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SITE-SPECIFIC TECHNICAL REPORT FOR FREE PRODUCT RECOVERY TESTING AT OU-2, GEORGE AFB, CALIFORNIA

DRAFT

PREPARED FOR:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
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AND

AFBCA/DD
GEORGE AFB, CA

27 FEBRUARY 1997

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SITE-SPECIFIC TECHNICAL REPORT (A003)

for

FREE PRODUCT RECOVERY TESTING AT GEORGE AFB, CALIFORNIA

by

A. Leeson, M. Place, and L. Cumming

for

Mr. Patrick Haas
U.S. Air Force Center for Environmental Excellence
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27 February 1997

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFCEE	U.S. Air Force Center for Environmental Excellence
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
ft/ft	foot per foot
HC1	hydrochloric acid
LNAPL	light-nonaqueous-phase liquid
MW	monitoring well
POL	petroleum, oils, and lubricants
ppmv	part(s) per million by volume
PVC	polyvinyl chloride
scfm	standard cubic foot (feet) per minute
TPH	total petroleum hydrocarbon
VOC	volatile organic compound

EXECUTIVE SUMMARY

This report summarizes the field activities conducted at George Air Force Base (AFB) for a short-term field pilot test to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery techniques used to remove light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at George 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 test at George is one of more than 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 George AFB were skimmer pumping and bioslurping. Drawdown pumping was not conducted due to poor recoveries during the skimmer and bioslurper pump tests.

Bioslurper pilot test activities were conducted at two monitoring wells at OU-2: (1) monitoring well MW-32, and (2) monitoring well MW-5. 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 gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity. No soil sampling was conducted due to the depth of contamination.

Following the site characterization activities, the pump tests were conducted. At monitoring well MW-32, pilot tests for skimmer pumping and bioslurping were conducted. The LNAPL recovery testing was conducted in the following sequence at monitoring well MW-32: 0.5 hr in the skimmer configuration and a total of 32 hr in the bioslurper configuration. There was a 12-hr and periodic 0.5 hr shutdown periods during the bioslurper pump test.

After the drawdown pump test at MW-32, LNAPL recovery testing was conducted at monitoring well MW-5 for approximately 91 hr in the bioslurper 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.

The main objective of the field pilot test at OU-2, George AFB was to determine if LNAPL recovery is feasible and to select the most effective method of LNAPL recovery. Depths to groundwater at George AFB typically are 120 to 130 ft bgl. These were the first bioslurper pump tests conducted at this depth.

A baildown recovery test was conducted at monitoring well MW-32. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and recovery potential. The initial LNAPL thickness was 1.62 ft and after approximately 24 hours recovered to 0.48 ft. Overall, the baildown recovery test indicated a relatively slow rate of LNAPL recovery into the well. Also, short-term baildown recovery resulted in LNAPL thicknesses approximately one-third of the initial apparent thickness. Pilot testing was initiated on monitoring well MW-32 to determine whether free product recovery was possible.

Direct pumping tests were conducted at monitoring wells MW-32 and MW-5. Skimmer pump testing was conducted at monitoring well MW-32 in a continuous extraction mode for 0.5 hr. No measurable free-phase LNAPL was recovered during this time period, indicating that gravity-driven recovery is minimal. LNAPL recovery was not possible during the bioslurper pump test, although a sheen of fuel was observed in the filter box by the end of the study. In an effort to recover fuel, a number of different configurations were tested, including different diameter of drop tubes, vacuum on drop tube, and vapor flowrate. Fuel was not recovered during any of the configurations; however, significant changes in groundwater extraction were noted. The smaller diameter drop tube resulted in decreased groundwater extraction. The most significant increase in water extraction was observed at higher vapor flowrates. Groundwater production rates during bioslurping were significant, indicating that vacuum enhanced fluid recovery was in effect during the bioslurper test. The on-site water treatment equipment, consisting of a filter tank, oil/water separator, and clarification tanks, resulted in water effluent that is considered compatible with typical sanitary sewer discharge limits.

In an effort to determine if the results at monitoring well MW-32 were representative of site conditions, bioslurper testing was conducted at monitoring well MW-5. Significant free-phase LNAPL was recovered during the first three days of bioslurper pumping (9.8, 12, and 11 gallons/day, respectively). By day 4, the free product recovery rate had dropped to 5.6 gallons/day, resulting in an average rate of 9.7 gallons/day. The well head vacuum on monitoring well MW-5 (18 inches H_2O) and groundwater production rate (1,360 gallons/day) were similar to those observed at monitoring well MW-32. Results at these two monitoring wells appear to be representative of the site and indicate that vacuum-enhanced liquid recovery techniques are feasible. However, given that monitoring well MW-5 is approximately 0.5 mile from monitoring well MW-32, it is apparent that little recoverable free product is present in the vicinity of monitoring well MW-32.

Bioslurping also promotes mass removal in the form of in situ biodegradation via bioventing and soil gas extraction. Vapor phase mass removal is the result of soil gas extraction as well as volatilization that occurs during the movement of LNAPL free product through the extraction network. During the bioslurper pump test at monitoring well MW-32, given a flowrate of 3 cfm from the bioslurper well and average vapor concentrations of 106,000 ppmv TPH and 1,700 ppmv benzene, emissions rates would have been approximately 190 lb/day of TPH and 1.5 lb/day of benzene. These results demonstrate that significant hydrocarbon removal was accomplished during bioslurping, although little free product was recovered. During the bioslurper pump test at monitoring well MW-5, given a flowrate of 19.5 cfm from the bioslurper well and average vapor concentrations of 135,000 ppmv TPH and 4,450 ppmv benzene before ICE treatment, emissions rates would have been approximately 1,400 lb/day of TPH and 24 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. With the ICE in place, at a vapor discharge rate of 166 cfm and using an average concentration of 1,300 ppmv TPH and 3 ppmv benzene, approximately 130 lb/day of TPH and 0.15 lb/day of benzene were emitted to the air during the bioslurping pump test. These results demonstrated the treatment efficiency of the ICE unit, with 91% destruction of TPH and >99% destruction of benzene.

The initial soil gas profiles at the site displayed some areas of oxygen-deficient, carbon dioxide-rich, high total volatile hydrocarbon vapor conditions. 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-32 to determine if the vadose zone was being oxygenated via the bioslurper action. Results were inconclusive, since oxygen concentrations increased and decreased at monitoring points. This is likely due to the barometric pumping. The construction of the monitoring wells also may have influenced the results, because the monitoring wells are screened over very large intervals (5 to 15 ft), resulting in an averaging of soil gas concentrations across the depth interval. Typically, soil gas concentrations are collected from a much narrower screened interval (6 inches). Based on the soil gas permeability test, where a radius of influence of 49 ft was measured, it is likely that areas within this radius of influence will become fully aerated. In short, a two day extraction time frame at 3 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In situ biodegradation rates of 0.0050 to 0.039 mg/kg-day were measured at three different locations. Based on the radius of influence of 49 ft and a hydrocarbon-impacted soil thickness of 130 ft, mass removal rates via biodegradation are on the order of 0.19 to 1.5 lb of hydrocarbon per day. Thus, mass removal rates via biodegradation are not as significant as the initial vapor phase removal rates measured during the bioslurper test. These results indicate that bioventing is probably not necessary at this site, but that natural attenuation is sufficient to degrade contaminants in the vadose zone.

In summary, the on-site testing at OU-2, George AFB, included the direct testing of gravity-driven and vacuum-driven LNAPL free product recovery techniques, bioventing, and tests relevant to soil vapor extraction. These field tests have demonstrated that free product removal via vacuum-enhanced recovery is possible at significantly greater depths than the maximum suction lift. Liquid phase recovery was sustainable only under vacuum-enhanced 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.

Periodic baildown recovery tests are recommended as a useful indicator of LNAPL free product 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 OU-2 is like the sites described above. Periodic hand bailing may also represent removing LNAPL free product to the extent practicable.

DRAFT SITE-SPECIFIC TECHNICAL REPORT (A003)

for

FREE PRODUCT RECOVERY TESTING AT GEORGE AFB, CALIFORNIA

27 February 1997

1.0 INTRODUCTION

This report describes activities performed and data collected during field tests at George Air Force Base (AFB), California 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 George 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 test at George AFB is one of more than 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 George AFB are 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 George AFB were skimmer pumping and bioslurping. Drawdown pumping was not conducted due to poor recoveries during the skimmer and bioslurper pump tests. The specific test objectives, methods, and results for the George AFB test program are discussed in the following sections.

1.2 Testing Approach

Bioslurper pilot test activities were conducted at two monitoring wells at OU-2: (1) monitoring well MW-32, and (2) monitoring well MW-5. 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 gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity. No soil sampling was conducted due to the depth of contamination.

Following the site characterization activities, the pump tests were conducted. At monitoring well MW-32, pilot tests for skimmer pumping and bioslurping were conducted. The LNAPL recovery testing was conducted in the following sequence at monitoring well MW-32: 0.5 hr in the skimmer configuration and a total of 32 hr in the bioslurper configuration. There was a 12-hr and periodic 0.5 hr shutdown periods during the bioslurper pump test.

After the drawdown pump test at MW-32, LNAPL recovery testing was conducted at monitoring well MW-5 for 91 hr in the bioslurper 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 SITE DESCRIPTION

The information presented in this section was obtained from documents entitled *Treatability Study Report, Free Product Recovery System Evaluation, Operable Unit 2, George Air Force Base, California* and addendum work plans to *Free Product and Dissolved Contaminant Study, Operable*

Unit 2, George Air Force Base prepared by IT Corporation in July 1995 and September 1994, respectively.

George AFB is located in San Bernardino County in a relatively flat desert valley in the southern portion of California and was used as a jet fighter base until its closure in 1992. Victorville is the nearest city. Operable Unit 2 (OU-2), in the east-central portion of the base, included the Liquid Fuels Distribution System (LFDS). Main fuel lines ran north from the aboveground tank farm to the ready reserve underground storage tanks (USTs) at Facility 708. Additional supply lines connected tanks at Facility 708 to fuel pits, and distribution lines extended from the fuel pits under the concrete flight line to the fuel ports. The fuel lines, USTs, and fuel pits were removed in 1994, and the fuel distribution lines under the flight line were drained and grouted.

Contamination at OU-2 consists of JP-4 jet fuel resulting from spills in the LFDS. A free product plume is found under the flight line and a plume of dissolved BTEX extends north into the area toward the runway (Figure 1). A separate plume is likely to exist northeast of the main plume as evidenced by significant levels of free product found in wells MW-32 and EX-5.

Soils at the site consist of three main units. An upper unit extending to approximately 40 to 50 ft below ground surface (bgs) is predominantly sand. The middle unit is located at a depth of 40 to 125 ft bgs and is predominantly clayey-sand. The lower sand unit contains a perched aquifer and extends 190 to 200 ft bgs. The base of the aquifer is a 20-ft silty clay lacustrine bed.

Depth to groundwater at the site ranges from approximately 120 to 140 ft bgs and free product thickness have ranged from 0 to 8 ft. With limited data on the subsurface geology and the lateral extent of the plume, the free product volume was originally estimated to be 250,000 gallons.

A treatability study was initiated in 1992 that utilized three to four permanent free-product recovery systems (PPRSs) and two mobile free product recovery systems (MPRSs). PPRSs were installed in MW-4, EX-1, and EX-4 in 1992 and were in place until 1994 when the removal of piping and storage tanks required the systems to be temporarily removed. PPRSs were reinstalled in EX-1, EX-4, and MW-4 in 1995. EX-2 was eliminated due to a slow recovery rate. Two MPRSs were rotated among various wells during the same time period and operated primarily on wells EX-3, MW-5, MW-18, MW-24, and MW-67. As of 11 April 1995, a total of 12,087 gallons of free product had been recovered by all units involved in the study. A schematic diagram of all soil boring and monitoring well locations is shown in Figure 2.

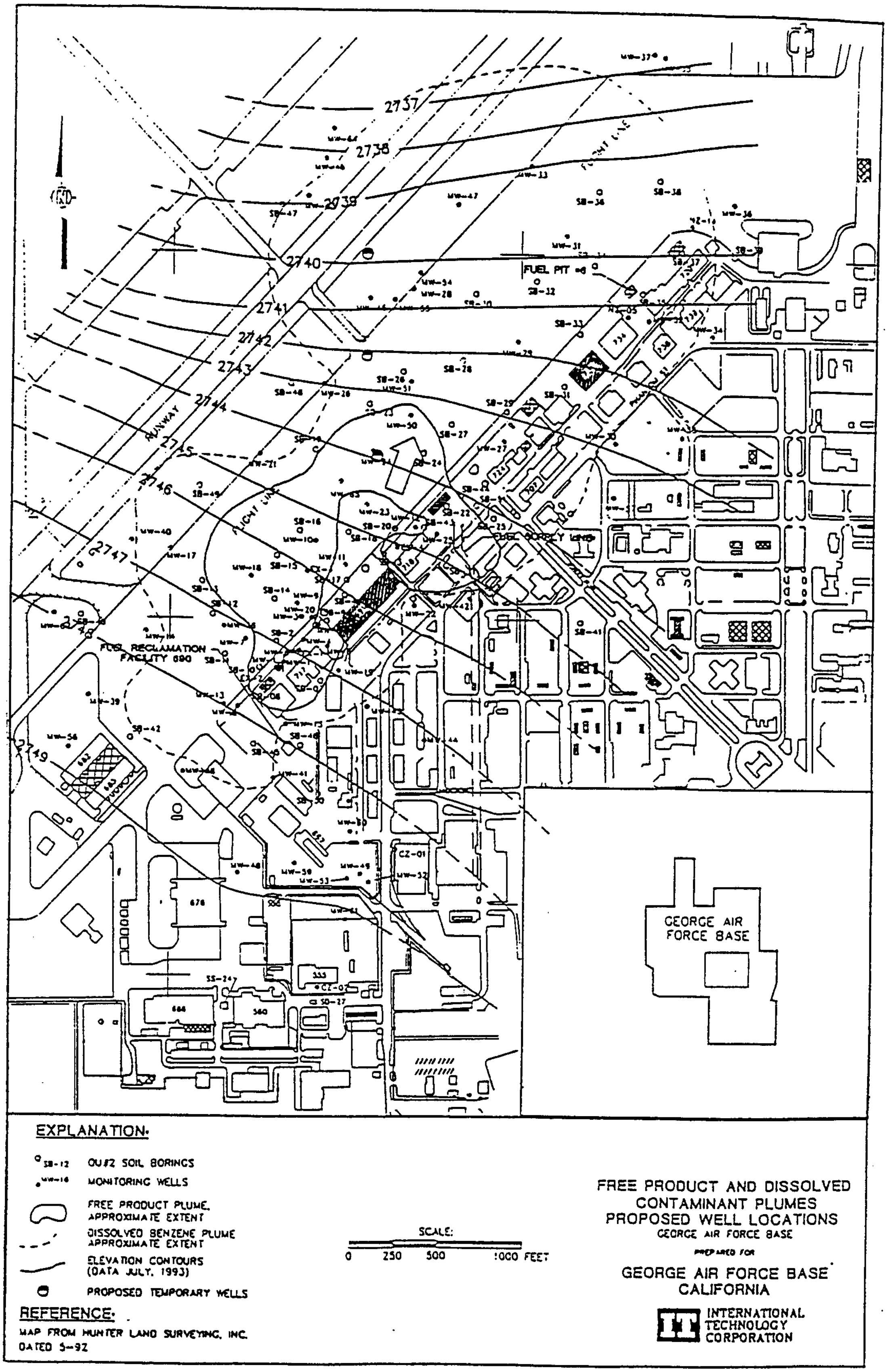

Figure 1. Schematic Diagram of the Free Product and Dissolved Contaminant Plumes at OU-2, George AFB, CA

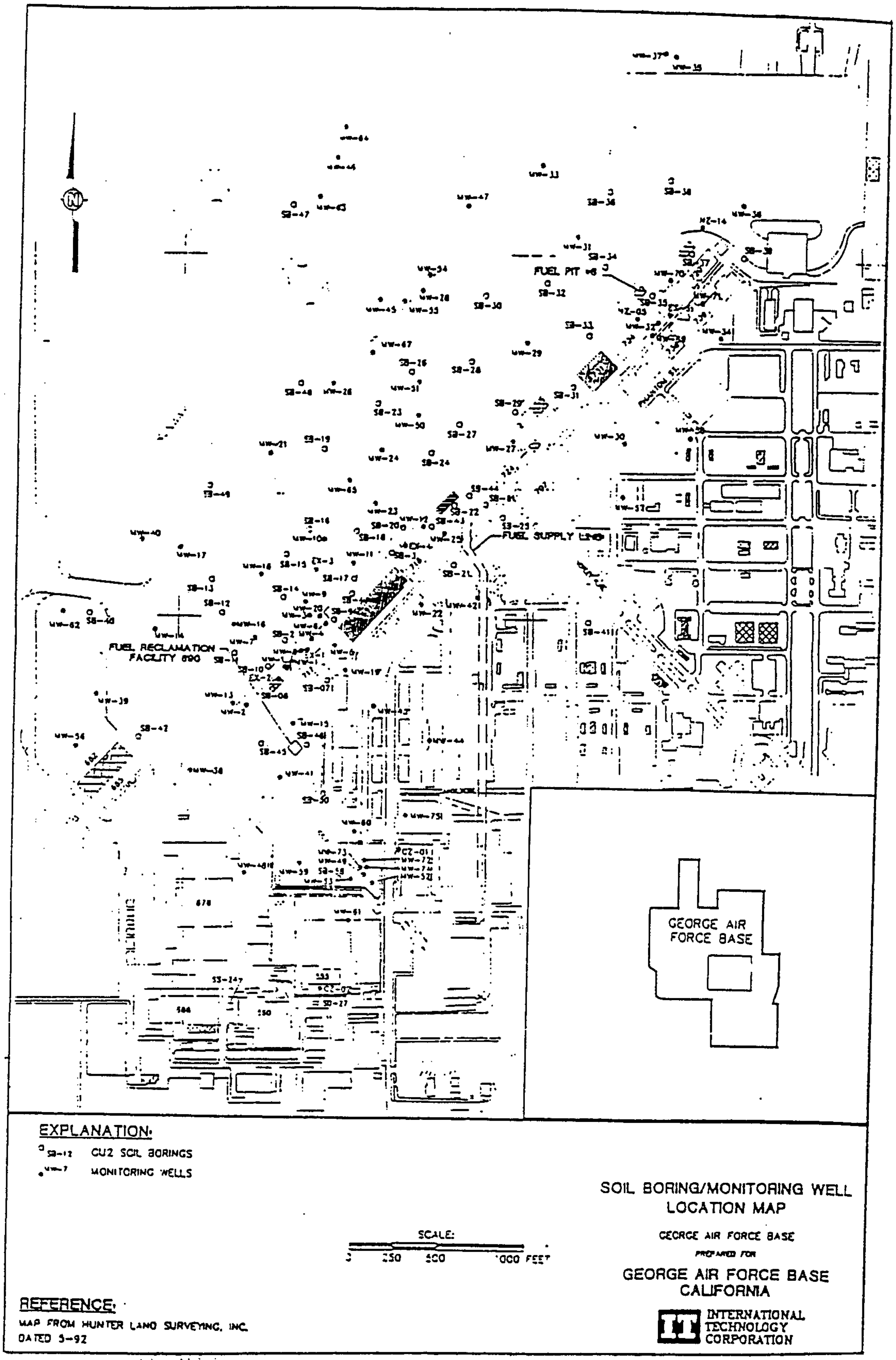

Figure 2. Map Showing Locations of Soil Borings and Monitoring Wells at OU-2, George AFB, CA

3.0 BIOSLURPER SHORT-TERM 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 George AFB.

3.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Monitoring well MW-32 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 8 hr at monitoring well MW-32.

3.2 Well Construction Details

Short-term bioslurper pump tests were conducted at existing monitoring well MW-32 and at monitoring well MW-5. Monitoring well MW-32 is constructed of 4-inch-diameter, schedule 80 polyvinyl chloride (PVC) with a total depth of 160 ft and 40 ft of 10-slot screen. Construction details for monitoring well MW-5 were not available. A schematic diagram illustrating general well construction details for monitoring wells MW-32 is provided in Figure 3.

3.3 Soil Gas Monitoring Point Installation

Soil gas monitoring points were not installed due to the deep depth to contamination. Existing soil gas monitoring wells MW-94, MW-95, MW-96, and MW-97 were used. The monitoring wells were constructed with three small diameter wells installed within the same borehole at different depths bgl. Monitoring well MW-94 consisted of ¾-inch diameter schedule 40 PVC to depths of 80 and 100 ft bgl with 10 ft of screen in each and 2-inch diameter schedule 40 PVC to a depth of 120 ft with 10 ft of screen. Monitoring wells MW-95, MW-96, and MW-97 consisted of ¾-inch diameter schedule 40 PVC to depths of 80 and 100 ft bgl with 5 ft of screen in each and 2-inch diameter schedule 40 PVC to a depth of approximately 130 ft with 15 ft of screen. The locations and constructions details of the monitoring points are illustrated in Figure 3.

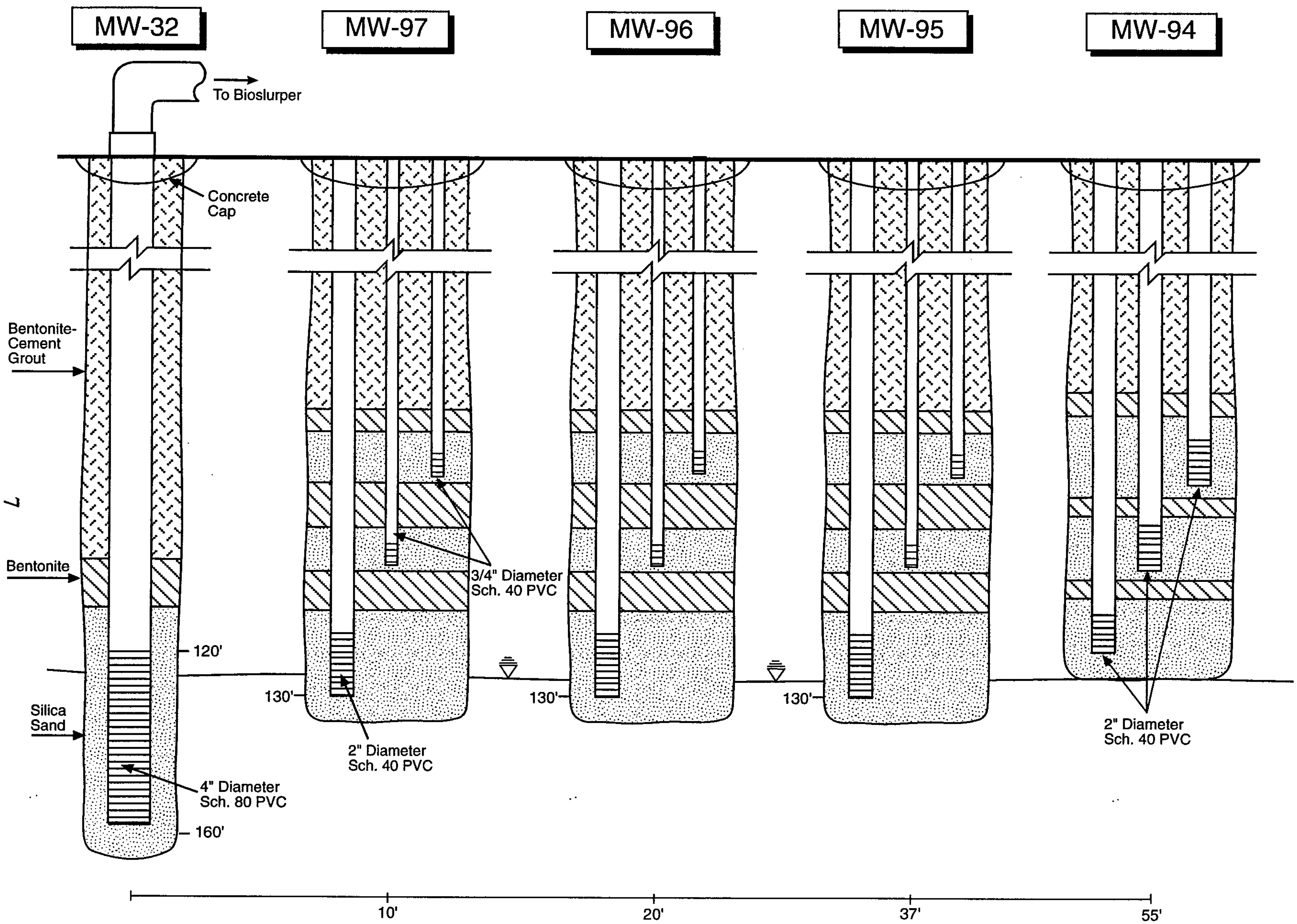

Figure 3. Construction Details of Monitoring Well MW-32 and Soil Gas Monitoring Points at George AFB, CA

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After installation of the monitoring points, initial soil gas measurements were taken with a GasTech portable O_2/CO_2 meter and a GasTech TraceTechtor portable hydrocarbon meter. Oxygen limitation was observed at many of the monitoring wells, with oxygen concentrations ranging from 0% to 20.5% (Table 1). Approximately one-half of the monitoring wells exhibited oxygen concentrations below 5%.

