Massachusetts Military Reservation

PLUME RESPONSE PROGRAM

Final Chemical Spill-19 Groundwater Plume Interim Record of Decision

April 2006

Prepared for:
AFCEE/MMR
Installation Restoration Program
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ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Environmental Excellence
alpha-BHC	alpha-hexachlorocyclohexane
ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Identification System
CFR	Code of Federal Regulations
CIA	Central Impact Area
CMR	Code of Massachusetts Regulations
COC	contaminant of concern
COPC	contaminant of potential concern
CS-#	chemical spill, as in CS-19
DDT	2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane
DOD	U.S. Department of Defense
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPS	Environmental Performance Standards
FFA	federal facility agreement
ft bgs	feet below ground surface
ft msl	feet mean sea level
HA	health advisory
HI	hazard index
HQ	hazard quotient

ACRONYMS AND ABBREVIATIONS

IAGWSP	Impact Area Groundwater Study Program
IART	Impact Area Review Team
IROD	Record of Decision for Interim Action
IRP	Installation Restoration Program
JPAT	Joint Process Action Team
LUC	land use control
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
mg/kg-day	milligrams per kilogram per day
MGL	Massachusetts General Laws
MC	munitions constituents
MM	military munitions
MMR	Massachusetts Military Reservation
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPP	Mashpee Pitted Plain
NCP	National Oil and Hazardous Substances Contingency Plan
NGB	National Guard Bureau
NPL	National Priorities List
OU	Operable Unit
PCE	tetrachloroethene
PCT	Plume Cleanup Team
PPIA	Proposed Plan for Interim Action
PVC	polyvinyl chloride
RAGS	Risk Assessment Guidance for Superfund

RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
SDI	subchronic daily intake
SVOC	semivolatile organic compound
TCE	trichloroethene
USCG	U.S. Coast Guard
µg/L	micrograms per liter

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1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Chemical Spill-19 (CS-19) Site Groundwater Operable Unit (OU)

Otis Air National Guard/Camp Edwards, Falmouth, Massachusetts

(Massachusetts Military Reservation [MMR], Cape Cod, Massachusetts)

MMR Comprehensive Environmental Response, Compensation and Liability Identification System (CERCLIS) number MA2570024487.

1.2 STATEMENT OF BASIS AND PURPOSE

This Record of Decision for Interim Action (IROD) presents the selected interim remedy for the CS-19 groundwater plume, located within the Central Impact Area (CIA) of the MMR. The remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendment and Reauthorization Act (SARA), and to the extent practicable, the National Oil and Hazardous Substances Contingency Plan (NCP). This decision is based on the administrative record for this site.

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

Because the CS-19 plume is located within the CIA and is located in and may be commingled with the CIA plume, a final groundwater remedy for the CS-19 plume will be evaluated and selected in a unitary, comprehensive manner along with the final remedy for the CIA plume in accordance with the Memorandum of Understanding (MOU) dated 13 December 2004. The Air Force Center for Environmental Excellence (AFCEE) will coordinate collected CS-19 information with the Impact Area Groundwater

Study Program (IAGWSP), and the final remedy for the CS-19 and CIA plumes will be evaluated and selected when all pertinent technical information is available.

1.3 ASSESSMENT OF THE SITE

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

1.4 DESCRIPTION OF SELECTED INTERIM REMEDY

The selected interim remedy for CS-19 groundwater includes the following components.

1. Sampling and analysis of groundwater associated with the CS-19 plume and reporting until a final remedy is selected and implemented.
2. Periodic optimization of the groundwater monitoring program.
3. Development, implementation, enforcement, and monitoring of land use controls (LUCs) to prevent or minimize unacceptable exposure to human receptors.

1.5 STATUTORY DETERMINATIONS

This interim action is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD is signed; the action complies with federal and Commonwealth of Massachusetts requirements that are applicable or relevant and appropriate for this limited-scope action, and is cost-effective. This action is an interim solution only, and is not intended to utilize permanent solutions and alternative treatment technologies to the maximum extent practicable for this OU. The groundwater will not be treated under the selected remedy. However, the source of groundwater contamination (the CS-19 soil OU) is currently being removed under a separate removal action (AFCEE 2003). Two feet of soil and the encompassed military munitions (MM) and/or munitions constituents (MC) debris have already been excavated from the site, and the soil has been treated in a low temperature thermal desorption unit to destroy hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); additional removal of soil and MM and/or MC debris at the site is ongoing. There is a statutory preference for treatment

as a principal element of the remedies (i.e., reduce the toxicity, mobility, or volume of contaminants comprising principal threats through treatment). Because this interim action does not constitute the final remedy for the OU, the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principle element will be addressed by the final response action. Subsequent actions are planned to address fully the threats posed by conditions at this OU, and review of the site and the remedy will be ongoing as AFCEE and the Army continue to develop a final remedy for groundwater at CS-19. Because RDX will remain in the aquifer for several years above levels that allow for unlimited use and unrestricted exposure, five-year reviews will be conducted to ensure that the interim action continues to be protective of human health and the environment.

1.6 DATA CERTIFICATION CHECKLIST

The following information is included in this IROD document:

Data Item	Location in Document
Contaminant of concern (COC) and its respective concentration.	Sections 2.5.4 and 2.7.3
Baseline risk represented by the COC.	Section 2.7
Cleanup level established for COC and the basis for this level.	Sections 2.5.2 and 2.5.4
How source materials constituting principal threats will be addressed.	Section 2.2
Current and reasonable anticipated future land use assumptions and current and potential future beneficial use of groundwater used in the baseline risk assessment and IROD.	Section 2.6
Potential land and groundwater use that will be available at the site as a result of the selected remedy.	Sections 2.6.1, 2.6.2, and 2.9.4
Estimated capital, annual, operation and maintenance, and total present value costs, discount rate, and the number of years over which the remedy cost estimate is projected.	Sections 2.10.2.7 and 2.11.3, Table 2-8 and Table 2-9
Key factor(s) that led to selecting the remedy.	Section 2.10.2

1.7 AUTHORIZING SIGNATURES

The foregoing represents the decision for interim remedial action for the CS-19 plume by AFCEE and the EPA, with the concurrence of the MassDEP.

Concur and recommend for immediate implementation.

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

By: _____ Date: 17 April 2006

Paul A. Parker
Director

U.S. ENVIRONMENTAL PROTECTION AGENCY

By: _____ Date: 7-20-06

for **Susan Studlien**
Director, Office of Site Remediation and Restoration

2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The MMR was listed on the National Priorities List (NPL) in 1989 as Otis Air National Guard/Camp Edwards in Falmouth, Massachusetts. The CERCLIS number for the MMR site is MA2570024487. In accordance with Executive Order 12580, DOD is the lead agency for remedial actions at the MMR. EPA and MassDEP are the support agencies for this action.

The FFA for the MMR site was signed in 1991 between the DOD, the EPA, and the U.S. Department of Transportation (U.S. Coast Guard)[1]. In 1995, the FFA was amended to add the U.S. Air Force as the lead agent for the cleanup at MMR. The FFA, as amended, requires the U.S. Air Force to implement CERCLA requirements at the MMR.

The MMR is surrounded by the towns of Bourne, Mashpee, Sandwich, and Falmouth, Massachusetts (Figure 2-1). This IROD addresses the CS-19 groundwater plume, which lies within the CIA plume in the MMR's Impact Area. CS-19 is located in the west-central region of the Impact Area (Figure 2-2). The Impact Area occupies most of the northern portion of the MMR and has been used for military training, law enforcement training, and sport shooting. Some of the training involved artillery firing from gun and mortar locations into the Impact Area. The CS-19 site is an inactive ordnance disposal area. The site measures approximately one acre in size, as defined by a perimeter road with an approximate 125-foot radius and evidence of remaining surface soil contamination determined during the remedial investigation (RI). Environmental investigations of the site began in 1991 (AFCEE 2003, 2005).

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[1] In 2000, the FFA was amended to remove the U.S. Department of Transportation (Coast Guard) as a signatory to the FFA.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The MMR occupies approximately 22,000 acres on western Cape Cod in Barnstable County and is situated within the towns of Falmouth, Bourne, Mashpee, and Sandwich; the CS-19 site is located within the MMR (Figure 2-1). The MMR provides facilities for several operating command units: the Air National Guard, the Army National Guard, the U.S. Air Force, the U.S. Coast Guard (USCG), and the Veterans Administration. Past military training and maneuvers, military aircraft operations, and maintenance and support activities have resulted in releases of hazardous materials at the MMR. The MMR has a year-round population of approximately 2000, which increases significantly during the summer months when military training activities increase the population by several thousand. Property use in towns surrounding the MMR is primarily residential and light industrial.

Military use of the MMR has occurred since 1911. The most intense periods of activity occurred from 1940 to 1946 and 1955 to 1970. Sources of contamination resulting from a variety of military operations include former chemical spills, motor pools, landfills, fire training areas, and drainage structures such as dry wells and drainage swales. CS-19 is located in the west-central region of the MMR Impact Area approximately 500 feet east of Pocasset-Sandwich Road (Figure 2-2). The Impact Area occupies most of the northern portion of the MMR and has been used for military training, law enforcement training, and sport shooting. Some of the training involved artillery firing from gun and mortar locations into the Impact Area.

The RI describes the CS-19 area as approximately one acre in size, as defined by the perimeter road with an approximate 125-foot radius and evidence of remaining surface soil contamination determined during the RI. This area is currently undergoing a removal action, and its full extent will be determined at the completion of this action once soil cleanup levels have been specified and reached. There may be additional sources beyond the perimeter road that may be contributing to groundwater contamination in this area and may need to be addressed at a later date.

The CS-19 site has been studied since 1991, including a series of literature reviews, progressing through several field investigations that included testing of groundwater. The studies were completed and documented in the CS-19 RI report (AFCEE 2003). Activities that took place between 1990 and 2004 include (1) identification of MM and MC, (2) removal of identified MM and MC from the surface of the site and limited subsurface MM and MC removal, (3) identification of contaminants (explosive compounds) in soil, (4) installation and sampling of groundwater monitoring wells and identification of contaminants (explosive compounds) in groundwater, (5) modeling and delineation of a groundwater plume, (6) calculating potential risk to human and ecological receptors that might be exposed to CS-19 soil and groundwater, and (7) data gap sampling to verify the site conceptual model. The CS-19 RI report concluded that the contaminated groundwater presents a low, but unacceptable, potential future risk to humans. However, since this plume is co-located and may be commingled with the CIA plume, a final remedy is not recommended until further monitoring is completed and a final decision on a remedy is made in conjunction with the CIA plume. In addition, the groundwater model suggested that the RDX plume will disperse to concentrations less than the lifetime health advisory (HA) of 2 micrograms per liter (µg/L) in 13 years and will not cross the MMR boundary, provided the source is removed. Source removal is currently being conducted under the CS-19 Source Area OU.

The site history follows a series of complex interactions between various federal agencies and the Commonwealth of Massachusetts. In 1940, the U.S. Army signed a 99-year lease with the Commonwealth of Massachusetts for the use of the MMR. The Army transferred this lease to the Air Force in 1953 for the Otis Air Force Base portion of the military reservation, and the Army maintained a sublease for the 14,000-acre area on the base known as Camp Edwards. In 1974, the Air Force licensed the Massachusetts Air National Guard to use Otis Air Force Base, and in 1975, the U.S. Army licensed the Massachusetts Army National Guard to use and occupy Camp Edwards. Legislation involving the environmental protection of the northern 15,000 acres of the MMR was submitted to the Massachusetts Senate and House of Representatives for consideration in July 2001. This legislation designated that area of the MMR as protected conservation

land dedicated for the purposes of water supply and wildlife habitat. The bill also ensured that the Massachusetts National Guard would be able to continue military training on the MMR that is compatible with the environmental protection of the land. The lease was extended to 2052. This bill was signed by the Governor and became law on 05 March 2002.

In 1982, the DOD initiated the Installation Restoration Program (IRP) at the Otis Air National Guard Base area of the MMR. NGB was responsible for implementing the IRP at the MMR. In 1986, the IRP was expanded to include all potential hazardous waste sites at the MMR. In 1989, the MMR was formally added to the NPL. An FFA among the the NGB, EPA, and the USCG was signed in 1991 (EPA et al. 1991). The FFA provides a framework for EPA oversight and enforcement of the investigations and cleanup activities and identifies a schedule for cleanup activities. A Community Relations plan is included as an attachment to the FFA. In 1996, EPA Region I Administrator requested that DOD provide a new management structure for the MMR IRP. In response to that request, the U.S. Air Force assumed the lead role in the execution of the IRP and assigned AFCEE to manage the program (EPA et al. 1996a). Under Amendment 2, additional enforceable milestones and the Plume Response Decision Criteria and Schedule were added to the FFA. More recently, the USCG has been removed from its status as a party to the FFA (Amendment 3 to the FFA). Amendment 4 added Section 7003 of the Resource Conservation and Recovery Act (RCRA) to the FFA in order to address contamination caused solely by petroleum releases that fall within the scope of the CERCLA "petroleum exclusion" described in the last sentence of CERCLA Section 101(14).

A wide variety of investigations, removal actions, and remedial actions have been and are currently being conducted at the MMR. A summary of past investigations and actions is presented in the MMR Strategic Plan (AFCEE 1997).

2.3 COMMUNITY PARTICIPATION

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

In addition, several citizen teams advise the IRP and the regulatory agencies about the AFCEE/MMR program. They include the Senior Management Board and the Plume Cleanup Team (PCT), which had been previously called the Joint Process Action Team (JPAT). The JPAT had been made up of the Plume Containment Team, the Long-Range Water Supply Team, and the Public Information Team. For the Army component of the MMR environmental program, the IAGWSP is advised by the Impact Area Review Team (IART). The IART, although not an AFCEE forum, is a citizen advisory committee that serves as a technical advisory resource and allows the EPA to hear firsthand the concerns of the public related to the ongoing investigation and cleanup effort at Camp Edwards, including the CS-19 site. All these teams are made up of citizen volunteers and government representatives working together to resolve problems and complete the cleanup. All citizen team meetings are open to the public. Assumptions about reasonably anticipated future land use and potential beneficial uses of groundwater and surface water are regularly discussed by these teams.

The public has been kept up to date on the progress of the CS-19 site through various public and citizen team meetings and public notices. From 14 January 2005 to 16 February 2005, AFCEE held a 34-day comment period to accept public comments on the single interim remedy presented for the CS-19 groundwater plume in a CS-19 Proposed Plan for Interim Action (PPIA). A presentation of the CS-19 PPIA was made to the PCT on 08 December 2005, and on 12 January 2005, AFCEE held a public meeting at the Falmouth Holiday Inn to present the PPIA in conjunction with the monthly

PCT meeting. At these meetings, representatives from AFCEE presented the PPIA and answered questions from the audience. On 15 February 2005, AFCEE held a public hearing at the Bourne Best Western to accept formal public comments on the PPIA. A transcript of the public hearing is provided in Appendix B. One individual provided verbal comments at the public hearing. No written comments were received by AFCEE from any community group.

AFCEE published a display advertisement for the public information meeting for the CS-19 PPIA in the *Falmouth, Mashpee, Bourne,* and *Sandwich Enterprises* and in the *Cape Cod Times* on 01 January 2005. AFCEE also published a display advertisement for the public information meeting and public comment period for the CS-19 PPIA in the *Falmouth, Mashpee, Bourne,* and *Sandwich Enterprises* and in the *Cape Cod Times* on 10 January 2005. The announcement of the public hearing was contained in display advertisements run in the *Falmouth, Mashpee, Bourne,* and *Sandwich Enterprises* and in the *Cape Cod Times* on 04 February 2005 and 11 February 2005.

The final CS-19 RI report describes the extent of contamination across the CS-19 site and was made available to the public in October 2003 (AFCEE 2003). A feasibility study (FS) has not yet been prepared for CS-19 groundwater. Before the start of the comment period, AFCEE made the RI reports and PPIA available for public review at the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts and on the MMR website. The PPIA has also been made part of the Administrative Record available for public review at the AFCEE IRP office at MMR, at the Bourne Public Library, and on the MMR website, http://www.mmr.org. AFCEE's responses to all oral and written comments received during the comment period are included in the Responsiveness Summary, which is Section 3.0 of this IROD.

An FS is being prepared by the IAGWSP for the CIA plume. In accordance with the MOU signed 13 December 2004, the IAGWSP and the IRP have committed to work on a comprehensive remedy(s) for the CIA plume and the CS-19 plume. This remedy(s) will be evaluated and selected in a unitary comprehensive manner. At present, the CS-19

groundwater portion of the aquifer is encompassed by the IAGWSP's evaluation of remedial alternatives for the CIA plume. AFCEE expects to be able to utilize the IAGWSP's FS to evaluate and propose the final remedy for the CS-19 groundwater OU.

2.4 SCOPE AND ROLE OF OPERABLE UNIT

The CS-19 site was organized into two OUs: source area and groundwater. The source area OU addresses the on-site soil contamination; the groundwater OU addresses the aquifer contamination.

The CS-19 source area OU is being investigated and remedied separately from the groundwater OU. It is anticipated that the sources of groundwater contamination will be excavated and either treated on-site and/or disposed of off the MMR. A separate administrative record is being maintained for the source area OU.

This IROD addresses the groundwater OU remedial actions. Because the CS-19 plume is located in and commingled with the CIA groundwater plume and study area, AFCEE will perform long-term groundwater monitoring of the CS-19 plume as an interim remedy. A final remedy will be evaluated and selected in conjunction with the evaluation of a range of alternatives for these plumes. AFCEE and the IAGWSP will evaluate all available CS-19 information to determine if contaminant concentrations are naturally decreasing to acceptable levels, and to determine if aquifer restoration is occurring. This IROD will dictate the groundwater OU interim remedy to be carried out until a final remedy is selected.

The recommendation for long-term monitoring (LTM) as an interim action is based on groundwater modeling and a risk assessment presented in the CS-19 RI report (AFCEE 2003), which indicated that the plume would not cause significant short-term impacts during the time it takes to finish the FS for a comprehensive remedy for both CS-19 and the CIA.

2.5 SITE CHARACTERISTICS

The MMR is located on two distinct sedimentary units that were deposited by a lobe of the Laurentian ice sheet. The majority of the MMR lies on a broad, flat, gently southward-sloping glacial outwash plain known as the Mashpee Pitted Plain (MPP) (Figure 2-3). The MPP consists of stratified outwash sand underlain by silty glaciolacustrine sediment, gravel, or basal till. The topography of the MPP gradually slopes from 70 feet mean sea level (ft msl) in the south to 140 ft msl in the north and is pocked with numerous kettle ponds. Moraines bound the MMR to the west and north. The Buzzards Bay Moraine consists of a north-south ridge of bouldery till overlying reworked drift deposits. The surface of the Buzzards Bay Moraine is hummocky with a complex topography that can vary from approximately 80 to 220 ft msl. There are generally few ponds located within the Buzzards Bay Moraine.

The single groundwater flow system that underlies western Cape Cod, including the MMR, is known as the Sagamore Lens. This sole-source aquifer is primarily unconfined and recharged by infiltration of precipitation. Groundwater flow is generally radial from the recharge area toward the ocean, which forms the lateral boundary of the aquifer on three sides; the Bass River in Yarmouth forms the eastern boundary of the Sagamore Lens. Groundwater flow in the CS-19 study area is northwesterly. Flow direction within the aquifer is generally horizontal with stronger vertical gradients near surface water bodies. Ponds are generally an expression of the water table and are hydraulically connected with the aquifer. Water table elevations fluctuate from 1 to 5 feet per year.

2.5.1 Conceptual Site Model

Figure 2-4 shows a schematic conceptual site model for CS-19. The primary source of contamination at the CS-19 site is historical disposal of ordnance. Because CS-19 is located within the Camp Edwards Impact Area, activities involving explosive materials, such as artillery firing from gun and mortar locations into the Impact Area and/or burial of MM and MC, may also have contributed to the contamination detected at and

upgradient of the CS-19 site. The conceptual site model was developed from the site investigation data and computer modeling.

Investigations conducted by AFCEE as part of the RIs have shown the source of explosive contaminants to be MM and MC. Characterizations of soil samples from trenches in areas of magnetic anomalies at the site have detected concentrations of the explosive RDX above its solubility limit. This indicates that in addition to particulate explosives present in munitions waste on-site, there are also particulate explosives in soil environmental samples. No particulate explosive was found in gridded soil sampling investigations outside of magnetic anomaly areas. Data collected subsequent to the RIs support the conclusions from the RI that the RDX detections are associated with MM and MC, and RDX contamination is not widespread over the entire site.

After deposition in or on soil, contaminant particles may dissolve and percolate deeper into recharge, resulting in releases to subsurface soil and groundwater. The groundwater table is approximately 65 ft msl, or approximately 100 to 150 feet below ground surface (ft bgs). The detections of RDX in groundwater at the site have all occurred in the upper portions of the aquifer. Once in groundwater, dissolved RDX migrates with groundwater flow to the northwest. The detections of RDX in groundwater generally become deeper with distance from the CS-19 source as recharge accrues on top of the plume as it flows downgradient. Because RDX is not appreciably degraded under aerobic conditions, it is expected to persist in the groundwater near CS-19.

Groundwater modeling was a vital tool in the development of the CS-19 conceptual site model. Both unsaturated and saturated modeling was conducted to better understand the nature and extent of RDX in the groundwater plume, its probable source, and eventual fate. Source characteristics associated with MM and MC at the CS-19 site were evaluated to simulate their potential to contribute to groundwater contamination. The modeling was used to determine which of the contaminants have a potential to leach to groundwater and create a plume at concentrations exceeding the human HAs. The contaminants that were modeled include RDX, octahydro-,3,5,7-tetranitro-1,3,5,7-

tetrazocine (HMX), trinitrotoluene (TNT), 2,4-dinitrotoluene (2,4-DNT) 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane (DDT), octachlorodibenzo-p-dioxin, barium, and lead.

Unsaturated zone modeling was conducted using a combination of the unsaturated conductivity function, The Hydrologic Evaluation of Landfill Performance (HELP) (Schroeder et al. 1994), Seasonal Soil Compartment Model (SESOIL) (Bonazountas and Wagner 1984), and Summers (EPA 1996b) models. These models provide estimates of infiltration, the time to leach materials from the unsaturated zone, and concentrations of contaminants in a mixing zone beneath the CS-19 source area. They were also used to estimate residual soil concentrations that would not cause groundwater contamination. Finally, these models provide an estimate of source mass loading to the water table for saturated transport modeling.

Saturated transport modeling was conducted to determine the effects of a range of mass loading rates on groundwater concentrations. Model runs evaluated the effects of removing all or partial sources on the existing groundwater plume and the rate of mass loading needed to create the observed groundwater plume. Specifically, source area modeling was used to determine the ranges of concentrations and vertical fluxes needed to predict the configuration of the existing CS-19 plume. Because MM and MC in three trench areas were removed as part of the CS-19 supplemental RI, the modeling evaluated the potential for groundwater contamination and plume generation from the remaining area of MM and MC on the site.

The modeling demonstrated that:

- Leaching of particulate RDX at the CS-19 site has created a portion of the observed CS-19 plume. There may be additional sources outside the CS-19 area that contribute to the plume mass.
- If it is assumed that the remaining uncharacterized, magnetic anomalies at the site have similar source characteristics to those already characterized, there is sufficient RDX at the site to create an exceedance of the groundwater HA limit in the foreseeable future.

- Not considering contaminants currently in transit through the vadose zone, complete removal of all potential particulate RDX in soil at the CS-19 site will cause the RDX plume to attenuate through dispersion in 13 years to concentrations below the HA limit.
- Leaching of some explosives from the CS-19 source area soil can result in RDX concentrations in groundwater above the HA of 2 µg/L. The model estimates the plume contains approximately 3.67 kilograms of RDX.

As a result, the CS-19 conceptual model was developed. Leaching of explosives related to the MM and MC at the site was sustaining the RDX plume in groundwater. Particulate explosives theoretically have the potential to create leachate at concentrations approaching their solubility limit if the water is in contact for sufficient time to reach equilibrium. In practice, dissolution kinetics result in leachate concentrations that are less than the solubility limit. Therefore, the areas of high concentration leachate are small areas around each RDX particulate. Multiple sources of RDX-contaminated leachate spreading in the unsaturated zone together with uncontaminated infiltration create an average leachate concentration at the water table that is significantly less than the RDX solubility limit. This combined leachate has created the low-concentration diffuse plume observed at the CS-19 site. Factors such as solubility limits, adsorption, and degradation will control the potential for waste material and contaminants (including RDX) in soil to contribute to the groundwater plume. For chemical constituents other than RDX, low initial source concentrations, low solubility limits and/or high adsorption have prevented them from contributing to groundwater plumes.

Low distribution coefficients for RDX prevent its adsorption to soil and do not retard its migration downward through the unsaturated zone. Once remaining particulate explosives are removed by removal of MM and MC from the source area, the remaining soil concentrations of RDX will leach relatively quickly and will not sustain a groundwater plume. Modeling predicts that the existing RDX groundwater plume will naturally attenuate through dispersion if the source of leachate is removed, and the current plume will be reduced to concentrations below HA limits before reaching the MMR boundary.

2.5.2 Site Overview

The CS-19 site is located within the MPP (Figure 2-3), a glacial outwash deposit composed of fine-to-coarse grained sands overlying basal till and bedrock. The thickness of the unconsolidated sands and sediments varies from 150 ft bgs near the Cape Cod Canal in the northwest to more than 400 ft bgs near Vineyard Sound in the south. The depth to water table is approximately 120 ft bgs.

Anthropogenic activities at CS-19 have left depressions of various shapes and sizes (ABB-ES 1992). Due to the high permeability of the sand and gravel underlying the Impact Area, there are no perennial streams and very little to no runoff (ANG 1997). Thus, almost all the precipitation in the Impact Area, and by inference CS-19, becomes groundwater recharge or evapotranspiration, limiting surface water runoff and ponding.

A single groundwater flow system underlies upper Cape Cod. This sole-source aquifer, designated as the Sagamore Lens, provides upper Cape Cod with its only potable water source. The sole source of recharge to the western Cape Cod system is precipitation, which averages 46 inches per year. Infiltration recharges the unconfined aquifer. Seasonal variations produce annual water table fluctuations from 1 to 5 feet. The high point in the water table is a mound approximately centered along the southeastern border of the MMR Impact Area. Groundwater flow radiates outward from this recharge mound. Groundwater flow over large distances within the aquifer is predominantly horizontal. Upward vertical hydraulic gradients have been measured near some surface water bodies such as the MPP kettle ponds. The kettle ponds are generally in hydraulic connection to the aquifer with their surface elevation representing an expression of the water table. Away from these features, gentle downward vertical gradients are prevalent as a result of recharge accretion. Other surface water features—such as drainage swales, ponds, marshes, streams, and rivers—influence groundwater flow rates and direction and water table slope on a regional scale.

The CS-19 site is located west/northwest of the high point of the groundwater recharge mound. Groundwater flow at the site is in a northwesterly direction (Figure 2-2). The

nearest surface water body is Succonessett Pond, which lies approximately 2,000 feet to the southwest (crossgradient) of the site. The closest surface water body downgradient of the site is Little Halfway Pond approximately 9,000 feet to the northwest. A third surface water body, Baileys Pond, is located approximately 7,200 feet to the north and is oriented approximately 30 degrees north of the predominant groundwater flow direction from the site (Figure 2-2).

The CS-19 groundwater plume is defined by RDX concentrations exceeding the EPA HA level of 2 µg/L. The risk assessment evaluated the risks posed by potential exposure to the CS-19 groundwater and determined that RDX was the sole COC for CS-19 groundwater (see Section 2.7). Results from laboratory tests on mice provide an indication that low-level exposure to RDX from contaminated drinking water could possibly cause cancer in humans (ATSDR 1996).

There is no maximum contaminant level (MCL) or Massachusetts MCL for RDX. The EPA has established HAs for specific contaminants for which no MCL exists. The HA for RDX is 2 µg/L. Based on the RDX data through January 2005, the CS-19 groundwater plume appears to be divided into two lobes representing upgradient and downgradient components (Figure 2-5). Maximum concentrations of RDX (7.5 µg/L in well 58MW0001 and 14 µg/L in well 58MW0002) continue to occur in the immediate vicinity of the source area and constitute the upgradient portion of the plume (5.5 µg/L in well 58MW0009E). The downgradient portion of the plume is defined by one RDX detection in well cluster WL201 where the most recent detection of RDX is 4.1 µg/L in well WL201M2. There are no RDX detections in monitoring wells between 58MW0009 and WL201; therefore, the plume contour in this area is hypothesized based on professional judgment.

2.5.3 Sampling Strategy

This section describes previous investigations, including the historical sampling efforts and applicable analytical results for CS-19 groundwater.

Preliminary Assessment and Site Assessment (1990-1992)

In 1990, the NGB initiated an investigation of a potentially hazardous waste site in the Impact Area at MMR (ABB-ES 1992). This was initiated by information provided to the MassDEP by an anonymous source. This source indicated that hazardous disposal activities might have occurred in the Impact Area in the late 1960s. This site had not been previously identified as a historical hazardous waste area in the MMR records searches. The MassDEP and NGB toured the CS-19 site in August 1990. The soil was described as unvegetated, lightly stained, and damp. Scattered debris such as drum covers and retaining rings, metal pipe, MM and MC debris were identified. The NGB designated the site as Study Area Chemical Spill No. 19 and decided that assessment and field sampling activities were warranted. The preliminary assessment began in the fall of 1991 to identify information about the history of the CS-19 site. It included a site visit, interviews of personnel, review of aerial photographs, and literature reviews. Interviews with base employees confirmed that the site was used for disposal of MM and MC in the 1960s.

Based on this information, a site investigation (ABB-ES 1992) was designed to determine the nature of the activities that occurred and potential contamination of the soil. Additional interviews and file reviews, geophysical surveys, and soil excavation were conducted. The interviews indicated that liquids, MM and MC were buried in pits during the 1960s and fuels were used to assist in burning combustible materials in burn pits.

