9.3.18 FUEL SPILL NO.1 (FS-1) GROUND WATER

A. BACKGROUND

A.1 Site Description

The FS-1 plume contains two separate areas of groundwater contamination (refer to **Figure 9.3.18-1**). In the source area, there is a small area of groundwater contaminated with lead that is limited to an area within 1,000 feet of the Eastern Aircraft Turnaround and Western Aircraft Turnaround. The other area of groundwater contamination is a detached plume beginning 2,000 feet downgradient from the suspected source area. At its trailing edge, this detached plume is deep within the aquifer, but then rises abruptly and discharges to surface water in the Quashnet River cranberry bogs which are east of Johns Pond. The Quashnet River is fed by a controlled head gate located on the northeast corner of Johns Pond. From there, the river flows through the large cranberry bog adjacent to Johns Pond and onward to Waquoit Bay. The upper reaches of the Quashnet River are fed by groundwater discharge.

A.2 Initial Responses

CERCLA Actions:

In April 1999, a groundwater extraction and treatment system with surface water discharge known as the Quashnet and Bogs Pilot Test and Bog Separation Project (Quashnet Pilot System) began operation. The system consisting of one deep extraction and 175 shallow extraction well points captured EDB near the leading edge of the FS-1 plume. Extracted groundwater was treated by a carbon bubbler and discharged into an infiltration trench and through a riser pipe to the Quashnet Bog.

Non-CERCLA Actions:

Controls instituted in association with FS-1 plume include a moratorium on installation of all wells (outside the facility boundary) in areas of groundwater contamination by the Mashpee Water District. Residents and workers on base obtain drinking water from the base water supply system.

A.3 Basis for Taking Action

Site characterization activities were conducted at FS-1 to determine the nature and extent of contamination. Provided below is a summary of investigation activities that provided a characterization of the site.

1983: An IRP Phase I records search to identify potential sites at MMR indicated the need for further investigation at AOC FS-1.

1985: An initial environmental investigation (Phase II, Stage I study) was performed in the source area. Explorations included eight test pits and one water table well. No contamination was identified.

1989: An SI was performed in the source area. Explorations included 30 soil gas sampling points, 1 soil boring, and 3 monitoring wells. Fuel-related compounds were detected in groundwater above MCLs.

1990: An initial RI was performed in which FS-1 was differentiated into two operable units: FS-1B source area and FS-1B downgradient groundwater. Seven source area wells were installed and two source area soil borings were completed. Twelve downgradient wells were installed in two well fences. Four additional water table wells were installed to aid in determination of local groundwater flow. Source area wells contained fuel-related compounds. Of these, only toluene and lead were above MCLs. Downgradient wells did not contain levels of fuel-related compounds above the MCL. Because of the absence of fuel-related compounds, it was hypothesized that the fuel compounds had degraded.

1993: A basewide EDB study included collection and analyses of groundwater from seven FS-1 source area wells for EDB. EDB was not detected in the samples.

1995: A Geoprobe investigation was performed to track a potential path of fuel contamination from FS-1. Twenty multilevel locations were sampled for fuel constituents and indicator parameters of biodegradation. Additionally, three new wells were installed and five surface soil samples were collected in the source area. No contamination was identified.

1997–1998: Additional downgradient groundwater and surface water investigations were performed as a result of public comment concerning FS-1. Thirty-two downgradient wells were installed along a path that had not previously been investigated. Thirty-nine surface water samples were collected from the Quashnet River and the Quashnet River bogs. This investigation identified a plume of EDB-contaminated groundwater discharging into the Quashnet River bogs.

1999: The results of the RI (HAZWRAP 1999a) triggered the need for an alternatives analysis in FS. Alternatives that were retained for detailed analysis in the FS (HAZWRAP 1999b) included Alternative 1 (No Action), Alternative 2B (Limited Action with Leading Edge Extraction, Treatment, and Reinjection/Discharge), Alternative 3 (Axial Well Extraction, Treatment, and Reinjection/Discharge), Alternative 3B (Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge).

B. REMEDIAL ACTIONS

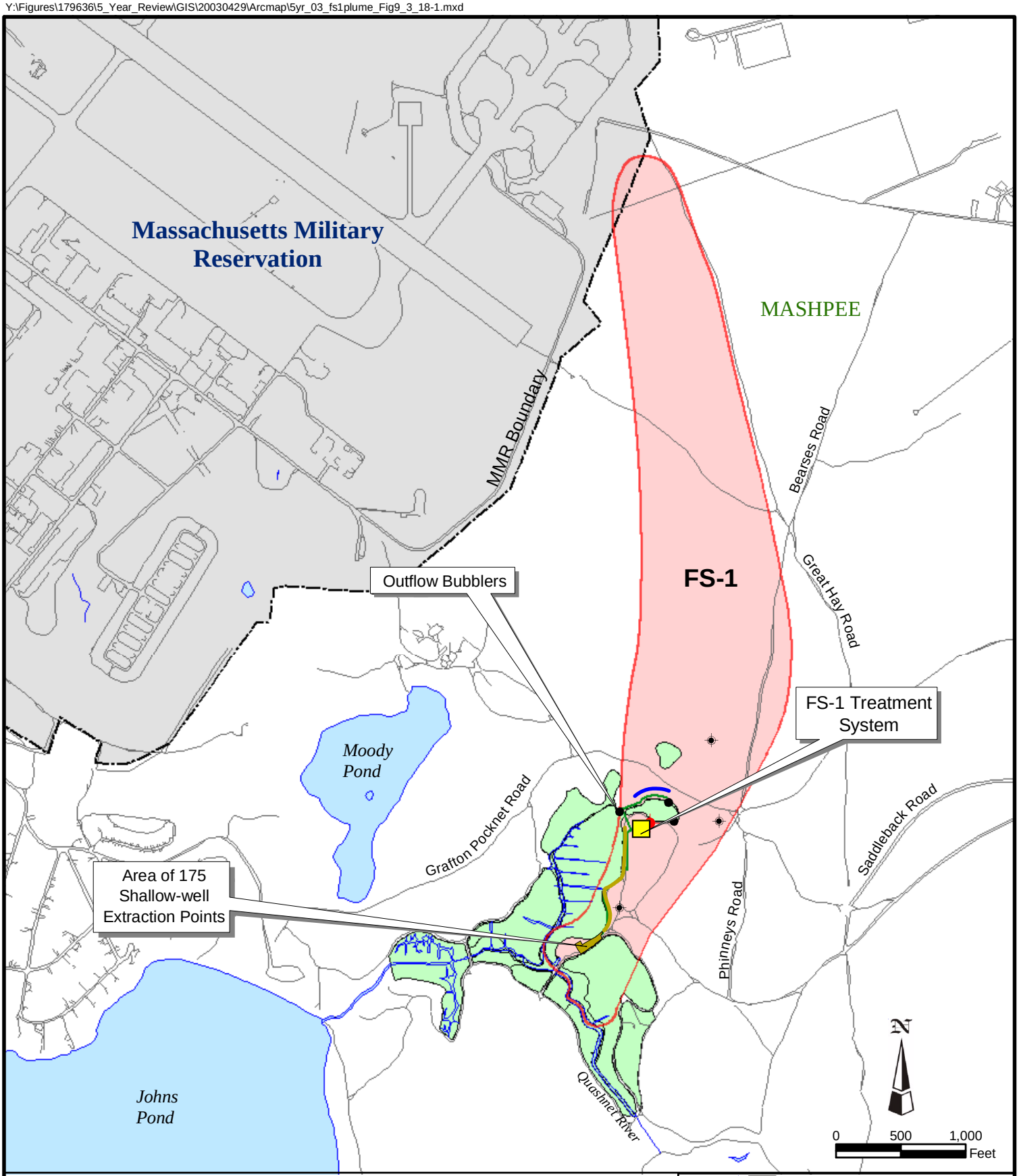
This section presents the regulatory actions, RAOs, remedy description, and a summary of the remedy implementation at FS-1.

B.1 Regulatory Actions

The *Record of Decision Area of Contamination FS-1* (AFCEE, 2000), presents this alternative to address the contaminated groundwater plume at FS-1. The selected remedial alternative was Alternative 3B (Axial and Leading Edge Extraction, Treatment, and Reinjection/Discharge). The Proposed Plan (AFCEE, 1999) presenting the remedy was issued in June 1999 for public comment. No comments were received.

In summary, the remedy provides for:

Y:\Figures\179636\5_Year_Review\GIS\20030429\Arcmap\5yr_03_fs1plume_Fig9_3_18-1.mxd



Legend

Plume Contour = Concentrations exceeding drinking water standards or Massachusetts Maximum Contaminant Level (MMCL). Represents an exceedance of ethylene dibromide (1,2-dibromoethane)(EDB) (EDB MCL = 0.02 µg/L)

- Outflow Bubbler
- Proposed Extraction Well
- Extraction Well
- Bogs
- Infiltration Trenches
- Treatment System Piping
- Treatment Facility
- Area of 175 Shallow-well Extraction Points

Air Force Center for Environmental Excellence

Fuel Spill 1 (FS-1) Plume
December 2002

Massachusetts Military Reservation
Cape Cod, Massachusetts

Figure 9.3.18-1

- extracting contaminated groundwater from the contaminant plume and potentially extracting groundwater from hot spot areas identified during remedial design;
- pumping and conveying the extracted groundwater to a treatment system to remove contaminants;
- discharging the treated water back to the groundwater and/or surface water;
- installing monitoring wells, measuring water levels, and sampling groundwater to monitor the performance of the extraction system;
- sampling the influent and effluent of the treatment system to monitor its performance;
- monitoring of source area groundwater for thallium, toluene, and lead;
- restricting groundwater use within the areas contained by the treatment system through imposition of institutional controls; and
- conducting a review after five years of operation to ensure the remedy provides adequate protection of human health and environment.

B.2 Remedial Action Objectives

The RAOs are the site-specific qualitative goals. Specifically, the objectives include:

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

Clean-up standards to achieve RAOs include Federal MCLs, non-zero Federal MCL Goals (MCLGs), Massachusetts MCLs, or risk-based guidance levels for compounds for which drinking water standards have not been set. **Table B-1** presents COCs and their respective cleanup levels.

Table B-1 Contaminants of Concern and Respective Cleanup Levels for FS-1 Plume

Contaminant	Basis	Conc (µg/l)	Standard
EDB	Human Health	0.02	MMCL
Lead	Human Health	15	Fed MCL
Thallium	Human Health	2	Fed MCL
Toluene	Human Health	1,000	Fed MCL

B.3 Remedy Description

The chosen alternative for FS-1 involves continued operation of the existing Quashnet pilot system and additional extraction within the body of the plume, north of the bog area. Specifically, the alternative includes:

- Construction of a surface water discharge system capable of discharging 800 gpm to the bog area.

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

B.4 Remedy Implementation

Described below is a summary of the implementation of the remedy, which includes system startup and modifications as a result of the analysis of monitoring data and groundwater, modeling. Modifying extraction and reinjection flow rates is an ongoing optimization process based on results of remedial system performance monitoring.

System Startup: The Quashnet and Bogs Pilot Test and Bog Separation Project began operating in the Quashnet bog Area in April 1999 as an interim remedy for the FS-1 plume. The pilot scale system captured EDB near the leading edge of the FS-1 plume. Currently the deep extraction well is pumping 300 gpm. Based on the recommendations presented in the 2000 annual report (AFCEE, 2000) the combined pumping rate of shallow extraction well points is 450 gpm.

Brook Trout Survey: During October 2000, AFCEE conducted a brook trout population survey in the bog ditches for the town of Mashpee. The results were compared to a pre-ROD survey (conducted in 1999). The data indicated a slight decrease in the brook population; however, there is no known correlation between treatment system operation and reduced habitat quality.

Wellfield Design Report: AFCEE completed the final wellfield design for the FS-1 Plume in December 2001 (AFCEE, 2001a). The design involves continued operation of the existing Quashnet pilot system and additional extraction within the body of the plume, north of the bog area. Based on Pre-Design sampling activities, groundwater modeling, and results of the 2001 Annual Quashnet and Bogs SPEIM, addition will include the installation of three deep extraction wells. Shallow well extraction points will be phased out or shut down completely based on timeliness of the deep extraction wells being bought on-line.

Post-ROD factsheet: Fish sampling was eliminated in a post –ROD factsheet (AFCEE, 2001b).

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted/observed since the last review.

- Pilot Scale System: Startup began on April 1999. The FS-1 Pilot Scale system pumped at 300 gpm from the deep extraction well and 450 gpm from 135 shallow extraction well points. Treated water was discharged to an infiltration trench and a bubbler. An estimated mass of 0.74 pounds of EDB has been removed between startup and April 2001 (AFCEE, 2002).
- ROD: A ROD was finalized in April 1999 (AFCEE, 2000). The selected alternative in the ROD for FS-1 involves continued operation of the existing Quashnet pilot system and additional extraction within the body of the plume, north of the bog area. Institutional controls prevent installation of new private wells above or near the FS-1 plume.
- Wellfield Design Report: AFCEE completed the final wellfield design for the FS-1 Plume in December 2001 (AFCEE, 2001a). The Final Design is based Pre-Design sampling activities, groundwater modeling, and results of annual Quashnet and Bogs SPEIM.
- Shutdown of System: Due to a fire that destroyed the treatment plant in October 2002, the system was shutdown.

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the remedy. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA 2001). **Table D-1** summarizes the Technical Assessment.

Question A: Is the remedy functioning as intended by the decision documents?

Yes. The remedy is functioning as intended despite the fire that shutdown the treatment system in October 2002. Institutional controls are in place to prevent exposures to contaminated groundwater. From April 1999 to April 2001, the pilot test treatment system removed approximately 0.74 lbs of EDB, which is close to the model-predicted mass removal (AFCEE, 2002) for this time period. AFCEE completed a final wellfield design in 2001, which is expected to achieve the RAOs in a shortened time frame than continuing pilot-scale system. The wellfield design has a total of four extraction wells operating at a combined flowrate of 750 gpm. Furthermore, the shallow well points will be turned off. The treatment plant will be rebuilt and the new extraction wells will be installed to be part of the remedy.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

There have been no changes in standards or TBC guidance.

Changes in Exposure Pathways

There have been no changes to exposure pathways and land use of the site that would affect the protectiveness of the remedy. Exposure pathways have been reduced by the implementation of institutional controls.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for COCs.

Changes in Risk Assessment Methods:

There were no changes in risk assessment methodology.

Expected Progress Towards Meeting RAOS:

The pilot scale system is capturing a significant portion of the plume that would otherwise discharge to bog perimeter ditches and the Quashnet River. EDB is upwelling in the K6 Bog. AFCEE is reconfiguring the current shallow well network to address this issue (AFCEE, 2002).

Question C: Has any other information come into light that could call into question the protectiveness of the remedy?

The treatment system was destroyed by fire in October 2002. The system will be reconstructed and the extraction wells need to be reconfigured to address the K6 bog upwelling.

Table D-1: Technical Assessment Summary for the FS-1 Plume

Question Item	Question	Response
A	Is the removal action functioning as intended by the decision documents?	Yes*
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the remedy?	Yes

*The remedy is functioning, however a fire has shut down treatment plant operations. AFCEE is planning to reconstruct the treatment plant.

E. ISSUES

The issues for the FS-1 plume include: reconstruction of the treatment plant and installation of new extractions to resume cleanup operations as intended by the ROD; and continued evaluation of monitoring data to determine if any actions need to be taken while the system is shutdown.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The treatment plant will be reconstructed. Furthermore, groundwater and ecological monitoring will continue.

G. PROTECTIVENESS STATEMENT

The remedy selected for the FS-1 Plume is expected to be protective of human health and the environment upon completion, and in the interim; exposure pathways that could result in unacceptable risks are being controlled by institutional and engineering controls.

H. REFERENCES

AFCEE, 2002. *Final Quashnet River and Bogs 2001 Annual System Performance and Ecological Impact Monitoring Report*. Prepared by Jacobs Engineering Group. Inc. for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. February, 2002

AFCEE, 2001b. *Final Fuel Spill-1 (FS-1) Post- Record of Decision (ROD) Change*. AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. December, 2001

AFCEE, 2001a. *Final Fuel Spill-1 Wellfield Design Report*. Prepared by Jacobs Engineering Group Inc. for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. December, 2001

AFCEE, 2000 Final *Record of Decision, Area of Contamination FS-1*. prepared by Hazardous Waste Remedial Action Program for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA.

AFCEE, 1999. *Proposed Plan for Groundwater and Surface Water Cleanup Related to FS-1, Massachusetts Military Reservation*. June 1999

OpTech.1996. *Installation Restoration Program, Plume Containment Design Groundwater Modeling Report, Massachusetts Military Reservation*. August, 1996

HAZWRAP, 1999b Feasibility *Study, Area of Contamination FS-1.* Lockheed Martin Energy Systems, Inc., Oakridge, Tennesee, 1999

HAZWRAP, 1999a Remedial *Investigation Report. Area of Concern FS-1* Lockheed Martin Energy Systems, Inc., Oakridge, Tennesee, 1999

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June, 2001.

