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FINAL DESIGN PACKAGE

BASIS OF DESIGN REPORT

SOIL AND GROUNDWATER REMEDIATION
OPERABLE UNIT NO. 2

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0222

MAY 10, 1994

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

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1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) effective October 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, the United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (NC DEHNR), and the United States Department of the Navy (DON) entered into a Federal Facilities Agreement (FFA) for MCB Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at MCB Camp Lejeune were thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives were developed and implemented as necessary to protect public health and the environment.

This Final Design Package Basis of Design presents Baker Environmental's (Baker) approach to the Remedial Design (RD) activities for soil and groundwater remediation at Operable Unit (OU) No.2, MCB Camp Lejeune, North Carolina. The purpose of this Basis of Design is to present a summary of the design approach including the critical design parameters and assumptions on which they were based. This document has been prepared under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-89-D-4814, based on the scope of work for Contract Task Order (CTO) Number 0222.

The planned remedial action has been documented in the Final Record of Decision (ROD) for OU No. 2, which was signed in September 1993. The Navy/Marine Corps has obtained concurrence from the State of North Carolina and USEPA Region IV to proceed with the design and implementation of this remedial action.

In accordance with discussions with LANTDIV, the "Final Design Package" is intended to present preliminary engineering data and performance based specifications for the remedial action for OU No. 2. The Final Design Package is intended to be equivalent in content to a 100 percent design submittal. The Final Design Package is not intended to be used for construction by a contractor.

1.1 Site Background

Detailed site background information on OU No. 2 is provided in the Final Remedial Investigation Report (RI) (Baker, 1993b) and the Project Plans for Contaminated Soil and Groundwater Remedial Design (Baker, 1994). A brief site description follows.

Camp Lejeune is a training base of the Marine Corps, located in Onslow County North Carolina (Figure 1-1). The base covers approximately 236 square miles and is bounded to the southeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is north of the base.

OU No. 2 is located approximately 2 miles east of the New River and 2 miles south of State Route 24 on the main section of MCB Camp Lejeune. The operable unit is bordered by Holcomb Boulevard to the west, Sneads Ferry Road to the south, Piney Green Road to the east, and by Wallace Creek, which makes up the northern boundary. Camp Lejeune Railroad operates rail lines parallel to Holcomb Boulevard bordering OU No. 2. OU No. 2 covers an area of approximately 210 acres, and contains Sites 6, 9, and 82. Figure 1-2 is a site plan of the operable unit. No soil or groundwater remediation was determined to be necessary at Site 9. Therefore, the remedial design focuses on the remediation of six areas of concern within Sites 6 and 82, and the restoration of the shallow and Castle Hayne aquifers.

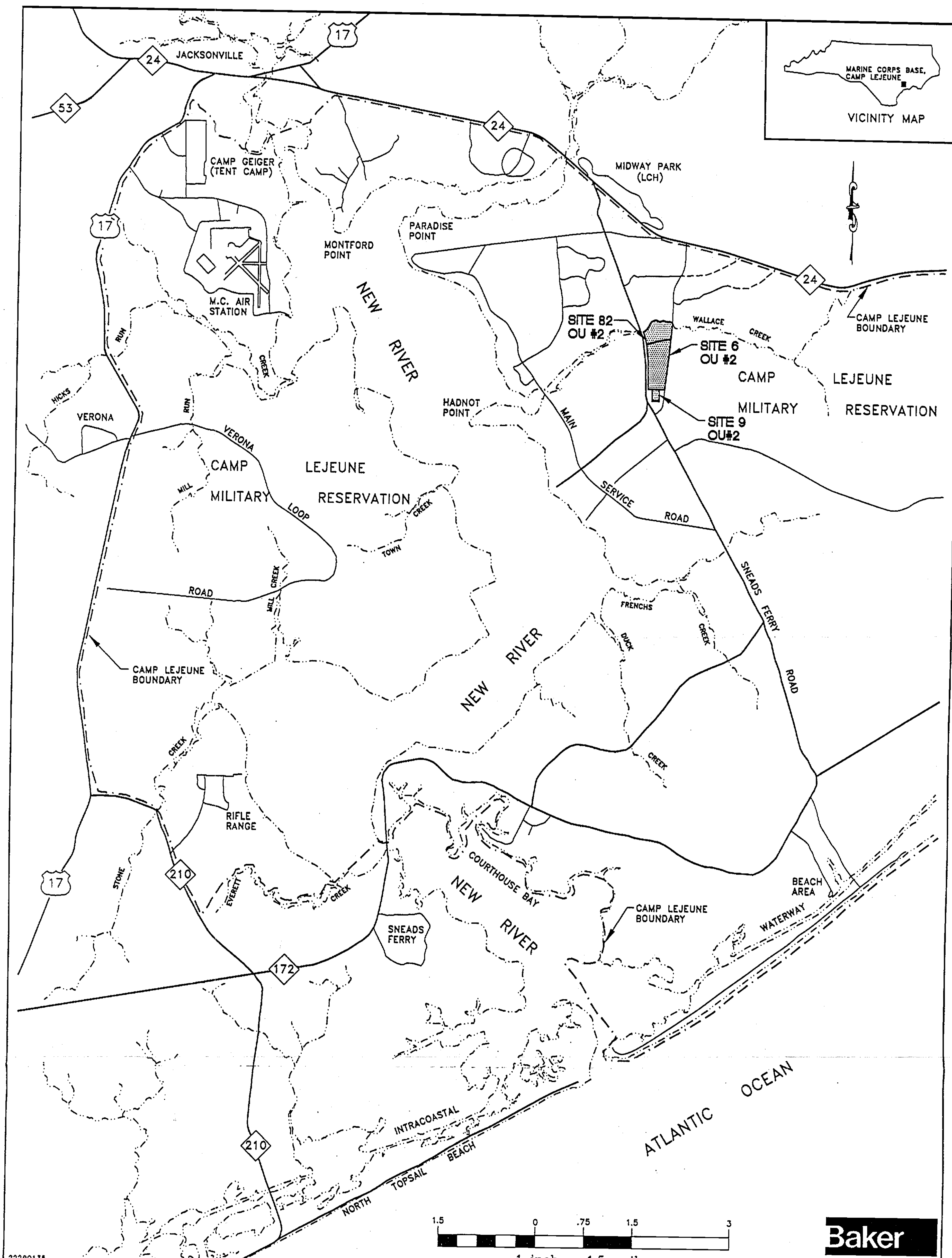

FIGURE 1-1
LOCATION MAP
OPERABLE UNIT No.2, SITES 6, 9, and 82
SOIL AND GROUNDWATER REMEDIATION
CTO-0222
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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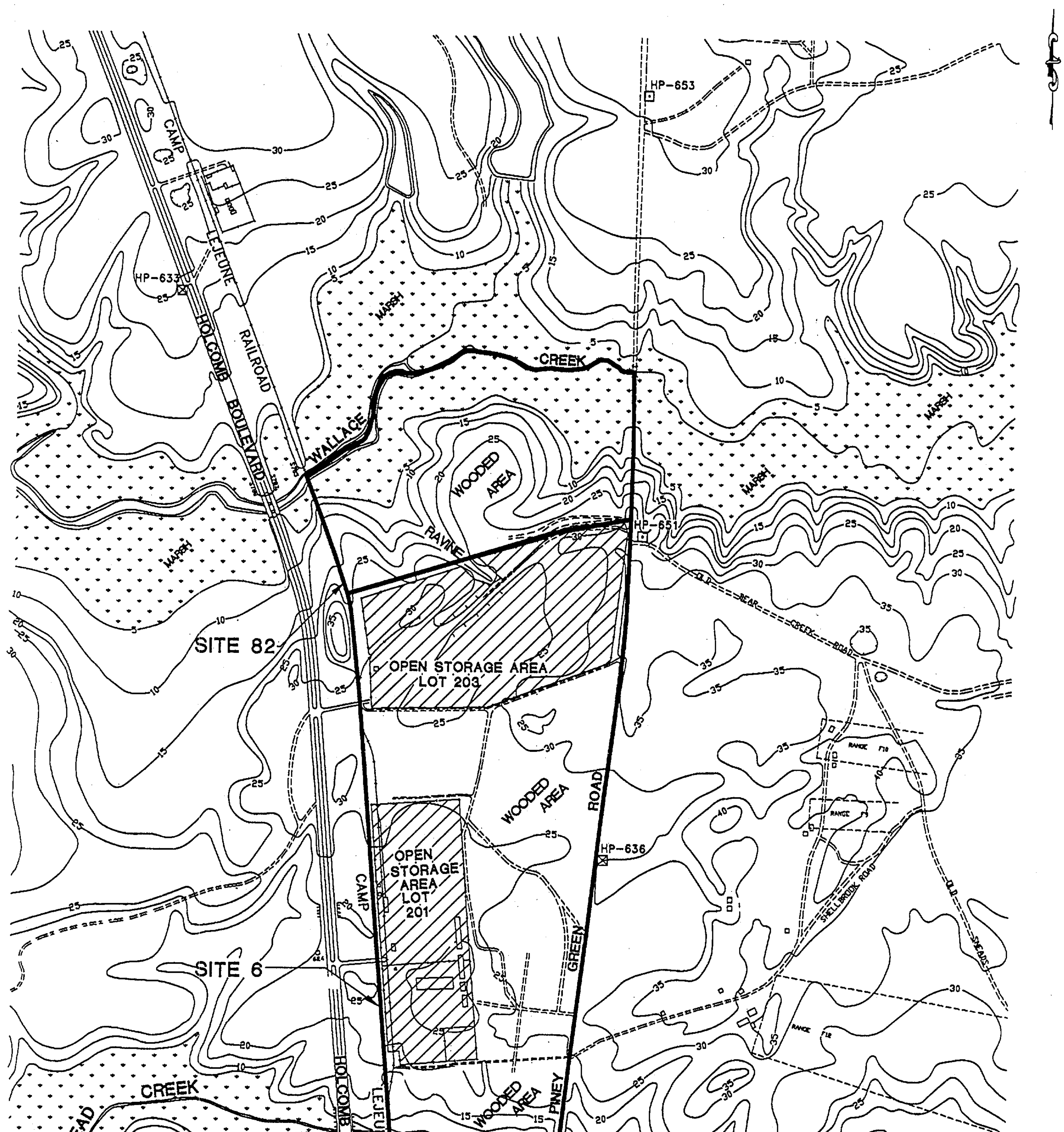

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LEGEND

- APPROXIMATE SITE BOUNDARIES
- OPEN STORAGE AREA
- UNPAVED ROAD
- HP-635 ACTIVE WATER SUPPLY WELL
- HP-653 INACTIVE WATER SUPPLY WELL

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 1-2
SITE PLAN OF OPERABLE UNIT No. 2,
SITES 6, 9, and 82
SOIL AND GROUNDWATER REMEDIATION
CTO-0222
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

1.2 Previous Investigations

In 1983 an Initial Assessment Study (IAS) was conducted at MCB Camp Lejeune by Water and Air Research, Inc. The study identified a number of areas within the facility, including Sites 6 and 9, as potential sources of contamination. As a result of this study, Environmental Science and Engineering, Inc. (ESE) was contracted by the DON to further investigate these sites.

During 1984 through 1987, ESE conducted a Confirmation Study at OU No. 2 which focused on potential source areas identified in the IAS and the administrative record file. The study consisted of collecting a limited number of environmental samples (soil, sediment, surface water, and groundwater) for purposes of constituent analysis. In general, the results detected the presence of pesticides in Lot 203, VOCs in the groundwater, and VOCs in the surface water.

A soil gas survey was conducted at Lot 203 in February 1989. The purpose of this survey was to identify the presence of VOCs that may potentially affect personnel working within Lot 203. No imminent hazards were observed from the results of the survey.

On October 4, 1989, Camp Lejeune was placed on the NPL. The DON, the USEPA, and the NC DEHNR entered into a FFA on February 13, 1991.

In June 1991, a Site Investigation was conducted at Site 82 by Halliburton/NUS Environmental Corporation. The investigation consisted of drilling and sampling six shallow soil borings; installing and sampling three shallow monitoring wells; and sampling surface water and sediment of Wallace Creek. The results indicated that Wallace Creek was contaminated. During this investigation, it was determined that the source of VOCs detected in Wallace Creek was not likely from Site 6. Therefore, the area north of Lot 203 was considered a new site, Site 82.

A Site Assessment Report was prepared by ESE in March 1992. This report contained a summary of the previously conducted Confirmation Study in addition to a preliminary risk evaluation for Site 6. This report recommended that a full human health and ecological risk assessment be performed at Site 6.

In 1992, Baker conducted a Remedial Investigation (RI) field program at OU No. 2 to characterize potential environmental impacts and threats to human health resulting from previous storage, operational, and disposal activities. The RI field program was conducted in two phases. The first phase was initiated on August 21, 1992 and continued through November 10, 1992. A second phase commenced in early 1993 and was completed by May 1993. Based on the results of the RI, Baker prepared a Feasibility Study (FS) that identified alternatives for remediating the contaminants detected at OU No. 2 (Baker, 1993c).

1.3 Summary of Remedial Investigation and Feasibility Studies

Based on the information collected during the RI, and the evaluation of potential human health and ecological risks, remedial action alternatives (RAAs) were developed as part of the FS to address contaminated media (both soil and groundwater) at various areas of concern (AOCs) within OU No. 2. Note that no AOCs were identified within Site 9. Wallace Creek will not be remediated since additional adverse environmental impacts could result via direct remediation, and the sources of the surface water and sediment contamination will be addressed (i.e., contaminated groundwater and contaminated soil in the ravine). In addition, with the exception of AOC 2, areas where drums and containers have been identified are not being considered as AOCs. All surficial drums and known buried drums/containers have been removed from OU No. 2 through a separate Time-Critical Removal Action.

The following soil AOCs were identified in the FS and are included in this remedial design:

- Source of groundwater VOC contamination at Site 82 (Soil AOC 1).
- Upper portion of the ravine at Site 6 with detected levels of PAHs, PCBs and metals in soil and sediment (Soil AOC 2). This may be the source of sediment contamination in Wallace Creek.
- North central portion of Lot 203 with detected levels of PCBs in soil (Soil AOC 3).
- Northwestern portion of Lot 203 with detected levels of PCBs in soil (Soil AOC 4).
- Northeastern corner of Lot 201 with detected levels of pesticides in soil (Soil AOC 5).
- Wooded area east of Lot 201 and adjacent to Piney Green Road with detected levels of PCBs in soil (AOC 6).

Figure 1-3 shows the locations of the soil AOCs.

The following groundwater AOCs were identified in the FS and are included in this remedial design:

- VOC contaminated groundwater plumes [shallow (i.e., less than 30 feet) and deep (i.e, greater than 100 feet) originating from Site 82.

Figure 1-4 shows the approximate location of the groundwater AOC at Site 82.

1.4 Site Remediation Goals

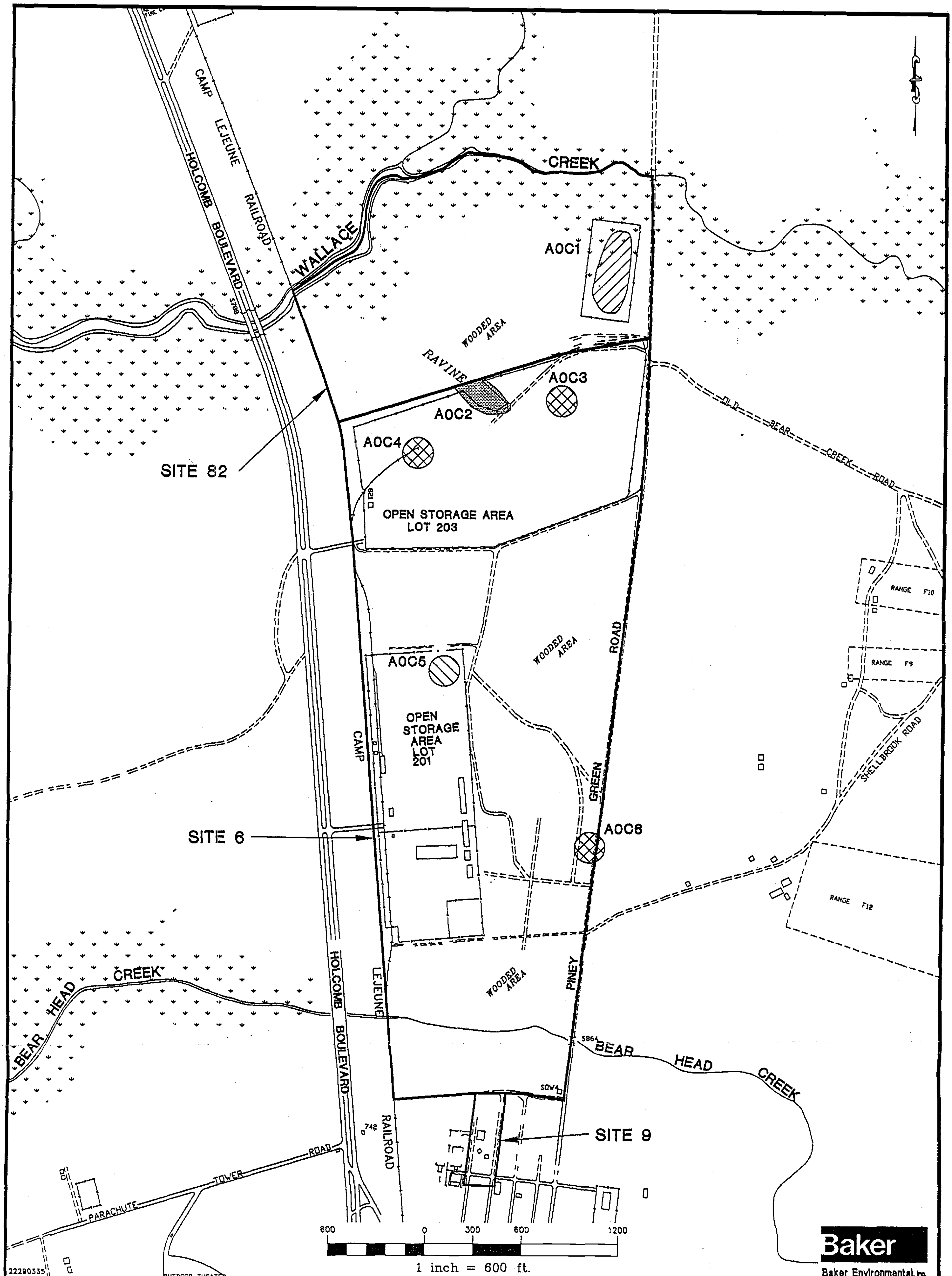
In accordance with Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup which assures protection of human health and the environment. Therefore, remediation goals have been based on meeting an Applicable or Relevant and Appropriate Requirement (ARAR), or a site-specific risk based action level. For groundwater restoration, the ARAR used as a basis for determining the remedial goal was either a federal Maximum Contaminant Level (MCL), a North Carolina Water Quality Standards (NCWQS), or a site-specific risk-based action level. Soil remedial goals were established based on ARARs (e.g., TSCA Guidelines for PCBs) or risk-based action levels for the protection of public health or groundwater. The FS for Operable Unit No. 2 presents a detailed description of the process used to determine the site cleanup goals.

Two sets of site remediation goals, or action levels, have been developed for OU No. 2, one set for soil, and one set for groundwater. These remediation goals, and the basis of each goal are shown on Table 1-1.

1.5 Site Remediation Description

As defined in the Final Record of Decision for Operable Unit No. 2, the selected remedy is a combination of Groundwater RAA No. 4 (Intensive Groundwater Extraction and Treatment) and Soil RAA No. 7 (On-Site Treatment and Off-Site Disposal). Overall, the major components of the selected remedy include:

- Collecting contaminated groundwater in both the shallow and deep portions of the aquifer through a series of extraction wells installed within the plume areas with the highest contaminant levels. Approximately three deep extraction wells will be installed to a depth of 110 feet and pumped at a rate of 150 gpm. In addition, three shallow extraction wells will be installed to a depth of 35 feet and pumped at a rate of 5 gpm.



LEGEND

AOC1 — SOILS TO BE TREATED VIA IN SITU VOLATILIZATION – VOC CONTAMINATED SOILS

AOC3,AOC4,AOC6 — SOILS TO BE EXCAVATED AND REMOVED – PCB CONTAMINATED SOILS

AOC5 — SOILS TO BE EXCAVATED AND REMOVED – PESTICIDE CONTAMINATED SOILS

AOC2 — DRUM, DEBRIS, AND SOIL REMOVAL AREA

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 1–3
SOIL AREAS OF CONCERN
SOIL AND GROUNDWATER REMEDIATION
CTO–0222

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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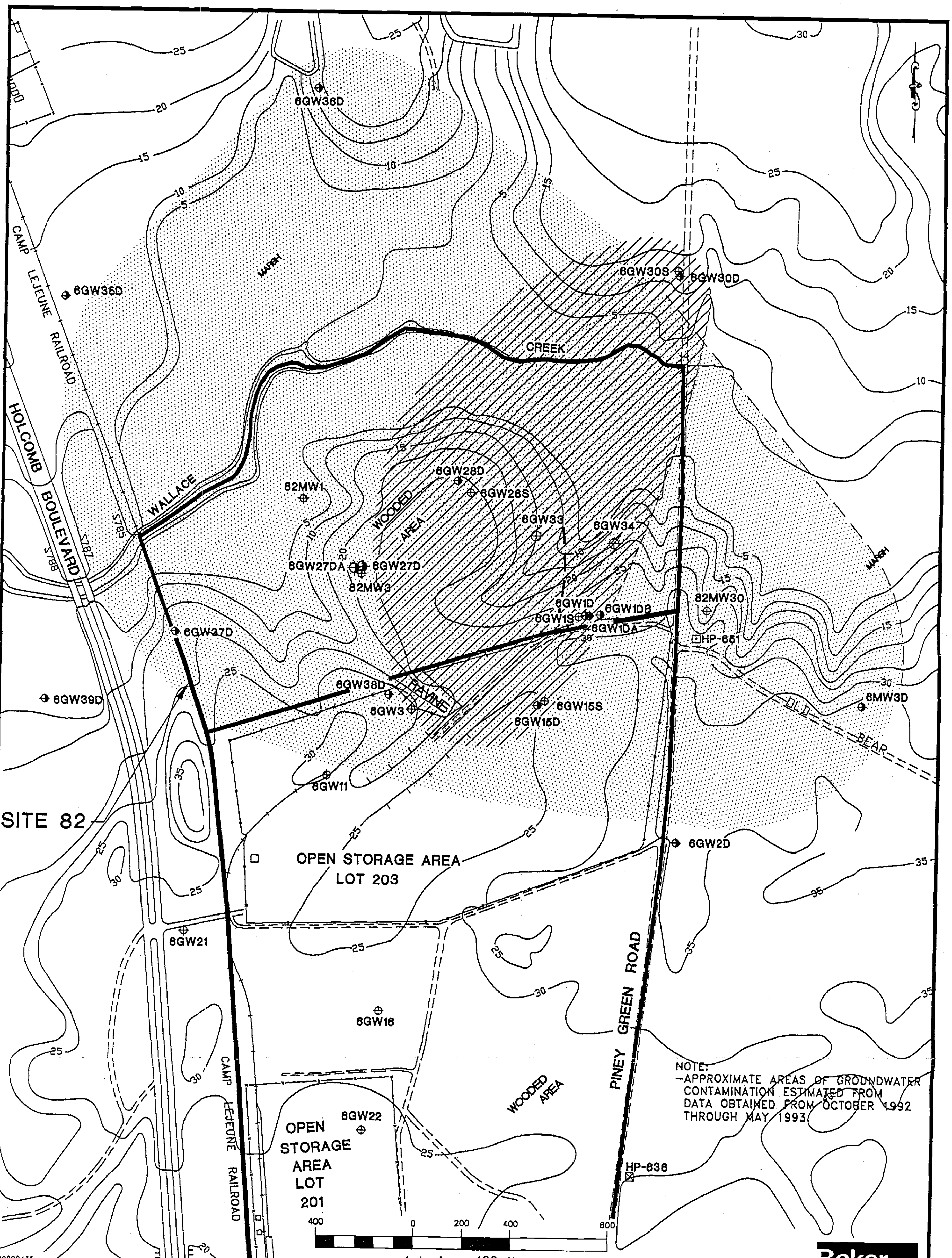

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LEGEND

6GW1S SHALLOW MONITORING WELL INCLUDED IN MONITORING PROGRAM
6GW1D DEEP MONITORING WELL INCLUDED IN MONITORING PROGRAM
HP-638 WATER SUPPLY WELL (TO BE MONITORED)
HP-651 WATER SUPPLY WELL (CLOSED)
APPROXIMATE AREA OF GROUNDWATER (DEEPER PORTION) CONTAMINATION EXCEEDING REMEDIATION GOALS
APPROXIMATE AREA OF GROUNDWATER (SHALLOW PORTION) CONTAMINATION EXCEEDING REMEDIATION GOALS

SOURCE: LANTDIV, FEB. 1992

FIGURE 1-4
APPROXIMATE LOCATION OF GROUNDWATER CONTAMINATION
SOIL AND GROUNDWATER REMEDIATION
CTO-0222
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

TABLE 1-1

FINAL
REMEDIATION GOALS FOR OU NO. 2
SOIL AND GROUNDWATER REMEDIATION - CTO-0222
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Contaminant of Concern	Preliminary Remediation Goal	Unit	Basis
Groundwater	1,2–Dichloroethane	0.38	μg/L	NCWQS
	Trans–1,2–Dichloroethene	70	μg/L	NCWQS
	Ethylbenzene	29	μg/L	NCWQS
	Tetrachloroethene	0.7	μg/L	NCWQS
	Trichloroethene	2.8	μg/L	NCWQS
	Vinyl Chloride	0.015	μg/L	NCWQS
	Arsenic	50	μg/L	NCWQS
	Barium	1,000	μg/L	NCWQS
	Beryllium	4	μg/L	MCL
	Chromium	50	μg/L	NCWQS
	Lead	15	μg/L	MCL
	Manganese	50	μg/L	NCWQS
	Mercury	1.1	μg/L	NCWQS
	Vanadium	80	μg/L	Health Advisory
Soil	PCBs	10,000	μg/kg	TSCA
	4,4'-DDT	60,000	μg/kg	Risk - Dermal Contact
	Benzene	5.4	μg/kg	Risk - Protection of Groundwater
	Trichloroethene	32.2	μg/kg	Risk - Protection of Groundwater
	Tetrachloroethene	10.5	μg/kg	Risk - Protection of Groundwater
	Arsenic	23,000	μg/kg	Risk - Ingestion
	Cadmium	39,000	μg/kg	Risk - Ingestion
	Manganese	390,000	μg/kg	Risk - Ingestion

NCWQS = North Carolina Water Quality Standard
MCL = Maximum Contaminant Level

- Treating the extracted groundwater for organics and inorganics removal via a treatment train which may consist of, but not be limited to, neutralization, precipitation, sedimentation, filtration, air stripping, and activated carbon adsorption.

- Discharging the treated groundwater to Wallace Creek.

- Restricting the use on nearby water supply wells which are currently inactive/closed (Nos. 637 and 651), and restricting the installation of any new water supply wells within the operable unit area.

- Implementing a long-term groundwater monitoring program to monitor the effectiveness of the groundwater remedy and to monitor the nearby water supply wells that are currently active. Under this monitoring program, groundwater from 21 existing monitoring wells and 3 nearby supply wells (Nos. 633, 635, and 636) will be collected on a semiannual basis and analyzed for Target Compound List volatiles. Additional wells may be added to the monitoring program, if necessary.

- Implementing in situ treatment via volatilization (or vapor extraction) of approximately 16,500 cubic yards of VOC-contaminated soils.

- Excavating approximately 70 cubic yards of PCB and pesticide contaminated soils for off-site disposal (incineration).

- Excavating approximately 750 cubic yards of contaminated soil and debris for off-site disposal (nonhazardous).

2.0 PRE-DESIGN SOIL FIELD INVESTIGATIONS AND SOIL REMEDIATION GOALS

The Pre-Design confirmation sampling at Operable Unit No. 2 was initiated to substantiate analytical results from sampling efforts performed during the RI. In addition, sampling was also conducted to better delineate the areas identified in the RI/FS requiring remediation. The Pre-Design field program was conducted during March 1994 and included collection of surface and subsurface soil samples from four AOCs at Operable Unit No. 2 (see Figure 1-3). The four AOCs are designated as AOC 3, AOC 4, AOC 5, and AOC 6. The samples from AOC 3, 4, and 6 were screened in the field utilizing an Enzyme Linked Immunosorbent Assay (ELISA) method for polychlorinated biphenyls (PCBs). It should be noted that this test method conforms to proposed USEPA Method 4020 for immunoassay-based field screening for PCBs in soil. This method was used to screen soil samples for Aroclor-1260 at detection levels of 1.0 mg/kg and 10 mg/kg. These detection limits were utilized to determine the presence or absence of PCBs and to delineate the extent of contamination based on the action levels established as part of the Feasibility Study.

The soil samples collected from AOC 5 were screened in the field utilizing an ELISA method for 4,4'-DDT and the associated metabolites. The theoretical operation of this screening method was similar to the PCB screening however, this technique detected a class of compounds (i.e., DDT) and its breakdown components (i.e., DDE and DDD) thus providing a cumulative total of the specific compound and its breakdown components.

Both screening techniques were performed utilizing a supplemental substrate and chromogen to produce a color change is the sample extract. The difference in optical density between the color of the sample and the color of the calibrators (DDT Test) or standard (PCB Test) was used to measure the amount of the specific analyte in the sample.

No additional field sampling was conducted at AOC 1, where soil vapor extraction is planned, and AOC 2, also known at the ravine. A description of the selected remediation action for AOC 1 is presented in Section 7.0. Previous investigations at AOC 2 have detected elevated levels of PAHs in the soil and low levels of PCBs in the sediment in the upper portion of the ravine, near Lot 203. The upper portion of the ravine is filled with debris, including empty and partially filled 55-gallon drums. The debris and contaminated soil in AOC 2 will be removed and disposed off-site, possibly at a RCRA Subtitle D landfill.

2.1 Soil Investigation

Surface soil samples were collected from all four of the AOCs at depths of 0 to 12 inches. Subsurface soil samples were collected in addition to the surface soil samples from AOC 3. These subsurface samples were collected at depths of 3 to 4 feet below ground surface (bgs) and 5 to 6 feet bgs. All samples were collected utilizing dedicated 4-inch stainless steel hand augers.

Following sample collection, each sample was homogenized to ensure that the sample was representative of the collection interval. Subsequent to homogenization, a representative portion was placed in a plastic bag and cooled to 4 degrees Celsius. Once the required number of samples were collected, 10 grams from each sample selected for PCB analysis and 50 grams from each sample selected for pesticide analysis were measured out for screening via the ELISA technique. The results of each sample were then plotted and evaluated to determine whether additional sampling was required to better define the extent of contamination.

Each AOC had a systematic grid established utilizing the boring/sample location identified during the RI program, which exhibited the highest concentration as the center point. The base grid for each AOC was established with four sample points. Subsequent to screening, the grid was modified (via expansion or truncation) to better delineate the extent of contamination.

2.1.1 AOC 3

A total of eight surface soil samples were collected from AOC 3. Four were collected at a radial distance of five and ten feet, respectively from monitoring well 6GW15. Seven subsurface (3 to 4 feet bgs) were also collected at locations corresponding to those collected at the surface. In addition, one subsurface sample was collected from a location offset from the corresponding surface soil sample due to auger refusal. Six subsurface (5 to 6 feet bgs) soil samples were collected from five locations corresponding the surface soil samples and the offset location. The limited number of samples collected at this depth was due to auger refusal. All 22 samples were screened utilizing the ELISA technique. Four samples were submitted to ORTEK Environmental Laboratory for confirmation analysis via EPA Method 8080.

2.1.2 AOC 4

A total of 29 surface soil samples were collected from AOC 4. Samples were collected at varying radial distances from monitoring well 6GW11. All 29 surface soil samples were screened utilizing the ELISA technique. Four samples were submitted to ORTEK Environmental Laboratory for confirmation analysis via EPA Method 8080.

2.1.3 AOC 5

A total of 28 surface soil samples were collected from AOC 5. Samples were collected at varying radial distances from soil boring SB17. Twenty-four of the 28 surface soil samples collected were screened utilizing the ELISA technique. This was the maximum number allowable due to the volume of reagents ordered from the manufacturer. Three of the samples screened were submitted to ORTEK Environmental Laboratory for confirmation analysis via EPA Method 8080. In addition, the four samples collected but not screened in the field were also submitted for laboratory analysis to better define the extent of contamination.

2.1.4 AOC 6

A total of 21 surface soil samples were collected from AOC 6. Samples were collected at varying radial distances from soil boring SB15. All 21 surface soil samples were screened utilizing the ELISA technique. Four samples were submitted to ORTEK Environmental Laboratory for confirmation analysis via EPA Method 8080.

2.2 Physical Data and Analytical Results

This section presents the field screening and laboratory analytical results of surface and subsurface soil samples collected at the four AOCs identified as part of the RI/FS activities performed at Operable Unit No. 2. Documentation regarding the collection of samples was recorded in personal log books, sample data sheets, and chain-of-custody forms which accompanied samples to the laboratory. Sample data sheets and chain-of-custody forms were utilized to track the handling of samples subsequent to collection. All laboratory analyses were performed in accordance with NEESA Level C requirements. It should be noted that the only QA/QC samples collected were rinsate samples, based on the data quality objectives.

Based on the information from the sample data sheets and the analytical laboratory report, the analytical results for the samples collected at Operable Unit No. 2 are considered representative of site conditions with the assurance that no inadvertent contamination has taken place. In general all data are considered representative of site conditions and have been presented as such.

2.2.1 Field and Analytical Results for AOC 3

A total of 22 samples were collected from AOC 3. Each sample was numbered sequentially AOC3-01 through AOC3-09 with the appropriate suffix attached for samples collected at depth. Field screening results indicated that Aroclor-1260 was not present in surficial soils at concentrations greater than 1.0 mg/kg. Aroclor-1260 was detected in one soil sample (AOC3-03-01, 3 to 4 feet bgs) at a concentration greater than 1.0 mg/kg but less than 10 mg/kg. Aroclor-1260 was not detected in any other subsurface soil samples.

Aroclor-1260 was not detected in any of the four samples submitted for laboratory analysis from AOC 3. Field screening and analytical results for AOC 3 are provided in Table 2-1.

2.2.2 Field and Analytical Results for AOC 4

A total of 29 surface soils were collected from AOC 4. Each sample was numbered sequentially AOC 4-01 through AOC 4-29. Field screening results indicated that Aroclor-1260 was present in 16 samples at concentrations greater than or equal to 1.0 mg/kg. In addition, eight samples contained concentrations greater than or equal to 10 mg/kg of Aroclor-1260.

Aroclor-1260 was present in all four samples submitted for laboratory analysis at concentrations ranging from 0.09 mg/kg to 37 mg/kg. Table 2-2 provides results from field screening activities and laboratory analysis for AOC 4.

2.2.3 Field and Analytical Results for AOC 5

A total of 28 surface soil samples were collected from AOC 5. Each sample was numbered sequentially AOC 5-01 through AOC 5-30 (note AOC 5-12 and 14 were not collected due to field modifications). Field screening results indicated the presence of 4,4-DDT and its associated metabolites at concentrations greater than or equal to 50 mg/kg in 12 samples.

All seven samples submitted for laboratory analysis contained 4,4'-DDT and 4,4'-DDE at concentrations ranging from 0.05 mg/kg to 48 mg/kg and 0.005 mg/kg to 7.4 mg/kg, respectively. One sample contained 4,4'-DDD at a concentration of 0.6 mg/kg. Table 2-3 provides field screening and analytical results for AOC 5.

2.2.4 Field and Analytical Results for AOC 6

A total of 21 surface soil samples were collected from AOC 6. Each sample was numbered sequentially AOC 6-01 through AOC 6-21. Field screening indicated that Aroclor-1260 was present in 18 samples at concentrations greater than or equal to 1.0 mg/kg. In addition, seven samples contained concentrations greater than or equal to 10 mg/kg of Aroclor-1260.

All four samples submitted for laboratory analysis contained concentrations of Aroclor-1260 ranging from 0.5 mg/kg to 35J mg/kg. Table 2-4 provides field screening and analytical results for AOC 6.

2.3 Nature and Extent of Contamination

This section provides an assessment of the nature and extent of constituent migration resulting from prior disposal practices/activities at Operable Unit No. 2. Media of interest include surface and subsurface soil. Information generated as part of the previous site investigation (i.e., RI/FS) as well as data generated from the Pre-Design field activities, serves as the basis for this evaluation.