The results of the field investigation confirmed the disposal history by uncovering large quantities of MM and MC such as rocket motors and assemblies and casings. The surface soil samples showed the presence of explosive compounds, semivolatile organic compounds (SVOCs), and metals, some of which may have been associated with MM and MC disposal. The soil sample analytical results also indicated the presence of pesticides and herbicides, but did not indicate the presence of fuels. The absence of fuel-related compounds was most likely from volatilization or consumption during burning. Dioxins and furans were also detected, most likely as by-products of burning.

Groundwater Investigations (1994 - 1999)

From 1994 to 1999, groundwater investigations were carried out in two phases: a limited-focus investigation (USACHPPM 1994) and a supplemental groundwater investigation (AFCEE 1999). As information was collected, more information and data were needed to understand the extent of soils and groundwater contamination. Groundwater monitoring wells were installed at various locations on the site and then sampled for a variety of chemical compounds to gain a better understanding of the contaminants and how far they had traveled. The results showed that in addition to sources located within the CS-19 site, there was a potential source of RDX upgradient of the CS-19 site and that these concentrations increased downgradient of the site. The maximum concentration of RDX in groundwater was 20 µg/L in monitoring well 58MW0002 (Figure 2-5). The conclusion was that the CS-19 site was a contributor to the RDX groundwater contamination in the area. RDX was the only compound present in concentrations high enough to exceed a drinking water threshold. Other nonexplosive contaminants were discovered, but did not exceed MCLs or HAs.

Initial RI (2000)

The initial RI was designed to understand the extent of contamination and to collect sufficient data to support a risk assessment (AFCEE 2000). This included a study of the extent of contamination in soil at the site, groundwater at the site, and risk to human and ecological receptors. The direction of groundwater flow was determined and a survey for MM and MC was conducted.

The initial RI groundwater analytical sample results showed that RDX concentrations were highest in the wells at and immediately downgradient of the CS-19 site, and higher in wells placed at shallower depths than in those placed at deeper depths. The maximum RDX result was 13 µg/L, measured downgradient of the site (monitoring well 59MW0009E). Well locations are shown in Figure 2-5. The next highest RDX concentration was 12 µg/L, measured within the site (59MW0002). RDX was also detected in wells upgradient of CS-19, but at lower concentrations. Other compounds

analyzed for included volatile organic compounds, SVOCs, pesticides, herbicides, metals, and dioxins/furans. The concentrations of these compounds in groundwater were either too low to be detected, were rejected due to lab contamination, or were not attributable to the CS-19 site. However, surrounding the designated CS-19 source area there are unknown sources (possibly MM and MC) that contribute to the groundwater contamination in the vicinity of CS-19 that are being evaluated by the IAGWSP.

Supplemental RI (2001)

The objectives of the supplemental RI were to address data gaps, evaluate soil contamination, and further define the leading edge of the RDX groundwater plume (AFCEE 2003). Activities included the excavation of three trenches and the installation of monitoring wells at the leading edge of the plume. The trenching activities resulted in the removal of contaminated soil, MM and MC, and metallic debris. The monitoring wells were installed to better understand the leading edge of the plume and to collect data that would improve the groundwater model (see Section 2.5.1).

The risk assessment indicated that the only unacceptable risk to human health for a resident would be from exposure to water from a water supply well installed in the CS-19 plume. The compounds in the resident's water that would cause this risk are RDX, the pesticides alpha-hexachlorocyclohexane (alpha-BHC), DDT, and the metals arsenic, manganese, and thallium. There were no ecological (non-human) risks attributable to CS-19 groundwater because the plume does not discharge to the surface where plants or animals could be exposed to it.

Second Supplemental Groundwater RI (2003)

A second supplemental groundwater RI was conducted in late 2003 to provide additional information on the leading edge of the groundwater plume. Two additional monitoring wells (58MW0021A and B) were installed downgradient of the leading edge of the plume (Figure 2-5). Samples from these wells were analyzed for explosives and perchlorate, neither of which was detected at this location. This was the first time that perchlorate

was analyzed for in groundwater sampling activities conducted at the CS-19 site. Perchlorate was detected at a trace level, in one location. These data were used with the results from other wells in the area to delineate the RDX plume. This work is presented as Appendix O in the CS-19 RI report (AFCEE 2003).

Data Gap Investigation (2004)

The August 2004 sampling effort focused on providing perchlorate data and additional RDX characterization of the source area soils. Soil samples were analyzed for perchlorate because prior to this data gap investigation none of the CS-19 soil samples had been analyzed for perchlorate, and the possible presence and concentrations of perchlorate in CS-19 source soils was to be determined. Soil samples were also analyzed for RDX to supply data to verify the conceptual model.

Samples were collected from surface and down to 4 ft bgs at 25 locations within the areas that were previously covered with vegetation, with the assumption that these areas were the least disturbed and most representative of site conditions. The sampling area for this investigation covered approximately one third of the area within the perimeter road.

The data collected from the data gap investigation support the conclusions from the RI that the RDX detections are associated with MM and MC, and RDX contamination is not widespread over the entire site. Perchlorate was not detected in any soil sample.

2.5.4 Contamination Summary

Data collected during the investigations at CS-19 (described in the previous section) were used in the CS-19 RI report (AFCEE 2003) to assess the nature, extent, and risk of groundwater contamination at and downgradient from the site. RDX, alpha-BHC, DDT, the metals arsenic, manganese, and thallium, and perchlorate were deemed groundwater contaminants of potential concern (COPCs) following the risk assessment. It was later determined that the pesticides and metals were attributable to background or upgradient sources and were not present at enough locations and detected on a consistent basis to consider them as groundwater plumes posing a significant risk to human health

(AFCEE 2004). The detailed rationale for elimination of pesticides and metals as COPCs is detailed in Section 2.7.1.1 of this IROD.

While perchlorate has been detected in several wells throughout the Impact Area, the concentrations of perchlorate did not contribute to the hazard indices (HIs) calculated for the risk assessment, and higher concentrations of perchlorate were detected upgradient of the CS-19 plume, indicating the source of perchlorate is upgradient of the CS-19 site. Nevertheless, perchlorate was considered a COPC in the CS-19 RI report because the maximum concentration detected in CS-19 groundwater exceeded the screening level. The perchlorate detects in the CS-19 plume area are sporadic and at low concentrations. In a recent sampling event (January 2005), samples were collected from 31 monitoring wells in and surrounding the CS-19 plume. Of those 31 wells, only five contained detectable levels of perchlorate. Most results were below 1 µg/L, and the highest detection was 2.9 µg/L in well 58MW0017B. EPA has not set a cleanup standard for perchlorate, but has set a reference dose (RfD) equivalent to drinking water exposure levels (see Section 2.10.2). The CS-19 data collected to date do not indicate that there is a perchlorate plume associated with CS-19 groundwater.

RDX is the only CS-19 groundwater COC and will be analyzed for in the interim remedy groundwater monitoring program. The EPA HA concentration of 2 µg/L will be considered in setting a cleanup standard for the CS-19 plume. Because perchlorate data were not collected as part of the RI, and only three sampling events of the CS-19 monitoring wells since the RI have included perchlorate as an analyte, there is insufficient information to determine the significance of perchlorate in CS-19 groundwater and whether it is attributable to the site. Therefore, the samples collected as part of the groundwater monitoring program IROD will be analyzed for perchlorate in addition to RDX to determine whether perchlorate is attributable to the CS-19 site and, thus, a COPC. If over time the data show that perchlorate is not a COPC, perchlorate analysis will be discontinued.

2.6 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

This section discusses the current and reasonably anticipated future land uses and current and potential beneficial groundwater uses in the vicinity of the CS-19 plume, and presents the basis for future groundwater use assumptions.

2.6.1 Land Use

The CS-19 site is presently inactive for military purposes, although the land use of the Impact Area is still considered military. The CS-19 site is within a restricted area surrounded by fencing and guarded gates.

An MOA, which included establishment of the Upper Cape Water Supply Reserve (Reserve) in the MMR Impact Area, was signed by the Governor of Massachusetts and the Deputy Assistant Secretary of the Army in October 2001; secondary signers included military representatives and commissioners of Commonwealth environmental agencies. In March 2002, the Governor signed legislation, referred to as Chapter 47 of the Acts of 2002, that made the MOA law for the purposes of the Reserve to be: permanent protection; development and construction of a drinking water supply; protection of wildlife habitat; and combined use and military training with the protection of the water supply and wildlife habitat. As a result, the potential for human exposure to on-site soil contaminants is limited to occasional trespassers, site workers and military trainees.

2.6.2 Water Resource Use

There are no current groundwater uses at the CS-19 site. The aquifer throughout upper Cape Cod, referred to as the Sagamore Lens, is generally highly transmissive and is a productive aquifer. Because the Sagamore Lens is designated as a sole-source aquifer, all groundwater underlying Camp Edwards is considered a potential drinking water supply from a regulatory perspective.

2.7 SUMMARY OF SITE RISKS

The baseline risk assessment estimates the risks posed by the present CS-19 groundwater plume if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed. This section of the IROD summarizes the results of the human health and ecological baseline risk assessments and COC selection for the CS-19 groundwater plume, which were conducted as part of the CS-19 RI report (AFCEE 2003) and the CS-19 Groundwater Monitoring Plan (AFCEE 2004). These risk assessments form the basis for the interim remedy.

The risk assessment showed that the only unacceptable risk to human health would be from exposure to water from a water supply well installed in the CS-19 plume. Although several contaminants were determined to be present in CS-19 groundwater, only RDX was not attributable to background or upgradient sources and detected consistently enough to potentially pose a risk to human health. The cumulative excess carcinogenic risks for an adult and child to RDX were $2x10^{-5}$ and $9x10^{-6}$, respectively, calculated using reasonable maximum exposure (RME) assumptions to groundwater. The noncarcinogenic HI was less than one for both adult and child. There were no ecological risks attributable to CS-19 groundwater because the plume does not discharge to the surface where plants or animals could be exposed to it.

2.7.1 Summary of Human Health Risk Assessment

This section summarizes the baseline human health risk assessment conducted as part of the final CS-19 RI. The following subsections focus primarily on exposure pathways, environmental media, and COPCs that contributed to potential unacceptable groundwater risks. A complete description of the methods and results of the baseline human health risk assessment is presented in Section 9.2 of the CS-19 RI report (AFCEE 2003).

The human health baseline risk assessment showed that the CS-19 plume contaminants RDX, alpha-BHC, DDT, arsenic, thallium, manganese, and perchlorate posed a potential risk for the future hypothetical off-site resident exposed to groundwater. It was later

determined that the pesticides (alpha-BHC and DDT) and metals (arsenic, thallium and manganese) were attributable to background or upgradient sources, and were not present at enough locations and detected on a consistent basis to consider them as groundwater plumes posing a significant risk to human health (AFCEE 2004). Therefore, the results from the risk assessment process indicated that only RDX is attributable to the CS-19 site. Perchlorate was not a risk driver, based on its low concentrations and sporadic detections. Because perchlorate in groundwater was not sampled for until 2001, there is insufficient information to determine its significance in CS-19 groundwater. Therefore, a groundwater monitoring program will collect samples for perchlorate in addition to RDX at CS-19 (AFCEE 2004). Perchlorate data will be collected and evaluated to determine whether perchlorate is attributable to the CS-19 site and, thus, a COPC.

2.7.1.1 Exposure Assessment

Current and future pathways and routes of exposure for each evaluated receptor are provided below. Appendix A contains the EPA Risk Assessment Guidance for Superfund Part D (RAGS D) standard tables applicable to the groundwater OU and this IROD (EPA 1998). RAGS Standard Table 1.1 (Appendix A) shows all groundwater exposure pathways considered, including those not quantitatively addressed. Specific exposure factors are included in RAGS Standard Tables 4.3 and 4.4, also presented in Appendix A.

A number of pathways through which chemical contaminants could possibly migrate from potential sources to existing receptors were considered. Receptor groups (i.e., human populations) that might potentially be exposed as a result of the presence of one or more chemicals in the groundwater were identified.

The groundwater conceptual exposure model (Figure 2-6) shows the on-base and off-base exposure pathways for the identified receptors and assumes that no actions are taken to mitigate contaminant release and transport. On-base and off-base refer to those media, settings, and receptors within the boundaries of the MMR and those media, settings, and receptors outside the MMR, respectively. Although residential use of the site in the near

term is unlikely, the risk assessment assumed that CS-19 groundwater could be used for residential purposes because the Impact Area, including the CS-19 site, is a potential future water supply that may serve residents of upper Cape Cod.

The CS-19 site has recently been designated as a "groundwater protection area." Although unlikely, it is feasible that an untreated municipal supply well installed at the site could supply drinking water to adult and child residents both on-site and off-site. Future residents (who could receive CS-19 groundwater through a municipal water supply system) are considered potential receptors. Potential exposure routes for these individuals are ingestion and dermal contact. Volatile organic compounds could also be inhaled during household use of water. Separate assumptions were used to calculate doses for adult and child off-site residents, then cancer risks for the adult and child were combined to represent total risks to off-site residents for a 30-year exposure period.

Exposure point concentrations (EPCs) for groundwater were developed based on the specific sampling scheme and exposure pathway. In all cases, one half of the reported sample detection limit was used as a proxy concentration for concentrations reported as not detected (i.e., qualified with "U").

For RME groundwater EPCs, EPA Region I (EPA 1998, 1999b) has adopted the highest temporal average concentration of each COPC for any single well provided sufficient data have been collected (i.e., sufficient number of sampling rounds over time). In general, the CS-19 RI groundwater sampling program involved one sampling round of monitoring wells in the study area. Therefore, calculation of a temporal average was not possible. CS-19 groundwater EPCs are the maximum concentration for the RME and the arithmetic average concentration for the central tendency (Standard Table 3.3 in Appendix A).

2.7.1.2 Toxicity Assessment

The potential for COPCs to produce adverse effects in humans was evaluated in the CS-19 risk assessment (AFCEE 2003). Toxicity values are obtained from EPA's most

current versions of the Integrated Risk Information System (IRIS) (EPA 2002) or the Health Effects Assessment Summary Table (HEAST) (EPA 1997), which are databases containing toxicity values for use in quantitative risk assessment. Non-cancer oral and dermal reference doses, reference concentrations, and affected target organs for each COPC are presented in RAGS Part D Table 5.1 (Appendix A). Cancer oral slope factors and unit risks are listed in RAGS Part D Table 6.1 (Appendix A).

2.7.1.3 Risk Characterization

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

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

Where

Risk = a unitless probability of an individual developing cancer
CDI = chronic daily intake (milligrams per kilogram per day [mg/kg/day])
DAD = dermally absorbed dose (mg/kg/day)
SF = slope factor $(\text{mg/kg/day})^{-1}$

Carcinogenic risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk of 1×10^{-6} indicates that an individual experiencing the RME theoretically has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risk of cancer an individual faces from other causes such as cigarette smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. EPA's target risk range for site-related exposures is 10^{-4} (one in 10,000) to 10^{-6} (one in 1,000,000). Under the Massachusetts Contingency Plan (310 Code of Massachusetts Regulations [CMR] 40), sites where the risk is less than 10^{-5} (one in 100,000) are considered to have attained a level of no significant risk.

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

Noncancer HQ = (CDI or DAD) / (RfD)

Where

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

The HI is calculated by adding the HQs for all COCs that affect the same target organ (e.g., prostate) within a medium or across all media to which a given individual may reasonably be exposed. An HI less than 1 indicates that, based on all of the different contaminants and exposure routes, toxic noncarcinogenic effects are unlikely. An HI greater than 1 indicates that site-related exposures might present a hazard to human health. As shown in RME Table 9.4 in Appendix A of the RI, the maximum HI for RDX in CS-19 groundwater was 0.32, indicating that toxic noncarcinogenic effects from CS-19 groundwater was unlikely. The noncarcinogenic HIs greater than 1 are summarized in Table 2-1.

The baseline cancer risk calculations in the CS-19 RI report summarized in Table 2-2 indicated that, unless remedial action is undertaken, future lifetime residential exposure to contaminated groundwater may present an excess lifetime cancer risk greater than the acceptable state threshold of 1×10^{-5} and the EPA target risk range of E-06 to E-04.

2.7.1.4 Uncertainty Analysis

Because risk assessments rely not just on measured or certain facts, but also on assumptions and estimates, risk assessments have historically used highly conservative assumptions in the place of unavailable data, with the net result often being a substantial overestimation of potential risks. Common areas of uncertainty include the frequency,

duration, and magnitude of possible exposure, the chemical-specific toxicity values, the one-size-fits-all exposure factors (e.g., body weight and ventilation rates), and possible synergistic or antagonistic chemical interactions. This section summarizes how assumptions made in the face of uncertainty may have affected the results and conclusions of the assessment.

The standard of care for environmental risk assessments for addressing many of the common areas of uncertainty is to use upper-bound (90th or 95th percentile) estimates of input values, such as exposure parameters and toxicity values. Some intake variables may not be at their individual maximum values, but when considered in combination with other variables, will result in estimates of the RME. The RME is intended to represent the highest exposure that is reasonably expected to occur at a site. Thus, the RME will tend to overestimate potential exposures for the majority of the population.

The primary uncertainties in the groundwater risk assessment described in detail in the CS-19 RI report (AFCEE 2003) and Groundwater Monitoring Plan (AFCEE 2004) are summarized here.

The uncertainty analysis addressed uncertainties associated with RDX, tetrachloroethene (PCE), trichloroethene (TCE), and chloroform in groundwater. The uncertainty associated with RDX is with regard to concentration whereas the uncertainty associated with PCE, TCE, and chloroform is related to the exclusion of these chemicals as COPCs. The combined cancer risk associated with slightly higher historical concentrations of RDX and the inclusion of PCE, TCE, and chloroform as COPCs is $4x10^{-5}$ and $3x10^{-5}$ for the adult and child, respectively. The combined non-cancer hazard associated with higher concentrations of RDX and the selection of PCE, TCE, and chloroform as COPCs is 0.2 and 0.6 for the adult and child, respectively. The conclusions of the risk analysis are not affected.

The risk estimates are all based on the assumption that future exposure to groundwater could occur at the maximum concentrations detected within the CS-19 site. The scenario of residential exposure to any CS-19 groundwater biases the risk evaluation

conservatively since it is a highly unlikely scenario. This exposure scenario is conservative because based on current and reasonably anticipated future land use, the land overlying the CS-19 plume (being public conservation land located within an impact area and leased to the DOD until 2052) is an unlikely site for future houses with private water supply wells. Under Chapter 47, however, the area underlying CS-19 could be used as a municipal drinking water supply. With respect to the off-site impacts, based on the groundwater model for CS-19 (AFCEE 2003), the maximum concentration in the plume at the time it is expected to reach the MMR boundary is predicted to be 0.3 µg/L. The non-cancer HIs and cancer risk levels associated with the maximum predicted off-site groundwater concentration of RDX (0.3 µg/L) are approximately 98 percent lower than the risks associated with the maximum concentration used in the risk assessment (15 µg/L). Lifetime cancer risks to RDX would be $5x10^{-7}$, and the lifetime non-cancer HI associated with exposure to RDX would be $9x10^{-3}$. Consequently, if the exposure route is limited to groundwater wells located at the MMR boundary rather than through wells located on base, risks to RDX may have been overestimated by as much as 98 percent.

2.7.2 Summary of Ecological Risk Assessment

The ecological baseline risk assessment concluded that there is no pathway of exposure to groundwater. Based on the absence of permanent surface water bodies at or in close downgradient proximity to the CS-19 site, aquatic species, both on-site and off-site, were assumed to be unaffected by site contamination. The concentration of compounds found in groundwater monitoring wells, in immediate proximity to and downgradient of CS-19, would be diluted to below the detection limit before water entered any ponds. Therefore, the potential exposure media for ecological receptors are surface soil and puddle water and do not include groundwater, and there are no COCs for the ecological risk assessment, as there is no exposure pathway.

2.7.3 Contaminants of Concern

COCs are those site-related chemicals identified in the risk assessment that pose a significant current or future risk and are sometimes referred to as risk-drivers. The

process of identifying COCs for human health began with the identification of COPCs. In accordance with EPA Region I guidance, COPCs were identified as compounds detected in CS-19 groundwater at concentrations greater than Region IX risk-based preliminary remediation goals (PRGs) (EPA 1999b). Infrequently detected compounds and essential nutrients were not retained as COPCs. Data from 42 groundwater wells (90 samples) were evaluated for COPCs. RDX, alpha-BHC, DDT, arsenic, manganese, perchlorate, and thallium were selected as groundwater COPCs.

Because COCs were not identified in the RI, the COC development process was performed as part of the development of the CS-19 Groundwater Monitoring Plan (AFCEE 2004), which took into consideration the site conceptual model and the findings of the risk assessment performed as part of the RI. The CS-19 Groundwater Monitoring Plan, which documented the COC development process, was issued as a project note and agreed to by AFCEE, EPA, and MassDEP. The COC development process is summarized here.

Results of groundwater investigations carried out from 1994 to 1999 showed that there was a potential source of RDX upgradient of the CS-19 site and that the concentrations increased downgradient of the site. The conclusion was that the CS-19 site was a contributor to the RDX groundwater contamination. Other non-explosive compounds were also discovered, but not at concentrations high enough to be of concern (i.e., less than the MCL or less than the HA level). Four constituents were found to increase the excess lifetime cancer risks (ELCR) for the maximally exposed hypothetical future residents using CS-19 groundwater for household purposes over the course of their lifetime. Those constituents were identified as COPCs and included RDX (RME ELCR = $2x10^{-5}$), alpha-BHC (RME ELCR = $1x10^{-5}$), DDT (RME ELCR = $2x10^{-5}$), and arsenic (RME ELCR = $3x10^{-4}$). With the exception of RDX, these compounds are not mobile and have a low potential to leach from the soil to groundwater in concentrations that can be mapped as a plume or create a human health risk in groundwater. The RME non-cancer HI values calculated for CS-19 groundwater were 4 for an adult resident and 10 for a child resident and were attributable to arsenic, thallium, and manganese. As was the

case for the COPCs that were associated with cancer risks, these metals are not mobile and have a low potential to leach from the soil to groundwater in concentrations that could be mapped as a plume. Therefore, based on mobility, distribution, and concentrations of alpha-BHC, DDT, arsenic, manganese, and thallium, these five contaminants are not attributed to the CS-19 source area. To show this, the HI of each of the three metal contaminants in the plume (HI_{RI}) was compared to the background groundwater HI (HI_{BKGND}), and the ELCR of each of the two pesticide contaminants in the plume ($ELCR_{RI}$) was compared to the upgradient groundwater ELCR ($ELCR_{PLUME}$). The results are summarized in Table 2-3.

The HI_{BKGND} for each metal COPC was calculated using the same exposure assumptions that were used for calculating future non-cancer risks from exposure to CS-19 groundwater. The calculated HI_{BKGND} values were compared to the HI_{RI} values for both adult and child exposures. The HI_{BKGND} values for all metal COPCs were greater than the respective HI_{RI} values. Therefore, the contribution of those metals to the overall non-cancer human health risk was considered due to background levels and not due to CS-19. Hence, none of the metal COPCs were considered CS-19 COCs.

The same method was used to calculate the $ELCR_{PLUME}$ of each organic COPC (alpha-BHC and DDT). The calculated $ELCR_{PLUME}$ value was then compared to the RI calculated ELCR ($ELCR_{RI}$) for each organic COPC. Because the maximum groundwater concentrations used in the baseline RI risk assessment were from a monitoring well upgradient of the CS-19 source area (58MW0005E, see Figure 2-5), the $ELCR_{RI}$ is not representative of the risks posed by household exposure to pesticide levels in the CS-19 groundwater. Therefore, another term ($ELCR_{PLUME}$) was used to represent the RME excess lifetime cancer risk associated with the maximum pesticide concentrations in the CS-19 plume. The $ELCR_{PLUME}$ values for both pesticide COPCs were less than the respective $ELCR_{RI}$ values. Therefore, the contribution of those compounds to the overall human health risk was considered due to background levels and not due to CS-19. Hence, none of the pesticide COPCs were considered COCs. Elimination of these five COPCs leaves RDX as the only COC. RDX results in wells within and surrounding the

CS-19 plume range from nondetect to 7.5 µg/L (58MW0001). The EPA HA limit is 2 µg/L.

Perchlorate has been detected in several wells throughout the Impact Area. The concentrations of perchlorate did not contribute to the HIs calculated for the CS-19 risk assessment, and higher concentrations of perchlorate were detected upgradient of the CS 19 plume. Nevertheless, perchlorate was considered a COPC in the CS-19 RI report because the maximum concentration detected in CS-19 groundwater during the supplemental investigations exceeded the Region IX screening level (AFCEE 2003). In a recent sampling event (January 2005), samples were collected from 31 monitoring wells in and surrounding the CS-19 plume. Of those 31 wells, only five contained detectable levels of perchlorate. Most results were below 1 µg/L, and the highest detection was 2.9 µg/L in well 58MW0017B. The data do not indicate that there is a perchlorate plume associated with CS-19 groundwater. AFCEE has proposed that groundwater monitoring samples be analyzed for perchlorate in addition to RDX. Perchlorate data will be collected and evaluated to determine whether perchlorate is attributable to the CS-19 site and, thus, a COPC.

2.8 REMEDIAL ACTION OBJECTIVES

Results of the human health risk assessment, the ecological risk assessment, and groundwater modeling are considered in conjunction with expected current and future use of the aquifer to develop remedial action objectives (RAOs) for the CS-19 groundwater OU.

2.8.1 Remedial Action Objectives

There is no risk to ecological receptors. Therefore, the following groundwater RAOs are established to protect human health:

- Prevent or reduce residential exposure to water containing unacceptable concentrations of RDX.
- Return useable groundwaters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site.

2.8.2 Basis and Rationale for Remedial Action Objectives

For human health concerns, the only media/exposure pathway that presents a cancer risk and/or a non-cancer HI above the target values is the RME of a future potential resident to groundwater, if drinking water is supplied from the site. A summary of the human health total non-cancer HIs and cancer risks for the CS-19 site indicates that RDX, alpha-BHC, DDT, arsenic, manganese, and thallium increase risk and hazards associated with exposure to groundwater.

Because the RME is based on the maximum detected concentration from any well in the vicinity of the site, the risk and HI are likely to overestimate the actual risk from CS-19 (see Section 2.7.1.5). In addition, some of the maximum concentrations of COPCs were not detected in monitoring wells located in or downgradient of the CS-19 site (e.g., tetrachlorodibenzo-p-dioxin in downgradient well 71MW0009S), suggesting that CS-19 is not a source of contamination to these wells, and the only contaminant from the CS-19 site and contributing to the potential risks and hazards is RDX.

2.9 DESCRIPTION OF INTERIM ALTERNATIVES

Two alternatives were considered for the CS-19 Interim Action: No Action and Long-Term Groundwater Monitoring.

2.9.1 Interim Alternative 1: No Action

The no-action alternative is required by the NCP (40 CFR 300.430[e][6]) to provide a baseline condition if no remedial action is taken. Under this alternative, no groundwater remediation measures would be initiated at CS-19 and LUCs would not be enforced. However, the source of groundwater contamination (the CS-19 soil OU), which is currently being removed under a separate removal action, would continue. With no action, the CS-19 plume will continue to naturally attenuate via dispersion.

2.9.2 Interim Alternative 2: Long-Term Monitoring With Land Use Controls

Under this alternative, AFCEE will collect and analyze groundwater data from a network of monitoring wells located along the boundaries of the plume (horizontal extent) and within the plume at various depths (vertical extent). This sampling and analysis and reporting of groundwater associated with the CS-19 plume will continue until a final remedy is selected. The monitoring program will be reviewed every year to ensure that it continues to provide adequate coverage of the plume and so that human health and the environment remain protected. Table 2-4 lists the monitoring wells that will be sampled for this interim remedy. Groundwater will be analyzed for RDX and perchlorate. More detail on the monitoring program can be found in Section 2.11.2. Five-year statutory reviews will be performed to revisit the appropriateness of the interim remedy in providing adequate protection of human health and the environment. The five-year review for the CS-19 groundwater OU will be part of the five-year reviews conducted for the CERCLA IRP sites that are on the MMR.

Land use controls developed by the DOD and approved by the EPA prohibit residential exposure to groundwater in the CS-19 plume. AFCEE is responsible for seeing that LUCs are established and followed and will work with the appropriate base organizations that are responsible for implementing, operating, maintaining, monitoring, reviewing, and enforcing LUCs as part of the OU interim remedy, in accordance with CERCLA and the NCP to ensure protection of human health and the environment, for the duration of the remedy selected in this IROD. Furthermore, at such time as the military's lease expires (currently the year 2052) and if not renewed, the IRP will work with the Commonwealth to develop appropriate deed restriction language for the transferring property to preclude future use of the groundwater in that area if contamination that poses a risk remains. More detail on the CS-19 LUCs can be found in Section 2.11.2.

2.9.3 Common Elements and Distinguishing Features of Interim Alternatives

Under both Alternatives 1 and 2, natural attenuation of the CS-19 plume would occur primarily through dispersion, and RDX concentrations within the plume would decrease

to below the HA limit in approximately 13 years. Existing controls in the form of the land reserve and base access would remain under both alternatives.

Under Alternative 2 only, RDX and perchlorate concentrations within and surrounding the CS-19 plume would be routinely measured, allowing for a check on modeling assumptions and verification of natural attenuation. Similarly, the effectiveness of LUCs would be evaluated under Alternative 2 only, in the CERCLA five-year reviews.

2.9.4 Expected Outcomes of the Alternatives

For both alternatives, it is assumed that RDX concentrations in the plume will be reduced through dispersion to below the HA level in 13 years. It is assumed that Alternative 2 will prevent a resident from drinking the groundwater from the CS-19 plume. The expected outcome of the fate of the plume is the same under both alternatives.

