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DRAFT

**Confirmation Sampling and Analysis Plan
for Building 457 Area**



**Eaker Air Force Base
Blytheville, Arkansas**

Prepared For

**Air Force Center for Environmental Excellence
Technology Transfer Division
Brooks Air Force Base
San Antonio, Texas**

and

**Air Force Base Conversion Agency/DA
Eaker Air Force Base, Arkansas**

May 1998

 **PARSONS
PARSONS ENGINEERING SCIENCE, INC.**

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DRAFT

**CONFIRMATION SAMPLING AND ANALYSIS PLAN
FOR BUILDING 457 AREA**

**EAKER AIR FORCE BASE
BLYTHEVILLE, ARKANSAS**

Prepared for:

**Air Force Center for Environmental Excellence
Brooks Air Force Base, Texas**

and

**Eaker AFBCA
Eaker Air Force Base, Arkansas**

May 1998

Prepared by:

**Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290**

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ACRONYMS AND ABBREVIATIONS

°C	degrees centigrade
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
ACL	alternative corrective action limit
ADEQ	Arkansas Department of Environmental Quality
AFB	Air Force Base
AFBCA	Air Force Base Conversion Agency
AFCEE	Air Force Center for Environmental Excellence
ASTM	American Society for Testing and Materials
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAL	corrective action limit
COPC	chemical of primary concern
DO	dissolved oxygen
ft/ft	foot per foot
HNUS	Haliburton NUS
IDW	investigation-derived waste
MCL	maximum contaminant levels
mg/kg	milligrams per kilogram
MP	monitoring point
NFRAP	No Further Response Action Planned
OD	outside diameter
ORP	oxidation/reduction potential
PAH	polynuclear aromatic hydrocarbon
Parsons ES	Parsons Engineering Science, Inc.
PID	photoionization detector
ppmv	parts per million, by volume
QA/QC	quality assurance/quality control
RBCA	risk-based corrective action
RBSL	risk-based screening level
redox	reduction oxidation
RNA	remediation by natural attenuation
SAP	Sampling and Analysis Plan
SSL	soil screening level
SSTL	site-specific target levels
TEPH	total extractable petroleum hydrocarbons
TVH	total volatile hydrocarbons
TVHA	total volatile hydrocarbon analyzer
USEPA	US Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound
VW	vent well

SECTION 1

INTRODUCTION

This confirmation sampling and analysis plan (SAP) for the Building 457 Area, Eaker Air Force Base (AFB), Arkansas has been prepared by Parsons Engineering Science, Inc. (Parsons ES) for submittal to the Arkansas Department of Environmental Quality (ADEQ); the US Air Force Center for Environmental Excellence (AFCEE), Brooks AFB, Texas; and Eaker Air Force Base Conversion Agency (AFBCA), Arkansas. ADEQ provides oversight of underground storage tank (UST) work at Eaker AFB. The SAP is intended to guide soil and groundwater sampling at the Building 457 Area to document the effectiveness of bioventing for the remediation of petroleum-hydrocarbon-contaminated soils and to provide data for a risk-based assessment of contaminants remaining in site soils and groundwater. The Building 457 Area is the location of a release of heating oil from a former UST and/or associated product piping.

In 1995, the Building 457 Area was selected as a pilot-test site for the AFCEE Extended Bioventing Program. This ongoing program involves more than 50 *in situ* bioventing sites at 32 military installations nationwide and provides funding for pilot- and full-scale bioventing system installation, extended operation of installed bioventing systems, and completion of confirmatory soil sampling and site closure documents, if extended bioventing testing results indicate adequate site remediation has been achieved.

Tank removal soil sampling results indicated that total petroleum hydrocarbon (TPH) concentrations were present in saturated soils at levels that exceeded the former ADEQ (formerly the Arkansas Department of Pollution Control and the Environment) corrective action limit (CAL) of 100 milligrams per kilogram (mg/kg) (Ogden Environmental and Energy Service, 1995). Therefore, to further investigate and address potential vadose-zone petroleum contamination at the Building 457 Area, a pilot-scale bioventing system was installed and initial pilot testing was performed in March/April 1996 (Parsons ES, 1996). The purpose of the pilot test was to evaluate the effectiveness of bioventing in remediating unsaturated soils contaminated with petroleum hydrocarbons thought to have resulted from heating oil released from the former UST. Following initial testing, the bioventing system was optimized, and system operation was continued for 1 year. One-year testing was performed in May/June 1997. Based on the results of the extended bioventing test, *in situ* bioventing appears to have reduced petroleum hydrocarbon contamination in vadose zone soils sufficiently to meet target risk-based concentrations outlined in the American Society for Testing and Materials (ASTM, 1995) *Standard Guide for Risk-Based Corrective Action (RBCA) Applied at Petroleum Release Sites*.

The objective of the confirmation sampling described in this SAP is to document the effectiveness of soil remediation at the Building 457 Area and to demonstrate compliance with ASTM (1995) RBCA guidance for site closure. Currently, clean-up requirements in Arkansas are site-specific, after consideration of risk according to the ASTM or other risk assessment protocol, until ADEQ implements their own risk-based guidance, which will be similar to the ASTM RBCA document (Atchley, 1998). The proposed confirmation sampling described in Section 4 targets vadose- and saturated-zone soils, and groundwater in the vicinity of the former UST. Soil and groundwater data will be used to prepare a streamlined risk-based assessment of remaining petroleum hydrocarbon contamination at the site, and groundwater data also will be used to evaluate the rate of natural chemical attenuation occurring in groundwater. The sampling effort is being performed as part of the AFCEE Extended Bioventing project. It is anticipated that analytical results will support an Air Force no-further-response-action-planned (NFRAP) decision, and that ADEQ will grant site closure.

This SAP consists of nine sections, including this introduction. Section 2 includes a site description, site history, and summaries of previous investigation and remediation activities. Section 3 summarizes current ASTM risk-based screening levels (RBSLs) and provides a brief discussion of anticipated ADEQ RBCA requirements. A detailed SAP is presented in Section 4. Analytical results will be presented in a closure sampling report as described in Section 5. Section 6 lists Eaker AFBCA support requirements, and Section 7 presents the proposed project schedule. Air Force, regulatory, and contractor points of contact are provided in Section 8, and the cited references are provided in Section 9.

SECTION 2

SITE DESCRIPTION

2.1 SITE LOCATION AND HISTORY

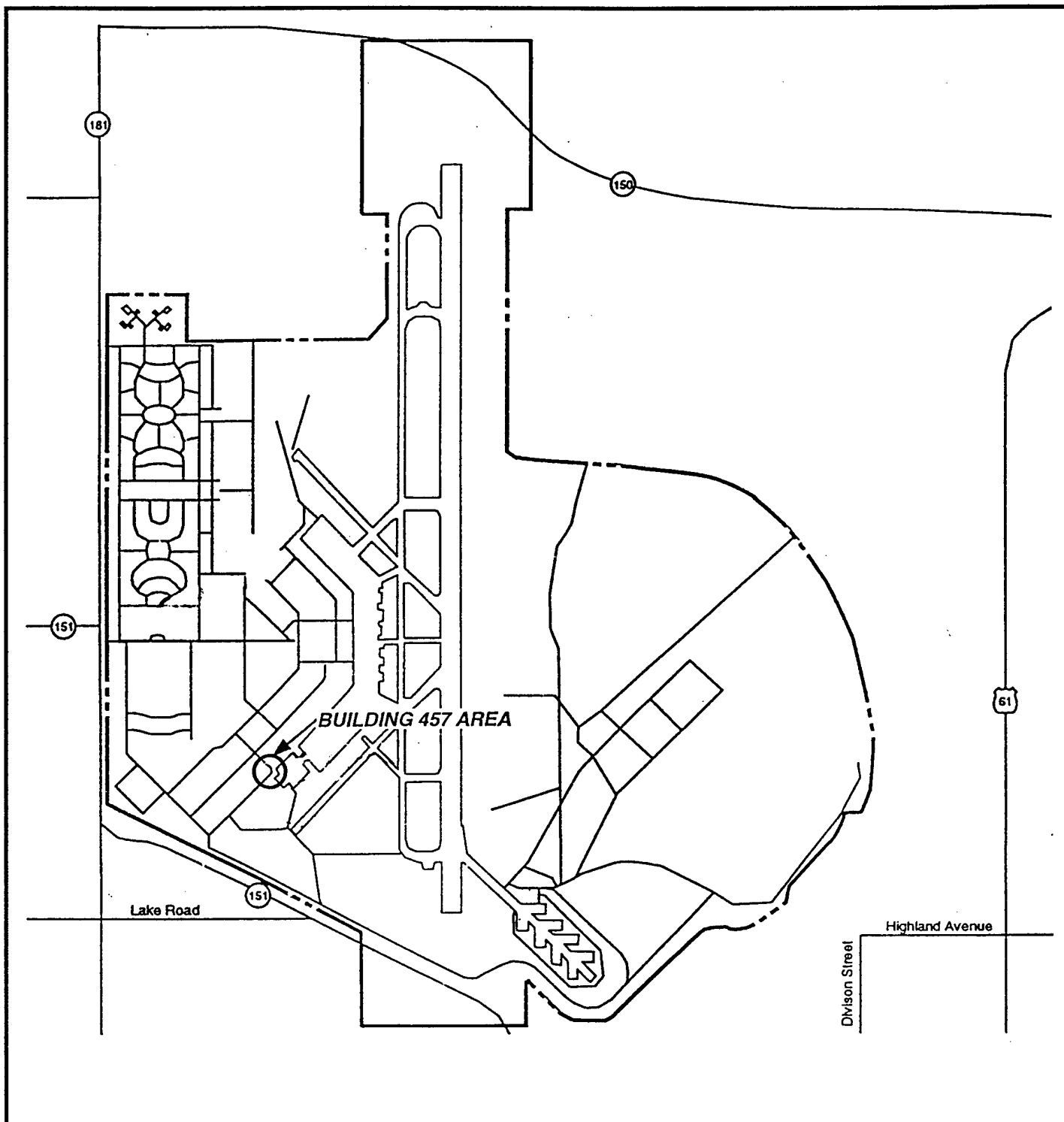
The Building 457 Area is located in the south-central portion of Eaker AFB, Blytheville, Arkansas (Figure 2.1). The layout of the Building 457 Area is shown on Figure 2.2. The site is bordered by Building 457 on the east, the Building 410 Area on the southwest, vacant office buildings on the west-northwest, and a grassy, open area on the northeast. A shallow storm water drainage ditch is located between Building 457 and the former tank area.

Building 457 was formerly used as a fuel cell maintenance and repair shop (US Air Force, 1995). A 20,074-gallon steel UST used to store heating oil, located west of Building 457, was removed in August 1994 by Ogden Environmental and Energy Service (Ogden, 1995). Analytical results for soil samples taken from the sidewalls of the excavation pit indicated that all contaminated soil had not been removed (US Air Force, 1995). After the tank was removed, the excavation was backfilled with landfarm-treated soil and the ground surface was seeded with grass. Building 457 is currently vacant and inactive.

Building 410 area, located immediately south of building 457, is the former location of twelve 25,000-gallon USTs. Three of the USTs formerly contained fuel oil, one contained MOGAS, and eight contained AVGAS. The fuel oil and MOGAS tanks were removed in 1988, however, no formal documentation was performed. A Corrective Measures Study (CMS), to be conducted by a separate contractor during 1998, will address these four USTs. A No-Further-Remedial-Action-Required letter for the remaining USTs was delivered to the Base in January 1997.

2.2 SITE GEOLOGY, HYDROGEOLOGY, AND HYDROLOGY

Unsaturated soils at the site consist of approximately 5 to 10 feet of silty clay, and clayey silt with traces of sand. In the vicinity of the former UST, landfarmed fill material consists of a mixture of clay, silt, and sand. The surface cover consists of grass. There are no permanent surface water bodies in the immediate vicinity of Building 457. The only surface water feature near the site is the shallow drainage ditch that is located between Building 457 and the former tank location. The ditch elevation is approximately 3 feet below the ground surface in the vicinity of the vapor monitoring points (MPs) and former tank area, and contains water only after precipitation events. There is no apparent hydrologic connection between the shallow groundwater and the ditch. Surface drainage at the site is toward the south.



