 - 0.216	0.58		0.34	C	5	MCL	NO	ASL, IFD
67-66-3	Chloroform	0.082	J	1.61	-	µg/L	WLM171M3	42/86	0.08 - 0.336	1.61		0.62	N/C	80	MCL	YES	ASL
127-18-4	Tetrachloroethene (PCE)	0.12	J	0.94	J	µg/L	90MW0090F	2/86	0.11 - 0.146	0.94		0.66	C	5	MCL	NO	ASL, IFD
108-88-3	Toluene	0.096	J	0.83	J	µg/L	90MW0033	9/86	0.09 - 0.185	0.83		72	N	1000	MCL	NO	BSL
107-06-2	1,2-Dichloroethane	0.095	J	0.17	J	µg/L	90MW0068	3/86	0.09 - 0.382	0.17		0.12	C	5	MCL	NO	ASL, IFD
67-64-1	Acetone	4.8	J	4.8	J	µg/L	WL169M2	1/1	2.8 - 2.8	4.8		61	N	3000	ORSG	NO	BSL
156-59-2	cis-1,2-dichloroethene	0.08	J	0.08	J	µg/L	90MW0090F	1/86	0.08 - 0.347	0.08		6.1	N	70	MCL	NO	BSL, IFD
100-41-4	Ethylbenzene	0.19	J	20	-	µg/L	90MW0039	4/86	0.1 - 0.229	20		2.9	C	700	MCL	NO	ASL, IFD
79-01-6	Trichloroethene (TCE)	0.1	J	1.2	-	µg/L	90MW0090F	3/86	0.09 - 0.15	1.2		0.028	C	5	MCL	NO	ASL, IFD
1330-20-7	Xylenes (total)	0.19	J	0.19	J	µg/L	90MW0042	1/60	0.11 - 0.47	0.19		21	N	10000	MCL	NO	BSL, IFD
117-81-7	BEHP[Bis(2-ethylhexyl)phthalate]	3	J	3	J	µg/L	90WT0010	1/7	1.32 - 5	3		4.8	C	6	MCL	NO	BSL
106-93-4	Ethylene Dibromide	0.005	J	0.019	-	µg/L	90MP0059B	11/254	0.0022 - 0.0054	0.019		0.00076	C	0.02	MMCL	NO	ASL, IFD
7429-90-5	Aluminum (total)	245	-	982	-	µg/L	90MW0079C	3/67	10.1 - 232	982		3600	N	50 to 200	SMCL	NO	BSL, IFD
7440-36-0	Antimony (total)	6.2	-	6.2	-	µg/L	90MW0066	1/60	2.6 - 5.7	6.2		1.5	N	6	MCL	YES	ASL, IFD
7440-38-2	Arsenic (total)	3.2	J	6.2	J	µg/L	90MW0066	4/67	1.6 - 7.3	6.2		0.045	C	10	MCL	YES	ASL
7440-39-3	Barium (total)	0.9	J	11.9	J	µg/L	90MW0079C	42/67	0.14 - 6.8	11.9		260	N	2000	MCL	NO	BSL
7440-42-8	Boron (total)	7.2	J	12.9	J	µg/L	90MW0066	7/7	1.3 - 3.1	12.9		730	N	NA	NA	NO	BSL
7440-43-9	Cadmium (total)	1.1	J	13.3	-	µg/L	90MW0015	6/67	0.28 - 0.81	13.3		1.8	N	5	MCL	YES	ASL
7440-70-2	Calcium (total)	692	J	7930	-	µg/L	90MW0056	67/67	7.2 - 71.9	7930		NA		NA	NA	NO	NUT, NSL
7440-47-3	Chromium (total)	0.9	J	12.5	-	µg/L	90MW0033	19/67	0.7 - 7	12.5		11	N	100	MCL	YES	ASL
7440-48-4	Cobalt (total)	1.2	J	3.2	J	µg/L	90MW0070	11/67	0.53 - 5	3.2		73	N	NA	NA	NO	BSL
7440-50-8	Copper (total)	1.4	J	43.2	-	µg/L	90MW0015	4/67	0.6 - 10.7	43.2		150	N	1000	SMCL	NO	BSL
7439-89-6	Iron (total)	37	J	1940	-	µg/L	90MW0066	26/67	12.7 - 254	1940		1100	N	300	SMCL	NO	NUT
7439-92-1	Lead (total)	1.7	J	1.8	J	µg/L	90MW0070	2/67	1.3 - 2.7	1.8		NA		15	AL	NO	BAL, IFD
7439-95-4	Magnesium (total)	410	J	2620	J	µg/L	90MW0079C	66/67	6.5 - 452	2620		NA		NA	NA	NO	NUT, NSL
7439-96-5	Manganese (total)	1.2	J	189	-	µg/L	90MW0066	18/67	0.34 - 11.4	189		88	N	50	SMCL	YES	ASL
7440-02-0	Nickel (total)	0.91	J	37.5	J	µg/L	90MW0033	15/67	0.9 - 9.4	37.5		73	N	100	ORSG	NO	BSL
7440-09-7	Potassium (total)	493	J	2050	J	µg/L	90MW0079C	36/67	21 - 1600	2050		NA		NA	NA	NO	NUT, NSL
7440-21-3	Silicon (total)	3750	-	10500	-	µg/L	90MW0066	7/7	5.7 - 5.7	10500		NA		NA	NA	NO	CC, NSL
7440-22-4	Silver (total)	0.7	J	0.7	J	µg/L	90JB0006B	1/67	0.5 - 3	0.7		18	N	100	SMCL	NO	BSL, IFD
7440-23-5	Sodium (total)	5580	-	11900	-	µg/L	90JB0006B	67/67	74.8 - 464	11900		NA		NA	NA	NO	NUT, NSL
7440-66-6	Zinc (total)	2.9	J	131	-	µg/L	90MW0015	5/67	0.3 - 18.1	131		1100	N	5000	SMCL	NO	BSL

Data Source: AFCEE, 14 and 30 March 2003, AFCEE-MMR Data Warehouse.

Table 2-3
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
FS-12 Off-Base Outside the Plume

(1) Minimum/maximum detected concentration.
(2) N/A = Refer to the *Final Fuel Spill-12 Groundwater Feasibility Study* (AFCEE 2005).
(3) MCL = maximum contaminant level
N = one-tenth of the EPA Region IX PRG based on non-carcinogenic effects
N/C = one-tenth of the EPA Region IX PRG based on non-carcinogenic effects (also protective of carcinogenic effects)
C = EPA Region IX PRG based on carcinogenic effects (at a risk of 1E-06)
(4) Rationale Codes:
Infrequent Detection (IFD)
Common Cation (CC)
Above Screening Levels (ASL)
No Screening Level (NSL)
Above Action Levels (AAL)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions:
AL = Action Level
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
C = Carcinogenic
CAS = Chemical Abstracts Service
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
J = Estimated Value
MCL = Maximum Contaminant Level
N = Non-Carcinogenic
N/A = Not Applicable
NA = Not Available
ORSG = Office of Research and Standards Guidelines
PRG = Preliminary Remediation Goal
SMCL = Secondary Maximum Contaminant Level
μg/L = micrograms per liter

Table 2-4
Medium-Specific Exposure Point Concentration Summary
FS-12 On-Base

Scenario Time Frame: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: On-base FS-12 groundwater

Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL of Data	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure (RME EPC)			Central Tendency (CT EPC)		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
VOCs												
Benzene	µg/L	7.28	NA	54	J	µg/L	54	Max	Reg Guide (2)	7.28	Mean-N	SF-Test (3)
Chloroform	µg/L	2.98	NA	1.3		µg/L	1.3	Max	Reg Guide (2)	2.98	Mean-N	SF-Test (3)
Ethylbenzene	µg/L	176	NA	695		µg/L	695	Max	Reg Guide (2)	176	Mean-N	SF-Test (3)
Ethylene Dibromide	µg/L	0.0097	NA	0.115		µg/L	0.115	Max	Reg Guide (2)	0.0097	Mean-N	SW-Test (4)
Tetrachloroethlene (PCE)	µg/L	2.88	NA	5.6	J	µg/L	5.6	Max	Reg Guide (2)	2.88	Mean-N	SF-Test (3)
Toluene	µg/L	1275	NA	10100		µg/L	10100	Max	Reg Guide (2)	1275	Mean-N	SF-Test (3)
Xylenes (total)	µg/L	588	NA	2900		µg/L	2900	Max	Reg Guide (2)	588	Mean-N	SW-Test (4)
Metals												
Arsenic	µg/L	2.1	NA	9	J	µg/L	9	Max	Reg Guide (2)	2.1	Mean-N	SW-Test (4)
Lead	µg/L	2.02	NA	19.1		µg/L	19.1	Max	Reg Guide (2)	2.02	Mean-N	SW-Test (4)
Manganese	µg/L	83	NA	472		µg/L	472	Max	Reg Guide (2)	83	Mean-N	SW-Test (1)
Thallium	µg/L	1.6	NA	3	J	µg/L	3	Max	Reg Guide (2)	1.6	Mean-N	SW-Test (4)

Notes:
EPC = Exposure Point Concentration
RME = reasonable maximum exposure
VOC = volatile organic compound
J = estimated value
UCL = upper confidence limit
µg/L = micrograms per liter
NA = not available
For nondetects, 1/2 sample detection limit was used as a proxy concentration in the calculation of means and UCLs.
Statistics: Maximum detected value (Max), arithmetic mean of normally distributed data (Mean-N), mean of log-normally distributed data (Mean-T).
(1) Shapiro-Wilk W test indicates that data are log-normally distributed, but regulatory guidance requires use of arithmetic mean (Mean-N).
(2) Regulators advise to use maximum value for RME EPC for groundwater.
(3) Shapiro-Francia test indicates samples are normally distributed.
(4) Shapiro-Wilk W test indicates that the data are neither normally nor log-normally distributed, arithmetic mean (Mean-N) used as default.

Table 2-5
Medium-Specific Exposure Point Concentration Summary
FS-12 Off-Base Within the Plume

Scenario Time Frame: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Off-base FS-12 groundwater within the plume

Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL of Data	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure (RME EPC)			Central Tendency (CT EPC)		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
VOCs												
Benzene	µg/L	1.18	NA	25		µg/L	25	Max	Reg Guide (2)	1.18	Mean-N	SF-Test (4)
Chloroform	µg/L	0.81	NA	3		µg/L	3	Max	Reg Guide (2)	0.81	Mean-N	SF-Test (1)
Ethylene Dibromide (EDB)	µg/L	1.25	NA	23		µg/L	23	Max	Reg Guide (2)	1.25	Mean-N	DA-Test (3)
Tetrachloroethlene (PCE)	µg/L	0.162	NA	5.6	J	µg/L	5.6	Max	Reg Guide (2)	0.162	Mean-N	SF-Test (5)
1,2-Dichloroethane	µg/L	0.147	NA	1.7		µg/L	1.7	Max	Reg Guide (2)	0.147	Mean-N	SF-Test (1)
SVOCs												
2-Methylnaphthalene	µg/L	6.2	NA	24	J	µg/L	24	Max	Reg Guide (2)	6.2	Mean-N	SW-Test (6)
Naphthalene	µg/L	18	NA	58	J	µg/L	58	Max	Reg Guide (2)	18	Mean-N	SW-Test (7)
Metals												
Antimony	µg/L	2.70	NA	10.6	J	µg/L	10.6	Max	Reg Guide (2)	2.7	Mean-N	SF-Test (1)
Arsenic	µg/L	2.54	NA	6.2	J	µg/L	6.2	Max	Reg Guide (2)	2.54	Mean-N	SF-Test (1)
Manganese	µg/L	78	NA	336		µg/L	336	Max	Reg Guide (2)	78	Mean-N	SF-Test (1)
Nickel	µg/L	10	NA	328		µg/L	328	Max	Reg Guide (2)	10	Mean-N	SF-Test (5)

Notes:
EPC = Exposure Point Concentration
J = estimated value
NA = not available
SVOC = semivolatile organic compound
UCL = upper confidence limit
VOC = volatile organic compound
µg/L = micrograms per liter
* = For manganese, EPCs based on dissolved are higher than EPCs based on total.
For nondetects, 1/2 sample detection limit was used as a proxy concentration in the calculation of means and UCLs.
Statistics: Maximum detected value (Max), arithmetic mean of normally distributed data (Mean-N), mean of log-normally distributed data (Mean-T).