Under Alternative 2, AFCEE and the IAGWSP will coordinate CS-19 information to evaluate the groundwater plume dispersion, determine if contaminant concentrations are naturally decreasing to acceptable levels and aquifer restoration is occurring, and verify the appropriateness of the interim remedy. As a result, Alternative 2 provides for monitoring of the CS-19 plume and tracking its dispersion, to verify that groundwater containing RDX above the HA is not used for residential purposes.

The area overlying the current and projected future position of the CS-19 plume lies within Camp Edwards, and the land use is expected to remain military (with the provisions of Chapter 47) during the time required for RDX concentrations to reach the HA. Groundwater use will necessarily be restricted through LUCs until cleanup goals are met.

2.10 COMPARATIVE ANALYSIS OF INTERIM ALTERNATIVES

Because this IROD documents an interim remedy, an FS has not yet been performed for the CS-19 groundwater OU. The following sections describe Alternatives 1 and 2 in

relation to the nine criteria normally evaluated in an FS for the purpose of evaluating and choosing a remedial alternative.

2.10.1 Criteria For Detailed Analysis of Alternatives

The NCP (40 CFR, Part 300) presents nine criteria for analyzing the acceptability of a given alternative. These nine criteria are categorized as threshold criteria, primary balancing criteria, and modifying criteria.

2.10.1.1 Threshold Criteria

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

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

Compliance with ARARs Each alternative is assessed to determine whether it complies with ARARs under federal and state laws. Section 121(d) of CERCLA requires that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, unless such ARARs are waived under CERCLA Section 121(d)(4).

Pursuant to Section 121(d)(1) of CERCLA (42 USC Section 9621[d]), remedial actions must attain a degree of cleanup that assures protection of human health and the environment. Additionally, remedial actions that leave hazardous substances, pollutants, or contaminants on site must meet substantive standards, requirements, limitations, or criteria that are ARARs. Federal ARARs for any site may include requirements under

any federal environmental laws. State ARARs include promulgated requirements under state environmental or facility siting laws that are more stringent than any federal ARARs and that have been identified by the state in a timely manner.

CERCLA Section 121 states that at the completion of a remedial action, a level or standard of control required by an ARAR will be attained for wastes that remain on site. In addition, the NCP, 20 CFR Section 300.435(b)(2) requires compliance with ARARs during the course of the design/remedial action.

2.10.1.2 Primary Balancing Criteria

The five primary balancing criteria are (1) long-term effectiveness and permanence, (2) reduction of toxicity, mobility or volume through treatment, (3) short-term effectiveness, (4) implementability, and (5) cost. Primary balancing criteria form the basis for comparing alternatives in light of site-specific conditions.

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

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

Short-Term Effectiveness This criterion addresses the effects of the alternative during construction and operational phases until remedial objectives are met. Each alternative is evaluated with respect to its (potentially negative) effects on community health, worker

safety, and environmental quality during the course of remedial actions. This criterion also addresses the time required by each alternative until remedial objectives are achieved.

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

Cost Costs associated with carrying out an alternative are normalized into a present value. This normalization discounts the annual costs back to the present at an annual rate of 2.8 percent. It is assumed that costs are incurred at the beginning of each year and that the expected useful project life is 15 years, to allow for two additional years of monitoring beyond the estimated date of reaching the RDX HA in groundwater.

Cost estimates included in this document are intended for comparative purposes only. The accuracy of the estimates are between –30 and +50 percent.

2.10.1.3 Modifying Criteria

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

State Acceptance State acceptance evaluates the technical and administrative issues and concerns of the state, specifically the MassDEP.

Community Acceptance Community acceptance evaluates the issues and concerns that the public may have regarding each of the alternatives. A summary of the public comments received during the public comment period on the CS-19 Groundwater Plume Proposed Plan for Interim Action (AFCEE 2005), along with AFCEE's responses, are provided in Section 3.0, Responsiveness Summary, of this IROD.

2.10.2 Comparison of CS-19 Groundwater Plume Interim Alternatives

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

2.10.2.1 Overall Protection of Human Health and the Environment

Because the assessment of overall protection of human health and the environment draws on assessments conducted under the long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs criteria, further discussion of this criterion will be found in the discussions of those respective criteria, below.

Alternatives 1 and 2 satisfy this criterion because appropriate controls would be put in place to restrict installation of a drinking water well within the CS-19 plume. The current and potential future risk from CS-19 groundwater would remain under Alternatives 1 and 2. Under Alternative 2, performance of the CERCLA five-year reviews requires evaluation of the existing controls and would ensure the controls remain in place.

2.10.2.2 Compliance with ARARs

Pursuant to EPA guidance (OSWER Directive 9234.2-01FS-A, June 1991), ARARs are triggered only when a remedial action is taken. Therefore, there are no ARARs for Alternative 1.

As discussed in the CS-19 RI report (AFCEE 2003), the CS-19 plume has been defined by RDX concentrations above the HA. Perchlorate is also being monitored because it is a COC at other sites within the Impact Area. Chemical-specific standards and guidance values in accordance with the ARARs are presented in Table 2-5.

The CS-19 site is a previously disturbed area, yet an ecological risk assessment of the MMR identified several rare species and their habitats. Monitoring and well maintenance activities have the potential to impact certain moths and other species that move throughout the MMR, and activities under Alternative 2 will be conducted to minimize these impacts. Location-specific ARARs are presented in Table 2-6.

Installation and sampling of monitoring wells under Alternative 2 could invoke certain action-specific ARARs, specifically creation of airborne pollutants and handling and disposal of investigation derived materials. The action-specific ARARs for Alternative 2 are presented in Table 2-7.

Chemical-specific ARARs Alternative 2 allows for continued migration and natural attenuation of the plume. Because no active remediation is performed, chemical-specific ARARs (Table 2-5) would be met only when the COC RDX reaches the lifetime HA limit and perchlorate meets applicable cleanup standard, if necessary. Because these limits are not promulgated standards, they are "to be considered" guidance rather than ARARs. There are no promulgated standards that would be considered ARARs for RDX or perchlorate.

An HA establishes the concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effect over a lifetime of exposure with a margin of safety. For RDX, the EPA recommends an HA of 2 µg/L.

The EPA has issued guidance regarding perchlorate cleanup levels. On 18 February 2005, EPA issued an RfD of 0.0007 mg/kg/day for perchlorate. This level is consistent with the recommended RfD included in the National Academy of Science's January 2005 report on perchlorate. The MassDEP is proposing a cleanup standard of 1 µg/L. The MassDEP perchlorate standard is not promulgated.

Location-Specific ARARs An ecological assessment of the MMR identified several rare species and their habitats protected by the Massachusetts Endangered Species Act (MGL c.131A and 321 CMR 10.00 et seq.). These include the grasshopper sparrow (*Ammodramus savannarum*), the upland sandpiper (*Bartramia longicauda*), the northern harrier (*Circus cyaneus*), the sharp-shinned hawk (*Accipiter striatus*), the Cooper's hawk (*Accipiter cooperii*), the eastern box turtle (*Terrapene carolina carolina*), the Melsheimer's sack bearer moth (*Cicinnus melsheimeri*), the pink streak moth (*Faronta rubripennis*), and the northern white cedar (*Thuja occidentalis*). Pursuant to the Massachusetts Endangered Species Act (MGL c.131A, 2), actions that jeopardize state-

listed species or critical habitat must be avoided, or appropriate mitigation measures must be taken, in consultation with the Massachusetts Division of Fisheries and Wildlife. ARARs for the protection of state-listed species are included in Table 2-6.

Long-term monitoring and well maintenance activities have the potential to impact certain moths and other of these listed species on the MMR that could potentially wander into the monitoring areas. In planning LTM activities, AFCEE has considered impacts on the surrounding area so as not to jeopardize state-listed species and their habitat and to minimize adverse impacts as much as possible.

Action-Specific ARARs Installation and sampling of LTM wells under Alternative 2 could invoke certain action-specific ARARs addressing airborne pollutants and handling and disposal of purge water and other investigation derived waste (Table 2-6). LTM activities will meet all action-specific ARARs.

Elevation of particulate concentrations resulting from any incidental soil-disturbing activities will be controlled and kept to a minimum so as to comply with the applicable Massachusetts Air Pollution Control regulations governing visible emissions and fugitive dust. The state standards for noise may be applicable as well, if the sound levels meet the definition of "noise" as defined in 310 CMR 7.00. Elevation of particulates or noise is not anticipated with LTM activities due to the low impact of these activities and the previously disturbed nature of the monitoring areas.

Purge water and all secondary wastes (e.g., personal protective equipment) will be characterized and tested for the presence of RCRA hazardous waste as required under 40 CFR 262.11(a). Either process knowledge or prescribed testing methods may be used for this determination. None of the contamination in the CS-19 plume is at a level high enough for it to be considered RCRA characteristic waste and, thus, no investigation derived waste is expected to require handling and disposal as hazardous waste. Purge water and secondary wastes will be treated prior to release to ensure that releases will not cause any violation of drinking water standards or guidelines in the receiving aquifer. The spent activated carbon from the treatment of purge water and secondary wastes will

be sent to a carbon-recycling center. Massachusetts RCRA Subtitle D regulations for solid waste management (310 CMR 19.000 et seq.) will apply to the handling and subsequent disposal of any material determined to be solid waste.

2.10.2.3 Long-Term Effectiveness and Permanence

Alternatives 1 and 2 do not actively remediate the plume and allow the plume to naturally attenuate. Therefore, both alternatives have the same long-term effectiveness and permanence. Once the RDX concentrations have decreased to below the HA level, there is minimal risk of exposure to groundwater at concentrations that would pose unacceptable health risks. Natural attenuation processes are irreversible physical, chemical, and biological reactions. Thus, reduction of RDX concentrations for both alternatives is permanent.

2.10.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Neither alternative actively treats the toxicity, mobility, or volume of contamination. Natural attenuation would reduce RDX levels and eventually restore the aquifer to its beneficial use.

2.10.2.5 Short-Term Effectiveness

There is no short-term impact to community, workers, or the environment under Alternative 1. Alternative 2 involves periodic monitoring, which does not pose short-term impacts to community or environment. Short-term impact to workers is low, since precautions for munitions or chemical exposure while sampling are controlled with standard safety and operating procedures, including personal protective equipment, monitoring instruments, and a site health and safety plan. Most of the monitoring wells in the groundwater monitoring plan are already being sampled by the IAGWSP on a regular basis; thus, no new risks to workers are presented with Alternative 2.

For both alternatives, RDX concentrations are expected to decrease to below the HA level in approximately 13 years.

2.10.2.6 Implementability

Because Alternative 1 is no action, there are no implementability issues.

Technical implementability concerns for Alternative 2 are not significant. The techniques, equipment, specialists, and facilities would be similar to those already involved with the current IAGWSP monitoring program. No new monitoring wells are expected to be installed under this alternative. However, if monitoring well installation is required, the techniques, material, and labor would be similar to that already performed at the MMR.

Administrative implementability concerns under Alternative 2 would include coordination with other agencies (EPA, MassDEP, Army) using the existing venues, which includes technical update meetings, remedial project manager meetings, and active communication. All monitoring wells are on the MMR, so there are no administrative implementability issues with obtaining access agreements with private landowners or towns. Impact Area access is already coordinated with the Army.

2.10.2.7 Cost

The cost of the no action alternative (Alternative 1) is $0. The estimated cost of Alternative 2 is approximately $1 million, represented as a present value. There are no capital costs associated with Alternative 2. Costs are for semiannual explosives and perchlorate monitoring and reporting results of 32 wells over 15 years. See Table 2-8 and Table 2-9.

2.10.2.8 State Acceptance

The MassDEP has expressed its support for Alternative 2.

2.10.2.9 Community Acceptance

A Proposed Plan was presented to the public in January 2005 (AFCEE 2005), and a public hearing was held on 15 February 2005. Appendix B of this IROD contains the

transcript of the public hearing. Section 3.0 of this IROD, Responsiveness Summary, summarizes the written comments received during the public review period and provides AFCEE's responses to the comments. The commenters did not directly oppose either interim alternative, but did support active remediation of the plume.

2.11 SELECTED INTERIM REMEDY FOR THE CS-19 GROUNDWATER OPERABLE UNIT

Based on the administrative record for the CS-19 site and the evaluation of comments received by interested parties during the public comment period, AFCEE has selected Alternative 2 as the interim remedy for the CS-19 groundwater OU.

2.11.1 Selected Interim Remedy Summary

Alternative 2 includes the following components:

- Sampling for RDX and perchlorate of selected monitoring wells within and surrounding the CS-19 plume. The number of monitoring wells is proposed at 32, and the frequency is proposed at semiannually. But the number and frequency may increase or decrease to ensure adequate data are collected to monitor the plume.
- Reporting of monitoring results.
- Continued use of site access restrictions, such as locked gates to the site and procedures for entering the Impact Area, and institutional controls for prohibiting new drinking water sources.
- Periodic reviews to include periodic verification of monitoring program appropriateness/optimization, and CERCLA five-year reviews of interim remedy appropriateness and site status.

2.11.2 Detailed Description of Selected Interim Remedy

The CS-19 plume is located in and commingled with the CIA groundwater plume and study area. AFCEE recommends long-term groundwater monitoring as an interim remedy until a final remedy is determined and implemented. A final remedy will be evaluated and selected in conjunction with the evaluation and selection of a remedy for the CIA. To accomplish this comprehensive approach, AFCEE will coordinate the collection and interpretation of CS-19 information with the IAGWSP. The combined

information will be used to evaluate the groundwater plume, determine if contaminant concentrations are naturally decreasing to acceptable levels as predicted, and determine if aquifer restoration is occurring. Until a final remedy is selected, periodic monitoring and reporting, LUCs, and five-year reviews will ensure that the remedy continues to provide adequate protection of human health and the environment. The following subsections outline the details for the LUCs and the LTM components of the interim remedy.

2.11.2.1 CS-19 Land Use Controls

The groundwater from the CS-19 plume currently poses an unacceptable risk to human health if used for drinking water purposes. The CS-19 plume is located on the MMR within the Upper Cape Water Supply Reserve, which includes the Camp Edwards Training Area, and is not expected to migrate past the MMR boundary. Therefore, administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use, known as LUCs must be established for this area of concern, in this case to avoid risk of exposure to groundwater in the CS-19 area. These LUCs are needed during the interim period until a final remedy is selected for the groundwater from the CS-19 plume in connection with the future selection of a remedy for the groundwater impacted by the CIA plume, which is co-located with the CS-19 plume.

The area of concern and surrounding area is controlled and operated by the U.S. Department of the Army, which leases this land from the Commonwealth of Massachusetts. It is expected that these entities will operate and own, respectively, the area of concern and the surrounding area for the duration of this IROD. As a result, the Air Force must develop and coordinate the LUCs for this site with these entities, as appropriate.

The performance objectives of the LUCs are:

- Prevent access to or use of the groundwater from the CS-19 plume area until the groundwater no longer poses an unacceptable risk or is otherwise addressed pursuant to a final remedy.
- Maintain the integrity of any current or future groundwater monitoring system.

The LUCs will encompass the area including the CS-19 plume (indicated on Figure 2-7 in this IROD) and surrounding areas as necessary to prevent a risk from exposure to contaminated groundwater. For the CS-19 plume, the Air Force is responsible for ensuring that LUCs are established, monitored, maintained, reported on and enforced as part of the interim remedy to ensure protection of human health and the environment in accordance with CERCLA and the NCP for the duration of the interim remedy selected in this IROD. The Air Force will work with the U.S. Department of the Army, Massachusetts Army National Guard, and the Commonwealth, whose cooperation will be needed for implementing, operating, maintaining, monitoring, reviewing, and/or enforcing these LUCs. The Air Force will inform these entities of the performance objectives of the LUCs and will request that compliance with the LUCs listed in this section be established as part of the standard operating procedures in the land management systems of those entities that operate in the area of concern.

The MassDEP administers a permitting process for any new drinking water supply wells in Massachusetts that propose to service more than 25 customers or exceed a withdrawal rate of 100,000 gallons per day. This permitting process, which serves to regulate the use of the CS-19 area for any withdrawals of groundwater for public drinking water purposes, constitutes one LUC for this interim remedy.

The Environmental Performance Standards (EPS) incorporated as Appendix 2 to the MOA made by and among the Commonwealth of Massachusetts, the U.S. Department of the Army, and the National Guard Bureau dated 04 October 2001, specifies that the development of water supplies will be permitted within the Camp Edwards Training Area after review and approval by the managing agencies, principally the Department of the Army and its divisions, together with the MassDEP, and the Massachusetts Division of Fisheries and Wildlife. The Environmental Management Commission, pursuant to this MOA and An Act Relative to the Environmental Protection of the Massachusetts Military Reservation, Chapter 47 of the Acts of 2002, effective 05 March 2002, oversees compliance with the EPS within the Upper Cape Water Supply Reserve, which includes the Camp Edwards Training Area. The EPS, which regulates the use of the CS-19 area

for any withdrawals of groundwater for drinking water purposes, also constitutes a LUC for this interim remedy. The Air Force does not manage this LUC, but will report on it as part of the annual monitoring report.

Massachusetts is a participant in the Dig Safe program. This program requires, by law, anyone conducting digging activities (e.g., well drilling) to request clearance through the Dig Safe network. The Air Force at the MMR is a member utility of Dig Safe. The CS-19 groundwater plume is encompassed by a geographical area identified by the Air Force as a notification region within the Dig Safe system. Through the Dig Safe process, the Air Force will be electronically notified at least 72 hours prior to any digging within this area. The notification will include the name of the party contemplating, and the nature of, the digging activity. If the digging activity is intended to provide a previously unknown water supply well, the Air Force will immediately notify the project sponsor (of the well drilling), the EPA and MassDEP in order to curtail the digging activity. This notification process, which may prevent the installation of water supply wells not addressed by the MassDEP regulations for public water supply wells, described above, also constitutes a LUC for this interim remedy

LUCs will be maintained until the concentrations of RDX in the groundwater are at such a level to allow unrestricted use and unlimited exposure, unless and until such LUCs are modified or are no longer required pursuant to a future final selected remedy for the CS-19 plume in connection with the selection of a remedy for the CIA plume.

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

The annual monitoring report, submitted to the Army and the regulatory agencies by the Air Force, will evaluate the status of the LUCs and how any LUC deficiencies or

inconsistent uses have been addressed. The annual evaluation will address (1) whether the use restrictions and controls referenced above were effectively communicated, (2) whether the operator, owner, and state and local agencies were notified of the use restrictions and controls affecting the property, and (3) whether use of the property has conformed with such restrictions and controls and, in the event of any violations, summarize what actions have been taken to address the violations.

The Air Force may transfer various operational responsibilities for institutional controls (i.e., monitoring) to other parties through agreements. However, the Air Force, as the currently designated lead agent under the FFA, acknowledges its ultimate liability under CERCLA for remedy integrity, including for the performance of any transferred operational responsibilities.

The Air Force shall notify EPA and MassDEP 45 days in advance of any proposed land changes that would be inconsistent with the LUC objectives or the interim remedy. If the Air Force discovers a proposed or ongoing activity that would be or is inconsistent with the LUC objectives or use restrictions, or any other action that may interfere with the effectiveness of the LUCs, it will address this activity or action as soon as practicable, but in no case will the process be initiated later than ten (10) days after the Air Force becomes aware of the breach. The Air Force will notify EPA and MassDEP as soon as practicable but no later than ten (10) days after the discovery of any activity that is inconsistent with the LUC objectives. The Air Force will notify EPA and MassDEP regarding how the Air Force has addressed or will address the breach within ten (10) days of sending EPA and MassDEP notification of the breach.

The Air Force will provide notice to EPA and MassDEP at least six (6) months prior to the Army relinquishing the lease for the CS-19 area so that EPA and MassDEP can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective LUCs. If it is not possible for the Air Force to notify EPA and MassDEP at least six months prior to any transfer or sale,

then the Air Force will notify EPA and MassDEP as soon as possible, but no later than 60 days prior to the transfer or sale of any property subject to LUCs.

The Air Force shall not modify or terminate LUCs, implementation actions, or modify land use without approval by EPA and MassDEP. The Air Force, in coordination with other agencies using or controlling the CS-19 area, shall seek prior concurrence before taking any anticipated action that may disrupt the effectiveness of the LUCs or any action that may alter or negate the need for LUCs.

2.11.2.2 CS-19 Long-Term Monitoring

AFCEE has developed a monitoring plan for the CS-19 groundwater OU that will include data from a network of 32 monitoring wells located along the boundaries of the plume (horizontal extent) and within the plume at various depths (vertical extent). Table 2-4 lists the 32 monitoring wells, with their screen depths, justification for selection as a monitoring well, and the analytes of interest. Wells will be sampled semiannually. Figure 2-8 shows the plan view of the CS-19 groundwater plume with the wells selected for AFCEE's interim groundwater monitoring program. Each sample will be analyzed for RDX by EPA Method SW8330 (reporting limit = 0.25 µg/L) and for perchlorate by EPA Method E314.0 (reporting limit = 1.0 µg/L).

Semiannual monitoring results will be reported in a data transmittal. Evaluation of all analytical results will include tracking the RDX plume migration and dispersion and monitoring perchlorate concentrations for plume contribution. The monitoring plan itself will be reviewed annually for adequate coverage of the plume and optimization, and the decision to implement monitoring as an interim remedy will be reviewed every five years (see Section 2.12.6).

Monitoring will continue for two years beyond the time at which RDX concentrations decrease below the HA, or until a final remedy for the site is determined. Existing controls will remain in place to restrict placement of a drinking water well within the CS-19 plume.

2.11.3 Cost Estimate for the Selected Interim Remedy

The cost estimate for Alternative 2 is provided in Table 2-8 and Table 2-9. The cost estimate was based on the following assumptions. The specific number of wells, monitoring frequency, and reporting frequency may change over the lifetime of the monitoring program due to changes in plume characteristics, monitoring optimization, or as a final remedy is selected and implemented.

- Semiannual sampling of 32 groundwater wells and analysis for RDX by EPA Method SW8330 and perchlorate by EPA Method E314.0.
- Assume the HA is reached in 13 years. Assume monitoring continues for two years after the HA is reached.
- Standard quality control samples will be collected in the field (field duplicates, equipment blanks, matrix spike/matrix spike duplicate) at standard frequencies.
- Sampling costs include labor, sampling equipment, vehicles, expendable items, personal protective equipment, monitoring instruments, logbooks, and equipment maintenance.
- Data will be reported in two data transmittals per year.
- CERCLA five-year reporting is included, but is part of a larger report of all sources and systems at the MMR.
- One residual risk assessment will be performed when the HA level is reached (if needed).
- Annual costs were discounted at 2.8 percent, based on EPA guidance (July 2000) and Office of Management and Budget Circular A-94, revised January 2005 (www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html) (EPA 2000; OMB 2005).

2.11.4 Estimated Outcomes of the Selected Interim Remedy

The groundwater model suggests that the RDX plume will disperse to concentrations less than the lifetime HA of 2 µg/L in 13 years and will not cross the MMR boundary, provided MM and MC are removed from the source area (AFCEE 2003). The current contaminant levels in groundwater present a low risk to humans, and active cleanup of the plume is not recommended until further monitoring is completed and a final decision on a remedy is made in conjunction with the CIA plume.

Until a final remedy is selected and implemented, AFCEE and the IAGWSP will coordinate collected CS-19 information to evaluate the groundwater plume, determine if contaminant concentrations are naturally decreasing to acceptable levels, and determine if aquifer restoration is occurring.

2.12 STATUTORY DETERMINATIONS

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

2.12.1 Protection of Human Health and the Environment

The selected interim remedy will protect human health and the environment through insuring implementation of LUCs and monitoring of the groundwater plume to ensure contaminant concentrations are being reduced through dispersion to below the HA level, as predicted by the groundwater model. Monitoring and LUCs will prevent residential exposure to the CS-19 plume, which lies downgradient of the source area and within the CIA. There are no short-term threats associated with the selected remedy that cannot be readily controlled.

2.12.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected interim remedy of LTM of the CS-19 plume complies with all chemical-, location-, and action-specific ARARs. See Table 2-5, Table 2-6, and Table 2-7.

2.12.3 Cost-Effectiveness

In AFCEE's judgment, the selected interim remedy for CS-19 groundwater is cost-effective. The overall effectiveness of the selected remedy was determined to be proportional to its costs and, hence, to represent a reasonable value for the money to be spent.

The cost-effectiveness of the CS-19 remedy was evaluated based on the data currently available for the CS-19 plume and the following considerations: (1) the remedy selected at this time is interim; (2) the final remedy will be evaluated with the evaluation of the CIA plume remedy in accordance with the MOU dated 13 December 2004; (3) the plume is naturally attenuating and RDX contamination is predicted to disperse to concentrations less than the RDX HA within 13 years and before reaching the MMR boundary; (4) LTM allows the plume dispersion to be verified.

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

The selected remedy does not treat the principal threat at the site, but does satisfy the criteria for long-term effectiveness and permanence by allowing natural attenuation to reduce RDX concentrations to acceptable levels. The selected remedy does not present short-term risks. There are no special implementability issues that make the selected remedy unacceptable.

2.12.5 Preference for Treatment as a Principal Element

The selected interim remedy does not treat the contamination present in the CS-19 plume. Because the CS-19 plume is surrounded by the CIA plume, and studies of the CIA plume are currently underway to determine the possible remedial alternatives for that plume, LTM with LUCs will serve as an interim remedy for the CS-19 plume until sufficient information on the CIA plume is available to determine possible remedial alternatives for both the CS-19 plume and the CIA plume. Should the plume persist and be present at the time a final remedy is evaluated for the CIA plume, treatment may be selected as the final

remedy. Although the statutory preference is for remedies that employ treatment as a principal element, active treatment is not practical at this stage.

2.12.6 Five-Year Review Requirements

Five-year statutory reviews will be performed, according to Section 121(c) of CERCLA and NCP Section 300.430(f)(5)(iii)(C). The purpose of the five-year reviews is to revisit the appropriateness of the interim remedy in providing adequate protection of human health and the environment. The five-year review for the CS-19 groundwater OU will be part of the five-year reviews conducted for the CERCLA IRP sites that are on the MMR.

2.13 DOCUMENTATION OF SIGNIFICANT CHANGES

AFCEE prepared a proposed plan for Interim Action (PPIA) for the CS-19 groundwater OU (AFCEE 2005). The PPIA described AFCEE's proposal for groundwater monitoring of the CS-19 plume as an interim remedy, and AFCEE's plan to develop a final remedy in conjunction with selection of a remedy for the CIA plume. AFCEE reviewed all formal comments received during the public comment period and determined that no significant changes to the remedy, as originally identified in the PPIA, were necessary.

3.0 RESPONSIVENESS SUMMARY FOR THE CHEMICAL SPILL-19 (CS-19) GROUNDWATER PLUME PROPOSED PLAN FOR INTERIM ACTION

PREFACE

This Responsiveness Summary has been prepared to meet the requirements of Sections 113(k)(2)(B)(iv) and 117(b) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), which requires responses to "... significant comments, criticisms, and new data submitted in written or oral presentations" on a Proposed Plan for remedial action. The purpose of this Responsiveness Summary is to document the Air Force Center for Environmental Excellence (AFCEE's) responses to questions and comments expressed during the comment period by the public and potentially responsible parties in written and oral comments regarding the *Chemical Spill 19 (CS-19) Groundwater Plume Proposed Plan for Interim Action (CS-19 PPIA).*

The public has been kept up-to-date on the progress of the CS-19 site through various public and citizen team meetings and public notices. From 14 January 2005, to 16 February 2005, AFCEE held a 34-day comment period to accept public comments on the single interim remedy. The public comment period was extended from 12 February 2005 to 16 February 2005 in response to re-scheduling the public hearing due to inclement weather. On 12 January 2005, AFCEE held a public meeting at the Falmouth Holiday Inn to present information on the CS-19 PPIA in conjunction with the monthly Plume Cleanup Team (PCT) meeting. Presentations were also made to the PCT on 08 December 2004 and 12 January 2005. At these meetings, representatives from AFCEE presented the Plan and answered questions from the audience. On 15 February 2005, AFCEE held a public hearing at the Bourne Best Western to accept formal public comments. A transcript of the public hearing is provided in Appendix C of the PPIA document. One individual provided verbal comments at the public hearing. No written comments were received by AFCEE from any community group.

AFCEE published a display advertisement for the public information meeting for the CS-19 PPIA in the *Falmouth, Mashpee, Bourne* and *Sandwich Enterprises*, the *Cape Cod Times* on 01 January 2005. AFCEE also published a display advertisement for the public information meeting and public comment period for the CS-19 PPIA in the *Falmouth, Mashpee, Bourne* and *Sandwich Enterprises*, and the *Cape Cod Times* on 10 January 2005. The announcement of the public hearing was contained in display advertisements run in the *Falmouth, Mashpee, Bourne* and *Sandwich Enterprises*, the *Cape Cod Times* on 04 February 2005 and 11 February 2005.

The final remedial investigation (RI) report describes the extent of contamination across the CS-19 site and was made available to the public in October 2003. A feasibility study (FS) has not yet been prepared for CS-19 groundwater. Before the start of the comment period, AFCEE made the RI reports and PPIA available for public review at the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts, at the AFCEE IRP office, and on the MMR website. The PPIA has also been made part of the

Administrative Record available for public review at the AFCEE IRP office at MMR, at the Bourne Public Library and available on the MMR website, http://www.mmr.org.

AFCEE's responses to the comments received at the hearing and during the public comment period are included in Section 3 of this Responsiveness Summary. This Responsiveness Summary is organized into the following sections:

1 "Overview of Selected Interim Remedy." This section briefly outlines the interim remedial action presented in the PPIA.

2 "Background on Community Involvement." This section provides a brief history of community involvement and AFCEE's initiatives to inform the community of site activities.

3 "Summary of Comments Received During the Public Comment Period and AFCEE Responses." This section provides AFCEE's responses to verbal and written comments received from the public. Copies of the comment letters are included in Attachment A of this Responsiveness Summary. A transcript of the 15 February 2005 public hearing is included as Appendix C of the Interim Record of Decision.

