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Environmental Restoration Program



FINAL
Extended Aquifer Air Sparging/Soil Vapor
Extraction Treatability Study for
Site SS59 (WP-21)
Dover Air Force Base
Dover, Delaware

July 1995

AQM01-01-0365

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FINAL
EXTENDED AQUIFER AIR SPARGING/SOIL VAPOR EXTRACTION
TREATABILITY STUDY
FOR
SITE SS59 (WP-21) - DOVER AIR FORCE BASE
DOVER, DELAWARE

Prepared for

United States Department of the Air Force
Dover Air Force Base
436 Support Group/CEV
Dover, Delaware 19902-6600

Prepared by

EA Engineering, Science, and Technology, Inc.
Two Oak Way
Berkeley Heights, New Jersey 07922

July 1995

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LIST OF ACRONYMS AND ABBREVIATIONS

AAS	Aquifer Air Sparging
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
cfm	cubic feet per minute
COC	Compound of Concern
DAFB	Dover Air Force Base
DCA	Dichloroethane
(c-,t-) DCE	(cis-1,2- or trans-1,2-) Dichloroethene
DMW	Deep Monitoring Well
DNREC	(Delaware) Department of Natural Resources and Environmental Control
DO	Dissolved Oxygen
DOD	Department of Defense
ECD	Electron Capture Detector
FID	Flame Ionization Detector
FS	Feasibility Study
ft	feet
GAC	Granular Activated Carbon
GC	Gas Chromatograph
HAP	Hazardous Air Pollutant
IR Program	Installation Restoration Program
PCE	Perchloroethylene
POTW	Publicly-Owned Treatment Works
ppb	parts per billion
ppm	parts per million (mass per volume)
ppm _v	parts per million (volume per volume)
psi	pounds per square inch
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
R.I.	Radius Of Influence
SF ₆	Sulfur Hexafluoride
SMW	Shallow Monitoring Well
SVE	Soil Vapor Extraction
TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
UIC	Underground Injection Control
v/v	volume per volume (units of measurement)
VMW	Vadose Monitoring Well
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
(-#)P	(well series designation (in area #) if aligned perpendicular to ground-water flow)

EXECUTIVE SUMMARY

Site SS59 at Dover Air Force Base, Delaware is under investigation for the remediation of ground water which was contaminated by a system of industrial waste basins operated to the north of this area and maintenance activities associated with the Paint Washout Area. The secondary basins of this system were closed in 1986 under RCRA. The primary chemicals of concern at Site SS59 include chlorinated-VOCs (e.g., DCE, TCE, TCA) and hydrocarbon compounds (e.g., BTEX). As part of the Department of Defense Installation Restoration Program, a Feasibility Study was completed for the site in September of 1994 by EA Engineering, Science, and Technology. Remedial Actions at Site SS59 will be addressed as part of the Area 6 investigation at Dover Air Force Base.

An initial series of pilot Aquifer Air Sparging/Soil Vapor Extraction (AAS/SVE) studies were conducted in two test areas at Site SS59 from July to November 1993 by EA in order to assess the viability of this technology for removing the primary chemicals of concern. It was determined from these studies that the effective radius of influence (ROI) of an AAS system at Site SS59 was approximately 45 ft. The ROI is indicative of the distance from the sparge well where air channels are of sufficient density that air flow through them will affect the saturated zone.

With respect to the need to initiate active remediation at the site, the AAS/SVE system was modified, and permanent hardware was installed, for utilization as an interim remedial action at Site SS59. However, the system was not designed to remediate the full site, rather mainly to further investigate the feasibility of an AAS/SVE system at Site SS59. In addition to monitoring system operational parameters for the interim remedial action, an extended pilot AAS/SVE study was conducted from June 1994 to January 1995 in both test areas of the site. This report contains a discussion of the feasibility of a full-scale AAS/SVE system at Site SS59 based upon the results of this extended study. The existing system is not intended to achieve the remedial goals for Site SS59. After the completion of the extended study, the AAS/SVE system remained in operation in both test areas as part of the remedial program for ground water at Site SS59.

In order to verify the ROI from the initial treatability studies, a tracer gas study also was conducted in Test Area 1 during the extended pilot test. The tracer gas study (which employed a mixture of air and gaseous sulfur hexafluoride injected into the saturated zone) was conducted over a two day period at injection flow rates of 4.0 and 8.4 scfm. The observed soil gas SF₆ concentrations suggested a slight influence due to AAS up to 45 ft in the shallow zone of the aquifer (7 to 17 ft bgs) and up to 45 ft in the deep zone (31 to 36 ft bgs). The observed ground-water SF₆ concentrations suggested a minimal influence due to AAS. The observed differential pressure data indicated a positive influence (≥ 0.1 inches of water) due to AAS up to 75 ft in the shallow zone with little or no effect in the deep zone. Increasing the flow rate into the AAS well did not appear to extend the ROI. Based upon the tracer gas data, the AAS system in Test Area 1 appeared to have some influence on the aquifer up to 45 ft from the point of injection (primarily in the shallow zone) but, since the observed SF₆ concentrations were far lower than anticipated, the degree of this influence did not appear to be substantial.

During the extended study, the SVE system was highly efficient for removing vapor-phase COCs from the vadose zone. An overall 99.4% reduction in the total vapor-phase VOC concentrations was affected (the average level decreased from 21.723 ppm_v to 0.126 ppm_v) in the vadose zone within Test Areas 1 and 2. Soil gas concentrations decreased in all of the monitoring points within the 45 ft ROI.

Over both test areas, ground-water VOC concentrations decreased in approximately 36% of the monitoring wells, increased in 52%, and remained the same in about 12% of the monitoring wells over the duration of the study. The increase of ground-water concentrations which was observed appears to indicate that contaminants were being mobilized due to AAS. These increases were related to the mechanisms of contaminant removal (i.e., mobilization processes such as desorption from subsurface soils) and represented a beneficial and expected effect of the AAS system. Mobilization of the COCs (and the subsequent increase in ground-water concentrations) would be a necessary first step for remediation with AAS/SVE. Once transferred into an aqueous phase, the contaminants could then be transported to, and extracted from, the vadose zone.

A time-weighted average of 0.05 lb/d of the primary COCs was observed in the offgas of the AAS/SVE system, although a peak of 0.54 lb/d was observed during one of the sampling events. Due to this low average mass removal rate, the AAS system was less effective than expected for volatilizing the contaminants present in the saturated zone. This appears to have been the result of flow channeling within the aquifer. The higher mass removal rate was observed following a six day period of non-operation and may be attributed to the mobilization of a zone of higher concentration of VOCs, or it may be attributed, in part, to the beneficial effects of system "pulsing". The lack of pulsing during operation of an AAS/SVE system, as supported in the literature, tends to lead to the formation of stable flow channels and reduced air/contaminant interaction.

A total of 19.1 lbs of the primary COCs were removed during the initial (8.9 lbs) and extended (10.2 lbs) treatability studies at Site SS59. Offgas emissions from the SVE system were treated with GAC prior to ventilation to the atmosphere. VOC concentrations in the emissions from the system (ranging from non-detect to 0.1 lb/d) did not exceed DNREC criteria (2.4 lb/d).

Based upon the results of the extended pilot test, it appears that, quantitatively, the existing AAS/SVE system had a positive effect within the 45 ft ROI with respect to approaching remedial goals at Site SS59. However, in a qualitative sense, the degree of this effect (e.g., the observed removal rate, the extent of flow channeling and the SF₆ concentrations found in groundwater) appears to be insufficient for the efficient remediation of the relatively low VOC concentrations at the site. In light of the Area 6 investigations at DAFB, other remedial alternatives will be implemented on an interim basis at the site. Intrinsic bioremediation will be evaluated to determine its viability for Site SS59. If intrinsic bioremediation addresses the low concentrations of ground-water contamination no other active remediation will occur. Therefore, it is recommended that the existing AAS/SVE system should not be expanded to a full-scale remedial action for the site.

1. INTRODUCTION

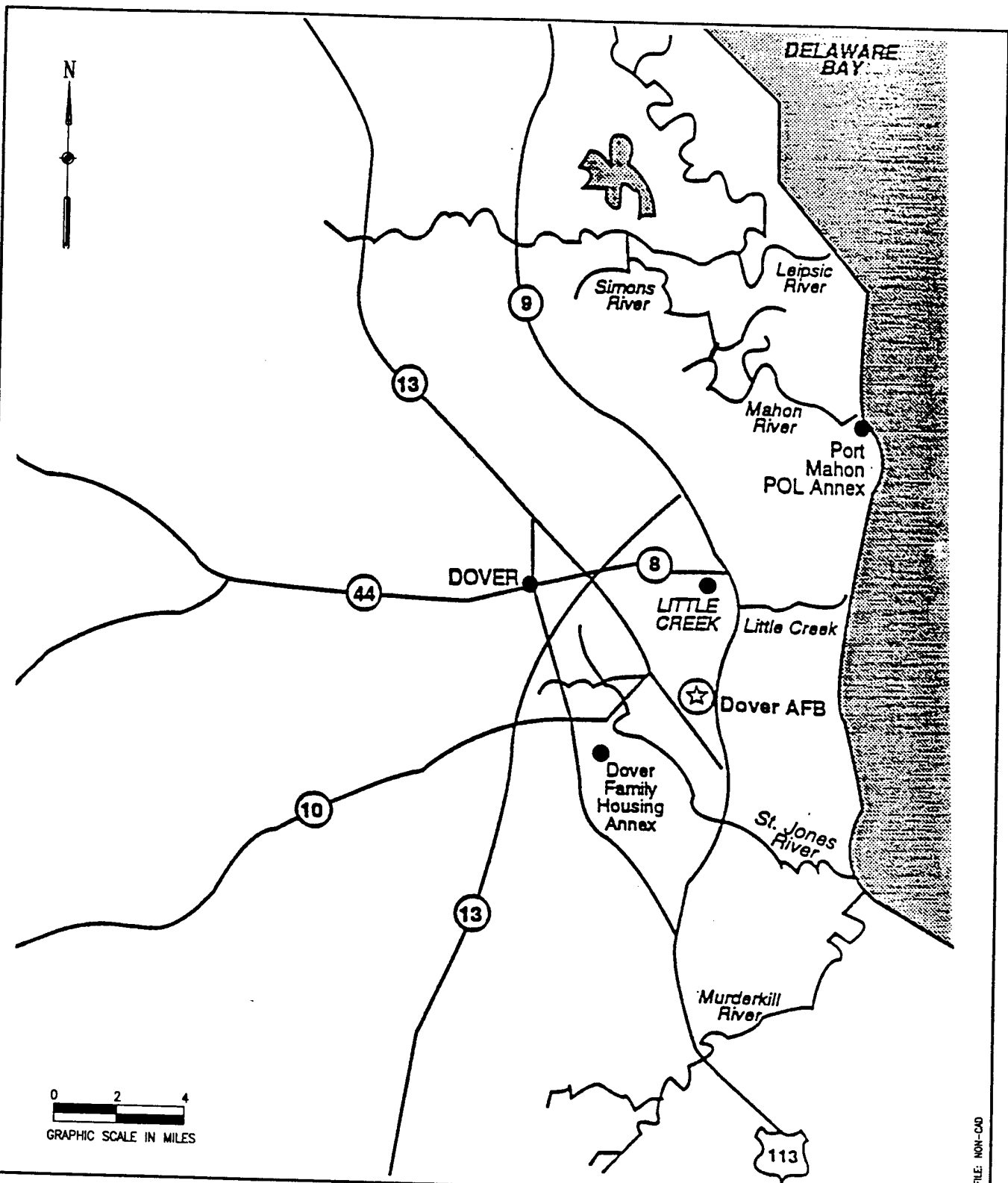
1.1 BACKGROUND

Dover Air Force Base (DAFB) is located next to the city of Dover in Kent County, Delaware (Figure 1-1). The installation encompasses approximately 4,000 acres of land including annexes, easements, and leased properties. Site SS59 at DAFB (Figure 1-2) is under investigation for the remediation of ground water which was contaminated by a system of industrial waste basins (Site WP-21) operated to the north of this area and the maintenance activities at the Paint Washout Area. The secondary basins of this system were closed in 1986 under RCRA. The primary Compounds of Concern (COCs) at Site SS59 include chlorinated-Volatile Organic Compounds (VOCs) (e.g., DCE, TCE, TCA) and hydrocarbons (e.g., BTEX). As part of the Department of Defense (DOD) Installation Restoration (IR) Program, a Feasibility Study (FS) was completed for the site in September of 1994 (EA, 1994a). Remedial Actions at Site SS59 will be addressed as part of the proposed plan for the Area 6 investigation at DAFB.

The study area is part of the larger study currently being conducted under the basewide RI/FS program at DAFB. Subsequent to the completion of the Feasibility Study Report for Site WP-21 (EA, 1994a) the area comprising Site WP-21 was redefined. Site WP-21 as a whole is located within Area 6 of the IR Program. It was divided into the former industrial basins (Site WP-21) and the area south of the maintenance area fence (Site SS59) (Figure 1-2a). The combined areas are located within what has been defined as Target Area 1 (the areas associated with shallow chlorinated solvent sources and the most significant portions of the associated plumes). The Treatability Study (EA, 1994b) previously conducted as part of the Site WP-21 FS, and the information reported in this document, have been performed in the area now designated as Site SS59. No further action, other than long-term monitoring, is being taken at Site WP-21.

1.2 OBJECTIVES

Site SS59 at DAFB has been identified as containing COCs, consisting primarily of VOCs, which exceed the regulated limits established by the State of Delaware. The FS for Site WP-21 (EA, 1994a) identified the *in-situ* technology of Aquifer Air Sparging/Soil Vapor Extraction (AAS/SVE) as an applicable technology for the remediation of ground water. A series of short-term treatability studies were performed in two test areas at Site SS59 from July to October 1993 (EA, 1994b) in order to evaluate the feasibility and effectiveness of the AAS and SVE systems to remove VOCs from the vadose and saturated zone beneath the site, and to establish the design criteria necessary for the potential design and implementation of a full scale AAS/SVE system at the site. The tests in each of the test areas included a 36-hour pilot test for each AAS (only) and SVE (only) system preceding a 12-day, combined, AAS/SVE system pilot test. Sampling consisted of VOCs in soil, ground water, and soil gas, differential pressures at the individual monitoring points, dissolved oxygen and CO₂ in ground water, and system operational parameters such as injection flow rate, injection pressure, offgas VOCs, and offgas temperature and CO₂ content. It was determined from this study that the effective



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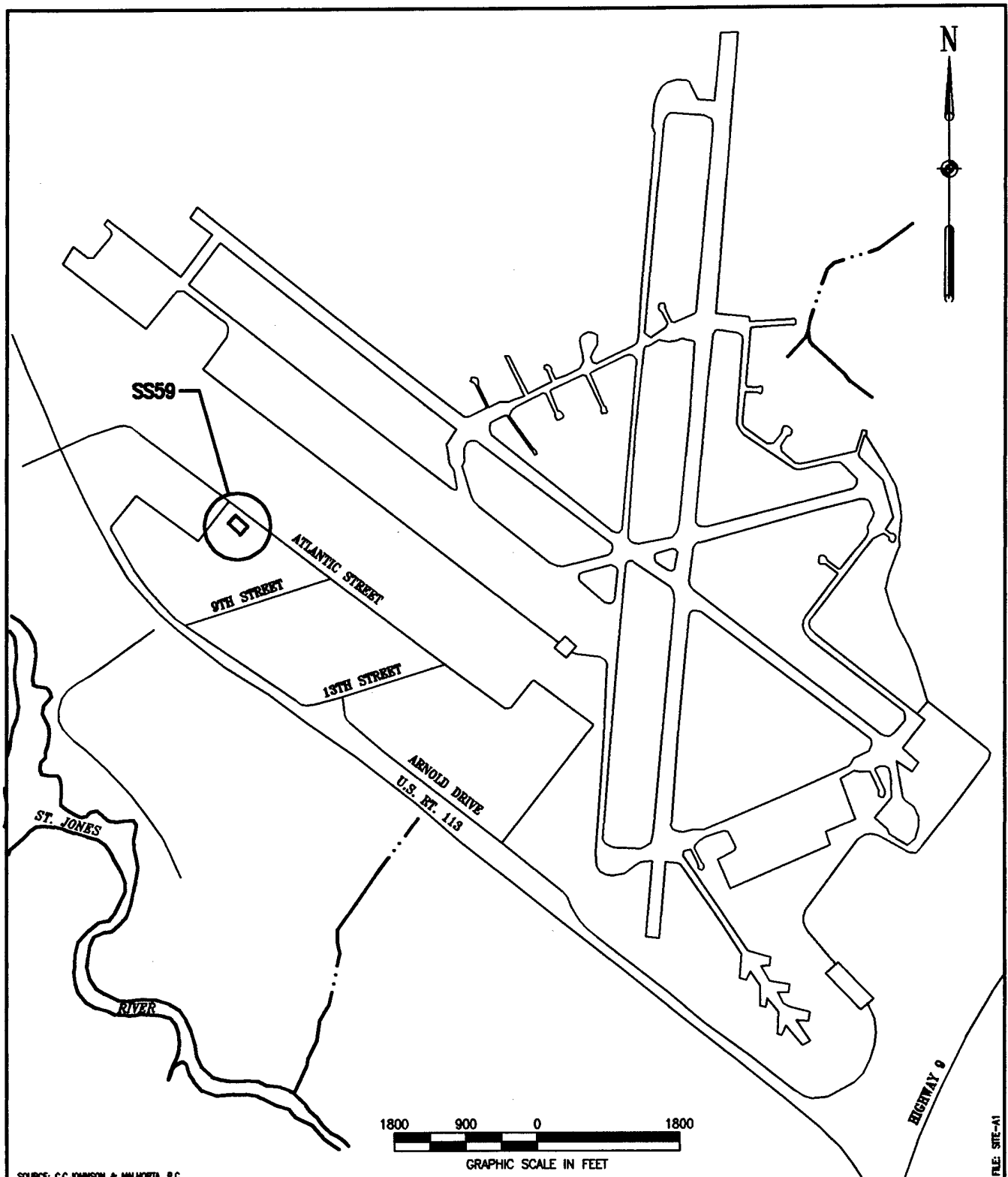


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DOVER AIR FORCE BASE
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LOCATION MAP

PROJECT MGR TRH	DESIGNED BY JDR	DRAWN BY MNJ	CHECKED BY JDR	SCALE SHOWN	DATE 2-16-95	PROJECT NO 60378.26	FIGURE 1-1



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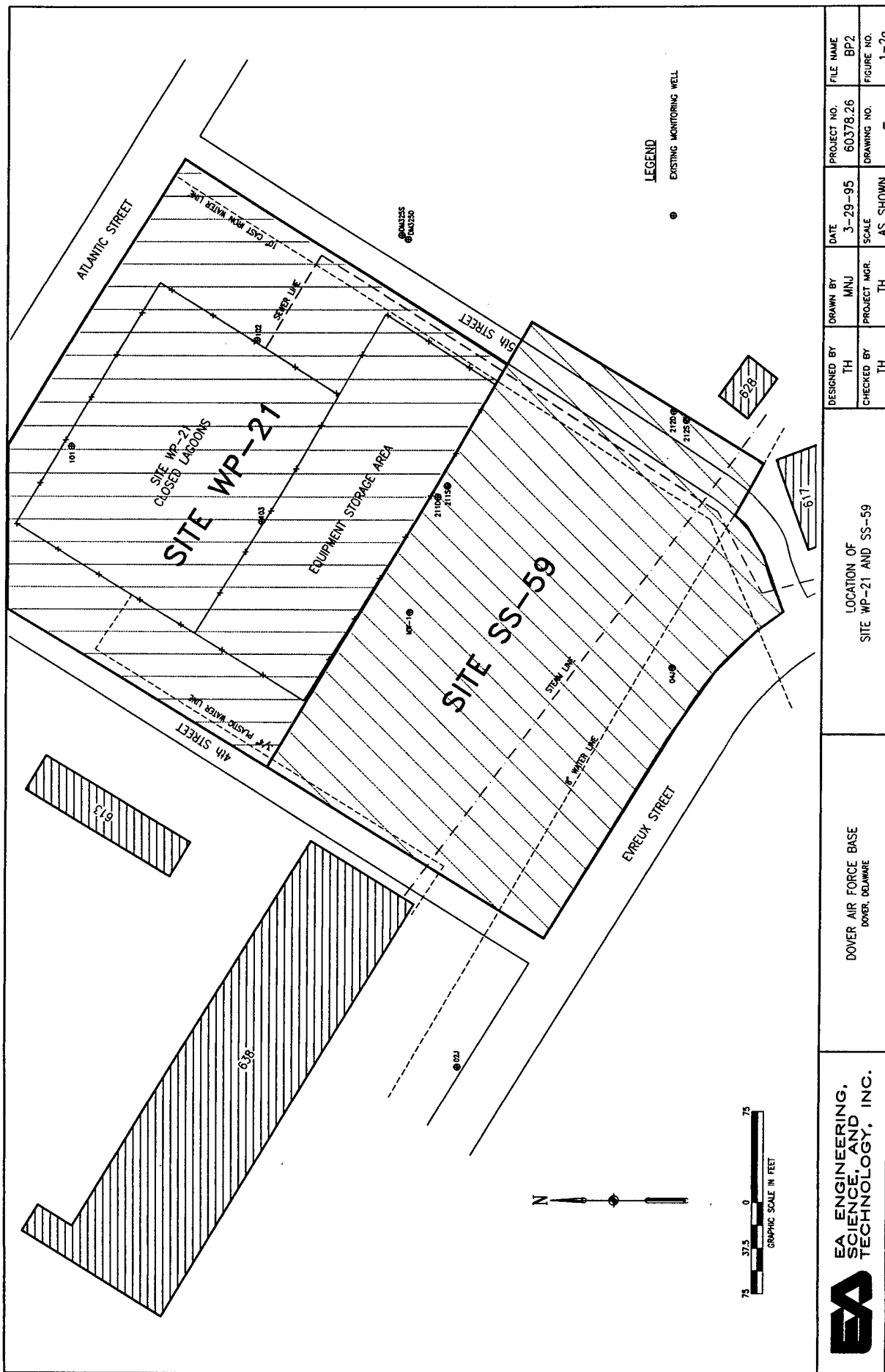


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SS59 SITE LOCATION MAP

PROJECT MGR TRH	DESIGNED BY GTC	DRAWN BY MSM	CHECKED BY JDR	SCALE 1"=1800'	DATE 3-23-95	PROJECT NO 60378.26	FIGURE 1-2



EA EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		LOCATION OF SITE WP-21 AND SS-59		DESIGNED BY TH	DRAWN BY MNU	DATE 3-29-95	PROJECT NO. 60378.26	FILE NAME BP2
					CHECKED BY TH	PROJECT MGR. TH	SCALE AS SHOWN	DRAWING NO. -	FIGURE NO. 1-2a

Radius of Influence (ROI) of an AAS system at Site SS59 was approximately 45 ft. As a result of this study, AAS/SVE was determined to be feasible for this site.

Based upon the need to initiate active remediation, the AAS/SVE system was modified, and permanent hardware was installed, for utilization as a limited interim remedial action for Site SS59. The system was not designed to remediate the full study area, rather, mainly to further investigate the feasibility of an AAS/SVE system at the site. In addition to monitoring system operational parameters and differential pressures for this interim remedial action, an extended pilot study was conducted between June 1994 and January 1995. This included monitoring offgas VOC concentrations during fourteen sampling events and ground-water VOC concentrations during three sampling events (pre-, mid-, and post-test). This report presents a discussion of the results obtained from this extended study.

Additionally, in order to verify the ROI determined from the initial treatability studies, a tracer gas study was conducted in Test Area 1 during the extended pilot test. The results of this study are included as Appendix A in this report.

1.3 GEOLOGY AND HYDROGEOLOGY

Information regarding the overburden geology at Site SS59 was obtained during the installation of the series of monitoring wells designed for the RCRA ground-water monitoring programs and the pilot AAS/SVE study. Site SS59 predominantly consists of the fine to medium grained sands of the Columbia Formation. Previous data suggests that the site is underlain by 40 ft of coarsening sand with discontinuous lenses of silt and fine sand. A possible channel lag deposit containing rip-up casts of clay and rock fragments was detected from 17 to 20 ft in the boring for well 211-D. No continuous clay layer was detected under the site. Discontinuous clay lenses are known to occur in the Columbia Formation (Bachman, 1984).

The Kirkwood Formation of the Chesapeake Group directly underlies the Columbia Formation and serves as the aquitard at the base of the unconfined aquifer. It consists of a stiff, dark gray, silty clay ranging from 18 to 28 ft thick. Paleotopography with up to 50 ft relief was developed on the surface of the Kirkwood formation during deposition of the Columbia sediments. This paleotopography exerts localized control over the ground-water flow direction in the overlying Columbia aquifer.

The Frederica aquifer underlies the Kirkwood Formation. It consists of silty sands with relatively low permeability and water yields. The Frederica aquifer is underlain by 60 to 70 ft of silty sand which serves as an aquitard and overlies the Cheswold Aquifer which is one of the primary water supply aquifers in the Dover area.

The average depth to ground water at the site is nominally 11 ft below grade but varies seasonally. During periods of a low water table, ground-water flow at DAFB is towards the south. The flow direction changes to the southeast during periods of elevated ground water. Baseflow discharge to downgradient surface water drainage ditches may occur at this time. Ground-water flow for Site SS59 is to the south. Evidence from wells which were drilled in

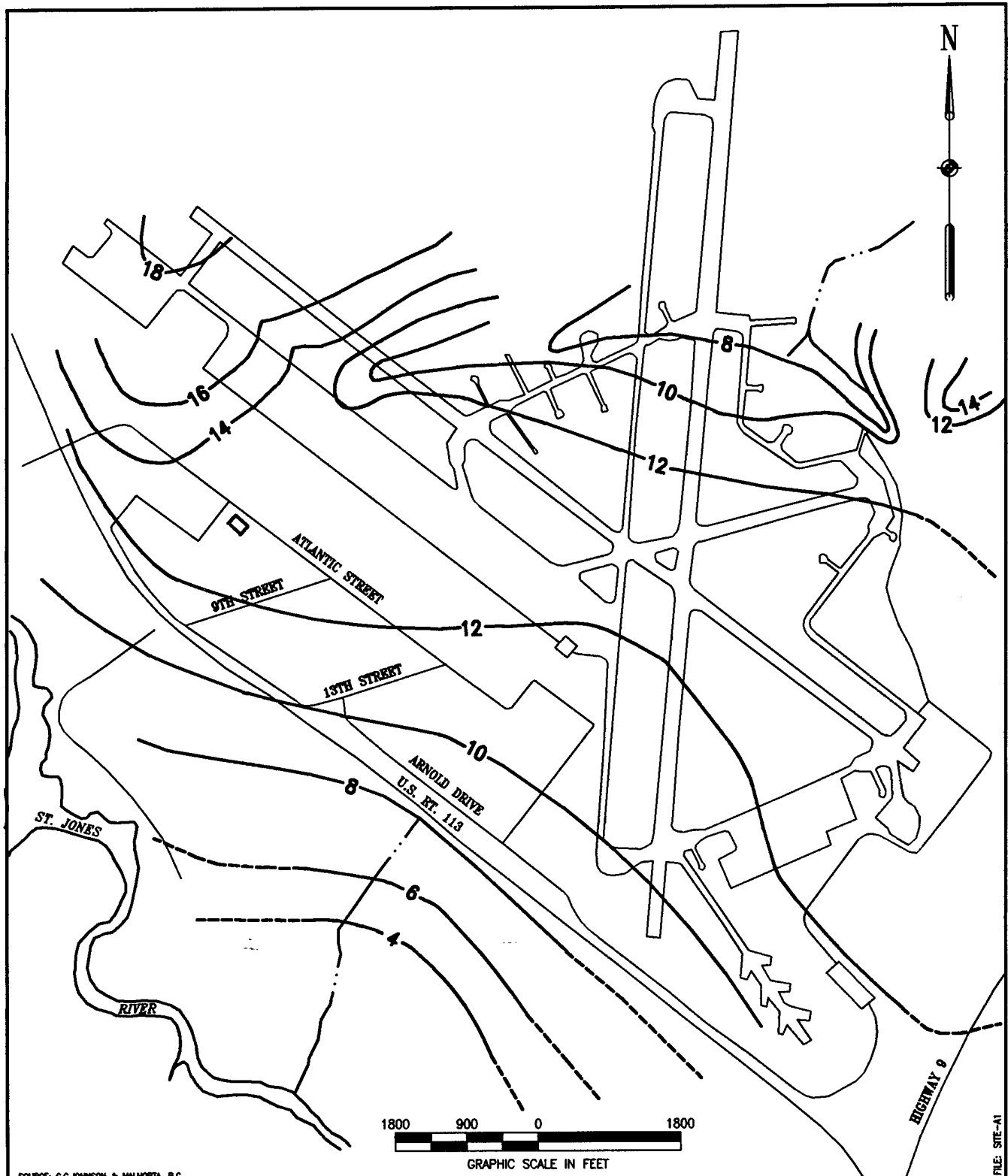
1990 suggest that a paleotopographic trough in the surface of the Kirkwood Formation may direct subsurface flow within the deeper portions of the Columbia aquifer beneath the site (HAZWRAP, 1990). The trough is aligned north to south and the site is located over the central axis which plunges to the south. This feature may help to channelize flow during low water conditions towards the south and have less of an effect during high water conditions when the water table "floods" the underlying paleotopography.

The saturated thickness of the Columbia aquifer ranges from 15 to 20 ft in the western portion of the base to 70 ft in the eastern portion. Hydraulic conductivities derived from previous, basewide, pump-test data range from 55 to 150 ft/day. The average hydraulic gradient is 0.001 but may vary with seasonal recharge. Assuming 30% porosity in the sediments, the ground-water flow velocity within the Columbia aquifer ranges from 67 to 182 ft/yr. Figure 1-3 shows the general ground-water flow patterns within the Columbia aquifer at DAFB. A ground-water flow divide is present in this aquifer, trending NW-SE, underlying the main runway trending in the same direction. Ground water to the northeast of the divide discharges into the St. Jones River. Although capable of producing low yields which would be suitable for domestic or light commercial use, the Columbia aquifer is not currently being used for this purpose at or near DAFB.

In May of 1993, twelve soil borings were installed using hollow-stem auger methods to the top of the Kirkwood (EA, 1994b). Total depths ranged from 38 to 52 ft below grade. The borings were installed immediately downgradient of the closed basins on a grid system in three rows, with adjustments for buried utilities (Figure 1-4). Borings B-1 through B-4 were positioned approximately 125 ft downgradient of the closed lagoons to the north of Site SS59. The second row of borings, B-5 through B-8, were positioned approximately 125 ft further downgradient. The third row of borings, B-9 through B-11 were positioned approximately 175 ft downgradient of the second row. Due to existing utilities, boring B-12 was repositioned between borings B-7 and B-8. The distance between borings in each row was approximately 110 ft.

Stratigraphic cross-sections were constructed using the soil boring data (Figures 1-5 to 1-8). The cross-sections were developed by correlating similar lithologies, as described in the soil logs, between boreholes. Soil types displayed between boreholes are therefore interpretive and based upon an evaluation of the available data. The correlation decision process was guided by the need to select the best stratigraphic location (i.e., the least amount of clay and silt) for the treatment system.

The stratigraphic data indicates that the site is underlain primarily by fine to coarse sand, interbedded with laterally-discontinuous lenses of silty sand and silty clay. In general, the formation coarsens downward. Silts and fine-grained sands were found predominantly above the water table in borings B-9, B-10, and B-11. The most significant clay layer (approximately 1 to 3 ft thick) was found 4 to 6 ft below grade in borings B-3, B-4, and B-7 in the northeast portion of the site. The clay lenses observed throughout the remainder of the site are situated below the water table and are generally only several inches thick. Thin (< 1 foot thick), discontinuous clay lenses were found below the water table in borings B-5, B-9, and B-10.



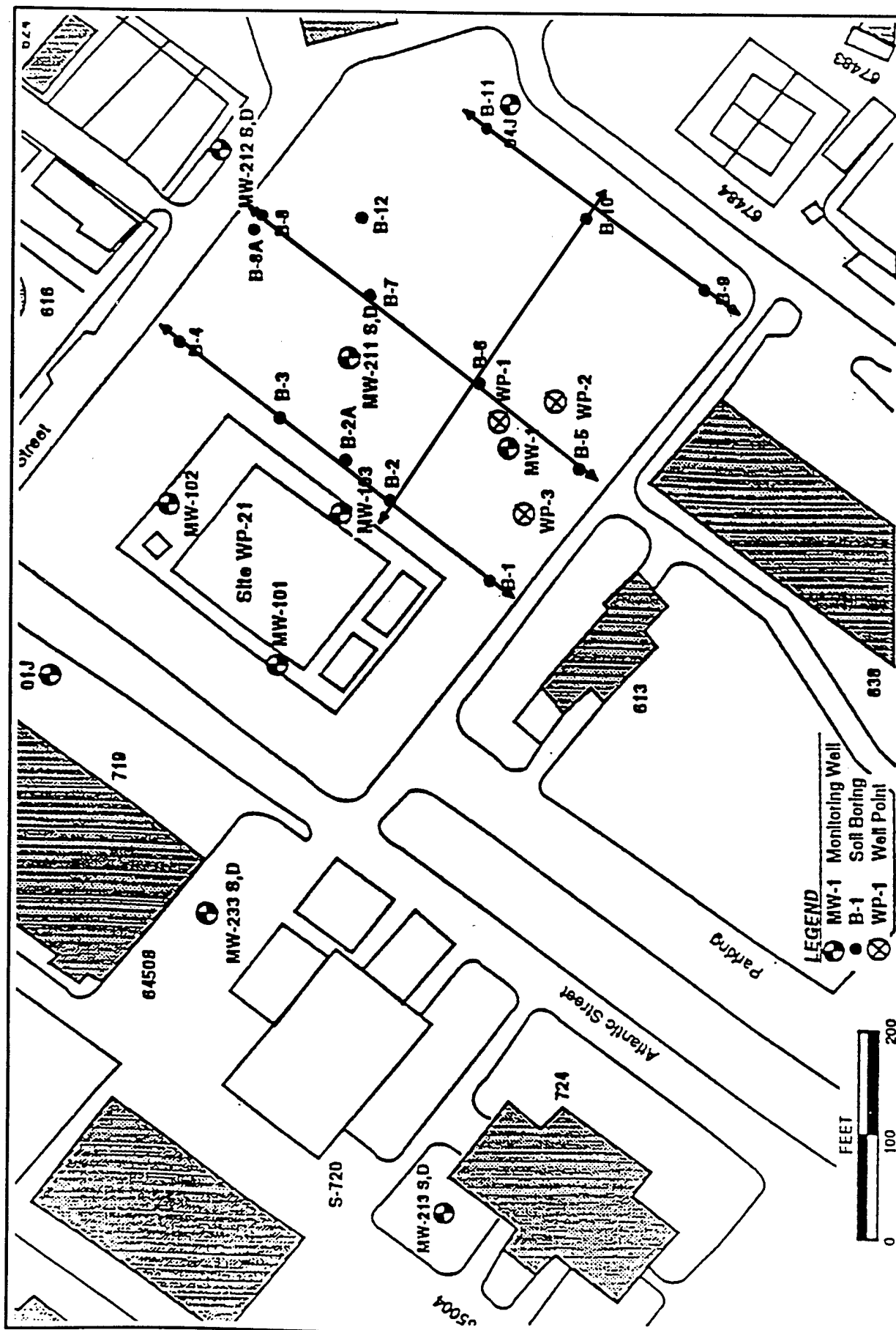
EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY, INC.

DOVER AIR FORCE BASE
DOVER, DELAWARE

SHALLOW GROUND-WATER
CONTOURS
COLUMBIA AQUIFER
DECEMBER 1989

PROJECT MGR TRH	DESIGNED BY GTC	DRAWN BY MSM	CHECKED BY JDR	SCALE 1"=1800'	DATE 3-16-95	PROJECT NO 60378.26	FIGURE 1-3

FILE: SITE-A1



EA
 EA ENGINEERING,
 SCIENCE, AND
 TECHNOLOGY, INC.

DOVER AIR FORCE BASE
 DOVER, DELAWARE

SOIL BORING
 LOCATIONS (MAY 1993)
 AT SITE WP-21

DESIGNED BY
 AC

DRAWN BY
 MNJ

DATE
 3-30-95

PROJECT NO.
 60378.26

CHECKED BY
 TRH

PROJECT MGR.
 TRH

SCALE
 1"=200'

FIGURE
 1-4

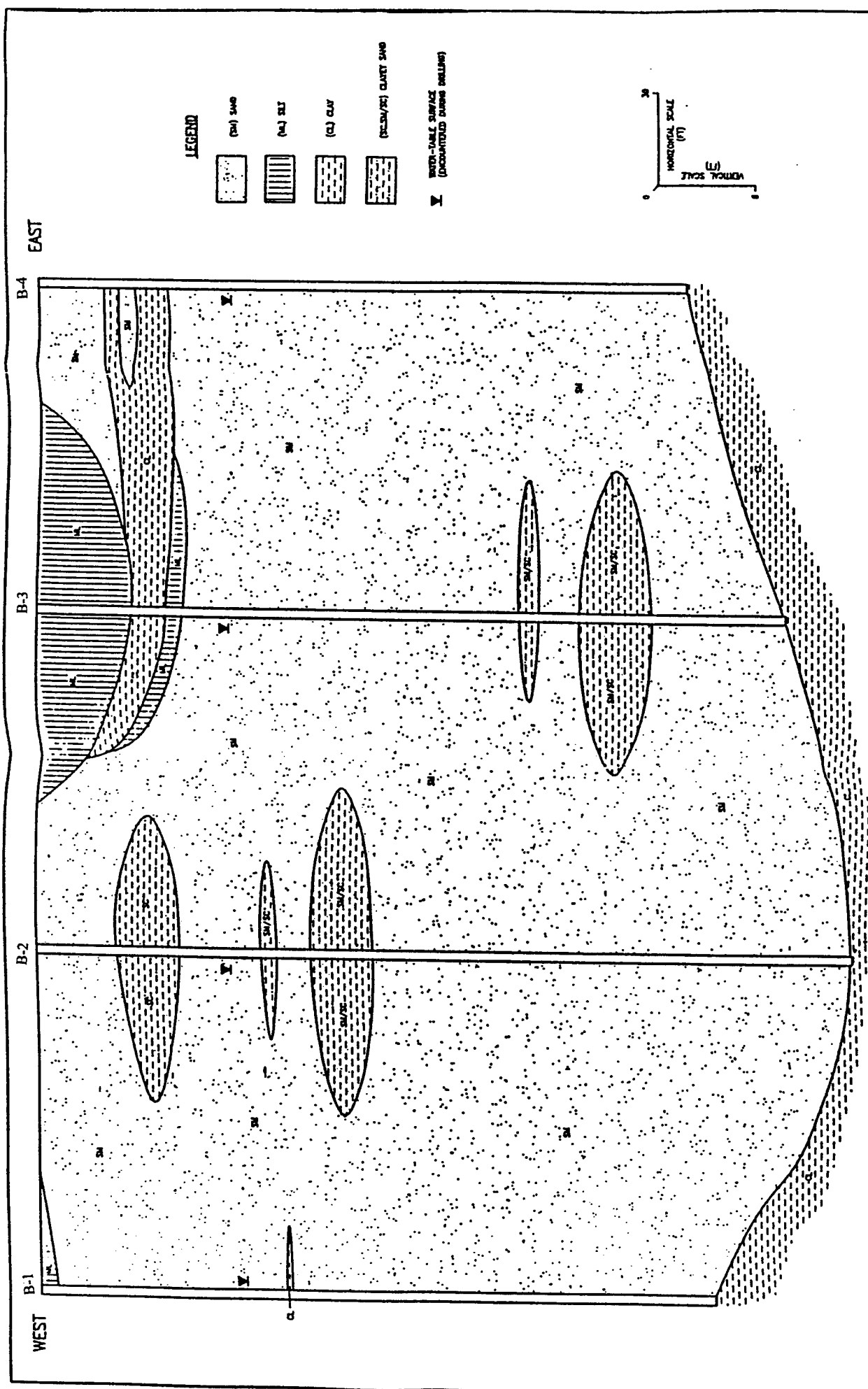


Figure 1-5 Generalized West-East Geologic Cross-Section, Borings B-1 to B-4

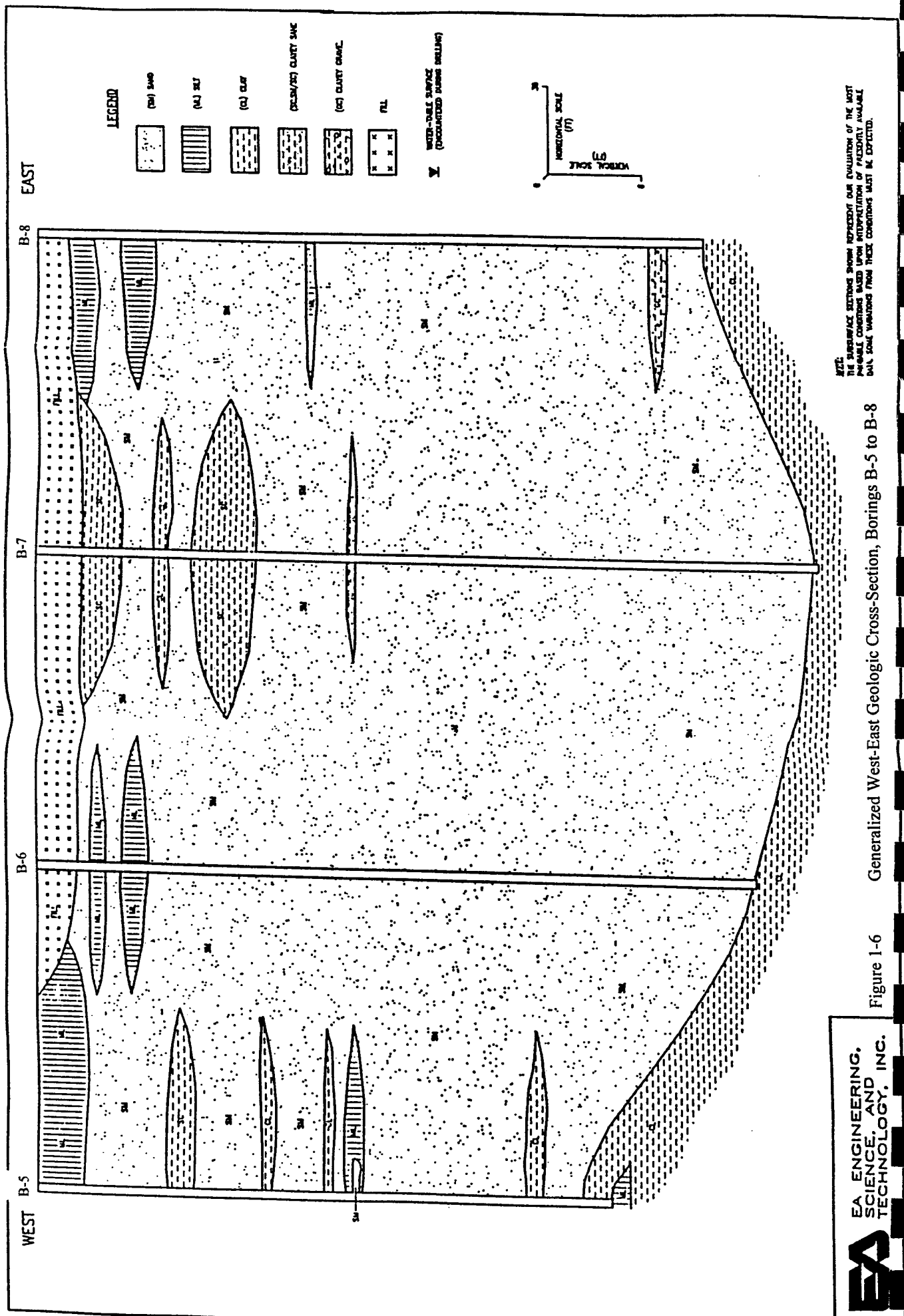
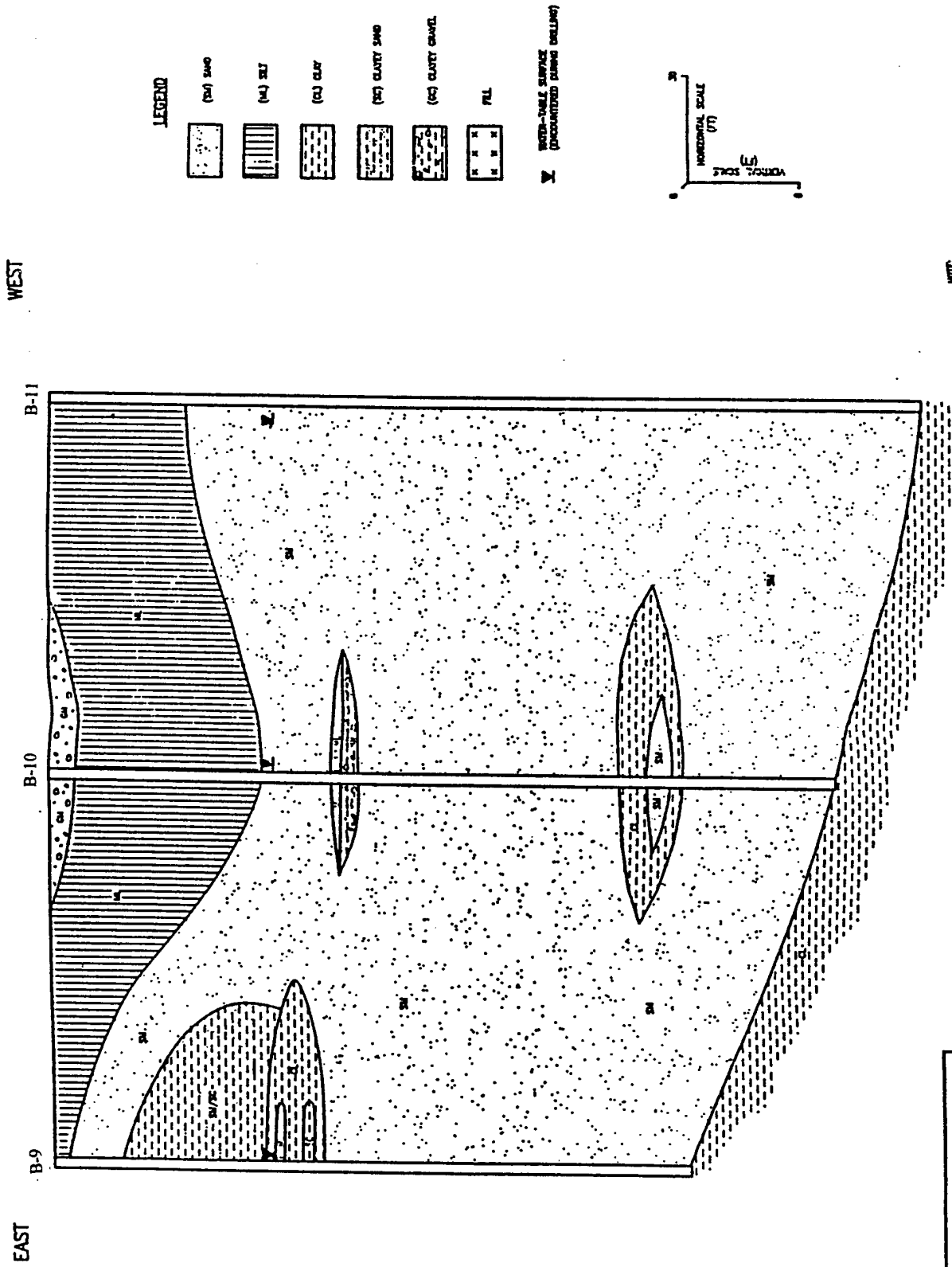


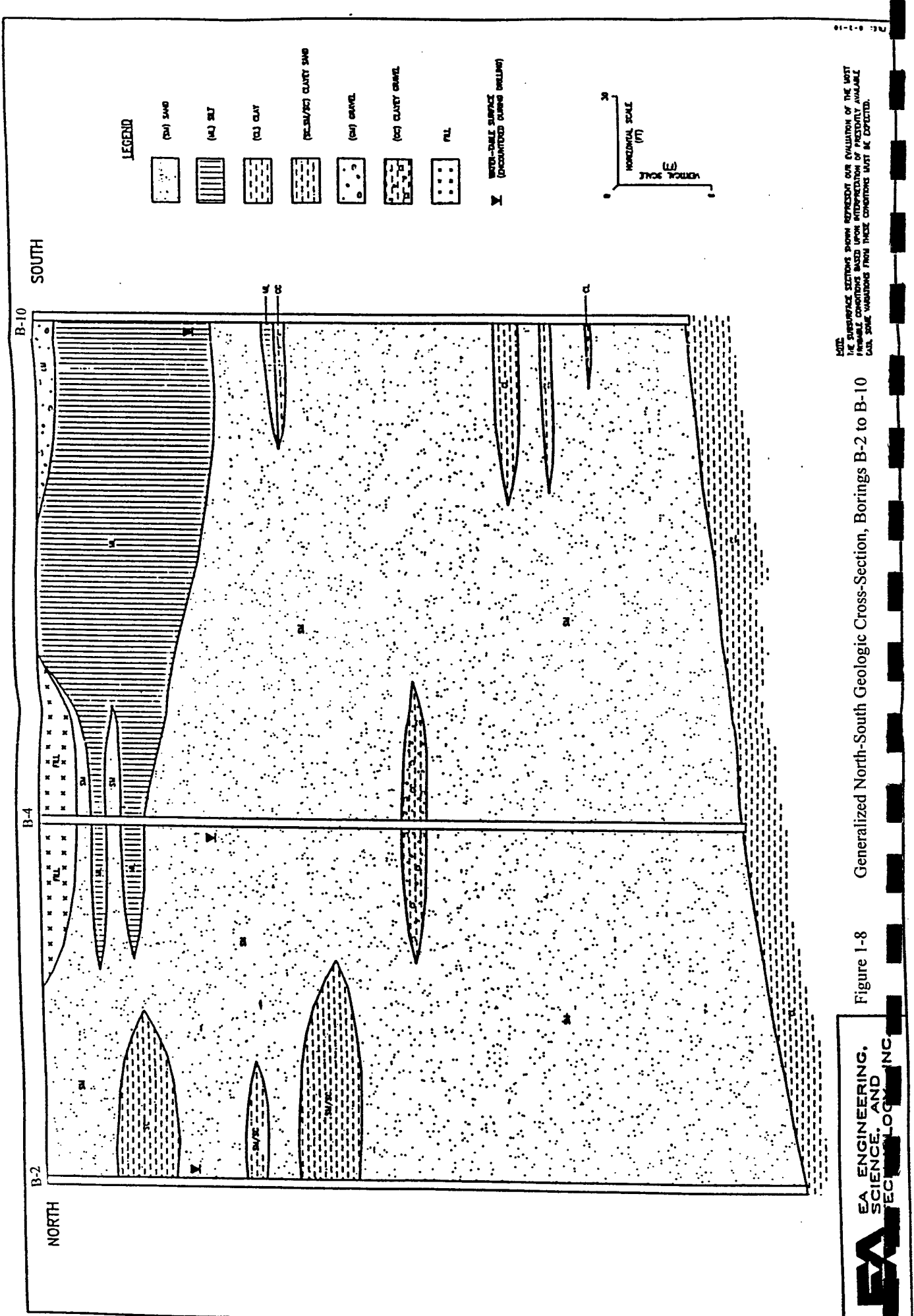
Figure 1-6 Generalized West-East Geologic Cross-Section, Borings B-5 to B-8



NOTE:
 SURFACE SECTIONS SHOWN REPRESENT AN EVALUATION OF THE DATA
 THE DATA COULD BE DIFFERENT UPON FURTHER INVESTIGATION.
 FROM SOME DRILLING FROM THESE CONDITIONS MUST BE EXPECTED.

**EA ENGINEERING,
 SCIENCE, AND
 TECHNOLOGY, INC.**

Figure 1-7 Generalized West-East Geologic Cross-Section, Borings B-9 to B-11

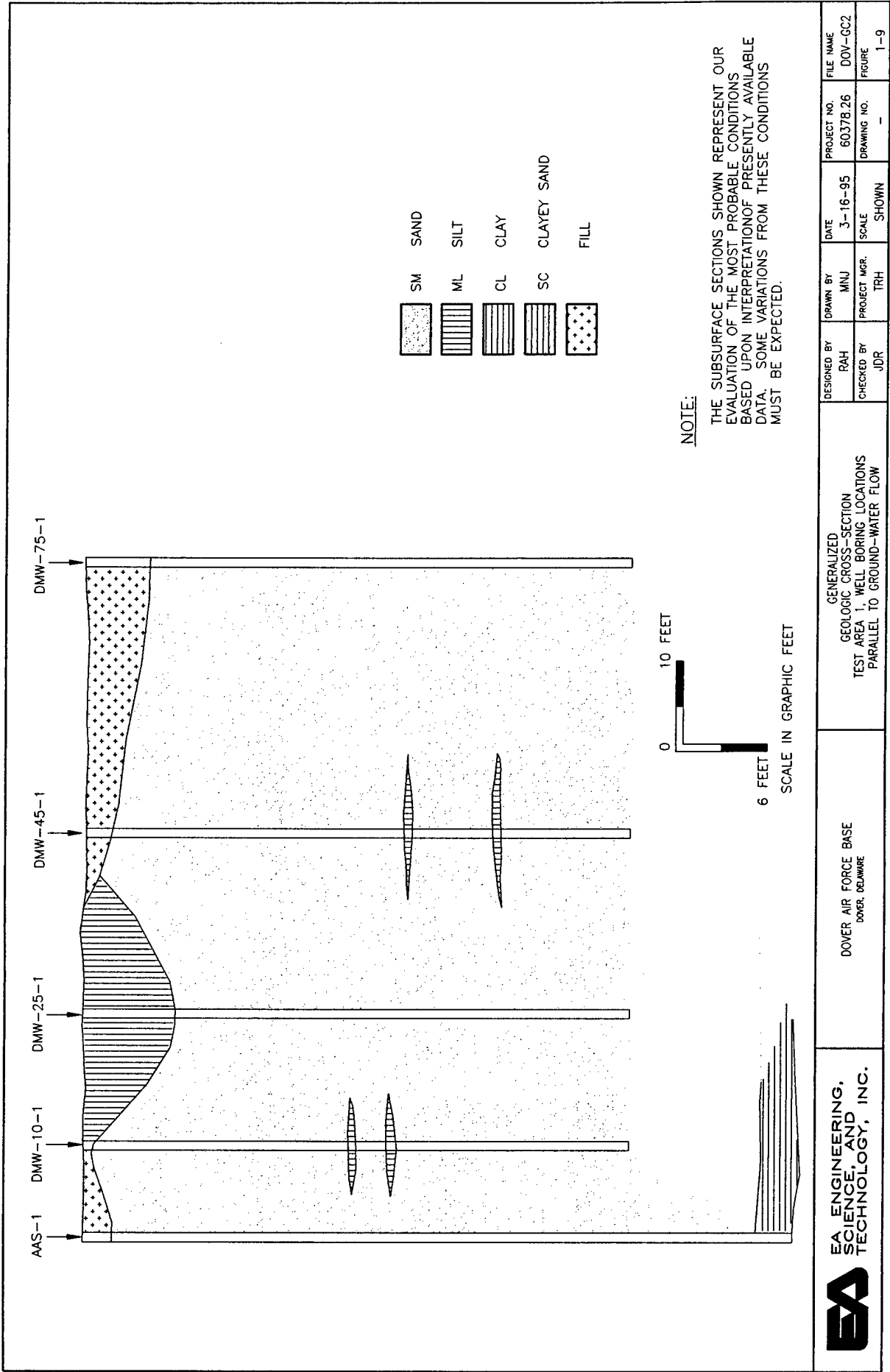


NOTE: THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE DATA OBTAINED FROM THE BORINGS AND ARE NOT A GUARANTEE OF THE EXACTNESS OF THE DATA. SOME MODIFICATIONS HAVE BEEN MADE TO THE DATA TO MAKE THEM MORE CONSISTENT WITH THE DATA.

Isolated gravel deposits, possibly channel lag, were found below the water table in borings B-7 and B-10.

The predominance of fine to coarse sand and the lack of continuous clay layers indicated that the site was amenable to conducting an AAS/SVE pilot study. The location of the test system took into account the site specific stratigraphy. The geometry and location of the test systems were selected to avoid the northeast corner clay layer, the fine-grained soils near B-9 and B-10, and site utilities.

Additional stratigraphy cross-sections were developed from the geologic data collected during the installation of the monitoring and sparge wells (Figures 1-9 to 1-12). The layout of the monitoring well network is presented in Figure 3.1-6. As observed from the original borings, these stratigraphic data indicated that the site is underlain primarily by fine to coarse sand, interbedded with laterally-discontinuous lenses of silty sand and silty clay. Again, small, non-contiguous clay lenses were identified below the water table.

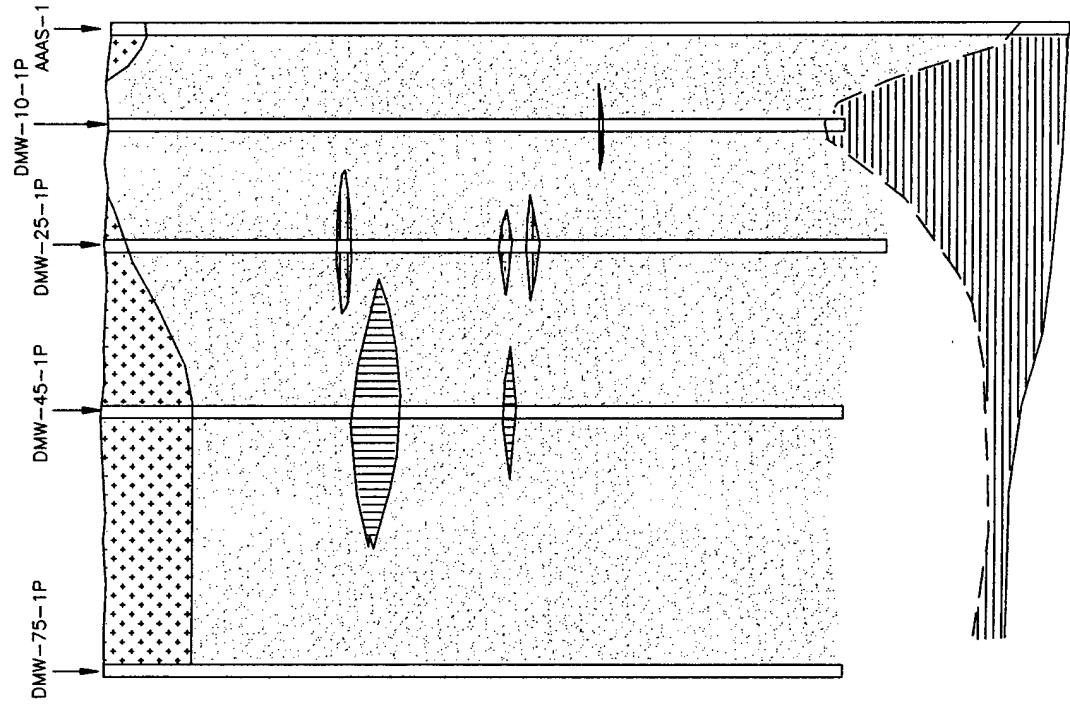


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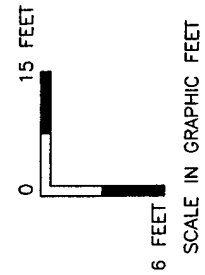
DOVER AIR FORCE BASE
DOVER, DELAWARE

GENERALIZED
GEOLOGIC CROSS-SECTION
TEST AREA 1, WELL BORING LOCATIONS
PARALLEL TO GROUND-WATER FLOW

DESIGNED BY RAH	DRAWN BY MNJ	DATE 3-16-95	PROJECT NO. 60378.26	FILE NAME DOV-GC2
CHECKED BY JDR	PROJECT MGR. TRH	SCALE SHOWN	DRAWING NO. -	FIGURE 1-9



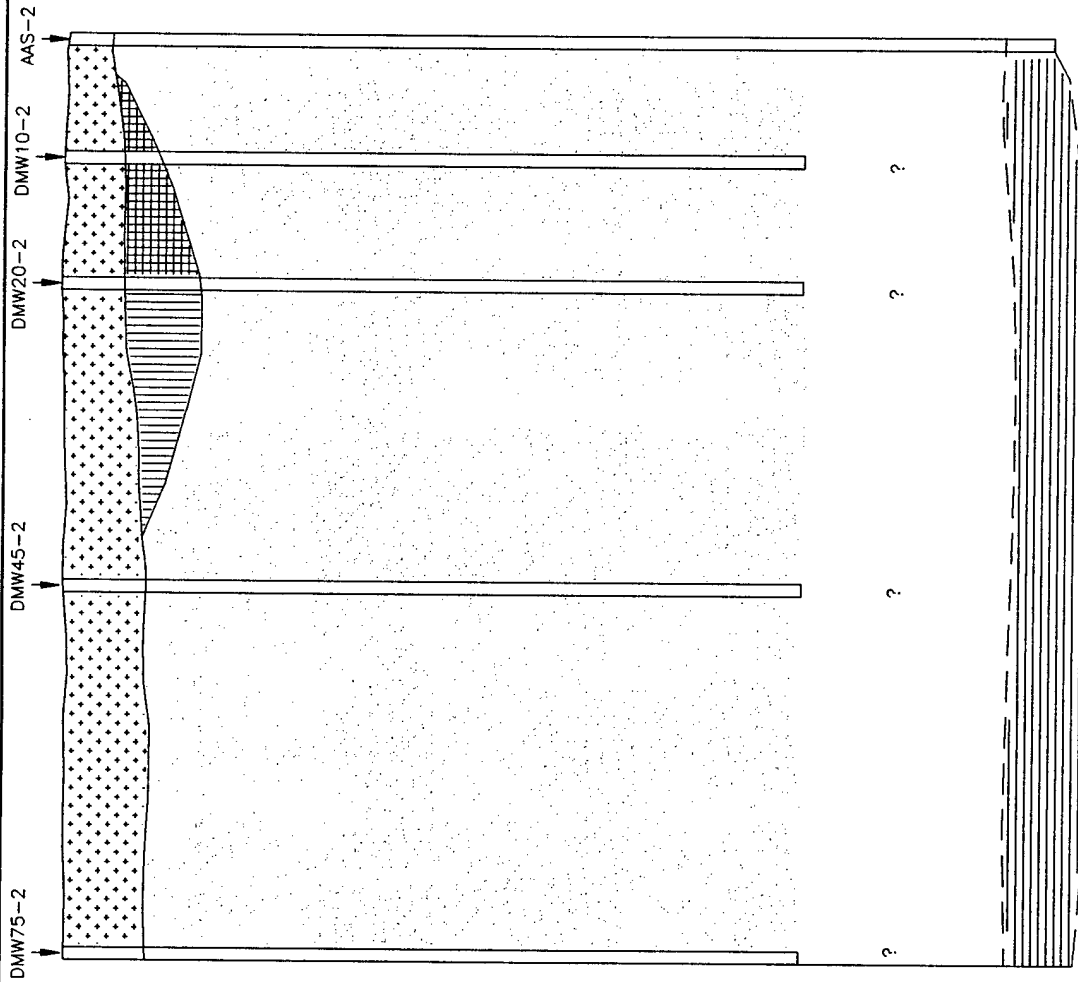
- SM SAND
- ML SILT
- CL CLAY
- SC CLAYEY SAND
- FILL



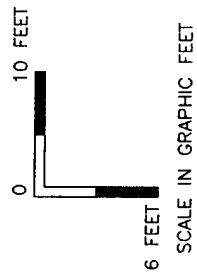
NOTE:

THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE	GENERALIZED GEOLOGIC CROSS-SECTION TEST AREA 1, WELL BORING LOCATIONS PERPENDICULAR TO GROUND-WATER FLOW		DESIGNED BY RAH	DRAWN BY MNJ	DATE 3-23-95	PROJECT NO. 60378.26	FILE NAME DOV-GC1
				CHECKED BY JDR	PROJECT MGR. TRH	SCALE SHOWN	DRAWING NO. -	FIGURE 1-10



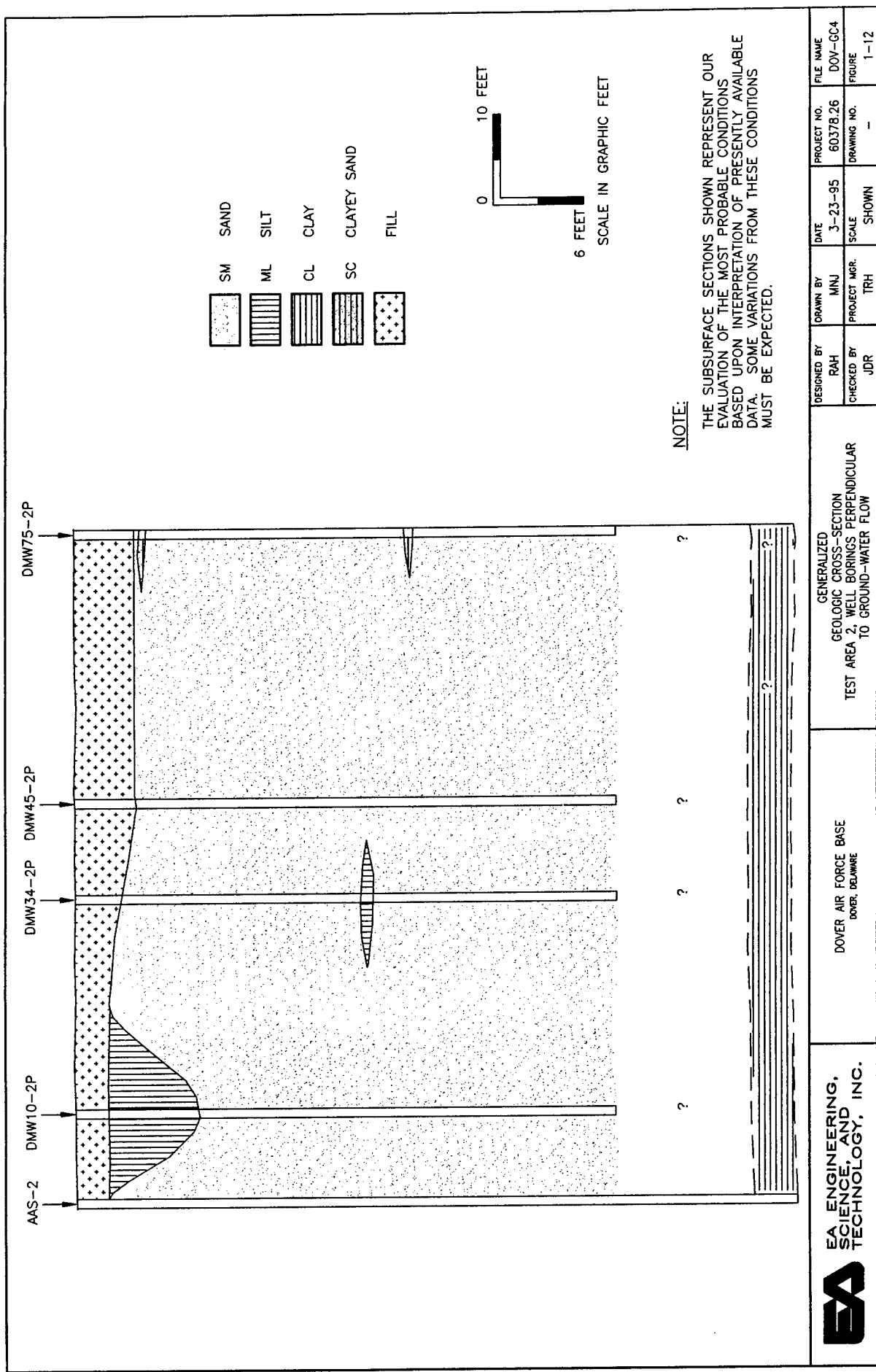
- SM SAND
- ML SILT
- CL CLAY
- SC CLAYEY SAND
- FILL



NOTE:

THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE	GENERALIZED GEOLOGIC CROSS-SECTION TEST AREA 2, WELL BORINGS PARALLEL TO GROUND-WATER FLOW	DESIGNED BY RAH	DRAWN BY MNJ	DATE 3-16-95	PROJECT NO. 60378.26	FILE NAME DOV-GC3
			CHECKED BY JDR	PROJECT MGR. TRH	SCALE SHOWN	DRAWING NO. -	FIGURE 1-11



EA ENGINEERING,
SCIENCE, AND
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DOVER AIR FORCE BASE
DOVER, DELAWARE

GENERALIZED
GEOLOGIC CROSS-SECTION
TEST AREA 2, WELL BORINGS PERPENDICULAR
TO GROUND-WATER FLOW

DESIGNED BY RAH	DRAWN BY MMJ	DATE 3-23-95	PROJECT NO. 60378.26	FILE NAME DOV-GC4
CHECKED BY JDR	PROJECT MGR. TRH	SCALE SHOWN	DRAWING NO. -	FIGURE 1-12

2. TECHNOLOGY DESCRIPTION

2.1 SOIL VAPOR EXTRACTION

Soil Vapor Extraction (SVE) is a proven and well-documented technology for the effective removal of vapor and adsorbed phase VOCs from the unsaturated (vadose) zone. VOCs are removed from the vadose zone as a negative pressure is exerted by a vacuum pump that is connected to an extraction well or trench. This results in the flow of soil gas towards the extraction well/trench, while concurrently effecting an interphase transfer from the immiscible and aqueous phases to the vapor phase, which is also subsequently extracted from the subsurface (Marley et al., 1990). This interphase transfer is dependent upon several factors, the most important perhaps being the volatility of the COCs. A chemical's volatility is directly related to the degree to which it will partition into the vapor phase in the soil gas. The parameter that best describes the volatility of a compound is its vapor pressure. It has been suggested that compounds with vapor pressures greater than 0.5 to 1.0 mm Hg at 20°C are amenable to removal by SVE (EPA, 1991a and The Hazardous Waste Consultant, 1990, respectively).

The pumping action of the SVE process supplies a continuous air flow through the soil which, in turn, provides rate-limiting oxygen which may enhance aerobic biodegradation of petroleum hydrocarbons. Biodegradation for petroleum hydrocarbons has been reported to contribute as much as 55 to 85 percent of the removal rate (of jet fuel) during SVE (Miller et al., 1990). Similar biodegradation would not be expected for chlorinated solvents.

The effectiveness of SVE is also affected by many other factors such as soil permeability. Soil permeability is a key parameter not only in deciding if SVE will be a feasible remedial option, but also for determining the SVE system design specifications. If the air permeability is less than 10^{-10} cm², SVE may not be feasible (EPA, 1991b). A soil that is not highly heterogeneous and which possesses an air permeability of 10^{-6} to 10^{-7} cm² or greater is believed to be adequate for SVE (EPA, 1991b and Guidemann & Hiller, 1988, respectively).

2.2 AQUIFER AIR SPARGING

Aquifer Air Sparging (AAS), sometimes referred to as "*in-situ* air stripping," is an emerging technology involving the removal of VOCs from the saturated zone. This technology involves the selective injection of atmospheric air into the saturated zone. This technology has been reported to have resulted in ground-water cleanup to the low ppb range (Ardito and Billings, 1990; Haress, 1989; Marley, 1991; Middleton and Hiller, 1990; EPA, 1992a; EPA, 1992b; Athens et al., 1993; Looney et al., 1991). Interim results at one AAS site indicate *in-situ* removal of BTEX compounds as great as 99.94 percent (Athens et al., 1993).

Similar to SVE, contaminant removal is achieved during AAS by a combination of volatilization and aerobic biodegradation. The degree to which each process contributes to contaminant removal is site specific. Cooley and Billings (1993) indicated that at typical petroleum hydrocarbon contaminated sites, 70 to 90 percent of the contaminant removal is achieved by biodegradation with the remainder being removed by volatilization.

Volatilization occurs during AAS as the injected air moves horizontally and vertically through the saturated soil column. Contaminant mass transfer occurs as the dissolved and residual (adsorbed) phase VOCs existing within the saturated soil column are contacted and partition into the advective air phase, roughly simulating an *in-situ* air stripping process. The "strippability" of VOCs is approximated by the chemical-specific Henry's Law constant (K_H). Henry's Law predicts the tendency of a compound to partition from the liquid to the vapor phase. A K_H value greater than $10^{-5} \text{ atm}\cdot\text{m}^3\cdot\text{mole}^{-1}$ would indicate a compound that is "strippable" by AAS (Brown et al., 1991). As the air channels (containing the "stripped" contaminants) displace water existing within the saturated zone pore space, they are transported to the vadose zone, where the contaminants can be captured by an SVE system (which is generally operated concurrently with an AAS system). Without SVE, the vapors introduced to the vadose zone by the AAS mass transfer process will increase the concentration and extent of vapor phase VOCs in the vadose zone, as well as presenting potential migration problems (e.g., into basements or utility conduits).

Similar to SVE, favorable soil conditions are prerequisite to a successful AAS system. Saturated soils that are not highly heterogeneous with a hydraulic conductivity (K) in the range of 10^{-3} cm/sec or greater are required to allow for sufficient air transmission through the saturated zone (Middleton and Hiller 1990; and Brown et al., 1991), however, some successful AAS projects have been undertaken at sites where the hydraulic conductivities were in the range of 10^{-4} cm/sec (Athens et al., 1993, Cooley and Billings 1993).

A hydraulic conductivity of 5×10^{-2} cm/sec in the Columbia surficial (unconfined) aquifer was calculated from the data obtained during an aquifer pump test at monitoring well MW-1 (EA, 1994b). Discontinuous clay lenses were thought to possibly exist in the Columbia Formation at this site based upon a literature reference (Bachman, 1984), which could restrict the effectiveness of AAS at this site. Clay or silt lenses of limited thickness and lateral extent were identified through the use of continuous split spoon sampling (EA, 1994b). Lateral discontinuous lenses of silty clay would impede the vertical migration of injected air. This impediment to vertical air flow may result in an unequal stripping of VOCs within the aquifer, and would potentially lead to a slower removal rate in some areas. The absence of large clay lenses was further verified from lithology descriptions of soils collected during the installation of the two AAS test wells (installed to a depth of 46 ft bgs) and the sixteen deep monitoring points (installed to a depth of 36 ft bgs) that were installed to support the original pilot tests.

The two mechanisms for the removal of contaminants by AAS are volatilization and biodegradation (Hinchee, 1994). Air injected into the aquifer travels as a separate gas phase, typically in flow channels. It appears doubtful that discrete air bubbles would form except perhaps in highly permeable gravel aquifers. If bubbles do form and are able to migrate, significant ground-water/air interaction will occur. The bubbles likely would induce advective flow, resulting in substantial air/water contact. If, however, bubbles do not form, as it appears they do not, air will flow in flow channels and are likely to have minimal interaction with water. Contaminated soil adjacent to those channels would be aerated; however, aquifer material not adjacent to these channels would be much less affected. Assuming flow channels do form, the interaction between the channels and the surrounding water is important. If interaction between

the air and water occurs, water circulation will be induced. The mechanism of diffusion transfers VOCs into the air channels and, similarly, oxygen from the air channels into the ground water. However, diffusion alone is a slow process which is typically the limiting factor for mass transfer processes during AAS. Typically during air sparging, microscale water circulations are induced and, therefore, the system is not diffusion limited.

3. AAS/SVE SYSTEM OPERATION

3.1 SYSTEM DESCRIPTION

This system included two test areas each containing an air sparging well and a soil vapor extraction well. In each test area, the AAS and SVE wells were installed in separate boreholes approximately 10 ft from each other. As part of the interim remedial action at Site SS59, permanent hardware was installed and utilized in conjunction with the existing monitoring well network. A shed with a concrete foundation was constructed for the AAS/SVE equipment and the associated electrical systems which were tied into an existing 167 kVA transformer (1 ϕ , 240V). The AAS/SVE system for both that test areas is controlled from this building. The existing system was not designed to remediate the site, rather initiate the removal of contaminants while concurrently studying the feasibility of this technology at the site.

3.1.1 Aquifer Air Sparging System

The AAS system was designed to provide properly filtered atmospheric air to the AAS wells that were selectively screened in the saturated zone of the aquifer. Atmospheric air was drawn into an air pump, where it was pressurized and discharged into manifold piping. The air then traveled in this manifold through control and monitoring devices and into the AAS well.

The AAS system consists of an air compressor (rated at 17.1 acfm at 175 psi) with a refrigerated air dryer, sampling ports, and the associated filters, piping, and valves (Figures 3.1-1 and 3.1-2). Three Swagelok sampling ports are available to test the air flow prior to injection. One or both of the AAS wells can be in use at once.

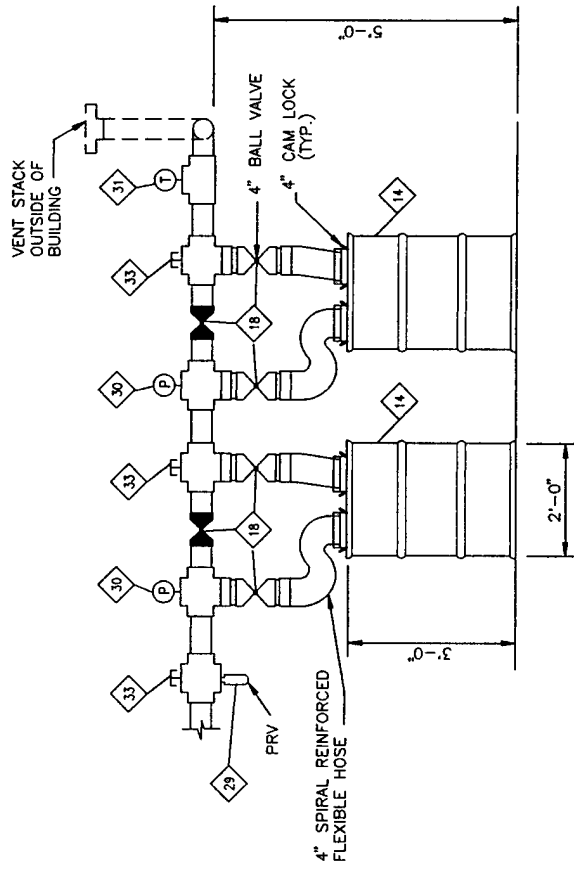
Concrete-lined manholes were installed at both of the existing AAS wellheads. Each AAS wellhead also was equipped with an air regulator, ball valves, a flow meter, a pressure gauge, and a tap intended for the tracer study (Figure 3.1-3).

A summary of the equipment installed and the monitoring equipment utilized is presented in Table 3.1-1.

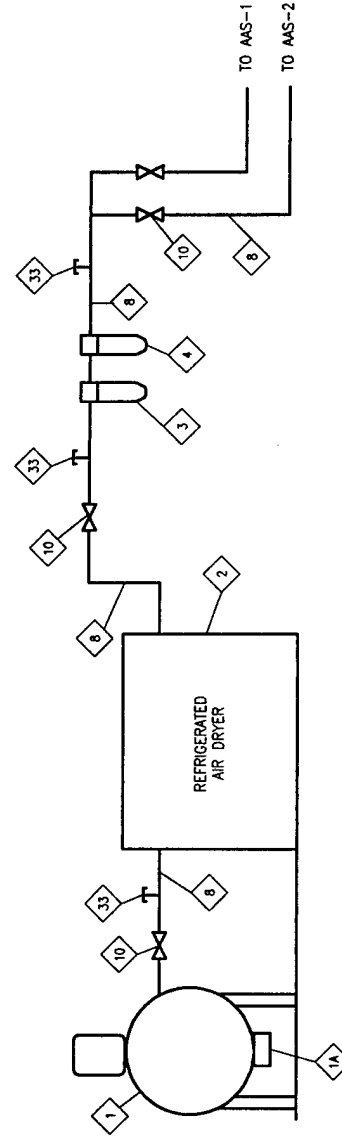
3.1.2 Soil Vapor Extraction System

The SVE system was designed to create a vacuum at the SVE wells that were selectively screened within the vadose zone. The vacuum draws soil vapor into the well, sends it through GAC, and discharges it out the emission stack of the SVE exhauster.

The SVE system consists of two skid-mounted SVE blowers (each rated at 83 scfm at 0-in. H₂O vacuum and 0 scfm at 138-in. H₂O vacuum), moisture separators and filters, sampling ports, two vapor phase GAC canisters, and the associated filters, valves, and piping (Figure 3.1-4). The GAC canisters are manifolded such that they can be operated in either series or parallel (Figure 3.1-2). Concrete-lined manholes were installed at both of the existing SVE wellheads.



CARBON ADSORBER



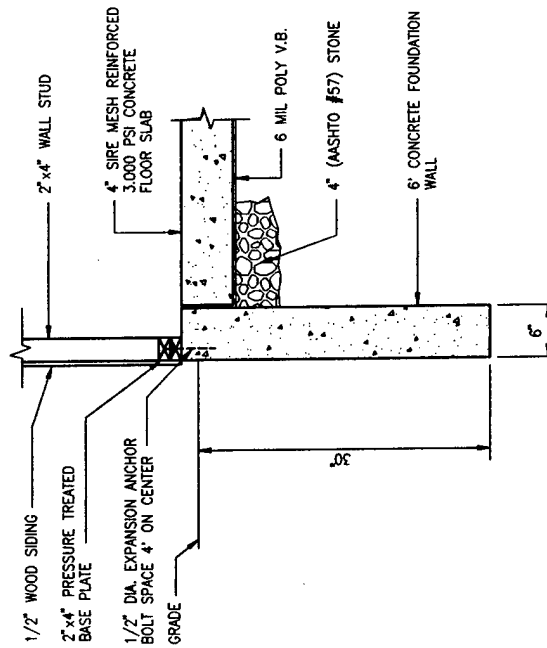
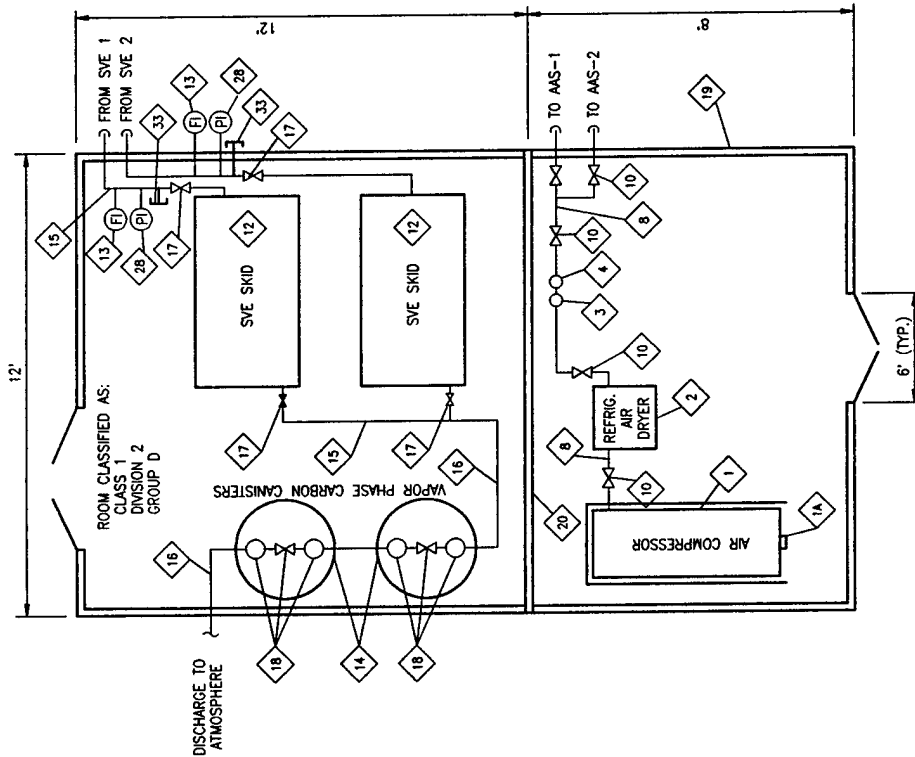
AIR COMPRESSOR AND AIR DRYING DETAILS

EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY, INC.