Table 1. Initial Soil Gas Compositions at George AFB, California

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH
MW97	80	0	7.0	NA
	100	12	6.5	NA
	130	15.1	2.0	NA
MW96	80	0.20	6.1	NA
	100	2.6	10.7	NA
	130	0.0	20.0	NA
MW95	80	0.0	7.0	NA
	100	1.5	3.8	NA
	130	20.5	0.05	NA
MW94	80	0	10.0	NA
	100	14.5	0.7	NA
	130	17.0	0.5	NA

NA Hydrocarbon meter was not operable.

3.4 LNAPL Recovery Testing

3.4.1 System Setup

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump (Atlantic Fluidics Model A100, 10-hp liquid ring pump), oil/water separator, and required support equipment were carried to the test location on a trailer. The trailer was located near the monitoring well, the well cap was removed, a well seal was placed on 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 well seal 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 recovered fluid through a filter box and an oil/water separator. Soil vapor was treated by passing it through an internal combustion engine (ICE). Output data for the ICE is provided in Appendix B.

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.

3.4.2 Skimmer Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface with the wellhead open to the atmosphere. The drop tube was held in position by the well seal, and was positioned to leave the wellhead vented 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 totalizer for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on 14 July 1996 to begin the skimmer pump test. The test was operated continuously for 0.5 hr. 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.

3.4.3 Bioslurper Pump Test

Two bioslurper pump tests were conducted: one at monitoring well MW-32 and one at monitoring well MW-5. Details of the tests are described in the following sections.

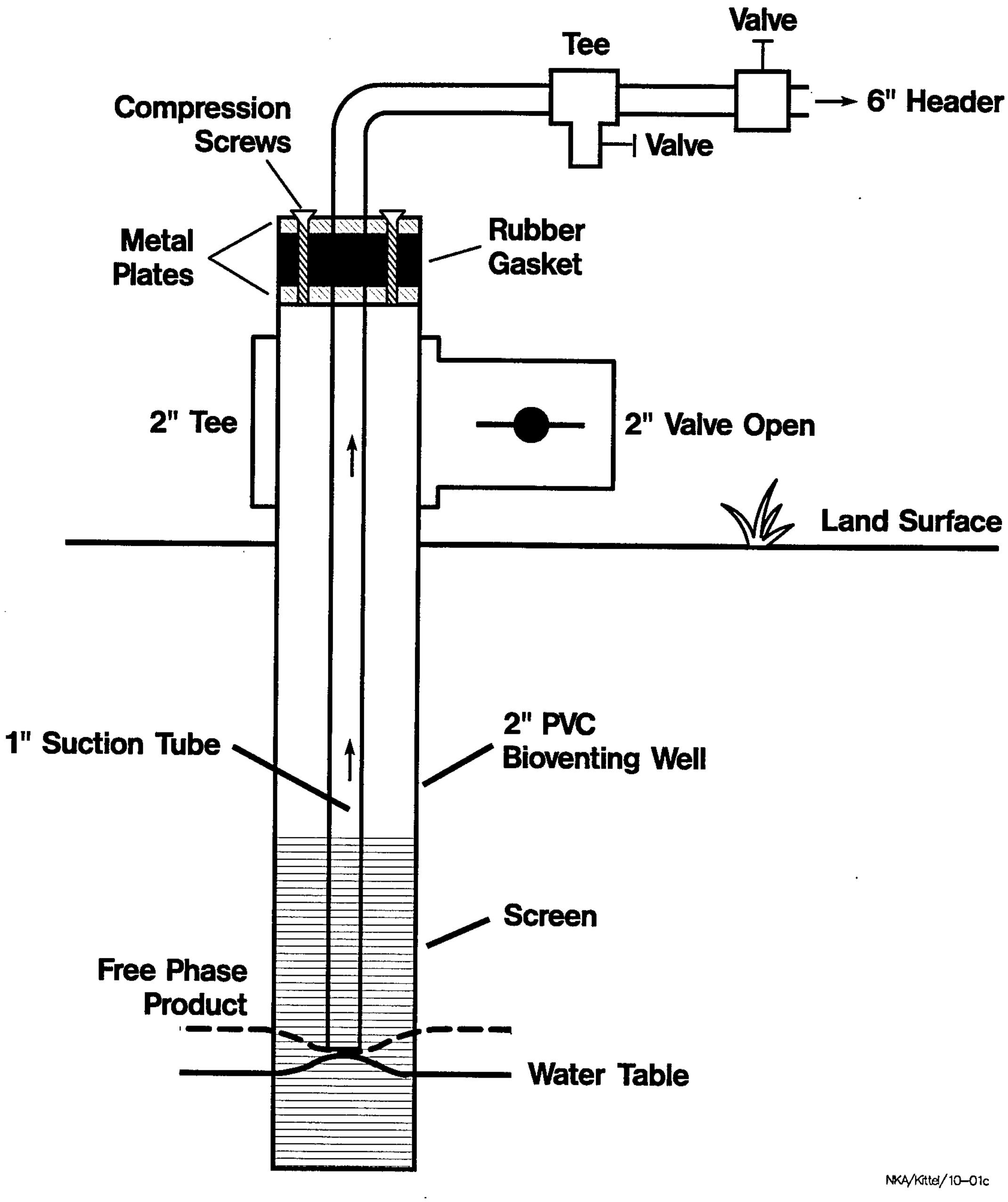

Figure 4. Slurper Tube Placement and Valve Position for the Skimmer Pump Test

3.4.3.1 Monitoring Well MW-32

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper pump test. The slurper tube was set at the LNAPL/groundwater interface. The LNAPL and groundwater depth were measured prior to any recovery testing. The sanitary well seal was positioned inside the well, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 5). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump was started on 14 July 1996 to begin the bioslurper pump test. The test was initiated approximately 3 hr after the skimmer pump test and was operated for a total of 32 hr at a pump pressure ranging from 15 to 24 inches of Hg. The test was shutdown for a period of 12 hr and for several 0.5 hr periods during the testing. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. The data sheets are provided in Appendix D.

3.4.3.2 Monitoring Well MW-5

The liquid ring pump was started on 17 July 1996 to begin the bioslurper pump test. The test was initiated approximately 1 hr after termination of the bioslurper pump test at MW-32 and was operated continuously for 91 hr at a pump pressure of approximately 22 inches of Hg. Two shutdown periods occurred during testing: the first was due to high water temperature (one-hour shutdown) and the second was due to running out of fuel (2-hour shutdown). 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 from the extracted fuel from monitoring well MW-5 for analysis of BTEX and for boiling point fractionation. The sample was sent to Alpha Analytical, Inc., in Sparks, Nevada for analysis.

3.4.4 Off-Gas Sampling and Analysis

Six soil gas samples were collected during the bioslurper pump tests. Samples Seal Tank #1 and Seal Tank #2 were collected during the bioslurper pump test at monitoring well MW-32 after approximately 19 hr of operation. During the bioslurper pump test as monitoring well MW-5,

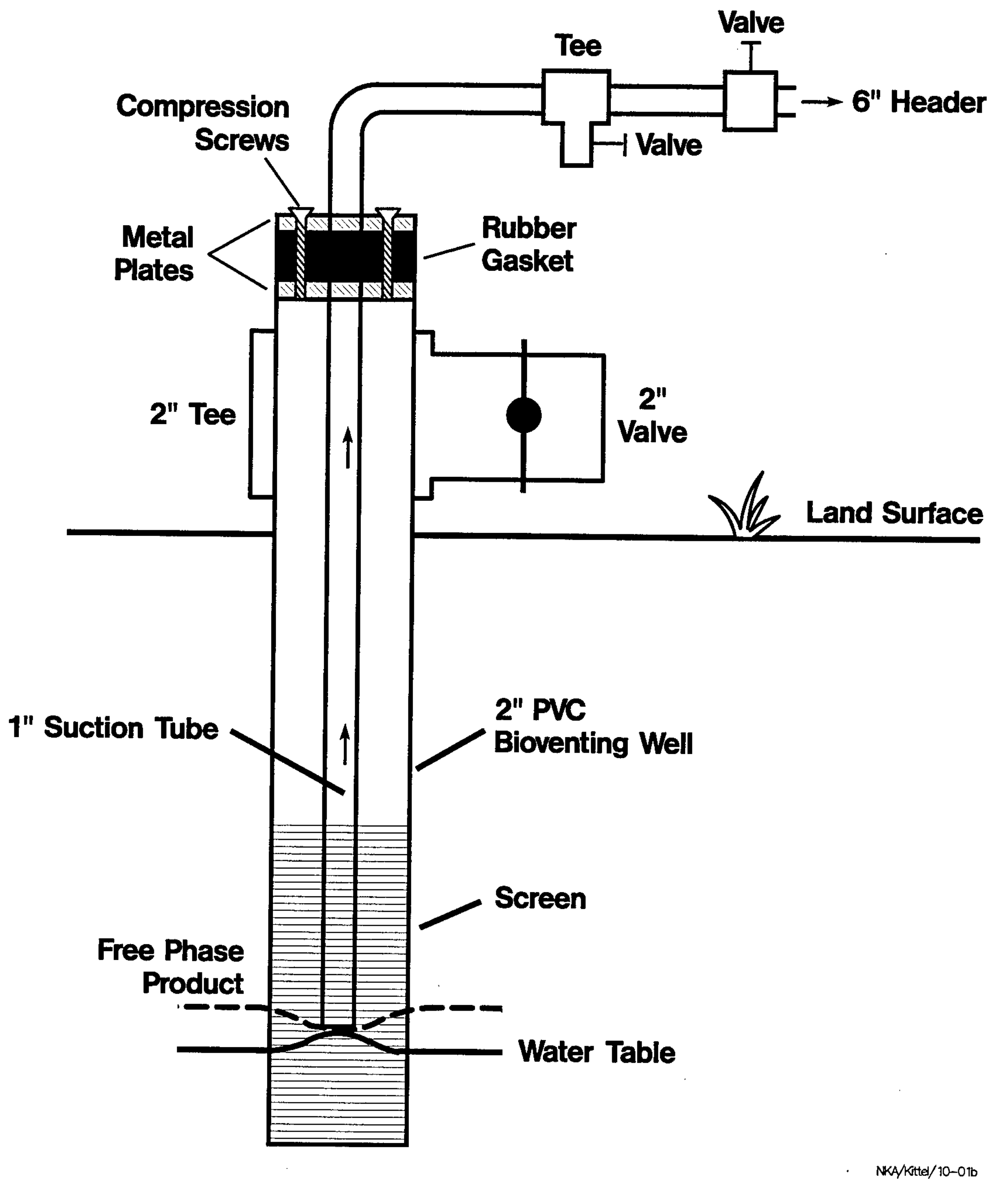

Figure 5. Slurper Tube Placement for the Bioslurper Pump Test

samples Seal Tank #3 and Seal Tank #4 were collected following approximately 43 hr of operation, and samples ICE-1 and ICE-2 were collected from the ICE off-gas after approximately 43.5 hr of operation. The samples were collected in Summa™ canisters. The samples were sent under chain of custody to Air Toxics, Ltd., in Folsom, California, for analyses of BTEX and TPH, using EPA Method TO-3. Analytical reports are provided in Appendix E.

3.4.5 Groundwater Sampling and Analysis

Two groundwater samples were collected during the bioslurper pump test at monitoring well MW-5 and were labeled GW-1 and GW-2. Each sample was collected after the oil/water separator, after approximately 53 hr of operation. Samples were collected in 40-mL VOA vials containing hydrochloric acid (HC1) 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 (purgeable). Analytical reports are provided in Appendix E.

3.5 Bioventing Analyses

3.5.1 Soil Gas Permeability Testing

The soil gas permeability test data were collected during the bioslurper pump test at monitoring well MW-32. Before a vacuum was established in the extraction well, the initial soil gas pressures at the three installed 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 F.

3.5.2 In Situ Respiration Testing

Air containing approximately 2% helium was injected into three monitoring points for approximately 24 hr beginning on 19 July 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 monitoring well MW-95-80′, MW-96-80′, MW-97-80′, and MW-97-100′. 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 22 July 1996. Oxygen utilization and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix G.

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.

3.5.3 Biometric Pumping Analysis

Due to the deep depth to groundwater at George AFB, it is possible that significant biometric pumping could be occurring at the site. Biometric pumping occurs when barometric changes cause significant volumes of air to pass in and out of the subsurface. Monitoring wells may exhibit "breathing", which may be taken advantage of to aerate the subsurface soils.

A DataWrite oxygen sensor was installed in monitoring well MW-32 after the bioslurper pump test in this well. Oxygen concentrations were measured continuously for approximately four days. The DataWrite oxygen sensors consist of an in situ oxygen probe, signal transfer line, and an aboveground data logger. DataWrite software was installed to a personal computer to calibrate, program, and initiate operation of the sensors. The in situ sensors respond to oxygen concentrations in the soil gas and generate a millivolt signal reflecting that concentration. The sensor was calibrated before being installed in the monitoring well by producing a response to the atmospheric oxygen level of 21%. The calibration factor (sensor voltage divided by 21) was then retained by the sensor's data logger. Future oxygen concentrations were calculated by applying that calibration factor to the millivolt signal from the sensor.

The DataWrite oxygen sensor was programmed through the data logger to generate oxygen measurements on a temporal basis. The millivolt signal from the sensor was recorded every 30 minutes. The data logger stored these millivolt signals and their resulting oxygen concentrations.

4.0 RESULTS

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

4.1 Baildown Test Results

Results from the baildown test are presented in Table 2. A baildown recovery test was conducted at monitoring well MW-32. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and recovery potential. Overall, the baildown recovery test indicated a relatively slow rate of LNAPL recovery into the well. Also, the short-term baildown recovery resulted in an LNAPL thickness approximately one-third of the initial apparent thickness. Pilot testing was initiated on monitoring well MW-32 to determine the potential for LNAPL recovery.

4.2 LNAPL Pump Test Results

4.2.1 Initial Skimmer Pump Test Results

No significant quantities of LNAPL or groundwater were recovered during this test during 0.5 hr of extraction. These results demonstrate that gravity-driven liquid recovery is not a feasible option at this monitoring well.

Table 2. Baildown Test Record at MW-32, George AFB, CA

Sample Collection Time (Date-Time)	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 7/10/96 - 2016	124.10	122.48	1.62
7/11/96 - 1205	123.00	122.93	0.07
7/11/96 - 1209	123.15	122.75	0.40
7/11/96 - 1221	123.20	122.75	0.45
7/11/96 - 1316	123.18	122.74	0.44
7/11/96 - 1413	123.15	122.70	0.45
7/11/96 - 2000	123.15	122.67	0.48

4.2.2 Bioslurper Pump Test Results

4.2.2.1 Monitoring Well MW-32

LNAPL recovery was not possible during the bioslurper pump test, although a sheen of fuel was observed in the filter box by the end of the study. In an effort to recover fuel, a number of different configurations were tested, including different diameter of drop tubes, vacuum on drop tube, and vapor flowrate. Fuel was not recovered during any of the configurations; however, significant changes in groundwater extraction were noted (Table 3). The smaller diameter drop tube resulted in decreased groundwater extraction. The most significant increase in water extraction was observed at higher vapor flowrates.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test at monitoring well MW-32 to determine whether the vadose zone was being oxygenated via the bioslurping action. Results were inconclusive, since oxygen concentrations increased and decreased at monitoring points (Table 4). This is likely due to the barometric pumping observed as described in Section 4.4.3. The construction of the monitoring wells also may have influenced the results, because the monitoring wells are screened over very large intervals (5 to 15 ft), resulting in an averaging of soil gas concentrations across the depth interval. Typically, soil gas concentrations are collected from

Table 3. Bioslurper Pump Results at Monitoring Well MW-32, George AFB, CA

Period (hr)	Pump Vacuum ("Hg)	Drop Tube Vacuum ("Hg)	Drop Tube Depth bgl (ft)	Drop Tube Diameter (inches)	Soil Gas Flowrate (scfm)	Recovery Rate (gal/day)	
						LNAPL[1]	Groundwater
24.25	21 - 24	20	125.92	1.25	1.5 - 3.0	0	860
1.75	22-23.5	22 - 23.5	127.25	1.25	2.5	0	1,400
1.75	17 - 20	17 - 21	125.7	0.5	5	0	180
10 min	22.5	16.5	125.7	0.5	4.5	0	190
25 min	22	9.75	125.7	0.5	4.0	0	130
0.50	21	20.75	126.6	0.5	1.7	0	190
0.75	20.5	20.5	125.7	1.25	21	0	1,600
0.80	19	13	125.7	1.25	17	0	200

1 A sheen was observed in the filter box, but was not present in sufficient quantities to measure.

Table 4. **Oxygen Concentrations During the Bioslurper Pump Test at MW-32, George AFB, CA**

Monitoring Point	Oxygen Concentrations (%) Versus Time (hours)	
	0	29.5
MW97-80	0	0
MW97-100	12	0
MW97-130	15.1	NA
MW96-80	0.2	0
MW96-100	2.6	0.8
MW96-130	0	13.8
MW95-80	0	0
MW95-100	1.5	5.0
MW95-130	20.5	20.9
MW94-80	0	3.0
MW94-100	14.5	3.0
MW94-130	17.0	15.0

a much narrower screened interval (6 inches). Based on the soil gas permeability test, where a radius of influence of 49 ft was measured, it is likely that areas within this radius of influence will become fully aerated. In short, a two day extraction time frame at 3 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

4.2.2.2 Monitoring Well MW-5

In an effort to determine if the results at monitoring well MW-32 were representative of site conditions, bioslurper testing was conducted at monitoring well MW-5. Significant free-phase LNAPL was recovered during the first three days of bioslurper pumping (9.8, 12, and 11 gallons/day, respectively) (Table 5). By day 4, the free product recovery rate had dropped to 5.6

Table 5. **Pump Results at Monitoring Well MW-5, George AFB, California**

Time (day)	Recovery Rate (gal/day)	
	LNAPL	Groundwater[1]
1	9.8	1,200
2	12	1,100
3	11	1,100
4	5.6	910
Average (gal/day)	9.7/11[2]	1,360
Total Recovery (gal)	36.9/40.8[2]	5,141

1 Groundwater production rates do not accurately reflect the quantity of groundwater recovered. Insufficient quantities of groundwater were produced to sufficiently cool the motor; therefore, tap water had to be added to cool the motor.

2 When cleaning OWS and filter tank, four gallons of fuel was acquired.

gallons/day, resulting in an average rate of 9.7 gallons/day. The LNAPL recovery versus time is shown in Figure 6. The LNAPL recovery rate versus time is shown in Figure 7. The well head vacuum on monitoring well MW-5 (18 inches H_2O) and groundwater production rate (1,360 gallons/day) were similar to those observed at monitoring well MW-32. Results at these two monitoring wells appear to be representative of the site and indicate that vacuum-enhanced liquid recovery techniques are feasible. However, given that monitoring well MW-5 is approximately 0.5 mile from monitoring well MW-32, it is apparent that little recoverable free product is present in the vicinity of monitoring well MW-32.

4.2.3 Extracted Groundwater, LNAPL, and Off-Gas Analyses

Results of groundwater analyses are shown in Table 6. Contaminant concentrations were similar between the two samples, with average TPH and total BTEX concentrations of 8.8 mg/L and 4.8 mg/L, respectively. The on-site water treatment equipment, consisting of a filter tank, oil/water separator, and clarification tanks, resulted in water effluent (8.4 to 9.2 mg/L total hydrocarbons) that is considered compatible with typical sanitary sewer discharge limits.

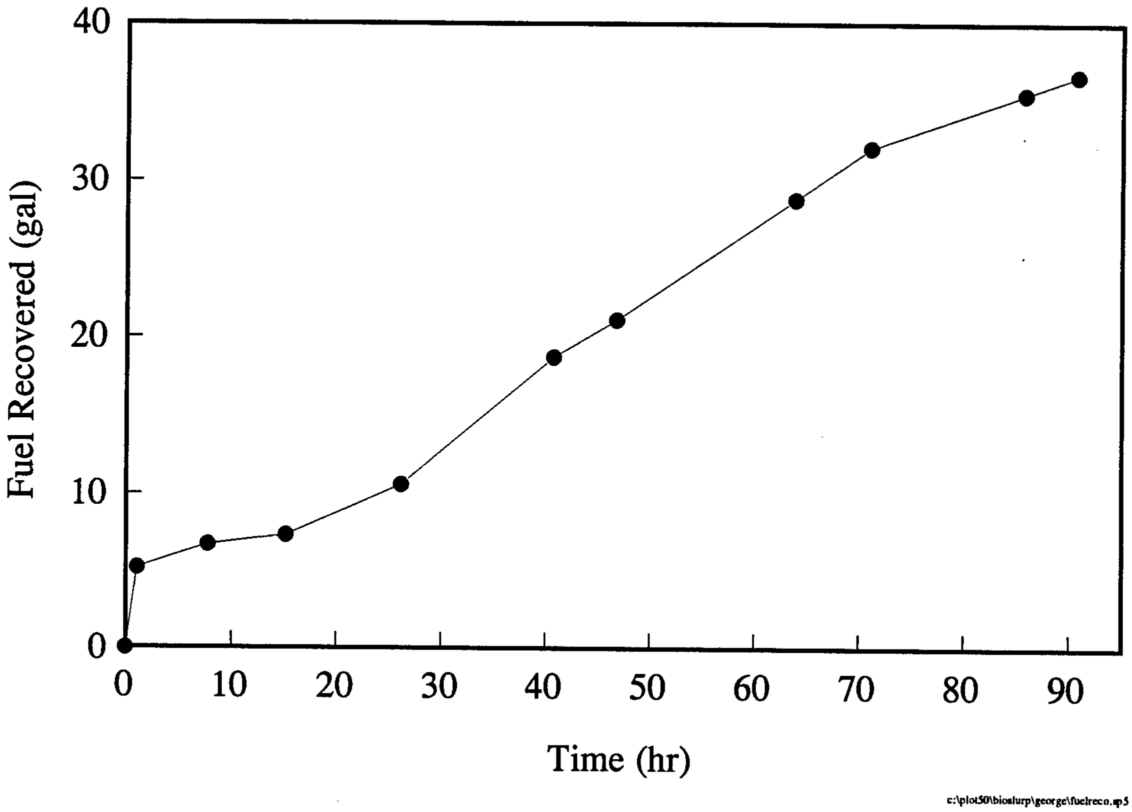

Figure 6. LNAPL Recovery Versus Time at Monitoring Well MW-5, George AFB, CA

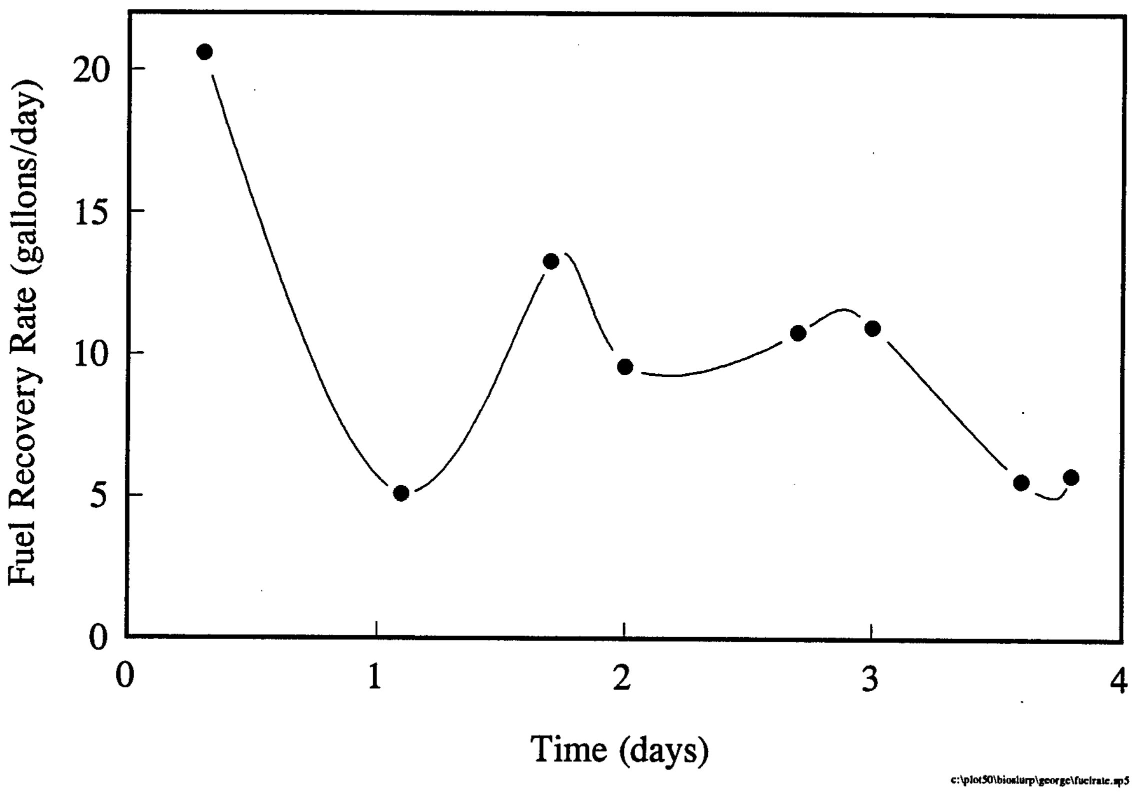

Figure 7. **LNAPL Recovery Rate Versus Time During the Bioslurper Pump Test at Monitoring Well MW-5**

Table 6. **BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Pump Test at George AFB, CA**

Parameter	Concentration (mg/L)	
	GW-1	GW-2
TPH (Purgeable)	9.2	8.4
Benzene	0.56	0.49
Toluene	1.6	1.4
Ethylbenzene	0.35	0.32
Total Xylenes	2.5	2.3

The results from the off-gas analyses are presented in Table 7. During the bioslurper pump test at monitoring well MW-32, given a flowrate of 3 cfm from the bioslurper well and average vapor concentrations of 106,000 ppmv TPH and 1,700 ppmv benzene, emissions rates would have been approximately 190 lb/day of TPH and 1.5 lb/day of benzene. These results demonstrate that significant hydrocarbon removal was accomplished during bioslurping, although little free product was recovered.