1. Overview of the Selected Interim Remedy

Proposed Plans usually present an analysis of several cleanup alternatives. However, this is an interim plan and only discusses a proposed groundwater monitoring program. EPA guidance permits issuance of PPIAs without a presentation of the alternatives from an FS. This interim alternative has been put forth as an initial recommendation by AFCEE for public comment for the groundwater plume. Active remediation alternatives will be evaluated with the Army's evaluation of groundwater remediation in this area.

AFCEE recommends monitoring of the CS-19 groundwater plume as an interim remedy. The CS-19 soil operable unit is being investigated and remedied separately from the groundwater; however, it is anticipated that the sources of groundwater contamination will be excavated and either treated on site and/or disposed of off MMR. A separate document is being prepared for the source area removal action, and it will be presented to the public for comment. This interim approach was developed with input from the regulatory agencies, EPA and MassDEP.

The CS-19 plume is located in the Central Impact Area (CIA) and may be comingled with the CIA groundwater plume. A final remedy for CS-19 Groundwater Operable Unit (GWOU) and the Army's CIA site will be evaluated and selected in a unitary, comprehensive manner at such time that all pertinent technical information is available. To accomplish this comprehensive approach, AFCEE will coordinate collected CS-19 information with the Impact Area Groundwater Study Program (IAGWSP). The combined information will be used to evaluate the groundwater plume and to evaluate a range of alternatives which restore the aquifer in a reasonable period of time. Until a final remedy is selected, periodic monitoring reports and five-year reviews will ensure

the interim remedy continues to provide adequate protection of human health and the environment. The recommendation for monitoring was made based on groundwater modeling and a risk assessment presented in the October 2003 CS-19 RI report and with consideration of the status of the RI and FS for the CIA. This is solely an interim measure and does not reflect the final actions that will be taken to ensure the long-term protection of human health and the environment on and off the MMR.

2. Background on Community Involvement

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

In addition, two citizen teams advise the IRP and the regulators about the program. They include the Senior Management Board and the PCT which previously had been called the Joint Process Action Team (JPAT). The JPAT had been made up of the Plume Containment Team, the Long-Range Water Supply Team, and the Public Information Team. For the Army component of the MMR environmental program, the Impact Area Groundwater Study Program is advised by the Impact Area Review Team (IART). The IART, although not an AFCEE forum, is a citizen advisory committee that serves as a technical advisory resource and allows the EPA to hear first hand the concern of the public related to the ongoing investigation and cleanup effort at Camp Edwards including the CS-19 site. These teams are made up of citizen volunteers and government representatives working together to resolve problems and complete the cleanup. All citizen team meetings are open to the public.

AFCEE's responses to the comments received at the hearing and during the public comment period are included in Attachment A. These written and verbal comments were primarily concerned with the certainty of a cleanup action and detailed questions about computer modeling work.

3. Summary of Public Comments Received During Public Comment Period and AFCEE Responses

Part I: Summary and Response to Local Community Concerns

Comment:

Susan Walker, Plume Cleanup Team Member, representing herself as a Sandwich resident.

I am submitting these comments to be part of the formal record of the Draft CS-19 Proposed Plan for Interim Action. I have been following this plume for fifteen years.

During that time period no clean up has taken place and the plume has been allowed to migrate and contaminate more groundwater. This plume deserved remediation years ago.

Now AFCEE wants to monitor the plume for the interim action. How much longer does the public have to wait for cleanup?

I understand that AFCEE is waiting for the Central Impact Work to be done and for a joint decision to be made. I could accept that, if there were a guarantee that CS-19 will be cleaned up. To wait several more years and then find out that the plan is not to cleanup CS-19 seems like a cruel joke on the public. The public has been patient and deserves to know that a real active cleanup is the fate of CS-19.

Response:

Thank you for your comment. AFCEE appreciates the effort you have made to stay involved with the cleanup program and respects your concerns for active treatment of the CS-19 groundwater plume.

A final remedy for CS-19 GWOU and the Army's CIA site will be evaluated and selected in a unitary, comprehensive manner at such time that all pertinent technical information is available. Based on information received from the Army's IAGWSP Office at MMR, AFCEE expects that a final groundwater cleanup plan for both the CIA and the CS-19 GWOU will be developed within the next two to three years. AFCEE intends to take the most appropriate cleanup action once the surrounding area is more fully investigated by the Army. The combined information will be used to evaluate the groundwater plume and to evaluate a range of alternatives that restore the aquifer in a reasonable period of time. Until a final remedy is selected, periodic monitoring reports and five-year reviews will ensure the interim remedy continues to provide adequate protection of human health and the environment. This is solely an interim measure and does not reflect the final actions that will be taken to ensure the long-term protection of human health and the environment on and off the MMR. After CS-19 source area soils have been removed, a more thorough evaluation of the final cleanup actions for the CS-19 groundwater plume will be made in conjunction with the IASGWSP.

Comment:

Frederick C. Carlton, Cape Cod Resident.

I'm not sure what to say about the air force's decision not to clean up CS-19 till other plumes and their impacts are researched. All I know is that the Army has no excuse to leave you and your men to single handedly monitor, research, and clean up the super-toxic site that is the impact zone. I hope that you have some of your best men on the job and are taking an extremely expedient approach to figuring out what else is below the surface.

As a lifetime Cape resident, I feel that the Army should be held liable for all damages especially those done to members of the community who have to suffer through drinking completely tainted water. As an environmental studies and public economics major I know both how serious perchlorate can be and the extent to which the Army should be

held financially responsible. I commend you and the Air Force for being responsible and saying you'll clean the area, I just want to know how much time you will take before you take action. As you know water 90% of the time is not localized and is constantly moving underground, so what kind of time frame are we looking at before CS-19 reaches drinking water, and given that Bourne closed 3 of their 6 water wells in 2002 due to high perchlorate levels what makes you think cape water isn't already heavily contaminated by the seeping chemicals of military ignorance?

Response:

Thank you for your comment. AFCEE's first and foremost role is to be protective of human health and the environment. Every effort has been made in the last decade to connect residents' homes to a safe drinking water source or to test their private drinking-water wells to ensure that any potential contamination is detected.

AFCEE and the Army are working cooperatively to investigate contamination in the Central Impact Area and together will develop a final remedial solution for cleanup of that portion of the aquifer. Based on current data, RDX has been identified as the contaminant of concern (COC) for the CS-19 site. Current modeling work predicts that RDX in groundwater from the CS-19 site would reach the MMR boundary in approximately 13 years at concentrations less than the EPA's lifetime health advisory of 2 ppb.

Perchlorate has been detected at very low concentrations and is not currently detected in enough wells to be considered a COC. While perchlorate was not identified as a COC in the CS-19 RI, AFCEE has agreed with EPA that perchlorate should be considered a contaminant to monitor and the groundwater sampling plan will include perchlorate analysis.

Part II: Comprehensive Response to Specific Legal and Technical Questions

Peter Schlesinger, Impact Area Review Team Member, representing himself as a Sandwich resident provided the following comments:

Comment #1:

What are the factors used by the model that predict that the CS-19 RDX plume will dilute to less than a 2 ppb HA within 13 years?

Response #1:

For a detailed description of the contaminant fate and transport parameters, unsaturated flow modeling and saturated solute transport modeling, please refer to Sections 8.2 through 8.4 of the CS-19 RI Report, which can be found in the Administrative Record for the site (Admin. Record document #16913). The parameters controlling the natural attenuation of the plume are represented in the saturated solute fate and transport model. The parameters considered in this model of RDX transport at CS-19 include recharge, advection, dispersion, bulk density, effective porosity, retardation and adsorption,

degradation and plume shell development/initialization in the model. The values or characteristics of each of these and their application in the model are discussed in Section 8.2 of the CS-19 RI. References for the sources of parameter values are included in the RI Report with the discussion. It is important to note that the values used for these parameters are considered representative of aquifer properties for the Sagamore Lens based on numerous field studies and modeling applications across western Cape Cod. For those parameters that are contaminant-specific, such as adsorption and degradation, conservative values were used. Because no degradation is applied in the RDX Transport model, the processes of advection (primarily) and dispersion are largely responsible for the attenuation of RDX. Even if no dispersion was applied in the model, only a few additional years would be required for the plume to attenuate below the health advisory of 2µg/L by advection alone. The travel time of contaminants through the vadose zone was not included in the 13-year estimate for concentrations to fall below the health advisory, as noted in the CS-19 RI.

Comment #2:

Please show peer-reviewed literature evidence that RDX can naturally attenuate.

Response #2:

Modeling for the RI used information from AMEC Earth and Environmental's *Draft Technical Memorandum 01-1. Shallow* Soil *Background Evaluation* (AMEC 2001) to derive RDX concentrations in leachate. Conclusions from a literature survey performed for the same document were used to determine RDX adsorption. Partition coefficients were measured by the University of Texas for the Impact Area under contract with the IAGWSP (AMEC 2001). The distribution coefficient was determined with measurements from Year 2000 CS-19 investigations.

Degradation of RDX (McGrath 1994; DuBois and Baytos 1972) assumed not to occur.

Dispersion was quantified based on studies by Luckner and Schestakow (1991),, Spitz and Moreno (1996), Hess et al. (1991), and AFCEE (1999b and 2001b)

AMEC Earth and Environmental. 2001 (January). *Draft Technical Memorandum 01-1. Shallow Soil Background Evaluation.* Prepared by AMEC for National Guard Bureau, Arlington, VA.

DuBois, F.W. and J.F. Baytos. 1972. *Effect of Soil and Weather on the Decomposition of Explosives.* LA-4943, Los Alamos National Laboratory, Los Alamos, NM.

McGrath, C.J. 1994. *Review of Formulation for Processes Affecting the Subsurface, Transport of Explosives.* Prepared for U.S. Army Corps of Engineers.

Luckner, L. and W.M. Schestakow. 1991. *Migration Processes in the Soil and Groundwater Zone.* Chelsea, MI: Lewis Publishers Inc.

Spitz, K. and J. Moreno. 1996. *A Practical Guide to Groundwater and Solute Transport Modeling.* New York, NY: John Wiley and Sons, Inc.

Hess, K.M., S.H. Wolf, M.A. Celia, and S.P. Garabedian. 1991. *Macrodispersion and Spatial Variability of Hydraulic Conductivity in a Sand and Gravel Aquifer, Cape Cod, Massachusetts.* Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma. U.S. Environmental Protection Agency, Environmental Research Brief EPA/600/M-91/005, 9p.

AFCEE (U.S. Air Force Center for Environmental Excellence). 2001b. *Plume Response Groundwater Modeling Report – Model Recalibration 2001.* A3P-J23-35Z01518-M23-0001. Prepared by Jacobs Engineering Group Inc. for AFCEE/MMR Installation Restoration Program, Otis Air National Guard Base, MA.

AFCEE (U.S. Air Force Center for Environmental Excellence). 1999b (July). *Final CS-19 Supplemental Groundwater Investigation Report.* AFC-J23-35G48400-M13-0009. Prepared by Jacobs Engineering Group Inc. for AFCEE/MMR Installation Restoration Program, Otis Air National Guard Base, MA.

Comment #3:

Please demonstrate that there is sufficient knowledge of the mass of the unexcavated source material to adequately determine how long it will take to move, where it will move, and what concentrations will result over what period of time?

Response #3:

The CS-19 site was extensively investigated in two phases.

In 2000, the initial soil RI was conducted using a grid system. Soil sampling locations were equally spaced every 100 feet along a grid for a total of 25 locations. In addition, four other sampling locations were placed along the sides of a 50-foot subgrid centered on the central location of the larger grid.

Surface soil samples were collected as composite samples from five sub-sampling locations at each of the selected 29 sampling grid points. The first interval was collected from the surface to 0.5 foot below ground surface (bgs). The second interval was collected from 1.5 to 2 feet bgs.

Subsurface soil samples were also collected from six locations at the center of the surface soil sampling grid. Attempts were made to collect samples from four intervals per location (2-4, 4-6, 6-8, and 8-10 feet bgs).

A total of 58 surface, 33 subsurface, and 11 field duplicate soil samples were collected for analysis for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, herbicides, explosive compounds, and inorganics to determine the nature and extent of contamination at the study area.

RDX was detected in three samples of a single location [58BH0003 (240 µg/kg at 2–4 feet bgs) and 58SS0015 (380 µg/kg at 0–0.5 foot bgs and 520 µg/kg at 1.5–2 feet bgs)]. The chemical, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine, (HMX) was detected once at location 58BH0003 (210 µg/kg at 2–4 feet bgs). One form of the chemical

dinitrotoluene (DNT), 2,4-DNT was reported twice at locations 58SS0014 (190 µg/kg at 0–0.5 foot bgs) and 58SS0022 (250 µg/kg at 0–0.5 foot bgs). At location 58SS0021, another type of DNT, 2A-DNT (370J µg/kg at 0–0.5 ft bgs) and an additional type of DNT, 4A-DNT (370J µg/kg at 0–0.5 ft bgs) were reported. At location 58SS0023, TNT (220 µg/kg at 0–0.5 ft bgs) was reported. In summary, one or more explosive compounds were detected in six of the 29 soil sampling locations.

In 2001, a supplemental RI was performed to address data gaps identified during the initial RI. Subsurface characterization involved excavation of three large test pits (i.e. trenches) in areas with magnetic anomalies, expecting that these areas would have the highest explosives concentrations. In addition, two deep boreholes were installed at locations in the trenches associated with potential explosive contaminant sources. The trenches were excavated to a depth of 10 feet bgs.

Subsurface soil samples in the trenches were collected following UXO clearance, and prior to excavation activities. For sampling purposes, trench 1 was divided into five 20-foot long cells. Trenches 2 and 3 were divided into four 10-foot long cells. The widths of the trench cells started at 32 feet at the surface, and diminished at a 1:1.5 ratio to 2 feet wide at the bottom. All trenches were terminated at 10 feet bgs.

Composite screening samples were collected from each trench cell at 2-foot intervals, starting at 1 foot bgs. Each sample consisted of approximately 200 grams of soil from the four corners and the center of each cell. Samples were collected at each cell at depths of 1, 3, 5, 7, and 9 ft bgs. In addition to these composite samples, samples were also collected under potential contaminant sources, and under the two blown-in-places (BIPs) in Trench 2. A total of 80 samples were collected.

In the boreholes, soil samples were collected at 2-foot intervals from the bottom of the trench to 10 feet below the bottom of the trench.

The highest concentrations of RDX and HMX of any of the trench samples were 1200 milligrams per kilogram (mg/kg) for RDX and 120 mg/kg for HMX. A subsequent (aliquot) equally divided sub-sample of this sample was analyzed and did not have a measurable HMX concentration and the RDX concentration was 9 mg/kg. This disparity of concentrations between the sub-samples (aliquots) in the same sample seems to indicate that there are very small explosive particulates in the soil and that this contamination is very limited.

The majority of the trench samples did not contain significant concentrations (less than the reporting limits) of any of the explosive compounds. All detections above the reporting limit were within 3 feet of the ground surface with the exception of those collected around the cache of 155mm projectiles discovered in Trench 2. Samples collected beneath surface ordnance debris also exhibited contamination that was limited to shallow samples. Among the detected explosive compounds, RDX (21 detections in 80 samples), HMX (11/80), and the trinitrotoluene (TNT) degradation products 2-DNT

and 4-DNT (8/80 each) were the most commonly detected. The remaining explosive compounds were detected in fewer than 5 percent of the samples.

The data summarized above provided ample evidence to develop a site-specific conceptual model and to support the evaluation of the fate and transport of the contaminants from the unexcavated source material in the unsaturated soil (vadose zone) and to the underlying aquifer in the CS-19 area.

The evaluation of the fate and transport of contaminants involved multiple approaches and extensive analysis. All the analyses were conducted using conservative assumptions in terms of source thickness and concentration.

- **Determining the infiltration through the unsaturated zone:** This was calculated by several methods including the unsaturated hydraulic conductivity function method and the HELP and SESOIL models.
- **Estimating contaminant leachate concentrations:** This was done with the SESOIL model.
- **Calculating the rate of mass loading:** This was calculated by dividing the amount of mass in the CS-19 plume by the years of possible discharge, and developed from information derived from simulations with the SESOIL model.
- **Determining the potential for creating a ground water plume:** This was done by considering dilution in the upper 5 ft of the aquifer using the Summers and SESOIL models.

Based on the unsaturated zone and aquifer characteristics (material properties and thickness), the time for the contaminant to reach the water table below (120 ft bgs) would be 5–7 years. Using the maximum concentration in the soil (1200 mg/kg for RDX), the resulting maximum concentration in groundwater would be 65 ug/L. The time for source depletion for the site is estimated to be less than 20 years without additional source contribution.

Comment #4:

Please demonstrate sufficient knowledge of the Fate and Transport of RDX.

Response #4:

Section 8.2 of the *Final Chemical Spill-19 Remedial Investigation Report* provides a detailed discussion of contaminant fate and transport evaluation. Cited references include those listed in the response to Comment #2 plus the following.

Baumer, O. W. and Brasher, B. R. 1982. *Prediction of Water Content at Selected Suctions.* USCS computer code SWRDAT, American Society of Agricultural Engineers, Paper No. 82-2590.

van Genuchten, M. Th., F.J. Leij, and S.R. Yates. 1991. *The RETC Code for Quantifying the Hydraulic Functions of Unsaturated Soils, version 1.0.* EPA Report 600/2-91/065, U.S. Salinity Laboratory, USDA, ARS, Riverside, California.

Comment #5:

Please demonstrate why excavation and removal of the CS-19 source material is sufficient to reduce concentrations below HA given an additional source of RDX upgradient of CS-19 (as noted on pg 5 of the CS-19 Proposed Plan for Interim Action).

Response #5:

Plumes are generated by the mass of a contaminant in the soil leaching to groundwater. Therefore, if the source material at CS-19 is removed as proposed, there will be less contamination to leach to groundwater; and thus, the plume will dissipate over time.

The CS-19 plume modeling assumes all CS-19 plume mass comes from the CS-19 site, and does not take into account other possible upgradient sources of RDX because this information would not accurately reflect the amount and location of groundwater contamination that is directly attributable to the activities at the CS-19 site. Once soil removal activities are completed at the CS-19 source area and more information about the CIA plume is gathered, the current conceptual model for the CS-19 site will be re-evaluated as part of selecting the final GWOU remedy.

Comment #6:

2nd paragraph of the section titled Interim Monitoring Plan on Pg 12 implies that monitoring alone, of Perchlorate data, can/will ensure that concentrations will not increase and that a plume will not form. This cannot be correct. Please explain.

Response #6:

We agree that the text referred to on page 12 is technically incorrect. We acknowledge the poor choice in wording, which may lead the reader to believe that monitoring will ensure that no plume is created. Monitoring will ensure that we can identify whether or not a plume develops over time and, if needed, respond accordingly. The IAGWSP has mapped a perchlorate plume from the CIA site, which surrounds the CS-19 GWOU to their depiction of a non-detect contour. There is no promulgated standard for perchlorate.

Comment #7:

The Proposed Plan does not address risk to potentially affected ecological receptors impacted by either soil excavation, nor proposed natural attenuation.

Response #7:

The ecological baseline risk assessment concluded that there is no pathway of exposure to groundwater. Based on the absence of permanent surface water bodies at or in close downgradient proximity to the CS-19 study area, aquatic species, both on-site and

off-site, were assumed to be unaffected by site contamination. The concentration of compounds found in groundwater monitoring wells, in immediate proximity to and downgradient of CS-19, would be diluted to below the detection limit before water entered any ponds. Therefore, the potential exposure media for ecological receptors are surface soil and puddle water and do not include groundwater, and there are no contaminants of concern (COCs) for the ecological risk assessment, as there is no exposure pathway.

Additionally, a separate document is being prepared for the source area removal action. That document will address the potential risks that result from the various removal actions or no action (natural attenuation) and will be available for pubic review and comment.

Comment #8:

What is the groundwater model used by AFCEE to predict the movement of the RDX plume? Which models were used? What error rates are associated with these models?

Response #8:

The CS-19 zoom model was developed by Jacobs specifically for flow and transport modeling of the CS-19 plume. The parent model of the CS-19 model was the 2001 Jacobs Regional Model (*Plume Response Groundwater Modeling Report – Model Recalibration*, reference AFCEE 2001b in the RI Report). A description of the development and calibration of the model is included in the CS-19 RI. The groundwater flow and transport model used is MODFLOW-Surfact, a proprietary version of MODFLOW, which was originally developed by the USGS in 1984. MODFLOW-Surfact was developed by Hydrogeologic in 1996 and included additional computational modules to enhance the simulation capabilities and robustness. Complete documentation and verification examples of the code are provided in the program manual. MODFLOW is the name that has been given the USGS Modular Three-Dimensional Groundwater Flow Model. Because of its ability to simulate a wide variety of systems, its extensive publicly available documentation, and its rigorous USGS peer review, MODFLOW has become the worldwide standard groundwater flow model. MODFLOW has been used to simulate systems for water supply, contaminant remediation and mine dewatering. MODFLOW is the recognized standard model used by courts, regulatory agencies, universities, consultants and industry. The groundwater flow and transport numerical error rates for flow models are normally expressed as mass balance errors. The mass balance error for the flow solution in the CS-19 model is 0.5 percent.

More generally, there are uncertainties associated with the model input parameters that were briefly discussed in the response to comment 1. As noted, for those aquifer or contaminant parameters that are less well defined, conservative values are normally applied in the model. While the calibrated groundwater model may represent the best technical attempt at matching the model results to observed conditions, the model solution is not unique and represents only one of many combinations of conditions and physical parameters that could provide equally valid calibration matches. However, it is important to note that during the AFCEE SPEIM program, the zoom models developed

from the parent regional model for Cape Cod were evaluated against several observed data sets and were generally found to be very good predictors of contaminant fate and transport. The predictive capabilities of the flow models have also been calibrated and verified against several shutdown/restart tests conducted for MMR remedial systems.

Comment:

Kevin Hood, Impact Area Review Team TOSC consultant, representing himself as a Project Manager for the University of Connecticut, Environmental Research Institute

Additional model information was requested, such as the modeling programs that were used and the assumptions made in modeling work.

Response:

Thank you for your comment. In addition to Section 8.0 of the Final CS-19 RI Report, please see responses provided to the previous commenter.

Comments Submitted at Public Hearing

Mr. Schlesinger, Sandwich resident:

I am Peter Schlesinger, Town of Sandwich, not associated with the Town of Sandwich, but living in the Town of Sandwich. I have to honestly say that I disagree wholeheartedly with the idea that natural attenuation is a suitable solution for any kind of action to cleaning up groundwater. Natural attenuation is nothing but doing nothing and hoping that it goes away. And I don't -- seeing as I didn't find any evidence that you have evidence of how this contaminant will naturally attenuate and was presented with no documentation, literature on how this contaminate (contaminant) will break up and disperse on its own and having learned of no such evidence through sitting on the Impact Area Review Team, as I have for the last almost seven years or so or eight years -- I've lost track of it -- I can't really say that this is an appropriate interim measure.

It's probably a very cost effective interim measure in the sense that one just goes on monitoring the situation but actually really doing nothing about it other than removing the source material.

I don't understand how one can know how well material can move and at what rate it will move and at what rate it will disappear without a good enough understanding of what the volume is of the material underground. I suppose you could make some ballpark guesses as to what potential volumes there are and try to model that out. But it doesn't sound like you have a very good understanding yet as to what you will find and/or nor at what depth you will find material that you area seeking. So I'm a bit concerned that not enough effort has gone into the plan for this interim action.

Response:

Thank you for your comment. Please refer to responses provided to your written comments, which were similar to concerns you expressed during the public hearing.

Susan V. Walker

197 Farmersville Road
Sandwich, MA 02563

(508) 477-1386
swalker@capecod.net

February 7, 2005

HQ AFCEE/MMR
Attn.: CS-19 Groundwater Plan
322 East Inner Rd.
Otis ANG Base, MA 02540-5028

Dear Doug Karson:

I am submitting these comments to be part of the formal record of the Draft CS-19 Proposed Plan for Interim Action. I have been following this plume for fifteen years. During that time period no clean up has taken place and the plume has been allowed to migrate and contaminate more groundwater. This plume deserved remediation years ago.

Now AFCEE wants to monitor the plume for the interim action. How much longer does the public have to wait for cleanup?

I understand that AFCEE is waiting for the Central Impact Work to be done and for a joint decision to be made. I could accept that, if there were a guarantee that CS-19 will be cleaned up. To wait several more years and then find out that the plan is not to cleanup CS-19 seems like a cruel joke on the public. The public has been patient and deserves to know that a real active cleanup is the fate of CS-19.

I hope the formal reply to this comment will guarantee an active cleanup of CS-19.

Sincerely,

Susan V. Walker

From: Peter Schlesinger [mailto:pschles@adelphia.net]
Sent: Tuesday, February 15, 2005 11:09 PM
To: Karson Doug Civ AFCEE/MMR
Cc: Kevin Hood
Subject: Written Comment for Submission to CS-19 Interim Action Public Hearing

Written Comment for Submission to CS-19 Interim Action Public Hearing

Please answer the following questions:

1) What are the factors used by the model that predict that the CS19 RDX plume will dilute to less than a 2ppb HA within 13 years?

2) Please show peer-reviewed literature evidence that RDX can naturally attenuate?

3) Please demonstrate that there is sufficient knowledge of the mass of the unexcavated source material to adequately determine how long it will take to move, where it will move, and what concentrations will result over what period of time?

4) Please demonstrate sufficient knowledge of the Fate and Transport of RDX.

5) Please demonstrate why excavation and removal of the CS-19 source material is sufficient to reduce concentrations below HA given an additional source of RDX upgradient of CS-19 (as noted on pg 5 of the CS19 Proposed Plan for Interim Action).

6) 2nd paragraph of the section titled Interim Monitoring Plan on Pg 12 implies that monitoring alone, of Perchlorate data, can/will ensure that concentrations will not increase and that a plume will not form. This cannot be correct. Please explain.

7) The Proposed Plan does not address risk to potentially affected ecological receptors impacted by either soil excavation, nor proposed natural attenuation.

8) What is the groundwater model used by AFCEE to predict the movement of the RDX plume? Which models were used? What error rates are associated with these models?

Peter Schlesinger
39 Shawme Road
Sandwich, MA 02563
Email: pschles@adelphia.net

-----Original Message-----
From: Frederick.C.Carleton.04@Alum.Dartmouth.ORG
[mailto:Frederick.C.Carleton.04@Alum.Dartmouth.ORG]
Sent: Wednesday, February 16, 2005 7:20 PM
To: Karson Doug Civ AFCEE/MMR
Subject: comment

Doug,

I'm not sure what to say about the air force's decision to not clean up CS-19 till other plumes and their impacts are researched. All I know is that the Army has no excuse to leave you and your men to singlehandedly monitor, research, and clean up the super-toxic site that is the impact zone. I hope that you have some of your best men on the job and are taking an extremely expedient approach to figuring out what else is below the surface.

As a lifetime Cape resident, I feel that the Army should be held liable for all damages especially those done to members of the community who have to suffer through drinking completely tainted water. As an environmental studies and public economics major I know both how serious perchlorate can be and the extent to which the Army should be held financially responsible. I commend you and the Air Force for being responsible and saying you'll clean the area, I just want to know how much time you will take before you take action. As you know water 90% of the time is not localized and is constantly moving underground, so what kind of a time frame are we looking at before CS-19 reaches drinking water, and given that Bourne closed 3 of their 6 water wells in 2002 due to high perchlorate levels what makes you think Cape water isn't already heavily contaminated by the seeping chemicals of military ignorance?

University of Connecticut

Kevin Patrick Hood, RS
Project Manager

Environmental Research Institute
270 Middle Turnpike, Unit 5210
Storrs, Connecticut 06269-5210
Telephone: (860) 486-2546 Facsimile: (860) 486-5488
Cellular: (860) 617-0665
e-mail: khood@eri.uconn.edu

Model Info.

