N00158.AR.000092
NAS WILLOW GROVE
5090.3a

Final Pilot Study Report
Product Recovery Pilot System
Navy Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

Contract No. N62472-92-D-1296
Contract Task Order No. 0009

Prepared for

Department of the Navy
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway
Mail Stop No. 82
Lester, Pennsylvania 19113-2090

Prepared by

EA Engineering, Science, and Technology
15 Loveton Circle
Sparks, Maryland 21152
(410) 771-4950

November 1996

296.0009

FINAL PILOT STUDY REPORT
PRODUCT RECOVERY PILOT SYSTEM
NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Contract No. N62472-92-D-1296
Contract Task Order No. 0009

Carl G. Reitenbach 11/26/96

Carl G. Reitenbach, P.E.
CTO Manager

Date

S Morekas 11/26/96

Sam Morekas
Program Manager

Date

26 November 1996
FINAL
EA Project No. 296.0009.3690

QUALITY REVIEW STATEMENT

Contract No. N62472-92-D-1296
Contract Task Order No. 0009
Activity 3690

EA Project Number: 29600.09

Description of Report/Deliverable:

Final - Pilot Study Report, Product Recovery Pilot System, Navy Fuel Farm Facility, Naval Air Station Willow Grove, Horsham Township, Pennsylvania

EA CTO Manager: Carl Reitenbach

In compliance with EA's Quality Procedures for review of deliverables outlined in the Quality Management Plan, this final deliverable has been reviewed for quality by the undersigned Senior Technical Reviewer(s). The information presented in this report/deliverable has been prepared in accordance with the approved Implementation Plan for the Contract Task Order (CTO) and reflects a proper presentation of the data and/or the conclusions drawn and/or the analyses or design completed during the conduct of the work. This statement is based upon the standards identified in the CTO and/or the standard of care existing at the time of preparation.

Senior Technical Reviewer(s):

Gloria D. McCleary, P.E.
Senior Technical Review

26 November 1996

Charles W. Houlik, Ph.D., CPG
Senior Technical Review

26 NOV 96
26 November 1996

TABLE OF CONTENTS

Page

LIST OF FIGURES vi

LIST OF TABLES vii

ACRONYMS AND ABBREVIATIONS viii

1. INTRODUCTION 1-1

1.1 Objective 1-1
1.2 Organization of the Report 1-1
1-3 Scope of Work 1-1

2. PILOT STUDY AREA DESCRIPTION 2-1

2.1 Site Setting 2-1
2.2 Site Geology 2-1
2.3 Site Hydrogeology 2-2
2.4 Previous Investigations 2-3
2.5 History of Fuel Storage and Product Releases at the Navy Fuel Farm Facility 2-4
2.6 Comparison of Analytical Results to Regulatory Action Levels 2-4

2.6.1 Soil Samples 2-5
2.6.2 Ground Water Samples 2-5

3. PILOT STUDY METHODOLOGIES 3-1

3.1 LNAPL Recovery Pilot System - Well NFFW-2R 3-1

3.1.1 Objective 3-1
3.1.2 Technology Description 3-1
3.1.3 System Components 3-1
3.1.4 Data Collection 3-2

3.2 Automated and Passive LNAPL Skimming 3-3

3.2.1 Objective 3-3
3.2.2 Technology Description 3-3
3.2.3 System Components 3-3
3.2.4 Data Collection 3-3

TABLE of CONTENTS (cont.)

Page

3.3 Soil Vapor Extraction Testing 3-4

3.3.1 Objective 3-4
3.3.2 Technology Description 3-4
3.3.3 Testing Methodologies 3-5

3.3.3.1 High Water Table Test (April 1995) 3-5
3.3.3.2 Low Water Table Test (July 1995) 3-5

4. PILOT STUDY RESULTS 4-1

4.1 Recovery System Operations 4-1

4.1.1 System Operations at NFFW-2R 4-1
4.1.2 System Operations at NFFW-6 and NFFW-19 4-1

4.2 Gauging Results 4-2

4.2.1 Water Table Fluctuation 4-2
4.2.2 Ground Water Flow Direction 4-2
4.2.3 LNAPL Occurrence and Distribution 4-2

4.3 LNAPL Recovery 4-3

4.3.1 Well NFFW-2R 4-3

4.3.1.1 LNAPL Recovery Without Vacuum Enhancement 4-3
4.3.1.2 Vacuum Enhanced LNAPL Recovery 4-5

4.3.2 Automated and Passive Skimming Operations 4-6

4.4 Influent and Effluent Monitoring 4-7
4.5 Soil Vapor Extraction Testing 4-7

4.5.1 High Water Table Test (April 1995) 4-7
4.5.2 Low Water Table Test (July 1995) 4-8

TABLE of CONTENTS (cont.)

Page

5. CONCLUSIONS and RECOMMENDATIONS 5-1

5.1 Summary and Conclusions of the pilot Study 5-1

5.1.1 Occurrence and Distribution of LNAPL 5-1
5.1.2 LNAPL Recovery Without Vacuum Enhancement 5-1
5.1.3 Vacuum-Enhanced LNAPL Recovery 5-2
5.1.4 Soil Vapor Extraction Testing 5-3
5.1.5 Conclusions 5-3

5.2 Options for Full Scale Remediation System 5-4

5.2.1 Vacuum-Enhanced Recovery 5-5
5.2.2 LNAPL Recovery Using Water Table Depression Without Vacuum-Enhancement Operated Only During Periods of Low Water Table 5-6
5.2.3 LNAPL Recovery Using Vacuum-Enhanced Recovery When Conditions are Favorable and Only Ground Water Table Depression When Conditions for Vacuum-Enhanced Recovery Are Not Favorable 5-6
5.2.4 Bioslurping 5-6

5.3 Recommendation 5-7

REFERENCES

APPENDIX A Summary of Groundwater Monitoring Results
APPENDIX B Graphs of Groundwater Elevation and Product Thickness for Selected Wells
APPENDIX C LNAPL Recovery Pilot System Laboratory Reports - Ground Water
APPENDIX D Results of Soil Vapor Extraction Test (April 1995)
APPENDIX E Results of Soil Vapor Extraction Test (July 1995)
APPENDIX F Hydrogeological Report - 31 March 1995

LIST of FIGURES

Number	Title
1	Site Location Map
2	Site Plan
3	Potentiometric Surface Map (4 April 1994)
4	Site Plan Showing Relevant Site Features Prior to 1991
5	Location of Soil Borings Installed in March 1989
6	Schematic of Vacuum-Enhanced LNAPL Recovery System Installed at Well NFFW-2R
7	Schematic of Automated LNAPL Skimming System Utilized at Wells NFFW-6, NFFW-14, and NFFW-19
8	Soil Vapor Extraction Test Equipment Schematic
9	Potentiometric Surface Map (27 April 1995)
10	Potentiometric Surface Map (8 December 1995)
11	Isopach Map of LNAPL Measured in Monitoring Wells (4 April 1994)
12	Isopach Map of LNAPL Measured in Monitoring Wells (5 August 1994)
13	Isopach Map of LNAPL Measured in Monitoring Wells (21 December 1994)
14	Isopach Map of LNAPL Measured in Monitoring Wells (4 January 1995)
15	LNAPL Distribution Map (27 April 1995)
16	Isopach Map of LNAPL Measured in Monitoring Wells (28 September 1995)
17	Graph of Ground Water Elevation and LNAPL Recovery Well NFFW-2R
18	Graph of Ground Water Elevation and Cumulative LNAPL Recovery Well NFFW-2R

LIST of TABLES

Number	Title
1	Summary of Pilot Study Activities
2	Summary of Soil Sample Results - Soil Borings
3	Summary of Soil Sample Results - Well Installations
4	Summary of Ground Water Sampling Results - June 1993
5	LNAPL Recovery Pilot System Analytical Results - Ground Water
6	LNAPL Occurrence and Thickness Distribution
7	Flow Rate Test Results - Well NFFW-2R
8	Thermal Oxidizer Operating Data Summary
9	Summary of LNAPL Recovery
10	Cost Comparison Summary - Remedial Alternatives

ACRONYMS AND ABBREVIATIONS

AAS	Aquifer Air Sparging
ARF	Air Reserve Facility
AST	Above Ground Storage Tank
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
cfm	cubic feet per minute
cm	centimeters
CTO	Contract Task Order
EA	EA Engineering, Science, and Technology
EPA	Environmental Protection Agency
ft	feet
GAC	Granular Activated Carbon
gal	gallon
gpm	gallons per minute
Hg	Mercury
HP	Horsepower
in.	inch
IR	Installation Restoration
kg	kilogram
L	Litre
lbs	pounds
LNAPL	Light Non-Aqueous Phase Liquid
LEL	Lower Explosive Limit
MCL	Maximum Contaminant Level
MEK	Methyl Ethyl Ketone
μg	microgram
msl	mean sea level
NAS	Naval Air Station
NAVFAC	Naval Facilities
Nos.	Numbers
OVA	Organic Vapor Analyzer
PAANG	Pennsylvania Air National Guard
ppmv	parts per million volume
psi	pounds per square inch
PVC	Polyvinyl Chloride
sec	second
SVE	Soil Vapor Extraction
TOC	Top of Casing
TPH	Total Petroleum Hydrocarbons
UST	Underground Storage Tank
VOC	Volatile Organic Compound

1. INTRODUCTION

This Final Pilot Study Report for the Navy Fuel Farm facility, Naval Air Station (NAS), Willow Grove, Horsham Township, Pennsylvania has been prepared for Northern Division, Naval Facilities Engineering Command under Contract No. N62472-92-D-1296), Contract Task Order (CTO) No. 0009.

1.1 OBJECTIVE

The objective of this project was to conduct remedial pilot studies to evaluate the effectiveness of two technologies, as described below, in reducing source hydrocarbons at the Navy Fuel Farm facility in order to recommend a full scale remedial design. This was accomplished by assessing the effectiveness of both light non-aqueous phase liquid (LNAPL) recovery and soil vapor extraction (SVE) as source hydrocarbon reduction technologies at the Navy Fuel Farm facility through a 32-month pilot study. The pilot study included the installation, operation, maintenance, and evaluation of a vacuum enhanced LNAPL recovery pilot system, one passive LNAPL skimming device, and two automated LNAPL skimming pumps. The pilot study also included performing and evaluating two SVE tests.

1.2 ORGANIZATION OF THE REPORT

This report is divided into five chapters. Chapter 1 is the Introduction and includes a summary of the scope of work. Chapter 2 describes the pilot study area and includes a summary of the site setting, characteristics, and history. Chapter 2 also compares past analytical results to current regulatory action levels. Chapter 3 summarizes the pilot study methodologies and Chapter 4 presents the pilot study results. Conclusions and recommendations for full scale remedial implementation at the Navy Fuel Farm facility are included in Chapter 5.

1.3 SCOPE OF WORK

The Pilot Study was conducted in accordance with the *Work Plan for Pilot-Scale Testing of Free-Product Recovery and Aquifer Air Sparging* (EA, 1993a). The scope of work outlined in the work plan included two phases:

Phase I - LNAPL Recovery

- Installation of a pilot LNAPL recovery system at well NFFW-2R and initiation of LNAPL recovery by water table depression and vacuum enhanced pumping at well NFFW-2R; and

- installation of automated LNAPL skimming pumps in wells NFFW-6 and NFFW-19 to assess the potential for continuous LNAPL yield without depressing the water table.

Phase II - Source and Residual Hydrocarbon Reduction

- Evaluation of the effectiveness of SVE in combination with Aquifer Air Sparging (AAS) including the installation and operation of a 14 trench/24 well SVE/AAS pilot system to remediate residual phase hydrocarbons in the zone of water table fluctuations.

Phase II of the scope of work was changed during the pilot study to substitute a two-part SVE field test for the SVE/AAS evaluation. This change was made because of concerns that SVE/AAS would not be appropriate due to the occurrence of LNAPL throughout the site. The occurrence of LNAPL is closely, if not exclusively, related to water table fluctuations in the fracture zone. Air sparging does not address LNAPL in this setting. Removal of LNAPL is substantially more cost effective than dissolved-phase remediation. Therefore, this change in scope allowed the LNAPL recovery portion (Phase I) of the pilot study to be extended and as a result accomplish more remediation during the course of the pilot study than would be gained by conducting the SVE/AAS evaluation. This change was authorized in a NAVFAC Record of Change letter dated 27 January 95. The Record of Change letter included provisions for the evaluation of small scale SVE testing during high and low water table periods (spring and summer) at 3 existing monitoring wells.

Activities conducted during the Pilot Study are summarized on Table 1. The scope of work included the following:

- gauging site monitoring wells to assess the nature and extent of LNAPL,
- evaluating the effectiveness of vacuum-enhanced LNAPL recovery,
- sampling of the pilot system ground-water effluent to demonstrate treatment prior to discharge to the sanitary sewer
- monitoring of the air emissions to evaluate the performance of the air treatment system.

2. PILOT STUDY AREA DESCRIPTION

2.1 SITE SETTING

The Navy Fuel Farm is located along the north side of Privet Road and immediately south of the Pennsylvania Air National Guard (PAANG) portion of the Air Reserve Facility (ARF) at NAS Willow Grove. Figure 1 is a site location map and Figure 2 is a site plan of the Navy Fuel Farm. The Navy Fuel Farm and a portion of the adjoining property to the north, occupied by PAANG (Buildings 345 and 340), constitute the area requiring remedial efforts and include the area within which the pilot test was conducted. The Navy Fuel Farm is bordered on all sides by NAS grounds. Abutting the Navy Fuel Farm to the north are ARF Buildings 330, 340, and 345. Several other base facilities exist within 1,000 ft of the site. The Navy Fuel Farm is approximately 2 acres in area and consists of three aboveground storage tanks, associated aboveground piping, and building Nos. 119 and 81.

The topography of the Navy Fuel Farm area is characterized as flat and gently sloping to the north-northwest. There is a slight downgrade at the north end of the facility which encourages runoff to flow northeast into the catchment basin or the adjacent ditch.

On and directly adjacent to the Navy Fuel Farm grounds exist several buried utilities, including water, electric, sewer, telephone, and product piping. Several storm sewer and sanitary sewer lines traverse the southern portion of Navy Fuel Farm grounds. In addition, a water main also extends across facility grounds.

2.2 SITE GEOLOGY

Site geology has been characterized based on the geologic logs of 40 soil borings installed on and adjacent to the Navy Fuel Farm, 21 of which were completed as ground-water monitoring wells. Soil cover at the site varies in thickness from 6 to 21 ft. In general, soil depth increases from south to north, reflecting the dip of the underlying strata. The northeast edge of the site is underlain by soil types belonging to the Readington Silt Loam group; the remainder of the site is covered with fill material. The site-specific shallow stratigraphy is comprised primarily of silty clay and clayey silt with varying amounts of sand and little gravel. The high proportion of clay in the soil leads to reduced permeability and slow infiltration rates.

Unconsolidated materials at the site are underlain by the Middle Arkosic Member of the Late Triassic Stockton Formation. This member consists of interbedded red shale, siltstone, and gray-tan, medium-grained, Arkosic sandstone which was deposited as part of coalescing fluvial channel system. Red shale and siltstone are predominant along the south edge of the site, whereas the Arkosic sandstone underlies the remainder of the site.

Depth to competent bedrock may range from 6 ft in areas where soil was previously removed to competent sandstone bedrock during site construction activities to 20 ft in areas underlain by shale or siltstone. Relict bedding structure is often present as a zone several feet thick and overlying shale or siltstone units. Regional dip ranges from 5 to 15 degrees with strike to the north-northwest (Rima *et al.* 1962). Beds vary in thickness, often pinching out or grading into other facies, making interpretation of lithologic occurrence difficult.

Regionally, small displacement normal faults trending northeast-southwest are present throughout the unit. Two sets of vertical joints, roughly parallel and perpendicular to the strike direction, are well developed. A third set of joints, though not as well expressed as the first two, trends northwest-southeast (Rima *et al.* 1962).

2.3 SITE HYDROGEOLOGY

The depth to static ground water at the site on 19 February 1996 ranged from approximately 4 ft (well NFFW-9) to 26 ft (well NFFW-20) below grade. However, water levels in the monitoring wells fluctuate several feet annually due to seasonal influences. In most cases, ground water is observed within bedrock fractures or within the weathered zone immediately overlying competent bedrock. Static water levels not only reflect the regional potentiometric surface but also the composite head resulting from the different water-yielding zones penetrated during drilling. For this reason, water levels may show marked differences in nearby wells depending on the number and size of fractures intercepted by each well.

Based upon several rounds of well gauging, historic ground-water flow at the Navy Fuel Farm is predominantly to the north, as illustrated in Figure 3. However, because flow is primarily through fractures within the bedrock or weathered bedrock, localized flow direction may vary. Ground water flow through the Arkosic sandstone is more rapid than through the shale/siltstone as evidenced by more rapid recharge rates during well development and purging than during sampling. This may be due to the greater size and density of the fractures present within the sandstone.

Using the Neuman Method for unconfined aquifers, the average hydraulic conductivity, as derived from pumping test data at wells NFFW-2R, NFFW-8, NFFW-12, NFFW-14, and NFFW-16 (EA 1991), was estimated at 4.05×10^{-5} cm/sec. The average ground-water velocity has been estimated at 30 ft/year, assuming an effective porosity of 7 percent and a hydraulic gradient of 0.029 ft/ft (EA 1991). Aquifer tests conducted during low water table conditions have indicated that the wells are low yielding, typically 0-2 gal per minute (EA 1991).

2.4 PREVIOUS INVESTIGATIONS

The pilot study was based on the conclusions and recommendations of the following reports and regulations:

- Plan of Action for Site Inspection, NAS Willow Grove, Pennsylvania. (EA February, 1988a).
- Draft Appendix B, Soil Vapor Contaminant Assessment at NAS Willow Grove. (EA December, 1988b).
- Interim Report, Electromagnetic Survey, Soil Vapor Contaminant Assessment, and Revised Field Sampling Plan for Site Inspection Studies at NAS Willow Grove. (EA March, 1989a).
- Final Report, Environmental Test Boring Investigation at the Navy Fuel Farm, NAS Willow Grove, Horsham Township, Pennsylvania. (EA June, 1989a)
- Final Report, Site Inspection Studies at NAS Willow Grove, Horsham Township, Pennsylvania. Volumes I and II. (EA May, 1990)
- Final Interim Report on Investigations at the Navy Fuel Farm, NAS Willow Grove, November 1990 - July 1991. (EA November, 1991).
- Final Report of Interim Site Investigations, Navy Fuel Farm - Willow Grove NAS. (EA September, 1993b).
- Commonwealth of Pennsylvania Department of Environmental Resources (PADER). Protective Levels and Criteria for the Excavation, Treatment, Cleanup and Disposal of Virgin Fuel Contaminated Soil. (PADER October, 1991).
- Commonwealth of Pennsylvania Department of Environmental Resources, Ground Water Quality Protection Strategy. (PADER February, 1992).
- Title 25 - Pennsylvania Code Chapter 245 Subchapter D, Storage Tanks; Corrective Action. August. Commonwealth of Pennsylvania, Environmental Quality Board (EQB 1993).

2.5 HISTORY OF FUEL STORAGE AND PRODUCT RELEASES AT THE NAVY FUEL FARM

From 1950 to 1991, two partially buried 210,000-gal JP-4/JP-5 aviation fuel tanks (Tank Nos. 115 and 116) were located at the site. A 500-gal underground waste oil tank and an underground diesel tank were also located at the southwestern corner of the site. Figure 4 is a site map of the Navy Fuel Farm prior to 1991.

In 1986, a spill occurred when Tank 115 was overfilled and fuel was released from the vent pipe onto the ground. The event was attributed to faulty gauges which registered less fuel than was actually present. During this same year, a utility trench was excavated along the western boundary of the site but work discontinued when LNAPL was observed floating on the water within the trench. The area where the LNAPL was discovered is immediately adjacent to a former drywell. The drywell accepted water which was periodically siphoned from the bottom of the fuel tanks.

In March 1989, JP-5 jet fuel was detected emanating from two patches of dead grass on the west side of Tank 115. Heavy rains flushed this fuel into the ditch on the north side of the site. Navy personnel responded with the placement of sorbant material in the ditch and adjacent to Tank 115. With this evidence of tank leakage, it was decided to empty and remove the two main fuel tanks (Tank Nos. 115 and 116). Removal of these tanks occurred in 1991. Also during this time, the waste oil and diesel underground storage tanks were removed. Inspection of the waste oil tank during removal revealed the tank was not intact as holes up to 1-in. in diameter were reported.

Subsequent to the completion of removal activities, a new aboveground tank system was installed to the east of the former tank field location. In order to accommodate the newly constructed Navy Fuel Farm, Building No. 157 was removed. The new tank system at the Navy Fuel Farm consists of aboveground steel tanks set in a concrete berm. The Navy Fuel Farm is currently inactive.

2.6 COMPARISON OF ANALYTICAL RESULTS TO REGULATORY ACTION LEVELS

As listed in Section 2.4, several previous investigations have been conducted at the Navy Fuel Farm. Regulatory oversight of the environmental concerns associated with the Navy Fuel Farm is in the process of being transferred from the Navy's Installation Restoration (IR) Program to the State of Pennsylvania's UST/AST program. Therefore, this section presents a comparison of the results of soil and ground-water sampling and analysis to the action levels established by Pennsylvania's Land Recycling Program.

2.6.1 Soil Samples

Soil samples in the vicinity of the fuel farm were first collected in March 1989 as part of an investigation to assess potential subsurface hydrocarbon contamination in areas planned for future construction (EA 1989b). At that time a total of 24 soil samples were collected from 18 borings installed around Building 340 (Figure 5). The samples were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX). As shown on Table 2 none of the samples collected contained individual BTEX components exceeding the action levels.

Also in 1989 as part of additional investigations at the Navy Fuel Farm 4 soil samples were collected during the installation of 3 monitoring wells and one soil boring (EA 1989b). The samples were analyzed for several volatile organic compounds and base neutral extractable compounds. Only 1 of the 4 samples collected contained volatile organic compound concentrations exceeding the regulatory action level. Methylene chloride and 2-butanone (or methyl ethyl ketone [MEK]) were reported in the soil sample collected from monitoring well NFFW-7. Methylene chloride was present at a concentration of 2,300 μg/kg and the action level is 500 μg/kg. The concentration of 2-butanone was 88 μg/kg and the action level is 50 μg/kg. The results of the volatile organic compound analyses are summarized on Table 3.

Additional soil samples were collected in April 1991 during the installation of 4 monitoring wells and analyzed for BTEX (EA 1991). Of the 4 samples collected, only 1 sample contained a concentration of any analyte exceeding the regulatory action level. The sample collected from monitoring well NFFW-8 reported a total xylene concentration of 290,000 μg/kg compared to a action level of 5,000 μg/kg. These results are also summarized on Table 3.

2.6.2 Ground Water Samples

A total of 36 ground-water samples were collected from selected monitoring wells on 5 occasions from June 1989 through June 1993. Of the 23 ground-water samples collected prior to June 1993, 8 samples contained concentrations of benzene in excess of the 5 μg/L guidance criteria with concentrations ranging from 10 to 990 μg/L. These wells were NFFW-1, 2 (two samples), 7 (two samples), 9, 13 and 16. None of the other anlytes tested exceeded the guidance criteria. It should be noted that several existing wells were not sampled due to the occurrence of LNAPL.

During the most recent, June 1993, sampling event 5 of the 13 ground-water samples collected contained benzene concentrations in excess of the 5 μg/L guidance criteria with concentrations ranging from 6-67 μg/L. These wells were NFFW-5, 9, 11, 17, and 19. Benzene was the only analyte to exceed the action level. The results of the June 1993 sampling event are summarized on Table 4. During this event wells NFFW-1, 2R, 6, 7, 12, 13, 14, 16, and 19 were not sampled due to the presence of LNAPL.

Ground water samples were also collected from well NFFW-2R during the pilot study. A total of 7 samples were collected between April 1995 and July 1996 and analyzed for BTEX, naphthalene, and total petroleum hydrocarbons (TPH). Each sample exceeded the 5 μg/L benzene and 20 μg/L naphthalene guidance criteria. The sample results are summarized on Table 5.

3. PILOT STUDY METHODOLOGIES

3.1 LNAPL RECOVERY PILOT SYSTEM - WELL NFFW-2R

3.1.1 Objective

The primary objective of the LNAPL recovery pilot system installed at well NFFW-2R was to evaluate vacuum enhanced LNAPL recovery in conjunction with water table depression.

3.1.2 Technology Description

LNAPL recovery employing water table depression, vacuum enhancement, and automated skimmers are proven technologies for the removal of LNAPL. Water table depression through ground-water pumping during vacuum enhanced recovery maintains localized hydraulic control and initiates a "cone of depression" around the pumping well. A conceptual diagram illustrating the technology and the pilot system components is shown in Figure 6.

A complete, detailed description of the mechanisms of vacuum enhanced LNAPL recovery is included in the Pilot Study Work plan (EA, 1993a). In summary, vacuum-enhanced recovery involves the application of a vacuum to the recovery well which increases the pressure gradient toward the recovery well, thus increasing the LNAPL recovery rate. Due to the higher pressure differential, the travel time from the edge of the capture zone is decreased and project life can be decreased. In addition, because the "effective" drawdown (pressure differential) is increased without an increase in the actual water table drawdown, smearing of LNAPL in the dewatered zone is decreased. Also, by applying a vacuum to the vadose zone, LNAPL entry pressures are reduced to facilitate collection of LNAPL at the recovery well. As a result, the amount of residual LNAPL is minimized and the potential for LNAPL recovery is maximized.

The potential advantages of employing vacuum-enhanced LNAPL recovery are: (1) increased LNAPL recovery rates, (2) increased capture zone, (3) decreased project life, and (4) increased LNAPL recovery from the unsaturated zone by inducing LNAPL collection at the recovery well and vapor-phase recovery through vacuum extraction.

The potential disadvantages of employing vacuum-enhanced LNAPL recovery are:
(1) increased ground-water pumping rates may increase water treatment costs, (2) air emissions may require treatment, and (3) additional capital costs associated with recovery equipment.

3.1.3 System Components

The LNAPL recovery pilot system was installed at well NFFW-2R during February and March 1994 in accordance with the LNAPL recovery pilot system implementation plan (EA, 1993c) and design documents. The major system components include an integral water table

depression/LNAPL recovery pump, LNAPL holding tank, two granular activated carbon (GAC) units, vacuum blower, and a thermal oxidizer. A description of each system component and its function is given below.

An ORS Small Diameter Filter Scavanger™ dual pumping system with an ORS SITEPRO™ 2000 Control Panel are utilized for water table depression and LNAPL recovery. This system consists of a 1/3 horsepower (HP) submersible pump with a maximum rating of 7 gallons per minute (gpm) at 40 ft head and a gear driven LNAPL pump with a rating of 0.67 gpm at a pressure of 40 pounds per square inch (psi). The LNAPL pump is equipped with a floating intake and a LNAPL reservoir providing 1 ft of intake travel. Recovered LNAPL is pumped directly to a 500 gallon (gal) double wall steel holding tank equipped with a high level shutoff. Ground water is pumped through dual 200 pound liquid-phase GAC canisters in series; treated ground-water discharge flows through an aboveground line approximately 400 ft to a sanitary sewer manhole (Figure 2).

Vacuum enhancement is accomplished with a Rietschle Model VFT 40 rotary vane vacuum pump capable of producing a flow rate of approximately 8 standard cubic feet per minute (scfm) at a vacuum of 25 inches mercury (in-Hg). Extracted air flows through a moisture separator and an in-line air filter prior to the vacuum pump and was initially treated with dual 200 pound vapor-phase GAC units in series prior to atmospheric discharge; however, elevated hydrocarbon concentrations made this treatment method uneconomical. A thermal oxidizer, Thermtech VAC-25, was later installed for vapor-phase hydrocarbon treatment.

All treatment equipment, with the exception of the thermal oxidizer, is contained in the treatment building at the location shown on Figure 2. A schematic of the vacuum-enhanced LNAPL recovery pilot system installed at well NFFW-2R illustrating the interconnection of the various components is shown in Figure 6.

3.1.4 Data Collection

Site visits were generally conducted twice monthly to monitor the operation of the LNAPL recovery pilot system. During each regular site visit all monitoring wells were gauged for depth-to-LNAPL and water. Flow rate, total flow, and LNAPL recovery of the pilot system were recorded and preventive system maintenance was conducted. Samples of influent, primary GAC effluent, and secondary GAC effluent were collected on several occasions to monitor the effectiveness of the GAC treatment system. These samples were analyzed at EA Laboratories in Sparks, Maryland for BTEX and naphthalene via EPA Method 8020 and for gasoline range TPH via EPA Modified Method 8015.

During vacuum-enhanced operations the vacuum system flow rate, temperature, vacuum, and influent hydrocarbon concentrations were monitored weekly during the first three months of operation and twice monthly thereafter. The thermal oxidizer operating temperature and hydrocarbon emission concentrations were also recorded during each visit. Hydrocarbon

concentrations (extracted soil vapor and air emissions) were field monitored with an organic vapor analyzer (OVA) and/or a lower explosive limit (LEL) meter. Samples of the extracted soil vapor and the air emissions were collected on several occasions and analyzed for TPH by gas chromatography (reported as toluene equivalents).

3.2 AUTOMATED AND PASSIVE LNAPL SKIMMING

3.2.1 Objective

Automated skimming at wells NFFW-6 and NFFW-19 and passive skimming at various wells including NFFW-14 and NFFW-16 without the aid of water table depression or vacuum-enhancement was conducted to evaluate whether automated and passive skimming devices can sufficiently diminish LNAPL occurrence at these locations.

3.2.2 Technology Description

Automated skimming utilizes a LNAPL pump to continuously remove LNAPL from a well thereby inducing a LNAPL gradient toward the well. Passive skimming devices function in a similar manner; however, they have a fixed LNAPL storage capacity. When the storage capacity is reached, the device must be manually removed from the well, emptied, and reinstalled. Each type of unit has a fixed intake range and must be manually positioned within the LNAPL layer. Each of these technologies require the LNAPL to be at zero entry pressure to move into the well. Therefore LNAPL trapped by capillary pressures or water pressures that preclude movement of LNAPL, can not be recovered.

3.2.3 System Components

The two automated skimming systems utilize ORS Small Diameter Filter Scavenger™ LNAPL pumps and ORS SITEPRO 2000™ Control Panels. As shown in Figure 7 the pumps discharge directly to a secondarily contained 55-gallon drum equipped with a high-level shutoff device. The passive skimming device was manufactured by Clean Environment Equipment and has a 19.5- inch intake travel range and a 0.37 gal storage capacity. The passive skimmer was installed completely within the well and manually removed and emptied into a secondarily contained 55-gallon drum.

3.2.4 Data Collection

As discussed in Section 3.1.4 site visits were regularly conducted twice monthly. During each visit the depth-to-LNAPL/water was recorded and the volume of LNAPL recovered was measured at each automated skimmer.

The passive skimmer was removed from the well, volume of LNAPL recovered was measured, LNAPL was transferred to a holding drum, depth-to-LNAPL/water was recorded and the skimmer was reinstalled.

In both cases the skimmer intake levels were maintained to coincide with the LNAPL/water interface.

3.3 SOIL VAPOR EXTRACTION TESTING

3.3.1 Objective

The objective of this phase of the pilot study was to evaluate the effectiveness of SVE as a remedial technology for reducing concentrations of residual petroleum hydrocarbons known to exist in the vadose and water table fluctuation zones. Because LNAPL occurrence varied with the water table elevation, SVE tests were conducted during periods of both high and low water table elevations to assess if SVE effectiveness also varies. Soil vapor extraction tests were conducted to specifically evaluate the relationship between (1) applied vacuum and extracted air flow rate and (2) applied vacuum and radial influence given different water table elevations. Petroleum hydrocarbon concentrations and removal rates were also characterized as part of the radial influence tests.

3.3.2 Technology Description

SVE is a proven and well documented technology effective in the removal of vapor and sorbed-phase petroleum hydrocarbons from the vadose zone. It differs from vacuum-enhanced LNAPL recovery in that the goal is to recover vapor and sorbed-phase petroleum hydrocarbons rather than separate-phase hydrocarbons. Hydrocarbons are removed from the vadose zone as a negative pressure (vacuum) is exerted by a vacuum pump connected to an extraction well. This results in the generation of soil vapor flow towards the extraction well, while concurrently effecting an interphase transfer from the immiscible and water phases to the vapor phase, which is subsequently extracted (Marley *et al.* 1990). Another important remedial process which occurs during SVE is *in situ* aerobic biodegradation. The pumping action of the SVE process provides a continuous soil air flow, which in turn supplies rate-limiting oxygen, enhancing aerobic biological degradation. For petroleum hydrocarbons, biodegradation has been reported to contribute as much as 55-85 percent of the removal rate (of jet fuel) during SVE (Miller *et al.* 1990). For purposes of this performance evaluation, biodegradation processes will be considered part of the overall SVE hydrocarbon mitigation process. A more complete technology description including a more detailed discussion of transfer and transport mechanisms is included in the Pilot Study Work plan (EA, 1993a).

3.3.3 Testing Methodologies

The testing methodologies employed during the high water table (April 1995) and low water table (July 1995) SVE tests are summarized below. The complete reports of the April and July tests are contained in Appendices A and B, respectively. In each case, the testing was conducted utilizing a mobile SVE test trailer. The trailer consists of a vacuum pump equipped with a moisture separator, activated carbon treatment canisters, flow and vacuum gauges, and sample ports. The vacuum extraction system is shown schematically in Figure 8.

3.3.3.1 High Water Table Test (April 1995)

Individual SVE tests were conducted on wells NFFW-4, NFFW- 7, and NFFW-16 from 4 April through 6 April 1995. Individual system head tests were conducted on each of the three test wells in order to develop site specific relationships between applied vacuum and extracted air flow rate. The tests were conducted by applying 5 different vacuums to the extraction well in a decreasing stepped manner. Each vacuum was applied until the corresponding flow rate stabilized, this occurred within approximately 20 minutes in each case. Once the flow rate stabilized, a different vacuum was applied and the test was repeated. System head tests were conducted before radial influence tests.

Radial influence tests were used to measure the radial distance influenced by the applied vacuum at the extraction well and to assess hydrocarbon removal rates. The radius of influence was measured by installing six soil vapor probes into the subsurface at various distances in two directions from the extraction well. During each test a constant vacuum was applied to the extraction well for approximately two hours and the induced vacuum on the soil vapor probes was recorded regularly. Vapor flow rate and temperature were also recorded throughout the test.

To assess hydrocarbon removal rates, samples of extracted soil vapor were collected approximately every 30 minutes and analyzed for petroleum range and chlorinated hydrocarbons. The samples were analyzed onsite with EA's mobile field gas chromatograph. The analysis results and the extraction air volume flow rate were utilized to assess the hydrocarbon mass removal rates associated with each test well.

3.3.3.2 Low Water Table Test (July 1995)

Individual system head and radial influence tests were conducted on wells NFFW-4 and NFFW-16 on 6 July 1995 in the manner discussed in Section 3.3.3.1.

4. PILOT STUDY RESULTS

4.1 RECOVERY SYSTEMS OPERATION

4.1.1 System Operation at NFFW-2R

The LNAPL recovery pilot system at well NFFW-2R began continuous operation in March 1994. Initial operation included only water table depression and LNAPL recovery as shown on Table 1. Vacuum-enhancement was added in June 1994. Vacuum-enhanced LNAPL recovery was only operated for a short time in June before it was apparent that hydrocarbon concentrations in the extracted air stream where too elevated for conventional GAC treatment. As a result the vacuum-enhanced portion of the system was turned off. Water table depression and LNAPL recovery continued through July 1995. Vacuum-enhancement was once again added in August 1995 upon the installation of a thermal oxidizer for vapor-phase hydrocarbon treatment.

As a result of circumstances noted, the LNAPL recovery pilot system was not operated for the following intervals during the 24-month test period:

17 August 1994 - 4 October 1994	System inoperable due to lightning damaged control panel
22 November 1995 - 26 February 1996	Vacuum system inoperable due to blower mechanical failure, LNAPL system operable
21 December 1995 - 23 February 1996	LNAPL recovery system inoperable due to a damaged discharge line

4.1.2 System Operation at NFFW-6 and NFFW-19

The automated skimmers were installed in wells NFFW-6 and NFFW-19 in March 1994 and the passive skimmer was first installed in well NFFW-16 in August 1994. The passive skimmer was used in several site wells as site conditions (LNAPL occurrence) dictated. Due to the absence of LNAPL in well NFFW-6, the automated skimmer was moved to well NFFW-14 in February 1996.

As a result of circumstances noted, the automated skimmers were not operated for the following intervals during the test period:

17 August 1994 - 4 October 1994	Both systems inoperable due to lightning damage to control panels

1 August 1995 - 26 February 1996	Both systems inoperable due to lightning damage to control panels

4.2 GAUGING RESULTS

All site monitoring wells were gauged at least twice a month. Some of the monitoring wells closer to the recovery well NFFW-2R were gauged more frequently. Complete gauging results are included in Appendix A.

4.2.1 Water Table Fluctuation

The gauging results indicate a large seasonal fluctuation of the water table. Several wells (NFFW-3, -4, -6, -7) went dry during the period of the pilot test. The average water table fluctuation was 17.9 ft and the range of water table fluctuation was 12.5 ft in NFFW-1 to 24.4 ft in NFFW-21. This fluctuation is typically seasonal with the low water table elevations occurring in the summer and the high water table elevations occurring in the spring. However, the water table elevation is variable even over short time periods. For example, in NFFW-14, the water table dropped 4.28 ft over a 12 day period from 290.08 ft on 1 July 1994 to 285.80 ft on 13 July 1994 and then rose 9.31 ft to 295.11 ft on 5 August 1994.

