HAFB 2003

BHATE
Environmental Engineers and Scientists
1608 13th Avenue South, Suite 300
Birmingham ■ Alabama ■ 35205
(205) 918-4000
(205) 918-4050 (FAX)

November 14, 2003

RECEIVED
NOV 2003
NMED Hazardous
Waste Bureau

Ms. Sandra Martin
NMED/Hazardous Waste Bureau
2905 Rodeo Park Dr. East
Santa Fe, NM 87505-6303

Subject: ***Feasibility Study Work Plan***
Spill Site 61
Holloman AFB, New Mexico
Contract No.: DACA45-02-D-0012
Delivery Order No: 5
Bhate Project No.: 9030024

Dear Mr. Martin:

Inadvertently, the cover letter to another report accompanied the above referenced work plan. Please accept this letter as the Letter of Transmittal for the ***Feasibility Study Work Plan Spill Site 61,*** Holloman AFB, New Mexico. We apologize for any inconvenience.

If you have any questions or need additional assistance, please feel free to call me at (970) 216-7819.

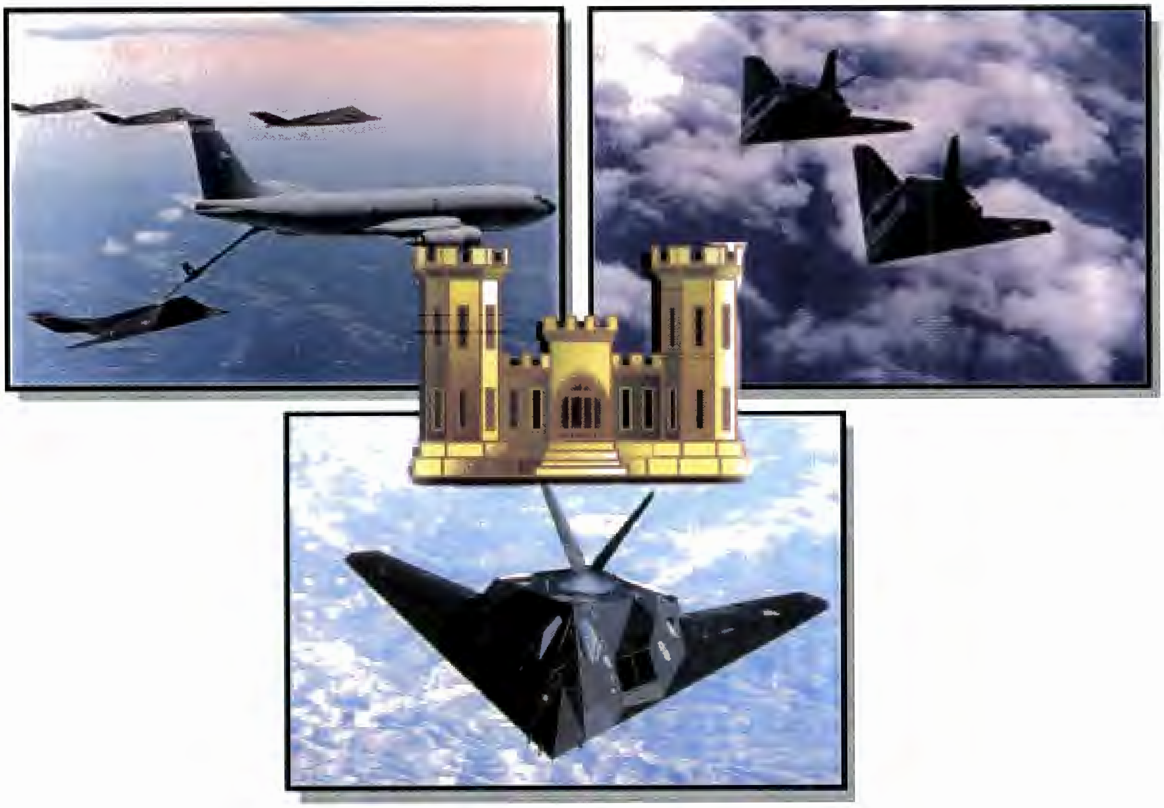
Sincerely,
BHATE ENVIRONMENTAL ASSOCIATES, INC.

for Frank Gardner
Program Manager
Holloman Air Force Base

cc Cornelius Amindyas (NMED)
Steve Jetter (NMED)
James Harris (USEPA)

FEASIBILITY STUDY WORK PLAN

SPILL SITE 61



Holloman Air Force Base
New Mexico

November 2003

Contract No. DACA45-02-D-0012
Delivery Order No. 005
BHATE Project No. 9030024

Headquarters, Air Combat Command
Langley Air Force Base, Virginia

49 CES/CEV
Holloman Air Force Base, New Mexico

FEASIBILITY STUDY WORK PLAN
SPILL SITE 61

HOLLOMAN AFB, NEW MEXICO

CONTRACT NO. DACA45-02-D-0012
DELIVERY ORDER NO. 5
Bhate Project Number: 9030024

Prepared For

U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

Prepared By

Bhate Environmental Associates, Inc.
1608 13th Avenue South
Suite 300
Birmingham, Alabama 35205

November 2003

This page intentionally blank.