TABLE 2-1
ENSYS SCREENING/LABORATORY RESULTS, AOC 3
OPERABLE UNIT NO. 2
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

					ENSYS SCREENING RESULTS							
SHALL.	INTER.	DEEP	DATE	TIME	Change in O.D. Standard	O.D. Sample 1 ppm	O.D. Sample 10 ppm	1 ppm Interpretation	10 ppm Interpretation	COMMENTS	Laboratory Result Aroclor-1260 mg/kg	Detection Limit ug/kg
C3-01-00			3/2/94	1253	- 0.29	0.63	0.54	-	-	< 1ppm		
	C3-01-01		3/2/94	1253	- 0.29	0.66	0.53	-	-	< 1ppm	U	0.04
		C3-01-02	3/2/94	1405	- 0.26	0.63	0.49	-	-	< 1ppm		
C3-02-00			3/2/94	1405	- 0.26	0.54	0.13	-	-	< 1ppm		
	C3-02-01		3/2/94	1405	- 0.26	0.82	0.44	-	-	< 1ppm		
		C3-02-02	3/2/94	1405	- 0.26	0.40	0.67	-	-	< 1ppm		
C3-03-00			3/2/94	1503	- 0.26	0.57	0.47	-	-	< 1ppm		
	C3-03-01		3/2/94	1503	- 0.00	- 0.90	0.47	+	-	> 1ppm, < 10ppm		
		C3-03-02								No sample collected		
C3-04-00			3/2/94	1503	- 0.00	0.38	0.40	-	-	< 1ppm		
	C3-04-01		3/2/94	1503	- 0.00	0.39	0.27	-	-	< 1ppm		
		C3-04-02	3/2/94	1503	- 0.00	0.27	0.19	-	-	< 1ppm	U	0.04
C3-05-00			3/5/94	1015	- 0.17	0.52	0.92	-	-	< 1ppm	U	0.04
	C3-05-01		3/5/94	1015	- 0.17	0.93	0.91	-	-	< 1ppm		
		C3-05-02	3/5/94	1015	- 0.17	0.78	1.04	-	-	< 1ppm		
C3-06-00			3/5/94	1015	- 0.17	0.79	1.00	-	-	< 1ppm		
	C3-06-01		3/5/94	1015	- 0.17	0.81	1.00	-	-	< 1ppm		
		C3-06-02	3/5/94	1015	- 0.17	0.77	0.90	-	-	< 1ppm		
C3-07-00			3/5/94	1139	- 0.16	0.75	0.73	-	-	< 1ppm		
	C3-07-01		3/5/94	1139	- 0.16	0.45	0.48	-	-	< 1ppm		

U - Not Detected

TABLE 2-1
ENSYS SCREENING/LABORATORY RESULTS, AOC 3
OPERABLE UNIT NO. 2
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

					ENSYS SCREENING RESULTS							
SHALL.	INTER.	DEEP	DATE	TIME	Change in O.D. Standard	O.D. Sample 1 ppm	O.D. Sample 10 ppm	1 ppm Interpretation	10 ppm Interpretation	COMMENTS	Laboratory Result Aroclor-1260 mg/kg	Detection Limit ug/kg
		C3-07-02								No sample collected		
C3-08-00			3/5/94	1139	- 0.16	0.59	0.77	-	-	< 1ppm		
	C3-08-01									No sample collected		
		C3-08-02								No sample collected		
C3-09-00										No sample collected		
	C3-09-01		3/5/94	1139	- 0.16	0.55	0.71	-	-	< 1ppm	U	0.04
		C3-09-02	3/5/94	1139	- 0.16	0.78	0.51	-	-	< 1ppm		

U - Not Detected

TABLE 2-2
ENSYS SCREENING/LABORATORY RESULTS, AOC 4
OPERABLE UNIT NO. 2
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

			ENSYS SCREENING RESULTS							
SHALL.	DATE	TIME	Change in O.D. Standard	O.D. Sample 1 ppm	O.D. Sample 10 ppm	1 ppm Interpretation	10 ppm Interpretation	COMMENTS	Laboratory Results Aroclor -1260 mg/kg	Detection Limits mg/kg
C4-01-00	3/2/94	955	- 0.07	0.65	0.75	-	-	< 1ppm		
C4-02-00	3/2/94	955	- 0.07	- 1.17	- 0.41	+	+	> 10ppm		
C4-03-00	3/2/94	955	- 0.07	0.44	1.13	-	-	< 1ppm		
C4-04-00	3/2/94	955	- 0.07	- 1.17	0.24	+	-	> 1ppm, < 10ppm		
C4-05-00	3/394	1116	- 0.27	0.78	0.54	-	-	< 1ppm		
C4-06-00	3/394	1116	- 0.27	- 0.13	0.53	+	-	> 1ppm, < 10ppm		
C4-07-00	3/394	1116	- 0.27	0.21	0.43	-	-	< 1ppm		
C4-08-00	3/394	1116	- 0.27	- 1.22	- 0.97	+	+	> 10ppm		
C4-09-00	3/394	1834	- 0.02	0.45	0.54	-	-	< 1ppm		
C4-10-00	3/394	1834	- 0.02	- 0.49	0.37	+	-	> 1ppm, < 10ppm	1.10	0.04
C4-11-00	3/394	1834	- 0.02	0.41	0.68	-	-	< 1ppm		
C4-12-00	3/394	1834	- 0.02	- 1.22	- 0.96	+	+	> 10ppm		
C4-13-00	3/394	1834	- 0.02	- 1.12	0.15	+	-	> 1ppm, < 10ppm	2.1	0.04
C4-14-00	3/4/94	949	- 0.57	- 1.20	- 0.94	+	+	> 10ppm	37	37
C4-15-00	3/4/94	949	- 0.57	0.72	0.57	-	-	< 1ppm	0.09	0.04
C4-16-00	3/4/94	949	- 0.57	0.29	0.58	-	-	< 1ppm		
C4-17-00	3/4/94	1635	- 0.10	- 0.12	0.71	+	-	> 1ppm, < 10ppm		
C4-18-00	3/4/94	1635	- 0.10	0.59	0.50	-	-	< 1ppm		
C4-19-00	3/4/94	1635	- 0.10	- 1.22	- 1.22	+	+	> 10ppm		
C4-20-00	3/4/94	1847	- 0.16	- 1.19	- 1.16	+	+	> 10ppm		

TABLE 2-2
ENSYS SCREENING/LABORATORY RESULTS, AOC 4
OPERABLE UNIT NO. 2
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

			ENSYS SCREENING RESULTS							
SHALL.	DATE	TIME	Change in O.D. Standard	O.D. Sample 1 ppm	O.D. Sample 10 ppm	1 ppm Interpretation	10 ppm Interpretation	COMMENTS	Laboratory Results Aroclor -1260 mg/kg	Detection Limits mg/kg
C4-21-00	3/4/94	1847	- 0.16	0.47	0.59	-	-	< 1ppm		
C4-22-00	3/5/94	1847	- 0.16	- 1.17	- 1.12	+	+	> 10ppm		
C4-23-00	3/5/94	1729	- 0.08	- 1.09	- 0.36	+	+	> 10ppm		
C4-24-00	3/5/94	1729	- 0.08	- 0.78	0.73	+	-	> 1ppm, < 10ppm		
C4-25-00	3/5/94	1729	- 0.08	- 0.49	0.26	+	-	> 1ppm, < 10ppm		
C4-26-00	3/5/94	1729	- 0.08	0.28	0.61	-	-	< 1ppm		
C4-27-00	3/5/94	1825	- 0.08	0.56	0.26	-	-	< 1ppm		
C4-28-00	3/5/94	1825	- 0.08	0.24	0.49	-	-	< 1ppm		
C4-29-00	3/5/94	1825	- 0.08	- 0.50	0.22	+	-	> 1ppm, < 10ppm		

TABLE 2-3
ENVIROGUARD SCREENING/LABORATORY RESULTS, AOC 5
OPERABLE UNIT NO. 2
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

			ENVIROGUARD RESULTS									
SHALL.	DATE	TIME	O.D. Negative Control	O.D. Calibrator 5ppm	O.D. Calibrator 50ppm	O.D. Sample	COMMENTS	Laboratory Results 4,4'-DDT	Laboratory Results 4,4'-DDE	Laboratory Results 4,4'-DDD	Total DDT and Metabolites	Detection Limits mg/kg
C5-01-00	2/28/94	1715	0.60	0.42	0.28	0.12	> 50 ppm					
C5-02-00	2/28/94	1715	0.60	0.42	0.28	0.57	< 5 ppm					
C5-03-00	2/28/94	1715	0.60	0.42	0.28	0.55	< 5 ppm					
C5-04-00	2/28/94	1715	0.60	0.42	0.28	0.49	< 5 ppm					
C5-05-00	3/1/94	1425	0.84	0.72	0.49	0.46	> 50 ppm					
C5-06-00	3/1/94	1425	0.84	0.72	0.49	0.21	> 50 ppm					
C5-07-00	3/1/94	1425	0.84	0.72	0.49	0.30	> 50 ppm					
C5-08-00	3/1/94	1425	0.84	0.72	0.49	0.25	> 50 ppm					
C5-09-00	3/1/94	1425	0.84	0.72	0.49	0.20	> 50 ppm					
C5-10-00	3/1/94	1425	0.84	0.72	0.49	0.25	> 50 ppm					
C5-11-00	3/2/94	805	0.83	NA	0.48	0.29	> 50 ppm					
C5-12-00	3/2/94	805					No sample collected					
C5-13-00	3/2/94	805	0.83	NA	0.48	0.43	> 50 ppm					
C5-14-00	3/2/94	805	0.83	NA	0.48	0.25	> 50 ppm					
C5-14-00	3/2/94	805					No sample collected					
C5-16-00	3/2/94	805	0.83	NA	0.48	0.60	< 50 ppm					
C5-17-00	3/2/94	805	0.83	NA	0.48	0.17	> 50 ppm					

All results in mg/kg
U - Not Detected

TABLE 2-3
ENVIROGUARD SCREENING/LABORATORY RESULTS, AOC 5
OPERABLE UNIT NO. 2
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

			ENVIROGUARD RESULTS									
SHALL.	DATE	TIME	O.D. Negative Control	O.D. Calibrator 5ppm	O.D. Calibrator 50ppm	O.D. Sample	COMMENTS	Laboratory Results 4,4'-DDT	Laboratory Results 4,4'-DDE	Laboratory Results 4,4'-DDD	Total DDT and Metabolites	Detection Limits mg/kg
C5-18-00	3/3/94	935	0.66	NA	0.28	0.64	< 50 ppm					
C5-19-00	3/3/94	935	0.66	NA	0.28	0.59	< 50 ppm					
C5-20-00	3/3/94	935	0.66	NA	0.28	0.42	< 50 ppm	7	1.1	U	8.1	0.7
C5-21-00	3/3/94	935	0.66	NA	0.28	0.55	< 50 ppm					
C5-22-00	3/3/94	1410	0.62	NA	0.36	0.50	< 50 ppm					
C5-23-00	3/3/94	1410	0.62	NA	0.36	0.55	< 50 ppm	0.2	0.1	U	0.3	0.04
C5-24-00	3/3/94	1410	0.62	NA	0.36	0.60	< 50 ppm					
C5-25-00	3/3/94	1410	0.62	NA	0.36	0.15	> 50 ppm	48	7.4	U	55.40	3.6
C5-26-00	3/3/94	1410	0.62	NA	0.36	0.53	< 50 ppm					
C5-27-00			NA	NA	NA	NA	Not Screened	0.4	0.2	U	0.6	0.2
C5-28-00			NA	NA	NA	NA	Not Screened	0.05	0.005	U	0.055	0.004
C5-29-00			NA	NA	NA	NA	Not Screened	0.05	0.02	U	0.07	0.004
C5-30-00			NA	NA	NA	NA	Not Screened	0.7	0.4	0.6	1.7	0.2

All results in mg/kg
U - Not Detected

TABLE 2-4
ENSYS SCREENING/LABORATORY RESULTS, AOC 6
OPERABLE UNIT NO. 2
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

SHALL.	DATE	TIME	ENSYS SCREENING RESULTS: Change in O.D. Standard	O.D. Sample 1 ppm	O.D. Sample 10 ppm	1 ppm Interpretation	10 ppm Interpretation	COMMENTS	Laboratory Results Aroclor-1260 mg/kg	Detection Limits mg/kg
C6-01-00	3/2/94	955	- 0.07	- 1.17	- 0.00	+	+	> 10ppm		
C6-02-00	3/2/94	1253	- 0.29	0.20	0.58	-	-	< 1ppm		
C6-03-00	3/2/94	1253	- 0.29	- 1.18	0.15	+	-	> 1ppm, < 10ppm		
C6-04-00	3/2/94	1253	- 0.29	- 1.17	0.15	+	-	> 1ppm, < 10ppm		
C6-05-00	3/3/94	1116	- 0.27	- 1.00	0.38	+	-	> 1ppm, < 10ppm		
C6-06-00	3/3/94	1116	- 0.27	- 0.00	0.55	+	-	> 1ppm, < 10ppm		
C6-07-00	3/3/94	1116	- 0.27	- 1.19	- 0.11	+	+	> 10ppm		
C6-08-00	3/3/94	1116	- 0.27	- 1.20	- 0.49	+	+	> 10ppm		
C6-09-00	3/4/94	949	- 0.57	- 1.21	- 0.77	+	+	> 10ppm		
C6-10-00	3/4/94	949	- 0.57	0.35	0.09	-	-	< 1ppm		
C6-11-00	3/4/94	1120	- 0.20	0.24	0.68	-	-	< 1ppm	0.5	0.04
C6-12-00	3/4/94	1120	- 0.20	- 0.00	0.60	+	-	> 1ppm, < 10ppm	0.6	0.04
C6-13-00	3/4/94	1120	- 0.20	- 1.01	0.10	+	-	> 1ppm, < 10ppm		
C6-14-00	3/4/94	1120	- 0.20	- 1.04	- 0.00	+	+	> 10ppm	35 J	37
C6-15-00	3/4/94	1120	- 0.20	- 0.77	0.25	+	-	> 1ppm, < 10ppm	4	0.04
C6-16-00	3/4/94	1635	- 0.10	- 1.22	- 0.80	+	+	> 10ppm		
C6-17-00	3/4/94	1635	- 0.10	- 0.44	0.33	+	-	> 1ppm, < 10ppm		
C6-18-00	3/4/94	1635	- 0.10	- 1.21	- 0.00	+	+	> 10ppm		
C6-19-00	3/4/94	1847	- 0.16	- 0.76	0.51	+	-	> 1ppm, < 10ppm		
C6-20-00	3/4/94	1847	- 0.16	- 0.90	0.19	+	-	> 1ppm, < 10ppm		
C6-21-00	3/4/94	1847	- 0.16	- 1.03	0.18	+	-	> 1ppm, < 10ppm		

J - Estimated value, concentration of analyte below method detection level

This evaluation will focus on the four AOCs previously identified and will include the following significant elements:

- Identification of the concentrations of constituents of interest in surface and subsurface soils.

- Definition of the horizontal and, where applicable, the vertical extent of constituent contamination in site soils.

As anticipated from previous investigations, analytical results for pesticides and PCBs confirmed their presence in surface and subsurface soils. The following subsections characterizes, based on all available data, surface and subsurface soil quality with respect to the specific constituents of concern for AOCs 2 through 6.

2.3.1 AOC 2

The presence of elevated levels of PAHs in the soil and low levels of PCBs in the sediment in the upper portion of AOC 2 (i.e., near Lot 203) is most likely due to former disposal practices. Data collected from the RI shows that the soil contamination in the ravine has likely migrated to Wallace Creek via surface runoff. Therefore, the contaminated soil and debris from AOC 2 will be removed and disposed of off-site.

2.3.2 AOC 3

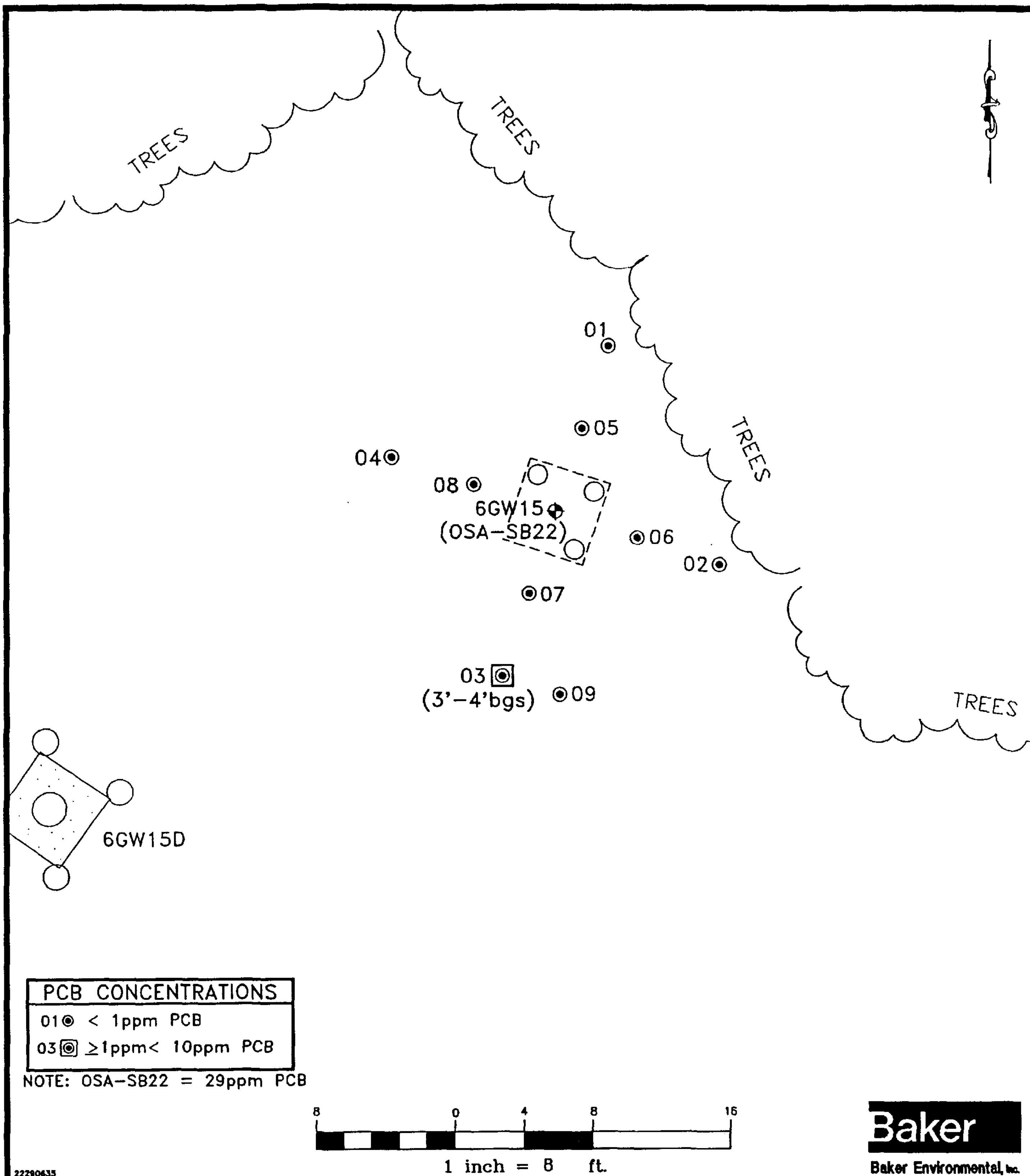
Polychlorinated biphenyls (PCBs) were detected at 29 ppm during a previous investigation from the source boring (6GW15) at AOC 3. During the predesign study samples were collected at three different depth intervals from each boring (0-12", 3-4' and 5-6'). Soil samples were collected in a radial direction at distance intervals of 5 and 10 feet from the source boring as shown on Figure 2-1. In addition Figure 2-1 presents sample locations and PCB screening results as well as the primary zones of contamination. The field screening results did not identify any additional contamination from the nine boring locations. However, based on previous investigation results and current findings approximately 15 cubic yards of material in the immediate vicinity of monitoring well 6GW15 has been estimated to be contaminated with Aroclor-1260.

2.3.3 AOC 4

Polychlorinated biphenyls were detected at a concentration of 42 ppm during a previous investigation from the source boring (OSA-SB24) at AOC 4. During the predesign study samples were collected at distance intervals of 5 and 10 feet, in order to determine the horizontal extent of contamination. Figure 2-2 presents sample locations and PCB screening results as well as the primary zone of contamination. Based on previous investigation results and current findings approximately ten cubic yards of soil has been estimated to be contaminated with Aroclor-1260 at concentrations equal to or greater than 10 mg/kg. The depth of contamination has been estimated to be equivalent to 12-inches.

2.3.4 AOC 5

During previous investigations at AOC 5, 4,4'-DDT was detected at a concentration of 1200 ppm at the source boring (SB-17). Predesign study samples were collected at distance intervals of 5 and 10 feet, in order to determine the horizontal extent of contamination. In addition, several samples were collected at further distances to ensure the horizontal extent of contamination was accurately defined. Figure 2-3 presents screening results from 4,4'-DDT and its associated metabolites as well as the primary zone of

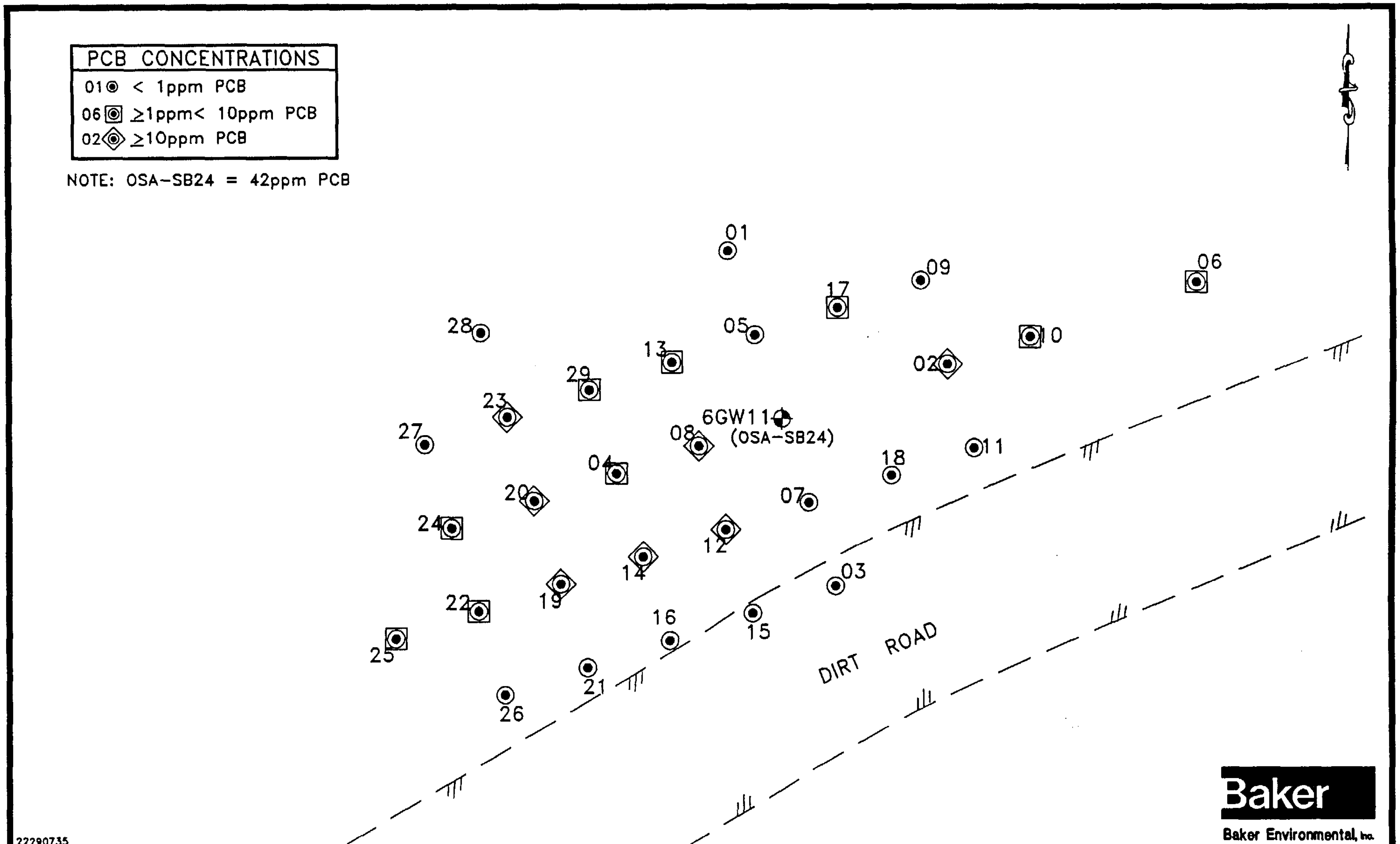


LEGEND

6GW15 PREVIOUS MONITORING WELL

08 NEW SOIL BORING LOCATION (0-12"), (3'-4'), AND (5'-6') BELOW GROUND SURFACE (bgs)

FIGURE 2-1
SOIL PCB CONCENTRATIONS, AOC 3
SOIL AND GROUNDWATER REMEDIATION
OPERABLE UNIT NO. 2
CTO-0222
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

6GW11 PREVIOUS MONITORING WELL

08 NEW SOIL BORING LOCATION (0-12")

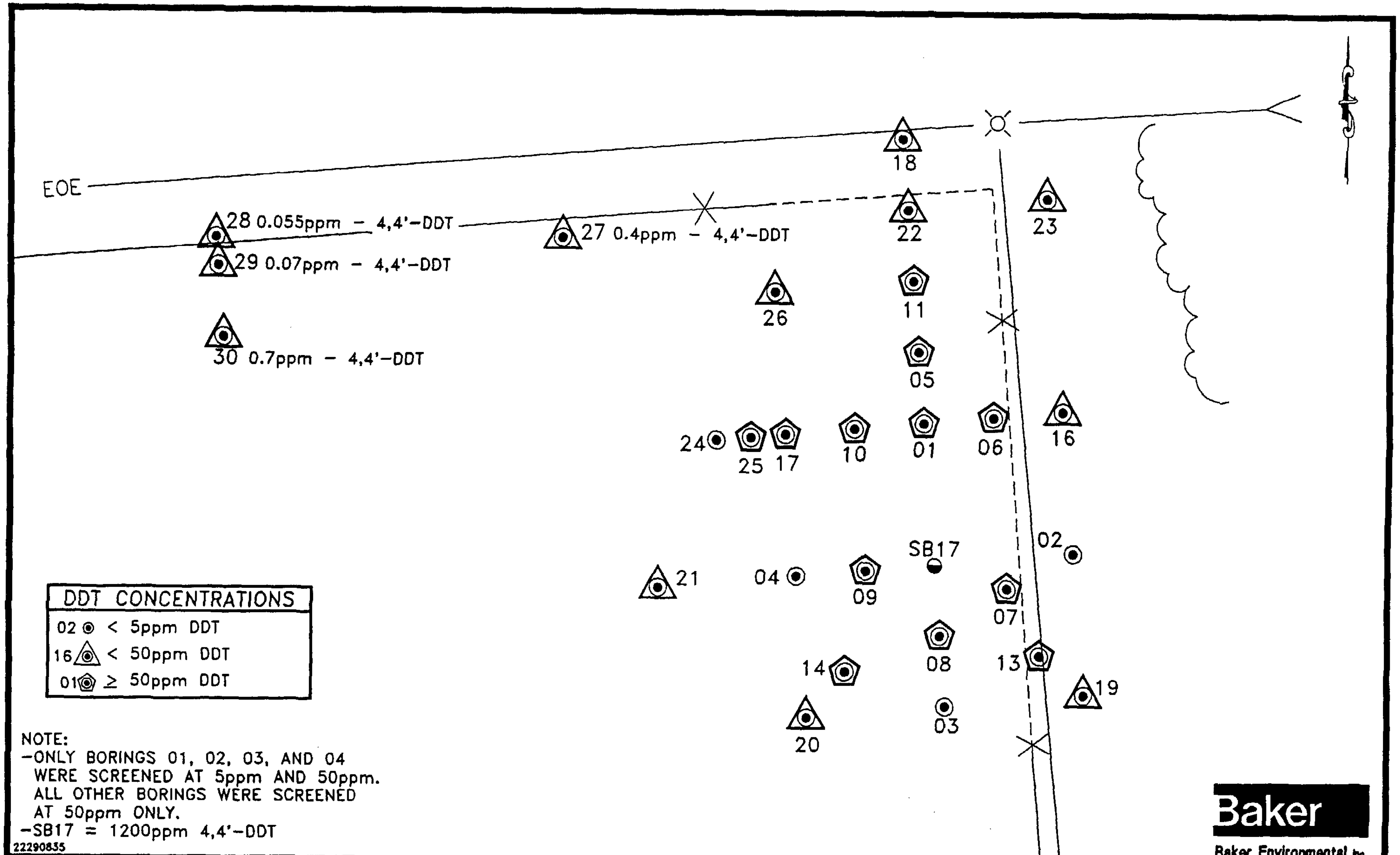
EDGE OF ROADWAY

8 0 4 8 16

1 inch = 8 ft.

FIGURE 2-2
SOIL PCB CONCENTRATIONS, AOC 4
SOIL AND GROUNDWATER REMEDIATION
OPERABLE UNIT NO. 2
CTO-0222

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



NOTE:
-ONLY BORINGS 01, 02, 03, AND 04 WERE SCREENED AT 5ppm AND 50ppm. ALL OTHER BORINGS WERE SCREENED AT 50ppm ONLY.
-SB17 = 1200ppm 4,4'-DDT

LEGEND

SB17 PREVIOUS SOIL BORING LOCATION
01 NEW SOIL BORING LOCATION (0-12")
EOE OVERHEAD ELECTRIC LINE
POWER POLE WITH LIGHT
CHAIN LINK FENCE

10 0 5 10 20
1 inch = 10 ft.

FIGURE 2-3
SOIL PESTICIDE CONCENTRATIONS, AOC 5
SOIL AND GROUNDWATER REMEDIATION
OPERABLE UNIT NO. 2
CTO-0222

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

contamination. Based on previous investigation results and current findings approximately 26 cubic yards of soil has been estimated to be contaminated with 4,4'-DDT and its metabolites at concentrations equal to or greater than 50 mg/kg. The depth of contamination has been estimated to be equivalent to 12-inches.

2.3.5 AOC 6

During previous investigations at AOC 6, Aroclor-1260 was detected at a concentration of 26 ppm at the source boring (201E-SB15). Predesign study samples were collected at distance intervals of 5 and 10 feet, in order to determine the horizontal extent of contamination. Figure 2-4 presents sample locations and PCB screening results as well as the primary zone of contamination. Based on previous investigation results and current findings approximately 17 cubic yards of soil has been estimated to be contaminated with Aroclor-1260 at concentration equal to or greater than 10 mg/kg. The depth of contamination has been estimated to be equivalent to 12-inches.

2.4 Summary and Remediation Goals

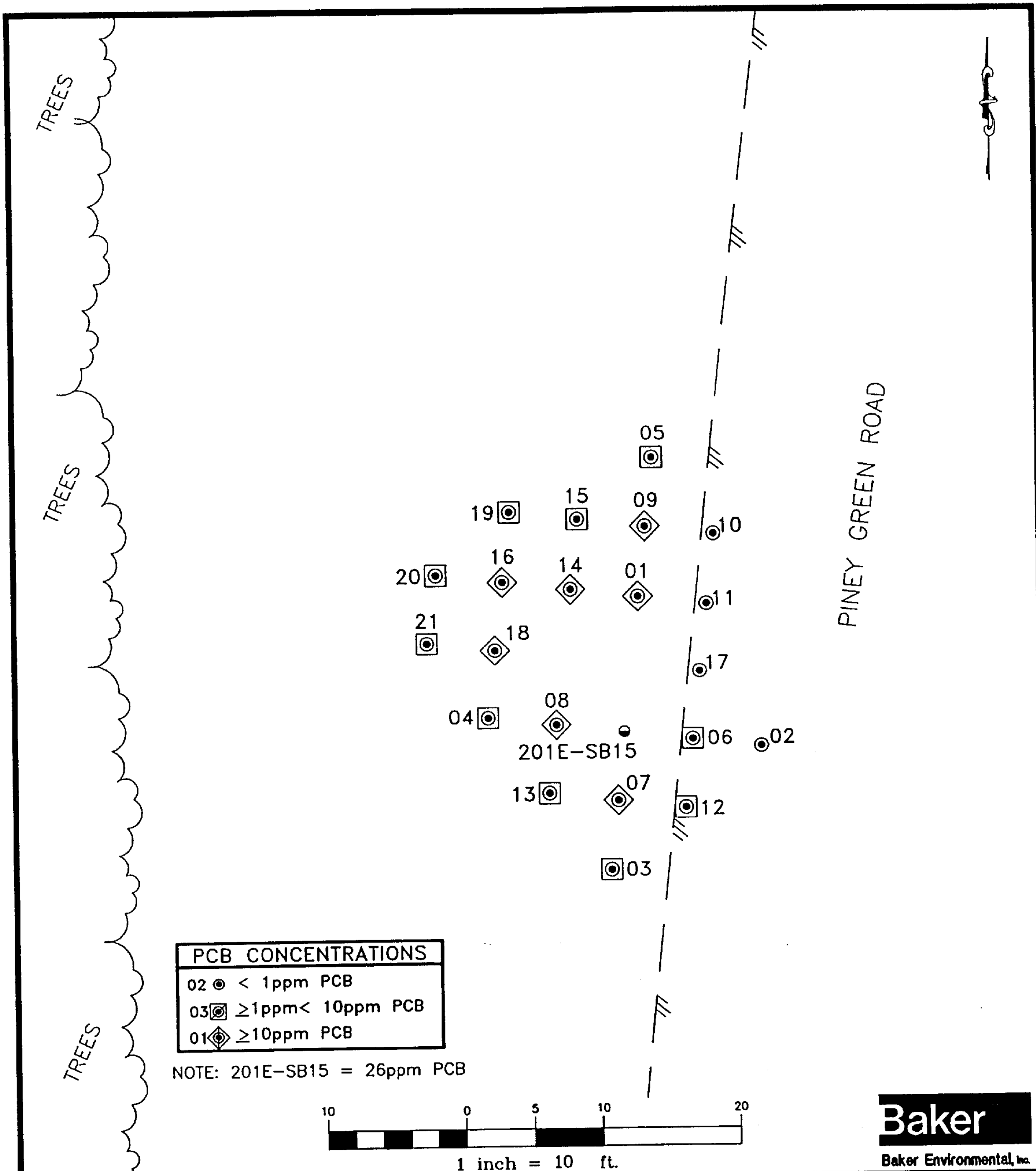
Based on site history, previous investigations (Baker RI, 1992) and Predesign findings, contamination from prior activities/disposal practices at AOC 2, AOC 3, AOC 4, AOC 5, and AOC 6 has impacted surface soils to various degrees. This section discusses the remediation goals and method of remediation for these sites.

In general, the primary constituents of concern for AOCs 3, 4, 5, and 6 are Aroclor-1260 and 4,4'-DDT. It should be noted that other Aroclors and metabolites of DDT were detected however, the aforementioned PCB and pesticide compounds represent the primary constituents of concern. In evaluating the current findings and considering the background information related to the AOCs, excavation and off-site disposal of the contaminated soil will mitigate any potential human health or environmental risk associated with these AOCs. In addition, focussing remediation efforts on the primary constituents of concern will also result in the remediation of similar compounds as well as breakdown constituents which are commonly found with the primary constituents of concern.

2.4.1 Remediation Action Goals

The selected soil remedial action for AOCs 2, 3, 4, 5, and 6 is excavation and off-site disposal. The estimated volumes of soil from each AOC and the method of disposal is a follows:

AOC	Area of Excavation (sq. ft.)	Depth of Excavation (ft.)	Volume (c.y.)	Disposal
2	20,000	1	750	Subtitle D Landfill
3	100	4	15	Incineration
4	280	1	10	Incineration
5	700	1	26	Incineration
6	450	1	17	Incineration
TOTAL			820	



LEGEND

201E-SB15 PREVIOUS SOIL BORING LOCATION

01 NEW SOIL BORING LOCATION (0-12")

EDGE OF ROADWAY

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-4
SOIL PCB CONCENTRATIONS, AOC 6
SOIL AND GROUNDWATER REMEDIATION
OPERABLE UNIT NO. 2
CTO-0222
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3.0 SITE PLAN

The site plan is used to identify construction work items completed outside of the groundwater treatment building that do not directly affect the operation of the facility. Items addressed in the site plan include:

- Site Layout
- Utility Connections
- Roads and Parking Areas

These topics will be addressed individually in the following sections of the design report.

Additional work items that will need to be addressed in the Contractor's Work Plan include:

- Site Grading
- Pavement design
- Runoff Control

3.1 Site Layout

In developing the layout of the treatment facility, the following factors were considered:

- The layout should make efficient use of the available land area.

- The layout should provide easy access from the main road (Piney Green road).

- Piping from the recovery wells must be easily incorporated into the site design.

- The layout must allow efficient access to the following areas:

  - The Sludge Processing Area for removal of processed solids
  - The Chemical Storage Areas for delivery and offloading of chemicals
  - The Granular Activated Carbon units for periodic replacement of the carbon media.

- The treated water discharge point should be accessible for gravity discharge.

3.2 Utility Connections

The groundwater treatment plant building will require the following utility connections: potable water, sanitary sewer, electric power, telephone service, and a building heat supply. A brief description of each of these utility systems is presented below.

3.2.1 Potable Water Service

A permanent potable water supply will be provided from a water distribution line to be constructed along Piney Green Road to a point approximately 1,300 feet south of the site. The new water line will be placed along the shoulder of the road. The waterline extension will end adjacent to the treatment plant building where a fire hydrant will be installed to provide fire protection for the treatment building and will also provide a flushing point for periodic line flushing. Service to the treatment plant building will be provided by a 1-inch service line extended to the building.