During the bioslurper pump test at monitoring well MW-5, given a flowrate of 19.5 cfm from the bioslurper well and average vapor concentrations of 135,000 ppmv TPH and 4,450 ppmv benzene before ICE treatment, emissions rates would have been approximately 1,400 lb/day of TPH and 24 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. With the ICE in place, at a vapor discharge rate of 166 cfm and using an average concentration of 1,300 ppmv TPH and 3 ppmv benzene, approximately 130 lb/day of TPH and 0.15 lb/day of benzene were emitted to the air during the bioslurping pump test. These results demonstrated the treatment efficiency of the ICE unit, with 91% destruction of TPH and >99% destruction of benzene.

Table 7. **BTEX and TPH Concentrations in Off-Gas During the Bioslurper Pump Test at George AFB, CA**

Parameter	Concentration (ppmv)					
	Seal Tank-1	Seal Tank-2	Seal Tank-3	Seal Tank-4	ICE-1	ICE-2
TPH as jet fuel	72,000	140,000	110,000	160,000	2,600	13
Benzene	1,400	2,000	3,800	5,100	5.8	0.11
Toluene	2,200	3,300	6,000[1]	3,500	52	0.25[1]
Ethylbenzene	860	1,400	2,200	3,000	58	0.12
Xylenes	2,200[1]	3,800[1]	5,000[1]	7,200[1]	190[1]	0.31[1]

[1] Reported value may be biased due to apparent matrix interferences.

The composition of LNAPL is shown in Tables 8 and 9 in terms of BTEX concentrations and distribution of C-range compounds, respectively. The distribution of C-range compounds also is shown graphically in Figure 8.

4.4 Bioventing Analyses

4.4.1 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 0.10 inch of H_2O can be measured. A radius of influence of approximately 49 ft was measured during testing at monitoring well MW-32 (Figure 9).

4.4.2 In Situ Respiration Test Results

Results from the in situ respiration test are presented in Table 10. Oxygen utilization rates were relatively low, ranging from 0.0050 to 0.039 $\%O_2$/hr. Biodegradation rates ranged from 0.087

Table 8. BTEX Concentrations in LNAPL from George AFB, California

Compound	Concentration (mg/kg)
Benzene	<193
Toluene	3,800
Ethylbenzene	3,100
Total Xylenes	22,000

Table 9. C-Range Compounds in LNAPL

C-Range Compounds	Percentage of Total
<C8	17.53
C9	17.18
C10	19.32
C11	16.81
C12	13.89
C13	8.75
C14	4.32
C15	1.41
>C16	0.80

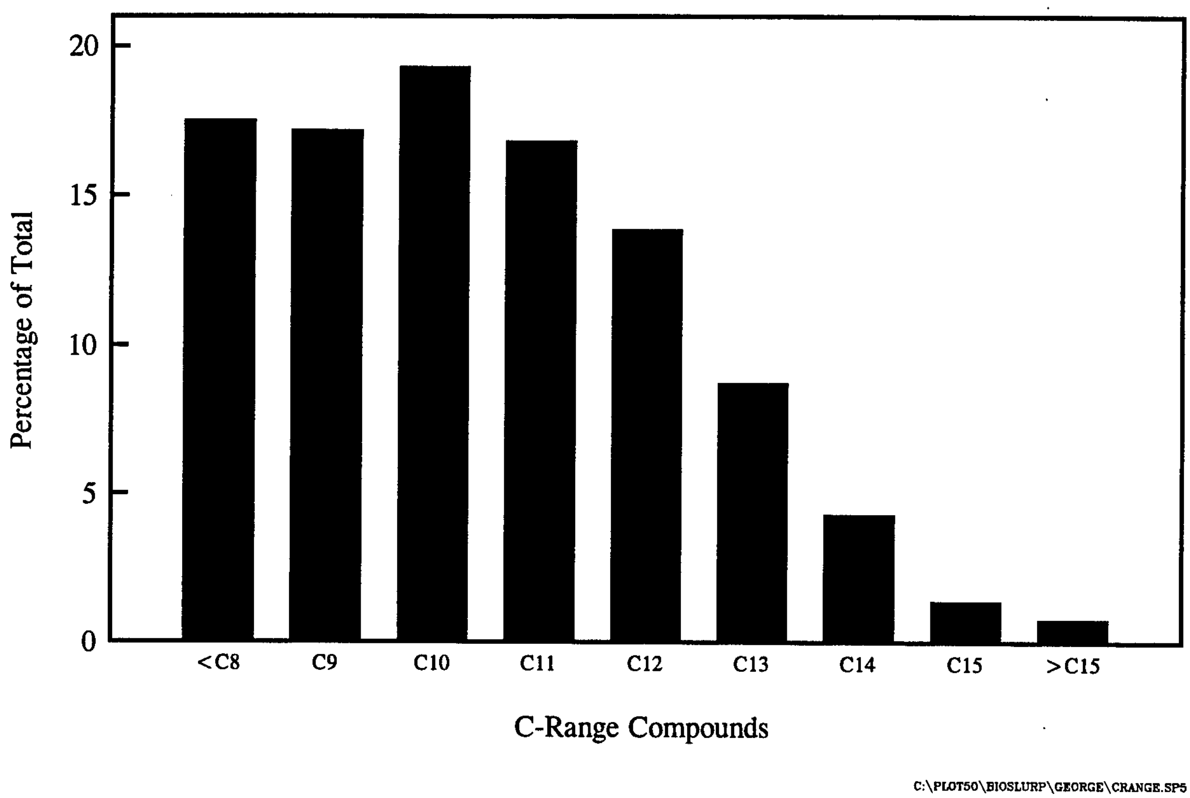

Figure 8. Distribution of C-Range Compounds in Extracted LNAPL at Griffis AFB, NY

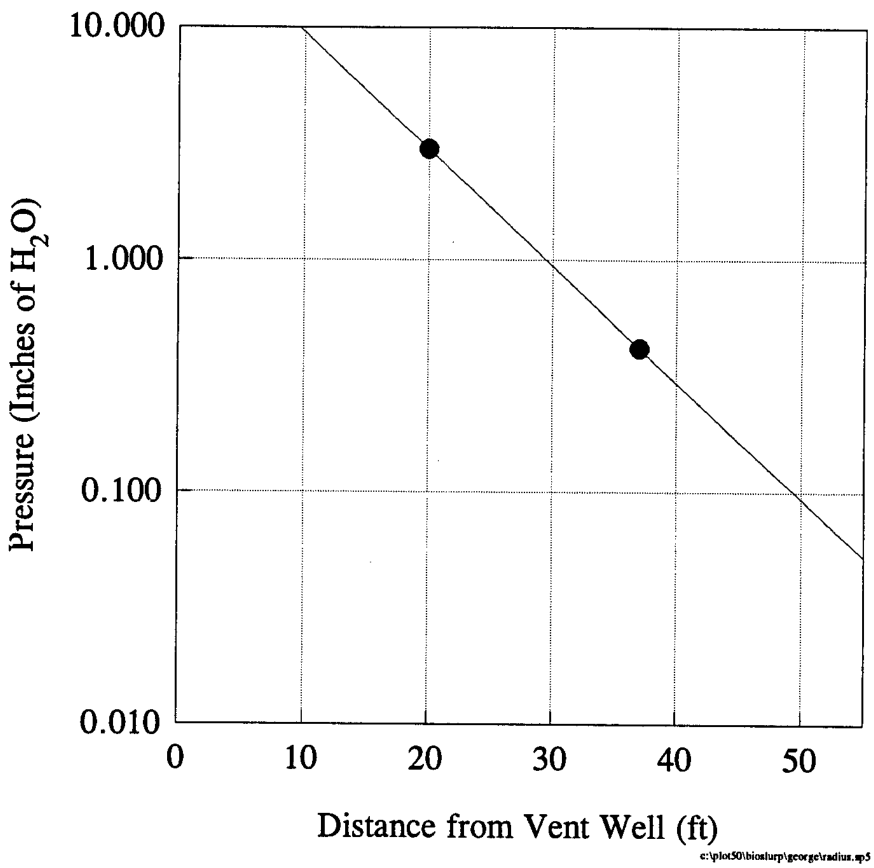

Figure 9. Radius of Influence Determination During Bioslurper Testing at Monitoring Well MW-32, George AFB, CA

Table 10. In Situ Respiration Test Results at George AFB, California

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg-day)
MW97-80	0.023	0.39
MW97-100	0.039	0.64
MW95-80	0.0050	0.087
MW96-80	0.0070	0.11

to 0.64 mg/kg-day. These results indicate that biodegradation in these locations is not significant and that bioventing may not increase microbial activity beyond what is attainable from natural diffusion of oxygen.

4.4.2 Biometric Pumping Results

Results from the oxygen measurements taken in monitoring well MW-32 are shown in Figure 10. As shown, oxygen concentrations fluctuation show a definitive trend, with concentrations fluctuating around a 24-hr period. Ambient levels of oxygen represent time periods when the monitoring well is "inhaling" ambient air, and periods where oxygen levels decrease represent time periods when the monitoring well is "exhaling" oxygen-limited soil gas. These results demonstrate that there is significant biometric pumping occurring at this site. Installation of a valve on monitoring wells which would allow ambient air to pass into the monitoring wells, but which would not allow soil gas to escape would provide a degree of aeration to the site.

5.0 DISCUSSION AND CONCLUSIONS

The main objective of the field pilot test at OU-2, George AFB was to determine if LNAPL recovery is feasible and to select the most effective method of LNAPL recovery. Depths to groundwater at George AFB typically are 120 to 130 ft bgl. These were the first bioslurper pump tests conducted at this depth.

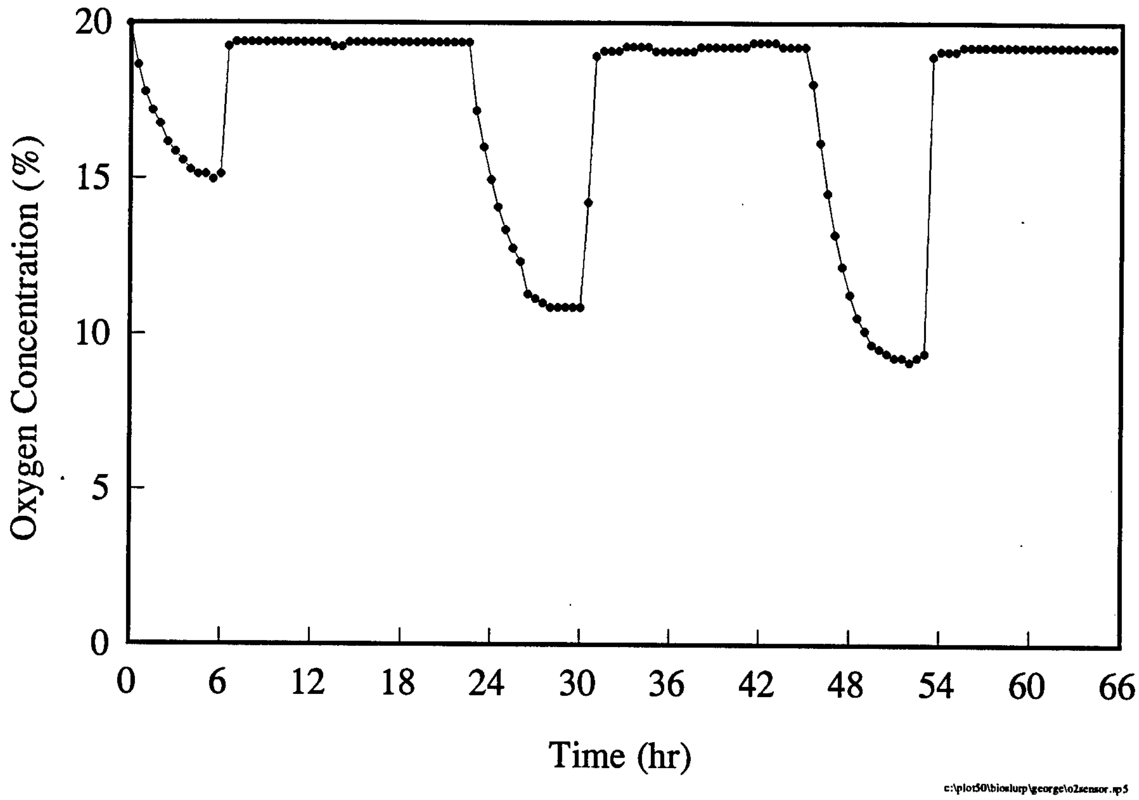

Figure 10. Oxygen Concentrations Versus Time in Monitoring Well MW-32 to Examine Biometric Pumping

A baildown recovery test was conducted at monitoring well MW-32. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and recovery potential. The initial LNAPL thickness was 1.62 ft and after approximately 24 hours recovered to 0.48 ft. Overall, the baildown recovery test indicated a relatively slow rate of LNAPL recovery into the well. Also, short-term baildown recovery resulted in LNAPL thicknesses approximately one-third of the initial apparent thickness. Pilot testing was initiated on monitoring well MW-32 to determine whether free product recovery was possible.

Direct pumping tests were conducted at monitoring wells MW-32 and MW-5. Skimmer pump testing was conducted at monitoring well MW-32 in a continuous extraction mode for 0.5 hr. No measurable free-phase LNAPL was recovered during this time period, indicating that gravity-driven recovery is minimal. LNAPL recovery was not possible during the bioslurper pump test, although a sheen of fuel was observed in the filter box by the end of the study. In an effort to recover fuel, a number of different configurations were tested, including different diameter of drop tubes, vacuum on drop tube, and vapor flowrate. Fuel was not recovered during any of the configurations; however, significant changes in groundwater extraction were noted. The smaller diameter drop tube resulted in decreased groundwater extraction. The most significant increase in water extraction was observed at higher vapor flowrates. Groundwater production rates during bioslurping were significant, indicating that vacuum enhanced fluid recovery was in effect during the bioslurper test. The on-site water treatment equipment, consisting of a filter tank, oil/water separator, and clarification tanks, resulted in water effluent that is considered compatible with typical sanitary sewer discharge limits.

In an effort to determine if the results at monitoring well MW-32 were representative of site conditions, bioslurper testing was conducted at monitoring well MW-5. Significant free-phase LNAPL was recovered during the first three days of bioslurper pumping (9.8, 12, and 11 gallons/day, respectively). By day 4, the free product recovery rate had dropped to 5.6 gallons/day, resulting in an average rate of 9.7 gallons/day. The well head vacuum on monitoring well MW-5 (18 inches H_2O) and groundwater production rate (1,360 gallons/day) were similar to those observed at monitoring well MW-32. Results at these two monitoring wells appear to be representative of the site and indicate that vacuum-enhanced liquid recovery techniques are feasible. However, given that monitoring well MW-5 is approximately 0.5 mile from monitoring well MW-32, it is apparent that little recoverable free product is present in the vicinity of monitoring well MW-32.

Bioslurping also promotes mass removal in the form of in situ biodegradation via bioventing and soil gas extraction. Vapor phase mass removal is the result of soil gas extraction as well as volatilization that occurs during the movement of LNAPL free product through the extraction network. During the bioslurper pump test at monitoring well MW-32, given a flowrate of 3 cfm from the bioslurper well and average vapor concentrations of 106,000 ppmv TPH and 1,700 ppmv benzene, emissions rates would have been approximately 190 lb/day of TPH and 1.5 lb/day of benzene. These results demonstrate that significant hydrocarbon removal was accomplished during bioslurping, although little free product was recovered. During the bioslurper pump test at monitoring well MW-5, given a flowrate of 19.5 cfm from the bioslurper well and average vapor concentrations of 135,000 ppmv TPH and 4,450 ppmv benzene before ICE treatment, emissions rates would have been approximately 1,400 lb/day of TPH and 24 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. With the ICE in place, at a vapor discharge rate of 166 cfm and using an average concentration of 1,300 ppmv TPH and 3 ppmv benzene, approximately 130 lb/day of TPH and 0.15 lb/day of benzene were emitted to the air during the bioslurping pump test. These results demonstrated the treatment efficiency of the ICE unit, with 91% destruction of TPH and >99% destruction of benzene.

The initial soil gas profiles at the site displayed some areas of oxygen-deficient, carbon dioxide-rich, high total volatile hydrocarbon vapor conditions. 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-32 to determine if the vadose zone was being oxygenated via the bioslurper action. Results were inconclusive, since oxygen concentrations increased and decreased at monitoring points. This is likely due to the barometric pumping. The construction of the monitoring wells also may have influenced the results, because the monitoring wells are screened over very large intervals (5 to 15 ft), resulting in an averaging of soil gas concentrations across the depth interval. Typically, soil gas concentrations are collected from a much narrower screened interval (6 inches). Based on the soil gas permeability test, where a radius of influence of 49 ft was measured, it is likely that areas within this radius of influence will become fully aerated. In short, a two day extraction time frame at 3 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In situ biodegradation rates of 0.0050 to 0.039 mg/kg-day were measured at three different locations. Based on the radius of influence of 49 ft and a hydrocarbon-impacted soil thickness of 130 ft, mass removal rates via biodegradation are on the order of 0.19 to 1.5 lb of hydrocarbon per day. Thus, mass removal rates via biodegradation are not as significant as the initial vapor phase removal rates measured during the bioslurper test. These results indicate that bioventing is probably not necessary at this site, but that natural attenuation is sufficient to degrade contaminants in the vadose zone.

In summary, the on-site testing at OU-2, George AFB, included the direct testing of gravity-driven and vacuum-driven LNAPL free product recovery techniques, bioventing, and tests relevant to soil vapor extraction. These field tests have demonstrated that free product removal via vacuum-enhanced recovery is possible at significantly greater depths than the maximum suction lift. Liquid phase recovery was sustainable only under vacuum-enhanced 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.

Periodic baildown recovery tests are recommended as a useful indicator of LNAPL free product 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 OU-2 is like the sites described above. Periodic hand bailing may also represent removing LNAPL free product to the extent practicable.

6.0 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 GEORGE AFB, CALIFORNIA

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT THE OPERABLE UNIT 2 GEORGE AIR FORCE BASE, CALIFORNIA

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GEORGE AFB, CALIFORNIA

16 FEBRUARY 1996

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

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16 February 1996

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to

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16 February 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 allows 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 George Air Force Base (AFB), California. It was prepared based on site-specific information received by Battelle from George AFB and other pertinent site-specific information to support the overall Test Plan and Technical Protocol.

Site-specific information for George AFB has identified subsurface hydrocarbon contamination at the Operable Unit 2 (OU-2). The contamination consists of JP-4 jet fuel resulting from fuel line spills in the Liquid Fuels Distribution System. Free product, as light, nonaqueous-phase liquid (LNAPL), has been detected directly under and adjacent to the flight line. A plume of dissolved benzene, toluene, ethylbenzene, and xylenes (BTEX) extends north (downgradient) into the area between the flight line and the runway. A separate plume of free product was detected at EX-5 and MW-32 where thicknesses greater than 5 ft were measured.

The OU-2 at George AFB is unique in that depths to groundwater are in the range of 120 to 140 ft bgs. Because this depth is greater than maximum suction lift, it will be necessary to create a linear air velocity in the drop tube such that the flow will entrain small droplets of fuel and water to be recovered by the three pumping systems.

For best comparison of recovery data, a well should be used that has shown appreciable fuel recovery in past operations. Likely candidates for the bioslurper demonstration included EX-3, MW-5, MW-18, MW-24, and MW-67. Two mobile free-product recovery systems (MPRSs) have been rotated primarily among these wells during the time period since 1992; therefore, recovery and recharge data already exist for these wells.

2.0 SITE DESCRIPTION

The information presented in this section was obtained from documents entitled *Treatability Study Report, Free Product Recovery System Evaluation, Operable Unit 2, George Air Force Base, California* and addendum work plans to *Free Product and Dissolved Contaminant Study, Operable Unit 2, George Air Force Base* prepared by IT Corporation in July 1995 and September 1994, respectively.

Hotel

George AFB is located in San Bernardino County in a relatively flat desert valley in the southern portion of California and was used as a jet fighter base until its closure in 1992. Victorville is the nearest city. OU-2, in the east-central portion of the base, included the Liquid Fuels Distribution System (LFDS). Main fuel lines ran north from the aboveground tank farm to the ready reserve underground storage tanks (USTs) at Facility 708. Additional supply lines connected tanks at Facility 708 to fuel pits, and distribution lines extended from the fuel pits under the concrete flight line to the fuel ports. The fuel lines, USTs, and fuel pits were removed in 1994, and the fuel distribution lines under the flight line were drained and grouted.

Contamination at OU-2 consists of JP-4 jet fuel resulting from spills in the LFDS. A free product plume is found under the flight line and a plume of dissolved BTEX extends north into the area toward the runway (Figure 1). A separate plume is likely to exist northeast of the main plume as evidenced by significant levels of free product found in wells MW-32 and EX-5.

Soils at the site consist of three main units. An upper unit extending approximately 40 to 50 ft below ground surface (bgs) is predominantly sand. The middle unit is located at a depth of 40 to 125 ft bgs and is predominantly clayey-sand. The lower sand unit contains a perched aquifer and extends 190 to 200 ft bgs. The base of the aquifer is a 20-ft silty clay lacustrine bed.

