LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

DTIC ACCESSION NUMBER

LEVEL

0

INVENTORY

Site-Specific Technical Rpt. for Free . . .

DOCUMENT IDENTIFICATION

20 May 97

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

H A N D L E W I T H C A R E

ACCESSION FOR

NTIS	GRA&I	☑
DTIC	TRAC	☐
UNANNOUNCED		☐
JUSTIFICATION		

BY

DISTRIBUTION/

AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

DATE RETURNED

20001122 047

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

SITE-SPECIFIC TECHNICAL REPORT FOR FREE PRODUCT RECOVERY TESTING AT SITE 160 AND SPILL SITE 2, EAKER AFB, ARKANSAS

DRAFT

PREPARED FOR:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
(AFCEE/ERT)
8001 ARNOLD DRIVE
BROOKS AFB, TEXAS 78235-5357

AND

EAKER AFB, ARKANSAS

20 MAY 1997

DEFENSE TECHNICAL INFORMATION CENTER
REQUEST FOR SCIENTIFIC AND TECHNICAL REPORTS

Title AFCEE Collection

1. Report Availability *(Please check one box)*

☒ This report is available. *Complete sections 2a - 2f.*

☐ This report is not available. *Complete section 3.*

2a. Number of Copies Forwarded 1 each

2b. Forwarding Date July/2000

2c. Distribution Statement *(Please check ONE box)*

DoD Directive 5230.24, "Distribution Statements on Technical Documents," 18 Mar 87, contains seven distribution statements, as described briefly below. Technical documents MUST be assigned a distribution statement.

☒ DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

☐ DISTRIBUTION STATEMENT B: Distribution authorized to U.S. Government Agencies only.

☐ DISTRIBUTION STATEMENT C: Distribution authorized to U.S. Government Agencies and their contractors.

☐ DISTRIBUTION STATEMENT D: Distribution authorized to U.S. Department of Defense (DoD) and U.S DoD contractors only.

☐ DISTRIBUTION STATEMENT E: Distribution authorized to U.S. Department of Defense (DoD) components only.

☐ DISTRIBUTION STATEMENT F: Further dissemination only as directed by the controlling DoD office indicated below or by higher authority.

☐ DISTRIBUTION STATEMENT X: Distribution authorized to U.S. Government agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoD Directive 5230.25, Withholding of Unclassified Technical Data from Public Disclosure, 6 Nov 84.

2d. Reason For the Above Distribution Statement *(in accordance with DoD Directive 5230.24)*

2e. Controlling Office HQ AFCEE

2f. Date of Distribution Statement Determination 15 Nov 2000

3. This report is NOT forwarded for the following reasons. *(Please check appropriate box)*

☐ It was previously forwarded to DTIC on .... *(date)* and the AD number is ....

☐ It will be published at a later date. Enter approximate date if known. ....

☐ In accordance with the provisions of DoD Directive 3200.12, the requested document is not supplied because:

Print or Type Name Laura Peña

Telephone 210-536-1431

Signature Laura Peña

(For DTIC Use Only)
AQ Number M01-01-0324

DRAFT

SITE-SPECIFIC TECHNICAL REPORT (A003)

for

FREE PRODUCT RECOVERY TESTING AT SITE 160 AND SPILL SITE 2, EAKER AFB, ARKANSAS

by

A. Leeson, L. Cumming, J. Eastep, and S. Walton

for

Mr. Patrick Haas
U. S. Air Force Center for Environmental Excellence
Technology Transfer Division
(AFCEE/ERT)
Brooks AFB, Texas 78235

20 May 1997

Battelle
505 King Avenue
Columbus, Ohio 43201-2693

Contract No. F41624-94-C-8012

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Eaker AFB, for a short-term field pilot test to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery techniques to remove light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Eaker AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe, and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The tests at Eaker AFB are two of over 40 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Eaker AFB were skimmer pumping, bioslurping, and drawdown pumping.

Bioslurper pilot test activities were conducted at two sites at Eaker AFB: Site 160 and Spill Site 2. Results from the two test sites are presented separately in the following sections.

Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil sampling to determine physical/chemical site characteristics, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pump tests were conducted. At Site 160, pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted at monitoring well TW1105. The LNAPL recovery testing was conducted in the following sequence: 25.5 hours in the skimmer configuration, approximately 92 hours in the bioslurper configuration (there were three shutdowns for system modifications), an additional 23 hours in the skimmer configuration, 6.2 hours in the drawdown configuration, and an additional 5 hours in the drawdown configuration under vacuum-enhanced conditions. Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

At Spill Site 2, pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted at monitoring well MW-316. The LNAPL recovery testing was conducted in the following sequence: 47 hours in the skimmer configuration, approximately 90 hours in the bioslurper configuration (there was one shutdown overnight), an additional 12.5 hours in the skimmer configuration, and 8.6 hours in the drawdown configuration. Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

Site 160

A baildown recovery test was conducted at monitoring well TW1105. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and LNAPL recovery potential. Overall the baildown recovery test indicated a relatively slow rate of LNAPL recovery into the well. Also, the baildown recovery resulted in an LNAPL thickness substantially less than the initial apparent thickness. The initial LNAPL thickness in the monitoring well was 5.83 ft and, 14 hours after baildown, had recovered to 1.12 ft. Although the recovery rate during the baildown test was relatively low, several sites under the Bioslurper Initiative have shown good LNAPL recovery during bioslurping despite low recovery rates during baildown tests. Therefore, this monitoring well was used for the pump tests.

A series of pump tests were conducted at monitoring well TW1105: skimmer pumping (before and after bioslurping), bioslurping, and drawdown pumping (atmospheric and vacuum-enhanced). Skimmer pump testing initially was conducted in a continuous extraction mode for approximately 25.5 hours. No significant free-phase LNAPL was recovered during skimmer pump testing, indicating that gravity-driven recovery is minimal. Bioslurper testing was conducted for approximately four days resulting in relatively high recovery in comparison to skimmer pumping. During the first day, the recovery rate averaged 54 gallons/day and dropped to 10 gallons/day by day 2. The LNAPL recovery rate appeared to stabilize by day 4 at approximately 8.9 gallons/day. Vacuum levels in the well were relatively high at approximately 18"Hg. LNAPL recovery during the second skimmer pump test was even lower than the first skimmer pump test, with an average recovery rate of 0.019 gallons/day. Drawdown pump testing was conducted to determine if a cone of groundwater depression would enhance LNAPL recovery. The water table was depressed 26 inches below the static water table. No measurable free-phase LNAPL and minimal groundwater was recovered in this mode during 6.2 hours of continuous extraction. In an effort to enhance recovery, vacuum was applied to the well once the water table was drawn down. Although groundwater was produced under these conditions, no free-phase LNAPL could be recovered. These results illustrate that the vacuum gradient maintained during the bioslurper test resulted in higher fluid recovery rates than the 26-inch groundwater drawdown test.

Groundwater production rates during bioslurping were significantly higher than rates during the skimmer or drawdown pump tests. The average rate was 98 gallons/day, which was transferred to a 21,000 gallon storage tank.

Bioslurping also promotes mass removal in the form of volatilization and in situ biodegradation via aeration of the vadose zone. Vapor phase mass removal is the result of soil gas extraction as well as volatilization that may occur during the movement of free-phase LNAPL through the extraction network. Given, the measured vapor flowrate and vapor concentrations, initial hydrocarbon removal rates were approximately 165 lb/day of TPH and 7.5 lb/day of benzene. Thus, initially, mass removal in the vapor phase is significant. However, this short-term test does not provide a good indication as to whether these rates would be sustained. Higher vapor mass removal rates are more often sustained at those sites where liquid product recovery is sustained.

In situ biodegradation rates of 13 to 17 mg/kg-day were measured at three different locations. Based on the radius of influence of 48 ft and a hydrocarbon-impacted soil thickness of 19 ft, mass removal rates via biodegradation are on the order of 160 to 200 lbs of hydrocarbon per day. Thus, mass removal rates via biodegradation could be significant. These results indicate that bioventing is feasible at this site. Air injection bioventing is preferable over bioslurping and soil vapor extraction with respect to the elimination of hydrocarbon vapor emissions.

The initial soil gas profiles at the site displayed oxygen-deficient, carbon dioxide-rich, high total volatile hydrocarbon vapor conditions across the 3 to 17 ft bgl horizons. These conditions indicate that natural biodegradation of residual petroleum hydrocarbons has occurred, but is limited by oxygen availability. Soil gas concentrations were measured during the bioslurper test at monitoring points adjacent to monitoring well TW1105 to determine if the vadose zone was being oxygenated via the bioslurper action. Oxygen concentrations were most influenced at monitoring point MPA, 10 ft from the bioslurper well; however, oxygen increases were low and not consistent throughout the test. Based on the soil gas permeability test, where a radius of influence of 48 ft was measured, it is likely that these areas will become fully aerated. In short, a four day extraction time frame at 11 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In summary, the on-site testing at Site 160, Eaker AFB, included the direct testing of gravity-driven and vacuum-driven LNAPL recovery techniques, bioventing, physical sampling, and tests relevant to soil vapor extraction. Liquid phase recovery was only sustainable in the bioslurper mode and therefore, bioslurping is recommended at this site provided a cost-effective means for long-term water treatment is viable. The generation of off-gas is undesirable and sustained rates of off-gas discharge cannot be estimated accurately from this test, since typically off-gas concentrations will decrease with time. The in situ respiration test and vadose zone radius of influence testing demonstrate that bioventing is feasible at this site.

Spill Site 2

A baildown recovery test was conducted at two monitoring wells at Spill Site 2: MW-316 and MW-306. Overall, the baildown recovery test indicated a relatively slow rate of LNAPL recovery into the monitoring wells. Also, the baildown recovery resulted in an LNAPL thickness approximately ⅓ to ½ that of the initial apparent thickness. The initial LNAPL thickness in monitoring well MW-316 was 3.75 ft and, approximately 24 hours after baildown, recovered to 1.09 ft. Recovery at monitoring well MW-306 was more rapid, where the initial LNAPL thickness was 5.17 ft and recovered to 2.60 ft approximately 4 hours after baildown. Two additional baildown tests were conducted at monitoring well MW-306 to verify the recovery rate. Recovery was less rapid during this test, with an LNAPL thickness less than half of the initial apparent thickness after 24 hours. Although the recovery rate during the baildown test was relatively low, several sites under the Bioslurper Initiative have shown good LNAPL recovery during bioslurping despite low recovery rates during baildown tests. Therefore, monitoring well MW-316 was selected for the bioslurper pump tests.

A series of pump tests were conducted at monitoring well MW-316: skimmer pumping (before and after bioslurping), bioslurping, and drawdown pumping. Skimmer pump testing was conducted in a continuous extraction mode for approximately 47 hours. Recovery of free-phase

LNAPL was low, indicating that gravity-driven recovery is minimal. LNAPL recovery decreased further during bioslurper testing, with a total of 0.33 gallons recovered during approximately four days of continuous extraction. No LNAPL was recovered until day 3. LNAPL recovery during the second skimmer pump test was significantly lower than the first skimmer pump test, with an average recovery rate of 0.30 gallons/day. Drawdown pump testing was conducted to determine if a cone of groundwater depression would enhance LNAPL recovery. The water table was depressed to 1.0 ft below the static water table. No measurable free-phase LNAPL or groundwater was recovered in this mode during 8.6 hours of continuous extraction. These results indicate that either the mobility of free-phase LNAPL is low or that the quantity of free-phase LNAPL is small, such that none of the recovery technologies are capable of sustaining significant recovery.

Groundwater production rates during bioslurping were significantly higher than rates during the skimmer or drawdown pump tests. The average rate was 380 gallons/day, which was transferred to a 21,000 gallon storage tank.

Bioslurping also promotes mass removal in the form of volatilization and in situ biodegradation via aeration of the vadose zone. Vapor phase mass removal is the result of soil gas extraction as well as volatilization that may occur during the movement of free-phase LNAPL through the extraction network. Given, the measured vapor flowrate and vapor concentrations, initial hydrocarbon removal rates were approximately 730 lb/day of TPH and 3.5 lb/day of benzene. Thus, initially, mass removal in the vapor phase is significant. However, this short-term test does not provide a good indication as to whether these rates would be sustained. Higher vapor mass removal rates are more often sustained at those sites where liquid product recovery is sustained.

In situ biodegradation rates of 46 to 50 mg/kg-day were measured at three different locations. Based on the radius of influence of 70 ft and a hydrocarbon-impacted soil thickness of 11 ft, mass removal rates via biodegradation are on the order of 680 to 740 lbs of hydrocarbon per day. Thus, mass removal rates via biodegradation could be as significant as the initial vapor phase removal rates measured during the bioslurper test. These results indicate that bioventing is feasible at this site. Air injection bioventing is preferable over bioslurping and soil vapor extraction with respect to the elimination of hydrocarbon vapor emissions.

The initial soil-gas profiles at the site displayed oxygen-deficient, carbon dioxide-rich, high total volatile hydrocarbon vapor conditions across the 8- to 12-ft below ground surface horizons. These conditions indicate that natural biodegradation of residual petroleum hydrocarbons has occurred, but is limited by oxygen availability. Soil-gas concentrations were measured during the bioslurper test at monitoring points adjacent to monitoring well MW-316 to determine if the vadose zone was being oxygenated via the bioslurper action. Oxygen concentrations were influenced at all monitoring points. Based on the soil-gas permeability test, where a radius of influence of approximately 70 ft was measured, it is likely that these areas will become fully aerated. In short, a four day extraction time frame at 13 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In summary, the on-site testing at Spill Site 2, Eaker AFB, included the direct testing of gravity-driven and vacuum-driven LNAPL free product recovery techniques, bioventing, physical sampling, and tests relevant to soil vapor extraction. Liquid-phase recovery was not sustainable in any of the extraction modes. The vacuum-enhanced mode is significant because if liquid phase LNAPL recovery is not sustainable under high vacuum conditions, then it is unlikely that it will be sustainable under any conditions. Vapor phase mass removal rates measured during bioslurper testing may be the result of soil-gas removal (i.e., SVE) or volatilization during liquid entrainment. The generation of off-gas is undesirable and sustained rates of off-gas discharge cannot be estimated accurately from this test. The in situ respiration test and vadose zone radius of influence testing demonstrate that bioventing is feasible at this site.

Periodic baildown recovery tests are recommended as a useful indicator of free-phase LNAPL recovery potential. Based on the conduct of identical pilot tests at over 25 different sites, there have been several sites where apparent LNAPL product thicknesses are significant (>3 ft). However, once the LNAPL free product is removed from the well, it may take weeks or months to return to initial apparent thicknesses. LNAPL free product continues to accumulate in monitoring wells, but not at a rate to make free product recovery worthwhile. The periodic baildown recovery test is the best method to verify whether or not Spill Site 2 is like the sites described above. Periodic hand bailing may also represent removing LNAPL free product to the extent practicable. A bioventing system may be installed for continued remediation of the vadose zone.

DRAFT SITE-SPECIFIC TECHNICAL REPORT (A003)

for

FREE PRODUCT RECOVERY TESTING AT SITE 160 AND SPILL SITE 2, EAKER AFB, ARKANSAS

20 May 1997

1.0 INTRODUCTION

This report describes activities performed and data collected during field tests at Eaker Air Force Base (AFB), Arkansas, to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery technologies for removal of light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Eaker AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

1.1 Objectives

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The tests at Eaker AFB are two of over 40 similar field tests to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the Test Plan and Technical Protocol for Bioslurping (Battelle, 1995). Test provisions specific to activities at Eaker AFB were described in the Site-Specific Test Plan provided in Appendix A.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Eaker AFB were skimmer pumping, bioslurping, and drawdown pumping. The specific test objectives, methods, and results for the Eaker AFB test program are discussed in the following sections.

1.2 Testing Approach

Bioslurper pilot test activities were conducted at two sites at Eaker AFB: Site 160 and Spill Site 2. Results from the two test sites are presented separately in the following sections.

Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil sampling to determine physical/chemical site characteristics, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pump tests were conducted. At Site 160, pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted at monitoring well TW1105. The LNAPL recovery testing was conducted in the following sequence: 25.5 hours in the skimmer configuration, approximately 92 hours in the bioslurper configuration (there were three shutdowns for system modifications), an additional 23 hours in the skimmer configuration, 6.2 hours in the drawdown configuration, and an additional 5 hours in the drawdown configuration under vacuum-enhanced conditions. Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

At Spill Site 2, pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted at monitoring well MW-316. The LNAPL recovery testing was conducted in the following sequence: 47 hours in the skimmer configuration, approximately 90 hours in the bioslurper configuration (there was one shutdown overnight), an additional 12.5 hours in the skimmer configuration, and 8.6 hours in the drawdown configuration. Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

2.0 FREE PRODUCT RECOVERY TESTING AT SITE 160

2.1 Site Description

The information presented in this section was obtained from site-specific information received by Battelle from Eaker AFB. Eaker AFB is located in Arkansas. The Base Exchange Shoppette Service Station is located on the corner of 3rd and Arkansas Avenue near residential units in the west central portion of the base (Figure 1). The service station has been in operation since 1969 and consists of two 10,000 gallon and one 6,000 gallon underground storage tanks (USTs) which were used to store unleaded gasoline. An additional 1,000 gallon UST with no form of corrosion protection contained waste oil and hydraulic fluid.

Records of past contamination include a 1974 leak in the UST fuel line, which resulted in an unknown amount of fuel spillage. In 1989 tank tightness tests were performed on the USTs. One of the 10,000 gallon tanks tested positive for leaks and therefore was deactivated.

Site geology consists of sand or sandy clay to a depth of 10 ft bgs with an underlying unit of gray to gray brown clay. Below this can be found a unit of medium to coarse grained sand which is poorly sorted and not laterally continuous.

Depth to groundwater at the service station is 7.5 to 10 ft bgs, with a depression in the water table being found in the vicinity of the UST pit. Indications suggest that water flows to this point from the northwest and the southeast. Free product has been found at various wells on site with greater than 4 ft being present at TW-1105. Additional wells which were bailed periodically by base personnel include TW-508 and B-20.

Past site investigations reveal that the highest concentrations of organic compounds were found in shallow subsurface soils near the gasoline pit and fuel lines. A 1991 investigation by PSI indicated the maximum BTEX concentration in subsurface soils to be 785 mg/kg at B-20 and the maximum TPH concentration to be 559 mg/kg at B-5. A 1992 investigation by Halliburton showed subsurface soils to have maximum concentrations of 172 mg/kg at TW-1110 and 172 mg/kg at TW-1109 for BTEX and TPH, respectively. BTEX concentrations in deeper soil tend to be higher in areas south and east of the tank pit. The full lateral and vertical extent of the plume has not yet been defined.

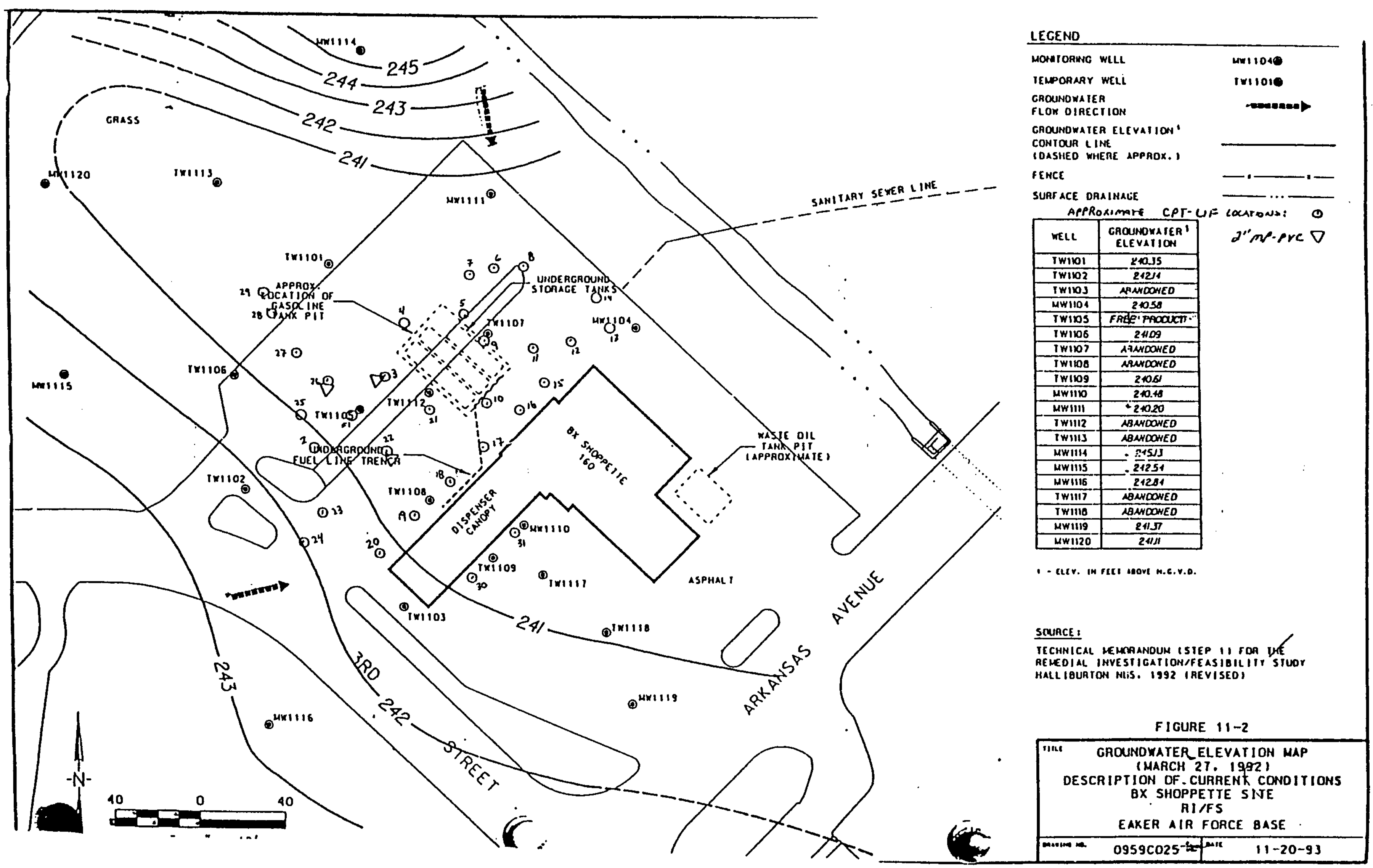


Figure 1. Schematic Diagram Illustrating Groundwater Elevations at the BX Shoppette Service Station

In addition to soil samples, groundwater samples from 8 permanent monitoring wells were analyzed for BTEX and TPH. Only two wells contained detectable levels of BTEX and TPH (MW-1110, MW-1111), with maximum concentrations found to be 14 mg/kg and 2.7 mg/kg respectively.

2.2 Pilot Test Methods

This section documents the initial conditions at the test site and describes the test equipment and methods used for the short-term pilot test at Eaker AFB.

2.2.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Monitoring well TW1105 was evaluated for use in the bioslurper pilot testing. Initial depths to LNAPL and to groundwater were measured using an oil/water interface probe (ORS Model #1068013). LNAPL was removed from the well with a Teflon® bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer was monitored using the oil/water interface probe for approximately 14 hours.

2.2.2 Well Construction Details

A short-term bioslurper pump test was conducted at existing monitoring well TW1105. The well is constructed of 2-inch-diameter, schedule 40 polyvinyl chloride (PVC). The precise construction details for the monitoring well have not been received from the Base. A schematic diagram showing general construction details and location of the monitoring well is shown in Figure 2.

2.2.3 Soil Gas Monitoring Point Installation

Three monitoring points were installed in the area of monitoring well TW1105 and were labeled MPA, MPB, and MPC. The locations and construction details of the monitoring points are illustrated in Figure 2.

The monitoring points consisted of sets of ¼-inch tubing, with 1-inch-diameter, 6-inch-long screened areas. The screened lengths were positioned at the appropriate depths, and the annular space

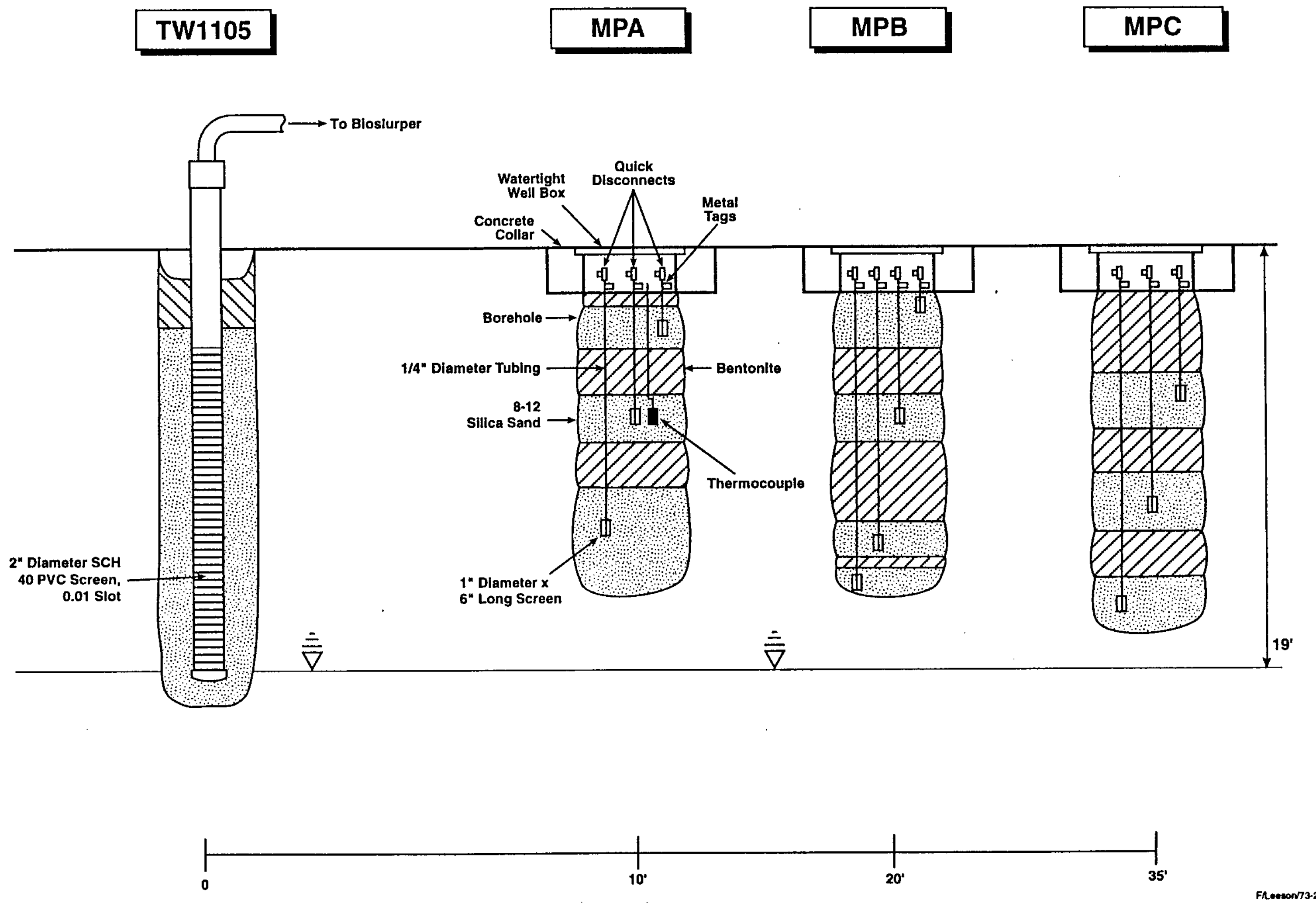


Figure 2. Schematic Diagram Showing Construction Details of Monitoring Well TW1105 and Soil Gas Monitoring Points at Site 160

filled with silica sand. The interval between the screened lengths was filled with bentonite clay chips, as was the space from the top of the shallowest screened length to the ground surface. After placement, the bentonite clay was hydrated with water to expand the chips and provide a seal. The monitoring points were installed at depths as follows:

- Monitoring point MPA was installed at a depth of 15.5 ft into a 6-inch diameter borehole. The monitoring point was screened to three depths: 3.5 to 4.0, 7.5 to 8.0 ft, and 12.0 to 12.5 ft. A Type K thermocouple was installed with the screened interval at 7.5 to 8.0 ft.

- Monitoring point MPB was installed at a depth of 15.5 ft into a 6-inch diameter borehole. The monitoring point was screened to four depths: 2.5 to 3.0 ft, 7.5 to 8.0 ft, 13.2 to 13.7 ft, and 15.0 to 15.5 ft.

- Monitoring point MPC was installed at a depth of 17.5 ft into a 6-inch diameter borehole. The monitoring point was screened to three depths: 6.5 to 7.0 ft, 11.5 to 12.0 ft, and 16.0 to 16.5 ft.

After installation of the monitoring points, initial soil gas measurements were taken with a GasTechtor portable O_2/CO_2 meter and a GasTech Trace-Techtor portable hydrocarbon meter. In general, oxygen-deficient, carbon dioxide-rich, high total volatile hydrocarbon vapor conditions were observed across the 3- to 17-ft bgs horizons (Table 1).

2.2.4 Soil Sampling and Analysis

Three soil samples were collected during the installation of monitoring point MPA and were labeled Facility 160-14.0-14.5, Facility 160-14.5-15.0, and Facility 160-15.0-15.5. The soil samples were collected in a brass sleeve using a split-spoon sampler. The samples were placed in an insulated cooler, chain-of-custody records and shipping papers were completed, and the samples were sent to Alpha Analytical, Inc., in Sparks, Nevada. All samples were analyzed for alkalinity, BTEX, bulk density, moisture content, particle size, pH, porosity, total iron, total Kjeldahl nitrogen (TKN), total phosphorus, and TPH. The laboratory analytical report is provided in Appendix B.

Table 1. Initial Soil Gas Compositions at Site 160

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
MPA	4.0	0	>25.0	>20,000
	8.0	0	24.5	>20,000
	12.6	0	24.0	>20,000
MPB	3.0	0	>25.0	>20,000
	8.0	0	>25.0	>20,000
	13.7	0	24.3	>20,000
MPC	7.0	0	>25.0	>20,000
	12.0	0.3	>25.0	>20,000
	16.5	0.5	>25.0	>20,000

2.2.5 LNAPL Recovery Testing

2.2.5.1 System Setup

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump (Atlantic Fluidics Model A100, 7.5-hp liquid ring pump), oil/water separator, and required support equipment are carried to the test location on a trailer. The trailer was located near monitoring well TW1105, the well cap was removed, a coupling and tee were attached to the top of the well, and the slurper tube was lowered into the well. The slurper tube was attached to the vacuum pump. Different configurations of the tee and the placement depth of the slurper tube allow for simulation of skimmer pumping, operation in the bioslurping configuration, or simulation of drawdown pumping. Extracted groundwater was treated by passing the effluent through an oil/water separator to a 375 gallon tank and then pumped to a 21,000 gallon storage tank.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is provided in Appendix C. All site data and field testing information were recorded in a field notebook and then transcribed onto pilot test data sheets provided in Appendix D.