DOVER AIR FORCE BASE
DOVER, DELAWARE

COMPRESSED AIR SYSTEM

DESIGNED BY TKF	DRAWN BY AMP	DATE 2-24-95	PROJECT NO. 60378.26	FILE NAME CAS-1
CHECKED BY JDR	PROJECT MGR. TRH	SCALE NONE	DRAWING NO. -	FIGURE 3.1-1



BUILDING FOUNDATION AND ANCHORING DETAIL

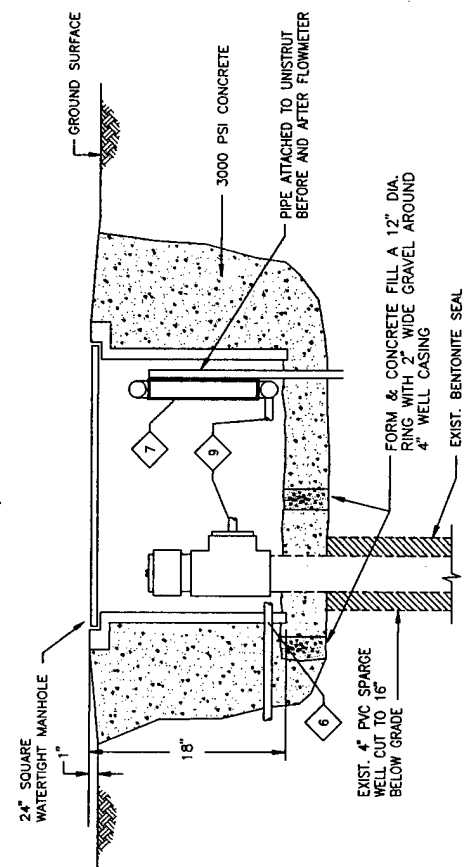
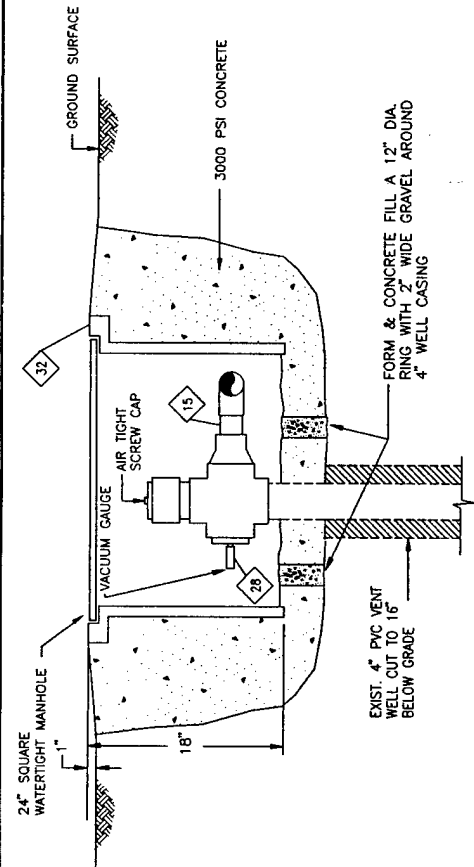


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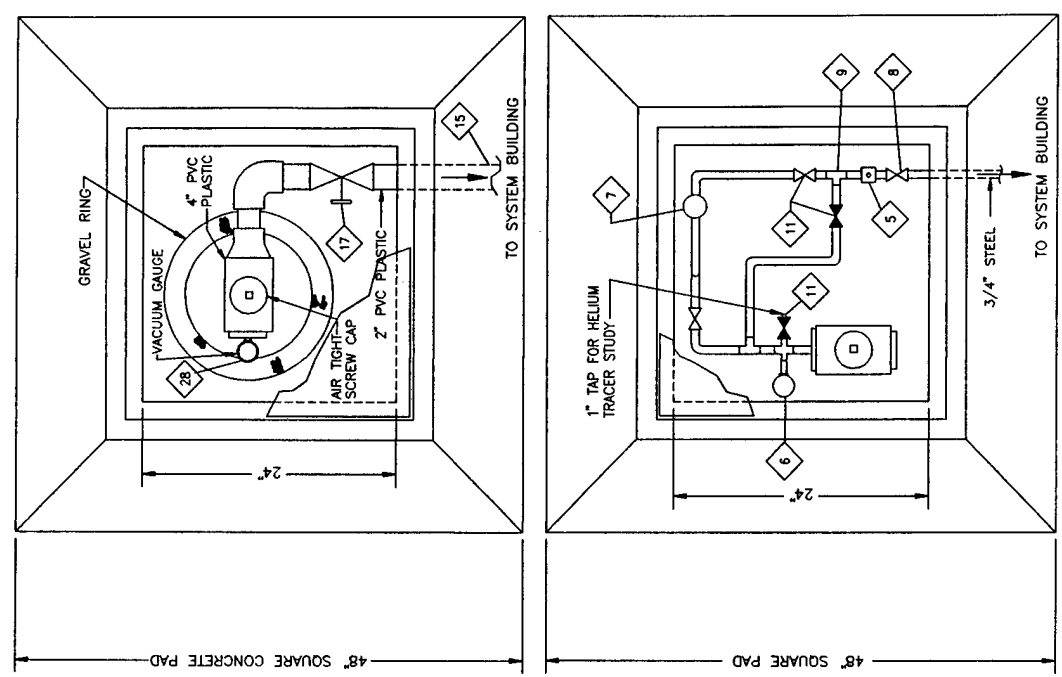
DOVER AIR FORCE BASE
DOVER, DELAWARE

BUILDING PLAN AND
FOUNDATION ANCHORING DETAIL

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
TKF	AMP	2-24-95	60378.26	SKIDBLDG
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
JDR	TRH	NONE	-	3.1-2



NOTE: PIPING, VALVES, AND REGULATOR NOT SHOWN FOR CLARITY OF FLOWMETER DETAIL.



PLAN VIEW

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE	VENT AND SPARGE WELL DETAIL				DESIGNED BY TKF	DRAWN BY AMP	DATE 3-14-95	PROJECT NO. 60378.26	FILE NAME SWELL
						CHECKED BY DEP	PROJECT MGR. TRH	SCALE 1" = 1'	DRAWING NO. -	FIGURE 3.1-3

TABLE 3.1-1 AAS/SVE EQUIPMENT LIST

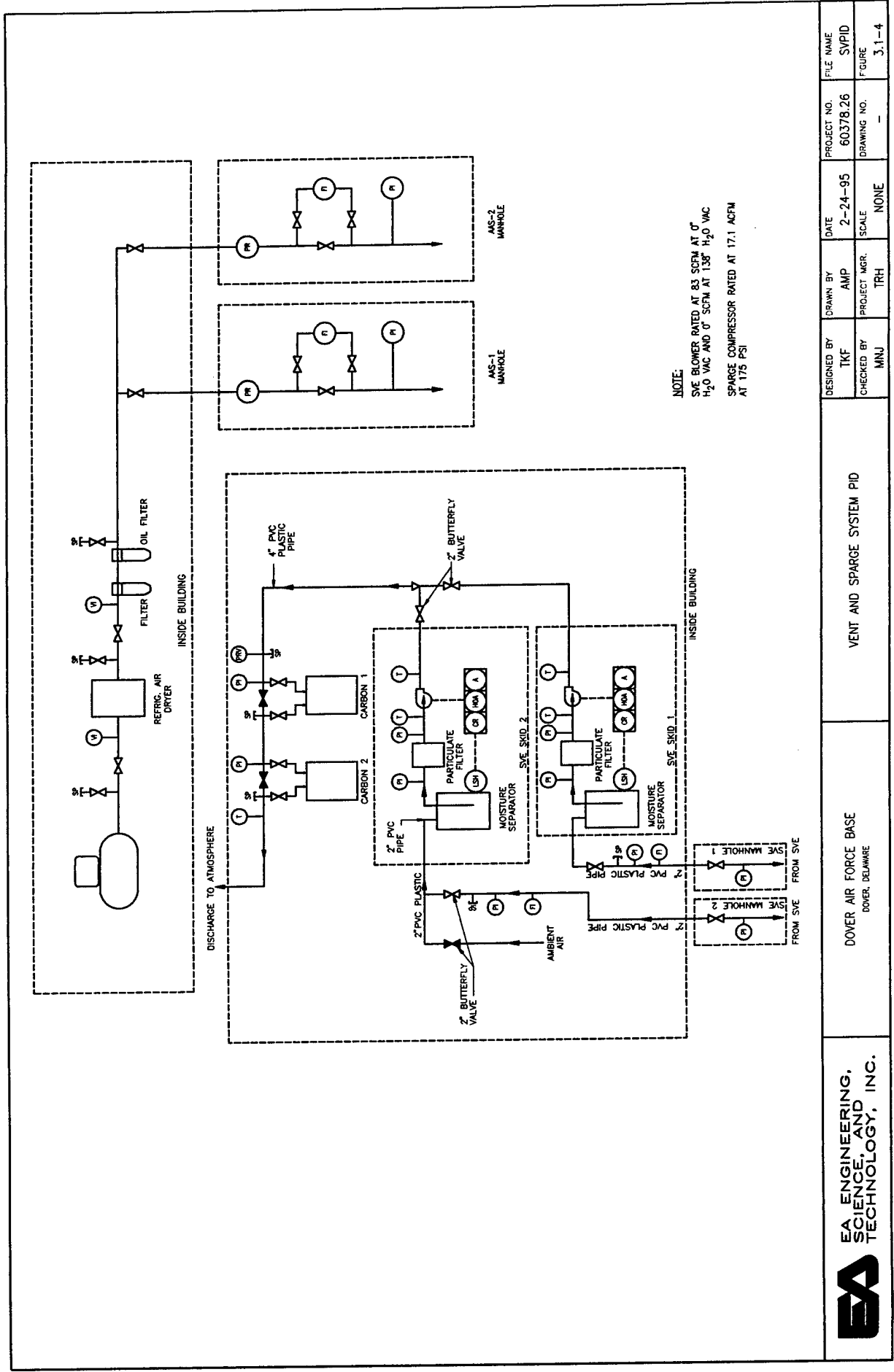
ITEM	DESCRIPTION	MANUFACTURER	MODEL	SPEC.	AMT.
1	Air Compressor	Grainger	7Z381	5 HP, 3/4" FNPT	1
1A	Air Compressor Auto Drain	Grainger	6Z984	-	1
2	Refrigerated Air Dryer	Grainger	5Z656	1" FNPT	1
3	Air Filter	Norgren	F17-600-M3DA	3/4" NPT	1
4	Oil Removal Filter	Norgren	F45-621-MODA	3/4" NPT	1
5	Air Regulator	Norgren	R17-600-RNLA	3/4" NPT	2
6	Pressure Gauges	U.S. Gauge	P555L-30	0-30 PSI	2
7	Flow Meter	Dakota Instruments	6B0220	1" FNPT 4-45 SCFM	1
8	Sch 40 Steel Pipe	-	-	3/4"	250 FT
9	Sch 40 Steel Pipe	-	-	1"	15 FT
10	Sch 40 Steel Ball Valve	-	-	3/4"	6
11	Sch 40 Steel Ball Valve	-	-	1"	6
12	Soil Vapor Extraction System (SVES)	-	-	3 HP	2
13	Air Flow Meter	Dakota Instruments	6B0220	1" FNPT 4-45 SCFM	2
14	Carbon Canister	Tigg	Nixton N-250 (400 lb.)	4" NPT Inlet and Outlet	2
15	Sch 80 PVC Pipe	-	-	2"	250
16	Sch 80 PVC Pipe	-	-	4"	30
17	Sch 80 PVC Ball Valve	-	-	2"	6
18	Sch 80 PVC Ball Valve	-	-	4"	6
19	Building	Hickory Sales	Cottage	12' x 20'	1
20	Air-tight Fire Wall	EA Engineering	-	-	1
21	Turbine Ventilator	McMaster-Carr	1992K12	6", 170 CFM	2
22	Ventilator Roof Jack	McMaster-Carr	2231K55	6"	2
23	Electric Heater (AAS)	Grainger	2E871	500 Watt	1
24	EXP Electric Heater (SVE) (Optional)	McMaster-Carr	1752K22	1800 Watt	1
24A	Thermostat	McMaster-Carr	1752K34	-	1

TABLE 3.1-1 AAS/SVE EQUIPMENT LIST (Continued)

ITEM	DESCRIPTION	MANUFACTURER	MODEL	SPEC.	AMT.
24B	Contactor	McMaster-Carr	1752K16	240 V	1
25	Light Fixture	Grainger	-	120 V	2
26	EXP Light Fixture	Grainger	2V738	120 V	2
26A	Light Mount and Lens Guard	Grainger	24740/2V742	-	2
27	120 V Recepticals	Grainger	-	-	4
28	Vacuum Gauge	Rotron	271950	0-160 IWG	4
29	Pressure Relief Valve	Rotron	529612	4-15 PSIG	1
30	Pressure Gauge	Rotron	271949	0-6 PSIG	2
31	Temperature Gauge	McMaster-Carr	3946K145	0-200 F	1
32	Well Manholes	-	-	24" Square	4
33	Pressure Gauges	-	-	-	-
34	Magnehelic Gauges	Dwyer	R18E, R10E, W34C*	-	-
35	Water Level Indicator	Solinist	101	-	1
36	Portable FID	Foxboro FID	OVA 128	-	1
37	Dissolved Oxygen Meter	Yellow Spring Instruments (YSI)	57	-	1
38	Field GC	Varian/HNU	3300	-	1
39	Combustible Gas Indicator	Industrial Scientific	MX251	-	1
40	Hydrolab	Surveyor	II	-	1
41	O2/CO2 Meter	GasTech	GX4000	-	1
42	Conductivity Meter	Yellow Spring Instruments (YSI)	33	-	1
43	Microtip	Photovac	HL2000	-	1

Note: Some items are indicated in Figures 3.1-1 to 3.1-4 (in a diamond outline) by the appropriate Item No. (first table column).

* - Magnehelic Ranges R18E (0 to 0.25") W43C (0 to 2.0") W43C (0 to 10.0")
 R10E (0 to 0.5") W43C (0 to 5.0") W43C (0 to 25.0")



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE	VENT AND SPARGE SYSTEM PID				DESIGNED BY TKF	DRAWN BY AMP	DATE 2-24-95	PROJECT NO. 60378.26	FILE NAME SVPID
						CHECKED BY MMU	PROJECT MGR. TRH	SCALE NONE	DRAWING NO. -	FIGURE 3.1-4

The SVE wellheads also were equipped with valves and vacuum gauges (Figure 3.1-3). A summary of the associated equipment is presented in Table 3.1-1.

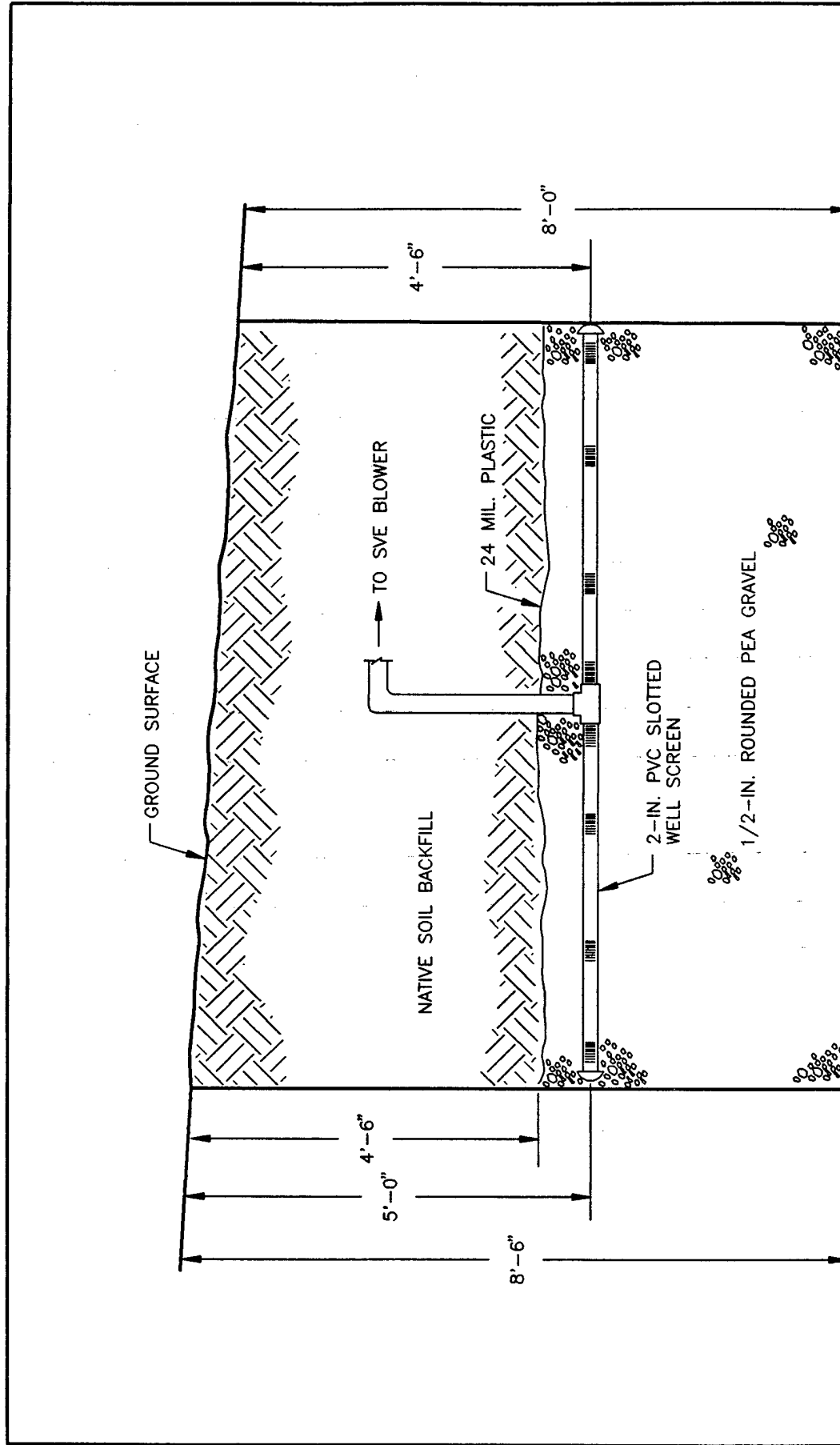
During occasional past operations of the AAS/SVE system, ground water was drawn into the SVE well in Test Area 1. Consequently, in order to increase the SVE flow rate and the system efficiency, the SVE-1 well was replaced with an 8-ft horizontal vent trench set at 4.5 ft bgs (Figure 3.1-5). The 2-in. PVC, slotted, horizontal well was installed in ½-in. rounded pea gravel (6-in. cover). The trench was then covered with a layer of 24-mil plastic and backfilled with native soil.

3.1.3 Monitoring Well Network

The existing monitoring well network, which was installed for the initial AAS/SVE Treatability Study (EA, 1994b), was also used during the extended pilot study. The existing network consisted of a series of 24 monitoring points in each test area along two straight lines radially outward from the test wells (Figure 3.1-6). The lines were oriented at right angles to each other and aligned so that one was approximately parallel to ground-water flow direction and the other perpendicular. The SVE wells were situated on the bisectors, outside of the area bounded by the monitoring lines. On each line the monitoring locations were spaced at approximately 10 ft, 25 ft, 45 ft, and 75 ft from the test wells. The spacing was slightly modified in Test Area 2 due to utility locations. Each monitoring location consisted of three points; a deep monitoring well screened near the bottom of the aquifer, a shallow monitoring well screened across the water table, and a vadose monitoring point screened in the unsaturated zone above the screened portion of the shallow monitoring well exposed to the vadose zone (Figure 3.1-7). Additional upgradient and downgradient monitoring wells are present at Site SS59 as part of a long-term, post-closure, monitoring program.

The monitoring wells were designated "MW" and qualified by depth (D = deep, S = shallow, and V = vadose), distance from the test wells, test area number, and their position with regard to ground-water flow direction. For example, "DMW45-1P" is the deep monitoring well located approximately 45 ft from the test wells in Test Area 1 on the line of monitoring wells oriented approximately perpendicular to ground-water flow. The corresponding monitoring point on the line approximately parallel to ground-water flow is numbered "DMW45-1". Well screen intervals were between 3 to 8 ft, 7 to 17 ft, 31 to 36 ft, and 36 to 41 ft for the vadose, shallow, deep, and AAS wells, respectively.

Twelve direct-push probes ("Geoprobes") were also installed throughout Site SS59 in order to provide a verification of the data obtained from the monitoring well samples. The locations of the geoprobes are depicted in Figure 3.1-6. The distances of the direct push locations from the sparge wells are summarized in Table 3.1-2. During the first sampling event, twelve shallow, direct-push probes were installed to a depth of 15 ft bgs and three deep geoprobes were installed to a depth of 40 ft bgs. During the final sampling event, five shallow, direct push probes were installed to a depth of 20 ft bgs (DP-3, DP-6, DP-7, DP-10, and DP-12) and five deep geoprobes were installed to a depth of 40 ft bgs (DP-4, DP-5, DP-8, DP-9, and DP-11). The depths of the



FILE: DOV-VI

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE	VENT TRENCH TO REPLACE SVE-1 WELL	DESIGNED BY TKF	DRAWN BY MNJ	DATE 2-24-95	PROJECT NO. 60378.26
			CHECKED BY JDR	PROJECT MGR. TRH	SCALE SHOWN	FIGURE 3.1-5

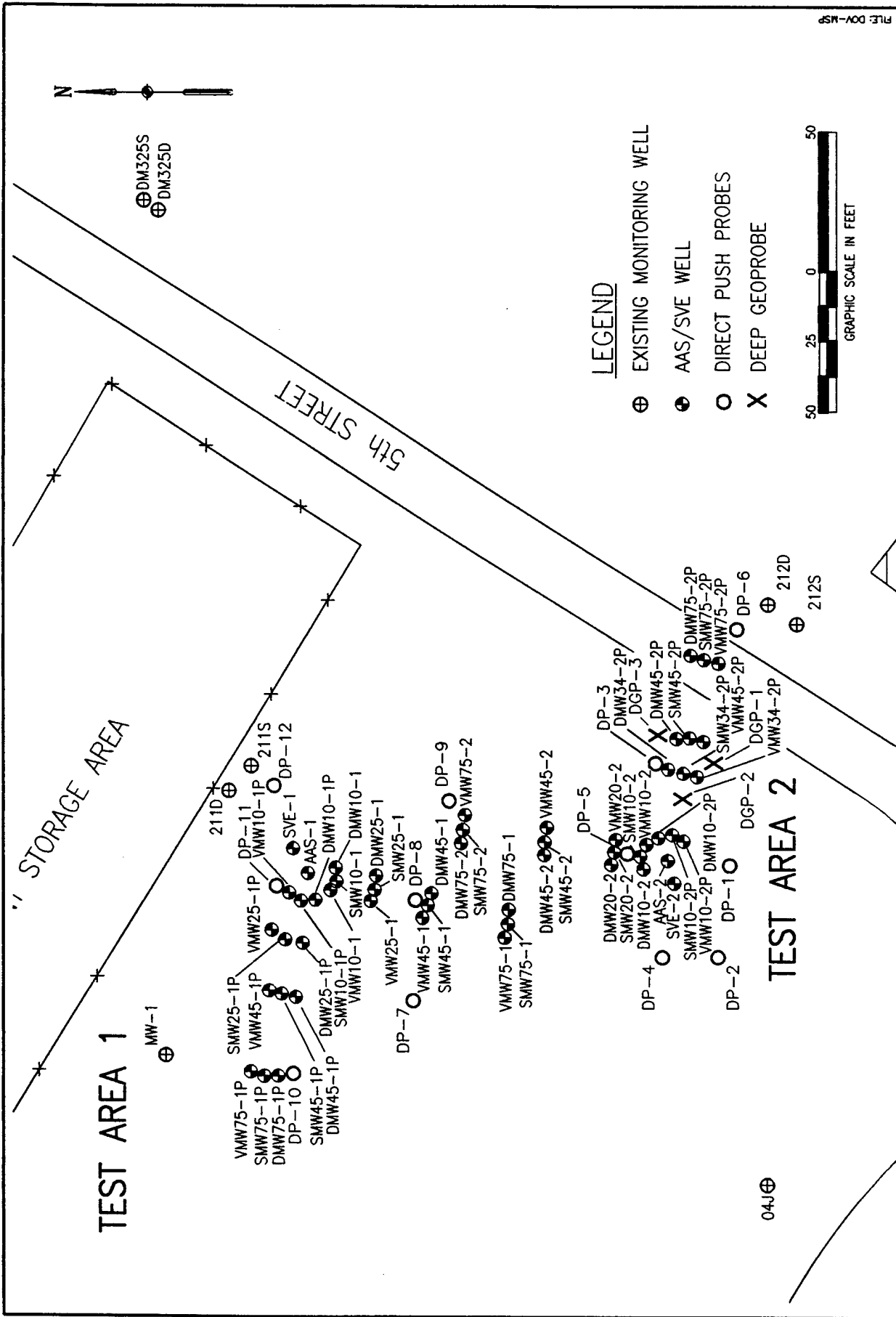
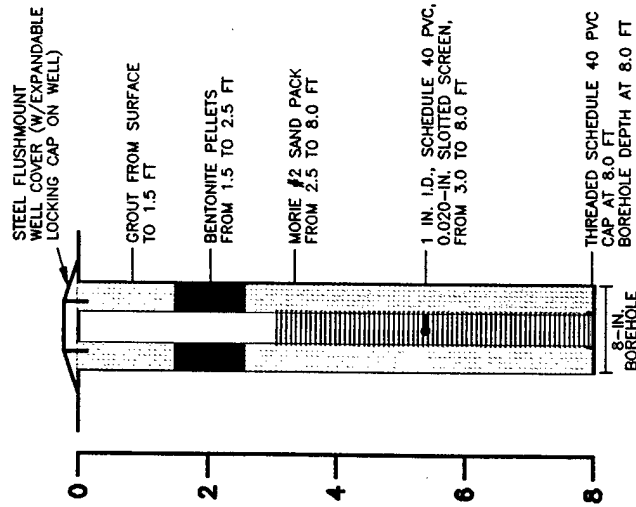
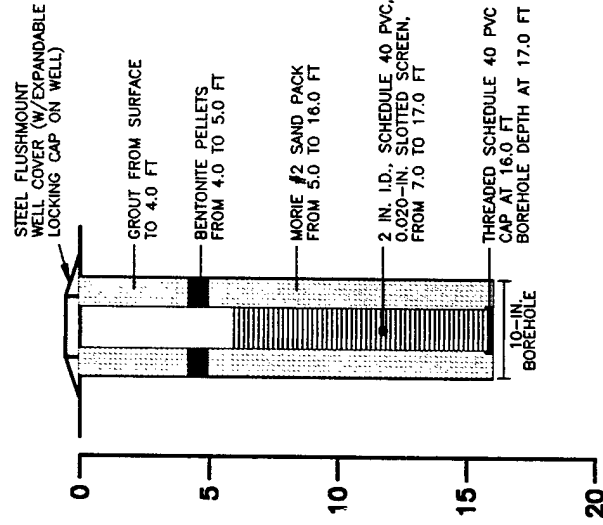


**TABLE 3.1-2 SUMMARY OF DISTANCES BETWEEN DIRECT PUSH LOCATIONS
AND SPARGE WELLS**

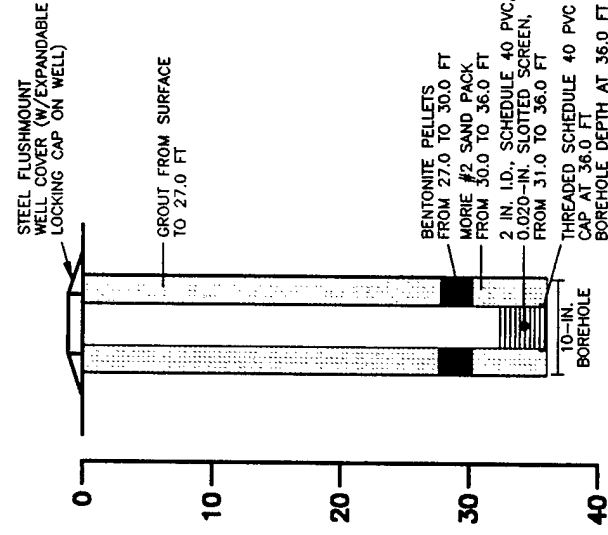
Direct Push Probe Location	Distance from AAS-1 (ft)
DP-7	53
DP-8	44
DP-9	75
DP-10	47
DP-11	12
DP-12	24
Direct Push Probe Location	Distance from AAS-2 (ft)
DP-1	15
DP-2	20
DP-3	46
DP-4	15
DP-5	15
DP-6	102
DP-7	130
DP-8	88
DP-9	76



VADOSE ZONE MONITORING POINTS
(VADOSE ZONE MONITORING)



SHALLOW MONITORING WELLS
(GROUND-WATER MONITORING)



DEEP MONITORING WELLS
(GROUND-WATER MONITORING)

FILE: DWR-2R

 EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		MONITORING WELL CROSS-SECTION		DESIGNED BY AC	DRAWN BY MNU	DATE 3-16-95	PROJECT NO. 60378.26
					CHECKED BY JDR	PROJECT MGR. TRH	SCALE SHOWN	FIGURE 3.1-7

probes were chosen in order to confirm data trends observed in the adjacent monitoring locations.

3.2 TEST PROCEDURES AND MONITORING

3.2.1 AAS/SVE Testing Procedures

The primary intent of the extended pilot study for the combined AAS/SVE system in Test Areas 1 and 2 was to add to the information collected during the initial Treatability Study (EA, 1994b) regarding system performance, ROI, and degree of site remediation (ground-water VOC concentrations). Monitoring during the combined AAS/SVE test included SVE flow rate and vacuum pressures, differential pressures at the monitoring points, offgas and soil gas concentrations of VOCs, and AAS injection rate and pressures. These data were collected between June 1994 and January 1995 as part of the IR Program activities at site SS59.

3.2.2 Sampling Program

In order to assess the degree of remediation, ground-water samples were collected from each of the shallow and deep monitoring wells in Test Areas 1 and 2. This sampling was performed during three separate events: once at the commencement of the study (June 1994), mid-way through the study (October 1994), and at the end of the study (January 1995). Samples were analyzed for the primary COCs (1,1-DCE, methylene chloride, trans-1,2-DCE, cis-1,2-DCE, chloroform, TCA, carbon tetrachloride, TCE, PCE, and BTEX including the o-, m-, and p-xylene isomers). The procedures used for the purging and sampling of the monitoring wells are presented in Sections 3.2.2.1 and 3.2.2.2, respectively.

Ground-water samples were collected from geoprobes during the first and final sampling events of the extended pilot study. These were installed and sampled one at a time due to equipment limitations. In order to preserve the geoprobe locations, it was attempted to install PVC pipes into the geoprobe holes. However, it turned that this was not feasible since water could not be drawn from these boreholes due to clogging from silt.

In order to assess the efficiency (or rate of remediation) of the system, offgas samples were collected into Tedlar bags from the SVE system prior to GAC filtration. This sampling was performed over fourteen separate sampling events during the study. Samples were analyzed for the primary COCs listed above. Analyses were performed by an environmental chemist with an onsite Gas Chromatograph (GC).

System operational parameters such as injection pressure and flow rate, vacuum pressure and flow rate, and differential pressures were monitored during each of the aforementioned sampling events and periodically by DAFB personnel throughout the duration of the study. Flow rates and pressures were monitored using in-line gauges located either at the wellhead or on the compressor/blowers. Differential pressures were measured using magnehelic gauges.

Water levels were monitored during the three ground-water sampling events and periodically throughout the six month study period. The well cap was removed and a headspace reading was taken with an HNu meter. Data was recorded on the sampling sheet for that well. After determination of the water level, the probe was lowered to the bottom of the well to measure the total depth. This was performed during each of the three sampling events. The interface probe was decontaminated between uses by means of an isopropyl alcohol rinse followed by a deionized water rinse.

3.2.2.1 Well Purging Procedures

Purging of the monitoring wells was necessary to remove ground water in the well casing which had been isolated for an extended period of time and was, therefore, no longer representative of the aquifer. The volume of water which was removed was calculated by adding the volume of water in the well casing to the volume of water in the filter pack surrounding the well. This volume of water was referred to as one well volume. For purposes of calculation for one well volume, a 8-in. diameter borehole and a 30 percent porosity of the filter pack was used.

A laboratory-cleaned Teflon bailer and a 2-in. submersible pump were used to purge the monitoring wells prior to sampling (shallow and deep wells, respectively). The wells were bailed or pumped at a rate that did not cause ground water to vigorously cascade down the sides of the screen (thereby potentially causing accelerated loss of VOCs). Three purge volumes of water were removed. Temperature, pH, and conductivity parameters were measured from the purge water. If a low yielding well dewatered before evacuation of the required volume, the well was allowed 30 minutes to recover before the bailing or pumping was resumed. If the well went dry again, bailing or pumping ceased, and the volume purged was recorded.

Ground-water sampling occurred within 24 hours of purging or as soon as a sufficient quantity of water was available. All non-dedicated field equipment which was used during purging was decontaminated by steam cleaning before the next monitoring well was purged. Dedicated bailers were used for sample collection in each well. New protective sample gloves were worn for each well which was sampled.

Data collected during ground-water sampling activities was recorded on standard field record sheets. A separate data sheet was completed for each sampling location.

3.2.2.2 Ground-Water Sampling Procedures

The following procedure was used to sample a purged well. The sampler donned clean protective gloves and attached new string, which was made of an inert material (polyethylene), to the leader of the dedicated Teflon bailer. The bailer was lowered into the well and one aliquot of water was removed and discarded. A second bailer of water was removed and this water was also discarded. Samples were collected into laboratory-cleaned, 40-mL VOA vials.

VOC sampling required special care not to agitate the sample and promote degassing. In addition, no headspace was present in the sample container after it was filled. VOC samples

were collected from the bailer using a slow, controlled pour down the inside of a tilted VOA container to minimize agitation. Containers with trapped air were refilled until no air bubbles were present in the sample. VOA vials contained preservative from the laboratory.

Collected samples were placed in a cooler with bagged ice to maintain a temperature of less than 4°C, and a chain-of-custody form was filled out detailing the analyses to be performed. Samples were analyzed within 48 hours of collection (samples were analyzed as soon as possible but the time of analysis depended upon the number of samples which were collected).

3.2.3 Chronology of Test Activities

A chronological summary of the pilot study activities is presented in Table 3.2-1.

3.3 DISPOSITION OF DERIVED WASTES

Wastes were generated over the duration of the extended AAS/SVE pilot study. The current disposition of these wastes is discussed in Section 3.3.1 (Ground Water) and 3.3.2 (Granular Activated Carbon).

3.3.1 Ground Water

Ground water was generated during the purging prior to ground-water sampling of the monitoring points. During the sampling events purge waters were disposed into the DAFB wastewater sewerage system. Wastewater collected in the DAFB system is sent to the Kent County POTW. One 55-gallon drum of condensate was generated from the pilot system. This was disposed to the wastewater system via the washrack. Significant quantities of condensate were not generated following the installation of the horizontal vent trench.

3.3.2 Granular Activated Carbon (GAC)

In order to reduce the amount of contaminants discharged to the atmosphere, two vapor-phase GAC canisters were used (in series) to treat the offgas from the SVE system. Discharge from the GAC canisters met DNREC emissions criteria over the duration of the pilot study (Section 3.4.2). No change-out of the GAC canisters was necessary during the pilot study. During the final sampling event, gas samples collected from between the two canisters indicated that breakthrough had not occurred from the first canister. Canisters will be shipped offsite for regeneration or disposal following breakthrough.

3.4 PERMITTING

As an NPL site, remedial activities were exempt from the administrative requirements of most permits. However, the substantive requirements of the appropriate permits were followed. Drilling permits are required for NPL and other sites.

TABLE 3.2-1 CHRONOLOGY OF FIELD ACTIVITIES

DATE	EVENT
31 May 1994	Began the Extended AAS/SVE Pilot Study at Site SS59.
31 May to 2 June 1994	Performed the initial sampling event. Conducted well purging and ground-water/soil gas sample collection and analysis. Ground-water DO concentrations were measured.
10 June 1994	Commenced operation of the AAS/SVE system in Test Areas 1 and 2.
12 to 29 June 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
16 June 1994	Water levels, DO concentrations, and monitoring well headspace concentrations were measured. Offgas samples were collected and analyzed. Recorded system operational parameters.
28 June 1994	Water levels, DO concentrations, and monitoring well headspace concentrations were measured. Offgas samples were collected and analyzed. Recorded system operational parameters.
1 and 7 July 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
8 July 1994	Water levels, DO concentrations, and monitoring well headspace concentrations were measured. Offgas samples were collected and analyzed.
11 to 12 July 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
15 July 1994	Changed AAS/SVE system operation from the temporary trailers to the permanent hardware installed in the equipment shed.
27 to 29 July 1994	AAS/SVE system was shut down for repair. (Damage to the SVE vent lines (melted PVC) occurred on 27 July. The lines were replaced with a 4" hose and the system was reactivated on 29 July.)
4 August 1994	Water levels, DO concentrations, and monitoring well headspace concentrations were measured. Offgas samples were collected and analyzed. Only the SVE system (SVE-1 and SVE-2) was in operation due to an air compressor malfunction identified on 3 August 1994. Recorded system operational parameters.

TABLE 3.2-1 CHRONOLOGY OF FIELD ACTIVITIES (Continued)

DATE	EVENT
8 August 1994	Corrected the air compressor problem and recommenced sparging in Test Areas 1 and 2. (The compressor was overheating and shutting down. A thermostat and an exhaust fan was installed to correct the problem by lowering the temperature in the equipment shed.)
8, 12, and 16 August 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
18 August 1994	Water levels, DO concentrations, and monitoring well headspace concentrations were measured. Offgas samples were collected and analyzed. Recorded system operational parameters.
1 September 1994	Water levels, DO concentrations, and monitoring well headspace concentrations were measured. Offgas samples were collected and analyzed. Recorded system operational parameters.
15 September 1994	Installed a horizontal vent trench at the SVE-1 wellhead (not yet hooked up to the SVE blower). The AAS/SVE system was shut down for 5 hours during this installation.
22 September 1994	Water levels, DO concentrations, and monitoring well headspace concentrations were measured. Offgas samples were collected and analyzed. Recorded system operational parameters.
27 September 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
5 and 7 October 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
7 October 1994	Offgas samples were collected and analyzed. Shut off the AAS/SVE system for the mid-term ground-water sampling event.
10 October 1994	The SVE-1 piping system was connected to the horizontal extraction well.
10 to 13 October 1994	Well purging and ground-water/soil gas sample collection/analysis.
13 October 1994	An offgas sample was collected one hour after the AAS/SVE system had been reactivated (after the ground-water sampling had been completed). DO concentrations were measured. Recorded system operational parameters.

TABLE 3.2-1 CHRONOLOGY OF FIELD ACTIVITIES (Continued)

DATE	EVENT
14, 18, 20, and 25 October 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
27 October 1994	Water levels and DO concentrations were measured. Offgas samples were collected and analyzed. Recorded system operational parameters.
8 and 14 November 1994	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
14 November 1994	Offgas samples were collected and analyzed. Recorded system operational parameters.
1 to 14 December 1994	AAS/SVE system shut-down due to air compressor repairs. On 1 December, it was discovered that the air compressor had broken down. On 6 December, a compressor serviceman examined the compressor and was unable to repair the problem that day. On 14 December, EA personnel with an electrical subcontractor installed a new motor. The AAS/SVE system was not reactivated in preparation for the tracer gas study.
19 to 21 December 1994	Performed the tracer gas study. Only AAS-1 was in operation during this study.
21 December 1994	Reactivated the AAS/SVE system except for AAS-2 which was shut off for the remainder of the pilot study in order to increase the injection flow rate into AAS-1. SVE-1 and SVE-2 remained in operation. VOC concentrations could not be quantified in an offgas sample which was collected due to residual SF ₆ within the aquifer.
6 January 1995	Water levels, DO concentrations, and monitoring well headspace concentrations were measured.
6 to 9 January 1995	The AAS system was shut down for the replacement of a frozen sparge line.
9 January 1995	Offgas samples were collected and analyzed after the system had been in operation for one hour.
13 January 1995	DAFB personnel monitored system operational parameters and differential pressures at the individual monitoring wells.
16 January 1995	Water level and DO concentrations were measured.
23 January 1995	Offgas samples were collected and analyzed.

TABLE 3.2-1 CHRONOLOGY OF FIELD ACTIVITIES (Continued)

DATE	EVENT
23 to 25 January 1995	Shut down AAS/SVE system for final ground-water and soil gas sampling event. Well purging and ground-water sample collection/analysis.
25 January 1995	Reactivated AAS/SVE system for 1-hour and collected/analyzed final offgas samples. Ended the Extended AAS/SVE Pilot Study. Left AAS/SVE system in operation in both Test Areas (including AAS-2).

3.4.1 Test Wells and Monitoring Points Installation Permits

The extended pilot test required the installation of 12 geoprobes (temporary) and one horizontal vent trench (permanent). The geoprobes were installed to a depth such that they penetrated the saturated zone and, therefore, required monitoring well permits from DNREC. These permits were secured prior to any installations. The horizontal vent trench was not installed within the saturated zone of the aquifer and, therefore, did not require a permit.

3.4.2 SVE Pilot Test Offgas Emissions Permit

DNREC requires that air pollution abatement systems be used if SVE offgas VOC emissions exceed 0.1 lb/hr (2.4 lb/day). Pilot tests are normally granted a 5-day exemption period. Some of the contaminants present at this site are considered to be Hazardous Air Pollutants (HAP) by DNREC. DNREC is currently preparing to distribute its final promulgation of its VOC air emission regulations. Offgases were treated with vapor phase GAC prior to ventilation to the atmosphere. Monitoring of the offgas from the SVE system during the pilot study confirmed that the emission rate of VOCs met the DNREC criterion.

3.4.3 Underground Injection Control Permits

DNREC does not consider the introduction of atmospheric air into the saturated zone during the AAS pilot test to be an injection process which requires an Underground Injection Control (UIC) permit. Hence, no UIC permits were required for the pilot test.

4. ANALYTICAL RESULTS

4.1 COMPOUNDS OF CONCERN

The compounds detected in previous investigations in soil and/or ground water at Site SS59 are listed in Table 4.1-1 and 4.1-2. Given that many of these compounds are difficult or impossible to be detected by gas chromatography, a selected group were chosen to be "representative" of what is present at the site. The analytes chosen for soil gas and offgas analysis included 1,1,1-trichloroethane (TCA), cis-1,2-dichloroethene (c-DCE), trans-1,2-dichloroethene (t-DCE), methylene chloride, carbon tetrachloride, tetrachloroethene (PCE), trichloroethane (TCE) (in this report, these are collectively referred to as "ECD VOCs" since they are identified using an Electron Capture Detector), and the hydrocarbon compounds benzene, toluene, ethylbenzene, and xylene (BTEX) (in this report, these are collectively referred to as "FID VOCs" since they are identified using a Flame Ionization Detector). The analysis of xylene included the o-, m-, and p-xylene isomers. Ground-water samples included an analysis for 1,1-dichloroethene (DCE) and chloroform (also ECD VOCs).

4.2 SOIL GAS

4.2.1 Methodology

Soil gas samples were collected at each shallow and vadose monitoring point. Soil vapor samples were analyzed for the VOCs described in Section 4.1. Samples were collected through Teflon-lined sampling ports into Tedlar bags for subsequent VOC analysis with an onsite GC.

Soil vapor samples typically contain several compounds. When a sample was injected into the GC, these compounds were first separated by the appropriate analytical column. As the separated compounds eluted from the GC column, they entered the chosen detector(s) where they became ionized. The resulting ions attached to an electrode which increased the signal current. The signal was then amplified, integrated, and reported as a chromatographic peak.

An FID is used for the detection of organics and responds specifically to compounds which will yield a carbon skeleton which can be oxidized when introduced into an air/hydrogen flame. Therefore, it is sensitive to all organic compounds except formaldehyde and formic acid. The ECD is used for the detection of chlorinated organic compounds and is both sensitive and selective to halogenated compounds.

The GC system was calibrated by injecting a known amount of vapor standard into the GC column. One set of standards contained a mixture of hydrocarbons, which was used to calibrate the FID, while the other set contained a mixture of chlorinated organics, which was used to calibrate the ECD. Compound retention time and response data were stored in the data system, and subsequently used to identify and quantify the selected compounds in the samples. Essentially, each analyte has a known retention time and a known GC response to a calibrating concentration; therefore, the corresponding chromatogram peak for a sample run can be identified by retention time and quantified by comparison to the calibration response.

TABLE 4.1-1 SUMMARY OF CHEMICALS DETECTED IN SHALLOW GROUND
WATER AT SITE SS59, DOVER AFB

<u>Contaminant</u>	<u>Range Detected at Site ($\mu\text{g/L}$)</u>	<u>NPDWR^(a) ($\mu\text{g/L}$)</u>	<u>No. of Samples above NPDWR^(a)</u>
VOLATILES			
1,1,1-Trichloroethane	ND-42,000	200	42
1,1-Dichloroethane	ND-1,100	NA ^(b)	--- ^(c)
1,1-Dichloroethene	ND-6,800	7	57
1,2-Dichloroethane	ND-340	5	29
1,2-Dichloroethene (total)	ND-32,000	^(f)	34
Methyl Ethyl Ketone ^(d)	ND-970	NA	---
4-Methyl-2-Pentanone	ND-100	NA	---
Acetone	ND-2,400	NA	---
Benzene	ND-170	5	11
Carbon Disulfide	ND-43	NA	---
Carbon Tetrachloride	ND-7,600	5	3
Chloroethane	ND-9	NA	---
Methylene Chloride	ND-5,200	5	35
Tetrachloroethene	ND-820	5	27
Trichloroethane	ND-14,000	5	64
Vinyl Chloride	ND-300	2	24
Chloroform	ND-2	^(e)	---
Bromodichloromethane	ND-5	^(e)	---

(a) Per National Primary Drinking Water Regulations (NPDWR) under the Safe Drinking Water Act. NPDWR values are used as a point of reference; 90% removal of the contaminants of concern is the ARAR.

(b) NA = Not Available.

(c) --- = Not Applicable.

(d) Also known as 2-Butanone.

(e) NPDWR for Total Trihalomethanes is 100 $\mu\text{g/L}$.

(f) Based upon individual NPDWRs for cis-1,2-Dichloroethene (70 $\mu\text{g/L}$) and trans-1,2-Dichloroethene (100 $\mu\text{g/L}$)

(g) All pesticide data except Lindane is from 1993 analyses of ground-water samples.

(h) These chemicals are secondary contaminants that do not adversely impact public health.

ND: Not Detected

Source: Dames & Moore, Quarterly Ground-Water Monitoring Data Reports (March 1990, April 1991, November 1991, March 1992, 1 September 1992, and 11 September 1992), and additional EA data through 11/93.

TABLE 4.1-1 SUMMARY OF CHEMICALS DETECTED IN
SHALLOW GROUND WATER AT SITE SS-59, DOVER AFB (Cont.)

<u>Contaminant</u>	<u>Range Detected at Site ($\mu\text{g/L}$)</u>	<u>NPDWR^(a) ($\mu\text{g/L}$)</u>	<u>No. of Samples above NPDWR^(a)</u>
1,1,2-Trichloroethane	ND-4	5	0
Toluene	ND-28	1000	0
Chlorobenzene	ND-86	100	0
Ethylbenzene	ND-15	700	0
Xylenes (total)	ND-37	10,000	0
SEMIVOLATILES			
Phenol	ND-440	NA	---
PESTICIDES ^(g)			
Lindane	0.290-88	0.2	8
alpha-BHC	0.600-2.300	NA	---
beta-BHC	0.170-0.320	NA	---
delta-BHC	1.100-2.800	NA	---
Aldrin	ND-0.017	NA	---
Heptachlor Epoxide	0.016-0.086	0.2	0
Endosulfan I	ND-0.023	NA	---
Endosulfan II	0.008-0.028	NA	---
4.4'-DDD	0.013-0.069	NA	---

(a) Per National Primary Drinking Water Regulations (NPDWR) under the Safe Drinking Water Act. NPDWR values are used as a point of reference; 90% removal of the contaminants of concern is the ARAR.

(b) NA = Not Available.

(c) --- = Not Applicable.

(d) Also known as 2-Butanone.

(e) NPDWR for Total Trihalomethanes is 100 $\mu\text{g/L}$

(f) Based upon individual NPDWRs for cis-1,2-Dichloroethene (70 $\mu\text{g/L}$) and trans-1,2-Dichloroethene (100 $\mu\text{g/L}$)

(g) All pesticide data except Lindane is from 1993 analyses of ground-water samples.

(h) These chemicals are secondary contaminants that do not adversely impact public health.

ND: Not Detected

Source: Dames & Moore, Quarterly Ground-Water Monitoring Data Reports (March 1990, April 1991, November 1991, March 1992, 1 September 1992, and 11 September 1992), and additional EA data through 11/93.

TABLE 4.1-1 SUMMARY OF CHEMICALS DETECTED IN
SHALLOW GROUND WATER AT SITE SS-59, DOVER AFB (Cont.)

<u>Contaminant</u>	<u>Range Detected at Site ($\mu\text{g/L}$)</u>	<u>NPDWR^(a) ($\mu\text{g/L}$)</u>	<u>No. of Samples above NPDWR^(a)</u>
Endosulfan Sulfate	ND-0.031	NA	---
4'4'-DDT	ND-0.018	NA	---
METALS - TOTAL			
Aluminum ^(h)	73.5-117,000	---	---
Iron ^(h)	47.3---166,000	---	---
Lead	3.5---92	15	11
Manganese ^(h)	21---2,120	---	---
Sodium ^(h)	5,060---39,700	---	---
METALS - DISSOLVED			
	<u>Maximum Conc.</u>	<u>Mean Conc.</u>	<u>No. of Detections</u>
Iron ^(h)	29300	3758	31
Magnesium	21900	6233	83
Manganese ^(h)	4760	233	83

(a) Per National Primary Drinking Water Regulations (NPDWR) under the Safe Drinking Water Act. NPDWR values are used as a point of reference; 90% removal of the contaminants of concern is the ARAR.

(b) NA = Not Available.

(c) --- = Not Applicable.

(d) Also known as 2-Butanone.

(e) NPDWR for Total Trihalomethanes is 100 $\mu\text{g/L}$

(f) Based upon individual NPDWRs for cis-1,2-Dichloroethene (70 $\mu\text{g/L}$) and trans-1,2-Dichloroethene (100 $\mu\text{g/L}$)

(g) All pesticide data except Lindane is from 1993 analyses of ground-water samples.

(h) These chemicals are secondary contaminants that do not adversely impact public health.

ND: Not Detected

Source: Dames & Moore, Quarterly Ground-Water Monitoring Data Reports (March 1990, April 1991, November 1991, March 1992, 1 September 1992, and 11 September 1992), and additional EA data through 11/93.

TABLE 4.1-2 SUMMARY OF CHEMICALS DETECTED IN DEEP GROUND WATER AT SITE SS59,
DOVER AFB

<u>Contaminant</u>	<u>Range Detected at Site ($\mu\text{g/L}$)</u>	<u>NPDWR^(a) ($\mu\text{g/L}$)</u>	<u>No. of Samples above NPDWR^(a)</u>
VOLATILES			
1,1,1-Trichloroethane	ND-3,700	200	39
1,1-Dichloroethane	ND-380	NA ^(b)	--- ^(c)
1,1-Dichloroethene	ND-2,100	7	49
1,2-Dichloroethane	ND-110	5	21
1,2-Dichloroethene (total)	ND-2,400	^(g)	41
Methyl Ethyl Ketone ^(d)	ND-53	NA	---
Acetone	ND-4,700	NA	---
Benzene	ND-11	5	2
Carbon Disulfide	ND-320	NA	---
Carbon Tetrachloride	ND-390	5	5
Methylene Chloride	ND-250	5	41
Tetrachloroethene	ND-940	5	56
Trichlorethene	ND-7,200	5	51
Vinyl Chloride	ND-240	2	17
Chloroform	ND-37	^(f)	---
Toluene	ND-6	1,000	0
Bromodichloromethane	ND-4	^(f)	---
Chloroethane	ND-17	NA	---
4 Methyl-2-Pentanone	ND-6	NA	---

(a) Per National Primary Drinking Water Regulation (NPDWR) under the Safe Drinking Water Act. NPDWR values are used as a point of reference; 90% removal of the contaminants of concern is the ARAR.

(b) NA = Not Available.

(c) --- = Not Applicable.

(d) Also known as 2-Butanone.

(e) Results are for total metals.

(f) NPDWR for Total Trihalomethanes is 100 $\mu\text{g/L}$

(g) Based upon individual NPDWRs for cis-1,2-Dichloroethene (70 $\mu\text{g/L}$) and trans-1,2-Dichloroethene (100 $\mu\text{g/L}$)

(h) All pesticide data except Lindane is from 1993 analyses of ground-water samples.

(i) These chemicals are secondary contaminants that do not adversely impact public health.

ND: Not Detected

Source: Dames & Moore, Quarterly Ground-water Monitoring Data Results (March 1990, April 1991, November 1991, March 1992, 1 September 1992, and 11 September 1992), and additional EA data through 11/93.

TABLE 4.1-2 SUMMARY OF CHEMICALS DETECTED IN DEEP GROUNDWATER AT SITE SS59,
DOVER AFB (Continued)

<u>Contaminant</u>	<u>Range Detected at Site ($\mu\text{g/L}$)</u>	<u>NPDWR^(a) ($\mu\text{g/L}$)</u>	<u>No. of Samples above NPDWR^(a)</u>
Ethylbenzene	ND-2	700	0
Xylenes (total)	ND-7	10,000	0
PESTICIDES ^(h)			
Lindane	0.042-1.3	0.2	3
alpha-BHC	0.018-0.060	NA	---
beta-BHC	0.021-0.096	NA	---
delta-BHC	0.019-0.130	NA	---
Heptachlor	ND-0.005	0.4	0
Heptachlor Epoxide	ND-0.007	0.2	0
Endosulfan I	ND-0.004	NA	---
Dieldrin	ND-0.003	NA	---
4,4'-DDE	ND-0.012	NA	---
Endrin	ND-0.005	2	0
4,4'-DDD	ND-0.500	NA	---
Endosulfan Sulfate	ND-0.004	NA	---
4'4-DDT	ND-0.028	NA	---
SEMIVOLATILES			
Phenol	ND-70	NA	---

(a) Per National Primary Drinking Water Regulation (NPDWR) under the Safe Drinking Water Act. NPDWR values are used as a point of reference; 90% removal of the contaminants of concern is the ARAR.

(b) NA = Not Available.

(c) --- = Not Applicable.

(d) Also known as 2-Butanone.

(e) Results are for total metals.

(f) NPDWR for Total Trihalomethanes is 100 $\mu\text{g/L}$

(g) Based upon individual NPDWRs for cis-1,2-Dichloroethene (70 $\mu\text{g/L}$) and trans-1,2-Dichloroethene (100 $\mu\text{g/L}$)

(h) All pesticide data except Lindane is from 1993 analyses of ground-water samples.

(I) These chemicals are secondary contaminants that do not adversely impact public health.

ND: Not Detected

Source: Dames & Moore, Quarterly Ground-water Monitoring Data Results (March 1990, April 1991, November 1991, March 1992, 1 September 1992, and 11 September 1992), and additional EA data through 11/93.

TABLE 4.1-2 SUMMARY OF CHEMICALS DETECTED IN DEEP GROUNDWATER AT SITE SS59,
DOVER AFB (Continued)

<u>Contaminant</u>	<u>Range Detected at Site ($\mu\text{g/L}$)</u>	<u>NPDWR^(a) ($\mu\text{g/L}$)</u>	<u>No. of Samples above NPDWR^(a)</u>
METALS ^(e)			
Aluminum ⁽ⁱ⁾	261-9,625	---	---
Iron ⁽ⁱ⁾	156-10,340	---	---
Lead	55.8-96.8	15	2
Manganese ⁽ⁱ⁾	17-365	---	---
Sodium ⁽ⁱ⁾	8,040-22,250	---	---

(a) Per National Primary Drinking Water Regulation (NPDWR) under the Safe Drinking Water Act. NPDWR values are used as a point of reference; 90% removal of the contaminants of concern is the ARAR.

(b) NA = Not Available.

(c) --- = Not Applicable.

(d) Also known as 2-Butanone.

(e) Results are for total metals.

(f) NPDWR for Total Trihalomethanes is 100 $\mu\text{g/L}$

(g) Based upon individual NPDWRs for cis-1,2-Dichloroethene (70 $\mu\text{g/L}$) and trans-1,2-Dichloroethene (100 $\mu\text{g/L}$)

(h) All pesticide data except Lindane is from 1993 analyses of ground-water samples.

(i) These chemicals are secondary contaminants that do not adversely impact public health.

ND: Not Detected

Source: Dames & Moore, Quarterly Ground-water Monitoring Data Results (March 1990, April 1991, November 1991, March 1992, 1 September 1992, and 11 September 1992), and additional EA data through 11/93.

Concurrent with compounds eluting from the GC column, the integrator printed out a chromatogram, which is a continuous graph of the GC detector response to the eluting compounds. Subsequently, a numerical summary of peak areas with corresponding compound identifications and concentrations was printed. Unknown peaks were quantified only by peak area.

Data reduction was accomplished by the onsite environmental chemist and subsequently verified by another environmental chemist.

4.2.2 QA/QC

Data quality needs were determined by the specified compound reporting limits and the Quality Assurance/Quality Control (QA/QC) protocols required by the analytical methods used. In order to maintain GC analysis QA/QC, vapor standards were analyzed at the beginning of each day and thereafter at least once every 10 samples. A system blank and an ambient air (syringe) blank was analyzed, minimally, at the beginning and end of each day. Vapor samples were analyzed in duplicate at least once every 10 samples, chronologically. Matrix spikes were analyzed every 20 samples.

4.2.3 Results

Monitoring well headspace concentrations, as measured with an HNu photoionization detector during the extended pilot study, are presented in Table 4.2-1. Headspace concentrations generally ranged from ND to 16.0 ppm for most dates of sampling (SMW45-2P; 1 September 1994); however, during the sampling event on 8 July 1994, headspace concentrations ranged from ND to 340 ppm.

Soil vapor samples were collected from the vadose zone monitoring points (VMWs and direct push locations) during the initial, mid-term, and final sampling events (Tables 4.2-2 through 4.2-4, respectively). Carbon tetrachloride was not identified in the soil gas samples during the three sampling events. BTEX compounds were non-detect in almost every soil gas sample during the three sampling events. Overall, the AAS/SVE system was efficient at removing vapor-phase contaminants from the vadose zone. Total VOC concentrations in the individual wells for the initial, mid-term, and final sampling events ranged from 0.016 to 273.137 ppm_v (DP-12), 0.014 to 344.187 ppm_v (DP-12), and non-detect to 0.661 ppm_v (VMW10-2P), respectively. Average total VOC concentrations (with standard deviations of those data) were 23.290 ± 53.364 ppm_v, 17.284 ± 45.260 ppm_v, and 0.120 ± 0.172 ppm_v for the initial, mid-term, and final sampling events, respectively. This represents a 99.4% reduction in the average level of the primary COCs within the vadose zone between the initial and final sampling events. Decreases in total VOC concentrations ranging from 87% to 99.99% were observed in all soil gas monitoring points within the 45 ft ROI (Table 4.2-5). In most of the samples collected during the initial and mid-term sampling events, methylene chloride and the two DCE isomers provided the greatest contribution to the total VOCs observed. The reported concentrations for these compounds during the final sampling event were reduced by one to three orders of magnitude as compared to the earlier data. This level of vapor extraction is a critical component

Table 4.2-1
Monitoring Well Headspace Concentrations (ppm-v) During the
Extended AAS/SVE Pilot Study - Site SS59 - Dover AFB, Delaware

Well	15 JUNE 93 (ppm-v)	28 JUNE 94 (ppm-v)	1 JULY 94 (ppm-v)	1 AUG 94 (ppm-v)	15 AUG 94 (ppm-v)	1 SEP 94 (ppm-v)	22 SEP 94 (ppm-v)	5 JAN 95 (ppm-v)
SMW-75-1P	0.4	0.5	2.2	ND	0.5	2.5	4.1	ND
VMW-75-1P	0.5	ND	340	ND	ND	2.1	7.2	ND
SMW-45-1P	0.5	1.0	131	1.0	1.0	3.2	14.3	0.1
VMW-45-1P	0.6	0.2	292	0.5	1.0	2.5	8.7	0.2
SMW-25-1P	0.5	1.2	36	1.0	1.0	1.6	8.9	0.2
VMW-25-1P	0.7	0.8	190	0.8	0.5	2.4	10.1	0.2
SMW-10-1P	0.7	1.4	0.9	1.2	0.1	1.5	8.7	1.0
VMW-10-1P	0.3	0.8	ND	1.6	0.2	1.8	4.8	1.0
SMW-10-1	0.9	1.2	1.2	2.0	0.5	3.2	6.5	1.5
VMW-10-1	0.4	0.4	ND	1.8	0.5	4.3	4.2	1.2
SMW-25-1	1.1	1.0	126	2.2	0.4	4.1	4.1	0.8
VMW-25-1	0.8	0.6	ND	0.8	ND	2.8	3.2	0.5
SMW-45-1	0.8	1.0	ND	2.2	0.2	3.6	3.7	0.4
VMW-45-1	0.4	0.4	ND	0.6	0.4	3.2	3.8	0.6
SMW-75-1	0.6	1.2	5.6	2.0	ND	1.5	4.1	0.2
VMW-75-1	0.6	0.2	ND	1.8	0.2	1.0	2.8	0.4
SVE-1	NS	NS	NS	NS	NS	NS	NS	ND
SMW-75-2	1.2	1.2	ND	2.5	0.2	3.4	3.7	NS
VMW-75-2	1.2	0.4	5.0	1.6	ND	2.1	4.1	NS
SMW-45-2	0.4	1.4	ND	2.0	ND	4.9	3.9	NS
VMW-45-2	1.0	0.6	ND	0.2	0.1	4.1	3.8	NS
SMW-20-2	0.7	1.2	ND	2.0	ND	4.1	3.2	NS
VMW-20-2	1.1	0.8	ND	2.7	ND	3.8	3.1	NS
SMW-10-2	0.8	1.0	ND	2.4	0.2	4.8	2.6	NS
VMW-10-2	0.7	1.2	ND	2.8	0.2	3.4	2.8	NS
SMW-10-2P	1.2	1.2	340	0.4	ND	7.6	6.0	NS
VMW-10-2P	1.2	1.0	ND	2.6	ND	8.2	5.5	NS
SMW-34-2P	1.1	1.4	8.1	0.3	1.0	9.6	6.7	NS
VMW-34-2P	0.8	1.0	340	0.2	2.0	9.2	6.3	NS
SMW-45-2P	0.9	1.2	ND	0.2	0.2	16.0	6.1	NS
VMW-45-2P	0.9	0.8	ND	0.2	0.2	14.2	5.4	NS
SMW-75-2P	1.1	0.8	ND	ND	1.0	3.7	3.2	NS
VMW-75-2P	1.2	0.7	ND	ND	ND	2.1	3.1	NS
SVE-2	NS	NS	NS	NS	NS	NS	NS	ND

ND = Not Detected

NS = Not Sampled

Notes: On 4 Aug 94, only the SVE system was in operation.

Headspace concentrations were taken using a HNu photoionization detector.

**INITIAL SOIL VAPOR VOC CONCENTRATIONS
MAY TO JUNE 1994 - SITE SS59 - DOVER AFB, DELAWARE**

DP = Direct Push Sample Location ND = Not Detected

"<#" = sample concentration was identified to be less than the detection limit (#)

MC	t-DCE	c-DCE	TCA	CT	PCE	Avg. ECD	BENZENE	TOLUENE	E-BENZ	m-p-XYL	o-XYL	Avg. BTEX	Avg. Total
19.597	2.784	0.280	0.327	ND	0.196	23.215	0.036	ND	ND	ND	0.039	0.075	23.290

Table 4.2-3
MID-TERM SOIL VAPOR VOC CONCENTRATIONS
October 1994 - SITE SS99 - DOVER AFB, DELAWARE

SAMPLE	CHLORINATED COMPOUNDS FROM ECD (PPM-V)				VOCs				HYDROCARBON COMPOUNDS FROM FID (PPM-V)				Total VOCs																																										
	MC	1-DCE	c-DCE	TCA	CT	TCF	PCE	Total ECD	BENZENE	TOLUENE	E-BENZ	m,p-XYL	Total BTEX																																										
VP-8	1.705	<0.1	<0.1	0.064	<0.001	0.218	0.522	2.509	<0.1	<0.1	<0.1	0.221	0.221																																										
VP-9	25.385	<0.1	0.975	0.119	<0.001	0.426	0.748	27.652	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-10	0.700	<0.1	0.534	0.085	<0.001	0.248	0.282	1.810	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-11	<0.1	<0.1	<0.1	0.014	<0.001	<0.001	<0.001	0.014	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-12	13.475	<0.1	0.508	0.508	<0.001	4.651	1.343	19.977	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-13	193.360	39.043	32.561	1.393	<0.001	31.548	6.456	304.352	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-5	2.038	<0.1	<0.1	0.292	<0.001	1.847	1.740	2.717	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-4	0.647	<0.1	<0.1	0.144	<0.001	0.773	1.191	2.756	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-2	54.345	<0.1	<0.1	0.081	<0.001	0.448	0.051	54.925	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-1	5.049	<0.1	<0.1	0.214	<0.001	0.579	0.477	6.320	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-3	5.054	<0.1	1.770	0.270	<0.001	0.733	1.763	9.589	<0.1	<0.1	<0.1	<0.1	ND																																										
VP-6	1.145	<0.1	<0.1	0.215	<0.001	0.475	0.683	1.517	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW75-2P	13.978	2.101	21.192	0.532	<0.001	2.447	4.243	44.494	0.157	<0.1	<0.1	<0.1	0.157																																										
SMW75-2P	6.958	<0.1	9.030	0.422	<0.001	1.602	3.562	21.574	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW45-2P	20.859	0.178	10.189	0.427	<0.001	2.658	3.871	38.183	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW45-2P	15.077	<0.1	5.846	0.395	<0.001	2.319	3.914	27.350	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW34-2P	2.566	<0.1	<0.1	0.167	<0.001	1.185	1.249	5.168	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW34-2P	15.180	<0.1	5.377	0.407	<0.001	2.766	3.087	26.798	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW10-2P	3.414	<0.1	<0.1	0.182	<0.001	1.840	3.258	8.694	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW10-2P	1.964	<0.1	<0.1	0.148	<0.001	1.296	2.791	6.200	<0.1	<0.1	<0.1	<0.1	ND																																										
SVE2	1.969	<0.1	<0.1	0.051	<0.001	0.337	0.323	2.680	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW10-2	1.476	<0.1	<0.1	0.115	<0.001	1.131	2.522	5.243	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW10-2	2.428	<0.1	<0.1	0.086	<0.001	0.791	1.836	5.142	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW20-2	5.037	<0.1	<0.1	0.127	<0.001	1.345	3.250	9.749	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW20-2	3.071	<0.1	<0.1	0.283	<0.001	2.702	2.844	6.528	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW45-2	0.472	<0.1	<0.1	0.202	<0.001	1.959	4.959	11.025	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW45-2	2.158	<0.1	<0.1	0.170	<0.001	1.127	1.740	5.184	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW75-2	33.096	<0.1	<0.1	0.461	<0.001	3.673	5.349	42.580	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW75-1	3.201	<0.1	<0.1	0.122	<0.001	1.349	1.272	5.945	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW45-1	0.556	<0.1	<0.1	0.194	<0.001	1.615	1.806	6.159	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW45-1	2.110	<0.1	<0.1	0.187	<0.001	2.247	3.534	6.524	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW25-1	<0.1	<0.1	<0.1	0.142	<0.001	1.190	2.732	6.175	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW25-1	3.077	<0.1	<0.1	0.138	<0.001	1.175	2.175	3.488	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW10-1	2.533	<0.1	0.219	0.020	<0.001	0.447	1.094	4.858	<0.1	<0.1	<0.1	<0.1	ND																																										
SVE1	<0.1	<0.1	0.557	0.015	<0.001	0.466	0.628	4.200	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW10-1P	3.068	<0.1	<0.1	0.004	<0.001	0.047	0.189	0.240	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW25-1P	3.391	<0.1	<0.1	0.063	<0.001	2.080	0.765	5.976	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW75-1P	1.707	<0.1	1.329	0.023	<0.001	0.982	0.690	6.396	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW45-1P	5.704	<0.1	1.205	0.021	<0.001	0.792	0.519	41.750	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW34-1P	2.227	<0.1	<0.1	0.019	<0.001	0.838	0.177	6.510	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW45-1P	1.824	<0.1	0.198	0.016	<0.001	0.610	0.177	6.510	<0.1	<0.1	<0.1	<0.1	ND																																										
SMW75-1P	0.754	<0.1	0.249	0.018	<0.001	0.539	0.519	3.137	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW75-1P	0.779	<0.1	0.204	0.006	<0.001	0.074	0.015	1.053	<0.1	<0.1	<0.1	<0.1	ND																																										
VMW75-1P(Dup)	0.145	<0.1	<0.1	0.010	<0.001	0.116	0.089	0.993	<0.1	<0.1	<0.1	<0.1	ND																																										
VP (Dup)	216.754	18.625	13.433	4.261	<0.001	76.226	14.887	344.187	<0.1	<0.1	<0.1	<0.1	ND																																										
Average (ppm-v)																																																							
VP = Vapor Probe ND = Not Detected																																																							
<#* = sample concentration was identified to be less than the detection limit (#)																																																							
<table> <tr> <th colspan="4">CHLORINATED COMPOUNDS FROM ECD (PPM-V)</th><th colspan="4">VOCs</th><th colspan="4">HYDROCARBON COMPOUNDS FROM FID (PPM-V)</th><th colspan="2">Total VOCs</th></tr> <tr> <th>MC</th><th>1-DCE</th><th>c-DCE</th><th>TCA</th><th>CT</th><th>TCF</th><th>PCE</th><th>Total ECD</th><th>BENZENE</th><th>TOLUENE</th><th>E-BENZ</th><th>m,p-XYL</th><th>Total BTEX</th><th>Avg. Total</th></tr> <tr> <td>11.016</td><td>0.898</td><td>1.988</td><td>0.189</td><td>ND</td><td>1.895</td><td>1.858</td><td>17.844</td><td>0.003</td><td>ND</td><td>ND</td><td>0.005</td><td>0.008</td><td>17.852</td></tr> </table>														CHLORINATED COMPOUNDS FROM ECD (PPM-V)				VOCs				HYDROCARBON COMPOUNDS FROM FID (PPM-V)				Total VOCs		MC	1-DCE	c-DCE	TCA	CT	TCF	PCE	Total ECD	BENZENE	TOLUENE	E-BENZ	m,p-XYL	Total BTEX	Avg. Total	11.016	0.898	1.988	0.189	ND	1.895	1.858	17.844	0.003	ND	ND	0.005	0.008	17.852
CHLORINATED COMPOUNDS FROM ECD (PPM-V)				VOCs				HYDROCARBON COMPOUNDS FROM FID (PPM-V)				Total VOCs																																											
MC	1-DCE	c-DCE	TCA	CT	TCF	PCE	Total ECD	BENZENE	TOLUENE	E-BENZ	m,p-XYL	Total BTEX	Avg. Total																																										
11.016	0.898	1.988	0.189	ND	1.895	1.858	17.844	0.003	ND	ND	0.005	0.008	17.852																																										

Table 4.2-5

Changes in Soil Gas VOC Concentrations within the 45 ft ROI
Dover AFB Site SS59 Extended AAS/SVE Pilot Study

	%Change	Decrease	No Change	Increase		%Change	Decrease	No Change	Increase
45 ft					45 ft				
VMW45-1	-98.29%	1			VMW45-2	-98.99%	1		
VMW45-1P	-99.26%	1			VMW45-2P	-99.84%	1		
SMW45-1	-99.87%	1			SMW45-2	-99.69%	1		
SMW45-1P	-97.74%	1			SMW45-2P	-97.68%	1		
DP-8 (44 ft)	-99.33%	1							
20-34 ft					20-34 ft				
VMW25-1	-99.76%	1			VMW34-2P	-98.98%	1		
VMW25-1P	-99.45%	1			SMW34-2P	-90.87%	1		
SMW25-1	-99.00%	1			VMW20-2	-96.98%	1		
SMW25-1P	-99.95%	1			SMW20-2	-98.68%	1		
DP-12 (24 ft)	-99.98%	1			DP-2 (20 ft)	-99.99%	1		
10-15 ft					10-15 ft				
VMW10-1	-98.25%	1			VMW10-2	-97.61%	1		
VMW10-1P	-99.69%	1			VMW10-2P	-86.98%	1		
SMW10-1	-99.83%	1			SMW10-2	-99.32%	1		
SMW10-1P	-99.61%	1			SMW10-2P	-98.39%	1		
DP-11 (12 ft)	-99.99%	1			DP-1 (15 ft)	-99.90%	1		
					DP-4 (15 ft)	-99.88%	1		
					DP-5 (15 ft)	-99.60%	1		
TOTAL		15	0	0			16	0	0

notes:

"No Change" indicates initial and final VOC concentrations within 5%.
 Shallow monitoring well data represent the mid- and final-term sampling events.
 Percent changes are determined from the data presented in Tables 4.2-2 to 4.2-4.

SUMMARY of Soil Gas Results for the Wells within the 45 ft ROI

Distance	# decrease	# same	# increase	% decrease	% same	% increase
45 ft	9	0	0	100%	0%	0%
20-34 ft	10	0	0	100%	0%	0%
10-15 ft	12	0	0	100%	0%	0%
TOTAL	31	0	0	100%	0%	0%

for efficient application of combined AAS and SVE technologies. The efficiency of air sparging, as indicated from the degree of ground-water remediation, is discussed in Sections 4.3 and 5.5.

4.3 GROUND WATER

4.3.1 Methodology

Ground-water samples were collected from each of the shallow and deep monitoring wells in Test Areas 1 and 2. Procedures followed those outlined in Section 3.2.2. This sampling was performed during three separate events: once at the commencement of the study (June 1994), mid-way through the study (October 1994), and at the end of the study (January 1995). Samples were analyzed by the procedures outlined in Section 4.2.1 by an environmental chemist with an onsite GC.

4.3.2 QA/QC

Data quality needs were determined by the specified compound reporting limits and the Quality Assurance/Quality Control (QA/QC) protocols required by the analytical methods used. In order to maintain GC analysis QA/QC, aqueous standards were analyzed at the beginning of each day and thereafter at least once every 10 samples. A system blank and a DI water blank were analyzed, minimally, at the beginning and end of each day. Aqueous samples were analyzed in duplicate at least once every 10 samples, chronologically. Matrix spikes were analyzed every 20 samples.

4.3.3 Results

Summaries of the analytical results for total VOCs in ground-water samples which were collected during the initial, mid-term, and final sampling events are presented in Tables 4.3-1 and 4.3-2. In these tables, a positive percent change indicates a net increase in the ground-water VOC concentration over when comparing the final (January 1995) to the initial (June 1994) analyses. Similarly, a negative percent change indicates a net decrease in VOC concentrations. These values can be taken as an indication of the mobilization/migration or remediation, respectively, of the COCs within the aquifer. The detailed chemical data for the individual VOCs identified in ground water are presented in Tables F.4-1 through F.4-8 (Appendix F). These data are summarized with respect to monitoring location and sampling event in Table F.4-9 (Appendix F).

Variable increases and decreases in dissolved VOC concentrations were observed in both test areas over the duration of the extended pilot study. In Test Area 1, the changes in ground-water VOC concentrations ranged from a 97.2% decrease (AAS-1; from 23,260 µg/L to 656 µg/L) to a 10,571% increase (DMW75-1P; from 7 to 747 µg/L). In Test Area 2, dissolved VOC concentrations ranged from a 77.5% reduction (SMW75-2P; from 249 to 56 µg/L) to a 485.6% increase (DMW34-2P; from 354 to 2,073 µg/L). The increases which were observed in ground-water VOC concentrations still may represent a beneficial and necessary aspect of ground-water

TABLE 4.3-1 SUMMARY OF THE CHANGES IN CHEMICAL CONCENTRATIONS
IN GROUND-WATER SAMPLES FOR TEST AREA NO. 1, SITE SS59,
DOVER AFB, DELAWARE

Deep Monitoring Points				Shallow Monitoring Points			
	Sample Well	TOTAL*	% CHANGE		Sample Well	TOTAL*	% CHANGE
(1)	DMW75-1	161	-18.6		SMW75-1	ND	Increase**
(2)		292.9				18.1	
(3)		131				39	
(1)	DMW45-1	490	-63.1		SMW45-1	19	-36.8
(2)		489.7				32.3	
(3)		181				12	
(1)	DMW25-1	1394	2.7		SMW25-1	12	266.7
(2)		763.7				55.3	
(3)		1432				44	
(1)	DMW10-1	951	-95.3		SMW10-1	7	485.7
(2)		665				61.9	
(3)		45				41	
(1)	AAS1	23260	-97.2				
(2)		2724.1					
(3)		656					
(1)	DMW10-1P	615	1.5		SMW10-1P	10	90.0
(2)		682.4				61.8	
(3)		624				19	
(1)	DMW25-1P	59	779.7		SMW25-1P	10	190.0
(2)		490.2				186.9	
(3)		519				29	
(1)	DMW45-1P	20	2235.0		SMW45-1P	17	17.6
(2)		354.6				93.9	
(3)		467				20	
(1)	DMW75-1P	7	10571.4		SMW75-1P	ND	Increase**
(2)		78.9				53.9	
(3)		747				9	

Notes: ND = Not Detected

* - Totals represent the summation of chlorinated VOC and BTEX concentrations.

** - Cannot determine %change (division by zero).

(1) = Initial Ground-Water Chemical Results (ug/L) (June 1994)

(2) = Mid-Term Ground-Water Chemical Results (ug/L) (October 1994)

(3) = Final Ground-Water Chemical Results (ug/L) (January 1995)

% CHANGE = ((AT-BT)/BT) * 100

where BT = Before Test (1) Total VOC Chemical Results (ug/L)

AT = After Test (3) Total VOC Chemical Results (ug/L)

TABLE 4.3-2 SUMMARY OF THE CHANGES IN CHEMICAL CONCENTRATIONS
IN GROUND-WATER SAMPLES FROM TEST AREA NO. 2, SITE SS59,
DOVER AFB, DELAWARE

<u>Deep Monitoring Points</u>				<u>Shallow Monitoring Points</u>			
	Sample Well	TOTAL*	% CHANGE		Sample Well	TOTAL*	% CHANGE
(1)	DMW75-2	4388	-37.6	(1)	SMW75-2	51	11.8
(2)		1412.2		(2)		147.7	
(3)		2740		(3)		57	
(1)	DMW45-2	3477	-1.2	(1)	SMW45-2	57	100.0
(2)		526.9		(2)		219.2	
(3)		3435		(3)		114	
(1)	DMW20-2	1060	37.0	(1)	SMW20-2	5	320.0
(2)		826.8		(2)		29.3	
(3)		1452		(3)		21	
(1)	DMW10-2	2054	-43.1	(1)	SMW10-2	43	-44.2
(2)		1400.9		(2)		4.2	
(3)		1168		(3)		24	
(1)	AAS2	1643	-35.7				
(2)		10991.8					
(3)		1056					
(1)	DMW10-2P	836	24.5	(1)	SMW10-2P	94	-69.1
(2)		1526.9		(2)		85.1	
(3)		1041		(3)		29	
(1)	DMW34-2P	354	485.6	(1)	SMW34-2P	1831	-89.6
(2)		1908.3		(2)		370.6	
(3)		2073		(3)		191	
(1)	DMW45-2P	1413	467.2	(1)	SMW45-2P	DRY	NA
(2)		1898.3		(2)		DRY	
(3)		8014		(3)		DRY	
(1)	DMW75-2P	928	233.6	(1)	SMW75-2P	249	-77.5
(2)		2154.2		(2)		309.4	
(3)		3096		(3)		56	

Notes: NA = Not Available

* - Totals represent the summation of chlorinated VOC and BTEX concentrations.

(1) = Initial Ground-Water Chemical Results (ug/L) (June 1994)

(2) = Mid-Term Ground-Water Chemical Results (ug/L) (October 1994)

(3) = Final Ground-Water Chemical Results (ug/L) (January 1995)

% CHANGE = ((AT-BT)/BT) * 100

where BT = Before Test (1) Total VOC Chemical Results (ug/L)

AT = After Test (3) Total VOC Chemical Results (ug/L)

remediation via AAS/SVE. This benefit is realized through the solubilization or desorption of adsorbed-phase contaminants resulting from increased circulation of ground water following air injection. By increasing the volume of water which passes over adsorbed- or non-aqueous-phase contaminants, the driving forces for mass transfer are increased and the concentrations of COCs in ground water can be expected to increase. With the presence of adsorbed-phase COCs, this would be a necessary first step for the remediation of Site SS59. Following the transformation to an aqueous phase, the COCs would then be available for volatilization and removal by SVE. Ground-water VOC concentrations would remain in an elevated state due to inadequate sparging. Additional sparge wells would act to enhance the removal of COCs.

As expected, a reduction in ground-water VOC concentrations was observed in the vicinity of the sparge wells in both test areas. The ability of AAS to vaporize the aqueous contaminants was reduced at greater distances from the point of injection. This was expected based upon mass transfer restrictions between the aqueous- and vapor-phases. At greater distances, the volume of soil which was required to be contacted by the injected air increased geometrically. Thus, the volume and flow rate of the injected air decreased such that the frequency of air/contaminant contact and the driving force for mass transfer to the vapor phase was reduced. Accordingly, although some degree of influence was observed at distances up to 45 ft, decreased volatilization of the COCs was affected due to the decreased intensity of sparging (i.e., the volume and flow rate of air) at greater distances. Additionally, the air which had reached the further monitoring points had already been in contact with contaminated soils. Thus, some degree of volatilized COCs were present in the air flow and a driving force for mass transfer (i.e., the concentration gradient) was reduced. Standard designs for full-scale AAS/SVE systems incorporate a series of sparge wells which are placed such that the ROIs partially overlap. This acts to maintain adequate volumes and flow rates of injected (clean) air as well as minimizing the occurrence of "dead spaces" (areas not reached by AAS due to flow channeling or gaps in the overlapping of ROIs where there is liquid phase diffusion limited operation).

Based upon the deep monitoring well data, total VOC concentrations appeared to decrease only in the series of wells which were aligned parallel to ground-water flow. This is consistent with the data obtained (under equivalent flowrates) during the tracer gas study (Appendix A). For the shallow monitoring wells, decreases in total VOC concentrations were generally observed in Test Area 2 for the series wells which were aligned in the perpendicular direction. Ground-water samples were also collected from the direct-push and the deep geoprobes during the initial and final sampling events (Table 4.3-3). The deep geoprobes were only sampled during the initial sampling event. During the initial sampling, all of the direct-push samples were collected from the shallow aquifer. During the final sampling, five of the 10 probes were placed into the deep aquifer; thus, for these five samples, the degree of VOC removal could not be determined. From the remaining direct push samples, the changes in total ground-water VOC concentrations ranged from a 71.4% reduction (DP-12; Test Area 1; from 63 to 18 $\mu\text{g/L}$) to a 25.2% increase (DP-3; Test Area 2; from 69.5 to 87 $\mu\text{g/L}$). The data for the geoprobes and adjacent wells are presented in Table 4.3.4. Large differences which were observed (e.g. between DP-12 and MW-2HS) may reflect either the heterogeneity of the subject site, the presence of a preferential flow channels to the monitoring well, or potential losses of aqueous phase VOCs within the immediate vicinity of the monitoring well to the vadose zone (since the

well is screened across the water table and the well casing may act as a preferential flow channel for the injected air). Variable consistency was observed between the other data collected from the direct push or geoprobe locations as compared to the respective adjacent monitoring wells (Table 4.3-4). There did not appear to be a trend toward lower VOC concentrations in the monitoring wells with respect to the direct push samples found at similar distances from the sparge wells. Thus, it is unlikely that preferential flow paths are being created by the monitoring wells and the differences with respect to the probe locations may have been due to site heterogeneity (i.e., air movement and contaminant distribution).