3.2.2 Sanitary Sewer

Sanitary sewer service will require installation of a grinder pump and sump. Sanitary drainage from the building will be discharged to a new sanitary sewer force main, to be installed to a point approximately 1,300 feet south of the site.

3.2.3 Electric Power

A permanent primary electric service will be provided by the Contractor from an overhead power pole line to be constructed along Piney Green Road to a point approximately 1,300 feet south of the site. Termination at this location will be to a power pole and power grid system to be supplied by the Government, with sufficient capacity to supply power to the Groundwater Treatment Plant Building.

3.2.4 Telephone Service

Telephone service to the site will be provided by the Government.

3.2.5 Building Heating Supply

Liquid propane was selected as the building heating supply source. Capital and operation costs for propane were determined to be less than using fuel oil.

3.3 <u>Roads and Parking Areas</u>

Access to the groundwater treatment plant building will be by a short asphalt paved access road from Piney Green Road (See Drawing C-7). In the front of the building, space has been provided for employee parking and direct entry into the office area. Adequate space has also been provided to maneuver trucks delivering supplies or for trucks entering the site to haul waste solids for disposal.

4.0 TREATMENT SYSTEM BUILDING

The groundwater treatment facility, of current consideration, has a clear interior dimension of 60'-0" x 100'-0" or 6000 square feet (SF). A minimum of 18'-0" vertical clearance is required throughout the structure to accommodate installation, operation, and maintenance of the equipment to be located within the building.

In general, the building materials under consideration for the facility consist of a brick exterior face/concrete masonry unit interior face, insulated cavity, masonry shell for the exterior walls, with a pre-engineered structure and roof.

Wall System: A brick face masonry system has been selected to provide the facility with an aesthetically pleasing appearance, while at the same time, creating a durable and practically maintenance free envelope. The insulated cavity wall design will provide the adequate insulated envelope for the type of structure, and as an extra precaution, it is also recommended that a protective repellent be applied after construction to prevent staining by waterborne or other substances. The brick face units are available in a variety of colors.

Doors: Mandoors will consist of durable insulated hollow metal doors and frames with a painted finish. The large coiling doors will be of steel slat construction with structural channel frames to protect the masonry jambs.

Roof: A standard 24 ga. standing seam roof with a baked on factory finish will enclose the structure. The framing will be of standard pre-engineered structural elements such as the bents and purlins. Roof insulation will be of the thickness required, and protected by a durable white polyester facing. Miscellaneous roof flashing and trim will also be provided from the Pre-Engineered Building manufacturer, with a baked on factory finish.

Interior: The building interior is sized to house the groundwater treatment equipment and related appurtenances. In addition, space has been made available for an operations office where records will be maintained and operation manuals kept for consultation. A small restroom is also included and will be equipped to be handicapped accessible.

4.1 Foundation

For designing the building foundation, a subsurface investigation was completed and a report written to evaluate the soil conditions in the area of the proposed treatment building. That report, prepared by McCallum Testing Laboratories Inc., titled Subsurface Exploration and Geotechnical Engineering, Groundwater Treatment Building, Camp Allen, Norfolk, Virginia, is attached to this report as Appendix A.

In this report, the soil conditions were reported as being adequate for the support of the building structure. If a spread footing is used, the maximum allowable soil bearing capacity was estimated as 2000 pounds per square foot (PSF). The Contractor should review the attached report and determine an acceptable building foundation alternative.

4.2 Mechanical Systems

Drawing M-1 (Mechanical Systems Design Layout Drawing) is used to reference the location of mechanical equipment and provide pertinent notations relative to the mechanical system design for the treatment plant building. Systems which are included are as follows:

- Heating, ventilation and air conditioning systems.
- General area exhaust.
- Process system industrial exhaust.
- Toilet room exhaust.
- Interior propane piping system.
- Exterior propane piping system.
- Propane storage tanks.
- Interior plumbing system including water and sanitary.

Follow the requirements outlined in the Naval Facilities Engineering Command (NAVFACENGCOM) "Design Manual for Heating, Ventilation, Air Conditioning and Dehumidifying Systems" and applicable "Guide Specification" sections. Design criteria for load calculations shall be based on the 1993 ASHRAE Fundamentals Handbook.

Design conditions shall be:

Area	Summer		Winter	
	Inside	Outside	Inside	Outside
Office	78°F/50%RH	91°FDB/76°FWB	68°F	22°F
Process Area	–	91°FDB/76°FWB	60°F	22°F

4.2.1 Heating, Ventilation and Cooling

The treatment plant building requires the following heating, ventilation and cooling systems:

- Exterior propane fuel system including storage tanks and distribution piping. Terminate at the treatment building with a pressure reducing station that reduces the pressure for building heating systems.

- Interior propane piping system for heating and ventilation units and unit heaters.

- Treatment area heating and ventilation systems consisting of:

  - Two (2) make-up air heating and ventilation units sized to provide a minimum of four (4) air changes per hour during winter ventilation. Indoor design temperature to be 60°F.

  - Process and general exhaust systems as follows:

    - The air stripper system is equipped with a blower exhausting 5,000 acfm at 4 inches of water column (WC).

- Tank T-130 and the Flocculation/Clarifier Complex require a 1,000 cfm exhaust fan system.

- Tank T-200 requires a 200 cfm exhaust fan system.

- Two (2) storage areas for hydrochloric acid and sodium hydroxide each require 500 cfm exhaust fan systems.

- A winter ventilation exhaust fan with a 2-speed fan motor to provide the difference between the minimum four (4) air changes per hour total ventilation and the total process exhaust rate at low speed and the addition of the air stripper rate at high speed.

- A summer ventilation exhaust fan to provide an additional six (6) air changes per hour of ventilation. Total summer ventilation is a minimum of ten (10) air changes per hour.

- Summer ventilation air intake louvers with motorized dampers.

- Supplemental propane unit heaters at doors as shown on Drawing M-1.

- Ancillary office area HVAC systems consisting of:

    - A through-wall packaged room air conditioning unit with electric heating element and minimum 20 percent outside air capability that is able to maintain 78°F summer cooling and 70°F winter heating.

    - Toilet room to be provided with baseboard electric heater and ten (10) air changes per hour exhaust fan which operates when the lights are turned on.

4.2.2 Plumbing Systems

The treatment plant building requires the following plumbing system requirements:

- Sanitary and cold water distribution systems to 5'-0" outside of the building.

- Toilet room fixtures, i.e., lavatory, water closet, etc.

- In-line instantaneous electric hot water heater for the lavatory.

- Floor drainage system and floor sump pump.

- Emergency shower and eyewash system.

- All required connections to the process and HVAC systems.

4.2.3 HVAC System Control

Operate the treatment building HVAC systems in accordance with the following sequences of operation:

- Make-up air heating and ventilation units are energized when the outside air temperature is below 60°F (adjustable). The propane gas-fired heater section is controlled to maintain a room temperature of 60°F (adjustable). The outside air intake motorized damper shall be open before the fan can start.

- Process exhaust fans operate continuously.

- The 2-speed winter exhaust fan shall be interlocked to operate at low speed when the air stripper fan is operating and at high speed when the air stripper is off. Fan runs continuously.

- The summer ventilation fan is energized when its thermostat senses a temperature of 80°F (adjustable) and de-energized when sensing a temperature of 70°F (adjustable). A photoelectric pressure switch at the intake of the winter exhaust fan shall energize the summer exhaust fan and sound an alarm upon sensing 40 percent of maximum airflow.

- Building outdoor air intake dampers open when the outdoor temperature is above 65°F (adjustable) and close when the outdoor temperature is below 60°F (adjustable).

- Propane gas-fired unit heaters to have local thermostats and door switches.

- Office through-wall air conditioner and toilet room electric heater to incorporate integral control systems. Toilet room exhaust connected to light switch.

4.3 Electrical Systems

Drawings E-1 through E-7 provide site and building power plans, main distribution details, and single line diagrams for the recovery wells. Electrical design requirements and assumptions are presented below.

4.3.1 Exterior Distribution Systems

4.3.1.1 Temporary Power

The Contractor will furnish and install temporary power and lighting in construction areas in accordance with governmental requirements. For both temporary and permanent power to the site, the Navy will insure that adequate power is available from the existing 12.47 KV overhead power pole line located on the east side of Piney Green Road.

4.3.1.2 Primary and Secondary Power

The Contractor will furnish and install all primary and secondary power distribution from a 12.47 KV, 3-phase, overhead power pole line located on the east side of Piney Green Road, at a point approximately 1,300 feet south of the site, to the groundwater treatment plant building. This shall include all metering, overhead cable, power poles, transformers, fuses, cutouts, etc., per the requirements of the Navy. Electrical service to the building shall be 480/277 volt, Y, 3-phase, 4-wire rated at 600 amperes from three 100 KVA 1-phase pole mounted transformers.

4.3.1.3 Remote Electrical Equipment Power and Control

The Contractor will furnish and install all underground and overhead conduits, cables, handholes, disconnect switches, transformers, starters, and mounting hardware for power and control of remote site pump locations as shown on the Site Plan. Voltage drop calculations have been provided for remote site pump location power based on expected pump sizing shown (see Appendix B).

4.3.1.4 Site Telephone Distribution System

The Government will furnish and install all necessary equipment, cabling, raceway, or cable support systems to bring telephone service to the site.

4.3.2 Interior Distribution Systems

4.3.2.1 Interior Secondary Power Distribution

The Contractor will furnish and install all secondary power distribution equipment including all electrical panelboards, transformers, power receptacles, lighting, emergency lighting, PLC equipment, control equipment, branch circuit wiring, control conduit, wiring, and connections. Contractor will also install all electrical equipment furnished by others.

4.3.2.2 Interior Telephone Distribution

The Contractor will furnish and install a telephone raceway system to include a telephone backboard located in the treatment plant office, outlet boxes, and conduit to the terminal backboard. It was assumed that all cabling, telephone switches, station cabling, phone equipment and terminations will be provided by the Navy.

4.4 Instrumentation and Control System

The design of the groundwater treatment system has been set up to provide a system that continuously processes contaminated groundwater with a minimal amount of required operator labor. The basis of this system will be a set of programmable logic controller (PLC) modules with a central, dedicated operator interface module. This PLC system will be located in the treatment system building office. Based on the Piping and Instrument Diagrams (P&IDs) issued April 8, 1994 there will be 116 Input/Outputs (I/Os) in the PLC system. In writing the PLC specification, at least 232 I/Os should be specified. A breakdown of the I/O count is as follows:

Digital Inputs (DI)	47
Digital Outputs (DO)	43
Analog Inputs (AI)	18
Analog Outputs (AO)	8
Total I/O Count	116

The PLC system logic and controls are designed to adjust to step changes that may be introduced to the system. The logic for the control of the treatment system is shown on the P&IDs. A detailed process description may be provided to the contractor if required. This was not in Baker's scope of work, but can be supplied if required.

The Contractor will provide the following items to complete the design and construct the control system:

- Cable/Conduit Layout Drawings
- Panel Layout Drawings
- Operator Interface Display Graphics Drawings
- Instrument Installation Detail Drawings

- Instrument Specifications
- PLC Specification
- Instrument Data Sheets
- Programming the Control Logic for the PLC

The PLC system will receive inputs from and send outputs to the extraction well system as well as the treatment system. The inputs include items such as levels, alarms, flow rates, pressures, on/off indicators, and start/stop signals. Outputs include control set points, start/stop signals, and speed controller signals. The logic controlling these items is the basis for the continuous, and self correcting operation of the treatment system. The versatility, reliability, and minimal requirement for operating labor is the basis for this type of control system.

5.0 GROUNDWATER EXTRACTION SYSTEM

The selected remedial action for groundwater at OU No. 2 is intensive groundwater extraction and treatment from the shallow and deep aquifer at Site 82. Extracted groundwater will be collected via a network of recovery or extraction wells placed in areas of the shallow and Castle Hayne aquifers with the highest contaminant levels. Up to three deep extraction wells (110 feet deep) will be installed. Each deep extraction well will be pumped at a rate up to approximately 150 gallons per minute (gpm). In addition, approximately three shallow extraction wells (35 feet deep) will be installed. Each shallow extraction well will be pumped at a rate up to 5 gpm. Extracted groundwater will be treated on site using a treatment system designed to remove metals and Volatile Organic Compounds (VOCs). The treated effluent will be discharged to Wallace Creek.

5.1 Basis of Extraction Well Design

The groundwater recovery (or extraction) system was designed with sufficient additional capacity to handle additional extraction wells that may be necessary for the remediation of the aquifer.

Preliminary calculations using appropriate variants of standard equations [Keely and Chin 1983] provide conceptual representations relevant to the design of the recovery well system. These calculations illustrate the interception of the flow of contaminated groundwater, and the distribution of recovery well stations [pumping wells] required to effect this capture.

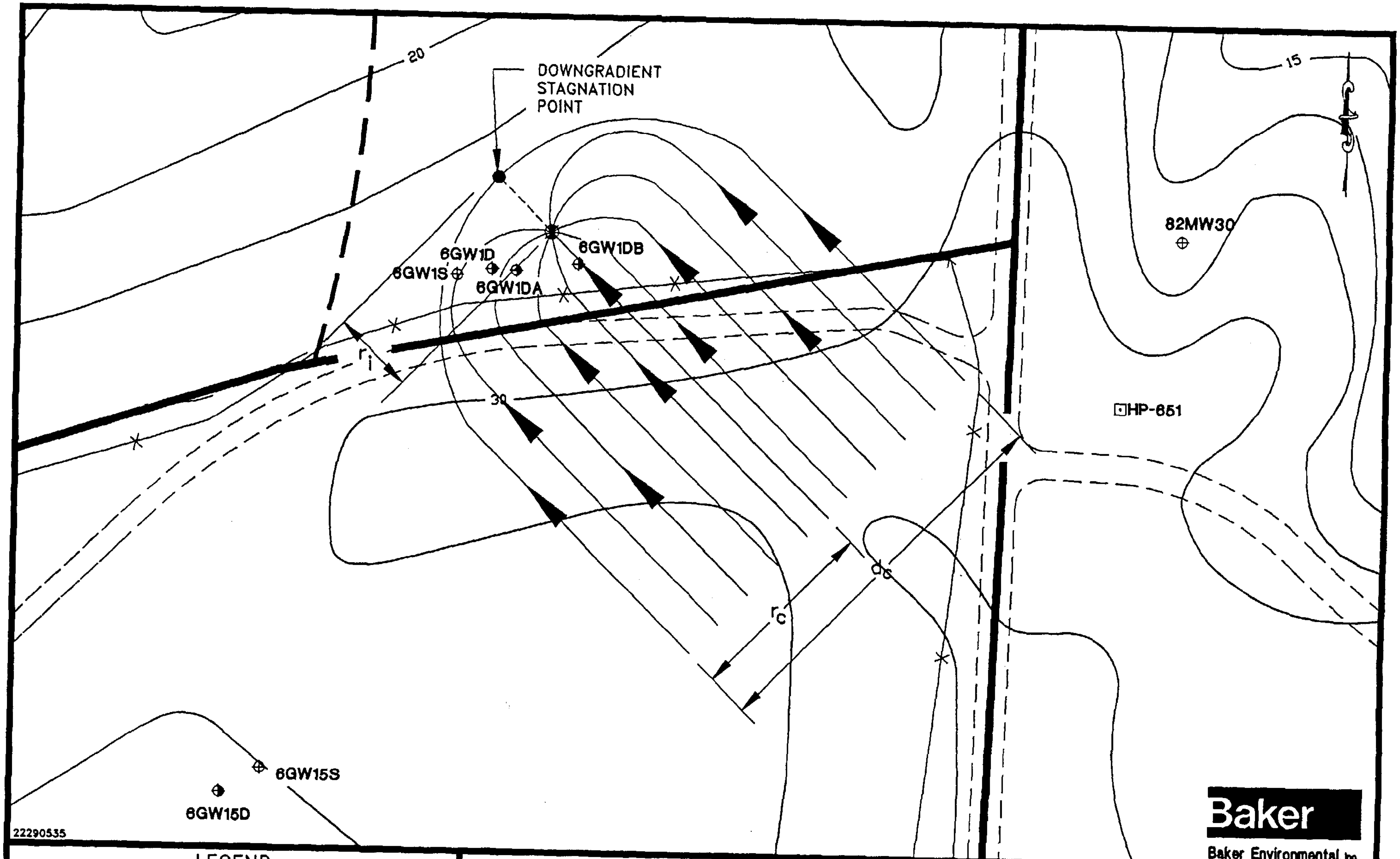
The calculated design parameters reflect the velocity distribution of groundwater flow in the vicinity of each extraction well. These calculations provide characteristic radii for the capture of groundwater by the extraction well at various angles to the direction of regional flow. The resultant calculations describe:

- The maximum distance [r_c] from the extraction well that a particular discharge rate will intercept the flow of groundwater [this distance is always normal to the direction of regional flow];
- The maximum width [d_c] across regional flow where groundwater will be captured by a given extraction well at a particular discharge rate [this width is also normal to the direction of regional flow]; and,
- The maximum distance [r_i] downgradient [along the direction of regional groundwater flow] of the extraction well within which flow will be reversed into the extraction well from regional interflow.

The resultant parameters of the calculation of velocity distribution represent the major [r_i] and minor axes [r_c] of a geometric design [Figure 5-1], with the external radius of the major axis [r_i] calculated and with r_c equal to πr_i and d_c equal to $2r_c$, where

- r_i is coincident with the regional gradient;
- r_c lies normal to r_i; and,
- The net velocity distribution within the capture radii r_c and r_i is directed into the extraction well.

The length of the downgradient capture radius and the position of the downgradient [trailing-edge] stagnation point are found directly downgradient from the production well at radius [r_i], where the velocity vector toward the well is exactly balanced by the velocity vector of the regional gradient [which condition



LEGEND

PROPOSED EXTRACTION WELL

GROUNDWATER FLOWLINES IN CAPTURE ZONE

r_i DOWNGRADIENT CAPTURE RADIUS

r_c CROSS-GRADIENT CAPTURE RADIUS

d_c CROSS-GRADIENT CAPTURE DIAMETER

SOURCE: LANTDIV, FEB. 1992

100 0 50 100 200

1 inch = 100 ft.

FIGURE 5-1
GENERAL CAPTURE OF REGIONAL GROUNDWATER FLOW BY AN EXTRACTION WELL
SOIL AND GROUNDWATER REMEDIATION
CTO-0222
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

creates the trailing-edge stagnation point]. Flow within this radius is toward the well, while flow beyond this radius escapes the well; at the stagnation point, there is no theoretical flow in either direction.

The length of the cross-gradient capture radius [r_c] and the position of the cross-gradient capture boundary [as the discharge perimeter of capture] lie normal to the regional gradient at $r_c = \pi r_i$. The cross-gradient capture diameter [d_c] lies normal to the regional gradient and is equal to $2\pi r_i$. Within the cross-gradient capture boundary at r_c, groundwater flows into the well and does not follow the regional interflow.

5.2 Site Condition Assumptions

These preliminary calculations require that the water-bearing layer be homogeneous, isotropic, planar and unbounded; the analyses of the field investigation indicate that these characteristics are approximated in the Castle Hayne Aquifer, at depths up to approximately 230 feet, within the study area. For the purposes of design and for illustration, these assumptions allow founding of the basic form of the remedial response. The final criterion of the suitability of the design will, however, be the actual performance of the system; the design provides the system with sufficient flexibility of implementation that adjustments can be made to bring performance into line with expectations.

The preliminary calculations are dependent on the aquifer parameters and flow conditions found during the pre-design investigation; these include:

Transmissivity	55000 gallons per day per foot
Regional Gradient	4.6E-03

The transmissivity value used was based on a summary of data collected from potable water production wells at Camp Lejeune, prepared by the U.S. Geological Survey (USGS, 1989). This summary includes the production well at Building 651, located very close to Site 82. The regional gradient was calculated from the recent field investigations.

The conditions represented in this design probably reflect the usual interflow regime of groundwater through the area. The gradient selected was calculated on data measured during a period of fairly well distributed precipitation. The data then reflect the local dissipation of the precipitation recharge imposed on the regional interflow. The calculation is, therefore, insensitive to the variations in flow caused by high or low rainfall.

5.3 Extraction System Design - General

The configuration of the extraction well and calculated capture zones appears in Figure 5-1. The distribution of interception radii at the particular discharge rate [Q] are:

Q	150 gallons per minute
r_c	136 feet
r_i	43 feet
d_c	275 feet

In reviewing the illustration of Figures 5-1, the baseline [capture line] indicates the total frontage past which the calculations indicate groundwater cannot pass. There is a half-cusp at each side of the capture figure [indicated by the curvature of the interception radii to the tangent coincident with the regional direction of flow]; however, the recurvatures of flow along the tangents do not allow contaminated groundwater to enter these half-cusps.

The remedial response, during operation, will monitor its effectiveness in containing the movement of contaminants, and in removing the highest concentrations of contaminants known. As part of the monitoring, adjustments can be made easily to redistribute the areal effectiveness of the response.

5.4 Extraction Design - Castle Hayne Aquifer

Figure 5-1 illustrates the location of one of the proposed extraction well stations for the Castle Hayne Aquifer. The groundwater flow direction was selected by reviewing groundwater contour maps for the site. There are three extraction stations presently planned for the Castle Hayne Aquifer. Figure 5-1 illustrates the location of one station and shows the discharge rate [Q], capture radius [r_c], capture width [d_c] and interception radius [r_i]. A capture width for three extraction stations is approximately 800 feet, and is intended to intercept the most contaminated zones of the aquifer. The total planned discharge capacity is 300 to 450 gallons per minute [gpm]. Drawing C-2 shows the planned arrangement of the deep and shallow extraction wells.

After installation of the two initial extraction wells (one shallow and one deep) and the groundwater treatment system, aquifer tests will be performed to evaluate actual performance of the extraction well system. Using data from the aquifer tests, the location of the remaining deep and shallow extraction wells, and the interconnecting piping will be determined. The Contractor will then install the remaining extraction wells and interconnected piping. Performance tests should then be performed on each of the additional shallow and deep extraction wells, to verify that each well is producing the desired yield and capture zone. Aspects relating to the treatment system design and construction are described below and in Section 6.

5.5 Extraction Well Piping

The extraction well piping will be high density polyethylene [HDPE] and will be run below grade approximately as shown on Drawing C-2. HDPE piping was chosen due to its chemical resistance, ease of installation and moderate cost. The piping will be run underground to protect the pipeline from damage due to other site work or maintenance activities, and to maintain pleasing aesthetics at site.

A pump building will be provided at each extraction well for access to valves, flow meters, and electrical equipment. Access manholes will also be located along the pipe routing, as shown on Drawing C-2.

Calculations for sizing of the extraction system piping and pumps may be seen in Appendix C of this Basis of Design.

6.0 GROUNDWATER TREATMENT SYSTEM

The groundwater extraction and treatment system for OU No. 2 will be designed to collect and treat the groundwater contamination originating from Site 82. Phase I of the project includes installation of two extraction wells to be placed in the plume area with the highest contaminant levels. One deep extraction well (approximately 110 feet deep) pumping at a rate of 150 gallons per minute (gpm) and one shallow extraction well (approximately 35 feet deep) pumping at a rate of 5 gpm will be installed (Phase II). Once extracted, the groundwater will be pumped to an on-site treatment system consisting of metals removal, air stripping, and carbon adsorption. The treated groundwater will be discharged to Wallace Creek. Following well development and testing, the remaining extraction wells will be installed (Phase II). The approximate location of the extraction wells and the treatment system are identified on Drawing C-2.

The groundwater treatment system will be defined to begin at the point the underground HDPE piping used in the extraction system comes above grade and changes to carbon steel piping. This happens at the same point near Groundwater Feed Tank T-110. The treatment system is designed to continuously process up to 500 gpm of influent groundwater and to remove dissolved Fe^{+2} as $Fe(OH)_2$, suspended solids, and volatile organic compounds (VOCs) to the required effluent limits. The treated effluent goals, as presented in Table 1-1, are based on applicable ARARs (See Section 1.4). Expected treatment system influent and effluent characteristics are presented in Table 6-1.

~~The influent and effluent concentrations of constituents of concern that formed the basis for all unit operations in the design of the treatment facility are presented in Table 6-1.~~ Additional sampling data from existing monitoring wells at the site is provided in Appendix C.

The treatment system consists of eight (8) major process areas: groundwater feed storage and equalization, initial pH adjustment, solids and metals removal, final pH adjustment, sand filtration, air stripping, granular activated carbon (GAC) adsorption, and treated effluent discharge and storage. The following section describes the basis for the equipment used in each major process area off the system. A summary table showing design data for all process tanks is provided in Appendix D.

6.1 Groundwater Storage and Feed

The extracted groundwater will be stored in Groundwater Feed Storage Tank T-110 located outside the building. The tank will be a vertical, cylindrical at the design volume, carbon steel tank, with a conical top and flat bottom, and a residence time of approximately 40 minutes. This will provide for adequate surge capacity as well as for appropriate time for contaminants of influent groundwater to come to equilibrium. The total capacity of the tank will be approximately 24,000 gallons which includes 4 feet of freeboard height in the tank and the conical top. Dimensions of the tank will be 13 feet diameter x 23 feet straight-side height.

The groundwater will be fed from T-110 to Initial pH Adjustment Tank T-130 by Groundwater Feed Pumps P-110A/B. Each of these pumps will be centrifugal pumps constructed of carbon steel and rated at 540 gpm at 40 feet TDH. The flow rate will be controlled by FCV-110. P-110A will be the main feed pump with P-110B being an on-line spare. The use of the on-line spare is to keep with the basic principle of continuous processing of the contaminated groundwater.

6.2 Initial pH Adjustment

The process water will be pumped to Initial pH Adjustment Tank T-130. The tank will be an agitated, vertical, cylindrical, carbon steel tank, with a standard flanged and dished top and a flat bottom, and a residence time of 10 minutes at the design volume. This will provide for adequate surge volume while being able to control the pH. The total capacity of the tank will be approximately 6,500 gallons which

TABLE 6-1

GROUNDWATER TREATMENT SYSTEM INFLUENT AND EFFLUENT CHARACTERISTICS
SOIL AND GROUNDWATER REMEDIATION - CTO-0222
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Influent Concentration (μg/L)	Required Effluent Concentration (μg/L)
Acetone	262	–
Ethylbenzene	52	29
1,2-Dichloroethane	30	0.38
1,2-Dichloroethene	30,000	70
Lead	38	15
Manganese	50	50
Mercury	0.17	1.1
Tetrachloroethene	920	0.7
Trichloroethene	58,000	2.8
Vanadium	330	80
Vinyl Chloride	800	0.015

includes 3 feet of freeboard height in the tank and the dished top. Dimensions of the tank will be approximately 9 feet diameter x 14 feet straight-side height.

In Tank T-130, the pH of the process water will be adjusted to between 9-9.5 so that the Fe^{+2} will precipitate out of solution as $Fe(OH)_2$. Although removal of dissolved Fe^{+2} is not an effluent requirement, its removal is necessary to prevent oxidation of the Fe^{+2} to FeO_2 in the air stripper. This could cause the air stripper to foul and, therefore, significantly reduce its efficiency such that effluent limits for VOCs may not be met.

The pH will be raised by addition of 20 percent by weight sodium hydroxide (NaOH) solution. The NaOH solution is commercially available in 55 gallon drums at a concentration of 50 percent by weight. The solution is diluted in NaOH Mix Tank T-120 to provide better pH control of the process water and to make the pump reasonably sized. The 20 percent NaOH solution will be added by Pumps P-120A/B at approximately 1.2 gph at the system design rate of 500 gpm of groundwater. Design flow rate of Pumps P-120A/B shall be 3.5 gph to allow for any buffers that may be present in the process water.

Tank T-120 will be an agitated, vertical, cylindrical, carbon steel tank with a standard flanged and dish top and a flat bottom. The total capacity of the tank will be approximately 3,000 gallons which includes 2 feet of freeboard height in the tank and the dished top. The overall dimensions of the tank will be approximately 3 feet diameter by 6 feet high.

From T-130, the process water will then be pumped to the solids removal section of the system by Solids Removal Feed Pumps P-130A/B. Each of these pumps will be centrifugal pumps constructed of carbon steel and rated at 540 gpm at 40 feet TDH. The flow rate will be controlled by FCV-130. P-130A will be the main feed pump with P-130B being an on-line spare. The use of the on-line spare is to keep with the basic principle of continuous processing of the contaminated groundwater.

6.3 Solids and Metals Removal

The solids and metals removal process includes polymer mixing and flocculation, clarification, sludge thickening, and sludge dewatering. It should be noted that this entire system is usually provided by one vendor. This provides for a system with integrated components, which is an important factor for a metals removal system.

The polymer mixing, flocculation, and clarification will take place in a single vessel with separate compartments. The size of the system will be based on the flow rate and solids loading as defined in the material balance and on the above influent concentrations of suspended solids and iron. Residence times, sizes, and dimensions of tanks and vessels in this system have been calculated, but will be finalized by the equipment vendor during detailed design.

6.3.1 Polymer Mixing and Flocculation

In the mixing compartment, X-130A, the process water from P-130A/B will be flash mixed with a polymer solution to promote flocculation of the suspended solids and precipitated metals. Polymer will be added to this compartment at a rate of 1.5 gpm to produce a polymer concentration of 3.0 mg/L in the process water. The polymer will be fed by metering pumps P-132A/B which will be provided by the equipment vendor. The polymer feed will be mixed to produce a concentration of 1,000 mg/L in Polymer Mix Tank T-125. Tank T-125 will be a vertical, cylindrical, carbon steel tank with a standard flanged and dish top and a flat bottom. The total capacity of the tank will be approximately 2,800 gallons which includes 2 feet of freeboard height in the tank and the dished top. The dimensions of the tank will be approximately 6 feet diameter by 10 feet straight-side height.

The process water then flows to compartment X-130B where slow mixing of the liquid allows the solids and precipitated metals to form flocculate that will settle in clarifier compartment X-130C. The flocculation step will also receive recycled sludge from the bottom of X-130C to enhance the efficiency of this step. The sludge recycle stream is included due to the relatively low solids concentration of the system.

6.3.2 Clarification

After flocculation, the process water will flow to an inclined-plate clarifier (X-130C) where the flocculated solids and precipitated metals settle. Settled solids form a sludge blanket on the bottom of this slanted rectangular vessel and clear water (a solids content of approximately 5 ppm) flows over a weir at the top of the tank and continues by gravity to Final pH Adjustment Tank T-200. The sludge collected on the clarifier bottom will be continuously recycled at a rate of 40 gpm by Sludge Recycle Pumps (P-140A/B) back to the flocculation chamber. Pumps P140A/B are air-operated diaphragm (AOD) pumps. Sludge will be blown down to Sludge Thickening Tank T-140 at approximately 5 gpm for 10 minutes every hour (50 gph). The blowdown sludge is expected to contain 1 percent solids by weight. The sludge blowdown will be pumped by a separate AOD pump P-143.

6.3.3 Sludge Thickening

The sludge blowdown from X-130C will be allowed to further thicken by gravity separation in the Sludge Thickening Tank T-140. This tank will be a vertical, cylindrical, carbon steel tank with a conical bottom and flat top. The total capacity of the tank will be approximately 1,900 gallons which includes 2 feet of freeboard height in the tank and the conical bottom. Dimensions of the tank will be 6 feet diameter x 9 feet straight-side height with a residence time of approximately 5 hours at the design volume. The tank will also be equipped with an automatic decant arm to remove clear liquid (supernatant) from the top of the tank.

The sludge enters at approximately 1 percent by weight solids and will thicken to approximately 3 percent by weight solids in the bottom of the tank. These solids will then be pumped, intermittently, to the sludge dewatering step by AOD pump P-141.

Clear supernatant from T-140 will flow to the Supernatant Holding Tank, T-145. Tank T-145 will be a vertical, cylindrical carbon steel tank with a flat bottom and flat top. The tank dimensions will be 6 feet diameter x 4 feet high. From T-145, supernatant will be pumped at a rate of 20 gpm by Pump P-145 to the mixing chamber portion of the metals removal system (X-130A) and reprocessed through the plant. Pump P-145 will be a centrifugal pump constructed of carbon steel and rated at 20 gpm at 40 feet TDH.

6.3.4 Sludge Dewatering

The sludge from the bottom of tank T-140 will be pumped, intermittently, to plate and frame Filter Press X-140 for dewatering of the sludge at a rate of 25 gpm and a pressure of 100 psig. The solid cake that collects on the filter plates will be approximately 30 percent by weight solids. At the completion of the dewatering cycle, an operator will open the filter plates and dump the filter cake to a dumpster. The filter press filtrate will flow to Supernatant Holding Tank T-145 and will be recycled with the Sludge Holding Tank supernatant.

6.4 <u>Final pH Adjustment</u>

The overflow from the clarifier will be fed by gravity to Final pH Adjust Tank T-200 where the pH will be lowered to approximately 7. This tank will be an agitated, vertical, cylindrical, carbon steel tank with a flat bottom and standard flanged and dished top. The total capacity of the tank will be approximately

6,000 gallons which includes 3 feet of freeboard height in the tank and the dished top. Dimensions of the tank will be 9 feet diameter x 14 feet straight-side height with a residence time of approximately 10 minutes at design volume. Adjustment of the pH will be done with addition of approximately 12 gpd of a 10 percent by weight hydrochloric acid (HCl) solution by Metering Pumps P-211A/B. Design flow rate for the pumps shall be 25 gpd to allow for any buffers that may be present in the process water.

The acid solution will be mixed in Acid Mix Tank T-211. This tank will be an agitated, vertical, cylindrical tank with a flat bottom and standard flanged and dished top constructed of FRP. The total capacity of the tank will be approximately 200 gallons which includes 2 feet of freeboard height in the tank and the dished top. Overall dimensions of the tank will be 3 feet diameter x 6 feet straight-side height. This volume provides approximately a 16 day supply of 10 percent HCl solution.

The adjusted process water will then be pumped to Sand Filters X-200A/B/C by Final pH Adjust Effluent Pumps P-200A/B. Each of these pumps will be centrifugal pumps constructed of carbon steel and rated at 540 gpm at 100 feet TDH. P-200A will be the main feed pump with P-200B being an on-line spare. The flow rate will be controlled by FCV-200.

6.5 Solids Filtration

Solids filtration will take place in Sand Filters X-220A/B/C. Each sand filter vessel will be a vertical, cylindrical, carbon steel tank with standard flanged and dished top and bottom, approximately 6 feet diameter x 12 feet high and will be constructed of carbon steel. The process water, at pH 7, will be fed to two (2) of the three (3) sand filters in parallel flow at a design rate of 250 gpm per sand filter. The filters will reduce the solids concentration from 5 ppm to <1 ppm. This filtration is to minimize the amount of solids that will be sent to the air stripper and thus prevent fouling. The sand filters will be designed to operate in parallel to reduce the size of each vessel and to reduce the amount of backwash water required. Two (2) units will always be in operation while one (1) unit is either in the backwash cycle or on stand-by. Backwash of the filters will occur automatically based on differential pressure across each vessel. This backwash will occur approximately once per day to one vessel at a flow rate of 300 gpm per vessel for 20 minutes. The backwash rate is based on use of 10 gpm of backwash water/ft^2 of sand filter area. The backwash water from the sand filters is sent to Spent Backwash Water Holding Tank T-205. Accumulated backwash water from T-205 is intermittently recycled to Initial pH Adjust Tank T-130.

6.6 Air Stripping

After removing solids to less than 1 ppm in the sand filters, the process water will flow to Air Stripper C-200. The air stripper will be an FRP, packed tower, 5 feet in diameter and approximately 35 feet of overall height (15 feet of packing height). The tower will be equipped with a 5 hp fan that will provide 5000 acfm of air at approximately 3 inches of W.C. at the design water flow of 500 gpm. C-200 will be sized to remove 99 percent of the least volatile VOC (99 percent efficiency). Any remaining VOCs will be removed to the effluent limits in the GAC Absorber system. The air stripping tower will also be equipped with acid flush connections for cleaning oxidized metals (such as magnesium or calcium), biological fouling, or scale build-up of various salts that will be naturally present in the groundwater.

A packed tower type unit was selected over a low-profile type unit because the low profile units, while being somewhat easier to maintain, have a much higher in capital cost (almost double the packed tower price) as well as a higher operating cost (five times as much per year). The maintenance issue was accounted for by providing the acid flush connections, limiting the solids loading to the column, and removal of iron by precipitation to iron hydroxide. This information was determined by comparison of vendor quotations.

The process water will enter the top of the air stripper column and will flow by gravity, counter-current to the influent air. After air contact, treated process water will be collected in the Air Stripper Effluent Holding Tank T-220. This tank will be a vertical, cylindrical, carbon steel tank with a flat bottom and flat top. The total capacity of the tank will be approximately 6,500 gallons which includes 2 feet of freeboard height in the tank. Dimensions of the tank will be 12 feet diameter x 8 feet high with a residence time of approximately 10 minutes. Column C-200 will be set on top of T-220 to allow T-220 to act as a sump for the packed tower air stripper.