FEASIBILITY STUDY WORK PLAN

SPILL SITE 61
HOLLOMAN AIR FORCE BASE
NEW MEXICO

REVIEW SHEET

COMMITMENT TO IMPLEMENT THIS WORK PLAN

for Frank Gardner	[signature]	13 Nov 03
Project Manager	Signature	Date
for Jerry Pelfrey	[signature]	11/13/03
Site Manager	Signature	Date

This page intentionally blank.

FEASIBILITY STUDY WORK PLAN
SPILL SITE 61
HOLLOMAN AFB, NEW MEXICO

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

This page intentionally blank.

ACRONYMS AND ABBREVIATIONS

AAF	Army Air Field
AFB	Air Force Base
AHA	Activity Hazard Analysis
ANSI	American National Standards Institute
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
Bhate	Bhate Environmental Associates, Inc.
BTEX	Benzene, toluene, ethylbenzene, xylenes
COC	Chain-of-Custody
DQOs	Data Quality Objectives
ERPIMS	Environmental Restoration Program Information Management System
F	Fahrenheit
GPS	Global Positioning System
HAFB	Holloman Air Force Base
HASP	Health and Safety Plan
hr	Hour
IDW	Investigation Derived Waste
IRP	Installation Restoration Program
kg	Kilogram
L	Liter
lbs	Pounds
LTM	Long Term Monitoring
mg	Milligram
mL	milliliter
NFA	No Further Action
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
OSHA	Occupational Safety and Health Administration
OWS	Oil/Water Separator
PA/SI	Preliminary Assessment/Site Investigation
PCS	Petroleum-Contaminated Soils
POL	Petroleum, Oil and Lubricants
PPE	Personal Protective Equipment
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI	Remedial Investigation

sec	Second
SSL	Soil Screening Level
SVE	Soil Vapor Extraction
SWPPP	Storm Water Pollution Prevention Plan
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
TRPH	Total Recoverable Petroleum Hydrocarbons
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

Bhate Environmental Associates, Inc. (Bhate) has been retained by the U.S. Army Corps of Engineers (USACE), under contract DACA45-02-D-0012, Delivery Order No. 5, to conduct additional field activities in support of a Feasibility Study (FS) for Spill Site 61 (SS-61), Holloman Air Force Base (HAFB), New Mexico. The primary objective of this field activity is to provide additional information on the site to support the recommendations for No Further Action (NFA) presented in the *Final Remedial Investigation (RI) Report for Spill Site 61*, Foster Wheeler Environmental Corporation, August 1999, and the *Final Phase II Remedial Investigation Report for SS-61 - Spill Site 61*, Foster Wheeler Environmental Corporation, December 2000.

1.1 Purpose

NFA was recommended for the north and south sections of SS-61 in the Phase I RI and Phase II RI, respectively. The New Mexico Environment Department (NMED) provided comments to the Final Phase II RI on March 29, 2001 and May 10, 2001. NMED requested additional investigation and data collection, conducted as part of the FS, to support NFA or Long Term Monitoring (LTM) of SS-61. The purpose of this FS Work Plan is to:

- Document groundwater quality in the area of SS-61
- Determine if the plume in the area of SS-61 is stationary, migrating, increasing or decreasing in size
- Assess the extent of the localized contamination in the vicinity of the southwest corner of Building 1079
- Determine if natural attenuation of contaminants is occurring in groundwater in the area of SS-61
- Assess whether free-phase liquids are present in the monitoring well MW-3 on a frequent basis
- Collect data to support the NFA Alternative recommended for the site

1.2 Description

HAFB is located in southeastern New Mexico in Otero County, approximately 100 miles north-northeast of El Paso, Texas, and six miles west of Alamogordo, New Mexico (Figure 1). HAFB was first established in 1942 as Alamogordo Army Air Field (AAF). From 1942 through 1945, Alamogordo AAF served as the training grounds for over 20 different flight groups, flying primarily B-17s, B-24s, and B-29s. After World War II, most operations had ceased at the base.

In 1947, Air Material Command announced the air field would be its primary site for the testing and development of un-manned aircraft, guided missiles, and other research programs. On January 13, 1948, the Alamogordo installation was renamed Holloman Air Force Base, in honor of the late Col. George V. Holloman, a pioneer in guided missile research. In 1968, the 49th Tactical Fighter Wing arrived at HAFB and has since remained. Today, HAFB also serves as the German Air Force's Tactical Training Center.