--- Base Boundary



FIGURE 2.1
SITE LOCATION WITH
RESPECT TO EAKER AFB

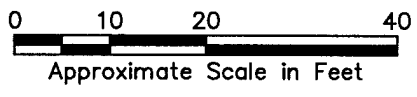
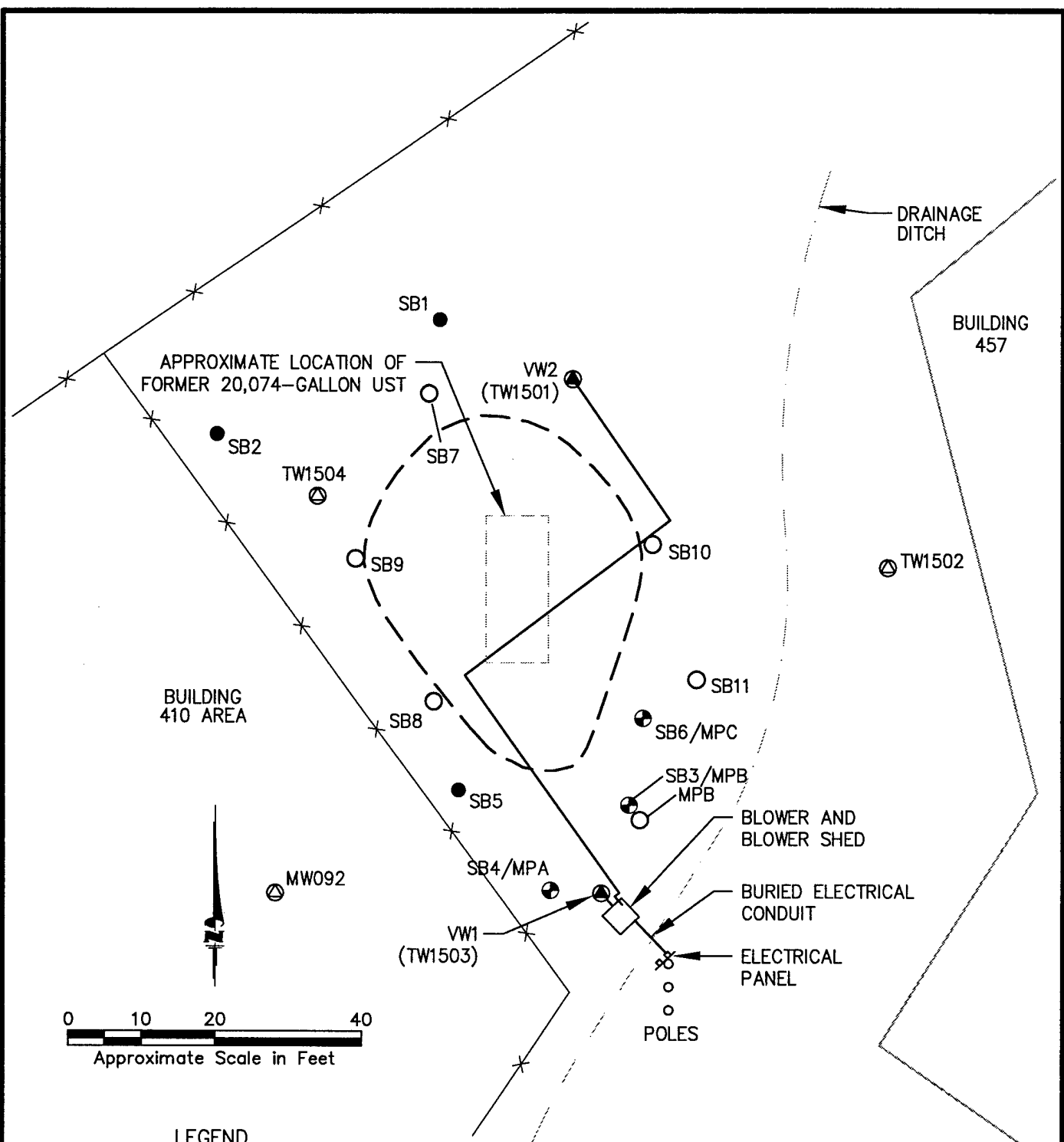
Eaker AFB, Arkansas

PARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

Source: US Air Force, 1995.

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LEGEND

- MPA ● VAPOR MONITORING POINT
- VW1 ⊕ AIR INJECTION VENT WELL/
GROUNDWATER MONITORING WELL
- TW1502 ⊕ GROUNDWATER MONITORING WELL
- SB5 ● GEOPROBE BORING (1996)
- SB11 ○ GEOPROBE BORING (1997)
- 2" PVC AIR INJECTION PIPE (BURIED)
- - - APPROXIMATE LIMITS OF
EXCAVATION
- x- CHAIN LINK FENCE

FIGURE 2.2

SITE LAYOUT

Building 457 Area
Eaker AFB, Arkansas

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

At the Building 457 Area, shallow groundwater occurs under water table (unconfined) conditions. In April 1996, static groundwater was measured in VW1 (TW1503) and in VW2 (TW1501) at depths of approximately 9 and 10 feet below ground surface (bgs), respectively, prior to air injection bioventing. In June 1997, the surface of the water table was measured at between 8 and 9 feet bgs. During the April 1996 and June 1997 field events, perched groundwater was purged from MPA, which is screened at a depth of approximately 5.5 to 6 feet bgs. Groundwater flow direction has not been determined; however, groundwater has been reported to flow northwesterly or southwesterly, depending on seasonal fluctuations (US Air Force, 1995).

2.3 PREVIOUS INVESTIGATIONS

2.3.1 1994 Tank Removal

In August 1994, Ogden (1995) performed tank removal activities at the Building 457 Area. A total of four soil samples for analysis of total extractable petroleum hydrocarbons (TEPH) were collected from the excavation side walls at a depth of 12 feet bgs, corresponding to the bottom of the excavation. Although the excavation was expanded in an effort to remove the entire volume of petroleum-impacted soil, analytical results indicated that TEPH concentrations exceeded 100 mg/kg in soil samples collected from the east and south walls. TEPH concentrations of 1,400 mg/kg and 4,700 mg/kg, were detected in the samples collected from the east and south sidewalls, respectively. TEPH were not detected in the samples collected from the north and west sidewalls. Soil analytical results from the tank removal (1994) and subsequent investigations are presented in Table 2.1, and the estimated extent of soil contamination at the Building 457 Area is shown on Figure 2.3.

2.3.2 1995 Initial Site Investigation

In August 1995, following removal of the UST, Haliburton NUS (US Air Force, 1995) performed an initial site characterization. Activities included installation of four groundwater monitoring wells (TW1501 through TW1504) in the vicinity of the former UST (Figure 2.2) and collection of soil samples at these locations. One groundwater sample was collected from monitoring well TW1503, which is located near the majority of the residual contamination. Soil and groundwater samples were analyzed for TEPH by United States Environmental Protection Agency (USEPA) Method SW8015M (modified for diesel-range organics). Findings indicated relatively insignificant TEPH concentrations in soil and groundwater. Soil and groundwater analytical results from the 1995 HNUS investigation are included on Tables 2.1 and 2.2, respectively.

2.3.3 Parsons ES Investigation and Bioventing Pilot Test

In March/April 1996, Parsons ES (1996) installed a pilot-scale bioventing system at the Building 457 Area to assess the potential of air injection bioventing for remediating the hydrocarbon contamination identified in vadose zone soils. The primary objectives of the pilot test were to: 1) assess the potential for supplying oxygen throughout the contaminated soil interval; 2) determine the rate at which indigenous microorganisms would degrade fuel when supplied with oxygen-rich soil gas; 3) evaluate the potential

TABLE 2.1
SOIL LABORATORY ANALYTICAL RESULTS
BUILDING 457
EAKER AFB, ARKANSAS

Parameter (Units)	Investigation		Tank Removal		Site Investigation				Initial Bioventing				1-Year Bioventing				
	Sampling Location	Pit (N)	Pit (W)	Pit (S)	Pit (E)	TW1501	TW1502	TW1503	TW1504	MPA	MPB	MPC	MPB	SB8	SB8	SB11	SB11
	Sampling Depth	12'	12'	12'	12'	2'-3'	6'-6.5'	5'-5.5'	5'-5.5'	5'-6.5'	5'-6'	6'-7'	5'-6'	11'-12.5'	12.5'-13.5'	10'-11'	11'-11.5'
	Date Sampled	8/2/94	8/2/94	8/2/94	8/2/94	8/26/95	8/28/95	8/27/95	8/27/95	3/19/96	3/18/96	3/19/96	6/16/97	6/16/97	6/16/97	6/16/97	6/16/97
USEPA Method SW8015 (mg/kg) ^a		<3.2 ^{c/}	<3.1	4,700	1,400	<3.9	4.8	<4.0	<4.0	1,900	5,000	290	4,720	d/			
Total Extractable Petroleum Hydrocarbons (TEPH) ^{b/}																	
USEPA Method SW8020 (µg/kg) ^{a/}																	
Volatile Aromatic Hydrocarbons																	
Benzene										<2.4	<230	<0.4	<25		<1.0		<5.0
Toluene										<2.4	<230	<0.4	<50		<2.0		<10.0
Ethylbenzene										<2.4	<230	<0.4	<50		<2.0		<10.0
Total Xylenes (m,p,o)										6.8	3,400	<0.4	203		<2.0		<10.0
1,3,5-TMB ^{d/}										62	2,500	0.9					
1,2,4-TMB										89	3,200	5.1					
1,2,3-TMB										220	1,500	6.1					
1,2,3,4-TEMB ^{e/}										1,300	42,000	25					
USEPA Method SW8310 (µg/kg)																	
Polynuclear Aromatic Hydrocarbons																	
Naphthalene																	
Acenaphthylene																	
Acenaphthene																	
Fluorene																	
Phenanthrene																	
Anthracene																	
Fluoranthene																	
Pyrene																	
Benzo(a)anthracene																	
Chrysene																	
Benzo(b)fluoranthene																	
Benzo(k)fluoranthene																	
Benzo(a)pyrene																	
Dibenzo(a,h)anthracene																	
Benzo(g,h,i)perylene																	
Indeno(1,2,3-cd)pyrene																	

Note: Tank removal sampling (1994) was performed by Ogden Environmental and Energy Service. August 1995 sampling was performed by Halliburton NUS. March 1996 and June 1997 sampling was performed by Parsons ES.

^{a/} USEPA = United States Environmental Protection Agency. mg/kg = milligrams per kilogram.

^{b/} Tank Removal: TEPH corresponds to carbon chain C6-C32. Investigation: Carbon chain unknown. Bioventing: TEPH corresponds to carbon chain C11-C28.

^{c/} < = compound analyzed for, but not detected. Number shown represents the sample quantitation limit.

^{d/} ---- = not analyzed.