6.7 Granular Activated Carbon (GAC) Adsorption

From T-220, the process water will be pumped to the GAC absorber system by GAC Feed Pumps P-220A/B. Each of these pumps will be centrifugal pumps constructed of carbon steel and rated at 540 gpm at 80 feet TDH. The flow rate will be controlled by FCV-220. P-220A will be the main feed pump with P-220B being an on-line spare.

GAC adsorption will be done by GAC Adsorbers X-220A/B/C/D. Each GAC vessel will be a vertical, cylindrical tank with standard flanged and dished top and bottom, approximately 10 feet diameter x 10 feet high and will be constructed of carbon steel. The process water will be fed to one (1) of two (2) parallel trains of two (2) GAC units in series at the design flow rate of 500 gpm per train. The GAC System will be the final treatment step for the groundwater (polishing step). Remaining VOCs will be adsorbed to the carbon bed and the concentration reduced to below the level less than the identified effluent limit. Sizing of these units is based on the design flow and contaminant concentrations. The GAC units will be operated with parallel trains in series to reduce the size of each vessel, therefore minimizing the amount of backwash water required. One (1) train will always be in operation while the other train is either in the backwash cycle or on stand-by. Backwash of the GAC units will occur automatically based either on differential pressure across each vessel or on a timer as recommended by the GAC vendor. GAC backwash is expected to occur approximately once per month to each vessel at a flow rate of 200 gpm per vessel for 20 minutes. This flow rate is based on vendor recommendation for this size unit. The backwash water from the GAC unit will be discharged to the Backwash Water Holding Tank T-205. The treated groundwater will then be discharged to the Treated Effluent Storage Tank T-240.

6.8 Groundwater Storage and Reuse

The treated groundwater will be stored in Treated Effluent Storage Tank T-240 located outside the building. The tank will be a vertical, cylindrical, carbon steel tank, with a conical top and flat bottom. The total capacity of the tank will be approximately 35,000 gallons which includes 4 feet of freeboard height in the tank. This will provide for adequate surge capacity for backwash water demands and dilution water demands for the acid, caustic, and polymer mix tanks. Dimensions of the tank will be 12 feet diameter x 26 feet straight-side height.

T-240 will be constructed with an overflow structure at the maximum water level to discharge the treated groundwater by gravity through an 8-inch pipe to Wallace Creek. By keeping the overflow structure at the top of the tank, the water stored in the tank will be available for backwash and plant service use. A weir and level measurement device will be used to measure and indicate the rate and totalize the effluent from T-240 to Wallace Creek.

Backwash water will be provided to either the sand filters or GAC adsorbers from T-241 by Backwash Water Pump P-241. This pump will be centrifugal pump constructed of carbon steel and rated at 300 gpm at 120 feet TDH. This pump will operate when a backwash cycle is required for the sand filters or the GAC absorber units. Dilution water for the caustic, acid, and polymer mix tanks will also be provided from T-240, and will be fed to these tanks by Mix Tank Feed Pump P-240. Pump P-240 will be centrifugal pump constructed of carbon steel and rated at 150 gpm at 50 feet TDH. This pump will operate when dilution water is required for the T-120 (caustic mix), T-125 (polymer mix), or T-211 (acid mix).

6.9 Treatment System Piping

The piping in the treatment system used for groundwater, process water, sludge, or treated groundwater service will be schedule 80, welded, carbon steel with 150 # flanged connections and will conform to specification 15401. Piping being used for caustic service will be schedule 80, carbon steel (C.S.) with screwed connections, and shall conform to specification 15402. Piping being used for acid service will be teflon lined C.S with screwed connections, and shall conform to specification 15403. Piping being used for sludge service will be schedule 80, welded, carbon steel, flanged and conform to specification 15404. Piping being used for plant air service will be schedule 40, welded, carbon steel with screwed connections and shall conform to specification 15405. Piping being used for vent and drain service will be schedule 40, welded, carbon steel with screwed connections and shall conform to specification 15400. All aboveground piping outside the treatment system building will be insulated. Locations of outside/inside piping changes are shown on the Piping and Instrument Diagrams (P&IDs).

The use of carbon steel piping inside the building for contaminated water (process water) was made based on the size of the piping system. It is intended that the piping not require excess supports and is able to support the liquid weight without excess bowing or vibration.

7.0 SOIL REMEDIATION SYSTEM

A Soil Vapor Extraction (SVE) system will be provided by the Contractor to treat the VOC contaminated soils located at AOC 1 (See Figure 1-2 and Drawing C-3). Details of the SVE shall be provided by the Contractor, based on available information and additional information generated by the Contractor. The intent of the Contractor's submittal shall be to provide a SVE system capable of remediating soils at the site to the goals specified on Table 1-1. The Contractor should also present recommended monitoring and performance testing requirements for the system, in a Sampling and Analysis Plan. The Contractor's detailed plan for the SVE system shall be approved by the Government prior to start of the work.

7.1 Available Site Information

Available information on contaminants detected in the soil at AOC 1 are provided in the RI and FS reports. The Contractor should review these other referenced documents for additional information on site conditions and contamination.

In addition, a one day soil permeability test was conducted at the site by Target Environmental Services, Inc. (Target, 1994). The objective of this test was to provide preliminary design data needed to design the SVE system. A copy of this report is provided in Appendix E of this report.

Based on the test, air permeabilities at the site, ranged between 1.2×10^{-7} and 2.8×10^{-7} cm^2, which is within a range of permeabilities conducive for soil remediation with a SVE system. A vacuum influence was observed at a maximum distance of 34.5 feet from the SVE well, when the SVE test equipment was operated at an air flow rate of 25.1 scfm and a vacuum of 1.3 in Hg.

7.2 SVE System Components

The SVE system will consist of several major components. The extraction system will include the extraction wells and below ground interconnecting well piping. The extraction/vapor treatment systems may include a vacuum pump system, an air/water separator system, a vapor phase carbon adsorption system, and a groundwater transfer pump.

The vacuum pump system will entrain vapor and any liquid from the extraction wells. This two-phase stream will be entrained in the air/water separator and split in to a liquid and vapor stream. The liquid will collect in the separator tank and will be periodically pumped to the groundwater treatment system. The vapor will continue through the vacuum pump system and will be discharged through the vapor phase carbon adsorption system. The treated vapor will be vented to atmosphere. The major equipment will be located in a building located adjacent to the contaminated area, which will also house the control equipment for a shallow groundwater extraction well.

8.0 REFERENCES

Baker Environmental, Inc. (Baker), 1993a. Record of Decision for Operable Unit No. 2 (Sites 6,9, and 82), Marine Corps Base, Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy Atlantic Division Naval Facilities Engineering Command, Norfolk, Virginia. August 1993.

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Baker, 1994. Project Plans, Contaminated Soil and groundwater Remedial Design, Marine Corps Base, Camp Lejeune, North Carolina . Final. Prepared for the Department of the Navy Atlantic Division Naval Facilities Engineering Command, Norfolk, Virginia. February, 1994.

Harned, Douglas A., Orville B. Lloyd, Jr., and M. W. Treece, Jr. 1989. Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina. USGS, Water Resources Investigations Report 89-4089.

Keely, J.F. and C.F. Tsang, 1983. "Velocity Plots and Capture Zones of Pumping Centers for Groundwater Investigations." Groundwater, Vol. 21, No. 6, pp. 701-714.

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Naval Facilities Engineering Command (NAVFACENGCOM). Design Manual for Heating, Ventilation, Air Conditioning and Dehumidifying Systems.

Naval Facilities Engineering Command (NAVFACENGCOM). Guide Specifications.

Summers et al. USEPA, 1980.

Target Environmental Services, Inc., 1994. Soil Vapor Extraction Pilot Test, AOC 1, Site 82, Marine Corps Base Camp Lejeune, North Carolina. April, 1994.

APPENDIX A
SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING, GROUNDWATER TREATMENT BUILDING, MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
McCALLUM TESTING LABORATORIES, INC.
APRIL 13, 1994

McCALLUM
TESTING LABORATORIES INC.
Subsurface Exploration • Geotechnical Engineering

SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING

GROUNDWATER TREATMENT BUILDING

MARINE CORPS BASE

CAMP LEJEUNE, NORTH CAROLINA

MTL PROJECT #94-2171

Prepared for: **Baker Environmental, Inc.**
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, PA 15108
Attention: Mr. John Lovely

1808 HAYWARD AVENUE P.O. BOX 13337 CHESAPEAKE, VIRGINIA 23325-0337
TELEPHONE (804) 420-2520 • FAX (804) 424-2874

McCALLUM
TESTING LABORATORIES INC.
Subsurface Exploration • Geotechnical Engineering

April 13, 1994

Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

Attention: John Lovely

Subject: Subsurface Exploration and Geotechnical Engineering
Groundwater Treatment Building
Marine Corps Base
Camp LeJeune, North Carolina
MTL Project #94-2171

Dear Mr. Lovely:

McCallum Testing Laboratories, Inc. is pleased to present this report of subsurface exploration and geotechnical engineering services for the above referenced project. Included in this report are:

1. A brief description of the project;
2. An outline of the services performed;
3. A description of the subsurface conditions encountered; and
4. Our detailed recommendations for site preparation and the design and construction of foundations, ground slabs and retaining walls.

Should you have any questions concerning this report, please do not hesitate to contact this office at your earliest convenience.

NORTH CAROLINA PROFESSIONAL SEAL No. 5855 ENGINEER DOUGLAS S. KINLOCH

Very truly yours,

McCALLUM TESTING LABORATORIES, INC.

Douglas S. Kinloch, P.E.
Chief Engineer

1808 HAYWARD AVENUE P.O. BOX 13337 CHESAPEAKE, VIRGINIA 23325-0337
TELEPHONE (804) 420-2520 • FAX (804) 424-2874

PROJECT INFORMATION

The site for the planned Groundwater Treatment Building is located west of Holcomb Boulevard and west of Building 65 on Site 82 in Camp LeJeune, North Carolina. The site is relatively level and partially wooded with an existing dirt road crossing the northeast corner of the building area.

The proposed building is to be a one story, pre-engineered building with overall plan dimensions of 70 ft. by 100 ft. It will likely be supported by a system of steel columns carrying loads of 15 to 60 kips.

The ground floor slab will likely be set at a finished floor elevation of 1 to 2 ft. above existing grade. Maximum slab live loads are not expected to exceed 150 psf.

SCOPE OF SERVICES

The evaluation of the site for the planned building required both the collection of subsurface data and the performance of various geotechnical analyses. These analyses were based on our experience with local conditions, available foundation types and site preparation methods. All work was directed and supervised by a Professional Engineer specializing in geotechnical design and construction. This written report which describes the exploration and provides our recommendations for site preparation and the design and construction of foundations, ground slabs and retaining walls was prepared after reviewing the project information provided to us and analyzing the subsurface data collected for the project.

A total of four soil test borings were drilled extending to depths of 15.5 ft. each beneath the existing ground surface. Standard Penetration Tests (SPT's) were performed at 2 ft. intervals in the upper 10 ft. and at 5 ft. intervals below 10 ft. All drilling, sampling and testing was performed in accordance with applicable ASTM Standards. At the completion of drilling, water level measurements were made within the completed bore holes. All samples obtained from the borings were visually examined by a Geotechnical Engineer and visually classified according to the Unified Soils Classification System. Selected samples were subjected to moisture content, Atterberg Limits testing and grain size analysis in the laboratory.

A Boring Location Plan and the detailed results of field sampling and testing are presented in Appendix A. The results of all laboratory testing are presented in Appendix B.

SUBSURFACE CONDITIONS

Stratigraphy

Directly beneath the existing ground surface, the borings encountered Coastal Plain Sediments. A summarization of the subsurface conditions encountered is presented in the following tabulation:

STRATUM	AVERAGE DEPTH (FT)	DESCRIPTION	STANDARD PENETRATION RESISTANCE (BLOWS/FT)
1	0.0 - 12.0	Loose to medium compact, moist to wet, light gray and gray, silty and clayey, fine sand (SP,SP-SM,SM,SC)	6 to 20
2	12.0 - 15.5*	Loose, wet, dark gray, silty, clayey fine sand (SC) and medium stiff, wet, dark gray, sandy, silty clay (CH)	6 to 9
* Maximum Depth of Exploration			

Groundwater

Our water level measurements made at the completion of drilling operations indicated the level of groundwater to be 10 to 12 ft. below the existing ground surface. Seasonal groundwater level fluctuations on the order of 2 to 3 ft. are not uncommon in this area. Maximum levels normally occur in late winter and early spring while minimum levels normally occur in late summer and early fall. At the time of our exploration program, we expect groundwater levels were dropping from their seasonal high elevations.

RECOMMENDATIONS

Basis

The following recommendations are based on data obtained by this subsurface exploration program, the structural and site orientation data given previously and our past experience within the area. If the project information presented is incorrect or changed in the final design or if site or subsurface conditions encountered during construction differ appreciably from those indicated by this report, this office should be notified to determine the applicability of our recommendations in light of the changed conditions.

Site Preparation

Initially, areas planned to support foundations, ground slabs or new fill should be stripped of all surface vegetation and any topsoil. Stripping should extend at least 5 feet beyond building lines. These areas should then be proofrolled with a heavily loaded dump truck and be monitored by the Geotechnical Engineer to locate any pockets of excessively soft surface soils. All areas that deflect excessively or rut and fail to tighten up under continued proofrolling should be undercut to firm material and be replaced with properly compacted fill.

After the successful completion of proofrolling and undercutting operations, fill required to reach finished subgrade elevation can be placed. Building pad fills should extend approximately 5 feet beyond building lines. Fill and backfill should be classified as SP-SM, SP or SW by the Unified Soils Classification System, with no more than 12 percent passing the No. 200 sieve. All fill materials proposed for use should be tested and approved by the Geotechnical Engineer prior to its placement on site. All fill and backfill placed beneath the structure should be compacted in loose lifts of 8 inches or less to a minimum of 95 percent of its maximum dry density as determined by the procedures outlined in ASTM D 698.

Foundations

The planned facility can be properly supported by a system of conventional shallow spread footings bearing directly in the inorganic near surface soils of Stratum 1 or on properly compacted fill placed directly above Stratum 1. Our bearing capacity analyses indicate that conventional shallow spread footings supporting loads of the magnitude indicated earlier in this report will have a sufficient factor of safety against a bearing capacity failure if designed for a net allowable soil bearing pressure of 2000 psf or less. However, under extremely light loads, we recommend footings maintain minimum width dimensions of 24 inches to help prevent a localized punching shear failure of the foundation supporting soils.

For both bearing capacity and frost heave protection considerations, all exterior footing bottoms should extend a minimum of 18 inches below finished exterior grade. Interior footings may be founded at nominal depths below finished subgrade elevation unless the subgrade will be subject to extended periods of freezing temperatures during construction or in service.

Based on the results of our Standard Penetration Testing and the anticipated loading conditions, we expect maximum settlements should be on the order of ½ inch. All settlement should have occurred by the completion of construction or shortly thereafter. Our previous experience with similar structures indicates this rate and magnitude of settlement will likely be tolerable; however, this should be confirmed by your Structural Engineer.

Foundation Installation

All foundation excavations should be inspected by the Geotechnical Engineer prior to the placement of reinforcing steel to confirm foundations will bear on soil material comparable to those recommended for foundation support by this report. Where unsuitable materials are encountered, they must be undercut to firm material as directed by the Geotechnical Engineer. If proper bearing does require over-excavation, the excavations should be backfilled in thin lifts up to design footing bottom elevation with properly compacted sand fill (95 percent of ASTM D 698) or No. 57 crushed stone compacted to a non-yielding condition, or sacrificial concrete.

Slabs-On-Grade

If the recommended site preparation procedures are performed, the ground floor slab for the planned facility can be properly supported on grade. However, localized concentrated loads due to tanks or equipment should be supported on individual foundations isolated from the ground slab. Grade slabs should also be jointed around columns and along any walls supported by individual foundations such that the slab and adjacent foundations can move independently without causing slab damage. Joints between slab sections should contain through reinforcing and keyways to permit rotational movement without cracking or vertical displacement. To help provide support for any concentrated slab loads, to provide stability to the building pad during construction and to allow for lateral movement of moisture beneath the slab, we recommend at least 4 inches of clean sand (SP or SW) be placed beneath the slab. If 4 inches or more of these materials are placed directly beneath the slabs as part of building pad construction, a separate porous fill layer will not be required. To help prevent interior damage due to excessive moisture, we further recommend the placement of a vapor barrier between the slab bottom and the sand blanket.

Retaining Walls

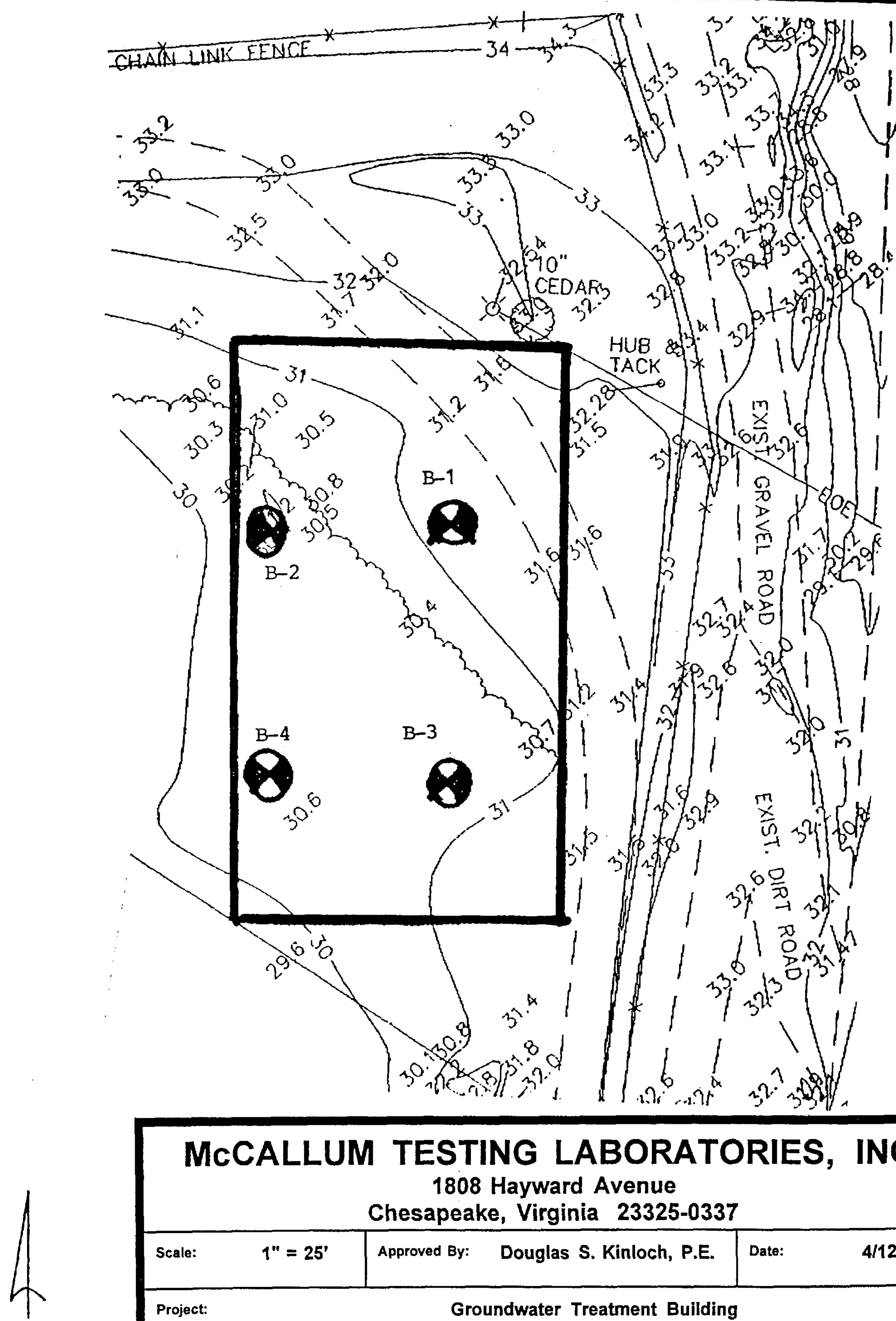
Should relatively low (less than 5 ft.) retaining walls be required for loading docks, truck wells of other grade transitions, we recommend the following parameters be utilized for design.

Unit Weight (pcf)	115
Buoyant Unit Weight (psf)	55
Cohesion (psf)	0
Angle of Internal Friction (degrees)	30
Coefficient of Active Earth Pressure Coefficient of Passive Earth Pressure Coefficient of At-Rest Earth Pressure	0.33 3.00 0.50
Friction Angle Against Concrete (degrees) Concrete Formed and Poured Concrete Poured Against Soil	 17 30

APPENDIX A

Boring Location Plan

Soil Test Boring Records



McCALLUM TESTING LABORATORIES, INC.

1808 Hayward Avenue
Chesapeake, Virginia 23325-0337

Scale:	1" = 25'	Approved By:	Douglas S. Kinloch, P.E.	Date:	4/12/94

Project: Groundwater Treatment Building
Marine Corps Base
Camp Lejeune, North Carolina

Drawing Title: Boring Location Plan

Drawing Number: 1-94-2171

Unified Soil Classification System

ASTM Designation D 2487

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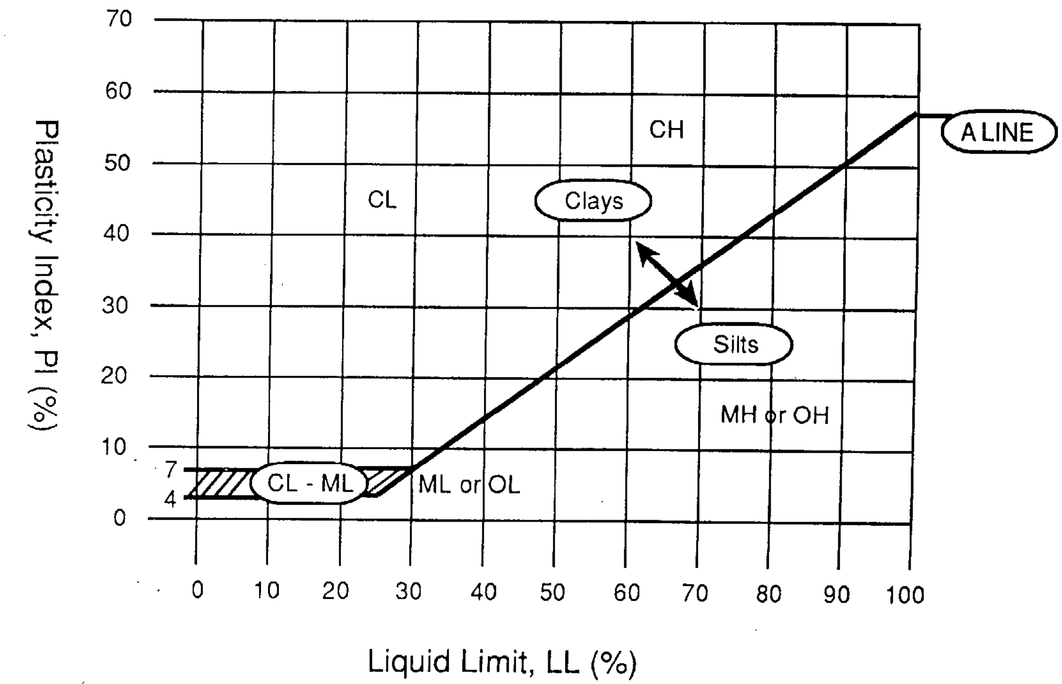
Based upon percentage of material passing No. 200 sieve classify as:

- Less than 5%: GW, GP, SW, SP
- More than 12%: GM, GC, SM, SC
- 5% to 12%: Borderline, use Dual symbols

Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Gravels (More than 50% retained on No. 4 sieve)	GW	Well graded gravels, gravel - sand mixtures, little or no fines	$C_U = \frac{D_{60}}{D_{10}} > 4$	$1 < C_C = \frac{(D_{30})^2}{D_{10} \cdot D_{60}} < 3$
		GP	Poorly graded gravels, gravel - sand mixtures, little or no fines	Does not meet all requirements for GW	
		GM	Silty gravels, gravel - sand - silt mixtures	below A Line, PI < 4	In shaded area 4 < PI < 7 Dual Symbols
		GC	Clayey gravels, gravel - sand - clay mixtures	above A Line, PI > 7	
	Sands (More than 50% passing a No. 4 sieve)	SW	Well graded sands, gravelly sands, little or no fines	$C_U = \frac{D_{60}}{D_{10}} > 6$	$1 < C_C = \frac{(D_{30})^2}{D_{10} \cdot D_{60}} < 3$
		SP	Poorly graded sands, gravelly sands little or no fines	Does not meet all requirements for SW	
		SM	Silty sands, sand - silt mixtures	below A Line, PI < 4	In shaded area 4 < PI < 7 Dual Symbols
		SC	Clayey sands, sand - clay mixtures	above A Line, PI > 7	
Fine Grained Soils (More than half of material is smaller than No. 200 sieve)	Silts & Clays (LL less than 50)	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity		
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays and lean clays		
		OL	Organic silts and organic silty clays of low plasticity		
	Silts & Clays (LL greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, plastic silts		
		CH	Inorganic clays of high plasticity, fat clays		
		OH	Organic clays of medium to high plasticity.		
Highly Organic Soil		PT	Peat and other highly organic soils		

Plot Intersection of PI and LL as determined by Atterberg Limits tests. Data points above A LINE indicate Clay soils, those below the A LINE indicate Silt.



McCallum Testing Laboratories, Inc.

CHESAPEAKE, VIRGINIA 23325-0337

LOG OF BORINGS

BORING NO. B-1
LOCATION Camp Lejeune, NC
PROJECT CTO-0222, Marine Corps Base
SURF. ELEV. ______ WATER ELEV: IMMEDIATE 12' AFTER ______ HRS. ______

OUR FILE NO. 94-2171
CLIENT'S ORDER ______
DATE STARTED 4/5/94
DATE COMPLETED 4/5/94

Elev.	Casing Blows	Samp. No.	Std. Pent. (N)*	Depth	Matl. & Color Change	DESCRIPTION
				0		
		1	2-4-3-2	2	2.0	Light grey, fine sand, moist, loose, SP
		2	2-4-6-6	4	4.0	Light grey, silty fine sand with traces of clay nodules, moist, loose, SP
		3	6-8-10-9	6	6.0	Grey, silty fine sand with traces of clay nodules, moist, medium compact, SM
		4	4-3-4-3	8	8.0	Grey, silty clayey fine sand, moist, loose, SC
		5	4-7-7-7	10		Grey, silty fine sand with traces of clay nodules, moist, medium compact, SP-SM
					12.0	
		6	4-3-3	15	15.5	Grey mottled brown silty clayey fine sand, wet, loose, SC-SM
						Bottom of Boring 15.5 ft.
				20		
				25		

*STANDARD PENETRATION INDICATED FOR EACH 6 INCHES OF DRIVE OF SPLIT TUBE SAMPLED.

McCallum Testing Laboratories, Inc.

CHESAPEAKE, VIRGINIA 23325-0337

LOG OF BORINGS

BORING NO. B-2

LOCATION Camp Lejeune, NC

PROJECT CTO-0222, Marine Corps Base

SURF. ELEV. ____ WATER ELEV: IMMEDIATE 10' AFTER ____ HRS. ____

OUR FILE NO. 94-2171

CLIENT'S ORDER ____

DATE STARTED 4/5/94

DATE COMPLETED 4/5/94

Elev.	Casing Blows	Samp. No.	Std. Pent. (N)*	Depth	Matl. & Color Change	DESCRIPTION
				0		
		1	3-3-4-4	2	2.0	Light grey, silty fine sand with traces of clay nodules, moist, loose, SP
		2	4-4-4-4	4		Grey, silty fine sand with traces of clay nodules, moist, loose, SP-SM
		3	6-8-10-9	6		Same - medium compact
		4	4-4-3-4	8		Same
		5	6-6-7-6	10		Same - medium compact
					12.0	
		6	3-3-4	15	15.5	Dark grey silty fine sandy clay, moist, medium stiff, CH
						Bottom of Boring 15.5 ft.
				20		
				25		

*STANDARD PENETRATION INDICATED FOR EACH 6 INCHES OF DRIVE OF SPLIT TUBE SAMPLED.

McCallum Testing Laboratories, Inc.

CHESAPEAKE, VIRGINIA 23325-0337

LOG OF BORINGS

BORING NO. B-3
LOCATION Camp Lejeune, NC
PROJECT CTO-0222, Marine Corps Base
SURF. ELEV. ______ WATER ELEV: IMMEDIATE 12' AFTER ______ HRS. ______

OUR FILE NO. 94-2171
CLIENT'S ORDER ______
DATE STARTED 4/6/94
DATE COMPLETED 4/6/94

Elev.	Casing Blows	Samp. No.	Std. Pent. (N)*	Depth	Mat'l. & Color Change	DESCRIPTION
				0		
		1	3-4-4-5	2		Grey, silty fine sand, moist, loose, SP-SM
		2	6-8-8-7	4		Grey mottled brown, silty fine sand, moist, medium compact, SM-SC
		3	4-6-6-7	6		Same - light grey, medium compact
		4	4-3-3-4	8	8.0	Same - light grey mottled brown
		5	4-4-5-5	10		Light grey silty fine sand, moist, loose, SM
					12.0	
		6	4-5-4	15	15.5	Dark grey, silty clayey fine sand, wet, loose, SC
						Bottom of Boring 15.5 ft.
				20		
				25		

*STANDARD PENETRATION INDICATED FOR EACH 6 INCHES OF DRIVE OF SPLIT TUBE SAMPLED.

McCallum Testing Laboratories, Inc.

CHESAPEAKE, VIRGINIA 23325-0337

LOG OF BORINGS

BORING NO. B-4

LOCATION Camp Lejeune, NC

PROJECT CTO-0222, Marine Corps Base

SURF. ELEV. ______ WATER ELEV: IMMEDIATE 12' AFTER ______ HRS. ______

OUR FILE NO. 94-2171

CLIENT'S ORDER ______

DATE STARTED 4/6/94

DATE COMPLETED 4/6/94

Elev.	Casing Blows	Samp. No.	Std. Pent. (N)*	Depth	Matl. & Color Change	DESCRIPTION
				0		
		1	5-9-10-8	2		Grey, silty fine sand with traces of clay nodules, moist, medium compact, SP-SM
		2	8-9-11-11	4		Same - light grey
		3	7-7-7-5	6		Same - light grey
		4	6-8-8-10	8		Same - light grey
		5	6-9-10-9	10		Same - light grey mottled light brown
					12.0	
		6	4-3-3	15	15.5	Dark grey, silty clayey fine sand, wet, loose, SC
						Bottom of Boring 15.5 ft.
				20		
				25		

*STANDARD PENETRATION INDICATED FOR EACH 6 INCHES OF DRIVE OF SPLIT TUBE SAMPLED.

APPENDIX B

Laboratory Test Results

LABORATORY TEST RESULTS
GROUNDWATER TREATMENT BUILDING
CAMP ALLEN
NORFOLK, VIRGINIA
MTL PROJECT #94-2171

Boring No.	B-1	B-1	B-1	B-1	B-2	B-2	B-2	B-2	B-3	B-3	B-3	B-3	B-4	B-3	B-4	B-4
Sample No.	S-2	S-3	S-4	S-6	S-2	S-3	S-4	S-6	S-2	S-3	S-4	S-6	S-2	S-3	S-4	S-6
Depth (ft)	2-4	4-6	6-8	14.14.5	2-4	4-6	6-8	14-15.5	2-4	4-6	6-8	14.15.5	2-4	4-6	6-8	14-15.5
Moisture Content (%)	5.2	16.7	25.3	20.7	10.6	9.6	22.7	34.8	9.4	12.7	20.7	18.6	7.8	14.4	17.8	26.2
Grain Size (% passing) Sieve Sizes																
No. 4	-	-	-	-	100	-	-	-	-	-	-	100	100	-	100	-
No. 10	-	-	-	-	100	-	-	-	-	-	-	100	100	-	100	-
No. 40	-	-	-	-	97	-	-	-	-	-	-	89	99	-	99	-
No. 100	-	-	-	-	37	-	-	-	-	-	-	36	36	-	17	-
No. 200	-	-	-	-	12	-	-	-	-	-	-	22	6	-	7	-
Atterberg Limits																
Liquid Limit	-	-	-	18	-	-	-	60	-	-	-	25	-	-	-	-
Plasticity Limit	-	-	-	14	-	-	-	19	-	-	-	15	-	-	-	-
Plasticity Index	-	-	-	4	-	-	-	41	-	-	-	10	-	-	-	-
Classification (USGS)	-	-	-	SM-SC	SP-SM	-	-	CH	-	-	-	SC	SP-SM	-	SP-SM	-

APPENDIX B
VOLTAGE DROP CALCULATIONS

COMPANY NAME :	BAKER AND ASSOCIATES
PROJECT NAME :	CAMP LEJEUNE
SERVICE ORDER NO. :	
ENGINEER / DESIGNER :	RJB
DATE :	4/29/94

VOLTAGE DROP CALCULATIONS
@ (90 % POWER FACTOR)
FOR 1 - PHASE or 3 - PHASE (600 V.) CIRCUITS
(WIRE SIZES BASED ON (75 DEG. C.) COPPER CABLES)

NOTES :
THE AC RESISTANCE AND REACTANCE OF CABLES IN THESE CALULATIONS IS BASED ON THE 1993 NATIONAL ELECTRIC CODE (CHAPTER 9) .
INPUT STANDARD NATIONAL ELECTRIC CODE FIXED TYPE CIRCUIT BREAKER SIZES FROM 15 AMPERES TO 1200 AMPERES ONLY .

VOLTAGE DROP CALCULATION NO : 1

CIRCUIT DESCRIPTION :		MDP,HH-1,SOIL VAPOR EXTRACTION UNIT
CIRCUIT NUMBER :		N/A
CIRCUIT VOLTAGE :		480 VOLTS
PHASE(S) :	(1 or 3)	1 PHASE
CIRCUIT WATTAGE :		19200 WATTS
CIRCUIT AMPERES :		40.0 AMPERES X 1.25 50.0 AMPERES
CIRCUIT BREAKER SIZE :		100 AMPERES

"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------ KCMIL
	(2) NO.	--------	KCMIL	
	(3) NO.	--------	KCMIL	

CIRCUITS TOTAL FEEDER LENGTH : 600 FEET LONG

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE (1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE (1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE (2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE (3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	12.03	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	2.5	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.300861	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.070800	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.3	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	1	Wire/KCMIL	83690	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	8.10	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	1.7	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.202615	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.068400	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.192	--------	-------	OHMS

VOLTAGE DROP CALCULATION NO : 2

CIRCUIT DESCRIPTION :		SITE WELL PUMPS MDP, HH-1, HH-2
CIRCUIT NUMBER :		N/A
CIRCUIT VOLTAGE :		480 VOLTS
PHASE(S) :	(1 or 3)	3 PHASE
CIRCUIT WATTAGE :		52300 WATTS
CIRCUIT AMPERES :		62.9 AMPERES X 1.25 78.6 AMPERES
CIRCUIT BREAKER SIZE :		100 AMPERES

"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------ KCMIL
	(2) NO.	--------	KCMIL	
	(3) NO.	--------	KCMIL	

CIRCUITS TOTAL FEEDER LENGTH : 300 FEET LONG

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE (1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE (1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE (2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE (3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	9.46	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	2.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.150431	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.035400	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.15	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	1/0	Wire/KCMIL	105600	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	4.98	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	1.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.079184	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.033000	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.072	--------	-------	OHMS

COMPANY NAME :	BAKER AND ASSOCIATES
PROJECT NAME :	CAMP LEJEUNE
SERVICE ORDER NO. :	
ENGINEER / DESIGNER :	RJB
DATE :	4/29/94

VOLTAGE DROP CALCULATIONS
@ (90 % POWER FACTOR)
FOR 1 - PHASE or 3 - PHASE (600 V.) CIRCUITS
(WIRE SIZES BASED ON (75 DEG. C.) COPPER CABLES)

NOTES :

THE AC RESISTANCE AND REACTANCE OF CABLES IN THESE CALULATIONS IS BASED ON THE 1993 NATIONAL ELECTRIC CODE (CHAPTER 9).
INPUT STANDARD NATIONAL ELECTRIC CODE FIXED TYPE CIRCUIT BREAKER SIZES FROM 15 AMPERES TO 1200 AMPERES ONLY.

VOLTAGE DROP CALCULATION NO : 3

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-2, RW-1-S	
CIRCUIT NUMBER :		N/A	
CIRCUIT VOLTAGE :		480 VOLTS	
PHASE(S) :	(1 or 3)	1 PHASE	
CIRCUIT WATTAGE :		700 WATTS	
CIRCUIT AMPERES :		1.5 AMPERES X 1.25	1.8 AMPERES
CIRCUIT BREAKER SIZE :		100 AMPERES	

"MIN." SIZE FEEDER(S) REQ'D ----------	(1) NO.	3 WIRE or	------	KCMIL
	(2) NO.	-------- KCMIL		
	(3) NO.	-------- KCMIL		

CIRCUITS TOTAL FEEDER LENGTH : 300 FEET LONG

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3 WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------ KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	-------- KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	-------- KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	0.22	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.150431	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.035400	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.15	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG), ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	3 Wire/KCMIL	52620	C. M.	
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.	Wire/KCMIL	-------	C. M.	
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.	Wire/KCMIL	-------	C. M.	