Baseline dissolved oxygen (DO) readings collected prior to the commencement of the extended pilot study are presented in Table 4.3-5. Baseline DO readings were generally less than 4 ppm which is typical for most shallow ground waters. DO measurements which were performed over the duration of the extended pilot study are presented in Table 4.3-6. These DO concentrations ranged from 0.3 to 12.8 mg/L. As expected, the highest DO concentrations were observed in the vicinity of the sparge wells. A comparison of dissolved oxygen concentrations prior to any AAS/SVE pilot testing, compared to average DO concentrations over the extended treatability study test, shows that 20 of the 22 monitoring wells had a substantial increase in DO concentrations. The results are presented in Table 4.3-7. Depth measurements to the ground-water table also were collected over the duration of the pilot study and are presented in Table 4.3-8. Changes in ground-water elevations were related to seasonal fluctuations in ground water and could not be attributed to the extended pilot test.

4.4 OFFGAS ANALYSIS

4.4.1 Methodology

Off gas samples were collected into Tedlar bags from the SVE system prior to treatment with GAC. This sampling was performed over twelve separate sampling events during the study. Samples were analyzed for the COCs discussed in Section 4.1. Analyses were performed according to the procedures outlined in Section 4.2.1 by an environmental chemist with an onsite GC.

4.4.2 QA/QC

Data quality needs were determined by the specified compound reporting limits and the QA/QC protocols required by the analytical methods used. In order to maintain GC analysis QA/QC, vapor standards were analyzed at the beginning of each day and thereafter at least once every 10 samples. A system blank and an ambient air (syringe) blank was analyzed, minimally, at the beginning and end of each day. Vapor samples were analyzed in duplicate at least once every 10 samples chronologically.

4.4.3 Results

Off gas samples were collected from various points of the SVE system. This included separate off gas from the SVE-1 and SVE-2 wells, a combined SVE-1/SVE-2 off gas prior to GAC

TABLE 4.3-3 SUMMARY OF THE CHANGES IN CHEMICAL CONCENTRATIONS
IN GROUND-WATER FOR ADDITIONAL SAMPLES, SITE SS59,
DOVER AFB, DELAWARE

	WELL	D/S	TOTAL*	% CHANGE		WELL	D/S	TOTAL*	% CHANGE
(1)	DP-1	S	23.3	N/A	(1)	DP-7	S	5.3	13.2
(2)			NS		(2)			NS	
(3)			NS		(3)		S	6	
(1)	DP-2	S	29.4	N/A	(1)	DP-8	S	ND	N/A
(2)			NS		(2)			NS	
(3)			NS		(3)		D	179	
(1)	DP-3	S	69.5	25.2	(1)	DP-9	S	ND	N/A
(2)			NS		(2)			NS	
(3)		S	87		(3)		D	264	
(1)	DP-4	S	1.3	N/A	(1)	DP-10	S	ND	Increase**
(2)			NS		(2)			NS	
(3)		D	292		(3)		S	18	
(1)	DP-5	S	29.5	N/A	(1)	DP-11	S	ND	N/A
(2)			NS		(2)			NS	
(3)		D	893		(3)		D	2175	
(1)	DP-6	S	29.7	-36.0	(1)	DP-12	S	63	-71.4
(2)			NS		(2)			NS	
(3)		S	19		(3)		S	18	
(1)	DGP-1	D	1045	NA	(1)	211-S	S	1842.6	NA
(2)			NS		(2)			NS	
(3)			NS		(3)			NS	
(1)	DGP-2	D	1415	NA	(1)	211-D	D	1625.2	NA
(2)			NS		(2)			NS	
(3)			NS		(3)			NS	
(1)	DGP-3	D	28	NA	(1)				
(2)			NS		(2)				
(3)			NS		(3)				

Notes:

* - Totals represent the summation of chlorinated VOC and BTEX concentrations.

** - Cannot determine %change (division by zero).

(1) = Initial Ground-Water Chemical Results (ug/L) (June 1994)

(2) = Mid-Term Ground-Water Chemical Results (ug/L) (October 1994)

(3) = Final Ground-Water Chemical Results (ug/L) (January 1995)

% CHANGE = ((AT-BT)/BT) * 100

where BT = Before Test (1) Total VOC Chemical Results (ug/L)

AT = After Test (3) Total VOC Chemical Results (ug/L)

NS = Not Sampled

DP = Direct Push

ND = Not Detected

N/A = Not Applicable

DGP = Deep Geoprobe

D/S = Deep vs. Shallow Monitoring Point

TABLE 4.3-4 COMPARISON OF THE DIRECT PUSH PROBE AND MONITORING WELL GROUND-WATER DATA

First Event			Final Event	
DP Location	DP Concentration (ug/L)	MW Concentration (ug/L) (Well#)	DP Concentration (ug/L)	MW Concentration (ug/L) (Well#)
DP-5	29.5	43 (SMW10-2) or compare to 5 (SMW20-2)	893	1,168 (DMW10-2) or compare to 1,452 (DMW20-2)
DP-6	29.7	249 (SMW75-2P)	19	56 (SMW75-2P)
DP-8	ND	19 (SMW45-1)	179	181 (DMW45-1)
DP-9	1.0	51 (SMW75-2)	264	2,740 (DMW75-2)
DP-10	Stet.	17 (SMW45-1P)	18	20 (SMW45-1P)
DP-11	15.0	10 (SMW10-1P)	2,175	624 (DMW10-1P)
DP-12	63.0	1,842.6 (211S)	18	NS

Notes: ND = Not Detected
 NS = Not Sampled
 Comparisons could not be shown for the direct push locations (i.e., DP-1, DP-2, DP-4, and DP-7) which were not located adjacent to monitoring wells and for DP-3 which was located adjacent to a dry monitoring well.

Table 4.3-5 Dissolved Oxygen Measurements Before the Extended AAS/SVE Pilot Study, Site SS59, Dover AFB, Delaware

WELL	Baseline** (PPM)	Baseline* (PPM)	Geoprobe	Baseline** (PPM)	Baseline* (PPM)
SMW-75-1P	3.0	0.2	DP-1	6	5.2
DMW-75-1P	3.0	2.4	DP-2	3	2.4
SMW-45-1P	1.0	1.0	DP-3	3	3.5
DMW-45-1P	3.0	6.2	DP-4	3	3.4
SMW-25-1P	1.0	0.2	DP-5	4	3.1
DMW-25-1P	4.0	5.1	DP-6	4	2.0
SMW-10-1P	0.8	0.3	DP-7	3	1.3
DMW-10-1P	3.0	4.6	DP-8	3	2.3
SMW-10-1	0.5	0.3	DP-9	4	2.2
DMW-10-1	1.0	0.9	DP-10	3	4.2
SMW-25-1	4.0	0.3	DP-11	2	0.8
DMW-25-1	4.0	0.4	DP-12	3	0.5
SMW-45-1	3.0	0.5	DGP-1	NA	1.0
DMW-45-1	3.0	0.3	DGP-2	NA	1.0
SMW-75-1	0.8	0.3	DGP-3	NA	1.0
DMW-75-1	2.0	0.5			
SMW-75-2	1.0	0.9			
DMW-75-2	2.0	0.9			
SMW-45-2	0.7	0.3			
DMW-45-2	3.0	1.8			
SMW-20-2	1.0	0.3			
DMW-20-2	0.5	0.2			
SMW-10-2	1.0	0.4			
DMW-10-2	3.0	2.4			
SMW-10-2P	NA	NA			
DMW-10-2P	2.0	0.3			
SMW-34-2P	0.8	0.6			
DMW-34-2P	3.0	1.8			
SMW-45-2P	dry	dry			
DMW-45-2P	NA	NA			
SMW-75-2P	1.0	0.9			
DMW-75-2P	2.0	0.9			
AAS-1	5.0	9.5			
AAS-2	2.0	2.8			
211-S	3.0	3.3			
211-D	2.0	2.3			
212-S	2.0	1.2			
212-D	3.0	2.2			
O4J-S	3.0	3.6			
O4J-D	4.0	NA			

* -- DO reading by Chemets (31 May to 2 June 1994)

** -- DO reading by YSI meter (31 May to 2 June 1994)

*** -- There are two different depths of the geoprobcs:

NS -- Not Sampled: Water level was below the depth that the oxygen probe could be lowered.

NA -- Not Available

DP -- (shallow) depths ranged from 12 to 15 ft bgs

DGP -- (deep) depths ranged from 30 to 35 ft bgs

Table 4.3-6

Dissolved Oxygen Measurements (PPM) during the Extended AAS/SVE Pilot Study
Site SS59, Dover AFB, Delaware

WELL	16 JUNE 94	18 JUNE 94	3 JULY 94	4 AUG 94	18 AUG 94	1 SEP 94	22 SEP 94	19 OCT 94	17 OCT 94	8 JAN 95	16 JAN 95
SMW-75-1P	3.2	2.0	0.8	2.2	0.8	2.8	1.5	0.7	3.8	2.1	0.7
SMW-75-1P	3.6	8.2	6.4	4.6	3.1	3.4	1.7	1.5	10.2	3.6	4.2
SMW-45-1P	6.2	3.8	7.4	2.4	6.9	3.5	3.4	2.1	3.7	2.0	7.4
DMW-45-1P	4.2	10.2	*	4.1	9.2	4.2	10.6	4.6	8.8	3.8	9.2
SMW-25-1P	3.6	1.7	6.3	2.6	3.5	2.5	3.4	1.0	4.8	2.1	1.2
DMW-25-1P	5.4	8.0	12.2	4.4	9.4	5.5	9.8	5.6	8.5	2.8	8.5
SMW-10-1P	6.1	7.8	10.1	2.2	3.2	4.2	6.4	1.4	6.4	3.6	8.8
DMW-10-1P	3.7	10.0	11.2	4.8	9.3	6.6	9.4	5.4	5.3	3.5	8.6
SMW-10-1	7.2	7.7	8.0	2.1	4.9	4.1	6.6	0.8	6.2	3.4	8.8
DMW-10-1	2.5	4.4	5.1	4.3	6.5	4.3	6.2	2.3	6.4	3.1	5.6
SMW-25-1	6.0	5.5	7.0	2.4	3.8	3.1	2.6	0.7	5.5	1.6	1.6
DMW-25-1	1.2	3.0	2.8	5.0	0.3	2.0	4.9	0.9	0.3	1.5	2.6
SMW-45-1	4.4	6.4	2.8	4.2	0.3	2.0	1.4	1.1	8.5	1.7	0.8
DMW-45-1	3.3	7.2	8.6	4.4	0.8	1.6	1.4	0.8	0.7	2.3	1.9
SMW-75-1	4.2	8.6	*	2.3	0.4	1.7	1.5	1.1	9.4	1.4	0.8
DMW-75-1	4.0	9.5	*	4.1	2.1	3.3	6.5	1.4	6.8	2.2	2.6
AAS-1	NS	NS	NS	NS	NS	NS	NS	5.8	NS	NS	4.2
SMW-75-2	6.5	1.2	7.4	2.1	0.5	1.7	3.4	0.5	3.8	NS	1.6
DMW-75-2	0.5	6.6	1.5	3.8	0.3	1.8	1.4	0.6	1.8	NS	0.8
SMW-45-2	6.3	9.5	*	2.0	0.4	4.8	9.8	1.7	10.2	NS	1.7
DMW-45-2	1.6	5.2	4.6	3.6	0.4	1.5	3.7	1.3	9.6	NS	1.6
SMW-20-2	7.4	8.2	*	2.4	5.9	5.2	6.8	3.4	10.2	NS	1.9
DMW-20-2	1.2	11.3	12.8	3.8	6.1	6.5	9.7	4.5	8.8	NS	1.7
SMW-10-2	10.2	11.2	*	2.5	6.4	6.4	6.9	5.5	10.4	NS	3.2
DMW-10-2	9.8	10.2	*	3.7	2.0	7.7	11.0	4.6	10.4	NS	8.2
SMW-10-2P	10.5	11.2	*	2.2	4.3	4.2	5.4	3.3	7.6	NS	2.3
DMW-10-2P	6.2	4.3	*	3.4	1.9	3.8	3.2	2.6	10.0	NS	4.3
SMW-34-2P	5.4	6.3	6.0	2.1	1.1	2.0	1.2	1.3	6.5	NS	1.2
DMW-34-2P	1.8	1.4	3.0	3.7	0.3	6.8	1.3	1.2	3.4	NS	2.5
SMW-45-2P	DRY	DRY	DRY	DRY	DRY	DRY	DRY	6.2	DRY	NS	DRY
DMW-45-2P	1.2	2.6	5.8	3.9	0.3	1.8	1.1	1.8	2.8	NS	1.6
SMW-75-2P	6.2	5.9	8.4	2.7	0.4	1.6	1.2	2.3	9.6	NS	2.4
DMW-75-2P	1.0	2.1	5.5	3.6	0.3	1.5	1.1	2.1	3.8	NS	1.7
AAS-2	NS	NS	NS	NS	NS	NS	NS	5.4	NS	NS	5.1

NS = Not Sampled

* = Not sampled since the water level was below the depth that the oxygen probe could be lowered.

On 4 Aug 94, only the SVE was in operation.

Notes: All data are expressed in units of ppm.

**Table 4.3-7 Changes in Ground-Water Dissolved Oxygen Concentrations within the 45 ft ROI
Dover AFB Site SS59 Extended AAS/SVE Pilot Study**

TEST AREA 1

	POST (1)	PRE (2)	%CHANGE	RESULTS		
				Decrease	No Change	Increase
45 ft						
SMW-45-1	3.1	0.9	239.5%			1
SMW-45-1P	4.4	1.5	195.8%			1
DMW-45-1	3.0	0.65	360.8%			1
DMW-45-1P	6.3	NS	NA	NA	NA	NA
25 ft						
SMW-25-1	3.6	0.6	503.0%			1
SMW-25-1P	3.0	0.8	271.6%			1
DMW-25-1	2.2	0.75	196.4%			1
DMW-25-1P	7.3	0.8	810.2%			1
10 ft						
SMW-10-1	5.4	0.9	504.0%			1
SMW-10-1P	5.5	1	447.3%			1
DMW-10-1	4.6	0.8	476.1%			1
DMW-10-1P	7.1	0.9	687.9%			1
TOTAL	-	-	-	0	0	11

TEST AREA 2

	POST (1)	PRE (2)	%CHANGE	RESULTS		
				Decrease	No Change	Increase
45 ft						
SMW-45-2	4.2	5.6	-24.8%	1		
SMW-45-2P	0.6	NS	NA	NA	NA	NA
DMW-45-2	3.0	0.95	216.6%			1
DMW-45-2P	2.1	1	108.5%			1
20-34 ft						
SMW-34-2P	3.0	1	200.5%			1
DMW-34-2P	2.3	1	130.9%			1
SMW-20-2	4.7	0.9	419.2%			1
DMW-20-2	6.0	1.2	403.0%			1
10 ft						
SMW-10-2	5.7	0.8	612.5%			1
SMW-10-2P	4.6	0.8	479.0%			1
DMW-10-2	6.1	8.2	-25.1%	1		
DMW-10-2P	3.6	0.9	300.5%			1
TOTAL	-	-	-	2	0	9

Notes:

- (1): Average of the reported D.O. concentrations over the duration of the extended AAS/SVE pilot study (May 1994 - Jan 1995)
- (2): Reported D.O. concentrations prior to the initial AAS/SVE Treatability Study (12 Oct 1993)

NS = Not Sampled
NA = Not Applicable

Table 4.3-8

Depth to Ground Water (ft) During the Extended AAS/SVE Pilot Study
Site SS59, Dover AFB, Delaware

WELL	16 JUNE 94	23 JUNE 94	3 JULY 94	4 AUG 94	19 AUG 94	1 SEP 94	22 SEP 94	27 OCT 94	6 JAN 95	18 JAN 95
SMW-75-1P	9.25	9.85	10.02	10.02	9.68	9.94	10.47	11.01	10.00	11.61
DMW-75-1P	9.20	9.97	10.23	10.06	9.77	10.00	10.50	11.08	10.04	11.62
SMW-45-1P	9.27	9.14	10.11	10.04	9.77	9.98	10.50	11.01	10.02	11.64
DMW-45-1P	9.77	10.57	10.41	10.55	12.42	10.50	11.50	11.85	10.51	12.16
SMW-25-1P	9.25	9.48	10.28	9.99	9.80	9.94	10.43	10.92	9.96	11.62
DMW-25-1P	9.30	9.68	9.81	10.07	9.82	10.00	10.50	11.07	10.03	11.67
SMW-10-1P	8.92	9.34	10.14	9.68	9.49	9.63	10.10	10.56	9.62	11.32
DMW-10-1P	9.10	10.19	10.34	9.96	9.74	9.86	10.37	11.65	9.92	11.52
SMW-10-1	9.30	10.19	10.55	10.00	9.82	9.98	10.35	11.04	9.95	11.71
DMW-10-1	9.25	10.05	10.38	10.07	9.74	9.92	10.47	11.00	10.02	11.52
SMW-25-1	9.42	10.28	10.52	10.17	9.93	10.09	10.48	11.17	10.15	11.80
DMW-25-1	9.32	9.85	10.46	10.12	9.84	10.04	10.59	11.11	10.09	11.72
SMW-45-1	9.58	9.95	10.59	10.35	10.14	10.27	10.75	11.33	10.41	11.92
DMW-45-1	9.70	10.20	10.46	10.45	10.31	10.38	10.10	11.45	11.17	12.04
SMW-75-1	10.43	10.97	11.40	11.21	11.08	11.15	11.38	12.20	11.16	13.00
DMW-75-1	10.05	10.77	11.00	11.04	10.88	10.95	11.65	12.02	10.97	12.24
AAS-1	NS	NS	NS	NS	NS	NS	NS	NS	NS	11.30
SMW-75-2	9.50	10.31	10.62	10.27	10.06	10.18	10.67	11.22	NS	11.88
DMW-75-2	9.45	10.45	10.52	10.25	9.89	10.18	10.58	11.26	NS	11.84
SMW-45-2	10.20	10.90	11.33	10.88	10.70	10.82	11.54	11.84	NS	12.52
DMW-45-2	9.66	10.35	10.65	10.82	10.30	10.54	10.98	11.62	NS	12.22
SMW-20-2	10.26	11.15	11.18	10.89	10.56	10.83	10.92	11.83	NS	12.52
DMW-20-2	10.10	11.30	11.14	10.81	10.20	10.74	11.32	11.71	NS	12.44
SMW-10-2	10.70	11.95	11.69	11.44	11.14	11.39	11.90	12.40	NS	13.08
DMW-10-2	9.40	11.68	11.61	11.35	9.99	11.33	12.30	12.44	NS	12.96
SMW-10-2P	10.28	11.57	11.69	11.07	10.80	11.05	11.52	12.12	NS	12.75
DMW-10-2P	10.40	11.73	11.53	11.17	10.68	11.17	11.70	12.26	NS	12.86
SMW-34-2P	10.02	10.60	10.92	10.68	10.50	10.70	11.20	11.71	NS	12.33
DMW-34-2P	9.92	11.00	10.70	10.53	10.50	10.60	11.05	11.66	NS	12.28
SMW-45-2P	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	NS	DRY
DMW-45-2P	9.80	10.35	10.49	10.47	10.30	10.55	11.00	11.63	NS	12.26
SMW-75-2P	9.86	10.63	10.90	10.68	10.39	10.62	11.12	11.67	NS	12.24
DMW-75-2P	9.88	10.40	10.65	10.68	10.47	10.56	10.70	11.49	NS	12.32
AAS-2	NS	NS	NS	NS	NS	NS	NS	NS	NS	12.50

NS = Not Sampled

Notes: On 4 AUG 94, only the SVE system was in operation.

filtration ("influent"), off gas between the two GAC canisters (manifolded in series), and after GAC treatment prior to discharge to the atmosphere. A summary of the total off gas VOCs for each of these sampling points during the fourteen sampling events is presented in Table 4.4-1.

Total (combined SVE-1 and SVE-2) influent off gas VOC concentrations ranged from 0.167 to 26.062 ppm_v. The average influent off gas VOC concentration was 2.737 ppm_v. The higher concentration was observed during the 13 October 1994 sampling event when unusually elevated concentrations of methylene chloride and c-DCE (particularly in the SVE-2 off gas) were identified. In general, off gas concentrations typically ranged from 0.167 to 2.548 ppm_v. The sample collected on 13 October 1994 followed a one week period of non-operation. It appears at this time that a zone of higher concentration methylene chloride was mobilized and subsequently stripped from solution.

Under the DNREC criterion, emission of SVE off gas VOCs is currently regulated to a level of 2.4 lb/day in offgases. Over the course of the extended pilot study, most of the offgases were non-detect (Table 4.4-1) for the primary VOCs of concern following treatment with GAC. Detectable concentrations of VOCs were present in the vented off gas during the 8 July, 1 September, and the 14 November 1994 sampling events. However, these emission levels did not exceed the DNREC criterion. Emissions of VOCs following GAC treatment were reported to be non-detect during the final sampling event on 25 January 1995. Thus, at that time, the GAC canisters had not reached breakthrough.

Table 4.4-1

Offgas VOC Concentrations during the Extended AAS/SVE Pilot Study
Site SS59, Dover AFB, Delaware

STATION	DATE	METHYLENE CHLORIDE (ppm)	trans-1,2 DCE (ppm)	cis-1,2 DCE (ppm)	TCA (ppm)	CARBON TETRACHL. (ppm)	TCE (ppm)	PCE (ppm)	TOT. VOL. HYDROCARB. (ppm)	TOTAL VOCs (ppm)
INFLUENT	16 JUNE 94	<4	<5	<9	0.635	<0.001	0.188	0.025	<1	0.828
Combined	28 JUNE 94	<4	<5	<9	0.187	<0.001	0.091	0.007	<1	0.285
Combined	8 JULY 94*	<4	<5	<9	0.618	<0.001	0.114	0.006	<1	0.738
Combined	4 AUG 94	<0.5	<0.6	<1.4	0.299	<0.001	0.053	0.008	<5	0.360
Combined	18 AUG 94	<0.4	<0.6	<1.2	0.067	<0.001	<0.001	1.308	<5	1.375
Combined	1 SEP 94	0.300	<0.1	<0.1	0.474	<0.001	0.243	0.079	<5	1.096
Combined	22 SEP 94	<0.1	<0.1	<0.1	0.071	<0.001	0.071	0.029	<5	0.171
Combined	7 OCT 94	0.100	<0.1	<0.1	1.003	<0.001	<0.001	0.103	<5	1.206
Combined	13 OCT 94	6.248	<0.1	17.442	0.042	<0.001	1.650	0.770	<0.5	26.152
Combined	27 OCT 94	0.830	<0.1	<0.1	0.841	<0.001	0.074	0.023	<0.5	1.768
Combined	14 NOV 94	0.630	<0.1	0.200	0.187	<0.001	0.080	0.017	<0.5	1.114
EFFLUENT										
BELOW GAC	4 AUG 94	<0.5	<0.8	<1.4	<0.001	<0.001	<0.001	<0.001	<5	ND
BELOW GAC	1 SEP 94	<0.1	<0.1	<0.1	0.002	<0.001	0.004	<0.001	<5	0.006
BELOW GAC	22 SEP 94	<0.1	<0.1	<0.1	0.004	<0.001	<0.001	<0.001	<5	0.004
BELOW GAC	25 JAN 95	<0.1	<0.1	<0.1	0.002	<0.001	<0.001	<0.001	<5	0.002
After GAC	16 JUNE 94	<0.3	<0.6	<1	<0.001	<0.001	<0.001	<0.001	<5	ND
After GAC	28 JUNE 94	<0.3	<0.6	<1	<0.001	<0.001	<0.001	<0.001	<5	ND
After GAC	8 JULY 94	<0.3	<0.6	<1	0.334	<0.001	0.031	0.004	3.700	4.069
After GAC	4 AUG 94	<0.5	<0.8	<1.4	<0.001	<0.001	<0.001	<0.001	<5	ND
After GAC	18 AUG 94	<0.4	<0.8	<1.2	<0.001	<0.001	<0.001	<0.001	<5	ND
After GAC	1 SEP 94	<0.1	<0.1	<0.1	0.005	<0.001	<0.001	0.005	<5	0.010
After GAC	22 SEP 94	<0.1	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001	<5	ND
After GAC	27 OCT 94	0.290	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001	<5	ND
After GAC	14 NOV 94	<0.1	<0.1	<0.1	0.004	<0.001	0.003	<0.001	<1	0.297
After GAC	25 JAN 95	<0.1	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001	<5	ND
OFFGAS										
SVE-1	16 JUNE 94	<0.3	<0.6	<1	0.987	<0.001	0.280	0.036	<5	1.303
SVE-1	28 JUNE 94	<0.3	<0.6	<1	0.211	<0.001	0.102	0.004	<5	0.317
SVE-1	8 JULY 94	<0.3	<0.6	<1	1.000	<0.001	0.114	0.007	<5	1.121
SVE-1	4 AUG 94	<0.5	<0.8	<1.4	1.306	<0.001	0.314	0.044	<5	1.664
SVE-1	18 AUG 94	<0.4	<0.8	<1.2	2.156	<0.001	0.521	0.060	<5	2.737
SVE-1	1 SEP 94	<0.1	1.790	0.18	0.943	<0.001	0.784	0.123	<5	3.820
SVE-1	22 SEP 94	<0.1	<0.1	<0.1	0.073	<0.001	0.018	0.002	<5	0.093
TRENCH	13 OCT 94	6.411	<0.1	<0.1	0.045	<0.001	1.907	0.749	<5	9.112
SVE-1	27 OCT 94	1.350	<0.1	<0.1	0.494	<0.001	0.167	0.025	<5	2.036
SVE-1	14 NOV 94	<0.1	<0.1	0.190	0.237	<0.001	0.125	0.017	<1	0.569
SVE-1	9 JAN 95	2.490	<	<	0.053	<	<	0.005	<	2.548
SVE-1	23 JAN 95	<0.1	<0.1	<0.1	0.085	<0.001	0.082	<0.001	<5	0.167
SVE-1 (DUP)	23 JAN 95	<0.1	<0.1	<0.1	0.088	<0.001	0.091	<0.001	<5	0.179
SVE-1	25 JAN 95	<0.1	<0.1	0.2	0.185	<0.001	0.186	0.034	<5	0.605
SVE-2	16 JUNE 94	<0.3	<0.6	<1	0.063	<0.001	0.010	0.005	<5	0.078
SVE-2	28 JUNE 94	<0.3	<0.6	<1	0.082	<0.001	0.015	0.003	<5	0.080
SVE-2	8 JULY 94	<0.5	<0.8	<1	<0.001	<0.001	NA	0.004	<5	0.004
SVE-2	4 AUG 94	<0.5	<0.8	<1.4	<0.001	<0.001	<0.001	<0.001	<5	ND
SVE-2	18 AUG 94	<0.4	<0.8	<1.2	0.066	<0.001	NA	0.013	<5	0.079
SVE-2	1 SEP 94	<0.1	0.220	<0.1	0.118	<0.001	0.033	0.081	<5	0.452
SVE-2	22 SEP 94	<0.1	<0.1	<0.1	0.071	<0.001	0.071	0.029	<5	0.171
SVE-2	13 OCT 94	1.693	<0.1	101.898	0.016	<0.001	0.217	0.723	<5	104.547
SVE-2	27 OCT 94	0.360	<0.1	<0.1	0.093	<0.001	0.013	0.018	<5	0.484
SVE-2	14 NOV 94	<0.1	<0.1	0.200	0.041	<0.001	0.014	0.020	<1	0.275

Notes:

ND = Not Detected

On 4 Aug 94, only the SVE system was in operation (the switch on the air compressor was not working).

* - Estimated Data

During January of 1995, the "combined" influent was SVE-1 only since SVE-2 was not in operation at that time.

5. AAS/SVE SYSTEM PERFORMANCE EVALUATION

5.1 OPERATIONAL PARAMETERS

System operational data which was collected over the course of the extended AAS/SVE pilot study are presented in Appendix G. These data include differential pressures at the individual monitoring wells and AAS and SVE flow rates and pressures. These data were collected by EA and DAFB Civil Engineering personnel.

5.1.1 AAS Injection Pressure

The injection pressure required to introduce air into the saturated zone is directly related to the resistance of saturated zone soils to air flow, as well as the pressure required to overcome the hydrostatic pressure of the water column present above the screened interval of the AAS wells. Injection pressures were measured periodically by directly recording the pressure (psig) from an in-line pressure gauge located at the AAS test wellhead.

The hydrostatic head representing the column of water present above the screened interval in each of the two AAS test wells was measured in order to estimate the required air injection pressure irrespective of the formational resistance of saturated zone soils. During the initial treatability study (EA, 1994b), it was calculated that a minimum of 10.7 psig and 9.9 psig would be required to overcome the hydrostatic head present at test wells AAS-1 and AAS-2, respectively. The injection pressures observed during the pilot test were in the range of 10 to 18 psig in Test Area 1 and 8 to 15 in Test Area 2 (Appendix G). The difference between the observed minimum injection pressure (to have induced a steady flow of air) and the hydrostatic pressure can be attributed to the inherent formational resistance to air flow in the saturated zone.

5.1.2 AAS Injection Flow Rate

Injection flow rates were measured periodically during the extended pilot study by directly recording the injection rate (acfm) from an in-line flowmeter located at the AAS wellhead. Recorded flow rates were subsequently corrected for the effects of pressure utilizing the following equation:

$$Q_2 = Q_1 (P_2/P_1)^{0.5}$$

Where:

Q_1 = Observed flow meter reading (acfm)

Q_2 = Actual flow rate (corrected for the effects of pressure) (scfm)

P_1 = Standard atmospheric pressure (14.7 psig)

P_2 = Actual pressure (pressure inside flow meter +14.7 psig)

Injection flow rates observed during the extended pilot test were in the range of 1 to 12 acfm in AAS-1 and 2 to 8 acfm in Test Area 2. With the above equation, these flow rates were equivalent to 1.4 to 16.5 scfm and 2.7 to 11.2 scfm, respectively. Injection pressures and flow

rates which were observed over the duration of the pilot study are plotted in Figures 5.1-1 and 5.1-2 and presented in Appendix G.

5.1.3 SVE Extraction Pressure

The SVE vacuum pressure is determined by the soil characteristics such as permeability, bulk density, particle density, porosity, grain size and moisture, the negative pressure generated by the vacuum pump, the depth of the extraction well, and the length of the screen section. During the extended pilot test, extraction pressures ranged from 38 to 64 inches of water (1.4 to 2.3 psig) at SVE-1 and 57 to 90 inches of water (1.4 to 3.3 psig) at SVE-2.

5.1.4 SVE Extraction Flow Rate

During the extended pilot study, the combined extraction flow rate ranged from 40 to 64.9 cfm. A flow velocity of approximately 3,000 ft/sec (64.9 cfm) was maintained for the beginning of the study. Between 13 October 1994 and 6 January 1995, the extraction flow rate was lowered to 55 cfm. After 6 January 1995, the extraction flow rate was maintained at 40 cfm. The extraction flow rate is a key parameter to determine the contaminant mass removal rate in the soil vapor extraction system. For certain chemical concentrations and mass transfer scenarios in the unsaturated zone, the higher the extraction flow rate, the greater the mass removal rate. At the same time, if the flow rate is too high, it will reduce the contact time to allow air flow to pick up diffused contaminants from the soil vapor phase and soil particles, and thus, the mass removal rate efficiency will be decreased. Thus, too high of an extraction vacuum pressure and flow rate may reduce the ROI of the soil vapor extraction system. During the extended pilot study, the offgas concentrations from the extraction wells were relatively stable regardless of the decreased extraction flow rates over time. This suggested that short-circuiting was not a significant factor which affected the offgas concentrations. Similarly, as discussed in Section 4.2.3, the changes observed in soil gas concentrations appeared to indicate that the SVE system was effective for removing VOCs from the vadose zone.

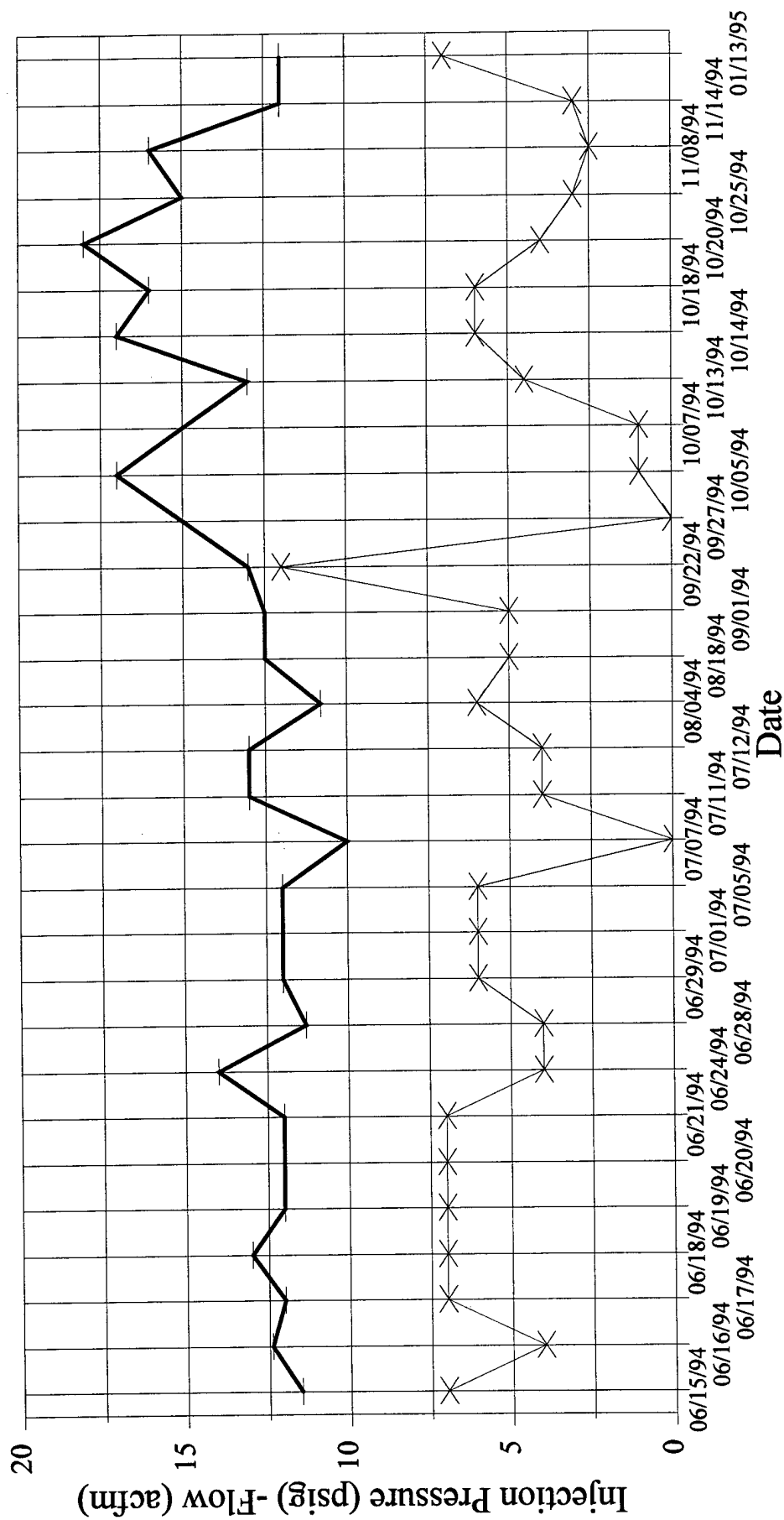
5.1.5 Offgas Concentrations

The concentration of COCs in the offgas of the SVE system can be dependent on a number of factors. Physically, the offgas concentration is a function of the vapor pressures of the individual COCs, mass transfer limitations, soil properties such as moisture content, temperature, and air permeability, and system operational parameters such as extraction flow rate and extraction vacuum pressure, among other factors. Offgas concentration is an important parameter for the evaluation of the potential effectiveness of an AAS/SVE system for a particular site. Offgas concentrations are directly related to the contaminant mass removal being affected by the AAS/SVE system and, therefore, can be used to estimate system efficiencies and the potential degree of remediation.

Chlorinated compounds such as methylene chloride, c-DCE, TCA, TCE, and PCE were detected in the offgas of the SVE system. The total concentrations of ECD VOCs in the offgas were relatively stable over the duration of the pilot study (ranging from 0.167 to 2.548 ppm_v) with the

Figure 5.1-1 Pressure and Flow vs Time

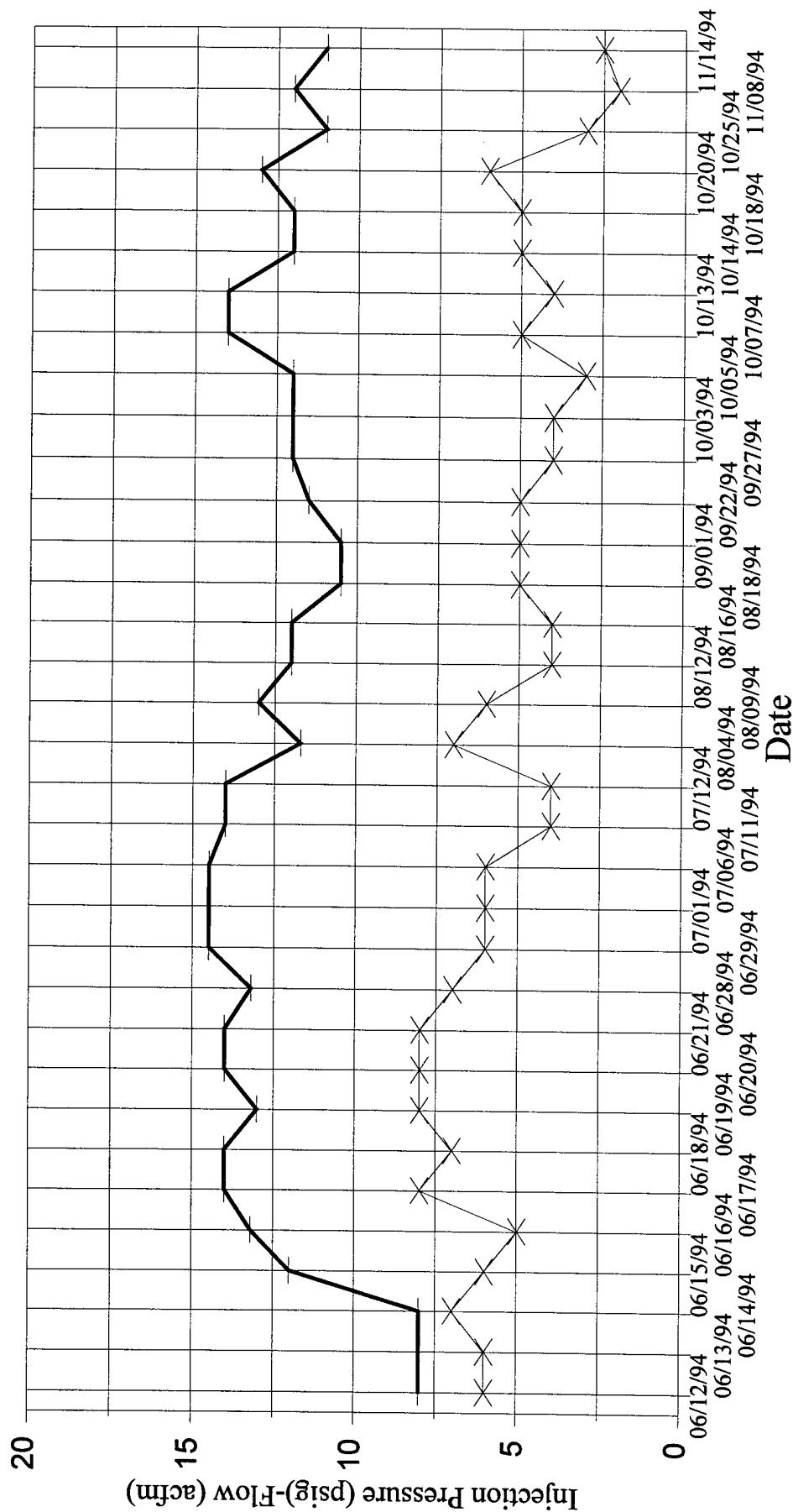
AAS-1



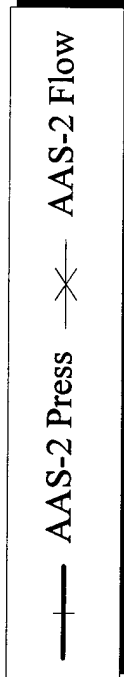
The X-axis is not to scale

Figure 5.1-2 Pressure and Flow vs Time

AAS-2



The X-axis is not to scale



exception of the sampling event on 13 October 1994 (26.152 ppm_v). This increase was predominantly attributed to elevated concentrations of methylene chloride (6.2 ppm_v) and c-DCE (17.4 ppm_v).

BTEX compounds were non-detect during each of the twelve offgas sampling events. BTEX compound are typical fuel components and their absence indicates that potential spills of JP-4 from the nearby flight line (during fueling operations or from pipeline leaks) have not affected Site SS59 at this time.

5.2 ESTIMATION OF HORIZONTAL AREA OF INFLUENCE

The Radius of Influence (ROI) for AAS at Site SS59 was estimated by conducting a tracer gas study in Test Area 1. Based upon the soil gas, ground-water, and differential pressure data which was collected, an influence was found up to 45 ft in the shallow (7 to 17 ft bgs) and deep (31 to 36 ft bgs) monitoring wells. This was in close agreement with the ROI (45 ft) which was estimated during the AAS/SVE Treatability Study for Site SS59 (EA, 1994b). Details of the tracer gas study which was performed at Site SS59 are presented in Appendix A.

5.3 OFFGAS MASS REMOVAL

During operation of the AAS/SVE system, the SVE system removed air that had been transported to the vadose zone by AAS, as well as soil air that was otherwise existing within the vadose zone. Accordingly, the SVE offgases consisted of both air transported to the vadose zone as a result of AAS as well as "native" soil air. Previous subsurface investigations (EA, 1994a) have identified that the COCs are present from non-detectable to very low concentrations adsorbed to soils in the vadose zone. Hence, the VOC mass removal during operation of the AAS/SVE system was largely attributable to mass transfer via AAS.

The emission rate of COCs removed during the extended AAS/SVE pilot study was calculated using the following equation (modified after EPA, 1989):

$$ER = Q \times C \times MW \times 1.581 \times 10^{-7} \times 24$$

Where: ER = emission rate of a COC (lbs/day)
 Q = SVE flow rate (CFM)
 C = offgas concentration of the COC (ppm_v)
 MW = molecular weight of the COC (lb/lb-mole)

Total emission rate calculations are presented in Table B.5-1 (Appendix B). In order to quantify the estimated amount of total petroleum hydrocarbons which were removed, the total peak area of constituents detected by the FID were normalized to toluene (i.e., the BTEX compound which has a molecular weight that best approximates the molecular weight of gasoline) and are expressed as "toluene equivalents".

Accordingly, the variation of the total emission rates over the duration of the extended pilot study is depicted in Figure 5.4-1. The average, time-weighted, mass removal rate observed from the pilot AAS/SVE system was 0.05 lb/d. This rate of VOC removal may be typical for the relatively low concentrations of COCs within the aquifer. Significantly larger mass removal rates have been observed at other AAS/SVE sites, but these studies involved aquifers which contained far greater concentrations of contaminants.

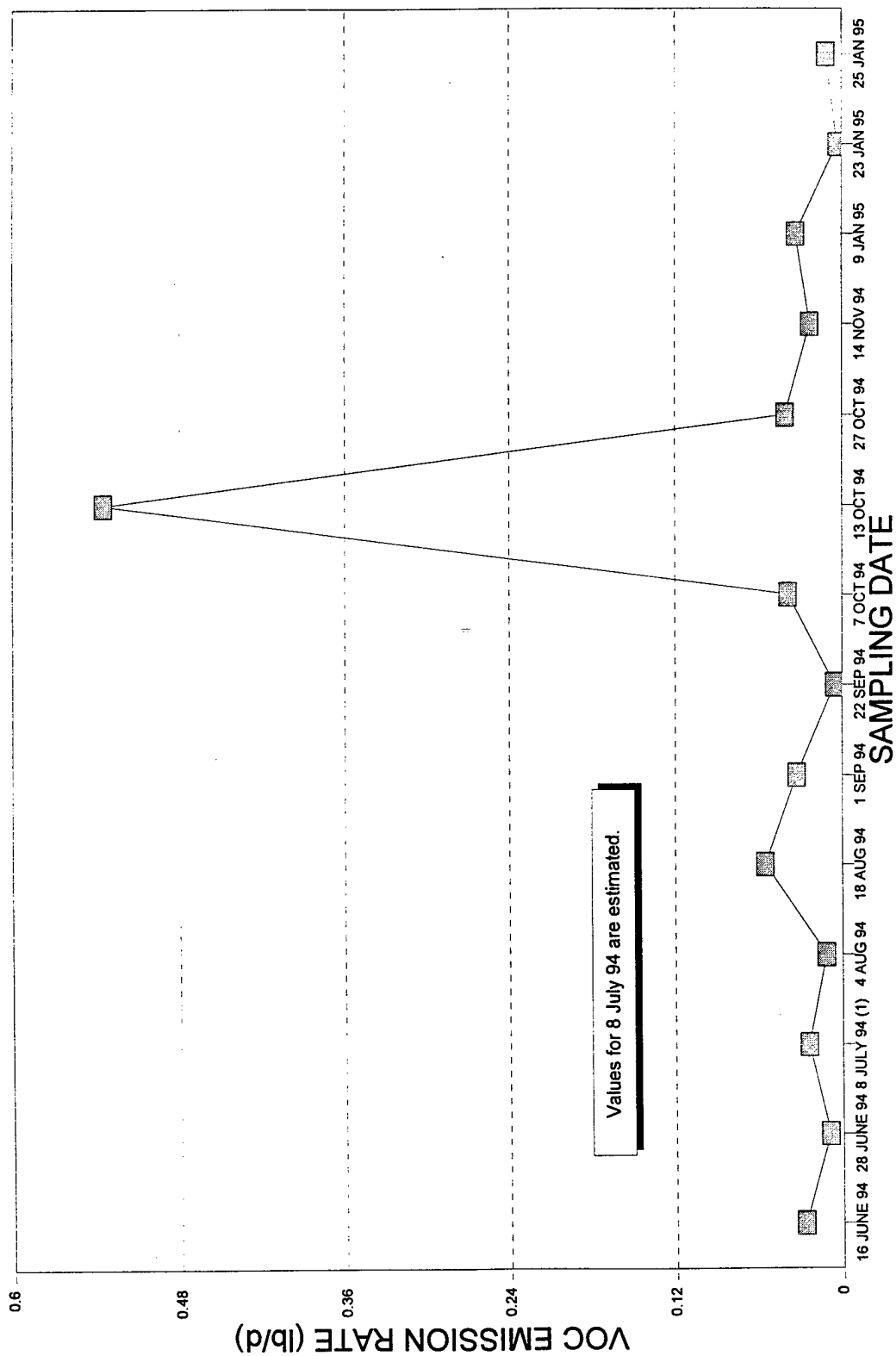
The maximum mass removal rate which was observed during the extended pilot study was 0.54 lb/d (13 October 1994). This larger removal rate may have been an indication that a "pulsing" of the AAS/SVE system would augment the overall removal efficiency. Beneficial affects from the "pulsing" of an AAS/SVE system have also been identified by the work of Marley et al. (1990) and Brown et al. (1995). Prior to the 13 October 1994 sampling event, the AAS/SVE system had been shut down for approximately one week in order to allow for the mid-term ground-water sampling event (the system was then run for one hour prior to offgas sampling). This hiatus may have presented an opportunity for the collapse of preferential flow channels which had been created during past operations of the system. Hence, potentially untouched areas of the aquifer may have been brought under the influence of the reactivated pilot system. Additionally, an increase in the ground-water movement resulting from air injection may have occurred and acted to increase desorption and/or solubilization of the COCs. The pulsing of an AAS/SVE system provides a dynamic approach to instigating contaminant removal within the aquifer. Changes in air injection flow rates will act to prevent equilibriums which inhibit the efficient and rapid remediation of a site. Actively affecting changes in air flow paths and ground-water movement will promote the solubilization and/or desorption of contamination intervals within the aquifer which would otherwise be missed. It is anticipated that this type of approach will increase the frequency of elevated VOC concentrations in the offgas. The lack of AAS/SVE system pulsing tends to lead to the formation of stable flow channels and will provide less air/contaminant interaction over time. As noted, pulsing of AAS systems have been reported in the literature to increase contaminant removal efficiency, data has not been generated during the course of these studies to confirm its application at site SS-59

The removal rate observed following the period of non-operation during the extended pilot study was similar to the removal rates observed during the initial, combined, AAS/SVE treatability studies (average removal rates of 0.68 and 0.11 lb/d in Test Areas 1 and 2, respectively) (EA, 1994b). The higher removal rates which were observed throughout the initial treatability study may have been due to the initiation of the study. In other words, the effect of a preferential flow path would be less significant over a 12 day period since raised concentrations would still exist in the subsurface as opposed to the effect during continual operation over several months (sufficient contaminant mass should exist to maintain steady removal rates over a short duration). By monitoring the VOC removal rates during a full-scale implementation, the AAS/SVE system could be turned on and off on a regular basis (i.e., pulsed) in order to allow for a re-equilibration of the aquifer. It is anticipated that the cycling of flow channel formation and collapse would be likely to maintain higher contaminant removal rates. However, based on the removal rates observed during extended pilot study, it is not clear whether pulsing would increase the removal efficiency to a sufficient degree for the long-term operation of an AAS/SVE system.

FIGURE 5.4-1 TOTAL VOC* EMISSION RATE

Extended AAS-SVE Pilot Test

Dover AFB, Site SS59, June 94 to January 95



* Primary Contaminants of Concern Only

From the removal rate data, the total mass of VOCs which were extracted by the AAS/SVE system was calculated as a means of estimating the mass volume of VOCs which were removed from below the water table at Site SS59. The total mass removed was estimated through a summation of a step-wise change in offgas concentration between each of the fourteen offgas sampling events. As summarized in Table 5.4-1, an estimated total of 10.2 lb of the primary VOCs was removed over the extended pilot test (all attributable to ECD VOCs). During the AAS/SVE Treatability Study (EA, 1994b) an estimated 6.32 lbs of ECD VOCs and 2.58 lbs of FID VOCs were extracted by the AAS/SVE system. Thus, an estimated total of 19.1 lbs of VOCs has been removed from Site SS59 between the AAS/SVE Treatability Study and the extended pilot study. As estimated during the FS (EA, 1994a), approximately 34.1 lbs of aqueous-phase VOCs are present within 50 ft of the sparge well. Although some of the total mass can be attributed to contaminants which were initially present within the soil gas, the 19.1 lbs which have been removed represent a substantial influence by AAS/SVE.

5.4 OFFGAS TREATMENT

Under the DNREC criterion, emission of SVE offgas VOCs is currently regulated to a level of 2.4 lb/day in offgases. Final stage GAC columns are common additions to SVE systems for the removal of offgas VOCs. GAC treatment is a proven method for the removal of organics from both aqueous and gaseous phases. The strong sorption characteristics and the surface area available for adsorption provide a means for removing large quantities of organics from contaminated air flows. Additionally, GAC treatment is highly implementable since it can be added directly onto existing SVE systems using commercially available equipment.

In order to meet the DNREC regulations, two GAC canisters (manifolded in series) were used during the pilot study to treat the offgas from the SVE system. The discharge rate of VOCs was monitored onsite using a field GC. In general, the samples which were collected from points following GAC treatment were non-detect for the primary VOCs (Table 4.4-1). Total emission rates from the AAS/SVE system, as determined from the three samples which had detectable concentrations of VOCs, are presented in Table B.5-2 (Appendix B). The maximum observed mass flow rate for VOCs which were vented to the atmosphere was 0.096 lb/d. This was largely attributable to an elevated concentration of BTEX compounds (3.7 ppm_v) in an offgas sample collected on 8 July 1994. This sample should be considered unrepresentative of the typical offgas VOC concentrations since BTEX compounds have been predominantly non-detect throughout the extended pilot study (including in other offgas samples taken that same day).

Although offgas VOC concentrations were well below the DNREC criterion, full-scale SVE systems still may employ final stage GAC columns as a precautionary measure. Continued monitoring of the offgases prior to and after GAC treatment will indicate whether this "polishing" process will need to remain on-line at all times. If necessary, the activated carbon column can undergo continual use until saturation, or breakthrough, occurs. At this point, the activated carbon must either be regenerated through a process of steam treatment or disposed as a hazardous waste.

Table 5.4-1

**Estimated Total VOC Mass Removal from the Pilot AAS/SVE System
at Site SS59, Dover AFB, Delaware**

		(1)	(2)	(3)	(4)	(5)
Event	Date	Removal Rate (lb/d)	Interval (days)	Time-Weighted Interval (2)/total days	Time-Weighted Removal Rate (1x3) (lb/d)	Mass Removed (1x2) (lb)
(6) Area 1 & 2 Pilot Tests(a)	25 AUG to 29 OCT 93	-	-	-	-	8.9
Begin Extended Test	(10 JUNE 94)(b)	0.0273	6	0.031	0.0008	0.1638
First Offgas Sampling	16 JUNE 94	0.0273	12	0.062	0.0017	0.3276
	28 JUNE 94	0.0094	10	0.051	0.0005	0.0940
	8 JULY 94 (c)	0.0242	25	0.128	0.0031	0.6050
down-time (repair)	27 to 29 JULY 94	0.0000	2	(e)	0.0000	0.0000
	4 AUG 94	0.0119	10	0.051	0.0006	0.1190
down-time (repair)	4 to 8 AUG 94	0.0000	4	(e)	0.0000	0.0000
	18 AUG 94	0.0556	14	0.072	0.0040	0.7784
	1 SEP 94	0.0329	21	0.108	0.0035	0.6909
	22 SEP 94	0.0058	15	0.077	0.0004	0.0870
	7 OCT 94	0.0392	1	0.005	0.0002	0.0392
gw sampling	7 to 13 OCT 94	0.0000	6	(e)	0.0000	0.0000
	13 OCT 94	0.5350	7	0.036	0.0192	3.7450
(linear decrease) (d)	(20 OCT 94)	0.2880	7	0.036	0.0103	2.0160
	27 OCT 94	0.0410	18	0.092	0.0038	0.7380
	14 NOV 94	0.0232	33	0.169	0.0039	0.7656
down-time (repair)	1 to 14 DEC 94	0.0000	13	(e)	0.0000	0.0000
tracer study	14 to 21 DEC 94	0.0000	7	(e)	0.0000	0.0000
down-time (repair)	6 to 9 JAN 95	0.0000	3	(e)	0.0000	0.0000
	9 JAN 95 (f)	0.0333	14	0.072	0.0000	0.0000
	23 JAN 95 (f)	0.0034	1	0.005	0.0000	0.0034
gw sampling	23 to 25 JAN 95	0.0000	2	(e)	0.0000	0.0000
End Extended Test	25 JAN 95 (f)	0.0113	1	0.005	0.0001	0.0113
(7) Subtotals			(e)	1.000	0.05	10.2
Total Mass Removed (lbs) (6+7)						19.1

Avg. Removal Rate =	0.05	lb/d
Total Mass Removed =	19.1	lb

- (a) - From the previous pilot test performed June to November 1993 (EA, 1994b).
 (b) - Assumed the mass removal rate to be the same as what was observed on 16 June 1994.
 (c) - Estimated mass removal (based upon a mass balance of the individual vent well concentrations).
 (d) - The data collected from the 13 October 1994 sampling event was considered to be atypical of the mass removal rate of the AAS/SVE system. Therefore, a linear decrease in the concentration was used to estimate the removal during that time interval.
 (e) - Days during down-time are not included in the time-weighted calculation. The AAS/SVE system was in operation for a total of 195 days.
 (f) - During this period, only AAS-1 was in operation.

5.5 DEGREE OF GROUND-WATER REMEDIATION

Tables 4.3-1 through 4.3-3 summarized the ground-water data for total VOCs in the AAS test wells, the shallow and deep monitoring points, and the direct push/geoprobe monitoring points during the three ground-water sampling events at Site SS59. Reductions in the concentrations for the primary COCs were observed in both of the sparge wells (97.2 and 35.7% reduction in Test Areas 1 and 2, respectively). This was to be expected due to the effect of direct sparging within that area. Within the 45 ft. ROI of both test areas, decreases in total VOC concentrations (between the initial and final sampling events for the primary COCs) were observed in 27% and 43% of the shallow and deep monitoring points, respectively (Table 5.5-1). Decreases also were observed in 2 of the 5 (40%) direct push/geoprobe monitoring points (only 5 of the 12 direct push/geoprobe data sets allowed for comparison due to differences in sample depths or probes not sampled during the final sampling event).

As discussed in Section 4.3.3, the increases which were observed in ground-water VOC concentrations (in 64% and 43% of the shallow and deep monitoring wells, respectively, still represent a beneficial and necessary aspect of ground-water remediation via AAS/SVE. The solubilization or desorption of adsorbed-phase contaminants resulting from increased circulation of ground water following air injection would be a necessary first step in order to allow for subsequent volatilization to, and removal from, the vadose zone. Increases in ground-water VOC concentrations also confirm that sparging is effective for influencing the aquifer at a distance from the point of injection. By optimizing the system operational parameters and injecting more air through the aquifer (through the installation of additional sparge wells), the removal of the aqueous phase VOCs would be enhanced.

The higher concentrations which were observed in AAS-2 as compared to AAS-1 were to be expected (and do not represent a reduced effect of sparging in Test Area 2) since AAS-2 was not in operation for the final month of the test in order to increase injection flow rates into Test Area 1 (which had higher concentrations of COCs). Increasing injection flow rates into AAS-1 did not appear to enhance removal in this area. It is likely that, in order to enhance VOC removal from the saturated zone, a better spatial distribution of sparge wells (i.e., additional sparge well locations and varied depths of sparging), and a more dynamic operation of the AAS/SVE system (i.e., pulsing), would be more beneficial than increased flow rates alone.

The mechanisms by which VOCs are removed from the saturated zone are dominated by phase transfer from the adsorbed and dissolved phases to the vapor phase. During AAS, phase disequilibrium is purposely enacted so that source VOCs (i.e., dissolved-phase or adsorbed VOCs) may seek to achieve phase equilibrium with the "clean" ambient air. Possible explanations which may describe the factors responsible for the increases in total VOC concentrations in ground water during active AAS include:

- The process of mass transfer for contaminants from the adsorbed phase to the dissolved phase within the saturated zone occurs due to the introduction of sparged ambient air (which disrupts phase equilibrium and creates a transient net increase in the dissolved-phase component). In this case, the concentrations of dissolved-phase VOCs will slowly

**Table 5.5-1 Changes in Ground-Water VOC Concentrations within the 45 ft ROI
Dover AFB Site SS59 Extended AAS/SVE Pilot Study**

	Decrease	No Change	Increase		Decrease	No Change	Increase
DMW45-1	1			DMW45-2		1	
DMW45-1P			1	DMW45-2P			1
SMW45-1	1			SMW45-2			1
SMW45-1P			1	SMW45-2P	NA	NA	NA
DMW25-1			1	DMW34-2P			1
DMW25-1P			1	SMW34-2P	1		
SMW25-1		1		DMW20-2			1
SMW25-1P			1	SMW20-2			1
DMW10-1	1			DMW10-2	1		
DMW10-1P		1		DMW10-2P			1
SMW10-1			1	SMW10-2	1		
SMW10-1P			1	SMW10-2P	1		
AAS1	1			AAS2	1		
TOTAL	4	2	7		5	1	6

notes: "No Change" indicates initial and final VOC concentrations within 5%.
VOC changes (%) observed at the monitoring points are presented in Tables 4.3-1 to 4.3-3.

Overall SUMMARY of Ground-Water Results within the 45 ft ROI

Distance	# decrease	# same	# increase	% decrease	% same	% increase
45 ft	2	1	4	29%	14%	57%
20-34 ft	1	1	6	13%	13%	75%
10 ft	4	1	3	50%	13%	38%
0 ft	2	0	0	100%	0%	0%
TOTAL	9	3	13	36%	12%	52%

SUMMARY (Shallow Monitoring Wells)

Distance	# decrease	# same	# increase	% decrease	% same	% increase
45 ft	1	0	2	33%	0%	67%
20-34 ft	0	1	3	0%	25%	75%
10 ft	2	0	2	50%	0%	50%
TOTAL	3	1	7	27%	9%	64%

SUMMARY (Deep Monitoring Wells)

Distance	# decrease	# same	# increase	% decrease	% same	% increase
45 ft	1	1	2	25%	25%	50%
20-34 ft	1	0	3	25%	0%	75%
10 ft	2	1	1	50%	25%	25%
0 ft	2	0	0	100%	0%	0%
TOTAL	6	2	6	43%	14%	43%

decrease as the VOC source is diminished. Such an effect is more prominent in regimes containing a large adsorbed-phase component within the saturated zone.

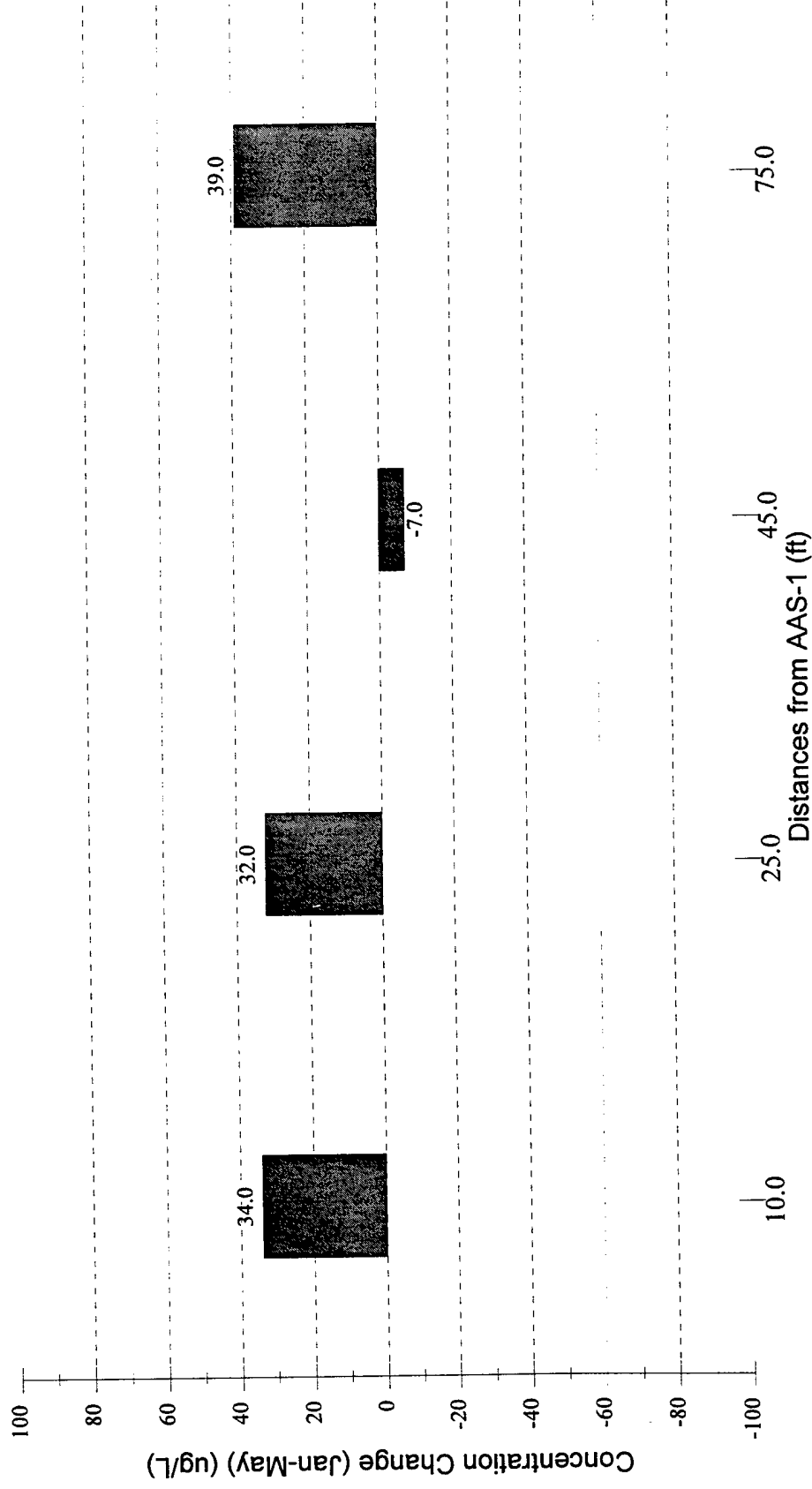
- The increase in total VOCs were a result of desorption of VOCs from the adsorbed phase into the aqueous phase. Enhanced or increased sparging was required to volatilize these aqueous-phase contaminants.
- The increase in total VOCs observed at a distance are the result of a "push" of the dissolved-phase plume laterally (or vertically upward) away from the point of air injection.

It is likely that the concentration increases which were observed in several of the monitoring wells may have been due to mobilization of the COCs via desorption from subsurface soils. If the concentration increases could not be attributed to mobilization via phase transfer from a non-aqueous source, then the increases which were observed at a distance may have been due to plume migration away from the point of air injection. Here, the effect of ground-water redistribution within the aquifer would be greater than the effect of drawing the aqueous-phase contaminants in the vapor phase (and thereby carried into the vadose zone to be removed by SVE). Full-scale implementation of an AAS/SVE system will involve the installation of several sparge wells; thus, by encompassing the entire area of concern, the injection of air will act to force the vertical migration of contaminants in the gas phase into the SVE removal zone. Some of the increases observed in the deep wells can be largely attributed to the increases in concentrations of methylene chloride. This compound was non-detect in the samples collected from the deep monitoring wells during the initial sampling event (however, methylene chloride was detected in DGP-1 (113 µg/L) and DGP-2 (41 µg/L) during this sampling event). During the final sampling, most of the samples from the deep wells had concentrations of methylene chloride in excess of 100 µg/L (up to 1,670 µg/L in DMW45-2P). Thus, it may be possible that the operation of the AAS/SVE system mobilized this compound through increased advection due to changes in ground-water movement. Methylene chloride is a highly volatile and soluble compound which does not adsorb well to sandy soils (Handbook of Environmental Fate and Exposure Data for Organic Compounds, 1990). Therefore, it is likely that changes in the air and ground-water advective forces affected a previously untouched, more contaminated interval of the aquifer (as opposed to a mobilization following desorption).

The differences between the initial and final ground-water data are plotted with respect to distance from the point of injection in Figures 5.5-1 through 5.5-8. In both test areas, variable increases and decreases were observed in total VOC concentrations in the deep monitoring wells which are aligned parallel to ground-water flow (Figures 5.5-3 and 5.5-7). In the deep monitoring wells aligned perpendicular to ground-water flow (Figures 5.5-4 and 5.5-8), the total ground-water VOC concentrations were observed to increase in both test areas. During the tracer study (Appendix A), more influence from the sparge wells was observed in the perpendicular direction at higher injection flow rates. This may support the possible explanation of greater desorption and solubilization from the subsurface soils due to AAS. However, insufficient air flow was available to volatilize the contaminants from solution, and it is likely that the air sparging through the subsurface was already contaminated thereby limiting the

Figure 5.5-1 Change in Total GW VOCs

Test Area 1 - SMW - Parallel



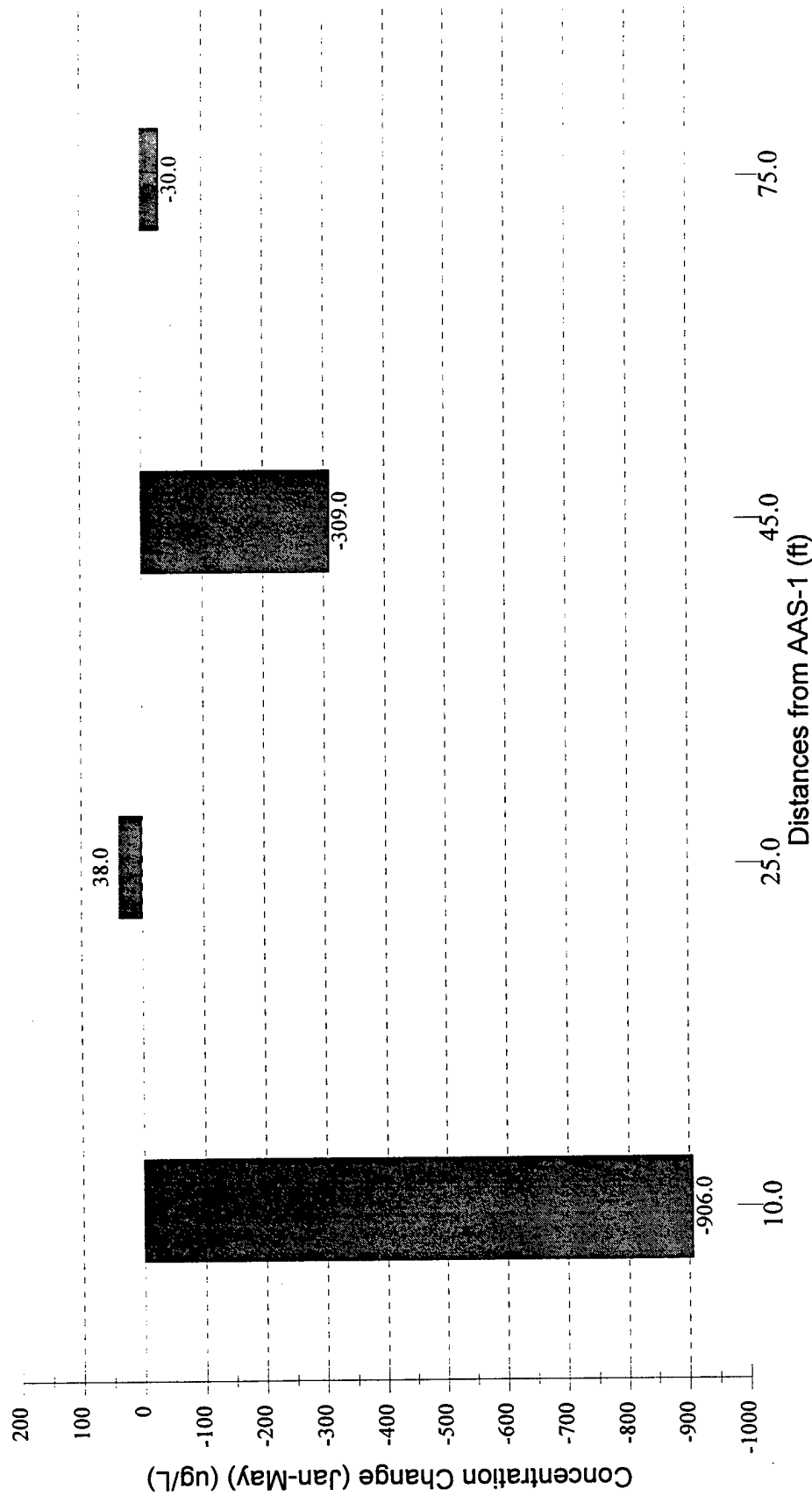
Concentration changes represent the difference between the Jan 95 and the May 94 sampling events.

Test Area 1 - SMW - Perpendicular



Figure 5.5-3 Change in Total GW VOCs

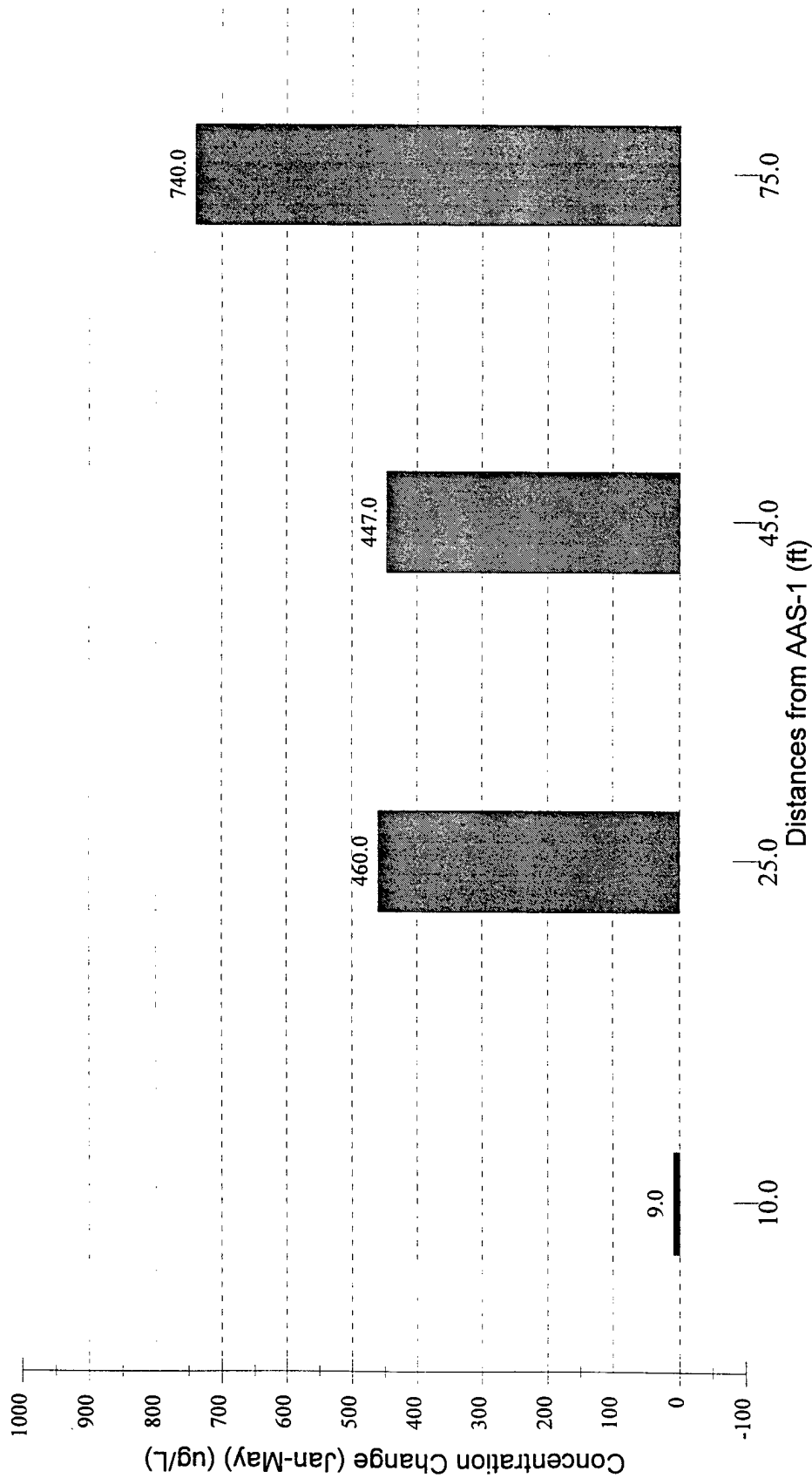
Test Area 1 - DMW - Parallel



Concentration changes represent the difference between the Jan 95 and the May 94 sampling events.

Figure 5.5-4 Change in Total GW VOCs

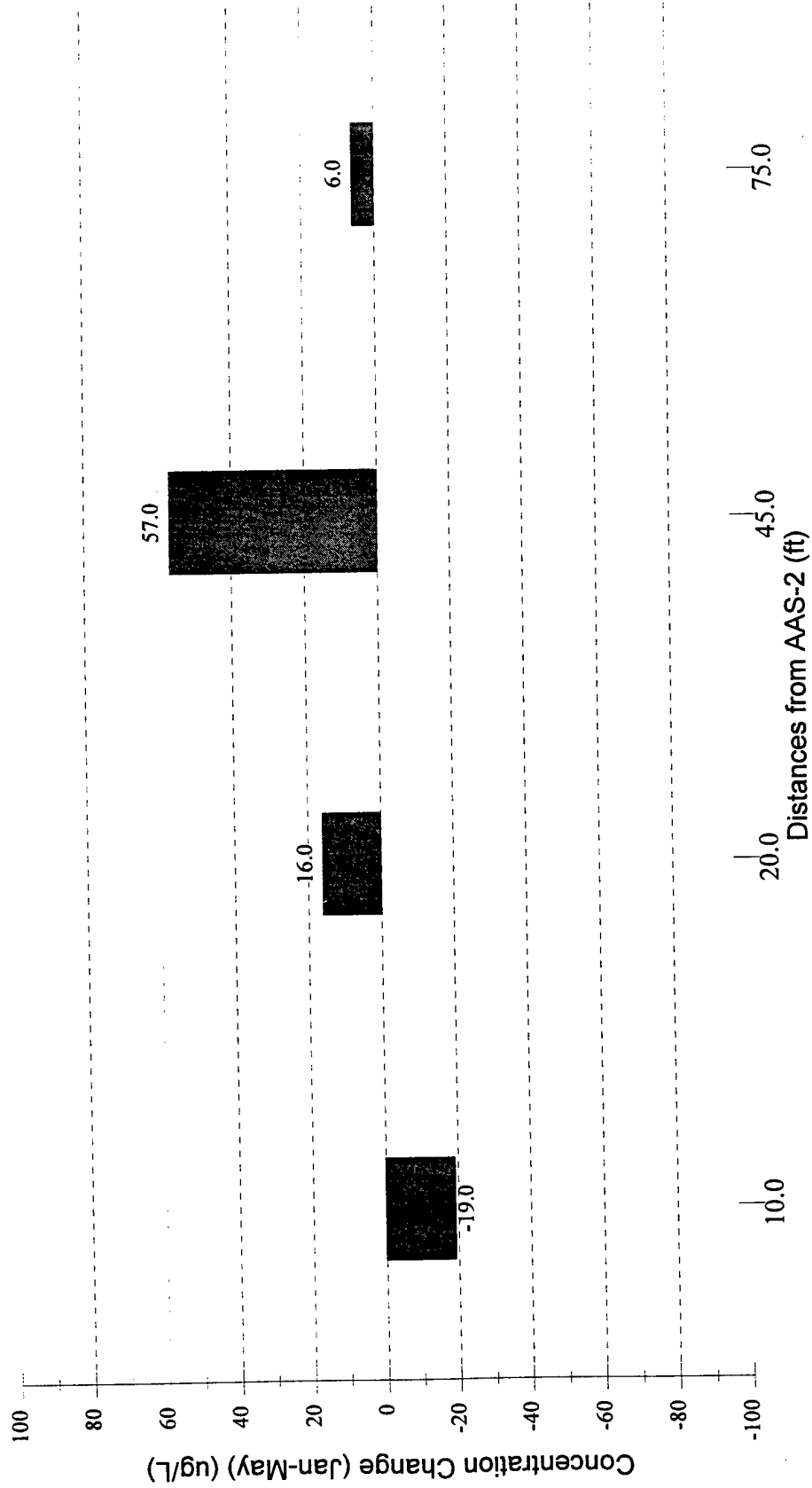
Test Area 1 - DMW - Perpendicular



Concentration changes represent the difference between the Jan 95 and the May 94 sampling events.

Figure 5.5-5 Change in Total GW VOCs

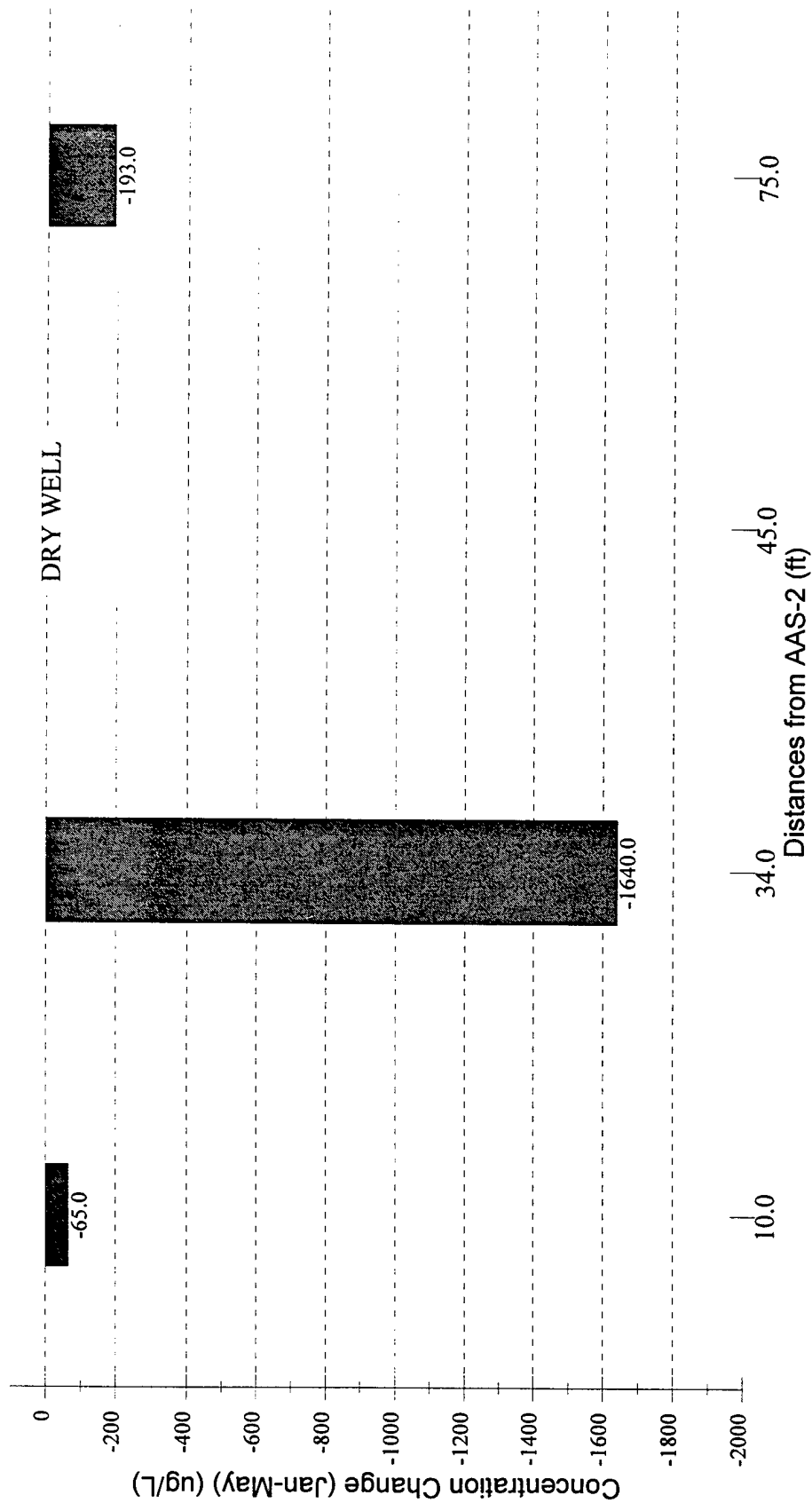
Test Area 2 - SMW - Parallel



Concentration changes represent the difference between the Jan 95 and the May 94 sampling events.