(1) Shapiro-Francia test indicates samples are normally distributed.
(2) Regulators advise to use maximum value for RME EPC for groundwater.
(3) D'Agostino normality test indicates that the data are neither normally nor log-normally distributed, arithmetic mean (Mean-N) used as default.
(4) Shapiro-Francia test indicates data are neither normally nor log-normally distributed, arithmetic mean (Mean-N) used as default.
(5) Shapior-Francia test indicates samples are log-normally distributed, but regulatory guidance requires use of arithmetic mean (Mean-N).
(6) Shapiro-Wilk W test indicates samples are log-normally distributed, but regulatory guidance requires use of arithmetic mean (Mean-N).
(7) Shapiro-Wilk W test indicates samples are normally distributed.

Table 2-6
Medium-Specific Exposure Point Concentration Summary
FS-12 Off-Base Outside the Plume

Scenario Time Frame: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Off-base FS-12 groundwater outside the plume

Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL of Data	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure (RME EPC)			Central Tendency (CT EPC)		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
VOCs												
Chloroform	µg/L	0.307	NA	1.61		µg/L	1.61	Max	Reg Guide (2)	0.307	Mean-N	SF-Test (1)
Metals												
Antimony	µg/L	2.48	NA	6.2		µg/L	6.2	Max	Reg Guide (2)	2.48	Mean-N	SF-Test (1)
Arsenic	µg/L	2.34	NA	6.2	J	µg/L	6.2	Max	Reg Guide (2)	2.34	Mean-N	SF-Test (1)
Cadmium	µg/L	0.726	NA	13.3		µg/L	13.3	Max	Reg Guide (2)	0.726	Mean-N	SF-Test (3)
Chromium	µg/L	1.63	NA	12.5		µg/L	12.5	Max	Reg Guide (2)	1.63	Mean-N	SF-Test (1)
Manganese	µg/L	28	NA	189		µg/L	189	Max	Reg Guide (2)	28	Mean-N	SF-Test (1)

Notes:

EPC = Exposure Point Concentration
UCL = upper confidence limit

J = estimated value
VOC = volatile organic compound

NA = not available
µg/L = micrograms per liter

* = For manganese, EPCs based on dissolved are higher than EPCs based on total.

For nondetects, 1/2 sample detection limit was used as a proxy concentration in the calculation of means and UCLs.

Statistics: Maximum detected value (Max), arithmetic mean of normally distributed data (Mean-N), mean of log-normally distributed data (Mean-T).

(1) Shapiro-Francia test indicates samples are normally distributed.

(2) Regulators advise to use maximum value for RME EPC for groundwater.

(3) Shapiro-Francia test indicates that the data are neither normally nor log-normally distributed, arithmetic mean (Mean-N) used as default.

Table 2-7
Values Used for Daily Intake Calculations
Groundwater - Adult

Scenario Time Frame: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Aquifer - Tap Water
Receptor Population: On-Site and Off-Site Resident
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
	IRW	Ingestion Rate of Water	L/day	2	EPA 1995	1.4	EPA 1995	
	EF	Exposure Frequency	days/yr	350	Site-specific	350	Site-specific	
	ED	Exposure Duration	yrs	24	EPA 1989	9	EPA 1995	
	CF1	Conversion Factor	mg/µg	0.001	-	0.001	-	
	BW	Body Weight	kg	70	EPA 1989	70	EPA 1989	
	AT-NC	Averaging Time (noncancer)	days	8,760	EPA 1989	3,285	EPA 1995	
	AT- C	Averaging Time (cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
Dermal	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
	DA_{event}	Dose absorbed per unit area per event	mg/cm^2-event	Chem.-specific	EPA 2001	Chem.-specific	EPA 2001	Where DA_{event} (mg/cm^2-event) is calculated in accordance
	SA	Skin surface area available for contact	cm^2	18,000	EPA 2001	18,000	EPA 2001	with EPA Superfund Dermal Risk Guidance (EPA 2001)
	ET	Exposure Time	hr/day	0.58	EPA 2001	0.25	EPA 2001	
	EV	Event	event/day	1	EPA 2001	1	EPA 2001	
	EF	Exposure Frequency	days/yr	350	Site-specific	350	Site-specific	
	ED	Exposure Duration	yrs	24	EPA 1989	9	EPA 1995	
	BW	Body Weight	kg	70	EPA 1989	70	EPA 1989	
	AT-NC	Averaging Time (noncancer)	days	8,760	EPA 1989	3,285	EPA 1995	
	AT- C	Averaging Time (cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
Inhalation	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRd x VF x EF x ED x CF1 x 1/BW x 1/AT
	Ird	Inhalation Rate, daily	m^3/day	15	EPA 1991a	15	EPA 1991a	
	VF	Volatilization Factor*	L/m^3	0.5	EPA 1991a	0.5	EPA 1991a	
	EF	Exposure Frequency	days/yr	350	Site-specific	350	Site-specific	
	ED	Exposure Duration	yrs	24	EPA 1989	9	EPA 1995	
	CF1	Conversion Factor	mg/µg	0.001	-	0.001	-	
	BW	Body Weight	kg	70	EPA 1989	70	EPA 1989	
	AT-NC	Averaging Time (noncancer)	days	8,760	EPA 1989	3,285	EPA 1995	
	AT- C	Averaging Time (cancer)	days	25,550	EPA 1989	25,550	EPA 1989	

Notes:
Chem. = chemical
cm^2 = square centimeter
CT = central tendency
hr = hour
kg = kilogram
L = liter
mg = milligram
m^3 = cubic meter
RME = reasonable maximum exposure
yr = year
µg = microgram
*Vapor from household use of groundwater.

Table 2-8
Values Used for Daily Intake Calculations
Groundwater - Child

Scenario Time Frame: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Aquifer - Tap Water
Receptor Population: On-Site and Off-Site Resident
Receptor Age: Child (0 - 6 years)

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
	IRW	Ingestion Rate of Water	L/day	1	EPA 1995	1	EPA 1995	
	EF	Exposure Frequency	days/yr	350	Site-specific	350	Site-specific	
	ED	Exposure Duration	yrs	6	EPA 1989	6	EPA 1989	
	CF1	Conversion Factor	mg/µg	0.001	-	0.001	-	
	BW	Body Weight	kg	15	EPA 1989	15	EPA 1989	
	AT-NC	Averaging Time (noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	
	AT- C	Averaging Time (cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
Dermal	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
	DA_{event}	Dose absorbed per unit area per event	mg/cm^2-event	Chem.-specific	EPA 2001	Chem.-specific	EPA 2001	Where DA_{event} (mg/cm^2-event) is calculated in accordance
	SA	Skin surface area available for contact	cm^2	6,600	EPA 2001	6,600	EPA 2001	with EPA Superfund Dermal Risk Guidance (EPA 2001)
	ET	Exposure Time	hr/day	1	EPA 2001	0.33	EPA 2001	
	EV	Event	event/day	1	EPA 2001	1	EPA 2001	
	EF	Exposure Frequency	days/yr	350	Site-specific	350	Site-specific	
	ED	Exposure Duration	yrs	6	EPA 1989	6	EPA 1989	
	BW	Body Weight	kg	15	EPA 1989	15	EPA 1989	
	AT-NC	Averaging Time (noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	
	AT- C	Averaging Time (cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
Inhalation	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRd x VF x EF x ED x CF1 x 1/BW x 1/AT
	Ird	Inhalation Rate, daily	m^3/day	10	EPA 1997	10	EPA 1991a	
	VF	Volatilization Factor*	L/m^3	0.5	EPA 1991a	0.5	EPA 1991a	
	EF	Exposure Frequency	days/yr	350	Site-specific	350	Site-specific	
	ED	Exposure Duration	yrs	6	EPA 1989	6	EPA 1989	
	CF1	Conversion Factor	mg/µg	0.001	-	0.001	-	
	BW	Body Weight	kg	15	EPA 1989	15	EPA 1989	
	AT-NC	Averaging Time (noncancer)	days	2,190	EPA 1989	2,190	EPA 1995	
	AT- C	Averaging Time (cancer)	days	25,550	EPA 1989	25,550	EPA 1989	

Notes:

Chem. = chemical
cm^2 = square centimeter
CT = central tendency
hr = hour
kg = kilogram
L = liter
m^3 = cubic meter
mg = milligram
RME = reasonable maximum exposure
yr = year
µg = microgram
*Vapor from household use of groundwater.

Table 2-9
Non-Cancer Chronic Toxicity Data - Oral/Dermal

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (1)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (MM/DD/YY)
Benzene	Chronic	4.0E-03	mg/kg/day	none	4.0E-03	mg/kg/day	Blood	300	IRIS	4/17/03
Chloroform	Chronic	1.0E-02	mg/kg/day	none	1.0E-02	mg/kg/day	Liver	1000	IRIS	4/17/03
1,2-Dichloroethane	Chronic	3.0E-02	mg/kg/day	none	3.0E-02	mg/kg/day	NA	NA	EPA 2002	4/17/03
Ethylbenzene	Chronic	1.0E-01	mg/kg/day	none	1.0E-01	mg/kg/day	Liver/Kidney	1000	IRIS	4/17/03
Ethylene Dibromide (EDB)	Chronic	NA	mg/kg/day	none	NA	mg/kg/day	NA	NA	IRIS	4/17/03
2-Methylnaphthalene	Chronic	9.0E-03	mg/kg/day	none	9.0E-03	mg/kg/day	Lung	1000	NCEA	4/18/03
Naphthalene	Chronic	2.0E-02	mg/kg/day	none	2.0E-02	mg/kg/day	Body weight	3000	IRIS	4/17/03
Tetrachloroethlene (PCE)	Chronic	1.0E-02	mg/kg/day	none	1.0E-02	mg/kg/day	Liver	1000	IRIS	4/17/03
Toluene	Chronic	2.0E-01	mg/kg/day	none	2.0E-01	mg/kg/day	Liver/Kidney	1000	IRIS	4/17/03
Xylenes (total)	Chronic	2.0E-01	mg/kg/day	none	2.0E-01	mg/kg/day	Body weight	1000	IRIS	4/17/03
Antimony	Chronic	4.0E-04	mg/kg/day	0.15	6.0E-05	mg/kg/day	Life Span / Blood	1000	IRIS	4/17/03
Arsenic	Chronic	3.0E-04	mg/kg/day	none	3.0E-04	mg/kg/day	Skin	3	IRIS	4/17/03
Cadmium	Chronic	5.0E-04	mg/kg/day	0.025	1.3E-05	mg/kg/day	Kidney	10	IRIS	4/17/03
Chromium	Chronic	3.0E-03	mg/kg/day	0.025	7.5E-05	mg/kg/day	None	900	IRIS	4/17/03
Lead (and compounds-inorg.)	Chronic	NA	mg/kg/day	NA	NA	mg/kg/day	CNS	NA	IRIS	4/17/03
Manganese	Chronic	1.4E-01 (food)	mg/kg/day	NA	NA	mg/kg/day	CNS	1	IRIS	4/17/03
Manganese	Chronic	7E-02 (soil)	mg/kg/day	0.04	2.8E-03 (soil)	mg/kg/day	CNS	1	EPA Region 1	9/99
Manganese	Chronic	2.4E-2 (water)	mg/kg/day	0.04	9.6E-04 (water)	mg/kg/day	CNS	1	EPA Region 1	11/96
Nickel	Chronic	2.0E-02	mg/kg/day	0.04	8.0E-04	mg/kg/day	Body weight	300	IRIS	4/17/03
Thallium	Chronic	6.6E-05	mg/kg/day	none	6.6E-05	mg/kg/day	Liver	3000	HEAST	4/17/03

Notes:
(1) EPA 2001 (September). Risk Assessment Guidance for Superfund (RAGS): Volume I: Human Health Evaluation Manual. (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance.