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	0.22	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.150431	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.035400	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.15	--------	-------	OHMS

VOLTAGE DROP CALCULATION NO : 4

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-2, HH-3	
CIRCUIT NUMBER :		N/A	
CIRCUIT VOLTAGE :		480 VOLTS	
PHASE(S) :	(1 or 3)	3 PHASE	
CIRCUIT WATTAGE :		51600 WATTS	
CIRCUIT AMPERES :		62.1 AMPERES X 1.25	77.6 AMPERES
CIRCUIT BREAKER SIZE :		100 AMPERES	

"MIN." SIZE FEEDER(S) REQ'D ----------	(1) NO.	3 WIRE or	------	KCMIL
	(2) NO.	-------- KCMIL		
	(3) NO.	-------- KCMIL		

CIRCUITS TOTAL FEEDER LENGTH : 300 FEET LONG

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3 WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------ KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	-------- KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	-------- KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	9.34	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	1.9	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.150431	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.035400	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.15	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG), ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	1/0 Wire/KCMIL	105600	C. M.	
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.	Wire/KCMIL	-------	C. M.	
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.	Wire/KCMIL	-------	C. M.	

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	4.91	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	1.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.079184	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.033000	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.072	--------	-------	OHMS

COMPANY NAME :	BAKER AND ASSOCIATES
PROJECT NAME :	CAMP LEJEUNE
SERVICE ORDER NO. :	
ENGINEER / DESIGNER :	RJB
DATE :	4/29/94

VOLTAGE DROP CALCULATIONS
@ (90 % POWER FACTOR)
FOR 1 - PHASE or 3 - PHASE (600 V.) CIRCUITS
(WIRE SIZES BASED ON (75 DEG. C.) COPPER CABLES)

NOTES :

THE AC RESISTANCE AND REACTANCE OF CABLES IN THESE CALULATIONS IS BASED ON THE 1993 NATIONAL ELECTRIC CODE (CHAPTER 9) .
INPUT STANDARD NATIONAL ELECTRIC CODE FIXED TYPE CIRCUIT BREAKER SIZES FROM 15 AMPERES TO 1200 AMPERES ONLY .

VOLTAGE DROP CALCULATION NO : 5

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-3,RW-1-D			
CIRCUIT NUMBER :		N/A			
CIRCUIT VOLTAGE :		480	VOLTS		
PHASE(S) :	(1 or 3)	3	PHASE		
CIRCUIT WATTAGE :		16700	WATTS		
CIRCUIT AMPERES :		20.1	AMPERES X 1.25	25.1	AMPERES
CIRCUIT BREAKER SIZE :		100	AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :		30	FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	0.30	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.1	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.015043	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.003540	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.015	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	3	Wire/KCMIL	52620	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	0.30	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.1	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.015043	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.003540	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.015	--------	-------	OHMS

VOLTAGE DROP CALCULATION NO : 6

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-3,HH-6			
CIRCUIT NUMBER :		N/A			
CIRCUIT VOLTAGE :		480	VOLTS		
PHASE(S) :	(1 or 3)	3	PHASE		
CIRCUIT WATTAGE :		34900	WATTS		
CIRCUIT AMPERES :		42.0	AMPERES X 1.25	52.5	AMPERES
CIRCUIT BREAKER SIZE :		100	AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :		870	FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	18.31	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	3.8	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.436248	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.102660	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.435	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	1/0	Wire/KCMIL	105600	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	9.64	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	2.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.229635	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.095700	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.2088	--------	-------	OHMS

COMPANY NAME :	BAKER AND ASSOCIATES
PROJECT NAME :	CAMP LEJEUNE
SERVICE ORDER NO. :	
ENGINEER / DESIGNER :	RJB
DATE :	4/29/94

VOLTAGE DROP CALCULATIONS
@ (90 % POWER FACTOR)
FOR 1 - PHASE or 3 - PHASE (600 V.) CIRCUITS
(WIRE SIZES BASED ON (75 DEG. C.) COPPER CABLES)

NOTES :
THE AC RESISTANCE AND REACTANCE OF CABLES IN THESE CALULATIONS IS BASED ON THE 1993 NATIONAL ELECTRIC CODE (CHAPTER 9) .
INPUT STANDARD NATIONAL ELECTRIC CODE FIXED TYPE CIRCUIT BREAKER SIZES FROM 15 AMPERES TO 1200 AMPERES ONLY .

VOLTAGE DROP CALCULATION NO : 7

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-6,RW-2-D			
CIRCUIT NUMBER :		N/A			
CIRCUIT VOLTAGE :		480	VOLTS		
PHASE(S) :	(1 or 3)	3	PHASE		
CIRCUIT WATTAGE :		16700	WATTS		
CIRCUIT AMPERES :		20.1	AMPERES X 1.25	25.1	AMPERES
CIRCUIT BREAKER SIZE :		100	AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :		320	FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	3.22	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.7	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.160459	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.037760	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.16	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	3	Wire/KCMIL	52620	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	3.22	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.7	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.160459	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.037760	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.16	--------	-------	OHMS

VOLTAGE DROP CALCULATION NO : 8

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-6,HH-7			
CIRCUIT NUMBER :		N/A			
CIRCUIT VOLTAGE :		480	VOLTS		
PHASE(S) :	(1 or 3)	3	PHASE		
CIRCUIT WATTAGE :		17500	WATTS		
CIRCUIT AMPERES :		21.0	AMPERES X 1.25	26.3	AMPERES
CIRCUIT BREAKER SIZE :		100	AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :		210	FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	2.22	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.5	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.105301	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.024780	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.105	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	3	Wire/KCMIL	52620	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	2.22	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.5	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.105301	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.024780	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.105	--------	-------	OHMS

COMPANY NAME :	BAKER AND ASSOCIATES
PROJECT NAME :	CAMP LEJEUNE
SERVICE ORDER NO. :	
ENGINEER / DESIGNER :	RJB
DATE :	4/29/94

VOLTAGE DROP CALCULATIONS
@ (90 % POWER FACTOR)
FOR 1 - PHASE or 3 - PHASE (600 V.) CIRCUITS
(WIRE SIZES BASED ON (75 DEG. C.) COPPER CABLES)

NOTES :
THE AC RESISTANCE AND REACTANCE OF CABLES IN THESE CALULATIONS IS BASED ON THE 1993 NATIONAL ELECTRIC CODE (CHAPTER 9).
INPUT STANDARD NATIONAL ELECTRIC CODE FIXED TYPE CIRCUIT BREAKER SIZES FROM 15 AMPERES TO 1200 AMPERES ONLY.

VOLTAGE DROP CALCULATION NO : 9

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-7,RW-3-D			
CIRCUIT NUMBER :		N/A			
CIRCUIT VOLTAGE :		480	VOLTS		
PHASE(S) :	(1 or 3)	3	PHASE		
CIRCUIT WATTAGE :		16700	WATTS		
CIRCUIT AMPERES :		20.1	AMPERES X 1.25	25.1	AMPERES
CIRCUIT BREAKER SIZE :		100	AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :		75	FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	0.76	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.2	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.037608	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.008850	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.0375	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG), ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	3	Wire/KCMIL	52620	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	0.76	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.2	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.037608	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.008850	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.0375	--------	-------	OHMS

VOLTAGE DROP CALCULATION NO : 10

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-7,RW-2-S			
CIRCUIT NUMBER :		N/A			
CIRCUIT VOLTAGE :		480	VOLTS		
PHASE(S) :	(1 or 3)	1	PHASE		
CIRCUIT WATTAGE :		800	WATTS		
CIRCUIT AMPERES :		1.7	AMPERES X 1.25	2.1	AMPERES
CIRCUIT BREAKER SIZE :		100	AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :		210	FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	0.18	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.105301	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.024780	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.105	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG), ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	3	Wire/KCMIL	52620	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	0.18	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.0	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.105301	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.024780	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.105	--------	-------	OHMS

COMPANY NAME :	BAKER AND ASSOCIATES
PROJECT NAME :	CAMP LEJEUNE
SERVICE ORDER NO. :	
ENGINEER / DESIGNER :	RJB
DATE :	4/29/94

VOLTAGE DROP CALCULATIONS
@ (90 % POWER FACTOR)
FOR 1 - PHASE or 3 - PHASE (600 V.) CIRCUITS
(WIRE SIZES BASED ON (75 DEG. C.) COPPER CABLES)

NOTES :
THE AC RESISTANCE AND REACTANCE OF CABLES IN THESE CALULATIONS IS BASED ON THE 1993 NATIONAL ELECTRIC CODE (CHAPTER 9).
INPUT STANDARD NATIONAL ELECTRIC CODE FIXED TYPE CIRCUIT BREAKER SIZES FROM 15 AMPERES TO 1200 AMPERES ONLY .

VOLTAGE DROP CALCULATION NO : 11

CIRCUIT DESCRIPTION :		SITE WELL PUMPS HH-6,RW-3-S			
CIRCUIT NUMBER :		N/A			
CIRCUIT VOLTAGE :		480	VOLTS		
PHASE(S) :	(1 or 3)	1	PHASE		
CIRCUIT WATTAGE :		700	WATTS		
CIRCUIT AMPERES :		1.5	AMPERES X 1.25	1.8 AMPERES	
CIRCUIT BREAKER SIZE :		100	AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	3	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :		400	FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	3	WIRE	52620	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	0.29	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.1	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.200574	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.047200	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.2	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.	3	Wire/KCMIL	52620	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	0.29	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	0.1	0.0	0.0	%
CIRCUIT IMPEDENCE :	0.200574	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.047200	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0.2	--------	-------	OHMS

VOLTAGE DROP CALCULATION NO :

CIRCUIT DESCRIPTION :					
CIRCUIT NUMBER :					
CIRCUIT VOLTAGE :			VOLTS		
PHASE(S) :	(1 or 3)		PHASE		
CIRCUIT WATTAGE :			WATTS		
CIRCUIT AMPERES :			AMPERES X 1.25	0.0 AMPERES	
CIRCUIT BREAKER SIZE :			AMPERES		
"MIN." SIZE FEEDER(S) REQ'D ---------	(1) NO.	--------	WIRE or	------	KCMIL
	(2) NO.	--------	KCMIL		
	(3) NO.	--------	KCMIL		
CIRCUITS TOTAL FEEDER LENGTH :			FEET LONG		

VOLTAGE DROP CALCULATION FOR "MINIMUM" SIZE FEEDER(S)

"MINIMUM" FEEDER WIRE SIZE	(1) NO.	--------	WIRE	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(1) NO.	------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(2) NO.	--------	KCMIL	-------	C. M.
"MINIMUM" FEEDER WIRE SIZE	(3) NO.	--------	KCMIL	-------	C. M.

VOLTAGE DROP : (ACTUAL)	0.00	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	ERR	ERR	ERR	%
CIRCUIT IMPEDENCE :	0	0	0	OHMS
SINGLE FEEDER REACTANCE :	------	------	-------	OHMS
SINGLE FEEDER RESISTANCE :	------	------	-------	OHMS
"MINIMUM" NUMBER OF FEEDER(S) :	ONE	TWO	THREE	

CALULATION NOTES :
* EXAMPLE WIRE SIZE INPUT = (12 = 12 AWG) , ("3/0 = 3/0 AWG) & (400 = 400 K
* * PARALLEL "MIMIMUM" WIRE SIZE IS NO. " 1/0 " AS PER THE N.E.C.

VOLTAGE DROP CALCULATION "REQUIRED" FOR FEEDER(S)

"REQUIRED" FEEDER WIRE SIZE : * (1) NO.		Wire/KCMIL	105600	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (2) NO.		Wire/KCMIL	-------	C. M.
"REQUIRED" FEEDER WIRE SIZE : * * (3) NO.		Wire/KCMIL	-------	C. M.

"REQUIRED" FEEDER(S) :	ONE	TWO	THREE	
VOLTAGE DROP : (ACTUAL)	0.00	0.00	0.00	VOLTS
VOLTAGE DROP : (ACTUAL) %	ERR	ERR	ERR	%
CIRCUIT IMPEDENCE :	0	0	0	OHMS
SINGLE FEEDER REACTANCE :	0.000000	--------	-------	OHMS
SINGLE FEEDER RESISTANCE :	0	--------	-------	OHMS

APPENDIX C
SITE SAMPLING DATA

TABLE C-1
DEEP WELL
VOLATILES

Sample No.:	6-GW01-DW-01	6-GW1DW-02	6-GW02-DW-01	6-GW2DW-02	6-GW27-DW-01
Depth:	N/A	N/A	N/A	N/A	N/A
Date Sampled:	11/4/92	3/23/93	11/3/92	3/21/93	11/3/92
Lab Id:	00603-07	930150-04	00603-11	930141-03	00603-15
CHLOROBENZENE					
CHLOROMETHANE		14 J			
1,4-DICHLOROBENZENE		17			
1,2-DICHLOROETHANE		30			
1,1-DICHLOROETHENE		51			
TOTAL-1,2-DICHLORETHENE	5600 J	26000			5800
METHYLENE CHLORIDE	790 J				
TETRACHLOROETHENE	630	920	1.4		
1,1,2-TRICHLOROETHANE		5.8			
TRICHLOROETHENE	58000 J	50000			18000
VINYL CHLORIDE		800 J			
BENZENE		6.7 J			
1,2-DICHLOROBENZENE					
1,4-DICHLOROBENZENE		10			
ETHYLBENZENE	48	52			
TOLUENE		1.4			
XYLENES (TOTAL)		2.1			

All concentrations in ug/L.

TABLE C-1 (continued)
DEEP WELL
VOLATILES

Sample No.:	6-GW27DW-02	6-GW28DW-01	6-GW28DW-02	6-GW1DA-01B	6-GW1DA-01T
Depth:	N/A	N/A	N/A	N/A	N/A
Date Sampled:	3/23/93	11/3/92	3/23/93	5/3/93	5/3/93
Lab Id:	93010-06	00603-17	930150-07	930259-01	930259-02
CHLOROBENZENE	3.6		18		
CHLOROMETHANE					
1,4-DICHLOROBENZENE					
1,2-DICHLOROETHANE	16		7.5		
1,1-DICHLOROETHENE	55		12		
TOTAL-1,2-DICHLORETHENE	30000	500	5800	38	100
METHYLENE CHLORIDE					
TETRACHLOROETHENE	18		42	1.3	2.9
1,1,2-TRICHLOROETHANE					
TRICHLOROETHENE	22000	3600	9100	83	160
VINYL CHLORIDE	250 J		100 J		
BENZENE					
1,2-DICHLOROBENZENE					
1,4-DICHLOROBENZENE					
ETHYLBENZENE			2		
TOLUENE					
XYLENES (TOTAL)					

All concentrations in ug/L.

TABLE C-1 (continued)
DEEP WELL
VOLATILES

Sample No.:	6-GW3D-01	6-GW15DW-01	6-GW36DW-01	6-GW37DW-01
Depth:	N/A	N/A	N/A	N/A
Date Sampled:	4/6/93	5/3/93	3/30/93	3/22/93
Lab Id:	930170-15	930259-03	930170-03	930141-36
CHLOROBENZENE				
CHLOROMETHANE				
1,4-DICHLOROBENZENE				
1,2-DICHLOROETHANE				
1,1-DICHLOROETHENE				
TOTAL-1,2-DICHLORETHENE	3.7	9.1	3.4	120
METHYLENE CHLORIDE				
TETRACHLOROETHENE		1		
1,1,2-TRICHLOROETHANE				
TRICHLOROETHENE	6.4	34	6.4	60
VINYL CHLORIDE				
BENZENE				
1,2-DICHLOROBENZENE				2.6
1,4-DICHLOROBENZENE				
ETHYLBENZENE				
TOLUENE				
XYLENES (TOTAL)				

All concentrations in ug/L.

TABLE C-2
DEEP WELLS
METALS, TOTAL AND DISSOLVED

Sample No.:	6-GW01-DW-01	6-GW01-DWD-01	6-GW02-DW-01	6-GW02-DWD-01	6-GW27-DW-01
Depth:	N/A	N/A	N/A	N/A	N/A
Date Sampled:	11/4/92	11/4/92	11/3/92	11/3/92	11/3/92
Lab Id:	00603-07	00603-08	00603-11	00603-11	00603-15
ALUMINUM		19.8 B			
ANTIMONY					15.3 B
ARSENIC			3.8 JB		
BARIUM	71.5 B	67.1 B			
CALCIUM	103000	97600	8110	1690 B	65100
MAGNESIUM	3160 B	3110 B	812 B	332 B	1720 B
MANGANESE	21.6	18.5			14.2 B
POTASSIUM	7640	7640	67600	70200	1350 B
SODIUM	13100	13100	26000	27300	6240

All concentrations in ug/L.

TABLE C-2 (continued)
DEEP WELLS
METALS, TOTAL AND DISSOLVED

Sample No.:	6-GW27-DWD-01	6-GW28-DW-01	6-GW28-DWD-01
Depth:	N/A	N/A	N/A
Date Sampled:	11/3/92	11/3/92	11/3/92
Lab Id:	00603-16	00603-17	00603-18
ALUMINUM			
ANTIMONY			
ARSENIC			
BARIUM			
CALCIUM	64800	52800	49400
MAGNESIUM	1800 B	1540 B	1470 B
MANGANESE	14.7 B	14.2 B	11.8 B
POTASSIUM	1470 B	1260 B	1230 B
SODIUM	6580	7960	7640

All concentrations in ug/L.

TABLE C-3
SHALLOW WELL
VOLATILES

Sample No.:	6GW1S-01	6-GW1S-02	6-GW28S-01	6-GW28S-02	6-GW32-01	6-GW32-01	6-TW2-01	6-TW3-01
Depth:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Date Sampled:	10/24/92	3/23/93	10/23/93	3/18/93	3/18/93	3/18/93	3/31/93	3/31/93
Lab Id:	00593-07	930150-03	00591-16	00135-02	00135-03	00135-03	930170-07	930170-08
1,2-DICHLOROETHANE						1.3		
1,1-DICHLOROETHENE								1.4
TOTAL-1,2-DICHLORETHENE			16	1.8 J	2200	410	280	430
1,1,2,2-TETRACHLOROETHANE	6.9					9600		
TETRACHLOROETHENE	2.9				74		6.6	3.6
1,1,1-TRICHLOROETHANE								
1,1,2-TRICHLOROETHANE			0.5 J			58		
TRICHLOROETHENE	1		120	4	1500	610	360	63
VINYL CHLORIDE					8.6 J			14
BENZENE					1.4			
1,2-DICHLOROBENZENE						4.4		
TOLUENE							1	
XYLENES (TOTAL)	1.4							

All concentrations in ug/L.

TABLE C-3 (continued)
SHALLOW WELL
VOLATILES

Sample No.:	6-82MW2-01	6-82MW2-02	6-82MW1-01	6-82MW1-02
Depth:	N/A	N/A	N/A	N/A
Date Sampled:	10/24/92	3/23/93	10/23/92	3/23/93
Lab Id:	00593-21	930150-09	00591-20	930150-08
1,2-DICHLOROETHANE				
1,1-DICHLOROETHENE				
TOTAL-1,2-DICHLORETHENE				
1,1,2,2-TETRACHLOROETHANE				
TETRACHLOROETHENE				
1,1,1-TRICHLOROETHANE			0.5 J	
1,1,2-TRICHLOROETHANE				
TRICHLOROETHENE				
VINYL CHLORIDE	1.6			
BENZENE				
1,2-DICHLOROBENZENE				
TOLUENE				
XYLENES (TOTAL)				

All concentrations in ug/L.

TABLE C-4
SHALLOW WELL
METALS, TOTAL AND DISSOLVED

Sample No.:	6-GW1S-01	6-GW1SD-01	6-GW28-01	6-GW28S-02	6-GW28D-01	6-8MW1-01	6-82MW2-01	6-82MW3-01
Depth:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Date Sampled:	10/24/92	10/24/92	10/23/92	N/A	10/23/92	10/23/92	10/24/92	10/23/92
Lab Id:	00593-07	00593-08	00591-16	30136-07	00591-17	00591-20	00593-21	00591-26
ALUMINUM	101000		17400	8170		57600	6230	93800
ARSENIC	11.2					67.8	3 B	24.4
BARIUM	161 B		26.2 JB	80.8 B		476	49.3 B	540
BERYLLIUM						4.1 B		2.6 B
CALCIUM	24300	18400	16400	2720 B	15200	6580	60800	4360 B
CHROMIUM	175			18.4		105	5.9 B	174
COBALT						6.4 B		8.6 B
COPPER	23.9 JB					24.8 JB		29.3 J
IRON	54300 J		517	4070		84800	10800 J	40500
LEAD	37.8		1.8 B	2.3 B	1 B	34.6		88.9
MAGNESIUM	5440	1770 JB	1550 B	2580 B	1420 B	6000	4370 B	7470
MANGANESE	49.9		26.9	12.9 B	21	283	55	160
MERCURY	0.17 B						0.66	0.27
NICKEL	15.9 B					34.6 B		16.2 JB
POTASSIUM	6620	1180 B	941 B	1220 B	976 B	4060 B	678 B	6600
SODIUM	1990 JB	2240 JB	7260	8310	6840	6360	36500 J	5670
VANADIUM	330			15.8 B		256		215
ZINC	58.5			19.6 B		166		186

All concentrations in ug/L.

APPENDIX D
EQUIPMENT SIZING CALCULATIONS LIST

APPENDIX D: TANK SIZING CALCULATION FOR CTO 222- MCB CAMP LEGEUNE GW TREATMENT SYSTEM

Parameter / Equipment No.	T-110	T-130	T-140	T-125	T-120	T-145
Shape	Flat-Bottom/Cone	Flat-Bottom/F&D	Cone-Bottom/Flat	Flat-Bottom/F&D	Flat-Bottom/F&D	Flat-Bottom/F&D
Outlet Vol. Flowrate (gpm)	500	500	2	2	0.02	20
Residence Time (min)	40	10	720	1,440	10,080	15
Min. Liquid Volume (gal)	20,000	5,000	1,440	2,160	181	300
Freeboard (ft)	4.0	3.0	2.0	2.0	2.0	2.0
H/D (design)	1.5	1.3	1.3	1.3	1.3	0.2
Diameter (ft)	13.0	8.6	5.7	6.5	2.8	6.3
Height (ft)	23.5	14.1	9.4	10.4	5.7	3.3
Cylinder Volume (gal)	19,229	4,807	1,384	2,077	174	288
Freeboard Volume (gal)	3,953	1,294	376	493	95	461
End Height (ft)	2	1.4	2	1.1	0.5	1.1
H/D (actual)	1.8	1.7	1.7	1.6	2.0	0.5
Tank Head Volume (gal)	659	381	125	165	14	149
Total Tank Volume (gal)	23,841	6,483	1,886	2,735	283	898
Diameter (ft)	13	9	6	6	3	6
Straight Side Height (ft)	23	14	9	10	6	3
Overall Tank Height (ft)	25	16	11	12	6	4

Parameter / Equipment No.	T-200	T-205	T-211	T-220	T-240
Shape	Flat-Bottom/F&D	Flat-Bottom/Cone	Flat-Bottom/F&D	Flat-Bottom/Top	Flat-Bottom/Cone
Outlet Vol. Flowrate (gpm)	500	30	0.0083	500	500
Residence Time (min)	10	667	18,072	10	40
Min. Liquid Volume (gal)	5,000	20,000	150	5,000	30,000
Freeboard (ft)	2.0	2.0	2.0	2.0	4.0
H/D (design)	1.3	1.5	1.4	0.5	1.5
Diameter (ft)	8.6	13.0	2.6	11.8	14.8
Height (ft)	13.1	21.5	5.6	7.9	26.3
Cylinder Volume (gal)	4,807	19,229	144	4,807	28,843
Freeboard Volume (gal)	863	1,977	79	1,632	5,180
End Height (ft)	1.4	2.0	0.4	0.0	2
H/D (actual)	1.5	1.7	2.2	0.7	1.8
Tank Head Volume (gal)	381	659	11	0	863
Total Tank Volume (gal)	6,052	21,864	234	6,439	34,887
Diameter (ft)	9	13	3	12	15
Height (ft)	13	21	6	8	26
Overall Tank Height	15	23	7	8	28

NOTES:
1. Tank T-200 & T-145 have lower H/D because they are gravityfed tanks.

DATE: 09-Sep-94
TIME: 04:24 PM
BY: JPM
CHECKED BY: ________________

MCB Camp Lejeune, Operable Unit No. 2 - Groundwater Extraction System Pressure Drop, Line Size and Pump Size Calculations

STREAM CHARACTERISTICS

MASS FLOW	(lb/hr)	232,749	2,503	230,246	75,080	155,166	77,583	2,503	75,080	2,503	75,080
VOLUMETRIC FLOW	(gpm)	465	5	460	150	310	155	5	150	5	150
SPECIFIC GRAVITY		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
VISCOSITY	(cp)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

LINE SIZING AND PRESSURE DROP

LINE #		---	---	---	---	---	---	---	---	---	---
P&ID		C-4	C-4	C-4	C-4	C-4	C-4	C-4	C-4	C-4	C-4
STREAM #		---	---	---	---	---	---	---	---	---	---
PFD		P-1	P-1	P-1	P-1	P-1	P-1	P-1	P-1	P-1	P-1
FROM (Start of Run)		Manhole 1 Tie-in	SRW-1	DRW-1 Tie-in	DRW-1	Manhole 2 Tie-in	Junction Point 1	SRW-2	DRW-2	SRW-3	DRW-3
AT PRESSURE	(psig)	5.07	25.29	5.21	70.61	13.47	14.14	35.15	81.88	32.46	81.18
AT PRESSURE	(ft H2O)	11.70	58.33	12.01	162.88	31.08	32.62	81.09	188.88	74.87	187.26
TO (End of Run)		Equalization	Manhole 1 Tie-in	Manhole 1 Tie-in	DRW-1 Tie-in	DRW-1 Tie-in	Manhole 2 Tie-in	Junction Point 1	Junction Point 1	Manhole 2 Tie-in	Manhole 2 Tie-in
AT PRESSURE	(psig)	0.00	5.07	5.07	5.21	5.21	13.47	14.14	14.14	13.47	13.47
AT PRESSURE	(ft H2O)	0.00	11.70	11.70	12.01	12.01	31.08	32.62	32.62	31.08	31.08
THRU CV #		0	0	0	0	0	0	0	0	0	0
CV PRESSURE LOSS	(psi)	0	0	0	0	0	0	0	0	0	0
DESIGN FLOWRATE	(gpm)	630	10	620	200	420	210	10	200	10	200
DESIGN MASS FLOWRATE	(lb/hr)	315,337	5,005	310,332	100,107	210,225	105,112	5,005	100,107	5,005	100,107
STATIC HEAD	(ft H2O)	10	43.5	0	150	5.5	1	44.5	154.5	40	154.5
STATIC PRESSURE	(psi)	4.34	18.86	0.00	65.03	2.38	0.43	19.29	66.98	17.34	66.98
EQUIPMENT LOSSES	(psi)	0	0	0	0	0	0	0	0	0	0
PIPING LENGTH	(ft)	200	335	50	170	1070	150	450	460	430	460
# OF GATE VALVES		0	0	0	0	0	0	0	0	0	0
# OF GLOBE VALVES		0	0	0	0	0	0	0	0	0	0
# OF ANGLE VALVES		0	0	0	0	0	0	0	0	0	0
# OF BALL VALVES		0	0	0	0	0	0	0	0	0	0
# OF BUTTERFLY VALVES		0	0	0	0	0	0	0	0	0	0
# OF PLUG VALVES ST		0	0	0	0	0	0	0	0	0	0
# OF PLUG VALVES 3T		0	0	0	0	0	0	0	0	0	0
# OF PLUG VALVES 3B		0	0	0	0	0	0	0	0	0	0
# OF STD ELBOWS 90		0	1	0	1	0	0	1	1	1	1
# OF STD ELBOWS 45		5	8	0	0	11	1	3	2	2	0
# OF STD ELBOWS 90 LR		0	0	0	0	0	0	0	0	0	0
# OF CLOSE RETURN		0	0	0	0	0	0	0	0	0	0
# OF STD TEE THRU		1	1	0	1	0	1	1	1	1	0
# OF STD TEE BRANCH		0	0	0	0	0	0	0	0	0	0
# OF SWING CHECKS		0	2	0	2	0	0	2	2	2	2
# OF LIFT CHECKS		0	0	0	0	0	0	0	0	0	0
NOMINAL PIPE SIZE	(in)	8	1.5	8	6	6	6	1.5	6	1.5	6
PIPE INNER DIAMETER	(ft)	0.6651	0.1342	0.6651	0.5054	0.5054	0.5054	0.1342	0.5054	0.1342	0.5054
EQUIV. LENGTH FITTINGS	(ft)	67	51	0	126	89	18	40	143	38	116
TOTAL EQUIV. LENGTH	(ft)	267	386	50	296	1159	168	490	603	468	576
FLUID VELOCITY	(fps)	4.04	1.58	3.98	2.22	4.66	2.33	1.58	2.22	1.58	2.22
REYNOLDS NUMBER		249510	19628	245549	104239	218901	109451	19628	104239	19628	104239
FRICTION FACTOR		0.0168	0.0283	0.0168	0.0193	0.0175	0.0192	0.0283	0.0193	0.0283	0.0193
FRICTION LOSS	(psi)	0.74	1.36	0.13	0.38	5.88	0.23	1.72	0.76	1.64	0.73
START OF RUN PRESSURE	(psig)	5.07	20.21	0.13	65.40	8.26	0.67	21.01	67.74	18.99	67.71
BRAKE HORSEPOWER	(hp)	---	0.16	---	8.93	---		0.22	10.35	0.21	10.26
MOTOR EFFICIENCY		---	0.7	---	0.7	---		0.7	0.7	0.7	0.7
REQUIRED HORSEPOWER	(hp)	---	0.23	---	12.75	---		0.32	14.79	0.29	14.66

APPENDIX E
SOIL VAPOR EXTRACTION PILOT TEST, AOC 1, SITE 82
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
TARGET ENVIRONMENTAL SERVICES, INC.

SOIL VAPOR EXTRACTION
PILOT TEST

AOC 1, SITE 82
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

PREPARED FOR

BAKER ENVIRONMENTAL , INC.
420 ROUSER ROAD
CORAOPOLIS, PENNSYLVANIA 15108

PREPARED BY

TARGET ENVIRONMENTAL SERVICES, INC.
9180 RUMSEY ROAD
COLUMBIA, MARYLAND 21045
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APRIL, 1994

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FIGURES

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TABLES

EXECUTIVE SUMMARY

On March 16, 1994, **TARGET Environmental Services, Inc. (TARGET)** conducted soil vapor extraction (SVE) pilot testing at **AOC 1, Site 82, Marine Corps Base, Camp Lejeune, North Carolina.** A total of 3 SVE pilot tests were conducted with **TARGET's** SVE pilot test data acquisition system and trailer-mounted vacuum pump. The objectives of the tests were to determine if site conditions are conducive to remediation by soil vapor extraction and to provide the data needed to optimally design a soil vapor extraction system for the site.

Air permeabilities measured on site ranged between 1.2 x 10^{-7} and 2.8 x 10^{-7} cm^2. These values are within the range of air permeabilities conducive for remediation using soil vapor extraction. Vacuum influence was observed to maximum distance of 34.5 feet, operating at an air flow rate of 25.1 scfm and vacuum of 1.3 inHg.

Introduction

Baker Environmental, Inc. (BAKER) contracted **TARGET Environmental Services, Inc. (TARGET)** to perform soil vapor extraction (SVE) pilot tests at **AOC 1, Site 82, Marine Corps Base, Camp Lejeune, North Carolina.** The purpose of this study was to test the feasibility of SVE on the site and to provide the data needed to optimally design an SVE system. The tests were designed to evaluate the permeabilities and flow characteristics of the soil intervals in which contamination has been detected.

Field Procedures

The SVE pilot tests at the **AOC 1, Site 82, Marine Corps Base, Camp Lejeune, North Carolina** were conducted on March 16, 1994. The pilot testing was performed in the wooded area approximately 80 feet WNW from monitoring well 6GW34, shown in Figure 1.

A vapor extraction well was installed by **TARGET** using a van-mounted portable auger to create a 6 inch diameter hole to a depth of 14 feet below ground surface (BGS). A 2-inch diameter PVC well screen with 0.020 inch slots was inserted into the hole, creating a screen interval of 4.5 to 14 feet BGS. Once the screen was installed, a sand filter pack consisting of clean, number 2 Morie sand was emplaced around the screen. A rehydrated bentonite seal was installed above the sand filter pack and extended to the ground surface. A wellhead fitting was securely attached to the top of the extraction well pipe to allow connection to the vacuum pump system and periodic collection of vapor stream samples through a quick connect port.

TARGET installed vapor monitoring probes (MPs) at selected distances along 2 radii intersected by the vapor extraction well. The probes were installed by advancing 1 inch steel pipe to a depth of 8 feet BGS using a van-mounted hydraulic probe, removing the steel pipe, and inserting a vapor implant to the bottom of the hole. The monitoring probes were completed with a sand filter pack surrounding the implant followed by a rehydrated bentonite seal to the surface. MP Z was installed to depth of 4 feet using a manually driven slide hammer. A cap with a quick-connect fitting was attached to the top of each monitoring probe for connection to the vacuum monitoring equipment. The locations of the extraction well, air sparge well, monitoring wells, and vapor monitoring probes are shown on Figure 1.

The pilot tests were performed with **TARGET**s trailer-mounted SVE pilot test system and data collection system, shown schematically in Figure 2. The pilot test system consists of a vacuum pump with air flow rate and pressure measurement capabilities, an air-water separator, and a self-contained electrical power supply. The vacuum pump has a rated maximum air flow rate of 28.8 cubic feet per minute (cfm) at 0 inches mercury (inHg) and a maximum vacuum level of 27.9 inHg at 0 cfm. Any water and water vapor present in the extraction well airstream are removed before entering the vacuum pump by the air-water separator. The effluent of the vacuum pump was directed to a vapor treatment system consisting of two, 200-pound activated carbon canisters connected in series to maximize the efficiency of contaminant adsorption.

Pressure decline measurements were obtained at the monitoring probes in each pilot test using high sensitivity pressure transducers mounted in a central monitoring console. The pressure responses from the transducers were digitally recorded on a computerized data logging system at operator-selectable sampling rates. Additional transducers on the monitoring console were used to measure vacuum levels and air flow rates in the SVE pilot system.

Encapsulated vapor samples were collected from the extraction well vapor sampling port at 15 minute intervals during Test 1 and at the beginning, mid-point, and end of Tests 2 and 3. The samples were returned to **TARGET**s laboratory for gas chromatographic analysis according to modified (for vapor) EPA Method 602 with a flame ionization detector (FID) for petroleum hydrocarbons and modified (for vapor) EPA Method 601 with an electron capture detector (ECD) for chlorinated compounds typically contained in industrial solvents.

Test 1 was conducted at the full achievable air flow rate. Tests 2 and 3 were conducted at reduced air flow rates by selectively opening the vacuum pump dilution valve while monitoring the dilution air flow rate. These results are used to evaluate the reproducibility of the SVE tests and to develop a system head curve for the site.

Discussion of Results

Pressure decline data and air flow and vacuum levels are listed for each test in Appendix A and shown graphically in Figures 3 through 5.

The estimates of soil permeability to vapor flow uses the maximum steady state pressure observed at each monitoring probe to solve a simplistic radial flow equation for compressible flow as discussed in Johnson et al, (1990).

The predicted change in subsurface pressure distribution is determined by:

$$P' = \frac{Q}{4\pi m\left(\frac{k}{\mu}\right)} \int_{\frac{r^2 \varepsilon \mu}{4kP_{atm}t}}^{\infty} \frac{e^{-x}}{x} dx$$

For $(r^2 \varepsilon \mu / 4kP_{atm}t) < 0.1$, the above equation can be approximated by:

$$P' = \frac{Q}{4\pi m\left(\frac{k}{\mu}\right)} \left(-0.5772 - \ln\left(\frac{r^2 \varepsilon \mu}{4kP_{atm}}\right) + \ln(t)\right)$$

where

P` = gauge pressure measured at distance r and time t

m = stratum thickness
r = radial distance from extraction well
k = soil permeability to air flow
μ = viscosity of air (= 1.8×10^{-4} g/cm-s)
ε = air-filled soil void fraction
t = time
Q = volumetric vapor flow rate from extraction well
P_{atm} = ambient atmospheric pressure (=1.0 atm = 1.013×10^{6} g/cm-s^2)

The above equation predicts a linear relationship between P` and ln(t) with slope A and y-intercept B. Factors A and B can be expressed by:

$$A = \frac{Q}{4\pi m(k/\mu)}$$

$$B = \frac{Q}{4\pi m(k/\mu)} \quad -0.5772 - \ln \frac{r^2 \varepsilon \mu}{4kP_{atm}}$$

Therefore, the permeability to air flow can be calculated from the vapor extraction test data by two methods.