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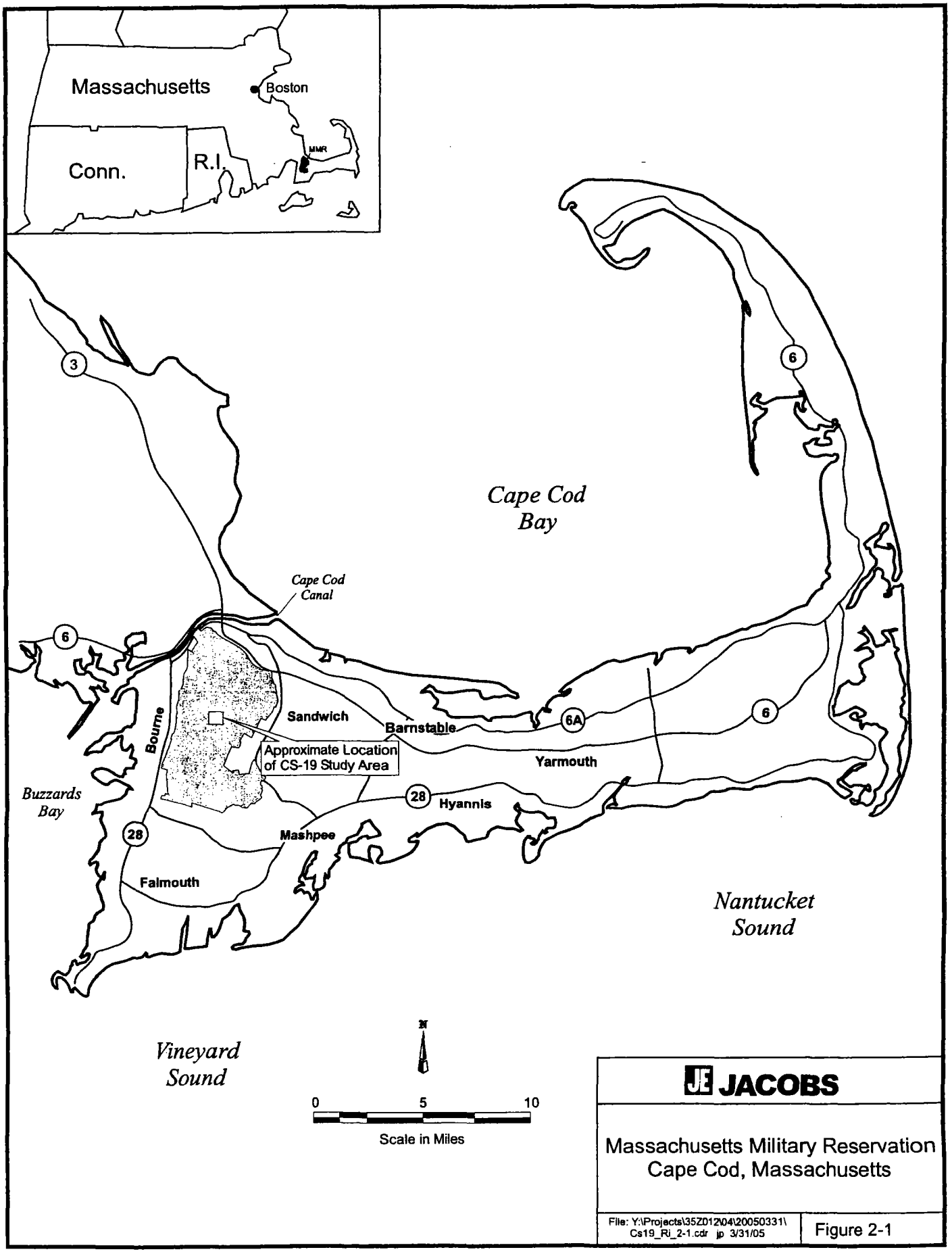
FIGURES



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Massachusetts Military Reservation
Cape Cod, Massachusetts

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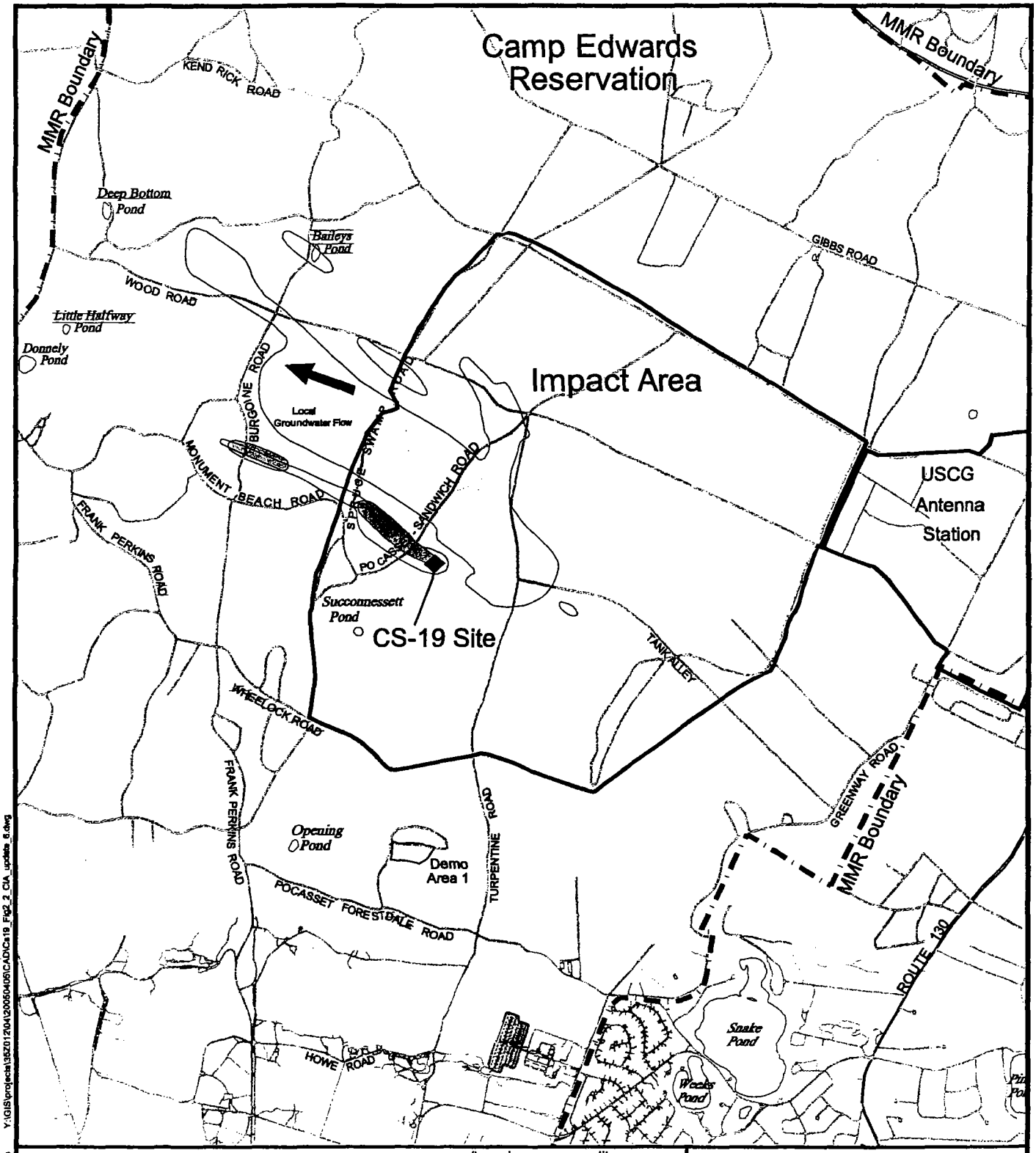
Figure 2-1



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CS-19 Site and Surrounding Features

Massachusetts Military Reservation
Cape Cod, Massachusetts

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Figure 2-2

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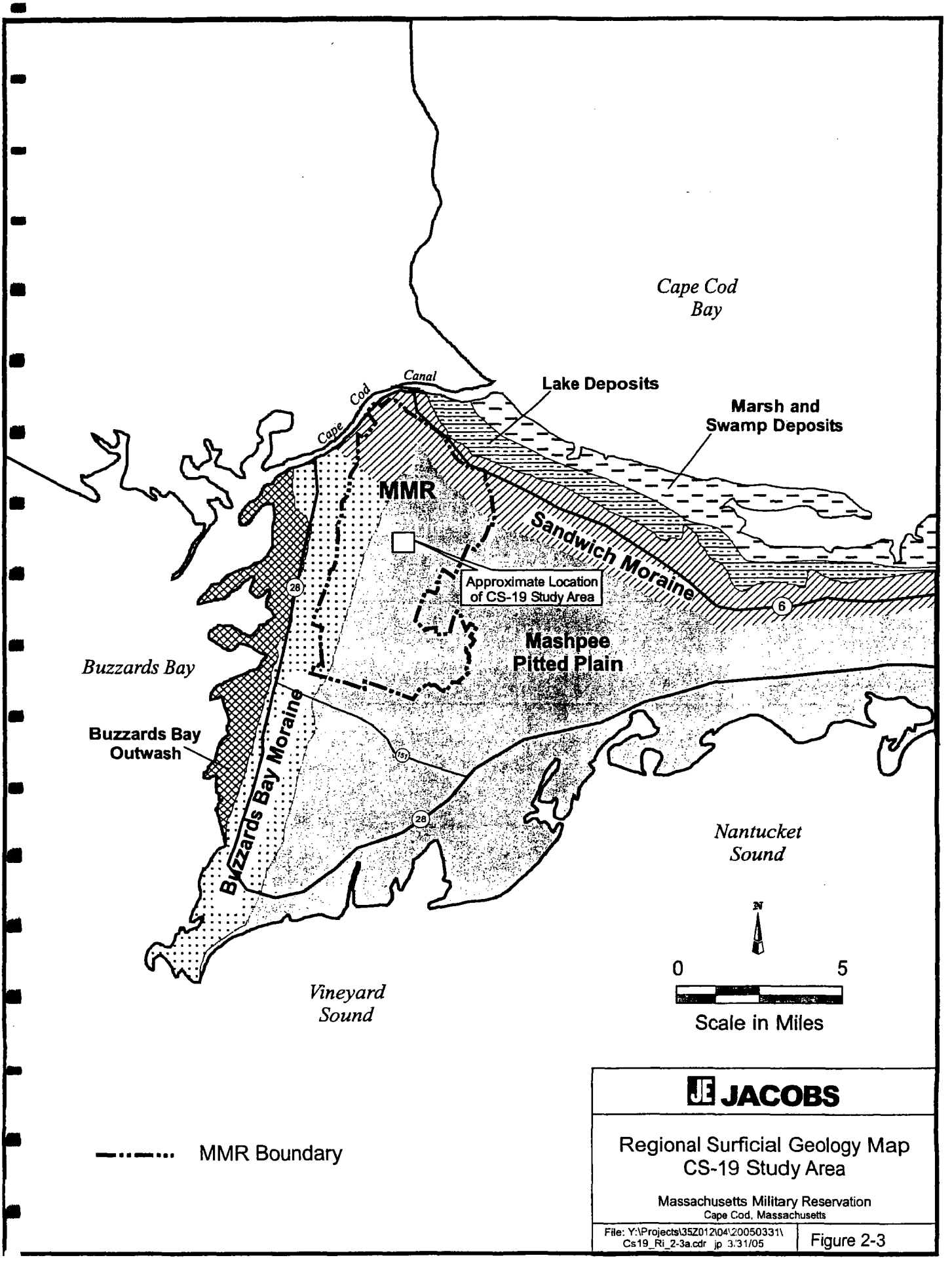

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Regional Surficial Geology Map
CS-19 Study Area

Massachusetts Military Reservation
Cape Cod, Massachusetts

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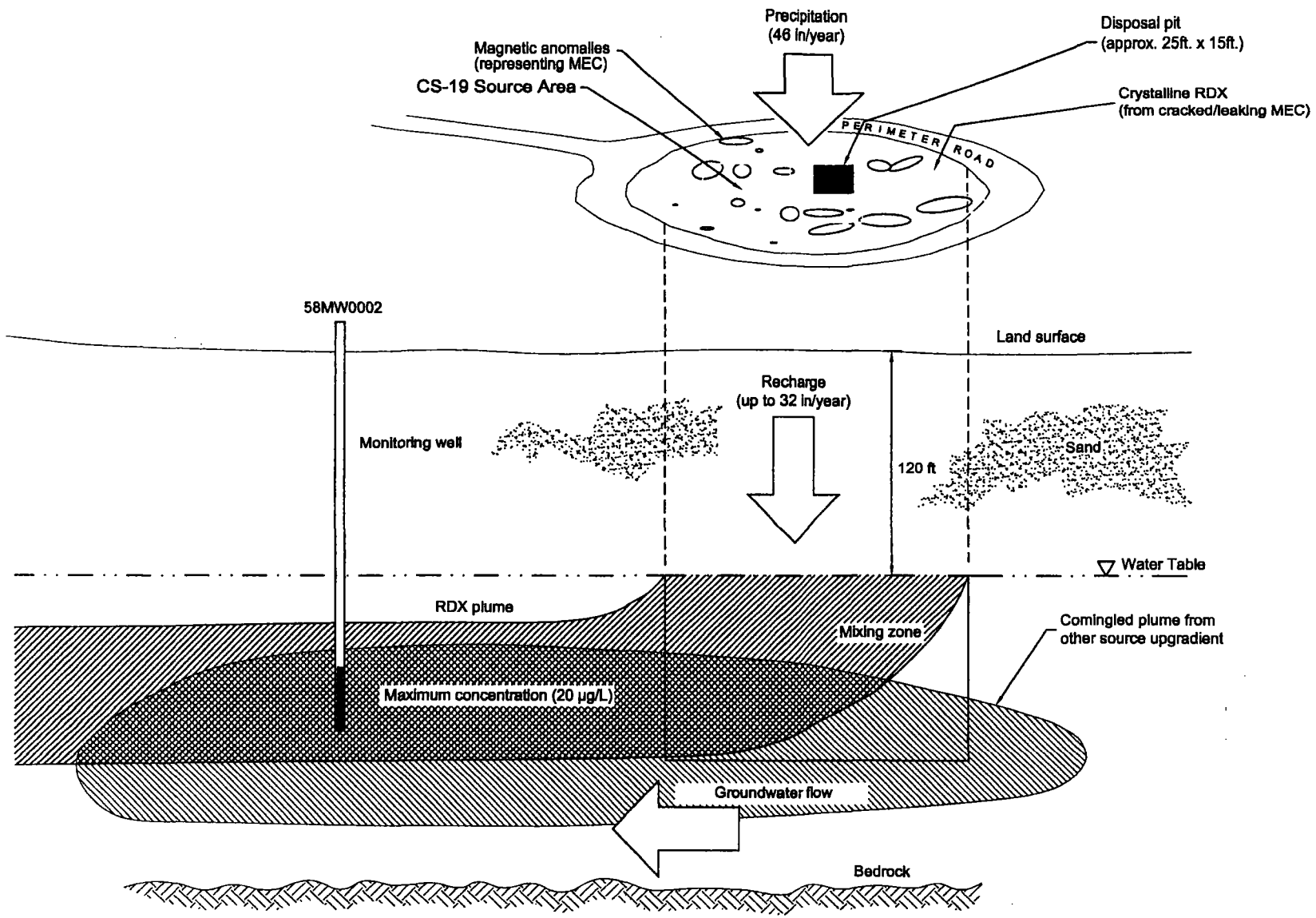
Figure 2-3



Legend

ppb = parts per billion

µg/L = micrograms per liter

RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine

Note: Entire site excavated 2 feet to remove munitions debris and unexploded ordnance (UXO) in Nov,Dec. 2004.

in/year = inches per year

MEC = Munitions and explosives of concern

ft = feet

figure not to scale

0 60

Scale in Feet

JACOBS

CS-19 Plume Conceptual Model

Massachusetts Military Reservation

Cape Cod, Massachusetts

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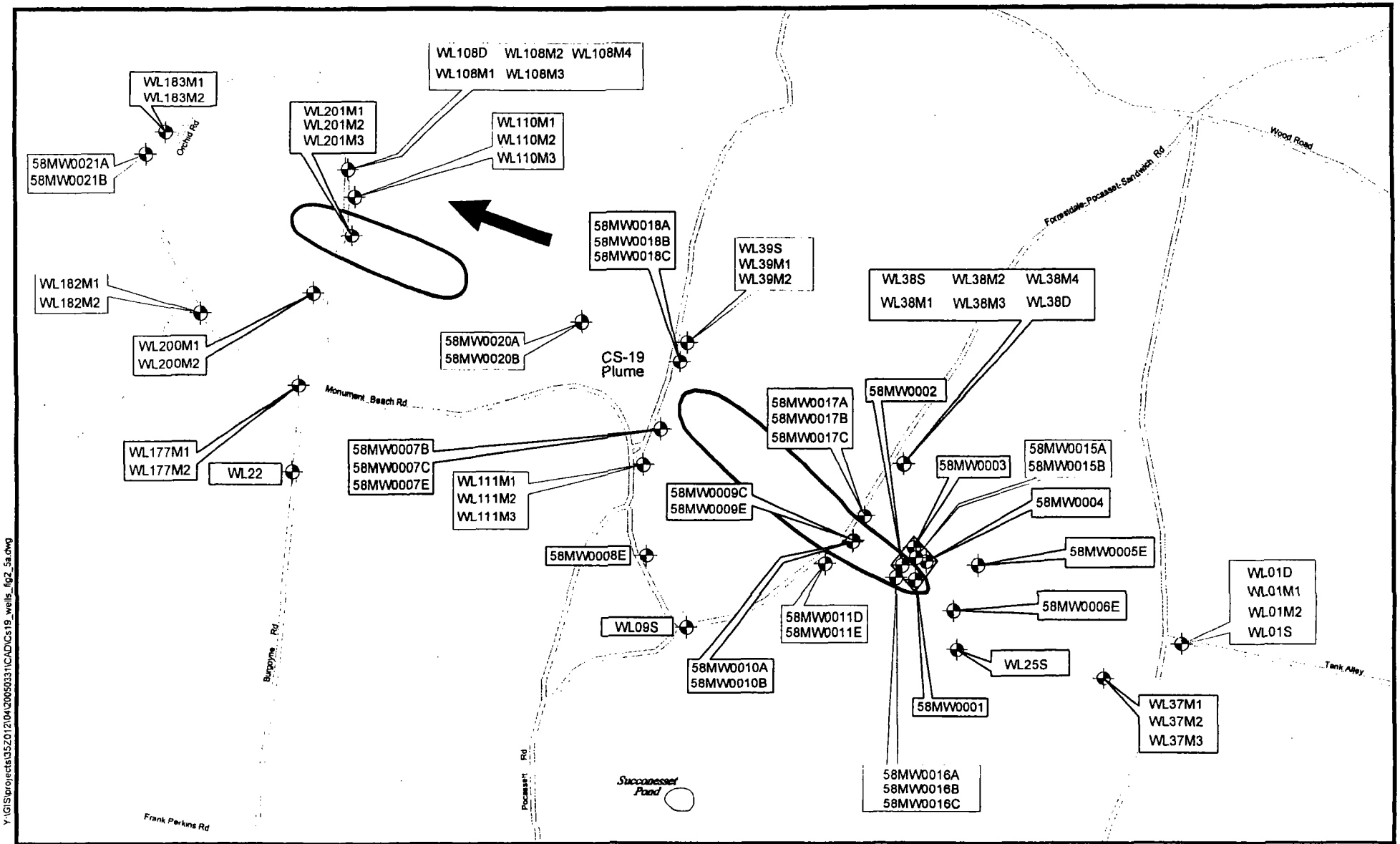
Figure 2-4



Data Source: AFCEE, January 2003, AFCEE-MMR Data Warehouse, AMEC file: ALL_EXP_GW_032805.xls.

Legend

- Monitoring Well
- CS-19 RDX Plume Contour (2 µg/L) as of January 2005
- Direction of Groundwater Flow

µg/L = micrograms per liter

RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine

N

0 1000

Scale in Feet

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Monitoring Wells Used in CS-19 Remedial Investigation

Massachusetts Military Reservation
Cape Cod, Massachusetts

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Figure 2-5

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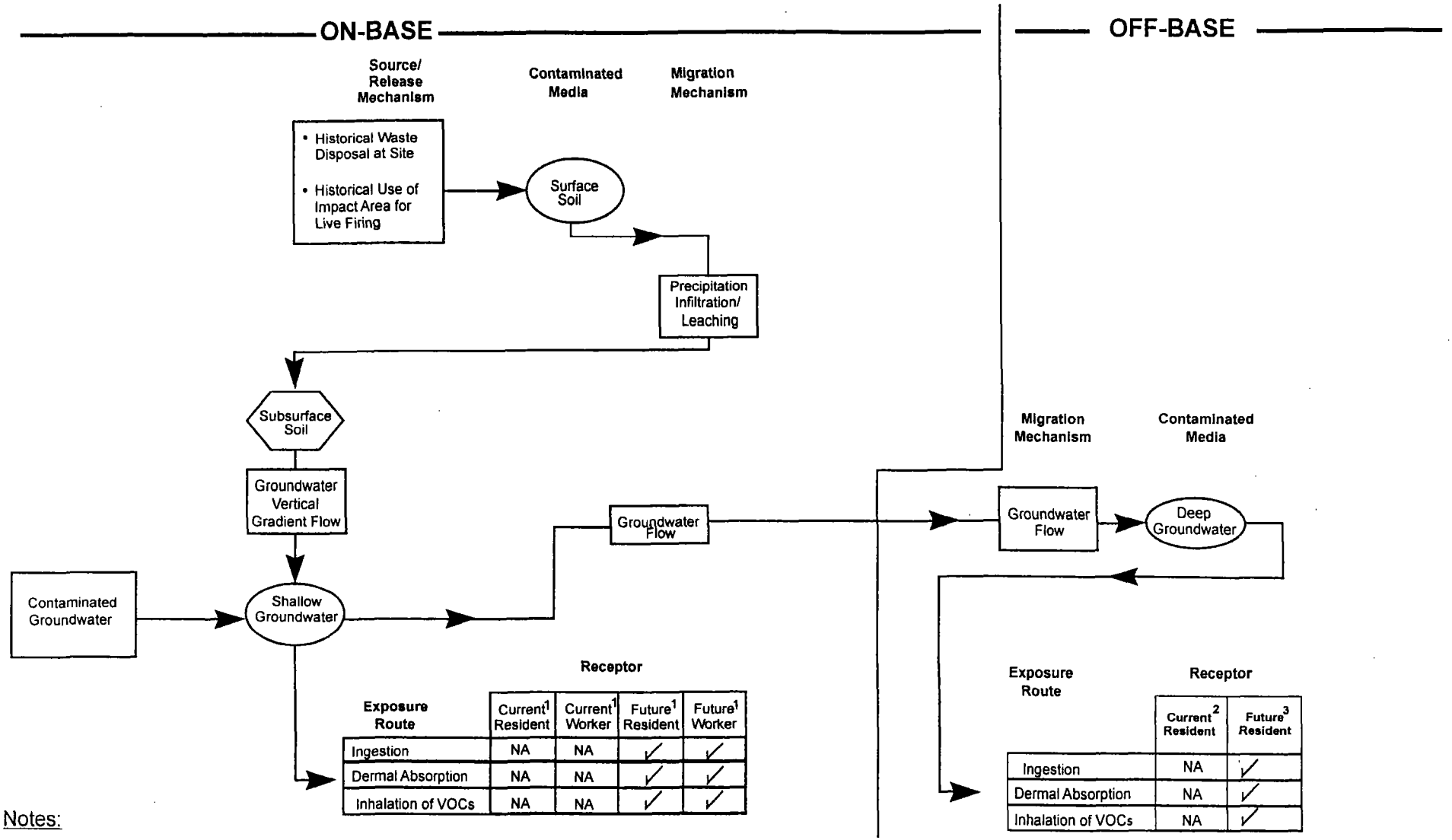

Notes:

1. There are no current residences overlying the plume and no existing water supply wells intercepting the plume. It is possible, although unlikely, that without institutional controls that there could be future residential or worker exposure to the CS-19 plume.

2. Existing data support the assumption that site contaminants have not migrated off-base.

3. MMR groundwater is classified as a sole source aquifer. Risk evaluated assuming groundwater could be available at any point in the aquifer by installing a municipal water supply well in the CS-19 study area.

NA= not applicable. VOC = volatile organic compound

Exposure/Transport Media

Transport Media

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Human Health Conceptual Exposure Model CS-19 Groundwater

Massachusetts Military Reservation
Cape Cod, Massachusetts

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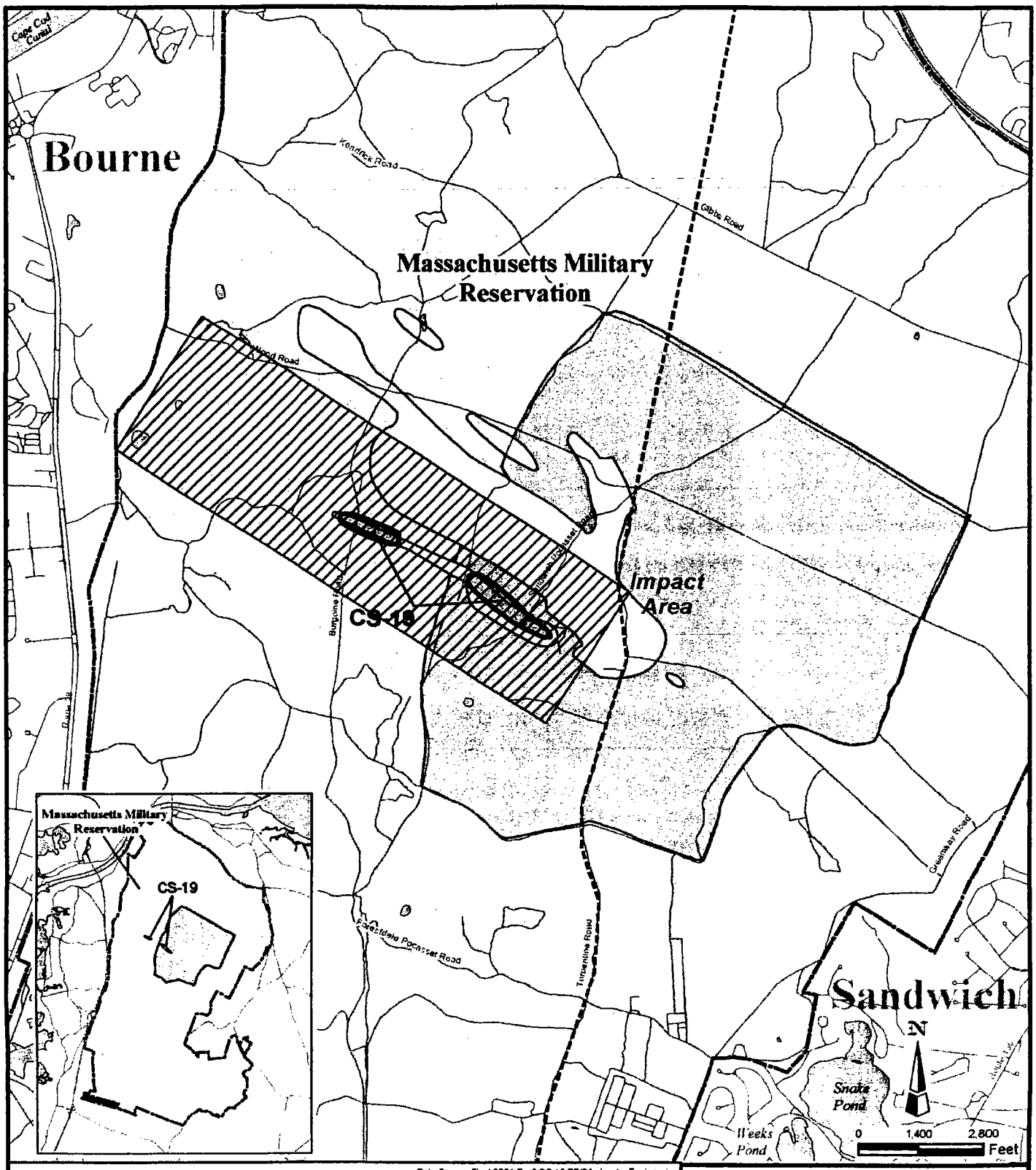
Figure 2-6



Data Source: Final 2004 Draft CS-19 EE/CA, Jacobs Engineering

Legend

- CS-19 Explosives Plume Concentrations Above EPA Health Advisory Level (Royal Demolition Explosive (RDX) Health Advisory = 2 µg/L)
- Central Impact Area Explosives Plume Concentrations Above EPA Health Advisory Level (Royal Demolition Explosive (RDX) Health Advisory = 2 µg/L) (As of February 2005)
- CS-19 Land Use Control Area

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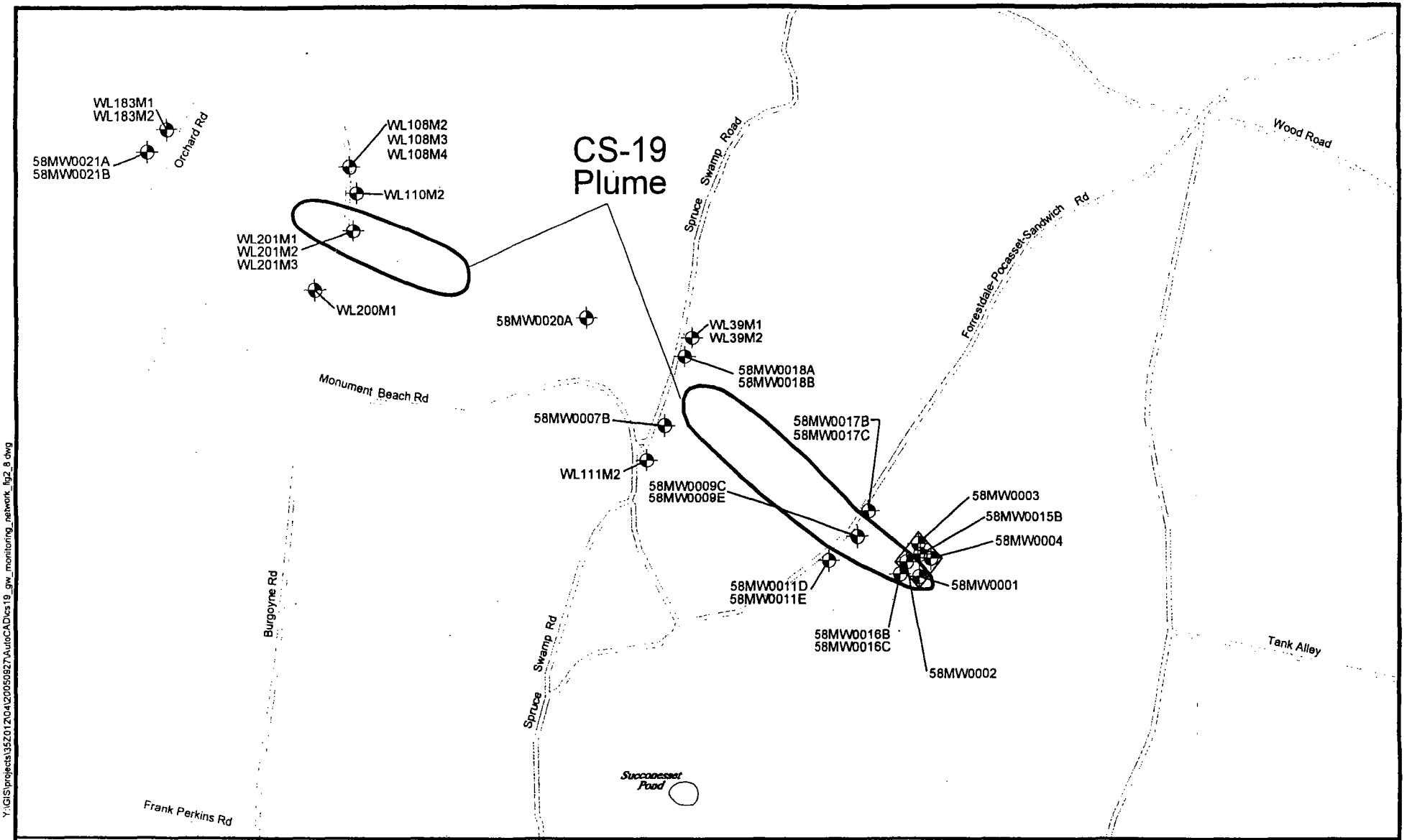
CS-19 Land Use Control Area

Massachusetts Military Reservation
Cape Cod, Massachusetts

9/27/2005 jp

Figure 2-7



Legend

- Monitoring Well
- CS-19 RDX Plume Contour (2 µg/L) as of January 2005

µg/L = micrograms per liter

RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine

Data Source: AFCEE, January 2005, AFCEE-MMR Data Warehouse.