2.2.5.2 Initial Skimmer Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. A peristaltic pump was used to conduct the skimmer pump test. The tube was held in place at the oil/water interface and the peristaltic pump was started at 8 am, 10 September 1996, to begin the skimmer pump test. The test was operated continuously for 25.5 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

2.2.5.3 Bioslurper Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface. The PVC connecting tee was removed, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 3). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started at 10:56 am, 12 September 1996, to begin the bioslurper pump test. The test was initiated approximately 25 hours after the skimmer pump test and was operated continuously for approximately 92 hours. The pump head vacuum was approximately 24.5″Hg, the well head vacuum was approximately 18″H_2O, the drop tube vacuum was approximately 18.6″Hg, and the vapor flowrate was approximately 9.5 scfm. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

2.2.5.4 Second Skimmer Pump Test

Upon completion of the bioslurper pump test, preparations were made to begin the second skimmer pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. A peristaltic pump was used to conduct the skimmer pump test. The tube was held in place at the oil/water interface and the peristaltic pump was started at 11:30 am, 16 September 1996, to begin the

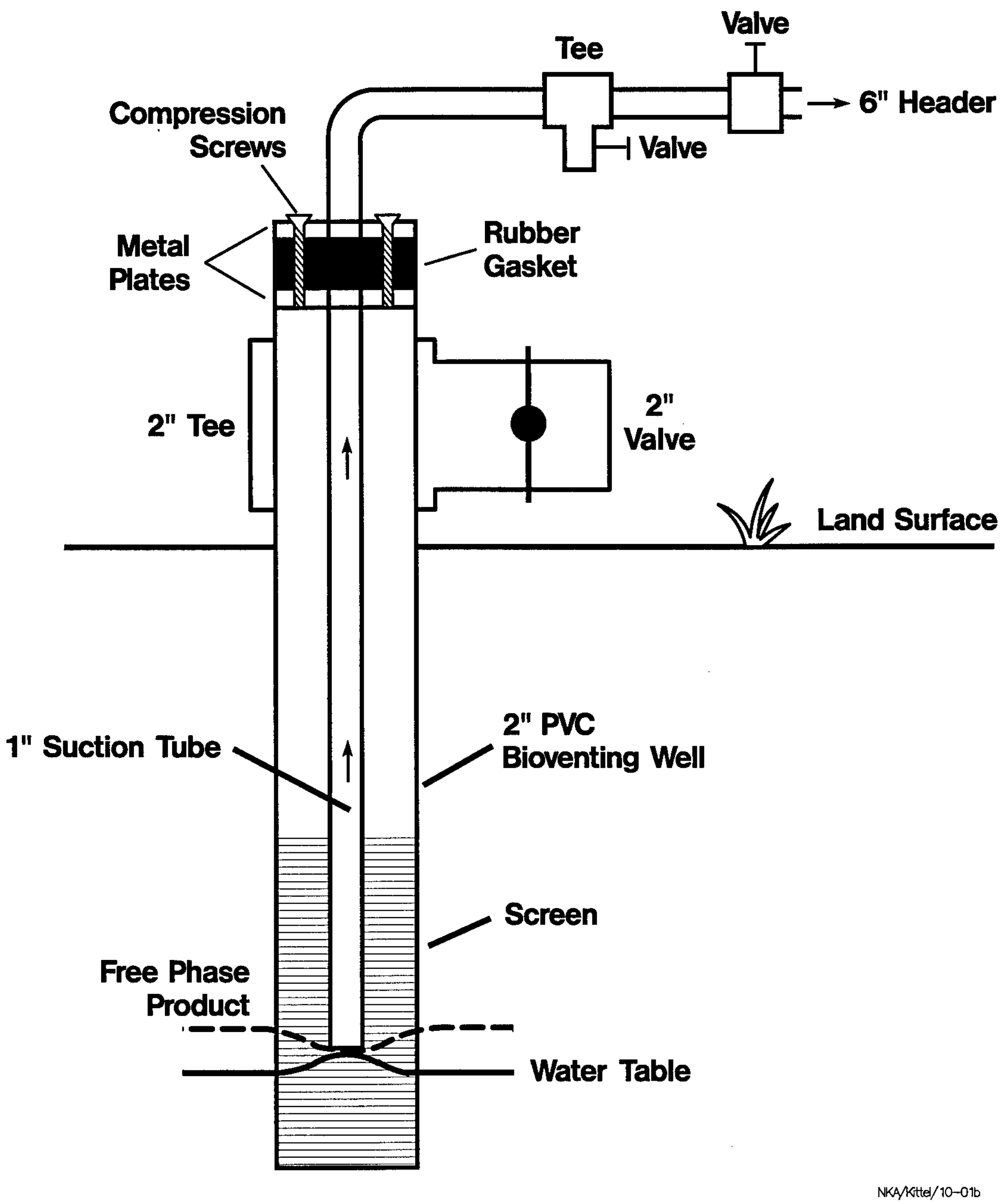


Figure 3. Drop Tube Placement and Valve position for the Bioslurper Pump Test

second skimmer pump test. The test was initiated approximately 0.5 hour after the bioslurper pump test and was operated continuously for 23 hours.

An LNAPL sample was collected during the second skimmer test and was labeled EAK-160-F. The sample was sent to Alpha Analytical, Inc., Sparks, Nevada for analysis of BTEX and TPH only. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

2.2.5.5 Drawdown Pump Test

Upon completion of the second skimmer pump test, preparations were made to begin the drawdown pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set so that the tip was 26 inches below the oil/water interface with the PVC connecting tee open to the atmosphere (Figure 4). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started at 1535, 17 September 1996, to begin the drawdown pump test. The test was initiated approximately 5 hours after the second skimmer pump test and was operated continuously for 6.2 hours. The pump head vacuum was approximately 17″Hg and the vapor flowrate was approximately 40 scfm. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the drawdown pump test. Test data sheets are provided in Appendix D.

2.2.5.6 Drawdown Pump Test (Vacuum-Enhanced)

Due to poor recovery during normal drawdown conditions, a vacuum was applied to the monitoring well when the pump was set up in a drawdown configuration. The slurper tube remained in the same position as during the atmospheric drawdown pump test. The pump head vacuum was approximately 26.5″Hg, the well head vacuum was approximately 21.9″H_2O, the drop tube vacuum was approximately 23.5″Hg, and the vapor flowrate was approximately 7.4 scfm. The vacuum on the wellhead was 21 inches of Hg. The test was initiated 12.75 hours after the atmospheric drawdown pump test and was operated continuously for 5 hours. The LNAPL and groundwater

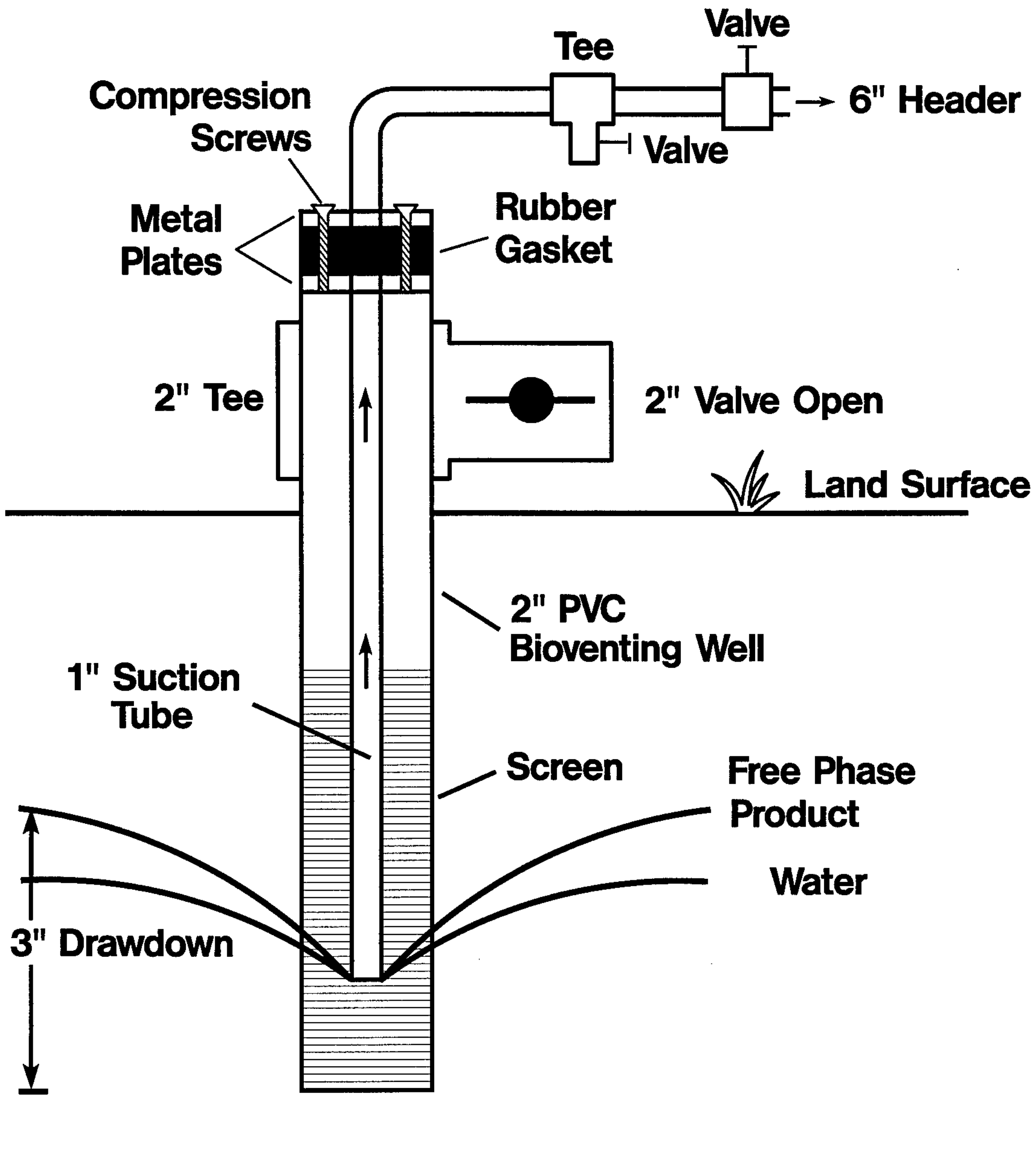


Figure 4. Drop Tube Placement and Valve position for the Drawdown Pump Test

extraction rates were monitored throughout the test, as were all other relevant data for the drawdown pump test. Test data sheets are provided in Appendix D.

2.2.5.7 Off-Gas Sampling and Analysis

Two soil gas samples were collected from the bioslurper off-gas during the bioslurper pump test. The samples were collected in a Tedlar® bag and transferred to Summa® canisters. The samples were labeled EAK-160-1 and EAK-160-2 and were collected 66 hours after initiation of bioslurping. The samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

2.2.5.8 Groundwater Sampling and Analysis

One groundwater sample was collected during the bioslurper pump test. The sample was collected from the oil/water separator and labeled EAK-160-OWS. The sample was collected in a 40-mL VOA vial containing HCl preservative. The sample was checked to ensure no headspace was present and was then shipped on ice and sent under chain of custody to Alpha Analytical, Inc., in Sparks, Nevada for analyses of BTEX and TPH.

2.2.6 Bioventing Analyses

2.2.6.1 Soil Gas Permeability Testing

Soil gas permeability test data were collected during the bioslurper pump test in monitoring well TW1105. Before a vacuum was established in the extraction well, the initial soil gas pressures at the monitoring points were recorded. The start of the bioslurper pump test created a steep pressure drop in the extraction well which was the starting point for the soil gas permeability testing. Soil gas pressures were measured at each of the three monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. The soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence. Test data are provided in Appendix E.

2.2.6.2 In Situ Respiration Testing

Air containing approximately 1.3% helium was injected into three monitoring points for approximately 23 hours beginning on 16 September 1996. The setup for the in situ respiration test is described in the Test Plan and Technical Protocol a Field Treatability Test for Bioventing (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air and helium injection. Air and helium were injected through the following monitoring points at the depths indicated: MPA-8.0′, MPA-12.5′, and MPB-13.7′. After the air/helium injection was terminated, soil gas concentrations of oxygen, carbon dioxide, TPH, and helium were monitored periodically. The in situ respiration test was terminated on September 18, 1996. Oxygen utilization and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix F.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributable to either diffusion through the soil or leakage. A rapid drop in helium concentration usually indicates leakage. A gradual loss of helium along with a first-order curve generally indicates diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium diffuses approximately 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations at test completion are at least 50 to 60% of the initial levels, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

2.3 Pilot Test Results

This section documents the results of the site characterization, the comparative LNAPL recovery pump test, and other supporting tests conducted at Eaker AFB.

2.3.1 Baildown Test Results

Results from the baildown test in monitoring well TW1105 are presented in Table 2. A total volume of 9.0 L (2.4 gallons) was removed by hand bailing from monitoring well TW1105. The

Table 2. Results of Baildown Testing at Monitoring Well TW1105, Site 160

Sample Collection Time	Time (hr)	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 9/9/96 - 1610	0	19.05	13.22	5.83
9/9/96 - 1704	0.93	18.07	17.94	0.13
9/9/96 - 1902	2.87	15.73	14.91	0.82
9/10/96 - 0715	15.08	15.51	14.39	1.12

LNAPL recovery rate was relatively slow and the LNAPL thickness did not recover to initial levels by the end of the 14-hour test period. Pilot testing was initiated in this well to determine if vacuum-enhanced conditions would facilitate free product recovery.

2.3.2 Soil Sample Analyses

Table 3 shows the BTEX and TPH concentrations measured in the soil samples collected from Site 160. BTEX and TPH concentrations were relatively high at an average total BTEX concentration of 6,200 mg/kg and an average TPH concentration of 28,000 mg/kg. The results of the physical characterization of the soil are presented in Table 4.

2.3.3 LNAPL Pump Test Results

2.3.3.1 Initial Skimmer Pump Test Results

The LNAPL thickness prior to the initial skimmer pump test was 1.12 ft. A total of 0.12 gallons of LNAPL was recovered during this test, with an average recovery rate of 0.11 gallons/day (Table 5). A total of 7.7 gallons of groundwater was produced with an average production rate of 7.2 gallons/day. Figure 5 illustrates the fuel recovery versus time during each pump test.

Table 3. TPH and BTEX Concentrations in Soil Samples from Site 160

Parameter	Concentration (mg/kg)		
	FAC 160-14.0-14.5	FAC 160-14.5-15.0	FAC 160-15.0-15.5
TPH (purgeable)	24,000	26,000	33,000
Benzene	170	200	240
Toluene	1,900	2,400	2,600
Ethylbenzene	480	580	670
Total Xylenes	2,500	3,200	3,600

Table 4. Physical Characterization of Soils from Site 160

Parameter		Sample		
		Facility 160-14.0-14.5	Facility 160-14.5-15.0	Facility 160-15.0-15.5
Alkalinity (mg/kg)		320	340	380
Density (g/cm^3)		1.61	1.73	1.62
Moisture Content (%)		12.2	14.6	14.3
Particle Size	Sand	89.7	81.4	90.4
	Silt	7.5	11.1	5.7
	Clay	2.8	7.5	3.9
pH		9.4	9.54	9.5
Porosity (%)		39.2	34.7	38.9
Total Iron (mg/kg)		5,100	8,400	4,200
Total Kjeldahl Nitrogen (mg/kg)		263	209	194
Total Phosphorus (mg/kg)		23	60	46

Table 5. Pump Test Results at Monitoring Well TW1105, Site 160

Time (days)	Recovery Rate (gallons/day)									
	Skimmer Pump Test		Bioslurper Pump Test		Second Skimmer Pump Test		Drawdown Pump Test		Drawdown Pump Test (Vacuum Enhanced)	
	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater
1	0.11	7.2	54	130	0.019	7.8	0	1.1	0	114
2	NA	NA	10	60	NA	NA	NA	NA	NA	NA
3	NA	NA	22	150	NA	NA	NA	NA	NA	NA
4	NA	NA	8.9	63	NA	NA	NA	NA	NA	NA
Average	0.11	7.2	25	98	0.019	7.8	0	1.1	0	114
Total Recovery (gal)	0.12	7.7	94.3	373	0.018	7.8	0	1.1	0	24

NA = Not applicable.

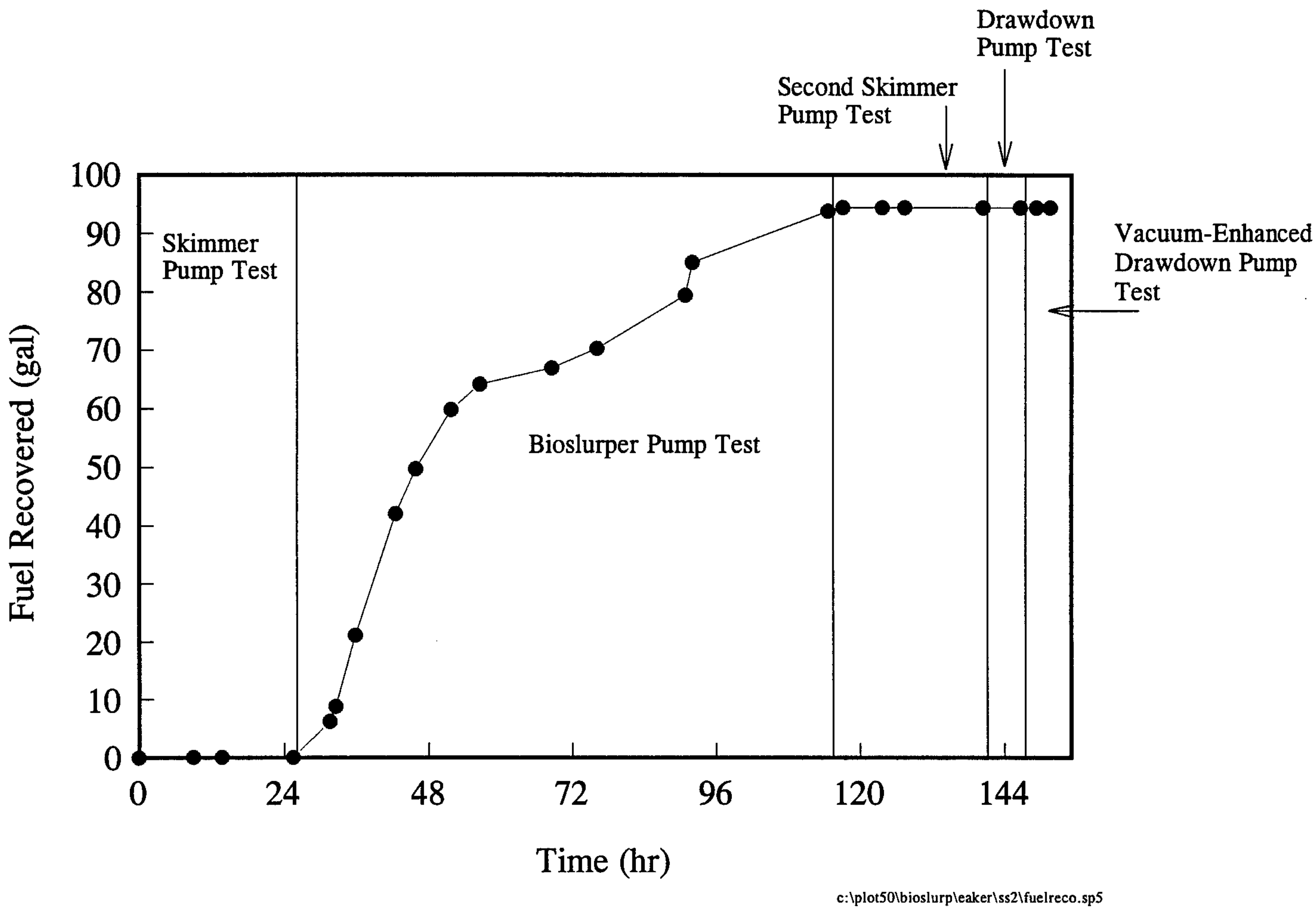


Figure 5. Fuel Recovery Versus Time During Each Pump Test at Site 160

2.3.3.2 Bioslurper Pump Test Results

LNAPL recovery rates increased significantly during the bioslurper pump test as compared to the skimmer pump test. A total of 94.3 gallons of LNAPL and 373 gallons of groundwater were extracted during the bioslurper pump test (Table 5). The initial free product recovery rate was 54 gallons/day, but decreased significantly by day 2 and had dropped to 8.9 gallons/day by day 4. Figure 6 presents the fuel recovery rate versus time during the bioslurper pump test.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations were impacted slightly at most monitoring points in the vicinity of TW1105 (Table 6). However, these increases were low and not consistent with respect to depth or distance from the bioslurper well. It is likely that over time, these areas would become oxygenated, given that a radius of influence of 48 ft was determined during the soil gas permeability test. It is our experience that areas where a pressure change is observed will generally become oxygenated.

2.3.3.3 Second Skimmer Pump Test

Totals of 0.018 gallons of LNAPL and 7.8 gallons of groundwater were recovered during the second skimmer pump test, with daily average recovery rates of 0.019 gallons/day for LNAPL and 7.8 gallons/day for groundwater (Table 5). These results demonstrate that operation of the bioslurper system in the skimmer mode was not an effective means of free-product recovery.

2.3.3.4 Drawdown Pump Test

Drawdown pump testing was conducted to determine if a cone of groundwater depression would enhance LNAPL recovery. The water table was depressed 26 inches below the static water table. No measurable free-phase LNAPL and minimal groundwater (1.1 gallons/day) was recovered in this mode during 6.2 hours of continuous extraction under normal atmospheric conditions (Table 5). These results demonstrate that operation of the bioslurper system in the drawdown mode was not an effective means of free-product recovery.

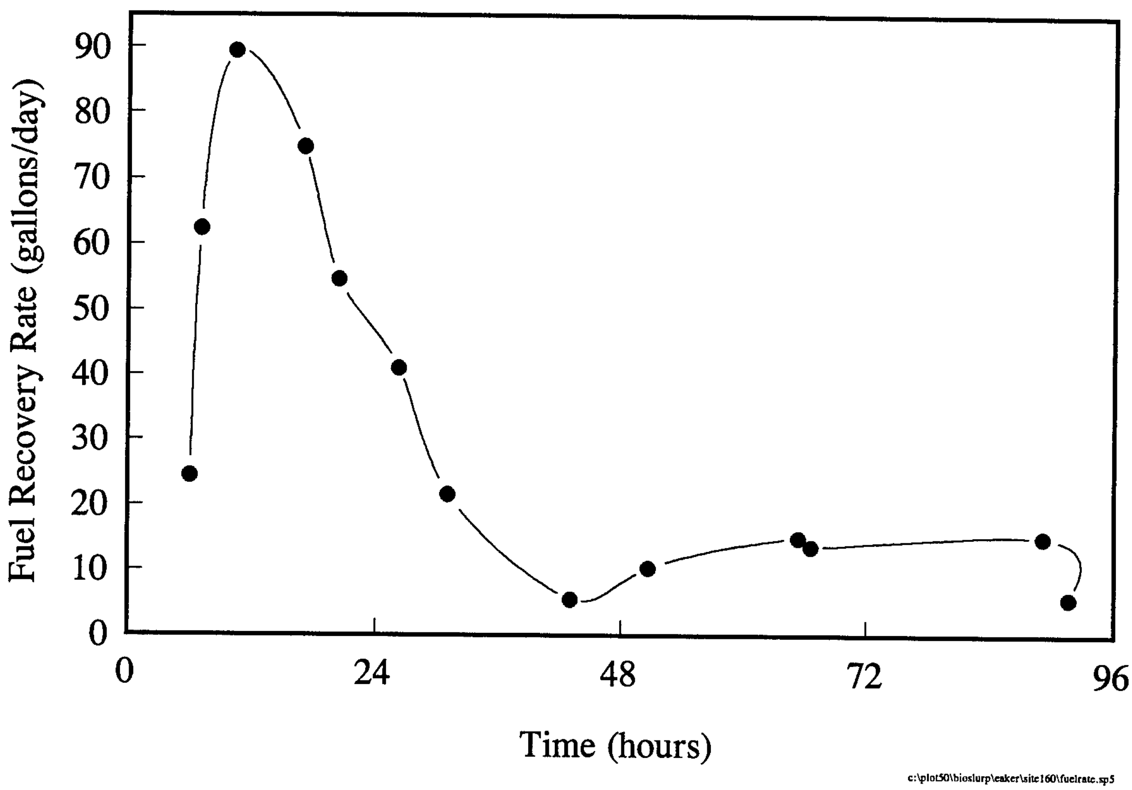


Figure 6. Fuel Recovery Rate Versus Time During the Bioslurper Pump Test at Site 160

Table 6. **In Situ Oxygen Concentrations During the Bioslurper Pump Test at Monitoring Well TW1105, Site 160**

Monitoring Point	Oxygen Concentrations (%) Versus Time (hours)			
	0	56	71	97
MPA-4.0	0	2.8	4.5	1.5
MPA-8.0	0	0.5	0.5	0
MPA-12.0	0	0	4.5	0
MPB-3.0	0	0	0	0
MPB-8.0	0	0.3	0	4.0
MPB-13.7	0	0.5	0	0
MPC-7.0	0	0	0	0
MPC-12.0	0.	0.01	0.7	1.5
MPC-16.5	0.5	0	0	0

2.3.3.5 Drawdown Pump Test (vacuum enhanced)

In an effort to enhance fluid recovery, a vacuum was applied to the well in the drawdown configuration. No LNAPL and very little groundwater was extracted, with totals of 0 gallons of LNAPL and 23.8 gallons of groundwater extracted (Table 5). These results demonstrate that operation of the bioslurper system in the drawdown mode under vacuum enhanced conditions was not an effective means of free-product recovery.

2.3.3.6 Extracted Groundwater, LNAPL, and Off-Gas Analyses

One groundwater sample was collected during the bioslurper pump test. TPH concentration was low, with a concentration of 86 mg/L (Table 7). The total BTEX concentration was 40.5 mg/L.

Off-gas samples from the bioslurper system also were collected during the bioslurper pump test. The results from the off-gas analyses are presented in Table 8. Given a vapor discharge rate of 9.4 scfm and using a concentration of 47,000 ppmv TPH and 2,750 ppmv benzene, approximately

Table 7. BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Pump Test at Site 160

Parameter	Concentration (mg/L)
	EAK-160-OWS
TPH (purgeable)	86
Benzene	5.6
Toluene	22
Ethylbenzene	1.9
Total Xylenes	11

Table 8. BTEX and TPH Concentrations in Off-Gas During the Bioslurper Pump Test at Site 160

Parameter	Concentration (mg/L)	
	EAK-160-1	EAK-160-2
TPH referenced to gasoline	51,000	43,000
C2 - C4 Hydrocarbons	25,000	17,000
Benzene	3,000	2,500
Toluene	8,900	7,800
Ethylbenzene	660	740
Total Xylenes	2,400	2,700

165 lb/day of TPH and 7.5 lb/day benzene was emitted to the air during the bioslurper pump test. The composition of LNAPL in terms of BTEX is shown in Table 9.

Table 9. BTEX Concentrations in LNAPL at Site 160

Compound	Concentration (mg/kg)
Benzene	1,300
Toluene	42,000
Ethylbenzene	21,000
Total Xylenes	110,000

2.3.4 Bioventing Analyses

2.3.4.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is then defined as the distance from the extraction well where 0.1 inch of H_2O can be measured. Based on this definition, the radius of influence during the bioslurper pump test at monitoring well TW1105 was approximately 48 ft (Figure 7).

2.3.4.2 In Situ Respiration Test Results

Results from the in situ respiration test are presented in Table 10. Oxygen depletion was relatively fast, with oxygen utilization rates ranging from 0.80 to 1.0 $\%O_2$/hr. Biodegradation rates ranged from 13 to 17 mg/kg-day.

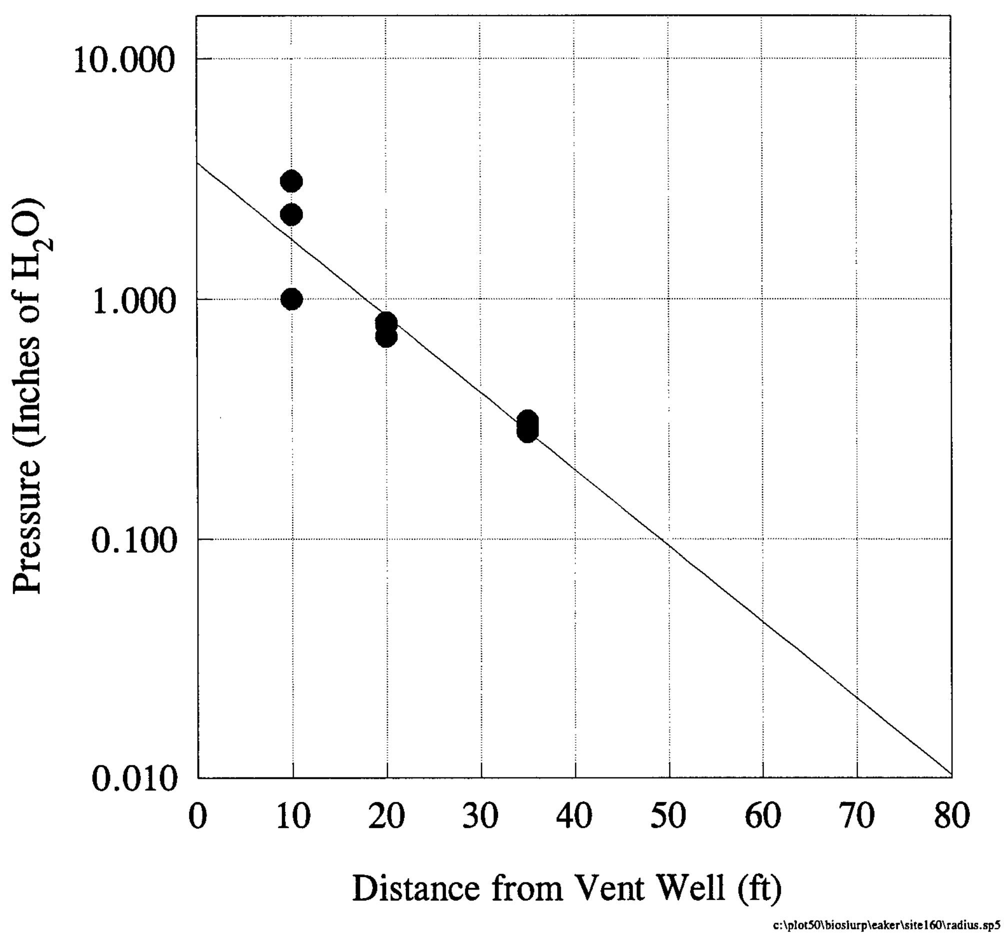


Figure 7. **Radius of Influence Determination Based on Soil Gas Pressure Change Versus Distance from Extraction Well at Site 160**

Table 10. In Situ Respiration Test Results at Site 160

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg-day)
MPA-8.0	0.94	15
MPA-12.6	1.03	17
MPA-13.7	0.80	13

2.4 Discussion

A baildown recovery test was conducted at monitoring well TW1105. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and LNAPL recovery potential. Overall the baildown recovery test indicated a relatively slow rate of LNAPL recovery into the well. Also, the baildown recovery resulted in an LNAPL thickness substantially less than the initial apparent thickness. The initial LNAPL thickness in the monitoring well was 5.83 ft and, 14 hours after baildown, had recovered to 1.12 ft. Although the recovery rate during the baildown test was relatively low, several sites under the Bioslurper Initiative have shown good LNAPL recovery during bioslurping despite low recovery rates during baildown tests. Therefore, this monitoring well was used for the pump tests.

A series of pump tests were conducted at monitoring well TW1105: skimmer pumping (before and after bioslurping), bioslurping, and drawdown pumping (atmospheric and vacuum-enhanced). Skimmer pump testing initially was conducted in a continuous extraction mode for approximately 25.5 hours. No significant free-phase LNAPL was recovered during skimmer pump testing, indicating that gravity-driven recovery is minimal. Bioslurper testing was conducted for approximately four days resulting in relatively high recovery in comparison to skimmer pumping. During the first day, the recovery rate averaged 54 gallons/day and dropped to 10 gallons/day by day 2. The LNAPL recovery rate appeared to stabilize by day 4 at approximately 8.9 gallons/day. Vacuum levels in the well were relatively high at approximately 18″Hg. LNAPL recovery during the second skimmer pump test was even lower than the first skimmer pump test, with an average recovery rate of 0.019 gallons/day. Drawdown pump testing was conducted to determine if a cone of groundwater depression would enhance LNAPL recovery. The water table was depressed 26 inches below the static water table. No measurable free-phase LNAPL and minimal groundwater was recovered in this mode during 6.2 hours of continuous extraction. In an effort to enhance recovery, vacuum was applied to the well once the water table was drawn down. Although groundwater was produced under these conditions, no free-phase LNAPL could be recovered. These results illustrate that the vacuum gradient maintained during the bioslurper test resulted in higher fluid recovery rates than the 26-inch groundwater drawdown test.

Groundwater production rates during bioslurping were significantly higher than rates during the skimmer or drawdown pump tests. The average rate was 98 gallons/day, which was transferred to a 21,000 gallon storage tank.

