BASEWIDE FIVE-YEAR REVIEWS
DOVER AIR FORCE BASE, DELAWARE

Volume I	**East Management Unit (EMU)**
Volume II	**South Management Unit (SMU)**
Volume III	**West Management Unit (WMU)**
Volume IV	**Land Use Controls (LUCs) Sites**

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under Contract DE-AC05-00OR22725

and

URS GROUP, INC.
200 Orchard Ridge Drive, Suite 101
Gaithersburg, Maryland 20878

Prepared for:

United States Department of the Air Force
Dover Air Force Base
436 CES/CEAO
600 Chevron Avenue
Dover AFB, Delaware 19902-5600

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

October 15, 2008

Colonel Steven B. Harrison
Commander, 436th Airlift Wing
436 AW/CC
201 Eagle Way
Dover AFB, DE 19902-5201

RE: Basewide Five-Year Review
Dover Air Force Base; Dover, Delaware

Dear Colonel Harrison:

Thank you for submitting the report, entitled *Basewide Five-Year Reviews, Dover Air Force Base, Delaware*, dated September 2008 to the EPA for review and concurrence. The report was prepared to fulfill the requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section 121 (c) to review Remedial Actions where hazardous substances remain every five years to assure that human health and the environment are being protected. EPA has reviewed this five-year review report and compared it to EPA's June 2001 guidance document, *Comprehensive Five-Year Review Guidance* (OSWER No. 9355.7-03B-P, EPA 540-R-01-007).

EPA concurs with the Air Force's recommendation that SMU Site FT01 be closed since the remedy monitoring data indicate that the remedial action objectives (RAOs) have been achieved. EPA also agrees with the recommendation that the seven Land-Use Control (LUC) sites (OT43, OT46, OT47, OT57, WP29, WP32, and OT55) be closed since no unacceptable human health risk was identified under the residential exposure scenario.

EPA concurs with the Air Force's determination that the remedies for the East Management Unit (EMU) (FT03, WP14/LF15, LF13), South Management Unit (SMU) (SS07/Area 2, LF17, LF18/Area 9, FT01), West Management Unit (WMU) (Area 5, Area 6, LF25 and SS08) and the LUC sites are protective of human health and the environment. Furthermore, as part of this five-year review, EPA has evaluated the Government Performance and Results Act (GPRA) measures for the above-listed sites and has determined their status is as follows:

Environmental Indicators

1. Human Health: Current Human Exposure Controlled

2. Groundwater Migration: Groundwater Migration Under Control

Sitewide Ready for Anticipated Use

The Site was determined to be Site-Wide Ready for Anticipated Use on January 24, 2008.

The requirement for this five-year review at Dover Air Force Base was triggered by the Remedial Action start date of March 2, 1992 at EMU Site FT03. A previous five-year review report was completed and signed by the Air Force on March 12, 2004. The next five-year review will be due five years from the date of this concurrence letter.

If you have any questions, please contact Ben Mykijewycz, Chief of the NPL/BRAC Federal Facilities Branch, at 215.814.3351 or Sun Yi at 215.814.3377.

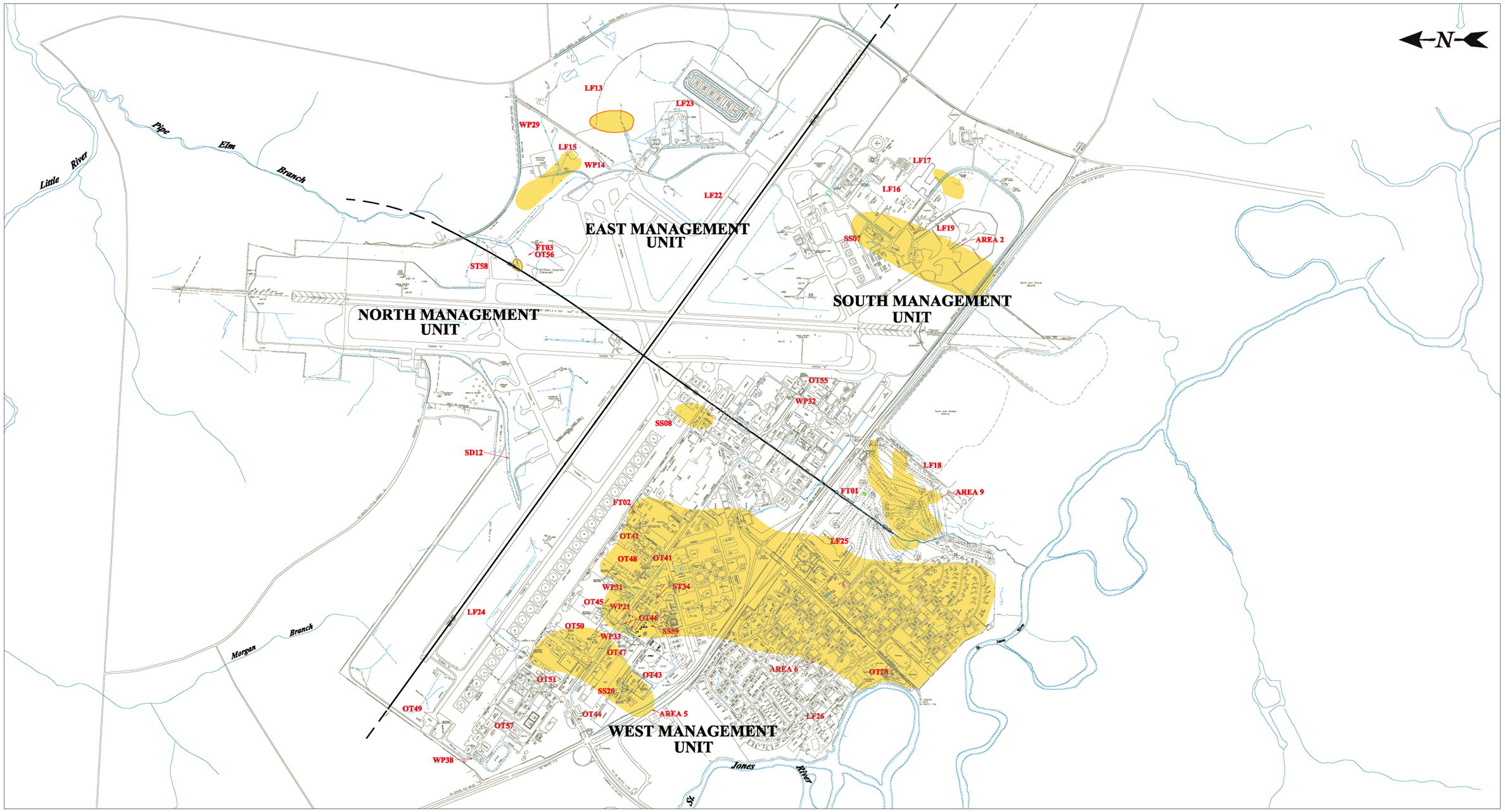
Sincerely,

James J. Burke

James J. Burke, Director
Hazardous Site Cleanup Division

cc: Jo Anne Deramo – DAFB CES / CEAO
Stephanie Scholl – DNREC-SIRB

P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\Five Year Reviews 2008\H. Reports\FIVE YEAR SITE MAP(07-08).dwg, 7/24/2008 11:43:42 AM, Adobe PDF.pc3



LEGEND:

Solvent Plume

LF17 ERP Site

AREA 6 Plume Label

0 1800
SCALE IN FEET

CLIENT	DOVER AFB			
PROJ	Basewide Five-Year Reviews			
REVISION NO	0	DES BY	LS	06/19/06
SCALE		DR BY	SS	07/24/08
FILE		CHK BY		

TITLE FIVE-YEAR REVIEW SITES

URS

PROJ NO 15300779

FIGURE

BASEWIDE FIVE-YEAR REVIEWS
DOVER AIR FORCE BASE, DELAWARE

VOLUME I – EAST MANAGEMENT UNIT

FIVE-YEAR REVIEWS FOR

- **FT03**
- **WP14/LF15**
- **LF13**

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Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Dover Air Force Base		
EPA ID *(from WasteLAN)*: DE8570024010		
Region: 3	**State:** DE	**City/County:** Dover/Kent County
SITE STATUS		
NPL status: _X_ Final __ Deleted __ Other (specify)		
Remediation status (choose all that apply): __ Under Construction _X_ Operating (FT03, WP14/LF15, and LF13) _X_ Complete (FT03 soil)		
Multiple OUs?* _X_ YES __NO	**Construction completion date:** 09 / 30 / 2006	
Has site been put into reuse? __ YES _X_ NO		
REVIEW STATUS		
Lead agency: __ EPA __ State __ Tribe _X_ Other Federal Agency - U.S. Air Force		
Author name: URS Group, Inc. (under U.S. Army Corps of Engineers contract) for USAF		
Author title:	**Author affiliation:**	
Review period:** October 2003 to September 2008		
Date(s) of site inspection: October 21, 2002, March 19, 2003, and July 27, 2007		
Type of review: X Post-SARA __ Pre-SARA __ NPL-Removal only __ Non-NPL Remedial Action Site __ NPL State/Tribe-lead __ Regional Discretion		
Review number: __ 1 (first) __ 2 (second) _X_ 3 (third) __ Other (specify) _____		
Triggering action: __ Actual RA Onsite Construction at OU #____ __ Actual RA Start at OU#____ __ Construction Completion X Previous Five-Year Review Report __ Other (specify)		
Triggering action date *(from WasteLAN)*: 30 Sep 2003		
Due date *(five years after triggering action date)*: 30 Sep 2008		

* [“OU” refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

Five-Year Review Summary Form, cont'd.

Issues:

During the March 2007 sampling event, there was one minor exceedence of a maximum contaminant level (MCL) in a point of compliance (POC) well at WP14/LF15 for the first time in over 10 years of monitoring. However, this minor exceedence was located in a well adjacent to an off-Base parcel of land that is included in the Groundwater Management Zone (GMZ) established by the Delaware Department of Natural Resources and Environmental Control. The GMZ is a State-enforced LUC that prevents groundwater use, and thus prevents exposure, in this off-Base area. Therefore, the remedy is still protective of human health and the environment, although continued monitoring of this area is recommended to assess future contaminant trends.

Since the last Five-Year Review, land use controls (LUCs) at the four East Management Unit (EMU) sites (FT03, WP14/LF15, and LF13) have been formalized and documented in an Environmental Appendix to the Base General Plan.

Recommendations and Follow-up Actions:

FT03: It is recommended that annual groundwater monitoring continue at this site to confirm that source area constituents naturally attenuate and that contaminants do not migrate off-Base at levels that could be harmful. Optimization of the monitoring network by discontinuing the sampling of well GS013D (used for both FT03 and WP14/LF15) is recommended. It is also recommended that LUCs continue to be enforced and monitored.

WP14/LF15: It is recommended that annual groundwater monitoring continue at this site to confirm that source area constituents naturally attenuate and that contaminants do not migrate off-Base at levels that could be harmful. This is particularly true due to the one minor exceedence of an MCL in one POC well during the March 2007 sampling event at this site. Optimization of the monitoring network by discontinuing the sampling of well GS013D (also used for FT03) is recommended. It is also recommended that LUCs continue to be enforced and monitored.

LF13: It is recommended that annual groundwater monitoring continue at this site to confirm that remaining source area constituents naturally attenuate and that contaminants do not migrate off-Base at levels that could be harmful. Optimization of the monitoring network by discontinuing the sampling of wells MW064S, GS014D, GS012S, GS012D, and GS060S is recommended. These wells have never contained contaminants at levels exceeding remedial action objectives, and are located generally upgradient of the landfill. It is also recommended that LUCs continue to be enforced and monitored.

Protectiveness Statement:

The remedies at FT03, WP14/LF15, and LF13 are protective of human health and the environment. In the interim until remedial action objectives are met at these sites, exposure pathways that could result in unacceptable risks are being controlled.

Other Comments:

None.

Steven B. Harrison

STEVEN B. HARRISON, Colonel, USAF
Commander, 436th Airlift Wing

FIVE-YEAR REVIEW FOR FT03
DOVER AIR FORCE BASE, DELAWARE

September 2008

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
EMU	East Management Unit
ERP	Environmental Restoration Program
FFS	Focused Feasibility Study
FS	Feasibility Study
ft	Feet
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
LUCs	Land use controls
MCL	Maximum contaminant level
mg/L	Milligrams per liter
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Not detected
NPL	National Priority List
O/W	Oil/water
ORNL	Oak Ridge National Laboratory
PCE	Tetrachloroethene
POC	Point of Compliance
RA	Risk assessment
RAO	Remedial Action Objective
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
SVOC	Semi-volatile organic compound
TCE	Trichloroethene
TGM	Technical Guidance Manual
TPH	Total petroleum hydrocarbons
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UST	Underground storage tank
VOC	Volatile organic compound

EXECUTIVE SUMMARY

Two remedies have been implemented at FT03, a former fire training area at Dover Air Force Base (DAFB), Delaware: 1) the decontamination and removal of the site structures and associated contaminated soil and gravel, and 2) natural attenuation monitoring of groundwater with land use controls (LUCs) for both soil and groundwater. The first remedy, initiated in March 1992, mitigated a potential petroleum source and included the removal of 17 dumpsters, an underground storage tank, an oil/water separator, and related piping. The site achieved construction completion with the submittal of a remediation oversight report in October 1992. The second remedy addresses groundwater contamination and began in 1999 with the first round of long-term monitoring. LUCs are also elements of this remedy.

The initial trigger date for the FT03 five-year review was the start of the 1992 soil action. The first five-year review for FT03 was conducted in 1997. DAFB initiated the second review in 2002 but subsequently merged all reviews into a comprehensive set of Base-wide five-year reviews, which was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of the previous five-year reviews found that the structures/soil remedial action was conducted in accordance with the 1990 Record of Decision (ROD) and that all remedial action objectives (RAOs) were met. The primary source of waste oil and fuel and associated contaminated structures and soil have been removed from FT03. Thus, as recommended in the previous five-year review (2003) for FT03 structures/soil, review of this portion of the remedy has been discontinued. The site as a whole, however, continues to be addressed in the five-year review process due to the LUC remedy that was implemented for soil and the continuation of groundwater remediation.

This assessment found that the groundwater remedy--monitored natural attenuation with LUCs--is operating as intended. The primary contaminant of concern (COC) is vinyl chloride. Its concentration steadily decreased, to below the maximum contaminant level (MCL), in one site well and continues to be detected at a low concentration slightly above the MCL in two other site wells. Vinyl chloride has not been detected in any of the four point of compliance (POC) wells near the Base boundary. No action levels have been exceeded in any POC well during the periodic monitoring that began in 1999. LUCs remain in effect and no new uses of groundwater or the site were observed. It is recommended that monitoring continue to confirm that COCs naturally attenuate to levels that meet the RAOs specified in the ROD for FT03 groundwater.

The draft-final five-year review for FT03 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

FT03 is an Environmental Restoration Program (ERP) former fire training area site at Dover Air Force Base (DAFB), Delaware (Attachment 1). Currently maintained as an open grassy field in the East Management Unit (EMU), the FT03 structures were decontaminated, cut up, and disposed of as scrap metal in 1992. Also, soils around the structures were sampled and analyzed, which resulted the removal and off-site disposal of soil and gravel. These activities were completed in 1992 in accordance with the 1990 Record of Decision (ROD; DAFB, 1990). Additional groundwater investigation was subsequently conducted that resulted in implementing a long-term natural attenuation monitoring program under a 1997 ROD. Land use controls (LUCs) for soil and groundwater are also part of the site remedy.

The remedial actions at FT03 were conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the third five-year review for FT03. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of the U.S. Army Corps of Engineers (USACE), Contract #DACA45-02-D-0003, Delivery Order #0021. The review was initiated in early 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001). The first five-year review for the structures/soil remedy was conducted by the USEPA (USEPA, 1997). The second five-year review was finalized in 2003 (BWXT, 2003).

The long-term natural attenuation monitoring is the second implemented remedy at FT03 and is similarly being conducted concurrently at three other EMU sites: WP14/LF15 and LF13. LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the FT03 groundwater remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
Pre-1970	Site used for fire training activities. The area was backfilled and graded.
1970s-1989	Site redeveloped for fire training purposes.
1986	Stage I Site Investigation (SI) conducted in response to evidence of oil contamination along the bank of nearby drainage ditch.
March 13, 1989	DAFB listed on National Priority List (NPL).
1989	Stage II SI conducted.
1990	Focused Feasibility Study (FFS) prepared.
August 14, 1990	The SI data, FFS, and proposed remedial action plan released for public comment.
August 30, 1990	Public meeting held.
December 6, 1990	ROD prepared for the decontamination and removal of site structures.
August 1991	Remedial action plans and final design specifications completed.
March 2, 1992	Remediation work began. (Trigger for five-year review.)
October 16, 1992	Remediation work completed and remediation oversight report submitted.
1995-1996	Groundwater studies conducted in the EMU (USGS, 1998, 1999a).
June 16, 1997	Proposed Plan for natural attenuation of groundwater at FT03 completed and released for public comment (DAFB, 1997b).
June 24, 1997	USEPA prepared first five-year review for FT03 structures/soil remediation (USEPA, 1997).
August 1997	Basewide Remedial Investigation (RI) finalized; included assessment of FT03.
September 30, 1997	ROD prepared for FT03 groundwater (DAFB, 1997a).
October 1997	Feasibility Study (FS) for EMU finalized.
June 1999 – present	Regular groundwater monitoring at FT03 begins.
Nov./Dec. 2000	Additional direct-push groundwater delineation data collected by USGS.
April 11, 2003	DNREC established groundwater management zone (GMZ) at DAFB.
September 2003	Second five-year review for FT03 structures/soil and groundwater remediation conducted by URS (BWXT, 2003).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report prepared, included FT03 (ORNL, 2006).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007)

USGS – U.S. Geological Survey
DNREC – Department of Natural Resources and Environmental Control
ORNL – Oak Ridge National Laboratory

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

FT03 is located in a remote portion of the Base at the north edge of the EMU adjacent to an inactive aircraft parking pad (Attachment 1). The area is currently an open grassy field. A small drainage ditch on the north side of the site directs runoff east to the Pipe Elm Branch, which subsequently flows off Base to the north. Groundwater at the site is typically encountered at depths between 4 and 10 feet (ft) below ground surface.

3.2 LAND AND RESOURCE USE

A portion of the approximately 2- to 3-acre site was used prior to 1970 by DAFB for fire training activities. Waste oil and fuel were burned in an open square pit during

the exercises. This area was backfilled and graded with approximately 6 to 8 ft of fill. In 1970, the fire training area was moved closer to the parking pad. Structures at the new area included 17 closely spaced dumpsters, an underground storage tank (UST), and an oil/water (O/W) separator. The O/W separator was identified as a distinct ERP site, OT56. Fire training exercises continued here until 1989. The removal of the training area and ancillary equipment occurred in 1992. The site has since been maintained as an open grassy field and is not currently used for any particular purpose. Other than grounds maintenance and routine security checks, there are no other personnel in the area. The site is not easily accessible to Base visitors.

The drainage ditch near the site and the Pipe Elm Branch are part of the Base's storm water drainage system.

The shallow groundwater (Columbia Aquifer) underlying the site generally flows north-northeast towards the drainage ditch and Pipe Elm Branch. This aquifer is not currently used as a drinking water source. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. Off site, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a small portion of off-base property adjacent to the northeast Base boundary. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

The first SI at FT03 was in 1986 (Science Applications International Corporation (SAIC), 1986). The SI concluded that sediments contained oil and grease and elevated metals although there was not enough evidence to clearly link these to FT03 activities. Two of three monitoring wells installed and sampled contained 0.14 milligrams per liter (mg/L) or less of oil and grease. A more thorough investigation was conducted a couple of years later (SAIC, 1989). Soil data indicated that toluene, xylenes, total petroleum hydrocarbons (TPH), and lead concentrations were highest near the surface within the area of the then-active fire training pit. A deeper zone of elevated lead and TPH in soil was also observed within the estimated boundary of the older fire training area. Groundwater samples from seven monitoring wells indicated minor impacts on groundwater quality.

Site structures and soil contamination associated with the fire training area were remediated in 1992. Additional characterization data were collected during the Basewide

RI, which was conducted after the FT03 structures/soil remediation project (USACE, 1997b). Soil was sampled next to the former UST and O/W separator, as well as at the older fire training area. Detected constituents were primarily fuel-related: BTEX (benzene, toluene, ethylbenzene, and xylenes), TPH, and lead. These post-remediation soil samples indicated that constituent concentrations had been significantly reduced. RI groundwater data revealed fuel-related volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) immediately downgradient of the former UST; benzene exceeded its maximum contaminant level (MCL). At the older fire training area, vinyl chloride exceeded its MCL.

The Basewide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

In 1990, a ROD was signed for the decontamination and removal of the fire training structures and removal of contaminated soil. The selected remedy was the decontamination and physical removal of the dumpsters, UST, and O/W separator, and the testing of soil with subsequent removal and disposal, if necessary. This was documented in an FFS (Hazardous Waste Remedial Actions Program (HAZWRAP), 1990) and proposed remedial action plan, which were submitted for public review on August 14, 1990.

Treatment alternatives for FT03 groundwater were evaluated in the Basewide FS (USACE, 1997a). Supplemental characterization specific to natural attenuation was conducted by the USGS (USGS, 2002a) to support FS conclusions. This study determined that natural attenuation appeared to be adequate for controlling the migration of the FT03 groundwater plume. The supporting evidence included the presence of breakdown products and favorable reducing conditions of the aquifer necessary for biodegradation. The selected remedial action for groundwater is monitored natural attenuation and LUCs, which was documented in a proposed plan and submitted for public review on June 16, 1997.

In 1997, a ROD was signed for the soil and groundwater at FT03. The selected remedy is the continued enforcement of existing LUCs for soil and monitored natural attenuation with LUCs for groundwater.

3.5 BASIS FOR TAKING ACTION

Human health risk calculations for exposure to soil were presented in the 1990 ROD (DAFB, 1990). Using a mathematical model, soil levels were calculated that would be protective of groundwater. The ROD concluded that “the risks posed by site FT-3 soil to dermal contact, accidental ingestion, and contaminant transport to groundwater are well below USEPA guidance levels” (DAFB, 1990, p. 16). It was also noted, however, that the existence of waste oil and fuels at the site posed a threat of fire and explosion. This potential threat was the primary reason for taking initial action at FT03.

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater at FT03 since it is located in an industrial portion of the Base (USACE, 1997b). The resulting risks were elevated: non-carcinogenic hazard index of 3 and a cancer risk of 1×10^{-4}. Manganese, an essential nutrient, was the primary contributor to the elevated hazard index. However, the RA evaluated this nutrient with respect to recommended adult daily allowances and found it to not be a concern. The cancer risk was due to vinyl chloride and arsenic. Arsenic, however, was below its MCL. Although groundwater from the Columbia Aquifer at site FT03 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences at the site, as well as the potential for contaminant migration to areas not under DAFB control, trigger the need for a second remedial action at FT03. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

The previous Five-Year Review concluded that RAOs were achieved for the soil remedy at FT03 in accordance with the ROD (BWXT, 2003). Thus, discussion of this portion of the site remedy is discontinued in the remainder of this document.

4.1 REMEDY SELECTION

The ROD for FT03 groundwater was signed by USEPA in September 1997 (DAFB, 1997a). The RAO was developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, the RAO for FT03 groundwater is the reduction of contaminant concentrations in groundwater to MCLs. For one constituent, manganese, there is no MCL. In this instance, the DAFB-specific background level of 1,440 micrograms per liter (µg/L) of dissolved manganese is the target concentration. However, as discussed in Section 3.5, the RA determined that manganese was not a concern.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. LUCs serve to prevent unacceptable exposure to groundwater until the RAOs are achieved. LUCs for soil and groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the EMU FS (USACE, 1997a). The selected remedy for FT03 groundwater as outlined in the 1997 ROD (DAFB, 1997a) includes the four major components listed below:

- Natural attenuation of contaminants of concern (COCs) in groundwater.
- Continued enforcement of existing LUCs.
- Restrictions on groundwater use.
- Groundwater monitoring.

4.2 REMEDY IMPLEMENTATION

In accordance with the 1997 ROD, DAFB enlisted the services of the USGS to develop a natural attenuation groundwater monitoring plan and to conduct regular groundwater sampling. The plan included similar monitoring at three other EMU sites: the combined WP14/LF15 sites, and LF13 (USGS, 1999b). Three wells were selected to be monitored specifically at FT03. Four additional wells were installed approximately 200 ft from the Base boundary where Pipe Elm Branch flows off-site; these wells serve as point of compliance (POC) wells for FT03 and the other EMU sites which are also upgradient (Attachment 1). Sample analyses include VOCs, total and dissolved metals (including manganese), and geochemical indicators of natural attenuation. At FT03, the primary COC is vinyl chloride, a breakdown product of cis-1,2-dichloroethene (cis-1,2-DCE), which is also present at the site. Vinyl chloride continues to anaerobically degrade to ethene, a harmless gas. The EMU sites were sampled on a semi-annual schedule, which switched to an annual schedule in 2003 and is on-going.

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including FT03. Some of the controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC implemented a GMZ that encompasses DAFB and a small portion of off-Base property adjacent to the northeast Base boundary. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (4) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for manganese and the fuel and chlorinated solvent contaminants found at FT03 are listed in Table 2. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are not exceeded in the POC wells.

Table 2 – RAO Groundwater Concentrations

Parameter	**RAO Concentration[a] (µg/L)**
Benzene	5
1,2-Dichloroethane	5
1,1-Dichloroethene	7
cis-1,2-DCE	70

Table 2 – cont'd

Parameter	RAO Concentration[a] (µg/L)
Ethylbenzene	700
Tetrachloroethene (PCE)	5
Toluene	1,000
1,1,1-Trichloroethane	200
1,1,2-Trichloroethane	5
Trichloroethene (TCE)	5
Vinyl chloride	2
Xylenes, total	10,000
Manganese	1,440

[a]The groundwater RAOs are the MCLs except for manganese, which is the DAFB-specific background level.

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the West Management Unit. There are no buildings on top of FT03. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEMDY OPERATION AND MAINTENANCE

After the soil remedy was completed and additional investigation conducted, a decision was made to monitor groundwater since groundwater quality appeared to have been affected by FT03 activities. Monitoring began in 1999 and is ongoing. The costs associated with this activity are summarized in Table 3. LUC inspections began in 2006 and occur annually.

Table 3 – Annual Monitoring Costs

Fiscal Year	Total Cost rounded to nearest $1,000
1998	$38,000
1999	$80,000
2000	$158,000
2001	$158,000
2002	$104,000
2003	$21,000
2004	$20,000
2005	$17,000
2006	$17,000
2007	$15,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the third five-year review for FT03. During the first review for the FT03 soil remedy (USEPA, 1997), the site was determined to not meet the protectiveness criteria due to contaminants in groundwater. It was recommended that groundwater monitoring be initiated under a proposed Natural Attenuation ROD. This recommendation has been implemented. Results of the groundwater monitoring are addressed in Section 6.0. LUCs were also implemented at FT03, including an annual Basewide-inspection of the LUCs, and this is discussed in Section 6.0 as well.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 meetings in 2007 that the five-year review for the FT03 groundwater remedy would begin in 2007 and would be conducted by the USACE contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for FT03 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of FT03 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant FT03 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) such as those in the DNREC UST guidance, were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the long-term monitored natural attenuation remedy (ORNL, 2003-2004; 2005-2008). The monitoring reports reviewed for the EMU, which includes FT03, evaluated groundwater flow in both the shallow and the deep portions of the Columbia Aquifer; COC

distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

Groundwater data at FT03 have been collected in multiple sampling rounds since 1986. The most recent data are from the periodic long-term monitoring program that began in 1999 and continues on an annual basis. For the initial June 1999 round, only one site well (GS003S) was sampled. GS003M and MW019 were added the following round. MW019 was later removed from the program and GSCP10B added. However, based on the recommendations in the September 2003 five-year review report (BWXT, 2003), MW019 was returned to the program, and GSCP10B and GS003M were removed. Thus, the current long-term monitoring program includes two wells in the immediate area, MW019 and GS003S, and four POC wells (GS004S,M,D and GS013D) at downgradient locations near the Base boundary. The GS004 wells were installed in the stream bed of Pipe Elm Branch to monitor groundwater below the drainage.

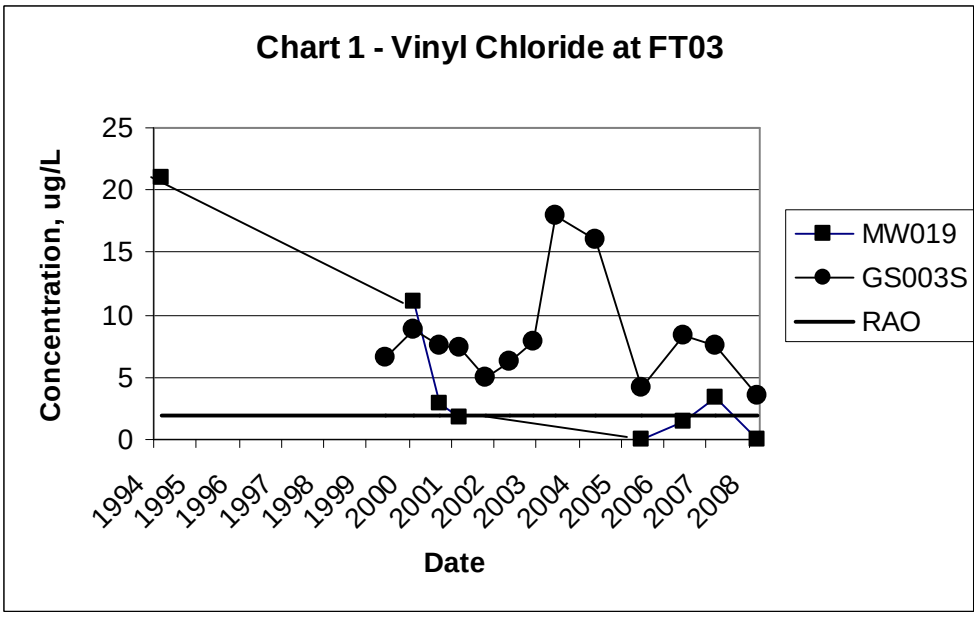
Vinyl chloride is the only contaminant to exceed its RAO/MCL (2 µg/L) consistently in FT03 wells. A few other VOC exceedences occurred in some of the earlier studies and during the 2000 direct-push delineation study (USGS, 2001c). These exceedences are summarized in Table 4. None of the analyzed metals, including manganese, exceeded RAOs in any well. No action level exceedences have occurred in any of the POC wells.

Table 4 – Groundwater Data

Sampling Event(s)	**Results**	
	Site Well(s)	**POC Wells**
1986 and 1989 SAIC Studies	1986 - limited analyses 1989 - MW019: vinyl chloride 3.4 µg/L	NA
1993-1994 RI	MW019: vinyl chloride 21 µg/L, 1,2-DCE (total) 70 µg/L. TW101 (next to former UST): benzene 150 µg/L.	NA
1999-2002 Semi-Annual Sampling (USGS)	GS003S: vinyl chloride 5 to 8.8 µg/L. MW019: vinyl chloride 1.8 to 11 µg/L (decreasing concentration Jan. 2000 to Mar. 2001). No other action level exceedences.	Minor detections of benzene, PCE, TCE, and cis-1,2-DCE (≤ 1.4 µg/L). No action level exceedences and vinyl chloride never detected.
2000 Direct-Push Groundwater Study (USGS)	12-16 ft bgs sample near GSCP10B: PCE 33.9 µg/L, cis-1,2-DCE 203.1 µg/L. 12-16 ft bgs sample on north edge of area about 100 ft due west of MW019: benzene 34.2 µg/L. No exceedences in any of the other 31 groundwater samples.	NA
2003-2008 Annual Sampling	GS003: vinyl chloride 4.1 to 18 µg/L (maximum concentration in 2003). MW019 (2005-2008): vinyl chloride 3.42 µg/L to ND.	2008 sampling round: Minor detections of benzene and cis-1,2-DCE (no action levels exceeded), vinyl chloride above RAO in both wells.

NA – not applicable ND – not detected

On-site vinyl chloride concentrations fluctuate within a narrow range (4.1 to 18 µg/L) in one well (GS003S) above its RAO/MCL of 2 µg/L. In MW019, vinyl chloride concentrations have consistently decreased from 21 µg/L in 1994 to 1.8 µg/L in 2001 (Chart 1). There has been a slight increase in vinyl chloride in this well in 2006 and 2007.



Other than single exceedences of PCE, cis-1,2-DCE, and benzene in two direct push samples (Table 4), none of these constituents exceed action levels in the regularly monitored on-site or POC wells. Thus, contamination in groundwater appears to be confined to the vicinity of FT03 and downgradient migration above action levels has not occurred.

6.4 SITE INSPECTION

A URS geologist visited the site on July 27, 2007. A photographic log documents the conditions at FT03 on that day (Attachment 4). The area that was excavated is currently covered with grass. The grass and surrounding areas are regularly maintained. Although burrowing animals may be present in the area, no disturbances were noted. No new uses of groundwater or the site were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of the groundwater remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that remedial action for FT03 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Ground water flow at this site is indicated by the arrows on Attachment 1. Other than vinyl chloride in two site wells, no other action levels have been exceeded in any other monitored well. No action levels are exceeded in any of the POC wells. As seen in Attachment 5, the total concentrations of COCs are contoured for groundwater samples collected in 1994 (RI) and the most recent annual monitoring event (March 2008). Plume extent and magnitude have decreased over the years.

Site conditions and usage are unchanged since the implementation of the remedy. The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

With the source removal and placement of a clean soil cover, possible ecological pathways have been eliminated. In addition, the Basewide Ecological Risk Assessment concluded that there were no unacceptable risks associated with groundwater discharging to surface streams.

The changes in ARARs (Attachment 3) are limited to those established for groundwater in DNREC's Delaware Risk-Based Corrective Action Program (DERBCAP) and remediation standards guidance. These standards are the same as or less stringent than MCLs.

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effect on risks are qualitatively summarized in Table 5. As outlined in Table 5, there are several changes that could increase the overall carcinogenic risks and non-carcinogenic hazards, and a couple that could decrease the risks. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 5 - Risk Assessment Review

Change	Effect
RBSC decreased for methylene chloride.	This chemical would be included in the RA. However, it is also a common laboratory contaminant and was detected in associated blanks; it is not likely site related.
RBSC increased for ethylbenzene	This chemical would be excluded from the RA, resulting in a slight decrease in overall hazard.
RBSCs decreased for naphthalene and beta-BHC.	These chemicals would be included in the RA, slightly increasing the overall hazard and risk, respectively.
Oral reference dose now available for benzene; slope factor increased.	A slight increase in overall hazard and risk.
Oral and inhalation reference doses now available for vinyl chloride; slope factors decreased.	A slight increase in overall hazard and decrease in overall risk.
Inhalation slope factor now available for bis(2-ethylhexyl)phthalate.	A slight increase in overall risk. However, this chemical is more likely a laboratory contaminant than site related.
Oral slope factor decreased for arsenic.	A slight decrease in overall risk.
Oral reference dose now available for iron.	A slight increase in overall hazard.
Oral reference dose now available for manganese.	A slight increase in overall hazard.

RBSC - Risk-based screening criterion

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

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

This review for FT03 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. FT03 has remained an open, unused field since the remediation. All information to date indicates that the removal action at FT03 was successful and that although vinyl chloride in groundwater remains above its action level in two site wells, there has been no expansion of the plume and constituents are not migrating off Base above action levels.

7.1 TECHNICAL ASSESSMENT SUMMARY

The site inspection revealed that FT03 is regularly maintained as an unused grassy field. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

According to the data and documents reviewed, the remedy for FT03 groundwater appears to be functioning as intended. Off-site migration of contaminants above action levels has not occurred. Two site wells (GS003S and MW019) continue to contain one constituent (vinyl chloride) above its RAO/MCL. MW019 has demonstrated a clear decreasing trend for this compound with the sample collected in 2005 below the RAO/MCL and only a slight increase since then. The 2002 USGS EMU study determined that there were insufficient data to meaningfully model degradation rates (2002a). Therefore, a time frame to achieve RAOs has not been estimated. However, trend graphs (see Chart 1) indicate that vinyl chloride appears to be at a steady state in GS003S, and is on an overall downward trend (and now hovering around the MCL) in MW019. The results from MW019 suggest that the source area contaminants are waning.

LUCs have been successfully implemented at the site.

8.0 ISSUES

No issues were discovered during the review that affects the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Based on the chemical data reviewed, groundwater sampling at FT03 has demonstrated that there are some lingering minor effects on groundwater quality. In response, long-term monitoring of the site was initiated. It is recommended that annual monitoring continue at FT03 and that LUCs continue to be enforced.

To optimize the monitoring well network for future events, it is recommended that monitoring of POC well GS013D be discontinued. This well has had no MCL exceedences, and nearby well triplet GS0004D, M, S provides more useful information on contaminants associated with FT03.

The site as a whole will also continue to be addressed in the five-year review process due to the LUC remedy and the continuation of groundwater remediation.

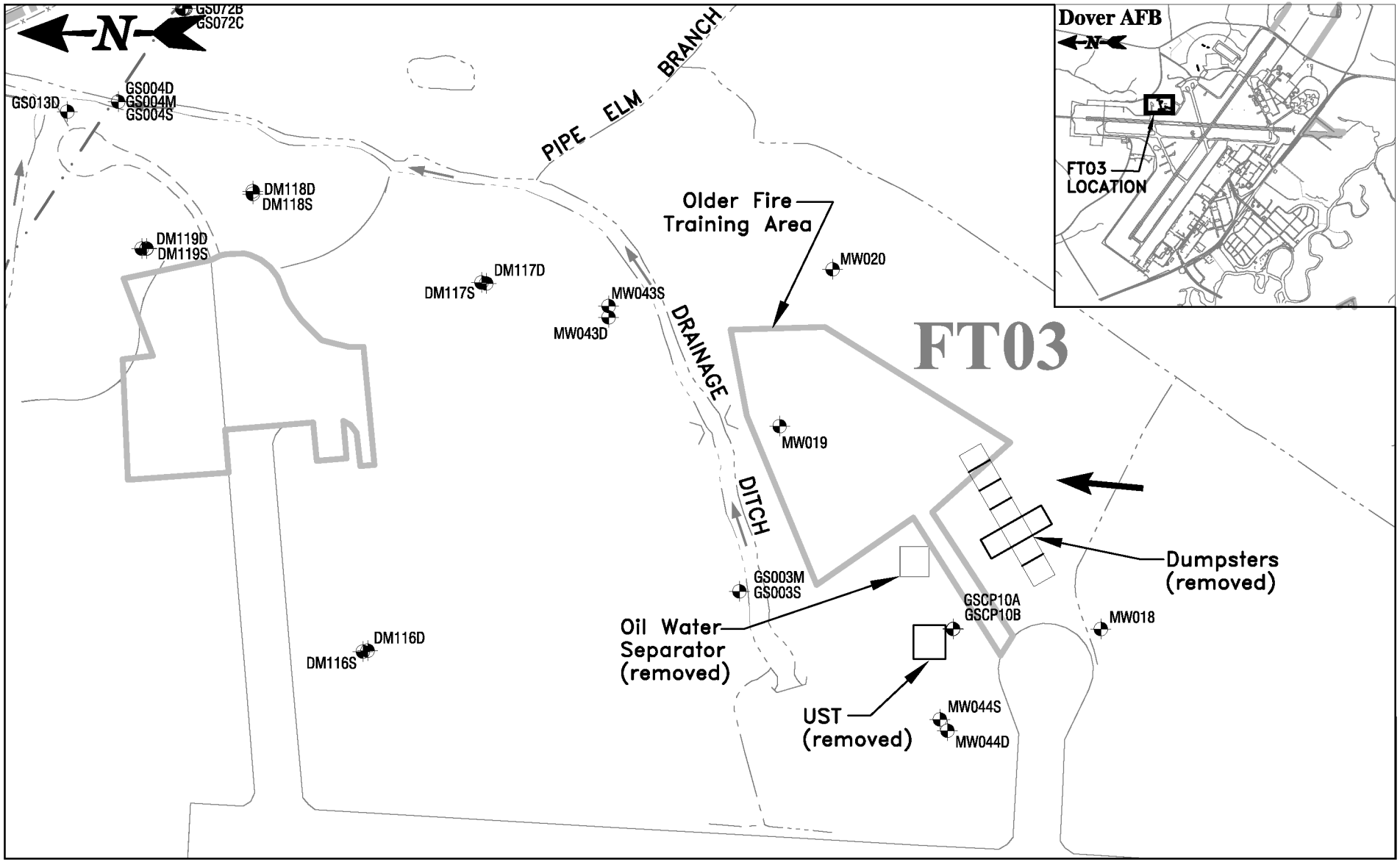
A worst-case vapor intrusion evaluation was performed in 2007 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with the protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

10.0 PROTECTIVENESS STATEMENT

The remedy at FT03 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for FT03 will be due in September 2013.



LEGEND:

MW031S Monitoring Well

Groundwater Flow

0 150
SCALE IN FEET

ATTACHMENT 1
FT03 SITE MAP

URS

P:\Gaithersburg\U0000005572 Omaha USACE\15294916 PPs & RODs\EMU 5YR 2007\FT03gw.DWG, Layout1, 9/7/2007 4:45:15 PM, soum sokhon, Adobe PDF.pc3, 1:1

Attachment 2 – Reviewed Documents

BWXT, 2003. Final Five-Year Reviews, Dover Air Force Base: LF18 Soil, FT03 Structures/Soil and Groundwater, WP14/LF15 Groundwater, LF13 Groundwater, submitted by URS Group, Inc., September 2003.

DAFB, 2006. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2006.

DAFB, 1997a. Record of Decision for Fire Training Area 3 (FT03), Groundwater Within the East Management Unit at Dover Air Force Base, Delaware, submitted by HAZWRAP, August 1997.

DAFB, 1997b. Proposed Plan for Natural Attenuation of Groundwater, Fire Training Area 3 (FT03), Dover Air Force Base, Delaware, submitted by HAZWRAP, June 1997.

DAFB, 1993. Facsimile communication to Laurie Stenberg (Dames & Moore, Bethesda, Maryland) from Milton Beck (DAFB), April 24, 1993.

DAFB, 1990. Record of Decision, Remedial Alternative Selection Site FT-3: Fire Training Area 3, Dover Air Force Base, Delaware, September 1990.

HAZWRAP, 1992. Fire Training Area 3, Remedial Quality Assurance Oversight Assistance Report, March 2 - June 15, 1992, submitted by Dames & Moore, October 16, 1992.

HAZWRAP, 1991. Final Remedial Action Work Plan, Site FT-3: Fire Training Area 3, Dover Air Force Base, Delaware, submitted by Dames & Moore, August 1991. [Includes Sampling and Analysis Plan.]

ORNL, 2007. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2005-2008. East Management Unit Annual Monitoring Reports, Multiple Sampling Events (June 2005, June 2006, March 2007, March 2008), Dover Air Force Base, Delaware, submitted by URS Group, Inc.

ORNL, 2006. Interim Remedial Action Completion Report, Sites FT03, WP14, LF15, and LF13, East Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., August 2006.

ORNL, 2003-2004. East Management Unit Semi-Annual Monitoring Reports, Multiple Sampling Events (December 2002, June 2003, May 2004), Dover Air Force Base, Delaware, submitted by URS Group, Inc.

Attachment 2 – (cont'd)

SAIC, 1989. Installation Restoration Program - Stage 2 Draft Final Report, Dover Air Force Base, Delaware.

SAIC, 1986. USAF Installation Restoration Program - Dover AFB, Delaware, Phase II - Stage 1 Confirmation/Quantification.

USACE, 2000. Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997a. Feasibility Study, East Management Unit, Dover Air Force Base, Delaware, submitted by Dames & Moore, October 1997.

USACE, 1997b. Basewide Remedial Investigation, North and East Management Units, Dover Air Force Base, Delaware, submitted by Dames & Moore, August 1997.

USEPA, 1997. Five-Year Review Report, Dover Air Force Base, Delaware, prepared by U.S. Environmental Protection Agency - Region III for site FT03, July 24, 1997.

USGS, 2002a. Assessment of Natural Attenuation of Ground-Water Contamination at Sites FT03, LF13, and WP14/LF15, Dover Air Force Base, Delaware, Water Resources Investigation Report 01-4150, Baltimore, Maryland 2002.

USGS, 2002b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, April-May 2002 Sampling Round, prepared by USGS Delaware Subdistrict Office, November 2002.

USGS, 2002c. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, October 2001 Sampling Round, prepared by USGS Delaware Subdistrict Office, April 2002.

USGS, 2001a. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, March 2001 Sampling Round, prepared by USGS Delaware Subdistrict Office, September 2001.

USGS, 2001b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, November-December 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, May 2001.

Attachment 2 – (cont'd)

USGS, 2001c. Analytical Results from Ground-Water Sampling Using Direct-Push Technique at Sites FT03, LF13, and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, November-December 2000, submitted by USGS Delaware Subdistrict Office, May 2001.

USGS, 2001d. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, September 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, February 2001.

USGS, 2000a. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, January-March 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, July 2000.

USGS, 2000b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, June 1999 Sampling Round, prepared by USGS Delaware Subdistrict Office, February 2000.

USGS, 1999a. Hydrogeologic and Water-Quality Data for the East Management Unit of Dover Air Force Base, Kent County, Delaware, 1995-1996, Open-File Report 99-253.

USGS, 1999b. External Draft of the Long-Term Monitoring Plan for Source Areas FT03, WP14/LF15, and LF13, Dover Air Force Base, Delaware, submitted by USGS, May 1999.

USGS, 1998. Assessment of Natural Attenuation of Contamination from Three Source Areas in the East Management Unit, Dover Air Force Base, Kent County, Delaware, Water-Resources Investigations Report 98-4153.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for each medium are discussed below.

Soil. The previous Five-Year Review documented that RAOs were achieved for the soil remedy at FT03 (BWXT, 2003). Thus, discussion of ARARs for this portion of the site remedy is discontinued.

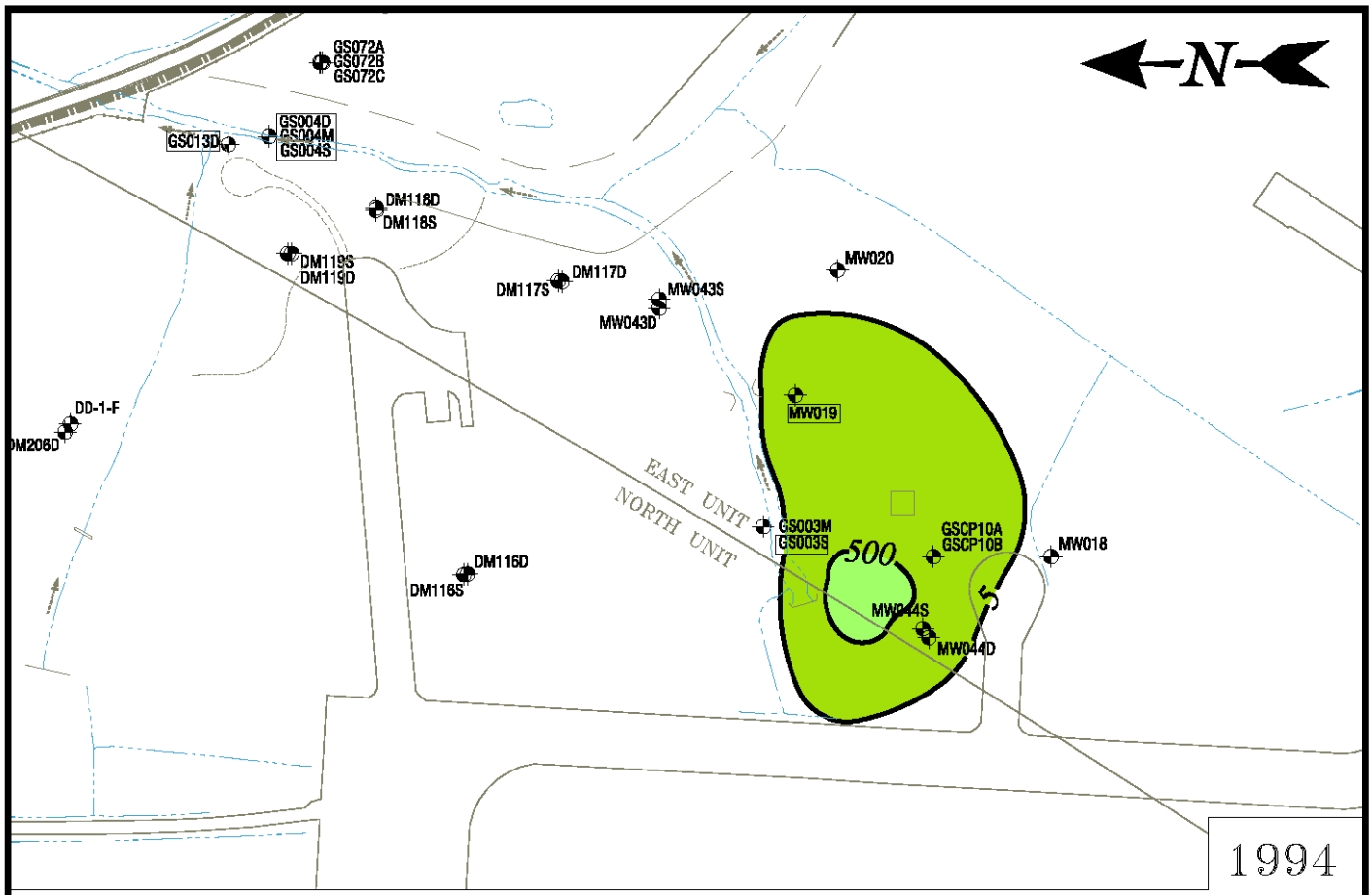
Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's DERBCAP established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For FT03 constituents, the standards in this guidance are the same as the Federal MCLs.

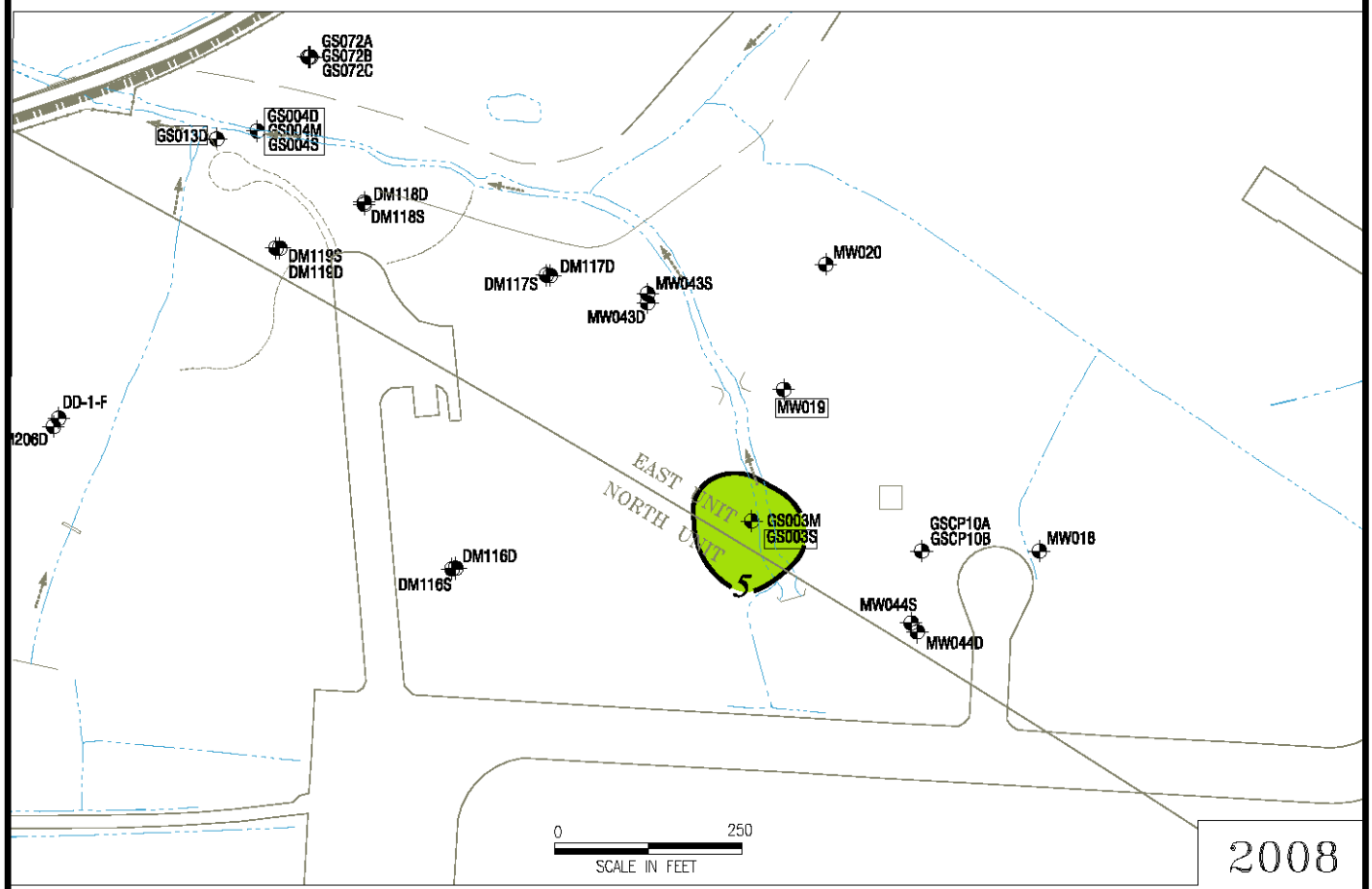
Surface Water and Sediment. The source area at FT03 has been removed and covered with clean fill; thus, surface transport of any residual constituents has been mitigated. Sampling conducted for the Ecological Risk Assessment revealed no VOC constituents in the surface water samples closest to FT03 indicating that groundwater discharge has little or no effect on this medium. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with the USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4
Site Photographs

Both photographs: Current condition of FT03 on July 27, 2007. Facing northeast.





LEGEND:

- MW031S Monitoring Well
- MW031S Well Sampled for Chemical Analysis
- Base Boundary
- >5 µg/L Total Solvent Concentration
- >500 µg/L Total Solvent Concentration

ATTACHMENT 5
PLUME MAPS FOR FT03
1994 & 2008

URS

P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\Five Year Reviews 2008\H. Reports\Figures_Plume\ATTACHMENT 6 PLUME MAP FT03.DWG, 9/10/2008 11:45:56 AM, Adobe PDF.pc3

FIVE-YEAR REVIEW FOR WP14/LF15
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
1,2-DCA	1,2-Dichloroethane
DCE	Dichloroethene
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
EMU	East Management Unit
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
PCE	Tetrachloroethene
POC	Point of Compliance
RA	Risk assessment
RAO	Remedial action objective
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
SVOC	Semi-volatile organic compound
TCA	Trichloroethane
TCE	Trichloroethene
TPH	Total petroleum hydrocarbons
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

EXECUTIVE SUMMARY

The remedy for the combined WP14 and LF15 sites--two adjacent former disposal sites at Dover Air Force Base (DAFB), Delaware--is monitored natural attenuation with land use controls (LUCs) for both soil and groundwater. Groundwater remediation began with the installation of additional monitoring wells in late 1997 in accordance with a 1997 Record of Decision. A small plume of fuel constituents had been observed at the sites, including free product in one well. The Base recovered the fuel (per a 1992 Record of Decision) and since then the plume of fuel constituents appears to have degraded almost completely. However, chlorinated solvents have a more widespread presence in groundwater at these sites.

The initial trigger date for five-year reviews in the EMU was the start date of construction for the first remedy implemented in the EMU: a structure/soil remediation that started on March 2, 1992, at site FT03. DAFB initiated a second review for the EMU in 2002, but subsequently merged all reviews into a comprehensive set of Base-wide five-year reviews, which was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the groundwater remedy--monitored natural attenuation with land use controls--is operating as intended. The primary contaminants of concern (COCs) are 1,1-dichloroethane, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride. Concentrations of these chlorinated solvents steadily decrease through the upper, middle, and lower portions of the plume indicating that natural attenuation processes are effective in reducing constituent concentrations to below their remedial action objectives (RAOs), i.e., maximum contaminant levels. With one minor exception during the March 2007 sampling event, no RAOs have been exceeded in any point of compliance (POC) well during the periodic monitoring that began in 1999. Overall, constituent concentration trends in individual wells have remained fairly constant, i.e., no clear increasing or decreasing trends, suggesting that the plume has reached a steady state condition. LUCs remain in effect and no new uses of groundwater or the site were observed. It is recommended that monitoring continue to confirm that COCs naturally attenuate to levels that meet the RAOs specified in the ROD for WP14/LF15.

The draft-final five-year review for WP14/LF15 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

WP14 and LF15 are Environmental Restoration Program (ERP) sites at Dover Air Force Base (DAFB), Delaware (Attachment 1). WP14 was a liquid waste disposal area and LF15 was an adjacent landfill used for solid waste and small quantities of shop wastes. When activities ceased (precise time frame unknown), the sites were covered with local soil and seeded with grass. No active remediation was conducted at the time of closure. The area is currently maintained as an open grassy field in the East Management Unit (EMU). Environmental investigations were subsequently conducted that revealed groundwater contamination as a particular concern and resulted in implementing a natural attenuation monitoring program under a 1997 Record of Decision (ROD). Land use controls (LUCs) for soil and groundwater are also part of the site remedy. The combined WP14/LF15 groundwater plume is also known as Area 1.

The remedial action at WP14/LF15 was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the second five-year review for the WP14/LF15 groundwater remedial action. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of the U.S. Army Corps of Engineers (USACE) Contract #DACA45-02-D-0003, Delivery Order #0021. The review was initiated in early 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

The natural attenuation monitoring at WP14/LF15 is one of several implemented remedies at EMU ERP sites. Similar groundwater monitoring occurs concurrently at two other EMU sites: FT03 and LF13. LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the WP14/LF15 groundwater remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
1950s	WP14 used for liquid waste disposal.
1960s	WP14 was covered with soil and seeded with grass in the early 1960s. LF15 was used as landfill for general refuse and small amounts of industrial shop waste. Closure date of LF15 is unknown.
1986	Stage I Site Investigation (SI) conducted at WP14 and LF15.
March 13, 1989	DAFB listed on National Priority List (NPL).
1989	Stage II SI conducted at LF15.
1990	Additional investigation of WP14/LF15 conducted (HAZWRAP, 1990).
March 2, 1992	Remediation work began at FT03. (Trigger for five-year review process in the EMU).
November 1992	Interim ROD prepared for removal of free product.
Feb./Mar. 1997	Groundwater studies conducted in the EMU (USGS, 1998 and 1999a).
June 16, 1997	Proposed Plan for natural attenuation of groundwater at WP14/LF15 completed and released for public comment (DAFB, 1997b).
August 1997	Basewide Remedial Investigation (RI) finalized; included assessment of WP14 and LF15.
September 30, 1997	ROD prepared for WP14/LF15.
October 1997	Feasibility Study (FS) for EMU finalized.
June 1999 – present	Regular groundwater monitoring at WP14/LF15 begins and is on-going.
Nov./Dec. 2000	Additional direct-push groundwater delineation data collected by USGS.
April 11, 2003	DNREC established groundwater management zone (GMZ).
September 2003	First five-year review conducted for WP14/LF15 (BWXT, 2003).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report prepared, included WP14/LF15 (ORNL, 2006).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007).

USGS - U.S. Geological Survey
HAZWRAP – Hazardous Waste Remedial Actions Program
DNREC - Department of Natural Resources and Environmental Control
ORNL – Oak Ridge National Laboratory

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

WP14 and LF15 are located near the northeast edge of the EMU and just south of the receiver station (Attachment 1). It is in a remote portion of the Base. The area is currently an open grassy field. Small drainage ditches at the sites direct runoff northwest to the Pipe Elm Branch, which subsequently flows off Base to the north. Groundwater at the site is typically encountered at depths between 5 and 13 feet (ft) below ground surface.

3.2 LAND AND RESOURCE USE

DAFB previously used the sites for disposal activities as discussed in Section 1 and the Site Chronology (Table 1). Once these activities ceased, the sites have been maintained as open grassy fields and are not currently used for any particular purpose.

Other than grounds maintenance and routine security checks, there are no other personnel in the area. The site is not easily accessible to Base visitors.

The drainage ditches that cross the sites and the nearby Pipe Elm Branch are part of the Base's storm water drainage system.

The shallow groundwater (Columbia Aquifer) underlying the site generally flows north-northwest towards the Pipe Elm Branch, a local discharge point. This aquifer is not currently used as a drinking water source. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. Off site, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a small portion of off-base property adjacent to the northeast Base boundary. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

The first SI at WP14/LF15 was in 1986 (Science Applications International Corporation (SAIC), 1986). The SI concluded that site activities had affected groundwater quality as indicated by the presence of volatile organic compounds (VOCs), oil and grease, and several metals. A more thorough investigation of LF15 was conducted several years later (SAIC, 1989). Soil gas detections of two solvents (trichloroethene [TCE] and trichloroethane [TCA]) suggested that the western part of LF15 (closest to WP14) was a source area. Groundwater data, obtained from all area wells including those at WP14, identified WP14 as the more likely source of chlorinated VOCs. Surface water and sediment sampling revealed some impacts probably from WP14/LF15: 1,2-dichloroethene (DCE), tetrachloroethene (PCE), and TCE in surface water, and total petroleum hydrocarbons (TPH) and a few metals in sediment. During the third investigation of the WP14/LF15 area (HAZWRAP, 1990), soil data indicated that residual VOCs and semi-volatile organic compounds (SVOCs), primarily phthalates, were present at WP14. Floating product was observed in one WP14 well: MW013. A solvent plume was delineated in groundwater that originated at WP14 and extended downgradient towards Pipe Elm Branch. Some minor impacts on the nearby portion of Pipe Elm Branch were again observed. However, no VOCs were detected in the surface water at the Base boundary.

The Basewide RI at WP14/LF15 confirmed minor localized constituents in soil: primarily SVOCs, pesticides (most likely from their long-term use rather than as disposed

materials), and very few chlorinated and fuel-related VOCs (USACE, 1997b). Groundwater sampling revealed a small plume of fuel constituents. (Product was not observed in MW013 during the RI. The Base had performed free product recovery efforts on well MW013 prior to the RI per the 1992 interim ROD.) The chlorinated solvent plume observed during the RI was similar as delineated previously, although source area concentrations were much lower.

The Basewide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

In 1992, an interim ROD was signed for the recovery of free product observed in well MW013. Attempts were made to recover the product in 1993 using peat-wicks, an absorbent material encased in a hydrophobic sock. A minor amount of product was recovered. The saturated peat-wicks were tested and disposed of as hazardous waste. MW013 has not contained appreciable amounts of free product since that time.

Treatment alternatives for WP14/LF15 groundwater (Area 1) were evaluated in the Basewide FS (USACE, 1997a). Supplemental characterization specific to natural attenuation was conducted by the USGS (USGS, 2002a) to support FS conclusions. This study determined that intrinsic biodegradation of groundwater contaminants is occurring at WP14/LF15. The supporting evidence included the presence of breakdown products and favorable reducing conditions of the aquifer in the source area necessary for biodegradation. The effectiveness of biodegradation in the downgradient portion of the plume was less clearly established. However, the monitoring well samples collected at the groundwater discharge location contained only small amounts of chlorinated VOCs below maximum contaminant levels (MCLs), indicating that natural attenuation processes are reducing contaminant concentrations. No VOCs have been detected in the surface water at the Base boundary. The selected remedial action for groundwater is monitored natural attenuation and LUCs, which was documented in a proposed plan and submitted for public review on June 16, 1997.

In 1997, a ROD was signed for the soil and groundwater at WP14/LF15. The selected remedy is continued enforcement of existing LUCs for soil and monitored natural attenuation with LUCs for groundwater.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater at Area 1, the combined WP14/LF15 sites, since it is located in an industrial portion of the Base (USACE, 1997b). The resulting hazard was not elevated, but risk was elevated: non-carcinogenic hazard index of 0.4 and a cancer risk of 1×10^{-4}. The cancer risk is due

primarily to vinyl chloride and arsenic, and secondarily to several other chlorinated VOCs. Arsenic, however, was detected at concentrations below its MCL. Although groundwater from the Columbia Aquifer at Area 1 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences at the site as well as the potential for contaminant migration to areas not under DAFB control, trigger the need for remedial action at WP14/LF15. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for WP14/LF15 groundwater was signed by USEPA in September 1997 (DAFB, 1997a). The remedial action objective (RAO) was developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, the RAO for WP14/LF15 groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. LUCs serve to prevent unacceptable exposure to groundwater until the RAOs are achieved. LUCs for soil and groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the EMU FS. The selected remedy for WP14/LF15 groundwater as outlined in the 1997 ROD includes the four major components listed below.

- Natural attenuation of contaminants of concern (COCs) in groundwater.
- Continued enforcement of existing LUCs.
- Restrictions on groundwater use.
- Groundwater monitoring.

4.2 REMEDY IMPLEMENTATION

In accordance with the 1997 ROD, DAFB enlisted the services of the USGS to develop a natural attenuation groundwater monitoring plan and to conduct regular groundwater sampling. The plan included similar monitoring at two other EMU sites: FT03 and LF13 (USGS, 1999b). Nine wells were initially selected to be monitored specifically at WP14/LF15. Four additional wells were installed approximately 200 ft from the Base boundary where Pipe Elm Branch flows off-site; these wells serve as point of compliance (POC) wells for WP14/LF15 as well as FT03. Two existing site wells and

three new wells along Postles Corner Road are also POC wells (Attachment 1). One of the existing wells, D-4-H, ceased to be sampled after March 2000 because it goes dry before providing a sufficient volume of water to be sampled. Monitoring and POC well IDs are listed in Table 2 with subsequent modifications to the program noted. Sample analyses include VOCs and geochemical indicators of natural attenuation. The EMU sites are currently sampled on an annual schedule based on recommendations in the September 2003 five-year review report (BWXT, 2003).

Table 2 - Monitoring and POC Wells

Monitoring Wells	POC Wells
DM107D, S	GS004D, M, S
DM108D, S	GS013D[4]
MW011[1]	GSCP3M
MW039D, S	MW227M
MW013[2]	D-4-H[5]
GS070A, B, C, D[3]	
GS071A, B, C[3]	
GS072A, B, C[3]	
GSCP9A, S	

(1) Replaced by well triplet GSCP9A, S, B (October 2001).
(2) Sampled only once (September 2000).
(3) Sampled only once (April-May 2002), except for GS071B.
(4) Added to program after first semi-annual sampling event.
(5) Removed from program after March 2000 because it goes dry.

At WP14/LF15, the primary mechanism of natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant, PCE, degrades to TCE, then to cis-1,2-dichloroethene (cis-1,2-DCE), then to vinyl chloride and finally to ethene, a harmless gas.

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including WP14/LF15. Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) The grass covers at WP14 and LF15 will be maintained. (4) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a small portion of off-Base property adjacent to the northeast Base boundary. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (5) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the contaminants found at WP14/LF15 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine

whether on-site concentrations decrease over time and to ensure that RAO concentrations are not exceeded in the POC wells.

Table 3 – RAO Groundwater Concentrations

Parameter	RAO Concentration[a] (µg/L)
Benzene	5
1,2-Dichloroethane (1,2-DCA)	5
1,1-DCE	7
cis-1,2-DCE	70
Ethylbenzene	700
PCE	5
Toluene	1,000
1,1,1-TCA	200
1,1,2-TCA	5
TCE	5
Vinyl chloride	2
Xylenes, total	10,000

[a]The groundwater RAOs are the MCLs.
µg/L - micrograms per liter

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the West Management Unit. There are no buildings on top of WP14/LF15. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

The WP14/LF15 disposal areas were covered with soil and seeded with grass. DAFB employs full-time staff for the maintenance of the Base grounds. At WP14/LF15, this consists primarily of periodically mowing the grass. There are no permanent structures (e.g., an engineered cap) associated with either site that would require regular inspection or corrective action.

Groundwater monitoring of WP14/LF15 began in 1999 and is ongoing. The costs associated with this activity are summarized in Table 4. LUC inspections began in 2006 and occur annually.

Table 4 – Annual Monitoring Costs

Fiscal Year	Total Cost rounded to nearest $1,000
1998	$130,000
1999	$60,000
2000	$315,000
2001	$315,000
2002	$238,000
2003	$105,000
2004	$99,000
2005	$86,000
2006	$86,000
2007	$75,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the second five-year review for WP14/LF15. Since the last review, groundwater monitoring has been on-going with minor adjustments to the monitoring well network and shifting from a semi-annual to annual sampling schedule. Groundwater monitoring results are discussed in Section 6.0. LUCs were also implemented at WP14/LF15, including an annual Basewide-inspection of the LUCs, and this is discussed in Section 6.0 as well.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 meetings in 2007 that the second five-year review for WP14/LF15 would begin in 2007 and would be conducted by the USACE contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for WP14/LF15 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of WP14/LF15 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant WP14/LF15 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the long-term monitored natural attenuation remedy (ORNL, 2003-2004; 2005-2008). The monitoring reports reviewed for the EMU, which includes WP14/LF15, evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

Groundwater data at WP14/LF15 have been collected in multiple sampling rounds since 1986. The most recent data are from the periodic long-term monitoring program that began in 1999 and continues on an annual basis. Twelve wells are now regularly sampled at WP14/LF15 as well as eight POC wells (Table 2). The GS002 monitoring wells and GS004 POC wells were installed in the stream bed of Pipe Elm Branch to monitor groundwater below the stream.

The small plume of fuel-related constituents appears to have degraded almost completely. Benzene, the only fuel-related compound to be detected above its MCL, was last detected in MW039S at 6.4 µg/L in June 1999; it has been below detection during the last eight years (March 2000 through March 2008). In GSCP9A, benzene was detected only once above its MCL (7.4 µg/L in June 2003) and then steadily declined during the next five sampling rounds until it was below detection in 2008 (Table 5).

Chlorinated VOCs are the primary concern at WP14/LF15. PCE, TCE, 1,2-dichloroethane (1,2-DCA), and vinyl chloride were detected most frequently above RAOs/MCLs in site monitoring wells (Table 5). Solvents originate in the vicinity of GSCP9A where concentrations are highest (and to a lesser degree at MW039S) and form a plume that decreases in concentration downgradient. With the exception of MW039S and possibly DM107D, none of the monitoring wells exhibit clear increasing or decreasing trends, suggesting that the plume is at or near steady state. The portion of the plume above RAOs/MCLs remains confined to DAFB. No RAO/MCL has been exceeded in any of the POC wells during any of the 13 sampling events except for one detection of vinyl chloride (6.6 µg/L) in GS010S in March 2007. However, data from the 2008 EMU monitoring event shows that vinyl chloride was not detected in this well, confirming that the 2007 detection was most likely an anomalous occurrence. Overall, these data indicate that natural attenuation processes are effective in reducing constituent concentrations.

Table 5 - Groundwater Data[1]

Monitoring Well	Analyte[2]	RAO (ug/L)	Sampling Round, positive detections only, µg/L[3]												
			Jun-99	Mar-00	Sep-00	Mar-01	Oct-01	May-02	Dec-02	Jun-03	May-04	Jun-05	Jun-06	Mar-07	Mar-08
MW039S	Benzene	5	6.4										(0.31)		
	PCE	5	89	310	320	300	450	(0.99)	16	(0.23)			52		202
	TCE	5	190	120	130	100	180	(0.32)	4.1				14		45
	1,2-DCA	5	15	7.5	9.5	5.9	13						0.57		
	cis-1,2-DCE	70	85	51	64	45	99		2.1				8.8		11.8
	Vinyl chloride	2	42	9.1	12	6.4	28						1.9		
MW011	PCE	5	180	3,000	1,900	2,300	Replaced by GSCP9 wells								
	TCE	5	110	1,400	1,200	680									
	cis-1,2-DCE	70	140	450	520	250									
GSCP9A	Benzene	5	Installed in mid 2001 to replace MW011						1.8	7.4	4.1	2.3	0.5		
	PCE	5					3,300	3,300	3,900	3,400	1,800	6,000	1,300	496	507
	TCE	5					2,100	1,600	1,100	930	340	1,100	230	80	99
	cis-1,2-DCE	70					2,000	1,600	620	2,000	540	1,200	370	199	297
	Vinyl chloride	2					19			63	22		0.73	5.75	0.88
GSCP9S	PCE	5	Installed in mid 2001 to replace MW011				200	340	1.9				29	93	51
	TCE	5					32	83	(0.3)			3.9	6.2	15	8.9
	cis-1,2-DCE	70													18
GSCP9B	PCE	5	Installed in mid 2001 to replace MW011				56	140	removed from program						
	TCE	5					7.5	17							
GS002D	PCE	5	(0.52)	8.3		17	(0.67)	17	17	16	21	15	9.6	16	11.8
	TCE	5	1.9	2	3.9	57	2.7	65	43	43	52	36	21	27	20
	1,2-DCA	5	2.7	27	6.8	73	2.6	74	60	58	76	52	28	98	45
	cis-1,2-DCE	70													19.2
	Vinyl chloride	2		(0.13)		(0.66)		(0.56)	0.63	0.57	0.83		0.32	5.45	
GS002S	Vinyl chloride	2	well not yet installed										8.3	7.5	
DM107D	PCE	5	66	15	31	14	14	3.8	1.6		12	10	30	5.3	
	TCE	5	92	21	42	19	18	3.7	1.5	3.7	8.2	3.7	9.5	2.3	
	1,2-DCA	5	77	12	31	6.4	3.4		(0.48)				2.1		
DM107S	PCE	5	23	6.7	12	9.7	38	9.7	19	7.8	13	18	17	13.9	14.5
	TCE	5	33	7.5	13	13	47	15	22	7.4	12	13	30	6.43	6.2
	1,2-DCA	5				1.2	14	4.2	3.9		2.5		3.6		1.4
	cis-1,2-DCE	70													3.3
DM108D	PCE	5	19	40	45	52	46	12	4.5	33	67	62	69	70	39
	TCE	5	69	110	130	140	140	34	6.4	71	150	140	140	122	65
	1,2-DCA	5	66	55	110	140	110	1.5		54	100	140	150	263	85
	cis-1,2-DCE	70													9.8
	Vinyl chloride	2				2.9	2.6			0.97	2.4	2.2	3.2	4.9	
DM108S	PCE	5	26	28	35	32	45	32	39	8.4	2.6	14	32	17	29
	TCE	5	83	84	110	93	140	110	120	19	6.3		44	20	46
	1,2-DCA	5					23	3.8	26						
	cis-1,2-DCE	70													9.2
GS071B	PCE	5	well not yet installed					8.8	21	1.2	3.9	3.9	2.6	2.2	6.9
	TCE	5						27	69	3.3	14	10	6.5	1.5	11.9

Site wells GS002M and MW039D had no RAO exceedences during any sampling event.

POC wells (D-4-H, MW227M, GSCP3M, GS010S/D, GS004D/M/S, and GS013D) had no RAO exceedences during any sampling event with one exception: vinyl chloride at 6.6 µg/L in GS010S, March 2007.

[1]The data summarized in this table are from the six long-term monitoring events conducted by the USGS from June 1999 to May 2002, and from seven events conducted by URS from December 2002 to March 2008.

[2]Only analytes that had at least one RAO exceedence are listed.

[3]Values in parentheses are estimated. Shaded values exceed the RAO.

A comprehensive direct-push groundwater study was conducted in late 2000 to more fully delineate the chlorinated solvent plume (USGS, 2001c). The results (constituent concentrations and distribution) were generally consistent with the interpretations made based on the monitoring well data.

6.4 SITE INSPECTION

A URS geologist visited the site on July 27, 2007. A photographic log documents the conditions at WP14/LF15 on that day (Attachment 4). The area is currently covered with grass. The grass and surrounding areas are regularly maintained. Burrowing animals may be present in the area and could disturb buried materials at WP14/LF15. However, no disturbances were noted during the site visit. No new uses of groundwater or the sites were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for WP14/LF15 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that the small petroleum-related plume has degraded. As seen in Attachment 6, the total concentration of chlorinated COCs are contoured for groundwater data collected in 1995 and the most recent annual monitoring event (March 2008). The plume's lateral extent has slightly shrunk and the plume is somewhat longer due to data from well GS071B, which was installed after 1994. Overall, concentrations have remained relatively stable with a moderate decline over the years at the source area. As seen in Attachment 5, source area wells MW039S and GSCP9A have had decreasing COC concentration trends since 2002. Figure DM108D (Attachment 5) has had stable trends for all COCs, which suggests that the plume is near steady state. Although on-site concentrations of several chlorinated VOCs exceed RAOs/MCLs, expansion of the plume to POC wells at levels above RAOs/MCLs has not occurred (with only one minor exception during the last monitoring round in March 2007).

Site conditions and usage are unchanged since the implementation of the remedy. The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

With the placement of a clean soil cover over the sites, possible ecological pathways have been minimized. In addition, the Basewide Ecological RA concluded that there were no unacceptable risks associated with groundwater discharging to surface streams, including Pipe Elm Branch.

The changes in ARARs (Attachment 3) are limited to those established for groundwater in DNREC's Delaware Risk-Based Corrective Action Program (DERBCAP) and remediation standards guidance. These standards are the same as or less stringent than MCLs.

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effects on risks, are qualitatively summarized in Table 6. As outlined in Table 6, most of the changes could increase the overall carcinogenic risks and non-carcinogenic hazard; four could decrease the hazards and/or risks. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 6 – Risk Assessment Review

Change	Effect
RBSCs decreased for methylene chloride, xylenes, naphthalene, DDD, DDE, and dieldrin.	These chemicals would be included in the RA, slightly increasing overall risks and/or hazards. Methylene chloride is most likely a laboratory contaminant and not site related.
RBSCs increased for 1,1-DCE, ethylbenzene, heptachlor, and beryllium.	These chemicals would be excluded from the RA, slightly decreasing overall risks and/or hazards.
Inhalation reference dose increased for 1,2-DCA.	Slight decrease in overall hazard.
Oral reference dose now available for benzene; slope factor increased.	A slight increase in overall risk and hazard.
Inhalation reference dose now available for PCE; slope factor increased.	A slight increase in overall risk and hazard.
Inhalation reference dose decreased and slope factor increased for TCE*.	A slight increase in overall risk and hazard.

Table 6 – cont'd

Change	Effect
Inhalation and oral reference doses now available for vinyl chloride; slope factors decreased.	A slight increase in overall hazard and decrease in overall risk.
Oral reference dose now available for 2-methylnaphthalene.	A slight increase in overall hazard.
Oral slope factor decreased for arsenic.	A slight decrease in overall risk.
Oral reference dose now available for iron.	A slight increase in overall hazard.
Oral reference dose decreased for manganese.	A slight increase in overall hazard.

RBSC - Risk-based screening criterion.
*Assessment of TCE based on 2001 provisional toxicity values.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

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

The review for WP14/LF15 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. WP14/LF15 has remained an open, unused field since disposal activities ceased. All information to date indicates that the chlorinated solvent plume (at levels above MCLs/RAOs) is confined to DAFB and has not migrated to the POC wells along the Base boundary at harmful levels with one exception. In 2007, vinyl chloride was detected for the first time in POC well GS010S at 6.6 µg/L. Sampling in 2008 confirms that this was a sporadic occurrence.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for WP14/LF15 groundwater appears to be functioning as intended. With one minor exception, off-site migration of contaminants above action levels has not occurred. The on-site plume concentrations are above RAOs/MCLs in several wells located within the core of the plume. However, contaminant concentrations decrease downgradient through the plume to below RAOs/MCLs. Overall, there are no clear long-term increasing or decreasing concentration trends observed within the plume during eight years of site data suggesting that the plume may be at or near steady state. The site inspection revealed that WP14/LF15 is regularly maintained as an unused grassy field. Review of the RA and

ARARs, revealed no significant changes that would affect remedy selection or implementation. The 2002 USGS EMU study determined that there were insufficient data to meaningfully model degradation rates (2002a). Therefore, a time frame to achieve RAOs has not been estimated. None of the monitoring wells exhibit clear increasing or decreasing trends, with the exception of MW039S and possibly DM107D, suggesting that the plume is at or near steady state.

LUCs have been successfully implemented at the sites.

8.0 ISSUES

No issues were discovered during the review that affect the protectiveness of the remedy. During the March 2007 sampling event, there was one minor exceedence of an MCL in a POC well at WP14/LF15 for the first time in over 10 years of monitoring. However, this minor exceedence was located in a well adjacent to an off-Base parcel of land that is included in the GMZ established by Delaware's DNREC. The GMZ is a State-enforced LUC that prevents groundwater use, and thus prevents exposure, in this off-Base area. Therefore, the remedy is still protective of human health and the environment, although continued monitoring of this area is recommended to assess future contaminant trends.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater sampling during the SIs and RI at WP14/LF15 demonstrated that site activities affected groundwater quality and that a potential exists for off-site migration. In response, long-term monitoring of the sites was initiated. It is recommended that monitoring continue on an annual schedule until the groundwater RAOs are achieved.

To optimize the monitoring well network for future events, it is recommended that monitoring of POC well GS013D be discontinued. This well has had no RAO exceedences, and nearby well triplet GS004D,M,S provides more useful information on the COCs associated WP14/LF15.

A worse-case vapor intrusion evaluation was performed in 2007 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

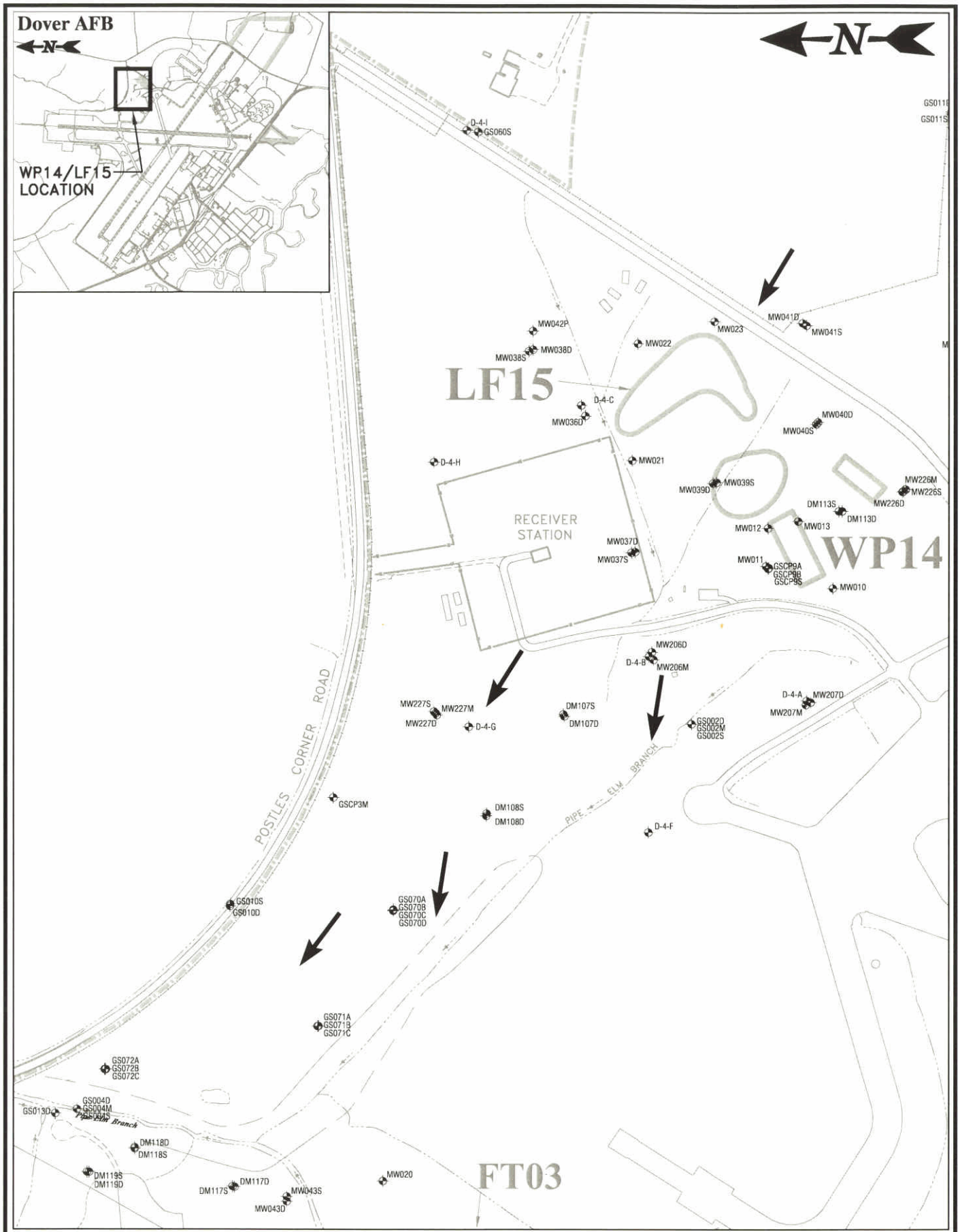
The site as a whole will also continue to be addressed in the five-year review process due to the LUC remedy and the continuation of groundwater monitoring.

10.0 PROTECTIVENESS STATEMENT

The remedy at WP14/LF15 is protective of human health and the environment. In the interim until RAOs are met at these sites, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for WP14/LF15 will be due in September 2013.



LEGEND:

- MW031S Monitoring Well
- Groundwater Flow
- Site Boundary
- Base Boundary

0 325
SCALE IN FEET

ATTACHMENT 1
WP14/LF15 SITE MAP

URS

P:\Gaithersburg\U000000572 Omaha USACE\15294916 PPs & RODs\EMU 5YR_2007\WP14-LF15.DWG, 8X11, 9/7/2007 3:58:27 PM, soum_sokhon, Adobe PDF, 1:1

Attachment 2 - Reviewed Documents

BWXT, 2003. Final Five-Year Reviews, Dover Air Force Base: LF18 Soil, FT03 Structures/Soil and Groundwater, WP14/LF15 Groundwater, LF13 Groundwater, submitted by URS Group, Inc., September 2003.

DAFB, 2006. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2006.

DAFB, 1997a. Record of Decision for Liquid Waste Disposal Area 14 (WP14) and Landfill 15 (LF15), Soil and Groundwater Within the East Management Unit at Dover Air Force Base, Delaware, submitted by HAZWRAP, August 1997.

DAFB, 1997b. Proposed Plan for Natural Attenuation of Groundwater, Liquid Waste Disposal Area 14 (WP14) and Landfill 15 (LF15), Dover Air Force Base, Delaware, submitted by HAZWRAP, June 1997.

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HAZWRAP, 1990. Draft Technical Memorandum, Sampling and Data Results, Sites: T-1, SP-9, D-4, and DD-1, Dover Air Force Base, Delaware, submitted by HAZWRAP, February 1990.

ORNL, 2007. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2005-2008. East Management Unit Annual Monitoring Reports, Multiple Sampling Events (June 2005, June 2006, March 2007, March 2008), Dover Air Force Base, Delaware, submitted by URS Group, Inc.

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ORNL, 2003-2004. East Management Unit Semi-Annual Monitoring Reports, Multiple Sampling Events (December 2002, June 2003, May 2004), Dover Air Force Base, Delaware, submitted by URS Group, Inc.

SAIC, 1989. Installation Restoration Program - Stage 2 Draft Final Report, Dover Air Force Base, Delaware.

SAIC, 1986. USAF Installation Restoration Program - Dover AFB, Delaware, Phase II - Stage 1 Confirmation/Quantification.

Attachment 2 - (cont'd)

USACE, 2000. Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997a. Feasibility Study, East Management Unit, Dover Air Force Base, Delaware, submitted by Dames & Moore, October 1997.

USACE, 1997b. Basewide Remedial Investigation, North and East Management Units, Dover Air Force Base, Delaware, submitted by Dames & Moore, August 1997.

USGS, 2002a. Assessment of Natural Attenuation of Ground-Water Contamination at Sites FT03, LF13, and WP14/LF15, Dover Air Force Base, Delaware, Water Resources Investigation Report 01-4150, Baltimore, Maryland 2002.

USGS, 2002b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, April-May 2002 Sampling Round, prepared by USGS Delaware Subdistrict Office, November 2002.

USGS, 2002c. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, October 2001 Sampling Round, prepared by USGS Delaware Subdistrict Office, April 2002.

USGS, 2001a. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, March 2001 Sampling Round, prepared by USGS Delaware Subdistrict Office, September 2001.

USGS, 2001b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, November-December 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, May 2001.

USGS, 2001c. Analytical Results from Ground-Water Sampling Using Direct-Push Technique at Sites FT03, LF13, and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, November-December 2000, submitted by USGS Delaware Subdistrict Office, May 2001.

USGS, 2001d. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, September 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, February 2001.

Attachment 2 - (cont'd)

USGS, 2000a. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, January-March 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, July 2000.

USGS, 2000b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, June 1999 Sampling Round, prepared by USGS Delaware Subdistrict Office, February 2000.

USGS, 1999a. Hydrogeologic and Water-Quality Data for the East Management Unit of Dover Air Force Base, Kent County, Delaware, 1995-1996, Open-File Report 99-253.

USGS, 1999b. External Draft of the Long-Term Monitoring Plan for Source Areas FT03, WP14/LF15, and LF13, Dover Air Force Base, Delaware, submitted by USGS, May 1999.

USGS, 1998. Assessment of Natural Attenuation of Contamination from Three Source Areas in the East Management Unit, Dover Air Force Base, Kent County, Delaware, Water-Resources Investigations Report 98-4153.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario. However, since residential risks were not evaluated, the Air Force has decided to implement land use controls as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's DERBCAP established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For WP14/LF15 constituents, the standards in this guidance are the same as the Federal MCLs.