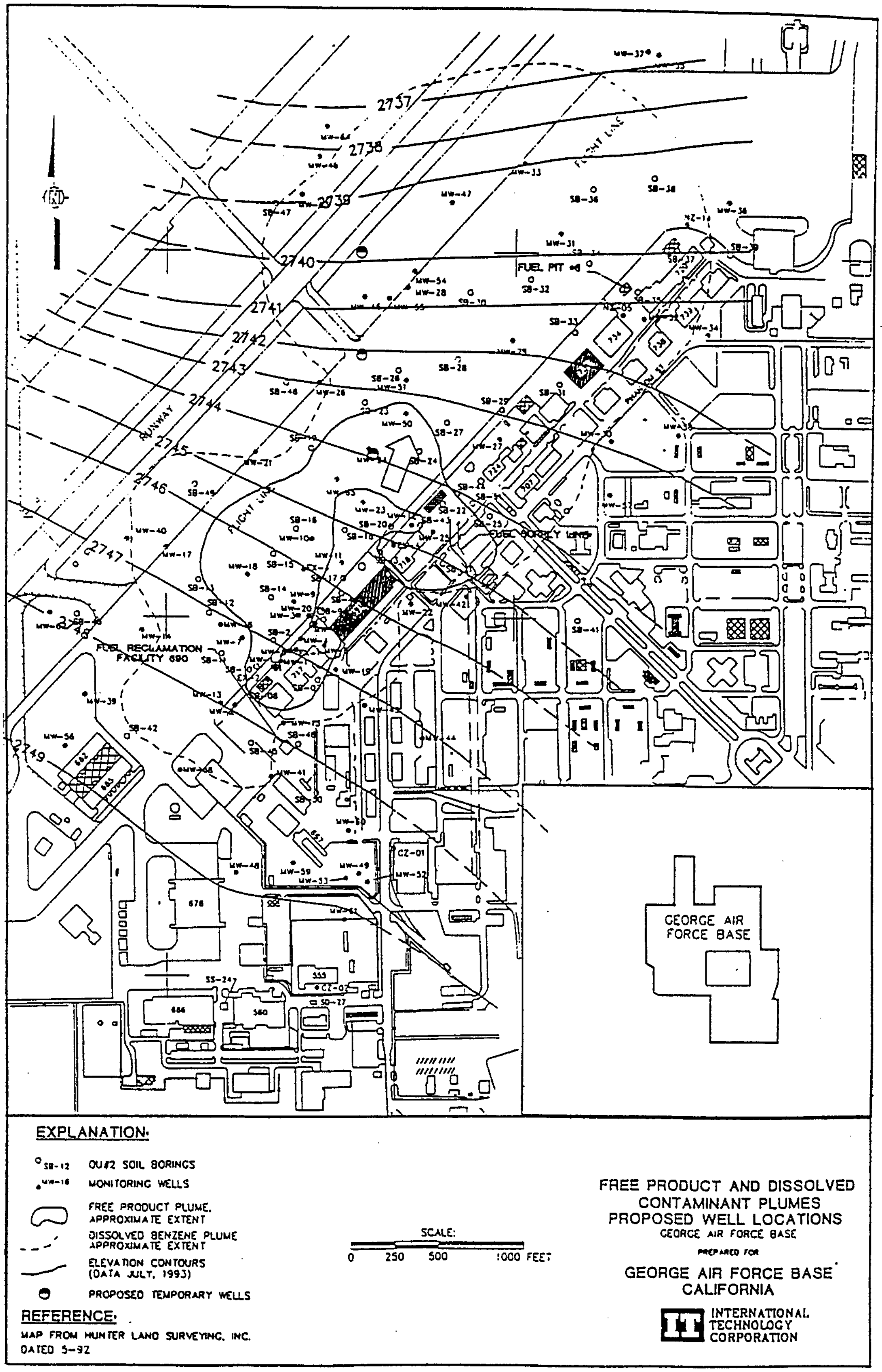

Figure 1. Schematic Diagram of the Free Product and Dissolved Contaminant Plumes at OU-2, George AFB, California.

Depth to groundwater at the site ranges from approximately 120 to 140 ft bgs, depth to product ranges from 120 to 127 ft bgs, and product thickness ranges from 0 to 8 ft. Groundwater depth and product thickness measurements for individual wells can be found in Appendix A. With limited data on the subsurface geology and the lateral extent of the plume, the free product volume was originally estimated to be 250,000 gal. Recharge tests were conducted by pumping wells continuously until they reached steady-state conditions (approximately 3 days) and then recording depth to product and depth to groundwater measurements (Table 1).

A treatability study was initiated in 1992 that utilized three to four permanent free-product recovery systems (PPRSs) and two MPRSs. PPRSs were installed in MW-4, EX-1, EX-2, and EX-4 in 1992 and were in place until 1994 when the removal of piping and storage tanks required the systems to be temporarily removed. PPRSs were reinstalled in EX-1, EX-4, and MW-4 in 1995. EX-2 was eliminated due to a slow recovery rate. The remaining PPRS is to be installed in EX-5, which is a well located in the isolated area of LNAPL northeast of the main plume. Two MPRSs were rotated among various wells during the same time period and operated primarily on wells EX-3, MW-5, MW-18, MW-24, and MW-67. As of April 11, 1995, a total of 12,087 gal of free product had been recovered by all units involved in the study. Rates of free product recovery and total gallons produced at individual wells can be found in Table 2. Recovery rates are based on actual run times consisting of 5- to 30-minute cycles at frequencies of 12 to 48 cycles per day.

Additional wells containing significant amounts of free product were MW-2, MW-7, MW-8, MW-10, and MW-11; however, they were eliminated from the study because the 2-inch-diameter well casings were incompatible with the recovery systems being used. A schematic diagram of all soil boring and monitoring well locations is shown in Figure 2.

Total petroleum hydrocarbon (TPH) and BTEX concentrations in soil and soil gas are not available at this time.

3.0 PROJECT ACTIVITIES

The field activities discussed in the following sections are planned for the bioslurper pilot test at George 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 3 presents the schedule of activities for the Bioslurper Initiative at George AFB.

3.1 Design Considerations

Bioslurping technology has generally been applied to sites where depth to groundwater is less than 30 ft bgs. At these shallow groundwater sites, the primary mechanism for fluid extraction is air- lift pumping. Because the wells being considered for the bioslurper pilot test at George AFB have LNAPL and groundwater depths of approximately 120 to 140 ft, it will be necessary to achieve an air lift in the well sufficient to recover the floating LNAPL from this depth. As stated previously, the air entrainment pumping method must be used, because of the impossibility of supporting a solid column of water more than approximately 30 ft by vacuum lift.

Table 1. Recharge Test Results

Well	Duration of Recovery (min)	DTP During Pumping (ft)	DTP After Recovery (ft)	DTW During Pumping (ft)	DTW After Recovery (ft)	Product Thickness During Pumping (ft)	Product Thickness After Recovery (ft)
EX-1	405	127.67	127.36	127.68	127.52	0.01	0.16
EX-3	300	126.19	125.80	126.22	127.19	0.03	1.39
EX-4	249	125.84	125.83	125.89	125.91	0.05	0.08
EX-5	290	121.80	121.11	121.87	122.72	0.07	1.61
MW-4	280	127.31	126.94	127.54	128.62	0.23	1.68
MW-5	335	128.98	127.80	129.17	129.39	0.19	1.59
MW-18	325	125.72	125.40	125.80	126.76	0.08	1.36
MW-24	243	123.49	123.34	123.50	123.56	0.01	0.22
MW-67	321	122.02	121.66	122.09	122.98	0.07	1.32

DTP = depth to product.
DTW = depth to groundwater.

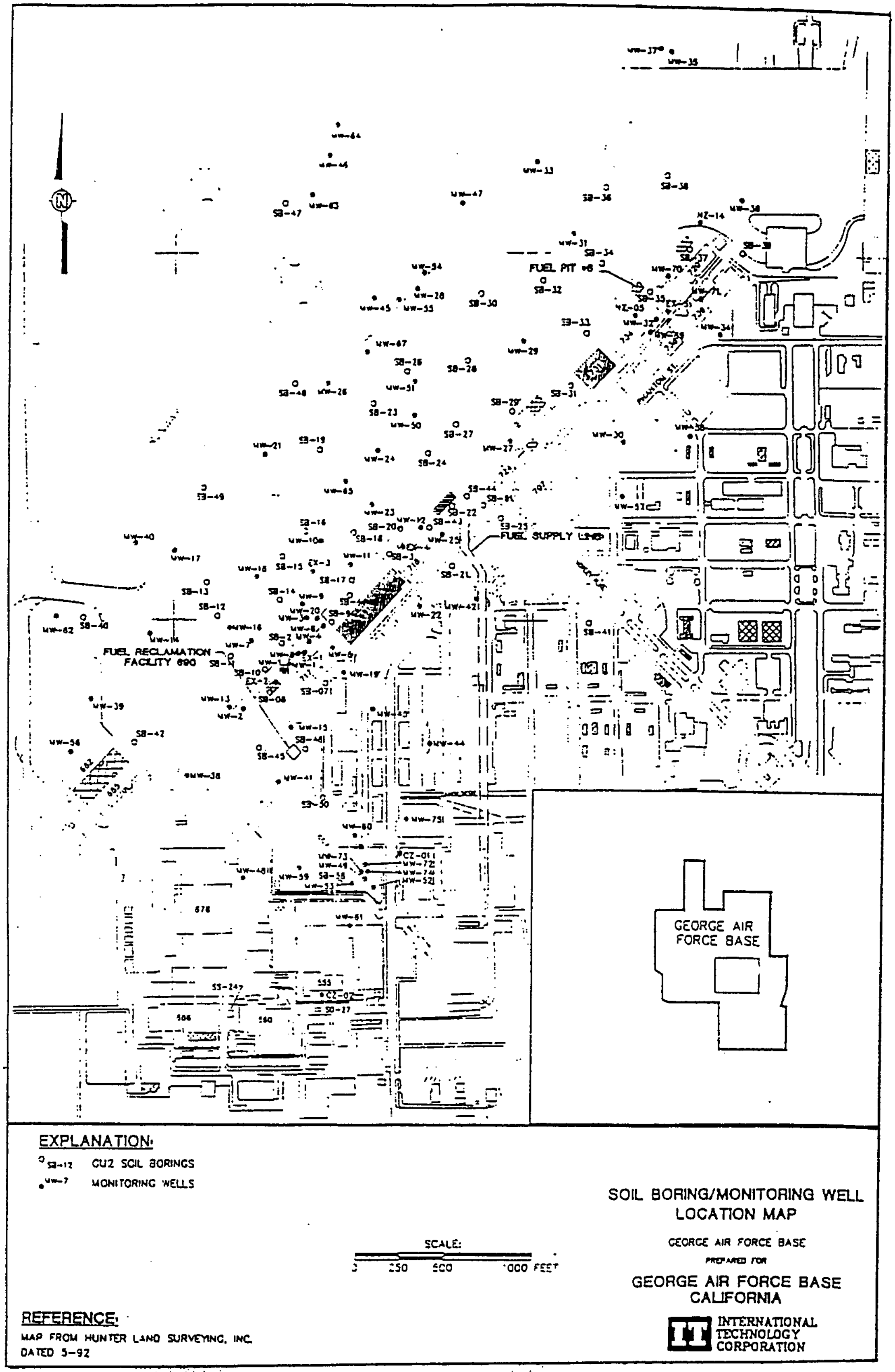

Figure 2. Location Map of Soil Borings and Monitoring Wells at OU-2, George AFB, California

Table 2. Free-Product Recovery Rates and Total Production at Individual Wells

Well	Type of Recovery System	Total Gallons Produced	Rate of Recovery (gal/hr)
EX-1	Permanent	694.7	NA
EX-2	Permanent	550.8	NA
EX-3	Mobile	2,221.4	4.05
EX-4	Permanent	469.0	NA
EX-5	Permanent	151.0	NA
MW-4	Permanent	4,224.3	NA
MW-5	Mobile	1,002.1	2.65
MW-18	Mobile	1,933.7	3.34
MW-24	Mobile	554.7	2.02
MW-32	Mobile	148.7	NA
MW-67	Mobile	46.8	2.15

Table 3. Schedule of Bioslurper Pilot Test Activities

Pilot Test Activity	Schedule
Mobilization	Days 1-2
Site Characterization	Days 2-3
LNAPL/Groundwater Interface Monitoring and Baildown Tests	
Monitoring Point Installation (3 monitoring points)	
Soil Sampling (BTEX, TPH, physical characteristics)	
System Installation	Days 2-3
Test Startup	Day 3
Skimmer Pump Test (2 days)	Days 3-4
Bioslurper Pump Test (4 days)	Days 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	Days 11-16
Drawdown Pump Test (2 days)	Days 11-12
Demobilization/Mobilization	Days 13-14

The air entrainment pumping method will lift water or LNAPL by aerodynamic drag. The airflow will entrain the water and LNAPL in an airstream, which will carry them to the ground surface and into the bioslurper separation unit. The principal advantages of the air entrainment method of pumping are that water and floating LNAPL can be secured from a deep well, providing the conditions at the site are suitable for its use.

A trailer-mounted 10-hp liquid ring pump manufactured by Atlantic Fluidics, Inc. will be used to maintain the air lift during the bioslurper pilot test operation. Based on previous bioslurper pilot tests, an airflow rate of approximately 50 ft^3/min has been extracted under such conditions. In addition, the vacuum created by a 10-hp pump is approximately 26 inches of mercury. Assuming a groundwater depth of 135 ft coupled with a 1-in-diameter, schedule 40 polyvinyl chloride (PVC) drop tube, the maximum linear air velocity that can be achieved is 140 ft/sec.

However, because it is necessary to minimize the rate at which the bioslurper test equipment releases vapor to the atmosphere, a linear air velocity of 50 ft/sec will be used to initiate the air lift. This air velocity will result in minimizing the rate of vapor discharge, but will also maintain the velocity required to initiate free-product recovery. Under these conditions, the calculated pressure drop in the extraction tube will be 2.7 in Hg, which is a change of approximately 9% from atmospheric pressure. Because the pressure drop in the extraction tube has been calculated to be negligible, the air lift created by the 10-hp liquid ring pump should entrain liquid droplets of approximately 8 mm in size at the stated air velocity rate of 50 ft/sec.

The correlation between upward flow and pressure drop in a tube presented above was used to calculate the necessary air lift required to entrain liquid droplets or induce the sheeting or wave flow up the tube. This correlation applies with reasonable accuracy to the experimental data on which it is based. However, it can be limited in some forms of application to the proposed field testing. Due to the nature and permeability of the site soils and groundwater hydraulics, the linear air velocity might be reduced below the necessary rate to achieve the air lift. If this occurs, a smaller diameter drop tube could be utilized, or the rate of air flow could be raised to greater than 50 ft/sec to increase the air lift in the extraction tube. No correlation between upward flow and pressure drop in a tube will apply to all of the experimental conditions found in the field; therefore, it may be necessary to modify the bioslurper system components to achieve and maintain the required air lift to initiate free product recovery.

Droplet entrainment is considered the primary mechanism for fluid recovery when bioslurping at depths greater than 30 ft bgs; however, field observations at previous bioslurper sites indicate that there may be another important mechanism for fluid extraction from deep wells. Observation of fluid movement in the clear portion of the vertical drop tube demonstrates that much of the extracted water is being pushed up the inside walls of the tube in sheets or waves. Anecdotal evidence indicates that this phenomenon can be accomplished at lower velocities than required for droplet entrainment. As part of the George AFB bioslurper study, an attempt to quantify the velocity requirements to induce "sheeting" or "wave" flow will be made during the skimming portion of the test.

3.2 Mobilization to the Site

After the site-specific Test Plan has been approved, Battelle staff will mobilize equipment to the site. Some of the equipment will be shipped via air express to George 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 George AFB.

In addition, Battelle requests that the free-product recovery systems already in place at OU-2 as part of the treatability study will be turned off 1 week prior to the initiation of fieldwork. This will be important in assuring quality data from the bioslurper pilot test.

3.3 Site Characterization Tests

3.3.1 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 (Battelle, 1995).

3.3.2 Soil Gas Survey (Limited)

A soil gas survey will not be conducted at this site due to the significant depth to groundwater.

3.3.3 Monitoring Point Installation

Existing monitoring points or wells will be used to perform subsurface monitoring.

3.3.4 Soil Sampling

Soil sampling will not be conducted at this site due to the significant depth to groundwater.

3.4 Bioslurper System Installation and Operation

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

3.4.1 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 3 shows a flow diagram of the bioslurper process. Figure 4 illustrates a typical bioslurper well that will be used at George 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 (Battelle, 1995).

3.4.2 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.

3.4.3 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 (Battelle, 1995).

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 (Battelle, 1995).

3.4.4 Soil Gas Profile/Oxygen 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.

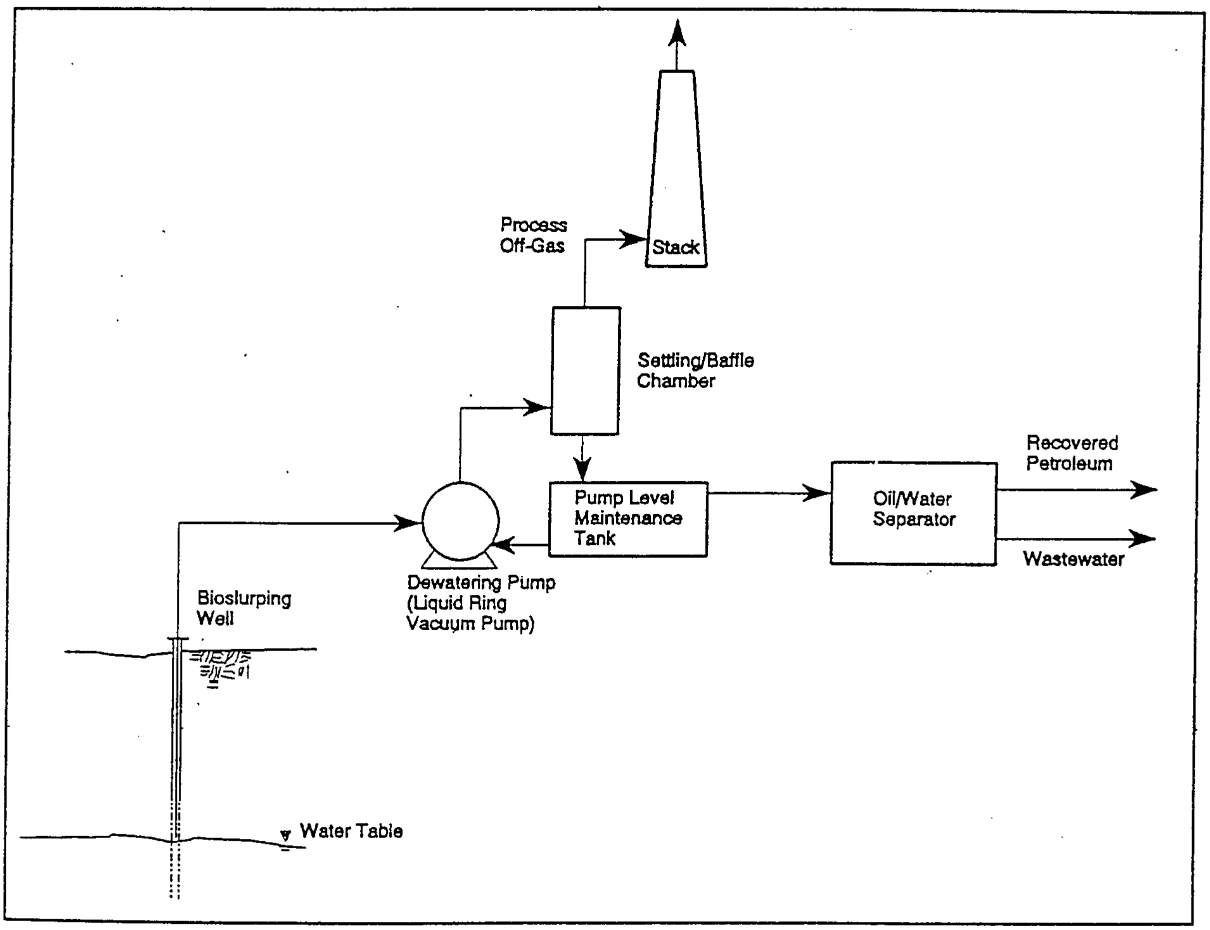

Figure 3. Bioslurper Process Flow at OU-2, George AFB, California.

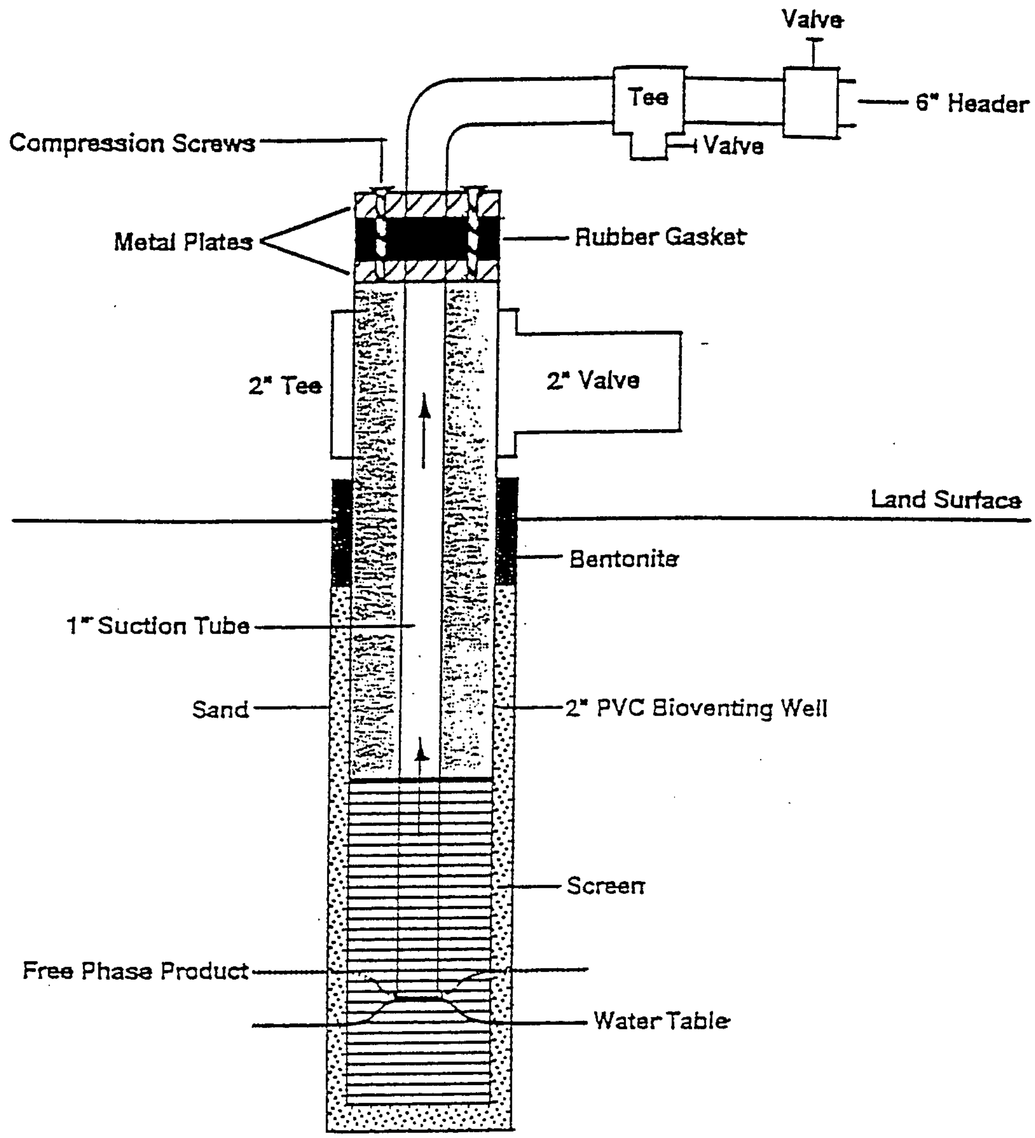

Figure 4. Schematic Diagram of a Typical Bioslurper Well.

3.4.5 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 (Battelle, 1995).

3.4.6 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 to contain the subsurface vacuum. Additional information for the monitoring of fluid levels is provided in Section 4.3.4 of the overall Test Plan and Technical Protocol (Battelle, 1995).

3.4.7 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. The 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 (Battelle, 1995).

3.4.8 Extended Testing

The Air Force has the option of extending the operation of the bioslurper system for up to 6 months at George 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.

3.5 Demobilization

Once all necessary tests have been completed at the George AFB site, 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 George AFB.

4.0 BIOSLURPER SYSTEM DISCHARGE

4.1 Vapor Discharge Disposition

Battelle expects that the operation of the bioslurper test system at George AFB will require a waiver or a point source air release registration and may require some additional permits. The Air Force has informed Battelle that the TPH and benzene vapor discharge limit for the bioslurper pilot test will be 25 lb/day. This limit may be difficult to achieve given the velocity of air flow needed for free product recovery. The data for benzene and TPH discharge levels for six previous bioslurper sites are presented in Table 4. The discharge value may vary depending on concentrations in soil gas and the permeability of the soil.

Table 4. 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
Johnston Atoll	Jet Fuel	10	0.60	975	0.0017	5.7
Travis AFB	Jet Fuel	20	100	10,800	0.58	130
Wright-Patterson AFB	Jet Fuel	3.0	ND	595	0	1.0

ND = Not detected.

To ensure the safety and regulatory compliance of the bioslurper system, field soil gas screening instruments will be used to monitor vapor discharge concentration. The volume of vapor discharge will be monitored daily using air flow instruments. If the field screening instruments show that the vapor discharge limit of 25 lb/day will be exceeded, an air release registration and/or vapor treatment may be required. If vapor treatment is required, alternative plans will be developed for short-term and long-term testing. Table 5 presents information typically required to complete an air release registration form.

Table 5. 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	JP-4 jet fuel
Planned date of test start	To be determined
Test duration	9-10 days (active pumping)
Maximum expected volatile organic compound level in air	~25 lb/day TPH and benzene
Stack height above ground level	10 ft

4.2 Aqueous Influent/Effluent Disposition

The flowrate of groundwater pumped by the bioslurper will be less than 5 gpm. However, it may be necessary in California to obtain a groundwater pumping waiver or registration permit. If one is required, the Base POC will inform Battelle of the necessary steps in obtaining the waiver or permit. The intention of Battelle staff will be to dispose of the wastewater by discharge directly to the Base wastewater treatment facility.