4.2.2 Ground Water Flow Direction

Throughout the pilot study the ground-water flow direction was primarily to the north-east. This flow direction was consistent during periods of high and low water table elevations. Figures 3, 9, and 10 show the potentiometric surface and ground-water flow directions on 4 April 1994, 27 April 1995, and 8 December 1995.

4.2.3 LNAPL Occurrence and Distribution

The occurrence of LNAPL in monitoring wells is directly related to periods where the water levels are falling. LNAPL has been detected in 11 of the site's 21 monitoring wells primarily at times when the water table elevation was decreasing. The occurrence is more dramatic in some wells (NFFW 2R and NFFW-14), however, it is an immediate and direct response. This relationship between LNAPL occurrence and water table fluctuation is illustrated graphically in Appendix B. The immediacy of the occurrence is indicative that the LNAPL's time-of-travel is short, indicating a more direct travel route and/or a short distance from the well. Obviously one of the limitations of documented occurrence, is the limits of the monitoring network (i.e. location of wells within the LNAPL plume). Table 6 summarizes the occurrence of LNAPL in the monitoring wells. LNAPL was present most often in NFFW-14 (77% of the gauging events), NFFW-2R (56%), and NFFW-16 (42%). These wells were also the only wells where a LNAPL layer over 1 ft thick was gauged.

Figures 11 through 16 are isopach maps for periods of both high and low water table conditions throughout 1994 and 1995. These figures illustrate that LNAPL is found in only a few wells during periods of high water table elevations and is more prevalent across the site during periods of low water table elevations.

Intuitively, if the water table (and LNAPL levels) fluctuate so dramatically, when LNAPL/water is below the intakes of the pump(s), vacuum (vapor) may facilitate removal (by partitioning from separate to vapor-phase). However, the potential for success is limited by air contacting separate or residual-phase hydrocarbons.

4.3 LNAPL RECOVERY

The LNAPL recovery systems at wells NFFW-2R, NFFW-6, and NFFW-19 were installed during February-March 1994. This section summarizes the operational data from these systems.

4.3.1 Well NFFW-2R

During the 32-month pilot period (March 1994 - October 1996) the LNAPL recovery pilot system at well NFFW-2R was operated both with and without vacuum-enhancement. The total volume of LNAPL recovered was 1,513 gal and 1,435,392 gal of ground water was pumped. Additionally, the equivalent of approximately 401 gal of LNAPL was recovered in the vapor-phase through vacuum-enhanced operation, for a total LNAPL recovery of 1,914 gal.

4.3.1.1 LNAPL Recovery Without Vacuum Enhancement

Operation of the LNAPL recovery pilot system started on 30 March 1994 and the results are summarized on the data table for well NFFW-2R in Appendix A. At startup of the system there was no LNAPL in NFFW-2R and the water pumping rate was approximately 4-6 gpm. The recovery system operated without vacuum enhancement until 3 June 1994. From 30 March-3 June 1994, the recovery system at NFFW-2R recovered 215.75 gal of LNAPL and pumped 151,922 gal of ground water. The average LNAPL recovery during this time period was approximately 3.3 gal per day at a ground-water flow rate of 1.6 gpm. However, the majority of the LNAPL was recovered between 13 May and 3 June when the LNAPL/water interface elevation in the well fell to between 288 and 291 ft msl. During this time period LNAPL recovery averaged approximately 9.7 gal per day at an average ground-water pumping rate of 1.4 gpm.

After operating under vacuum enhanced conditions in June 1994, the recovery system at NFFW-2R operated without vacuum enhancement from July 1994-July 1995. During this time period, approximately 980 gal of LNAPL was recovered and 194,951 gal of ground water was pumped. The average recovery was 2.5 gal of LNAPL per day at a ground-water flow rate of 0.3 gpm. However, during periods of low water table elevation the oil/water interface

dropped below the intake for the recovery pump and LNAPL could not be recovered except by bailing well NFFW-2R. Well NFFW-2R has an approximate depth of 35.5 ft from the top-of-casing (TOC) and the water table depression/LNAPL skimming pump has a length of approximately 6 ft with a LNAPL intake range of approximately 4.5 to 5.5 ft. Therefore, when the LNAPL/water interface is greater than approximately 30 ft below TOC the LNAPL layer is outside (below) the operable range of the pump. Furthermore, when the water table is high, LNAPL appears to become isolated from the well.

The relationship between ground-water table elevation and LNAPL recovery is illustrated for well NFFW-2R in Figures 17 and 18. These figures compare instantaneous and cumulative LNAPL recovery and water table elevation, respectively. Figures 17 and 18 illustrate that LNAPL recovery is greatest during periods of low water table elevation and virtually no LNAPL is recovered during periods of high ground-water table elevations. In addition, both figures reveal the optimum water table elevation for LNAPL recovery at well NFFW-2R falls in the approximate range of 285 to 292 ft above mean seal level (msl); approximately 30 to 23 ft below TOC. Because there was no LNAPL in the well, LNAPL recovery was not accomplished when the water table elevation at well NFFW-2R was greater than 292 ft above msl. As a result it is apparent that water table depression is essential to optimize LNAPL recovery; however, when the LNAPL/water interface fell below approximately 285 ft above msl (30 ft below TOC), LNAPL recovery was limited by the well depth and the mechanics of the recovery pump. This is a significant limitation at this site where the range of fluctuation is up to 24 ft.

In order to assess the flow rate necessary to maintain drawdown and optimize LNAPL recovery during high water table conditions a 48-hour flow rate test was conducted on well NFFW-2R from 27 through 29 March 1996. A 20 gpm capacity submersible pump and trailer mounted GAC treatment system was utilized for the test. During the test, flow rates were varied from 4.71 to 8.25 gpm and drawdown in the pumping well reached a maximum of 15 ft. A total of 14,523 gal of ground water was pumped at an average flow rate of 5.04 gpm; LNAPL thickness in well NFFW-2R increased from 0.00 ft to 0.44 ft maximum, no LNAPL was recovered. Maximum drawdown in wells NFFW-7, NFFW-14 and NFFW-16 was 0.71, 0.66, and 0.26 ft, respectively. The water level in well NFFW-12 increased (0.14 ft) during the test. LNAPL thickness in well NFFW-2R ranged from 0.01 ft to 0.44 ft at corresponding ground-water elevations of 289.21 and 291.08 ft mean sea level (msl). Results of this rate check indicate that ground-water pumping rates are significantly higher (5-10 gpm) when the water table is high than when the water table is low (< 1 gpm). The test results are summarized on Table 7.

After operating under vacuum-enhanced conditions from July through November 1995, the recovery system at NFFW-2R operated without vacuum-enhancement from mid-November 1995 through June 1996. During this period, approximately 12 gal of LNAPL was recovered and 659,263 gal of ground water was pumped. The average recovery was 0.05 gal of LNAPL per day at a ground-water flow rate of 2.07 gpm. The low LNAPL recovery rate can be attributed to the high amount of precipitation during the period. This is illustrated by the fact

that the average ground-water elevation at NFFW-2R remained above 296 ft and fell below 292 ft on only one occasion. As a result, LNAPL recovery was limited.

Vacuum-enhancement was employed briefly during July 1996 as the water table elevation fell; operation without vacuum-enhancement was then conducted from 18 July through 12 September. During this period, approximately 68 gal of LNAPL was recovered and 153,165 gal of ground water was pumped. The average recovery was 1.21 gal of LNAPL per day at a ground-water flow rate of 1.9 gpm. In addition, the average water table elevation was approximately 290.7 ft, or within the optimal range of 285 ft to 292 ft discussed previously in this section. This period of operation further illustrates the need for water table depression in conjunction with LNAPL recovery at the Fuel Farm.

Vacuum-enhancement was again briefly employed during September 1996 and operation without vacuum-enhancement was then conducted from 19 September through 31 October. During this period, approximately 3 gal of LNAPL was recovered and 85,470 gal of ground water was pumped. The average recovery was 0.07 gal of LNAPL per day at a ground-water flow rate of 1.4 gpm. During this period of operation, the average water table elevation remained above 292 ft effectively limiting LNAPL recovery.

4.3.1.2 Vacuum Enhanced LNAPL Recovery

During June 1994, the vacuum enhanced system was started and operated for 4 days. Approximately 70 gal of LNAPL was recovered and 1,643 gal of ground water was pumped. During this period the average LNAPL recovery was 19.9 gal per day at a ground-water pumping rate of less than 0.01 gpm. This represents a 105 percent increase in LNAPL recovery using vacuum enhanced recovery. Petroleum hydrocarbons were detected at a concentration of 25,000 parts per million by volume (ppmv) in the extracted air stream. This converts to a hydrocarbon loading rate of 233 pounds per day (lbs/day) based on the operating flow rate of 30 cfm. This loading rate corresponds to an approximate GAC usage rate of 800 lbs/day. Due to the high carbon usage, EA and the Navy decided to suspend vacuum enhanced recovery.

After the installation of a thermal oxidizer for off-gas treatment, vacuum enhanced recovery was conducted from August-November 1995. During this time a total of 21.61 gal of LNAPL was recovered and 85,303 gal of ground water was pumped. All of the LNAPL was recovered from 6 October to 21 November because prior to then the LNAPL/water interface was below the intake on the recovery pump and hydrocarbon recovery was limited to the vapor phase. The average LNAPL recovery from 6 October to 21 November was 0.5 gal per day at a ground-water flow rate of 1.3 gpm. In addition, from August to November, the equivalent liquid-phase volume of approximately 378 gal of LNAPL was recovered in the vapor-phase through the action of the vacuum enhanced system.

During the period from August-November 1995 the vacuum system operated at vacuums

ranging from 2 to 19 in-Hg at corresponding flow rates of 39 and 14 cfm, respectively. Higher vacuums and decreased air flow rates were present during late October and November. The lower air flow rate is a result of air being extracted from a smaller screened interval on well NFFW-2R due to high water table conditions. Recovered hydrocarbon vapor concentrations and mass loading rates ranged from 4,500 to 19,000 ppmv (TPH as toluene equivalents) and approximately 7.21 to 130.45 lbs/day, respectively.

Vacuum-enhanced operations were conducted briefly during July and again in September 1996. During an eight day period in July the system recovered 19.11 gal of LNAPL at an average recovery rate of approximately 2.4 gal per day. An additional 15.20 gal of LNAPL was recovered in the vapor-phase. The rising water table then inhibited vacuum-enhanced operation; however, the water table fell sufficiently for a 6 day period of vacuum-enhanced operation in September. During that time, 11.75 gal of LNAPL was pumped at an average recovery rate of approximately 2 gal per day and an additional 6.7 gal of LNAPL was recovered in the vapor-phase. The complete results of the vacuum-enhanced portion of the pilot system are summarized on Table 8.

4.3.2 Automated and Passive LNAPL Skimming Operations

As shown on Table 9, automated skimming operations recovered a total of 1.86 and 0.00 gal of LNAPL from wells NFFW-6 and NFFW-19, respectively. Passive LNAPL skimming recovered a total of 55.11 and 14.32 gal of LNAPL from wells NFFW-14 and NFFW-16, respectively. Small amounts of LNAPL were also recovered through hand bailing at wells NFFW-1, NFFW-7, NFFW-12, and NFFW-20. LNAPL skimming and hand bailing recovered a total of 86.32 gal of LNAPL or approximately 6% of the 1,513.09 gal of LNAPL recovered during the pilot study.

The low volume of LNAPL recovered from well NFFW-6 and the lack of recovery from well NFFW-19 is attributable to the general absence of LNAPL from those wells during the pilot study. Prior to the pilot study LNAPL was consistently present in the two wells at thicknesses up to 1.20 and 2.00 ft, respectively. During the pilot study LNAPL was detected in well NFFW-6 at a maximum thickness of 0.27 ft and has been detected on only one occasion (at a thickness of 0.01 ft) since 25 October 1994 and was detected in well NFFW-19 at a maximum thickness of only 0.10 ft and has not been detected since 1 July 1994 (Appendix A). Based on the graphs of ground-water elevation and LNAPL thickness vs time for wells NFFW-6 and NFFW-19 contained in Appendix B, it appears that LNAPL is no longer present in those areas of the site. This conclusion is supported by the predominant absence of LNAPL in both wells throughout more than one year of seasonal ground-water fluctuations.

The automated skimmer from well NFFW-19 was installed at well NFFW-14 in February 1996 and has recovered approximately 12 gal of LNAPL through October 1996. This represents an increase in recovery of approximately 2.4 gal over the same time period in 1995. Based on the gauging data in Appendix A, it is apparent that LNAPL occurrence in well

NFFW-14 is similar to that in well NFFW-2R in that it is dependent on water table elevation. Thus automated skimming had limited success at well NFFW-14 due to the high water table.

4.4 INFLUENT AND EFFLUENT MONITORING

Average hydrocarbon concentrations in extracted ground-water as determined from the 7 samples collected from April 1995 through July 1996 were 1,106.3 μg/l total BTEX, 317.14 μg/l naphthalene, and 10,100 μg/l TPH as gasoline, the complete results of each sampling event are summarized on Table 5 and included as Appendix C. As discussed in Section 2.6.2 and illustrated on Table 5, each sample exceeded the 5 μg/L benzene and 20 μg/L naphthalene site cleanup criteria.

The 200 lb GAC treatment units were changed out on three occasions during the pilot study. In February 1995, both the primary and secondary units were replaced after pumping a total 146,925 gal of ground water resulting in a carbon usage rate of 0.002 pounds per gallon. In November 1995 only the primary GAC unit was replaced after processing a total of 279,765 gal of ground water. This corresponds to a carbon usage rate of 0.0007 pound per gal. At that time the new GAC unit was placed in the secondary position and the former secondary unit was rotated to the primary position. Both units were again changed out in August 1996 after processing an additional 863,190 gal of ground water at a carbon usage rate of 0.0005 pounds per gal.

4.5 SOIL VAPOR EXTRACTION TESTING

As previously described, dual-phase (LNAPL and ground water) recovery is generally limited not only by the LNAPL/water level but also by the physical constraints of the system, such as the ability to raise/lower the pump intakes in response to water table fluctuations of up to 24 ft. The alternative to LNAPL pumping is inducing a phase change to vapor and using vacuum extraction as the removal mechanism. This method though less direct and efficient is nonetheless not constrained by the physical location of a pump intake.

In order to evaluate the effectiveness of vapor-phase extraction SVE tests were conducted from several site wells on two separate occasions as discussed in Section 3.3. The results of the SVE tests are summarized below, the complete results for the April and July tests are included in Appendices D and E, respectively.

4.5.1 High Water Table Test (April 1995)

Soil vapor extraction (SVE) tests were conducted on monitoring wells NFFW-4, NFFW-7, and NFFW-16 from 4-6 April 1995. The purpose of the SVE tests was to evaluate the potential for SVE as a remedial technology during periods of high water table elevation. These wells were chosen to assess SVE performance in areas with varying amounts of LNAPL. LNAPL has not been observed in NFFW-4, has been present periodically in NFFW-

7, and has consistently been present in NFFW-16.

The SVE tests consisted of a system head test and a radial influence test. The system head test evaluates the relationship between the applied vacuum and the extracted air flow rate. The radial influence test evaluates the radial distance from the well influenced by the applied vacuum at the extraction well and to assess the volatile organic compound (VOC) removal rates.

The results of the system head test indicate the area is characterized by a low permeability subsurface resulting in a high vacuum - low flow rate relationship. Applied vacuums ranged from 2 to 14.8 in-Hg while observed flow rates ranged from 2.18 to 43.6 cfm. In general, the three test wells (NFFW-4, NFFW-7, and NFFW-16) responded similarly to the range of vacuums applied and no significant differences were observed.

The results of the radial influence tests indicate that preferential pathways may exist in the subsurface. The tests on wells NFFW-4, NFFW-7, and NFFW-16 were conducted at vacuums of approximately 7, 9, and 10 in-Hg, respectively, with corresponding average air flow rates of 33, 33, and 26 cfm. In general, the greatest radial influence was observed from well NFFW-16 and the least radial influence was present in the vicinity of well NFFW-4. The inconsistent nature of the results does not allow the determination of an effective radius of influence about each well. However, it should be noted that vacuum influence was observed during each test at distances of up to 25 feet from the extraction well.

Removal rates in lbs/day were calculated for each sample collected based on TPH as toluene equivalents. Extraction from well NFFW-7 produced the highest average hydrocarbon removal rate (28.46 lbs/day) while extraction from wells NFFW-4 and NFFW-16 resulted in lower average removal rates of 0.74 and 11.46 lbs/day, respectively.

The results of the chlorinated hydrocarbon analysis indicated the presence of several target compounds in samples from each of the three test wells. Chlorinated hydrocarbons were most prevalent in the extracted air samples from well NFFW-4 where methylene chloride was present at a maximum of 19.18 ppmv. The occurrence of chlorinated hydrocarbons is not coincident with the occurrence of LNAPL since NFFW-4 is in an area where LNAPL has not been detected.

4.5.2 Low Water Table Test (July 1995)

Soil vapor extraction (SVE) tests were conducted on monitoring wells NFFW-4 and NFFW-16 on 6 July 1995. The purpose of the SVE tests was to evaluate the potential for SVE as a remedial technology during periods of low water table elevation. This test was conducted at a time when water table was approximately 3 to 7 ft lower than it was during the high water table (April) test. It was anticipated that improved removal efficiencies would be observed during the low water table test. These wells were chosen to assess SVE performance in areas

with varying amounts of LNAPL. LNAPL has not been observed in NFFW-4 and has consistently been present in NFFW-16. An SVE test was not conducted on NFFW-7 because it had been damaged during the removal of a large soil stockpile at he Navy Fuel Farm.

The SVE tests consisted of a system head test and a radial influence test. The system head test evaluates the relationship between the applied vacuum and the extracted air flow rate. The radial influence test evaluates the radial distance from the well influenced by the applied vacuum at the extraction well and to assess the volatile organic compound (VOC) removal rates.

During the system head tests applied vacuums ranged from 1 to 5 in-Hg while observed flow rates ranged from 8.7 to 37.6 cfm. In general, a higher flow rate was achieved in NFFW-4 than in NFFW-16 for the same applied extraction pressures.

The radial influence tests again produced varying results. The tests on wells NFFW-4 and NFFW-16 were conducted at extraction pressures of 4 in-Hg with corresponding average flow rates of 37 and 16 cfm respectively. In general, the greater radial influence was observed from well NFFW-16 and minimal radial influence was present in the vicinity of well NFFW-4. The effective zone of radial influence about each well, which is defined as the area within a differential pressure of 0.10 inches of water (Keech, 1989), is approximately 5 ft for NFFW-4 and 25 ft for NFFW-16. This estimate is based on an observed vacuum of 0.1 inches of water in the monitoring points.

Extraction from well NFFW-16 produced the highest average petroleum hydrocarbon removal rate (1.0 lb/day) while extraction from well NFFW-4 resulted in a minimal average removal rate of less than 0.05 lbs/day.

The results of the chlorinated hydrocarbon analysis indicated the presence of several target compounds in samples from NFFW-4 while samples from NFFW-16 contained no detectable level of chlorinated hydrocarbons. As discussed in Section 5.2.1, the occurrence of chlorinated hydrocarbons in NFFW-4 is not consistent with the occurrence of LNAPL as NFFW-4 is in an area where LNAPL has not been detected. The most prevalent chlorinated hydrocarbon present in the extracted air samples from NFFW-4 was methylene chloride which was detected at a maximum concentration of 25 ppmv. The maximum total hydrocarbon removal rate at NFFW-4, which includes both petroleum and chlorinated hydrocarbons, was 0.26 lbs/day.

A comparison of the two SVE tests is presented below:

- Flow rates for NFFW-4 in July were consistent with those found in April but extraction pressures were significantly less to achieve the same flow rate, 12 in-Hg in April and 4 in-Hg in July to achieve the same flow of 37 cfm. NFFW-16 exhibited significantly lower flow rates in July (18.5 cfm) than in April (44

cfm). Noting that the same vacuum extraction blower was utilized during both tests, the maximum achievable extraction vacuum was also significantly less during July (4 in-Hg) than in April (18 in-Hg). This is a result of more screened interval (3-7 ft) in the wells being exposed during the low water table SVE test than during the high water table SVE test.

- The July radial influence tests indicate a significant difference in radial influence between NFFW-4 (5 ft) and NFFW-16 (25 ft). These results are similar to those found during the April test with the exception that the July results were more symmetrical for the two axis. The results of the April investigation indicate that the radial influence was not symmetrical.

- Average petroleum hydrocarbon removal rates (< 1 lb/day) were minimal during the July testing event for both wells tested. These removal rates were also less than those found during the April testing event where the average petroleum hydrocarbon removal rate was 28 lbs/day.

- The results are counter-intuitive since the high water levels generally preclude efficient vapor interaction with the LNAPL while a low water table promotes access for air flow and interaction with LNAPL.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY AND CONCLUSIONS OF THE PILOT STUDY

5.1.1 Occurrence and Distribution of LNAPL

Significant amounts of LNAPL remain in the subsurface at the Navy Fuel Farm and the occurrence of LNAPL is related to the ground-water table elevations. During periods of high ground-water table elevations, LNAPL is present sporadically in a few wells. However, during periods of low or falling ground-water table elevations, LNAPL is found throughout the Navy Fuel Farm. LNAPL was observed in a 4.6 acre area bounded by monitoring wells NFFW-19, NFFW-6, NFFW-20, NFFW-12, and NFFW-8 excluding NFFW-5.

LNAPL tends to be present in monitoring wells when the ground-water table elevation is in the fractured rock zone and not when the ground-water table elevation is in the overburden. For example, in NFFW-2R, LNAPL was typically present in the well only after the water table was depressed or fell to a level approximately 20 ft below the top of the well casing (295 ft above msl). One possible explanation for the relationship between the water table elevation and the occurrence of LNAPL in the monitoring wells is that the LNAPL is present in the rock fractures and flows into the wells during periods of low ground-water table elevation. However, during periods of high ground-water table elevation, the LNAPL becomes hydraulically isolated from the well. The result is that the LNAPL can not enter the well and therefore, no LNAPL is observed in the well during periods of high ground-water table elevation.

5.1.2 LNAPL Recovery without Vacuum Enhancement

LNAPL recovery without vacuum enhancement was successful when the ground-water table was depressed. While operating the recovery system at NFFW-2R without vacuum enhancement from July 1994 to July 1995, the average LNAPL recovery rate was 2.5 gal per day at a ground-water pumping rate of 0.3 gal per minute. However, the fluctuation of the ground-water table had a large influence on the rate of LNAPL recovery. In addition to the absence of LNAPL when the ground-water table elevation was high, heavy rainfalls also affected LNAPL recovery. Heavy rainfalls often raised the water table elevation fast enough that the water table depression pump (rated at 7 gpm) was often not able to pump as fast as water recharged the well. As a result, the recovery pump would become submerged. The ground-water pumping rate needed to maintain the desired drawdown in NFFW-2R during periods of high water table elevation is estimated at 10-15 gpm, based on results of a rate check conducted in March 1996.

Furthermore, recovery was also limited during drought periods when the LNAPL/water interface dropped below the level of the recovery pump intake. The option of deepening the wells was considered, however, because of the potential to cross-contaminate the lower portion of the Stockton Formation, which is utilized as a water supply, this option was ruled out. Appendix F contains the letter report recommending against deepening well NFFW-2R.

Depending on the monitoring well, the pilot study reports limited success in skimming of LNAPL. Typically, both automated skimming and hand bailing are effective methods of recovering LNAPL in the immediate area of the well but do not create a significant capture zone. Based on the hand bailing and automated skimming results, the automated skimmers were not deployed in the proper wells. Manual bailing of LNAPL from NFFW-14 and NFFW-16 recovered 55 gal and 14.32 gal respectively. The hand bailing results indicate that automated bailing should also be effective. Based on the available information at the start of the pilot study, automated skimming systems were installed in NFFW-6 and NFFW-19. However, the amount of LNAPL recovered from wells NFFW-6 and NFFW-19 (1.86 gal and 0 gal respectively) did not justify the effort of installing the automated skimmers. The automated skimmer from NFFW-19 was subsequently moved to NFFW-14, but high groundwater table elevations have limited LNAPL recovery. However, 12 gal of LNAPL was recovered in 1996 through the use of the automated skimmer at well NFFW-14 representing nearly a 25 percent increase in recovery over the same period in 1995.

5.1.3 Vacuum Enhanced LNAPL Recovery

Vacuum enhanced LNAPL recovery was also hampered by the fluctuations in the water table. For much of the time that vacuum enhanced recovery was conducted, the LNAPL/water interface was below the level of the recovery pump intake. As a result, during the August-November 1995 time period, most of the hydrocarbons recovered during the vacuum enhanced recovery operations were recovered in the vapor-phase. The equivalent of approximately 4.1 gal per day was recovered in the vapor phase compared to 0.24 gal per day of LNAPL. Comparing the amount of LNAPL recovered during the July 1994-July 1995 period of recovery without vacuum-enhancement and the August-November 1995 period of vacuum-enhanced recovery; vacuum-enhanced recovery resulted in a 64 percent increase in hydrocarbon recovery when vapor-phase recovery is considered.

Vacuum-enhanced recovery also increased the LNAPL recovery rate during the June 1994 vacuum-enhanced recovery operations when compared to the 30 March-3 June 1994 recovery operations without vacuum-enhancement. Approximately 9.7 gal per day of LNAPL was recovered without vacuum-enhancement as compared to 19.9 gal per day with vacuum-enhancement. This is a 105 percent increase in LNAPL recovery using vacuum-enhanced recovery. However, the June 1994 vacuum-enhanced recovery operations were of too short a duration to draw any conclusions about the long-term effectiveness of vacuum-enhanced recovery.

Based on each period of vacuum-enhanced recovery operations, ground-water table fluctuations had a large impact on the amount of LNAPL recovered. As discussed above, deepening of NFFW-2R is not recommended. However, when the ground-water table elevation fell below the recovery pump intake, vacuum-enhanced recovery did result in the removal of significant amount of hydrocarbons which would not have been recovered otherwise. In addition, oxygen is typically the limiting factor for subsurface biological activity and the biodegradability of petroleum products is well documented. Therefore, it is likely that vacuum-enhanced recovery will stimulate biological degradation of residual-phase petroleum hydrocarbons in the vadose zone.

5.1.4 Soil Vapor Extraction Testing

Based on the results of two sets of SVE tests, SVE appears to be of limited use as a remedial option for this site. This is a result of the small radial influences observed, low vapor flow rates, and low vapor phase hydrocarbon recovery rates. The results from the April 1994 test (high ground-water table conditions) indicate hydrocarbon recovery rates between approximately 11.5 and 28.5 lbs/day are attainable for wells NFFW-7 and NFFW-16, respectively. During the July 1995 test (low water table conditions) recovery rates for the same two wells were less than 1.0 lb/day. However, as with vacuum-enhanced recovery, SVE would result in the removal of some residual phase hydrocarbons which would not otherwise be recovered and would stimulate biodegradation of the residual phase petroleum hydrocarbons.

5.1.5 Conclusions

Based on the results of the pilot study, the following conclusions can be made. These form the basis for the recommendations contained in Section 5.3.

- Based on a comparison of the analytical results from previous investigations to the Pennsylvania cleanup levels, the remedial action objectives at the Navy Fuel Farm should include source reduction through recovery of LNAPL and ground-water remediation.

- Significant amounts of LNAPL remain at the Navy Fuel Farm. Recoverable amounts of LNAPL have been gauged in wells NFFW-1, NFFW-2R, NFFW-7, NFFW-14, NFFW-16, and NFFW-20.

- LNAPL occurrence is directly related to ground-water table elevation. During periods of high ground-water table elevation, LNAPL is present in only a few monitoring wells. During periods of low ground-water table elevation, the occurrence of LNAPL increases, both in areal extent and in thickness of the LNAPL layer observed in the monitoring wells.

- Recovery of the LNAPL is limited by the hydrogeology of the site. In particular, the LNAPL appears to be present in the fractures of the bedrock and becomes isolated from the site wells during periods of high ground-water table elevation. The ground-water table fluctuates seasonally and with rainfall. The large and relatively quick acting fluctuations (up to 24 ft) make maintaining the pump intake at the proper level very difficult.

- LNAPL recovery using ground-water table depression without vacuum-enhancement was an effective method of recovery. Automated skimming of LNAPL was not an effective method of recovery.

- LNAPL recovery using vacuum-enhanced recovery was limited due to both high and low ground-water table elevations resulting in the LNAPL/water interface being either above or below the level of the intake of the recovery pump during portions of the periods that vacuum-enhanced recovery was tested. However, when vapor-phase recovery of LNAPL is accounted for, vacuum-enhanced recovery did increase the amount of petroleum hydrocarbons recovered.

- Because of small radius of influence and low vapor recovery rates, SVE is only marginally effective at the Navy Fuel Farm.

5.2 OPTIONS FOR FULL SCALE REMEDIATION SYSTEM

Based on the results of the pilot study the following options for LNAPL recovery were considered for the full-scale remedial system:

- vacuum-enhanced recovery using water table depression operating all year

- LNAPL recovery using water table depression without vacuum-enhancement operated only during periods of low water table elevations

- LNAPL recovery using vacuum-enhanced recovery when conditions are favorable and only ground-water table depression when conditions for vacuum-enhanced recovery are not favorable

- bioslurping

Each option would include expansion of the recovery efforts to include new wells installed in the vicinity of NFFW-2R, NFFW-14 and NFFW-16, except bioslurping which would require additional extraction points due to the anticipated minimal radius of influence as evidenced by the results of SVE tests. Furthermore, each option would be supplemented by a bailing program to recover LNAPL which occurs intermittently at other site wells. The following discusses the advantages and disadvantages of each option. Approximate design, construction

and operation and maintenance costs are also provided.

5.2.1 Vacuum-Enhanced Recovery

The advantages to operating a full scale vacuum-enhanced recovery system include the increased rate of LNAPL recovery; recovery of vapor-phase hydrocarbons during periods when the water table elevation falls below the well; reduction of residual-phase hydrocarbons; treatment of dissolved-phase hydrocarbons; and increased biodegradation. All of these advantages result in a decreased duration for remediation as compared to the pump and treat option.

The disadvantages include the high cost of treating the air emissions and the increased water flow rates. In addition, to accommodate the water flow rates which would result from expanding the system, larger water table depression pumps and water treatment equipment will be required.

Currently, the vacuum-enhanced recovery system at NFFW-2R utilizes a dual pumping system (individual ground-water and LNAPL pumps). During periods of extremely low water table elevations, the LNAPL/water interface falls below the LNAPL intake and the pump can not recover LNAPL; however vapor-phase extraction and bioremediation are enhanced in this situation. Because, as discussed in section 5.1.2, deepening NFFW-2R is not an option other pumps, such as a total fluids pump could be used. However, use of a total fluids pump would require an oil/water separator and possibly iron removal.

Treatment of the air emissions is an expensive part of the vacuum enhanced recovery system. The recovery rate of vapor phase hydrocarbons varies with the water table elevation and the amount of LNAPL in the well. This makes selection of an off-gas treatment technology difficult. For example, when vapor-phase concentrations are high as is the case when the water table is low, the cost of carbon treatment is prohibitive; conversely, when vapor-phase concentrations are low, the cost of providing supplemental fuel for the thermal oxidizer is also expensive. The thermal oxidizer currently at the site is large enough to handle the increased air flow from additional wells. The operating costs of the thermal oxidizer can be decreased by adding a heat exchanger and/or a catalytic oxidizer option to the thermal oxidizer. These features will reduce the amount of supplemental fuel required to treat the air emissions.

The approximate cost for design of this option ranges from $25,000 to $30,000 with construction costs in the range of $320,000 to $510,000. This assumes installation of three new wells, purchasing the existing thermal oxidizer, installing new ground-water treatment units, and equipping the system with telemetry. Average annual operation and maintenance costs are estimated to range between $72,000 and $120,000. Approximate cost ranges for each option considered are summarized on Table 10.

5.2.2 LNAPL Recovery Using Water Table Depression Without Vacuum-Enhancement Operated Only During Periods of Low Water Table Elevations

This option would operate only during periods of low water table elevation. This option would recover significant amounts of LNAPL at the lowest cost. The disadvantage is that during periods of high water table elevation no remediation would be accomplished.

Several additions to the current system would be required to expand recovery operations. Three new larger diameter wells would be installed, new ground-water depression pumps would be required, and the water treatment system would need to be expanded to add larger carbon adsorption units to accommodate the increased water flow.

The approximate cost for design of this option ranges from $20,000 to $25,000 with construction costs in the range of $250,000 to $420,000. Additionally, average annual operation and maintenance costs are estimated to range between $40,000 and $60,000. Approximate cost ranges for this option are also summarized on Table 10.

5.2.3 LNAPL Recovery Using Vacuum-Enhanced Recovery when Conditions are Favorable and Only Ground Water Table Depression When Conditions for Vacuum Enhanced Recovery are not Favorable

This option is a combination of the first two options. When conditions are favorable, selective use of vacuum-enhancement would increase the LNAPL recovery rate and allow remediation to continue when the LNAPL/water interface drops below the well. Remediation of the residual phase and increased biodegradation would also occur.

The approximate cost for design of this option ranges from $25,000 to $30,000 with construction costs in the range of $320,000 to $510,000. Average annual operation and maintenance costs are estimated to range between $72,000 and $120,000. These cost ranges are summarized on Table 10.

5.2.4 Bioslurping

Conceptually, bioslurping and vacuum enhanced recovery (as discussed in Section 5.2.1) are the same remedial technology. Both options extract LNAPL, ground water, and soil vapor. The difference is that bioslurping uses a uses a vacuum pump to withdraw liquids and vapors from the extraction well. Vacuum pumps are limited to 1 atmosphere of pressure (33 ft of water). Therefore, accounting for head losses, after the LNAPL/water interface dropped more than 20-25 ft below the ground surface, bioslurping would not be able to extract liquids. While the extraction of LNAPL and a ground water/soil vapor mixture may allow recovery from depths greater than 20-25 ft, an advantage of bioslurping is that it minimizes the amount of water pumped. However, due to the large water table fluctuation at this site, placement of the intake in a bioslurping system would be well below the ground water table during much of the year and the amount of water pumped may not be decreased. Therefore, bioslurping is not

an appropriate technology at this site because of the large water table fluctuations. Because bioslurping, using a single vacuum pump, is not appropriate, costs have not been estimated.

5.3 RECOMMENDATION

Based on the results of the pilot study to date, operation of an LNAPL recovery system using ground-water table depression and vacuum-enhancement is recommended. This recommendation allows recovery of LNAPL to be conducted during periods of low and high water table elevations at a cost which is in the same order of magnitude as the other options considered. The following items should be incorporated into the design of the full scale remedial system.

- Install new 6-in. or 8-in. diameter recovery wells in the vicinity of wells NFFW-14 and NFFW-16 to accommodate dual pumping systems.

- Expand the vacuum-enhanced recovery system to include the two new wells along with existing well NFFW-2R. Install dual pumping systems in each well that are amenable to vacuum-enhanced operation within the range of ground-water table elevation fluctuations observed during the pilot study. It is anticipated that the three LNAPL pumps currently in use at the Fuel Farm can also be utilized as part of the final design; however, three new ground-water pumps will be required. Also install variable speed drives and pressure transducers on each pump. This will allow manipulation of pumping rates in relation to ground-water table elevations in order to maintain the desired level of drawdown. Expected flow rate is < 1-15 gpm per well.

- Install individual underground lines (LNAPL, ground-water and SVE) to each recovery well along with underground electrical service.

- Upgrade the ground-water treatment system to accommodate a flow rate of up to 45 gpm. This could be accomplished by installing two new 1,000 pound high pressure carbon treatment vessels. These units along with the ground-water system controls should be placed in a new non-explosion proof enclosure. The existing explosion proof enclosure will continue to house the existing vacuum portion of the system and will also provide equipment and material storage space. It should be noted that air stripping is not recommended due to the low carbon usage during the pilot study and because Pennsylvania Regulations (25 PA Code Chapter 127) require treatment of air emissions.

- Upgrade the water discharge line to 6-in diameter PVC pipe or larger and install below ground.

- Install telemetry to allow for remote monitoring of the entire system. This will enable a timely response to any system malfunctions that may occur.

REFERENCES

Commonwealth of Pennsylvania Department of Environmental Resources (PADER). Protective Levels and Criteria for the Excavation, Treatment, Cleanup and Disposal of Virgin Fuel Contaminated Soil. October (PADER 1991).

Commonwealth of Pennsylvania Department of Environmental Resources, Ground Water Quality Protection Strategy. February (PADER 1992).

EA. 1988a. Plan of Action for Site Inspection, NAS Willow Grove, Pennsylvania. February.

EA. 1988b. Draft Appendix B, Soil Vapor Contaminant Assessment at NAS Willow Grove. December.

EA. 1989a. Interim Report, Electromagnetic Survey, Soil Vapor Contaminant Assessment, and Revised Field Sampling Plan for Site Inspection Studies at NAS Willow Grove. March.

EA. 1989b. Draft Report, Environmental Test Boring Investigation at the Navy Fuel Farm, NAS Willow Grove, Horsham Township, Pennsylvania. June.

EA. 1990. Final Report, Site Inspection Studies at NAS Willow Grove, Horsham Township, Pennsylvania. Volumes I and II. May.

EA. 1991. Final Interim Report on Investigations at the Navy Fuel Farm, NAS Willow Grove, November 1990 - July 1991. November.

EA. 1993a. Final Work Plan for Pilot-Scale Testing of Free-Product Recovery and Aquifer Air Sparging at the Navy Fuel Farm Facility - NAS Willow Grove. November.

EA. 1993b. Final Report of Interim Site Investigations, Navy Fuel Farm - Willow Grove NAS. September.