Figure 5.5-6 Change in Total GW VOCs

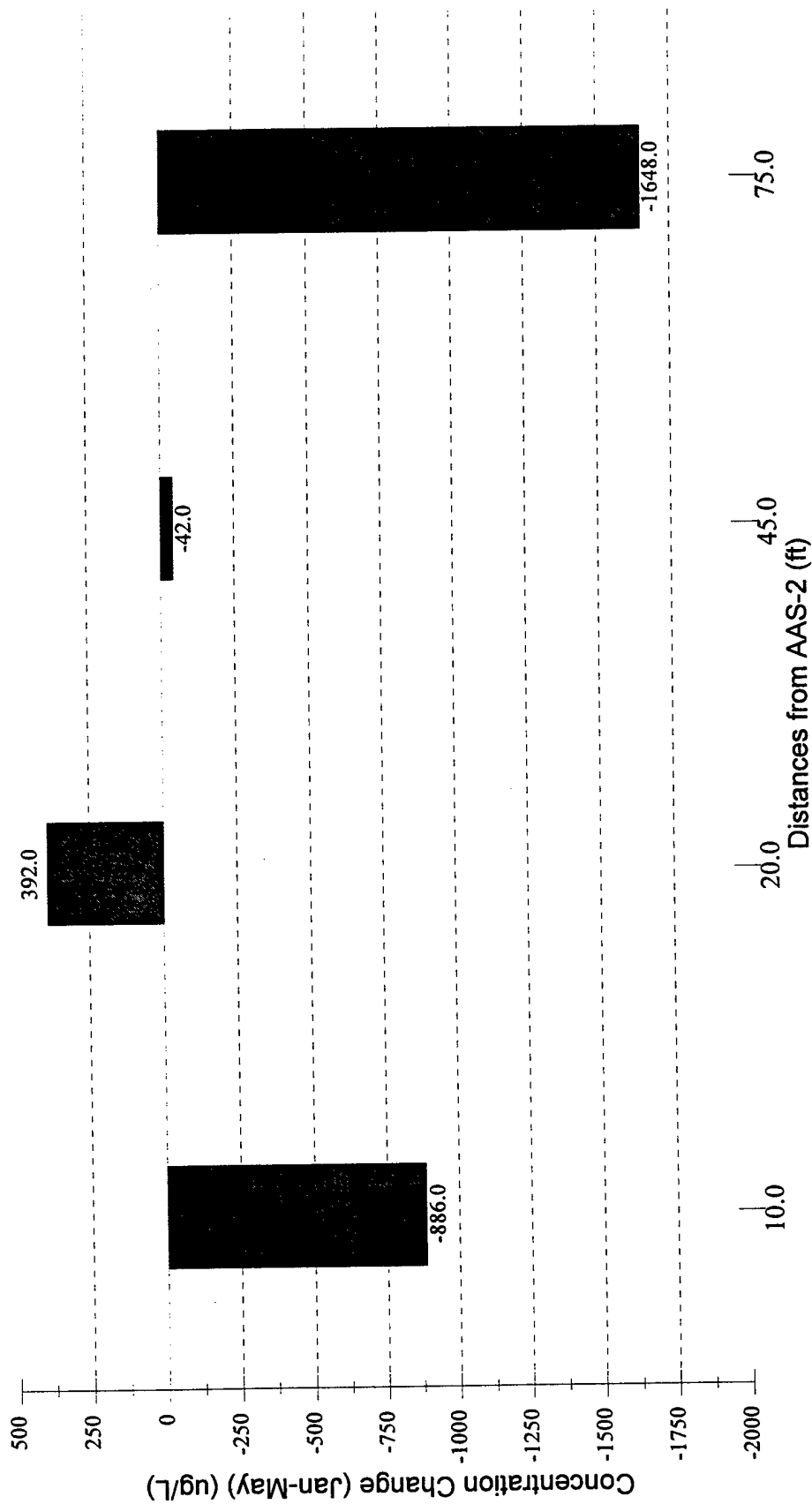
Test Area 2 - SMW - Perpendicular



Concentration changes represent the difference between the Jan 95 and the May 94 sampling events.

Figure 5.5-7 Change in Total GW VOCs

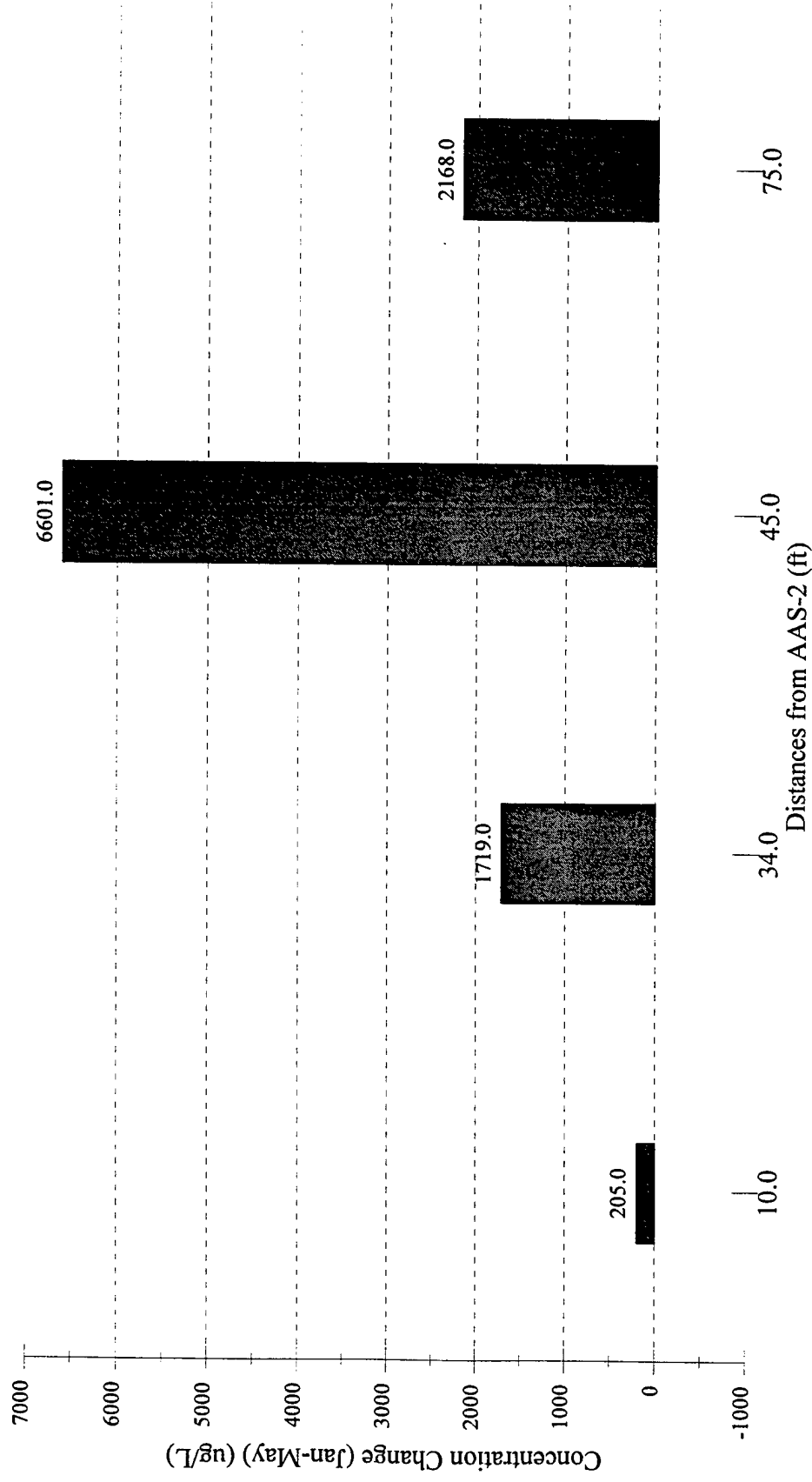
Test Area 2 - DMW - Parallel



Concentration changes represent the difference between the Jan 95 and the May 94 sampling events.

Figure 5.5-8 Change in Total GW VOCs

Test Area 2 - DMW - Perpendicular



Concentration changes represent the difference between the Jan 95 and the May 94 sampling events.

driving force. The increases may still represent a beneficial effect of AAS/SVE operation. Aside from volatilization, the influence of the AAS well can act to displace ground water. The increase in ground-water velocity will increase the rate of VOC desorption from subsurface soils. Similarly, the instigation of ground-water movement can increase the influence of sparging into areas of the aquifer which may not receive significant air flow. The solubilization or desorption of non-aqueous-phase VOCs is a necessary first step in the application of an AAS/SVE system. The placement of additional sparge wells is anticipated to increase the removal rate of the aqueous-phase contaminants by providing the additional air flow which is necessary to promote mass transfer to the vapor phase.

With respect to the shallow monitoring wells, consistent reductions of the total VOC concentrations were observed in the perpendicular direction in Test Area 2 (69.1% to 89.6% reductions) in three wells. This influence was observed up to 75 ft from AAS-2. Only the shallow monitoring well at 10 ft showed a decrease in the parallel direction. This effect was not observed in Test Area 1 (with reductions only at 10 ft from AAS-2) and may have indicated that preferential flow channels toward SVE2 were created in the perpendicular direction of the vadose zone. Additional total VOC reductions were observed in SMW45-1 (36.8%), SMW10-2 (44.2%), DP-6 (36.0%), and DP-12 (71.4%). The reduction observed at the DP-6 location agrees with the data collected from the other shallow monitoring wells in the perpendicular direction of Test Area 2. The reductions in DP-12 and SMW10-2 may have been attributed to their proximity to the sparge and vent wells.

Remediation goals for Site SS59 have been established to achieve a 90% reduction (or reaching an asymptotic removal plateau) in the primary chlorinated VOCs in ground water (based upon an average of VOC concentrations presented in the Post Closure Permits). Over the duration of the extended pilot study, a 90% reduction was observed in three of the monitoring points (DMW10-1, AAS-1, and SMS34-2P). The changes observed in the individual VOC's in each of the monitoring wells are summarized in Appendix F, Table F.4-9. The 90% remediation goal for total VOC concentrations is based upon seven ethylene-based VOCs (EA, 1994c). The total ground-water VOC concentrations presented in Table F.4-9 are based upon a slightly different set of compounds and, therefore, can only be used as a qualitative approximation of the degree of remediation for total VOCs.

5.6 TIMEFRAME FOR CLEAN-UP

Based upon the results of the extended treatability study and the system performance evaluation, as determined during the tracer gas injection study presented in Appendix A and Chapter 6, the estimated timeframe to remediate Site SS59 has been calculated. The timeframe for the AAS/SVE system to remediate the site was determined by a number of factors:

1. The estimated total mass of the contaminants in the vadose and the saturated zones within the site;
2. The number of the AAS and SVE wells to be installed at the site and operational conditions for the system;
3. The VOCs mass removal rate for each well;

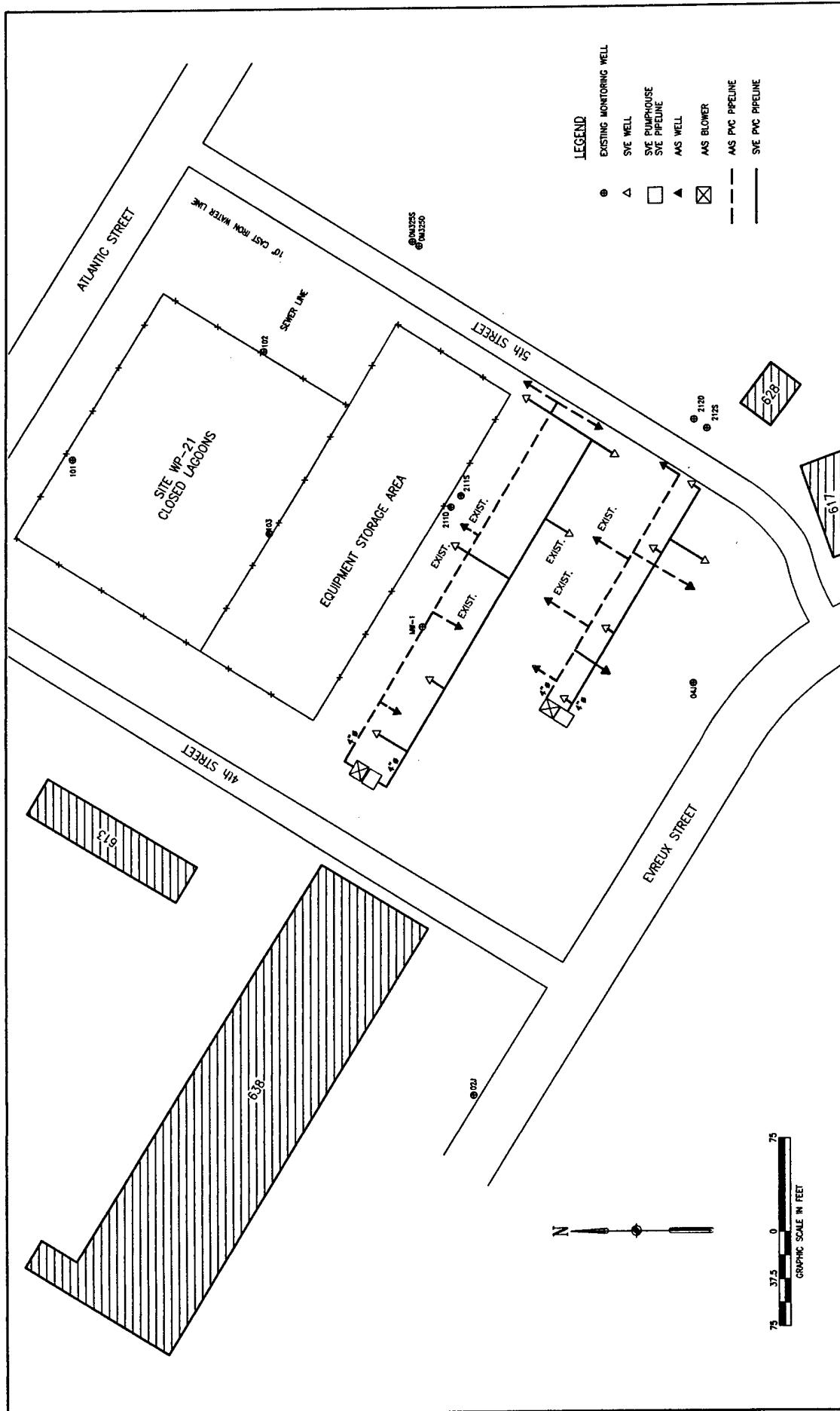
4. The rate of contaminant desorption from the soil particles was determined by subsurface characteristics such as organic carbon content, soil particle size, soil structure, and ground-water flow velocities. For example, contaminants can be released from soil in a shorter period of time when the ground-water velocity is high. Additionally, when the organic carbon content of soil is higher, a greater percentage of contaminants will exist in an adsorbed phase, and they will take a longer period of time to be released from the soil.
5. The natural reduction of the contaminants due to the biodegradation, chemical transformation, and decay processes.

Site SS59 is now defined as the area south of the maintenance area fence that is surrounded by 4th, 5th, and Evreux Streets. Within these borders, the area of attainment has been approximated as 66,700 sq ft. This consists of the area that is covered by the layout of the AAS/SVE wells as shown in Figure 5.6-1. For the site, the maximum concentration of total VOCs (8,014 µg/L at well DMW-45-2P) found during the latest ground-water sampling event was used as the concentration requiring remediation throughout Site SS59. The data for the sampling event is presented in Appendix F, Table F.4-6. This provides a conservative basis for the total mass present at the site since the next highest measured concentrations for total VOCs was 3,435 µg/L. The actual layout of the system should be based upon a round of predesign ground-water sampling.

To date there is no documented standard procedure to determine the timeframe for ground-water cleanup using an AAS/SVE system, since this is a relatively new and innovative ground-water treatment method and the subsurface processes that are occurring are not fully defined. However, it is anticipated approximately six years will be needed to clean up Site SS59 by AAS/SVE. This timeframe is based on the VOC mass removal rate of extraction wells, the number of wells, the total VOC mass within the site, and that no VOC contamination will be entering the site from outside of Site SS59 (Appendix B). The ROI of the AAS and SVE wells, and thus the number of wells required, was based on results from the extended treatability study. This data was then used to estimate the timeframe required to cleanup Site SS59. Another conservative factor was utilized in that the six year cleanup timeframe was based on removing the entire mass of VOCs calculated to be present. However, the cleanup criteria for Site SS59 is 90 percent removal criteria for chlorinated organics.

As discussed above, there are five major factors influencing the timeframe for site cleanup. The factors utilized follow:

- The total VOC's mass needed to be removed was computed based on the known COC distribution in both vertical and horizontal directions. For Site SS59, a very conservative scenario was used.
- The number of wells needed was determined by the size of the site and the effective ROI of the AAS well.
- The results from the extended AAS/SVE pilot study was used to predict the relationship between the mass removal rate and the operational time. It was assumed that the



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE	AAS/SVE WELL PLACEMENT				DESIGNED BY ES	DRAWN BY MMJ	DATE 3-30-95	PROJECT NO. 60378.26	FILE NAME BP2-R1
		AS SHOWN				CHECKED BY ES	PROJECT MGR. TRH	SCALE AS SHOWN	DRAWING NO. -	FIGURE NO. 5.6-1

operational conditions which were observed during the extended pilot study will persist over the estimated time frame for remediation.

- The rate of contaminant desorption from the soil particles was based on instantaneous equilibrium between the solute (COC) and soil particles, and it is assumed that there are no other sources of contaminants from the outside of Site SS59.
- The natural reduction of the VOCs was ignored in this analysis.

Based upon the above information, the timeframe for remediation was tentatively predicted (Appendix B). Due to the complexity of the conditions of the site and the amount of information known at this time, the timeframe given in this report is the best estimate that can be made since there is not an extensive database of long-term operational data at existing AAS/SVE sites to draw upon from the literature. It must be noted that the average removal rate over the extended AAS/SVE study may not be able to be sustained over time, and thus the six year timeframe for cleanup may be extended.

5.7 SYSTEM CONFIGURATION

The number of wells for the proposed AAS/SVE system was chosen based upon the ROI which was estimated during the extended pilot study. The system configuration was selected in order to incorporate as many of the existing wells as possible. Equipment specifications were based upon those presented in the FS for the site (EA, 1994a). Further design of the proposed, full-scale, AAS/SVE system would be performed as part of the Remedial Design phase of the IR Program should the system be implemented. System components and specifications for the AAS/SVE system for Site SS59 consist of the following: AAS wells (10 cfm/each), SVE wells (30 cfm/EA), air sparging blowers (150 cfm/each), vapor extraction pumps (450 scfm/each), air/water separators (105 gal/each), carbon adsorption system, and piping system. In the present scenario, two existing wells, DMW75-1P and DMW75-1, will be modified for use as AAS wells, together with the existing air sparging wells AAS-1 and AAS-2. The two existing soil vapor extraction wells, SVE-1 and SVE-2, will also be used. The existing monitoring wells could be converted into AAS or SVE wells through a modification of the well head (Figure 3.1-3) and the placement of additional manifold piping. The well risers and screened intervals would not require modification. This scenario will require the installation of 7 new air sparging wells and 9 new SVE wells. The same number of SVE wells as AAS wells has been utilized to provide for the capture of VOC migration from the perimeter of the site. The system is planned to operate and be monitored for approximately 6 years. The monitoring program will continue to be implemented from years 7 through 12. For system monitoring, ground-water VOC sampling and analysis (2 times/year) is recommended since the performance of the AAS wells needs to be monitored to determine the operating characteristics. Based on the initial operations, the configuration of the number of wells in operation and the operating parameters may be modified periodically. During the system design, a few of the existing shallow wells where higher VOC concentrations are found (e.g. SMW34-2P) should be connected to the system to allow for periodic use. Sparging in both the shallow and deep aquifer should act to enhance removal rates in that portion of the aquifer (Hoag, 1995).

5.8 COST ANALYSIS

The total costs for implementing the AAS/SVE system at Site SS59 have been estimated. The capital costs include the AAS wells, SVE wells, air/water separators, air sparging blowers, vapor extraction pumps, piping system, and carbon adsorption system. The operation and maintenance costs associated with this alternative include periodic replacement of the pumps, blowers, and the GAC replacement and regeneration. The monitoring costs associated with this alternative include the sampling of 12 ground-water wells existing at the site, and the analysis of the VOC concentrations of the offgas treatment system. See Table 5.8-1A through 5.8-1C for an estimate of the costs incurred by implementation of the AAS/SVE system. As compared to the other remedial alternatives which were developed for the site during the FS (EA, 1994a), AAS/SVE is a more cost effective option with respect to the total mass of COC's to be removed (Appendix B). However, in comparison to intrinsic bioremediation, as proposed in the Proposed Plan for Target Area 1 of Area 6 in the West Management Unit, the present worth costs for active AAS/SVE would be substantially more. Details are presented in the Proposed Plan and in the Draft-Final Area 6 Focused Feasibility Study Report, Dover Air Force Base (Dames & Moore, 1995).

Assuming continued operation under identical rates of contaminant removal (e.g., offgas concentrations, desorption rates), it is anticipated that approximately six years will be required to achieve remedial goals using an expanded system of a total of eleven AAS and SVE wells. Under this scenario, the estimated present worth cost over 11 years for implementation (6 years) and long-term monitoring (5 years) of the expanded system is \$1,690,000. This consists of \$390,000 in capital costs and \$231,000 in annual operation, maintenance, and monitoring costs for years 1 to 6 and \$39,000 in annual monitoring costs for years 7 to 11 of the system. However, the degree of flow channeling at the site and the variable trends observed during this study suggest that an expanded system may not be able to maintain these conditions in order to ensure remediation within six years. The time estimate was based on the average removal rate, however, these removal rates may not be able to be sustained, and thus, the six year timeframe may be extended.

Table 5.8-1A. Preliminary Estimate of Capital Costs for
Aquifer Air Sparging/Soil Vapor Extraction at Site SS59*

ITEM	DESCRIPTION	QUANTITY	UNIT COST	TOTAL
1	Air Sparging Well depth: 45 ft diameter: 2 in 10 cfm/EA	7	\$2,700	\$18,900
2	Vapor Extraction Well depth: 9 ft diameter: 2 in 30 cfm/EA	9	\$540	\$4,900
3	Air/Water Separator 105 gal/EA	2	\$2,150	\$4,300
4	Air Sparging Blowers 150 cfm/blower 50 Hp	2	\$6,000	\$12,000
5	Vapor Extraction Pumps 450 scfm 25 Hp	2	\$6,500	\$13,000
6	Piping 4 in PVC header pipe 2 in PVC well lines valves, fittings, meters	1250 LF 510 LF LS	\$18/LF \$14/LF LS	\$22,500 \$7,140 \$50,000
7	GAC Offgas Treatment GAC treatment Unit One time non RCRA GAC acceptance fee One time RCRA GAC acceptance fee Piping (10 % of component-1 unit) Electricity (10 % of component-1 unit) Instrumentation (5 % of component-1 unit) Site preparation (5% of component-1 unit)	2 10.00% 10.00% 5.00% 5.00%	\$14,480.00 	\$29,000 \$400 \$2,500 \$2,900 \$2,900 \$1,500 \$1,500
8	Electrical (circuit breaker, panel, drop, etc.)	LS	LS	\$30,000
9	Concrete	1000 CF	\$7.5/CF	\$7,400
10	Building	LS	LS	\$30,000
11	Mobilization/Demobilization	LS	LS	\$10,000
12	SUBTOTAL			\$250,800
13	Construction Management, and Site Services		10%	\$25,000
14	Implementation and Design		22%	\$55,000
15	Contingency		25%	\$63,000
16	TOTAL CAPITAL COST			\$390,000

* --- The cost estimation is based on a 45 ft radius of influence for AAS wells.

Table 5.8-1B. Preliminary Estimate of Operation and Maintenance Costs for AAS/SVE Treatment at Dover AFB

Years: 1 to 6

ITEM	DESCRIPTION	ANNUAL COST
1	Replacement Parts	
	- Pumps 1/every other year	\$3,300
	- Blowers 1/every other year	\$3,300
2	Carbon Usage (2 canisters)	\$9,000
3	System Maintenance	\$49,900
	- 2 persons, 1 day/week @ labor rate = \$60/hr	
4	Monitoring and Analysis	
	VOC Analysis	\$7,200
	Pesticides Analysis*	\$5,400
	Metals Analysis*	\$6,100
	Semi-VOCs (Phenols), Acid Extractables	\$2,900
	VOC Gas Samples	\$2,800
	Offgas Sample after GAC	\$14,000
	Sampling and Reporting	\$17,000
5	Electricity	
	- Air Sparging Blowers (2 @ 50 Hp/EA)	\$65,700
	- Vacuum Pumps (2 @ 25 Hp/EA)	\$33,000
6	Treatment of Groundwater from the A/W Separator	\$11,000
	\$1.5/gal/day at 20 gal/day	
7	TOTAL	\$231,000

*As required by Post Closure Permit criteria.

Table 5.8-1 C. Preliminary Estimate of Sampling and Analysis Costs for Post-Closure Monitoring for AAS/SVE

Years: 7 to 11

ITEM	DESCRIPTION	ANNUAL COST
1	VOC Sampling/Analysis 12 wells @ 2 samples/yr Method 8240	\$7,200
2	Pesticides Sampling/Analysis 12 wells @ 2 samples/yr Method 8080	\$5,400
3	Metals Sampling/Analysis 12 wells @ 2 samples/yr Method 6010/7000	\$6,100
4	Semi-VOCs (Phenols), Acid Extractables 12 wells @ 1 sample/yr	\$2,900
5	Sampling Labor \$5000/event x 2 events/year	\$10,000
6	Reporting	\$7,000
7	TOTAL	\$39,000

Capital Costs = \$390,000

O&M Costs (Years 1 - 6) = \$231,000

6 Year Present Worth O&M Costs =
(O&M Cost) x (P/A, 5%, 6 yrs) = \$1,172,000

O&M Costs (Years 7 - 11) = \$39,000

5 Year Present Worth O&M Costs =
(O&M Cost)x(P/A,5%,5yrs)x(P/F,5%,6yrs) \$126,000

Total 11 Year Present Worth O&M Cost = \$1,300,000

TOTAL 11 YEAR PRESENT WORTH = \$1,690,000

*As required by Post Closure Permit criteria.

6. SYSTEM PERFORMANCE EVALUATION VIA TRACER GAS INJECTION

The purpose of this study was to determine the travel pathway and distribution of injected air within the test aquifer and to verify the ROI from the initial AAS/SVE Treatability Study. The Radius of Influence (ROI) of the test AAS system at Site SS59 was up to 45 ft. The ROI is indicative of the distance where air channels in the subsurface are of sufficient density that air flow through them will substantially affect the saturated zone. The ROI reported in the feasibility study (EA 1994a) was based on the monitoring of several parameters (e.g. differential pressure and dissolved oxygen measurements). This SF₆ tracer gas study was proposed as part of the extended AAS/SVE pilot test. This tracer study was conducted in Test Area 1 at Site SS59.

The pre-existing sparging well in Test Area 1 (AAS-1) was modified to inject a fixed concentration (approximately 4,000 ppm_v) of SF₆ into the aquifer. The SVE systems were not operated during the injection of the tracer gas. The existing monitoring system was used to collect soil gas and ground-water samples from the vadose, shallow ground-water, and deep ground-water zones of the aquifer. The study was conducted over two days at two different flow rates (4.0 and 8.4 scfm, for day 1 and day 2 respectively). Soil gas samples were collected from key monitoring points at various time intervals during the tests. Ground-water samples were collected at the end of each day. System operational parameters, dissolved oxygen and differential pressures also were measured in the groundwater monitoring wells during the study. The spatial distribution of the tracer gas in Test Area 1 was examined with respect to time as well as distance from the point of injection.

The observed soil gas SF₆ concentrations appeared to indicate an influence due to AAS up to 45 ft in both the shallow zone (7 to 17 ft bgs) and the deep zone (31 to 36 ft bgs) of the aquifer. The observed ground-water SF₆ concentrations were much lower than anticipated and indicated a minimal influence. The observed differential pressure data suggested a positive influence (≥ 0.1 inches of water) due to AAS up to between 45 and 75 ft in the shallow zone with little or no effect in the deep zone. Finally, increasing the flow rate from 4.0 scfm to 8.4 scfm increased the concentrations of tracer gas throughout the subsurface but, overall, this did not appear to significantly extend the ROI.

Another observation of the tracer gas study was the presence of preferential air flow paths. In particular, the distribution of SF₆ throughout the subsurface appeared to depend on the flow rate and pressure of the injection system. On Day 1 of the study, the tracer gas distribution throughout the test area appeared to be relatively symmetrical in the shallow zone with a possible preferential flow regime aligned parallel to ground-water flow in the vadose and deep zones. When the injection pressure and flow rate were increased on Day 2 of the study, the preferential flow path appeared to shift in a direction which was perpendicular to ground-water flow. Overall, the AAS system did appear to have some influence on the subsurface up to 45 ft (mainly in the shallow zone) but, the observed SF₆ concentrations in groundwater and to a lesser degree in soil gas samples were lower than anticipated. Accordingly, a portion of the injected air during AAS at site SS59 was believed to be lost to the atmosphere within the immediate vicinity of the sparge well.

7. CONCLUSIONS

7.1 ESTIMATION OF HORIZONTAL AREA OF INFLUENCE

Based upon the soil gas, ground-water, and differential pressure data which was collected during the tracer gas study (Appendix A), the ROI in Test Area 1 appeared to be approximately 45 ft. The ROI is indicative of the distance where the air channels in the subsurface are of sufficient density that air flow through them will substantially affect the saturated zone. This was in close agreement with the ROI (45 ft) which was estimated during the initial AAS/SVE treatability study for Site SS59 (EA, 1994b). It was determined that a ROI of 45 ft (primarily in the shallow zone) provides a conservative estimate of what can be quantitatively expected from the AAS system at Site SS59. However, in a qualitative sense, the degree of this effect (e.g. the removal rate, the extent of flow channeling, and the SF_6 concentrations found in groundwater) appears to be insufficient for efficient remediation of low VOC concentrations at the site.

7.2 CONTAMINANT MASS REMOVAL

Based upon the change in soil gas VOC concentrations between the initial and final sampling events, the operation of the SVE system was highly efficient for removing vapor-phase COCs from the vadose zone. Here, an overall 99.4% reduction in the total vapor-phase VOC concentrations was affected (the average level decreased from 21.723 ppm_v to 0.126 ppm_v) in the vadose zone within Test Areas 1 and 2.

A time-weighted average of 0.05 lb/d of the primary COCs was observed to be removed by the combined AAS/SVE system, although a peak of 0.54 lb/d was observed on 13 October 1994. Due to this low mass removal, the AAS system was less effective than expected for volatilizing the contaminants present in the saturated zone. However, in comparison to the initial 34.1 lbs of soluble VOCs estimated to be within 50 ft of the sparge wells, the 19.1 lbs removed is substantial. It appeared that the low removal rates may have been due to the creation of preferential flow channels within the aquifer. Thereby, only portions of the aquifer would have been influenced by AAS and the removal rates would have been mass transfer limited. The higher removal rate observed on 13 October 1994 followed a one-week period of non-operation. This may be attributed to the mobilization of a zone of higher concentration of VOCs, or it may have been contributed to by the collapse of existing flow channels and the formation of new channels in the aquifer upon reactivation of the AAS/SVE system. Thus, pulsing of the AAS/SVE system is anticipated to potentially improve the influence of the system within the aquifer. This effect is supported in the literature. The lack of pulsing during operation of an AAS system tends to lead to the formation of stable flow channels and reduced air/contaminant interaction. Although improved removal may be realized by pulsing, it is unclear whether this would be of a sufficient degree to warrant the operation of a full-scale AAS/SVE system at the site.

The fact that the 10.2 lbs of VOCs removed during the extended pilot study was roughly equivalent to the mass removed during the initial (brief) treatability study (8.9 lbs) indicated that the system may have reached steady state conditions with respect to mass removal. This is due

in part to the formation of stable air channels. To increase COC removal from the saturated zone, pulsing of the AAS system is one strategy that should be employed to disrupt the steady state conditions. While pulsing of AAS systems have been reported in the literature to increase contaminant removal efficiency, data has not been generated during the course of these studies to confirm its application at Site SS-59. Continued operation of an AAS/SVE system under steady-state conditions would be acceptable provided that mass removal rates were sufficient to achieve remediation goals.

It was determined that increasing flow rates in the existing wells did not appear to improve performance when attempted in Test Area 1. The installation of additional sparge points will provide a greater volume of air to new areas of the saturated zone. Similarly, adequate flow rates of air will be easier to maintain throughout the aquifer.

Over both test areas, variable increases and decreases of ground-water VOC concentrations were observed in the monitoring points over the duration of the pilot study. The increase of ground-water concentrations which was observed in the remaining wells appear to indicate that contaminants were being mobilized due to AAS. This is a beneficial and expected effect of the AAS system. Here, contaminants can be desorbed or solubilized from a non-aqueous phase through the influence of direct contact with the injected air or through enhanced mass transfer resulting from increased ground-water advection. This mobilization (and the subsequent increase in ground-water concentrations) would be a necessary first step for remediation with AAS/SVE. Once mobilized into an aqueous phase, the contaminants could then be volatilized/transported to, and extracted from, the vadose zone provided a sufficient volume of air is supplied to the subsurface. This would require the installation of additional AAS wells.

7.3 RECOMMENDATIONS

Based upon the results of the extended pilot study, it is recommended that an expanded, full-scale AAS/SVE system should not be implemented at site SS59. During the study, low VOC mass removal rates were observed. It is thought that flow channeling of the injected air was the predominant air flow regime. Although a concern with respect to the time frame required to achieve remedial goals, the low mass removal rates were representative of the low VOC concentrations present within the aquifer. It was estimated that an expanded system consisting of 11 pairs of ASS/SVE wells which would operate under the same conditions should be able to achieve remedial goals for VOCs within 6 years (with 5 years of subsequent long-term monitoring). Based upon the variable results which were observed during the extended pilot test and the associated tracer gas study, it appears that the flow channeling at the site in combination with the low concentrations of COCs in the aquifer may inhibit the success of an expanded system within the estimated time frame. Under typical operational conditions, flow channeling will result in several "dead zones" (i.e., liquid phase diffusion limited operation) in the aquifer where the injected air cannot reach, and COCs will not be removed. A reduction in the degree of flow channeling, and an increase in the mass removal rate, may be achieved through the operations of a "pulsed" AAS/SVE systems. By using an on/off sparging cycle consisting of pulsed flow, it is anticipated that flow channels which may form would collapse and allow for the transport of injected air into different areas of the aquifer. Thus, removal rates may be

increased by minimizing the occurrence of dead zones and increasing the opportunities for mass transfer (e.g., providing higher COC concentration gradients by contacting more zones of the aquifer, and increasing the advective forces resulting from the injected air and ground-water displacement). This effect is supported by the research of Brown et al. (1995) and Marley et al. (1990). Another method for minimizing the effect of flow channeling is to sparge at various depths of the aquifer (Hoag, 1995). It is also possible to utilize some of the existing shallow monitoring wells as AAS wells. When combined with deep-aquifer sparging, this will act to provide greater air flows to different intervals of the aquifer.

Thus, in a quantitative sense, as indicated by the offgas concentrations, the AAS/SVE pilot system was able to remove VOCs from the aquifer at Site SS59 and a modified expanded system would be expected to continue remediating the site. However, qualitatively, the removal rates and the degree to which the system affects the site may be insufficient for the efficient remediation of the site. Therefore, although an AAS/SVE system may provide some removal of the subsurface VOCs, alternative remedial options should be considered. Alternatives such as intrinsic bioremediation are discussed in the Proposed Plan for Target Area 1 of Area 6 in the West Management Unit. If intrinsic bioremediation addresses the low concentrations of ground-water contamination, then no other active remediation needs to occur.

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Appendix A

SF₆ Tracer Gas Study

**FINAL
SF₆ TRACER GAS STUDY
SITE SS59: TEST AREA NO. 1
DOVER AIR FORCE BASE
DOVER, DELAWARE**

Prepared by:

EA Engineering, Science, and Technology, Inc.
Two Oak Way
Berkeley Heights, New Jersey 07922

Prepared for:

United States Department of the Air Force
Dover Air Force Base
436 Support Group/CEV
Dover, Delaware 19902-6600

July 1995
EA Project No. 60378.26

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LIST OF FIGURES (continued)

Figure

Title

5-32	Soil Gas SF ₆ vs. dP - Deep Monitoring Wells - Day 2
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LIST OF ACRONYMS AND ABBREVIATIONS

AAS	Aquifer Air Sparging
acfm	(actual) cubic feet per minute
bgs	below ground surface
COC	Contaminant of Concern
DAFB	Dover Air Force Base
DMW	Deep Monitoring Well
DO	Dissolved Oxygen
ECD	Electron Capture Detector
FID	Flame Ionization Detector
FS	Feasibility Study
ft	feet
GC	Gas Chromatograph
ppb	parts per billion
ppm	parts per million (mass per volume)
ppm _v	parts per million (volume per volume)
psi	pounds per square inch (absolute)
psig	pounds per square inch (gauge)
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
ROI	Radius Of Influence
scfm	(standard) cubic feet per minute
SF ₆	Sulfur Hexafluoride
SMW	Shallow Monitoring Well
SVE	Soil Vapor Extraction
v/v	volume per volume (units of measurement)
VMW	Vadose Monitoring Well
VOA	Volatile Organic Analyte
(-#)P	(designates a well series (in area #) which is aligned perpendicular to ground-water flow)

EXECUTIVE SUMMARY

The purpose of this study was to determine the travel pathway and distribution of injected air within the test aquifer and to verify the ROI from the initial AAS/SVE Treatability Study. The Radius of Influence (ROI) of the test AAS system at Site SS59 was up to 45 ft. The ROI is indicative of the distance where air channels in the subsurface are of sufficient density that air flow through them will substantially affect the saturated zone. The ROI reported in the feasibility study (EA 1994a) was based on the monitoring of several parameters (e.g. differential pressure and dissolved oxygen measurements). This SF₆ tracer gas study was proposed as part of the extended AAS/SVE pilot test. This tracer study was conducted in Test Area 1 at Site SS59.

The pre-existing sparging well in Test Area 1 (AAS-1) was modified to inject a fixed concentration (approximately 4,000 ppm_v) of SF₆ into the aquifer. The SVE systems were not operated during the injection of the tracer gas. The existing monitoring system was used to collect soil gas and ground-water samples from the vadose, shallow ground-water, and deep ground-water zones of the aquifer. The study was conducted over two days at two different flow rates (4.0 and 8.4 scfm, for day 1 and day 2 respectively). Soil gas samples were collected from key monitoring points at various time intervals during the tests. Ground-water samples were collected at the end of each day. System operational parameters, dissolved oxygen and differential pressures also were measured in the groundwater monitoring wells during the study. The spatial distribution of the tracer gas in Test Area 1 was examined with respect to time as well as distance from the point of injection.

The observed soil gas SF₆ concentrations appeared to indicate an influence due to AAS up to 45 ft in both the shallow zone (7 to 17 ft bgs) and the deep zone (31 to 36 ft bgs) of the aquifer. The observed ground-water SF₆ concentrations were much lower than anticipated and indicated a minimal influence. The observed differential pressure data suggested a positive influence (≥ 0.1 inches of water) due to AAS up to between 45 and 75 ft in the shallow zone with little or no effect in the deep zone. Finally, increasing the flow rate from 4.0 scfm to 8.4 scfm increased the concentrations of tracer gas throughout the subsurface but, overall, this did not appear to significantly extend the ROI.

Another observation of the tracer gas study was the presence of preferential air flow paths. In particular, the distribution of SF₆ throughout the subsurface appeared to depend on the flow rate and pressure of the injection system. On Day 1 of the study, the tracer gas distribution throughout the test area appeared to be relatively symmetrical in the shallow zone with a possible preferential flow regime aligned parallel to ground-water flow in the vadose and deep zones. When the injection pressure and flow rate were increased on Day 2 of the study, the preferential flow path appeared to shift in a direction which was perpendicular to ground-water flow. Overall, the AAS system did appear to have some influence on the subsurface up to 45 ft (mainly in the shallow zone) but, the observed SF₆ concentrations in groundwater and to a lesser degree in soil gas samples were lower than anticipated. Accordingly, a portion of the injected air during AAS at site SS59 was believed to be lost to the atmosphere within the immediate vicinity of the sparge well.

1. INTRODUCTION

1.1 BACKGROUND

Dover Air Force Base (DAFB) is located next to the city of Dover in Kent County, Delaware (Figure 1-1). The installation encompasses approximately 4,000 acres of land including annexes, easements, and leased properties. Site SS59 at DAFB (Figure 1-2) is under investigation for the remediation of ground water which was contaminated by a system of industrial waste basins operated in this area. The secondary basins of this system were closed in 1986 under RCRA. An Aquifer Air Sparging/Soil Vapor Extraction (AAS/SVE) System was one of the recommended remedial technologies presented in the FS for the site. A series of pilot AAS/SVE studies were conducted at Site SS59 from July to November 1993 in order to assess the viability of this technology for removing the contaminants of concern (COCs). Based upon the recommendations of that study, the AAS/SVE system was reactivated for an extended study. This report is an appendix for the extended AAS/SVE pilot study report.

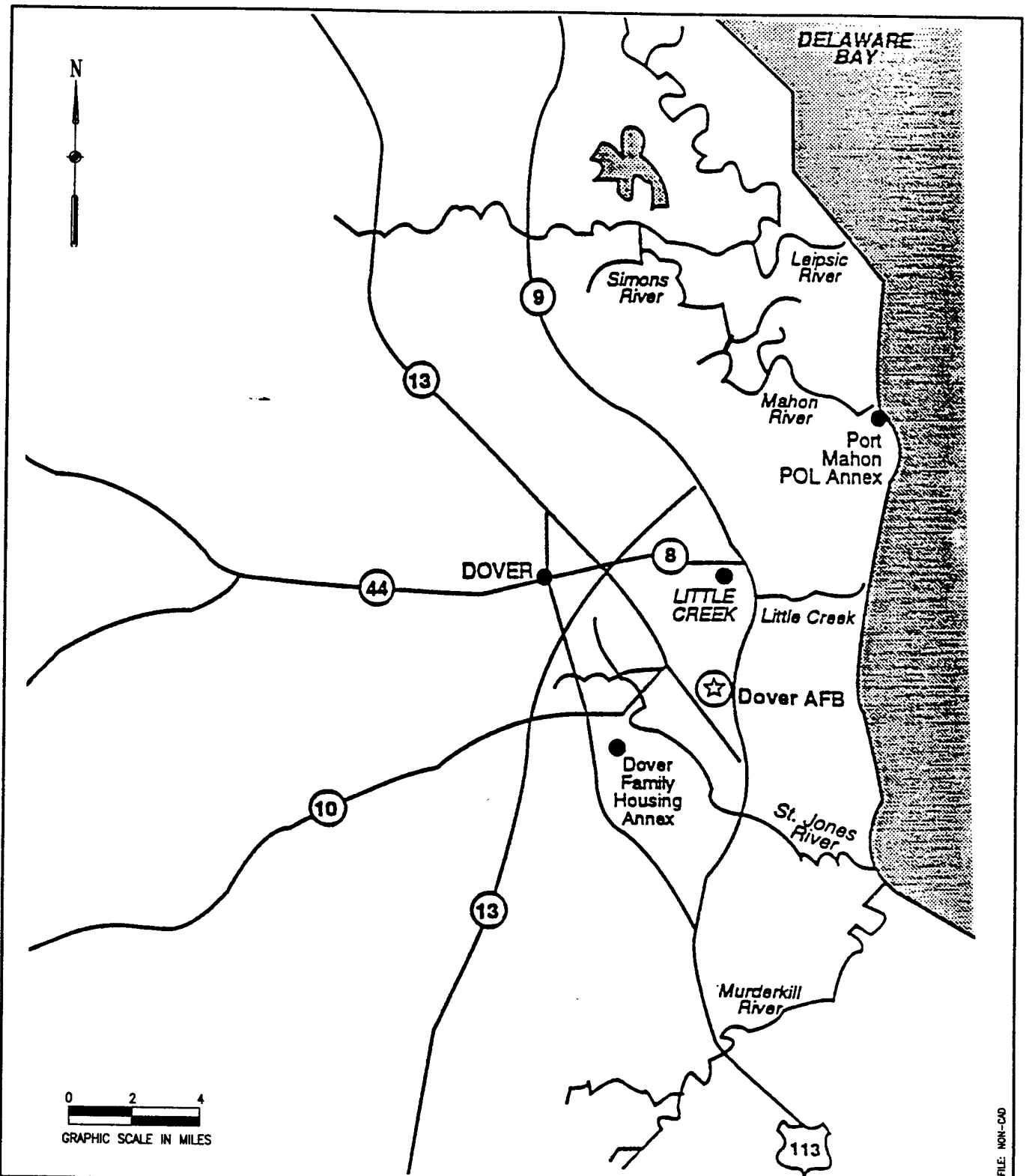
1.2 OBJECTIVES

Tracers can be used in a similar manner to elicit information regarding ground-water and air flow path in the unsaturated (vadose) zone of an aquifer. It was determined from the initial Aquifer Air Sparging/Soil Vapor Extraction (AAS/SVE) treatability study (EA, 1994b) conducted during the FS (EA, 1994a) that the Radius of Influence (ROI) of an AAS system at Site SS59 was up to 45 ft. This ROI was based on monitoring parameters such as differential pressure, dissolved oxygen (DO), as well as changes in the ground-water table. The ROI is indicative of the distance where air channels in the subsurface are of sufficient density that air flow through the channels will substantially affect the saturated zone. In order to verify this ROI and to determine the travel pathway and the distribution of the injected air/tracer gas within the test aquifer, the tracer gas study presented in this report was proposed as a part of the extended, AAS/SVE pilot test. Test Area 1 at Site SS59 was selected for the tracer study.

1.3 GEOLOGY AND HYDROGEOLOGY

Information regarding the overburden at Site SS59 was obtained during the installation of the series of monitoring wells designed for RCRA ground-water monitoring programs and the initial AAS/SVE treatability studies (EA, 1994b). Site SS59 predominantly consists of the fine- to medium-grained sands of the Columbia Formation. Previous data suggests that the site is underlain by 40 ft of coarsening sand with discontinuous lenses of silt and fine sand. A possible channel lag deposit containing rip-up casts of clay and rock fragments was detected from 17 to 20 ft in the boring for well 211-D. No continuous clay layer was detected under the site. Discontinuous clay lenses do occur in the Columbia Formation (Bachman, 1984).

The Kirkwood Formation of the Chesapeake Group directly underlies the Columbia Formation and serves as the aquitard at the base of the unconfined aquifer. It consists of a stiff, dark gray, silty clay ranging from 18 to 28 ft thick. Paleotopography with up to 50 ft relief was developed on the surface of the Kirkwood formation during deposition of the Columbia sediments. This



FILE: NON-CAD

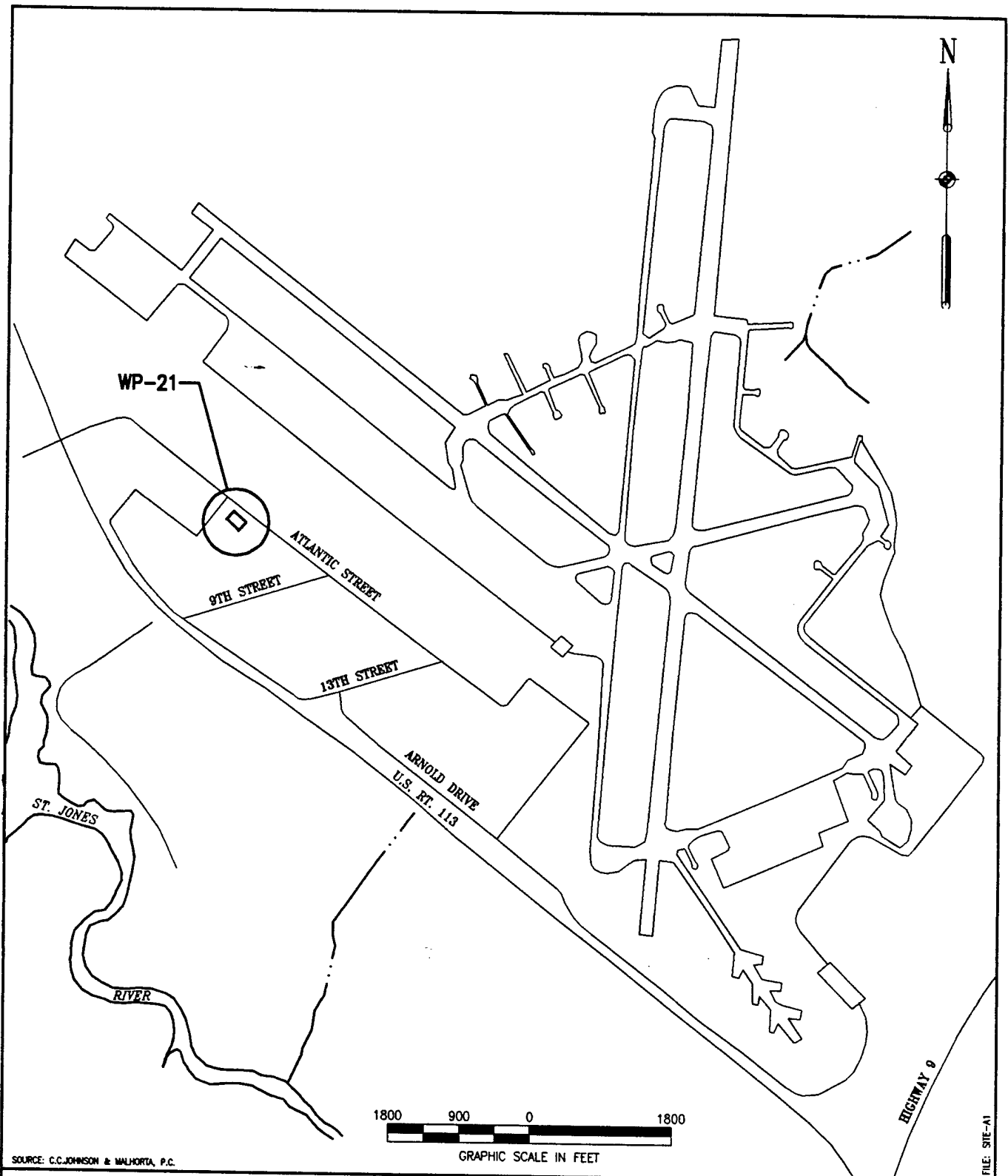


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DOVER AIR FORCE BASE
DOVER, DELAWARE

LOCATION MAP

PROJECT MGR TRH	DESIGNED BY JDR	DRAWN BY MNJ	CHECKED BY JDR	SCALE SHOWN	DATE 2-16-95	PROJECT NO 60378.26	FIGURE 1-1



SOURCE: C.C. JOHNSON & WALHORTH, P.C.

FILE: SITE-A1



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DOVER AIR FORCE BASE
DOVER, DELAWARE

WP-21 SITE LOCATION MAP

PROJECT MGR TRH	DESIGNED BY GTC	DRAWN BY MSM	CHECKED BY JDR	SCALE 1"=1800'	DATE 2-16-95	PROJECT NO 60378.26	FIGURE 1-2

paleotopography exerts localized control over the ground-water flow direction in the overlying Columbia aquifer.

The Frederica aquifer underlies the Kirkwood Formation. It consists of silty sands with relatively low permeability and water yields. The Frederica aquifer is underlain by 60 to 70 ft of silty sand which serves as an aquitard and overlies the Cheswold Aquifer which is one of the primary water supply aquifers in the Dover area.

The average depth to ground water at the site is nominally 11 ft below grade but varies seasonally. During periods of a low water table, ground-water flow at the base is towards the south. The flow direction changes to the southeast during periods of elevated ground water. Baseflow discharge to downgradient surface water drainage ditches may occur at this time. Ground-water flow for Site SS59 is to the south. Evidence from wells which were drilled in 1990 suggest that a paleotopographic trough in the surface of the Kirkwood Formation may direct subsurface flow within the deeper portions of the Columbia aquifer beneath the site (Dames and Moore with HAZWRAP, 1990). The trough is aligned north to south and the site is located over the central axis which plunges to the south. This feature may help to channelize flow during low water conditions towards the south and have less of an effect during high water conditions when the water table "floods" the underlying paleotopography.

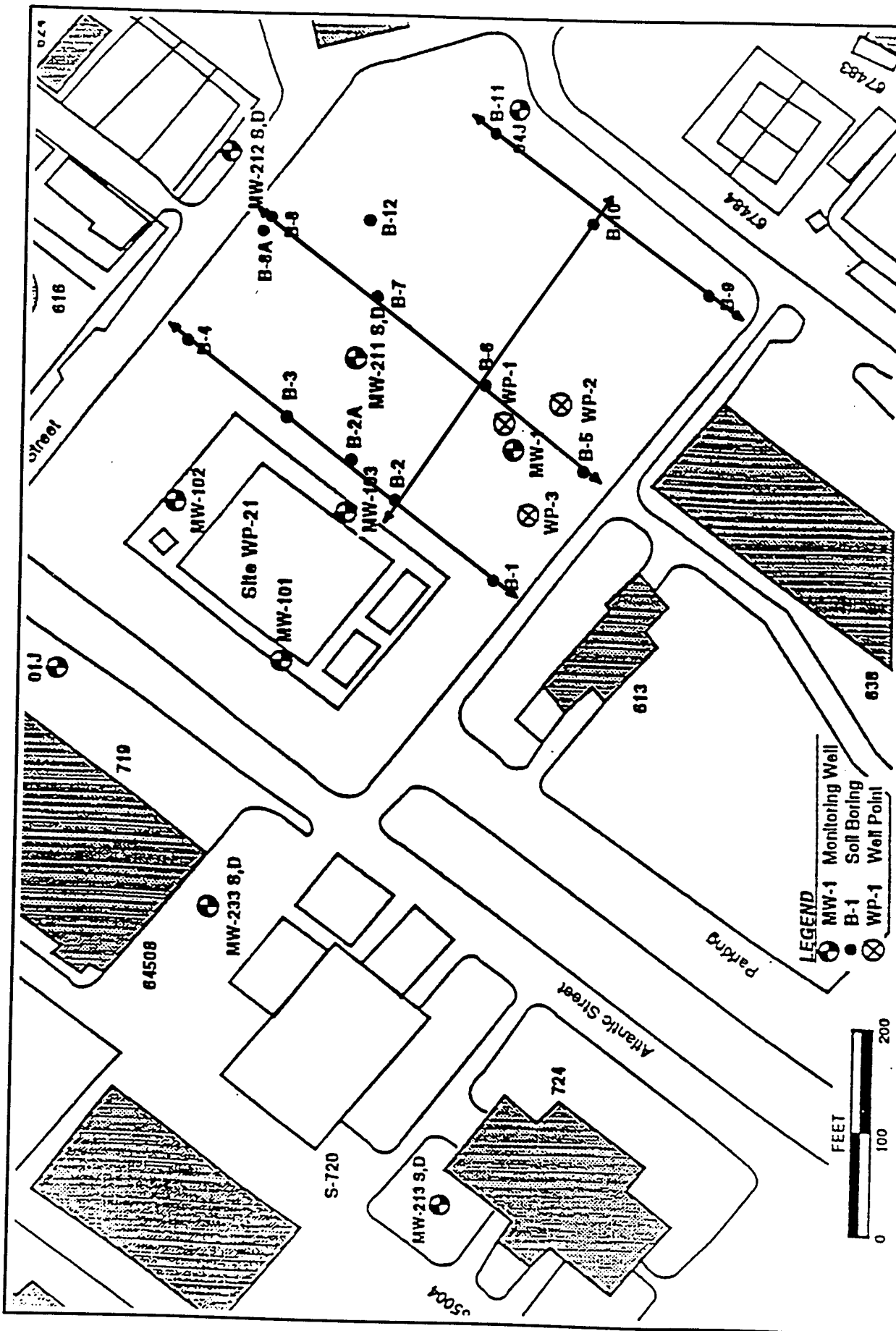
The saturated thickness of the Columbia aquifer ranges from 15 to 20 ft in the western portion of the base to 70 ft in the eastern portion. Hydraulic conductivities derived from previous, basewide, pump-test data range from 55 to 150 ft/day. The average hydraulic gradient is 0.001 but may vary with seasonal recharge. Assuming 30% porosity in the sediments, the ground-water flow velocity within the Columbia aquifer ranges from 67 to 182 ft/yr.

Twelve soil borings installed in May of 1993 (Figure 1-3) were used to construct geologic cross-sections of the underlying stratigraphy at Site SS59. The cross-sections were developed by correlating similar lithologies, as described in the soil logs, between boreholes. Soil types displayed between boreholes are therefore interpretive and based upon an evaluation of the available data. Generalized cross-sections through soil borings 5 through 8 (Figure 1-4 through 1-7) can be used to describe the stratigraphy at Site SS59. The orientation of the cross sections are shown in Figure 1-3.

1.4 TRACER GAS SELECTION

Numerous natural or artificially-produced gases may be introduced into ground water to serve as a tracer. The tracer gas to be monitored can either be already present in the aquifer or can be artificially injected and dissolved into the ground-water. Few examples of injected tracer gases are available in the literature.

There are several factors which may influence the concentration, and therefore, the effectiveness, of a tracer in ground water. For example, the concentration of dissolved tracer gas can be expected to increase with an increase of the gas pressure. In most situations, once the gas is dissolved in ground water at near-atmospheric pressures, the gas will tend to stay in solution



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DOVER AIR FORCE BASE
DOVER, DELAWARE

SOIL BORING
LOCATIONS (MAY 1993)
AT SITE WP-21

DESIGNED BY
AC

CHECKED BY
TRH

DRAWN BY
MNJ

PROJECT MGR.
TRH

DATE
3-30-95

SCALE
1"=200'

PROJECT NO.
60378.26

FIGURE
1-3

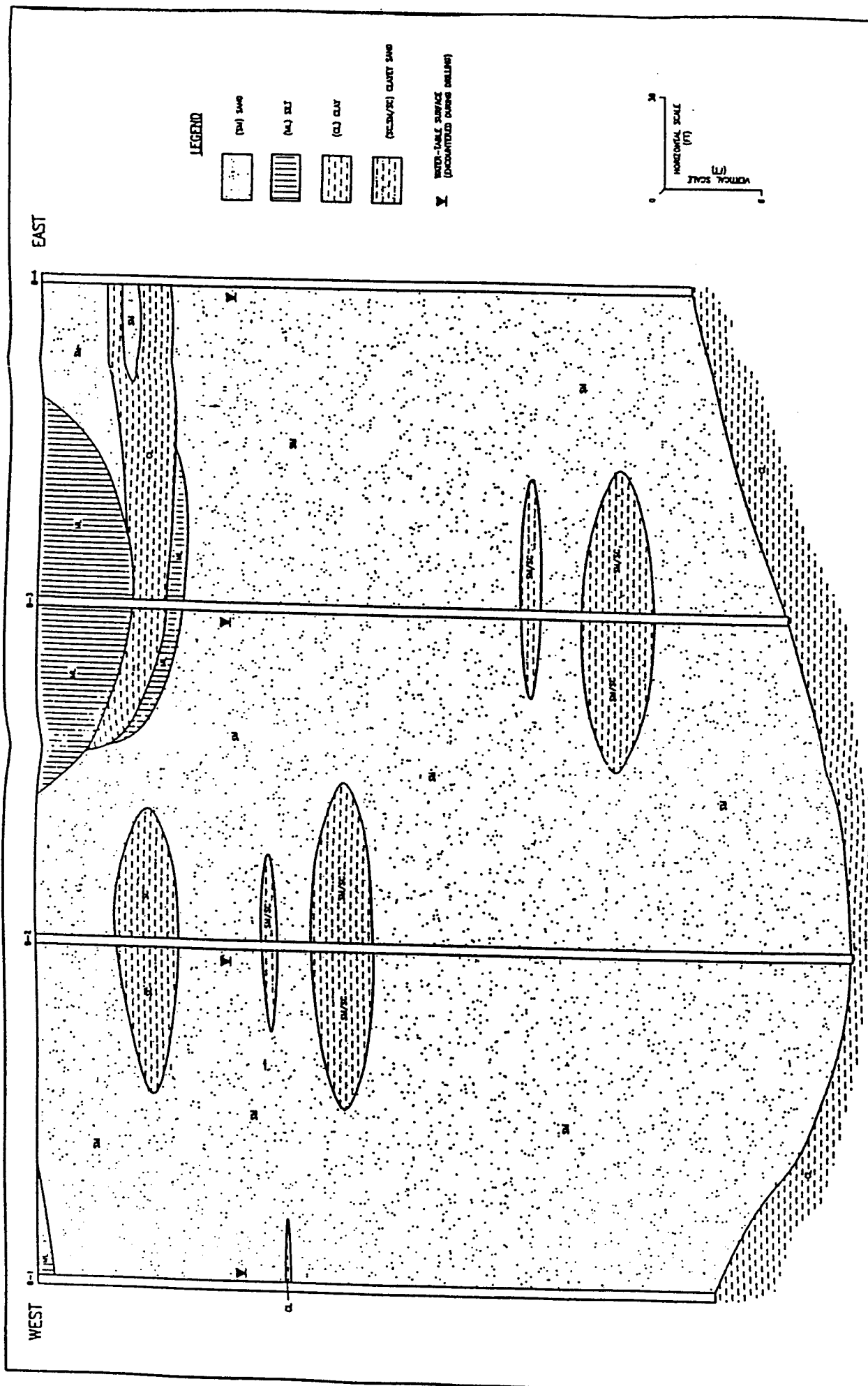
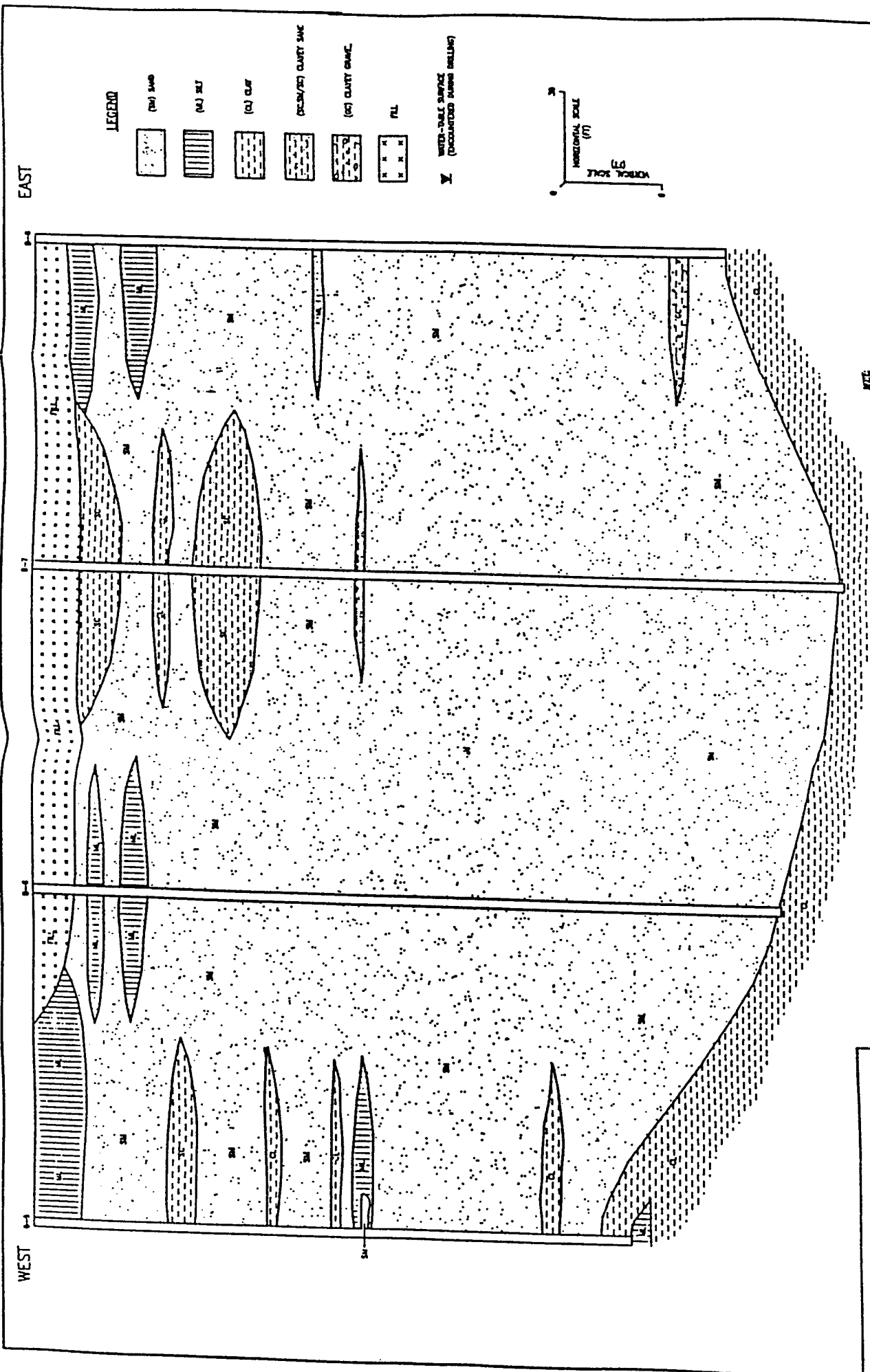


Figure 1-4 Generalized West-East Geologic Cross-Section, Borings B-1 to B-4



NOTE: THE SURFACE SETTINGS SHOWN REFLECT THE EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPOLATION OF PREVIOUSLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

Figure 1-5 Generalized West-East Geologic Cross-Section, Borings B-5 to B-8

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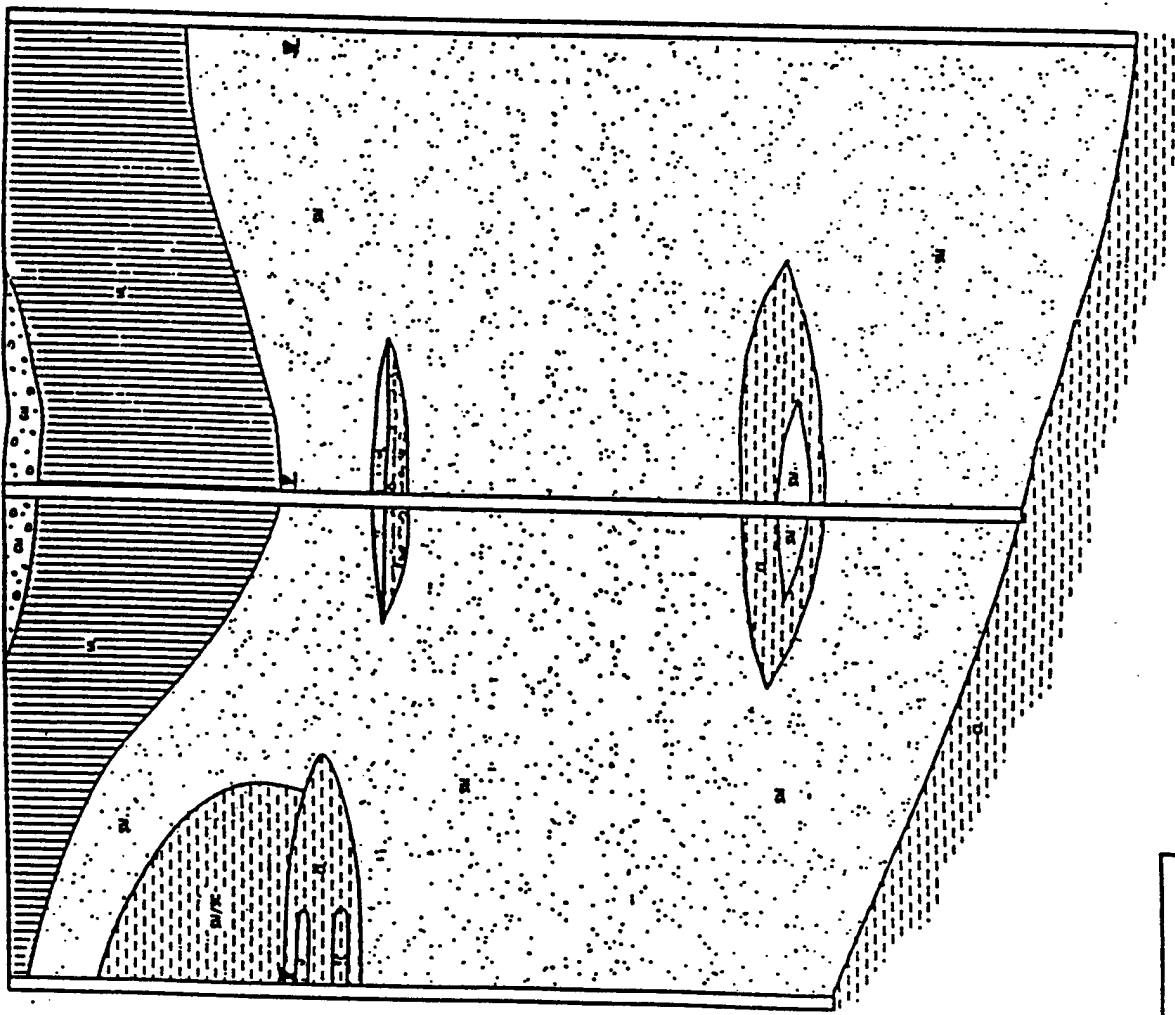
EAST

B-9

B-10

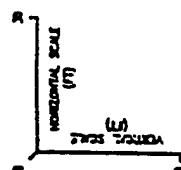
B-11

WEST



LEGEND

- (M) SAND
- (S) SILT
- (CL) CLAY
- (GS) CLAYEY SAND
- (GC) CLAYEY GRAVEL
- ALL
- WATER-BEARING SURFACE (DISCONTINUOUS BARS BELOW)



NOTE:
THE SUBSURFACE SECTIONS SHOWN HEREIN ARE EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

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Figure 1-6 Generalized West-East Geologic Cross-Section, Borings B-9 to B-11

since fluid pressure rapidly increases as water moves downward into an aquifer. Another consideration arises if large quantities of a gas such as methane is being generated in the subsurface. This gas may work its way up through the aquifer in the form of undissolved bubbles and will act to remove much of the pre-existing dissolved gases out of solution. Other factors, such as increases in temperature or salinity will also lower tracer gas concentrations in the aquifer by reducing the solubility of the gas.

A summary of the typical gases which are available for use in hydrogeological studies is presented in Table 1-1. Most tracer gases used for the hydrogeological studies can be placed into one of three categories: inert radioactive gases, inert natural gases, and fluorocarbons. Common pre-requisites for a ground-water tracer include the following:

- the tracer should be non-toxic;
- the potential chemical and physical behaviors of the tracer must be understood for the specific ground-water quality;
- the tracer should behave similar to atmospheric air to determine the flow pathway;
- the tracer should not interact with solid materials;
- the tracer should be easily detected with a technology which is readily available, easy to use, and reliable;
- the tracer should be able to be injected at concentrations which are well above background concentrations of the same constituent in the study area;
- the tracer should be relatively inexpensive.

Because of their non-reactive and non-toxic nature, and low naturally occurring concentrations inert gases (e.g., the noble gases) are potentially useful tracers. Helium is widely used as a tracer for industrial processes and, to a limited extent, it also has been used as a ground-water tracer (Carter et al., 1959). Neon, krypton, and xenon are other possible candidates for injected tracers due to their low natural background concentrations (Table 1-1). Although, under normal conditions, these inert gases do not undergo chemical reactions and do not participate in ion exchange processes, the heavier noble gases (i.e., krypton and xenon) may adsorb onto clays and organic materials which are present in the aquifer.

Helium is a relatively cheap, non-toxic, chemically-stable noble gas, and its storage, transportation, and handling in the field are easy and safe. Its low solubility and molecular weight allows the injected helium gas to travel easily within the ROI both horizontally and vertically. The transport of helium within an aquifer can, therefore, be delineated by sampling and analyzing the headspace of the monitoring wells (including vadose zone monitoring points). However, for the tracer study presented in this report, a reliable and sensitive detector was not available for helium analyses.

Sulfur hexafluoride (SF_6) was chosen for this tracer study since it is a non-toxic and relatively insoluble gas which is readily detectable with a standard field equipment. In addition, since SF_6 is not a naturally occurring gas, the background concentrations in an aquifer were likely to be undetectable. SF_6 is commercially available as a compressed gas.

TABLE 1-1 GASES OF POTENTIAL INTEREST AS TRACERS

Tracer Gas Options	Approximate Natural Background Assuming Equilibrium with Atmosphere at 20° C (mg gas / liter water)	Maximum Amount in Solution Assuming 100 % Gas at Pressure of 1 Atm at 20° C (mg gas / liter water)
Argon	5.7E-1	60.6
Neon	1.7E-4	9.5
Helium	8.2E-6	1.5
Krypton	2.7E-4	234
Xenon	5.7E-5	658
Carbon Monoxide	6.0E-6	28
Sulfur Hexafluoride	Not available	2.4 (Linke, 1965)

Source: Davis, 1985

2. DESIGN AND EQUIPMENT

The field techniques and equipment required for the injection of tracer gases are relatively standardized. It is primarily in the detection and analysis of an individual tracer that the techniques and required analytical equipment vary substantially. The basic equipment necessary to conduct a multiple-well gas tracer study includes an injection (sparge) well, several monitoring wells (fitted with sampling ports for the collection of gas samples), a tracer gas tank and associated injection connections, and the associated monitoring equipment. The injection and monitoring systems employed during this study are presented in Sections 2.1 and 2.2, respectively.

2.1 INJECTION SYSTEM LAYOUT

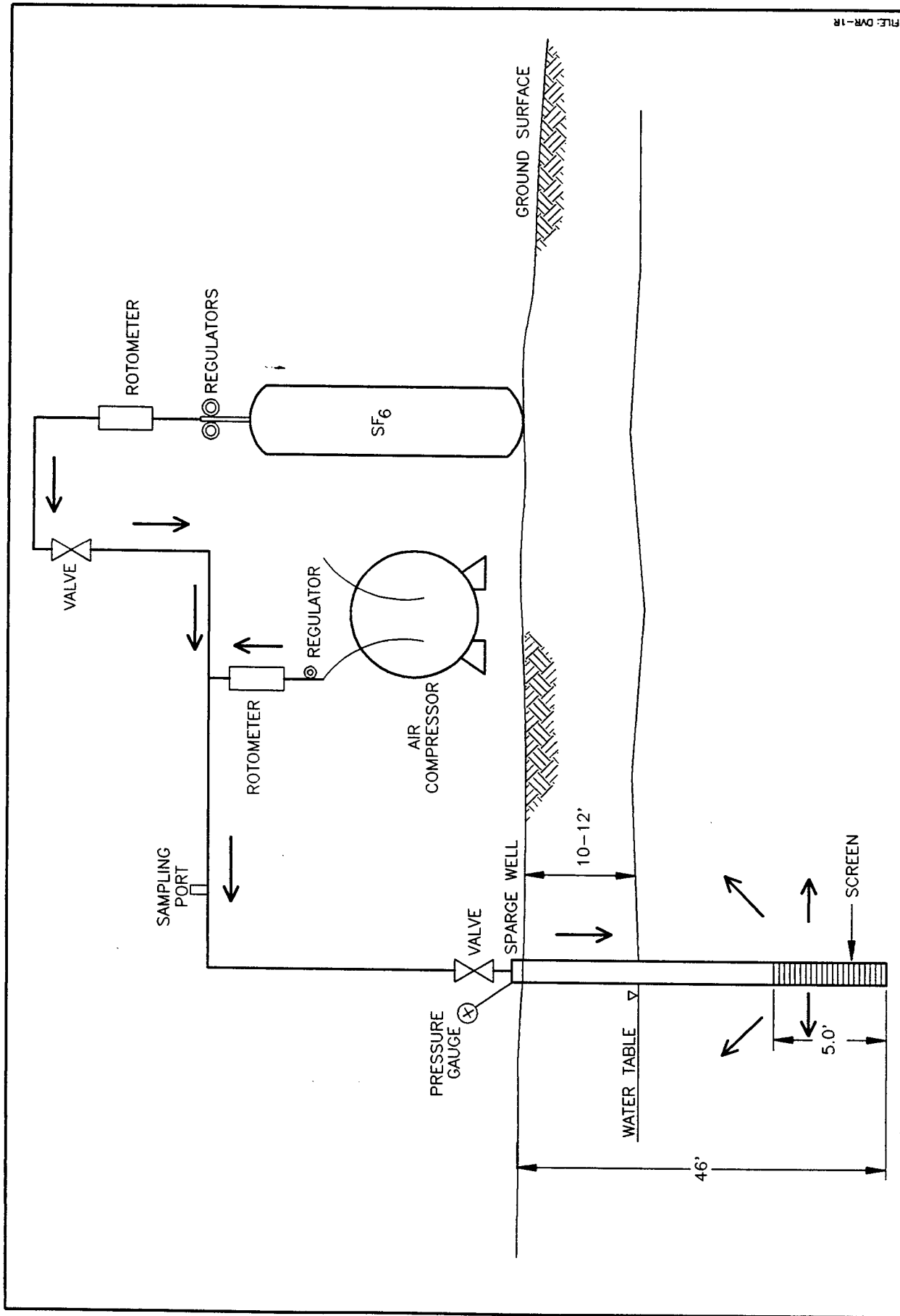
The study presented in this report utilized a single injection well for the SF_6 tracer. The pre-existing Aquifer Air Sparging well in Test Area 1 (AAS-1) was used to inject a fixed concentration (0.4%, v/v) of SF_6 into the aquifer at a depth of 46 ft (screened interval from 41 to 46 ft). The water table in the test area is typically located 10 to 12 ft bgs. The SVE systems were not operated during the injection of tracer gas.

The tracer gas injection system consisted of a pressurized SF_6 tank, an air compressor, and the associated piping systems including valves and regulators (Figure 2-1). Since SF_6 is a gas, it was convenient to transport the tracer to the study site in pressurized gas containers. The injected air and tracer gas were mixed in-line at the well head. A sampling port was also present at the well head in order to allow for the verification of the influent SF_6 concentrations.

2.2 MONITORING SYSTEM LAYOUT

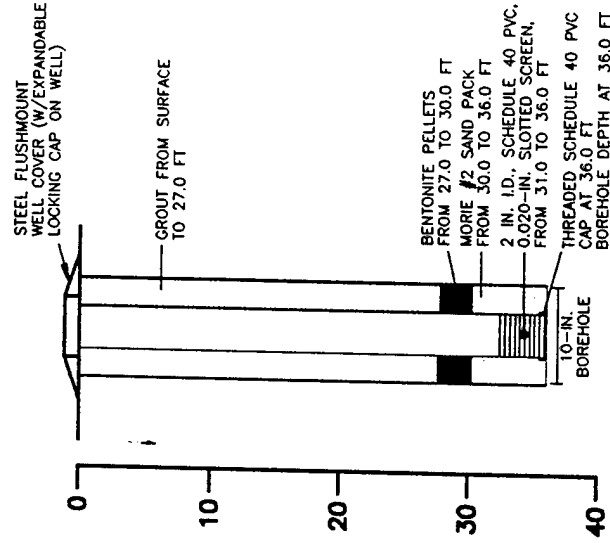
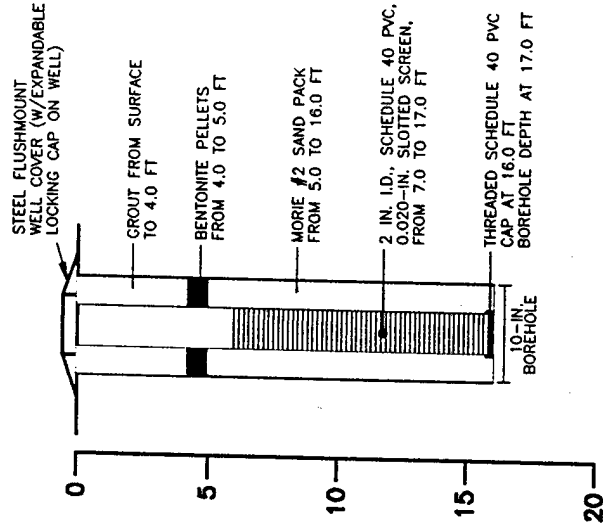
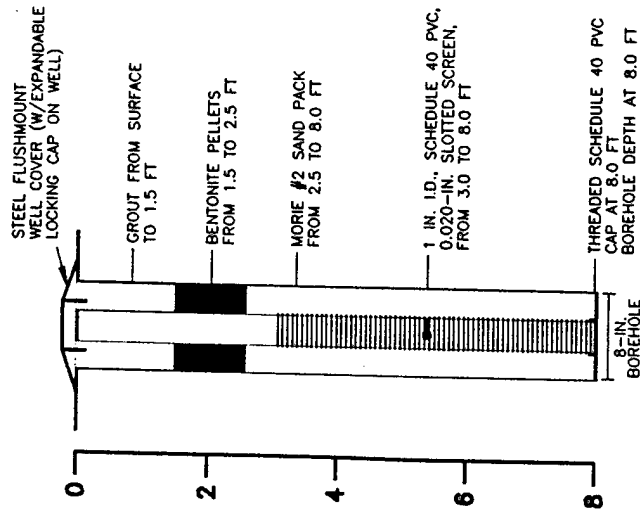
Once the tracer gas was injected into Test Area 1, it traveled horizontally and vertically through the saturated zone of the aquifer. Due to its low solubility (Table 1-1), most of the injected SF_6 did not go into solution with the ground water. Thus, it traveled by advection/diffusion/dispersion mechanisms into the vadose zone along with the injected air. Some of the injected SF_6 which remained in the saturated zone passed through the screened intervals of the monitoring wells and entered the headspace of the well. The concentrations of SF_6 in the well headspace and vadose zone monitoring points were, therefore, a function of the distance of the monitoring points from the injection point, the time interval since injection, air injection pressure and the site-specific aquifer characteristics. Localized, preferential flow channels would also strongly affect the resultant concentrations identified in the monitoring points.