SS-61 is located in an industrial area in the central part of HAFB. The site is located north of two hangers, Buildings 1079 and 1080, and is divided into two study sections by DeZonia Drive (Figure 2). The northern section of the site consists of a concrete pad, located east of Building 1001, which may have been used for dispensing fuel. North of this pad was a debris pile that covered approximately 1500 square feet. The pile contained concrete pieces, asphalt rubble and some piping. Northeast of the concrete pad and debris pile were two aboveground storage tanks (ASTs) that had been removed. The ground surface rises approximately 10 feet toward the former AST area. A partial outline of the containment berm in the area of the northern AST is still visible. The circular berm is approximately 180 feet in diameter, rising approximately 8 feet above grade, and approximately 10 feet wide at the base. No remnant of a berm is visible for the southern AST. A 12-inch diameter steel pipe emerges from the ground at a 45° angle, oriented north to south. The piping was traced to an apparent T-junction located 450 feet south of the AST area. A geophysical survey, conducted during the Phase I RI, traced one branch of the piping west from the junction to an area directly north of the concrete pad to two concrete valving vaults. The other piping branch runs south toward the hanger area.

The southern portion of SS-61, south of DeZonia Drive, consists of two hangers, Building 1079 and Building 1080. South of the hangers is the tarmac. The eastern hanger, Building 1080, is the newer of the two buildings. The western hanger, Building 1079, dates to the 1940s. A concrete sump is located outside the northwest entrance to the hangar. A shallow surface depression, approximately 100 ft x 70 ft by 3 ft deep, is located in the north parking lot to Building 1079. It was used as a stormwater collection basin. The piping traced from the former ASTs is located underneath Building 1087, east of Building 1079.

1.3 Physiography

HAFB is located within the Sacramento Mountains Physiographic Province on the western edge of the Sacramento Mountains. The region is characterized by high tablelands with rolling summit plains; cuesta-formed mountains dipping eastward; west-facing escarpments with the wide bracketed basin forming the basin and range complex. HAFB is approximately 59,600 acres in area and is located at a mean elevation of 4,093 feet above sea level. The Base is located in the Tularosa Sub-basin which is part of the Central Closed Basins. The San Andreas Mountains bound the basin to the west (about 30 miles) with the Sacramento Mountains approximately 10 miles to the east. At its widest, the basin is about 60 miles east to west and stretches approximately 150 miles north to south.

1.4 Surface Water

The Tularosa Sub-basin contains all of the surface flow in its boundaries. The nearest inflow of surface waters to HAFB comes from Lost River, located in the north-central region of the Base. The upper reaches of the Three Rivers and the Sacramento River are perennial in the basin. HAFB is dissected by several southwest trending arroyos that control the surface drainage. Hay Draw is located in the far north. Malone and Rita's Draw, which drain into the Lost River, and Dillard Draw are located along the eastern perimeter of the Base. Approximately 10,000 years ago, indications are of a much wetter climate. The present day Lake Otero encompassed a much larger area, possibly upwards of several hundred square miles. Its remains are the Alkali Flat and Lake Lucero. Lake Lucero is a temporary feature of merely a few inches in depth during the rainy season.

Ancient lakes and streams deposited water bearing deposits over the older bedrock basement material. Fractures, cracks and fissures, in the Permian and Pennsylvanian bedrock, yield small quantities of relatively good quality water in the deeper peripheral. Potable water is only found from a handful of wells near the edges of the basin with more saline water towards the center. Two of the principal sources of potable water are a long narrow area on the upslope sides of Tularosa and Alamogordo with the other in the far southwestern part of the basin. Alamogordo's water, as well as water for HAFB, is supplied from Lake Bonito (which is in the Pecos River Basin).

1.5 Groundwater

The predominance of the groundwater occurs as an unconfined aquifer in the unconsolidated deposits of the central basin, with the primary source of recharge as rainfall percolation and minor amounts of stream run-off along the western edge of the Sacramento Mountains. Surface water/rainfall migrates downward into the alluvial sediments at the edge of the shallow aquifer near the ranges, and flows downgradient through progressively finer-grained sediments towards the central basin. Because the Tularosa Sub-basin is a closed system, water that enters the area only leaves either through evaporation or percolation. This elevated amount of percolation results in a fairly high water table. Beneath HAFB, groundwater ranges from 5 to 50 feet. Flow for the Base is generally towards the southwest with localized influences from the variations in the topography of the Base. Near the arroyos, groundwater flows directly toward the surface drainage feature.

Previous analyses indicate total dissolved solids (TDS) of greater than 10,000 mg/L in groundwater beneath HAFB. This exceeds the New Mexico Water Quality Control Commission (NMWQCC) limit as potable water and thus, the groundwater beneath HAFB has been designated as unfit for human consumption. Likewise, United States Environmental Protection Agency (USEPA) guidelines have identified the groundwater as a Class IIIB water source, characterized by TDS concentrations exceeding 10,000 mg/L.