EA. 1993c. Final Implementation Pan for Pilot-Scale Testing of Free-Product Recovery and Aquifer Air Sparging at the Navy Fuel Farm Facility - NAS Willow Grove. November.

Keech, D.A. 1989. Surface Venting Research and Venting Manual by the American Petroleum Research Institute. Presented at the Workshop on Soil Vacuum Extraction, R.S. Kerr Environmental Research Laboratory. 27-28 April. Ada, Oklahoma.

Marley, M.C., S.D. Richler, R.J. Cody, and B.J. Cliff. 1990. Modeling of *In Situ* Evaluation of Soil Properties and Engineered Vapor Extraction System Design. National Water Well Association/American Petroleum Institute Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Restoration. Houston, Texas.

REFERENCES (Continued)

Miller, R.N., R.E. Hinchee, C.M. Vogel, R.R. Dupont, and D.C. Downey. 1990. A Field Scale Investigation of Enhanced Petroleum Hydrocarbon Biodegradation in the Vadose Zone at Tyndal AFB, Florida. National Water Well Association/American Petroleum Institute Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Restoration. Houston, Texas.

Rima, D.R., H. Meisles, and S. Longwill. 1962. Geology and Hydrology of the Stockton Formation in Southeastern Pennsylvania. Bulletin W-14, Pennsylvania Topographic and Geologic Survey. 111 pp.

Title 25 - Pennsylvania Code Chapter 245 Subchapter D, Storage Tanks; Corrective Action. August. Commonwealth of Pennsylvania, Environmental Quality Board (EQB 1993).

FIGURES

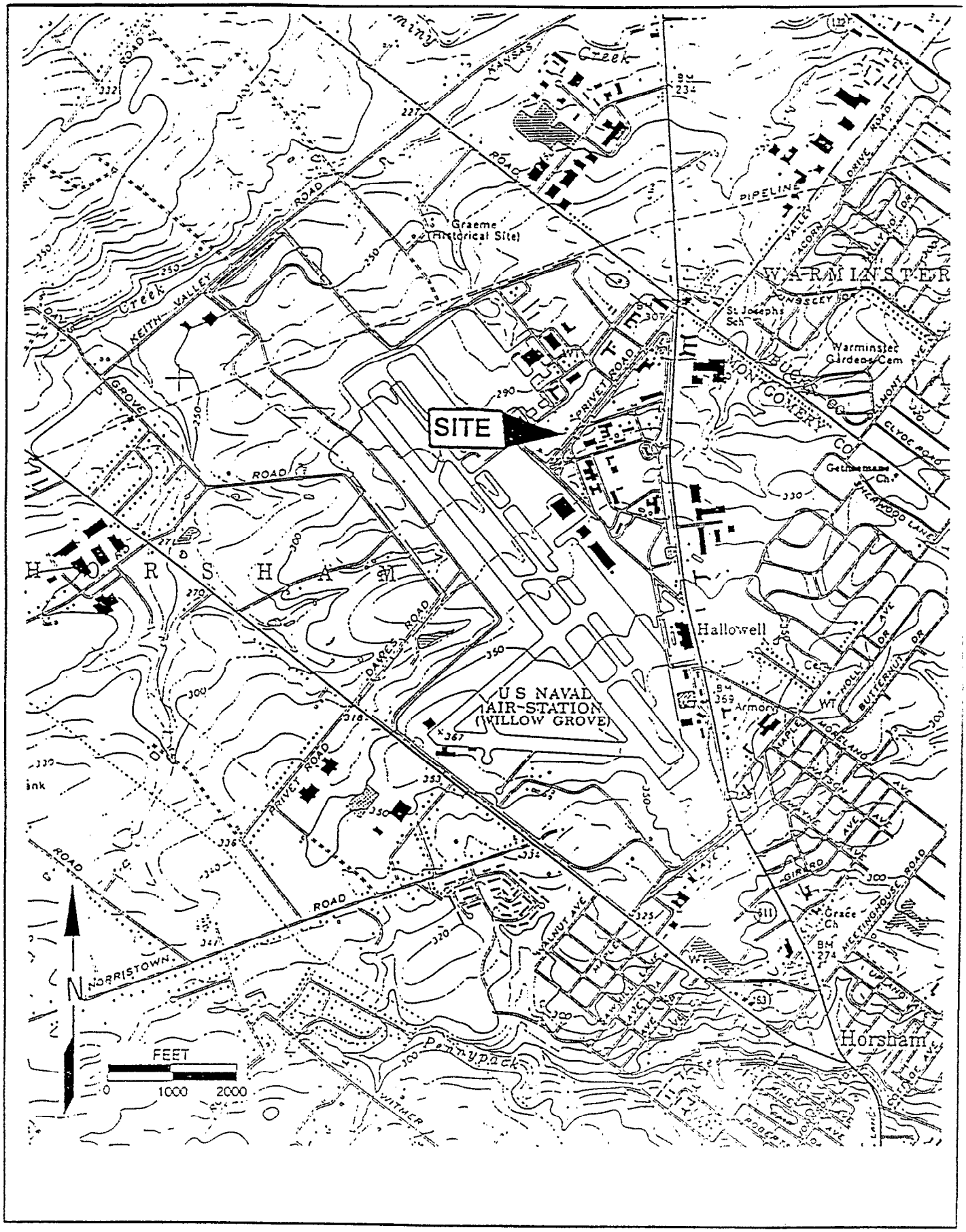
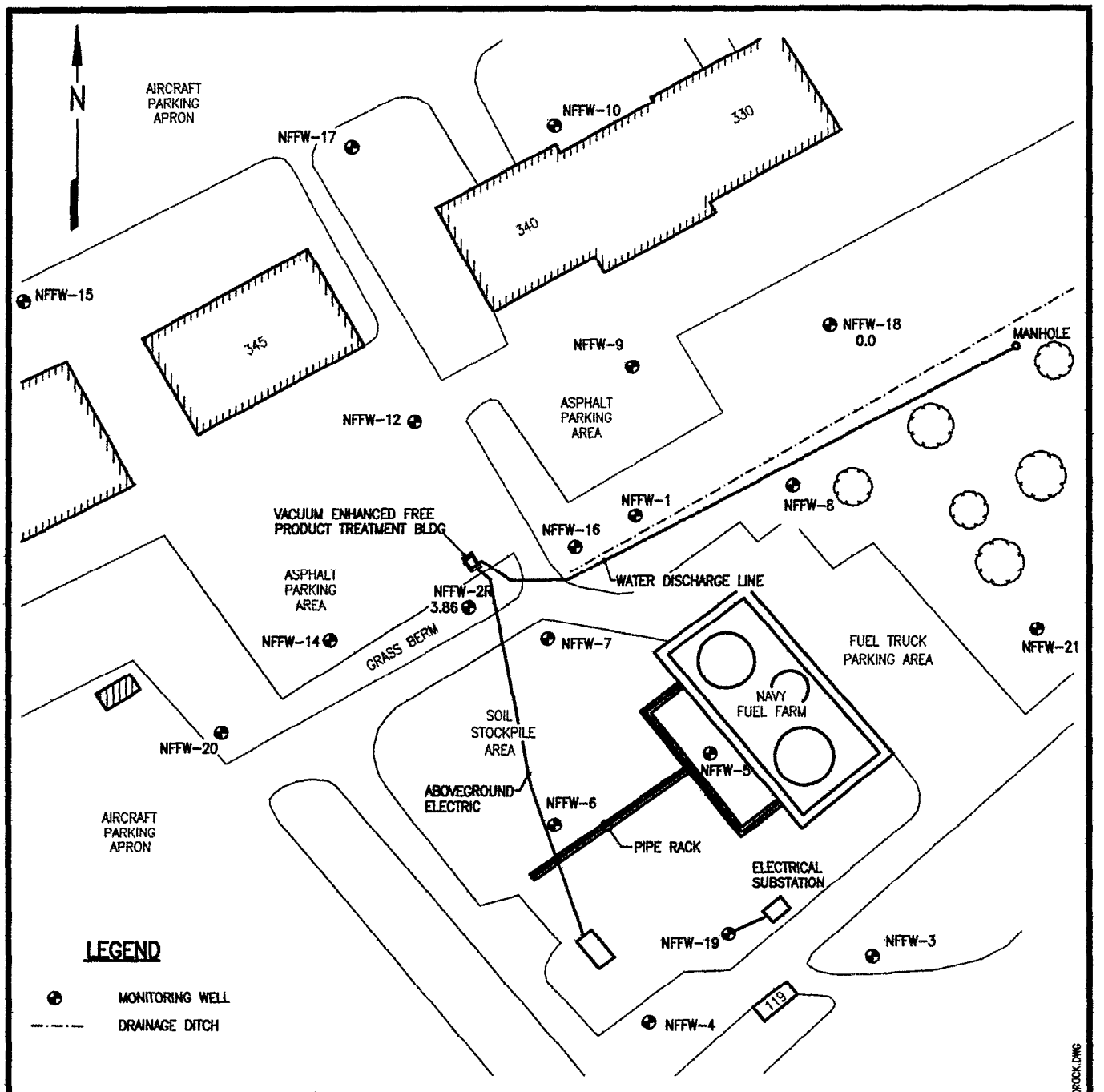


Figure 1. Site location map, Navy Fuel Farm facility, Naval Air Station, Willow Grove Grove, Pennsylvania.



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

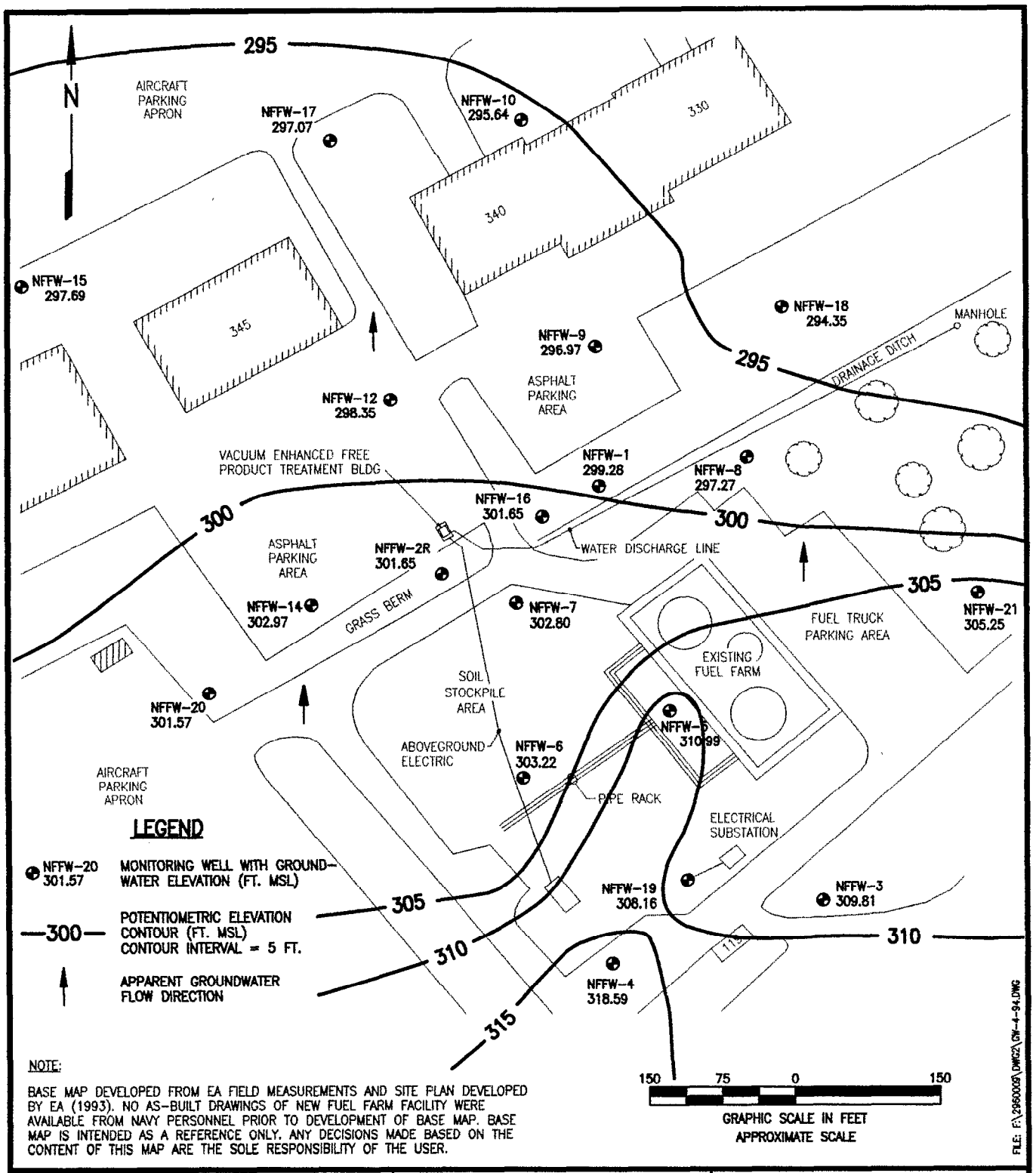
150 75 0 150

GRAPHIC SCALE IN FEET
APPROXIMATE SCALE

FILE: F:\29600009\DWG2\BEDROCK.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	NAVY FUEL FARM FACILITY NAVAL AIR STATION WILLOW GROVE, PENNSYLVANIA	SITE PLAN

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	2



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

POTENTIOMETRIC SURFACE
4 APRIL 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	4-8-96	29600.09	3

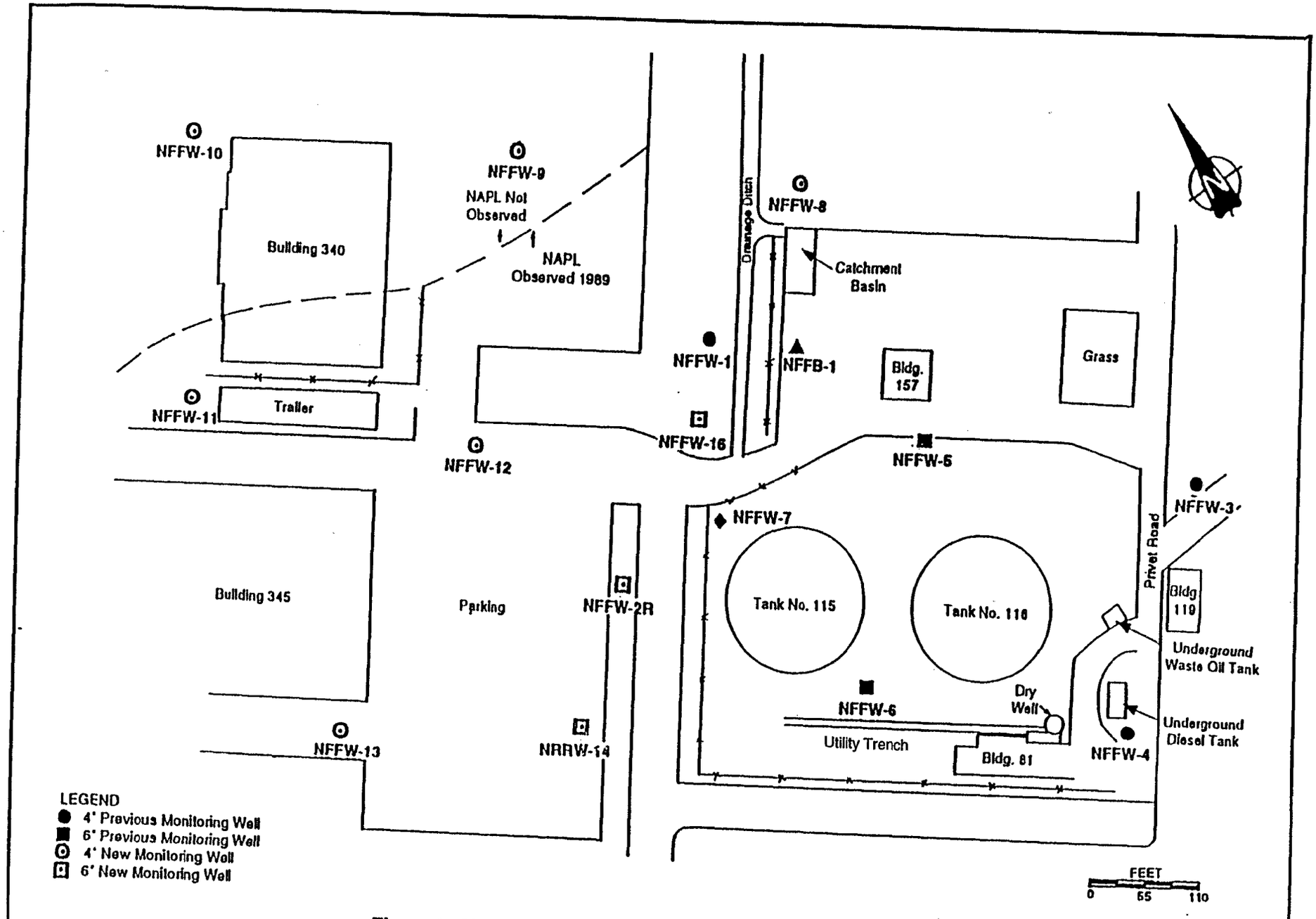


Figure 4. Site plan showing relevant site features, prior to 1991.
Navy Fuel Farm Facility, Naval Air Station, Willow Grove, Horsham Township, Pennsylvania.

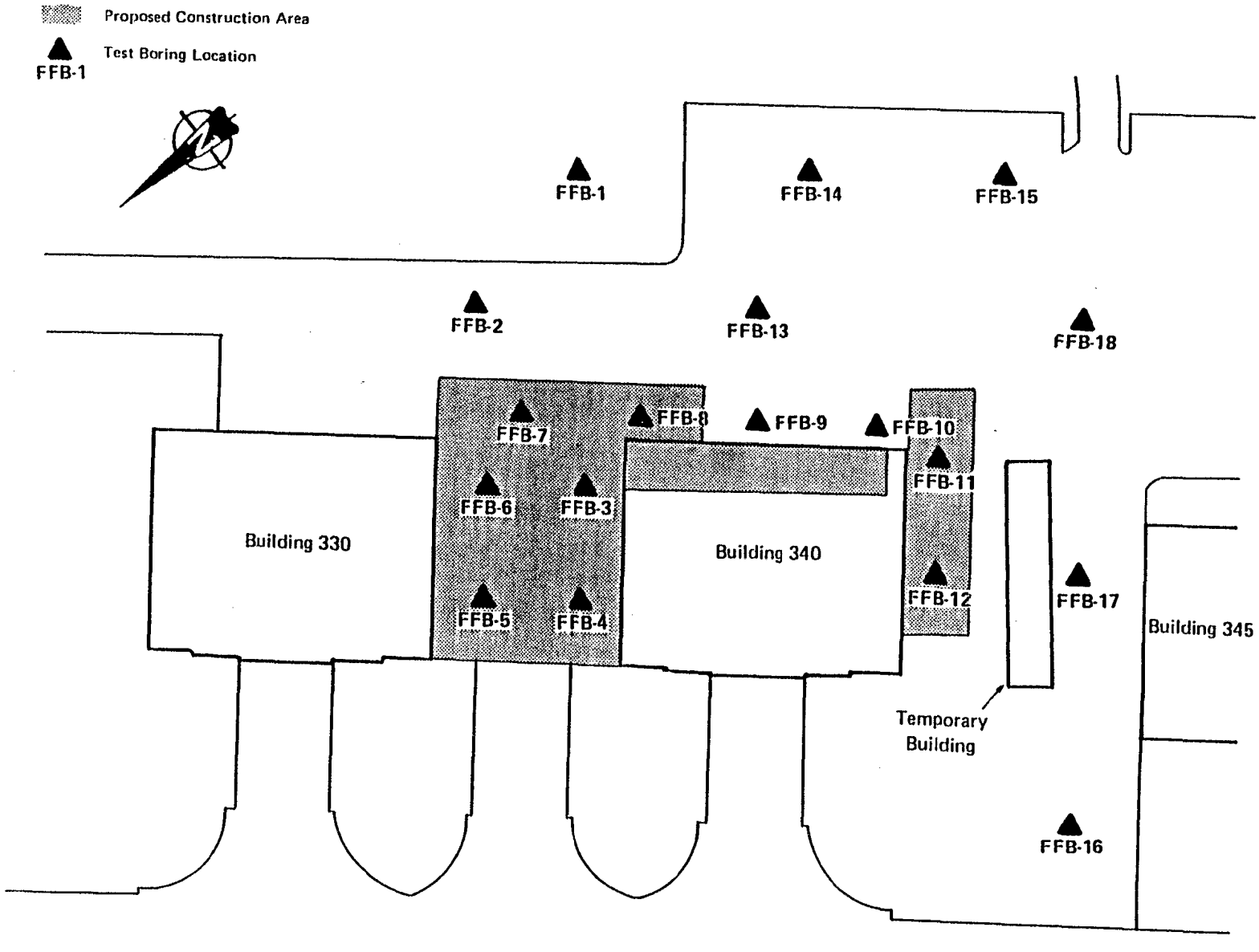


Figure 5. Location of soil borings installed in March 1989.
Navy Fuel Farm Facility, Naval Air Station, Willow Grove, Horsham Township, Pennsylvania.

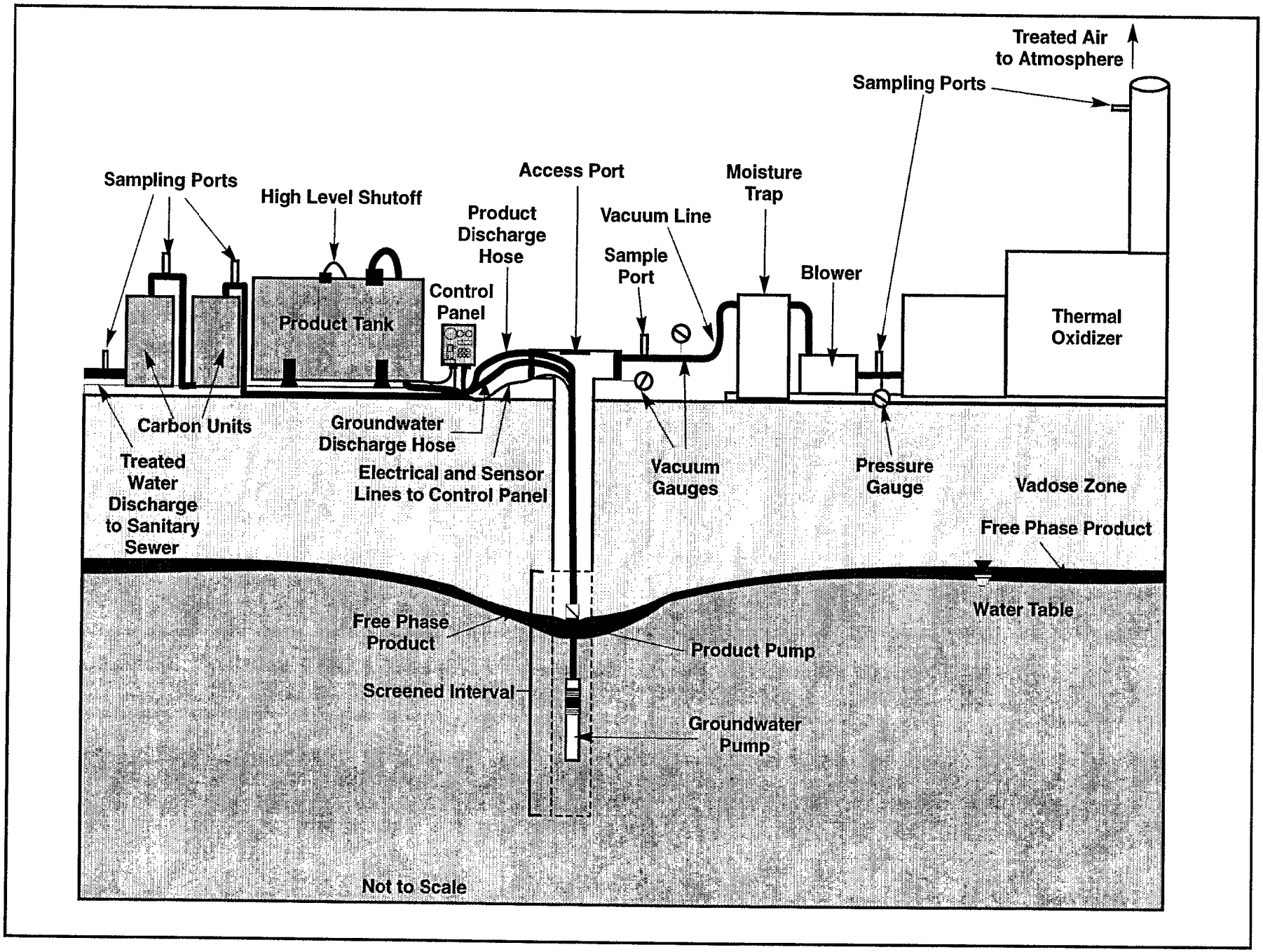


Figure 6. Schematic of vacuum-enhanced free product recovery system installed at Well NFFW-2R, Navy Fuel Farm facility, NAS Willow Grove, Horsham Township, Pennsylvania.

F:\2960009\3690\2960009.cdr

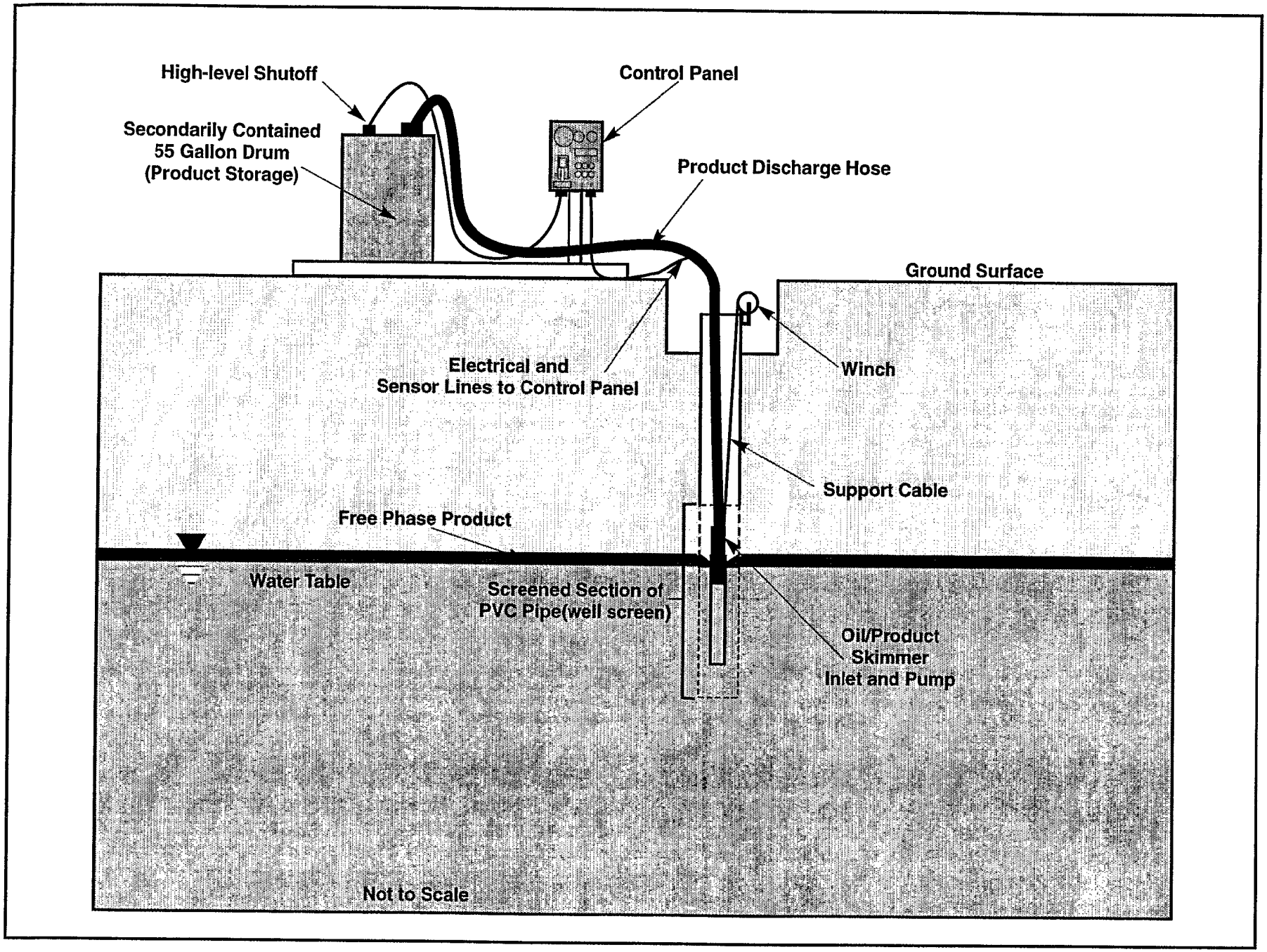


Figure 7. Schematic of automated product skimming system utilized at wells NFFW-6, NFFW-14, and NFFW-19, Navy Fuel Farm facility, NAS Willow Grove, Horsham Township, Pennsylvania.

F:\2960009\3690\2960009.cdr

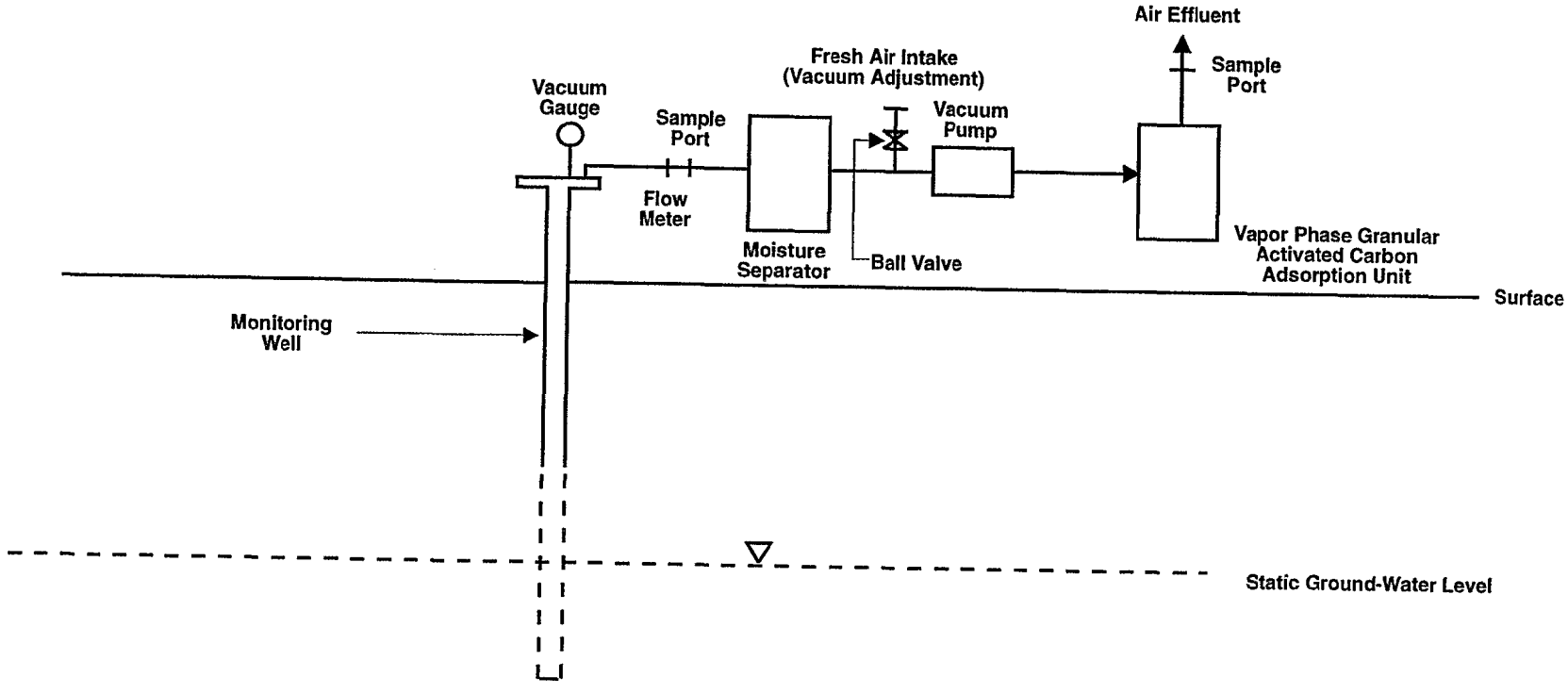
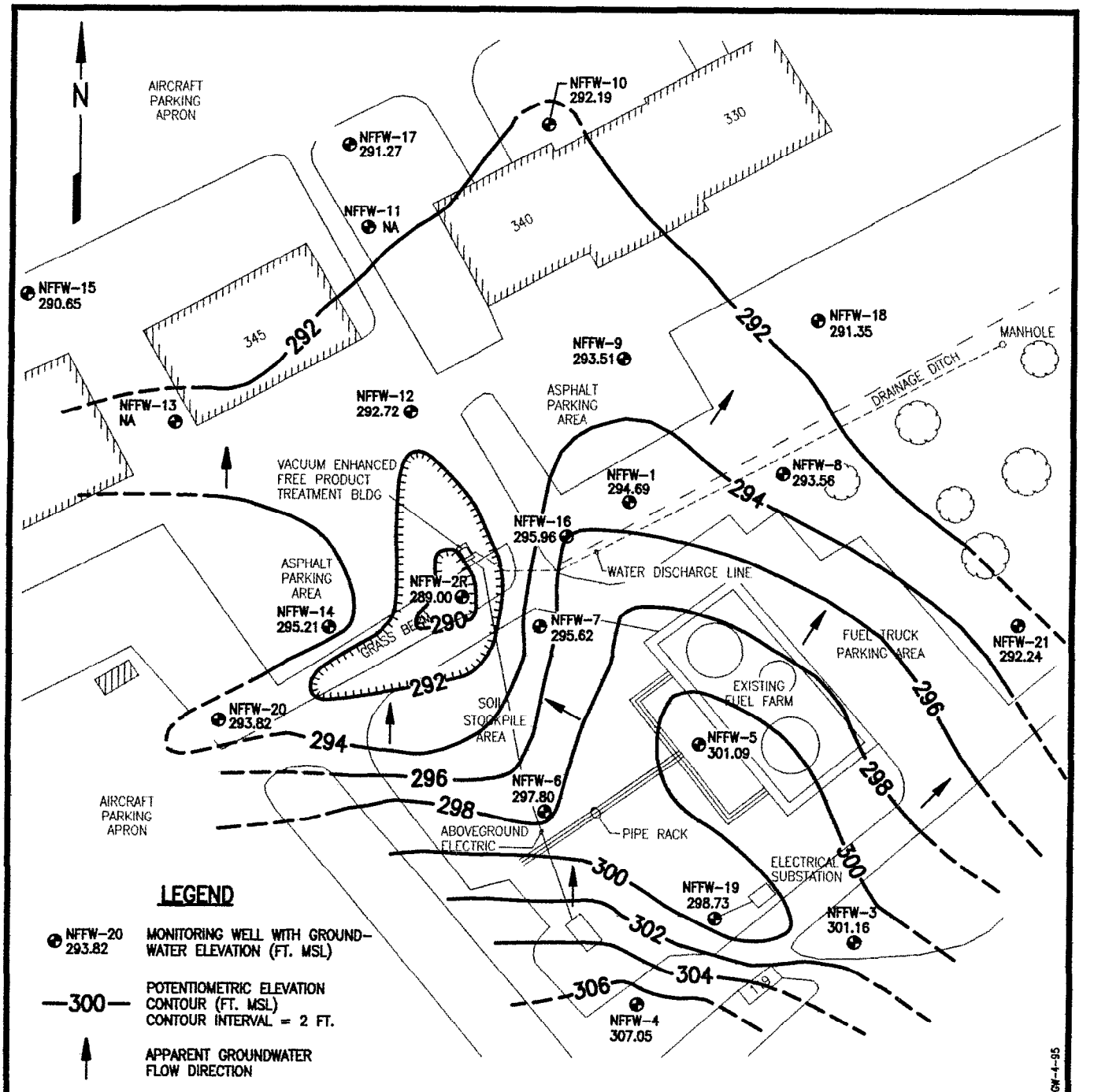


Figure 8. Soil vapor extraction test equipment schematic, Naval Fuel Farm Facility, Naval Air Station Willow Grove, Horsham Township, Pennsylvania.