Bioslurping also promotes mass removal in the form of volatilization and in situ biodegradation via aeration of the vadose zone. Vapor phase mass removal is the result of soil gas extraction as well as volatilization that may occur during the movement of free-phase LNAPL through the extraction network. Given, the measured vapor flowrate and vapor concentrations, initial hydrocarbon removal rates were approximately 165 lb/day of TPH and 7.5 lb/day of benzene. Thus, initially, mass removal in the vapor phase is significant. However, this short-term test does not provide a good indication as to whether these rates would be sustained. Higher vapor mass removal rates are more often sustained at those sites where liquid product recovery is sustained.

In situ biodegradation rates of 13 to 17 mg/kg-day were measured at three different locations. Based on the radius of influence of 48 ft and a hydrocarbon-impacted soil thickness of 19 ft, mass removal rates via biodegradation are on the order of 160 to 200 lbs of hydrocarbon per day. Thus, mass removal rates via biodegradation could be significant. These results indicate that bioventing is feasible at this site. Air injection bioventing is preferable over bioslurping and soil vapor extraction with respect to the elimination of hydrocarbon vapor emissions.

The initial soil gas profiles at the site displayed oxygen-deficient, carbon dioxide-rich, high total volatile hydrocarbon vapor conditions across the 3 to 17 ft bgl horizons. These conditions indicate that natural biodegradation of residual petroleum hydrocarbons has occurred, but is limited by oxygen availability. Soil gas concentrations were measured during the bioslurper test at monitoring points adjacent to monitoring well TW1105 to determine if the vadose zone was being oxygenated via the bioslurper action. Oxygen concentrations were most influenced at monitoring point MPA, 10 ft from the bioslurper well; however, oxygen increases were low and not consistent throughout the test. Based on the soil gas permeability test, where a radius of influence of 48 ft was measured, it is likely that these areas will become fully aerated. In short, a four day extraction time frame at 11 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In summary, the on-site testing at Site 160, Eaker AFB, included the direct testing of gravity-driven and vacuum-driven LNAPL recovery techniques, bioventing, physical sampling, and tests relevant to soil vapor extraction. Liquid phase recovery was only sustainable in the bioslurper mode and therefore, bioslurping is recommended at this site provided a cost-effective means for long-term water treatment is viable. The generation of off-gas is undesirable and sustained rates of off-gas discharge cannot be estimated accurately from this test, since typically off-gas concentrations will decrease with time. The in situ respiration test and vadose zone radius of influence testing demonstrate that bioventing is feasible at this site.

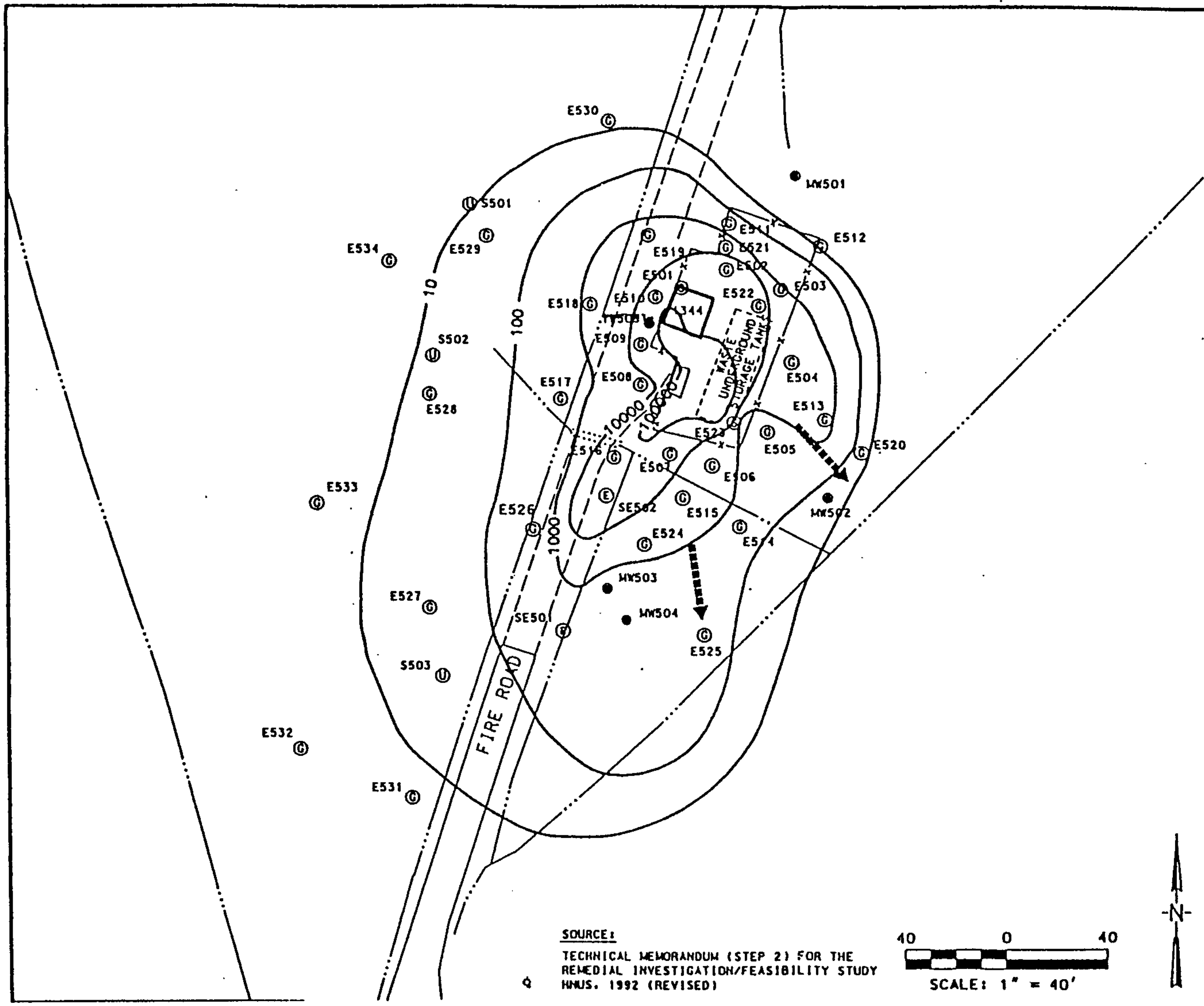
3.0 FREE PRODUCT RECOVERY TESTING AT SPILL SITE 2

3.1 Site Description

The Underground Waste Oil Tank (UWOT) site (Facility #1344) has operated since 1972 and is still active. The UWOT is located in the northwest portion of the base about 800 ft south of the FPTA (Figure 8). The facility consists of two currently empty 10,000 gallon USTs installed in 1988 which previously contained waste oil and JP-4 jet fuel. A concrete pad containing a drain leading to an oil/water separator was installed in 1988 for vehicles transferring waste oil. The surface of the UWOT is gravel paved over soil and discoloration is evident in the vicinity of the transfer area. Facility #1344 is used to store hazardous and nonhazardous waste oils until their removal to off-site disposal facilities which occurs about once every 3 months. Four 4,000 gallon USTs and one 500 gallon UST were previously located at the site until their removal in 1987. The tanks had been used to hold waste oils, solvents, and JP-4 jet fuel and were not cathodically protected.

Site geology consists predominately of clay to a depth of 22 ft bgs. The unit below this depth tends to be dominated by sand. Depth to groundwater at the site ranges from 9 to 12 ft bgs and groundwater flow is to the south.

Investigations have been made to characterize the site, however, data collection is insufficient to define the extent of the contamination. Soil and groundwater samples taken from five 25 ft borings were analyzed in 1987. Four monitoring wells (MW501, MW502, MW503, and MW504) were



LEGEND

MONITORING WELL — MW501
TEMPORARY WELL — TW508
SOIL GAS SAMPLING POINT — E501
SEDIMENT SAMPLE — SE501
SUBSURFACE SOIL GRAB SAMPLE — S501
APPROX. GROUNDWATER FLOW DIRECTION
TOTAL VOCs[1] ISOCONCENTRATION LINE (DASHED WHERE APPROX.)
FENCE
SURFACE DRAINAGE

SOV POINTS	TOTAL VOCs[1] (FID)	SOV POINTS	TOTAL VOCs[1] (FID)
E501	17740	E518	1105
E502	8131	E519	2017
E503	28560	E520	31
E504	9213	E521	13300
E505	757	E522	40960
E506	7608	E523	153600
E507	10960	E524	2446
E508	9408	E525	139
E509	41990	E526	158
E510	168800	E527	43
E511	635	E528	17
E512	7.5	E529	14
E513	14890	E530	6.1
E514	508	E531	1.9
E515	4954	E532	<1
E516	99610	E533	<1
E517	331	E534	1.8

SAMPLE NO.	TOTAL BTEX[2]
S501	<20
S502	<20
S503	<20

1 - CONCENTRATIONS IN µg/L OF AIR
2 - CONCENTRATIONS IN µg/kg OF SOIL

NOTE:
SOIL SAMPLES S501-S503 WERE ANALYZED FOR TCL VOCS.

FIGURE 3-7

TITLE: TOTAL VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL GAS
UNDERGROUND WASTE OIL TANKS SITE
DESCRIPTION OF CURRENT CONDITIONS
RFI
EAKER AIR FORCE BASE

DRAWING NO. 0114G010 | DATE 1-25-94

Figure 8. Schematic Diagram Showing Monitoring Well Locations and Total Volatile Organic Compounds in Soil Gas at Spill Site 2

installed in 1988, three of which had depths of 25 to 30 ft bgs and one of which had a depth of 70 ft bgs. Volatile organic compounds (VOCs) were found at concentrations of up to 169 mg/L in soil gas during this 1988 investigation. In 1991, groundwater samples were taken from existing wells in addition to soil gas sampling. Samples were analyzed for BTEX, VOCs, and chlorinated hydrocarbons. Soil samples were taken from the vadose and saturated zones again in 1992. Results revealed the highest concentrations of organic compounds downgradient from the UWOT. Organic compounds were detected at depths of 2 to 19 ft bgs with maximum concentrations being found at 3 to 11 ft bgs. A maximum TPH concentration of 8,900 mg/kg and a maximum xylene concentration of 25 mg/kg were found.

In general, low levels of organic and inorganic compounds were found in the groundwater. None of the organic compounds at the site exceeded MCLs in the sampling conducted by Halliburton NUS in 1988 and 1991. Inorganic analytes exceeding MCLs were antimony and cadmium. There was, however, about 6 ft of free product found in TW508. Free product was encountered in a sandy unit at 16 ft bgs and is thought to have migrated through vertical sand-filled fractures since it does not appear to be present in clay units at the same depth. Groundwater sampling conducted in 1995 revealed the presence of small amounts of chlorinated compounds. Maximum concentrations of 1,2-Dichloroethene, 1,4-Dichlorobenzene, and 1,2-Dichlorobenzene were 45, 75, and 9 ppb, respectively.

3.2 Pilot Test Methods

This section documents the initial conditions at the test site and describes the test equipment and methods used for the short-term pilot test at Eaker AFB.

3.2.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Monitoring wells MW-306 and MW-316 was evaluated for use in the bioslurper pilot testing. Initial depths to LNAPL and to groundwater were measured using an oil/water interface probe (ORS Model #1068013). LNAPL was removed from the well with a Teflon® bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer was monitored using the oil/water interface probe for approximately 19 hours at monitoring well MW-316. At monitoring well MW-306, the baildown test was conducted for approximately 4 hours, at which point the well was bailed down again and monitored for approximately 2 hour. A final baildown test was performed in monitoring well MW-306 the following day and was monitored for approximately 5 hours.

3.2.2 Well Construction Details

A short-term bioslurper pump test was conducted at existing monitoring well MW-316. The well is constructed of 4-inch-diameter, schedule 40 PVC. Precise construction details have not been received from the Base to date. A schematic diagram illustrating general monitoring well construction details and location is shown in Figure 9.

3.2.3 Soil Gas Monitoring Point Installation

Three monitoring points were installed in the area of monitoring well MW-316 and were labeled MPA, MPB, and MPC. The locations and construction details of the monitoring points are illustrated in Figure 9. The monitoring points consisted of sets of ¼-inch tubing, with 1-inch-diameter, 6-inch-long screened areas. The screened lengths were positioned at the appropriate depths, and the annular space corresponding to the screened length was filled with silica sand. The interval between the screened lengths was filled with bentonite clay chips, as was the space from the top of the shallowest screened length to the ground surface. After placement, the bentonite clay was hydrated with water to expand the chips and provide a seal. The monitoring points were installed to a depth of 12.5 ft into a 6-inch diameter borehole. Each monitoring point was screened to three depths: 3.5 to 4.0, 7.5 to 8.0, and 11.5 to 12.0 ft. A Type K thermocouple was installed at monitoring point MPB-4.0′ and MPC-12.5′.

After installation of the monitoring points, initial soil gas measurements were taken with a GasTechtor portable O_2/CO_2 meter and a GasTech Trace-Techtor portable hydrocarbon meter. In general, oxygen limitation was observed at the deeper depths (8 ft and greater) of all three monitoring points. Also, TPH levels were greater than 20,000 ppmv at all monitoring points at depths 8.0 ft and greater (Table 11).

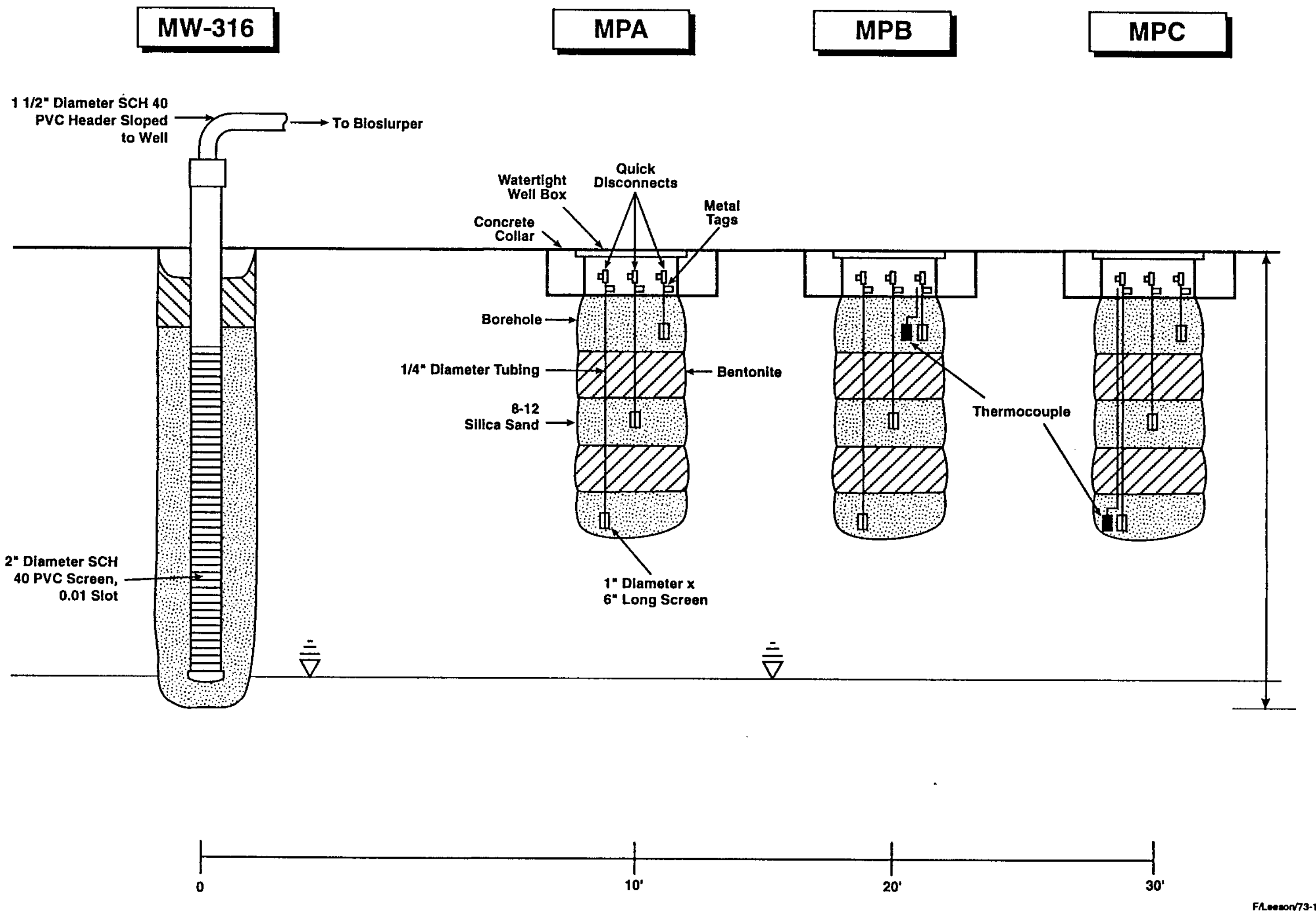


Figure 9. Schematic Diagram Showing Construction Details for Monitoring Well MW-316 and Soil Gas Monitoring Points at Spill Site 2

Table 11. Initial Soil Gas Compositions at Site 2

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
MPA	4.0	10.0	10	8,600
	8.0	1.0	22	>20,000
	12.0	0.30	17	>20,000
MPB	4.0	17.5	5.5	320
	8.0	3.0	15	>20,000
	12.0	0	14	>20,000
MPC	4.0	18.8	3.0	520
	8.0	2.0	16	>20,000
	12.0	0	13	>20,000

3.2.4 Soil Sampling and Analysis

Three soil samples were collected during the installation of monitoring point MPA and was labeled EAFB-2 10.5-11.0, EAFB-2 11.0-11.5, and EAFB-2 11.5-12.0. The soil samples were collected in a brass sleeve using a split-spoon sampler. The samples were placed in an insulated cooler, chain-of-custody records and shipping papers were completed, and the samples were sent to Alpha Analytical, Inc., in Sparks, Nevada. All samples were analyzed for alkalinity, BTEX, bulk density, moisture content, particle size, porosity, pH, total iron, total Kjeldahl nitrogen (TKN), total phosphorus, and TPH. The laboratory analytical report is provided in Appendix B.

3.2.5 LNAPL Recovery Testing

3.2.5.1 System Setup

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump (Atlantic Fluidics Model A100, 7.5-hp liquid ring pump), oil/water separator, and required support equipment are carried to the test location on a trailer. The trailer was located near monitoring well

MW-316, the well cap was removed, a coupling and tee were attached to the top of the well, and the slurper tube was lowered into the well. The slurper tube was attached to the vacuum pump. Different configurations of the tee and the placement depth of the slurper tube allow for simulation of skimmer pumping, operation in the bioslurping configuration, or simulation of drawdown pumping. Extracted groundwater was treated by passing the effluent through an oil/water separator to a 375 gallon tank and then pumped into a 21,000 gallon storage tank. Per request by Eaker AFB, the groundwater was discharged on an impermeable liner located on base and allowed to evaporate.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is provided in Appendix C. All site data and field testing information were recorded in a field notebook and then transcribed onto pilot test data sheets provided in Appendix D.

3.2.5.2 Initial Skimmer Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. A peristaltic pump was used to conduct the skimmer pump test. The tube was held in place at the oil/water interface and the peristaltic pump was started 1020, 11 September 1996, to begin the skimmer pump test. The test was operated continuously for approximately 47 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

3.2.5.3 Bioslurper Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface. The PVC connecting tee was removed, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 3). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started at 1045, 13 September 1996, to begin the bioslurper pump test. The test was initiated approximately 1.5 hr after the skimmer pump test and was operated for approximately 90 hours with one shutdown overnight. The pump head vacuum was approximately 25"Hg, the well head vacuum was approximately 10"H_2O, and the vapor flowrate was approximately 9.7 scfm. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

An LNAPL sample was collected during the bioslurper pump test and was labeled EAK-2-F. The sample was sent to Alpha Analytical, Inc., Sparks, Nevada for analysis of BTEX and TPH only.

3.2.5.4 Second Skimmer Pump Test

Upon completion of the bioslurper pump test, preparations were made to begin the second skimmer pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. A peristaltic pump was used to conduct the skimmer pump test. The tube was held in place at the oil/water interface and the peristaltic pump was started at 1145, 17 September 1996, to begin the second skimmer pump test. The test was initiated approximately 45 minutes after the bioslurper pump test and was operated continuously for 12.5 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

3.2.5.5 Drawdown Pump Test

Upon completion of the second skimmer pump test, preparations were made to begin the drawdown pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set so that the tip was 1.0 ft below the oil/water interface with the PVC connecting tee open to the atmosphere (Figure 4). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started at 0940, 18 September 1996, to begin the drawdown pump test. The test was initiated approximately 9.5 hours after the bioslurper pump test and was operated continuously for 8.6 hours. The pump head vacuum was approximately 15.5"Hg and the vapor flowrate was approximately 35 scfm. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the drawdown pump test. Test data sheets are provided in Appendix D.

3.2.5.6 Off-Gas Sampling and Analysis

Soil gas samples were collected from the bioslurper off-gas during the bioslurper pump test. The samples were collected in a Tedlar® bag and transferred to a Summa® canister. The samples were labeled EAK-S2-1 and EAK-S2-2 and were collected approximately 48 hr after test initiation. The samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

3.2.5.7 Groundwater Sampling and Analysis

Two groundwater samples were collected during the bioslurper pump test. Samples were collected from the oil/water separator and the 21,000 gallon tank and were labeled EAK-2-OWS and EAK-2-TW, respectively and were collected approximately 77 hr after test initiation. Samples were collected in 40-mL VOA vials containing HCl preservative. Samples were checked to ensure no headspace was present and were then shipped on ice and sent under chain of custody to Alpha Analytical, Inc., in Sparks, Nevada for analyses of BTEX and TPH.

3.2.6 Bioventing Analyses

3.2.6.1 Soil Gas Permeability Testing

Soil gas permeability test data were collected during the bioslurper pump test in monitoring well MW-316. Before a vacuum was established in the extraction well, the initial soil gas pressures at the monitoring points were recorded. The start of the bioslurper pump test created a steep pressure drop in the extraction well which was the starting point for the soil gas permeability testing. Soil gas pressures were measured at each of the three monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. The soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence. Test data are provided in Appendix E.

3.2.6.2 In Situ Respiration Testing

Air containing approximately 0.4 to 1% helium was injected into three monitoring points for approximately 21 hours beginning on September 17, 1996. The setup for the in situ respiration test is described in the Test Plan and Technical Protocol a Field Treatability Test for Bioventing (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air and helium injection. Air and helium were injected through the following monitoring points at the depths indicated: MPA-12.0′, MPB-12.0′, and MPC-12.0′. After the air/helium injection was terminated, soil gas concentrations of oxygen, carbon dioxide, TPH, and helium were monitored periodically. The respiration test was terminated on September 22, 1996. Oxygen utilization and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix F.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributable to either diffusion through the soil or leakage. A rapid drop in helium concentration usually indicates leakage. A gradual loss of helium along with a first-order curve generally indicates diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium diffuses approximately 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations at test completion are at least 50 to 60% of the initial levels, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

3.3 Pilot Test Results

This section documents the results of the site characterization, the comparative LNAPL recovery pump test, and other supporting tests conducted at Eaker AFB.

3.3.1 Baildown Test Results

Results from the baildown tests in monitoring wells MW-306 and MW-316 are presented in Tables 12 and 13. The initial LNAPL thickness in monitoring well MW-316 was 3.75 ft and, approximately 24 hours after baildown, recovered to 1.09 ft. Recovery at monitoring well MW-306

Table 12. Results of Baildown Testing in Monitoring Well MW-306, Site 2

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 9/10/96	19.27	14.10	5.17
9/10/96 - 1008	17.12	16.51	0.61
9/10/96 - 1012	17.00	15.90	1.10
9/10/96 - 1019	16.95	15.27	1.68
9/10/96 - 1033	17.03	14.83	2.20
9/10/96 - 1252	17.18	14.63	2.55
9/10/96 - 1415	17.20	14.60	2.60
Second Baildown			
9/10/96 - 1422	15.89	15.80	0.09
9/10/96 - 1444	15.30	15.20	0.10
9/10/96 - 1635	15.31	15.135	0.18
Third Baildown			
9/11/96 - 0920	15.98	15.10	0.88
9/11/96 - 1444	15.99	14.99	1.00

Table 13. Results of Baildown Testing in Monitoring Well MW-316, Site 2

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 9/10/96	19.21	15.46	3.75
9/10/96 - 1425	18.82	18.73	0.09
9/10/96 - 1441	18.54	18.00	0.54
9/10/96 - 1544	17.89	17.11	0.78
9/10/96 - 1632	17.56	16.78	0.78
9/11/96 - 0925	17.18	16.09	1.09

was more rapid, where the initial LNAPL thickness was 5.17 ft and recovered to 2.60 ft approximately 4 hours after baildown. Two additional baildown tests were conducted at monitoring well MW-306 to verify the recovery rate. Recovery was less rapid during these tests, with an LNAPL thickness less than half of the initial apparent thickness after 24 hours. Although the recovery rate during the baildown test was relatively low, several sites under the Bioslurper Initiative have shown good LNAPL recovery during bioslurping despite low recovery rates during baildown tests. Therefore, monitoring well MW-316 was selected for the bioslurper pump tests.

3.3.2 Soil Sample Analyses

Table 14 shows the BTEX and TPH concentrations measured in the soil samples collected from Site 2. BTEX and TPH concentrations were relatively high at a total BTEX concentration ranging from 80 to 150 mg/kg and a TPH concentration ranging from 2,600 to 4,500 mg/kg. Toluene was below detection limits at depths from 11.0 to 12.0 ft. The results of the physical characterization of the soil are presented in Table 15.

Table 14. TPH and BTEX Concentrations in Soil Samples from Site 2

Parameter	Concentration (mg/kg)		
	EAFB-2 10.5-11.0	EAFB-2 11.0-11.5	EAFB-2 11.5-12.0
TPH (purgeable)	4,500	2,600	3,600
Benzene	9.1	5.7	11
Toluene	1.2	<1.0	<1.0
Ethylbenzene	22	12	20
Total Xylenes	120	62	110

Table 15. Physical Characterization of Soils from Site 2

Parameter		Sample		
		EAFB-2-10.5-11.0	EAFB-2-11.0-11.5	EAFB-2-11.5-12.0
Alkalinity (mg/kg)		730	660	730
Density (g/cm^3)		1.25	1.25	1.26
Moisture Content (%)		23.6	23.1	23.3
Particle Size	Sand	22.5	29.2	30.0
	Silt	55.8	51.3	50.9
	Clay	21.7	19.2	19.1
pH		9.46	9.62	9.54
Porosity		52.8	52.8	52.4
Total Iron (mg/kg)		15,000	14,000	16,000
Total Kjeldahl Nitrogen (mg/kg)		278	388	347
Total Phosphorus (mg/kg)		232	319	244

3.3.3 LNAPL Pump Test Results

3.3.3.1 Initial Skimmer Pump Test Results

A total of 5.01 gallons of LNAPL was recovered during this test, with an average recovery rate of 2.6 gallons/day (Table 16). A total of 17.06 gallons of groundwater was produced with an average production rate of 9.5 gallons/day (Table 16). Fuel recovery versus time during each pump test is shown in Figure 10.

3.3.3.2 Bioslurper Pump Test Results

LNAPL recovery rates were very low during the bioslurper pump test (Figure 10). A total of 0.33 gallons of LNAPL and 1,498 gallons of groundwater were extracted during the bioslurper pump test, with daily average recovery rates of 0.083 gallons/day for LNAPL and 380 gallons/day for groundwater (Table 16). These results demonstrate that operation of the bioslurper system in the bioslurper mode was not an effective means of free-product recovery.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations generally increased at all monitoring points in the vicinity of MW-316 (Table 17). These results correlate with radius of influence results from the soil gas permeability test.

3.3.3.3 Second Skimmer Pump Test

Totals of 0.16 gallons of LNAPL and 4.8 gallons of groundwater were recovered during the second skimmer pump test, with daily average recovery rates of 0.31 gallons/day for LNAPL and 9.3 gallons/day for groundwater (Table 16). These results demonstrate that operation of the bioslurper system in the skimmer mode was not an effective means of free-product recovery.

3.3.3.4 Drawdown Pump Test

Drawdown pump testing was conducted to determine if a cone of groundwater depression would enhance LNAPL recovery. The water table was depressed 1 ft below the static water table.

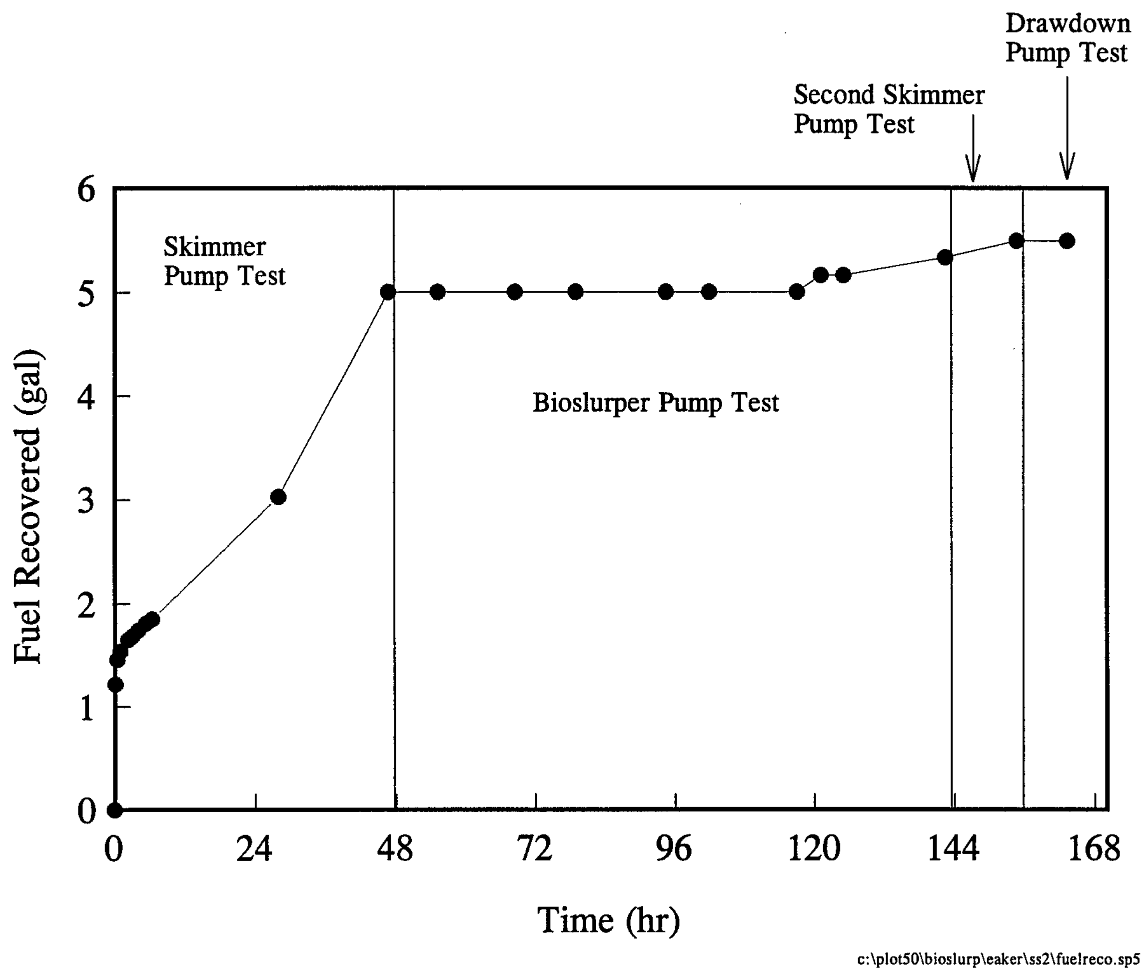


Figure 10. Fuel Recovery Versus Time During Each Pump Test at Spill Site 2

Table 16. Pump Test Results at Monitoring Well MW-316, Site 2

Time (days)	Recovery Rate (gallons/day)							
	Skimmer Pump Test		Bioslurper Pump Test		Second Skimmer Pump Test		Drawdown Pump Test	
	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater
1	2.6	6.1	0	260	0.31	9.3	0	0
2	2.5	13	0	390	NA	NA	NA	NA
3	NA	NA	0.14	460	NA	NA	NA	NA
4	NA	NA	0.19	370	NA	NA	NA	NA
Average	2.6	8.7	0.083	380	0.31	9.3	0	0
Total Recovery (gal)	5.0	17.05	0.33	1,498	0.16	4.8	0	0

NA = Not applicable

Table 17. In Situ Oxygen Concentrations During the Bioslurper Pump Test at Monitoring Well MW-316, Site 2

Monitoring Point	Oxygen Concentrations (%) Versus Time (hours)			
	0	48	76	96
MPA-4.0	10	19.1	14.9	14.9
MPA-8.0	1.0	11.9	9.0	9.0
MPA-12.0	0.3	2.0	1.0	0.8
MPB-4.0	17.5	20	14.5	15.8
MPB-8.0	3.0	7.0	9.0	7.9
MPB-12.0	0	0	0.5	0.5
MPC-4.0	18.8	20	19.5	19.5
MPC-8.0	2.0	8.9	10.0	7.3
MPC-12.0	0	0	0	1.8

No measurable free-phase LNAPL and minimal groundwater (9.3 gallons/day) was recovered in this mode during 8.6 hours of continuous extraction (Table 16). These results demonstrate that operation of the bioslurper system in the drawdown mode was not an effective means of free-product recovery.