Surface Water and Sediment. The disposal areas have been covered with clean fill and grass; thus, surface transport of any residual constituents has been mitigated. Sampling conducted for the Ecological Risk Assessment revealed minor impacts to the surface water in the on-Base portion of Pipe Elm Branch most likely from groundwater discharge. However, these effects do not persist to the off-Base portion of Pipe Elm Branch and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

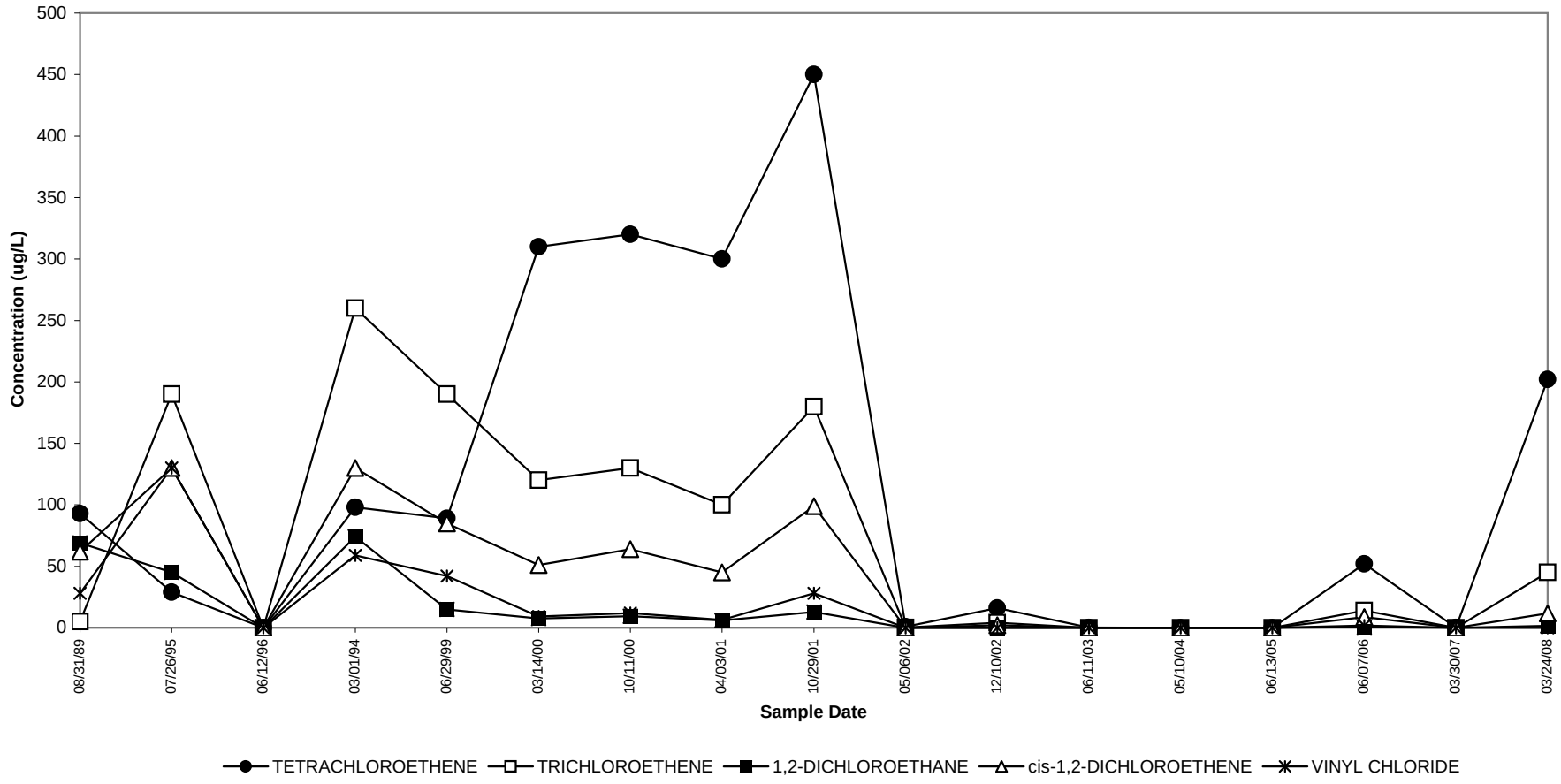
Attachment 4
Site Photographs

Current condition of WP14/LF15 on July 27, 2007. Top: facing northwest. Bottom: facing north.

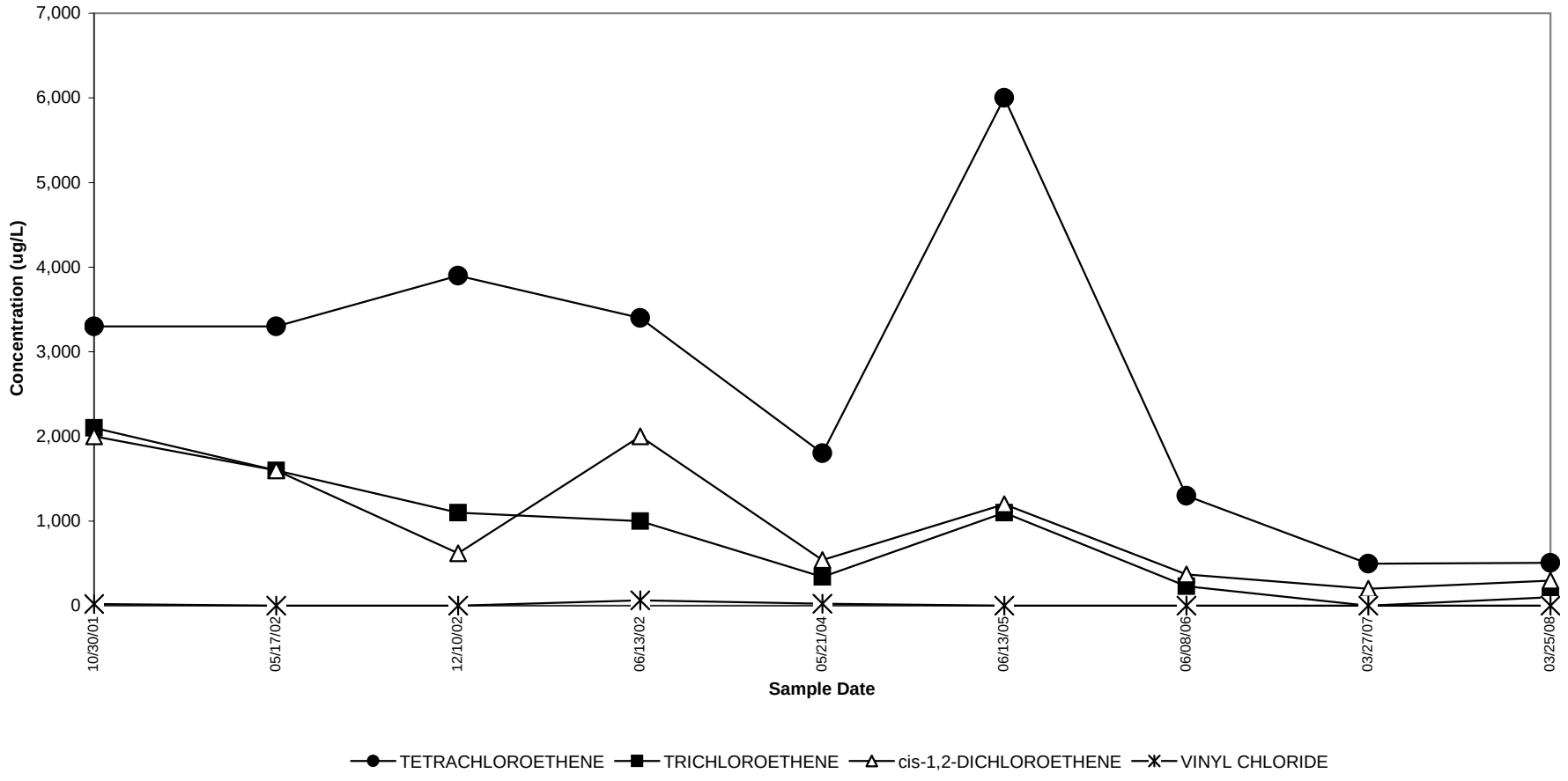
Attachment 4 – cont'd

Current condition of WP14/LF15 on July 27, 2007. Facing northeast.

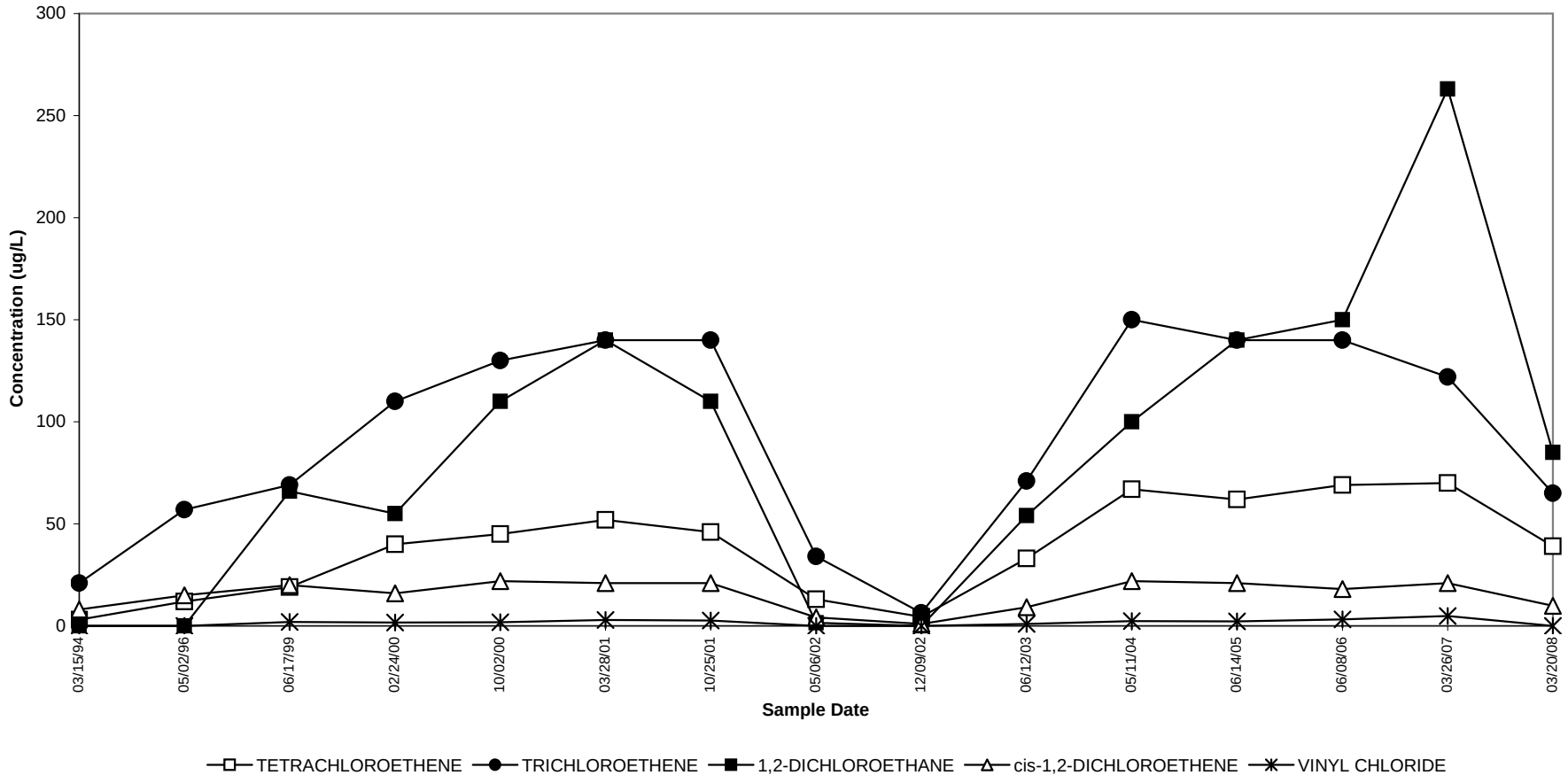
Attachment 5
MW039S
Trend Chart

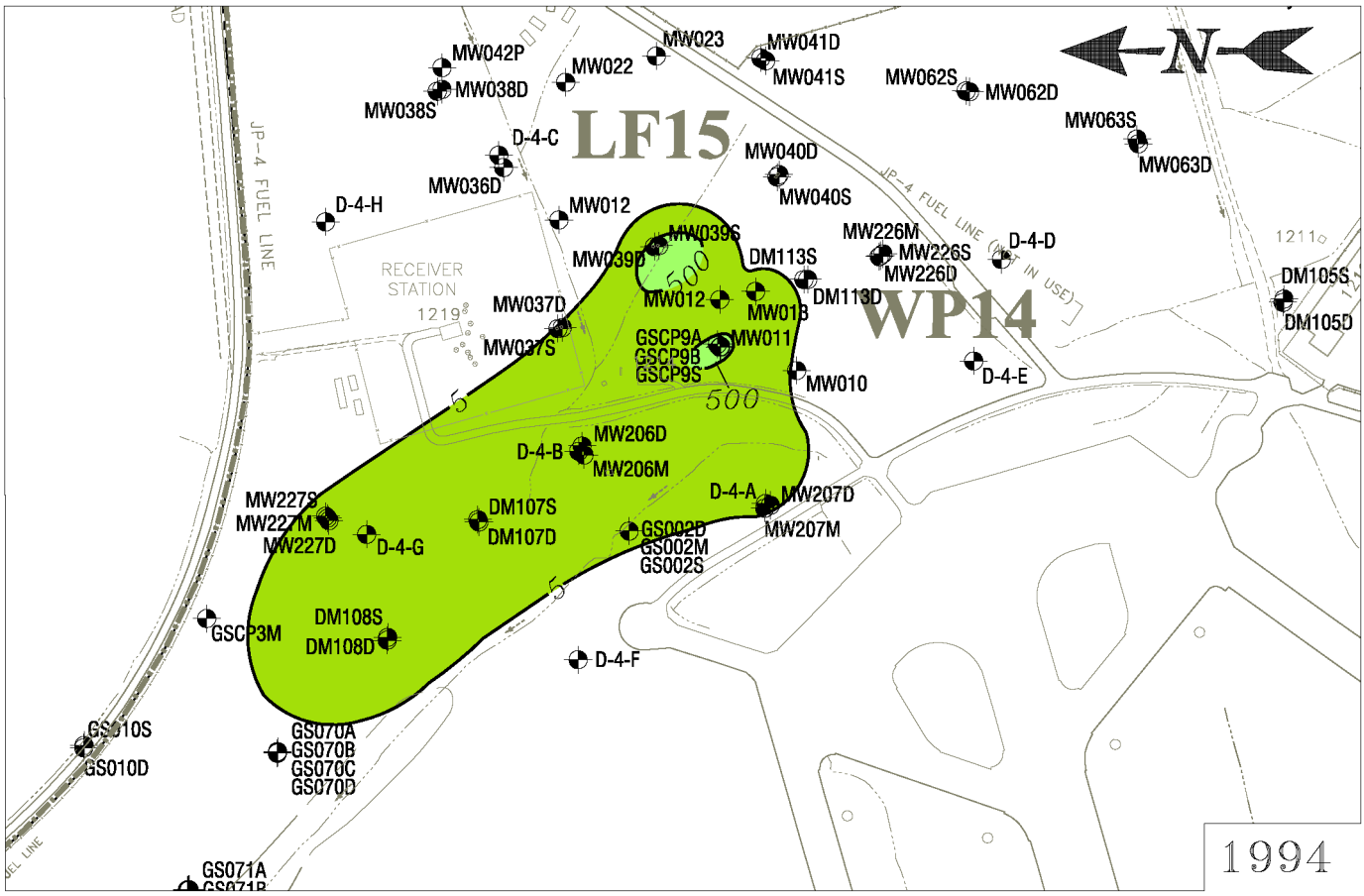


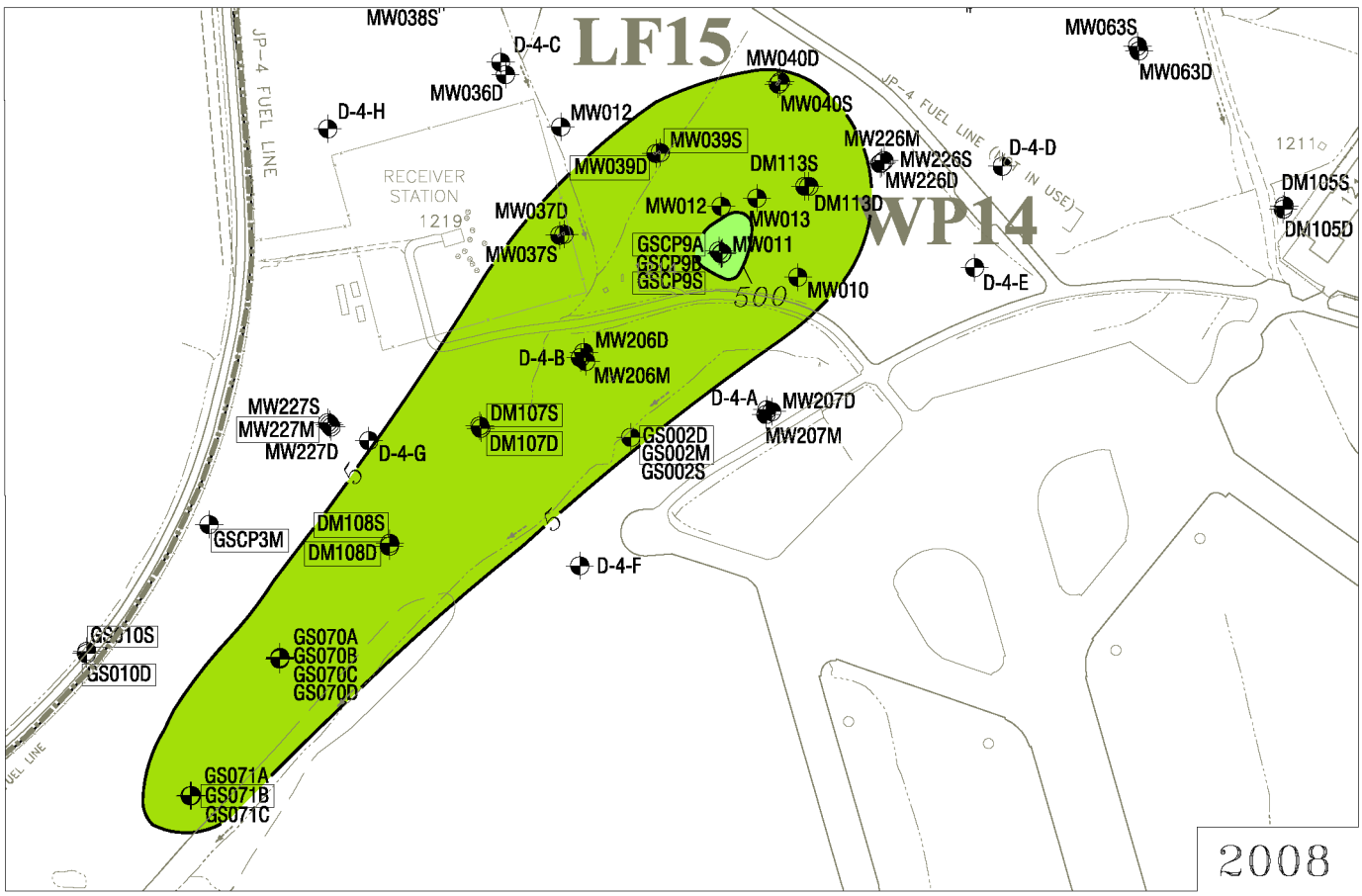
Attachment 5 - (cont'd)
GSCP9A
Trend Chart



Attachment 5 - (cont'd)
DM108D
Trend Chart







LEGEND:

49S Monitoring Well

Base Boundary

Groundwater Flow

>5 µg/L Total Solvent Concentration

>500 µg/L Total Solvent Concentration

0 300

SCALE IN FEET

ATTACHMENT 6
PLUME MAPS FOR WP14/LF15
1994 & 2008

URS

P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\Five Year Reviews 2008\H. Reports\Figures_Plume\ATTACHMENT 6 WP14-LF15.DWG, 9/10/2008 11:49:06 AM, Adobe PDF.pc3

FIVE-YEAR REVIEW FOR LF13
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

and

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
1,2-DCA	1,2-Dichloroethane
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
EMU	East Management Unit
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
PCE	Tetrachloroethene
POC	Point of Compliance
RA	Risk assessment
RAO	Remedial action objective
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
TCE	Trichloroethene
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

EXECUTIVE SUMMARY

The remedy for LF13, a former landfill site at Dover Air Force Base (DAFB), Delaware, is natural attenuation with groundwater monitoring and land use controls (LUCs) for both soil and groundwater. Groundwater remediation began with installation of additional monitoring wells in late 1997 in accordance with a 1997 Record of Decision (ROD).

The initial trigger date for five-year reviews in the EMU was the start date of construction for the first remedy implemented in the EMU: a structures/soil remediation that started on March 2, 1992, at site FT03. DAFB initiated a second review for the EMU in 2002, but subsequently merged all reviews into a comprehensive set of Base-wide five-year reviews, which was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008.

The assessment of this five-year review found that the groundwater remedy--monitored natural attenuation with LUCs--is operating as intended. The primary contaminants of concern (COCs) are benzene, 1,2-dichloroethene, and vinyl chloride. Concentrations of these volatile organic compounds (VOCs) exceed remedial action objectives (RAOs)/maximum contaminant levels (MCLs) in two site wells suggesting small point sources. No RAOs have been exceeded in any other site wells or point of compliance (POC) wells during the periodic monitoring that began in 1999. Well-developed plumes are not present at LF13 indicating that natural attenuation processes are successfully reducing constituent concentrations to below RAOs/MCLs. Constituent concentration trends in the two individual site wells have remained fairly constant, i.e., no clear increasing or decreasing trends, suggesting that the source area has reached a steady state condition. LUCs remain in effect and no new uses of groundwater or the site were observed. It is recommended that monitoring continue to confirm that COCs naturally attenuate to levels that meet the RAOs specified in the ROD for LF13.

The draft-final five-year review for LF13 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

LF13 is an Environmental Restoration Program (ERP) landfill site at Dover Air Force Base (DAFB), Delaware, in the East Management Unit (EMU) (Attachment 1). The site was used from the 1960s through the 1990s for disposal of small quantities of solid waste and for large quantities of construction rubble. It is currently an inactive landfill and uncontaminated soil from Base construction work is occasionally staged at the site. No active remediation was conducted at the time of closure. The area is currently an open shrub- and weed-covered field with some small trees and partially exposed construction debris. Environmental investigations were subsequently conducted that revealed groundwater contamination as a particular concern and resulted in implementing a natural attenuation monitoring program under a 1997 Record of Decision (ROD). Land use controls (LUCs) for soil and groundwater are also a component of the remedy.

The remedial action at LF13 was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the second five-year review for the LF13 remedy. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of U.S. Army Corps of Engineers (USACE), Contract #DACA45-02-D-0003, Delivery Order #0021. The review was initiated in early 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

The natural attenuation monitoring at LF13 is one of several implemented remedies at EMU ERP sites. Similar groundwater monitoring occurs concurrently at three other EMU sites: FT03 and WP14/LF15. LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the LF13 groundwater remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
1960s-1990s	LF13 was used as landfill for small amounts of general refuse and larger amounts of construction rubble.
1986	Stage I Site Investigation (SI) conducted at LF13.
March 13, 1989	DAFB listed on National Priority List (NPL).
1989	Stage II SI conducted at LF13.
March 2, 1992	Remediation work began at FT03. (Trigger for five-year review process in the EMU.)
1995-1996	Groundwater studies conducted in the EMU (USGS, 1998 and 1999a).
June 16, 1997	Proposed Plan for natural attenuation of groundwater at LF13 completed and released for public comment (DAFB, 1997b).
August 1997	Basewide Remedial Investigation (RI) finalized; included assessment of LF13.
September 30, 1997	ROD prepared for LF13 groundwater.
October 1997	Feasibility Study (FS) for EMU finalized.
June 1999 – present	Regular groundwater monitoring at LF13 begins.
Nov./Dec. 2000	Additional direct-push groundwater delineation data collected by USGS.
April 11, 2003	DNREC established a groundwater management zone (GMZ).
September 2003	First five-year review conducted for LF13 (BWXT, 2003).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report prepared, included LF13 (ORNL, 2006).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007).

USGS – U.S. Geological Survey
DNREC – Department of Natural Resources and Environmental Control.
ORNL – Oak Ridge National Laboratory

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

LF13 is located near the east edge of the EMU (Attachment 1) in a remote portion of the Base. The area is currently accessed by a gated gravel road. Disposal activities have created a 15- to 20-foot mound with hummocky topography. Wetlands and dense forested areas exist around the edges of the site boundaries. Small drainage ditches at the site direct runoff parallel to the road and ultimately to the Pipe Elm Branch, which subsequently flows off Base to the north. Groundwater at the site is typically encountered at depths between 10 and 16 feet (ft) below ground surface. Perched groundwater is present over a significant portion of the site.

3.2 LAND AND RESOURCE USE

DAFB previously used the site for disposal activities as discussed in Section 1 and the Site Chronology (Table 1). Once these activities ceased, the site has been maintained as is and is not used other than for staging clean soil from construction work. Other than minimal grounds maintenance and routine security checks, there are no other personnel in the area. The site is not easily accessible to Base visitors.

The drainage ditches that cross the sites and the nearby Pipe Elm Branch are part of the Base's storm water drainage system.

The shallow groundwater (Columbia Aquifer) underlying the site generally flows north-northwest towards the Pipe Elm Branch, a local discharge point. This aquifer is not currently used as a drinking water source. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Branch Aquifers, which are below the Columbia and Frederica Aquifers. Groundwater flows radially from the region of the perched water table. Off site, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a small portion of off-base property adjacent to the northeast Base boundary. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

The first SI at LF13 was in 1986 (Science Applications International Corporation (SAIC), 1986). Sediments were sampled during the SI; slightly elevated arsenic was reported, which may be related to past use of pesticides rather than landfill activities. A more thorough investigation of LF13 was conducted several years later (SAIC, 1989). Eight wells were installed and sampled. The data indicated that there were localized impacts to groundwater quality. MW061D was reported to contain floating product, but this was not confirmed in later sampling events. The primary constituents of concern were fuels and chlorinated solvents. However, no volatile organic compounds (VOCs) were detected in the surface water or sediment samples collected at the site.

The Basewide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

Treatment alternatives for LF13 groundwater were evaluated in the Basewide FS (USACE, 1997a). Supplemental characterization specific to natural attenuation was conducted by the USGS (USGS, 2002a) to support FS conclusions. This study determined that natural attenuation appeared to be adequate for controlling the migration of constituents from LF13. The supporting evidence included the presence of breakdown products and favorable reducing conditions of the aquifer necessary for biodegradation. The selected remedial action for groundwater is monitored natural attenuation and LUCs,

which was documented in a proposed plan and submitted for public review on June 16, 1997.

In 1997, a ROD was signed for the soil and groundwater at LF13. It recommended continued enforcement of existing LUCs for soil and monitored natural attenuation with LUCs for groundwater.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater at LF13 since it is located in an industrial portion of the Base (USACE, 1997b). The resulting hazard was equal to (but did not exceed) its comparison criterion and the risk was elevated: non-carcinogenic hazard index of 1 and a cancer risk of 9×10^{-4}. The hazard is due to beryllium, which was detected in only one of 14 samples at a concentration slightly above background and is not a concern. The cancer risk is due primarily to vinyl chloride and arsenic. Arsenic, however, was detected at concentrations below its maximum contaminant level (MCL). Although groundwater from the Columbia Aquifer at site LF13 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences at the site, as well as the potential for contaminant migration to areas not under DAFB control, trigger the need for remedial action at LF13. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for LF13 groundwater was signed by USEPA in September 1997 (DAFB, 1997a). The remedial action objective (RAO) was developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, the RAO for LF13 groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. LUCs serve to prevent unacceptable exposure to groundwater until the RAOs are achieved. LUCs for soil and groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the EMU FS. The selected remedy for LF13 groundwater as outlined in the 1997 ROD includes the four major components listed below.

- Natural attenuation of contaminants of concern (COCs) in groundwater.
- Continued enforcement of existing LUCs.
- Restrictions on groundwater use.
- Groundwater monitoring.

4.2 REMEDY IMPLEMENTATION

In accordance with the 1997 ROD, DAFB enlisted the services of the USGS to develop a natural attenuation groundwater monitoring plan and to conduct regular groundwater sampling. The plan included similar monitoring at three other EMU sites: FT03 and WP14/LF15 (USGS, 1999b). Nine wells were initially selected to be monitored specifically at LF13. Four additional wells were installed near the Base boundary; these wells serve as point of compliance (POC) wells for LF13 (Attachment 1). One existing site well, D-4-I, was also a POC well, but was only sampled twice because it goes dry before producing a sufficient volume of water to be sampled. Monitoring and POC well IDs are listed in Table 2 with subsequent modifications to the program noted. Sample analyses include VOCs and geochemical indicators of natural attenuation. The EMU sites are sampled on an annual schedule.

Table 2 – Monitoring and POC Wells

Monitoring Wells	POC Wells
DM101D,S[(1)]	GS012D, S
DM110D,S[(2)]	GS014D
GS011D, S	GS060S
MW061S	D-4-I[(3)]
MW062S	
MW064S	

(1) DM101D&S were removed from the program based on recommendations in the September 2003 five-year review report.
(2) DM110D removed from program after September 2000.
(3) Well D-4-I removed from program after March 2000 because it goes dry.

At LF13, the primary mechanism of natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant tetrachloroethene (PCE), degrades to trichloroethene (TCE), then to cis-1,2-dichloroethene (cis-1,2,-DCE), then to vinyl chloride, and finally to ethene, a harmless gas. At this site, parent contaminants (PCE, TCE) are no longer present and only cis-1,2-DCE and vinyl chloride remain.

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including LF13. Some of the

primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) The soil cover at LF13 will be maintained. (4) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a small portion of off-Base property adjacent to the northeast Base boundary. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (5) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the contaminants found at LF13 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are not exceeded in the POC wells.

Table 3 – RAO Groundwater Concentrations

Parameter	RAO Concentration[a] (µg/L)
Benzene	5
Chlorobenzene	100
1,2-Dichloroethane (1,2-DCA)	5
1,1-Dichloroethene	7
cis-1,2-DCE	70
Ethylbenzene	700
PCE	5
Toluene	1,000
1,1,1-Trichloroethane	200
1,1,2-Trichloroethane	5
TCE	5
Vinyl chloride	2
Xylenes, total	10,000

[a]The groundwater RAOs are the MCLs
µg/L - micrograms per liter

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the West Management Unit. There are no buildings on top of LF13. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

The LF13 disposal area has been allowed to re-vegetate naturally over large portions of the site. Minimal maintenance is performed at the site. There are no permanent structures (e.g., an engineered cap), other than a locked gate across the access road, associated with the site that would require regular inspection or corrective action.

Groundwater monitoring of LF13 began in 1999 and is ongoing. The costs associated with this activity are summarized in Table 4. LUC inspections began in 2006 and occur annually.

Table 4 – Annual Monitoring Costs

Fiscal Year	Total Cost rounded to nearest $1,000
1998	$65,000
1999	$80,000
2000	$158,000
2001	$158,000
2002	$135,000
2003	$33,000
2004	$32,000
2005	$27,000
2006	$27,000
2007	$24,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the second five-year review for LF13. Since the last review, groundwater monitoring has been on-going with minor adjustments to the monitoring well network and shifting from a semi-annual to annual sampling schedule, based on recommendations in the September 2003 five-year review report (BWXT, 2003). Groundwater monitoring results are discussed in Section 6.0. LUCs were also implemented at LF13, including an annual Basewide-inspection of the LUCs, and this is discussed in Section 6.0 as well.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for the LF13 groundwater remedy would begin in 2007 and would be conducted by the USACE contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for LF13 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of LF13 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant LF13 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the long-term monitored natural attenuation remedy (ORNL, 2003-2004; 2005-2008). The monitoring reports reviewed for the EMU, which includes LF13, evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

Groundwater data at LF13 have been collected in multiple sampling rounds since 1986. The most recent data are from the periodic long-term monitoring program that began in 1999 and continues on an annual basis. Six wells are now regularly sampled at LF13 as well as four POC wells (Table 2). RAO/MCL exceedences are summarized in Table 5.

The small plume of fuel-related constituents appears to exist at DM110S and MW061S. It is unclear if this is a continuous plume or there are two small point sources. Benzene, the only fuel-related compound to be detected consistently above its RAO/MCL, was reported in both wells but not in any other downgradient site or POC well. There is no clear long-term increasing or decreasing trend in the benzene data in either site well. However, since fuel constituents are not found in other site wells, the plume is likely degrading before migrating. Chlorobenzene occasionally exceeds its MCL in these two wells (Table 5).

Chlorinated VOCs are limited to one well, DM110S, where 1,2-DCE and vinyl chloride exceed their RAOs/MCLs. Other than a few sporadic trace detections of 1,1-DCE, 1,2-DCA, and TCE in MW061S and DM110S, all of the VOCs of interest were below detection in all remaining wells during the 12 sampling events conducted since 1999. The distribution of solvents that originate in the vicinity of DM110S suggest a limited point source that quickly degrades before a wide-spread plume forms. The conditions observed by the USGS in their supporting natural attenuation study indicate

Table 5 - Groundwater Data[1]

Monitoring Well	Analyte[2]	RAO (µg/L)	Sampling Round, positive detections only, µg/L[3]						
			Jun-99	Mar-00	Sep-00	Mar-01	Oct-01	May-02	Dec-02
DM110S	Benzene	5	5	3.7	8.6	4.5	11	7.8	12
	Chlorobenzene	100	47	47	73	47	110	70	100
	cis-1,2-DCE	70	470	270	480	560	390	87	33
	Vinyl chloride	2	230	130	200	210	130	61	29
MW061S	Benzene	5	6.6	8.5	7.1	9.3	8.3	11	14
	Chlorobenzene	100	52	75	58	85	68	92	100

Monitoring Well	Analyte[2]	RAO (µg/L)	Sampling Round, positive detections only, µg/L[3]					
			Jun-03	May-04	Jun-05	Jun-06	Mar-07	Mar-08
DM110S	Benzene	5	6.3	6.8	5.9	6.7	ND	2.7
	Chlorobenzene	100	87	120	120	89	100	45
	cis-1,2-DCE	70	250	350	320	320	277	30
	Vinyl chloride	2	120	150	98	140	122	8.6
MW061S	Benzene	5	7.8	12	8.5	8.4	5	6.3
	Chlorobenzene	100	80	120	100	110	115	85
Site wells DM101D/S, DM110D, GS011D/S, MW062S, and MW064S had no RAO/MCL exceedences during any sampling event.								
POC wells (GS012D/S, GS014D, and GS060S) had no RAO/MCL exceedences during any sampling event.								

[1]The data summarized in this table are from the six long-term monitoring events conducted by the USGS from June 1999 to May 2002, and from the seven events conducted by URS Group Inc. from December 2002 to March 2008.

[2]Only analytes that had at least one RAO exceedence are listed.

[3]Shaded values exceed the RAO.

ND = not detected

that this is the case. The 2000 direct-push groundwater study confirmed a likely source area near well DM110S (USGS, 2001c). PCE and TCE were also found to be elevated (above RAOs/MCLs) at intermediate depths at one location next to the paved road north of the site about 800 ft from DM110S. However, the concentrations in intervening samples (between that location and DM110S) were not elevated. This may be evidence of a separate small source perhaps related to the nearby WP14/LF15 sites. The absence of VOCs above RAOs/MCLs in all of the POC wells indicates that natural attenuation processes are effective in reducing LF13 constituent concentrations.

6.4 SITE INSPECTION

A URS geologist visited the site on July 27, 2007. A photographic log documents the conditions at LF13 on that day (Attachment 4). The area is currently an open scrub- and weed-covered field with some small trees and partially exposed construction debris. Burrowing animals may be present in the area. No new uses of groundwater or the site were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for LF13 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that the chlorinated solvents and the small petroleum-related plume are currently at or near steady state. Evidence of this is seen in the trend charts for DM110S and MW061S (Attachment 5). Well DM110S had a significant decreasing trend from 1994 to 2000, and has been stable for the past 8 years. In well MW061S chlorobenzene appears to be on a slight upward trend although it is currently below its RAO/MCL. Overall, expansion of the contamination at levels above RAOs/MCLs has not occurred (Attachment 6). Site conditions and usage are unchanged since the implementation of the remedy. The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

The changes in ARARs (Attachment 3) are limited to those established for groundwater in DNREC's Delaware Risk-Based Corrective Action Program (DERBCAP) and remediation standards guidance. These standards are the same as or less stringent than MCLs.

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effects on risks, are qualitatively summarized in Table 6. As outlined in Table 6, most of the changes could increase the overall carcinogenic risks and non-carcinogenic hazard; one could decrease the risks. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 6 – Risk Assessment Review

Change	Effect
RBSCs decreased for aldrin and dieldrin.	These chemicals would be included in the RA, slightly increasing overall risks and hazards.
RBSC increased for chlorobenzene.	This chemical would be excluded from the RA, slightly decreasing the overall hazard.
Inhalation reference dose decreased for 1,2-DCA.	A slight increase in overall hazard.
Oral reference dose now available for 1,4-dichlorobenzene.	A slight increase in overall hazard.
Oral reference dose now available for benzene; slope factor increased.	A slight increase in overall risk and hazard.
Inhalation and oral reference doses now available for vinyl chloride; slope factors decreased.	A slight increase in overall hazard and decrease in overall risk.
Oral slope factor decreased for arsenic.	A slight decrease in overall risk.
Oral reference dose now available for iron.	A slight increase in overall hazard.
Oral reference dose decreased for manganese.	A slight increase in overall hazard.

RBSC - Risk-based screening criterion.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection,

implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

Most of the debris is covered with clean soil minimizing possible ecological pathways.

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

This review for LF13 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Landfilling activities have ceased at LF13, and clean soil is staged at the site occasionally. All information to date indicates that the chlorinated solvents (at levels above MCLs/RAOs) are confined to one site well and benzene (and occasionally chlorobenzene) to two site wells. Constituents appear to naturally attenuate within a short distance of these wells and have not migrated to the POC wells along the Base boundary.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for LF13 groundwater appears to be functioning as intended. Off-site migration of contaminants above action levels has not occurred. The on-site VOC concentrations are above RAOs/MCLs in only two site wells (DM110S and MW061S) located near the source areas. However, contaminant concentrations quickly decrease downgradient to below RAOs/MCLs indicating that natural attenuation processes are effectively reducing constituent concentrations. There are no clear long-term increasing or decreasing concentration trends observed in three years of site data suggesting that the small point sources may be at or near steady state, fluctuating primarily in response to seasonal precipitation. The site inspection revealed that LF13 is rarely visited and is naturally re-vegetated in many areas. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

The 2002 USGS EMU study determined that there were insufficient data to meaningfully model degradation rates (2002a). Therefore, a time frame to achieve RAOs has not been estimated. As seen in Table 5, since May 2004 vinyl chloride and cis-1,2-DCE have been in an overall downward trend, although still elevated above their MCLs, in well DM110S. The results from DM110S suggest that the source area contaminants are waning.

LUCs have been successfully implemented at the site.

8.0 ISSUES

No issues were discovered during the review that affects the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater sampling during the SIs and RI at LF13 demonstrated that site activities locally affected groundwater quality and that a potential exists for off-site migration. In response, natural attenuation monitoring of the sites was initiated. It is recommended that monitoring continue on an annual schedule until the RAO is achieved.

For future events, it is recommended that the monitoring well network be optimized. Specifically, sampling of wells MW064S, GS014D, GS012S, GS012D, and GS060S should be discontinued. These wells have never contained the contaminants of concern at levels above RAOs/MCLs, and they are located generally upgradient of the landfill. Based on eight years (12 rounds) of monitoring data, the two minor residual sources at LF13 are confined to small, localized area and do not appear to be migrating. Contaminants here are unlikely to ever affect the five wells listed above. Removal of these wells from the network will have no negative effect on the monitoring program at LF13.

A worse-case vapor intrusion evaluation was performed in 2007 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

The site as a whole will also continue to be addressed in the five-year review process due to the LUC remedy and the continuation of groundwater monitoring.

10.0 PROTECTIVENESS STATEMENT

The remedy at LF13 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for LF13 will be due in September 2013.

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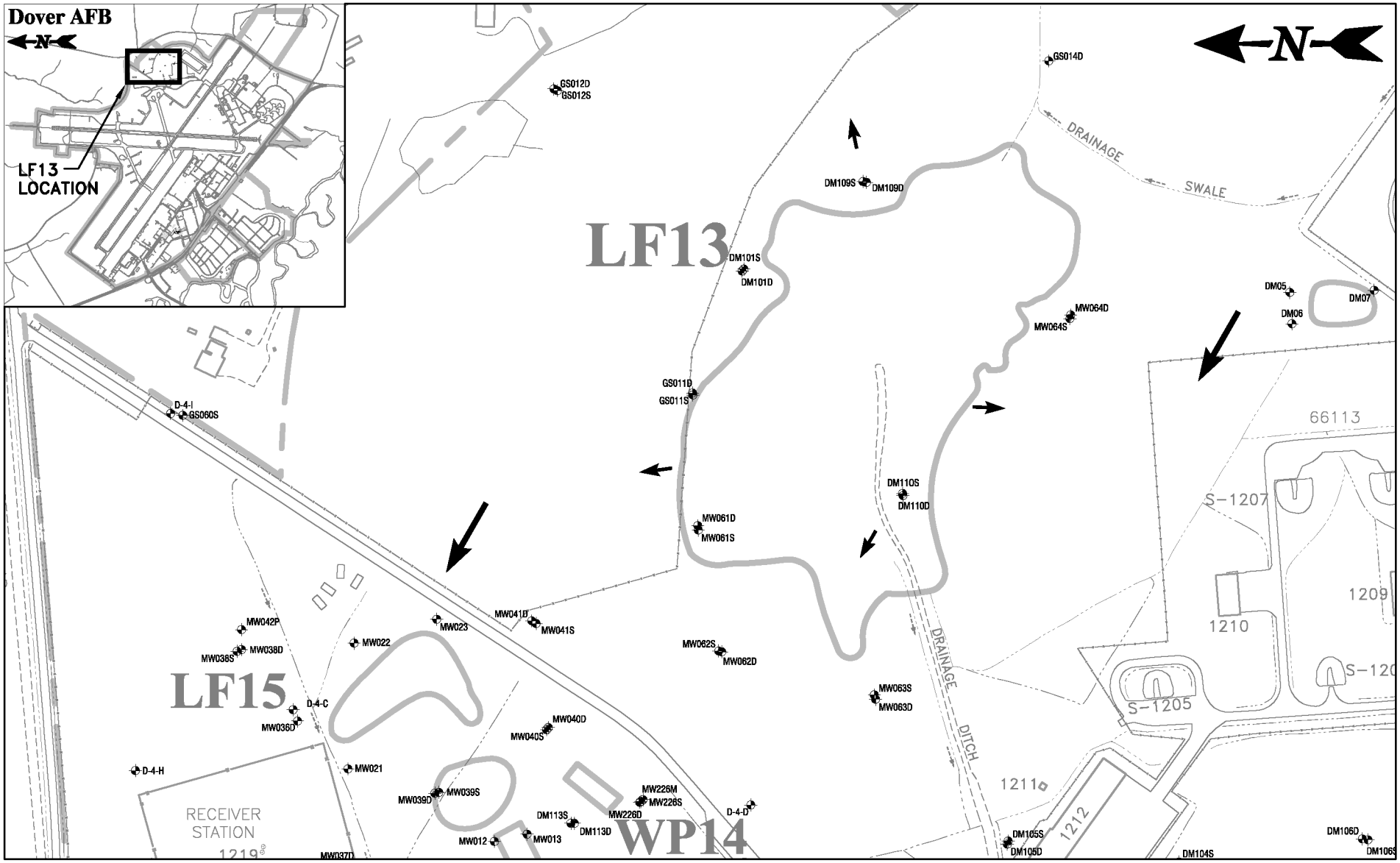

LEGEND:

- MW031S Monitoring Well
- Local Groundwater Flow Affected by Perched Water
- Dominant Groundwater Flow
- Base Boundary

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SCALE IN FEET

URS

ATTACHMENT 1
LF13 SITE MAP

Attachment 2 - Reviewed Documents

BWXT, 2003. Final Five-Year Reviews, Dover Air Force Base: LF18 Soil, FT03 Structures/Soil and Groundwater, WP14/LF15 Groundwater, LF13 Groundwater, submitted by URS Group, Inc., September 2003.

DAFB, 2006. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2006.

DAFB, 1997a. Record of Decision for Landfill 13 (LF13), Soil and Groundwater Within the East Management Unit at Dover Air Force Base, Delaware, submitted by HAZWRAP, August 1997.

DAFB, 1997b. Proposed Plan for Natural Attenuation of Groundwater for Landfill 13 (LF13), Dover Air Force Base, Delaware, submitted by HAZWRAP, June 1997.

ORNL, 2007. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2005-2008. East Management Unit Annual Monitoring Reports, Multiple Sampling Events (June 2005, June 2006, March 2007, March 2008), Dover Air Force Base, Delaware, submitted by URS Group, Inc.

ORNL, 2006. Interim Remedial Action Completion Report, Sites FT03, WP14, LF15, and LF13, East Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., August 2006.

ORNL, 2003-2004. East Management Unit Semi-Annual Monitoring Reports, Multiple Sampling Events (December 2002, June 2003, May 2004), Dover Air Force Base, Delaware, submitted by URS Group, Inc.

SAIC, 1989. Installation Restoration Program - Stage 2 Draft Final Report, Dover Air Force Base, Delaware.

SAIC, 1986. USAF Installation Restoration Program - Dover AFB, Delaware, Phase II - Stage 1 Confirmation/Quantification.

USACE, 2000. Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997a. Feasibility Study, East Management Unit, Dover Air Force Base, Delaware, submitted by Dames & Moore, October 1997.

USACE, 1997b. Basewide Remedial Investigation, North and East Management Units, Dover Air Force Base, Delaware, submitted by Dames & Moore, August 1997.

Attachment 2 – (cont'd)

USGS, 2002a. Assessment of Natural Attenuation of Ground-Water Contamination at Sites FT03, LF13, and WP14/LF15, Dover Air Force Base, Delaware, Water Resources Investigation Report 01-4150, Baltimore, Maryland 2002.

USGS, 2002b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, April-May 2002 Sampling Round, prepared by USGS Delaware Subdistrict Office, November 2002.

USGS, 2002c. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, October 2001 Sampling Round, prepared by USGS Delaware Subdistrict Office, April 2002.

USGS, 2001a. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, March 2001 Sampling Round, prepared by USGS Delaware Subdistrict Office, September 2001.

USGS, 2001b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, November-December 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, May 2001.

USGS, 2001c. Analytical Results from Ground-Water Sampling Using Direct-Push Technique at Sites FT03, LF13, and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, November-December 2000, submitted by USGS Delaware Subdistrict Office, May 2001.

USGS, 2001d. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, September 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, February 2001.

USGS, 2000a. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, January-March 2000 Sampling Round, prepared by USGS Delaware Subdistrict Office, July 2000.

USGS, 2000b. Analytical Results from Long-Term Ground-Water Monitoring at Sites FT03, LF13 and WP14/LF15, East Management Unit, Dover Air Force Base, Delaware, June 1999 Sampling Round, prepared by USGS Delaware Subdistrict Office, February 2000.

Attachment 2 – (cont'd)

USGS, 1999a. Hydrogeologic and Water-Quality Data for the East Management Unit of Dover Air Force Base, Kent County, Delaware, 1995-1996, Open-File Report 99-253.

USGS, 1999b. External Draft of the Long-Term Monitoring Plan for Source Areas FT03, WP14/LF15, and LF13, Dover Air Force Base, Delaware, submitted by USGS, May 1999.

USGS, 1998. Assessment of Natural Attenuation of Contamination from Three Source Areas in the East Management Unit, Dover Air Force Base, Kent County, Delaware, Water-Resources Investigations Report 98-4153.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario. However, since residential risks were not evaluated, the Air Force has decided to implement land use controls as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's DERBCAP established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For LF13 chlorinated solvents, the standards in this guidance are the same as the Federal MCLs.

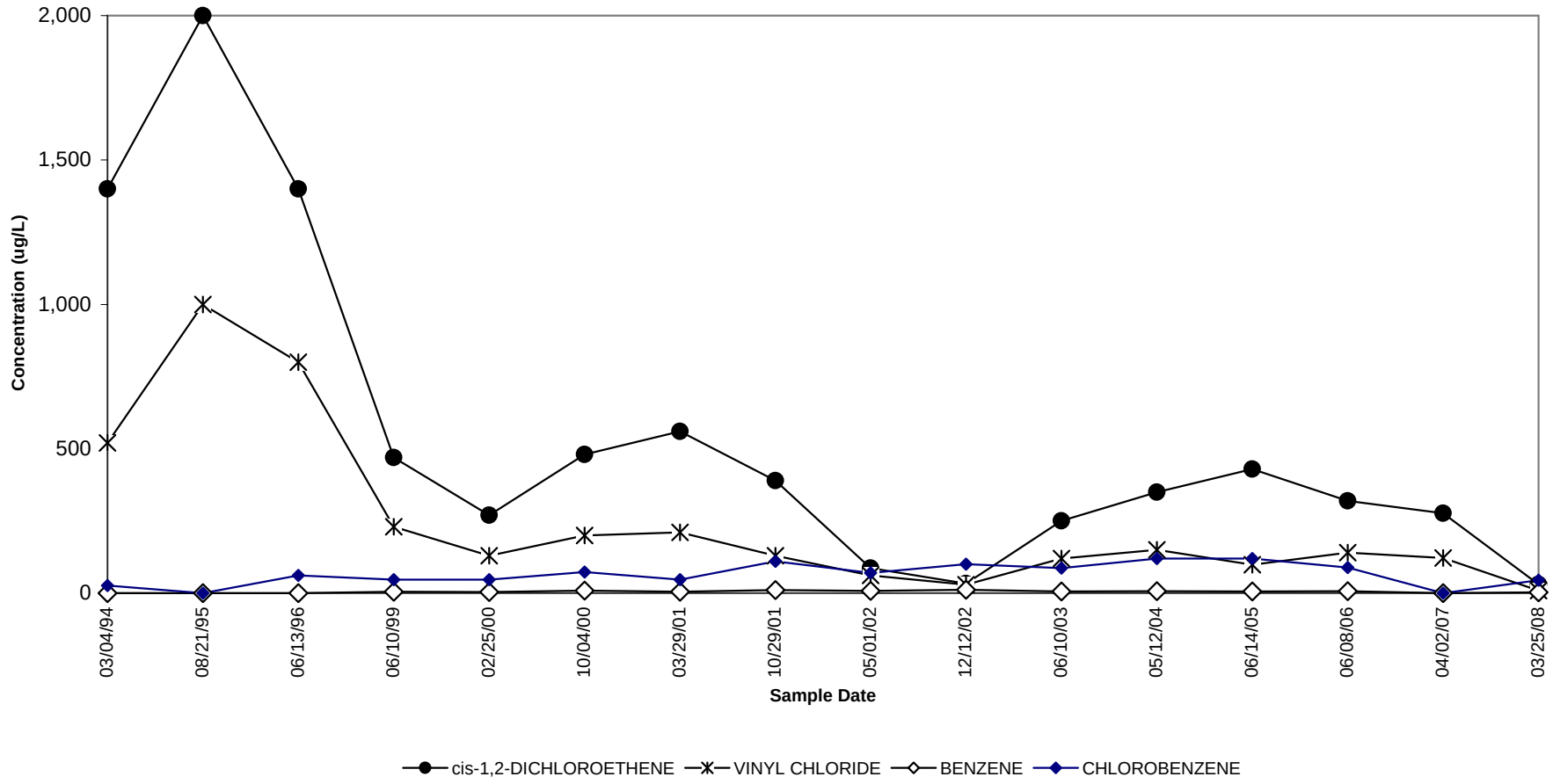
Surface Water and Sediment. Most of the debris is buried and the site appears to be naturally re-vegetating; thus, surface transport of any residual constituents has been mitigated. Sampling conducted for the Ecological Risk Assessment revealed no VOCs in the surface water or sediment collected from site drainages and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

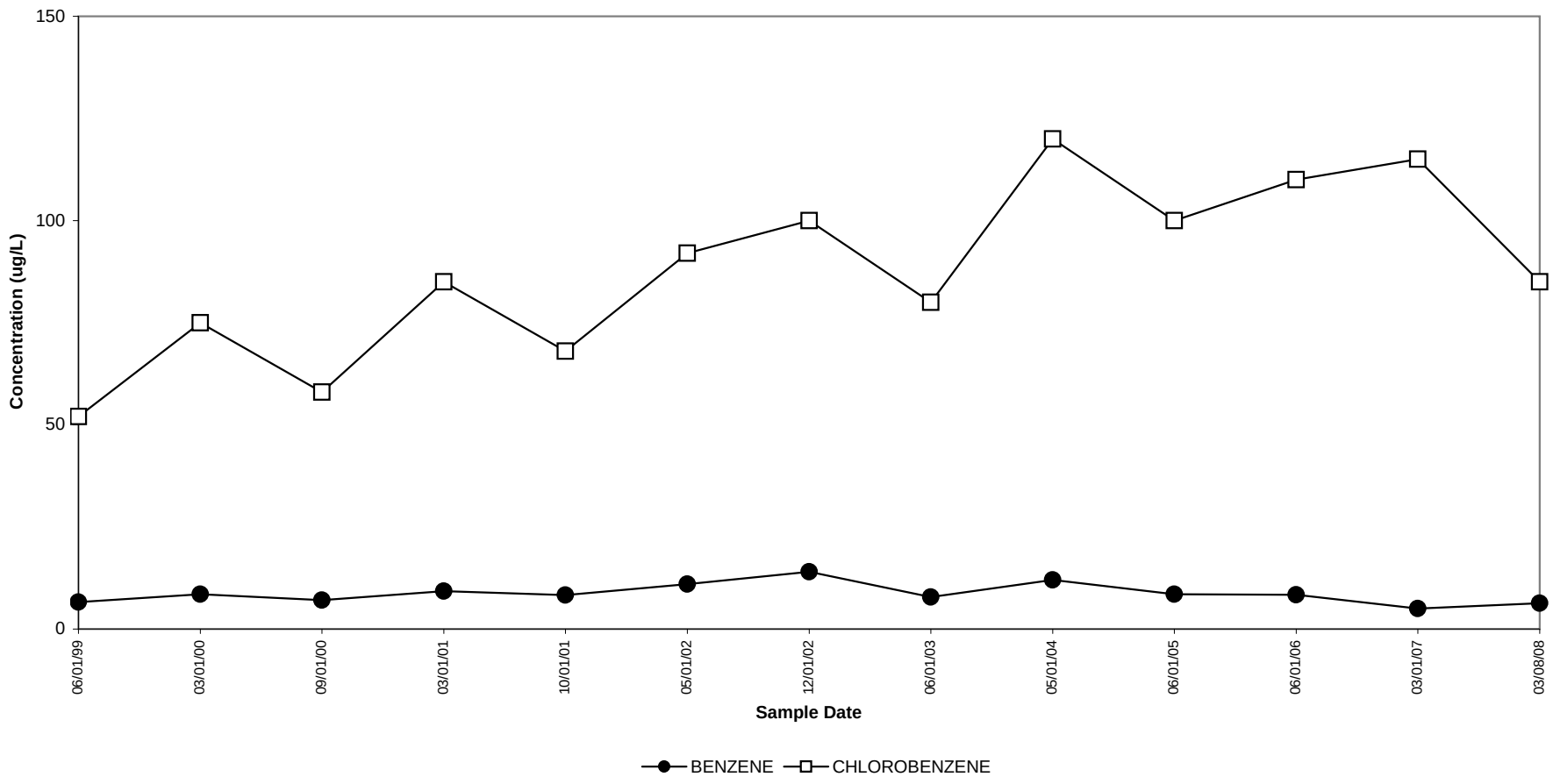
Attachment 4
Site Photographs

Current condition of LF13 on July 27, 2007. Top view looking north. Bottom view looking northeast.

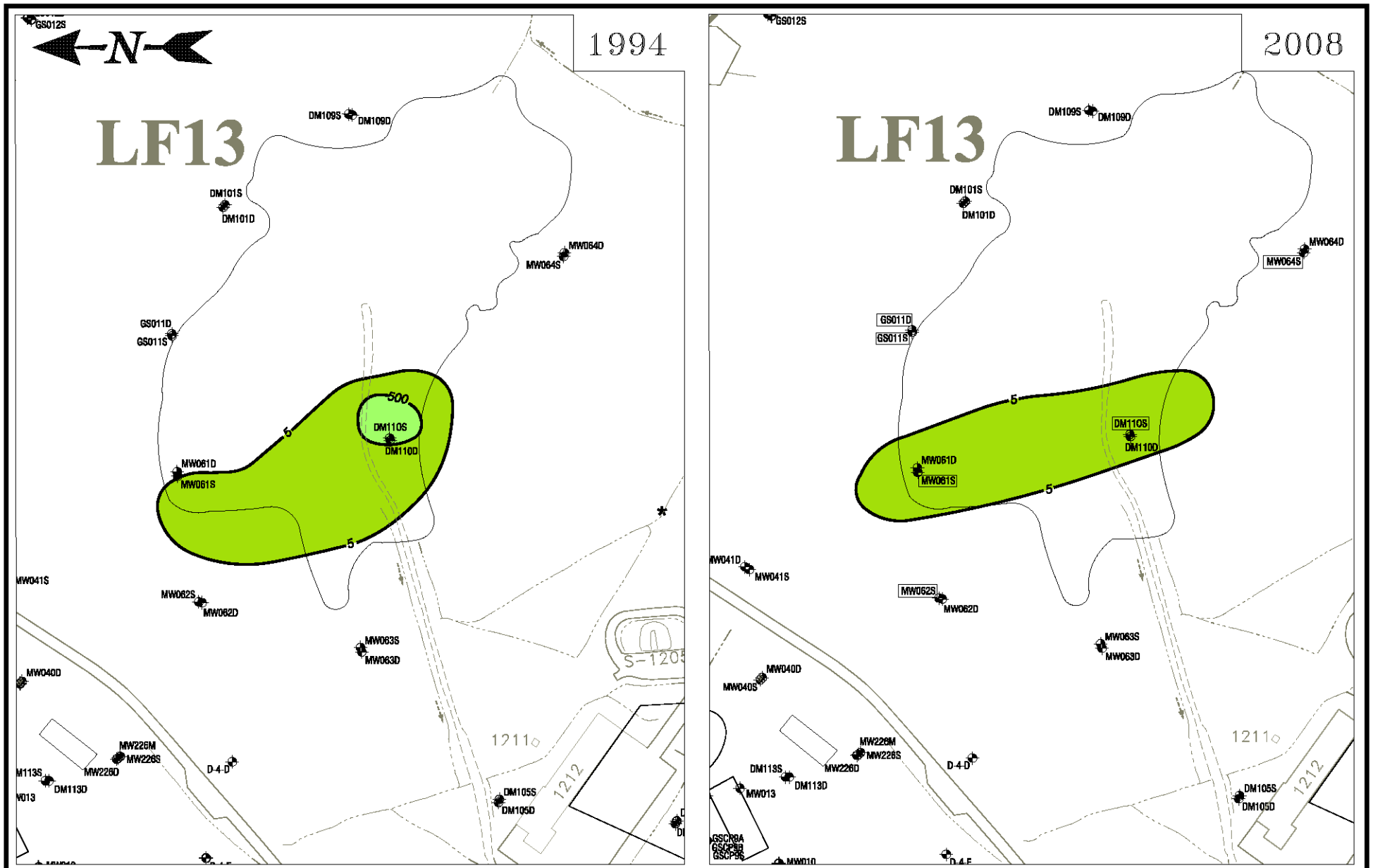
Attachment 5
DM110S
Trend Chart



Attachment 5 - (cont'd)
MW061S
Trend Chart



P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\Five Year Reviews 2008\H. Reports\Figures_Plume\ATTACHMENT 6 LF13.DWG, 9/10/2008 11:51:41 AM, Adobe PDF (temporary).pc3



ATTACHMENT 6
PLUME MAPS FOR LF13
1994 & 2008

URS

BASEWIDE FIVE-YEAR REVIEWS
DOVER AIR FORCE BASE, DELAWARE

VOLUME II - SOUTH MANAGEMENT UNIT

FIVE-YEAR REVIEWS FOR

- **SS07/Area 2**
- **LF17**
- **LF18/Area 9**
- **FT01**

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

and

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200 Orchard Ridge Drive, Suite 101
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Prepared for:

United States Department of the Air Force
Dover Air Force Base
436 CES/CEAO
600 Chevron Avenue
Dover AFB, Delaware 19902-5600

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Dover Air Force Base		
EPA ID *(from WasteLAN)*: DE8570024010		
Region: 3	**State:** DE	**City/County:** Dover/Kent County
SITE STATUS		
NPL status: _X_ Final __ Deleted __ Other (specify)		
Remediation status (choose all that apply): __ Under Construction _X_ Operating (SS07/Area 2, LF17, and LF18/Area 9) _X_ Complete (FT01)		
Multiple OUs?* __ YES _X_NO	**Construction completion date:** 09 / 30 / 2006	
Has site been put into reuse? __ YES _X_ NO		
REVIEW STATUS		
Lead agency: __ EPA __ State __ Tribe _X_ Other Federal Agency - U.S. Air Force		
Author name: URS Group, Inc. (under Oak Ridge National Laboratory contract) for USAF		
Author title:	**Author affiliation:**	
Review period:** October 2003 to September 2008		
Date(s) of site inspection: October 21, 2002 and November 14, 2007		
Type of review: X_ Post-SARA __ Pre-SARA __ NPL-Removal only __ Non-NPL Remedial Action Site __ NPL State/Tribe-lead __ Regional Discretion		
Review number: ___ 1 (first) _X_ 2 (second) ____ 3 (third) __ Other (specify) _____		
Triggering action: __ Actual RA Onsite Construction at OU #____ __ Actual RA Start at OU#____ __ Construction Completion X_ Previous Five-Year Review Report __ Other (specify)		
Triggering action date *(from WasteLAN)*: 30 Sep 2003		
Due date *(five years after triggering action date)*: 30 Sep 2008		

* ["OU" refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

Five-Year Review Summary Form, cont'd.

Issues:

Final remedies for SS07/Area 2, LF17, LF18/Area 9, and FT01 were selected in the 2005 South Management Unit (SMU) Record of Decision (ROD). Remedial action objectives (RAOs) were established for soil and groundwater at each site. For groundwater, the RAOs are the federal drinking water maximum contaminant levels (MCLs) for the contaminants of concern (COCs) specific to each site. Land use controls (LUCs) are also a component of the remedy for groundwater and for soil at all four sites except at FT01 where no further action was required for soil. No issues were noted during the Five-Year Review of the SMU sites.

Recommendations and Follow-up Actions:

SS07/Area 2: It is recommended that regular groundwater monitoring continue at this site to confirm that plume contaminants naturally attenuate and that they do not migrate off-Base at levels that could be harmful. Optimization of the monitoring network by discontinuing the sampling of wells DM409S and DM451D is recommended. Should well DM451M continue to show COCs to be below the RAOs/MCLs, this well should also be removed from the sampling program. It is also recommended that LUCs continue to be enforced and monitored.

LF17: It is recommended that regular groundwater monitoring continue at this site to confirm that plume contaminants naturally attenuate and that they do not migrate off-Base at levels that could be harmful. Optimization of the monitoring network by discontinuing the sampling of well MW083D is recommended. It is also recommended that LUCs continue to be enforced and monitored.

LF18/Area 9: It is recommended that regular groundwater monitoring continue at this site to confirm that plume contaminants naturally attenuate and that they do not migrate off-Base at levels that could be harmful. Optimization of the monitoring network by discontinuing the sampling of six wells (MW028D, MW029S, MW031S, MW032S, MW035S, and DM419S) is recommended. It is also recommended that LUCs continue to be enforced and monitored.

FT01: In accordance with the ROD, no further action was required for soil. Review of groundwater analytical data indicates that the RAOs for groundwater have been achieved at this site. Groundwater monitoring has confirmed that no RAO (MCL) has been exceeded during four successive semi-annual sampling events. It is recommended that monitoring be discontinued and that the site be closed.

Protectiveness Statement:

The remedy at FT01 has been successful in achieving the RAOs which are protective of human health and the environment. The remedies at SS07/Area 2, LF17, and LF18/Area 9 are protective of human health and the environment. In the interim until RAOs are met at these three sites, exposure pathways that could result in unacceptable risks are being controlled.

Other Comments:

None.

Steven B. Harrison

STEVEN B. HARRISON, Colonel, USAF
Commander, 436th Airlift Wing

FIVE-YEAR REVIEW FOR SS07/AREA 2
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

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Dover Air Force Base
436 CES/CEAO
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Dover AFB, Delaware 19902-5600

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LIST OF ACRONYMS AND ABBREVIATIONS

AAB	Accelerated anaerobic bioremediation
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
1,2-DCA	1,2-Dichloroethane
DNREC	Department of Natural Resources and Environmental Control
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
PCE	Tetrachloroethene
RA	Risk assessment
RAO	Remedial action objective
RAWP	Remedial Action Work Plan
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
SMU	South Management Unit
TCE	Trichloroethene
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound

EXECUTIVE SUMMARY

The remedy for SS07/Area 2, a former industrial site and current hazardous waste storage area at Dover Air Force Base (DAFB), Delaware, is accelerated anaerobic bioremediation (AAB), natural attenuation with monitoring, and land use controls (LUCs) for groundwater as well as soil. AAB was conducted to treat the source area at SS07 that is near Building 1306. Natural attenuation is being monitored to address the remainder of the Area 2 plume. Groundwater remediation began with installation of additional monitoring wells in accordance with a 2005 Record of Decision (ROD) for the South Management Unit (SMU).

The initial trigger date for five-year reviews in the SMU was the start date of construction for the first remedy implemented in the SMU; a soil remediation that started on December 12, 1997 at site LF18. This is the first five-year review for SS07/Area 2. Since achieving the construction complete milestone for all sites, DAFB has merged reviews for all sites into a comprehensive set of Base-wide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the groundwater remedy—AAB, natural attenuation with monitoring, and LUCs—is operating as intended. The primary contaminants of concern (COCs) are tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2, DCE), and vinyl chloride. LUCs remain in effect and no new uses of groundwater or soil at the site were observed. As documented in the latest semi-annual monitoring report, parent COCs have been reduced to levels below the remedial action objectives (RAOs) in the AAB treatment area. RAOs are still exceeded in two wells near the Base boundary. It is recommended that monitoring continue to confirm that COCs naturally attenuate to levels that meet the RAOs specified for SS07/Area 2 in the SMU ROD.

The draft-final five-year review for SS07/Area 2 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

SS07 is an Environmental Restoration Program (ERP) site used for industrial purposes since the 1940s at Dover Air Force Base (DAFB), Delaware, in the South Management Unit (SMU) (Attachment 1). SS07 is an area encompassing Building 1306 that has been used since 1981 as an intermediate hazardous waste storage area. Wastes derived from various industrial shop activities are stored at Building 1306 prior to off-Base disposal. Although there are no documented releases of contaminants at SS07, signs of surface spills were evident outside the facility in the past. Environmental investigations were subsequently conducted that revealed groundwater contamination as a particular concern. Chlorinated solvents in groundwater formed a long, narrow plume that is referred to as Area 2. Under a 2005 Record of Decision (ROD) accelerated anaerobic bioremediation (AAB) was conducted in the vicinity of Building 1306 and natural attenuation with monitoring implemented for the remainder of the Area 2 plume. Land use controls (LUCs) for soil and groundwater are also a component of the remedy.

The remedial action at SS07/Area 2 is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the first five-year review for the SS07/Area 2 remedy. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

The AAB remedy at SS07, and natural attenuation with monitoring at the remainder of the Area 2 plume, is one of several implemented remedies at SMU ERP sites. SS07 is the only SMU ERP site at which AAB was part of the groundwater remedy. Similar groundwater monitoring for natural attenuation occurs concurrently at three other SMU sites: LF17, LF18/Area 9, and FT01. LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the SS07/Area 2 remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
1940s-1981	Industrial activities are conducted at SS07.
1981-present time	SS07 is used as a temporary hazardous waste storage area, prior to off-Base disposal.
1986	Phase II-Stage I Site Investigation (SI) conducted at SS07, soil and groundwater sampled (SAIC, 1986).
March 13, 1989	DAFB listed on National Priority List (NPL).
1989	Stage II SI conducted at SS07 (SAIC, 1989).
August 1997	Basewide Remedial Investigation (RI) finalized; included assessment of SS07 (USACE, 1997).
2000	Basewide Ecological Risk Assessment (USACE, 2000).
April 11, 2003	DNREC established a groundwater management zone (GMZ).
January 2005	Feasibility Study (FS) and Addendum for SMU finalized. Included assessment of AAB and natural attenuation in groundwater at SS07 (USACE, 2005a).
January 2005	Proposed Plan prepared, included SS07 (USACE, 2005b).
December 2005	Final SMU ROD prepared, included SS07 (USACE, 2005c).
January 6, 2006	Remedial Action Work Plan (RAWP) finalized, included SS07 (ORNL, 2006b)
March 2006	AAB direct injections conducted at SS07 source area and AAB monitoring begins.
March 2006	Installation of monitoring wells at SS07.
April 2006-ongoing	Semi-annual natural attenuation groundwater monitoring (ORNL, 2007 - 2008).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report prepared, included SS07 (ORNL, 2006a).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007a).

DNREC – Department of Natural Resources and Environmental Control.
SAIC – Science Applications International Corporation
USACE – U.S. Army Corps of Engineers (Omaha District)

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

SS07 is located in the middle of the SMU (Attachment 1). It encompasses the area around Building 1306. There are no other buildings adjacent to the site, which is surrounded by runways and taxiways, a paint ball field, and a boat/trailer long-term parking area. SS07 is the primary source of contaminants that form the Area 2 plume which is long, relatively narrow and flows southwest to the Base boundary at U.S. Route 113. A privately owned sand and gravel quarry is located directly across U.S. Route 113 downgradient of the Area 2 plume. There is a drainage ditch, which is part of the Base's storm water drainage system, to the east of the building. Around Building 1306 are areas of paved lots as well as maintained grass. Groundwater at the site is typically encountered at depths between 10 and 15 feet (ft) below ground surface.

3.2 LAND AND RESOURCE USE

Since 1981, DAFB has used Building 1306 for temporary hazardous waste storage until wastes are picked up for off-Base disposal. SS07 is located in the southern industrial area of the Base and is not easily accessible to Base visitors.

The shallow groundwater (Columbia Aquifer) of the Area 2 plume flows approximately 2,800 ft southwest to the Base boundary at U.S. Route 113. This aquifer is not currently used as a drinking water source. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. There is a privately owned sand and gravel quarry that is located downgradient of the Area 2 plume that uses large dredge ponds dug into the upper portion of the Columbia Aquifer. The quarry uses this water in its processing operations; however the quarry does not use the aquifer as a potable water source. Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and the portion of off-Base property between DAFB and the St. Jones River. The GMZ includes the quarry. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

SS07 has been used since the 1940s for industrial activities. Since 1981, hazardous waste has been stored at the site pending off-Base disposal. Drums of waste oil, hydraulic fluids and other wastes are stored inside the facility on a bermed concrete floor. There is no record of waste releases; however there were signs of surface spills outside the facility in the past. Solvents that were historically used in aircraft maintenance activities are the primary contaminants of concern (COCs) within the Area 2 plume. Although evidence of natural biodegradation of the chlorinated solvents has been observed within this plume, natural biodegradation has been insufficient to keep the plume from reaching the Base boundary at levels exceeding maximum contaminant levels (MCLs). Delineation sampling conducted in 2006 revealed a source area (i.e., elevated COC concentrations in shallow groundwater) off the east corner of Building 1306.

The Base-wide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

Treatment alternatives for SS07/Area 2 groundwater were evaluated in the SMU FS (USACE, 2005a). Supplemental characterization specific to natural attenuation at SS07/Area 2 was conducted in 2005 to support FS conclusions. This study determined that natural attenuation alone appeared to be occurring but at a rate inadequate for controlling the migration of constituents off-Base at levels above MCLs. The selected remedy for SS07/Area 2 is treatment using AAB at the source area, natural attenuation with monitoring of the entire plume, and LUCs for both soil and groundwater, which was documented in a proposed plan and submitted for public review on February 15, 2005.

In 2006, a ROD was signed for the soil and groundwater at SS07/Area 2. The selected remedy included AAB to treat the source of groundwater contamination at SS07, natural attenuation with monitoring to address the remainder of the Area 2 plume, and LUCs for both soil and groundwater.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater at SS07 since it is located in an industrial portion of the Base (USACE, 1997). Based on this commercial/industrial use scenario evaluation, groundwater contamination did not result in risk exceeding established federal criteria. However, Federal Safe Drinking Water Act MCLs were exceeded at the site. Although groundwater from the Columbia Aquifer at site SS07 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences as well as the potential for contaminant migration to areas not under DAFB control trigger the need for remedial action at SS07. Based on the RA for soil, a cleanup action is not warranted. However, this conclusion is based on the assumption that the future on-Base land use at the site will remain industrial. Thus, the response action for soil is to ensure the permanence and reliability of the land use assumptions, and thereby protect the public health from hazardous substances at the site. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for SS07 was signed by USEPA in January 2006 (USACE, 2005c). The remedial action objectives (RAOs) were developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, one of the RAOs for groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. By restricting access, potential exposures to soil and groundwater are mitigated. LUCs for soil and groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the SMU FS. The selected remedy for SS07/Area 2 groundwater as outlined in the 2005 ROD includes the six major components listed below.

- Source delineation sampling.
- AAB to treat groundwater contaminants in the source area.
- Natural attenuation of COCs for remainder of Area 2 plume.
- LUCs for soil and groundwater.
- Groundwater monitoring.
- Evaluation of vapor intrusion during groundwater remedial action phase (accomplished in 2007) (ORNL, 2007a).

4.2 REMEDY IMPLEMENTATION

In accordance with the 2005 ROD, a RAWP was prepared documenting injection, monitoring, and sampling procedures for SS07. The RAWP included similar monitoring programs at three other SMU sites: LF17, FT01, and LF18/Area 9. SS07 was the only site in the SMU at which AAB was used to treat a contaminant source area.

Prior to starting AAB, shallow groundwater samples were collected upgradient of SS07 to determine if other source areas existed. No defined source area was found. Additional study of the SS07 source area was also conducted to optimize AAB treatment. In March 2006, AAB substrate was injected using a direct-push rig at 49 locations and at multiple depths ranging between 5 and 30 ft below ground surface. Nearly 103,000 gallons of water amended with sodium lactate and emulsified vegetable oil were injected at SS07. Monitoring programs for both AAB and natural attenuation were implemented at SS07/Area 2 in accordance with the RAWP. Wells used to monitor progress of AAB are listed in Table 2 and shown on Attachment 1. Sampling was conducted with all samples being analyzed for biodegradation indicators and quarterly samples analyzed for volatile organic compounds (VOCs) during the first year after injections. Monitoring for natural attenuation includes VOCs and indicators on a semi-annual schedule. Wells in this program are also listed in Table 2.

Table 2 - SS07/Area 2 Wells

WELL ID	WELL PURPOSE	
	AAB	NA
GP4302	X	
GP4303	X	
GP4305	X	
GP4306	X	X
GP4343	X	
GP4344	X	
GP4345	X	
GP4346	X	
GP4347	X	
DM409D		X
DM409S		X
DM413D		X
DM451S		X
DM451M		X
DM451D		X
DM452M		X
DM452D		X
DM463	X	
DM464	X	
DM465	X	
DM466	X	
MW051D		X

NA - natural attenuation

At SS07, the primary mechanism of both AAB and natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant, tetrachloroethene (PCE), degrades to trichloroethene (TCE), then to cis-1,2-dichloroethene (cis-1,2-DCE), then to vinyl chloride, and finally to ethene, a harmless gas.

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including SS07. Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a portion of off-Base property between DAFB and the St. Jones River. This area includes the sand and gravel quarry. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (4) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the contaminants found at SS07 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 3 – RAO Groundwater Concentrations

Parameter	**RAO Concentration[a] (µg/L)**
cis-1,2-DCE	70
PCE	5
TCE	5
Vinyl chloride	2

[a]The groundwater RAOs are the MCLs
µg/L - micrograms per liter

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the SMU ROD, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the West Management Unit. The only building at SS07 – Building 1306 – is not occupied. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

In accordance with the ROD and RAWP for the SMU, groundwater monitoring of SS07/Area 2 began in 2006 and is ongoing. To date, it has not been necessary to conduct follow-on rounds of AAB injections at this site. Monitoring results continue to be evaluated to determine when or if additional injections will be needed. The costs associated with the AAB remedy and natural attenuation monitoring are summarized in Table 4. LUCs inspections began in 2006 and occur annually.

Table 4 – Annual Remedy Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$337,000 (includes initial capital costs)
2007	$132,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for SS07/Area 2.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for SS07/Area 2 would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for SS07 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of SS07/Area 2 had been performed and was available for review. The public comment period was in effect for 30 days (May 21- June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant SS07/Area 2 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the AAB monitoring as well as the long-term natural attenuation portion of remedy (ORNL, 2006a and 2007b). Data were collected more frequently immediately after AAB injections at the SS07 source area. At this time, the entire plume, including the source area, is monitored on a semi-annual schedule, in accordance with the RAWP. Groundwater sampling and analysis is the primary means of determining the remedy's continued effectiveness at SS07. The monitoring reports reviewed for the SMU, which includes SS07/Area 2, evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

COC concentration trends in the source area are illustrated for six monitoring wells in Attachment 5. Rapid degradation of PCE and TCE are observed in response to treatment. These two COCs are now below their RAOs/MCLs in the source area.

Breakdown products increased as anticipated and they too are now declining although still above RAOs/MCLs in some wells.

The Area 2 plume as a whole is assessed using 10 monitoring wells (Table 2). COC detections and RAO/MCL exceedences during the semi-annual monitoring events since April 2006 are summarized in Attachment 6. The data for well GP4306 reflects source area treatment. The other wells are farther downgradient and show relatively stable to gently declining COC concentrations. In these wells, RAO/MCL exceedences are limited to DM451S (PCE), DM452D (TCE), and DM452M (TCE).

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at SS07 on that day (Attachment 4). The area currently consists of building 1306 surrounded by pavement and grassy areas. Other than lawn care, there is minimal maintenance at the site. No new uses of groundwater or soil at the site were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for SS07 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Excellent progress has been made towards achieving the RAOs in the source area where AAB was applied (Attachments 5 and 7). Attachment 7 also shows the entire extent of the Area 2 plume both before the remedy was implemented and during the latest sampling event. By late 2007/early 2008, the main plume appears to be somewhat narrower and is detaching from the source area.

The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the SMU ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effects on risks, are qualitatively summarized in Table 5 (USEPA, 2007). The various changes could increase and decrease the overall carcinogenic risks and non-carcinogenic hazards. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 5 – Risk Assessment Review

Change	Effect
RBSC values increased for 1,2-DCE, manganese, and beryllium.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
RBSC values decreased for alpha-BHC and dieldrin.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
Inhalation reference dose increased for 1,2-DCA	A slight decrease in overall hazard.
Inhalation reference dose is now available for PCE and TCE*.	A slight increase in overall hazard.
Oral reference dose decreased for TCE*.	A slight increase in overall hazard.
Oral and inhalation slope factors increased for PCE and TCE*.	A slight increase in overall risk.

RBSC - Risk-based screening criterion.
*Assessment of TCE based on 2001 provisional toxicity values.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). In addition, groundwater monitoring has shown that the contaminant plume in this area has remained relatively stable. In fact, source area remediation is successfully reducing contaminant mass within the plume. Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological risk assessment. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

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

This review for SS07 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Use of the site is unchanged and there have been no reports of new contaminant releases. All information collected to date indicates that the remedy is operating as intended and that progress has been made towards achieving the RAOs.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for SS07 groundwater is functioning as intended. PCE and TCE are below the RAOs/MCLs in the source area. Cis-1,2-DCE and vinyl chloride at the source area are above RAOs but they are on a declining trend. Elevated ethene concentrations are also found in the source area indicating that treatment is achieving complete degradation. Natural attenuation monitoring data indicates that wells DM452M,D (near U.S. Route 113) are the only wells outside the source area with a COC (TCE) above an RAO. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

Although degradation rates were not provided in the SS07/Area 2 monitoring reports, inspection of the contaminant trend charts (Attachment 6) indicates that degradation of chlorinated solvents significantly increased in response to AAB treatment. Should the trends established during the first two years continue, the remedy appears to be capable of achieving RAOs in the 7-year time frame stated in the SMU ROD for the plume core and in 42 years for the distal plume.

LUCs have been successfully implemented at the site.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater sampling during the SIs and RI at SS07 demonstrated that site activities locally affected groundwater quality and that a potential exists for off-site migration. In response, AAB, natural attenuation with monitoring, and LUCs for soil and groundwater were initiated at SS07/Area 2.

It is recommended that monitoring continue on a regular schedule until the RAOs are achieved. For future sampling events, it is recommended that the monitoring well network be optimized. Specifically, sampling of well DM409S should be discontinued.

It has not had an MCL exceedence since it was installed in 1994. For the well triplet DM451, the mid-level and deep-screened wells have not had a COC exceed an RAO/ MCL during any sampling event. It is recommended that the deep well (DM451D) be removed from the sampling network. Should the intermediate well (DM451M) continue to have no MCL exceedences, it too should be removed from the network.

A worst case vapor intrusion evaluation was performed in 2008 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

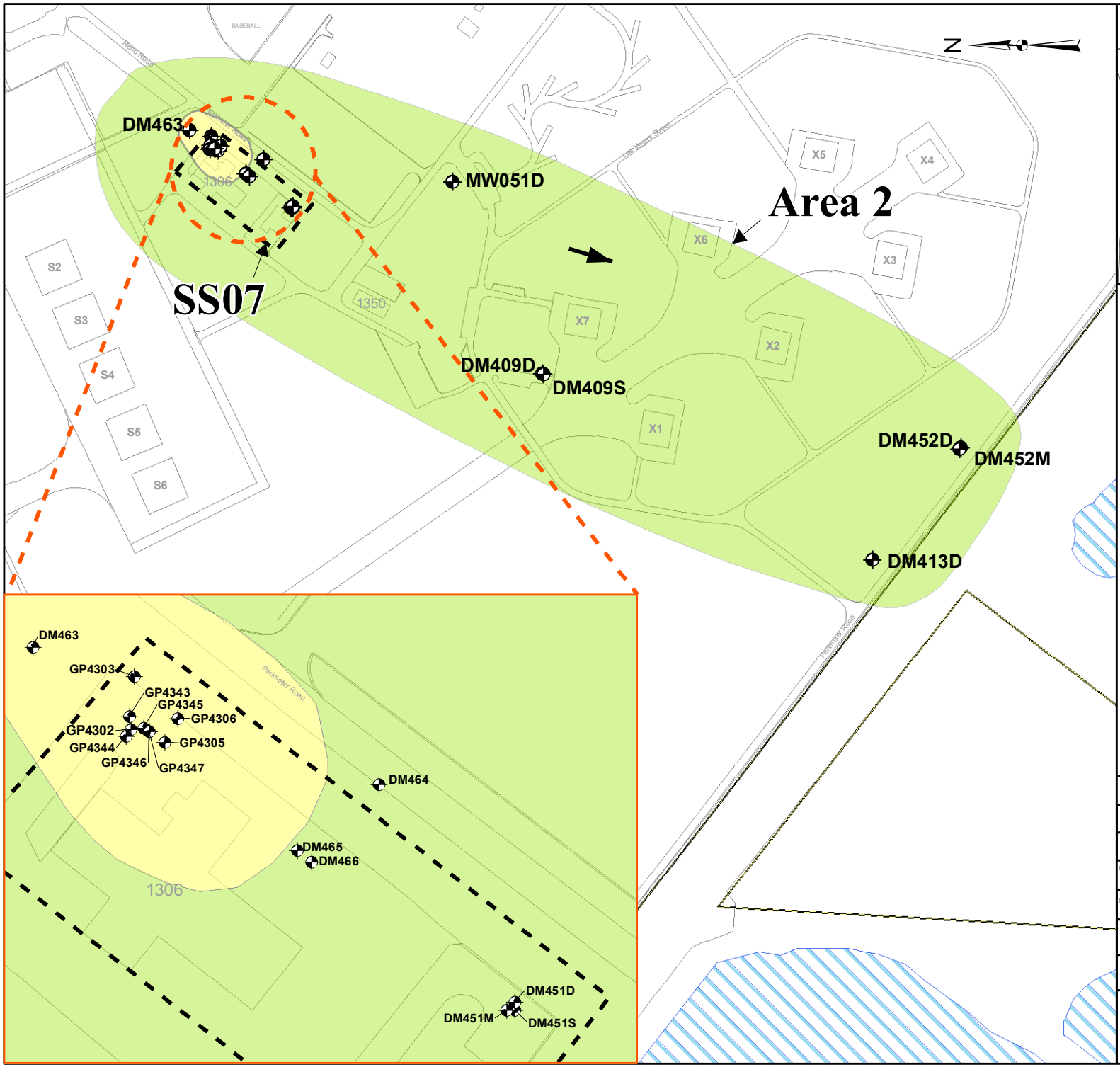
The site as a whole will also continue to be addressed in the five-year review process due to the LUCs and the continuation of groundwater monitoring.

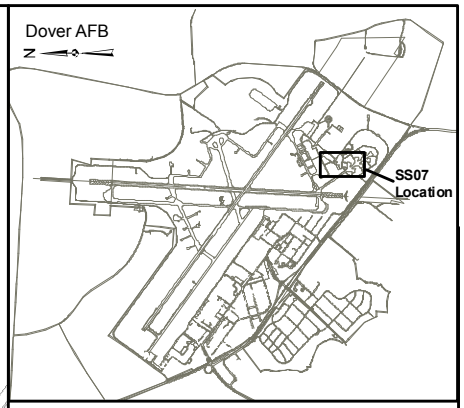
10.0 PROTECTIVENESS STATEMENT

The remedy at SS07/Area 2 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for SS07/Area 2 will be due in September 2013.





Legend

- SS07 Boundary
- Plume
- Source Treatment
- Monitoring Wells
- Groundwater Flow

0 150 300 600 Feet

TITLE	SS07 / Area 2 Site Map
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DES BY	DJM 07/14/2008
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878

Attachment 2 - Reviewed Documents

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

ORNL, 2007 - 2008. Monitoring Reports, Sites LF17, SS07, FT01, and LF18, South Management Unit (multiple events), Dover Air Force Base, DE, submitted by URS Group, Inc., March 2007, September 2007, and May 2008.

ORNL, 2007a. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. Interim Remedial Action Completion Report, Sites LF17, SS07, FT01, and LF18, South Management Unit (SMU), Dover Air Force Base, DE, submitted by URS Group, Inc., August 2006.

ORNL, 2006b. South Management Unit Remedial Action Work Plan [and Addendum] Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2006.

SAIC, 1989. Installation Restoration Program - Dover AFB, Delaware, Stage 2 Report, Dover Air Force Base, Delaware.

SAIC, 1986. USAF Installation Restoration Program – Dover AFB, Delaware, Phase II – Stage I Confirmation/Quantification.

USACE, 2005a. Final Feasibility Study [and Addendum: Plume Delineation and Assessment of Natural Attenuation], South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2005.

USACE, 2005b. Proposed Plan South Management Unit, Dover AFB, Delaware, January 2005.

USACE, 2005c. Record of Decision for LF17, SS07/Area 2, FT01, and LF18/Area 9 South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., December 2005.

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [South Management Unit, Volumes I - IV].

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for site SS07 are listed in the SMU ROD and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the ROD. ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario. However, since residential risks were not evaluated, the Air Force has decided to implement LUCs as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's *Delaware Risk-Based Corrective Action Plan* (DERBCAP) established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For SS07 chlorinated solvents, the standards in this guidance are the same as the Federal MCLs.