4.3 Free-Product Recovery Disposition

The bioslurper system will recover free-phase product from the pilot tests performed at George 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 George AFB will depend on approval of this Site-Specific 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 George 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, George AFB, and AFCEE during the bioslurper field test.

6.1 Battelle Activities

The obligations of Battelle in the Bioslurper Initiative at George AFB will be to supply all 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 George AFB Support Activities

To support the necessary field tests at George 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 25 lb/day of TPH and benzene without treatment. 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 6 is a checklist for the information required to complete the Health and Safety Plan and is based on information obtained in 1994. All emergency information will be obtained by the Site Health and Safety Office before operations begin.

6.3 AFCEE Activities

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

The following list provides the Battelle, AFCEE, and George AFB staff who can be contacted in case of emergency and/or for required technical support during the Bioslurper Initiative tests at George AFB.

Battelle POCs	Jeff Kittel	(614) 424-6122
	Eric Drescher	(614) 424-3088
AFCEE POC	Patrick Haas	(210) 536-4314
George AFB POC		
Regulatory POCs		

Table 6. Health and Safety Information Checklist

Emergency Contacts	Name	Telephone Number
Hospital	Victor Valley Community Hosp.	(619) 245-8691
Fire Department	Victorville Fire Dept.	911/(619) 955-5227
Base Fire Station		(619) 246-6479
Ambulance and Paramedics	Emergency Switchboard	911/(619) 245-9342
Police Department (County Sheriff)	Emergency Switchboard	911/(619) 245-4211
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
George AFB	BOB SOMMER	(619) 246-5360
Other		FAX 246-3315

Emergency Routes

Hospital HAROLD REED

Other

7.0 REFERENCES

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APPENDIX A

GROUNDWATER DEPTH AND FREE-PRODUCT THICKNESS AT OU-2, GEORGE AFB, CALIFORNIA

TABLE 1-1
Groundwater Depth and Product Thickness
George AFB, California
Project No. 409860
(Sheet 1 of 2)

Monitor Well	Casing Elev. (ft msl)	Surface Elev. (ft msl)	Water Elev. (ft msl)	Water Depth (feet)	JP-4 Elevation (feet)	Product Thickness (feet)	Date Measured
PMW-1	2876.01	2876.42	2807.75	68.26	67.93	0.33	3/22/95
MW-1	2875.64	2876.24	2747.92	127.72	-	-	3/9/95
MW-2	2877.31	2877.69	2747.18	130.13	128.34	1.79	3/9/95
MW-3	2874.1	2874.39	2746.51	127.59	127.14	0.45	3/9/95
MW-4	2874.86	2875.03	2745.51	129.35	126.92	2.43	3/22/95
MW-5	2875.04	2875.44	2743.3	131.74	127.02	4.72	3/22/95
MW-6	2874.19	2874.49	2746.6	127.59	-	-	3/9/95
MW-7	2874.76	2874.96	2745.67	129.09	126.14	2.95	3/9/95
MW-8	2875.33	2875.43	2746.09	129.24	127.18	2.06	3/9/95
MW-9	2873.6	2873.89	2745.82	127.78	126.82	0.96	3/9/95
MW-10	2871.45	2871.7	2743.19	128.26	125.08	3.18	3/9/95
MW-11	2872.46	2872.71	2744.58	127.88	126.52	1.36	3/9/95
MW-12	2871.04	2871.35	2745.3	125.74	125.73	0.01	3/9/95
MW-13	2877.02	2877.39	2748.37	128.65	-	-	2/18/95
MW-14	2873.68	2874.05	2748.04	125.64	-	-	2/18/95
MW-15	2878.57	2879.12	2748.27	130.30	-	-	2/18/95
MW-16	2874.02	2874.42	2747.53	126.49	-	-	2/18/95
MW-17	2870.73	2871.04	2744.07	126.66	-	-	3/2/95
MW-18	2872.43	2872.73	2745.66	126.77	125.26	1.51	3/22/95
MW-19	2875.88	2876.24	2746.82	129.06	-	-	3/6/95
MW-20	2873.95	2874.52	2746.06	127.89	127.06	0.83	3/9/95
MW-21	2867.94	2868.05	2744.8	123.14	-	-	3/2/95
MW-22	2873.90	2874.24	2745.74	128.16	-	-	3/6/95
MW-23	2870.26	2870.52	2745.23	125.03	125.02	0.01	3/9/95
MW-24	2868.12	2868.46	2740.68	127.44	122.23	5.21	3/9/95
MW-25	2870.85	2871.17	2744.94	125.91	125.42	0.49	3/9/95
MW-26	2864.63	2865.02	2743.49	121.14	-	-	3/2/95
MW-27	2868.69	2869.05	2745.07	123.62	-	-	3/2/95
MW-28	2861.60	2862.34	2740.52	121.08	-	-	3/2/95
MW-29	2864.70	2865.09	2741.95	122.75	-	-	3/2/95
MW-30	2867.75	2868.11	2743.13	124.62	-	-	3/6/95
MW-31	2861.90	2862.12	2739.68	122.22	-	-	3/2/95
MW-32	2863.84	2864.56	2737.64	126.20	120.94	5.26	3/2/95
MW-33	2859.27	2859.82	2739.03	120.24	-	-	3/2/95
MW-34	2864.97	2865.50	2741.39	123.58	-	-	3/2/95
MW-35	2856.90	2856.99	2737.81	119.09	-	-	3/6/95
MW-36	2861.17	2861.49	2738.78	122.39	-	-	3/2/95
MW-38	2878.46	2878.86	2749.17	129.29	-	-	3/2/95
MW-39	2873.88	2873.78	2748.75	125.13	-	-	3/2/95
MW-40	2869.06	2868.97	2747.12	121.94	-	-	3/2/95
MW-41	2880.41	2880.70	2748.89	131.52	-	-	3/7/95
MW-42	2873.34	2873.54	2745.54	127.80	-	-	3/6/95
MW-43	2877.15	2877.34	2747.3	129.85	-	-	3/6/95
MW-44	2878.67	2878.66	2747.37	131.30	-	-	3/6/95
MW-45	2862.28	2862.49	2740.93	121.35	-	-	3/2/95
MW-46	2858.48	2858.76	2738.46	120.02	-	-	3/2/95
MW-47	2859.42	2859.73	2739.04	120.38	-	-	3/2/95
MW-48	2881.98	2882.30	2748.84	133.14	-	-	3/2/95
MW-49	2882.37	2882.62	2748.53	133.84	-	-	3/2/95
MW-50	2866.44	2867.26	2737.66	128.78	120.39	8.39	3/2/95
MW-51	2865.02	2865.94	2743.2	121.82	-	-	3/2/95
MW-52	2882.49	2882.84	2739.79	142.70	-	-	3/2/95

TABLE 1-1
Groundwater Depth and Product Thickness
George AFB, California
Project No. 409860
(Sheet 2 of 2)

Monitor Well	Casing Elev. (ft msl)	Surface Elev. (ft msl)	Water Elev. (ft msl)	Water Depth (feet)	JP-4 Elevation (feet)	Product Thickness (feet)	Date Measured
MW-53	2882.80	2882.89	2742.74	140.06	-	-	3/2/95
MW-54	2861.68	2862.03	2738.14	123.54	-	-	3/2/95
MW-55	2862.22	2862.41	2740.9	121.32	-	-	3/2/95
MW-56	2874.67	2874.96	2749.09	125.58	-	-	3/2/95
MW-57	2870.58	2870.53	2743.8	126.78	-	-	3/2/95
MW-58	2867.84	2868.14	2742.42	125.42	-	-	3/6/95
MW-59	2881.55	2881.96	2747.48	134.07	-	-	3/2/95
MW-60	2881.18	2881.30	2747.78	133.40	-	-	3/2/95
MW-61	2883.80	2884.23	2748.67	135.13	-	-	3/2/95
MW-62	2870.61	2871.19	2748.31	122.30	-	-	3/2/95
MW-63	2859.51	2859.90	2741.19	118.32	-	-	3/2/95
MW-64	2856.48	2857.23	2738.16	118.32	-	-	3/2/95
MW-65	2869.22	2869.41	2743.71	125.51	125.49	0.02	3/9/95
MW-67	2864.39	n/a	2741.52	122.87	121.57	1.30	3/2/95
MW-69	2864.74	2863.29	2741.89	122.85	-	-	3/7/95
MW-70	2862.61	2864.99	2741.11	121.50	-	-	3/2/95
MW-71	2863.69	2863.09	2741.55	122.14	-	-	3/5/95
MW-72	2881.43	2863.93	2748.43	133.00	-	-	3/7/95
MW-73	2881.31	2882.21	2747.96	133.35	-	-	3/7/95
MW-74	2881.28	2882.19	2748.28	133.00	-	-	3/7/95
MW-75	2880.88	2881.60	2745.8	135.08	-	-	3/7/95
EX-1	2874.90	2875.51	2744.86	130.04	126.64	3.40	2/13/95
EX-2	2875.97	2876.64	2746	129.97	127.35	2.62	2/9/95
EX-3	2872.18	2872.72	2744.69	127.49	125.60	1.89	2/13/95
EX-4	2871.29	2871.8	2742.95	128.34	125.07	3.27	2/9/95
EX-5	2863.29	2864.18	2737.76	125.53	120.31	5.22	3/30/95

ft msl = feet mean sea level

* = Well not screened to the top of the aquifer.

JP-4 = Jet propulsion fuel 4.

GEORGE AFB
ATTN: BOB SOMMER/JON EASTEP
13436 SABRE BLVD. BLDG 321
GEORGE AFB, CA. ~~923~~ 92392

619-246-5360

APPENDIX B

ICE DATA

GEORGE AFB

WELL #32 w/ VR-SVE

DROP TUBE ½"

07/21/96 12:48:48 UNIT 182																
100	2152.	183.F	188.F	871.F	52.	22.3	-0.8	0.	-20.	13.4	67.4	0.565	2.72	115	231	1393.
07/21/96 12:49:56 UNIT 182																
100	2131.	183.F	189.F	906.F	52.	20.0	-0.8	27.	-38.	13.4	65.5	0.569	2.75	115	234	1393.
07/21/96 12:52:14 UNIT 182																
100	2139.	184.F	191.F	948.F	52.	20.0	-0.7	38.	-53.	13.4	65.2	0.570	2.27	115	240	1393.
07/21/96 12:52:33 UNIT 182																
100	2148.	184.F	191.F	952.F	52.	20.0	-0.7	38.	-53.	13.4	65.5	0.569	2.29	115	240	1393.
07/21/96 12:55:35 UNIT 182																
100	2147.	184.F	192.F	963.F	52.	20.1	-0.7	38.	-53.	13.4	63.2	0.574	2.30	115	247	1393.
07/21/96 12:57:36 UNIT 182																
100	2187.	184.F	192.F	984.F	52.	20.0	11.1	58.	-83.	13.4	66.5	0.567	2.23	115	252	1393.
07/21/96 12:58:05 UNIT 182																
100	2186.	184.F	192.F	993.F	52.	20.0	14.7	63.	-90.	13.4	68.3	0.563	2.18	115	253	1393.
07/21/96 13:00:00 UNIT 182																
100	2171.	184.F	192.F	1006.F	52.	19.4	25.0	73.	-105.	13.3	68.2	0.564	2.09	115	257	1393.
07/21/96 13:01:57 UNIT 182																
100	2150.	184.F	192.F	1001.F	52.	19.5	11.8	62.	-85.	13.4	65.9	0.568	2.12	115	262	1393.
07/21/96 13:03:03 UNIT 182																
100	1842.	185.F	191.F	980.F	52.	14.3	7.4	60.	-83.	13.2	68.5	0.563	1.85	115	264	1393.
07/21/96 13:05:03 UNIT 182																
100	1849.	184.F	189.F	890.F	52.	19.0	-0.3	0.	-20.	13.4	75.2	0.550	1.90	115	267	1393.

GEORGE AFB

BIOSLURPING AT WELL #32

07/18/96 16:12:06 UNIT 182
100 6. 171.F 129.F 182.F 0. 23.9 -0.1 0. -21. 12.6 9.7 0.681 0.00 110 549 1324.
07/18/96 16:12:48 UNIT 182
100 1691. 164.F 153.F 290.F 53. 23.4 -0.5 0. -20. 13.4 9.7 0.681 0.00 110 549 1324.
07/18/96 16:13:15 UNIT 182
100 1769. 165.F 160.F 384.F 53. 23.5 -0.5 0. -20. 13.4 9.7 0.681 0.00 110 549 1324.
07/18/96 16:14:29 UNIT 182
100 1854. 167.F 165.F 568.F 53. 24.2 -0.5 0. -20. 13.5 9.7 0.681 0.00 110 549 1324.
07/18/96 16:15:02 UNIT 182
100 1859. 168.F 166.F 617.F 53. 24.3 -0.5 0. -20. 13.5 9.7 0.681 0.00 110 550 1324.
07/18/96 16:17:19 UNIT 182
100 2025. 167.F 170.F 751.F 53. 21.4 -0.5 0. -20. 13.5 58.4 0.583 0.00 110 551 1324.
07/18/96 17:19:37 UNIT 182
100 2032. 177.F 186.F 1069.F 52. -1.4 25.0 158. -22. 13.4 68.1 0.564 0.77 110 595 1325.
07/18/96 17:20:16 UNIT 182
100 1963. 178.F 185.F 1066.F 52. -1.4 23.3 152. -21. 13.4 69.6 0.561 0.76 110 595 1325.
07/18/96 17:20:52 UNIT 182
100 1997. 178.F 185.F 1063.F 52. 1.2 22.3 145. -21. 13.4 67.1 0.566 0.73 110 595 1325.
07/18/96 17:23:28 UNIT 182
100 1987. 178.F 184.F 1057.F 52. 13.8 12.7 94. -18. 13.4 65.8 0.568 0.00 110 597 1325.
07/18/96 17:26:43 UNIT 182
100 2007. 179.F 184.F 1047.F 52. 23.0 -0.1 41. -17. 13.5 66.5 0.567 0.88 110 600 1325.
07/18/96 17:32:39 UNIT 182
100 1849. 177.F 182.F 924.F 52. 22.8 -0.7 28. -17. 13.4 64.3 0.571 0.00 110 611 1325.
07/18/96 17:32:47 UNIT 182
100 1935. 177.F 183.F 939.F 52. 23.9 -0.6 28. -17. 13.4 65.7 0.569 1.50 110 611 1325.
07/18/96 17:33:25 UNIT 182
100 2181. 177.F 183.F 986.F 52. 30.4 -0.6 35. -17. 13.4 59.9 0.580 1.12 110 611 1325.
07/18/96 18:00:00 UNIT 182
100 2071. 178.F 185.F 1075.F 52. -0.3 25.0 157. -21. 13.4 67.2 0.566 0.82 110 633 1326.
07/18/96 19:00:00 UNIT 182
100 2050. 176.F 184.F 1072.F 52. -0.3 24.4 156. -20. 13.4 65.0 0.570 0.86 110 686 1327.
07/18/96 20:00:00 UNIT 182
100 2036. 173.F 181.F 1071.F 52. -0.3 24.5 155. -20. 13.5 64.3 0.571 0.89 110 742 1328.
07/18/96 21:00:00 UNIT 182
100 2028. 170.F 179.F 1071.F 52. -0.3 24.6 156. -20. 13.5 62.6 0.575 0.94 110 800 1329.
07/18/96 22:00:00 UNIT 182
100 2041. 168.F 176.F 1075.F 52. -0.3 24.6 156. -20. 13.6 63.3 0.573 0.95 110 859 1330.
07/18/96 23:00:00 UNIT 182
100 2035. 168.F 176.F 1075.F 52. -0.2 24.6 156. -20. 13.6 60.3 0.579 0.98 110 920 1331.
07/19/96 00:00:00 UNIT 182
100 2053. 168.F 175.F 1074.F 52. -0.2 24.6 156. -20. 13.6 60.3 0.579 1.00 110 982 1332.
07/19/96 01:00:00 UNIT 182
100 2106. 167.F 174.F 1071.F 52. 0.2 26.2 164. -21. 13.8 56.7 0.587 0.99 111 46 1333.
07/19/96 02:00:00 UNIT 182
100 2057. 167.F 173.F 1070.F 52. -2.3 25.2 160. -21. 13.8 59.7 0.581 1.00 111 109 1334.
07/19/96 03:00:00 UNIT 182
100 2050. 166.F 172.F 1068.F 52. -2.3 25.1 159. -21. 13.8 59.9 0.580 1.00 111 171 1335.
07/19/96 04:00:00 UNIT 182
100 2062. 167.F 175.F 1068.F 52. -2.2 24.7 158. -21. 13.7 61.2 0.578 1.02 111 236 1336.
07/19/96 05:00:00 UNIT 182
100 2074. 167.F 174.F 1065.F 52. -2.2 24.6 158. -21. 13.7 59.5 0.581 1.04 111 300 1337.
07/19/96 06:00:00 UNIT 182
100 2060. 168.F 174.F 1065.F 52. -2.2 24.5 157. -21. 13.7 62.4 0.575 0.98 111 365 1338.

V.R.SYSTEMS INC. MODEL V3 S/N 182
PERMIT NO.

ENGINE	TEMPERATURE			OIL	POSITIONS		WELL FLOW	BATTERY	DUTY	PERCENT	AUXILIARY FUEL	ENGINE
RPM	COOLANT	OIL	EXHAUST	PSI	CARB.	BYPASS	CFM-VAC.H20	VOLTS	CYCLE	OXYGEN	CFM THOUSANDS-UNITS	HOURS

07/19/96 07:00:00 UNIT 182

Date / Time	Unit		Engine RPM	Coolant	Oil	Exhaust	Oil PSI	Carb.	Bypass	CFM	VAC.H2O	Battery Volts	Duty Cycle	Percent Oxygen	Auxiliary Fuel CFM	Thousands	Units	Engine Hours
07/19/96 07:46:31	UNIT 182	100	2031.	171.F	179.F	1071.F	52.	-2.8	25.4	161.	-20.	13.6	65.0	0.570	0.88	111	465	1340.
07/19/96 07:58:57	UNIT 182	100	1839.	169.F	177.F	1048.F	52.	21.1	1.2	48.	-15.	13.6	66.9	0.566	0.98	111	475	1340.
07/19/96 08:00:00	UNIT 182	100	1854.	169.F	177.F	976.F	52.	20.6	-0.5	0.	-14.	13.6	60.9	0.578	1.65	111	481	1340.
07/19/96 08:00:30	UNIT 182	100	1644.	171.F	177.F	962.F	52.	22.1	-0.5	37.	-15.	13.6	68.6	0.563	2.08	111	482	1340.
07/19/96 09:00:00	UNIT 182	100	2067.	169.F	177.F	1075.F	52.	-1.1	27.0	166.	-20.	13.7	63.2	0.574	0.90	111	538	1341.
07/19/96 09:22:25	UNIT 182	100	1937.	169.F	177.F	1070.F	52.	-1.7	23.6	154.	-19.	13.7	68.8	0.562	0.80	111	559	1341.
07/19/96 09:23:34	UNIT 182	100	1807.	169.F	176.F	1062.F	52.	-1.7	22.0	148.	-19.	13.7	68.0	0.564	0.00	111	560	1341.
07/19/96 09:24:54	UNIT 182	100	1806.	169.F	176.F	1056.F	52.	-1.7	22.0	148.	-19.	13.6	66.2	0.568	0.00	111	561	1341.
07/19/96 09:25:34	UNIT 182	100	1798.	170.F	175.F	1055.F	52.	-1.7	22.1	148.	-19.	13.6	67.2	0.566	0.00	111	561	1341.
07/19/96 09:28:31	UNIT 182	100	2338.	169.F	176.F	1075.F	52.	19.0	22.0	119.	-18.	13.7	58.0	0.584	0.87	111	563	1341.
07/19/96 09:29:29	UNIT 182	100	2211.	170.F	178.F	1099.F	52.	14.0	21.9	127.	-18.	13.6	64.1	0.572	1.37	111	565	1341.
07/19/96 09:30:16	UNIT 182	100	1694.	170.F	178.F	1092.F	52.	10.2	20.6	73.	-16.	13.7	67.7	0.565	1.18	111	566	1341.
07/19/96 09:30:43	UNIT 182	100	1588.	170.F	178.F	1061.F	52.	14.9	20.3	28.	-14.	13.6	63.1	0.574	1.02	111	566	1341.
07/19/96 09:31:12	UNIT 182	100	1728.	170.F	177.F	1020.F	52.	19.8	20.3	27.	-15.	13.7	65.7	0.569	0.96	111	566	1341.
07/19/96 09:35:06	UNIT 182	100	1863.	169.F	177.F	994.F	52.	26.9	12.7	56.	-16.	13.6	99.9	0.500	0.00	111	575	1341.
07/19/96 09:35:21	UNIT 182	100	1642.	168.F	177.F	1060.F	52.	29.4	12.6	50.	-16.	13.6	9.3	0.681	0.00	111	575	1341.
07/19/96 09:35:29	UNIT 182	100	2224.	167.F	177.F	1055.F	52.	30.2	12.6	52.	-16.	13.7	66.8	0.566	1.27	111	575	1341.
07/19/96 09:36:04	UNIT 182	100	2069.	168.F	177.F	1044.F	52.	25.8	12.6	58.	-16.	13.7	62.6	0.575	1.02	111	576	1341.
07/19/96 09:40:56	UNIT 182	100	2093.	170.F	179.F	1075.F	52.	1.8	26.4	162.	-21.	13.7	64.5	0.571	0.85	111	580	1342.
07/19/96 09:41:12	UNIT 182	100	2070.	170.F	179.F	1074.F	52.	0.3	27.1	166.	-21.	13.7	65.0	0.570	0.85	111	580	1342.
07/19/96 10:00:00	UNIT 182	100	2060.	172.F	181.F	1077.F	52.	-0.5	26.9	165.	-20.	13.5	66.1	0.568	0.84	111	597	1342.
07/19/96 11:00:00	UNIT 182	100	2046.	173.F	182.F	1078.F	52.	-2.4	27.6	168.	-20.	13.6	64.3	0.571	0.84	111	650	1343.
07/19/96 12:00:00	UNIT 182	100	2031.	184.F	192.F	1081.F	52.	-1.6	26.5	166.	-20.	13.2	70.5	0.559	0.78	111	701	1344.
07/19/96 13:00:00	UNIT 182	100	2065.	184.F	190.F	1080.F	52.	-1.5	26.6	166.	-21.	13.3	70.5	0.559	0.81	111	751	1345.
07/19/96 13:59:21	UNIT 182	100	2033.	182.F	190.F	1080.F	52.	-1.4	26.7	166.	-21.	13.4	69.6	0.561	0.79	111	801	1346.
07/19/96 14:00:00	UNIT 182	100	2055.	182.F	190.F	1080.F	52.	-1.5	26.7	165.	-21.	13.3	69.7	0.561	0.79	111	802	1346.
07/19/96 15:00:00	UNIT 182	100	2021.	183.F	188.F	1075.F	52.	-1.4	26.1	163.	-26.	13.3	69.5	0.561	0.78	111	852	1347.