1.6 Climate

As a whole, New Mexico has a mild, arid to semi-arid continental climate characterized by light precipitation totals, abundant sunshine, relatively low humidity and relatively large annual and diurnal temperature range. The climate of the Central Closed Basins varies with elevation. HAFB is found in the low areas and is characterized by warm temperatures and dry air. Daytime temperatures often exceed 100°F in the summer months and middle 50°s F in the winter. A preponderance of clear skies and relatively low humidity permits rapid night time cooling resulting in average diurnal temperature ranges of 25° to 35°F. Potential evapotranspiration, at 67 inches per year, significantly exceeds annual precipitation, usually less than 10 inches (Foster Wheeler and Radian, 1997). The very low rainfall amounts resulting in the arid conditions, which with the topographically induced wind patterns combining with the sparse vegetation, tend to cause localized "dust devils". Much of the precipitation falls during the mid-summer monsoonal period (July and August) as brief, yet frequent, intense thunderstorms culminating to 30 – 40% of the annual total rainfall.

1.7 Geology

The sedimentary rocks which make up the adjacent mountain ranges are between 500 and 250 million years old. During the period when the area was submerged under the shallow intra-continental sea, the layers of limestone, shale, gypsum and sandstone were deposited. In time, these layers were pushed upward through various tectonic forces forming a large bulge on the surface. Approximately 10 million years ago the center began to subside resulting in a vertical drop of thousands of feet leaving the edges still standing (the present day Sacramento and San Andreas mountain ranges). In the millions of years following, rainfall, snowmelt and wind eroded the mountain sediments depositing them in the valley (*i.e.* Tularosa Sub-basin). Water carrying eroded gypsum, gravel and other matter continues to flow into the basin.

The Tularosa Sub-basin is a bolson, which is a basin with no surface drainage outlet and sediments are carried by surface water into a closed basin forming bolson deposits. The overlying alluvium generally consists of unconsolidated gravels, sands and clays. Soils in the basin are derived from the adjacent ranges as erosional deposits of limestone, dolomite and gypsum. A fining sequence from the ranges towards the basin's center characterizes the area with the near surface soils as alluvial, eolian and lacustrine deposits. The alluvial fan deposits are laterally discontinuous units of interbedded sand, silt and clay, while the eolian deposits consist primarily of gypsum sands. The eolian and alluvial deposits are usually indistinguishable due to the reworking of the alluvial sediment by eolian processes. The playa, or lacustrine deposits, consist of clay containing gypsum and are contiguous with the alluvial fan and eolian deposits throughout HAFB. There has been the identification of stiff caliche layers, varying in thickness, at different areas of the Base. At SS-61, soils are predominantly silty sands and interbedded clays.

2 PREVIOUS INVESTIGATIONS

In 1994, during a RCRA Facility Investigation (RFI) of Solid Waste Management Unit (SWMU) 104, the Former Army Landfill used for the disposal of waste munitions, contamination was detected in samples collected from monitoring well MW-29-05. Volatile organic compounds (VOCs) detected in the groundwater included benzene, 1,2-dichloroethane (1,2-DCA), 2,4,6-trinitrotoluene (TNT), and 1,3,5-trinitrobenzene. Water levels collected from SWMU 104, also designated as Installation Restoration Program (IRP) Site LF-29, indicated a hydraulic gradient to the north-northwest. Monitoring well MW-29-05 was determined as being upgradient of the former landfill; therefore, the source of the contamination was located south southeast of the former landfill. Based on the results of MW-29-05, an NFA was requested for SWMU 104. The area south southeast of IRP Site LF-29 was designated Area of Concern (AOC) 1001, due to its location in the vicinity of Building 1001.

2.1 Phase I RI

A Phase I and Phase II RFI was conducted at AOC 1001 in 1996 and 1997, respectively. Soil vapor samples, soil samples and groundwater samples were collected across the area. At this time, results from the investigations designated this area as IRP Spill Site (SS) 61.

A Phase I RI was conducted at SS-61 in 1999. The investigation area included two former ASTs, underground piping, debris pile and a concrete pad that may have been a fuel dispensing area. These are located north of DeZonia Drive. Information of the area is limited because part of the area was used for classified operations conducted by the Strategic Air Command. Aerial photographs indicated that operations at the concrete pad and ASTs began after 1945 and had ended by 1972. Soil samples collected during the Phase I RI indicated the presence of Total Recoverable Petroleum Hydrocarbons (TRPH), benzene, toluene, ethylbenzene and xylenes (BTEX), and two explosive constituents (tetryl and trinitrotoluene) immediately above the water table, in the capillary fringe, at the northeast corner of the concrete pad. Groundwater samples collected indicated elevated levels of BTEX, north of the concrete pad, with lower levels of BTEX, 1,2-DCA, trichloroethene (TCE), and explosives to the south and east of the pad. Free product was not observed in the wells sampled. The Phase I RI confirmed that past releases in the vicinity of the concrete pad resulted in elevated concentrations of groundwater contaminants in a plume that extends north toward SWMU 104. Soil sampling showed that there was no continuing source of groundwater contamination. The risk assessment conducted indicated that there was no unacceptable risk to either human or ecological receptors; therefore, the Phase I RI concluded that no remediation was required in the northern section of SS-61.

