EPA/ROD/R03-97/175
1997

EPA Superfund
Record of Decision:

DOVER AIR FORCE BASE
EPA ID: DE8570024010
OU 06
DOVER, DE
09/30/1997

EPA/541/R-97/175

<IMG SRC 971750>

INSTALLATION RESTORATION PROGRAM

RECORD OF DECISION
FOR NATURAL ATTENUATION OF GROUNDWATER
AND NO FURTHER ACTION FOR SOIL AT LANDFILL 13 (LF13)
WITHIN THE EAST MANAGEMENT UNIT AT
DOVER AIR FORCE BASE, DELAWARE

AUGUST 1997

Submitted to
436th Airlift Wing, CES/CEV
Dover Air Force Base, Delaware 19902-6600

Submitted by
HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs
Oak Ridge, Tennessee 37831-7606
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. Department of Energy
Under Contract DE-AC05-84OR21400

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

4,4'-DDD	1,1 -dichloro-2.2-bis(p-chlorophenyl)ethane
ARARs	Applicable or relevant and appropriate requirements
AS	Air sparging
AWQC	Ambient Water Quality Criteria
bgs	Below ground surface
BRA	Baseline Risk Assessment
BTEX	Benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cfm	Cubic feet per minute
COC	Contaminant of concern
DAFB	Dover Air Force Base
DCA	1,2-Dichloroethane
DCE	1,2-Dichloroethene
DDC	Density-driven convection
DNREC	State of Delaware Department of Natural Resources and Environmental Control
EMU	East Management Unit
ER-L	Effects Range-Low
FS	Feasibility Study
ft.	Feet or foot
ft. 2	Square feet
FT03	Fire Training Area 3
GAC	Granular activated carbon
gal	Gallon
gpm	Gallons per minute
HI	Hazard Index
IRP	Installation Restoration Program
lb	Pound
lbs/day	Pounds per day
LECR	Lifetime excess cancer risk
LF13	Landfill 13
LF15	Landfill 15
MCL	Maximum Contaminant Level
Ig/kg	Micrograms per kilogram
Ig/L	Micrograms per Liter
mg/kg	Milligrams per kilogram
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operations and maintenance
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
PP	Proposed Plan
psig	Pounds per square inch-gauge
RAO	Remedial action objective
RBC	Risk-based concentration
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986 and 1990
SDWA	Safe Drinking Water Act
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
TPH	Total petroleum hydrocarbon
USACE	U.S. Army Corp of Engineers
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WP14	Liquid Waste Disposal Area 14

1. DECLARATION OF THE SELECTED REMEDY

1.1 SITE NAME AND LOCATION

Landfill 13 (LF13), East Management Unit (EMU), Dover Air Force Base (DAFB), Kent County, Delaware

1.2 STATEMENT OF BASIS AND PURPOSE

This record of decision (ROD) presents the selected remedial action for soil and groundwater at LF13 which was chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations Part 300. The U.S. Air Force (USAF), the lead agency, as the owner/operator of the Base, prepared this decision based on the Administrative Record for the site. The U.S. Environmental Protection Agency (USEPA) Region III and the State of Delaware Department of Natural Resources and Environmental Control (DNREC) provided support.

The State of Delaware concurs with the selected remedy. The Information Repository for the Administrative Record contains the information supporting this remedial action decision and is at
the Dover Public Library, Dover, Delaware.

1.3 ASSESSMENT OF THE SITE

Dover AFB identified soil and groundwater contamination related to the activities that occurred in and around the LF13 site. LF13 is the location of an inactive surface landfill located in the eastern portion of the Base. It is located north of the ammunition storage facility and approximately 1000 feet (ft.) to the southeast of Site LF15. The approximately eight (8) acre site is covered with small trees and underbrush and has a gravel road down the center. The landfill slopes upward to the east; with the western edge of the site ending abruptly at a 20-ft. ledge of concrete and debris. Abundant rubble and concrete debris litter the toe of the landfill. The area surrounding LF13 was delineated as a wetland, and portions are densely forested.

LF13 was used in the 1960s for the disposal of small quantities of general refuse and large quantities of construction rubble. From the late 1960s to the early 1990s, the site primarily received construction rubble. Buried metal was indicated by ground-penetrating radar anomalies. The dumping of rubble over the edge of the site, with subsequent covering and grading of the slope, created a 15- to 20-ft. mound on the former lowlands as the landfill was advanced toward the Base boundary. At present, this site is inactive and is partially covered with lumber and construction rubble such as concrete, metal scraps, and cans.

The findings from the soil sampling conducted during the remedial investigation (RI) (Draft Final Basewide Remedial Investigation, August 1995) showed the presence of contaminants in soil and sediments, but their levels are below action levels and do not indicate a soil problem at this site. Analyses of the soil detected volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and total petroleum hydrocarbons (TPH). The highest TPH detection was 1,750 mg/kg. Several metals were detected above their background concentrations, mostly in association with areas identified by a geophysical survey as having buried metals. Remaining soil contaminants do not appear to be a human health or ecological risk; therefore, No Further Action of soils and sediments at LF13 is the selected remedy.

Environmental investigations identified VOCs in groundwater. Both fuel-related and chlorinated compounds were detected in groundwater. Although floating product was observed once in one well, its presence was never confirmed by subsequent observations at that well. Chlorinated compounds detected in groundwater included 1,2-dichloroethane (1,2-DCA), tetrachloroethene (PCE), vinyl chloride, and methylene chloride. The concentrations of these contaminants are not sufficiently elevated to indicate the presence of free-phase product. Data collected during the investigations suggest that LF13 is a source for organic and inorganic contaminants in soil and groundwater.

A Baseline Risk Assessment (BRA) (Draft Final RI Report, August 1995) was conducted for LF13. The risks to exposure of LF13 soils produce a lifetime excess cancer risk (LECR) less than 1E-04 and Hazard Index (HI) of less than 1 for both current and future commercial/industrial scenarios. The LECR and HI associated with the hypothetical future commercial/industrial use of groundwater are 9E-04 and 1, respectively. The HI is the criterion used to evaluate the noncarcinogenic effects. Because the LECR value is above the 1E-04 to 1E-06 range, it is appropriate to consider risk-reducing action for groundwater at this site. No further action is selected for soil and sediment. The carcinogenic risk at LF13 is primarily attributable to vinyl chloride and arsenic in groundwater and beryllium in soil. The noncarcinogenic: risk in groundwater is primarily attributable to antimony.

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the enviromnent.

1.4 DESCRIPTION OF THE SELECTED REMEDY

The selected remedy consists of in situ remediation of soil and groundwater using natural attenuation, institutional controls consisting of continuation of the restrictions on using on-Base groundwater from the Columbia Aquifer, and performance of groundwater monitoring. Final evaluation of the performance of this interim remedy, remediation of contaminated soil and groundwater at the site, and compliance with applicable or relevant and appropriate requirements (ARARs) will occur in the final Basewide ROD.

1.5 STATUTORY DETERMINATIONS

The selected remedial action satisfies the remedial selection process requirements of CERCLA and the NCP. As required under CERCLA the selected remedy provides the best balance of trade-offs among the nine evaluation criteria. The selected action provides protection of human health and the environment complies with federal and state requirements that are legally applicable or relevant and appropriate to the action and is cost effective. This remedy uses permanent solutions and alternative treatment technology to the maximum extent practicable and satisfies the statutory preference for remedies that use treatments that reduce toxicity, mobility, or volume as a principal element.

Because the remedy will result in the continued presence of hazardous substances on the site above action levels a review will be conducted within 5 years of commencement of the remedial action to ensure the remedy continues to provide adequate protection of human health and the environment in accordance with NCP Section 300.43 (f)(4)(ii). This 5 year review will be performed as a part of a Basewide monitoring program.

<IMG SRC 97175A>

2. DECISION SUMMARY

2.1 INTRODUCTION

DAFB recently completed a Feasibility Study (FS) and a technical assessment of natural attenuation processes at DAFB that addressed contaminated soil and groundwater in the immediate vicinity of LF13. LF13 is located along its eastern boundary at DAFB, Delaware.

The Draft Feasibility Study, East Management Unit, Dover Air Force Base (Dames & Moore May 1997) was undertaken as part of the USAF's Installation Restoration Program (IRP). The basis for the FS was the Draft Final Basewide Remedial Investigation, East and North Management Units, Dover Air Force Base report (Dames & Moore August 1995), which characterized contamination and evaluated potential risks to public health and the environment. This document was supplemented by two administrative reports titled Hydrogeologic and Water-Quality Data for the East Management Unit of Dover Air Force Base, 1995-96 and Assessment of Natural Attenuation of Contamination from Three Source Areas in the East Management Unit, Dover Air Force Base, both prepared by the U.S. Geological Survey (USGS), Baltimore, Maryland, in February and March 1997, respectively.

Early environmental investigations suggested that LF13 was a source of organic and inorganic contaminants in soil and groundwater. VOCs found in groundwater included fuel-related and chlorinated compounds. The fuel-related compounds [i.e., benzene, toluene, ethylbenzene, xylene (BTEX)]l were not migrating away from the their source area because of the absence of the compounds in the downgradient wells. Although floating product was observed once in one well its presence was never confirmed by subsequent observations at that well. Chlorinated compounds detected in groundwater included 1,2-DCA, PCE, chloroform, and methylene chloride. The concentrations of these contaminants were not sufficiently elevated to indicate the presence of free-phase product.

During the RI, analyses of the soil detected VOCs, SVOCs, pesticides, PCBs, metals and TPH. Nine metals were detected above their respective background concentrations in soil, and one TPH value was measured at 1,750 mg,/kg. No other contaminants were detected above regulatory limits in soil. Nine VOCs were detected in groundwater during the RI, primarily in two well pairs: MW61S/MW61D and DM110S/DM110D. Groundwater samples from these wells had the highest VOC concentrations at the site. 1,2-Dichloroethene (1,2-DCE), vinyl chloride, and benzene each exceeded their MCLs in at least one sample. All other VOCs [except bis(2-ethylhexyl)phthalate, a common laboratory artifact], SVOCs, pesticides, and PCBs were detected at concentrations below their MCLs. Several metals (including arsenic, antimony, calcium, cobalt magnesium, nickel, potassium, and sodium) exceeded their DAFB background concentrations.

This ROD addresses the source of potentially hazardous substances present in LF13 soil and groundwater. Also, this ROD summarizes the FS, describes the remedial alternatives that were evaluated, identifies the remedial alternative selected by DAFB, and explains the reasons for this selection. The USEPA and the State of Delaware concur with the remedy selected in this ROD.

As an aid to the reader, a glossary of the technical terms used in this ROD is provided at the end of the summary.

2.2 PUBLIC PARTICIPATION

DAFB offered opportunities for public input and community participation during the RI/FS and Proposed Plan (PP) for LF13 in the EMU. The PP was made available to the public in the Administrative Record. Documents composing the Information Repository for the Administrative Record for the site are available at the Dover Public Library, Dover, Delaware. The notice of availability for the PP was published in the local newspaper and the Base newspaper. A public comment period was held from Monday, June 16, 1997, until Wednesday, July 15, 1997. The public comment period was not extended as there were no requests for an extension. No written comments were received from the public, and no public meeting was requested. These community participation activities fulfill the requirements of Section 113(k)(2)(B)(I-v) and 117(a)(2) of CERCLA.

Comments submitted by the USEPA and DNREC consisted of editorial changes and clarification of some issues; however, the editing and clarification did not result in any significant change to the preferred alternative presented in the PP.