1) (if Q and m are known)

$$k = \frac{Q\mu}{4A\pi m}$$

2) (if Q or m are not known)

$$k = \frac{r^2 \varepsilon \mu}{4P_{atm}} \quad \exp \frac{B}{A} + 0.5772$$

Table 1 lists the distance of each monitoring probe from the extraction well, the monitoring probe depths, maximum steady state pressures, calculated air permeabilities and pump system conditions for the vapor extraction tests. Calculated air permeabilities range from 1.2×10^{-7} to 2.8×10^{-7} cm^2. Permeability values greater than 10^{-10} cm^2 are generally recognized to be conducive to remediation by vapor extraction. Therefore, soil vapor extraction should be considered as a remediation technique for this site.

The tabulated results of the GC/FID and GC/ECD analyses of the vapor samples collected during the tests are reported in units of micrograms per liter (µg/l) along with the time of collection in Tables 2 and 3, respectively.

The radius of vacuum influence of a site is defined by the zone in which vapor flow is induced by applying a pressure change to an extraction well. As shown in Figure 6, a best fit line was generated from the pilot test data from the southeast trending MP radius to predict a maximum radius of influence of 34.5 feet at an air flow rate of 25.1 scfm and vacuum of 1.3 inHg. Figure 7 shows a maximum radius of influence of 25 feet along the northwest MP radius at an air flow rate of 25.1 scfm and vacuum of 1.3 inHg. The effective radial distance may be affected by variations of the soil properties of the vented zone, the depth of the extraction well screen, and the presence of any impermeable boundaries.

A graph of air flow rate Q (scfm) vs. wellhead vacuum P (inHg) is shown in Figure 8. The relationship between the vacuum and air flow rate is used to estimate air flow rates at given wellhead vacuum levels. This curve predicts the vacuum level that would be observed at given air flow rates using an extraction well constructed to the specifications of the pilot test well. The method used to extrapolate the pilot test data is shown in Appendix C. The maximum achievable air flow rate for this site would be approximately 235 scfm at a vacuum level of 29.9 inHg. Since it is not possible to obtain an absolute vacuum, the realistically achievable air flow rate may be somewhat lower. The achievable air flow rate and vacuum conditions for a site are most sensitive to changes to the extraction well geometry, specifically the screen length and the radius of the well bore used for the pilot test..

References

Johnson, P.C., M.W. Kemblowski, J.D. Colthart, D.L. Byers, and C.C. Stanley. 1990. A Practical Approach to the Design, Operation, and Monitoring of In-Situ Soil Venting Systems: Ground Water Monitoring Review, 10(2): 150-178.

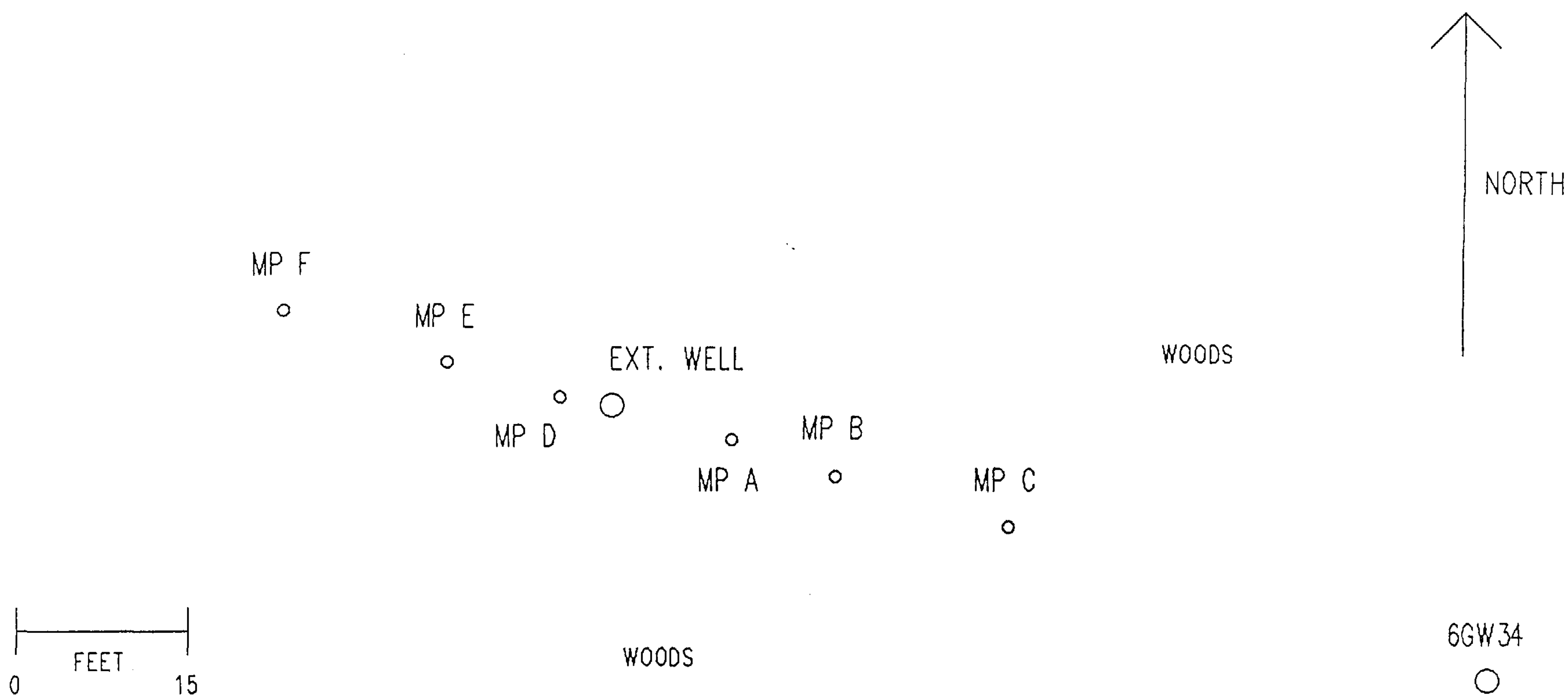
U.S. Environmental Protection Agency. Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction, Interim Guidance. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/2-91/019A, 1991.

Figure 1

AOC 1, SITE 82

MARINE CORPS BASE

CAMP LEJEUNE, NORTH CAROLINA



This map is integral to a written report and should be viewed in that context

TARGET ENVIRONMENTAL SERVICES

Figure 2

SVE PILOT TEST SYSTEM

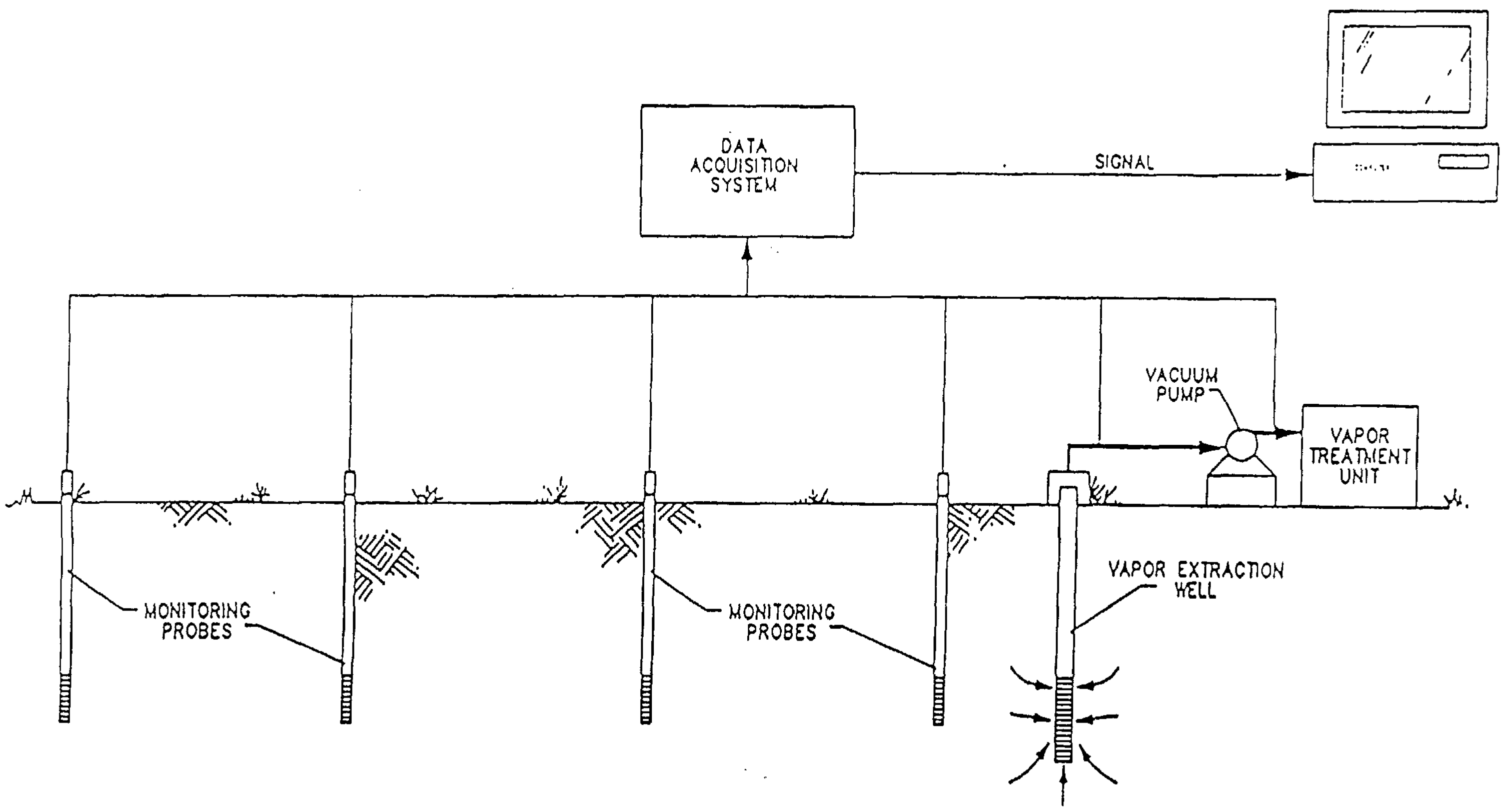


Figure 3
PRESSURE DECREASE vs. TIME
Test 1

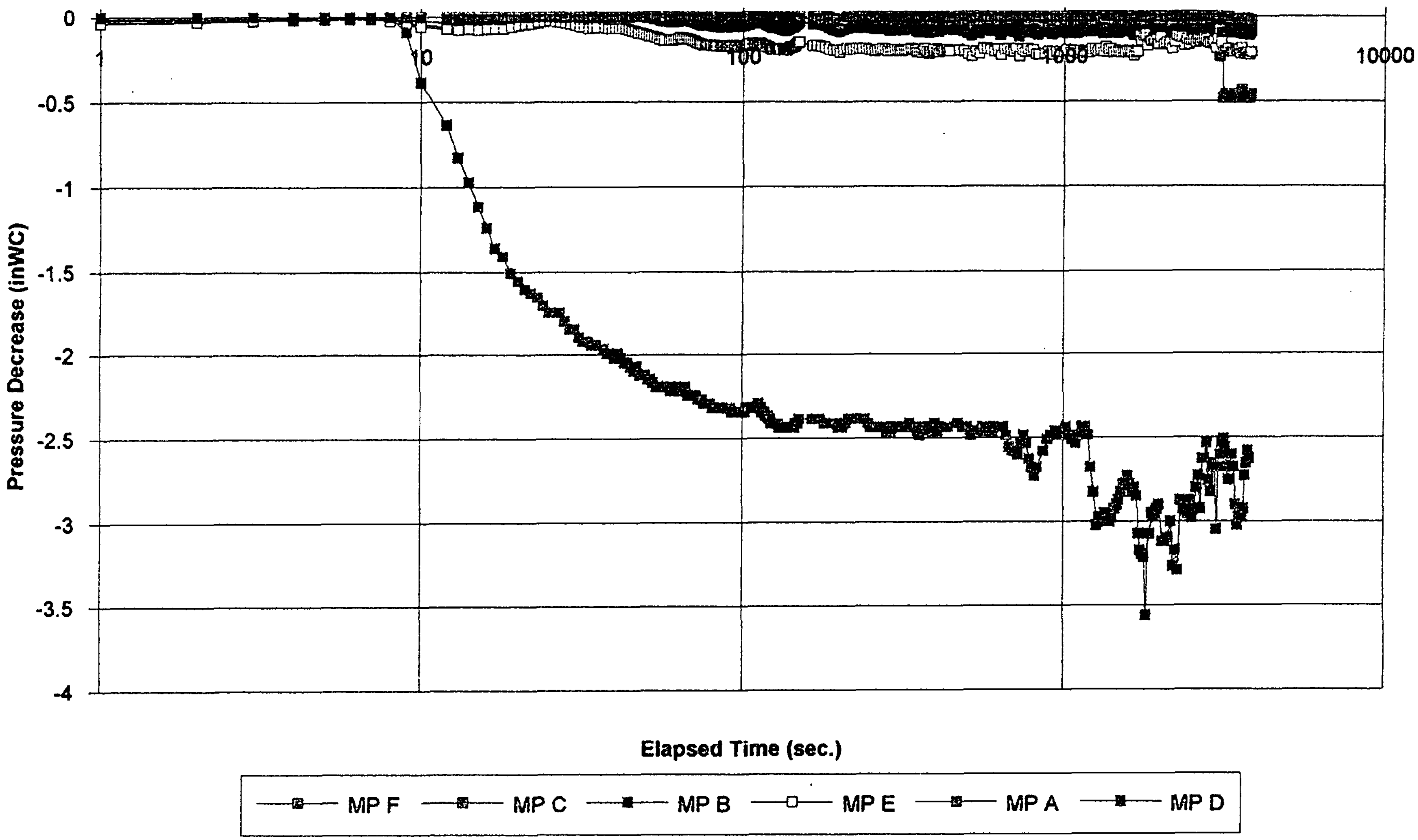


Figure 4
PRESSURE DECREASE vs. TIME
Test 2

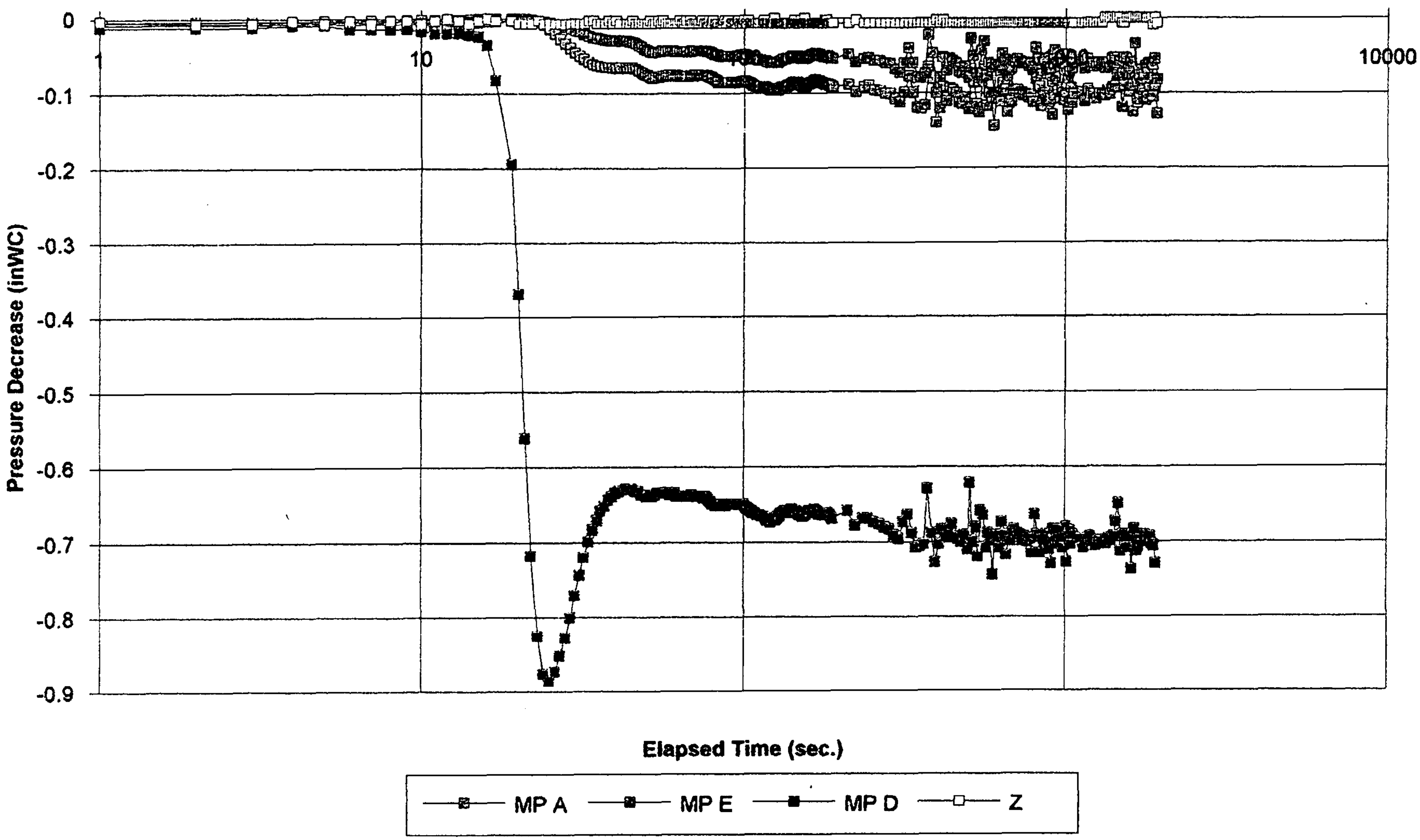


Figure 5
PRESSURE DECREASE vs. TIME
Test 3

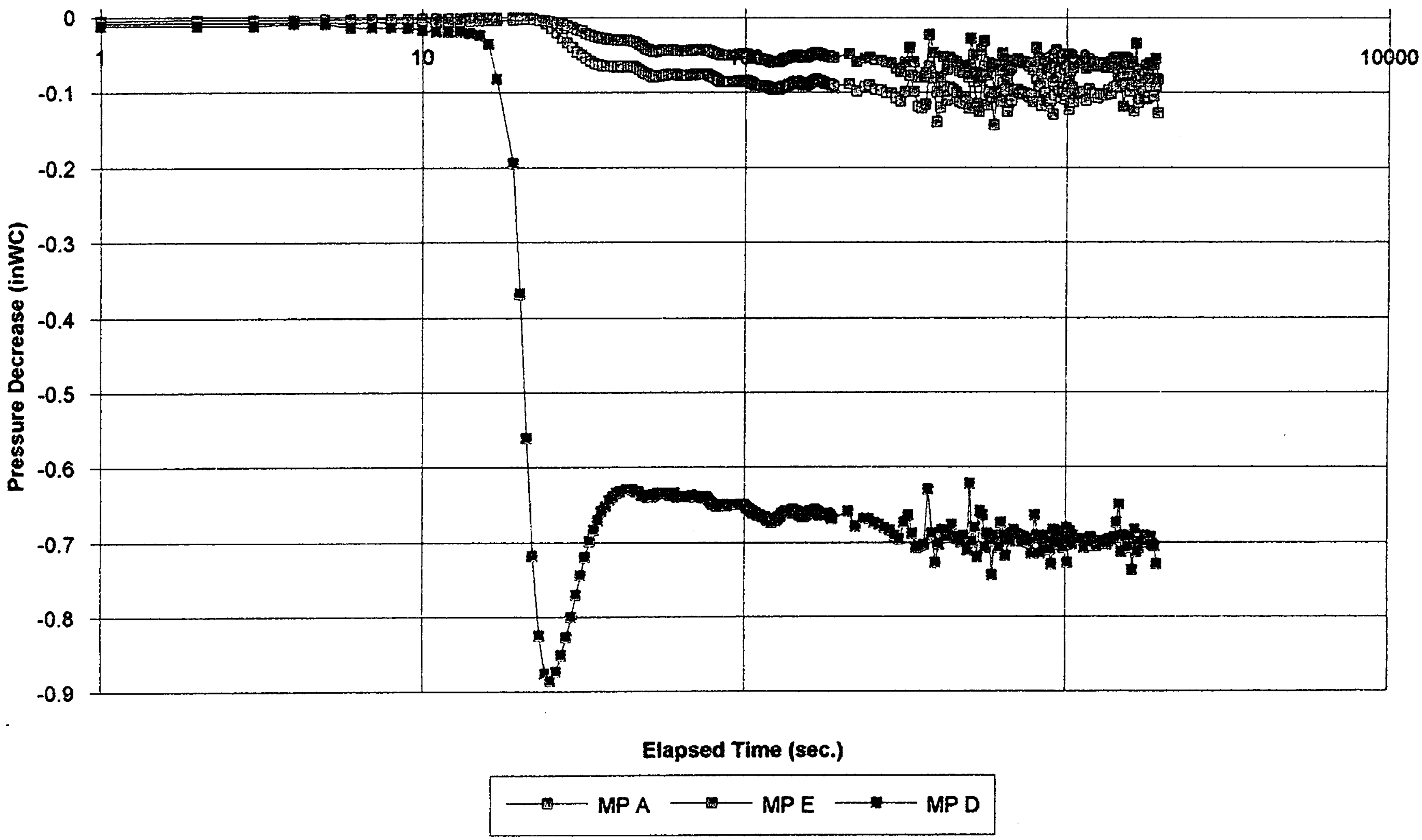
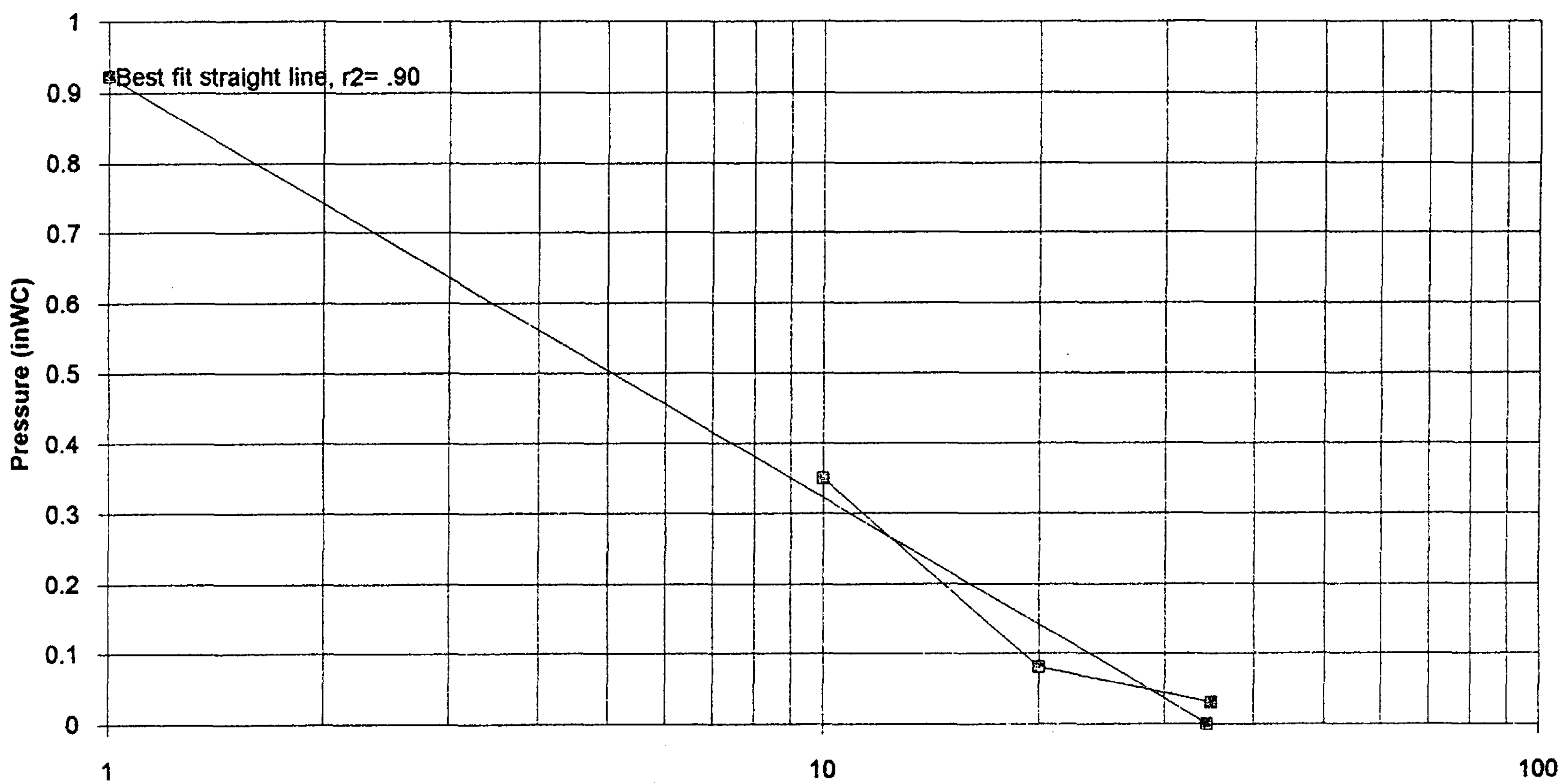


Figure 6
Radius of Influence
Test 1 - Southeast Direction - MP A, MP B, MP C
Q = 25.1 scfm / Well Vac. = 1.3 inHG



Distance from the Extraction Well (feet)
Radius of Influence = 34.5 feet

Figure 7
Radius of Influence
Test 1 - Northwest Direction - MP D, MP E, MP F
Q = 25.1 scfm / Well Vac. = 1.3 inHG

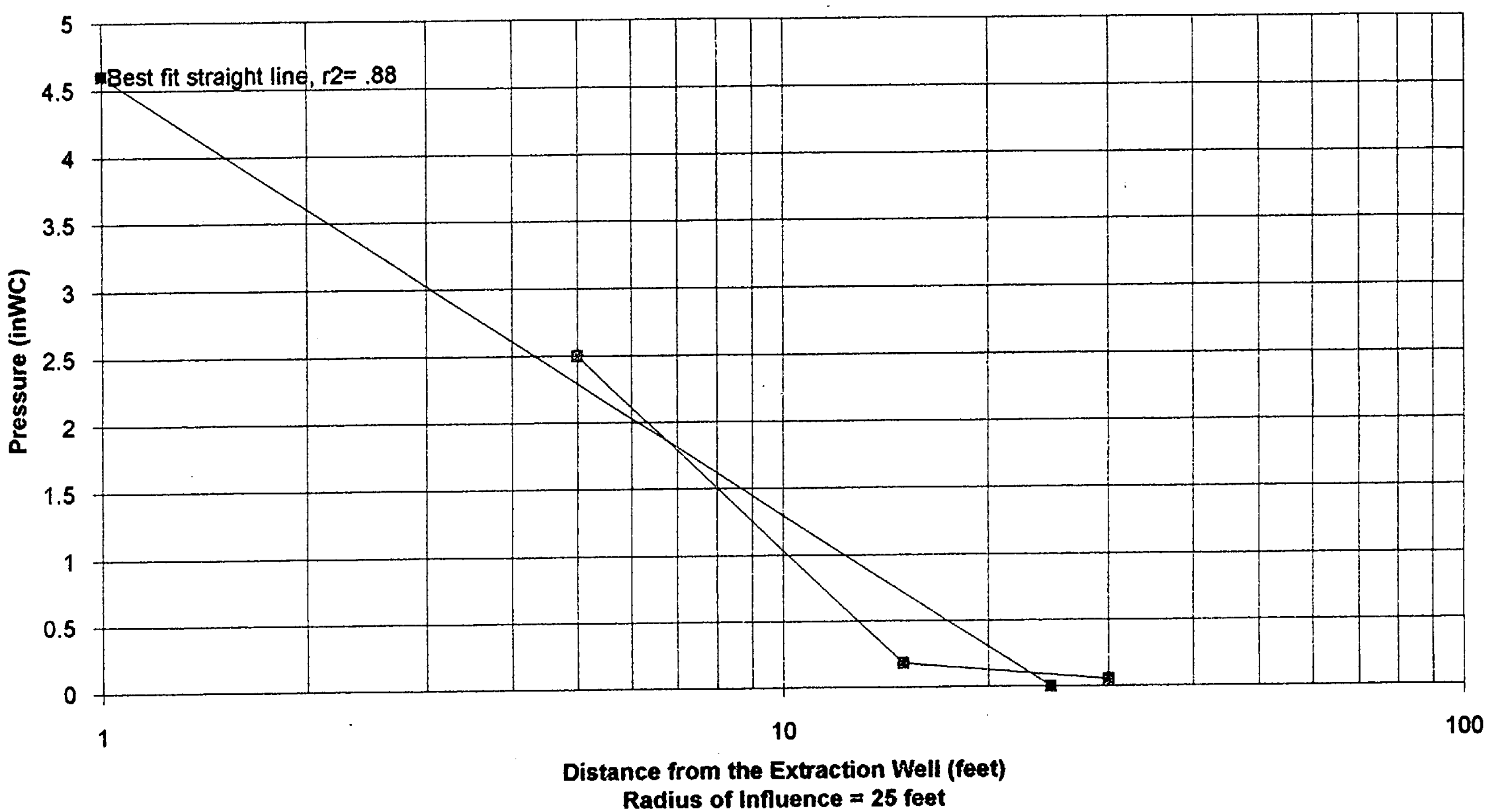


Figure 8
SYSTEM HEAD CURVE

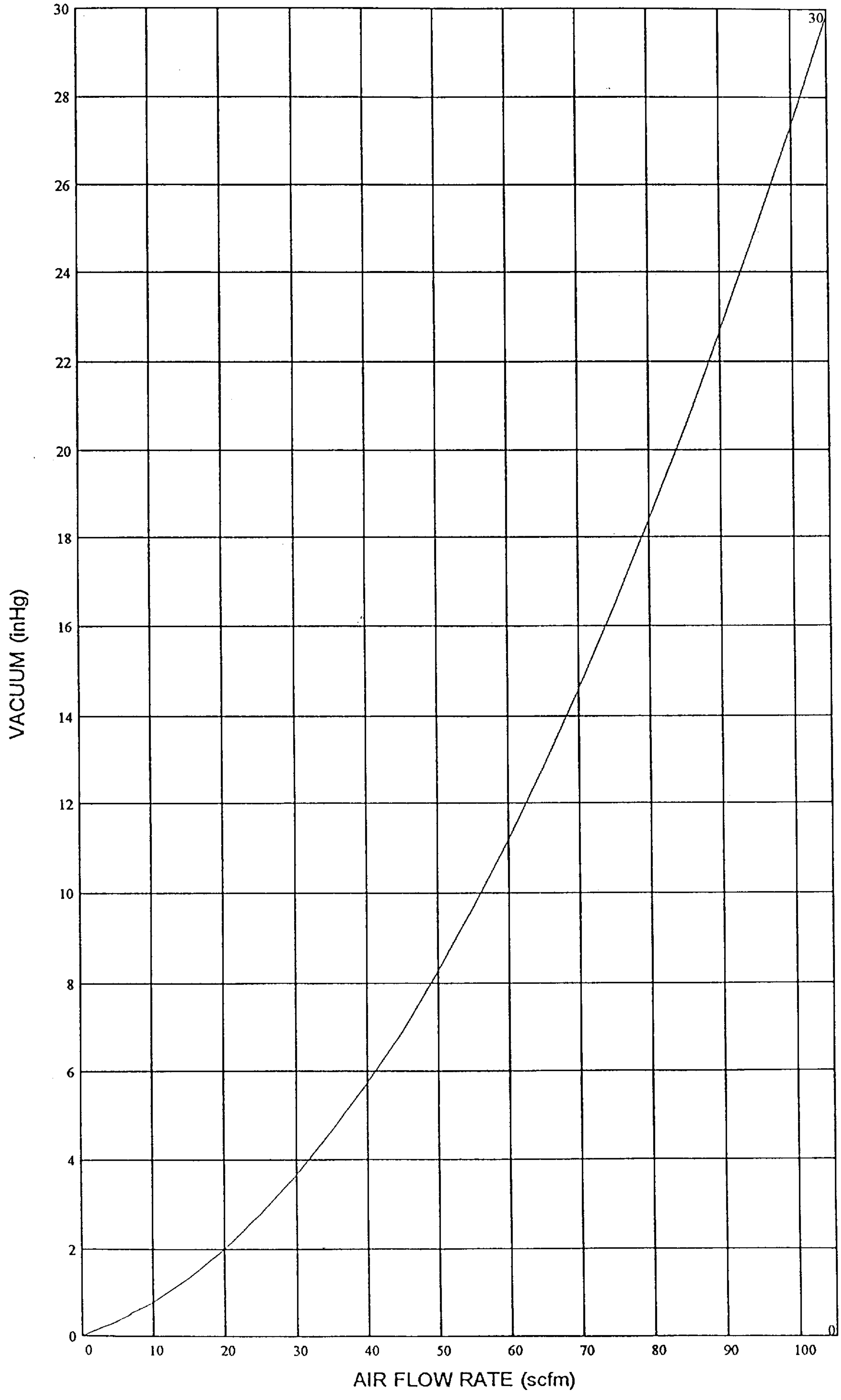


FIGURE 9

PERFORMANCE CURVE FOR ALTERNATE EXTRACTION WELL GEOMETRY

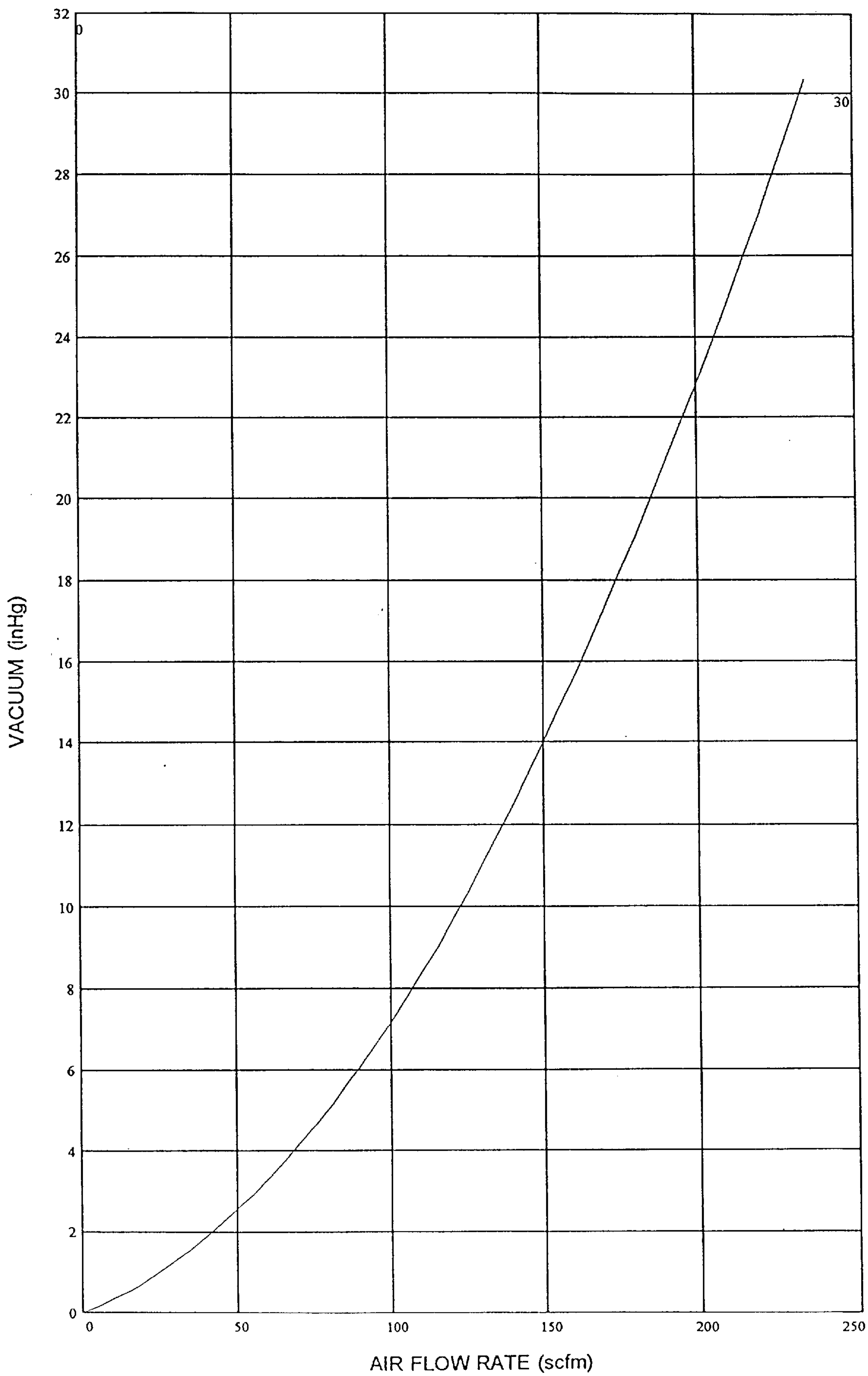


TABLE 1

PILOT TEST DATA SUMMARY

MXCL - Test 1

Well Flow Rate = 25.1 scfm
Well Vacuum = 1.3 inHG
Temperature - well flow (degrees F) = 58
Temperature - carbon inlet (degrees F) = 97

Monitoring Probe	Distance from Well (ft)	Probe Depth (ft)	Max. Pressure (inWC)	Permeability (sq cm)
MPF	30.0	8.0	-0.05	1.70E-07
MP C	35.0	8.0	-0.03	1.80E-07
MP B	20.0	8.0	-0.08	1.6E-07
MP E	15.0	8.0	-0.18	1.5E-07
MP A	10.0	8.0	-0.35	1.3E-07
MP D	5.0	8.0	-2.50	1.2E-07
MP Z	8.0	4.0	-0.18	1.3E-07

MXCL - Test 2

Well Flow Rate = 16.3 scfm
Well Vacuum = .8 inHG
Temperature - well flow (degrees F) = 59
Temperature - carbon inlet (degrees F) = 118

Monitoring Probe	Distance from Well (ft)	Probe Depth (ft)	Max. Pressure (inWC)	Permeability (sq cm)
MP B	20.0	8.0	-0.03	1.70E-07
MP E	15.0	8.0	-0.11	1.60E-07
MP A	10.0	8.0	-0.21	1.50E-07
MP D	5.0	8.0	-1.49	1.40E-07
MP Z	8.0	4.0	-0.10	1.50E-07

MXCL - Test 3

Well Flow Rate = 7.9 scfm
Well Vacuum = .3 inHG
Temperature - well flow (degrees F) = 57
Temperature - carbon inlet (degrees F) = 112

Monitoring Probe	Distance from Well (ft)	Probe Depth (ft)	Max. Pressure (inWC)	Permeability (sq cm)
MP A	10.0	8.0	-0.09	2.50E-07
MP E	15.0	8.0	-0.05	2.70E-07
MP D	5.0	8.0	-0.67	2.80E-07
MP Z	8.0	4.0	-0.05	2.40E-07

* - Insufficient data for permeability calculation.