N

0 1000

Scale in Feet

JACOBS

CS-19 Groundwater Monitoring Network

Massachusetts Military Reservation
Cape Cod, Massachusetts

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Figure 2-8

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TABLES

Table 2-1
CS-19 Groundwater Risk Characterization Summary – Noncarcinogens
Based on Reasonable Maximum Exposure for Future Residents

Contaminant of Potential Concern*	Primary Target Organ	Maximum Concentration (µg/L)	CS-19 Adult				CS-19 Child (0-6 years)			
			Dermal HQ	Ingestion HQ	Inhalation HQ	Exposure Routes Total HQ	Dermal HQ	Ingestion HQ	Inhalation HQ	Exposure Routes Total HQ
arsenic	skin	12.4	6.0E-03	1.1E+00	NA	1.1E+00	1.7E-02	2.6E+00	NA	2.6E+00
manganese	CNS	466	NA	NA	NA	NA	8.3E-03	1.2E+00	NA	1.2E+00
thallium	liver	5.3	1.2E-02	2.2E+00	NA	2.2E+00	3.3E-02	5.1E+00	NA	5.1E+00
			Total Groundwater HI			3.3E+00	Total Groundwater HI			9.0E+00

Notes:
CNS = central nervous system
HQ = Hazard Quotient
HI = Hazard Index
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
µg/L = micrograms per liter

*This table provides non-cancer risk estimates for the contaminants of potential concern listed on Table 10.3 RME and Table 10.4 RME in Appendix A. HQs for each route of exposure and the HI (sum of HQs) for all routes of exposure.

Table 2-2
CS-19 Groundwater Risk Characterization Summary - Carcinogens
Based on Reasonable Maximum Exposure for Future Residents

Contaminant of Potential Concern*	Maximum Concentration (µg/L)	CS-19 Adult				CS-19 Child (0-6 years)			
		Dermal Risk	Ingestion Risk	Inhalation Risk	Exposure Routes Total	Dermal Risk	Ingestion Risk	Inhalation Risk	Exposure Routes Total
RDX	15	1.4E-07	1.6E-05	NA	1.6E-05	7.7E-08	9.1E-06	NA	9.2E-06
Alpha-BHC	0.079	2.3E-06	4.7E-06	NA	7.0E-06	1.3E-06	2.7E-06	NA	4.0E-06
P,P'-DDT (DDT)	0.3	1.2E-05	9.6E-07	NA	1.3E-05	6.8E-06	5.6E-07	NA	7.4E-06
arsenic	12.4	9.2E-07	1.7E-04	NA	1.7E-04	6.8E-07	1.0E-04	NA	1.0E-04
		Total Groundwater Risk			**2.1E-04**	**Total Groundwater Risk**			**1.2E-04**

Notes:
alpha-BHC = alpha-hexachlorocyclohexane
COC = contaminant of concern
DDT = 2,2-bix(p-chlorophenyl)-1,1,1-trichloroethane
NA= not applicable
µg/L = micrograms per liter

*This table provides cancer risk estimates for the chemicals of potential concern listed on Table 10.3 RME and Table 10.4 RME in Appendix A.

Table 2-3
Data Used for CS-19 COC Determination

	Measured Values				Calculated Values	
Metal COPC	**C_{BKGND} (µg/L)**	**C_{RI} (µg/L)**	**Child HI_{RI}**	**Adult HI_{RI}**	**Child HI_{BKGND}**	**Adult HI_{BKGND}**
As	34.5	12.4	2.6E+00	1.1E+00	7.2E+00	3.1E+00
Mn	11500	466	1.2E+00	NA	3.0E+01	NA
Tl	13.3	5.3	5.1E+00	2.2E+00	1.3E+01	5.5E+00
Pesticide COPC	**C_{RI} (µg/L)**	**C_{PLUME} (µg/L)**	**ELCR$_{RI}$**		**ELCR$_{PLUME}$**	
alpha-BHC	0.079	0.014	1.1E-05		1.9E-06	
DDT	0.3	0.12	2.0E-05		8.0E-06	

Notes:

alpha-BHC = alpha-hexachlorocyclohexane

As = arsenic

BKGND = background

C = concentration

COC = contaminant of concern

COPC = contaminant of potential concern

DDT = 2,2'-bis(p-chlorophenyl)-1,1,1-trichloroethane

ELCR = combined adult and child RME excess cancer risks

HI = RME non-cancer hazard index

Mn=manganese

NA = not applicable

RI = remedial investigation

RME = reasonable maximum exposure

Tl = thallium

µg/L = micrograms per liter

Table 2-4
CS-19 Groundwater Monitoring Network

Location	Well Screen Midpoint Depth (ft msl)	Justification	Analytes
WL183M1	-53.5	Monitor leading edge	RDX, Perchlorate
WL183M2	-37.6	Monitor leading edge	RDX, Perchlorate
58MW0021A	-83.0	Monitor leading edge	RDX, Perchlorate
58MW0021B	-63.2	Monitor leading edge	RDX, Perchlorate
WL110M2	-19.5	Monitor lateral extent	RDX, Perchlorate
WL108M2	-61.8	Monitor for trend and lateral extent	RDX, Perchlorate
WL108M3	-41.69	Monitor for trend and lateral extent	RDX, Perchlorate
WL108M4	-19.7	Monitor for trend	RDX, Perchlorate
WL111M2	11	Monitor perchlorate detection and leading edge	RDX, Perchlorate
WL200M1	-40.4	Monitor lateral extent	RDX, Perchlorate
WL201M1	-57.4	Monitor vertical extent	RDX, Perchlorate
WL201M2	-37.4	Monitor vertical extent	RDX, Perchlorate
WL201M3	-17.4	Monitor vertical extent	RDX, Perchlorate
58MW0020A	-24.2	Monitor plume geometry	RDX, Perchlorate
58MW0007B	7.5	Monitor leading geometry	RDX, Perchlorate
58MW0018A	-5.2	Monitor leading geometry	RDX, Perchlorate
58MW0018B	21.0	Monitor leading geometry	RDX, Perchlorate
WL39M1	-23.4	Monitor for trend	RDX, Perchlorate
WL39M2	21.6	Monitor for trend	RDX, Perchlorate
58MW0011D	13.3	Monitor vertical and lateral extent	RDX, Perchlorate
58MW0011E	43.7	Monitor vertical and lateral extent	RDX, Perchlorate
58MW0009C	18.6	Monitor vertical extent	RDX, Perchlorate
58MW0009E	53.4	Monitor vertical extent	RDX, Perchlorate
58MW0017B	18.2	Monitor vertical and lateral extent	RDX, Perchlorate
58MW0017C	47.6	Monitor vertical and lateral extent	RDX, Perchlorate
58MW0002	59.4	Monitor vertical extent and trend	RDX, Perchlorate
58MW0004	58.4	Monitor vertical extent and trend	RDX, Perchlorate
58MW0016B	29.1	Monitor vertical extent and trend	RDX, Perchlorate
58MW0016C	63.5	Monitor vertical extent and trend	RDX, Perchlorate
58MW0001	59.2	Monitor vertical extent and trend	RDX, Perchlorate
58MW0003	62.3	Monitor vertical extent and trend	RDX, Perchlorate
58MW0015B	49.4	Monitor vertical extent and trend	RDX, Perchlorate

Notes:
msl = mean sea level
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine

Table 2-5
Chemical-Specific ARARs
For CS-19 Groundwater Operable Unit Interim Remedy Alternative 2

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Groundwater	FEDERAL – EPA Risk Reference Doses (RfDs)	RfDs are considered the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime. RfDs are guidelines, not enforceable standards.	EPA RfDs are used to calculate risk-based groundwater screening or cleanup levels for non-carcinogens when no federal or state MCL or non-zero MCLG or state GWQS is available. EPA's RfD for perchlorate is 0.0007mg/kg/day.	TBC guidance
Groundwater	FEDERAL – EPA Carcinogen Assessment Group, Cancer Slope Factors (CSFs)	CSFs represent the most-up-to-date information on cancer risk from EPA's Carcinogen Assessment Group. CSFs are guidelines, not enforceable standards.	EPA CSFs are used to calculate risk-based groundwater screening or cleanup levels for carcinogens when no federal or state MCL or non-zero MCLG or state GWQS is available.	TBC guidance
Groundwater	FEDERAL – EPA RDX Health Advisory	Lifetime health advisories (HAs) establish the concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effect over a lifetime of exposure with a margin of safety. HAs are guidelines, not enforceable standards.	The HAs are used to calculate risk-based groundwater screening or cleanup levels (e.g., 2 µg/L for RDX) when no federal or state MCL or non-zero MCLG or state GWQS is available. EPA's HA for RDX is 2 µg/L	TBC guidance

Notes:

ARAR	applicable or relevant and appropriate requirement
CSF	cancer slope factor
EPA	U.S. Environmental Protection Agency
GWQS	groundwater quality standard
HA	health advisory
LTM	long-term monitoring
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RfD	reference dose
ROD	Record of Decision
TBC	to be considered
µg/L	micrograms per liter

Table 2-6
Location-Specific ARARs
for CS-19 Groundwater Operable Unit Interim Remedy Alternative 2

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Endangered and threatened species and their habitats	STATE – MA Endangered Species Act (321 CMR 10.00 et seq.)	Actions that (1) jeopardize state-listed endangered or threatened species or (2) species of special concern or their habitats that have been identified on the MMR must be avoided, or appropriate mitigation measures must be taken.	LTM and well maintenance activities have the potential to impact certain moth and other state-listed species on the MMR that could potentially wander into the monitoring areas. Activities will be designed and implemented to minimize effects to such species.	Applicable

Notes:
ARAR applicable or relevant and appropriate requirement
CMR *Code of Massachusetts Regulations*
LTM long-term monitoring
MA Massachusetts
MMR Massachusetts Military Reservation
ROD Record of Decision

Table 2-7
Action-Specific ARARs
for CS-19 Groundwater Operable Unit Interim Remedy Alternative 2

Media	Requirements	Requirement Synopsis	Action to be Taken to Attain Requirements	Status
Groundwater	FEDERAL - Underground Injection Control Program (40 CFR 144-148)	These regulations outline minimum program and performance standards for underground injection wells and prohibit any injection that may cause a violation of any primary drinking water regulations in the aquifer. This program has been delegated to the State and takes effect through the State requirements listed below.	Monitoring well purge water and secondary waste water will be treated prior to release to ensure that releases will not cause any violation of drinking water standards or guidelines in the receiving aquifer.	Applicable
Groundwater	STATE – MA Underground Water Source Protection (310 CMR 27.00 et seq.)	These regulations prohibit the injection of fluid containing any pollutant into underground sources of drinking water where such pollutant will or is likely to cause a violation of any State drinking water standard or adversely affect the health of persons.	Monitoring well purge water and secondary waste water will be treated prior to release to ensure that releases will not cause any violation of drinking water standards or guidelines in the receiving aquifer.	Applicable
Air	STATE-MA Air Pollution Control Regulations (310 CMR 7.06, 7.08 – 7.10, 7.14, and 7.18 – 7.24)	Establishes the standards and requirements for air pollution control in the Commonwealth. Potentially relevant sections include those pertaining to: visible emissions (7.06); dust, odor, construction and demolition (7.09); and noise (7.10). The regulations also contain air pollutant emission standards for, among other things, hazardous waste incinerators, organic materials, and VOCs.	Dust, noise, and visible emissions will be managed to meet these State requirements during LTM activities. Air emissions will not be at a level high enough to trigger the standards for hazardous waste incinerators, organic materials, or VOCs.	Applicable
Solid waste	STATE – MA RCRA Subtitle D Solid Waste Management Regulations (310 CMR 19.000 et seq.)	If a waste is determined to be a solid waste, it must be managed in accordance with the state regulations at 310 CMR 19.000 et seq.)	Any solid wastes (e.g., spent carbon and personal protective equipment) generated during LTM activities that are determined to be non-hazardous will be managed in accordance with these regulations and disposed of appropriately.	Applicable

Notes:

ARAR	applicable or relevant and appropriate requirement
CFR	Code *of Federal Regulations*
CMR	Code *of Massachusetts Regulations*
LTM	long-term monitoring
MA	Massachusetts
MMR	Massachusetts Military Reservation
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
VOC	volatile organic compound

Table 2-8
Cost Basis for CS-19 Groundwater Operable Unit Interim Remedy Alternative 2

Item	Quantity	Units	Unit Cost	Total	Subtotal	Comments
Annual Costs						
Chemical Monitoring and Reporting Years 0-15						Assume sample 32 wells twice a year for explosives and perchlorate. Assume no new wells installed. Assume monitoring continues two years after HA reached.
Analytical	32	WELL	$ 700	$ 22,400		Sampled twice/year. Includes QC
Sample Collection	32	WELL	$ 750	$ 24,000		Assume 3 wells/day. Two samplers/day
Data Management	32	WELL	$ 375	$ 12,000		Generate chains of custody, validate data, enter data into database.
Reporting	1	LS	$ 4,000	$ 4,000	$ 62,400	Two reports/year
Overhead & Support				$ 18,096		
Total					$ 80,496	Overhead and support costs are included in the actual costs used to derive monitoring costs.
Periodic Costs						
CERCLA Five-Year Reporting						Years 5, 10 (2 events)
Report Preparation and Submittal	1	EA	$ 2,000	$ 2,000		Report is part of a larger review of all sources and systems at MMR.
Overhead & Support				$ 580		
Total					$ 2,580	
Residual Risk Assessment						Year 13 (1 event)
Report Preparation and Submittal	1	EA	$ 50,000	$ 50,000		
Overhead & Support				$ 14,500		
Total					$ 64,500	

Notes:
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
EA = each
HA = health advisory
LS = lump sum
MMR = Massachusetts Military Reservation
QC = quality control

Table 2-9
Present Value Calculation for CS-19
Groundwater Operable Unit Interim Remedy Alternative 2

Year	Annual Chemical Monitoring	Periodic Costs	Total Cost (0% Discount)	Discount Factor (for 2.8%)	Total Present Value Cost at 2.8%	Calendar Year
1	80,496	0	80,496	0.9728	78,304	2005
2	80,496	0	80,496	0.9463	76,171	2006
3	80,496	0	80,496	0.9205	74,096	2007
4	80,496	0	80,496	0.8954	72,078	2008
5	80,496	2,580	83,076	0.8710	72,362	2009
6	80,496	0	80,496	0.8473	68,205	2010
7	80,496	0	80,496	0.8242	66,347	2011
8	80,496	0	80,496	0.8018	64,540	2012
9	80,496	0	80,496	0.7799	62,782	2013
10	80,496	2,580	83,076	0.7587	63,030	2014
11	80,496	0	80,496	0.7380	59,409	2015
12	80,496	0	80,496	0.7179	57,791	2016
13	80,496	64,500	144,996	0.6984	101,262	2017
14	80,496	0	80,496	0.6794	54,685	2018
15	80,496	0	80,496	0.6609	53,196	2019
Total	1,207,440	69,660	1,277,100		1,024,256	

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APPENDIX A

RAGS Part D Standard Tables

APPENDIX A TABLES

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Appendix A
Standard Table 1.1
Selection of Groundwater Exposure Pathways
MMR CS-19

Scenario Time Frame	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current and Future	Groundwater	Groundwater	**Aquifer - Tap Water**	Trespasser	Youth	Ingestion Dermal Inhalation of VOCs	On-site	None	The site is within MMR's controlled security zone. Although, illegal trespassers may infrequently access the site, groundwater at the site is not and would not be available as drinking water to trespassers.
Future	Groundwater	Groundwater	**Aquifer - Tap Water**	Construction Worker	Adult	Ingestion Dermal Inhalation of VOCs	On-site	None	The site is within MMR's controlled security zone. The land use of the impact area is considered military, and it remains an inactive small arms, mortar, and heavy artillery firing range. Although, short-term construction activities may occur in the future, groundwater at the site would not be available as drinking water to construction workers.
Current	Groundwater	Groundwater	**Aquifer - Tap Water**	Resident	Adult	Ingestion Dermal Contact Inhalation of VOCs	On-site or Off-site	None	The site is situated in the west-central portion of the impact area, which lies in MMR's controlled security zone. The land use of the impact area is considered military, and it remains an inactive small arms, mortar, and heavy artillery firing range. There is no current residential exposure to groundwater.
					Child	Ingestion Dermal Inhalation of VOCs	On-site or Off-site	None	
Future	Groundwater	Groundwater	**Aquifer - Tap Water**	On-site Off-site Resident	Adult	Ingestion Dermal Contact Inhalation of VOCs	On-site or Off-site	Quantitative	The site is designated as a "groundwater protection area," and it is feasible that a water supply well could be installed at the site to supply residents.
					Child	Ingestion Dermal Inhalation of VOCs	On-site or Off-site	Quantitative	
Current and Future	Groundwater	Groundwater	**Aquifer - Tap Water**	Commercial/ Industrial Site Worker	Adult	Ingestion Dermal Inhalation of VOCs	On-site or Off-site	None	There is no current worker exposure to CS-19 groundwater. Although it is feasible that a future worker exposure scenario may exist, no quantitative analysis was performed because risks were calculated for the future resident, a more maximally exposed receptor.

MMR = Massachusetts Military Reservation
VOCs = volatile organic compounds

Appendix A
Standard Table 2.3
Occurrence, Distribution and Selection of Chemicals of Potential Concern
MMR CS-19 Groundwater

Scenario Time Frame: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Aquifer - Tap Water

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (Maximum)	Preliminary Background Value (2)	Screening Toxicity Value Region IX PRGs (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source (4)	COPC Flag	Rationale for Contaminant Deletion or Selection (5)
	VOCs																
67-64-1	ACETONE	40	J	40	J	µg/L	WL39M1	1/12	2.01-2.01	40.0	NA	61	nc	NA	NA	N	BSL
67-66-3	CHLOROFORM	0.11	J	4		µg/L	WL39S	7/36	0.08-0.14	4.0	3.60	0.16	ca**	100	MCL	N	Reg. GW
127-18-4	TETRACHLOROETHENE(PCE)	0.55	J	5.03		µg/L	58MW0020A-09	4/86	0.5-0.5	5.0	NA	1.10	ca	5	MCL	N	IFD
108-88-3	TOLUENE	0.5	J	0.5	J	µg/L	58MW0016A-	1/86	0.09-0.09	0.5	ND	72	nc	1000	MCL	N	IFD,BSL
79-01-6	TRICHLOROETHENE(TCE)	1.08		9.16		µg/L	58MW0020A-09	3/86	0.4-0.4	9.2	NA	1.60	ca*	5	MCL	N	IFD
	SVOCs																
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	9	J	9	J	µg/L	WL111M1-	1/36	0.8-0.8	9.0	NA	4.80	ca	6	MCL	N	IFD
	Dioxins/Furans																
17460-10-6	2,3,7,8-TCDD equivalent	0.043	NA	0.175	NA	pg/L	58MW0007B-	29/34	NA	0.2		0.45	ca	30	MCL	N	BSL
	Explosives																
118-96-7	2,4,6-TRINITROTOLUENE	0.29		0.29		µg/L	58MW0002-	1/86	0.07-0.07	0.3	ND	2.20	ca**	NA	NA	N	IFD, BSL
121-14-2	2,4-DINITROTOLUENE	0.32		0.32		µg/L	58MW0002-	1/86	0.03-0.03	0.3	ND	7.30	nc	NA	NA	N	IFD, BSL
606-20-2	2,6-DINITROTOLUENE	150	J	150	J	µg/L	58MW0018A-AQ549	1/87	NA-NA	150.0	NA	3.60	nc	NA	NA	N	IFD
35572-78-2	2-AMINO-4,6-DINITROTOLUENE	0.46		0.59	J	µg/L	58MW0009E-AQ535	2/86	0.04-0.04	0.6	ND	0.22	nc*	NA	NA	N	IFD, BSL
99-08-1	3-NITROTOLUENE	0.37		0.37		µg/L	58MW0020A-09	1/86	0.0771-0.0771	0.4	NA	6.10	nc	NA	NA	N	IFD, BSL
19406-51-0	4-AMINO-2,6-DINITROTOLUENE	0.48	*	0.59		µg/L	58MW0009E-AQ535	2/86	NA-NA	0.6	NA	0.22	nc*	NA	NA	N	IFD, BSL
#N/A	HEXAHYDRO-1,3,5-TRINITRO-1,3,5,7-TETRAZOCINE	0.29		1		µg/L	WL111M3-	3/8	0.0564-0.06	1.0	NA	NA	NA	NA	NA	N	NSL
121-82-4	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE	0.27		15	*	µg/L	58MW0002-AS708	30/90	0.0564-0.06	15.0	ND	0.61	ca	NA	NA	Y	ASL
2691-41-0	OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCINE	0.26		4.95	*	µg/L	58MW0002-AS708	13/88	0.03-0.03	5.0	ND	180	nc	NA	NA	N	BSL
	Pesticides																
319-84-6	ALPHA BHC (ALPHA HEXACHLOROCYCLOHEXANE)	0.011	J	0.079		µg/L	58MW0005E-	5/36	0.009-0.009	0.1	ND	0.011	ca	NA	NA	Y	ASL
319-85-7	BETA BHC (BETA HEXACHLOROCYCLOHEXANE)	0.0088	J	0.032	J	µg/L	58MW0005E-	3/36	0.005-0.005	0.0	ND	0.037	ca	NA	NA	N	BSL
58-89-9	GAMMA BHC (LINDANE)	0.0059	J	0.011	J	µg/L	58MW0009C-	3/36	0.005-0.005	0.0	ND	0.052	ca	0.20	MCL	N	BSL
76-44-8	HEPTACHLOR	0.007	J	0.007	J	µg/L	58MW0018C-	1/36	0.007-0.007	0.0	ND	0.015	ca	0.40	MCL	N	IFD, BSL
72-54-8	P,P'-DDD (DDD)	0.014	J	0.014	J	µg/L	58MW0005E-	1/36	0.012-0.012	0.0	ND	0.28	ca	NA	NA	N	IFD, BSL
72-55-9	P,P'-DDE (DDE)	0.016	J	0.016	J	µg/L	58MW0005E-	1/36	0.009-0.009	0.0	ND	0.20	ca	NA	NA	N	IFD, BSL
50-29-3	P,P'-DDT (DDT)	0.033	J	0.3		µg/L	58MW0005E-	3/36	0.012-0.012	0.3	ND	0.20	ca*	NA	NA	Y	ASL
	Herbicides																
93-65-2	MCPP	150	J	150	J	µg/L	58MW0020A-FD	1/36	26.8-26.8	150.0	NA	3.60	nc	NA	NA	N	IFD
6607	PICLORAM	0.12	UJ	0.12	UJ	µg/L	WL39M2	1/5	0.056-0.056	0.1	NA	NA	NA	500	MCL	N	NSL
	Water Quality Parameters																
ALKB	ALKALINITY, BICARBONATE (AS CACO3)	2000		6000		µg/L	WL39S	5/5	1000-1000	6,000.0	NA	NA	NA	NA	NA	N	NSL
ALK	ALKALINITY, TOTAL (AS CaCO3)	2000		37400		µg/L	58MW0010A-	18/36	1000-5000	37,400.0	NA	NA	NA	NA	NA	N	NSL
24959-67-9	BROMIDE	40	J	330	J	µg/L	58MW0005E-01	9/34	13-100	330.0	NA	NA	NA	NA	NA	N	NSL
16887-00-6	CHLORIDE (AS CL)	4900		10300		µg/L	WL39S	36/36	56-80	10,300.0	13000.00	NA	NA	250000	SMCL	N	NSL
7664-41-7	NITROGEN, AMMONIA (AS N)	20		90	J	µg/L	WL09	3/5	20-20	90.0	NA	NA	NA	NA	NA	N	NSL
14797-55-8	NITROGEN, NITRATE (AS N)	40	J	330		µg/L	58MW0009E-	17/34	8.1-8.1	330.0	1100.00	1000	nc	10000	MCL	N	BSL
7727-37-9	NITROGEN, NITRATE-NITRITE	20		120		µg/L	WL25	5/5	10-10	120.0	NA	NA	NA	NA	NA	N	NSL

Appendix A
Standard Table 2.3
Occurrence, Distribution and Selection of Chemicals of Potential Concern
MMR CS-19 Groundwater

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (Maximum)	Preliminary Background Value (2)	Screening Toxicity Value Region IX PRGs (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source (4)	COPC Flag	Rationale for Contaminant Deletion or Selection (5)
PDORTHO	PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (AS P)	92	J	240	J	µg/L	58MW0010A-01	2/12	92-92	240.0	NA	NA	NA	NA	NA	N	NSL
#N/A	PHOSPHORUS, TOTAL ORTHOPHOSPHATE (AS PO4)	10		50		µg/L	WL39S	4/5	10-10	50.0	NA	NA	NA	NA	NA	N	NSL
PORTHO	PHOSPHORUS, TOTAL PO4 (AS P)	560		560		µg/L	58MW0010A-	1/31	26-26	560.0	150.00	NA	NA	NA	NA	N	IFD, NSL
14808-79-8	SULFATE (AS SO4)	2800		11600		µg/L	58MW0010A-	36/38	90-100	11,600.0	11400.00	NA	NA	250000	SMCL	N	NSL
	Inorganics																
7429-90-5	ALUMINUM	12.1	J	96.8	UJ	µg/L	WL09	3/25	8.35-25.8	96.8	No UTL	3600	nc	50 to 200	SMCL	N	BSL
7429-90-5	ALUMINUM (TOTAL)	5060		5060		µg/L	71MW0009S-	1/35	21.6-21.6	5,060.0	NA	3600	nc	50 to 200	SMCL	N	IFD
7440-38-2	ARSENIC	2.3	J	6.7		µg/L	58MW0010A-01	3/25	1.8-2.6	6.7	ND	0.045	ca	50 (10)	MCL	Y	ASL
7440-38-2	ARSENIC (TOTAL)	2.2	J	12.4		µg/L	58MW0010A-	4/35	2.2-2.6	12.4	ND	0.045	ca	50 (10)	MCL	Y	ASL
7440-39-3	BARIUM	1.7	J	9.1	J	µg/L	58MW0008E-LR1	16/25	0.2-0.7	9.1	No UTL	260	nc	2000	MCL	N	BSL
7440-39-3	BARIUM (TOTAL)	2	J	13.1	J	µg/L	71MW0009S-	14/35	0.25-3.6	13.1	No UTL	260	nc	2000	MCL	N	BSL
7440-41-7	BERYLLIUM	0.23	J	0.23	J	µg/L	58MW0011D-LR1	1/25	0.2-0.2	0.2	NA	7.30	nc	4	MCL	N	IFD, BSL
7440-42-8	BORON	6.7		12.6		µg/L	WL09	5/5	7.4-7.4	12.6	NA	330	nc	NA	NA	N	BSL
7440-43-9	CADMIUM (TOTAL)	0.41	J	0.41	J	µg/L	W25SSA	1/35	0.4-0.4	0.4	NA	1.80	nc	5	MCL	N	IFD, BSL
7440-70-2	CALCIUM	615		11100		µg/L	58MW0010A-01	24/25	4.15-323.1	11,100.0	4200.00	NA	NA	NA	NA	N	NUT, NSL
7440-70-2	CALCIUM (TOTAL)	731		8610		µg/L	58MW0010A-	35/35	7.4-89.1	8,610.0	4200.00	NA	NA	NA	NA	N	NUT, NSL
7440-47-3	CHROMIUM (TOTAL)	3.6	J	5.1		µg/L	58MW0015B-	3/35	0.51-0.51	5.1	No UTL	5500	nc	100 (total)	MCL	N	BSL
7440-47-3	CHROMIUM, TOTAL	3.2	J	4.1	J	µg/L	58MW0009C-01	3/25	0.4-1.1	4.1	No UTL	5500	nc	100 (total)	MCL	N	BSL
7440-48-4	COBALT	0.94	J	4.3	J	µg/L	58MW0010B-01	5/25	0.3-1.4	4.3	ND	220	nc	NA	NA	N	BSL
7440-48-4	COBALT (TOTAL)	0.72	J	6.5		µg/L	58MW0008E-	8/35	0.56-1.3	6.5	ND	220	nc	NA	NA	N	BSL
7440-50-8	COPPER	2.1	J	3.2	J	µg/L	58MW0006E-01	2/25	0.75-0.9	3.2	No UTL	140	nc	1300	TT Action Level	N	BSL
7440-50-8	COPPER (TOTAL)	1.2	J	1.2	J	µg/L	71MW0009S-	1/35	0.9-0.9	1.2	No UTL	140	nc	1300	TT Action Level	N	IFD, BSL
7439-89-6	IRON	11.4	J	256		µg/L	58MW0010B-01	7/25	1.85-19.2	256.0	No UTL	1100	nc	300	SMCL	N	BSL, NUT
7439-89-6	IRON (TOTAL)	39.5	J	4750		µg/L	71MW0009S-	10/35	17.3-19.2	4,750.0	No UTL	1100	nc	300	SMCL	N	NUT
7439-92-1	LEAD	1.2	J	11.8	J	µg/L	58MW001-01	3/25	0.9-1.3	11.8	No UTL	NA	NA	15	TT Action Level	N	NSL
7439-92-1	LEAD (TOTAL)	3.1		3.1		µg/L	71MW0009S-	1/35	1.4-1.4	3.1	No UTL	NA	NA	15	TT Action Level	N	IFD, NSL
7439-95-4	MAGNESIUM	721		4090		µg/L	58MW0010A-01	25/25	6.9-319.1	4,090.0	3100.00	NA	NA	NA	NA	N	NUT, NSL
7439-95-4	MAGNESIUM (TOTAL)	696		3230		µg/L	58MW0010A-	34/35	6.9-88.9	3,230.0	3100.00	NA	NA	NA	NA	N	NUT, NSL
7439-96-5	MANGANESE	1.2		436		µg/L	58MW0010A-01	13/25	0.2-0.9	436.0	130.00	88	nc	50	SMCL	Y	ASL
7439-96-5	MANGANESE (TOTAL)	0.7	J	466		µg/L	58MW0010A-	17/35	0.31-0.4	466.0	130.00	88	nc	50	SMCL	Y	ASL
7439-98-7	MOLYBDENUM	1.9	UJ	1.9	UJ	µg/L	WL09	1/5	2.3-2.3	1.9	NA	18	nc	NA	NA	N	BSL
7440-02-0	NICKEL	1.1	J	8	J	µg/L	58MW0006E-01	10/25	1-3.4	8.0	No UTL	73	nc	NA	NA	N	BSL
7440-02-0	NICKEL (TOTAL)	2.7	J	3		µg/L	W25SSA	2/35	0.9-0.95	3.0	No UTL	73	nc	NA	NA	N	BSL
14797-73-0	PERCHLORATE	0.41	J	2.09	J	µg/L	58MW0015A	10/38	0.35-1.5	2.09	NA	1.5	nc**	NA	NA	Y	ASL
7440-09-7	POTASSIUM	369	J	2070	J	µg/L	58MW0020A-FD	20/25	22.6-542.6	2,070.0	150.00	NA	NA	NA	NA	N	NUT, NSL
9/7/7440	POTASSIUM (TOTAL)	270	J	2240		µg/L	58MW0020A-	35/35	22.6-193.1	2,240.0	150	NA	NA	NA	NA	N	NUT, NSL
7782-49-2	SELENIUM (TOTAL)	2.5	J	2.5	J	µg/L	WL39M1-	1/35	2.4-2.4	2.5	NA	18	nc	50	MCL	N	IFD,BSL
7440-22-4	SILVER	0.91	J	3.5	J	µg/L	58MW0010B-01	4/25	0.5-1	3.5	NA	18	nc	100	SMCL	N	BSL
7440-23-5	SODIUM	3550		10900		µg/L	58MW0010A-01	25/25	14.35-442.1	10,900.0	1900.00	NA	NA	NA	NA	N	NUT, NSL
7440-23-5	SODIUM (TOTAL)	4220		9480		µg/L	58MW0010A-	35/35	110-430.2	9,480.0	1900.00	NA	NA	NA	NA	N	NUT, NSL
7440-28-0	THALLIUM	3.9	J	5.3	J	µg/L	WL25	5/25	3.2-4.8	5.3	NA	0.24	nc	2	MCL	Y	ASL
7440-28-0	THALLIUM (TOTAL)	4.7	J	4.7	J	µg/L	WL111M3-	1/35	3.8-3.8	4.7	NA	0.24	nc	2	MCL	N	IFD
7440-62-2	VANADIUM	0.74	J	0.82	J	µg/L	58MW0007E-01FD	2/25	0.7-0.7	0.8	9800.00	26	nc	NA	NA	N	BSL

Appendix A
Standard Table 2.3
Occurrence, Distribution and Selection of Chemicals of Potential Concern
MMR CS-19 Groundwater

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (Maximum)	Preliminary Background Value (2)	Screening Toxicity Value Region IX PRGs (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source (4)	COPC Flag	Rationale for Contaminant Deletion or Selection (5)
7440-62-2	VANADIUM (TOTAL)	0.82	J	9.3	J	µg/L	71MW0009S-	2/35	0.8-0.8	9.3	9800.00	26	nc	NA	NA	N	BSL
7440-66-6	ZINC	2.3		83.9		µg/L	58MW0009C-01	13/25	0.25-4.6	63.9	No UTL	1100	nc	5000	SMCL	N	BSL

(1) Minimum/maximum detected concentration. Shaded value indicates exceedance of federal drinking water maximum contaminant level (MCL).