9.3.19 FUEL SPILL NO.4 (FS-4)

A. BACKGROUND

A.1 Site Description

Area of Contamination (AOC) FS-4 consists of the area surrounding the former Building 178, a fuel pumphouse. It is approximately 0.75 acres, and is located on the MMR within the restricted zone of the flightline (**Figure 11**).

AOC FS-4 was evaluated as part of the Task 6 Records Search. According to the records search, five USTs were installed at the pumphouse in 1956. Four USTs were used to store AVGAS, one UST was used as a defueling tank, and the other UST was used as a collection tank. From the late 1950 until the early 1970s, AVGAS was pumped to the pumphouse and the USTs from the Petroleum Fuels Storage Area. During this period the pumphouse had the capability of fueling and defueling aircraft through a network of underground fuel distribution lines in the aircraft apron. The fuel line from the PFSA was abandoned after EC-121 aircraft operations ceased at MMR in the early 1970s. (E.C. Jordan Co., 1986).

A.2 Initial Response

Fuel System Upgrade (FSU) Activities: In 1994, as part of the fuel systems upgrade the five USTs at Pumphouse 178 were removed along with a 25,000 gallon defueling UST located east of the former pumphouse. The pumphouse was demolished to gain access to the underlying USTs. During the removal, residual fuel contamination consisting of PAHs was identified beneath the former collection and defueling USTs, at 10 feet and 22 feet below ground surface, respectively. Qualitative PID headspace results obtained during the UST removals were the basis for this study area being included in the Priority 2 and 3 Study Areas and DDOU EE/CA (AFCEE, 1998).

A.3 Basis for Taking Action

Site Investigation (SI): A SI was completed in October 1993 to determine the nature and extent of contamination at FS-4 (ABB-ES, 1993). The exploration program was conducted in two phases, the investigation phase and the confirmatory phase. Exploration locations were selected based on the findings of the Preliminary Assessment and observations of study area conditions made during the SI. The investigation phase consisted of the completion of two monitoring wells, one soil boring and 30 soil gas samples. The confirmation phase consisted of the installation of two monitoring wells and one soil boring, all abandoned in-place and filled with grout. The SI report recommended that no further action be conducted at this study area depending on results of the Fuel System Upgrade Project activities.

Supplemental Site Investigation (SSI): In 1995, the two monitoring wells installed at study area FS-4 during Phase I of the SI were sampled for EDB analysis. Results indicated that EDB was not present in groundwater at concentrations above the sample quantitation limit (ABB-ES, 1995).

Risk Evaluation Summary: A site-wide preliminary risk evaluation (PRE) was completed for surface and subsurface soil at AOC FS-4 including human-health and ecological exposure scenarios. The PRE was not intended to quantify study-area-specific risks, but rather to indicate if risks above regulatory guidance levels are possible. The PRE was completed in 1995. Due to the relatively low

concentrations of compounds detected during the SSI, the PRE was not updated to include those results. Results of Tier I of the human-health PRE showed no hazard equivalent concentration (HEC) exceedances for surface or subsurface soil. Tier II human-health HEC exceedances were not identified in groundwater. Tiers I and II of the ecological PRE showed that maximum surface soil concentrations of several PAHs, as well as dieldrin and arsenic, exceeded the lowest HECs.

Engineering Evaluation/Cost Analysis (EE/CA): AOC FS-4 was included as part of the Priority 2 and 3 Study Areas and DDOU EE/CA completed in October 1998 (AFCEE, 1998). The EE/CA provided detailed analysis of three alternatives. All three alternatives included in-situ treatment for study area FS-4.

B. REMEDIAL/REMOVAL ACTIONS

This section presents the regulatory actions, removal action objectives (RAOs), a description of the selected removal action, and a summary of the removal action implementation at AOC FS-4.

B.1 Regulatory Actions

Described below are the controlling documents that present the selected removal action and post-EE/CA documents that identified changes to the selected removal action.

Action Memorandum (AM): An AM for the Priority 2 and 3 Study Areas and DDOU Source Removal (AFCEE, 1999) documented the decision to perform removal actions at several Priority 2 and 3 study areas including FS-4. Based on the evaluation of removal action alternatives presented in the EE/CA, the selected alternative was Alternative 2 which included in-situ treatment for study area FS-4 as warranted. The AM called for additional investigation activities at FS-4 to focus on subsurface soil sampling and laboratory analysis to evaluate the amount and distribution of residual fuel contamination beneath the former collection and defueling USTs that may potentially act as a source of groundwater contamination. Implementation of the in-situ treatment system would be based upon results of this additional sampling.

Action Memorandum Addendum: AM Addendum for Priority 2 and 3 Study Areas and DDOU Source Removal (AFCEE, 2003) was prepared to document changes to the selected remedial action for several sites encompassed by the AM. The selected remedial action for AOC FS-4 was changed with the establishment of new removal action levels (RALs) for aliphatic and aromatic hydrocarbons.

Source Areas Remedial Design: In August 1999, soil sampling was completed at the AOC FS-4 source area as required by the AM for the Priority 2 and 3 Study Areas and DDOU Source Removal. Sampling was performed to evaluate the lateral and vertical extent of soil contamination to address the need for a possible removal action.

A total of 30 soil samples were collected and screened by headspace analysis. Six of these samples were selected for off-site analysis. The analysis included sampling for MADEP S-1/GW-1 standards for petroleum hydrocarbons including volatile petroleum hydrocarbons (VPH) and extractable petroleum hydrocarbons (EPH). The analytical results reported all samples to be below laboratory detection limits for EPH/VPH, benzene, toluene, ethyl-benzene and xylenes (total). In accordance with the Source Areas Remedial Design, “No further action” is planned for this site and a Remedial Design Fact Sheet will be prepared to document this decision (AFCEE, 2000a).

B.2 Removal Action Objectives (RAOs)

The RAOs are site specific qualitative cleanup goals that must be achieved to meet remedial response objectives. Investigations conducted at the AOC FS-4 demonstrate that soil is not contaminated with TPH compounds and does not pose unacceptable risk to humans and ecological receptors.

MMR-specific Soil Target Cleanup Levels (STCLs) used for the DSRP (AFCEE, 1996) were retained and used to develop cleanup level concentrations for identified COCs. In 2000, AFCEE with concurrence from USEPA and MADEP revised ecological risk based STCLs for inorganic chemicals in a Technical Memorandum (AFCEE, 2000b).

The revised STCLs led to the development of RALs, which also took into account terrestrial plant screening levels, terrestrial invertebrate screening levels, and MMR-specific background levels. Development and establishment of RALs were documented in the AM Addendum prepared in 2003 (AFCEE, 2003). Presented in **Table B-1** are RAOs that must be achieved to meet remedial response objectives for the FS-4.

Table B-1 MADEP S-1/GW-1 Standards for Petroleum Hydrocarbons

Type of Petroleum Hydrocarbons	BASIS	New RAL (mg/kg)
Aliphatic Hydrocarbons		
C_5 through C_8 Aliphatic Hydrocarbons	Human Health	100
C_9 through C_{12} Aliphatic Hydrocarbons	Human Health	1,000
C_9 through C_{18} Aliphatic Hydrocarbons	Human Health	1,000
C_{19} through C_{36} Aliphatic Hydrocarbons	Human Health	2,500
Aromatic Hydrocarbons		
C_9 through C_{10} Aromatic Hydrocarbons	Human Health	100
C_{11} through C_{22} Aromatic Hydrocarbons	Human Health	200

B.3 Remedy Description

The selected remedy documented in the AM (AFCEE, 1999) consisted of in-situ treatment for AOC FS-4 soil based upon results of additional sampling activities.

The selected remedy for FS-4 was modified by the AM Addendum. Changes to the selected remedy included: establishment of RALs to replace cleanup levels presented in the AM. These changes are documented in AM Addendum for Priority 2 and 3 Study Areas and Drum Disposal Operable Unit Source Removal (AFCEE, 2003) for the SARAP.

B.4 Remedy Implementation

As a result of additional sampling activities and sample results with concentrations below RALs, no action was taken at FS-4. Documentation of no action at FS-4 will be provided in a future remedial design fact sheet (AFCEE, 2000a).

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted since the last review.

- Priority 2 and 3 Study Areas and DDOU AM: Completed in June 1999
- Remedial Design Delineation Sampling: Completed in August 1999
- Source Areas Remedial Design: Completed in September 2000
- Priority 2 and 3 Study Areas and DDOU AM Addendum: Completed in February 2003

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the removal action. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA, 2001).

Question A: Is the remedy/removal action functioning as intended by the decision documents?

The review of documents, ARARs, risk assumptions, and the results of the site inspection indicate that the remedy has been completed as intended by the AM and modified by the AM Addendum. Excavation of contaminated soil was not required, and the RAOs of mitigating the migration of contaminants to groundwater and preventing direct contact with, or ingestion of contaminants in soil has been achieved.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

ARARs and TBC guidance for soil contamination cited in the AM and AM Addendum have been met. There have been changes in chemical-specific ARARs and TBC guidance. In particular, the MADEP chemical specific standards for petroleum hydrocarbons were used as new cleanup levels. These standards subdivide the hydrocarbons into aliphatic and aromatic groups. AFCEE recalculated risk-based STCLs for ecological receptors to reflect current toxicity information. RALs were derived from the comparison of the following: revised STCLs, background, phytotoxicity screening levels, and invertebrate screening levels. The new cleanup levels remain protective of human health and the environment. Cleanup levels identified in the AM were derived from the comparison of cleanup levels used in the DSRP and background. These cleanup levels initially did not take into account invertebrate or phytotoxicity screening levels; however, they were taken into account in the AM Addendum. **Table D-1** provides the changes in cleanup levels at AOC FS-4.

Table D-1 Changes in Cleanup Levels at FS-4

Contaminant	Media	AM Addendum RAL (mg/kg)	AM RAL (mg/kg)
Total Petroleum Hydrocarbons	Soil	See **Table B-1**	500

Changes in Exposure Pathways

There have been no changes in the physical conditions, exposure pathways, and land use of the site that would affect the protectiveness of the removal action.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for contaminants of concern that were used for the human health risk assessment. However, risk-based cleanup levels for ecological receptors were calculated using new toxicity information. Calculation of ecological risk-based STCLs using new toxicity information was completed in 2000 (AFCEE, 2000). These STCLs were used in the development of RALs. Cleanup was based on these RALs.

Changes in Risk Assessment Methods:

There were no changes in human health risk assessment methodology.

Expected Progress Towards Meeting RAOS:

Implementation of the remedy has achieved RAOs.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy/removal action?

There is no information that calls into question of the protectiveness of the selected remedy.

Technical Assessment Summary

The remedy was completed as intended by the AM as modified by the AM Addendum. There have been no changes in the physical conditions and land use of the site that would affect the protectiveness of the remedy. ARARs and TBC guidance for soil contamination cited in the AM and AM Addendum have been met. There is no information that calls into question of the protectiveness of the selected remedy.

Table D-2 presents the technical assessment summary for AOC FS-4.

Table D-2: Technical Assessment Summary for AOC FS-4

Question		Response
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the removal action?	No

E. ISSUES

The issue for FS-4 source is that the documentation of no action based on additional sampling results needs to be completed.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendation and follow-up action is to prepare and issue the documentation of no action with regulatory review and comment.

G. PROTECTIVENESS STATEMENT

The recommendation and follow-up action is a preparation and issuance of the appropriate documentation.

H. REFERENCES

ABB Environmental Services, Inc. (ABB-ES), 1995. *Supplemental Sampling Report for Priority 2 and 3 Study Areas Sites*; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Portland, Maine; 1995.

ABB-ES, 1993. *Priority 2 and 3 Study Areas Site Investigation*, Installation Restoration Program, Massachusetts Military Reservation, prepared for HAZWRAP; Portland, Maine; October 1993.

AFCEE, 2003. *Action Memorandum Addendum Priority 2 and 3 Study Areas and Drum Disposal Unit Source Removal*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program; February 2003.

AFCEE, 2002. *Addendum to Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program; September 2002.

AFCEE, 2000b. *Final Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics.* Prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program; December 2000.

AFCEE, 2000a. *Massachusetts Military Reservation, Cape Cod, Massachusetts, Source Areas Remedial Design, Volume 2 – Biosparging/Soil Vapor Extraction – Final Design for: FTA-2/LF-2, CS-10/FS-24, PFSA/FS-10/FS-11, and FS-4*. Prepared by T N & Associates, Inc for AFCEE/MMR Installation Restoration Program; September 2000.

AFCEE, 1999. *Action Memorandum Priority 2 and 3 Study Areas and Drum Disposal Operable Unit Source Removal*. Prepared by Harding Lawson Associates (HLA) for AFCEE/MMR Installation Restoration Program; June 1999.

AFCEE, 1998. *Priority 2 and 3 Study Areas Drum Disposal Operable Unit Engineering Evaluation/Cost Analysis.* Prepared by HLA for AFCEE/MMR Installation Restoration Program; October 1998.

AFCEE, 1996. *Soil Target Cleanup Levels, DSRP*. Prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program; January 1996.

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June 2001.

9.3.20 FUEL SPILL-5 (FS-5)/STORM DRAIN-5 (SD-5) SOURCE

A. BACKGROUND

A.1 Site Description

Area of Contamination (AOC) FS-5/SD-5 is located in the central part of the MMR cantonment area between North Inner Road and Langley Avenue on the north and south, respectively, and Base Runway No. 5 on the east, approximately 3,000 feet from the southern MMR boundary. (**Figure-11**). The AOC occupies approximately 40 acres and extends approximately 2,000 feet along an unfilled portion of a drainage swale and varies in width from approximately 750 to 1,200 feet. AOC FS-5/SD-5 includes the site of Fuel Spill No. 5 and is within the flightline security area.

The central drainage swale at the AOC receives stormwater runoff from approximately 100 acres of paved runways and ramps through and extensive stormwater drainage system. The swale is unlined and water that does not evaporate or infiltrate flows south to an unlined 1-acre stormwater infiltration basin. During extensive storm or runoff events, the Stormwater Infiltration Basin overflows into two buried 72-inch-diameter pipelines, flows southward beneath AOC FTA-2/LF-2, and discharges to Study Area SD-1.

SD-5 began receiving stormwater runoff in the 1950s from a number of sources including the Eastern and Western Aquafarms, the former Nondestructive Inspection Laboratory (NDIL), the corrosion Control Shop, and the Permanent Field Training Site (PFTS) hangar. In the early 1960s, three refueling aircraft were destroyed in a fire, resulting in the FS-5 fuel spill of up to 15,000 gallons of AVGAS. The spill was washed into the storm drain leading to SD-2.

A.2 Initial Response

- 1994, the NDIL and Corrosion Control Shop were demolished and removed;
- 1994, two 12,000-gallon underground storage tanks were removed from the AVLUBE area as part of the Fuel System Upgrade Program;
- 1994-1995, a total of 17 USTs, including all six 25,000 gallon tanks at the Western Aquafarm, all four 25,000 gallon tanks at the Eastern Aquafarm, and seven 550 gallon tanks associated with water separator control pits were removed;
- 1996, as part of the Drainage Structure Removal Program, the NDIL leaching well and surrounding soil were removed.

A.3 Basis for Taking Action

Field Investigations: Potential environmental effects associated with industrial activities at AOC FS-5/SD-5 were first reported in a 1983 records search that identified the NDIL as a potential source of groundwater contamination. A supplemental investigation conducted in 1985 included the excavation of four test pits and collection of liquid and sludge samples from the NDIL leaching well. The expanded records search in 1986 identified historical activities at AOC FS-5/SD-5 with potential to cause soil and groundwater contamination. These activities were associated with the Eastern and western Aquafarms, the Corrosion Control Shop, the PFTS hangar, and FS-5 (AFCEE, 1997a).

A sampling investigation (SI) was completed in 1988 to further characterize the distribution of soil and groundwater contamination at suspected source locations. The program included a stormwater drainage pipe inspection, a soil gas survey, excavation of seven test pits in the vicinity of the Central Drainage Swale, and the installation of six soil borings completed as monitoring wells. The monitoring wells were also sampled during the SI program (AFCEE, 1997a).

A stormwater drainage pipe inspection was conducted to determine the integrity of underground drainage lines. The soil gas survey consisted of 53 sampling points, distributed in the Central Drainage Swale, the Western Aquafarm, and NDIL. Seven test pits were excavated, soil borings were placed near specific drain outfalls, downgradient of disposal areas, and in the vicinity of Aquafarms USTs. Samples were collected for field-screening for VOCs as well as laboratory analysis for target Compound List (TCL) VOCs and SVOCs and Target Analyte List (TAL) inorganics. Six groundwater samples were also collected for analysis for the same compounds (AFCEE, 1997a).

Remedial Investigation (RI) and Supplemental RI: In 1989, a RI was performed to characterize the nature and extent of sediment, soil, and groundwater contamination at the AOC. Since the SI recommended that the RI focus on groundwater contamination rather than residual soil contamination, the RI investigated soil contamination only where the SI had identified specific source areas. The supplemental RI was performed in 1993 to addressed data needs that were identified upon completion of the RI, including additional source investigations, additional downgradient monitoring wells, and a confirmatory round of groundwater sampling. The RIs consisted of surface soil and sediment sampling; excavation of test pits; installation of soil borings, several of which were completed as monitoring wells; ground-penetrating radar surveys; TerraProbe® sampling; and monitoring well installation. Samples collected during the investigations were analyzed for TCL VOCs and SVOCs, pesticides, PCBs, TPH, TAL inorganics, and 1,2-dibromoethane (AFCEE, 1997a).