2.3 SITE BACKGROUND

DAFB is located in Kent County, Delaware, 3.5 miles southeast of the city of Dover (Figure 1) and is bounded on the southwest by the St. Jones River. DAFB comprises approximately 4,000 acres of land, including annexes, easements, and leased property (Figure 2). DAFB is relatively flat, with elevations ranging from approximately 10 to 30 ft. above mean sea level. The surrounding area is primarily cropland and wetlands.

DAFB began operation in December 1941. Since then, various military services have operated out of DAFB. The current host organization is the 436th Airlift Wing. Its mission is to provide global airlift capability, including transport of cargo, troops, equipment and relief supplies.

DAFB is the U.S. East Coast home terminal for the C-5 Galaxy aircraft. The Base also serves as the joint services port mortuary, designed to accept casualties in the event of war. The C-5 Galaxy, a cargo transport plane, is the largest aircraft in the USAF, and DAFB is one of the few military bases at which hangars and runways are designed to accommodate these planes.

The portion of DAFB addressed in this RODCIRP Site LF13 is located within the EMU, one of four management units into which the Base has been divided (Figure 2). LF13 is the site of an inactive surface landfill located in the eastern portion of the Base. It is located north of the ammunition storage facility and approximately 1000 ft. to the southeast of Site LF15. The approximately 8-acre site is covered with small trees and underbrush and has a gravel road down the center. The landfill slopes upward to the east; with the western edge of the site ending abruptly at a 20-ft. ledge of concrete and debris. Abundant rubble and concrete debris litter the toe of the landflll. The area surrounding LF13 was delineated as a wetland, and portions are densely forested.

LF13 was used in the 1960s for the disposal of small quantities of general refuse and large quantities of construction rubble. From the late 1960s to the early 1990s, the site primarily received construction rubble. Buried metal was indicated by ground-penetrating radar anomalies. The dumping of rubble over the edge of the site, with subsequent covering and grading of the slope, created a 15- to 20-ft. mound on the former lowlands as the landfill was advanced toward the Base boundary. At present, this site is inactive and is partially covered with lumber and construction rubble such as concrete, metal scraps, and cans.

<IMG SRC 97175B>
<IMG SRC 97175C>

Ground cover at LF13 consists of grasses, weeds, and small trees. The topography is hummocky,
perhaps because of the uneven nature of landfill materials. A 20-ft. ravine forms the eastern portion of the site. The site is surrounded by delineated wetlands that were formed by construction of the landfill. Runoff from the northern side of the site is collected by shallow swales that flow north to a drainage ditch that ultimately discharges to the Pipe Elm Branch of Little River. Seasonal standing water is common along the southern and eastern sides of LF13 and appears to be the result of topographic irregularities in the surface construction of the landfill.

The shallow lithology at LF13 consists of alternating layers of clay, silt, and sand. A semicontinuous clay layer is present at approximately 17 to 25 ft. below ground surface (bgs) and appears to underlie most of the area. This clay layer acts as a lower confining unit, and groundwater is found perched on top. The perched water table is generally encountered at a depth of approximately 10 to 12 ft. bgs at LF13. The deeper lithology is typically fine-to-coarse sand, with some silt. The dark gray clay of the Calvert Formation ranges in depth between 45 and 76 ft. bgs.

The Columbia Formation is the shallowest water-bearing unit and holds the water table aquifer. Deeper aquifers are protected by the extensive upper clay of the Calvert Formation. The upper portion of the Columbia Formation is finer grained and contains more silt and clay tenses than the deeper portions. The deeper portion of the Columbia Formation typically consists of fine-to-coarse-grained sand with occasional lenses of fine-to-medium sand and discontinuous gravel lenses interpreted as channel lag deposits. The thickness of the Columbia Formation at LF13 is approximately 50 feet. The shallow water table is generally encountered at a depth of 12 to 16 ft. bgs at LF13.

Other structures near LF13 include an inactive JP-4 fuel pipeline approximately 1000 feet downgradient (north) of the area.

LF13 has undergone several previous investigations, two conducted by Science Application International Corporation (1986 and 1989) and one, the RI, conducted by Dames & Moore (1995). During the early investigations both fuel-related (i.e., BTEX) and chlorinated compounds were detected in groundwater. Chlorinated compounds detected in groundwater included 1,2-DCA, PCE, chloroform, and methylene chloride. Although floating product was observed once in one well, its presence was never confirmed by subsequent observations at that well. The concentrations of these contaminants were not sufficiently elevated to indicate the presence of free-phase product. A geophysical survey across the site indicated several area of buried metals as deep as 25 ft. bgs. The early investigation indicated that there were two potential source areas of contamination.

The RI further helped define the areas of potential contamination. The first area is along the access road to LF13 near the southwestern edge of the landfill. Groundwater samples from DM110S and DM110D had the highest VOC concentrations at the site. 1,2-DCE and vinyl chloride exceeded the Maximum Contaminant Levels (MCLs). The limited number of contaminants implies the source may have been a discrete spill or dumping of chlorinated solvents rather than extensive disposal of liquid wastes. The extent of contaminants in groundwater appears limited because contaminants were not detected in downgradient wells.

The second area of associated contaminants occurred at MW61. Benzene was detected at 5 Ig/L equal to its MCL. All other VOCs were present below their MCLs at this location. The extent of the VOC contaminants in groundwater in the vicinity of MW61 appears to be limited because the detected concentrations were below their MCLs and they were not detected in downgradient wells. No SVOCs were detected in LF13 groundwater. As in the VOC data, SVOCs data suggest a localized occurrence of fuel-related compounds. Pesticides were detected; all at exceedingly low estimated concentrations of 0.0098 Ig/L or less. Of all the metals, only antimony exceeded its MCL in a filtered sample. In addition to antimony, several other metals exceeded their DAFB background levels. These metals were arsenic, calcium, cobalt, magnesium, nickel, potassium, and sodium. The metals were primarily elevated in shallow wells screened in the perched groundwater. The types of contaminants detected between the two areas and their difference in concentrations indicate that separate areas of associated VOCs may exist in groundwater at LF13. The area around DM110 is dominated by chlorinated hydrocarbons and the area around MW61 by fuel-related hydrocarbons.

Only pesticides and metals were detected in unfiltered surface water samples collected from LF13. All pesticides were detected in exceedingly low estimated concentrations, often less than one part per trillion. Iron exceeded the chronic Ambient Water Quality Criteria (AWQC) in filtered and unfiltered samples, and copper slightly exceeded its chronic freshwater AWQC. Pesticides and metals were detected in sediment. The pesticides were limited to low, estimated concentrations. Only cobalt and copper slightly exceeded background levels. No other metals appeared to be elevated. The investigations concluded that associated surface water and sediment do not appear to have been impacted by the site activities and the substances in them do not appear to be a significant concern.

Analyses of the soil detected VOC concentrations below action levels, all metals except arsenic are below background or cleanup concentrations, and a TPH detection as high as 1,750 mg/kg. All VOCs except chlorobenzene and total xylenes were detected at concentrations of 15 Ig/kg or less. The maximum concentration of chlorobenzene was 130 Ig/kg in one boring and 47 Ig/kg for total xylenes in a test pit sample. While most SVOCs were detected at concentrations of 1,100 Ig/kg or less, higher concentrations of several fuel-related polycyclic aromatic hydrocarbons (PAHs) were detected in test pit samples. These PAHs are believed to be related to the numerous JP-4 fuel filters, auto filters, and motor parts encountered in the test pits. TPH detections also corresponded to the SVOC concentrations. The elevated TPH concentration was detected along the southern edge of the landfill.

Most pesticide/PCB detections in soil were at concentrations of 12 Ig/kg or less. However, some significant concentrations of pesticides up to 470 Ig/kg and PCBs up to 2,600 Ig/kg were detected in soil samples from the western portion of the landfill. No pesticide or PCB, contaminants exceeded their regulatory limits for the commercial/industrial soil ingestion scenario. Also the concentrations decreased with depth. Only arsenic exceeded its background or cleanup concentrations for DAFB soils. The investigation concluded that this metal may be related to wastes in LF13 disposal pits. Data collected during the investigations suggest that LF13 is a source for organic and inorganic contaminants in soil and groundwater. Summaries of the major contaminants detected in soil and groundwater during the RI are given on Tables 1 and 2, respectively.

Pesticides and PCBs were detected in soil and groundwater at the site; however, their concentrations were below their regulatory levels for commercial/industrial soil ingestion and MCLs for water. The concentrations of PCBs and pesticides in the soil from the western portion of LF13 indicated they may be site related. The occurrence of most pesticides in groundwater across the site is generally attributed to the proper long-term application of these compounds across the Base and surrounding farmlands and is not related to improper use, spills, or releases.

Approximately 6 soil borings and 14 monitoring wells have been installed during the investigation of LF13. Figure 3 illustrates the LF13 site area and sampling locations. The estimated size of the LF13 source area is 183,000 square feet (ft.2).

2.4 SUMMARY OF SITE RISKS

The purpose of the BRA (Draft Final RI Report, August 1995) is to determine whether exposure to site-related contaminants could adversely affect human health and the environment. The focus of the BRA is on the possible human health and environmental effects that could occur under current or potential future use conditions if the contamination is not remediated. The risk is expressed as LECR for carcinogens and as HI for noncarcinogens. For example, an LECR of 1E-06 represents one additional case of cancer in one million exposed population, whereas an HI above one presents a likelihood of noncarcinogenic health effects in exposed populations. The USEPA has established the target risk range of 1E-04 to 1E-06 for LECR. Risks greater than 1E-04 generally warrant an action under CERCLA. An HI greater than 1 indicates a possibility of adverse noncancer health effects based on exposure to multiple contaminants or pathways. The uncertainty with noncancerous health toxicity values is a factor of 10, so HI values greater than 1 may not necessarily require an action under CERCLA in order to be protective of human health. It is considered very unlikely that the Columbia Aquifer would be used by the Base. To ensure the Columbia Aquifer would not be used, institutional controls for restrictions of the groundwater use at LF13 would be implemented as part of the selected alternative. The restriction would
be applicable to all scenarios of groundwater use, including residential, recreational, and commercial/industrial.