TABLE 2

ANALYTE CONCENTRATIONS VIA GC/FID (µg/l)

SAMPLE	TEST NO.	TIME	BENZENE	TOLUENE	ETHYL-BENZENE	XYLENES	TOTAL FID VOLATILES*
REPORTING LIMIT			1.0	1.0	1.0	1.0	10
1	1	2:04	<1.0	1.0	<1.0	<1.0	34
2	1	2:15	<1.0	<1.0	<1.0	<1.0	41
3	1	2:30	<1.0	<1.0	<1.0	<1.0	<10
4	1	2:45	<1.0	<1.0	<1.0	<1.0	<10
5	1	3:00	<1.0	<1.0	<1.0	<1.0	<10
6	2	3:28	<1.0	<1.0	<1.0	<1.0	<10
7	2	3:40	<1.0	<1.0	<1.0	<1.0	<10
8	2	3:55	<1.0	<1.0	<1.0	<1.0	<10
9	3	4:03	<1.0	<1.0	<1.0	<1.0	12
10	3	4:15	<1.0	<1.0	<1.0	<1.0	<10
11	3	4:30	<1.0	<1.0	<1.0	<1.0	<10
FIELD CONTROL SAMPLES							
100			<1.0	<1.0	<1.0	<1.0	<10
101			<1.0	<1.0	<1.0	<1.0	<10
LABORATORY DUPLICATE ANALYSIS							
8			<1.0	<1.0	<1.0	<1.0	<10
8R			<1.0	<1.0	<1.0	<1.0	<10
LABORATORY BLANKS							
8B			<1.0	<1.0	<1.0	<1.0	<10

** CALCULATED USING THE SUM OF THE AREAS OF ALL INTEGRATED CHROMATOGRAM PEAKS AND THE INSTRUMENT RESPONSE FACTOR FOR TOLUENE*

TABLE 3

ANALYTE CONCENTRATIONS VIA GC/ECD (µg/l)

SAMPLE	TEST NO.	TIME	11DCE	CH2CL2	t12DCE	11DCA	c12DCE	CHCl3	111TCA	CCL4	TCE	112TCA	PCE
REPORTING LIMIT			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1	2:04	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2	1	2:15	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3	1	2:30	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4	1	2:45	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
5	1	3:00	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6	2	3:28	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
7	2	3:40	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
8	2	3:55	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
9	3	4:03	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
10	3	4:15	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
11	3	4:30	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
FIELD CONTROL SAMPLES													
100			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
101			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
LABORATORY DUPLICATE ANALYSIS													
8			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
8R			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
LABORATORY BLANKS													
8B			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

11DCE = 1,1-dichloroethene
11DCA = 1,1-dichloroethane
111TCA = 1,1,1-trichloroethane
112TCA = 1,1,2-trichloroethane
CH2Cl2 = methylene chloride
c12DCE = cis-1,2-dichloroethene
CCl4 = carbon tetrachloride
PCE = tetrachloroethene
t12DCE = trans-1,2-dichloroethene
CHCl3 = chloroform
TCE = trichloroethene

APPENDIX A

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
1	-0.01	-0.02	-0.03	-0.04	0.00	0.00
2	-0.01	-0.02	-0.03	-0.03	0.00	0.00
3	-0.01	-0.02	-0.02	-0.02	0.00	0.00
4	0.00	-0.02	-0.01	-0.01	0.00	0.00
5	0.00	-0.02	-0.01	0.00	0.00	0.00
6	0.00	-0.01	0.00	0.00	0.00	0.00
7	0.00	-0.01	-0.01	-0.01	0.00	0.00
8	0.00	-0.02	-0.02	-0.02	0.00	0.00
9	-0.01	-0.02	-0.03	-0.04	0.00	-0.09
10	-0.02	-0.03	-0.05	-0.06	0.00	-0.39
12	-0.03	-0.03	-0.06	-0.07	0.00	-0.63
13	-0.04	-0.04	-0.07	-0.08	0.00	-0.83
14	-0.04	-0.05	-0.07	-0.07	0.00	-0.97
15	-0.04	-0.05	-0.07	-0.08	0.00	-1.12
16	-0.04	-0.05	-0.07	-0.07	0.00	-1.24
17	-0.04	-0.06	-0.07	-0.07	0.00	-1.36
18	-0.03	-0.06	-0.07	-0.07	0.00	-1.41
19	-0.03	-0.05	-0.06	-0.06	0.00	-1.51
20	-0.02	-0.05	-0.05	-0.05	0.00	-1.56
21	-0.01	-0.05	-0.04	-0.04	0.00	-1.61
22	0.00	-0.04	-0.03	-0.04	0.00	-1.63
23	0.00	-0.04	-0.01	-0.03	0.00	-1.66
24	0.00	-0.03	0.00	-0.02	0.00	-1.71
25	0.00	-0.02	0.00	-0.02	0.00	-1.75
26	0.00	-0.02	0.00	-0.03	0.00	-1.75
27	0.00	-0.01	0.00	-0.03	0.00	-1.75
28	0.00	0.00	0.00	-0.04	0.00	-1.80
29	0.00	0.00	0.00	-0.04	0.00	-1.85
30	0.00	0.00	0.00	-0.05	0.00	-1.85
31	0.00	0.00	0.00	-0.06	0.00	-1.90
32	0.00	0.00	0.00	-0.06	0.00	-1.93
33	0.00	0.00	0.00	-0.07	0.00	-1.93
34	0.00	0.00	0.00	-0.07	0.00	-1.95
35	0.00	0.00	0.00	-0.07	0.00	-1.95
37	0.00	0.00	0.00	-0.07	0.00	-1.97
38	0.00	0.00	0.00	-0.07	0.00	-2.00
39	0.00	0.00	0.00	-0.07	0.00	-2.00
40	0.00	0.00	0.00	-0.07	0.00	-2.02
41	0.00	0.00	0.00	-0.07	0.00	-2.00
42	0.00	0.00	0.00	-0.07	0.00	-2.02
43	0.00	0.00	0.00	-0.07	0.00	-2.05

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
44	0.00	0.00	0.00	-0.08	0.00	-2.05
45	0.00	0.00	0.00	-0.08	0.00	-2.07
46	0.00	0.00	0.00	-0.09	0.00	-2.10
47	0.00	0.00	0.00	-0.09	0.00	-2.07
48	0.00	0.00	0.00	-0.10	0.00	-2.12
49	0.00	0.00	0.00	-0.10	0.00	-2.12
50	0.00	0.00	0.00	-0.11	0.00	-2.12
51	0.00	0.00	0.00	-0.11	0.00	-2.15
52	0.00	0.00	-0.01	-0.12	0.00	-2.15
53	0.00	0.00	-0.01	-0.12	0.00	-2.17
54	0.00	0.00	-0.01	-0.12	0.00	-2.19
55	0.00	0.00	-0.02	-0.13	0.00	-2.19
56	0.00	0.00	-0.02	-0.13	0.00	-2.19
57	0.00	0.00	-0.03	-0.14	0.00	-2.19
59	0.00	0.00	-0.03	-0.14	0.00	-2.19
60	0.00	0.00	-0.03	-0.14	0.00	-2.22
61	0.00	0.00	-0.03	-0.14	0.00	-2.19
62	0.00	0.00	-0.03	-0.13	0.00	-2.22
63	0.00	0.00	-0.03	-0.13	0.00	-2.19
64	0.00	0.00	-0.02	-0.12	0.00	-2.19
65	0.00	0.00	-0.02	-0.12	0.00	-2.22
66	0.00	0.00	-0.02	-0.13	0.00	-2.22
67	0.00	0.00	-0.02	-0.13	0.00	-2.19
68	0.00	0.00	-0.02	-0.13	0.00	-2.24
69	0.00	0.00	-0.03	-0.13	0.00	-2.24
70	0.00	0.00	-0.03	-0.14	0.00	-2.24
71	0.00	0.00	-0.03	-0.15	0.00	-2.24
72	-0.01	0.00	-0.04	-0.15	0.00	-2.24
73	-0.01	0.00	-0.04	-0.16	0.00	-2.27
74	-0.01	0.00	-0.05	-0.16	0.00	-2.27
75	-0.01	0.00	-0.05	-0.16	0.00	-2.27
76	-0.01	-0.01	-0.05	-0.16	0.00	-2.29
77	-0.02	-0.01	-0.05	-0.16	0.00	-2.29
78	-0.02	-0.01	-0.05	-0.16	0.00	-2.29
79	-0.02	-0.01	-0.05	-0.16	0.00	-2.29
80	-0.02	-0.01	-0.05	-0.17	0.00	-2.29
81	-0.02	-0.01	-0.06	-0.17	0.00	-2.32
82	-0.02	-0.01	-0.06	-0.17	0.00	-2.32
83	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
85	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
86	-0.02	-0.02	-0.06	-0.17	0.00	-2.32

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
87	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
88	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
89	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
90	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
91	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
92	-0.02	-0.02	-0.06	-0.17	0.00	-2.32
93	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
94	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
95	-0.02	-0.02	-0.05	-0.17	0.00	-2.34
96	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
97	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
98	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
99	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
100	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
101	-0.02	-0.02	-0.06	-0.17	0.00	-2.34
102	-0.02	-0.01	-0.05	-0.17	0.00	-2.34
103	-0.01	-0.01	-0.05	-0.16	0.00	-2.32
104	-0.01	-0.01	-0.05	-0.16	0.00	-2.32
105	-0.01	-0.01	-0.04	-0.16	0.00	-2.32
107	-0.01	-0.01	-0.04	-0.16	0.00	-2.32
108	-0.01	-0.01	-0.04	-0.16	0.00	-2.32
109	-0.01	0.00	-0.04	-0.16	0.00	-2.32
110	-0.01	0.00	-0.03	-0.16	0.00	-2.32
111	-0.01	0.00	-0.03	-0.16	0.00	-2.32
112	-0.01	0.00	-0.03	-0.16	0.00	-2.29
113	-0.01	0.00	-0.03	-0.16	0.00	-2.32
114	-0.01	0.00	-0.04	-0.16	0.00	-2.32
115	-0.02	0.00	-0.04	-0.17	0.00	-2.34
116	-0.02	0.00	-0.04	-0.17	0.00	-2.34
117	-0.02	0.00	-0.04	-0.17	0.00	-2.34
118	-0.02	0.00	-0.05	-0.17	0.00	-2.37
119	-0.02	0.00	-0.05	-0.18	0.00	-2.37
120	-0.03	0.00	-0.05	-0.18	0.00	-2.37
121	-0.03	0.00	-0.06	-0.19	0.00	-2.39
122	-0.03	0.00	-0.06	-0.19	0.00	-2.39
123	-0.03	-0.01	-0.07	-0.19	0.00	-2.41
124	-0.03	-0.01	-0.07	-0.19	0.00	-2.41
125	-0.03	-0.01	-0.07	-0.19	0.00	-2.41
126	-0.03	-0.01	-0.07	-0.19	0.00	-2.41
127	-0.03	-0.01	-0.07	-0.19	0.00	-2.41
128	-0.03	-0.01	-0.07	-0.19	0.00	-2.41

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
129	-0.03	-0.02	-0.07	-0.19	0.00	-2.41
130	-0.03	-0.02	-0.07	-0.19	0.00	-2.44
132	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
133	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
134	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
135	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
136	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
137	-0.04	-0.03	-0.08	-0.20	0.00	-2.44
138	-0.03	-0.02	-0.07	-0.19	0.00	-2.44
139	-0.03	-0.02	-0.07	-0.18	0.00	-2.44
140	-0.03	-0.02	-0.07	-0.18	0.00	-2.44
141	-0.02	-0.02	-0.07	-0.18	0.00	-2.44
142	-0.02	-0.02	-0.07	-0.18	0.00	-2.44
143	-0.02	-0.02	-0.06	-0.18	0.00	-2.44
144	-0.02	-0.02	-0.06	-0.18	0.00	-2.44
145	-0.02	-0.02	-0.06	-0.17	0.00	-2.44
146	-0.01	-0.01	-0.05	-0.16	0.00	-2.41
147	-0.01	-0.01	-0.04	-0.16	0.00	-2.41
148	0.00	0.00	-0.04	-0.15	0.00	-2.41
149	0.00	0.00	-0.03	-0.15	0.00	-2.41
150	0.00	0.00	-0.03	-0.15	0.00	-2.39
165	-0.02	0.00	-0.04	-0.17	0.00	-2.39
170	-0.01	0.00	-0.04	-0.17	0.00	-2.39
175	-0.02	0.00	-0.05	-0.17	-0.02	-2.39
180	-0.02	0.00	-0.05	-0.18	-0.02	-2.41
185	-0.03	0.00	-0.07	-0.19	-0.02	-2.41
190	-0.04	-0.01	-0.08	-0.20	-0.02	-2.41
195	-0.04	-0.02	-0.08	-0.20	-0.02	-2.41
200	-0.05	-0.02	-0.09	-0.21	-0.05	-2.44
205	-0.04	-0.02	-0.08	-0.20	-0.02	-2.44
210	-0.03	-0.01	-0.06	-0.19	0.00	-2.41
215	-0.03	-0.01	-0.07	-0.20	0.00	-2.39
220	-0.03	-0.01	-0.07	-0.19	0.00	-2.39
225	-0.03	-0.01	-0.07	-0.19	0.00	-2.39
230	-0.03	-0.01	-0.07	-0.19	0.00	-2.39
235	-0.03	-0.01	-0.07	-0.19	0.00	-2.39
241	-0.03	-0.01	-0.06	-0.19	0.00	-2.39
246	-0.03	0.00	-0.07	-0.20	0.00	-2.41
251	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
256	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
261	-0.04	-0.01	-0.07	-0.20	0.00	-2.44

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
266	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
271	-0.04	-0.01	-0.06	-0.19	0.00	-2.44
276	-0.04	-0.01	-0.07	-0.19	0.00	-2.44
281	-0.04	-0.01	-0.08	-0.20	0.00	-2.46
286	-0.04	-0.02	-0.08	-0.20	0.00	-2.46
291	-0.04	-0.02	-0.08	-0.20	0.00	-2.46
296	-0.04	-0.01	-0.08	-0.20	0.00	-2.44
301	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
306	-0.04	-0.01	-0.08	-0.20	0.00	-2.44
311	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
316	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
321	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
326	-0.03	-0.01	-0.07	-0.20	0.00	-2.44
332	-0.03	-0.01	-0.07	-0.19	0.00	-2.41
337	-0.03	-0.01	-0.07	-0.19	0.00	-2.44
342	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
347	-0.05	-0.01	-0.09	-0.21	0.00	-2.44
352	-0.05	-0.02	-0.09	-0.21	0.00	-2.46
357	-0.05	-0.03	-0.09	-0.22	0.00	-2.49
362	-0.04	-0.02	-0.08	-0.20	0.00	-2.46
367	-0.03	-0.01	-0.07	-0.19	0.00	-2.44
372	-0.04	-0.02	-0.08	-0.21	0.00	-2.44
377	-0.05	-0.02	-0.09	-0.22	0.00	-2.46
382	-0.05	-0.02	-0.09	-0.21	0.00	-2.44
387	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
392	-0.04	-0.02	-0.07	-0.20	0.00	-2.44
397	-0.03	-0.01	-0.07	-0.19	0.00	-2.41
402	-0.04	-0.01	-0.08	-0.20	0.00	-2.44
407	-0.05	-0.02	-0.09	-0.21	0.00	-2.46
412	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
417	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
422	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
428	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
433	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
438	-0.04	-0.01	-0.08	-0.20	0.00	-2.44
471	-0.04	-0.02	-0.08	-0.20	0.00	-2.41
486	-0.04	-0.02	-0.09	-0.20	0.00	-2.44
501	-0.05	-0.02	-0.10	-0.22	0.00	-2.44
516	-0.06	-0.04	-0.11	-0.24	0.00	-2.49
531	-0.04	-0.01	-0.08	-0.21	0.00	-2.46
546	-0.05	-0.03	-0.10	-0.22	0.00	-2.46

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
562	-0.04	-0.02	-0.07	-0.19	0.00	-2.44
577	-0.04	-0.01	-0.07	-0.19	0.00	-2.44
592	-0.05	-0.03	-0.09	-0.20	0.00	-2.46
607	-0.04	-0.01	-0.08	-0.21	0.00	-2.46
622	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
637	-0.06	-0.03	-0.11	-0.23	0.00	-2.44
652	-0.04	-0.01	-0.07	-0.20	0.00	-2.44
667	-0.04	-0.02	-0.08	-0.19	0.00	-2.49
682	-0.05	-0.02	-0.09	-0.20	0.00	-2.56
697	-0.05	-0.03	-0.09	-0.21	0.00	-2.58
712	-0.03	0.00	-0.06	-0.19	0.00	-2.58
727	-0.07	-0.03	-0.12	-0.24	0.00	-2.61
742	-0.04	-0.03	-0.08	-0.20	0.00	-2.54
757	-0.05	-0.02	-0.09	-0.21	0.00	-2.49
772	-0.04	-0.03	-0.08	-0.19	0.00	-2.54
787	-0.05	-0.04	-0.09	-0.20	0.00	-2.63
802	-0.04	0.00	-0.07	-0.20	0.00	-2.68
817	-0.06	-0.02	-0.10	-0.22	0.00	-2.73
832	-0.06	-0.04	-0.11	-0.23	0.00	-2.68
871	-0.05	-0.01	-0.09	-0.22	0.00	-2.58
896	-0.05	-0.03	-0.09	-0.21	0.00	-2.51
921	-0.06	-0.04	-0.10	-0.23	0.00	-2.49
946	-0.05	-0.02	-0.09	-0.21	0.00	-2.46
971	-0.05	-0.03	-0.09	-0.21	0.00	-2.49
996	-0.05	-0.01	-0.09	-0.21	0.00	-2.49
1021	-0.04	-0.02	-0.08	-0.20	0.00	-2.44
1046	-0.05	-0.02	-0.10	-0.22	0.00	-2.49
1071	-0.05	-0.02	-0.08	-0.20	0.00	-2.51
1096	-0.06	-0.03	-0.10	-0.22	0.00	-2.54
1122	-0.05	-0.02	-0.09	-0.20	0.00	-2.49
1147	-0.05	-0.02	-0.09	-0.21	0.00	-2.44
1172	-0.05	-0.02	-0.09	-0.21	0.00	-2.44
1197	-0.05	-0.02	-0.09	-0.22	0.00	-2.49
1222	-0.04	-0.03	-0.08	-0.20	0.00	-2.68
1247	-0.04	-0.02	-0.08	-0.19	0.00	-2.83
1272	-0.05	-0.02	-0.09	-0.20	0.00	-3.02
1297	-0.04	0.00	-0.07	-0.19	-0.02	-2.98
1322	-0.05	-0.04	-0.10	-0.21	-0.05	-3.00
1347	-0.03	-0.01	-0.06	-0.18	0.00	-2.95
1372	-0.04	-0.01	-0.07	-0.20	-0.02	-3.00
1397	-0.04	-0.01	-0.07	-0.19	0.00	-3.00

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
1422	-0.05	-0.03	-0.10	-0.22	0.00	-2.98
1447	-0.05	-0.02	-0.08	-0.20	0.00	-2.93
1472	-0.05	-0.03	-0.10	-0.22	0.00	-2.90
1497	-0.05	-0.03	-0.09	-0.22	0.00	-2.88
1522	-0.05	-0.02	-0.09	-0.21	0.00	-2.83
1547	-0.05	-0.02	-0.09	-0.22	0.00	-2.78
1572	-0.05	-0.03	-0.09	-0.20	0.00	-2.78
1597	-0.05	-0.01	-0.08	-0.20	0.00	-2.73
1623	-0.05	-0.02	-0.09	-0.21	0.00	-2.78
1648	-0.07	-0.04	-0.11	-0.23	0.00	-2.83
1673	-0.06	-0.03	-0.09	-0.22	0.00	-2.80
1698	-0.05	-0.01	-0.09	-0.21	0.00	-2.85
1723	-0.04	-0.03	-0.10	-0.11	0.00	-3.07
1748	-0.06	-0.04	-0.09	-0.15	0.00	-3.17
1773	-0.04	-0.02	-0.08	-0.12	0.00	-3.20
1798	-0.04	-0.03	-0.09	-0.11	0.00	-3.22
1823	-0.04	0.00	-0.09	-0.17	0.00	-3.56
1848	-0.02	-0.01	-0.07	-0.13	0.00	-3.07
1873	-0.03	0.00	-0.08	-0.15	0.00	-3.07
1898	-0.03	0.00	-0.08	-0.14	0.00	-2.95
1923	-0.03	0.00	-0.08	-0.15	0.00	-2.98
1948	-0.04	-0.02	-0.09	-0.14	0.00	-2.95
1973	-0.06	-0.03	-0.11	-0.16	0.00	-2.93
1998	-0.03	-0.01	-0.07	-0.12	0.00	-2.90
2052	-0.07	-0.03	-0.12	-0.16	0.00	-3.12
2092	-0.05	-0.02	-0.10	-0.15	0.00	-3.12
2132	-0.05	0.00	-0.09	-0.16	0.00	-3.10
2172	-0.07	-0.04	-0.12	-0.19	0.00	-3.00
2212	-0.04	0.00	-0.07	-0.15	0.00	-3.27
2252	-0.04	-0.03	-0.09	-0.11	0.00	-3.17
2292	-0.04	-0.03	-0.09	-0.12	0.00	-3.29
2332	-0.03	-0.01	-0.07	-0.12	0.00	-2.88
2373	-0.06	-0.02	-0.09	-0.17	0.00	-2.93
2413	-0.02	-0.02	-0.08	-0.13	0.00	-2.93
2453	-0.04	-0.02	-0.10	-0.16	0.00	-2.95
2493	-0.03	-0.02	-0.08	-0.15	0.00	-2.88
2533	-0.02	-0.01	-0.07	-0.14	0.00	-2.98
2573	-0.03	-0.02	-0.09	-0.15	0.00	-2.93
2613	-0.02	-0.02	-0.09	-0.14	0.00	-2.80
2653	-0.03	-0.02	-0.09	-0.15	0.00	-2.73
2693	-0.04	-0.02	-0.08	-0.13	0.00	-2.93

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 25.12

Vacuum Level (in HG) = -1.30

Time(sec)	MP F	MP C	MP B	MP E	MP A	MP D
2733	-0.04	-0.02	-0.09	-0.13	0.00	-2.63
2773	-0.04	-0.02	-0.09	-0.14	0.00	-2.63
2813	-0.04	0.00	-0.08	-0.15	0.00	-2.54
2853	-0.05	-0.01	-0.07	-0.16	0.00	-2.76
2893	-0.03	-0.02	-0.11	-0.16	0.00	-2.83
2933	-0.02	-0.01	-0.09	-0.15	0.00	-2.68
2973	-0.02	0.00	-0.07	-0.19	0.00	-2.66
3013	-0.01	-0.03	-0.10	-0.13	0.00	-3.05
3053	-0.03	-0.02	-0.08	-0.08	-0.24	-2.68
3093	-0.04	-0.01	-0.09	-0.15	-0.09	-2.61
3133	-0.05	-0.02	-0.09	-0.21	-0.48	-2.54
3173	-0.05	-0.02	-0.08	-0.20	-0.46	-2.51
3213	-0.05	-0.02	-0.09	-0.20	-0.46	-2.56
3253	-0.04	0.00	-0.07	-0.19	-0.46	-2.68
3294	-0.05	-0.02	-0.09	-0.21	-0.48	-2.76
3334	-0.05	-0.03	-0.09	-0.21	-0.48	-2.68
3374	-0.05	-0.02	-0.09	-0.21	-0.48	-2.61
3414	-0.05	-0.03	-0.09	-0.20	-0.46	-2.68
3454	-0.05	-0.02	-0.09	-0.20	-0.46	-2.90
3494	-0.05	-0.02	-0.08	-0.20	-0.46	-3.02
3534	-0.06	-0.04	-0.10	-0.22	-0.48	-2.98
3574	-0.03	-0.01	-0.07	-0.19	-0.44	-2.93
3614	-0.06	-0.03	-0.10	-0.22	-0.48	-2.98
3654	-0.06	-0.04	-0.11	-0.22	-0.48	-2.93
3694	-0.05	-0.01	-0.09	-0.21	-0.48	-2.73
3734	-0.05	-0.02	-0.09	-0.21	-0.48	-2.66
3774	-0.07	-0.04	-0.11	-0.23	-0.48	-2.58
3814	-0.05	-0.02	-0.09	-0.21	-0.46	-2.63

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00
16	0.00	0.00	-0.01	0.00
17	0.00	-0.01	-0.01	0.00
18	0.00	-0.01	-0.01	0.00
19	0.00	-0.01	-0.02	0.00
20	0.00	-0.01	-0.02	0.00
21	0.00	-0.02	-0.02	0.00
22	-0.01	-0.02	-0.02	0.00
23	-0.01	-0.02	-0.02	0.00
24	-0.01	-0.02	-0.02	0.00
25	-0.01	-0.01	-0.01	0.00
26	-0.01	-0.01	-0.01	0.00
27	-0.01	-0.01	0.00	0.00
28	0.00	-0.01	0.00	0.00
29	0.00	-0.01	0.00	0.00
31	0.00	-0.01	0.00	0.00
32	0.00	0.00	-0.01	-0.09
33	0.00	-0.01	-0.01	-0.19
34	0.00	-0.01	-0.01	-0.35
35	0.00	-0.01	-0.02	-0.49
36	0.00	-0.01	-0.03	-0.62
37	0.00	-0.01	-0.04	-0.76
38	0.00	-0.01	-0.05	-0.86
39	0.00	-0.02	-0.06	-0.96
40	0.00	-0.02	-0.07	-1.16
41	0.00	-0.02	-0.08	-1.30
42	0.00	-0.03	-0.09	-1.33
43	-0.01	-0.03	-0.10	-1.33

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
44	0.00	-0.03	-0.10	-1.33
45	0.00	-0.03	-0.10	-1.33
46	0.00	-0.04	-0.11	-1.33
47	0.00	-0.04	-0.11	-1.33
48	0.00	-0.04	-0.11	-1.33
49	0.00	-0.04	-0.11	-1.33
50	0.00	-0.05	-0.12	-1.33
51	0.00	-0.05	-0.12	-1.33
52	0.00	-0.04	-0.11	-1.33
53	0.00	-0.04	-0.11	-1.33
54	0.00	-0.04	-0.11	-1.33
56	0.00	-0.04	-0.11	-1.34
57	0.00	-0.05	-0.12	-1.34
58	0.00	-0.05	-0.12	-1.35
59	0.00	-0.05	-0.13	-1.36
60	0.00	-0.05	-0.14	-1.37
61	0.00	-0.06	-0.14	-1.38
62	0.00	-0.06	-0.15	-1.38
63	0.00	-0.07	-0.15	-1.39
64	0.00	-0.07	-0.16	-1.40
65	0.00	-0.07	-0.16	-1.40
66	-0.01	-0.08	-0.16	-1.41
67	-0.01	-0.08	-0.17	-1.41
68	-0.01	-0.08	-0.17	-1.42
69	-0.02	-0.08	-0.18	-1.42
70	-0.02	-0.09	-0.18	-1.43
71	-0.02	-0.09	-0.18	-1.43
72	-0.02	-0.09	-0.18	-1.43
73	-0.03	-0.09	-0.19	-1.44
74	-0.03	-0.10	-0.19	-1.44
75	-0.03	-0.10	-0.19	-1.44
76	-0.03	-0.10	-0.18	-1.44
77	-0.03	-0.10	-0.18	-1.44
79	-0.03	-0.09	-0.17	-1.43
80	-0.03	-0.09	-0.17	-1.43
81	-0.02	-0.09	-0.17	-1.43
82	-0.02	-0.08	-0.17	-1.43
83	-0.02	-0.08	-0.17	-1.43
84	-0.02	-0.08	-0.16	-1.43
85	-0.02	-0.08	-0.17	-1.43
86	-0.02	-0.08	-0.17	-1.43

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
87	-0.01	-0.08	-0.17	-1.43
88	-0.01	-0.08	-0.17	-1.43
89	-0.01	-0.08	-0.17	-1.44
90	-0.01	-0.08	-0.17	-1.44
91	-0.01	-0.08	-0.17	-1.44
92	-0.01	-0.08	-0.17	-1.45
93	-0.02	-0.09	-0.18	-1.45
94	-0.02	-0.09	-0.18	-1.45
95	-0.02	-0.09	-0.18	-1.46
96	-0.02	-0.09	-0.18	-1.46
97	-0.02	-0.09	-0.18	-1.46
98	-0.02	-0.09	-0.19	-1.46
99	-0.02	-0.09	-0.19	-1.46
100	-0.02	-0.09	-0.19	-1.46
101	-0.02	-0.09	-0.18	-1.46
102	-0.02	-0.09	-0.18	-1.46
104	-0.02	-0.09	-0.18	-1.46
105	-0.02	-0.09	-0.18	-1.46
106	-0.02	-0.09	-0.18	-1.46
107	-0.02	-0.09	-0.18	-1.46
108	-0.02	-0.09	-0.18	-1.46
109	-0.02	-0.09	-0.18	-1.46
110	-0.02	-0.09	-0.18	-1.46
111	-0.01	-0.09	-0.18	-1.46
112	-0.01	-0.09	-0.18	-1.46
113	-0.01	-0.09	-0.18	-1.46
114	-0.01	-0.09	-0.18	-1.46
115	-0.01	-0.09	-0.18	-1.47
116	-0.01	-0.09	-0.18	-1.47
117	-0.01	-0.09	-0.18	-1.47
118	-0.02	-0.09	-0.18	-1.47
119	-0.02	-0.09	-0.18	-1.48
120	-0.02	-0.09	-0.18	-1.48
121	-0.01	-0.09	-0.18	-1.48
122	-0.01	-0.09	-0.18	-1.47
123	-0.01	-0.09	-0.18	-1.47
124	-0.01	-0.09	-0.17	-1.47
125	-0.01	-0.09	-0.17	-1.47
127	-0.01	-0.09	-0.18	-1.48
128	-0.01	-0.09	-0.18	-1.48
129	-0.01	-0.09	-0.18	-1.48

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
130	-0.01	-0.09	-0.18	-1.48
131	-0.01	-0.09	-0.19	-1.49
132	-0.01	-0.10	-0.19	-1.49
133	-0.01	-0.10	-0.19	-1.49
134	-0.02	-0.10	-0.19	-1.49
135	-0.02	-0.10	-0.20	-1.49
136	-0.02	-0.10	-0.20	-1.50
137	-0.02	-0.11	-0.20	-1.50
138	-0.03	-0.11	-0.21	-1.50
139	-0.03	-0.11	-0.21	-1.51
140	-0.03	-0.11	-0.21	-1.51
141	-0.03	-0.12	-0.21	-1.51
142	-0.04	-0.12	-0.21	-1.51
143	-0.04	-0.12	-0.22	-1.51
144	-0.04	-0.12	-0.21	-1.51
145	-0.04	-0.12	-0.21	-1.51
146	-0.04	-0.12	-0.21	-1.51
147	-0.04	-0.12	-0.21	-1.50
148	-0.04	-0.12	-0.21	-1.50
149	-0.04	-0.12	-0.20	-1.50
150	-0.04	-0.11	-0.21	-1.50
152	-0.04	-0.11	-0.21	-1.50
153	-0.04	-0.11	-0.21	-1.50
154	-0.04	-0.12	-0.21	-1.51
155	-0.04	-0.12	-0.22	-1.51
156	-0.04	-0.12	-0.22	-1.52
157	-0.04	-0.12	-0.22	-1.52
158	-0.05	-0.12	-0.22	-1.51
159	-0.05	-0.12	-0.21	-1.51
160	-0.04	-0.12	-0.21	-1.51
161	-0.04	-0.12	-0.21	-1.51
162	-0.04	-0.12	-0.21	-1.50
163	-0.04	-0.11	-0.20	-1.50
164	-0.04	-0.11	-0.20	-1.50
165	-0.04	-0.11	-0.20	-1.50
166	-0.04	-0.11	-0.20	-1.50
167	-0.03	-0.11	-0.20	-1.50
168	-0.03	-0.10	-0.20	-1.50
169	-0.03	-0.10	-0.19	-1.50
170	-0.03	-0.10	-0.19	-1.50
171	-0.03	-0.10	-0.20	-1.50

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
172	-0.03	-0.10	-0.20	-1.50
173	-0.03	-0.10	-0.20	-1.50
175	-0.03	-0.10	-0.20	-1.50
176	-0.03	-0.10	-0.20	-1.50
177	-0.03	-0.11	-0.20	-1.51
178	-0.03	-0.11	-0.20	-1.51
179	-0.03	-0.11	-0.21	-1.52
180	-0.03	-0.11	-0.21	-1.52
181	-0.03	-0.11	-0.21	-1.52
182	-0.03	-0.11	-0.21	-1.52
183	-0.03	-0.11	-0.21	-1.52
184	-0.03	-0.11	-0.21	-1.52
185	-0.04	-0.12	-0.21	-1.52
186	-0.04	-0.12	-0.21	-1.52
187	-0.04	-0.12	-0.21	-1.52
188	-0.04	-0.12	-0.21	-1.52
189	-0.04	-0.12	-0.21	-1.52
190	-0.04	-0.12	-0.21	-1.52
191	-0.04	-0.12	-0.21	-1.52
192	-0.04	-0.12	-0.21	-1.52
193	-0.04	-0.12	-0.21	-1.52
194	-0.04	-0.12	-0.21	-1.52
195	-0.04	-0.12	-0.21	-1.52
196	-0.04	-0.12	-0.21	-1.52
197	-0.04	-0.12	-0.21	-1.52
198	-0.04	-0.12	-0.21	-1.52
200	-0.04	-0.12	-0.21	-1.52
201	-0.04	-0.12	-0.21	-1.52
202	-0.04	-0.11	-0.21	-1.52
203	-0.04	-0.11	-0.21	-1.52
204	-0.04	-0.11	-0.21	-1.52
205	-0.04	-0.12	-0.21	-1.52
206	-0.04	-0.11	-0.21	-1.52
207	-0.04	-0.11	-0.20	-1.52
208	-0.04	-0.11	-0.21	-1.52
209	-0.04	-0.11	-0.21	-1.52
210	-0.04	-0.11	-0.21	-1.52
211	-0.04	-0.11	-0.21	-1.52
212	-0.04	-0.11	-0.21	-1.52
213	-0.04	-0.11	-0.21	-1.52
214	-0.04	-0.11	-0.21	-1.52

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
215	-0.04	-0.11	-0.21	-1.52
216	-0.04	-0.11	-0.21	-1.52
217	-0.03	-0.11	-0.21	-1.52
218	-0.04	-0.11	-0.21	-1.52
219	-0.03	-0.11	-0.21	-1.52
220	-0.03	-0.11	-0.21	-1.52
222	-0.03	-0.11	-0.21	-1.52
223	-0.03	-0.11	-0.21	-1.52
224	-0.03	-0.11	-0.21	-1.52
225	-0.03	-0.11	-0.21	-1.52
226	-0.03	-0.11	-0.21	-1.52
227	-0.03	-0.11	-0.21	-1.52
228	-0.03	-0.11	-0.21	-1.52
229	-0.04	-0.12	-0.21	-1.52
230	-0.04	-0.12	-0.22	-1.53
231	-0.04	-0.12	-0.22	-1.53
232	-0.04	-0.12	-0.22	-1.53
233	-0.04	-0.12	-0.22	-1.53
234	-0.04	-0.12	-0.22	-1.53
235	-0.04	-0.12	-0.22	-1.53
236	-0.04	-0.12	-0.22	-1.53
237	-0.04	-0.12	-0.22	-1.53
238	-0.04	-0.12	-0.22	-1.53
239	-0.04	-0.12	-0.22	-1.53
262	-0.05	-0.12	-0.22	-1.53
272	-0.04	-0.12	-0.21	-1.53
283	-0.03	-0.11	-0.20	-1.53
293	-0.03	-0.12	-0.22	-1.53
303	-0.07	-0.15	-0.25	-1.55
313	-0.06	-0.13	-0.22	-1.55
323	-0.03	-0.11	-0.20	-1.56
333	-0.04	-0.12	-0.22	-1.58
343	-0.04	-0.12	-0.22	-1.59
353	-0.05	-0.13	-0.23	-1.59
363	-0.04	-0.12	-0.21	-1.59
373	-0.04	-0.12	-0.22	-1.60
383	-0.04	-0.12	-0.22	-1.60
393	-0.05	-0.13	-0.23	-1.60
403	-0.05	-0.12	-0.22	-1.60
413	-0.04	-0.12	-0.22	-1.61
423	-0.04	-0.12	-0.22	-1.61