CNS = central nervous system
EPA = U.S. Environmental Protection Agency
EPA 2002 = EPA Region 9 PRGs Table 2002 Update, October 1, 2002.
HEAST=Health Effects Assessment Summary Tables (EPA 1997).
IRIS =Integrated Risk Information System. Online database. Accessed 4/17/2003.
mg/kg/day = milligrams per kilogram per day
NA = not available
NCEA = National Center For Environmental Assessment. Toxicological Review of 2-Methylnaphthalene [and IRIS Summary]. EPA 2003b.
PRG = preliminary remediation goal
RfD = reference dose

Table 2-10
Non-Cancer Toxicity Data - Inhalation

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted (1) Inhalation RfD	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates (MM/YY)
Benzene	Chronic	3.0E-02	mg/m^3	8.6E-03	mg/kg/day	Blood	300	IRIS	4/17/2003
Chloroform	Chronic	NA	mg/m^3	8.6E-04	mg/kg/day	NA	NA	NCEA	4/17/03
1,2-Dichloroethane	Chronic	NA	mg/m^3	1.4E-03	mg/kg/day	NA	NA	NCEA	4/17/03
Ethylbenzene	Chronic	1.0E+00	mg/m^3	2.9E-01	mg/kg/day	Developmental	300	IRIS	4/17/03
Ethylene Dibromide (EDB)	Chronic	2.0E-04	mg/m^3	5.7E-05	mg/kg/day	Developmental	1000	HEAST	4/17/03
2-Methylnaphthalene	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	NCEA	4/18/2003
Naphthalene	Chronic	3.0E-03	mg/m^3	8.6E-04	mg/kg/day	Respiratory	3000	IRIS	4/17/03
Tetrachloroethlene (PCE)	Chronic	NA	mg/m^3	1.7E-01	mg/kg/day	NA	NA	NCEA	4/17/2003
Toluene	Chronic	4.0E-01	mg/m^3	1.1E-01	mg/kg/day	CNS	300	IRIS	4/10/2003
Xylenes (total)	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg/day	Motor Coordination	300	IRIS	4/17/2003
Antimony	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	IRIS	4/17/2003
Arsenic	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	NA	4/17/03
Cadmium	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	NA	4/17/03
Chromium	Chronic	1.0E-04	mg/m^3	2.9E-05	mg/kg/day	Lung	300	IRIS	4/17/03
Lead	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	NA	4/17/03
Manganese	Chronic	5.0E-05	mg/m^3	1.4E-05	mg/kg/day	CNS	1000	IRIS	4/17/03
Nickel	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	NA	4/17/03
Thallium	Chronic	NA	mg/m^3	NA	mg/kg/day	NA	NA	IRIS	4/17/2003

Notes:
(1) Adjustment factor applied to inhalation RfC to calculate inhalation RfD = 20 m^3/day x 1/70 kg.

CNS = central nervous system
EPA = U.S. Environmental Protection Agency
HEAST = Health Effects Assessment Summary Tables (EPA 1997).
IRIS =Integrated Risk Information System. Online database. Accessed 4/17/2003.
mg/kg/day = milligrams per kilogram per day
mg/m^3= milligrams per cubic meter
NA = not available
NCEA = National Center for Environmental Assessment. Cited in EPA 2002 except for 2-Methylnaphthalene.
NCEA = National Center For Environmental Assessment. Toxicological Review of 2-Methylnaphthalene [and IRIS Summary]. EPA 2003b. Accessed 4/18/03.
RfC = reference concentration
RfD = reference dose

Table 2-11

Cancer Toxicity Data - Oral

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Benzene	5.5E-02	none	5.5E-02	$(mg/kg/day)^{-1}$	A	IRIS	4/17/03
Chloroform	NA	NA	NA	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
1,2-Dichloroethane	9.1E-02	none	9.1E-02	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
Ethylbenzene	NA	NA	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Ethylene Dibromide (EDB)	8.5E+01	none	8.5E+01	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
2-Methylnaphthalene	NA	NA	NA	$(mg/kg/day)^{-1}$	D	NCEA	4/18/03
Naphthalene	NA	NA	NA	$(mg/kg/day)^{-1}$	C	IRIS	4/17/03
Tetrachloroethlene (PCE)	5.2E-02	none	5.2E-02	$(mg/kg/day)^{-1}$	NA	NCEA	4/17/03
Toluene	NA	NA	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Xylenes (total)	NA	NA	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Antimony	NA	NA	NA	$(mg/kg/day)^{-1}$	NA	IRIS	4/17/03
Arsenic	1.5E+00	none	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	4/17/03
Cadmium	NA	0.05	NA	$(mg/kg/day)^{-1}$	B1	IRIS	4/17/03
Chromium	NA	0.025	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Lead (and compounds-inorganic)	NA	NA	NA	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
Manganese	NA	0.04	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Nickel	NA	0.04	NA	$(mg/kg/day)^{-1}$	NA	IRIS	4/17/03
Thallium	NA	none	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03

Notes:

(1) EPA 2001 (September). Risk Assessment Guidance for Superfund (RAGS): Volume I: Human Health Evaluation Manual. (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance.

EPA = U.S. Environmental Protection Agency

IRIS = Integrated Risk Information System. Online database. Accessed 4/17/03.

mg/kg/day = milligrams per kilogram per day

NA = not available

NCEA = National Center for Environmental Assessment. Cited in EPA 2002 except for 2-Methylnaphthalene. For 2-Methylnaphthalene, the following reference was used: Toxicological Review of 2-Methylnaphthalene [and IRIS Summary]. EPA 2003b. Accessed 4/18/03.

EPA Weight of Evidence Classification:

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

Table 2-12
Cancer Toxicity Data - Inhalation

Chemical of Potential Concern	Unit Risk	Units	Adjustment (1)	Inhalation Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Benzene	7.8E-03	$(mg/m^3)^{-1}$	3.5E+00	2.90E-02	$(mg/kg/day)^{-1}$	A	IRIS	4/17/03
Chloroform	2.3E-02	$(mg/m^3)^{-1}$	3.5E+00	8.05E-02	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
1,2-Dichloroethane	2.6E-02	$(mg/m^3)^{-1}$	3.5E+00	9.10E-02	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
Ethylbenzene	NA	$(mg/m^3)^{-1}$	3.5E+00	3.85E-03	$(mg/kg/day)^{-1}$	D	EPA 2002	4/17/03
Ethylene Dibromide (EDB)	2.2E-01	$(mg/m^3)^{-1}$	3.5E+00	7.70E-01	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
2-Methylnaphthalene	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	D	NCEA	4/18/03
Naphthalene	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	C	IRIS	4/17/03
Tetrachloroethlene (PCE)	5.9E-03	$(mg/m^3)^{-1}$	3.5E+00	2.07E-02	$(mg/kg/day)^{-1}$	NA	EPA Region 1	1/30/03
Toluene	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Xylenes (total)	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Antimony	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	NA	IRIS	4/17/03
Arsenic	4.3E+00	$(mg/m^3)^{-1}$	3.5E+00	1.51E+01	$(mg/kg/day)^{-1}$	A	IRIS	4/17/03
Cadmium	1.8E+00	$(mg/m^3)^{-1}$	3.5E+00	6.30E+00	$(mg/kg/day)^{-1}$	B1	IRIS	4/17/03
Chromium	1.2E+01	$(mg/m^3)^{-1}$	3.5E+00	4.20E+01	$(mg/kg/day)^{-1}$	A	IRIS	4/17/03
Lead (and compounds-inorganic)	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	B2	IRIS	4/17/03
Manganese	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03
Nickel	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	NA	IRIS	4/17/03
Thallium	NA	$(mg/m^3)^{-1}$	3.5E+00	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/17/03

Notes:

(1) Adjustment factor applied to Unit Risk to calculate Inhalation Slope Factor = 70 kg x 1/20 m^3/day

EPA = U.S. Environmental Protection Agency
EPA 2002 = EPA Region 9 PRGs Table 2002 Update, October 1, 2002
EPA Region 1 = Correspondence from EPA Region 1 to AFCEE dated 1/30/03. EPA 2003c.
IRIS = Integrated Risk Information System. Online database. Accessed 4/17/03.
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
NA = not available
NCEA = National Center For Environmental Assessment. Toxicological Review of 2-Methylnaphthalene [and IRIS Summary]. EPA 2003b.
PRG = preliminary remediation goal
EPA Weight of Evidence Classification:

A = human carcinogen
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

Table 2-13
Risk Assessment Summary, Reasonable Maximum Exposure
FS-12 On-Base Adult

Scenario Time Frame: Future
Receptor Population: On-Base 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	On-Base Groundwater-Tap Water	Benzene	2.8E-05	NA	4.4E-06	3.2E-05	Toluene	Liver/Kidney	1E+00	NA	5E-01	2E+00
			Ethylene Dibromide	9.2E-05	NA	5.5E-06	9.8E-05						
			Tetrachloroethene (PCE)	2.8E-05	NA	1.8E-05	4.6E-05						
			Arsenic	1.3E-04	NA	6.7E-07	1.3E-04						
			(Total)	2.8E-04	NA	2.9E-05	3.1E-04	(Total)		1E+00	NA	5E-01	2E+00
	Vapor	On-Base Groundwater-Vapor	Benzene	NA	5.5E-05	NA	5.5E-05	Toluene	CNS	NA	9E+00	NA	9E+00
			Chloroform	NA	3.7E-06	NA	3.7E-06	Xylenes (total)	Motor Coordination	NA	1E+01	NA	1E+01
			Ethylene Dibromide	NA	3.1E-06	NA	3.1E-06						
			Tetrachloroethene (PCE)	NA	4.1E-06	NA	4.1E-06						
			(Total)	NA	6.6E-05	NA	6.6E-05	(Total)		NA	2E+01	NA	2E+01
							Total Risk Across Groundwater	3.7E-04					Total Hazard Index Across All Media and All Exposure Routes	2E+01
							Total Adult Risk Across All Media and All Exposure Routes	3.7E-04					
							Total Child Risk Across All Media and All Exposure Routes	2.3E-04					
							Total Lifetime Risk Across All Media and All Exposure Routes	6.0E-04					

Notes:
CNS = central nervous system
NA = not available

Table 2-14
Risk Assessment Summary, Reasonable Maximum Exposure
FS-12 On-Base Child

Scenario Time Frame: Future
Receptor Population: On-Base Resident
Receptor Age: Child

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	On-Base Groundwater-Tap Water	Benzene	1.6E-05	NA	2.6E-06	1.9E-05	Toluene	Liver/Kidney	3E+00	NA	1E+00	4E+00
			Ethylene Dibromide	5.4E-05	NA	3.1E-06	5.7E-05	Xylenes (total)	Body Weight	9E-01	NA	6E-01	2E+00
			Tetrachloroethene (PCE)	1.7E-05	NA	1.0E-05	2.7E-05	Arsenic	Skin	2E+00	NA	1E-02	2E+00
			Arsenic	7.4E-05	NA	4.9E-07	7.4E-05	Manganese	CNS	1E+00	NA	2E-01	2E+00
			(Total)	1.6E-04	NA	1.6E-05	1.8E-04	Thallium	Liver	3E+00	NA	2E-02	3E+00
								(Total)		1E+01	NA	2E+00	1E+01
	Vapor	On-Base Groundwater-Vapor	Benzene	NA	4.3E-05	NA	4.3E-05	Benzene	Blood	NA	2E+00	NA	2E+00
			Chloroform	NA	2.9E-06	NA	2.9E-06	Toluene	CNS	NA	3E+01	NA	3E+01
			Ethylene Dibromide	NA	2.4E-06	NA	2.4E-06	Xylenes (total)	Motor Coordination	NA	3E+01	NA	3E+01
			Tetrachloroethene (PCE)	NA	3.2E-06	NA	3.2E-06						
			(Total)	NA	5.2E-05	NA	5.2E-05	(Total)		NA	6E+01	NA	6E+01
							Total Risk Across Groundwater	2.3E-04					
							Total Hazard Index Across All Media and All Exposure Routes						7E+01
							Total Child Risk Across All Media and All Exposure Routes	2.3E-04					
							Total Adult Risk Across All Media and All Exposure Routes	3.7E-04					
							Total Lifetime Risk Across All Media and All Exposure Routes	6.0E-04					