This tracer study utilized the existing monitoring system (Figure 2-2) which was designed for the AAS/SVE treatability study (EA, 1994b). The tracer gas concentrations in the monitoring points were sampled both the gradient and the cross-gradient ground-water flow directions at the site. Nested monitoring points with different depths (Figure 2-3) were used to determine the concentrations of the tracer gas within the aquifer. The monitoring wells were designated "MW" and qualified by depth (D = deep, S = shallow, and V = vadose), distance from the test wells,



FILE: DWR-1R

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		TRACER GAS INJECTION SYSTEM		DESIGNED BY AC	DRAWN BY MNJ	DATE 2-17-95	PROJECT NO. 60378.26
					CHECKED BY JDR	PROJECT MGR. TRH	SCALE NONE	FIGURE 2-1



FILE: DMR-2R



EA ENGINEERING,
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DOVER AIR FORCE BASE
DOVER, DELAWARE

NESTED
MONITORING WELL
CROSS-SECTION

DESIGNED BY
AC

DRAWN BY
MNU

DATE
2-8-95

PROJECT NO.
60378.26

CHECKED BY
JDR

PROJECT MGR.
TRH

SCALE
SHOWN

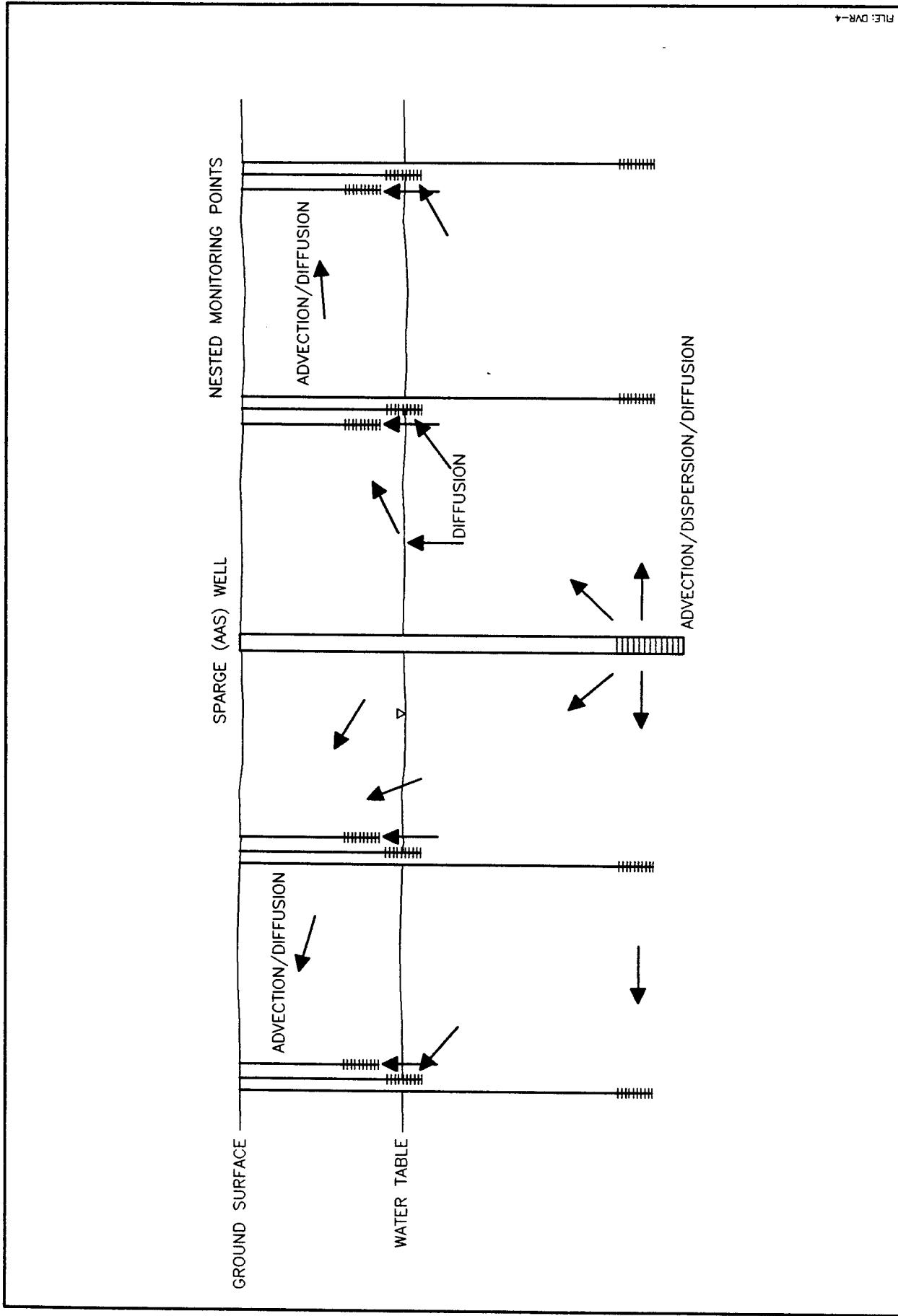
FIGURE
2-3

test area number, and their position with regard to ground-water flow direction. For example, "DMW45-1P" is the deep monitoring well located approximately 45 ft from the test wells in Test Area 1 on the line of monitoring wells oriented approximately perpendicular to ground-water flow. The corresponding monitoring point on the line approximately parallel to ground-water flow is numbered "DMW45-1".

Since the SF_6 gas enters the headspace of the ground-water monitoring wells only by diffusion/advection/dispersion mechanisms, the tracer gas concentrations identified in the shallow and deep ground-water monitoring wells were expected to approximate the tracer gas concentrations within the aquifer (Figure 2-4). The tracer gas concentrations identified in the vadose zone monitoring points may not have necessarily originated from the ground water located directly below the monitoring point. However, the data which was collected from these wells may provide valuable information regarding air flow through the unsaturated zone.

2.3 EQUIPMENT

The equipment used for this tracer study was identical to what was used for the AAS/SVE pilot study (EA, 1994) with the exception of the SF_6 gas and the associated piping system, regulators, and valves. A list of the equipment which was used in this study is presented in Table 2-1.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		CONCEPTUAL TRACER GAS FLOW DIAGRAM		DESIGNED BY AC	DRAWN BY CAC	DATE 7-24-95	PROJECT NO. 60378.26
					CHECKED BY JDR	PROJECT MGR. TRH	SCALE NONE	FIGURE 2-4

**TABLE 2-1 LIST OF EQUIPMENT EMPLOYED DURING THE TRACER GAS
STUDY, SITE SS59, DOVER AFB, DELAWARE**

Description	Manufacturer	Model/Serial Number
<i>Tracer Gas Injection System</i>		
Pressurized SF ₆ Tanks	Scott Specialty Gases	
Air Compressor	Ingersoll Rand	T-305805V
Two 80-Gallon Air Tanks	Ingersoll Rand	5Z365
Three Coalescing Filters (Pre-Filter and High Efficiency Vapor Filters)	Ultrafilter International	AG0006
Pressure Regulator	Parker	08R5
Hydrogard	Ingersoll Rand	HG-25
Piping System With Valves		
<i>Process Measurement</i>		
Pressure Gauges		
In-Line Flow Meter	Dwyer	VEC121-FC
Magnehelic Gauges	Dwyer	R18E, R10E, W34C
<i>Sampling Equipment</i>		
Gas Chromatograph	HNu Shimadzu	421 GC CRCH Integrator
Portable Flame Ionization Detector	Foxboro FID	OVA 128
Sampling Port	Swagelock	
Dissolved Oxygen Meter	Yellow Spring Instruments	57

3. TEST PROCEDURE

3.1 FIELD TEST PROTOCOL

The tracer gas study was conducted in Test Area 1 at Site SS59. The Aquifer Air Sparging/Soil Vapor Extraction (AAS/SVE) system was shut down for 24 hours prior to the test in order to serve as an equilibrium period for the test aquifer. Before injecting the tracer gas, the AAS system (air only) was activated for one hour. The resistance to airflow into the aquifer due to the static head of water which was present in the injection well was determined by using the following equation:

$$P_i = (W_c) \times (0.434 \text{ psig/ft})$$

where:

P_i = Initial pressure (resistance) (psig)

W_c = Standing water column in the well above the top of the well screen (ft)

Using this equation, the initial resistance to air sparging was approximately 12.9 psig (Appendix A-1). Thus, an initial injection pressure of 17 psig was used to overcome the standing column of water and to allow airflow through the screened interval into the saturated zone. The injection pressure soon equalized down to 12 psig and the injection flow rates were adjusted to maintain the desired influent concentration of tracer gas. The injection pressure was checked every 15 minutes throughout the test (and held steady once the injection of tracer gas had begun).

The flow rates from the air compressor and the pressurized SF_6 tank were adjusted such that a 0.4% (v/v) mixture (4,000 ppm_v) was being injected into AAS-1. For Day 1 of the tracer study, the tracer/air mixture was injected at 3 acfm. The actual mass flow rate of SF_6 which was injected into the aquifer during the tracer study is presented in Section 4.1.3.

Injection flow rates were measured by directly recording the injection rate (acfm) from an in-line flowmeter. Recorded flow rates were subsequently corrected for the effects of pressure utilizing the following equation:

$$Q_2 = Q_1 (P_2/P_1)^{0.5}$$

Where Q_1 = Observed flow meter reading (acfm)

Q_2 = Actual flow rate (corrected for the effects of pressure) (scfm)

P_1 = Standard atmospheric pressure (14.7 psi)

P_2 = Actual pressure (gauge pressure (psig) + 14.7 psi)

Thus, the flow rate on Day 1 was equivalent to 4.0 scfm (Appendix A-1).

Over the course of the study, vapor samples were collected from the individual monitoring points and analyzed for SF_6 concentrations according to the schedule indicated in Table 3-1.

**TABLE 3-1 SAMPLING AND MONITORING SCHEDULE FOR THE TRACER GAS STUDY
AT SITE SS59, DOVER AFB, DELAWARE**

Injection System Operational Parameters		Interval				Ground-Water Sampling (After Test for SF6)	
Sample SF6 Concentration (Day 1)		15 min, 45 min, 150 min, and 360 min.				SMW10-1 DMW10-1 SMW45-1 DMW45-1 SMW25-1P DMW25-1P	
Sample SF6 Concentration (Day 2)		15 min, 240 min.					
Measure Injected Pressure		As above					
Measure Flow Rate		As above					
SF6 Measurements		Day 1				Day 2	
Deep Wells		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round
DMW10-1		X	X	X	X		
DMW25-1P		X	X	X	X	X	X
DMW45-1		X	X	X	X	X	X
DMW75-1P		X	X	X	X	X	X
Shallow Wells							
SMW10-1		X	X	X	X		
SMW25-1P		X	X	X	X		X
SMW45-1		X	X	X	X	X	X
Vadose Zone Monitoring Points							
VMW10-1		X	X	X	X		
VMW25-1P		X	X	X	X		X
VMW45-1		X	X	X	X		
Additional Points							
VMW25-1				X	X		
SMW25-1				X	X	X	X
DMW25-1				X	X	X	X
VMW75-1				X	X		
SMW75-1				X	X	X	X
DMW75-1				X	X	X	X
VMW45-1P				X	X		X
SMW45-1P				X	X	X	X
DMW45-1P				X	X	X	X
SMW10-1P				X	X		
Soil Gas Probes							
Probe A (10 ft)				X	X		X
Probe B (25 ft)				X	X	X	X
Probe C (45 ft)				X	X	X	X

System operational parameters and sampling point differential pressures were also monitored as appropriate. In addition to the monitoring wells and vadose zone monitoring points, three soil vapor probes were installed in the test area in order to confirm the accuracy of the SF₆ concentrations observed in the wells. The location of three direct push, vapor probes (10 ft, 25 ft, and 45 ft from AAS-1) within the test area is presented in Figure 2-2. The depth of the probes were identical to the shallow ground-water monitoring wells (i.e., 12 to 15 ft BGS).

A second day of the tracer study was operated under the same test conditions except that a higher flow rate (6 acfm = 8.4 scfm) and injection pressure (14 psig) was used. The existing SVE system was operated only during the hiatus between the two study days.

3.2 DATA COLLECTION

System operational parameters such as the injection flow rates, the injection pressures, the temperature of the injected air, and the injected SF₆ concentrations were monitored during the tracer study. The critical parameters which were monitored during the tracer study were the differential pressures at the individual monitoring points and the concentration of SF₆ in the soil vapor and ground-water samples.

The monitoring network, sampling instrumentation, sampling frequency (Table 3-1), and detection methods were determined by the flow regime of the aquifer. The headspace of the monitoring points (including the three geoprobes) was sampled over four time intervals on Day 1 of the study. Additional wells were sampled during the second half of the tracer study in order to further identify the reach of the tracer gas from AAS-1. The system operational parameters were also monitored during these intervals. The differential pressures were recorded on each day of the study.

The system setup, operation, and monitoring procedures were conducted by EA personnel.

3.3 CHRONOLOGY OF FIELD ACTIVITIES

The AAS/SVE systems in Test Areas 1 and 2 were shut down for 24 hours prior to the commencement of the tracer study in order to provide an equilibration period for the test aquifer. During the equilibration period, the SF₆ injection system was calibrated to deliver an approximate 0.4% tracer/air mixture to AAS-1. On Day 1 of the study, prior to the injection of the tracer gas, the AAS-1 system was activated for one hour (air only). Then the tracer gas mixture was injected into AAS-1 and monitoring was performed according to the procedures outlined in Section 3.2. The SVE systems were not in operation during the injection of tracer gas. At the end of the study on Day 1, ground-water samples were collected, the air compressor was deactivated, and the SVE was reactivated until the following morning when Day 2 of the study began. Identical procedures were employed on Day 2 of the study, but using a higher injection flow rate and pressure. The AAS/SVE systems were reactivated following the completion of the tracer study. A summary of the field activities is presented in Table 3-2.

TABLE 3-2 CHRONOLOGY OF FIELD ACTIVITIES

DATE/TIME	EVENT
19 December 1995	MOBILIZATION AND TRACER STUDY PREPARATION
0700 to 1815 hrs	Turned off AAS/SVE system in Test Areas 1 and 2. Checked equipment and piping. Calibrated tracer injection equipment to supply a 0.4% mixture. Calibrated GC with vapor standards.
20 December 1995	DAY 1 OF TRACER STUDY
0700 hrs	Mobilized for Day 1 of the study. Activated air compressor. Rechecked influent concentrations of tracer gas.
0815 hrs	Began sparging at AAS-1 (air only) with an injection pressure of 17 psi. Adjusted flow rates to compensate for decreasing (stabilizing) pressure.
0845 hrs	Began tracer study in Test Area 1 with an injection pressure of 12 psig and a flow rate of 3 acfm (4.0 scfm).
0900 hrs	First sampling interval (15 min). Soil gas samples collected ¹ . Began GC analysis of soil gas samples.
0930 hrs	Second sampling interval (45 min). Soil gas samples collected ¹ .
1115 hrs	Third sampling interval (150 min). Soil gas samples collected ¹ .
1130 hrs	Differential pressure measurements collected from each of the monitoring wells.
1445 hrs	Final sampling interval (360 min). Soil gas samples collected ¹ .
1500 hrs	Ground-water samples collected from 10 of the monitoring wells (onsite GC analysis). Turned off AAS-1 system. Activated SVE system in Test Areas 1 and 2.
21 December 1995	DAY 2 OF TRACER STUDY
1100 hrs	Turned off SVE systems. Turned on AAS-1 (air only) with an injection pressure of 17 psig. Adjusted flow rates to compensate for decreasing (stabilizing) pressure.
1200 hrs	Began tracer study in Test Area 1 with an injection pressure of 14 psig and a flow rate of 6 acfm (8.4 scfm).
1215 hrs	First sampling interval (15 min). Soil gas samples collected ¹ . Began onsite GC analysis of soil gas samples.
1415 hrs	Differential pressure measurements collected from 10 of the monitoring wells.

TABLE 3-2 CHRONOLOGY OF FIELD ACTIVITIES (continued)

DATE/TIME	EVENT
1600 hrs	Final sampling interval (240 min). Soil gas samples ¹ and differential pressure measurements collected.
1605 hrs	Collected ground-water samples from each of the monitoring wells (onsite GC analysis).
1620 hrs	End of Tracer Study. Activated AAS/SVE system in both Test Areas.

1. The specific monitoring wells which were sampled during each of the intervals are summarized in Table 3-1.

4. SAMPLE ANALYSIS AND RESULTS

4.1 SOIL GAS

4.1.1 Sample Collection and Analytical Methods

Soil gas samples were collected into dedicated Tedlar sample bags using a vacuum pump. Swagelok sampling ports were fitted to pre-existing monitoring wells within the test area. In order to prevent contaminants from entering the pump, the sample bag was placed in a secondary plastic container which was fitted to the sampling port on one end and the vacuum pump on the other. A dedicated hose was used to connect the sample port to the Tedlar bag. The soil vapor was drawn into the sample bag by the applied vacuum inside the secondary container. At each location, the sample bag was filled and purged 2 to 3 times in this manner prior to the actual sample collection.

The samples were analyzed by EA personnel with an onsite Gas Chromatograph (GC) that was equipped with an Electron Capture Detector (ECD) which had been calibrated to 1 ppm_v of SF₆. Samples which required dilution (e.g., influent concentrations) were diluted in nitrogen-filled glass bulbs which produced a 500:1 dilution. Further dilution was obtained, if necessary, by reducing the injected volume of 1,000 µL.

Differential pressure readings in each of the monitoring wells were measured using magnehelic gauges which were calibrated immediately prior to usage in the field. Magnehelic gauges were zeroed at the beginning of each day and as necessary during the sampling event.

4.1.2 QA/QC

Data quality needs were determined by the specified compound reporting limits and the Quality Assurance/Quality Control (QA/QC) protocols required by the analytical methods used. Analytical gaseous standards were used to calibrate the GC/ECD at the beginning of each day prior to the analysis of any samples, once in the middle of each day, and once at the end of each day after all of the vapor samples had been analyzed. Analytical blanks were analyzed each day prior to any analyses and at the end of each day to demonstrate cleanliness of the system. In addition, analytical blanks were analyzed throughout the day as deemed necessary by the onsite environmental chemist to demonstrate system cleanliness. Samples were analyzed in duplicate for ten percent of the total samples run. Gas standards (1 ppm_v) were run, on average, every eight samples.

Cross-contamination and drifts in the baseline were checked by running air or nitrogen blanks. The results of these analysis are presented in Table 4-1. It can be seen that the majority of the vapor blanks were below the detection limit of 0.001 ppm_v. Detectable concentrations of SF₆ in the vapor blanks were due to two factors. Some carryover was detected in blanks which had immediately followed samples with extremely high concentrations of SF₆ (e.g., inlet concentration samples). Additional purging of the syringe used for the injection of vapor samples reduced the amount of carryover observed in subsequent samples. Blanks which

**TABLE 4-1 QA/QC RESULTS (BLANKS) FOR
SOIL VAPOR SAMPLES**

DATE	TIME (hr)	CONCENTRATION (ppm-v)
20 DEC 94	748	0.039
	752	0.003
	821	0.177
	828	0.067
	833	0.051
	915	0.001
	1100	0.01
	1105	<0.001
	1204	<0.001
	1206	<0.001
	1409	<0.001
	1551	<0.001
	1553	<0.001
	1810	<0.001
21 DEC 94	749	0.015
	754	0.01
	800	<0.001
	805	<0.001
	848	<0.001
	854	<0.001
	910	<0.001
	1011	<0.001
	1141	<0.001
	1155	<0.001
	1340	0.007
	1344	0.003
	1348	<0.001
	1633	<0.001
22 DEC 94	1159	0.005
	1203	0.003
	1207	<0.001
	1527	<0.001
	1647	<0.001
23 DEC 94	922	<0.001
	942	<0.001
	1254	<0.001

contained low concentrations of SF₆ (e.g., less than 0.005 ppm_v) were due to the fact that the ambient air in the enclosed mobile laboratory was found to contain approximately 0.002 ppm_v of SF₆. Once this had been discovered, nitrogen blanks were used instead of air blanks. Thereafter, the vapor blanks were non-detect for SF₆. The ambient air in the laboratory should not have affected the analytical samples since the syringe was cleaned with nitrogen between each sample and the samples were kept in sealed Tedlar bags. In either case, sample analysis ceased until a clean blank was obtained. The deviation between duplicate samples was within 5.5%.

A distant well (DMW45-2P) was sampled in order to provide an estimate of the background concentration of SF₆ at Site WP-21. However, this well was sampled after the tracer study had begun and these samples were reported to contain 0.005 ppm_v of SF₆. In addition, since SF₆ is neither a naturally occurring gas nor a known contaminant at Site WP-21, these background samples are not considered to be representative of the true background levels (i.e., non-detect). A "time-zero" sampling of SF₆ concentrations was not performed on Day 2 of the study.

4.1.3 Results

Based upon the influent tracer gas concentration and the injection flow rates, the mass flow rate of SF₆ was approximately 2,876 and 6,040 mg/min during Day 1 and Day 2 of the study, respectively. From this, it was determined that a total of 1,070 and 1,569 grams of SF₆ was injected into the aquifer over the two study days, respectively (Appendix A-1).

Soil gas samples were collected at 15, 45, 150, and 360 minute intervals on Day 1 of the tracer gas study (Table 4-2). Tracer gas concentrations in the monitoring points ranged from non-detect to 8.34 ppm_v of SF₆ over the duration of the study. Concentrations of tracer gas 10 ft from the point of injection were generally an order of magnitude greater than those observed in the more distant monitoring points. However, elevated concentrations of tracer gas were observed in the headspace of the most distant ground-water monitoring wells in both the parallel and perpendicular directions.

Soil gas samples were collected at 15 and 240 minute intervals on Day 2 of the tracer gas study (Table 4-3). Tracer gas concentrations in the monitoring points were reported to range from 0.003 to 24.9 ppm_v of SF₆ over the duration of the study. Again, elevated concentrations of tracer gas were observed in the most distant monitoring wells in both the parallel and perpendicular directions. Higher concentrations of tracer gas (2.09 ppm_v) were observed in SMW45-1 during the first sampling interval (15 min). This concentration decreased to 0.006 ppm_v at the next sampling interval (240 min) which may have indicated a change in flow channeling during sparging.

The largest concentrations which were observed from the headspace of the monitoring wells were 1.89 (SMW10-1) and 7.3 ppm_v (VMW25-1P) during Day 1 and 2 of the study, respectively. The largest concentrations which were observed from the vapor probes were 8.34 ppm_v (VP-10) and 24.9 ppm_v (VP-10) during Day 1 and 2, respectively. Overall, the SF₆ concentrations observed in the vapor probes appear to confirm the data collected from the headspace of the groundwater monitoring wells with respect to time and distance from the point

TABLE 4-2 SF6 CONCENTRATIONS OBSERVED IN SOIL GAS SAMPLES - DAY 1

SAMPLE	SF6 CONCENTRATION			
	Interval = 15 min PPM-v	Interval = 45 min PPM-v	Interval = 150 min PPM-v	Interval = 360 min PPM-v
DMW-10-1	0.018	0.017	0.119	0.124
DMW-10-1 DUP	NS	NS	0.124	NS
DMW-25-1P	0.007	0.029	0.028	0.025
DMW-45-1	0.013	0.026	0.020	0.023
DMW-45-1 DUP	0.02	NS	NS	NS
DMW-75-1P	0.017	0.007	<0.001	0.008
SMW-10-1	0.022	0.286	1.57	1.89
SMW-25-1P	<0.001	0.014	0.026	0.052
SMW-45-1	0.009	0.006	0.010	0.009
VMW-10-1	0.094	0.125	0.133	0.154
VMW-25-1P	0.018	0.023	0.011	0.018
VMW-45-1	0.015	0.012	0.010	0.014
VP-10	NS	NS	0.36	8.34
VP-25	NS	NS	0.002	0.036
VP-25 DUP	NS	NS	0.003	NS
VP-45	NS	NS	0.011	0.008
DMW-25-1	NS	NS	0.007	0.014
DMW-25-1 DUP	NS	NS	NS	0.01
DMW-75-1	NS	NS	0.004	0.006
DMW-45-1P	NS	NS	0.007	0.008
SMW-75-1P	NS	NS	0.020	0.036
SMW-75-1	NS	NS	0.018	0.040
SMW-25-1	NS	NS	0.008	0.014
SMW-25-1 DUP	NS	NS	0.01	NS
SMW-45-1P	NS	NS	<0.001	0.005
VMW-75-1P	NS	NS	NS	0.011
VMW-75-1	NS	NS	NS	0.005
VMW-45-1P	NS	NS	NS	0.006

Injection Time (hr)	Inlet SF6 Concentration
0848	4654 ppm-v
0900	4251 ppm-v

VP = Vapor Probe (Geoprobes) - direct push
NS = Not Sampled

TABLE 4-3

SF6 CONCENTRATIONS OBSERVED IN
SOIL GAS SAMPLES - DAY 2

SAMPLE	SF6 CONCENTRATION	
	Interval = 15 min PPM-v	Interval = 240 min PPM-v
DMW-75-1	0.014	0.007
SMW-75-1	0.005	0.006
SMW-75-1 DUP	NS	0.006
DMW-75-1P	0.005	0.068
SMW-75-1P	0.003	0.016
VMW-75-1P	NS	0.004
DMW-45-1	0.005	0.004
SMW-45-1	2.09	0.006
SMW-45-1 DUP	1.98	NS
SMW-45-1P	0.013	0.118
VMW-45-1P	NS	0.037
DMW-25-1	0.005	0.007
SMW-25-1	0.014	0.375
DMW-25-1P	0.009	0.178
SMW-25-1P	NS	6.1
VMW-25-1P	NS	7.3
VP-10	NS	24.9
VP-25	0.005	0.008
VP-45	0.003	0.517

NS = Not Sampled

VP = Vapor Probe (Geoprobes)

of injection (Tables 4-2 and 4-3). Data from both the vapor probe and headspace from the monitoring wells indicate higher concentrations of SF₆ closer to the point of SF₆ injection into the groundwater.

Differential pressures (Table 4-4) were collected once during Day 1 and twice during Day 2 of the tracer study. Differential pressures ranged from non-detect to +0.5 inches of water during Day 1 and Day 2 of the study. In general, pressures were highest in the wells closest to the point of injection, but a definite trend with respect to distance was not identified. The presence of variable pressures further away from the injection well may have indicated that flow channeling was occurring during the study. Measurable differential pressure (>0.1 inches of water) readings were observed at some of the shallow 75 ft monitoring points. The data indicates minimal differential pressure was measured in the deeper groundwater monitoring wells.

4.2 GROUND WATER

4.2.1 Sample Collection and Analytical Methods

Ground-water samples were collected using dedicated Teflon bailers into 40-mL VOA bottles with Teflon-lined septa. Monitoring wells were not purged prior to sample collection. Although the wells were not purged, the data does show the gas reached the well and the data should be comparable to geoprobe concentrations. The geoprobes were installed to evaluate if preferential flow paths traveled to existing monitoring wells. The location of the geoprobe vapor monitoring wells are presented in Figure 5-1. There may be some bias for higher concentrations since the wells were not purged. VOA bottles were filled halfway in order to allow for headspace analysis (minor differences in the volume of ground water added to the vial would not affect the resultant concentration since, according to Henry's Law, the amount of a given VOC that partitions to the gas phase will be constant at a given temperature and pressure). Samples were analyzed by puncturing the septa of the VOA bottle using a clean, gas-tight syringe and directly injecting 1000 µL of the headspace into the GC/ECD. Analysis of ground-water samples followed the procedures outlined in Section 4.1.1.

4.2.2 QA/QC

Data quality needs were determined by the specified compound reporting limits and the QA/QC protocols required by the analytical methods used. Analytical gaseous standards were used to calibrate the GC/ECD at the beginning of each day prior to the analysis of any samples, once in the middle of each day, and once at the end of each day after all of the samples had been analyzed. Analytical blanks (which consisted of sampling the headspace of a VOA vial half-filled with deionized water) were analyzed each day prior to any analyses and at the end of each day to demonstrate cleanliness of the system. In addition, analytical blanks were analyzed throughout the day as deemed necessary by the onsite environmental chemist to demonstrate system cleanliness. Samples were analyzed in duplicate for ten percent of the total samples run. Gas standards (1 ppm_v) were run on average every eight samples.

TABLE 4-4

DIFFERENTIAL PRESSURE MEASUREMENTS

WELL	DIFFERENTIAL PRESSURE (inches of water)		
	20 DEC 94 @ 165 min	21 DEC 94 @ 135 min	21 DEC 94 @ 240 min
VMW-75-1P	0.13	0.1	0.1
SMW-75-1P	0.13	0.09	0.1
DMW-75-1P	**	0.02	0.02
VMW-45-1P	0	0.25	0.25
SMW-45-1P	0.18	0.21	0.22
DMW-45-1P	*	0	0.01
VMW-25-1P	0.29	0.43	0.5
SMW-25-1P	0.28	0.2	0.2
DMW-25-1P	0.02	0	0.02
VMW-10-1P	0.32	0.5	0.45
SMW-10-1P	0.32	0.5	0.5
DMW-10-1P	NS	0	0.05
VMW-10-1	0.21	0.28	0.3
SMW-10-1	NS	0.14	0.15
DMW-10-1	0.32	0	0.01
VMW-25-1	0.15	0.2	0.025
SMW-25-1	0	0	0.1
DMW-25-1	0	0	0.01
VMW-45-1	0.1	0.15	0.2
SMW-45-1	0.1	0.02	0.02
DMW-45-1	0	0	0
VMW-75-1	0.06	0.1	0.1
SMW-75-1	0.1	0.1	0.1
DMW-75-1	0	0	0

NS = not sampled

* under vacuum (-0.40") until equalized pressure then
returned to 0" at 215 min and +0.08" at 234 min

** under vacuum until equalized pressure then
returned to 0" at 235 min and 0" at 300 min

Flow rates: Day 1 = 4.0 scfm; Day 2 = 8 scfm

VMW = Vadose monitoring well

SMW = Shallow monitoring well

DMW = Deep monitoring well

4.2.3 Results

QA/QC sample results were within acceptable limits for the analytical protocol. Ground-water blanks were non-detect for SF₆. The deviation between duplicate samples was within 0.002 ppm_v.

Ground-water samples were collected at the end of each day just before the sparge system was turned off. The results of the ground-water headspace samples are presented in Table 4-5. Tracer gas concentrations ranged from non-detect to 0.897 (SMW10-1) and 1.062 ppm_v (SMW25-1P), on Day 1 and 2 of the study, respectively. A sample collected from SMW10-1 had a concentration which could not be quantified since it exceeded the calibrated range of the GC. Elevated tracer gas concentrations were reported from the most distant monitoring points in the perpendicular direction. Samples from the 45 ft intervals in the parallel direction did contain reportable concentrations of tracer gas.

Based on SF₆ concentrations observed in groundwater headspace samples, an associated aqueous concentration was calculated. Using the maximum SF₆ tracer gas headspace concentration of 1.062 ppm_v, a groundwater concentration of 0.052 µg/L was calculated (see Appendix B). This concentration of SF₆ in the groundwater was lower than anticipated, and indicates that qualitatively, based on this data, that the influence of the AAS system was not substantial.

TABLE 4-5 SF6 CONCENTRATIONS OBSERVED IN GROUND-WATER HEADSPACE SAMPLES

SAMPLE	SF6 CONCENTRATIONS	
	20 DEC 94 PPM-v	21 DEC 94 PPM-v
BLANK	<0.001	<0.001
SMW-75-1P	0.011	0.084
DMW-75-1P	0.037	<0.001
SMW-45-1	0.01	0.003
SMW-45-1 DUP	NS	0.002
DMW-45-1	0.005	0.001
SMW-25-1P	0.311	1.062
BLANK	<0.001	<0.001
DMW-25-1P	0.008	0.098
SMW-25-1	0.012	0.005
DMW-25-1	0.005	0.006
DMW-25-1 DUP	0.003	NS
SMW-10-1	0.897	E
DMW-10-1	0.005	0.542

E = Unable to quantify, concentration out of range.

NS = Not Sampled

Note: Samples were collected at the end of each day of the study.

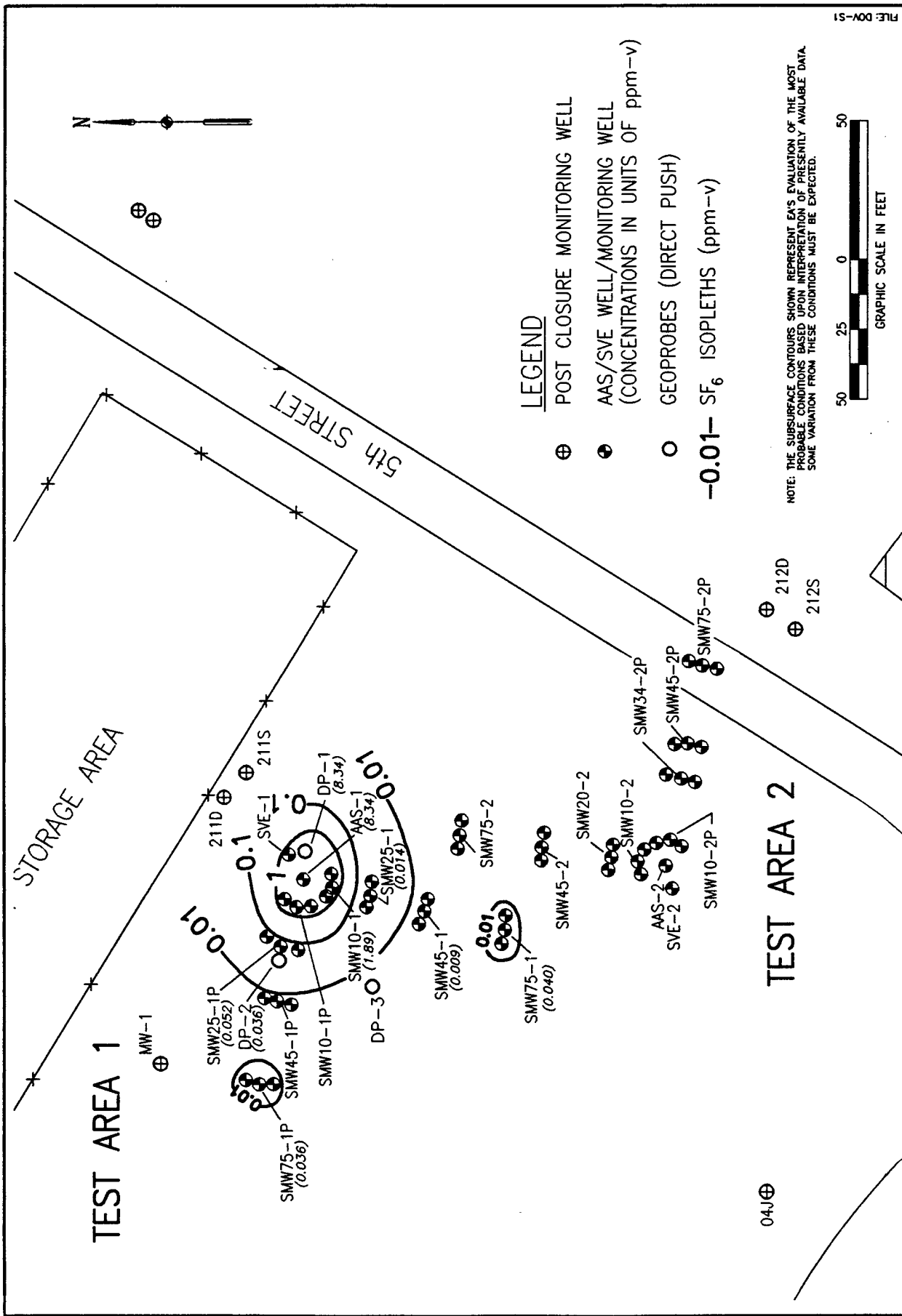
5. DATA ANALYSIS AND INTERPRETATION

5.1 SOIL GAS

From the data presented in Tables 4-2 and 4-3, the SF_6 concentration isopleths were approximated in Test Area 1 as an indication of the extent and preferential flow direction within the aquifer at Site SS59. These isopleths represent the evaluation of the most probable conditions based upon interpretation of presently available data. Some variation from these conditions must be expected.

In Figures 5-1 and 5-2, the shallow well isoconcentration lines in Test Area 1 are depicted utilizing the data from the last sampling interval (in order to reflect the equilibration of the aquifer following air injection) of Day 1 and 2, respectively. Based upon the data collected at the end of Day 1, the distribution of tracer gas within the aquifer appears to be symmetrical throughout the test area. This would indicate a relatively non-heterogeneous soil matrix and pressure distribution. At the 75 ft intervals, detectable concentrations of SF_6 were reported in both the parallel and perpendicular flow directions. This may have been the result of preferential flow channeling from the AAS-1 well to the 75 ft monitoring wells. The geologic cross-section from the soil borings B-5 through B-8 (Figure 1-5) may best approximate the (transverse) stratigraphy along the monitoring wells which are aligned perpendicular to ground-water flow in Test Area 1. Similarly, Figure 1-7 may best represent the (longitudinal) stratigraphy parallel to ground-water flow. From these figures, which are based upon available geologic information characterizing the subsurface, it does not appear as though this channeling was due to the presence of lenses in the vicinity of the 45 ft monitoring wells since most of the lenses are located within the vadose zone. In addition, the concentrations of tracer gas in the geoprobe point at 45 ft were similar to the concentrations in the monitoring well at 45 ft. At the end of Day 2 (Figure 5-2), this increase was not observed at the 75 ft intervals. However, unlike Day 1, the concentrations of tracer gas were slightly greater in the series of wells which were aligned perpendicular to ground-water flow. This may have been the result of new flow channels being created following injection at a higher flow rate.

Overall, the data collected from the different time intervals for the perpendicular, shallow monitoring wells were representative of the response expected from a relatively non-heterogeneous aquifer matrix (Figure 5-3). Here, the concentration of tracer gas at each monitoring distance increased with time and decreased with distance from the point of injection. In the parallel direction during Day 1 of the study (Figure 5-4), only the wells 10 ft from AAS-1 appeared to show increasing concentration with time; however, the concentrations did typically decrease with increasing distance. Elevated concentrations of tracer gas were observed at 75 ft in both the parallel and perpendicular directions. The elevated concentrations indicated that the system was able to affect the aquifer up to 75 ft. from AAS-1, but due to observed SF_6 concentration as compared to the injected concentration, this effect was not very substantial at this distance. The increase of the injection flow rate on Day 2 of the study did increase the concentrations of SF_6 within the ROI of AAS-1 (up to 45 ft) but it did not appear to extend the ROI since these values were similar to those reported at lower flow rates.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		SF ₆ ISOPLETHS (ppm-v) SHALLOW POINTS - DAY 1 (360 min.)		DESIGNED BY JDR	DRAWN BY MNJ	DATE 2-28-95	PROJECT NO. 60378.26
					CHECKED BY JDR	PROJECT MGR. TRH	SCALE 1" = 50'	FIGURE 5-1

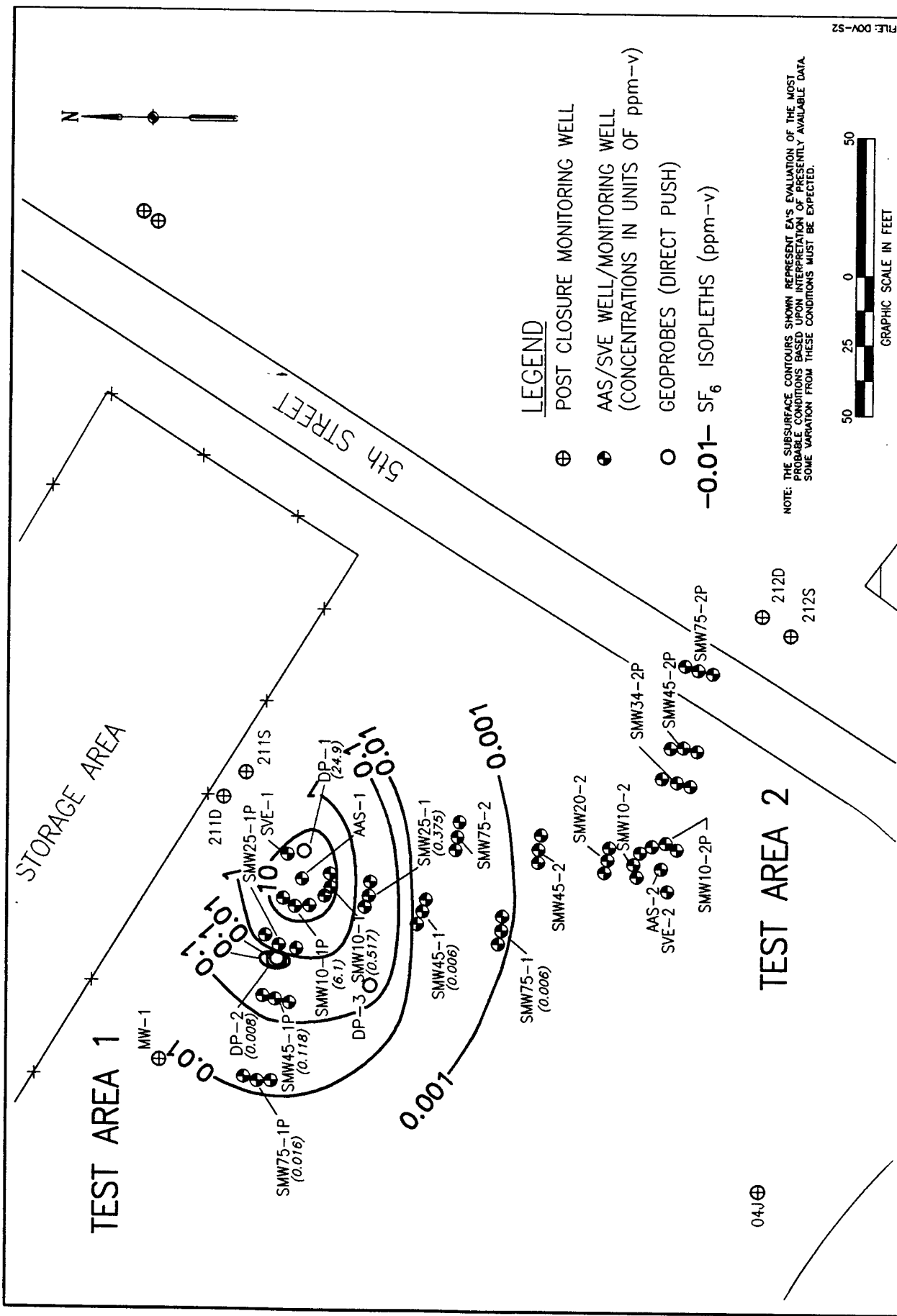
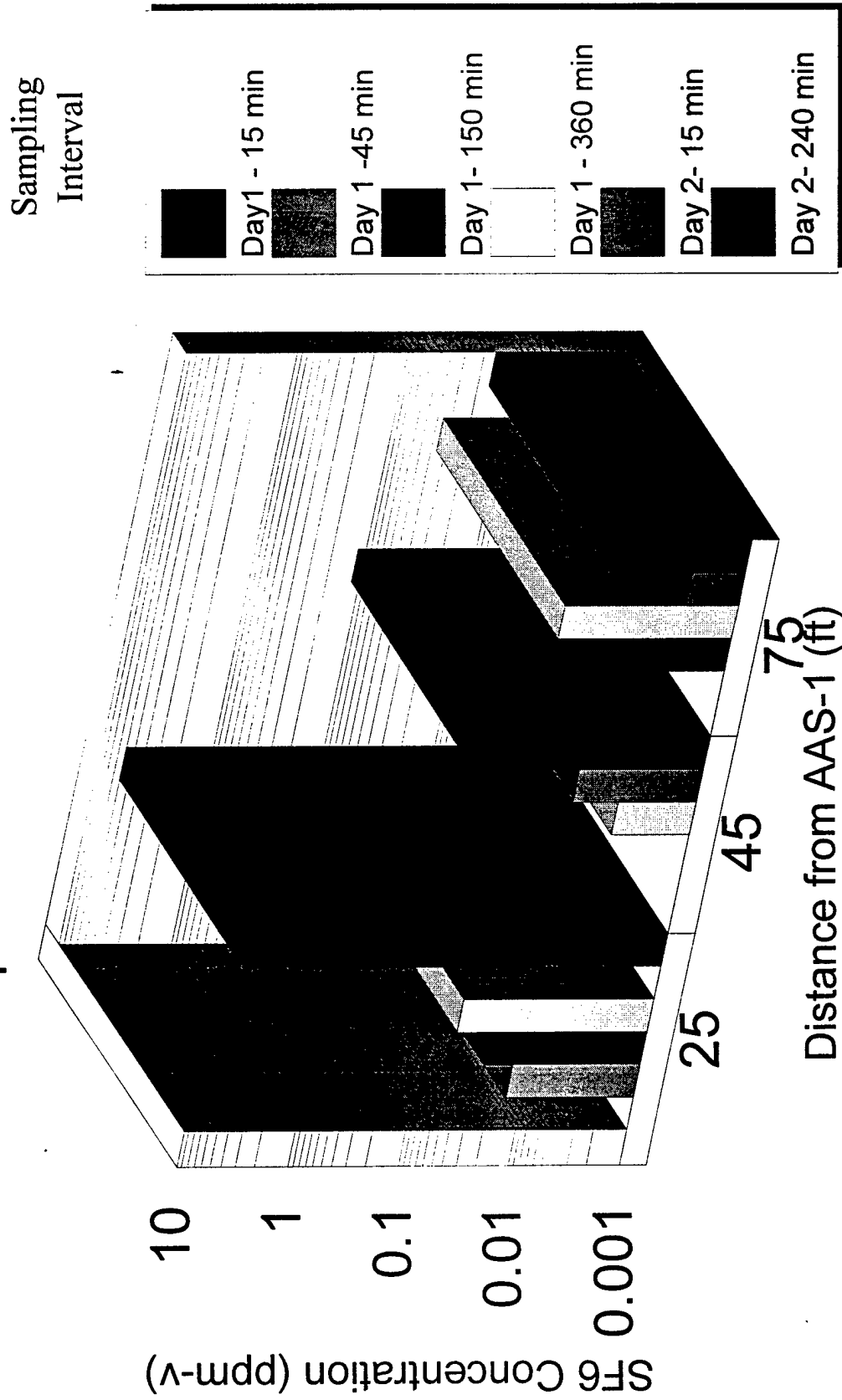


Figure 5-3 SF6 in Soil Gas

Perpendicular Shallow Wells

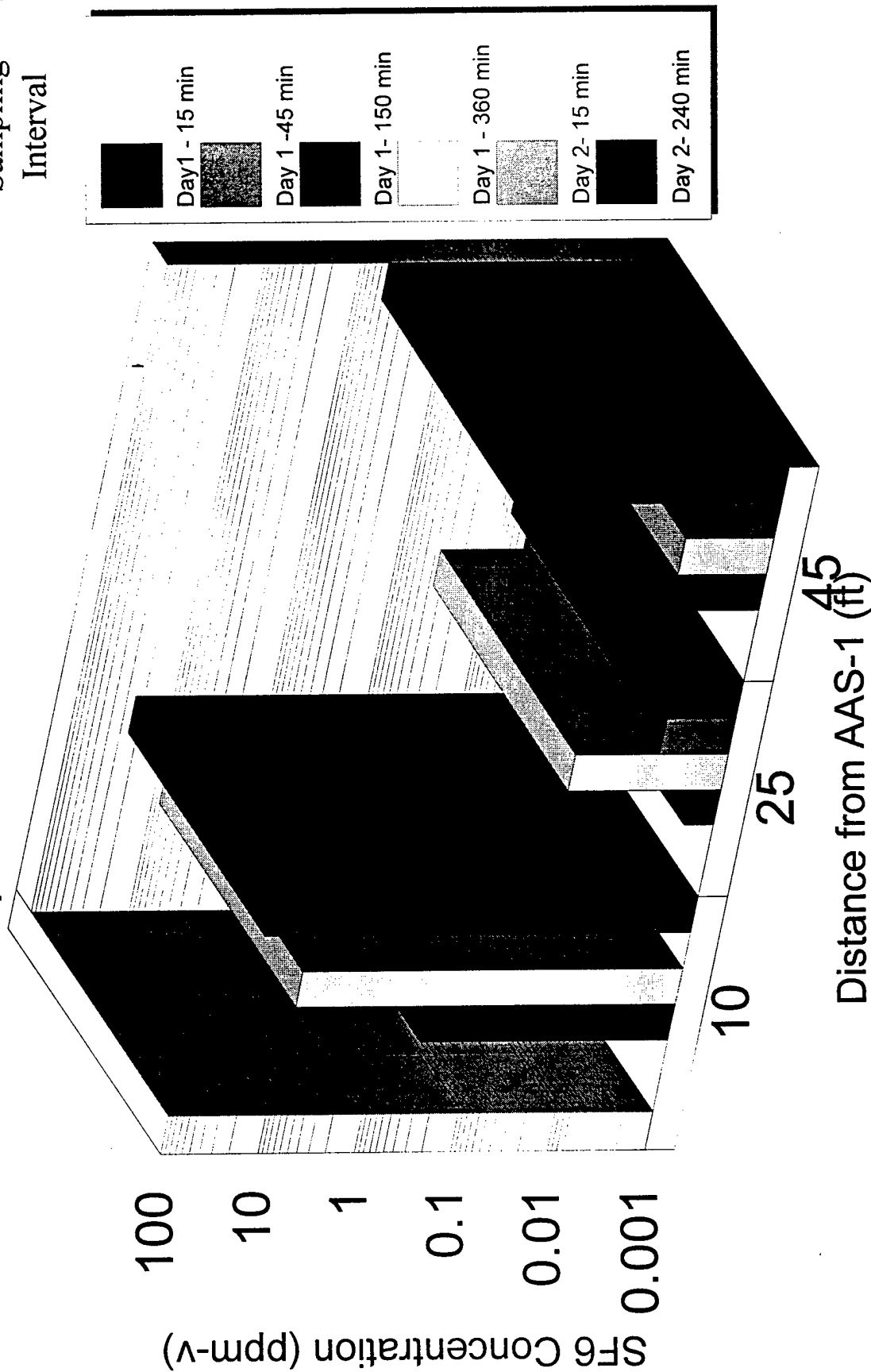


Parallel Shallow Wells



Figure 5-5 SF6 in Soil Gas

Geoprobe Points (Shallow)

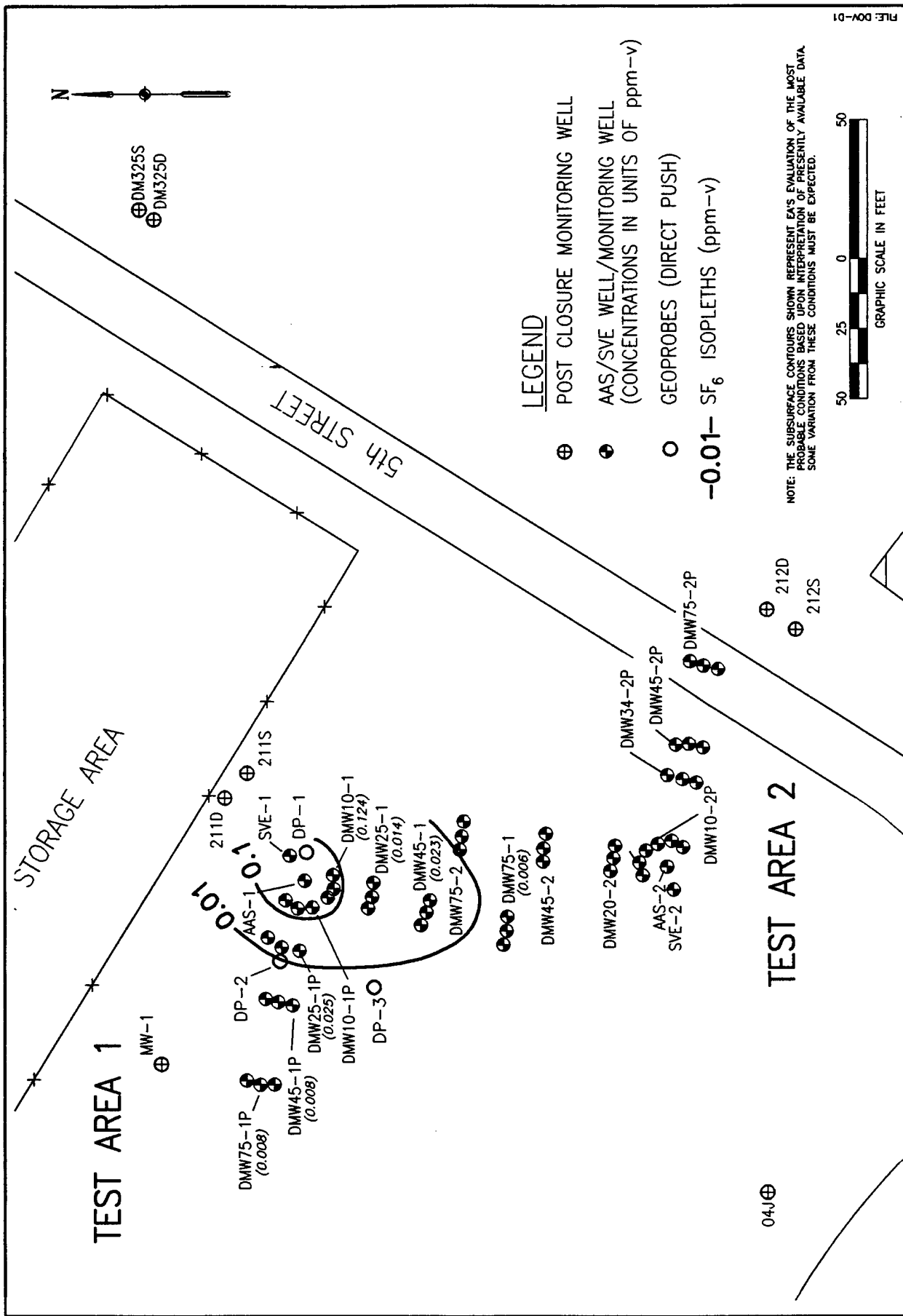


The data collected from the deep wells presented conflicting preferential flow directions over the two days of the tracer study. As shown in Figures 5-6 and 5-7, the sparge well appeared to have a greater influence in the parallel direction on Day 1 and in the perpendicular direction on Day 2. Again, the conflict could have been attributed the formation of new flow channels in the perpendicular direction after injecting at the higher flow rate and pressure.

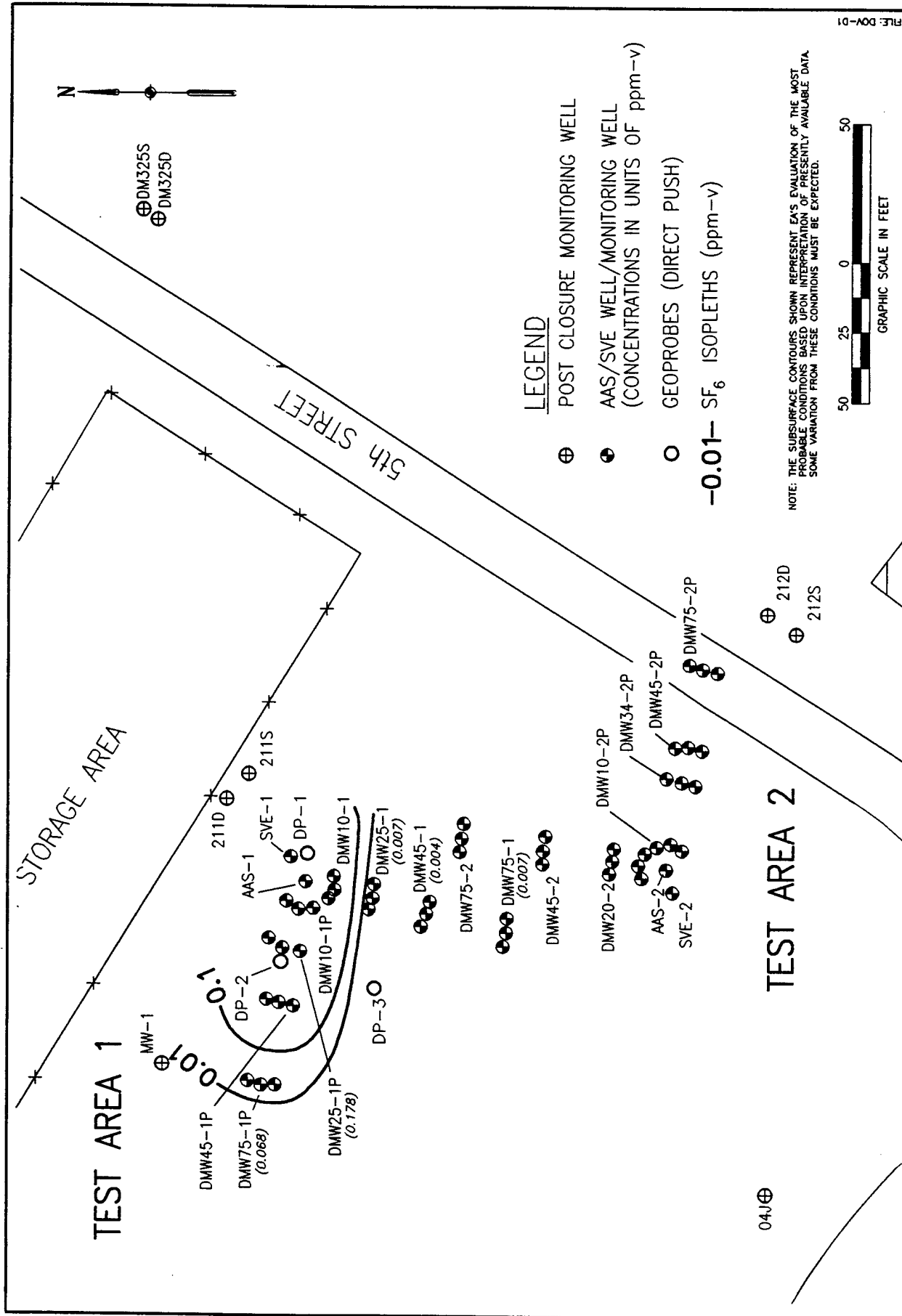
It can be seen in Figures 5-8 and 5-9 that the effect of sparging, as indicated by SF_6 concentrations at the deeper monitoring points, was greatly reduced. Due to the low solubility and density of the tracer gas, the SF_6 was transported toward the surface faster than the horizontal transport mechanisms. Thus most of the tracer gas migrated toward the vadose zone prior to reaching the deeper monitoring points, particularly those situated further from the point of injection. However, low concentrations of SF_6 were reported from the 75 ft intervals and suggest a similar, although less prominent, ROI as inferred from the shallow-well data. A ROI which reaches the 45 ft intervals is more evident from these data, particularly in the series of wells which are parallel to ground-water flow. As observed in the shallow well data, the increase in the injection flow rate on Day 2 of the study increased the concentrations of SF_6 within the ROI of AAS-1 but did not appear to extend the ROI past the 75 ft interval.

Soil gas data were also collected from the unsaturated (vadose) zone in Test Area 1. These data are not directly indicative of the efficiency of an AAS system, but may still relate some information regarding transport mechanisms. Since the ROI of an AAS system is typically determined from the samples collected within the saturated zone, a reduced data set was collected for the vadose zone. As shown in Figures 5-10 through 5-13, diffusion into the unsaturated zone appeared to be most significant within 45 ft from the point of injection. However, elevated concentrations of tracer gas were still present at the most distant monitoring points (indicating a ROI of 75 ft). From these data, it is unclear whether preferential flow paths were present within the vadose zone. As in the shallow and deep wells, the increase in the injection flow rate on Day 2 of the study increased the concentrations of SF_6 within the ROI of AAS-1 but, overall, it did not appear to significantly extend the ROI.

Overall, the observed concentrations of SF_6 in soil gas were generally lower than anticipated. Based upon the injection flow rate, it was estimated that approximately 692.0ppm_v and 1697.9ppm_v should have been present within 40ft of AAS-1 on day 1 and day 2 of the study, respectively (assuming uniform distribution of the tracer gas). The observed soil gas concentrations varied from 0.005 to 8.34 ppm_v, and .004 to 24.9 ppm_v, at the end of Day 1 and Day 2, respectively. One factor which accounts for these lower concentrations assumed that equilibrium conditions existed. As shown in Appendix B, an insufficient mass of SF_6 was injected in order to achieve equilibrium throughout the ROI. A second, and more critical, factor was that a significant quantity of the injected air and SF_6 was likely to be transported to the vadose zone and the atmosphere in the immediate vicinity of the sparge well. Accordingly, a portion of the SF_6 mass would be lost prior to reaching the 10ft monitoring intervals. The soil gas SF_6 concentrations which were observed during this study may indicate that the system can affect the aquifer between 45 to 75ft from AAS-1 but, qualitatively, the degree of this effect may be limited as the distance from the sparge well increases.



 EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		SF ₆ ISOPLETHS (ppm-v) DEEP WELLS - DAY 1 (360 min.)		DESIGNED BY JDR	DRAWN BY MNJ	DATE 2-28-95	PROJECT NO. 60378.26
					CHECKED BY JDR	PROJECT MGR. TRH	SCALE 1"=50'	FIGURE 5-6



LEGEND

- ⊕ POST CLOSURE MONITORING WELL
- ⊙ AAS/SVE WELL/MONITORING WELL
(CONCENTRATIONS IN UNITS OF ppm-v)
- GEOPROBES (DIRECT PUSH)
- 0.01- SF₆ ISOPLETHS (ppm-v)

NOTE: THE SUBSURFACE CONTOURS SHOWN REPRESENT EA'S EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATION FROM THESE CONDITIONS MUST BE EXPECTED.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		SF ₆ ISOPLETHS (ppm-v) DEEP WELLS - DAY 2 (240 min.)		DESIGNED BY JDR	DRAWN BY MNJ	DATE 2-28-95	PROJECT NO. 60378.26
					CHECKED BY JDR	PROJECT MGR. TRH	SCALE 1"=50'	FIGURE 5-7



FILE DOV-D1

Figure 5-8 SF6 in Soil Gas

Parallel Deep Wells

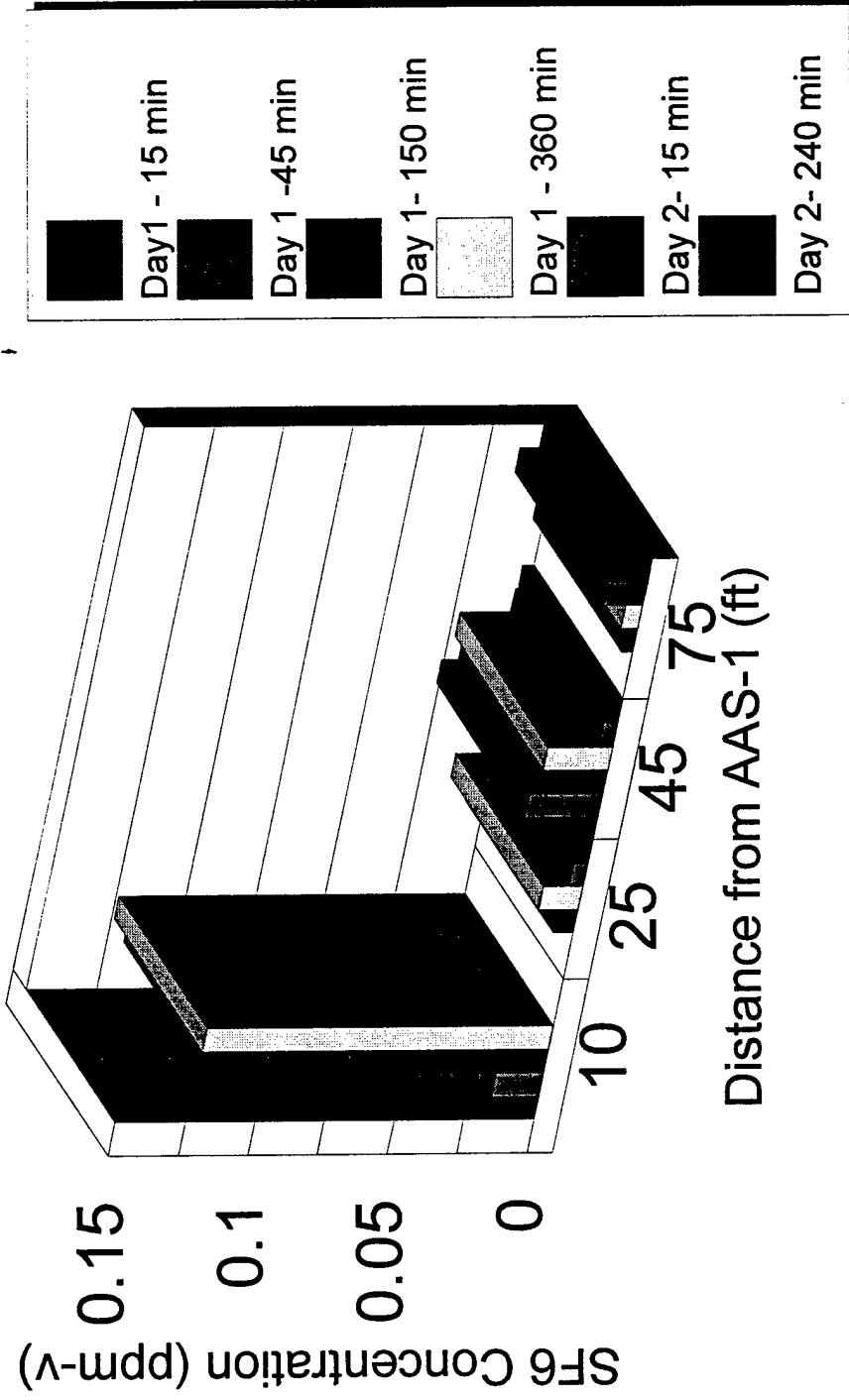
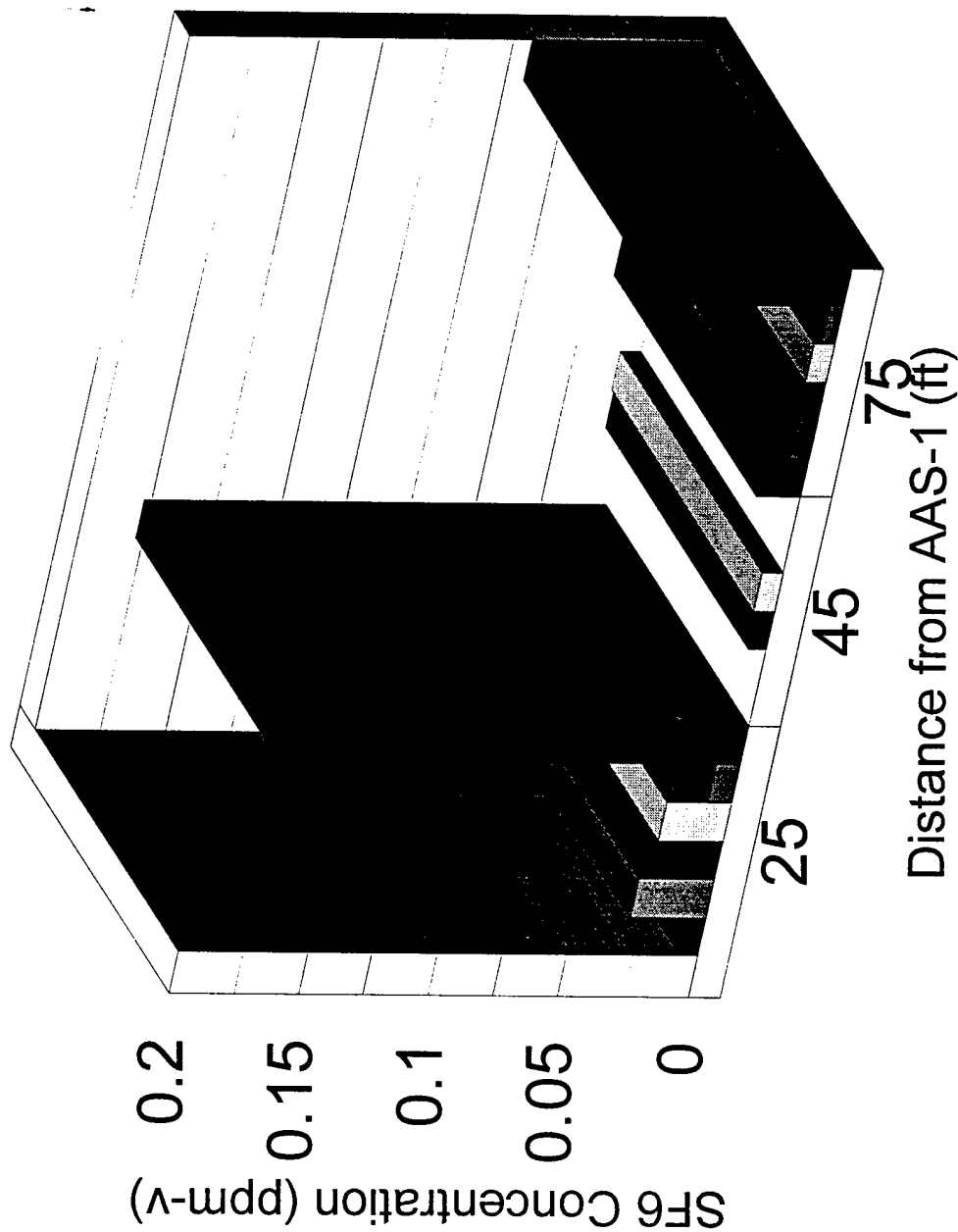
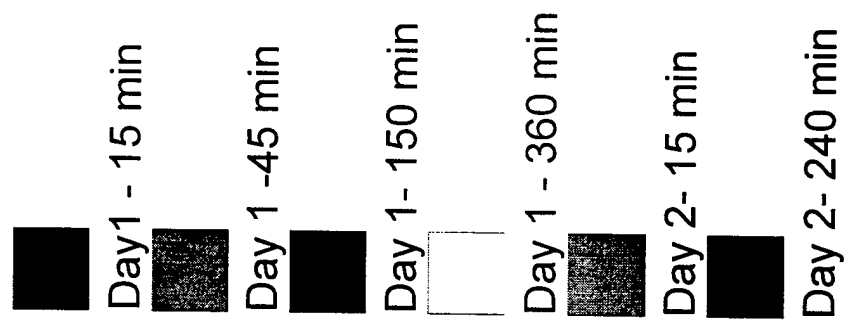
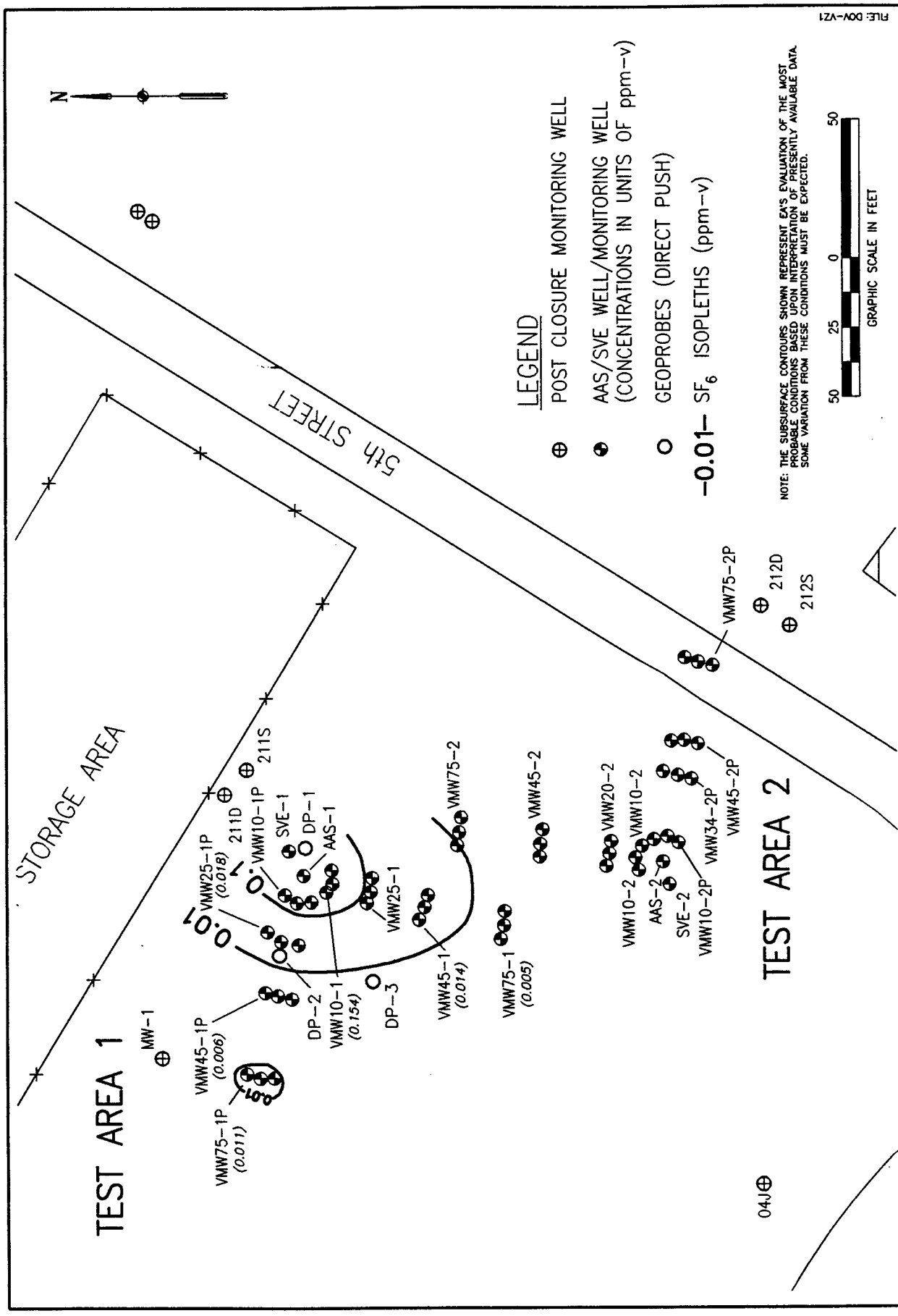


Figure 5-9 SF6 in Soil Gas

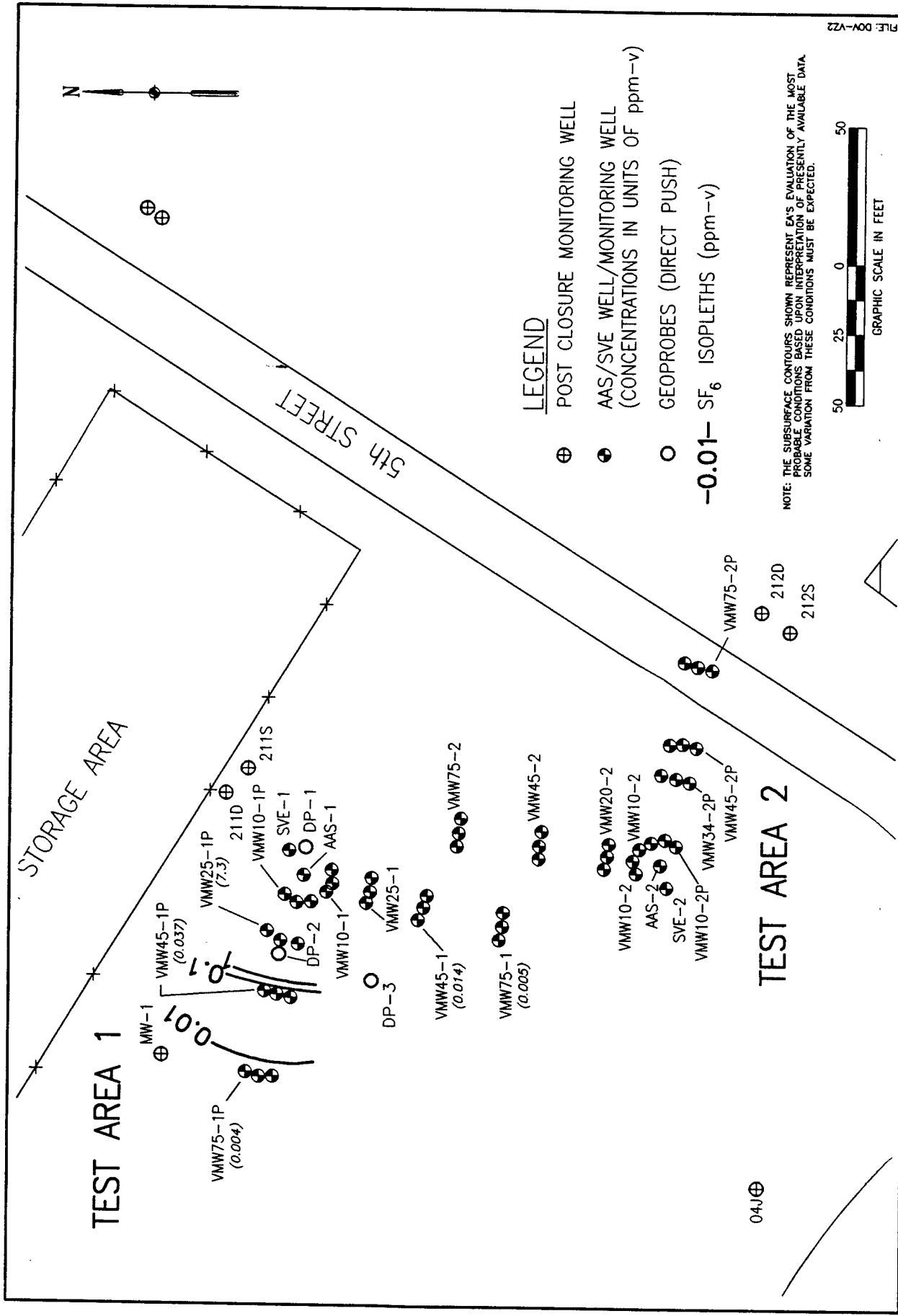
Perpendicular Deep Wells

Sampling
Interval





EA EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE		SF ₆ ISOPLETHS (ppm-v) VADOSE WELLS - DAY 1 (360 min.)		DESIGNED BY JDR	DRAWN BY MNJ	DATE 3-1-95	PROJECT NO. 60378.26
					CHECKED BY JDR	PROJECT MGR. TRH	SCALE 1"=50'	FIGURE 5-10



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DOVER AIR FORCE BASE DOVER, DELAWARE	SF ₆ ISOPLETHS (ppm-v) VADOSE WELLS - DAY 2 (240 min.)	DESIGNED BY JDR	DRAWN BY MNJ	DATE 3-1-95	PROJECT NO. 60378.26
			CHECKED BY JDR	PROJECT MGR. TRH	SCALE 1"=50'	FIGURE 5-11

FILE DOV-VZ2

Figure 5-12 SF6 in Soil Gas

Parallel Vadose Wells

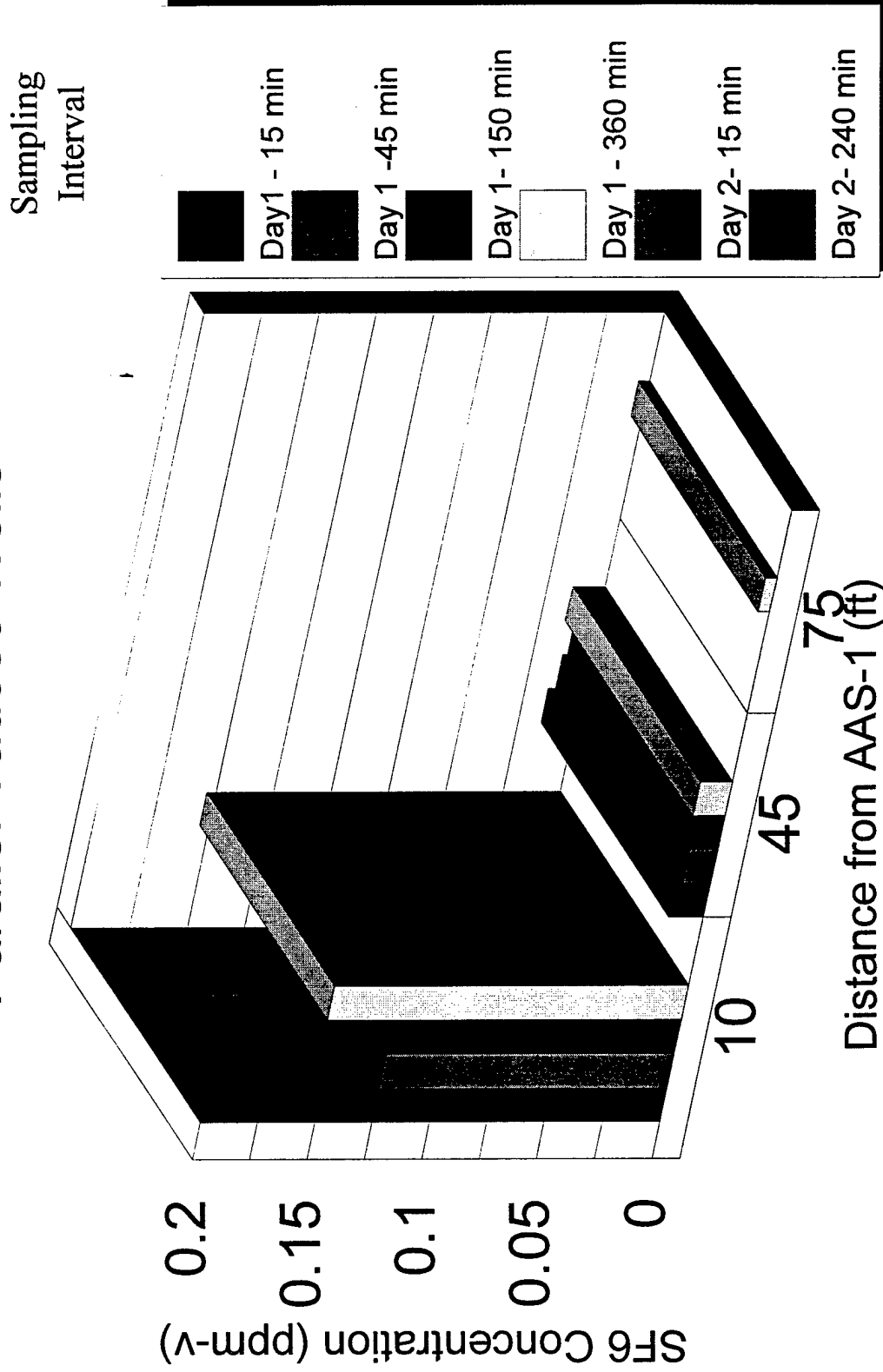
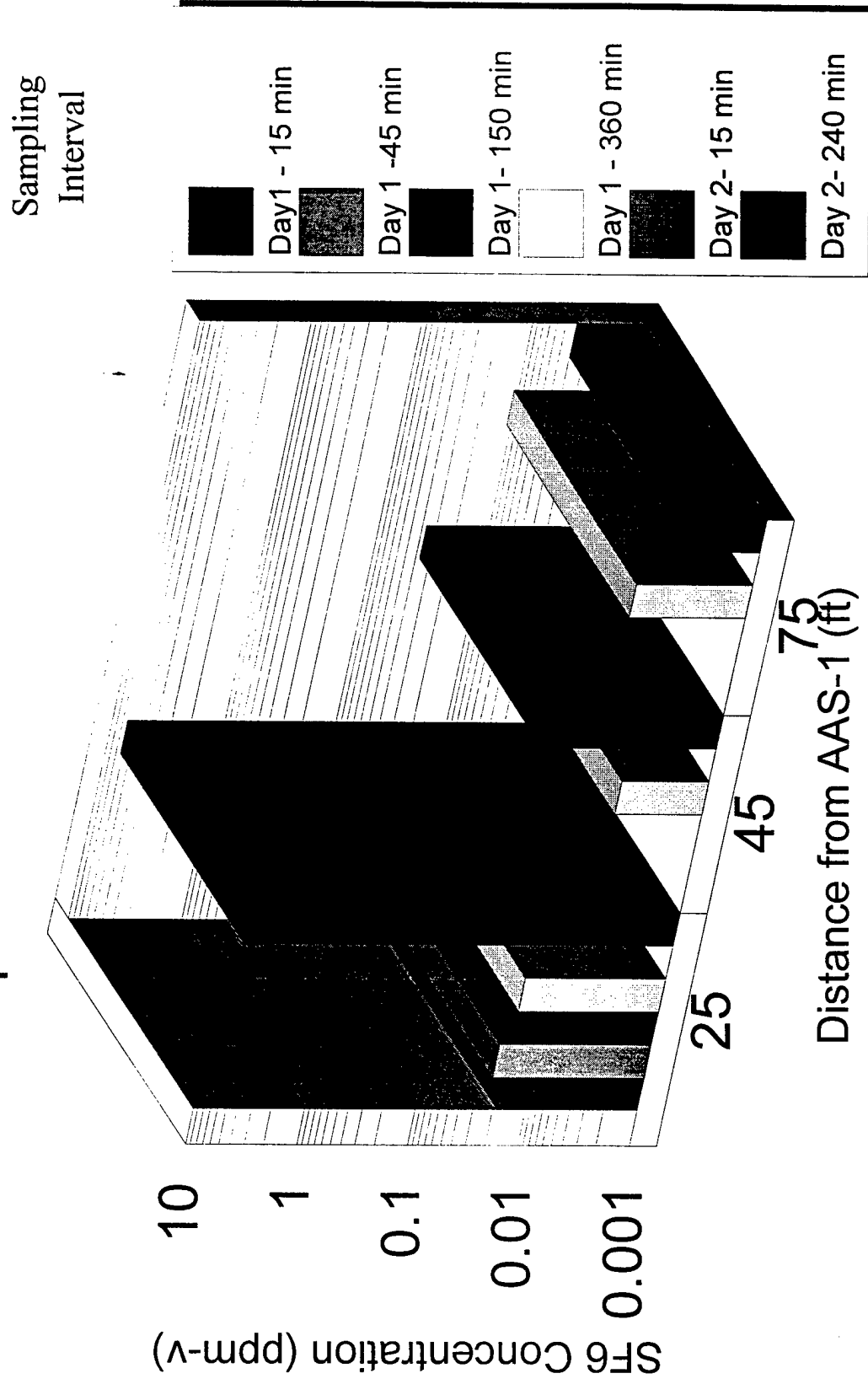


Figure 5-13 SF6 in Soil Gas

Perpendicular Vadose Wells



Vertical profiles of soil gas SF_6 concentrations are presented in Figures 5-14 through 5-17 with respect to the distance from the point of injection. As an indication of the greatest effect from the sparge well, only the data which were collected from the final sampling interval of each study day were shown in these graphs. Here, it appears that the greatest influence from sparging in AAS-1 was realized in the shallow aquifer zone (7 to 17 ft bgs). The screened interval of the sparge well is between 41 and 46 ft bgs. Due to the low solubility and density of the tracer gas, the vertical migration of SF_6 was greater than the horizontal transport mechanisms. As previously mentioned, this resulted in decreasing concentrations with increasing distance from the point of injection. The deep monitoring wells are screened from 31 to 36 ft bgs and generally only could receive tracer gas through diffusion/advection (of the dissolved fraction) and flow channeling (of gaseous tracer gas). Some of the higher concentrations reported from the 75 ft intervals in both the shallow (e.g., Figure 5-15) and deep monitoring points (e.g., Figure 5-17) could have been the result of flow channeling. It should also be noted that the shallow monitoring wells are screened across the water table (typically between 11 and 12 ft bgs) and, therefore, these samples were affected by tracer gas in both the saturated and vadose zone.