Risk Evaluation Summary: A human-health Preliminary Risk Assessment (PRA) was performed to evaluate potential human-health risks associated with exposure to contaminated surface and subsurface soil under current and future site conditions. The ecological PRA evaluated potential ecological risks associated with exposure to contaminated surface soil (zero to 2 feet bgs). Results of the PRA triggered the need for an evaluation of remedial alternatives (i.e. Feasibility Study). The contaminants of concern (COCs) identified at AOC FS-5/SD-5 are chromium, copper, lead, mercury, zinc, cyanide, benzene, trichloroethene, and total petroleum hydrocarbons.

Feasibility Study: AOC FS-5/SD-5 was included as part of the Six Areas of Contamination Source Area Feasibility Study completed in November 1997 (AFCEE, 1997a). The Feasibility Study assessed how well the following four alternatives would meet the evaluation criteria while controlling migration of contaminants from deep soil to groundwater at the AOC:

- Alternative 1: No action
- Alternative 2: Limited action
- Alternative 4: Excavation/Asphalt batching
- Alternative 5: Excavation/Off-site Treatment and Disposal

B. REMEDIAL/REMOVAL ACTIONS

This section presents the regulatory actions, removal action objectives (RAOs), a description of the selected remedy, and a summary of the remedy implementation at AOC FS-5/SD-5.

B.1 Regulatory Actions

Described below are the controlling documents that present the selected remedy and post-record of decision (ROD) documents that identified changes to the selected remedy.

ROD: The *Record of Decision for Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and FS-5/SD-5 Source Areas* finalized in September 1998 (AFCEE, 1998) was prepared to document the decision to perform removal actions a several AOCs including FS-5/SD-5. The selected remedial alternative for the FS-5/SD-5 source area was Alternative 4, Excavation and Asphalt Batching. This alternative provides institutional and engineering controls to limit exposure to site-related contaminants and to reduce source-area contaminant concentrations to protective levels. The *Proposed Plan to Cleanup Six Areas of Contamination* (AFCEE, 1997b) was issued in November 1997 for public comment. All comments received at the public hearing and during the public comment period are included in Appendix C of the ROD.

Explanation of Significant Differences (ESD): The *Explanation of Significant Differences to the Record of Decision for Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and FS-5/SD-5 Source Areas* finalized in January 2003 (Portage, 2003) was prepared to remove the CS-2 drainage swale from the CS-2 Study Area and add it to the FS-5/SD-5 AOC. This drainage swale, although historically identified as part of CS-2, was also within the footprint of the SD-5 drainage swale. Delineation of the extent of contamination and subsequent remediation as warranted at CS-2 will be completed during the SD-5 delineation and remediation effort.

Additional Actions: The remedy has been modified to include a soil vapor extraction system to remediate contaminated soil from the vadose zone at SD-5. In summary, this remedy for vadose zone soil provides for:

- Performance of baseline ambient air monitoring
- Collecting confirmation soil samples to refine the horizontal and vertical extent of the target contaminants
- Designing and installing a soil vapor extraction system with off-gas collection and treatment for areas with capillary-fringe contamination
- Collecting ambient air samples to assess compliance with ARARs
- Maintaining institutional controls that restrict site access and limit potential human exposure to contaminants

B.2 Removal Action Objectives (RAOs)

The RAOs are site specific qualitative cleanup goals that must be achieved to meet remedial response objectives. The RALs are the site-specific quantitative cleanup levels that will meet these goals. The PRA completed at the AOC FS-5/SD-5 identified potential risks to receptors for the

following COCs: chromium, copper, lead, mercury, zinc, cyanide, benzene, trichloroethene, and total petroleum hydrocarbons. MMR-specific Soil Target Cleanup Levels (STCLs) used for the DSRP were retained and used to develop cleanup levels for identified contaminants of concern. In 2000, AFCEE with concurrence from USEPA and MADEP revised ecological risk based STCLs for inorganic chemicals in a Technical Memorandum (AFCEE, 2000).

In 2002, AFCEE revised phytotoxicity and invertebrate STCLs for several inorganics in an addendum to the Technical Memorandum (AFCEE, 2002). The revised STCLs led to the development of RALs, which also took into account terrestrial plant screening levels, terrestrial invertebrate screening levels, and MMR-specific background levels. Development and establishment of RALs are documented in another ESD to be prepared in 2003. Furthermore, this ESD will document the establishment of MADEP Method S-1/GW-1 Extractable Petroleum Hydrocarbon/Volatile Petroleum Hydrocarbon (EPH/VPH) cleanup standards as RALs in instances where TPH were considered COCs. COCs and respective cleanup levels are presented in **Table B-1.** Specifically, the RAOs established for AOC FS-5/SD-5 are:

- Protect potential human receptors from exposure to unacceptable concentrations of TPH and lead in surface soil.
- Protect ecological receptors from unacceptable risk resulting from exposure to surface soil.
- Prevent organic compounds in soil from being a source of groundwater contamination (AFCEE, 1997a).

Table B-1 Contaminants of Concern and Respective Cleanup Levels for AOC FS-5/SD-5 Source Areas

Contaminant	Basis	Concentration (mg/kg)
Chromium	Background	19
Copper	Ecological Risk	61
Lead	Ecological Risk	99
Mercury	Ecological Risk	18
Zinc	Ecological Risk	68
Cyanide	Background	1
Benzene	Leaching Potential	0.1
Trichloroethene	Leaching Potential	0.01
Total Petroleum Hydrocarbons	MCP S-1/GW-1 Standards	See **Table B-2**

Table B-2 MCP S-1/GW-1 Standards for Petroleum Hydrocarbons

Type of Petroleum Hydrocarbons	BASIS	New RAL (mg/kg)
Aliphatic Hydrocarbons		
C_5 through C_8 Aliphatic Hydrocarbons	Human Health	100
C_9 through C_{12} Aliphatic Hydrocarbons	Human Health	1,000
C_9 through C_{18} Aliphatic Hydrocarbons	Human Health	1,000
C_{19} through C_{36} Aliphatic Hydrocarbons	Human Health	2,500
Aromatic Hydrocarbons		
C_9 through C_{10} Aromatic Hydrocarbons	Human Health	100
C_{11} through C_{22} Aromatic Hydrocarbons	Human Health	200

B.3 Remedy Description

The selected remedy documented in the ROD is Excavation and Asphalt Batching. This alternative provides institutional and engineering controls to limit exposure to site-related contaminants and to reduce source-area contaminant concentrations to protective levels. Confirmatory sampling after excavation would ensure that all soil with COC concentrations exceeding these cleanup levels were removed. The remedy does not include a management of migration component. Groundwater contamination attributed to AOC FS-5/SD-5 is being addressed by the SD-5 North Groundwater Plume Extraction, Treatment and Reinjection System and the SD-5 South Recirculation Well System.

Excavated soil that is found to have contaminant concentrations in exceedance of TCLP allowable concentrations would be deemed hazardous and disposed of off-site in a RCRA Subtitle C TSDF. Soil that is determined to be below TCLP allowable concentrations and therefore nonhazardous (and that is determined to contain contaminant concentrations below MADEP MCP Method 1 S-1/GW-1 standards for pesticides and Massachusetts Permitted Soil Recycling facility Summary Levels) would be treated at the on-site cold mix emulsion asphalt-batching plant.

The selected remedy for FS-5/SD-5 was modified. The remedy has been modified to include a soil vapor extraction system to remediate contaminated soil from the vadose zone at a portion of SD-5. Furthermore, additional changes to the selected remedy including changing the selected alternative from Alternative 4, Excavation/Asphalt Batching to Alternative 5, Excavation/Off-site Treatment and Disposal. Also new removal action levels (RALs) were developed for several COCs. Installation of the soil vapor extraction (SVE) system to remediate contaminated soil that was not identified in the ROD will be documented in a future ESD.

B.4 Remedy Implementation

Excavation and Disposal: AFCEE conducted removal activities in 2001 at FS-5/SD-5. Remedial activities and results of confirmatory sampling will be documented in a Remedial Action Report which is anticipated in 2003. Approximately 1,800 cubic yards of contaminated soil were removed from the AOC. Confirmatory sampling results indicated that the contaminant concentrations in soil were below the RALs. Excavated soil was transported to a central bulking facility located on the MMR. Soil from AOC FS-5/SD-5 was combined with soil from other sites. Composite sampling of the consolidated soil stockpiles determined that the consolidated soil were considered non-hazardous and suitable for reuse as daily cover at a Resource Conservation and Recovery Act (RCRA) Subtitle D Landfill. Soil from SD-5 was disposed of at the Taunton Landfill in Massachusetts. Disposal activities were performed in compliance with the MADEP *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills Policy #COMM-97-001* (MADEP, 1997).

Soil Vapor Extraction (SVE) System: In summary, the remedy provides for:

- Performance of baseline ambient air monitoring
- Collecting confirmation soil samples to refine the horizontal and vertical delineation of the target contaminants
- Designing and installing a full-scale soil vapor extraction treatment system with off-gas collection and treatment for areas with capillary-fringe contamination
- Collecting ambient air samples to assess compliance with ARARs

- Maintaining institutional controls that restrict site access and limit potential human exposure to contaminants

Provided below is a summary of the implementation of the SVE system. The summary includes Design Optimization, System Installation, System Start-up and Operations and Maintenance Activities.

Design Optimization: The primary objective of design optimization was to determine the vertical and horizontal limits of the AOC and to verify design parameters through field-testing.

System Installation: Installation of the SVE system began in May 2002. Vapor from SD-5 system extraction points were piped to the treatment system associated with the FTA-2/LF-2 SVE system because the two sites are closely located. The SVE system with a design flowrate of 180 cfm began operations in August 2002 and, as of October 2002, had removed 2.54 pounds of hydrocarbons.

System Start-up: The system start-up consisted of a mechanical shakedown of the system, optimization of operating parameters, and collection of process air samples and field data to demonstrate achievement of system performance efficiency criteria. The remedial system start-up date was on August 21, 2001, ahead of the Federal Facilities Agreement milestone of October 10, 2001. The start-up data showed that the system met established performance guidelines.

Operations and Maintenance Activities: Operations and Maintenance activities consisted of daily monitoring of the system and performance parameters. The wellfield parameters were monitored and air samples for off-site analysis are collected on a monthly basis. As of October 15, 2002:

- the system had operated for 648 hours and the average extraction rate was 174 cfm;
- the influent vapor concentration has decreased from 7,431 $\mu g/m^3$ at start-up to 4,888 $\mu g/m^3$;

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted since the last review.

- Source Areas Remedial Design: Completed September 2000.
- Removal Action: Completed in December 2001.
- SVE system startup: May 2002.
- ESD: Completed in January 2003 (AFCEE, 2003).

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the remedy/removal action. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA, 2001).

Question A: Is the remedy/removal action functioning as intended by the decision documents?

The review of documents, ARARs, risk assumptions, and the results of the site inspection indicate that the removal action has been completed as intended by the ROD and modified by the ESD. The excavation and offsite disposal of contaminated soil has achieved the RAOs of mitigating the migration of contaminants to groundwater and preventing direct contact with, or ingestion of contaminants in soil. The in-situ remedy of SVE treatment system is functioning as intended and the RAOs are being achieved.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

The removal work has been completed, and ARARs and TBC guidance for soil contamination cited in the ROD have been met. There have been changes in chemical-specific ARARs and TBC guidance. AFCEE recalculated risk-based STCLs for ecological receptors to reflect current toxicity information. RALs were derived from the comparison of the following: revised STCLs, background, phytotoxicity screening levels, and invertebrate screening levels. The new cleanup levels remain protective of human health and the environment. Cleanup levels identified in the ROD were derived from the comparison of cleanup levels used in the DSRP and background. These cleanup levels initially did not take into account invertebrate or phytotoxicity screening levels; however, they were taken into account in the ESD to be published in 2003 (AFCEE, 2003).

Table D-2 presents changes in cleanup levels at FS-5/SD-5.

Table D-2: Changes in Cleanup Levels at FS-5/SD-5

Contaminant	Media	ROD RAL (mg/kg)	ESD RAL (mg/kg)
Chromium	Soil	6.8	19
Copper	Soil	19.3	61
Lead	Soil	15.8	99
Zinc	Soil	16	68
Total Petroleum Hydrocarbons	Leaching Based	1,200	See **Table B-2**

Changes in Exposure Pathways

There have been no changes in the physical conditions, exposure pathways, and land use of the site that would affect the protectiveness of the remedy/removal action.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for contaminants of concern that were used for the human health risk assessment. However, risk-based cleanup levels for ecological receptors were calculated using new toxicity information. Calculation of ecological risk-based STCLs using new

toxicity information was completed in 2000 (AFCEE, 2000). These STCLs were used in the development of RALs for which cleanup was based.

Changes in Risk Assessment Methods:

There were no changes in risk assessment methodology.

Expected Progress Towards Meeting RAOs:

Implementation of the remedy is expected to achieve RAOs.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy/removal action?

There is no information that calls into question of the protectiveness of the selected remedy.

Technical Assessment Summary

The remedy was completed as intended by the ROD, and was modified to include an SVE system based on contamination discovered after the ROD was finalized. There have been no changes in the physical conditions and land use of the site that would affect the protectiveness of the remedy. ARARs and TBC guidance for soil contamination cited in the ROD are being achieved. There is no information that calls into question of the protectiveness of the selected remedy.

Table D-2 presents the technical assessment summary for AOC FS-5/SD-5.

Table D-2: Technical Assessment Summary for AOC FS-5/SD-5

Question		Response
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the removal action?	No

E. ISSUES

The issues for FS-5/SD-5 are: documentation for the removal action (i.e., soil removal and off-site disposal) and for the SVE are not complete; and SVE system must be operated and maintained.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendations and follow-up actions are preparation and issuance of a remedial action report, and an ESD to document the SVE system. The biosparging system at AOC FS-5/SD-5 should continue operation until the primary shutdown criteria is achieved. If the primary criteria can not be achieved, system shut down should occur only after the two secondary criteria are achieved.

- Primary shutdown criteria: comparison of soil sampling results with approved cleanup levels. If the results are below these cleanup levels, then the primary criteria for system shutdown has been achieved.

- Secondary shutdown criteria: if the in-situ respiration rate has leveled off and is asymptotically approaching a minimum concentration or is near background concentration, and if CO_2 production has reached non-detect or background levels, the system will be considered to have reached it's maximum treatment capacity. After the treatment system has reached its maximum treatment capacity, one of the two secondary criteria for system shutdown will have been achieved.
- Secondary shutdown criteria: if the removal rate of hydrocarbons, as measured at the treatment system, has leveled off to a minimum concentration or no significant change is observed over time, the second secondary criteria for system shutdown will have been achieved.

G. PROTECTIVENESS STATEMENT

The remedy for AOC FS-5/SD-5 is expected to be protective of human health and the environment upon both its completion and in the interim. Soil with concentrations of COCs above RALs have been removed, and the exposure pathways that could result in unacceptable risks are being controlled.

H. REFERENCES

AFCEE, 2003. *Explanation of Significant Differences Areas of Contamination CS-10 (A, B & C); CS-16/CS-17; FS-9; SD-2/FS-6/FS-8; and SD-3/FTA-3/CY-4*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program, Otis ANGB Cape Cod, MA, January 2003.

AFCEE, 2002. *Addendum to Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program, Otis ANGB Cape Cod, MA; September, 2002.

AFCEE, 2000. *Final Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics;* prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; December, 2000.

AFCEE, 1998. *Record of Decision for Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and SD-5/FS-5 Source Areas*. Prepared by HLA for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; September 1998.

AFCEE, 1997b. *Proposed Plan to Cleanup Six Areas of Contamination*; AFCEE/MMR Installation Restoration Program, Massachusetts Military Reservation Otis ANGB, Cape Cod, MA; November 1997.

AFCEE, 1997a. *Final Six Areas of Contamination Source Area Feasibility Study*. Prepared by ABB-ES for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod, MA; November 1997.

MADEP, 1997. *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills Policy # COMM-97-001*, Massachusetts Department of Environmental Protection, 1997.

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June 2001.

9.3.21 FUEL SPILL-6 (FS-6)/FUEL SPILL-8 (FS-8)/STORM DRAIN-2 (SD-2) SOURCE

A. BACKGROUND

A.1 Site Description

Area of Contamination (AOC) SD-2/FS-6/FS-8 consists of a storm drainage ditch (SD-2) that extends from the southern boundary of MMR at south Outer Road, south-southwest toward Ashumet Pond. Two 42-inch diameter storm drains and an oil/water separator discharged to the upstream end of SD-2 until their removal in 2002. AOC SD-2/FS-6/FS-8 had received stormwater discharge from the MMR runway/aircraft maintenance ramp storm sewer system since 1950 (**Figure 11**). The storm sewer system had collected stormwater from approximately 80 acres of concrete and asphalt paved surfaces, hangar nosedocks, and support buildings. In the early 1960s, two AVGAS fuel spills (i.e., FS-4 and FS-8) occurred on the aircraft maintenance ramp, resulting in the release of approximately 23,000 gallons of fuel. Reportedly, the spills were washed directly to the storm sewer and discharge to the SD-2 storm drainage ditch.