(2) Preliminary background data from Ogden Environmental and Energy Services. 1998 (July). Draft Completion of Work Report, Volume 5: Appendix F - Evaluation of Background Data. Massachusetts Military Reservation, Cape Cod, MA. Prepared for National Guard Bureau, Arlington, VA.
NA - Not Analyzed. ND - Not Detected in background samples. UTL - Upper Tolerance Limit. No UTL - no UTL calculated due to % detects <71%.

(3) US EPA Region IX. 2000 (November). Region 9 Preliminary Remediation Goals (PRGs) 2000. ca= Cancer PRG. nc=Noncancer PRG.
c* Indicates that the noncancer PRG is less than or equal to 10X the cancer PRG.
c** Indicates that the noncancer PRG is less than or equal to 100X the cancer PRG.
nc* No Region IX PRG was available; Region III Risk-Based Concentrations (September 2001) were used.
nc** Value is the current perchlorate screening concentration in use by EPA Region 1 to evaluate groundwater.

(4) MCL - Maximum Contaminant Level. p - proposed. The maximum permissible level of a contaminant in water which is delivered to any use of a public water system. MCLs are enforceable standards.
Value in parenthesis for arsenic (10 µg/L) has been recently proposed.
SMCL - Secondary Maximum Contaminant Level. These are unenforceable federal guidelines regarding taste, odor, color, and certain other non-aesthetic effects of drinking water.
TT - Treatment Technique. An unenforceable procedure or level of technical performance which public water systems must follow to ensure control of a contaminant. Lead and copper are regulated in a Treatment Technique which requires systems to take tap water samples at sites with lead pipes or copper pipes that have lead solder and/or are served by lead service lines. The action level triggers water systems into taking treatment steps if exceeded in more than 10% of tap water samples.
Source: US EPA Current Drinking Water Standards - National Primary and Secondary Drinking Water Regulations. Office of Ground Water and Drinking Water webpage.

(5) Rationale Codes
Selection Reason:
Above Screening Levels (ASL)

Deletion Reason:
Infrequent Detection (IFD)
Essential Nutrient (NUT)
Below Screening Level (BSL)
No Screening Level (NSL)
Regional Groundwater (REG GW) - Chloroform has been documented in groundwater throughout the upper Cape (Ogden 1998).

Definitions:
ARAR/TBC = applicable or relevant and appropriate requirement/to be considered
COPC = chemical of potential concern
DDD = 2,2-bis(p-chlorophenyl)-1,1-dichloroethane
DDE = 2,2-bis(p-chlorophenyl)-1,1-dichloroethene
DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane
EPA = U.S. Environmental Protection Agency
HI = hazard index
J = estimated value
MCPP = 2-(2-methyl-1,4-chlorophenoxy) propionic acid
N = no
NA = not analyzed
ND = not detected
SVOC = semivolatile organic compound
TCDD = tetrachlorodibenzo-p-dioxin
UJ = estimated nondetect
UTL = upper tolerance limit
VOC = volatile organic compound
Y = yes
µg/L = micrograms per liter
#N/A = number not available

Appendix A
Standard Table 3.3
Medium-Specific Exposure Point Concentration Summary
MMR CS-19 Groundwater

Scenario Time Frame: Current and Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Aquifer - Tap Water

Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure (RME EPC)			Central Tendency (CT EPC)		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE (RDX)	µg/L	0.722	1.08 (N)	15	*	µg/L	15	Max	(1)	0.722	Mean	(2)
ALPHA BHC (ALPHA HEXACHLOROCYCLOHEXANE)	µg/L	0.00691	0.0078 (T)	0.079		µg/L	0.079	Max	(1)	0.00691	Mean	(2)
P,P'-DDT (DDT)	µg/L	0.0151	0.014 (T)	0.3		µg/L	0.3	Max	(1)	0.0151	Mean	(2)
ARSENIC (TOTAL)	µg/L	1.72	2.26 (N)	12.4		µg/L	12.4	Max	(1)	1.72	Mean	(2)
MANGANESE (TOTAL)	µg/L	36.1	59.4 (N)	466		µg/L	466	Max	(1)	36.1	Mean	(2)
PERCHLORATE	µg/L	0.465	.597 (T)	2.09		µg/L	2.09	Max	(1)	0.465	Mean	(2)
THALLIUM	µg/L	2.24	2.82 (T)	5.3	J	µg/L	5.3	Max	(1)	2.24	Mean	(2)

Notes:
* = maximum concentration from composite sample
DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane
EPA = U.S. Environmental Protection Agency
EPC = exposure point concentration
J = estimated value
UCL = upper confidence limit
µg/L = micrograms per liter

Statistics: maximum detected value (Max); arithmetic mean of non-transformed data (Mean).
For nondetects, 1/2 the sample detection limit was used as a proxy concentration in the calculation of arithmetic means and UCLs.
(1) The maximum concentration used for RME EPC, per EPA Region I guidance.
(2) The arithmetic average concentration was used to calculate the CT EPC instead of the highest temporal average due to data set limitations.

(N) The data conform to a normal distribution as determined by either Shapiro-Wilk or Shapiro-Francia normality test.

(T) The log-transformed data conform to a normal distribution as determined by either Shapiro-Wilk or Shapiro-Francia normality test.

Appendix A
Standard Table 4.3
Medium-Specific Exposure Point Concentration Summary
MMR CS-19 Groundwater

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

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
	IRW	Ingestion Rate of Water	L/day	2	EPA Region I	1.4	EPA Region I	RME
	EF	Exposure Frequency	days/yr	350	Site-specific**			CDI = CW x 2.7E-05 (Noncarcinogenic)
	ED	Exposure Duration	yrs	24	RAGS, Part A	9	EPA Region I	CDI = CW x 9.4E-06 (Carcinogenic)
	CF1	Conversion Factor	mg/µg	0.001	-			CT
	BW	Body Weight	kg	70	RAGS, Part A			CDI = CW x 1.9E-05 (Noncarcinogenic)
	AT-NC	Averaging Time (noncancer)	days	8,760	RAGS, Part A	3,285	EPA Region I	CDI = CW x 2.5E-06 (Carcinogenic)
	AT- C	Averaging Time (cancer)	days	25,550	RAGS, Part A			
Dermal	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
	DA_{event}	Dose absorbed per unit area per event	mg/cm^2-event	Chem.-specific	EPA 2000	Chem.-specific	EPA 2000	Where DA_{event} (mg/cm^2-event) is calculated in accordance
	SA	Skin surface area available for contact	cm^2	18,000	DRA 1998			with Draft EPA Superfund Dermal Risk Guidance (EPA, 2000)
	ET	Exposure Time	hr/day	0.58	DRA 1998	0.25	DRA 1998	RME
	EV	Event	event/day	1	EPA 2000	1	EPA 2000	DAD = DA_{event} x 2.5E+02 (Noncarcinogenic)
	EF	Exposure Frequency	days/yr	350	Site-specific**			DAD = DA_{event} x 8.5E+01 (Carcinogenic)
	ED	Exposure Duration	yrs	24	RAGS, Part A	9	EPA Region I	CT
	BW	Body Weight	kg	70	RAGS, Part A			DAD = DA_{event} x 2.5E+02 (Noncarcinogenic)
	AT-NC	Averaging Time (noncancer)	days	8,760	RAGS, Part A	3,285	EPA Region I	DAD = DA_{event} x 3.2E+01 (Carcinogenic)
	AT- C	Averaging Time (cancer)	days	25,550	RAGS, Part A			

Appendix A
Standard Table 4.3
Medium-Specific Exposure Point Concentration Summary
MMR CS-19 Groundwater

References:

EPA 2000. Draft EPA Superfund Dermal Risk Guidance (RAGS, Volume I, Part E) and EPA EXCEL Spreadsheets.

DRA 1998. EPA, Supplemental Guidance on Dermal Risk Assessment (Interim Guidance): Human Health Evaluation Manual.

EFH 1997. (August). EPA, Exposure Factors Handbook.

EPA Region I. EPA, Region I, Risk Updates. 1994 (August). Attachment 2-Interim Default Exposure Parameters for the Central Tendency. Attachment 3-Interim Default Exposure Parameters for the High End Exposure.

RAGS, Part A. 1989 (December). EPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A, Interim Final.

Notes:

The maximum concentration will be used as the RME for groundwater. The arithmetic average concentration will be used as the CT for groundwater.

** - Site-specific exposure time and frequency based on site location and accessibility.

cm^2 = square centimeters
CT = central tendency
days/yr = days per year
kg = kilograms
kg/mg = kilograms per milligram
hr/day = hours per day
L/day = liters per day
mg/cm^2 = milligrams per square centimeter
mg/cm^2 - event = milligrams per square centimeter per event
mg/day = milligrams per day
mg/kg = milligrams per kilogram
mg/kg/day = milligrams per kilogram per day
mg/L = milligrams per liter
mg/µg = milligrams per microgram
RME = reasonable maximum exposure
UCL = upper confidence limit
yr = year
µg/L = micrograms per liter

Appendix A
Standard Table 4.4
Values Used for Daily Intake Calculations
MMR CS-19 Groundwater

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

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Chronic Daily Intake (CDI) (mg/kg/day) = CW x IRW x EF x ED x CF1 x 1/BW x 1/AT
	IRW	Ingestion Rate of Water	L/day	1	EPA Region I			RME
	EF	Exposure Frequency	days/yr	350	Site-specific**			CDI = CW x 6.4E-05 (Noncarcinogenic)
	ED	Exposure Duration	yrs	6	RAGS, Part A			CDI = CW x 5.5E-06 (Carcinogenic)
	CF1	Conversion Factor	mg/µg	0.001	-			CT
	BW	Body Weight	kg	15	RAGS, Part A			CDI = CW x 6.4E-05 (Noncarcinogenic)
	AT-NC	Averaging Time (noncancer)	days	2,190	RAGS, Part A			CDI = CW x 5.5E-06 (Carcinogenic)
	AT- C	Averaging Time (cancer)	days	25,550	RAGS, Part A			
Dermal	CW	Chemical Concentration in Water	µg/L	Chem.-specific Maximum	-	Chem.-specific Arithmetic Mean	-	Dermal Absorbed Dose (DAD) (mg/kg/day) = DA_{event} x SA x EV x EF x ED x 1/BW x 1/AT
	DA_{event}	Dose absorbed per unit area per event	mg/cm^2-event	Chem.-specific	EPA 2000	Chem.-specific	EPA 2000	Where DA_{event} (mg/cm^2-event) is calculated in accordance
	SA	Skin surface area available for contact	cm^2	6,600	DRA 1998			with Draft EPA Superfund Dermal Risk Guidance (EPA, 2000)
	ET	Exposure Time	hr/day	1	DRA 1998	0.33	DRA 1998	RME
	EV	Event	event/day	1	EPA 2000	1	EPA 2000	DAD = DA_{event} x 4.2E+02 (Noncarcinogenic)
	EF	Exposure Frequency	days/yr	350	Site-specific**			DAD = DA_{event} x 3.6E+01 (Carcinogenic)
	ED	Exposure Duration	yrs	6	RAGS, Part A			CT
	BW	Body Weight	kg	15	RAGS, Part A			DAD = DA_{event} x 4.2E+02 (Noncarcinogenic)
	AT-NC	Averaging Time (noncancer)	days	2,190	RAGS, Part A			DAD = DA_{event} x 3.6E+01 (Carcinogenic)
	AT- C	Averaging Time (cancer)	days	25,550	RAGS, Part A			

Appendix A
Standard Table 4.4
Values Used for Daily Intake Calculations
MMR CS-19 Groundwater

References:

EPA 2000. Draft EPA Superfund Dermal Risk Guidance (RAGS, Volume I, Part E) and EPA EXCEL Spreadsheets.

DRA 1998. EPA, Supplemental Guidance on Dermal Risk Assessment (Interim Guidance): Human Health Evaluation Manual.

EFH 1997. (August). EPA, Exposure Factors Handbook.

EPA Region I. EPA, Region I, Risk Updates. 1994 (August). Attachment 2-Interim Default Exposure Parameters for the Central Tendency. Attachment 3-Interim Default Exposure Parameters for the High End Exposure.

RAGS, Part A. 1989 (December). EPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A, Interim Final.

Notes:

The maximum concentration will be used as the RME for groundwater. The arithmetic average concentration will be used as the CT for groundwater.

** - Site-specific exposure time and frequency based on site location and accessibility.

cm^2 = square centimeters

CT = central tendency

days/yr = days per year

EPA = U.S. Environmental Protection Agency

kg = kilograms

kg/mg = kilograms per milligram

hr/day = hours per day

L/day = liters per day

mg/cm^2 = milligrams per square centimeter

mg/cm^2 - event = milligrams per square centimeter per event

mg/day = milligrams per day

mg/kg = milligrams per kilogram

mg/kg/day = milligrams per kilogram per day

mg/L = milligrams per liter

mg/µg = milligrams per microgram

RME = reasonable maximum exposure

UCL = upper confidence limit

yrs = year

µg/L = micrograms per liter

Appendix A
Standard Table 5.1
Non-Cancer Chronic Toxicity Data-Oral/Dermal
MMR CS-19

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (MM/YY) (3)
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	Chronic	3.0E-03	mg/kg/day	none	3.0E-03	mg/kg/day	Prostate	100	IRIS	11/01
P,P'-DDT (DDT)	Chronic	5.0E-04	mg/kg/day	none	5.0E-04	mg/kg/day	Liver	100	IRIS	11/01
alpha-BHC	Chronic	--	mg/kg/day	--	--	mg/kg/day	--	--	IRIS	11/01
Arsenic	Chronic	3.0E-04	mg/kg/day	none	3.0E-04	mg/kg/day	Skin	3	IRIS	11/01
Manganese	Chronic	2.4E-02	mg/kg/day	none	2.4E-02	mg/kg/day	CNS	1	EPA Region 1	11/96
Perchlorate	Chronic	5.0E-04	mg/kg/day	none	5.0E-04	mg/kg/day	Thyroid	--	EPA (NCEA)	--
Thallium	Chronic	6.6E-05	mg/kg/day	none	6.6E-05	mg/kg/day	Liver	3000	IRIS	11/01

Notes:
-- = not available
alpha-BHC = alpha-hexachlorocyclohexane
CNS = central nervous system
DDT = 2,2-bis(p-chlorophenyl)-1,1-dichloroethane
EPA = U.S. Environmental Protection Agency
mg/kg/day = milligrams per kilogram per day
RfD = reference dose
IRIS =Integrated Risk Information System. Online database. Accessed 4/1/00, 5/23/00, 5/31/00, 11/23/2001, and 08/13/02 EPA, 2002.
EPA Region I, Risk Updates, Number 4. November 1996.
EPA (NCEA)= National Center For Environmental Assessment
HEAST=Health Effects Assessment Summary Tables
(1), (2), and (3) DRA, 1998. EPA, Supplemental Guidance on Dermal Risk Assessment (Interim Guidance): Human Health Evaluation Manual.

Appendix A
Standard Table 6.1
Cancer Toxicity Data - Oral
MMR CS-19

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (2)
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	1.1E-01	none	1.1E-01	$(mg/kg/day)^{-1}$	C	IRIS	11/01
P,P'-DDT (DDT)	3.4E-01	none	3.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	11/01
alpha-BHC	6.3E+00	none	6.3E+00	$(mg/kg/day)^{-1}$	B2	IRIS	11/01
Arsenic	1.5E+00	none	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	11/01
Manganese	--	--	--	$(mg/kg/day)^{-1}$	D	IRIS	11/01
Perchlorate	--	--	--	$(mg/kg/day)^{-1}$	--	EPA	2000
Thallium	--	--	--	$(mg/kg/day)^{-1}$	D	IRIS	11/01

Notes:
-- = not available
alpha-BHC = alpha-hexachlorocyclohexane
DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane
EPA = U.S. Environmental Protection Agency
mg/kg/day = milligrams per kilogram per day
(1) DRA 1998. EPA, Supplemental Guidance on Dermal Risk Assessment (Interim Guidance): Human Health Evaluation Manual.
(2) IRIS - Toxicity values were obtained from Integrated Risk Information System (IRIS) (on-line November 2001 and August 2002).
EPA - Draft Dioxin Reassessment (September 2000).
HEAST - Toxicity values were obtained from Health Effects Assessment Summary Tables (HEAST) Annual FY-1997.
EPA - Region 9 PRGs (2000)
EPA Weight of Evidence Classification:
A - Human carcinogen
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen

Appendix A
Standard Table 7.5 RME
Calculation of Non-Cancer Hazards, Adult
CS-19 Study Area

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

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	4.1E-04	mg/kg-day	3.0E-03	mg/kg-day	--	--	1.4E-01
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	2.1E-06	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	8.1E-06	mg/kg-day	5.0E-04	mg/kg-day	--	--	1.6E-02
	Arsenic	12.4	µg/L	12.4	µg/L	M	3.3E-04	mg/kg-day	3.0E-04	mg/kg-day	--	--	1.1E+00
	Manganese	466	µg/L	466	µg/L	M	1.3E-02	mg/kg-day	2.4E-02	mg/kg-day	--	--	5.2E-01
	Perchlorate	2.09	µg/L	2.09	µg/L	M	5.6E-05	mg/kg-day	5.0E-04	mg/kg-day	--	--	1.1E-01
	Thallium	5.30	µg/L	5.30	µg/L	M	1.4E-04	mg/kg-day	6.6E-05	mg/kg-day	--	--	2.2E+00
	(Total)												4.1E+00
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	3.7E-06	mg/kg-day	3.0E-03	mg/kg-day	--	--	1.2E-03
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	1.0E-06	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	1.0E-04	mg/kg-day	5.0E-04	mg/kg-day	--	--	2.0E-01
	Arsenic	12.4	µg/L	12.4	µg/L	M	1.8E-06	mg/kg-day	3.0E-04	mg/kg-day	--	--	6.0E-03
	Manganese	466	µg/L	466	µg/L	M	6.7E-05	mg/kg-day	2.4E-02	mg/kg-day	--	--	2.8E-03
	Perchlorate	2.09	µg/L	2.09	µg/L	M	3.0E-07	mg/kg-day	5.0E-04	mg/kg-day	--	--	6.0E-04
	Thallium	5.30	µg/L	5.30	µg/L	M	7.6E-07	mg/kg-day	6.6E-05	mg/kg-day	--	--	1.2E-02
	(Total)												2.2E-01
												Total Hazard Index Across All Exposure Routes/Pathways	4.3E+00

Notes:

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

(2) Specify if subchronic.

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

EPC = exposure point concentration

mg/kg-day = milligrams per kilogram per day

RME = reasonable maximum exposure

µg/L = micrograms per liter

Appendix A
Standard Table 7.5 CT
Calculation of Non-Cancer Hazards, Adult
CS-19 Study Area

Scenario Time Frame:	Future
Medium:	Groundwater
Exposure Medium:	Groundwatet
Exposure Point:	Aquifer - Tap Water
Receptor Population:	Resident
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	1.4E-05	mg/kg-day	3.0E-03	mg/kg-day	--	--	4.6E-03
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	1.3E-07	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	2.9E-07	mg/kg-day	5.0E-04	mg/kg-day	--	--	5.7E-04
	Arsenic	1.72	µg/L	1.72	µg/L	M	3.3E-05	mg/kg-day	3.0E-04	mg/kg-day	--	--	1.1E-01
	Manganese	36.1	µg/L	36.1	µg/L	M	6.9E-04	mg/kg-day	2.4E-02	mg/kg-day	--	--	2.9E-02
	Perchlorate	0.465	µg/L	0.465	µg/L	M	8.8E-06	mg/kg-day	5.0E-04	mg/kg-day	--	--	1.8E-02
	Thallium	2.24	µg/L	2.24	µg/L	M	4.3E-05	mg/kg-day	6.6E-05	mg/kg-day	--	--	6.4E-01
	(Total)												8.1E-01
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	1.2E-07	mg/kg-day	3.0E-03	mg/kg-day	--	--	4.0E-05
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	6.0E-08	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	3.4E-06	mg/kg-day	5.0E-04	mg/kg-day	--	--	6.8E-03
	Arsenic	1.72	µg/L	1.72	µg/L	M	1.1E-07	mg/kg-day	3.0E-04	mg/kg-day	--	--	3.7E-04
	Manganese	36.1	µg/L	36.1	µg/L	M	2.2E-06	mg/kg-day	2.4E-02	mg/kg-day	--	--	9.2E-05
	Perchlorate	0.465	µg/L	0.465	µg/L	M	3.0E-08	mg/kg-day	5.0E-04	mg/kg-day	--	--	6.0E-05
	Thallium	2.24	µg/L	2.24	µg/L	M	1.4E-07	mg/kg-day	6.6E-05	mg/kg-day	--	--	2.1E-03
	(Total)												9.5E-03
												Total Hazard Index Across All Exposure Routes/Pathways	8.1E-01

Notes:

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

(2) Specify if subchronic.

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

CT = central tendency

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

EPC = exposure point concentration

mg/kg-day = milligrams per kilogram per day

µg/L = micrograms per liter

Appendix A
Standard Table 7.6 RME
Calculation of Non-Cancer Hazards, Child
CS-19 Study Area

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

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	9.6E-04	mg/kg-day	3.0E-03	mg/kg-day	--	--	3.2E-01
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	5.1E-06	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	1.9E-05	mg/kg-day	5.0E-04	mg/kg-day	--	--	3.8E-02
	Arsenic	12.4	µg/L	12.4	µg/L	M	7.9E-04	mg/kg-day	3.0E-04	mg/kg-day	--	--	2.6E+00
	Manganese	466	µg/L	466	µg/L	M	3.0E-02	mg/kg-day	2.4E-02	mg/kg-day	--	--	1.2E+00
	Perchlorate	2.09	µg/L	2.09	µg/L	M	1.3E-04	mg/kg-day	5.0E-04	mg/kg-day	--	--	2.7E-01
	Thallium	5.30	µg/L	5.30	µg/L	M	3.4E-04	mg/kg-day	6.6E-05	mg/kg-day	--	--	5.1E+00
	(Total)												9.7E+00
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	8.2E-06	mg/kg-day	3.0E-03	mg/kg-day	--	--	2.7E-03
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	2.3E-06	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	2.3E-04	mg/kg-day	5.0E-04	mg/kg-day	--	--	4.6E-01
	Arsenic	12.4	µg/L	12.4	µg/L	M	5.2E-06	mg/kg-day	3.0E-04	mg/kg-day	--	--	1.7E-02
	Manganese	466	µg/L	466	µg/L	M	2.0E-04	mg/kg-day	2.4E-02	mg/kg-day	--	--	8.3E-03
	Perchlorate	2.09	µg/L	2.09	µg/L	M	8.8E-07	mg/kg-day	5.0E-04	mg/kg-day	--	--	1.8E-03
	Thallium	5.30	µg/L	5.30	µg/L	M	2.2E-06	mg/kg-day	6.6E-05	mg/kg-day	--	--	3.3E-02
	(Total)												5.2E-01
												Total Hazard Index Across All Exposure Routes/Pathways	1.0E+01

Notes:

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

(2) Specify if subchronic.