Notes:
CNS = central nervous system
NA = not available

Table 2-15
Risk Assessment Summary, Reasonable Maximum Exposure
FS-12 Off-Base Within the Plume - Adult

Scenario Time Frame: Future
Receptor Population: Off-Base Residen
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	Off-Base in Groundwater Plume-Tap Water	Benzene	1.3E-05	NA	2.0E-06	1.5E-05	none					
			Ethylene Dibromide (EDB)	1.8E-02	NA	1.1E-03	1.9E-02						
			Tetrachloroethene (PCE)	2.8E-05	NA	1.8E-05	4.6E-05						
			1,2-Dichloroethane	1.5E-06	NA	7.4E-08	1.6E-06						
			Arsenic	8.7E-05	NA	4.6E-07	8.7E-05						
			(Total)	1.8E-02	NA	1.1E-03	1.9E-02	(Total)					
	Vapor	Off-Base in Groundwater Plume-Vapor	Benzene	NA	2.6E-05	NA	2.6E-05						
			Chloroform	NA	8.5E-06	NA	8.5E-06	Ethylene Dibromide (EDB)	Developmental	NA	4.0E+01	NA	4.0E+01
			Ethylene Dibromide (EDB)	NA	6.2E-04	NA	6.2E-04						
			Tetrachloroethene (PCE)	NA	4.1E-06	NA	4.1E-06						
			1,2-Dichloroethane	NA	5.4E-06	NA	5.4E-06						
			(Total)	NA	6.7E-04	NA	6.7E-04	(Total)		NA	4.0E+01	NA	4.0E+01
							Total Risk Across Groundwater	2.0E-02					Total Hazard Index Across All Media and All Exposure Routes	4.0E+01
							Total Adult Risk Across All Media and All Exposure Routes	2.0E-02					
							Total Child Risk Across All Media and All Exposure Routes	1.2E-02					
							Total Lifetime Risk Across All Media and All Exposure Routes	3.2E-02					

Notes:
NA = not available

Table 2-16
Risk Assessment Summary, Reasonable Maximum Exposure
FS-12 Off-Base Within the Plume - Child

Scenario Time Frame: Future
Receptor Population: Off-Base Residen
Receptor Age: Child

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	Off-Base in Groundwater Plume-Tap Water	Benzene	7.5E-06	NA	1.2E-06	8.7E-06	Antimony	Life Span/Blood	2E+00	NA	8E-02	2E+00
			Ethylene Dibromide (EDB)	1.1E-02	NA	6.1E-04	1.2E-02						
			Tetrachloroethene (PCE)	1.7E-05	NA	1.0E-05	2.7E-05						
			Arsenic	5.1E-05	NA	3.4E-07	5.1E-05						
			(Total)	1.1E-02	NA	6.2E-04	1.2E-02	(Total)		2E+00	NA	8E-02	2E+00
	Vapor	Off-Base in Groundwater Plume-Vapor	Benzene	NA	2.0E-05	NA	2.0E-05						
			Chloroform	NA	6.6E-06	NA	6.6E-06	Ethylene Dibromide (EDB)	Developmental	NA	1E+02	NA	1E+02
			Ethylene Dibromide (EDB)	NA	4.9E-04	NA	4.9E-04						
			Tetrachloroethene (PCE)	NA	3.2E-06	NA	3.2E-06						
			1,2-Dichloroethane	NA	4.2E-06	NA	4.2E-06						
			(Total)	NA	5.2E-04	NA	5.2E-04	(Total)		NA	1E+02	NA	1E+02
							Total Risk Across Groundwater	1.2E-02					Total Hazard Index Across All Media and All Exposure Routes	1E+02
							Total Child Risk Across All Media and All Exposure Routes	1.2E-02					
							Total Adult Risk Across All Media and All Exposure Routes	2.0E-02					
							Total Lifetime Risk Across All Media and All Exposure Routes	3.2E-02					

Notes:
NA = not available

Table 2-17
Risk Assessment Summary, Reasonable Maximum Exposure
FS-12 Off-Base Outside the Plume - Adult

Scenario Time Frame: Current\Future
Receptor Population: Off-Base 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	Off-Base Outside Groundwater Plume-Tap Water	Arsenic	8.7E-05	NA	4.6E-07	8.7E-05	none					
			(Total)	8.7E-05	NA	9.3E-07	8.7E-05	(Total)					
	Vapor	Off-Base Outside Groundwater Plume-Vapor	Chloroform	NA	4.6E-06	NA	4.6E-06	none					
			(Total)	NA	9.3E-07	NA	4.6E-06	(Total)					
						Total Risk Across Groundwater	9.2E-05					Total Hazard Index Across All Media and All Exposure Routes	
						Total Adult Risk Across All Media and All Exposure Routes	9.2E-05						
						Total Child Risk Across All Media and All Exposure Routes	5.5E-05						
						Total Lifetime Risk Across All Media and All Exposure Routes	1.5E-04						

Notes:
NA = not available

Table 2-18
Risk Assessment Summary, Reasonable Maximum Exposure
FS-12 Off-Base Outside the Plume - Child

Scenario Time Frame: Current\Future
Receptor Population: Off-Base Resident
Receptor Age: Child

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	Off-Base Outside Groundwater Plume-Tap Water	Arsenic	5.1E-05	NA	3.4E-07	5.1E-05	Cadmium	Kidney	2E+00	NA	4E-01	2E+00
			(Total)	5.1E-05	NA	3.4E-07	5.1E-05	(Total)		2E+00	NA	4E-01	2E+00
	Vapor	Off-Base Outside Groundwater Plume-Vapor	Chloroform	NA	3.6E-06	NA	3.6E-06	none					
			(Total)	NA	3.6E-06	NA	3.6E-06	(Total)					
							Total Risk Across Groundwater	5.5E-05					Total Hazard Index Across All Media and All Exposure Routes	2E+00
							Total Child Risk Across All Media and All Exposure Routes	5.5E-05					
							Total Adult Risk Across All Media and All Exposure Routes	9.2E-05					
							Total Lifetime Risk Across All Media and All Exposure Routes	1.5E-04					

Notes:
NA = not available

Table 2-19
Summary of Human Health Risk Drivers
FS-12 Groundwater

Area	COPC	ELCR	HI (Child)	HI (Adult)	EPC (µg/L)	(M)MCL (µg/L)	Exceeds MCL?	Detection Frequency	COC?	Why Not?
On-Base Groundwater										
	arsenic	2.E-04	2		9 J	10	No	4/22	No	Concentrations are equivalent to background.
	benzene	1.E-04	3		54 J	5	Yes	10/38	No	Benzene concentrations have decreased since the risk assessment was conducted. The maximum 2005 concentration was 4.1 µg/L.
	EDB	2.E-04			0.115	0.02	Yes	9/33	No	EDB concentrations have decreased since the risk assessment was conducted. All samples collected in 2004 and 2005 were nondetect.
	PCE	8.E-05			5.6 J	5	Yes	1/38	No	Compound is detected infrequently.
	chloroform	7.E-06			1.3	80[1]	No	12/38	No	Concentrations are equivalent to background.
	toluene		34	11	10,100	1,000	Yes	26/38	No	Toluene concentrations have decreased since the risk assessment was conducted. All samples collected from December 2002 through 2005 had toluene concentrations below the MCL.
	xylenes (total)		32	10	2,900	10,000	No	21/29	Yes	
	manganese		2		472			8/9	No	Concentrations are equivalent to background.
	thallium		3		3 J	2	Yes	1/25	No	Compound is infrequently detected at concentrations equivalent to background.
Off-Base Groundwater, Within Plume										
	1,2-DCA	1.E-05			1.7	5	No	4/74	No	Compound was detected in only 2 wells, and only once at concentrations greater than 1 µg/L.
	arsenic	1.E-04			6.2 J	10	No	4/39	No	Concentrations are equivalent to background.
	benzene	7.E-05			25	5	Yes	16/80	Yes	
	EDB	3.E-02	100	40	23	0.02	Yes	47/94	Yes	
	PCE	8.E-05			5.6 J	5	Yes	2/80	No	Compound is detected infrequently.
	chloroform	2.E-05			3	80	No	48/74	No	Concentrations are equivalent to background.
	antimony		2		10.6 J	6	Yes	1/36	No	Concentrations are equivalent to background.
Off-Base Groundwater, Outside of Plume										
	arsenic	1.E-04			6.2 J	10	No	4/67	No	Concentrations are equivalent to background.
	chloroform	8.E-06			1.61	80	No	42/86	No	Concentrations are equivalent to background.
	cadmium		2		13.6	5	Yes	6/67	No	Concentrations are equivalent to background.

Table 2-19
Summary of Human Health Risk Drivers
FS-12 Groundwater

Notes:
[1] = The MCL listed for chloroform is the MCL for total trihalomethanes
1,2-DCA = 1,2-dichloroethane
COC = contaminant of concern
COPC = contaminant of potential concern
EDB = ethylene dibromide
ELCR = excess lifetime cancer risk
EPC = exposure point concentration
HI = hazard index
J = estimated concentration
MCL = maximum contaminant level
MMCL = Massachusetts maximum contaminant level
PCE = tetrachloroethene
µg/L = micrograms per liter

Table 2-20
FS-12 Feasibility Study Comparison of Alternatives

Alternative	Description	Threshold Criteria	Primary Balancing Criteria
Alternative 1: No Action	• No activity at the site	• Not protective of human health and environment • RAOs reached in 2051	• Baseline scenario • $0
Alternative 2: Land Use Controls and Long-Term Monitoring	• No active treatment • Land Use Controls • Chemical monitoring of plume and periphery	• Protective of human health through land use controls • Long-term monitoring will enable confirmation of natural attenuation and achievement of RAOs • RAOs reached in 2051	• Alternative to active treatment that is protective of human health • $6.3 M
Alternative 3: Operation, Maintenance, and Monitoring of the Existing ETR System and Land Use Controls	• Active remediation with existing treatment system • Land Use Controls • Chemical and hydraulic monitoring of the treatment system and plume to allow for optimization	• Protective of human health through land use controls • Contains the plume • Decrease cleanup time of FS-12 plume; RAOs reached in 2030	• Active treatment scenario; permanent removal of contaminants • $22.4 M

Notes:
ETR = extraction, treatment, and reinjection
M =million
RAO = remedial action objective