3.3.3.5 Extracted Groundwater, LNAPL, and Off-Gas Analyses

Two groundwater samples were collected during the bioslurper pump test. TPH concentrations were low, with an average concentration of 5.1 mg/L (Table 18). Toluene was present below detection limits. The average BTEX concentration was 2.8 mg/L.

Off-gas samples from the bioslurper system also were collected during the bioslurper pump test. The results from the off-gas analyses are presented in Table 19. Given a vapor discharge rate of 9.7 scfm and using an average concentration of 130,000 ppmv TPH and 1,250 ppmv benzene, approximately 730 lb/day of TPH and 3.5 lb/day benzene was emitted to the air during the bioslurper pump test. The composition of LNAPL in terms of BTEX concentrations is shown in Table 20.

3.3.4 Bioventing Analyses

3.3.4.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is then defined as the distance from the extraction well where 0.1 inch of H_2O can be measured. However, based on this data and the clayey soils, a pressure of 1 inch of H_2O appears to be a more reasonable value for determining the radius of influence. Based on this definition, the radius of influence during the bioslurper pump test at monitoring well MW-316 was approximately 70 ft (Figure 11). Pressure data from the shallow monitoring points were not used, since no significant response was obtained.

3.3.4.2 In Situ Respiration Test Results

Results from the in situ respiration test are presented in Table 21. Oxygen depletion was relatively fast, with oxygen utilization rates ranging from 2.8 to 3.0 $\%O_2$/hr. Biodegradation rates ranged from 46 to 50 mg/kg-day.

Table 18. **BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Pump Test at Site 2**

Parameter	Concentration (mg/L)	
	EAK-2-OWS	EAK-2-TW
TPH (purgeable)	6.5	3.6
Benzene	1.8	0.57
Toluene	<0.010	<0.0020
Ethylbenzene	0.39	0.10
Total Xylenes	2.1	0.60

Table 19. **BTEX and TPH Concentrations in Off-Gas During the Bioslurper Pump Test at Site 2**

Parameter	Concentration (ppmv)	
	EAK-S2-1	EAK-S2-2
TPH referenced to JP-4 jet fuel	130,000	130,000
C2 - C4 Hydrocarbons	11,000	8,100
Benzene	1,200	1,360
Toluene	980	790
Ethylbenzene	390	780
Total Xylenes	5,300	1,100

Table 20. BTEX Concentrations in LNAPL at Site 2

Compound	Concentration (mg/kg)
Benzene	<93
Toluene	300
Ethylbenzene	120
Total Xylenes	920

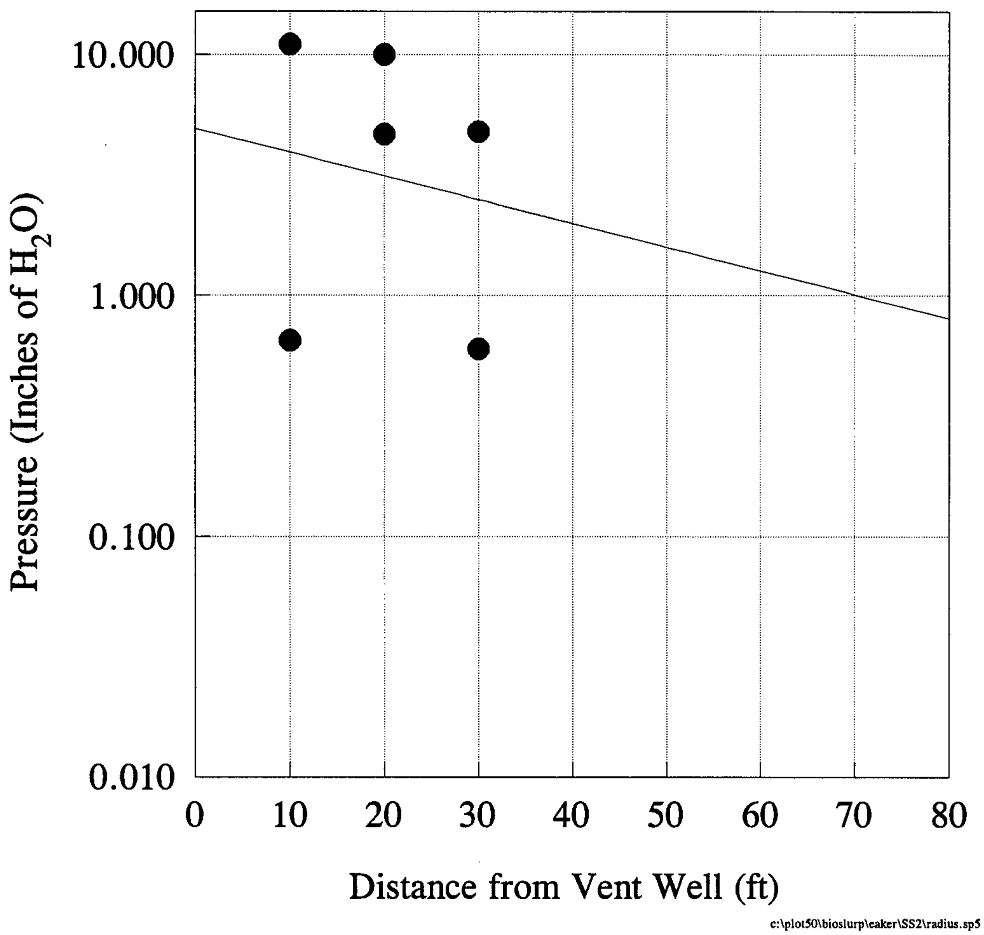


Figure 11. **Radius of Influence Determination Based on Soil Gas Pressure Change Versus Distance from Extraction Well at Spill Site 2**

Table 21. In Situ Respiration Test Results at Site 2

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg-day)
MPA-12.0	2.8	46
MPB-12.0	3.0	49
MPC-12.0	2.9	47

3.4 Discussion

A baildown recovery test was conducted at two monitoring wells at Spill Site 2: MW-316 and MW-306. Overall, the baildown recovery test indicated a relatively slow rate of LNAPL recovery into the monitoring wells. Also, the baildown recovery resulted in an LNAPL thickness approximately ⅓ to ½ that of the initial apparent thickness. The initial LNAPL thickness in monitoring well MW-316 was 3.75 ft and, approximately 24 hours after baildown, recovered to 1.09 ft. Recovery at monitoring well MW-306 was more rapid, where the initial LNAPL thickness was 5.17 ft and recovered to 2.60 ft approximately 4 hours after baildown. Two additional baildown tests were conducted at monitoring well MW-306 to verify the recovery rate. Recovery was less rapid during this test, with an LNAPL thickness less than half of the initial apparent thickness after 24 hours. Although the recovery rate during the baildown test was relatively low, several sites under the Bioslurper Initiative have shown good LNAPL recovery during bioslurping despite low recovery rates during baildown tests. Therefore, monitoring well MW-316 was selected for the bioslurper pump tests.

A series of pump tests were conducted at monitoring well MW-316: skimmer pumping (before and after bioslurping), bioslurping, and drawdown pumping. Skimmer pump testing was conducted in a continuous extraction mode for approximately 47 hours. Recovery of free-phase LNAPL was low, indicating that gravity-driven recovery is minimal. LNAPL recovery decreased further during bioslurper testing, with a total of 0.33 gallons recovered during approximately four days of continuous extraction. No LNAPL was recovered until day 3. LNAPL recovery during the second skimmer pump test was significantly lower than the first skimmer pump test, with an average recovery rate of 0.30 gallons/day. Drawdown pump testing was conducted to determine if a cone of groundwater depression would enhance LNAPL recovery. The water table was depressed to 1.0 ft below the static water table. No measurable free-phase LNAPL or groundwater was recovered in this mode during 8.6 hours of continuous extraction. These results indicate that either the mobility of free-phase LNAPL is low or that the quantity of free-phase LNAPL is small, such that none of the recovery technologies are capable of sustaining significant recovery.

Groundwater production rates during bioslurping were significantly higher than rates during the skimmer or drawdown pump tests. The average rate was 380 gallons/day, which was transferred to a 21,000 gallon storage tank.

Bioslurping also promotes mass removal in the form of volatilization and in situ biodegradation via aeration of the vadose zone. Vapor phase mass removal is the result of soil gas extraction as well as volatilization that may occur during the movement of free-phase LNAPL through the extraction network. Given, the measured vapor flowrate and vapor concentrations, initial hydrocarbon removal rates were approximately 730 lb/day of TPH and 3.5 lb/day of benzene. Thus, initially, mass removal in the vapor phase is significant. However, this short-term test does not provide a good indication as to whether these rates would be sustained. Higher vapor mass removal rates are more often sustained at those sites where liquid product recovery is sustained.

In situ biodegradation rates of 46 to 50 mg/kg-day were measured at three different locations. Based on the radius of influence of 70 ft and a hydrocarbon-impacted soil thickness of 11 ft, mass removal rates via biodegradation are on the order of 680 to 740 lbs of hydrocarbon per day. Thus, mass removal rates via biodegradation could be as significant as the initial vapor phase removal rates measured during the bioslurper test. These results indicate that bioventing is feasible at this site. Air injection bioventing is preferable over bioslurping and soil vapor extraction with respect to the elimination of hydrocarbon vapor emissions.

The initial soil-gas profiles at the site displayed oxygen-deficient, carbon dioxide-rich, high total volatile hydrocarbon vapor conditions across the 8- to 12-ft below ground surface horizons. These conditions indicate that natural biodegradation of residual petroleum hydrocarbons has occurred, but is limited by oxygen availability. Soil-gas concentrations were measured during the bioslurper test at monitoring points adjacent to monitoring well MW-316 to determine if the vadose zone was being oxygenated via the bioslurper action. Oxygen concentrations were influenced at all monitoring points. Based on the soil-gas permeability test, where a radius of influence of approximately 70 ft was measured, it is likely that these areas will become fully aerated. In short, a four day extraction time frame at 13 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In summary, the on-site testing at Spill Site 2, Eaker AFB, included the direct testing of gravity-driven and vacuum-driven LNAPL free product recovery techniques, bioventing, physical sampling, and tests relevant to soil vapor extraction. Liquid-phase recovery was not sustainable in any of the extraction modes. The vacuum-enhanced mode is significant because if liquid phase LNAPL recovery is not sustainable under high vacuum conditions, then it is unlikely that it will be sustainable under any conditions. Vapor phase mass removal rates measured during bioslurper testing may be the result of soil-gas removal (i.e., SVE) or volatilization during liquid entrainment. The generation of off-gas is undesirable and sustained rates of off-gas discharge cannot be estimated accurately from this test. The in situ respiration test and vadose zone radius of influence testing demonstrate that bioventing is feasible at this site.

Periodic baildown recovery tests are recommended as a useful indicator of free-phase LNAPL recovery potential. Based on the conduct of identical pilot tests at over 25 different sites, there have been several sites where apparent LNAPL product thicknesses are significant (>3 ft). However, once the LNAPL free product is removed from the well, it may take weeks or months to return to initial apparent thicknesses. LNAPL free product continues to accumulate in monitoring wells, but not at a rate to make free product recovery worthwhile. The periodic baildown recovery test is the best method to verify whether or not Spill Site 2 is like the sites described above. Periodic hand bailing may also represent removing LNAPL free product to the extent practicable. A bioventing system may be installed for continued remediation of the vadose zone.

4.0 REFERENCES

Battelle. 1995. Test Plan and Technical Protocol for Bioslurping, Report prepared by Battelle Columbus Operations for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. Test Plan and Technical Protocol for a Field Treatability Test for Bioventing (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT EAKER AFB, ARKANSAS

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT EAKER AIR FORCE BASE, ARKANSAS

DRAFT

PREPARED FOR:

**AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
(AFCEE/ERT)
8001 ARNOLD DRIVE
BROOKS AFB, TEXAS 78235-5357**

AND

EAKER AFB, ARKANSAS

18 APRIL 1996

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING
AT EAKER AIR FORCE BASE, ARKANSAS
CONTRACT NO. F41624-94-C-8012

DRAFT

to

Air Force Center for Environmental Excellence
Technology Transfer Division
(AFCEE/ERT)
8001 Arnold Drive
Building 642
Brooks AFB, Texas 78235-5357

and

Eaker Air Force Base, Arkansas

18 April 1996

by

Battelle
505 King Avenue
Columbus, Ohio 43201-2693

This report is a work prepared for the United States Government by Battelle. In no event shall either the United States Government or Battelle have any responsibility or liability for any consequences of any use, misuse, inability to use, or reliance upon the information contained herein, nor does either warrant or otherwise represent in any way the accuracy, adequacy, efficacy, or applicability of the contents hereof.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
amu	atomic mass unit
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
BX	Base Exchange
FPTA	Fire Protection Training Area
gpm	gallon(s) per minute
LNAPL	light, nonaqueous-phase liquid
MCL	maximum contaminant level
MP	monitoring point
MW	monitoring well
POC	Point-of-Contact
ppmv	part(s) per million by volume
SWMU	Solid Waste Management Unit
TPH	total petroleum hydrocarbons
UST	underground storage tank
UWOT	Underground Waste Oil Tank
VOC	volatile organic compound

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT EAKER AIR FORCE BASE, ARKANSAS

DRAFT

to

Air Force Center for Environmental Excellence
Technology Transfer Division
(AFCEE/ERT)
Brooks AFB, Texas 78235-5357

18 April 1996

1.0 INTRODUCTION

The U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division is conducting a nationwide application of an innovative technology for free-product recovery and soil bioremediation. The technologies tested in the Bioslurper Initiative include vacuum-enhanced free-product recovery/bioremediation (bioslurping) as well as traditional skimmer and groundwater depression approaches. The field test and evaluation are intended to demonstrate the feasibility of free-product recovery by measuring system performance in the field. System performance parameters, mainly free-product recovery, will be determined at numerous sites. Field testing will be performed at many sites to determine the effects of different organic contaminant types and concentrations and different geologic conditions on bioslurping effectiveness.

Plans for the field test activities are presented in two documents. The first is the overall Test Plan and Technical Protocol for the entire program entitled *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). The overall plan is supplemented by plans specific to each test site. The concise site-specific plans effectively communicate planned site activities and operational parameters.

The overall Test Plan and Technical Protocol was developed as a generic plan for the Bioslurper Initiative to improve the accuracy and efficiency of site-specific Test Plan preparation. The field program involves installation and operation of the bioslurping system supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities. The basic methods to be applied from site to site do not change. Preparation and review of the overall Test Plan and Technical Protocol allow efficient documentation and review of the basic approach to the test program. Peer and regulatory review were performed for the overall Test Plan and Technical Protocol to ensure the credibility of the overall program.

This report is the site-specific Test Plan for application of bioslurping at Eaker Air Force Base (AFB), Arkansas. It was prepared based on site-specific information received by Battelle from Eaker AFB and other pertinent site-specific information to support the overall Test Plan and Technical Protocol.

Site-specific information for Eaker AFB has identified subsurface hydrocarbon contamination at the Base Exchange (BX) Shoppette Service Station and at the Underground Waste Oil Tank (UWOT) site. The contamination at the service station is generally associated with unleaded gasoline, waste oil, and hydraulic fluid. JP-4 jet fuel and waste oil are the primary contaminants at the UWOT site. Free product, as light, nonaqueous-phase liquid (LNAPL), has been found in various wells at both sites. A free-product thickness of greater than 4 ft was measured in well TW1105 at the service station site and a thickness of approximately 6 ft was found in well TW508 at the UWOT site. Based on these thicknesses, these wells are candidates for the bioslurper demonstration.

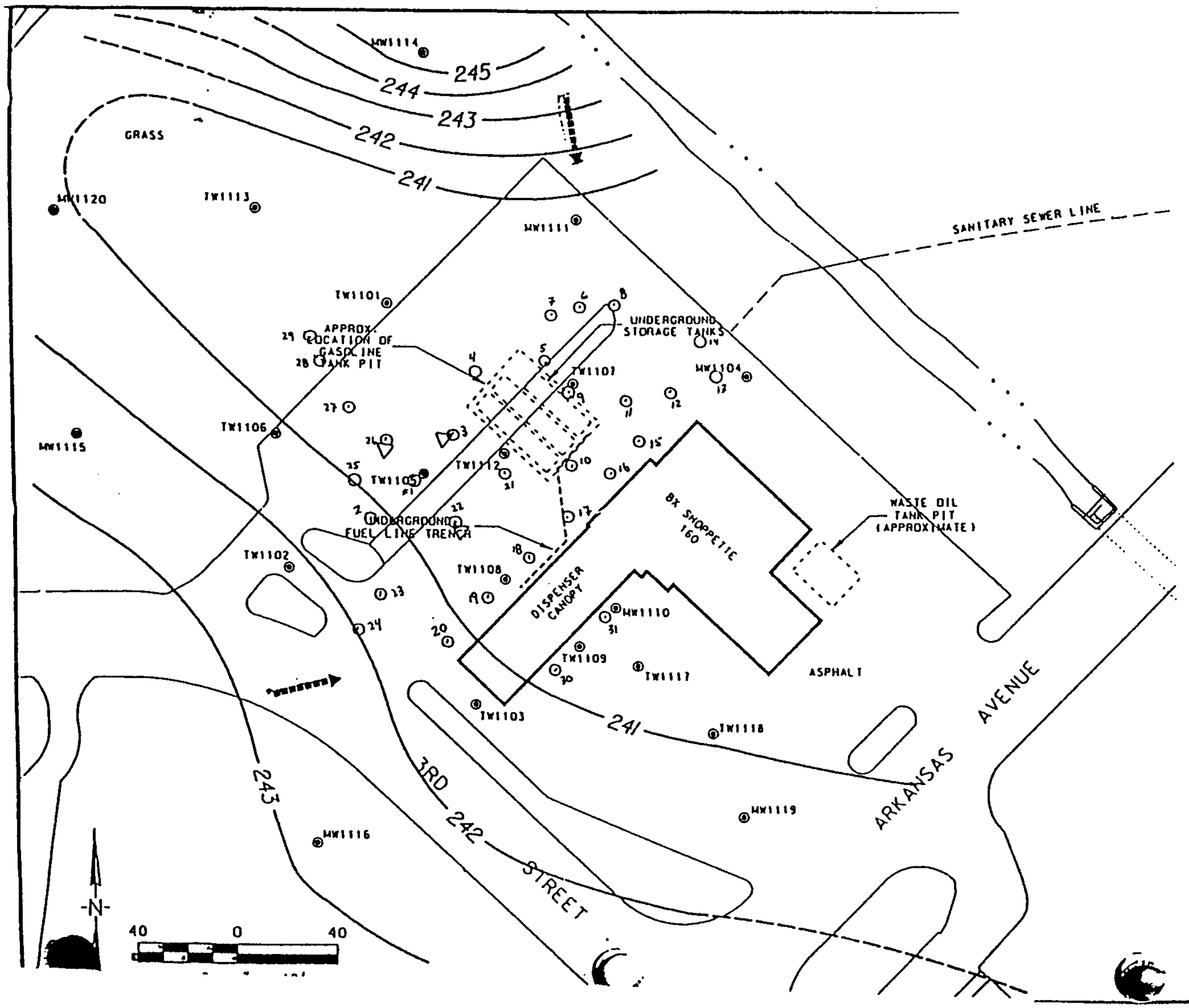
2.0 SITE DESCRIPTION

The information presented in this section was obtained from site-specific information received by Battelle from Eaker AFB.

Eaker AFB is located in Arkansas. The two sites under investigation for bioslurping activity include the BX Shoppette Service Station (Facility #160) and the Solid Waste Management Unit (SWMU) No. 2 UWOT site (Facility #1344).

2.1 Base Exchange Shoppette Service Station

The BX Shoppette Service Station (Facility #160) is located on the corner of 3rd Street and Arkansas Avenue near residential units in the west central portion of the base (Figure 1). The service station has been in operation since 1969 and consists of two 10,000-gallon and one 6,000-gallon underground storage tanks (USTs) that were used to store unleaded gasoline. An additional 1,000-gallon UST with no form of corrosion protection contained waste oil and hydraulic fluid.



LEGEND

MONITORING WELL MW1104
TEMPORARY WELL TW1101
GROUNDWATER FLOW DIRECTION
GROUNDWATER ELEVATION[1] CONTOUR LINE (DASHED WHERE APPROX.)
FENCE
SURFACE DRAINAGE
APPROXIMATE CPT-UF LOCATIONS:
3" MP-PVC

WELL	GROUNDWATER[1] ELEVATION
TW1101	240.35
TW1102	242.14
TW1103	ABANDONED
MW1104	240.58
TW1105	FREE PRODUCT
TW1106	241.09
TW1107	ABANDONED
TW1108	ABANDONED
TW1109	240.61
MW1110	240.48
MW1111	240.20
TW1112	ABANDONED
TW1113	ABANDONED
MW1114	245.13
MW1115	242.54
MW1116	242.84
TW1117	ABANDONED
TW1118	ABANDONED
MW1119	241.37
MW1120	241.11

1 - ELEV. IN FEET ABOVE N.G.V.D.

SOURCE:
TECHNICAL MEMORANDUM (STEP 1) FOR THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY HALLIBURTON NUS, 1992 (REVISED)

FIGURE 11-2

TITLE GROUNDWATER ELEVATION MAP (MARCH 27, 1992)
DESCRIPTION OF CURRENT CONDITIONS
BX SHOPPETTE SITE
RI/FS
EAKER AIR FORCE BASE

DRAWING NO. 0959C025 DATE 11-20-93

Figure 1. Schematic Diagram of the BX Shoppette Service Station, Eaker AFB, Arkansas, Along with Groundwater Elevations.

Records of past contamination include a 1974 leak in the UST fuel line, which resulted in an unknown amount of fuel spillage. In 1989, tank tightness tests were performed on the USTs. When one of the 10,000-gallon tanks tested positive for leaks, it was deactivated.

The site geology consists of sand or sandy clay to a depth of 10 ft bgs with an underlying unit of gray to gray-brown clay. Below this can be found a unit of medium- to coarse-grained sand that is poorly sorted and is not laterally continuous.

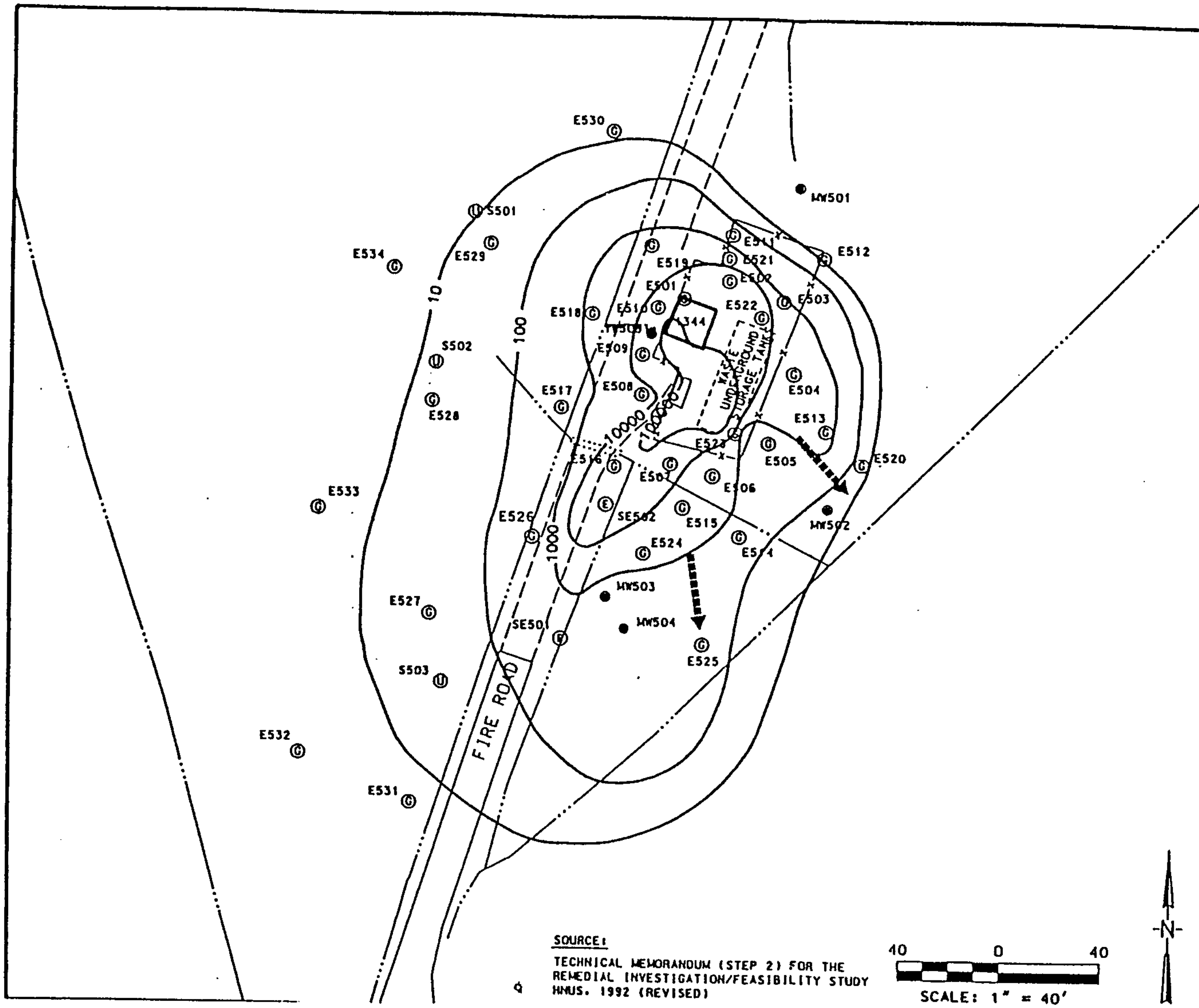
The depth to groundwater at the service station is 7.5 to 10 ft below ground surface (bgs), with a depression in the water table being found in the vicinity of the UST pit. Indications suggest that water flows to this point from the northwest and the southeast. Free product has been found at various wells on site with a thickness of greater than 4 ft being present at TW1105. Additional wells that were bailed periodically by base personnel include TW508 and B20.

Past site investigations reveal that the highest concentrations of organic compounds were found in shallow subsurface soils near the gasoline pit and fuel lines. A 1991 investigation by PSI indicated the maximum benzene, toluene, ethylbenzene and xylenes (BTEX) concentration in subsurface soils to be 785 mg/kg at B20 and the maximum total petroleum hydrocarbon (TPH) concentration to be 559 mg/kg at B5. An investigation by Halliburton NUS (1992) showed subsurface soils to have maximum concentrations of 172 mg/kg at TW1110 and 172 mg/kg at TW1109 for BTEX and TPH, respectively (Appendix A). BTEX concentrations in deeper soil tend to be higher in areas south and east of the tank pit. Figures in Appendix B show the distribution of BTEX at various soil depths. The full lateral and vertical extent of the plume has not yet been defined.

In addition to soil samples, groundwater samples from 8 permanent monitoring wells (MWs) were analyzed for BTEX and TPH. Only two wells contained detectable levels of BTEX and TPH (MW1110, MW1111), with maximum concentrations found to be 14 mg/L and 2.7 mg/L, respectively.

2.2 SWMU No. 2, Underground Waste Oil Tank

The UWOT site (Facility #1344) has operated since 1972 and is still active. The UWOT is located in the northwest portion of the base about 800 ft south of the Fire Protection Training Area (FPTA) (Figure 2). The facility consists of two currently empty 10,000-gallon USTs installed in 1988 that previously contained waste oil and JP-4 jet fuel. A concrete pad containing a drain leading



LEGEND

MONITORING WELL	MW501 ●
TEMPORARY WELL	TW508 ●
SOIL GAS SAMPLING POINT	E501 Ⓖ
SEDIMENT SAMPLE	SE501Ⓔ
SUBSURFACE SOIL GRAB SAMPLE	S501 Ⓤ
APPROX. GROUNDWATER FLOW DIRECTION	
TOTAL VOCs[1] ISOCONCENTRATION LINE (DASHED WHERE APPROX.)	
FENCE	
SURFACE DRAINAGE	

SOV POINTS	TOTAL VOCs[1] (FID)	SOV POINTS	TOTAL VOCs[1] (FID)
E501	17740	E518	1105
E502	8131	E519	2017
E503	28560	E520	31
E504	9213	E521	13300
E505	757	E522	40960
E506	7608	E523	153600
E507	10960	E524	2446
E508	9408	E525	139
E509	41990	E526	158
E510	168800	E527	43
E511	635	E528	17
E512	7.5	E529	14
E513	14890	E530	6.1
E514	508	E531	1.9
E515	4954	E532	<1
E516	99610	E533	<1
E517	331	E534	1.8

SAMPLE NO.	TOTAL BTEX[2]
S501	<20
S502	<20
S503	<20

1 - CONCENTRATIONS IN mg/L OF AIR
2 - CONCENTRATIONS IN mg/kg OF SOIL

NOTE:
SOIL SAMPLES S501-S503 WERE ANALYZED FOR TCL VOCS.

SOURCE:
TECHNICAL MEMORANDUM (STEP 2) FOR THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY HNUS. 1992 (REVISED)

40 0 40
SCALE: 1" = 40'

-N-

FIGURE 3-7

TITLE
TOTAL VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL GAS
UNDERGROUND WASTE OIL TANKS SITE
DESCRIPTION OF CURRENT CONDITIONS
RFI
EAKER AIR FORCE BASE

DRAWING NO. 0114G010 DATE 1-25-94

Figure 2. Schematic Diagram of the UWOT Site, Eaker AFB, Arkansas, Along with Total Volatile Organic Compounds Detected in Soil Gas.

to an oil/water separator was installed in 1988 for vehicles transferring waste oil. The surface of the UWOT is gravel paved over soil, and discoloration is evident in the vicinity of the transfer area. Facility #1344 is used to store hazardous and nonhazardous waste oils until their removal to offsite disposal facilities which occurs about once every 3 months. Four 4,000-gallon USTs and one 500-gallon UST had been located at the site until their removal in 1987. The tanks had been used to hold waste oils, solvents, and JP-4 jet fuel and were not cathodically protected.

The site geology consists predominately of clay to a depth of 22 ft bgs. The unit below this depth tends to be dominated by sand. Depth to groundwater at the site ranges from 9 to 12 ft bgs and groundwater flow is to the south.

Investigations have been made to characterize the site; however, data collection is insufficient to define the extent of the contamination. Soil and groundwater samples taken from five 25-ft borings were analyzed in 1987. Four monitoring wells (MW501, MW502, MW503, and MW504) were installed in 1988, three of which had depths of 25 to 30 ft bgs and one of which had a depth of 70 ft bgs. Volatile organic compounds (VOCs) were found at concentrations of up to 169 mg/L in soil gas during this 1988 investigation. The locations of highest concentration are shown in Figure 2. In 1991, groundwater samples were taken from existing wells in addition to the soil gas samples. The groundwater samples were analyzed for BTEX, VOCs, and chlorinated hydrocarbons. Soil samples were taken from the vadose and saturated zones again in 1992. The results revealed the highest concentrations of organic compounds downgradient from the UWOT. Organic compounds were detected at depths of 2 to 19 ft bgs with maximum concentrations being found at 3 to 11 ft bgs. A maximum TPH concentration of 8,900 mg/kg and a maximum xylene concentration of 25 mg/kg were found. Analytical results of the 1992 subsurface soil samples are found in Appendix C.