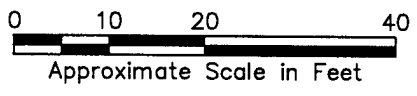
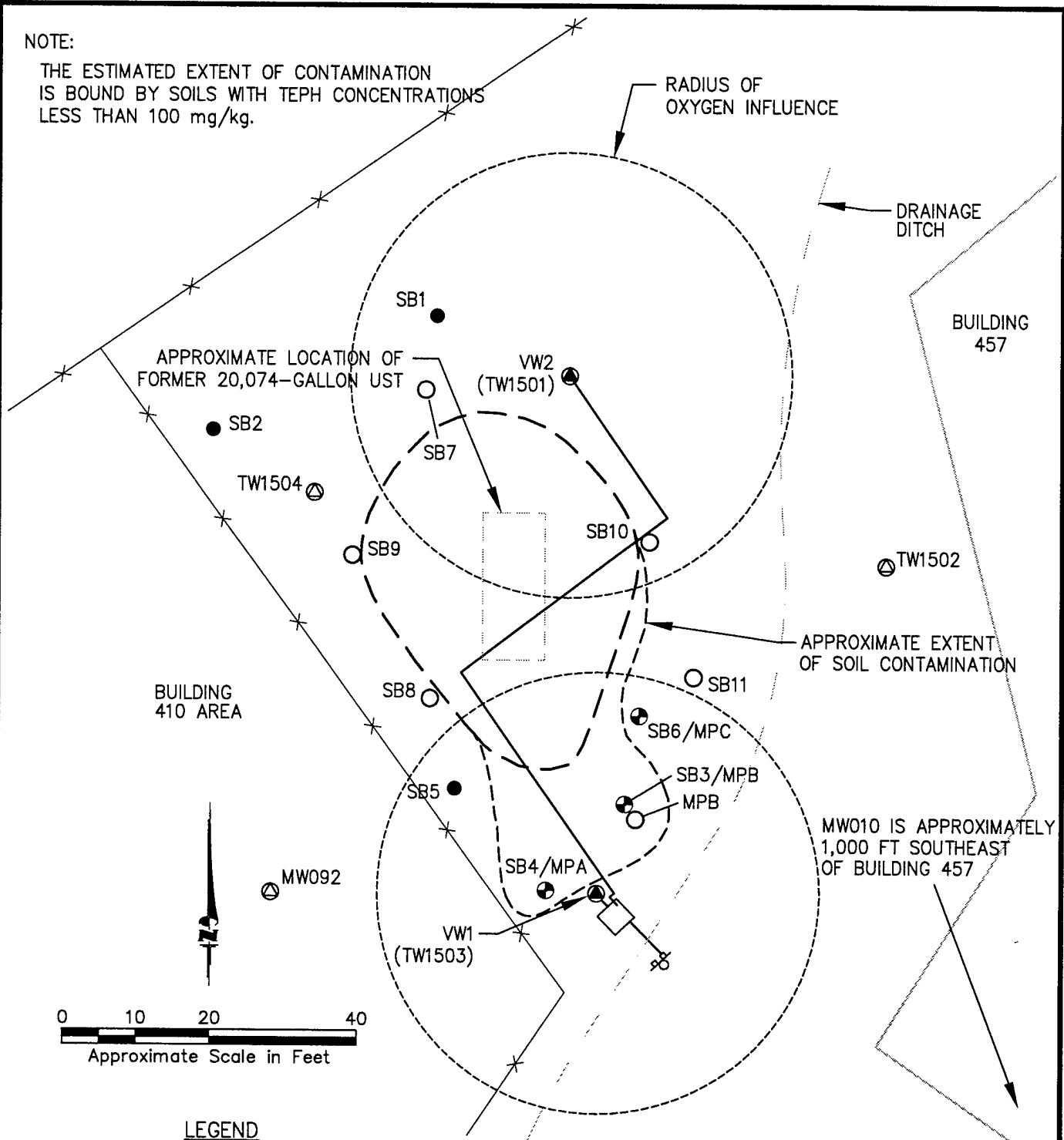
^{e/} µg/kg = micrograms per kilogram.

^{f/} TMB = trimethylbenzene.

^{g/} TEMB = tetramethylbenzene.

NOTE:

THE ESTIMATED EXTENT OF CONTAMINATION IS BOUND BY SOILS WITH TEPH CONCENTRATIONS LESS THAN 100 mg/kg.



LEGEND

- MPA ● VAPOR MONITORING POINT (1996)
- VW1 ● AIR INJECTION VENT WELL/
GROUNDWATER MONITORING WELL
- TW1502 ● GROUNDWATER MONITORING WELL
- SB5 ● GEOPROBE BORING (1996)
- SB11 ○ GEOPROBE BORING (1997)
- 2" PVC AIR INJECTION PIPE (BURIED)
- - - APPROXIMATE LIMITS OF EXCAVATION

FIGURE 2.3
ESTIMATED EXTENT OF SOIL CONTAMINATION
 Building 457 Area
 Eaker AFB, Arkansas
PARSONS ENGINEERING SCIENCE, INC.
 Denver, Colorado

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SOURCES: US AIR FORCE, 1995; PARSONS ES, 1996 & 1997

TABLE 2.2
GROUNDWATER ANALYTICAL DATA SUMMARY
BUILDING 457
EAKER AFB, ARKANSAS

		Well number		
		TW1503	TW1502	TW1504
Parameter (Units)	Date Sampled	8/29/95	6/19/97	6/19/97
USEPA Method SW8015 (mg/L) ^{a/}				
Total Extractable Petroleum Hydrocarbons (TEPH)		1.5	---- ^{b/}	----
USEPA Method SW8020 (µg/L) ^{c/}				
Volatile Aromatic Hydrocarbons				
Benzene		----	< 0.4 ^{d/}	< 0.4
Toluene		----	< 0.4	< 0.4
Chlorobenzene		----	< 0.4	< 0.4
Ethylbenzene		----	< 0.4	< 0.4
Total Xylenes (m,p,o)		----	< 0.4	< 0.4
Total BTEX		----	< 1.6	< 1.6
1,3,5-TMB ^{e/}		----	< 0.4	< 0.4
1,2,4-TMB		----	< 0.4	< 0.4
1,2,3-TMB		----	< 0.4	< 0.4
1,2,3,4-TEMB ^{f/}		----	< 0.5	< 0.5
MTBE ^{g/}		----	< 1.6	< 1.6
USEPA Method SW8310 (µg/L)				
Polynuclear Aromatic Hydrocarbons				
Naphthalene		----	---- ^{h/}	< 18
Acenaphthylene		----	----	< 23
Acenaphthene		----	----	< 18
Fluorene		----	----	< 2.1
Phenanthrene		----	----	< 6.4
Anthracene		----	----	< 6.6
Fluoranthene		----	----	< 2.1
Pyrene		----	----	0.32 J
Benzo(a)anthracene		----	----	0.056 * J, B
Chrysene		----	----	< 1.5
Benzo(b)fluoranthene		----	----	< 0.18
Benzo(k)fluoranthene		----	----	< 0.17
Benzo(a)pyrene		----	----	< 0.23
Dibenzo(a,h)anthracene		----	----	< 0.30
Benzo(g,h,i)perylene		----	----	< 0.76
Indeno(1,2,3-cd)pyrene		----	----	< 0.43

Notes: 1995 sampling was performed by Haliburton NUS (US Air Force, 1996).

* = matrix interferences

J = detected above the method detection limit (MDL) and below the practical quantitation limit.

B = also found in blank

^{a/} mg/L = milligrams per liter.

^{b/} ---- = not analyzed.

^{c/} µg/L = micrograms per liter.

^{d/} < = compound analyzed for, but not detected. Number shown represents the practical quantitation limit.

^{e/} TMB = trimethylbenzene.

^{f/} TEMB = tetramethylbenzene.

^{g/} MTBE = methyl tertiary-butyl ether.

^{h/} Sample jar for well TW1502 was broken during shipment.

for sustaining fuel biodegradation rates until fuel contamination was remediated to concentrations below regulatory standards; and 4) determine design parameters, such as air injection vent well (VW) spacing and air injection flow rates, if it was determined that a full-scale bioventing system was necessary to treat the entire volume of contaminated soils at the Building 457 Area.

Prior to the installation of the bioventing system, six Geoprobe® pushes (SB1 through SB6) were advanced at the site to further define the areal extent of petroleum hydrocarbon contamination in vadoze zone soils (Figure 2.2). The three borings exhibiting vadose zone contamination (SB3, SB4, and SB6) were converted for use as vapor monitoring points (MPB, MPA, and MPC, respectively). A blower unit was installed, and two existing groundwater monitoring wells, TW1501 and TW1503 and TW1501, were plumbed to the blower system using 2-inch diameter PVC pipe, and were designated as air injection vent wells VW1 and VW2, respectively. During installation of the pilot-scale system, soil and soil gas sampling, and respiration and air permeability testing were performed. Based on oxygen influence and air permeability testing performed during installation of the pilot-scale system, the long-term radius of oxygen influence around the VWs was expected to exceed 25 feet at depths to shallow groundwater. From this information, it was determined that the pilot-scale bioventing system was capable of delivering oxygen throughout the contaminated vadose zone, making installation of a larger bioventing system unnecessary. A detailed description of the pilot-scale bioventing system design and initial testing results are provided in the interim pilot test results report prepared by Parsons ES (1996) for this site.

Following completion of pilot-scale system installation and testing, the system was started, optimized, and operated continuously until May 1997. In May, Parsons ES conducted oxygen influence monitoring at the site to confirm that the targeted soil zone was being provided with an adequate supply of oxygen. Following oxygen influence monitoring, the system was shut down for 1 month to allow soils and soil gas to come to equilibrium in order to compare initial and 1-year conditions. Soil gas samples were collected, and *in situ* respiration testing was performed from 15 June through 21 June 1997 following 13 months of system operation.

To further define the extent of contamination and to evaluate the potential for remediation by natural attenuation (RNA) of dissolved organics in groundwater, soil and groundwater samples were also collected at the site during the June 1997 field event. Parsons ES advanced six soil borings (SB7 through SB11, and MPB) with a Geoprobe® rig, and collected groundwater samples from wells TW1502 and TW1504. The blower system was restarted following 1-year testing to continue bioventing treatment of site soils. Initial and 1-year soil and soil gas sampling results, groundwater sampling results to date, and respiration testing results have been provided by Parsons ES (1997) to AFCEE and Eaker AFBCA and are summarized below.

2.3.3.1 Soil Sampling Results

1996 Pre-Bioventing

During installation of the pilot-scale bioventing system (Parsons ES, 1996), a total of six Geoprobe® pushes (SB1 through SB6) were advanced at the site to further define the

full-areal extent of petroleum hydrocarbon contamination in vadose zone soils (Figure 2.2). The three borings (SB3, SB4, and SB6) exhibiting vadose zone contamination were converted for use as vapor MPs (MPB, MPA, and MPC, respectively). Three soil samples collected from the MP borings at depths of 5 to 7 feet bgs, were submitted for laboratory analysis of TEPH and benzene, toluene, ethylbenzene, and xylenes (BTEX). As shown in Table 2.1, TEPH was detected in soil samples collected from all boreholes, which are located southeast of the former UST (Figure 2.2). TEPH concentrations of 1,900 mg/kg, 5,000 mg/kg, and 290 mg/kg were detected at MPA, MPB, and MPC, respectively. These concentrations exceeded the former ADEQ CAL of 100 mg/kg for TPH. Xylenes were detected at a maximum concentration of 3,400 micrograms per kilogram ($\mu\text{g}/\text{kg}$) at MPB from a depth of 5-6 feet bgs. Benzene, toluene, and ethylbenzene were not detected in any of the three soil samples (Table 2.1). Based on visual and olfactory observations made of the soil samples collected from the six Geoprobe® pushes, it appears that vadose zone petroleum contamination at the site is limited to the area near the three MPs.

Soil sample headspace readings from Geoprobe® pushes SB1, SB2, and SB5 indicated that vadose zone and smear zone contamination was not present at these locations, therefore samples from these pushes were not submitted for laboratory analysis. The highest photoionization detector (PID) headspace reading for soil samples collected from the six Geoprobe® pushes was 52 parts per million, volume per volume (ppmv) at a depth of 7 feet bgs from MPB.

1997 Post-Bioventing

To assess the presence or absence of BTEX and polynuclear aromatic hydrocarbon (PAH) compounds in saturated soils, Parsons ES performed additional soil sampling at the site during the June 1997 field event. A total of six Geoprobe® pushes (SB7 through SB11, and MPB) were advanced at the site to further define the full-areal extent of petroleum hydrocarbon contamination in saturated zone soils (Figure 2.2). One saturated sample each from Geoprobe® pushes SB8 and SB11, collected from a depth corresponding to the bottom of the former tank excavation (approximately 12 feet bgs), were analyzed for BTEX using USEPA Method SW8020 and for PAHs using USEPA Method SW8310. BTEX compounds were not detected in either sample, however, several PAH compounds were detected in the sample collected from SB11 at a depth of 10 to 11 feet bgs. Phenanthrene, fluoranthene, pyrene, and chrysene were present at detectable concentrations (Table 2.1).

Shallow soil samples collected from Geoprobe® pushes SB7 through SB11 (Figure 2.3) exhibited no visible or olfactory evidence of vadose zone contamination; therefore, samples from these pushes were not submitted for laboratory analysis. Additionally, there was no visible or olfactory evidence of saturated zone contamination at Geoprobe® pushes SB7 through SB11.