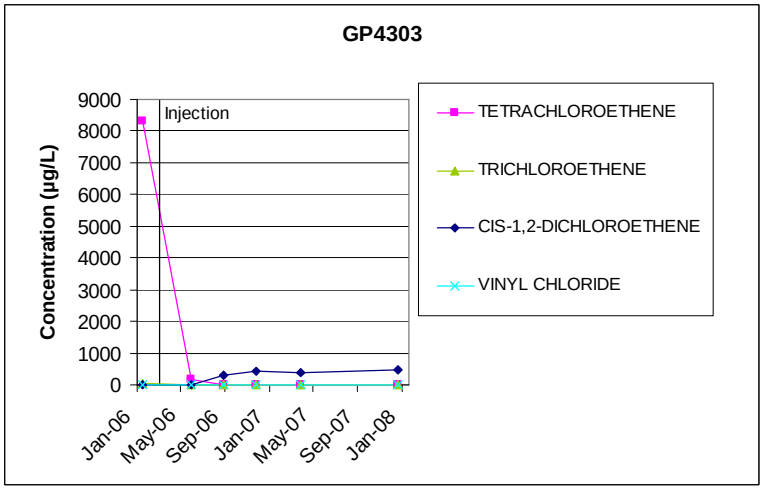
Surface Water and Sediment. Surface water and sediment are not present at SS07. Sampling conducted for the Basewide Ecological Risk Assessment revealed no VOCs in the surface water or sediment collected from downstream drainages that could be affected by SS07 and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

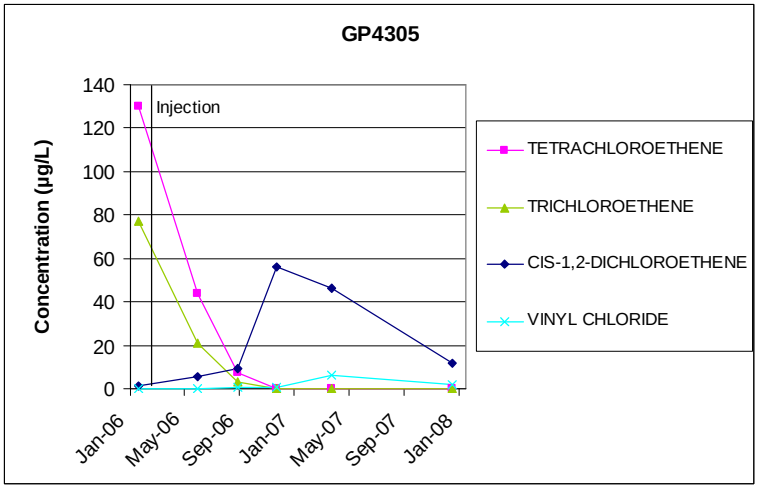
Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

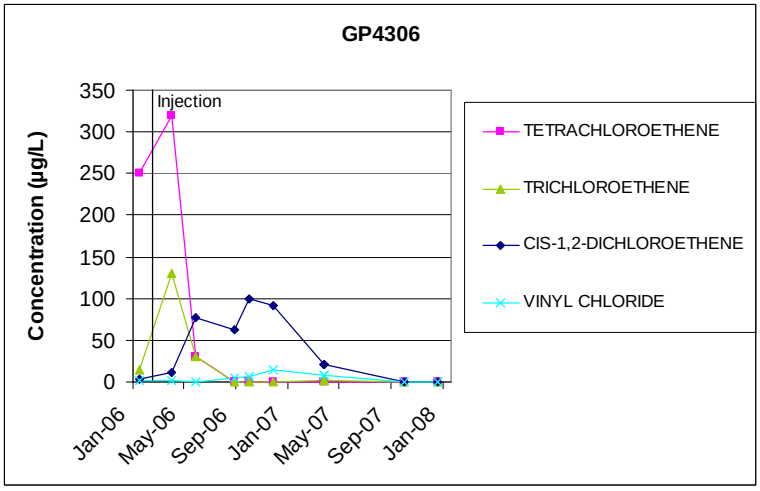
Attachment 4 – Site Photographs for SS07

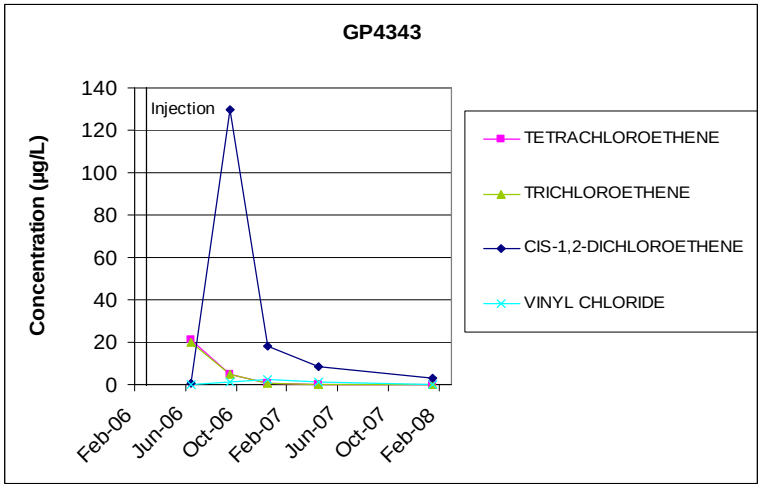
Top: Source area at SS07 (foreground) looking east on November 14, 2007.
Bottom: SS07/Area 2, looking southwest and in downgradient direction on November 14, 2007.

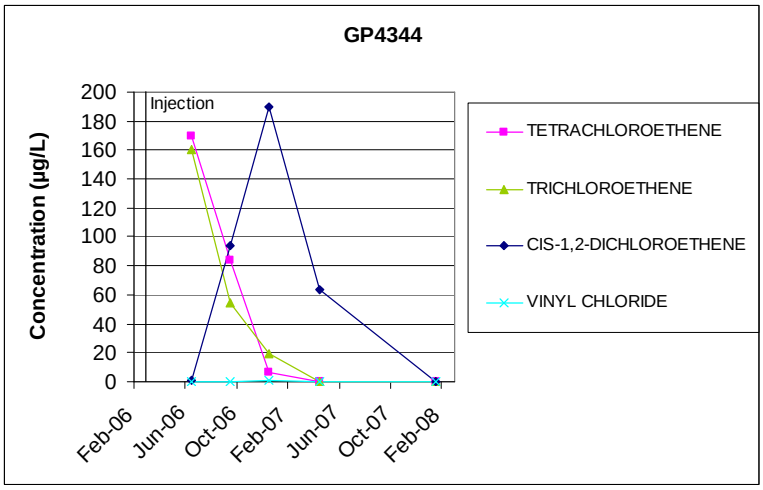
Attachment 5 - AAB Monitoring Data at SS07

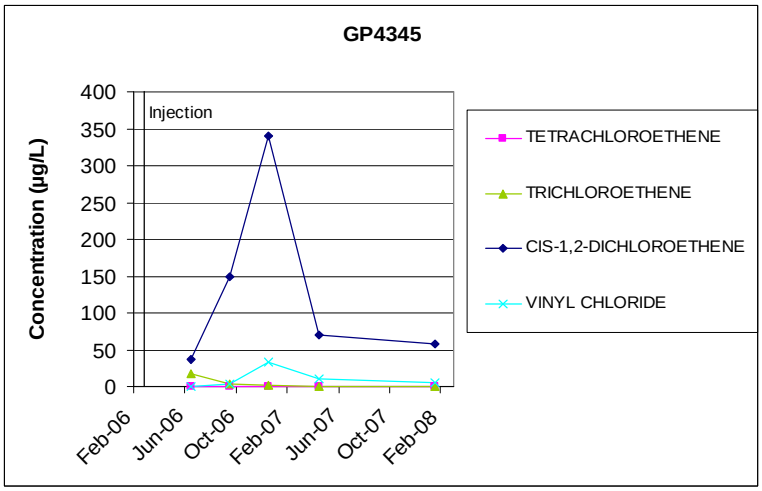












Attachment 6 - RAO Exceedences, SS07/Area 2

Contaminant	DM409D 4/17/2006	DM409S 4/17/2006	DM413D 4/17/2006	DM451D 4/19/2006	DM451M 4/19/2006	DM451S 4/19/2006	DM452D 4/19/2006	DM452M 4/19/2006	GP4306 4/19/2006	MW051D 4/17/2006	RAO* (µg/L)
cis-1,2-DCE	1.1	ND	2.4	14	9.4	1.1	9.3	36	12	12	70
PCE	ND	ND	ND	ND	0.53	37	0.6	2.1	320	ND	5
TCE	1.6	ND	3.6	0.67	0.37	1.1	11	21	130	8.1	5
VC	ND	ND	ND	1.5	1	ND	ND	ND	2	ND	2

Contaminant	DM409D 10/18/2006	DM409S 10/18/2006	DM413D 10/19/2006	DM451D 10/17/2006	DM451M 10/17/2006	DM451S 10/17/2006	DM452D 10/20/2006	DM452M 10/20/2006	GP4306 10/18/2006	MW051D 10/24/2006	RAO* (µg/L)
cis-1,2-DCE	ND	ND	0.6	11	12	2.8	5.9	43	100	18	70
PCE	ND	0.21	ND	ND	ND	27	0.3	0.31	ND	ND	5
TCE	ND	ND	1.6	0.78	1.1	0.91	9.5	58	ND	2.4	5
VC	ND	ND	ND	0.69	0.47	ND	ND	ND	6.8	1.3	2

Contaminant	DM409D 4/19/2007	DM409S 4/19/2007	DM413D 4/17/2007	DM451D 4/18/2007	DM451M 4/18/2007	DM451S 4/18/2007	DM452D 4/17/2007	DM452M 4/17/2007	GP4306 4/11/2007	MW051D 4/18/2007	RAO* (µg/L)
cis-1,2-DCE	ND	ND	ND	13	13	ND	6	14	21	16	70
PCE	0.02	0.12	0.07	0.02	0.06	5.6	0.44	0.44	0.29	0.1	5
TCE	0.14	ND	1.92	2.25	2.2	0.18	10	22	1.05	ND	5
VC	ND	ND	ND	ND	ND	ND	ND	ND	7.3	0.74	2

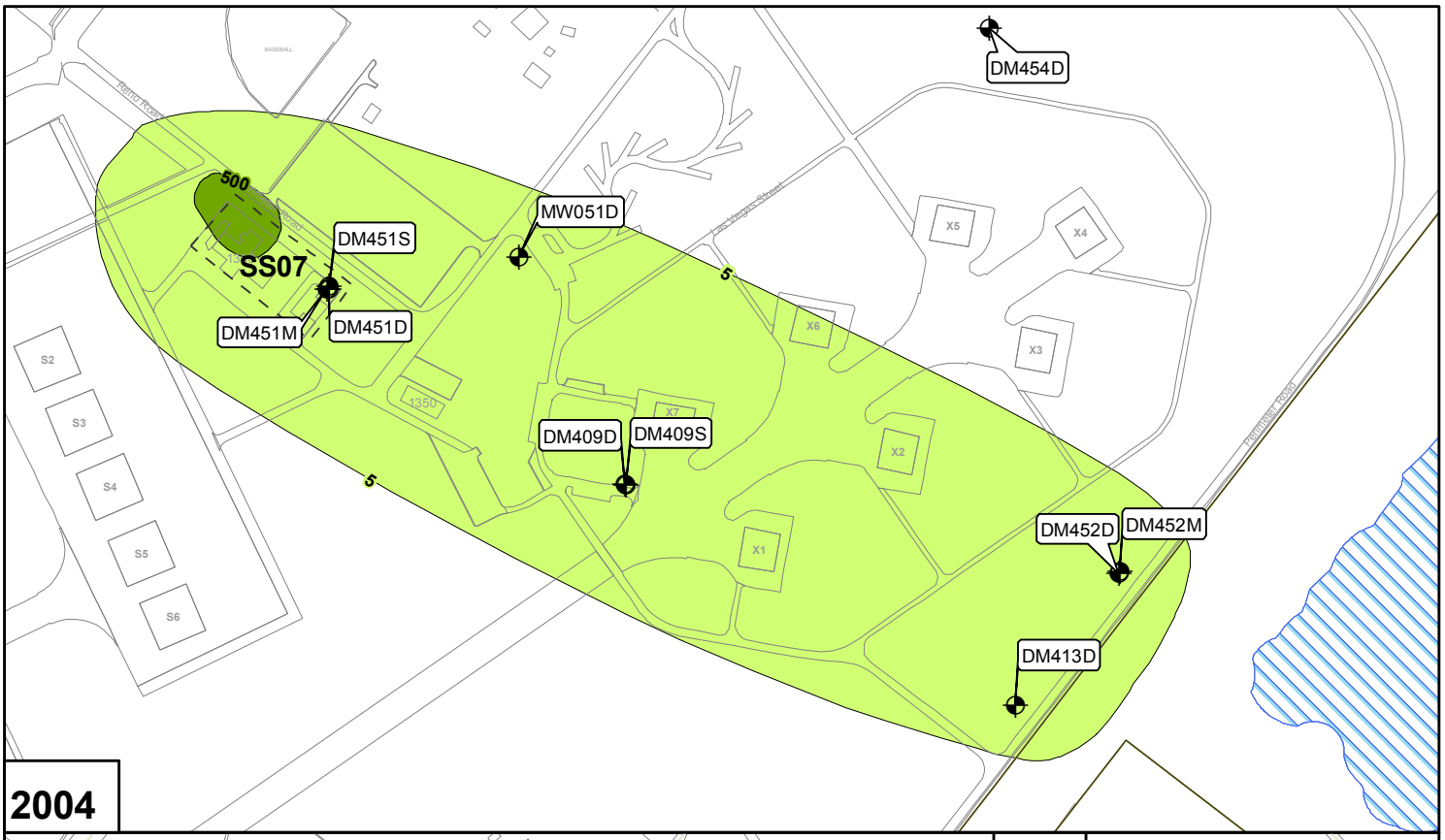
Contaminant	DM409D 10/17/2007	DM409S 10/17/2007	DM413D 10/16/2007	DM451D 10/17/2007	DM451M 10/17/2007	DM451S 10/17/2007	DM452D 10/16/2007	DM452M 10/16/2007	GP4306 10/18/2007	MW051D 10/17/2007	RAO* (µg/L)
cis-1,2-DCE	ND	ND	1.18	1.4	1.2	ND	2.3	17.2	ND	ND	70
PCE	ND	ND	ND	ND	ND	ND	ND	9.4	ND	5	5
TCE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
VC	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.9	2

Attachment 6 - (cont'd)

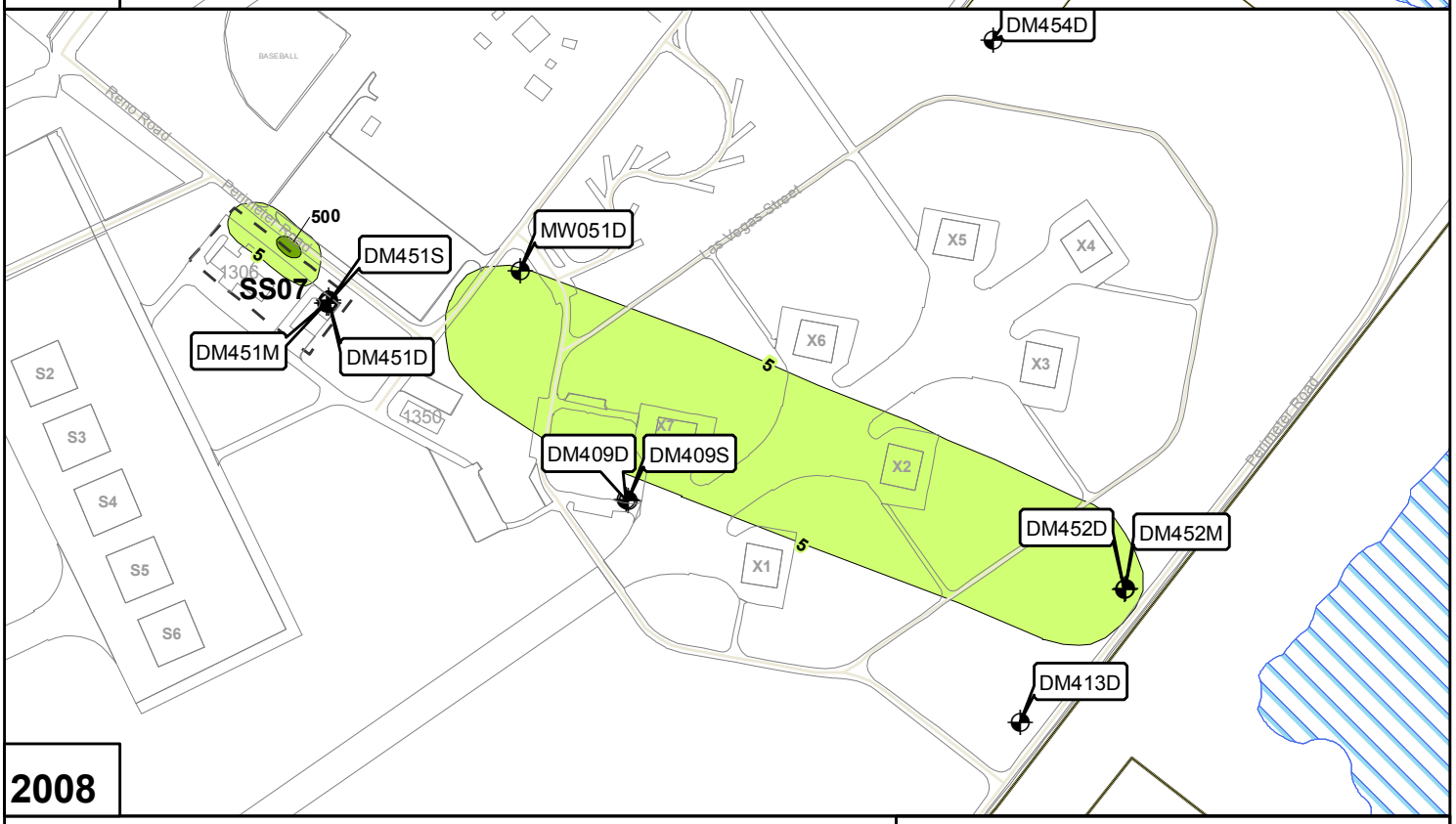
Contaminant	DM463 1/7/2008	DM464 1/7/2008	DM465 1/4/2008	DM466 1/4/2008	GP4302 1/3/2008	GP3403 1/4/2008	GP4305 1/2/2008	GP4306 1/4/2008	GP4343 1/4/2008	GP4344 1/3/2008	RAO* (µg/L)
cis-1,2-DCE	ND	371	ND	ND	18	452	11.7	ND	3.2	ND	70
PCE	1.4	ND	ND	ND	ND	1.4	ND	ND	ND	ND	5
TCE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
VC	ND	39	ND	ND	3.1	10.6	2.1	ND	ND	ND	2

Contaminant	GP4345 1/2/2008	GP4346 1/2/2008	GP4347 1/2/2008	RAO* (µg/L)
cis-1,2-DCE	58	64	16.3	70
PCE	ND	ND	ND	5
TCE	ND	ND	ND	5
VC	4.6	16	3.1	2

All units in µg/L
VC - vinyl chloride
ND - not detected
RAO exceedences are shaded.



2004



2008

Legend

N

Site Boundary

Monitoring Well

>5µ/L Total Solvent Concentration Contour

>500µ/L Total Solvent Concentration Contour

0 150 300 600 900 1,200 Feet

Attachment 7
Plume Maps for SS07/Area 2
2004 & 2008

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DES BY	DJM 09/23/08
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 7

URS

200 Orchard Ridge Drive
Gaithersburg, MD 20878

FIVE-YEAR REVIEW FOR LF17
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
ERP	Environmental Restoration Program
FS	Feasibility Study
ft	Feet
GMZ	Groundwater management zone
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
PCE	Tetrachloroethene
RA	Risk assessment
RAO	Remedial action objective
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
SMU	South Management Unit
TCE	Trichloroethene
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

EXECUTIVE SUMMARY

The remedy for LF17, a former landfill site at Dover Air Force Base (DAFB), Delaware, is natural attenuation with groundwater monitoring and land use controls (LUCs) for both soil and groundwater. Groundwater remediation began with the installation of additional monitoring wells in 2006 in accordance with the Record of Decision (ROD) for the South Management Unit (SMU).

The initial trigger date for five-year reviews in the SMU was the start date of construction for the first remedy implemented in the SMU; a soil remediation that started on December 12, 1997 at site LF18. This is the first five-year review for LF17. Since achieving the construction complete milestone for all sites, DAFB has merged reviews for all sites into a comprehensive set of Base-wide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the groundwater remedy—natural attenuation with monitoring and LUCs—is operating as intended. The primary contaminants of concern (COCs) are benzene, tetrachloroethene, trichloroethene, cis-1,2-dichloroethene, and vinyl chloride. LUCs remain in effect and no new uses of groundwater on the site were observed. It is recommended that monitoring continue to confirm that COCs naturally attenuate to levels that meet the remedial action objectives specified for LF17 in the SMU ROD.

The draft-final five-year review for LF17 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

LF17 is an Environmental Restoration Program (ERP) site used as a landfill at Dover Air Force Base (DAFB), Delaware, in the South Management Unit (SMU) (Attachment 1). LF17 is a 3.5-acre area that was used as a trench-and-fill landfill during the 1960s for disposal of general refuse. The landfill was covered with several feet of soil and seeded with grass after disposal activities ceased. No active remediation was conducted at the time of closure. It has been maintained ever since as an open grassy field. Environmental investigations were subsequently conducted that revealed groundwater contamination as a particular concern and resulted in implementing a natural attenuation monitoring program under a 2005 Record of Decision (ROD). Land use controls (LUCs) for soil and groundwater are also a component of the remedy.

The remedial action at LF17 was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the first five-year review for the LF17 remedy. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

The natural attenuation monitoring at LF17 is one of several implemented remedies at SMU ERP sites. Similar groundwater monitoring occurs concurrently at three other SMU sites: FT01, LF18/Area 9, and SS07/Area 2. LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the LF17 remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
1960s	LF17 was used as landfill for general refuse.
March 13, 1989	DAFB listed on National Priority List (NPL).
1989	Stage II SI conducted at LF17, groundwater only (SAIC, 1989).
August 1997	Basewide Remedial Investigation (RI) finalized; included assessment of LF17 (USACE, 1997).

Table 1 (cont'd)

Date	Event
2000	Base-wide Ecological Risk Assessment (DAFB, 2000).
April 11, 2003	DNREC established a groundwater management zone (GMZ).
January 2005	Feasibility Study (FS) and Addendum for SMU finalized. Included assessment of natural attenuation in groundwater at LF17 (USACE, 2005a).
January 2005	Proposed Plan prepared, included LF17 (USACE, 2005b).
December 2005	Final SMU ROD signed, included LF17 (USACE, 2005c).
January 2006	Remedial Action Work Plan (RAWP) prepared, included LF17 (ORNL, 2006b).
Early 2006	Remedy delineation sampling conducted at LF17, documented in RAWP addendum.
March 2006	Installation of monitoring wells at LF17.
April 2006 - ongoing	Semi-annual natural attenuation monitoring at LF17 (ORNL, 2007 - 2008).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report prepared, included LF17 (ORNL, 2006a).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007a).

DNREC – Department of Natural Resources and Environmental Control.
ORNL – Oak Ridge National Laboratory
SAIC – Science Applications International Corporation
USACE – U.S. Army Corps of Engineers (Omaha District)

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

LF17 is located in the SMU northeast of U.S. Route 113 and near the southern edge of the Base near Route 9 (Attachment 1). This portion of the SMU can only be entered by passing through the Base's security gates, and is not accessible to the general public. The site is covered with grass and its topography is slightly hummocky. Runoff is controlled by shallow surface ditches. Groundwater at the site is typically encountered at depths between 10 and 15 feet (ft) below ground surface (bgs).

3.2 LAND AND RESOURCE USE

Site LF17 is a former landfill of approximately 3.5 acres, currently maintained as an open grassy field. DAFB previously used the site for disposal of general refuse. The trenches were reportedly dug to the depth of the water table, approximately 10 to 15 ft bgs. Once these activities ceased, the site was covered with soil and seeded with grass. It has been maintained as is and has not been used for any other purpose. Other than minimal grounds maintenance and routine security checks, there are no other personnel located at the site. The site is not easily accessible to Base visitors. The site itself is an open field. Nearby are runways and taxiways, a fire training area, skeet and small arms firing ranges, a paint ball field, and boat/trailer long-term parking areas.

The shallow groundwater (Columbia Aquifer) underlying the site generally flows south towards the Base boundary and a sand and gravel quarry, a local discharge point. This aquifer is not currently used as a drinking water source. DAFB obtains potable

water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. The solvent plume does not extend to the Base boundary. However, there is a potential for off-site migration and the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a small portion of off-Base property between DAFB and the St. Jones River. This area includes the nearby quarry. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well-permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

In the past, general refuse was placed in shallow trenches at LF17. Although much of the material was probably benign, over time one small area of the landfill (near its southern corner) released chlorinated solvents (and a small amount of fuel) into the surrounding subsurface soil. Benzene and the solvents (tetrachloroethene [PCE], trichloroethene [TCE], cis-1,2-dichloroethene [cis-1,2-DCE], and vinyl chloride) migrated downward through the soil column where they encountered the water table aquifer. The contaminants were transported as a dissolved phase with the natural flow of groundwater, forming a small plume. Soil samples collected from test pits excavated during the RI indicated small amounts of residual fuel contaminants in soil, although there were only minor indications of the fuel leaching to groundwater. No chlorinated solvents were detected in soil.

Based on the groundwater chemistry observed at this site, the solvents appear to be naturally attenuating through anaerobic biodegradation. According to the most recent groundwater sampling data, the contaminant plume at this site does not extend to the Base boundary.

The Basewide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

Treatment alternatives for LF17 groundwater were evaluated in the SMU FS (USACE, 2005a). Supplemental characterization specific to natural attenuation was conducted in 2005 to support FS conclusions. This study determined that natural attenuation appeared to be adequate for controlling the migration of constituents from LF17. The supporting evidence included the presence of breakdown products and

favorable reducing conditions of the aquifer necessary for biodegradation. The selected remedial action for groundwater is natural attenuation with monitoring and LUCs for both soil and groundwater, which was documented in a proposed plan and submitted for public review on February 15, 2005.

In 2006, a ROD was signed for the soil and groundwater at LF17. The selected remedy included natural attenuation with monitoring for groundwater and LUCs for soil and groundwater.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater at LF17 since it is located in an industrial portion of the Base (USACE, 1997). Based on this commercial/industrial use scenario evaluation, groundwater contamination did not result in risk exceeding established federal criteria. However, Federal Safe Drinking Water Act maximum contaminant levels (MCLs) were exceeded at the site. Although groundwater from the Columbia Aquifer at LF17 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences as well as the potential for contaminant migration to areas not under DAFB control, trigger the need for remedial action at LF17. Based on the RA for soil, a cleanup action is not warranted. However, this conclusion is based on the assumption that the future on-Base land use at the site will remain industrial. Thus, the response action for soil is to ensure the permanence and reliability of the land use assumptions, and thereby protect the public health from hazardous substances at the site. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for LF17 was signed by USEPA in January 2006 (USACE, 2005c). The remedial action objectives (RAOs) were developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, one of the RAOs for groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. By restricting access, potential exposures to soil and groundwater are mitigated. LUCs for soil and groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only

commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the SMU FS. The selected remedy for LF17 groundwater as outlined in the 2005 ROD includes the five major components listed below.

- Natural attenuation of COCs.
- LUCs for soil and groundwater.
- Groundwater monitoring.
- Delineation of the downgradient plume edge (accomplished in 2006).
- Evaluation of vapor intrusion during groundwater remedial action phase (accomplished in 2007) (ORNL, 2007a).

4.2 REMEDY IMPLEMENTATION

In accordance with the 2005 ROD, plume delineation sampling was conducted via direct-push to ensure the proper placement of monitoring wells needed to complete the well network. A RAWP was then prepared documenting the monitoring plan and sampling procedures (ORNL, 2006a). The plan included similar monitoring at three other SMU sites: SS07/Area 2, FT01, and LF18/Area 9. Five wells were selected to be monitored specifically at LF17. Of these, two were new wells installed to complete the network: one very close to the landfill and the other near the toe of the solvent plume (Attachment 1). Monitoring well IDs are listed in Table 2. Sample analyses include VOCs and geochemical indicators of natural attenuation. The SMU sites are sampled on a semi-annual schedule, with the first round completed in April 2006.

Table 2 – Monitoring Wells

Monitoring Wells		
MW081S MW083D	MW083S DM453S	DM454D

At LF17, the primary mechanism of natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant, PCE, degrades to TCE, then to cis-1,2-DCE, then to vinyl chloride, and finally to ethene, a harmless gas.

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including LF17. Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) The soil cover at LF17 will be maintained. (4) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and the off-Base

property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (5) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the contaminants found at LF17 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 3 – RAO Groundwater Concentrations

Parameter	RAO Concentration[a] (µg/L)
Benzene	5
cis-1,2-DCE	70
PCE	5
TCE	5
Vinyl chloride	2

[a]The groundwater RAOs are the MCLs
µg/L - micrograms per liter

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the SMU ROD, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the West Management Unit. There are no buildings located at or near LF17 or above the small plume at the site. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

In accordance with the ROD and RAWP for the SMU, groundwater monitoring for natural attenuation at LF17 began in 2006 and is ongoing. Groundwater monitoring is currently conducted on a semi-annual basis. The costs associated with this activity are summarized in Table 4. LUC inspections began in 2006 and occur annually.

Table 4 – Annual Monitoring Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$96,000 (includes initial capital costs)
2007	$66,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for LF17.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for LF17 would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for LF17 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of LF17 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant LF17 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the long-term monitoring of the natural attenuation remedy (ORNL, 2006a and 2007b). Groundwater sampling and analysis is the primary means of determining the continued effectiveness of the remedy at LF17. The monitoring reports reviewed for the SMU, which includes LF17, evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

Groundwater data at LF17 have been collected during semi-annual sampling rounds since April 2006 in accordance with the RAWP. There have been three sampling

events and monitoring is ongoing. Five wells are regularly sampled at LF17 (Table 2). RAO/MCL exceedences are highlighted in Table 5. This table also includes data from 2001 for the three older wells.

Table 5 - COC Summary

Well	Date	Benzene (µg/L)	cis-1,2-DCE (µg/L)	PCE (µg/L)	TCE (µg/L)	Vinyl Chloride (µg/L)
RAO	**--**	***5***	***70***	***5***	***5***	***2***
MW081S	9/5/2001	6	97	28	24	120
	4/17/2006	1.7	5	3	2	39
	10/23/2006	ND	ND	ND	ND	ND
	4/19/2007	ND	26	5.5	2.9	41
	10/18/2007	ND	52	43	13.8	73
MW083D	9/6/2001	ND	ND	ND	ND	ND
	4/17/2006	ND	ND	ND	ND	ND
	10/20/2006	ND	ND	ND	ND	ND
	4/19/2007	ND	ND	0.01	ND	ND
	10/18/2007	ND	ND	ND	ND	ND
MW083S	9/6/2001	ND	ND	ND	ND	ND
	4/17/2006	ND	ND	ND	ND	ND
	10/20/2006	0.78	8.1	1	0.92	13
	4/19/2007	ND	ND	0.03	0.02	ND
	10/18/2007	ND	12.6	ND	1.04	ND
DM453S	4/19/2006	ND	1	6	ND	1.0
	10/18/2006	ND	12	190	3	12
	4/17/2007	10	42	114	3.7	52
	10/16/2007	ND	901	91	76	511
DM454D	4/20/2006	0.59	1.1	1.2	0.99	1.7
	10/18/2006	1.2	0.42	ND	ND	ND
	4/19/2007	ND	ND	0.17	0.32	ND
	10/18/2007	ND	ND	ND	ND	ND

= RAO exceedence

ND – not detected

A plume of groundwater contamination, consisting primarily of chlorinated solvents and a small amount of benzene extends approximately 750 ft from the southeastern edge of LF17 (Attachment 1). Benzene rarely exceeded its RAO in any of the wells. It was detected once at 6 µg/L in MW081S (2001) and in DM453S above its MCL for the first time in April 2007. Almost all chlorinated RAO exceedences occur in the two wells closest to the landfill (MW081S and DM453S). No RAO exceedences were observed during any sampling round in the downgradient most well, DM454D. This indicates that the plume has not expanded and remains more than 1,000 ft from the Base boundary.

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at LF17 on that day (Attachment 4). The area is currently an open grass-covered field with some small trees near the road. Burrowing animals may be present in the area. No new uses of groundwater or the site were observed. Complete site status info was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for LF17 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that the chlorinated solvent plume is at or near steady state. Benzene, one of the COCs, has been detected above its MCL/RAO once since 2001 in one well. Although on-site concentrations of two chlorinated VOCs in the two wells closest to the landfill routinely exceed RAOs/MCLs, expansion of the contamination at levels above RAOs/MCLs has not occurred. Attachment 5 shows the extent of the plume in 2004 and in late 2007, which is approximately the same at both times.

Site conditions and usage are unchanged since the implementation of the remedy. The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the SMU ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effects on risks are qualitatively summarized in Table 6 (USEPA, 2007). As outlined in Table 6, the various changes could both increase and decrease the overall carcinogenic risk and non-carcinogenic hazard. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 6 – Risk Assessment Review

Change	Effect
RBSCs decreased for 1,4-dichlorobenzene and PCE.	These chemicals would be included in the RA, slightly increasing overall risks and hazards.
For benzene, oral reference dose now available, and inhalation reference dose increased.	A slight increase and decrease, respectively, in overall hazard.
For benzene, oral slope factor increased and inhalation slope factor decreased.	A slight increase and decrease, respectively, in overall risk.
Oral and inhalation reference doses now available for vinyl chloride.	A slight increase in overall hazard.
Oral and inhalation slope factors decreased for vinyl chloride.	A slight decrease in overall risk.
Oral slope factor decreased for arsenic.	A slight decrease in overall risk.

RBSC - Risk-based screening criterion.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. In addition, groundwater monitoring has shown the contaminant plume has remained relatively stable and remains more than 1,000 ft from the Base boundary. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

All of the landfill debris is covered with clean soil and grass turf minimizing possible ecological pathways.

<u>Question C: Has any other information come to light that could call into question the protectiveness of the remedy?</u>

This review for LF17 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Landfilling activities ceased at LF17 in the 1960s and the site has since remained unused. All information to

date indicates that the chlorinated solvents (at levels above MCLs/RAOs) are confined to a small plume emanating from the landfill. With one minor exception, benzene has been consistently below its MCL/RAO during the last four semi-annual monitoring events. The plume appears to be at steady state and remains more than 1,000 ft from the Base boundary.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for LF17 groundwater appears to be functioning as intended. Off-site migration of contaminants above action levels has not occurred. The on-site VOC concentrations are above RAOs/MCLs primarily in the two site wells located near the landfill (MW081S and DM453S). However, contaminant concentrations quickly decrease downgradient to below RAOs/MCLs indicating that natural attenuation processes are effectively reducing constituent concentrations. Cis-1,2-DCE and vinyl chloride are present indicating anaerobic biodegradation of the parent material. The presence of ethane and ethene in the two wells closest to the landfill indicates that complete degradation is occurring. The only long-term decreasing concentration trends observed since 2001 are in MW081S. Data from the other wells suggest that the small plume is at or near steady state, fluctuating primarily in response to seasonal precipitation. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

LUCs have been successfully implemented at the site.

Although degradation rates were not provided in the SMU monitoring reports, inspection of the contaminant trends (Table 5) indicates that degradation of chlorinated solvents occurs at a rate sufficient to prevent significant migration from the site although considerable fluctuation is noted in the two wells closet to the landfill. The remedy appears to be capable of achieving RAOs in the approximate 19- to 20-year time frame stated in the SMU ROD.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater sampling during the SI and RI at LF17 demonstrated that site activities locally affected groundwater quality and that a potential exists for off-site migration. In response, natural attenuation monitoring of the site was initiated. It is recommended that monitoring continue on a regular schedule until the RAOs are achieved.

For future events, it is recommended that the monitoring well network be optimized. Specifically, sampling of well MW083D should be discontinued. This well has never contained the COCs at levels above RAOs/MCLs, and it is likely screened too deep in the aquifer to be in contact with the plume. Removal of this well from the network will have no negative effect on the monitoring program at LF17.

A worse-case vapor intrusion evaluation was performed in 2007 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

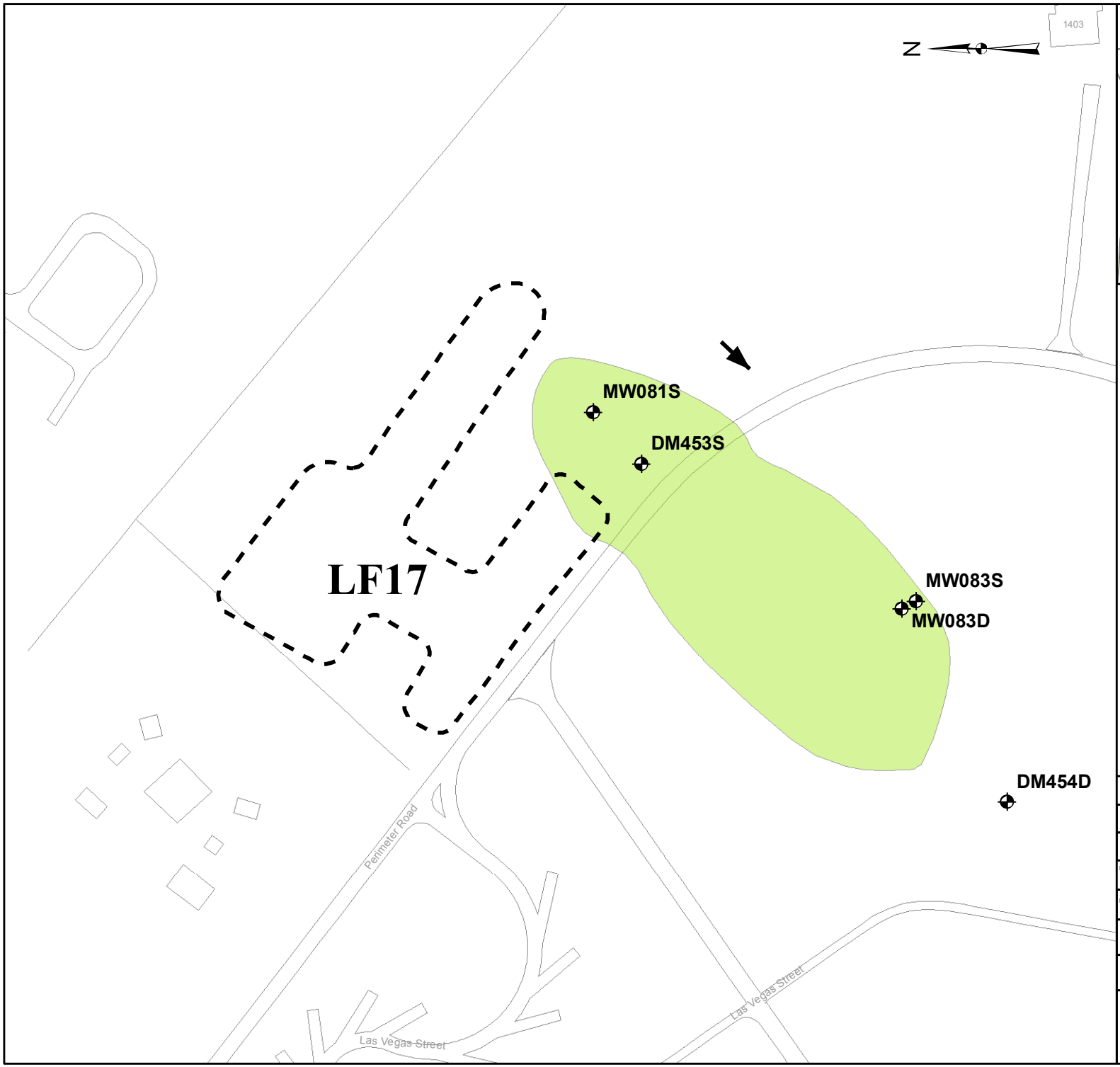
The site as a whole will also continue to be addressed in the five-year review process due to the LUC remedy and the continuation of groundwater monitoring.

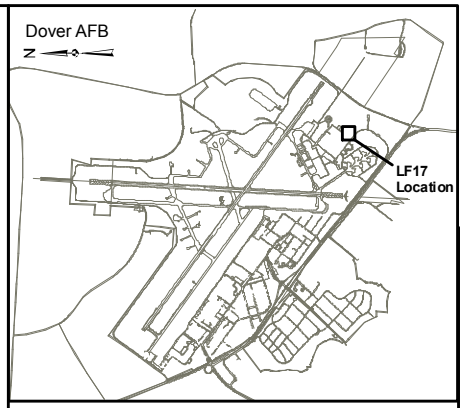
10.0 PROTECTIVENESS STATEMENT

The remedy at LF17 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for LF17 will be due in September 2013.





Legend

- LF17 Boundary
- Plume
- Monitoring Well
- Groundwater Flow

0 50 100 200 Feet

TITLE	LF17 Site Map
CLIENT	DAFB/ORNL
PROJ	2008 Five-Year Reviews
PATH	G:\Projects\Dover_AFB\5yr_Review_Figures\LF17.mxd
PATH	P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\ Five Year Reviews 2008\H. Reports\SMU\Figures\LF17_Attch1_20080108.pdf
DES BY	DJM 01/08/2008
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878

Attachment 2 – Reviewed Documents

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

ORNL, 2007 - 2008. Monitoring Reports, Sites LF17, SS07, FT01, and LF18, South Management Unit (multiple events), Dover Air Force Base, DE, submitted by URS Group, Inc., March 2007, September 2007, and May 2008.

ORNL, 2007a. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. Interim Remedial Action Completion Report, Sites LF17, SS07, FT01, and LF18, South Management Unit (SMU), Dover Air Force Base, DE, submitted by URS Group, Inc., August 2006.

ORNL, 2006b. South Management Unit Remedial Action Work Plan [and Addendum] Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2006.

SAIC, 1989. Installation Restoration Program - Stage 2 Draft Final Report, Dover Air Force Base, Delaware.

USACE, 2005a. Final Feasibility Study [and Addendum: Plume Delineation and Assessment of Natural Attenuation], South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2005.

USACE, 2005b. Proposed Plan South Management Unit, Dover AFB, Delaware, January 2005.

USACE, 2005c. Record of Decision for LF17, SS07/Area 2, FT01, and LF18/Area 9 South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., December 2005.

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [South Management Unit, Volumes I - IV].

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.
.

USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening, USEPA Region III, EPA/903/R-93-001, January 1993.

Attachment 2 – (cont'd)

USEPA, 1991. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, OSWER 9355.0-30, April 1991.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for site LF17 are listed in the SMU ROD and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the ROD. ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario. However, since residential risks were not evaluated, the Air Force decided to implement LUCs as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

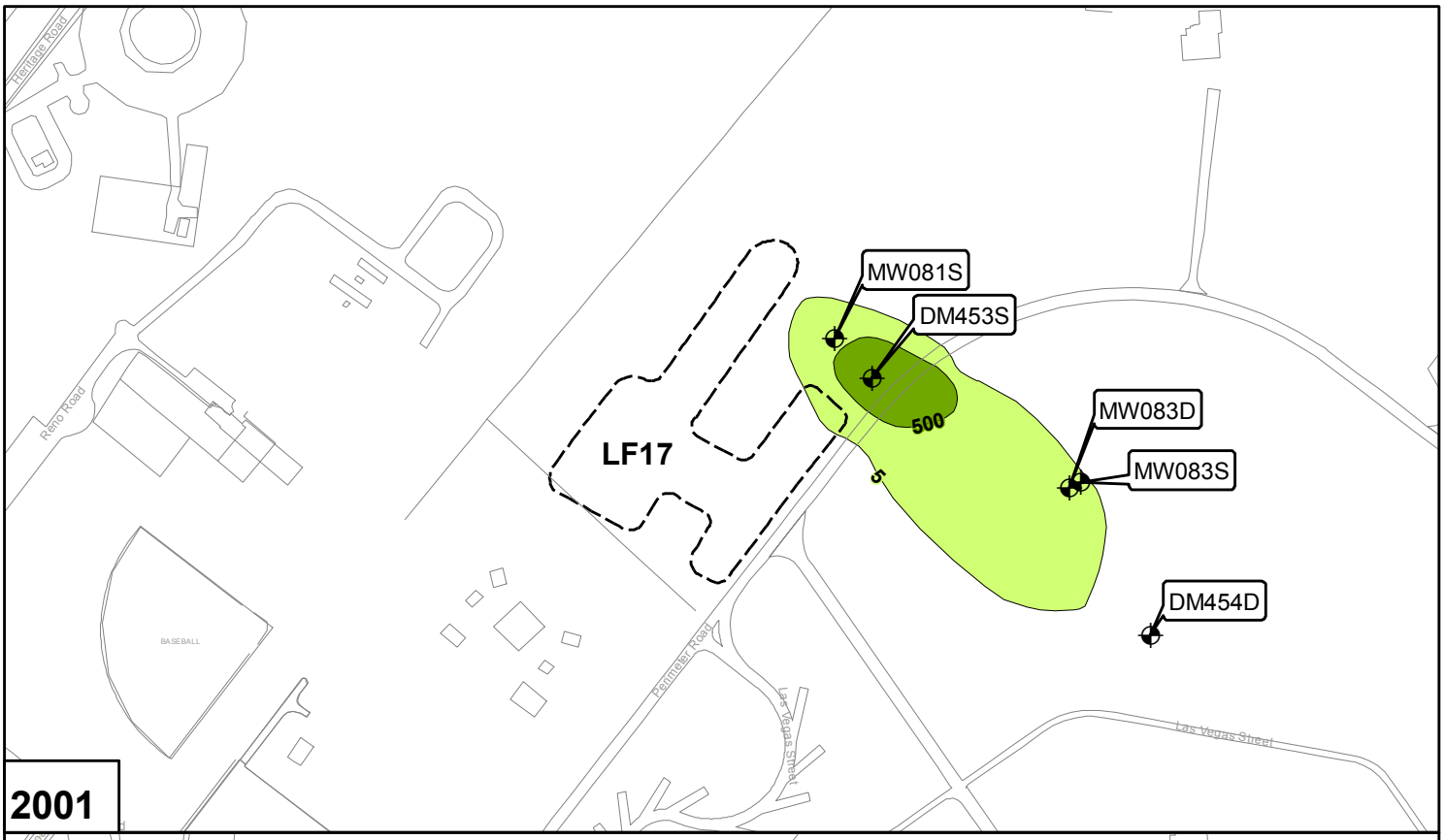
Groundwater. Federal MCLs for the COCs are unchanged. DNREC's Delaware Risk-Based Corrective Action Program (DERBCAP) established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For LF17 chlorinated solvents and benzene, the standards in this guidance are the same as the Federal MCLs.

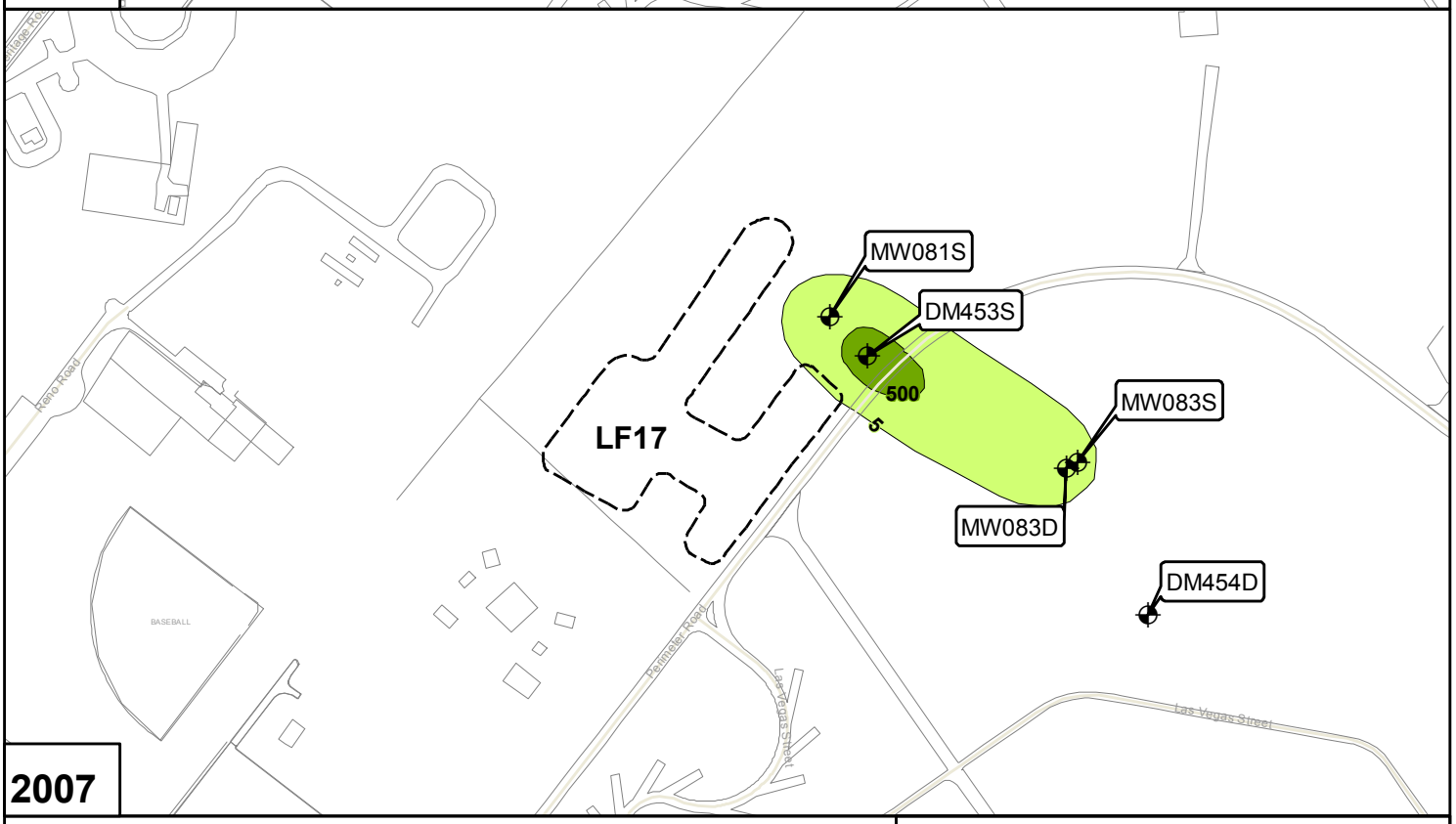
Surface Water and Sediment. The debris at this site is buried and the site is covered with maintained turf; thus, surface transport of any residual constituents has been mitigated. Sampling conducted for the Ecological Risk Assessment revealed no VOCs in the surface water or sediment collected from downstream drainages that could be affected by LF17 and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4 - Site Photographs for LF17

Top: Looking north at LF17 on November 14, 2007
Bottom: Looking east at LF17 on November 14, 2007.





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Legend

Site Boundary

Monitoring Well

>5µ/L Total Solvent Concentration Contour

>500µ/L Total Solvent Concentration Contour

0 120 240 480 720 960 Feet

Attachment 5
Plume Maps for LF17
2001 & 2007

PATH	G:\Projects\Dover_AFB\5yr_Review_Figures\Sept 2008\LF17.mxd
DES BY	DJM 09/09/08
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 5

URS

200 Orchard Ridge Drive
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FIVE-YEAR REVIEW FOR LF18/AREA 9
DOVER AIR FORCE BASE, DELAWARE

September 2008

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Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
1,2-DCE	1,2-Dichloroethene
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
EE/CA	Engineering Evaluation/Cost Analysis
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
LNAPL	Light Non-Aqueous Phase Liquid
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
PCE	Tetrachloroethene
RA	Risk assessment
RAO	Remedial action objective
RAWP	Remedial Action Work Plan
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
SMU	South Management Unit
TCE	Trichloroethene
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VC	Vinyl chloride
VOC	Volatile organic compound

EXECUTIVE SUMMARY

Two remedies have been implemented at LF18/Area 9, a former landfill at Dover Air Force Base (DAFB), Delaware: 1) a soil remedial action for petroleum-contaminated soil, and 2) natural attenuation with groundwater monitoring and land use controls (LUCs) for both soil and groundwater. The remedial action for soil was taken in 1997-1998 based on a Record of Decision (ROD) signed in 1996. The second remedy addresses groundwater contamination and began with source confirmation sampling and the installation of new monitoring wells in accordance with the 2005 South Management Unit (SMU) ROD. LUCs are also elements of this remedy.

The initial trigger date for five-year reviews in the SMU was the start date of construction for the first remedy implemented in the SMU: the soil remediation that started on December 12, 1997 at site LF18. This is the second five-year review for LF18. Since achieving the construction complete milestone for all sites, DAFB has merged reviews for all sites into a comprehensive set of Base-wide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of the previous five-year review found that the soil remedy was conducted in accordance with the 1996 ROD and that the remedial action objectives (RAOs) were met. Thus, a primary source of waste (particularly fuel contamination) has been removed from LF18. Therefore, as recommended in the previous five-year review (2003) for LF18, review of this portion of the remedy has been discontinued. The site as a whole, however, continues to be addressed in the five-year review process due to the LUC remedy that was implemented for soil and the continuation of groundwater remediation.

The assessment of this five-year review found that the groundwater remedy—monitoring of natural attenuation with LUCs—is operating as intended. The primary contaminants of concern (COCs) consist of solvents that were historically used in aircraft maintenance activities. LUCs remain in effect for both soil and groundwater. It is recommended that monitoring for groundwater continue to confirm that COCs naturally attenuate to levels that meet the RAOs specified for LF18 in the SMU ROD.

The draft-final five-year review for LF18 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

LF18 is an Environmental Restoration Program (ERP) site formerly used as a landfill at Dover Air Force Base (DAFB), Delaware in the South Management Unit (SMU) (Attachment 1). Currently part of the Base golf course, it underwent a soil remediation that was completed in accordance with the 1996 Record of Decision (ROD) (DAFB, 1996). This remedy met remedial action objectives (RAOs) and is no longer being reviewed. A second remedy was implemented under a 2005 ROD to address the chlorinated solvents in groundwater at LF18/Area 9. This remedy includes natural attenuation with monitoring and land use controls (LUCs) for both soil and groundwater.

The remedial action at LF18 was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use or unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the second five-year review for site LF18. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

Natural attenuation with monitoring is the second implemented remedy at LF18/Area 9. Similar groundwater monitoring occurs concurrently at three other SMU sites: LF17, FT01, and SS07/Area 2. LUCs for groundwater and soil are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting LF18 are listed in Table 1.

Table 1 – Site Chronology

Date	Event
Mid-1950s	LF18 was used as a landfill.
1960s	Base golf course was constructed over LF18/Area 9.
1986	USAF installation restoration program-Phase II-Stage I, groundwater only, free product observed in well MW007J (SAIC, 1986).
1989	Stage II Site Investigation (SI) conducted, soil gas survey, geophysical survey, and surface water, sediment, and groundwater sampling at LF18 (SAIC, 1989).
March 13, 1989	DAFB listed on National Priority List (NPL).
Early 1990s	Remedial investigation (RI) for soil at LF18.
November 1992	Interim ROD signed for removal of free product in well MW007J.
1993	Phase I: Site Characterization, surface water and sediment sampling at LF18

Table 1 (cont'd)

Date	Event
	(HAZWRAP, 1993).
1994	Attempts to recover product were unsuccessful.
August 1995	Free product delineation investigation conducted.
June 1996	Engineering Evaluation/Cost Analysis (EE/CA) and Proposed Plan completed for soil removal; EE/CA included additional soil sampling and product thickness measurements (USACE, 1996a).
September 24, 1996	Final ROD prepared for soil removal at LF18 (DAFB, 1996).
August 1997	Basewide RI finalized; included assessment of LF18 (USACE, 1997).
December 12, 1997	After mobilization and construction of temporary facilities, ground was broken for soil excavation. Soil removal occurred in two phases.
July/October 1998	U.S. Geological Survey (USGS) conducted post-removal groundwater sampling of temporary piezometers and site monitoring wells.
May 1999	Post excavation report for site LF18 completed (USACE, 1999).
2000	Basewide Ecological Risk Assessment (DAFB, 2000).
April 2001-2003	Post excavation semi-annual groundwater monitoring conducted (USGS, 2001, 2002a, b).
April 11, 2003	DNREC established a groundwater management zone (GMZ).
September 2003	First five-year review LF18 soil remedy.
January 2005	Feasibility Study (FS) and Addendum for SMU finalized. Included assessment of natural attenuation in groundwater at LF18 (USACE, 2005a).
January 2005	Proposed Plan prepared, included LF18 (USACE, 2005b).
December 2005	Final ROD prepared, included LF18 (USACE, 2005c).
January 6, 2006	Remedial Action Work Plan (RAWP) finalized, included LF18 (ORNL, 2006b).
March 2006	Installation of monitoring wells at SMU sites, including LF18/Area 9.
April 2006-ongoing	Semi-annual natural attenuation monitoring begins at LF18 (ORNL, 2007 - 2008).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report (IRACR) prepared, included LF18 (ORNL, 2006).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007a).

DNREC – Department of Natural Resources and Environmental Control.
HAZWRAP - Hazardous Waste Remedial Actions Program
SAIC – Science Applications International Corporation
USACE – U.S. Army Corps of Engineers (Omaha District)
USGS – U. S. Geological Survey

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

LF18 is located underneath the southeastern edge of the Base golf course, encompassing approximately 3 acres (Attachment 1). It is adjacent to the Tilcon sand and gravel quarry. A small drainage ditch directs runoff from the site west to the golf course tributary and then to the St. Jones River. Groundwater at the site is typically encountered at a depth of about 7 feet (ft) below ground surface.

3.2 LAND AND RESOURCE USE

LF18 was used in the mid 1950s by DAFB for disposal of general refuse, drums of waste solvents, and other shop wastes in a series of four trenches. When disposal activities ceased (date unknown), the area was covered with several feet of local soil and seeded with grass. The site was subsequently developed to be part of the Base golf course, which exists to this day. The drainage ditch near the site and the golf course tributary are part of the Base's storm water drainage system.

The shallow groundwater (Columbia Aquifer) underlying the site generally flows southwest towards the golf course tributary although it can be locally and temporarily influenced by pumping of pond water at the Tilcon quarry. This aquifer is not currently used as a drinking water source. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. Off site, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and some off-Base properties, including the golf course and the quarry. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

Various materials were buried in trenches at LF18 that resulted in both soil and groundwater contamination. These materials are mostly solvents that were historically associated with airplane maintenance, as well as general refuse and other shop wastes. Oil was present as a light-non-aqueous phase liquid (LNAPL) in an area around monitoring well MW007J at the southeastern corner of the landfill. A small dissolved-phase plume associated with this area consisted of petroleum constituents, and also contained chlorinated solvents, primarily trichloroethene (TCE), tetrachloroethene (PCE), cis-1,2-dichlorethene (cis-1,2-DCE), and vinyl chloride. A soil remedial action in 1997-1998 removed the LNAPL and oil-impacted soil. The dissolved-phase petroleum contaminants subsequently dissipated to levels below MCLs.

Chlorinated solvents are also present in groundwater in a larger area northwest of LF18. The overall extent of chlorinated solvents in groundwater located in the area between LF18 and the golf course tributary is a plume called Area 9 (Attachment 1). Although RI data suggested very old sources of contamination in Area 9, data from the 2001-2002 SMU FS groundwater study found only trace detections of chlorinated solvents in the shallow portion of the aquifer, indicating that no source areas remain.

Additional groundwater sampling conducted in early 2006 in areas east of Route 113 revealed no upgradient sources of contamination (ORNL, 2006a).

Samples of surface water and sediment were collected downstream of LF18. Three pesticides were reported slightly above comparison criteria but were determined to be more likely related to the long term historic usage of pesticides at the Base golf course rather then landfill activities at LF18. The Base-wide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

In 1992, a ROD was signed for the recovery of the free product observed in a site monitoring well. Attempts were made in 1994 to do this, but the project was unsuccessful. Subsequently, additional data were obtained on the extent of free product and an EE/CA was prepared that evaluated alternatives for treating the petroleum contamination. The selected remedy was the physical removal of soil and product, which was documented in a Proposed Plan and submitted for public review on June 20, 1996. The soil removal action at LF18 began in 1997 and successfully achieved the RAOs. Per the recommendation of the first five-year review for LF18, this remedy is complete and no longer being reviewed.

Treatment alternatives for solvents in LF18/Area 9 groundwater were evaluated in the SMU FS (USACE, 2005a). The selected remedial action for groundwater in the Area 9 plume is natural attenuation with monitoring and LUCs for both soil and groundwater, which was documented in a proposed plan and submitted for public review on February 15, 2005. Supplemental characterization specific to natural attenuation was conducted in 2005 to support FS conclusions.

In 2006, a final ROD was signed for the soil and groundwater at LF18/Area 9. The selected remedy is natural attenuation with monitoring for groundwater and LUCs for both groundwater and soil.

3.5 BASIS FOR TAKING ACTION

The Basewide RI risk assessment (RA) evaluated hypothetical future commercial/industrial and residential use scenarios for groundwater and soil at LF18 (USACE, 1997). Based on this evaluation, groundwater contamination did not result in risk exceeding established federal criteria. However, Federal Safe Drinking Water Act MCLs were exceeded at the site. Although groundwater from the Columbia Aquifer at site LF18 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences as well as the potential for contaminant migration to areas not under DAFB control, trigger the need for remedial action at LF18. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

For soil the resulting hazards were not elevated. A cancer risk to hypothetical future residents was elevated (2×10^{-4}) due to polycyclic aromatic hydrocarbons (PAHs) in soil. LUCs is a component of the site remedy in order to prevent potential future residential exposure to soil.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The second ROD for LF18/Area 9 was signed by USEPA in January 2006 (USACE, 2005c). The RAOs were developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, one of the RAOs for groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. By restricting access, potential exposures to soil and groundwater are mitigated.

Various remedial actions were evaluated in the SMU FS. The selected remedy for LF18 as outlined in the 2005 ROD includes the five major components listed below.

- Natural attenuation of contaminants of concern (COCs).
- LUCs for soil and groundwater.
- Groundwater monitoring.
- Additional sampling northeast of LF18/Area 9 (accomplished in 2006).
- Evaluation of vapor intrusion during groundwater remedial action phase (accomplished in 2007) (ORNL, 2007a).

4.2 REMEDY IMPLEMENTATION

In accordance with the 2005 ROD, a RAWP was prepared documenting the monitoring plan and sampling procedures for LF18/Area 9 (ORNL, 2006b). The plan included similar monitoring at three other SMU sites: LF17, SS07/Area 2, and FT01. Delineation sampling was conducted via direct-push to confirm whether other sources exist upgradient of the site. None was found and no further investigation upgradient was required. A total of 15 wells were selected to be monitored specifically for LF18/Area 9 (Table 2 and Attachment 1). Of these, two were new wells installed as part of the remedy (ORNL, 2006b). The SMU sites are sampled on a semi-annual schedule, with the first round completed during April 2006.

Table 2 – Well List for LF18/Area 9

Monitoring Wells	
DM419D	MW029S
DM419S	MW031D
DM420D	MW031S
DM456S	MW032D
DM457D	MW032S
GS401D	MW035D
MW028D	MW035S
MW029D	

At LF18, the primary mechanism of natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant, PCE, degrades to TCE, then to cis-1,2-DCE, then to vinyl chloride, and finally to ethene, a harmless gas.

Another aspect of the remedy includes the continued enforcement of existing LUCs for soil and groundwater. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including LF18. Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) The soil cover at LF18 will be maintained. (4) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and the off-Base property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (5) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the contaminants found at LF18 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 3 – RAO Groundwater Concentrations

Parameter	RAO Concentration[a] (µg/L)
cis-1,2-DCE	70
PCE	5
TCE	5
Vinyl chloride	2

[a]The groundwater RAOs are the MCLs
µg/L - micrograms per liter

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second,

DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the SMU ROD, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the West Management Unit. There are no buildings on top of LF18 or the Area 9 plume. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

In accordance with the ROD and RAWP for the SMU, groundwater monitoring of LF18/Area 9 began in 2006 and is ongoing. The costs associated with this activity are summarized in Table 4. LUC inspections began in 2006 and occur annually. Additionally, the turf covering at LF18 is regularly maintained as part of the Base golf course.

Table 4 – Annual Monitoring Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$99,000 (includes initial capital costs)
2007	$62,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the second five-year review for LF18. Since the last review, a new groundwater monitoring program has begun for natural attenuation of chlorinated solvents in groundwater. Groundwater monitoring results are discussed in Section 6.0. LUCs were also implemented at LF18, including an annual Base-wide inspection of the LUCs, and this is discussed in Section 6.0 as well.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for the LF18 groundwater remedy would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for LF18 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of LF18 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant LF18 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the long-term monitoring of the natural attenuation remedy at LF18/Area 9 (ORNL, 2006a, and 2007 - 2008). Groundwater sampling and analysis is the primary means of determining the remedy's continued effectiveness at LF18. The monitoring reports reviewed for the SMU, which includes LF18, evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

In accordance with the RAWP, the most recent groundwater data were collected in four semi-annual monitoring events beginning in April 2006. A total of 15 wells are sampled for volatile organic compounds (VOCs) and natural attenuation indicators. The RAO/MCL exceedences are highlighted in Table 5.

The COCs associated with LF18/Area 9 are cis-1,2-DCE, PCE, TCE, and vinyl chloride. Of these contaminants, only TCE has been detected with any frequency at levels above a RAO/MCL in two wells.

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at LF18 on that day (Attachment 4). The area is currently a well maintained fairway on the Base golf course. No new uses of groundwater on the site were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

Table 5 - RAO Exceedences at LF18/Area 9

Well	Date	cis-1,2-DCE (µg/L)	PCE (µg/L)	TCE (µg/L)	VC (µg/L)
RAO	--	*70*	*5*	*5*	*2*
DM419D	4/18/2006	0.98	3	65	ND
	10/17/2006	0.29	2.8	10	ND
	4//20/2007	ND	4.2	31	ND
	10/23/2007	ND	3.6	9.5	ND
DM419S	4/18/2006	ND	ND	ND	ND
	10/17/2006	ND	ND	0.2	ND
	4/20/2007	ND	0.01	ND	ND
	10/23/2007	ND	3.6	9.5	ND
DM420D	4/18/2006	1.5	ND	3.7	ND
	10/25/2006	1.7	ND	5.8	ND
	4/20/2007	ND	0.02	2.5	ND
	10/23/2007	ND	ND	3.1	ND
DM456S	4/18/2006	ND	ND	ND	ND
	10/16/2006	ND	ND	ND	ND
	4/25/2007	ND	ND	ND	ND
	10/22/2007	ND	ND	ND	ND
DM457D	4/18/2006	2.9	4.4	16	ND
	10/16/2006	2.8	5.6	24	ND
	4/20/2007	ND	4	17	ND
	10/23/2007	ND	5.6	16	ND
GS401D	4/19/2006	2.5	1.2	2	ND
	10/25/2006	4.7	ND	2	ND
	4/25/2007	ND	1.7	4.5	ND
	10/22/2007	ND	1.4	2.1	ND
MW028D	4/19/2006	ND	ND	1	ND
	10/24/2006	ND	ND	0.39	ND
	4/24/2007	ND	ND	0.7	ND
	10/22/2007	ND	ND	ND	ND
MW029D	4/17/2006	4.3	0.96	1.7	ND
	10/20/2006	ND	1.1	2.7	ND
	4/25/2007	ND	2.2	1.2	ND
	10/22/2007	ND	1.35	3.3	ND
MW029S	4/17/2006	ND	ND	ND	ND
	10/20/2006	ND	ND	ND	ND
	4/25/2007	ND	ND	ND	ND
	10/22/2007	ND	ND	ND	ND
MW031D	4/18/2006	ND	2.4	2.2	ND
	10/23/2006	ND	3	6.6	ND
	4/24/2007	ND	2.7	5.5	ND
	10/29/2007	ND	2.5	2.1	ND
MW031S	4/18/2006	ND	ND	ND	ND
	10/23/2006	ND	ND	ND	ND
	4/24/2007	ND	ND	ND	ND
	10/29/2007	ND	ND	ND	ND
MW032D	4/18/2006	1.3	0.83	4.9	ND
	10/23/2006	0.84	1.2	4.7	ND
	4/24/2007	ND	1.32	4.6	ND
	10/29/2007	ND	1.4	5.2	ND
MW032S	4/18/2006	0.23	ND	ND	ND
	10/23/2006	ND	ND	ND	ND
	4/24/2007	ND	ND	ND	ND
	10/29/2007	ND	ND	ND	ND
MW035D	4/18/2006	1.1	ND	1.6	ND
	10/24/2006	3.4	0.21	8.6	ND
	4/24/2007	ND	0.36	2.2	ND
	10/23/2007	ND	ND	10.3	ND
MW035S	4/18/2006	ND	ND	0.26	ND
	10/24/2006	ND	ND	ND	ND
	4/24/2007	ND	ND	ND	ND
	10/23/2007	ND	ND	ND	ND

ND - Not Detected
VC - Vinyl Chloride

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedy for LF18/Area 9 is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that the LF18/Area 9 COCs are consistently elevated in only two wells (DM419D and DM457D). Attachment 5 shows the plume as it was delineated in 2001 and in late 2007. Natural attenuation in conjunction with the source removal has made considerable progress in shrinking the plume at this site as illustrated in Attachment 5.

Site conditions and usage are unchanged since the implementation of the remedy. The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy. There have been no changes in ARARs since the RAOs were established in the SMU ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Commercial/industrial and residential exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed (USACE, 1997). The changes in these values and their effects on risks are qualitatively summarized in Table 6 (USEPA, 2007). As outlined in Table 6, the various changes could increase and decrease the overall carcinogenic risks and non-carcinogenic hazards. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 6 – Risk Assessment Review

Change	Effect
RBSCs decreased for dieldrin and gamma-BHC (lindane).	These chemicals would be included in the RA, slightly increasing overall risks and hazards.
RBSCs increased for 1,2-DCE, chlorobenzene, and manganese.	These chemicals would be excluded from the RA, slightly decreasing the overall hazards.

Table 6 – (cont'd)

Change	Effect
Inhalation reference dose increased for carbon tetrachloride and benzene.	A slight decrease in overall hazard.
Inhalation reference dose now available for PCE and TCE*.	A slight increase in overall hazard.
Oral reference dose decreased for TCE*.	A slight increase in overall hazard.
Oral reference dose now available for 1,4-dichlorobenzene, benzene, and iron.	A slight increase in overall hazard.
Inhalation slope factor decreased for benzene.	A slight decrease in overall risk.
Inhalation slope factor increased for PCE and TCE*.	A slight increase in overall risk.
Inhalation slope factor now available for 1,4-dichlorobenzene, and delta-BHC.	A slight increase in overall risk.
Oral slope factor increased for benzene, PCE, and TCE*.	A slight increase in overall risk.
Oral slope factor now available for delta-BHC.	A slight increase in overall risk.

RBSC - Risk-based screening criterion.
*Assessment of TCE based on 2001 provisional toxicity values.

The landfill at LF18 is no longer used and is currently part of the Base golf course. It is covered with soil and grass, minimizing possible ecological pathways.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological risk assessment. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

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

This review for LF18 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Landfill activities ceased at LF18 in the 1960s, and the site remains a well-maintained area on the Base golf course. Groundwater sampling upgradient of LF18/Area 9 did not reveal any chlorinated solvent source affecting groundwater as it migrates towards the Base golf course (SMU RAWP Addendum; ORNL, 2006b). RAO/MCL exceedences occur primarily in two wells located very close to the golf course tributary. Very minor exceedences occur sporadically in a few other wells. There is some evidence that the chlorinated solvents detected close to the tributary may be coming from site LF25, a former landfill, located on the other side of the stream. All information to date indicates that the COCs (cis-1,2-

DCE, PCE, TCE and vinyl chloride) are confined to the deeper portion of the Columbia Aquifer.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for LF18/Area 9 groundwater appears to be functioning as intended. Off-site migration of contaminants above action levels has not occurred. Chlorinated solvent concentrations are routinely above the RAOs/MCLs in only two site wells (DM419D and DM457D). These two wells are located at the southern edge of the plume, and may be at least partially affected by another nearby site (LF25). Long-term concentration trends in all wells continue to be downward. The site inspection revealed no physical changes at the site. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

Although degradation rates were not provided in the SMU monitoring reports, inspection of the contaminant trends (Table 5) indicates that degradation of chlorinated solvents occurs at a rate sufficient to prevent significant migration from the site. The remedy appears to be capable of achieving RAOs in the approximate 25-year time frame stated in the SMU ROD for the source area at LF18.

LUCs have been successfully implemented at the site.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater sampling during several investigations at LF18 demonstrated that site activities locally affected groundwater quality and that a potential exists for off-site migration. In response, natural attenuation with monitoring was initiated. LUCs were also implemented for soil and groundwater. It is recommended that monitoring continue on a regular schedule until the RAOs are achieved.

For future sampling events, it is recommended that the monitoring well network be optimized. Specifically, sampling of wells DM456S, MW028D, MW029S, MW029D, GS401D, MW031S, MW032S, and MW035S should be discontinued. For the last four sampling rounds (or even longer), no RAOs/MCLs have been exceeded in these wells and for most of the wells the COCs are below analytical detections limits. In addition, it is recommended that chloride be removed from the analysis list. The chloride data have not been useful in evaluating remedy progress at this site.

A worst case vapor intrusion evaluation was performed in 2008 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation

performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

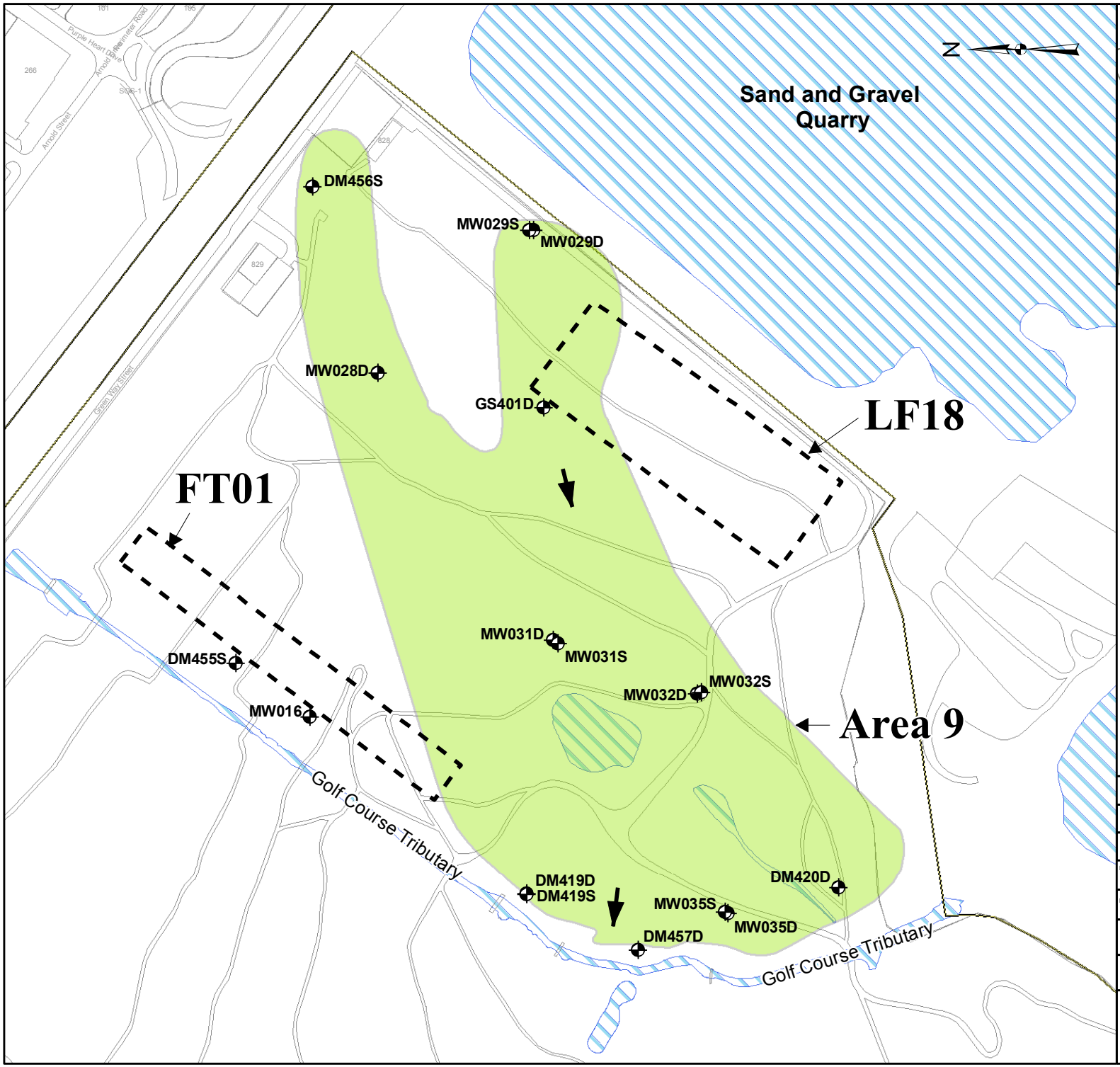
The site as a whole will also continue to be addressed in the five-year review process due to the LUCs and the continuation of groundwater monitoring.

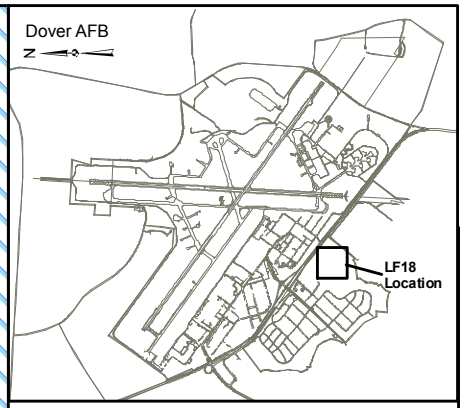
10.0 PROTECTIVENESS STATEMENT

The remedy at LF18 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for LF18 will be due in September 2013.





Legend

- Site Boundary
- Plume
- Monitoring Wells
- Groundwater Flow

0 100 200 400 Feet

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DES BY	DJM 07/14/2008
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878

Attachment 2 - Reviewed Documents

BWXT, 2003. Final Five-Year Reviews LF18 Soil, FT03 Structures/Soil and Groundwater, WP14/LF15 Groundwater, LF13 Groundwater, Dover Air Force Base, Delaware, prepared by URS Group, Inc, September 2003.

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

DAFB, 1996. Record of Decision, Site LF18, South Management Unit, Dover Air Force Base, Delaware, submitted August 1996, signed September 24, 1996.

DAFB, 1992. Interim Record of Decision for Recovery of Floating Wastes, WP14 (D-4) and LF18 (D-10) Sites, Dover Air Force Base, Delaware, November 1992.

ORNL, 2007 - 2008. Monitoring Reports, Sites LF17, SS07, FT01, and LF18, South Management Unit (multiple events), Dover Air Force Base, DE, submitted by URS Group, Inc., March 2007, September 2007, and May 2008.

ORNL, 2007a. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. Interim Remedial Action Completion Report, Sites LF17, SS07, FT01, and LF18, South Management Unit (SMU), Dover Air Force Base, DE, submitted by URS Group, Inc., August 2006.

ORNL, 2006b. South Management Unit Remedial Action Work Plan [and Addendum] Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2006.

USACE, 2005a. Final Feasibility Study [and Addendum: Plume Delineation and Assessment of Natural Attenuation], South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2005.

USACE, 2005b. Proposed Plan South Management Unit, Dover AFB, Delaware, January 2005.

USACE, 2005c. Record of Decision for LF17, SS07/Area 2, FT01, and LF18/Area 9 South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., December 2005.

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1999. Post Excavation Report, Site LF18, Dover Air Force Base, Delaware, submitted May 1999 by the U.S. Army Corps of Engineers, Omaha District.

Attachment 2 – (cont'd)

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [South Management Unit, Volumes I - IV].

USACE, 1996a. Final Engineering Evaluation and Cost Analysis, Site LF18, Dover Air Force Base, Delaware, submitted by Dames & Moore, June 1996.

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

USGS, 2002a. Summary of Ground-Water Quality for the LF18 Source Area/9th Tee Area, Dover Air Force Base, Delaware, April 2002. Letter report submitted September 6, 2002.

USGS, 2002b. Summary of Ground-Water Quality for the LF18 Source Area/9th Tee Area, Dover Air Force Base, Delaware, October 2001. Letter report submitted January 28, 2002.

USGS, 2001. Summary of Ground-Water Quality for the LF18 Source Area/9th Tee Area, Dover Air Force Base, Delaware, April 2001. Letter report submitted October 16, 2001.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for site LF18 are listed in the SMU ROD and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the SMU ROD. ARARs for each medium are discussed below.

Soil. A soil removal action has been completed at this site. Monitoring was conducted to confirm that impacts to groundwater were mitigated. Per the recommendation of the previous five-year review no further review of this removal action is necessary. However, the Basewide RI determined that there was an elevated risk to potential future residents. To control this potential exposure route, the Air Force decided to implement LUCs as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

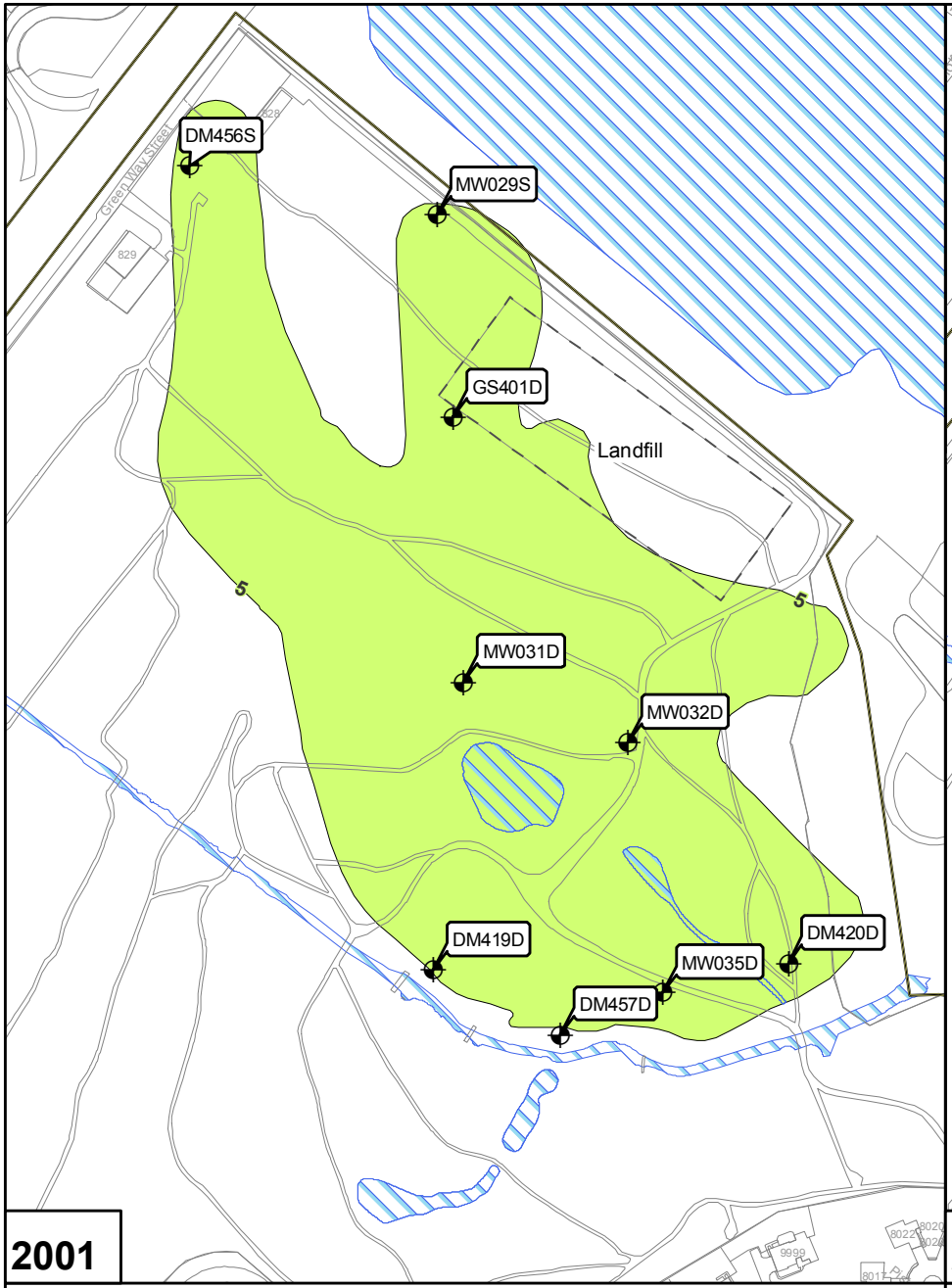
Groundwater. Federal MCLs for the COCs are unchanged. DNREC's *Delaware Risk-Based Corrective Action Plan* (DERBCAP) established Tier 1 groundwater standards that are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Action* (December 1999). For LF18 constituents, the standards in the guidance are the same as the Federal MCLs.

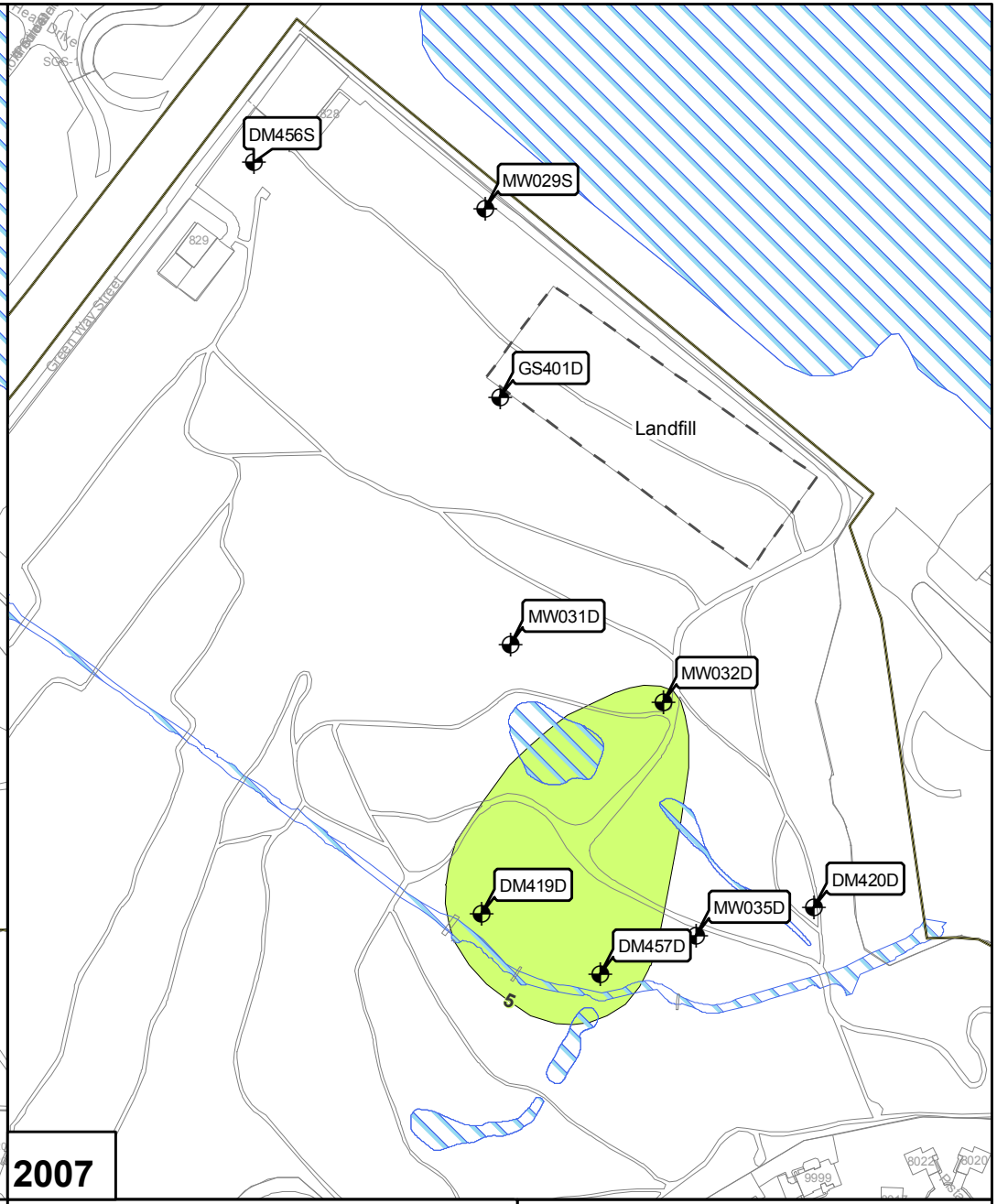
Surface Water and Sediment. The removal actions at LF18 and nearby site FT01 mitigated any continuing source that might have affected surface water or sediment in the nearby golf course tributary. Sampling conducted by the USGS found no impacts on the stream from groundwater. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4 - Site Photographs for LF18/Area 2

Top: Golf Course, soil removal area at LF18, looking north. November 14, 2007
Bottom: Golf Course, LF18 looking northeast along long dimensions of former landfill on November 14, 2007





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N

Site Boundary

Monitoring Well

>5µ/L Total Solvent Concentration Contour

>500µ/L Total Solvent Concentration Contour

0 100 200 400 600 800 Feet

PATH G:\Projects\Dover_AFB\5yr_Review_Figures\Sept 2008\LF18.mxd	
DES BY DJM 09/23/08	CHK BY LS
PROJ NO 15300779	FIGURE Attachment 5

URS

200 Orchard Ridge Drive
Gaithersburg, MD 20878

Attachment 5
Plume Maps for LF18/Area 9
2001 & 2007

FIVE-YEAR REVIEW FOR FT01
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under Contract DE-AC05-00OR22725

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of concern
DAFB	Dover Air Force Base
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
PCE	Tetrachloroethene
RA	Risk assessment
RAO	Remedial action objective
RAWP	Remedial Action Work Plan
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
SMU	South Management Unit
TCE	Trichloroethene
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

EXECUTIVE SUMMARY

The remedy for FT01, a former fire training area used during the 1950s and early 1960s at Dover Air Force Base (DAFB), Delaware, is natural attenuation with groundwater monitoring and land use controls (LUCs) for groundwater. No further action was required for soil. A feasibility study was finalized in January 2005 to determine the remedial action for contaminated groundwater. Groundwater remediation began with the installation of an additional monitoring well in 2006 in accordance with the Record of Decision (ROD) for the South Management Unit (SMU).

The initial trigger date for five-year reviews in the SMU was the start date of construction for the first remedy implemented in the SMU; a soil remediation that started on December 12, 1997 at site LF18. This is the first five-year review for FT01. Since achieving the construction complete milestone for all sites, DAFB has merged reviews for all sites into a comprehensive set of Base-wide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the groundwater remedy— natural attenuation with monitoring and LUCs— is operating as intended. The primary contaminants of concern (COCs) were benzene and chlorobenzene that formed a small plume, directly downgradient from former buried 55-gallon drums at the site. LUCs remain in effect and no new uses of groundwater or the site were observed. Monitoring data collected during the last two years show the COCs to be consistently below the remedial action objectives (RAOs), which are the drinking water maximum contaminant levels (MCLs). The latest monitoring report recommends site closure. This review confirmed the achievement of the RAOs established in the ROD and recommends that monitoring be stopped and closure documents be prepared for FT01.