Table 2-21
Chemical-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Groundwater	FEDERAL — SDWA MCLs (40 CFR 141.61-141.63)	MCLs have been promulgated for organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies, but are also considered relevant and appropriate for CERCLA groundwater response actions where the groundwater aquifer is used or classified for use as drinking water.	These standards were used to develop cleanup standards to be met through cleanup of the FS-12 plume. Under Alternative 3, the FS-12 ETR system is designed to treat extracted groundwater to these standards, unless the state promulgates more stringent drinking water or groundwater quality standards, in which case the more stringent state standards will apply. SPEIM will determine when these standards are met.	Relevant and Appropriate
Groundwater	FEDERAL — SDWA Non-Zero MCLGs (40 CFR 141.50-141.51)	Non-zero MCLGs are nonenforceable health goals for public water systems set at levels that would result in no known or expected adverse health effects with an adequate margin of safety. Non-zero MCLGs are also considered relevant and appropriate for CERCLA groundwater response actions where the groundwater aquifer is used or classified for use as drinking water.	These standards were used to develop cleanup standards to be met through cleanup of the FS-12 plume. Under Alternative 3, the FS-12 ETR system is designed to treat extracted groundwater to these standards, unless the state promulgates more stringent drinking water or groundwater quality standards, in which case the more stringent state standards will apply. SPEIM will determine when these standards are met.	Relevant and Appropriate
Groundwater	STATE — MA Drinking Water Standards (310 CMR 22.05-22.09)	These standards establish MCLs for public drinking water systems but are also considered relevant and appropriate for CERCLA groundwater contamination response actions. When state MCLs are more stringent than federal levels, state levels must be used.	These standards were used to develop cleanup standards to be met through cleanup of the FS-12 plume. The state MCLs for benzene, toluene, and xylenes are 5, 1000, and 10,000 µg/L (ppb), respectively, the same as the federal MCLs. The state MCL for EDB is 0.02 µg/L (ppb), which is more stringent than the federal MCL of 0.05 µg/L (ppb) and will be used as the cleanup standard for EDB. Under Alternative 3, the FS-12 ETR system is designed to treat extracted groundwater to these standards, unless the state promulgates more stringent drinking water or groundwater quality standards, in which case the more stringent state standards will apply. SPEIM will determine when these standards are met.	Relevant and Appropriate

Table 2-21
Chemical-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Groundwater	STATE - MA Groundwater Quality Standards (314 CMR 6.06)	These standards limit the concentration of certain materials allowed in classified Massachusetts waters. The groundwater beneath MMR has been classified as a Class I water (fresh groundwater found in the saturated zone of unconsolidated deposits) and is designated as a source of potable water. The standards for Class I groundwater are the same as the state's MCLs.	Use of the containment remedy will result in attainment of these standards in groundwater. Under Alternative 3, the FS-12 ETR system is designed to treat extracted groundwater to these standards, unless the state promulgates more stringent groundwater quality standards, in which case the more stringent state standards will apply. SPEIM will determine when these standards are met.	Applicable

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CMR	*Code of Massachusetts Regulations*
EDB	ethylene dibromide
ETR	extraction, treatment, and reinjection
FS-12	Fuel Spill-12
MA	Massachusetts
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MMR	Massachusetts Military Reservation
ppb	parts per billion
SDWA	Safe Drinking Water Act
SPEIM	system performance and ecological impact monitoring
µg/L	micrograms per liter

Table 2-22
Location-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Endangered and threatened species and their habitats	STATE – MA Endangered Species Act (321 CMR 10.00 *et seq*.)	Actions that jeopardize state-listed endangered or threatened species, or species of special concern or their habitats must be avoided, or appropriate mitigation measures must be taken.	Operation and maintenance of the current monitoring well system, as well as the installation of new monitoring wells, if needed, will be designed to minimize effects to endangered or threatened species. Several state-listed species have been identified on the MMR. The Camp Edwards Natural Resource Office (http://www.eandrc.org/rarespecies.htm) continues to search for, identify, and map locations of rare species on the MMR and provides this information to the Massachusetts Division of Fisheries and Wildlife.	Applicable
Historic, archeological, and Native American artifacts and resources	FEDERAL – NHPA (16 USCA 470 *et seq*.; 36 CFR 800); AHPA (16 USCA 469a-c); ARPA (16 USC 470aa-ll; 43 CFR 7); NAGPRA (25 USCA 3001-3013; 43 CFR 10)	These statutes and regulations provide for the protection of historical, archaeological, and Native American burial sites, artifacts, and objects that might be lost as a result of a federal construction project. If a discovery is made, all activity in the area must stop and reasonable effort must be made to secure and protect the objects discovered.	After consultation with the Wampanoag Indian Tribes and the SHPO, the parties may determine that a cultural resources survey is needed to discover and identify objects and artifacts, particularly Native American artifacts of the Wampanoag Indian Tribes. If SPEIM wells need to be sited in areas that may have such resources, all such resources discovered during a survey or inadvertently discovered during on-site remedial activities (for example, siting new monitoring wells) will be secured and protected as required by law and in accordance with the consulting parties' memorandum of agreement.	Applicable

Table 2-22
Location-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Historic, archeological, and Native American artifacts and resources	STATE – MA Historic Preservation Act (MGL Ch. 9 Sections 26-27C; MGL Ch. 7, Section 38A; MGL Ch. 38 Sections 6B-6C; and 950 CMR 70-71)	The MHC is the state historic preservation office and is authorized by Massachusetts law to identify, evaluate, and protect the Commonwealth's important historic and archaeological resources. The MHC administers state and federal preservation programs, including planning, review, and compliance.	After consultation with the Wampanoag Indian Tribes and the SHPO, the parties may determine that a cultural resources survey is needed to discover and identify objects and artifacts, particularly Native American artifacts of the Wampanoag Indian Tribes. If SPEIM wells need to be sited in areas that may have such resources, all such resources discovered during a survey or inadvertently discovered during on-site remedial activities (for example, siting new monitoring wells) will be secured and protected as required by law and in accordance with the consulting parties' memorandum of agreement.	Applicable
Wetlands	FEDERAL – Protection of Wetlands (EO 11990, 40 CFR 6, Appendix A)	Under this order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and beneficial values of wetlands. Appendix A requires that no remedial alternatives adversely affect a wetland if another practicable alternative is available. If no alternative is available, effects from implementing the alternative must be mitigated.	If the continued operation and maintenance of the remedial system and/or LTM well system and construction of any new LTM wells, if needed, would adversely affect nearby wetlands, such impacts will be mitigated to comply with these requirements.	Applicable
Wetlands	FEDERAL – CWA Section 404 (40 CFR 230; 33 CFR Parts 320-323)	No activity that adversely affects a wetland shall be permitted if a practicable alternative with fewer effects is available. If no practicable alternative exists, impacts must be mitigated.	If the continued operation and maintenance of the remedial system and/or LTM well system and construction of any new LTM wells, if needed, would adversely affect nearby wetlands, such impacts will be mitigated to comply with CWA 404 requirements.	Applicable

Table 2-22
Location-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Wetlands	STATE – MassDEP Wetlands Protection Act (MGL Ch. 131, Section 40) and regulations (310 CMR 10.00)	This regulation outlines performance standards that must be met to work within 100 feet of a coastal or inland wetland and within 200 feet of a river. It governs all work involving the filling, dredging, or alteration of wetlands, banks, land under water bodies, waterways, land subject to flooding and riverfront areas.	The continued operation and maintenance of the remedial system and SPEIM program, including the installation of new monitoring wells (if needed), will be designed to meet the performance standards in 310 CMR 10.21 through 10.60 to minimize adverse effects to any nearby wetlands.	Applicable
Wetlands	FEDERAL – Fish and Wildlife Coordination Act (40 CFR 6.302; 16 USC 661 *et seq*.)	This act and regulations require federal agencies to take into consideration the effect that water-related projects would have on fish and wildlife, and to consult with the U.S. Fish and Wildlife Service and the state to develop measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife.	The continued operation and maintenance of the remedial system and the SPEIM well system, and any new wells (if needed), will be designed to minimize adverse effects to fish and wildlife in any wetland areas. Relevant federal and state agencies will be contacted, if indicated, to help analyze the effects of the ETR and SPEIM systems on fish and wildlife in wetlands in and around the site.	Applicable
Floodplains	FEDERAL – Protection of Floodplains (EO 11099, 40 CFR 6, Appendix A)	Requires federal agencies to minimize potential harm to or within floodplains and avoid the long- and short-term adverse impacts with modifications to floodplains. Appendix A requires that no remedial alternatives adversely affect a floodplain if another practicable alternative is available. If no alternative is available, effects from implementing the alternative must be mitigated.	These requirements are ARARs only if new SPEIM wells are needed and are sited in floodplains. If the placement of any such well is needed, these requirements will be complied with if the location is within or affects a floodplain.	Applicable

Table 2-22
Location-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Floodplains	STATE – MassDEP Wetland Protection Act (MGL Ch. 131, Section 40, and 310 CMR 10.00)	Governs work proposed within land subject to flooding (100-year floodplain) and coastal storm flow. Compensatory flood storage is required for any loss of floodplain area.	These requirements are ARARs only if new SPEIM wells are needed and are sited in floodplains. If the placement of any such well is needed, these requirements will be complied with if the location is within or affecting a floodplain.	Applicable

AHPA	Archaeological and Historic Preservation Act
ARAR	applicable or relevant and appropriate requirement
ARPA	Archaeological Resources Protection Act
CFR	*Code of Federal Regulations*
Ch.	chapter
CMR	*Code of Massachusetts Regulations*
CWA	Clean Water Act
EO	Executive Order
ETR	extraction, treatment and reinjection
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
MGL	Massachusetts General Laws
MHC	Massachusetts Historic Commission
MMR	Massachusetts Military Reservation
NAGPRA	Native American Graves Protection and Repatriation Act
NHPA	National Historic Preservation Act
SHPO	State Historic Preservation Officer
SPEIM	system performance and ecological impact monitoring
USC	*United States Code*
USCA	*United States Code, Annotated*

Table 2-23
Action-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Groundwater	FEDERAL – Underground Injection Control Program (40 CFR 144-148)	These regulations outline minimum program and performance standards for underground injection wells and prohibit any injection that may cause a violation of any primary drinking water regulation under 40 CFR 142 in the aquifer. The state program has been authorized by EPA and takes effect through the state requirements listed below.	Extracted groundwater will be treated to levels at or below the most stringent federal and state primary drinking water standards prior to release to ensure that releases will not cause any violation of drinking water standards in the receiving aquifer. The SPEIM program will determine when groundwater contaminant levels are at or below these standards.	Applicable
Groundwater	STATE – MA Underground Water Source Protection (310 CMR 27.00 *et seq*.)	These regulations prohibit the injection of fluid containing any pollutant into underground sources of drinking water where such pollutant will or is likely to cause a violation of any state drinking water regulations under 310 CMR 22.00 or adversely affect the health of persons.	Extracted groundwater will be treated to levels at or below the most stringent federal and state primary drinking water standards prior to release to ensure that releases will not cause any violation of drinking water standards in the receiving aquifer. The SPEIM program will determine when groundwater contaminant levels are at or below these standards.	Applicable
Air	STATE – MA Air Pollution Control Regulations (310 CMR 7.06, 7.08 – 7.10, 7.14, and 7.18 – 7.24)	Establishes the standards and requirements for air pollution control in the Commonwealth. Potentially relevant sections include those pertaining to: visible emissions (7.06); dust, odor, construction, and demolition (7.09); and noise (7.10). The regulations also contain air pollutant emission standards for, among other things, hazardous waste incinerators, organic materials, and VOCs.	Dust, noise, and visible emissions will be managed to meet the state requirements during operation and maintenance activities, including the construction of any new monitoring wells. Air emissions will not be at a level high enough to trigger the standards for hazardous waste incinerators, organic materials, and VOCs.	Applicable