2.2 Phase II RI

The Phase II RI was conducted in 2000 and investigated the southern portion of SS-61, in the vicinity of two hangers, Building 1079 and 1080. Phase II investigated the area of the two hangars, the outlying areas around the two hangars, an area southeast of Building 1080 where suspected fuel spills occurred during past operations, and in the former stormwater overflow basin north of Building 1079, directly south and upgradient of the concrete pad. Soil sampling results from Phase II indicated the same as results from the Phase I study. There did not appear to be a continuing source of groundwater contamination. An elevated level of TRPH was detected in one soil sample, collected from 1'-2' below ground surface (bgs), at the southwest corner of Building 1079. Groundwater sampling results indicated the presence of low-level cross-gradient and upgradient contamination that the Phase II RI report attributed to multiple sources in the vicinity of Building 1079. It was reported that Building 1079 had an oil/water separator (OWS) formerly located at the southeast corner of the building. BTEX constituents were not as prevalent in the samples collected in the southern portion of SS-61; however, low concentrations of chloroform, 1,2-DCA and TCE were detected in samples collected from the eastern and western boundaries. The Phase II report attributed these solvents to likely released cleaning fluids used in aircraft maintenance in the area. The Phase II RI report presented the extent of contamination, shown on Figure 3, and on Figure 5-6 included in Appendix A. Benzene and the other VOCs were evaluated as part of the human health and screening-level ecological risk assessments. Based in the results, no significant risk to human or ecological receptors was found and the Phase II RI recommended NFA.

3 NATURAL ATTENUATION

As defined by the USEPA, Natural Attenuation (NA) is the physical, chemical, and biological processes that, under favorable conditions, act to reduce the mass, toxicity, mobility, volume, or concentrations of contaminants in soil and groundwater (EPA, September 1998). The processes that affect natural attenuation include advection, dispersion, sorption, volatilization, and biodegradation of contaminants. Parameters and field activities conducted under this Work Plan will be concerned with the natural biodegradation of the contaminants. Other mechanisms such as sorption, advection, etc., will be investigated during the FS.

3.1 Biotic Processes

Natural biotic mechanisms that affect contaminants include the mineralization of contaminants or the substitution of various biologic media by metabolic processes. Organic constituents are biodegraded by indigenous microorganisms in the subsurface. During biodegradation, dissolved contaminants in the groundwater are ultimately metabolized into innocuous byproducts such as carbon dioxide, methane, and water.

3.1.1 Aerobic Biodegradation

At SS-61, the predominant contaminants are BTEX constituents. Direct biological degradation is the most important destructive process for BTEX constituents. They are very readily degraded under aerobic conditions until available oxygen is depleted. Mineralization of the BTEX constituents to carbon dioxide and water involves the use of oxygen as a co-substrate in the initial stages of degradation and as an electron acceptor in the later stages.

A way to estimate the potential for natural biodegradation of BTEX constituents in groundwater is the relation of dissolved oxygen (DO) concentrations and BTEX concentrations. A reduction in the DO within the existing BTEX plume is a strong indication that indigenous bacteria are established and actively degrading the BTEX. In general, the concentrations of DO within the plume will be lower than the background concentrations.

3.1.2 Anaerobic Biodegradation

BTEX constituents are biodegraded under anaerobic conditions once DO has been depleted. Benzene is more easily degraded under methanogenic conditions. It has been shown to degrade under sulfate-reducing conditions but not very readily under denitrifying conditions. This is the opposite of ethylbenzene, which appears to degrade anaerobically only under nitrate-reducing conditions.

Chlorinated VOCs, such as 1,2-DCA and TCE, are biodegraded under natural conditions via reductive dechlorination. Reductive dechlorination is the most important process for the natural biodegradation of the more highly chlorinated contaminants. The chlorinated hydrocarbon is used as an electron acceptor rather than a carbon source. The chlorine atom is removed from the contaminant molecule and replaced by a hydrogen atom. Of the chlorinated contaminants detected at SS-61, TCE is the most susceptible to reductive dechlorination because it is the most oxidized. Conversely, vinyl chloride is the least susceptible to reductive dechlorination because it is the least oxidized. Biodegradation of chlorinated contaminants under this mechanism is an electron-donor-limited process.

3.1.3 Cometabolism

Cometabolism is the catalyzed degradation of a contaminant by an enzyme or cofactor that is produced by the organism for other purposes; however, there is no benefit to the microorganism (EPA, September 1998). Cometabolism is best seen under aerobic conditions, although it can potentially occur under anaerobic conditions. The rate of cometabolism increases as the degree of dechlorination decreases. Chlorinated contaminants are usually only partially transformed during cometabolic processes, with additional degradation generally required to complete the transformation.