The RI/FS focused, on the collection of data to determine extent of contamination in the vicinity of LF13. The BRA identified several contaminants of concern (COCs) in soils:

SVOCS:	2-Methylnaphthalene
	4-Chloro-3-methylphenol
	Benzo[g,h,i]perylene
	Dibenzofuran
	Phenanthrene
Pesticides/PCBs:	Delta-benzene hexachloride
	Endosulfan sulfate
	Endosulfan aldehyde
	Endrin ketone
	PCB 1242, 1248, and 1260

Table 1. Summary of Major Contaminants Detected During the RI in LF13 Soil

Analyte	Highest Concentration (Ig/kg)	Number of hits	Number of samples	Background Conc. (Ig/kg)
Volatile organic compounds				
Chlorobenzene	130	4	17	4.1 E+07*
Xylene (total)	47	4	17	1E+09*
Semivolatile organic compounds				
2-Methylnaphthalene	10,000	3	17	
Bis(2-ethylhexyl)phthalate	8700	3	17	410,000*
Naphthalene	3500	5	17	8.2E+07*
Pesticides/PCBs				
4,4'-DDD	470	6	17	24,000*
PCB 1242	2600	1	17	740*
PCB 1248	260	1	17	740*
Metals (mg/kg)				
Aluminum	25,200	17	17	23,855
Arsenic	39	12	17	19.8
Cadmium	52.8	1	17	0.84
Calcium	1240	17	17	1080
Cobalt	11.4	13	17	6
Copper	16.5	14	17	7.8
Lead	152	17	17	33.1
Mercury	0.48	8	17	0.16
Silver	1.4	1	17	0.97
Total petroleum hydrocarbons (mg/kg)	1750	151	15	

* USEPA, Region III, Risk-Based Concentrations for Commercial/Industrial Soil Ingestion

Table 2. Summary of Major Contaminants Detected During the RI in LF13 Groundwater

Analyte	Highest Concentration (Ig/L)	Number of hits	Number of samples	Maximum Contaminant Levels (Ig/L)
Volatile organic compounds				
Benzene	5	1	14	5
Chlorobenzene	41.0	3	14	100
1,2-Dichloroethene	1400	2	14	70
Vinyl chloride	520	2	14	2
Semivolatile organic compounds				
Bis(2-ethylhexyl)phthalate	39	5	14	6
Pesticides/PCBs				
Chlordane - Gamma,	0.0018	5	14	2
Lindane	0.0047	2	14	0.2
Methoxychlor	0.0072	2	14	40
Metals (Dissolved)				
Antimony	59.9	1	14	6
Arsenic	9.4	2	14	50
Barium	430	14	14	2000
Copper	4.6	2	14	1300
Nickel	46.8	2	14	100

<IMG SRC 97175D>

Metals: Arsenic
Beryllium
Cadmium
Calcium
Cobalt
Manganese
Silicon
Thallium

The BRA, performed as part of the Basewide RI, considered hypothetical current and future soil use under the commercial/industrial scenario. Details concerning the selection of COCs and the human health risks may be reviewed in the Draft Final RI, Volumes III and IV, August 1995.

The total LECRs for the hypothetical current and future commercial/industrial exposure to soil is 2E-07 and 3E-06, respectively. Beryllium is the primary contributor to the LECR for soil. The resulting risk exposures are presented in Table 3.

Table 3a. Hypothetical Current Commercial/Industrial Scenario for Soil at LF13

Pathway	Hazard Index	LECR
Ingestion	1E-03	2E-07
Inhalation	2E-05	7E-11
Total	1E-03	2E-07

Table 3b. Hypothetical Future Commercial/Industrial Scenario for Soil at LF13

Pathway	Hazard Index	LECR
Ingestion	3E-01	3E-06
Inhalation	2E-02	6E-09
Total	3E-01	3E-06

The BRA identified several groundwater COCs at LF13:

VOCs:	1,2-DCA	Metals:	Antimony
	1,2-DCE		Arsenic
	1,4-Dichlorobenzene		Calcium
	Benzene		Cobalt
	Chlorobenzene		Magnesium
	Vinyl chloride		Potassium
			Sodium
SVOCs:	4-Chloro-3-methylphenol	Pesticides:	Endosulfan sulfate
	Bis(2-chloroethoxy)methane		Endrin ketone
	Bis(2-ethylhexyl)phthalate		

The detected concentrations of three contaminants (e.g., 1.2-DCE, benzene, and vinyl chloride) in groundwater exceeded their respective MCLs in at least one of the samples collected during the RI in the vicinity of the source area. The source area for groundwater contamination is in close proximity to the Base boundary. Groundwater discharges to Pipe Elm Branch through a deep flow system, hence the potential exists for the future off-Base migration of contaminants with groundwater.

The BRA, performed as part of the Basewide RI, considered hypothetical future groundwater use from the Columbia Aquifer under the commercial/industrial scenario. Details concerning the selection of COCs and the human health risks may be reviewed in the Draft Final RI Volumes III and IV, August 1995.

The total LECRs for the hypothetical future commercial/industrial exposure to groundwater is 9E-04. Vinyl chloride and arsenic are the primary contributors to the LECR and antimony is the primary contributor to the HI for groundwater. The resulting risk exposures are presented in Table 4.

Table 4. Hypothetical Future Commercial/Industrial Scenario for Groundwater at Area 1

Pathway	Hazard Index	LECR
Ingestion	1E+00	7E-04
Inhalation	6E-02	2E-04
	1E+00	9E-04

2.5 REMEDIAL ACTION OBJECTIVE

Remedial action objectives (RAOs) are media-specific goals to be reached during site remediation that are protective of human health. These objectives are typically achieved by preventing exposure and reducing contaminant levels (Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, USEPA, October 1988). The RAO for LF13 is the reduction of contaminant concentrations in soil to the USEPA Region III Risk-Based Concentrations (RBCs) for the commercial/industrial ingestion scenario. The RAO for groundwater is the Safe Drinking Water Act (SDWA) MCLs, or Delaware's DNREC regulatory levels. The selected acceptable contaminant levels in groundwater are MCLs. For COCs that do not have a RBC or an MCL, the DAFB-specific background level will be used. The selected acceptable contaminant levels for soil are Base-specific background concentrations and are available for most of the COCs at LF13. The primary contributor to the total LECR in soil is beryllium, which the DAFB-specific background concentration is 1.70 mg/kg. In groundwater, vinyl chloride and arsenic are the primary contributors to the total LECR, and antimony is the primary contributor for the HI. The MCLs for vinyl chloride, arsenic, and antimony are 2 Ig/L, 50 Ig/L, and 6 Ig/L respectively. Antimony was detected in only 1 of 14 samples. This single detection is only about 6% above background.

The area to be remediated is defined as the area of attainment. The area of attainment defines the area over which cleanup levels will be achieved in the groundwater. It encompasses the area outside the boundary of any waste remaining in place and up to the boundary of the contaminant plume. Cleanup levels are to be achieved throughout the area of attainment. Within the area of attainment, the goal of the remedial action for soil and groundwater is to reduce the concentrations of COCs below their RAOs.

DAFB does not use the Columbia Aquifer for two primary reasons: (1) the aquifer cannot meet the residential and industrial demand and (2) the water quality is less desirable than that of the deeper aquifer. Land-use restrictions, which are more fully described in DAFB's Real Estate Property Management System, will remain in place because DAFB is one of the few airports capable of servicing the C-5 Galaxy aircraft and it very likely will remain a USAF Base in the distant future. These institutional controls help minimize exposure to site contaminants

The potential exposure routes for LF13 contaminants are ingestion/inhalation of soil particles that have sorbed contaminants and contact and ingestion of contaminants in groundwater/surface water. The potential off-Base migration of groundwater contaminants to areas not under DAFB land-use restrictions is another route of exposure. In this case, the objective is to prevent unacceptable levels of contaminants from migrating off-Base by achieving the RAO within the area of attainment.

2.6 SUMMARY OF ALTERNATIVES

General response actions are the steps that could be taken to achieve the RAOs for the soil and groundwater at LF13. Based on results of the initial screening of the response action technologies presented in the FS and the selection of representative process options, the following six technologies are considered to be applicable:

- No Action

- Institutional Controls
  - Land-use restrictions
  - Groundwater-use restrictions
  - Groundwater monitoring

- In situ Groundwater Treatment

- Natural attenuation
- Density-driven convection
- Permeable reactive barrier wall

- Groundwater Collection
  - Vertical groundwater extraction wells

- Ex situ Groundwater Treatment
  - Metals pretreatment
  - Air stripping

- Groundwater Disposal
  - Surface water discharge

These technologies are combined to form five distinct alternatives that have varying degrees of success at achieving the RAOs for LF13. The five alternatives and features of each technology are summarized as follows.

- Alternative 1-No Action. This alternative involves no activities to reduce contamination or to monitor site conditions. Institutional controls (e.g., restriction of groundwater use by DAFB) are already in place and are likely to remain so in the future. These controls, however, do not apply beyond the Base boundary.

- Alternative 2-In Situ Remediation of Soil and Groundwater Using Natural Attenuation. This alternative relies on passive treatment of contaminated soil and groundwater through natural physical, chemical, and biochemical processes. These processes, particularly biodegradation processes, result in the reduction of soil and groundwater contaminant concentrations at reasonably predicted rates. Institutional controls consisting of continuation of the restrictions on using the Columbia Aquifer and performance of groundwater monitoring are also included.

- Alternative 3-In Situ Remediation of Groundwater Using Density-Driven Convection. Density-driven convection is an in situ groundwater treatment technology that specifically addresses source-area contamination. Soil contamination is addressed by use of soil vapor extraction technology. The distal end of the plume is addressed by natural attenuation. Institutional controls consisting of continuation of the restrictions on using the Columbia Aquifer and performance of groundwater monitoring are also included.

- Alternative 4-In Situ Remediation of Groundwater Using Permeable Reactive Barrier Walls and Ex Situ Remediation of Groundwater Using Air Stripping at LF13. The alternatives were developed with the assumption that remedial actions would be implemented concurrently at three EMU sites which included LF13, Fire Training Area 3 (FT03), and WP14/LF15. This alternative reflects that concurrent action. The technology described in Alternative 4 for LF13 is the same as that presented in Alternative 5, ex situ remediation of groundwater using air stripping. For Alternative 4, groundwater in the source area is treated in situ using a permeable wall of reactive iron filings at FT03 and WP14/LF15. In the ex situ treatment system for LF13, groundwater is removed from the source areas using extraction wells. The extracted water undergoes metals pretreatment and is then processed through an air stripper. The treated water is subsequently discharged to an on-Base stream: Pipe Elm Branch. The distal end of the plumes and soil are addressed by natural attenuation. Institutional controls consisting of continuation of the restrictions on using the Columbia Aquifer and performance of groundwater monitoring are also included.

- Alternative 5-Ex Situ Remediation of Groundwater Using Air Stripping. Groundwater is removed from the source areas using extraction wells. The extracted water undergoes metals pretreatment and is then processed through an air stripper. The treated water is subsequently discharged to an on-Base stream: Pipe Elm Branch. The distal end of the plume and soil are addressed by natural attenuation. Institutional controls consisting of continuation of the restrictions on using the Columbia Aquifer and performance of groundwater monitoring are also included.

These remedial alternatives are described in the following subsections. In addition, the capital, annual operation and maintenance (O&M), and present worth costs of each alternative are provided.

2.6.1 Alternative 1-No Action

Alternative 1, the No Action alternative, is considered in the range of alternatives to serve as a baseline or to address sites that do not require active remediation. The NCP and CERCLA guidance require that the No Action alternative be evaluated. This alternative assumes that no remedial action will occur and that the site would be left in its present condition. No efforts are undertaken to reduce groundwater contaminants. Any changes to the site would be a direct result of natural processes, and no monitoring would be conducted to document changes in contaminant levels. Existing land-use restriction in place at DAFB will continue to be enforced to prohibit the unauthorized extraction and use of groundwater from the Columbia Aquifer. This action will prevent human exposure to the groundwater, thereby averting a public health risk at DAFB. This alternative does not comply with the chemical-specific ARARs of the Base-specific background concentrations for soil and SDWA MCLs for groundwater (See Table 7). The success of meeting the RAOs must be determined. No cost is associated with this alternative.

Alternative 1

Cost Category	Cost ($)
Capital	0
Annual Operations and Maintenance	0
Present Worth	0

2.6.2 Alternative 2-In Situ Remediation of Soil and Groundwater Using Natural Attenuation

Alternative 2, in situ remediation of soil and groundwater using natural attenuation, relies on passive treatment of contaminated soil and groundwater through natural physical, chemical, and biochemical processes. USGS conducted an extensive natural attenuation study of the EMU sites (USGS, 1997) and concluded that none of the COCs were currently migrating past the Base boundary above MCL concentrations in either groundwater or surface water. In addition, the COCs are not predicted to migrate off-Base in the future. Nonetheless, groundwater monitoring will be employed to demonstrate that natural attenuation is effectively reducing contaminant concentrations and preventing their off-Base migration at levels above the RAO concentrations over the long term. Natural attenuation processes, particularly biodegradation processes, result in the reduction of soil and groundwater contaminant concentrations at reasonably predicted rates.