F:\2960009\Reports\Fig8.cdr



NOTE:

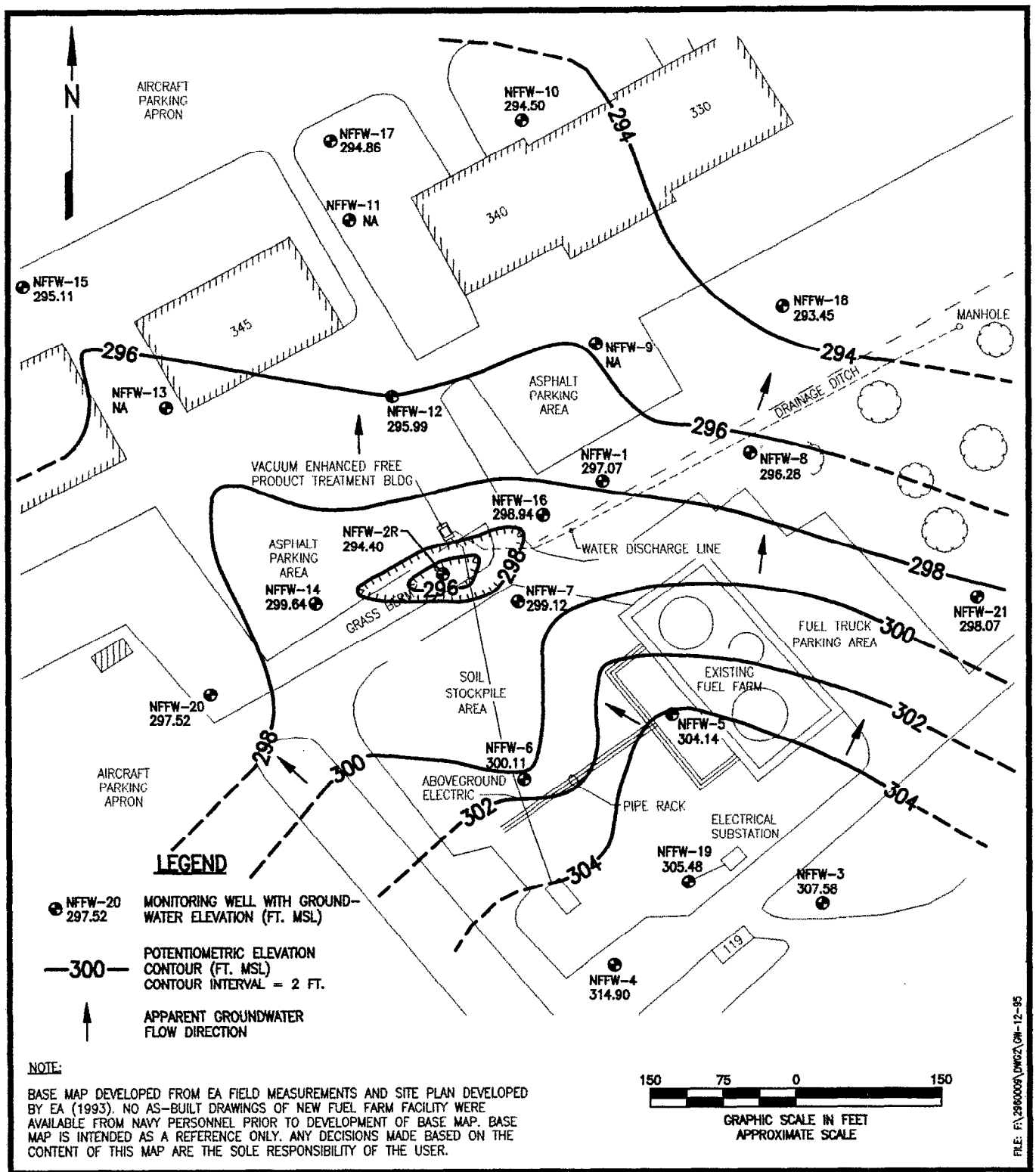
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

POTENTIOMETRIC SURFACE
27 APRIL 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	BS	MSM	BS	1"=150'	4-8-96	29600.09	9



NOTE:

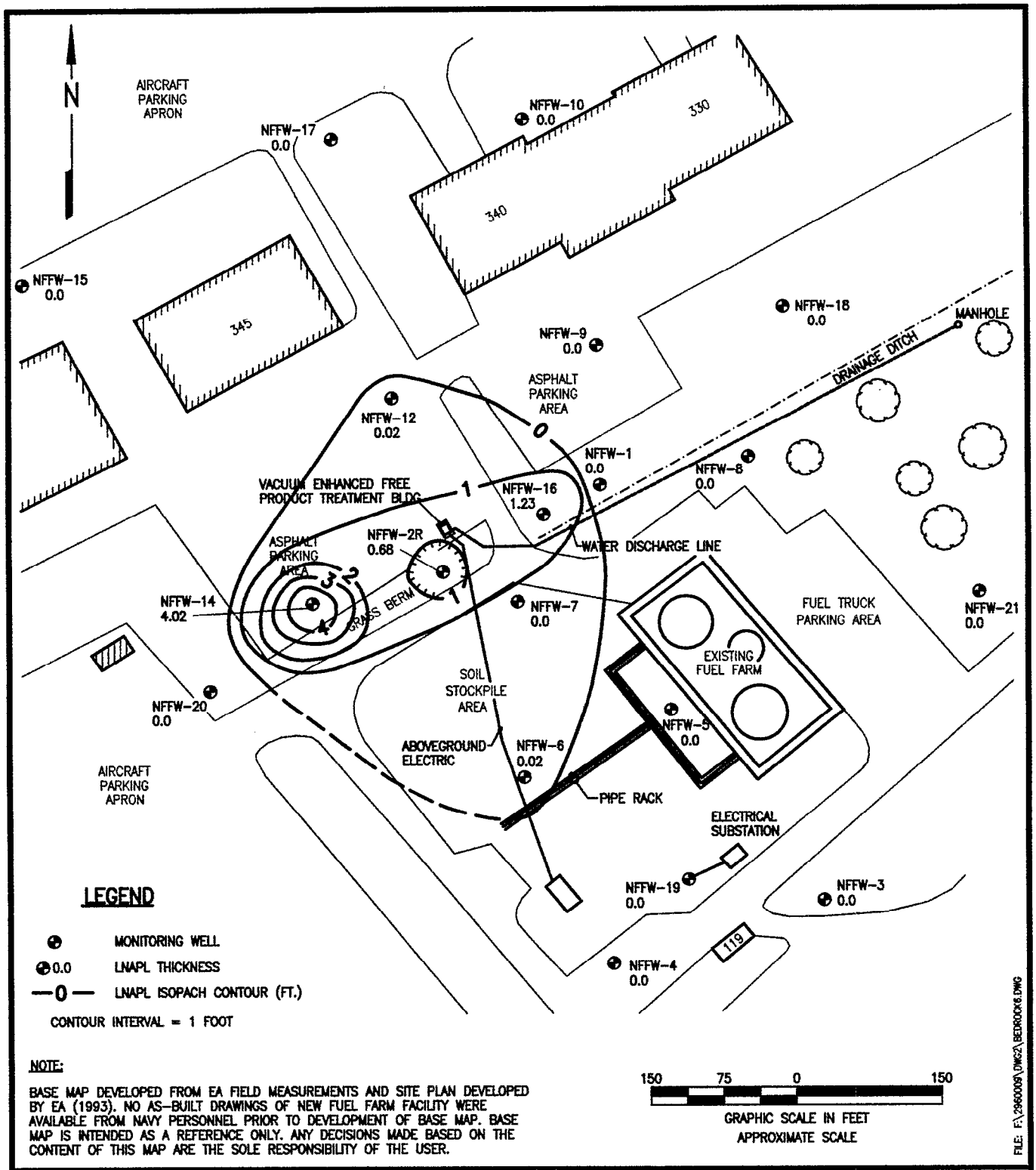
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

POTENTIOMETRIC SURFACE
8 DECEMBER 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	BS	DWM	BS	1"=150'	4-8-96	29600.09	10



NOTE:

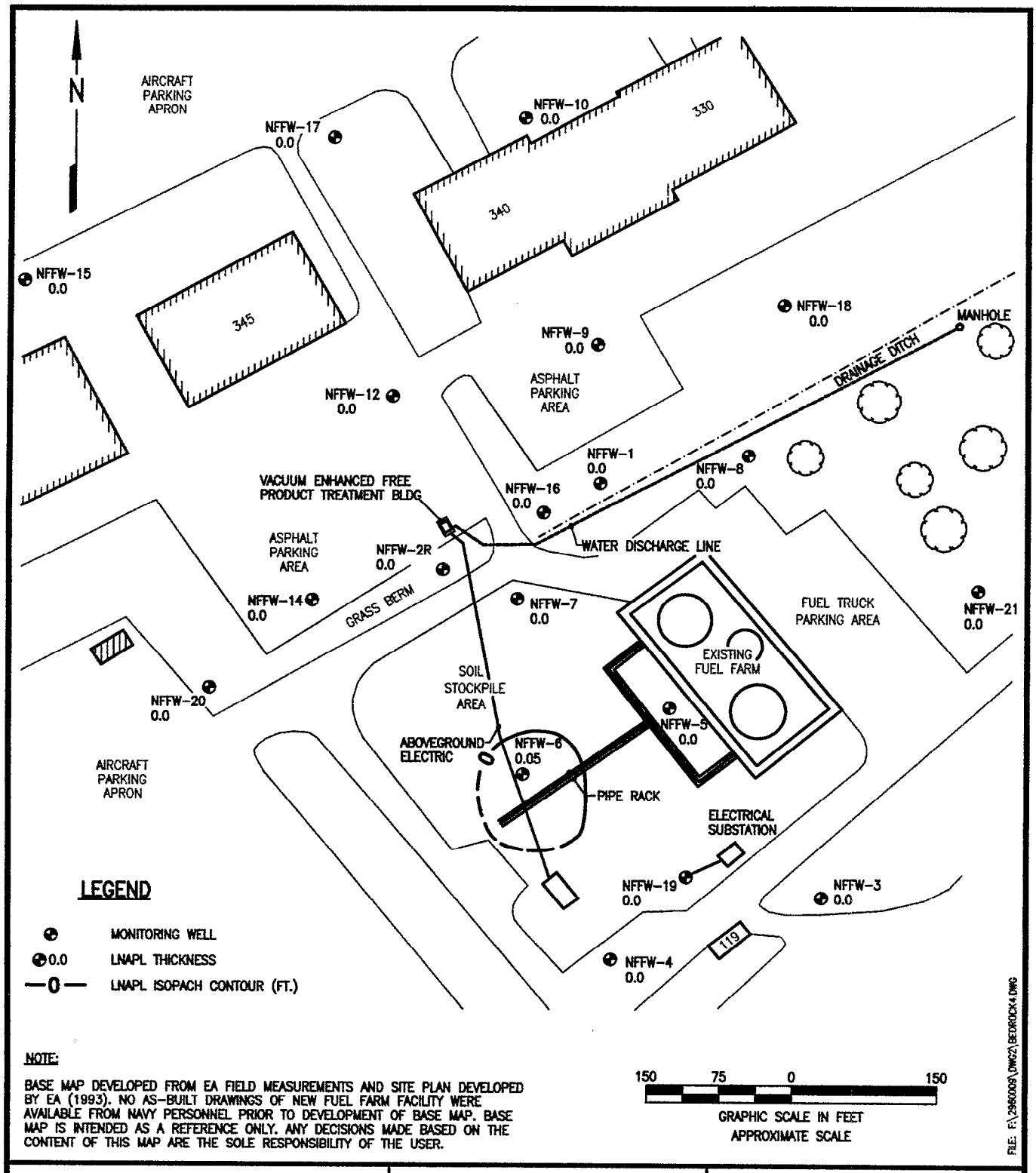
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
5 AUGUST 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	11



NOTE:

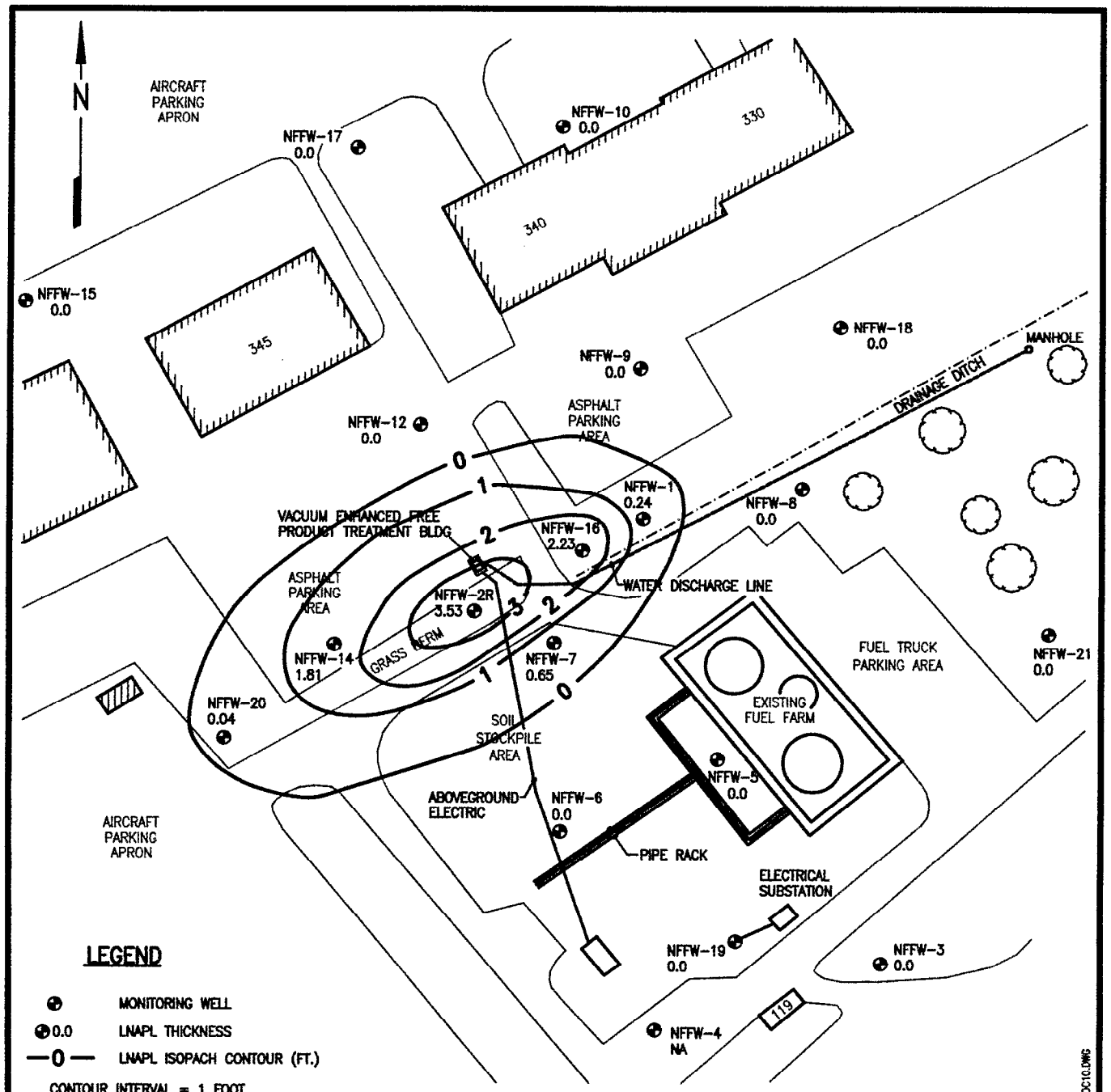
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
4 APRIL 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	AMPLS	CR	1"=150'	3-21-95	29600.09	12



LEGEND

- MONITORING WELL
- 0.0 LNAPL THICKNESS
- —0— LNAPL ISOPACH CONTOUR (FT.)

CONTOUR INTERVAL = 1 FOOT

NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

150 75 0 150

GRAPHIC SCALE IN FEET
APPROXIMATE SCALE

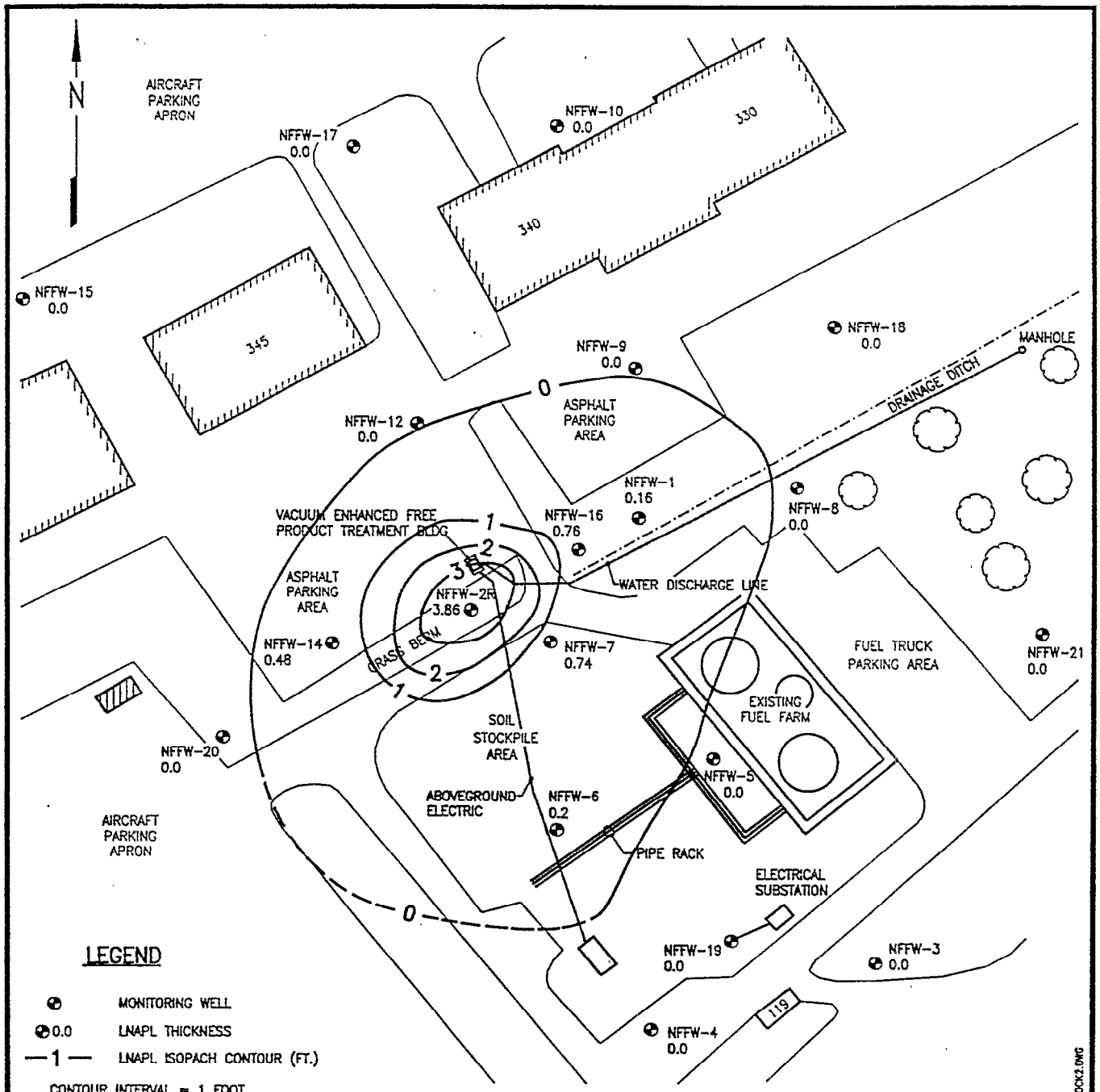
FILE: F:\29600009\DWG2\BEDROC10.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
21 DECEMBER 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	4-12-96	29600.09	13



NOTE:

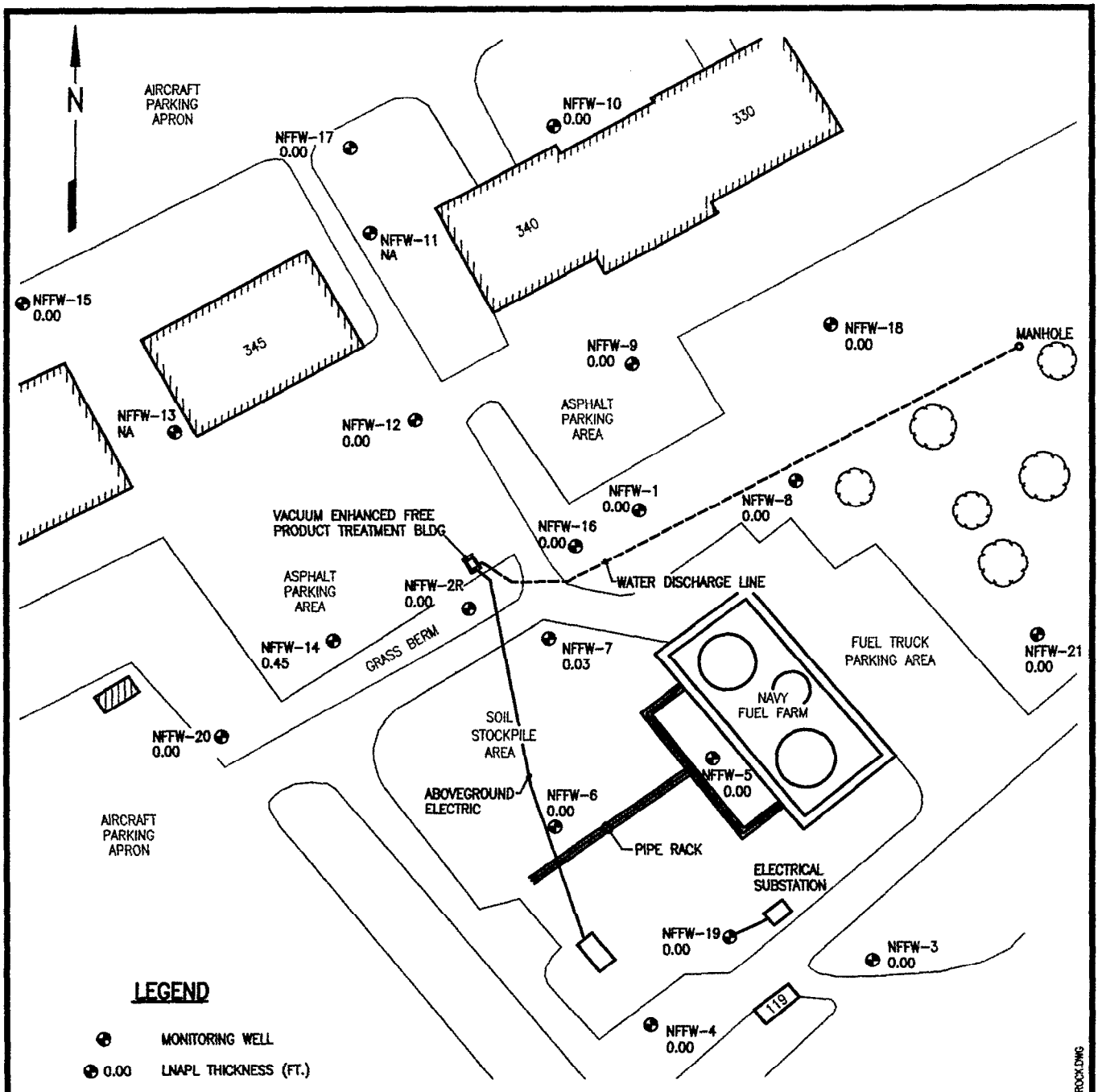
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
4 JANUARY 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	14



NOTE:

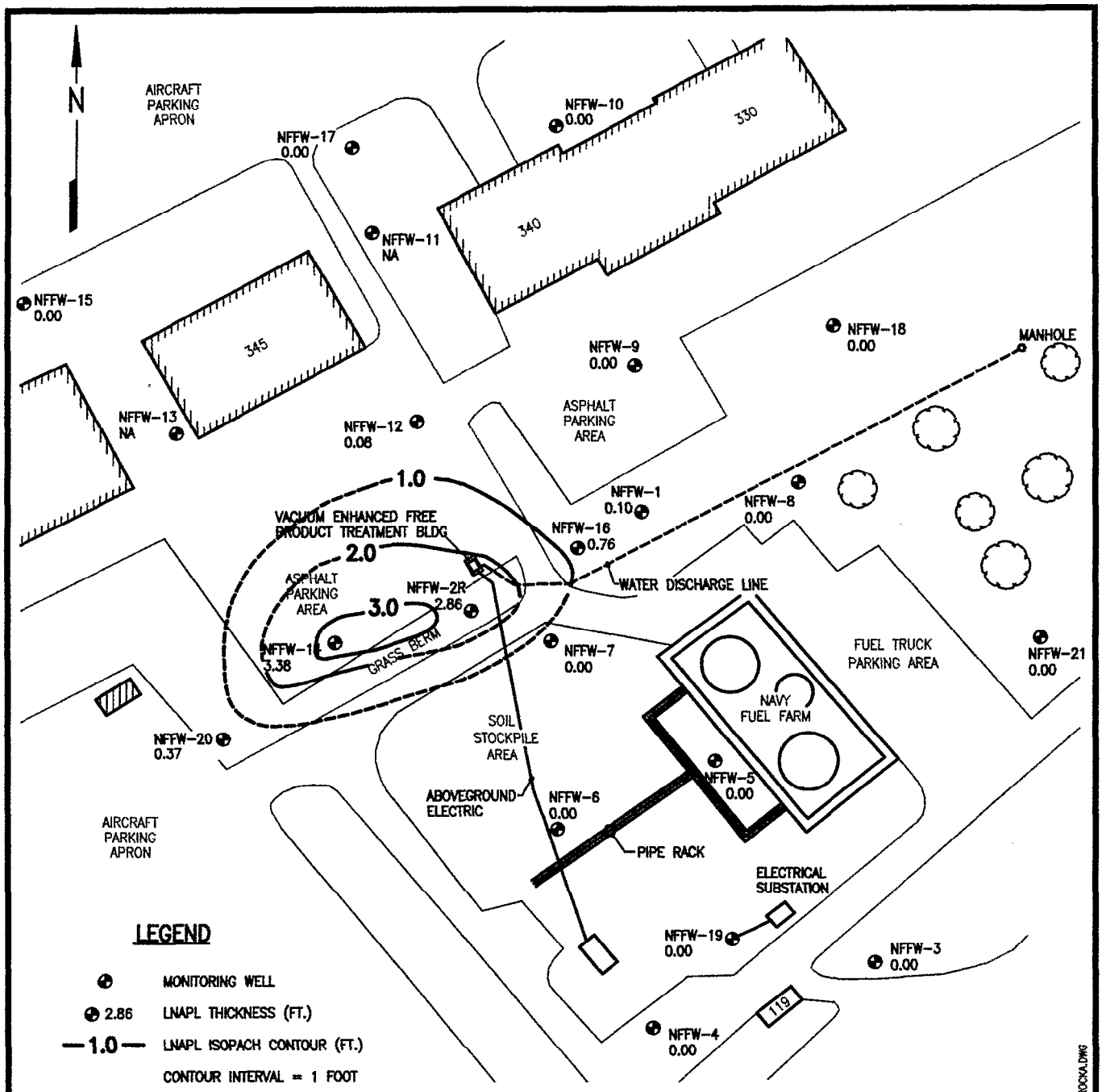
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

LNAPL DISTRIBUTION MAP
27 APRIL 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	BS	1"=150'	4-12-96	29600.09	15



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
28 SEPTEMBER 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	BS	1"=150'	4-12-96	29600.09	16

FIGURE 17

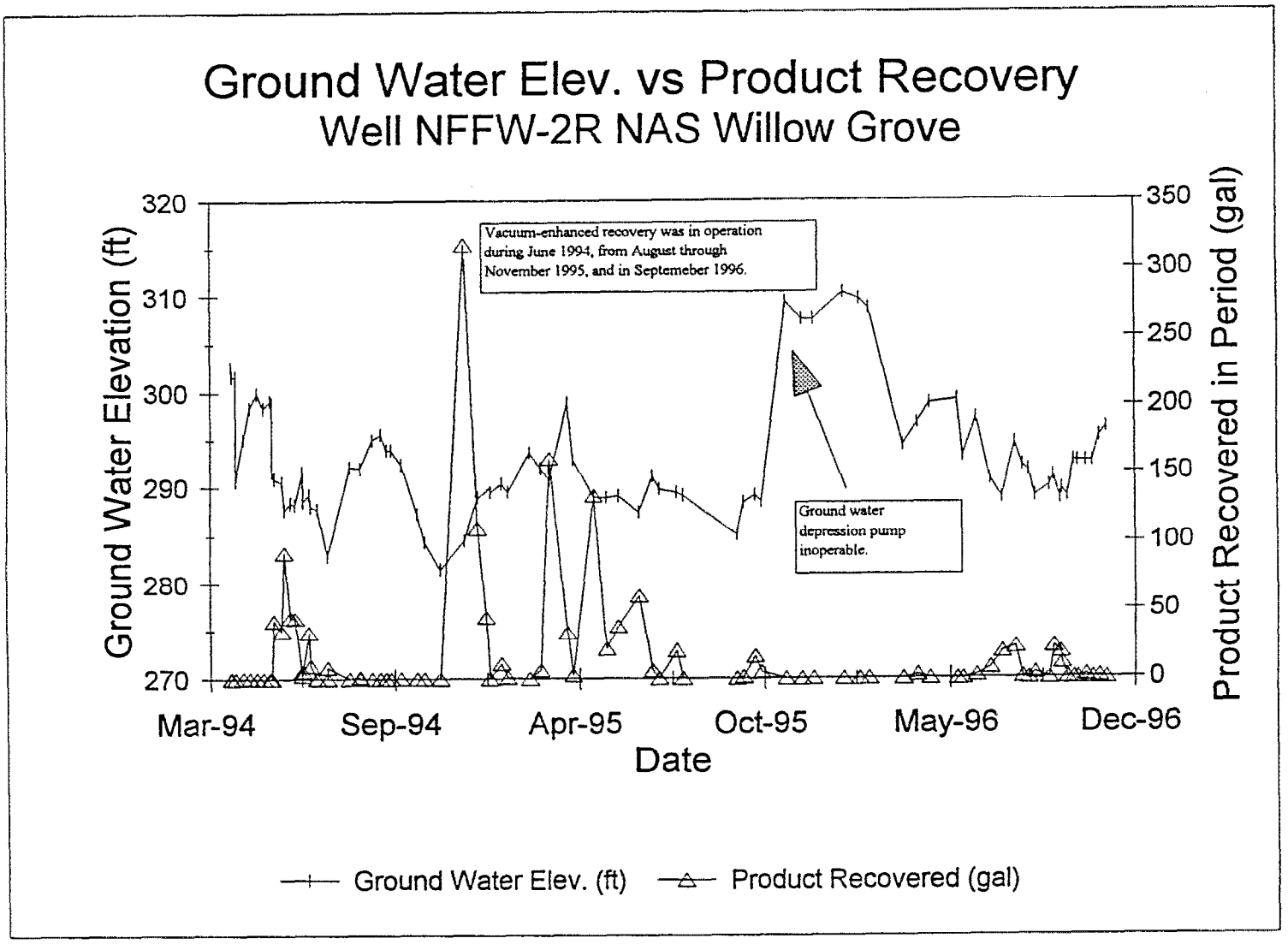
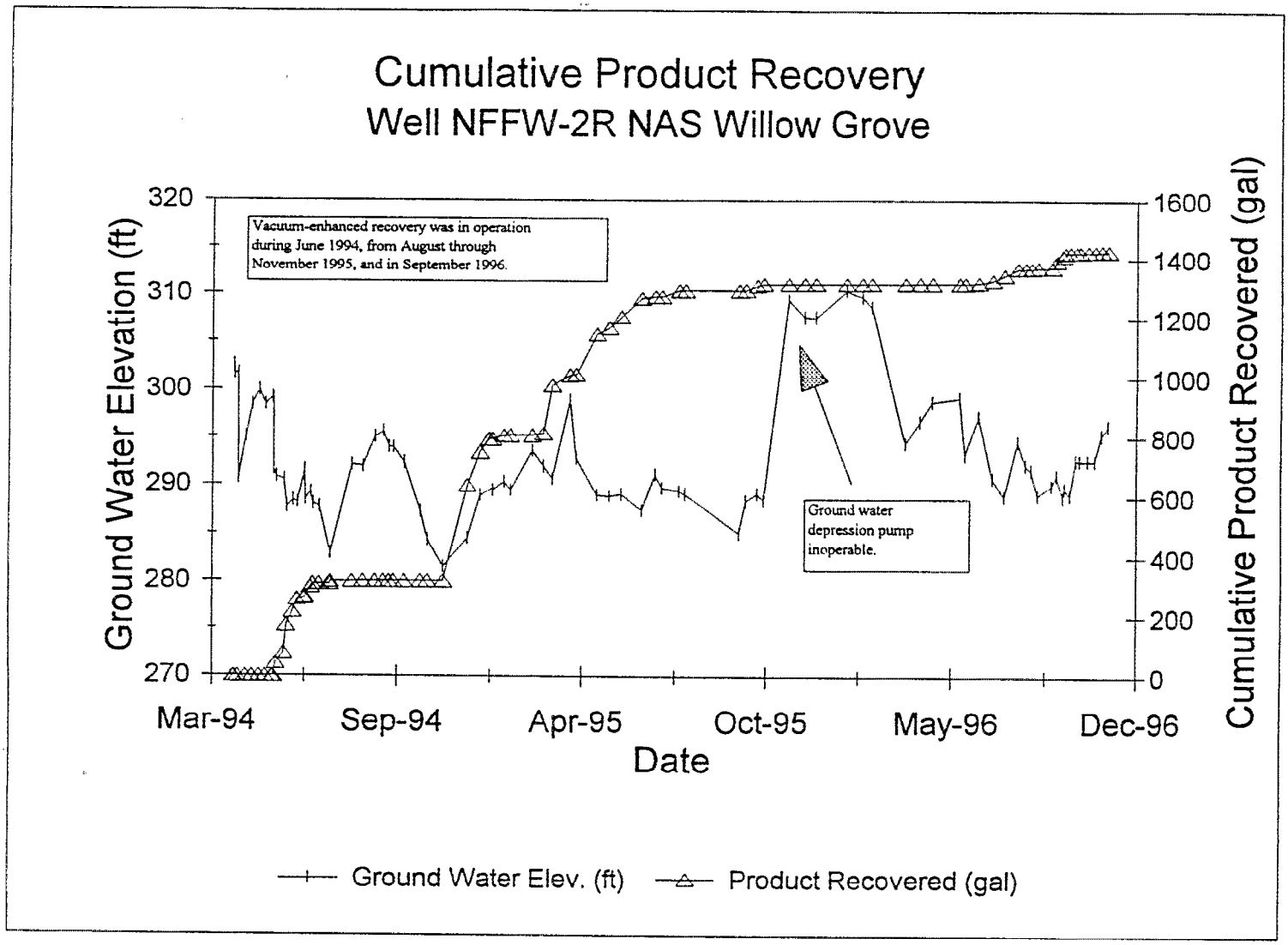

Ground Water Elev. vs Product Recovery
Well NFFW-2R NAS Willow Grove
Ground Water Elevation (ft)
320
310
300
290
280
270
Product Recovered in Period (gal)
350
300
250
200
150
100
50
0
Vacuum-enhanced recovery was in operation during June 1994, from August through November 1995, and in Septemeber 1996.
Ground water depression pump inoperable.
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96
Date
Ground Water Elev. (ft)
Product Recovered (gal)

FIGURE 18


Cumulative Product Recovery
Well NFFW-2R NAS Willow Grove
Vacuum-enhanced recovery was in operation during June 1994, from August through November 1995, and in September 1996.
Ground water depression pump inoperable.
Ground Water Elevation (ft)
320
310
300
290
280
270
Cumulative Product Recovered (gal)
1600
1400
1200
1000
800
600
400
200
0
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96
Date
Ground Water Elev. (ft)
Product Recovered (gal)

TABLES

TABLE 1 SUMMARY of PILOT STUDY ACTIVITIES

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Pilot Study Activity	Date
PHASE I	
Install Free Product Recovery Pilot System at Well NFFW-2R	February - March 1994
Operate Free Product Recovery Pilot System at Well NFFW-2R	March 1994 - October 1996
Operate Vacuum Enhanced Free Product Recovery Pilot System at Well NFFW-2R Utilizing GAC for Off-gas Treatment	June 1994
Operate Vacuum Enhanced Free Product Recovery Pilot System at Well NFFW-2R Utilizing Thermal Oxidizer for Off-gas Treatment	August 1995 - November 1995 September 1996
Operate Automated Product Skimmer in Well NFFW-6	March 1994 - September 1996
Operate Automated Product Skimmer in Well NFFW-19	March 1994 - January 1996
Operate Passive Product Skimmer in Well NFFW-14	March 1994 - January 1996
Operate Automated Product Skimmer in Well NFFW-14	February - September 1996
Conduct High Water Table Rate Check on Well NFFW-2R	March 1996
PHASE II	
Conduct First SVE Test (High Water Table)	April 1995
Conduct Second SVE Test (Low Water Table)	July 1995

TABLE 2 SUMMARY OF SOIL SAMPLE RESULTS—SOIL BORINGS

NAVY FUEL FARM FACILITY, NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Results of Soil Samples Collected on 2-16 March 1989

Parameter	Units	*Cleanup Standard	FFB1	FFB2	FFB3	FFB4	FFB5	FFB6	FFB7	FFB-8	FFB9	FFB10	FFB10	FFB11
Sample Depth	ft		1	1	4.5	4.5	6	3.5	3.5	5.5	5	2	5	4
Benzene	µg/kg	800	ND	2	2	2	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/kg	70,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/kg	100,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes, total	µg/kg	5,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Parameter	Units	*Cleanup Standard	FFB11	FFB12	FFB12	FFB-13	FFB14	FFB15	FFB15	FFB16	FFB16	FFB17	FFB18	FFB18
Sample Depth	ft		5	6	8	6.5	4.5	6.5	7	5	8.5	4	3	9
Benzene	µg/kg	800	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/kg	70,000	ND	ND	52	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/kg	100,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes, total	µg/kg	5,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND: Not Detected.
*: Cleanup Standard per Pennsylvania's Land Recycling Program, Technical Guidance, 18 July 1995, Soil to Ground Water Pathway.