Cometabolism has been shown to occur where petroleum and chlorinated constituents are present in the groundwater. Where BTEX plumes overlay chlorinated plumes, a degradation mechanism of the chlorinated contaminants is by enzymatic activity using BTEX or another substrate to fulfill the bacteria's energy requirement. This is shown by low concentration levels of chlorinated hydrocarbons in the center of the BTEX plume and increased concentrations outward toward the edges of the BTEX plume. Concentrations of chloride will be higher near the center of the BTEX plume and decrease toward the edges of the BTEX plume.

3.2 Natural Attenuation Parameters

The natural geochemistry of an aquifer plays an important role in the biodegradation of contaminants. Conversely, the biodegradation of petroleum and chlorinated contaminants can measurably change the geochemistry of the groundwater in the affected area. By quantifying these changes, NA, also called intrinsic remediation, can be assessed and its importance at SS-61 can be evaluated.

3.2.1 pH

The presence and activity of microbial populations in groundwater is affected by pH. Methanogens are especially influenced by pH. The optimal pH range for aerobic degradation is between 6 and 8 S.U. For reductive dechlorination via anaerobic degradation, the optimal pH range is greater than 5 S.U. and less than 7 S.U.

3.2.2 Temperature

Temperature of groundwater directly affects the solubility of dissolved gasses and other geochemical species. Microbial activity is also affected by temperature. At groundwater temperatures above 20° C, biochemical processes are accelerated. The lower the temperature, the less likely biological activity and biodegradation is occurring.

3.2.3 Dissolved Oxygen

DO is the most thermodynamically favored electron acceptor used in the biodegradation of fuel hydrocarbons. DO concentrations are used to estimate the mass of BTEX constituents that can be biodegraded by aerobic conditions. Anaerobic bacteria cannot generally function at DO rates of 0.5 mg/L or higher.

3.2.4 Nitrate

Once DO concentrations have been depleted, nitrate can be used as an electron acceptor for the anaerobic biodegradation of BTEX contaminants by denitrification. Nitrate may be used as an electron acceptor for anaerobic biodegradation of chlorinated VOCs by way of dechlorination. Nitrate concentrations in the impacted portion of the aquifer should be less than 1.0 mg/L for reductive dechlorination. At higher concentrations, nitrate may compete with the reductive pathway.

3.2.5 Ferrous Iron

In some cases, ferrous iron (Fe^{2+}) can be used, under anaerobic processes, as an electron acceptor for the degradation of petroleum constituents. At concentrations of Fe^{2+} greater than 1.0 mg/L, the reductive pathway is possible for chlorinated hydrocarbons.

3.2.6 Sulfate

After DO, nitrate, and available ferrous iron have been depleted, sulfate may be used as an electron acceptor. This anaerobic process is termed sulfate reduction and results in the production of sulfide. At concentrations of sulfate greater than 20 mg/L, there may be competitive exclusion of dechlorination; however, reductive dechlorination can still occur. Sulfate reducing microorganisms are very pH and temperature sensitive.

3.2.7 Methane

Methanogenesis generally occurs after oxygen, nitrate, ferrous iron, and sulfate have been depleted. The presence of methane in groundwater is indicative of strong reducing conditions. During methanogenesis, carbon dioxide is used as the electron acceptor.

3.2.8 Alkalinity

In zones of increased microbial activity, there is an increase in alkalinity that results from the dissolution of rock. This dissolution of rock is driven by the carbon dioxide produced by the microorganism's metabolism of the contaminants. Alkalinity maintains the pH of groundwater because it buffers against acids generated during both aerobic and anaerobic biodegradation. Increases in alkalinity due to increased microbial activity are generally taken as twice the normal background.

3.2.9 Chloride

Chloride is the halogen of greatest abundance in natural waters. The chloride form (Cl^-) is the only form of major significance in groundwater. Chloride ions do not generally enter into redox reactions, form no important solute complexes with other ions unless the concentration is extremely high, do not form salts of low solubility, are not significantly absorbed onto mineral surfaces, and are not very important substrates for biochemical processes. However, during biological degradation of chlorinated organics, Cl^- is released into the groundwater. Therefore, Cl^- is a good tracer element to estimate biological activity.

3.2.10 Oxidation Reduction Potential

Oxidation Reduction Potential (ORP) in groundwater is the measure of electron activity. Since redox reactions in groundwater are usually biologically mediated, the ORP depends on and influences the rates of biodegradation. ORP is one of the best indicators of aerobic/anaerobic conditions. Theoretically, aerobic degradation occurs at a highly positive redox potential, indicating highly oxidizing conditions, and anaerobic degradation occurs at a strongly negative redox potential, indicating highly reductive conditions. This is presented in Table 1.