It is also useful to compare the ground-water tracer gas concentrations to those observed in soil gas. This is due to the fact that the ROI observed during the tracer study can be biased by the mass transfer of tracer gas from the vapor to the aqueous phase. The soil gas samples from the soil vapor probes are diluted due to the screen length within the vadose zone, and thus the sample concentrations would be lower. As the injected air travels through the saturated zone to the more distant monitoring points, more time is allowed for the tracer gas to enter the aqueous phase. Thus, the actual influence of the sparge well may be underestimated at the more distant points when considering the vapor data alone. A discussion of the ground-water data is presented in Section 5.2.

5.2 GROUND WATER

Tracer gas which remained dissolved in ground water was predominantly found in the vicinity of the injection well (i.e., within 25 ft) (Figures 5-18 and 5-19). This was to be expected since the solubility of SF_6 is relatively low (approximately 2.4 mg/L) and, therefore, the majority of the injected gas would be transported to vadose zone of the aquifer. The concentrations of dissolved SF_6 from the point of injection appeared to be greater in the series of wells which were perpendicular to ground-water flow. It should be noted that ground-water samples were not collected from the 75 ft intervals in the parallel direction. Again, the greatest influence on the aquifer was observed to be generally in the region of the shallow monitoring wells in both the parallel and perpendicular directions (Figures 5-20 and 5-21). Overall, based upon the ground-water data, the sparge well in Test Area 1 appeared to have some influence on the aquifer 75 ft from the point of injection (in the perpendicular direction) with respect to dissolving gases in ground water; however, due to the low observed concentrations, the degree of this effect within the ROI does not appear to be sufficient to extend the ROI to this distance.

As described in section 5.1 (Soil Gas), it was anticipated that a portion of the injected tracer gas would be transported to the vadose zone and, subsequently, to the atmosphere, prior to reaching the 10ft monitoring intervals. This effect is reflected in the fact that the observed SF_6

Soil Gas SF6 - Parallel Direction



Figure 5-15 Vertical Profiles

Soil Gas SF6 - Perpendicular Direction

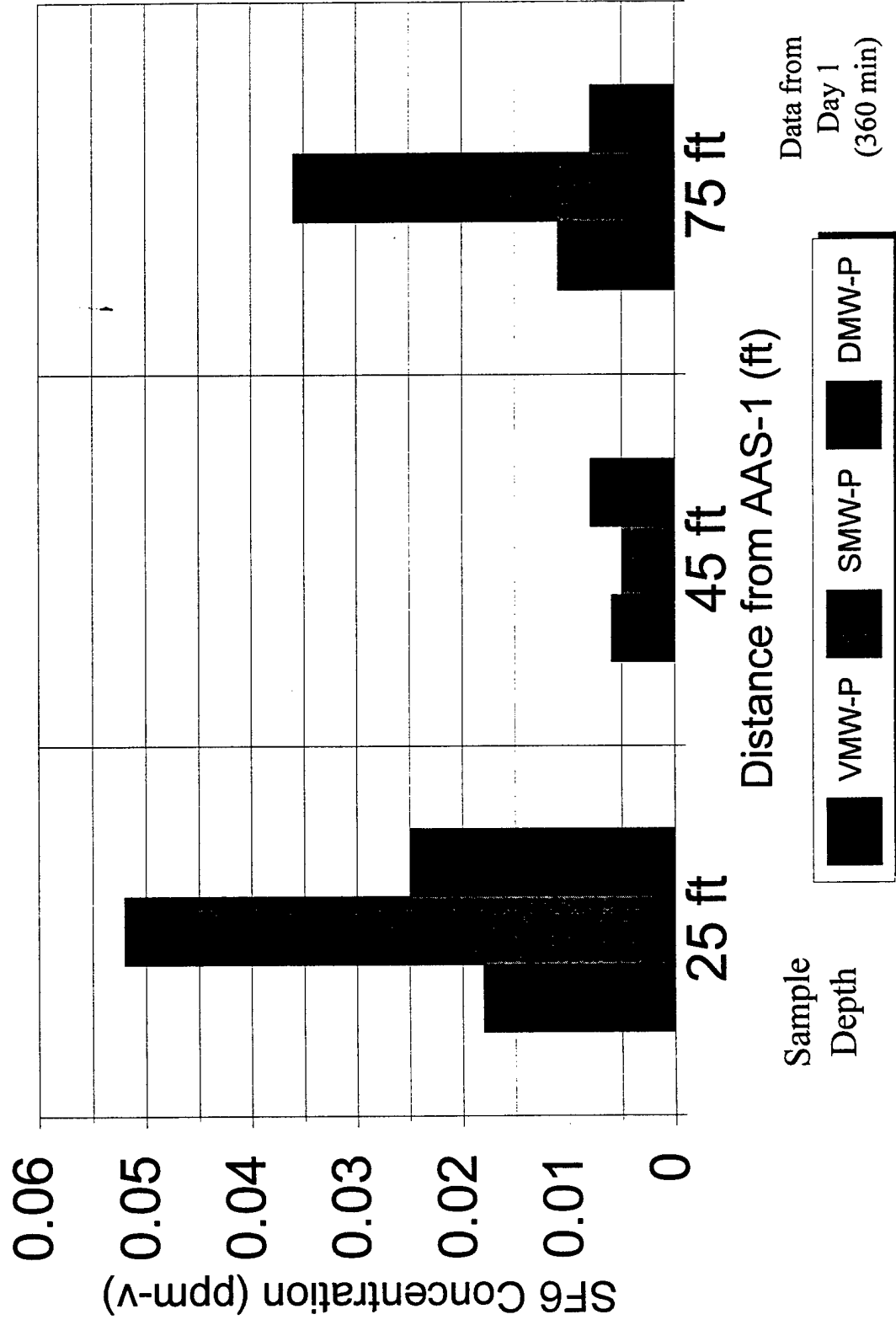


Figure 5-16 Vertical Profiles

Soil Gas SF6 - Parallel Direction

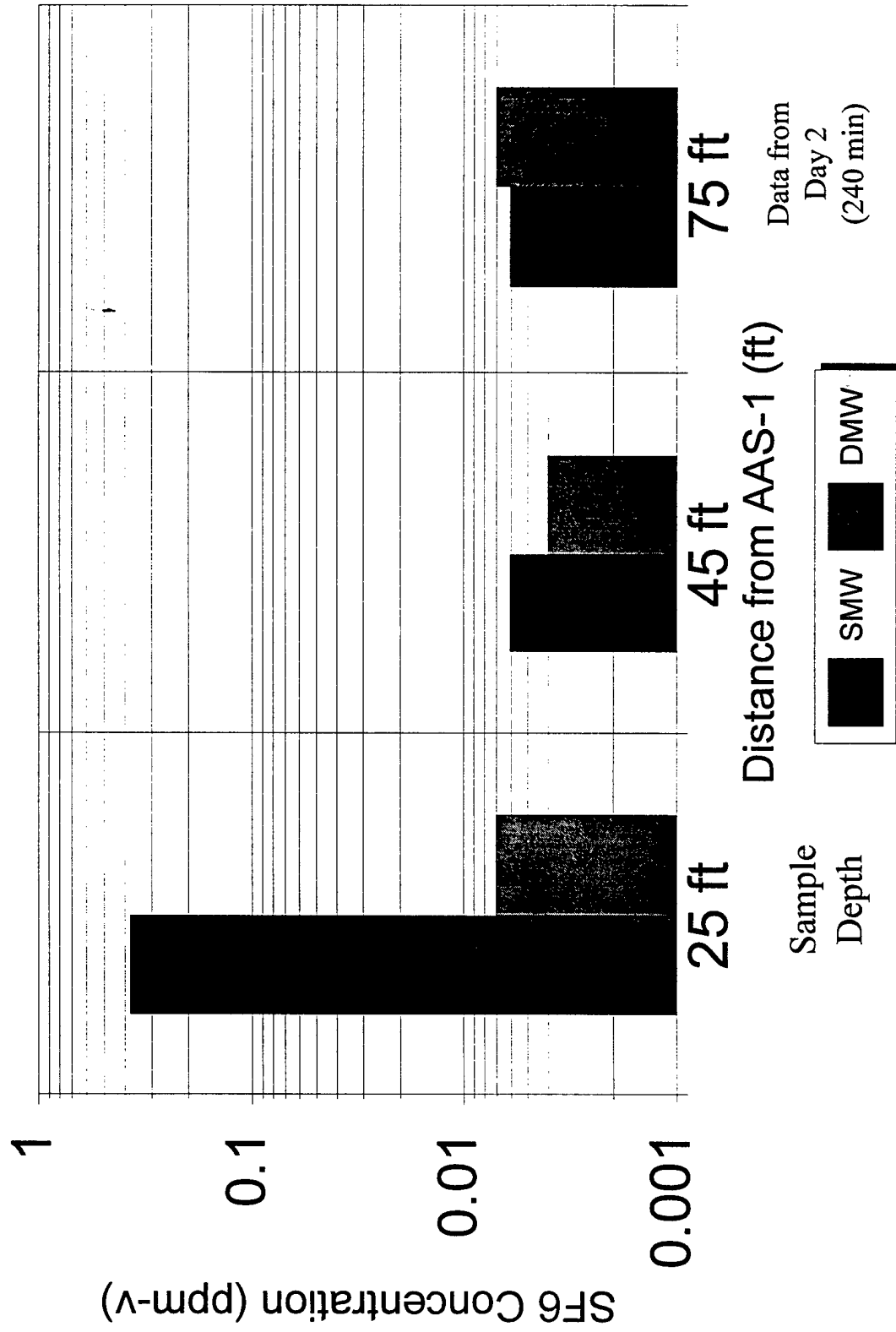


Figure 5-17 Vertical Profiles

Soil Gas SF6 - Perpendicular Direction

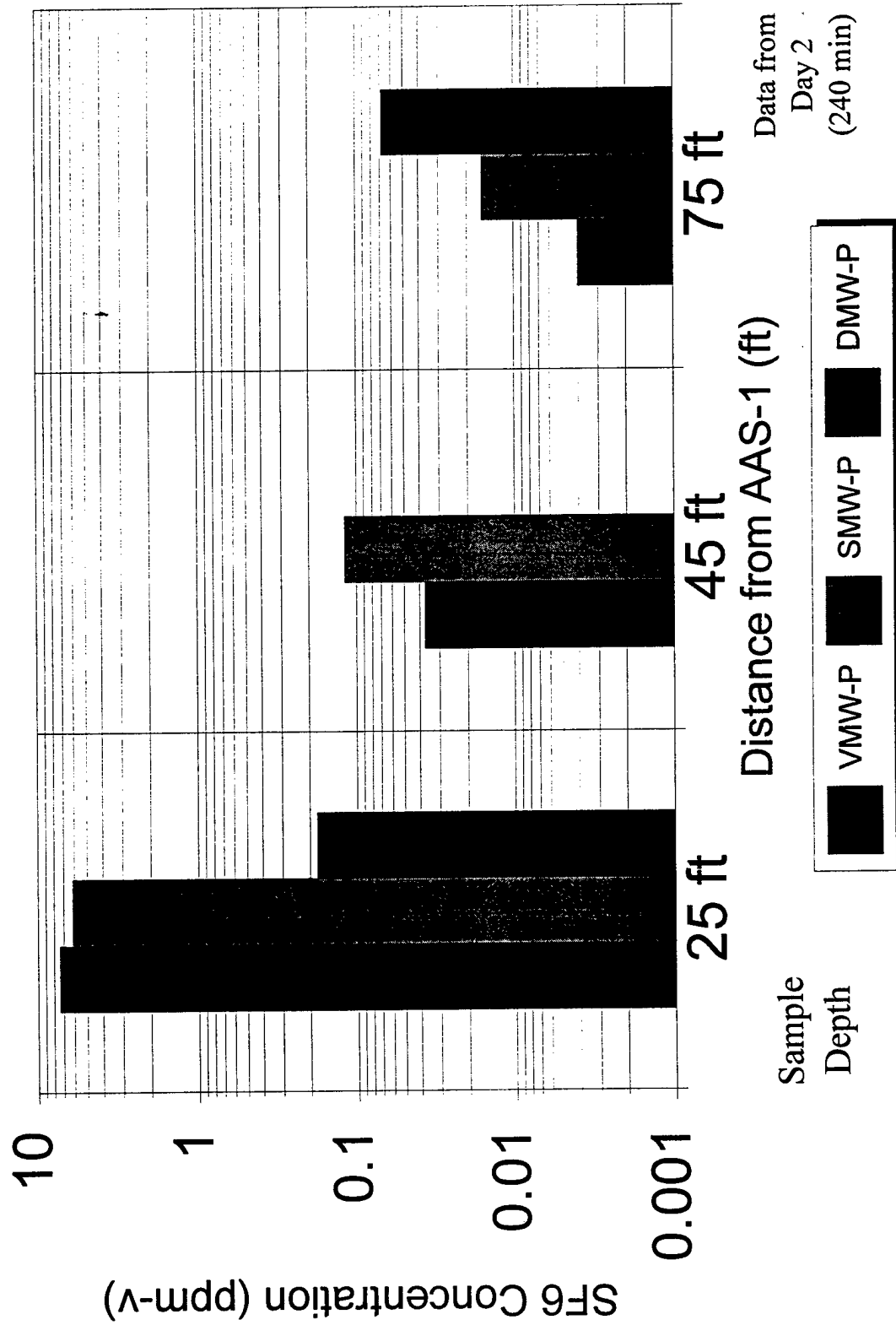


Figure 5-18 SF6 in Ground Water

Parallel Direction Wells

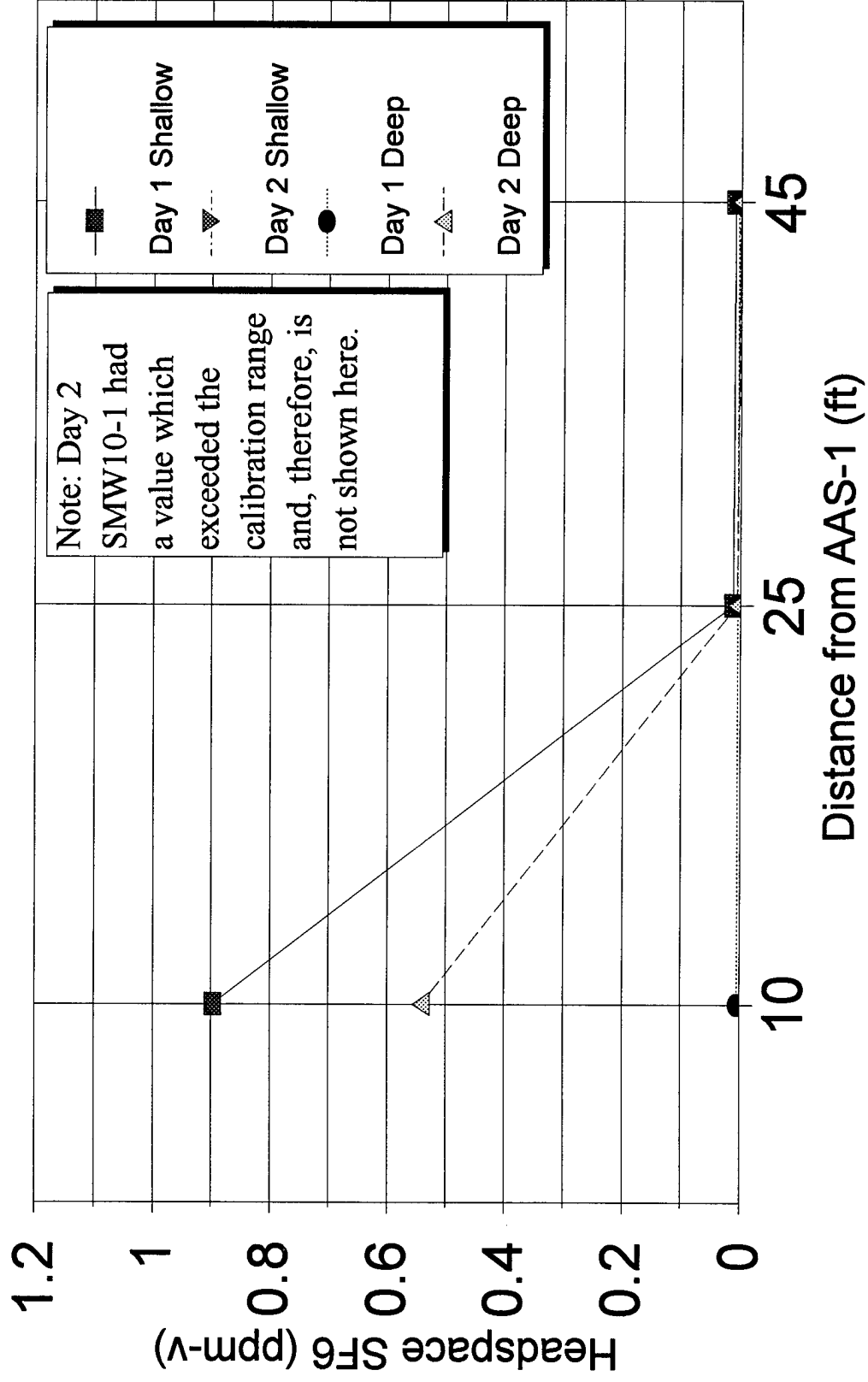


Figure 5-19 SF6 in Ground Water

Perpendicular Direction Wells

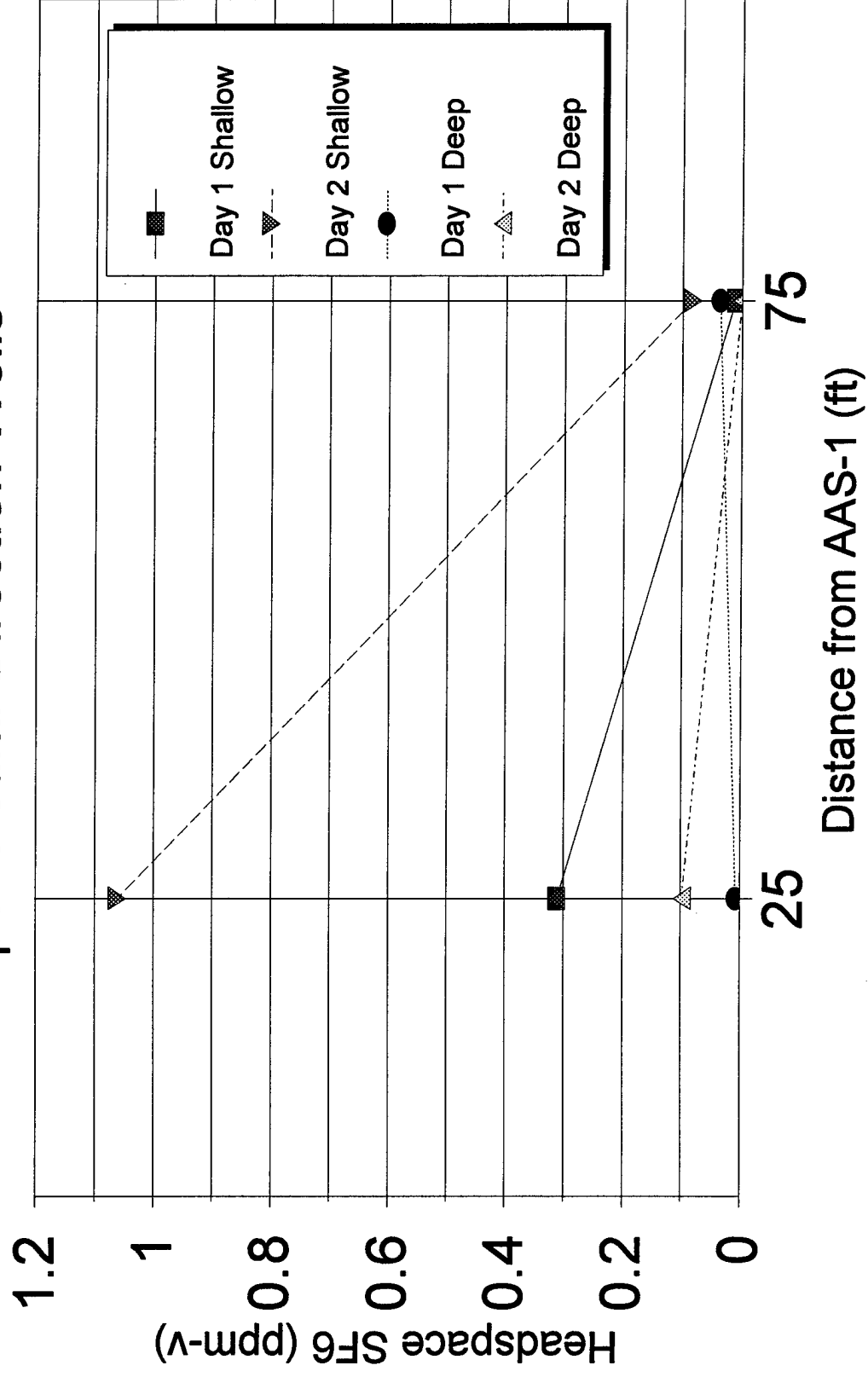


Figure 5-20 Vertical Profiles

Ground-Water SF6 - Parallel Wells

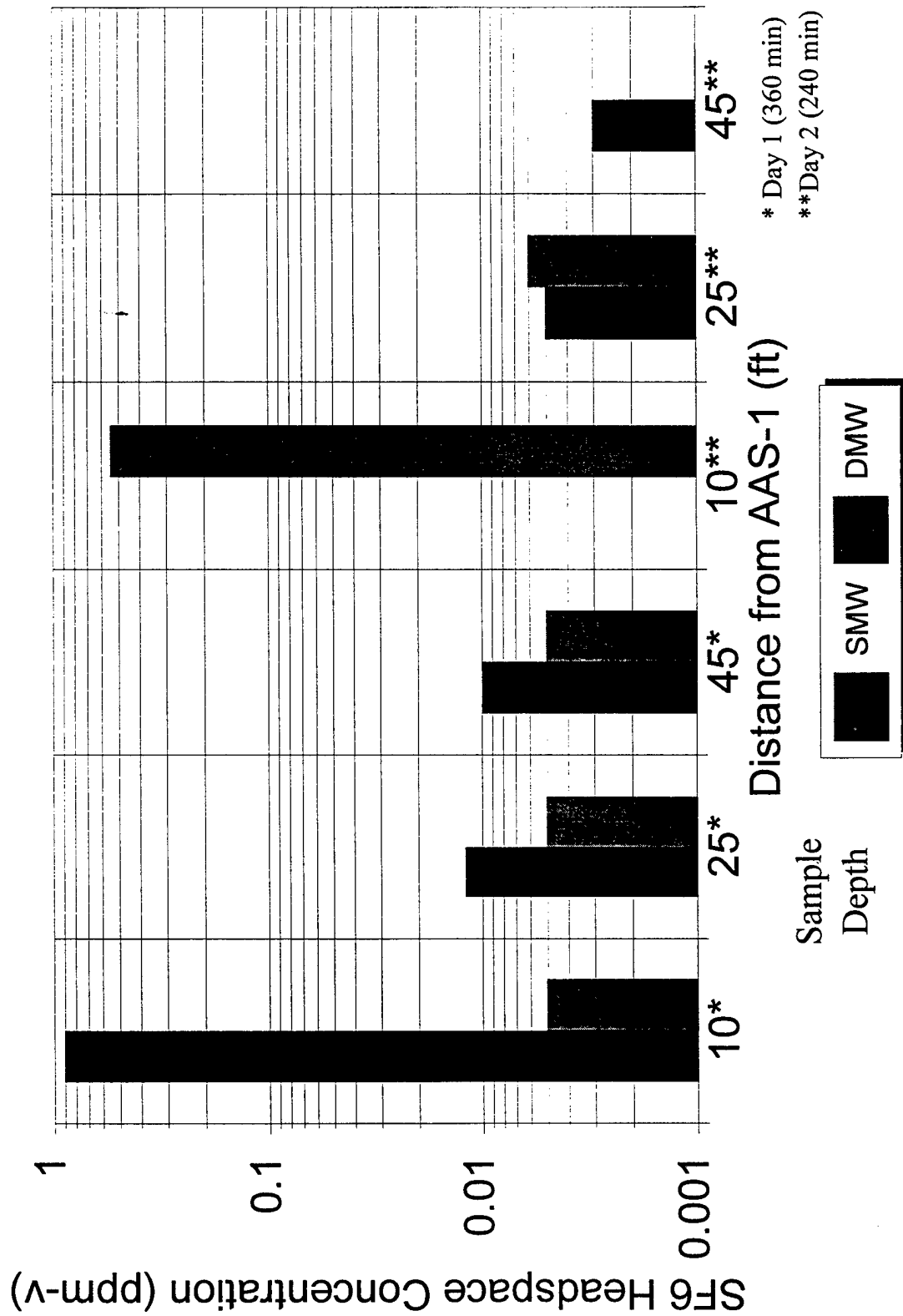
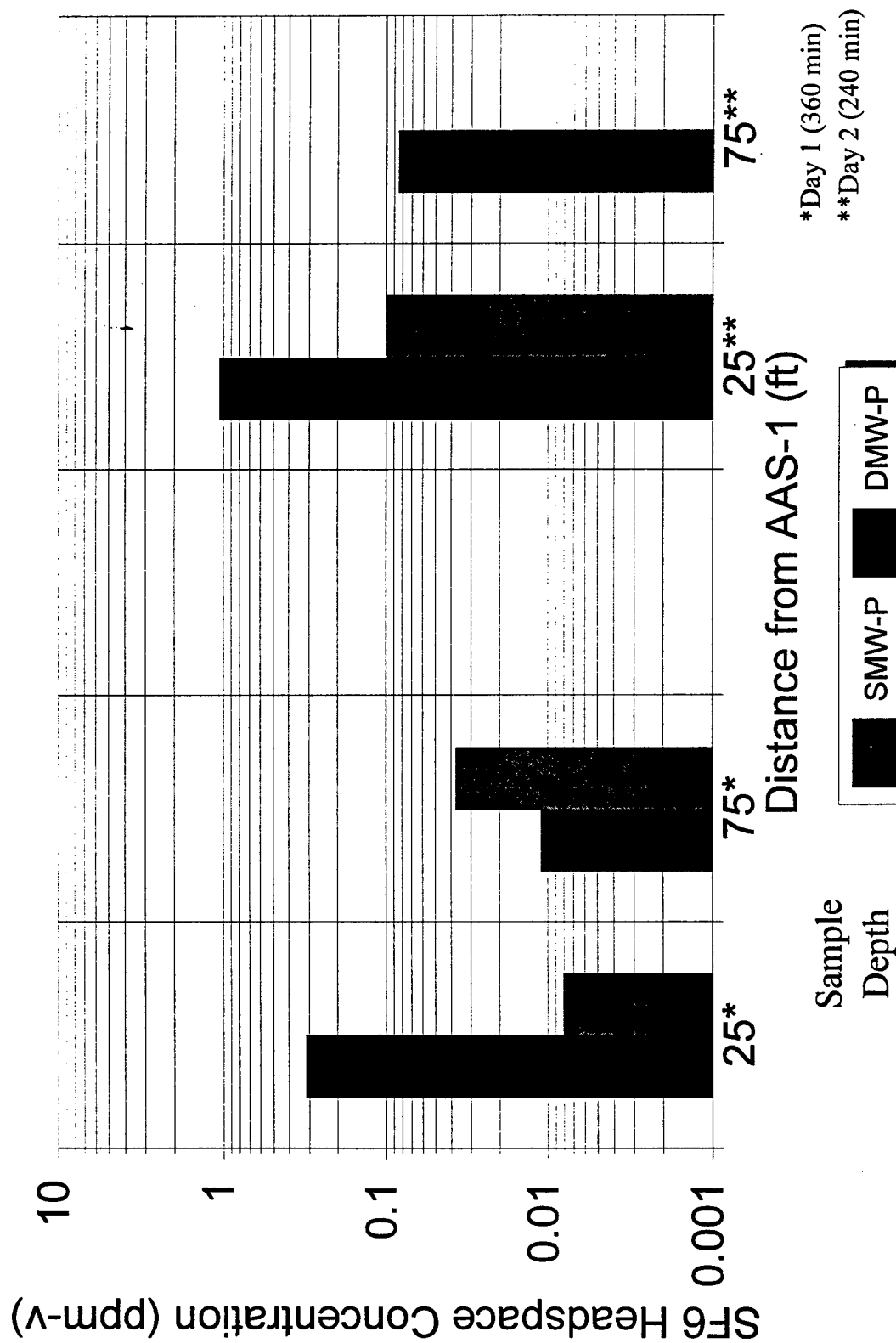


Figure 5-21 Vertical Profiles

Ground-Water SF6 - Perpendicular Wells



concentrations in the ground-water headspace samples within the ROI (a maximum groundwater concentration of $0.052 \mu\text{g/L}$) were far lower than the anticipated SF_6 concentrations (Appendix B). During AAS, inadequate contact and contaminant transfer between the injected air and the dissolved contaminants will result in reduced system efficiency since COCs will be volatilized at a slower rate.

5.3 DIFFERENTIAL PRESSURE

Figures 5-22 through 5-27 depict the variations of differential pressure observed over the duration of the tracer study with respect to distance from AAS-1. The axis representing the differential pressures are drawn to the same scale for ease of comparison. From the literature, differential pressures which correspond to the radial zone of influence for an AAS system are site specific and have been reported to range from +0.01 to +1.0 inches of water (Brown et al., 1991; Leonard and Brown, 1992, respectively).

Table 5.3-1 presents a summary of the number of monitoring wells which showed an influence (≥ 0.1 inches of water) due to AAS with respect to differential pressure. The actual differential pressure data for each of these wells is presented in Table 4-4. Overall, slightly greater than half of the wells appeared to be influenced by the injection into AAS-1 during day 1 and 2 of the study. Table 5.3-1 also summarizes the effected wells with respect to depth (vadose, shallow, and deep wells). Here, it can be seen that there was minimal affect in the deep monitoring points. However, almost all of the shallow and vadose monitoring wells had reported a pressure reading which was greater than +0.1 inches of water, even at the 75ft monitoring intervals. These data suggest that AAS in this area is able to influence the aquifer up to 75ft from the point of injection in the vadose and shallow zones but would have little or no effect at greater depths.

Figure 5-22 is typical of the differential pressure distribution for an AAS system. Here, the positive pressure induced by the injected air both increased with higher injection flow rates and decreased with distance from the point of injection.

Based upon the differential pressures, the effect of the injection well was much less pronounced in the deep monitoring wells as compared to the shallow and vadose wells, (+0.01 inches of water with an injection flow of 8.4 scfm) at a distance of 25 ft from AAS-1. The influence in the perpendicular direction may have reached the 75 ft interval, but again, the influence at this depth was less pronounced (+0.02 inches of water with an injection flow of 8.4 scfm).

In general, the differential pressures were slightly greater in the series of wells which were aligned perpendicular to ground-water flow. This corresponded to some of the trends inferred from the soil gas and ground-water analyses (Sections 5.1 and 5.2, respectively) which had higher concentrations of SF_6 in the perpendicular direction. A comparison was drawn between the differential pressures and the concentrations of tracer gas observed in each monitoring well (Figures 5-28 to 5-33). In theory, greater influences from the sparge well (as indicated by higher differential pressures) should correlate to higher concentrations of tracer gas. It should be noted that this correlation also can be affected by the distance from the point of injection because of partitioning into the aqueous phase, and dilution. Vapor samples collected from the distant

Figure 5-22 Variation of dP

VMW Parallel to Ground-Water Flow

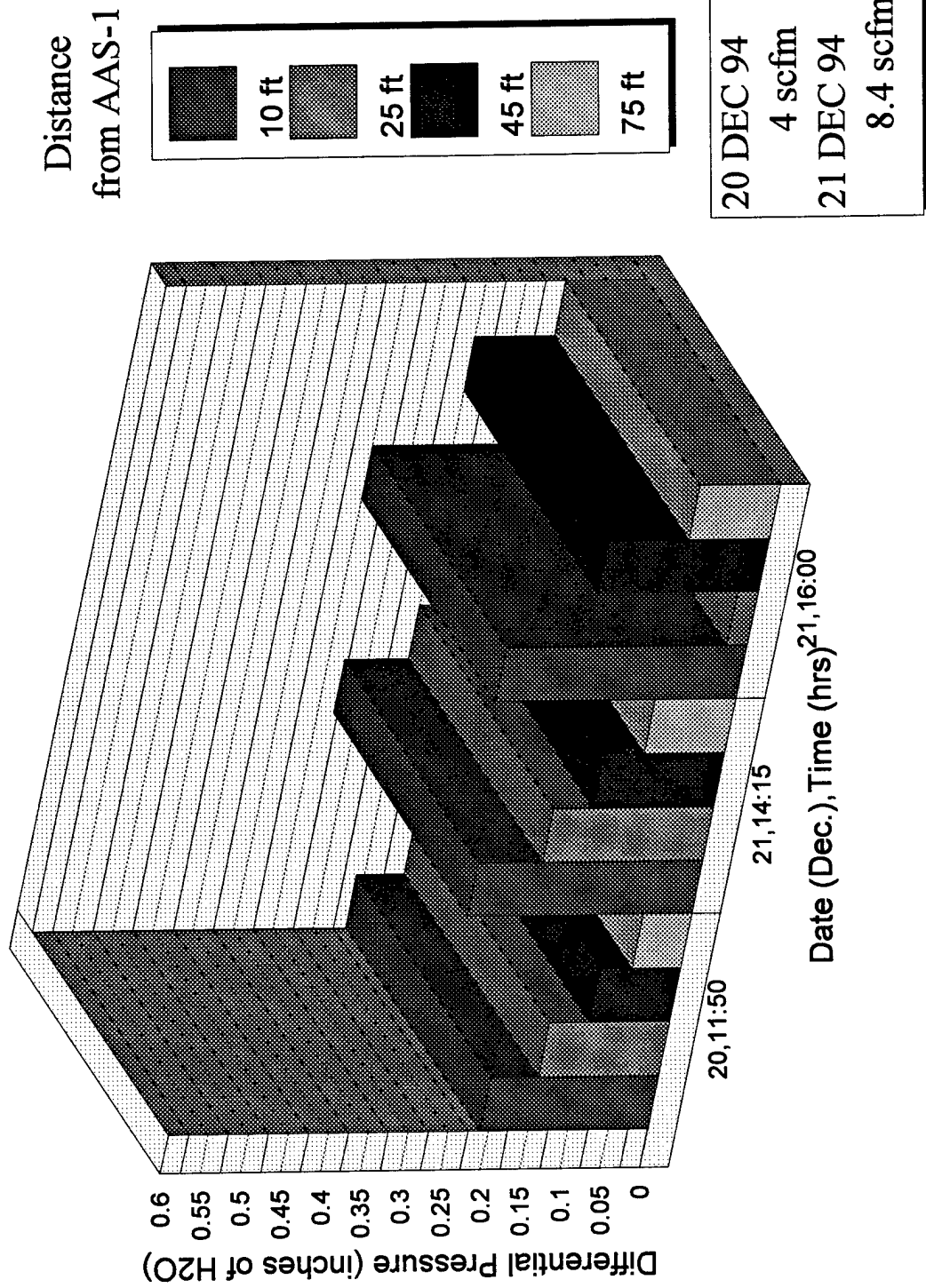


Figure 5-23 Variation of dP

VMW Perpendicular to Ground-Water Flow

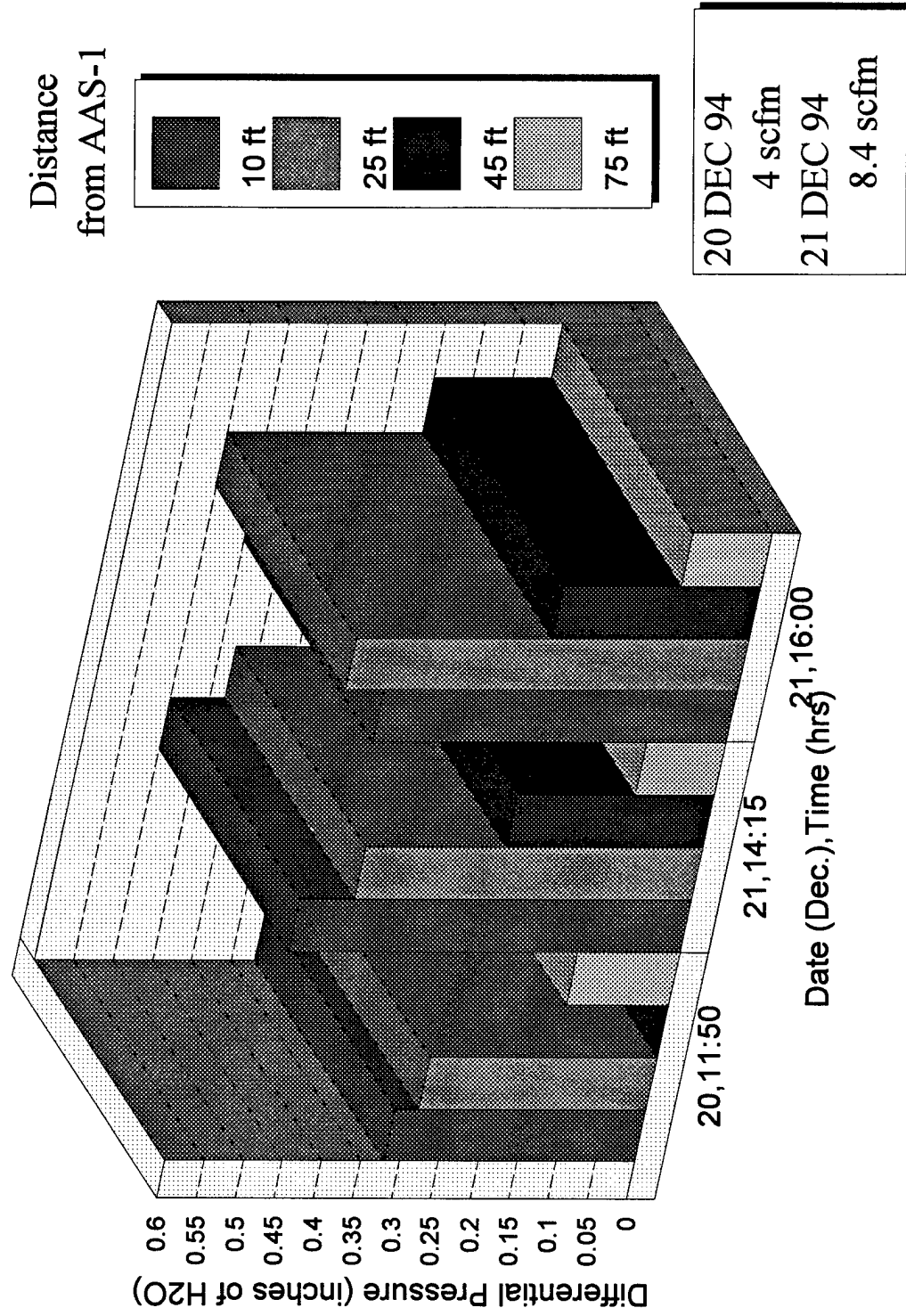


Figure 5-24 Variation of dP

SMW Perpendicular to GroundWater Flow

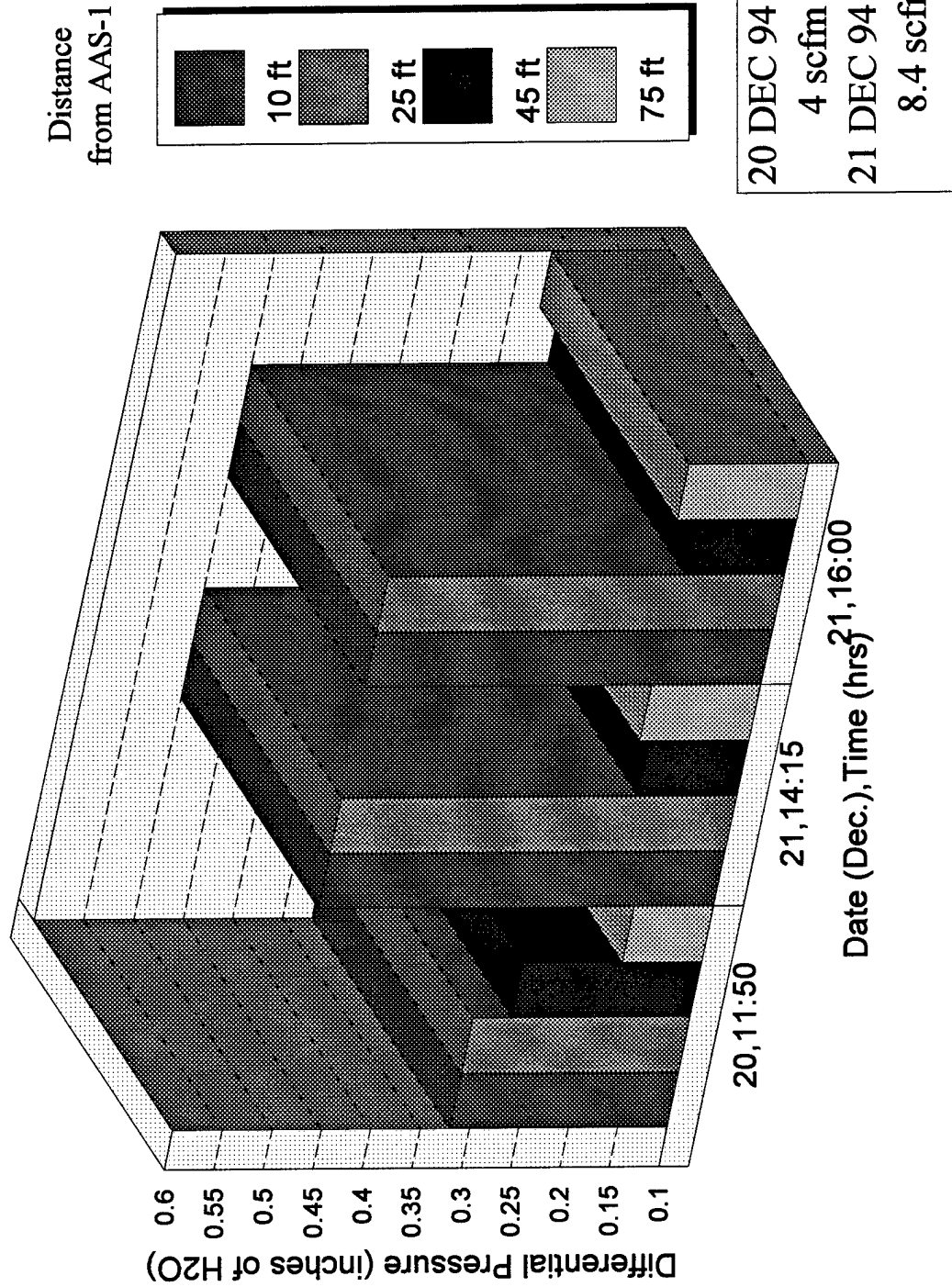


Figure 5-25 Variation of dP

SMW Parallel to Ground-Water Flow

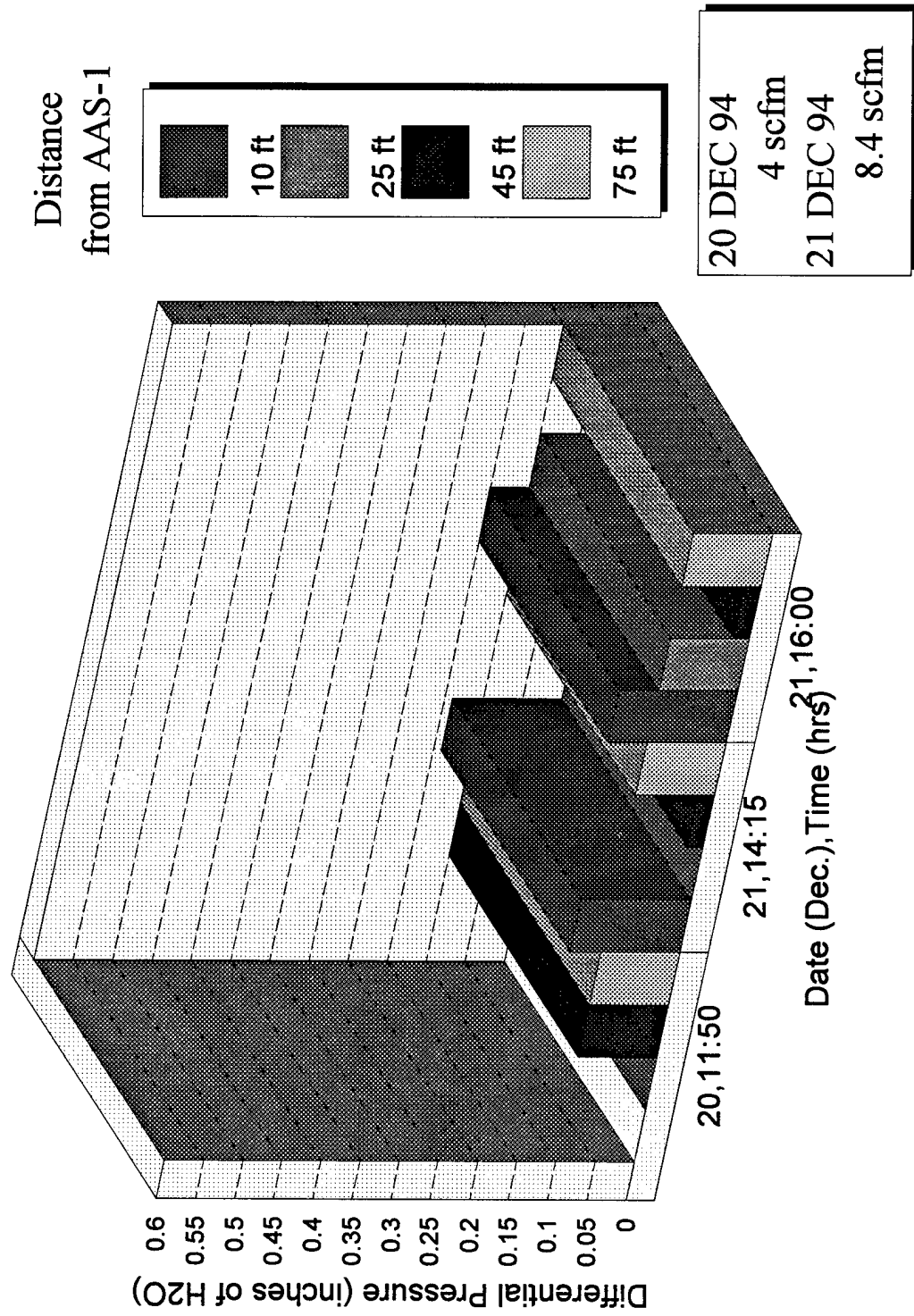
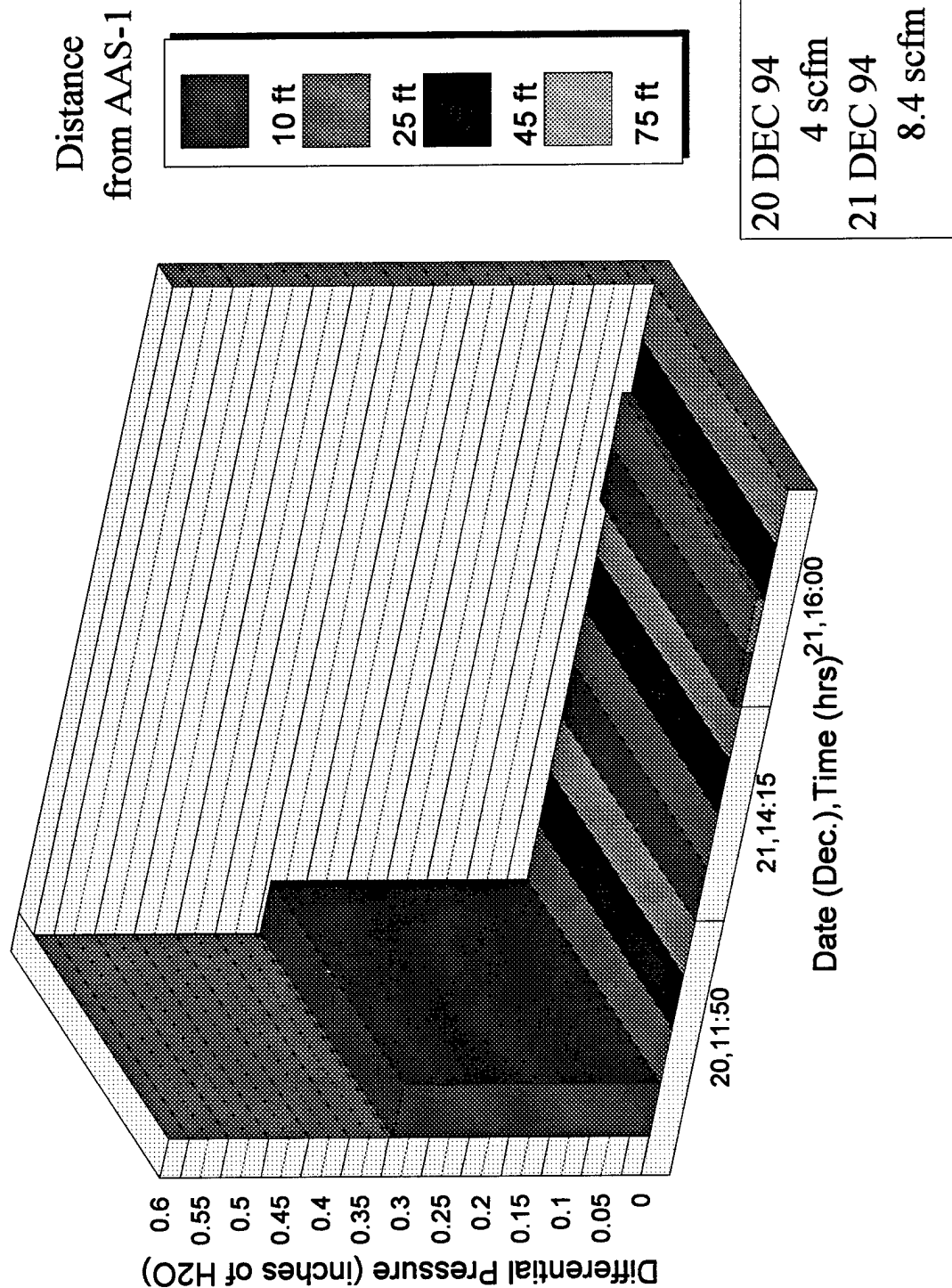


Figure 5-26 Variation of dP

DMW Parallel to Ground-Water Flow



DMW Perpendicular to Ground-Water Flow



Table 5.3-1 Number of Wells Showing Effect with Respect to Differential Pressure
Dover AFB Site SS59 SF6 Tracer Gas Study

Monitoring Location	Day 1 <0.1	Day 2 = or > 0.1	Monitoring Location	Day 1 <0.1	Day 2 = or > 0.1
DMW75-1	x		DMW75-1	x	
DMW75-1P	x		DMW75-1P	x	
SMW75-1		x	SMW75-1		x
SMW75-1P		x	SMW75-1P		x
VMW75-1			VMW75-1		x
VMW75-1P		x	VMW75-1P		x
DMW45-1	x		DMW45-1	x	
DMW45-1P	x		DMW45-1P	x	
SMW45-1		x	SMW45-1	x	
SMW45-1P		x	SMW45-1P		x
VMW45-1		x	VMW45-1		x
VMW45-1P	x		VMW45-1P		x
DMW25-1	x		DMW25-1	x	
DMW25-1P	x		DMW25-1P	x	
SMW25-1	x		SMW25-1		x
SMW25-1P		x	SMW25-1P		x
VMW25-1		x	VMW25-1	x	
VMW25-1P		x	VMW25-1P		x
DMW10-1		x	DMW10-1	x	
DMW10-1P	NS		DMW10-1P	x	
SMW10-1		NS	SMW10-1		x
SMW10-1P		x	SMW10-1P		x
VMW10-1		x	VMW10-1		x
VMW10-1P		x	VMW10-1P		x
TOTAL	9	13	TOTAL	10	14

notes: <0.1" H₂O indicates Minimal to No Effect
=> 0.1" H₂O indicates Positive Effect
See Table 4-4 for the original data.

NS = Not Sampled

Summary - Deep Monitoring Wells

Distance	No Effect	Effect
75 ft	0	0
45 ft	0	0
20-34 ft	0	0
10 ft	0	0
TOTAL	0	0

Summary - Shallow Monitoring Wells

Distance	No Effect	Effect
75 ft	0	0
45 ft	0	0
20-34 ft	0	0
10 ft	0	0
TOTAL	0	0

Summary - Vadose Monitoring Wells

Distance	No Effect	Effect
75 ft	0	0
45 ft	0	0
20-34 ft	0	0
10 ft	0	0
TOTAL	0	0

Figure 5-28 Soil Gas SF6 vs. dP

Shallow Monitoring Wells - Day 1

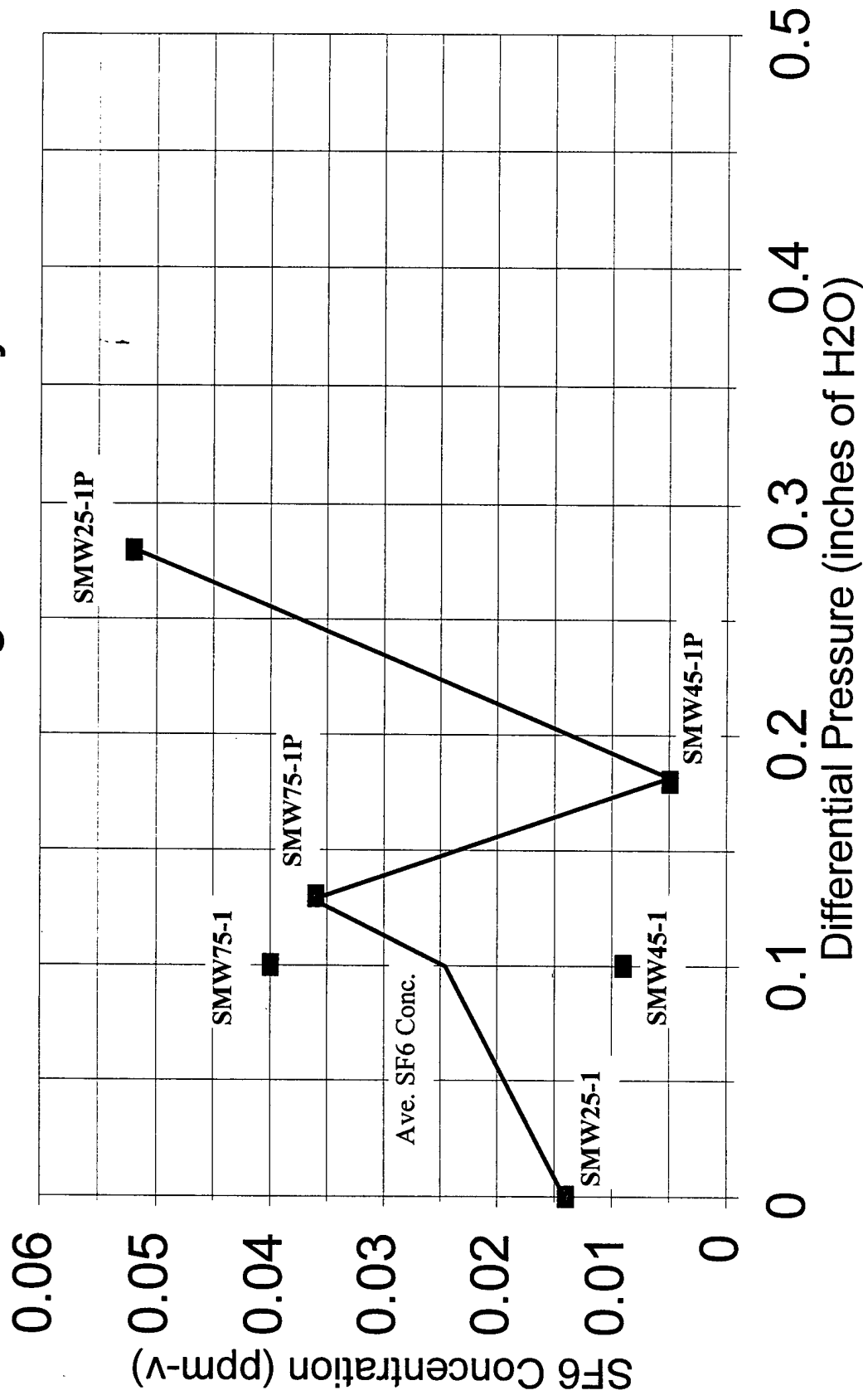


Figure 5-29 Soil Gas SF6 vs. dP
Deep Monitoring Wells - Day 1

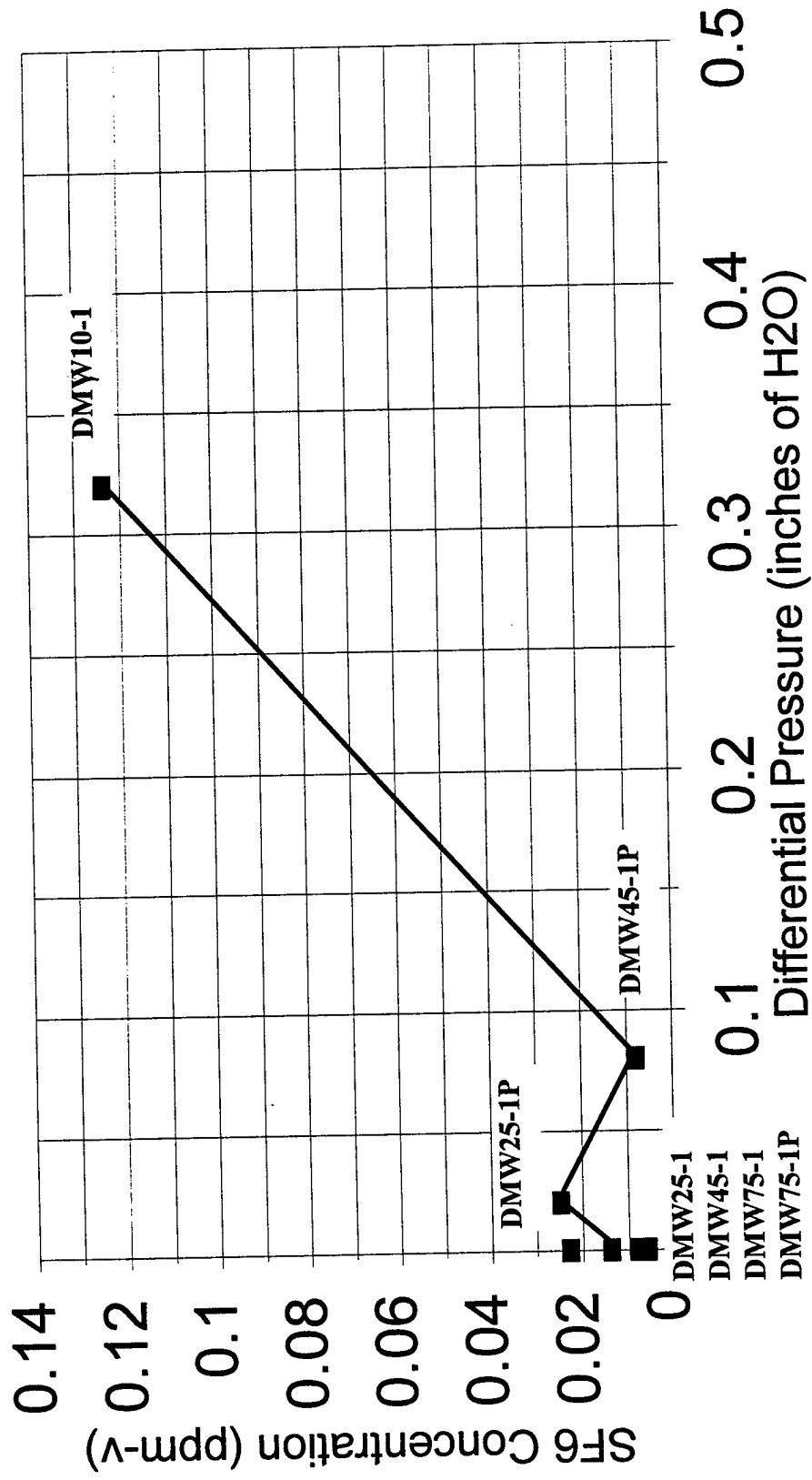


Figure 5-30 Soil Gas SF6 vs. dP

Vadose Monitoring Wells - Day 1

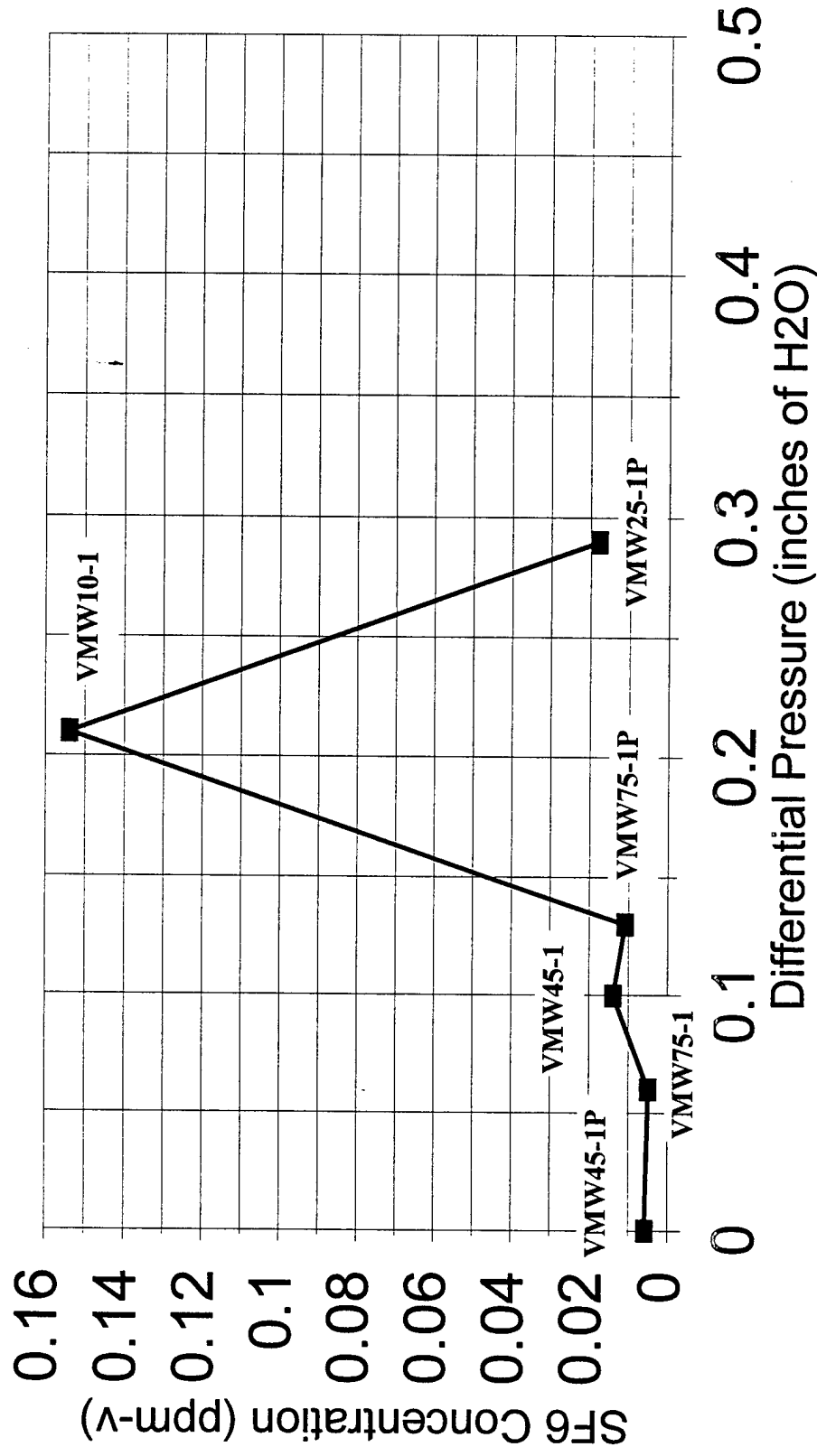


Figure 5-31 Soil Gas SF6 vs. dP

Shallow Monitoring Wells - Day 2

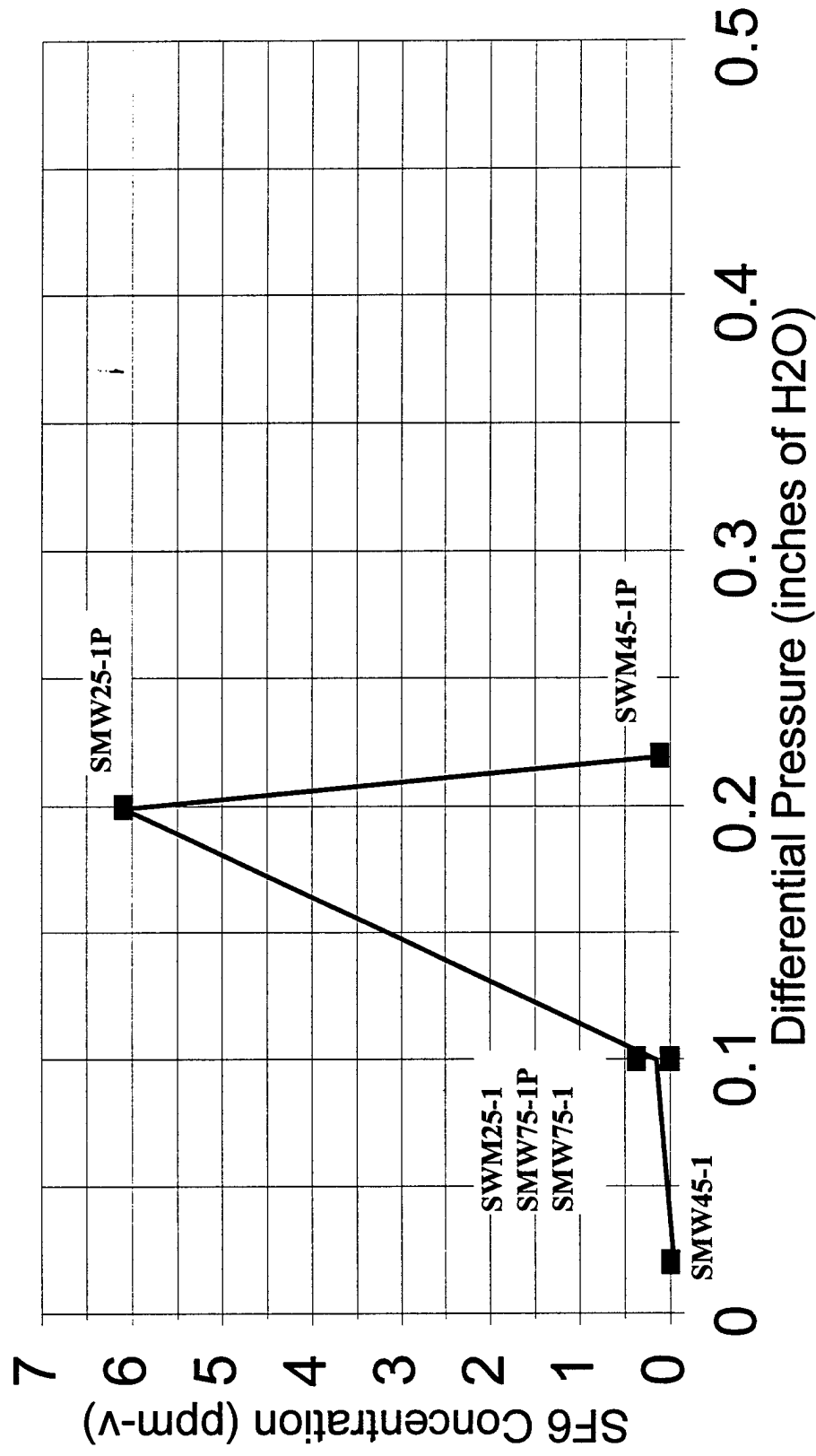
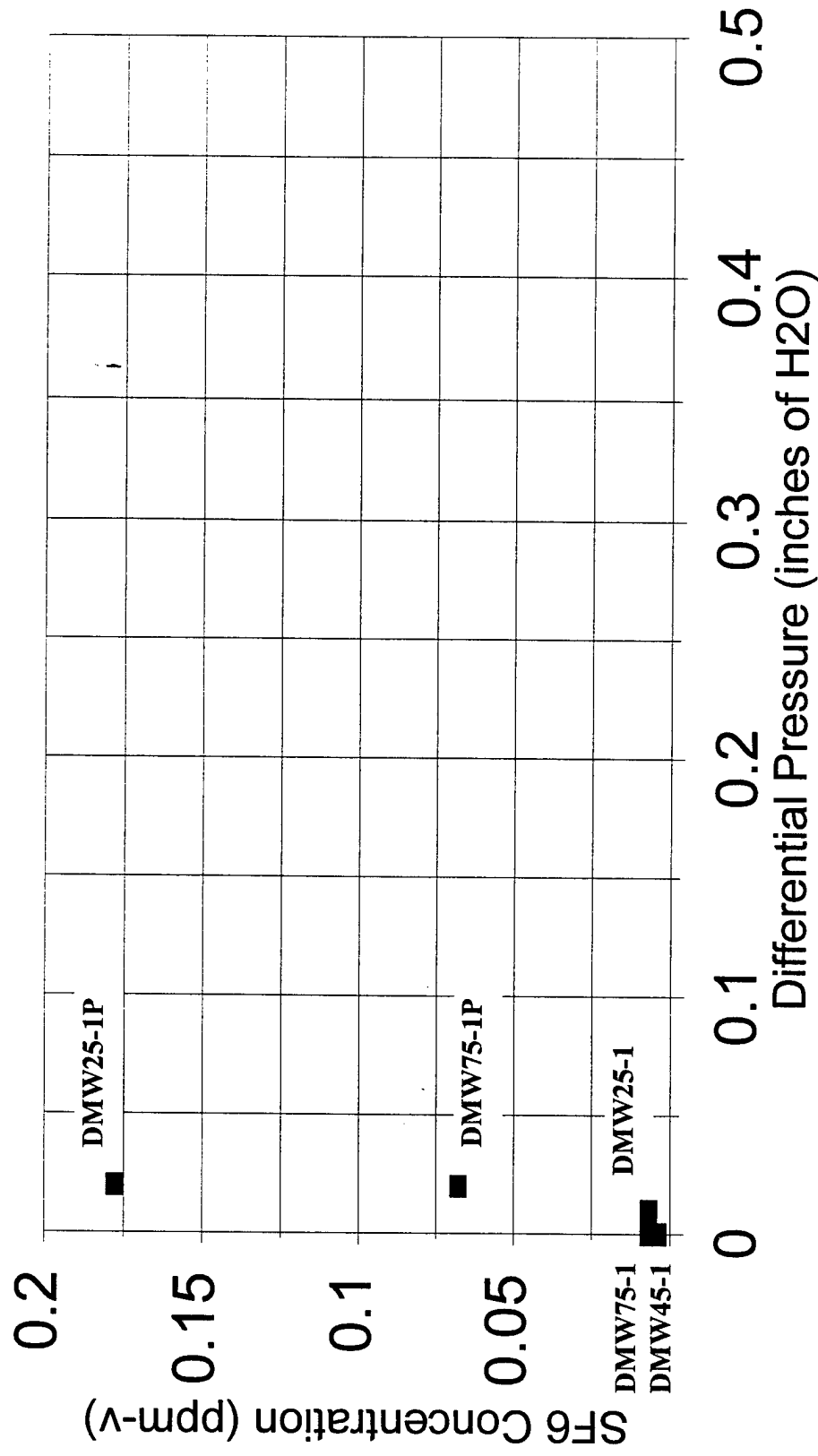


Figure 5-32 Soil Gas SF6 vs. dP

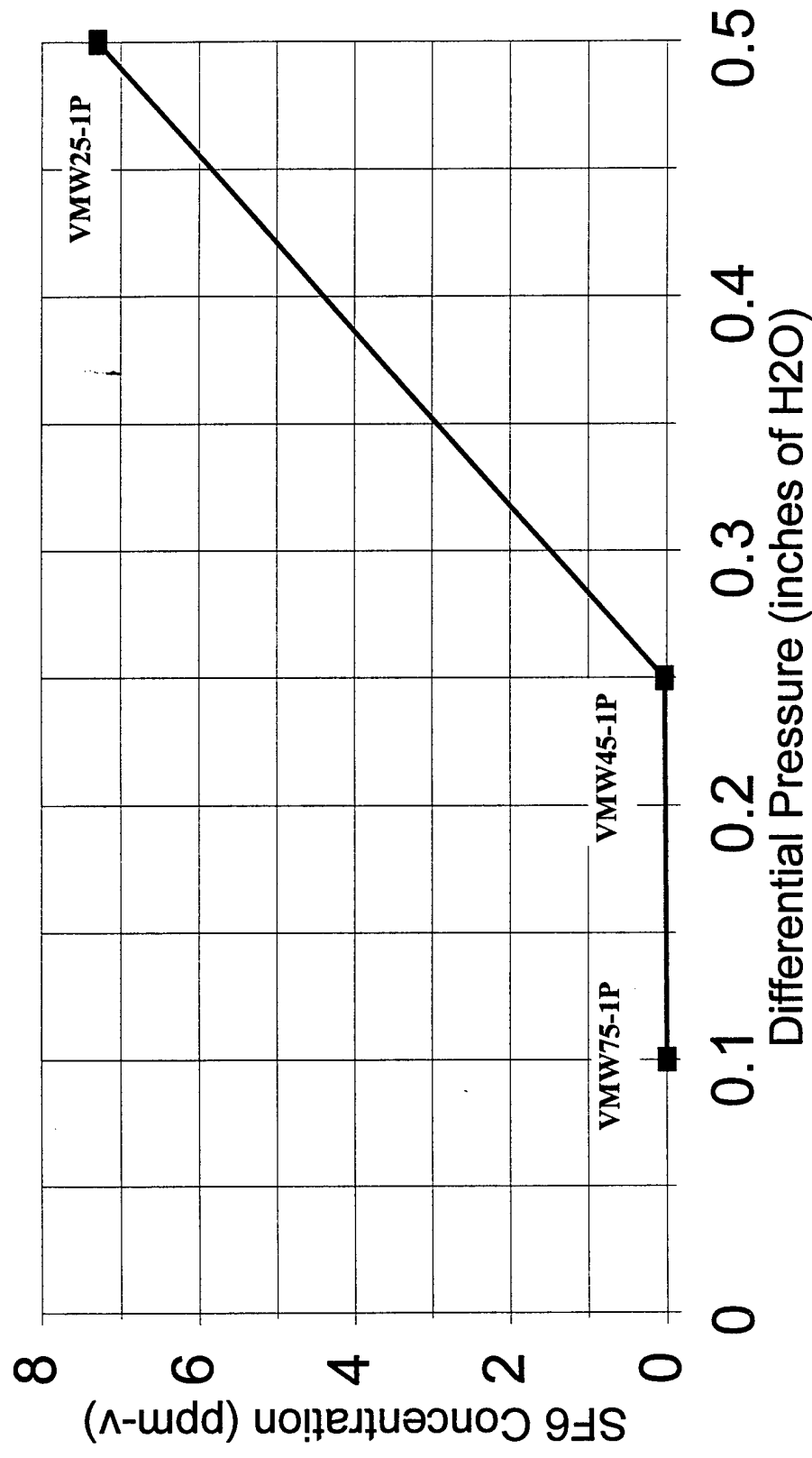
Deep Monitoring Wells - Day 2



Note: The graph line was not drawn due to the scale which was used for the differential pressure axis.

Figure 5-33 Soil Gas SF6 vs. dP

Vadose Monitoring Wells - Day 2



monitoring points may have been biased toward lower concentrations of SF_6 since more time was allowed for the mass transfer of tracer gas to the aqueous phase. In this case, it would then be possible to have wells with a positive differential pressure yet still are non-detect for SF_6 . Thus, correlations presented in this manner should be taken more as a qualitative indication of the sparge well's influence within the aquifer. As shown in Figures 5-28 through 5-33, increases in tracer gas concentrations were weakly correlated to increases in differential pressure. Flow channeling through the saturated and vadose zones of the aquifer may explain these deviations.

5.4 SUMMARY

Elevated soil gas concentrations of SF_6 were observed 75 ft from the point of injection, particularly in the shallow monitoring points. Some indication of an influence that extends to 75 ft was present in the deep wells but the effect at this distance was less significant and a 45 ft ROI is a more appropriate estimate for both depths. During Day 1 of the study, the distribution of SF_6 in Test Area 1 appeared to be symmetrical in the shallow monitoring points. A slight, increased influence toward the series of wells which are aligned parallel to ground-water flow may have been present in the vadose and deep monitoring points. However, during Day 2 of the study, there appeared to be a greater influence in the series of wells which are perpendicular to ground-water flow in both the shallow and deep monitoring points (insufficient data were available to identify trends in the vadose zone). This may have been due to the creation of new, preferential flow channels in the perpendicular direction resulting from the increase in flow rate and injection pressure. In addition, existing flow channels may have remained open, and the increased air flow rate may have dewatered and enlarged them. Based upon the available geologic data, it did not appear as though this flow channeling was due to the presence of lenses within the site since these are predominantly located within the vadose zone of the aquifer. In general, the increase in the injection flow rate on Day 2 also increased the concentrations of SF_6 within the ROI of AAS-1 but, overall, this did not appear to significantly extend the ROI. Overall, the results suggest that the AAS system was able to affect the aquifer at distances up to 45 ft but, since the observed SF_6 concentrations were far lower than anticipated, the degree of this effect was minimal at 45 ft.

Elevated ground-water concentrations of SF_6 were observed at distances up to 45 (parallel direction) and 75 ft (perpendicular direction) from the point of injection, particularly in the shallow monitoring wells. A reduced influence was observed in the deeper monitoring points. Although not indicative of the true ROI of an AAS well, these data may provide information regarding the extent to which the system is influencing ground water at the site.

6. CONCLUSION

The observed soil gas SF₆ concentrations indicate an influence due to AAS up to 45 ft in both the shallow zone (7 to 17 ft bgs) and in the deep zone (31 to 36 ft bgs) of the aquifer. The observed ground-water SF₆ concentrations were much lower than anticipated and indicated a minimal influence. The observed differential pressure data suggested a positive influence (≥ 0.1 inches of water) due to AAS up to between 45 and 75 ft in the shallow zone with little or no effect in the deep zone. In general, the ROI which may be estimated from this data are in agreement with the ROI which was estimated during the initial Treatability Study (45 ft).

Increasing the flow rate from 4.0 scfm to 8.4 scfm on Day 1 and 2 of the test, respectively, increased the concentrations of tracer gas throughout the aquifer but, overall, this did not appear to significantly extend the ROI.

On Day 1 of the study, the tracer gas distribution throughout the test area appeared to be relatively symmetrical in the shallow (7 to 17 ft bgs) zone with a possible preferential flow regime aligned parallel to ground-water flow in the vadose (3 to 8 ft bgs) and deep (31 to 36 ft bgs) zones. When the injection pressure and flow rate was increased on Day 2 of the study, the preferential flow path appeared to shift in a direction which was perpendicular to ground-water flow.

Overall, the AAS system appeared to have some influence on the aquifer (with some flow channeling) up to 45 ft but, since the observed SF₆ concentrations were lower than anticipated, the degree of this effect appeared to be minimal at 45 ft.