In general, low levels of organic and inorganic compounds were found in the groundwater. None of the organic compounds at the site exceeded the maximum contaminant levels (MCLs) in the sampling conducted by Halliburton NUS in 1988 and 1991. Inorganic analytes exceeding MCLs were antimony and cadmium. There was, however, about 6 ft of free product found in well TW508. Free product was encountered in a sandy unit at 16 ft bgs and is thought to have migrated through vertical sand-filled fractures since it does not appear to be present in clay units at the same depth. Groundwater sampling conducted in 1995 revealed the presence of small amounts of chlorinated compounds. Maximum concentrations of 1,2-dichloroethene, 1,4-dichlorobenzene, and 1,2-dichlorobenzene were 45, 75, and 9 ppb, respectively.

3.0 PROJECT ACTIVITIES

The field activities discussed in the following sections are planned for the bioslurper pilot test at Eaker AFB. Additional details about the activities are presented in the overall Test Plan and Technical Protocol (Battelle, 1995). As appropriate, specific sections in the overall Test Plan and Technical Protocol are referenced. Table 1 presents the schedule of activities for the Bioslurper Initiative at Eaker AFB.

3.1 Mobilization to the Site

After the site-specific Test Plan is approved, Battelle staff will mobilize equipment to the site. Some of the equipment will be shipped via air express to Eaker AFB prior to staff arrival. The Base Point-of-Contact (POC) will have been asked in advance to find a suitable holding facility to receive the bioslurper pilot test equipment so that it will be easily accessible to the Battelle staff when they arrive with the remainder of the equipment. The exact mobilization date will be confirmed with the Base POC as far in advance of fieldwork as is possible. The Battelle POC will provide the Base POC with information on each Battelle employee who will be on site. Battelle personnel will be mobilized to the site after confirmation that the shipped equipment has been received by Eaker AFB.

3.2 Site Characterization Tests

3.2.1 Baildown Tests

The baildown test is the primary test for selection of the bioslurper test well. Baildown tests are also useful for the evaluation of actual versus apparent free-product thicknesses. Baildown tests will be performed at wells that contain measurable thicknesses of LNAPL to estimate the LNAPL recovery potential at those particular wells. In most cases, the well exhibiting the highest rate of LNAPL recovery will be selected for the bioslurper extraction well. A sample of free LNAPL will be collected at this point for analyses of boiling point distribution and BTEX concentration. Detailed procedures for the baildown tests are provided in Section 5.6 of the overall Test Plan and Technical Protocol.

Table 1. Schedule of Bioslurper Pilot Test Activities

Pilot Test Activity	Schedule
Mobilization	Day 1-2
Site Characterization	Day 2-3
LNAPL/Groundwater Interface Monitoring and Baildown Tests	
Soil Gas Survey (Limited)	
Monitoring Point Installation (3 monitoring points)	
Soil Sampling (BTEX, TPH, physical characteristics)	
System Installation	Day 2-3
Test Startup	Day 3
Skimmer Pump Test (2 days)	Day 3-4
Bioslurper Pump Test (4 days)	Day 6-9
Soil Gas Permeability Testing	Day 6
Skimmer Pump Test (continued)	Day 10
In Situ Respiration Test - Air/Helium Injection	Day 10
In Situ Respiration Test - Monitoring	Day 11-16
Drawdown Pump Test (2 days)	Day 11-12
Demobilization/Mobilization	Day 13-14

3.2.2 Soil Gas Survey (Limited)

A small-scale soil gas survey will be conducted to identify the best location for installation of the bioslurping system. The soil gas survey will be conducted in areas where historical site data indicated the highest contamination levels. These areas will be surveyed to select the locations for installation of soil gas monitoring points. Monitoring points will be located in areas that exhibit the following soil gas characteristics.

1. Relatively high TPH concentrations (10,000 ppmv or greater).

2. Relatively low oxygen concentrations (between 0% and 2%).

3. Relatively high carbon dioxide concentrations (depending on soil type, between 2% and 10% or greater).

Additional information on the soil gas survey is provided in Section 5.2 of the overall Test Plan and Technical Protocol.

3.2.3 Monitoring Point Installation

Monitoring points must be installed to determine the radius of influence of the bioslurper system in the vadose zone. A general arrangement of the bioslurping well and monitoring points is shown in Figure 3. Upon completion of the initial soil gas survey and baildown tests, at least three soil gas monitoring points will be installed (unless existing monitoring points are available for use) to measure soil gas changes that occur during bioslurper operation. These monitoring points should be located in highly contaminated soils within the free-phase plume and should be positioned to allow detailed monitoring of the in situ changes in soil gas composition caused by the bioslurper system. A schematic diagram of a typical monitoring point is shown in Figure 4. Information on monitoring point installation can be found in Section 4.2.1 of the overall Test Plan and Technical Protocol.

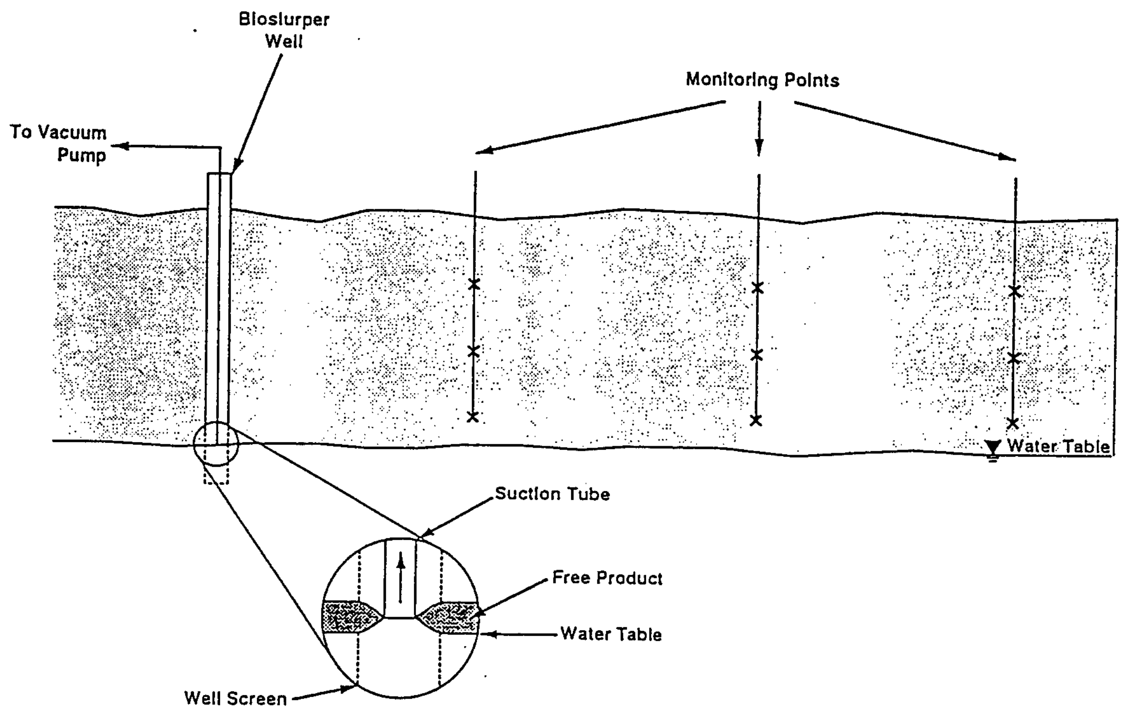


Figure 4. General Bioslurper Well and Monitoring Point Arrangement

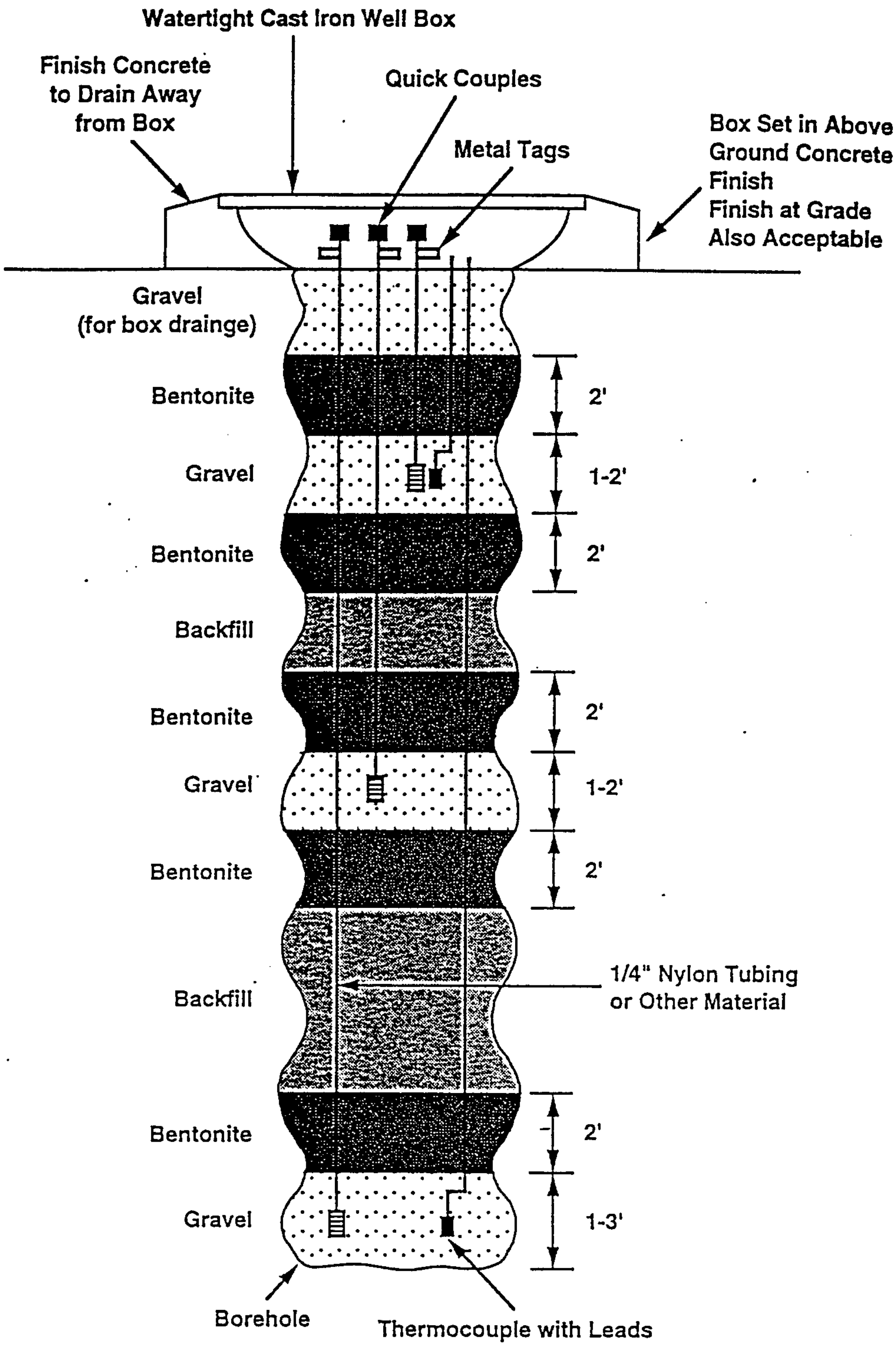


Figure 4. Schematic Diagram of a Typical Monitoring Point.

3.2.4 Soil Sampling

Soil samples will be collected from each boring to determine the physical and chemical composition of the soil near the bioslurper test site. Soil samples will be collected from the boreholes advanced for monitoring point installation at two or three locations at the site chosen for the bioslurper test. Generally, samples will be collected from the capillary fringe over the free product.

Soil samples from each boring will be analyzed for BTEX, bulk density, moisture content, particle size distribution, porosity, and TPH. Section 5.5.1 of the overall Test Plan and Technical Protocol contains additional information on field measurements and sample collection procedures for soil sampling.

3.3 Bioslurper System Installation and Operation

Once the well to be used for the bioslurper test installation at Eaker AFB has been identified, the bioslurper pump and support equipment will be installed and pilot testing will be initiated.

3.3.1 System Setup

After the preliminary site characterization has been completed and the bioslurper candidate well has been selected, the shipped equipment will be mobilized from the holding facility to the test site, and the bioslurper system will be assembled. Figure 5 shows a flow diagram of the bioslurper process. Figure 6 illustrates a typical bioslurper well that will be used at Eaker AFB.

Before the LNAPL recovery tests are initiated, all relevant baseline field data will be collected and recorded. These data will include soil gas concentrations, initial soil gas pressures, the depth to groundwater, and the LNAPL thickness. Ambient soil and all atmospheric conditions (e.g., temperature, barometric pressure) also will be recorded. All emergency equipment (i.e., emergency shutoff switches and fire extinguishers) will be installed and checked for proper operation at this time.

A clear, level 20-ft by 10-ft area near the well selected for the bioslurper test installation will be identified to station the equipment required for bioslurper system operation. Additional information on bioslurper system installation is provided in Section 6.0 of the overall Test Plan and Technical Protocol.

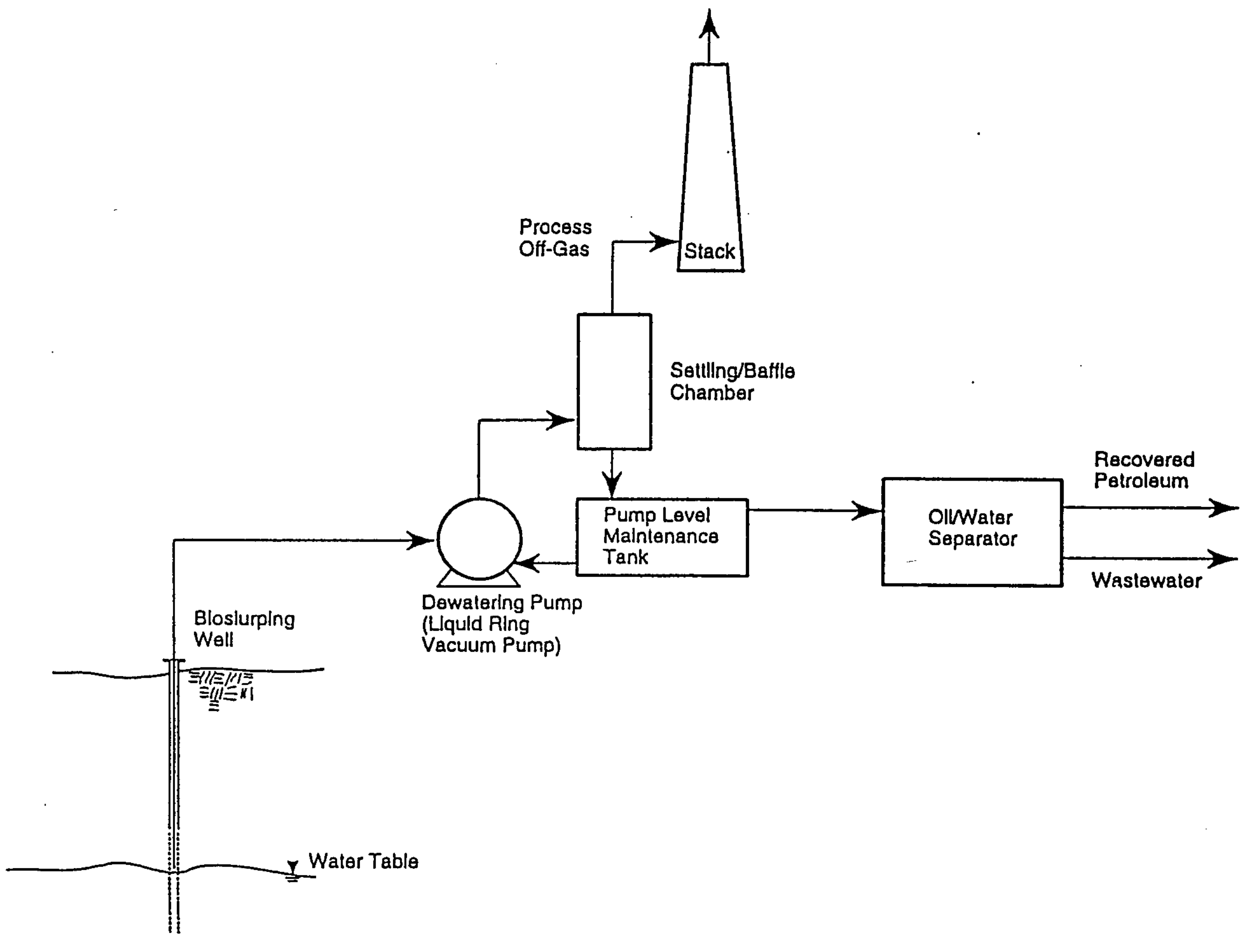


Figure 5. Bioslurper Process Flow at the BX Service Station and UWOT, Eaker AFB, Arkansas.

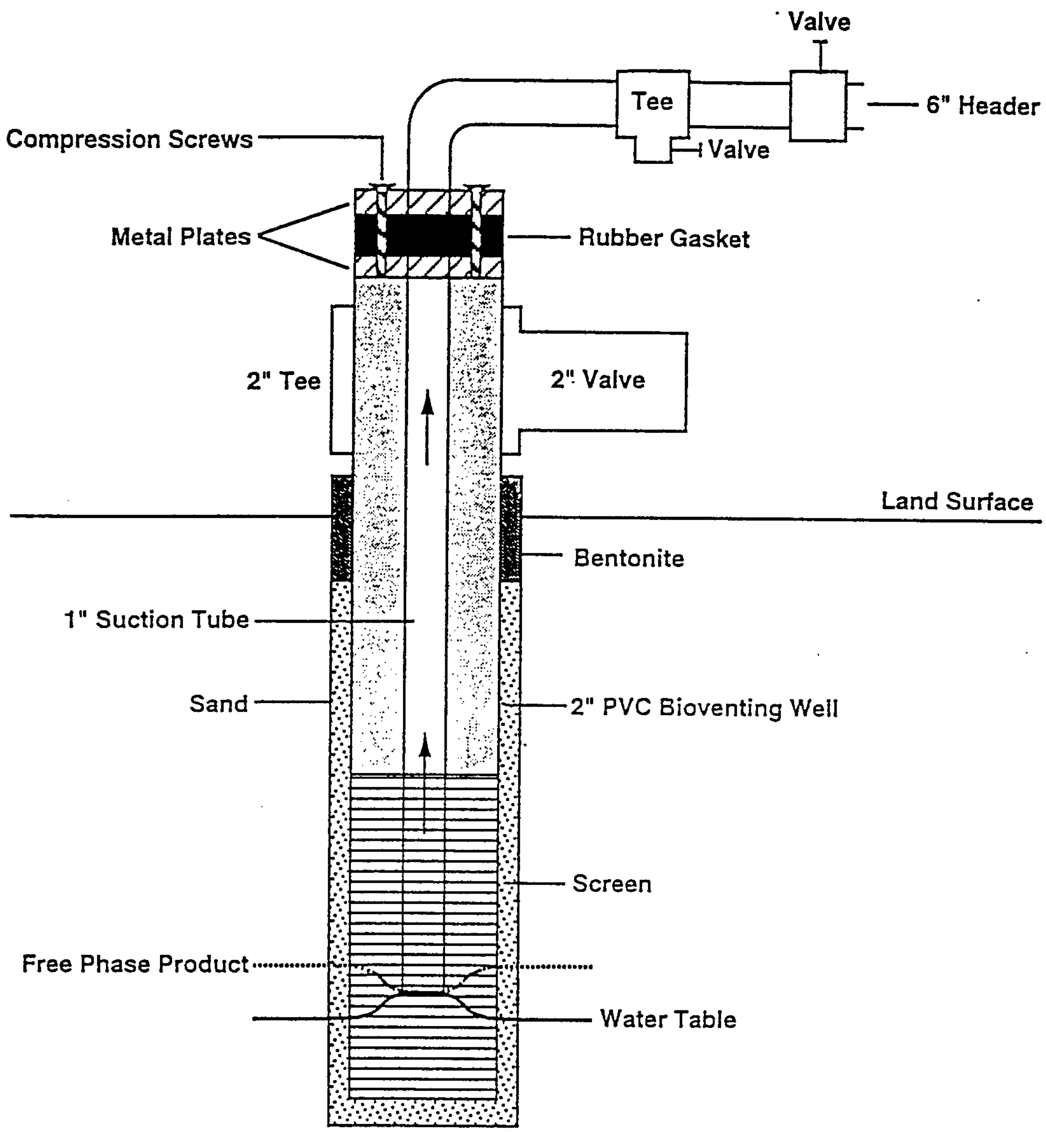


Figure 6. Schematic Diagram of a Typical Bioslurper Well.

3.3.2 System Shakedown

A brief startup test will be conducted to ensure that the system is constructed properly and operates safely. All system components will be checked for problems and/or malfunctions. A checklist will be provided to document the system shakedown.

3.3.3 System Startup and Test Operations

After installation is complete and the bioslurper system is confirmed to be operating properly, the LNAPL recovery tests will be started. The Bioslurper Initiative has been designed to evaluate the effectiveness of bioslurping as an LNAPL recovery test technology relative to conventional gravity-driven LNAPL recovery technologies. The Bioslurper Initiative includes three separate LNAPL recovery tests: (1) a skimmer pump test, (2) a bioslurper pump test, and (3) a drawdown pump test. The three recovery tests are described in detail in Section 7.3 of the overall Test Plan and Technical Protocol.

The bioslurper system operating parameters that will be measured during operation are vapor discharge, aqueous effluent, LNAPL recovery volume rates, vapor discharge volume rates, and groundwater discharge volume rates. Vapor monitoring will consist of periodic monitoring of TPH using hand-held instruments supplemented by two samples collected for detailed laboratory analysis. Two samples of aqueous effluent will be collected for analysis of BTEX and TPH. Recovered LNAPL volume will be recorded using an in-line flow-totalizing meter. The off-gas discharge volume will be measured using a calibrated pitot tube, and the groundwater discharge volume will be recorded using an in-line flow-totalizing meter. Section 8.0 of the overall Test Plan and Technical Protocol describes process monitoring of the bioslurper system.

3.3.4 Soil Gas Profile/Soil Gas Radius of Influence Test

Changes in soil gas profiles will be measured before and during the bioslurper pump test. Soil gas will be monitored for concentrations of oxygen, carbon dioxide, and TPH using field instruments. These measurements will be used to determine the oxygen radius of influence of the bioslurper.

3.3.5 Soil Gas Permeability Tests

A soil gas permeability test will be conducted concurrently with startup of the bioslurper pump test. Soil gas permeability data will support the process of estimating the vadose zone radius of influence of the bioslurper system. Soil gas permeability results also will aid in determining the number of wells required if it is decided to treat the site with a full-scale bioslurper system. The soil gas permeability test method is described in Section 5.7 of the overall Test Plan and Technical Protocol.

3.3.6 LNAPL and Groundwater-Level Monitoring

During the bioslurper pump test, the LNAPL and groundwater levels will be monitored in a well adjacent to the extraction well if such a well exists. The top of the monitoring well will be sealed from the atmosphere so the subsurface vacuum will be contained. Additional information for the monitoring of fluid levels is provided in Section 4.3.4 of the overall Test Plan and Technical Protocol.

3.3.7 In Situ Respiration Test

An in situ respiration test will be conducted after completion of the bioslurper pilot tests. The in situ respiration test will involve injection of air and helium into selected soil gas monitoring points followed by monitoring changes in concentrations of oxygen, carbon dioxide, TPH, and helium in soil gas at the injection point. Measurement of the soil gas composition typically will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours for about 2 days. Timing of the tests will be adjusted based on the oxygen-use rate. If oxygen depletion occurs rapidly, more frequent monitoring will be required. If oxygen depletion is slow, less frequent readings will be acceptable. The oxygen utilization rate will be used to estimate the biodegradation rate at the site. Further information on the procedures and data collection of the in situ respiration test is provided in Section 5.8 of the overall Test Plan and Technical Protocol.

3.3.8 Install and Checkout

The Air Force has the option of extending the operation of the bioslurper system for up to 6 months at Eaker AFB, if LNAPL recovery rates are promising. If extended testing is to be performed, additional site support will be required. The Air Force will need to provide electrical power for long-term operation of the bioslurper pump. Disposition of all generated wastes and routine operation and maintenance of the system will be the Air Force's responsibility. Battelle will provide technical support during the extended testing operation.

If the extended testing option is exercised, Battelle is scoped to remain on site an additional 2 days after the short-term pilot test is completed. The additional time on site will allow for connection of the bioslurper system to Air Force-supplied power. Battelle will provide the base with a detailed operation manual for the bioslurper system and will provide operations training to Air Force personnel. The Base POC will be given a project record book to record system data. The POC will be given a Battelle contact and an alternative contact for technical assistance and will be contacted weekly for updates on system operation. At the end of the extended testing option (up to 6 months of operation) Battelle will return to the site to remove all bioslurper equipment. All waste generated during the operation of the bioslurper system will be the responsibility of the Air Force.

3.4 Demobilization

If the install and checkout option is not employed, the equipment will be disassembled by Battelle staff. The equipment then will be moved back to the holding facility, where it will remain until its next destination is determined. Battelle staff will receive this information and will be responsible for shipment of the equipment to the next site before they leave Eaker AFB.

4.0 BIOSLURPER SYSTEM DISCHARGE

4.1 Vapor Discharge Disposition

Battelle understands that an air discharge permit will not be required for the operation of the bioslurper pilot test system at Eaker AFB unless the TPH discharge rate exceeds 10 tons/site/year. Based on the average discharge rates at two other gasoline-contaminated bioslurper test sites (Hickam AFB and Bolling AFB), it can be assumed that the concentrations of TPH and benzene released to the atmosphere at the BX Shoppette Service Station will be approximately 386 lb/day and 0.6 lb/day, respectively. The contaminant type at Hickam AFB does, however, differ in that it is aviation gasoline. Therefore, the discharge rates at the BX site may be different than the average of Hickam AFB and Bolling AFB. Estimates for vapor discharge at the UWOT site are based on three previous bioslurper test sites (Johnston Atoll, Travis AFB, and Wright-Patterson AFB) that are contaminated with a similar type of fuel. Using an average flowrate of 11 scfm and average concentrations of 4,123 ppmv TPH and 33 ppmv benzene in off-gas, a site contaminated with JP-4 jet fuel can be expected to have a discharge rate of approximately 19 lb/day for TPH and 0.11 lb/day for benzene. The discharge rate for TPH was calculated using a molecular weight of 111 atomic mass units (amu) for jet fuel. Discharge rates may vary depending on concentrations in soil gas and the permeability of the soil. The data for benzene and TPH discharge levels for previous bioslurper sites are presented in Table 2. Using the average TPH discharge rates from the former sites as the discharge rates for the BX and UWOT sites, the discharge limit of 10 tons/year will not be exceeded.

Table 2. Benzene and TPH Vapor Discharge Levels at Previous Bioslurper Test Sites

Site Location	Fuel Type	Extraction Rate (scfm)	Benzene (ppmv)	TPH (ppmv)	Benzene Discharge (lb/day)	TPH Discharge (lb/day)
Andrews AFB	No. 2 Fuel Oil	8.0	16	2,000	0.0010	0.20
Site 1, Bolling AFB	No. 2 Fuel Oil	4.0	0.20	153	0.00030	0.0090
Site 2, Bolling AFB	Gasoline	21	370	70,000	2.3	470
Hickam	Gasoline	11	ND	100,000	0	453
Johnston Atoll	Jet Fuel	10	0.60	975	0.0017	4.0
Travis AFB	Jet Fuel	20	100	10,800	0.58	89
Wright-Patterson AFB	Jet Fuel	3.0	ND	595	0	0.7

ND=Not detected.

To ensure the safety and regulatory compliance of the bioslurper system, field soil gas screening instruments will be used to monitor the vapor discharge concentrations. The volume of vapor discharge will be monitored daily using air flow instruments. Air release information is presented in Table 3.

Table 3. Air Release Summary Information

Data Item	Air Release Information
Contractor Point-of-Contact	Jeff Kittel, (614) 424-6122
Contractor address	Battelle, 505 King Avenue, Columbus, OH 43201
Estimated total quantity of petroleum product to be recovered	To be determined
Description of petroleum product to be recovered	
BX Shoppette Service Station	Motor gasoline
UWOT	JP-4 jet fuel
Planned date of test start	To be determined
Test duration	4 days-Bioslurper pump test 3 days-Skimmer pump test 2 days-Drawdown pump test
Maximum expected volatile organic compound level in air	
BX Shoppette Service Station	~386 lb/day TPH, 0.6 lb/day benzene
UWOT	~19 lb/day TPH, 0.11 lb/day benzene
Stack height above ground level	10 ft

4.2 Aqueous Influent/Effluent Disposition

The groundwater recovered at both the BX and the UWOT site will be collected in a 20,000-gallon holding tank after being passed through an oil/water separator. The flowrate of groundwater pumped by the bioslurper will be less than 5 gpm, and the extraction rate is expected to be approximately 1 gpm. Therefore, during the 9 days of pumping the bioslurper is expected to recover approximately 13,000 gallons of water at each site. Two samples of the recovered water will be collected during the operation of the bioslurper system and will be sent to a laboratory for analysis of TPH and BTEX. Battelle expects that the recovered groundwater from the BX site will be discharged to the sanitary sewer; however, the water may be discharged under permit to the ground surface using an irrigation-style dripline. Depending on the analytical results of the effluent samples collected during the bioslurper test, the recovered groundwater may need to be treated prior to discharge. It is anticipated that the recovered water from the UWOT site will be discharged to the surface using an irrigation-style dripline. It is also likely that this water will need to be treated prior to being discharged to meet the discharge permit requirements.

4.3 Free-Product Recovery Disposition

The bioslurper system will recover free-phase product from the pilot tests performed at Eaker AFB. Recovered free product will be turned over to the Base for disposal and/or recycling. The volume of free product recovered from the Base will not be known until the tests have been performed. The maximum recovery rate for this system is 5 gpm, but the actual rate of LNAPL recovery likely will be much lower.

5.0 SCHEDULE

The schedule for the bioslurper fieldwork at Eaker AFB will depend on approval of the project Test Plan. Battelle will determine a definitive schedule as soon as possible after approval is received. Battelle will have two to three staff members on site for approximately 2 weeks to conduct all necessary pilot testing. At the conclusion of the field testing at Eaker AFB, all staff will return their Base passes. Battelle staff will remove all bioslurper field testing equipment from the Base before they leave the site.

6.0 PROJECT SUPPORT ROLES

This section outlines some of the major functions of personnel from Battelle, Eaker AFB, and AFCEE during the bioslurper field test.

6.1 Battelle Activities

The obligations of Battelle in the Bioslurper Initiative at Eaker AFB will be to supply the staff and equipment necessary to perform all the tests on the bioslurper system. Battelle also will provide technical support in the areas of water and vapor discharge permitting, digging permits, staff support during the extended testing period, and any other technical areas that need to be addressed.

6.2 Eaker AFB Support Activities

To support the necessary field tests at Eaker AFB, the Base must be able to provide the following:

a. Any digging permits and utility clearances that need to be obtained prior to the initiation of the fieldwork. Any underground utilities should be clearly marked to reduce the chance of utility damage and/or personal injury during soil gas probe and possible well installation. Battelle will not begin field operations without these clearances and permits.

b. The Air Force will be responsible for obtaining Base and site clearance for the Battelle staff that will be working at the Base. The Base POC will be furnished with all necessary information on each staff member at least 1 week prior to field startup.

c. Access to the local sanitary sewer must be furnished so that Battelle staff can discharge the bioslurper aqueous effluent directly to the Base treatment facility.

d. Regulatory approval, if required, must be obtained by the Base POC prior to startup of the bioslurper pilot test. As stated previously, it is likely that a waiver or permit to allow air releases or a point source air release registration will be required for emissions of approximately 386 lb/day of TPH and 0.6 lb/day benzene without treatment at the BX Shoppette Service Station and for emissions of approximately 19 lb/day of TPH and 0.11 lb/day benzene at the UWOT site. A waiver for pumping and discharging groundwater at a rate of 5 gpm may be required. The Base POC will obtain all necessary Base permits prior to mobilization to the site. Battelle will provide technical assistance in preparing regulatory approval documents.

e. The Base also will be responsible for the disposition of all waste generated from the pilot testing. Such waste includes any soil cuttings generated from drilling, and all aqueous wastestreams produced from the bioslurper tests. All free product recovered from the bioslurper operation will be disposed of or recycled by the Base. Battelle will provide technical assistance in disposing of the waste generated from the bioslurper pilot test.

f. Before field activities begin, the Health and Safety Plan will be finalized with information provided by the Base POC. Table 4 is a checklist for the information required to complete the Health and Safety Plan. All emergency information will be obtained by the Site Health and Safety office before operations begin.

g. If extended testing is to be performed, additional site support will be required. The Air Force will be responsible for the routine operation and maintenance of the system, during which time they will also record system data in a project record book. Battelle will provide technical support during the extended testing period. In addition, the Air Force will need to provide electrical power for long-term operation of the bioslurper pump.