4 SAMPLING AND ANALYSIS

Sampling protocols and analyses conducted under this FS Work Plan will be performed in accordance with the *Basewide Quality Assurance Project Plan* (QAPP), Bhate, October 2003, and the *Quality Assurance Project Plan Addendum*, Bhate, November 2003, included as Appendix B.

4.1 Groundwater Sampling

Low flow or low stress techniques will be used during purging activities for sampling to minimize the disturbance of the water column and generation of investigation derived waste (IDW).

4.1.1 Monitoring Well Locations for Sampling

Shown on Figure 4 are the monitoring wells to be sampled under this Work Plan. Monitoring wells were selected to represent groundwater conditions and were based on the most current potentiometric information for the site as presented on Figure 5, past potentiometric information as shown on Figure 3-3, Foster Wheeler, included in Appendix A and the BTEX concentrations depicted on Figure 5-6, Foster Wheeler, also included in Appendix A. Monitoring wells included in the sampling scheme are:

- The three monitoring wells located inside the plume: MW-03, MW-04 and MW-06
- A monitoring well located outside the plume area to provide background information: MW-01
- A monitoring well located downgradient/side gradient on the periphery of the plume: MW-08.

4.1.2 Groundwater Sampling Schedule

Sampling of groundwater at SS-61 will be conducted during the current quarterly monitoring being conducted at HAFB by Bhate personnel. Monitoring wells will be sampled quarterly for the one year with the first quarter for fiscal year 2004 ending at the end of December 2003. Quarterly sampling will be conducted by the ends of March 2004, June 2004, and September 2004, respectively. Well MW-03 will be monitored weekly for the presence of free product for a period of one year. Gauging of MW-03 will commence when the quarterly sampling at SS-61 begins.

4.1.3 Water Levels

Immediately prior to sampling, a complete round of groundwater level measurements will be collected from the monitoring wells at SS-61 concurrently with the monitoring wells in the quarterly monitoring program. The water level, time, date, well identification and weather conditions at the time of measurement will be permanently recorded in the field logbook.

4.1.4 Groundwater Analytical Methods

Groundwater samples collected from the five monitoring wells specified in Section 4.1.1 will be analyzed for VOCs and various NA parameters. The specific suite of analyses is based on the contaminants present in site groundwater and the geochemical parameters required to evaluate the occurrence of NA processes. The analyses shall consist of field and laboratory measurements. The following is a list of parameters that will be analyzed in the field at the time of groundwater sample collection:

- Temperature
- pH
- Dissolved Oxygen
- Conductivity
- ORP
- Nitrate per Hach Method 8039
- Ferrous iron per Hach Method 8146
- Total iron per Hach Method 8008
- Sulfate per Hach Method 8051

Temperature, pH, dissolved oxygen, conductivity and ORP will be measured in the field using a multi-parameter sonde and a flow-through cell. Nitrate, ferrous iron, and sulfate will be measured in the field using a HACH Colorimeter and associated reagents.

Groundwater samples will also be collected for analyses by ELAB of Tennessee, LLC, Nashville, Tennessee, with a normal turnaround time of 14 days. The laboratory analysis will be conducted using the laboratory's standard turnaround time or a turnaround not to exceed 21 calendar days, whichever is less. The following is a list of parameters that will be analyzed by the laboratory:

- VOCs per EPA Method 8260B, including trimethylbenzenes.

- TDS per EPA Method 160.1
- Methane, ethane, and ethene per EPA Method RSK 175
- Chloride per EPA Method 300.0
- Total Organic Carbon (TOC) per EPA Method 9060
- Alkalinity per EPA Method 310.1

4.2 Soil Boring Samples

In the area of DP-40, collected at the southwest corner of Building 1079 during the Phase II RI, four soil boring samples will be collected. To delineate the limited petroleum contamination indicated at this location, samples will be collected 10 feet laterally to the north, south, east, and west of the original boring location (Figure 6). Since the contamination was limited to the first 2 feet, two samples will be collected from each location using hand auger methods. Samples will be collected from 0' to 1' and 1' to 2', and analyzed for TPH by Massachusetts TPH Method and for TOC by EPA Method 9060.

The original survey of DP-40 will be used to verify its position. The positions of the four additional soil borings will be located using HAFB's Global Positioning System (GPS) equipment.

4.3 Sample Identification

Each environmental sample collected will be identified on the sample label and COC records, regardless of type. USACE duplicates will be paired with another random sample and will be blind samples. The duplicate samples will appear in sequence with the regular samples. The identifier nomenclature will be as follows:

####AA##BB

####	Site alpha-numeric identifier, SS61
AA	Sample type identifier; SB = Soil boring sample, MW = Monitoring well sample
##	Soil boring depth, or
##	Monitoring well number
BB	reserved for QA sample identifiers; FD = field duplicate, MS = matrix spike, MSD = matrix spike duplicate

4.4 Standard Operating Procedures

Applicable Basewide Standard Operating Procedures (SOPs) for completing the field activities are located in the Basewide QAPP (Bhate, October 2003) and the addendum included in Appendix B.