Based on the aquifer characteristics and findings from the RI Report and the Natural Attenuation Study, the USGS reasoned that most of the attenuation is the result of biodegradation. The estimated time needed for biodegradation of chlorinated aliphatic hydrocarbons [e.g., vinyl chloride, 1,2-DCE] to decrease concentrations by one order of magnitude ranges from 0.1 to 3.7 years; the time needed for biodegradation to decrease concentrations by two orders of magnitude ranges from approximately 0.3 to 7.4 years. Using the longest flow path from LF13 to Pipe Elm Branch, approximately 3000 ft. long, the groundwater traveltimes are somewhere between 8 and 180 years from recharge to discharge. Given theses conditions, the USGS then reasoned that biodegradation can decrease concentrations to near or below the detection level in the long flow path. In the short flow path, it was concluded that although
biodegradation can decrease concentrations, it would only do so by an order of magnitude. A table is included at the end of the ROD which shows the comparison of remediation times for natural attenuation of groundwater versus the calculated groundwater travel times. The results showed that for short travel paths (i.e., 100 ft. at FT03) and high flow velocities (i.e., 376 ft./year), natural attenuation processes are insufficient to decrease concentrations by one order of magnitude. In a couple of cases, the intermediate flow path of 1500 ft. and a high flow velocity was not satisfactory to decrease concentrations of TCE by one order of magnitude. It should be noted that the initial concentration of a specific contaminant will dictate cause for concern that groundwater will discharge to a surface water body and pose a risk to human health

or the environment. Potential concerns for LF13 are described in the following paragraphs.

For LF13, all scenarios showed there is sufficient time for natural attenuation to effectively reduce the contaminant concentrations to below their RAOs. This assumes the worst case of a flow path of 3000 ft. to a surface water body, a high flow velocity of 376 ft./year, and the highest contaminant concentrations detected in the RI. The estimated remediation time through natural attenuation processes for LF13 groundwater ranges from less than 1 year to 2.5 years. It is assumed that soil remediation times would be comparable because similar degradation processes are also occurring.

The RI and Natural Attenuation Study showed that concentrations of aliphatic and aromatic hydrocarbons (i.e., fuel-related components) are greatest near the spill sites and least downgradient. No fuel-related hydrocarbons were detected in the surface water samples collected in 1995 and 1996. In general, the USGS concluded that redox conditions measured at the sites are favorable for biodegradation of these compounds. One could then hypothesize that fuel-related hydrocarbons are being successfully biodegraded prior to discharge to the surface water bodies.

The proposed monitoring network is illustrated in Figure 4 and consists of five groundwater wells. To the extent possible, existing wells were selected for monitoring. At LF13, four wells (i.e., MW62S, MW64S, DMW101S, and DM110S) and a new well (NEW 1) will be monitored to confirm the predicted decrease in concentrations and to observe that contaminant levels are below MCLs around the perimeter of the site. Groundwater from this source will eventually be entrained in the overall flow path toward Area 1 And finally to the Base boundary. Well MW227M and the monitoring wells GSCP3M and POC2 used for Area 1 will also serve as final downgradient monitoring points for LF13, which is hydraulically upgradient to Area 1.

Groundwater samples will be collected using dedicated pumps installed in each of the monitoring wells. During the Remedial Design, the base will develop, with DNREC and EPA review and approval, an "Operation and Maintenance" plan which will detail the monitoring wells, sampling parameters, frequency, and performance standards necessary to support the natural attenuation decision both prior to and after the issuance of the final base-wide ROD.

Alternative 2

Cost Category	Cost ($)
Capital	4,200
Annual Operations and Maintenance	8,400
Present Worth	40,000

This alternative is considered capable of complying with the chemical-specific (e.g., Base-specific background concentrations and MCLs) and action-specific (e.g., long-term monitoring) ARARs (See Table 7). In addition to monitoring, institutional controls such as land-use and groundwater-use restrictions that prohibit the use of the contaminated soil mid aquifer will remain in place.

2.6.3 Alternative 3-In Situ Remediation Using Density-Driven Convection

This alternative includes the in situ treatment of groundwater using density-driven convection (DDC) over the source areas of contamination. The DDC process is a recently developed in situ method for removal of VOCs from the saturated zone. The DDC process involves injection of air into the bottom of a well screened at both the top and the bottom. The injected air bubbles rise upward in the well and creates a turbulent, frothing action inside of the wellbore. The rising air bubbles strip contaminants from the water and increase the dissolved oxygen content of the water. The rising bubbles create a frictional drag, which produces a positive hydraulic head (i.e., greater than static aquifer head) at the bottom of the well. Thus, the frictional drag acts as a groundwater pump sucking contaminated water from the surrounding aquifer through the bottom well screen and pushing the water through the wellbore and out of the top well screen. Aerated water discharged through the top well screen then infiltrates back down to the water table, while the discharged air bubbles travel through the vadose zone and are captured by soil vapor extraction (SVE) wells. The designed air injection pressures range from 12 to 16 pounds per square inch - gauge (psig) with an injection flow rate of 20 cubic feet per minute (cfm) for DDC wells.

The DDC wells are assumed to have a diameter of 8 in. and will be installed to the bottom of the Columbia Aquifer at an average depth of 45 ft. bgs. The DDC wells will have a dual well screen. The bottom screen will be 15 ft. long and anchored at the bottom of the well. The bottom screen will be connected to a 5-ft. section of well casing to which the upper screen will be connected. The upper screen will be 15 ft. long and will straddle the water table. The well packing of the two screened intervals will be separated by a bentonite seal. Before completion of the well, a "tee" with a capped 3-ft. horizontal extension will be installed 3 ft. below grade to facilitate air piping. The wells will be completed with a flush-mount manhole and concrete cap.

The DDC wells will be operated by injecting air into the wells with a blower or compressor. Based on the estimated number of DDC wells, two air compressor units will be used at LF13. The compressor stations can each service 4 to 15 DDC wells. For costing purposes, each air compressor is assumed to have a 5-horse power motor producing 36 cfm at 16 psig. Each air compressor unit will have a control panel and will be located within a weatherproofed shed. The control panels will have pressure controls, flow rate indicators, and control valves for each sparging line.

<IMG SRC 97175E>

The DDC systems will operate in tandem with the SVE systems to capture volatile contaminants stripped from the saturated zone. SVE wells are constructed of slotted screen pipe surrounded by gravel or sand pack; a vacuum-tight seal at the ground surface will prevent short circuiting of air. The SVE wells are connected to a vacuum pump by air-handling piping. The vacuum pump produces a lateral air flow through the soil that picks up and carries gaseous-phase contaminants that are located in the interstitial soil pore spaces of the vadose zone. An air/liquid separator is used to remove liquids before entering the vacuum blower. Offgas carbon adsorption treatment systems are included to remove extracted VOCs before atmosphere discharge of the gas stream.

Based on the formation permeability and thickness, the vendor that offers this technology (Wasatch Environmental) estimated that the effective radius of influence for single DDC wells will be 50 ft.. This radius of influence was used to determine the location and the number of the wells that will be required to remediate the source areas. The radius of influence for an SVE well is estimated to be 45 ft. based on the air sparging (AS)/SVE treatability study conducted at WP21 in the West Management Unit [Extended Aquifer Air Sparging/Soil Vapor Extraction Treatability Study for Site SS59 (WP21), Dover Air Force Base, EA Engineering, Science and Technology, 1994]. SVE wells were spaced approximately 80 ft. apart allowing for some overlap and providing full coverage. Based on the spacing requirements, LF13 is estimated to need 20 DDC wells and 27 SVE wells.

Using the results of the air sparging/SVE treatability study at WP21, the extraction vacuum pressures and flow rates are assumed to be 50 to 70 in. water column pressure and 25 to 30 cfm, respectively. For LF13 SVE wells, an estimated 2 vapor extraction stations will be used. The extraction stations will receive and treat vapors from 27 SVE wells. Each extraction station will consist of a knock-out pot, a vacuum pump, and a vapor phase carbon adsorption unit to treat VOC-contaminated vapors. The knock-out pot will be located between the extraction wells and the vacuum pump and will separate entrained water in the extracted gas stream. Water generated in each knock-out pot will be piped to a 55-gallon (gal) liquid phase carbon adsorption unit. Liquid phase granular activated carbon (GAC) treatment units will be used to reduce the level of the organics to levels that comply with discharge requirements (See Table 7). Following treatment, the treated water will be discharged into surface drainage that flows into Pipe Elm Branch.

Vapor from the knock-out pot will be treated in vapor-phase carbon adsorption units where organic contaminants will be removed. The air flow at each station will be split into two parallel streams, each of which will be treated using a 150-pound (lb) canister of GAC. For each vapor extraction station, two carbon canisters will be required. Initially (i.e., the first year of operation), the carbon canisters will have to be replaced about every 6 months. Each extraction station will be located within a weatherproofed shed. During subsequent years of operation, the carbon consumption rate will be progressively less as the contaminant extraction rates decline.

The SVE systems will require periodic monitoring. For costing purposes, 24 air samples are assumed to be collected and analyzed the first month during startup. The first month's samples will be collected both upstream and downstream of the vapor-phase GAC units weekly. Thereafter, two air samples/month will be, collected to track the progress and efficiency of remediation. In addition, the emissions from the SVE stations will be monitored semiannually to ensure that it is in compliance with standards (See Table 7).

A field pilot test of the DDC system will be necessary before final design of the remediation action. The study will be used for system design and modeling of contaminant removal rates. Selected test wells will be installed to evaluate field responses to applied air pressures, identify the locations of clay lenses, confirm the radius of influence of the vapor extraction wells, determine the radius of influence of the DDC wells, and determine optimum operating conditions. The system addresses the source area at the site. The distal ends of the plume will be allowed to attenuate naturally.

Groundwater monitoring will be performed to track the long-term progress and effectiveness of groundwater remediation and to monitor contaminant migration. One new monitoring well (NEW1) will be installed at LF13. The new well, in addition to the 4 existing wells, will be used to monitor plume migration. Samples will be collected and analyzed from the 5 wells semiannually. All groundwater samples will be tested for all COCs. The actual frequency, duration, and analytical parameters may change, depending on the long-term results of sampling. For costing purposes, monitoring is assumed to occur for 5 years.

Alternative 3

Cost Category	Cost ($)
Capital	380,000
Annual Operations and Maintenance	27,000
Present Worth	440,000

This alternative is considered capable of complying with the chemical-specific (e.g., emissions, Base-specific background concentrations, and MCLs) and action-specific (e.g., active land treatment and long-term monitoring) ARARs (See Table 7). In addition to monitoring, institutional controls such as land-use and groundwater-use restrictions that prohibit use of the contaminated soil and aquifer will remain in place. This action will prevent huma exposure to the contaminated soil and groundwater, thereby averting a public health risk.

2.6.4 Alternative 4-Ex Situ Treatment of LF13 Groundwater Using Air Stripping

Alternative 4 is the ex situ treatment system of LF13 groundwater using air stripping. The LF13 treatment system will consist of one extraction well and will be operational over the course of approximately 2 years. Because contamination exists primarily in the perched water, the well will be installed and screened across that interval (i.e, 10 to 12 ft. bgs). The pumping rate is estimated to be 10 gallons per minute (gpm). Collected groundwater will be passed through two 500-lb liquid-phase carbon canisters and then will be discharged to Pipe Elm Branch.