TABLE 3 SUMMARY OF SOIL SAMPLE RESULTS—WELL INSTALLATIONS

NAVY FUEL FARM FACILITY, NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Results of Soil Samples Collected in 1989

Parameter	Units	*Cleanup Standard	NFB-1 (5 ft)	NFFW-5 (3 ft)	NFFW-6 (9 ft)	NFFW-7 (7 ft)
2-Butanone (MEK)	µg/kg	50	ND	ND	ND	**88**
4-Methyl-2-pentanone	µg/kg	NA	ND	29	ND	ND
Acetone	µg/kg	400,000	42	120	ND	190
Ethylbenzene	µg/kg	70,000	ND	ND	ND	160
Methylene chloride	µg/kg	500	ND	ND	ND	**2,300**
Toluene	µg/kg	100,000	ND	ND	ND	83
Xylenes, total	µg/kg	5,000	ND	ND	ND	1,500

Results of Soil Samples Collected in April 1991

Parameter	Units	*Cleanup Standard	NFFW-8 (5 ft)	NFFW-9 (5 ft)	NFFW-10 (5 ft)	NFFW-11 (5 ft)	NFFW-12 (5 ft)
Benzene	µg/kg	800	ND	ND	ND	ND	ND
Ethylbenzene	µg/kg	70,000	39,000	ND	ND	6,000	ND
Toluene	µg/kg	100,000	6,000	ND	ND	13,000	ND
Xylenes, total	µg/kg	5,000	**290,000**	ND	ND	4,000	ND

NFFW-1 (5 ft): Sample Identification (depth)
ND: Not Detected.
*: Cleanup Standard per Pennsylvania's Land Recycling Program, Technical Guidance, 18 July 1995, Soil to Ground Water Pathway.
88: Bolded result exceeds Cleanup Standard.

TABLE 4 SUMMARY OF GROUND-WATER SAMPLING RESULTS

NAVY FUEL FARM FACILITY, NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Results of Ground-Water Samples Collected on 10-21 June 1993

Parameter	Units	*Cleanup Standard	NFFW-3	NFFW-4	NFFW-5	NFFW-5 DUP	NFFW-8	NFFW-9	NFFW-10
Benzene	μg/L	5	ND	ND	**53**	52	ND	**29**	ND
Toluene	μg/L	1,000	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	μg/L	700	ND	ND	23	21	30	ND	ND
Xylenes, total	μg/L	10,000	ND	ND	12	11	9	ND	ND

Parameter	Units	*Cleanup Standard	NFFW-11	NFFW-15	NFFW-17	NFFW-18	NFFW-19	NFFW-20	NFFW-21
Benzene	μg/L	5	**16**	ND	**6**	2	**67**	2	1
Toluene	μg/L	1,000	ND	ND	ND	1	17	6	1
Ethylbenzene	μg/L	700	70	ND	ND	ND	320	2	ND
Xylenes, total	μg/L	10,000	ND	ND	ND	ND	500	ND	ND

Wells NFFW-1, NFFW-2R, NFFW-7, NFFW-13, NFFW-14, NFFW-16, and NFFW-19 not sampled due to presence of free-product in well.

ND: Not Detected.

*: Cleanup Standard per Pennsylvanian's Land Recycling Program, Technical Guidance, 18 July 1995, Aquifer Ingestion Standard.

53: Bolded result exceeds Cleanup Standard.

TABLE 5 FREE PRODUCT RECOVERY PILOT SYSTEM ANALYTICAL RESULTS - GROUND WATER

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Sample Location	Date	Benzene (µg/L)	Toluene (µg/)	Ethylbenzene (µg/L)	m&p Xylenes (µg/L)	o-Xylenes (µg/L)	Total BTEX (µg/L)	Naphthalene (µg/L)	TPH (µg/L)
BEFORE	4/27/95	**420**	15	400	420	20	1,275	**260**	8,900
CARBON	5/11/95	**410**	12	470	610	30	1,532	**310**	9,800
UNITS	6/15/95	**410**	24	510	470	24	1,438	**290**	7,400
	10/25/95	**260**	10	450	460	19	1,199	**310**	13,000
	11/21/95	**140**	14	340	330	16	840	**480**	6,300
	03/27/96	**140**	ND	420	450	23	1,033	**390**	18,000
	07/18/96	**100**	9.2	180	130	8.2	427.4	**180**	7,300
BETWEEN	4/27/95	**8.4**	ND	ND	ND	ND	8.4	ND	ND
CARBON	5/11/95	**6.2**	ND	ND	ND	ND	6.2	ND	260
UNITS	6/15/95	ND	ND	ND	ND	ND	ND	ND	ND
	10/25/95	ND	ND	ND	2	ND	2	ND	390
	11/21/95	ND	ND	ND	ND	ND	ND	ND	140
	03/27/96	NA	NA	NA	NA	NA	NA	NA	NA
	07/18/96	120	ND	13	2.3	ND	135.3	ND	690
AFTER	4/27/95	ND	ND	ND	ND	ND	ND	ND	ND
CARBON	5/11/94	ND	ND	ND	ND	ND	ND	ND	ND
UNITS	6/15/95	ND	ND	ND	ND	ND	ND	ND	ND
	10/25/95	ND	ND	ND	ND	ND	ND	ND	150
	11/21/95	ND	ND	ND	ND	ND	ND	ND	ND
	03/27/96	ND	ND	ND	ND	ND	ND	ND	ND
	07/18/96	3.5	ND	ND	ND	ND	3.5	ND	ND

NOTES:
ND = Not Detected
NA = Not Analyzed
Bolded result exceeds Cleanup Standard per Pennsylvania's Land Recycling Program, Technical Guidance, 18 July 1995, aquifer ingestion standard. Standards in µg/l are as follows: benzene = 5, toluene = 1,000, ethylbenzene = 700, total xylenes = 10,000, and naphthalene = 20.

TABLE 6 FREE-PRODUCT OCCURRENCE and THICKNESS DISTRIBUTION

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Well #	Number of Monitoring Events	Free-Product Occurrence and Thickness Distribution				Product Occurrence Total
		0.01 ft - 0.10 ft	0.11 ft - 0.50 ft	0.51 ft - 1.00 ft	> 1.00 ft	
NFFW-1	72	9	8	0	0	17
NFFW-2R	92	13	9	7	23	52
NFFW-6	68	19	6	0	0	25
NFFW-7	71	14	15	2	0	31
NFFW-8	61	5	0	0	0	5
NFFW-12	71	9	2	0	0	11
NFFW-14	77	28	18	4	9	59
NFFW-16	72	12	7	3	8	30
NFFW-19	71	4	0	0	0	4
NFFW-20	62	3	11	2	0	16
NFFW-21	62	1	0	0	0	1

TABLE 7 FLOW RATE TEST RESULTS - WELL NFFW-2R

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

				WELL NUMBER															
				NFFW-2R					NFFW-7					NFFW-12					
Time	Date	Flow Rate (gpm)	Total Flow (gal)	Depth to Product (ft)	Depth to Water (ft)	Product Thickness (ft)	Elevation (ft)	Drawdown (ft)	Depth to Product (ft)	Depth to Water (ft)	Product Thickness (ft)	Elevation (ft)	Drawdown (ft)	Depth to Product (ft)	Depth to Water (ft)	Product Thickness (ft)	Elevation (ft)	Drawdown (ft)
1520	03/27	-	0	-	15.40	0.00	299.75	0.00	-	13.96	0.00	300.12	0.00	-	10.27	0.00	297.09	0.00
1535	03/27	8.25	-	26.37	26.38	0.01	288.78	10.98	-	13.96	0.00	300.12	0.00	-	10.27	0.00	297.09	0.00
1550	03/27	8.10	-	-	28.63	0.00	286.52	13.23	-	13.96	0.00	300.12	0.00	-	10.27	0.00	297.09	0.00
1605	03/27	7.33	-	-	27.38	0.00	287.77	11.98	-	13.96	0.00	300.12	0.00	-	10.27	0.00	297.09	0.00
1620	03/27	7.35	-	26.58	26.62	0.04	288.56	11.22	-	13.96	0.00	300.12	0.00	-	10.28	0.00	297.08	0.01
1635	03/27	7.15	600	26.55	26.61	0.06	288.58	11.21	-	13.97	0.00	300.11	0.01	-	10.27	0.00	297.09	0.00
1650	03/27	7.13	673	26.43	26.51	0.08	288.70	11.11	-	13.97	0.00	300.11	0.01	-	10.27	0.00	297.09	0.00
1705	03/27	7.23	788	27.32	27.36	0.04	287.82	11.96	-	13.98	0.00	300.10	0.02	-	10.27	0.00	297.09	0.00
1720	03/27	7.07	909	-	27.68	0.00	287.47	12.28	-	13.98	0.00	300.10	0.02	-	10.28	0.00	297.08	0.01
1015	03/28	4.83	6,085	24.07	24.51	0.44	290.95	9.11	-	14.29	0.00	299.79	0.33	-	10.37	0.00	296.99	0.10
1100	03/28	7.00	6,345	-	29.40	0.00	285.75	14.00	-	14.31	0.00	299.77	0.35	-	10.37	0.00	296.99	0.10
1200	03/28	5.62	6,632	-	27.66	0.00	287.49	12.26	-	14.31	0.00	299.77	0.35	-	10.37	0.00	296.99	0.10
1300	03/28	5.60	7,065	-	28.40	0.00	286.75	13.00	-	14.33	0.00	299.75	0.37	-	10.37	0.00	296.99	0.10
1400	03/28	5.67	7,322	-	28.50	0.00	286.65	13.10	-	14.34	0.00	299.74	0.38	-	10.37	0.00	296.99	0.10
1500	03/28	5.59	7,692	-	29.74	0.00	285.41	14.34	-	14.35	0.00	299.73	0.39	-	10.37	0.00	296.99	0.10
1538	03/28	4.71	7,870	-	25.06	0.00	290.09	9.66	-	-	-	-	-	-	-	-	-	-
1110	03/29	4.63	13,350	25.05	25.48	0.43	289.97	10.08	-	14.63	0.00	299.45	0.67	-	10.18	0.00	297.18	-0.09
1210	03/29	5.20	13,638	26.55	26.91	0.36	288.49	11.51	-	14.63	0.00	299.45	0.67	-	10.16	0.00	297.20	-0.11
1310	03/29	4.86	13,942	25.80	25.83	0.03	289.34	10.43	-	14.64	0.00	299.44	0.68	-	10.15	0.00	297.21	-0.12
1410	03/29	Pump malfunction, not pumping until 1420																
1430	03/29	5.70	14,336	-	30.40	0.00	284.75	15.00	-	14.66	0.00	299.42	0.70	-	10.13	0.00	297.23	-0.14
1520	03/29	4.99	14,559	25.94	25.98	0.04	289.20	10.58	-	14.67	0.00	299.41	0.71	-	10.13	0.00	297.23	-0.14

TABLE 7 (cont.) FLOW RATE TEST RESULTS - WELL NFFW-2R

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

				WELL NUMBER									
				NFFW-14					NFFW-16				
Time	Date	Flow Rate (gpm)	Total Flow (gal)	Depth to Product (ft)	Depth to Water (ft)	Product Thickness (ft)	Elevation (ft)	Drawdown (ft)	Depth to Product (ft)	Depth to Water (ft)	Product Thickness (ft)	Elevation (ft)	Drawdown (ft)
1520	03/27	-	0	-	14.93	0.00	300.22	0.00	-	13.17	0.00	299.77	0.00
1535	03/27	8.25	-	-	14.93	0.00	300.22	0.00	-	13.17	0.00	299.77	0.00
1550	03/27	8.10	-	-	14.93	0.00	300.22	0.00	-	13.17	0.00	299.77	0.00
1605	03/27	7.33	-	-	14.93	0.00	300.22	0.00	-	13.18	0.00	299.76	0.01
1620	03/27	7.35	-	-	14.93	0.00	300.22	0.00	-	13.18	0.00	299.76	0.01
1635	03/27	7.15	600	-	14.93	0.00	300.22	0.00	-	13.18	0.00	299.76	0.01
1650	03/27	7.13	673	-	14.93	0.00	300.22	0.00	-	13.18	0.00	299.76	0.01
1705	03/27	7.23	788	-	14.92	0.00	300.23	-0.01	-	13.18	0.00	299.76	0.01
1720	03/27	7.07	909	-	14.93	0.00	300.22	0.00	-	13.19	0.00	299.75	0.02
1015	03/28	4.83	6,085	15.19	15.20	0.01	299.96	0.27	-	13.31	0.00	299.63	0.14
1100	03/28	7.00	6,345	-	15.23	0.00	299.92	0.30	-	13.31	0.00	299.63	0.14
1200	03/28	5.62	6,632	-	15.25	0.00	299.9	0.32	-	13.31	0.00	299.63	0.14
1300	03/28	5.60	7,065	-	15.26	0.00	299.89	0.33	-	13.30	0.00	299.64	0.13
1400	03/28	5.67	7,322	-	15.27	0.00	299.88	0.34	-	13.29	0.00	299.65	0.12
1500	03/28	5.59	7,692	-	15.28	0.00	299.87	0.35	-	13.29	0.00	299.65	0.12
1538	03/28	4.71	7,870	-	-	-	-	-	-	-	-	-	-
1110	03/29	4.63	13,350	15.56	15.58	0.02	299.58	0.65	-	13.44	0.00	299.5	0.27
1210	03/29	5.20	13,638	15.57	15.60	0.03	299.57	0.67	-	13.44	0.00	299.5	0.27
1310	03/29	4.86	13,942	-	15.56	0.00	299.59	0.63	-	13.43	0.00	299.51	0.26
1410	03/29	Pump malfunction, not pumping until 1420											
1430	03/29	5.70	14,336	-	15.58	0.00	299.57	0.65	-	13.43	0.00	299.51	0.26
1520	03/29	4.99	14,559	-	15.59	0.00	299.56	0.66	-	13.43	0.00	299.51	0.26

TABLE 8 SUMMARY OF VACUUM ENHANCED OPERATIONS - THERMAL OXIDIZER DATA

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Date	Vapor System Vacuum ("Hg)	Vapor System Flow Rate (cfm)	Vapor System Influent OVA/LEL (ppm/%)	Fresh air (% open)	Thermal Oxidizer Operating Temp. (F)	Thermal Oxidizer Effluent OVA/LEL (ppm/%)	Recovery/Emissions Rates Influent TPH as Toluen Equivalents (ppmv)	TPH Recovery Rate as Toluene Equivalents (pounds/day)	Recovery (in period) (gal)	Cumulative Recovery (gal)	Effluent TPH as Toluen Equivalents (ppmv)	TPH Emission Rate as Toluene Equivalents (pounds/day)
08/17/95	2	39.24	8% LEL	100	1410	0% LEL	1000 (est.)	11.71	0.90	0.90	NA	NA
08/18/95	2	39.24	33% LEL	75	1410	0% LEL	4000 (est.)	46.85	7.21	8.11	NA	NA
08/21/95	3.4	28.34	40% LEL	15	1410	0% LEL	4500	38.07	11.71	19.82	0.00	0.00
08/24/95	2.5	28.34	145/160	15	1412	40/0	7000	59.22	9.11	28.93	NA	NA
08/29/95	2.5	28.34	180% LEL	12	1414	0% LEL	9000	76.31	58.70	87.63	NA	NA
09/01/95	2.7	28.56	92% LEL	30	1410	0	NA	NA	NA	87.63	NA	NA
09/05/95	2.6	28.34	112% LEL	0	1412	0	4000	33.40	35.97	123.60	NA	NA
09/07/95	3	27.25	402/125	0	1418	0	4000 (est.)	32.22	9.91	133.51	NA	NA
09/14/95	3.2	21.8	2500+/125	0	1412	240/1	9000 (est.)	58.09	49.97	183.48	NA	NA
09/21/95	2.5	23	1692/75	0	1410	61/0	19000	130.45	140.48	323.96	0.00	0.00
10/06/95	5.8	22	49% LEL	0	1410	0	2000 (est.)	10.26	12.63	336.59	NA	NA
10/13/95	4.8	23	45%LEL	0	1410	0	2000 (est.)	11.61	10.72	347.31	NA	NA
10/18/95	4.8	20	72% LEL	0	1410	0	3000 (est)	14.67	24.83	372.14	NA	NA
10/27/95	14	15	>100% LEL	0	1410	0	10000	46.13	3.55	375.69	0.00 (est.)	0.00 (est.)
11/09/95	10	4	42% LEL	0	1415	0	2000 (est.)	2.06	2.22	377.91	NA	NA
11/14/95	19	14	40% LEL	0	1415	0	2000 (est.)	6.55	1.01	378.92	0.00 (est.)	0.00 (est.)
12/01/96*	NA	NA	NA	NA	NA	NA	NA	NA	NA	378.92	NA	NA
01/01/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	378.92	NA	NA
02/26/96	3.8	8.72	300/20	0	1408	2.5/0	NA	NA	NA	378.92	NA	NA
07/10/96	3.2	6.5	426/268	0	1410	0	10000 (est.)	19.76	15.20	394.12	0.00 (est.)	0.00 (est.)
07/18/96	System off due to high water table. System remained off through 09/12/96.											
09/12/96	4.6	13	335/60	0	1420	0	3,000 (est.)	12.00	0.00	394.12		
09/13/96	3.8	15	192/179	0	1409	25/0	2,000 (est.)	7.26	6.71	400.83	0.00 (est.)	0.00 (est.)
09/18/96												

Notes:

* The thermal oxidizer was turned off on 22 November due to a damaged vacuum extraction blower. The blower was repaired and operations resumed on 26 February 1996. The system was not operated from March through June due to high water table conditions.

cfm - cubic feet per minute
OVA - organic vapor analyzer (flame ionization detector)
LEL - lower explosive limit
TPH - total petroleum hydrocarbons
NA - not applicable, laboratory sample not collected

Recovery/Emissions rates calculated as follows:

$$(\text{pounds/day}) = \frac{Q(\text{cfm}) \times C(\text{ppmv} \times 1\text{EE-6}) \times P(\text{atm}) \times V(L) \times 0.4719\ (L/\text{sec}) \times 86400(\text{sec/day}) \times 92.1(\text{g/mol}) \times 0.0022(\text{pound/g})}{R(\text{L-atm/mol-K}) \times T(K)}$$

$$= \frac{Q(CFM) \times C(\text{ppmv}) \times 0.0083}{0.082 \times T(K)}$$

Where: Q = vapor volume flow rate
C = TPH concentration as toluene equivalents
P = atmospheric pressure (1 atm)
V = volume (1 Litre)
R = ideal gas constant (0.082 L-atm/mol-K)
T = vapor influent temperature

Volume product recovered = Recovery rate (pounds/day) / 6.5 (pounds/gallon) x days of operation.
Recovery rate estimated (from LEL measurement) for dates indicated.

TABLE 9 SUMMARY OF FREE PRODUCT RECOVERY

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Well No.	Cumulative Product Recovered (gal)*
NFFW-1	0.25
NFFW-2R	1427.02/400.83
NFFW-6	1.86
NFFW-7	2.00
NFFW-12	0.25
NFFW-14	67.29
NFFW-16	14.32
NFFW-19	0.00
NFFW-20	0.35
TOTAL	**1513.09/400.83**

Note: * Where two numbers appear (1312.75/378), the first number references product recovered as liquid-phase and the second number estimates the liquid equivalent of product recovered via vapor-phase during vacuum enhanced free product recovery. Vacuum enhanced free product recovery from well NFFW-2R began on 17 August 1995 and has been operated on an intermittent basis.

TABLE 10 COST COMPARISON SUMMARY - REMEDIAL ALTERNATIVES

NAVY FUEL FARM FACILITY
NAVAL AIR STATION, WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Remedial Option	Approximate Design Cost	Approximate Construction Cost	Approximate Operation and Maintenance Cost (Annual)
Vacuum-Enhanced Recovery Using Water Table Depression Operating All Year	$25,000-30,000	$320,000-510,000	$72,000-120,000
LNAPL Recovery Using Water Table Depression Without Vacuum-Enhancement Operated Only During Periods of Low Water Table Elevations	$20,000-25,000	$250,000-420,000	$40,000-60,000
LNAPL Recovery Using Vacuum-Enhanced Recovery when Conditions are Favorable and Only Ground-Water Table Depression when Conditions for Vacuum-Enhanced Recovery are Not Favorable	$25,000-30,000	$320,000-510,000	$55,000-65,000

APPENDIX A

SUMMARY OF GROUND WATER MONITORING RESULTS

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 28600.00 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-1	03/30/94	-	11.60	0.00	299.58						-
311.18	04/04/94	-	11.90	0.00	299.28						-
	04/06/94	-	12.12	0.00	299.06						-
	04/07/94	-	12.30	0.00	298.88						-
	04/12/94	-	12.83	0.00	298.35						-
	04/20/94	-	13.04	0.00	298.14						-
	04/27/94	-	13.31	0.00	297.87						-
	05/04/94	-	14.17	0.00	297.01						-
	05/12/94	-	14.20	0.00	296.98						-
	05/13/94	-	14.27	0.00	296.91						-
	05/16/94	-	14.54	0.00	296.64						-
	05/24/94	-	15.35	0.00	295.83						-
	05/27/94	-	15.60	0.00	295.58						-
	06/03/94	-	16.35	0.00	294.83						-
	06/15/94	17.20	17.21	0.00	293.98						-
	06/16/94	17.29	17.30	0.01	293.89						-
	07/01/94	18.11	18.16	0.05	292.98						-
	07/13/94	20.82	21.10	0.18	290.34				0.25	0.25	-
	08/05/94	-	17.42	0.00	293.76				0.00	0.25	-
	08/17/94	-	17.68	0.00	293.50				0.00	0.25	-
	08/30/94	-	16.20	0.00	294.98				0.00	0.25	-
	09/08/94	-	16.46	0.00	294.72				0.00	0.25	-
	09/14/94	-	17.07	0.00	294.11				0.00	0.25	-
	09/19/94	-	17.53	0.00	293.65				0.00	0.25	-
	09/30/94	-	17.88	0.00	293.30				0.00	0.25	-
	10/17/94	20.27	20.33	0.06	290.90				0.00	0.25	-
	10/25/94	21.42	21.56	0.14	289.74				0.00	0.25	-
	11/11/94	23.20	23.55	0.35	287.93				0.00	0.25	-
	11/22/94	23.22	23.56	0.34	287.92				0.00	0.25	-
	12/07/94	21.18	21.46	0.27	289.95				0.00	0.25	-
	12/21/94	19.48	19.70	0.24	291.98				0.00	0.25	-
	01/04/95	19.32	19.48	0.16	291.94				0.00	0.25	-
	01/16/95	17.79	17.88	0.09	293.38				0.00	0.25	-
	01/23/95	-	16.87	0.00	294.31				0.00	0.25	-
	02/16/95	-	16.94	0.00	294.24				0.00	0.25	-
	02/28/95	-	15.96	0.00	295.22				0.00	0.25	-
	03/10/95	-	14.80	0.00	296.38				0.00	0.25	-
	03/29/95	-	14.84	0.00	296.34				0.00	0.25	-
	04/04/95	-	15.24	0.00	295.94				0.00	0.25	-
	04/27/95	-	16.48	0.00	294.69				0.00	0.25	-
	05/11/95	-	16.50	0.00	294.68				0.00	0.25	-
	05/24/95	-	16.85	0.00	294.33				0.00	0.25	-
	06/15/95	-	17.35	0.00	293.83				0.00	0.25	-
	06/29/95	-	18.11	0.00	293.07				0.00	0.25	-
	07/06/95	-	18.90	0.00	292.28				0.00	0.25	-
	07/25/95	20.01	20.02	0.01	291.17				0.00	0.25	-
	08/01/95	20.34	20.43	0.09	290.83				0.00	0.25	-
	08/21/95	23.10	23.42	0.32	288.04				0.00	0.25	-
	09/14/95	24.08	24.18	0.10	287.08				0.00	0.25	-
	09/28/95	22.55	22.65	0.10	288.62				0.00	0.25	-
	10/06/95	21.08	21.14	0.06	290.08				0.00	0.25	-
	10/25/95	-	16.17	0.00	295.01				0.00	0.25	-
	11/21/95	-	12.87	0.00	298.31				0.00	0.25	-
	12/06/95	-	14.11	0.00	297.07				0.00	0.25	-
	12/21/95	-	14.15	0.00	297.03				0.00	0.25	-
	01/23/96	-	12.98	0.00	298.20				0.00	0.25	-
	02/06/96	-	12.02	0.00	299.16				0.00	0.25	-
	02/19/96	-	13.25	0.00	297.93				0.00	0.25	-
	03/27/96	-	13.01	0.00	298.17						
	04/11/96	-	11.75	0.00	299.43						
	04/24/96	-	11.97	0.00	299.21						
	05/29/96	-	13.68	0.00	297.50						
	06/13/96	-	14.72	0.00	296.46						
	06/28/96	-	14.58	0.00	296.60						
	07/10/96	-	14.73	0.00	296.45						
	07/25/96	-	13.68	0.00	297.50						
	08/08/96	-	14.24	0.00	296.94						
	08/30/96	-	15.00	0.00	296.18						
	09/12/96	-	15.92	0.00	295.26						
	09/26/96	-	14.78	0.00	296.40						
	10/09/96	-	13.90	0.00	297.28						
	10/24/96	-	12.49	0.00	298.69						

Appendix A

Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29606.09 Task 3613

WELL # CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-2R 315.15	03/30/94	-	12.50	0.00	302.57	-	-	-	-	-	-
	03/31/94	-	13.50	0.00	301.65	-	-	-	-	0.00	9984498
	04/04/94	-	13.50	0.00	301.65	-	-	-	-	0.00	-
	04/04/94	24.40	24.70	0.30	290.71	-	-	-	-	0.00	9991820
	04/04/94	-	17.50	0.00	297.65	-	-	-	-	0.00	-
	04/04/94	-	19.50	0.00	295.65	-	-	-	-	0.00	5080
	04/12/94	-	20.08	0.00	295.07	3.98	3.98	0.02	0.57	0.57	35000
	04/20/94	-	16.73	0.00	298.42	3.98	3.98	0.02	0.00	0.57	80330
	04/27/94	-	15.25	0.00	299.90	3.89	3.91	0.02	0.28	0.85	81930
	05/04/94	-	16.75	0.00	298.40	3.90	3.91	0.01	0.00	0.85	87460
	05/12/94	18.00	18.02	0.02	299.15	3.84	3.91	0.07	0.00	0.85	90207
	05/13/94	16.23	16.25	0.02	298.82	3.89	3.91	0.02	0.00	0.85	-
	05/13/94	23.50	23.52	0.02	291.65	3.89	3.91	0.02	0.00	0.85	90280
	05/16/94	24.21	24.23	0.02	290.94	3.42	3.90	0.48	42.48	43.33	101440
	05/24/94	24.18	27.08	2.89	290.58	3.42	3.90	0.48	34.68	78.01	11815
	05/27/94	27.41	27.42	0.01	287.74	2.51	3.88	1.37	92.98	170.99	124480
	06/03/94	-	26.75	0.00	288.40	2.25	3.83	1.58	44.78	215.75	136420
	06/07/94	-	-	-	-	-	-	-	0.00	215.75	141037
	06/07/94	-	-	-	-	-	-	-	0.00	215.75	141040
	06/07/94	-	-	-	-	-	-	-	0.00	215.75	141040
	06/07/94	-		-	-	-	-	-	0.00	215.75	141060
	06/07/94	-	-	-	-	-	-	-	0.00	215.75	141066
	06/07/94	-	-	-	-	-	-	-	0.00	215.75	141100
	06/07/94	-	-	-	-	-	-	-	19.21	234.96	141110
	06/07/94	-	-	-	-	2.06	3.90	1.84	10.53	245.49	141120
	06/07/94	-	-	-	-	-	-	-	0.00	245.49	141155
	06/08/94	26.93	26.94	0.01	288.22	1.97	3.89	1.92	14.28	259.77	141839
	06/08/94	-	-	-	-	-	-	-	0.00	259.77	142083
	06/09/94	Re-piped system to replace PVC pipe with galvanized steel pipe - run system without vacuum									
	06/15/94	23.53	23.72	0.19	291.60	1.94	3.85	1.91	2.60	262.37	143110
	06/15/94	-	-	-	-	-	-	-	0.00	262.37	143125
	06/15/94	-	-	-	-	-	-	-	0.00	262.37	143132
	06/15/94	-	-	-	-	-	-	-	0.00	262.37	143135
	06/15/94	-	-	-	-	-	-	-	0.00	262.37	143142
	06/15/94	-	-	-	-	-	-	-	0.00	262.37	143181
	06/15/94	-	-	-	-	-	-	-	0.00	262.37	143285
	06/16/94	-	26.60	0.00	288.55	1.91	3.86	1.95	5.55	267.92	143904
	06/16/94	-	-	-	-	-	-	-	0.00	267.92	143908
	06/16/94	-	-	-	-	-	-	-	0.00	267.92	143918
	06/16/94	-	-	-	-	-	-	-	0.00	267.92	143922
	06/16/94	-	-	-	-	-	-	-	0.00	267.92	143940

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.09 Task 3013

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-2R	06/16/94	-	-	-	-	-	-	-	0.00	267.92	143951
315.15	06/18/94	Vacuum enhanced system shut down at 1115 hrs. System operated under normal conditions									
	06/20/94	-	-	-	-	1.83	3.85	2.02	12.52	280.44	145544
	06/21/94	-	-	-	-	1.80	3.85	2.05	4.92	285.36	145788
	06/21/94	-	-	-	-	-	-	-	0.00	285.36	145819
	06/21/94	-	-	-	-	-	-	-	0.00	285.36	145834
	06/21/94	-	-	-	-	-	-	-	0.00	285.36	145894
	06/22/94	-	-	-	-	-	-	-	0.00	285.36	145940
	06/22/94	25.50	26.25	2.75	289.29	1.74	3.85	2.11	9.81	295.17	145964
	06/22/94	-	-	-	-	-	-	-	0.00	295.17	145978
	06/22/94	-	26.40	0.00	288.75	1.70	3.85	2.15	6.52	301.69	145987
	06/24/94	-	-	-	-	-	-	-	0.00	301.69	146380
	06/24/94	-	27.10	0.00	288.05	1.64	3.85	2.21	9.74	311.43	146436
	07/01/94	27.10	28.65	1.46	287.77	1.64	3.85	2.21	0.00	311.43	-
	07/13/94	32.05	33.28	1.23	282.94	1.70	3.85	2.15	0.00	311.43	-
	07/13/94	32.05	33.28	1.23	282.94	1.64	3.83	2.19	8.45	319.88	-
	08/05/94	22.95	23.63	0.68	292.11	1.62	3.80	2.18	0.00	319.88	-
	08/05/94	22.95	23.63	0.68	292.11	1.60	3.80	2.20	0.00	319.88	-
	08/17/94	22.98	24.47	1.49	291.98	1.64	3.80	2.16	1.16	321.04	-
	08/17/94	22.98	24.47	1.49	291.98	1.60	3.78	2.18	0.00	321.04	-
	08/30/94	20.08	20.35	0.27	295.03	1.60	3.77	2.17	0.00	321.04	-
	09/08/94	19.54	19.73	0.19	295.58	1.60	3.77	2.17	0.00	321.04	-
	09/14/94	21.15	21.63	0.48	293.94	1.60	3.77	2.17	0.00	321.04	-
	09/19/94	21.67	22.00	0.33	293.98	1.60	3.77	2.17	0.00	321.04	-
	09/30/94	22.63	24.00	1.37	292.34	1.63	3.76	2.13	0.00	321.04	146450
	10/17/94	27.11	33.27	6.16	287.24	1.64	3.78	2.14	0.00	321.04	146450
	10/25/94	29.85	36.47	6.52	284.35	1.64	3.78	2.14	0.00	321.04	146450
	11/11/94	33.35	35.30	1.95	281.55	1.64	3.78	2.14	0.00	321.04	146450
	11/22/94	IFP BROKE DURING GAUGING, NO INFORMATION AVAILABLE							-	321.04	146450
	12/07/94	30.08	34.15	4.07	284.54	1.51	3.60	2.18	318.04	639.07	146450
	12/21/94	25.73	29.26	3.53	288.99	0.28	3.23	2.95	110.74	749.82	146457
	12/31/94	-	-	-	-	0.28	3.23	2.95	45.00	794.82	146457
	01/04/95	25.12	28.98	3.86	289.53	3.98	3.98	0.00	0.00	794.82	146480
	01/16/95	24.11	29.11	5.00	290.39	3.64	3.78	0.14	10.95	805.76	146602
	01/23/95	25.12	28.98	3.86	289.53	3.63	3.78	0.15	0.95	806.71	146650
	02/16/95	21.28	23.18	1.90	293.62	3.56	3.70	0.14	0.24	806.95	146925
	02/28/95	-	23.15	0.00	292.00	3.50	3.70	0.20	6.36	813.30	147045
	03/10/95	-	24.45	0.00	290.70	2.34	3.65	1.31	160.89	974.20	173100
	03/29/95	-	18.24	SHEEN	298.91	2.17	3.71	1.54	33.24	1007.44	208987
	04/04/95	-	22.36	0.00	292.85	2.18	3.72	1.58	2.51	1009.95	229415
	04/27/95	-	26.15	0.00	289.00	1.32	3.70	2.38	134.25	1144.20	279610
	05/11/95	26.25	26.28	0.03	289.90	1.18	3.70	2.52	21.35	1165.55	289820
	05/24/95	-	26.05	0.00	289.10	0.91	3.69	2.78	38.09	1203.64	311661
	06/15/95	-	27.76	0.00	287.45	0.36	3.66	3.29	61.20	1264.84	337480
	06/29/95	23.96	24.76	0.90	291.17	0.31	3.66	3.35	5.98	1270.83	340050
	07/06/95	25.35	25.54	0.19	289.78	3.98	4.02	0.04	0.00	1270.83	340130
	07/25/95	25.61	26.45	0.84	289.43	3.66	3.99	0.33	20.31	1291.13	341387
	08/01/95	25.62	27.29	1.47	288.14	3.66	3.99	0.33	0.00	1291.13	341387
	08/21/95	COULD NOT OPEN				3.66	3.99	0.33	0.00	1291.13	341387
	09/14/95		DRY	0.00		3.72	3.96	0.24	0.00	1291.13	341387
	09/28/95	29.73	32.58	2.86	285.05	3.71	3.93	0.22	0.00	1291.13	341387
	10/06/95	26.55	27.95	1.40	288.42	3.69	3.92	0.23	1.23	1292.37	341387
	10/19/95	25.75	27.46	1.71	289.18	3.51	3.89	0.38	16.08	1308.44	351340
	10/25/95	26.62	26.72	0.10	288.52	3.46	3.87	0.41	4.30	1312.75	352183
	11/21/95	17.60	17.60	sheen	297.55	3.45	3.81	0.36	0.00	1312.75	426690
	12/06/95	20.71	21.05	0.34	294.40	3.46	3.81	0.35	0.00	1312.75	508660
	12/21/95	16.23	16.32	0.09	298.91	3.45	3.81	0.36	0.00	1312.75	527680
	01/23/96	-	14.35	0.00	300.80	3.45	3.81	0.36	0.00	1312.75	527728
	02/09/96	17.60	17.80	0.20	297.52	3.45	3.81	0.36	0.00	1312.75	528240
	02/19/96	-	17.00	0.00	298.15	3.45	3.81	0.36	0.00	1312.75	585830
	03/27/96	-	20.75	0.00	294.40	3.45	3.81	0.36	0.00	1312.75	692000
	04/11/96	18.40	18.40	0.00	296.75	3.36	3.71	0.35	2.44	1315.18	774915
	04/24/96	16.21	17.25	1.04	298.80	3.40	3.75	0.35	0.00	1315.18	863250
	05/24/96	15.90	16.50	0.60	299.17	3.40	3.75	0.35	0.00	1315.18	1013210
	05/29/96	21.81	22.48	0.67	293.25	3.40	3.75	0.35	0.00	1315.18	1026870
	06/13/96	17.85	18.19	0.34	297.26	3.34	3.69	0.35	1.99	1317.18	1033903
	06/26/96	-	24.40	0.00	290.75	3.25	3.65	0.40	7.56	1324.74	1085953
	07/10/96	-	26.27	0.00	288.88	3.12	3.67	0.55	18.11	1343.85	1131810
	07/25/96	20.55	20.60	0.05	294.59	2.84	3.64	0.79	22.53	1366.38	1189245
	08/02/96	-	22.97	0.00	292.18	2.84	3.65	0.71	0.96	1367.34	1184140
	08/08/96	-	23.50	0.00	291.65	2.83	3.62	0.69	0.00	1367.34	1208390
	08/15/96	-	26.15	0.00	289.00	2.82	3.64	0.72	3.41	1370.75	1233060
	08/30/96	-	25.10	0.00	290.05	2.83	3.62	0.69	0.00	1370.75	1289680
	09/04/96	23.85	25.25	1.40	291.12	2.78	3.64	0.85	22.75	1393.50	1303905
	09/12/96	-	26.34	0.00	289.81	2.68	3.66	0.98	18.74	1412.24	1322410
	09/13/96	-	25.45	0.00	289.70	2.58	3.63	1.04	11.16	1423.40	1324890
	09/19/96	-	26.18	0.00	288.97	2.58	3.62	1.04	0.59	1424.00	1334420
	09/26/96	22.50	22.55	0.05	292.84	2.58	3.62	1.04	0.00	1424.00	1351100
	09/30/96	-	22.24	0.00	292.91	2.58	3.62	1.04	0.00	1424.00	1353850
	10/09/96	-	22.55	0.00	292.60	2.58	3.60	1.02	2.00	1426.00	1385400
	10/17/96	20.71	20.75	0.04	294.43	2.58	3.62	1.04	0.00	1426.00	1408210
	10/24/96	19.96	19.92	0.04	295.28	2.57	3.58	1.01	1.02	1427.02	1410750
	10/31/96	-	18.90	0.00	296.25	2.57	3.59	1.02	0.00	1427.02	1419690