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM THOUSANDS-UNITS	ENGINE HOURS

07/19/96 16:00:00 UNIT 182

07/19/96 16:46:17 UNIT 182																
100	2034.	180.F	185.F	1075.F	52.	-2.2	26.1	163.	-26.	13.4	68.4	0.563	0.85	111	944	1349.
07/19/96 17:00:00 UNIT 182																
100	2053.	179.F	185.F	1073.F	52.	-2.3	26.0	163.	-27.	13.4	68.7	0.563	0.85	111	956	1349.
07/19/96 18:00:00 UNIT 182																
100	2048.	178.F	185.F	1075.F	52.	-2.3	26.1	163.	-25.	13.4	68.1	0.564	0.87	112	10	1350.
07/19/96 19:00:00 UNIT 182																
100	2056.	175.F	182.F	1076.F	52.	-2.3	26.2	164.	-23.	13.4	64.1	0.572	0.95	112	67	1351.
07/19/96 20:00:00 UNIT 182																
100	2047.	171.F	181.F	1075.F	52.	-2.9	26.3	163.	-24.	13.5	62.3	0.575	0.99	112	128	1352.
07/19/96 21:00:00 UNIT 182																
100	2064.	169.F	178.F	1077.F	52.	-2.9	26.3	163.	-23.	13.5	61.9	0.576	1.01	112	191	1353.
07/19/96 22:00:00 UNIT 182																
100	2050.	169.F	177.F	1079.F	52.	-2.8	26.1	163.	-23.	13.6	61.1	0.578	1.03	112	256	1354.
07/19/96 23:00:00 UNIT 182																
100	2060.	167.F	176.F	1075.F	52.	-2.2	25.8	162.	-23.	13.6	59.9	0.580	1.04	112	321	1355.
07/20/96 00:00:00 UNIT 182																
100	2054.	166.F	175.F	1070.F	52.	-2.7	25.3	160.	-23.	13.5	61.2	0.578	1.08	112	388	1356.
07/20/96 01:00:00 UNIT 182																
100	2074.	166.F	174.F	1071.F	52.	-0.2	25.6	161.	-23.	13.7	57.9	0.584	1.08	112	455	1357.
07/20/96 02:00:00 UNIT 182																
100	2056.	165.F	172.F	1065.F	52.	-0.7	24.7	158.	-24.	13.7	61.4	0.577	1.09	112	524	1358.
07/20/96 03:00:00 UNIT 182																
100	2051.	165.F	172.F	1063.F	52.	-0.7	24.6	158.	-24.	13.7	58.4	0.583	1.11	112	593	1359.
07/20/96 04:00:00 UNIT 182																
100	2038.	164.F	171.F	1063.F	52.	-0.8	24.6	157.	-24.	13.7	57.6	0.585	1.13	112	663	1360.
07/20/96 05:00:00 UNIT 182																
100	2069.	164.F	170.F	904.F	52.	-3.1	13.7	112.	-22.	13.8	56.5	0.587	2.53	112	753	1361.
07/20/96 06:00:00 UNIT 182																
100	2070.	165.F	173.F	904.F	52.	-3.1	13.8	113.	-21.	13.7	56.9	0.586	2.54			1362.
07/20/96 07:00:00 UNIT 182																
100	2050.	165.F	174.F	898.F	52.	-3.1	13.7	112.	-1[illegible]	[illegible]	60.0	0.5[illegible]				
07/20/96 07:26:04 UNIT 182																
100	2030.	167.F	176.F	897.		-3.1	13.[illegible]									
										13.6	61.4	0.577	2.48	113	134	1363.
07/20/96 07:27:31 UNIT 182																
100	1978.	167.F	176.F	889.F	52.	-3.1	12.6	109.	-18.	13.3	63.5	0.573	2.45	113	134	1363.
07/20/96 07:28:45 UNIT 182																
100	1972.	167.F	176.F	885.F	52.	-3.1	12.7	108.	-18.	13.6	61.2	0.578	2.45	113	137	1363.
07/20/96 07:30:16 UNIT 182																
100	1785.	168.F	176.F	867.F	52.	-0.8	7.7	86.	-17.	13.6	63.0	0.574	2.19	113	141	1363.
07/20/96 07:31:46 UNIT 182																
100	1804.	167.F	175.F	855.F	52.	7.2	1.8	61.	-17.	13.5	60.5	0.579	2.18	113	144	1363.
07/20/96 08:00:00 UNIT 182																
100	1568.	166.F	170.F	775.F	52.	15.9	-0.5	0.	-19.	13.5	68.4	0.563	1.82	113	197	1364.
07/20/96 08:59:29 UNIT 182																
100	1846.	165.F	166.F	763.F	52.	19.1	-0.4	0.	-18.	13.7	55.3	0.589	1.81	113	308	1365.
07/20/96 08:59:43 UNIT 182																
100	2046.	165.F	167.F	771.F	52.	21.0	-0.4	0.	-18.	13.7	58.8	0.582	2.01	113	308	1365.
07/20/96 09:00:00 UNIT 182																
100	1790.	166.F	167.F	796.F	52.	22.0	-0.4	40.	-19.	13.6	69.6	0.561	2.11	113	309	1365.
07/20/96 09:00:17 UNIT 182																
100	2008.	166.F	168.F	847.F	52.	24.7	-0.4	38.	-19.	13.7	53.7	0.593	0.00	113	309	1365.

V.R.SYSTEMS INC. MODEL V3 S/N 182
PERMIT NO.

ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM THOUSANDS-UNITS	ENGINE HOURS

07/20/96 10:00:00 UNIT 182

07/20/96 11:00:00 UNIT 182																
100	2063.	182.F	188.F	1082.F	52.	-0.5	26.5	164.	-24.	13.3	68.4	0.563	0.88	113	399	1367.
07/20/96 12:00:00 UNIT 182																
100	2051.	188.F	194.F	1080.F	52.	-0.7	26.6	164.	-23.	13.2	71.4	0.557	0.88	113	454	1368.
07/20/96 13:00:00 UNIT 182																
100	2072.	185.F	191.F	1075.F	52.	-2.5	26.3	164.	-26.	13.3	69.0	0.562	0.89	113	510	1369.
07/20/96 14:00:00 UNIT 182																
100	2060.	183.F	188.F	1070.F	52.	-2.5	26.5	164.	-27.	13.3	67.6	0.565	0.93	113	566	1370.
07/20/96 15:00:00 UNIT 182																
100	2057.	184.F	190.F	1073.F	52.	-2.6	26.4	163.	-26.	13.3	69.6	0.561	0.90	113	625	1371.
07/20/96 16:00:00 UNIT 182																
100	2069.	183.F	188.F	1070.F	52.	-2.6	26.4	164.	-27.	13.3	68.7	0.563	0.93	113	682	1372.
07/20/96 17:00:00 UNIT 182																
100	2058.	182.F	188.F	1073.F	52.	-2.6	26.4	164.	-26.	13.3	66.6	0.567	0.95	113	742	1373.
07/20/96 18:00:00 UNIT 182																
100	2076.	180.F	186.F	1071.F	52.	-2.3	26.4	164.	-26.	13.3	65.8	0.568	1.01	113	804	1374.
07/20/96 19:00:00 UNIT 182																
100	2058.	176.F	184.F	1070.F	52.	-1.9	25.8	161.	-26.	13.4	67.2	0.566	1.04	113	869	1375.
07/20/96 20:00:00 UNIT 182																
100	2024.	169.F	178.F	1073.F	52.	-2.1	25.8	161.	-24.	13.5	64.9	0.570	1.06	113	935	1376.
07/20/96 21:00:00 UNIT 182																
100	2033.	168.F	177.F	1076.F	52.	-2.0	25.8	162.	-24.	13.5	61.9	0.576	1.08	114	2	1377.
07/20/96 22:00:00 UNIT 182																
100	2085.	167.F	176.F	1078.F	52.	-1.1	25.8	163.	-24.	13.6	62.8	0.574	1.14	114	73	1378.
07/20/96 23:00:00 UNIT 182																
100	2064.	166.F	178.F	1069.F	52.	-4.0	24.8	161.	-23.	13.5	62.6	0.575	1.12	114	144	1379.
07/21/96 00:00:00 UNIT 182																
100	2073.	167.F	173.F	1074.F	52.	-3.7	25.6	161.	-24.	13.7	61.3	0.577	1.15	114	215	1380.
07/21/96 01:00:00 UNIT 182																
100	2067.	167.F	174.F	1072.F	52.	-3.7	25.2	160.	-24.	13.7	62.3	0.575	1.14	114	287	1381.
07/21/96 02:00:00 UNIT 182																
100	2059.	166.F	173.F	1072.F	52.	-3.7	25.2	160.	-24.	13.7	59.8	0.580	1.14	114	359	1382.
07/21/96 03:00:00 UNIT 182																
100	2054.	167.F	175.F	1068.F	52.	-3.8	24.4	159.	-23.	13.6	62.7	0.575	1.15	114	430	1383.
07/21/96 04:00:00 UNIT 182																
100	2062.	166.F	174.F	1066.F	52.	-3.8	24.8	159.	-23.	13.6	60.0	0.580	1.18	114	503	1384.
07/21/96 05:00:00 UNIT 182																
100	2065.	166.F	174.F	1067.F	52.	-3.8	24.8	159.	-23.	13.6	60.9	0.578	1.18	114	577	1385.
07/21/96 06:00:00 UNIT 182																
100	2031.	167.F	174.F	1067.F	52.	-3.8	24.7	158.	-23.	13.5	62.6	0.575	1.13	114	650	1386.
07/21/96 07:00:00 UNIT 182																
100	2139.	170.F	179.F	1083.F	52.	0.5	27.6	169.	-22.	13.4	63.4	0.573	1.29	114	721	1387.
07/21/96 08:00:00 UNIT 182																
100	2057.	175.F	183.F	1077.F	52.	-4.8	26.3	163.	-23.	13.4	69.1	0.562	1.11	114	794	1388.
07/21/96 09:00:00 UNIT 182																
100	2037.	169.F	177.F	1072.F	52.	-5.0	26.5	165.	-23.	13.6	65.2	0.570	1.09	114	863	1389.
07/21/96 10:00:00 UNIT 182																
100	2081.	184.F	188.F	1087.F	52.	-1.5	27.4	167.	-23.	13.3	68.9	0.562	1.11	114	931	1390.
07/21/96 11:00:00 UNIT 182																
100	2033.	183.F	192.F	1077.F	52.	-5.0	26.6	164.	-23.	13.3	70.8	0.558	1.04	114	999	1391.
07/21/96 12:00:00 UNIT 182																
100	2080.	185.F	192.F	908.F	52.	-5.0	14.6	116.	-22.	13.3	68.1	0.564	2.70	115	107	1392.
07/21/96 12:01:09 UNIT 182																
100	1986.	186.F	192.F	899.F	52.	-4.8	12.8	108.	-21.	13.3	70.0	0.560	2.57	115	110	1392.

V.R.SYSTEMS INC. MODEL V3 S/N 182
PERMIT NO.

ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM THOUSANDS-UNITS	ENGINE HOURS

07/21/96 12:02:31 UNIT 182

07/21/96 12:32:59 UNIT 182

100	2036.	184.F	191.F	888.F	52.	12.4	-0.2	50.	-20.	13.3	64.6	0.571	2.61	115	193	1392.

07/21/96 12:33:27 UNIT 182

100	1881.	184.F	191.F	887.F	52.	10.4	-0.1	52.	-20.	13.4	71.4	0.557	2.57	115	195	1392.

PERMIT NO.

ENGINE TEMPERATURE OIL POSITIONS WELL FLOW BATTERY DUTY PERCENT AUXILIARY FUEL ENGINE
RPM COOLANT OIL EXHAUST PSI CARB. BYPASS CFM-VAC.H2O VOLTS CYCLE OXYGEN CFM THOUSANDS-UNITS HOURS

07/12/96 15:25:39 UNIT 182
100 0. 97.F 100.F 107.F 0. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 165 1263.
07/12/96 15:26:07 LIMIT 302 OIL PSI 0. LOW OIL PSI SD UNIT 182
¿ESTART AT: 07/12/96 15:26:42 (07/12/96 15:26:16) S5245 V2.23 .
07/12/96 15:26:46 UNIT 182
100 0. 99.F 99.F 134.F 0. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 166 1263.
07/12/96 15:27:12 LIMIT 302 OIL PSI 0. LOW OIL PSI SD UNIT 182
¿ESTART AT: 07/12/96 15:31:25 (07/12/96 15:27:24) S5245 V2.23 .
07/12/96 15:31:28 UNIT 182
100 0. 112.F 99.F 148.F 0. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 166 1263.
07/12/96 15:31:55 LIMIT 302 OIL PSI 0. LOW OIL PSI SD UNIT 182
¿ESTART AT: 07/12/96 15:33:07 (07/12/96 15:32:43) S5245 V2.23 .
07/12/96 15:33:10 UNIT 182
100 0. 114.F 99.F 202.F 0. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 166 1263.
07/12/96 15:33:31 UNIT 182
100 4. 116.F 100.F 195.F 0. 23.5 -0.7 0. -20. 12.2 9.7 0.681 0.00 104 166 1263.
¿ESTART AT: 07/12/96 15:34:13 (07/12/96 15:33:40) S5245 V2.23 .
07/12/96 15:34:16 UNIT 182
100 0. 119.F 99.F 184.F 0. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 166 1263.
07/12/96 15:34:40 UNIT 182
100 4. 119.F 99.F 178.F 0. 23.5 -0.7 0. -21. 12.2 9.7 0.681 0.00 104 167 1263.
07/12/96 15:39:06 UNIT 182
100 1747. 162.F 138.F 709.F 44. 23.5 -0.7 0. -20. 13.7 9.7 0.681 0.00 104 167 1263.
07/12/96 15:40:37 UNIT 182
100 1706. 163.F 148.F 725.F 44. 22.1 -0.7 0. -20. 13.6 9.7 0.681 0.00 104 167 1263.
07/12/96 15:42:29 UNIT 182
100 1779. 164.F 157.F 756.F 44. 23.3 -0.8 0. -19. 13.5 9.7 0.681 0.00 104 167 1263.
07/12/96 15:45:37 UNIT 182
100 1788. 165.F 166.F 781.F 44. 23.3 -0.8 0. -19. 13.5 9.7 0.681 0.00 104 167 1263.
07/12/96 15:48:26 UNIT 182
100 2109. 169.F 173.F 861.F 44. 23.3 -0.8 0. -19. 13.5 54.3 0.591 1.69 104 170 1263.
07/12/96 15:48:48 UNIT 182
100 2126. 170.F 174.F 871.F 44. 23.3 -0.8 0. -19. 13.5 54.7 0.591 2.68 104 171 1263.
07/12/96 15:50:23 UNIT 182
100 2224. 172.F 178.F 888.F 44. 24.4 -0.8 0. -19. 13.5 57.6 0.585 2.69 104 175 1263.
07/12/96 15:55:42 UNIT 182
100 1904. 175.F 185.F 904.F 44. 20.5 -0.8 0. -19. 13.4 61.7 0.577 2.63 104 190 1263.
07/12/96 16:00:28 UNIT 182
100 1490. 179.F 183.F 803.F 44. 18.1 -0.8 0. -19. 13.4 9.7 0.681 0.00 104 196 1264.
¿ESTART AT: 07/14/96 12:56:59 (07/12/96 16:00:58) S5245 V2.23 .
07/14/96 12:57:02 LIMIT 110 BATTERY 0.0 LOW BATT. VOLT ALARM UNIT 182
07/14/96 12:57:02 LIMIT 414 ENG TMR 1570. ENGINE FAILED ALARM UNIT 182
07/14/96 12:57:02 UNIT 182
100 0. 95.F 98.F 106.F 53. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 196 1264.
07/14/96 12:57:42 UNIT 182
100 6. 95.F 98.F 106.F 0. 21.1 -0.7 0. -21. 12.1 39.9 0.620 0.00 104 196 1264.
07/14/96 12:58:14 LIMIT 302 OIL PSI 0. LOW OIL PSI SD UNIT 182
¿ESTART AT: 07/14/96 12:58:50 (07/14/96 12:58:21) S5245 V2.23 .
07/14/96 12:58:53 UNIT 182
100 0. 98.F 96.F 133.F 0. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 196 1264.
07/14/96 12:59:08 UNIT 182
100 4. 98.F 97.F 133.F 0. 23.8 -0.7 0. -20. 12.2 9.7 0.681 0.00 104 196 1264.
07/14/96 12:59:31 LIMIT 302 OIL PSI 0. LOW OIL PSI SD UNIT 182
¿ESTART AT: 07/14/96 13:00:03 (07/14/96 12:59:38) S5245 V2.23 .
07/14/96 13:00:06 UNIT 182
100 0. 105.F 97.F 197.F 0. -25.0 -25.0 0. -398. 0.0 0.1 0.700 0.00 104 196 1264.

07/14/96 13:00:35 LIMIT 302 OIL PSI 0. LOW OIL PSI SD UNIT 182

RESTART AT: 07/14/96 13:01:39 (07/14/96 13:00:43) 55245 V2.23

V.R.SYSTEMS INC. MODEL V3 S/N 182

PERMIT NO.

ENGINE	TEMPERATURE			OIL	POSITIONS		WELL FLOW	BATTERY	DUTY	PERCENT	AUXILIARY FUEL	ENGINE
RPM	COOLANT	OIL	EXHAUST	PSI	CARB.	BYPASS	CFM-VAC.H2O	VOLTS	CYCLE	OXYGEN	CFM THOUSANDS-UNITS	HOURS

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07/14/96 13:01:42  UNIT 182
100    0.   113.F   98.F  245.F    0.   -25.0  -25.0     0.  -398.    0.0     0.1  0.700   0.00   104   197   1264.
07/14/96 13:01:59  UNIT 182
100    4.   116.F   96.F  237.F    0.    23.8   -0.7     0.   -21.   12.3     9.7  0.681   0.00   104   197   1264.
07/14/96 13:02:24 LIMIT  302  OIL PSI    0.  LOW OIL PSI SD      UNIT 182
¿ESTART AT: 07/14/96 13:05:23 (07/14/96 13:04:26) S5245  V2.23 .
07/14/96 13:05:26  UNIT 182
100    0.   128.F   98.F  236.F    0.   -25.0  -25.0     0.  -399.    0.0     0.1  0.700   0.00   104   197   1264.
07/14/96 13:05:39  UNIT 182
100    4.   128.F   98.F  233.F    0.    23.8   -0.7     0.   -21.   12.2     9.7  0.681   0.00   104   197   1264.
07/14/96 13:11:33  UNIT 182
100  1833.  165.F  149.F  741.F   53.    26.2   -0.8     0.   -20.   13.7     9.7  0.681   0.00   104   197.  1264.
07/14/96 13:14:33  UNIT 182
100  2041.  169.F  164.F  816.F   53.    22.3   -0.8     0.   -20.   13.6    50.1  0.600   2.21   104   200   1264.
07/14/96 13:14:44  UNIT 182
100  2152.  169.F  165.F  820.F   53.    24.0   -0.8     0.   -20.   13.6    50.9  0.598   2.35   104   201   1264.
07/14/96 13:15:23  UNIT 182
100  2310.  170.F  168.F  869.F   53.    23.8   -0.8    30.   -20.   13.6    54.2  0.592   2.79   104   203   1264.
07/14/96 13:16:55  UNIT 182
100  2280.  172.F  174.F  924.F   53.    21.4   -0.7    43.   -20.   13.6    52.3  0.595   2.74   104   207   1264.
07/14/96 13:18:37  UNIT 182
100  2152.  174.F  178.F  920.F   53.    18.2   -0.7    45.   -20.   13.6    54.6  0.591   2.51   104   211   1264.
07/14/96 13:30:00  UNIT 182
100  2174.  181.F  190.F  950.F   52.    -0.3   17.1   124.   -21.   13.5    57.2  0.586   2.44   104   240   1264.
07/14/96 13:32:29  UNIT 182
100  2169.  181.F  191.F  948.F   53.    -0.2   17.1   124.   -21.   13.4    60.1  0.580   2.44   104   246   1264.
07/14/96 13:33:13  UNIT 182
100  2099.  181.F  191.F  948.F   53.    -0.3   16.1   120.   -20.   13.4    60.9  0.578   2.45   104   248   1264.
07/14/96 13:34:22  UNIT 182
100  2104.  181.F  190.F  940.F   53.    -0.3   16.1   120.   -20.   13.4    59.0  0.582   2.37   104   251   1264.
07/14/96 14:00:00  UNIT 182
100  2115.  185.F  193.F  935.F   52.    -0.3   16.1   120.   -20.   13.4    60.2  0.580   2.41   104   314   1264.
07/14/96 14:07:52  UNIT 182
100  2129.  183.F  193.F  943.F   52.    -0.3   16.7   123.   -20.   13.4    62.2  0.576   2.40   104   333   1265.
07/14/96 14:09:16  UNIT 182
100  2051.  183.F  192.F  938.F   52.    -0.3   15.9   119.   -20.   13.5    61.2  0.578   2.33   104   336   1265.
07/14/96 14:26:36  UNIT 182
100  2038.  182.F  191.F  928.F   52.    -0.3   15.9   119.   -20.   13.5    60.0  0.580   2.30   104   377   1265.
07/14/96 14:29:19  UNIT 182
100  1956.  185.F  191.F  925.F   52.    -0.3   14.3   114.   -19.   13.4    60.9  0.578   2.23   104   383   1265.
07/14/96 14:30:17  UNIT 182
100  1985.  184.F  191.F  917.F   52.     3.7   12.1   103.   -19.   13.5    59.3  0.581   2.21   104   385   1265.
07/14/96 14:34:40  UNIT 182
100  1852.  184.F  191.F  913.F   52.    13.2   -0.0    50.   -18.   13.4    62.8  0.574   2.28   104   396   1265.
07/14/96 15:00:00  UNIT 182
100  2044.  181.F  188.F  889.F   52.    16.0   -0.6    47.   -18.   13.3    61.2  0.578   2.36   104   453   1265.
07/14/96 16:00:00  UNIT 182
100  2044.  182.F  190.F  921.F   52.    -0.3   16.4   121.   -21.   13.5    55.1  0.590   2.26   104   593   1266.
07/14/96 17:00:00  UNIT 182
100  2012.  180.F  188.F  929.F   52.    -0.4   16.4   122.   -21.   13.5    56.2  0.588   2.32   104   733   1267.
07/14/96 18:00:00  UNIT 182
100  2045.  178.F  187.F  944.F   52.    -0.4   16.8   122.   -20.   13.5    58.7  0.583   2.39   104   877   1268.
07/14/96 19:00:00  UNIT 182
100  2029.  179.F  188.F  982.F   52.    -0.4   18.6   129.   -20.   13.5    61.9  0.576   2.54   105    26   1269.
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V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM THOUSANDS-UNITS	ENGINE HOURS

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100 1951.  183.F  189.F  932.F  52.   5.0  12.5  103.  -18.  13.4  65.8  0.568  2.42  107  380  1284.
07/15/96 10:01:48  UNIT 182
100 1793.  183.F  189.F  930.F  52.   2.8  10.7   98.  -18.  13.4  62.9  0.574  2.35  107  382  1284.
07/15/96 10:02:23  UNIT 182
100 1643.  184.F  188.F  916.F  52.   6.3   9.0   66.  -18.  13.4  62.7  0.575  2.14  107  383  1284.
07/15/96 10:03:05  UNIT 182
100 1759.  184.F  188.F  900.F  52.  12.8   8.3   45.  -17.  13.4  66.5  0.567  1.98  107  384  1284.
07/15/96 10:03:31  UNIT 182
100 1685.  184.F  188.F  893.F  52.  16.2   7.0   14.  -17.  13.4  66.5  0.567  2.03  107  385  1285.
07/15/96 11:00:00  UNIT 182
100 1865.  185.F  190.F  911.F  52.  -0.5  14.9  116.  -19.  13.4  62.4  0.575  2.19  107  514  1285.
07/15/96 11:10:05  UNIT 182
100 1865.  186.F  189.F  911.F  52.  -0.5  14.9  115.  -20.  13.5  60.4  0.579  2.19  107  536  1286.
07/15/96 11:11:34  UNIT 182
100 1809.  185.F  189.F  903.F  52.   3.8  10.4   96.  -19.  13.4  60.2  0.580  2.06  107  539  1286.
07/15/96 11:24:18  UNIT 182
100 2015.  183.F  188.F  891.F  52.  18.2  -0.2   46.  -18.  13.4  57.1  0.586  2.28  107  568  1286.
07/15/96 12:00:00  UNIT 182
100 2052.  185.F  192.F  955.F  52.  -0.3  18.3  129.  -20.  13.4  56.3  0.587  2.50  107  659  1286.
07/15/96 13:00:00  UNIT 182
100 2062.  185.F  192.F  962.F  52.  -0.3  18.3  129.  -21.  13.4  59.9  0.580  2.50  107  810  1287.
07/15/96 13:18:26  UNIT 182
100 2048.  186.F  193.F  959.F  52.  -0.3  18.3  129.  -21.  13.4  59.3  0.581  2.49  107  857  1288.
07/15/96 14:00:00  UNIT 182
100 2065.  186.F  191.F  961.F  52.  -0.3  18.3  129.  -21.  13.4  60.0  0.580  2.46  107  961  1288.
07/15/96 14:27:06  UNIT 182
100 2005.  186.F  191.F  957.F  52.   0.7  16.7  121.  -21.  13.4  60.7  0.579  2.41  108   30  1289.
07/15/96 14:27:44  UNIT 182
100 2005.  185.F  191.F  953.F  52.   4.4  14.7  111.  -20.  13.4  58.5  0.583  2.39  108   31  1289.
07/15/96 14:28:21  UNIT 182
100 1538.  186.F  191.F  952.F  52.   5.6  13.9   66.  -18.  13.4  62.4  0.575  2.25  108   33  1289.
07/15/96 14:28:54  UNIT 182
100 1790.  187.F  190.F  920.F  52.  11.1  13.9   63.  -18.  13.4  56.7  0.587  1.96  108   34  1289.
07/15/96 14:29:24  UNIT 182
100 1686.  186.F  190.F  912.F  52.  15.0  12.8   27.  -17.  13.4  59.7  0.581  1.87  108   35  1289.
07/15/96 15:00:00  UNIT 182
100 1837.  180.F  185.F  822.F  52.  19.6  -0.4    0.  -19.  13.4  58.9  0.582  2.19  108  103  1289.
07/15/96 16:00:00  UNIT 182
100 1833.  178.F  183.F  815.F  52.  19.7  -0.4    0.  -19.  13.5  55.7  0.589  2.19  108  238  1290.
07/15/96 19:00:30  UNIT 182
100 1411.  170.F  171.F  739.F  52.  14.8  -0.4    0.  -19.  13.5  59.3  0.581  1.62  108  569  1293.
¿ESTART AT: 07/16/96 06:48:48 (07/15/96 19:00:39) S5245  V2.23 .
07/16/96 06:48:51 LIMIT  110 BATTERY      0.0  LOW BATT. VOLT ALARM    UNIT 182
07/16/96 06:48:51 LIMIT  414 ENG TMR  OVRNG    ENGINE FAILED ALARM     UNIT 182
07/16/96 06:48:51  UNIT 182
100    0.   75.F   74.F   76.F  61. -25.0 -25.0    0. -394.   0.0   0.1  0.700  1.60  108  570  1293.
07/16/96 06:49:05  UNIT 182
100    5.   75.F   74.F   76.F   0.  15.1  -0.4    0.  -21.  12.1  10.4  0.679  1.65  108  570  1293.
¿ESTART AT: 07/16/96 06:49:49 (07/16/96 06:49:18) S5245  V2.23 .
¿ESTART AT: 07/16/96 06:50:15 (07/16/96 06:49:52) S5245  V2.23 .
07/16/96 06:50:18  UNIT 182
100    0.   75.F   75.F   77.F  13. -25.0 -25.0    0. -394.   0.0   0.1  0.700  0.00  108  570  1293.
07/16/96 06:50:50  UNIT 182
100    4.   75.F   75.F   77.F   0.  18.8  -0.3    0.  -21.  12.2  18.8  0.662  0.00  108  570  1293.
¿ESTART AT: 07/16/96 06:51:49 (07/16/96 06:51:26) S5245  V2.23 .
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V.R.SYSTEMS INC. MODEL V3 S/N 182

PERMIT NO.