Groundwater monitoring will be performed to track the long-term progress and effectiveness of the groundwater remediation systems. It is proposed that 1 additional well (NEW1) will be installed at LF13. The new well and 4 existing wells will be used in the groundwater monitoring program. Samples will be collected and analyzed from the wells semiannually. The groundwater samples are assumed to be tested for all COCs. The actual frequency, duration, and analytical parameters may change, depending on the long term results of sampling. For estimating purposes, monitoring for 5 years is assumed. Groundwater from this source will eventually be entrained in the overall flow path toward Area 1 and finally to the Base boundary. Well MW227M and monitoring wells GSCP3M and POC2 used for Area 1 will also serve as final downgradient monitoring points for LF13, which is hydraulically upgradient to Area 1.

This alternative is considered capable of complying with the chemical-specific (e.g., MCLs) and action-specific (e.g., active land treatment and long-term monitoring) ARARs (See Table 7). In addition to monitoring, institutional controls such as land-use and groundwater-use restrictions that prohibit use of the contaminated soil and aquifer will remain in place. This action will prevent human exposure to the groundwater, thereby averting a public health risk.

Alternative 4

Cost Category	Cost ($)
Capital	170,000
Annual Operations and Maintenance	28,000
Present Worth	240,000

2.6.5 Alternative 5-Ex Situ Remediation Groundwater Using Air Stripping

This alternative includes groundwater extraction, pretreatment of groundwater for metals removal, air stripping treatment to remove chlorinated solvents and fuel-related compounds, and surface water discharge of treated groundwater from LF13.

Groundwater extraction will be accomplished by using 1 new extraction well installed at the site. The extraction well location was selected to control and capture the areas of contaminated groundwater at the site. The extraction rate and capture area from the well was estimated using the two-dimensional groundwater model TWODAN. The extraction well will operate at 10 gpm and will create a capture zone that will limit further migration of contaminants and prevent discharge to the Pipe Elm Branch.

The Basewide RI report indicates that the perched water table is located at a depth of approximately 10 to 12 ft. bgs in the LF13 area. The RI/FS reports also indicate that the most significant contamination is found in the perched water and not in the Columbia Aquifer. Therefore, the extraction well at LF13 will be installed across the shallow perched water and will be screened using slotted stainless steel casing from 10 ft. bgs (screen length of approximately 5 ft.) to 15 ft. bgs. The well will be 6 in. in diameter. The filter pack will extend a minimum of 1 ft. above the well screen. Above the filter pack, a minimum 2-ft. bentonite seal will be installed, and the well will be grouted to the surface using a bentonite grout.

Contaminated groundwater will be extracted using a 4-in. stainless steel electric submersible pump. Following extraction, the groundwater will be pumped through 2-in. Schedule 80 plastic piping to the treatment system. The piping will be buried below the frost line at a minimum depth of 3 ft., An estimated 100 ft. of pipe will be required at LF13 to convey extracted water from the recovery well to the treatment system and from the treatment system to the closest surface water discharge point.

The groundwater treatment system includes an initial pretreatment stage to reduce the metals content. This stage is added to prevent iron and manganese fouling in the subsequent air stripping unit as well as to ensure compliance with the National Pollutant Discharge Elimination System discharge standards (See Table 7). Groundwater will be pumped on a continual basis to an equalization tank, where it will be dosed with potassium permanganate to oxidize iron and manganese to their insoluble forms followed by pH adjustment with sodium hydroxide. Next, a cationic polymer will be introduced into a rapid mix tank, where it will be mixed instantly into solution. Rapid mixing will be followed by slow mixing or flocculation. The clarification tank follows flocculation and provides for quiescent settling of the metal-polymer flocs. The flocs will settle and produce an aqueous sludge. Clarified groundwater will be sent to subsequent treatment systems void of high concentrations of iron and manganese, which can interfere with operation of the system. A bench-scale treatability study (USACE, 1994) was conducted for groundwater at Site WP21 to determine the type and amount of chemicals required for the metals pretreatment process. The results of this study were used to estimate the chemical dosage required for metals pretreatment.

A sludge characterization test such as the Toxicity Characteristic Leachate Procedure test will have to be conducted to determine the leachability of the metals and thus the method and cost of disposal (See Table 7). For costing purposes, the sludge will be assumed to be nonhazardous. The sludge will be dewatered to reduce the volume requiring disposal.

After pretreatment for metals, groundwater will be pumped to the top of a low-profile, four-tray air stripper. The water will be uniformly distributed across each tray and brought into contact with air forced up from the bottom of the unit by a blower. The counter-current airflow through the stripper unit transfers VOCs dissolved in the groundwater to the air stream. The air stream containing the VOCs then exits through the top of the air stripper unit, while the treated groundwater flows out through the bottom of the air stripper unit. The air stripper unit selected has a liquid throughput capacity of up to 20 gpm.

Based on the average VOC concentration of groundwater samples collected at the site, an appropriate extraction rate, and assuming complete removal during treatment, 0.033 pounds per day (lbs/day) of VOCs will be stripped from the groundwater at LF13. The air stream exiting the air stripper will not require treatment before release to the atmosphere since the total VOC discharge is less than 2.5 lbs/day. Air samples will be collected monthly to ensure continued compliance with air emission standards (See Table 7).

Preliminary modeling of the air stripper performance using recent groundwater data from the site and the expected flow rate indicate that the treated groundwater will meet the surface water discharge standards (See Table 7) without further polishing or treatment. The model also shows that air emissions will be significantly below the emission standard of 2.5 lbs/day (See Table 7).

Effluent samples will be collected from the groundwater treatment system at a rate required to satisfy regulatory requirements (See Table 7)(which is assumed to be weekly for the first month and semiannually thereafter). All groundwater and effluent samples are assumed to be tested for all COCs. Sampling is assumed to continue for 5 years.

The groundwater pump-and-treat system will address contamination in the source area. The distal ends of the plume will be treated by natural attenuation. Groundwater monitoring will be performed to track the long-term progress and effectiveness of the groundwater remediation system. To perform the groundwater monitoring accurately, one additional well (NEW 1) will be installed. As was shown in Figure 4, the well will be located at the south of the site. Samples will be collected and analyzed from five wells semiannually. Groundwater from this source will eventually be entrained in the overall flow path toward Area 1 and finally to the Base boundary. Well MW227M and monitoring wells GSCP3M and POC2 used for Area will also serve as final downgradient monitoring points for LF13, which is hydraulically upgradient to Area 1.

Alternative 5

Cost Category	Cost ($)
Capital	170,000
Annual Operations and Maintenance	28,000
Present Worth	240,000

This alternative is considered capable of complying with the chemical-specific (e.g., MCLs) and action-specific (e.g., active land treatment, waste handling, and long-term monitoring) ARARs (See Table 7). In addition to monitoring, institutional controls such as land-use and groundwater-use restrictions that prohibit use of the contaminated soil and aquifer will remain in place. This action will prevent human exposure to the groundwater, thereby averting a public health risk.

2.7 COMPARISON OF REMEDIAL ALTERNATIVES

This section provides a comparative analysis of the five remedial alternatives that were evaluated in detail in the FS and are described in Section 2.6 of this ROD. The focus of the comparative analysis is on the relative advantages and disadvantages offered by each of the alternatives in relation to the seven evaluation criteria (excluding regulatory and community acceptance) that were analyzed. A detailed summary of this analysis is provided in Table 5, and an illustrative comparative summary is presented in Table 6.

2.7.1 Overall Protection of Human Health and the Environment

The overall protectiveness criterion is a composite of other evaluation criteria, especially short-term effectiveness, long-term effectiveness, and compliance with ARARs. All five of the alternatives are considered to be protective of human health because of institutional controls, such as land-use restrictions, that prohibit the unauthorized extraction or use of contaminated soil and groundwater on-Base. The institutional controls, however, do not apply to off-Base properties.

Alternative 1 (No Action) is not considered effective at protecting human health and the environment past the Base boundary because no provisions are made to monitor the groundwater migration off-Base or to evaluate compliance with the RAO.

Alternatives 2 (Natural Attenuation), 3 (Density-Driven Convection), 4 (Permeable Reactive Barrier Wall, Tump and Treat), and 5 (Pump and Treat) will all meet the RAOs and are considered highly protective of human health and the environment.

2.7.2 Compliance with ARARs

The RAOs that have been established for the EMU sites are based on achievement of the Base-specific background concentrations and MCLs across the area of attainment. Alternative 1 (No Action) provides no mechanism to evaluate compliance with the MCLs and therefore does not comply with ARARs. The treatment actions and groundwater monitoring provisions of Alternatives 2 through 5 will result in demonstrated compliance with the MCLs. A summary of the ARARs used in the evaluation of the alternatives is provided in Table 7. Table 7 specifies which ARARs are applicable to each alternative.

A number of other ARARs C including the Clean Air Act, Clean Water Act, and Resource Conservation and Recovery Act C must be considered for Alternatives 3, 4, and 5. Primary among them are compliance with VOC emission limitations to the atmosphere, land treatment regulations, and effluent discharge limitations to surface water. Alternatives 2 through 5 are in compliance with the ARARs relevant to their respective technologies.

2.7.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence criterion considers primarily the magnitude of residual risk that would remain after the implementation of an alternative, and the adequacy and reliability of the controls instituted. All of the alternatives provide for the long-term protection of human health through the existing institutional controls such as land-use and groundwater-use restrictions. However, reliance upon institutional controls is considered neither a permanent remedy nor applied to off-Base property.

Under Alternative 1 (No Action), the contamination in groundwater will not be monitored. Therefore, as groundwater migrates from the EMU off-Base, the adequacy and reliability of this alternative cannot be established. Hence, the long-tem protectiveness of this alternative cannot be demonstrated.

All of the action alternatives employ remedial measures to control the source areas and rely upon natural attenuation to address the distal ends of the plumes. The magnitude of residual contamination residing in the source area is dependent on the time allowed for the remediation to continue. For Alternative 2 (Natural Attenuation), physical, chemical, and biochemical attenuation processes will continue to reduce contaminant concentrations indefinitely into the future. Alternatives 3 (Density-Driven Convection), 4 (Permeable Reactive

Barrier Walls/Pump and Treat), and 5 (Pump and Treat) will all be operated and/or maintained for finite periods of time until high levels of confidence are reached, that natural attenuation can address remaining contamination.