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.09 Task 3413

WELL # CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFPW-3	03/30/94	-	12.18	0.00	310.40						
322.58	04/04/94	-	12.77	0.00	309.81						
	04/12/94	-	9.84	0.00	312.74						
	04/20/94	-	14.25	0.00	308.33						
	05/12/94	-	17.03	0.00	305.55						
	05/24/94	-	19.35	0.00	303.23						
	06/03/94	-	23.40	0.00	299.18						
	07/01/94	-	28.25	0.00	294.33	Total depth of well = 28.25 ft.					
	07/13/94	-	DRY	0.00	-						
	08/05/94	-	23.26	0.00	299.32						
	08/17/94	-	25.90	0.00	296.68						
	09/30/94	-	19.72	0.00	302.86						
	09/06/94	-	22.38	0.00	300.19						
	09/19/94	-	27.90	0.00	294.68						
	09/30/94	-	28.18	0.00	294.40						
	10/17/94	-	28.20	0.00	294.38						
	10/25/94	-	28.19	0.00	294.39						
	11/11/94	-	28.21	0.00	294.37						
	11/22/94	-	28.21	0.00	294.37						
	12/07/94	-	28.17	0.00	294.41						
	12/21/94	-	28.19	0.00	294.39						
	01/04/95	-	28.18	0.00	294.40						
	01/23/95	-	25.76	0.00	296.82						
	02/16/95	-	24.77	0.00	297.81						
	02/28/95	-	21.06	0.00	301.52						
	03/10/95	-	16.64	0.00	305.94						
	03/29/95	-	16.48	0.00	306.10						
	04/04/95	-	17.40	0.00	305.18						
	04/27/95	-	21.42	0.00	301.16						
	05/11/95	-	21.83	0.00	300.75						
	05/24/95	-	23.28	0.00	299.28						
	06/15/95	-	27.12	0.00	295.46						
	06/29/95	-	28.22	0.00	294.36						
	07/06/95	-	28.14	0.00	294.44						
	07/25/95	-	28.15	0.00	294.43						
	08/01/95	-	28.20	0.00	294.38						
	08/21/95	-	DRY	0.00	NA						
	09/14/95	-	DRY	0.00	NA						
	09/28/95	-	DRY	0.00	NA						
	10/06/95	-	23.78	0.00	298.78						
	10/25/95	-	15.80	0.00	306.78						
	11/21/95	-	13.21	0.00	309.37						
	12/06/95	-	15.00	0.00	307.58						
	12/21/95	-	15.01	0.00	307.57						
	01/23/96	-	12.26	0.00	310.32						
	02/09/96	-	12.88	0.00	309.70						
	02/19/96	-	13.94	0.00	308.64						
	03/27/96	-	14.04	0.00	308.54						
	04/11/96	-	12.34	0.00	310.24						
	04/24/96	-	13.00	0.00	309.58						
	05/29/96	-	15.30	0.00	307.28						
	06/13/96	-	16.68	0.00	305.90						
	06/28/96	-	15.60	0.00	306.98						
	07/10/96	-	15.83	0.00	306.75						
	07/25/96	-	14.92	0.00	307.66						
	08/08/96	-	15.95	0.00	306.63						
	08/30/96	-	17.36	0.00	305.22						
	09/12/96	-	19.33	0.00	303.25						
	09/26/96	-	18.08	0.00	306.50						
	10/09/96	-	15.10	0.00	307.48						
	10/24/96	-	12.91	0.00	309.67						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.09 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-4	03/30/94	-	8.38	0.00	318.47						
326.86	04/04/94	-	8.27	0.00	318.59						
	04/12/94	-	9.93	0.00	316.93						
	04/20/94	-	14.27	0.00	312.59						
	05/12/94	-	15.02	0.00	311.84						
	05/24/94	-	17.85	0.00	309.01						
	06/03/94	-	22.15	0.00	304.71						
	07/01/94	-	DRY	0.00	-						
	07/13/94	-	DRY	0.00	-						
	08/05/94	-	24.35	0.00	302.51						
	08/17/94	-	DRY	0.00	-						
	08/30/94	-	21.58	0.00	305.28						
	09/06/94	-	23.07	0.00	303.79						
	09/19/94	-	24.36	0.00	302.50						
	09/30/94	-	DRY	0.00	-						
	10/17/94	-	DRY	0.00	-						
	10/25/94	-	DRY	0.00	-						
	11/11/94	-	DRY	0.00	-						
	11/22/94	-	DRY	0.00	-						
	12/07/94	-	DRY	0.00	-						
	12/21/94	-	DRY	0.00	-						
	01/04/95	-	DRY	0.00	-						
	01/23/95	-	23.89	0.00	302.97						
	02/16/95	-	23.81	0.00	303.05						
	02/28/95	-	21.66	0.00	305.20						
	03/10/95	-	16.02	0.00	310.84						
	03/29/95	-	14.47	0.00	312.39						
	04/04/95	-	15.43	0.00	311.43						
	04/27/95	-	19.81	0.00	307.05						
	05/11/95	-	20.62	0.00	306.24						
	05/24/95	-	21.87	0.00	304.99						
	06/15/95	-	DRY	0.00							
	06/29/95	-	DRY	0.00							
	07/06/95	-	DRY	0.00							
	07/25/95	-	DRY	0.00							
	08/01/95	-	DRY	0.00							
	08/21/95	-	DRY	0.00							
	09/14/95	-	DRY	0.00							
	09/26/95	-	DRY	0.00							
	10/06/95	-	23.93	0.00	302.93						
	10/25/95	-	16.73	0.00	310.13						
	11/21/95	-	10.49	0.00	316.37						
	12/08/95	-	11.96	0.00	314.90						
	12/21/95	-	12.03	0.00	314.83						
	01/23/96	-	9.17	0.00	317.69						
	02/09/96	-	8.81	0.00	318.05						
	02/19/96	-	10.32	0.00	316.54						
	03/27/96	-	10.13	0.00	316.73						
	04/11/96	-	7.97	0.00	318.89						
	04/24/96	-	8.45	0.00	318.41						
	05/29/96	-	-	-	-	Well Inaccessible					
	06/13/96	-	14.67	0.00	312.19						
	06/28/96	-	14.02	0.00	312.84						
	07/10/96	-	14.15	0.00	312.71						
	07/25/96	-	13.09	0.00	313.77						
	08/08/96	-	14.08	0.00	312.78						
	08/30/96	-	15.79	0.00	311.07						
	09/12/96	-	17.90	0.00	308.96						
	09/26/96	-	15.40	0.00	311.46						
	10/09/96	-	14.13	0.00	312.73						
	10/24/96	-	10.35	0.00	316.51						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 28600.08 Task 3613

WELL # / CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)*	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-5	03/30/94	-	3.40	0.00	313.48						
316.88	04/04/94	-	5.89	0.00	310.99						
	04/12/94	-	4.13	0.00	312.75						
	04/20/94	-	11.50	0.00	305.38						
	05/12/94	-	12.12	0.00	304.76						
	05/24/94	-	13.85	0.00	303.03						
	06/03/94	-	15.48	0.00	301.40						
	07/01/94	-	12.64	0.00	304.24						
	07/13/94	-	20.95	0.00	295.93						
	08/05/94	-	13.28	0.00	303.60						
	08/17/94	-	14.23	0.00	302.65						
	08/30/94	-	13.55	0.00	303.33						
	09/08/94	-	16.38	0.00	300.50						
	09/19/94	-	12.53	0.00	304.35						
	09/30/94	-	12.84	0.00	303.94						
	10/17/94	-	18.35	0.00	298.53						
	10/25/94	-	12.34	0.00	304.54						
	11/11/94	-	12.10	0.00	304.78						
	11/22/94	-	4.57	0.00	312.31						
	12/07/94	-	4.97	0.00	311.91						
	12/21/94	-	15.04	0.00	301.84						
	01/04/95	-	6.58	0.00	310.30						
	01/23/95	-	5.69	0.00	311.19						
	02/16/95	-	4.32	0.00	312.56						
	02/28/95	-	2.85	0.00	314.03						
	03/10/95	-	4.60	0.00	312.28						
	03/29/95	-	13.06	0.00	303.82						
	04/04/95		Not Gauged								
	04/27/95	-	15.79	0.00	301.09						
	05/11/95	-	5.91	0.00	310.97						
	05/24/95	-	15.41	0.00	301.47						
	06/15/95	-	16.96	0.00	299.92						
	06/29/95	-	19.10	0.00	297.78						
	07/06/95	-	19.96	0.00	296.92						
	07/25/95	-	14.46	0.00	302.42						
	08/01/95	-	18.88	0.00	298.00						
	08/21/95	-	22.89	0.00	293.99						
	09/14/95	-	8.49	0.00	308.39						
	09/28/95	-	6.67	0.00	310.21						
	10/06/95	-	4.17	0.00	312.71						
	10/25/95	-	10.19	0.00	306.69						
	11/21/95	-	6.09	0.00	310.79						
	12/06/95	-	12.74	0.00	304.14						
	12/21/95	-	5.70	0.00	311.18						
	01/23/96	-	5.18	0.00	311.70						
	02/09/96	-	2.85	0.00	314.03						
	02/19/96	-	11.92	0.00	304.96						
	03/27/96	-	12.08	0.00	304.80						
	04/11/96	-	4.24	0.00	312.64						
	04/24/96	-	11.22	0.00	305.66						
	05/29/96	-	5.88	0.00	311.00						
	06/13/96	-	5.12	0.00	311.76						
	06/28/96	-	13.26	0.00	303.62						
	07/10/96	-	10.22	0.00	306.66						
	07/25/96	-	12.94	0.00	303.94						
	08/08/96	-	13.65	0.00	303.23						
	08/30/96	-	13.19	0.00	303.69						
	09/12/96	-	14.27	0.00	302.61						
	09/26/96	-	11.81	0.00	304.07						
	10/09/96	-	4.20	0.00	312.68						
	10/24/96	-	10.08	0.00	306.80						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.09 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)*	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV (GAL)	FLOW METER READING (GAL)
NFFW-6	03/30/94	15.73	15.92	0.19	303.67	-	-	-	0.00	0.00	-
319.62	03/30/94	15.66	15.86	0.20	303.93	-	-	-	0.00	0.00	-
	04/04/94	16.41	16.46	0.05	303.20	2.67	2.73	0.06	1.24	1.24	-
	04/06/94	16.40	16.43	0.03	303.22	2.66	2.73	0.07	0.21	1.45	-
	04/07/94	-	16.58	0.00	303.04	2.66	2.73	0.07	0.00	1.45	-
	04/12/94	17.86	18.00	0.14	301.74	2.66	2.73	0.07	0.00	1.45	-
	04/20/94	-	18.09	0.00	301.53	2.64	2.73	0.09	0.41	1.86	-
	04/27/94	18.17	18.19	0.02	301.45	2.65	2.73	0.08	0.00	1.86	-
	05/04/94	19.22	19.29	0.07	300.39	2.65	2.71	0.06	0.00	1.86	-
	05/12/94	19.34	19.45	0.11	300.27	2.62	2.71	0.09	0.00	1.86	-
	05/13/94	19.49	19.50	0.01	300.13	-	-	-	0.00	1.86	-
	05/16/94	-	20.04	0.00	299.58	2.64	2.68	0.04	0.00	1.86	-
	05/24/94	20.76	20.77	0.01	298.86	2.64	2.73	0.09	0.00	1.86	-
	05/27/94	21.04	21.05	0.01	298.58	2.64	2.73	0.09	0.00	1.86	-
	06/03/94	21.64	21.66	0.02	297.98	2.64	2.73	0.09	0.00	1.86	-
	06/15/94	23.20	23.24	0.04	296.41	2.64	2.73	0.09	0.00	1.86	-
	06/16/94	23.40	23.46	0.05	296.21	2.64	2.73	0.09	0.00	1.86	-
	06/21/94	24.40	24.50	0.10	295.21	2.66	2.71	0.05	0.00	1.86	-
	07/01/94	26.44	26.62	0.18	293.19	2.65	2.74	0.09	0.00	1.86	-
	07/13/94	27.30	27.31	0.01	292.32	2.65	2.71	0.06	0.00	1.86	-
	08/05/94	21.38	21.40	0.02	298.24	2.63	2.69	0.06	0.00	1.86	-
	08/17/94	22.82	22.94	0.02	296.70	2.62	2.69	0.07	0.00	1.86	-
	08/30/94	20.62	20.65	0.03	299.00	2.62	2.69	0.07	0.00	1.86	-
	09/08/94	21.57	21.65	0.08	298.04	2.62	2.69	0.07	0.00	1.86	-
	09/14/94	22.83	23.01	0.08	296.88	2.62	2.69	0.07	0.00	1.86	-
	09/19/94	24.05	24.11	0.06	295.58	2.62	2.69	0.07	0.00	1.86	-
	09/30/94	-	24.05	0.00	295.57	2.58	2.66	0.07	0.00	1.86	-
	10/17/94	26.90	27.17	0.27	292.68	2.66	2.70	0.04	0.00	1.86	-
	10/25/94	-	27.69	0.00	291.73	2.66	2.70	0.04	0.00	1.86	-
	11/11/94	-	DRY	0.00	NA	2.66	2.70	0.04	0.00	1.86	-
	11/22/94	-	DRY	0.00	NA	2.66	2.70	0.04	0.00	1.86	-
	12/07/94	-	27.85	0.00	291.77	2.66	2.70	0.04	0.00	1.86	-
	12/21/94	-	24.82	0.00	294.80	2.66	2.70	0.04	0.00	1.86	-
	01/04/95	-	25.54	0.00	294.08	2.66	2.70	0.04	0.00	1.86	-
	01/16/95	-	23.09	0.00	296.53	2.66	2.70	0.04	0.00	1.86	-
	01/23/95	-	21.03	0.00	298.58	2.57	2.65	0.08	0.00	1.86	-
	02/16/95	-	22.20	0.00	297.42	2.59	2.65	0.06	0.00	1.86	-
	02/28/95	-	20.77	0.00	298.85	2.58	2.65	0.08	0.00	1.86	-
	03/10/95	-	19.32	0.00	300.30	2.58	2.65	0.08	0.00	1.86	-
	03/29/95	-	19.66	0.00	299.96	2.59	2.65	0.06	0.00	1.86	-
	04/04/95		Not Gauged			2.59	2.65	0.06	0.00	1.86	-
	04/27/95	-	21.82	0.00	297.80	2.59	2.65	0.06	0.00	1.86	-
	05/11/95	-	21.82	0.00	297.80	2.59	2.65	0.06	0.00	1.86	-
	05/24/95	-	22.40	0.00	297.22	2.59	2.65	0.06	0.00	1.86	-
	06/15/95	-	22.97	0.00	296.65	2.59	2.65	0.06	0.00	1.86	-
	06/29/95	-	24.86	0.00	294.76	2.59	2.65	0.06	0.00	1.86	-
	07/06/95	-	25.74	0.00	293.88	2.59	2.65	0.06	0.00	1.86	-
	07/25/95	-	25.98	0.00	293.64	2.59	2.65	0.06	0.00	1.86	-
	08/01/95	-	25.48	0.00	294.14	2.59	2.65	0.06	0.00	1.86	-
	08/21/95	-	DRY	0.00	NA	2.59	2.65	0.06	0.00	1.86	-
	09/14/95	-	DRY	0.00	NA	2.59	2.65	0.06	0.00	1.86	-
	09/28/95	-	27.71	0.00	291.91	2.59	2.65	0.06	0.00	1.86	-
	10/06/95	-	25.10	0.00	294.52	2.59	2.65	0.06	0.00	1.86	-
	10/25/95	-	20.15	0.00	299.47	2.59	2.65	0.06	0.00	1.86	-
	11/21/95	-	17.30	0.00	302.32	2.59	2.65	0.06	0.00	1.86	-
	12/06/95	-	19.51	0.00	300.11	2.59	2.65	0.06	0.00	1.86	-
	12/21/95	-	19.37	0.00	300.25	2.59	2.65	0.06	0.00	1.86	-
	01/23/96	-	17.10	0.00	302.52	2.59	2.65	0.06	0.00	1.86	-
	02/09/96	-	16.00	0.00	303.62	2.59	2.65	0.06	0.00	1.86	-
	02/19/96	-	18.40	0.00	301.22	2.59	2.65	0.06	0.00	1.86	-
	03/27/96	-	18.06	0.00	301.56	2.59	2.65	0.06	0.00	1.86	-
	04/11/96	-	16.37	0.00	303.25	2.59	2.65	0.06	0.00	1.86	-
	04/24/96	-	16.21	0.00	303.41	2.59	2.65	0.06	0.00	1.86	-
	05/28/96	-	18.94	0.00	300.68	2.59	2.65	0.06	0.00	1.86	-
	06/13/96	-	20.03	0.00	299.59	2.59	2.65	0.06	0.00	1.86	-
	06/26/96	-	19.92	0.00	299.70	2.59	2.65	0.06	0.00	1.86	-
	07/10/96	-	20.17	0.00	299.45	2.59	2.65	0.06	0.00	1.86	-
	07/25/96	-	18.60	0.00	301.02	2.59	2.65	0.06	0.00	1.86	-
	08/08/96	-	20.01	0.00	299.61	2.59	2.65	0.06	0.00	1.86	-
	08/30/96	-	20.54	0.00	299.08	2.59	2.65	0.06	0.00	1.86	-
	09/12/96	21.32	21.33	0.01	298.30	2.59	2.65	0.06	0.00	1.86	-
	09/26/96	-	19.38	0.00	300.23	2.59	2.65	0.06	0.00	1.86	-
	10/09/96	-	19.35	0.00	300.27	2.59	2.65	0.06	0.00	1.86	-
	10/24/96	-	16.71	0.00	302.91	2.59	2.65	0.06	0.00	1.86	-

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 28606.09 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FTM)	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-7	03/30/94	-	11.50	0.00	302.58						
314.08	03/30/94	-	11.42	0.00	302.66						
	04/04/94	-	11.28	0.00	302.80						
	04/06/94	-	11.09	0.00	302.99						
	04/07/94	-	12.18	0.00	301.82						
	04/12/94	-	13.57	0.00	300.51						
	04/20/94	-	14.08	0.00	300.00						
	04/27/94	-	13.50	0.00	300.58						
	05/04/94	-	14.64	0.00	299.44						
	05/12/94	-	14.89	0.00	299.19						
	05/13/94	-	14.93	0.00	299.15						
	05/18/94	15.92	15.93	0.01	298.16						
	05/24/94	16.92	16.96	0.04	297.15						
	05/27/94	17.69	17.78	0.09	296.38						
	06/03/94	18.52	18.60	0.08	295.55						
	06/15/94	20.06	20.26	0.20	293.99						
	06/16/94	20.38	20.56	0.18	293.68						
	07/01/94	24.12	24.41	0.29	289.92						
	07/13/94	26.57	26.95	0.38	287.48				0.50	0.50	
	08/05/94	-	18.38	0.00	294.70				0.00	0.50	
	08/17/94	20.24	20.25	0.01	293.84				0.00	0.50	
	08/30/94	-	17.33	0.00	296.75				0.00	0.50	
	09/08/94	18.41	18.42	0.00	295.67				0.00	0.50	
	09/14/94	18.96	19.97	0.01	294.12				0.00	0.50	
	09/19/94	21.25	21.27	0.02	292.83				0.00	0.50	
	09/30/94	21.10	21.10	0.00	292.98				0.00	0.50	
	10/17/94	24.76	24.90	0.14	289.30				0.00	0.50	
	10/25/94	27.14	27.48	0.34	286.90				0.00	0.50	
	11/11/94	-	DRY	0.00	NA				0.00	0.50	
	11/22/94	-	DRY	0.00	NA				0.00	0.50	
	12/07/94	27.68	28.08	0.29	286.17				0.00	0.50	
	12/21/94	22.92	23.57	0.65	291.08				0.00	0.50	
	01/04/95	23.17	23.91	0.74	290.81				1.00	1.50	
	01/16/95	21.09	21.29	0.20	292.98				0.00	1.50	
	01/23/95	19.05	19.12	0.07	295.02				0.00	1.50	
	02/16/95	18.80	18.93	0.13	295.28				0.00	1.50	
	02/28/95	17.17	17.22	0.05	296.90				0.00	1.50	
	03/10/95	18.42	18.45	0.03	297.66				0.00	1.50	
	03/29/95	14.98	14.98	0.01	299.10				0.00	1.50	
	04/04/95	18.46	18.51	0.05	297.61				0.00	1.50	
	04/27/95	18.46	18.49	0.03	295.62				0.00	1.50	
	05/11/95	17.90	17.96	0.06	296.17				0.00	1.50	
	05/24/95	19.08	19.25	0.17	294.98				0.00	1.50	
	06/15/95	Well Knocked Over During Soil Removal Operations							0.00	1.50	
	06/29/95	22.02	22.25	0.23	292.03				0.00	1.50	
	07/06/95	23.05	23.30	0.25	291.00				0.25	1.75	
	07/25/95	23.35	23.50	0.15	290.71				0.00	1.75	
	08/01/95	23.42	23.65	0.23	290.63				0.25	2.00	
	08/21/95		DRY	0.00	NA				0.00	2.00	
	09/14/95		DRY	0.00	NA				0.00	2.00	
	09/28/95		DRY	0.00	NA				0.00	2.00	
	10/06/95	23.97	24.08	0.11	290.10				0.00	2.00	
	10/25/95		16.86	0.00	297.22				0.00	2.00	
	11/21/95		12.70	0.00	301.38				0.00	2.00	
	12/06/95		14.96	0.00	299.12				0.00	2.00	
	12/21/95		15.18	0.00	298.90				0.00	2.00	
	01/23/96		12.83	0.00	301.25				0.00	2.00	
	02/09/96		11.46	0.00	302.62				0.00	2.00	
	02/19/96		14.12	0.00	299.96				0.00	2.00	
	03/27/96		14.06	0.00	300.02						
	04/11/96		12.72	0.00	301.36						
	04/24/96		12.21	0.00	301.87						
	05/29/96		14.46	0.00	299.62						
	06/13/96		15.70	0.00	298.38						
	06/28/96		16.09	0.00	297.99						
	07/10/96		16.39	0.00	297.69						
	07/25/96		14.09	0.00	299.99						
	08/06/96		15.98	0.00	298.10						
	08/30/96		16.92	0.00	297.16						
	09/12/96		18.05	0.00	296.03						
	09/26/96		14.54	0.00	299.54						
	10/09/96		15.74	0.00	298.34						
	10/24/96		12.31	0.00	301.77						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.88 Task 3813

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)*	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFPW-8	03/30/94	-	12.25	0.00	297.82						
310.07	04/04/94	-	12.80	0.00	297.27						
	04/12/94	-	13.26	0.00	296.81						
	04/20/94	-	13.63	0.00	296.44						
	05/12/94	-	14.80	0.00	295.27						
	05/24/94	-	15.82	0.00	294.25						
	06/03/94	-	16.94	0.00	293.13						
	07/01/94	-	19.83	0.00	290.24						
	07/13/94	21.78	21.79	0.01	288.29						
	08/05/94	-	18.03	0.00	292.04						
	08/17/94	-	18.83	0.00	291.24						
	08/30/94	-	16.77	0.00	293.30						
	09/08/94	-	17.51	0.00	292.56						
	09/19/94	-	18.55	0.00	291.52						
	09/30/94	-	18.69	0.00	291.38						
	10/17/94	-	21.28	0.00	288.79						
	10/25/94	-	21.97	0.00	288.10						
	11/11/94	24.42	24.45	0.03	285.65						
	11/22/94	24.71	24.76	0.05	285.35						
	12/07/94	-	20.89	0.00	289.18						
	12/21/94	-	20.20	0.00	289.87						
	01/04/95	-	20.00	0.00	290.07						
	01/23/95	-	16.48	0.00	293.59						
	02/16/95	-	17.32	0.00	292.75						
	02/28/95	-	15.38	0.00	294.69						
	03/10/95	-	13.99	0.00	296.08						
	03/29/95	-	14.88	0.00	295.19						
	04/04/95	-	15.29	0.00	294.78						
	04/27/95	-	16.51	0.00	293.56						
	05/11/95	-	16.25	0.00	293.82						
	05/24/95	-	17.01	0.00	293.06						
	06/15/95	-	17.51	0.00	292.56						
	06/29/95	-	18.02	0.00	292.05						
	07/06/95	-	19.20	0.00	290.87						
	07/25/95	-	19.02	0.00	291.05						
	08/01/95	-	20.36	0.00	289.71						
	08/21/95	23.37	23.37	sheen	286.70						
	09/14/95	26.21	26.32	0.11	283.85						
	09/26/95	-	19.90	0.00	290.17						
	10/06/95	-	17.48	0.00	292.59						
	10/25/95	-	15.38	0.00	294.69						
	11/21/95	-	12.59	0.00	297.48						
	12/06/95	-	13.79	0.00	296.28						
	12/21/95	-	13.78	0.00	296.29						
	01/23/96	-	12.69	0.00	297.38						
	02/09/96	-	12.12	0.00	297.95						
	02/19/96	-	12.19	0.00	297.88						
	03/27/96	-	13.11	0.00	296.96						
	04/11/96	-	11.89	0.00	298.18						
	04/24/96	-	12.29	0.00	297.78						
	05/29/96	-	13.71	0.00	296.36						
	06/13/96	-	14.31	0.00	295.76						
	06/28/96	-	14.39	0.00	295.68						
	07/10/96	-	14.47	0.00	295.60						
	07/25/96	-	13.92	0.00	296.15						
	08/08/96	-	14.32	0.00	295.75						
	08/30/96	-	14.94	0.00	295.13						
	09/12/96	-	15.54	0.00	294.53						
	09/26/96	-	14.50	0.00	295.57						
	10/08/96	-	13.16	0.00	296.91						
	10/24/96	-	12.92	0.00	297.15						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29609.08 Task 3813

WELL # CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-9	03/30/94	-	2.92	0.00	297.69						
300.61	04/04/94	-	3.64	0.00	296.97						
	04/12/94	-	3.91	0.00	296.70						
	04/20/94	-	4.25	0.00	296.36						
	05/12/94	-	5.18	0.00	295.43						
	05/24/94	-	6.19	0.00	294.42						
	06/03/94	-	7.44	0.00	293.17						
	07/01/94	-	9.91	0.00	290.70						
	07/13/94	-	12.65	0.00	287.96						
	08/05/94	-	8.62	0.00	291.99						
	08/17/94	-	9.40	0.00	291.21						
	08/30/94	-	7.33	0.00	293.28						
	09/08/94	0.10	8.18	0.00	292.43						
	09/19/94	-	8.91	0.00	291.70						
	09/30/94	-	9.14	0.00	291.47						
	10/17/94	-	11.93	0.00	288.68						
	10/25/94	-	11.50	0.00	289.11						
	11/11/94	-	13.53	0.00	287.08						
	11/22/94	-	13.15	0.00	287.46						
	12/07/94	-	10.36	0.00	290.25						
	12/21/94	-	10.64	0.00	289.97						
	01/04/95	-	10.14	0.00	290.47						
	01/23/95	-	-	0.00	-						
	02/18/95	-	7.54	0.00	293.07						
	02/28/95	-	-	0.00	-						
	03/10/95	-	4.39	0.00	296.22						
	03/29/95	-	5.54	0.00	294.53						
	04/04/95	-	6.95	0.00	293.66						
	04/27/95	-	7.10	0.00	302.97						
	05/11/95	-	6.63	0.00	303.44						
	05/24/95	-	7.58	0.00	302.49						
	06/15/95	-	8.52	0.00	301.55						
	06/29/95	-	7.95	0.00	302.12						
	07/06/95	-	8.68	0.00	300.39						
	07/25/95	-	9.45	0.00	300.62						
	08/01/95	-	10.95	0.00	299.12						
	08/21/95	-	14.49	0.00	295.58						
	09/14/95	-	17.84	0.00	292.43						
	09/28/95	-	9.85	0.00	300.22						
	10/06/95	-	7.35	0.00	302.72						
	10/25/95	-	6.04	0.00	304.03						
	11/21/95	-	4.10	0.00	305.97						
	12/06/95	-	-	0.00	-						
	12/21/95	-	-	0.00	-						
	01/23/96	-	3.94	0.00	306.13						
	02/09/96	-	3.60	0.00	306.47						
	02/19/96	-	4.28	0.00	305.81						
	03/27/96	-	4.31	0.00	305.78						
	04/11/96	-	3.34	0.00	306.73						
	04/24/96	-	3.74	0.00	306.33						
	05/29/96	-	4.74	0.00	305.33						
	06/13/96	-	5.06	0.00	305.01						
	06/26/96	-	Well inaccessible								
	07/10/96	-	Well inaccessible								
	07/25/96	-	4.95	0.00	305.12						
	08/06/96	-	5.28	0.00	304.79						
	08/30/96	-	5.63	0.00	304.24						
	09/12/96	-	6.42	0.00	303.65						
	09/26/96	-	5.27	0.00	304.80						
	10/09/96	-	3.61	0.00	306.26						
	10/24/96	-	4.01	0.00	306.06						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29690.09 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-10	03/30/94	-	5.33	0.00	295.77						
301.10	04/04/94	-	5.46	0.00	295.64						
	04/12/94	-	6.60	0.00	294.50						
	04/20/94	-	6.96	0.00	294.14						
	05/12/94	-	3.65	0.00	297.45						
	07/01/94	-	12.45	0.00	288.65						
	07/13/94	-	15.78	0.00	285.32						
	08/05/94	-	11.05	0.00	290.05						
	08/17/94	-	11.31	0.00	289.79						
	08/30/94	-	8.88	0.00	292.22						
	09/08/94	-	9.56	0.00	291.54						
	09/19/94	-	11.32	0.00	289.78						
	09/30/94	-	11.23	0.00	289.87						
	10/17/94	-	14.27	0.00	286.83						
	10/25/94	-	15.66	0.00	285.44						
	11/11/94	-	19.18	0.00	281.92						
	11/22/94	-	19.77	0.00	281.33						
	12/07/94	-	15.75	0.00	285.35						
	12/21/94	-	13.83	0.00	287.27						
	01/04/95	-	13.66	0.00	287.44						
	01/23/95	-	10.27	0.00	290.83						
	02/16/95	-	-	0.00	-						
	02/28/95	-	8.76	0.00	292.34						
	03/10/95	-	7.72	0.00	293.38						
	03/29/95	-	-	0.00	-						
	04/04/95	-	7.73	0.00	293.37						
	04/27/95	-	9.91	0.00	292.19						
	05/11/95	-	9.81	0.00	292.19						
	05/24/95	-	8.53	0.00	291.57						
	06/15/95	-	10.57	0.00	290.53						
	06/29/95	-	-	0.00	-						
	07/06/95	-	-	0.00	-						
	07/25/95	-	12.86	0.00	288.24						
	08/01/95	-	13.79	0.00	287.31						
	08/21/95	-	17.75	0.00	283.35						
	09/14/95	-	22.38	0.00	278.71						
	09/28/95	-	15.00	0.00	286.10						
	10/06/95	-	12.09	0.00	289.01						
	10/25/95	-	8.24	0.00	292.86						
	11/21/95	-	-	0.00	-						
	12/06/95	-	6.60	0.00	294.50						
	12/21/95	-	-	0.00	-						
	01/23/96	-	-	0.00	-						
	02/09/96	-	-	0.00	-						
	02/16/96	-	-	0.00	-						
	03/27/96		CAR ON WELL								
	04/11/96	-	6.27	0.00	294.83						
	04/24/96	-	6.12	0.00	294.98						
	05/29/96	-	6.31	0.00	294.79						
	06/13/96	-	7.01	0.00	294.09						
	06/26/96	-	Well Inaccessible								
	07/10/96	-	Well Inaccessible								
	07/25/96	-	6.54	0.00	294.56						
	08/08/96	-	6.58	0.00	294.54						
	08/30/96	-	6.32	0.00	294.78						
	09/12/96	-	8.03	0.00	293.07						
	09/26/96	-	7.50	0.00	293.60						
	10/08/96	-	6.85	0.00	294.25						
	10/24/96	-	6.50	0.00	294.60						
NFFW-11	03/30/94										
301.49	04/04/94										

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 28600.00 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)*	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV (GAL)	CUMM LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-12	03/30/94	-	8.73	0.00	298.63						
307.36	04/04/94	-	9.01	0.00	298.35						
	04/06/94	-	9.22	0.00	298.14						
	04/07/94	-	9.28	0.00	298.08						
	04/12/94	-	10.04	0.00	297.32						
	04/20/94	-	10.43	0.00	296.93						
	04/27/94	-	10.74	0.00	296.62						
	05/04/94	-	11.72	0.00	295.64						
	05/12/94	-	11.95	0.00	295.41						
	05/13/94	-	11.98	0.00	295.38						
	05/16/94	-	12.35	0.00	295.01						
	05/24/94	-	13.23	0.00	294.13						
	05/27/94	-	13.65	0.00	293.71						
	06/03/94	-	14.44	0.00	292.92						
	06/15/94	15.74	15.75	0.02	291.62						
	06/16/94	15.81	15.82	0.02	291.45						
	07/01/94	18.03	18.11	0.08	289.32						
	07/13/94	20.08	20.20	0.12	287.28				0.25	0.25	
	08/05/94	18.82	18.84	0.02	290.44				0.00	0.25	
	08/17/94	18.35	18.37	0.02	291.01				0.00	0.25	
	08/30/94	-	14.17	0.00	293.19				0.00	0.25	
	09/06/94	-	14.31	0.00	293.05				0.00	0.25	
	09/14/94	-	14.17	0.00	293.19				0.00	0.25	
	09/19/94	-	15.99	0.00	291.37				0.00	0.25	
	09/30/94	-	16.77	0.00	290.59				0.00	0.25	
	10/17/94	18.95	19.05	0.10	288.40				0.00	0.25	
	10/25/94	-	20.80	0.00	286.56				0.00	0.25	
	11/11/94	23.89	23.97	0.08	283.46				0.00	0.25	
	11/22/94	IFP BROKE DURING GAUGING, NO INFORMATION AVAILABLE							0.00	0.25	
	12/07/94	22.52	22.52	0.00	284.84				0.00	0.25	
	12/21/94	-	19.30	0.00	288.06				0.00	0.25	
	01/04/95	-	19.10	0.00	288.26				0.00	0.25	
	01/16/95	-	17.54	0.00	289.82				0.00	0.25	
	01/23/95	-	15.95	0.00	291.41				0.00	0.25	
	02/16/95	-	15.33	0.00	292.03				0.00	0.25	
	02/28/95	-	14.14	0.00	293.22				0.00	0.25	
	03/10/95	-	12.96	0.00	294.40				0.00	0.25	
	03/29/95	-	12.32	0.00	295.04				0.00	0.25	
	04/04/95	-	13.02	0.00	294.34				0.00	0.25	
	04/27/95	-	14.64	0.00	292.72				0.00	0.25	
	05/11/95	-	14.57	0.00	292.79				0.00	0.25	
	05/24/95	-	15.19	0.00	292.17				0.00	0.25	
	06/15/95	-	16.14	0.00	291.22				0.00	0.25	
	06/29/95	-	17.14	0.00	290.22				0.00	0.25	
	07/06/95	-	17.84	0.00	289.52				0.00	0.25	
	07/25/95	-	18.88	0.00	288.48				0.00	0.25	
	08/01/95	-	19.05	0.00	288.31				0.00	0.25	
	08/21/95	22.37	22.38	0.01	284.99				0.00	0.25	
	09/14/95	25.38	25.65	0.27	281.94				0.00	0.25	
	09/28/95	21.50	21.64	0.08	285.79				0.00	0.25	
	10/06/95	-	18.28	0.00	288.18				0.00	0.25	
	10/25/95	-	13.78	0.00	293.58				0.00	0.25	
	11/21/95	-	9.70	0.00	297.66				0.00	0.25	
	12/06/95	-	11.37	0.00	295.99				0.00	0.25	
	12/21/95	-	11.80	0.00	295.56				0.00	0.25	
	01/23/96	-	10.37	0.00	296.99				0.00	0.25	
	02/06/96	-	9.45	0.00	297.91				0.00	0.25	
	02/16/96	-	10.60	0.00	296.76				0.00	0.25	
	03/27/96	-	10.26	0.00	297.10						
	04/11/96	-	8.98	0.00	298.38						
	04/24/96	-	9.25	0.00	298.11						
	05/29/96	-	11.19	0.00	296.17						
	06/13/96	-	12.52	0.00	294.84						
	06/28/96	-	12.26	0.00	295.10						
	07/10/96	-	12.41	0.00	294.95						
	07/25/96	-	11.02	0.00	296.34						
	08/06/96	-	11.74	0.00	295.62						
	08/30/96	-	12.82	0.00	294.54						
	09/12/96	-	13.88	0.00	293.48						
	09/26/96	-	12.38	0.00	294.98						
	10/09/96	-	11.70	0.00	295.66						
	10/24/96	-	9.78	0.00	297.58						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.00 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-13	03/30/94	-	8.59	0.00	298.51						
305.10	04/04/94	-	-	-	-						
	04/12/94	-	8.02	0.00	297.08						
	04/20/94	-	8.38	0.00	296.72						
	05/12/94	-	-	-	-						
NFFW-14	03/30/94	-	10.28	0.00	302.88						
313.16	04/04/94	-	10.19	0.00	302.97						
	04/06/94	-	10.88	0.00	302.28						
	04/07/94	-	11.09	0.00	302.07						
	04/12/94	12.57	12.58	0.01	300.58						
	04/20/94	12.57	12.96	0.39	300.54						
	04/27/94	12.85	12.87	0.02	300.51						
	05/04/94	13.85	13.89	0.04	299.30						
	05/12/94	14.23	14.29	0.06	298.92						
	05/13/94	14.17	14.18	0.01	298.99						
	05/16/94	15.30	15.38	0.08	297.85						
	05/24/94	16.44	16.50	0.06	296.71						
	05/27/94	17.04	17.09	0.05	296.12						
	06/03/94	17.93	17.98	0.05	295.22						
	06/15/94	19.54	19.58	0.04	293.61						
	06/16/94	19.72	19.83	0.11	293.43						
	07/01/94	23.03	23.38	0.35	290.06						
	07/13/94	26.70	31.74	5.04	285.80				10.00	10.00	
	08/05/94	17.53	21.55	4.02	295.11				5.00	15.00	
	08/17/94	17.70	21.78	4.08	294.93				7.00	22.00	
315.49	08/30/94	18.28	18.31	0.03	297.21				0.00	22.00	
	09/08/94	19.15	19.42	0.27	296.30				0.00	22.00	
	09/14/94	20.77	20.80	0.03	294.72				0.00	22.00	
	09/19/94	21.90	21.92	0.02	293.58				0.00	22.00	
	09/30/94	22.35	22.36	0.01	293.14				0.00	22.00	
	10/17/94	25.36	25.46	0.10	290.12				0.00	22.00	
	10/25/94	27.86	33.50	5.64	286.90				0.00	22.00	
	11/11/94	31.31	36.54	5.23	283.50				1.10	23.10	
	11/22/94	IFP BROKE DURING GAUGING							5.00	28.10	
	12/07/94	27.86	33.90	6.04	286.84				11.00	39.10	
	12/21/94	23.47	25.28	1.81	291.78				3.00	42.10	
	01/04/95	24.00	24.48	0.48	291.43				1.00	43.10	
	01/18/95	22.35	22.56	0.21	293.11				0.00	43.10	
	01/23/95	-	20.64	0.00	294.85				0.37	43.47	
	02/16/95	20.36	20.37	0.01	295.13				0.00	43.47	
	02/28/95	-	18.93	0.00	296.56				0.00	43.47	
	03/10/95	-	17.73	0.00	297.76				0.00	43.47	
	03/29/95	16.60	16.76	0.16	298.87				0.00	43.47	
	04/04/95	18.29	18.54	0.25	297.17				0.00	43.47	
	04/27/95	20.22	20.67	0.45	295.21				0.00	43.47	
	05/11/95	20.11	20.35	0.24	295.35				0.37	43.84	
	05/24/95	21.07	21.22	0.15	294.40				0.37	44.21	
	06/15/95	21.86	22.12	0.26	293.60				0.00	44.21	
	06/29/95	23.79	23.89	0.10	291.69				0.37	44.58	
	07/06/95	24.52	24.58	0.06	290.96				0.00	44.58	
	07/25/95	24.52	24.86	0.34	290.93				0.55	45.13	
	08/01/95	25.44	25.64	0.20	290.02				0.37	45.50	
	08/21/95	31.66	35.21	3.55	283.37				0.37	45.87	
313.16	09/14/95	33.93	34.45	0.52	278.16				0.37	46.24	
	09/28/95	24.80	28.18	3.38	287.92				6.50	52.74	
	10/06/95	22.12	22.77	0.65	290.98				0.00	52.74	
	10/25/95	15.78	16.02	0.24	297.35				0.37	53.11	
	11/21/95	11.29	12.03	0.74	301.77				0.00	53.11	
	12/06/95	13.36	14.36	0.97	299.64				2.00	55.11	
	12/21/95	-	-	0.00	-				0.00	55.11	
	01/23/96	-	-	0.00	-				0.00	55.11	
	02/09/96	-	-	0.00	-				0.00	55.11	
	02/19/96	-	-	0.00	-				0.00	55.11	
	03/27/96	-	14.49	0.00	298.67						
	04/11/96	13.72	13.74	0.02	299.44						
	04/24/96	13.22	13.32	0.10	299.93						
	05/29/96	15.68	15.69	0.01	297.48						
	06/13/96	-	17.09	0.00	296.07						
	06/28/96	17.48	17.49	0.01	295.68	-	-	-	0.00	55.31	-
	07/10/96	17.62	17.66	0.04	295.53	2.11	2.61	0.50	10.58	65.89	-
	07/25/96	-	15.35	0.00	297.81	2.07	2.56	0.49	0.00	65.89	-
	08/02/96	16.15	16.19	0.04	297.00	-	-	-	-	65.89	-
	08/08/96	17.11	17.12	0.01	296.05	2.08	2.58	0.50	0.20	66.09	-
	08/15/96	-	17.41	0.00	295.75	2.08	2.58	0.50	0.00	66.09	
	08/30/96	15.12	15.30	0.18	298.02	-	-	-	-	66.09	-
	09/04/96	18.58	18.81	0.23	294.55	2.05	2.55	0.50	0.00	66.09	-
	09/12/96	19.33	19.39	0.23	293.97	2.09	2.6	0.51	0.00	66.09	-
	09/19/96	-	19.48	0.00	294.68	2.02	2.56	0.54	0.80	66.89	-
	09/26/96	-	19.98	0.00	296.20	2.02	2.56	0.54	0.00	66.89	-
	10/09/96	16.79	16.85	0.06	296.38	1.98	2.53	0.55	0.20	67.09	-
	10/17/96	15.55	15.59	0.04	297.60	1.97	2.52	0.55	0.00	67.09	-
	10/24/96	13.65	13.65	0.00	299.51	1.97	2.52	0.55	0.00	67.09	-
	10/31/96	14.03	14.06	0.03	299.13	1.95	2.51	0.56	0.20	67.29	-