6.3 AFCEE Activities

The AFCEE POC will act as a liaison between Battelle and Eaker AFB staff. The AFCEE POC will ensure that all necessary permits are obtained and the space required to house the bioslurper field equipment is found.

Table 4 shows the contacts at Battelle, AFCEE, and Eaker AFB who can be contacted in case of emergency and/or for required technical support during the Bioslurper Initiative tests at Eaker AFB.

Table 4. Health and Safety Information Checklist

Emergency Contacts	Name	Telephone Number
Hospital		
Fire Department	Emergency Switchboard	911/
Ambulance and Paramedics	Emergency Switchboard	911/
Police Department	Emergency Switchboard	911/
EPA Emergency Response Team	Switchboard	(800) 424-8802
Program Contacts		
Air Force	Patrick Haas	(210) 536-4314
Battelle	Jeff Kittel	(614) 424-6122
	Eric Drescher	(614) 424-3088
Eaker AFB		
Other		
Emergency Routes		
Hospital		
Other		

7.0 REFERENCES

Battelle. 1995. *Test Plan and Technical Protocol for Bioslurping*. Prepared by Battelle Columbus Operations for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

Halliburton NUS. 1992. Technical Memorandum (Step 1) for the Remedial Investigation/Feasibility Study (Revised).

PSI - PSI, maps sent to Battelle from Eaker AFB, January, 1995.

APPENDIX A

ANALYTES DETECTED IN SUBSURFACE SOILS AT BX SHOPPETTE SERVICE STATION, EAKER AFB, ARKANSAS

TABLE 3-16A

ANALYTES DETECTED IN SUBSURFACE SOILS
BX SHOPPETTE, PSI REPORT
FEBRUARY 1991

Boring	Depth (Feet)	Benzene	Toluene	Ethyl-benzene	Xylenes	BTEX	TPH
B-1	5-10*	6.2	47	14	80	147.2	322
B-1	15	2.4	8.2	4.5	17	32.1	176
B-2	5-10*	2.3	24	7.7	40	74	248
B-2	15	3.1	8.6	0.3	2.1	14.1	478
B-3	5-10*	14	250	62	300	626	338
B-3	15	3.6	16	1.8	9.8	31.2	176
B-4	5-10*	BRL	22	3.7	14	39.7	484
B-4	15	BRL	BRL	BRL	BRL	BRL	477
B-5	5-10*	15	130	22	90	257	559
B-5	15	2.4	15	3.9	16	37.3	351
B-6	5-10*	1.5	18	2.5	14	36	218
B-6	15	1.6	6.2	1.0	4.6	13.4	147
B-7	5-10*	3.8	44	7.3	44	99.1	212
B-7	15	1.1	0.9	0.2	0.1	2.3	247
B-8	5-10*	5.0	27	7.0	39	78	157
B-8	15	BRD	BRL	BRL	BRL	BRL	163
B-9	5-10*	7.6	43	16	88	154.6	136
B-9	15	1.6	1.4	0.2	0.5	3.7	179
B-10	5-10*	11	72	20	110	213	152
B-10	15	BRL	BRL	BRL	BRL	BRL	203
B-11	5-10*	3.2	15	2.8	14	35	234
B-11	15	1.9	5.2	0.6	2.2	9.9	240
B-12	5-10*	6.3	35	8.2	44	93.5	207
B-12	15	1.6	5.2	0.5	2.4	9.7	210

Footnotes:

* - Composite collected at 5 and 10 feet
BRL - Below Reported Limits
BTEX Detection Limits: 0.1 mg/kg
TPH Detection Limits: 5.0 mg/kg
Levels are in mg/kg (ppm)

TABLE 3-16B

ANALYTES DETECTED IN SUBSURFACE SOILS
BX SHOPPETTE, PSI REPORT
JUNE 1991

Boring	Depth (Feet)	Benzene	Toluene	Ethyl-benzene	Xylenes	BTEX	TPH
B-13	5-10*	5.3	24	6.8	33	69.1	<30
B-13	15	0.7	1.1	BRL	0.4	2.2	<30
B-13	20	0.8	1.2	0.2	0.8	3.0	<30
B-15	5-10*	5.1	4.2	9.4	73	91.7	46
B-15	15	7.9	30	6.1	27	7.1	<30
B-15	20	3.7	16	4.5	24	48.2	35
B-16	5-10*	9.0	37	11	46	103	<30
B-16	15	BRL	BRL	BRL	BRL	BRL	<30
B-16	20	BRL	BRL	BRL	0.5	0.5	<30
B-17	5-10*	2.3	13	4.3	26	55.6	<30
B-18	5-10*	7.2	20	3.7	22	52.9	<30
B-18	15	6.2	19	5.2	24	54.4	<30
B-19	5-10*	0.5	3.0	5.4	19	27.9	<30
B-19	15	0.6	1.8	BRL	0.7	3.1	<30
B-19	20	0.7	1.9	0.3	0.8	3.7	<30
B-20	5-10*	3.3	26	BRL	26	55.3	<30
B-20	15	37	280	68	400	785	<30
B-20	20	14	130	31	160	335	<30
B-21	5-10*	18	84	15	100	217	30
B-21	15	13	54	18	83	168	64
B-21	20	8.4	22	4.7	27	52.1	<30
B-22	5-10*	5.3	32	7.5	44	88.8	<30
B-22	20	15	65	10	51	121	<30
B-23	5-10*	1.0	17	7.1	28	53.1	<30
B-23	15	0.6	2.0	1.9	7.8	12.3	<30
B-24	5-10*	1.3	17	11	29	58.3	<30
B-24	15	0.2	2.3	1.6	7.1	11.2	<30
B-24	20	0.2	0.6	0.2	0.9	1.9	<30
B-25	5-10*	4.4	28	7.9	44	84.3	<30
B-25	15	0.2	0.8	0.1	0.8	1.9	<30
B-27	5-10*	2.4	23	9.2	36	70.6	<30
B-27	15	1.1	10	1.6	15	29.7	<30

Footnotes:

* - Composite collected at 5 and 10 feet
BRL - Below Reported Limits
BTEX Detection Limits: 0.1 mg/kg
TPH Detection Limits: 5.0 mg/kg
Levels are in mg/kg (ppm)

TABLE 11-3

ANALYTES DETECTED IN SUBSURFACE SOILS - BX SHOPPETTE, SITE ASSESSMENT REPORT

Location	Sample Number	Depth	Date Sampled	Benzene	Ethylbenzene	Toluene	m-Xylene	o-Xylene	p-Xylene	TPH (a)
Units				(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(mg/kg)
TW1103	E11-SU-TW1103A	3'	12/11/91	<1,000	<1,000	<1,000	3,000 (b)	<1,000	(b)	<20
TW1103	E11-SU-TW1103B	10'	12/11/91	77	127	5	<1	13	84	<20
TW1103	E11-SU-TW1103C	22'	12/11/91	<1	8	4	17	4	4	<20
TW1108	E11-SU-TW1108A	5'	12/14/91	<1,000	<1,000	<1,000	<1,000 (b)	3,000	(b)	<20
TW1108	E11-SU-TW1108B	17'	12/14/91	<1,000	1,000	<1,000	4,000 (b)	<1,000	(b)	<20
TW1108	E11-SU-TW1108C	21'	12/14/91	3	<1	11	7	1	<1	<20
TW1109	E11-SU-TW1109A	6'	12/14/91	5,000	17,000	17,000	53,000 (b)	25,000	(b)	172
TW1109	E11-SU-TW1109B	10'	12/14/91	12	4	3	4	<1	<1	<20
TW1109	E11-SU-TW1109C	18'	12/14/91	3	7	21	8	<1	<1	<20
TW1110	E11-SU-TW1110A	6-7'	12/14/91	2,000	19,000	58,000	63,000 (b)	30,000	(b)	23
TW1110	E11-SU-TW1110B	8.5'	12/14/91	1,000	<1,000	19,000	37,000 (b)	14,000	(b)	<20
TW1110	E11-SU-TW1110C	16.5'	12/14/91	<1,000	<1,000	3,000	<1,000 (b)	3,000	(b)	<20

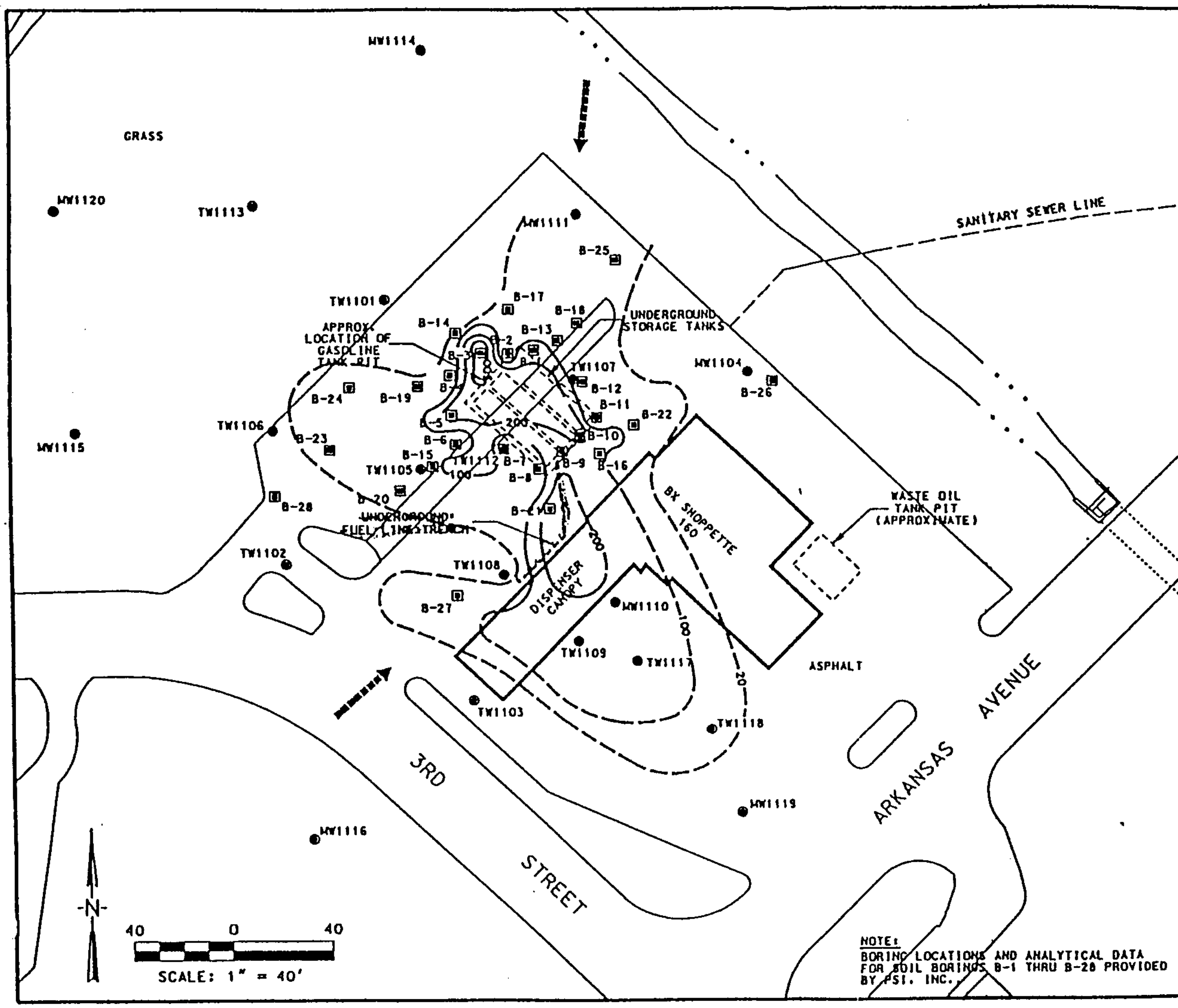
Footnotes:

(a) TPH - Total Petroleum Hydrocarbons

(b) m-and p- Xylene coelute; the concentration presented is the sum of the two analytes.

APPENDIX B

BTEX DISTRIBUTION IN SOILS AT THE BASE EXCHANGE SHOPPETTE SERVICE STATION, EAKER AFB, ARKANSAS



LEGEND

MONITORING WELL MW1104●
TEMPORARY WELL TW1101●
SOIL BORING B-1 ▣
TOTAL BTEX[1] ISOCON CONTOUR LINE (DASHED WHERE APPROX.)
FENCE
SURFACE DRAINAGE
GROUNDWATER FLOW DIRECTION

BORING OR WELL	BENZENE [1]	TOTAL BTEX [1]
B-1	6.2	147.2
B-2	2.3	74
B-3	14	626
B-4	NOT DETECTED	39.7
B-5	15	257
B-6	1.5	36
B-7	3.8	99.1
B-8	5	78
B-9	7.6	154.6
B-10	11	213
B-11	3.2	35
B-12	6.3	93.5
B-13	5.3	69.1
B-14	NOT SAMPLED	NOT SAMPLED
B-15	5.1	91.7
B-16	9	103
B-17	2.3	55.6
B-18	7.2	52.9
B-19	0.5	27.9
B-20	3.3	55.3
B-21	18	217
B-22	5.3	88.8
B-23	1.0	53.1
B-24	1.3	58.3
B-25	4.4	84.3
B-26	NOT SAMPLED	NOT SAMPLED
B-27	2.4	70.6
B-28	NOT SAMPLED	NOT SAMPLED
TW1103	<1	3
TW1108	<1	3
TW1109	5	117
MW1110	2	172

1 - CONCENTRATIONS IN mg/kg OF SOIL

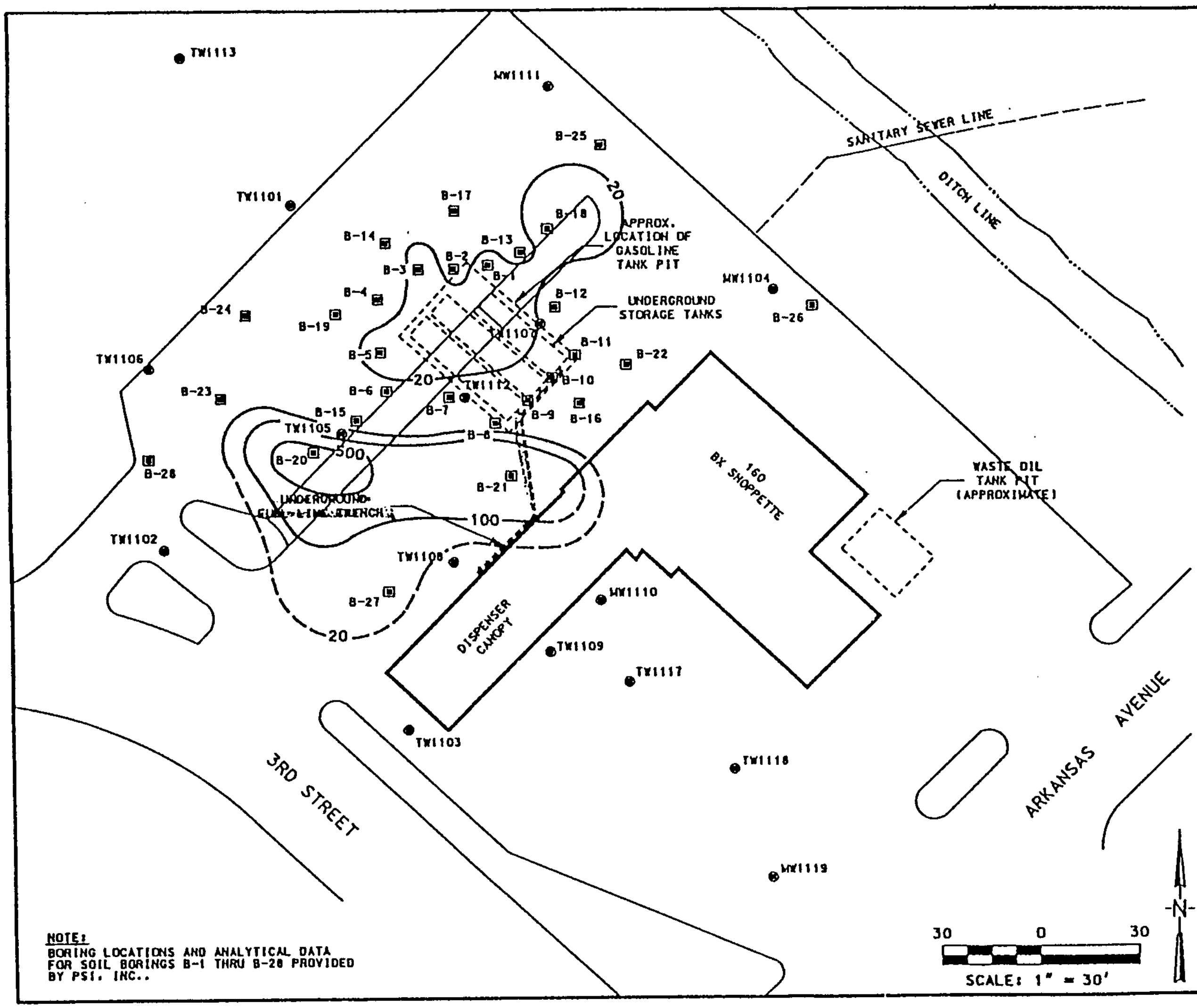
SOURCE:
DRAFT SITE ASSESSMENT REPORT FOR THE BX SHOPPETTE UNDERGROUND STORAGE TANK SITE HALLIBURTON NUS, 1992 (REVISED)

FIGURE 3-28

TITLE TOTAL BTEX CONCENTRATIONS IN SHALLOW SOILS (0'-10')
BX SHOPPETTE SITE
DESCRIPTION OF CURRENT CONDITIONS
RFI
EAKER AIR FORCE BASE

DRAWING NO. 0959C025.dgn DATE 1-25-94

B-1. Total BTEX Concentrations in Shallow Soils (0′-10′) at the BX Shoppette Site, Eaker AFB, Arkansas.



LEGEND

MONITORING WELL	MW1104●
TEMPORARY WELL	TW1101●
SOIL BORING	B-1 ⊡
TOTAL BTEX[1] ISOCON CONTOUR LINE (DASHED WHERE APPROX.)	———
FENCE	—x—x—
SURFACE DRAINAGE	—···—

BORING OR WELL	BENZENE[1]	TOTAL BTEX[1]
B-1	2.4	32.1
B-2	3.1	14.1
B-3	3.6	31.2
B-4	NOT DETECTED	NOT DETECTED
B-5	2.4	37.3
B-6	1.6	13.4
B-7	1.1	2.3
B-8	NOT DETECTED	NOT DETECTED
B-9	1.6	3.7
B-10	NOT DETECTED	NOT DETECTED
B-11	1.9	9.9
B-12	1.6	9.7
B-13	0.7	2.2
B-14	NOT SAMPLED	NOT SAMPLED
B-15	7.9	7.1
B-16	NOT DETECTED	NOT DETECTED
B-17	NOT SAMPLED	NOT SAMPLED
B-18	6.2	54.4
B-19	0.6	3.1
B-20	37	785
B-21	13	168
B-22	NOT SAMPLED	NOT SAMPLED
B-23	0.6	12.3
B-24	0.2	11.2
B-25	0.2	1.9
B-26	NOT SAMPLED	NOT SAMPLED
B-27	1.1	29.7
B-28	NOT SAMPLED	NOT SAMPLED
TW1103	NOT SAMPLED	NOT SAMPLED
TW1108	<1	5
TW1109	NOT SAMPLED	NOT SAMPLED
MW1110	<1	6

1 – CONCENTRATIONS IN mg/kg OF SOIL

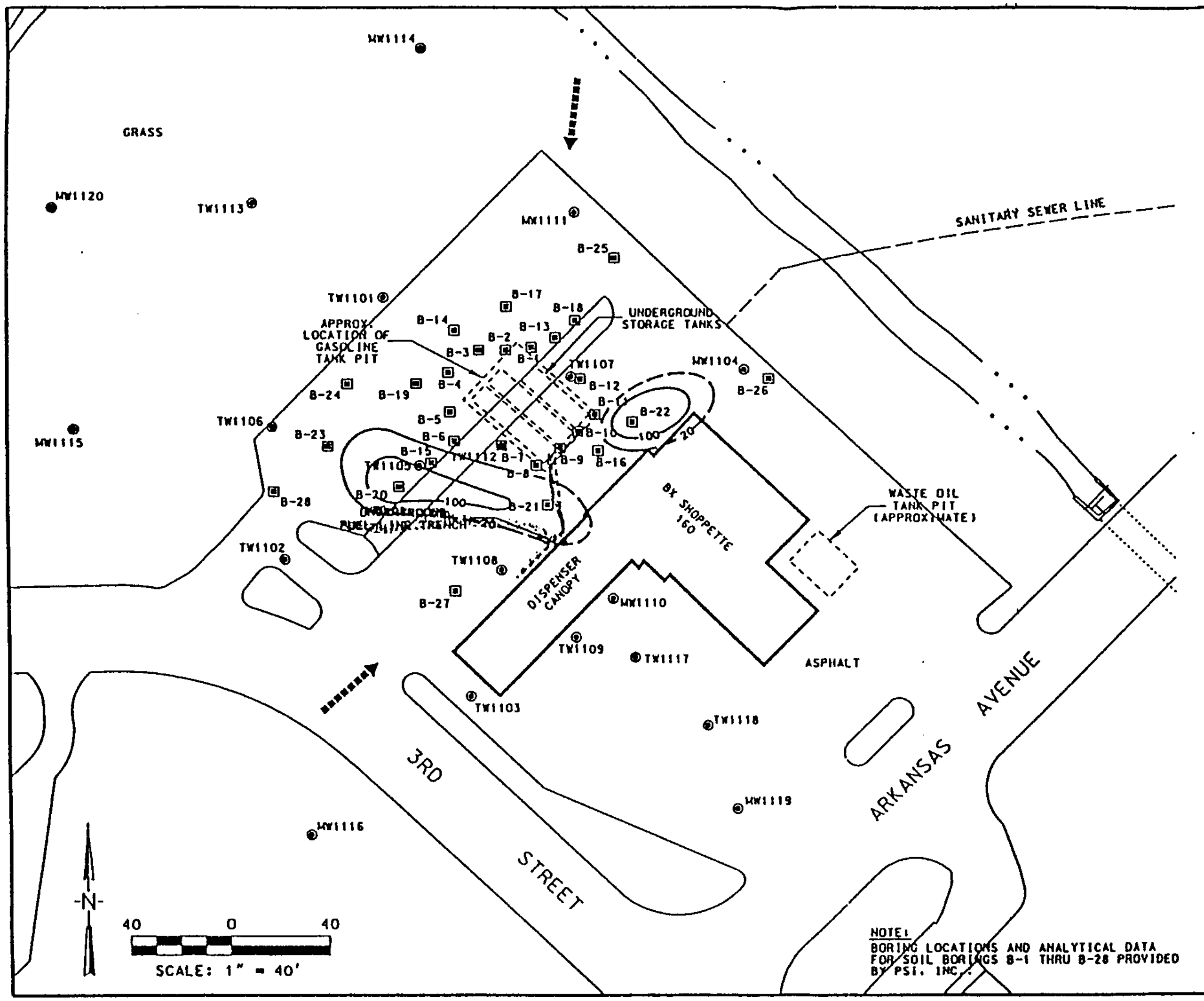
SOURCE:
DRAFT SITE ASSESSMENT REPORT FOR THE BX SHOPPETTE UNDERGROUND STORAGE TANK SITE HNUS, 1992 (REVISED)

FIGURE 3-29

TITLE TOTAL BTEX CONCENTRATIONS IN SOILS (10'–17')
DESCRIPTION OF CURRENT CONDITIONS
BX SHOPPETTE SITE
EAKER AIR FORCE BASE

DRAWING NO. 0114G014 | DATE 12-29-93

Figure B-2. Total BTEX Concentrations in Soils (10′-17′) at the BX Shoppette Site, Eaker AFB, Arkansas.



LEGEND

MONITORING WELL	MW1104
TEMPORARY WELL	TW1101
SOIL BORING	B-1
TOTAL BTEX[1] ISOCON CONTOUR LINE (DASHED WHERE APPROX.)	
FENCE	
SURFACE DRAINAGE	
GROUNDWATER FLOW DIRECTION	

BORING OR WELL	BENZENE[1]	TOTAL BTEX[1]
B-1	NOT SAMPLED	NOT SAMPLED
B-2	NOT SAMPLED	NOT SAMPLED
B-3	NOT SAMPLED	NOT SAMPLED
B-4	NOT SAMPLED	NOT SAMPLED
B-5	NOT SAMPLED	NOT SAMPLED
B-6	NOT SAMPLED	NOT SAMPLED
B-7	NOT SAMPLED	NOT SAMPLED
B-8	NOT SAMPLED	NOT SAMPLED
B-9	NOT SAMPLED	NOT SAMPLED
B-10	NOT SAMPLED	NOT SAMPLED
B-11	NOT SAMPLED	NOT SAMPLED
B-12	NOT SAMPLED	NOT SAMPLED
B-13	0.8	3
B-14	NOT SAMPLED	NOT SAMPLED
B-15	3.7	48.2
B-16	NOT DETECTED	0.5
B-17	NOT SAMPLED	NOT SAMPLED
B-18	NOT SAMPLED	NOT SAMPLED
B-19	0.7	3.7
B-20	14	335
B-21	8.4	52.1
B-22	15	121
B-23	NOT SAMPLED	NOT SAMPLED
B-24	0.2	1.9
B-25	NOT SAMPLED	NOT SAMPLED
B-26	NOT SAMPLED	NOT SAMPLED
B-27	NOT SAMPLED	NOT SAMPLED
B-28	NOT SAMPLED	NOT SAMPLED
TW1103	<1	<1
TW1108	<1	<1
TW1109	<1	<1
MW1110	NOT SAMPLED	NOT SAMPLED

1 - CONCENTRATIONS IN mg/kg OF SOIL

SOURCE:
DRAFT SITE ASSESSMENT REPORT FOR THE BX SHOPPETTE UNDERGROUND STORAGE TANK SITE HALLIBURTON NUS. 1992 (REVISED)

FIGURE 3-30

TITLE TOTAL BTEX CONCENTRATIONS IN SOILS (17'-22')
BX SHOPPETTE SITE
DESCRIPTION OF CURRENT CONDITIONS
RFI
EAKER AIR FORCE BASE

DRAWING NO. 0959C025.dgn | DATE 1-25-94

Figure B-3. Total BTEX Concentrations in Soils (17'-22') at the BX Shoppette Site, Eaker AFB, Arkansas.