Other historical sources of contamination reported at AOC SD-2/FS-6/FS-8 were (1) the release of large quantities (i.e., up to 500,000 gallons) of petroleum distillate solvent (i.e., PD-680) on the aircraft maintenance ramp; (2) the release of unknown quantities of TCE, 4-methyl-2-pentanone, 2-butanone, toluene, and possibly 1,1,2,2-tetrachloroethane at nosedocks or maintenance shops adjacent to the ramp; and (3) other fuel spills, including an estimated 3,000 gallons of AVGAS from EC-121 aircraft fuel dump valve accidents inside Hangar 165. These releases were likely washed to the storm sewer discharging to the SD-2 storm drainage ditch. In 1968, an oil/water separator was constructed (demolished in 2002) at the storm sewer outfalls to intercept fuels from the aircraft maintenance ramp (E.C. Jordan Col, 1986). The adjacent AOC PFSA/FS-10/FS-11 also contains storm sewers that discharged to AOC SD-2/FS-6/FS-8, and may have contributed contaminants to it.

A.2 Initial Response

In June 1996, heavy rains and a pump failure at the PFSA caused the release on an estimated 6,000 gallons of fuel-contaminated water, containing approximately 300 gallons of product (diesel and/or jet fuel) from a fuel pumphouse at the PFSA. The water and fuel were released to a storm drain leading to the oil/water separator at the head of the SD-2 drainage ditch. Because of high stormwater flows, some of the fuel passed through the oil/water separator and was discharged to the SD-2 drainage ditch. In accordance with the MCP and the Immediate Response Action plan (RTN 4-12276) submitted to the MADEP on July 1996, AFCEE excavated an estimated 480 cy of fuel contaminated soil at the PFSA, and approximately 120 cy for fuel contaminated soil in the SD-2 drainage ditch.

A.3 Basis for Taking Action

Field Investigations and Mashpee Groundwater Investigation: AOC SD-2/FS-6/FS-8 has been investigated several times since 1985. During the 1986 field investigation, one surface water and one sediment sample were collected immediately dowggradient of the former oil/water separator for laboratory analysis. The sampling and analysis program detected SVOCs, pesticides, and PCBs in the sediment sample (E.C. Jordan Co., 1988).

As part of the Mashpee groundwater study, a monitoring well was installed just downgradient of the former oil/water separator at the head of the ditch. Six groundwater sampling events did not detect TCL fuel-related organic chemicals in this monitoring well (E.C. Jordan Co., 1990).

During the 1988 SI, two monitoring wells were installed to investigate the potential for groundwater contamination. Six sediment samples were collected from the storm drainage ditch between the oil/water separator and the mouth of the ditch; SVOCs and PCBs were detected. Based on results of the SI, AOC SD-2/FS-6/FS-8 was recommended for an RI (E.C. Jordan Co., 1990).

RI and Supplemental RI: The 1989 RI program for AOC SD-2/FS-6/FS-8 was designed to (1) characterize the distribution of groundwater contamination, and (2) complete characterization of sediment in the SD-2 drainage ditch (ABB-ES, 1996d). Four sediment samples were collected within the alluvial fan at Ashumet Pond and three groundwater samples were collected from the monitoring wells located in the ditch for laboratory analysis. In 1993, a supplemental RI program was completed to address regulatory agency concerns. The supplemental RI included collection of seven sediment samples and analysis for TCL VOCs (ABB-ES, 1996).

Risk Evaluation Summary: The RI report for AOC SD-2/FS-6/FS-8 included a human-health Preliminary Risk Assessment (PRA) to evaluate potential human-health risks associated with exposure to contaminated surface soil and sediment under current and future site conditions and an ecological PRA to evaluate potential ecological risks associated with exposure to contaminated surface soil and sediment (zero to two feet bgs.). The results of the PRA triggered the need for an evaluation of remedial alternatives (i.e. Feasibility Study). The contaminants of concern (COCs) identified at AOC SD-2/FS-6/FS-8 are chromium, lead, and zinc.

Feasibility Study: AOC SD-2/FS-6/FS-8 was included as part of the Six Areas of Contamination Source Area Feasibility Study completed in November 1997 (AFCEE, 1997a). The Feasibility Study assessed how well the following three alternatives would meet the evaluation criteria while controlling migration of contaminants from deep soil to groundwater at the AOC:

- Alternative 1: No Action
- Alternative 4: Excavation/Asphalt Batching
- Alternative 5: Excavation/Off site Treatment and Disposal

B. REMEDIAL/REMOVAL ACTIONS

This section presents the regulatory actions, removal action objectives (RAOs), a description of the selected remedy, and a summary of the remedy implementation at AOC SD-2/FS-6/FS-8.

B.1 Regulatory Actions

Described below are the controlling documents that present the selected remedy and post-record of decision (ROD) documents that identified changes to the selected remedy.

ROD: The *Record of Decision for Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and SD-5/FS-5 Source Areas* was finalized in September 1998 (AFCEE, 1998) to document the decision to perform remedial actions a several AOCs including SD-2/FS-6/FS-8. The selected remedial alternative for the SD-2/FS-6/FS-8 source area was Alternative

2, Excavation/Asphalt Batching. This alternative provides institutional and engineering controls to limit exposure to site-related contaminants and to reduce source-area contaminant concentrations to protective levels. The *Proposed Plan to Cleanup Six Areas of Contamination* (AFCEE, 1997b) was issued in November 1997 for public comment. All comments received at the public hearing and during the public comment period are included in Appendix C of the ROD.

Explanation of Significant Differences (ESD): The *Explanation of Significant Differences for Areas of Contamination CS-10 (A, B & E); CS-16/CS-17; FS-9; SD-2/FS-6/FS-8; SD-3/FTA-3/CY-4* was finalized in January 2003 (AFCEE, 2003) to document changes to the selected remedy for several sites in the Source Area Remedial Action Program (SARAP) including SD-2/FS-6/FS-8. Three changes are made to the selected remedy presented in 6 AOC ROD: (1) establishment of removal action levels (RALs) for certain inorganic chemicals; (2) removal of the asphalt-batching component from the selected remedy; and (3) the expansion of offsite disposal options to include RCRA Subtitle D facilities.

B.2 Removal Action Objectives (RAOs)

The RAOs are site-specific qualitative cleanup goals that must be achieved to meet remedial response objectives. The RALs are the site-specific quantitative cleanup levels that will meet these goals. Based on this comparison, the following RAO was established for AOC SD-2/FS-6/FS-8:

- Protect human and ecological receptors at AOC SD-2/FS-6/FS-8 from exposure to chromium, lead, and zinc in surface soil at concentrations exceeding STCLs and in the vicinity of sample locations SD-1 and SD-6 (AFCEE, 1997a).

The PRA completed at the AOC SD-2/FS-6/FS-8 identified potential risks to receptors for the following COCs: chromium, lead, and zinc. MMR-specific Soil Target Cleanup Levels (STCLs) used for the DSRP were retained and used to develop cleanup levels for identified contaminants of concern. In 2000, AFCEE with concurrence from USEPA and MADEP revised ecological risk based STCLs for inorganic chemicals in a Technical Memorandum (AFCEE, 2000).

In 2002, AFCEE revised phytotoxicity and invertebrate STCLs for several inorganics in an addendum to the Technical Memorandum (AFCEE, 2002). The revised STCLs led to the development of RALs, which also took into account terrestrial plant screening levels, terrestrial invertebrate screening levels, and MMR-specific background levels. COCs and respective cleanup levels are presented in **Table B-1.**

Table B-1 Contaminants of Concern and Respective Cleanup Levels for AOC SD-2/FS-6/FS-8 Source Areas

Contaminant	Basis	RAL Concentration (mg/kg)
Chromium	Background	19
Lead	Ecological Risk	99
Zinc	Ecological Risk	68

B.3 Remedy Description

The selected remedy documented in the ROD is Excavation/Asphalt Batching. This alternative provides institutional and engineering controls to limit exposure to site-related contaminants and to reduce source-area contaminant concentrations to protective levels. Confirmatory sampling after

excavation would be conducted to ensure that all soil with COC concentrations exceeding RALs were removed. Excavated soil that is found to contain contaminant concentrations in exceedance of TCLP allowable concentrations would be deemed hazardous and disposed of off-site in a RCRA Subtitle C TSDF. Soil that is found to contain contaminant concentrations below TCLP allowable concentrations (and that has contaminant concentrations below MADEP MCP Method 1 S-1/GW-1 standards for pesticides and Massachusetts Permitted Soil Recycling Facility Summary Levels) would be deemed nonhazardous and treated at the on-site cold mix emulsion asphalt-batching plant.

The selected remedy for AOC SD-2/FS-6/FS-8 was modified. Changes to the selected remedy included deletion of the on-site asphalt batching component of the remedy; establishment of RALs to replace cleanup levels presented in the ROD; and expansion of offsite disposal options to include RCRA Subtitle D facilities. These changes are documented in an ESD for the SARAP (AFCEE, 2003).

The modified remedy consisted of excavating contaminated surface soil at the AOC. Excavated soil would be transported to on-base central bulking facility for waste characterization. Excavated soil that is found to have contaminant concentrations in exceedance of TCLP allowable concentrations would be deemed hazardous and disposed of off-site in a RCRA Subtitle C TSDF. Soil that is found to have contaminant concentrations below TCLP allowable concentrations (and that have contain contaminant concentrations below MADEP MCP Method 1 S-1/GW-1 standards for pesticides and Massachusetts Permitted Soil Recycling Facility Summary Levels) would be deemed nonhazardous and transported off-site to a Subtitle D facility.

B.4 Remedy Implementation

Excavation and Disposal: AFCEE conducted removal activities in 2002 at AOC SD-2/FS-6/FS-8. Removal activities and results of confirmatory sampling will be documented in a Remedial Action Report which is anticipated in 2003. Approximately 350 cubic yards of contaminated soil was removed from the AOC. Confirmatory sampling results indicated that the contaminant concentrations in soil were below the RALs. Excavated soil was transported to a central bulking facility located on the MMR. Soil from AOC SD-2/FS-6/FS-8 was combined with soil from other sites. Composite sampling of the consolidated soil stockpiles determined that the consolidated soil was considered non-hazardous and suitable for reuse as daily cover at a Resource Conservation and Recovery Act (RCRA) Subtitle D Landfill. Soil from the AOC was disposed of at the North Carver Landfill in Massachusetts. Disposal activities were performed in compliance with the MADEP *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills Policy #COMM-97-001* (MADEP, 1997).

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted since the last review.

- Source Areas Remedial Design: Completed September 2000
- Removal Action: Completed August 2002.
- ESD: Completed January 2003 (AFCEE, 2003).

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the removal action. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA, 2001).

Question A: Is the remedy/removal action functioning as intended by the decision documents?

The review of documents, ARARs, risk assumptions, and the results of the site inspection indicate that the removal action has been completed as intended by the ROD and modified by the ESD. The excavation and offsite disposal of contaminated soil has achieved the RAOs of mitigating the migration of contaminants to groundwater and preventing direct contact with, or ingestion of contaminants in soil.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

The removal work has been completed, and ARARs and TBC guidance for soil contamination cited in the ROD have been met. There have been no changes in chemical-specific ARARs and TBC guidance. AFCEE recalculated risk-based STCLs for ecological receptors to reflect current toxicity information. RALs were derived from the comparison of the following: revised STCLs, MMR-specific background levels, phytotoxicity screening levels, and invertebrate screening levels. The new cleanup levels remain protective of human health and the environment. Cleanup levels identified in the ROD were derived from the comparison of cleanup levels used in the DSRP and background. These cleanup levels initially did not take into account invertebrate or phytotoxicity screening levels; however, they were taken into account in the ESD.

Table D-1 presents changes in cleanup levels at AOC SD-2/FS-6/FS-8.

Table D-1: Changes in Cleanup Levels at SD-2/FS-6/FS-8

Contaminant	Media	ROD RAL (mg/kg)	ESD RAL (mg/kg)
Chromium	Soil	6.8	19
Lead	Soil	15.8	99
Zinc	Soil	16	68

Changes in Exposure Pathways

There have been no changes in the physical conditions, exposure pathways, and land use of the site that would affect the protectiveness of the remedy/removal action.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for contaminants of concern that were used for the human health risk assessment. However, risk-based cleanup levels for ecological receptors were calculated using new toxicity information. Calculation of ecological risk-based STCLs using new toxicity information was completed in 2000 (AFCEE, 2000). These STCLs were used in the development of RALs for which cleanup was based.

Changes in Risk Assessment Methods:

There were no changes in risk assessment methodology.

Expected Progress Towards Meeting RAOs:

Implementation of the remedy is expected to achieve RAOs.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy/removal action?

There is no information that calls into question of the protectiveness of the selected remedy.

Technical Assessment Summary

The remedy was completed as intended by the ROD as modified by the ESD. There have been no changes in the physical conditions and land use of the site that would affect the protectiveness of the remedy. ARARs and TBC guidance for soil contamination cited in the ROD are being achieved. There is no information that calls into question of the protectiveness of the selected remedy.

Table D-2 presents the technical assessment summary for AOC SD-2/FS-6/FS-8.

Table D-2: Technical Assessment Summary for AOC SD-2/FS-6/FS-8

Question		Response
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the removal action?	No

E. ISSUES

The issue for SD-2/FS-5/FS-8 is that documentation for the remedial action (i.e., soil removal and off-site disposal) is not complete.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendation and follow-up action is to prepare and issue the final remedial action report with regulatory review and comment.

G. PROTECTIVENESS STATEMENT

The remedy for AOC SD-2/FS-6/FS-8 is protective of human health and the environment. Soil with concentrations of COCs above RALs has been removed.

H. REFERENCES

ABB-ES, 1996. *Final Remedial Investigation Report for the Runway/Aircraft Maintenance Storm Drainage Ditch No. 2 (AOC SD-2/FS-6/FS-8)*; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Portland, Maine; December 1996.

AFCEE, 2003. *Explanation of Significant Differences Areas of Contamination CS-10 (A, B & C); CS-16/CS-17; FS-9; SD-2/FS-6/FS-8; and SD-3/FTA-3/CY-4*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program, Otis ANGB Cape Cod, MA, January 2003.

AFCEE, 2002. *Addendum to Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program, Otis ANGB Cape Cod, MA; September, 2002.

AFCEE, 2000. *Final Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics;* prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; December, 2000.

AFCEE, 1998. *Record of Decision for Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and SD-5/FS-5 Source Areas*. Prepared by HLA for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; September 1998.

AFCEE, 1997b. *Proposed Plan to Cleanup Six Areas of Contamination*; Installation Restoration Program, Massachusetts Military Reservation, November 1997.

AFCEE, 1997a. *Final Six Areas of Contamination Source Area Feasibility Study*. Prepared by ABB-ES for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod, MA; November 1997.

E.C. Jordan Co., 1990. *Task 5 Mashpee Groundwater Study*; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Portland, Maine; August 1990.

E.C. Jordan Co., 1988. *Task 2-1 Field Investigations, Summer/Fall 1986; Base Landfill, Petroleum Fuels Storage Area, and Fire-Training Area*; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Portland, Maine; July 1988.

E.C. Jordan Co., 1986. *U.S. Air Force Installation Restoration Program, Phase I: Records Search, Air National Guard, Camp Edwards, Air Force, and Veterans Administration Facilities at MMR, Task 6*; prepared for Oak Ridge National Laboratory; Oak Ridge, Tennessee; December 1986.

MADEP, 1997. *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills Policy # COMM-97-001*, Massachusetts Department of Environmental Protection, 1997.

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June 2001.

9.3.22 FUEL SPILL NO.7 (FS-7) SOURCE

A. BACKGROUND

A.1 Site Description

Area of Contamination (AOC) FS-7 is approximately one acre, and is located in the vicinity of the former Building 1820 at the northwest rotary between West Outer Road and West Inner Road on the MMR (**Figure 11)**.

AOC FS-7 was evaluated as part of the Task 6 Records Search (E.C. Jordan Co., 1986). According to the records search, current product tank (CPT)-115, a 500-gallon UST installed in 1970 at the study area and used to store No. 2 fuel oil, may have leaked up to 11,000 gallons of fuel.

A.2 Initial Response

A non-CERCLA action was completed at AOC FS-7. According to records, an underground storage tank, current product tank (CPT)-115, was removed in June 1985. It is unclear whether soil around the tank was removed or placed back in the excavation after tank removal. In 1996, Building 1820 at the study area was demolished and the asphalt driveway that surrounded the building was removed.

A.3 Basis for Taking Action

Site Investigation (SI): A SI was completed in October 1993 to determine the nature and extent of contamination suspected at FS-7 (ABB-ES, 1993). The primary contaminant was No. 2 fuel oil that leaked from CPT 115, prior to its excavation in 1985. The exploration program was conducted in three phases. Exploration locations were selected based on the findings of the Preliminary Assessment and observations of study area conditions made during the SI. Phase 1 consisted of investigating the study area utilizing ground-penetrating radar, a magnetometer, and a metal detector. Also ten soil gas samples were taken and one monitoring well was installed. Phase 2 consisted of two surface soil samples and Phase 3 consisted of the installation of one monitoring well.