TABLE 5

Comparative Analysis of Alternatives for LF13

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Description	No action	In situ remediation of LF13 groundwater using natural attenuation.	In situ remediation of LF13 groundwater using density-driven convection.	Ex situ treatment of LF13 groundwater using air stripping.	Ex situ treatment of LF13 groundwater using air stripping.
Overall Protection					
D Human Health Protection	Offers a high level of overall protection of human health through the existing land-use restrictions on-Base, but cannot be guaranteed effective past the Base boundary.	Offers a high level of overall protection of human health through the existing land-use restrictions on-Base Biodegradation of source area constituents allow achievement of RAOs off-Base as demonstrated through groundwater monitoring.	Offers a high level of overall protection of human health through the existing land-use restrictions. Active treatment of source area constituents allow achievement of RAOs off-Base as demonstrated through groundwater monitoring	Offers a high level of overall protection of human health through the existing land-use restrictions. Active treatment of source area constituents allow achievement of RAOs off-Base as demonstrated through groundwater monitoring.	Offers a high level of overall protection of human health through the existing land-use restrictions. Active treatment of source area constituents allow achievement of RAOs off-Base as demonstrated through groundwater monitoring
D Environmental Protection	Does not provide a mechanism to monitor groundwater constituent concentrations. Therefore, potential impacts of surface water from discharging groundwater cannot be assessed	Groundwater constituents discharging to surface water meet MCLs off-Base.	Groundwater constituents discharging to surface water meet MCLs off-Base	Groundwater constituents discharging to surface water meet MCLs off-Base	Groundwater constituents discharging to surface water meet MCLs off-Base.
			Groundwater released to surface water through pump and treat operations will meet surface water quality criteria.	Groundwater released to surface water through pump and treat operations will meet surface water quality criteria.	
Compliance with ARARs					
D Chemical-Specific ARARs	Success at meeting RAOs will be determined	Natural attenuation is considered capable of maintaining RAO compliance.	Density-driven convection treatment is considered capable of maintaining RAO compliance.	Pump and treat system is considered capable of maintaining RAO compliance.	Pump and treat system is considered capable of maintaining RAO compliance
				Air stripper system will comply with DRGCAP requirements	Air stripper system will comply with DRGCAP requirements

TABLE 5 (cont'd)

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
D Action-Specific ARARs groundwater	Does not provide for long- term groundwater monitoring.	Long term groundwater monitoring is provided.	Complies with DRGHW for active land treatment. Long- term groundwater monitoring provided.	Complies with DRGHW for active land treatment. Long- term groundwater monitoring provided.	Long-term monitoring provided
Long-term Effectiveness and Permanence					
D Magnitude of risk expected for the the land- provided alternative are provide long- human	Because DAFB is expected to remain active for the foreseeable future, the land- use restrictions provided under this alternative are considered to provide long- term protection of human health on-Base.	Because DAFB is expected to remain active of the foreseeable future, the land- use restrictions provided under this alternative are considered to provide long- term protection of human health on-Base.	Because DAFB is expected to remain active for the foreseeable future, the land- use restrictions provided under this alternative are considered to provide long- term protection of human health on-Base.	Because DAFB is expected to remain active for the foreseeable future, the land- use restrictions provided under this alternative are considered to provide long- term protection of human health on-Base.	Because DAFB is to remain active foreseeable future, use restrictions under this considered to term protection of health on-Base.
off-Base eliminated as are	However, this alternative provides no mechanisms to determine whether the RAOs are achieved over time (i.e. preventing risks due to off- Base migration of contaminants above RAO levels).	Risk for potential off-Base users will be reduced as contaminant levels are lowered.	Risk for potential off-Base users will be reduced as contaminant levels are lowered.	Risk for potential off-Base users will be reduced as contaminant levels are lowered.	Risk for potential users will be contaminant levels lowered
D Reliability of Controls restrictions are extremely reliable on-Base	Land-use restrictions enforced by DAFB are considered extremely reliable in preventing on-Base exposure.	Land-use restrictions enforced by DAFB are considered extremely reliable in preventing on-Base exposure.	Land-use restrictions enforced byn DAFB are considered extremely reliable in preventing on-Base exposure.	Land-use restrictions enforced by DAFB are considered extremely reliable in preventing on-Base exposure.	Land-use enforced by DAFB considered in preventing exposure.
system will control areas in a time preventing the further contaminants	Off-Base, the reliability of this alternative is questionable because there is no mechanisms to determine whether the RAOs are being met.	The 2-year study conducted by the USGS indicates that natural attenuation can be relied upon to achieve the whether the RAOs are being boundary.	The DDC technology is considered reliable. However, because operation of the DDC system will change the redox condition of the aquifer in the source	The extraction system will establish hydraulic control over the source areas in a relatively short time preventing the further migration of contaminants.	The extraction establish hydraulic over the source relatively short the further migration of

areas, high efficiency removal of the polychlorinated constituents

technologies highly		The technologies proposed for ex situ treatment of groundwater are proven and highly reliable	The proposed are proven and reliable

TABLE 5 (cont'd)

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Reduction of Toxicity, Mobility, and Volume					
D Treatment Process Used	Not applicable	Dominant process is biodegradation. Other attenuation processes include volatilization, adsorption, and dilution.	Source are treatment using density-driven convection combined with soil vapor extraction (SVE). Distal ends of plumes treated by natural attenuation processes.	Source areas treated ex situ using metals pretreatment and air stripping. Sludge generated during metals pretreatment will be sent offsite for disposal. Distal ends of plumes treated by natural attenuation processes.	Source are groundwater addressed by extraction followed by metals pretreatment and air stripping. Sludge generated during metals pretreatment will be sent offsite for disposal. Distal ends of plumes treated by natural attenuation processes.
D Amount Treated	Not applicable.	Area covered by LF13 is approximately 8 acres.	Area covered by LF13 is approximately 8 acres.	Area covered by LF13 is approximately 8 acres.	Area covered by LF13 is approximately 8 acres.
D Reduction in toxicity mobility, and volume through treatment	None demonstrated.	Reduction in groundwater toxicity achieved through natural attenuation processes. No reductions in mobility or volume.	DDC process reduces groundwater toxicity in the source area. Contaminant mobility is increased during treatment, but mobilized contaminant should be captured by SVE. Natural attenuation reduces the toxicity of the distal ends of the plumes.	Groundwater extraction and treatment reduces groundwater toxicity and limits constituents mobility in the capture area. The technology does not impact the volume of contamination Removal of volatile organic constituents present in groundwater by air stripping will reduce the toxicity of groundwater. The volume of contaminated media is not affected. Natural attenuation reduces	Groundwater extraction and treatment reduces groundwater toxicity and limits constituents nobility in the capture area. The technology does not impact the volume of contamination Removal of volatile organic constituents present in groundwater by air stripping will reduce the toxicy of groundwater. The volume of contaminated media is not affected. Natural attenuation reduces

distal ends of the plumes					the toxicity of the distal of the plumes.	the toxicity of
treatment permanent constituents irreversible	D Irreversibility of Treatment	Not applicable	Natural attenuation will provide premanent removal of constituents through irreversible processes.	DDC treatment results in permanent removal of constituents through irreversible processes.	Air stripping treatment results in the permanent removal of constituents through irreversible processes	Air stripping results in the removal of through processes

TABLE 5 (cont'd)

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
D Type and Quality of residue volumes of require	No residues generated	No residues generated	Spend activated carbon will be generated from air treatment.	Small quantities of sludge will be generated by the ex situ metals pretreatment process at LF13.	Metals pretreatment generates small sludge which will disposal
Short-term Effectiveness					
D Protection of Community impact on the During Remedial Action surrounding the construction or	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site during construction or operation.	No short term impact on the community surrounding the site during construction or operation.	No short term community site during operation.
D Protection of Workers will be During Remedial Action applying dust and equipment during	Not applicable.	Standard Health & Safety procedures and personal protective equipment will prevent exposure during well installations and sampling	Worker's exposure will be minimized by applying dust control techniques and providing personal protection equipment during construction.	Worker's exposure will be minimized by applying dust control techniques and providing personal protection equipment during construction.	Worker's exposure minimized by control techniques providing personal protection construction
D Environmental Impact disturbance installing new impacts construction are treated Elm to the	None	Minimal disturbance will result from installing three new monitoring wells. Environmental impacts related to construction are minimal.	Moderate land disturbance due to installment of a number of wells throughout the sites. Environmental impacts related to construction are minimal.	Moderate land disturbance result from installing new monitoring wells. Environmental impacts related to construction are minimal. Discharge of treated groundwater to Pipe Elm Branch not expected to adversely impact the environment.	Moderate land result from monitoring wells Environmental related to minimal. Discharge of groundwater to Pipe Branch not expected adversely impact environment.
D Time Required the course or remediation. Two years of treatment of LF13 is	Unkown This alternative does not monitor for RAO compliance.	It is predicted that RAOs will continue to be met while contaminants naturally degrade. Data will be evaluated after 5 years of monitoring to determine whether contaminant concentrations are significant	It is predicted RAO compliance will be maintained during the course of remediation. Two years of source area treatment is estimated.	It is predicted RAO compliance will be maintained during the course of remediation. Two years of treatment of LF13 is estimated.	It is predicted RAO compliance will be maintained during estimated.

enough to warrant continued
monitoring

TABLE 5 (cont'd)

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Implementability					
D Ability to Construct and are Operate Technology construction of and treatment	Not applicable	This alternative requires the installation of only three monitoring wells. No difficulties are anticipated	No difficulties are anticipated in installation of the DDC/SVE wells or equipment. Operation of the DDC system is straight forward.	No difficulties are anticipated in construction of the extraction and treatment system.	No difficulties anticipated in the extraction system
D Reliability of Technology technology is for removal of constituents	Not applicable.	USGS confirms ongoing natural attenuation in the EMU. Continued attenuation of constituents is anticipated in the future.	DDC and SVE are reliable technologies for removal and destruction of VOCs in homogenous permeable soils. However, presence of clay layers in the EMU reduces the reliability of these technologies.	Air stripping technology is highly reliable for removal of volatile organic constituents.	Air stripping highly reliable volatile organic
D Ease of Undertaking rebound Additional Action result in additional be restarting the The network and/or could be augmented if replaced with	Not applicable	Additional actions could easily be performed if necessary.	If contaminant rebound occur that may result in RAO failure, additional remediation can be performed by restarting the in situ treatment. The DDC/SVE well networks could be expanded or scrapped and replaced with new technologies if necessary.	If contaminant rebound occurs that may result in RAO failure, additional remediation can be performed by restarting the treatment system The extraction network and/or treatment system could be expanded or augmented if necessary, or replaced with new technologies.	If contaminant occurs that may RAO failure, remediation can performed by treatment system extraction treatment system expanded or necessary, or new technologies
D Ability to Monitor the pump is easily	Not applicable.	Performance of natural attenuation is easily monitored.	Performance of the DDC system is easily monitored.	Performance of the pump and treat system is easily monitored.	Performance of and treat system monitored.
D Regulatory Agency set by Coordination/Approval branch prior to	None.	Coordination with appropriate personnel at DAFB is necessary Groundwater wells will	Coordination with appropriate personnel at DAFB is necessary. Groundwater wells will	Effluent limits set by DNREC's NPDES branch have to be met prior to discharge to surface water	Effluent limits DNREC's NPDES have to be met discharge to

surface water wells will permits with the personnel at necessary	require State permits.	require State permits.	Groundwater wells will require State permits. Coordination with appropriate personnel at DAFB is necessary	Groundwater require State Coordination appropriate DAFB is

TABLE 5 (cont'd)

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
D Availability of Services	Not applicable.	Ready available.	The density-driven convection component will require a specialty contractor, however, the remaining portions of this alternative are readily available.	Readily available.	Readily available
D Availability of Equipment	Not applicable.	Readily available.	Readily available.	Readily available.	Readily available.
D Availability of Technology	Not applicable.	In place.	Readily available.	Readily available.	Readily available.
Cost (IRP Site LF13)					
Capital Cost	$0	$4,200	$380,000	$170,000	$170,000
Annual O&M Cost (first year)	$0	8,400	27,000	28,000	28,000
Net Present Worth Cost	$0	40,000	440,000	240,000	240,000