The draft-final five-year review for FT01 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

FT01 is an Environmental Restoration Program (ERP) site formerly used for fire training activities at Dover Air Force Base (DAFB), Delaware, in the South Management Unit (SMU) (Attachment 1). The site was used from the 1950s to the early 1960s for a fire training area. The site was covered over with soil and grass when the Base golf course was constructed during the 1960s. No active remediation was conducted at the time of closure. Environmental investigations were subsequently conducted that revealed groundwater contamination as a particular concern and resulted in implementing a natural attenuation monitoring program under a 2005 Record of Decision (ROD). Land use controls (LUCs) for groundwater are also a component of the remedy. Due to a removal action, no further action for soil was required.

The groundwater remedial action at FT01 was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the first five-year review for the FT01 remedy. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

The natural attenuation monitoring at FT01 is one of several implemented remedies at SMU ERP sites. Similar groundwater monitoring occurs concurrently at three other SMU sites: LF17, LF18/Area 9, and the portion of the SS07/Area 2 plume that is not treated with accelerated anaerobic biodegradation. LUCs for groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the FT01 remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
1950s-1960s	FT01 was used as fire training area.
1960s	Base golf course was constructed over FT01.
1986	Stage I Site Investigation (SI) conducted at FT01, groundwater and surface water sampled (SAIC, 1986).
March 13, 1989	DAFB listed on National Priority List (NPL).

Table 1 (cont'd)

Date	Event
1991	SI at FT01 (HAZWRAP, 1991).
August 1997	Base-wide Remedial Investigation (RI) finalized; included assessment of FT01 (USACE, 1997).
March 1998	Removal action for three crushed 55-gallon drums and associated oil-contaminated soil at FT01.
1998	Post-removal groundwater sampling (USGS, 1999).
2000	Base-wide Ecological Risk Assessment (DAFB, 2000).
April 11, 2003	DNREC established a groundwater management zone (GMZ).
January 2005	Feasibility Study (FS) and Addendum for SMU finalized (USACE, 2005a).
January 2005	Proposed Plan prepared, included FT01 (USACE, 2005b).
December 2005	Final SMU ROD prepared, included FT01 (USACE, 2005c).
January 2006	Remedial Action Work Plan (RAWP) prepared, included FT01 (ORNL, 2006b).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report prepared, included FT01 (ORNL, 2006a).
2006 - 2008	Semi-annual natural attenuation monitoring at FT01 (ORNL, 2007 - 2008).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007a).

DNREC – Department of Natural Resources and Environmental Control.
HAZWRAP – Hazardous Waste Remedial Actions Program
SAIC – Science Applications International Corporation
USACE – U.S. Army Corps of Engineers (Omaha District)
USGS – U. S. Geological Survey

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

FT01 is located underneath the Base golf course next to a drainage tributary in the SMU, south of U.S. Route 113 (Attachment 1). It is approximately 900 feet (ft) long and 50 ft wide. The ground surface is covered with highly maintained grass and is currently part of the Base golf course. It is gently sloping and is contoured to direct surface water runoff into the Base golf course tributary which discharges into the St. Jones River. Groundwater at the site is typically encountered at depths between 2.71 to 15.20 ft below ground surface.

3.2 LAND AND RESOURCE USE

DAFB previously used the site for fire training exercises in the 1950s and 1960s. Once these activities ceased, the site was covered with soil and part of the Base golf course was constructed above it. This site has been consistently used for recreational purposes since that time.

The shallow groundwater (Columbia Aquifer) underlying the site flows to the west towards the golf course tributary and southwest towards the confluence of the golf course tributary and the St. Jones River. This aquifer is not currently used as a drinking water source. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and

Frederica Aquifers. Off site, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB, including the Base golf course. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

At FT01, waste oils, waste solvents, paint thinners and jet fuel were stored on site and used for fire training activities. Operations at the site consisted of spreading approximately 1,000 gallons of waste fuels and flammable liquids on a water-saturated area, igniting the material and using protein foams to extinguish the flames. Although most of the materials most likely burned, some contaminants may have been released to the soil and groundwater.

Soil samples taken at FT01 during the RI were found to have limited contaminants, primarily some pesticides and metals. The presence of these contaminants is related to the routine maintenance of the golf course grass and not related to historical activities at the fire training area. DAFB conducted a removal action in 1998 after discovery of a buried drum by golf course maintenance workers. Oil-contaminated soil was removed during the excavation of three 55-gallon drums. Thus, the soil is not currently affecting the groundwater, and does not require further remedial action.

Groundwater contamination was present in a localized area directly downgradient of the former buried drums. The two contaminants are benzene and chlorobenzene. The maximum detected concentrations of these contaminants were 96 and 170 micrograms – per liter (µg/L), respectively (USGS, 1999). The contaminant concentrations rapidly declined in the downgradient direction and no fuel contaminants were found in groundwater samples collected one foot into the golf course tributary streambed.

The Base-wide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

In the late 1990s, Base workers discovered a buried drum during installation of a sprinkler system on the golf course at FT01. DAFB conducted a removal action to prevent drum contents from further leakage into the ground. Three 55-gallon drums, their contents, and associated oil-contaminated soil were removed.

Treatment alternatives for FT01 groundwater were evaluated in the Basewide FS (USACE, 2005a). The selected remedial action for groundwater is natural attenuation with monitoring and LUCs, which was documented in a proposed plan and submitted for public review on February 15, 2005. At the end of 2005/early 2006, a ROD was signed for the soil and groundwater at FT01. The selected remedy is natural attenuation with monitoring and LUCs for groundwater, and no further action for the soil medium.

3.5 BASIS FOR TAKING ACTION

The Basewide RI risk assessment (RA) evaluated a hypothetical future unrestricted industrial and residential use scenarios for groundwater and soil at FT01 (USACE, 1997). Based on this industrial/residential use scenario evaluation, groundwater contamination did not result in risk exceeding established federal criteria. However, Federal Safe Drinking Water Act maximum contaminant levels (MCLs) were exceeded at the site. Although groundwater from the Columbia Aquifer at FT01 is not a drinking water source, there is a potential for contaminants of concern (COCs) to migrate off Base where the aquifer has the potential for beneficial use. This potential for contaminant migration to areas not under DAFB control was the reason for taking remedial action at FT01. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for FT01 was signed by USEPA in January 2006 (USACE, 2005c). The remedial action objective (RAO) was developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, the RAO for FT01 groundwater is the reduction of contaminant concentrations in groundwater to MCLs. No further action was required for soil.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. LUCs serve to prevent unacceptable exposure to groundwater until the RAOs are achieved.

Various remedial actions were evaluated in the SMU FS. The selected remedy for FT01 groundwater as outlined in the 2005 ROD includes the four major components listed below.

- Natural attenuation of COCs in groundwater.
- LUCs for groundwater.
- Groundwater monitoring.

- Evaluation of vapor intrusion during groundwater remedial action phase (accomplished in 2007; ORNL 2007a).

4.2 REMEDY IMPLEMENTATION

In accordance with the 2005 ROD, a RAWP was prepared documenting the monitoring plan and sampling procedures (ORNL, 2006b). The plan included similar monitoring at three other SMU sites: LF17, LF18/Area 9, and SS07/Area 2. Two wells were selected to be monitored specifically for FT01 on a semi-annual schedule. Of these, one was a new well installed as part of the remedy, to monitor the progress of natural attenuation. Monitoring well IDs are listed in Table 2. Sample analyses include volatile organic compounds (VOCs) and geochemical indicators of natural attenuation. The SMU sites are sampled on a semi-annual schedule.

Table 2 – Monitoring Wells

Monitoring Wells
DM455S
MW016

Another aspect of the remedy includes the continued enforcement of existing LUCs for groundwater at FT01. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including FT01. Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (4) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the contaminants found at FT01 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 3 – RAO Groundwater Concentrations

Parameter	RAO Concentration[a] (µg/L)
Benzene	5
Chlorobenzene	100

[a]The groundwater RAOs are the MCLs

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second,

DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the SMU ROD, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the West Management Unit. There are no buildings on top of FT01. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

In accordance with the ROD and RAWP for the SMU, groundwater monitoring of FT01 began in 2006 and is ongoing. The costs associated with this activity are summarized in Table 4. LUC inspections began in 2006 and occur annually.

Table 4 – Annual Monitoring Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$59,000 (includes initial capital costs)
2007	$14,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for FT01.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for the FT01 groundwater remedy would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for FT01 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of FT01 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public

Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant FT01 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the long-term monitoring of natural attenuation at FT01 (ORNL, 2006a, and 2007 - 2008). Groundwater sampling and analysis is the primary means of determining the remedy's continued effectiveness at FT01. The monitoring reports reviewed for the SMU, which includes FT01, evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

Groundwater data at FT01 have been collected in semi-annual sampling rounds since 2006 in accordance with the RAWP. There have been four sampling events, during which two wells are regularly sampled at FT01. The two groundwater COCs associated with the site are benzene and chlorobenzene. As summarized in Table 5, there have been no RAO/MCL exceedences in either monitoring well. Notably, most samples contained no detectable concentration of either COC.

Table 5 – COC Summary

Well	Date	Benzene (µg/L)	Chlorobenzene (µg/L)
RAO	**--**	***5***	***100***
DM455S	4/20/2006	0.3	18
	10/26/2006	ND	0.96
	4/20/2007	ND	ND
	10/29/2007	ND	ND
MW016	4/19/2006	ND	ND
	10/24/2006	ND	ND
	4/20/2007	ND	ND
	10/29/2007	ND	ND

ND- not detected

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at FT01 on that day (Attachment 4). The area is currently a well-maintained fairway on the Base golf course. No new uses of groundwater on the site were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the

comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for FT01 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that the small plume of benzene and chlorobenzene has significantly degraded. All COCs have been below RAOs/MCLs for four successive semi-annual sampling events. Site conditions and usage are unchanged since the implementation of the remedy. The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring the could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the SMU ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Commercial/industrial and residential exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed (USACE, 1997). The changes in these values and their effects on risks, are qualitatively summarized in Table 6 (USEPA, 2007). As outlined in Table 6, the various changes could increase and decrease the overall carcinogenic risks and non-carcinogenic hazards. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 6 – Risk Assessment Review

Change	Effect
RBSCs decreased for PCE and bis(2-ethylhexyl) phthalate.	These chemicals would be included in the RA, slightly increasing overall risks and hazards.
Inhalation reference dose increased for carbon tetrachloride.	A slight decrease in overall hazard.
Inhalation reference dose now available for chloroform, PCE, and TCE*.	A slight increase in overall hazard.
Oral reference dose decreased for TCE*.	A slight increase in overall hazard.
Oral slope factor increased for PCE and TCE*.	A slight increase in overall risk.
Inhalation slope factor increased for PCE and TCE*.	A slight increase in overall risk.
Oral slope factor now available for chloroform.	A slight increase in overall risk.

RBSC - risk-based screening criterion.
*Assessment of TCE based on 2001 provisional toxicity values.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). In addition, groundwater monitoring has shown that the RAOs have been achieved at this site. Natural attenuation was successful at reducing the contaminant mass within the small FT01 plume. Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

All of the fire training area is covered with clean soil and grass turf, minimizing possible ecological pathways.

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

This review for FT01 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Fire training activities ceased at FT01 in the 1960s, and the site remains a well-maintained golf course. All information to date indicates that the COCs (benzene and chlorobenzene) are below RAOs/MCLs.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for FT01 groundwater appears to be functioning as intended. Off-site migration of contaminants above action

levels has not occurred. In fact, COC concentrations are below RAOs/MCLs in both site wells. The lack of RAO/MCL exceedences in four successive rounds of sampling indicates that RAOs have been achieved and that this condition is stable. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

LUCs have been successfully implemented at the site.

8.0 ISSUES

No issues were discovered during the review that affects the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater sampling during the SI and RI at FT01 demonstrated that site activities locally affected groundwater quality and that a potential existed for off-site migration. In response, natural attenuation monitoring at the site was initiated. Based on assessment of the remedy monitoring data, the RAOs established in the ROD for the SMU have been achieved at FT01.

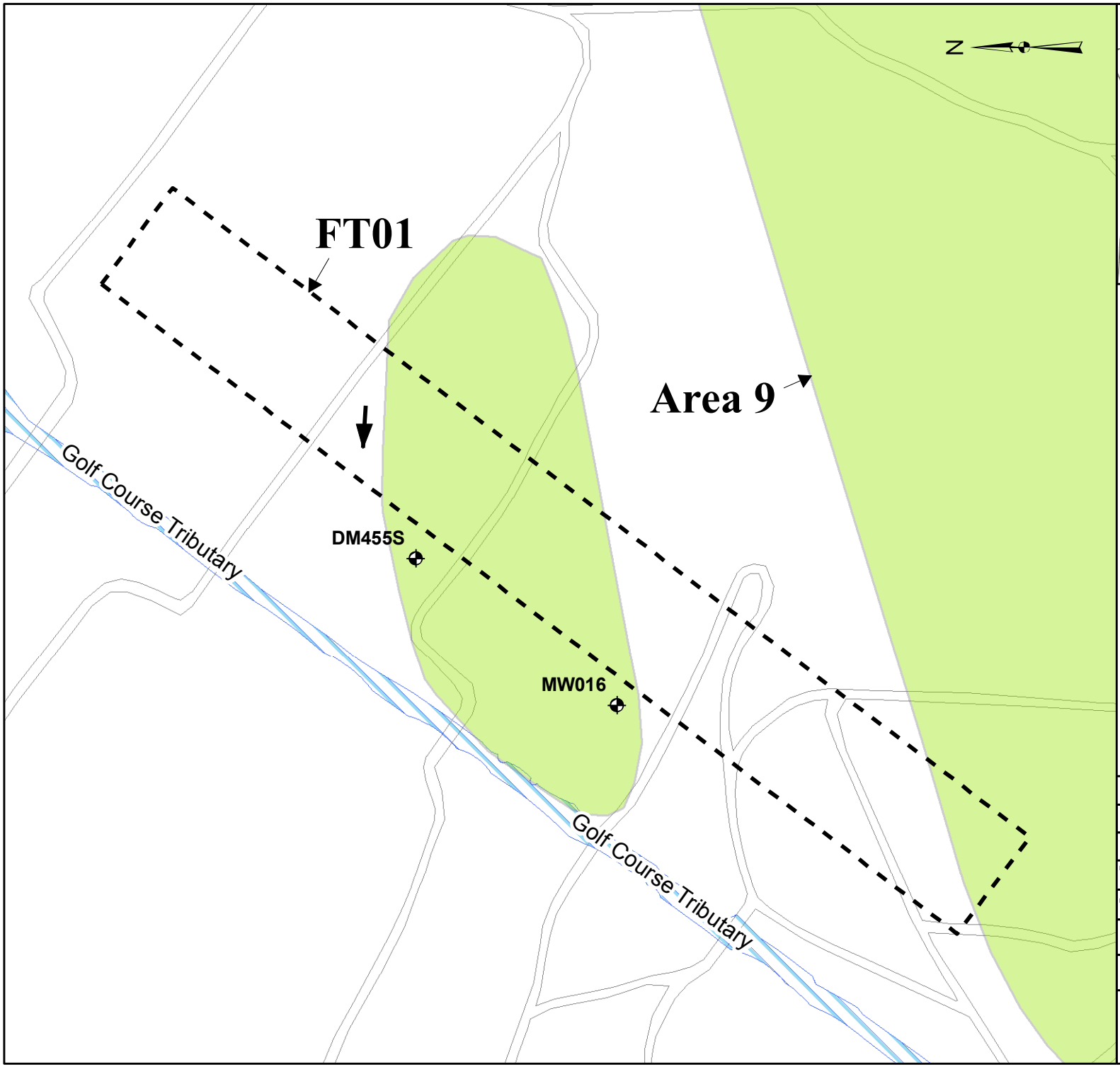
FT01 is recommended for site closure. It is recommended that monitoring be suspended and that closure documents for the site be prepared. On-site use of groundwater from the Columbia Aquifer will remain prohibited due to the proximity of the nearby LF18/Area 9 groundwater plume. LUCs for groundwater will be maintained in accordance with the remedy for the LF18/Area 9 plume.

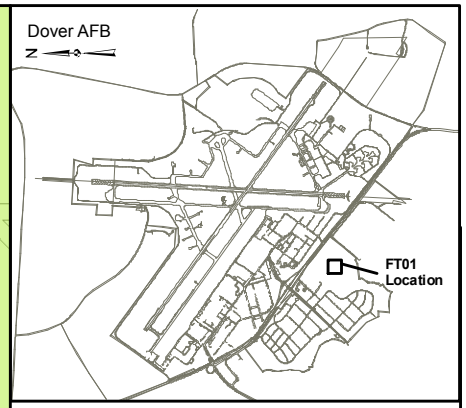
10.0 PROTECTIVENESS STATEMENT

The remedy at FT01 has achieved the RAOs and remains protective of human health and the environment.

11.0 NEXT REVIEW

No further reviews will be required if the site is closed per the recommendations in this report.





Legend

- FT01 Boundary
- Plume
- Monitoring Wells
- Groundwater Flow

0 50 100 200 Feet

TITLE	FT01 Site Map
CLIENT	DAFB/ORNL
PROJ	2008 Five-Year Reviews
PATH	G:\Projects\Dover_AFB\5yr_Review_Figures\SMU\FT01.mxd
PATH	P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\ Five Year Reviews 2008\H. Reports\SMU\Figures\FT01_Attch1.pdf
DES BY	DJM 07/14/2008
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878

Attachment 2 – Reviewed Documents

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

HAZWRAP, 1991. Site Investigation Report for FT01, submitted by Dames & Moore, September 1991.

ORNL, 2007 - 2008. Monitoring Reports, Sites LF17, SS07, FT01, and LF18, South Management Unit (multiple events), Dover Air Force Base, DE, submitted by URS Group, Inc., March 2007, September 2007, and May 2008.

ORNL, 2007a. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. Interim Remedial Action Completion Report, Sites LF17, SS07, FT01, and LF18, South Management Unit (SMU), Dover Air Force Base, DE, submitted by URS Group, Inc., August 2006.

ORNL, 2006b. South Management Unit Remedial Action Work Plan [and Addendum] Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2006.

SAIC, 1986. USAF Installation Restoration Program – Dover AFB, Delaware, Phase II – Stage I Confirmation/Quantification.

USACE, 2005a. Final Feasibility Study [and Addendum: Plume Delineation and Assessment of Natural Attenuation], South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2005.

USACE, 2005b. Proposed Plan South Management Unit, Dover AFB, Delaware, January 2005.

USACE, 2005c. Record of Decision for LF17, SS07/Area 2, FT01, and LF18/Area 9 South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., December 2005.

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [South Management Unit, Volumes I - IV].

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

USGS, 1999. Data Letter for FT01 Groundwater Samples, Summer 1998, submitted to Dover Air Force Base, Delaware on February 9, 1999.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for site FT01 are listed in the SMU ROD and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the ROD. ARARs for each medium are discussed below.

Soil. A soil removal action has been completed at this site. Monitoring was conducted to confirm that impacts to groundwater were mitigated. No further action was required for soil.

Groundwater. Federal MCLs for the monitored constituents (benzene and chlorobenzene) are unchanged. DNREC's DERBCAP established Tier 1 groundwater standards that are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Action* (December 1999). For FT01 constituents, the standards in the guidance are the same as the Federal MCLs.

Surface Water and Sediment. The removal action at FT01 mitigated any continuing source that might have affected surface water or sediment in the nearby golf course tributary. Sampling conducted by the USGS found no impacts on the stream from groundwater. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4 - Site Photograph for FT01

Looking west along golf course tributary at FT01 on November 14, 2007.

BASEWIDE FIVE-YEAR REVIEWS
DOVER AIR FORCE BASE, DELAWARE

VOLUME III - WEST MANAGEMENT UNIT

FIVE-YEAR REVIEWS FOR

- **Area 5**
- **Area 6**
- **LF25**
- **SS08**

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

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Prepared for:

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Dover Air Force Base
436 CES/CEAO
600 Chevron Avenue
Dover AFB, Delaware 19902-5600

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Dover Air Force Base		
EPA ID *(from WasteLAN)*: DE8570024010		
Region: 3	**State:** DE	**City/County:** Dover/Kent County
SITE STATUS		
NPL status: _X_ Final __ Deleted __ Other (specify)		
Remediation status (choose all that apply): __ Under Construction _X_ Operating (Area 5[a], Area 6[b], LF25, SS08) ___ Complete		
Multiple OUs?* _X_ YES __NO	**Construction completion date:** 09 / 30 / 2006	
Has site been put into reuse? __ YES _X_ NO		
REVIEW STATUS		
Lead agency: __ EPA __ State __ Tribe _X_ Other Federal Agency - U.S. Air Force		
Author name: URS Group, Inc. (under Oak Ridge National Laboratory contract) for USAF		
Author title:	**Author affiliation:**	
Review period:** October 2003 to September 2008		
Date(s) of site inspection: November 14, 2007		
Type of review: X Post-SARA __ Pre-SARA __ NPL-Removal only __ Non-NPL Remedial Action Site __ NPL State/Tribe-lead __ Regional Discretion		
Review number: _x[c]_ 1 (first) _X[d]_ 2 (second) ___ 3 (third) __ Other (specify) _____		
Triggering action: __ Actual RA Onsite Construction at OU #____ __ Actual RA Start at OU#____ __ Construction Completion X Previous Five-Year Review Report __ Other (specify)		
Triggering action date *(from WasteLAN)*: 30 Sep 2003		
Due date *(five years after triggering action date)*: 30 Sep 2008		

* [“OU” refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]
a – Area 5 sites include OT51, OT50, SS20, OT41/Motor Pool, and OT44
b – Area 6 sites include WP21, WP31, ST34, OT41/Bldg. 719, OT48, SS59, and OT28
c – All Area 5 sites and four Area 6 sites (WP31, ST34, OT48, and OT28)
d – Three Area 6 sites (WP21, OT41/Bldg. 719, and SS59)

Five-Year Review Summary Form, cont'd.

Issues:

Final remedies for sites in the West Management Unit (WMU) at Dover AFB were selected in three 2006 Records of Decision (RODs): the ROD for Area 5, the ROD for Area 6, and the ROD for SS08 and LF25. Area 5 and Area 6 are multi-site groundwater contaminant plumes. Area 5 includes sites OT51, OT50, SS20, OT41/Motor Pool, and OT44. Area 6 includes sites WP21, WP31, ST34, OT41/Bldg. 719, OT48, SS59, and OT28. Remedial action objectives (RAOs) were established for soil and groundwater at each site. For groundwater, the RAOs are the federal drinking water maximum contaminant levels (MCLs) for the contaminants of concern (COCs) specific to each plume or site. For each plume, accelerated anaerobic biodegradation (AAB) and natural attenuation with groundwater monitoring are the primary remedy components. Land use controls (LUCs) are also a component of the remedy for groundwater and for soil at all sites except at OT28 where no further action was required for soil. No issues were noted during the Five-Year Review of the WMU sites that could affect the protectiveness of the remedies.

Recommendations and Follow-up Actions:

Area 5: Based on the initial success of the remedy, it is recommended that AAB and natural attenuation activities continue in Area 5. It is recommended that semi-annual groundwater monitoring continue across the plume to confirm that contaminants are biodegrading. It is also recommended that LUCs continue to be enforced and monitored. Ongoing optimization of the operation & maintenance (O&M) of the remedy, as documented in the Area 5 monitoring reports and the Area 5 chapter of this review, is recommended as well.

Area 6: Based on the initial success of the remedy, it is recommended that AAB and natural attenuation activities continue in Area 6. It is recommended that semi-annual groundwater monitoring continue across the plume to confirm that contaminants are biodegrading. It is also recommended that LUCs continue to be enforced and monitored. As documented in the Area 6 monitoring reports and the Area 6 chapter of this review, ongoing optimization of remedy O&M, and additions/substitutions to the monitoring well network, are recommended as well.

LF25: It is recommended that AAB and natural attenuation activities continue at LF25, and that semi-annual groundwater monitoring continue at the site to confirm that contaminants are biodegrading. It is also recommended that LUCs continue to be enforced and monitored. As documented in the monitoring reports and the LF25 chapter of this review, ongoing optimization of remedy O&M and deletion of one well from the monitoring network are recommended as well.

SS08: It is recommended that AAB activities continue at SS08, and that semi-annual groundwater monitoring continue at the site to confirm that contaminants are degrading. It is also recommended that LUCs continue to be enforced and monitored. As documented in the monitoring reports and the SS08 chapter of this review, ongoing optimization of remedy O&M and deletion of one well from the monitoring network are recommended as well.

Protectiveness Statement: *The remedies at Area 5, Area 6, LF25, and SS08 in the West Management Unit at Dover AFB are protective of human health and the environment. In the interim until RAOs are met at these sites, exposure pathways that could result in unacceptable risks are being controlled.*

Other Comments:

None.

Steven B. Harrison

STEVEN B. HARRISON, Colonel, USAF
Commander, 436th Airlift Wing

FIVE-YEAR REVIEW FOR AREA 5
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

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For the
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Under Contract DE-AC05-00OR22725

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LIST OF ACRONYMS AND ABBREVIATIONS

AAB	Accelerated anaerobic biodegradation
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of concern
DAFB	Dover Air Force Base
DAP	Dibasic ammonium phosphate
DCE	Dichloroethene
DelDOT	Delaware Department of Transportation
DERBCAP	Delaware Risk-Based Corrective Action Program
DO	Dissolved Oxygen
DNREC	Department of Natural Resources and Environmental Control
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMA	Grounds Maintenance Area
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
IRACR	Interim Remedial Action Completion Report
IWCD	Industrial waste collection drain
LUC	Land use control
MCL	Maximum contaminant level
MIP	Membrane Interface Probe
µg/L	Micrograms per liter
NA	Natural attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
ORP	Oxidation reduction potential
PCE	Tetrachloroethene
PICT	Permanent injection circulation transect
RA	Risk assessment
RAO	Remedial action objective
RAWP	Remedial Action Work Plan
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
TCE	Trichloroethene
TOC	Total organic carbon

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile organic compound
WMU	West Management Unit

EXECUTIVE SUMMARY

Area 5 is a large groundwater contaminant plume located in the West Management Unit (WMU) at Dover Air Force Base (DAFB), Delaware. It is associated with five sites: OT51, OT50, SS20, OT44, and OT41/Motor Pool. DAFB's general strategy for addressing contaminant release sites is to group sites within their associated groundwater plumes and address cleanup requirements by plume. Thus, the Area 5 plume and its five sites are being addressed as one operable unit in this Five-Year Review.

The remedy for Area 5 was selected in a Record of Decision (ROD) signed in April 2006. The remedy addresses the plume as a whole and individual sites as necessary. For groundwater, the remedy includes a combination of accelerated anaerobic biodegradation (AAB), natural attenuation with monitoring, and land use controls (LUCs). LUCs have also been implemented for soil at all sites.

This is the first five-year review for Area 5. Since achieving the construction complete milestone for all sites, DAFB has merged reviews for sites into a comprehensive set of Base-wide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the Area 5 remedy is operating as intended. Source area treatments and transect injections are reducing the concentrations of the contaminants of concern (COCs). LUCs remain in effect and no new uses of groundwater or soil at any of the sites were observed. It is recommended that AAB injections and remedy monitoring continue in accordance with the Remedial Action Work Plan (RAWP) and the recommendations made in the semi-annual monitoring reports. Also monitoring of natural attenuation should continue to confirm that COCs decline to levels that meet the remedial action objectives (RAOs) specified in the Area 5 ROD.

The draft-final five-year review for Area 5 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

Area 5 is a large groundwater contaminant plume that resulted from several commingling releases and is located at Dover Air Force Base (DAFB), Delaware, in the West Management Unit (WMU) (Attachment 1). Area 5 is associated with five Environmental Restoration Program (ERP) sites OT51, OT50, SS20, OT44, and OT41/Motor Pool, which were used for various industrial purposes. The majority of the activity at the sites has ceased; however OT44 is currently used as a facility to maintain refueling vehicles. Also, OT41/Motor Pool, a portion of the former industrial waste collection drain (IWCD), is now part of the Base's sanitary sewer. The contaminants in the Area 5 plume primarily include chlorinated solvents. Benzene and toluene (components of fuel) are minor components. Although interim actions have occurred at some of the sites, the final remedies were selected in a 2006 Record of Decision (ROD) for Area 5. The remedies include accelerated anaerobic biodegradation (AAB), natural attenuation with monitoring, and land use controls (LUCs) for soil and groundwater.

The remedial action at Area 5 is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use or unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the first five-year review for Area 5. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

The AAB and natural attenuation with monitoring remedies are the major components of Area 5. Similar remedies for groundwater were implemented concurrently at nine other WMU sites: SS08, LF25, and the seven sites associated with another plume called Area 6 (WP31, WP21, ST34, OT41/Bldg 719, OT49, OT28, and SS50.). LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the Area 5 sites and remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
1969	OT50 oil/water separator and attached underground storage tank (UST) installed.
1984	Underground pipe leak was repaired and visibly contaminated soil was removed at SS20.
March 1989	DAFB listed on the National Priority List (NPL).
1990	Installation Restoration Program, soil gas surveys, subsurface soil and groundwater sampling at SS20 (HAZWRAP, 1990).
1991	Site Investigation (SI) reports for OT51, OT50, OT44, and OT41 (HAZWRAP, 1991a, b, c, d).
1992	Oil/water separator at OT51 removed.
1994	USTs, pumps and associated piping and 60 yards of contaminated soil removed at SS20.
April 1997	Oil/water separator and associated soil at OT44 was removed and replaced.
August 1997	Basewide Remedial Investigation (RI) finalized for WMU. Included OT51, OT50, SS20, OT44, OT41/Motor Pool, and Area 5 (USACE, 1997).
2000	Base-wide Ecological Risk Assessment (USACE, 2000b)
September 2000	Source Characterization of ST04, OT50 and OT51 (USACE, 2000a).
September 29, 2000	Groundwater sampling at Grounds Maintenance Area (GMA) (USGS, 2000).
April 11, 2003	DNREC established a groundwater management zone (GMZ) encompassing DAFB.
May 2005	Final Feasibility Study (FS) for WMU, including Area 5 (USACE, 2005).
January 2006	Proposed Plan prepared, Area 5 (USACE, 2006a).
March 2006	ROD prepared for OT51, OT50, SS20, OT44, OT41/Motor Pool, and Area 5 (USACE, 2006b).
May 2006	Area 5 – WMU Remedial Action Work Plan (RAWP) completed (ORNL, 2006a).
May-July 2006	Installation of injection/extraction and monitoring wells at Area 5.
May-October 2006	First round of AAB injections.
June 2006 - ongoing	AAB and natural attenuation monitoring begins (ORNL, 2007 – 2008).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
September 2006	Interim Remedial Action Completion Report (IRACR) prepared for Area 5 (ORNL, 2006b).
July 2007	Second round of AAB injections.
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007a).

HAZWRAP – Hazardous Waste Remedial Actions Program
USACE – U.S. Army Corps of Engineers
USGS – U.S. Geological Survey

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

The Area 5 plume is located in the northern portion of the WMU (Attachment 1). The plume of commingling contaminants begins at the large hangars near the parking apron and extends downgradient to U.S. Route 113 towards the St. Jones River. The ground surface at Area 5 is covered almost entirely by buildings, concrete, and asphalt. Isolated grassy areas in this industrialized portion of the Base are contoured to direct surface runoff to nearby storm drains. The water table is usually encountered between 10

and 12 feet (ft) below ground surface (bgs) although it can be found as shallow as 3 ft bgs closer to the St. Jones River.

Contaminants are found in the shallow portion of the aquifer near the industrial source areas and they migrate deeper within the aquifer as groundwater flows southwestward.

3.2 LAND AND RESOURCE USE

A brief summary of the activities at each site is provided in Table 2. All five of the Area 5 sites are located in the industrial area of DAFB and none are accessible to the general public. Aircraft and vehicle maintenance and other industrial activities are conducted in the location of Area 5.

The shallow groundwater (Columbia Aquifer) underlying the site generally flows southwest towards the St. Jones River, the ultimate discharge location. This aquifer is not currently used as a drinking water source and any on-site groundwater use is prohibited at all five sites and Area 5 as a whole. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. The river is used for recreational purposes but is not used for potable water. Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, Department of Natural Resources and Environmental Control (DNREC) has implemented a GMZ that encompasses DAFB and the portion of off-Base property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. There is currently no use of the unconfined Columbia Aquifer occurring on the off-Base properties downgradient of the Area 5 plume.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

Area 5 is a multi-source groundwater plume to which each of the five sites have contributed contamination. The contaminants of concern (COCs) found at Area 5 are benzene, cis-1,2-dichloroethene (cis-1,2-DCE), tetrachloroethene (PCE), trichloroethene (TCE), toluene, and vinyl chloride. Benzene and toluene are minor components of the plume. Although evidence of natural biodegradation of the chlorinated solvents has been observed within this plume, it has been insufficient to keep the plume from reaching the Base boundary at levels exceeding maximum contaminant levels (MCLs). Brief summaries of the history of contamination based primarily on data collected during the Basewide RI at each of the individual sites are provided in Table 2.

Table 2 - Site Summary

Site ID	Site Description	Contamination Assessment Conclusions	Previous Remedial Activities
OT51	OT51 is a former oil/water separator that served adjacent Building 794, a large aircraft hangar. Effluent from the oil/water separator flowed through a pipe to a ditch that eventually discharged to the North Drainage Ditch (ERP Site SD12). The site was expanded to include the area around nearby Buildings 794, 789 and former Buildings 790 and 791, all aircraft hangars.	Groundwater data collected during the RI at OT51 showed a wide area of chlorinated solvent contamination encompassing a number of large aircraft hangars in this area (Buildings 794, 789 and former Buildings 790 and 791).	The oil/water separator was removed in early 1992 as part of normal Base operations, and the area around the drainage ditch was re-graded.
OT50	An oil/water separator with an attached UST installed in 1969 at the south side of Building 715, an aircraft maintenance hangar. The site was expanded to include the area surrounding Building 716, another adjacent aircraft hangar. There are no signs of a release from the separator itself, however, groundwater data suggests that solvents were relased in the area probably from past maintenance activities at nearby buildings.	Groundwater data at this site show a wide area of contamination encompassing another nearby aircraft hanger, Building 716.	None.
SS20	SS20 is the site of a former vehicle refueling facility near Building 635 (the vehicle maintenance shop) and U.S. Route 113. An underground pipe leak was identified in 1984 after an indeterminate volume of fuel had been released. A PCE spill also occurred at this site at an unkonwn date. Base employees believe that the contaminated soil from this spill was excavated and was properly disposed; however, there is no written record of this activity.	Fuel is known to have been released from the former vehicle refueling facility. Also sampling conducted during the RI found both fuel and solvent contamination commingled in shallow groundwater at this site.	Tanks, pumps, associated piping and 60 cubic yards of contaminated soil were removed in 1994 under an Environmental Compliance project in accordance with DNREC Tank Management Program requirements. In 1997, a pilot-scale field test of permeable reactive barrier system for treating chlorinated solvent contamination in groundwater was installed in the vicinity of SS20.
OT44	A former oil/water separator at Building 636, a refueling vehicle maintenance facility, with interior service bays and two outdoor washracks. The reinforced concrete oil/water separator was located below ground in a grass-covered area. It was replaced as part of normal Base operations in 1997 and is currently in service.	Both fuel and chlorinated solvent trichloroethene (TCE) were found in the groundwater.	The oil/water separator, its holding tank, and some contaminated soil were removed in 1997 as part of normal Base operations. A new oil/water separator was installed at the same location.
OT41/Motor Pool	A portion of the IWCD in the vicinity of the Base Motor Pool (Buildings 635 and 636). Wastewater from vehicle maintenance associated with Buildings 635 and 636 is discharged through the IWCD and into the sanitary sewer.	Mixed solvent and fuel contamination was found in groundwater here during the RI. The contaminants found in the deep portion of the aquifer are related to the sources farther upgradient at OT51, OT50 and SS20.	None.
Area 5	Area 5 is the multi-source groundwater plume to which each of the five sites have contributed contamination.	The plume originates near the aircraft maintenance hangars (OT51 and OT50), and extends southwestward past the former refueling facility (SS20) and beyond the motor vehicle shops (OT44 and OT41/Motor Pool) to cover approximately 30 acres. A small area of very low level solvent contamination in groundwater near the GMA, north of the DAFB North Gate is also being addressed with Area 5.	None.

For the purpose of evaluating remedies under the WMU FS, a target area within Area 5 was defined based on groundwater data collected during a 2000 source characterization study of OT50 and OT51 (USACE, 2000a). This area, the core of the Area 5 plume, is enclosed by the 500 micrograms per liter (µg/L) total chlorinated solvent contour (Attachment 1).

A small area of low-level solvent contamination in groundwater, located near the GMA north of the DAFB North Gate, is also being addressed as part of Area 5 (Attachment 1). No source areas or sites specific to the GMA were identified during investigations of that area, and, therefore, the residual groundwater contamination in that area is being addressed in association with Area 5.

There are currently four separately owned State or private properties that are potentially in the downgradient flow path of the Area 5 plume. In 1989/1990, investigations by the Delaware Department of Transportation (DelDOT) showed that there is a fuel source at one of the off-Base properties and a shallow PCE source at another. Based on the locations and levels of contamination found, it is probable that these are the sources for the contamination found in nearby drinking water wells (previously removed from service), although the investigation could not completely eliminate DAFB (Area 5 plume) as a possible contributing source. DAFB provided potable water to these affected off-Base properties from the early 1980s through 2003, at which time the properties were connected to a municipal water supply.

The Base-wide Ecological Risk Assessment (USACE, 2000b) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

Area 5 and its associated five ERP sites have a long and complex history of investigation, cleanup action, and interim remedies. In overview, DAFB's strategy for Area 5 is organized into three parts:

(1) DAFB's first considerations were to address source materials constituting principal threats, soil contamination that could pose a continuing threat to groundwater, and soil contamination that could pose risks to on-Base workers at the five sites. All required soil cleanup actions for the five sites have been completed using industrial cleanup standards prior to preparing the final ROD for Area 5. These actions are listed in Tables 1 and 2.

(2) The next stage of the Area 5 cleanup strategy was addressed in the Area 5 ROD. A final groundwater remedy was selected and this included the controls necessary to ensure that land use restrictions and groundwater use prohibitions are maintained. The selected remedy addresses all remaining response actions required for all media at the five sites and the Area 5 groundwater plume.

Treatment alternatives for Area 5 were evaluated in the WMU FS (USACE, 2005). The selected remedial action for Area 5 was primarily a combination of AAB and natural attenuation with monitoring, and LUCs for both soil and groundwater. It was documented in a proposed plan and submitted for public review on July 10, 2005. In early 2006, a ROD was signed for the soil and groundwater at Area 5. The selected remedy included AAB, natural attenuation with monitoring, and LUCs for soil and groundwater.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater at Area 5 since it is located in an industrial portion of the Base (USACE, 1997b). The human health RA for Area 5 and its five associated sites (OT51, OT50, SS20, OT44, and OT41/Motor Pool) concluded that:

- Carcinogenic risk from hypothetical future commercial/industrial exposure to groundwater at OT51, OT50, SS20, and Area 5 exceeds the USEPA risk criterion.

- Groundwater contaminant concentrations at all five sites and Area 5 exceed federal MCLs. There are residential, industrial, and agricultural users of the Columbia Aquifer within the surrounding community. Although groundwater at the Columbia Aquifer at Area 5 is not a drinking water source, there is potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences at all five sites and the Area 5 plume trigger the need for action.

- Non-carcinogenic risk from hypothetical future commercial/industrial exposure to groundwater at OT51, OT50, SS20, OT41/Motor Pool, and Area 5 equals or exceeds the USEPA risk criterion.

Additionally, although no unacceptable human health risks were found for soil at OT51, OT50, SS20, OT44, OT41/Motor Pool, and Area 5, this conclusion was based on the assumption that land use at these five sites will remain industrial. Therefore, action was required to address groundwater risks at all five sites and the Area 5 plume, and to ensure the permanence and reliability of the land use assumptions used to assess the sites. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for Area 5 was signed by USEPA in April 2006 (USACE, 2006b). The remedial action objectives (RAOs) were developed based on the potential for

contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, one of the RAOs for groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. By restricting access, potential exposures to soil and groundwater are mitigated. LUCs for soil and groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the WMU FS. The selected remedies for Area 5 groundwater and soil as discussed in the 2006 ROD include the five major components listed below.

- Injection/diffusion AAB in the core of the Area 5 plume, including several source areas.
- Natural attenuation at the Area 5 plume outside the AAB treatment areas.
- Groundwater monitoring.
- LUCs for soil and groundwater.
- Evaluation of vapor intrusion during groundwater remedial action phase (accomplished in 2007) (ORNL, 2007a).

4.2 REMEDY IMPLEMENTATION

Remedy implementation and monitoring were performed in accordance with the Area 5 RAWP (ORNL, 2006a) and documented in the IRACR for Area 5 (ORNL, 2006b). For the AAB application, two injection methods were used to deliver substrate into the ground: direct push injection in four source areas, and injection into permanent well transects installed perpendicular to groundwater flow across the plume. Initial injections in Area 5 occurred between May and August 2006. Prior to starting AAB, shallow source areas were delineated using membrane interface probes (MIPs) to focus the direct push application of amendments. The four source areas (labeled E, F, G, and H; Attachment 1) were then treated by injecting substrate at closely located points. The substrate consisted of emulsified vegetable oil and sodium lactate added to potable water. Dibasic ammonium phosphate (DAP) was also added to the mixture to provide metabolic nutrients. The potable water was processed through activated carbon to remove chlorine before mixing. A direct-push rig and pump truck were used to inject the mixture into temporary boreholes on an approximate 10-foot grid pattern at multiple depths within each of the four source areas.

For the transect injections, a total of 59 4-inch stainless steel injection and extraction wells were installed across the core of the Area 5 plume to create ten plume

injection circulation transects (PICTs; Attachment 1). As with the direct-push injections, a combination of emulsified vegetable oil, sodium lactate, and DAP were injected into the subsurface to stimulate the biodegradation of chlorinated solvents. However, the PICT process uses a mobile AAB process trailer powered by a generator to extract groundwater, amend it with substrate, and re-inject the mixture into the aquifer. Three mobile injection trailers were assembled on-site for use in the entire WMU in accordance with the generalized designs presented in the RAWP. Along each PICT, groundwater was extracted from every other well, amended, and then returned to the aquifer under pressure through adjacent injection wells, creating a push-pull effect. Injection quantities for both the source area injections and the initial PICT injections are documented in the Area 5 IRACR.

At Area 5. the primary mechanism of both AAB and natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant, PCE, degrades to TCE, then to cis-1,2-DCE, then to vinyl chloride, and finally to ethene, a harmless gas.

Monitoring programs for both AAB and natural attenuation were established at Area 5 in accordance with the RAWP. Wells used to monitor progress of AAB are listed in Table 3. AAB monitoring was conducted more frequently just after injections and then progressed to monthly, then quarterly, then semi-annual sampling after a year. Early in the AAB monitoring program the focus was on the distribution of total organic carbon (TOC) and indicator parameters: dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, dissolved iron, and sulfate. At month 3, after the substrate had some time to stimulate biodegradation, volatile organic compound (VOC) and dissolved gases analyses were added to the monitoring program.

Monitoring for natural attenuation includes VOCs and indicator parameters on a semi-annual schedule. Wells in the natural attenuation program are also listed in Table 3. The first semi-annual sampling round for natural attenuation was completed in July 2006. The monitoring results for both the initial AAB monitoring and the initial natural attenuation monitoring are documented in the Area 5 IRACR.

Table 3 – Area 5 Wells

Well ID	Well Purpose	
	AAB	NA
DM3501S	X	
DM3502S	X	
DM3503S	X	
DM3504S	X	X
DM3504D	X	X
DM3505S	X	
DM4507D	X	
DM4506D	X	
DM3507D	X	
DM3508S	X	X
DM3508D	X	X

Well ID	Well Purpose	
	AAB	NA
DM3517M	X	
DM329S		X
DM329D		X
DM331S		X
DM331D		X
DM334S	X	X
DM334D	X	X
DM335S		X
DM335D		X
DM339S	X	
DM339D	X	

Table 3 – (cont'd)

Well ID	Well Purpose	
	AAB	NA
DM3509F		X
DM3510D	X	
DM3511D		X
DM3512S		X
DM3513D	X	
DM3514D	X	X
DM3515D	X	
DM3516M	X	X

Well ID	Well Purpose	
	AAB	NA
DM375D		X
DM378F		X
MW078S		X
MW078D		X
MW214S		X
MW214D	X	X
MW216S	X	X
MW216D	X	X

NA – natural attenuation

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including Area 5. Some of the primary controls are: (1) Land use of sites OT50, OT51, SS20, OT44, and OT41/Motor Pool is restricted to industrial purposes. (2) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (3) All work that disturbs the subsurface is required to be cleared through the Base digging permit process to ensure compliance with land use restrictions. (4) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a portion of off-Base property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (5) DAFB conducts an annual inspection of the LUCs and documents the findings.

The groundwater RAOs for the contaminants found at each site in Area 5 are listed in Table 4. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 4 – Groundwater RAOs

Contaminant	OT51	OT50	SS20	OT44	OT41/Motor Pool	Area 5	RAO* (µg/L)
Benzene	**X**		**X**	**X**	**X**	**X**	**5**
cis-1,2-DCE	**X**	**X**	**X**	●	**X**	**X**	**70**
PCE	**X**	**X**	**X**		**X**	**X**	**5**
TCE	**X**	**X**	**X**	**X**	**X**	**X**	**5**
Toluene	**X**		**X**		**X**		**1,000**
Vinyl chloride	**X**	**X**	●	●	●	**X**	**2**

X = COC present at this site.
● Potential COC due to the breakdown of other COCs
* RAO is the Federal MCL

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the Area 5 ROD, a RA was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). In-door air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the WMU, and six of these are above the Area 5 plume. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the sites change, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

Remedial operations have been ongoing in Area 5 since the initial injections were completed in August 2006. A second round of PICT injections was accomplished during 2007, and a third round of PICT injections commenced in April 2008. AAB and natural attenuation monitoring events are currently both conducted on a semi-annual schedule in accordance with the Area 5 RAWP. Semi-annual reports document all of the monitoring results. Additionally, LUCs inspections and reporting are conducted annually.

The main maintenance activities associated with the Area 5 remedy are:

- Maintain integrity of the PICT wells, ensure that well caps and protective covers are secured.
- Maintain the mobile treatment trailer hoses, pumps, and monitoring equipment in good working order.
- Maintain the generator in good working order so as to provide adequate power to the control panels, light fixtures, submersible and metering pumps and receptacles at the system trailer.
- LUCs inspections are conducted on an annual basis.

The costs associated with the Area 5 AAB remedy and natural attenuation monitoring are summarized in Table 5.

Table 5 – Annual Remedy Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$665,000 (includes initial capital costs)
2007	$501,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for Area 5.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for Area 5 would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for Area 5 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of Area 5 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant Area 5 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the information collected to date as part of the combination of remedies at Area 5. Major components of the selected remedy are AAB for groundwater in the core of the plume and source areas, natural attenuation with monitoring for the areas not being treated by AAB, and LUCs for soil and groundwater. The latest groundwater monitoring data for AAB and natural attenuation were collected in January 2008 (ORNL 2007 - 2008). The monitoring reports reviewed for Area 5 evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network. Data for each remedy component are summarized below with selected contaminant trend charts to illustrate remedy progress where applicable.

1. At the source areas treated by direct injection of AAB substrates, degradation of parent COCs is observed with corresponding increases in breakdown products. These trends are shown for Source Area E in Attachment 5. After injection, PCE

and TCE concentrations declined and increases in cis-1,2-DCE, vinyl chloride, and in particular ethene occurred, which indicates complete dechlorination is being achieved.

2. Ten PICTs cross the core of the Area 5 plume. Trend charts for two examples are shown in Attachment 6. At PICT 1, breakdown products (cis-1,2-DCE and vinyl chloride) are the predominant COCs indicating perhaps a very old release. After injection, both of these COCs eventually declined to concentrations less than 25 µg/L while ethene (proving complete dechlorination) remained stable at about 100 µg/L (Figure 6a). Near PICT 3, TCE had been present at almost 200 µg/L and has since declined to below its MCL of 5 µg/L. Successful breakdown is illustrated by the increasing cis-1,2-DCE trend and the relatively stable presence of ethene (Figure 6b).

3. Natural attenuation is a component of the overall treatment strategy and pertains primarily to the portions of the Area 5 plume that are as yet unaffected by the AAB treatments. This includes the GMA. Two examples illustrate COC trends within Area 5: DM3508D (Figure 7a) and DM3511D (Figure 7b). DM3508D is in the upgradient portion of Area 5. COC trends in this well are relatively stable over time and at elevated concentrations. As treatment progresses at Source Area E and PICT 3 (both upgradient of DM3508D), declines are expected to be observed in this well. DM3511D is used to observe conditions near the edge of the Area 5 plume. COC concentrations are much lower here although PCE routinely hovers slightly above its RAO/MCL in this well. The RAO/MCL exceedences at Area 5 are summarized in Attachment 8 for the most recent sampling event (January 2008). At the GMA, only one slight MCL exceedence occurred in MW078S (PCE at 11.4 µg/L) and this is consistent with past sampling rounds.

4. LUCs have been implemented for soil and groundwater at all sites and Area 5. No new uses of groundwater, soil, or the sites were observed during the November 2007 site inspection. These observations were corroborated in DAFB's annual LUCs monitoring report (DAFB, 2007).

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at Area 5 sites on that day (Attachment 4). The facilities here are surrounded by lawns and parking lots.

A summary of the site inspections is listed below. Overall, no new uses of groundwater, soil or the sites were observed. No conditions were observed that would affect the integrity of the remedy.

- OT51 – The oil/water separator at this site was removed and the drainage ditch where it discharged was graded and seeded with grass. The surrounding area

remains covered by hangars (Buildings 794, 789, and 760), large paved areas, and a few small grassy areas.

- OT50 – The oil/water separator is present and surrounded by patched asphalt pavement. Building 715 and the adjacent Building 716 continue to be used as hangars. The area around these buildings is paved.

- SS20 – The location of a former vehicle refueling facility, this area is currently a parking lot. Building 639 is also part of SS20, and the location of a PCE spill. The building is surrounded by parking lots.

- OT44 – OT44 was the oil/water separator that services Building 636, the maintenance shop for aircraft refueling vehicles. The separator was removed in 1997 and replaced with a new one at the same location.

- OT41/Motor Pool – This site is the IWCD (now part of the sanitary sewer) that collects industrial wastewater from the motor pool buildings. The area above the IWCD is paved.

Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for Area 5 is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that excellent progress has been made towards achieving the RAOs in the source areas where AAB was applied. The change in plume extent is shown in Attachment 9, which illustrates the plume as it existed in 2005 (prior to starting remediation) and in 2008.

The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies

were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effects on risks are qualitatively summarized in Table 6 (USEPA, 2007). The various changes could increase and decrease the overall carcinogenic risks and non-carcinogenic hazards. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 6 – Risk Assessment Review

Site	Change	Effect
OT51	RBSC values increased for 4-methylphenol, beryllium, and manganese, and is no longer available for di-n-octyl phthalate.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
	RBSC values decreased for 1,2-dichloropropane, benzo[k]fluoranthene, naphthalene, and vanadium, and is now available for iron.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	Inhalation reference doses increased for 1,2-DCA and benzene.	A slight decrease in overall hazards.
	Inhalation reference doses are now available for PCE, TCE*, and vinyl chloride.	A slight increase in overall hazards.
	Oral reference doses decreased for TCE* and are now available for 1,2-dibromo-3-chloropropane, benzene, and vinyl chloride.	A slight increase in overall hazards.
	Inhalation slope factors increased for 1,2-dibromo-3-chloropropane, PCE, and TCE*, and is now available for 1,2-dichloropropane.	A slight increase in overall risks.
	Inhalation slope factors decreased for benzene and vinyl chloride.	A slight decrease in overall risks.
	Inhalation slope factors are no longer available for benzo[a]anthracene and benzo[b]fluoranthene.	A slight decrease in overall risks.

Table 6 – (cont'd)

Site	Change	Effect
OT51 (cont'd)	Oral slope factors increased for PCE and TCE*, and is now available for benzo[k]fluoranthene.	A slight increase in overall risks.
	Oral slope factors decreased for 1,2-dibromo-3-chloropropane, benzene, vinyl chloride, and arsenic.	A slight decrease in overall risks.
OT50	RBSC value increased for manganese.	This chemical would be excluded from the RA, slightly decreasing overall hazards.
	Inhalation reference doses are now available for PCE, TCE*, and vinyl chloride.	A slight increase in overall hazards.
	Oral reference doses decreased for TCE*, and are now available for vinyl chloride and 1,4-dichlorobenzene.	A slight increase in overall hazards.
	Inhalation slope factors increased for PCE and TCE*, and is now available for 1,4-dichlorobenzene.	A slight increase in overall risks.
	Inhalation slope factor decreased for vinyl chloride.	A slight decrease in overall risks.
SS20	Oral slope factors increased for PCE and TCE*, and decreased for vinyl chloride.	A slight increase and decrease, respectively, in overall risks.
	RBSC values increased for ethylbenzene, toluene, and nickel.	These chemicals would be excluded from the RA, slightly decreasing overall hazards.
	RBSC values decreased for xylenes, bis(2-ethylhexyl)phthalate, and naphthalene.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	RBSC values now available for 2-methyl naphthalene and iron.	A slight increase in overall hazards.
	Inhalation reference doses increased for 1,2-DCA and benzene.	A slight decrease in overall hazards.
	Inhalation reference doses are now available for PCE and TCE*.	A slight increase in overall hazards.
	Oral reference dose increased for manganese.	A slight decrease in overall hazard.
	Oral reference dose decreased for TCE*, and is now available for benzene.	A slight increase in overall hazards.
	Inhalation slope factors increased for PCE and TCE*, and decreased for benzene.	A slight increase and decrease, respectively, in overall risks.
	Inhalation slope factor is no longer available for benzo[a]anthracene.	A slight decrease in overall risk.
	Oral slope factors increased for benzene, PCE, and TCE*, and decreased for arsenic.	A slight increase and decrease, respectively, in overall risks.
OT44	RBSC values increased for toulene and manganese.	These chemicals would be excluded from the RA, slightly decreasing overall hazards.
	RBSC value decreased for xylene and is now available for 2-methyl naphthalene.	These chemicals would be included in the RA, slightly increasing overall hazards.

Table 6 – (cont'd)

Site	Change	Effect
OT44 (cont'd)	Inhalation reference dose increased for benzene.	A slight decrease in overall hazard.
	Inhalation reference doses are now available for PCE, TCE,* and naphthalene.	A slight increase in overall hazards.
	Oral reference doses decreased for PCE, TCE*, and naphthalene, and is now available for benzene.	A slight decrease and increase, respectively, in overall hazards.
	Inhalation slope factor increased for PCE and TCE,* and decreased for benzene.	A slight increase and decrease, respectively, in overall risks.
	Oral slope factors increased for benzene, PCE, and TCE.*	A slight increase in overall risks.
OT41/Motor Pool	RBSC values increased for beryllium and manganese.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
	RBSC values decreased for bis(2-ethylhexyl)phthalate, naphthalene, and aldrin.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	Inhalation reference dose increased for benzene and is now available for PCE and TCE*.	A slight decrease and increase, respectively, in overall hazards.
	Oral reference dose decreased for TCE* and is now available for benzene.	A slight increase in overall hazards.
	For benzene, inhalation slope factor decreased, and oral slope factor increased.	A slight decrease and increase, respectively, in overall risks.
	Inhalation and oral slope factors increase for PCE and TCE*.	A slight increase in overall risks.
Area 5	RBSC values increased for 1,1-DCE, ethylbenzene, toluene, 4-methylphenol, beryllium, and nickel.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
	RBSC values decreased for xylene, N-nitrosodipropylamine, aldrin, vanadium, and are now available for 2-methyl naphthalene and iron.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	Inhalation reference doses increased for 1,2-DCA, and benzene.	A slight decrease in overall hazards.
	Inhalation reference doses decreased for methylene chloride, and are now available for PCE, TCE*, vinyl chloride, and naphthalene.	A slight increase in overall hazards.
	Oral reference doses increased for manganese.	A slight decrease in overall hazards.
	Oral reference doses decreased for TCE, and naphthalene, and are now available for benzene and vinyl chloride.	A slight increase in overall hazards.
	Inhalation slope factors increased for PCE and TCE*.	A slight increase in overall risks.

Table 6 – (cont'd)

Site	Change	Effect
Area 5 (cont'd)	Inhalation slope factors decreased for benzene and vinyl chloride, and is no longer available for benzo[a]anthracene.	A slight decrease in overall risks.
	Oral slope factors increased for benzene, PCE, and TCE*.	A slight increase in overall risks.
	Oral slope factors decreased for vinyl chloride and arsenic.	A slight decrease in overall risks.

RBSC – Risk-based screening criterion
*Assessment of TCE based on 2001 provisional toxicity values.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). In addition, groundwater monitoring has shown that the contaminant plume in this area has remained relatively stable. In fact, source area and plume core remediation is successfully reducing contaminant mass within the plume. Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

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

This review for Area 5 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Land use across Area 5 is unchanged and there have been no reports of new contaminant releases. All information collected to date indicates that the remedy is operating as intended and that progress has been made towards achieving the RAOs.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for Area 5 groundwater is functioning as intended. The monitoring data presented in the latest 2008 Area 5 Monitoring Report (ORNL, 2007 - 2008) provides evidence that the injections created anaerobic zones within the plume favorable to reductive dechlorination. In the treatment zones, COC degradation is progressing more rapidly. Ethene is also present in several wells indicating that complete degradation is occurring. It will be some time before areas downgradient of the AAB treatments see the effects.

Although degradation rates were not provided in the Area 5 monitoring reports, inspection of the contaminant trend charts (Attachments 5, 6, and 7) indicates that degradation of chlorinated solvents significantly increased in response to AAB treatment. Should the trends established during the first two years continue, the remedy appears to be capable of achieving RAOs in the 6 – to 20-year time frame state in the Area 5 ROD for the plume core.

At this time, natural attenuation alone is insufficient to prevent migration of the Area 5 plume. The AAB remedy, implemented along multiple transects across the Area 5 plume is designed to increase degradation rates to levels sufficient to reduce overall contaminant mass, and eventually, in combination with natural attenuation, achieve the RAOs. Data collected to date provide positive evidence of initial remedy success. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

LUCs have been successfully implemented at the site.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater data from several past studies at Area 5 demonstrated that site activities locally affected groundwater quality and that a potential exists for off-site migration. In response, AAB and natural attenuation with monitoring were initiated.

Based on the initial success of the remedy, it is recommended that AAB and natural attenuation activities continue in Area 5. It is also recommended that the proposals made in the semi-annual reports for optimizing both AAB and the monitoring well network be implemented. The recommended operation and maintenance improvements include the following actions:

- Conduct future sampling activities for both AAB and natural attenuation at Area 5 on a semi-annual schedule in accordance with the RAWP.
- Remove chloride from the sample analyte list. This indicator has not been useful in assessing site conditions.
- Continue to enforce LUCs at the site.

A worst case vapor intrusion evaluation was performed in 2008 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

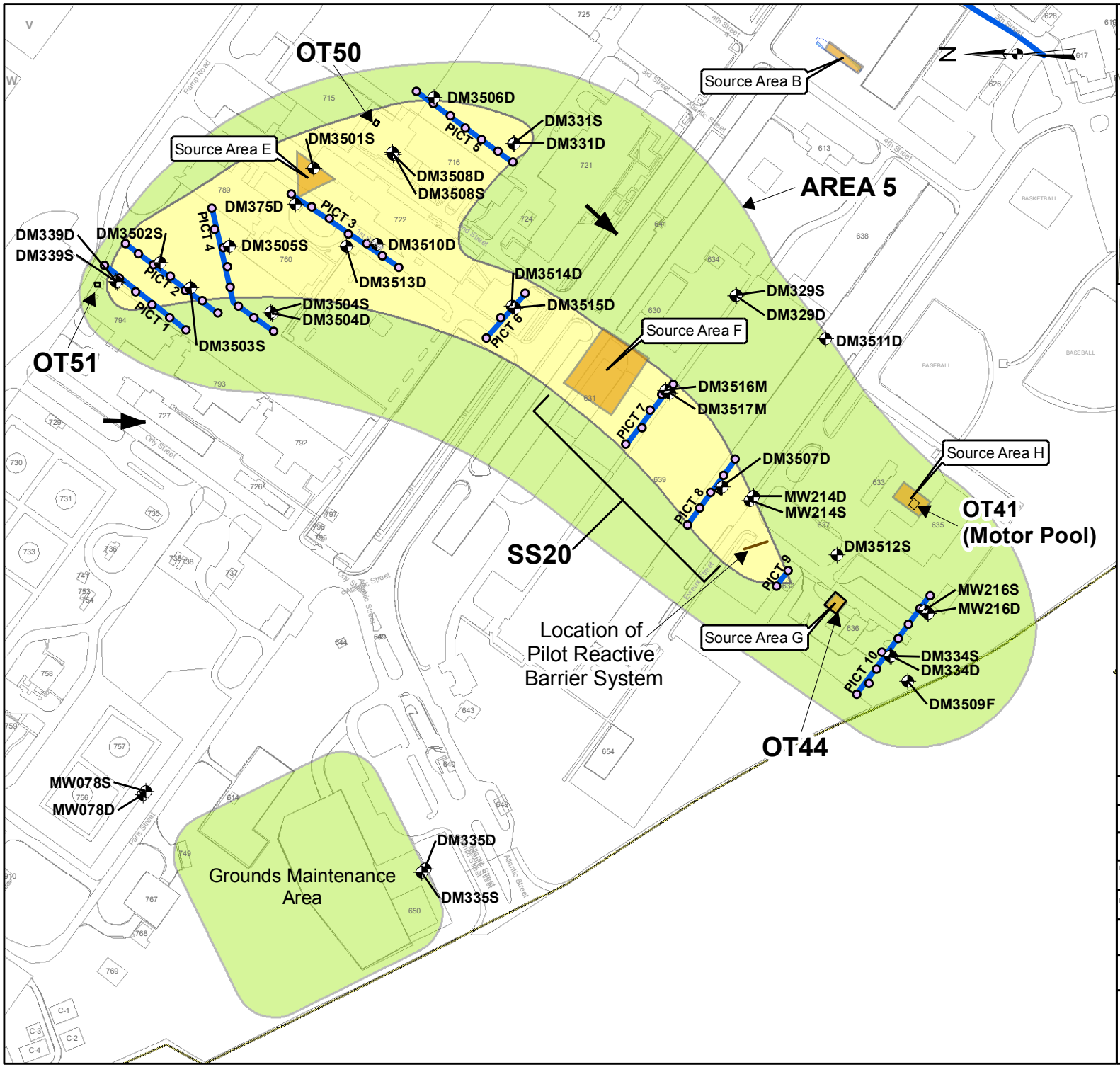
The site as a whole will continue to be addressed in the five-year review process since the remedy (including LUCs) and groundwater monitoring are still active at Area 5.

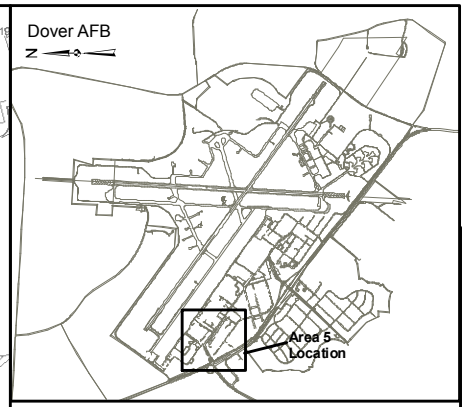
10.0 PROTECTIVENESS STATEMENT

The remedy at Area 5 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for Area 5 will be due in September 2013.





Legend

- Plume
- Plume Core
- Source Treatment
- Monitoring Well
- PICT
- Groundwater Flow

0 150 300 600 Feet

TITLE	Area 5 Site Map
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PROJ	2008 Five-Year Reviews
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DES BY	DJM 07/14/2008
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878

Attachment 2 - Reviewed Documents

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

HAZWRAP, 1991 a-d. Site Investigation Reports for OT51, OT50, OT44, and OT41, submitted by Dames & Moore, September 1991.

HAZWRAP, 1990. Installation Restoration Program, Draft Technical Memorandum: Sampling and Data Results, Sites T-1, SP-9 *[SS20]*, D-4, and DD-1, Dover Air Force Base, Delaware, submitted by E.C. Jordan and C.C. Johnson & Malhotra, February 1990.

ORNL, 2007 - 2008. Monitoring Report for Area 5, West Management Unit (through January 2008), Dover Air Fore Base, Delaware, submitted by URS Group, Inc., June 2008.

ORNL, 2007a. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. Area 5 – West Management Unit Remedial Action Work Plan, Dover Air Force Base, Delaware, submitted by URS Group, Inc., May 2006.

ORNL, 2006b. Interim Remedial Action Completion Report. Area 5 – West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., September 2006.

USACE, 2006a. Proposed Plan, Area 5, Dover AFB, Delaware, submitted by URS Group, Inc., January 2006.

USACE, 2006b. Record of Decision for OT51, OT50, SS20, OT44, OT41/Motor Pool, and Area 5, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., March 2006.

USACE, 2005. Final Feasibility Study West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., May 2005.

USACE, 2000a. Summary Report Source Characterization of ST04, OT50, and OT51, Dover Air Force Base, Delaware, submitted by Dames & Moore, September 2000.

USACE, 2000b. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [West Management Unit, Volumes I - IV].

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs are listed in the ROD for Area 5 and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the ROD. ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario. In addition, soil removal actions were completed at several sites (see Table 2). However, since residential risks were not evaluated, the Air Force decided to implement LUCs as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's *Delaware Risk-Based Corrective Action Plan* (DERBCAP) established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For Area 5 COCs, the standards in this guidance are the same as the Federal MCLs.

Surface Water and Sediment. Surface water and sediment are not present at Area 5. Sampling conducted for the Basewide Ecological Risk Assessment revealed no VOCs in the surface water or sediment collected from downstream drainages that could be affected by Area 5 and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4 – Site Photographs Area 5
Site OT51

Top: northeast corner of Building 794 at OT51 (former location of oil/water separator) on November 14, 2007.
Bottom: former drainage from Building 794 at OT51 on November 14, 2007. Facing southeast.

Attachment 4 – Site Photographs Area 5
Site OT50

Oil/Water Separator at Building 715 (OT50) on November 14, 2007.

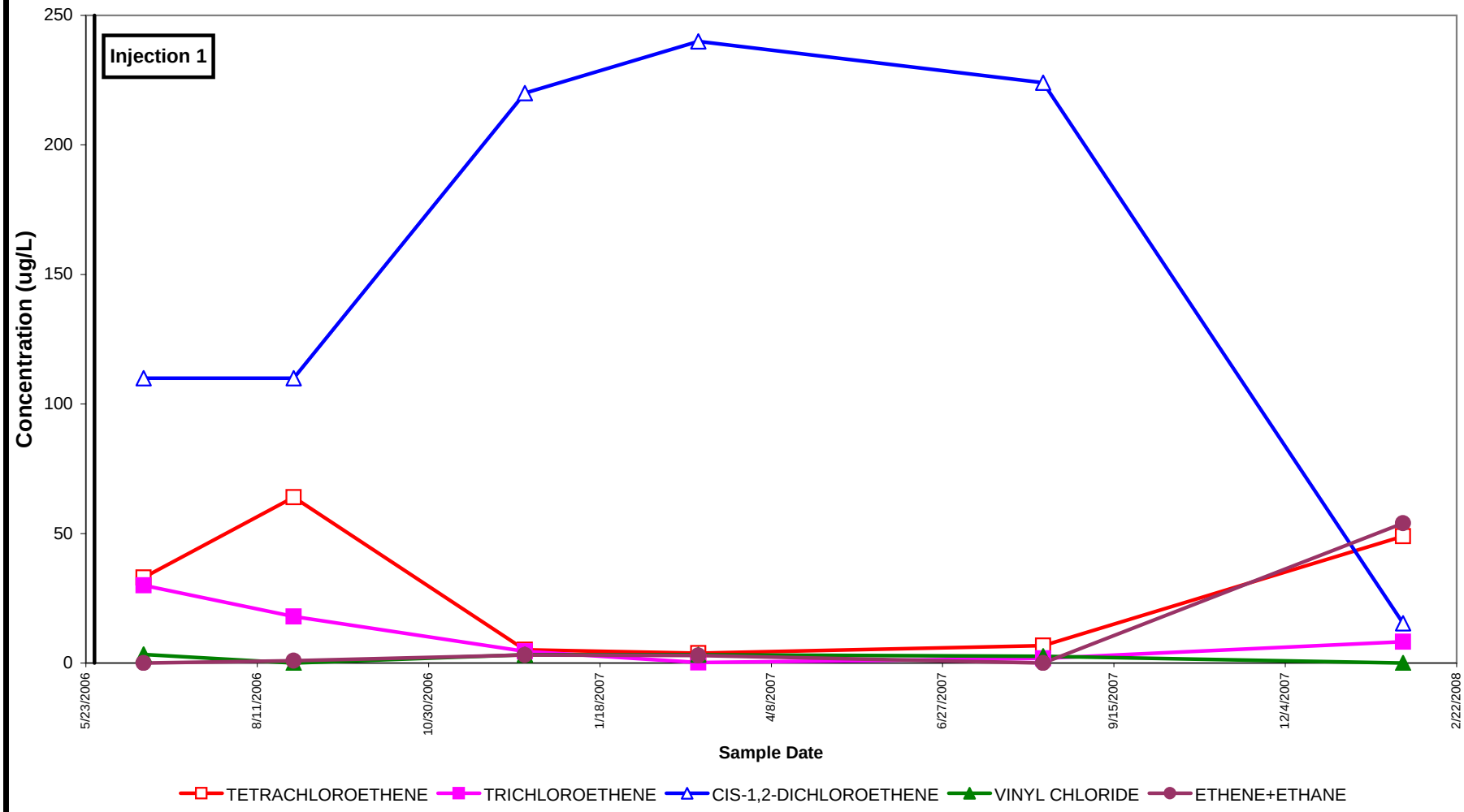
Attachment 4 – Site Photographs Area 5
Site SS20

Top: Former gas station location at SS20 on November 14, 2007.
Bottom: Building 639, former Permeable Reactive Barrier Pilot Test at SS20 on November 14, 2007.

Attachment 4 – Site Photographs Area 5
Sites OT41/Motor Pool and OT43

Top: Oil/water separator next to Building 636 at OT44 on November 14, 2007.
Bottom: OT41/Motor Pool on December 17, 2007; IWCD is below parking area and near the oil/water separator (Site OT43) seen between two buses.

Attachment 5
Source Area E
DM3501S
Concentration vs. Time Graph



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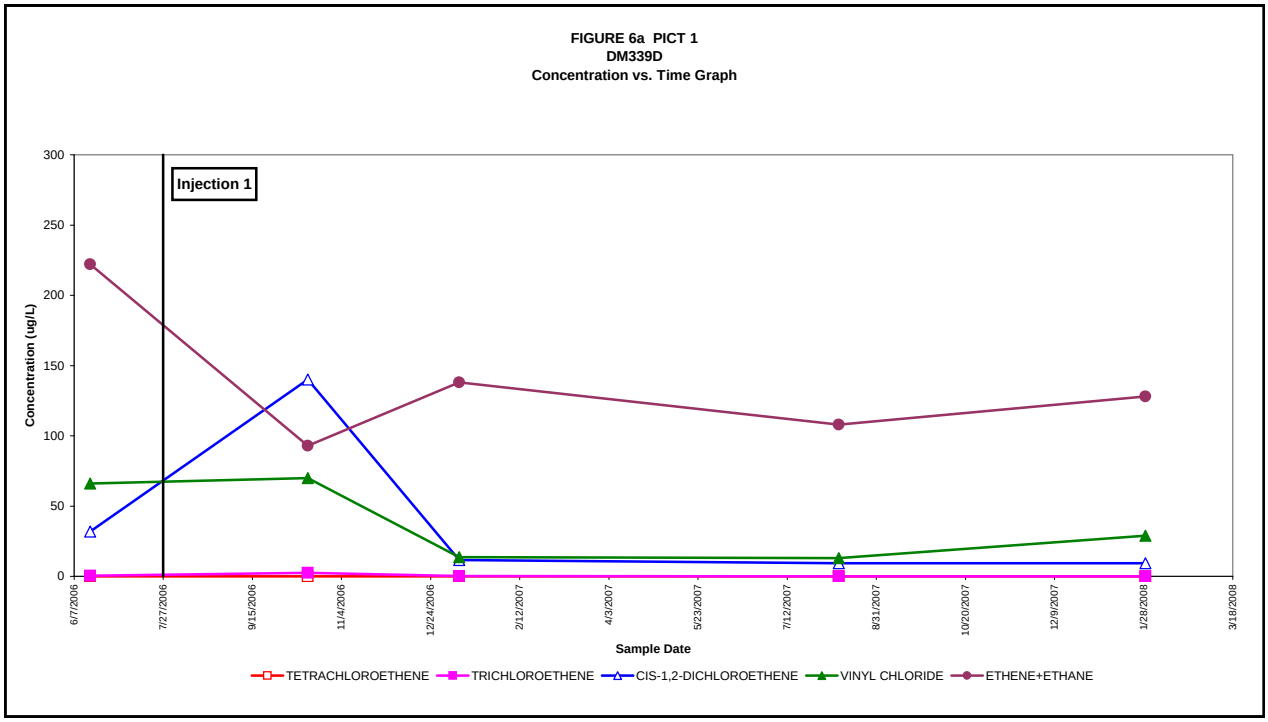

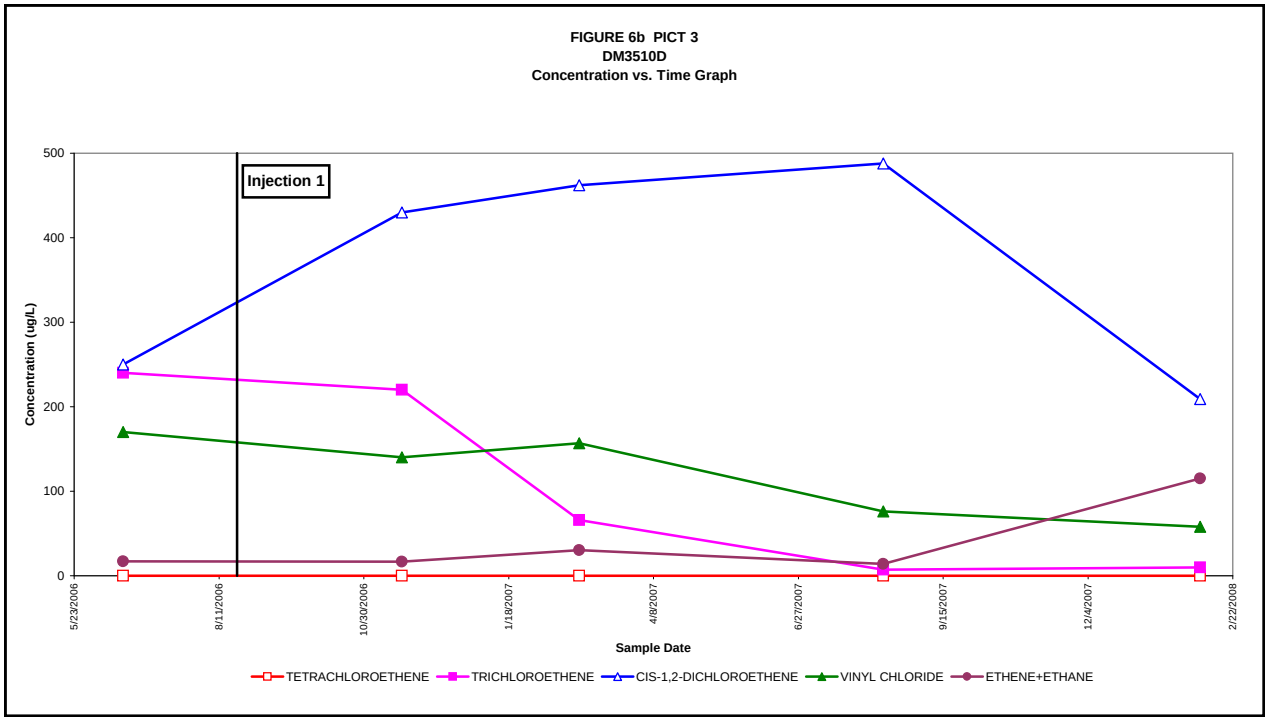

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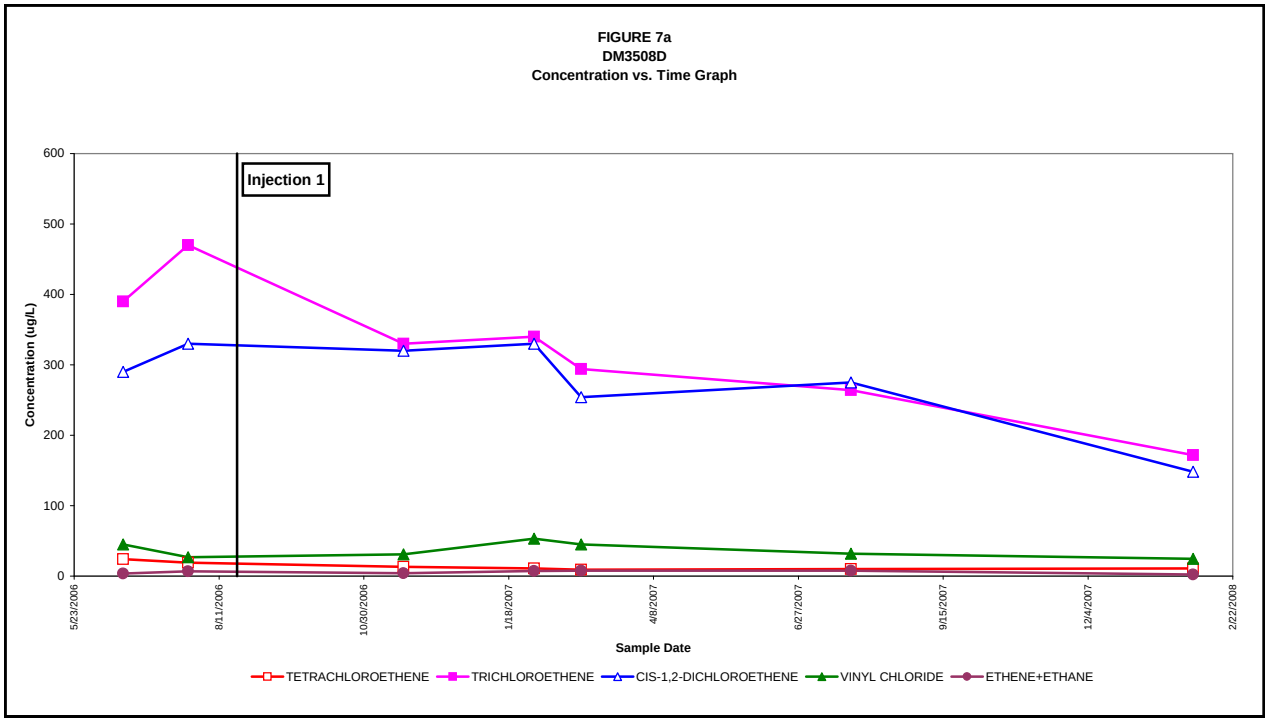

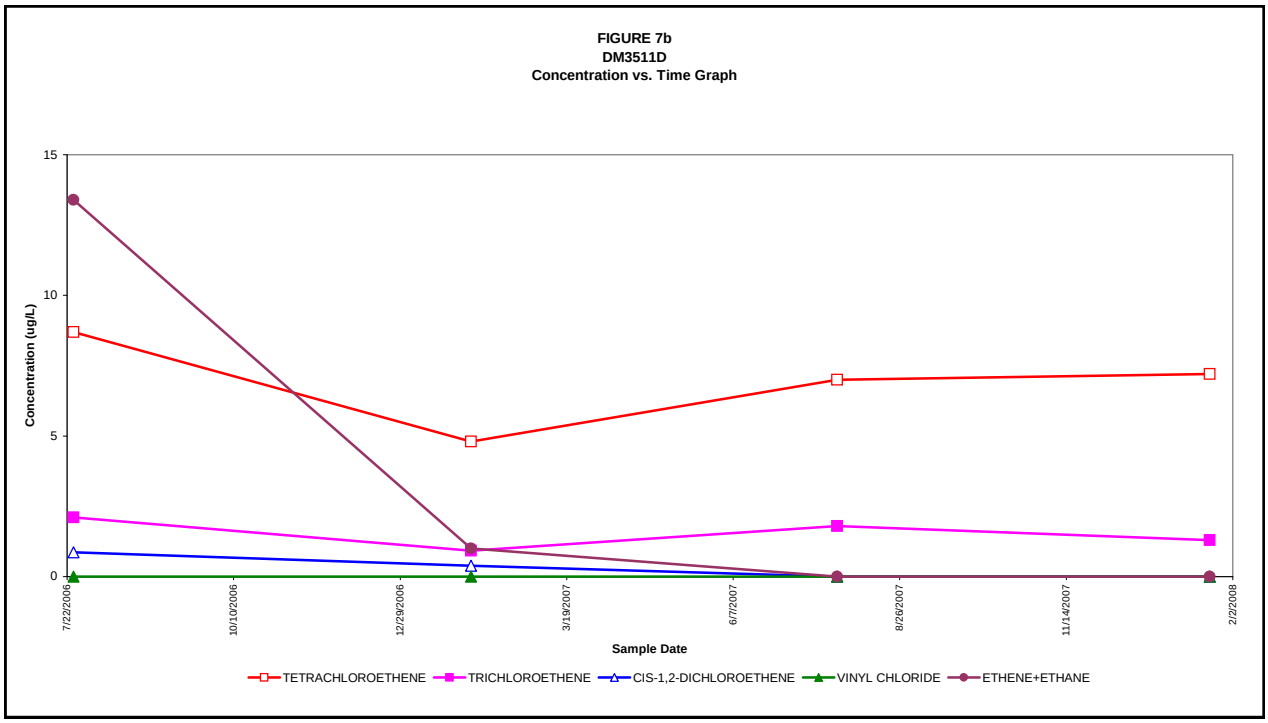

Attachment 8
RAO Exceedances

Contaminant	RAO* (µg/L)	DM329D 1/25/2008	DM329S 1/24/2008	DM331D 1/31/2008	DM331S 1/31/2008	DM334D 1/28/2008	DM334S 1/25/2008	DM335D 1/24/2008	DM335S 1/24/2008
TETRACHLOROETHENE	5	33.9	ND	584	33	1.6	ND	ND	ND
TRICHLOROETHENE	5	6.3	ND	30	9.1	3.2	ND	ND	ND
CIS-1,2-DICHLOROETHENE	70	6.5	ND	27	7.5	3.2	69	ND	ND
VINYL CHLORIDE	2	ND	ND	10	ND	ND	ND	ND	ND
BENZENE	5	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	1000	ND	ND	ND	ND	ND	2.3	ND	ND

Contaminant	RAO* (µg/L)	DM339D 1/29/2008	DM339S 1/29/2008	DM3501S 1/28/2008	DM3502S 1/29/2008	DM3503S 1/30/2008	DM3504D 1/30/2008	DM3504S 1/30/2008	DM3505S 1/30/2008
TETRACHLOROETHENE	5	ND	ND	49	ND	ND	ND	ND	ND
TRICHLOROETHENE	5	ND	ND	8.2	ND	7.4	6	5.3	3.9
CIS-1,2-DICHLOROETHENE	70	9.4	1.5	15.3	47	174	175	91	88
VINYL CHLORIDE	2	29	21	ND	43	292	481	68	ND
BENZENE	5	ND	ND	ND	3.7	ND	ND	ND	15
TOLUENE	1000	ND	ND	ND	4.7	2.2	ND	ND	ND

Contaminant	RAO* (µg/L)	DM3506D 1/31/2008	DM3507D 1/28/2008	DM3508D 1/31/2008	DM3508S 1/31/2008	DM3509F 1/25/2008	DM3510D 2/4/2008	DM3511D 1/22/2008	DM3512S 1/22/2008
TETRACHLOROETHENE	5	ND	18	10.7	2.4	ND	ND	7.2	ND
TRICHLOROETHENE	5	235	61	172	10.6	ND	10	1.3	ND
CIS-1,2-DICHLOROETHENE	70	250	259	148	10.1	ND	209	ND	ND
VINYL CHLORIDE	2	31	41	24.5	ND	ND	58.1	ND	ND
BENZENE	5	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	1000	ND	ND	ND	ND	ND	ND	ND	ND

Attachment 8 - (cont'd)

Contaminant	RAO* (µg/L)	DM3513D 2/4/2008	DM3514D 2/4/2008	DM3515D 2/4/2008	DM3516M 1/29/2008	DM3517M 1/29/2008	DM3518S 1/23/2008	MW078D 1/23/2008	MW078S 1/23/2008
TETRACHLOROETHENE	5	ND	ND	ND	49	112	2.2	ND	11.4
TRICHLOROETHENE	5	233	89	93	2.7	4.1	12.7	ND	4.7
CIS-1,2-DICHLOROETHENE	70	531	299	442	4.3	ND	23.8	ND	6.2
VINYL CHLORIDE	2	176	114	304	ND	ND	2.6	ND	ND
BENZENE	5	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	1000	ND	ND	ND	ND	ND	ND	ND	ND

Contaminant	RAO* (µg/L)	MW214D 1/23/2008	MW214S 1/23/2008	MW216D 1/28/2008	MW216S 1/28/2008
TETRACHLOROETHENE	5	348	2245	6.5	ND
TRICHLOROETHENE	5	27	31	4.1	ND
CIS-1,2-DICHLOROETHENE	70	89	64	5.2	ND
VINYL CHLORIDE	2	ND	ND	ND	ND
BENZENE	5	0.85	ND	ND	ND
TOLUENE	1000	ND	ND	ND	ND

*RAO is the federal MCL (EPA 816-F-03-016, June 2003)

- MCL exceedance

Legend

N

- Site Boundary
- Monitoring Well
- Source Area
- >5µ/L Total Solvent Concentration Contour
- >500µ/L Total Solvent Concentration Contour

0 250 500 1,000 1,500 Feet

Attachment 9
Plume Maps for Area 5
2005 & 2008

PATH	G:\Projects\Dover_AFB\5yr_Review_Figures\Sept 2008\Area5.mxd
DES BY	DJM 09/22/08
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 9

URS

200 Orchard Ridge Drive
Gaithersburg, MD 20878

FIVE-YEAR REVIEW FOR AREA 6
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under Contract DE-AC05-00OR22725

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LIST OF ACRONYMS AND ABBREVIATIONS

AAB	Accelerated anaerobic biodegradation
AFCEE	Air Force Center for Environmental Excellence
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of concern
DAFB	Dover Air Force Base
DAP	Dibasic Ammonium phosphate
DCA	Dichloroethane
DCE	Dichloroethene
DO	Dissolved Oxygen
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
DPIT	Direct push injection transect
EECA	Engineering Evaluation and Cost Analysis
ERP	Environmental Restoration Program
EVO	Emulsified vegetable oil
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
IRACR	Interim Remedial Action Completion Report
HAZWRAP	Hazardous Waste Remedial Actions Program
IWCD	Industrial waste collection drain
LUC	Land use control
MCL	Maximum contaminant level
MIP	Membrane interface probe
msl	Mean sea level
µg/L	Micrograms per liter
NA	Natural attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
O&M	Operation and maintenance
ORNL	Oak Ridge National Laboratory
ORP	Oxidation reduction potential
PCE	Tetrachloroethene
PICT	Plume injection circulation transect
RA	Risk assessment
RAO	Remedial action objective
RAWP	Remedial Action Work Plan
RBSC	Risk-based screening criterion
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

RI	Remedial Investigation
ROD	Record of Decision
RTDF	Remediation Technologies Development Forum
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
TCA	Trichloroethane
TCE	Trichloroethene
TOC	Total organic carbon
USAF	U.S. Air Force
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile organic compound
WMU	West Management Unit

EXECUTIVE SUMMARY

Area 6 is a large groundwater contaminant plume located in the West Management Unit (WMU) at Dover Air Force Base (DAFB), Delaware. It is associated with seven sites: WP21, WP31, ST34, OT41/Bldg. 719, OT48, SS59, and OT28. DAFB's general strategy for addressing contaminant release sites is to group sites within their associated groundwater plumes and address cleanup requirements by plume. Thus, the Area 6 plume and its seven sites are being addressed as one operable unit in this Five-Year Review.

The remedy for Area 6 was selected in a Record of Decision (ROD) signed in 2006. The remedy addresses the plume as a whole and individual sites as necessary. For groundwater, the remedy includes a combination of accelerated anaerobic biodegradation (AAB), natural attenuation with monitoring, and land use controls (LUCs). For soil, LUCs have been implemented at all sites except at OT28 where no further action is necessary for the soil medium. Maintenance of the asphalt cover at SS59 is also a component of the remedy.

This is the first five-year review for Area 6 as a whole, however for three sites (WP21, OT41/Bldg. 719, and SS59) this is their second five-year review. Since achieving the construction complete milestone for all sites, DAFB has merged all reviews into a comprehensive set of Base-wide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the Area 6 remedy is operating as intended. Source area treatments and transects injections are reducing the concentrations of the contaminants of concern (COCs). LUCs remain in effect and no new uses of groundwater or soil at any of the sites were observed. The cover system at SS59 has also been maintained. It is recommended that AAB injections and remedy monitoring continue in accordance with the Remedial Action Work Plan and the recommendations made in the semi-annual monitoring reports. Also, monitoring of natural attenuation should continue to confirm that COCs decline to levels that meet the RAOs specified in the Area 6 ROD.