The following two paragraphs describe the analytes detected in soil and groundwater samples during Phases 1 through 3 of the SI at AOC FS-7, and focus on the detection of fuel-related compounds.

Soil. VOCs and volatile tentatively identified compounds (TICs) were not detected in surface soil collected from AOC FS-7. Petroleum hydrocarbons were detected in the two surface soil samples from the underground storage tank (UST) footprint. Also, barium, chromium, copper, lead, vanadium, aluminum, nickel, magnesium and zinc were detected above MMR-specific background levels in various surface soil samples at FS-7.

Groundwater. Benzene was detected at an estimated concentration in groundwater collected during Phase 1. However, benzene was not detected in a duplicate of this sample, nor in the subsequent Phase 2 sample round. Ethylbenzene was detected in groundwater collected during the Phase 1 and Phase 3 sampling rounds. In addition, xylenes were detected in groundwater during Phase 3. Naphthalene was detected during Phase 2 and 3. In addition, fuel-related VOC and SVOC TICs

were detected in the Phase 3 groundwater sample. Also, arsenic, iron, manganese, and sodium were consistently detected above the MMR background levels in groundwater samples.

Phases 1 Through 3 Risk Evaluation and Assessment Summary: To identify potential risks associated with exposures to study-area-related contaminants of potential concern, sitewide PRE and Preliminary Risk Assessment (PRA) calculations were completed for surface and subsurface soil for both human health and ecological exposure scenarios. Results of the Tier I assessment for the human-health PRE for future residential use showed HEC exceedances for selected SVOCs, arsenic, and beryllium in surface soil, and arsenic, benzene, iron, and manganese in groundwater. Tier II human-health HEC exceedances were not identified in soil or groundwater samples. Tiers I and II of the ecological PRE showed that maximum concentrations of several organic and inorganic chemicals exceeded the lowest HECs. Results of the ecological and human health risk assessments triggered the need for an alternative evaluation. Contaminants of concern (COCs) identified at AOC FS-7 included the following PAHs: benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3,-cd)pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene, benzo(a)ahthracene, chrysene, and phenanthrene.

Supplemental Site Investigation: (SSI) A SSI was completed by Aneptek Corporation in 1995. The SSI consisted of the completion of one test pit, the collection of six surface soil samples, and the completion of two soil borings. Each soil boring was completed as a monitoring well, and a round of groundwater samples was collected for off-site analysis. The data collected during the SSI was utilized to complete a second Preliminary Risk Evaluation (PRE) for the study area.

Data collection during the SSI showed the presence of polycyclic aromatic hydrocarbons (PAHs) in surface soil above Hazard Equivalent Concentrations (HECs) at two locations. Groundwater contamination documented during the initial SI and SSI was attributed to a fuel spill located upgradient of Study Area FS-7 (i.e., FS-13). Based on the SSI PRE, which showed exceedances of HECs by several PAHs, the SSI recommended that a soil remediation be conducted to remove the PAH contamination.

Engineering Evaluation/Cost Analysis (EE/CA): AOC FS-7 was one of the sites in the Priority 2 and 3 Study Areas and Drum Disposal Operable Unit (DDOU) EE/CA which was issued in October 1998 (AFCEE, 1998).

The following alternatives received detailed analysis in the EE/CA:

- Alternative 1: On-Base Thermal Desorption and Off-base Treatment and Disposal for AOC FS-7
- Alternative 2: On-Base Asphalt batching and Off-Base Treatment and Disposal for AOC FS-7
- Alternative 3: Off-base Treatment and /or Disposal for AOC FS-7.

B. REMEDIAL/REMOVAL ACTIONS:

This section presents the regulatory actions, removal action objectives (RAOs), a description of the selected removal action, and a summary of the removal action implementation at AOC FS-7.

B.1 Regulatory Actions

Described below are controlling documents that present the selected removal action and post-AM documents that identified changes to the selected removal action.

Action Memorandum (AM): The Priority 2 and 3 Study Areas and DDOU Source Removal AM (AFCEE, 1999) documented the decision to perform removal actions at several Priority 2 and 3 Study Areas including FS-7. Based on the evaluation of removal action alternatives presented in the EE/CA, the selected alternative was Alternative 2 which included excavating FS-7 soil and treating the excavated material on-base using an asphalt batching facility and/or off-base at an approved treatment and disposal facility.

Action Memorandum Addendum: Priority 2 and 3 Study Areas and DDOU Source Removal AM Addendum (AFCEE, 2003) was prepared to document changes to the selected removal action for several sites in the Source Area Remedial Action Program (SARAP) including FS-7. Three changes were made to the selected removal action presented in the Priority 2 and 3 Study Areas EE/CA: (1) establishment of removal action levels (RALs) for certain inorganic chemicals and PCBs; (2) removal of the asphalt-batching component from the selected removal action; and (3) the expansion of offsite disposal options to include RCRA Subtitle D facilities.

B.2 Removal Action Objectives (RAOs)

The RAOs are the site-specific qualitative goals that must be achieved to meet the remedial response objectives. The RALs are the site-specific quantitative cleanup levels that will meet these goals. Investigations conducted at AOC FS-7 demonstrate that surface soil contaminated with PAHs may pose unacceptable risk to humans and ecological receptors. At AOC FS-7 contaminant concentrations were compared to MMR-specific Soil Target Cleanup Levels (STCLs) to determine the need for removal actions. RAOs were developed based on these considerations and were established to achieve the overall objective of protecting human health and the environment. These objectives identify the responses that are necessary to adequately address human-health and ecological risks, as well at the potential groundwater impact posed by contaminated soil. STCLs used for the DSRP (AFCEE, 1996) were retained and used to develop cleanup levels for identified COCs.

B.3 Removal Action Description

The selected removal action consisted of excavating contaminated soil and treating it on-base using an asphalt batching facility and/or off-base at an approved treatment and disposal facility. Excavated soil found to have contaminant concentrations in exceedance of TCLP allowable concentrations would be deemed hazardous and disposed of off-site in a RCRA Subtitle C TSDF. Soil that has contaminant concentrations below TCLP allowable concentrations would be deemed nonhazardous (and that have contaminant concentrations below MADEP MCP Method 1 S-1/GW-1 standards for pesticides and Massachusetts Permitted Soil Recycling Facility Summary Levels) and treated at the on-site cold mix emulsion asphalt-batching plant. Post excavation confirmatory sampling would be conducted to ensure that all soil with COC concentrations exceeding FS-7 soil cleanup levels were removed.

The selected removal action for FS-7 was modified to include the deletion of the on-site asphalt batching component of the removal action. This change is documented in Priority 2 and 3 Study Areas and DDOU Source Removal AM Addendum (AFCEE, 2003) for the SARAP.

The modified removal action consisted of excavating contaminated surface soil at AOC FS-7. Excavated soil would be transported to an on-base central bulking facility for waste characterization. Excavated soil found to have contaminant concentrations in exceedance of TCLP allowable concentrations would be deemed hazardous and disposed of off-site in a RCRA Subtitle C TSDF. Soil that is determined to be below TCLP allowable concentrations would be deemed nonhazardous (and that have contaminant concentrations below MADEP MCP Method 1 S-1/GW-1 standards for pesticides and Massachusetts Permitted Soil Recycling Facility Summary Levels) and transported offsite to a Subtitle D facility.

B.4 Removal Action Implementation

AFCEE conducted removal activities in 2001 at FS-7. Removal activities and results of confirmatory sampling will be documented in the Priority 2 and 3 and DDOU Removal Action Report anticipated in 2003. Approximately 18 cubic yards of contaminated soil was excavated from AOC FS-7 and combined with soil excavated from other SARAP sites with similar disposal requirements. Composite sampling of the consolidated soil stockpiles determined that the consolidated soil was considered non-hazardous and suitable for reuse as daily cover at a RCRA Subtitle D Landfill. FS-7 soil was disposed of at the Taunton Landfill in Massachusetts, in compliance with the MADEP *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills Policy #COMM-97-001* (MADEP, 1997).

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted since the last review.

- Priority 2 and 3 Study Areas and DDOU AM: Completed in June 1999
- Removal Action: Completed in May 2001
- Priority 2 and 3 Study Areas and DDOU AM Addendum: Completed February 2003

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the implemented remedy/removal action. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA 2001).

Question A: Is the remedy functioning as intended by the decision documents?

The review of documents, ARARs, risk assumptions, and the results of the site inspection indicate that the removal action has been completed as intended by the AM as modified by the AM Addendum. The excavation and offsite disposal of contaminated soil has achieved the RAOs of mitigating the migration of contaminants to groundwater and preventing direct contact with, or ingestion of contaminants in soil.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

ARARs and TBC guidance for soil contamination cited in the AM and AM Addendum have been met. There have not been changes in chemical-specific ARARs and TBC guidance.

Changes in Exposure Pathways

There have been no changes in the physical conditions, exposure pathways, and land use of the site that would affect the protectiveness of the removal action.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for contaminants of concern that were used for the human health risk assessment. However, risk-based cleanup levels for ecological receptors were calculated using new toxicity information. Calculation of ecological risk-based STCLs using new toxicity information was completed in 2000 (AFCEE, 2000). These STCLs were used in the development of RALs (AFCEE, 2002). Cleanup was based on these RALs.

Changes in Risk Assessment Methods:

There were no changes in human health risk assessment methodology.

Expected Progress Towards Meeting RAOS:

Implementation of the selected removal action has achieved RAOs.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy?

There is no information that calls into question of the protectiveness of the selected removal action.

Technical Assessment Summary

The removal action was completed as intended by the AM as modified by the AM Addendum. There have been no changes in the physical conditions and land use of the site that would affect the protectiveness of the removal action. ARARs and TBC guidance for soil contamination cited in the AM and AM Addendum have been met. There is no information that calls into question of the protectiveness of the selected removal action.

Table D-1 presents the technical assessment summary for AOC FS-7.

Table D-1: Technical Assessment Summary for AOC FS-7		
Question		**Response**
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the removal action?	No

E. ISSUES

The issue for FS-7 is: documentation for the removal action (i.e., soil removal and off-site disposal) is not complete.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendation and follow-up action is to prepare and issue the final removal action report with regulatory review and comment.

G. PROTECTIVENESS STATEMENT

The removal action for the AOC FS-7 (source control including excavation and off-site disposal) is protective of human health and the environment. Soil containing COCs above RALs have been removed, and FS-7 has achieved unlimited use and unrestricted exposure.

H. REFERENCES

ABB-ES, 1993. *Priority 2 and 3 Study Areas Site Investigation*, Installation Restoration Program, Massachusetts Military Reservation, prepared for HAZWRAP; Portland, Maine; October 1993.

AFCEE, 2003. *Action Memorandum Addendum Priority 2 and 3 Study Areas and Drum Disposal Unit Source Removal*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program; February 2003.

AFCEE, 2002. *Addendum to Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program; September 2002.

AFCEE, 2000. *Final Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics.* Prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program; December 2000.

AFCEE, 1999. *Action Memorandum Priority 2 and 3 Study Areas and Drum Disposal Operable Unit Source Removal*. Prepared by Harding Lawson Associates (HLA) for AFCEE/MMR Installation Restoration Program; June 1999.

AFCEE, 1998. *Priority 2 and 3 Study Areas Drum Disposal Operable Unit Engineering Evaluation/Cost Analysis.* Prepared by HLA for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; October 1998.

AFCEE, 1996. *Soil Target Cleanup Levels, DSRP*. Prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; January 1996.

E.C. Jordan Co., 1986. *U.S. Air Force Installation Restoration Program Phase I: Records Search, Air National Guard, Camp Edwards, U.S. Air Force, and Veterans Administration Facilities at Massachusetts Military Reservation, Task 6*; Installation Restoration Program, Massachusetts Military Reservation; prepared for Oak Ridge National Laboratory; Oak Ridge, Tennessee; December 1986.

MADEP, 1997. *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills Policy # COMM-97-001*, Massachusetts Department of Environmental Protection, 1997.

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June 2001.

9.3.23 FUEL SPILL NO.10 (FS-10)/FUEL SPILL NO.11 (FS-11)/PETROLEUM FUEL STORAGE AREA (PFSA) SOURCE

A. BACKGROUND

A.1 Site Description

The PFSA, located on the north side of South Outer Road has been the main fuel delivery and distribution area for the flightline since the early 1950s. Area of Contamination (AOC) PFSA/FS-10/FS-11 occupies approximately 12 acres located down gradient of the PFSA (**Figure 11**).

The facility is an active fuel storage facility that has operated since the early 1950's. The facility consists of three aboveground storage tanks, aboveground fuel distribution lines, pumphouses, and truck fill stands. The tanks vary in capacity from 0.5 to 1.2 million gallons. Each aboveground tank is surrounded by a containment berm made of native sand coated with asphalt. The PFSA serves or has served as the primary storage and distribution center for JP-4 jet fuel, AVGAS, motor gasoline, and No. 2 fuel oil for Otis ANGB.

Two fuel spills occurred at AOC PFSA/FS-10/FS-11 in the 1960s. The FS-10 spill, which involved approximately 2,000 gallons of JP-4 jet fuel at the Building 170 pumphouse, likely discharged through floor drains nearby French drains. Another 2,000 gallon JP-4 jet fuel spill (FS-11) resulted from overfilling of aboveground Tank 21. The overflow likely seeped into the ground within the tank containment berm.

Other releases of fuel at the AOC included discharges of fuel to the pumphouse french drains during routine filter maintenance activities and discharge of fuel and fuel-contaminated water during routine discharge of water drained from the bottoms of Tanks 23 and 24. These tanks were equipped with floating lid that allowed some rainwater to enter the tanks.

A.2 Initial Response

MMR Fuel Systems Upgrade Program: In 1993, the fuel distribution lines at the PFSA were upgraded from below ground to an aboveground system. Approximately 11 cubic yards of fuel-contaminated soil was excavated from around the below ground fuel lines during construction activities. Buildings 170 and 173 were demolished. Building 174 and four associated 50,000 gallon underground storage tanks were removed from the PFSA in November 1994.

Immediate Response Action: In June 1996, a heavy rain combined with a pump failure at the PFSA caused 6,000 gallons of fuel-contaminated water to spill from a fuel pumphouse (Building 172). Of the 6,000 gallons, approximately 300 gallons was diesel and/or jet fuel. Because of high stormwater flows, some fuel discharged to SD-2 south of the PFSA. In response to the spill, 480 cy of fuel-contaminated soil was removed from the PFSA, and 120 cy of fuel-contaminated soil was excavated from the SD-2 drainage ditch as part of an Immediate Response Action performed under the MCP. A soil vapor extraction system was installed as part of the immediate Response Action to remove additional contamination associated with the spill.

A.3 Basis for Taking Action

FS-10/FS-11/PFSA site has been investigated several times beginning in 1985.

Field Investigations and Mashpee Groundwater Study: A phase II confirmation and quantification study was completed in 1985 that documented evidence of fuel related VOCs in a monitoring well installed downgradient of the PFSA. A field investigation conducted in 1986 found BTEX, related SVOCs, and elevated concentrations of inorganics in soil sampled collected within the bermed areas of the tanks. The Mashpee groundwater study in 1987-1988 documented soil contamination in a boring downgradient of the PFSA near the AOC SD-2 oil/water separator, and also detected fuel-related compounds in groundwater (AFCEE, 1997a).

Remedial Investigation (RI): The RI program was conducted in 1989 and 1990 to characterize the nature and distribution of sediment, deep soil, and groundwater contamination. This program included a ground penetrating radar survey, french drain/catch basin sediment sampling, installation of 13 soil borings completed as monitoring wells, and groundwater sampling. The downgradient groundwater flow pattern was also investigated. Contaminants similar to those found during earlier investigations were detected, and the capillary fringe of the water table was identified as a continuing source of contaminants to groundwater (AFCEE, 1997a).

Southeast Region Groundwater Operable Unit (SERGOU) RI: This supplemental RI was performed in 1994 to further characterize groundwater contamination and evaluate potential site risks. Using the screened hollow-stem-auger sampling technique, downgradient groundwater quality with depth was tested at additional locations, including several near the northwestern shore of Johns Pond. The SERGOU RI identified Johns Pond as the primary discharge point for contaminated groundwater migrating from AOC PFSA/FS-10/FS-11 (AFCEE, 1997a).

Risk Evaluation Summary: A human-health Preliminary Risk Assessment (PRA), based on samples collected during the SI and RI for samples from zero to 10 feet bgs, was performed to evaluate potential human-health risks associated with exposure to contaminated surface soil under current and future site conditions. A qualitative evaluation concluded that potential ecological receptors are unlikely to be exposed to fuel-contaminated soil at the AOC due to lack of suitable habitat. Therefore, because the exposure pathway is not complete, a quantitative ecological risk assessment was not conducted. Results of the PRA triggered the need for an evaluation of remedial alternatives (i.e. Feasibility Study). The contaminants of concern (COCs) identified at AOC PFSA/FS-10/FS-11 are ethylbenzene and total xylenes.