5 HEALTH AND SAFETY REQUIREMENTS

Project Health and Safety practices will adhere to the Draft Basewide HASP Revision 1 (Bhate, October 2003) and the Activity Hazards Analysis (AHA) attached as Appendix C. It is anticipated that no greater than modified Level D personal protection equipment (PPE) will be required to complete the sampling activities at SS-61. This includes: OSHA approved safety shoes, ANSI approved safety glasses (Z87.1) and hard hat (Z89.1-1997: Type I), sleeved shirt and long pants, hearing protection, as required, and latex/vinyl or nitrile gloves during sampling.

This page intentionally blank.

6 INVESTIGATION-DERIVED WASTE MANAGEMENT

IDW will be managed and characterized according to the Basewide QAPP (Bhate, October 2003) and the addendum included in Appendix B. Whenever possible, waste minimization techniques will be used to reduce the amount of IDW. Wastes generated during this field program will be characterized using the analytical results available from samples collected.

6.1 Decontamination and Purge Water

Sampling equipment will be decontaminated in accordance with the Basewide QAPP (Bhate, October 2003) and the addendum included in Appendix B. Decontamination water will be discharged to the HAFB wastewater treatment plant as directed by HAFB personnel. Purge water will be collected and allowed to evaporate or discharged to the HAFB wastewater treatment plant as directed by HAFB personnel.

6.2 Personal Protective Equipment and Disposable Sampling Equipment

PPE and other site non-hazardous debris/waste shall be placed in plastic trash bags and disposed in a standard trash dumpster or receptacle as directed by HAFB personnel.

This page intentionally blank.

7 SAMPLE DOCUMENTATION

Sample documentation, identification and tracking will adhere to the prescribed methods found in the Basewide QAPP (Bhate, October 2003) and the addendum included in Appendix B. Sampling activities will include documentation of significant activities, significant occurrences and sample identification information. At a minimum, field log books will be utilized to record dates and times, sampling protocols, project numbers, and sampler's name. Other pertinent information will include COC numbers and air-bill tracking number. COC forms will be completed and included with each sample shipment.

This page intentionally blank.

8 DATA REPORTING

Data obtained during the field activities conducted under this Work Plan will be reported according to the Basewide QAPP (Bhate, October 2003) and the addendum included in Appendix B. Sampling results will be tabulated and summarized in the Feasibility Study Report. An Environmental Restoration Program Information Management System (ERPIMS) submittal is required for this project.

This page intentionally blank.

9 ORGANIZATION AND SCHEDULE

During the field operations at the SS-61 site, *Mr. Jerry Pelfry* will serve as the Bhate Site Manager overseeing and directing the activities. Mr. Pelfry will also provide on-site management of sub-contractors for the project. *Mr. Frank Gardner* is the Bhate Program Manager and will ensure required project documents, contractual agreements and other program tasks are completed.

Sampling activities for natural attenuation parameters will be conducted according to the schedule of the current quarterly sampling on-going at HAFB.

This page intentionally blank.

10 REFERENCES

Air Force Center for Environmental Excellence, *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation for Fuel Contamination Dissolved in Groundwater*, March 1999.

Bhate Environmental Associates, Inc., *Draft Basewide Health and Safety Plan, Revision 1,* October 2003.

Bhate Environmental Associates, Inc., *Basewide Quality Assurance Project Plan,* October 2003.

Cyto Culture Environmental Biotechnology Website, *Important New Site Remediation Protocol: Monitored Natural Attenuation of Contaminated Groundwater Technical Update*, www.cytoclture.com/MNA.htm.

Environmental Protection Agency, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* Interim Final, EPA/540/G-89/004, October 1988.

Environmental Protection Agency, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water,* EPA/600/R-98/128, September 1998.

Foster Wheeler Environmental Corporation, *Work Plan Addendum Field Sampling and Analysis Plan and Quality Assurance Plan for the Remedial Investigation of SS-61*, March 1999.

Foster Wheeler Environmental Corporation, *Final Remedial Investigation Report for Spill Site 61*, August 1999.

Foster Wheeler Environmental Corporation, *Final Phase II Remedial Investigation Report for SS-61 - Spill Site 61*, December 2000.

HACH Company, *DR/820-DR/850-DR/890 Datalogging Colorimeter Handbook*, 1999.

Kallestad, Thor, Sojourn Environmental Co. Website, November 1999, www.sojournweb.com/nas.htm.

New Mexico Environment Department, Hazardous Waste Bureau and Ground water Quality Bureau Voluntary Remediation Program, *Technical Background Document for the Development of Soil Screening Levels*, December 2000, Revised January 2001.

U. S. Environmental Protection Agency, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water,* EPA/600/R-98/128, September 1998.

This page intentionally blank.

FIGURES