The draft-final five-year review for Area 6 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

Area 6 is a large groundwater contaminant plume that resulted from several commingling releases and is located at Dover Air Force Base (DAFB), Delaware, in the West Management Unit (WMU). Area 6 is associated with seven Environmental Restoration Program (ERP) sites: WP21, WP31, ST34, OT41/Bldg. 719, OT48, OT28 and SS59, which were used for various industrial purposes since the 1960s (Attachment 1a). The majority of the activity at all of the sites ceased during the 1980s; however, the oil/water separator at site OT48 is still in use today. The contaminants in the Area 6 plume include primarily chlorinated solvents, although fuels and Lindane are also found. Although several interim actions have occurred at some of the sites, the final remedies were selected in a 2006 Record of Decision (ROD) for Area 6. The remedies include accelerated anaerobic biodegradation (AAB), natural attenuation with monitoring, land use controls (LUCs) for soil and groundwater, and maintenance of the SS59 asphalt cover.

The remedial action at Area 6 is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the first five-year review for Area 6 as a whole. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

AAB and natural attenuation with monitoring are the major components of the Area 6 remedy. Similar remedies for groundwater and soil were implemented concurrently at seven other WMU sites: SS08, LF25, and the five sites associated with another plume called Area 5 (OT51, OT50, SS20, OT44, and OT41/Motor Pool). LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the Area 6 sites and remedy are listed in Table 1.

Table 1 - Site Chronology

Date	Event
1963-1986	WP21 wastewater lagoons in operation for treatment of liquid industrial wastes.
1969-ongoing	Two oil/water separators in use at Bldg. 711 (OT48).
1960s-1970s	Degreasing operations at OT41/Bldg. 719.
1975	OT28 wastewater treatment plant closes.
1986	U.S. Air Force (USAF) Installation Restoration Program - Phase II-Stage I, groundwater, surface water and sediment sampling at WP21 (SAIC, 1986).
1986	WP21 lagoons were removed under the supervision of DNREC; certified closed on September 4, 1989. Two oil/water separators were installed (OT46).
1986-1998	WP21 concrete wastewater basin in operation.
1987	Former underground storage tanks (USTs) next to maintenance building removed at ST34.
1989	Installation Restoration Program - Stage II report, soil gas survey and soil and groundwater sampling at ST34 (SAIC, 1989).
1989	Two USTs removed from WP31.
March 1989	DAFB listed on the National Priority List (NPL).
April 1990	Quarterly groundwater compliance monitoring began as required by the DNREC Secretary's Order for WP21.
1991	Site Investigation (SI) Reports: WP31, OT41, OT48, and OT28 (HAZWRAP, 1991 a, b, c, d).
1992	USTs at Site OT41/Bldg. 719 were removed.
January 1994	WP21 groundwater monitoring changed to semiannual schedule.
July 1994	Area 6 Remedial Investigation (RI) finalized, including WP21, WP31, ST34, OT41/Bldg. 719, OT48, and SS59 (USACE, 1994).
1995	DNREC issued Post-Closure permit for WP21.
August 3, 1995	ROD prepared for the Interim Remedies of Target Areas 1, 2, and 3 of Area 6, WMU (DAFB, 1995a,b,c).
1996	Results of Aquifer Air Sparging/Soil Vapor Extraction Treatability Study released for site WP21.
1996	Lindane source area investigation at SS59 (HAZWRAP, 1996).
December 1996	Stage 2 Lindane source area investigation (HAZWRAP, 1997c).
1997	Final Engineering Evaluation and Cost Analysis (EECA) at Lindane source area at SS59 (HAZWRAP, 1997b).
1997	Summary report, WP21 soil sampling (HAZWRAP, 1997a).
1997	Industrial waste collection drain (IWCD) removed from service.
March 1997	Remediation Technologies Development Forum (RTDF) completed natural attenuation study of Area 6.
August 1997	Basewide RI finalized for WMU, including OT28 (USACE, 1997).
1998	Concrete wastewater basins at WP21 removed along with the OT46 oil/water separators, and contaminated soil was removed and treated off-site.
1998-1999	Pesticide-contaminated soil at Site SS59 was excavated and sent off-Base for incineration (AIMTech, 2000). An asphalt cover was installed over SS59.
1998-1999	Soil co-metabolic bio-venting system operated for one year at OT41/Bldg. 719.
November 1999	Closure Report for WP21/Industrial Waste Basins approved by DNREC (HAZWRAP, 1999).
2000	Base-wide Ecological Risk Assessment finalized (USACE, 2000).
2001	AAB recirculation system installed at OT41/Bldg. 719.
2002-2006	AAB recirculation system in operation at OT41/Bldg. 719; now in passive mode.
April 11, 2003	DNREC established a groundwater management zone (GMZ) encompassing DAFB.
January 2005	Final Feasibility Study (FS) for WMU (USACE, 2005).

Table 1 – (cont'd)

Date	Event
July 2005	Proposed Plan, Area 6 (AFCEE, 2005).
January 2006	ROD prepared for sites WP21, WP31, ST34, OT41/Bldg. 719, OT48, SS59, OT28, and Area 6 (USACE, 2006).
February 2006	Remedial Action Work Plan (RAWP) finalized for WMU (ORNL, 2006a).
March – May 2006	Installation of injection/extraction and monitoring wells at Area 6.
April – August 2006	First round of AAB injections in Area 6.
April 2006	AAB monitoring begins; merges with natural attenuation monitoring program for Area 6 plume at end of 2007 (ORNL, 2008).
May 2006	1,4-Dioxane in groundwater assessment (DAFB, 2006).
May 2006- ongoing	Target Area 1 semi-annual groundwater monitoring sampling event. Begins transition from RCRA post-closure monitoring to CERCLA RAWP program.
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	Interim Remedial Action Completion Report (IRACR) prepared for Area 6, WMU (ORNL, 2006b).
March 5, 2007	OT41/Bldg. 719 AAB remedy began operating in passive AAB mode.
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007).

AFCEE – Air Force Center for Environmental Excellence
DNREC – Department of Natural Resources and Environmental Control
HAZWRAP – Hazardous Waste Remedial Actions Program
ORNL – Oak Ridge National Laboratory
RCRA – Resource Conservation and Recovery Act
SAIC – Science Applications International Corporation
USACE – U.S. Army Corps of Engineers

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

Area 6 is a multi-source groundwater plume associated with seven sites at DAFB: WP21, WP31, ST34, OT41/Bldg. 719, OT48, OT28, and SS59. It is located in the WMU (Attachment 1a), with its main sources located in the central portion of the WMU industrial sites. The plume of commingling contaminants extends downgradient across U.S. Route 113 and underneath Base housing. The ground surface at Area 6 is covered almost entirely by buildings, concrete, and asphalt. Isolated grassy areas in this industrialized portion of the Base are contoured to direct surface runoff to nearby storm drains. The WMU of DAFB is heavily industrialized northeast of U.S. Route 113 with Base housing and a portion of the golf course lying southwest of U.S. Route 113. Six of the seven ERP sites included in this Five-Year Review are located in the industrialized area. OT28 is located at the far west edge of the Base housing area.

The surface topography of DAFB is relatively flat, with elevations ranging from 10 to 30 feet (ft) above mean sea level (msl). Areas of lower elevations (10 ft above msl or less) are located adjacent to the St. Jones River. Surface water runoff is controlled by the storm drainage system. The water table is usually encountered between 10 and 12 ft

Table 2 - Site Summary

Site ID	Site Description	Contamination Assessment Conclusions	Previous Remedial Activities
WP21	WP21 is a pair of former unlined industrial waste lagoons built in 1963 to receive wastes from the engine overhaul shop (Bldg. 719). At that time, the system included a 12,000-gallon primary basin, and a 170,000-gallon secondary impoundment. In 1968, the system was expanded to accept wastewater from other Base facilities via the IWCD (OT41) that was processed first through two concrete basins and two oil/water separators. From the lagoons, treated wastewater was sent to the north drainage ditch (1963-1969), DAFB Wastewater Treatment Plant (OT28, 1969-1975), and the Kent County Treatment Plant (1975-1986).	The RI was conducted during the early 1990s after the lagoons had been excavated and capped. No COCs were identified in soil during the RI. Subsequent soil sampling in 1997 revealed chlorinated solvent contamination in soil around the concrete waste basins. The contaminated soil was subsequently excavated. Groundwater COCs identified during the RI are primarily chlorinated solvents (1,1,1-TCA, 1,1-DCE, cis-1,2-DCE, PCE, and TCE).	Two soil excavation actions have been accomplished at WP21: a) The unlined waste lagoons underwent RCRA closure in 1986. The lagoons (sludge and underlying soil) were excavated, filled with clean soil, and capped. Due to groundwater contamination at the site, DNREC issued a RCRA post-closure permit. Under the permit, post-closure monitoring was initiated and is ongoing. b) Under a 1998 interim ROD, the adjoining concrete basins, contaminated soil, oil/water separators (ERP site OT46), and WP21 cap were removed. EPA Region 3 risk-based criteria for industrial scenarios were used as the cleanup standard.
WP31	WP31 is the location of two former USTs between Buildings 780 and 781, aircraft maintenance hangars. One was a 500-gallon-capacity waste oil tank and the other held 1,000 gallons of fuel oil. The installation date of the tanks is unknown. They were removed in 1989.	No COCs were identified in soil. In groundwater, benzene and TCE are the primary concerns; both were present at concentrations above their MCLs.	The USTs were both removed in 1989 and the area backfilled with soil. No closure report was prepared and it is unknown whether there were signs of leakage. Sampling during a subsequent investigation revealed residual contaminants suggesting that one or both of the USTs had leaked.
ST34	ST34 is the location of a former fuel oil UST between Buildings 608 and 609, an equipment maintenance area. The installation date of the UST is unknown. The UST reportedly leaked for an unknown period of time. The tank was removed in 1987 at which time free product was observed in the excavation. The UST and other maintenance activities have impacted this site.	During the RI, no contaminants were identified in soil that caused a health risk. Thus, there are no soil COCs at this site. Fuel and chlorinated solvent contaminants in groundwater were above MCLs. These contaminants are benzene, 1,2-DCA, cis-1,2-DCE, PCE, and TCE. Lindane is also present in this area.	The UST at this site was removed in 1987 at which time the visibly contaminated soil was reportedly removed. No analytical data or closure report are available from this activity since it occurred before the adoption of DNREC's UST regulations.
OT41/ Bldg. 719	OT41/Bldg. 719 was originally a portion of the IWCD next to Bldg. 719, an engine maintenance hangar. The site was expanded to include Bldg. 719 itself when investigation revealed a significant chlorinated solvent source below the engine cleaning rooms. Two former USTs (between the IWCD and Bldg. 719) may also have been minor sources.	No soil COCs were identified during the Basewide RI. However, later sampling revealed an area of chlorinated solvent contamination in soil around the former USTs, which was subsequently remediated. Groundwater COCs are chlorinated solvents including PCE, TCE, cis-1,2-DCE, and vinyl chloride. This source at Bldg. 719 is the single largest contributor to the Area 6 plume.	The USTs next to Bldg. 719 were removed in 1992. Under a 1995 Interim ROD, soil in the area of the former USTs was remediated via cometabolic bioventing in 1997-1998. Under another 1995 Interim ROD, groundwater treatment of the major chlorinated solvent source below Bldg. 719 using an AAB recirculation system began in 2002 and is ongoing. This system was incorporated into the final Area 6 remedy and currently is in passive mode.
OT48	OT48 is the location of two oil/water separators at the south and west corners of Bldg. 711, an avionics maintenance facility. Each separator is 7 x 9 x 10 ft deep and has an associated 400-gallon-capacity holding tank for accumulated waste oil. The separated water is discharged to the sanitary sewer.	No COCs were identified in soil. In groundwater, TCE, vinyl chloride, and benzene were present above their MCLs. The chlorinated solvents are present in the deeper portion of the aquifer on the eastern edge of Area 6.	None.

Table 2 - (cont'd)

Site ID	Site Description	Contamination Assessment Conclusions	Previous Remedial Activities
SS59	SS59 is the open storage area adjacent to WP21 and has been used for the temporary storage of various materials. It has also been referred to as the Paint Washout Area and Lindane Source Area.	No COCs were identified in soil based on the RI data and risk assessment. Post-RI soil sampling, however, found the pesticides DDD and DDT, which were the focus of a removal and capping action. Although not a concern in soil, Lindane (probably originating at SS59) is above its MCL.	A removal/capping action for pesticide-contaminated soil was conducted in 1998-1999 under a 1995 Interim ROD. The objective of the action was to reduce risk of human exposure, eliminate stormwater runoff, and reduce rainwater infiltration, thus protecting groundwater from residual pesticides that might otherwise leach from the soil.
OT28	OT28 is the former wastewater treatment plant located at the western edge of the Base next to the St. Jones River. The plant originally processed sanitary effluent; however beginning in 1969 it received treated industrial wastewater, until its closure in 1975. The plant has been dismantled, and the area is fenced. It is occasionally used for storage of contractor equipment and materials.	No COCs were identified in soil based on the RI data and risk assessment. In groundwater, carbon tetrachloride and TCE are COCs.	None.
Area 6	Area 6 is the largest multi-source groundwater plume at DAFB. The sites listed above contribute primarily chlorinated solvents although fuels and lindane are also minor components. The sources are generally located in the central part of the WMU at industrial sites and a plume of commingling contaminants extends downgradient across U.S. Route 113 and underneath Base housing.	Area 6 is defined by the distribution of commingling contaminants in groundwater. COCs for Area 6 (see Table 4) are present in the shallow portion of the aquifer at source areas and migrate to the deeper portion of the aquifer as the plume flows to the south-southwest under Base housing and towards the St. Jones River.	Under a 1995 Interim ROD, a three-year study was conducted by the RTDF demonstrating the effectiveness of natural attenuation. Based on the five-year review, natural attenuation has been incorporated as a component of the remedy for Area 6.

Note: See page iii for abbreviations used in this table.

below ground surface (bgs) although it can be found as shallow as 3 ft bgs near the St. Jones River.

3.2 LAND AND RESOURCE USE

The uses of the seven sites associated with Area 6 were generally for industrial purposes and waste storage. A brief summary of the activities at each site is provided in Table 2 under the Site Description column. The shallow groundwater (Columbia Aquifer) underlying the sites generally flows south-southwest towards the St. Jones River, the ultimate discharge location. This aquifer is not currently used as a drinking water source and any on-site groundwater use is prohibited at all seven sites and Area 6 as a whole. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. The river is used for recreational purposes but is not used for potable water. Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and the portion of off-Base property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

Area 6 is the largest multi-source groundwater contaminant plume at DAFB. Two ‘target areas’ (known as Target Area 1,2,3 and Target Area 6) within the Area 6 plume were defined in the WMU FS to assist with the remedial alternative layouts (USACE, 2005). Target areas define regions of highest contaminant concentrations in groundwater (Attachment 1a). The seven sites associated with Area 6 contribute primarily chlorinated solvents, although fuels and Lindane (a pesticide) are also major components of the plume. Although evidence of natural biodegradation of the chlorinated solvents has been observed within this plume, natural biodegradation has been insufficient to keep the plume from reaching the Base boundary at levels exceeding maximum contaminant levels (MCLs). Brief summaries of the history of contamination at each of the individual sites are provided in Table 2.

The Base-wide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

Area 6 and its associated seven ERP sites have a long and complex history of investigation, clean up action, and interim remedies. In overview, DAFB's strategy for Area 6 is organized into three parts:

(1) DAFB's first considerations were to address source materials constituting principal threats, soil contamination that could pose a continuing threat to groundwater, and soil contamination that could pose risks to on-Base workers at the seven sites. All required soil cleanup actions for the seven sites have been completed using industrial cleanup standards prior to preparing the final ROD for Area 6. These actions are listed in Table 1.

(2) The second part of the Area 6 cleanup strategy was to conduct interim groundwater remedies (also listed in Table 1). The purpose of these interim remedies was to collect data for use in evaluating alternatives for the entire Area 6 groundwater plume, and to begin remediating areas of the highest contaminant concentrations.

(3) The final stage of the Area 6 cleanup strategy was addressed in the Area 6 ROD. A final groundwater remedy was selected and this included the controls necessary to ensure that land use restrictions and groundwater use prohibitions are maintained. The selected remedy addresses all remaining response actions required for all media at the seven sites and the Area 6 groundwater plume.

Treatment alternatives for Area 6 were evaluated in the WMU FS (USACE, 2005). This evaluation relied heavily on the past studies, demonstrations, and results of interim actions. At this stage, two "target areas" within the Area 6 plume were defined. They represent regions of highest contaminant concentrations in groundwater; i.e., where total chlorinated solvent concentrations exceeded 1,000 micrograms per liter (µg/L), based on data available at that time. The target areas were used as a tool during the FS to help in determining the best application of source area treatment alternatives.

The selected remedial action for Area 6 is primarily a combination of AAB and natural attenuation with monitoring, and LUCs for both soil and groundwater. It was documented in a proposed plan and submitted for public review on July 10, 2003. In early 2006, a ROD was signed for the soil and groundwater at Area 6. The selected remedy included AAB, natural attenuation with monitoring, and LUCs for soil and groundwater.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater

at Area 6 and at WP21, WP31, ST34, OT41/Bldg. 719, OT48, and SS59 since they are located in an industrial portion of the Base (USACE, 1994 and 1997). OT28 was evaluated for a hypothetical future commercial/industrial and residential scenario for groundwater because of its location near the Base housing area. The human health RA for Area 6 and its seven associated sites concluded that:

- Carcinogenic risk from hypothetical future commercial/industrial exposure to groundwater at WP21, ST34, OT41/Bldg. 719, and Area 6 (which includes SS59) exceeds the USEPA risk criterion.
- Groundwater contaminant concentrations at all seven sites and Area 6 exceed federal MCLs. There are residential, industrial, and agricultural users of the Columbia Aquifer within the surrounding community. Although groundwater from the Columbia Aquifer is not a drinking water source at DAFB, there is potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences at all seven sites and the Area 6 plume trigger the need for action.
- Non-carcinogenic risk from hypothetical future commercial/industrial exposure to groundwater at WP21, WP31, ST34, OT41/Bldg. 719, OT48, OT28, and Area 6 (which includes SS59) exceeds the USEPA risk criterion.

Additionally, although no unacceptable human health risks were found for soil at WP21, WP31, ST34, OT41/Bldg. 719, OT48, and Area 6 (which includes SS59), this conclusion was based on the assumption that land use at these six sites will remain industrial, and that the integrity of the asphalt cover at SS59 will be maintained. At OT28, the soil was determined to be suitable for unrestricted exposure and unlimited use based on the residential scenario used for its RA. Therefore, action was required to address groundwater risks at all seven sites and the Area 6 plume, and to ensure the permanence and reliability of the land use assumptions used to assess the sites. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for Area 6 was signed by USEPA in January 2006 (USACE, 2006). The remedial action objectives (RAOs) were developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, one of the RAOs for groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. LUCs serve to prevent unacceptable exposure to groundwater until the RAOs are achieved. LUCs for soil and

groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the WMU FS. The selected remedies for Area 6 groundwater and soil as discussed in the 2006 ROD include the seven major components listed below.

- Injection/diffusion AAB to treat groundwater contaminants at the two target areas within the Area 6 plume.
- Continued treatment at OT41/Bldg. 719 using the installed AAB injection/recirculation system.
- Natural attenuation to address the portions of the Area 6 plume that are not being treated via AAB.
- Groundwater monitoring.
- LUCs for soil and groundwater at all sites except OT28 where no further action for soil is required.
- Maintenance of the asphalt cover at site SS59.
- Evaluation of vapor intrusion during groundwater remedial action phase (accomplished in 2007; ORNL, 2007).

4.2 REMEDY IMPLEMENTATION

Remedy implementation and monitoring were performed in accordance with the Area 6 RAWP (ORNL, 2006a) and documented in the IRACR for Area 6 (ORNL, 2006b). For the AAB application, two injection methods were used to deliver substrate into the ground: direct push injection in three source areas, and injection into permanent well transects installed perpendicular to groundwater flow across the plume. Initial injections in Area 6 occurred between April and August 2006. Prior to starting AAB, shallow source areas were delineated using membrane interface probes (MIPs) to focus the direct push application of amendments. The three source areas (labeled A, B, and C; Attachment 1b) were then treated by injecting substrate at closely located points. The substrate consisted of emulsified vegetable oil and sodium lactate added to potable water. Dibasic ammonium phosphate (DAP) was also added to the mixture to provide metabolic nutrients. The potable water was processed through activated carbon to remove chlorine before mixing. A direct-push rig and pump truck were used to inject the mixture into temporary boreholes on an approximate 10-foot grid pattern at multiple depths within each of the three source areas. Direct push injection transects (DPITs), which are lines of direct injection points installed perpendicular to groundwater flow, were also completed in three areas where infrastructure made installing permanent wells difficult.

For the permanent transect injections, a total of 109 4-inch stainless steel injection and extraction wells were installed across the core of the Area 6 plume to create nine plume injection circulation transects (PICTs; Attachment 1b). As with the direct-push injections, a combination of emulsified vegetable oil, sodium lactate, and DAP were injected into the subsurface to stimulate the biodegradation of chlorinated solvents.

However, the PICT process uses a mobile AAB process trailer powered by a generator to extract groundwater, amend it with substrate, and re-inject the mixture into the aquifer. Three mobile injection trailers were assembled on-site for use in the entire WMU in accordance with the generalized designs presented in the RAWP. Along each PICT, groundwater was extracted from every other well, amended, and then returned to the aquifer under pressure through adjacent injection wells, creating a push-pull effect. Injection quantities for both the source area injections and the initial PICT injections are documented in the Area 6 IRACR.

At Area 6, the primary mechanism of both AAB and natural attenuation is the anaerobic biodegradation of chlorinated ethenes and ethanes. For the ethenes, the parent contaminant, PCE, degrades to TCE, then to cis-1,2-DCE, then to vinyl chloride, and finally to ethene, a harmless gas. For the ethanes, which are present along the northwest portion of the Area 6 plume, the predominant degradation sequence is 1,1,1-TCA to 1,1-DCA to chloroethane to ethane. Less commonly, 1,1,1-TCA breaks down to 1,1-DCE to vinyl chloride to ethene.

Monitoring programs for both AAB and natural attenuation were implemented at Area 6 in accordance with the RAWP. Wells used to monitor progress of AAB are listed in Table 3. AAB monitoring was conducted more frequently just after injections and then progressed to monthly, then quarterly, then semi-annual sampling after a year. Early in the AAB monitoring program the focus was on the distribution of total organic carbon (TOC) and indicator parameters: dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, dissolved iron, and sulfate. At month 3, after the substrate had some time to stimulate biodegradation, volatile organic compounds (VOCs) and dissolved gases analyses were added to the monitoring program.

Monitoring for natural attenuation includes VOCs and indicator parameters on a semi-annual schedule. Wells in the natural attenuation program are also listed in Table 3 and shown in Attachment 1b. The first semi-annual sampling round for natural attenuation was completed in May 2006 for the entire Area 6 plume. The monitoring results for both the initial AAB monitoring and the initial natural attenuation monitoring are documented in the Area 6 IRACR.

Table 3 - Area 6 Wells

Well ID	AAB	NA	Well ID	AAB	NA	Well ID	AAB	NA
DM3001S	X		DM325D	X		IR03D*		X
DM3002S	X		DM325S	X		IR04D		X
DM3003S	X		DM326D		X	IR05D*		X
DM3004S	X		DM326S		X	IR06D	X	
DM3005S	X		DM353D*		X	IR07D*		X
DM3006D	X		DM354D*		X	MW072S		X
DM3007D	X		DM355D	X		MW101D		X
DM3009D	X		DM356D		X	MW101S		X

Table 3 – (cont'd)

Well ID	AAB	NA	Well ID	AAB	NA	Well ID	AAB	NA
DM3010D	X		DM360D		X	MW102D		X
DM3011D	X		DM361D		X	MW102S		X
DM3012D	X		DM367D		X	MW103D		X
DM3013D	X		DM369D		X	MW103S		X
DM3014D	X		DM397DR		X	MW211D		X
DM3015D	X		DM398DR		X	MW211S		X
DM3016D		X	EA5D		X	MW212D	X	
DM3017D		X	EA5F		X	MW212S	X	
DM3018D	X		EA9F		X	MW235D	X	
DM3019D	X		F1		X	MW236D	X	
DM3020D	X		F2		X	MW236S		X
DM315D		X	IR01D		X	MW237D		X
DM316D	X		IR02D*		X	MW237S	X	

*Well has been abandoned due to Base construction activities, but will be replaced in the future.

At OT41/Bldg. 719, an AAB recirculation system was in operation from 2002-2006 treating the single largest source contributing to the Area 6 plume. The AAB treatment system was switched into a passive mode of operation on March 5, 2007 based on operation and maintenance (O&M) summary report recommendations. This occurred due to significant reductions in dissolved phase contaminant concentrations within the treatment zone. Quarterly groundwater sampling of 14 wells at the site is ongoing to ensure degradation of COCs continues (Attachment 1c).

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including Area 6. Some of the primary controls are: (1) Land use of sites WP21, WP31, OT41/Bldg. 719, OT48, and SS59 is restricted to industrial purposes. (2) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (3) All work that disturbs the subsurface is required to be cleared through the Base digging permit process to ensure compliance with land use restrictions. (4) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a portion of off-Base property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (5) DAFB conducts an annual inspection of the LUCs and documents the findings.

The groundwater RAOs for the contaminants found at each site in Area 6 are listed in Table 4. Groundwater monitoring was selected as part of the remedy to

determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 4 - Groundwater RAOs

Contaminant	WP21	WP31	ST34	OT41/ Bldg 719	OT48	SS59	OT28	Area 6	RAO* (µg/L)
Benzene		X	X		X			X	5
1,1,1-TCA	X							X	200
1,1-DCE	X							X	7
1,2-DCA	●		X					X	5
cis-1,2-DCE	X	●	X	X	●		●	X	70
PCE	X		X	X				X	5
TCE	X	X	X	X	X		X	X	5
Carbon tetrachloride							X	X	5
Vinyl chloride	●	●	●	X	X		●	X	2
Lindane	X		X			X		X	0.2

X = COC present at this site.
● Potential COC due to the breakdown of other COCs
* RAO is the Federal MCL

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the Area 6 ROD, a RA was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the WMU, and two of these are above the Area 6 plume. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the sites change, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

Remedial operations have been ongoing in Area 6 since the initial injections were completed in August 2006. A second round of PICT injections was accomplished during 2007, and a third round of PICT injections is scheduled to commence during the spring of 2008. AAB and natural attenuation monitoring events are currently both conducted on a semi-annual schedule in accordance with the Area 6 RAWP. Semi-annual reports document all of the monitoring results. Additionally, LUCs inspections and reporting are conducted annually.

The main maintenance activities associated with the Area 6 remedy are:

- Maintain integrity of the PICT wells; ensure that well caps and protective covers are secured.

- Maintain the mobile treatment trailer hoses, pumps, and monitoring equipment in good working order.
- Ensure that the SS59 asphalt cap is maintained properly to effectively prevent unacceptable human exposure and to reduce infiltration to groundwater.
- Keep Building 720 (the process equipment shed for the OT41/Bldg. 719 AAB remedy) locked when not in use. Maintain the injection, extraction and monitoring wells installed within and around Building 719. Extraction well pumps have been mothballed and stored on site since the system is currently in passive mode.
- LUCs inspections are conducted on an annual basis.

The costs associated with the Area 6 AAB remedy and natural attenuation monitoring are summarized in Table 5.

Table 5 - Annual Remedy Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$3,358,000 (includes initial capital costs)
2007	$1,414,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for Area 6 as a whole; however, interim actions at sites WP21, SS59, and OT41/Bldg. 719 have undergone one previous five-year review. The interim actions at these sites were folded into the final remedy for Area 6 as documented in the Area 6 ROD. Since the last five-year review for the interim remedies, the final remedy for Area 6 and its seven sites has been implemented and is ongoing as discussed in Section 4.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 meetings in 2007 that the five-year review for Area 6 would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for Area 6 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of Area 6 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant Area 6 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the information collected to date for each remedy component for Area 6. The latest groundwater monitoring data for AAB and natural attenuation were collected in late 2007/early 2008 (ORNL, 2008). For the SS59 cover and LUCs, a site inspection was conducted in November 2007. The monitoring reports reviewed for Area 6 evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network. Data for each remedy component are summarized below with selected contaminant trend charts or tables to illustrate remedy progress where applicable.

1. At the source areas treated by direct injection of AAB substrates, degradation of parent COCs is observed with corresponding increases in breakdown products. These trends are shown for Source A in Figure 5a, Source Area C in Figure 5b, and Source Area B in Figures 5c & d (Attachment 5). At Source Area B, both chlorinated ethenes and ethanes are present.

2. Nine PICTs cross the core of the Area 6 plume. Trend charts for two examples are shown in Attachment 6. Both chlorinated ethenes and ethanes are present in well DM3011D, directly downgradient of PICT 4a. The PCE concentration is now only 0.81 µg/L and TCE is below detection. Here, parent COCs are now below MCLs. Breakdown products are present, as expected—cis-1,2-DCE (978 µg/L), vinyl chloride (159 µg/L), and ethene (355 µg/L)—with the notable elevated ethene concentration proving complete dechlorination (Figure 6b). The degradation of chlorinated ethanes is occurring more slowly (Figure 6a). Similar trends are observed for the chlorinated ethenes at PICT 8 in well DM3015D (Figure 6c).

3. The AAB system at OT41/Bldg. 719 is part of the overall remedy for Area 6. This system became operational in February 2002. Total chlorinated ethene

concentrations at OT41/Bldg. 719 were in excess of 100,000 µg/L early in the treatment program. Based on the success of treatment, a final injection of emulsified vegetable oil (EVO) into the reactive zone was performed and then the injection/extraction wells were shut off in early 2007. Monitoring is ongoing. The table in Attachment 7 shows that MCLs have been nearly reached in all of the wells within the reactive zone (the highest TCE concentration in key wells close to the treatment zone is only 33 µg/L) and progress towards MCLs continues to be made in the wells farther out. Based on these results, restarting of the system was not recommended in the last monitoring report (ORNL, 2008).

4. Natural attenuation is a component of the overall treatment strategy and pertains primarily to the downgradient portion of the Area 6 plume that is as yet unaffected by the AAB treatments. Overall, the distribution of COCs and natural attenuation indicators reveal that degradation via anaerobic reductive dechlorination occurs primarily in the upgradient half of the plume while the plume becomes more aerobic below Base housing and reductive dechlorination is less effective. Three monitoring wells illustrate COC trends in the Area 6 plume below Base housing (Attachment 8). TCE is the dominant contaminant in DM360D, where it has been relatively stable since about 1999 (Figure 8a), and in IR01D where an increasing trend was observed until 2003 after which concentrations declined (Figure 8b). The highest COC concentrations are routinely found in DM398DR; however, cis-1,2-DCE is the dominant contaminant here (Figure 8c). The data tabulated in Attachment 9 show that MCLs are still widely exceeded across the Area 6 plume during the last round of monitoring. Lindane, a pesticide found in the northwest portion of Area 6 exceeds its MCL in four wells although is has declined from 27 µg/L in MW212D (1999) to 0.032 µg/L (below its MCL) in October 2007. MW212D is the well closest to the suspected historic source of Lindane (site SS59) indicating that the soil removal and capping activity has been effective in preventing further Lindane contamination.

5. The asphalt cover at SS59 has been maintained. The site is currently used for parking (see photographs in Attachment 4). One of the functions of the cover is to reduce infiltration that may mobilize contaminants from soil into groundwater. As mentioned under item 4 above, Lindane, the only pesticide COC, is now well below its MCL in the monitoring well closest to SS59.

6. LUCs have been implemented for soil and groundwater at all sites and Area 6 (except for soil at OT28 where no further action was required). No new uses of groundwater, soil, or the sites were observed during the November 2007 site inspection. These observations were corroborated in DAFB's annual LUCs monitoring report (DAFB, 2007).

7. In May 2006, groundwater sampling for 1,4-dioxane was conducted at 12 Area 6 monitoring wells where elevated concentrations of 1,1,1-TCA were previously detected (DAFB, 2006). 1,4-Dioxane was used as a stabilizer in chlorinated

solvents and has been linked specifically to 1,1,1-TCA. Eight of the 12 wells contained 1,4-dioxane at concentrations of 13 µg/L or less and indicates that 1,4-dioxane was present in the 1,1,1-TCA (Table 6). However, based on the low detections, 1,4-dioxane is of minimal concern at DAFB.

Table 6. 1,1,1-TCA and 1,4-Dioxane Concentrations (µg/L)

Well ID	Maximum 1,1,1-TCA / date		Current[1] 1,1,1-TCA / date		1,4-Dioxane[2]
DM325D	2,900	11/17/04	83	11/17/05	ND (1.9)
DM325S	1,200	05/04/99	87	11/17/05	1.4 J
DM326D	330	05/13/03	290	11/16/05	8.3
DM395S	8,002	06/24/98	6.5	10/24/05	3.2
MW102D	800	11/18/99	380	11/15/05	ND (1.9)
MW102S	2,600	05/09/05	1,400	11/15/05	4.9
MW212D	1,800	09/14/89	25	11/17/05	1.2 J
MW212S	42,000	04/03/90	7.6	11/18/05	ND (1.9)
MW236D	595	11/20/98	10	11/16/05	13
MW237S	120,000	11/15/00	850	11/15/05	ND (1.9)
MW601S	3,700	10/22/02	2,500	04/18/05	4.3
MW604S	530	07/31/03	18	10/24/05	4.9

[1] Most recent data available at the time the study was conducted.
[2] ND – not detected, reporting limited listed in parentheses
J flag – estimated value; positive detection at a concentration below the reporting limit.

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at Area 6 sites on that day (Attachment 4). The upgradient half of the Area 6 plume is in the industrialized portion of the WMU. The facilities here are surrounded by lawns and parking lots. The downgradient and deeper portion of the plume is below Base housing.

A summary of the site inspections is listed below. Overall, no new uses of groundwater, soil or the sites were observed. No conditions were observed that would affect the integrity of the remedy.

- WP21 – The area is a well-maintained grassy field. Runoff is controlled by the storm water drainage system that includes a large ditch on the northeast side of the site.

- WP31 – The location of the former USTs is covered with grass. Minor ruts with ponded water from a recent rain event were noted near the edge of the site.

- ST34 – The location of the former UST is now covered by an extension of the adjacent building (#609). The surrounding area is paved.

- OT41/Bldg. 719 – The site is covered by Buildings 719 and 720. Building 720 is the process equipment shed for the AAB remedy and is kept locked. The extraction wells for the system are installed in the small grassy areas surrounding Building 719. The well vaults, Building 720, and the AAB equipment (pumps, piping, mixing tanks, etc.) are properly maintained and in good working order.

- OT48 – The two oil/water separators are surrounded by grassy areas.

- SS59 – The asphalt cover at SS59 is used for a parking lot and is in generally good condition.

- OT28 – This area is used for temporary storage of construction materials for ongoing Base housing renovation activities. It is fenced and appears to remain open during working hours.

Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for Area 6 is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that the chlorinated solvents in the Area 6 plume are degrading in the areas treated using AAB. Achievement of RAOs was so close at the OT41/Bldg. 719 source area, that the AAB recirculation system at OT41/Bldg. 719 was put into passive mode. A series of maps (Attachments 10a-10d) was prepared for Area 6 using Environmental Visualization software to illustrate the changes in total chlorinated ethenes and ethanes in both the shallow and deep portions of the Columbia Aquifer. The top views show the concentrations prior to AAB treatment. The bottom views show distinct reductions in concentrations approximately 18 months after the AAB injections.

The latest (December 2007) natural attenuation conditions observed in areas as yet unaffected by AAB injections are similar to those observed in previous semi-annual

sampling rounds. As the Area 6 plume migrates under Base housing, conditions gradually become more aerobic, and anaerobic reductive dechlorination appears to be less effective. In this area, as the environment transitions from anaerobic to aerobic the degradation of daughter products proceeds via aerobic pathways.

The annual LUCs report and URS' site inspection determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA for all sites except OT28. OT28 is located near Base housing so commercial/industrial and residential exposure scenarios were assessed. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effects on risks, are qualitatively summarized in Table 7 (USEPA, 2007). The various changes could increase and decrease the overall carcinogenic risks and non carcinogenic hazards. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). In addition, groundwater monitoring has shown that the contaminant plume in this area has remained relatively stable. In fact, source area and plume core remediation is successfully reducing contaminant mass within the plume. Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this time.

Table 7 - Risk Assessment Review

Site	Change	Effect
WP21	RBSC values decreased for 1,2,3-trichlorobenzene, napthalene, 4,4-DDD, beta- BHC, and vanadium.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	RBSCs increased for 1,1,1-TCA and 1,2-DCA.	These chemicals would be excluded from the RA, slightly decreasing overall hazards.
	Inhalation reference dose increased for 1,2-DCA.	A slight decrease in overall hazard.
	Inhalation reference doses decreased or are now available or 1,1-DCE, methylene chloride, PCE, TCE*, and naphthalene.	A slight increase in overall hazard.
	Oral reference doses increased for 1,1-DCE and manganese.	A slight decrease in overall hazard.
	Oral reference doses decreased or are now available for 1,4-dichlorobenzene, TCE*, naphthalene, and iron.	A slight increase in overall hazard.
	Inhalation slope factors increased or are now available for PCE, TCE*, and 1,4-dichlorobenzene.	A slight increase in overall risk.
	Oral slope factor increased for PCE and TCE*, and is now available for delta-BHC.	A slight increase in overall risk.
WP31	RBSC values decreased for PCE, xylenes, carbozole, naphthalene, and pyrene.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	RBSC values increased for 1,2-DCE, toluene, phenol, heptachlor, manganese, and nickel.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
	Inhalation reference doses increased for benzene and is no longer available for 1,2-DCA.	A slight decrease in overall hazard.
	Inhalation reference doses decreased for methylene chloride and naphthalene and is now available for TCE*.	A slight increase in overall hazard.
	Oral reference doses decreased or are now available for benzene, 2-methylnapthalene, and TCE*.	A slight increase in overall hazard.
	Oral slope factors decreased for arsenic and it increased for benzene and TCE*.	A slight decrease and increase, respectively, in overall risk.
	Inhalation slope factors increased for TCE* and decreased for benzene.	A slight increase and decrease, respectively, in overall risk.
ST34	RBSC values increased for 1,2-dichlorobenzene, cadmium, and manganese.	These chemicals would be excluded from the RA, slightly decreasing overall risks and hazards.
	RBSC values decreased for naphthalene and dieldrin, and is now available for delta-BHC.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	Inhalation reference doses increased for 1,2- DCA and benzene.	A slight decrease in overall hazard.
	Inhalation reference doses are now available for chloroform, PCE, and TCE*, and decreased for methylene chloride.	A slight increase in overall hazard.
	Oral reference doses decreased for TCE* and are now available for benzene and 1,2-dichlorobenzene.	A slight increase in overall hazard.
	Inhalation slope factors increased for PCE and TCE*, and decreased for benzene.	A slight increase and decrease, respectively, in overall risk.

Table 7 – (cont'd)

Site	Change	Effect
ST34 – (cont'd)	Inhalation slope factor is now available for 1,2-dichlorobenzene.	A slight increase in overall risk.
	Oral slope factor increased for benzene, PCE, and TCE*, and is no longer available for chloroform.	A slight increase and decrease, respectively, in overall risk.
	Oral slope factor decreased for arsenic.	A slight decrease in overall risk.
OT41/Bldg. 719	RBSC value decreased for naphthalene.	This chemical would be included in the RA, slightly increasing overall hazard.
	RBSC values increased for 1,2-dichlorobenzene, phenol, beryllium, and manganese.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
	Inhalation reference dose increased for 1,2-DCA and benzene, and are now available for chloroform, PCE, TCE*, and vinyl chloride.	A slight decrease and increase, respectively, in overall hazard.
	Oral reference doses decreased for TCE*, and are now available for benzene, vinyl chloride, 1,4-dichlorobenzene, and 2-methylnaphthalene.	A slight increase in overall hazard.
	Inhalation slope factors increased for PCE and TCE*, and decreased for benzene and vinyl chloride.	A slight increase and decrease, respectively, in overall risk.
	Inhalation slope factor is now available for 1,4-dichlorobenzene.	A slight increase in overall risk.
	Oral slope factor increased for benzene, PCE, and TCE*, and decreased for vinyl chloride.	A slight increase and decrease, respectively, in overall risk.
OT48	RBSC values increased for 1,2-DCE and 4-methyl-2-pentanone.	These chemicals would be excluded from the RA, slightly decreasing overall hazards.
	RBSC value decreased for dieldrin.	This chemical would be included in the RA, slightly increasing overall hazard and risk.
	Inhalation reference dose increased for benzene, and are now available for TCE* and vinyl chloride.	A slight decrease and increase, respectively, in overall hazard.
	Oral reference doses decreased for TCE* and increased for manganese.	A slight increase and decrease, respectively, in overall hazard.
	Oral reference doses are now available for benzene and vinyl chloride.	A slight increase in overall hazard.
	Inhalation slope factors increased for TCE*, and decreased for benzene and vinyl chloride.	A slight increase and decrease, respectively, in overall risk.
	Oral slope factors increased for benzene and TCE*, and decreased for vinyl chloride and arsenic.	A slight increase and decrease, respectively in overall risk.
OT28	RBSC values decreased for PCE, bis(2-ethylhexl)phthalate, and aldrin.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	RBSC value is now available for iron. RBSC increased for manganese.	These chemicals would be excluded from the RA, slightly decreasing overall hazards.
	Inhalation reference doses increased for 1,2-DCA.	A slight decrease in overall hazard.
	Inhalation reference doses are now available for chloroform and TCE*.	A slight increase in overall hazard.

Table – 7 (cont'd)

Site	Change	Effect
OT28 (cont'd)	Inhalation slope factor increased for TCE*.	A slight increase in overall risk.
	Oral slope factor is no longer available for chloroform.	A slight decrease in overall risk.
	Oral slope factor increased for TCE*.	A slight increase in overall risk.
Area 6	RBSC values increased for 1,1,1-TCA, 1,1-DCA, 4-methyl-2-pentanone, 1,2,4 trichlorobenzene, 1,2-dichlorobenzene, acetaphenone, heptachlor, beryllium, cadmium, and mercury.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
	RBSC values decreased for carbazole, 4,4-DDD, naphthalene, and vanadium, and are now available for 2-methylnaphthalene, di-n-octyl-phthalate, dimethyl phthalate, delta-BHC, and iron.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
	Inhalation reference doses increased for 1,1-DCE, 1,2-DCA, benzene, carbon tetrachloride, and toluene.	A slight decrease in overall hazard.
	Inhalation reference doses decreased for methlyene chloride, and are now available for chloroform, PCE, TCE*, vinyl chloride, and xylenes.	A slight increase in overall hazard.
	Oral reference dose increased for manganese.	A slight decrease in overall hazard.
	Oral reference doses decreased for toluene, TCE*, and xylenes, and are now available for 1,1-DCE, benzene, vinyl chloride, and 1,4 dichlorobenzene.	A slight increase in overall hazard.
	Inhalation slope factors increased for PCE and TCE*, and is now available for 1,4 dichlorobenzene.	A slight increase in overall risk.
	Inhalation slope factors decreased for benzene and vinyl chloride, and is no longer available for 1,1-DCE.	A slight decrease in overall risk.
	Oral slope factors increased for benzene, PCE, and TCE*.	A slight increase in overall risk.
	Oral slope factors decreased for vinyl chloride and arsenic, and are no longer available for 1,1-DCE and chloroform.	A slight decrease in overall risk.

RBSC – Risk based screening criterion
*Assessment of TCE based on 2001 provisional toxicity values.

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

This review for Area 6 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Land use across Area 6 is unchanged and there have been no reports of new contaminant releases. All information collected to date indicates that the remedy is operating as intended and that progress has been made towards achieving the RAOs.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for Area 6 groundwater is functioning as intended. The monitoring data from the most recent sampling events provide evidence that the injections created anaerobic zones within the plume favorable to reductive dechlorination. In the treatment zones, parent contaminant concentrations are decreasing and daughter contaminant concentrations are increasing. Ethene is also present in several wells indicating that complete degradation is occurring.

It will be some time before areas downgradient of the AAB treatments see the effects. Data from natural attenuation groundwater sampling in the Area 6 plume suggests degradation via anaerobic reductive dechlorination primarily in the upgradient half of the plume northeast of U.S. Route 113. Downgradient, however, as the plume crosses U.S. Route 113, conditions gradually transition to more aerobic conditions and dechlorination slows. In that area, natural attenuation alone is insufficient to prevent plume migration. The AAB remedy, implemented along multiple transects across the Area 6 plume is designed to increase natural degradation rates to levels sufficient to prevent plume migration and reduce overall contaminant mass. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

Although degradation rates were not provided in the Area 6 monitoring reports, inspection of the contaminant trend charts (Attachment 6) indicates that degradation of chlorinated solvents significantly increased in response to AAB treatment. Should the trends established during the first two years continue, the remedy appears to be capable of achieving RAOs in the 6- to 22-year time frame stated in the Area 6 ROD for the plume cores.

LUCs have been successfully implemented at the site.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater data from several past investigations at Area 6 demonstrated that past site activities locally affected groundwater quality and that a potential exists for off-Base migration. In response, a comprehensive remediation program, including AAB and natural attenuation with monitoring among other actions, was implemented.

Based on the initial success of the remedy, it is recommended that AAB and natural attenuation activities continue in Area 6. It is recommended that the proposals made in the semi-annual reports for optimizing both AAB and the monitoring well

network be implemented. The recommended operation and maintenance improvements include the following actions:

- When feasible, install replacement wells for the monitoring wells abandoned due to Base housing construction (DM353D, DM354D, IR02D, IR03D, IR05D, and IR07D).
- Add wells DM3028D and DM3029D, which are newly installed wells close to PICT 3, to the monitoring network to better assess AAB results in this area.
- Remove well MW072S from the monitoring network. MW072S will be abandoned due to planned construction at the Base gas station. This shallow well, located sidegradient to the Area 6 plume, does not contain Area 6 COCs. Therefore, a replacement well is not recommended at this location.
- Replace well DM3003S with newly installed well DM3027S which is better placed to monitor source area C.
- Conduct future AAB and natural attenuation sampling activities at Area 6 on a semi-annual schedule in accordance with the RAWP.
- In wells where carbon tetrachloride is detected, add chloroform and dichloromethane to the analyte list since these are breakdown products.
- Remove chloride from the sample analyte list. This indicator has not been useful in assessing site conditions.
- Continue to enforce LUCs at the site.

A worst case vapor intrusion evaluation was performed in 2008 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

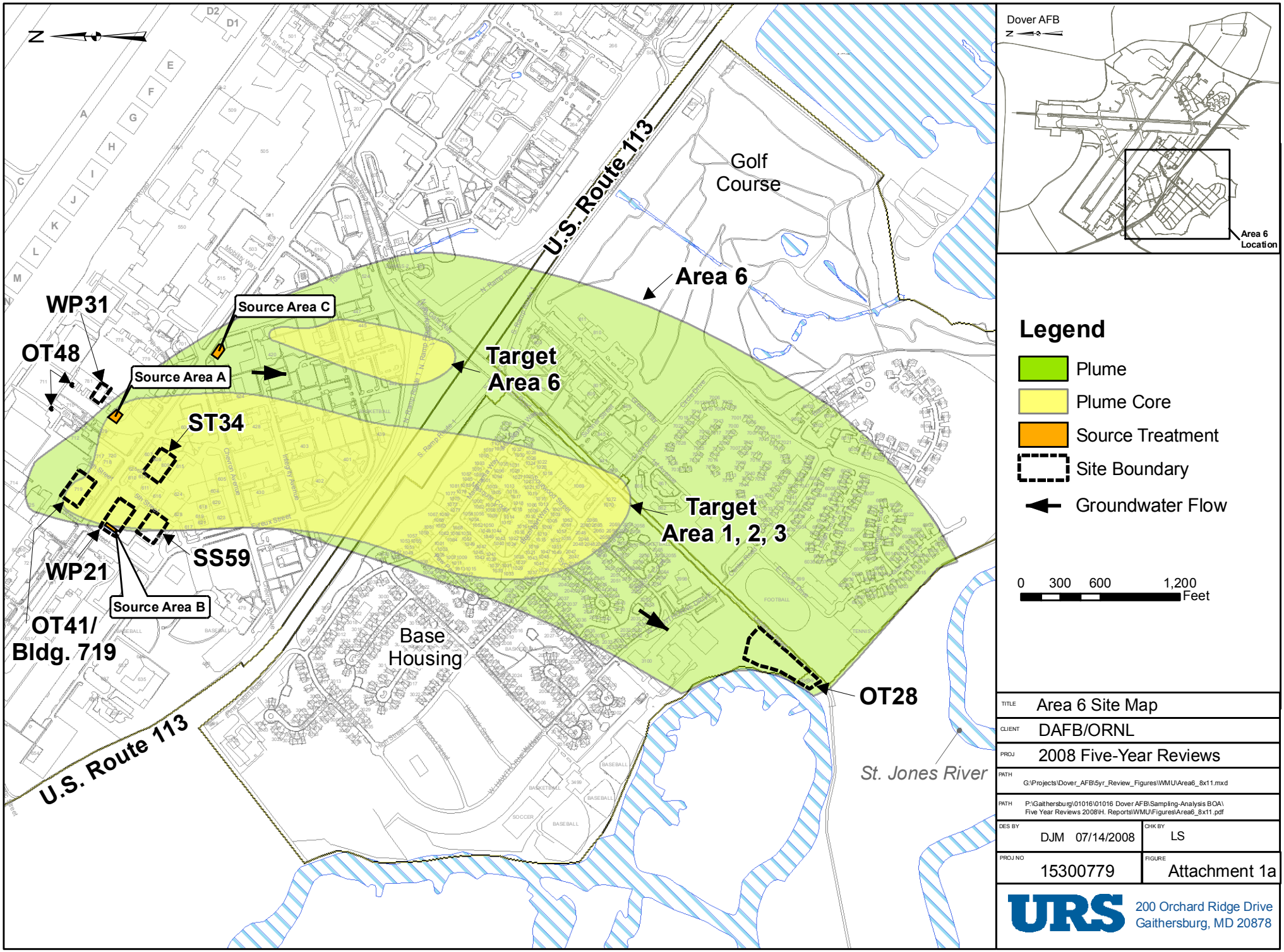
The site as a whole will continue to be addressed in the five-year review process since the remedy (including LUCs) and groundwater monitoring are still active at Area 6.

10.0 PROTECTIVENESS STATEMENT

The remedy at Area 6 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for Area 6 will be due in September 2013.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Dover AFB
Area 6 Location
Golf Course
U.S. Route 113
Area 6
Target Area 6
Target Area 1, 2, 3
Source Area C
Source Area A
Source Area B
WP31
OT48
ST34
SS59
WP21
OT41/ Bldg. 719
Base Housing
OT28
St. Jones River
Legend
Plume
Plume Core
Source Treatment
Site Boundary
Groundwater Flow
0 300 600 1,200 Feet
TITLE Area 6 Site Map
CLIENT DAFB/ORNL
PROJ 2008 Five-Year Reviews
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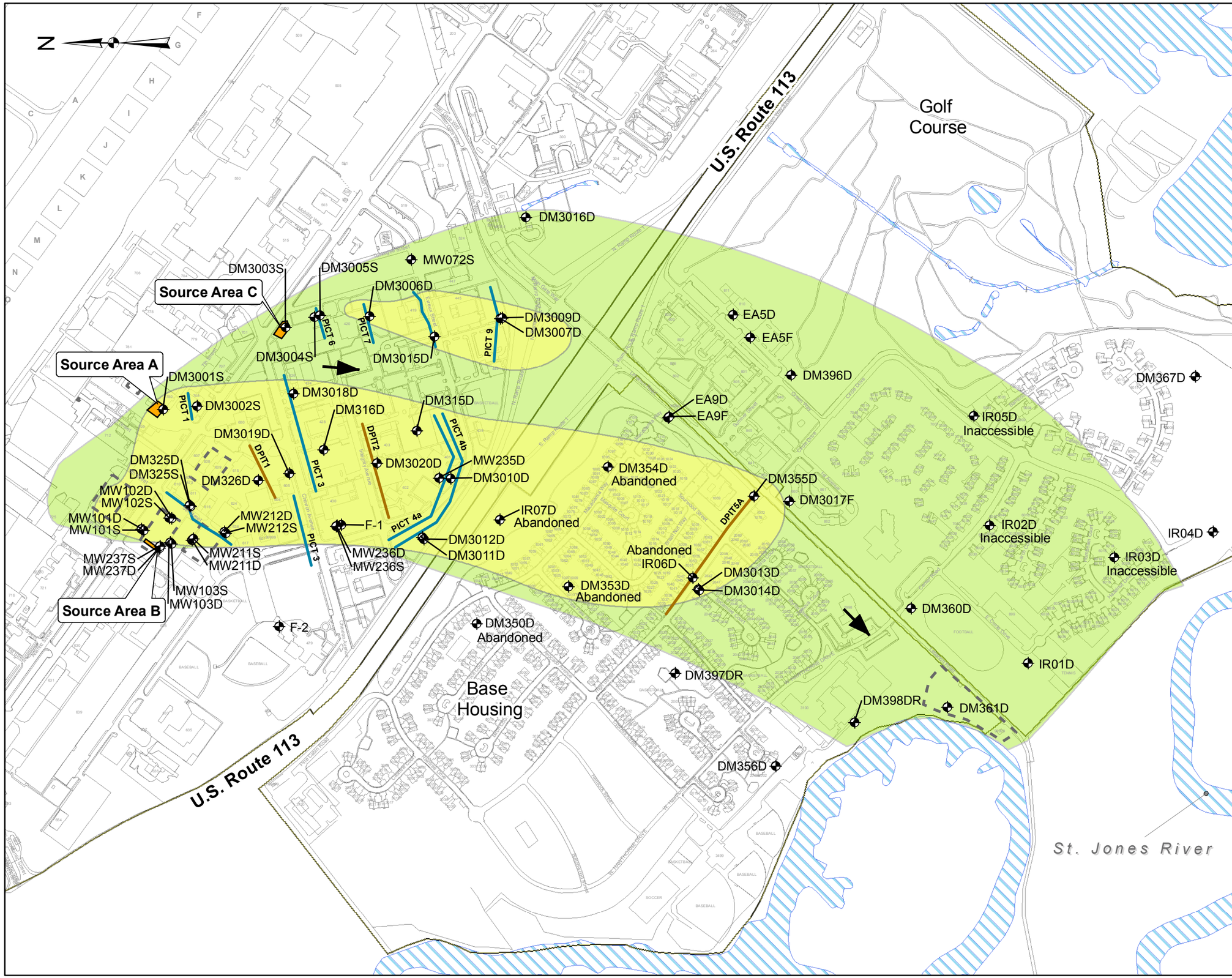
CHK BY LS
PROJ NO 15300779
FIGURE Attachment 1a
URS
200 Orchard Ridge Drive
Gaithersburg, MD 20878



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CLIENT	DAFB/ORNL
PROJ	2008 Five-Year Reviews
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FIGURE	Attachment 1b

URS
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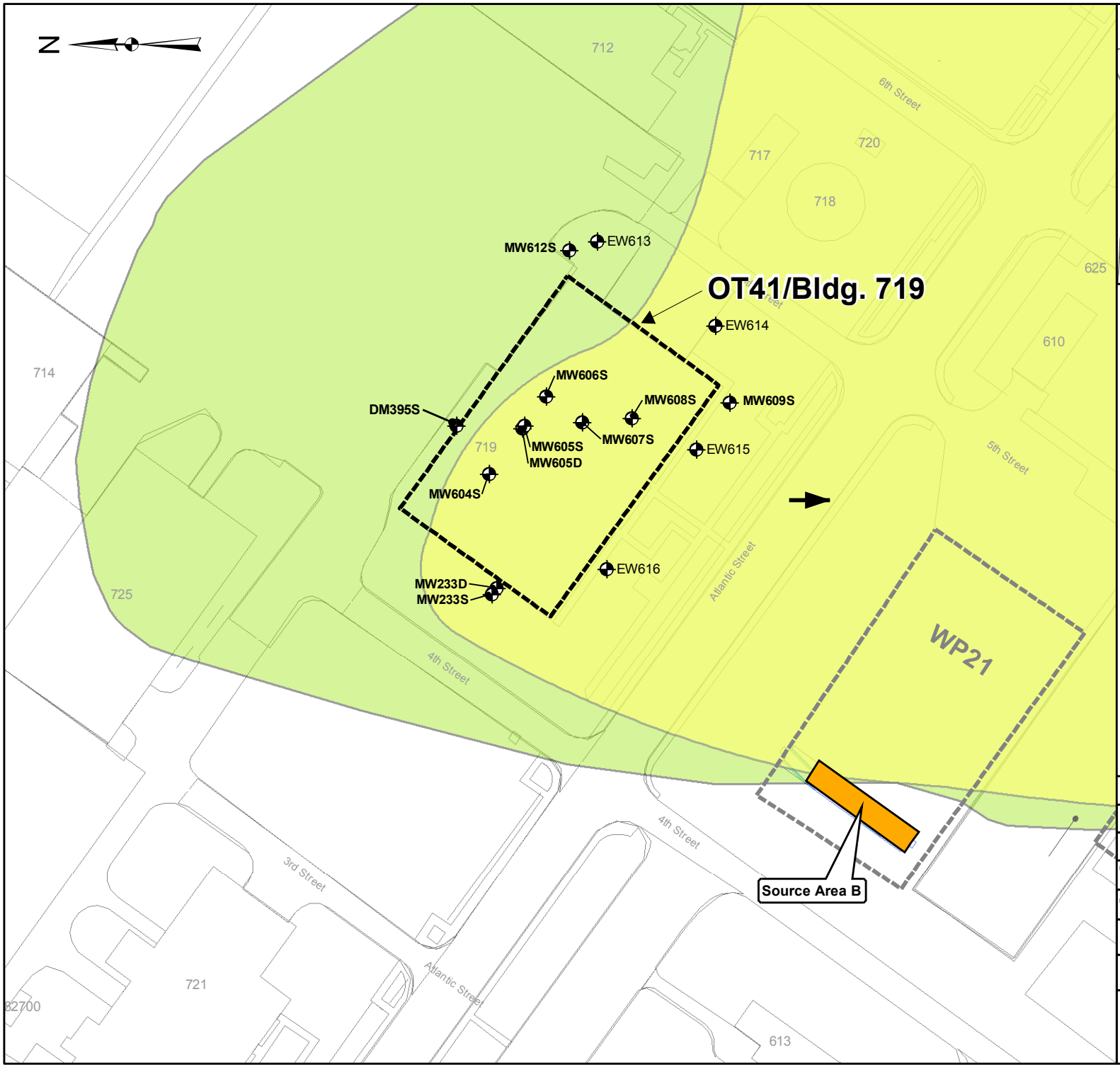

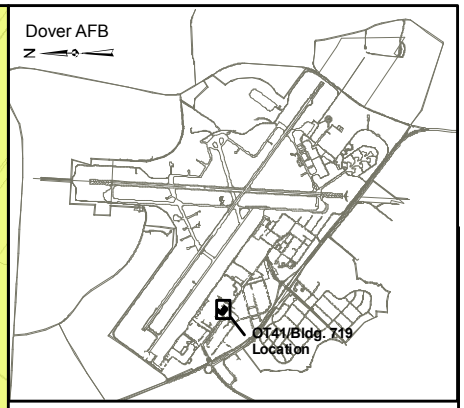

Legend

- Plume
- Plume Core
- Source Treatment
- Site Boundary
- Monitoring Well
- Groundwater Flow

0 50 100 200 Feet

TITLE	OT41/Bldg. 719 Site Map
CLIENT	DAFB/ORNL
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PROJ NO	15300779
FIGURE	Attachment 1c

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Attachment 2 - Reviewed Documents

AFCEE, 2005. Proposed Plan, Area 6, Dover AFB, Delaware, submitted by URS Group, Inc., July 2005.

AIMTech, 2000. Construction Documentation Report for Remedial Action Activities to Eliminate and Bypass Wastewater Industrial System and Pesticide Removal at the Lindane Source Area (SS59), Dover Air Force Base, Delaware, submitted by AIMTech, March 2000.

ATSDR, 2003. Public Health Assessment for Dover Air Force Base, Dover, Kent County, Delaware, dated December 31, 2003 (final release).

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

DAFB, 2006. Summary Results, 1,4-Dioxane in Groundwater, Area 6, Dover Air Force Base, Delaware, submitted by URS Group, Inc., July 25, 2006.

DAFB, 1995a,b,c. Records of Decision for the Interim Remedy of Target Areas 1, 2, and 3 of Area 6, West Management Unit, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 3, 1995.

HAZWRAP, 1999. Closure Report for the Industrial Waste System Open Oil/Water Separator Basins, Dover Air Force Base, Delaware, submitted by HAZWRAP, November 1999.

HAZWRAP, 1997a. Summary Report, WP21 Soil Sampling, Dover Air Force Base, Delaware, submitted by Dames & Moore, September 1997.

HAZWRAP, 1997b. Final Engineering Evaluation and Cost Analysis, Lindane Source Area, Dover Air Force Base, Delaware, submitted by HAZWRAP, April 1997.

HAZWRAP, 1997c. Final Technical Memorandum, Lindane Source Area Investigation, December 1996 (Stage 2), Dover Air Force Base, Delaware, submitted by HAZWRAP, April 1997.

HAZWRAP, 1991a,b,c,d. Site Investigation Reports for WP31, OT41, OT48 and OT28, submitted by Dames & Moore, September 1991.

ORNL, 2007 - 2008. Area 6 Monitoring Reports (multiple events), Dover Air Force Base, Dover, Delaware, submitted by URS Group, Inc., May 2007, October 2007, May 2008.

ORNL, 2007. Vapor Intrusion Assessment, Dover Air Force Base, Delaware, submitted by URS Group, Inc., December 2007.

Attachment 2 – (cont'd)

ORNL, 2006a. Area 6, West Management Unit, Remedial Action Work Plan, Dover Air Force Base, Delaware, submitted by URS Group, Inc., February 2006.

ORNL, 2006b. Interim Remedial Action Completion Report Sites WP21, WP31, ST34, OT41/Bldg. 719, OT48, SS59 and OT28; Area 6, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., November 2006.

SAIC, 1989. Installation Restoration Program – Stage a report, Dover Air Force Base, Delaware.

SAIC, 1986. USAF Installation Restoration Program – Dover AFB, Delaware, Phase II – Stage 1 Confirmation/Quantification.

USACE, 2006. Record of Decision for Sites WP21, WP31, ST34, OT41/Bldg. 719, OT48, SS59, OT28 and Area 6 West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2006.

USACE, 2005. Final Feasibility Study West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., May 2005.

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [West Management Unit, Volumes I - IV].

USACE, 1994. Area 6 Remedial Investigation, Dover Air Force Base, Delaware, submitted by Dames & Moore, July 1994.

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

USEPA, 2000. Cometabolic Bio-venting Field Test Conducted at Dover Air Force Base, Tech Trends, G. Sayles, EPA 542-N-00-005 August 2000, Issue No 38.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs are listed in the ROD for Area 6 and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the ROD. ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario. In addition, soil removal actions were completed at several sites (see Table 1, Site Chronology). One site, OT28, was evaluated under a residential scenario due to its proximity to Base housing. No unacceptable risks were found at OT28. However, since residential risks were not evaluated for the other six sites, the Air Force has decided to implement LUCs as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's *Delaware Risk-Based Corrective Action Plan* (DERBCAP) established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For Area 6 COCs, the standards in this guidance are the same as the Federal MCLs.

Surface Water and Sediment. Surface water and sediment are not present at Area 6. Sampling conducted for the Basewide Ecological Risk Assessment revealed no VOCs in the surface water or sediment collected from downstream drainages that could be affected by Area 6 and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4 - Site Photographs for Area 6
WP21

Top: Looking northwest at WP21, OT46, WP33 on November 14, 2007.
Bottom: Looking north at WP21, OT46, WP33 on November 14, 2007.

Attachment 4 - Site Photographs for Area 6
WP31 & ST34

Top: Former UST between Buildings 781 and 780 at WP31 on November 14, 2007.
Bottom: East side of Building 609 at ST34 on November 14, 2007.

Attachment 4 - Site Photograph for Area 6
OT41/Bldg 719

Looking south at OT41/Bldg 719 on November 14, 2007. AAB process Building (#720) is to the left next to the red traffic cone.

Attachment 4 - Site Photographs for Area 6
OT48

Top: Oil/water separator at northwest corner of Building 711 at OT48 on November 14, 2007.
Bottom: Oil/water separator at southwest corner of Building 711 at OT48 on November 14, 2007. Well pair MW232 in foreground.

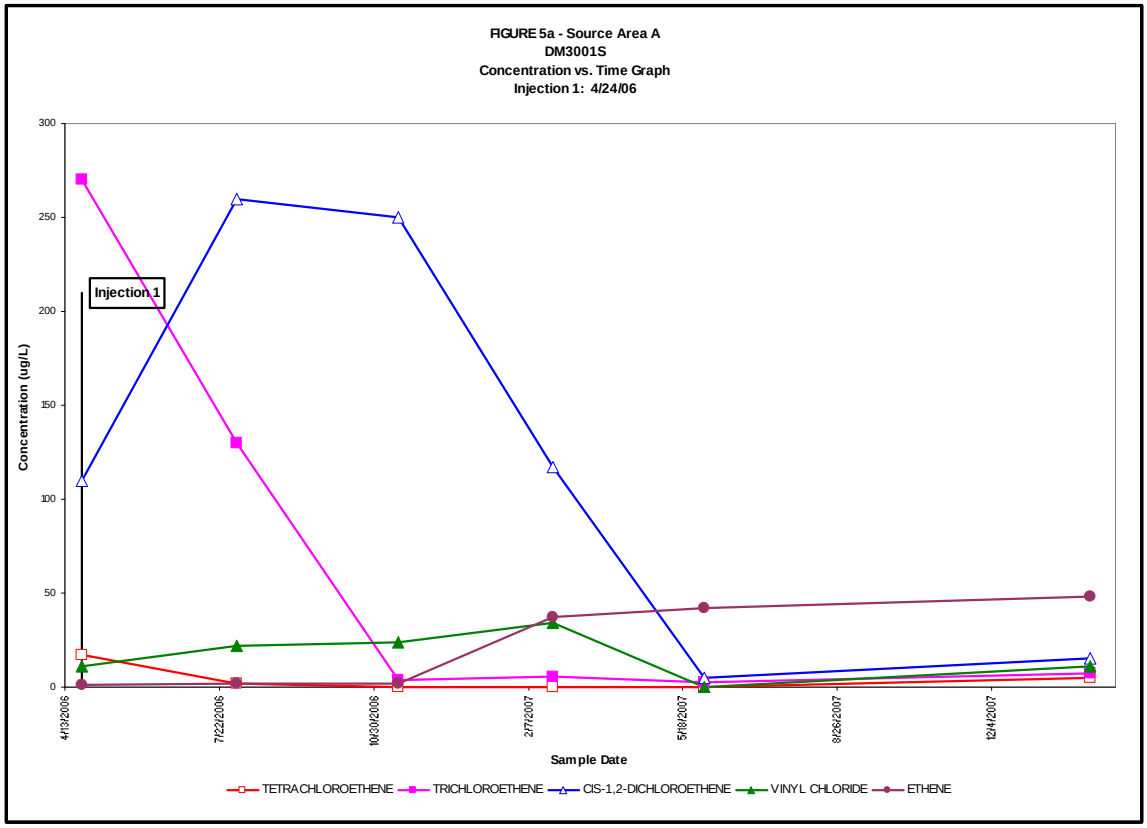
Attachment 4 - Site Photographs for Area 6
SS59

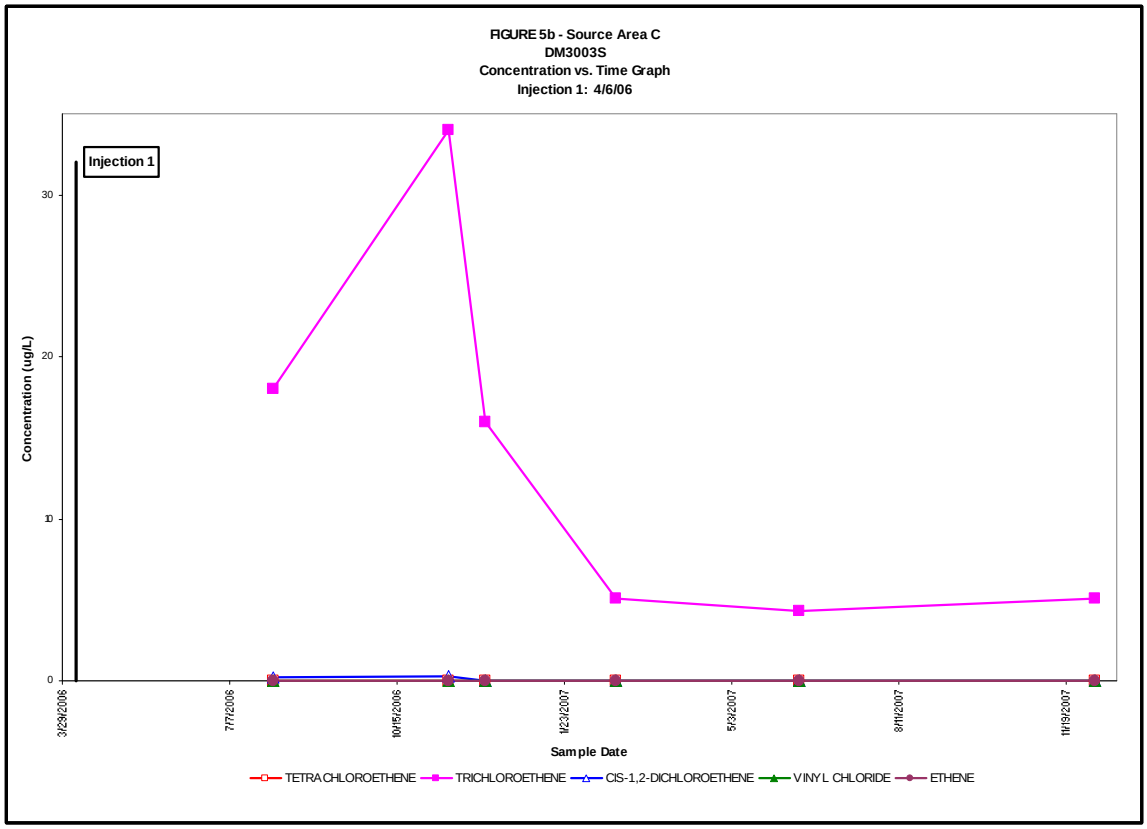
Both Photographs: Asphalt parking lot at SS59 on November 14, 2007.

Attachment 4 - Site Photographs for Area 6
OT28

Top: Construction materials storage area at OT28 on November 14, 2007.
Bottom: Fence and gate at OT28 on November 14, 2007.

Attachment 5 – Source Area Trend Charts





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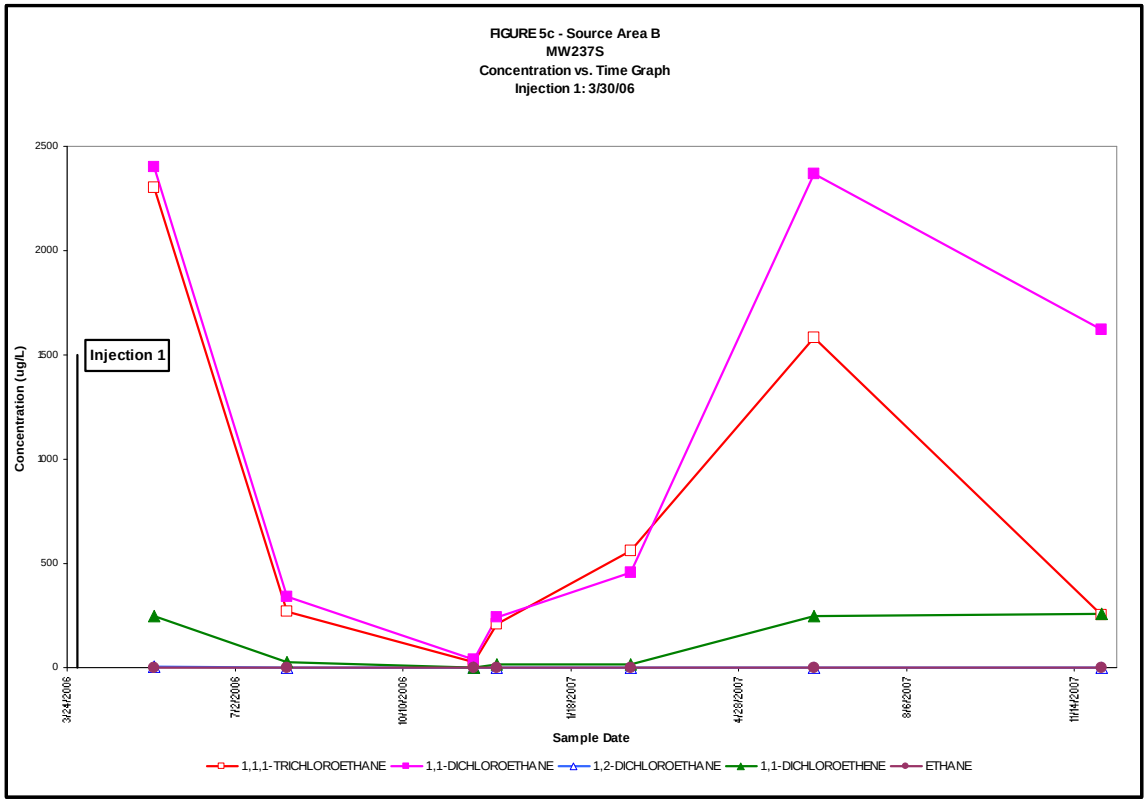
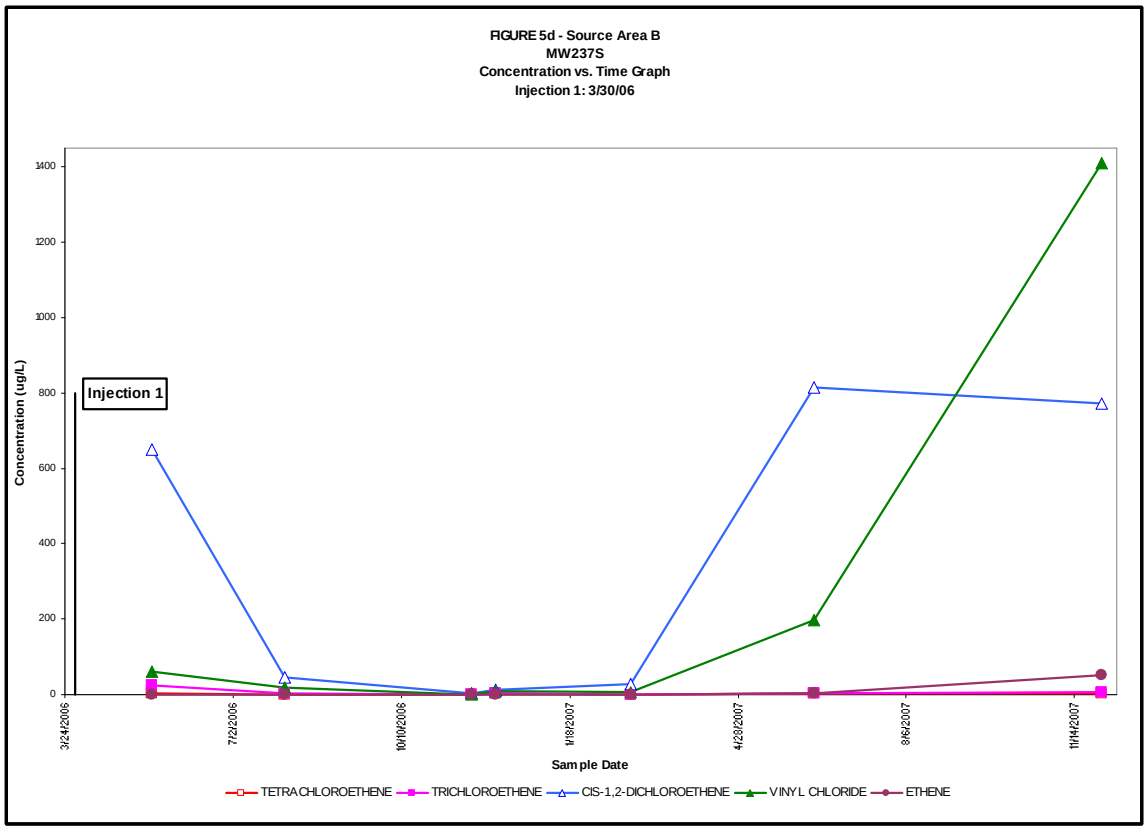
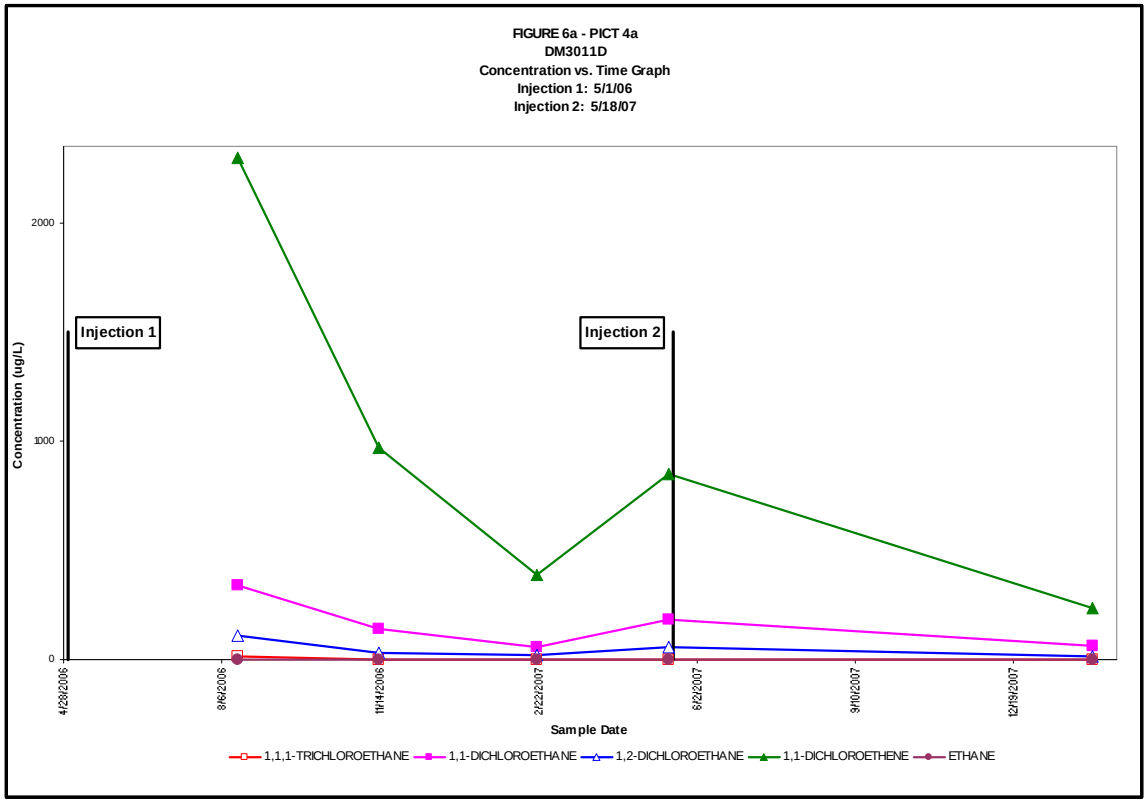
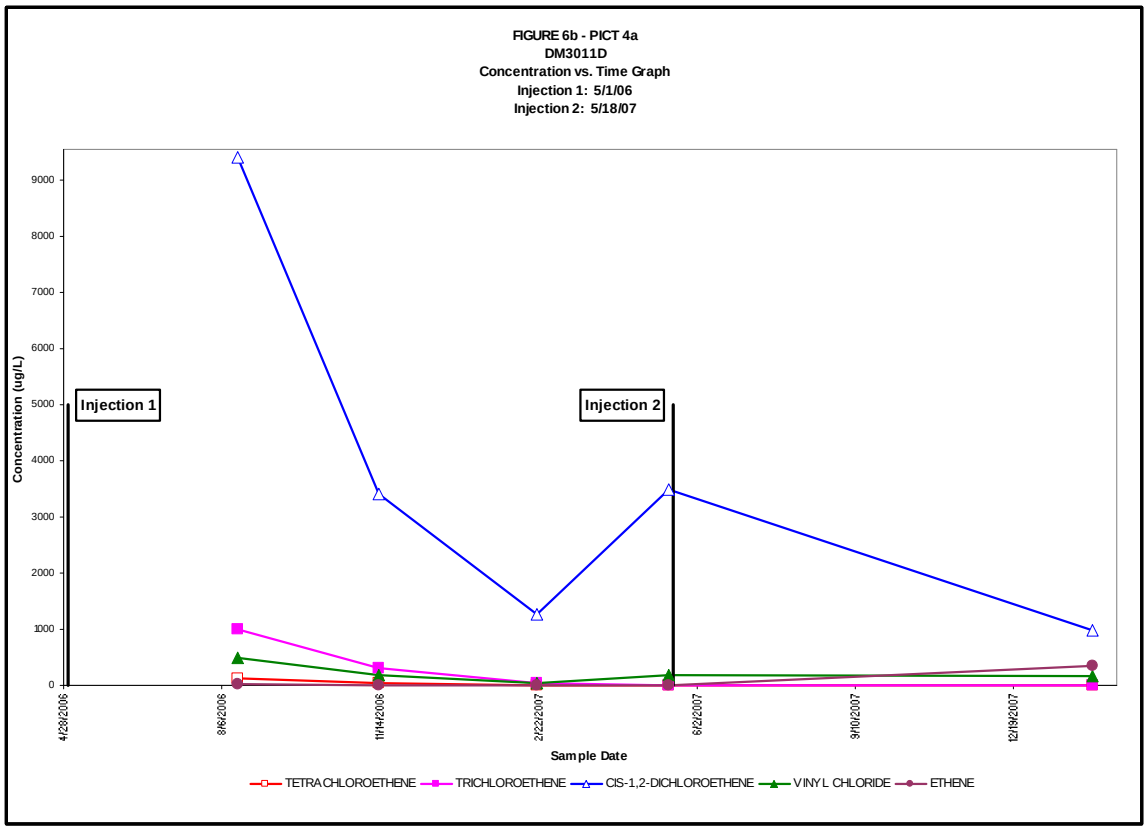




Attachment 6 – PICT Trend Charts





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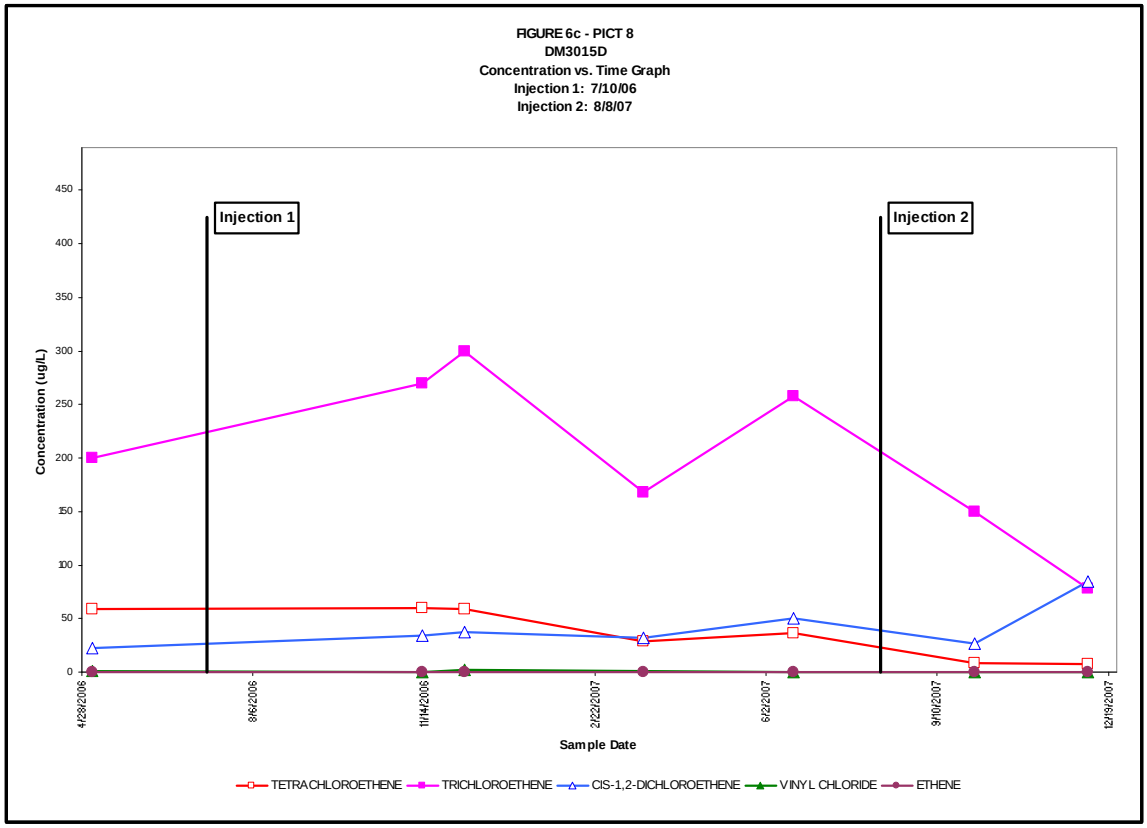


Attachment 7 - OT41/Bldg. 719 RAO/MCL Comparison Table

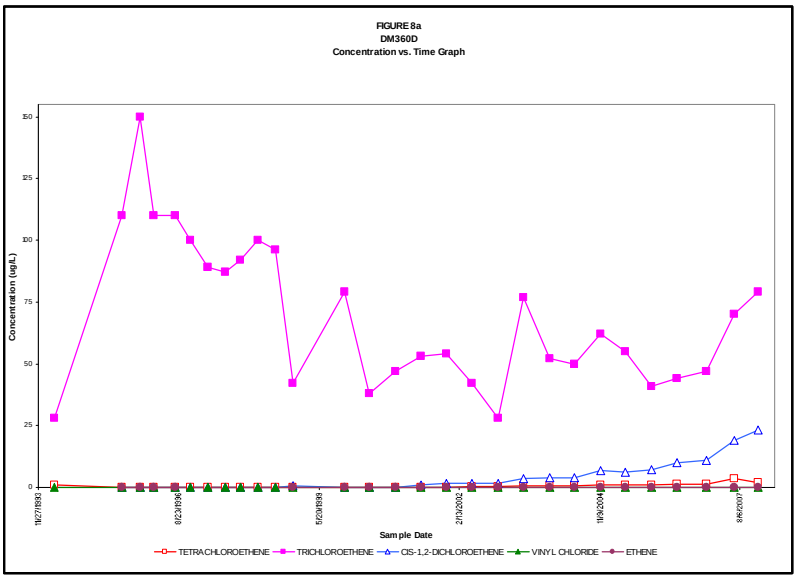
	Compound	PCE	TCE	cis-1,2-DCE	Vinyl Chloride	1,1,1-TCA	1,1-DCE	1,2-DCA
	RAO/MCL	**5 µg/L**	**5 µg/L**	**70 µg/L**	**2 µg/L**	**200 µg/L**	**7 µg/L**	**5 µg/L**
KEY MONITORING WELLS	DM395S	ND	ND	ND	ND	ND	1	ND
	MW604S	ND	6.3	6.3	ND	ND	0.96	4.5
	MW605D	ND	5.7	ND	ND	ND	ND	3.7
	MW605S	ND	33	13.7	ND	ND	0.54	5.1
	MW606S	ND	24	12.5	0	0	0.63	4.4
OTHER WELLS	EW613	ND	ND	ND	ND	ND	ND	3.1
	EW614	ND	ND	9.3	ND	ND	ND	2.7
	EW615	ND	ND	5.5	ND	ND	ND	ND
	MW607S	ND	106	51	6.2	ND	0.75	9.7
	MW608S	ND	47	1201	288	ND	4	46
	MW609S	ND	6	24	0	0	0	0
	MW612S	ND	ND	ND	ND	ND	ND	ND
BACK-GROUND WELLS	MW233D	95	83	29	ND	ND	ND	ND
	MW233S	ND	ND	ND	ND	ND	ND	ND