Feasibility Study: AOC PFSA/FS-10/FS-11 was part of the Six Areas of Contamination Source Area Feasibility Study which was completed in November 1997 (AFCEE, 1997a). The Feasibility Study assessed how well the following three alternatives would meet the evaluation criteria while controlling migration of contaminants from deep soil to groundwater at the AOC:

- Alternative 1: No action
- Alternative 2: Limited action
- Alternative 3: Biosparging with Off-gas Collection and Treatment

B. REMEDIAL/REMOVAL ACTIONS

This section presents the regulatory actions, removal action objectives (RAOs), a description of the selected remedy, and a summary of the remedy implementation at AOC PFSA/FS-10/FS-11.

B.1 Regulatory Actions

Described below are the controlling documents that present the selected remedy and post-record of decision (ROD) documents that identified changes to the selected remedy.

ROD: The *Record of Decision for Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and SD-5/FS-5 Source Areas* finalized in September 1998 (AFCEE, 1998) was prepared to document the decision to perform remedial actions a several AOCs including PFSA/FS-10/FS-11. The selected remedial alternative was Alternative 3, Biosparging with Off-gas Collection and Treatment. The *Proposed Plan to Cleanup Six Areas of Contamination* (AFCEE, 1997b) was issued in November 1997 for public comment. All comments received at the public hearing and during the public comment period are included in Appendix C of the ROD.

In summary, the remedy provides for:

- Performance of baseline ambient air monitoring
- Collecting confirmation soil samples to refine the horizontal and vertical delineation of the target contaminants ethylbenzene and total xylenes
- Designing and installing a full-scale biosparging treatment system with off-gas collection and treatment for areas with capillary-fringe contamination
- Designing and installing a bioventing system for areas with shallow vadose zone contamination
- Collecting ambient air samples to assess compliance with ARARs
- Maintaining institutional controls that restrict site access and limit potential human exposure to contaminants

B.2 Removal Action Objectives (RAOs)

The RAOs are site specific qualitative cleanup goals that must be achieved to meet remedial response objectives. The RALs are the site-specific quantitative cleanup levels that will meet these goals. Investigations conducted at the AOC PFSA/FS-10/FS-11 demonstrate that source area soil may be a source of release of ethylbenzene and total xylenes to groundwater. Such a release could result in an unacceptable risk to those who drink groundwater at or downgradient of the source area. Therefore the MMR-specific Soil Target Cleanup Levels (STCLs) established for the DSRP (AFCEE, 1996) were retained and used to develop cleanup level concentrations for identified COCs. COCs and respective cleanup levels are presented in **Table B-1**.

Specifically, the RAO established for AOC PFSA/FS-10/FS-11 is:

- Reduce ethylbenzene and total xylenes concentrations in soil to less than the leaching-based STCLs of 700 and 10,000 µg/kg, respectively, in order to prevent them from acting as a source of groundwater contamination at AOC PFSA/FS-10/FS-11. (AFCEE, 1997a)

Table B-1 Contaminants of Concern and Respective Cleanup Levels for AOC PFSA/FS-10/FS-11 Source Areas			
Contaminant	Basis	Concentration (μg/l)	Standard
Ethylbenzene	Leaching Potential	700	MCP S-1/GW-1
Total Xylenes	Leaching Potential	10,000	Inside Flightline, Human Health Only, MMR Specific

B.3 Remedy Description

The selected remedy documented in the ROD (AFCEE, 1998) consists of Biosparging with Off-gas Collection and Treatment. The remedy was selected to reduce levels of contaminants from subsurface soil to meet protective groundwater clean-up concentrations. The selected remedy consists of designing, constructing, and operating a biosparging treatment system, maintaining institutional controls, and conducting five-year reviews of remedy protectiveness.

B.4 Remedy Implementation

The biosparge/vapor recovery treatment system installation began on July 3, 2001 and includes: an air compressor; a regenerative blower; a moisture separator; a heat exchanger; carbon vessels; and a condensate holding tank. The system design combined 125 cfm of sparging capacity with 300 cfm of extraction capacity. The air sparge and extraction wells were separated into six zones. The system began operations on October 2, 2001, however one of the six zones still needs to be installed and started-up. As of October 2002, approximately 428 pounds of hydrocarbons have been removed

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted since the last review.

- Source Areas Remedial Design: Completed September 2000

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the remedy. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA, 2001).

Question A: Is the remedy/removal action functioning as intended by the decision documents?

The review of documents, ARARs, risk assumptions, and the results of the site inspection indicate that the remedy is functioning as intended by the ROD. As of December 2002, five of the six zones are operating. The sixth zone will be brought on-line once access to the land is obtained. The RAO of mitigating the migration of contaminants to groundwater is being achieved.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

There have been no changes in standards or TBC guidance

Changes in Exposure Pathways

There have been no changes in the physical conditions, exposure pathways, and land use of the site that would affect the protectiveness of the removal action.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for COCs.

Changes in Risk Assessment Methods:

There were no changes in risk assessment methodology.

Expected Progress Towards Meeting RAOs:

Implementation of the remedy is expected to achieve RAOs.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy/removal action?

There is no information that calls into question of the protectiveness of the selected remedy.

Technical Assessment Summary

Table D-1 presents the technical assessment summary for the AOC PFSA/FS-10/FS-11.

Table D-1: Technical Assessment Summary for the AOC PFSA/FS-10/FS-11

Question		Response
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the removal action?	No

E. ISSUES

The issues for FS-10/FS-11/PFSA are: system is not complete because one of the six zones has not been installed; and documentation for the interim remedial action is not complete.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendations and follow-up actions are:

1. install the sixth zone once access to the site is obtained;

2. prepare and issue the interim remedial action report with regulatory review and comment;
3. The biosparging system at AOC PFSA/FS-10/FS-11 should continue operation until the primary shutdown criteria is achieved. If the primary criteria can not be achieved, system shut down should occur only after the two secondary criteria are achieved.

- Primary shutdown criteria: comparison of soil sampling results with approved cleanup levels. If the results are below these cleanup levels, then the primary criteria for system shutdown has been achieved.
- Secondary shutdown criteria: if the in-situ respiration rate has leveled off and is asymptotically approaching a minimum concentration or is near background concentration, and if CO_2 production has reached non-detect or background levels, the system will be considered to have reached it's maximum treatment capacity. After the treatment system has reached its maximum treatment capacity, one of the two secondary criteria for system shutdown will have been achieved.
- Secondary shutdown criteria: if the removal rate of hydrocarbons, as measured at the treatment system, has leveled off to a minimum concentration or no significant change is observed over time, the second secondary criteria for system shutdown will have been achieved.

G. PROTECTIVENESS STATEMENT

The remedy for AOC PFSA/FS-10/FS-11 is expected to be protective of human health and the environment upon both its completion and in the interim. Exposure pathways that could result in unacceptable risks are being controlled.

H. REFERENCES

AFCEE, 1998. *Record of Decision for Areas of Contamination FTA-2/LF-2, PFSA/FS-10/FS-11, SD-2/FS-6/FS-8, SD-3/FTA-3/CY-4, and SD-5/FS-5 Source Areas*. Prepared by HLA for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; September 1998.

AFCEE, 1997b. *Proposed Plan to Cleanup Six Areas of Contamination*; AFCEE/MMR Installation Restoration Program, Massachusetts Military Reservation Otis ANGB, Cape Cod, MA; November 1997.

AFCEE, 1997a. *Final Six Areas of Contamination Source Area Feasibility Study*. Prepared by ABB-ES for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod, MA; November 1997.

AFCEE, 1996. *Soil Target Cleanup Levels, DSRP*. Prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program, Otis ANGB, Cape Cod MA; January 1996.

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June 2001.

9.3.24 FUEL SPILL NO.12 (FS-12) SOURCE

A. BACKGROUND

A.1 Site Description

Area of Contamination (AOC) FS-12 is the location of a leak in a now abandoned fuel pipeline along the base border in the Town of Sandwich. FS-12 is located west of Route 130 and north of Snake Pond in the Town of Sandwich. The abandoned fuel pipeline runs along the north shoulder of Greenway Road. The leak occurred near the intersection of Greenway Road and an unpaved road providing access to artillery range "L". The pipeline carried both jet fuel and aviation gasoline during its use from 1965 to 1973.

A.2 Initial Response

The damaged portion of the underground fuel pipeline was removed and replaced in 1972.

A.3 Basis for Taking Action

RI field investigation: The purpose of the RI field investigation (1992) was to locate the source of groundwater contamination, more completely define the vertical and horizontal extent of contamination, and obtain sufficient information to enable planning of remedial actions, if required. Additional data was required to supplement existing groundwater data, and to characterize soil and sediment from the unsaturated and saturated zones. Soil characterization included an investigation of the unsaturated zone near suspected source areas.

Monitoring wells were installed during January and February of 1993 to estimate the extent of floating/free product detected in monitoring wells during remedial investigation field activities conducted during December 1992 (ASI, 1995). The areal extent of floating/free product was initially defined as approximately 7.8 acres. However, based on additional characterization information collected during performance of pilot studies in 1993, the FS-12 source area was subsequently redefined to be approximately 11 acres of contaminated vadose zone soil, groundwater, and floating product. Based on information collected during the pilot studies and other data available from previous RI activities, the vertical extent of subsurface soil petroleum contamination was estimated to be a 10 ft to 20 ft layer above the water table.

Remedial Investigation (RI)/Feasibility Study: The purpose of the RI was to: (1) attempt to locate the source of the groundwater contamination, (2) define the lateral and vertical extent of fuel and EDB contamination, and (3) obtain sufficient chemical and physical information on which to support future remedial activities. The field program was divided into two operable units (OUs): soil (unsaturated zone soil) and groundwater.

Investigations of the soil OU consisted of three activities. Activity 1 involved geophysical surveys of four areas on Camp Good News where obvious human disturbances had occurred. Activity 2 consisted of a series of shallow soil probes along the entire upgradient potion of the fuel pipeline. At locations determined by Activity 2, Activity 3 consisted of the collection of soil samples from the vadose zone to confirm the presence of hydrocarbon contamination in this area. The ultimate goal of these efforts was to establish a presumed source area and, if possible identify the exact source.

Risk Evaluation Summary: The RI report for AOC FS-12 included a human-health Preliminary Risk Assessment (PRA) to evaluate potential human-health risks associated with exposure to contaminated surface soil and sediments under current and future site conditions. Ecological exposures to COCs and resultant risk were also evaluated. It was determined that no complete pathway exists for ecological exposure. The contaminants of concern (COCs) identified at AOC FS-12 are ethylene dibromide (EDB) and benzene.

B. REMEDIAL/REMOVAL ACTIONS

This section presents regulatory actions, a description of the selected remedy, and a summary of the remedy implementation at AOC FS-12.

B.1 Regulatory Actions

Action Memorandum: In November 1996, the *Final Action Memorandum AOC FS-12 Source Removal* was finalized. The Action Memorandum documents the decision by AFCEE to conduct a time critical removal action at AOC FS-12. This Action Memorandum provides a written record of the decision process for removal of jet fuel that has been identified beneath a former fuel pipeline at the AOC and explains the rationale for this removal action (ASI, 1996).

The selected removal action utilized an air sparging/soil vapor extraction (AS/SVE) system to achieve in situ air stripping and biodegradation of petroleum-derived hydrocarbons from subsurface soil in the FS-12 AOC.

B.2 Removal Action Objectives (RAOs)

The RAOs are site specific qualitative cleanup goals that must be achieved to meet remedial response objectives. Based on calculations from the risk assessment, the risk values calculated for current/future exposure to groundwater indicate carcinogenic risk for human exposure to groundwater, it was concluded that subsurface soil required immediate attention for cleanup. For subsurface soil, the RAOs include:

- Prevent direct contact or ingestion of the soil and
- Prevent migration of benzene and EDB with concentrations that would contribute to groundwater concentrations greater than federal/state maximum contaminant levels.

B.3 Removal Action Description

The removal action utilized an AS/SVE system to achieve in situ air stripping and biodegradation of petroleum-derived hydrocarbons from subsurface soil at the FS-12 source area. Compressed air was supplied through 23 air sparging wells, and withdrawn from the contaminated soil region by 23 SVE wells. Oxygen in the air activated microbial communities in the soil, which, in turn, enhanced the contaminant biodegradation process. The relative level of biodegradation was qualitatively determined by increased carbon dioxide levels detected in the SVE wells during operation of the system. The wells were positioned to maintain a net negative pressure over this area of influence during operation of the AS/SVE system. This net negative pressure eliminated the potential for off-site migration of vapors generated as a result of the AS/SVE system.

B.4 Remedy Implementation

The AS/SVE system commenced operation on October 23, 1995 and was shut down on February 25, 1998. Petroleum-derived contaminants in the soil vapor drawn from the venting wells include benzene, toluene, ethylbenzene, xylene (BTEX), and EDB. Vapor phase BTEX contaminants were destroyed thermally by passing the soil vapor through a catalytic oxidation unit. Since EDB is not readily removed by thermal oxidization, and to prevent the airborne release of EDB, gases from the catalytic oxidation unit were then passes through a carbon adsorption unit (AFCEE, 2000).

Table B-1 summarizes the system closure criteria specified in the Final Action Memorandum compared to the actual system performance achieved during the operational phase of the project (AFCEE, 2000).

Table B-1: Action Memorandum System Closure Criteria

Closure criteria specified in Appendix B of the Final Action Memorandum	Actual System Performance
VOC removal rate per SVE well less than 0.5 pounds per day over 3 consecutive sampling periods.	Criteria satisfied for all SVE wells except SV-8 and SV-14. Average VOC removal rate for all SVE wells was 0.08 pounds per day, much less than the 0.5 pound per day criteria.
Contaminant concentrations in vadose zone soil less than MADEP Method 1 S-3/GW-1 and Method 1 S-3/GW-3 standards specified in 310 CMR 40.0933.	All samples collected above the water table were below applicable MADEP cleanup standards. Two of the 20 samples collected below the water table contained VPH and EPH contaminants above the applicable MADEP cleanup standards; however, the average exposure concentration of the contaminants were below applicable MADEP cleanup standards. Based on these results, the removal action goals for soil have been met.
Contaminant concentrations in groundwater less than MADEP Method 1 GW-1 and Method 1 GW-3 standards specified in 310 CMR 40.0932.	19 source area wells sampled as part of closure requirements. Analytical results indicate samples collected from wells were below Method 1 GW-1 and Method 1 GW-3 standards, except for samples collected from SV-14 and SV-13, SV-24, OW-2, WT-18, and GMW-100.

In a March 1, 1999 letter from USEPA to AFCEE, regarding FS-12 source area closure the USEPA and MADEP agreed that elevated levels in the zone of saturation would not be effectively addressed by continued operation of the AS/SVE system. As a condition to shutdown of the AS/SVE removal system at the FS-12 source area, AFCEE agreed to monitor ten selected groundwater-monitoring wells on a semi-annual basis. During initial sampling of these ten wells, three of the wells were unable to be sampled; therefore, a decision was made, with concurrence from the regulators, to eliminate these wells from the FS-12 performance monitoring evaluation (PME) program and to add well SV-6. These eight wells were added to the FS-12 PME program commencing with the April/May 1999 sampling round, and the results are included in the applicable quarterly reports submitted to USEPA and MADEP (AFCEE, 2000).

Based on results of groundwater and soil closure sampling, as well as the decreased mass removal rates determined in each SVE well towards the end of the operational phase of the AS/SVE system, the scope of work as specified in the Action Memorandum has been completed to the extent

practicable with the condition that post-closure groundwater sampling be conducted as part of the FS-12 PME (AFCEE, 2000).

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following documents present activities that have been conducted since the last review.

- Final FS-12 Source Area Removal Action Summary Report: Completed in March 2000
- Final FS-12 2000 Annual System Performance and Ecological Impact Monitoring Report
- Draft FS-12 2001 Annual System Performance and Ecological Impact Monitoring Report

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the remedy. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA, 2001).

Question A: Is the remedy/removal action functioning as intended by the decision documents?

The review of documents, site inspections and annual system performance and ecological impact monitoring reports demonstrate that the remedy functioned as intended by the Action Memorandum.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

There have been no changes in standards and to-be considered guidance documents.

Changes in Exposure Pathways

There have been no changes in the physical conditions, exposure pathways, and land use of the site that would affect the protectiveness of the remedy.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for contaminants of concern that were used for the human health risk assessment.

Changes in Risk Assessment Methods:

There were no changes in human health risk assessment methodology.

Expected Progress Towards Meeting RAOs:

Implementation of the selected remedy has achieved RAOs.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy?

There is no information that calls into question of the protectiveness of the selected remedy.

Technical Assessment Summary

Table D-1 presents the technical assessment summary for the AOC FS-12.

Table D-1: Technical Assessment Summary for the AOC FS-12		
Question		**Response**
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the removal action?	No

E. ISSUES

No issues have been identified.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Continue to monitor the eight wells that were added to the FS-12 PME program and include the results in the applicable reports submitted to USEPA and MADEP. AOC FS-12 shall be reviewed again in five years.

G. PROTECTIVENESS STATEMENT

The remedy for AOC FS-12 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled.

H. REFERENCES

Advanced Sciences, Inc. (ASI), 1994. *Final Design Package for the FS-12 Product Recovery System*; Volume III, Report of Air Sparging, Soil Vapor Extractions, and Product Recovery Pilot Studies Conducted at the FS-12 Source Area August 23, 1993; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Oak Ridge, Tennessee; July 1994.