<IMG SRC 97175F>

Table 7. Summary of ARARs

Environmental Laws and Regulations	Consideration as an ARAR	Retain for ARAR Analysis?
I. RCRA(42 USC 6901-92k,esp.6921-39e), Delaware Hazardous Waste Management Act(7 Del. Code Ann. 6301-19. esp. 6306-07), Delaware Solid Waste Management Act(7 Del. Code Ann. 6401-60)		
A. Delaware Solid Waste Disposal Regulations (DNREC Regulations Governing Solid Waste)	A solid waste landfill will not be constructed on-base	No
B. Delaware Hazardous Waste Management Regulations(DNREC Regulations Governing Hazardous Waste (DRGHW)		
1. Closure and Postclosure (DRGHW Part 264, Subpart G)	Waste will not be contained in place	No
2. Groundwater Monitoring and Protection (DRGHW Part 264, Subpart F)	Groundwater monitoring shall be conducted in accordance with	Yes
3. Standards applicable to container and tanks (DRGHW Part 264, Subpart I and J)	Contaiminated groundwater may be temporaily stored on-site in tanks or containers awaiting treatment.	Yes
4. Standards applicable to surface impoundments, waste piles, land treatment facilities (other than closure and post-closure requirements) (DRGHW Part 264, Subpart K, L, and M)	In Situ treatment technologies such as air sparging and soil vapor extraction may be considered land treatment. Excavated soil may be temporarily stored in piles awaiting shipment for off-site disposal	Yes
5. Location Standards (DRGHW Part 264.18)	The site is not located in a 100-year floowplain, as defined by RCRA	No
6. Transportation Standards (DRGHW Part 263)	Any shipment of hazardous waste off-base must comply with transporter standards and ;manifesting requirements.	Yes
7. Incinerator Standards (DRGHW Part 264, Subpart O)	On-site incineration is not considered a remedial alternative	No
8. Landfill Standards (DRGHW Part 264, Subpart N)	A hazardous waste landfill will not be constructed on-base	No
9. Underground Storage Tank Regulations (Delaware Regulations	UST rules are not applicable to remedial alternatives for this site	No
10. Land Diposal Restrictions (DRGHW Part 268)	Land disposal restriction and treatment requirements shall be met with respect to residuals generated by the alternatives under consideration	Yes

Table 7. Summary of ARARs

Environmental Laws and Regulations			Consideration as an ARAR	Retain for ARAR Analysis?
II.	Delaware Environmental Control Act(7 Del. Code Ann. 6001-93) and Delaware Water Pollution Control Regulations(11 Code of Del. Reg. 70 500 005)			
	A.	Delaware National Pollutant Discharge Elimination System (NPDES) Regulations (Delaware Water Pollution Control Regulations (DWPCR) Section 4	Discharges to surface water would have to meet NPDES requirements	Yes
	B.	Delaware Industrial Waste Effluent Limitations (DWPCR Section 8)	Effluents generated by site remedial activities may require pretreatment Any effluent discharge to POTWs must meet pretreatment standards	Yes
	C.	Delaware Water Quality Standards (DNREC Surface Water Quality Standards)	Remedial alternatives resulting in discharge to surface water may affect water quality.	Yes
III.	Clean Water Act, 33 USC 1251-1387, exp. 1311-17			
	A.	Effluent guidlines (40 CFR 403)	Effluents discharged to a POTW would be subject to general pretreatment guidelines	Yes
	B.	Ambient Water Quality Criteria (AWQC) (Federal Register 1980, 1985)	Erosion of soils during remediation activities may affect the surrounding surface water.	Yes
IV.	Safe Drinking Water Act (SDWA), 42 USC 300f			
	A.	Underground Injection Control (40 CFR Parts 144-147)	Extracted groundwater may be reinjected under some remedial alternatives.	Yes
	B.	Maximum Contaminant Levels (MCLs) (40 CFR Parts 141 and 143)	Some compounds exceed their MCLs in groundwater, remedial action shall reduce contaminants to below MCLs.	Yes
V.	Marine Protection, Research, and Sanctuaries Act.			
	A.	Incineration at sea requirements (40 CFR Part 761)	No wastes for the site will be incinerated at sea	No
VI.	Toxic Substances Control Act (TSCA)			
	A.	Polychlorinated biphenyls (PCB) requirements (40 CFR Part 761)	PCBs are not present at the site	No

Table 7. (cont.)Summary of ARARs

Environmental Laws and Regulations		Consideration as an ARAR	Retain for ARAR
VII.	U. S. Army Corps of Engineers Program		
	A. Dredge and fill (33 CFR Part 323)	Remedial alternatives under consideration will not involved dredging or filling in of a navigable waterway.	No
	B. Construction in waterways (40 CFR Part 323)	No construction in navigable waters will be required for the remedial actions under consideration.	No
VIII.	Clean Air Act (CAA) (42 USC Sections 7401-7671q)		
	A. National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50)	Groundwater treatment alternatives may involve emissions to air.	Yes
IX.	Delaware Regulations Governing the Contol of Air Pollution (8 Code of Del. Reg. 70 100 003 (NAAQS))	Groundwater treatment alternatives may involve emissions to air.	Yes
X.	U.S. Department of Transportation Regulations 49 CFR Part 170-179)	Waste may be transported off-site for treatment of disposal under the considered remedial alternatives.	Yes
XI.	Response in a Floodplain or Wetlands (40 CFR Part 6, Appendix A, and Executive Orders 11988 and 11990)	The site is not located within a 100-year floodplain	No
XII.	Conservation of Wildlife Resources (Endangered Species Act, 16 USC 1531, 50 CFR 200, 50 CFR 402)	Threatened or endangered species are not found at the site. If they are found, remedial action shall be implemented so as to conserve threatened or endangered species or resources.	No
XIII.	Wild and Scenic Rivers Act (16 USC 1274; 50 CFR 27)	No wild and scenic rivers are found in the vicinity of the site.	No
XIV.	Preservation of Scientific, Historic, or Archaeological Data (National Historic Preservation Act, 16 U.S.C. 470, 40 CFR 6.301(b), 46 CFR 800; Archaeological and Historic Preservation Act of 1974, 16 U.S.C. 469, 40 CFR 6.301(c); Historic Sites, Buildings, and Antiquities Act, 15 U.S.C. 461-467; 40 CFR 6.301(a), 36 CFR Part 65)	Scientific, historic, or archaeological sites are located in the vicinity of the site. Consultations with Sate Historic Preservation officals have been made.	Yes
XV.	Delaware Erosion and Sedimentation Act(7 Delaware Code Annotated Chapter 40)	Alternatives resulting in the disturbance of soil will require measures to control erosion.	Yes

All four action alternatives are considered reliable. The efficacy of Alternative 2 was proven in a 2-year natural attenuation study performed by the USGS at the EMU sites. The technologies associated with Alternative 3, 4, and 5 ahve been applied successfully at other installations.

2.7.4 Reduction of Toxicity, Mobility, and Volume

Reduction in toxicity, mobility, or volume will not be documented with the implementation of Alternative 1 (No Action). While dilution and dispersion of all contaminants occurs naturally, only the organic contaminants will degrade, and it cannot be demonstrated that the RAOs will be met at the Base boundary for all contaminants over time. The four action alternatives include components that are capable of reducing significantly the toxicity and/or mobility of contaminants in groundwater through irreversible treatment processes.

Alternative 2 (Natural Attenuation) relies upon a variety of physical, chemical, and biochemical processes to achieve reductions in contaminant concentrations and lowered groundwater toxicity. Anaerobic biodegradation is the dominant process.

Alternative 3 (Density-Driven Convection) uses an in situ technology to strip volatile contaminants from the source are and oxygenate the groundwater. Oxygenating the groundwater will stimulateaerobic biodegradation processes, which will augment other attenuation processes to reduce groundwater toxicity.

Alternative 4 (Permeable Reactive Barrier Wall/Pump and Treat) uses two separate technologies. Contact with the reactive barrier wall causes contaminated groundwater to undergo an abiotic reductive dehalogenation reaction, thus reducing the toxicity of the groundwater. The pump-and-treat component creates a hydraulic barrier to contaminant migration, thus limiting mobility. Treatment of the extracted groundwater using air stripping reduces its toxicity.

Alternative 5 (Pump and Treat) offers the benefits of extraction and treatment discussed for Alternative 4, but includes all of the EMU sites.

All of the action alternatives satisfy the CERCLA statutory preference for treatment.

2.7.5 Short-Term Effectiveness

Alternative 1 (No Action) provides no remedial actions. Therefore, no short-term effects on community or worker health or the environment will result from construction activities. However, because Alternative 1 does not provide monitoring to ensure compliance with the RAOs established for this project, it is considered to be ineffective.

Alternative 2 (Natural Attenuation), 3 (Density-Driven Convection), 4 (Permeable Reactive Barrier Wall/Pump and Treat), and 5 (Pump and Treat) will be effective in reducing groundwater contaminant concentrations in the EMU. None of the alternatives is expected to have significant impacts on worker or public health or the environment.

Alternative 2 is currently meeting the RAOs and is projected to continue meeting them in the future. Alternative 3 will change the redox character of the source areas from anaerobic (reducing) to aerobic oxidative). An aerobic environment is less conductive to the biodegradation of polychlorinated alkenes than an anerobic environment, thus the DDC system operation will have to continue until the polychlorinated compounds are removed to low levels. DDC system operation is estimated to continue for 2 years. Alternative 4 includes the permanent installation of reactive barrier walls, which will greatly enhance the rate of abiotic reductive dehalogenation reaction. These abiotic reaction augment the naturally occurring biodegradation reactions. Maintenance of the barrier wall is estimated to continue for 5 years. The pump-and-treat components of Alternatives 4 and 5 are estimated to continue for 2 years.

2.7.6 Implementability

Three main factors are considered under this criterion: technical feasibility, administrative feasibility, and availability of services and materials. All five alternatives are administratively feasible, and the required services and materials are readily available. Hence, the comparison will focus on the technical feasibility of implementing the alternatives.

No technical feasibility considerations are associated with Alternative 1 (No Action). Of the action alternatives, Alternative 2 (Natural Attenuation) has by far the fewest implentability considerations. Because the USGS natural attenuation study in the EMU has already been completed, long-term groundwater monitoring is the only component remaining and is easily implemented.

Alternatives 3 (Density-Driven Convection) and 4 (Permeable Reactive Barier Wall/Pump and Treat) are relatively the most complex systems to design, construct, and operate. Both of these alternatives require treatability studies before their design and include the most extensive construction. Alternative 3 includes installing and balancing a total of 31 DDC wells and 50 SVE wells across three sites (includes FT03 and WP14/LF15). Alternative 4/Alternative 5 (Pump and Treat) involves systems that are much easier to design, install, and operate relative to the systems included under Alternatives 3 and 4, but it is still more complex than Alternative 2.

All of the technologies considered in the action alternatives are considered reliable and are easily monitored. None of the technologies precludes the implementation of additional remedial measures at a later time if they are deemed necessary.

2.7.7 Cost

No direct costs are associated with the implentation of Alternative 1 (No action). The estimated costs of the four action alternatives, including capital costs, annual O&M costs, and present net worth, are summarized in Table 8. Alternative 2 (Natural Attenuation) offers a substantial cost advantage over the other action alternatives with a present worth cost of $40,000. Alternatives 3 (Density Driven Convection) and 4/5 (Pump and Treat) offer higher present worth costs of $440,000 and $240,000, respectively.

2.7.8 Regulatory Acceptance

The USEPA and the State of Delaware have reviewed the alternatives and are in agreement with the selected remedy for LF13.

TABLE 8
Action Alternative Cost Summary
for LF13

Alternative	Capital Cost	Annual O&M*	Net Worth
2. Natural Attentuation	$4,200	$8,400	$40,000
3. Density Driven Convection	$380,000	$27,000	$440,000
4. Ex Situ Treatment	$170,000	$28,000	$240,000
5. Groundwater Extraction with Air Stripping	$170,000	$28,000	$240,000

* First year O&M costs.