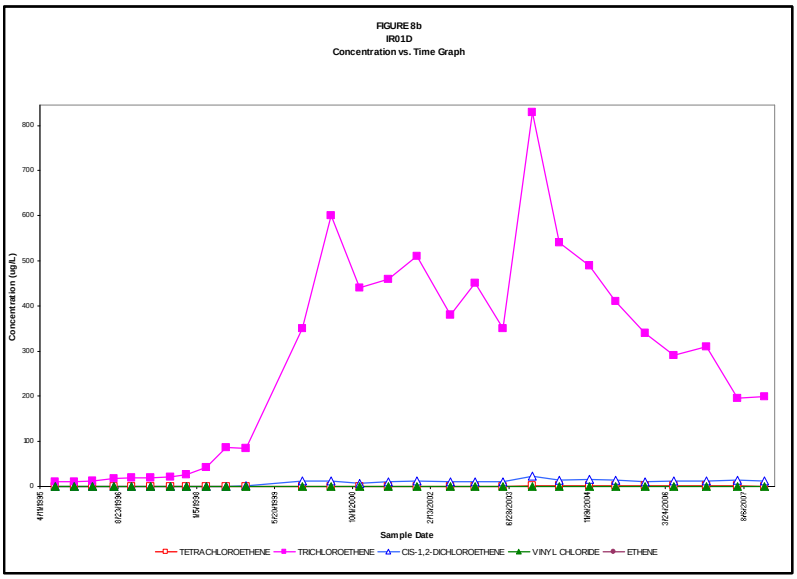
= MCL exceedance

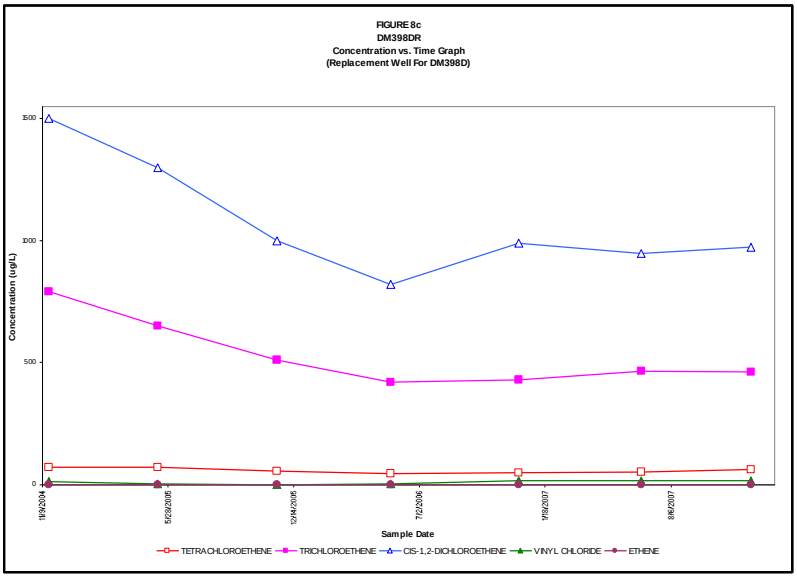
Samples were collected in January 2008

ND = not detected

Attachment 8 – Natural Attenuation Trend Charts







Attachment 9 - RAO Exceedences

Contaminant	RAO*(µg/L)	DM3003S 12/6/2007	DM3009D 12/7/2007	DM3012D 12/11/2007	DM3013D 12/11/2007	DM3015D 10/2/2007	DM3015D 12/7/2007	DM3016D 12/12/2007	DM3017F 12/17/2007	DM3018D 10/2/2007	DM3025S 12/12/2007	DM3026S 12/12/2007
TETRACHLOROETHENE	5	ND	7.3		10	9	7.4	ND	ND	5.3	ND	ND
TRICHLOROETHENE	5	5.1	238		143	150	78	5.3	ND	558	56168	215
CIS-1,2-DICHLOROETHENE	70	ND	160		152	27	84	ND	ND	148	14388	39790
VINYL CHLORIDE	2	ND	0.95		ND	ND	ND	ND	ND	8.7	558	2224
1,1,1-TRICHLOROETHANE	200	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	7	ND	ND		ND	ND	ND	ND	ND	2.7	20	22
1,2-DICHLOROETHANE	5	ND	30		98	13	ND	ND	ND	ND	24	ND
CARBON TETRACHLORIDE	5	ND	ND		ND	ND	ND	ND	ND	ND	1.01	ND
BENZENE	5	ND	**		ND	**	96	ND	ND	ND	ND	ND
BHC-GAMMA (LINDANE)	0.2			1.1	10							

Contaminant	RAO*(µg/L)	DM3027S 12/12/2007	DM3029D 10/2/2007	DM315D 12/12/2007	DM316D 12/10/2007	DM325D 12/4/2007	DM325S 12/4/2007	DM326D 12/10/2007	DM326S 12/5/2007	DM355D 12/11/2007	DM356D 12/14/2007	DM360D 12/17/2007
TETRACHLOROETHENE	5	ND	29	4.3	26	6.3	4	210	ND	2.2	ND	2.01
TRICHLOROETHENE	5	230	138	1723	98	4.7	32	883	1.01	357	ND	79
CIS-1,2-DICHLOROETHENE	70	110	586	943	59	84	406	1741	17	58	ND	23
VINYL CHLORIDE	2	4.4	10.4	18	7.1	93	5.7	9.3	ND	ND	ND	ND
1,1,1-TRICHLOROETHANE	200	ND	2	ND	ND	19	82	70	ND	ND	ND	ND
1,1-DICHLOROETHENE	7	ND	83	17	ND	14	53	459	1.7	ND	ND	ND
1,2-DICHLOROETHANE	5	ND	3.7	21	ND	ND	4.2	5.9	ND	28	ND	11.4
CARBON TETRACHLORIDE	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	5	ND	ND	ND	0.88	ND	ND	0.97	ND	ND	ND	ND
BHC-GAMMA (LINDANE)	0.2				0.011			0.17		0.024		

Contaminant	RAO*(µg/L)	DM361D 12/17/2007	DM367D 12/17/2007	DM396D 12/13/2007	DM397DR 12/14/2007	DM398DR 12/11/2007	EA5D 12/14/2007	EA5F 12/14/2007	EA9D 12/14/2007	EA9F 12/14/2007	F-1 12/6/2007	F-2 12/6/2007
TETRACHLOROETHENE	5	1.4	ND	57	ND	61	4.4	ND	ND	ND	ND	ND
TRICHLOROETHENE	5	42	ND	15	ND	461	615	ND	11	ND	ND	ND
CIS-1,2-DICHLOROETHENE	70	9.6	ND	ND	ND	975	4.2	ND	ND	ND	ND	ND
VINYL CHLORIDE	2	ND	ND	ND	ND	15	ND	ND	ND	ND	ND	ND
1,1,1-TRICHLOROETHANE	200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	7	ND		ND	ND	11	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	5	10.4	ND	ND	ND	443	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	5	ND	9	2.3	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BHC-GAMMA (LINDANE)	0.2					12						

Attachment 9 - Continued

Contaminant	RAO*(µg/L)	IR01D 12/17/2007	IR04D 12/17/2007	MW072S 12/7/2007	MW101D 12/3/2007	MW101S 12/3/2007	MW102D 11/30/2007	MW102S 12/3/2007	MW103D 12/4/2007	MW103S 11/30/2007	MW211D 12/5/2007
TETRACHLOROETHENE	5	ND	ND	ND	299	ND	94	ND	13	1.6	8.2
TRICHLOROETHENE	5	199	ND	ND	173	5.6	74	23	17	4	11
CIS-1,2-DICHLOROETHENE	70	13	ND	ND	27	3	11	570	ND	728	ND
VINYL CHLORIDE	2	ND	ND	ND	ND	ND	ND	4.6	ND	ND	ND
1,1,1-TRICHLOROETHANE	200	ND	ND	ND	ND	15	ND	123	ND	702	ND
1,1-DICHLOROETHENE	7	ND	ND	ND	ND	0.85	ND	55	ND	76	ND
1,2-DICHLOROETHANE	5	ND	ND	ND	ND	ND	1.3	ND	ND	ND	ND
CARBON TETRACHLORIDE	5	ND	47	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	5	ND	ND	**	ND	ND	ND	ND	ND	ND	8.6
BHC-GAMMA (LINDANE)	0.2										

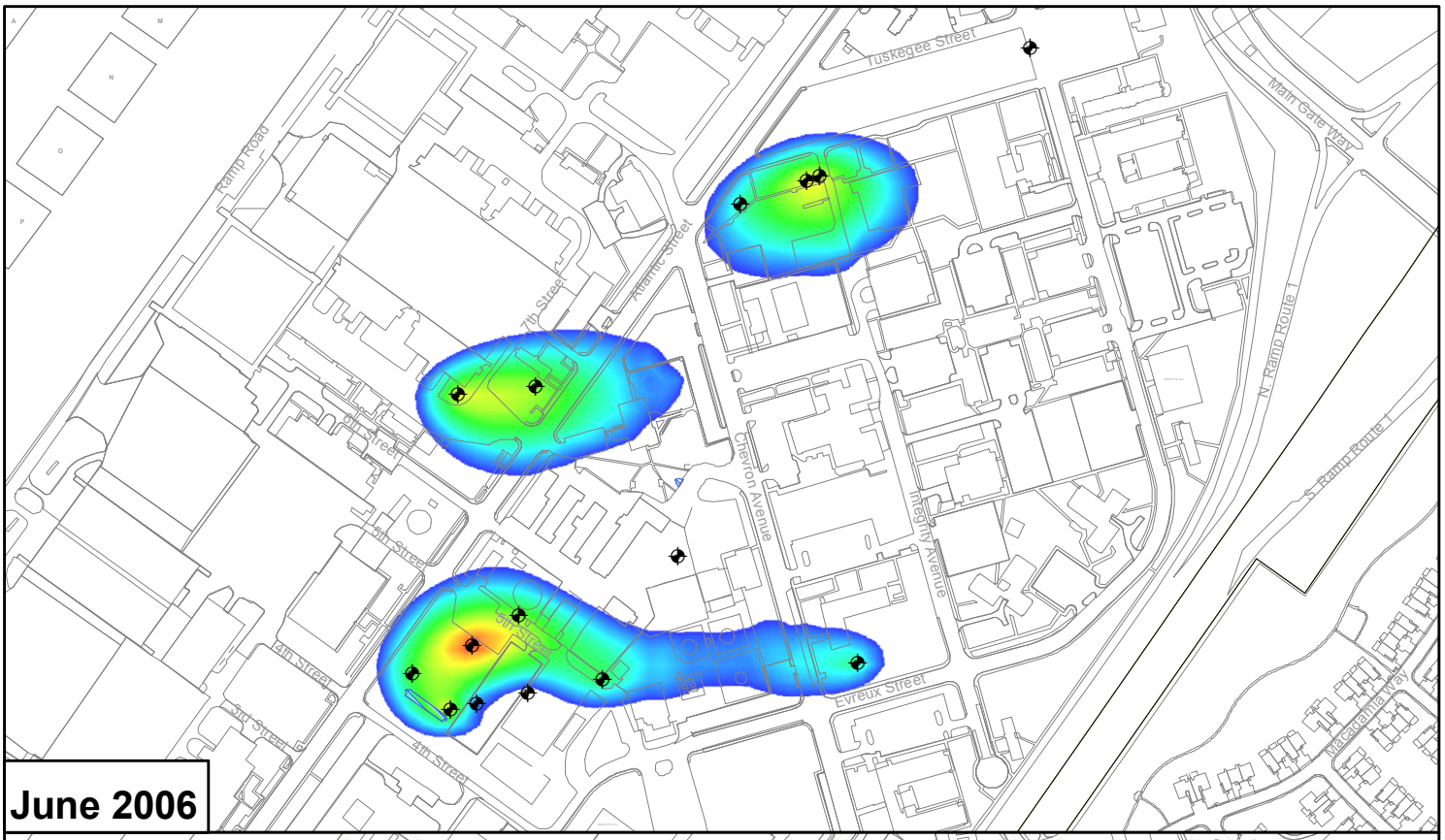
Contaminant	RAO*(µg/L)	MW211S 12/5/2007	MW212D 10/1/2007	MW212D 12/10/2007	MW212S 10/1/2007	MW212S 12/4/2007	MW235D 12/12/2007	MW236D 12/11/2007	MW236S 12/7/2007	MW237D 11/29/2007	MW237S 11/30/2007
TETRACHLOROETHENE	5	ND	26	31	22	8.7	243	ND	ND	ND	3.1
TRICHLOROETHENE	5	ND	2	3.4	4.9	2.7	577	29	ND	ND	4.9
CIS-1,2-DICHLOROETHENE	70	ND	19	26	25	24	96	598	ND	ND	772
VINYL CHLORIDE	2	ND	7	10.7	8.1	6.5	ND	160	ND	ND	1410
1,1,1-TRICHLOROETHANE	200	1.3	3	4.1	ND	ND	ND	ND	ND	ND	252
1,1-DICHLOROETHENE	7	ND	ND	1.3	2.3	ND	12	98	ND	ND	257
1,2-DICHLOROETHANE	5	ND	ND	ND	ND	ND	9.2	6.5	ND	ND	ND
CARBON TETRACHLORIDE	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	5	ND	1.1	1.4	ND	ND	3.9	3.5	ND	ND	2.4
BHC-GAMMA (LINDANE)	0.2			0.032				5.1			

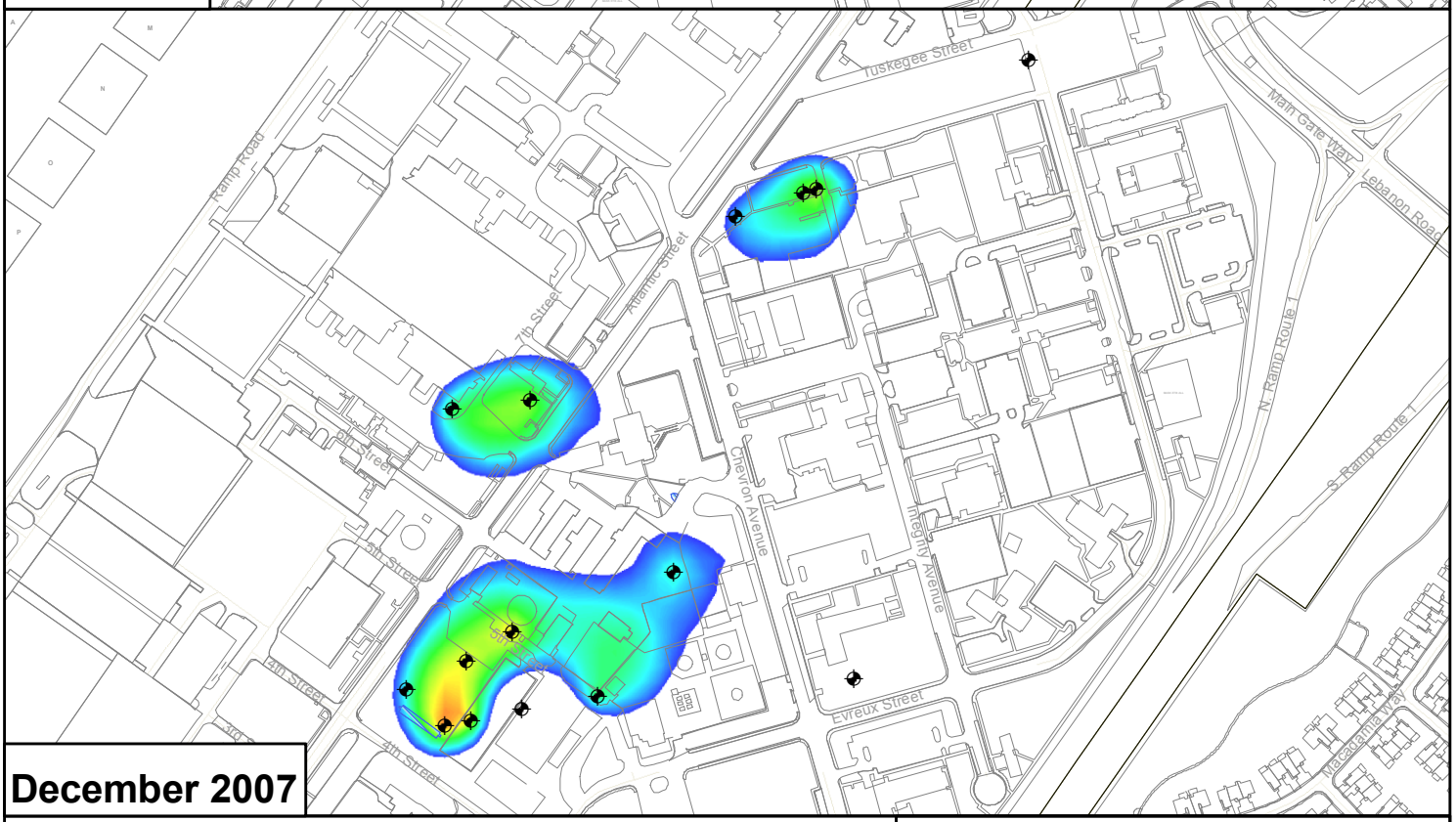
All units in µg/L

RAO Exceedence

*RAO is the federal MCL (EPA 816-F-03-016, June 2003)

**Benzene detected in these wells is attributed to site ST04, a petroleum exclusion site. Benzene associated with ST04 is being addressed under the Delaware Tank Mangaement Program and, therefore, not reported here.





Legend

Monitoring Well

3µg/l 30µg/l 300µg/l 3000µg/l

0 250 500 1,000 1,500 Feet

1:6,000

N

Attachment 10a
Plume Maps for Area 6: 2006 & 2007
Shallow Chlorinated Ethenes

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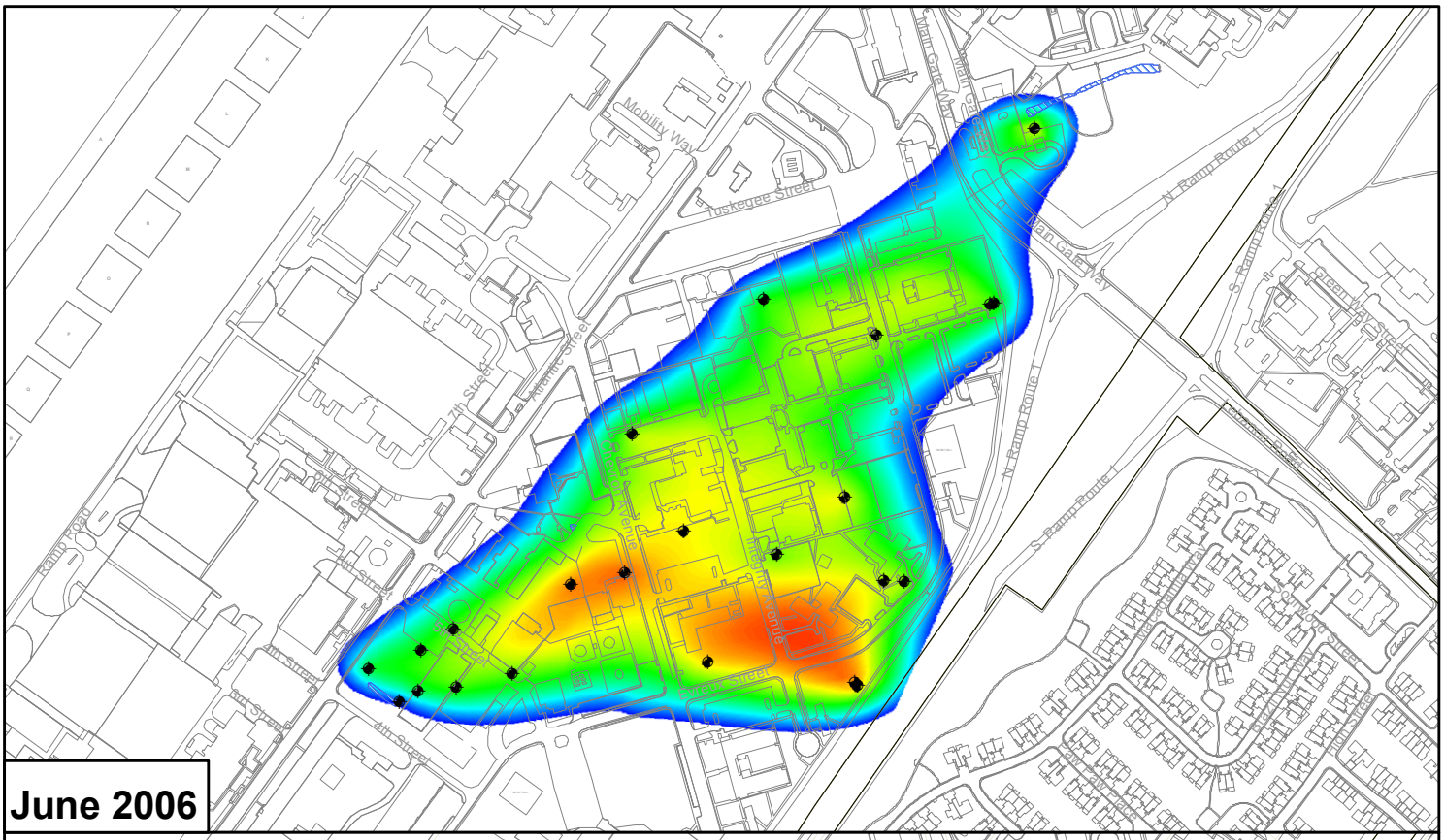

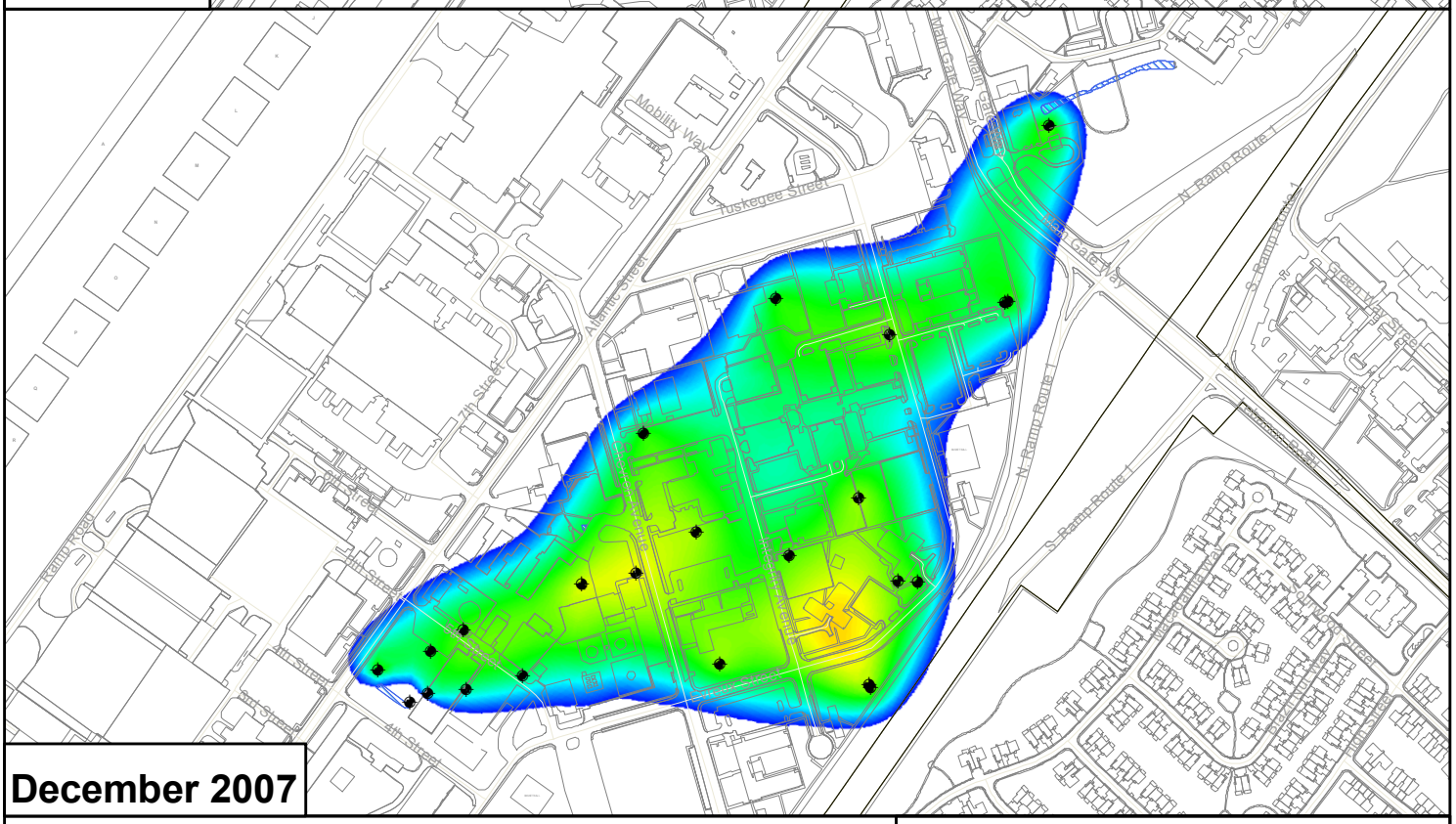

Legend

Monitoring Well

1µg/l 10µg/l 100µg/l 1000µg/l 10000µg/l

0 250 500 1,000 1,500 Feet

1:8,000

N

Attachment 10b
Plume Maps for Area 6: 2006 & 2007
Deep Chlorinated Ethenes

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PROJ NO 15300779	FIGURE Attachment 10b

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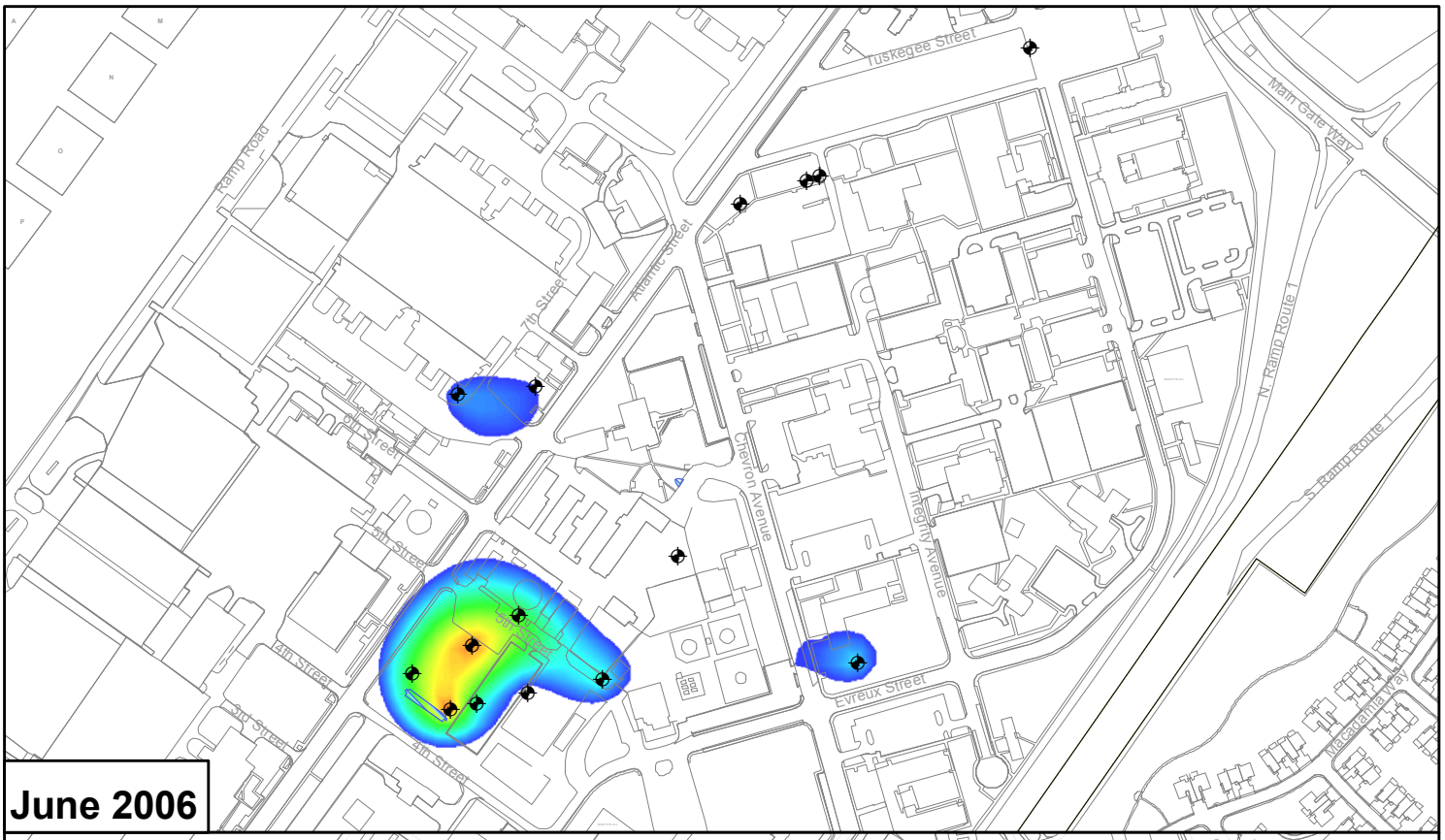
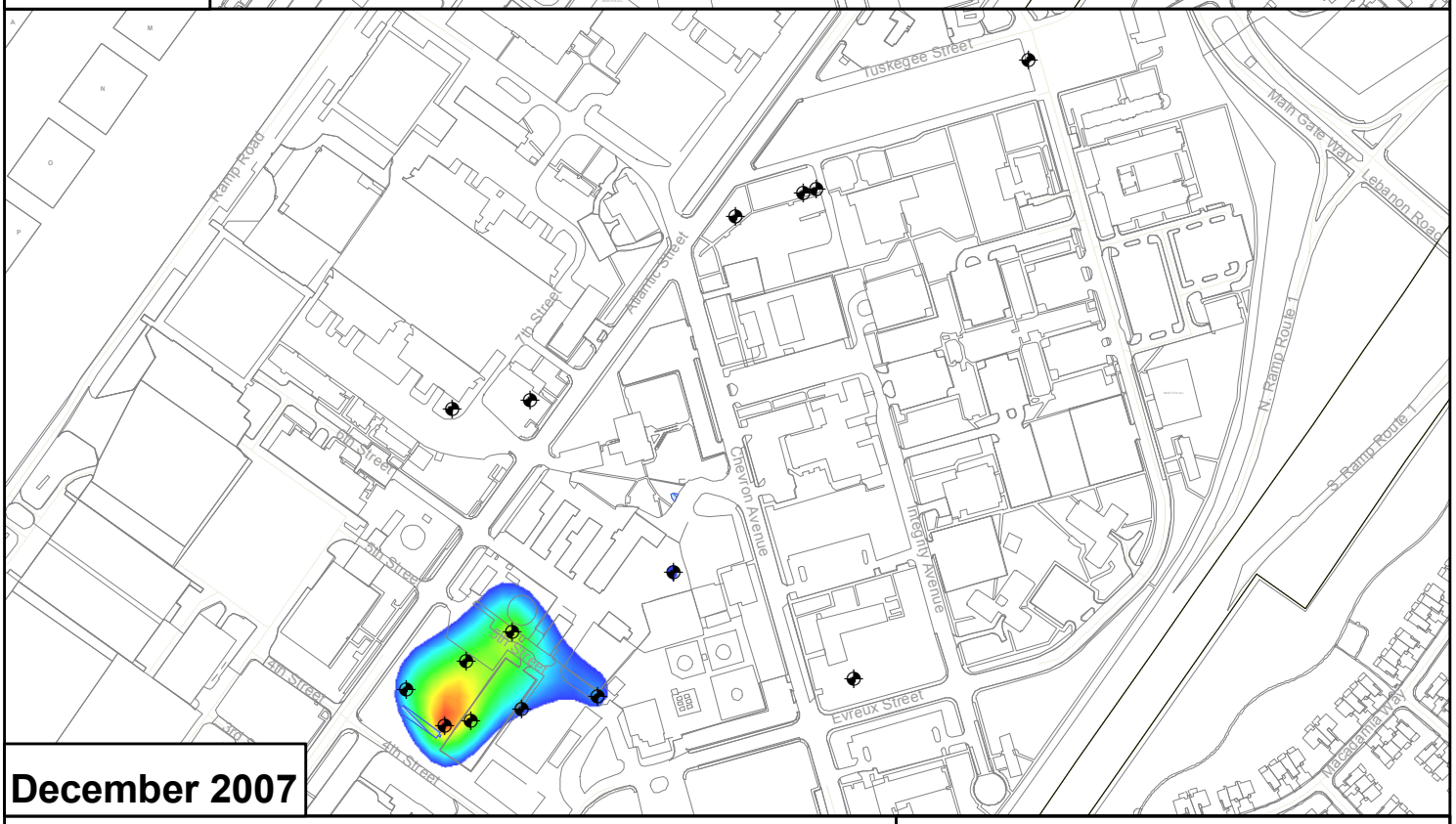
200 Orchard Ridge Drive
Gaithersburg, MD 20878





Legend

Monitoring Well

3µg/l 30µg/l 300µg/l 3000µg/l

0 250 500 1,000 1,500 Feet

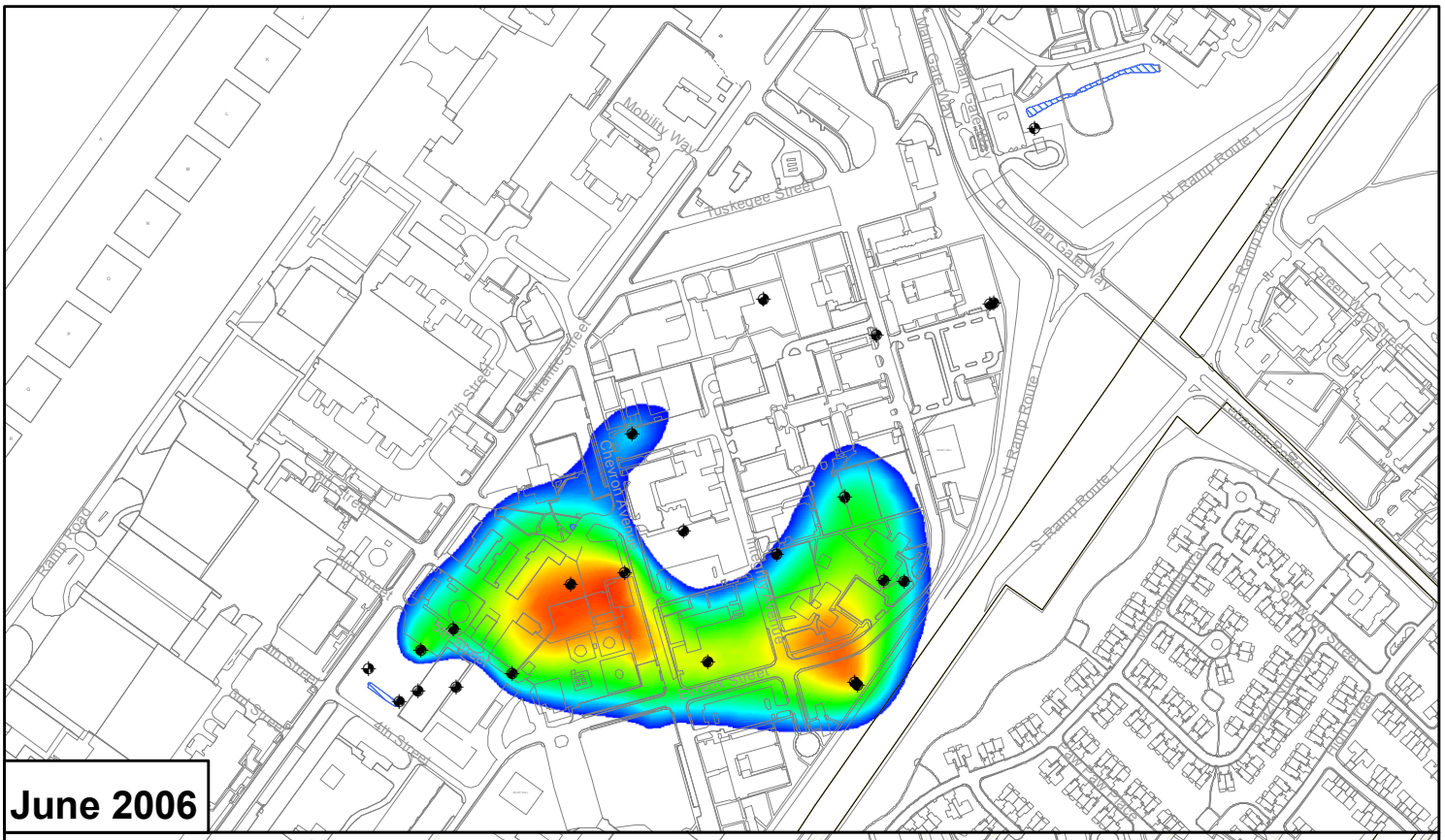
1:6,000

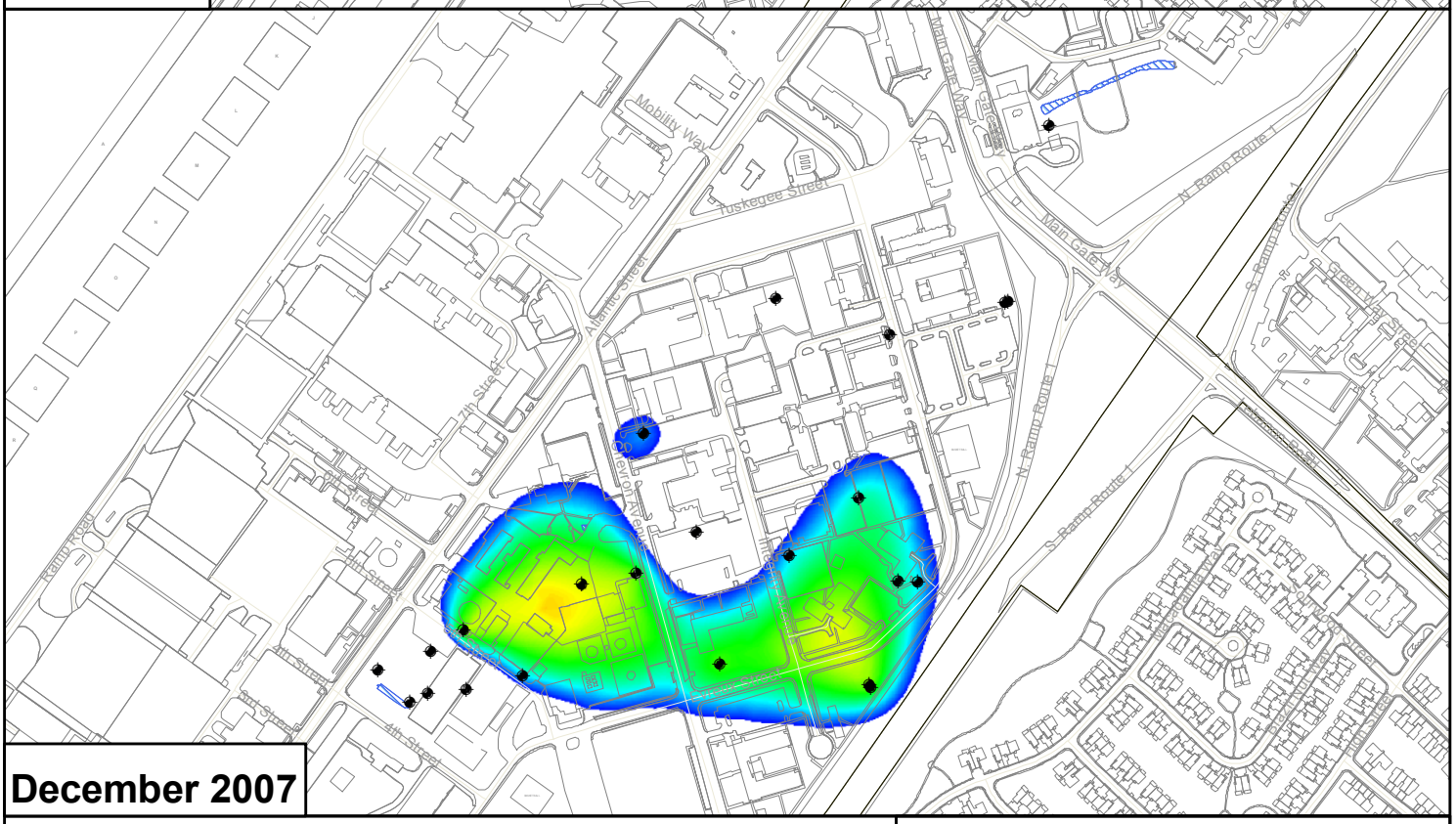
N

Attachment 10c
Plume Maps for Area 6: 2006 & 2007
Shallow Chlorinated Ethanes

PATH	G:\Projects\Dover_AFB\5yr_Review_Figures\Sept 2008\Ethanes_Shallow.mxd
DES BY: DJM 09/22/08	CHK BY: LS
PROJ NO: 15300779	FIGURE: Attachment 10c

URS
200 Orchard Ridge Drive
Gaithersburg, MD 20878





Legend

Monitoring Well

N

1µg/l 10µg/l 100µg/l 1000µg/l 10000µg/l

0 250 500 1,000 1,500 Feet

1:8,000

Attachment 10d
Plume Maps for Area 6: 2006 & 2007
Deep Chlorinated Ethanes

PATH G:\Projects\Dover_AFB\5yr_Review_Figures\Sept 2008\Ethanes_Deep.mxd	
DES BY DJM 09/22/08	CHK BY LS
PROJ NO 15300779	FIGURE Attachment 10d

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FIVE-YEAR REVIEW FOR LF25
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

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Environmental Sciences Division
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LIST OF ACRONYMS AND ABBREVIATIONS

AAB	Accelerated anaerobic biodegradation
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
DAP	Dibasic ammonium phosphate
DERBCAP	Delaware Risk-Based Corrective Plan
DO	Dissolved oxygen
DNREC	Department of Natural Resources and Environmental Control
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
IRACR	Interim Remedial Action Completion Report
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Not Detected
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
ORP	Oxidation reduction potential
PCE	Tetrachloroethene
PICT	Plume injection/circulation transect
RA	Risk assessment
RAO	Remedial action objective
RAWP	Remedial Action Work Plan
RBSC	Risk-based screening criterion
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
TCE	Trichloroethene
TOC	Total organic carbon
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound
WMU	West Management Unit

EXECUTIVE SUMMARY

The remedy for LF25, a former landfill at Dover Air Force Base (DAFB), Delaware, is accelerated anaerobic biodegradation (AAB), natural attenuation with monitoring, and land use controls (LUCs) for groundwater as well as soil. AAB was conducted to treat the source area within the LF25 plume and natural attenuation is being monitored to address the remainder of the plume which is not being treated by AAB. The remedy for LF25 was selected in a Record of Decision (ROD) signed in May 2006. This ROD addresses LF25 and SS08, both of which are small sites with similar remedies.

This is the first five-year review for LF25. (The review for SS08 is documented separately and appears as its own chapter in this West Management Unit (WMU) Five-Year Review volume.) Since achieving the construction complete milestone for all sites, DAFB has merged reviews for all sites into a comprehensive set of Base-wide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the groundwater remedy—AAB, natural attenuation with monitoring, and LUCs—is operating as intended. The primary contaminants of concern (COCs) are carbon tetrachloride, tetrachloroethene (PCE), and trichloroethene (TCE) that form a small, narrow plume. Groundwater treatment is reducing the concentrations of the COCs. LUCs remain in effect and no new uses of groundwater or soil at the site were observed. It is recommended that AAB treatment and monitoring continue to confirm that COCs are reduced to levels that meet the remedial action objectives (RAOs) specified for LF25 in the ROD for sites SS08 and LF25.

The draft-final five-year review for LF25 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

LF25 is an Environmental Restoration Program (ERP) site formerly used as a landfill from 1947 to 1959 at Dover Air Force Base (DAFB), Delaware, in the West Management Unit (WMU) (Attachment 1). It is currently located on part of the Base golf course. General refuse and construction rubble were buried at this site before being covered with soil and seeded with grass for the golf course. No active remediation was conducted at the time of closure. Environmental investigations were subsequently conducted that revealed groundwater contamination as a particular concern. Under a 2006 Record of Decision (ROD), accelerated anaerobic biodegradation (AAB) and natural attenuation with monitoring were selected to reduce the contaminants of concern (COCs) in the groundwater at LF25. Land use controls (LUCs) for soil and groundwater are also a component of the remedy.

The remedial action at LF25 was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the first five-year review for the LF25 remedy. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

AAB and natural attenuation with monitoring are the major components of the LF25 remedy. Similar remedies for groundwater were implemented concurrently at thirteen other WMU sites: SS08, the five sites associated with the Area 5 plume (OT51, OT50, SS20, OT44, and OT41/Motor Pool), and the seven sites associated with another plume called Area 6 (WP31, WP21, ST34, OT41/Bldg. 719, OT49, OT28, and SS59). LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the LF25 remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
1947-1959	LF25 was used as a landfill.
1960s	The Base golf course was constructed over LF25.
March 13, 1989	DAFB listed on National Priority List (NPL).
1991	LF25 was evaluated during the 1991 Site Investigation (SI) (HAZWRAP, 1991).
August 1997	Basewide Remedial Investigation (RI) finalized; included assessment of LF25 (USACE, 1997).
2000	Basewide Ecological Risk Assessment finalized (USACE, 2000).
April 11, 2003	DNREC established a groundwater management zone (GMZ) encompassing DAFB.
May 2005	Feasibility Study (FS) completed for the WMU, included evaluation of LF25 (USACE, 2005).
2005	Supplemental groundwater sampling conducted for the purpose of remedy implementation.
May 2006	ROD prepared for SS08 and LF25 (USACE, 2006).
May 2006	Remedial Action Work Plan (RAWP) finalized for SS08 and LF25 (ORNL, 2006b).
June-August 2006	Injection/extraction and monitoring wells installed at LF25.
June 2006-ongoing	AAB and natural attenuation monitoring at LF25.
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	AAB trailer injections performed at LF25 plume injection/circulation transect (PICT).
September 2006	Interim Remedial Action Completion Report (IRACR) prepared for SS08 and LF25 (ORNL, 2006a).
November 2007	AAB injections performed at LF25 PICT.
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007a).

DNREC – Department of Natural Resources and Environmental Control
HAZWRAP – Hazardous Waste Remedial Actions Program
USACE – U.S. Army Corps of Engineers (Omaha District)

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

LF25 is located on the Base golf course southwest of U.S. Route 113. During the construction of the golf course, the landfill was covered and seeded with grass. Groundwater at the site is typically encountered at depths between 10 and 15 feet (ft) below ground surface (bgs), although it can be found as shallow as 3 ft bgs closer to the St. Jones River and its tributary that borders the southeast side of LF25. The groundwater flow at LF25 is strongly influenced by the nearby golf course tributary, a drainage ditch which is a local groundwater discharge point. The golf course is inaccessible to the general public.

3.2 LAND AND RESOURCE USE

DAFB had previously used LF25 as a landfill for over 10 years. Once these activities ceased, the site was covered with soil, seeded with grass and part of the Base

golf course was constructed above it. This site has been consistently used as a golf course since that time.

The shallow groundwater (Columbia Aquifer) underlying the site generally flows to the south towards the golf course tributary and towards the confluence of the golf course tributary and the St. Jones River. This aquifer is not currently used as a drinking water source. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. The river is used for recreational purposes but is not used for potable water. Off site, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB, including the Base golf course. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well-permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

LF25 was used as a landfill from 1947 to 1959. It was a 7- to 8-acre landfill used for disposal of general Base refuse and construction rubble, located on what is now the Base golf course. Groundwater data suggest that industrial wastes also may have been disposed of in the landfill. The landfill was filled to a depth of approximately 8 ft. The primary source of contaminants is a chlorinated solvent plume in the groundwater which appears to originate in the vicinity of the southern corner of the landfill. The three COCs found during the RI at this site are carbon tetrachloride, tetrachloroethene (PCE), and trichloroethene (TCE). All were detected at concentrations above their maximum contaminant levels (MCLs). Two volatile organic compounds (VOCs), cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride, are also considered potential COCs for LF25 because they are expected to become present in the aquifer as PCE and TCE degrade. Groundwater sampling conducted in 2005 revealed that there is likely some impact from the former off-Base dry cleaners located upgradient of LF25, and this is most likely the source of the carbon tetrachloride. Additionally, constituents migrating from the upgradient Area 6 plume may also impact the LF25 area. Some evidence of natural biodegradation of the chlorinated solvents has been observed within this plume; however, it has been insufficient to keep the plume from reaching the golf course tributary at levels exceeding MCLs.

Although there is some discharge to the golf course tributary from LF25, the Basewide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

Treatment alternatives for LF25 were evaluated in the WMU FS (USACE, 2005). Supplemental groundwater characterization specific to remedy implementation was conducted in 2005 and documented in the RAWP. In early 2006, a ROD was signed for the soil and groundwater at LF25. The selected remedy included AAB, natural attenuation with monitoring, and LUCs for soil and groundwater.

3.5 BASIS FOR TAKING ACTION

The Basewide RI risk assessment (RA) evaluated hypothetical future commercial/industrial and residential scenarios for groundwater and soil at LF25 (USACE, 1997). Non-carcinogenic risks from hypothetical future commercial/industrial and residential exposures to groundwater at LF25 exceeded the USEPA risk criterion. The carcinogenic risk from hypothetical future residential exposure to groundwater at LF25 also exceeds the USEPA risk criterion. Groundwater contaminant concentrations in the Columbia Aquifer at LF25 also exceed federal MCLs. Although groundwater from the Columbia Aquifer at LF25 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifer has the potential for beneficial use. MCL exceedences at the site as well as the potential for contaminant migration to areas not under DAFB control, trigger the need for remedial action at LF25. Based on the RA for soil, a cleanup action is not warranted. However, this conclusion is based on the assumption that the future on-Base land use at the site will remain industrial or its current use as a golf course. Thus, the response action for soil is to ensure the permanence and reliability of the land use assumptions, and thereby protect the public health from hazardous substances at the site. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for LF25 was signed by USEPA in May 2006 (USACE, 2006). The remedial action objectives (RAOs) were developed based on the potential for contaminants in groundwater to migrate off Base, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, one of the RAOs for groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of off-site migration at harmful levels is mitigated. By restricting access, potential exposures to soil and groundwater are mitigated.

Various remedial actions were evaluated in the WMU FS. The selected remedy for LF25 groundwater as outlined in the 2006 ROD includes the five major components listed below.

- Injection/diffusion AAB of the source area at LF25.
- Natural attenuation of the LF25 plume outside the AAB treatment zone.
- LUCs for soil and groundwater.
- Groundwater monitoring.
- Evaluation of vapor intrusion pathway during groundwater remedial action phase (accomplished in 2007) (ORNL, 2007a).

4.2 REMEDY IMPLEMENTATION

Remedy implementation and monitoring were performed in accordance with the RAWP for SS08 and LF25 (ORNL, 2006b) and documented in the IRACR for SS08 and LF25 (ORNL, 2006a). The plume at LF25 is relatively small and contaminant concentrations are much lower than seen in the other large plumes at DAFB. For the AAB application, one PICT was installed perpendicular to groundwater flow across the plume. In June through August 2006, a PICT comprising six 4-inch-diameter wells was installed to create a linear AAB zone perpendicular to groundwater flow within the plume at LF25 where the highest solvent concentrations were detected (Attachment 1). Additional monitoring wells were also installed. Initial injections at LF25 occurred in August 2006. The substrate consisted of emulsified vegetable oil and sodium lactate added to potable water. Dibasic ammonium phosphate (DAP) was also added to the mixture to provide metabolic nutrients. A mobile AAB process trailer powered by a generator was used to extract groundwater, amend it with substrate, and re-inject the mixture into the aquifer. Groundwater was extracted from every other well, amended, and then returned to the aquifer under pressure through adjacent injection wells, creating a push-pull effect. Injection quantities for the initial injection are documented in the IRACR for SS08 and LF25.

At LF25, the primary mechanism for AAB and natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant PCE, degrades to TCE, then to cis-1,2-DCE, then to vinyl chloride, and finally to ethene, a harmless gas.

Monitoring programs for both AAB and natural attenuation were established at LF25 in accordance with the RAWP. Wells used to monitor progress of AAB are listed in Table 2. AAB monitoring was conducted more frequently just after injections and then progressed to monthly, then quarterly, then semi-annual sampling after a year. Early in the AAB monitoring program the focus was on the distribution of total organic carbon (TOC) and indicator parameters: dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, dissolved iron, and sulfate. At month 3, after the substrate had some time to stimulate biodegradation, VOC and dissolved gases analyses were added to the monitoring program.

Table 2 – LF25 Wells

Well ID	Well Purpose	
	AAB	NA
DM3603S	X	X
DM3603D	X	X
DM376S	X	X
DM376D	X	X
DM376F		X

NA - natural attenuation

Monitoring for natural attenuation includes VOCs and indicator parameters on a semi-annual schedule. Wells in the natural attenuation program are also listed in Table 2. The first semi-annual sampling round for natural attenuation was completed in July 2006. The monitoring results for both the initial AAB monitoring and the initial natural attenuation monitoring are documented in the IRACR for SS08 and LF25.

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including LF25. Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the Base digging permit process to ensure compliance with land use restrictions. (3) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a portion of off-Base property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (4) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the contaminants found at LF25 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 3 – RAO Groundwater Concentrations

Parameter	RAO Concentration[a] (µg/L)
Carbon tetrachloride	5
cis-1,2-DCE	70
PCE	5
TCE	5
Vinyl chloride	2

[a]The groundwater RAOs are the MCLs
µg/L - micrograms per liter

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the ROD, a RA was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the WMU. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

Remedial operations have been ongoing at LF25 since the initial injections were completed in August 2006. A second round of PICT injections was accomplished during November 2007. The second injection event was designed to fill substrate distribution gaps and provide a more uniform substrate distribution. Almost four times the amount of substrate was injected during the second event relative to the first. AAB and natural attenuation monitoring events are currently both conducted on a semi-annual schedule in accordance with the RAWP for SS08 and LF25. Semi-annual reports document all of the monitoring results. Additionally, LUCs inspections and reporting are conducted annually.

The main maintenance activities associated with the LF25 remedy are:

- Maintain integrity of the PICT wells, ensure that well caps and protective covers are secured.
- Maintain the mobile treatment trailer hoses, pumps, and monitoring equipment in good working order.
- Maintain the generator in good working order so as to provide adequate power to the control panels, light fixtures, submersible and metering pumps and receptacles at the system trailer.
- LUCs inspections are conducted on an annual basis.

The costs associated with the AAB remedy and natural attenuation monitoring are summarized in Table 4.

Table 4 – Annual Remedy Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$190,000 (includes initial capital costs)
2007	$140,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for LF25.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for LF25 would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for LF25 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of LF25 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant LF25 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the AAB monitoring as well as the long-term natural attenuation portion of remedy (ORNL, 2008). Data were collected more frequently immediately after AAB injections at LF25. At this time, the entire plume is monitored on a semi-annual schedule in accordance with the RAWP. Groundwater sampling and analysis is the primary means of determining the remedy's continued effectiveness at LF25. The monitoring reports reviewed for LF25 evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequacy/optimization of the current monitoring well network.

PCE has been the dominant constituent in most of the wells. The November 2007 sampling is the first round that showed clear signs of PCE degradation in DM3604M (close to the PICT) and DM376D (about 100 ft downgradient). Trend charts for the COCs in these two wells appear in Attachment 5. PCE daughter products, TCE and cis-1,2-DCE, have also increased in these two wells. Vinyl chloride was not detected in any of the wells. Results for carbon tetrachloride, which originates upgradient at a former dry cleaners, are summarized in Table 5 below. Relatively stable trends are observed in site wells. Ethane and ethene, when present, indicate that complete degradation of the chlorinated ethenes is occurring. Trace amounts of ethane and ethene were detected at DM3604M.

Table 5 – Carbon Tetrachloride at LF25 (µg/L)

Date	**Well ID**					
	DM3603D	DM3603S	DM3604M	DM376D	DM376F	DM376S
4/1994				17	ND	ND
6/2005				69		ND
7/2006	46	61		92	ND	ND
11/2006	73	60				
12/2006			47	85		ND
1/2007	86	80		100	ND	ND
3/2007	85	110	63	83		0.01
8/2007	85	95	60	72	ND	ND
11/2007	84	75	50	51	ND	ND

ND - not detected
An empty cell indicates that no sample was collected.

At LF25, there are still RAO exceedences in four of the six wells sampled (Table 6). PCE, TCE, and carbon tetrachloride all exceed their RAOs. There were no RAO exceedences in the Frederica Aquifer well (DM376F).

Table 6 - RAO Comparison

November/December 2007 (µg/L)							
Contaminant	DM3603D	DM3603S	DM3604M	DM376D	DM376S	DM376F	RAO
Carbon Tetrachloride	84	75	50	51	ND	ND	5
Cis-1,2-DCE	8.2	11	31	6.9	6.6	ND	70
PCE	771	553	22	70	ND	ND	5
TCE	32	37	35	24	ND	ND	5
Vinyl Chloride	ND	ND	ND	ND	ND	ND	2

RAO exceedence

ND - not detected

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at LF25 on that day (Attachment 4). The area is currently a well-maintained fairway on the Base golf course. No new uses of groundwater on the site were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for LF25 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Progress has been made towards achieving the RAOs in the immediate vicinity of the AAB transect. Attachment 6 illustrates the extent of the LF25 plume in 2005 (prior to implementing AAB) and in late 2007. Overall, the plume has changed little to date.

The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the SS08 and LF25 ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial and future residential exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA

were reviewed. The changes in these values and their effects on risks, are qualitatively summarized in Table 7 (USEPA, 2007). The various changes could increase and decrease the overall carcinogenic risks and non-carcinogenic hazards. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 7 – Risk Assessment Review

Change	Effect
RBSC value increased for manganese.	This chemical would be excluded from the RA, slightly decreasing overall hazard.
RBSC values decreased for bis(2-ethylhexyl)phthalate and dieldrin.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
Inhalation reference doses increased for benzene and carbon tetrachloride.	A slight decrease in overall hazard.
Inhalation reference doses are now available for chloroform, PCE, and TCE*.	A slight increase in overall hazards.
Oral reference doses decreased for TCE*, and is now available for benzene.	A slight increase in overall hazards.
Inhalation slope factors increased for PCE and TCE*.	A slight increase in overall risks.
Inhalation slope factor decreased for benzene.	A slight decrease in overall risk.
Oral slope factors increased for benzene, PCE, and TCE*.	A slight increase in overall risks.
Oral slope factor is no longer available for chloroform.	A slight decrease in overall risk.

RBSC – Risk-based screening criterion
*Assessment of TCE based on 2001 provisional toxicity values.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). In addition, groundwater monitoring has shown that the contaminant plume in this area has remained relatively stable. In fact, plume remediation is successfully reducing contaminant mass. Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological RA. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this site.

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

This review for LF25 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Use of the site is unchanged and there have been no reports of new contaminant releases. All information collected to date indicates that the remedy is operating as intended and that progress has been made towards achieving the RAOs.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for LF25 groundwater is functioning as intended. Data show that an anaerobic environment exists, but that reductive capacity is still developing at this time. The second substrate injection event occurred in November 2007 and was designed to fill potential gaps along the PICT. Additionally, approximately four times the amount of substrate relative to the first event was injected. This should strengthen the reductive environment and result in more effective degradation.

Although degradation rates were not provided in the LF25 monitoring reports, inspection of the contaminant trend charts (Attachment 5) indicates that degradation of chlorinated solvents increased in response to AAB treatment. Should the trends established during the first two years continue, the remedy appears to be capable of achieving RAOs in the 6-year time frame stated in the SS08/LF25 ROD for the plume core and within 26 years for the distal plume.

Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

LUCs have been successfully implemented at the site.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater sampling during the SI and RI at LF25 demonstrated that site activities locally affected groundwater quality and that a potential exists for off-site migration. In response, AAB, natural attenuation with monitoring, and LUCs for soil and groundwater were initiated at LF25.

It is recommended that AAB and natural attenuation activities continue at LF25. It is also recommended that the proposals made in the semi-annual reports for optimizing

both AAB and the monitoring well network be implemented. The recommended operation and maintenance improvements from the latest report include the following actions:

- Remove DM376F from the monitoring network. DM376F contains no COCs and, based on the slight upward vertical gradient near the adjacent stream, it is unlikely to be affected by the LF25 plume.
- Conduct future AAB and natural attenuation sampling activities at LF25 on a semi-annual schedule in accordance with the RAWP.
- Add chloroform and dichloromethane to the analytical list since they are breakdown products of carbon tetrachloride.
- Remove chloride from the sample analyte list. This indicator has not been useful in assessing site conditions.
- Continue to enforce LUCs at the site.

A worst case vapor intrusion evaluation was performed in 2008 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

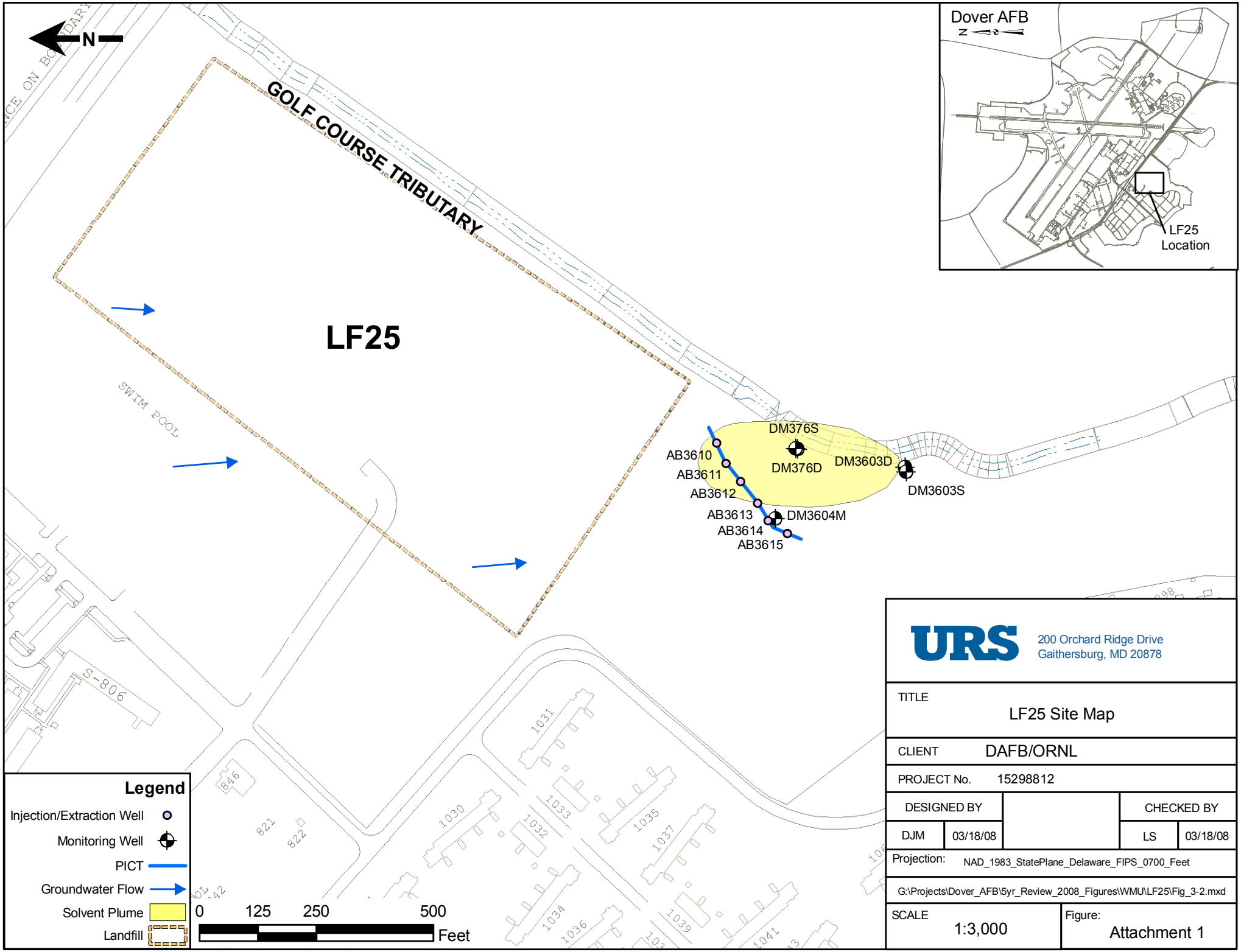
The site as a whole will continue to be addressed in the five-year review process since the remedy (including LUCs) and groundwater monitoring are still active at LF25.

10.0 PROTECTIVENESS STATEMENT

The remedy at LF25 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for LF25 will be due in September 2013.


N
GOLF COURSE TRIBUTARY
LF25
SWIM POOL
S-806
DM376S
DM376D
DM3603D
DM3603S
DM3604M
AB3610
AB3611
AB3612
AB3613
AB3614
AB3615
Dover AFB
LF25
Location
Legend
Injection/Extraction Well
Monitoring Well
PICT
Groundwater Flow
Solvent Plume
Landfill
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125
250
500
Feet
URS
200 Orchard Ridge Drive
Gaithersburg, MD 20878
TITLE
LF25 Site Map
CLIENT
DAFB/ORNL
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DJM
03/18/08
CHECKED BY
LS
03/18/08
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G:\Projects\Dover_AFB\5yr_Review_2008_Figures\WMU\LF25\Fig_3-2.mxd
SCALE
1:3,000
Figure:
Attachment 1

Attachment 2 - Reviewed Documents

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

HAZWRAP, 1993. Ecological Risk Assessment, Phase 1: Site Characterization, Dover AFB, Dover, Delaware, submitted by Dames & Moore, February 1993.

HAZWRAP 1991. Site Investigation Report for LF25, submitted by Dames & Moore, September 1991.

ORNL, 2008. Monitoring Report for Sites SS08 and LF25, West Management Unit (through November 2007), Dover Air Force Base, submitted by URS Group Inc., March 2008.

ORNL, 2007. Vapor Intrusion Assessment, Dover Air Force Base, Delaware, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. Interim Remedial Action Completion Report, Sites SS08 and LF25, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., September 2006.

ORNL, 2006b. SS08 and LF25 – West Management Unit Remedial Action Work Plan, Dover Air Force Base, Delaware, submitted by URS Group, Inc., May 2006.

USACE, 2006. Proposed Plan for SS08 and LF25, Dover AFB, Delaware, submitted by URS Group, Inc., January 2006.

USACE, 2006. Record of Decision for SS08 and LF25, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., April 2006.

USACE, 2005. Final Feasibility Study, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., May 2005.

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [South Management Unit, Volumes I - IV].

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs are listed in the ROD for SS08 and LF25 and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the ROD. ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial or residential scenario. However, the Air Force has decided to implement LUCs as an action for soil to prevent unearthing or disturbance of landfill contents. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's *Delaware Risk-Based Corrective Action Plan* (DERBCAP) established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For LF25 chlorinated solvents, the standards in this guidance are the same as the Federal MCLs.

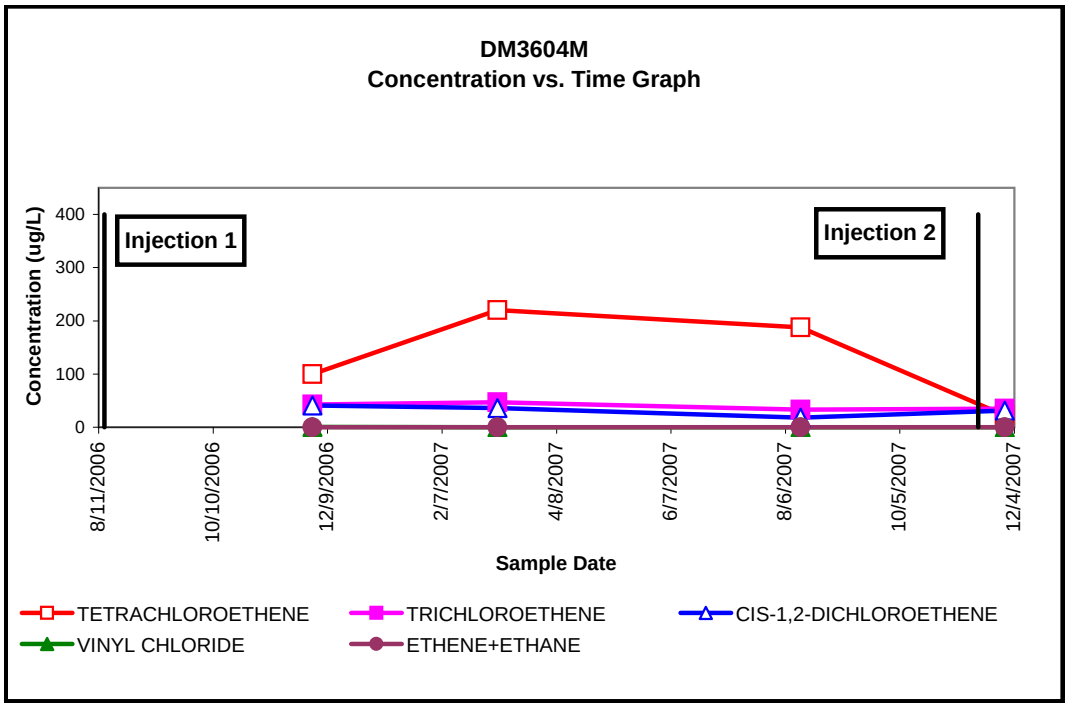
Surface Water and Sediment. Surface water and sediment are not present at LF25. Sampling conducted for the Basewide Ecological Risk Assessment revealed no VOCs in the surface water or sediment collected from downstream drainages that could be affected by LF25 and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

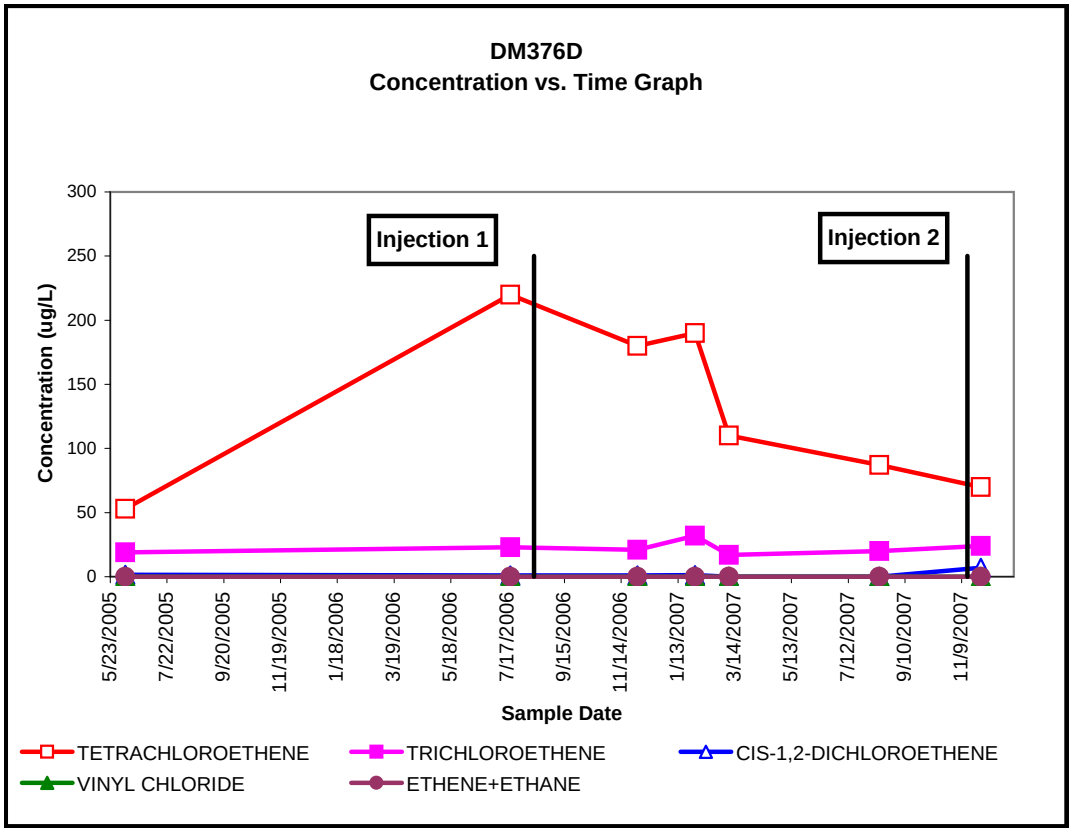
Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4 – LF25 Site Photographs

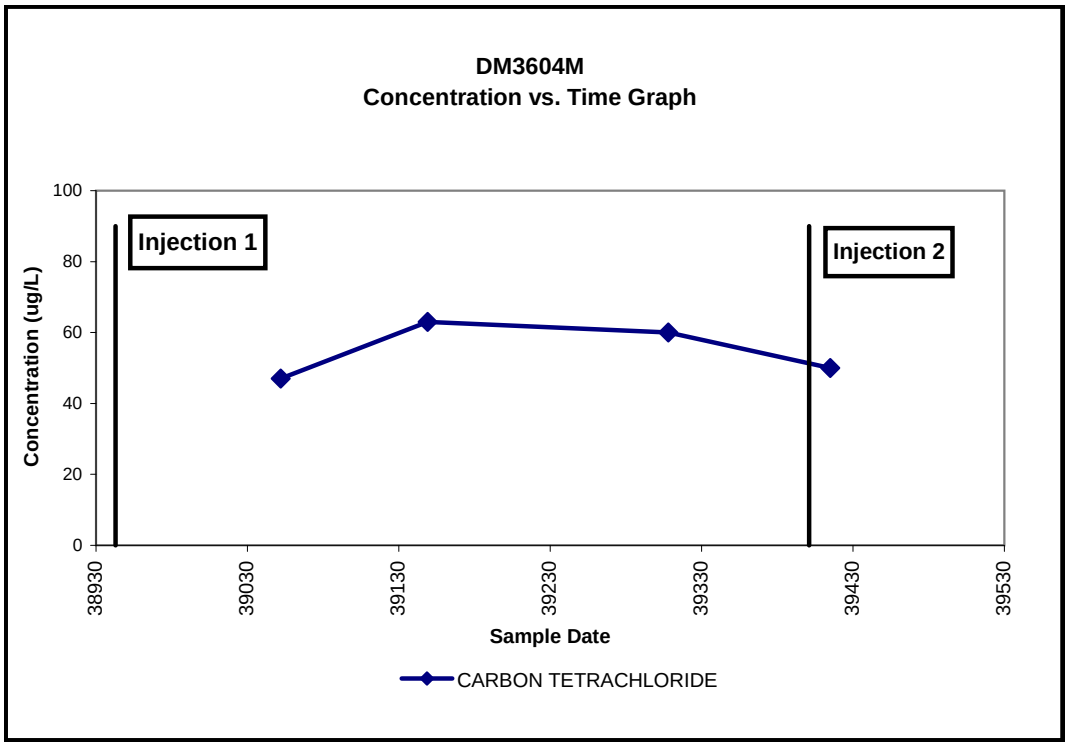
Top: Looking east across landfill, golf course tributary to the right, LF25 on November 14, 2007.
Bottom: Treatment trailer at LF25 on November 14, 2007.

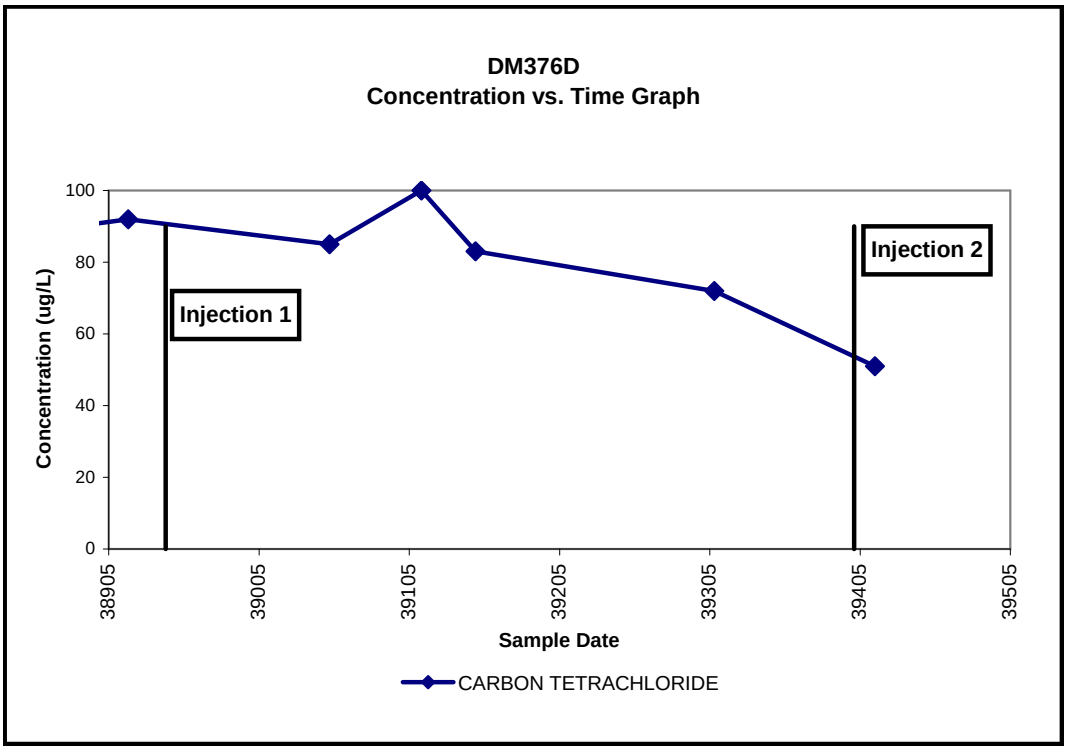
Attachment 5 - Trend Charts

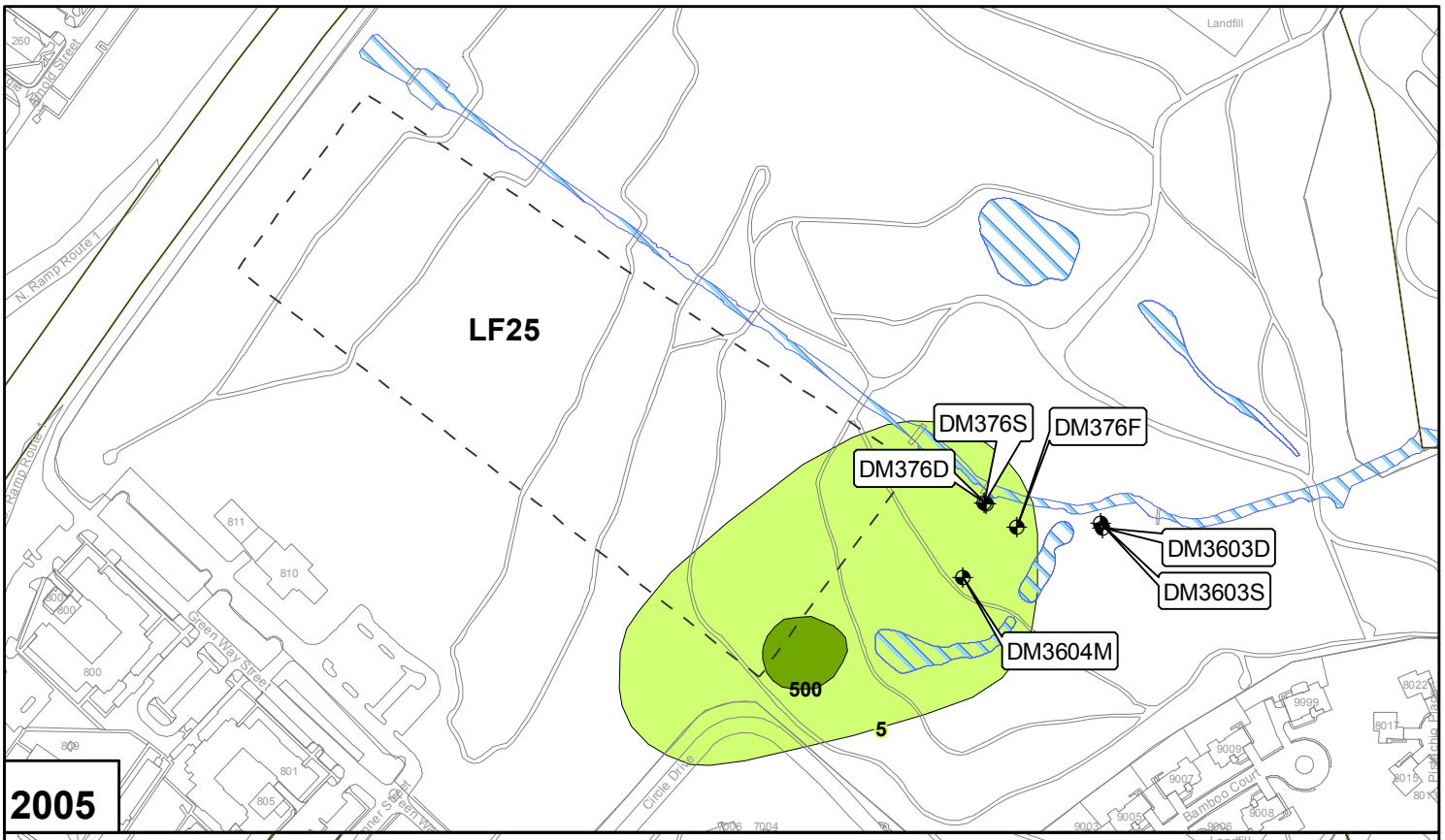


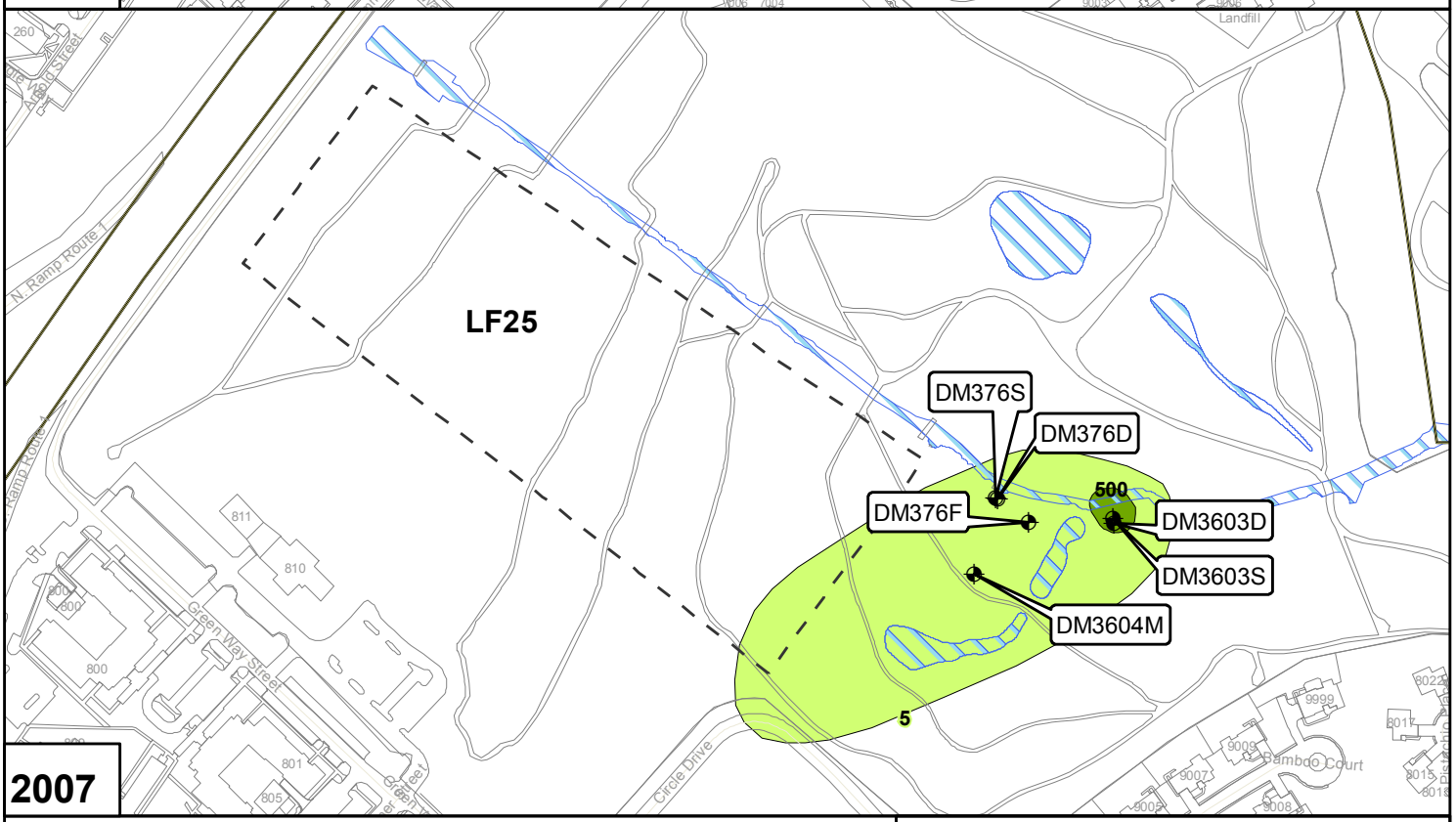


Attachment 5 - Trend Charts Cont'd









Legend

- Site Boundary
- Monitoring Well
- >5µ/L Total Solvent Concentration Contour
- >500µ/L Total Solvent Concentration Contour

N

0 150 300 600 900 1,200 Feet

Attachment 6
Plume Maps for LF25
2005 & 2007

PATH	G:\Projects\Dover_AFB\5yr_Review_Figures\Sept 2008\LF25.mxd
DES BY	DJM 09/23/08
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 6

URS
200 Orchard Ridge Drive
Gaithersburg, MD 20878

FIVE-YEAR REVIEW FOR SS08
DOVER AIR FORCE BASE, DELAWARE

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

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LIST OF ACRONYMS AND ABBREVIATIONS

AAB	Accelerated anaerobic biodegradation
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
CAP	Corrective Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
DAP	Dibasic ammonium phosphate
DERBCAP	Delaware Risk Based Corrective Action Plan
DO	Dissolved Oxygen
DNREC	Department of Natural Resources and Environmental Control
ERP	Environmental Restoration Program
FS	Feasibility study
ft	Feet
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
IRACR	Interim Remedial Action Completion Report
LUCs	Land use controls
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
ORP	Oxidation Reduction Potential
PCE	Tetrachloroethene
PICT	Plume injection/circulation transect
RA	Risk assessment
RAO	Remedial action objective
RAWP	Remedial Action Work Plan
RBSC	Risk-based screening criterion
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
TCE	Trichloroethene
TOC	Total organic carbon
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

USEPA	U.S. Environmental Protection Agency
WMU	West Management Unit
VOC	Volatile organic compound

EXECUTIVE SUMMARY

The remedy for SS08, a paved area in the vicinity of Building 501 at Dover Air Force Base (DAFB), Delaware, is accelerated anaerobic biodegradation (AAB), groundwater monitoring, and land use controls (LUCs) for groundwater as well as soil. AAB was conducted to treat the source area within the SS08 plume. Groundwater monitoring is performed to monitor the effectiveness of the AAB treatments. The remedy for SS08 was selected in a Record of Decision (ROD) signed in May 2006. The ROD addresses SS08 and LF25, both of which are small sites with similar remedies.

This is the first five-year review for SS08. (The review for LF25 is documented separately and appears as its own chapter in this West Management Unit (WMU) Five-Year Review volume.) Since achieving the construction complete milestone for all sites, DAFB has merged reviews for all sites into a comprehensive set of Basewide five-year reviews. The last round of reviews for a subset of sites was finalized in September 2003. Thus, the deadline for all future Basewide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the groundwater remedy—AAB, groundwater monitoring, and LUCs—is operating as intended. The primary contaminant of concern (COC) is trichlorethene (TCE). It is found in the shallow Columbia Aquifer and also at low concentrations in the deeper Frederica Aquifer, where the silty clay layer separating the two aquifers is thin or missing. Source area treatment and transect injections are reducing the concentrations of the COCs at SS08. LUCs remain in effect and no new uses of groundwater or soil at the site were observed. It is recommended that AAB treatment and monitoring continue to confirm that COCs naturally attenuate to levels that meet the remedial action objectives (RAOs) specified for SS08 in the ROD for sites SS08 and LF25

The draft-final five-year review for SS08 was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

SS08 is an Environmental Restoration Program (ERP) site that is the location of an industrial facility surface spill at Dover Air Force Base (DAFB), Delaware, in the West Management Unit (WMU) (Attachment 1). SS08 is a paved area near Building 501 used for loading and unloading aircraft cargo at DAFB. Environmental investigations revealed chlorinated solvent and fuel contamination in groundwater at SS08. The fuel contamination resulted from a spill associated with aircraft refueling. It is unknown how solvents were released at the site. The fuel and solvent spills resulted in separate contaminant plumes. The fuel contamination is being addressed under State Resource Conservation and Recovery Act (RCRA) authority per a Corrective Action Plan (CAP) prepared in accordance with Delaware Department of Natural Resources and Environmental Control (DNREC) Tank Management Program. The fuel remedy is therefore not further addressed in this review. The remedial action for the solvent contamination at SS08 is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use and unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

Under a 2006 Record of Decision (ROD) accelerated anaerobic biodegradation (AAB) and groundwater monitoring were recommended to reduce the solvent concentrations in the groundwater at SS08. Land use controls (LUCs) for soil and groundwater are also a component of the remedy.

This is the first five-year review for the SS08 remedy. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

The AAB remedy is the major component of SS08. Similar remedies for groundwater were implemented concurrently at thirteen other WMU sites: LF25, the five sites associated with the Area 5 plume (OT51, OT50, SS20, OT44, and OT41/Motor Pool), and the seven sites associated with another plume called Area 6 (WP31, WP21, ST34, OT41/Bldg 719, OT49, OT28, and SS59). LUCs for soil and groundwater are also a component of the remedy.

2.0 SITE CHRONOLOGY

The major environmental events affecting the SS08 remedy are listed in Table 1.

Table 1 – Site Chronology

Date	Event
March 1978	Fuel release at SS08.
1978	Pipeline leak discovered near SS08 (ST37).
1987	Three pipeline leaks discovered near SS08 (ST05).
1989	Installation Restoration Program – Stage 2 Final Report (SAIC, 1989).
March 13, 1989	DAFB listed on National Priority List (NPL).
1991	SS08 was evaluated during the 1991 Site Investigation (SI) (HAZWRAP, 1991).
August 1997	Basewide Remedial Investigation (RI) finalized; included assessment of SS08 (USACE, 1997).
2000	Basewide Ecological Risk Assessment finalized (USACE, 2000).
Mar 2000	Corrective Action Plan for fuel remediation at ST05 & ST37 approved (includes SS08 fuel contamination).
June 2001	Natural attenuation monitoring for fuel constituents begins (ST37, ST05, SS08).
April 11, 2003	DNREC established a groundwater management zone (GMZ) encompassing DAFB.
2005	Feasibility Study (FS) completed for the WMU, included evaluation of SS08 (USACE, 2005).
May 2006	ROD prepared for SS08 and LF25 (WMU).
May 2006	Remedial Action Work Plan (RAWP) finalized for SS08 and LF25 (ORNL, 2006).
June 2006	AAB direct injections performed at Source Area I (SS08).
June-August 2006	Injection/extraction and monitoring wells installed at SS08 and LF25.
June 2006	First AAB injections performed at SS08 permanent injection circulation transect (PICT).
June 2006-ongoing	Groundwater monitoring at SS08. Semi-annual reports submitted.
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
August 2006	AAB trailer injections performed at SS08 PICT.
September 2006	Interim Remedial Action Completion Report (IRACR) issued for SS08 and LF25.
November 2007	Second AAB injections performed at SS08 PICT.
December 2007	Assessment of vapor intrusion pathways (ORNL, 2007a).