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.09 Task 3613

WELL # CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV (GAL)	CUMM. LNAPL RECOV (GAL)	FLOW METER READING (GAL)
NFFW-15	03/30/94	-	8.94	0.00	297.83						
306.87	04/04/94	-	9.18	0.00	297.69						
	04/12/94	-	16.48	0.00	296.41						
	04/20/94	-	16.39	0.00	296.48						
	05/12/94	-	13.35	0.00	293.52						
	05/24/94	-	14.61	0.00	292.26						
	06/03/94	-	16.15	0.00	290.72						
	07/01/94	-	21.48	0.00	285.39						
	07/13/94	-	24.28	0.00	282.59						
	08/05/94	-	17.29	0.00	289.58						
	08/17/94	-	17.38	0.00	289.51						
	08/30/94	-	13.95	0.00	292.92						
	09/08/94	-	14.93	0.00	291.94						
	09/19/94	-	17.32	0.00	289.55						
	09/30/94	-	18.21	0.00	288.66						
	10/17/94	-	21.37	0.00	285.50						
	10/25/94	-	23.82	0.00	283.05						
	11/11/94	-	27.50	0.00	279.37						
	11/22/94	-	28.30	0.00	278.57						
	12/07/94	-	23.33	0.00	283.54						
	12/21/94	-	19.95	0.00	286.92						
	01/04/95	-	20.56	0.00	286.31						
	01/23/95	-	17.01	0.00	289.86						
	02/16/95	-	17.17	0.00	289.70						
	02/28/95	-	15.72	0.00	291.15						
	03/10/95	-	13.42	0.00	293.45						
	03/29/95	-	13.27	0.00	293.60						
	04/04/95	-	14.01	0.00	292.86						
	04/27/95	-	16.22	0.00	290.65						
	05/11/95	-	16.70	0.00	290.17						
	05/24/95	-	17.31	0.00	289.56						
	06/15/95	-	18.50	0.00	288.37						
	06/29/95	-	20.48	0.00	286.39						
	07/06/95	-	21.55	0.00	285.32						
	07/25/95	-	21.72	0.00	285.15						
	08/01/95	-	22.04	0.00	284.83						
	08/21/95	-	28.98	0.00	278.89						
	09/14/95	-	31.88	0.00	274.99						
	09/28/95	-	23.00	0.00	283.87						
	10/06/95	-	18.91	0.00	287.96						
	10/25/95	-	13.42	0.00	293.45						
	11/21/95	-	9.48	0.00	297.38						
	12/08/95	-	11.76	0.00	295.11						
	12/21/95	-	12.46	0.00	294.41						
	01/23/96	-	-	0.00	-						
	02/09/96	-	9.69	0.00	297.18						
	02/19/96	-	10.92	0.00	295.95						
	03/27/96	-	10.34	0.00	296.53						
	04/11/96	-	8.85	0.00	298.02						
	04/24/96	-	9.21	0.00	297.66						
	05/29/96	-	11.76	0.00	295.11						
	06/13/96	-	13.69	0.00	293.18						
	06/28/96	-	12.33	0.00	294.54						
	07/15/96	-	12.60	0.00	294.27						
	07/25/96	-	11.08	0.00	295.79						
	08/08/96	-	11.87	0.00	295.00						
	08/30/96	-	13.24	0.00	293.63						
	09/12/96	-	14.74	0.00	292.13						
	09/26/96	-	12.20	0.00	294.67						
	10/09/96	-	11.36	0.00	295.51						
	10/24/96	-	9.71	0.00	297.16						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.09 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-18	03/30/94	-	11.40	0.00	301.54						
312.94	04/04/94	-	11.29	0.00	301.65						
	04/06/94	-	11.83	0.00	301.11						
	04/07/94	-	12.11	0.00	300.83						
	04/12/94	-	13.08	0.00	299.86						
	04/20/94	-	13.44	0.00	299.50						
	04/27/94	-	3.30	0.00	309.64						
	05/04/94	-	14.15	0.00	298.79						
	05/12/94	-	14.32	0.00	298.62						
	05/13/94	-	14.39	0.00	298.55						
	05/16/94	-	14.88	0.00	298.06						
	05/24/94	-	15.71	0.00	297.23						
	05/27/94	16.10	16.10	0.00	296.76						
	06/03/94	16.04	16.07	0.03	296.80						
	06/15/94	16.27	16.34	0.07	294.66						
	06/16/94	16.49	16.56	0.07	294.45						
	07/01/94	21.62	21.77	0.15	291.30						
	07/13/94	24.18	24.68	0.50	288.70				0.25	0.25	
	08/05/94	17.43	18.66	1.23	295.35				1.00	1.25	
	08/17/94	18.52	19.26	0.74	294.32				0.50	1.75	
	08/30/94	16.45	16.58	0.13	296.47				0.25	2.00	
	09/08/94	17.11	17.17	0.06	295.82				0.00	2.00	
	09/14/94	20.77	20.80	0.03	292.17				0.00	2.00	
	09/19/94	19.28	19.29	0.01	293.66				0.07	2.07	
	09/30/94	19.38	19.38	0.00	293.58				0.00	2.07	
	10/17/94	22.52	22.61	0.08	290.41				0.00	2.07	
	10/25/94	24.86	26.20	1.34	287.91				0.00	2.07	
	11/11/94	29.80	32.36	2.56	282.81				0.00	2.07	
	11/22/94	31.22	34.19	2.87	281.33				0.00	2.07	
	12/07/94	25.45	28.90	3.45	287.04				0.00	2.07	
	12/21/94	20.88	23.11	2.23	291.77				4.00	6.07	
	01/04/95	21.27	22.03	0.76	291.57				1.00	7.07	
	01/16/95	19.33	19.64	0.31	293.57				1.00	8.07	
	01/23/95	17.72	17.97	0.25	295.19				0.00	8.07	
	02/16/95	17.58	17.73	0.15	295.34				0.00	8.07	
	02/28/95	-	18.41	0.00	296.53				0.00	8.07	
	03/10/95	-	15.84	0.00	297.10				0.00	8.07	
	03/26/95	-	14.90	0.00	298.04				0.25	8.32	
	04/04/95	-	15.47	0.00	297.47				0.00	8.32	
	04/27/95	16.98	16.98	0.00	295.96				0.00	8.32	
	05/11/95	-	16.85	0.00	296.08				0.00	8.32	
	05/24/95	17.58	17.60	0.01	295.35				0.00	8.32	
	06/15/95	18.48	18.47	0.01	294.48				0.00	8.32	
	06/29/95	19.78	19.86	0.08	293.15				0.00	8.32	
	07/06/95	-	21.08	0.00	291.86				0.00	8.32	
	07/25/95	21.75	21.83	0.08	291.18				0.00	8.32	
	08/01/95	21.90	21.98	0.08	291.03				0.00	8.32	
	08/21/95	27.72	29.10	1.38	285.04				0.00	8.32	
	09/14/95	33.58	36.60	3.01	278.96				6.00	14.32	
	09/28/95	27.05	27.81	0.76	285.78				0.00	14.32	
	10/06/95	22.20	22.38	0.18	290.72				0.00	14.32	
	10/25/95	-	15.92	0.00	297.02				0.00	14.32	
	11/21/95	-	12.17	0.00	300.77				0.00	14.32	
	12/06/95	-	14.00	0.00	298.94				0.00	14.32	
	12/21/95	-	14.15	0.00	298.79				0.00	14.32	
	01/23/96	-	12.55	0.00	300.39				0.00	14.32	
	02/09/96	-	11.24	0.00	301.70				0.00	14.32	
	02/19/96	-	13.28	0.00	299.66				0.00	14.32	
	03/27/96	-	13.21	0.00	299.73						
	04/11/96	-	12.05	0.00	300.89						
	04/24/96	-	11.85	0.00	301.09						
	05/29/96	-	13.74	0.00	299.20						
	06/13/96	-	14.77	0.00	298.17						
	06/28/96	-	14.85	0.00	298.09						
	07/10/96	-	15.06	0.00	297.88						
	07/25/96	-	11.06	0.00	301.88						
	08/08/96	-	14.61	0.00	298.33						
	08/30/96	-	14.42	0.00	298.52						
	09/12/96	-	16.33	0.00	296.61						
	09/26/96	-	14.80	0.00	298.14						
	10/09/96	-	14.56	0.00	298.38						
	10/24/96	-	12.06	0.00	300.88						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29660.00 Task 3813

WELL W/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)*	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-17	03/30/94	-	2.38	0.00	297.14						
299.52	04/04/94	-	2.45	0.00	297.07						
	04/12/94	-	3.58	0.00	295.94						
	04/20/94	-	3.67	0.00	295.85						
	05/12/94	-	5.97	0.00	293.55						
	05/24/94	-	7.13	0.00	292.39						
	06/03/94	-	8.26	0.00	291.26						
	07/01/94	-	11.70	0.00	287.82						
	07/13/94	-	14.15	0.00	285.37						
	08/05/94	-	10.67	0.00	288.85						
	08/17/94	-	9.78	0.00	289.74						
	08/30/94	-	7.15	0.00	292.37						
	09/06/94	-	7.62	0.00	291.90						
	09/19/94	-	10.85	0.00	288.67						
	09/30/94	-	9.98	0.00	289.54						
	10/17/94	-	12.35	0.00	287.17						
	10/25/94	-	14.15	0.00	285.37						
	11/11/94	17.91	17.91	0.00	281.61						
	11/22/94	-	18.37	0.00	281.15						
	12/07/94	-	15.44	0.00	284.08						
	12/21/94	-	12.82	0.00	286.70						
	01/04/95	-	12.62	0.00	286.90						
	01/23/95	-	9.62	0.00	289.90						
	02/16/95	-	-	0.00	-						
	02/28/95	-	7.72	0.00	291.80						
	03/10/95	-	6.35	0.00	293.17						
	03/29/95	-	6.01	0.00	293.51						
	04/04/95	-	6.49	0.00	293.03						
	04/27/95	-	8.25	0.00	291.27						
	05/11/95	-	6.45	0.00	291.07						
	05/24/95	-	8.94	0.00	290.58						
	06/15/95	-	9.77	0.00	289.75						
	06/28/95	-	10.81	0.00	288.71						
	07/06/95	-	11.78	0.00	287.74						
	07/25/95	-	12.82	0.00	286.70						
	08/01/95	-	13.17	0.00	286.35						
	08/21/95	-	17.03	0.00	282.49						
	09/14/95	-	21.62	0.00	277.90						
	09/28/95	-	15.25	0.00	284.27						
	10/06/95	-	11.22	0.00	288.30						
	10/25/95	-	6.80	0.00	292.72						
	11/21/95	-	2.62	0.00	296.90						
	12/06/95	-	4.66	0.00	294.86						
	12/21/95	-	-	0.00	-						
	01/23/96	-	3.51	0.00	296.01						
	02/09/96	-	2.78	0.00	296.74						
	02/19/96	-	-	0.00	-						
	03/27/96	-	3.49	0.00	296.03						
	04/11/96	-	2.13	0.00	297.39						
	04/24/96	-	3.42	0.00	296.10						
	05/29/96	-	4.58	0.00	294.94						
	06/13/96	-	6.30	0.00	293.22						
	06/28/96	-	5.27	0.00	294.25						
	07/10/96	-	5.55	0.00	293.97						
	07/25/96	-	4.08	0.00	295.44						
	08/06/96	-	4.80	0.00	294.72						
	08/30/96	-	6.06	0.00	293.46						
	09/12/96	-	7.33	0.00	292.19						
	09/26/96	-	5.30	0.00	294.22						
	10/09/96	-	4.40	0.00	295.12						
	10/24/96	-	2.89	0.00	296.63						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29660.09 Task 3613

WELL # / CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-16	03/30/94	-	11.95	0.00	294.99						
306.94	04/04/94	-	12.59	0.00	294.35						
	04/12/94	-	12.84	0.00	294.10						
	04/20/94	-	13.09	0.00	293.85						
	05/12/94	-	13.95	0.00	292.99						
	05/24/94	-	14.93	0.00	292.01						
	06/03/94	-	16.12	0.00	290.82						
	07/01/94	-	19.30	0.00	287.64						
	07/13/94	-	22.05	0.00	284.89						
	08/05/94	-	17.15	0.00	289.79						
	08/17/94	-	18.17	0.00	288.77						
	08/30/94	-	15.78	0.00	291.16						
	09/08/94	-	16.74	0.00	290.20						
	09/19/94	-	17.80	0.00	289.14						
	09/30/94	-	17.91	0.00	288.03						
	10/17/94	-	21.15	0.00	285.79						
	10/25/94	-	21.49	0.00	285.49						
	11/11/94	-	24.55	0.00	282.38						
	11/22/94	-	24.83	0.00	282.11						
	12/07/94	-	19.49	0.00	287.45						
	12/21/94	-	19.27	0.00	287.67						
	01/04/95	-	19.23	0.00	287.71						
	01/23/95	-	15.23	0.00	291.71						
	02/16/95	-	16.30	0.00	290.64						
	02/28/95	-	14.12	0.00	292.82						
	03/10/95	-	12.91	0.00	294.03						
	03/29/95	-	14.07	0.00	292.87						
	04/04/95	-	14.42	0.00	292.52						
	04/27/95	-	15.59	0.00	291.35						
	05/11/95	-	15.26	0.00	291.68						
	05/24/95	-	16.11	0.00	290.83						
	06/15/95	-	16.41	0.00	290.53						
	06/29/95	-	17.12	0.00	289.82						
	07/06/95	-	18.41	0.00	288.53						
	07/25/95	-	18.25	0.00	288.69						
	08/01/95	-	19.87	0.00	287.07						
	08/21/95	-	23.80	0.00	283.14						
	09/14/95	-	27.81	0.00	279.13						
	09/28/95	-	18.70	0.00	288.24						
	10/06/95	-	15.85	0.00	291.09						
	10/25/95	-	14.39	0.00	292.55						
	11/21/95	-	12.66	0.00	294.28						
	12/06/95	-	13.49	0.00	293.45						
	12/21/95	-	13.33	0.00	293.61						
	01/23/96	-	12.64	0.00	294.30						
	02/09/96	-	12.36	0.00	294.58						
	02/19/96	-	12.91	0.00	294.03						
	03/27/96	-	12.94	0.00	294.00						
	04/11/96	-	12.01	0.00	294.93						
	04/24/96	-	12.33	0.00	294.61						
	05/29/96	-	13.30	0.00	293.64						
	06/13/96	-	13.63	0.00	293.31						
	06/28/96	-	13.06	0.00	293.88						
	07/10/96	-	13.88	0.00	293.06						
	07/25/96	-	13.43	0.00	293.51						
	08/08/96	-	13.73	0.00	293.21						
	08/08/96	-	14.23	0.00	292.71						
	09/12/96	-	14.74	0.00	292.20						
	09/26/96	-	13.69	0.00	293.25						
	10/09/96	-	12.30	0.00	294.64						
	10/24/96	-	12.56	0.00	294.38						

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29600.08 Task 3413

WELL # CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)*	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-19	03/30/94	-	12.93	0.00	308.51	-	-	-	0.00	0.00	-
321.44	04/04/94	-	13.28	0.00	308.16	-	-	-	0.00	0.00	-
	04/06/94	-	13.59	0.00	307.85	-	-	-	0.00	0.00	-
	04/07/94	-	13.87	0.00	307.47	-	-	-	0.00	0.00	-
	04/12/94	-	15.24	0.00	306.20	-	-	-	0.00	0.00	-
	04/20/94	-	15.22	0.00	306.22	-	-	-	0.00	0.00	-
	04/27/94	-	15.31	0.00	306.13	-	-	-	0.00	0.00	-
	05/04/94	-	15.27	0.00	306.17	-	-	-	0.00	0.00	-
	05/12/94	-	18.50	0.00	302.94	-	-	-	0.00	0.00	-
	05/16/94	-	19.35	0.00	302.09	-	-	-	0.00	0.00	-
	05/24/94	-	14.35	0.00	307.09	-	-	-	0.00	0.00	-
	05/27/94	-	22.33	0.00	299.11	-	-	-	0.00	0.00	-
	06/03/94	-	25.46	0.00	295.98	-	-	-	0.00	0.00	-
	06/15/94	31.66	31.74	0.07	289.77	-	-	-	0.00	0.00	-
	06/16/94	32.23	32.30	0.07	289.20	-	-	-	0.00	0.00	-
	06/21/94	33.32	33.42	0.10	288.11	-	-	-	0.00	0.00	-
	07/01/94	33.33	33.43	0.10	288.10	-	-	-	0.00	0.00	-
	07/13/94	-	29.30	0.00	292.14	-	-	-	0.00	0.00	-
	08/05/94	-	28.13	0.00	293.31	-	-	-	0.00	0.00	-
	08/17/94	-	29.78	0.00	291.66	-	-	-	0.00	0.00	-
	08/30/94	-	24.02	0.00	297.42	-	-	-	0.00	0.00	-
	09/08/94	-	25.97	0.00	295.47	-	-	-	0.00	0.00	-
	09/14/94	-	29.87	0.00	291.57	-	-	-	0.00	0.00	-
	09/19/94	-	21.18	0.00	300.26	-	-	-	0.00	0.00	-
	10/17/94	-	33.37	0.00	288.07	-	-	-	0.00	0.00	-
	10/25/94	-	33.35	0.00	288.09	-	-	-	0.00	0.00	-
	11/11/94	-	33.34	0.00	288.10	-	-	-	0.00	0.00	-
	11/22/94	-	33.31	0.00	288.13	-	-	-	0.00	0.00	-
	12/07/94	33.26	33.28	0.00	288.18	-	-	-	0.00	0.00	-
	12/21/94	-	33.29	0.00	288.15	-	-	-	0.00	0.00	-
	01/04/95	-	33.27	0.00	288.17	-	-	-	0.00	0.00	-
	01/16/95	-	32.11	0.00	289.33	-	-	-	0.00	0.00	-
	01/23/95	-	26.21	0.00	295.23	-	-	-	0.00	0.00	-
	02/16/95	-	26.73	0.00	294.71	-	-	-	0.00	0.00	-
	02/28/95	-	23.80	0.00	297.64	-	-	-	0.00	0.00	-
	03/10/95	-	18.67	0.00	302.77	-	-	-	0.00	0.00	-
	03/29/95	-	17.87	0.00	303.57	-	-	-	0.00	0.00	-
	04/04/95	-	18.81	0.00	302.63	-	-	-	0.00	0.00	-
	04/27/95	-	22.71	0.00	298.73	-	-	-	0.00	0.00	-
	05/11/95	-	23.23	0.00	298.21	-	-	-	0.00	0.00	-
	05/24/95	-	24.78	0.00	296.66	-	-	-	0.00	0.00	-
	06/15/95	-	28.10	0.00	293.34	-	-	-	0.00	0.00	-
	06/29/95	-	32.55	0.00	288.89	-	-	-	0.00	0.00	-
	07/06/95	-	23.28	0.00	298.16	-	-	-	0.00	0.00	-
	07/25/95	-	32.45	0.00	288.99	-	-	-	0.00	0.00	-
	08/01/95	-	33.28	0.00	288.16	-	-	-	0.00	0.00	-
	08/21/95	-	33.28	0.00	288.16	-	-	-	0.00	0.00	-
	09/14/95	Could Not Gauge		0.00		-	-	-	0.00	0.00	-
	09/28/95	-	32.53	0.00	289.91	-	-	-	0.00	0.00	-
	10/06/95	-	26.15	0.00	295.29	-	-	-	0.00	0.00	-
	10/25/95	-	18.92	0.00	302.52	-	-	-	0.00	0.00	-
	11/21/95	-	14.58	0.00	306.86	-	-	-	0.00	0.00	-
	12/08/95	-	15.96	0.00	305.48	-	-	-	0.00	0.00	-
	12/21/95	-	16.01	0.00	305.43	-	-	-	0.00	0.00	-
	01/23/96	-	13.14	0.00	308.30	-	-	-	0.00	0.00	-
	02/09/96	-	13.12	0.00	308.32	-	-	-	0.00	0.00	-
	02/19/96	-	14.46	0.00	306.98	-	-	-	0.00	0.00	-
	03/27/96	-	14.38	0.00	307.06	-	-	-	0.00	0.00	-
	04/11/96	-	12.38	0.00	309.06	-	-	-	0.00	0.00	-
	04/24/96	-	12.33	0.00	309.11	-	-	-	0.00	0.00	-
	05/29/96	-	15.78	0.00	305.65	-	-	-	0.00	0.00	-
	06/13/96	-	17.97	0.00	303.47	-	-	-	0.00	0.00	-
	06/28/96	-	17.26	0.00	304.18	-	-	-	0.00	0.00	-
	07/10/96	-	17.55	0.00	303.89	-	-	-	0.00	0.00	-
	07/25/96	-	16.56	0.00	304.85	-	-	-	0.00	0.00	-
	08/08/96	-	17.47	0.00	303.87	-	-	-	0.00	0.00	
	08/30/96	-	18.91	0.00	302.53	-	-	-	0.00	0.00	
	09/12/96	-	20.69	0.00	300.75	-	-	-	0.00	0.00	
	09/26/96	-	18.11	0.00	303.33	-	-	-	0.00	0.00	
	10/09/96	-	16.75	0.00	304.69	-	-	-	0.00	0.00	
	10/24/96	-	14.21	0.00	307.23	-	-	-	0.00	0.00	

Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 29680.09 Task 3613

WELL # CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FT)#	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV. (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-20	03/30/94	-	23.18	0.00	301.38						
324.55	04/04/94	-	22.98	0.00	301.57						
	04/12/94	-	25.41	0.00	299.14						
	04/20/94	-	25.90	0.00	298.65						
	05/12/94	-	27.88	0.00	296.67						
	05/24/94	-	29.45	0.00	295.10						
	06/03/94	30.94	30.94	0.00	293.61						
	07/01/94	34.29	34.84	0.55	290.18						
	07/13/94	35.29	35.31	0.02	289.28				0.10	0.10	
	08/05/94	-	32.04	0.00	292.51				0.00	0.10	
	08/17/94	-	31.52	0.00	293.03				0.00	0.10	
	08/30/94	-	29.45	0.00	295.10				0.00	0.10	
	09/08/94	-	30.25	0.00	294.30				0.00	0.10	
	09/19/94	-	31.60	0.00	292.95				0.00	0.10	
	09/30/94	-	31.99	0.00	292.56				0.00	0.10	
	10/17/94	33.30	33.55	0.25	291.22				0.00	0.10	
	10/25/94	35.09	35.13	0.04	289.45				0.25	0.35	
	11/11/94	35.57	35.77	0.20	288.95				0.00	0.35	
	11/22/94	35.90	36.15	0.25	288.62				0.00	0.35	
	12/07/94	36.00	36.29	0.29	288.51				0.00	0.35	
	12/21/94	34.60	34.64	0.04	289.94				0.00	0.35	
	01/04/95	-	33.31	0.00	291.24				0.00	0.35	
	01/23/95	-	31.18	0.00	293.37				0.00	0.35	
	02/16/95	-	31.10	0.00	293.45				0.00	0.35	
	02/28/95	-	30.08	0.00	294.47				0.00	0.35	
	03/10/95	-	28.41	0.00	296.14				0.00	0.35	
	03/29/95	-	27.65	0.00	296.90				0.00	0.35	
	04/04/95	-	28.80	0.00	295.75				0.00	0.35	
	04/27/95	30.73	30.74	0.00	293.82				0.00	0.35	
	05/11/95	-	30.27	0.00	294.28				0.00	0.35	
	05/24/95	-	30.27	0.00	294.28				0.00	0.35	
	06/15/95	-	31.67	0.00	292.88				0.00	0.35	
	06/29/95	32.55	33.54	0.99	291.87				0.00	0.35	
	07/06/95	33.09	33.54	0.45	291.40				0.00	0.35	
	07/25/95	35.05	35.29	0.24	289.47				0.00	0.35	
	08/01/95	34.81	34.97	0.16	289.72				0.00	0.35	
	08/21/95	35.08	35.39	0.31	289.43				0.00	0.35	
	09/14/95	36.00	36.37	0.37	288.50				0.00	0.35	
	09/26/95	36.13	36.50	0.37	288.37				0.00	0.35	
	10/06/95	36.00	36.27	0.27	288.51				0.00	0.35	
	10/25/95	-	28.77	0.00	295.78				0.00	0.35	
	11/21/95	-	24.37	0.00	300.18				0.00	0.35	
	12/08/95	-	27.03	0.00	297.52				0.00	0.35	
	12/21/95	-	27.31	0.00	297.24				0.00	0.35	
	01/23/96	-	24.72	0.00	299.83				0.00	0.35	
	02/09/96	-	23.25	0.00	301.30						
	02/19/96	-	28.08	0.00	296.47						
	03/27/96	-	25.74	0.00	298.81						
	04/11/96	-	24.15	0.00	300.40						
	04/24/96	-	23.77	0.00	300.78						
	05/29/96	-	26.66	0.00	297.89						
	06/13/96	-	28.19	0.00	296.36						
	06/28/96	-	27.67	0.00	296.88						
	07/10/96	-	27.79	0.00	296.76						
	07/25/96	-	26.26	0.00	298.29						
	08/08/96	-	27.37	0.00	297.18						
	08/30/96	-	28.36	0.00	296.19						
	09/12/96	-	29.62	0.00	294.93						
	09/26/96	-	27.57	0.00	296.98						
	10/08/96	-	27.03	0.00	297.52						
	10/24/96	-	24.03	0.00	300.52						

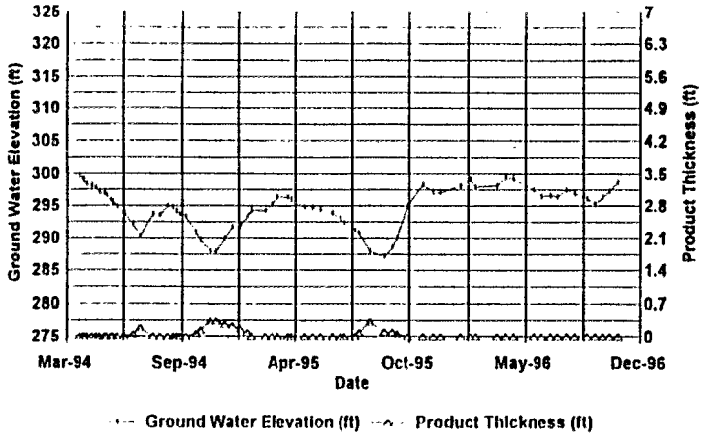
Appendix A
Willow Grove NAS - Pilot Product Recovery System Monitoring - Project No. 28600.00 Task 3613

WELL #/ CSG. ELEV.	GAUGE DATE	DEPTH TO LNAPL (FT)	DEPTH TO WATER (FT)	LNAPL THICK-NESS (FT)	CORR. WATER ELEV. (FTMSL)	TANK DEPTH TO LNAPL (FT)	TANK DEPTH TO WATER (FT)	TANK LNAPL THICKNESS (FT)	LNAPL RECOV (GAL)	CUMM. LNAPL RECOV. (GAL)	FLOW METER READING (GAL)
NFFW-21	03/30/94	-	12.11	0.00	305.25						
317.36	04/04/94	-	12.11	0.00	305.25						
	04/12/94	-	13.32	0.00	304.04						
	04/20/94	-	18.94	0.00	298.42						
	05/12/94	-	22.96	0.00	294.40						
	05/24/94	-	25.55	0.00	291.81						
	06/03/94	-	28.56	0.00	288.80						
	07/01/94	-	36.47	0.00	280.89						
	07/13/94	-	36.51	0.00	280.85						
	08/05/94	-	32.54	0.00	284.82						
	08/17/94	-	32.78	0.00	284.58						
	08/30/94	-	30.15	0.00	287.21						
	09/08/94	29.27	29.28	0.01	288.09						
	09/19/94	-	32.95	0.00	284.41						
	09/30/94	-	33.39	0.00	283.97						
	10/17/94	-	36.47	0.00	280.89						
	10/25/94	-	36.50	0.00	280.86						
	11/11/94	-	36.51	0.00	280.85						
	11/22/94	-	36.51	0.00	280.85						
	12/07/94	36.48	36.48	0.00	280.88						
	12/21/94	-	36.48	0.00	280.88						
	01/04/95	-	36.48	0.00	280.88						
	01/23/95	-	28.31	0.00	288.05						
	02/16/95	-	28.49	0.00	288.87						
	02/28/95	-	25.38	0.00	291.98						
	03/10/95	-	21.55	0.00	295.81						
	03/29/95	-	21.07	0.00	296.29						
	04/04/95	-	22.07	0.00	295.29						
	04/27/95	-	25.12	0.00	292.24						
	05/11/95	-	25.47	0.00	291.89						
	05/24/95	-	26.82	0.00	290.54						
	06/15/95	-	29.08	0.00	288.28						
	06/28/95	-	32.33	0.00	285.03						
	07/06/95	-	33.03	0.00	284.33						
	07/25/95	-	34.18	0.00	283.18						
	08/01/95	-	34.70	0.00	282.66						
	08/21/95	-	36.45	0.00	280.91						
	09/14/95	-	36.48	0.00	280.88						
	09/28/95	-	36.49	0.00	280.87						
	10/06/95	-	32.65	0.00	284.71						
	10/25/95	-	22.82	0.00	294.54						
	11/21/95	-	16.64	0.00	300.72						
	12/06/95	-	19.29	0.00	298.07						
	12/21/95	-	19.70	0.00	297.66						
	01/23/96	-	14.89	0.00	302.47						
	02/06/96	-	15.58	0.00	301.78						
	02/16/96	-	17.61	0.00	299.75						
	03/27/96	-	17.90	0.00	299.46						
	04/11/96	-	14.87	0.00	302.49						
	04/24/96	-	15.73	0.00	301.63						
	05/29/96	-	19.57	0.00	297.79						
	06/13/96	-	22.18	0.00	295.18						
	06/28/96	-	20.58	0.00	296.78						
	07/10/96	-	20.91	0.00	296.45						
	07/25/96	-	19.69	0.00	297.67						
	08/08/96	-	20.80	0.00	296.56						
	08/30/96	-	22.21	0.00	295.15						
	09/12/96	-	23.18	0.00	294.18						
	09/26/96	-	21.50	0.00	295.86						
	10/09/96	-	20.05	0.00	297.31						
	10/24/96	-	16.00	0.00	301.36						

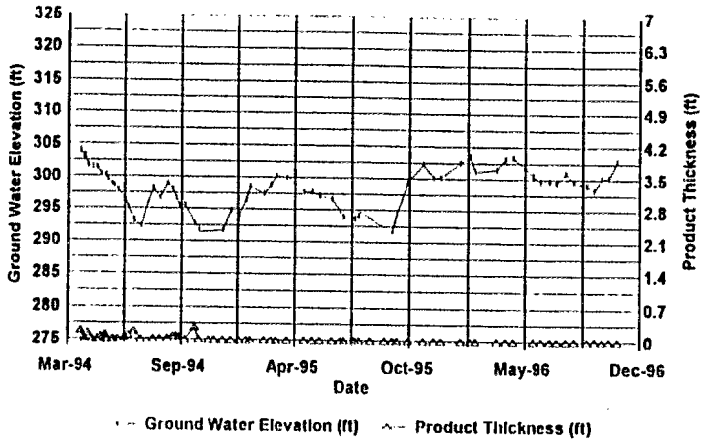
APPENDIX B

GRAPHS OF GROUND WATER ELEVATION AND PRODUCT THICKNESS FOR SELECTED WELLS

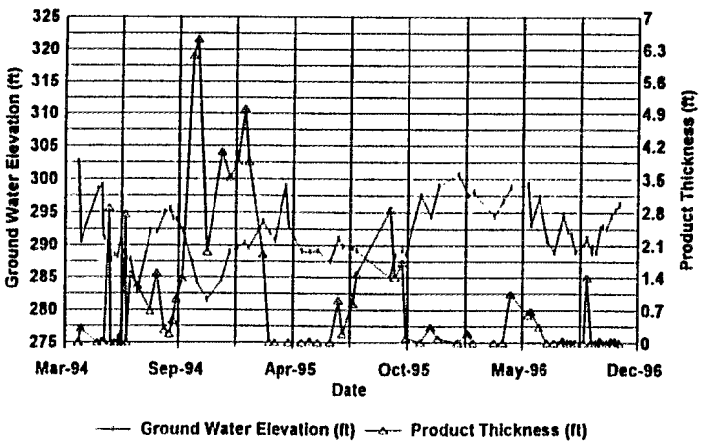
Ground Water Elev and Product Thickness
Well NFFW-1 NAS Willow Grove