LIST OF INFORMATIONAL RESOURCES

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Appendix A-1
Calculation Sheets



Project TOVER AFB TRACER GAS STUDY Project No. 60378.26
Subject SF₆ FLOW RATE / MASS INJECTED Sheet No. 1 of 1
ATTACHMENT A Drawing No. —
Computed by JDR Date 2/24/95 Checked by JH Date 3/6/95

ESTIMATE OF TOTAL MASS / MASS FLOW RATE OF SF₆ INJECTED INTO AAC-1

influent concentration ≈ 4250 ppmv of SF₆ (last measurement of influent concentration of Day 1)
(TABLE 4-2)

DAY 1 flow rate = 3 acfm = 4.0 scfm

DAY 2 " " = 6 acfm = 8.4 scfm

convert ppmv to mg/L_{air} (ASTM D 1914 pg 37)

$$\text{ppmv} \times \frac{\text{molecular weight}}{24450} = \frac{\text{mg}}{\text{L}_{\text{air}}} \quad @ 25^\circ\text{C} \text{ \& } 101.3 \text{ kPa} \quad (\text{thus, this will only be an approximation})$$

$$= \frac{(4250 \text{ ppmv})(146.048 \text{ g/mol})}{24450}$$

$$= 25.39 \text{ mg/L}_{\text{air}}$$

mass flow rate

$$\text{DAY 1} \quad \left(4.0 \frac{\text{ft}^3}{\text{min}}\right) \left(\frac{25.39 \text{ mg}}{\text{L}}\right) \left(\frac{\text{L}}{0.03531 \text{ ft}^3}\right) = 2,876 \text{ mg/min}$$

$$\text{DAY 2} \quad \left(8.4 \frac{\text{ft}^3}{\text{min}}\right) \left(\frac{25.39 \text{ mg}}{\text{L}}\right) \left(\frac{\text{L}}{0.03531 \text{ ft}^3}\right) = 6,040 \text{ mg/min}$$

total mass injected

$$\text{DAY 1} \quad \text{inject from } 0845 \text{ to } 1500 \text{ hr} = 6 \text{ hr } 15 \text{ min} = 375 \text{ min}$$

$$(2876 \text{ mg/min})(375 \text{ min}) \left(\frac{\text{g}}{1000 \text{ mg}}\right) \left(\frac{\text{lb}}{454 \text{ g}}\right) = 2.38 \text{ lb of SF}_6 \quad (1.08 \text{ kg of SF}_6)$$

$$\text{DAY 2} \quad \text{inject from } 1200 \text{ to } 1620 \text{ hr} = 4 \text{ hr } 20 \text{ min} = 260 \text{ min}$$

$$(6040 \text{ mg/min})(260 \text{ min}) \left(\frac{\text{g}}{1000 \text{ mg}}\right) \left(\frac{\text{lb}}{454 \text{ g}}\right) = 3.46 \text{ lb of SF}_6 \quad (1.57 \text{ kg of SF}_6)$$



Project DOVER AFE SFG TRACER GAS STUDY Project No. 20378.20
Subject CALCULATION OF THE INITIAL Sheet No. 1 of 1
RESISTANCE TO SPARGING IN AAS-1 Drawing No. —
Computed by JDR Date 27 FEB 95 Checked by JH Date 3/6/95

INITIAL RESISTANCE TO AIRFLOW IN AAS-1

$$P_i = (W_c)(0.434 \text{ PSI/ft})$$

Injection well AAS-1

top of screened interval @ 41 ft bgs

depth to water @ 11.3 bgs (measured on 16 JAN 95)

standing water column (W_c) above well screen = $41 - 11.3 = 29.7 \text{ ft}$

$$P_i = (29.7 \text{ ft})(0.434 \text{ PSI/ft})$$

$$= 12.9 \text{ psi}$$



Project DOYER AFE SFG TRACER GAS STUDY Project No. 603732
Subject AFC FLOW RATE CONVERSION Sheet No. 1 of 1
Drawing No. -
Computed by JDR Date 23 FEB 95 Checked by JH Date 3/6/95

ACFM to SCFM CONVERSION

$$Q_{SCFM} = Q_{ACFM} \left(\frac{P_{atm} + P_{sig}}{P_{atm}} \right)^{1/2} \quad (\text{Dwyer Instruments Inc.})$$

DAY 1 $\rightarrow$ 3 acfm @ 12 psig

$$Q_{SCFM} = (3 \text{ acfm}) \left(\frac{12 \text{ psig} + 14.7 \text{ psi}}{14.7 \text{ psi}} \right)^{1/2}$$
$$= 4.0 \text{ scfm} \quad (4.043)$$

DAY 2 $\rightarrow$ 6 acfm @ 14 psig

$$Q_{SCFM} = (6 \text{ acfm}) \left(\frac{14 \text{ psig} + 14.7 \text{ psi}}{14.7 \text{ psi}} \right)^{1/2}$$
$$= 8.4 \text{ scfm} \quad (8.334)$$

ATTACHMENT B

CALCULATIONS FOR MAXIMUM SF₆ AT DOVER AFB

Assumptions:

Depth of Air Injection = 35' BWT
Radius of Influence of 40'
Total Porosity = 0.35
Air Porosity = 0.05
Water Porosity = 0.30

This focuses only on the zone below the water table
Does not account for Unsaturated Zone (USZ)
partitioning or for mass present in the USZ

$V_w = \text{Volume of Water in Ri} = \pi \cdot r^2 \cdot 35' \cdot 0.30$

$H = 121.7$ (dimensionless) for SF₆

$C_{g,i} = 4250 \text{ ppm(v/v)} = 25.39 \text{ mg/L (air)}$

121.7 from Groundwater 31,5, 1993: Wilson and Mackay

25.39 Calc. from EA SF₆ report

(i=inlet gas concentration)

The maximum aqueous phase SF₆ concentration = $Cl,i = C_{g,i}/H$

$Cl,i = 0.209 \text{ mg/L (water) or } 209 \text{ ppb SF}_6$ max. aqueous phase SF₆ concentration

$V_w \text{ in Ri} = 52785.6 \text{ ft}^3$

$V_w \text{ in Ri} = 394836.288 \text{ gallons water} \quad 1494455.35 \text{ liters water}$ vol. of pore water in area of infl. below water table

$M_i = \text{mass of SF}_6 \text{ needed for all of this water to contain } Cl,i = 0.209 \text{ mg/L (water)}$

$M_i = 312341.168 \text{ mg SF}_6 \quad 0.31234117 \text{ Kg SF}_6$
to compare 1.07 Kg was actually injected on DAY 1
and 1.57 was injected on Day 2

(this is only SF₆ in water)

Since we assume that 0.05 contains air and that the air contain SF₆ at the injection Concentration

$V_a = \text{Volume of air in Ri}$

$V_a \text{ in Ri} = 8797.6 \text{ ft}^3$

248972.08 liters air

M_i needed to have SF₆ in soil air equal to injection concentration

$M_i = 6321401.11 \text{ mg SF}_6$

6.32140111 Kg SF₆

this is SF₆ in gas phase of infl. zone below water table

so this means that the mass of injected SF₆ was inadequate for equilibrium to be reached

ATTACHMENT B (continued)

An example is provided:

Assume that the 1.08 Kg of SF₆ injected during the first day is in equilibrium with the gas and aqueous phases

$$M_t = M_g + M_l, \text{ where } M_g = C_g * V_l \text{ and } M_l = C_l * V_l$$

$$\text{solve for } C_g, M_g = C_g * V_a \text{ and } M_l = C_g/H * V_w$$

$$C_g = 4.13394106 \text{ mg/L (air)} \quad 691.975168 \text{ ppmv in air}$$

$$C_l = 0.03396829 \text{ mg/L (water)} \quad 34 \text{ ppb in water}$$

considering the total volume of injected SF₆ from both days

$$M_t = 2.65$$

$$C_g = 10.1434665 \text{ mg/L (air)} \quad 1697.90203 \text{ ppmv in air}$$

$$C_l = 0.08334812 \text{ mg/L (water)} \quad 83.3 \text{ ppb in water}$$

If equilibrium between the gas and liquid phase is reached quickly then the aqueous phase can act as a scrubber (absorption operation) and significantly reduce the SF₆ concentration prior to the gas phase reaching the water table. Once adequate mass of SF₆ is injected then higher gas phase and aqueous phase concentrations would likely be observed in Unsaturated zone. This would clearly take place closer to the borehole first.

Calculated by: GEH 12 June 1995

Checked by: TRH 12 June 1995

Project DOVER AFB Project No. _____Subject SF₆ GW HEADSPACE TO AQUEOUS Sheet No. _____ of _____CONCENTRATION CONVERSION Drawing No. _____Computed by SDR Date 6/15/95 Checked by THT Date 7/12/95

ATTACHMENT C

$$\frac{C_g}{C_s} = \frac{\text{CONC IN GAS PHASE (mg/m}^3\text{)}}{\text{SATURATED CONC IN LIQUID PHASE (mg/m}^3\text{)}} = H_L \text{ (DIMENSIONLESS)}$$

$$H_{\text{SF}_6} = 121.7$$

HEADSPACE CONCENTRATION CONVERSION (FOR MAXIMUM CONCENTRATION)

$$C_g \text{ mg/m}^3 = \text{CONC ppm} \times \frac{\text{MOLECULAR WEIGHT}}{24500} \times 10^6$$

$$= (1.062 \text{ ppm}) \left(\frac{146.048 \text{ g/g-mol}}{24450} \right) (10^6) = 6343.68 \text{ mg/m}^3$$

$$\left(\frac{6343.68 \text{ mg/m}^3}{121.7} \right) \left(\frac{1 \text{ m}^3}{1000 \text{ L}} \right) = \underline{\underline{0.052 \text{ mg/L}}}$$

Appendix B
Calculation Sheets

TABLE B.5-1

**CALCULATION OF INFLUENT EMISSION RATE OF VOCs (lb/d) FROM THE SVE SYSTEM PRIOR TO GAC FILTRATION
SITE SS59 - DOVER AFB, DELAWARE**

EMISSION RATE (ER) (lb/d) = $Q \cdot C \cdot MW \cdot 1.581 \cdot (1E-7)^{24}$ (modified from EPA, 1989)											
Q = extraction flow rate (CFM) C = extracted soil vapor concentration (ppm-v) MW = molecular weight of the compound (lb/lb-mole) (1.581)*(1E-7)*(24) = conversion factors											
	DATE	METHYLENE CHLORIDE (ppm)	TRANS -1,2 DCE (ppm)	CIS-1,2 DCE (ppm)	TCA (ppm)	CARBON TETRACHL. (ppm)	TCE (ppm)	PCE (ppm)	TOTAL VOLATILE HYDROCARBON (ppm)	TOTAL VOCs (ppm)	
INFLUENT DATA (2)											
COMBINED INFLUENT	16 JUNE 94	<4	<5	<9	0.635	<0.001	0.168	0.025	<1	0.828	
COMBINED INFLUENT	28 JUNE 94	<4	<5	<9	0.187	<0.001	0.091	0.007	<1	0.285	
COMBINED INFLUENT	8 JULY 94 (1)	<4	<5	<9	0.618	<0.001	0.114	0.006	<1	0.738	
COMBINED INFLUENT	4 AUG 94	<0.5	<0.6	<1.4	0.299	<0.001	0.053	0.008	<5	0.360	
COMBINED INFLUENT	18 AUG 94	<0.4	<0.6	<1.2	0.067	<0.001	<0.001	1.308	<5	1.375	
COMBINED INFLUENT	1 SEP 94	0.3	<0.1	<0.1	0.474	<0.001	0.243	0.079	<5	1.096	
COMBINED INFLUENT	22 SEP 94	<0.1	<0.1	<0.1	0.071	<0.001	0.071	0.029	<5	0.171	
COMBINED INFLUENT	7 OCT 94	0.1	<0.1	<0.1	1.003	<0.001	<0.001	0.103	<0.5	1.206	
COMBINED INFLUENT	13 OCT 94	6.2	<0.1	<0.1	0.042	<0.001	1.65	0.77	<0.5	26.062	
COMBINED INFLUENT	27 OCT 94	0.83	<0.1	<0.1	0.841	<0.001	0.074	0.023	<0.5	1.768	
COMBINED INFLUENT	14 NOV 94	0.63	<0.1	0.2	0.187	<0.001	0.08	0.017	<0.5	1.114	
SVE-1	9 JAN 95	2.49	<	<	0.053	<	<	0.005	<	2.548	
SVE-1	23 JAN 95	<0.1	<0.1	<0.1	0.085	<0.001	0.082	<0.001	<5	0.167	
SVE-1	25 JAN 95	<0.1	<0.1	0.2	0.185	<0.001	0.186	0.034	<5	0.605	
		METHYLENE CHLORIDE (lb/d)	TRANS -1,2 DCE (lb/d)	CIS-1,2 DCE (lb/d)	TCA (lb/d)	CARBON TETRACHL. (lb/d)	TCE (lb/d)	PCE (lb/d)	TOTAL VOLATILE HYDROCARBON (as toluene) (lb/d)		
MOLECULAR WEIGHT (lb/lb-mole)		84.93	96.95	96.95	133.41	153.82	131.5	165.83	92.1		
at Site WP-21, an extraction flow velocity of 3,000 ft/min was measured which converts to 64.9 CFM with the 2" diameter extraction pipe (see attached sheet for example calculation)											
(3000 ft/min * pi * (0.083ft) ² = 64.9 CFM)											
Flow rate of SVE system after 13 Oct 94 was 55 CFM Flow rate of SVE1 for 6 and 9 Jan 95 was 40 scfm											
EMISSION RATE	DATE	METHYLENE CHLORIDE (lb/d)	TRANS -1,2 DCE (lb/d)	CIS-1,2 DCE (lb/d)	TCA (lb/d)	CARBON TETRACHL. (lb/d)	TCE (lb/d)	PCE (lb/d)	TOTAL VOLATILE HYDROCARBON (lb/d)	TOTAL EMISSION RATE (lb/d)	
COMBINED (Vertical wells)	16 JUNE 94	0.0000	0.0000	0.0000	0.0209	0.0000	0.0054	0.0010	0.0000	0.0273	
COMBINED (Vertical wells)	28 JUNE 94	0.0000	0.0000	0.0000	0.0061	0.0000	0.0029	0.0003	0.0000	0.0094	
COMBINED (Vertical wells)	8 JULY 94 (1)	0.0000	0.0000	0.0000	0.0203	0.0000	0.0037	0.0002	0.0000	0.0242	
COMBINED (Vertical wells)	4 AUG 94	0.0000	0.0000	0.0000	0.0098	0.0000	0.0017	0.0003	0.0000	0.0119	
COMBINED (Vertical wells)	18 AUG 94	0.0000	0.0000	0.0000	0.0022	0.0000	0.0000	0.0534	0.0000	0.0556	
COMBINED (Vertical wells)	1 SEP 94	0.0063	0.0000	0.0000	0.0156	0.0000	0.0079	0.0032	0.0000	0.0329	
COMBINED (Vertical wells)	22 SEP 94	0.0000	0.0000	0.0000	0.0023	0.0000	0.0023	0.0012	0.0000	0.0058	
COMBINED (Vertical wells)	7 OCT 94	0.0021	0.0000	0.0000	0.0330	0.0000	0.0000	0.0042	0.0000	0.0392	
COMBINED (Trench) (3)	13 OCT 94	0.1099	0.0000	0.3520	0.0012	0.0000	0.0453	0.0266	0.0000	0.5350	
COMBINED (Trench)	27 OCT 94	0.0147	0.0000	0.0000	0.0234	0.0000	0.0020	0.0008	0.0000	0.0410	
COMBINED (Trench)	14 NOV 94	0.0112	0.0000	0.0040	0.0052	0.0000	0.0022	0.0008	0.0000	0.0232	
SVE-1 (Trench)	9 JAN 95	0.0321	0.0000	0.0000	0.0011	0.0000	0.0000	0.0001	0.0000	0.0333	
SVE-1 (Trench)	23 JAN 95	0.0000	0.0000	0.0000	0.0017	0.0000	0.0016	0.0000	0.0000	0.0034	
SVE-1 (Trench)	25 JAN 95	0.0000	0.0000	0.0029	0.0037	0.0000	0.0037	0.0009	0.0000	0.0113	

- (1) - Estimated data.
 (2) - For determining total emission rates, a concentration of zero was assumed for analytes which were non-detect.
 (3) - First sampling event after the horizontal vent trench was installed.

TABLE B.5-2

**CALCULATION OF VOC MASS FLOW RATE FOLLOWING GAC FILTRATION (1)
SITE SS59 - DOVER AFB, DELAWARE**

EMISSION RATE (ER) (lb/d) = $Q \cdot C \cdot MW \cdot 1.581 \cdot (1E-7)^{24}$ (modified from EPA, 1989)										
Q = extraction flow rate (CFM)										
C = extracted soil vapor concentration (ppm-v)										
MW = molecular weight of the compound (lb/lb-mole)										
(1.581) * (1E-7) * (24) = conversion factors										
OFFGAS DATA (2)	DATE	METHYLENE CHLORIDE (ppm)	TRANS -1,2 DCE (ppm)	CIS-1,2 DCE (ppm)	TCA (ppm)	CARBON TETRACHL. (ppm)	TCE (ppm)	PCE (ppm)	TOTAL VOLATILE HYDROCARBON (ppm)	TOTAL VOCs (ppm)
BETWEEN GAC	1 SEPT 94	<0.1	<0.1	<0.1	0.002	<0.001	0.004	<0.001	<5	0.006
BETWEEN GAC	22 SEPT 94	<0.1	<0.1	<0.1	0.004	<0.001	<0.001	<0.001	<5	0.004
BETWEEN GAC	25 JAN 95	<0.1	<0.1	<0.1	0.002	<0.001	<0.001	<0.001	<5	0.002
AFTER GAC	8 JULY 94	<0.3	<0.6	<1	0.334	<0.001	0.031	0.004	3.7	4.069
AFTER GAC	1 SEPT 94	<0.1	<0.1	<0.1	0.005	<0.001	<0.001	0.005	<5	0.010
AFTER GAC	14 NOV 94	0.29	<0.1	<0.1	0.004	<0.001	0.003	<0.001	<1	0.297
at Site WP-21, an extraction flow velocity of 3,000 ft/min was measured which converts to 64.9 CFM with the 2" diameter extraction pipe (see attached sheet for example calculation) (3000 ft/min * pi * (0.083 ft) ² = 64.9 CFM)										
MOLECULAR WEIGHT (lb/lb-mole)		METHYLENE CHLORIDE	TRANS -1,2 DCE	CIS-1,2 DCE	TCA	CARBON TETRACHL.	TCE	PCE	TOTAL VOLATILE HYDROCARBON (as toluene)	
		84.93	96.95	96.95	133.41	153.82	131.5	165.83	92.1	
EMISSION RATE	DATE	METHYLENE CHLORIDE (lb/d)	TRANS -1,2 DCE (lb/d)	CIS-1,2 DCE (lb/d)	TCA (lb/d)	CARBON TETRACHL. (lb/d)	TCE (lb/d)	PCE (lb/d)	TOTAL VOLATILE HYDROCARBON (lb/d)	TOTAL EMISSION RATE (lb/d)
BETWEEN GAC	1 SEPT 94	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0002
BETWEEN GAC	22 SEPT 94	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
BETWEEN GAC	25 JAN 95	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
AFTER GAC	8 JULY 94	0.0000	0.0000	0.0000	0.0110	0.0000	0.0010	0.0002	0.0839	0.0961
AFTER GAC	1 SEPT 94	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0002	0.0004	0.0004
AFTER GAC	14 NOV 94	0.0061	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0063

(1) - Only data from the sampling events which had detectable concentrations of VOCs are presented here.

(2) - For determining total emission rates, a concentration of zero was assumed for analytes which were non-detected.

Cleanup Timeframe Estimation for a Full-Scale AAS/SVE System Dover AFB - Site SS59

Project Number 60378.26

Calculated by: JDR 22 March 95

Checked by: TRH 23 March 95

The following assumptions and calculations were utilized to estimate the cleanup timeframe for ground water using a full-scale AAS/SVE system at Site SS59 (formerly part of Site WP-21). The estimates provided below consider the entire area of attainment and are based upon data collected during the extended pilot study (June 1994 to January 1995).

ASSUMPTIONS:

1. No active sources of VOCs are present within Site SS59.
2. No VOCs will enter Site SS59 from other sites during the estimated timeframe.
3. No natural attenuation of VOCs due to biodegradation, chemical transformation, or decay processes will occur during the estimated timeframe.
4. No residual LNAPLs and DNAPLs are present within the site.
5. Instantaneous equilibrium between the aqueous- and adsorbed-phase COCs occurs.

CALCULATION PROCEDURE:

1. Total VOC mass within the site - assumptions
 - a. The concentration of total VOCs is 8,014 ug/L (based upon the ground-water results following the extended pilot study). As a conservative measure, the maximum concentration data was used to estimate the total mass in the aqueous phase. A clean-up goal of a 90% reduction for the individual VOCs and the total of the seven ethylene-based VOCs of concern (1,1-DCA, 1,1-DCE, 1,2-DCA, 1,2-DCE, TCE, PCE, and VC), was established for Site SS59 (EA, 1994c). Removal of the entire estimated mass present was used for these calculations in order to provide a more conservative estimate of the time for remediation.
 - b. The area of attainment is 66,700 sq. ft. for Site SS59.
 - c. The average depth of the saturated zone is 34 ft at Site SS59.
 - d. A porosity of 30% was assumed.
 - e. Considering the majority of VOCs present at the site are TCA, PCE, DCE, and TCE, the average partition coefficient $K_d = 0.45$ was chosen (Michael et al., 1991)
 - f. The bulk density of the soil is equal to 1.66 gram/cm³ (based upon the sand/silty sands present in the aquifer).

ESTIMATED TOTAL VOC MASS (AQUEOUS PHASE)

$$\begin{aligned} &= (66,700 \text{ sf} \times 34 \text{ ft}) \times 2.832 \times (10\text{E}-2 \text{ m}^3/1.0 \text{ ft}^3) \times (1000 \text{ L} / 1 \text{ m}^3) \times (8,014 \text{ ug/L}) \\ &\quad \times 0.3 \\ &= 1.54\text{E}+11 \text{ (ug)} \\ &= 340 \text{ (lbs)} \end{aligned}$$

ESTIMATED TOTAL VOC MASS (ADSORBED PHASE)

$$\begin{aligned} &= (66,700 \text{ sf} \times 34 \text{ ft}) \times 2.832 \times (10\text{E}-2 \text{ m}^3/1.0 \text{ ft}^3) \times (10\text{E}+6 \text{ cm}^3/\text{m}^3) \times (1.66 \\ &\quad \text{gram}/\text{cm}^3) \times (1\text{kg}/10\text{E}+3 \text{ gram}) \times 0.45 \times (8,014 \text{ ug/L}) \\ &= 3.85\text{E}+11 \text{ (ug)} \\ &= 847 \text{ (lbs)} \end{aligned}$$

Therefore, the estimated total VOCs mass within Site SS59

$$\begin{aligned} &= \text{VOC mass (aqueous phase)} + \text{VOC mass (adsorbed phase)} \\ &= 340 \text{ (lbs)} + 847 \text{ (lbs)} \\ &= 1,187 \text{ (lbs)} \end{aligned}$$

2. VOC MASS REMOVAL RATE (LBS/DAY) FOR THE AAS/SVE SYSTEM

Based on the results from the extended pilot study, the average, time-weighted, VOC mass removal rate was 0.05 lb/day. This removal rate is utilized below to estimate the minimum time necessary to remediate Site SS59.

3. ESTIMATED TIME FOR THE REMEDIATION OF SITE SS59

Assume the full-scale system will use 11 SVE wells (based upon the area of attainment and the ROI of the AAS wells).

Removal of Entire VOC Mass Present

$$\begin{aligned} \text{Time (yr)} &= \text{Total VOC mass} / \text{Mass removal rate for the whole system} \\ &= 1,187 \text{ lbs} / (0.05 \text{ lb/well-day} \times 11 \text{ wells} \times 365 \text{ day/yr}) \\ &= \mathbf{5.9 \text{ years}} \end{aligned}$$

Removal of VOC Mass until 90% Clean-Up Goal is Attained

$$\begin{aligned} \text{Time (yr)} &= (1,187 \text{ lbs}) \times (0.9) / (0.05 \text{ lb/well-day} \times 11 \text{ wells} \times 365 \text{ days/year}) \\ &= \mathbf{5.3 \text{ years}} \end{aligned}$$

Project DOVER ARSIVEProject No. 6037826 0013Subject CONFIRMATION OF MASS REMOVAL RATESheet No. 1 of 1EQUATION (EPA 1991)Drawing No. 01-01-001Computed by JDRDate 8/4/94Checked by PACDate 8/4/94

example calculation of mass flow rate

$$\dot{m} = QC$$

$$\text{Flow velocity} = 3000 \text{ FT/MIN}$$

$$\text{well } 2" \phi \times \frac{\text{FT}}{12"} = 0.167 \text{ FT}$$

$$Q = VA = \left(\frac{3000 \text{ FT}}{\text{min}} \right) \left[\pi (0.083 \text{ FT})^2 \right]$$

$$\text{radius} = 0.083 \text{ FT}$$

$$Q = 64.9 \text{ CFM}$$

$$\text{USE TCE @ 14 JUNE 94} = 0.168 \text{ ppm (V/V)}$$

$$1 \text{ ppm} = 5.46 \text{ mg/m}^3 \quad (\text{Handbook of Env. Data of Org. Chem. 2nd ed})$$

$$(0.168 \text{ ppm}) \left(\frac{5.46 \text{ mg/m}^3}{\text{ppm}} \right) = 0.917 \text{ mg/m}^3$$

$$(0.917 \text{ mg/m}^3) \left(\frac{\text{m}^3}{35.3147 \text{ ft}^3} \right) = 0.0260 \text{ mg/ft}^3$$

$$(0.0260 \text{ mg/ft}^3) \left(\frac{1}{1000 \text{ mg}} \right) \left(\frac{1 \text{ lb}}{454 \text{ g}} \right) = 5.73 \times 10^{-8} \text{ lb/ft}^3$$

$$\dot{m} = (64.9 \text{ ft}^3/\text{min}) (5.73 \times 10^{-8} \text{ lb/ft}^3) = 3.72 \times 10^{-6} \text{ lb/min}$$

$$\times \frac{60 \text{ min}}{\text{hr}} \times \frac{24 \text{ hr}}{\text{day}}$$

$$= \boxed{0.0054 \text{ lb/d TCE}} = 0.0054 \text{ lb/d}$$

as calculated by
EPA equation

$$\text{1,1,1-trichloroethane} \quad 1 \text{ ppm} = 5.54 \text{ mg/m}^3$$

$$\text{tetrachloroethene} \quad 1 \text{ ppm} = 6.89 \text{ mg/m}^3$$

$$\dot{m} = Q C (MW) (501) (10^{-3}) (24)$$

(see previous page)



Project DOVER AFB - SITE SS59 Project No. 6037826 02
Subject AAS/SVE COST PER Sheet No. of
POUND OF VOCs REMOVED Drawing No.
Computed by JDR Date 6/7/95 Checked by JH Date 6/12/95

costs and total VOC mass taken from the FS* (Sept 1994)

<u>alternative</u>	<u>COST**</u>	<u>VOCs (lb)</u>	<u>COST/lb</u>
GW-3 (pump and treat/metals pretreatment/GAC adsorption/discharge under NPDES)	\$4,490,000	6298.6	\$713/lb
GW-4 (pump and treat/metals pretreatment/air stripping/GAC/NPDES)	\$4,680,000	6298.6	\$743/lb
IN-SITU ALT. NO. 1 (AAS/SVE)	\$3,340,000	6298.6	\$530/lb

** TOTAL PRESENT WORTH (11 year for AAS/SVE and 30 year for ground-water pump and treat)

$$\begin{array}{l} \text{GW-4 vs AAS/SVE} \\ \frac{\$743 - \$530}{\$743} \times 100\% = 28.7\% \end{array}$$

$$\begin{array}{l} \text{GW-3 vs AAS/SVE} \\ \frac{\$713 - \$530}{\$713} \times 100\% = 25.7\% \end{array}$$

The current AAS/SVE design presented in the Extended Pilot Study report has a total 11 year present worth of \$2,690,000 for a total VOC mass of 1,187 lb. However, for purposes of comparison, the original costs were used (since the total mass and area to be treated was reduced since the FS).



Project DOVER AFB - SITE 3359 Project No. 6037826 02
Subject GAC USAGE RATE Sheet No. 1 of 1
Drawing No. —
Computed by JDR Date 6/7/95 Checked by JH Date 6/12/95

assumptions

$Q = 65 \text{ scfm}$ $P = 70-80 \text{ "H}_2\text{O}$ $T = 125^\circ\text{F} - 150^\circ\text{F}$
 $\rightarrow$ (constant use)

relative humidity = 50%

maximum concentrations = $\text{TCE} = 1 \text{ ppmv}$
 $\text{PCE} = 1 \text{ ppmv}$
 $1,2\text{-DCE} = 17 \text{ ppmv}$
 $\text{TCA} = 1 \text{ ppmv}$

model #: Nixtox N-250 (400 lbs)

according to Tigg Environmental, Inc. (6/3/95)

@ 125°F usage = 10 lb/d
@ 150°F usage = 14 lb/d

our average concentrations are approximately $1/10^{\text{th}}$ * of the max. conc.

therefore usage is between 1.0 - 1.4 lb/d

or
365 - 511 lb/yr

* slightly conservative in order to account for VOCs which are not included on the COC analyte list.

Appendix C

Well Purging Records - May/June 1994



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE W21 Date: 31 MAR 94

Well No.: DMW-75-1P Well Diam. 2" Time: 1630

Weather: P-CLOUDY 75°

Well condition: Good, LOCKED Sounding Method: W.L.I.

Stickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.81 Purge Method: 2" SUBMERSIBLE PUMP

2. Depth to Liquid: _____ Purge rate: 2.5

3. Depth to Water: 8.92 Purge Time: _____

4. Liquid Column: 25.89

5. Liquid Volume: 11.54 Purge Volume: 46.16

Pump Dry? YES

Describe: AFTER 37 GAL, WAIT 30 MIN, PURGED 8 GAL, 45 GAL TOTAL

Samplers: TBS

Sample date: 4-31-94 Sample Time: 1730

Sample Type: TCL VOC Split? NO

With Whom? _____

Comments: D.O. = 2.4 TEMP = 20.15
PH = 5.32
COND 190



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WF-21 Date: 31 MAY 94

Well No.: SMW-75-1P Well Diam. 2 Time: 1630

Weather: P CLOUDY OVERCAST 75°

Well condition: Good, LOCKED Sounding Method: W.L.T.

Slickup/Flush? Flush Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 16.02 Purge Method: BAILER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 8.80 Purge Time: _____

4. Liquid Column: 7.22

5. Liquid Volume: 6.50 Purge Volume: 26

Pump Dry? NO

Describe: _____

Samplers: JBS

Sample date: 5-31-94 Sample Time: 1725

Sample Type: GC VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 0.2

pH = 4.7

COND = 500

T = 15



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE 21 Date: 31 MAY 94

Well No.: DMW-45-1P Well Diam. 2 Time: 1803

Weather: P. CLOUDY 75°

Well condition: Good, Locked Sounding Method: W. L. I.

Slickup/Flush? Flush Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 35.03 Purge Method: 2" pump

2. Depth to Liquid: _____ Purge rate: 2

3. Depth to Water: 9.46 Purge Time: 23 min

4. Liquid Column: 25.57

5. Liquid Volume: 11.49 Purge Volume: 46

Pump Dry? YES

Describe: AFTER 14 GALS, WAIT 30min, PURGED 13 GALS, 27 GALS TURN

Samplers: TBS

Sample date: 5-31-94 Sample Time: 1845

Sample Type: TCL VOC Split? NO

With Whom? _____

Comments: D.O. = 6.2 T = 15

pH = 5.72

COND = 130



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 31 MAR 94
Well No.: SMW-45-1P Well Diam. 2" Time: 1804
Weather: P-CLOUDY 75°
Well conditions: GOOD, LOCKED Sounding Method: W.L.I.
Slickup/Flush? FLUSH Reference: TOP OF CASING
Odor (if any): _____
1. Well Depth: 14.70 Purge Method: 2" DAILER
2. Depth to Liquid: _____ Purge rate: _____
3. Depth to Water: 8.81 Purge Time: _____
4. Liquid Column: 5.89
5. Liquid Volume: 5.3 Purge Volume: 21.2
Pump Dry? NO
Describe: _____
Samplers: TBJ
Sample date: 3-31-94 Sample Time: 1900
Sample Type: TCL VOC Split? NO

With Whom? _____
Comments: D.O. = 0.99 T = 16
pH = 4.99
COND = 1850



Field record of well gauging,
purging, and sampling

Location: DEVER AFB SITE WD-21 Date: 1 JUNE 94
Well No.: DMW-25-1P Well Diam. 2" Time: 0745
Weather: SUNNY 80°
Well condition: GOOD LOCKED Sounding Method: W.L.I.
Slickup/Flush? FLUSH Reference: TOP OF CASING
Odor (if any): _____
1. Well Depth: 35.54 Purge Method: 2" PUMP
2. Depth to Liquid: _____ Purge rate: 2 GPM
3. Depth to Water: 8.82 Purge Time: _____
4. Liquid Column: 26.72
5. Liquid Volume: 11.68 Purge Volume: 46.72
Pump Dry? NO
Describe: _____
Samplers: JBS
Sample date: 1 JUNE 94 Sample Time: 1035
Sample Type: TCL VOC Split? NO
_____ With Whom? _____
Comments: DO 5.10 T=15
pH = 5.52
COND = 230



Field record of well gauging,
purging, and sampling

Location: Revere AFB Site WA-21 Date: 1 JUNE 94

Well No.: SMW-25-1P Well Diam. 2" Time: 0745

Weather: SUNNY 80°

Well condition: Good, Locked Sounding Method: W.L.I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 15.94 Purge Method: 2" BAILER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 8.78 Purge Time: _____

4. Liquid Column: 7.16

5. Liquid Volume: 6.44 Purge Volume: 25.76

Pump Dry? NO

Describe: _____

Samplers: JBS

Sample date: 1 JUNE 94 Sample Time: 1040

Sample Type: TEL VOC Split? NO

0 With Whom? _____

Comments: P.O. = 0.20 T=15

pH = 5.15

COND = 1900



Field record of well gauging,
purging, and sampling

Location: DMW-10-1P

Date: 1 JUNE 94

Well No.: DMW-10-1P Well Diam. 2

Time: 1030 0910

Weather: SUNNY 80°

Well condition: GOOD, LOCKED

Sounding Method: W.L.I.

Slickup/Flush? FLUSH

Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.51

Purge Method: 2" PUMP

2. Depth to Liquid: _____

Purge rate: _____

3. Depth to Water: 8.76

Purge Time: _____

4. Liquid Column: 25.75

5. Liquid Volume: 11.52

Purge Volume: 46.08

Pump Dry? YES

Describe: AFTER 24 GALS WAIT 30 MIN. PURGED 12 GALS. 42 GALS TOTAL

Samplers: TBS

Sample date: 1 JUNE 94 Sample Time: 1030

Sample Type: TCL VOL Split? NO

With Whom? _____

Comments: B.O. = 4.55 T = 18

PH = 5.32

COND = 90



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 1 June 94

Well No.: SMW-10-1P Well Diam. 2" Time: 910

Weather: SUNNY 80°

Well condition: GOOD LOCKED Sounding Method: W.L.I.

Slickup/Flush? Flush Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 15.81 Purge Method: 2" BAILED

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 8.46 Purge Time: _____

4. Liquid Column: 7.35

5. Liquid Volume: 6.62 Purge Volume: 26.48

Pump Dry? NO

Describe: _____

Samplers: TBS

Sample date: 1 June 94 Sample Time: 1025

Sample Type: TEL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 0.30

SMW-10-1P pH = 5.05 T = 15

COND = 650



Field record of well gauging,
purging, and sampling

Location: DEVER AFB SITE W-21 Date: 1 June 94
Well No.: AAS-1 Well Diam. 4" Time: 1100
Weather: SUNNY 80°
Well condition: Good Locked Sounding Method: W.L.I.
Slickup/Flush? FLUSH Reference: TOP OF CASING
Odor (if any): _____
1. Well Depth: 39.00 Purge Method: 2" pump
2. Depth to Liquid: _____ Purge rate: 3 gpm
3. Depth to Water: 8.38 Purge Time: _____
4. Liquid Column: 30.62
5. Liquid Volume: 19.90 Purge Volume: 79.6
Pump Dry? NO
Describe: _____
Samplers: TBS
Sample date: 1 June 94 Sample Time: 1130
Sample Type: TCL VOC Split? NO

With Whom? _____
Comments: _____
D.O. = 9.45 COND = 150
pH = 5.83 T = 15



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE W-21 Date: 1 June 94

Well No.: PMW-75-1 Well Diam. 2" Time: 1130

Weather: SUNNY 80°

Well condition: GOOD LOCKED Sounding Method: W.L.T.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.60 Purge Method: 2" pump

2. Depth to Liquid: _____ Purge rate: 3 gpm

3. Depth to Water: 9.84 Purge Time: 22

4. Liquid Column: 24.76

5. Liquid Volume: 22.3 Purge Volume: 67

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 June 94 Sample Time: 1250

Sample Type: TCL VOC Split? NO

RO = 0.5 With Whom? _____

Comments: LUNA = 120

pH = 6.15

T = 15



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 1 JUNE 94

Well No.: SMW-75-1 Well Diam. 2" Time: 1130

Weather: SUNNY 80°

Well condition: Good, LOCKED Sounding Method: W.L.I.

Slickup/Flush? Flush Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 17.48 Purge Method: 2" BAKER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 9.98 Purge Time: _____

4. Liquid Column: 7.5

5. Liquid Volume: 6.75 Purge Volume: 20.2

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUNE 94 Sample Time: 1240

Sample Type: TCL VOC. Split? NO

_____ With Whom? _____

Comments: D.O. = 0.3 T=15

pH = 5.25

COND = 410



Field record of well gauging,
purging, and sampling

Location: DOVER AER SITE WP-21 Date: 1 JUN 94

Well No.: DMW-45-1 Well Diam. 2" Time: 0930

Weather: SUNNY 80°

Well condition: Good, Locked Sounding Method: W.L.I.

Slickup/Flush? Flush Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.6 Purge Method: 2" purg

2. Depth to Liquid: _____ Purge rate: 3 gpm

3. Depth to Water: 9.23 Purge Time: 22 min

4. Liquid Column: 25.77

5. Liquid Volume: 22.8 Purge Volume: 68

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUNE 94 Sample Time: 1205

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 0.3 T = 15

pH = 5.50

COND = 275



Field record of well gauging,
purging, and sampling

Location: OVER AFB SITE WP-21 Date: 1 JUN 74

Well No.: SMW-45-1 Well Diam. 2" Time: 0930

Weather: SUNNY 80°

Well condition: _____ Sounding Method: W. L. I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 15.88 Purge Method: 2" BAILER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 9.09 Purge Time: _____

4. Liquid Column: 6.79

5. Liquid Volume: 6.111 Purge Volume: 18.3

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUN 74 Sample Time: 1205

Sample Type: TCL VOL. Split? _____

_____ With Whom? _____

Comments: D.O. = 0.45 T = 15

pH = 5.32

COND = 200



Field record of well gauging,
purging, and sampling

Location: DWEN AFB SITE WP-21 Date: 1 JUNE 94

Well No.: RAW-25-1 Well Diam. 2" Time: 1015

Weather: SUNNY 80°

Well condition: GOOD, LOCKED Sounding Method: W.L.T.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.81 Purge Method: 2" PUMP

2. Depth to Liquid: _____ Purge rate: 4 gpm

3. Depth to Water: 8.94 Purge Time: 18 min

4. Liquid Column: 25.87

5. Liquid Volume: 23.3 Purge Volume: 70.00

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUNE 94 Sample Time: 1150

Sample Type: TEL VOC Split? NO

_____ With Whom? _____

Comments: DO = 0.4 T = 18

PH = 5.8

COND = 170



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 1 JUL 94

Well No.: SMW-25-1 Well Diam. 2" Time: 1025

Weather: SUNNY 80°

Well condition: GOOD LOCKED Sounding Method: W. L. I

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 17.14 Purge Method: 2" BAILED

2. Depth to Liquid: 8.95 Purge rate: _____

3. Depth to Water: 8.95 Purge Time: _____

4. Liquid Column: 8.2

5. Liquid Volume: 7.37 Purge Volume: 22.1

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUNE 94 Sample Time: 1145

Sample Type: TEL VOC Split? NO

With Whom? _____

Comments: P.O. = 0.3 T=13

pH = 5.32

COND = 500



Field record of well gauging,
purging, and sampling

Location: DEVER AFB SITE WP-21 Date: 1 June 74

Well No.: DMW-10-1 Well Diam. 2" Time: 0945

Weather: SUNNY 80°

Well condition: Good, Locked Sounding Method: W.L.T.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 31.51 Purge Method: 2" pump

2. Depth to Liquid: _____ Purge rate: 3 gpm

3. Depth to Water: 8.79 Purge Time: 21 min

4. Liquid Column: 22.72

5. Liquid Volume: 20.5 Purge Volume: 62 GAL

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 June 74 Sample Time: 1130

Sample Type: TOL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 0.85 T = 15

pH = 8.1

COND = 320



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 1 JUNE 94
Well No.: SMW-10-1 Well Diam. 2" Time: 0940
Weather: SUNNY 80°
Well condition: GOOD, LOCKED Sounding Method: W.L.F.
Stickup/Flush? FLUSH Reference: _____
Odor (if any): _____
1. Well Depth: 15.61 Purge Method: 2" BAILER
2. Depth to Liquid: _____ Purge rate: _____
3. Depth to Water: 8.96 Purge Time: _____
4. Liquid Column: 6.65
5. Liquid Volume: 5.99 Purge Volume: 18
Pump Dry? NO
Describe: _____
Samplers: MB
Sample date: 1 JUNE 94 Sample Time: 1115
Sample Type: TCL VOC. Split? NO
With Whom? _____
Comments: D.O. = 0-30 T=15
pH = 4.80
COND = 510



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 31 MAY 94

Well No.: DMW-75-3P Well Diam. 2" Time: 0800

Weather: SUNNY 85°

Well condition: GOOD, LOCKED Sounding Method: W.L.I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.61 Purge Method: 2" pump

2. Depth to Liquid: _____ Purge rate: 4 gpm

3. Depth to Water: 9.51 Purge Time: 17 MIN

4. Liquid Column: 25.1

5. Liquid Volume: 22.6 Purge Volume: 68

Pump Dry? NO

Describe: _____

Samplers: SHD

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TCL VOL Split? _____

_____ With Whom? _____

Comments: DO = 1.8 T = 15

pH = 5.2

COND = 210



Field record of well gauging,
purging, and sampling

Location: DELMAR AFB SITE WP-21 Date: 31 MAY 94

Well No.: SMW-75-27 Well Diam. 2" Time: 0830

Weather: SUNNY 85°

Well condition: Good, LOCKED Sounding Method: W.L.T

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 16.82 Purge Method: 2" BAILER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 9.51 Purge Time: _____

4. Liquid Column: 7.31

5. Liquid Volume: 6.58 Purge Volume: 20

Pump Dry? NO

Describe: _____

Samplers: SHD

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TEL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 1.7 T = p5

PH = 5.60

WIND 350



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WD-21 Date: 31 MAY 94

Well No.: DMW-45-20 Well Diam. 2" Time: 1430

Weather: SUNNY 85°

Well condition: Good LOCKED Sounding Method: W.C.I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 35.20 Purge Method: 2" pump

2. Depth to Liquid: _____ Purge rate: 4 gpm

3. Depth to Water: 9.09 Purge Time: 18 min

4. Liquid Column: 26.11

5. Liquid Volume: 23.5 Purge Volume: 71

Pump Dry? NO

Describe: _____

Samplers: SHD

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: DO = 1.8 T = 15

pH = 6.45

COND = 215



Field record of well gauging,
purging, and sampling

Location: DEVER AFB SITE W-21 Date: 31 MAY 94

Well No.: SMW-45-2P Well Diam. 2" Time: 0940

Weather: SUNNY 85°

Well condition: Good, LOCKED Sounding Method: W.L.I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: _____ Purge Method: _____

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: WELL IS DRY Purge Time: _____

4. Liquid Column: _____

5. Liquid Volume: _____ Purge Volume: _____

Pump Dry? _____

Describe: _____

Samplers: _____

Sample date: _____ Sample Time: _____

Sample Type: _____ Split? _____

_____ With Whom? _____

Comments: _____



Field record of well gauging,
purging, and sampling

Location: DEVER AFB. SITE WP-21 Date: 31 MAY 94

Well No.: DMW-34-2P Well Diam. 2" Time: 1100

Weather: SUNNY 85°

Well condition: Good Locked Sounding Method: W.L.I.

Stickup/Flush? Flush Reference: top of casing

Odor (if any): _____

1. Well Depth: 35.39 Purge Method: 2" pump

2. Depth to Liquid: _____ Purge rate: 4 gpm

3. Depth to Water: 9.46 Purge Time: 18 min

4. Liquid Column: 25.93

5. Liquid Volume: 23.34 Purge Volume: 70

Pump Dry? NO

Describe: _____

Samplers: SHD

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TOL VOL Split? _____

_____ With Whom? _____

Comments: Q.O. = 0.5 t = 15

pH = 6.21

COND = 180



Field record of well gauging,
purging, and sampling

Location: NOVER AFB SITE WP-21 Date: 31 MAY 94

Well No.: SMW-34-2P Well Diam. 2" Time: 1105

Weather: SUNNY 85°

Well condition: GOOD, LOCKED Sounding Method: W.L.T.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 16.56 Purge Method: 2" BAILEY

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 9.57 Purge Time: _____

4. Liquid Column: 6.99

5. Liquid Volume: 6.29 Purge Volume: 19

Pump Dry? NO

Describe: _____

Samplers: SH-7

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: P.O. = 0.6 7-15

pH = 6.51

COND = 195



Field record of well gauging,
purging, and sampling

Location: DAVIES AFB SITE WP-21 Date: 31 MAY 94
Well No.: DMW-10-2P Well Diam. 2" Time: 1300
Weather: SUNNY 85°
Well condition: Good, LOCKED Sounding Method: W.L.I.
Slickup/Flush? Flush Reference: TOP OF CASING
Odor (if any): _____
1. Well Depth: 33.64 Purge Method: 2" pump
2. Depth to Liquid: _____ Purge rate: 3 GPM
3. Depth to Water: 10.5 Purge Time: 21 min
4. Liquid Column: 23.14
5. Liquid Volume: 20.8 Purge Volume: 63
Pump Dry? NO
Describe: _____
Samplers: SHD
Sample date: 31 MAY 94 Sample Time: _____
Sample Type: TCL VOC Split? NO
_____ With Whom? _____
Comments: D.O. = 4.1 T=15
pH = 8.1
COND = 350



Field record of well gauging,
purging, and sampling

Location: POWER AFB SITE WP-21 Date: 31 MAY 94

Well No.: SMW-10-2P Well Diam. 2" Time: 1305

Weather: SUNNY 85°

Well condition: Good Locked Sounding Method: W.C.I.

Slickup/Flush? Flush Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 17.08 Purge Method: 2" BAILER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 9.0 Purge Time: _____

4. Liquid Column: 8.08

5. Liquid Volume: 7.3 Purge Volume: 22.0

Pump Dry? NO

Describe: _____

Samplers: SPD

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: NO = 0.3 T = 15

PIT = 6.90

COND = 200



Field record of well gauging,
purging, and sampling

Location: DEVER AFB CITE WP-21 Date: 1 JUNE 94

Well No.: AAS-2 Well Diam. 4" Time: 1130

Weather: SUNNY 85°

Well condition: GOOD, LOCKED Sounding Method: W.L.T.

Slickup/Flush? FLUSH Reference: TOP OF CASE

Odor (if any): _____

1. Well Depth: 39.90 Purge Method: 2" PUMP

2. Depth to Liquid: _____ Purge rate: 5 gpm

3. Depth to Water: 9.85 Purge Time: 30 min

4. Liquid Column: 30.05

5. Liquid Volume: 50 Purge Volume: 150

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUNE 94 Sample Time: 1215

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 2.8 T = 15

pH = 5.50

COND = 50



Field record of well gauging,
purging, and sampling

Location: DAVER A.F.B. SITE WP-21 Date: 31 MAY 94

Well No.: QMW-10-2 Well Diam. 2" Time: 1415

Weather: SUNNY 85°

Well condition: GOOD, LOCKED Sounding Method: W.L.F.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 36.15

Purge Method: 2" PUMP

2. Depth to Liquid: _____

Purge rate: 3 gpm

3. Depth to Water: 10.11

Purge Time: 24 MIN

4. Liquid Column: 26.04

5. Liquid Volume: 23.4

Purge Volume: 71

Pump Dry? NO

Describe: _____

Samplers: SHD

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 2.4 T = 15

pH = 7.05

COND = 50



Field record of well gauging,
purging, and sampling

Location: ROVER AFB SITE WP-21 Date: 31 MAY 94

Well No.: SMW-10-2 Well Diam. 2" Time: 1430

Weather: SUNNY 85°

Well condition: Good, LOCKED Sounding Method: W.I.T.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 16.36 Purge Method: 2" BAILER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 10.21 Purge Time: _____

4. Liquid Column: 6.15

5. Liquid Volume: 5.5 Purge Volume: 17

Pump Dry? NO

Describe: _____

Samplers: SND

Sample date: 31 MAY 94 Sample Time: _____

Sample Type: TEL VOL Split? _____

D.O. = 0.4 With Whom? _____

Comments: pH = 7.25

LWD = 175

T = 15



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 1 JUNE 94

Well No.: DMW-20-2 Well Diam. 2" Time: 0730

Weather: SUNNY EC

Well condition: Good, LOCKED Sounding Method: W.L.I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.89 Purge Method: 2" Pump

2. Depth to Liquid: _____ Purge rate: 3 gpm

3. Depth to Water: 7.59 Purge Time: 23

4. Liquid Column: 25.3

5. Liquid Volume: 22.8 Purge Volume: 69

Pump Dry? NO

Describe: _____

Samplers: SHD

Sample date: 1 June 94 Sample Time: 14.00

Sample Type: TEL VOC Split? NO

_____ With Whom? _____

Comments: pH = 5.60 T = 15

cond = 150



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE W-21 Date: 1 JUNE 94
Well No.: SMW-20-2 Well Diam. 2" Time: 0900
Weather: SUNNY 80°
Well condition: GOOD, LOCKED Sounding Method: W.L.I.
Slickup/Flush? FLUSH Reference: TOP OF CASING
Odor (if any): _____

1. Well Depth: 16.10 Purge Method: 2" BAILER
2. Depth to Liquid: _____ Purge rate: _____
3. Depth to Water: 9.66 Purge Time: _____
4. Liquid Column: 6.44
5. Liquid Volume: 5.8 Purge Volume: 17.4
Pump Dry? NO
Describe: _____
Samplers: MB
Sample date: 1 JUNE 94 Sample Time: 1350
Sample Type: TCL VOC Split? NO

With Whom? _____
Comments: D.O. = 0.3 T = 15
pH = 5.60
CO₂ = 115



Field record of well gauging,
purging, and sampling

Location: DAVEN AFB SITE Wp-21 Date: 1 JUNE 94

Well No.: DMW-45-2 Well Diam. 2" Time: 1000

Weather: SUNNY 80°

Well condition: GOOD, LOCKED Sounding Method: W.L.I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 34.47

Purge Method: 2" pump

2. Depth to Liquid: _____

Purge rate: 3 gpm

3. Depth to Water: 10.68

Purge Time: 22 min

4. Liquid Column: 23.79

5. Liquid Volume: 21.4

Purge Volume: 65

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUNE 94 Sample Time: 13.35

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 0.3 T = 15

pH = 5.90

CND = 410



Field record of well gauging,
purging, and sampling

Location: DUVER AFB SITE VP-21 Date: 1 JUNE 94

Well No.: SNW-45-2 Well Diam. 2" Time: 1015

Weather: SUNNY 80°

Well condition: Good, Locked Sounding Method: W.L.I.

Slickup/Flush? FLUSH Reference: TOP OF CASING

Odor (if any): _____

1. Well Depth: 16.10 Purge Method: 2" BAILER

2. Depth to Liquid: _____ Purge rate: _____

3. Depth to Water: 9.66 Purge Time: _____

4. Liquid Column: 6.44

5. Liquid Volume: 5.8 Purge Volume: 18 GAL

Pump Dry? NO

Describe: _____

Samplers: MB

Sample date: 1 JUNE 94 Sample Time: 1325

Sample Type: TCL VOC Split? NO

With Whom? _____

Comments: D.O. = 0.3 T=15

pH = 5.20

COND = 160



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 1 JUN 94
Well No.: DMW-75-2 Well Diam. 2" Time: 1200
Weather: SUNNY 85°
Well condition: GOOD LOCKED Sounding Method: W.L.T.
Slickup/Flush? FLUSH Reference: TOP OF CASING
Odor (if any): _____
1. Well Depth: 34.11 Purge Method: 2" PURGE
2. Depth to Liquid: _____ Purge rate: 3-6 gpm
3. Depth to Water: 9.02 Purge Time: 25 min
4. Liquid Column: 25.09
5. Liquid Volume: 22.6 Purge Volume: 68
Pump Dry? NO
Describe: _____
Samplers: MB
Sample date: 1 JUN 94 Sample Time: 1310
Sample Type: TCL VOC Split? NO

With Whom? _____
Comments: D.O. = 0.9 r = 16
pH = 5.90
COND = 200



Field record of well gauging,
purging, and sampling

Location: DOVER AFB SITE WP-21 Date: 1 June 94

Well No.: SMW-75-2 Well Diam. 2" Time: 1210

Weather: Sunny 85°

Well condition: Good, Locked Sounding Method: W.L.I.

Slickup/Flush? Flush Reference: Top of casing

Odor (if any): _____

1. Well Depth: 1205 Purge Method: 2" BAILEY

2. Depth to Liquid: _____ Purge rate: —

3. Depth to Water: 8.99 Purge Time: —

4. Liquid Column: 8.06

5. Liquid Volume: 7.3 Purge Volume: 22

Pump Dry? NO

Describe: _____

Samplers: SHD

Sample date: 1 June 94 Sample Time: 1305

Sample Type: TCL VOC Split? NO

_____ With Whom? _____

Comments: D.O. = 0.35 T=13

pH = 5.81

COND = 175

Appendix D

Well Purging Records - October 1994

WELL INFORMATION

Well No.: 5mw102P

Date: 11/10/94

Gauger: JLW

Time: 1130

Well Diameter: 2"

Sounding Method: W.L.I

Stickup or (Flush)

Measurement Ref.: *T.O.C*

GAUGING AND PURGING

Well Depth: 17.20

Purge Method: HAND BAIL

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 11.80

Purge Time: _____

Liquid Column: 5.46

Purge Volume: 2.5

Liquid Volume: 0.86

Pump Dry? Describe: No

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pos/VPCB	Metals Total/Dissolved	Others

[illegible]

Date: 11/OCT/94

Time: 1135

Sounding Method: W-L, I

Measurement Ref.: T.O.C

GAUGING AND PURGING

Purge Method: 2" KEDI-Flow

Purge Rate: 1 GPM

Purge Time: 11 mins

Purge Volume: 10.4

Pump Dry? Describe: No

SAMPLING INFORMATION

Date: _____

Time: _____

With Whom?

Type of Sampling Equipment:

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pesl/PCB	Metals Total/Dissolved	Others

[illegible]

WELL GAUGING, PURGING AND SAMPLING SHEET

WELL INFORMATION

Well No.: Smw 34 2P

Date: 11/0ct/94.

Gauger: JLW

Time: 1115

Well Diameter: 2"

Sounding Method: *W-I-I*

Stickup or Flusly

Measurement Ref.: T.O.C

GAUGING AND PURGING

Well Depth: 16.75

Purge Method: HAND BAIL

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 11.41

Purge Time: _____

Liquid Column: 5.34

Purge Volume: 3.8

Liquid Volume: 0.85

Pump Dry? Describe: no

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: Dmw34 2P

Date: 11/OCT/94

Gauger: JLW

Time: 1110

Well Diameter: 2"

Sounding Method: W.L.I

Stickup or Flush

Measurement Ref.: T.O.C

GAUGING AND PURGING

Well Depth: 35.60

Purge Method: 2" REDI-Flow

Depth to Liquid: _____

Purge Rate: 1.5 ppm

Depth to Water: 11.32

Purge Time: 12 min's

Liquid Column: 24.28

Purge Volume: 11.6

Liquid Volume: 3.8

Pump Dry? Describe:

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split?

With Whom? _____.

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pest/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: 2MW452P

Date: 11/0CT/94

Gauger: JLW

Time: 1035

Well Diameter: 2"

Sounding Method: W.L.I

Stickup or (Flush)

Measurement Ref.: T.O.C

GAUGING AND PURGING

Well Depth: 35-30

Purge Method: 2" REDI-Flow

Depth to Liquid: _____

Purge Rate: 1 GPM

Depth to Water: 11.27

Purge Time: 12 min's

Liquid Column: 24.03

Purge Volume: 11.5

Liquid Volume: 3.8

Pump Dry? Describe: No

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pest/PCB	Metals Total/Dissolved	Others

[illegible]

Date: 11/OCT/94

Gauger: JLW

Time: 1015

Well Diameter: 2"

Sounding Method: W.L.I

Stickup or Flush

Measurement Ref.: *T.O.C*

GAUGING AND PURGING

Well Depth: 16.70

Purge Method: HAND BAIL

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 11.35

Purge Time: _____

Liquid Column: 5.35

Purge Volume: 2.5

Liquid Volume: 0.8

Pump Dry? Describe: NO

SAMPLING INFORMATION

Sampler: _____ Date: _____ Time: _____

Split? _____ With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: Dmw752P

Date: 11/OCT/94

Gauger: JLW

Time: 0958

Well Diameter: 2"

Sounding Method: *W. L. I*

Slickup or Flush

Measurement Ref.: *T.O.C.*

GAUGING AND PURGING

Well Depth: 34.60

Purge Method: 2 REDI FLOW

Depth to Liquid: _____

Purge Rate: 1.0 gpm

Depth to Water: 11.27

Purge Time: 12 min's

Liquid Column: 23.33

Purge Volume: 11.1

Liquid Volume: 3.7

Pump Dry? Describe: No

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom?

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Date: 11/0CT/94

Time: 1220

Sounding Method: W.L.I

Measurement Ref.: T.O.C.

Purge Method: HAND BAIL

Purge Rate: _____

Purge Time: _____

Purge Volume: 2.1

•

Pump Dry? Describe: NO

Date: _____ Time: _____

With Whom? _____

Type of Sampling Equipment:

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: DMW10-2

Date: 11/OCT/94

Gauger: JLW

Time: 1215

Well Diameter: 2"

Sounding Method: W.L.I

Stickup or (Flush)

Measurement Ref.: T.O.C.

GAUGING AND PURGING

Well Depth: 36.0

Purge Method: 2" REDI-Flow

Depth to Liquid: _____

Purge Rate: 1 GPM

Depth to Water: 12.02

Purge Time: 12 mins

Liquid Column: 23.98

Purge Volume: 11.5

Liquid Volume: 3.8

Pump Dry? Describe: No

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	THH	TCL VOA	TCL SVOCs	TCL Pest/PCB	Metals Total/Dissolved	Others

[illegible]

Date: 11 OCT 194

Time: 1330

Sounding Method: W.L.I

Measurement Ref.: T.O.C-

GAUGING AND PURGING

Purge Method: HAND BAIL

Purge Rate:

Purge Time:

Purge Volume: 2.2

:

Pump Dry? Describe: NO

SAMPLING INFORMATION

Date: _____

Time:_____

With Whom?

Type of Sampling Equipment: .

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: DMW 202

Date: 11/OCT/94

Gauger: JLW

Time: 1310

Well Diameter: 2"

Sounding Method: WLI

Stickup or / Flush

Measurement Ref.: T.O.C.

GAUGING AND PURGING

Well Depth: 35-10

Purge Method: 2nd Redi^o-Flow

Depth to Liquid: _____

Purge Rate: 1 gpm

Depth to Water: 11.60

Purge Time: 12 min's

Liquid Column: 23.5

Purge Volume: 11.2

Liquid Volume: 3.7

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

Date: 11/OCT/94

Time: 1345

Sounding Method: W.L.I

Measurement Ref.: T.O.C.

Purge Method: HAND BAIL

Purge Rate:

Purge Time:

Purge Volume: 2.0

Pump Dry? Describe: No

Date: _____

With Whom?

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: Dmw45-2

Date: 11/OCT/94

Gauger: JW

Time: 1340

Well Diameter: 2"

Sounding Method: W. I. I

Stickup of Flush

Measurement Ref.: T.O.C.

GAUGING AND PURGING

Well Depth: 34.20

Purge Method: 2" Redi Flow

Depth to Liquid: _____

Purge Rate: 1 gpm

Depth to Water: 11.28

Purge Time: 11 mins

Liquid Column: 22.92

Purge Volume: 11.0

Liquid Volume: 3.6 .

Pump Dry? Describe: No

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pest/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: 5mw 75.2

Date: 11/OCT/94

Gauger: JLW

Time: 1430

Well Diameter: 211

Sounding Method: W.L.I

Stickup or Flush

Measurement Ref.: T.O.C.

GAUGING AND PURGING

Well Depth: 16.50

Purge Method: HAND BAIL

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 10.92

Purge Time: _____

Liquid Column: 5.58

Purge Volume: 2.6

Liquid Volume: 0.89 x 3

Pump Dry? Describe: No

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split?

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

Measurement Ref.: T.O.C.

Pump Dry? Describe: NO

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: RAS-I

Date: 12/0CT/94

Gauger: JLW.

Time: 0900

Well Diameter: 4 1/2

Sounding Method: W.L.I

Stickup or Flush

Measurement Ref.: T.O.C.

GAUGING AND PURGING

Well Depth: 39.00

Purge Method: 2" Redi-Flow

Depth to Liquid: _____

Purge Rate: 4 GPM

Depth to Water: 10.35

Purge Time: 15 min's

Liquid Column: 28.65

Purge Volume: 55.0

Liquid Volume: 18.6

Pump Dry? Describe: ALO

SAMPLING INFORMATION

Sampler: _____

Date:_____

Time:

Split? _____

With Whom?

Type of Sampling Equipment:

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: SNW 10-1

Date: 10/11/94

Gauger: WJP

Time: 12:30

Well Diameter: 2'

Sounding Method: WLI

Slickup or Flush

Measurement Ref.: 100

GAUGING AND PURGING

Well Depth: 15.60

Purge Method: HAND BAIL

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 10.72

Purge Time: _____

Liquid Column: 4.28

Purge Volume: 234

Liquid Volume: 78

Pump Dry? ☒ Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PPCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Date: 12/11/54

Time: 1.2 hrs

Sounding Method: W&T

Measurement Ref.: 700

Purgo Method: 2 Redi Flow

Purge Rate:

Purge Time:

Purge Volume: 10-cj

Pump Dry? Describe:_____

Date: _____

Time: _____

With Whom?

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PPCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: SMW 25-1

Date: 10/11/94

Gauger: WJP

Time: 1340

Well Diameter: 2"

Sounding Method: WLT

Stickup or Flush

Measurement Ref.: *Toc*

GAUGING AND PURGING

Well Depth: 11-60

Purge Method: HAND BAIL

Depth to Liquid: _____

Purge Rate:

Depth to Water: 10.80

Purge Time:

Liquid Column: 6.3

Purge Volume: 3

Liquid Volume: 1

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____

Time: _____

Split? _____

With Whom?

Type of Sampling Equipment:

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: Dm w 25-1

Date: 10/11/94

Gauger: WNP

Time: 1340

Well Diameter: 2"

Sounding Method: WLI

Stickup or Flush

Measurement Ref.: *Toc*

GAUGING AND PURGING

Well Depth: 34.8

Purge Method: _____

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 10.98

Purge Time: _____

Liquid Column: 24.02

Purge Volume: 11.5

Liquid Volume: 3.8

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: SMW 45-1

Date: 10/11/94

Gauger: WRF

Time: 1415

Well Diameter: 2"

Sounding Method: WLI

Stickup or Flush

Measurement Ref.: 70c

GAUGING AND PURGING

Well Depth: 15.92

Purge Method: Baker

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 16: 95

Purge Time: _____

Liquid Column: 4.91

Purge Volume: 2-4

Liquid Volume: 19

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____ Date: _____ Time: _____

Split? _____ With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: OMW45-1

Date: 10/11/94

Gauger: WJP

Time: 1415

Well : Diarneler: 2"

Sounding Method: WLT

Stickup or Flush

Measurement Ref.: *Toe*

GAUGING AND PURGING

Well Depth: 39.55

Purgo Method: _____

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 11.01

Purge Time: _____

Liquid Column: 23.54

Purge Volume: 11.3

Liquid Volume: 3.7

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom?

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pest/PCB	Metals Total/Dissolved	Others

[illegible]

Date: 11/OCT/94

Gauger: W. R. P.

Time: _____

Well Diameter: 2"

Sounding Method: W.L.I

Stickup or Flush

Measurement Ref.: J.O.C.

GAUGING AND PURGING

Well Depth: 17.46

Purge Method: HAND BAIL

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 11.84

Purge Time: _____

Liquid Column: 5.62

Purge Volume: 2.7

Liquid Volume: 0.90

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

Measurement Ref.: T.O.C

Pump Dry? Describe: _____

Sample	Analyte	THP1	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

ALL SUBJECTS, FEMALE AND MALE AND STUDENT

Date: 10/11/94

Time: 1205

Sounding Method: ULF

Measurement Ref.: TOL

GAUGING AND PURGING

Purge Method: Boiler

Purge Rate: _____

Purge Time: _____

Purge Volume: 26

•

Pump Dry? Describe: ND

SAMPLING INFORMATION

Date:_____

Time: _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PPCB	Metals Total/Dissolved	Others

[illegible]

Date: 10/11/94

Time: 1.205

Sounding Method: WLI

Measurement Ref.: Toe

Well Depth: 3456

Purge Method: 2-REV1 FLOW

Depth to Liquid: _____

Purge Rate:

Depth to Water: 10-60

Purge Time:

Liquid Column: 21.96

Purge Volume: 11.5

Liquid Volume: 3.8

Pump Dry? ~~Yes~~ Describe: Yes - Dry AT ABOUT 7 GAL / STUCK FOR 3 MIN AND R...

Not slower rate

Sampler: _____

Date: _____

Time:

Split? _____

With Whom?

Type of Sampling Equipment: .

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL GAUGING, PURGING AND SAMPLING SHEET

WELL INFORMATION

Well No.: SMW25-1P

Date: 10/18/94

Gauger: WNP

Time: 1125

Well Diameter: 2"

Sounding Method: ULI

Stickup or Flush

Measurement Ref.: Toc

GAUGING AND PURGING

Well Depth: 15.9

Purge Method: UMP

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 10.7

Purge Time: _____

Liquid Column: 5.2

Purge Volume: 2.5

Liquid Volume: 83

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split?

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PPCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: DMU25-1P

Date: 10/11/94

Gauger: WPD

Time: 1125

Well Diameter: 2"

Sounding Method: WLI

Stickup or Flush

Measurement Ref.: TOC

GAUGING AND PURGING

Well Depth: 37-5

Purge Method: _____

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 10.74

Purge Time: _____

Liquid Column: 26.76

Purge Volume: 12.8

Liquid Volume: 4.28

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: SNW 45-1P

Date: 10/11/94

Gauger: lms

Time: 1055

Well Diameter: 7"

Sounding Method: WLI

Slickup or Flush

Measurement Ref.: Tac

GAUGING AND PURGING

Well Depth: 14.50

Purge Method: Br. Gr

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 10.72

Purge Time: _____

Liquid Column: 4.68

Purge Volume: 20.26

Liquid Volume: 65

Pump Dry? Describe: no

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCs	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

Date: 10/11/94

Time: 1055

Sounding Method: WLF

Measurement Ref.: 7dc

Purge Method: 2nd Pump

Purge Rate: _____

Purge Time: _____

Purge Volume: 11.3

•

Pump Dry? Describe: *MS*

Date: _____ Time: _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

WELL INFORMATION

Well No.: SMW-75-1P

Date: 10/11/91

Gauger: W.P.

Time: 1015

Well Diameter: 8"

Sounding Method: WLI

Stickup or Flush

Measurement Ref.: 70c

GAUGING AND PURGING

Well Depth: 160

Purge Method: Ozoker

Depth to Liquid: _____

Purge Rate: _____

Depth to Water: 10.70

Purge Time: _____

Liquid Column: 5-A

Purge Volume: 2.5 Gpc / 4 gpc

Liquid Volume: 85

Pump Dry? Describe: _____

SAMPLING INFORMATION

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom? _____

Type of Sampling Equipment: _____

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

Date: 10/11/94

Time: 10:00

Sounding Method: WIT

Measurement Ref.: 100

Well Depth: 34.7

Purgo Method: Pump

Depth to Liquid: 10.75

Purge Rate:

Depth to Water: 10.75

Purge Time:

Liquid Column: 23.95

Purge Volume: 12 Gals

Liquid Volume: 3.832 g

Pump Dry? Describe: Dry for about 1 min. Residual Pumping H₂O lower

Flow RATE

Sampler: _____

Date: _____ Time: _____

Split? _____

With Whom?

Type of Sampling Equipment: .

Sample	Analyte	TPH	TCL VOA	TCL SVOCS	TCL Pes/PCB	Metals Total/Dissolved	Others

[illegible]

Appendix E

Well Purging Records - January 1995

FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover A.F.B.

Well No: SMW-75-1P Gauge Date: 24/JAN/95 Time: 1605

Weather: Cloudy 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 16.04 Purge Date: _____ Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: HAND-BAIL

(3) Depth to Water (ft): 11.61 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 4.43 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 3.9 Purge Volume (gal): 11.9

Did Well Pump Dry? Describe: No

Samplers: JLW

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 260
TEMP - 11.8°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-25-1P Gauge Date: 24/JAN/95 Time: 1050

Weather: Sunny 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 35.65 Purge Date: 24/JAN/95 Time: 1100

(2) Depth to Liquid (ft): _____ Purge Method: 2" REDI-Flow

(3) Depth to Water (ft): 11.67 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 23.98 Purge Time (min): _____

(5) Liquid Volume [(4)x(F)] (gal): 21.5x3 Purge Volume (gal): 64.7

Did Well Pump Dry? Describe: No

Samplers: JLW

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 180

TEMP - 11.0°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: SMW 45-1 Gauge Date: 24/JAN/95 Time: 0850

Weather: CLOUDY - 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 15.90 Purge Date: 24/JAN/95 Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 12.16 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 3.74 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 3.37 Purge Volume (gal): 10.1

Did Well Pump Dry? Describe: No

Samplers: J.R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 90

TEMP - 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW 20-2 Gauge Date: 23/JAN/95 Time: 1535

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L. I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 34.75 Purge Date: _____ Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: _____

(3) Depth to Water (ft): 12.44 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 22.31 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.0 Purge Volume (gal): 60.0

Did Well Pump Dry? Describe: No

Samplers: JR.

Sampling Date: _____ Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 80

TEMP - 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER AFB.

Well No: SMW 75-2 Gauge Date: 23/JAN/95 Time: _____

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 17.08 Purge Date: 23/JAN/95 Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 12.04 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 5.04 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 4.5 Purge Volume (gal): 13.5

Did Well Pump Dry? Describe: No

Samplers: JR

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND. 60
TEMP - 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-10-2 Gauge Date: 23/JAN/95 Time: 1430

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 35.30 Purge Date: 23/JAN/95 Time: 1430

(2) Depth to Liquid (ft): _____ Purge Method: 2" REDI-Flow

(3) Depth to Water (ft): 12.96 Purge Rate (gpm): 1.5 SPM

(4) Liquid Depth [(1)-(2)]: 23.34 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 210 X 3 Purge Volume (gal): 63.0

Did Well Pump Dry? Describe: NO

Samplers: J.R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND 50

TEMP - 9.°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-10 2P Gauge Date: 23/JAN/95 Time: 1420

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 33.60 Purge Date: 23/JAN/95 Time: 1425

(2) Depth to Liquid (ft): _____ Purge Method: 2" REDI FLOW

(3) Depth to Water (ft): 12.86 Purge Rate (gpm): 1.5 SPM

(4) Liquid Depth [(1)-(2)]: 20.74 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 18.6 Purge Volume (gal): 56.0

Did Well Pump Dry? Describe: No

Samplers: J.R.

Sampling Date: 23/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND -
TEMP.

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B

Well No: SMW-45-2 Gauge Date: 23/JAN/95 Time: 1600

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 15.70 Purge Date: 23/JAN/95 Time: 1605

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 12.72 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 2.98 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 2.68 Purge Volume (gal): 8.0

Did Well Pump Dry? Describe: _____

Samplers: J.R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND 75
TEMP. 9°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-34-2-P Gauge Date: 23/JAN/95 Time: 1400

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 35.40 Purge Date: 23/JAN/95 Time: 1405

(2) Depth to Liquid (ft): _____ Purge Method: 2"REDI-FLOW

(3) Depth to Water (ft): 12.28 Purge Rate (gpm): 1.5

(4) Liquid Depth [(1)-(2)]: 23.12 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.8 Purge Volume (gal): 62.4

Did Well Pump Dry? Describe: No

Samplers: J.R

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND -

TEMP -

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: SMW-20.2 Gauge Date: 23/JAN/95 Time: 1345

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 16.10 Purge Date: 23/JAN/95 Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: _____

(3) Depth to Water (ft): 12.54 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 3.56 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 3.2 Purge Volume (gal): 9.6

Did Well Pump Dry? Describe: No

Samplers: JLW

Sampling Date: 23/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND-120

TEMP-15.6

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: 5MW-10-2 Gauge Date: 23/JAN/95 Time: 1220

Weather: SUNNY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): _____

(1) Well Depth (ft): 16.40 Purge Date: 23/JAN/95 Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 13.27 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 3.13 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 2.8 x 3 Purge Volume (gal): 8.4

Did Well Pump Dry? Describe: No

Samplers: JLW

Sampling Date: 23/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 110
TEMP - 15°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: SMW-10 2P Gauge Date: 23/JAN/95 Time: 1155

Weather: CLOUDY 40°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 17.05 Purge Date: 23/JAN/95 Time: 1200

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 12.75 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 4.30 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 3.8 Purge Volume (gal): 11.5

Did Well Pump Dry? Describe: NO

Samplers: J.L.W

Sampling Date: 23/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND- 120

TEMP- 15.0°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: Dmw-45 2P Gauge Date: 23 JAN 95 Time: 1145

Weather: Cloudy 38°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 35.40 Purge Date: 23 JAN 95 Time: 1145

(2) Depth to Liquid (ft): _____ Purge Method: 2" REDI-FLOW

(3) Depth to Water (ft): 12.26 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 23.14 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.0 x 3 Purge Volume (gal): 60

Did Well Pump Dry? Describe: No

Samplers: J.L.W

Sampling Date: 23 JAN 95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND- 100

TEMP- 14.7

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover AFB

Well No: SMW-34-2P Gauge Date: 23/JAN/95 Time: 1115

Weather: cloudy 38°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: _____

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 16.60 Purge Date: 23/JAN/95 Time: 1115

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 12.33 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 4.27 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 3.8 Purge Volume (gal): 11.5

Did Well Pump Dry? Describe: NO

Samplers: JLW

Sampling Date: 23/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 200

TEMP - 14.8

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover AFB

Well No: Dmw-75-2P Gauge Date: 23/JAN/95 Time: 1105

Weather: Cloudy 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 33.75 Purge Date: 23/JAN/95 Time: 1105

(2) Depth to Liquid (ft): _____ Purge Method: 2" REDI-FLOW

(3) Depth to Water (ft): 12.32 Purge Rate (gpm): 1.5

(4) Liquid Depth [(1)-(2)]: 21.43 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 19.2 Purge Volume (gal): 58.0

Did Well Pump Dry? Describe: No

Samplers: JLW

Sampling Date: 23/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND- 270
TEMP- 14.5

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover AFB

Well No: 5mw-75-2P Gauge Date: 23/JAN/95 Time: 1005

Weather: Cloudy 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 16.55 Purge Date: 23/JAN/95 Time: 1005

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 12.24 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 4.31 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 3.8X3 Purge Volume (gal): 11.6

Did Well Pump Dry? Describe: No

Samplers: J.L.W

Sampling Date: 23/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: PH-NIA PH METER BROKEN

COND - 240

TEMP - 14.5

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW 45-2 Gauge Date: 23 JAN 195 Time: 1540

Weather: CLOUDY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 33.0 Purge Date: 23 JAN 195 Time: 1545

(2) Depth to Liquid (ft): _____ Purge Method: 2"REDI-FLOW

(3) Depth to Water (ft): 12.22 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 20.78 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 18.7 Purge Volume (gal): 56.0

Did Well Pump Dry? Describe: No

Samplers: J.R.

Sampling Date: 24 JAN 195 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND- 185
TEMP- 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover A.F.B.

Well No: Smw. 75-1 Gauge Date: 24/JAN/95 Time: 0805

Weather: Cloudy 28°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 17.50 Purge Date: 24/JAN/95 Time: 0810

(2) Depth to Liquid (ft): _____ Purge Method: ~~2-1/2" DI FLOW~~

(3) Depth to Water (ft): 13.00 Purge Rate (gpm): ~~1.5~~ SPAN

(4) Liquid Depth [(1)-(2)]: 4.50 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 4.0 Purge Volume (gal): 12.0

Did Well Pump Dry? Describe: NO

Samplers: JR.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 440

TEMP - 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover A.F.B.

Well No: Dmw-75-1 Gauge Date: 24/JAN/95 Time: 0810

Weather: Cloudy 30°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 34.50 Purge Date: 24/JAN/95 Time: 0815

(2) Depth to Liquid (ft): _____ Purge Method: 2" REVI-Flow

(3) Depth to Water (ft): 12.24 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 22.26 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.0 Purge Volume (gal): 60.0

Did Well Pump Dry? Describe: No

Samplers: J.R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND. 80°
TEMP. 12°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover A.F.B.

Well No: Dmw-75.2 Gauge Date: 24/JAN/95 Time: 0815

Weather: Cloudy 30°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 34.24 Purge Date: 24/JAN/95 Time: 0820

(2) Depth to Liquid (ft): _____ Purge Method: 2"REDI-Flow

(3) Depth to Water (ft): 11.84 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 22.40 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.1 Purge Volume (gal): 60.0

Did Well Pump Dry? Describe: No

Samplers: J-R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND-80

TEMP-10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-45-1 Gauge Date: 24/JAN/95 Time: 0950

Weather: CLOUDY 30°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 34.96 Purge Date: 24/JAN/95 Time: 0955

(2) Depth to Liquid (ft): _____ Purge Method: 2" REDI-FLOW

(3) Depth to Water (ft): 12.04 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 22.92 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.6 Purge Volume (gal): 61.8

Did Well Pump Dry? Describe: No

Samplers: J.R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 140

TEMP - 11°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-25-1 Gauge Date: 24/JAN/95 Time: 1000

Weather: CLOUDY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 34.90 Purge Date: 24/JAN/95 Time: 1005

(2) Depth to Liquid (ft): _____ Purge Method: 2"REDI-FLOW

(3) Depth to Water (ft): 11.72 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 23.18 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.8 Purge Volume (gal): 62.4

Did Well Pump Dry? Describe: No

Samplers: JR

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND-85
TEMP-11°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-10-1 Gauge Date: 24/JAN/95 Time: 1105

Weather: CLOUDY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 31.48 Purge Date: 24/JAN/95 Time: 1110

(2) Depth to Liquid (ft): _____ Purge Method: 2"REDI-FLOW

(3) Depth to Water (ft): 11.52 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 19.96 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 17.9 Purge Volume (gal): 53.8

Did Well Pump Dry? Describe: No

Samplers: J.R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND 85
TEMP- 11°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER AFB-

Well No: DMW-10-1P Gauge Date: 24/JAN/95 Time: 1115

Weather: CLOUDY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 34.60 Purge Date: 24/JAN/95 Time: 1120

(2) Depth to Liquid (ft): _____ Purge Method: 2"REDI-Flow

(3) Depth to Water (ft): 11.52 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 23.08 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.7 Purge Volume (gal): 62.3

Did Well Pump Dry? Describe: No

Samplers: J.R.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND. 80

TEMP - 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER AFB

Well No: DMW-45-1P Gauge Date: 24/JAN/95 Time: 1250

Weather: SUNNY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 35.40 Purge Date: 24/JAN/95 Time: 1300

(2) Depth to Liquid (ft): _____ Purge Method: 2" RED-FLOW

(3) Depth to Water (ft): 12.16 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 23.24 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 20.9 Purge Volume (gal): 62.7

Did Well Pump Dry? Describe: NO

Samplers: J.L.W.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 110

TEMP. 110°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: SMW-25-1 Gauge Date: 24/JAN/95 Time: 1310

Weather: SUNNY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 17.15 Purge Date: 24/JAN/95 Time: 1310

(2) Depth to Liquid (ft): _____ Purge Method: HAND BAIL

(3) Depth to Water (ft): 11.80 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 5.35 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 4.8 Purge Volume (gal): 14.4

Did Well Pump Dry? Describe: No

Samplers: JLW

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND-280

TEMP- 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: SMW-10-1 Gauge Date: 24/JAN/95 Time: 1105

Weather: SUNNY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 15.75 Purge Date: 24/JAN/95 Time: 1110

(2) Depth to Liquid (ft): _____ Purge Method: HAND-BAIL

(3) Depth to Water (ft): 11.71 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 4.04 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 3.6 Purge Volume (gal): 10.9

Did Well Pump Dry? Describe: No

Samplers: J.R

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 460
TEMP - 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: DMW-75-1P Gauge Date: 24/JAN/95 Time: 1410

Weather: Sunny

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 35.50 Purge Date: 24/JAN/95 Time: 1415

(2) Depth to Liquid (ft): _____ Purge Method: 2"REDI-Flow

(3) Depth to Water (ft): 11.62 Purge Rate (gpm): 1.5 gpm

(4) Liquid Depth [(1)-(2)]: 23.88 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 21.4 Purge Volume (gal): 64.4

Did Well Pump Dry? Describe: NO

Samplers: JLW

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND-260

TEMP-11.0°C

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: SMW-10-1P Gauge Date: 24/JAN/95 Time: 1315

Weather: SUNNY 35°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): FLUSH

(1) Well Depth (ft): 15.96 Purge Date: 24/JAN/95 Time: 1315

(2) Depth to Liquid (ft): _____ Purge Method: HAND-BAIL

(3) Depth to Water (ft): 11.32 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 4.64 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 4.1 Purge Volume (gal): 12.5

Did Well Pump Dry? Describe: No

Samplers: JLW

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND. 425
TEMP. 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: Dover A.F.B.

Well No: APS-1 Gauge Date: 24/JAN/95 Time: 1600

Weather: SUNNY 35°

Well Condition: Good

Well Diameter (inches): 4"

Odor (describe): _____

Sounding Method: W.L.I Measurement Reference: T.O.C.

Stick up/down (ft): 00.00

(1) Well Depth (ft): 39.00 Purge Date: _____ Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: _____

(3) Depth to Water (ft): 11.30 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: _____ Purge Time (min): _____

(5) Liquid Volume [(4)x(F)] (gal): _____ Purge Volume (gal): _____

Did Well Pump Dry? Describe: _____

Samplers: _____

Sampling Date: _____ Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND - 85

TEMP - 10°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER AFB

Well No: AAS-2 Gauge Date: 24/JAN/95 Time: 1545

Weather: SUNNY 35

Well Condition: Good

Well Diameter (inches): 4"

Odor (describe): _____

Sounding Method: _____ Measurement Reference: _____

Stick up/down (ft): _____

(1) Well Depth (ft): 39.70 Purge Date: _____ Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: _____

(3) Depth to Water (ft): 12.50 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 27.20 Purge Time (min): _____

(5) Liquid Volume [(4)x(F)] (gal): _____ Purge Volume (gal): _____

Did Well Pump Dry? Describe: _____

Samplers: _____

Sampling Date: _____ Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND. 70

TEMP - 11°

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: SMW-25-1P Gauge Date: 24/JAN/95 Time: _____

Weather: SUNNY 38°

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): _____

(1) Well Depth (ft): 16.20 Purge Date: 24/JAN/95 Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: HAND-BAIL

(3) Depth to Water (ft): 11.62 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 4.58 Purge Time (min): _____

(5) Liquid Volume [(4)x(F)] (gal): 4.1 x 3 Purge Volume (gal): 12.3

Did Well Pump Dry? Describe: No

Samplers: J.L.W.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND 950

TEMP 12.0

Figure 4-1. Field Purge/Sample Sheets.



FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: DOVER A.F.B.

Well No: 5mw-45 1P Gauge Date: 24/JAN/95 Time: 1350

Weather: SUNNY 40°C

Well Condition: Good

Well Diameter (inches): 2"

Odor (describe): _____

Sounding Method: W.L.I. Measurement Reference: T.O.C.

Stick up/down (ft): _____

(1) Well Depth (ft): 14.74 Purge Date: 24/JAN/95 Time: _____

(2) Depth to Liquid (ft): _____ Purge Method: HAND-BAIL

(3) Depth to Water (ft): 11.64 Purge Rate (gpm): _____

(4) Liquid Depth [(1)-(2)]: 3.1 Purge Time (min): _____

(5) Liquid Volume [(4)xF] (gal): 2.79 Purge Volume (gal): 8.3

Did Well Pump Dry? Describe: No

Samplers: J.L.W.

Sampling Date: 24/JAN/95 Time: _____

Sample Type: _____ Split? _____ With Whom: _____

Comments and Observations: COND. 810

TEMP 12°C

Figure 4-1. Field Purge/Sample Sheets.