To determine remedial progress after 13 months of bioventing treatment, a vadose zone soil sample was collected near MPB at a depth of 5 feet bgs, and analyzed for BTEX (SW8020), and for TEPH using USEPA Method SW8015M. At MPB, TEPH concentrations were slightly lower during the June 1997 sampling than during the March 1996 sampling event, and xylenes were present at 6 percent of the initial

concentration (Table 2.1). These results suggest that xylenes may be biodegraded preferentially over the higher-molecular weight compounds detected in the TEPH analysis. Based on review of soil analytical data, it appears that the horizontal extent of vadose zone contamination is limited to the area immediately south of the former tank excavation (near VW1).

2.3.3.2 Soil Gas Sampling Results

Soil gas sampling was performed prior to, and following 13 months of air injection bioventing to determine relative changes in total volatile hydrocarbon (TVH), BTEX, and oxygen concentrations. Initial soil gas field-screening results at MPB and MPC indicated depleted oxygen concentrations and high TVH concentrations, and suggested that air injection would oxygenate contaminated soils and enhance biodegradation of residual petroleum hydrocarbons. As can be seen from the field-screening results presented in Table 2.3, static oxygen concentrations in soil gas have increased slightly at all locations except MPA with continued bioventing at the site.

During the June 1997 sampling event, static soil gas oxygen concentrations were below 5 percent at all MPs, indicating that significant oxygen demand still exists in the soils, and that aerobic biodegradation is still occurring at significant rates. Higher oxygen levels at VW1 and VW2 are the result of long-term air injection at these wells; most of the fuel contamination initially present at these locations has been aerobically biodegraded or has volatilized and migrated away from the injection point via soil gas advection. At all locations except MPB-5, June 1997 field TVH levels in soil gas were still low, ranging from 52 to 380 ppmv (Table 2.3).

At MPB-5 and MPC-4.5, laboratory soil gas TVH concentrations may have increased due to the "smearing effect" of groundwater fluctuations. Laboratory TVH concentrations exceeding 400 ppmv were detected only at MPB-5, indicating that low levels of volatile petroleum hydrocarbons still exist at discrete locations in vadose zone soils. Although laboratory TVH levels at MPB are somewhat elevated, concentrations of the risk-driving BTEX compounds are very low (Table 2.3).

A soil gas sample was also collected from monitoring well MW092 during the June 1997 sampling event. MW092 is located in the Building 410 area, approximately 50 feet southwest of the former tank location at Building 457 (Figure 2.3). Total volatile hydrocarbons were detected at 20,000 ppmv. Because soils contaminated with heating oil rarely contain TVH soil gas concentrations that exceed 5,000 ppmv, it is suspected that soils in the vicinity of MW092 may have been impacted by releases of volatile fuels (aviation gasoline or motor gasoline) from the former USTs in the Building 410 area. It is possible that the zone of soil contamination originating from the former UST at the Building 457 area overlaps the extent of contamination from the Building 410 area.

2.3.3.3 Respiration Test Results

Observed *in situ* microbial respiration (oxygen utilization) rates have decreased slightly as a result of pilot-scale bioventing system operation at the Building 457 Area. As can be seen from the results presented in Table 2.4, reductions occurred in both respiration and fuel biodegradation rates following the first year of system operation.

TABLE 2.3
SOIL GAS FIELD SCREENING AND LABORATORY ANALYTICAL RESULTS
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Sampling Location	Screen Depth (feet bgs) ^{c/}	Sampling Event ^{d/}	Field Screening Data			Laboratory Analytical Data ^{a/}				
			Oxygen (percent)	Carbon Dioxide (percent)	TVH ^{b/} (ppmv) ^{e/}	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
VW1 (TW1503)	5.5-15.5	Initial	5.0	8.0	540	48	0.016	0.17	0.048	0.80
		13-Month ^{f/}	9.6	3.0	380	---- ^{g/}	----	----	----	----
VW2 (TW1501)	6-16	Initial	2.5	10.3	540	----	----	----	----	----
		13-Month	12.8	0.3	52	----	----	----	----	----
MPA	5.5	Initial ^{h/}	5.1	1.6	230	----	----	----	----	----
		13-Month	4.2	7.0	240	300	<0.006 ^{i/}	<0.006	0.007	0.062
MPB	5	Initial	0.0	8.0	3,200	380	0.34	2.7	1.5	0.93
		13-Month	1.3	17.7	3,200	820	0.23	1.3	0.85	4.9
MPC	4.5	Initial	0.0	8.1	920	81	0.013M ^{j/}	0.024	0.084	0.28
		13-Month	0.8	15.8	200	140	<0.002	0.015	0.009	0.38
TW1502	8-18	Initial	9.5	7.3	94	----	----	----	----	----
		13-Month	Purged water			----	----	----	----	----
TW1504	5.5-15.5	Initial	7.9	5.9	140	----	----	----	----	----
		13-Month	9.1	6.2	70	----	----	----	----	----
MW092 (410 Area)	6-16	13-Month	0.9	13.0	20,000	----	----	----	----	----

^{a/} Laboratory analysis of soil gas performed using USEPA Method TO-3. Laboratory TVH referenced to jet fuel (MW=156).

^{b/} TVH = total volatile hydrocarbons.

^{c/} bgs = below ground surface.

^{d/} Soil gas sampling performed in March 1996 (initial event) and June 1997 (13-month event).

^{e/} ppmv = parts per million, volume per volume.

^{f/} 13-month soil gas samples were collected approximately 1 month following blower shut down. The blower operated almost continuously from April 4, 1996 until May 13, 1997.

^{g/} ---- = not analyzed.

^{h/} Sample could not be collected prior to air injection for the respiration test because the screened interval was under perched groundwater. Therefore, soil gas chemistry after the respiration test and prior to the permeability test is presented. The initial oxygen concentration may have been slightly lower than the value shown; however, based on respiration data and sufficient time for soil gas stabilization, the reported oxygen concentrations may closely represent initial soil gas concentrations.

^{i/} < = compound analyzed for, but not detected. Number shown represents the sample quantitation limit.

^{j/} M = reported laboratory value may be biased due to apparent matrix interferences.

TABLE 2.4
RESPIRATION TEST RESULTS AND FUEL BIODEGRADATION RATES
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Sampling Location-Depth (feet below ground surface)	Initial (March 1996)		13-Month (June 1997)	
	O ₂ Utilization Rate (K _o) (% O ₂ /hour)	Biodegradation Rate (mg/kg/year) ^{a/}	O ₂ Utilization Rate (K _o) (% O ₂ /hour)	Biodegradation Rate ^{b/} (mg/kg/year)
VW1-5.5-15.5	2.59	1,220	NM ^{c/}	NC ^{d/}
MPA-5.5	3.04	1,430	NM ^{e/}	NC
MPB-5	3.13	1,470	2.41	1,130
MPC-4.5	3.45	1,620	2.57	1,210

^{a/} Milligrams of petroleum hydrocarbons per kilogram of soil per year.

^{b/} Assumes soil moisture content is equal to March 1996 values.

^{c/} NM = not measured.

^{d/} NC = not calculated.

^{e/} MPA screened interval was submerged in groundwater.

Average 1-year respiration rates measured 76 percent of the initial values. Similar reductions are evident in calculated fuel biodegradation rates for the site. Oxygen utilization and fuel biodegradation rates typically decrease with continued bioventing as the lighter, more readily biodegraded hydrocarbons are preferentially destroyed over more biologically recalcitrant, higher-molecular-weight hydrocarbons. As demonstrated by the soil gas results presented in Table 2.3, each BTEX compound, except xylenes has decreased in concentration since bioventing system installation.

2.3.3.4 Natural Attenuation Monitoring

During the June 1997 field event, Parsons ES collected groundwater samples from two site monitoring wells (TW1502 and TW1504) and one background monitoring well (MW010) to evaluate RNA of heating oil constituents in groundwater. Table 2.2 summarizes site laboratory analytical data for groundwater samples. Groundwater samples also were analyzed by Parsons ES personnel in the field for alkalinity, dissolved oxygen (DO), ferrous iron, free carbon dioxide, pH, oxidation/reduction potential (ORP), nitrate, soluble manganese, sulfate, and temperature. The results of these geochemical analyses are provided in Table 2.5. Groundwater samples were collected and analyzed according to the protocol developed for the AFCEE Natural Attenuation Initiative (Wiedemeier *et al.*, 1995). The limited organic and geochemical data collected during June 1997 suggest that groundwater is not significantly impacted by hydrocarbons. Dissolved oxygen was not depleted; BTEX and PAH compounds were not detected at well TW1504; and BTEX compounds were not detected at well TW1502. A distinct geochemical trend for groundwater at this site is not readily apparent, likely because there is little, if any groundwater contamination present to induce geochemical changes in the groundwater. During confirmation groundwater sampling, additional geochemical data will be collected from each site well to further define a geochemical trend, if present.

2.3.4 Results Summary

Based on the results of the previous investigations, the former heating oil UST, and/or associated product piping has been identified as the probable source(s) of the remaining petroleum hydrocarbon contamination at the Building 457 Area. Figure 2.3 shows the estimated extent of soil contamination at the Building 457 Area that exceeds the former CAL of 100 mg/kg of TPH. Because soil contamination appeared to exceed regulatory requirements in the area southeast of the former UST (near TW1504), a bioventing pilot-scale system was installed. Field screening and analytical results of soil samples collected during installation of the monitoring wells (US Air Force, 1995) and during bioventing field activities (Parsons ES, 1996 and 1997) indicated that the majority of the vadose zone contamination has been limited to the soils near VW1 (groundwater monitoring well TW1503).

Initial and 1-year bioventing pilot test results indicate the effective treatment area of the bioventing system encompasses the entire area of contaminated vadose zone soil identified on Figure 2.3. Considering the type of contamination (heating oil), PAH concentrations in vadose zone soils at the Building 457 Area are not expected to exceed ASTM RBSLs; based on this expectation, AFCEE recommended that planning for

TABLE 2.5
GROUNDWATER GEOCHEMICAL DATA
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Sampling Location	Sampling Date	Temperature (°C) ^{a/}	Conductivity (µS/cm) ^{b/}	Dissolved Oxygen (mg/L) ^{c/}	Total Alkalinity (mg/L)	pH	Redox Potential (mV) ^{d/}	Sulfate (mg/L)	Ferrous Iron (mg/L)	Nitrate (mg/L)	CO ₂ (mg/L)	Mn ²⁺ (mg/L)
TW1502	6/19/97	17.6	535	1.37	280	6.44	260	38.57	0.20	ND ^{e/}	11.2	0.1
TW1504	6/19/97	17.3	322	2.53	160	6.09	610	27.09	0.04	1.9	11.8	ND
MW010 ^{f/} (Background)	6/19/97	16.6	528	1.54	300	6.68	270	21.77	0.10	0.32	12.5	0.9

^{a/} °C = degrees Celsius

^{b/} µS/cm = microsiemens per centimeter

^{c/} mg/L = milligrams per liter

^{d/} mV = millivolts.

^{e/} ND = not detected above the method detection limit (MDL).

^{f/} Background monitoring well MW010 is located approximately 1,000 feet southeast of Building 457.

confirmation sampling be initiated while the bioventing pilot-scale system continues to operate.

Analytical results of the limited number of groundwater samples indicate no impacts on the groundwater quality in areas adjacent to the former tanks (Table 2.2). No drinking water maximum contaminant levels (MCLs) were exceeded by the BTEX compounds detected in groundwater. To confirm the absence of groundwater contamination at the site, additional groundwater sampling will be performed at the site, as described in Section 4.3.

SECTION 3

SITE CLEANUP REQUIREMENTS

3.1 SAMPLING OBJECTIVES

The objective of the confirmatory sampling is to support an Air Force NFRAP decision for the soils and groundwater that were contaminated by heating oil released from the former UST, and to meet anticipated ADEQ cleanup goals pursuant to closure of the Building 457 Area. Data to assess RNA of fuel constituents in groundwater also will be collected. In addition, groundwater level measurements will be collected and a determination of groundwater flow direction will be made. This sampling plan targets saturated and unsaturated soils, and groundwater in the vicinity of the former UST, and groundwater immediately downgradient and upgradient from the former tank.