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

EPC = exposure point concentration

mg/kg-day = milligrams per kilogram per day

RME = reasonable maximum exposure

µg/L = micrograms per liter

Appendix A
Standard Table 7.6 CT
Calculation of Non-Cancer Hazards, Child
CS-19 Study Area

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

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	4.6E-05	mg/kg-day	3.0E-03	mg/kg-day	--	--	1.5E-02
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	4.4E-07	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	9.7E-07	mg/kg-day	5.0E-04	mg/kg-day	--	--	1.9E-03
	Arsenic	1.72	µg/L	1.72	µg/L	M	1.1E-04	mg/kg-day	3.0E-04	mg/kg-day	--	--	3.7E-01
	Manganese	36.1	µg/L	36.1	µg/L	M	2.3E-03	mg/kg-day	2.4E-02	mg/kg-day	--	--	9.6E-02
	Perchlorate	0.465	µg/L	0.465	µg/L	M	3.0E-05	mg/kg-day	5.0E-04	mg/kg-day	--	--	6.0E-02
	Thallium	2.24	µg/L	2.24	µg/L	M	1.4E-04	mg/kg-day	6.6E-05	mg/kg-day	--	--	2.2E+00
	(Total)												2.7E+00
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	2.3E-07	mg/kg-day	3.0E-03	mg/kg-day	--	--	7.7E-05
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	1.2E-07	mg/kg-day	NA	mg/kg-day	--	--	--
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	6.7E-06	mg/kg-day	5.0E-04	mg/kg-day	--	--	1.3E-02
	Arsenic	1.72	µg/L	1.72	µg/L	M	2.4E-07	mg/kg-day	3.0E-04	mg/kg-day	--	--	8.0E-04
	Manganese	36.1	µg/L	36.1	µg/L	M	5.0E-06	mg/kg-day	2.4E-02	mg/kg-day	--	--	2.1E-04
	Perchlorate	0.465	µg/L	0.465	µg/L	M	6.3E-08	mg/kg-day	5.0E-04	mg/kg-day	--	--	1.3E-04
	Thallium	2.24	µg/L	2.24	µg/L	M	3.1E-07	mg/kg-day	6.6E-05	mg/kg-day	--	--	4.7E-03
	(Total)												1.9E-02
												Total Hazard Index Across All Exposure Routes/Pathways	2.7E+00

Notes.
(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic.
-- = not available
alpha-BHC = alpha-hexachlorocyclohexane
CT = central tendency
DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane
EPC = exposure point concentration
mg/kg-day = milligrams per kilogram per day
µg/L = micrograms per liter

Appendix A
Standard Table 8.5 RME
Calculation of Cancer Risks, Adult
CS-19 Study Area

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

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	1.4E-04	mg/kg-day	1.1E-01	$(mg/kg\text{-}day)^{-1}$	1.6E-05
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	7.4E-07	mg/kg-day	6.3E+00	$(mg/kg\text{-}day)^{-1}$	4.7E-06
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	2.8E-06	mg/kg-day	3.4E-01	$(mg/kg\text{-}day)^{-1}$	9.6E-07
	Arsenic	12.4	µg/L	12.4	µg/L	M	1.2E-04	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1.7E-04
	Manganese	466	µg/L	466	µg/L	M	4.4E-03	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Perchlorate	2.09	µg/L	2.09	µg/L	M	2.0E-05	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Thallium	5.30	µg/L	5.30	µg/L	M	5.0E-05	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	(Total)										2.0E-04
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	1.3E-06	mg/kg-day	1.1E-01	$(mg/kg\text{-}day)^{-1}$	1.4E-07
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	3.6E-07	mg/kg-day	6.3E+00	$(mg/kg\text{-}day)^{-1}$	2.3E-06
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	3.6E-05	mg/kg-day	3.4E-01	$(mg/kg\text{-}day)^{-1}$	1.2E-05
	Arsenic	12.4	µg/L	12.4	µg/L	M	6.1E-07	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	9.2E-07
	Manganese	466	µg/L	466	µg/L	M	2.3E-05	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Perchlorate	2.09	µg/L	2.09	µg/L	M	1.0E-07	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Thallium	5.30	µg/L	5.30	µg/L	M	2.6E-07	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	(Total)										1.6E-05
										Total Risk Across All Exposure Routes/Pathways	2.1E-04

Notes:

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

EPC = exposure point concentration

mg/kg-day = milligrams per kilogram per day

RME = reasonable maximum exposure

µg/L = micrograms per liter

Appendix A
Standard Table 8.5 CT
Calculation of Cancer Risks, Adult
CS-19 Study Area

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

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	1.8E-08	mg/kg-day	1.1E-01	$(mg/kg\text{-}day)^{-1}$	2.0E-07
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	1.7E-08	mg/kg-day	6.3E+00	$(mg/kg\text{-}day)^{-1}$	1.1E-07
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	3.8E-08	mg/kg-day	3.4E-01	$(mg/kg\text{-}day)^{-1}$	1.3E-08
	Arsenic	1.72	µg/L	1.72	µg/L	M	4.3E-06	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	6.5E-06
	Manganese	36.1	µg/L	36.1	µg/L	M	9.0E-05	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Perchlorate	0.465	µg/L	0.465	µg/L	M	1.2E-06	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Thallium	2.24	µg/L	2.24	µg/L	M	5.6E-06	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	(Total)										6.8E-06
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	1.5E-08	mg/kg-day	1.1E-01	$(mg/kg\text{-}day)^{-1}$	1.7E-09
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	7.7E-09	mg/kg-day	6.3E+00	$(mg/kg\text{-}day)^{-1}$	4.9E-08
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	4.4E-07	mg/kg-day	3.4E-01	$(mg/kg\text{-}day)^{-1}$	1.5E-07
	Arsenic	1.72	µg/L	1.72	µg/L	M	1.4E-08	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	2.1E-08
	Manganese	36.1	µg/L	36.1	µg/L	M	2.9E-07	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Perchlorate	0.465	µg/L	0.465	µg/L	M	3.8E-09	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	Thallium	2.24	µg/L	2.24	µg/L	M	1.8E-08	mg/kg-day	--	$(mg/kg\text{-}day)^{-1}$	--
	(Total)										2.2E-07
										Total Risk Across All Exposure Routes/Pathways	7.0E-06

Notes:

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

CT = central tendency

DDT - 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

EPC = exposure point concentration

mg/kg-day = milligrams per kilogram per day

µg/L = micrograms per liter

Appendix A
Standard Table 8.6 RME
Calculation of Cancer Risks, Child
CS-19 Study Area

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

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	8.3E-05	mg/kg-day	1.1E-01	$(mg/kg-day)^{-1}$	9.1E-06
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	4.3E-07	mg/kg-day	6.3E+00	$(mg/kg-day)^{-1}$	2.7E-06
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	1.7E-06	mg/kg-day	3.4E-01	$(mg/kg-day)^{-1}$	5.6E-07
	Arsenic	12.4	µg/L	12.4	µg/L	M	6.8E-05	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	1.0E-04
	Manganese	466	µg/L	466	µg/L	M	2.6E-03	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Perchlorate	2.09	µg/L	2.09	µg/L	M	1.1E-05	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Thallium	5.30	µg/L	5.30	µg/L	M	2.9E-05	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	(Total)										1.1E-04
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	15.0	µg/L	15.0	µg/L	M	7.0E-07	mg/kg-day	1.1E-01	$(mg/kg-day)^{-1}$	7.7E-08
	alpha-BHC	7.90E-02	µg/L	7.90E-02	µg/L	M	2.0E-07	mg/kg-day	6.3E+00	$(mg/kg-day)^{-1}$	1.3E-06
	P,P'-DDT (DDT)	0.300	µg/L	0.300	µg/L	M	2.0E-05	mg/kg-day	3.4E-01	$(mg/kg-day)^{-1}$	6.8E-06
	Arsenic	12.4	µg/L	12.4	µg/L	M	4.5E-07	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	6.8E-07
	Manganese	466	µg/L	466	µg/L	M	1.7E-05	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Perchlorate	2.09	µg/L	2.09	µg/L	M	7.6E-08	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Thallium	5.30	µg/L	5.30	µg/L	M	1.9E-07	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	(Total)										8.8E-06
										Total Risk Across All Exposure Routes/Pathways	1.2E-04

Notes:

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

EPC = exposure point concentration

mg/kg-day = milligrams per kilogram per day

RME = reasonable maximum exposure

µg/L = micrograms per liter

Appendix A
Standard Table 8.6 CT
Calculation of Cancer Risks, Child
CS-19 Study Area

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

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	4.0E-06	mg/kg-day	1.1E-01	$(mg/kg-day)^{-1}$	4.4E-07
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	3.8E-08	mg/kg-day	6.3E+00	$(mg/kg-day)^{-1}$	2.4E-07
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	8.3E-08	mg/kg-day	3.4E-01	$(mg/kg-day)^{-1}$	2.8E-08
	Arsenic	1.72	µg/L	1.72	µg/L	M	9.5E-06	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	1.4E-05
	Manganese	36.1	µg/L	36.1	µg/L	M	2.0E-04	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Perchlorate	0.465	µg/L	0.465	µg/L	M	2.6E-06	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Thallium	2.24	µg/L	2.24	µg/L	M	1.2E-05	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	(Total)										1.5E-05
Dermal	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	0.722	µg/L	0.722	µg/L	M	1.9E-08	mg/kg-day	1.1E-01	$(mg/kg-day)^{-1}$	2.1E-09
	alpha-BHC	0.00691	µg/L	0.00691	µg/L	M	1.0E-08	mg/kg-day	6.3E+00	$(mg/kg-day)^{-1}$	6.3E-08
	P,P'-DDT (DDT)	0.0151	µg/L	0.0151	µg/L	M	5.8E-07	mg/kg-day	3.4E-01	$(mg/kg-day)^{-1}$	2.0E-07
	Arsenic	1.72	µg/L	1.72	µg/L	M	2.1E-08	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	3.2E-08
	Manganese	36.1	µg/L	36.1	µg/L	M	4.3E-07	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Perchlorate	0.465	µg/L	0.465	µg/L	M	5.4E-09	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	Thallium	2.24	µg/L	2.24	µg/L	M	2.7E-08	mg/kg-day	--	$(mg/kg-day)^{-1}$	--
	(Total)										2.9E-07
										Total Risk Across All Exposure Routes/Pathways	1.5E-05

Notes:

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

CT = central tendency

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

EPC = exposure point concentration

mg/kg-day = milligrams per kilogram per day

µg/L = micrograms per liter

Appendix A
Standard Table 9.3 RME
Summary of Receptor Risks and Hazards for COPCs, Adult
CS-19 Study Area

Scenario Time Frame: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	1.6E-05	--	1.4E-07	1.6E-05	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	Prostate	1.4E-01	--	1.2E-03	1.4E-01
			alpha-BHC	4.7E-06	--	2.3E-06	7.0E-06	alpha-BHC	NA	--	--	--	--
			P,P'-DDT (DDT)	9.6E-07	--	1.2E-05	1.3E-05	P,P'-DDT (DDT)	Liver	1.6E-02	--	2.0E-01	2.2E-01
			Arsenic	1.7E-04	--	9.2E-07	1.7E-04	Arsenic	Skin	1.1E+00	--	6.0E-03	1.1E+00
			Manganese	--	--	--	--	Manganese	CNS	5.2E-01	--	2.8E-03	5.2E-01
			Perchlorate	--	--	--	--	Perchlorate	Thyroid	1.1E-01	--	6.0E-04	1.1E-01
			Thallium	--	--	--	--	Thallium	Liver	2.2E+00	--	1.2E-02	2.2E+00
			(Total)	1.9E-04	--	1.5E-05	2.1E-04	(Total)		4.1E+00	--	2.2E-01	4.3E+00

Total Risk Across Groundwater	2.1E-04
Total Adult Risk Across All Media and All Exposure Routes	2.1E-04
Total Child Risk Across All Media and All Exposure Routes	1.2E-04
Total Adult and Child Risk Across All Media and All Exposure Routes	3.3E-04

Total Hazard Index (HI) Across All Media and All Exposure Routes	4.3E+00

Total Prostate HI =	1.4E-01
Total Liver HI =	2.4E+00
Total CNS HI =	5.2E-01
Total Skin HI =	1.1E+00
Total Thyroid HI =	1.1E-01

Notes:

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

CNS = central nervous system

COPC = chemical of potential concern

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

RME = reasonable maximum exposure

Appendix A
Standard Table 9.3 CT
Summary of Receptor Risks and Hazards for COPCs, Adult
CS-19 Study Area

Scenario Time Frame: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	2.0E-07	--	1.7E-09	2.0E-07	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	Prostate	4.6E-03	--	4.0E-05	4.6E-03
			alpha-BHC	1.1E-07	--	4.9E-08	1.6E-07	alpha-BHC	NA	--	--	--	--
			P,P'-DDT (DDT)	1.3E-08	--	1.5E-07	1.6E-07	P,P'-DDT (DDT)	Liver	5.7E-04	--	6.8E-03	7.4E-03
			Arsenic	6.5E-06	--	2.1E-08	6.5E-06	Arsenic	Skin	1.1E-01	--	3.7E-04	1.1E-01
			Manganese	--	--	--	--	Manganese	CNS	2.9E-02	--	9.2E-05	2.9E-02
			Perchlorate	--	--	--	--	Perchlorate	Thyroid	1.8E-02	--	6.0E-05	1.8E-02
			Thallium	--	--	--	--	Thallium	Liver	6.4E-01	--	2.1E-03	6.4E-01
			(Total)	6.8E-06	--	2.2E-07	7.0E-06	(Total)		8.0E-01	--	9.5E-03	8.1E-01

Total Risk Across Groundwater	7.0E-06	Total Hazard Index (HI) Across All Media and All Exposure Routes	8.1E-01
Total Adult Risk Across All Media and All Exposure Routes	7.0E-06		
Total Child Risk Across All Media and All Exposure Routes	1.5E-05	Total Prostate HI =	4.6E-03
Total Adult and Child Risk Across All Media and All Exposure Routes	2.2E-05	*Total Liver HI =*	6.5E-01
		Total CNS HI =	2.9E-02
		Total Skin HI =	1.1E-01
		Total Thyroid HI =	1.8E-02

Notes:

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

CNS = central nervous system

COPC = chemical of potential concern

CT = central tendency

Appendix A
Standard Table 9.4 RME
Summary of Receptor Risks and Hazards for COPCs, Child
CS-19 Study Area

Scenario Time Frame:	Future
Receptor Population:	Resident
Receptor Age:	Child (0-6 years)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	9.1E-06	--	7.7E-08	9.2E-06	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	Prostate	3.2E-01	--	2.7E-03	3.2E-01
			alpha-BHC	2.7E-06	--	1.3E-06	4.0E-06	alpha-BHC	NA	--	--	--	--
			P,P'-DDT (DDT)	5.6E-07	--	6.8E-06	7.4E-06	P,P'-DDT (DDT)	Liver	3.8E-02	--	4.6E-01	5.0E-01
			Arsenic	1.0E-04	--	6.8E-07	1.0E-04	Arsenic	Skin	2.6E+00	--	1.7E-02	2.6E+00
			Manganese	--	--	--	--	Manganese	CNS	1.2E+00	--	8.3E-03	1.2E+00
			Perchlorate	--	--	--	--	Perchlorate	Thyroid	2.7E-01	--	1.8E-03	2.7E-01
			Thallium	--	--	--	--	Thallium	Liver	5.1E+00	--	3.3E-02	5.1E+00
			(Total)	1.1E-04	--	8.9E-06	1.2E-04	(Total)		9.5E+00	--	5.2E-01	1.0E+01

Total Risk Across Groundwater	1.2E-04
Total Child Risk Across All Media and All Exposure Routes	1.2E-04
Total Adult Risk Across All Media and All Exposure Routes	2.1E-04
Total Adult and Child Risk Across All Media and All Exposure Routes	3.3E-04

Total Hazard Index (HI) Across All Media and All Exposure Routes	1.0E+01

Total Prostate HI =	3.2E-01
Total Liver HI =	5.6E+00
Total CNS HI =	1.2E+00
Total Skin HI =	2.6E+00
Total Thyroid HI =	2.7E-01

Notes:

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

CNS = central nervous system

COPC = chemical of potential concern

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

RME = reasonable maximum exposure

Appendix A
Standard Table 9.4 CT
Summary of Receptor Risks and Hazards for COPCs, Child
CS-19 Study Area

Scenario Time Frame:	Future
Receptor Population:	Resident
Receptor Age:	Child (0-6 years)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Noncarcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	4.4E-07	--	2.1E-09	4.4E-07	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	Prostate	1.5E-02	--	7.7E-05	1.5E-02
			alpha-BHC	2.4E-07	--	6.3E-08	3.0E-07	alpha-BHC	NA	--	--	--	--
			P,P'-DDT (DDT)	2.8E-08	--	2.0E-07	2.3E-07	P,P'-DDT (DDT)	Liver	1.9E-03	--	1.3E-02	1.5E-02
			Arsenic	1.4E-05	--	3.2E-08	1.4E-05	Arsenic	Skin	3.7E-01	--	8.0E-04	3.7E-01
			Manganese	--	--	--	--	Manganese	CNS	9.6E-02	--	2.1E-04	9.6E-02
			Perchlorate	--	--	--	--	Perchlorate	Thyroid	6.0E-02	--	1.3E-04	6.0E-02
			Thallium	--	--	--	--	Thallium	Liver	2.2E+00	--	4.7E-03	2.2E+00
			(Total)	1.5E-05	--	3.0E-07	1.5E-05	(Total)		2.7E+00	--	1.9E-02	2.8E+00

Total Risk Across Groundwater	1.5E-05
Total Child Risk Across All Media and All Exposure Routes	1.5E-05
Total Adult Risk Across All Media and All Exposure Routes	7.0E-06
Total Adult and Child Risk Across All Media and All Exposure Routes	2.2E-05

Total Hazard Index (HI) Across All Media and All Exposure Routes	2.8E+00

Total Prostate HI =	1.5E-02
Total Liver HI =	2.2E+00
Total CNS HI =	9.6E-02
Total Skin HI =	3.7E-01
Total Thyroid HI =	6.0E-02

Notes:

-- = not available

alpha-BHC = alpha-hexachlorocyclohexane

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

CNS = central nervous system

COPC = chemical of potential concern

CT = central tendency

Appendix A
Standard Table 10.3 RME
Risk Assessment Summary, Adult
CS-19 Study Area

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

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	1.6E-05	--	1.4E-07	1.6E-05	Arsenic	Skin	1.1E+00	--	6.0E-03	1.1E+00
								Thallium (Total)	Liver	2.2E+00	--	1.2E-02	2.2E+00
			alpha-BHC	4.7E-06	--	2.3E-06	7.0E-06			3.3E+00	--	1.8E-02	3.3E+00
			P,P'-DDT (DDT)	9.6E-07	--	1.2E-05	1.3E-05						
			Arsenic	1.7E-04	--	9.2E-07	1.7E-04						
			(Total)	1.9E-04	--	1.5E-05	2.1E-04						

Total Risk Across Groundwater	2.1E-04	Total Hazard Index Across All Media and All Exposure Routes	3.3E+00
Total Adult Risk Across All Media and All Exposure Routes	2.1E-04		
Total Child Risk Across All Media and All Exposure Routes	1.2E-04		
Total Adult and Child Risk Across All Media and All Exposure Routes	3.3E-04		

Notes:

alpha-BHC = alpha-hexachlorocyclohexane

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

Appendix A
Standard Table 10.3 CT
Risk Assessment Summary, Adult
CS-19 Study Area

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

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Arsenic	6.5E-06	--	2.1E-08	6.5E-06	None					
			(Total)	6.5E-06	--	2.1E-08	6.5E-06						

Total Risk Across Groundwater	6.5E-06
Total Adult Risk Across All Media and All Exposure Routes	6.5E-06
Total Child Risk Across All Media and All Exposure Routes	1.4E-05
Total Adult and Child Risk Across All Media and All Exposure Routes	2.1E-05

Total Hazard Index Across All Media and All Exposure Routes

Appendix A
Standard Table 10.4 RME
Risk Assessment Summary, Child
CS-19 Study Area

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Child (0-6 years)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX)	9.1E-06	--	7.7E-08	9.2E-06	Arsenic	Skin	2.6E+00	--	1.7E-02	2.6E+00
								Manganese	CNS	1.2E+00	--	8.3E-03	1.2E+00
			alpha-BHC	2.7E-06	--	1.3E-06	4.0E-06	Thallium	Liver	5.1E+00	--	3.3E-02	5.1E+00
			P,P'-DDT (DDT)	5.6E-07	--	6.8E-06	7.4E-06	(Total)		8.9E+00	--	5.8E-02	9.0E+00
			Arsenic	1.0E-04	--	6.8E-07	1.0E-04						
			(Total)	1.1E-04	--	8.9E-06	1.2E-04						

Total Risk Across Groundwater	1.2E-04
Total Child Risk Across All Media and All Exposure Routes	1.2E-04
Total Adult Risk Across All Media and All Exposure Routes	2.1E-04
Total Adult and Child Risk Across All Media and All Exposure Routes	3.3E-04

Total Hazard Index Across All Media and All Exposure Routes	9.0E+00

Notes:

alpha-BHC = alpha-hexachlorocyclohexane

CNS - central nervous system

DDT = 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane

RME = reasonable maximum exposure

Appendix A
Standard Table 10.4 CT
Risk Assessment Summary, Child
CS-19 Study Area

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Child (0-6 years)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Aquifer - Tap Water	Arsenic	1.4E-05		3.2E-08	1.4E-05	Thallium	Liver	2.2E+00		4.7E-03	2.2E+00
			(Total)	1.4E-05	--	3.2E-08	1.4E-05	(Total)		2.2E+00	--	4.7E-03	2.2E+00

Total Risk Across Groundwater	1.4E-05
Total Child Risk Across All Media and All Exposure Routes	1.4E-05
Total Adult Risk Across All Media and All Exposure Routes	6.5E-06
Total Adult and Child Risk Across All Media and All Exposure Routes	2.1E-05

Total Hazard Index Across All Media and All Exposure Routes	2.2E+00

APPENDIX B

Transcript of Public Hearing

MASSACHUSETTS MILITARY RESERVATION

INSTALLATION RESTORATION PROGRAM

In Re:

Chemical Spill 19 (CS-19)
Groundwater Proposed Plan for
Interim Action

Best Western
Bridge-Bourne Hotel
100 Trowbridge Road
Bourne, MA 02532
Tuesday, February 15, 2005
6:45 p.m.

HEARING OFFICER:

Douglas Karson, AFCEE

Mary E. Phillips, RPR
M&M Phillips Enterprises, Inc.
P.O. Box 160, Sagamore Beach, MA 02562-0160
508.888.6717

ATTENDEES:
(Signed in)

Peter Schlesinger, Citizen

Henry Cui, DEP

Mike Minior, Air National Guard

Jim Murphy, EPA

Kevin Hood

Lana Brodziak, Portage Environmental

Anita Riggassio-Smith, Jacobs Engineering

Paul Marchassault

P R O C E E D I N G S

THE HEARING OFFICER: We are now starting the public hearing portion of the meeting. The official record is now open.

My name is Doug Karson, community involvement lead for the Installation Restoration Program at the Massachusetts Military Reservation. I am the Hearing Officer here tonight.

The purpose of this hearing is to accept oral comments, testimony and written comments on the Chemical Spill 19 Groundwater Proposed Plan for Interim Action.

All comments or testimony that are given tonight will be transcribed verbatim and become part of the official record on the project.

AFCEE and the regulatory agencies will consider all formal comments prior to making a final interim decision for the CS-19 groundwater plume.

Each and every comment will be responded to in a Responsiveness Summary that will be issued at a later date as part of the Record of Decision. All those who comment will receive a copy of the Responsiveness Summary.

The Record of Decision will contain the

Air Force's interim decision for CS-19, the groundwater portion. Please note that a final remedy for the CS-19 plume will be evaluated at a later date and will include the opportunity for public comment at that time.

This hearing tonight is exclusively for listening to and recording your oral comments. We will not respond to your comments during the hearing unless you need clarification on something. We may ask you for clarification if we are not sure what your comment is. You can also provide written comments to me at any time this evening. Everyone wanting to comment must state their name and town of residence. Also, please make sure that you sign in for tonight's meeting so we have your mailing address.

The floor is now open to comment on the Chemical Spill 19 Groundwater Plume Proposed Plan for Interim Action. Yes, sir.

MR. SCHLESINGER: I am Peter Schlesinger, town of Sandwich, not associated with the Town of Sandwich, but living in the town of Sandwich.

I have to say honestly that I disagree wholeheartedly with the idea that natural

attenuation is a suitable solution for any kind of action to cleaning up groundwater.

Natural attenuation is nothing but doing nothing and hoping that it goes away. And I don't -- seeing as I didn't find any evidence that you have evidence of how this contaminant will naturally attenuate and was presented with no documentation, literature on how this contaminate will break up and disperse on its own and having learned of no such evidence through the sitting on the Impact Area Review Team, as I have for the last almost seven years or so or eight years -- I've lost track of it -- I can't really say that this is an appropriate interim measure.

It's probably a very cost effective interim measure in the sense that one just goes on monitoring the situation but actually really doing nothing about it other than removing the source material.

I don't understand how one can know how well material can move and at what rate it will move and at what rate it will disappear without a good enough understanding of what the volume is of the material underground. I suppose you could make some ballpark guesses as to what potential

volumes there are and try to model that out.

But it doesn't sound like you have a very good understanding yet as to what you will find and/or nor at what depth you will find material that you're seeking.

So I'm a bit concerned that not enough effort has gone into the plan for this interim action.

THE HEARING OFFICER: Thank you. I would ask if there are any additional comments to be made by anyone here tonight on the CS-19 Proposed Plan for Interim Action.

(No response.)

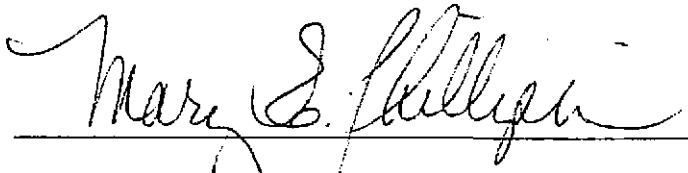
THE HEARING OFFICER: If there are no further comments to be made at this time, I shall now close the formal public hearing for Chemical Spill 19 Proposed Plan for Interim Action. The record is now closed.

(Whereupon the hearing concluded at 6:47 p.m.)

C E R T I F I C A T E

I, MARY E. PHILLIPS, Registered Professional Reporter, do hereby certify that the foregoing transcript, pages 2 through 7 inclusive, was taken by me stenographically and thereafter under my direction was reduced to typewriting and is a true record of the testimony of the proceedings to the best of my ability.

Dated at Sagamore Beach, Massachusetts, this 28th day of February, 2005.



MARY E. PHILLIPS, RPR

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APPENDIX C

Commonwealth of Massachusetts Concurrence Letter

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

MITT ROMNEY
Governor

KERRY HEALEY
Lieutenant Governor

STEPHEN R. PRITCHARD
Secretary

ROBERT W. GOLLEDGE, Jr.
Commissioner

May 23, 2006

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

RE: BOURNE—BWSC-4-0037
Massachusetts Military Reservation,
Final Chemical Spill-19 Groundwater Plume Interim Record of Decision, Concurrence

Dear Ms. Studlein:

The Massachusetts Department of Environmental Protection (the "MassDEP") has reviewed the document entitled **"Final Chemical Spill-19 Groundwater Plume Interim Record of Decision"** (the "CS-19 IROD"), dated December 2005. The CS-19 IROD was prepared for the Air Force Center for Environmental Excellence ("AFCEE") by the Jacobs Engineering Group, Inc. The MassDEP concurs with the interim remedy proposed in the CS-19 IROD.

The CS-19 IROD presents the selected interim remedy for the CS-19 groundwater plume, located within the Central Impact Area (CIA) at the Massachusetts Military Reservation (MMR). The remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendment and Reauthorization Act (SARA), and to the extent practicable, the National Oil and Hazardous Substances Contingency Plan (NCP). This decision is based on the administrative record for this site. Because the CS-19 plume is located within the CIA and may be commingled with the CIA plume, a final groundwater remedy for the CS-19 plume will be evaluated and selected in a unitary, comprehensive manner along with the final remedy for the CIA plume in accordance with the Memorandum of Understanding (MOU) between the U.S. Air Force, U.S. Army and U.S. EPA dated 13 December 2004. The Air Force Center for Environmental Excellence (AFCEE) will coordinate collected CS-19 information with the Impact Area Groundwater Study Program (IAGWSP), and the final remedy for the CS-19 and CIA plumes will be evaluated and selected when all pertinent technical information is available.

The response action selected is necessary to protect the public health and welfare or the environment from actual or threatened releases of hazardous substances into the environment. The selected interim remedy for CS-19 groundwater includes the following components:

1. Sampling and analysis of groundwater associated with the CS-19 plume and reporting until a final remedy is selected and implemented.

2. Periodic optimization of the groundwater monitoring program.

3. Development, implementation, enforcement, and monitoring of land use controls (LUCs) to prevent or minimize unacceptable exposure to human receptors.

This interim action is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD is signed; the action complies with federal and Commonwealth of Massachusetts requirements that are applicable or relevant and appropriate for this limited-scope action, and is cost-effective.

The CS-19 groundwater plume is defined by concentrations of the explosive constituent *Royal Dutch Explosive* (RDX) exceeding the EPA Health Advisory (HA) level of 2 ug/L. *Perchlorate* has been detected in only five of the 31 monitoring wells for the CS-19 plume and only one well had a perchlorate concentration in excess of the proposed MassDEP standard of 2 ug/L. Therefore, the data suggests that a perchlorate plume is not associated with CS-19 groundwater. However, the AFCEE has proposed groundwater monitoring for perchlorate in addition to RDX during the interim remedy to evaluate whether perchlorate is attributable to the CS-19 site and therefore, a possible future chemical of concern (COC).

The source of the CS-19 groundwater plume is located within the Impact Area of Camp Edwards at the MMR that was used historically for military training and ordnance disposal. The CS-19 Source Area is also within the Upper Cape Water Supply Reserve. The CS-19 source area is approximately one acre in size and is defined by a perimeter road in the west-central region of the MMR Impact Area approximately 500 feet east of Pocasset-Sandwich Road and approximately 2 miles from the western boundary of the MMR in the Town of Bourne. The source area is currently undergoing a removal action consisting of the excavation and removal of military munitions (MM) and munitions constituents (MC). Additional sources of potential groundwater contamination have been identified beyond the perimeter road during the removal action at the source area and the source area investigation will be expanded to encompass these areas.

Administrative and/or legal controls known as land use controls (LUCs) will be implemented to minimize the potential future risk for human exposure to groundwater contamination by limiting land and resource use. The LUCs will be maintained during the interim period until a final remedy is selected for the CS-19 groundwater plume. The Environmental Performance Standards ("EPS") incorporated as Appendix 2 to the Memorandum of Agreement made by and among the Commonwealth of Massachusetts, the Department of the Army and the National Guard Bureau, dated October 4, 2001, specifies that the development of water supplies will only be permitted within the Camp Edwards Training Area after review and

approval by the managing agencies, principally the Department of the Army and its divisions, together with the Massachusetts Department of Environmental Protection, and the Massachusetts Division of Fish and Wildlife. The Environmental Management Commission oversees compliance with the EPS, which regulates the use of the CS-19 area for any withdrawals of groundwater for drinking water purposes and also constitutes an LUC for this interim remedy.

The MassDEP concurs with the Interim Remedy selected in the CS-19 IROD and the LUCs. The MassDEP will re-assess the remedy and the LUCs for the CS-19 groundwater plume during the evaluation process specified for both the Central Impact Area and CS-19 groundwater plume final Record of Decision. The MassDEP's concurrence with the CS-19 selected Interim Remedy is based upon representations made to the MassDEP by the AFCEE and assumes that all information provided is substantially complete and accurate. Without limitation, if the MassDEP determines that any material omissions or misstatements exist, if new information becomes available, or if conditions at the Study Area change, resulting in potential or actual human exposure or threats to the environment, the MassDEP reserves its authority under M.G.L. c. 21E, and the MCP, 310 CMR 40.0000 et seq., and any other applicable law or regulation to require further response actions.

Please incorporate this letter into the Administrative Record for the CS-19 groundwater plume. If you have any questions regarding this matter, please contact Leonard J. Pinaud, Chief of Federal Facilities Remediation Section, at (508) 946-2871 or Millie Garcia-Surette, Deputy Regional Director of the Bureau of Waste Site Cleanup at (508) 946-2727.

Sincerely,

Robert W. Golledge, Jr., Commissioner
Department of Environmental Protection

RWG/LP/xx

CS19 IROD Concurrenec.doc

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

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