Table 2-23
Action-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Stormwater Runoff	FEDERAL – CWA NPDES Stormwater Discharge Requirements (40 CFR 122.26)	Establishes requirements for stormwater discharges associated with construction activities that are in a land disturbance of equal to or greater than one acre of land. The requirements include good construction management techniques; phasing of construction projects; minimal clearing; and sediment, erosion, structural, and vegetative controls to be implemented to mitigate stormwater run-on and runoff.	If stormwater runoff associated with SPEIM well placement or remedial action construction, operation, and maintenance activities discharges to a surface water body, including wetlands, and the area of land disturbance is greater than one acre of land, it will be controlled in accordance with these requirements.	Applicable
Stormwater Runoff	STATE – Stormwater Discharge Requirements (314 CMR 3.04 and 314 CMR 3.19)	Requires that stormwater discharges associated with construction activities be managed in accordance with the general permit conditions of 314 CMR 3.19 so as not to cause a violation of Massachusetts surface water quality standards in the receiving surface water body (including wetlands).	If stormwater runoff associated with SPEIM well placement or remedial action construction, operation and maintenance activities discharges to a surface water body, including wetlands, and the area of land disturbance is greater than one acre of land, it will be controlled in accordance with these requirements.	Applicable
Stormwater Runoff	STATE – Stormwater Management Program Policy (18 November 1996)	Provides policies and guidance on complying with the state's stormwater discharge requirements.	If stormwater runoff associated with LTM well placement, remedial action construction, and operation and maintenance activities discharges to a surface water body, including wetlands, it will be controlled in accordance with these requirements.	TBC
Soil	STATE – MA Erosion and Sediment Control Guidelines for Urban and Suburban Areas (May 2003)	Provides guidance and best management practices regarding erosion and sediment control.	Construction of any new SPEIM wells (if needed) and operation and maintenance of SPEIM system and remedial activities will be performed in accordance with this guidance as appropriate.	TBC

Table 2-23
Action-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Hazardous Waste	FEDERAL – Subtitle C Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264 *et seq*.)	These requirements establish minimum national standards that define the acceptable management of hazardous waste.	Because Massachusetts has been authorized to run the RCRA base program, hazardous materials will be managed according to the state requirements listed below.	Relevant and Appropriate
Hazardous Waste	FEDERAL – RCRA Subtitle C Standards for Identification and Listing of Hazardous Wastes (40 CFR 261.24)	These requirements identify the maximum concentrations of contaminants at which the waste would be considered characteristically hazardous waste.	Materials generated during the remedial action will be analyzed according to the TCLP. If TCLP results exceed the standards in 261.24, the material will be managed in accordance with hazardous waste regulations.	Relevant and Appropriate
Hazardous Waste	STATE – MA HWMR Requirements for Generators of Hazardous Waste (310 CMR 30.300 – 30.353)	A generator of solid waste must determine whether that waste is hazardous using various methods, including the TCLP method, or application of knowledge of hazardous characteristics of the waste. If waste is determined to be hazardous, it must be managed in accordance with the applicable Massachusetts generator requirements, which require management in accordance with 310 CMR 30.000 *et seq*.	Massachusetts has been authorized to run the RCRA base program. As a result, hazardous materials will be managed in accordance with these requirements.	Applicable
Hazardous Waste	STATE – MA HWMR Standards for the Identification and Listing of Hazardous Waste: Toxicity Characteristic (310 CMR 30.125)	These requirements identify the maximum concentrations of contaminants at which the waste would be considered characteristically hazardous waste.	Materials generated during the remedial action will be analyzed according to the TCLP. If TCLP results exceed the standards in 310 CMR 30.125, the material will be managed in accordance with hazardous waste regulations.	

Table 2-23
Action-Specific ARARs
FS-12 Groundwater Operable Unit Remedy Alternative 3

ARAR	applicable or relevant and appropriate requirement
CFR	*Code of Federal Regulations*
CMR	*Code of Massachusetts Regulations*
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
HWMR	Hazardous Waste Management Regulations
MA	Massachusetts
NPDES	National Pollutant Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
SPEIM	system performance and ecological impact monitoring
TBC	to be considered
TCLP	Toxicity Characteristic Leaching Procedure
VOC	volatile organic compound

Table 2-24
Present Value Calculation for
FS-12 Groundwater Operable Unit Alternatives 2 and 3

	Alternative 2				Alternative 3				
Year	Monitoring Well Construction Costs	Annual Chemical Monitoring and Periodic Costs	Total Cost (0% Discount)	Total Present Value Cost at 3.5%	Monitoring Well Construction Costs	Annual O&M	Annual Monitoring and Periodic Costs	Total Cost (0% Discount)	Total Present Value Cost at 3.5%
0	0	215186	215186	215186	0	760607	860744	1621351	1621351
1	0	215186	215186	207909	0	760607	860744	1621351	1566523
2	0	215186	215186	200878	92530	760607	860744	1713881	1599926
3	0	215186	215186	194085	0	760607	860744	1621351	1462366
4	185060	215186	400246	348791	92530	552872	860744	1506145	1312519
5	0	217983	217983	183536	0	552872	863541	1416413	1192582
6	0	215186	215186	175054	92530	552872	860744	1506145	1225250
7	0	215186	215186	169134	0	552872	688595	1241467	975782
8	185060	215186	400246	303951	92530	552872	688595	1333997	1013052
9	0	215186	215186	157889	0	552872	688595	1241467	910903
10	0	217983	217983	154533	92530	552872	519244	1164645	825639
11	0	215186	215186	147391	0	552872	516446	1069318	732425
12	185060	215186	400246	264876	92530	552872	516446	1161848	768891
13	0	215186	215186	137591	0	552872	516446	1069318	683726
14	0	215186	215186	132938	92530	552872	516446	1161848	717768
15	0	217983	217983	130112	0	552872	519244	1072115	639936
16	185060	215186	400246	230824	92530	552872	516446	1161848	670045
17	0	215186	215186	119902	0	552872	516446	1069318	595828
18	0	215186	215186	115848	92530	552872	344298	989699	532816
19	0	215186	215186	111930	0	552872	344298	897169	466668
20	185060	217983	403043	202556	92530	552872	347095	992496	498795
21	0	215186	215186	104488	0	552872	344298	897169	435639
22	0	215186	215186	100955	92530	552872	344298	989699	464318
23	0	215186	215186	97541	0	552872	344298	897169	406674
24	185060	215186	400246	175291	92530	552872	344298	989699	433446
25	0	217983	217983	92239	0	552872	347095	899966	380818
26	0	215186	215186	87976	0	0	86074	86074	35190
27	0	215186	215186	85001	0	0	86074	86074	34000
28	185060	215186	400246	152756	0	0	86074	86074	32851
29	0	215186	215186	79349	0	0	86074	86074	31740
30	0	217983	217983	77663	0	0	234122	234122	83413
31	0	215186	215186	74074	0	0	0	0	0
32	185060	215186	400246	133118	0	0	0	0	0
33	0	215186	215186	69148	0	0	0	0	0
34	0	215186	215186	66810	0	0	0	0	0
35	0	217983	217983	65390	0	0	0	0	0
36	185060	215186	400246	116004	0	0	0	0	0
37	0	215186	215186	60259	0	0	0	0	0
38	0	215186	215186	58221	0	0	0	0	0
39	0	215186	215186	56252	0	0	0	0	0
40	185060	217983	403043	101798	0	0	0	0	0
41	0	215186	215186	52512	0	0	0	0	0
42	0	215186	215186	50736	0	0	0	0	0
43	0	215186	215186	49021	0	0	0	0	0
44	185060	215186	400246	88095	0	0	0	0	0
45	0	217983	217983	46356	0	0	0	0	0
46	0	215186	215186	44214	0	0	0	0	0
47	0	215186	215186	42719	0	0	0	0	0
48	0	215186	215186	41274	0	0	0	0	0
49	0	215186	215186	39878	0	0	0	0	0
50	0	363234	363234	65038	0	0	0	0	0
51	0	215186	215186	37227	0	0	0	0	0
TOTAL	2,035,660	11,362,895	13,398,554	6,316,317	1,110,360	15,205,603	15,569,350	31,885,313	22,350,878

Table 2-25
Cost Estimate Basis for FS-12 Groundwater Operable Unit Alternative 3

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS (1)
Monitoring Well Construction Costs						
DIRECT COSTS						Based on historical costs for the MMR program. Actual costs include overhead and support.
Monitoring Well Installatior						1 new well every 2 years
Site Prep/Restoration-Well Area	1	EA	$ 3,800	$ 3,800		
Well Drilling	1	EA	$ 77,000	$ 77,000		Assume 200 feet per well
Analytical, Data Management	20	SAMP	$ 200	$ 4,000		1 sample per 10 feet of well depth, VOCs and EDB only, onsite lab
IDM	1	WELL	$ 1,200	$ 1,200		
TOTAL					$ 86,000	
TOTAL ESCALATED TO YEAR 0					$ 92,530	
Treatment System O&M Costs						
DIRECT COSTS						
Existing FS-12 ETR Treatment System	1	YR	$ 760,140	$ 760,140		Based on AFCEE actual 2004 costs for FS-12 system operation at the MMR adjusted for flow rate change (3 percent above 2004 rate).
ESCALATED TO YEAR 0					$ 817,857	
Years 0-3				$ 760,607		Assume flow rate is 93 percent of 2004 flow rate
Years 4-25				$ 552,872		Assume flow rate is 67.6 percent of 2004 flow rate
Monitoring Costs						
DIRECT COSTS						Based on current actual costs with ongoing monitoring under the SPEIM program. Includes equipment, personnel, laboratory analyses, IDM, maintenance, data interpretation, and reporting. Actual costs also include overhead and support.
Chemical Monitoring and Reporting						
Years 0-6	1	YR	$ 800,000	$ 800,000		
Escalated to Year 0					$ 860,744	
Years 7-9	1	YR	$ 688,595	$ 688,595		Assume monitoring program will be reduced by 20 percent.
Years 10-17	1	YR	$ 516,446	$ 516,446		Assume monitoring program will be reduced by 40 percent.
Years 18-25	1	YR	$ 344,298	$ 344,298		Assume monitoring program will be reduced by 60 percent.

Table 2-25
Cost Estimate Basis for FS-12 Groundwater Operable Unit Alternative 3

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL	SUBTOTAL	COMMENTS (1)
Years 26-project lifetime	1	YR	$ 86,074	$ 86,074		Chemical monitoring only after system shut down.
Periodic Costs						
DIRECT COSTS						Based on historical costs for the MMR program. Actual costs include overhead and support.
CERCLA 5-Year Reporting						Every 5 years from Year 5 through Year 30 (6 events)
Report Preparation and Submittal	1	EA	$ 2,600	$ 2,600		Report is part of a larger review of all sources and systems at the MMR
ESCALATED TO YEAR 0					$ 2,797	
Residual Risk Assessment						Year 30 (1 event)
Additional Sampling and Analysis	1	LS	$ 45,000	$ 45,000		
Report Preparation and Submittal	1	EA	$ 90,000	$ 90,000		
TOTAL					$ 135,000	
TOTAL ESCALATED TO YEAR 0					$ 145,251	

Notes:
AFCEE = Air Force Center for Environmental Excellence
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
EA = each
EDB = ethylene dibromide
ETR = extraction, treatment, and reinjection
FS-12 = Fuel Spill-12
IDM = investigation-derived material
LS = lump sum
MMR = Massachusetts Military Reservation
SAMP = sample
SPEIM = system performance and ecological impact monitoring
VOC = volatile organic compound
YR = year

APPENDIX A

MassDEP Concurrence Letter

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
SOUTHEAST REGIONAL OFFICE
20 RIVERSIDE DRIVE, LAKEVILLE, MA 02347 508-946-2700

MITT ROMNEY
Governor

KERRY HEALEY
Lieutenant Governor

ROBERT W. GOLLEDGE, Jr
Secretary

ARLEEN O'DONNELL
Commissioner

September 19, 2006

Ms. Susan Studlein
Office of Site Remediation and Restoration
U.S. Environmental Protection Agency,
Region 1
One Congress Street, Suite 1100
Boston, MA 02114-2023

RE: BOURNE—BWSC-4-0037
Massachusetts Military Reservation,
Final Record of Decision for Fuel Spill-12 Groundwater, Concurrence

Dear Ms. Studlein:

The Massachusetts Department of Environmental Protection (the "MassDEP") has reviewed the document entitled **"Final Record of Decision for Fuel Spill-12 Groundwater"** (the "FS-12 ROD"), dated August 2006. The FS-12 ROD was prepared for the Air Force Center for Environmental Excellence ("AFCEE") in connection with the Massachusetts Military Reservation ("MMR") situated in Bourne, Cape Cod, Massachusetts. The FS-12 ROD presents the selected remedy for FS-12 groundwater, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The MassDEP concurs with the final remedy proposed in the FS-12 ROD, to continue active treatment of the FS-12 plume with the existing extraction, treatment, and reinjection (ETR) system and include certain land use controls (LUCs) to reduce exposure to contaminated groundwater.