3.2 STATE SOIL AND GROUNDWATER CLEANUP GOALS

ASTM (1995) has developed a tiered, RBCA approach for petroleum-hydrocarbon-contaminated sites. This iterative approach allows first for screening of contaminant concentrations against generic RBSLs, followed (if necessary) by the development of site-specific target levels (SSTLs) based on an analysis of site data and receptors that could potentially be exposed to chemical contamination at, or downgradient from, the release site. As approved by the ADEQ, Parsons ES and Eaker AFBCA will reference the ASTM RBCA guidance for soil and groundwater cleanup goals. Because RBCA criteria are based on current or foreseeable land uses and human receptor exposure scenarios, a review of available information is provided below.

3.2.1 Land Use and Potential Receptors

The site is currently vacant and zoned for industrial/commercial use. Current land use adjacent to the site is commercial/industrial. Former aircraft hangers are located to the north, and vacant office buildings are located to the northwest. Vacant land (former Building 410 area) is located southwest of the site. A specific future land use for Building 457 has not been established, but will be predominantly commercial and industrial.

Based on the future industrial land use assumption and the site description presented in Section 2, current and future onsite workers are likely to represent the primary potential human receptors. Because the heating oil release was subsurface and the contaminated area is developed, no ecological receptors are likely to be exposed to contaminants in site media under current or anticipated future land uses.

Groundwater within Eaker AFB property is not currently used as a potable water source; moreover, site groundwater impacts from the heating oil releases appear to be minimal (Table 2.2). Therefore, exposure of onsite and off-site human receptors to site contaminants through ingestion or inhalation of, or dermal contact with, contaminants in groundwater extracted for potable use is unlikely. Soil sample results from previous investigations (Table 2.1) indicate that soil contamination appears to be significant only within soils located near well TW1503 at depths greater than 3 feet bgs.

Based on this information, it is anticipated that the most significant contaminant migration pathways resulting from soil contamination at the Building 457 Area are the leaching of contaminants from soil to groundwater and the volatilization of fuel vapors into soil gas. Volatilization of fuel hydrocarbons from soil and/or groundwater and vapor migration into onsite or off-site structures is expected to be the most significant potential exposure pathway resulting from contamination at the Building 457 Area.

3.2.2 Cleanup Goals

The ASTM (1995) RBCA standard RBSLs for soil, presented in a look-up table, are utilized in the Tier 1 evaluation of site contaminant concentrations. The RBSLs are not intended as cleanup goals, but serve as conservative values against which to compare site contaminant concentrations. If site contaminant concentrations are lower than the RBSLs, then the RBCA standard suggests that no further corrective action is required. If site contaminant concentrations exceed the RBSLs, then SSTLs can be developed through a Tier 2 evaluation.

PAH and other petroleum contaminant (e.g., BTEX and TEPH) concentrations in soil at Building 457 will be determined from the soil samples to be collected and analyzed in accordance with Section 4 in order to compare these values with ASTM RBSLs, and to compare to pre-treatment soil analytical results. If the detected site contaminant concentrations do not exceed the most stringent RBSLs, the compounds will not be considered chemicals of potential concern (COPCs), and will not be retained for further Tier 2 evaluation. Under these circumstances, no additional remediation would be warranted for such compounds in order to protect potential receptors. If a detected site contaminant exceeds the appropriate RBSL, the compound will be identified as a COPC and retained for further quantitative fate and transport and risk analyses.

For the purpose of comparison, generic RBSLs for commercial/industrial land use and maximum TEPH, BTEX, and PAH soil concentrations detected during previous site investigations (Section 2.3) are presented in Table 3.1. Table 3.2 presents similar data for groundwater. The generic RBSLs from the ASTM (1995) *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* and soil screening levels (SSLs) from the USEPA (1996) *Soil Screening Guidance: Technical Background Document* are presented. As previously mentioned, leaching of hydrocarbon contaminants from soil to groundwater and volatilization of hydrocarbon contaminants from groundwater and vapor intrusion to buildings are likely to represent the most significant contaminant migration and potential receptor exposure pathway represented by soil and groundwater contamination, respectively.

TABLE 3.1
SOIL CONTAMINANT LEVELS COMPARED TO
RISK-BASED CLEANUP CRITERIA
BUILDING 457 AREA
EAKER AFB, ARKANSAS

TEPH	Units ^{c/}	Detected Site Maximum Concentration	ASTM ^{d/}			USEPA ^{b/}		
			Comm/Indus Vapor Intrusion RBSL ^{d/}	Comm/Indus Leachability RBSL ^{e/}	Ingestion SSL	Inhalation SSL	Groundwater Migration SSL (20 DAF) ^{f/}	Groundwater Migration SSL (1 DAF) ^{g/}
			NA ^{iv/}	NA	NA	NA	NA	NA
Benzene	mg/kg	5,000	0.0109 *	0.0578 *	22	0.8	0.03	0.002
Toluene	mg/kg	<0.025 ^{iv/}	54.5	361	16,000	650	12	0.6
Ethylbenzene	mg/kg	<0.050	1,100	1,610	7,800	400	13	0.7
Xylenes	mg/kg	3.4	RES ^{iv/}	RES	160,000 ^{iv/}	410 ^{iv/}	190 ^{iv/}	9 ^{iv/}
Naphthalenes	mg/kg	<0.207	107	64.2	3,100	NA	84	4
Benzo(a)pyrene	mg/kg	<0.0159	RES *	1.85 *	0.09	NA	8	0.4
Acenaphthene	mg/kg	<0.125	---	---	4,700	NA	570	29
Anthracene	mg/kg	<0.0455	---	---	23,000	NA	12,000	590
Fluoranthene	mg/kg	0.0832	---	---	3,100	NA	4,300	210
Flourene	mg/kg	<0.0145	---	---	3,100	NA	560	28
Pyrene	mg/kg	0.166	---	---	2,300	NA	4,200	210
Benz(a)anthracene	mg/kg	<0.00897	---	---	0.9	NA	2	0.08
Chrysene	mg/kg	0.0383	---	---	88	NA	160	8
Benzo(b)fluoranthene	mg/kg	<0.0125	---	---	0.9	NA	5	0.2
Benzo(k)fluoranthene	mg/kg	<0.0117	---	---	9	NA	49	2
Dibenzo(a,h)anthracene	mg/kg	<0.0207	---	---	0.09	NA	2	0.08
Benzo(g,h,i)perylene	mg/kg	<0.0524	---	---	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	mg/kg	<0.0297	---	---	0.9	NA	14	0.7

Notes: The corrective action limits or target concentrations exceeded by the maximum site concentration detected are shown in gray.
The target concentrations that are lower than the method detection limit, and may potentially exceed the screening level are shown in a box.
* Indicates that the compound is a carcinogen, and the RBSL is based on a cancer risk of 10⁻⁶ resulting from the specified exposure.
The RBSLs for compounds that have not been classified as carcinogens are based on a hazard quotient (HQ) equal to 1.

TABLE 3.1 (Continued)
SOIL CONTAMINANT LEVELS COMPARED TO
RISK-BASED CLEANUP CRITERIA

BUILDING 457 AREA
EAKER AFB, ARKANSAS

-
- a/ Risk-based screening levels (RBSLs) from Table X2.1 (ASTM, 1995).
- b/ Generic soil screening levels (SSLs) from Table A-1 (USEPA, 1996).
- c/ mg/kg = milligrams per kilogram.
- d/ Values shown represent example Tier 1 Risk-Based Screening Levels (RBSLs) for commercial/industrial receptor scenario considering soil-vapor intrusion from soil to buildings (ASTM, 1995).
- e/ Values shown represent example Tier 1 Risk-Based Screening Levels (RBSLs) for commercial/industrial receptor scenario considering soil-leachate to protect groundwater ingestion target level (ASTM, 1995).
- f/ Generic SSL values for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20 to account for natural processes that reduce contaminant concentrations in the subs
- g/ Generic SSLs for the migration to groundwater pathway developed assuming no dilution or attenuation between the source and the receptor well (i.e., DAF = 1). Note that the 20 DAF values are not exactly 20 times the 1 DAF values because each SSL is calculated independently with the final value rounded to two significant figures for values greater than 10, and one significant figure if the value is less than 10.
- h/ Target data concentrations not available in the sources which are referenced.
- i/ < = analyte concentration less than laboratory reporting limit shown.
- j/ RES = Selected risk level is not exceeded for pure compound present at any concentration (ASTM, 1995).
- k/ SSL data provided is for *o*-Xylene which has the most conservative SSLs of the three xylene isomers.
- l/ A RBSL for many of the polynuclear compounds is not provided in Table X2.1 (ASTM, 1995).
If concentrations of these compounds are detected above the RBSL for benzo(a)pyrene, then a chemical-specific screening level will be calculated based on ASTM (1995) guidance.

TABLE 3.2
GROUNDWATER CONTAMINANT LEVELS COMPARED TO ASTM
RISK-BASED CLEANUP CRITERIA
BUILDING 457 AREA
EAKER AFB, ARKANSAS

	Units ^{b/}	Detected Site Maximum Concentration	Federal MCL ^{c/}	ASTM ^{a/} Comm/Indus Vapor Intrusion RBSL ^{d/}
Benzene	µg/L	<0.4 ^{e/}	5	73.9 *
Toluene	µg/L	<0.4	1,000	85,000
Ethylbenzene	µg/L	<0.4	700	>S ^{f/}
Xylenes	µg/L	<0.4	10,000	>S
Naphthalenes	µg/L	<18	NA ^{g/}	12,300
Benzo(a)pyrene	µg/L	<0.23	NA	>S *

Note: * indicates that the compound is a carcinogen, and the risk-based screening level (RBSL) is based on a cancer risk of 10⁻⁶ resulting from vapor intrusion.

The RBSLs for compounds that have not been classified as carcinogens are based on a hazard quotient (HQ) equal to 1.

^{a/} Risk-based screening levels (RBSLs) from Table X2.1 (ASTM, 1995).

^{b/} µg/L = micrograms per liter.

^{c/} MCL = maximum contaminant level.

^{d/} Values shown represent example Tier 1 Risk-Based Screening Levels (RBSLs) for commercial/ industrial receptor scenario considering vapor intrusion from groundwater to buildings (ASTM, 1995).

^{e/} < = compound analyzed for, but not detected. Number shown represents the sample quantitation limit.

^{f/} >S = selected risk level is not exceeded for all possible dissolved levels (less than or equal to solubility of pure component) (ASTM, 1995).

^{g/} NA = target data concentration not available in the source which was referenced.

As can be seen in Table 3.1, no soil contaminant exceeding its ASTM (1995) RBSL or USEPA (1996) SSL has been detected at the site. Likewise, as shown in Table 3.2, no groundwater contaminant exceeding its ASTM (1995) RBSL has been detected at the site. While not readily apparent, benzene concentrations from the 1996 soil sampling event may have exceeded the ASTM commercial/industrial leachability RBSL and the USEPA groundwater migration SSLs because the analytical method detection limit shown is higher than these target screening levels. However, following more than 2 years of air injection bioventing, residual benzene contamination in soil is likely to be less than the screening levels.

The risk-based criteria for groundwater shown in Table 3.2 represent dissolved concentrations of BTEX and naphthalene that potentially could cause adverse indoor air concentrations resulting from contamination vapor intrusion. These values represent a worst-case scenario, as no buildings currently are located directly above the area affected by the release (Figure 2.3).

SECTION 4

SITE CONFIRMATION SOIL AND GROUNDWATER SAMPLING AND ANALYSIS PLAN

The following SAP describes the sampling locations and procedures, and the analytical methods proposed to collect sufficient data to verify remediation of the Building 457 Area soils and groundwater to acceptable cleanup levels, to determine the extent to which natural attenuation processes are reducing contaminant mass in groundwater, and to support site closure.

As described in Section 2, soil contamination at the Building 457 Area was characterized during the 1994 through 1997 investigations. Based on results from these investigations, petroleum hydrocarbon contamination exceeding the former ADEQ TEPH CAL of 100 mg/kg (prior to initiation of *in situ* bioventing) appear to have been confined to vadose zone soils between 4 and 8 feet bgs near well TW1503 (Figure 2.3). To confirm that petroleum hydrocarbon contaminants in site soils have been remediated to within acceptable levels, Parsons ES proposes to sample soils in the vicinity of the former UST and within the area of previously identified TEPH CAL exceedances.