APPENDIX C

ANALYTICAL RESULTS OF SUBSURFACE SOIL SAMPLES AT UWOT SITE, EAKER AFB, ARKANSAS

TABLE 3-3C

STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

Boring	SB505	SB505	SB505	SB505	SB506
Sample number	E05-SU-SB505A	E05-SU-SB505C	E05-SU-SB505D	E05-SU-SB505E	E05-SU-SB506A
Date Sampled	5/23/92	5/23/92	5/23/92	5/23/92	5/23/92
Depth	1' V	11' S	16' S	19' S	2' V
Sample Container	Glass Jar	Glass Jar	Glass Jar	Glass Jar	Glass Jar
ANALYTES					
VOCs (ug/kg) (Method EPA CLP, 1988a)					
Acetone		1400 J			
2-Butanone					
4-Methyl-2-Pentanone					7 J
Methylene Chloride					
Benzene			24		
Ethylbenzene		12000	12		
Toluene					
Xylene (total)		25000	22	970	
Total BTEX		37000	58	970	
BNAs (ug/kg) (Method EPA CLP, 1988a)					
Bis (2-Ethylhexyl) Phthalate					
2-Methylnaphthalene		1000		170 J	
Napthalene		440 J			
Phenanthrene					
PESTICIDES / PCBS (ug/kg) (Method EPA CLP, 1988a)					
TPH (mg/kg) (Method EPA 418.1)		1300 J		170 J	
INORGANICS (mg/kg)					
Arsenic (EPA 206.2 CLP-M)		5.6			
Beryllium (EPA 200.7 CLP-M)			0.84		0.74
Chromium (EPA 200.7 CLP-M)		17.7 J	21.3	7.3	16.4
Copper (EPA 200.7 CLP-M)	5.4	29.8	28.3	2.9	17.9
Lead (EPA 239.2 CLP-M)	6.2 J	12.7 J	15.4 J	2.7 J	13.6 J
Nickel (EPA 200.7 CLP-M)	11	39.1	26.9		23.6
Selenium (EPA 270.2 CLP-M)				0.56	
Zinc (EPA 200.7 CLP-M)	25.7 J	91.1	88.9	14.1 J	58.3

TABLE 3-3C
STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

(PAGE TWO)

Boring	SB506	SB506	SB507	SB507	SB507
Sample number	E05-SU-SB506B	E05-SU-SB506C	E05-SU-SB507A	E05-SU-SB507B	E05-SU-SB507BD
Date Sampled	5/23/92	5/23/92	5/24/92	5/24/92	5/24/92
Depth	8' V	14' S	7' V	11' S	15' S
Sample Container	Glass Jar	Glass Jar	Liner	Liner	Liner
ANALYTES					
VOCs (ug/kg) (Method EPA CLP, 1988a)					
Acetone			1500 J		
2-Butanone					
4-Methyl-2-Pentanone					
Methylene Chloride					
Benzene		10			4 J
Ethylbenzene			540 J		
Toluene					
Xylene (total)	45 J		1800		
Total BTEX	45 J	10	2340 J		4
BNAs (ug/kg) (Method EPA CLP, 1988a)					
Bis (2-Ethylhexyl) Phthalate					
2-Methylnaphthalene			480		
Napthalene			220 J		
Phenanthrene					
PESTICIDES / PCBS (ug/kg) (Method EPA CLP, 1988a)					
TPH (mg/kg) (Method EPA 418.1)			80 J		
INORGANICS (mg/kg)					
Arsenic (EPA 206.2 CLP-M)			4.6	9.2	7.5
Beryllium (EPA 200.7 CLP-M)	0.75	0.85			
Chromium (EPA 200.7 CLP-M)	18.6	18	15.6 J	17.2 J	18.7 J
Copper (EPA 200.7 CLP-M)	31.9	28.2	18.6	28.2	28.1
Lead (EPA 239.2 CLP-M)	12.2 J	13	10.5 J	18.3 J	16.2 J
Nickel (EPA 200.7 CLP-M)	23.1	29.6	24.5	25.6	28.7
Selenium (EPA 270.2 CLP-M)					
Zinc (EPA 200.7 CLP-M)	61.4	89.9	54.9 J	90.2	88.7

TABLE 3-3C
STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

(PAGE THREE)

Boring	SB508	SB508	SB508	SB509	SB509
Sample number	E05-SU-SB508A	E05-SU-SB508C	E05-SU-SB508D	E05-SU-SB509A	E05-SU-SB509AD
Date Sampled	5/24/92	5/24/92	5/24/92	5/25/92	5/25/92
Depth	3' V	11' S	15' S	3' V	3' V
Sample Container	Liner	Liner	Liner	Liner	Liner
ANALYTES					
VOCs (ug/kg) (Method EPA CLP, 1988a)					
Acetone	840 J				
2-Butanone					
4-Methyl-2-Pentanone					
Methylene Chloride					
Benzene	600 J	140 J	170		
Ethylbenzene	7200	54 J	48		
Toluene			5 J		
Xylene (total)		87 J	110		
Total BTEX	7800 J	281 J	333 J		
BNAs (ug/kg) (Method EPA CLP, 1988a)					
Bis (2-Ethylhexyl) Phthalate					
2-Methylnaphthalene	1200				
Napthalene	490				
Phenanthrene					
PESTICIDES / PCBS (ug/kg) (Method EPA CLP, 1988a)					
TPH (mg/kg) (Method EPA 418.1)					
INORGANICS (mg/kg)					
Arsenic (EPA 206.2 CLP-M)	8.0	5.1	6.5	4.5	5.0
Beryllium (EPA 200.7 CLP-M)					
Chromium (EPA 200.7 CLP-M)	10.6 J	15.7 J	20.4 J	11.5 J	12.8 J
Copper (EPA 200.7 CLP-M)	14.1	27.8	25.7	14.6	15.3
Lead (EPA 239.2 CLP-M)	13.6 J	15.8 J	16.0 J	9.0 J	11.2 J
Nickel (EPA 200.7 CLP-M)	24.2	26.4	24.3	19	21.5
Selenium (EPA 270.2 CLP-M)	0.37	0.32	0.3		
Zinc (EPA 200.7 CLP-M)	42.0 J	100	84.7	49.7 J	51.3 J

TABLE 3-3C
STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

(PAGE FOUR)

Boring	SB509	SB509	SB510	SB510	SB510
Sample number	E05-SU-SB509B	E05-SU-SB509D	E05-SU-SB510A	E05-SU-SB510B	E05-SU-SB510C
Date Sampled	5/25/92	5/25/92	5/25/92	5/25/92	5/25/92
Depth	7' V	13' S	2' V	7' V	11' S
Sample Container	Liner	Liner	Liner	Liner	Liner
ANALYTES					
VOCs (ug/kg) (Method EPA CLP, 1988a)					
Acetone					
2-Butanone					
4-Methyl-2-Pentanone					
Methylene Chloride					
Benzene					35
Ethylbenzene				7	70
Toluene					
Xylene (total)			6 J	91	120
Total BTEX			6 J	98	225
BNAs (ug/kg) (Method EPA CLP, 1988a)					
Bis (2-Ethylhexyl) Phthalate					
2-Methylnaphthalene					
Napthalene					
Phenanthrene					
PESTICIDES / PCBS (ug/kg) (Method EPA CLP, 1988a)					
TPH (mg/kg) (Method EPA 418.1)				75 J	
INORGANICS (mg/kg)					
Arsenic (EPA 206.2 CLP-M)	4.9 J	5.8			
Beryllium (EPA 200.7 CLP-M)				0.76	0.87
Chromium (EPA 200.7 CLP-M)	13.9 J	16.1 J	10.1	17.3	20.2
Copper (EPA 200.7 CLP-M)	15.4	26.6	7.1	18.0	27.5
Lead (EPA 239.2 CLP-M)	7.7 J	17.8 J		16.2 J	22.8
Nickel (EPA 200.7 CLP-M)	21.6	26.6	14.3	22.6	28.6
Selenium (EPA 270.2 CLP-M)					
Zinc (EPA 200.7 CLP-M)	52.3 J	66	40	55.8	91.0

TABLE 3-3C
STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

(PAGE FIVE)

Boring	SB511	SB511	SB511	SB512	SB512
Sample number	E05-SU-SB511B	E05-SU-SB511BD	E05-SU-SB511D	E05-SU-SB512A	E05-SU-SB512B
Date Sampled	5/27/92	5/27/92	5/27/92	5/27/92	5/27/92
Depth	5.5' V	5.5' V	12.5' S	3.0' V	6.5' V
Sample Container	Liner	Liner	Liner	Liner	Liner
ANALYTES					
VOCs (ug/kg) (Method EPA CLP, 1988a)					
Acetone					
2-Butanone					
4-Methyl-2-Pentanone					
Methylene Chloride	7	6 J	9 J		
Benzene			4 J	5 J	
Ethylbenzene					
Toluene					
Xylene (total)				10	
Total BTEX			4 J	15 J	
BNAs (ug/kg) (Method EPA CLP, 1988a)					
Bis (2-Ethylhexyl) Phthalate					
2-Methylnaphthalene					
Napthalene					
Phenanthrene					
PESTICIDES / PCBS (ug/kg) (Method EPA CLP, 1988a)					
TPH (mg/kg) (Method EPA 418.1)					33
INORGANICS (mg/kg)					
Arsenic (EPA 206.2 CLP-M)	4.7 J	6.4 J	8.4 J	4.8 J	3.5 J
Beryllium (EPA 200.7 CLP-M)	0.74 J	0.74 J	1.1 J	0.50 J	0.76 J
Chromium (EPA 200.7 CLP-M)	15.0	14.1	17.6	11.3	14.9
Copper (EPA 200.7 CLP-M)	15.5	15.8	31.2	15.0	14.4
Lead (EPA 239.2 CLP-M)	16.4 J	11.6 J	28.7 J	9.7 J	8.4 J
Nickel (EPA 200.7 CLP-M)		21.2	27.2	14.0	21.3
Selenium (EPA 270.2 CLP-M)					
Zinc (EPA 200.7 CLP-M)	47.5 J	47.8 J	91.3 J	47.6 J	42.8 J

TABLE 3-3C
STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

(PAGE SIX)

Boring	SB513	SB514	SB514	SB515	SB515
Sample number	E05-SU-SB513B	E05-SU-SB514A	E05-SU-SB514B	E05-SU-SB515A	E05-SU-SB515B
Date Sampled	5/27/92	5/27/92	5/27/92	5/28/92	5/28/92
Depth	11' S	3' V	7' V	3' V	6.5' V
Sample Container	Liner	Liner	Liner	Liner	Liner
ANALYTES					
VOCs (ug/kg) (Method EPA CLP, 1988a)					
Acetone					
2-Butanone	6 J				
4-Methyl-2-Pentanone					
Methylene Chloride	5 J	13	8	8	12
Benzene		10			
Ethylbenzene		23			
Toluene					
Xylene (total)	12	49			
Total BTEX	12	82			
BNAs (ug/kg) (Method EPA CLP, 1988a)					
Bis (2-Ethylhexyl) Phthalate					
2-Methylnaphthalene					
Napthalene					
Phenanthrene					
PESTICIDES / PCBS (ug/kg) (Method EPA CLP, 1988a)					
TPH (mg/kg) (Method EPA 418.1)					
INORGANICS (mg/kg)					
Arsenic (EPA 206.2 CLP-M)	4.1 J	7.4 J	4.1 J	2.6 J	2.8 J
Beryllium (EPA 200.7 CLP-M)	0.52 J	0.76 J	0.77 J	0.50 J	1.0 J
Chromium (EPA 200.7 CLP-M)	9.8	14.3	12.8	8.8	11.9
Copper (EPA 200.7 CLP-M)	12.6	19.9	14.6	10.6	13.5
Lead (EPA 239.2 CLP-M)	12.0 J	16.5 J	12.3 J	9.1 J	9.3 J
Nickel (EPA 200.7 CLP-M)	11.9	20.9	15.1	14.1	12.7
Selenium (EPA 270.2 CLP-M)					
Zinc (EPA 200.7 CLP-M)	38.9 J	60.9 J	45.4 J	46.7 J	39.9 J

TABLE 3-3C
STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

(PAGE SEVEN)

Boring	SB516	SB516	SB516
Sample number	E05-SU-SB516A	E05-SU-SB516AD	E05-SU-SB516B
Date Sampled	5/28/92	5/28/92	5/28/92
Depth	3.5' V	3.5' V	7' V
Sample Container	Liner	Liner	Liner
ANALYTES			
VOCs (ug/kg) (Method EPA CLP, 1988a)			
Acetone			120 J
2-Butanone			
4-Methyl-2-Pentanone			
Methylene Chloride	8	7	
Benzene			
Ethylbenzene			
Toluene			
Xylene (total)			
Total BTEX			
BNAs (ug/kg) (Method EPA CLP, 1988a)			
Bis (2-Ethylhexyl) Phthalate			
2-Methylnaphthalene			
Napthalene			
Phenanthrene			
PESTICIDES / PCBS (ug/kg) (Method EPA CLP, 1988a)			
TPH (mg/kg) (Method EPA 418.1)			
INORGANICS (mg/kg)			
Arsenic (EPA 206.2 CLP-M)	7.4 J	6.5 J	6.0 J
Beryllium (EPA 200.7 CLP-M)	0.78 J	0.78 J	1.0 J
Chromium (EPA 200.7 CLP-M)	14.5	14.5	12.8
Copper (EPA 200.7 CLP-M)	19.1	18.4	17.9
Lead (EPA 239.2 CLP-M)	19.1 J	18.0 J	11.2 J
Nickel (EPA 200.7 CLP-M)	14.2	15.3	16.8
Selenium (EPA 270.2 CLP-M)			
Zinc (EPA 200.7 CLP-M)	60.7 J	54.9 J	52.8 J

TABLE 3-3C
STEP 2 ANALYTICAL RESULTS - UNDERGROUND WASTE OIL TANK SITE

(PAGE EIGHT)

	Soil Grab Samples		
Boring	S501	S502	S503
Sample number	5/12/92	5/12/92	5/12/92
Date Sampled	11' - 12'	11' - 12'	11' - 12'
Depth	Glass Jar	Glass Jar	Glass Jar
Sample Container			
ANALYTES			
VOCs (ug/kg) (Method EPA CLP, 1988a)			
Acetone			
2-Butanone			
4-Methyl-2-Pentanone			
Methylene Chloride			
Benzene			
Ethylbenzene			
Toluene			
Xylene			
Total BTEX			

Results are presented in micrograms/kilogram (ug/kg), or milligrams/kilograms (mg/kg)
V or S qualifier in the Sample Depth row indicates samples collected from the vadose zone or saturated zone, respectively
VOCs - Volatile Organic Compounds
Total BTEX - Sum total of Benzene, Toluene, Ethylbenzene, and Xylene
TPH - Total Petroleum Hydrocarbons
BNAs - Base Neutral/Acids
NA - Not Analyzed
D qualifier in sample number indicates a field duplicate sample
D qualifier in data tables indicates concentration reported is taken from a dilution
J - compound is detected, but concentration is estimated

The presence of a compound group name (i.e., VOCs, BNAs) indicates that all the compounds in that group were analyzed. A list of all analyzed compounds, their quantitation limits, and their analytical method references may be found in Appendix L.

APPENDIX B

LABORATORY ANALYTICAL REPORTS

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30C0301
Phone: (614) 424-6199
Attn: Tom Zwick

Sampled: 09/16/96 Received: 09/18/96 Analyzed: 09/21-24/96

Matrix: [ ] Soil [X] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
EAK-2-OWS /BMI091896-01	TPH (Purgeable)	6.5	5.0	mg/L
	Benzene	1,800	10	ug/L
	Toluene	ND	10	ug/L
	Ethylbenzene	390	10	ug/L
	Total Xylenes	2,100	10	ug/L
EAK-2-TW /BMI091896-02	TPH (Purgeable)	3.6	1.0	mg/L
	Benzene	570	2.0	ug/L
	Toluene	ND	2.0	ug/L
	Ethylbenzene	100	2.0	ug/L
	Total Xylenes	600	2.0	ug/L
EAK-160-OWS /BMI091896-03	TPH (Purgeable)	86	25	mg/L
	Benzene	5,600	50	ug/L
	Toluene	22,000	50	ug/L
	Ethylbenzene	1,900	50	ug/L
	Total Xylenes	11,000	50	ug/L

ND - Not Detected

Approved by: Roger L. Scholl Date: 9/27/96
Roger L. Scholl, Ph.D.
Laboratory Director

Billing Information:

Name
Address
City, State, Zip
Phone Number Fax

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 1 of 1

Client Name Battelle		P.O. # G462201-30203	Job # EAKer AFB
Address		PWS #	DWR #
City, State, Zip		Phone #	Fax #

Time Sampled	Date Sampled	Matrix* See Key Below	Office Use Only Lab ID Number	Sample Description (Report Attention: Tom Zwick)	Total and type of containers ** See below	TPH/GAS	BTXE									
	9/16	Aq	BMI09189601	EAK-2-OWS	3	X	X									
	✓	✓	02	EAK-2-TW	3	X	X									
	✓	✓	03	EAK-16-OWS	3	X	X									

Sampled by:

REMARKS:

NOT CA

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Tammy Brace	TAMMY BRACE	Alpha Analytical	9/18/96	1230
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other **: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

AIR TOXICS LTD.

SAMPLE NAME: EAK-S2-1 (12034)

ID#: 9609151B-03A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6091820**		**Date of Collection: 9/15/96**	
Dil. Factor:	**5120**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	5.1	17	1200	3900
Toluene	5.1	20	980	3800
Ethyl Benzene	5.1	23	390	1700
Total Xylenes	5.1	23	1200	5300

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as JP-4 Jet Fuel)

File Name:	**6091820**		**Date of Collection: 9/15/96**	
Dil. Factor:	**5120**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	51	330	130000	840000
C2 - C4** Hydrocarbons	51	93	11000	20000

*TPH referenced to JP-4 Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: EAK-S2-2 (12027)

ID#: 9609151B-04A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6091821**		**Date of Collection: 9/15/96**	
Dil. Factor:	**5220**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	5.2	17	1300	4200
Toluene	5.2	20	790	3000
Ethyl Benzene	5.2	23	380	1700
Total Xylenes	5.2	23	1100	4800

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as JP-4 Jet Fuel)

File Name:	**6091821**		**Date of Collection: 9/15/96**	
Dil. Factor:	**5220**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	52	340	130000	840000
C2 - C4** Hydrocarbons	52	95	8100	15000

*TPH referenced to JP-4 Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9609151B-05A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6091812**		**Date of Collection: NA**	
Dil. Factor:	**1.00**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as JP-4 Jet Fuel)

File Name:	**6091812**		**Date of Collection: NA**	
Dil. Factor:	**1.00**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.010	0.065	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to JP-4 Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

№ 008455

Page ___ of ___

Contact Person AL POLLACK
Company BATTELLE
Address 505 KING AVE. City Columbus State OH Zip 43201
Phone (614) 424-3753 FAX (614) 424-3667
Collected By: Signature Greg Headington

Project Info:
P.O. # ___
Project # G462201-30C0301
Project Name BIOSLURPING BATTELLE

Turn Around Time:
☒ Normal
☐ Rush ___ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
	EAK-160-1 (12286)	15SEP96/1000	BTEX/TPH GAS	28.75	0	1.0"Hg
	EAK-160-2 (11629)	15SEP96/1005	BTEX/TPH GAS	21.5	0	1.0"Hg
03A	EAK-S2-1 (12034)	15SEP96/1040	BTEX/TPH JP-4	28.75	0	0.5"Hg
04A	EAK-S2-2 (12027)	15SEP96/1050	BTEX/TPH JP-4	28.5"	0	1.0"Hg

9/17

Relinquished By: (Signature) Date/Time: Greg L Headington 9-15-96 — Print Name: GREG HEADINGTON
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time: Scott Amerson ATL 9/17/96 1005

Notes: DATA TO: AL POLLACK

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	FED EX	1263940510	[illegible]	9/17/96 1005	AMBIENT	GOOD	Yes No None N/A	9609151B

AIR TOXICS LTD.

SAMPLE NAME: EAK-160-1 (12286)

ID#: 9609151A-01A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6091817		Date of Collection: 9/15/96	
Dil. Factor:	52200		Date of Analysis: 9/18/96	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	52	170	3000	9700
Toluene	52	200	8900	34000
Ethyl Benzene	52	230	660	2900
Total Xylenes	52	230	2400	10000

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Gasoline)

File Name:	6091817		Date of Collection: 9/15/96	
Dil. Factor:	52200		Date of Analysis: 9/18/96	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	520	2200	51000	210000
C2 - C4** Hydrocarbons	520	950	25000	46000

*TPH referenced to Gasoline (MW=100)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: EAK-160-2 (11629)

ID#: 9609151A-02A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6091818 **Date of Collection:** 9/15/96
Dil. Factor: 52200 **Date of Analysis:** 9/18/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	52	170	2500	8100
Toluene	52	200	7800	30000
Ethyl Benzene	52	230	740	3300
Total Xylenes	52	230	2700	12000

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Gasoline)

File Name: 6091818 **Date of Collection:** 9/15/96
Dil. Factor: 52200 **Date of Analysis:** 9/18/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	520	2200	43000	180000
C2 - C4** Hydrocarbons	520	950	17000	31000

*TPH referenced to Gasoline (MW=100)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: EAK-160-2 (11629) Duplicate

ID#: 9609151A-02AA

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6091819**		**Date of Collection: 9/15/96**	
Dil. Factor:	**52200**		**Date of Analysis: 9/18/96**	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	52	170	2500	8100
Toluene	52	200	7800	30000
Ethyl Benzene	52	230	700	3100
Total Xylenes	52	230	2600	11000

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Gasoline)

File Name:	**6091819**		**Date of Collection: 9/15/96**	
Dil. Factor:	**52200**		**Date of Analysis: 9/18/96**	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	520	2200	41000	170000
C2 - C4** Hydrocarbons	520	950	17000	31000

*TPH referenced to Gasoline (MW=100)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Method Spike
ID#: 9609151A-03A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6091803**		**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 9/18/96**

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	% Recovery
Benzene	0.001	0.003	94
Toluene	0.001	0.004	93
Ethyl Benzene	0.001	0.004	95
Total Xylenes	0.001	0.004	95

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Gasoline)

File Name:	**6091807**		**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 9/18/96**

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	% Recovery
TPH* (C5+ Hydrocarbons)	0.010	0.042	88
C2 - C4** Hydrocarbons	0.010	0.018	88

*TPH referenced to Gasoline (MW=100)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9609151A-04A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6091812**		**Date of Collection: NA**	
Dil. Factor:	**1.00**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Gasoline)

File Name:	**6091812**		**Date of Collection: NA**	
Dil. Factor:	**1.00**		**Date of Analysis: 9/18/96**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.010	0.042	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Gasoline (MW=100)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

№ 008455
Page ___ of ___

Contact Person: AL POLLACK
Company: BATTELLE
Address: 505 KING AVE. City: Columbus State: OH Zip: 43201
Phone: (614) 424-3753 FAX: (614) 424-3667
Collected By: Signature: Greg Headington

Project info:
P.O. #: ___
Project #: G462201-30C0301
Project Name: BIOSLURPING BATTELLE

Turn Around Time:
☒ Normal
☐ Rush ___ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	EAK-160-1 (12286)	15SEP96/1000	BTEX/TPH GAS	28.75	0	1.0"Hg
02A/AA	EAK-160-2 (11629)	15SEP96/1005	BTEX/TPH GAS	21.5	0	1.0"Hg
~~03A~~	EAK-S2-1 (12034)	15SEP96/1040	BTEX/TPH JP-4	28.75	0	0.5"Hg
~~04A~~	EAK-S2-2 (12027)	15SEP96/1050	BTEX/TPH JP-4	28.5"	0	1.0"Hg

9/17

Relinquished By: (Signature) Greg Headington Date/Time 9-15-96 Print Name GREG HEADINGTON
Relinquished By: (Signature) Date/Time Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time Received By: (Signature) Scott Ameison ATL Date/Time 9/17/96 1095

Notes: DATA TO: AL POLLACK

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	FED EX	1263940510	[illegible]	9/17/96 1005	AMBIENT	GOOD	Yes No None N/A	9609151A

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

No 008455

Page ___ of ___

Contact Person AL POLLACK
Company BATTELLE
Address 505 KING AVE. City Columbus State OH Zip 43201
Phone (614) 424-3753 FAX (614) 424-3667
Collected By: Signature [signature]

Project info:
P.O. # ___
Project # G462201-3060301
Project Name BIOSLURPING BATTELLE

Turn Around Time:
☒ Normal
☐ Rush ___ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
	EAK-160-1 (12286)	15SEP96/1000	BTEX/TPH GAS	28.75	0	
	EAK-160-2 (11629)	15SEP96/1005	BTEX/TPH GAS	21.5	0	
	EAK-S2-1 (12034)	15SEP96/1040	BTEX/TPH JP-4	28.75	0	
	EAK-S2-2 (12027)	15SEP96/1050	BTEX/TPH JP-4	28.5"	0	

Relinquished By: (Signature) Date/Time [signature] 9-15-96 Print Name GREG HEADINGTON
Relinquished By: (Signature) Date/Time Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time Received By: (Signature) Date/Time

Notes: DATA TO: AL POLLACK

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
							Yes No None N/A	

Form 1293 rev. 06

Battelle
Columbus Laboratories

Form No. ______

CHAIN OF CUSTODY RECORD

Proj. No.	Project Title
64162201-3000301	EAKER AFB BIOSLURPER

SAMPLERS: (Signature) Jon Eastep

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√): BTEX	Container No.	Number of Containers	Remarks
09-16-96		EAK-110-F (GW)	X		1	
09-16-96		EAK-7-F (TP-11)	X		1	

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[illegible]	[illegible]				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ____________

Proj. No.	Project Title
6462201-31-60301	EAKER AFB, [illegible]

SAMPLERS: (Signature) Jon Eastep

DATE	TIME	SAMPLE I.D.	BTEX	TPH [illegible]	Container No.	Number of Containers	Remarks
09-16-96	1400hrs	EAK-2-OWS (31.4)	X	X		3	40 ml [illegible]
" " "	1400hrs	EAK-2-TW (31.4)	X	X		3	"
" " "		EAK-160-OWS ([illegible])	X	X		3	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[illegible signature]	16 SEP 96 1545				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 1

Proj. No. G462201-30C0301

Project Title EAKER AFB/BIOSLURPING

SAMPLERS: (Signature) Jon T. Easter

DATE	TIME	SAMPLE I.D.	BTEX	TPH (95 gasoline)	Total Phthalate	Total Kjeldahl N.	Alkalinity	pH	Total Iron	Part. Size Dist.	Bulk Density	Porosity	Moisture Cont.			Container No.	Number of Containers	Remarks
09-11-96	1301 HRS	EAFB-2 10.5-11.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				1	SOIL SAMPLES
09-11-96	1305 HRS	EAFB-2 11.0-11.5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				1	"
09-11-96	1309 HRS	EAFB-2 11.5-12.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				1	"
09-11-96	1200 HRS	FACILITY 160-14.0-14.5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				1	"
09-11-96	1205 HRS	FACILITY 160-14.5-15.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				1	"
09-11-96	1210 HRS	FACILITY 160-15.0-15.5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				1	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
J. T. Easter	09/15/96 1500 HRS				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
				SEND RESULTS TO: JEFF KITTEL 505 KING AVE COLUMBUS OHIO 43201

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 1

Proj. No. G462201-30C0301

Project Title: EAKER AFB / BIOSLURPING

SAMPLERS: (Signature) Jon T. Eastep

DATE	TIME	SAMPLE I.D.	BTEX	TPH/95 GASOLINE	TOTAL PHOSPHORUS	TOTAL KJELDAHL N.	ALKALINITY	pH	TOTAL IRON	PART. SIZE DIST.	BULK DENSITY	POROSITY	MOISTURE CONT.			Container No.	Number of Containers	Remarks
09-11-96	1301 HRS	EAFB-2 10.5-11.0															1	SOIL SAMPLES
09-11-96	1305 HRS	EAFB-2 11.0-11.5															1	"
09-11-96	1309 HRS	EAFB-2 11.5-12.0															1	"
09-11-96	1200 HRS	FACILITY 160-14.0-14.5															1	"
09-11-96	1205 HRS	FACILITY 160-14.5-15.0															1	"
09-11-96	1210 HRS	FACILITY 160-15.0-15.5	√	√	√	√	√	√	√	√	√	√	√				1	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Jon T. Eastep	09/15/96 0800 HRS				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
				SEND RESULTS TO: JEFF KITTEL 505 KING AVE COLUMBUS, OHIO 43201

Billing Information:

Name ____

Address ____

City, State, Zip ____

Phone Number ____ Fax ____

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 1 of 1

Client Name Battelle	P.O. #	Job # C-462201-30C0301
Address	PWS #	DWR #
City, State, Zip	Phone #	Fax #

Sampled by Client

Report Attention JEFF Kittel

Analyses Required

Time Sampled	Date Sampled	Matrix* See Key Below	Office Use Only Lab ID Number	Sample Description	Total and type of containers ** See below	BTXE	TPH GAS	TOTAL KJELDAHL N	ALKALINITY	PH	TOTAL IRON	PART SIZE	BULK DENSITY	POROSITY	MOISTURE CONT	TOTAL PHOSPHORUS	
	9/11	SO	BMI 091796-01	EAFB-2 10.5-11.0	1 BRASS	–	X	X	X	X	X	X	X	X	X	X	
		✓	02	EAFB-2 11.0-11.5	✓	+	X	X	X	X	X	X	X	X	X	X	
		✓	03	EAFB-2 11.5-12.0	✓	+	X	X	X	X	X	X	X	X	X	X	
		✓	04	Facility 160-14.0-14.5	✓	–	–	X	X	X	X	X	X	X	X	X	
		✓	05	Facility 160-14.5-15.0	✓	–	–	X	X	X	X	X	X	X	X	X	
	9/11	SO	06	Facility 160-15.0-15.5	✓	+	+	X	X	X	X	X	X	X	X	X	

REMARKS:

NOT CA

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Danny Brace	DANNY BRACE	Alpha Analytical	9/17/96	1250
Relinquished by	[signature]	CRAIG GRESY	AAI	9/18/96	1240
Received by	[signature]	L. ANSERT	SEM, INC.	9/18/96	1240
Relinquished by					
Received by					

*Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*: AQ-Aqueous SO - Soil WA - Waste OT - Other **: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30C0301
Phone: (614) 424-6199
Attn: Al Pollock

Sampled: 09/11/96 Received: 09/17/96 Analyzed: 09/21/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
EAFB-2 10.5-11.0 /BMI091796-01	TPH (Purgeable)	4,500	500	mg/Kg
	Benzene	9,100	1,000	ug/Kg
	Toluene	1,200	1,000	ug/Kg
	Ethylbenzene	22,000	1,000	ug/Kg
	Total Xylenes	120,000	1,000	ug/Kg
EAFB-2 11.0-11.5 /BMI091796-02	TPH (Purgeable)	2,600	500	mg/Kg
	Benzene	5,700	1,000	ug/Kg
	Toluene	ND	1,000	ug/Kg
	Ethylbenzene	12,000	1,000	ug/Kg
	Total Xylenes	62,000	1,000	ug/Kg
EAFB-2 11.5-12.0 /BMI091796-03	TPH (Purgeable)	3,600	500	mg/Kg
	Benzene	11,000	1,000	ug/Kg
	Toluene	ND	1,000	ug/Kg
	Ethylbenzene	20,000	1,000	ug/Kg
	Total Xylenes	110,000	1,000	ug/Kg
Facility 160-14.0-14.5 /BMI091796-04	TPH (Purgeable)	24,000	5,000	mg/Kg
	Benzene	170	10	mg/Kg
	Toluene	1,900	10	mg/Kg
	Ethylbenzene	480	10	mg/Kg
	Total Xylenes	2,500	10	mg/Kg

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
Facility 160- 14.5-15.0 /BMI091796-05	TPH (Purgeable)	26,000	5,000	mg/Kg
	Benzene	200	10	mg/Kg
	Toluene	2,400	10	mg/Kg
	Ethylbenzene	580	10	mg/Kg
	Total Xylenes	3,200	10	mg/Kg
Facility 160- 15.0-15.5 /BMI091796-06	TPH (Purgeable)	33,000	5,000	mg/Kg
	Benzene	240	10	mg/Kg
	Toluene	2,600	10	mg/Kg
	Ethylbenzene	670	10	mg/Kg
	Total Xylenes	3,600	10	mg/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 9/30/96
Roger L. Scholl, Ph.D.
Laboratory Director

Laboratory Analysis Report

Sierra Environmental Monitoring, Inc.

ALPHA ANALYTICAL
255 GLENDALE AVENUE, SUITE 21
SPARKS NV 89431

Date : 10/04/96
Client : ALP-855
Taken by: CLIENT
Report : 17533
PO# :

Sample	Collected Date	Time	ALKALINITY MG/L CACO3	PH S.U.	MOISTURE CONTENT %	KJELDAHL-N MG/L	PHOSPHORUS -TOTAL MG/L	IRON, TOTAL MG/L
BMI091796-01-EAFB-2 10.5-11.0	9/11/96	:	730 mg/kg*	9.46	23.6	278 mg/kg	232mg/kg	15 mg/g
BMI091796-02-EAFB-2 11.0-11.5	9/11/96	:	660 mg/kg*	9.62	23.1	388 mg/kg	319mg/kg	14 mg/g
BMI091796-03-EAFB-2 11.5-12.0	9/11/96	:	730 mg/kg*	9.54	23.3	347 mg/kg	244mg/kg	16 mg/g
BMI091796-04-FAC 160 14.0-14.5	9/11/96	:	320 mg/kg*	9.40	12.2	263 mg/kg	23mg/kg	5.1 mg/g
BMI091796-05-FAC 160 14.5-15.0	9/11/96	:	340 mg/kg*	9.54	14.6	209 mg/kg	60mg/kg	8.4 mg/g
BMI091796-06-FAC 160 15.0-15.5	9/11/96	:	380 mg/kg*	9.50	14.3	194 mg/kg	46mg/kg	4.2 mg/g

Sample	Collected Date	Time	DIGESTION-TOTAL METALS	AQUEOUS EXTRACT	DENSITY G/CM3	PARTICLE SIZE DISTIBUTION FRACTION %	POROSITY	
BMI091796-01-EAFB-2 10.5-11.0	9/11/96	:	yes	yes	1.25	REPORT	52.8	
BMI091796-02-EAFB-2 11.0-11.5	9/11/96	:	yes	yes	1.25	REPORT	52.8	
BMI091796-03-EAFB-2 11.5-12.0	9/11/96	:	yes	yes	1.26	REPORT	52.4	
BMI091796-04-FAC 160 14.0-14.5	9/11/96	:	yes	yes	1.61	REPORT	39.2	
BMI091796-05-FAC 160 14.5-15.0	9/11/96	:	yes	yes	1.73	REPORT	34.7	
BMI091796-06-FAC 160 15.0-15.5	9/11/96	:	yes	yes	1.62	REPORT	38.9	

Approved By: ____________

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

Laboratory
Analysis Report

Sierra
Environmental
Monitoring, Inc.

ALPHA ANALYTICAL
255 GLENDALE AVENUE, SUITE 21
SPARKS NV 89431

Date :
Client : ALP-855
Taken by: CLIENT
Report : 17533
PO# :

* Alkalinity is milligrams of $CaCO_3$ extractable per kilogram of soil.

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

Sierra
Environmental
Monitoring, Inc.

September 26, 1996

TO: **Alpha Analytical**

FROM: Sierra Environmental Monitoring, Inc.

RE: Particle Size Distribution Analysis for Samples:

SEM 9609-0711 BMI 091796-01-EAFB-160 10.5-11.0

SEM 9609-0712 BMI 091796-02-EAFB-2 11.0-11.5

SEM 9609-0713 BMI 091796-03-EAFB-2 11.5-12.0

As per your request, we have performed particle size analysis on the samples submitted to our laboratory. Test results are as follows:

9609-0711	**Clay: 21.7 %**	**Silt: 55.8 %**	**Sand: 22.5 %**
9609-0712	**Clay: 19.2 %**	**Silt: 51.3 %**	**Sand: 29.2 %**
9609-0713	**Clay: 19.1 %**	**Silt: 50.9 %**	**Sand: 30.0 %**

The samples were passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,
SIERRA ENVIRONMENTAL MONITORING, INC.

John Seher
Laboratory Manager

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

Sierra
Environmental
Monitoring, Inc.

September 26, 1996

TO: **Alpha Analytical**

FROM: Sierra Environmental Monitoring, Inc.