The FS-12 plume is located along the eastern boundary of the MMR and is situated immediately north east of Snake Pond in Sandwich. The source of the FS-12 contamination was a leak in an underground fuel line along Greenway Road. The fuel line carried aviation gasoline and jet propulsion fuel. The leak was believed to have occurred in 1972 and the pipeline was shut down in 1973. The FS-12 plume is comprised of the Contaminants of Concern (COCs) benzene (Maximum Contaminant Level (MCL) of 5.0 ug/L) and ethylene dibromide (EDB) (Massachusetts MCL of 0.02 ug/L).

An air sparging/soil vapor extraction (AS/SVE) system was constructed for the FS-12 source area in 1995 as a time-critical removal action. During 29 months of operation, the

AS/SVE system removed approximately 11 percent of the estimated 70,000 gallons of fuel believed to have leaked from the pipeline. The AV/SVE system was shut down in 1998 with approval from the regulatory agencies, the source area was closed and the subject of long-term monitoring.

In 1995, the Department of Defense and the EPA, with concurrence from the MassDEP, agreed to implement an interim remedy for the FS-12 groundwater plume. The proposed FS-12 interim remedy presented in the *Final Record of Decision for Interim Action, Containment of Seven Groundwater Plumes at Massachusetts Military Reservation, Cape Cod, Massachusetts* (referred to as the Interim Record of Decision or IROD). The selected interim remedy for the FS-12 groundwater plume is an extraction, treatment and reinjection system (ETR) consisting of 25 extraction wells and 23 reinjection wells and a granular activated carbon (GAC) treatment plant. The extraction wells are aligned across the toe of the plume for containment, and aligned in an axial arrangement parallel to groundwater flow through the central portion of the plume with the highest contaminant concentrations to expedite contaminant mass removal and shorten the cleanup time frame. The FS-12 ETR system began operation in September 1997.

The outcome of the risk assessment for the FS-12 groundwater plume indicated that there is no ecological risk associated with the plume since it is not currently discharging to Snake Pond or any other surface waters. The human health risk assessment revealed that there is a potential risk to a resident of Sandwich who consumes groundwater from a drinking water well or a municipal water supply well within the FS-12 plume.

Administrative and/or legal controls known as land use controls (LUCs) have been implemented by the AFCEE to prevent access to or use of the groundwater from the FS-12 plume until the groundwater no longer poses an unacceptable risk to human health. Monitoring of the environmental use restrictions and controls will be conducted annually by the AFCEE. The AFCEE will submit an annual monitoring report to the regulatory agencies that will evaluate the status of the LUCs and addresses how any LUC deficiencies or inconsistent uses .

The AFCEE also performed a Feasibility Study (FS) as part of the IROD to ROD process to evaluate remedial alternatives for the FS-12 groundwater plume. Three remedial alternatives were evaluated in the FS, including; 1) No Action, 2) Long-term Monitoring with Institutional Controls, and 3) Continue Operating and Optimizing the Existing ETR System with System Performance and Ecological Impact Monitoring Until Cleanup Levels are Met Throughout the Plume (Status Quo). Alternative 3 also includes LUCs to reduce exposure to contaminated groundwater. The AFCEE issued a Proposed Plan in September 2005, which identified Alternative 3 as the AFCEE's preferred remedial alternative.

The MassDEP concurs with the final remedy proposed in the FS-12 ROD. The MassDEP's concurrence with the FS-12 ROD is based upon representations made to the MassDEP by the AFCEE and assumes that all information provided is substantially complete and accurate. Without limitation, if the MassDEP determines that any material omissions or misstatements exist, if new information becomes available, or if conditions within the FS-12 groundwater plume change, resulting in potential or actual human exposure or threats to the environment, the MassDEP reserves

its authority under M.G.L. c. 21E, and the MCP, 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 the FS-12 groundwater plume. If you have any questions regarding this matter, please contact Leonard J. Pinaud, Chief of the Federal Facilities Remediation Section, at (508) 946-2871 or Millie Garcia-Surette, Deputy Regional Director of the Bureau of Waste Site Cleanup at (508) 946-2727.

Sincerely,

for Edward P. Kunce, DCOP
Arleen O'Donnell
Acting Commissioner
Department of Environmental Protection

AO/P/xx
FS-12 ROD Concurrence.doc

Cc: DEP - SERO
Attn: Gary S. Moran, Regional Director
Millie Garcia-Surette, Deputy Regional Director
Leonard J. Pinaud, Chief Federal Facilities Remediation Section

Distributions: SERO
SMB
Plume Cleanup Team (IRP)
Boards of Selectmen
Boards of Health
Mark Begley, Environmental Management Commission

APPENDIX B

Transcript of Public Hearing

MASSACHUSETTS MILITARY RESERVATION

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

IN RE:
PROPOSED PLAN FOR
GROUNDWATER AT
FUEL SPILL 12 (FS-12)

PUBLIC HEARING

Oak Cove Meeting Room
Quaker Meeting House Road
Forestdale, Massachusetts

HEARING OFFICER: Michael Minior, AFCEE

Thursday, November 17, 2005
6:30 p.m.

Carol P. Tinkham
Professional Court Reporter
321 Head of the Bay Road
Buzzards Bay, MA 02532
caroltinkham@verizon.net

A T T E N D E E S:

Mike Minior - AFCEE

Dan Miller - Portage Environmental

Lauren Gosster - Jacobs Engineering

Len Pinaud - Mass. DEP

Paul Marchessault - EPA

David Dow - Sierra Club - Cape Cod Group

P R O C E E D I N G S

MR. MINIOR: We are now starting the public hearing portion of the meeting and the official record is now open. My name is Michael Minior, deputy program manager for the Installation Restoration Program at the Massachusetts Military Reservation. I will be the hearing officer for tonight.

The purpose of this hearing is to accept oral and written comments on the Proposed Plan for Fuel Spill 12. All oral comments that are received tonight will be transcribed verbatim. Those comments along with any comments submitted in writing will become part of the official record on this project. AFCEE and the regulatory agencies will consider all comments prior to making a final decision. Each and every comment will be responded to in a Responsiveness Summary that will be issued at a later date as part of the Record of Decision. All those who comment will receive a copy of the responsiveness summary. The Record of Decision will contain the Air Force's final decision for Fuel Spill 12.

The floor is now open for public comment.

Are there any comments to be offered at this time?

[No response.]

MR. MINIOR: I note that I have spoken

with David Dow representing the Cape Cod Chapter of the Sierra Club. Mr. Dow has informed me that he has decided to provide written rather than oral comment for the record.

I shall now close the formal public hearing for the Proposed Plan for Groundwater at Fuel Spill 12. The record is now closed. Please note that you can still provide written comments through November 28, 2005. I thank you for coming and have a good evening.

[Whereupon, this matter adjourned.]

C E R T I F I C A T E

COMMONWEALTH OF MASSACHUSETTS

COUNTY OF BARNSTABLE

I, Carol P. Tinkham, a Professional Court Reporter and Notary Public in and for the Commonwealth of Massachusetts, do hereby certify that the foregoing transcript represents a complete, true and accurate transcription of my audiographic recordings taken in the matter of Massachusetts Military Reservation AFCEE Public Hearing on Fuel Spill 12, heard at Oak Cove Meeting Room on Thursday, November 17, 2005.

Carol P. Tinkham

Carol P. Tinkham
Notary Public
My Commission Expires
May 14, 2010

PLEASE NOTE: THE FOREGOING CERTIFICATION OF THIS TRANSCRIPT DOES NOT APPLY TO ANY REPRODUCTION OF THE SAME BY ANY MEANS UNLESS UNDER THE DIRECT CONTROL AND/OR DIRECTION OF THE CERTIFYING REPORTER.

APPENDIX C

Sandwich Board of Health Well Regulations

TOWN OF SANDWICH

THE OLDEST TOWN ON CAPE COD

TELEPHONE: (508) 888-4200
FACSIMILE: (508) 833-0018
EMAIL: health@townofsandwich.net

BOARD OF HEALTH

16 JAN SEBASTIAN DRIVE
SANDWICH, MASSACHUSETTS 02563

PRIVATE WELL REGULATION

APRIL 11, 2005

A TRUE COPY ATTEST
Barbara J Walling
TOWN CLERK
SANDWICH

TOWN CLERK
TOWN OF SANDWICH
APR 13 2005
4 H 15 M P M 52
RECEIVED & RECORDED

PRIVATE WELL REGULATION

Definitions:

Abandoned well: A well that has not been used for water supply for a period of one year or more, unless the owner declares his intention to use the well again for supplying water within one year.

Board of Health: The Board of Health or its agent.

Contamination: Adverse impact on water quality created by the introduction of any chemical, mineral, and/or biological material.

Non-potable well: Any well supplying water not intended for human consumption.

Pollution: Adverse effect on water quality created by the introduction of any matter.

Private Potable Well: Any well supplying water for human consumption, bathing or washing purposes, which is not otherwise regulated as a "public water system" (community or non-community water supply) under 310 CMR 22.00

Rented or leased property: Any dwelling used for habitation or business purposes by an occupant other than the owner, for the use of which a fee is paid. This includes, but is not limited to, campgrounds, motels, bed and breakfast, inns, and other accommodations used on a transient basis, as well as community-type buildings which are rented to community groups.

Well: Any pit, pipe, excavation, spring, casing, drill hole, or other source of water to be used for any purpose of supplying water, and shall include dug wells, driven or tubular wells, drilled wells (artesian or otherwise) and springs, gravel packed, gravel walled wells, gravel developed and wash borings and as further described in the U.S. EPA Manual of Individual Water Supply Systems. For the purpose of these regulations, it shall include both private potable wells and non-potable wells.

Well Drillers: Any person, firm, company or corporation engaged in the business of drilling, constructing, or destroying a water supply well.

Yield: Quantity of water delivered per unit time, which may flow or be continuously pumped from the well.

Authority: The Private Well Regulation is promulgated under the authority of M.G.L. c. 111 sec.31 with the intention of the protection of public health to provide a safe and adequate water supply.

Registration of Well Drillers:

1. All well drillers doing business in the Town of Sandwich shall annually file with the Board of Health a copy of their current well driller's registration certificate issued by the Commonwealth of Massachusetts under MGL, Chapter 21, Section 16.

(Private well regulation cont'd.)

Well Construction Permit:

1. No well shall be installed, altered or repaired until a permit has been obtained from the Board of Health. A permit so granted shall expire 6 months from date of issue unless construction has begun.

2. The fee for this permit shall be set by the Board of Health; the fee for each well construction permit shall be $ 40.00.

3. An application for a water well construction permit shall be submitted by the drilling contractor or his agent to the Board of Health on forms furnished by the Board. The well driller is responsible for obtaining said permit prior to well construction.

4. The location and design of the water well must be approved by the Board of Health prior to issuance of a well construction permit. Prior to approval, the Board of Health requires the following information to be submitted:

   For construction of a private potable well at a new building, the owner or his agent shall submit a site plan drawn by a Massachusetts Registered Professional Land Surveyor, showing the location of the well in relation to building foundations, property lines, building sewer lines, the subsurface sanitary disposal systems serving the lit, all other septic systems within 200 feet and any other known potential sources of contamination within 200 feet which could affect the well. Such sources of known potential existing or previously existing contamination shall include but not limited to sanitary landfills; auto junk yards; municipal sewage treatment facilities with on site disposal of primary or secondary effluent; car washes; road salt stockpiles; dry cleaning establishments; boat and motor vehicle service and repair; cabinet making; electronic circuit assembly; metal plating, finishing, and polishing; motor and machinery service and assembly; commercial paint, wood preserving and furniture stripping; sites where pesticides and herbicides are regularly applied, including golf courses and cranberry bogs; photographic processing; printing; chemical and bacteriological laboratories; transportation terminals; funeral homes; any principal use involving the sale, storage or transportation of fuel or oil; and any use which involves as an activity the manufacture, storage, use, transportation or disposal of toxic or hazardous materials. To meet this requirement, well location may be shown on the same plot plan submitted to the Board of Health for approval of septic system installation.