During June 1997, BTEX compounds were not detected in groundwater samples collected from wells TW1502 or TW1504, and the PAH compounds (pyrene, benzo(a)anthracene) that were detected in a sample collected from well TW1504 were present above the method detection limit, yet below the practical quantitation limit (Table 2.2). During August 1995, the only detected dissolved contamination was 1.5 mg/L TEPH measured in well TW1503 (US Air Force, 1995). To further assess the presence or absence of dissolved BTEX at the site, groundwater samples for laboratory analysis will be collected from the two vent wells (TW1501 and TW1503). Groundwater samples from these wells and from well TW1502 also will be analyzed for PAHs. In addition, samples from all four site wells will be collected and analyzed onsite for various geochemical parameters, including electron acceptors. The geochemical data will be used to assess whether or not natural chemical attenuation is occurring in the groundwater and to assess the groundwater assimilative capacity for RNA of the remaining concentrations of petroleum hydrocarbon compounds, if present.

The blower system will be turned off 30 days prior to the collection of soil and groundwater samples. After sampling is conducted, the blower system will be restarted, and should continue to operate until an NFRAP decision has been made and site closure has been approved by ADEQ.

4.1 SOIL SAMPLING

This section describes the scope of work required for collecting confirmation soil samples at the Building 457 Area. An estimated seven Geoprobe® locations will be sampled within the area where TEPH results exceeded the former ADEQ (1995) CAL of 100 mg/kg, and adjacent to the site (Figure 2.2), within the 410 Area. A maximum of two additional Geoprobe® locations may be sampled if field screening results indicate significant contamination extending beyond the proposed sampling area. Proposed Geoprobe® sampling locations are shown on Figure 4.1.

Soil sampling will be conducted by qualified Parsons ES scientists and technicians trained in the conduct of soil sampling, records documentation, and chain-of-custody procedures. In order to provide complete documentation of the sampling event, detailed records will be maintained by the Parsons ES field engineer. In addition, sampling personnel will have thoroughly reviewed this SAP prior to sample collection and will have a copy available onsite for reference.

4.1.1 Soil Sampling Procedures

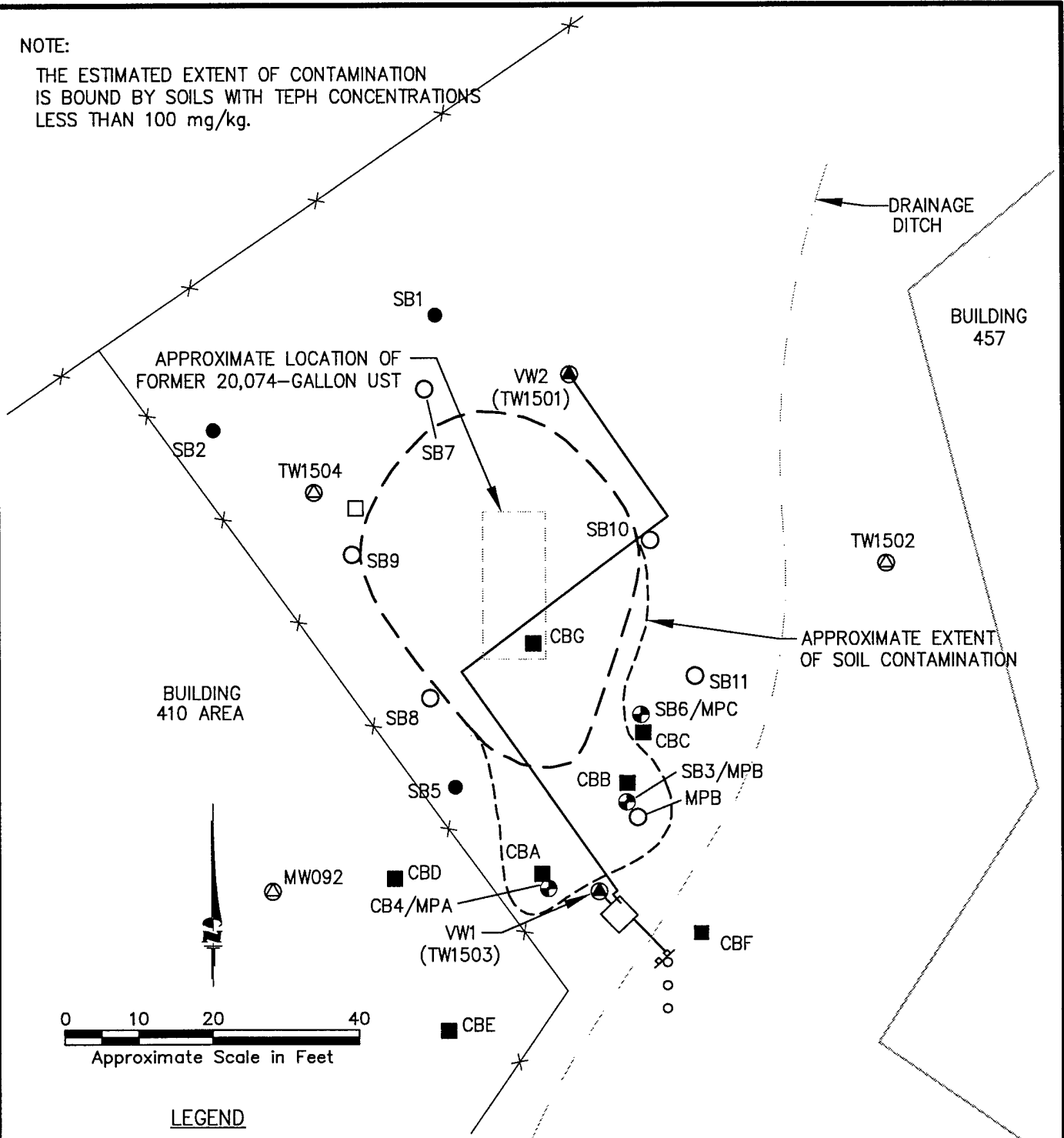
Seven Geoprobe® locations will be sampled in the vicinity of the former UST at the approximate locations shown on Figure 4.1. At borings CBA, CBB, CBC and CBG, samples will be collected at two depths (5 and 12 feet bgs) from each borehole. The shallow intervals represent the intervals and locations sampled during bioventing system installation, and additional locations of potential concern (*i.e.*, backfill material near proposed boring CBG, and saturated soils near MPA, MPB, and MPC). At borings CBD and CBE, one sample will be collected from a depth corresponding to the "smear" zone, and submitted to the laboratory for analysis. At boring CBF, samples will be collected from depths of 3 and 9 feet bgs to verify the southeastern extent of contamination. If samples from CBF exhibit no visible or olfactory evidence of petroleum contamination, samples from this location will not be submitted for laboratory analysis. Subsurface soil samples will be collected using a truck-mounted, hydraulically powered Geoprobe® percussion/probing machine capable of advancing sampling tools through unconsolidated soils. The Geoprobe® system provides for the rapid collection of soil samples at shallow depths while minimizing the generation of investigation-derived waste materials.

Soil samples will be collected using a probe-drive sampler. The probe-drive sampler serves as both the driving point and the sample collection device, and is attached to the leading end of the probe rods. To collect a soil sample, the sampler is pushed or driven to the desired sampling depth, the drive point is retracted, to open the sampling barrel, and the sampler is subsequently pushed into the undisturbed soils. The soil cores are retained within clear acetate liners inside the sampling barrel. The probe rods are then retracted, bringing the sampling device to the surface. The soil sample can then be extruded from the liners for lithologic logging, or the liners can be capped, and the undisturbed samples can be submitted to the analytical laboratory for testing. Soil samples will be screened with a PID or a total volatile hydrocarbon analyzer (TVHA).

Samplers, drive rods, and other sampling equipment will be cleaned before use and between sampling locations to prevent cross-contamination. All sampling equipment

NOTE:

THE ESTIMATED EXTENT OF CONTAMINATION IS BOUND BY SOILS WITH TEPH CONCENTRATIONS LESS THAN 100 mg/kg.



- LEGEND**
- MPA ● VAPOR MONITORING POINT (1996)
 - VW1 ● AIR INJECTION VENT WELL/
GROUNDWATER MONITORING WELL
 - TW1502 ● GROUNDWATER MONITORING WELL
 - SB5 ● GEOPROBE BORING (1996)
 - SB11 ○ GEOPROBE BORING (1997)
 - CBE ■ PROPOSED SOIL SAMPLING LOCATION
 - 2" PVC AIR INJECTION PIPE (BURIED)
 - - - APPROXIMATE LIMITS OF EXCAVATION

FIGURE 4.1

PROPOSED SOIL AND GROUNDWATER SAMPLING LOCATIONS

Building 457 Area
Eaker AFB, Arkansas

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

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will be washed with Alconox[®] detergent and rinsed with tap water. Between sampling events, the probe-drive sampler will be cleaned with Alconox[®], followed by successive potable and distilled water rinses.

Geoprobe[®] pushes will extend no more than 15 feet bgs. Relatively undisturbed soil samples, suitable for chemical analysis, will be collected from depths of 5 to 9 feet bgs and/or 11 to 15 feet bgs, depending on borehole location. Soil types will be classified according to the Unified Soil Classification System and described in accordance with the standard Parsons ES soil description format. All soil samples will be visually examined and field analyzed using a PID or a TVHA. The acetate liners containing the sample will be cut into 6-inch sections, and the ends of the sections will be screened with a PID or TVHA. Based on field screening results, two samples with the greatest apparent contamination from each boring will be selected and submitted for laboratory analysis of BTEX and PAHs. (Table 4.1).

In preparation for laboratory submittal, the ends of the selected sections will be covered with Teflon[®] sheets and plastic end caps. The samples will be labeled with the site name and borehole number, sample depth, date of collection, project name, and other pertinent data. The samples will be sealed in plastic bags and immediately placed in an insulated cooler containing ice. The soil samples will be maintained in a chilled condition until delivered to the analytical laboratory. Chain-of-custody records will be prepared in the field and will accompany the samples to the analytical laboratory.

Following sampling, boreholes will be abandoned using granular bentonite. The granular bentonite will be placed in 3-foot lifts and hydrated. The upper 1 foot of each borehole will be filled with excess soil sample.

4.1.2 Soil Sample Analyses

The numbers of primary and field quality assurance/quality control (QA/QC) soil samples are listed in Table 4.2. All samples will be analyzed by a State of Arkansas-certified and AFCEE-approved laboratory. Proposed soil sample analytical methods and corresponding reporting limits are presented in Table 4.3. Parsons ES proposes to analyze samples from the Building 457 Area for PAHs by USEPA Method SW8310; and BTEX by USEPA Method SW8021B. Soil samples collected near existing MPs will also be analyzed for TEPH by USEPA Method SW8015B, modified for diesel-range organics to determine actual reductions in concentrations of TEPH over the air injection period. QC samples also will be analyzed to assess laboratory methods. The laboratory will perform analyses on one matrix spike, one laboratory control, and one laboratory control sample duplicate.

4.2 SOIL GAS SAMPLING

To gather information on site soil gas chemistry and to provide data against which the progress of bioventing may be evaluated, and to monitor any potential VOC migration, soil gas samples for field analysis will be collected from each of the VWs, MPs, and groundwater monitoring wells at and near the site. Each soil gas sample will be analyzed in the field for initial oxygen, carbon dioxide, and TVH concentrations.

TABLE 4.1
SUPPLEMENTAL SOIL AND GROUNDWATER CHARACTERIZATION
ACTIVITIES
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Sample Location	Soil/Sediment Analytes ^{a/}	Groundwater Analytes	Maximum Number of Samples ^{b/}	Rationale
457-CBA, -457-CBB, and 457-CBC	TEPH, BTEX, and PAHs	none	6	<ul style="list-style-type: none"> Assess presence of PAHs in saturated and unsaturated soils Assess TEPH reductions in unsaturated soils after 2 years of bioventing
457-CBD and 457-CBE	BTEX and PAHs	none	2	<ul style="list-style-type: none"> Assess impact of upgradient release on smear zone soils
457-CBF	BTEX and PAHs	none	1	<ul style="list-style-type: none"> Confirm that petroleum contamination is fully defined southeast of the former UST.
457-CBG	BTEX and PAHs	none	2	<ul style="list-style-type: none"> Assess presence of BTEX and PAHs in backfill material and PAHs in native soil under the former UST
TW1501, TW1502, TW1503, and TW1504	None	BTEX, PAHs, and geochemical suite ^{c/}	4	<ul style="list-style-type: none"> Assess presence of BTEX and PAHs in groundwater, and to ascertain that dissolved contaminants are not present in groundwater.

a/ BTEX = benzene, toluene, ethylbenzene, and xylenes. TEPH = total extractable petroleum hydrocarbons. PAH = polynuclear aromatic hydrocarbons.

b/ See Sections 4.1 and 4.2 for a detailed description of sampling that will be performed for each location.

c/ The geochemical suite will include nitrate/nitrite, pH, temperature, oxidation/reduction potential, dissolved oxygen, ferrous iron, manganese, and sulfate.