RE: Particle Size Distribution Analysis for Samples:

SEM 9609-0714	BMI 091796-04-FAC-160 14.0-14.5
SEM 9609-0715	BMI 091796-05-FAC-160 14.5-15.0
SEM 9609-0716	BMI 091796-06-FAC-160 15.0-15.5

As per your request, we have performed particle size analysis on the samples submitted to our laboratory. Test results are as follows:

9609-0714	**Clay: 2.8 %**	**Silt: 7.5 %**	**Sand: 89.7 %**
9609-0715	**Clay: 7.5 %**	**Silt: 11.1 %**	**Sand: 81.4 %**
9609-0716	**Clay: 3.9 %**	**Silt: 5.7 %**	**Sand: 90.4 %**

The samples were passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,
SIERRA ENVIRONMENTAL MONITORING, INC.

John Seher
Laboratory Manager

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

APPENDIX C

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: EAKER AFB, site #160

Date: 09 SEP 96

Operator's Initials: GH

Equipment	Check if Okay	Comments
Liquid Ring Pump	✓	
Aqueous Effluent Transfer Pump	✓	
Oil/Water Separator	✓	
Vapor Flow Meter	✓	
Fuel Flow Meter	✓	
Water Flow Meter	✓	
Emergency Shut off Float Switch -Effluent Transfer Tank	✓	
Analytical Field Instrumentation -GasTechtor O_2/CO_2 Analyzer -TraceTechtor Hydrocarbon Analyzer -Oil/Water Interface Probe -Magnehelic Boards -Thermocouple Thermometer	✓	

APPENDIX D

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Bioslurper Pilot Test Monitoring Well Data Sheet

Site: EAKER AFB/Site 160

Test Type (Skimmer, Bioslurper Vacuum Extraction, Drawdown): Bioslurper

Depth to Groundwater: 15.5' TOC Depth to Fuel: 15.5' TOC Depth of Slurper Tube: 15.58' TOC

Date at Start of Test: 12 SEP 96

Time at Start of Test: 1056 HRS Operator's Initials: JK

Time	Vapor Extraction Flow Pressure (in H_2O)	Vapor Extraction Flow Flowrate (scfm)	LNAPL Totalizer (gal)	Groundwater Totalizer (gal)	Well-Head Vacuum (~~in H_2O~~)	Comments (include samples collection/analysis information)
T=0						
100 min	0.01" DP				16" Hg	Seal water temp = 147.6°F
124 min	0.015" DP				18" Hg	Seal water temp = 133°F
364 min	0.015" DP		6.2 GAL	Very low	18" Hg	Seal water temp = 129°F
424 min	0.0125" DP		8.8 GAL	60 GAL	18" Hg	Seal water temp = 126°F / 1.2 GPH water
622 min	0.01" DP		21.1 GAL	75 GAL	18" Hg	Seal water temp = 121.6°F
1024 min	0.0065" DP		42.0 GAL	Rate 3.6 GPH	18.5" Hg	Seal water temp = 118.6°F
1224 min	0.005" DP		49.6 GAL	—	18" Hg	Seal water temp = 118.8°F
1579 min	0.012" DP		59.7 GAL	145 GAL	18" Hg	Seal water temp = 136°F Rate: 5.5 GAL/HR water
~~1824~~ 1864 min	0.01" DP		64.0 GAL	150 GAL	19.5" Hg	Seal water temp = 111.0°F Rate 4.8 GAL/HR.

Hour meter 31.2 HRS

Bioslurper Pilot Test Monitoring Well Data Sheet

Site: EAKER AFB/Site #160   WELL TW1105

Test Type (Skimmer, Bioslurper Vacuum Extraction, Drawdown): Bioslurping

Depth to Groundwater: 15.5' TOC   Depth to Fuel: 15.5' TOC   Depth of Slurper Tube: 15.58' TOC

Date at Start of Test: 12 SEP 96   STOPPED 91.4 Hours.   DTP 17.44'   DTW 17.465'   Adaptor pipe = 0.55' above original TOC.

Time at Start of Test: 1056 HOURS   Operator's Initials: ______

Time	Vapor Extraction Flow Pressure (in H_2O)	Vapor Extraction Flow Flowrate (scfm)	LNAPL Totalizer (gal)	Groundwater Totalizer (gal)	Well-Head Vacuum ~~(in H_2O)~~	Comments (include samples collection/analysis information)
2584 min	0.06" DP		66.8	170 GAL	16.5" Hg	Seal water temp 111°F / HAD AIR BYPASS VALVE OPEN OVERNIGHT DUE TO PUMP PROBLEM
System off	after	this reading,	Repair pump	AND install	after cooler	Unit start 14 SEP/1030 HRS → HR METER 4300
50.5 HRS	0.005" DP		70.1 GAL	206 GAL	17.5" Hg	Seal water temp = 130.8°F /
65.25 HRS	0.005" DP		79.3 GAL	262 GAL	18.5" Hg	water temp = 120.4°F / 15 SEP / 0845 HRS.
66.4 HRS	Collect	VAPOR	Emmission	SAMPLES		CAN # 12286 - EAK-160-1 CAN # 11629 - EAK-160-2
75.25 HRS	VERY WINDY CANNOT ZERO	MAGNEHELIC	85 GAL	307 GAL	20" Hg	water temp = 121°F / 15 SEP - 1845 HRS.
89.0 HRS	0.005" DP		93.7 GAL	368 GAL	20" Hg	water temp = 106.6°F
91.4 HR	System	Stopped	94.3 GAL	373 GAL	20" Hg	Stopped Slurping 1100 HRS 16 SEP 96
				← DOES NOT	Include volume	for filter box and OWS PRIME
				Could be	an additional	7-10 GALLONS

Bioslurper Pilot Test Monitoring Well Data Sheet

Site: EAKER AFB / Site #160 WELL TW1105

Test Type (Skimmer, Bioslurper Vacuum Extraction, Drawdown): DRAWDOWN (Atmospheric)

Depth to Groundwater: 16.56' Depth to Fuel: 16.56' Depth of Slurper Tube: 18.70'

Date at Start of Test: 17 SEP 96

Time at Start of Test: 1535 HRS Operator's Initials: DH

Time	Vapor Extraction Flow Pressure (in H_2O)	Vapor Extraction Flow Flowrate (scfm)	LNAPL Totalizer (gal)	Groundwater Totalizer (gal)	~~Well~~ ~~Head~~ Pump Vacuum ~~(in H_2O)~~	Comments (include samples collection/analysis information)
T=0	0.145" DP		0	0	17" Hg	water temp = 41.2°C / water Rate 3 l/HR
370 min	0.145" DP	NO PULLING	water	or fuel,	Seal water	tank level has dropped
					Approx	4", we are evaporating water
					and	any fuel which might be recovered.
						System off until 18 SEP when
						a vacuum drawdown test will be done

Baildown Test Record Sheet

Site: EAKER AFB, Site #160

Well Identification: TW 1105

Well Diameter (OD/ID): 2" PVC

Date at Start of Test: 09 SEP 96

Sampler's Initials: CH

Time at Start of Test: 1704

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L
19.05'	13.~~03~~ 22'	5.83'	9.0 Liters

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1704 HR	18.07'	17.94'	0.13'
1902 HR	15.725'	14.91'	0.815'
10SEP 96 0715 HR	15.51'	14.39'	1.12'

Bioslurping Pilot Test
(Data Sheet 3)
Fuel and Water Recovery Data

Page 1 of 1

Site: EAKER AFB, Site #160

Start Date: 10 SEP 96

Test Type: Skimming

Operators: J. EASTEP/S. WALTON

2nd Skimming

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
10SEP/0800	0	0	0
10 SEP/1700	540 min	450 cc	3.0 gallons
10 SEP/2140	820 min	less than 10 cc	1.5 gallons
11 SEP/0930	1530 min	no additional fuel RECOVERED	3.2 gallons
→	GO TO SLURPING MODE		←
16 SEP 96	START SKIMMING AT 1130 HRS.		
16SEP96/1130	0	0	0
16SEP96/1805	395 min	NO MEASURABLE PRODUCT	9.5 LITERS
16SEP96/2150	620 min	70 cc of fuel RECOVERED	5.0 liters (14.5 ℓ)
17SEP96/1045	1395 min	Stop, No Additional fuel recovered	15 liters (29.5 ℓ)

FUEL AND WATER RECOVERY DATA

Site: 160

Start Date: 9 12 96

Test Type: Bioslurper

Operators: Eastep + Walton

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
9.12.96 1056	0	0	0
1:00 pm		Shutdown for	1 hr
2 pm		restart	
6 pm	6.07	6.2 gal	minimal
7 pm	7.07	8.8 gal	
2218	10.37	21.1 gal	
9.13.96 0500	17.07	42 gal	40 gal
0820	20.4	49.6 gal	
1415	26.3	59.7	145
1900	31.07	Pump off	
2100	31.07	restart	
~~9.14.96 0900~~		64 gal (cum)	150 gal
9.14.96 0900	43.07	2.8 gal	170 gal
0907	43.19	System off	
10:30	43.19	System on	
1800	50.69	70.1 (total)	206 gal.
9.15.96 0845	65.4	79.3	262 gal
1845 ~~0956~~	~~66.6~~ 75.4	85	307 gal
~~1700~~	~~Stop~~	~~Stop~~	

9.16.96 0830 89.2 93.7 368

1100 91.7 stop

94.3 373

FUEL AND WATER RECOVERY DATA

Site: 160 Start Date: ~~8~~ 9.17.96

Test Type: Drawdown Operators: GH/JE/SW

Tube @ 18.7' 26" drawdown

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
9.17.96 1535	0	0	0 / 3L/m
2145	6.2	0	1.1L

FUEL AND WATER RECOVERY DATA

Site: EAKER AFB / site 160

Start Date: 18 SEP 96

Test Type: VACUUM ENHANCED DRAWDOWN

Operators: GH / JE / SW

DTW = 15.485'
DTP = 15.48'
PRODUCT LAYER = 0.005'
DROP tube depth = 18.7'

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
18 SEP 96 / 1030 HR	0	0	0
18 SEP / 1315 HR		0	Rate = 0.3 lpm 49.5
18 SEP / 15 30 HR	300 min	0	Rate = 300 cc/min
1540 HR	DTP = 18.25'	DTW = 18.35'	Air Flow Avg = 0.005" DP
Reset	drop tube	at 15.58' where	
it ran	during	slurping test.	
Will	begin	extended testing	18 SEP 96 - 2030 HRS
after	installation	of oil storage	tank.

Baildown Test Record Sheet

Site: Eaker AFB Site 2
Well Identication: MW316
Well Diameter: 4"
Date at Start of Test: 09/10/96
Time at Start of Test: 1425
Sampler's Initials: JK, GH

Initial Readings: Time: N/R	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (gallons)
	19.21	15.46	3.750	N/R

Test Data: MW306	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Sample Time (hrs)
Notes:	18.820	18.730	0.090	1425
	18.540	18.000	0.540	1441
	17.890	17.110	0.780	1544
	17.560	16.780	0.780	1632
Date: 09/11/96	17.180	16.090	1.090	O925

Baildown Test Record Sheet

Site: Eaker AFB Site 2
Well Identication: MW306
Well Diameter: 4"
Date at Start of Test: 09/10/96
Time at Start of Test: 1008
Sampler's Initials: JK, GH

Initial Readings: Time: N/R	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (gallons)
	19.27	14.1	5.170	3.17

Test Data: MW306	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Sample Time (hrs)
Notes:	17.120	16.510	0.610	1008
	17.000	15.900	1.100	1012
	16.950	15.270	1.680	1019
	17.030	14.830	2.200	1033
	17.180	14.630	2.550	1252
	17.200	14.600	2.600	1415
Bail downed again	15.890	15.800	0.090	1422
	15.300	15.200	0.100	1444
	15.310	15.135	0.175	1635
Date: 09/11/96	15.980	15.100	0.880	O920
	15.990	14.990	1.000	1444

Fuel And Water Recovery Data

Site: Eaker AFB, AR Site II | **Start Date: 09/11/96**
Test Type: Skimmer (peristaltic pump) | **Operators: GH, JK, JE, SW**

Date	10:20 Time	0 Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
09/11/96	1028hrs	Initial	4.6L 1.22 gallons	.5L 0.13 gallons
09/11/96	1100hrs	0.533hrs	.9L 0.24 gallons	1 0.26 gallons
09/11/96	1132hrs	1.066hrs	.31L 0.08 gallons	1 0.26 gallons
09/11/96	1248hrs	2.333hrs	.4L 0.11 gallons	2 0.53 gallons
09/11/96	1335hrs	3.116hrs	.15 L 0.04 gallons	1.5 0.40 gallons
09/11/96	1430hrs	4.033hrs	.2 L 0.05 gallons	2 0.53 ggallons
09/11/96	1547hrs	5.316hrs	.25L 0.07 gallons	3.2 0.85 gallons
09/11/96	1650hrs	6.366hrs	.15L 0.04 gallons	2 0.53 gallons
09/12/96	1325hrs	27.950hrs	4.45 L 1.18 gallons	13.5 3.57 gallons
09/13/96	0915hrs	46.783hrs	7.5 L 1.98 gallons	10 gal 10.00 gallons
	Total	46.783hrs	5.01 gallons	17.06 gallons
		Ave./Day	2.57 gal/day	8.75 gal/day

Site: Eaker AFB, AR Site II | **Start Date: 09/13/96**
Test Type: Vacuum Enhanced (full vacuum) | **Operators: GH, JK, JE, & SW**

system off restart 8:45am

Date	Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
9/13/96	1045hrs	Initial	N/A	N/A
9/13/96	1915hrs	8.500hrs	N/D	145 gallons
9/14/96	0830hrs	21.750hrs	N/D	95 gallons
9/14/96	1900hrs	32.250hrs	Sheen in filter tank	170 gallons
9/15/96	1030hrs	47.750hrs	✓ Thin layer in filter tank	256 gallons
9/15/96	1830hrs	55.250hrs	✓ Thin layer in separator	157 gallons
9/16/96	0930hrs	70.250hrs	✓ 0.25"-0.50" fuel layer	258 gallons
9/16/96	1340hrs	74.416hrs	.6L ✓ 0.158 gallons	91 gallons
9/16/96	1730hrs	78.249hrs	✓None in storage area since 1340hrs	51 gallons
9/17/96	1100hrs	95.749hrs	650mL 0.172 gallons ✓	275 gallons
#	Total	95.749hrs	0.330 gallons	1,498 gallons
		Ave./Day	0.083 gal/day	375.48 gal/day

Site: Eaker AFB, AR Site II | **Start Date: 09/17/96**
Test Type: Skimmer (peristaltic pump) | **Operators: GH, JE, & SW**

Date	Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
9/17/96	1145hrs	Initial	N/A	N/A
9/18/96	0010hrs	12.416hrs	0.158 gallons 600 mL	4.80 gallons
	Total	12.416hrs	0.158 gallons	4.80 gallons
		Ave./Day	0.305 gal/day	9.28 gal/day

Site: Eaker AFB, AR Site II
Test Type: Drawdown

Start Date: 09/18/96
Operators: GH, JE, & SW

Date	Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
9/18/96	0940hrs	Initial	N/A	N/A
9/18/96	1818hrs	8.633hrs	N/D	little water recovery (evaporating)
	Total	23.75hrs	N/A	N/A
		Ave./Day	N/A	N/A

Baildown Test Record Sheet

Site: Park # 2

Well Identification: MW 316

Well Diameter (OD/ID): 4" Nom Pipe (O.D.)

Date at Start of Test: 09/10/96

Sampler's Initials: JK

Time at Start of Test: 1425 hrs

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L
19.21'	15.46'	3.75	

Test Data

Reading ~~Sample Collection~~ Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1425	18.82	18.73	
1441	18.54	18.00	
1544	17.89	17.11	
1632	17.56	16.78	
0925	17.18	16.09	

BAILDOWN.RS (G462201-1001 DISK)

Bioslurping Pilot Test
(Data Sheet 3)
Fuel and Water Recovery Data

Page ___ of ___

Site: [illegible] Site 2 MW316 Start Date: [illegible]

Test Type: Skimming (peristaltic pump) Operators: ______

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
09-11/1020	0	0	0
09-11/1028	8 min	4.6 l	0.5 l
09-11/1100	32 min	0.9 l	1.0 l
09-11/1132	32 min	0.31 l	1.0 l
09-11/1248	1.26 hrs	0.40 l	2.0 l
09-11/[illegible]	.783 hrs	0.15 l	1.5 l
09-11/1430	.916 hrs	0.2 l	3.0 l
09-11/1547	1.283 hrs	0.25 l	3.2 l
09-11/1650	1.05 hrs	0.15 l	3.0 l

SLURPPT.DS3 (G462201-1001 DISK)

APPENDIX E

SOIL GAS PERMEABILITY TEST RESULTS

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST			DATE/TIME: 12SEP96 / 1056	
TYPE OF BLOWER: LIQUID RING		SIZE OF BLOWER (HP): 7.5		SITE: EAKER AFB / SITE #160	
				RECORDED BY: JEFF KITTEL	
TIME FROM START-UP (MIN.)	WELL VACUUM ~~PRESSURE~~ ~~(PSI)~~ "Hg	OFF GAS FLOW ~~(SCFM)~~ " H_2O (peto tube)	SEAL WATER TEMP ~~(°C)~~ (°F)	COMMENTS PUMP VAC	DROP TUBE VAC
0 min	24 "Hg	trace	80.6°	27.0" Hg	24.5" Hg
10 min	21.8" Hg	trace	92.8°	26.5" Hg	24.0" Hg
20 min	23" Hg	trace	103.8°	26" Hg	21.5" Hg
30 min	21" Hg	trace	112°	25.5" Hg	22.5" Hg
40 min	21" Hg	trace	121.4°	25" Hg	21.8" Hg
100 min	16" Hg	0.01" H_2O	147.6°	22.5" Hg	18.2" Hg

Record Sheet for Air Permeability Test

Site: EAKER AFB / SITE #160	Monitoring Point: A
Liquid ring pump size: 7.5 HP	Distance from recovery well: 10'
Depth of points: Green = 4.0'	Recorded by: S. Walton
Blue = 8.0'	DATE: 12 SEP 96 / 1102
Red = 12.6'	

Time	Green	Blue	Red	Time	Green	Blue	Red
1 min	0.07"	0.33"	0.47"				
2 min	0.17"	0.42	—				
3 min	0.24"	0.49"	0.75"				
4 min	0.26"	0.60"	0.80"				
5 min	0.26"	0.60"	0.80"				
6 min	0.26"	0.60"	0.80"				
7 min	0.27"	0.60"	0.80"				
8 min	0.275"	0.60"	0.80"				
9 min	0.28"	0.60"	0.80"				
10 min	0.30"	0.65"	0.85"				
15 min	0.36"	0.80"	1.0"				
20 min	0.42"	0.85"	1.5"				
25 min	0.44"	0.85"	1.2"				
30 min	0.48"	1.0"	1.4"				
35 min	0.47"	1.0"	1.4"				
107 min	0.8"	1.2"	2.0"				
1804 min	1.0"	2.25"	3.1"				

Remarks:

Record Sheet for Air Permeability Test

Site: EAKER AFB / SITE #160	Monitoring Point: B
Liquid ring pump size: 7.5 HP	Distance from recovery well: 20'
Depth of points: Green = 3.0'	Recorded by: JE
Blue = 8.0'	DATE: 12 SEP96 / 1102 HR
Red = 13.7'	

Time	Green	Blue	Red	Time	Green	Blue	Red
1 min	0.03"	0.05"	0.10"				
2 min	0.10"	0.12"	0.14"				
3 min	0.14"	0.14"	0.20"				
4 min	0.15"	0.18"	0.20"				
5 min	0.16"	0.175"	0.22"				
6 min	0.175"	0.20"	0.24"				
7 min	0.175"	0.21"	0.24"				
8 min	0.18"	0.21"	0.245"				
9 mins	0.18"	0.22"	0.25"				
10 min	0.20"	0.235"	0.25"				
15 min	0.25"	0.25"	0.30"				
25 min	0.30"	0.35"	0.40"				
38 min	0.30"	0.35"	0.40"				
107 min	0.40"	0.40"	0.45"				
1804 min	0.70"	0.78"	0.80"				

Remarks:

Record Sheet for Air Permeability Test

Site: EAKER AFB / SITE #160	Monitoring Point: C
Liquid ring pump size: 7.5 HP	Distance from recovery well: 35 feet
Depth of points: Green = 7.0'	Recorded by: GH
Blue = 12.0'	DATE: 12 SEP 96 / 1102 HR
Red = 16.5'	

Time	Green	Blue	Red	Time	Green	Blue	Red
2 min	0.0"	0.0"	0.0"				
3 min	0.03"	0.03"	0.04"				
4 min	0.06"	0.06"	0.06"				
5 min	0.07"	0.06"	0.05"				
7 min	0.06"	0.06"	0.05"				
8 min	0.06"	0.06"	0.055"				
9 min	—	—	—				
10 min	0.07"	0.07"	0.055"				
12 min	0.07"	0.07"	0.04"				
18 min	0.11"	0.10"	0.09"				
26 min	0.10"	0.09"	0.072"				
38 min	0.125"	0.105"	0.09"				
107 min	0.14"	0.112"	0.095"				
1804 min	0.31"	0.30"	0.28"				

Remarks: Monitoring Point C located very close to the tank cavity where tanks were removed. It is possible that some short circuiting may be taking place.

Record Sheet for Air Permeability Test

Site: Eaker AFB, Site 2	**Monitoring Point: A**
Liquid ring pump size: 7.5 HP	**Distance from recovery well: 10ft**
Depth of points: Green = 3.5'-4.0'	**Recorded by: Shane Walton**
Blue =7.5'-8.0'	**Date/Time: Sept 13 '96 / 1045hrs**
Red =11.5'-12.0'	

Time(min)	Green	Blue	Red	Time	Green	Blue	Red
1	0.070	0.800	4.800				
2	0.145	0.015	6.000				
3	0.160	0.050	7.000				
4	0.230	0.060	9.500				
5	0.300	0.090	10.000				
6	0.350	N/R	10.000				
7	0.350	0.080	10.500				
8	0.350	0.090	11.000				
9	0.350	0.100	11.000				
10	0.350	0.090	11.000				
12	0.350	0.080	11.000				
14	0.350	0.075	11.000				
16	0.350	0.070	11.000				
18	0.350	0.075	11.000				
20	0.350	0.075	11.000				
25	0.350	0.750	11.500				
30	0.350	0.750	11.500				
50	0.350	0.700	11.500				
372	0.400	0.650	11.000				

*******NOTE:*** **Measurements for Green, Blue, and Red in "H_2O**

*******NOTE:*** **N/R = No Reading Taken**

Remarks: MP A, Blue, unusual reading initially were perhaps caused by a saturated or plugged point (screen area); however, later readings became more normal.

Record Sheet for Air Permeability Test

Site: Eaker AFB, Site 2	Monitoring Point: B
Liquid ring pump size: 7.5 HP	Distance from recovery well: 20ft
Depth of points: Green = 3.5'-4.0'	Recorded by: Jon Eastep
Blue =7.5'-8.0'	Date/Time: Sept 13 '96 / 1045hrs
Red =11.5'-12.0'	

Time(min)	Green	Blue	Red	Time	Green	Blue	Red
1	0.000	0.140	3.000				
2	0.010	0.650	4.000				
3	0.010	1.000	5.000				
4	0.010	1.500	7.000				
5	0.005	2.000	8.000				
6	0.005	2.000	8.500				
7	0.000	2.500	9.000				
8	0.005	2.800	9.500				
9	0.010	2.400	10.000				
10	0.005	2.600	9.900				
12	0.005	3.800	10.000				
14	0.005	3.700	10.000				
16	0.005	3.500	10.000				
18	0.005	3.400	10.000				
20	0.005	3.100	10.000				
25	0.005	4.800	10.500				
30	0.005	4.800	10.500				
50	0.005	5.000	10.000				
372	0.005	4.700	10.000				

*****NOTE:* Measurements for Green, Blue, and Red in "H_2O

*****NOTE:* N/R = NO Reading Taken

Remarks:

Record Sheet for Air Permeability Test

Site: Eaker AFB, Site 2	**Monitoring Point: C**
Liquid ring pump size: 7.5 HP	**Distance from recovery well: 30ft**
Depth of points: Green = 3.5'-4.0'	**Recorded by: Greg Headington**
Blue =7.5'-8.0'	**Date/Time: Sept 13 '96 / 1045hrs**
Red =11.5'-12.0'	

Time(min)	Green	Blue	Red	Time	Green	Blue	Red
1	0.000	0.020	0.500				
2	0.000	0.050	1.500				
3	0.000	0.080	2.200				
4	0.000	0.130	3.000				
5	0.000	0.190	3.800				
6	0.000	0.240	4.200				
7	0.000	0.280	4.500				
8	0.000	0.340	4.650				
9	0.000	0.350	4.800				
10	N/R	N/R	N/R				
12	0.000	1.400	5.000				
14	0.000	1.200	5.000				
16	0.000	1.100	5.000				
18	0.000	1.100	5.000				
20	0.000	1.100	5.100				
25	0.000	1.700	5.200				
30	0.000	1.700	5.200				
50	0.000	1.000	5.400				
372	0.000	0.600	4.800				

*****NOTE:* Measurements for Green, Blue, and Red in "H_2O

*****NOTE:* N/R = No Reading Taken

Remarks:

APPENDIX F

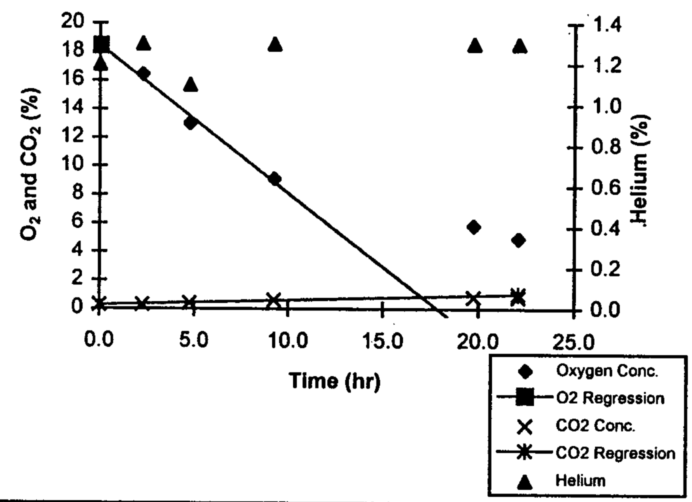
IN SITU RESPIRATION TEST RESULTS

In Situ Respiration Test: Data Analysis

Date: 9/17/96 **Site Name:** Eaker AFB

Monitoring Point: MPA **Depth of MP (ft):** 12.6'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
9/17/96 12:15	0.0	18.50	0.30	1.20
9/17/96 14:30	2.3	16.40	0.30	1.30
9/17/96 17:00	4.8	13.00	0.40	1.10
9/17/96 21:30	9.3	9.10	0.60	1.30
9/18/96 8:00	19.8	5.80	0.80	1.30
9/18/96 10:20	22.1	4.90	0.80	1.30



Biodegradation Rate (mg/kg/day)

17.079

O_2 Utilization Rate

Ko

0.017 %/min
1.033 %/hr
24.797 %/day

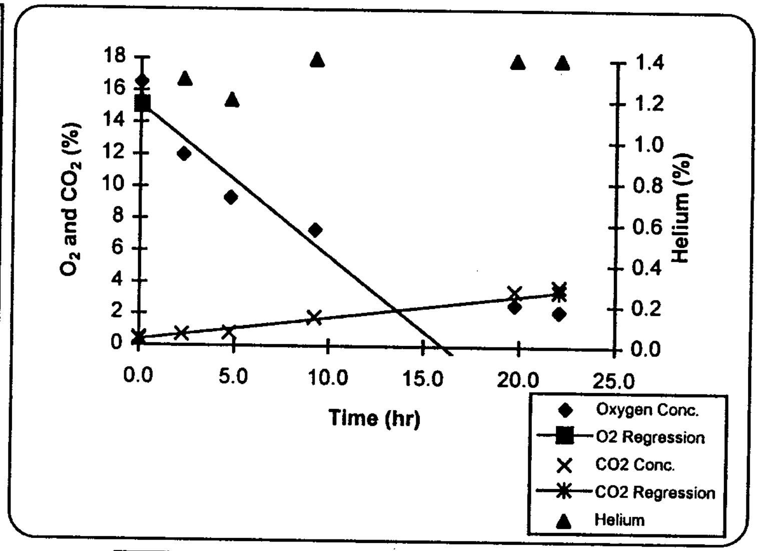
Regression Lines	O_2	CO_2
Slope	-1.0332	0.0344
Intercept	18.4473	0.2601
Determination Coef.	0.9918	0.9330
No. of Data Points	4	4

In Situ Respiration Test: Data Analysis

Date: 9/17/96 **Site Name:** Eaker AFB

Monitoring Point: MPA **Depth of MP (ft):** 8.0'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
9/17/96 12:15	0.0	16.50	0.50	1.20
9/17/96 14:30	2.3	12.00	0.70	1.30
9/17/96 17:00	4.8	9.30	0.80	1.20
9/17/96 21:30	9.3	7.30	1.80	1.40
9/18/96 8:00	19.8	2.60	3.50	1.40
9/18/96 10:20	22.1	2.20	3.80	1.40



Biodegradation Rate (mg/kg/day)

15.600

O_2 Utilization Rate

Ko 0.016 %/min
0.944 %/hr
22.650 %/day

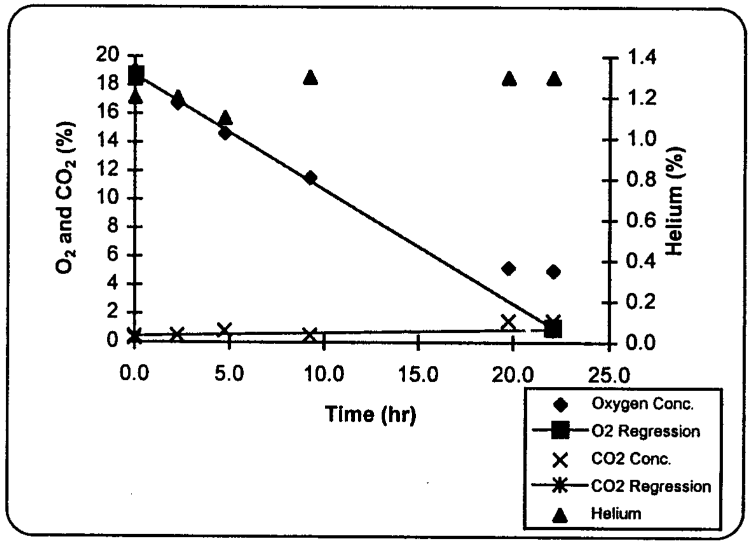
Regression Lines	O_2	CO_2
Slope	-0.9438	0.1396
Intercept	15.1090	0.3827
Determination Coef.	0.8840	0.9108
No. of Data Points	4	4

In Situ Respiration Test: Data Analysis

Date: 9/17/96 **Site Name:** Eaker AFB

Monitoring Point: MPB **Depth of MP (ft):** 13.7'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
9/17/96 12:15	0.0	19.00	0.30	1.20
9/17/96 14:30	2.3	16.70	0.50	1.20
9/17/96 17:00	4.8	14.60	0.80	1.10
9/17/96 21:30	9.3	11.50	0.50	1.30
9/18/96 8:00	19.8	5.20	1.50	1.30
9/18/96 10:20	22.1	5.00	1.50	1.30



Biodegradation Rate (mg/kg/day)

13.233

O_2 Utilization Rate

Ko 0.013 %/min
0.801 %/hr
19.213 %/day

Regression Lines	O_2	CO_2
Slope	-0.8005	0.0216
Intercept	18.7022	0.4373
Determination Coef.	0.9915	0.1726
No. of Data Points	4	4

Record Sheet For In Situ Respiration Test

Site: Eaker AFB, AR; Site II
Recorded by: SW, GH, & JE

Shutdown Date: 09/18/96
Shutdown Time: 0855hrs

Monitoring Point: A (Red)

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°F)	Notes
09/18/96	0855	18.200	0.500	1,300	0.50	N/A	
09/18/96	1400	4.000	0.500	1,000	0.41	N/A	

Monitoring Point: B (Red)

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°F)	Notes
09/18/96	0855	16.800	0.700	1,400	0.53	N/A	
09/18/96	1400	1.500	1.000	6,400	0.58	N/A	

Monitoring Point: C (Red)

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°F)	Notes
09/18/96	0855	15.000	0.600	2,000	0.53	N/A	
09/18/96	1400	0.030	1.000	8,000	0.58	N/A	