   A Massachusetts Registered Land Surveyor must determine and mark the location of the well on the lot prior to its installation.

   For emergency repair, alteration or replacement of an existing well, the Board of Health may waive the requirements that the site plan be submitted and that the location of the well be staked on the lot.

5. Permit Conditions: All permits issued shall be subject to the conditions that all facilities shown shall be constructed in the location approved by the Board of Health.

(Private Well Regulation Cont'd.)

All permits issued shall be subject to the requirements of these regulations and to such further conditions as the Board of Health shall prescribe.

Prohibition of Construction of Private Water Supply Wells for Certain New Buildings:

1. Whereas there are known and documented areas of groundwater contamination within the Town of Sandwich and there may be future areas of groundwater contamination unknown at present, the Board of Health prohibits the construction of new potable supply wells for new buildings if the Sandwich Water District Service is available. (Amended April 11, 2005)

Well Construction:

1. The Board of Health recommends that well construction meet the guidelines of the New England Water Well Driller's Association.

2. The top of a well shall be above ground that is higher than any surface sources of contamination and above any known conditions of flooding by drainage or runoff from the surrounding land, unless located in a flood-proofed well house.

3. Wells must be constructed so as to maintain existing natural protection against pollution of the groundwater and to exclude all known sources of pollution from entering the well.

4. In areas where salt water or other pollutant intrusion is known or likely to occur, the Board of Health, working with a designing engineer, may specify the well screen level, pumping rate, water storage capacity or any other construction parameter which must be used to ensure that water of adequate quality is obtained.

Well Driller's Report

1. Within 30 days after completion of the construction of any well, the well driller shall submit to the Board of Health a copy of the Water Well Completion Report as required by M.G.L.c.21&26. The Board of Health will not issue a Certificate of Approval for the well until this report has been received.

Well Destruction

1. Any abandoned well shall be filled and sealed with clean sand or other inert material in such a manner as to prevent it from acting as a channel for pollution to the groundwater.

2. Prior to destruction of any well, a well destruction permit must be obtained from the Board of Health. The Board of Health will require a site plan showing the well location prior to issuance of the well destruction permit.

(Private Well Regulation cont'd.)

3. Within 30 days after completion of the destruction of any private well, the well owner or well driller acting as agent for the well owner shall submit to the Board of Health a report containing the following:

a) The name of owner of the well;
b) The geographic location of the well;
c) Any preliminary cleaning or redrilling;
d) Types, depths, and materials of seals used.

Well Location

1. In general, private potable wells shall be located as far as possible from potential sources of contamination. The following minimum distances are required:

Property Line	10 feet
Leaching catch basin/drywell	25 feet, 100 feet recommended
Utility Right of Way	50 feet minimum, 100 feet recommended
Septic Tank	50 feet
Septic Leaching Facility	100 feet, (150 feet on any lot subdivided after April 17, 1983)
Septic Distribution Box	50 feet
Building Sewer	50 feet

2. Where, in the opinion of the Board of Health, adverse conditions exist, the above distances may be increased. In certain cases, special means of protection may be provided. Where possible, the well shall be up the groundwater gradient from sources of contamination.

Water Quality

1. The Board of Health will not approve any new well for human consumption until its water has been tested for the following chemical and bacteriological standards and the Board of Health has determined that the water is potable. Water samples taken from the well will be submitted to a state certified testing laboratory for analysis with the cost to be borne by the applicant, and results of this analysis submitted to the Board of Health for approval of water quality. Water quality and potability will be evaluated by the Board of Health in light of the National Interim Primary and Secondary Drinking

Water Standards and the U.S. EPA Minimum Contaminant Levels (MCLs) as amended from time to time.

Water Quality Standards

Total Coliform	0 Colonies/100 ml. MF
pH	Recommend pH above 5.0
Sodium	20 ppm
Conductivity	500
Iron (Amended*)	0.3 ppm
Nitrate	10 ppm

In view of the fact that the local average iron concentration is 0.55 ppm, the Board of Health may choose to waive the 0.3 ppm requirement for approval; the Board may recommend or require additional testing in cases of elevated iron content.

2. In locations where potential sources of contamination are believed to exist, or where geologic or hydrologic conditions require more restrictive or additional standards than those outlined above, additional water testing and special standards may be required by the Board of Health to ascertain that water meets the Minimum Contaminant Levels set for public water supplies by the U.S. EPA under the Safe Drinking Water Act (SDWA) and 1986 SDWA amendments. Such testing may include EPA methods 601, 602, 502, 503, 624, 625 analysis for purgeable halocarbone or pesticides or aromatics, analysis for petroleum hydrocarbons or pesticides or any other analysis the Board of Health deems necessary to ascertain water quality.

   (A technical handout discussing water quality standards in more depth is included as Section 2 of these Regulations; various test methodologies for common contaminants are outlined in Section 3).

3. The Board of Health further recommends that all well owners have their wells tested at a minimum of every two years and at more frequent intervals when water quality problems are known to exist.

Yield Test

1. Before approval, every private potable well shall be pump tested to determine yield. The pump test shall include a draw down test at a minimum pumping rate of 5 gallons per minute per 1 hour.

2. In areas where the possibility of salt water intrusion is known to exist, the Board of Health may increase the requirements for the drawdown test, in order to obtain a sample which is representative of the actual sodium content which may be found in the well once it is put into use.

Submission of Well Water Test Results

1. For all private potable wells, the results of the above water quality and yield tests shall be submitted to the Board of Health. The owner of the property which the well will serve or the well driller acting as agent for the owner, shall certify, on a form provided by the Board of Health, the following:

    a) The location, date the sample was taken and the laboratory at which it was analyzed;

    b) That the water sample whose analysis results were submitted to the Board of Health was taken from the well for which approval is being sought;

    c) The results of the yield test performed by the well driller.

Well Approval

1. New private potable wells shall not be placed into use for human consumption until the Board of Health has approved the potability and quantity of the water provided and issued a Certificate of Approval to the owner of the property, which the well serves.

2. Any such approval given by the Board of Health shall indicate only that the water quality is within the parameters set forth in these regulations. By its approval, the Board of Health specifically does not assure to the well owner or any third party that the water so tested is free from all potential contaminants, and well owners are encouraged to conduct further testing if contamination is suspected.

3. Approval of the well will be based on the water meeting the water quality criteria outlined above and the well being able to provide a yield of 5 gallons per minute at 40 psi.

4. In addition, for private potable wells installed as newly constructed buildings, the Board of Health will require that a certified plot plan be submitted to the Board of Health by a registered land surveyor or registered professional engineer showing the actual location of the well on the lot after installation. This information may be included in the certified plot plan required by the building inspector, which shows the location of the foundation on the lot.

5. The Board of Health shall not approve a Building Permit or a Certificate of Occupancy until it has issued a Certificate of Approval for the well serving that building.

6. Private potable wells which fail to meet some or all of the requirements in these regulations may be approved by the Board of Health after a hearing at which a variance from these standards may be granted.

(Private Well Regulation Cont'd)

Existing Wells Serving Rental Properties

1. Every private potable well serving property which is rented or leased must have its water tested for the above water quality parameters at a minimum of once every two years. Where water quality problems are known to exist, the Board of Health may require more frequent testing.

2. Results of water quality tests shall be made available to all tenants of the property.

3. In cases where the well water does not meet the water quality standards outlined above, the Board of Health shall require the property owner to notify all tenants of the property and may require the property owner to provide an alternative approved source of drinking water for the tenants.

Test of Water Quality Upon Transfer of Real Estate

1. Prior to selling, conveying or transferring title to real property in the Town of Sandwich, the owner thereof shall have tested the water of every private potable well serving that property if access to the water service provided by the Sandwich Water District is not available. (Amended April 11, 2005) A water sample from each well shall be submitted to a State certified laboratory for testing for the parameters outlined under the Water Quality section of this regulation. This water quality test shall be performed not more than 30 days prior to transfer of the property. Results of the water test shall be submitted to the Board of Health prior to property transfer on a form provided by the Board of Health on which the owner will certify that the sample was taken from the well serving the property being transferred.

   *In addition, a yield test shall be run to certify the well as capable of providing a minimum of 5 gallons per minute for 1 hour. ** The yield test is to be conducted by a State of Massachusetts Certified Well Driller. (* Amended November 13, 1989 - ** Amended April 11, 2005)

2. In addition, the owner shall give copies of all water test results of which he has knowledge (regardless of age of results) for the private potable well in question to any buyer and/or broker identified with the transfer. In the event that there is no buyer at the time the water is tested, a copy of all water test results must be given by the owner to the buyer before the property is put under agreement.

3. This regulation shall not apply to the conveyance or devise of a property to a surviving spouse or to any of the heirs or devisees of the property owner, and further, shall not apply to a sale under power of sale in a bona fide mortgage affecting the property.

4. *Prior to selling, conveying, or transferring title to real property in the Town of Sandwich, for properties with wells that are within the Sandwich Water District boundaries and have access to water service along the frontage of the property, the property shall be connected to service provided by the Sandwich Water District to

(Private Well Regulation Cont'd.)

ensure a continual safe supply of water. The connection must meet the specifications and requirements of the Sandwich Water District. (*Amended April 11, 2005)

Variance and Enforcement Procedure

1. The Board of Health may vary the application of any provision of this article with respect to any particular case when, in its opinion the enforcement thereof would do manifest injustice; provided that the decision of the Board of Health shall not conflict with the spirit of these minimum standards nor with the protection of human health and environmental quality.

2. Every request for a variance shall be made in writing and shall state the specific variance requested and the reasons therefore. Any variance granted by the Board of Health shall be in writing and shall state the reasons for the grant. Any denial of a variance shall also be in writing and shall state the reasons for the denial. A copy of any variance granted shall be available to the public at all reasonable hours in the office of the Town Clerk or the Board of Health.

3. Any variance or other modification authorized to be made by these regulations may be subject to such qualifications, revocation, suspension or expiration as the Board of Health expresses in its grant. A variance or modification authorized to be made by these regulations may otherwise be revoked, modified or suspended, in whole or in part, only after the holder thereof has been notified in writing and has been given an opportunity to be heard in conformity with the requirements of 310 CMR 11.00 for orders and hearings.

4. As a condition of granting a variance, the Board of Health may require a restriction to be recorded in the Registry of Deeds when, in the opinion of the Board of Health, knowledge that the well does not meet minimum standards would benefit future potential consumers of water supplied by the well.

5. So far as the Board of Health may provide, each section of these rules and regulations shall be construed as separate. If any section, regulation, paragraph, sentence, clause, phrase, or word of these rules and regulations shall be declared invalid for any reason, the remainder of these rules and regulations shall remain in full force and effect.

6. The provisions of Title 1 of the State Environmental Code (310 CMR 11.00) shall govern the enforcement of these regulations.

Adopted December 14, 1987, effective February 1, 1988

CERTIFICATION OF WELL WATER TEST RESULTS

I _____, acting as agent

for _____, do certify, under
name of property owner

the penalty of perjury, that the following water taken from a well located at:

_____

and serving property located at: _____

Name of Property/Well Owner: _____

Date Water Sample was taken: _____

Laboratory at which water was tested: _____
(Must be state certified laboratory)

Date water analysis performed: _____

Result of yield test performed by well driller or other agent of owner: _____ gal/min

Tested for _____ hours.

_____ _____
Signature Date

Water Quality Test Results

Parameter	Sample Result
pH	_____
Conductivity	_____
Iron	_____
Nitrate Nitrogen	_____
Sodium	_____
Other: _____	_____