TABLE 4.2
FIELD SAMPLING OVERVIEW AND QUALITY ASSURANCE SUMMARY
SAMPLING AND ANALYSIS PLAN
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Matrix	No. of Samples	Analytical Parameter Method ^{a/}	No. of Field/Trip Blanks	No. of Rinseate Blanks	No. of Duplicates	No. of MS/MSD ^{b/}	Total Max. No. of Analyses
Groundwater	4	BTEX USEPA SW8021B	1 per cooler	1	1	1	8
Groundwater	4	PAHs USEPA SW8310	0	1	1	1	7
Groundwater	4	Dissolved oxygen Field meter	0	0	0	0	4
Groundwater	4	pH field meter	0	0	0	0	4
Groundwater	4	Temperature Field meter	0	0	0	0	4
Groundwater	4	Oxidation-reduction potential Field meter	0	0	0	0	4
Groundwater	4	Ferrous iron Colorimetric (Hach Method #8146)	0	0	1	0	5
Groundwater	4	Manganese Colorimetric (Hach Method #8034)	0	0	1	0	5
Groundwater	4	Sulfate USEPA E300	0	0	1	1	6
Groundwater	4	Nitrate/nitrite USEPA E300	0	0	1	1	6
Soil	13 max	BTEX USEPA SW8021B	0	0	1	1	15
Soil	3 max	TEPH USEPA SW8015B	0	0	1	1	5
Soil	13 max	PAHs USEPA SW8310	0	0	1	1	15
Soil Gas	7 max	TVH field meter	0	0	0	0	7
Soil Gas	7 max	carbon dioxide field meter	0	0	0	0	7
Soil Gas	7 max	oxygen field meter	0	0	0	0	7

Note: If dedicated sampling equipment is used, (e.g., dedicated bailers), then rinseate blanks will not be collected.

^{a/} BTEX = benzene, toluene, ethylbenzene, and xylenes; USEPA = U.S. Environmental Protection Agency;

PAHs = polynuclear aromatic hydrocarbons; TEPH = total extractable petroleum hydrocarbons;

TVH = total volatile petroleum hydrocarbons.

^{b/} MS = matrix spike; MSD = matrix spike duplicate.

TABLE 4.3
PROPOSED SOIL SAMPLE ANALYTICAL METHODS
AND REPORTING LIMITS
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Analytical Method	Maximum Reporting Limit ^{a/}	Units ^{b/}	Field or Fixed-Base Laboratory
USEPA Method SW8015 Modified			
Diesel-Range Organics	10	mg/kg	Fixed-base
USEPA Method SW8310			
Acenaphthene	1,200	µg/kg	Fixed-base
Acenaphthylene	1,540	µg/kg	Fixed-base
Anthracene	440	µg/kg	Fixed-base
Benzo(a)anthracene	9	µg/kg	Fixed-base
Benzo(a)pyrene	15	µg/kg	Fixed-base
Benzo(a)fluoranthene	12	µg/kg	Fixed-base
Benzo(g,h,i)perylene	50	µg/kg	Fixed-base
Benzo(k)fluoranthene	11	µg/kg	Fixed-base
Chrysene	100	µg/kg	Fixed-base
Dibenzo(a,h)anthracene	20	µg/kg	Fixed-base
Fluoranthene	140	µg/kg	Fixed-base
Fluorene	140	µg/kg	Fixed-base
Indeno(1,2,3-cd)pyrene	30	µg/kg	Fixed-base
Naphthalene	1,200	µg/kg	Fixed-base
Phenanthrene	420	µg/kg	Fixed-base
Pyrene	180	µg/kg	Fixed-base
USEPA Method SW8021B			
Benzene	0.002	mg/kg	Fixed-base
Toluene	0.6	mg/kg	Fixed-base
Ethylbenzene	0.7	mg/kg	Fixed-base
Xylenes	2	mg/kg	Fixed-base

^{a/} Project reporting limit as specified in subcontract for analytical services.

^{b/} mg/kg = milligrams per kilogram; µg/kg = micrograms per kilogram.

Prior to collecting soil gas samples from the VWs and groundwater monitoring wells, depth to groundwater will be measured. If the well screen is completely submerged under perched groundwater, then a soil gas sample for field analysis will be collected following well purging for groundwater sampling. The existing blower system will be turned off 30 days prior to soil gas sampling to allow subsurface conditions to stabilize.

4.3 NATURAL ATTENUATION MONITORING AND GROUNDWATER SAMPLING

Groundwater sampling will be performed at the site to better define any fuel contamination in groundwater, and to qualitatively determine the effects of RNA of dissolved BTEX and PAHs, if present in groundwater. As with soil sampling, groundwater sampling will be conducted by qualified Parsons ES scientists and technicians in accordance with the procedures outlined in this SAP. The following subsections describe the rationale for targeting selected geochemical parameters for analysis, and present the recommended groundwater sampling strategy for the site.

4.3.1 Well Purging, Sample Collection, and Decontamination

This section describes the scope of work required for collecting groundwater samples at each of five existing groundwater monitoring wells (Figure 4.1). All water samples collected from groundwater monitoring wells will be obtained using either disposable bailers, decontaminated Teflon® bailers, or a thoroughly decontaminated peristaltic pump. In order to maintain a high degree of QC during this sampling event, the procedures described in the following sections will be followed.

4.3.1.1 Equipment Decontamination

All portions of sampling and test equipment that will contact the sample will be thoroughly cleaned before each use. This equipment includes the peristaltic pump and tubing, Teflon® bailers, water-level probe and cable, lifting line, test equipment for onsite use, and other equipment or portions thereof which will contact the samples. Based on the types of sample analyses to be conducted, the following decontamination protocol will be used:

- Clean with potable water and phosphate-free laboratory detergent;
- Rinse with potable water;
- Triple rinse with distilled or deionized water;
- Air dry the equipment prior to use.

If precleaned, dedicated sampling equipment is used, the decontamination protocol specified above will not be required. Laboratory-supplied sample containers will be cleaned and sealed by the laboratory.

4.3.1.2 Water Level Measurement and Well Purging

Prior to removing any water from the well, the static water level will be measured. An electrical water level probe will be used to measure the depth to groundwater below the datum to the nearest 0.01 foot. After measuring the static water level, the water level probe will be lowered slowly to the bottom of the well, and the total well depth will be measured to the nearest 0.01 foot. Based on these measurements, the volume of water to be purged from the well will be calculated, and three times the calculated volume will be removed from the well. The pH, temperature, and specific conductivity will be monitored before, during, and after well purging and recorded on well sampling forms. Purge water will be discharged onto the ground surface adjacent to the well from which it was removed.

4.3.1.3 Sample Extraction

Either disposable, polyethylene bailers, reusable Teflon[®] bailers, or a thoroughly decontaminated peristaltic pump will be used to extract groundwater samples from the wells. The extraction equipment will be lowered into the water gently to prevent splashing, and extracted gently to prevent creation of excessive vacuum in the well. The sample will be transferred directly to the appropriate sample container. The water sample will be transferred from the bottom of the bailer using a bottom-emptying device to allow a controlled flow into the sample container. Water from the peristaltic pump can be directly discharged into the sample container. The water will be carefully poured down the inner walls of the sample bottle to minimize aeration of the sample. Unless other instructions are given by the analytical laboratory, sample containers will be completely filled so that no air space remains in the container.

4.3.2 Natural Attenuation Monitoring and Field Measurements

Microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous reduction/oxidation (redox) reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors at the site include natural organic carbon and fuel hydrocarbon compounds. Fuel hydrocarbons are completely degraded or detoxified if they are used as the primary electron donor for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states, and include oxygen, nitrate, ferric iron, sulfate, manganese, nitrogen gas, and carbon dioxide.

Microorganisms preferentially use electron acceptors while metabolizing fuel hydrocarbons (Bouwer, 1992). DO is used first as the prime electron acceptor. After the DO is consumed, anaerobic microorganisms typically use electron acceptors in the following order of preference: nitrate, manganese, ferric iron hydroxide, sulfate, nitrogen gas, and finally carbon dioxide. Environmental conditions and microbial competition ultimately determine which processes will dominate. As a result of the occurrence of biodegradation processes, concentrations of electron acceptors (e.g., DO, nitrate, and sulfate) become depleted in the plume area, and concentrations of metabolic byproducts of biodegradation processes (e.g., methane and ferrous iron) are enhanced.

Other geochemical indicators that allow assessment of whether subsurface conditions are favorable for biodegradation to occur include ORP, temperature, and pH. ORP is a measure of the relative tendency of a solution or chemical reaction to accept or transfer electrons, and can be used as a crude indicator of which redox reactions may be operating at a site. Temperature affects the types and growth rates of chemical-degrading bacteria that can be supported in the groundwater environment, and pH affects the presence and activity of microbial populations. Microbes capable of degrading petroleum hydrocarbon compounds generally prefer pH values varying from 6 to 8 standard units (Wiedemeier *et al.*, 1995).

4.3.2.1 Onsite Chemical Parameter Measurement

Many of the groundwater chemical parameters will be measured onsite by Parsons ES personnel (Table 4.4). Some of the measurements will be made using direct-reading meters, while others will be made using a Hach® portable colorimeter in accordance with specific Hach® analytical procedures. These procedures are described in the following subsections.

All glassware or plasticware used in the analyses will have been cleaned prior to sample collection by thoroughly washing with a solution of Alconox® and water, and rinsing with deionized water and ethanol to prevent interference or cross contamination between measurements. If concentrations of an analyte are above the range detectable by the titrimetric method, the analysis will be repeated by diluting the groundwater sample with double-distilled water until the analyte concentration falls to a level within the range of the method. All rinseate and sample reagents accumulated during field groundwater analysis will be discharged onto the ground surface at the site. Sample reagents to be used for field analysis are composed of innocuous salts, and only a few grams of the reagents will be required.

Dissolved Oxygen Measurements. DO is an important electron acceptor in the aerobic biodegradation of dissolved fuel hydrocarbons. DO measurements will be made using a meter with a downhole oxygen sensor or a sensor in a flow-through cell. Measurements will be taken before and following groundwater sample acquisition. When DO measurements are taken in monitoring wells that have not yet been sampled, the existing monitoring wells will be purged until DO levels stabilize. Measured values will be recorded in the groundwater sampling record.

pH, Temperature, and Specific Conductance. Because the pH, temperature, and specific conductance of a groundwater sample can change significantly within a short time following sample acquisition, these parameters will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made in a clean glass container separate from those intended for laboratory analysis, and the measured values will be recorded in the groundwater sampling record.

Other Electron Acceptor Measurements. Nitrate, nitrite, sulfate, and ferrous iron concentrations in groundwater act as potential electron acceptors for fuel hydrocarbon degradation under anaerobic conditions. These analytes will be measured by

experienced Parsons ES scientists via colorimetric analysis using a Hach® portable colorimeter according to the appropriate Hach® methods (Table 4.4).

Oxidation/Reduction Potential. The ORP of groundwater is an indicator of the relative tendency of a solution to accept or transfer electrons. Redox reactions in groundwater often are biologically mediated; therefore, the redox potential of a groundwater system depends upon and influences rates of biodegradation. ORP can be used to provide real-time data on the location of the contaminant plume, especially in areas undergoing anaerobic biodegradation. The ORP of a groundwater sample can change significantly within a short time following sample acquisition and exposure to atmospheric oxygen. Therefore, this parameter will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made as quickly as possible in a clean glass container separate from those intended for laboratory analysis.