	ENGINE	TEMPERATURE			OIL	POSITIONS		WELL FLOW		BATTERY	DUTY	PERCENT	AUXILIARY FUEL			ENGINE
	RPM	COOLANT	OIL	EXHAUST	PSI	CARB.	BYPASS	CFM	VAC.H2O	VOLTS	CYCLE	OXYGEN	CFM	THOUSANDS	UNITS	HOURS
07/16/96 06:51:52 UNIT 182																
100	0.	76.F	75.F	77.F	0.	-25.0	-25.0	0.	-393.	0.0	0.1	0.700	0.00	108	570	1293.
RESTART AT: 07/16/96 06:52:45 (07/16/96 06:52:11) 55245 V2.23 .																
07/16/96 06:52:48 UNIT 182																
100	0.	76.F	75.F	78.F	21.	-25.0	-25.0	0.	-394.	0.0	0.1	0.700	0.00	108	570	1293.

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100    4.   76.F   75.F   78.F    0.   23.4   -0.3    0.   -22.   12.3   10.3  0.679   0.00   108   570   1293.
¿ESTART AT: 07/16/96 06:53:43 (07/16/96 06:53:22) S5245  V2.23 .
07/16/96 06:53:46  UNIT 182
100    0.   76.F   75.F   79.F    6.  -25.0  -25.0    0.  -393.    0.0    0.1  0.700   0.00   108   570   1293.
¿ESTART AT: 07/16/96 06:54:45 (07/16/96 06:54:00) S5245  V2.23 .
07/16/96 06:54:48  UNIT 182
100    0.   76.F   76.F   80.F   32.  -25.0  -25.0    0.  -394.    0.0    0.1  0.700   0.00   108   570   1293.
07/16/96 06:54:56  UNIT 182
100    4.   76.F   75.F   80.F    0.   23.4   -0.3    0.   -23.   12.4   10.3  0.679   0.00   108   570   1293.
¿ESTART AT: 07/16/96 06:56:36 (07/16/96 06:55:11) S5245  V2.23 .
07/16/96 06:56:39  UNIT 182
100    0.   76.F   75.F   80.F   29.  -25.0  -25.0    0.  -394.    0.0    0.1  0.700   0.00   108   570   1293.
07/16/96 06:56:53  UNIT 182
100    4.   76.F   75.F   80.F    0.   23.5   -0.3    0.   -21.   12.4   10.3  0.679   0.00   108   570   1293.
¿ESTART AT: 07/16/96 06:58:16 (07/16/96 06:57:14) S5245  V2.23 .
07/16/96 06:58:19  UNIT 182
100    0.   76.F   75.F   81.F   45.  -25.0  -25.0    0.  -394.    0.0    0.1  0.700   0.00   108   570   1293.
07/16/96 06:59:50  UNIT 182
100    5.   76.F   75.F   81.F    0.   23.5   -0.3    0.   -21.   12.3   99.9  0.500   0.00   108   570   1293.
07/16/96 07:02:16  UNIT 182
100 1660.   94.F   83.F  317.F   53.   27.7   -0.3    0.   -21.   13.8   10.4  0.679   0.00   108   570   1293.
07/16/96 07:05:52  UNIT 182
100 1859.  153.F  118.F  796.F   53.   28.6   -0.4    0.   -20.   13.9   10.4  0.679   0.00   108   570   1294.
07/16/96 07:07:00  UNIT 182
100 1836.  161.F  129.F  820.F   53.   28.8   -0.6    0.   -20.   14.0   10.3  0.679   0.00   108   570   1294.
07/16/96 07:08:40  UNIT 182
100 1863.  163.F  141.F  840.F   53.   31.0   -0.6    0.   -20.   13.9   10.3  0.679   0.00   108   570   1294.
07/16/96 07:10:10  UNIT 182
100 1788.  159.F  148.F  844.F   53.   25.4   -0.5    0.   -20.   13.8   10.3  0.679   0.00   108   571   12
07/16/96 08:55:05  UNIT 182
100 1691.  167.F  170.F  699.F   52.   22.3   -0.4    0.   -18.   13.6   10               0.00   1
07/16/96 08:55:17  UNIT 182
100 1765.  167.F  170.F  707.F   52.   24.3           0.   -18.
07/16/96 08:55:54
100 2110.           1.F  779.F

07/16/96 08:57:28  UNIT 182
100 2117.  168.F  173.F  815.F   52.   22.7   -0.4    0.   -18.   13.6   53.6  0.593   2.49   108   577   1295.
07/16/96 08:58:40  UNIT 182
100 2228.  170.F  176.F  865.F   52.   18.7   -0.4   44.   -19.   13.6   55.8  0.588   2.63   108   580   1295.
07/16/96 09:00:00  UNIT 182
100 2088.  171.F  177.F  887.F   52.   17.3    1.8   54.   -19.   13.6   57.9  0.584   2.26   108   583   1295.
07/16/96 09:10:30  UNIT 182
100 2027.  172.F  180.F  913.F   52.   -0.5   16.6  122.   -20.   13.6   60.3  0.579   2.31   108   610   1296.
07/16/96 10:00:00  UNIT 182
100 2060.  175.F  184.F  949.F   52.   -0.7   18.4  132.   -21.   13.5   62.6  0.575   2.46   108   733   1296.
07/16/96 11:00:00  UNIT 182
100 2050.  177.F  184.F  929.F   52.   -0.7   17.6  127.   -21.   13.5   58.7  0.583   2.52   108   884   1297.
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V.R.SYSTEMS INC.            MODEL V3 S/N 182
                            PERMIT NO.

 ENGINE       TEMPERATURE         OIL    POSITIONS      WELL FLOW    BATTERY  DUTY   PERCENT   AUXILIARY FUEL          ENGINE
   RPM    COOLANT  OIL  EXHAUST   PSI  CARB.  BYPASS   CFM-VAC.H20    VOLTS  CYCLE   OXYGEN  CFM THOUSANDS-UNITS      HOURS

07/16/96 11:18:27  UNIT 182
100  2068.   178.F  186.F  947.F   52.   -0.7   14.4   114.   -20.   13.5   62.9  0.574   2.79   108    933   1298.
07/16/96 11:20:21  UNIT 182
100  1790.   178.F  186.F  884.F   52.   -0.7    8.7    91.   -19.   13.5   64.1  0.572   2.31   108    937   1298.
07/16/96 11:21:05  UNIT 182
100  1732.   176.F  185.F  860.F   52.    4.4    7.6    67.   -18.   13.5   65.6  0.569   2.11   108    939   1298.
07/16/96 11:21:44  UNIT 182
100  1628.   178.F  184.F  846.F   52.   10.8    7.2    36.   -17.   13.3   62.1  0.576   2.05   108    940   1298.
07/16/96 11:22:32  UNIT 182
100  1589.   178.F  184.F  833.F   52.   17.6    6.3     0.   -17.   13.4   61.8  0.576   1.87   108    942   1298.
07/16/96 12:53:24  UNIT 182
100  1362.   174.F  174.F  691.F   52.   14.8   -0.4     0.   -19.   13.6   65.1  0.570   0.00   109     90   1299.
¿ESTART AT: 07/16/96 12:58:31 (07/16/96 12:53:37) S5245  V2.23 .
07/16/96 12:58:34 LIMIT  110 BATTERY     0.0   LOW BATT. VOLT ALARM     UNIT 182
07/16/96 12:58:34 LIMIT  414 ENG TMR   21136.   ENGINE FAILED ALARM      UNIT 182
07/16/96 12:58:34  UNIT 182
100     0.   191.F  150.F  416.F   61.  -25.0  -25.0     0.  -404.    0.0    0.1  0.700   0.00   109     90   1299.
07/16/96 12:58:49  UNIT 182
100     6.   190.F  149.F  410.F    0.   19.5   -0.4     0.   -20.   12.6    9.6  0.681   0.00   109     90   1299.
07/16/96 12:59:06  UNIT 182
100     5.   190.F  148.F  404.F    0.   19.0   -0.4     0.   -20.   12.5    9.6  0.681   0.00   109     90   1299.
07/16/96 12:59:32  UNIT 182
100     5.   189.F  147.F  395.F    0.   22.0   -0.4     0.   -20.   12.5    9.6  0.681   0.00   109     90   1299.
07/16/96 13:04:21 LIMIT  414 ENG TMR    283.   ENGINE FAILED ALARM    UNIT 182
¿ESTART AT: 07/17/96 14:01:03 (07/16/96 13:10:21) S5245  V2.23 .
07/17/96 14:01:06  UNIT 182
100     0.    92.F   95.F  124.F    2.  -25.0  -25.0     0.  -396.    0.0    0.1  0.700   0.00   109     90   1299.
07/17/96 14:01:17  UNIT 182
100    11.    92.F   95.F  124.F    8.   21.1   -0.4     0.   -24.   12.3    9.8  0.680   0.00   109     90   1299.
07/17/96 14:05:07  UNIT 182
100  1866.   153.F  116.F  722.F   53.   31.6   -0.5     0.   -21.   13.8    9.8  0.680   0.00   109     90   1299.
07/17/96 14:05:54  UNIT 182
100  1864.   162.F  126.F  760.F   53.   28.6   -0.5     0.   -21.   13.8    9.8  0.680   0.00   109     90   1299.
07/17/96 14:07:32  UNIT 182
100  2064.   164.F  142.F  808.F   53.   22.8   -0.4     0.   -21.   13.7   56.3  0.587   0.00   109     91   1300.
07/17/96 14:09:05  UNIT 182
100  2177.   166.F  152.F  806.F   53.   23.7   -0.4     0.   -21.   13.7   54.0  0.592   2.38   109     93   1300.
07/17/96 14:12:23  UNIT 182
100  2241.   168.F  168.F  901.F   53.   20.6   -0.4    36.   -21.   13.6   56.4  0.587   2.69   109    102   1300.
07/17/96 15:00:00  UNIT 182
100  2189.   178.F  186.F  989.F   52.   -0.9   19.1   136.   -25.   13.4   66.0  0.568   0.79   109    172   1300.
07/17/96 15:24:38 LIMIT  302  OIL PSI    27.   LOW OIL PSI SD         UNIT 182
07/17/96 15:24:41 LIMIT  414 ENG TMR   4981.   ENGINE FAILED ALARM    UNIT 182
¿ESTART AT: 07/17/96 15:58:03 (07/17/96 15:26:41) S5245  V2.23 .
07/17/96 15:58:[illegible]  UNIT 182
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07/17/96 15:58:18 UNIT 182

100	6.	184.F	143.F	298.F	0.	20.7	0.9	0.	-22.	12.5	9.8	0.680	0.00	109	190	1301.

07/17/96 15:58:41 UNIT 182

100	5.	184.F	143.F	296.F	0.	23.5	0.9	0.	-22.	12.5	32.1	0.636	0.00	109	190	1301.

07/17/96 15:59:30 UNIT 182

100	1705.	169.F	169.F	419.F	52.	23.2	-0.7	0.	-22.	13.7	9.7	0.681	0.00	109	190	1301.

07/17/96 16:04:15 UNIT 182

100	1852.	167.F	171.F	736.F	52.	23.2	-0.8	0.	-21.	13.6	9.8	0.680	0.00	109	190	1301.

07/17/96 16:08:38 UNIT 182

100	2214.	168.F	173.F	811.F	52.	24.0	-0.8	0.	-21.	13.6	56.8	0.586	2.32	109	194	1301.

ENGINE	RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM	VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS	UNITS	ENGINE HOURS
07/[illegible]/96 16:08:53 UNIT 182																
10[illegible]	[illegible].	168.F	174.F	830.F	52.	24.2	-0.8	0.	-21.	13.6	58.1	0.584	2.47	109	195	1301.
07/17/96 16:20:15 UNIT 182																
100	2202.	177.F	185.F	1108.F	52.	0.9	29.5	170.	-27.	13.5	64.9	0.570	1.35	109	208	1301.
07/17/96 17:00:00 UNIT 182																
100	2165.	176.F	185.F	1060.F	52.	-0.8	25.9	161.	-27.	13.5	62.3	0.575	1.38	109	254	1302.
07/17/96 17:04:28 UNIT 182																
100	2148.	176.F	185.F	1060.F	52.	-0.8	[illegible]	161.	-27.	13.5	63.5	0.573	1.32	109	260	1302.
07/17/96 18:00:00 UNIT 182																
100	2012.	171.F	180.F	1058.F	52.	-0.8	24.7	158.	-21.	13.6	63.2	0.574	1.06	109	323	1303.
07/17/96 19:00:00 UNIT 182																
100	2050.	168.F	177.F	1067.F	52.	-0.8	25.3	160.	-21.	13.7	61.8	0.576	1.02	109	388	1304.
07/17/96 20:00:00 UNIT 182																
100	2035.	168.F	176.F	1064.F	52.	-0.8	24.6	158.	-21.	13.7	62.6	0.575	0.90	109	447	1305.
07/17/96 21:00:00 UNIT 182																
100	2037.	168.F	176.F	1067.F	52.	-0.1	24.6	159.	-21.	13.7	62.6	0.575	0.90	109	504	1306.
07/17/96 22:00:00 UNIT 182																
100	2070.	168.F	175.F	1070.F	52.	-2.0	25.6	161.	-21.	13.8	61.0	0.578	0.92	109	564	1307.
07/17/96 23:00:00 UNIT 182																
100	2048.	168.F	177.F	1070.F	52.	-2.1	25.4	161.	-21.	13.7	61.9	0.576	0.96	109	623	1308.
07/17/96 23:21:41 UNIT 182																
100	2064.	167.F	176.F	1070.F	52.	-2.0	25.4	161.	-21.	13.7	61.3	0.577	0.96	109	645	1308.
07/18/96 00:00:00 UNIT 182																
100	2074.	167.F	176.F	1070.F	52.	-2.0	25.4	161.	-21.	13.7	62.2	0.576	0.97	109	684	1309.
07/18/96 01:00:00 UNIT 182																
100	2069.	167.F	175.F	1072.F	52.	-1.5	25.5	161.	-21.	13.8	61.4	0.577	0.96	109	744	1310.
07/18/96 02:00:00 UNIT 182																
100	2046.	167.F	174.F	1074.F	52.	-0.7	25.1	160.	-21.	13.8	59.6	0.581	0.93	109	805	1311.
07/18/96 03:00:00 UNIT 182																
100	2041.	168.F	175.F	1082.F	52.	-0.6	25.6	162.	-21.	13.7	62.8	0.574	0.96	109	864	1312.
07/18/96 04:00:00 UNIT 182																
100	2064.	168.F	175.F	1078.F	52.	-0.7	25.3	161.	-21.	13.7	60.4	0.579	0.96	109	925	1313.
07/18/96 05:00:00 UNIT 182																
100	2083.	167.F	173.F	1075.F	52.	-1.2	25.3	161.	-21.	13.8	60.6	0.579	0.98	109	987	1314.
07/18/96 06:00:00 UNIT 182																
100	2023.	167.F	174.F	1076.F	52.	-1.4	25.2	160.	-21.	13.7	61.5	0.577	0.91	110	46	1315.
07/18/96 06:42:34 UNIT 182																
100	1932.	168.F	175.F	1072.F	52.	-0.6	22.6	151.	-19.	13.7	66.3	0.567	0.78	110	86	1316.
07/18/96 06:44:00 UNIT 182																
100	1368.	170.F	174.F	1055.F	52.	-0.6	20.4	110.	-17.	13.6	99.9	0.500	0.00	110	87	1316.
07/18/96 06:44:33 UNIT 182																
100	1360.	170.F	173.F	1047.F	52.	-0.6	20.4	103.	-17.	13.7	99.9	0.500	0.00	110	87	1316.
07/18/96 06:45:05 UNIT 182																
100	1368.	169.F	172.F	1017.F	52.	-0.8	20.4	103.	-17.	13.7	99.9	0.500	0.00	110	87	1316.
07/18/96 06:45:47 UNIT 182																
100	1348.	168.F	170.F	990.F	52.	-1.1	20.4	103.	-17.	13.6	99.9	0.500	0.00	110	87	1316.
07/18/96 06:46:29 UNIT 182																
100	1379.	166.F	170.F	975.F	52.	-1.3	20.4	103.	-17.	13.6	99.9	0.500	0.00	110	87	1316.
07/18/96 06:47:07 UNIT 182																
100	1442.	165.F	169.F	964.F	52.	-1.5	20.4	113.	-17.	13.4	99.9	0.500	0.00	110	87	1316.
07/18/96 06:48:44 UNIT 182																
100	1889.	165.F	168.F	1002.F	52.	10.2	19.4	116.	-17.	13.7	65.2	0.570	0.00	110	87	1316.
07/18/96 06:49:31 UNIT 182																
100	1521.	166.F	168.F	1001.F	52.	15.4	17.5	28.	-15.	13.7	63.1	0.574	0.00	110	88	1316.
07/18/96 06:53:11 UNIT 182																
100	2096.	165.F	171.F	865.F	52.	23.6	-0.3	0.	-15.	13.7	49.7	0.601	2.28	110	96	1316.

	ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM	VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS	UNITS	ENGINE HOURS
07/18/96 07:00:00 UNIT 182																
100	2142.	168.F	175.F	1088.F	52.	5.2	26.4	159.	-21.	13.8	61.5	0.577	0.98	110	103	1316.
07/18/96 08:00:00 UNIT 182																
100	2047.	170.F	180.F	1089.F	52.	-2.4	27.5	167.	-20.	13.6	64.2	0.572	0.91	110	163	1317.
07/18/96 09:00:00 UNIT 182																
100	2045.	169.F	177.F	1080.F	52.	-2.3	27.5	168.	-21.	13.8	62.9	0.574	0.85	110	218	1318.
07/18/96 10:00:00 UNIT 182																
100	2039.	171.F	179.F	1089.F	52.	-2.9	28.5	171.	-21.	13.7	64.0	0.572	0.88	110	273	1319.
07/18/96 11:00:00 UNIT 182																
100	2047.	182.F	188.F	1093.F	52.	-2.8	28.1	169.	-20.	13.4	67.5	0.565	0.85	110	328	1320.
07/18/96 12:00:00 UNIT 182																
100	2050.	181.F	189.F	1096.F	52.	-2.3	28.0	170.	-20.	13.4	67.6	0.565	0.84	110	381	1321.
07/18/96 13:00:00 UNIT 182																
100	2043.	179.F	186.F	1089.F	52.	-2.3	28.0	170.	-24.	13.4	66.8	0.566	0.85	110	434	1322.
07/18/96 14:00:00 UNIT 182																
100	2034.	180.F	188.F	1089.F	52.	-2.3	27.8	170.	-24.	13.4	69.6	0.561	0.82	110	487	1323.
07/18/96 15:00:00 UNIT 182																
100	2047.	183.F	190.F	1087.F	52.	-1.9	27.8	169.	-24.	13.3	69.7	0.561	0.82	110	540	1324.
07/18/96 15:08:32 UNIT 182																
100	1955.	186.F	190.F	1082.F	52.	-1.8	24.9	159.	-26.	13.2	73.8	0.552	0.82	110	548	1324.
07/18/96 15:09:20 UNIT 182																
100	1935.	186.F	190.F	1077.F	52.	-1.8	24.8	158.	-26.	13.3	71.9	0.556	0.77	110	548	1324.
07/18/96 15:09:52 UNIT 182																
100	1947.	185.F	190.F	1074.F	52.	-1.8	24.9	157.	-26.	13.3	71.8	0.556	0.73	110	549	1324.
07/18/96 15:10:31 UNIT 182																
100	1810.	186.F	189.F	1072.F	52.	-1.8	21.4	144.	-25.	13.3	77.1	0.546	0.00	110	549	1324.
07/18/96 15:11:01 UNIT 182																
100	1411.	187.F	189.F	1065.F	52.	-1.8	21.4	114.	-23.	13.3	95.1	0.510	0.00	110	549	1324.
07/18/96 15:11:35 UNIT 182																
100	1511.	187.F	188.F	1049.F	52.	-1.8	21.3	119.	-24.	13.3	99.9	0.500	0.00	110	549	1324.
07/18/96 15:12:20 UNIT 182																
100	1492.	186.F	187.F	1031.F	52.	-1.8	21.3	123.	-24.	13.2	99.4	0.501	0.00	110	549	1324.
07/18/96 15:12:52 UNIT 182																
100	1617.	186.F	187.F	1060.F	52.	-1.8	21.3	132.	-25.	13.3	74.9	0.550	0.00	110	549	1324.
07/18/96 15:13:28 UNIT 182																
100	1635.	186.F	186.F	1046.F	52.	-1.8	21.3	134.	-25.	13.3	74.0	0.552	0.00	110	549	1324.

[illegible]ESTART AT: 07[illegible]18/96 16:06:09 (07/18/96 15:[illegible]3:36) S5245 V2.23

07/18/96 16:06:12 LIMIT 110 BATTERY 0.0 LOW BATT. VOLT ALARM UNIT 182

07/18/96 16:06:12 LIMIT 414 ENG TMR OVRNG ENGINE FAILED ALARM UNIT 182

	ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM	VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS	UNITS	ENGINE HOURS
07/18/96 16:06:12 UNIT 182																
100	0.	173.F	135.F	200.F	61.	-25.0	-25.0	0.	-398.	0.0[illegible]	0.1	0.700	0.00	110	549	1324.
07/18/96 16:06:23 UNIT [illegible]2																
100	19.	173.F	135.F	200.F	0.	-1.8	20.6	0.	-21.	12.3	9.7	0.681	0.00	110	549	1324.
07/18/96 16:06:50 UNIT 182																
100	8.	173.F	135.F	198.F	0.	0.8	18.7	0.	-21.	12.4	40.8	0.618	0.00	110	549	1324.
07/18/96 16:07:18 UNIT 182																
100	8.	173.F	135.F	196.F	0.	5.3	16.8	0.	-21.	12.4	99.9	0.500	0.00	110	549	1324.
07/18/96 16:07:56 UNIT 182																
100	8.	172.F	135.F	194.F	0.	11.6	14.0	0.	-21.	12.4	99.9	0.500	0.00	110	549	[illegible]324.
07/18/96 16:09:18 UNIT 182																
100	8.	171.F	134.F	189.F	0.	23.5	8.4	0.	-21.	12.5	99.9	0.500	0.00	110	549	1324.
07/18/96 16:10:17 UNIT 182																
100	8.	171.F	134.F	185.F	0.	23.6	4.6	0.	-21.	12.5	99.9	0.500	0.00	110	549	1324.
07/18/96 16:10:47 UNIT 182																
100	8.	171.F	133.F	183.F	0.	23.6	2.7	[illegible]	-21.	12.5	99.9	0.500	0.00	110	549	1324.