AFCEE, 2000. *FS-12 Source Area Removal Action Summary Report*; Installation Restoration Program; Massachusetts Military Reservation; prepared by Jacobs Engineering Group Inc.; March 2000.

ASI, 1996. *Final Action Memorandum, AOC FS-12 Source Removal*; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Oak Ridge, Tennessee; November, 1996.

ASI, 1995. *Remedial Investigation Report, FS-12 Study Area, Final*; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Oak Ridge, Tennessee; January 1995.

USEPA, 2001. C*omprehensive Five-Year Review Guidance*, EPA 540R-01-007, June 2001.

9.3.25 FUEL SPILL NO.12 (FS-12) GROUND WATER

A. BACKGROUND

A.1 Site Description

The FS-12 groundwater plume consists of fuel-related contaminants and is a result of a leak of nearly 70,000 gallons of aviation fuel from an abandoned fuel pipeline along Greenway Road on base near the town of Sandwich. The FS-12 groundwater plume migrated downgradient off base and under private property.

A.2 Initial Responses

AFCEE has addressed source contamination by implementing an AS/SVE system. The AS/SVE system, which operated between October 1995 and February 1998, had removed over 44,580 pounds of fuel constituents. The source removal was conducted in accordance with the CERCLA time-critical removal action process. A source area removal action summary report has been prepared and approved by the regulatory agencies (AFCEE 2000a). Refer to Section 9.3.24 for the five-year review for the FS-12 Source Area.

A.3 Basis for Taking Action

Groundwater contamination associated with FS-12 was first discovered in 1990 when the Sandwich Water District detected hydrocarbon odors in two exploratory wells installed off-base as part of an effort to identify suitable locations for additional water supply production wells.
The RI completed in 1993 concluded that fuel leaking from the pipeline contaminated soil and groundwater (HAZWRAP, 1995). Free product was found in the vadose zone over a five-acre area at and south of Greenway Road. The FS-12 source area was subsequently identified as an 11-acre area of contaminated vadose zone soil, groundwater, and floating product. COCs identified in the FS-12 plume included benzene and EDB.

B. REMEDIAL/REMOVAL ACTIONS

This section presents the regulatory actions, RAOs, remedy description, and a summary of the remedy implementation at FS-12.

B.1 Regulatory Actions

The *Record of Decision for Interim Action Containment of Seven Groundwater Plumes*, known as the Interim Record of Decision (IROD) (Stone& Webster, 1995), presents the interim remedial action to address contaminated groundwater plumes at MMR. It states that extraction and treatment will continue until the final remedy for the site is chosen. The interim and final remedies must be consistent with the cleanup goals for the entire MMR site.

In summary, the interim remedy for FS-12 provides for:

- extracting contaminated groundwater at the leading edge of the contaminant plume and potentially extracting groundwater from hot spot areas identified during remedial design;

- pumping and conveying the extracted groundwater to a treatment system to remove contaminants;
- discharging the treated water back to the groundwater and/or other beneficial use;
- installing monitoring wells, measuring water levels, and sampling groundwater to monitor the performance of the extraction system;
- sampling the influent and effluent of the treatment system to monitor its performance;
- restricting groundwater use within the areas contained by the ETR through imposition of institutional controls;
- and conducting a review after five years of operation to ensure the remedy provides adequate protection of human health and environment.

B.2 Remedial Action Objectives

The RAOs are the site-specific qualitative goals. The objectives in the IROD are described as follows:

- reduce the risks to human health associated with the potential future consumption and direct contact with groundwater and surface waters;
- protect uncontaminated groundwater and surface waters for future use by minimizing the migration of contaminants;
- reduce potential ecological risks to surface waters and through the implementation of the containment system; and,
- restore the aquifer to its beneficial uses with a 20 year timeframe.

The long-term cleanup goals for reducing contamination in the groundwater at MMR are to meet Federal Maximum Contaminant Levels (MCLs), non-zero Federal MCL Goals (MCLGs), Massachusetts MCLs, or risk-based guidance levels for compounds for which drinking water standards have not been set. Please note that the FS-12 Plume is one of the seven groundwater plumes included in the Interim Record of Decision (IROD) (ANG, 1995), and is currently undergoing the IROD to Final ROD process. As part of the IROD to ROD process, COCs will be identified for the final ROD. **Table B-1** presents COCs and their respective cleanup levels.

Table B-1 Interim Action Contaminants of Concern and Respective Cleanup Levels for FS-12 Plume

Contaminant	Basis	Conc (µg/l)	Standard
EDB	Human Health	0.02	MMCL
Benzene	Human Health	5	Federal MCL

B.3 Remedy Description

The FS-12 ETR system design initially consisted of a network of 30 extraction wells (EWs) pumping at a design rate of 830 gallons per minute (gpm) and 30 reinjection wells (RWs) . The computer modeling that provided the basis for that network was described in the *Plume Containment Design I Modeling Report* (OpTech, 1996).

The major components of the ETR system at FS-12 include:

- extraction of contaminated groundwater and transfer of the groundwater from the EWs through double-walled high-density polyethylene pipe to an influent (equalization) tank;
- pH adjustment of influent;
- greensand filters to remove suspended solids, iron, and manganese;
- solids settling and collection facilities;
- ultraviolet/oxidation (UV/OX) system to oxidize organics (i.e., EDB and benzene)
- granular-activated carbon (GAC) system to reduce the organic contaminant concentrations to below detection limits;
- return of the treated water to the aquifer through RWs situated between the axial EWs and Snake Pond and downgradient of the southern toe extraction fence

B.4 Remedy Implementation

Described below is a summary of the remedy, which includes system startup and modifications as a result of the analysis of monitoring data and groundwater modeling. Only major modifications are described below. Modification of extraction and reinjection flow rates is an ongoing optimization process based on results of remedial system performance monitoring conducted by AFCEE on an annual basis.

System Startup: Startup began in September 1997. The FS-12 ETR system then pumped 772 gpm from the aquifer using 25 EWs and returned the treated water to the aquifer via 23 RWs.

System Modification: In November 1997, the UV/OX system taken off-line because concentrations of contaminants were not high enough to warrant its use.

Ecological Monitoring: Based on the FS-12 ecological impact monitoring results showing negligible impact, ecological monitoring is no longer required. Approval granted by regulatory agencies in December 1999.

Additional EDB Contamination: AFCEE began modification of the existing system to address EDB zones west of the main FS-12 plume in December 2000. An existing RW was converted into an EW in June 2001. The current system now uses 19 EW and 16 RW. The total flow rate is 688 gpm (AFCEE,2002c).

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted/observed since the last review.

- Phase II Technical Memorandum: This document was completed in May 2000. The purpose of the document was to evaluate if additional extraction wells were needed. Results of the risk evaluation concluded that EDB residuals present no unacceptable risk to human health, and therefore no additional wells were needed for the extraction fence (AFCEE, 2000b).

- System Modification: The system was modified December 2000 to address EDB contamination west of main plume. An RW was converted to an EW in June 2001. The highest EDB concentration in this area (2.2 µg/L) has decreased to 0.045 µg/L (AFCEE, 2002b). The system now uses 19 EW and 16 RW. The total flow rate is 688 gpm (AFCEE 2002c).
- System Performance: Plume size has decreased considerably as depicted by **Figure 9.3.25-1** and **Figure 9.3.25-2**. No COCs were detected above MMCLs downgradient of the southern toe of the extraction fence since 1999.

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the remedy. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA 2001). **Table D-1** summarizes the technical assessment.

Question A: Is the remedy functioning as intended by the decision documents?

Yes. The remedy is functioning as intended by the IROD. The FS-12 ETR system has performed a system lifetime mass removal of approximately 131 pounds of EDB and 270 pounds of benzene (from September 1997 through December 2001). It is estimated that 97% of both benzene and EDB has been removed (AFCEE, 2002c). Temporal changes of EDB and benzene are depicted in **Figure 9.3.25-1** and **9.3.25-2**.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

There have been no changes in standards or TBC guidance.

Changes in Exposure Pathways

There have been no changes to exposure pathways and land use of the site that would affect the protectiveness of the remedy. Additional EDB contamination west of the main FS-12 plume was detected in March 2000. AFCEE has modified the existing FS-12 system to address the EDB contamination. The highest EDB concentration in this area (2.2 µg/l) has decreased to 0.045 µg/l (AFCEE, 2002b). Exposure pathways have been reduced by the implementation of institutional controls including connecting potentially impacted homes to Sandwich Water District water and providing periodic testing of downgradient, potentially-impacted, residential wells.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for COCs.

Changes in Risk Assessment Methods:

There were no changes in risk assessment methodology.

Expected Progress Towards Meeting RAOS:

The system is removing EDB and benzene contamination. The long-term decrease in EDB and benzene mass is largely due to extraction by the axial fence. Since treatment system startup, EDB concentrations in the core have been reduced from more than 500 µg/L to a concentrations less than 20 µg/L based on May 2002 sampling results (AFCEE, 2002b). Benzene concentrations in the core have been reduced from more than 2,000 µg/L to a concentrations less than of 25 µg/L based on May 2002 sampling results(AFCEE, 2002b). The FS-12 ETR system has performed a system lifetime mass removal of approximately 131 pounds of EDB and 270 pounds of benzene (from September 1997 through August 2002). It is estimated that 97% of both benzene and EDB has been removed (AFCEE, 2002c).

Question C: Has any other information come into light that could call into question the protectiveness of the remedy?

There is no information that calls into question the protectiveness of the remedy.

Table D-1: Technical Assessment Summary for the CS-12 Plume

Question Item	Question	Response
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the remedy?	No

E. ISSUES

The issue for FS-12 groundwater is a final remedy is required.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendations and follow-up actions are: a final remedy should be selected and documented in a final ROD. This process is underway with the issuance of the IROD to ROD workplan of which the FS-12 plume is a part. In addition, FS-12 groundwater treatment system operations including monitoring should continue until RAOs have been achieved.

G. PROTECTIVENESS STATEMENT

The remedy selected for the FS-12 plume is expected to be protective of human health and the environment upon completion, and in the interim; exposure pathways that could result in unacceptable risks are being controlled.

H. REFERENCES

AFCEE, 2002c. Plume Cleanup Team Update. FS-12 Overview & Update. Oct 9, 2002.

AFCEE, 2002b. *Fuel Spill-12 2002 Semiannual System Performance and Ecological Impact Monitoring Report*. Prepared by Jacobs Engineering for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. August, 2002

AFCEE, 2002a. *Draft Fuel Spill-12 Treatment System 2001 Annual System Performance and Ecological Impact Monitoring Report*. Prepared by Jacobs Engineering for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. June, 2002

AFCEE, 2001 *Final Fuel Spill –12 Interim Remedial Action Report.* Prepared by the AFCEE at the Installation Restoration Program, Otis ANG Base, MA. April, 2001

AFCEE, 2000b *Final Fuel Spill-12 Phase II Technical Memorandum*. Prepared by Jacobs Engineering for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. May, 2000

AFCEE, 2000a *Final Installation Restoration Program FS-12 Source Area Removal Action Summary Report, Massachusetts Military Reservation, Cape Cod, Massachusetts.* Prepared by Advanced Infrastructure Management Technologies (AIMTECH) for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA., March, 2000

HAZWRAP, 1995 *Remedial Investigation Report. FS-12 Study Area.* Three Volumes. Prepared by Hazardous Waste Remedial Action Program for ANG Readiness Center, Installation Restoration Program, Otis ANG Base, MA. January,1995

OpTech.1996 *Installation Restoration Program, Plume Containment Design Groundwater Modeling Report, Massachusetts Military Reservation*. August, 1996

Stone & Webster Environmental Technology & Services, 1995 *Final Record of Decision for Interim Action Containment of Seven Groundwater Plumes at MMR, Cape Cod, MA.* Prepared by Stone & Webster Environmental Technology & Services for ANG Readiness Center, Installation Restoration Program, Otis ANG Base, MA., September, 1995

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June, 2001.

9.3.26 FUEL SPILL NO.13 (FS-13) GROUND WATER

A. BACKGROUND

A.1 Site Description

The FS-13 plume consists of fuel-related contaminants and lies within the footprint of the CS-10 plume. The source of this contamination is a fuel spill suspected to have occurred in 1972. The spill site is near the rotary at the east end of Connery Avenue. The COCs for the FS-13 plume are 1,2,4-trimethybenzene and 1,3,5-trimethylbenzene (AFCEE, 1999b). In 1997, a drill and sampling program was conducted to better define the plume. The investigation showed that the groundwater contamination from FS-13 has not spread significantly beyond the FS-13 source area. The plume does not discharge to surface water and has not migrated offpost.

A.2 Initial Responses

None

A.3 Basis for Taking Action

The FS-13 plume is a component of the SWOU, which also includes the CS-4 plume, CS-20 plume, FS-21 plume, FS-28 plume, and FS-29 plume. Based on site characterization activities conducted for the SWOU RI (AFCEE, 1999a), 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene have been identified as primary contaminants.

B. REMEDIAL ACTIONS

This section presents the regulatory actions, RAOs, and remedy description for the FS-13 Plume.

B.1 Regulatory Actions

The Final Record of Decision for the CS-4, CS-20, CS-21, and FS-13 Plumes (AFCEE, 2000a) is the controlling document for the FS-13 Plume. The selected remedy for the FS-13 Plume is Limited Action and Institutional Controls. The remedy (Alternative Two) was selected from the analysis of alternatives presented in the SWOU Feasibility Study (AFCEE, 1999b). The Proposed Plan presenting the preferred alternative was released to the public for comment in June 1999 (AFCEE, 1999c).

B.2 Remedial Action Objectives

Remedial Action Objectives to protect human health as presented in the ROD (AFCEE, 2000) are:

- Reduce COCs to cleanup levels as presented in **Table B-1**.

Table B -1 Contaminants of Concern and Respective Remedial Action Levels for FS-13 Plume

Contaminant	Basis	Conc (µg/l)	Standard
1,2,4-trimethylbenzene	Calculated HI=1	17	None
1,3,5-trimethylbenzene	Calculated HI=1	17	None

- Restore aquifer (within confines of the FS-13 plume) to its beneficial uses with a reasonable timeframe.

B.3 Remedy Description

This alternative has three components:

- Long-term monitoring of the plume for VOCs and EDB.
- Institutional controls within MMR boundaries prevent the use of contaminated groundwater because installation of any water supply would have to be approved by the base civil engineer.

B.4 Remedy Implementation

AFCEE is conducting annual monitoring for the FS-13 Plume which includes sampling six monitoring wells(AFCEE, 2002b). Institutional and engineering controls to mitigate exposure to humans from contaminated groundwater are currently in place.

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted/observed since the last review.

- Final RI completed in May 1999 (AFCEE, 1999a)
- Final FS completed in June 1999 (AFCEE, 1999b)
- Final ROD completed in February 2000 (AFCEE, 2000)
- Long-Term Monitoring Data Transmittal (Annual Report), November 2001 (AFCEE, 2002a)
- Comprehensive Long-Term Monitoring Plan, Version 3.0 April 2002 (AFCEE, 2002b)

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the remedy. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA 2001). **Table D-1** summarizes the technical assessment.

Question A: Is the remedy functioning as intended by the decision documents?

Yes, institutional controls are in place to mitigate exposure pathways to humans, and long-term monitoring of groundwater is being conducted. However, results of samples collected from five of six monitoring wells as part of the Long-Term Monitoring Data Submittal for 2001 (AFCEE, 2002a) have detections of COCs above cleanup levels. In addition, concentrations of COCs from the recent monitoring effort were higher than in the RI (AFCEE, 1999a). At this time, whether or not the remedy is functioning cannot be determined. A determination can be made when more data is available for a proper evaluation.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

There have been no changes in standards or TBC guidance.

Changes in Exposure Pathways

There have been no changes to exposure pathways and land use of the site that would affect the protectiveness of the remedy.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for COCs.

Changes in Risk Assessment Methods:

There were no changes in risk assessment methodology.

Expected Progress Towards Meeting RAOS:

The results of the most recent sampling rounds (AFCEE, 2002a) had maximum detections of COCs higher than the detections in the RI (AFCEE, 1999a). However, data from the same monitoring wells over a period of time is required to make a determination if there is progress of achieving RAOs.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy?

No, data from the same monitoring wells over a period of time is required to make a determination if the remedy is protective.

Table D-1: Technical Assessment Summary for the FS-13 Plume

Question Item	Question	Response
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the remedy?	No

E. ISSUES

The issue for FS-13 groundwater is: monitoring needs to continue until cleanup levels are met.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendation and follow-up action is: continue monitoring until cleanup levels are met, or to determine if additional remedial alternative evaluation is required.

G. PROTECTIVENESS STATEMENT

Based on the presence of on-base institutional controls, the remedy for FS-13 is protective in the short-term and will be protective once cleanup levels are met. AFCEE is currently monitoring six wells (AFCEE, 2002b). AFCEE has determined that there is not an immediate danger, which would require time-critical response for the FS-13 plume.