2.7.9 Community Acceptance

No comments were received during the public comment period and no community opposition to the
preferred remedy was noted.

2.8 SELECTED REMEDY

The selected remedy for cleanup of soil and groundwater at LF13 is Alternative 2, which includes the following major components:

- natural attenuation,
- continued enforcement of existing land use restrictions,
- restrictions of groundwater use, and
- groundwater monitoring.

The reasoning to support the selected remedy for cleanup of groundwater at LF13 is summarized as follows:

- Natural attenuation is capable of meeting the RAOs. The USGS conducted an extensive natural attenuation study of the site and concluded that none of the COCs were currently migrating past the Base boundary above MCL concentrations in either groundwater or surface water. In addition, the COCs are not predicted to migrate off-Base in the future.
- Alternative 2 is considered protective of human health and the environment. It complies with all ARARs that address off-site migration or movement of contamination and reduces the toxicity of contaminants in the soil and groundwater.
- The technology offers good long-term and short-term effectiveness.
- Alternative 2 offers a great implementability advantage over all other alternatives. The only component of Alternative 2 still requiring implementation is the long-term groundwater monitoring. Simple monitoring well construction and operation considerations are required in addition to the groundwater monitoring requirements. The monitoring program will verify the status of the groundwater contamination and therefore protect future receptors before exposure. The monitoring program is currently being developed in consultation with the USEPA and DNREC. As Alternative 2 is implemented, the monitoring program will provide the data necessary to verify that natural attenuation of groundwater contaminants is working.
- Alternative 2 offers substantially lower capital, O&M, and present worth costs than any of the other action alternatives. This cost advantage is particularly important given that all of the alternatives offer similar performance. There are no treatment by-products (e.g., spent carbon and sludges) produced and no hazardous chemicals (e.g., oxidizing agents) need to be stored on-site with Alternative 2.
- Institutional controls are already in place to limit access to or use ofthe site resources, including soil and groundwater.

DAFB, USEPA, and DNREC have agreed that the installation of additional monitoring points (i.e., monitoring wells, well points, etc.) is necessary to help demonstrate that the remedial action will accomplish its intended goal and that if the additional data collected during the remedial action suggests otherwise, that the remedial action will be readdressed in the Basewide ROD.

2.8.1 PERFORMANCE STANDARD FOR THE SELECTED REMEDY

The COCs in groundwater at this site, which are listed in Section 2.4 of this ROD, shall not exceed their respective federal MCLs at or beyond the boundary of DAFB. COCs that do not have an MCL shall not exceed DAFB-specific background levels at or beyond the boundary of DAFB.

The concentrations of the COCs in groundwater at this site, listed in Section 2.4 of this ROD, shall be reduced to below federal MCLs (or, if no MCL exists, the DAFB-specific background level) within the area of attainment within a reasonable time, not to exceed 30 years. The area of attainment is the area outside the boundary of any waste that remains in place at the site and up to the boundary of the contaminant plume. Existing institutional controls, which are more fully described in DAFB's Real Estate Property Management System, and site use restrictions shall continue to remain in effect.

2.9 STATUTORY DETERMINATION

Based on consideration of the requirements of CERCLA, the comparative analysis, and comments,
DAFB, USEPA, and the State of Delaware believe Alternative 2 provides the best balance of the trade-offs among the alternatives with respect to the criteria used to evaluate remedies. The selected remedy is consistent with CERCLA and, to the extent practicable, the NCP. The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, is cost-effective, and uses permanent solutions and alternative treatment to the maximum extent practicable.

The reliability of natural attenuation mechanisms, such as bio-degradation, adsorption/ desorption, and dilution for the cleanup of petroleum- and chlorinated-based media has been demonstrated at various sites around the country to be cost effective and, if properly monitored, an environmentally sound solution to soil and groundwater contamination. It results in permanent reduction in concentrations of contaminants in the subsurface. Investigative data show natural attenuation is already at work within the site area. Therefore, Alternative 2 is the selected remedial action for Site LF13. Because the hazard index and LECR calculated for the different soil scenarios in the BRA are within an acceptable risk range, no further action than that already taken is determined to be appropriate for site soils.

GLOSSARY

air sparging - A process whereby air is pumped into the subsurface, groundwater, or soils to enhance the volatilization or aerobic biodegradation of compounds.

air stripper - A device to remove (strip) volatile organics from contaminated water by bringing the water into contact with air, causing volatile compounds to change from liquid phase to the vapor phase.

aquifer - A geologic formation capable of yielding water to wells and springs.

Applicable or Relevant and Appropriate Requirements (ARARs) - Criteria set forth by federal, state, or local regulations that must be considered in the evaluation of remedial alternatives and govern the environmental actions at a particular site.

Ambient Water Quality Criteria (AWQC) - Regulatory standards for surface water quality.

Baseline Risk Assessment (BRA) - A statistical evaluation of the current and future risks to human health and the environment from the exposure to contaminants at a site if no remedial actions are taken.

Benzene, toluene, ethylbonzene, and xylone (BTZX) - Chemical compounds that are common constituents of fuels and petroleum products.

biodegradation - The breakdown of organic constituents by microorganisms into less complex compounds.

bioremodiation - the cleanup of a contaminated medium through natural biological processes.

bioventing - A treatment process that introduces air into the subsurface soils to stimulate the growth of microorganisms what naturally attack certain compounds. This process speeds up the rate at which some chemicals biodegrade.

Capital Cost - Cost incurred for the construction and startup of a facility.

Carcinogen - A chemical capable or suspected of producing cancer as a result of exposure.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - A federal law passed in 1980 and revised in 1986 by the Superfund Amendments and Reauthorization Act (SARA). CERCLA provides federal authority and money. for the USEPA to respond directly to the release or threatened release of hazardous substances into the environment at inactive sites.

Density-driven convection (DDC) - An in situ process for removal of VOCs from the groundwater using air to strip contaminants from the water.

The State of Delaware Department of Natural Resources and Environmental Control (DNRSC) - State regulatory agency in charge of overseeing environmental programs at DAFB.

Delaware Regulations Governing the Control of Air Pollution (DRGCJLP) - Regulatory protocols and standards for control of particulates and emissions to the air within the state.

Delaware Regulations Governing Hazardous Waste (DRGHW) - Regulatory protocols and standards for control of handling, transport, storage, and disposal of hazardous wastes within the state.

Electromagnetic (EM) - A geophysical survey instrument used to locate changes in specific conductance in subsurface materials.

Feasibility Study - A study to develop and evaluate options for remedial actions.

Granular activated carbon (GAC) - Carbon material that is has ionically charged sites capable of filtering organic and inorganic compounds from a waste stream.

Groundwater - Subsurface water residing in a zone of saturation.

Ground penetrating radar(GPR) - A geophysical survey instrument used primarily to locate changes in lithological character of the subsurface soil.

Hazard Index (HI) - An indicator of the health risk associated with exposure to a noncarcinogenic chemical.

in situ - in the original location (in the ground or this report).

Installation Restoration Program (IRP) - The Department of Defense (DOD) program designed to identify, report, and correct environmental deficiencies at DOD installations. At DAFB, this program implements the requirements for cleanup under CERCLA.

leachate - The solubilization and transport of constituents in soil through the percolation of surface water to groundwater.

Lifetime Excess Cancer Risk (LECR) - Represents the risk of exposure to cancer-causing compounds over a lifetime.

Maximum Contaminant Level (MCL) - Federal drinking water standards enacted by the Safe Drinking Water Act.

Natural attenuation - A remediation approach that depends upon natural processes such as dilution, dispersion, sorption, volatilization, chemical transformation, and biodegradation, that act to contain contaminants, reduce contaminant concentrations, and restore soil and groundwater quality.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) - The federal regulation that provides a contingency plan for discharges or releases of hazardous substances, pollutants, contaminants, or oil into the environment that may present an immediate danger to public health or welfare.

Operation and Maintenance Costs (O&M) - Annual costs incurred for operation and maintenance of a facility.

plume - A recognizable distribution of constituents in groundwater.

Selected Alternative - The clean-up strategy that offers the best chance of success in protecting human health and the environment from contamination at a site. The selected alternative is selected from several clean-up strategies because it satisfies USEPA criteria for effectiveness, implementability, cost, and public and regulatory acceptance.

Remedial Action objective (RAO) - Clean-up goal established for remediation.

Reactive iron filings - For the case proposed in Alternative 4, metal shavings are placed in the path of a contaminant plume to act as a catalyst in the abiotic degradation of halogenated organic compounds. The plume is allowed to pass through a permeable wall that contains the iron filings. This actual physicochemical degradation process is also called dehalogenation.

Resource Conservation and Recovery Act (RCRA) - Federal law enacted to address environmental issues created by current waste disposal, spills, and handling practices.

Remedial investigation (RI) - An investigation that involves sampling the air, soil, and water to determine the nature and extent of contamination at an abandoned waste sit and the human health and environmental risks that result from that contamination.

Record of Decision (ROD) - A legal document that explains the specific clean-up alternative to be implemented at a Superfund site.

Superfund Amendments and Reauthorization Act (SARA) - A congressional act that modified CERCLA. SARA was enacted in 1986 and again in 1990 to authorize additional funding for the Superfund program.

Soil vapor extraction (SVE) - A process by which air and volatilized compounds are extracted from the subsurface soils through screened wells using a vacuum.

Toxicity Characteristics Leaching Procedure (TCLP) - An analytical procedure that measures the level of organic leachate from a soil sample. This method is commonly used to determine whether soil to be disposed of is hazardous.

Total Petroleum Hydrocarbons (TPH) - This analytical parameter is a measure of the hydrocarbons, often within a particular petroleum weight range.

U.S. Environmental Protection Agency (USEPA) - The federal regulatory agency in charge of overseeing environmental programs at DAFB.

vadoso zone - Soil zone above the water table.

RESPONSIVENESS SUMMARY

The following Responsiveness Summary is a compilation of the comments and responses on the Proposed Plan for Natural Attenuation of Groundwater, Fire Training Area 3 (FT03), Dover Air Force Base. Dover, Delaware (HAZWRAP, June 1997), Proposed Plan for Natural Attenuation of Groundwater, Liquid Waste Disposal Area 14 (WP14) and Landfill 15 (LF15), Dover Air Force Base. Dover. Delaware (HAZWRAP, June 1997), and Proposed Plan for Natural Attenuation of Groundwater. Landfill 13 (LF13), Dover Air Force Base, Dover, Delaware (HAZWRAP, June 1997).

Dover Air Force Base (DAFB) offered opportunities for public input and community participation during the Remedial Investigation (Rl)/Feasibility Study (FS)and Proposed Plans (PP) for all three site in the East Management Unit. The PPs was made available to the public in the Administrative Record. Documents composing the Information Repository for the Administrative Record for the site are available at the Dover Public Library, Dover, Delaware. The notice of availability for the PPs was published in the local newspaper and the Base newspaper. A public comment period was held from Monday, June 16, 1997 until Wednesday, July 15, 1997. The public comment period was not extended as there were no requests for an extension. No written comments were received from the public and no public meeting was requested. These community participation activities fulfill the requirements of Section 113(k)(2)(B)(i-v) and 11 7(a)(2)of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

Comments submitted by the U.S. Environmental Protection Agency (USEPA) and the State of Delaware Department of Natural Resources and Environmental Control (DNREC), requested editorial changes and clarification of some issues; however, the editing and clarification did not result in any significant change to the preferred alternative presented in the PPs.

TIME CALCULATIONS FOR NATURAL ATTENUATION

<IMG SRC 97175G>