HAZWRAP – Hazardous Waste Remedial Actions Program
SAIC – Science Applications International Corporation
USACE – U.S. Army Corps of Engineers (Omaha District)

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

SS08 is located southeast of the freight loading area (Attachment 1), in the WMU. The ground cover in this area is primarily asphalt. Isolated locations of maintained grass exist around the buildings. Surface water runoff is directed to nearby underground storm drains, which ultimately discharge into the Pipe Elm Branch of the Little River. Groundwater at the site is typically encountered at depths between 10 and 18 feet (ft) below ground surface (bgs).

3.2 LAND AND RESOURCE USE

SS08 is a site used for loading and unloading of aircraft freight in the industrial area of the WMU at DAFB. The largest portion of the Base is the industrial area which includes taxiways and runways, aircraft hangars, maintenance and support facilities. The industrial portion of the Base is completely enclosed by a security fence. It is only accessible to authorized personnel through manned security gates; it is not accessible to the general public.

The shallow groundwater (Columbia Aquifer) underlying the site flows south-southwest towards the St. Jones River. This aquifer and the next deeper Frederica Aquifer, are not currently used as drinking water sources. The direction of flow in the deeper Frederica Aquifer is similar to that of the shallow aquifer. DAFB obtains potable water from several deep supply wells installed within the Cheswold or Piney Point Aquifers, which are below the Columbia and Frederica Aquifers. The river is used for recreational purposes but is not used for potable water. Off site, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

The State of Delaware considers all aquifers potential sources of drinking water and the Columbia and Frederica Aquifers are used by the surrounding community. Moreover, the aquifers would be considered Class IIA aquifers, currently used sources of drinking water, based on Guidelines for Ground-Water Classification under the USEPA Ground-Water Protection Strategy. Off-Base, the Columbia and Frederica Aquifers are used predominantly for irrigation and domestic supply.

3.3 HISTORY OF CONTAMINATION

SS08 is a solvent release site in an area also affected by a large jet fuel release (Attachment 1). It is unknown how the solvents were released at SS08. A series of fuel releases occurred as listed in Table 1. All of the pipeline leaks were associated with a fuel hydrant system that was replaced in the mid-1990s. Cleanup of the petroleum releases is excluded from regulation under CERCLA and is being addressed under the DNREC Tank Management Program per a CAP. However, the solvent trichloroethene (TCE) is regulated under CERCLA, and, therefore, it is the focus of the SS08 remedy.

The relatively small groundwater plume highlighted in yellow in Attachment 1 extends from Source Area I in the shallow portion of the aquifer below the aircraft parking apron downgradient (southwest) to about Purple Heart Blvd. where contaminants were found in deeper portion of the aquifer. The primary volatile organic compound (VOC) identified in groundwater at SS08 is TCE, a chlorinated solvent. TCE is found in the shallow Columbia Aquifer and is also found at very low concentrations in the deeper Frederica Aquifer at a location where the upper unit of Calvert Formation (silty clay aquitard) is thin or missing (well MW85P). Overall, the area of TCE contamination at SS08 is relatively small.

Cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride were not seen at SS08 during the RI but they are biodegradation products of TCE. Therefore, they are expected to become present in the aquifer as the TCE biodegrades and they are considered potential contaminants of concern (COCs) for SS08. In 2005, groundwater samples were collected at multiple depths to delineate the distribution of solvents at SS08. TCE and its daughter product, cis-1,2-DCE, were found (from upgradient to downgradient) in the shallow Columbia Aquifer below the parking apron; at an intermediate depth in the vicinity of Ramp Road; and in the deeper portion of the aquifer primarily between Buildings 500 and 501.

The Base-wide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams.

3.4 INITIAL RESPONSE

Treatment alternatives for SS08 were evaluated in the WMU FS (USACE, 2005). The selected remedial action for SS08 was AAB, groundwater monitoring, and LUCs for both soil and groundwater.

In 2006, a ROD was signed for the soil and groundwater at SS08. The selected remedy included AAB to treat the source of groundwater contamination at SS08, groundwater monitoring to assess the effectiveness of the AAB treatments, and LUCs for both soil and groundwater.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater and soil at SS08 since it is located in an industrial portion of the Base (USACE, 1997). Non-carcinogenic risks from hypothetical future commercial/industrial exposure to groundwater at SS08 exceed the USEPA risk criterion. Groundwater contaminant concentrations in the Columbia Aquifer also exceed federal maximum contaminant levels (MCLs). The TCE MCL is also slightly exceeded in the Frederica Aquifer at SS08. Although groundwater from both aquifers at SS08 is not a drinking water source, there is a potential for constituents to migrate off Base where the aquifers have the potential for beneficial use. Based on the RA results, MCL exceedences, and offsite aquifer use, action was warranted.

Based on the RA for soil, a cleanup action is not warranted. However, this conclusion is based on the assumption that the future on-Base land use at the site will remain industrial. Thus, the response action for soil is to ensure the permanence and reliability of the land use assumptions, and thereby protect the public health from hazardous substances at the site. Also, taking action will eventually restore the aquifer to its beneficial use, which is consistent with USEPA groundwater protection policies.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for SS08 was signed by USEPA in May 2006 (USACE, 2006). The remedial action objectives (RAOs) were developed based on the RA for SS08, and the fact that concentrations of hazardous substances in soil and groundwater are above levels that allow for unrestricted exposure and unlimited use. Thus, one of the RAOs for groundwater is the reduction of contaminant concentrations in groundwater to MCLs.

The RAO serves as a source control and migration response objective. By reducing the mass of contaminants in the area of attainment, i.e., the on-site plume, the threat of exposure to contaminants at harmful levels is reduced. By restricting access, potential exposures to soil and groundwater are mitigated. LUCs for soil and groundwater are part of the selected remedy due to the Air Force and EPA management decision to assess only commercial/industrial risk scenarios for this site. LUCs will mitigate potential exposures in areas where residential risks were not evaluated.

Various remedial actions were evaluated in the WMU FS. The selected remedy for SS08 groundwater as outlined in the 2006 ROD includes the four major components listed below.

- Injection/diffusion AAB of the source area at SS08.
- Groundwater monitoring to ensure AAB treatment effectiveness.
- LUCs for soil and groundwater.
- Evaluation of vapor intrusion pathway during groundwater remedial action phase (accomplished in 2007) (ORNL, 2007a).

4.2 REMEDY IMPLEMENTATION

Remedy implementation and monitoring were performed in accordance with the RAWP for SS08 and LF25 (ORNL, 2006b) and documented in the IRACR for SS08 and LF25 (ORNL, 2006a). The plume at SS08 is relatively small and contaminant concentrations are much lower than seen in the other large plumes at DAFB.

Since permanent wells are not feasible at Source Area I of SS08, which is on the aircraft parking apron, substrate was injected in this area using direct push techniques in June 2006. The source area was treated by injecting substrate at closely located points at multiple depths. The substrate consisted of emulsified vegetable oil and sodium lactate added to potable water. Dibasic ammonium phosphate (DAP) was also added to the mixture to provide metabolic nutrients.

A PICT comprised of nine 4-inch-diameter wells was also installed to create a linear AAB zone perpendicular to groundwater flow within the plume at SS08, approximately 250 ft downgradient of Source Area I (Attachment 1). The first injections into the PICT occurred in June 2006. A mobile AAB process trailer powered by a

generator was used to extract groundwater, amend it with substrate, and re-inject the mixture into the aquifer. Groundwater was extracted from every other well, amended, and then returned to the aquifer under pressure through adjacent injection wells, creating a push-pull effect. Injection quantities for the initial injection are documented in the IRACR for SS08 and LF25.

At SS08, the primary mechanism of both AAB and natural attenuation is the anaerobic biodegradation of chlorinated ethenes. The parent contaminant, at this site is TCE, which degrades to cis-1,2-DCE, then to vinyl chloride, and finally to ethene, a harmless gas.

A monitoring program for SS08 was established in accordance with the RAWP. Wells used to monitor progress of the remedy are listed in Table 2. Monitoring was conducted more frequently just after injections and then progressed to monthly, then quarterly, then semi-annual sampling after a year. Early in the AAB monitoring program the focus was on the distribution of total organic carbon (TOC) and indicator parameters: dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, dissolved iron, and sulfate. At month 3, after the substrate had some time to stimulate biodegradation, VOC and dissolved gases analyses were added to the monitoring program. The SS08 plume is small, and the AAB well network sufficiently monitors the entire plume.

Table 2 – SS08 Wells

WELL ID	
DM302S	DM3601F
DM302D	DM3602M
DM304F	MW085P
DM3601D	MW070D

Another aspect of the remedy includes the continued enforcement of existing LUCs. DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites, including SS08. Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer and next deeper Frederica Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the Base digging permit process to ensure compliance with land use restrictions. (3) Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and a portion of off-Base property between DAFB and the St. Jones River. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process. (4) DAFB conducts an annual inspection of the LUCs and documents the findings.

The RAO concentrations for the COCs in the Columbia and Frederica Aquifers at SS08 are listed in Table 3. Groundwater monitoring was selected as part of the remedy to determine whether on-site concentrations decrease over time and to ensure that RAO concentrations are eventually achieved.

Table 3 – RAO Groundwater Concentrations

Parameter	RAO Concentration[a] (µg/L)
cis-1,2-DCE	70
TCE	5
Vinyl chloride	2

[a]The groundwater RAOs are the MCLs
µg/L - micrograms per liter

The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the Base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, in accordance with the ROD, a risk assessment was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the WMU. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the site changes, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

Remedial operations have been ongoing at SS08 since the initial injections were completed in June 2006. A second round of PICT injections was accomplished during November 2007. The second injection event was designed to fill substrate distribution gaps and provide a more uniform substrate distribution. Almost four times the amount of substrate was injected during the second event relative to the first. Monitoring events are currently conducted on a semi-annual schedule in accordance with the RAWP for SS08 and LF25. Semi-annual reports document all of the monitoring results. Additionally, LUCs inspections and reporting are conducted annually.

The main maintenance activities associated with the SS08 remedy are:

- Maintain integrity of the PICT wells, ensure that well caps and protective covers are secured.
- Maintain the mobile treatment trailer hoses, pumps, and monitoring equipment in good working order.
- Maintain the generator in good working order so as to provide adequate power to the control panels, light fixtures, submersible and metering pumps, and receptacles at the system trailer.
- LUCs inspections are conducted on an annual basis.

The costs associated with the AAB remedy and monitoring are summarized in Table 4.

Table 4 – Annual Remedy Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$204,000 (includes initial capital costs)
2007	$128,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for SS08.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2008 that the five-year review for SS08 would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for SS08 are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of SS08 had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant SS08 documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed for groundwater (Attachment 3).

6.3 DATA REVIEW

This review focuses on the groundwater data collected to date as part of the AAB monitoring (ORNL, 2008). Data were collected more frequently immediately after AAB

injections at the SS08 source area, with the latest data collected in the fall of 2007. At this time, the entire plume, including the source area, is monitored on a semi-annual schedule, in accordance with the RAWP. The monitoring reports reviewed for SS08 evaluated groundwater flow in both the shallow and deep portions of the Columbia Aquifer; COC distribution, migration, and concentration trends over time; RAO exceedences; and the adequate/optimization of the current monitoring well network. Groundwater sampling and analysis is the primary means of determining the remedy's continued effectiveness at SS08.

1. Rapid degradation of TCE is observed in response to the AAB treatment in Source Area I (see Table 5). In DM302S, TCE, the parent COC, declined from 310 µg/L in 1994 to non-detected by December 2006 following the substrate injection, and continued to be undetectable during the September 2007 sampling event. Cis-1,2-DCE steadily declined over time while vinyl chloride briefly spiked to 13 µg/L in March 2007. Ethene was not detected in September 2007, but has been present in trace amounts in the past, indicating complete dechlorination is occurring at the site to a limited extent.

Table 5 – Trends in DM302S - Source Area I (µg/L)

Date	TCE	cis-1,2-DCE	Vinyl chloride	Ethene
4/7/1994	310	52	ND	NS
6/9/2005	56	19	ND	ND
8/28/2006	4.3	7.1	ND	0.72
12/18/2006	ND	6.2	ND	ND
3/15/2007	0.04	0.04	13	0.12
9/10/2007	ND	ND	0.32	ND

ND – not detected

NS – no sample

2. DM3602M is the well closest to the SS08 PICT. Here, COC concentrations were already below the RAO/MCLs. Minor fluctuations in concentrations were observed after injections. More significantly, data from DM3602M indicates the establishment of anaerobic conditions along the PICT (ORNL, 2008). Wells farther downgradient of the PICT have not yet seen the effects of substrate injections. In fact, TCE has increased in one of these wells (DM3601D) from 4 to 17 µg/L, although it decreased in MW070D.

3. At SS08, there are only two TCE RAO exceedences in the eight wells monitored. TCE in MW085P is slightly above its RAO of 5 µg/L. MW085P is a well located in an area with a thin or missing confining unit between Columbia and Frederica Aquifers. The TCE present in this well indicates that small amounts of contamination is moving downwards into the Frederica Aquifer. There were no detections in the other Frederica Aquifer wells, DM304F and DM3601F. It is important to note that the TCE concentration in MW070D, a well adjacent to MW085P screened in the Columbia Aquifer, is only 3 µg/L, which is below its RAO. Thus, the TCE concentration in MW085P may begin to decline.

4. LUCs have been implemented for soil and groundwater at SS08. No new uses of groundwater, soil, or the sites were observed during the November 2007 site inspection. These observations were corroborated in DAFB's annual LUCs monitoring report (DAFB, 2007).

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at SS08 on that day (Attachment 4). The site is currently a large paved area. Other than occasional snow removal, there is minimal maintenance at the site. No new uses of groundwater or soil at the site were observed. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the remedial action for SS08 groundwater is functioning as intended. This review found that groundwater flow direction has remained stable, with some minor seasonal fluctuations. The monitoring network provides reliable data within these fluctuations and is adequate to assess changes in the plume, including potential downgradient migration or expansion. Groundwater flow at this site is indicated by the arrows on Attachment 1. Groundwater monitoring data indicate that the chlorinated solvents in Source Area I are now below the RAOs/MCLs. In the downgradient plume, COC concentrations appear to be at or near steady state. With the effective treatment of Source Area I and along the PICT, contribution to the downgradient plume is being stemmed. However, it will still be some time before the effects are seen in downgradient wells. Attachment 5 illustrates the extent of the SS08 plume in 2005 (prior to AAB implementation) and in late 2007.

The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the ROD; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2007).

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

There have been no physical changes at the site or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the ROD (Attachment 3).

Exposure assumptions used in the human health RA for groundwater exposures are still valid. Current and future commercial/industrial exposure scenarios were assessed in the RA. Screening and toxicological values used in the RA were reviewed. The changes in these values and their effects on risks are qualitatively summarized in Table 6 (USEPA, 2007). The various changes could increase and decrease the overall carcinogenic risks and non-carcinogenic hazards. Regardless of the overall minor changes to the risks and hazards, remedy selection, implementation, and current protectiveness would not be affected by these variations.

Table 6 – Risk Assessment Review

Change	Effect
RBSC values increased for 1,1-DCE, 1,2-DCE, 1,2,4-trichlorobenzene, heptachlor, and beryllium.	These chemicals would be excluded from the RA, slightly decreasing overall hazards and risks.
RBSC values decreased for bis(2-ethylhexyl)phthalate, naphthalene, and 4,4-DDE.	These chemicals would be included in the RA, slightly increasing overall hazards and risks.
Inhalation reference doses increased for 1,2-DCA, benzene, and carbon tetrachloride.	A slight decrease in overall hazards.
Inhalation reference doses decreased for methylene chloride, and is now available for chloroform, tetrachloroethene (PCE), TCE*, and vinyl chloride.	A slight increase in overall hazards.
Oral reference dose decreased for TCE*, and are now available for 1,4-dichlorobenzene, benzene, and vinyl chloride.	A slight increase in overall hazards.
Oral reference dose increased for manganese.	A slight decrease in overall hazards.
Inhalation slope factors increased for PCE and TCE*, and is now available for 1,4-dichlorobenzene.	A slight increase in overall risks.
Inhalation slope factors decreased for benzene and vinyl chloride, and are no longer available for benzo(a)anthracene, benzo(b)fluoranthene, and benzo(k)fluoranthene.	A slight decrease in overall risks.
Oral slope factors increased for benzene, PCE, and TCE*.	A slight increase in overall risks.
Oral slope factor decreased for vinyl chloride and arsenic, and is no longer available for chloroform.	A slight decrease in overall risks.

RBSC – Risk-based screening criterion
*Assessment of TCE based on 2001 provisional toxicity values.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). In addition, groundwater monitoring has shown that the contaminant plume in this area has remained relatively stable. In fact, source area remediation is successfully reducing contaminant mass within the plume. Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological risk assessment. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this site.

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

This review for SS08 produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. Use of the site is unchanged and there have been no reports of new contaminant releases. All information collected to date indicates that the remedy is operating as intended and that progress has been made towards achieving the RAOs.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the remedy for SS08 groundwater is functioning as intended. A strong anaerobic reactive zone has been established at Source Area I and is developing along the downgradient PICT. All indicators are positive and degradation is being observed. TCE, the parent COC, fell below the RAO/MCL in August 2006 has not been detected in the source area since September 2007. Both breakdown products (cis-1,2-DCE and vinyl chloride) are well below their RAO/MCLs in the source area. Favorable conditions have also been established at the SS08 PICT. A second substrate injection event occurred in November 2007 to enhance the anaerobic conditions along the PICT. It is still too early to expect changes in wells downgradient of the PICT. Review of the RA and ARARs revealed no significant changes that would affect remedy selection or implementation.

Although degradation rates were not provided in the SS08 monitoring reports, inspection of the contaminant concentration trend charts (Table 5) indicates that degradation of chlorinated solvents significantly increased in response to AAB treatment. Should the trends established during the first two years continue, the remedy appears to be capable of achieving RAOs in the 5-year time frame stated in the SS08/LF25 ROD.

LUCs have been successfully implemented at the site.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Groundwater data from past investigations at SS08 demonstrated that site activities locally affected groundwater quality in the Columbia and Frederica Aquifers. In response, AAB, groundwater monitoring, and LUCs for soil and groundwater were initiated at SS08.

It is recommended that AAB activities continue at SS08. It is also recommended that proposals made in the semi-annual reports for optimizing both AAB and the monitoring well network be implemented. The recommended operation and maintenance improvements from the latest report include the following actions:

- Remove DM304F from the well network. DM304F (a Frederica Aquifer well) is side-gradient to the SS08 plume and has never contained any of the COCs. The plume is better monitored by wells MW085P and DM3601F.
- Conduct future sampling activities at SS08 on a semi-annual schedule in accordance with the RAWP.
- Remove chloride from the sample analyte list. This indicator has not been useful in assessing site conditions.
- Continue to enforce LUCs at the site.

A worst case vapor intrusion evaluation was performed in 2008 per acceptable protocol at that time. In the next Five-Year Review, the 2007 vapor intrusion evaluation performed at the Base should be compared with protocol established in the final vapor intrusion guidance document to determine if the pathway continues to be protective.

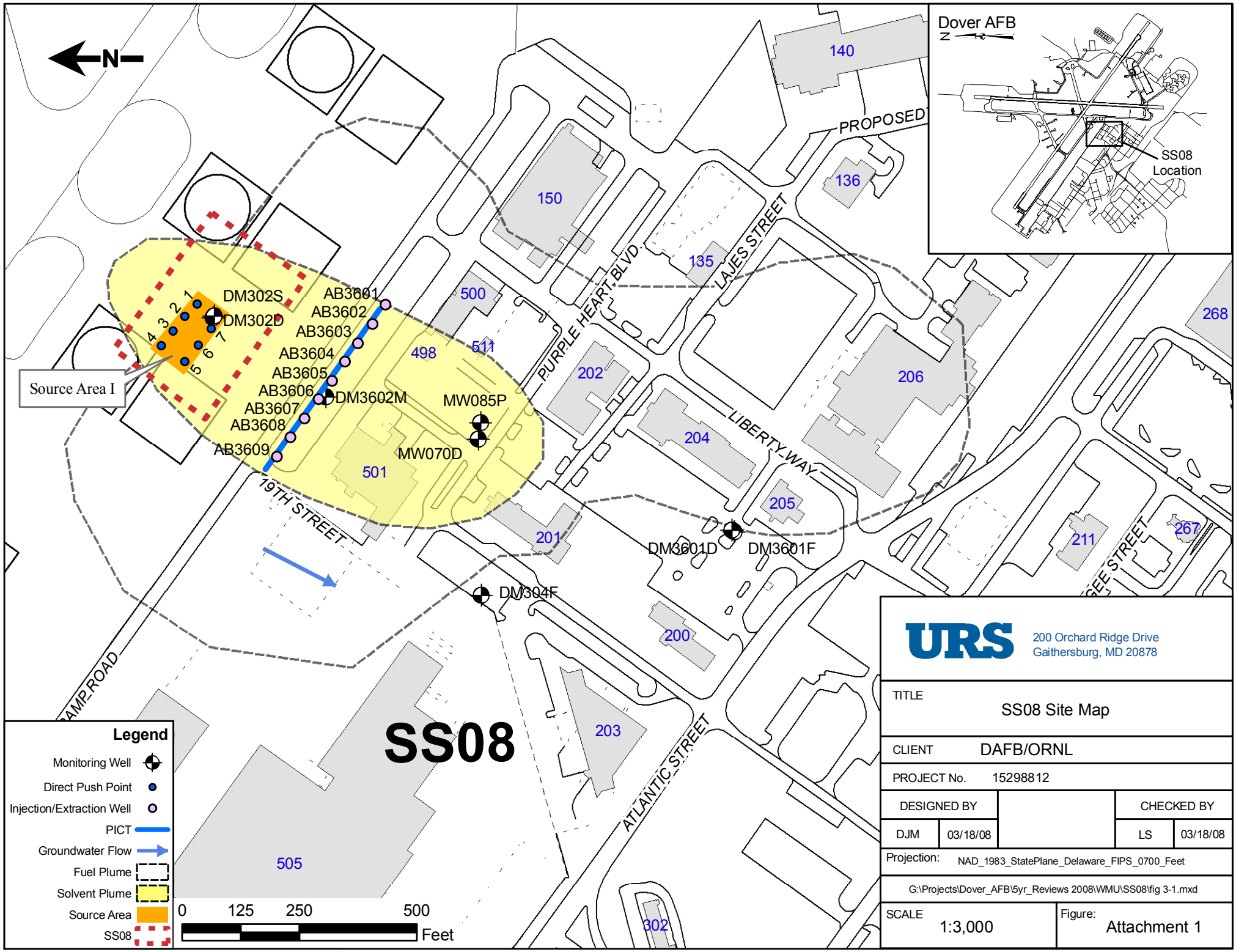
The site as a whole will also continue to be addressed in the five-year review process since the remedy (including LUCs) and groundwater monitoring are still active at SS08.

10.0 PROTECTIVENESS STATEMENT

The remedy at SS08 is protective of human health and the environment. In the interim until RAOs are met at this site, exposure pathways that could result in unacceptable risks are being controlled.

11.0 NEXT REVIEW

The next review for SS08 will be due in September 2013.


N
Dover AFB
SS08 Location
140
136
150
135
500
498
511
202
206
204
205
201
200
203
505
501
302
268
267
211
PROPOSED
LAJES STREET
PURPLE HEART BLVD.
LIBERTY WAY
19TH STREET
ATLANTIC STREET
CAMP ROAD
Source Area I
DM302S
DM302D
AB3601
AB3602
AB3603
AB3604
AB3605
AB3606
AB3607
AB3608
AB3609
DM3602M
MW085P
MW070D
DM3601D
DM3601F
DM304F
SS08
Legend
Monitoring Well
Direct Push Point
Injection/Extraction Well
PICT
Groundwater Flow
Fuel Plume
Solvent Plume
Source Area
SS08
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CHECKED BY
LS
03/18/08
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G:\Projects\Dover_AFB\5yr_Reviews 2008\WMU\SS08\fig 3-1.mxd
SCALE
1:3,000
Figure:
Attachment 1

Attachment 2 - Reviewed Documents

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

ORNL, 2008. Monitoring Report for Sites SS08 and LF25, West Management Unit (through November 2007), Dover Air Force Base, Delaware, submitted by URS Group Inc., March 2008.

ORNL, 2007a. Vapor Intrusion Assessment, Dover Air Force Base, Delaware, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. Interim Remedial Action Completion Report, Sites SS08 and LF25, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., September 2006.

ORNL, 2006b. SS08 and LF25 – West Management Unit Remedial Action Work Plan, Dover Air Force Base, Delaware, submitted by URS Group, Inc., May 2006.

SAIC, 1989. Installation Restoration Program – Stage 2 Draft Final Report, Dover Air Force Base, Delaware.

USACE, 2006. Proposed Plan for SS08 and LF25, Dover AFB, Delaware, submitted by URS Group, Inc., January 2006.

USACE, 2006. Record of Decision for SS08 and LF25, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., April 2006.

USACE, 2005. Final Feasibility Study, West Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., May 2005.

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [South Management Unit, Volumes I - IV].

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs are listed in the ROD for SS08 and LF25 and were reviewed during this Five-Year Review. There have been no changes in ARARs since the RAOs were established in the ROD. ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario. However, since residential risks were not evaluated, the Air Force has decided to implement LUCs as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial settings as well as soil screening levels for the protection of groundwater. Since groundwater is actively monitored at this site, any impacts from soil leaching beyond what has already occurred will be observed. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

Groundwater. Federal MCLs for the monitored constituents are unchanged. DNREC's *Delaware Risk-Based Corrective Action Plan* (DERBCAP) established Tier 1 groundwater standards for some of the monitored constituents (primarily fuel-related compounds), but they are less stringent than MCLs. DNREC also provides guidelines for the remediation of hazardous sites in *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (December 1999). For SS08 chlorinated solvents, the standards in this guidance are the same as the Federal MCLs.

Surface Water and Sediment. Surface water and sediment are not present at SS08. Sampling conducted for the Basewide Ecological Risk Assessment revealed no VOCs in the surface water or sediment collected from downstream drainages that could be affected by SS08 and no unacceptable risks were identified. Therefore, surface water and sediment are not relevant to the selected remedy.

Air. Vapor intrusion was assessed in 2007-2008 in accordance with USEPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002. There have been no updates to this guidance as of the date of this Five-Year Review.

Attachment 4 – SS08 Site Photographs

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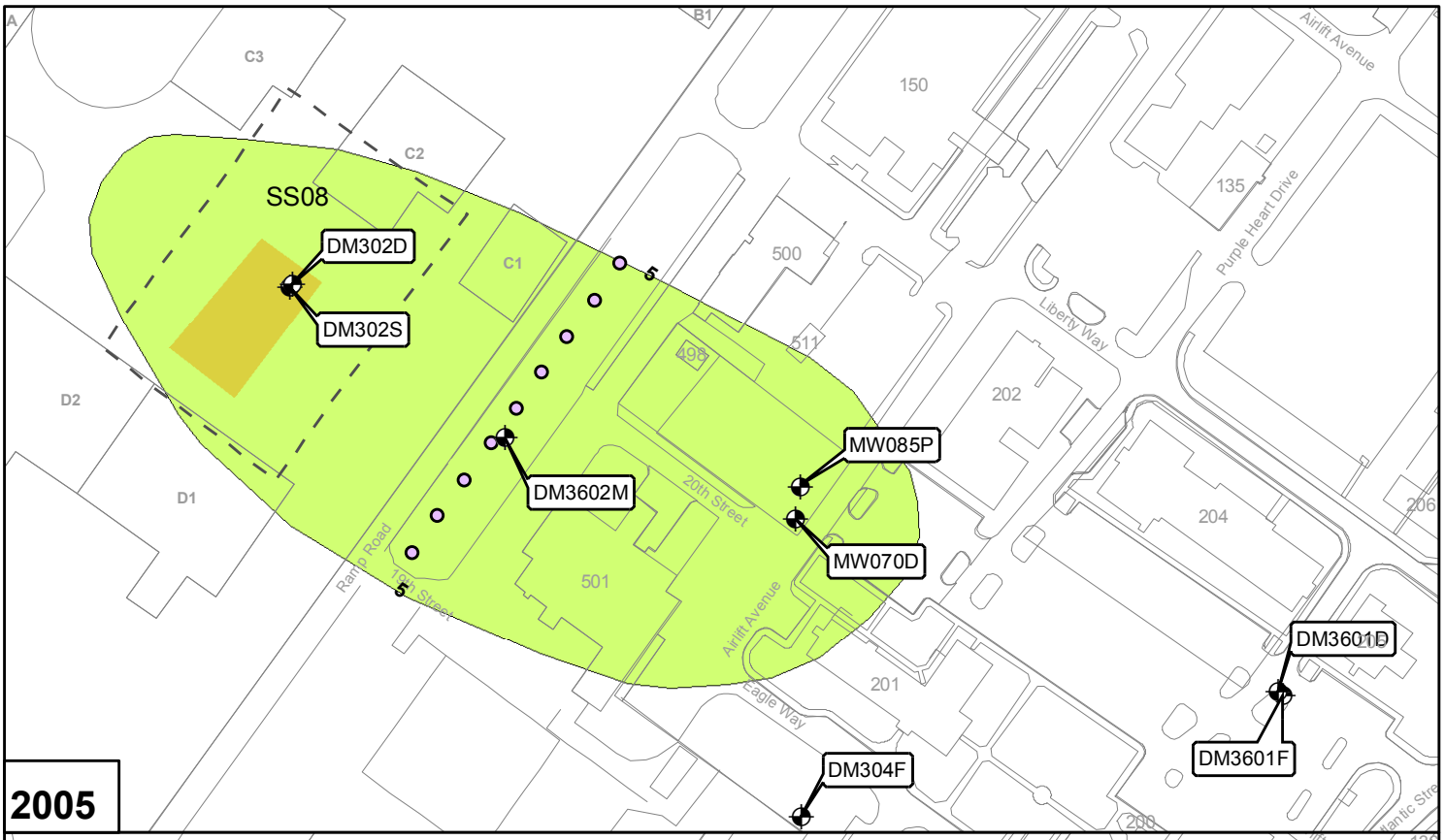
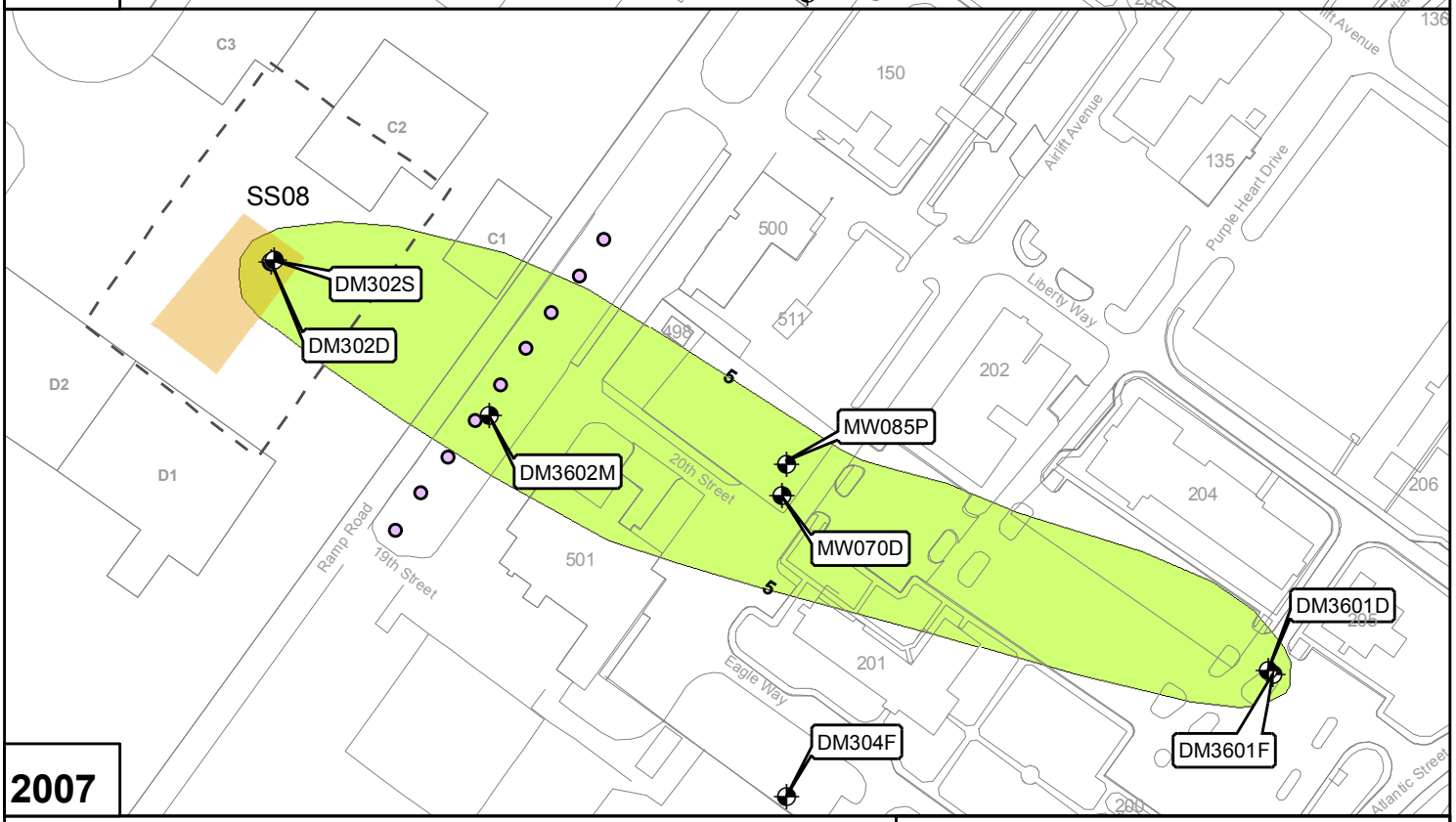
Top: Treatment trailer at SS08 on November 14, 2007.
Bottom: Monitoring well DM302S at SS08, with treatment trailer in background on November 14, 2007.





Legend

N

- Site Boundary
- Monitoring Well
- Injection/Extraction Well
- >5µ/L Total Solvent Concentration Contour
- >500µ/L Total Solvent Concentration Contour
- Source Area

0 100 200 400 600 800 Feet

Attachment 5
Plume Maps for SS08
2005 & 2007

PATH G:\Projects\Dover_AFB\5yr_Review_Figures\Sept 2008\SS08.mxd	
DES BY DJM 09/22/08	CHK BY LS
PROJ NO 15300779	FIGURE Attachment 5

URS
200 Orchard Ridge Drive
Gaithersburg, MD 20878

BASEWIDE FIVE-YEAR REVIEWS
DOVER AIR FORCE BASE, DELAWARE

VOLUME IV – LAND USE CONTROLS (LUCs)

FIVE-YEAR REVIEW FOR
22 LUCs SITES

September 2008

Prepared by:

Oak Ridge National Laboratory
Environmental Sciences Division
For the
U.S. Department of Energy
Under the Contract DE-AC05-00OR22725

and

URS GROUP, INC.
200 Orchard Ridge Drive, Suite 101
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Prepared for:

United States Department of the Air Force
Dover Air Force Base
436 CES/CEAO
600 Chevron Avenue
Dover AFB, Delaware 19902-5600

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Dover Air Force Base		
EPA ID *(from WasteLAN)*: DE8570024010		
Region: 3	**State:** DE	**City/County:** Dover/Kent County
SITE STATUS		
NPL status: _X_ Final __ Deleted __ Other (specify)		
Remediation status (choose all that apply): __ Under Construction _X_ Operating (22 sites***) __ Complete		
Multiple OUs?* _X_ YES __NO	**Construction completion date:** 09 / 30 / 2006	
Has site been put into reuse? __ YES _X_ NO		
REVIEW STATUS		
Lead agency: __ EPA __ State __ Tribe _X_ Other Federal Agency - U.S. Air Force		
Author name: URS Group, Inc. (under Oak Ridge National Laboratory contract) for USAF		
Author title:	**Author affiliation:**	
Review period:** October 2003 to September 2008		
Date(s) of site inspection: October 21, 2002 and November 14, 2007		
Type of review: X Post-SARA __ Pre-SARA __ NPL-Removal only __ Non-NPL Remedial Action Site __ NPL State/Tribe-lead __ Regional Discretion		
Review number: _X_ 1 (first) ___ 2 (second) ___ 3 (third) __ Other (specify) _____		
Triggering action: __ Actual RA Onsite Construction at OU #____ __ Actual RA Start at OU#____ __ Construction Completion X Previous Five-Year Review Report __ Other (specify)		
Triggering action date *(from WasteLAN)*: 30 Sep 2003		
Due date *(five years after triggering action date)*: 30 Sep 2008		

* ["OU" refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]
*** SD12, LF22, LF23, WP29, OT56, ST58, LF16, LF19, WP32, OT55, FT02, LF24, LF26, WP33, WP38, OT42, OT43, OT45, OT46, OT47, OT49, and OT57

Five-Year Review Summary Form, cont'd.

Issues:

Final remedies for 22 sites were selected in two Records of Decision (RODs): site SD12 signed in 2005, and the remaining 21 sites (LF22, LF23, WP29, OT56, ST58, LF16, LF19, WP32, OT55, FT02, LF24, LF26, WP33, WP38, OT42, OT43, OT45, OT46, OT47, OT49, and OT57) signed in 2006. Past investigations found only minor environmental impacts at these sites; no active remediation was determined to be necessary although removal actions had occurred at several sites. However, since the sites were not evaluated for potential human health risks under a residential scenario, land use controls (LUCs) were implemented to control potential exposure. Performance objectives for LUCs were established for soil and groundwater at each site in the two RODs. No issues were noted during the Five-Year Review of the LUCs sites.

Recommendations and Follow-up Actions:

SD12, LF22, LF23, OT56, ST58, LF16, LF19, FT02, LF24, LF26, WP33, WP38, OT42, OT45, and OT49: It is recommended that LUCs continue to be enforced and annually inspected at these 15 sites.

OT43, OT46, OT47, OT57, WP29, WP32, and OT55: A residential risk screening was conducted for seven of the 22 sites. Based on the screening results, LUCs are not necessary and these sites are recommended for closure.

Protectiveness Statement:

LUCs were successfully implemented and continue to meet the performance objectives defined in the two RODs. The remedy at all 22 sites is protective of human health and the environment. At seven of the sites (OT43, OT46, OT47, OT57, WP29, WP32, and OT55), it was determined that unacceptable residential risks are not present and that exposure pathways do not need to be controlled.

Other Comments:

None.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Environmental Excellence
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
COC	Contaminant of concern
DAFB	Dover Air Force Base
DNREC	Department of Natural Resources and Environmental Control
EMU	East Management Unit
ERP	Environmental Restoration Program
FFS	Focused Feasibility study
ft	Feet
GMZ	Groundwater management zone
HAZWRAP	Hazardous Waste Remedial Actions Program
IWB	Industrial waste basin
LUC	Land use control
MCL	Maximum contaminant level
msl	Mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NMU	North Management Unit
NPL	National Priority List
ORNL	Oak Ridge National Laboratory
PCE	Tetrachloroethene
ppb	Parts per billion
RAO	Remedial action objective
RBC	Risk-based criterion
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Investigation
SMU	South Management Unit
TCE	Trichloroethene
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
WMU	West Management Unit

EXECUTIVE SUMMARY

For twenty-two sites at Dover Air Force Base (DAFB), Delaware, past investigations found only minor environmental impacts; no active remediation was determined to be necessary although removal actions have occurred at several sites. However, since the sites discussed herein were not evaluated for the potential human health risks under a residential scenario, land use controls (LUCs) were implemented to control potential exposure in accordance with two Records of Decision (RODs): one for site SD12 (signed in 2005) and another for the remaining 21 sites (signed in 2006). The other 21 sites are LF22, LF23, WP29, OT56, ST58, LF16, LF19, WP32, OT55, FT02, LF24, LF26, WP33, WP38, OT42, OT43, OT45, OT46, OT47, OT49, and OT57.

LUCs were formally implemented at these sites in 2006, and no previous five-year reviews have been accomplished for these sites. Since achieving the construction complete milestone for all sites, DAFB has merged reviews for all sites into a comprehensive set of Base-wide five-year reviews. The last round of reviews was finalized in September 2003. Thus, the deadline for all future Base-wide reviews will be every five years from September 30, 2003 (i.e., September 30, 2008, 2013, 2018, etc.). This review fulfills the September 2008 requirement.

The assessment of this five-year review found that the LUCs are operating as intended and in accordance with the performance objectives listed in the RODs. A site inspection of all 22 sites revealed that LUCs remain in effect and no new uses of soil, groundwater, or the sites were observed. DAFB's two annual LUCs monitoring reports documented similar conclusions. The remedy remains protective of human health and the environment. A residential risk screening was conducted for seven sites: OT43, OT46, OT47, OT57, WP29, WP32, and OT55. Based on the screening results, which are provided as an attachment to this report, it is recommended that these seven sites be closed.

The draft-final five-year review for the 22 LUCs sites was submitted for public comment from May 21 – June 20, 2008. No comments were received.

1.0 INTRODUCTION

Twenty-two (22) Environmental Restoration Program (ERP) sites at Dover Air Force Base (DAFB), Delaware, have undergone environmental investigations that found only minor environmental impacts. At the few sites where groundwater contaminants exceeded federal drinking water maximum contaminant levels (MCLs), it was determined that other upgradient sites were the sources and action is being taken at those sites. No active remediation was determined to be necessary at any of the 22 sites. However, since the sites discussed herein were not evaluated for the potential health risks under a residential scenario, land use controls (LUCs) were implemented to control potential exposure. This five-year review assesses the LUCs action taken at these sites.

LUCs are being implemented at one site (SD12) per a 2005 Record of Decision (ROD) and at another 21 sites per a 2006 ROD under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA §121, where contaminants remain on site at concentrations that do not allow for unlimited use or unrestricted exposure, five-year reviews are required to evaluate the implementation and performance of a remedial action to determine if it is or will continue to be protective of human health and the environment.

This is the first five-year review for the 22 LUCs sites. It is prepared for DAFB by URS Group, Inc. (URS) under contract and technical oversight of Oak Ridge National Laboratory (ORNL). The review was initiated in late 2007 and completed in September 2008. This report documents the findings of the review, which was conducted using U.S. Environmental Protection Agency's (USEPA) Comprehensive Five-Year Review Guidance (EPA 540-R-01-007, June 2001).

DAFB is organized into four management units that divide the Base into approximate quadrants: North, South, East, and West. The LUCs sites are located in all four management units as listed in Table 1. Site maps appear in Attachment 1.

Table 1 – LUCs Site List

Site ID	Attachment 1 Map #	Description
North Management Unit (NMU)		
SD12	1a	North Drainage Ditch
East Management Unit (EMU)		
LF22	1b	Landfill
LF23	1b	Landfill
WP29	1c	Sludge Spreading Area
OT56	1d	Oil/Water Separator at Fire Training Area 3
ST58	1e	Engine Test Facility
South Management Unit (SMU)		
LF16	1f	Landfill
LF19	1f	Landfill
WP32	1g	Hobby Shop Waste Oil Tank at Building 124
OT55	1g	Hobby Shop Oil/Water Separator at Building 124
West Management Unit (WMU)		
FT02	1h	Fire Training Area 2
LF24	1i	Landfill
LF26	1j	Landfill
WP33	1k	Underground Waste Liquid Storage Tank at Industrial Waste Basins
WP38	1l	Entomology Shop at Building 921
OT42	1h	Oil/Water Separator at Building 583 Aircraft Wash Rack
OT43	1m	Oil/Water Separator at Building 635 Vehicle Maintenance
OT45	1k	Oil/Water Separator at Building 725 Jet Engine Shop
OT46	1k	Oil/Water Separators at Industrial Waste Basins (IWBs)
OT47	1k	Oil/Water Separator at Building 613 Jet Engine Test Facility
OT49	1n	Oil/Water Separator at Building 945 Fuel Cell Dock
OT57	1l	Oil/Water Separator at Building 914 Grounds Maintenance Storage

2.0 SITE CHRONOLOGY

The major environmental events affecting the LUCs sites are listed in Table 2.

Table 2 – Site Chronology

Date	Event
1986	Stage I Site Investigation (SI) conducted at SD12, groundwater and surface water sampled (Science Applications International Corporation [SAIC], 1986).
1989	Stage I SI conducted at OT56, LF16, and LF19, groundwater and surface water sampled (SAIC, 1989).
March 13, 1989	DAFB listed on National Priority List (NPL).
1991	SI at LF22, LF23, WP29, WP32, OT55, FT02, LF26, WP33, WP38, OT42, OT43, OT45, OT46, OT47, OT49, and OT57 (Hazardous Waste Remedial Actions Program [HAZWRAP], 1991a-p).
July 1994	Area 6 Remedial Investigation (RI) finalized; included assessment of WP33, OT45, OT46, and OT47 (U.S. Army Corps of Engineers [USACE], 1994).
June 1995	Focused Feasibility Study (FFS) for SD12 finalized (Air Force Center for Environmental Excellence [AFCEE], 1995).
August 1997	Basewide RI finalized; included assessment of all LUCs sites except WP33, OT45, OT46, OT47, and OT57 (USACE, 1997).
2000	Basewide Ecological Risk Assessment (USACE, 2000).
April 11, 2003	Department of Natural Resources and Environmental Control (DNREC) established a groundwater management zone (GMZ).
September 2003	FFS for all LUCs sites except SD12 finalized (BWXT Y-12, 2003).
January 2005	Proposed Plan prepared for SD12 (USACE, 2005a).
June 2005	Proposed Plan prepared for all LUCs sites excluding SD12 (ORNL, 2005).
September 2005	Final ROD for SD12 prepared (USACE, 2005b).
May 2006	Final ROD for all LUCs sites excluding SD12 prepared (ORNL, 2006b).
July 2006	DAFB prepared implementation plan for Basewide LUCs (i.e., Environmental Appendix to the Base General Plan).
December 2006	DAFB conducted Basewide Inspection of LUCs (DAFB, 2006).
December 2007	DAFB conducted Basewide Inspection of LUCs (DAFB, 2007).
December 2007	Assessment of vapor intrusion pathway (ORNL, 2007a).

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

DAFB is located in Kent County, Delaware, about 3.5 miles southeast of the city of Dover and is bounded to the southwest by the St. Jones River. DAFB encompasses approximately 4,000 acres of land, including annexes, easements, and leased property. Since the LUCs sites are located throughout the Base, this section summarizes the physical characteristics of the Base as a whole. The EMU forms the eastern quadrant of the Base and is primarily open grassy fields with some wooded and wetland areas along the eastern boundary. The SMU comprises the Base museum, a few industrial-use

buildings, taxiways, and large open fields. Most industrial activities occur in the WMU northeast of U.S. Route 113. On the other side of the highway is Base housing and the golf course. The NMU is dominated by a large drainage ditch, which is site SD12, and the surrounding area is covered by maintained grass turf, the perimeter road to the north, and runways/taxiways to the west, south, and east.

The surface topography of DAFB is relatively flat, with surface elevations ranging from 10 to 30 feet (ft) above mean sea level (msl). Surface water runoff is handled by an extensive storm drainage network of open ditches and pipe culverts. The storm drainage network for the EMU discharges to the Pipe Elm Branch of the Little River. The SMU discharges to the St. Jones River. At the golf course, surface water first flows to the golf course tributary and then into the St. Jones River. Drainage from the WMU discharges either to the Pipe Elm Branch via the SD12 drainage ditch or to the St. Jones River. In the NMU, the 15-ft deep and 40-ft wide ditch at SD12 is unlined and has steeply sloped sides. Weeds, tall grasses, and some small trees grow along the sides and bottom of the ditch.

The water table aquifer at DAFB is the Columbia Aquifer. The water table is usually encountered at 10 to 15 ft below ground surface (bgs), but varies according to surface topography from 30 ft bgs to within a few feet of the ground surface. The thickness of the Columbia Aquifer ranges from 15 to 20 ft in the northern portion of the Base and up to 70 ft in the southeastern portion. Underlying the Columbia Aquifer is a dense clay and silt layer known as the Calvert Formation, which is approximately 20 ft thick. The Calvert Formation separates the Columbia Aquifer from the Frederica Aquifer, and over most of the Base acts as a barrier to prevent the vertical migration of contaminants from the Columbia Aquifer to the Frederica Aquifer.

Twenty one of the 22 sites are located in the industrial area of the Base, northeast of U.S. Route 113. This portion of the Base is enclosed by a security fence and is only accessible through manned entry gates. LF26 is located in the Base housing area southwest of U.S. Route 113. Brief descriptions of the sites, grouped by management unit, are provided in Table 3.

3.2 LAND AND RESOURCE USE

Current land use at DAFB includes both industrial and residential areas. The largest portion of the Base is the industrial area which includes taxiways and runways, aircraft hangars, and maintenance and support facilities. The industrial portion of the Base is completely enclosed by a security fence. It is only accessible to authorized personnel through manned security gates; it is not accessible to the general public. The residential area of the Base is on the southwest side of U.S. Route 113 and includes a military family housing area, golf course, and military dependents school. Twenty one of the LUCs sites are all located in the industrial area of the Base. One site, LF26, is located in the Base housing area.

Table 3 - Site Summary

Site ID	Site Description	Contamination Assessment Conclusions
	NMU Site	
SD12	Years of Operation: 1951 - 1963 SD12 is the main drainage ditch in the northern portion of DAFB, which is dominated by runways, taxiways, access roads, and empty grassy fields. Wastes from various industrial activities that occurred predominantly in the WMU were discharged to SD12 for two decades. In 1999, in accordance with Clean Water Act storm water quality provisions, ten rows of chevron jacks were installed and the ditch was re-vegetated for purposes of sediment and erosion control (Attachment 1a).	Sampling of soils, sediment, surface water, and groundwater found contaminants primarily in sediments that likely came from run off of nearby aircraft parking pads and taxiways, and past industrial activities. None of the detected contaminants resulted in human health risks under commercial/industrial scenarios; thus, there are no COCs identified for this site.
	EMU Sites	
LF22	Years of Operation: Early 1950s - late 1960s This former landfill was used to dispose of rock, hard fill, empty drums, and paint cans (Attachment 1b). The area was covered with soil and seeded with grass in the late 1960s. It is currently maintained as an open grassy field.	Sampling of soil and groundwater revealed only minor impacts that might be related to past disposal activities. None of the detected contaminants resulted in human health risks under commercial/industrial scenarios; thus, there are no COCs identified for this site. No groundwater MCLs were exceeded at this site.
LF23	Years of Operation: Briefly in the 1960s LF23 was a small trench used briefly (about 6 weeks) for disposal of general refuse. The site is covered with soil and grass (Attachment 1b).	Sampling of soil and groundwater revealed only isolated detections of a few contaminants. None of the detected contaminants resulted in human health risks under commercial/industrial scenarios, and no COCs were identified for soil or groundwater at this site. No groundwater MCLs were exceeded at this site.
WP29	Years of Operation: 1969 - 1975 WP29 is a former sludge spreading area where sewage sludge from the former wastewater treatment plant was spread and tilled into the soil. The site is currently an open, grassy field (Attachment 1c).	Soil, sediment, and groundwater analyses indicated that past activities at the site did not result in significant accumulation of metals which are associated with sewage sludge. In addition, none of the detected contaminants resulted in elevated human health risks under commercial/industrial scenarios; thus, there are no COCs identified for this site. No groundwater MCLs were exceeded at this site.
OT56	Years of Operation: 1970s, removed in 1992 This site is a former oil/water separator located at site FT03, a former fire training area (Attachment 1d). The separator was removed along with contaminated soil during a remedial action at the fire training area in 1992. In addition to removal of the separator, an UST, dumpsters, associated structures and contaminated soil were removed. A monitored natural attenuation remedy for groundwater contamination at site FT03 was implemented per a 1997 ROD.	OT56 was investigated as an integral part of site FT03. Fuel-related contaminants were detected in soil, however post-remediation sampling confirmed achievement of the soil clean up goals at the site. Additionally, none of the residual soil contaminants resulted in unacceptable risks to human health under commercial/industrial scenarios. In groundwater, benzene and vinyl chloride are COCs. Groundwater contamination is being addressed under the remedial action for site FT03, and, therefore, is not addressed in this five-year review.
ST58	Years of Operation: 1960s and 1970s This 2- to 3-acre site was used as an engine testing and repair facility in the 1960s (Attachment 1e). After this, pesticides were stored at the site and a jet fuel (JP-4) spill reportedly occurred in the 1970s at a UST. A UST was reported to be located at the site, however, investigations were unable to locate it. The facility was demolished at an unknown date, and a concrete slab is currently all that remains of the structure.	Residual organic contaminants were present to a limited extent in site soil, groundwater, and sediments. Two contaminants, chloroform and TCE were detected at concentrations exceeding federal MCLs in one groundwater probe sample. These contaminants were not detected in nearby groundwater probe locations and there were no MCL exceedences in the groundwater samples from any nearby monitoring wells Lead, from one monitoring well (filtered sample) slightly exceeded (26.4 ppb) its action level (15 ppb). None of the detected contaminants resulted in elevated human health risks under industrial scenarios; thus, there are no COCs identified for this site.
	SMU Sites	
LF16	Years of Operation: Late 1960s Two trenches were used for disposal of general refuse at this site in the late 1960s. The area was covered with soil and seeded with grass. It is currently a grassy area with a paintball field and the Base dog kennel nearby (Attachment 1f).	No COCs were identified in soil at LF16. Fuel contaminants in one groundwater sample resulted in an elevated hazard and are related to a known source at upgradient site OT53. The fuel contamination was addressed per a Corrective Action Plan for site OT53 under Delaware's Regulations Governing Underground Storage Tank Systems and has since been closed. Thus, no COCs are associated with site LF16.
LF19	Years of Operation: Early to late 1960s This 4-acre site was used in the 1960s for disposal of construction rubble. The area was covered with soil and seeded with grass. It is currently an open grassy area that is occasionally used for archery practice and temporary trailer parking (Attachment 1f).	No COCs were identified at the site. Minor groundwater contaminants originate at an upgradient site and are being addressed under a separate action for LF17 in the SMU. No groundwater MCLs were exceeded at this site.

Table 3 - Site Summary

Site ID	Site Description	Contamination Assessment Conclusions
WP32	Years of Operation: up to mid-1991 A former 1,000-gallon UST was located near the western corner of Building 124, an automotive hobby shop (Attachment 1g). It stored waste oil from the automotive shop located in the building until mid-1991. The tank and associated contaminated soil were removed per a 1994 ROD.	Contaminated soil was removed when the UST was removed, and post-excavation soil samples met the industrial cleanup standards of the Delaware Regulations Governing Underground Storage Tank Systems. No COCs remain in soil. In September 1995, EPA issued a closeout report for the UST and soil at WP32. For groundwater, WP32 and OT55 were assessed as a unit. PCE (a solvent) was detected in a localized area above its MCL in two groundwater probe samples. The MCL for PCE was not exceeded in the groundwater samples from any nearby monitoring wells. It was the only solvent detected in groundwater; it was not found in site soils; and it does not result in unacceptable risks under commercial/industrial land use scenarios. During a 2006 sampling event, three direct-push groundwater samples were collected directly downgradient of Building 124 to assess the presence of chlorinated solvents. None of the samples contained any COCs above an MCL (ORNL, 2006a).
OT55	Years of Operation: up to 1995 OT55 is also at the automotive hobby shop at Building 124, and comprises three former oil/water separators and associated USTs (Attachment 1g). The separators collected the liquid wastes that were discharged to floor drains in the building. The oil/water separators and USTs were removed in 1995.	No COCs were identified in soil at this site. See the discussion of groundwater under site WP32.
WMU Sites		
FT02	Years of Operation: 1956-1958 Fire training exercises were held at this site in a pit approximately 60 ft long and 40 ft wide, surrounded by a 6-inch-high soil berm (Attachment 1h). Contaminated waste oils, waste solvents, paint thinners, and jet fuel were stored onsite and used in the training exercises. During the 1960s, Building 582, an aircraft maintenance facility, was constructed over the site. Building 582 was subsequently demolished in 2007, and the site is currently covered with asphalt pavement.	Fuel-related contaminants were present in soil in a localized area beneath Building 582. Primary contaminants detected in the groundwater of the deeper portion of the Columbia Aquifer were cis-1,2-DCE and TCE. These contaminants were not detected in shallow wells or in site soil, indicating that FT02 is not the source of the contaminants. They are likely related to nearby sites that are being addressed separately (see five-year review for WMU, Area 6). None of the detected soil contaminants resulted in elevated human health risks under commercial/industrial land use scenarios.
LF24	Years of Operation: 1970s LF24 is a former landfill underneath the northwestern end of the northwest/southeast runway (Attachment 1i). General refuse was disposed of in the landfill during the 1970s. 5,000 tons of general refuse along with approximately 30 5-gallon cans of aircraft and traffic paint were unearthed in 1987. This material was removed and disposed of offsite when the runway was extended in 1987.	A few fuel and solvent contaminants were detected in soil samples collected after remediation of the landfill. However, no solvent contaminants were found in the groundwater downgradient of LF24, and very low concentrations of fuel contaminants (below MCLs) were detected in only one of the two downgradient samples. The major portion of LF24 that is currently underneath the northwest/southeast runway was removed in 1987. If any residual portion of the landfill contents remain, they are underneath a soil and grass cover next to the runway. This site no longer appears to be a source of concern. No COCs were identified in the human health risk assessment.
LF26	Years of Operation: Early 1960s LF26 is approximately 2 acres in size and was used in the early 1960s for the disposal of general refuse, clearance debris such as trees and branches, and construction rubble. When disposal activities ceased, the site was covered with local soil and seeded with grass. It is currently maintained as grass-covered baseball playing fields (Attachment 1j).	Typical debris was revealed in test pits dug at the site. In addition, two buckets containing an oily substance were unearthed. One COC, arsenic, was identified in site soil. However, its distribution indicates that it is more likely naturally occurring. In groundwater, the risk assessment identified no COCs under the commercial/industrial and residential land use scenarios.
WP33	Years of Operation: 1965-1984 This former 15,000-gallon UST was used at the former IWBs to store oils separated from industrial wastewater at the WP21 lagoons, oils pumped from oil/water separators, and other hazardous wastes. The UST was removed in 1984 and the site is currently covered with grass (Attachment 1k).	Remnant fuel-related contaminants from the UST, or possibly related to infiltration of stormwater runoff from the adjacent road, were found in soil. However, none of the detected contaminants resulted in elevated human health risks under commercial/industrial land use scenarios; thus, there are no COCs (in soil or groundwater) identified for this site. No groundwater MCLs were exceeded at this site.
WP38	Years of Operation: 1969-present Building 921 was initially built as an aircraft support center and was a paint shop from 1969-1970. In 1971, it was converted to an entomology shop and now houses quantities of pesticides and herbicides (Attachment 1l).	Some pesticides were detected in soil, and in groundwater at low concentrations similar to those detected across the Base. Lead from one monitoring well (filtered sample) slightly exceeded (31.2 ppb) its action level (15 ppb). None of the detected contaminants resulted in elevated human health risks under commercial/industrial scenarios; thus, there are no COCs identified for this site.

Table 3 - Site Summary

Site ID	Site Description	Contamination Assessment Conclusions
OT42	Years of Operation: 1959-2007 This site is a former oil/water separator that serviced Buildings 582 (now demolished) and 706, aircraft maintenance facilities. It was housed within Building 583 and was constructed of reinforced concrete measuring 13 ft wide by 24 ft long by 12 ft deep. Separated oil was held in a 500-gallon tank, and processed water was discharged to the sanitary sewer (Attachment 1h). Building 583 and the oil/water separator were demolished in 2007, and the site is currently covered with grass.	Distribution of contaminants in soil suggests a release of fuel may have occurred from the separator. Groundwater quality at the site does not appear to be affected. None of the detected contaminants resulted in elevated human health risks under commercial/industrial land use scenarios; thus, there are no COCs identified for this site. No groundwater MCLs were exceeded at this site.
OT43	Years of Operation: 1954-present The oil/water separator at this site supports operations at Building 635, a motor vehicle maintenance facility (Attachment 1m). It is a below-ground structure 5 ft wide by 6.5 ft long by 12 ft deep. Processed water had been discharged to the industrial waste collection drain but now goes to the sanitary sewer.	Residual contaminants were detected in soil in a limited area near the separator. Site groundwater contained elevated levels of benzene (not detected in soil) and TCE. These contaminants are likely related to adjacent sites OT41 (motor pool) and OT44, which contribute to a large groundwater contaminant plume known as Area 5. None of the detected contaminants in soil at OT43 resulted in elevated human health risks under commercial/industrial land use scenarios and the small area of groundwater contamination was addressed under site OT41/Motor Pool and Area 5 in the Area 5 ROD; thus, there are no COCs associated with OT43.
OT45	Years of Operation: Installation date unknown-present The oil/water separator at this site supports Building 725, a jet engine maintenance facility (Attachment 1k). Separated waste oils accumulate in a 275-gallon underground holding tank located outside the building. Separated water is discharged to the sanitary sewer.	Residual petroleum-related contaminants were detected in soil samples, probably related to minor spills during servicing or runoff from the adjacent asphalt-paved street and parking lot. Low concentrations of solvent contaminants detected in groundwater appear to be related to a source near the Area 5 plume upgradient from the site. None of the detected contaminants resulted in elevated human health risks under commercial/industrial land use scenarios; thus, there are no COCs identified for this site.
OT46	Years of Operation: 1985-1998 Two former oil/water separators were located at the northern and western corners of the concrete IWBs at site WP21 (Attachment 1k). They were installed in 1985 and removed on October 14, 1998. Closure of the separators was in accordance with the approved Closure Plan and performance standards were met (including those for confirmation soil samples).	During the RI, residual petroleum-related contaminants were detected in low concentration at shallow depths in the soil, and were likely due to minor spillage or surface runoff. These soils were removed during the 1998 excavation of the separators. Chlorinated solvents were detected at low concentrations in groundwater during the RI. None of the detected contaminants resulted in elevated human health risks; thus, there are no COCs identified for this site.
OT47	Years of Operation: 1969-present This site is an oil/water separator located at Building 613, a jet engine testing facility (Attachment 1k). Separated oils are stored in a 275-gallon holding tank at the southeast side of the oil/water separator.	No COCs were identified at this site. No groundwater MCLs were exceeded at this site.
OT49	Years of Operation: 1969-present This site is an oil/water separator on the west side of Building 945, an aircraft maintenance facility (Attachment 1n). A 400-gallon storage tank is attached to the oil/water separator.	Several fuel contaminants were detected in soil, primarily confined to the northwest side of the separator. Trace amounts of fuel-related contaminants were also detected in groundwater; all the detections were below the MCLs. None of the detected contaminants resulted in elevated human health risks under commercial/industrial scenarios; thus, there are no COCs identified for this site.
OT57	Years of Operation: 1959-present This site is an oil/water separator located at the northwestern side of Building 914, a grounds maintenance facility (Attachment 1l). Processed wastewater is discharged to the sanitary sewer, separated oil is collected in a 500-gallon holding tank.	Minimal contaminants were detected in soil and groundwater samples. None of the detected contaminants resulted in elevated human health risks under commercial/industrial scenarios; thus, there are no COCs identified for this site. No groundwater MCLs were exceeded at this site.

Note: See page iii for abbreviations used in this table.

The shallow groundwater (Columbia Aquifer) underlying the site is not currently used as a drinking water source. Groundwater on Base flows primarily towards the Pipe Elm Branch in the eastern half of the Base and towards the St. Jones River in the western half of the Base. Off Base, the shallow groundwater may be used for various purposes. To mitigate this potential, DNREC has implemented a GMZ that encompasses DAFB and some off-Base portions immediately adjacent to DAFB. The GMZ prohibits unauthorized access to the aquifer and is enforced by the DNREC well permitting process.

3.3 HISTORY OF CONTAMINATION

A brief summary of contamination for each site is provided in Table 3. Many of the 22 sites appear to have released minor quantities of contaminants to the subsurface (or to sediments for site SD12); however, these contaminants remained at only residual levels at the time of the RI. Exposure to residual soil contamination is a possible exposure route for Base maintenance or utility workers at these sites and for residents at site LF26, which is located in the Base housing area.

For groundwater, some of the sites may have had minor effects on water quality. Although a few isolated detections of contaminants in groundwater were observed, no migrating plumes originate from any of the 22 sites. At five sites (OT56, LF16, FT02, OT43, and OT46), groundwater quality is affected by contaminants migrating from other upgradient or adjacent sites. Groundwater from the Columbia Aquifer is not used for any purpose on Base at this time, and there are no off-Base users of the Columbia Aquifer currently affected by groundwater contamination from DAFB. Thus, there are no current exposures to this medium.

Surface contamination is not a problem at any of the sites (excluding SD12, see below), thus transport via runoff is not a migration route.

The Basewide Ecological Risk Assessment (USACE, 2000) concluded that there were no unacceptable risks associated with surface water, sediments, soil, or groundwater discharging to surface streams. SD12 in particular underwent extensive assessment. In the SD12 ROD, EPA confirmed the conclusions regarding this site with the qualification that potential ecological risks could exist but only at a few localized spots within the ditch.

3.4 INITIAL RESPONSE

At SD12, a sediment erosion and control system was constructed in 1999 at the east end of the drainage ditch near its discharge point into the Pipe Elm Branch. This system was installed to comply with Clean Water Act storm water quality provisions. Ten rows of concrete chevron jacks were installed and the ditch was re-vegetated with wetland plants to slow the flow of storm water runoff and reduce sediment erosion from the ditch.

Treatment alternatives for SD12 were evaluated in an FFS for SD12 (AFCEE, 1995). A proposed plan was submitted for public review on February 13, 2005, and the ROD for SD12 was signed in late 2005. The ROD selected LUCs as the final remedy for SD12.

Treatment alternatives for the remaining 21 LUCs sites were evaluated in an FFS (BWXT Y-12, 2003). A proposed plan for the 21 sites was submitted for public review on July 10, 2005. In May 2006, a ROD was signed for the 21 sites which selected LUCs as the final remedy.

3.5 BASIS FOR TAKING ACTION

The Air Force evaluated current and reasonably anticipated future use scenarios in the Basewide RI human health risk assessment (RA) as documented in the RI reports. Thus, a hypothetical future commercial/industrial scenario was evaluated for groundwater and soil at all 21 LUC sites since they are located in industrial portions of the Base (USACE, 1997). A recreational use scenario was evaluated for LF26 because it is located near Base housing.

Based on the evaluation of human health and ecological risks, cleanup action is not warranted at the 22 sites. The human health risk assessment identified exceedences of federal and/or State risk criteria at eight of the 22 sites, based on a hypothetical future commercial/industrial exposure to groundwater contamination. Five of these eight sites are simply in the pathway of migrating contaminant plumes that are being addressed via remedial or corrective actions at other nearby or upgradient sites. At the other three of these eight sites, the risk exceedence is due to the presence of non site-related arsenic in groundwater at levels below the federal MCL. Based on the risk assessment, cleanup action was not warranted at the 22 sites. However, this conclusion is based on assumptions that future on-Base land use at the sites will be limited to industrial uses (or recreational use at LF26), and that prohibitions on use of groundwater from the Columbia Aquifer will remain in place. Thus, the limited response action selected in the ROD was necessary to ensure the permanence and reliability of these land use assumptions, and thereby protect the public health from hazardous substances at these sites.

4.0 REMEDIAL ACTION

4.1 REMEDY SELECTION

The ROD for SD12 was signed by USEPA in November 2005 (USACE, 2005b) and the ROD for the other 21 sites was signed by USEPA in May 2006 (ORNL, 2006b). The remedial action objective (RAO) was developed to restrict land use in order to protect human health.

Various options were evaluated in the FFSs. The selected remedy for the 22 sites as outlined in the 2005 and 2006 RODs includes the following major LUCs performance objectives listed below.

- Prohibit the development and use of all the sites for residential housing, elementary or secondary schools, day care centers, and playgrounds until concentrations of hazardous substances at the site are at levels allowing for unrestricted exposure and unlimited use. At LF26 land use is restricted to commercial/industrial uses or to its current recreational use as a baseball field.
- Prohibit the use of on-Base groundwater from the Columbia Aquifer (first shallow, unconfined aquifer) near any of the 22 sites until risks from groundwater use are shown to be at levels that allow for unrestricted exposure and unlimited use.
- Prevent exposure to landfill contents at sites LF16, LF19, LF22, LF23, LF24, and LF26.
- Prevent drilling of wells or other ground-disturbing activities that could penetrate or otherwise disturb the landfill contents at sites LF16, LF19, LF22, LF23, LF24, and LF26. Prevent digging or other ground-disturbing activities that penetrate the groundwater table at OT43, OT46, OT56, FT02, WP29, and ST58.
- Prohibit digging and other ground-disturbing activities at all of the 22 sites that are inconsistent with the objectives listed above.
- Maintain the integrity of any nearby current and future remedial or monitoring system.

4.2 REMEDY IMPLEMENTATION

To formally implement LUCs at the 22 sites, DAFB generated an Environmental Appendix to the Base General Plan in June 2006 and submitted it to federal and state regulators. This Appendix is the implementation plan for LUCs at all DAFB contaminant release sites (including the 22 being addressed solely through LUCs). Some of the primary controls are: (1) Use of groundwater from the unconfined Columbia Aquifer is prohibited except for monitoring purposes. (2) All work that disturbs the subsurface is required to be cleared through the digging permit process, including the installation of groundwater wells. (3) Annual monitoring of LUCs.

Although not part of the performance objectives for LUCs, the LUCs ROD indicated that vapor intrusion risks would be further evaluated. The vapor intrusion pathway at DAFB was assessed in several stages. First, risks were assessed in 2003 for the base residential area during a public health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). Second, DAFB conducted a risk screening in 2005 for workers in the industrial areas of the Base. Finally, a RA was conducted in 2007 by evaluating the areas most likely to be affected by shallow groundwater contamination (ORNL, 2007a). Indoor air samples were collected in 2007 from eight buildings located where the most contaminated shallow groundwater is found. These buildings are all located in the WMU. Based on these worst-case evaluations, it was concluded that vapor intrusion is not a significant exposure pathway at DAFB under existing land use scenarios. If future land use at the sites change, the potential risks associated with vapor intrusion may need to be re-evaluated.

4.3 REMEDY OPERATION AND MAINTENANCE

In accordance with the RODs and DAFB's Environmental Appendix to the Base General Plan, annual inspection of LUCs began in 2006 and is on-going. The most recent inspection was completed in December 2007 (DAFB, 2007). The costs associated with this activity are summarized in Table 4.

Table 4 – Annual Monitoring Costs

Fiscal Year	Total Cost rounded to nearest $1,000
2006	$1,000
2007	$1,000

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for the 22 LUCs sites.

6.0 FIVE-YEAR REVIEW PROCESS

DAFB announced at several Tier 1 Meetings in 2007 that the five-year review for the LUCs remedy would begin in 2007 and would be conducted by the ORNL contractor. The Tier 1 meetings and conference calls are regularly attended by USEPA Region III and DNREC representatives.

The main components of the review process for the LUCs sites are:

- Community Involvement
- Document Review
- Data Review
- Site Inspection

6.1 COMMUNITY INVOLVEMENT

DAFB informed the public via a notice in the local newspaper that the five-year review of LUCs sites had been performed and was available for review. The public comment period was in effect for 30 days (May 21 – June 20, 2008). A copy of the draft-final document was placed in the information repository maintained at the Dover Public Library. The public was invited to comment on the five-year review. No comments were received.

6.2 DOCUMENT REVIEW

Relevant documents were examined to complete this five-year review. They are listed in Attachment 2. Applicable or relevant and appropriate requirements (ARARs) were also reviewed (Attachment 3).

6.3 DATA REVIEW

There are two main sources of information used to assess LUCs implementation: (1) the site visit conducted in November 2007 for the purpose of these five-year reviews and (2) DAFB's annual LUCs monitoring reports (DAFB, 2006 and 2007). Land use at all of the 22 sites remains unchanged since the signing of the RODs. The 21 sites within the fenced area of the Base remain industrial, and site LF26, located in the Base housing area, remains recreational. No disturbance of landfill soil covers was observed. DAFB's annual monitoring report documents similar observations and found no LUC deficiencies or activities that could interfere with the effectiveness of the LUCs.

6.4 SITE INSPECTION

A URS geologist visited the site on November 14, 2007. A photographic log documents the conditions at the LUCs sites on that day (Attachment 4). There are no photographs of LF24 because it is located beneath an active runway and was inaccessible. Complete site status information was available from the DAFB environmental office, from the monitoring reports prepared for all the sites, and from the comprehensive database of geologic data and chemical results maintained by URS. The site inspection revealed no site changes that would require conducting interviews of other site personnel or agencies.

7.0 TECHNICAL ASSESSMENT

The assessment of remedy effectiveness is addressed by answering three questions as posed in USEPA's five-year review guidance.

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

The review of documents, ARARs, and risk assumptions indicates that the LUCs are functioning as intended. Site conditions and usage are unchanged since the implementation of the remedy. The annual LUCs report determined the following: (1) LUCs have been implemented in accordance with the RODs; (2) No inconsistent uses or LUC deficiencies were identified; and (3) There are no activities occurring that could interfere with the effectiveness of the LUCs (DAFB, 2006 and 2007). This was confirmed during the site inspection visit in November 2007.

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

Because the RAOs for the sites addressed in this five year review are performance-based rather than risked-based, detailed review of the risk assessment was unnecessary. As previously discussed, the exposure assumptions have remained valid through the successful implementation of LUCs at all 22 sites. There have been no physical changes at the sites or the Base in general that would affect the protectiveness of the selected remedy.

There have been no changes in ARARs since the RAOs were established in the SD12 and LUCs RODs (Attachment 3).

In late 2007, the Air Force reviewed the RI soil and groundwater chemical data for the 22 LUCs sites to determine whether some of the sites might be suitable for closure if a residential risk screening evaluation was conducted. Seven sites (OT43, OT46, OT47, OT57, WP29, WP32, and OT55) are recommended for closure based on that evaluation. For each site, maximum detected concentrations of all soil and groundwater contaminants were screened against either residential soil risk-based criteria (RBCs) or tap water RBCs from EPA Region III's most recent RBC table (October 2007). Details of this assessment are included in Attachment 5.

Ecological risks were thoroughly evaluated in the Basewide Ecological Risk Assessment (USACE, 2000). Since that time, there have been no land use changes affecting the site's ecological setting, which was confirmed during the 2007 site visit and in the LUCs annual report (DAFB, 2007). Thus, the original conservative conclusion that groundwater discharging to surface water poses little risk remains valid. There have also been some changes in the screening criteria used in the Stage 1 ecological risk assessment. For example, the national recommended water quality criterion for arsenic decreased from 190 to 150 µg/L and it increased from 100 to 120 µg/L for zinc. Regardless of the potential minor changes in ecological risk calculations, remedy selection, implementation, and current protectiveness would not be affected. There is no new information to suggest that a re-evaluation of ecological risk is needed at this site.

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

The review for the 22 LUCs sites produced no information that could call into question the protectiveness of the remedy. The mission of DAFB has remained unchanged over the last five years and is likely to remain so in the foreseeable future. All information to date indicates that the LUCs at the 22 sites are working as intended.

7.1 TECHNICAL ASSESSMENT SUMMARY

According to the data and documents reviewed, the LUCs remedy at all 22 sites has been successfully implemented and is functioning as intended. Review of site land uses and ARARs revealed no significant changes that would affect remedy selection or implementation.

8.0 ISSUES

During the review, no issues were discovered that affect the protectiveness of the remedy.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

It is recommended that LUCs continue to be enforced at 15 of the 22 sites. Based on the residential risk screening evaluation (Attachment 5), it is recommended that LUCs be terminated at seven sites (OT43, OT46, OT47, OT57, WP29, WP32, and OT55). It is recommended that these seven sites be closed and that future five-year reviews for LUCs exclude these seven sites.

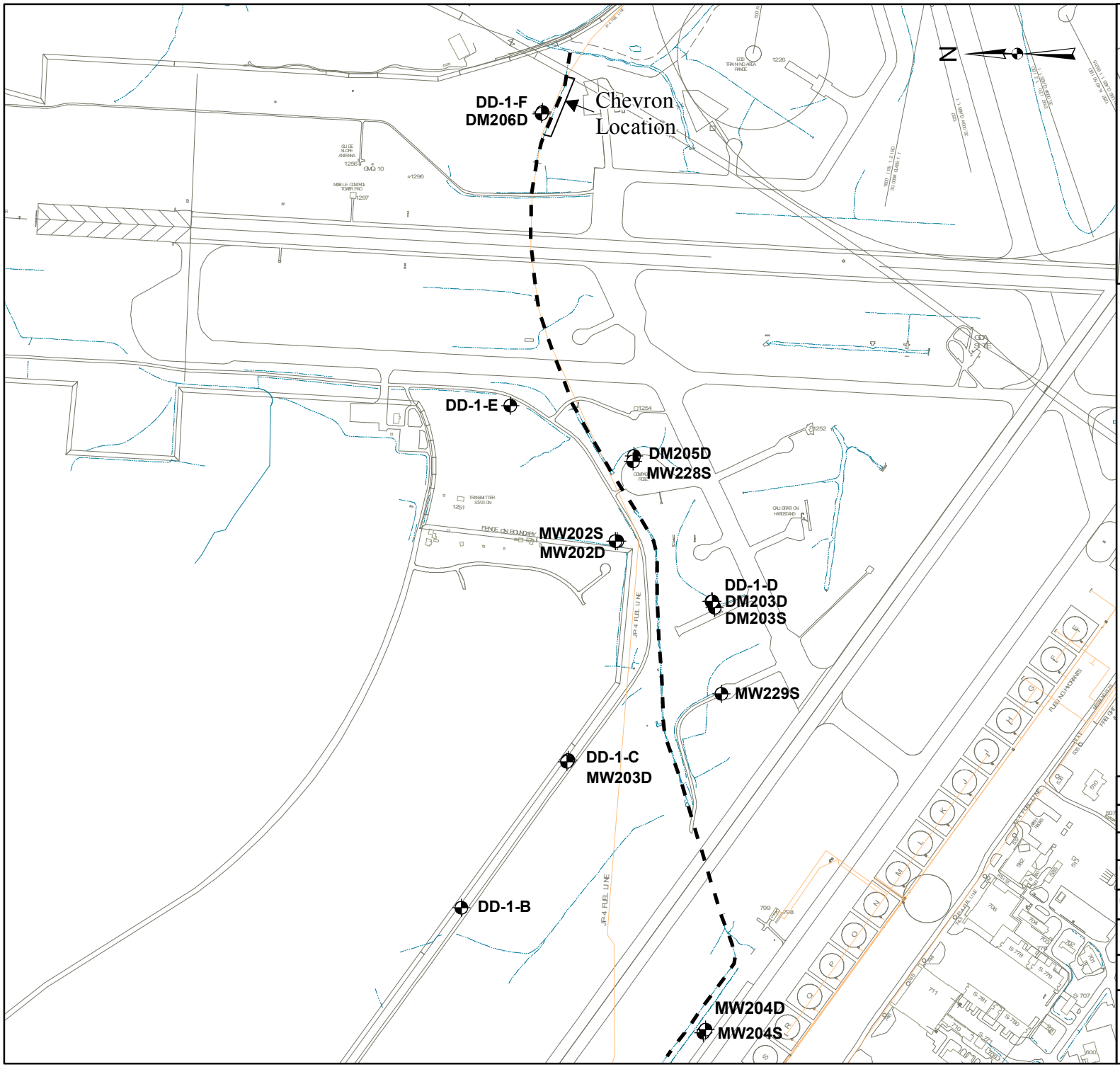
10.0 PROTECTIVENESS STATEMENT

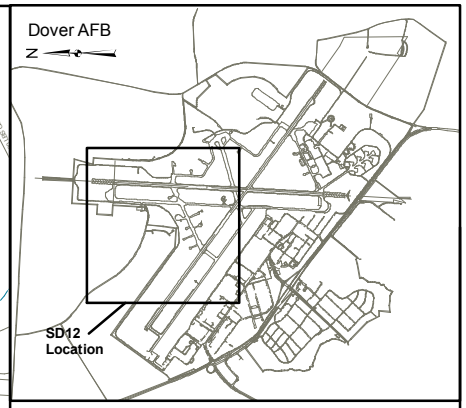
The LUCs remedy at all 22 sites is meeting the performance objectives established in the SD12 and LUCs RODs, and remains protective of human health and the environment.

11.0 NEXT REVIEW

The next review for LUCs sites will be due in September 2013.