H. REFERENCES

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AFCEE, 2002c. *Final Southwest Operable Unit Proposed Plan for the Southwest Operable Unit* Prepared by Jacobs Engineering for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. June, 1999

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AFCEE, 2002a. *Final Southwest Operable Unit Remedial Investigation for the Southwest Operable Unit* Prepared by Jacobs Engineering for AFCEE/MMR, Installation Restoration Program, Otis ANG Base, MA. May, 1999

USEPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA 540R-01-007, June, 2001.

9.3.27 FUEL SPILL 18 (FS-18)

A. BACKGROUND

A.1 Site Description

Area of Contamination (AOC) FS-18, a World War II motor pool and fuel transfer site, is approximately one acre and located at the intersection of Gaffney Street and North Gaffney Street in the Cantonment Area on the MMR (**Figure 11)**.

AOC FS-18 was evaluated as part of the Task 6 Records Search (E.C. Jordan Co., 1986). According to the records search, four 5,000-gallon USTs were installed at the study area in 1941. Two tanks, Current Product Tank (CPT)-102 and CPT-103, associated with a fuel-pump island adjacent to Building 3591 were found to contain diesel fuel. Similarly, there were two USTs, CPT-100 and CPT-101, associated with a fuel-pump island at Building 3594, that were reported to contain motor vehicle gasoline. Three motor vehicle maintenance buildings, Buildings 3592, 3593, and 3595, were also part of AOC FS-18 motor pool.

A.2 Initial Response

A non-CERCLA action was completed at the FS-18. CPTs-100 and 101 were reportedly emptied and removed in June 1985. Demolition of the motor pool buildings occurred in late 1990. CPT-102 and CPT-103 were removed in August 1994. During the DSRP, two additional leaching wells located north of Building 3594 and former Building 3591 were identified. Four vehicle maintenance pits were also identified. A total of nine drainage structures and approximately 430 cy of surrounding soil were removed as part of the DSRP at AOC FS-18 in 1996. The excavated soil was treated in an on-site asphalt batching facility (AFCEE, 1998).

A.3 Basis for Taking Action

Site Investigation (SI): A SI was completed in October 1993 to determine the nature and extent of contamination at FS-18 (ABB-ES, 1993). Three monitoring wells were installed during Phase 1 of the field investigation with an additional well installed during Phase 2. Also, as part of the Phase 1 field investigation, 45 soil gas samples were collected and screened for targeted VOCs using a GC. In addition, six soil samples collected during Phase 2 were screened for target VOCs.

During Phase 1 and Phase 2, six surface soil samples and three subsurface soil samples were collected and submitted for off-site laboratory chemical analysis. During Phase 3, three subsurface samples were recollected and analyzed because hold times were exceeded during previous sampling. In all, three rounds of groundwater samples were completed.

SI soil investigation and sampling at FS-18 focused on three areas: the drainage course south of the study area and east of South Gaffney Street, the topographic depression west of the study area, and the area around the two former fuel islands and leaching wells.

The off-site laboratory did not detect VOCs in soil samples collected from the drainage course south of the study area. PAHs were not detected in subsurface samples analyzed; however petroleum hydrocarbons were detected at a test pit at 5,550 mg/kg at four feet bgs and 20 mg/kg at six feet bgs. Lead also was reported at 86.8 mg/kg at 4 feet bgs at the same location.

In the topographic depression on the western side of the study area, PAHs were detected in samples collected from several sediment locations. The maximum total PAH concentration observed was 2 mg/kg. Many PAH detections in surface soil samples were below their respective SQLs. Petroleum hydrocarbons also were found in detectable concentrations up to 226 mg/kg in the surface soil samples from this area. 4,4'-DDT was reported at concentrations less than 0.4 mg/kg.

In the area around the former leaching wells and fuel islands, petroleum hydrocarbons were detected in all but one soil sample, ranging in concentration from 147 to 4,060 mg/kg. VOCs and SVOCs were not reported in this area; however, some inorganics were detected at concentrations in excess of MMR background concentrations.

Based on results of chemical analysis, sediment in the depression west of the study area has been affected by the use of leaded fuel-related products. Concentrations of PAHs and petroleum hydrocarbons in this depression and in the drainage course on the eastern side of South Gaffney Road indicate releases and contaminant transport from the study area (AFCEE, 1998).

Supplemental Site Investigation (SSI): A SSI was completed in 1995. As part of the SSI, an additional monitoring well was installed. A groundwater sample was collected from the new monitoring well and an existing well. Three VOCs and one SVOC were detected in the new monitoring well; however, each concentration was below the most conservative or Tier I human-health hazard equivalent concentrations (HECs). Several inorganic compounds also were detected, but they were below MMR background concentrations. Also, the groundwater sample from the existing well was only analyzed for EDB and none was detected (ABB-ES, 1995).

Risk Evaluation Summary: To identify potential risks associated with exposures to study-area-related contaminants of potential concern, site-wide Preliminary Risk Evaluation (PRE) was completed for surface and subsurface soil for both human health and ecological exposure scenarios. The PRE was not intended to quantify study-area-specific risks, but rather to indicate if risks above regulatory guidance levels are possible. The PRE was completed in 1995. Results of the PRE triggered the need for an alternative evaluation. Contaminants of concern (COCs) identified at AOC FS-18 included Total Petroleum Hydrocarbons.

Engineering Evaluation/Cost Analysis (EE/CA): AOC FS-18 was one of the sites in the Priority 2 and 3 Study Areas and Drum Disposal Operable Unit (DDOU) EE/CA which was issued in October 1998 (AFCEE, 1998).

The following alternatives received detailed analysis in the EE/CA:

- Alternative 1: On-Base Thermal Desorption and Off-base Treatment and Disposal for AOC FS-18
- Alternative 2: On-Base Asphalt batching and Off-Base Treatment and Disposal for AOC FS-18
- Alternative 3: Off-base Treatment and /or Disposal for AOC FS-18.

B. REMEDIAL/REMOVAL ACTIONS:

This section presents the regulatory actions, removal action objectives (RAOs), a description of the selected removal action, and a summary of the removal action implementation at AOC FS-18.

B.1 Regulatory Actions

Described below are the controlling documents that present the selected removal action and post-EE/CA documents that identified changes to the selected removal action.

Action Memorandum (AM): The Priority 2 and 3 Study Areas and DDOU Source Removal AM (AFCEE, 1999) documented the decision to perform removal actions at several Priority 2 and 3 Study Areas including FS-18. Based on the evaluation of removal action alternatives presented in the EE/CA, the selected alternative was Alternative 2 which included excavating AOC FS-18 soil and treating the excavated material on-base using an asphalt batching facility and/or off-base at an approved treatment and disposal facility.

Action Memorandum Addendum: Priority 2 and 3 Study Areas and DDOU Source Removal AM Addendum (AFCEE, 2003) was prepared to document changes to the selected removal action for several sites in the Source Area Remedial Action Program (SARAP) including FS-18. Three changes were made to the selected removal action presented in the Priority 2 and 3 Study Areas EE/CA: (1) establishment of removal action levels (RALs) for certain aliphatic and aromatic hydrocarbons; (2) removal of the asphalt-batching component from the selected removal action; and (3) the expansion of offsite disposal options to include RCRA Subtitle D facilities.

B.2 Removal Action Objectives (RAOs)

The RAOs are the site-specific qualitative goals that must be achieved to meet remedial response objectives. The RALs are the site-specific quantitative cleanup levels that will meet these goals. Investigations conducted at AOC FS-18 demonstrate that soil contaminated with total petroleum hydrocarbons may pose unacceptable risk to humans and ecological receptors. Elevated levels of petroleum hydrocarbons also are present in surface soil at this study area. At AOC FS-18 contaminant concentrations were compared to the HECs. Concentrations exceeding this risk-based value indicate the need for a removal action at the AOC. Removal action objectives were developed based on these considerations, and were established to achieve the overall objective of protecting human health and the environment. The objectives identify responses that are necessary to adequately address human-health and ecological risks posed by contaminated soil.

MMR-specific Soil Target Cleanup Levels (STCLs) used for the DSRP (AFCEE, 1996) were retained and used to develop cleanup levels for identified COCs. In 2002, AFCEE with concurrence from USEPA and MADEP revised ecological risk based STCLs for inorganic chemicals in a Technical Memorandum (AFCEE, 2000). In addition, AFCEE used USEPA screening level guidance for Superfund sites as the RAL for PCBs. In 2002, AFCEE revised phytotoxicity and invertebrate STCLs for several inorganics in an addendum to the STCL Technical Memorandum (AFCEE, 2002).

The revised STCLs led to the development of RALs, which also took into account terrestrial plant screening levels, terrestrial invertebrate screening levels, and MMR-specific background levels. Development and establishment of RALs will be documented in an AM Addendum (AFCEE, 2003). Presented in **Table B-1** are RALs that must be achieved to meet remedial response objectives for FS-18.

Table B-1 MADEP S-1/GW-1 Standards for Petroleum Hydrocarbons		
Type of Petroleum Hydrocarbons	**BASIS**	**New RAL (mg/kg)**
Aliphatic Hydrocarbons		
C_5 through C_8 Aliphatic Hydrocarbons	Human Health	100
C_9 through C_{12} Aliphatic Hydrocarbons	Human Health	1,000
C_9 through C_{18} Aliphatic Hydrocarbons	Human Health	1,000
C_{19} through C_{36} Aliphatic Hydrocarbons	Human Health	2,500
Aromatic Hydrocarbons		
C_9 through C_{10} Aromatic Hydrocarbons	Human Health	100
C_{11} through C_{22} Aromatic Hydrocarbons	Human Health	200

B.3 Removal Action Description

The selected removal action consisted of excavating contaminated soil and treating this material on-base using an asphalt batching facility and/or off-base at an approved treatment and disposal facility. Excavated soil where contaminant concentrations are found to exceed TCLP allowable concentrations shall be deemed hazardous and disposed of off-site in a RCRA Subtitle C TSDF. Soil that is found to have contaminant concentrations below TCLP allowable concentrations and deemed nonhazardous (and that are determined to contain contaminant concentrations below MADEP MCP Method 1 S-1/GW-1 standards for pesticides and Massachusetts Permitted Soil Recycling Facility Summary Levels) would be treated at the on-site cold mix emulsion asphalt-batching plant. Post-excavation confirmatory sampling would be conducted to ensure that all soil with COC concentrations exceeding FS-18 soil cleanup levels were removed.

The selected removal action for FS-18 was modified. Changes to the selected removal action included deletion of the on-site asphalt batching component of the removal action; establishment of RALs to replace cleanup levels presented in the AM; and expansion of offsite disposal options to include RCRA Subtitle D facilities. These changes are documented in Priority 2 and 3 Study Areas and DDOU Source Removal AM Addendum (AFCEE, 2003) for the SARAP.

The modified removal action consisted of excavating contaminated surface soil at FS-18. Excavated soil would be transported to an on-base central bulking facility for waste characterization. Excavated soil that has contaminant concentrations in exceedance of TCLP allowable concentrations would be deemed hazardous and disposed of off-site in a RCRA Subtitle C TSDF. Soil that has contaminant concentrations below TCLP allowable concentrations (and that have contaminant concentrations below MADEP MCP Method 1 S-1/GW-1 standards for pesticides and Massachusetts Permitted Soil Recycling Facility Summary Levels) would be deemed nonhazardous and transported offsite to a Subtitle D facility.

B.4 Removal Action Implementation

AFCEE completed additional soil characterization activities as part of the SARAP in 2001 at AOC FS-18. Based on a comparison of the soil sampling results with the MADEP S-1/GW-1 standards for petroleum hydrocarbons which includes EPH/VPH analysis, it was concluded that soil removal was not necessary at FS-18.

C. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The following activities were conducted since the last review:

- Priority 2 and 3 Study Areas and DDOU AM: Completed in June 1999
- Source Area Removal Action Program Investigation: Completed in August 2001
- Priority 2 and 3 Study Areas and DDOU AM Addendum: Completed in February 2003

D. TECHNICAL ASSESSMENT

The technical assessment component of the five-year review consists of evaluating the protectiveness of the removal action. AFCEE performed the technical assessment based on USEPA guidance provided in section 4.0 of the Comprehensive Five-Year Review Guidance (USEPA 2001).

Question A: Is the remedy functioning as intended by the decision documents?

The review of documents, ARARs, risk assumptions, and the results of the additional investigations indicate that the remedy has been completed as intended by the AM as modified by the AM Addendum. Excavation of contaminated soil was not required, and the RAOs of mitigating the migration of contaminants to groundwater and preventing direct contact with, or ingestion of contaminants in soil has been achieved.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Standards and To-Be Considered

ARARs and TBC guidance for soil contamination cited in the AM and AM Addendum have been met. There have been changes in chemical-specific ARARs and TBC guidance for petroleum hydrocarbons. AFCEE recalculated risk-based STCLs for ecological receptors to reflect current toxicity information. RALs were derived from the comparison of the following: revised STCLs, MMR-specific background levels, phytotoxicity screening levels, and invertebrate screening levels. The new cleanup levels remain protective of human health and the environment. Cleanup levels identified in the AM were derived from the comparison of cleanup levels used in the DSRP and background. These cleanup levels initially did not take into account invertebrate or phytotoxicity screening levels; however, they were taken into account in the AM Addendum. **Table D-1** provides the changes in cleanup levels at AOC FS-18.

Table D-1 Changes in cleanup Levels at AOC FS-18

Contaminant	Media	AM Addendum RAL (mg/kg)	AM RAL (mg/kg)
Total Petroleum Hydrocarbons	Soil	See **Table B-1**	500

Changes in Exposure Pathways

There have been no changes in the physical conditions, exposure pathways, and land use of the site that would affect the protectiveness of the removal action.

Changes in Toxicity and Other Contaminant Characteristics

There have been no changes in the toxicity factors for contaminants of concern that were used for the human health risk assessment. However, risk-based cleanup levels for ecological receptors were calculated using new toxicity information. Calculation of ecological risk-based STCLs using new toxicity information was completed in 2000 (AFCEE, 2000). These STCLs were used in the development of RALs. Cleanup was based on these RALs.

Changes in Risk Assessment Methods:

There were no changes in human health risk assessment methodology.

Expected Progress Towards Meeting RAOS:

RAOs have been met because it was determined that concentrations of COCs were below their cleanup levels, and removal was not needed.

Question C: Has any other information come into light that could call into question the protectiveness of the remedy?

There is no information that calls into question of the protectiveness of the selected removal action.

Technical Assessment Summary

The remedy was completed as intended by the AM and modified by the AM Addendum. There have been no changes in the physical conditions and land use of the site that would affect the protectiveness of the removal action. There is no information that calls into question of the protectiveness of the selected removal action.

Table D-2 presents the technical assessment summary for AOC FS-18.

Table D-2: Technical Assessment Summary for AOC FS-18

Question		Response
A	Is the removal action functioning as intended by the decision documents?	Yes
B	Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the removal action selection are still valid?	Yes
C	Has information come to light that calls into question the protectiveness of the removal action?	No

E. ISSUES

The issue at FS-18 source is that a removal action report documenting the cleanup actions has not been completed.

F. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendation and follow-up action is to prepare and issue a removal action report after receiving regulatory approval.

G. PROTECTIVENESS STATEMENT

The removal action selected for the AOC FS-18 (source control including excavation and off-site disposal) is protective of human health and the environment. Excavation of contaminated soil was not required because soil containing COCs above RALs were not detected in the 2001 SARAP. The RAOs of mitigating the migration of contaminants to groundwater and preventing direct contact with, or ingestion of contaminants in soil have been achieved.

H. REFERENCES

ABB Environmental Services, Inc. (ABB-ES), 1995. *Supplemental Sampling Report for Priority 2 and 3 Study Areas Sites*; Installation Restoration Program; Massachusetts Military Reservation; prepared for HAZWRAP; Portland, Maine; 1995.

ABB-ES, 1993. *Priority 2 and 3 Study Areas Site Investigation*, Installation Restoration Program, Massachusetts Military Reservation, prepared for HAZWRAP; Portland, Maine; October 1993.

AFCEE, 2003. *Action Memorandum Addendum Priority 2 and 3 Study Areas and Drum Disposal Unit Source Removal*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program; February 2003.

AFCEE, 2002. *Addendum to Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics*. Prepared by Portage Environmental Inc. and Engineering Strategies Corporation for AFCEE/MMR Installation Restoration Program; September 2002.

AFCEE, 2000. *Final Technical Memorandum Revised Ecological Soil Target Cleanup Levels For Inorganics.* Prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program; December 2000.

AFCEE, 1999. *Action Memorandum Priority 2 and 3 Study Areas and Drum Disposal Operable Unit Source Removal*. Prepared by Harding Lawson Associates (HLA) for AFCEE/MMR Installation Restoration Program; June 1999.

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AFCEE, 1996. *Soil Target Cleanup Levels, DSRP*. Prepared by HAZWRAP for AFCEE/MMR Installation Restoration Program; January 1996.

E.C. Jordan Co., 1986. *U.S. Air Force Installation Restoration Program Phase I: Records Search, Air National Guard, Camp Edwards, U.S. Air Force, and Veterans Administration Facilities at Massachusetts Military Reservation, Task 6*; Installation Restoration Program, Massachusetts Military Reservation; prepared for Oak Ridge National Laboratory; Oak Ridge, Tennessee; December 1986.

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