Appendix F
Ground-Water VOC Data

TABLE F.4-1

INITIAL GROUND-WATER VOC CONCENTRATIONS IN SHALLOW MONITORING POINTS
MAY TO JUNE 1994 - SITE SS59 - DOVER AFB, DELAWARE

WELL	VOCs											HYDROCARBON COMPOUNDS FROM FID (PPB)											Total VOCs
	CHLORINATED COMPOUNDS FROM ECD (PPB)											Total Conc.											
	DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total Conc.	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX							
SMW-75-2P	24	<4	<5	188	<1	33	3	1	<1	249.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	249.0						
SMW-45-2P	DRY	DRY	<108	1400	<1	186	<1	26	3	N/A	DRY	DRY	DRY	DRY	DRY	N/A	N/A						
SMW-34-2P	216	<91	<5	76	<1	3	<1	3	<1	1831.0	<54	<54	<54	<54	<54	ND	1831.0						
SMW-10-2P	3	9	<5	37	<1	2	<1	1	<1	94.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	94.0						
SMW-10-2	3	<4	<5	<9	<1	2	<1	<1	<1	43.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	43.0						
SMW-20-2	3	<4	<5	<9	<1	2	<1	<1	<1	5.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	5.0						
SMW-45-2	12	<4	<5	29	<1	14	<1	2	<1	57.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	57.0						
SMW-75-2	11	<4	<5	24	<1	13	<1	3	<1	51.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	51.0						
SMW-75-1	<1	<4	<5	<9	<1	<1	<1	<1	<1	ND	<3.0	<3.0	<3.0	<3.0	<3.0	ND	ND						
SMW-45-1	5	<4	<5	<9	<1	7	<1	6	1	19.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	19.0						
SMW-25-1	2	<4	<5	<9	<1	6	<1	4	<1	12.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	12.0						
SMW-10-1	<1	<4	<4	<6	<1	4	<1	3	<1	7.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	7.0						
SMW-10-1P	3	<4	<5	<9	<1	4	<1	3	<1	10.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	10.0						
SMW-25-1P	2	<4	<4	<4	<1	6	<1	2	<1	10.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	10.0						
SMW-45-1P	3	<4	6	<9	<1	4	<1	3	1	17.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	17.0						
SMW-75-1P	<1	<4	<5	<9	<1	<1	<1	<1	<1	ND	<3.0	<3.0	<3.0	<3.0	<3.0	ND	ND						
DP-1	<1	<4	9	<9	<1	<1	<1	2	<1	11.0	12.590	<3.0	<3.0	<3.0	<3.0	12.590	23.6						
DP-2	3	17	<5	<9	<1	3	<1	1	<1	24.0	5.390	<3.0	<3.0	<3.0	<3.0	5.390	29.4						
DP-3	11	<4	38	20	<1	<1	<1	<1	<1	69.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	69.0						
DP-4	1	<4	<5	<9	<1	<1	<1	<1	<1	1.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	1.0						
DP-5	7	<4	<5	17	<1	<1	<1	<1	<1	24.0	5.900	<3.0	<3.0	<3.0	<3.0	5.900	29.9						
DP-6	3	<4	5	18	<1	3	<1	<1	<1	29.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	29.0						
DP-7	4	<4	<5	<9	<1	1	<1	<1	<1	5.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	5.0						
DP-8	<1	<4	<5	<9	<1	<1	<1	<1	<1	ND	<3.0	<3.0	<3.0	<3.0	<3.0	ND	ND						
DP-9	1	<4	<5	<9	<1	<1	<1	<1	<1	1.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	1.0						
DP-10	3	<4	6	<9	<1	1	<1	1	<1	11.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	11.0						
DP-11	4	<4	<5	<9	10	<1	<1	1	<1	15.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	15.0						
DP-12	14	19	<5	19	<1	7	<1	4	<1	63.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	63.0						

Notes: DP = Direct Push Location N/A = Not Applicable ND = Not Detected

<#> = sample concentration was identified to be less than the detection limit (#)

DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg. BTEX	Avg. Total
12.071	1.607	2.286	65.286	0.357	10.679	0.107	2.357	0.179	94.929	0.853	ND	ND	ND	ND	0.853	95.781
Average (ppb)																

TABLE F.4-2

INITIAL GROUND-WATER VOC CONCENTRATIONS IN DEEP MONITORING POINTS
MAY TO JUNE 1994 - SITE SS59 - DOVER AFB, DELAWARE

WELL	VOCs																Total VOCs
	CHLORINATED COMPOUNDS FROM ECD (PPB)										HYDROCARBON COMPOUNDS FROM FID (PPB)						
	DCE	MC	1-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX	
DMW-75-2P	132	<202	<224	<277	<1	327	<1	309	160	928.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	928.0
DMW-45-2P	183	<202	<224	521	<1	468	57	131	53	1413.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	1413.0
DMW-34-2P	112	<227	<270	<425	<1	165	<1	58	19	354.0	<133	<133	<133	<133	<133	ND	354.0
DMW-10-2P	331	<452	<540	<851	<1	297	<1	117	91	836.0	<266	<266	<266	<266	<266	ND	836.0
DMW-10-2	637	<91	<108	870	<1	306	38	149	54	2054.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	2054.0
DMW-20-2	306	<100	<98	205	<1	354	<1	172	23	1060.0	<41	<41	<47	<42	<42	ND	1060.0
DMW-45-2	875	<100	<98	702	<1	1240	<1	618	42	3477.0	<41	<41	<47	<42	<42	ND	3477.0
DMW-75-2	1350	<25	<25	1230	<1	1330	<1	442	36	4388.0	<103	<104	<116	<103	<104	ND	4388.0
DMW-75-1	56	<4	<5	<9	<1	53	<1	43	9	161.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	161.0
DMW-45-1	168	<4	<5	79	<1	94	<1	131	15	487.0	<3.0	3.04	<3.0	<3.0	<3.0	3.04	490.0
DMW-25-1	688	<202	<224	659	<1	34	<1	13	<1	1394.0	<3.0	<3	<3.0	<3.0	<3.0	ND	1394.0
DMW-10-1	420	<906	<1078	<2300	<1	414	<1	102	15	951.0	<532	<532	<532	<532	<532	ND	951.0
DMW-10-1P	107	<4	<5	246	<1	86	<1	133	43	615.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	615.0
DMW-25-1P	6	<4	<5	<5	<1	28	<1	4	21	59.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	59.0
DMW-45-1P	5	<4	<5	<9	<1	5	<1	8	2	20.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	20.0
DMW-75-1P	4	<4	<5	<9	<1	2	<1	1	<1	7.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	7.0
AAS-1	10500	<186	<208	<352	<2	1230	<1	9080	2450	23260.0	<266	<266	<266	<266	<266	ND	23260.0
AAS-2	180	<202	<224	<277	<1	772	<1	204	487	1643.0	<20	<20	<20	<20	<20	ND	1643.0
DGP-1	186	113	<5	624	<1	51	<1	69	2	1045.0	<1	<1	<1	<1	<1	ND	1045.0
DGP-2	473	41	<5	751	<1	48	<1	89	4	1406.0	<1	9	<1	<1	<1	9	1415.0
DGP-3	5	<4	<5	13	<1	6	<1	2	<1	26.0	<1	2	<1	<1	<1	2	28.0

Notes:

DGP = Deep Geoprobe Location ND = Not Detected

<#> = sample concentration was identified to be less than the detection limit (#)

Average (ppb)	DCE	MC	1-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg. BTEX	Avg. Total
	796.381	7.333	ND	280.95	ND	348.1	4.524	565.48	167.9	2170.667	ND	0.669	ND	ND	ND	0.669	2171.335

TABLE F.4-3 MID-TERM GROUND-WATER VOC CONCENTRATIONS IN SHALLOW MONITORING POINTS
11 OCT 1994 - SITE SS59 - DOVER AFB, DELAWARE

WELL	VOCs																Total VOC
	CHLORINATED COMPOUNDS FROM ECD (PPB)										HYDROCARBON COMPOUNDS FROM FID (PPB)						
	DCE	MC	1-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX	
SMW-75-2P	38.8	34.2	36.2	158	<1	4.53	<1	1.26	1.51	274.5	<1	<1	<1	<1	<1	ND	274.5
SMW-34-2P	195	<4	13.5	150	4.17	3.42	<1	3.74	1.13	371.0	<1	<1	<1	<1	<1	ND	371.0
SMW-10-2P	22.2	<4	9.06	47	<1	2.85	<1	2.54	1.5	85.2	<1	<1	<1	<1	<1	ND	85.2
SMW-10-2	<1	<4	<5	<9	<1	1.88	<1	1.18	1.12	4.2	<1	<1	<1	<1	<1	ND	4.2
SMW-20-2	27.9	<4	<5	<9	<1	1.4	<1	<1	<1	29.3	<1	<1	<1	<1	<1	ND	29.3
SMW-45-2	51.7	<4	32.8	124	<1	5.66	<1	1.89	1.43	217.5	1.430	<1	<1	<1	<1	1.4	218.9
SMW-75-2	188	<4	28.8	93	2.24	4.09	<1	2.84	1.22	320.2	<1	<1	<1	<1	<1	ND	320.2
SMW-75-1	13	<4	<5	<9	<1	1.66	<1	1.3	<1	16.0	2.050	<1	<1	<1	<1	2.1	18.0
SMW-45-1	23.2	<4	<5	<9	<1	3.24	1	3.419	1.18	32.0	1.250	<1	<1	<1	<1	1.3	33.3
SMW-25-1	43.4	<4	<5	<9	<1	4.4	<1	3.76	1.43	53.0	2.290	<1	<1	<1	<1	2.3	55.3
SMW-10-1	27.1	<4	27.17	<9	<1	2.38	<1	1.79	<1	58.4	<1	<1	<1	<1	<1	ND	58.4
SMW-10-1P	23	13.6	16.1	<9	<1	3.25	<1	2.01	<1	58.0	<1	<1	3.810	<1	<1	3.8	61.8
SMW-25-1P	94.9	13.89	47.8	<9	<1	3.63	<1	2.56	1.07	163.9	<1	<1	23.070	<1	<1	23.1	186.9
SMW-45-1P	60.1	9.35	15.2	<9	<1	4.8	<1	2.77	1.67	93.9	<1	<1	<1	<1	<1	ND	93.9
SMW-75-1P	34.5	7.91	7.79	<9	2.33	1.31	<1	<1	<1	53.8	<1	<1	<1	<1	<1	ND	53.8
SMW-45-2P	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	N/A	DRY	DRY	DRY	DRY	DRY	N/A	N/A
SMW-25-DUP	39.7	<4	5.42	9.86	<1	2.25	<1	<1	<1	57.2	2.250	<1	<1	<1	<1	2.3	59.5
SMW-75-2P DU	38.8	34.2	36.9	132	<1	4.41	<1	1.28	1.5	249.1	<1	<1	<1	<1	<1	ND	249.1

Notes:

N/A = Not ApplicableND = Not Detected

VOCs										Avg. ECD		Avg. BTEX		Avg. Total		
DCE	MC	1-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE		BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg. BTEX	Avg. Total
56,187	5,263	15,628	38,133	0,583	3,233	0,067	2,071	0,884	122,049	0,468	ND	1,792	ND	ND	2,260	124.3
Average (ppb)																

Notes: N/A = Not Applicable ND = Not Detected

Average (ppb)	DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg. BTEX	Avg. Total
	56.187	5.263	15.628	38.133	0.583	3.233	0.067	2.071	0.884	122.049	0.468	ND	1.792	ND	ND	2.260	124.3

TABLE F.4-4 MID-TERM GROUND-WATER VOC CONCENTRATIONS IN DEEP MONITORING POINTS
11 OCT 1994 - SITE SS59 - DOVER AFB, DELAWARE

WELL	VOCs												HYDROCARBON COMPOUNDS FROM FID (PPB)												Total VOC	
	CHLORINATED COMPOUNDS FROM ECD (PPB)												BENZ TOLU E-BENZ M+P XYL O-XYL Total BTEX													
	DCE	MC	I-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX										
DMW-75-2P	1074	<4	149.0	860.0	<1	18.4	<1	42.9	9.6	2153.9	<1	<1	<1	<1	<1	<1	2153.9			<1	<1	<1	<1	2153.9		
DMW-45-2P	261	530.0	<5	1057.0	6.8	10.8	<1	24.0	7.7	1897.3	<1	<1	<1	<1	<1	<1	1897.3			<1	<1	<1	<1	1897.3		
DMW-34-2P	254	331.0	190.0	1091.0	6.4	8.5	<1	22.3	5.1	1908.3	<1	<1	<1	<1	<1	<1	1908.3			<1	<1	<1	<1	1908.3		
DMW-10-2P	1010	<4	76.7	387.0	4.7	15.0	<1	24.6	8.4	1526.4	<1	<1	<1	<1	<1	<1	1526.4			<1	<1	<1	<1	1526.4		
DMW-10-2	816	<4	108.0	433.0	<1	15.8	<1	20.0	7.4	1400.2	<1	<1	<1	<1	<1	<1	1400.2			<1	<1	<1	<1	1400.2		
DMW-20-2	505	<4	66.1	228.0	5.7	11.2	<1	8.5	2.7	827.1	<1	<1	<1	<1	<1	<1	827.1			<1	<1	<1	<1	827.1		
DMW-45-2	178	<4	<5	336.0	<1	2.9	<1	2.8	6.1	525.9	<1	<1	<1	<1	<1	<1	525.9			<1	<1	<1	<1	527.2		
DMW-75-2	1020	<4	8.5	327.0	5.0	13.7	<1	30.7	5.0	1409.8	<1	1.1	<1	<1	<1	<1	1412.0			<1	<1	<1	<1	1412.0		
DMW-75-1	251	<4	<5	22.9	<1	6.0	<1	9.9	3.5	293.2	<1	<1	<1	<1	<1	<1	293.2			<1	<1	<1	<1	293.2		
DMW-45-1	410	<4	<5	47.1	5.0	8.3	<1	15.6	3.5	489.4	<1	<1	<1	<1	<1	<1	489.4			<1	<1	<1	<1	489.4		
DMW-25-1	649	<4	<5	89.0	<1	9.3	<1	13.0	3.1	763.4	<1	<1	<1	<1	<1	<1	763.4			<1	<1	<1	<1	763.4		
DMW-10-1	423	<4	42.3	176.0	<1	10.5	<1	12.9	<1	664.7	<1	<1	<1	<1	<1	<1	664.7			<1	<1	<1	<1	664.7		
DMW-10-1P	439	<4	56.8	163.0	<1	13.2	<1	10.8	<1	682.8	<1	<1	<1	<1	<1	<1	682.8			<1	<1	<1	<1	682.8		
DMW-25-1P	293	<4	56.0	129.0	<1	3.3	<1	7.5	1.3	490.1	<1	<1	<1	<1	<1	<1	490.1			<1	<1	<1	<1	490.1		
DMW-45-1P	281	<4	16.0	25.0	<1	10.2	<1	15.6	6.8	354.6	<1	<1	<1	<1	<1	<1	354.6			<1	<1	<1	<1	354.6		
DMW-75-1P	54	10.1	10.4	<9	<1	3.0	<1	1.4	<1	78.9	<1	<1	<1	<1	<1	<1	78.9			<1	<1	<1	<1	78.9		
AAS-1	1489	357.0	86.4	316.0	<1	104.0	<1	280.0	91.7	2724.1	<1	<1	<1	<1	<1	<1	2724.1			<1	<1	<1	<1	2724.1		
AAS-2	9067	<44	276.0	282.0	<1	376.0	<1	917.0	73.6	10991.6	<1	<1	<1	<1	<1	<1	10991.6			<1	<1	<1	<1	10991.6		

Notes: ND = Not Detected

<#> = sample concentration was identified to be less than the detection limit (#)

Camp 10 - 6/20/2014 - 11/20/2014 - 12/20/2014																	Camp 10 - 6/20/2014 - 11/20/2014 - 12/20/2014				Camp 10 - 6/20/2014 - 11/20/2014 - 12/20/2014			
Average (ppb)																	Average (ppb)				Average (ppb)			
DCE	MC	I-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg BTEX	Avg Total								
1026.3	68.228	63.456	331.61	1.859	35.559	ND	81.082	13.077	1621.204	ND	0.061	ND	0.133	ND	0.194	1621.4								

TABLE F.4-5 FINAL GROUND-WATER VOC CONCENTRATIONS IN SHALLOW MONITORING POINTS
25 JAN 1995 - SITE SS59 - DOVER AFB, DELAWARE

WELL	VOCs																
	CHLORINATED COMPOUNDS FROM ECD (PPB)										HYDROCARBON COMPOUNDS FROM FID (PPB)						
	DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX	Total VOC
SMW-75-2P	6	7	<5	34	<1	2	<1	1	2	52.0	<1	<1	<1	<1	<1	ND	52.0
SMW-34-2P	35	4	<5	146	2	<1	<1	3	1	191.0	<1	<1	<1	<1	<1	ND	191.0
SMW-10-2P	4	4	<5	19	<1	<1	<1	1	1	29.0	<1	<1	<1	<1	<1	ND	29.0
SMW-10-2	3	5	<5	14	<1	<1	<1	1	1	24.0	<1	<1	<1	<1	<1	ND	24.0
SMW-20-2	1	4	<5	13	<1	<1	<1	1	2	21.0	<1	<1	<1	<1	<1	ND	21.0
SMW-45-2	6	38	<5	69	<1	<1	<1	<1	1	114.0	<1	<1	<1	<1	<1	ND	114.0
SMW-75-2	9	4	<5	41	<1	<1	<1	2	1	57.0	<1	<1	<1	<1	<1	ND	57.0
SMW-75-1	3	23	<5	11	<1	2	<1	<1	<1	39.0	<1	<1	<1	<1	<1	ND	39.0
SMW-45-1	5	<4	<5	<9	<1	3	<1	2	2	12.0	<1	<1	<1	<1	<1	ND	12.0
SMW-25-1	14	13	10	<9	<1	<1	<1	2	2	41.0	3.0	<1	<1	<1	<1	3.0	44.0
SMW-10-1	3	34	<5	<9	<1	<1	<1	2	2	41.0	<1	<1	<1	<1	<1	ND	41.0
SMW-10-1P	19	<4	<5	<9	<1	<1	<1	<1	<1	19.0	<1	<1	<1	<1	<1	ND	19.0
SMW-25-1P	4	13	<5	<9	<1	10	<1	1	1	29.0	<1	<1	<1	<1	<1	ND	29.0
SMW-45-1P	7	<4	<5	<9	<1	11	<1	1	1	20.0	<1	<1	<1	<1	<1	ND	20.0
SMW-75-1P	1	5	<5	<9	<1	3	<1	<1	<1	9.0	<1	<1	<1	<1	<1	ND	9.0
SMW-25-1P DU	6	<4	<5	<9	<1	10	<1	1	1	18.0	<1	<1	<1	<1	<1	ND	18.0
SMW-25-1 DUP	14	13	10	<9	<1	<1	<1	2	2	41.0	3.0	<1	<1	<1	<1	3.0	44.0
SMW-75-2 DUP	9	4	<5	40	<1	<1	<1	2	1	56.0	<1	<1	<1	<1	<1	ND	56.0
SMW-34-2P DU	38	4	<5	158	2	<1	<1	4	1	207.0	<1	<1	<1	<1	<1	ND	207.0
SMW-45-2P	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	N/A	DRY	DRY	DRY	DRY	DRY	N/A	N/A

Notes: N/A = Not Applicable ND = Not Detected
<#> = sample concentration was identified to be less than the detection limit (#)

Average (ppb)																
DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg BTEX	Avg. Total
8.000	10.267	0.667	23.133	0.133	2.067	0.000	1.133	1.133	46.533	0.200	0.000	0.000	0.000	0.000	0.200	46.7

TABLE F.4-6

FINAL GROUND-WATER VOC CONCENTRATIONS IN DEEP MONITORING POINTS
25 JAN 1995 - SITE SS59 -DOVER AFB, DELAWARE

WELL	CHLORINATED COMPOUNDS FROM ECD (PPB)											VOCs							Total VOC
	HYDROCARBON COMPOUNDS FROM FID (PPB)											BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX		
	DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total ECD									
DMW-75-2P	660	1245	107	923	<1	5	<1	112	44	3096.0	<1	<1	<1	<1	<1	<1	ND	3096.0	
DMW-45-2P	2700	1670	<5	3120	<1	49	42	377	32	7990.0	<1	24	<1	<1	<1	<1	24.0	8014.0	
DMW-34-2P	438	766	96	700	<1	6	<1	48	19	2073.0	<1	<1	<1	<1	<1	<1	ND	2073.0	
DMW-10-2P	125	423	<5	430	<1	18	<1	27	18	1041.0	<1	<1	<1	<1	<1	<1	ND	1041.0	
DMW-10-2	114	570	<5	415	14	20	<1	23	12	1168.0	<1	<1	<1	<1	<1	<1	ND	1168.0	
DMW-20-2	207	583	<5	606	<1	7	4	33	12	1452.0	<1	<1	<1	<1	<1	<1	ND	1452.0	
DMW-45-2	2317	<4	<5	891	<1	44	30	63	90	3435.0	<1	<1	<1	<1	<1	<1	ND	3435.0	
DMW-75-2	581	<4	<5	2080	<1	8	6	53	12	2740.0	<1	<1	<1	<1	<1	<1	ND	2740.0	
DMW-75-1	80	<4	<5	<9	<1	19	<1	15	17	131.0	<1	<1	<1	<1	<1	<1	ND	131.0	
DMW-45-1	44	116	<5	10	2	5	<1	4	<1	181.0	<1	<1	<1	<1	<1	<1	ND	181.0	
DMW-25-1	391	647	117	178	<1	6	10	57	18	1424.0	<1	8	<1	<1	<1	<1	8.0	1432.0	
DMW-10-1	19	<4	<5	22	<1	<1	<1	4	<1	45.0	<1	<1	<1	<1	<1	<1	ND	45.0	
DMW-10-1P	315	<4	71	100	<1	6	8	56	68	624.0	<1	<1	<1	<1	<1	<1	ND	624.0	
DMW-25-1P	42	336	<5	9	<1	100	<1	17	15	519.0	<1	<1	<1	<1	<1	<1	ND	519.0	
DMW-45-1P	67	303	<5	23	<1	25	<1	29	20	467.0	<1	<1	<1	<1	<1	<1	ND	467.0	
DMW-75-1P	21	685	<5	<9	<1	15	<1	12	8	741.0	<1	6	<1	<1	<1	<1	6.0	747.0	
AAS-1	63	223	187	<9	<1	46	<1	49	88	656.0	<1	<1	<1	<1	<1	<1	ND	656.0	
AAS-2	368	260	198	<9	<1	38	20	135	37	1056.0	<1	<1	<1	<1	<1	<1	ND	1056.0	

Notes: N/A = Not Applicable ND = Not Detected

<# = sample concentration was identified to be less than the detection limit (#)

Average (ppb)																	Avg. Total
DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg. BTEX		
475.11	434.83	43.111	528.17	0.889	23.167	6.667	61.889	28.333	1602.167	ND	2.111	ND	ND	ND	2.111	1604.3	

TABLE F.4-7 FINAL GROUND-WATER VOC CONCENTRATIONS IN SHALLOW DIRECT PUSH MONITORING POINTS
25 JAN 1995 - SITE SS59 - DOVER AFB, DELAWARE

WELL	VOCs																
	CHLORINATED COMPOUNDS FROM ECD (PPB)								HYDROCARBON COMPOUNDS FROM FID (PPB)								
	DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX	Total VOC
DP-3	6	<4	<5	75	<1	2	<1	<1	<1	83.0	2	2	<1	<1	<1	4.0	87.0
DP-6	6	<4	<5	11	<1	1	<1	<1	1	19.0	<1	<1	<1	<1	<1	ND	19.0
DP-7	4	<4	<5	<9	<1	2	<1	<1	<1	6.0	<1	<1	<1	<1	<1	ND	6.0
DP-10	3	<4	9	<9	<1	2	<1	2	2	18.0	<1	<1	<1	<1	<1	ND	18.0
DP-12	4	9	5	<9	<1	<1	<1	<1	<1	18.0	<1	<1	<1	<1	<1	ND	18.0

Average (ppb)	DCE	MC	t-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg. BTEX	Avg. Total
	4.600	1.800	2.800	17.200	ND	1.400	ND	0.400	0.600	28.800	0.400	0.400	ND	ND	ND	0.800	29.6

TABLE F.4-8 FINAL GROUND-WATER VOC CONCENTRATIONS IN DEEP DIRECT PUSH MONITORING POINTS
25 JAN 1995 - SITE SS59 - DOVER AFB, DELAWARE

WELL	VOCs																	Total VOC
	CHLORINATED COMPOUNDS FROM ECD (PPB)								HYDROCARBON COMPOUNDS FROM FID (PPB)									
	DCE	MC	1-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Total ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Total BTEX		
DP-4	19	163	29	12	<1	4	2	43	9	281.0	2	5	2	2	<1	11.0	292.0	
DP-5	120	180	340	103	10	33	3	17	13	819.0	48	14	6	6	<1	74.0	893.0	
DP-8	11	40	<5	42	<1	<1	<1	5	11	109.0	4	9	12	45	<1	70.0	179.0	
DP-9	12	61	<5	138	<1	6	<1	31	16	264.0	<1	<1	<1	<1	<1	ND	264.0	
DP-11	758	<4	<5	1304	<1	6	9	83	15	2175.0	<1	<1	<1	<1	<1	ND	2175.0	

Notes:
ND= Not Detected
<#'' = sample concentration was identified to be less than the detection limit (#)

DCE	MC	1-DCE	c-DCE	CHLOR	TCA	CT	TCE	PCE	Avg. ECD	BENZ	TOLU	E-BENZ	M+P XYL	O-XYL	Avg. BTEX	Avg. Total
184	88.800	73.800	319.8	2.000	9.800	2.800	35.800	12.800	729.600	10.800	5.600	4.000	10.600	ND	31.000	760.6

Average (ppb)

Notes: ND= Not Detected
<# = sample concentration was identified to be less than the detection limit (#)

Table F.4-9

DOVER AFB SITE SS59 AREA 2
GROUND-WATER MONITORING RESULTS - EXTENDED AAS/VE TEST

	1,1-DCE (ug/L)	MC (ug/L)	1,1,2-DCE (ug/L)	1,1,2-DCE (ug/L)	CHLOROFORM (ug/L)	TCA (ug/L)	CT (ug/L)	TCE (ug/L)	PCE (ug/L)	BENZENE (ug/L)	TOLUENE (ug/L)	ETHYLBENZ. (ug/L)	m,p-XYLENES (ug/L)	o-XYLENE (ug/L)	Total BTEX (ug/L)	Total VOC (ug/L)
DMW-10-2P																
31 May 94	331.0	<452	<540	<851	<1	297.0	<1	117.0	91.0	<266	<266	<266	<266	<266	ND	836.0
11 Oct 94	1010	<4	76.7	387	4.7	15	<1	24.6	8.40	<1	<1	<1	<1	<1	ND	1528.9
24 Jan 95	125.0	423.0	<5	430.0	<1	18.0	<1	27.0	18.0	<1	<1	<1	<1	<1	ND	1041.0
DMW-34-2P																
31 May 94	112.0	<227	<270	<425	<1	165.0	<1	58.0	19.0	<133	<133	<133	<133	<133	ND	354.0
11 Oct 94	254	331	190	1091	6.4	8.5	<1	22.3	5.07	<1	<1	<1	<1	<1	ND	1908.3
24 Jan 95	438.0	766.0	96.0	700.0	<1	6.0	<1	48.0	19.0	<1	<1	<1	<1	<1	ND	2073.0
DMW-45-2P																
31 May 94	183.0	<202	<224	521.0	<1	468.0	57.0	131.0	53.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	1413.0
11 Oct 94	281	530	<5	1057	6.8	10.8	<1	24.0	7.70	<1	<1	<1	<1	<1	ND	1896.3
24 Jan 95	2700.0	1670.0	<5	3120.0	<1	49.0	42.0	377.0	32.0	<1	24.0	<1	<1	<1	24.0	8014.0
DMW-75-2P																
31 May 94	132.0	<202	<224	<277	<1	327.0	<1	309.0	160.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	928.0
11 Oct 94	1074	<4	149	860	<1	18.4	<1	42.9	9.80	<1	<1	<1	<1	<1	ND	2154.2
24 Jan 95	860.0	1245.0	107.0	923.0	<1	5.0	<1	112.0	44.0	<1	<1	<1	<1	<1	ND	3096.0
AAS-2																
1 June 94	180.0	<202	<224	<277	<1	772.0	<1	204.0	487.0	<20	<20	<20	<20	<20	ND	1843.0
11 Oct 94	9067	<44	276	282	<1	376	<1	917	73.6	<7	<7.2	<9	<14.3	<2.9	ND	10991.8
24 Jan 95	368.0	280.0	198.0	<9	<1	38.0	20.0	135.0	37.0	<7	<7.2	<9	<14.3	<2.9	ND	1056.0
DMW-10-2																
31 May 94	637.0	<91	<108	870.0	<1	306.0	38.0	149.0	54.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	2054.0
11 Oct 94	816	<4	108	433	<1	15.8	<1	20.0	7.40	<1	<1	<1	<1	<1	ND	1400.9
24 Jan 95	114.0	570.0	<5	415.0	14.0	20.0	<1	23.0	12.0	<1	<1	<1	<1	<1	ND	1168.0
DMW-20-2																
1 June 94	306.0	<100	<98	205.0	<1	354.0	<1	172.0	23.0	<41	<41	<47	<42	<42	ND	1060.0
11 Oct 94	505	<4	66.1	228	5.65	11.2	<1	8.50	2.66	<1	<1	<1	<1	<1	ND	928.8
24 Jan 95	207.0	583.0	<5	606.0	<1	7.0	4.0	33.0	12.0	<1	<1	<1	<1	<1	ND	1452.0
DMW-45-2																
1 June 94	875.0	<100	<98	702.0	<1	1240.0	<1	618.0	42.0	<41	<41	<47	<42	<42	ND	3477.0
11 Oct 94	178	<4	<5	336	<1	2.91	<1	2.82	6.13	<1	<1	<1	<1	<1	1.3	526.9
24 Jan 95	2317.0	<4	<5	891.0	<1	44.0	30.0	63.0	90.0	<1	<1	<1	<1	<1	ND	3435.0
DMW-75-2																
1 June 94	1350.0	<25	<25	1230.0	<1	1330.0	<1	442.0	36.0	<103	<104	<116	<103	<104	ND	4388.0
11 Oct 94	1020	<4	8.5	327	4.96	13.7	<1	30.7	4.95	<1	1.1	<1	1.1	<1	2.2	1412.2
24 Jan 95	581.0	<4	<5	2060.0	<1	8.0	6.0	53.0	12.0	<1	<1	<1	<1	<1	ND	2740.0
SMW-10-2P																
31 May 94	3.0	9.0	<5	76.0	<1	3.0	<1	3.0	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	94.0
13 Oct 94	22.2	<4	9.1	47.0	<1	2.8	<1	2.5	1.5	<1	<1	<1	<1	<1	ND	85.1
24 Jan 95	4.0	4.0	<5	19.0	<1	<1	<1	1.0	1.0	<1	<1	<1	<1	<1	ND	29.0
SMW-34-2P																
31 May 94	216.0	<91	<108	1400.0	<1	186.0	<1	26.0	3.0	<54	<54	<54	<54	<54	ND	1831.0
12 Oct 94	195.0	<4	13.5	149.7	4.2	3.4	<1	3.7	1.1	<1	<1	<1	<1	<1	ND	370.8
24 Jan 95	35.0	4.0	<5	146.0	2.0	<1	<1	3.0	1.0	<1	<1	<1	<1	<1	ND	191.0
SMW-45-2P																
31 May 94	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	NA	NA
24 Jan 95	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	NA	NA
SMW-75-2P																
31 May 94	24.0	<4	<5	188.0	<1	33.0	3.0	1.0	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	249.0
14 Oct 94	46.1	36.5	42.1	177.2	<1	4.6	<1	1.3	1.5	<1	<1	<1	<1	<1	ND	309.4
DUP 14 Oct 9	46.2	36.4	43.0	147.9	<1	4.5	<1	1.3	1.5	<1	<1	<1	<1	<1	ND	280.8
DUP 24 Jan 9	9.0	4.0	<5	40.0	<1	<1	<1	2.0	1.0	<1	<1	<1	<1	<1	ND	56.0
SMW-10-2																
31 May 94	3.0	<4	<5	37.0	<1	2.0	<1	1.0	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	43.0
13 Oct 94	<1	<4	<5	<9	<1	1.9	<1	1.2	<1	<1	<1	<1	<1	<1	ND	4.2
24 Jan 95	3.0	5.0	<5	14.0	<1	<1	<1	1.0	1.0	<1	<1	<1	<1	<1	ND	24.0
SMW-20-2																
1 June 94	3.0	<4	<5	<9	<1	2.0	<1	<1	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	5.0
12 Oct 94	27.9	<4	<5	<9	<1	1.4	<1	<1	<1	<1	<1	<1	<1	<1	ND	29.3
24 Jan 95	1.0	4.0	<5	13.0	<1	<1	<1	1.0	2.0	<1	<1	<1	<1	<1	ND	21.0
SMW-45-2																
1 June 94	12.0	<4	<5	29.0	<1	14.0	<1	2.0	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	57.0
12 Oct 94	51.7	<4	32.8	124.3	<1	5.7	<1	1.9	1.4	<1	<1	<1	<1	<1	1.4	219.2
24 Jan 95	6.0	38.0	<5	69.0	<1	<1	<1	<1	1.0	<1	<1	<1	<1	<1	ND	114.0
SMW-75-2																
1 June 94	11.0	<4	<5	24.0	<1	13.0	<1	3.0	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	51.0
12 Oct 94	87.7	<4	7.4	40.6	3.7	3.1	<1	2.3	1.3	1.6	<1	<1	<1	<1	1.6	147.7
24 Jan 95	9.0	4.0	<5	41.0	<1	<1	<1	2.0	1.0	<1	<1	<1	<1	<1	ND	57.0

NA = Not Applicable ND = Not Detected
 c# = sample concentration was determined to be less than the detection limit (#)

Table F.4-9 (Continued) Dover AFB - Site SS59 - Area 1
Ground-Water Monitoring Results - Extended AAS/SVE Test

	1,1-DCE (ug/L)	MC (ug/L)	1,1,2-DCE (ug/L)	1,2-DCE (ug/L)	CHLOROFORM (ug/L)	TOA (ug/L)	CT (ug/L)	TCE (ug/L)	PCE (ug/L)	BENZENE (ug/L)	TOLUENE (ug/L)	ETHYLBENZ. (ug/L)	m,p-XYLENES (ug/L)	o-XYLENE (ug/L)	Total BTEX (ug/L)	Total VOC (ug/L)
DMW-10-1P 1 June 94 11 Oct 94 24 Jan 95	107.0 439 315.0	<4 <4 <4	<5 56.8 71.0	<5 163 100.0	<1 <1 <1	86.0 13.2 6.0	<1 <1 8.0	133.0 10.8 56.0	43.0 <1 68.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	615.0 682.4 624.0
DMW-25-1P 1 June 94 11 Oct 94 24 Jan 95	6.0 293 42.0	<4 <4 336.0	<5 56.0 <5	<5 129 9.0	<1 <1 <1	26.0 3.28 100.0	<1 <1 <1	4.0 7.5 17.0	21.0 1.34 15.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	59.0 490.2 519.0
DMW-45-1P 1 June 94 11 Oct 94 24 Jan 95	5.0 281 67.0	<4 <4 303.0	<5 16 <5	<5 25 23.0	<1 <1 <1	5.0 10.2 25.0	<1 <1 <1	8.0 15.6 29.0	2.0 6.80 20.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	20.0 354.6 467.0
DMW-75-1P 1 June 94 11 Oct 94 24 Jan 95	4.0 54 21.0	<4 10.1 685.0	<5 10.4 <5	<5 <9 <9	<1 <1 <1	2.0 3.02 15.0	<1 <1 <1	1.0 1.37 12.0	<1 <1 8.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	7.0 76.9 747.0
AAS-1 1 June 94 11 Oct 94 24 Jan 95	10500.0 1489 63.0	<186 357 223.0	<208 86.4 187.0	<352 316 <9	<2 <1 <1	1230.0 104 46.0	<1 <1 <1	9080.0 280 49.0	2450.0 91.7 88.0	<266 <7 <7	<266 <7.2 <7.2	<266 <9 <9	<266 <14.3 <14.3	<266 <2.9 <2.9	ND ND ND	23260.0 2724.1 656.0
DMW-10-1 1 June 94 11 Oct 94 24 Jan 95	420.0 423 19.0	<908 44 <4	<1078 42.3 <5	<2300 176 22.0	<1 <1 <1	414.0 10.5 <1	<1 <1 <1	102.0 12.9 4.0	15.0 <1 <1	<532 <1 <1	<532 <1 <1	<532 <1 <1	<532 <1 <1	<532 <1 <1	ND ND ND	951.0 665.0 45.0
DMW-25-1 1 June 94 11 Oct 94 24 Jan 95	688.0 649 391.0	<202 44 647.0	<224 45 117.0	659.0 89 178.0	<1 <1 <1	34.0 9.30 6.0	<1 <1 10.0	13.0 13.0 57.0	<1 3.11 16.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	1394.0 763.7 1432.0
DMW-45-1 1 June 94 11 Oct 94 24 Jan 95	168.0 410 44.0	<4 44 116.0	<5 47.1 <5	79.0 47.1 10.0	<1 4.96 2.0	94.0 8.26 5.0	<1 <1 <1	131.0 15.6 4.0	15.0 3.47 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	490.0 489.7 181.0
DMW-75-1 1 June 94 11 Oct 94 24 Jan 95	56.0 251 80.0	<4 44 <4	<5 45 <5	<9 22.9 <9	<1 <1 <1	53.0 5.99 19.0	<1 <1 <1	43.0 9.88 15.0	9.0 3.45 17.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	161.0 292.9 131.0
SMW-10-1P 1 June 94 13 Oct 94 24 Jan 95	3.0 23.0 19.0	<4 13.6 <4	<5 16.1 <5	<9 <9 <9	<1 <1 <1	4.0 3.2 <1	<1 <1 <1	3.0 2.0 <1	<1 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	10.0 61.8 19.0
SMW-25-1P 1 June 94 13 Oct 94 24 Jan 95	2.0 94.9 4.0	<4 13.9 13.0	<4 47.8 <5	<4 <9 <9	<1 <1 <1	6.0 3.8 10.0	<1 <1 <1	2.0 2.8 1.0	<1 1.1 1.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	10.0 186.9 29.0
SMW-45-1P 1 June 94 13 Oct 94 24 Jan 95	3.0 60.1 7.0	<4 9.4 <4	6.0 15.2 <5	<9 <9 <9	<1 <1 <1	4.0 4.8 11.0	<1 <1 <1	3.0 2.8 1.0	1.0 1.7 1.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	17.0 93.9 20.0
SMW-75-1P 1 June 94 13 Oct 94 24 Jan 95	<1 34.6 1.0	<4 7.9 5.0	<5 7.8 <5	<9 <9 <9	<1 2.3 <1	<1 1.3 3.0	<1 <1 <1	<1 <1 <1	<1 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	ND 53.9 9.0
SMW-10-1 1 June 94 12 Oct 94 24 Jan 95	<1 27.1 3.0	<4 34.0 <4	<4 27.2 <5	<6 <9 <9	<1 <1 <1	4.0 2.4 <1	<1 <1 <1	3.0 1.8 2.0	<1 <1 2.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	7.0 61.9 41.0
SMW-25-1 1 June 94 12 Oct 94 24 Jan 95	2.0 43.4 39.7	<4 44 <4	<5 5.4 10.0	<9 9.9 <9	<1 <1 <1	6.0 4.4 1.5	<1 <1 <1	4.0 3.8 2.0	<1 1.4 2.0	<3.0 2.3 3.0	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	12.0 55.3 63.8
DUP 12 Oct 94 DUP 24 Jan 95	14.0	13.0	10.0	<9	<1	<1	<1	6.0	1.0	<3.0	<3.0	<3.0	<3.0	<3.0	ND	19.0
SMW-45-1 1 June 94 12 Oct 94 24 Jan 95	5.0 23.2 5.0	<4 44 <4	<5 45 <5	<9 49 <9	<1 <1 <1	7.0 3.2 3.0	<1 <1 <1	6.0 3.4 2.0	1.0 1.2 2.0	<3.0 1.3 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	19.0 32.3 12.0
SMW-75-1 1 June 94 12 Oct 94 24 Jan 95	<1 13.0 3.0	<4 44 23.0	<5 45 <5	<9 49 11.0	<1 <1 <1	<1 1.7 2.0	<1 <1 <1	<1 1.3 <1	<1 2.1 <1	<3.0 2.1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	<3.0 <1 <1	ND ND ND	ND 18.1 39.0

NA = Not Applicable ND = Not Detected
 *C# = sample concentration was determined to be less than the detection limit (#)

Table F.4-9 (Continued) Dover AFB - Site SS59 - Misc. Wells
Ground-Water Monitoring Results - Extended AAS/SVE Test

	1,1-DCE (ug/L)	MC (ug/L)	1,1,2-DCE (ug/L)	1,1,2-DCE (ug/L)	CHLOROFORM (ug/L)	TCM (ug/L)	CI (ug/L)	ICE (ug/L)	PCE (ug/L)	BENZENE (ug/L)	TOLUENE (ug/L)	ETHYLBENZ. (ug/L)	m,p-XYLENES (ug/L)	o-XYLENE (ug/L)	total BTEX (ug/L)	total VOC (ug/L)
Z11-S 2 June 94	95.2	346.9	439.8	716.7	3.7	180.6	<1	55.9	3.9	<1	<1	<1	<1	<1	ND	1842.6
Z11-O 2 June 94	38.1	136.7	175.9	286.7	1.5	16.5	<1	889.1	278.8	<1	<1	<1	<1	<1	ND	1625.2
DGP-1 9 June 94	186.0	113.0	<5	624.0	<1	51.0	<1	89.0	2.0	<1	<1	<1	<1	<1	ND	1045.0
DGP-2 9 June 94	473.0	41.0	<5	751.0	<1	48.0	<1	89.0	4.0	<1	9.0	<1	<1	<1	9.0	1415.0
DGP-3 9 June 94	5.0	<4	<5	13.0	<1	6.0	<1	2.0	<1	<1	2.0	<1	<1	<1	2.0	28.0

Table F.4-9 (Continued) Dover AFB - Site SS59 - Direct Push Samples
Ground-Water Monitoring Results - Extended AAS/SVE Test

	1,1-DCE (ug/L)	MC (ug/L)	1,1,2-DCE (ug/L)	1,1,2-DCE (ug/L)	CHLOROFORM (ug/L)	TCM (ug/L)	CI (ug/L)	ICE (ug/L)	PCE (ug/L)	BENZENE (ug/L)	TOLUENE (ug/L)	ETHYLBENZ. (ug/L)	m,p-XYLENES (ug/L)	o-XYLENE (ug/L)	total BTEX (ug/L)	total VOC (ug/L)
DP-1 2 June 94	<1	<4	8.9	<8.0	<1	<1	<1	1.9	<1	12.8	<1	<1	<1	<1	12.6	23.3
DP-2 2 June 94	2.9	17.2	<5	<8.0	<1	2.9	<1	1.2	<1	5.4	<1	<1	<1	<1	5.4	29.4
DP-3 2 June 94	10.8	<4	38.4	20.3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ND	69.5
DP-4 25 Jan 95	6.0	<4	<5	75.0	<1	2.0	<1	<1	<1	2.0	2.0	<1	<1	<1	4.0	87.0
DP-5 2 June 94	1.3	<4	<5	<8.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ND	1.3
DP-6 25 Jan 95	19.0	183.0	29.0	12.0	<1	4.0	2.0	43.0	9.0	2.0	5.0	2.0	2.0	<1	11.0	292.0
DP-7 2 June 94	6.8	<4	<5	16.9	<1	<1	<1	<1	<1	5.9	<1	<1	<1	<1	5.9	29.5
DP-8 25 Jan 95	120.0	180.0	340.0	103.0	<1	33.0	3.0	17.0	13.0	48.0	14.0	6.0	6.0	<1	74.0	893.0
DP-9 2 June 94	3.2	<4	5.1	18.1	<1	3.3	<1	<1	<1	<1	<1	<1	<1	<1	ND	29.7
DP-10 25 Jan 95	6.0	<4	<5	11.0	<1	2.0	<1	<1	<1	<1	<1	<1	<1	<1	ND	19.0
DP-11 2 June 94	4.3	<4	<5	<8.0	<1	1.0	<1	<1	<1	<1	<1	<1	<1	<1	ND	5.3
DP-12 25 Jan 95	4.0	<4	<5	<8.0	<1	2.0	<1	<1	<1	<1	<1	<1	<1	<1	ND	6.0
DP-13 2 June 94	<1	<4	<5	<8.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ND	4.2
DP-14 25 Jan 95	11.0	40.0	<5	42.0	<1	<1	<1	<1	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	ND
DP-15 2 June 94	1.0	<4	<5	<8.0	<1	<1	<1	5.0	11.0	4.0	9.0	12.0	45.0	<1	70.0	179.0
DP-16 25 Jan 95	12.0	61.0	<5	138.0	<1	6.0	<1	<1	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	1.0
DP-17 2 June 94	3.0	<4	6.0	<8.0	<1	<1	<1	<1	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	264.0
DP-18 25 Jan 95	3.0	<4	9.0	<8.0	<1	2.0	<1	2.0	2.0	<1	<1	<1	<1	<1	ND	9.0
DP-19 2 June 94	4.0	<4	<5	<8.0	10.0	<1	<1	1.0	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	15.0
DP-20 25 Jan 95	755.0	<4	<5	1304.0	<1	6.0	9.0	83.0	15.0	<1	<1	<1	<1	<1	ND	2175.0
DP-21 2 June 94	14.0	19.0	<5	19.0	<1	7.0	<1	4.0	<1	<3.0	<3.0	<3.0	<3.0	<3.0	ND	63.0
DP-22 25 Jan 95	4.0	9.0	5.0	<8.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ND	18.0

NA = Not Applicable ND = Not Detected
*# = sample concentration was determined to be less than the detection limit (#)

Appendix G

System Operational Data

6-Month AAS/SVE System Operational Condition Record

Date (MM-DD-YY)	Extraction Flow Rate (acfm)		Extraction Pressure (inches of H ₂ O)		Injection Flow Rate (acfm)		Injection Pressure (psig)	
	SVE1	SVE2	SVE1	SVE2	AAS1	AAS2	AAS1	AAS2
6-16-94			58	67	4	5	12.4	13.2
6-28-94			55	80	4	7	11.3	13.2
7-8-94(NA)								
8-4-94			56	79	6	7	10.8	11.7
8-18-94			56	89	5	5	12.5	10.5
9-1-94			64	90	5	5	12.5	10.5
9-22-94			52	64	12	5	13	11.5
10-7-94 (NA) (1)					SD	SD	SD	SD
10-13-94			40	40	4.5	4	13	14
10-27-94			49	40	SD	SD	SD	SD
11-14-94			38	40	3	2.5	12	11

1 -- SVE1 well was not operated on 7 Oct. 94. SVE1 piping system was connected with the horizontal extraction well on 10 Oct 94.

SD -- Air compressor was not operating.

WELLS - SECTION 1

#	Location Name	Sunday -94	Monday -94	Tuesday -94	Wednesday -94	Thursday -94	Friday 6-10-94	Saturday 6-12-94
	Initials							MOO
	Time						✓	0830
1	VMW75-1P						TR	noy.
2	SMW75-1P						TR	noy.
3	VMW45-1P						TR	noy.
4	SMW45-1P							.01
5	VMW25-1P						I	noy.
6	SMW25-1P						U	noy.
7	VMW10-1P						U	noy.
8	SMW10-1P						U	OFF SCALE
9	AAS-1 (CFM)							N/A
10	AAS-1 (PSI)							N/A
11	SVE-1 (in H ₂ O)							N/A
12	VMW10-1							noy.
13	SMW10-1							OFF SCALE
14	VMW25-1							.14
15	SMW25-1							OFF SCALE
16	VMW45-1							.25
17	SMW45-1							OFF SCALE
18	VMW75-1							.29
19	SMW75-1							.30

sum

7.5

12-10W 9:52

WELLS - SECTION 1

#	Location Name	Sunday 6-12-94	Monday 6-13-94	Tuesday 6-14-94	Wednesday 6-15-94	Thursday 6-16-94	Friday 6-17-94	Saturday 6-18-94
	Initials	SD	SD	SD	SD	RAW	SD	SD
	Time	1205	1442	0804	0950	0745	1320	0815
1	VMW75-1P	.02	.05	.02	0	.02-L	.02	0
2	SMW75-1P	.02	.06	.02	0	.02-L	.03	0
3	VMW45-1P	.02-L	.02-L	.05-L	.05-L	.07-L	.02	.02
4	SMW45-1P	.03	.06	.02-L	.04-L	.03-L	.02	.02
5	VMW25-1P	.22-L	.24-L	.29-L	.17-L	.05-L	.02-L	.03-L
6	SMW25-1P	.06-L	.12-L	.13-L	.10-L	.17-L	.05-L	.03-L
7	VMW10-1P	.49-L	.46-L	OFF SCALE-L	.33 OFF SCALE-L	.10-L	.19-L	.04-L
8	SMW10-1P	OFF SCALE	OFF SCALE	.30	.18-L	.24-L	.08-L	.04-L
9	AAS-1 (CFM)	N/A	N/A	N/A	7	57.4	7	7
10	AAS-1 (PSI)	N/A	N/A	N/A	115	12	12	13
11	SVE-1 (in H ₂ O)	N/A	N/A	N/A	25 N/A	AIR LEAK AROUND PVC 4" PLUG		
12	VMW10-1	.08-L	.10-L	.13-L	.17-L	.17-L	.08-L	.08-L
13	SMW10-1	OFF SCALE	OFF SCALE	OFF SCALE	.12	.12	.06-L	0
14	VMW25-1	.22	.20	.17	0	.02	.10	.10
15	SMW25-1	OFF SCALE	OFF SCALE	OFF SCALE	.20	.07	.12	.14
16	VMW45-1	.33	.35	.30	.12	.15	.23	.22
17	SMW45-1	OFF SCALE	OFF SCALE	OFF SCALE	1.15	.25	1.05	2.00
18	VMW75-1	.37	.37	.34	.11	.12	.22	.20
19	SMW75-1	.40	.39	.34	.12	.13	.25	.24

Turned
AAS-1 on
11:00

12-0

WELLS - SECTION 1

#	Location Name	Sunday 6-19-94	Monday 6-20-94	Tuesday 6-21-94	Wednesday 6-22-94	Thursday 6-23-94	Friday 6-24-94	Saturday 6-25-94
	Initials	AD	TK	PLW	AD		AD	
	Time	1205	1309	0755	0847		0849	
1	VMW75-1P	.04	.04	.01	.14-L		.10-L	
2	SMW75-1P	.05	.03	.02	.13-L		.10-L	
3	VMW45-1P	.05	.04	.02	.27-L		.23-L	
4	SMW45-1P	.06	.05	.02	.27-L		.21-L	
5	VMW25-1P	.02-L	.03-L	.03-L	.49-L		.46-L	
6	SMW25-1P	.03-L	.04-L	.03-L	.43-L		.37-L	
7	VMW10-1P	.05-L	.06	.09	.65-L		.68-L	
8	SMW10-1P	0	.02-L	.07-L	.50-L		.50-L	
9	AAS-1 (CFM)	7	7	7	N/A		N/A ⁴	
10	AAS-1 (PSI)	12	12	12	N/A		N/A ¹⁴	
11	SVE-1 (in H ₂ O)	-	-	-	N/A		N/A	
12	VMW10-1	.07-L	.5-L	.07-L	.44-L		.43-L	
13	SMW10-1	.01-L	.01	.00	.33-L		.38-L	
14	VMW25-1	.13	.12	.13	.31-L		.32-L	
15	SMW25-1	.16	.17	.13	.25-L		.29-L	
16	VMW45-1	.26	.25	.23	.26-L		.26-L	
17	SMW45-1	OFF SCALE-2	1.90	1.80	.24-L		.02	
18	VMW75-1	.25	.24	.23	.26-L		.26-L	
19	SMW75-1	.30	.28	.27	.27-L		.28-L	

*
Turned
Comp.
on
@
12:00
TRF

WELLS - SECTION 1

Recurrent
Boiler
PPL

#	Location Name	Sunday 6-26-94	Monday 6-27-94	Tuesday 6-28-94	Wednesday 6-29-94	Thursday 6-30-94	Friday - -94	Saturday - -94
	Initials			RD	RD	HW		
	Time			1340	1253	5905		
1	VMW75-1P			.05	.08	.10		
2	SMW75-1P			.05	.09	.09		
3	VMW45-1P			.05	.20	.03 ^L		
4	SMW45-1P			.04	.17	.04 ^L		
5	VMW25-1P			.03 ^L	.25	.32 ^L		
6	SMW25-1P			.06 ^L	.16	.15 ^L		
7	VMW10-1P			.45 ^L	.02	.90 ^L		
8	SMW10-1P			OFF SCALE-2	OFF SCALE-2	1.50		
9	AAS-1 (CFM)			6	6	6		
10	AAS-1 (PSI)			12	12	12		
11	SVE-1 (in H ₂ O)			N/A	N/A	N/A		
12	VMW10-1			.22 ^L	.05	.50 ^L		
13	SMW10-1			OFF SCALE-2	OFF SCALE-2	.25		
14	VMW25-1			0	.15	.17		
15	SMW25-1			.05 ^L	.16	.10 ^L		
16	VMW45-1			.11	.20	.08		
17	SMW45-1			.32 ^L	.12	0		
18	VMW75-1			.11	.12	.16		
19	SMW75-1			.15	.15	.18		

data end on 7/7/94
 JK

WELLS - SECTION 1

#	Location Name	Sunday 3 July 94	Monday 4 July 94	Tuesday 5 July 94	Wednesday 6 July 94	Thursday 7 July 94	Friday 8 July 94	Saturday 9 July 94
	Initials			RHW		JK		
	Time			0930		0918		
1	VMW75-1P			.05		0		
2	SMW75-1P			.25		0		
3	VMW45-1P			.08		.02-L		
4	SMW45-1P			.07		.04-L		
5	VMW25-1P			.06		.14-L		
6	SMW25-1P			0		.49-L		
7	VMW10-1P			.15 ^L		.47-L		
8	SMW10-1P			.OFF HAIL		1.25		
9	AAS-1 (CFM)			6 ⁺		0		
10	AAS-1 (PSI)			12		10		
11	SVE-1 (in H ₂ O)			N/A		N/A		
12	VMW10-1			.08		.27-L		
13	SMW10-1			1.90		.33		
14	VMW25-1			.06		.08		
15	SMW25-1			.06		.08-L		
16	VMW45-1			.14		.02		
17	SMW45-1			.04		1.55-L		
18	VMW75-1			.11		.01-L		
19	SMW75-1			.12		.01-L		

WELLS - SECTION 2

#	Location Name	Sunday -94	Monday -94	Tuesday -94	Wednesday -94	Thursday -94	Friday 6-10-94	Saturday 6-11-94
	Initials							TL00
	Time							0820
20	SMW75-2						S	OFF SCALE
21	VMW75-2						P	OFF SCALE
22	SMW45-2						P	OFF SCALE
23	VMW45-2						P	OFF SCALE
24	SMW20-2							OFF SCALE
25	VMW20-2						C	OFF SCALE
26	SMW10-2						D	OFF SCALE
27	VMW10-2							OFF SCALE
28	AAS-2 (CFM)							6 BOTTOM
29	AAS-2 (PSI)							8
30	SVE-2 (in H ₂ O)							22
31	SMW10-2P							.49
32	VMW10-2P							.19
33	SMW34-2P							OFF SCALE
34	VMW34-2P							OFF SCALE
35	SMW45-2P							OFF SCALE
36	VMW45-2P							OFF SCALE
37	SMW75-2P							
38	VMW75-2P							

WELLS - SECTION 2

#	Location Name	Sunday 6-12-94	Monday 6-13-94	Tuesday 6-14-94	Wednesday 6-15-94	Thursday 6-16-94	Friday 6-17-94	Saturday 6-18-94
	Initials	YDN	YDN	YDN	YDN	RAW	YDN	YDN
	Time	1245	1454	0819	1010	0843	1331	0826
20	SMW75-2	OFF SCALE	OFF SCALE	OFF SCALE	.40	.34	.50	.50
21	VMW75-2	OFF SCALE	OFF SCALE	OFF SCALE	.40	.32	.55	.50
22	SMW45-2	OFF SCALE	OFF SCALE	OFF SCALE	1.10	1.00	1.80	1.75
23	VMW45-2	OFF SCALE	OFF SCALE	OFF SCALE	.95	.90	1.30	1.25
24	SMW20-2	OFF SCALE	OFF SCALE	OFF SCALE	2.00	1.95	OFF SCALE	OFF SCALE
25	VMW20-2	OFF SCALE	OFF SCALE	OFF SCALE	.65	.60	1.00	.95
26	SMW10-2	OFF SCALE	OFF SCALE	OFF SCALE	1.10	1.00	1.50	1.45
27	VMW10-2	OFF SCALE	OFF SCALE	OFF SCALE	.80	.75	1.15	1.10
28	AAS-2 (CFM)	6-Bottom	6-Bottom	6-8	5-7	5	8	7
29	AAS-2 (PSI)	8	8	8	12	12.8	14	14
30	SVE-2 (in H ₂ O)	21	21	21	20	20	20	20
31	SMW10-2P	OFF SCALE	OFF SCALE	OFF SCALE	.20-L	.22-L	.08	.06
32	VMW10-2P	.37	.40	.38	.45-L	.46-L	.18-L	.20-L
33	SMW34-2P	OFF SCALE	OFF SCALE	OFF SCALE	.50	.495	.80	.85
34	VMW34-2P	OFF SCALE	OFF SCALE	OFF SCALE	.20	.20	.50	.45
35	SMW45-2P	OFF SCALE	OFF SCALE	OFF SCALE	.70	.75	1.40	1.40
36	VMW45-2P	OFF SCALE	OFF SCALE	OFF SCALE	.45	.45	.80	.85
37	SMW75-2P							
38	VMW75-2P							

WELLS - SECTION 2

#	Location Name	Sunday 6-19-94	Monday 6-20-94	Tuesday 6-21-94	Wednesday 6-22-94	Thursday 6-23-94	Friday 6-24-94	Saturday 6-25-94
	Initials	THO	THO	RHW	THO		THO	
	Time	1230	1325	0812	0856		0903	
20	SMW75-2	.50	.50	.48	.20-L		.19-L	
21	VMW75-2	.35	.35	.50	.22-L		.21-L	
22	SMW45-2	1.85	1.80	1.80	.35-L		.32-L	
23	VMW45-2	.75	.15	.06	0		0	
24	SMW20-2	OFF SCALE-2	OFF SCALE-2	OFF SCALE	.35-L		.60-L	
25	VMW20-2	1.05	1.00	1.00	.35-L		.60-L	
26	SMW10-2	1.55	1.55	1.55	.80-L		.85-L	
27	VMW10-2	1.20	1.20	1.15	.80-L		.80-L	
28	AAS-2 (CFM)	8	8	8	N/A		N/A 4	
29	AAS-2 (PSI)	13	14	14	N/A		N/A 14	
30	SVE-2 (in H ₂ O)	20	20	20	N/A		N/A	
31	SMW10-2P	.14	.12-L	.13	.80-L		.95-L	
32	VMW10-2P	.12-L	.12-L	.15	1.00-L		1.10-L	
33	SMW34-2P	.90	.90	.80	.40-L		.50-L	
34	VMW34-2P	.55	.50	.42	.35-L		.60-L	
35	SMW45-2P	1.45	1.45	1.27	.25-L		.37-L	
36	VMW45-2P	.90	.90	.80	.25-L		.36-L	
37	SMW75-2P							
38	VMW75-2P							

*
 Turned
 Comp
 @ 12:00
 TCF

WELLS - SECTION 2

#	Location Name	Sunday 6-26-94	Monday 6-27-94	Tuesday 6-28-94	Wednesday 6-29-94	Thursday 7-1-94	Friday - -94	Saturday - -94
	Initials	I		JKO	JKO	Rdw		
	Time			1348	130.3	0922		
20	SMW75-2			.36	.38	.39		
21	VMW75-2			.34	.40	.40		
22	SMW45-2			.75	.75	1.00		
23	VMW45-2			.03	0	0		
24	SMW20-2			1.45	1.50	1.80		
25	VMW20-2			.35	.50	.85		
26	SMW10-2			1.25	1.75	1.95		
27	VMW10-2			0	0	0		
28	AAS-2 (CFM)			6	6	6		
29	AAS-2 (PSI)			15	14.5	14.5		
30	SVE-2 (in H ₂ O)			N/A	N/A	N/A		
31	SMW10-2P			.27-L	.35-L	0		
32	VMW10-2P			.50-L	.85-L	.18 ^L		
33	SMW34-2P			.30	.21	.50		
34	VMW34-2P			.07	.19-L	.28		
35	SMW45-2P			.35	.50	.60		
36	VMW45-2P			.35	.25	.50		
37	SMW75-2P			0	0	0		
38	VMW75-2P			0	0	0		

WELLS - SECTION 2

#	Location Name	Sunday - -94	Monday - -94	Tuesday 7-6-94	Wednesday - -94	Thursday 7-7-94	Friday - -94	Saturday - -94
	Initials			RHW		YOK		
	Time			0945		1937		
20	SMW75-2			.33		.27		
21	VMW75-2			.34		.25		
22	SMW45-2			.80		.75		
23	VMW45-2			0		0		
24	SMW20-2			1.10		.85		
25	VMW20-2			.35		.20		
26	SMW10-2			1.25		.60		
27	VMW10-2			0		0		
28	AAS-2 (CFM)			6		—		
29	AAS-2 (PSI)			14.5		—		
30	SVE-2 (in H ₂ O)			N/A		N/A		
31	SMW10-2P			.48 ^L		NO PRESSURE RELEASED BY E.P.		
32	VMW10-2P			.65 ^L				
33	SMW34-2P			.20				
34	VMW34-2P			.07 ^L				
35	SMW45-2P			.50				
36	VMW45-2P			.29				
37	SMW75-2P							
38	VMW75-2P							

TRAILERS

SPARGE

	Location	Sunday -94	Monday -94	Tuesday -94	Wednesday -94	Thursday -94	Friday 6-11-94	Saturday 6-12-94
	Initials						TKF	TKD
	Time						3:15	0815
39	PRESSURE						95	92
40	OIL						OK	OK
41	CONDENSATE						✓	✓
42	AIR DRYER						✓	✓

VENT

	Location	Sunday -94	Monday -94	Tuesday -94	Wednesday -94	Thursday -94	Friday 6-11-94	Saturday 6-12-94
	Initials						TKF	TKD
	Time						3:15	0818
46	PRESSURE (IN)						50	50
47	PRESSURE (OUT)						NA	N/A
48	FLOW (CFM) <i>FP4</i>						3000	3000
49	MOIST SEP <i>PPM</i>						✓	✓
50	PRTC FILTER						✓	✓

If you have any questions or problems, or if the system is not operating properly please call:

Tom Fruehstorfer (302) 325-3560
 EA Engineering
 92 Read's Way, Suite 109
 New Castle, DE 19720

After business hours or weekends call (302) 655-0485 and leave a message

TRAILERS

SPARGE

	Location	Sunday 6-12-94	Monday 6-13-94	Tuesday 6-14-94	Wednesday 6-15-94	Thursday 6-16-94	Friday 6-17-94	Saturday 6-18-94
	Initials	JLD	JLD	JLD	JLD	RHW	JLD	JLD
	Time	1257	1438	0757	0947	0855	1316	0810
39	PRESSURE	93	95	94	92	94	80	80
40	OIL	OK	OK	OK	OK	OK	OK	OK
41	CONDENSATE	✓	✓	✓	✓	✓	✓	✓
42	AIR DRYER	✓	✓	✓	✓	✓	✓	✓

VENT

	Location	Sunday 6-12-94	Monday 6-13-94	Tuesday 6-14-94	Wednesday 6-15-94	Thursday 6-16-94	Friday 6-17-94	Saturday 6-18-94
	Initials	JLD	JLD	JLD	JLD	RHW	JLD	JLD
	Time	1205	1435	0755	0945	0800	1315	0812
46	PRESSURE (IN)	50	48	48	48	48	~~46~~	44
47	PRESSURE (OUT)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48	FLOW (CFM) FAN	3000	3000	3000	3000	3000	3000	3000
49	MOIST SEP	✓	✓	✓	✓	✓	✓	✓
50	PRTC FILTER	✓	✓	✓	✓	✓	✓	✓

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TRAILERS

SPARGE

	Location	Sunday 6-19-94	Monday 6-20-94	Tuesday 6-21-94	Wednesday 6-22-94	Thursday 6-23-94	Friday 6-24-94	Saturday 6-25-94
	Initials	JRD	JRD	RHW	JRD		JRD	
	Time	1200	1305	0750	0846		0845	
39	PRESSURE	78	80	80	OFF		OFF	
40	OIL	OK	OK	OK	OFF		OFF	
41	CONDENSATE	✓	✓	✓	✓		OFF	
42	AIR DRYER	✓	✓	✓	✓		OFF	

VENT

	Location	Sunday 6-19-94	Monday 6-20-94	Tuesday 6-21-94	Wednesday 6-22-94	Thursday 6-23-94	Friday 6-24-94	Saturday 6-25-94
	Initials	JRD	JRD	RHW	JRD		JRD	
	Time	1202	1307	0750	0845		0846	
46	PRESSURE (IN)	46	46	46	46		46	
47	~~PRESSURE (OUT)~~	N/A	N/A	N/A	N/A		N/A	
48	FLOW (CFM) ~~FAH~~	3000	3000	3000	3000		3000	
49	MOIST SEP	✓	✓	✓	✓		✓	
50	PRTC FILTER	✓	✓	✓	✓		✓	

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TRAILERS

SPARGE

	Location	Sunday 6-26-94	Monday 6-27-94	Tuesday 6-28-94	Wednesday 6-29-94	Thursday 6-30-94 ~~Friday~~ FRI 1-Jul-94	Friday - .94	Saturday - .94
	Initials			QND	QND	RHW		
	Time			0810	1231	0800		
39	PRESSURE			120	110	110		
40	OIL			OK	OK	OK		
41	CONDENSATE			✓	✓	✓		
42	AIR DRYER			✓	✓	✓		
	CFM			8	8			

VENT

	Location	Sunday 6-26-94	Monday 6-27-94	Tuesday 6-28-94	Wednesday 6-29-94	Thursday 6-30-94 ~~Friday~~ FRI 1-Jul-94	Friday - .94	Saturday - .94
	Initials			QND	QND	RHW		
	Time			0950	1230	0850		
46	PRESSURE (IN)			80-130 64	64	82-88		
47	PRESSURE (OUT)			N/A	N/A	N/A		
48	FLOW (CFM)			3000	2800	2900		
49	MOIST SEP			✓	✓	15+ Gal		
50	PRTC FILTER			✓	✓	✓		

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TRAILERS

SPARGE

	Location	Sunday - -94	Monday - -94	Tuesday 5 July -94	Wednesday - -94	Thursday 7-7 -94	Friday - -94	Saturday - -94
	Initials			RHW		OK		
	Time			0920		0917		
39	PRESSURE			110		114		
40	OIL			OK		OK		
41	CONDENSATE			✓		✓		
42	AIR DRYER			✓		✓		

VENT

	Location	Sunday - -94	Monday - -94	Tuesday 6-7 -94	Wednesday - -94	Thursday 7-7 -94	Friday - -94	Saturday - -94
	Initials			RHW		OK		
	Time			0925		0915		
46	PRESSURE (IN)			69		72		
47	PRESSURE (OUT)							
48	FLOW (FPM)			2700	~~2700~~	2800		
49	MOIST SEP			861		✓		
50	PRTC FILTER			✓		✓		

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 EA Engineering
 92 Read's Way, Suite 109
 New Castle, DE 19720

After business hours or weekends call (302) 655-0485 and leave a message

L = Low (vacuum) WELLS - SECTION 1

8-18
RAIN

#	Location Name	7-11 ⁹⁴	7-12 ⁹⁴	8-9 ⁹⁴	8-12 ⁹⁴	8-16 ⁹⁴	9-27 ⁹⁴	.94
	Initials	AD	AD	AD	FE	AD	AD	
	Time	0915	0840	0840	0917	0942	1320	
1	VMW75-1P	.09	.08-L	.19-L	.18-L	.18-L	.70-L	
2	SMW75-1P	*.14	.08-L	0	0	.16-L	.70-L	
3	VMW45-1P	.35	.05-L	.44-L	.45-L	.38-L	1.50-L	
4	SMW45-1P	*.35	.05	.40-L	.42-L	.34-L	1.45-L	
5	VMW25-1P	.55	.07-L	.70-L	.75-L	.55-L	OFF SCALE-L	
6	SMW25-1P	.50	.54	.06-L	.08-L	.06-L	OFF SCALE-L	
7	VMW10-1P	.65	.37-L	1.15-L	1.25-L	.90-L	OFF SCALE-L	
8	SMW10-1P	1.35	.50	.85-L	1.00-L	.65-L	OFF SCALE-L	
9	AAS-1 (CFM)	4	4	0	0	0	0	
10	AAS-1 (PSI)	13	13	0	0	0	15	
11	SVE-1 (in H ₂ O)	—	—	—	—	—	—	
12	VMW10-1	.50	.18-L	.65-L	.80-L	.55-L	OFF SCALE-L	
13	SMW10-1	1.20	.53	.65-L	.75-L	1.52-L	1.60-L	
14	VMW25-1	.50	.03	.40-L	.50-L	.37-L	OFF SCALE-L	
15	SMW25-1	.50	.03	.35-L	.49-L	.33-L	OFF SCALE-L	
16	VMW45-1	.50	.17	.16-L	.28-L	.18-L	1.55-L	
17	SMW45-1	.09	.02	.10-L	.22-L	.15-L	1.60-L	
18	VMW75-1	.50	.15	.03-L	.16-L	.04-L	.90-L	
19	SMW75-1	.55	.17	.02-L	.15-L	.02-L	.90-L	

* OPEN

* OPEN

COMMENTS:

- 7-11 - RESULTS FALSE READINGS, (NO VACUUM) (PRIOR TO SHUT DOWN)
- 7-27 - PVC MELTED ON VAC SIDE. AIR COMING FROM MOTORS BLOWERS TO HOT.
- 7-29 - PIPES REPLACED WITH 4" HOSE.
- 8-3 - COMPRESSOR KICKING BREAKER, VAC SIDE VERY HOT IN BLDG., NEEDS VENT. FLOW METERS BOUNCING UP + DOWN.
- 8-4 - COMPRESSOR PRESSURE LOW, WILL NOT KEEP UP WITH DEMAND, WELL FLOW METERS AT 4 CFM. SEEMS TO BE BREAK IN LINE, SIDE NEAR STREET.

WELLS - SECTION 2

#	Location Name	7-11 ⁰⁴	7-12 ⁰⁴	8-9 ⁰⁴	8-12 ⁰⁴	8-16 ⁰⁴	9-27 ⁰⁴	.04
	Initials	AD	AD	AD	AD	AD	AD	
	Time	0925	0852	0851	0925	0950	1335	
20	SMW75-2	.85	.50	.10	.05-L	.03	.95-L	
21	VMW75-2	.85	.50	.10	.06-L	.03	1.25-L	
22	SMW45-2	OFF SCALE-2	1.65	.75	.45-L	.50	1.24-L	
23	VMW45-2	0	0	0	0	0	.21-L	
24	SMW20-2	1.55	.35	1.15	.75-	.85	.44	
25	VMW20-2	1.85	.75	.55	.35	.55	.12	
26	SMW10-2	OFF SCALE-2	1.80	1.25	.80	1.35	0	
27	VMW10-2	OFF SCALE-2	1.10	.75	.45	.90	0	
28	AAS-2 (CFM)	4	4	6	4	4	4	
29	AAS-2 (PSI)	14	14	13	12	12	12	
30	SVE-2 (in H ₂ O)	—	—	—	—	—	—	
31	SMW10-2P	1.25	.44-L	.06-L	.28-L	.12	.22-L	
32	VMW10-2P	1.20	.50-L	.15-L	.39-L	.12	.29-L	
33	SMW34-2P	1.60	.60	.49	.22	.48	.11	
34	VMW34-2P	1.30	.32	.26	.01	.30	0	
35	SMW45-2P	1.80	1.20	.60	.34	.45	.22	
36	VMW45-2P	1.30	.70	.44	.20	.35	.15	
37	SMW75-2P	—	—	—	—	—	—	
38	VMW75-2P	—	—	—	—	—	—	

COMMENTS

8-05, NOTIFIED EA OF PROBLEM WITH COMPRESSOR + PRESSURE.

8-8, EA CHECKED + SET PRESSURE, COMPRESSOR WAS OK.

" , INSTALLED 2 ELECTRIC EXHAUST FANS.

8-11, ELECTRIC EXHAUST FANS SET FOR 90° SHUT OFF

TRAILERS

SPARGE

(compressor set for 150# + 120#)

Location	7-11 ⁰⁴	7-12 ⁰⁴	8-9 ⁰⁴	.04	.04	.04	.04
Initials	<i>TD</i>	<i>TD</i>	<i>TD</i>				
Time	0905	0835					
39 PRESSURE	20	30					
40 OIL	OK	OK					
41 CONDENSATE	✓	✓					
42 AIR DRYER	✓	✓					

VENT

Location	7-11 ⁰⁴	7-12 ⁰⁴	8-9 ⁰⁴	8-12 ⁰⁴	8-16 ⁰⁴	9-27 ⁰⁴	.04
Initials	<i>TD</i>	<i>TD</i>	<i>TD</i>	<i>TD</i>	<i>TD</i>	<i>TD</i>	
Time	0900	0833	0830	0915	0940	1315	
47 PRESSURE (IN)	58	56	VACUUM 58	56	64	52	
48 PRESSURE (OUT)	—	—	88	89	90	64	
48 FLOW (CFM)	2800	2600	10	11 1/2	5 + 5	32 + 5	
49 MOIST SEP	6 gal.	✓	✓	✓	✓	✓	
50 PRTC FILTER	✓	✓	✓	✓	✓	✓	

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EA Engineering
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COMMENTS:

7-13, TRAILERS DISCONNECTED + RECONNECTED

7-15, SYSTEM TURNED OFF, EXCESS WATER FROM STORM.

11, CHANGE OVER FROM TRAILERS TO PERMANENT OPERATION.

11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100

TRAILERS

SPARGE

COMPRESSOR - 120# ON + 150# OFF

	Location	10-5-94	10-7-94	10-14-94	10-18-94	10-20-94	10-25-94	11-8-94
	Initials	(JAL)	(JAL)	(JAL)	(JAL)	(JAL)	(JAL)	(JAL)
	Time	0815	0840	0955	0840	1310	0930	0820
39	PRESSURE	130	130	30	30	30	150	150
40	OIL	OK	OK	OK	OK	OK	OK	OK
41	CONDENSATE	OK	OK	OK	OK	OK	OK	OK
42	AIR DRYER	OK	OK	OK	OK	OK	OK	OK

VENT

	Location	10-5-94	10-7-94	10-14-94	10-18-94	10-20-94	10-25-94	11-8-94
	Initials	(JAL)	(JAL)	(JAL)	(JAL)	(JAL)	(JAL)	(JAL)
	Time	0816	0850	0956	0841	1312	0935	0822
46	PRESSURE (IN) #1	49	36	60	60	60	60	50
47	PRESSURE (OUT) #2	83	83	80	80	80	80	78
48	FLOW (FPM) 142	43+10	44+11	44+16	50+15	50+18	50+20	42+25
49	MOIST SEP	✓	✓	✓	✓	✓	✓	✓
50	PRTC FILTER	✓	✓	✓	✓	✓	✓	✓

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0930-10-30, Compressor off, no readings taken.
11-4, System was turned back on for service.
11-7, Tom Fruehstorfer adjusted pressure in wells 1+2, + changed all in compressor.
11-8, System seems to be operating. Compressor cycling on + off normally.

L = Low (Vacuum)

WELLS - SECTION 1

#	Location Name	10-5 ⁹⁴	10-7 ⁹⁴	10-14 ⁹⁴	10-18 ⁹⁴	10-20 ⁹⁴	10-25 ⁹⁴	11-8 ⁹⁴
	Initials	EA	EA	EA	EA	EA	EA	EA
	Time	0818	0855	0938	0842	1317	0907	0825
1	VMW75-1P	.40-L	.42-L	.26-L	.22-L	.23-L	.27-L	.27-L
2	SMW75-1P	.47-L	.43-L	.26-L	.21-L	.24-L	.28-L	.26-L
3	VMW45-1P	.80-L	.80-L	.50-L	.48-L	.50-L	.50-L	.50-L
4	SMW45-1P	.80-L	.75-L	.45-L	.46-L	.45-L	.50-L	.50-L
5	VMW25-1P	1.40-L	1.30-L	.90-L	.73-L	.80-L	.85-L	.90-L
6	SMW25-1P	1.25-L	1.20-L	.95-L	.80-L	.90-L	.95-L	.90-L
7	VMW10-1P	OFF SCALE-L	.90-L	1.75-L	1.50-L	1.65-L	1.65-L	1.60-L
8	SMW10-1P	OFF SCALE-L	.85-L	1.40-L	1.35-L	1.30-L	1.50-L	1.30-L
9	AAS-1 (CFM)	1	0	6	6	4	3	2.5
10	AAS-1 (PSI)	17	15	17	16	18	15	16
11	SVE-1 (in H ₂ O)	—	—	—	—	—	—	—
12	VMW10-1	OFF SCALE-L	.45-L	1.65-L	1.50-L	1.35-L	1.70-L	1.45-L
13	SMW10-1	OFF SCALE-L	1.0-L	2.0-L	1.75-L	1.95-L	OFF SCALE-L	1.65-L
14	VMW25-1	1.40-L	.38-L	1.05-L	.90-L	1.95-L	1.10-L	1.0-L
15	SMW25-1	1.35-L	.28-L	1.0-L	.90-L	1.0-L	1.15-L	1.0-L
16	VMW45-1	.80-L	.32-L	.60-L	.50-L	.50-L	.65-L	.65-L
17	SMW45-1	.80-L	.40-L	.55-L	.50-L	.50-L	.65-L	.65-L
18	VMW75-1	.50-L	.25-L	.35-L	.30-L	.35-L	.50-L	.50-L
19	SMW75-1	.45-L	.05-L	.35-L	.30-L	.30-L	.50-L	.50-L

10-7, (EA) Tom TAKING AIR SAMPLES AT TIME OF READINGS ON 10-7-94

10-11, EA TAKING WATER SAMPLES 11, 12, 13 OCT, System Down.

10-14, AIR TANK COMPRESSOR CONTINUES TO RUN & STAYS AT 30LB.

10-20, AIR COMPRESSOR SHUT OFF, PUSHED RESET & RESTARTED COMPRESSOR

10-30-11, BUILT UP PRESSURE TO 150LB FOR CURRENT CYCLE OF COMPRESSOR

11-13-11, PRESSURE BACK TO 30LB ON COMPRESSOR, DOESN'T KEEP UP TO 120-LB
 RUNNING TO HOT - AUTOMATIC SHUTS OFF.

WELLS - SECTION 2

#	Location Name	10-6 ⁰⁴	10-7 ⁰⁴	10-14 ⁰⁴	10-18 ⁰⁴	10-20 ⁰⁴	10-25 ⁰⁴	11-8 ⁰⁴
	Initials	TKO	TKO	TKO	TKO	TKO	TKO	TKO
	Time	0827	0900	1605	0852	1327	0915	0833
20	SMW75-2	.50-L	.26-L	.32-L	.22-L	.31-L	.50-L	.50-L
21	VMW75-2	.55-L	.37-L	.34-L	.15-L	.16-L	.38-L	.45-L
22	SMW45-2	0	.23	.30	0	.18-	.03-L	.30-L
23	VMW45-2	.06	.18	.21	.20	.10	.01-L	.25-L
24	SMW20-2	.41	.40	.40	.02	0	0	.50-L
25	VMW20-2	.12	.08	.17	.05	.03-L	.27-L	.65-L
26	SMW10-2	0	0	.55	.41	.89	.07-L	1.10-L
27	VMW10-2	0	.06-L	.17	.01-L	.03-L	.44-L	1.05-L
28	AAS-2 (CFM)	3	5	5	5	6	3	2
29	AAS-2 (PSI)	12	14	12	12	13	11	12
30	SVE-2 (in H ₂ O)	-	-	-	-	-	-	-
31	SMW10-2P	.30-L	.38-L	.30-L	.44-L	.43-L	.75-L	1.0-L
32	VMW10-2P	.40-L	.52-L	.48-L	.55-L	.55-L	.85-L	1.20-L
33	SMW34-2P	.08	0	.17	.10	0	0	.30-L
34	VMW34-2P	.06-L	0	0	0	.07	.38-L	.45-L
35	SMW45-2P	.20	.20	.38	.28	.45	0	.25-L
36	VMW45-2P	.09	.10	.23	.15	.25	.08-L	.29-L
37	SMW75-2P	-	-	-	-	-	-	-
38	VMW75-2P	-	-	-	-	-	-	-

10-20, EXHAUST FAN NEEDS THERMOSTAT ADJUSTED, (TO HOT!) ON VACUUM STOP.

(0810) 10-25, INFORMED TOM FRUEH STORFER OF COMPRESSOR PROBLEMS.

(0820) 10-25, TOM CALLED BACK & INFORMED US TO TURN PRESSURE TO (3 CFM) IN BOTH WELLS.

(0900) 10-25, Set both wells to 3 CFM, Compressor seems to be operating, will check later.

(1340) 10-25, Checked compressor & found compressor off & 0 pressure.

10-27, 1340 hrs. checked compressor, found operating normal. Checked well pressure. #1 well 2 CFM & #2 well 6 CFM. Drop well cap blue off on #2 well side during visit. Water was gushing from well, turned off compressor.

TRAILERS

SPARGE

	Location	11/14/01	1-13-85	.01	.01	.04	.04	.04
	Initials	FOE	FOE					
	Time	0915	1010					
39	PRESSURE	150	150					
40	OIL	OK	LEAKING					
41	CONDENSATE	OK	OK					
42	AIR DRYER	OK	OK					

VENT

	Location	11/14/01	1-13-85	.01	.01	.04	.04	.04
	Initials	FOE	FOE					
	Time	0917	1011					
46	PRESSURE (IN) #1	50	60					
47	PRESSURE (IN) #2	78	82					
48	FLOW (FPM) 142	42425	48415					
49	MOIST SEP	✓	✓					
50	PRTC FILTER	✓	✓					

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- = VACUUM
+ = SFARGE

WELLS - SECTION 1

#	Location Name	11-14 94	1-13 95	94	94	94	94	94
	Initials	AD	AD					
	Time	0918	1012					
1	VMW75-1P	.35-	.50-					
2	SMW75-1P	.34-	.55-					
3	VMW45-1P	.60-	1.0-					
4	SMW45-1P	.60-	1.0-					
5	VMW25-1P	1.05-	1.5-					
6	SMW25-1P	1.05-	1.0-					
7	VMW10-1P	1.75-	OFF SCALE					
8	SMW10-1P	1.45-	1.65-					
9	AAS-1 (CFM)	2	7					
10	AAS-1 (PSI)	16	12					
11	SVE-1 (in H ₂ O)	-	-					
12	VMW10-1	1.60-	OFF SCALE					
13	SMW10-1	1.80-	OFF SCALE					
14	VMW25-1	1.20-	OFF SCALE					
15	SMW25-1	1.15-	OFF SCALE					
16	VMW45-1	.80-	1.50-					
17	SMW45-1	.75-	1.55-					
18	VMW75-1	1.65-	1.10-					
19	SMW75-1	1.60-	1.15-					

- = VACUUM
+ = SPARGE

WELLS - SECTION 2

#	Location Name	11-14-94	1-13-95	.01	.01	.04	.04	.94
	Initials	ELH	AD					
	Time	709:24	10:20					
20	SMW75-2	.65-	1.35-					
21	VMW75-2	.65-	1.25-					
22	SMW45-2	.50-	1.05-					
23	VMW45-2	.40-	1.0-					
24	SMW20-2	.60-	1.10-					
25	VMW20-2	.80-	1.10-					
26	SMW10-2	1.10-	1.10-					
27	VMW10-2	1.15-	1.15-					
28	AAS-2 (CFM)	2	REG.					
29	AAS-2 (PSI)	12	REMOVED					
30	SVE-2 (in H ₂ O)	-	-					
31	SMW10-2P	1.15-	1.15-					
32	VMW10-2P	1.35-	1.25-					
33	SMW34-2P	.45-	.75-					
34	VMW34-2P	.65-	.80-					
35	SMW45-2P	.30-	0					
36	VMW45-2P	.35-	.50-					
37	SMW75-2P	-	-					
38	VMW75-2P	-	-					