4.3.2.2 Sample Handling

Sample containers and appropriate container lids will be provided by the laboratory. The laboratory will add any necessary chemical preservatives prior to shipping the containers to the site. The sample containers will be filled as described in Section 4.2.1.3, and the container lids will be tightly closed. The sample bottles will be labeled with the site name and well number, sample depth, date of collection, project name, and other pertinent data. Samples will be properly prepared for transportation to the laboratory by placing the samples in a cooler containing ice to maintain a shipping temperature of approximately 4 degrees centigrade (°C). Chain-of-custody records will be prepared in the field and will accompany the samples to the analytical laboratory.

4.3.3 Groundwater Analyses

This section describes the analytical protocols for laboratory analysis of groundwater samples by a State of Arkansas-certified and AFCEE-approved laboratory. Parsons ES proposes to analyze groundwater samples from the Building 457 Area for BTEX by USEPA Method SW8021B; for PAHs by USEPA Method SW8310; and for sulfate and nitrate/nitrite by USEPA Method E300. Proposed groundwater sampling locations are shown on Figure 4.1, and the groundwater analytical methods and corresponding reporting limits are presented in Table 4.4.

Samples from all four existing site monitoring wells (TW1501, TW1502, TW1503, and TW1504) will be sent to the laboratory for BTEX, PAH, sulfate, and nitrate/nitrite analysis. Samples from all four site monitoring wells also will be analyzed in the field for a suite of geochemical indicator parameters to assess aerobic and anaerobic biodegradation of fuel constituents dissolved in groundwater. Summaries of proposed groundwater sampling activities, and primary and QA/QC samples are presented in Tables 4.1 and 4.2, respectively.

4.4 CHAIN-OF-CUSTODY CONTROL

After the samples for laboratory analysis have been collected, chain-of-custody procedures will be followed to establish a written record of sample handling and

TABLE 4.4
PROPOSED GROUNDWATER SAMPLE ANALYTICAL
METHODS AND REPORTING LIMITS
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Analytical Method	Reporting Limit ^{a/}	Units ^{b/}	Field or Fixed-Base Laboratory
USEPA Method SW8310			
Acenaphthene	18	µg/L	Fixed-base
Acenaphthylene	23	µg/L	Fixed-base
Anthracene	6.6	µg/L	Fixed-base
Benzo(a)anthracene	0.1 ^{c/}	µg/L	Fixed-base
Benzo(a)pyrene	0.2 ^{c/}	µg/L	Fixed-base
Benzo(b)fluoranthene	0.18	µg/L	Fixed-base
Benzo(g,h,i)perylene	0.76	µg/L	Fixed-base
Benzo(k)fluoranthene	0.17	µg/L	Fixed-base
Chrysene	0.2 ^{c/}	µg/L	Fixed-base
Dibenzo(a,h)anthracene	0.3	µg/L	Fixed-base
Fluoranthene	2.1	µg/L	Fixed-base
Fluorene	2.1	µg/L	Fixed-base
Indeno(1,2,3-cd)pyrene	0.4 ^{c/}	µg/L	Fixed-base
Naphthalene	18	µg/L	Fixed-base
Phenanthrene	6.4	µg/L	Fixed-base
Pyrene	2.7	µg/L	Fixed-base
USEPA Method SW8021B			
Benzene	2	µg/L	Fixed-base
Toluene	2	µg/L	Fixed-base
Ethylbenzene	2	µg/L	Fixed-base
Xylenes	2	µg/L	Fixed-base
USEPA SW9056			
Sulfate	0.2	mg/L	Fixed-base
Hach Method 8000 Series ^{d/}			
Nitrate	---	---	Field
Nitrite	---	---	Field
Sulfide	---	---	Field
Ferrous Iron	---	---	Field
Manganese	---	---	Field

TABLE 4.4 (Continued)
PROPOSED GROUNDWATER SAMPLE ANALYTICAL
METHODS AND REPORTING LIMITS
BUILDING 457 AREA
EAKER AFB, ARKANSAS

Analytical Method	Reporting Limit ^{b/}	Units ^{d/}	Field or Fixed-Base Laboratory
Direct Reading Meter			
pH	---	---	Field
Conductivity	---	---	Field
Temperature	---	---	Field
Dissolved Oxygen	---	---	Field
Redox Potential	---	---	Field

^{a/} Project reporting limit as specified in subcontract for analytical services.

^{b/} $\mu\text{g/L}$ = micrograms per liter; mg/L = milligrams per liter.

^{c/} Number shown represents proposed or actual Federal maximum contaminant level (MCL) for groundwater.

Laboratory reporting limits for these and all other analytes will be less than or equal to MCLs.

^{d/} "Hach" refers to methods described in the Hach Company catalog, 1990.

movement between the sampling site and the laboratory. Samples collected for onsite field analyses will not require chains-of-custody. Each shipping container will have a chain-of-custody form completed in triplicate by the sampling personnel. One copy of this form will be kept by the sampling contractor after sample delivery to the analytical laboratory, and the other two copies will be retained at the laboratory. One of the laboratory copies will become a part of the permanent record for the sample and will be returned with the sample analytical results. The chain-of-custody record will contain the following information:

- Site name and address;
- Sample identification number;
- Sample collector's printed name and signature;
- Date and time of collection;
- Place and address of collection;
- Type of sample (e.g., composite, grab, etc.);
- Sample matrix (soil, sediment, soil gas, or groundwater);
- Chemical preservatives added;
- Analytical laboratory to be utilized;
- Analyses requested;
- Signatures of individuals involved in the chain of possession; and
- Inclusive dates of possession.

The chain-of-custody documentation will be placed inside the shipping container so that it will be immediately apparent to the laboratory personnel receiving the container, but will not be damaged or lost during transport. The shipping container will be sealed so that it will be obvious if the seal has been tampered with or broken.

4.5 FIELD QA/QC SAMPLES

Field QA/QC samples will include duplicates/replicates, equipment rinseates, and combination field/trip blanks (Table 4.2). Other QA/QC procedures will include decontamination of all equipment that contacts the sample medium before and after each use, use of analyte-appropriate containers, and chain-of-custody procedures for sample handling and tracking, as detailed in this SAP. All samples to be transferred to the analytical laboratory will be clearly labeled to indicate sample number, location, matrix (e.g., groundwater), and analyses requested. Samples will be preserved in accordance with the analytical methods to be used, and sample containers will be packaged in coolers with ice to maintain a temperature of as close to 4 °C as possible.

All field sampling activities will be recorded in a bound, sequentially paginated field notebook in permanent ink. All sample collection entries will include the date, time, sample locations and numbers, notations of field observations, and the sampler's name and signature.

4.6 WASTE MANAGEMENT PLAN

The investigation-derived waste (IDW) that will be generated during the confirmation sampling include solid materials, and water produced during decontamination of sampling equipment, and purged groundwater. Because the Geoprobe® system will be utilized to collect soil samples, minimal quantities of excess soil will be generated. The probe-sampling device generates no soil cuttings. The sampler is 24 inches long and 1.25 inches in diameter. Typically, 6 inches of the sample are sent to the laboratory for analysis. The remaining sample material will be used to fill the upper portion of the abandoned boreholes and/or spread on the ground surface at the site. The estimated total volume of excess soil sample is 0.7 cubic foot.

Water generated during decontamination of sampling equipment will be spread on the ground surface, near the former UST. An estimated 5 gallons of decontamination water will be generated. Groundwater removed from the wells during purging also will be discharged onto the ground surface adjacent to the well from which it was removed. It is anticipated that 15 gallons of purge water will be generated during groundwater sampling activities.

SECTION 5

SITE CONFIRMATION SAMPLING REPORT FORMAT

Following receipt of the laboratory analytical results, draft, draft final, and final versions of a closure sampling report will be prepared and submitted to ADEQ, Eaker AFBCA, and AFCEE. Comments received on the draft, and draft final reports will be incorporated into the final report.

The report will contain the following information for the Building 457 Area:

- Site plot plan showing sampling locations;
- Summary of field activities;
- Comparison of confirmation sampling and testing results to pre-treatment results;
- Assessment of soil, and groundwater analytical results in comparison to applicable ASTM RBCA RBSLs and/or USEPA SSLs for PAHs and BTEX;
- Assessment of the potential for RNA in groundwater;
- ADEQ-required information, including ADEQ site-specific monitoring well elevation data (based on area benchmarks or topographic maps), and depth to groundwater (referenced to the tops of monitoring well casings or ground level);
- Laboratory analytical reports and chain-of-custody forms;
- Borehole logs; and
- Conclusions and recommendations for NFRAP and site closure, additional cleanup action, or continued monitoring.

SECTION 6
EAKER AFBCA SUPPORT REQUIREMENTS

The following Eaker AFBCA support is needed prior to the arrival of the Parsons ES team:

- Assistance in obtaining digging permits.
- Provision of a potable water supply for drilling and decontamination activities.
- Use of telephone and facsimile machine.

SECTION 7

PROJECT SCHEDULE

The following schedule is contingent upon timely approval of this confirmation SAP and fulfillment of the Eaker AFBCA support requirements outlined in Section 6.

Event	Start Date	End Date	Duration (working days)
Submit Draft SAP to AFCEE and Eaker AFBCA	NA	22 May 1998	NA
Review Period	26 May 1998	19 June 1998	19 days
Respond to Comments on Draft Work Plan	22 June 1998	26 June 1998	5 days
Submit Draft Final SAP to AFCEE, Eaker AFBCA, and ADEQ*	NA	26 June 1998	NA
Submit Work Permit (digging permit) Request	NA	26 June 1998	NA
Review Period	29 June 1998	17 July 1998	15 days
Respond to Comments on Draft Final Work Plan	20 July 1998	24 July 1998	10 days
Submit Final SAP to AFCEE and Eaker AFBCA*	NA	24 July 1998	NA
Turn Blower Off	NA	12 June 1998	NA
Soil and Groundwater Sampling	27 July 1998	1 August 1998	6 days
Respiration Testing	28 July 1998	30 July 1998	3 days
Prepare Closure Report	31 August 1998	6 November 1998	50 days
Submit Draft Closure Report to AFCEE and Eaker AFBCA	NA	6 November 1998	NA
Review Period	9 November 1998	18 December 1998	30 days
Respond to Comments on Draft Closure Report	21 December 1998	4 January 1999	11 days
Submit Draft Final Closure Report to AFCEE, and Eaker AFBCA*	NA	4 January 1999	NA

* Copies of SAP for ADEQ will be sent to Eaker AFBCA for distribution.

SECTION 8

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SECTION 9

REFERENCES CITED

- Atchley, James. 1998. Personal Communication. Phone conversation between James Atchley (Arkansas Department of Environmental Quality) and David Teets (Parsons Engineering Science, Inc.), February 5.
- ASTM, 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. Designation E 1739-95. November.
- Bouwer, E.J. 1992. Bioremediation of Subsurface Contaminants, In: Mitchell, R., ed.: *Environmental Microbiology*. Wiley-Liss, New York, New York.
- HACH. 1997. Third Edition, HACH Water Analysis Handbook. Loveland, Colorado.
- Haliburton NUS (HNUS). 1994. *Description of Current Conditions*. Prepared for Air Force Base Conversion Agency (AFBCA), Eaker AFB, Arkansas. June.
- Ogden Environmental and Energy Service (Ogden). 1995. Tank Removal Report for Building 457, Eaker AFB, Arkansas.
- Parsons Engineering Science, Inc. (Parsons ES). 1996. *Interim Bioventing Pilot Test Results Report for Spill Site No.1, Building 457 Area, and UST 702, Eaker AFB, Arkansas*. Prepared for Air Force Center for Environmental Excellence. Denver, Colorado. August.
- Parsons ES, 1997. Letter to AFCEE and Eaker AFBCA re: Results of Bioventing System Monitoring at Spill Site No. 1, Building 457 Area, and UST 702, Eaker AFB, Arkansas. October 1.
- USEPA, 1996. Soil Screening Guidance: Technical Background Document. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/R-95/128, PB96-963502. May.
- US Air Force. 1995. Unpublished site history and data, Eaker, AFB, Arkansas.
- Weidemeier, T.H., Downey, D.C., Wilson, J.T., Kampbell, D.H., Miller, R.N., and Hansen, J.E. 1995. *Technical Protocol for Implementing the Intrinsic Remediation (Natural Attenuation) with Long-term Monitoring Option for Dissolved-phase Fuel Contamination in Groundwater*. Prepared by the Air Force Center for Environmental Excellence, Brooks AFB, San Antonio, Texas.