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
433	-0.05	-0.13	-0.23	-1.62
443	-0.06	-0.14	-0.24	-1.62
453	-0.06	-0.13	-0.23	-1.62
463	-0.05	-0.12	-0.22	-1.62
474	-0.05	-0.13	-0.23	-1.63
484	-0.03	-0.12	-0.21	-1.64
494	-0.04	-0.12	-0.22	-1.64
504	-0.04	-0.12	-0.22	-1.65
514	-0.04	-0.12	-0.22	-1.65
524	-0.04	-0.12	-0.22	-1.65
534	-0.05	-0.13	-0.23	-1.65
544	-0.06	-0.13	-0.23	-1.64
554	-0.05	-0.13	-0.22	-1.64
564	-0.05	-0.13	-0.23	-1.64
574	-0.06	-0.13	-0.23	-1.64
584	-0.02	-0.09	-0.18	-1.62
594	-0.02	-0.12	-0.22	-1.61
604	-0.05	-0.13	-0.23	-1.61
614	-0.06	-0.14	-0.24	-1.61
624	-0.06	-0.14	-0.24	-1.61
634	-0.07	-0.14	-0.25	-1.61
644	-0.05	-0.12	-0.21	-1.59
654	-0.05	-0.12	-0.23	-1.58
664	-0.04	-0.12	-0.22	-1.57
674	-0.05	-0.13	-0.23	-1.57
685	-0.04	-0.12	-0.22	-1.57
695	-0.05	-0.13	-0.23	-1.57
705	-0.05	-0.12	-0.22	-1.57
715	-0.05	-0.12	-0.22	-1.57
725	-0.05	-0.13	-0.23	-1.57
735	-0.06	-0.13	-0.24	-1.57
745	-0.05	-0.12	-0.22	-1.57
755	-0.06	-0.14	-0.24	-1.58
765	-0.09	-0.16	-0.25	-1.58
775	-0.04	-0.11	-0.20	-1.57
785	-0.05	-0.14	-0.25	-1.57
795	-0.05	-0.12	-0.21	-1.57
805	-0.05	-0.13	-0.24	-1.57
815	-0.05	-0.13	-0.23	-1.57
825	-0.06	-0.13	-0.23	-1.57
835	-0.05	-0.13	-0.23	-1.57

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 16.30

Vacuum Level (in HG) = 0.81

Time(sec)	MP B	MP E	MP A	MP D
845	-0.05	-0.12	-0.23	-1.57
855	-0.05	-0.12	-0.22	-1.57
865	-0.04	-0.12	-0.22	-1.57
876	-0.05	-0.13	-0.24	-1.58
886	-0.06	-0.13	-0.24	-1.58
896	-0.04	-0.11	-0.22	-1.57
906	-0.06	-0.14	-0.25	-1.58
916	-0.06	-0.14	-0.24	-1.58
926	-0.07	-0.14	-0.24	-1.59
976	-0.03	-0.11	-0.20	-1.58
1006	-0.03	-0.11	-0.22	-1.57
1036	-0.06	-0.13	-0.24	-1.56
1066	-0.05	-0.12	-0.21	-1.56
1096	-0.05	-0.12	-0.22	-1.57
1126	-0.05	-0.13	-0.23	-1.57
1156	-0.06	-0.13	-0.22	-1.56
1186	-0.06	-0.13	-0.22	-1.57
1216	-0.05	-0.13	-0.23	-1.59
1246	-0.05	-0.13	-0.23	-1.60
1276	-0.06	-0.14	-0.25	-1.57
1309	-0.04	-0.12	-0.21	-1.57
1342	-0.03	-0.11	-0.21	-1.56
1366	-0.05	-0.12	-0.22	-1.56
1396	-0.08	-0.15	-0.25	-1.56
1426	-0.05	-0.13	-0.23	-1.56
1456	-0.07	-0.14	-0.24	-1.59
1486	-0.07	-0.15	-0.26	-1.60
1516	-0.05	-0.12	-0.22	-1.61
1547	-0.05	-0.13	-0.24	-1.62
1577	-0.02	-0.10	-0.20	-1.61
1607	-0.06	-0.13	-0.23	-1.63
1637	-0.05	-0.13	-0.23	-1.65
1667	-0.05	-0.13	-0.23	-1.65
1697	-0.05	-0.13	-0.23	-1.64
1727	-0.06	-0.13	-0.24	-1.64
1757	-0.04	-0.12	-0.23	-1.63
1787	-0.05	-0.13	-0.23	-1.62

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 7.90

Vacuum Level (in HG) = 0.36

Time(sec)	MP A	MP E	MP D
1	0.00	-0.01	-0.01
2	0.00	-0.01	-0.01
3	0.00	-0.01	-0.01
4	0.00	-0.01	-0.01
5	0.00	-0.01	-0.01
6	0.00	-0.01	-0.01
7	0.00	-0.01	-0.01
8	0.00	-0.01	-0.01
9	0.00	-0.01	-0.01
10	0.00	-0.01	-0.02
11	0.00	-0.01	-0.02
12	0.00	-0.01	-0.02
13	0.00	-0.01	-0.02
14	0.00	0.00	-0.02
15	0.00	0.00	-0.02
16	0.00	0.00	-0.04
17	0.00	0.00	-0.08
19	0.00	0.00	-0.19
20	0.00	0.00	-0.37
21	0.00	0.00	-0.56
22	0.00	0.00	-0.72
23	0.00	0.00	-0.83
24	-0.01	0.00	-0.88
25	-0.01	-0.01	-0.89
26	-0.02	-0.01	-0.87
27	-0.03	-0.01	-0.85
28	-0.03	-0.01	-0.83
29	-0.04	-0.01	-0.80
30	-0.05	-0.02	-0.77
31	-0.05	-0.02	-0.74
32	-0.05	-0.02	-0.72
33	-0.06	-0.02	-0.70
34	-0.06	-0.03	-0.68
35	-0.06	-0.03	-0.67
36	-0.07	-0.03	-0.66
37	-0.07	-0.03	-0.65
38	-0.07	-0.03	-0.64
39	-0.07	-0.03	-0.64
40	-0.07	-0.03	-0.63
41	-0.07	-0.03	-0.63
43	-0.07	-0.03	-0.63

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 7.90

Vacuum Level (in HG) = 0.36

Time(sec)	MP A	MP E	MP D
44	-0.07	-0.03	-0.63
45	-0.07	-0.03	-0.63
46	-0.07	-0.03	-0.63
47	-0.07	-0.04	-0.63
48	-0.07	-0.04	-0.64
49	-0.08	-0.04	-0.64
50	-0.08	-0.04	-0.64
51	-0.08	-0.04	-0.64
52	-0.08	-0.05	-0.64
53	-0.08	-0.05	-0.64
54	-0.08	-0.05	-0.63
55	-0.08	-0.04	-0.63
56	-0.08	-0.04	-0.63
57	-0.08	-0.04	-0.63
58	-0.08	-0.04	-0.63
59	-0.08	-0.04	-0.64
60	-0.08	-0.04	-0.64
61	-0.08	-0.04	-0.63
62	-0.08	-0.05	-0.64
63	-0.08	-0.05	-0.64
64	-0.08	-0.05	-0.64
65	-0.08	-0.05	-0.64
66	-0.08	-0.05	-0.64
68	-0.08	-0.04	-0.64
69	-0.08	-0.04	-0.64
70	-0.08	-0.04	-0.64
71	-0.08	-0.04	-0.64
72	-0.08	-0.04	-0.64
73	-0.08	-0.04	-0.64
74	-0.08	-0.04	-0.64
75	-0.08	-0.04	-0.64
76	-0.08	-0.04	-0.64
77	-0.08	-0.05	-0.64
78	-0.08	-0.05	-0.64
79	-0.08	-0.05	-0.65
80	-0.08	-0.05	-0.65
81	-0.08	-0.05	-0.65
82	-0.08	-0.05	-0.65
83	-0.09	-0.05	-0.65
84	-0.09	-0.05	-0.65
85	-0.09	-0.05	-0.65

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 7.90

Vacuum Level (in HG) = 0.36

Time(sec)	MP A	MP E	MP D
129	-0.09	-0.06	-0.67
130	-0.09	-0.06	-0.66
131	-0.09	-0.06	-0.66
132	-0.09	-0.05	-0.66
133	-0.09	-0.05	-0.66
134	-0.09	-0.05	-0.66
135	-0.09	-0.05	-0.66
136	-0.09	-0.05	-0.66
137	-0.09	-0.05	-0.66
139	-0.09	-0.05	-0.66
140	-0.09	-0.05	-0.66
141	-0.09	-0.05	-0.66
142	-0.09	-0.05	-0.66
143	-0.09	-0.05	-0.66
144	-0.09	-0.05	-0.66
145	-0.09	-0.05	-0.66
146	-0.09	-0.05	-0.66
147	-0.09	-0.05	-0.66
148	-0.09	-0.05	-0.66
149	-0.09	-0.05	-0.66
150	-0.09	-0.05	-0.66
151	-0.09	-0.05	-0.66
152	-0.09	-0.05	-0.67
153	-0.09	-0.05	-0.67
154	-0.09	-0.05	-0.66
155	-0.09	-0.05	-0.66
156	-0.09	-0.05	-0.66
157	-0.09	-0.05	-0.66
158	-0.09	-0.05	-0.66
159	-0.09	-0.05	-0.66
160	-0.09	-0.05	-0.66
162	-0.09	-0.05	-0.66
163	-0.09	-0.05	-0.66
164	-0.08	-0.05	-0.66
165	-0.08	-0.05	-0.66
166	-0.08	-0.05	-0.66
167	-0.08	-0.05	-0.66
168	-0.08	-0.05	-0.66
169	-0.08	-0.05	-0.66
170	-0.08	-0.05	-0.66
171	-0.08	-0.05	-0.66

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 7.90

Vacuum Level (in HG) = 0.36

Time(sec)	MP A	MP E	MP D
172	-0.09	-0.05	-0.66
173	-0.09	-0.05	-0.66
174	-0.09	-0.05	-0.66
175	-0.09	-0.05	-0.66
176	-0.09	-0.05	-0.66
177	-0.09	-0.05	-0.66
178	-0.09	-0.05	-0.66
179	-0.09	-0.05	-0.66
180	-0.09	-0.05	-0.66
181	-0.09	-0.05	-0.66
182	-0.09	-0.05	-0.66
183	-0.09	-0.05	-0.66
184	-0.09	-0.05	-0.66
186	-0.09	-0.05	-0.66
187	-0.09	-0.05	-0.67
188	-0.09	-0.05	-0.67
189	-0.09	-0.05	-0.67
211	-0.09	-0.05	-0.66
222	-0.10	-0.06	-0.68
236	-0.09	-0.05	-0.67
244	-0.09	-0.05	-0.67
254	-0.10	-0.06	-0.67
264	-0.10	-0.06	-0.68
274	-0.10	-0.06	-0.68
284	-0.10	-0.06	-0.68
294	-0.11	-0.07	-0.69
304	-0.11	-0.07	-0.70
314	-0.10	-0.06	-0.67
324	-0.08	-0.04	-0.66
334	-0.10	-0.06	-0.69
344	-0.12	-0.08	-0.71
354	-0.12	-0.08	-0.71
364	-0.12	-0.07	-0.70
374	-0.07	-0.02	-0.63
384	-0.08	-0.05	-0.69
394	-0.14	-0.10	-0.73
404	-0.12	-0.08	-0.70
414	-0.09	-0.05	-0.68
424	-0.11	-0.07	-0.69
434	-0.09	-0.05	-0.68
444	-0.10	-0.06	-0.68

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 7.90

Vacuum Level (in HG) = 0.36

Time(sec)	MP A	MP E	MP D
456	-0.10	-0.06	-0.69
464	-0.11	-0.07	-0.70
475	-0.12	-0.07	-0.70
485	-0.11	-0.06	-0.69
497	-0.12	-0.08	-0.71
505	-0.07	-0.03	-0.62
515	-0.09	-0.05	-0.70
525	-0.12	-0.07	-0.68
535	-0.13	-0.09	-0.72
545	-0.09	-0.04	-0.66
555	-0.07	-0.03	-0.66
565	-0.12	-0.08	-0.71
575	-0.10	-0.06	-0.69
585	-0.11	-0.07	-0.70
595	-0.14	-0.10	-0.74
605	-0.11	-0.06	-0.69
615	-0.11	-0.07	-0.69
625	-0.11	-0.07	-0.71
635	-0.09	-0.05	-0.67
645	-0.10	-0.06	-0.69
655	-0.13	-0.08	-0.72
665	-0.11	-0.07	-0.70
675	-0.11	-0.07	-0.70
685	-0.10	-0.06	-0.69
695	-0.10	-0.06	-0.68
706	-0.10	-0.06	-0.69
716	-0.10	-0.06	-0.69
726	-0.10	-0.06	-0.69
736	-0.10	-0.06	-0.70
746	-0.10	-0.06	-0.69
756	-0.10	-0.06	-0.70
766	-0.11	-0.06	-0.70
776	-0.10	-0.06	-0.70
787	-0.11	-0.07	-0.72
807	-0.08	-0.04	-0.66
817	-0.09	-0.05	-0.69
827	-0.09	-0.06	-0.69
837	-0.12	-0.08	-0.72
847	-0.10	-0.06	-0.69
857	-0.10	-0.06	-0.70
867	-0.11	-0.07	-0.71

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 7.90

Vacuum Level (in HG) = 0.36

Time(sec)	MP A	MP E	MP D
877	-0.11	-0.07	-0.70
887	-0.11	-0.07	-0.71
897	-0.11	-0.07	-0.71
907	-0.13	-0.09	-0.73
917	-0.10	-0.06	-0.68
927	-0.08	-0.04	-0.68
937	-0.09	-0.06	-0.69
947	-0.10	-0.06	-0.70
957	-0.11	-0.07	-0.70
967	-0.10	-0.06	-0.70
977	-0.10	-0.06	-0.70
987	-0.11	-0.07	-0.71
997	-0.10	-0.06	-0.69
1007	-0.09	-0.05	-0.68
1017	-0.12	-0.08	-0.73
1027	-0.11	-0.07	-0.70
1037	-0.09	-0.05	-0.69
1047	-0.11	-0.07	-0.70
1057	-0.10	-0.06	-0.69
1122	-0.10	-0.06	-0.70
1147	-0.11	-0.07	-0.71
1172	-0.10	-0.06	-0.70
1197	-0.10	-0.06	-0.69
1222	-0.10	-0.06	-0.70
1248	-0.11	-0.07	-0.71
1273	-0.10	-0.06	-0.70
1298	-0.10	-0.06	-0.70
1324	-0.10	-0.07	-0.70
1347	-0.10	-0.06	-0.70
1372	-0.10	-0.07	-0.70
1397	-0.09	-0.05	-0.70
1423	-0.09	-0.05	-0.69
1448	-0.08	-0.07	-0.67
1475	-0.08	-0.06	-0.65
1500	-0.12	-0.08	-0.71
1523	-0.09	-0.05	-0.69
1548	-0.08	-0.05	-0.69
1574	-0.10	-0.07	-0.71
1599	-0.09	-0.06	-0.69
1624	-0.13	-0.09	-0.74
1649	-0.08	-0.03	-0.68

PRESSURE INCREASE (in WC)

Air Flow Rate (scfm) = 7.90

Vacuum Level (in HG) = 0.36

Time(sec)	MP A	MP E	MP D
1674	-0.11	-0.09	-0.71
1699	-0.11	-0.08	-0.71
1724	-0.09	-0.07	-0.70
1749	-0.11	-0.08	-0.70
1774	-0.11	-0.06	-0.69
1799	-0.11	-0.07	-0.70
1824	-0.09	-0.06	-0.69
1849	-0.08	-0.06	-0.69
1874	-0.11	-0.06	-0.70
1899	-0.09	-0.05	-0.71
1924	-0.13	-0.08	-0.73

APPENDIX B

TARGET ENVIRONMENTAL SERVICES INC.
SVE Pilot Test

Job Code:MXCL
Test #1

This equation estimates the permeability of the soil matrix using solutions for the radial darcian velocity distribution and the volumetric vapor flow rate developed be P.C. Johnson et al. 1990.

Input the following variables from the pilot test data.

$Q := 25.1$			Well flow rate in cfm.
$P := 1.3$			Well Vacuum in inHG.
$W := 3$			Radius of the well bore in inches.
$H := 7.5$			Height of the well screen in feet.
$P1 := .05$	Pressure at MP F in inWC.	$R1 := 30$	Radius of the monitoring point in feet.
$P2 := .03$	Pressure at MP C in inWC.	$R2 := 35$	Radius of the monitoring point in feet.
$P3 := .08$	Pressure at MP B in inWC.	$R3 := 20$	Radius of the monitoring point in feet.
$P4 := .18$	Pressure at MP E in inWC.	$R4 := 15$	Radius of the monitoring point in feet.
$P5 := .35$	Pressure at MP A in inWC.	$R5 := 10$	Radius of the monitoring point in feet.
$P6 := 2.5$	Pressure at MP D in inWC.	$R6 := 5$	Radius of the monitoring point in feet.
$P7 := .18$	Pressure at MP Z in inWC.	$R7 := 8$	Radius of the monitoring point in feet.

The following calculations are unit conversions and secondary calculations.

$q := Q \cdot 471.95$	
$q = 1.185 \cdot 10^{4}$	Flow rate in cc/sec.
$\mu := 1.8 \cdot 10^{-4}$	Density of the extracted air.
$w := W \cdot 2.54$	
$w = 7.62$	Radius of the well bore in cm.
$h := H \cdot 30.48$	
$h = 228.6$	Height of the well screen in cm.
$p := 1.013 \cdot 10^{6} - \left(P \cdot 3.3857 \cdot 10^{4}\right)$	
$p = 9.69 \cdot 10^{5}$	Absolute pressure at the extraction well.

Absolute pressures at the monitoring points.

$p1 := P1 \cdot 2483$	$p3 := P2 \cdot 2483$	$p5 := P3 \cdot 2483$	$p7 := P4 \cdot 2483$	$p9 := P5 \cdot 2483$
$p1 = 124.15$	$p3 = 74.49$	$p5 = 198.64$	$p7 = 446.94$	$p9 = 869.05$
$p2 := 1.01 \cdot 10^{6} - p1$	$p4 := 1.01 \cdot 10^{6} - p3$	$p6 := 1.01 \cdot 10^{6} - p5$	$p8 := 1.01 \cdot 10^{6} - p7$	$p10 := 1.01 \cdot 10^{6} - p9$
$p2 = 1.01 \cdot 10^{6}$	$p4 = 1.01 \cdot 10^{6}$	$p6 = 1.01 \cdot 10^{6}$	$p8 = 1.01 \cdot 10^{6}$	$p10 = 1.009 \cdot 10^{6}$

MXCL - Test 1

$p11 := P6 \cdot 2483$ $\quad p13 := P7 \cdot 2483$

$p11 = 6.208 \cdot 10^{3}$ $\quad p13 = 446.94$

$p12 := 1.01 \cdot 10^{6} - p11$ $\quad p14 := 1.01 \cdot 10^{6} - p13$

$p12 = 1.004 \cdot 10^{6}$ $\quad p14 = 1.01 \cdot 10^{6}$

Radius of the Monitoring Points in centimeters:

$r1 := 30.48 \cdot R1$ $\quad r2 := 30.48 \cdot R2$ $\quad r3 := 30.48 \cdot R3$ $\quad r4 := 30.48 \cdot R4$ $\quad r5 := 30.48 \cdot R5$

$r1 = 914.4$ $\quad r2 = 1.067 \cdot 10^{3}$ $\quad r3 = 609.6$ $\quad r4 = 457.2$ $\quad r5 = 304.8$

$r6 := 30.48 \cdot R6$ $\quad r7 := 30.48 \cdot R7$

$r6 = 152.4$ $\quad r7 = 243.84$

MP F

$$k1 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r1}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p2}{p}\right)^{2}\right]}$$

$k1 = 1.702 \cdot 10^{-7}$

MP C

$$k2 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r2}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p4}{p}\right)^{2}\right]}$$

$k2 = 1.755 \cdot 10^{-7}$

MP B

$$k3 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r3}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p6}{p}\right)^{2}\right]}$$

$k3 = 1.561 \cdot 10^{-7}$

MP E

$$k4 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r4}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p8}{p}\right)^{2}\right]}$$

$k4 = 1.468 \cdot 10^{-7}$

MP A

$$k5 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r5}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p10}{p}\right)^{2}\right]}$$

$k5 = 1.336 \cdot 10^{-7}$

MP D

$$k6 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r6}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p12}{p}\right)^{2}\right]}$$

$k6 = 1.255 \cdot 10^{-7}$

MP Z

$$k7 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r5}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p14}{p}\right)^{2}\right]}$$

$k7 = 1.322 \cdot 10^{-7}$

TARGET ENVIRONMENTAL SERVICES INC.
SVE Pilot Test

Job Code:MXCL
Test #2

This equation estimates the permeability of the soil matrix using solutions for the radial darcian velocity distribution and the volumetric vapor flow rate developed be P.C. Johnson et al. 1990.

Input the following variables from the pilot test data.

$Q := 16.3$	Well flow rate in cfm.
$P := .8$	Well Vacuum in inHG.
$W := 3$	Radius of the well bore in inches.
$H := 7.5$	Height of the well screen in feet.

$P3 := .03$	Pressure at MP B in inWC.	$R3 := 20$	Radius of the monitoring point in feet.
$P4 := .11$	Pressure at MP E in inWC.	$R4 := 15$	Radius of the monitoring point in feet.
$P5 := .21$	Pressure at MP A in inWC.	$R5 := 10$	Radius of the monitoring point in feet.
$P6 := 1.49$	Pressure at MP D in inWC.	$R6 := 5$	Radius of the monitoring point in feet.
$P7 := .1$	Pressure at MP Z in inWC.	$R7 := 8$	Radius of the monitoring point in feet.

The following calculations are unit conversions and secondary calculations.

$q := Q \cdot 471.95$	
$q = 7.693 \cdot 10^3$	Flow rate in cc/sec.
$\mu := 1.8 \cdot 10^{-4}$	Density of the extracted air.
$w := W \cdot 2.54$	
$w = 7.62$	Radius of the well bore in cm.
$h := H \cdot 30.48$	
$h = 228.6$	Height of the well screen in cm.
$p := 1.013 \cdot 10^6 - \left(P \cdot 3.3857 \cdot 10^4\right)$	
$p = 9.859 \cdot 10^5$	Absolute pressure at the extraction well.

Absolute pressures at the monitoring points.

$p5 := P3 \cdot 2483$	$p7 := P4 \cdot 2483$	$p9 := P5 \cdot 2483$	$p11 := P6 \cdot 2483$
$p5 = 74.49$	$p7 = 273.13$	$p9 = 521.43$	$p11 = 3.7 \cdot 10^3$
$p6 := 1.01 \cdot 10^6 - p5$	$p8 := 1.01 \cdot 10^6 - p7$	$p10 := 1.01 \cdot 10^6 - p9$	$p12 := 1.01 \cdot 10^6 - p11$
$p6 = 1.01 \cdot 10^6$	$p8 = 1.01 \cdot 10^6$	$p10 = 1.009 \cdot 10^6$	$p12 = 1.006 \cdot 10^6$

$p13 := P7 \cdot 2483$

$p13 = 248.3$

$p14 := 1.01 \cdot 10^6 - p13$

$p14 = 1.01 \cdot 10^6$

MXCL - Test 2

Radius of the Monitoring Points in centimeters:

$r6 := 30.48 \cdot R6$ $\quad r7 := 30.48 \cdot R7$ $\quad r3 := 30.48 \cdot R3$ $\quad r4 := 30.48 \cdot R4$ $\quad r5 := 30.48 \cdot R5$

$r6 = 152.4$ $\quad r7 = 243.84$ $\quad r3 = 609.6$ $\quad r4 = 457.2$ $\quad r5 = 304.8$

MP B

$$k3 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r3}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p6}{p}\right)^2\right]}$$

$k3 = 1.738 \cdot 10^{-7}$

MP E

$$k4 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r4}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p8}{p}\right)^2\right]}$$

$k4 = 1.638 \cdot 10^{-7}$

MP A

$$k5 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r5}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p10}{p}\right)^2\right]}$$

$k5 = 1.491 \cdot 10^{-7}$

MP D

$$k6 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r6}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p12}{p}\right)^2\right]}$$

$k6 = 1.402 \cdot 10^{-7}$

MP Z

$$k7 := \frac{q \cdot \mu \cdot \ln\left(\frac{w}{r5}\right)}{h \cdot \pi \cdot p \cdot \left[1 - \left(\frac{p14}{p}\right)^2\right]}$$

$k7 = 1.474 \cdot 10^{-7}$

TARGET ENVIRONMENTAL SERVICES INC.
SVE Pilot Test

Job Code:MXCL
Test #3

This equation estimates the permeability of the soil matrix using solutions for the radial darcian velocity distribution and the volumetric vapor flow rate developed be P.C. Johnson et al. 1990.

Input the following variables from the pilot test data.

$Q := 7.9$		Well flow rate in cfm.	
$P := .3$		Well Vacuum in inHG.	
$W := 3$		Radius of the well bore in inches.	
$H := 7.5$		Height of the well screen in feet.	
$P4 := .05$	Pressure at MP E in inWC.	$R4 := 15$	Radius of the monitoring point in feet.
$P5 := .09$	Pressure at MP A in inWC.	$R5 := 10$	Radius of the monitoring point in feet.
$P6 := .87$	Pressure at MP D in inWC.	$R6 := 5$	Radius of the monitoring point in feet.
$P7 := .05$	Pressure at MP Z in inWC.	$R7 := 8$	Radius of the monitoring point in feet.

The following calculations are unit conversions and secondary calculations.

$q := Q \cdot 471.95$

$q = 3.728 \cdot 10^3$ Flow rate in cc/sec.

$\mu := 1.8 \cdot 10^{-4}$ Density of the extracted air.

$w := W \cdot 2.54$

$w = 7.62$ Radius of the well bore in cm.

$h := H \cdot 30.48$

$h = 228.6$ Height of the well screen in cm.

$p := 1.013 \cdot 10^6 - (P \cdot 3.3857 \cdot 10^4)$

$p = 1.003 \cdot 10^6$ Absolute pressure at the extraction well.

Absolute pressures at the monitoring points.

$p13 := P7 \cdot 2483$	$p7 := P4 \cdot 2483$	$p9 := P5 \cdot 2483$	$p11 := P6 \cdot 2483$
$p13 = 124.15$	$p7 = 124.15$	$p9 = 223.47$	$p11 = 2.16 \cdot 10^3$
$p14 := 1.01 \cdot 10^6 - p13$	$p8 := 1.01 \cdot 10^6 - p7$	$p10 := 1.01 \cdot 10^6 - p9$	$p12 := 1.01 \cdot 10^6 - p11$
$p14 = 1.01 \cdot 10^6$	$p8 = 1.01 \cdot 10^6$	$p10 = 1.01 \cdot 10^6$	$p12 = 1.008 \cdot 10^6$

Radius of the Monitoring Points in centimeters:

$r6 := 30.48 \cdot R6$	$r7 := 30.48 \cdot R7$	$r4 := 30.48 \cdot R4$	$r5 := 30.48 \cdot R5$
$r6 = 152.4$	$r7 = 243.84$	$r4 = 457.2$	$r5 = 304.8$

MXCL - Test 2

MP Z

$$k7 := \frac{q\cdot\mu\cdot\ln\left(\frac{w}{r5}\right)}{h\cdot\pi\cdot p\cdot\left[1-\left(\frac{p14}{p}\right)^2\right]}$$

$$k7 = 2.442\cdot10^{-7}$$

MP E

$$k4 := \frac{q\cdot\mu\cdot\ln\left(\frac{w}{r4}\right)}{h\cdot\pi\cdot p\cdot\left[1-\left(\frac{p8}{p}\right)^2\right]}$$

$$k4 = 2.711\cdot10^{-7}$$

MP A

$$k5 := \frac{q\cdot\mu\cdot\ln\left(\frac{w}{r5}\right)}{h\cdot\pi\cdot p\cdot\left[1-\left(\frac{p10}{p}\right)^2\right]}$$

$$k5 = 2.477\cdot10^{-7}$$

MP D

$$k6 := \frac{q\cdot\mu\cdot\ln\left(\frac{w}{r6}\right)}{h\cdot\pi\cdot p\cdot\left[1-\left(\frac{p12}{p}\right)^2\right]}$$

$$k6 = 2.794\cdot10^{-7}$$

APPENDIX C

TARGET ENVIRONMENTAL SERVICES
SVE Pilot Test

Project code: MXCL

The following equations predict the flow rate and vacuum levels that would be seen from an extraction well of with a different screen length and bore radius than the pilot test well. This data can be used in sizing a pump for the particular well geometry that would be used in a full scale SVE remediation system. Again this method comes from the reference cited on the previous page.

$A1 := .001871$ $\quad A2 := .00007270475$ Constants derived from the pilot test data.

$h1 := 7.5$ Length of the pilot test well screen in feet.

$r1 := .25$ Radius of the pilot test well bore in feet.

$r2 := 35$ Radius of influence.

$$A := \frac{A1 \cdot 2 \cdot \pi \cdot h1}{\ln\left(\frac{r2}{r1}\right)} \qquad B := \frac{A2 \cdot (2 \cdot \pi)^2 \cdot h1^2}{\left(\frac{1}{r1} - \frac{1}{r2}\right)}$$

$A = 0.018$ $\quad B = 0.041$ Constants derived based on the pilot test data.

$h2 := 12$ New well screen length in feet.

$r11 := .5$ New well bore radius in feet.

$$A3 := \frac{A \cdot \ln\left(\frac{r2}{r11}\right)}{2 \cdot \pi \cdot h2} \qquad A4 := \frac{B \cdot \left(\frac{1}{r11} - \frac{1}{r2}\right)}{(2 \cdot \pi)^2 \cdot h2^2}$$

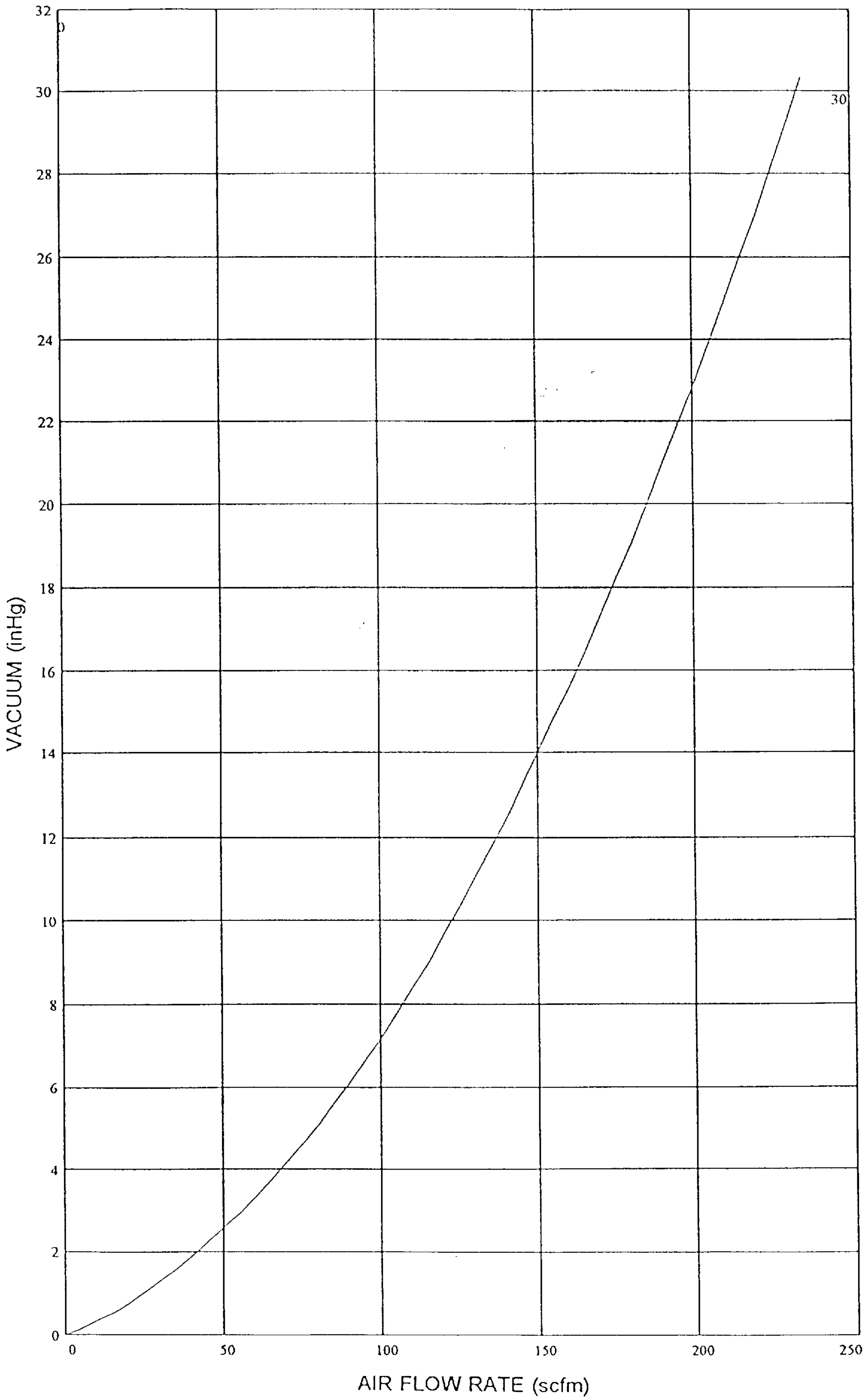
$A3 = 0.001$ $\quad A4 = 1.41 \cdot 10^{-5}$ Constants derived based on the new extraction well geometry.

$j := 0, 5 .. 235$

$Q1_j := j$

$P1_j := \left[Q1_j \cdot A3 + \left(Q1_j\right)^2 \cdot A4\right] \cdot 29.92$

PERFORMANCE CURVE FOR ALTERNATE EXTRACTION WELL GEOMETRY



TARGET ENVIRONMENTAL SERVICES INC.
SVE Pilot Test

Project Code: MXCL

The following equaitons extrapolate the pilot scale data to predict the vacuum levels that will be seen at higher flow rates, from the pilot test extraction well. The method can be found in:

A.N. Clarke, M.M. Megehee, and D.J. Wilson, "Soil Cleanup by In Situ Aeration. XII. Effect of Departures from Darcy's Law on Soil Vapor Extraction", Separation Science Technology, 28, 1678, (1993).

$i := 1..3$

$Q_i :=$ Flow rates in scfm. $P_i :=$ Corresponding wellhead vacuums in atmospheres.

Q_i	P_i
7.9	.0434
16.3	.027
25.1	.1

The following calculations use the method of least squares to determine the coefficients A_1 and A_2 in the equation: $P_{well} = A_1 Q + A_2 Q^2$ (1)

$U := \sum_i (Q_i)^2$ $V := \sum_i (Q_i)^3$ $W := \sum_i (Q_i)^4$

$U = 958.11$ $V = 2.064 \cdot 10^4$ $W = 4.714 \cdot 10^5$

$X := \sum_i P_i \cdot Q_i$ $Y := \sum_i (Q_i)^2 \cdot P_i$

$X = 3.29296$ $Y = 72.883$

$D := \begin{pmatrix} U & V \\ V & W \end{pmatrix}$ $E := \begin{pmatrix} X & V \\ Y & W \end{pmatrix}$ $F := \begin{pmatrix} U & X \\ V & Y \end{pmatrix}$

$|D| = 2.576 \cdot 10^7$ $|E| = 4.82 \cdot 10^4$ $|F| = 1.873 \cdot 10^3$

$A_1 := |E| \cdot (|D|)^{-1}$ $A_2 := |F| \cdot (|D|)^{-1}$

$A_1 = 0.002$ $A_2 = 7.27 \cdot 10^{-5}$

The following graph shows an extrapolation of the pilot scale data based on equation (1).

$j := 0, 5 .. 105$

$Q1_j := j$

$P1_j := \left[Q1_j \cdot A_1 + (Q1_j)^2 \cdot A_2 \right] \cdot 29.92$

The expressions above establish the domain and the range for the following gragh.

SYSTEM HEAD CURVE