Attachment 1
Site Maps





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- - - SD12 Boundary

Monitoring Well

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CHK BY	LS
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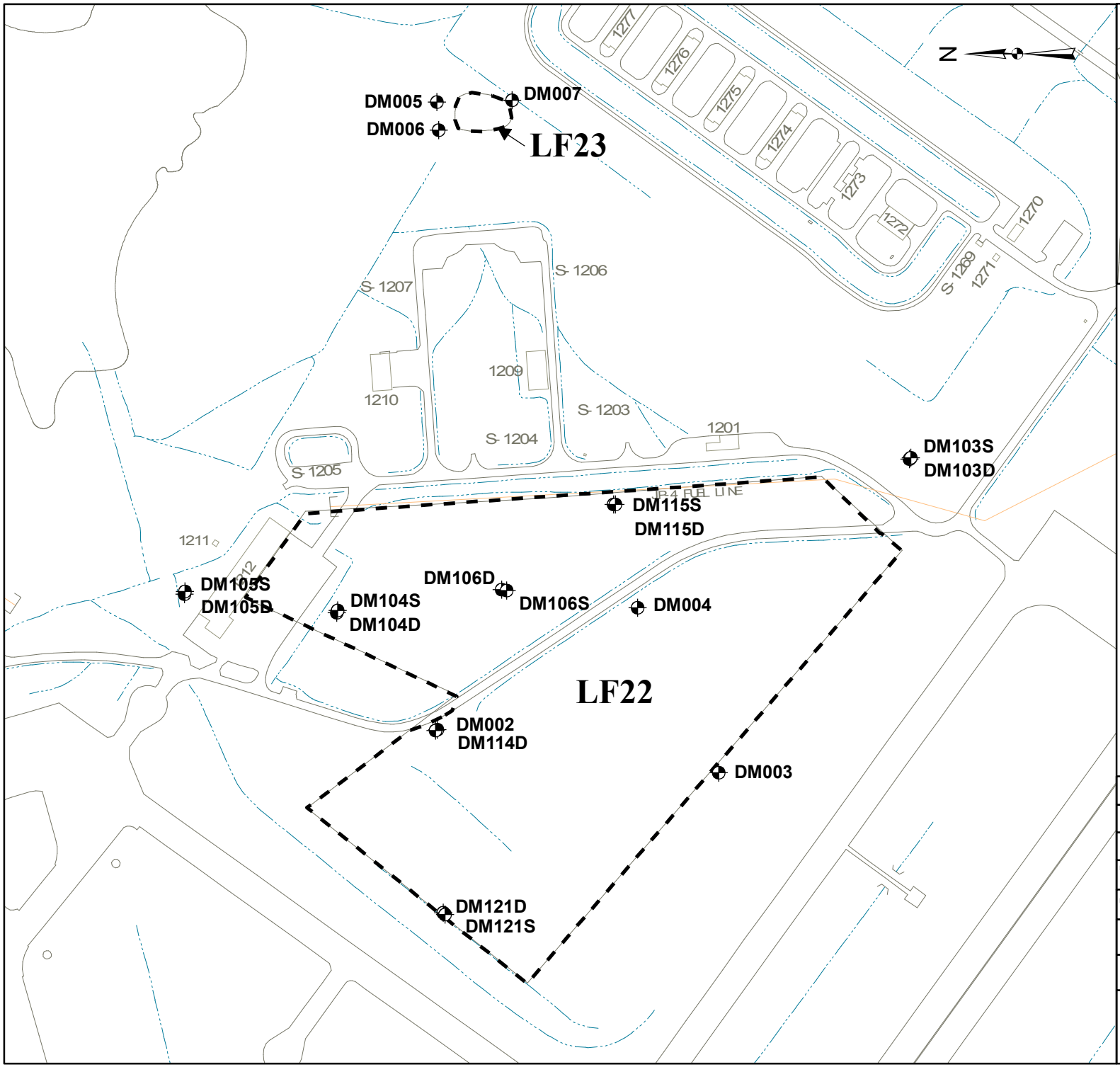
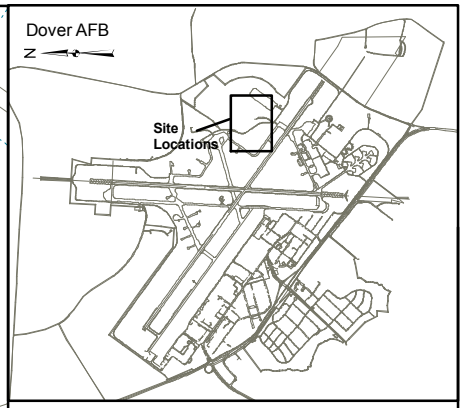
FIGURE	Attachment 1a

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878





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Site Boundary

Monitoring Well

0 150 300 600 Feet

TITLE	LF22 and LF23 Site Map
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FIGURE	Attachment 1b

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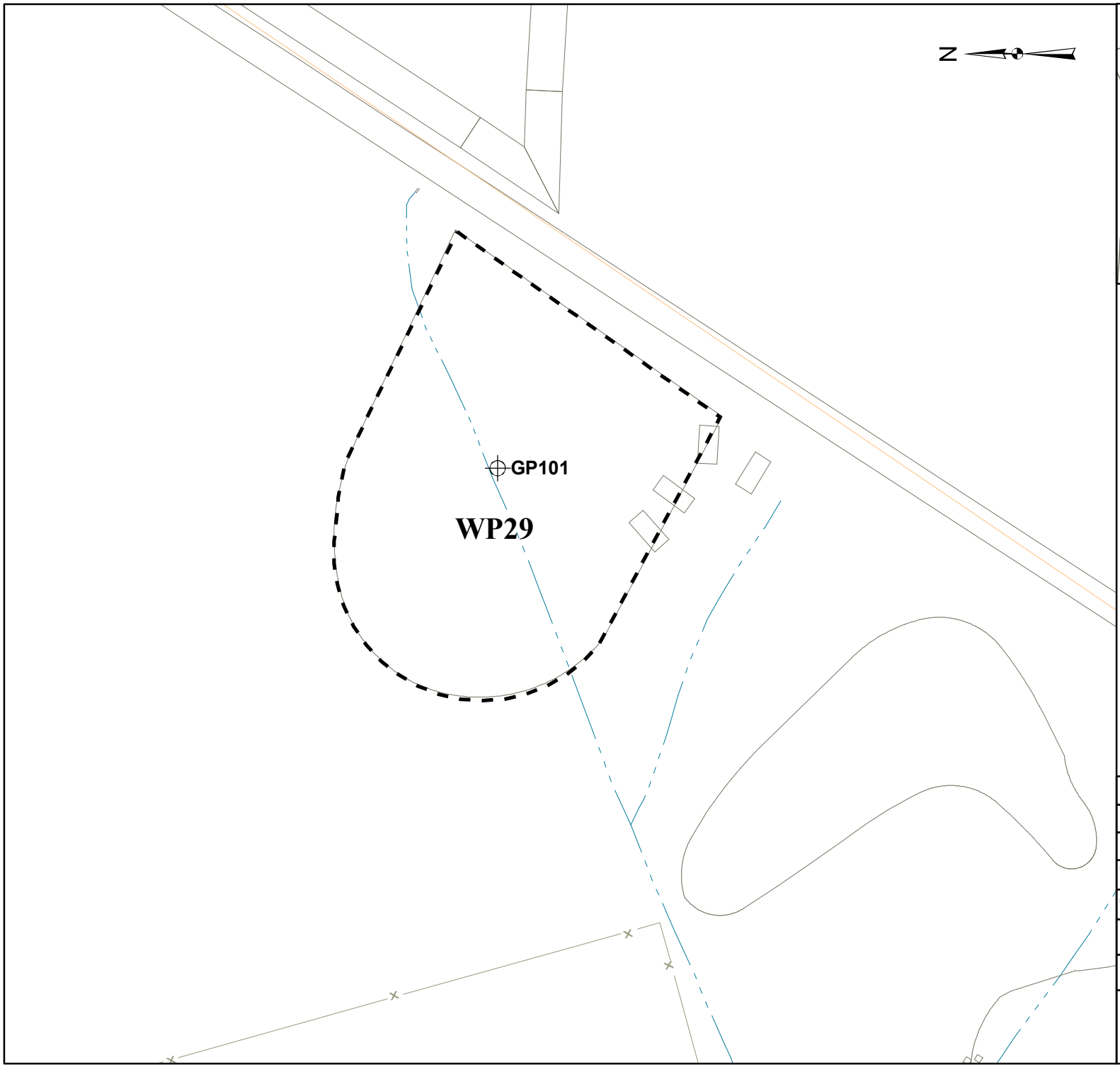

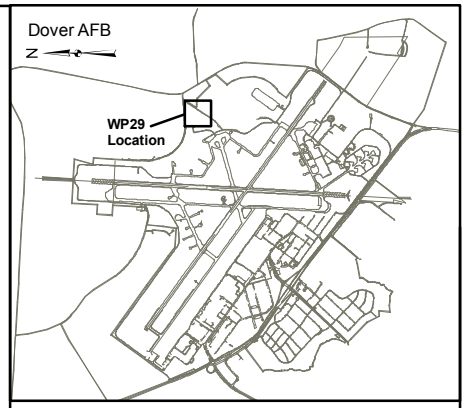

Legend

WP29 Boundary

Direct Push

0 50 100 200 Feet

TITLE	WP29 Site Map
CLIENT	DAFB/ORNL
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PROJ NO	15300779
FIGURE	Attachment 1c

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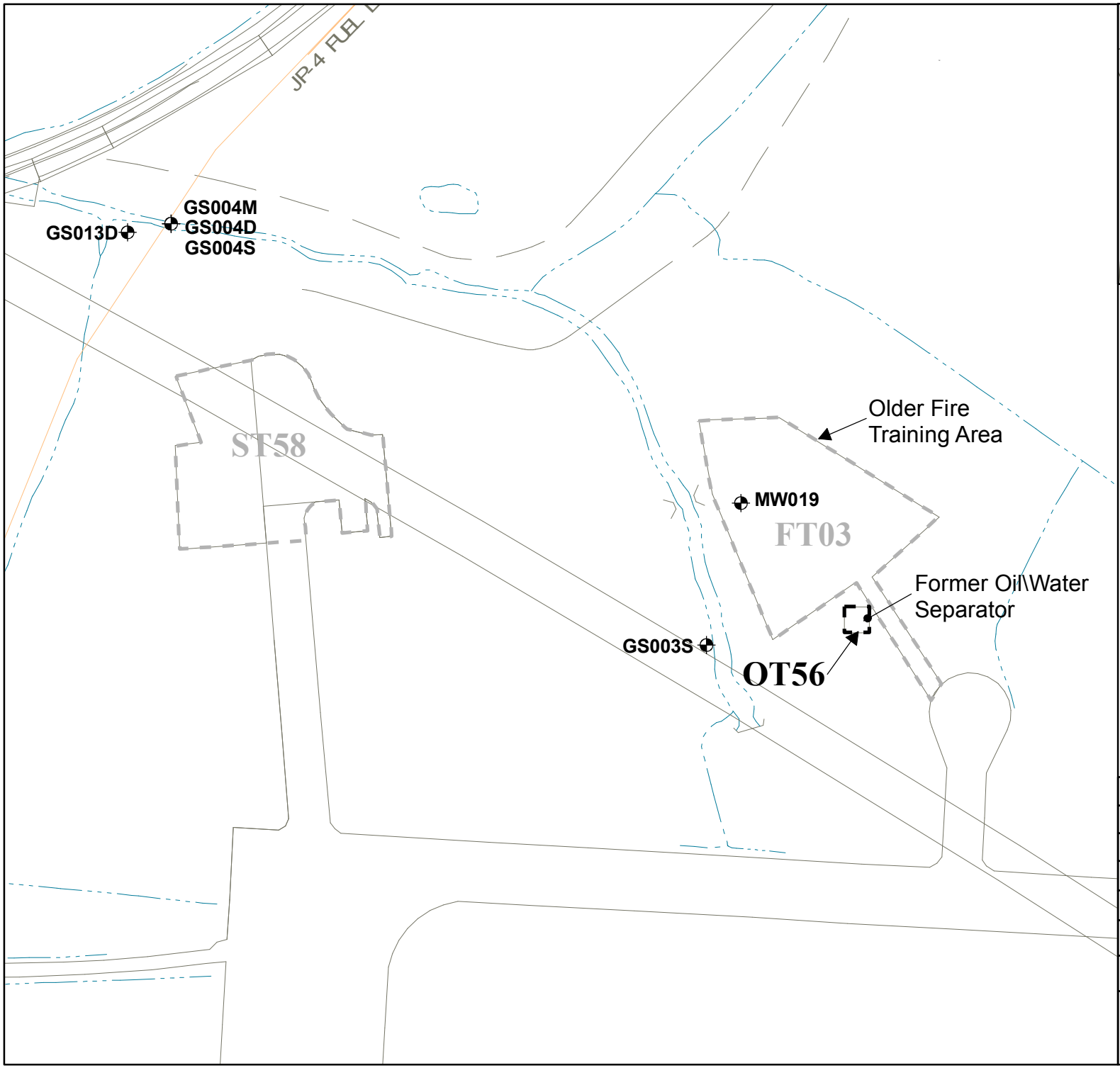

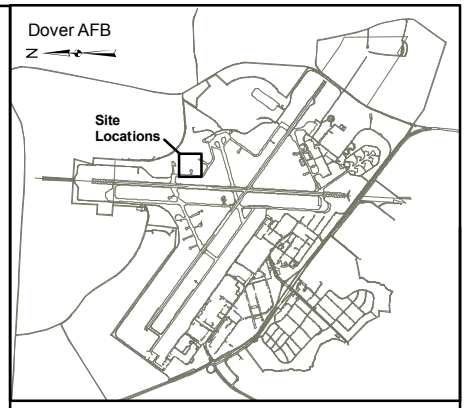

Legend

Site Boundary

Monitoring Wells

0 75 150 300 Feet

TITLE	OT56 Site Map
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FIGURE	Attachment 1d

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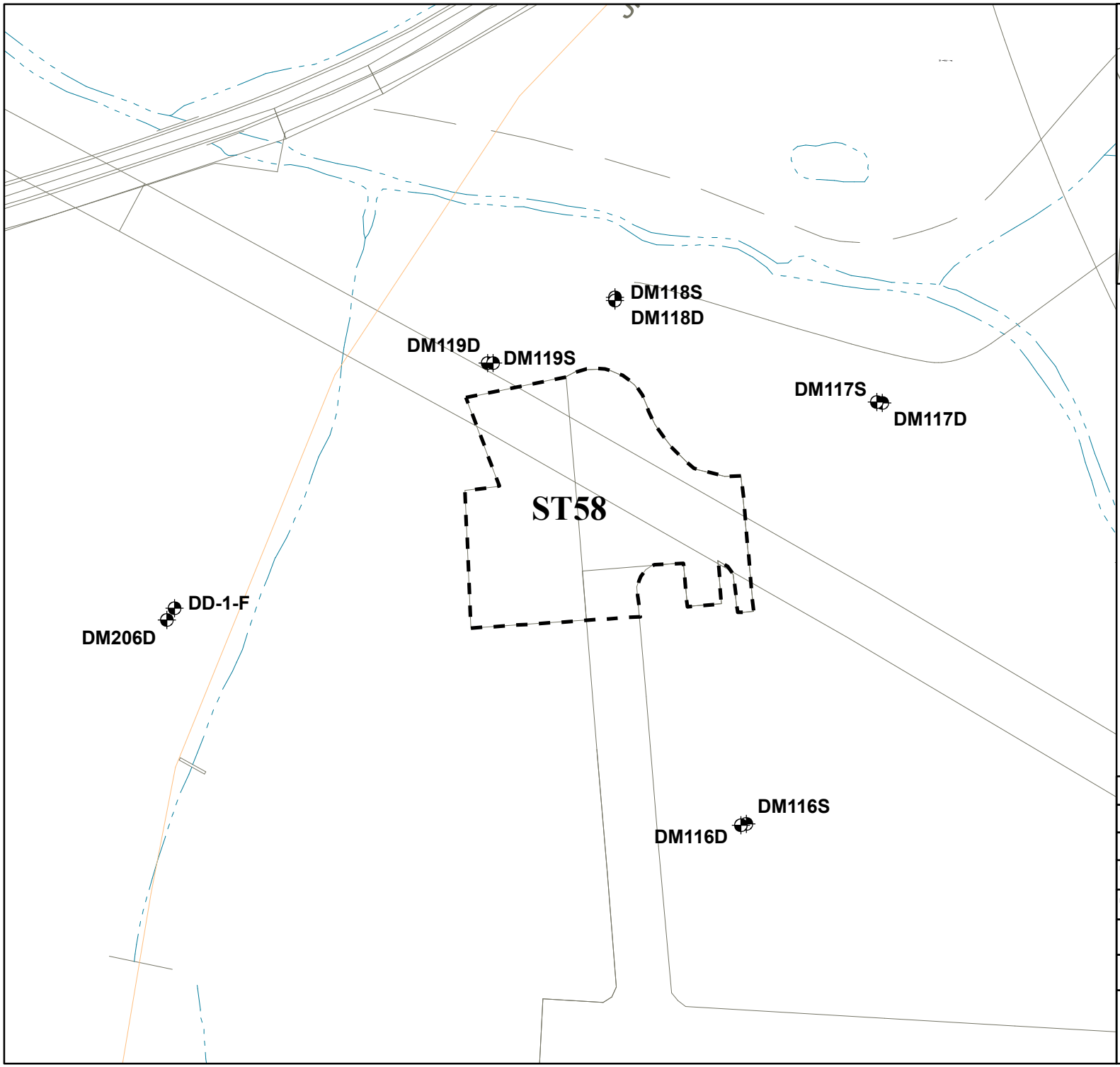

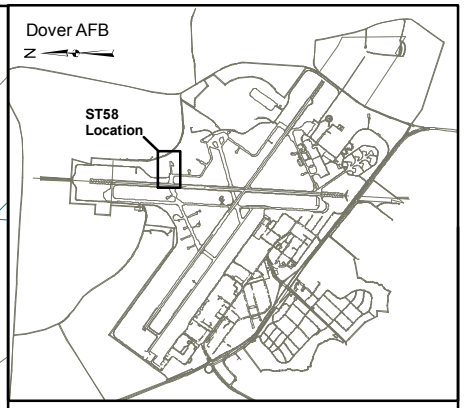

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ST58 Boundary

Monitoring Well

0 50 100 200 Feet

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PROJ	2008 Five-Year Reviews
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FIGURE	Attachment 1e

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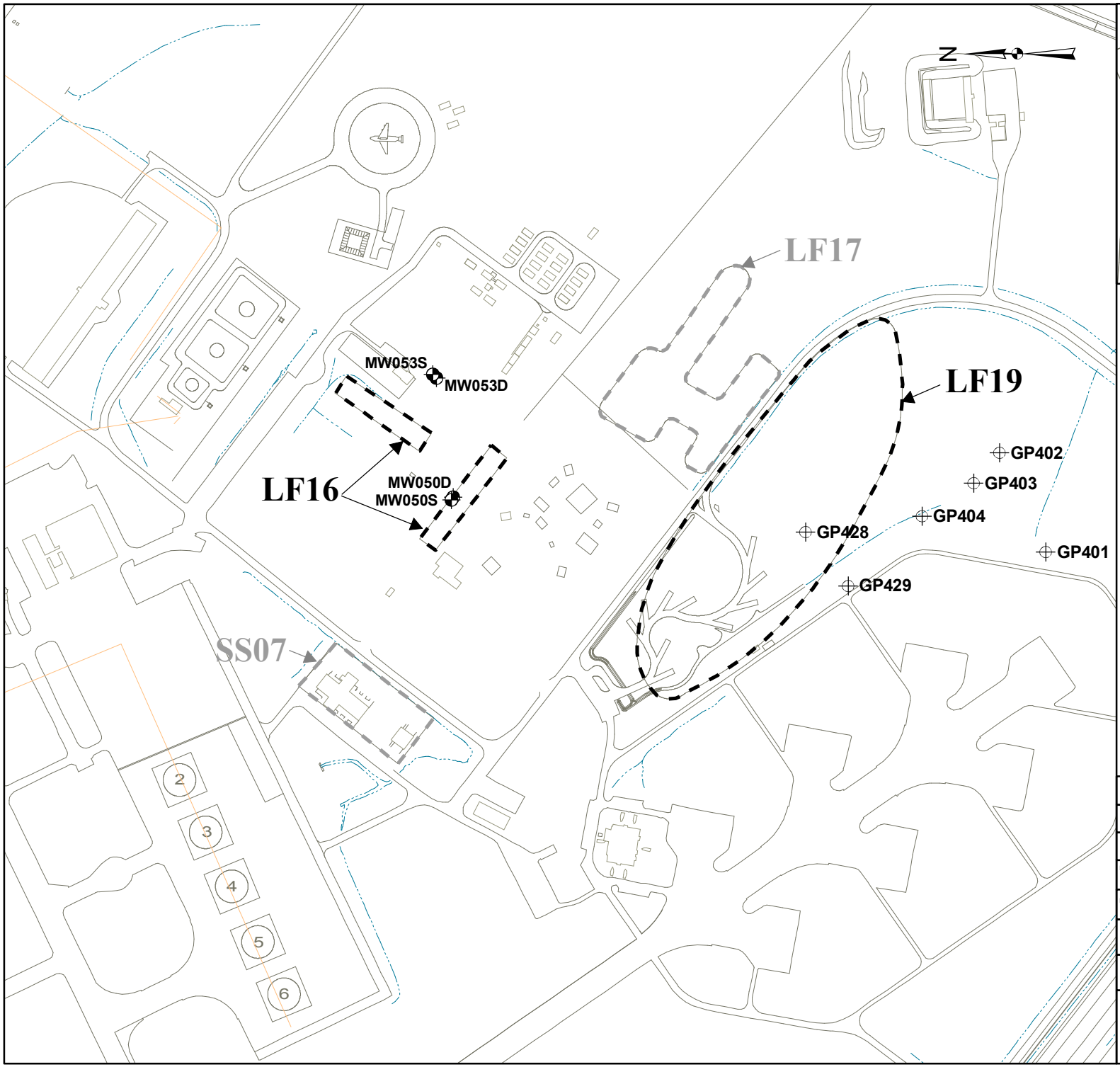

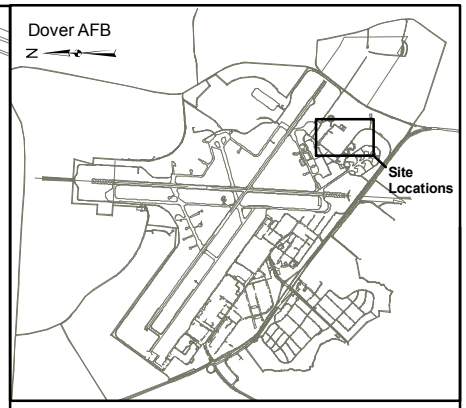

Legend

- Site Boundary
- Monitoring Well
- Direct Push

0 150 300 600 Feet

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FIGURE	Attachment 1f

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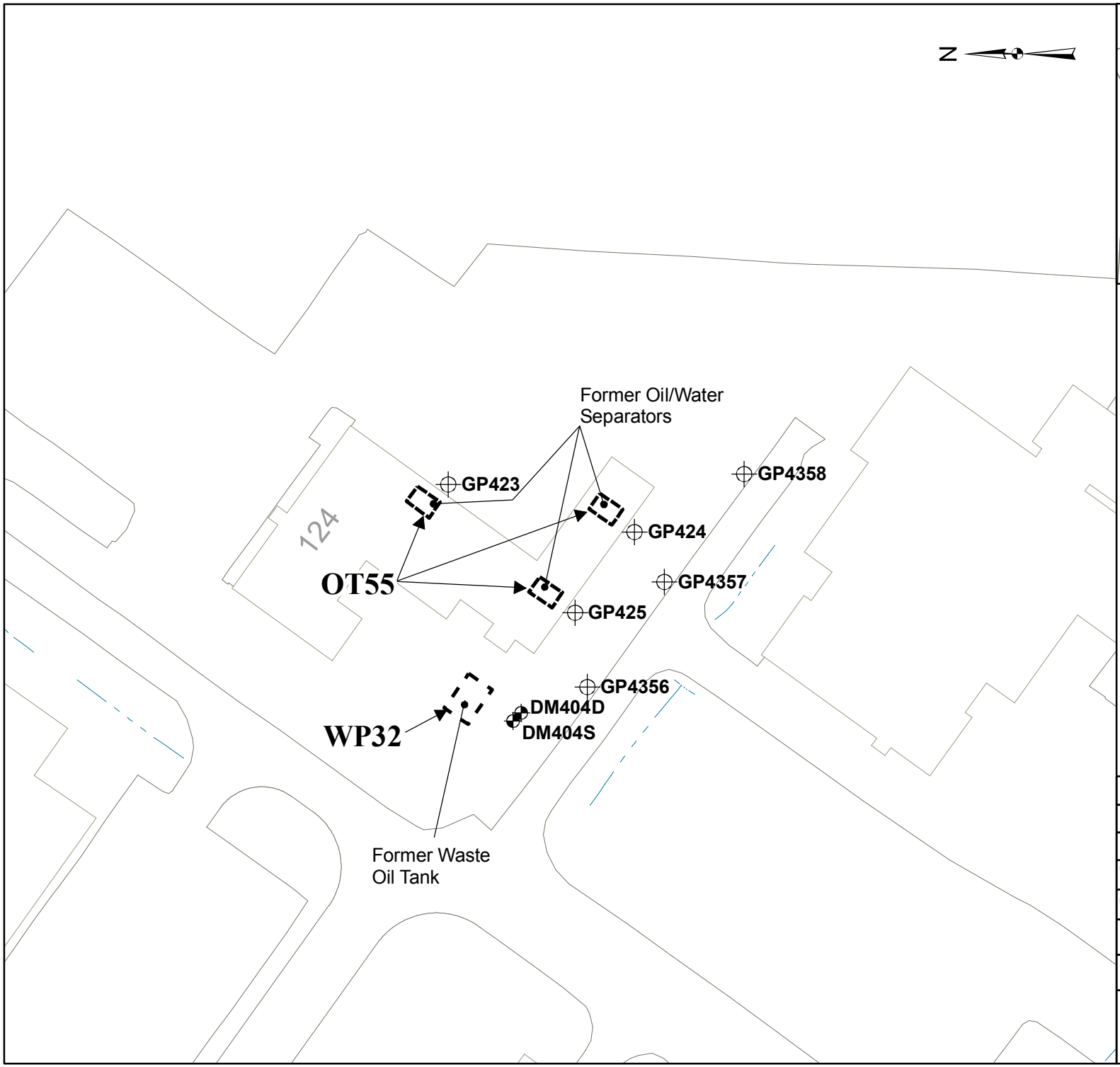

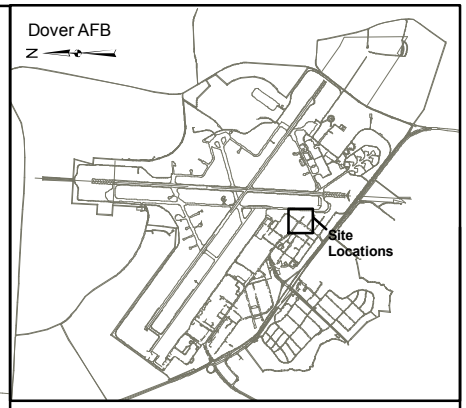

Legend

- Site Boundary
- Monitoring Well
- Direct Push

0 25 50 100 Feet

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FIGURE	Attachment 1g

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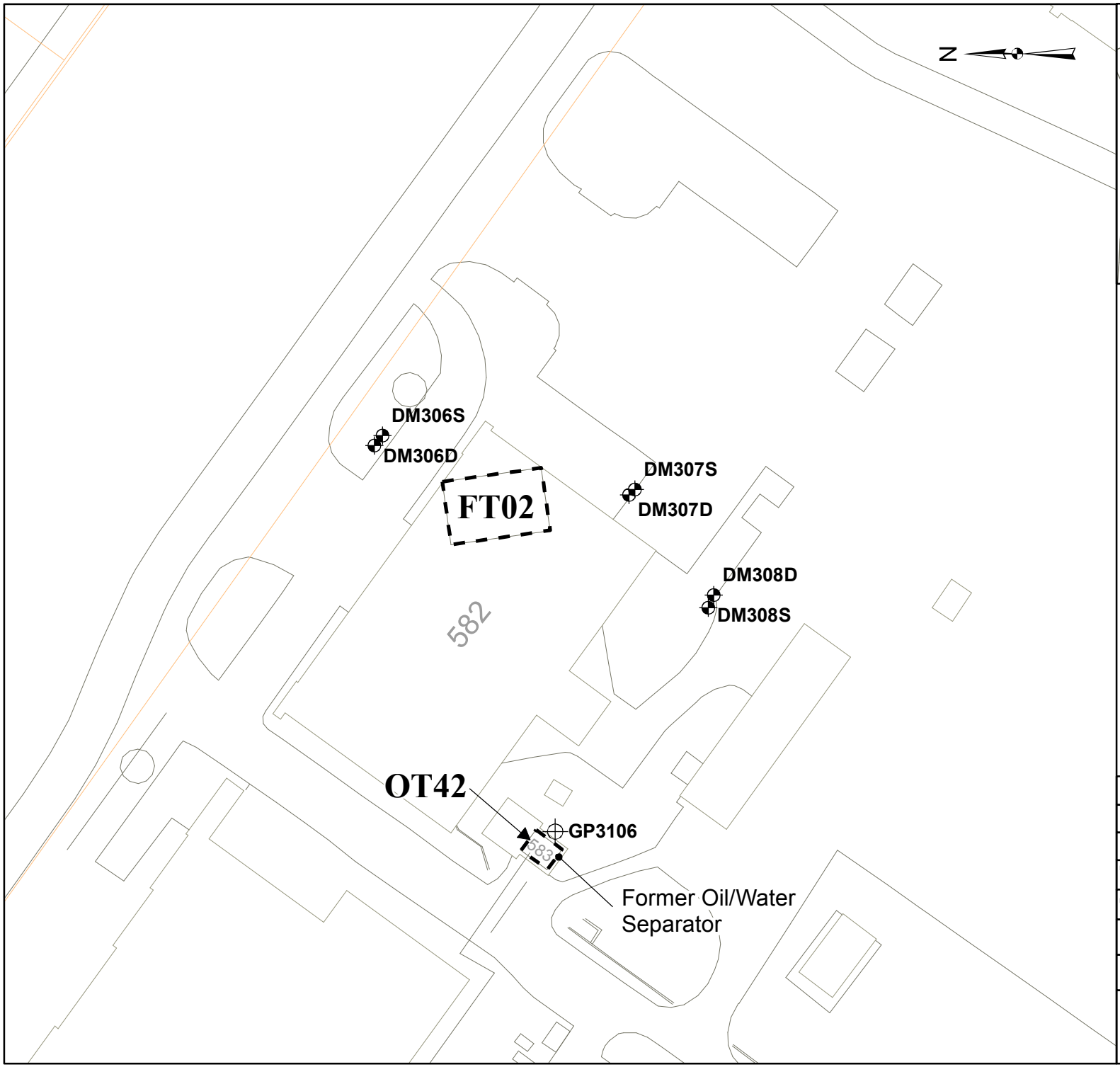

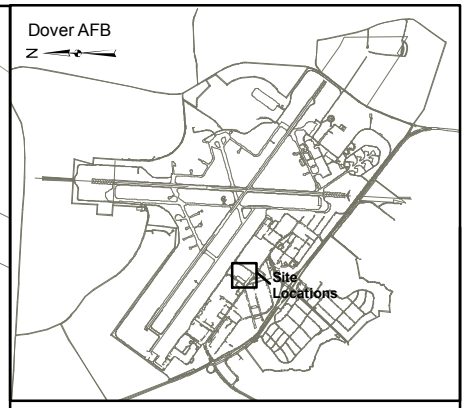

Legend

- Site Boundary
- Monitoring Well
- Direct Push

0 37.5 75 150 Feet

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FIGURE	Attachment 1h

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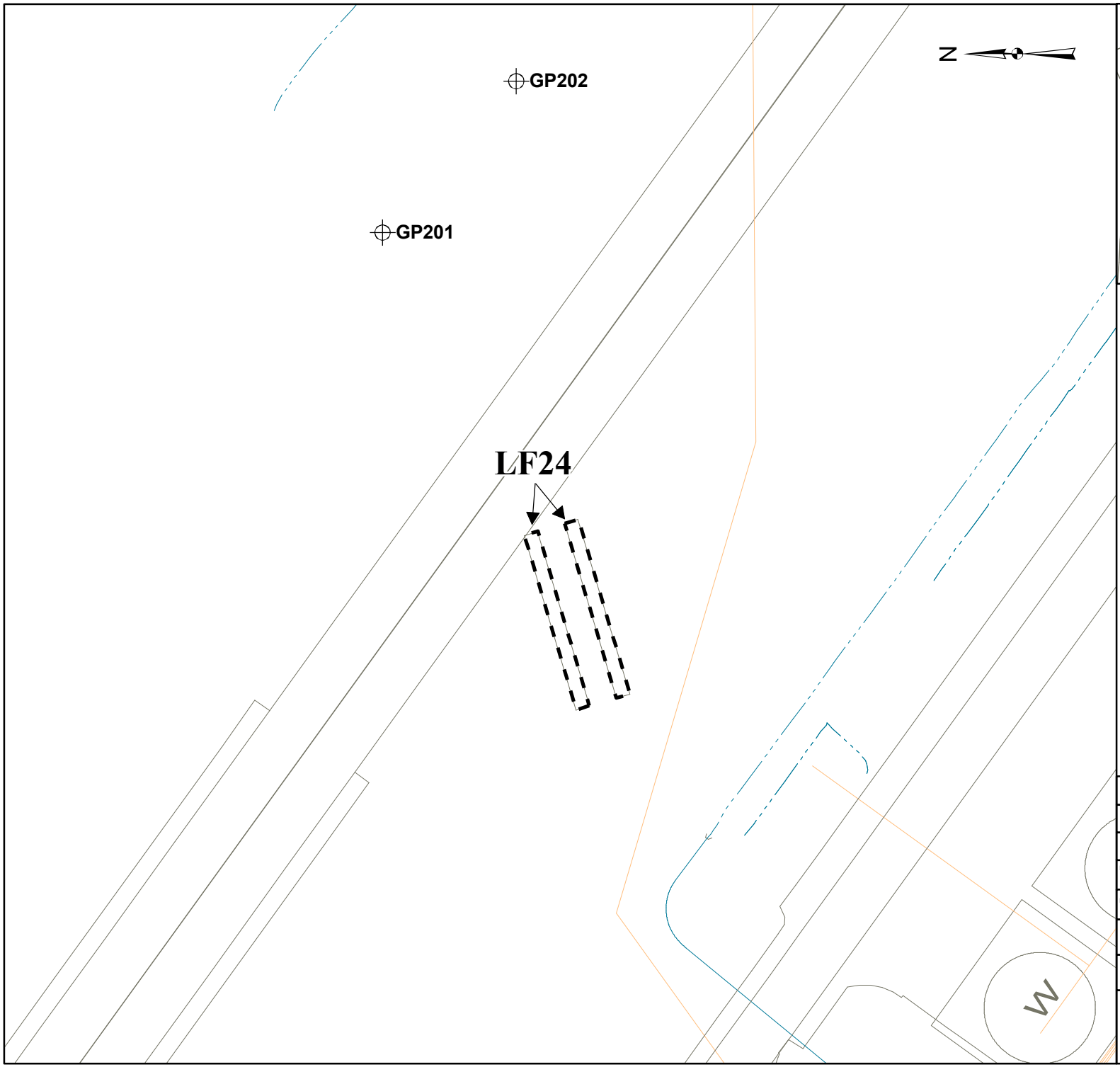

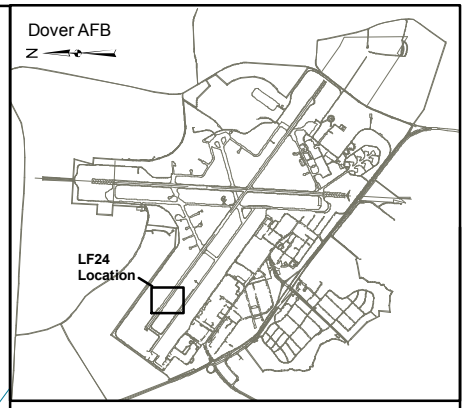

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LF24 Boundary

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FIGURE	Attachment 1i

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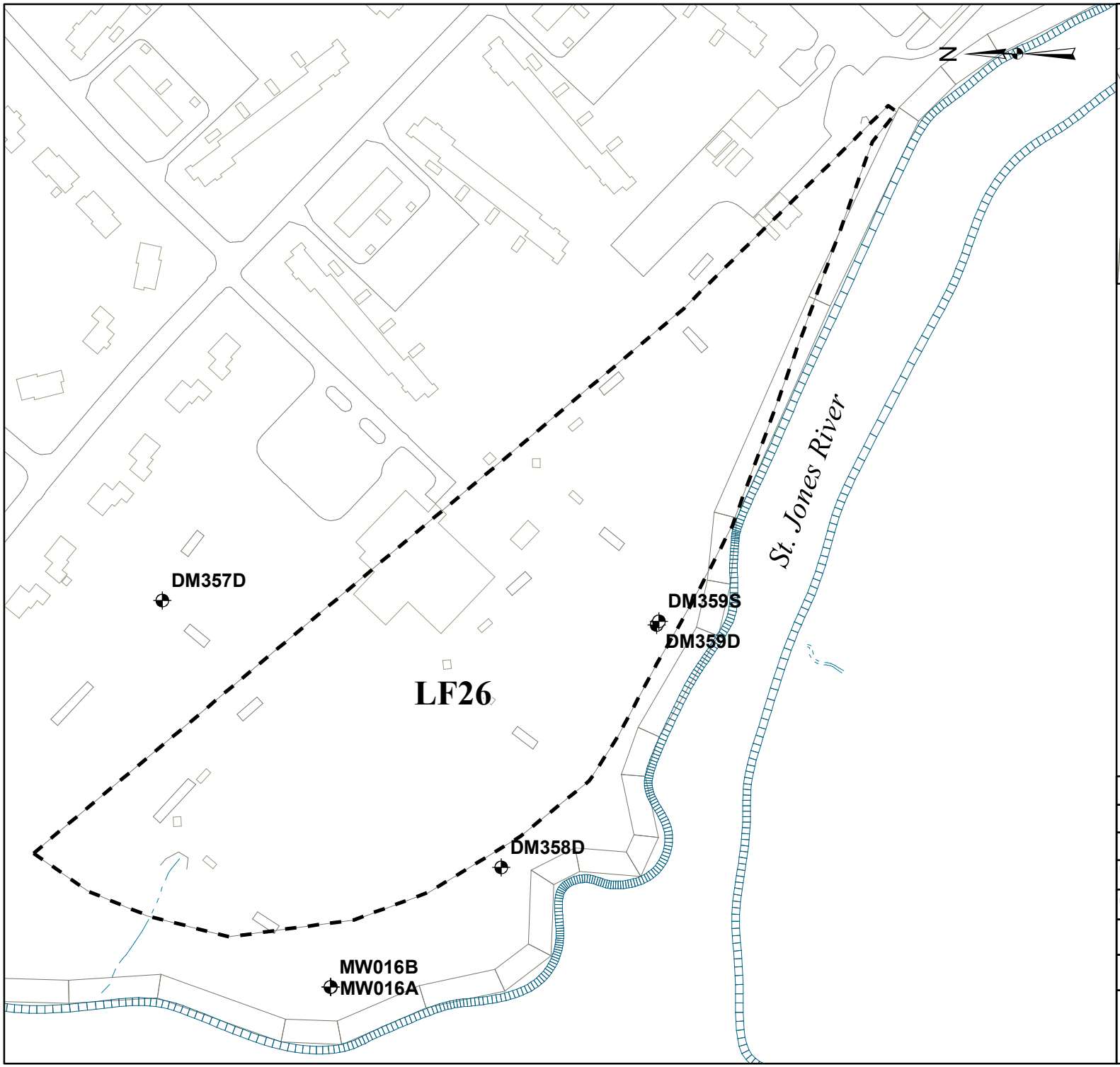

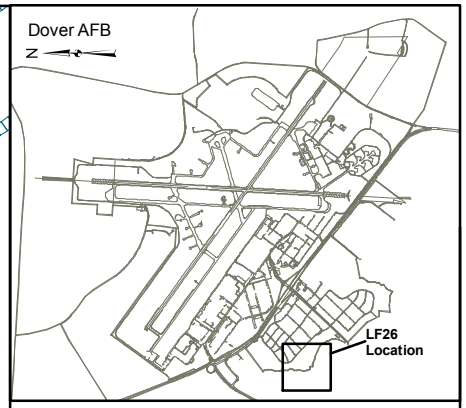

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LF26 Boundary

Monitoring Well

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FIGURE	Attachment 1j

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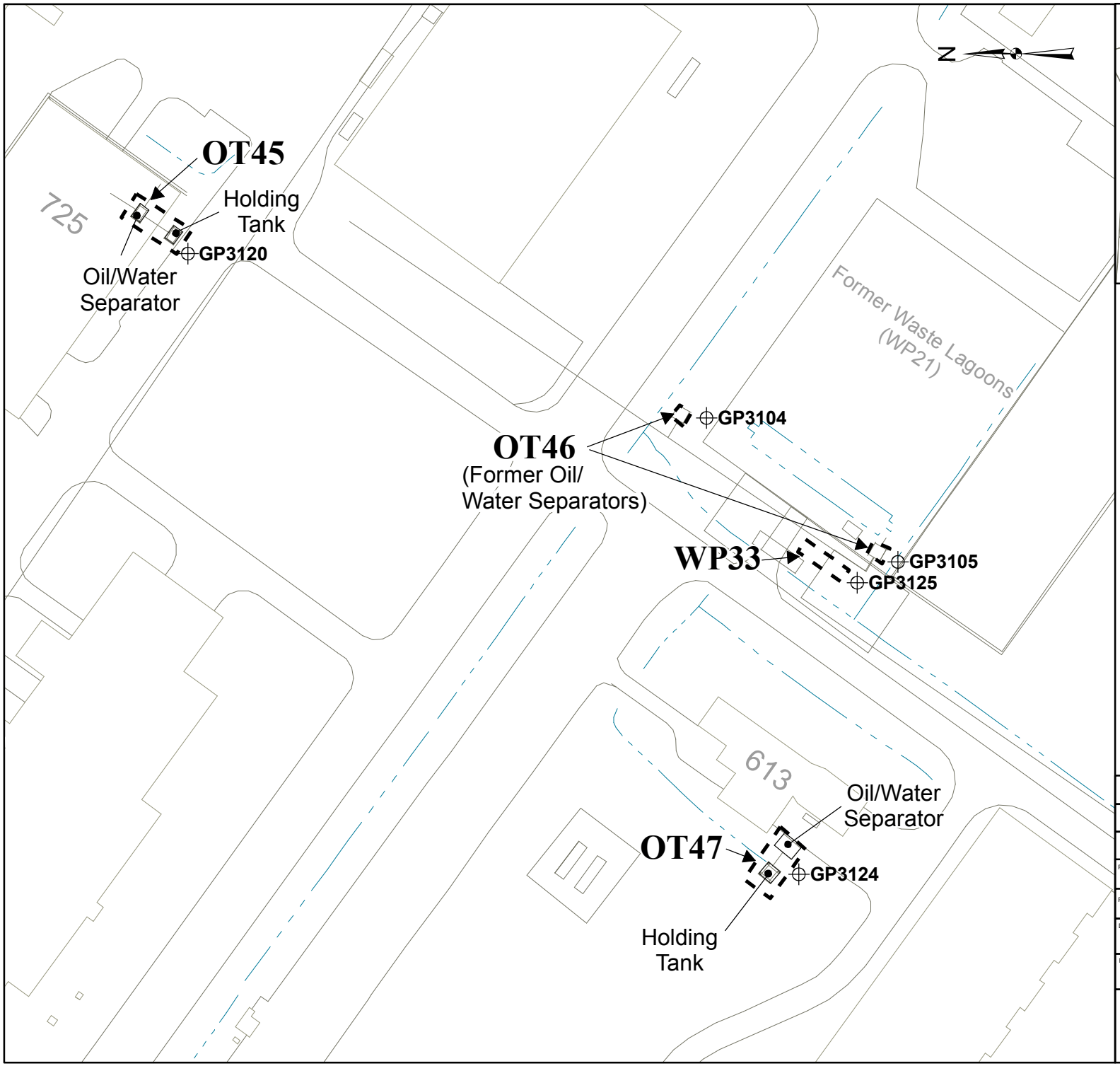

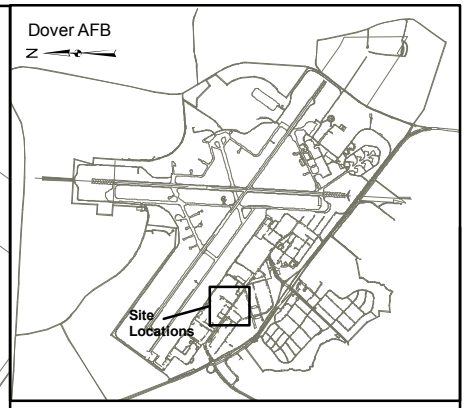

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Site Boundary

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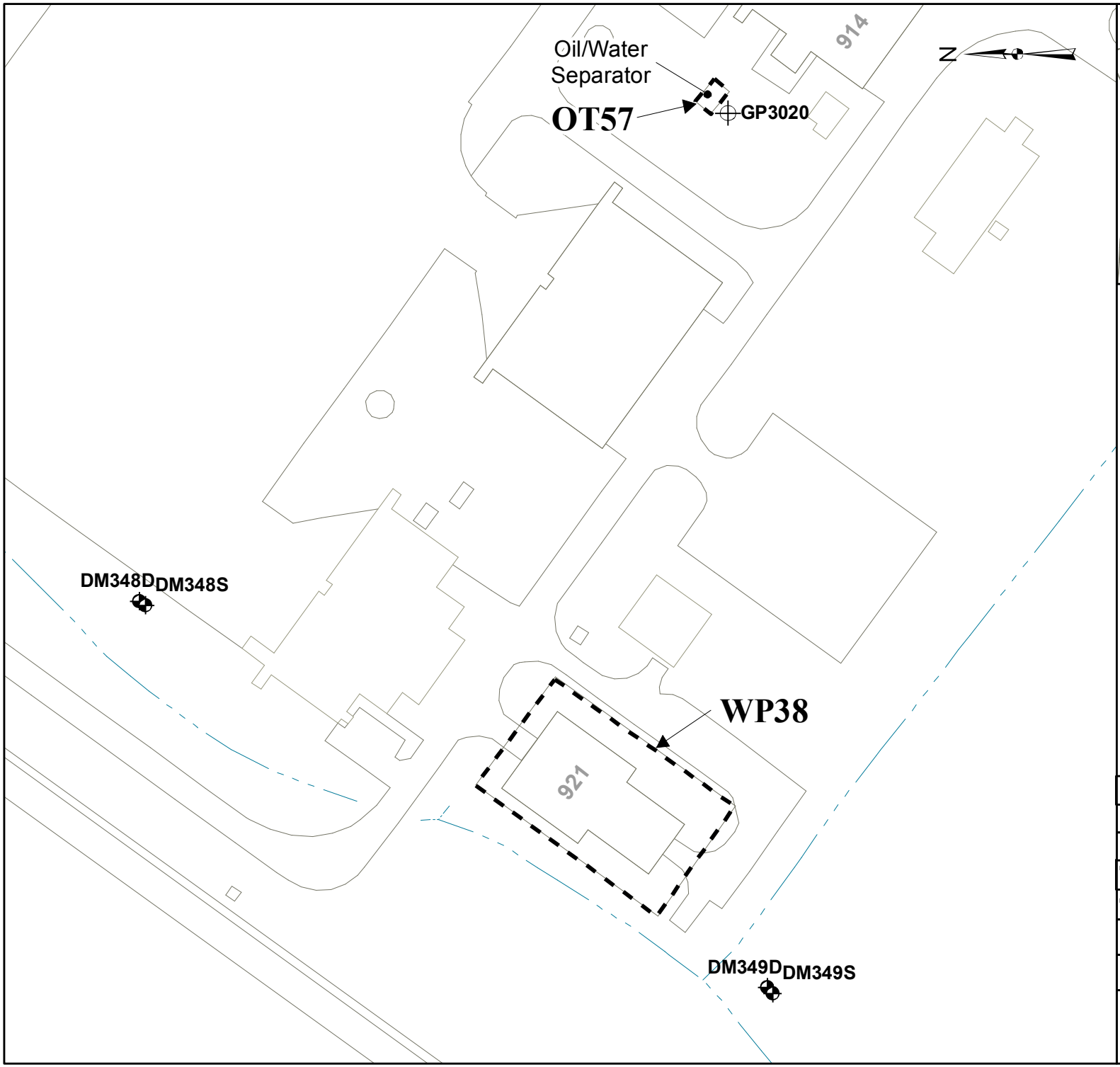
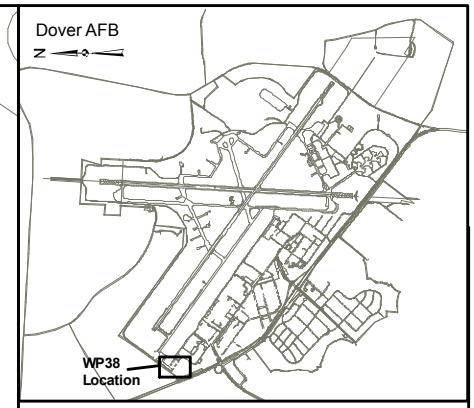
FIGURE	Attachment 1k

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878





Legend

- Site Boundary
- Monitoring Well
- Direct Push

0 35 70 140 Feet

TITLE	OT57 and WP38 Site Map
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PROJ	2008 Five-Year Reviews
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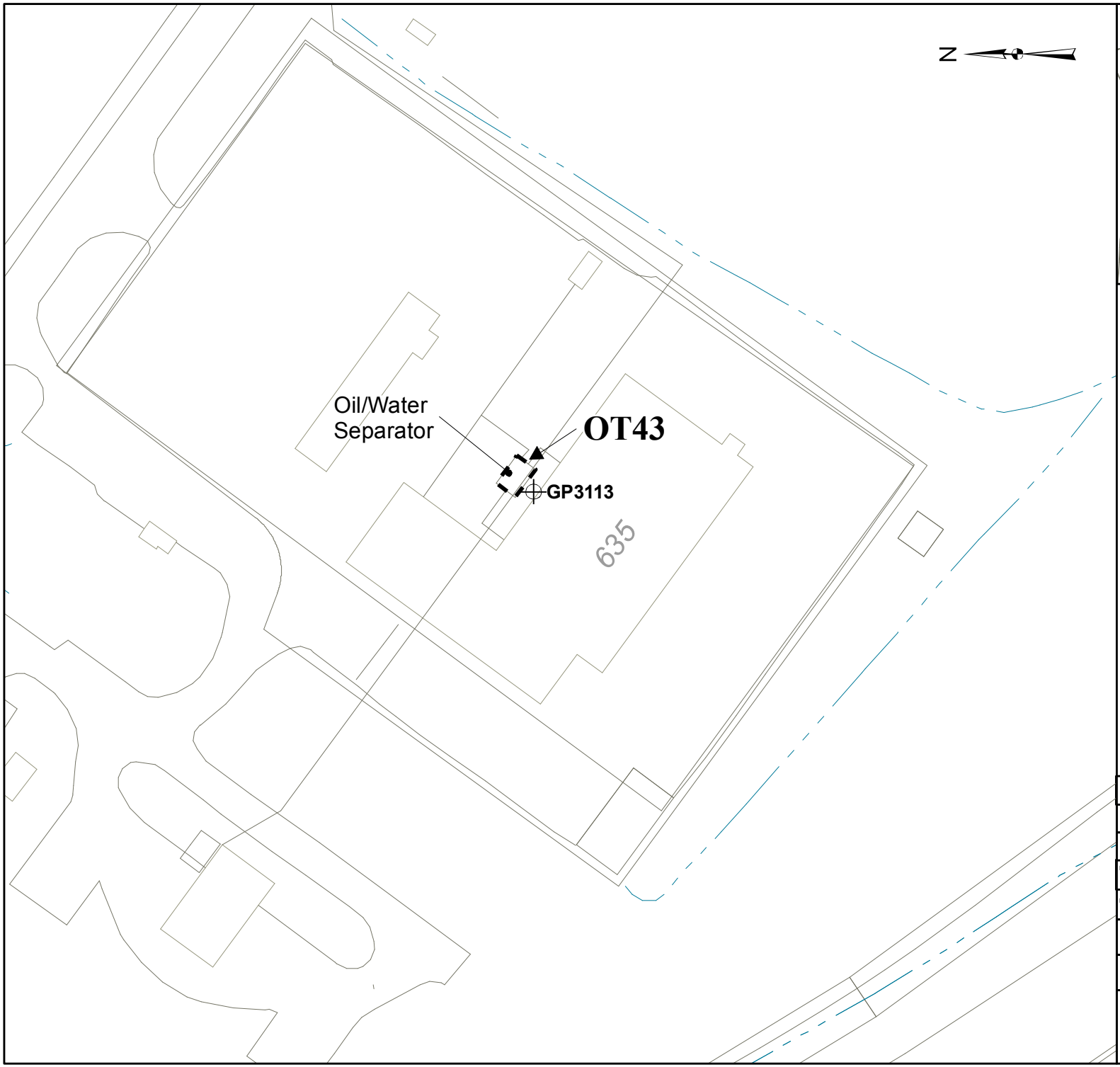
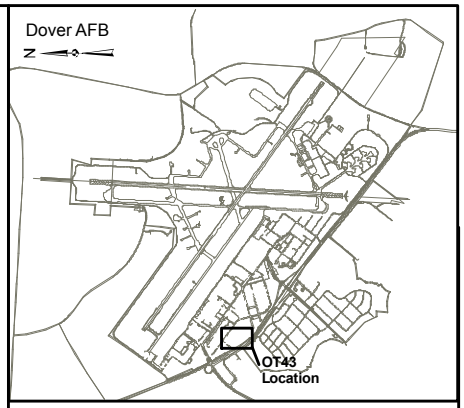
PATH	P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\ Five Year Reviews 2008\H. Reports\LUC\Figures\OT57_WP38_Attch1_.pdf
DES BY	DJM 01/11/2008
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1I

URS 200 Orchard Ridge Drive
Gaithersburg, MD 20878





Legend

OT43 Boundary

Direct Push

0 25 50 100 Feet

TITLE	OT43 Site Map
CLIENT	DAFB/ORNL
PROJ	2008 Five-Year Reviews
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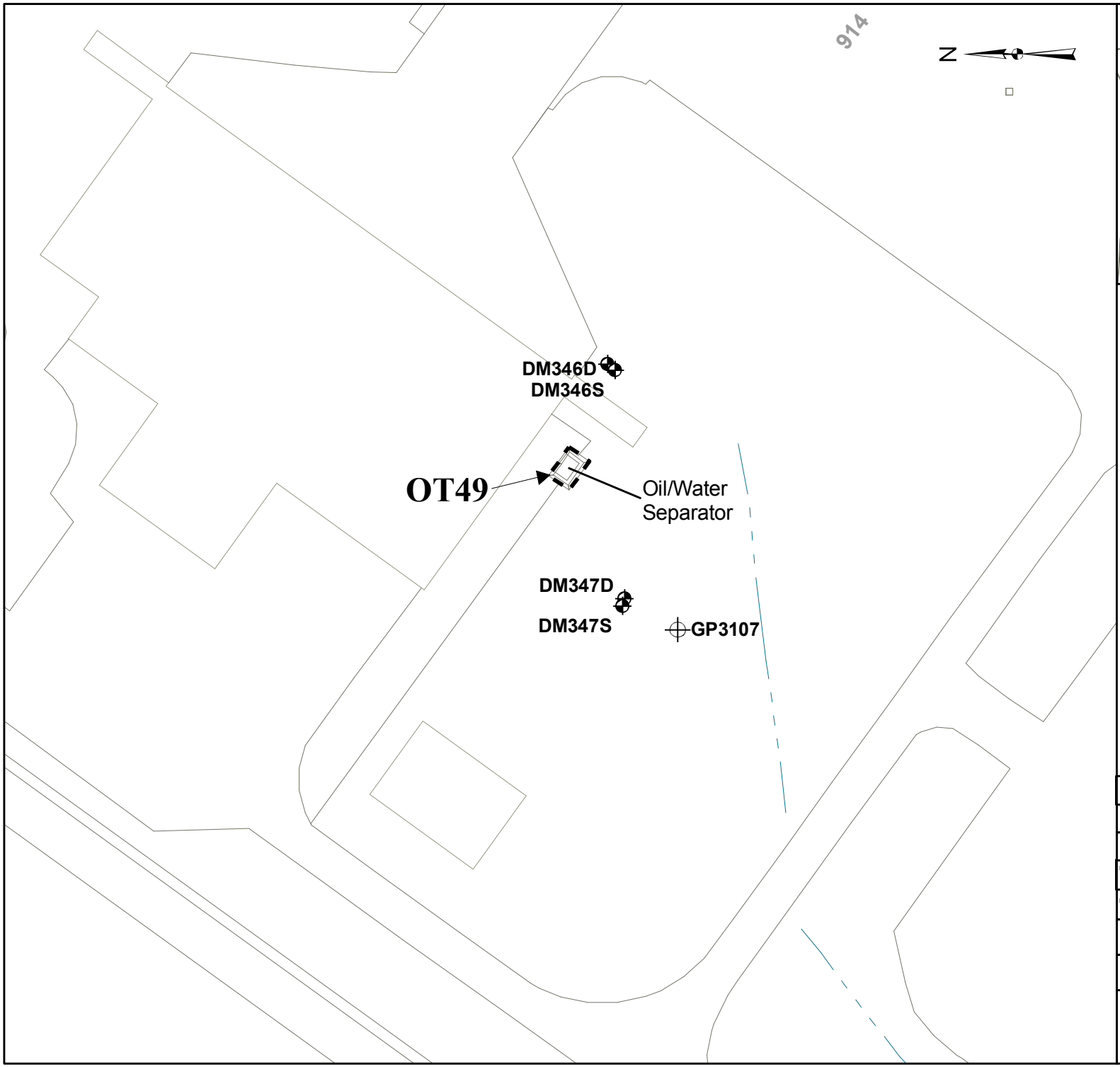
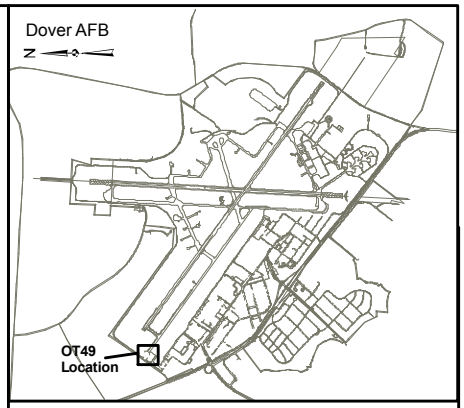
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1m

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878





Legend

- OT49 Boundary
- Monitoring Well
- Direct Push

0 25 50 100 Feet

TITLE	OT49 Site Map
CLIENT	DAFB/ORNL
PROJ	2008 Five-Year Reviews
PATH	G:\Projects\Dover_AFB\5yr_Review_Figures\OT49.mxd
PATH	P:\Gaithersburg\01016\01016 Dover AFB\Sampling-Analysis BOA\ Five Year Reviews 2008\H. Reports\LUC\Figures\OT49_Attch1_.pdf
DES BY	DJM 01/11/2008
CHK BY	LS
PROJ NO	15300779
FIGURE	Attachment 1n

URS 200 Orchard Ridge Drive Gaithersburg, MD 20878

Attachment 2 – Reviewed Documents

AFCEE, 1995. Final Focused Feasibility Study Report for North Drainage Ditch IRP Site (SD-12), Dover Air Force Base, submitted by Law Environmental, inc., June 1995.

BWXT Y-12, 2003. Final Focused Feasibility Study for Land Use Controls, Dover Air Force Base, Delaware, submitted by URS Group, Inc., September 2003.

DAFB, 2007. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2007.

DAFB, 2006. Report of Annual Land Use Control (LUC) Monitoring, Dover Air Force Base, Delaware, prepared by DAFB-CES/CEVR, dated December 2006.

DAFB, 1994. Record of Decision; Underground Storage Tank at Building 124 (Site WP32), Dover Air Force Base, 1994.

HAZWRAP, 1991a. Site Investigation for the Landfill/Disposal Area at Site D-1 (LF22), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991b. Site Investigation for the Landfill/Disposal Area at Site D-3 (LF23), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991c. Site Investigation for the Sludge Spreading Area at Site SD-1 (WP29), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991d. Site Investigation for the Underground Storage Tank at Site S-6 (WP32), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991e. Site Investigation for the O/W Separators at Site 124 (OT55), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991f. Site Investigation for Fire Training Area 2 (FT02), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991g. Site Investigation for the Landfill/Disposal Area at Site D-11 (LF26), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991h. Site Investigation for the Underground Waste Liquid Storage Tank at Site S-2 (WP33), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991i. Site Investigation for the Entomology Shop at Site S-4 (WP38), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991j. Site Investigation for the O/W Separator at Site 583 (OT42), submitted by Dames & Moore, September 1991.

Attachment 2 – (cont'd)

HAZWRAP, 1991k. Site Investigation for the O/W Separator at Site 635 (OT43), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991l. Site Investigation for the O/W Separator at Site 725 (OT45), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991m. Site Investigation for the O/W Separators at Site IWB (OT46), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991n. Site Investigation for the O/W Separator at Site 613 (OT47), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991o. Site Investigation for the O/W Separator at Site 945 (OT49), submitted by Dames & Moore, September 1991.

HAZWRAP, 1991p. Site Investigation for the O/W Separator at Site 914 (OT57), submitted by Dames & Moore, September 1991.

ORNL, 2007. Vapor Intrusion Assessment, Dover Air Force Base, DE, submitted by URS Group, Inc., December 2007.

ORNL, 2006a. South Management Unit Remedial Action Work Plan [and Addendum] Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2006.

ORNL, 2006b. Record of Decision, Land Use Controls at Multiple Sites, Dover Air Force Base, Delaware, submitted by URS Group, Inc., March 2006.

ORNL, 2005. Proposed Plan, for Land Use Controls, Multiple Sites, Dover AFB, Delaware, submitted by URS Group, Inc., June 2005.

SAIC, 1989. IRP Stage 2 Draft Final Report, Dover Air Force Base, Delaware, Science Applications International Corporation, March 1989.

SAIC, 1986. USAF Installation Restoration Program – Dover AFB, Delaware, Phase II – Stage I Confirmation/Quantification.

USACE, 2005a. Proposed Plan, Site SD12, Dover Air Force Base, DE, submitted by URS Group, Inc., January 2005.

USACE, 2005b. Record of Decision, Land Use Controls at SD12, North Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., September 2005.

Attachment 2 – (cont'd)

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997.

USACE, 1994. Area 6 Remedial Investigation, Dover Air Force Base, Delaware, submitted by Dames & Moore, July 1994, [an accelerated portion of the Basewide RI].

USEPA, 2007. EPA Region III Risk-Based Concentration Table, October 11, 2007.

Attachment 3
Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs for the LUCs sites are listed in the SD12 and LUCs RODs and were reviewed during this Five-Year Review. There have been no changes in ARARs since the performance objectives were established in the RODs. ARARs for each medium are discussed below.

Soil. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario at any of the 22 sites. However, since residential risks were not evaluated, the Air Force has decided to implement LUCs as an action for soil. This is addressed by the implementation plan for LUCs, i.e., the Environmental Appendix to the Base General Plan, which was submitted to federal and state regulators.

USEPA Region III has risk-based criteria for soil in industrial and residential settings as well as soil screening levels for the protection of groundwater. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of soil is unnecessary.

In 2007, the Air Force reviewed the data for the 22 sites in this five-year review. The soil data for seven sites were screened against current residential risk criteria (USEPA, 2007). Based on the results (Attachment 5 and summarized in Section 7.0 question B), these seven sites are recommended for closure.

Groundwater. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under a commercial/industrial scenario at any of the 22 sites. However, since residential risks were not evaluated, the Air Force has decided to implement LUCs as an action for groundwater. This was implemented via DAFB's Environmental Appendix to the Base General Plan.

USEPA Region III has risk-based criteria for groundwater in industrial and residential settings. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. For the few sites where MCLs were exceeded in groundwater samples, the contamination is related to a different nearby site and, therefore, being addressed via remedies under separate RODs and five-year reviews for those remedies. Thus, additional screening or evaluation of groundwater is unnecessary for the 22 sites in this review.

In 2007, the Air Force reviewed the data for the 22 sites in this five-year review. The groundwater data for seven sites were screened against current residential risk criteria (USEPA, 2007). Based on the results (Attachment 5 and summarized in Section 7.0 question B), these seven sites are recommended for closure.

Attachment 3 – (cont'd)

Surface Water and Sediment. With the exception of SD12, surface water and sediment are not present at the 22 sites included in this review. The Basewide RI RA determined that there are no unacceptable risks associated with this medium under an on-site commercial/industrial scenario and an off-site residential use for SD12, the north drainage ditch in the NMU. However, since residential risks were not evaluated for the on-site portion of SD12, the Air Force has decided to implement LUCs. This was done via DAFB's Environmental Appendix to the Base General Plan.

The Basewide Ecological Risk Assessment (which included SD12) revealed no unacceptable risks. The technical assessment made during this review has determined that the implemented remedy is currently protective of human health and the environment. Therefore, additional screening or evaluation of these media is unnecessary.

Site SD12

Both photographs: Drainage ditch looking east (top) and west (bottom) at SD12 on November 14, 2007.

Sites LF22 and LF23

Top: Looking northeast at LF22 on November 14, 2007.
Bottom: Looking north at LF23, near fence line and gap between trees, on November 14, 2007.

Sites WP29 and OT56

Top: Looking north at WP29 on November 14, 2007.
Bottom: Looking northeast at OT56 on November 14, 2007.

Sites ST58 and LF16

Top: Looking east at ST58 on November 14, 2007.
Bottom: LF16 next to paintball field looking north on November 14, 2007.

Site LF19

Open field at LF19 on November 14, 2007.

Site WP32/OT55

Top: South side of Building 124 at OT55/WP32 on November 14, 2007.
Bottom: West side of Building 124 at OT55/WP32 on November 14, 2007.

Sites OT42 and FT02

Top: The former oil/water separator at OT42 is located underneath the grass on the northwest corner of Building 550.
Bottom: FT02 is located underneath the paved driveway between the northeast side of Building 550 and the concrete jersey barriers along the flightline.

Sites LF26 and WP33/OT46

Top: Looking southwest towards St. Jones River with well pair (DM359S/D) at LF26 on November 14, 2007.
Bottom: Looking northwest at OT46 and WP33 on November 14, 2007.

Sites WP38 and OT43

Top: Drainage ditch, north side of WP38 on November 14, 2007.
Bottom: Oil/Water separator next to Building 635 (between buses) at OT43 on November 14, 2007.

Sites OT45 and OT47

Top: Oil/Water Separator w/ building 725 at OT45 on November 14, 2007.
Bottom: Oil/Water Separator next to Building 613 at OT47 on November 14, 2007.

Site OT49 and OT57

Top: Oil/Water separator at OT49 on November 14, 2007.
Bottom: Looking northeast at site OT57 on November 14, 2007.

Attachment 5 – Residential Risk Screening

1.0 INTRODUCTION

As a preliminary step of the Five-Year Review for the LUCs sites, DAFB performed a residential risk screening evaluation for certain LUC sites to ascertain whether these sites may be recommended for closure. The sites included in this risk screening are: OT43, OT46, OT47, OT57, WP29, WP32, and OT55. During the RI for these sites, only industrial use scenarios were evaluated. While no unacceptable risks were found at these sites under industrial scenarios, the sites could not be recommended for closure in the absence of a residential risk evaluation. Therefore, LUCs were implemented at these sites to prevent residential uses.

The objective of this task is to screen the RI chemical concentration data for each medium at these sites against risk-based criteria assuming residential exposure scenarios as described in Section 2. Results of the screening and a weight-of-evidence discussion are presented for each site in Section 3 justifying the recommendation for closure.

2.0 METHODOLOGY

For each site, the soil and groundwater data that were used in the 1993-1994 RI human health risk assessment were screened against the USEPA's risk-based criteria (RBCs) suitable for residential scenarios. The only exception to this was the groundwater data for sites OT43, OT46, WP32, and OT55, which included a number of chemicals with concentrations exceeding MCLs. As documented in the *Record of Decision (ROD) for LUCs at Multiple Sites*, groundwater contamination at these sites is attributed to other nearby sites and is being addressed under the RODs for Area 6, Area 5, and the SMU. Therefore, the residential risk screening evaluation for these five sites only included the soil medium.

For groundwater, the maximum concentration of every detected constituent was compared to the most recent tap water RBCs (October 2007 values [USEPA, 2007]). In the same manner, soil data were compared to the residential soil RBCs.

For non-carcinogens, the screening value was adjusted to correspond to a hazard index (HI) of 0.1 to account for cumulative health effects. For example, the groundwater RBC for iron is 26,000 micrograms per liter (µg/L). When adjusted for an HI of 0.1, the iron RBC is 2,600 µg/L. This procedure allows more chemicals through the screen. Thus, for those non-carcinogens that fail the screen, a total HI is then estimated proportionately. The generic example below illustrates this method. This analysis also considers whether the hazards are additive based on similar health effects and is discussed for each site as applicable.

Chemical	Max Det.	RBC (HI=0.1)	RBC (HI=1)	Proportional Hazard
A	5	1	10	5/10 = 0.5
B	2	0.5	5	2/5 = 0.4
C	0.7	0.2	2	0.7/2 = 0.35
TOTAL HI (A+B+C)				***1.25****

*Note, this HI exceeds 1 and the site fails the screening. However, if only chemicals A and B were present, the HI would be less than 1 (0.9), and the site would still be eligible for closure.

The screening process also considered DAFB-specific background concentrations for metals, essential human nutrients, and MCLs.

3.0 RESULTS

The screening results for each site are discussed below.

3.1 OT43. Groundwater at OT43 is being addressed under the Record of Decision for the Area 5 Plume. Therefore, no screening was conducted for groundwater constituents.

Several VOCs, SVOCs, and pesticides/PCBs were detected in the soil at this site, but none exceeded the RBCs (Table A5-1). For metals with no RBCs, maximum detected concentrations were compared to DAFB background levels; there were no exceedences of background levels for these metals. Arsenic exceeded its RBC but is well within natural background levels for DAFB soil. Aluminum, iron, and vanadium did not exceed their RBCs, but did exceed their adjusted RBCs (HI=0.1). Iron and vanadium are within natural background levels and aluminum just slightly above its background level. Assuming these three metals had cumulative non-cancer health effects, their combined HI would be slightly above one. This was determined proportionately as tabulated below.

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Aluminum	28,300	78,000	28,300/78,000 = 0.36
Iron	8,600	55,000	8,600/55,000 = 0.16
Vanadium	45.3	78	45.3/78 = 0.58
			Total HI = 1.1

However, toxicity profiles for aluminum and vanadium indicate that they have little overlapping health effects, thus summing the individual HIs is overly conservative (http://rais.ornl.gov/tox/profiles/; see Note 1 at the end of this report for summary of target organs/critical effects). No toxicity profile is available for iron, which is an essential human nutrient.

On their own, none of these metals poses an unacceptable health risk. Additionally, the cumulative non-cancer health hazard is overestimated by summing aluminum and vanadium together, based on their differing toxicity profiles. Therefore, based on the weight of evidence, OT43 poses no unacceptable health risk and is recommended for closure.

3.2 OT46. Groundwater at OT46 is being addressed under the ROD for the Area 6 Plume. Therefore, no screening was conducted for groundwater constituents.

No VOCs were detected in soil. One of the nine SVOCs exceeded an RBC (Table A5-2). Benzo[a]pyrene was positively detected in only two of 14 soil samples at 0.035 and 0.051 milligrams per kilograms (mg/kg; see footnote to Table A5-2). These concentrations only slightly exceed the RBC of 0.022 mg/kg. Given its very low detection frequency, generally low concentrations, and lack of other exceedences in soil, this constituent does not appear to be a concern. Two pesticides were detected but neither exceeded their RBCs. For metals with no RBCs, maximum detected concentrations were compared to DAFB background levels; there were no exceedences of background levels for these metals. Arsenic exceeded its RBC but was well within natural background levels for DAFB soil. Two other metals, aluminum and vanadium, were well within natural background levels for DAFB soil and did not exceed their RBCs. However, these two metals did exceed their adjusted RBCs (HI=0.1). Assuming the two non-carcinogenic metals (aluminum and vanadium) had cumulative non-cancer health effects, their combined HI would be still be below one. This was determined proportionately as tabulated below.

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Aluminum	17,300	78,000	17,300 /78,000 = 0.22
Vanadium	16.9	78	16.9/78 = 0.22
			Total HI = 0.44

Additionally, toxicity profiles for aluminum and vanadium indicate that they have little overlapping health effects, thus summing the individual HIs is overly conservative (see Note 1).

Based on the weight of evidence, OT46 poses no unacceptable health risk and is recommended for closure.

3.3 OT47. No VOCs or SVOCs were detected in groundwater at OT47. Two pesticides and eight dissolved metals were detected but none exceeded their RBCs (Table A5-3). For metals with no RBCs, maximum detected concentrations were compared to DAFB background levels; there were no exceedences of background levels for these metals.

No VOCs or pesticides/PCBs were detected in soil. Six SVOCs were detected but none exceeded their RBCs. For metals with no RBCs, maximum detected concentrations were

compared to DAFB background levels; there were no exceedences of background levels for these metals. Aluminum, iron, and vanadium were also within natural background levels for DAFB soil and did not exceed their RBCs. However, these three metals did exceed their adjusted RBCs (HI=0.1). On their own, these metals all have HIs well below 1. Assuming these three metals had cumulative non-cancer health effects, their combined HI would be still be below one. This was determined proportionately as tabulated below.

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Aluminum	23,800	78,000	23,800/78,000 = 0.31
Iron	9,110	55,000	9,110/55,000 = 0.17
Vanadium	36.5	78	36.5/78 = 0.47
			Total HI = 0.95

Additionally, toxicity profiles for aluminum and vanadium indicate that they have little overlapping health effects, thus summing the individual HIs is overly conservative (see Note 1). No toxicity profile is available for iron, which is an essential human nutrient.

Based on the weight of evidence, OT47 poses no unacceptable health risk and is recommended for closure.

3.4 OT57. In groundwater, four VOCs were detected and none exceeded their RBCs (Table A5-4). Four SVOCs were also detected and one (naphthalene) slightly exceeded its adjusted RBC. Three pesticides were detected and none exceeded an RBC. Two metals, iron and manganese, exceeded their adjusted RBCs. Both metals are well within natural background levels for DAFB groundwater. Iron is also an essential human nutrient. Naphthalene and manganese have similar health effects and, thus, their hazards are additive (see Note 1); however, the total hazard is still below one (see below).

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Naphthalene	1	6.5	1/6.5 = 0.15
Manganese	333	730	333/740 = 0.46
			Total HI = 0.61

For those metals detected in groundwater with no RBCs, maximum detected concentrations were compared to DAFB background levels. Only cobalt slightly exceeded its background level.

No VOCs or pesticides/PCBs were detected in soil at OT57. One SVOC was reported but it was below its RBC. For those metals with no RBCs, maximum detected concentrations were compared to DAFB background levels for soil. There was one very slight exceedence by cobalt. Arsenic exceeded its RBC, however, it was well within

natural background levels for DAFB soil. Three metals (aluminum, iron, and vanadium) did not exceed their RBCs, but did exceed their adjusted RBCs (HI=0.1). Iron and vanadium were well within natural background levels. Iron is also an essential human nutrient. The maximum concentration of aluminum was slightly above its background level. Assuming these three metals had cumulative non-cancer health effects, their combined HI would be slightly above one. This was determined proportionately as tabulated below.

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Aluminum	27,100	78,000	27,100 /78,000 = 0.35
Iron	18,500	55,000	18,500/55,000 = 0.34
Vanadium	48.6	78	48.6/78 = 0.62
			Total HI = 1.3

However, toxicity profiles for aluminum and vanadium indicate that they have little overlapping health effects, thus summing the individual HIs is overly conservative (see Note 1). No profile was available for iron, which is an essential human nutrient.

On their own, these metals all have HIs below 1. Additionally, the cumulative non-cancer health hazard is overestimated by summing aluminum and vanadium together, based on their differing toxicity profiles. Therefore, based on the weight of evidence, OT57 poses no unacceptable health risk and is recommended for closure.

3.5 WP29. In groundwater at this site, no VOCs, SVOCs, or pesticides/PCBs were detected. Several dissolved metals were present (Table A5-5). Arsenic at 5.4 ug/L exceeded its RBC. However, it is below the current MCL of 10 µg/L considered safe for drinking water. This metal is not a concern. Iron was above its adjusted RBC (HI=0.1). However, it is an essential human nutrient and is well within natural background levels for groundwater at DAFB. Manganese only slightly exceeded its adjusted RBC and is also well within natural DAFB background level. Assuming these two metals had cumulative non-cancer health effects, their combined HI would still be below one. This was determined proportionately as follows:

Chemical	Max. Det. (µg/L)	RBC (HI=1)	Proportional Hazard
Iron	4,470	26,000	4,470/26,000 = 0.17
Manganese	88.2	730	88.2/730 = 0.12
			Total HI = 0.29

None of the metals detected in groundwater is a concern.

In soil, no VOCs or SVOCs were detected. One pesticide was found, but it is well below its RBC. Arsenic exceeded its RBC but was well within normal background levels for

soil at DAFB. Three metals—aluminum, iron, and vanadium—exceeded their adjusted RBCs but are well within natural background levels. Iron is also an essential nutrient. In addition, assuming these three metals had cumulative non-cancer health effects, their combined HI would still be below one. This was determined proportionately as follows:

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Aluminum	18,400	78,000	18,400/78,000 = 0.24
Iron	15,000	55,000	15,000/55,000 = 0.27
Vanadium	30.2	78	30.2/78 = 0.39
			Total HI = 0.90

Based on the weight of evidence, WP29 poses no unacceptable health risk and is recommended for closure.

3.6 WP32. Groundwater at WP32 is being addressed under the ROD for the SMU. Therefore, no screening was conducted for groundwater constituents.

In soil, four VOCs and three SVOCs were detected (Table A5-6). None exceeded RBCs. No pesticides/PCBs were detected. Arsenic exceeded its RBC but was well within natural background levels for DAFB soil. Lead also exceeded its screening value of 400 mg/kg. This exceedence occurred in only one soil sample. Lead in the other 11 samples collected at the site ranged between 2.3 to 11.3 mg/kg, which are well below both the screening value and DAFB background value of 33.1 mg/kg. This single exceedence does not indicate a significant environmental contaminant release.

Three other metals (aluminum, iron, and vanadium) did not exceed their RBCs but did exceed their adjusted RBCs (HI=0.1). All were well within natural background levels. Iron is also an essential human nutrient. Assuming these three metals had cumulative non-cancer health effects, their combined HI would still be below one. Thus, none of these metals are a concern.

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Aluminum	13,100	78,000	13,100/78,000 = 0.17
Iron	12,500	55,000	12,500/55,000 = 0.23
Vanadium	43.9	78	43.9/78 = 0.56
			Total HI = 0.96

For metals with no RBCs, maximum detected concentrations were compared to DAFB background levels for soil; there were no exceedences of background levels for these metals. There are no organic constituents of concern at WP32. With the exception of one detection of lead, all metals are below RBCs or within natural background

concentration ranges. The one elevated lead detection is insignificant compared to the very low lead levels in 11 other soil samples. Based on the weight of evidence, WP32 poses no unacceptable health risk and is recommended for closure.

3.7 OT55. Groundwater at OT55 is being addressed under the ROD for the SMU. Therefore, no screening was conducted for groundwater constituents.

No VOCs or pesticides/PCBs were detected in soil samples collected at OT55. Ten SVOCs were detected and none exceeded RBCs (Table A5-7). Arsenic exceeded its RBC but was well within natural background levels for DAFB soil. Three other metals (aluminum, iron, and vanadium) did not exceed their RBCs but did exceed their adjusted RBCs (HI=0.1). All were well within natural background levels. Iron is also an essential human nutrient. Assuming these three metals had cumulative non-cancer health effects, their combined HI would still be below one. This was determined proportionately as tabulated below. Additionally, toxicity profiles for aluminum and vanadium indicate that they have little overlapping health effects, thus summing the individual HIs is overly conservative (see Attachment 1). No profile was available for iron.

Chemical	Max. Det. (mg/kg)	RBC (HI=1)	Proportional Hazard
Aluminum	11,200	78,000	11,200/78,000 = 0.14
Iron	23,500	55,000	23,500/55,000 = 0.43
Vanadium	17.3	78	17.3/78 = 0.22
			Total HI = 0.79

For metals with no RBCs, maximum detected concentrations were compared to DAFB background levels for soil; there were no exceedences of background levels for these metals. Based on the weight of evidence, OT55 poses no unacceptable health risk and is recommended for closure.

Note 1
Summary of Target Organs/Critical Effects

Aluminum. Via ingestion, adverse health effects involve the central nervous system and reproductive system. The respiratory system is affected through inhalation of aluminum.

Manganese. The primary target organs via ingestion include the central nervous system, reproductive system, and blood (anemia). The central nervous system, reproductive system, and respiratory system are affected through inhalation of manganese.

Naphthalene. The blood, gastrointestinal tract, central nervous system, liver, kidneys, and eye are primarily affected via both the ingestion and inhalation routes of exposure. The reproductive system is also affected through ingestion of naphthalene.

Vanadium. The primary target organs affected by vanadium via the oral route of exposure include the gastrointestinal system, kidneys, and blood. The respiratory system is affected through inhalation of vanadium.

Table A5-1. OT43 Residential Risk Screening Results

GROUNDWATER
-addressed as part of Area 6 plume

SOIL	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs						
2-BUTANONE	0.002	4700		47,000	NO	
ACETONE	3	7000		70,000	NO	
ETHYLBENZENE	1	780		7,800	NO	
METHYLENE CHLORIDE	3.1	85	c		NO	
TRICHLOROETHENE	0.004	1.6	c		NO	
XYLENES	1.8	1600		16,000	NO	
SVOCs						
1,2,4-TRICHLOROBENZENE	0.097	78		780	NO	
1,2-DICHLOROBENZENE	0.19	700		7,000	NO	
2-METHYLNAPHTHALENE	2.6	31		310	NO	
BIS(2-ETHYLHEXYL)PHTHALATE	0.35	46	c		NO	
DI-N-OCTYL PHTHALATE	0.078	NA		NA	NO	
NAPHTHALENE	4	160		1,600	NO	
PHENANTHRENE	0.081	NA		NA	NO	
Pesticides/PCBs						
4,4-DDD	0.0047	2.7	c		NO	
4,4-DDE	0.0039	1.9	c		NO	
4,4-DDT	0.017	1.9	c		NO	
ALPHA-BHC	0.00011	0.1	c		NO	
CHLORDANE	0.0078	1.8	c		NO	
DIELDRIN	0.00026	0.04	c		NO	
ENDRIN ALDEHYDE	0.00062	2.3		23	NO	(RBC for endrin)
HEPTACHLOR	0.0013	0.14	c		NO	
METHOXYCHLOR	0.053	39		390	NO	
PCBs	0.026	0.32	c		NO	
Metals						
ALUMINUM	28300	7800		78,000	YES	background = 23,855 mg/kg
ARSENIC	3	0.43	c		YES	background = 19.8 mg/kg
BARIUM	49.6	1600		16,000	NO	
CALCIUM	368	NA		NA	NO	human nutrient, background = 1,800 mg/kg
CHROMIUM (+3)	19.8	12000		120,000	NO	
COBALT	3.5	NA		NA	NO	background = 10.4 mg/kg
COPPER	4.3	310		3,100	NO	
IRON	8600	5500		55,000	YES	background = 72,895 mg/kg
LEAD**	23.4	400			NO	
MAGNESIUM	874	NA		NA	NO	human nutrient, background = 10,166 mg/kg
MANGANESE (nonfood)	30	160		1,600	NO	
NICKEL	12.6	160		1,600	NO	
POTASSIUM	808	NA		NA	NO	human nutrient, background = 2,250 mg/kg
SODIUM	180	NA		NA	NO	human nutrient, background = 618 mg/kg
VANADIUM	45.3	7.8		78	YES	background = 83.6 mg/kg
ZINC	20	2300		23,000	NO	

* c = carcinogen

**Lead is a special case. For screening, 400 mg/kg is commonly used for a residential scenario.

Table A5-2. OT46 Residential Risk Screening Results

GROUNDWATER
-addressed as part of Area 6 plume

SOIL	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs - none						
SVOCs						
BENZO[A]ANTHRACENE	0.122	0.22	c		NO	
BENZO[A]PYRENE	0.118	0.022	c		YES	***
BENZO[B]FLUORANTHENE	0.14	0.22	c		NO	
BENZO[K]FLUORANTHENE	0.14	2.2	c		NO	
BIS(2-ETHYLHEXYL)PHTHALATE	0.1255	46	c		NO	
CHRYSENE	0.1405	22	c		NO	
FLUORANTHENE	0.1105	310		3,100	NO	
PHENANTHRENE	0.1525	NA		NA	NO	
PYRENE	0.11	230		2,300	NO	
Pesticides/PCBs						
HEPTACHLOR	0.00052	0.14	c		NO	
HEPTACHLOR EPOXIDE	0.00013	0.07	c		NO	
Metals						
ALUMINUM	17300	7800		78,000	YES	background = 23,855 mg/kg
ARSENIC	1.5	0.43	c		YES	background = 19.8 mg/kg
BARIUM	42.1	1600		16,000	NO	
CALCIUM	153	NA		NA	NO	human nutrient, background = 1,800 mg/kg
CHROMIUM (+3)	9.25	12000		120,000	NO	
COPPER	3.3	310		3,100	NO	
IRON	2170	5500		55,000	NO	
LEAD**	14.95	400			NO	(DAFB background = 33.1 mg/kg)
MAGNESIUM	327	NA		NA	NO	human nutrient, background = 10,166 mg/kg
MANGANESE (nonfood)	12.25	160		1,600	NO	
NICKEL	3.4	160		1,600	NO	
SODIUM	98.75	NA		NA	NO	human nutrient, background = 618 mg/kg
VANADIUM	16.9	7.8		78	YES	background = 83.6 mg/kg
ZINC	8.9	2300		23,000	NO	

* c = carcinogen
**Lead is a special case. For screening, 400 mg/kg is commonly used for a residential scenario.
***Actual detection is 0.051 mg/kg; max detect determined by averaging the positive detection in a duplicate sample with 1/2 the detection limit of the primary sample (0.051 + 0.370/2)/2 = 0.118 mg/kg. Benzo[a]pyrene detected only twice (0.035 and 0.051 mg/kg) out of 14 soil samples.

Table A5-3. OT47 Residential Risk Screening Results

GROUNDWATER	Max Det (ug/L)	Tap Water RBC (ug/L) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs - none						
SVOCs - none						
Pesticides/PCBs						
DIELDRIN	0.0024	0.0042	c		NO	
ENDOSULFAN SULFATE	0.021	22		220	NO	(RBC for endosulfan)
Dissolved Metals						
ALUMINUM	80.1	3700		37,000	NO	
BARIUM	59.6	730		7,300	NO	
CALCIUM	4550	NA		NA	NO	human nutrient, background = 72,400 ug/L
IRON	1210	2600		26,000	NO	human nutrient, background = 112,000 ug/L
MAGNESIUM	3860	NA		NA	NO	human nutrient, background = 18,300 ug/L
MANGANESE (nonfood)	64.6	73		730	NO	
SODIUM	6400	NA		NA	NO	human nutrient, background = 33,300 ug/L
ZINC	10.3	1100		11,000	NO	

SOIL	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs - none						
Pesticides/PCBs - none						
SVOCs						
BENZO[A]ANTHRACENE	0.048	0.22	c		NO	
BENZO[K]FLUORANTHENE	0.12	2.2	c		NO	
BENZOIC ACID	0.12	31000		310,000	NO	
CHRYSENE	0.113	22	c		NO	
FLUORANTHENE	0.121	310		3,100	NO	
PYRENE	0.119	230		2,300	NO	
Metals						
ALUMINUM	23800	7800		78,000	YES	background = 23,855 mg/kg
BARIUM	53.9	1600		16,000	NO	
CALCIUM	419	NA		NA	NO	human nutrient, background = 1,800 mg/kg
CHROMIUM (+3)	14	12000		120,000	NO	
IRON	9110	5500		55,000	YES	background = 72,895 mg/kg
LEAD**	20.25	400			NO	(DAFB background = 33.1 mg/kg)
MAGNESIUM	372	NA		NA	NO	human nutrient, background = 10,166 mg/kg
MANGANESE (nonfood)	11.9	160		1,600	NO	
SODIUM	118	NA		NA	NO	human nutrient, background = 618 mg/kg
VANADIUM	36.5	7.8		78	YES	background = 83.6 mg/kg
ZINC	12.5	2300		23,000	NO	

* c = carcinogen

**Lead is a special case. For screening, 400 mg/kg is commonly used for a residential scenario.

Table A5-4. OT57 Residential Risk Screening Results

GROUNDWATER	Max Det (ug/L)	Tap Water RBC (ug/L) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs						
1,1-DICHLOROETHANE	2	89.6		896	NO	
1,2-DICHLOROETHENE	0.6	5.5		55	NO	
ETHYLBENZENE	0.6	134		1,340	NO	
XYLENE (TOTAL)	3	21.3		213	NO	
SVOCs						
2-METHYLNAPHTHALENE	2	2		24	NO	
DI-N-BUTYL PHTHALATE	0.7	370		3,700	NO	
DIETHYL PHTHALATE	0.7	2900		29,000	NO	
NAPHTHALENE	1	0.65		6.5	YES	
Pesticides/PCBs						
4,4'-DDE	0.00053	0.2	c		NO	
ALDRIN	0.0027	0.0039	c		NO	
DIELDRIN	0.0012	0.0042	c		NO	
Dissolved Metals						
ALUMINUM	80.5	3700		37,000	NO	
BARIUM	76.4	730		7,300	NO	
CALCIUM	8830	NA		NA	NO	human nutrient, background = 72,400 ug/L
COBALT	12.3	NA		NA	NO	human nutrient, background = 10.4 ug/L
IRON	3240	2600		26,000	YES	human nutrient, background = 112,000 ug/L
MAGNESIUM	6180	NA		NA	NO	human nutrient, background = 18,300 ug/L
MANGANESE (nonfood)	333	73		730	YES	background = 1,440 ug/L
POTASSIUM	2260	NA		NA	NO	human nutrient, background = 11,100 ug/L
SODIUM	7630	NA		NA	NO	human nutrient, background = 33,300 ug/L
ZINC	9.2	1100		11,000	NO	

SOIL	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs - none						
Pesticides/PCBs - none						
SVOCs						
BIS(2-ETHYLHEXYL)PHTHALATE	0.14	46	c		NO	
Metals						
ALUMINUM	27100	7800		78,000	YES	background = 23,855 mg/kg
ARSENIC	10.4	0.43	c		YES	background = 19.8 mg/kg
BARIUM	86.6	1600		16,000	NO	
BERYLLIUM	1.7	16		160	NO	
CALCIUM	865	NA		NA	NO	human nutrient, background = 1,800 mg/kg
CHROMIUM (+3)	42.4	12000		120,000	NO	

Table A5-4. OT57 Residential Risk Screening Results - continued

SOIL - cont'd	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)	Unadjusted RBC (HI=1)	Exceed?	
Metals - cont'd					
COBALT	6.4	NA	NA	NO	background = 6 mg/kg
COPPER	11.2	310	3,100	NO	
IRON	18500	5500	55,000	YES	background = 72,895 mg/kg
LEAD**	29.5	400		NO	(DAFB background = 33.1 mg/kg)
MAGNESIUM	3390	NA	NA	NO	human nutrient, background = 10,166 mg/kg
MANGANESE (nonfood)	121	160	1,600	NO	
NICKEL	15.3	160	1,600	NO	
POTASSIUM	2010	NA	NA	NO	human nutrient, background = 2,250 mg/kg
SODIUM	227	NA	NA	NO	human nutrient, background = 618 mg/kg
VANADIUM	48.6	7.8	78	YES	background = 83.6 mg/kg
ZINC	49.2	2300	23,000	NO	

* c = carcinogen
**Lead is a special case. For screening, 400 mg/kg is commonly used for a residential scenario.

Table A5-5. WP29 Residential Risk Screening Results

GROUNDWATER	Max Det (ug/L)	Tap Water RBC (ug/L) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs - none						
SVOCs - none						
Pesticides/PCBs - none						
Dissolved Metals						
ALUMINUM	251	3700		37,000	NO	
ARSENIC	5.4	0.045	c		YES	MCL = 10 ug/L, background = 3.4 ug/L
BARIUM	15	730		7,300	NO	
CALCIUM	2610	NA		NA	NO	human nutrient, background = 72,400 ug/L
IRON	4470	2600		26,000	YES	human nutrient, background = 112,000 ug/L
MAGNESIUM	1770	NA		NA	NO	human nutrient, background = 18,300 ug/L
MANGANESE (nonfood)	88.2	73		730	YES	background = 1,440 ug/L
SODIUM	18900	NA		NA	NO	human nutrient, background = 33,300 ug/L
ZINC	19.4	1100		11,000	NO	

SOIL	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs - none						
SVOCs - none						
Pesticides/PCBs						
4,4-DDE	0.00023	1.9	c		NO	
Metals						
ALUMINUM	18400	7800		78,000	YES	background = 23,855 mg/kg
ANTIMONY	2.9	3.1		31	NO	
ARSENIC	2	0.43	c		YES	background = 19.8 mg/kg
BARIUM	70	1600		16,000	NO	
BERYLLIUM	0.36	16		160	NO	
CALCIUM	488	NA		NA	NO	human nutrient, background = 1,800 mg/kg
CHROMIUM (+3)	24.4	12000		120,000	NO	
COBALT	6	NA		NA	NO	background = 6 mg/kg
COPPER	10.3	310		3,100	NO	
IRON	15000	5500		55,000	YES	background = 72,895 mg/kg
LEAD**	8.5	400			NO	DAFB background = 33.1 mg/kg
MAGNESIUM	2660	NA		NA	NO	human nutrient, background = 10,166 mg/kg
MANGANESE (nonfood)	67.6	160		1,600	NO	
NICKEL	12.7	160		1,600	NO	
POTASSIUM	1120	NA		NA	NO	human nutrient, background = 2,250 mg/kg
SODIUM	177	NA		NA	NO	human nutrient, background = 618 mg/kg
VANADIUM	30.2	7.8		78	YES	background = 83.6 mg/kg
ZINC	31.6	2300		23,000	NO	

* c = carcinogen

**Lead is a special case. For screening, 400 mg/kg is commonly used for a residential scenario.

Table A5-6. WP32 Residential Risk Screening Results

GROUNDWATER
-addressed as part of Area 9 plume

SOIL	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
Pesticides/PCBs - none						
VOCs						
1,1,1-TRICHLOROETHANE	0.009	16000		160,000	NO	
ACETONE	0.07	7000		70,000	NO	
METHYLENE CHLORIDE	0.032	85	c		NO	
TOLUENE	0.001	630		6,300	NO	
SVOCs						
2-METHYLNAPHTHALENE	0.049	31		310	NO	
BIS(2-ETHYLHEXYL)PHTHALATE	0.21	46	c		NO	
PYRENE	0.053	230		2,300	NO	
Metals						
ALUMINUM	13100	7800		78,000	YES	background = 23,855 mg/kg
ARSENIC	3.4	0.43	c		YES	background = 19.8 mg/kg
BARIUM	26.3	1600		16,000	NO	
CALCIUM	406	NA		NA	NO	human nutrient, background = 1,800 mg/kg
CHROMIUM (+3)	9.3	12000		120,000	NO	
COBALT	2	NA		NA	NO	background = 6 mg/kg
COPPER	4.3	310		3,100	NO	
IRON	12500	5500		55,000	YES	background = 72,895 mg/kg
LEAD**	747	400			YES	***
MAGNESIUM	724	NA		NA	NO	human nutrient, background = 10,166 mg/kg
MANGANESE (nonfood)	128	160		1,600	NO	
SODIUM	101	NA		NA	NO	human nutrient, background = 618 mg/kg
VANADIUM	43.9	7.8		78	YES	background = 83.6 mg/kg
ZINC	32.1	2300		23,000	NO	

* c = carcinogen
**Lead is a special case. For screening, 400 mg/kg is commonly used for a residential scenario.
***Elevated lead was detected in one SI composite sample (2 to 12 ft bgs). In 11 other soil samples, lead concentrations ranged from 2.3 to 11.3 mg/kg, all of which are well below both the 400 mg/kg screening value and DAFB's background level of 33.1 mg/kg.

Table A5-7. OT55 Residential Risk Screening Results

GROUNDWATER
-addressed as part of Area 9 plume

SOIL	Max Det (mg/kg)	Residential RBC (mg/kg) RBC* (HI=0.1)		Unadjusted RBC (HI=1)	Exceed?	
VOCs - none						
Pesticides/PCBs - none						
SVOCs						
2-CHLOROPHENOL	0.045	39		390	NO	
2-METHYLNAPHTHALENE	4.3	31		310	NO	
4-METHYLPHENOL	0.17	39		390	NO	
ACENAPHTHENE	0.89	470		4,700	NO	
BIS(2-ETHYLHEXYL)PHTHALATE	0.32	46	c		NO	
FLUORENE	0.51	310		3,100	NO	
NAPHTHALENE	1.2	160		1,600	NO	
PENTACHLOROPHENOL	0.11	5.3	c		NO	
PHENANTHRENE	0.14	NA		NA	NO	
PHENOL	0.036	2300		23,000	NO	
Metals						
ALUMINUM	11200	7800		78,000	YES	background = 23,855 mg/kg
ARSENIC	11.9	0.43	c		YES	background = 19.8 mg/kg
BARIUM	20.3	1600		16,000	NO	
CALCIUM	184	NA		NA	NO	human nutrient, background = 1,800 mg/kg
CHROMIUM (+3)	13.5	12000		120,000	NO	
COPPER	0.95	310		3,100	NO	
IRON	23500	5500		55,000	YES	background = 72,895 mg/kg
LEAD**	11.1	400			NO	(DAFB background = 33.1 mg/kg)
MAGNESIUM	150	NA		NA	NO	human nutrient, background = 10,166 mg/kg
MANGANESE (nonfood)	46.8	160		1,600	NO	
SODIUM	129	NA		NA	NO	human nutrient, background = 618 mg/kg
VANADIUM	17.3	7.8		78	YES	background = 83.6 mg/kg
ZINC	8.2	2300		23,000	NO	

* c = carcinogen
**Lead is a special case. For screening, 400 mg/kg is commonly used for a residential scenario.