[illegible]T[illegible]AT AT: 07/18/96 16:11:49 (07/18/96 16:1[illegible]24) S5245 V2.23

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

Date / Time	Unit		Engine RPM	Temperature Coolant	Temperature Oil	Temperature Exhaust	Oil PSI	Positions Carb.	Positions Bypass	Well Flow CFM	Well Flow Vac.H2O	Battery Volts	Duty Cycle	Percent Oxygen	Auxiliary Fuel CFM	Thousands	Units	Engine Hours
7/14/96 20:00:00	UNIT 182	00	2071.	177.F	185.F	1003.F	52.	-0.4	20.1	138.	-21.	13.5	58.5	0.583	2.61	105	185	1270.
7/14/96 21:00:00	UNIT 182	00	2024.	175.F	183.F	998.F	52.	-0.4	19.6	135.	-21.	13.6	58.9	0.582	2.64	105	345	1271.
7/14/96 22:00:00	UNIT 182	00	2069.	173.F	181.F	995.F	52.	-0.4	19.4	135.	-21.	13.7	54.4	0.591	2.59	105	505	1272.
7/14/96 23:00:00	UNIT 182	00	2033.	173.F	181.F	998.F	52.	-0.4	19.6	135.	-21.	13.6	58.6	0.583	2.64	105	665	1273.
7/15/96 00:00:00	UNIT 182	00	2035.	171.F	179.F	1006.F	52.	-0.4	20.1	138.	-21.	13.6	57.6	0.585	2.68	105	827	1274.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
07/15/96 06:48:54	UNIT 182	100	2046.	169.F	178.F	949.F	52.	-0.6	17.0	123.	-20.	13.7	59.3	0.581	2.46	106	922	1281.
07/15/96 07:00:00	UNIT 182	100	2059.	170.F	179.F	949.F	52.	-0.6	17.0	123.	-19.	13.6	58.8	0.582	2.47	106	950	1281.
07/15/96 07:19:26	UNIT 182	100	1992.	169.F	179.F	928.F	52.	-0.6	13.2	110.	-18.	13.6	61.2	0.578	2.50	106	999	1282.
07/15/96 07:20:18	UNIT 182	100	1998.	169.F	178.F	912.F	52.	1.6	11.5	102.	-18.	13.7	60.9	0.578	2.48	107	1	1282.
07/15/96 07:20:46	UNIT 182	100	1916.	169.F	178.F	908.F	52.	0.6	10.8	100.	-18.	13.7	62.5	0.575	2.47	107	2	1282.
07/15/96 07:21:04	UNIT 182	100	1830.	169.F	178.F	903.F	52.	-0.4	9.6	96.	-18.	13.7	61.5	0.577	2.39	107	3	1282.
07/15/96 07:22:33	UNIT 182	100	1503.	171.F	177.F	863.F	52.	11.2	7.5	25.	-16.	13.6	64.2	0.572	1.95	107	6	1282.
07/15/96 08:00:00	UNIT 182	100	1851.	168.F	175.F	840.F	52.	19.5	-0.4	0.	-17.	13.6	61.5	0.577	2.25	107	93	1282.
07/15/96 08:58:28	UNIT 182	100	1826.	180.F	183.F	832.F	52.	19.5	-0.5	0.	-17.	13.5	63.3	0.573	2.21	107	227	1283.
07/15/96 09:00:00	UNIT 182	100	1811.	179.F	184.F	836.F	52.	19.4	-0.5	0.	-17.	13.5	62.7	0.575	2.19	107	230	1283.
07/15/96 09:30:28	UNIT 182	100	1795.	182.F	189.F	930.F	52.	-0.5	11.8	104.	-18.	13.4	65.7	0.569	2.27	107	304	1284.
07/15/96 09:31:20	UNIT 182	100	1778.	182.F	188.F	907.F	52.	0.6	10.5	98.	-18.	13.4	63.2	0.574	2.03	107	306	1284.
07/15/96 09:32:36	UNIT 182	100	1826.	183.F	187.F	898.F	52.	8.3	5.4	69.	-17.	13.4	63.4	0.573	2.07	107	309	1284.
07/15/96 09:37:17	UNIT 182	100	2109.	179.F	186.F	912.F	52.	19.2	0.8	48.	-17.	13.4	61.5	0.577	2.25	107	320	1284.
07/15/96 09:59:51	UNIT 182	100	1839.	183.F	190.F	940.F	52.	-0.3	12.6	107.	-18.	13.4	64.9	0.570	2.34	107	377	1284.
07/15/96 10:00:00	UNIT 182	100	1786.	183.F	190.F	935.F	52.	-0.3	12.5	108.	-18.	13.4	66.4	0.567	2.25	107	378	1284.
07/15/96 10:00:36	UNIT 182																	

APPENDIX C

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: George AFB

Date: 07-10-96

Operator's Initials: RMW

Equipment	Check If Okay	Comments
Liquid Ring Pump	✓	
Aqueous Effluent Transfer Pump	✓	
Oil/Water Separator	✓	
Vapor Flowmeter	✓	
Fuel Flowmeter	✓	
Water Flowmeter	✓	
Emergency Shut off Float Switch	✓	High
Effluent Transfer Tank	✓	Low
Analytical Field Instrumentation	✓	
GasTector™ O_2/CO_2 Analyzer	-	
TraceTector™ Hydrocarbon Analyzer	-	
Oil/Water Interface Probe	✓	
Magnehelic Boards	✓	
Thermocouple Thermometer	✓	

APPENDIX D

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Baildown Test Record Sheet

Site: ColumBus AFB CA.

Well Identification: mw - 32

Well Diameter (OD/ID): 4" ID

Date at Start of Test: 7/11/96

Sampler's Initials: JE

Time at Start of Test: 1205

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L
124.10	122.48	1.62	

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1205	123.0	122.93	0.07
1209	123.15	122.75	0.4
1221	123.2	122.75	0.45
1316	123.18	122.74	0.44
1413	123.15	122.70	0.45
2000	123.15	122.67	0.48

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

Page ___ of ___

Site: George AFB - MW52 Test Type: Bioslurper

State Date and Time: 7.14.96 2:10 pm Operators: Eastep & Headington

	Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
7.14.96	2:10 pm	0	0	0
	3.16 pm	1.1		6L / 3 min
7.15.96	6:30 am	16.3		9L / 4 min
	8 am	17.8		7.5L / 4 min
	8:30 am	18.3	Shutdown to move TC	& install 2" pitot tube
	9:05 am	18.3	restarted	
	9:10 am	18.4		6.7 L / 3 min
	9:30 am	18.8		6.5 L / 3 min
	10 am	19.3		6.5 L / 4 min
	10:35 am	19.8		7.5 L / 6 min
	11 am	20.3		4 L / 5 min
	11:35	20.8		7.2 L / 3 min
	12:15 pm	21.5		8.5L / 3.5 min
	1:41 pm	22.9		7.3L / 3 min
	3 pm	24.3		7.9L / 3.5 min
	3.30 pm	24.8	Shutdown - lowered drop tube	
	4 pm	24.8	restarted	5.7 L / 3 min
	4:45 pm	25.5		7L / 2 min
	5:15	26		8.2 L / 2 min
	5:45	26.5		7.9 L / 2.5 min
	5:45	26.5	Shutdown to change to 0.5" drop tube	
	6:17 pm	26.5	startup	
	6:30 pm	26.7		2.4L / 4 min

continued

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

Page 2 of ___

Site: George MW-32 Test Type: Bioslurpe

State Date and Time: 7.14.96 2:10pm Operators: Eastep & Headington

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
7.15 96 6:51 pm	27.1 ~~0~~	Ø	2.1 L/4 min
7:10pm	~~0.32~~	27.7 Ø	2 L/4.5 min
7:30	~~0.65~~	28.1 Ø	1.35 L/3 min
8	~~1.18~~	28.6 shutdown	
7.16.96 7:50am	~~1.15~~	28.6 startup	
7:55am	~~1.23~~	28.63 Ø	1.85 L/3 min
8:10 am	~~1.48~~	28.9 Ø	1.495 L /3 min
8:20am	~~1.68~~	29.1 Ø	1 L/3 min
8:45am	29.5	Ø	2.05 L/4.1 min
	29.5	shutdown to change to 1.25" drop tube	
9.56am	29.5	startup	
10:36am	30.1	Ø	7.5 L/2 min
11:38am	31.2	Ø	6.7 L/1.5 min
11:58am	31.7	Ø	2.1 L/4 min
12:30pm	32.2	Shutdown	
1:30		startup, but unable to maintain flow	

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

Site: George AFB   Test Type: Bioslurper

State Date and Time: 17 July 1996 - 3:11 pm

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
7/17/96 3:11 pm	0	0	0
4:10 pm	1	Shutdown for 1 hour - high water T	
5:12 pm		Restarted	
5:20 pm	1.12 h	5.2 gallons	0
9 pm	4.79 h	0	3 L/min (all tap water)
7/18/96 12 am	7.79 h	1.5 gallons	8 L/2.35 min
7:23 am	15.2 h	0.7 gallons	8 L/2.37 min
6:25 pm	26.2 h	3.3 gallons	8 L/2.41 min
7/19/96 9 am	40.8 h	8.1 gallons	6 L/2.13 min
3 pm	46.8	2.4 gallons	6 L/2.12 min
7/20/96 8 am		Shutdown - out of fuel	
10 am		Restarted	
10:08 am	63.9 h	7.7 gallons	6 L/2.07 min
5:16 pm	71.1 h	3.3 gallons	6 L/2.15 min
7/21/96 8 am	85.8 h	3.4 gallons	6 L/2.52 min
1 pm	90.8 h	1.2 gallons	6 L/2.43 min
		4 gallons of fuel recovered when cleaning OWS and filter tank	

APPENDIX E

LABORATORY ANALYTICAL REPORTS

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9607217

Work Order Summary

CLIENT:	Ms. Amanda Bush Battelle Memorial Institute 505 King Avenue Columbus, OH 43201-2693	**BILL TO:**	Same
PHONE:	614-424-4996	**INVOICE #**	11151
FAX:	614-424-3667	**P.O. #**	91221
DATE RECEIVED:	7/22/96	**PROJECT #**	G462201-30D0301 George AFB
DATE COMPLETED:	7/30/96	**AMOUNT$:**	$836.17

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	Seal Tank - #1	TO-3	4.5 "Hg	$120.00
02A	Seal Tank - #2	TO-3	4.5 "Hg	$120.00
03A	Seal Tank - #3	TO-3	5.0 "Hg	$120.00
04A	Seal Tank - #4	TO-3	5.5 "Hg	$120.00
05A	ICE - 1	TO-3	7.0 "Hg	$120.00
06A	ICE - 2	TO-3	7.0 "Hg	$120.00
07A	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter Summa Canister Preparation (6) @ $15.00 each.	$90.00
	Shipping (7/3/96)	$26.17

CERTIFIED BY: Linda L. Freeman

Laboratory Director

DATE: 7/31/96

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

AIR TOXICS LTD.

SAMPLE NAME: Seal Tank - #1

ID#: 9607217-01A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6072511**		**Date of Collection: 7/15/96**	
Dil. Factor:	**23800**		**Date of Analysis: 7/25/96**	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	24	77	1400	4500
Toluene	24	91	2200	8400
Ethyl Benzene	24	110	860	3800
Total Xylenes	24	110	2200 M	9700 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	**6072511**		**Date of Collection: 7/15/96**	
Dil. Factor:	**23800**		**Date of Analysis: 7/25/96**	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	240	1600	72000	470000
C2 - C4** Hydrocarbons	240	440	10000	18000

*TPH referenced to Jet Fuel (MW=156)

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

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Seal Tank - #2

ID#: 9607217-02A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6072512**		**Date of Collection: 7/15/96**	
Dil. Factor:	**23800**		**Date of Analysis: 7/25/96**	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	24	77	2000	6500
Toluene	24	91	3300	13000
Ethyl Benzene	24	110	1400	6200
Total Xylenes	24	110	3800 M	17000 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	**6072512**		**Date of Collection: 7/15/96**	
Dil. Factor:	**23800**		**Date of Analysis: 7/25/96**	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	240	1600	140000	910000
C2 - C4** Hydrocarbons	240	440	10000	18000

*TPH referenced to Jet Fuel (MW=156)

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

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Seal Tank - #3

ID#: 9607217-03A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6072514		Date of Collection: 7/19/96	
Dil. Factor:	121000		Date of Analysis: 7/25/96	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	120	390	3800	12000
Toluene	120	460	6000 M	23000 M
Ethyl Benzene	120	530	2200	9700
Total Xylenes	120	530	5000 M	22000 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6072514		Date of Collection: 7/19/96	
Dil. Factor:	121000		Date of Analysis: 7/25/96	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	1200	7800	110000	710000
C2 - C4** Hydrocarbons	1200	2200	50000	91000

*TPH referenced to Jet Fuel (MW=156)

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

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Seal Tank - #4

ID#: 9607217-04A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6072515		Date of Collection: 7/19/96	
Dil. Factor:	124000		Date of Analysis: 7/25/96	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	120	390	5100	16000
Toluene	120	460	3500	13000
Ethyl Benzene	120	530	3000	13000
Total Xylenes	120	530	7200 M	32000 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6072515		Date of Collection: 7/19/96	
Dil. Factor:	124000		Date of Analysis: 7/25/96	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	1200	7800	160000	1000000
C2 - C4** Hydrocarbons	1200	2200	72000	130000

*TPH referenced to Jet Fuel (MW=156)

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

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: ICE - 1

ID#: 9607217-05A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6072516 **Date of Collection:** 7/19/96

Dil. Factor: 1320 **Date of Analysis:** 7/25/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.3	4.3	5.8	19
Toluene	1.3	5.1	52	200
Ethyl Benzene	1.3	5.8	58	260
Total Xylenes	1.3	5.8	190 M	840 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name: 6072516 **Date of Collection:** 7/19/96

Dil. Factor: 1320 **Date of Analysis:** 7/25/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	13	86	2600	17000
C2 - C4** Hydrocarbons	13	24	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

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

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: ICE - 2

ID#: 9607217-06A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6072520		Date of Collection: 7/19/96	
Dil. Factor:	13.2		Date of Analysis: 7/25/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.013	0.043	0.11	0.36
Toluene	0.013	0.051	0.25 M	0.96 M
Ethyl Benzene	0.013	0.058	0.12	0.53
Total Xylenes	0.013	0.058	0.31 M	1.4 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6072520		Date of Collection: 7/19/96	
Dil. Factor:	13.2		Date of Analysis: 7/25/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.13	0.86	13	84
C2 - C4** Hydrocarbons	0.13	0.24	0.65	1.2

*TPH referenced to Jet Fuel (MW=156)

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

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9607217-07A

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

GC/PID

File Name:	**6072506**		**Date of Collection: NA**	
Dil. Factor:	**1.00**		**Date of Analysis: 7/25/96**	

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 Jet Fuel)

File Name:	**6072506**		**Date of Collection: NA**	
Dil. Factor:	**1.00**		**Date of Analysis: 7/25/96**	

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 Jet Fuel (MW=156)

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

Container Type: NA

Battelle
Columbus Laboratories

9607217

Form No. /

CHAIN OF CUSTODY RECORD

Proj. No. 3462201 – 30D0301

Project Title GEORGE AFB

SAMPLERS: (Signature) [illegible]

	DATE	TIME	SAMPLE I.D.	BTEX	TPH												Container No.	Number of Containers	Remarks
1A	07-15-96	0935	SEAL TANK – #1	X	X													1	4.5' ft
2A	07-15-96	0938	SEAL TANK – #2	X	X													1	4.5' ft
3A	07-19-96	1020	SEAL TANK – #3	X	Y													1	5.0' ft
4A	07-19-96	1022	SEAL TANK – #4	X	Y													1	5.5' ft
5A	07-19-96	1042	ICE – 1	X	X													1	7.0' ft
6A	07-19-96	1050	ICE – 2	X	X													1	7.0' ft
																			7/22/96

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[illegible]	07/19/96 1855				

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
		Scott [illegible] ATL	7/22/96 928	SEND RESULTS TO: JEFF KITTEL 505 KING AVE. [redacted]

[redacted]

Alpha Analytical, Inc.
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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#: G462201-30D0301
Phone: (614) 424-6199
Attn: Jeff Kittel

Sampled: 07/19/96 Received: 07/22/96 Analyzed: 08/02/96

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
GW-1 /BMI072296-02	TPH (Purgeable)	9.2	2.50 mg/L
	Benzene	560	5.0 ug/L
	Toluene	1600	5.0 ug/L
	Ethylbenzene	350	5.0 ug/L
	Total Xylenes	2500	5.0 ug/L
GW-2 /BMI072296-03	TPH (Purgeable)	8.4	2.50 mg/L
	Benzene	490	5.0 ug/L
	Toluene	1400	5.0 ug/L
	Ethylbenzene	320	5.0 ug/L
	Total Xylenes	2300	5.0 ug/L

ND - Not Detected

Approved by: Roger L. Scholl Date: 8/2/96
Roger L. Scholl, Ph.D.
Laboratory Director

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ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30D0301
Phone: (614) 424-6199
Attn: Al Pollack

Alpha Analytical Number: BMI072296-01

Client I.D. Number: GF-1

Date Sampled: 07/19/96

Date Received: 07/22/96

Compound	Method	Concentration mg/Kg	Detection Limit mg/Kg	Date Analyzed
Benzene	8240	ND	193	07/31/96
Toluene	8240	3,800	193	07/31/96
Total Xylenes	8240	3,100	193	07/31/96
Ethylbenene	8240	22,000	193	07/31/96
C-range Compounds	**Method**	**Percentage of Total**	**Detection Limit (Not Applicable)**	**Date Analyzed**
≤C08	GC/FID	17.53	NA	11/05/96
C9	GC/FID	17.18	NA	11/05/96
C10	GC/FID	19.32	NA	11/05/96
C11	GC/FID	16.81	NA	11/05/96
C12	GC/FID	13.89	NA	11/05/96
C13	GC/FID	8.75	NA	11/05/96
C14	GC/FID	4.32	NA	11/05/96
C15	GC/FID	1.41	NA	11/05/96
>C16	GC/FID	0.80	NA	11/05/96

Approved by: Roger L. Scholl

Roger L. Scholl, Ph.D.
Laboratory Director

Date: 11/5/96

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ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30D0301
Phone: (614) 424-6199
Attn: Al Pollack

Alpha Analytical Number: BMI072296-01

Client I.D. Number: GF-1

Date Sampled: 07/19/96

Date Received: 07/22/96

Compound	Method	Concentration mg/Kg	Detection Limit mg/Kg	Date Analyzed
Benzene	8240	ND	193	07/31/96
Toluene	8240	3,800	193	07/31/96
Total Xylenes	8240	3,100	193	07/31/96
Ethylbenene	8240	22,000	193	07/31/96
C-range Compounds	**Method**	**Percentage of Total**	**Detection Limit (Not Applicable)**	**Date Analyzed**
≤C08	GC/FID	17.53	NA	11/05/96
C9	GC/FID	17.18	NA	11/05/96
C10	GC/FID	19.32	NA	11/05/96
C11	GC/FID	16.81	NA	11/05/96
C12	GC/FID	13.89	NA	11/05/96
C13	GC/FID	8.75	NA	11/05/96
C14	GC/FID	4.32	NA	11/05/96
C15	GC/FID	1.41	NA	11/05/96
>C16	GC/FID	0.80	NA	11/05/96

Approved by: Roger L. Scholl

Date: 11/5/96

Roger L. Scholl, Ph.D.
Laboratory Director

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ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G462201-30D0301
Phone: (614) 424-6199
Attn: Jeff Kittel

Sampled: 07/19/96 Received: 07/22/96 Analyzed: 07/31/96

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	
GF-1 /BMI072296-01	TPH (Purgeable)	780,000	97,000	mg/Kg
	Benzene	ND	193,000	ug/Kg
	Toluene	3,800	193,000	ug/Kg
	Ethylbenzene	3,100	193,000	ug/Kg
	Total Xylenes	22,000	193,000	ug/Kg

SAMPLE LAB LABELED AS FUEL SAMPLE

ND - Not Detected

Approved by: Roger L. Scholl Date: 8/1/96
Roger L. Scholl, Ph.D.
Laboratory Director

APPENDIX F

SOIL GAS PERMEABILITY TEST RESULTS

Record Sheet for Air Permeability Test	
Site GEORGE AFB	Monitoring Point MW-96
Blower Type 10 HP BIOSLURPER	Distance from Vent Well
Depth of Point 80'-100'-130'	Recorded by

Time	80 ~~MP1~~	100 ~~MP2~~	130 ~~MP3~~	Time	MP1	MP2	MP3
-0-	<0	<0	.50				
1 min	<0	<0	.50				
2 min	<0	<0	.95				
10 min	<0	<0	1.25				
28 min	<0	<0	1.50				
57 min	<0	<0	2.00				
2 HR 4 min	<0	<0	2.00				
7/15/96 1020	.37	.46	3.00				
1353	-0	-0	3.00				

AIRPERM.RS (G462201-1001 DISK)

Record Sheet for Air Permeability Test

Site GEORGE AFB	**Monitoring Point** MW - 95
Blower Type 10 HP BIOSLURPER	**Distance from Vent Well**
Depth of Point 80' - 100' - 130'	**Recorded by** M WOOLFE

Time	80 ~~MP1~~	100 ~~MP2~~	130 ~~MP3~~	Time	MP1	MP2	MP3
1410 -0-	0	0	0				
1 min	-0	-0	-0				
2 min	-0	-0	-0				
3 min	-0	-0	-0				
4 min	-0	-0	-0				
5 min	-0	-0	-0				
6							
7							
8							
9							
10 min	-0	-0	.20				
20 min	-0	-0	.32				
60 min	-0	-0	.40				
1508 120 min	-0	0	.42				
7/15/96 1020	.30	.27	1.0				
1354	-0	-0	0.08				

Record Sheet for Air Permeability Test	
Site GEORGE AFB	Monitoring Point mW-94
Blower Type 10 HP BIOSLURPER	Distance from Vent Well
Depth of Point 80'-100'-130'	Recorded by M Woolfe

Time	80 ~~MP1~~	100 ~~MP2~~	130 ~~MP3~~	Time	MP1	MP2	MP3
1910 -0-	-0	-0	-0				
1 min	-0	-0	-0				
2 min	-0	-0	-0				
3 min	-0	-0	-0				
4 min	-0	-0	-0				
5 min	-0	-0	-0				
6							
7							
8							
9							
10 min	<0	-0	-0				
20 min	<0	-0	-0				
60 min	≈0	-0	-0				
1608 120 min	-0	-0	-0				
7/15/96 1022	.28	.55	.50				
1354	-0	-0	-0				

APPENDIX G

IN SITU RESPIRATION TEST RESULTS

Record Sheet for In Situ Respiration Test

Site GEORGE AFB

Monitoring Point MW-97

Shutdown Date 07-19-96

O_2/CO_2 Meter No.

TPH Meter No. GASTECH-GT201 (HAZCO)

Shutdown Time 1530 HRS

Recorded by WOLFE / EASTEP

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
07-19-96	1530	20.9	0.0	680	1.3	—	80' DEEP
"	"	20.5	0.0	700	1.2	—	100' DEEP
07-19-96	1730	20.0	0.0	440	1.1	—	
"	"	20.0	0.0	640	1.2	—	
07-20-96	1030	19.3	0.3	2,220	1.1	—	
"	"	19.3	0.3	820	1.2	—	
07-20-96	1716	19.8	0.7	>10,000	1.1	—	
"	"	20.0	0.3	2,740	1.1	—	
07-21-96	2200	19.0	1.0	>10,000	1.2	—	
"	"	1.0	18.5	>10,000	.90	—	
07-22-96	1823	18.7	1.0	>10,000	1.1	—	
"	"	17.2	1.1	>10,000	0.84	—	

Record Sheet for In Situ Respiration Test

Site GEORGE AFB

Shutdown Date 07-19-96

Shutdown Time 1530

Monitoring Point MW 95

O_2/CO_2 Meter No.

TPH Meter No. GASTECH GT201 (HAZCO)

Recorded by WOOHE / EASTEP

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
07-19-96	1530	20.3	0.2	1720	1.1	—	80' DEEP
07-19-96	1730	20.8	0.0	1120	1.2	—	
07-20-96	1030	19.0	0.5	3900	1.1	—	
07-20-96	1716	20.0	0.5	>10,000	1.2	—	
07-21-96	2200	19.8	0.7	>10000	1.2	—	
07-22-96	1823	19.5	0.7	>10,000	1.1	—	

Record Sheet for In Situ Respiration Test

Site George AFB	Monitoring Point mw 96
Shutdown Date 07-19-96	O_2/CO_2 Meter No. — TPH Meter No. GASTECH GT201 (HAZCO)
Shutdown Time 1530	Recorded by Woolfe / EASTEP

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
07-19-96	1530	20.5	0.0	820	1.2	—	80' DEEP
07-19-96	1730	20.0	0.0	220	1.1	—	
07-20-96	1030	19.0	0.5	1,140	1.2	—	
07-20-96	1716	20.2	0.3	9,820	1.1	—	
07-21-96	2200	19.9	0.8	>10,000	1.2	—	
07-22-96	1823	19.5	0.8	>10,000	1.1	—	

INSITU.RS (G462201-1001 DISK)