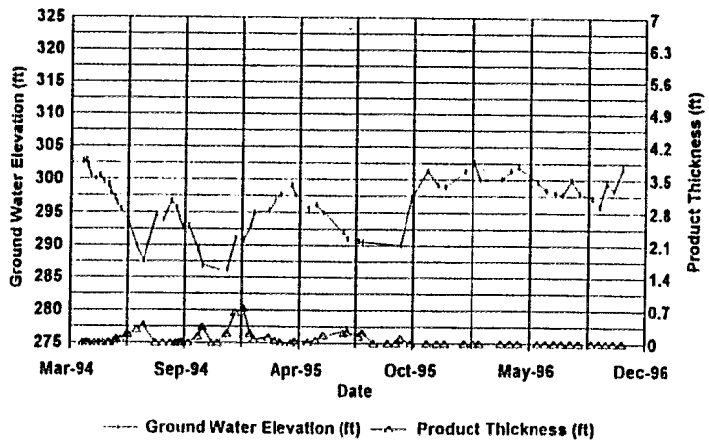
Ground Water Elev and Product Thickness
Well NFFW-6 NAS Willow Grove

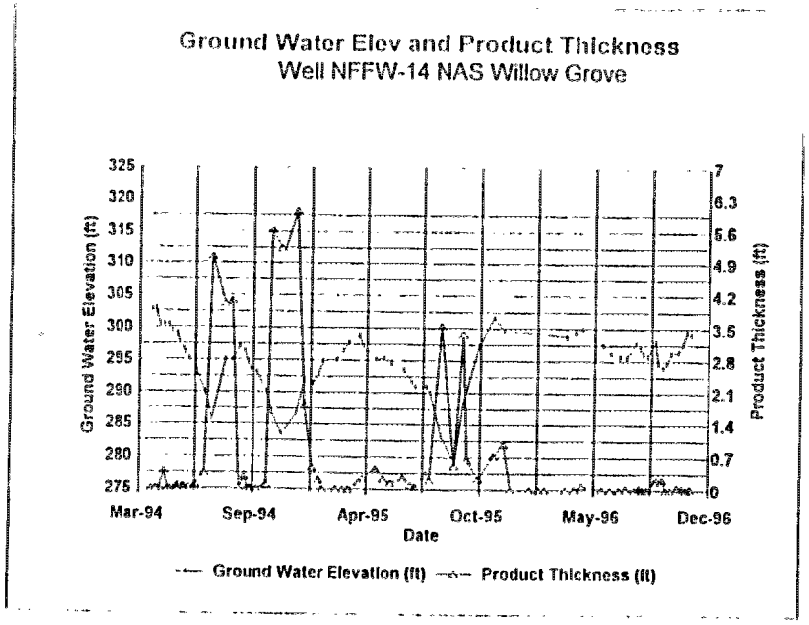


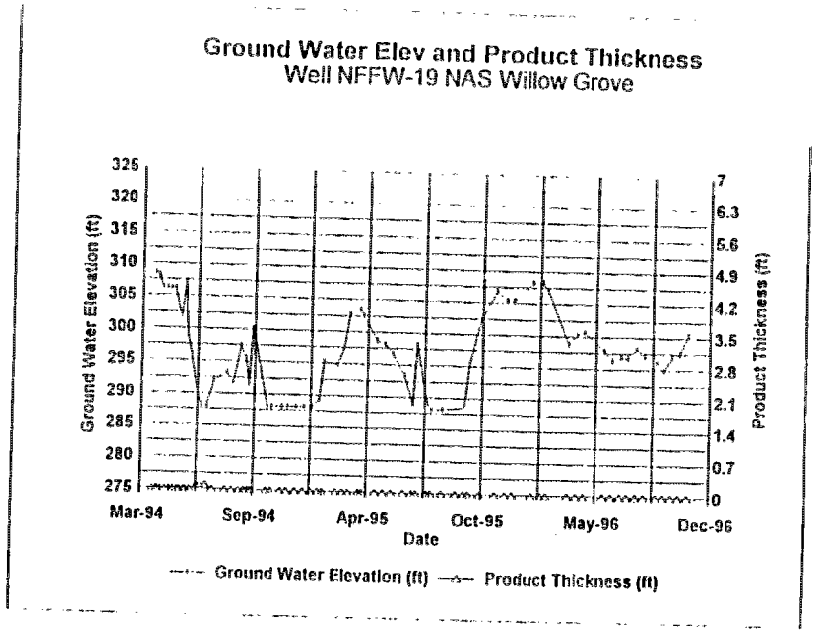
Ground Water Elev and Product Thickness
Well NFFW-2R NAS Willow Grove

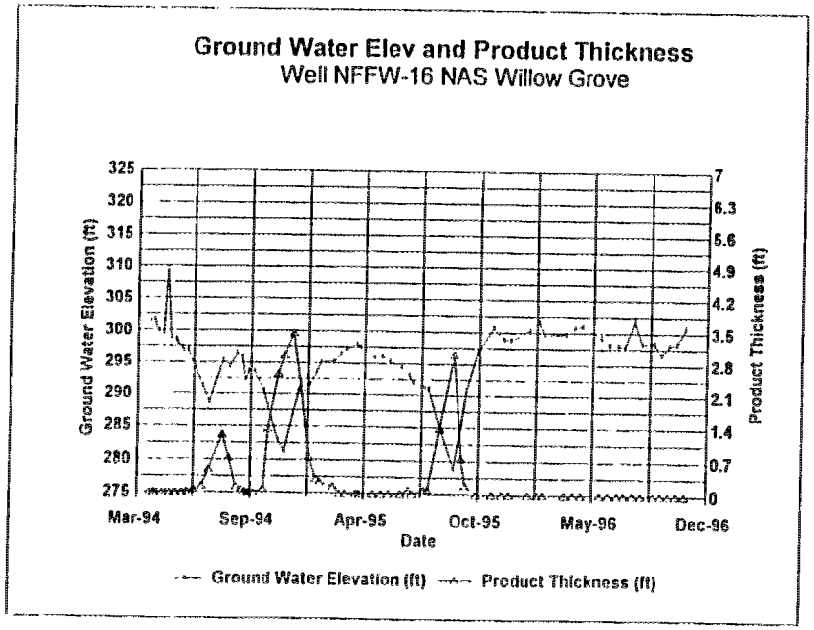


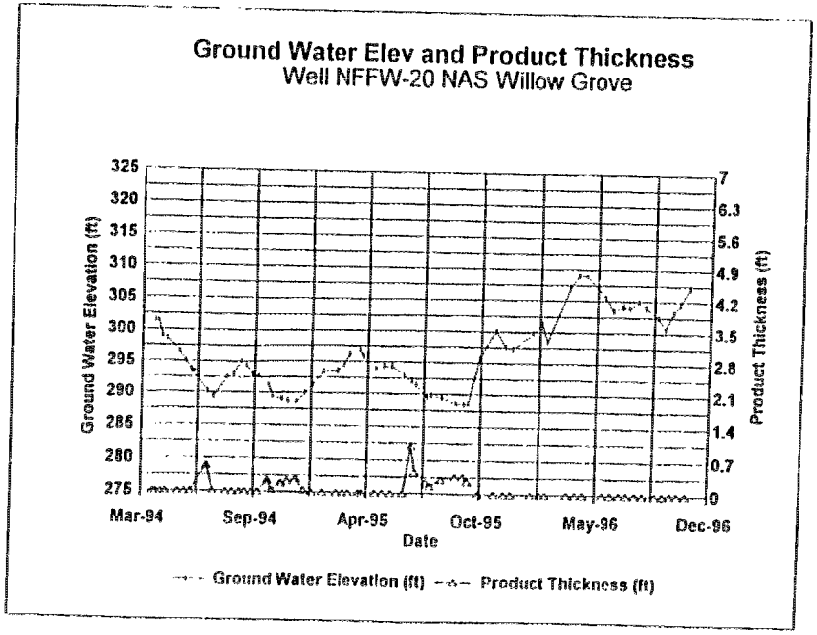
Ground Water Elev and Product Thickness
Well NFFW-7 NAS Willow Grove




Ground Water Elev and Product Thickness
Well NFFW-14 NAS Willow Grove
Ground Water Elevation (ft)
Product Thickness (ft)
325
320
315
310
305
300
295
290
285
280
275
7
6.3
5.6
4.9
4.2
3.5
2.8
2.1
1.4
0.7
0
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96
Date
Ground Water Elevation (ft)
Product Thickness (ft)


Ground Water Elev and Product Thickness
Well NFFW-19 NAS Willow Grove
Ground Water Elevation (ft)
Product Thickness (ft)
325
320
315
310
305
300
295
290
285
280
275
7
6.3
5.6
4.9
4.2
3.5
2.8
2.1
1.4
0.7
0
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96
Date
Ground Water Elevation (ft)
Product Thickness (ft)


Ground Water Elev and Product Thickness
Well NFFW-16 NAS Willow Grove
Ground Water Elevation (ft)
Product Thickness (ft)
325
320
315
310
305
300
295
290
285
280
275
7
6.3
5.6
4.9
4.2
3.5
2.8
2.1
1.4
0.7
0
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96
Date
Ground Water Elevation (ft)
Product Thickness (ft)


Ground Water Elev and Product Thickness
Well NFFW-20 NAS Willow Grove
Ground Water Elevation (ft)
Product Thickness (ft)
325
320
315
310
305
300
295
290
285
280
275
7
6.3
5.6
4.9
4.2
3.5
2.8
2.1
1.4
0.7
0
Mar-94
Sep-94
Apr-95
Oct-95
May-96
Dec-96
Date
Ground Water Elevation (ft)
Product Thickness (ft)

APPENDIX C

FREE-PRODUCT RECOVERY PILOT SYSTEM LABORATORY REPORTS GROUND WATER

EA Engineering, Science, and Technology

Corporate Headquarters
11019 McCormick Road
Hunt Valley, MD 21031
Telephone: 410-584-7000
Fax: 410-771-1625

12 May 1995

Mr. Carl Reitenbach
EA Engineering, Science and Technology, Inc.
15 Loveton Circle
Sparks, Maryland 21152

Re: NAVY-BRAC - Willow Grove (29600.09)

Dear Mr. Reitenbach:

Enclosed is our report on the analysis of three water samples collected for the NAVY-BRAC - Willow Grove project on 27 April 1995. The invoice is included.

Please contact me if you have any questions or require further information and refer to report 950541. Unless other arrangements are made, we reserve the right to dispose of your samples sixty (60) days from the date of this letter. We will retain the raw data for seven years from this date.

Sincerely,

Mary E. Asper
Laboratory Project Manager

enclosure

LABORATORY DATA REPORT

Prepared for:

NAVY-BRAC - Willow Grove

Prepared by:

EA Laboratories
19 Loveton Circle
Sparks, Maryland 21152

May 1995

Table of Conents
NAVY-BRAC - Willow Grove
EA Laboratories Report 950541

---

1. NARRATIVE

2. CHAIN OF CUSTODY

3. ORGANIC DATA

   A. BTEX Data
   B. TPH-Gas Data

1. NARRATIVE

EA Laboratories
ANALYTICAL NARRATIVE

Client: **NAVY-BRAC**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Mary E. Asper**
EA Laboratories Report:**950541**
Date: **12 May 1995**

This report contains the results of the analysis of three water samples collected on 27 April 1995 in support of the referenced project.

SAMPLE RECEIPT

The samples arrived by Federal Express at EA Laboratories on 28 April 1995. Upon receipt, the samples were inspected and compared with the chain-of-custody record. The samples were then logged into the laboratory computer system with assigned laboratory accession numbers and released for analysis.

Client Sample Designation	EA Lab Number
BEFORE	9505690
BETWEEN	9505691
AFTER	9505692

Following this narrative section are a glossary of data qualifiers used in this report (Table 1) and the original chain-of-custody record. Analytical results and quality control information are summarized in the appended data package which has been formatted to be consistent with the deliverable requirements of this project.

QUALITY CONTROL

The following sections are ordered as the data appears in this report. They contain observations made during sample analysis, summarize the results of quality control measurements, and address the impact on data usability based upon project Data Quality Objectives. For each fractional analysis the narrative includes:

- Sample chronology: This section summarizes the sample history by fraction including the sample preparation method and date, analytical method, and analysis date. Anything unusual about the samples, digestates, or extracts is identified. Holding time compliance is evaluated in this section.

EA Laboratories
ANALYTICAL NARRATIVE

Client: NAVY-BRAC
Site: Willow Grove
Project number: 29600.09

Laboratory Project Manager: Mary E. Asper
EA Laboratories Report:950541
Date: 12 May 1995

- Laboratory method performance: All quality control criteria for method performance must be met for all target analytes for data to be reported. These criteria generally apply to instrument tune, calibration, method blanks, and Laboratory Control Samples (LCS). In some instances where method criteria fail, useable data can be obtained and are reported with client approval. The narrative will then include a thorough discussion of the impact on data quality.

- Sample performance: Quality control field samples are analyzed to determine any measurement bias due to the sample matrix based on evaluation of matrix spikes (MS), matrix spike duplicates (MSD), and laboratory duplicates (D). If acceptance criteria are not met, matrix interferences are confirmed either by reanalysis or by inspection of the LCS results to verify that laboratory method performance is in control. Data are reported with appropriate qualifiers or discussion.

AROMATIC VOLATILES BY GC - WATER (EA9505690 - EA9505692)

Sample Chronology: Three samples were analyzed on 10 May 1995 for benzene, toluene, ethylbenzene, xylenes and naphthalene by USEPA SW-846, Methods 5030/8020. All specified holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

VOLATILE TOTAL PETROLEUM HYDROCARBONS (VTPH) - WATER (EA9505690 - EA9505692)

Sample Chronology: Three samples were analyzed on 9 May 1995 for JP-4 fuel by USEPA SW-846, Methods 5030/8015-modified. All specified holding times were met.

Sample BEFORE required a 2X dilution in order to achieve concentrations of target analytes within linear calibration range.

EA Laboratories
ANALYTICAL NARRATIVE

Client: NAVY-BRAC
Site: Willow Grove
Project number: 29600.09

Laboratory Project Manager: Mary E. Asper
EA Laboratories Report:950541
Date: 12 May 1995

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

CERTIFICATION OF RESULTS

The Laboratory certifies that this report meets the project requirements for analytical data as stated in the Analytical Task Order (ATO) and the chain-of-custody. In addition, the Laboratory certifies that the data as reported meet the Data Quality Objectives for precision, accuracy, and completeness specified for this project or as stated in EA Laboratories Quality Assurance program for other than the conditions detailed above. Release of the data contained in this report has been authorized by the appropriate Laboratory Manager as verified by the following signature.

Walter E. Miller 12 May 1995
Walter E. Miller, Organics Division Manager

TABLE 1. ORGANIC ANALYSIS DATA QUALIFIERS

ND or U Indicates a compound on the target compound list (TCL) was analyzed for but not detected. The sample quantitation limit must be corrected for dilution and, if a soil sample, for percent moisture. For example, 10 U is used for phenol in water if the sample final volume is the protocol-specified final volume. If a 1-to-10 dilution of the extract was necessary, the reported limit is (10 x 10 U) or 100 U. For a soil sample, the value is also adjusted for percent moisture. For example, if the sample had 24% moisture and a 1-to-10 dilution factor, the soil sample quantitation limit for phenol (330 U) would be corrected as follows:

Reported limit = (330 U) x df / D

where: df = dilution factor = 10
D = (100 - % moisture) / 100 (At 24% moisture, D = (100-24) / 100 = 0.76)

Reported limit = (330 U) x 10 / 0.76 = 4300 U (rounded to two significant figures)

For soil samples subjected to gel permeation chromatography (GPC) cleanup procedures, the contract required quantitation limit (CRQL) is also multiplied by 2 to account for the fact that only half of the extract is recovered. Note: If GPC procedures are employed, the factor of 2 is not included in the dilution factor reported; a "Y" is entered for GPC (Y/N).

TR or J Indicates an estimated value. This flag is used under the following circumstances: 1) when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed, 2) when the mass spectral and retention time data indicate the presence of a compound that meets the volatile and semivolatile GC/MS identification criteria, and the result is less than the CRQL but greater than zero, 3) when the retention time data indicate the presence of a compound that meets the pesticide/Aroclor identification criteria and the result is less than the CRQL but greater than zero. Note: the "J" code is not used and the compound is not reported as being identified for pesticide/Aroclor results less than the CRQL, if the technical judgement of the pesticide residue analysis expert determines that the peaks used for compound identification resulted from instrument noise or other interferences (column bleed, solvent contamination, etc.). For example, if the sample quantitation limit is 10 ug/L but a concentration of 3 ug/L is calculated, report it as 3 J. The sample quantitation limit must be adjusted for dilution as discussed for the U flag

C This flag applies to pesticide results where the identification has been confirmed by GC/MS. Single component pesticides with concentration equal to or greater than 10 ng/uL in the final extract must be confirmed by GC/MS.

B This flag is used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. This flag is used for a TIC as well as for a positively identified TCL compound.

E This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis. This flag does not apply to pesticides/PCBs analyzed by GC/EC methods. If one or more compounds have a response greater that full scale, the sample or extract must be diluted and reanalyzed according to the specifications listed in the SOW. All such compounds with a response greater than full scale should have a concentration flagged with an "E" on Form I for the original analysis. If the dilution of the extract causes any compounds identified in the first analysis to be below the calibration range in the second analysis, then the results of both analyses are reported on separate Forms I. The Form I for the diluted sample will have the "DL" suffix appended to the sample number. NOTE: For total xylenes, where three isomers are quantified as two peaks, the calibration range of each peak is considered separately; e.g., a diluted analysis is not required for total xylenes unless the concentration of either peak separately exceeds 200 ug/L.

D This flag identifies all compounds identified in the analysis at a secondary dilution factor. If a sample or extract is reanalyzed at a higher dilution factor, as in the "E" flag above, the "DL" suffix is appended to the sample number on the Form I for the diluted sample, and all concentration values reported on that Form I are flagged with the "D" flag.

A This flag indicates that a TIC is a suspected aldol-condensation product.

X Other specific flags may be required to properly define the results. If used, they are fully described and such description attached to the Sample Data Summary Package and the Case Narrative. The flags begin by using "X". If more that one flag is required, "Y" and "Z" are used, as needed. For instance, the "X" flag might combine the "A", "B", and "D" flags for some sample.

N Indicates presumptive evidence of a compound. This flag is only used for tentatively identified compounds, where the identification is based on a mass spectral library search. It is applied to all TIC results. For generic characterization of a TIC, such as chlorinated hydrocarbon, the N code is not used.

P This flag is used for GC analyses when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported on Form 1 and flagged with a "P".

2. CHAIN-OF-CUSTODY

Company Name:	Project Manager or Contact:
NAVY BEAC	CARL ROSENBACH Phone: 771-4550
Project No. 99600.09 TASK 3613	Project Name: WILLOWGROVE N.A.S. FUEL FARM
Sample Storage Location: 9C	ATO Number: 5284
Page 1 of 1	Job ID: 950541

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
(410) 771-4920
Fax (410) 771-4407

Report/Deliverables: Report level IE Data Due 5/12/95

Parameters/Method Numbers for Analysis*: BTEX + MTBE (8020); TPH as TPH (8015) 40 gasoline

Date	Time	Water	Soil	Sample Identification 19 Characters	No. of Containers	BTEX + MTBE (8020)	TPH as TPH (8015) 40 gasoline	EA Labs Accession Number	Remarks
4/27/95	1320	X		BEFA01AA	4	X	X	9505690	LPM: MEA
4/27/95	1327	X		BEFA01AA	4	X	X	9505691	NORMAL TURNAROUND
4/27/95	1330	X		AATTIAA	4	X	X	9505692	
									STANDARD EA REPORT
									L6903

Sampled by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Bill Pinella	4/27/95 1730	Bill Pinella	4/27/95 1730	[illegible]	4/28/95 1000
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Airbill Number:	Sample Shipped by: (Circle) Fed Ex Puro. UPS Hand Carried Other:

Cooler Temp: 2 C pH: ☐ Yes ☒ No Comments: VOA'S Custody Seals Intact ☐ Yes ☒ No none

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques.

WHITE - EA Laboratories YELLOW - EA Laboratories PINK - Project Manager *Shaded Areas for Lab Use Only*

3. ORGANIC DATA

A. BTEX Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: 9505690

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B895F

Level: (low/med) LOW Date Received: 04/28/95

% Moisture: not dec. _____ Date Analyzed: 05/10/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	420	
108-88-3	TOLUENE	15	
100-41-4	ETHYLBENZENE	400	
108-38-3/106-42-3	META & PARA XYLENES	420	
95-47-6	ORTHO XYLENE	20	
91-20-3	NAPHTHALENE	260	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9505691

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B891F

Level: (low/med) LOW Date Received: 04/28/95

% Moisture: not dec. _____ Date Analyzed: 05/10/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	8.4	
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9505692

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B890F

Level: (low/med) LOW Date Received: 04/28/95

% Moisture: not dec. _____ Date Analyzed: 05/10/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: VG7B888

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B888F

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 05/10/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

B. TPH-Gas Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: 9505690

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D400

Level: (low/med) LOW Date Received: 04/28/95

% Moisture: not dec. _____ Date Analyzed: 05/09/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 2

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	8900	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract: 29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9505691

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D403

Level: (low/med) LOW Date Received: 04/28/95

% Moisture: not dec. _____ Date Analyzed: 05/09/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9505692

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D402

Level: (low/med) LOW Date Received: 04/28/95

% Moisture: not dec. _____ Date Analyzed: 05/09/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: VD4D399

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D399

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 05/09/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	----------TPH	100	U

EA Laboratories

19 Loveton Circle
Sparks, MD 21152
Telephone: 410-771-4920
Fax: 410-771-4407

23 May 1995

Mr.Carl Reitenbach
EA Engineering, Science and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

Re: Willowgrove N.A.S. - Fuel Farm (29600.09)

Dear Mr. Reitenbach:

Enclosed is our report on the analysis of three water samples collected for the Willowgrove N.A.S. - Fuel Farm project on 11 May 1995. The invoice is included.

Please contact me if you have any questions or require further information and refer to report 950637. Unless other arrangements are made, we reserve the right to dispose of your samples sixty (60) days from the date of this letter. We will retain the raw data for seven years from this date.

Sincerely,

Mary E. Asper
Laboratory Project Manager

enclosure

Final Invoice

Invoice# : L7013
Invoice Date: 24-MAY-95

Carl G Reitenbach, JR
Petroleum Environmental Services - New York
3 Washington Center
Newburgh, NY 12550

FED. ID#: 52-099-1911
Please Remit to:
EA Engineering, Science,
and Technology, Inc.
PO Box 75031
Baltimore, Maryland 21275

Project# : 29600.09 **NAV-BRAC-FUEL FARM AIR SPARGING PIL** Dept#: 5120 Task#: 3613 Report#: 950637
Quotation#: Client PO#:

Catalog#	Description	STD Price	QTY	QkTnAr Prem(%)	Cont Disc(%)	Volume Disc(%)	Adj Price	Total Price
C051	TPH, as Gasoline by GC	$125.75	3		32.50		$84.88	$254.64
C049	BTEX and Naphthalene by GC	$125.75	3		32.50		$84.88	$254.64

			Subtotal	$509.28
	(%)	($)		
Quick Turn-Around Premium:	.00	$0.00	$509.28	
Electronic Data Deliverable Premium:	.00	$0.00	$509.28	
Contract Discount:	.00	$0.00	$509.28	
Volume Discount:	.00	$0.00	$509.28	
			Total Payment Due	**$509.28**

EA#: 9507266-9507268

LABORATORY DATA REPORT

Prepared for:

Willowgrove N.A.S. - Fuel Farm

Prepared by:

EA Laboratories
19 Loveton Circle
Sparks, Maryland 21152

May 1995

TABLE OF CONTENTS

Willowgrove N.A.S. - Fuel Farm
EA Laboratories Report No. 950637

---

1. NARRATIVE

2. CHAIN OF CUSTODY

3. ORGANIC DATA

   A. TPH GRO Data
   B. BTEX and Naphthalene Data

1. NARRATIVE

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng., Sci. and Tech., Inc.**
Site: **Willowgrove N.A.S. - Fuel Farm**
Project number: **29600.09**

EA Laboratories Report: **950637**
Laboratory Project Manager: **Mary E. Asper**
Report Date: **23 May 1995**

This report contains the results of the analysis of three water samples collected on 11 May 1995 in support of the referenced project.

SAMPLE RECEIPT

The samples arrived by hand at EA Laboratories on 12 May 1995. Upon receipt, the samples were inspected and compared with the chain-of-custody record. The samples were then logged into the laboratory computer system with assigned laboratory accession numbers and released for analysis.

Client Sample Designation	EA Lab Number
BEFORE	9507266
BETWEEN	9507267
AFTER	9507268

Following this narrative section are a glossary of data qualifiers used in this report (Table 1) and the original chain-of-custody. Analytical results and quality control information are summarized in the appended data package which has been formatted to be consistent with the deliverable requirements of this project.

QUALITY CONTROL

The following sections are ordered as the data appears in this report. They contain observations made during sample analysis, summarize the results of quality control measurements, and address the impact on data usability based upon project Data Quality Objectives. For each fractional analysis the narrative includes:

- Sample chronology: This section summarizes the sample history by fraction including the sample preparation method and date, analytical method, and analysis date. Anything unusual about the samples, digestates, or extracts is identified. Holding time compliance is evaluated in this section.

- Laboratory method performance: All quality control criteria for method performance must be met for all target analytes for data to be reported. These criteria generally apply to instrument tune, calibration, method blanks, and Laboratory Control Samples (LCS). In some instances where method criteria fail, useable data can be obtained and are reported with client approval. The narrative will then include a thorough discussion of the impact on data quality.

- Sample performance: Quality control field samples are analyzed to determine any measurement

bias due to the sample matrix based on evaluation of matrix spikes (MS), matrix spike duplicates (MSD), and laboratory duplicates (D). If acceptance criteria are not met, matrix interferences are confirmed either by reanalysis or by inspection of the LCS results to verify that laboratory method performance is in control. Data are reported with appropriate qualifiers or discussion.

VOLATILE TOTAL PETROLEUM HYDROCARBONS (VTPH) - WATER (EA9507266 - EA9507268)

Sample Chronology: Three samples were analyzed on 17 May 1995 for JP-4 fuel by USEPA SW-846, Methods 5030/8015-modified. All specified holding times were met.

Sample BEFORE required a 2X dilution in order to achieve concentrations of target analytes within linear calibration range.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

AROMATIC VOLATILES BY GC - WATER (EA9507266 - EA9507268)

Sample Chronology: Three samples were analyzed on 17 and 18 May 1995 for benzene, toluene, ethylbenzene, xylenes and naphthalene by USEPA SW-846, Methods 5030/8020. All specified holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

CERTIFICATION OF RESULTS

The Laboratory certifies that this report meets the project requirements for analytical data as stated in the Analytical Task Order (ATO) and the chain-of-custody. In addition, the Laboratory certifies that the data as reported meet the Data Quality Objectives for precision, accuracy, and completeness specified for this project or as stated in EA Laboratories Quality Assurance program for other than the conditions detailed above

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng., Sci. and Tech., Inc.**
Site: **Willowgrove N.A.S. - Fuel Farm**
Project number: **29600.09**

EA Laboratories Report: **950637**
Laboratory Project Manager: **Mary E. Asper**
Report Date: **23 May 1995**

Release of the data contained in this report has been authorized by the appropriate Laboratory Manager as verified by the following signature.

Walter E. Miller 23 May 1995
Walter E. Miller, Organics Division Manager

TABLE 1. ORGANIC ANALYSIS DATA QUALIFIERS

ND or U Indicates a compound on the target compound list (TCL) was analyzed for but not detected. The sample quantitation limit must be corrected for dilution and, if a soil sample, for percent moisture. For example, 10 U is used for phenol in water if the sample final volume is the protocol-specified final volume. If a 1-to-10 dilution of the extract was necessary, the reported limit is (10 x 10 U) or 100 U. For a soil sample, the value is also adjusted for percent moisture. For example, if the sample had 24% moisture and a 1-to-10 dilution factor, the soil sample quantitation limit for phenol (330 U) would be corrected as follows:

Reported limit = (330 U) x df / D

where: df = dilution factor = 10
D = (100 - % moisture) / 100 (At 24% moisture, D = (100-24) / 100 = 0.76)

Reported limit = (330 U) x 10 / 0.76 = 4300 U (rounded to two significant figures)

For soil samples subjected to gel permeation chromatography (GPC) cleanup procedures, the contract required quantitation limit (CRQL) is also multiplied by 2 to account for the fact that only half of the extract is recovered. Note: If GPC procedures are employed, the factor of 2 is not included in the dilution factor reported; a "Y" is entered for GPC (Y/N).

TR or J Indicates an estimated value. This flag is used under the following circumstances: 1) when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed, 2) when the mass spectral and retention time data indicate the presence of a compound that meets the volatile and semivolatile GC/MS identification criteria, and the result is less than the CRQL but greater than zero, 3) when the retention time data indicate the presence of a compound that meets the pesticide/Aroclor identification criteria and the result is less than the CRQL but greater than zero. Note: the "J" code is not used and the compound is not reported as being identified for pesticide/Aroclor results less than the CRQL, if the technical judgement of the pesticide residue analysis expert determines that the peaks used for compound identification resulted from instrument noise or other interferences (column bleed, solvent contamination, etc.). For example, if the sample quantitation limit is 10 ug/L but a concentration of 3 ug/L is calculated, report it as 3 J. The sample quantitation limit must be adjusted for dilution as discussed for the U flag

C This flag applies to pesticide results where the identification has been confirmed by GC/MS. Single component pesticides with concentration equal to or greater than 10 ng/uL in the final extract must be confirmed by GC/MS.

B This flag is used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. This flag is used for a TIC as well as for a positively identified TCL compound.

E This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis. This flag does not apply to pesticides/PCBs analyzed by GC/EC methods. If one or more compounds have a response greater that full scale, the sample or extract must be diluted and reanalyzed according to the specifications listed in the SOW. All such compounds with a response greater than full scale should have a concentration flagged with an "E" on Form I for the original analysis. If the dilution of the extract causes any compounds identified in the first analysis to be below the calibration range in the second analysis, then the results of both analyses are reported on separate Forms I. The Form I for the diluted sample will have the "DL" suffix appended to the sample number. NOTE: For total xylenes, where three isomers are quantified as two peaks, the calibration range of each peak is considered separately; e.g., a diluted analysis is not required for total xylenes unless the concentration of either peak separately exceeds 200 ug/L.

D This flag identifies all compounds identified in the analysis at a secondary dilution factor. If a sample or extract is reanalyzed at a higher dilution factor, as in the "E" flag above, the "DL" suffix is appended to the sample number on the Form I for the diluted sample, and all concentration values reported on that Form I are flagged with the "D" flag.

A This flag indicates that a TIC is a suspected aldol-condensation product.

X Other specific flags may be required to properly define the results. If used, they are fully described and such description attached to the Sample Data Summary Package and the Case Narrative. The flags begin by using "X". If more that one flag is required, "Y" and "Z" are used, as needed. For instance, the "X" flag might combine the "A", "B", and "D" flags for some sample.

N Indicates presumptive evidence of a compound. This flag is only used for tentatively identified compounds, where the identification is based on a mass spectral library search. It is applied to all TIC results. For generic characterization of a TIC, such as chlorinated hydrocarbon, the N code is not used.

P This flag is used for GC analyses when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported on Form 1 and flagged with a "P".

2. CHAIN OF CUSTODY

Company I.D.: NAVY BRAC

Project Manager or Contact: CARL Rarbourdell

Phone: 771-4950

Project No.: 99600.09 TASK 3613

Project Name: Willowgrove N.A.S. FUEL FARM

Sample Storage Location: GC

ATO Number: 5285

Page 1 of 1 | Job ID: 950 637

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
(410) 771-4920
Fax (410) 771-4407

Report/Deliverables: Report Level: IE
Date Due: 5/26/95

Parameters/Method Numbers for Analysis*: BTEX + NAPH (8020); TPH - AS JP4 (8015); GASOLINE

Date	Time	Water	Soil	Sample Identification 19 Characters	No. of Containers	BTEX + NAPH (8020)	TPH - AS JP4 (8015)	GASOLINE	EA Labs Accession Number	Remarks
5/11/95	1300	X		BEFORE	4	X	X		9507266	LPM: MEA
5/11/95	1305	X		BATTERY	4	X	X		9507267	
5/11/95	1310	X		AFTER	4	X	X		9507268	NORMAL TURNAROUND
										STANDARD EA REPORT
										L7013

Sampled by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[signature]	5/11/95 1310	[signature]	5/11/95 1530	[signature]	5/11/95 1530
Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Date/Time**	**Airbill Number:**	**Sample Shipped by: (Circle)**
[signature]	5/11 1710	Mazouchehr Kavani	5/12/95 8:30		Fed Ex. Puro. UPS Hand Carried Other:

Cooler Temp: 2 C pH: ☐ Yes ☒ No Comments: H2O Custody Seals Intact ☐ Yes ☒ No None

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques.

Shaded Areas for Lab Use Only

WHITE - EA Laboratories YELLOW - EA Laboratories PINK - Project Manager

3. ORGANIC DATA

A. TPH GRO Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: 9507266

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D460

Level: (low/med) LOW Date Received: 05/12/95

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 2

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
----------	TPH	9800	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9507267

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D458

Level: (low/med) LOW Date Received: 05/12/95

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	260	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9507268

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D457

Level: (low/med) LOW Date Received: 05/12/95

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VD4D456

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D456

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	----------TPH	100	U

B. BTEX and Naphthalene Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9507266

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B927F

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	410	
108-88-3	TOLUENE	12	
100-41-4	ETHYLBENZENE	470	
108-38-3/106-42-3	META & PARA XYLENES	610	E
95-47-6	ORTHO XYLENE	30	
91-20-3	NAPHTHALENE	310	

5/22/95

2. CHAIN-OF-CUSTODY

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9507267

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B914F

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	6.2	
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9507268

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B913F

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VG7B912

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7B912F

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 05/17/95

GC Column:RTX502.2 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

EA Laboratories

13 Loveton Circle
Sparks, MD 21152
Telephone: 410-771-4920
Fax: 410-771-4407

28 June 1995

Mr. Carl Reitenbach
EA Engineering, Science and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

Re: Willowgrove N.A.S. - Fuel Farm (29600.09)

Dear Mr. Reitenbach:

Enclosed is our report on the analysis of three water samples collected for the Willowgrove N.A.S. - Fuel Farm project on 15 June 1995. The invoice is included.

Please contact me if you have any questions or require further information and refer to report 950863. Unless other arrangements are made, we reserve the right to dispose of your samples sixty (60) days from the date of this letter. We will retain the raw data for seven years from this date.

Sincerely,

Mary E. Asper
Laboratory Project Manager

enclosure

LABORATORY DATA REPORT

Prepared for:

Willowgrove N.A.S. - Fuel Farm

Prepared by:

EA Laboratories
19 Loveton Circle
Sparks, Maryland 21152

June 1995

TABLE OF CONTENTS

Willowgrove N.A.S. - Fuel Farm
EA Laboratories Report No. 950863

---

1. NARRATIVE

2. CHAIN OF CUSTODY

3. ORGANIC DATA

   A. TPH GRO Data
   B. BTEX and Naphthalene Data

1. NARRATIVE

EA Laboratories
ANALYTICAL NARRATIVE

Client: EA Eng., Sci. and Tech., Inc.
Site: Willowgrove N.A.S. - Fuel Farm
Project number: 29600.09

EA Laboratories Report: 950863
Laboratory Project Manager: Mary E. Asper
Report Date: 28 June 1995

This report contains the results of the analysis of three water samples collected on 15 June 1995 in support of the referenced project.

SAMPLE RECEIPT

The samples arrived by hand at EA Laboratories on 16 June 1995. Upon receipt, the samples were inspected and compared with the chain-of-custody record. The samples were then logged into the laboratory computer system with assigned laboratory accession numbers and released for analysis.

Client Sample Designation	EA Lab Number
BEFORE	9508902
BETWEEN	9508903
AFTER	9508904

Following this narrative section are a glossary of data qualifiers used in this report (Table 1) and the original chain-of-custody. Analytical results and quality control information are summarized in the appended data package which has been formatted to be consistent with the deliverable requirements of this project.

QUALITY CONTROL

The following sections are ordered as the data appears in this report. They contain observations made during sample analysis, summarize the results of quality control measurements, and address the impact on data usability based upon project Data Quality Objectives. For each fractional analysis the narrative includes:

- Sample chronology: This section summarizes the sample history by fraction including the sample preparation method and date, analytical method, and analysis date. Anything unusual about the samples, digestates, or extracts is identified. Holding time compliance is evaluated in this section.

- Laboratory method performance: All quality control criteria for method performance must be met for all target analytes for data to be reported. These criteria generally apply to instrument tune, calibration, method blanks, and Laboratory Control Samples (LCS). In some instances where method criteria fail, useable data can be obtained and are reported with client approval. The narrative will then include a thorough discussion of the impact on data quality.

- Sample performance Quality control field samples are analyzed to determine any measurement

bias due to the sample matrix based on evaluation of matrix spikes (MS), matrix spike duplicates (MSD), and laboratory duplicates (D). If acceptance criteria are not met, matrix interferences are confirmed either by reanalysis or by inspection of the LCS results to verify that laboratory method performance is in control. Data are reported with appropriate qualifiers or discussion.

VOLATILE TOTAL PETROLEUM HYDROCARBONS (VTPH) - WATER (EA9508902 - EA9508904)

Sample Chronology: Three samples were analyzed on 21 May 1995 for JP-4 fuel by USEPA SW-846, Methods 5030/8015-modified. All specified holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

AROMATIC VOLATILES BY GC - WATER (EA9508902 - EA9508904)

Sample Chronology: Three samples were analyzed on 22 June 1995 for benzene, toluene, ethylbenzene, xylenes and naphthalene by USEPA SW-846, Methods 5030/8020. All specified holding times were met.

Sample BEFORE required a 2X dilution in order to achieve concentrations of target analytes within linear calibration range.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

CERTIFICATION OF RESULTS

The Laboratory certifies that this report meets the project requirements for analytical data as stated in the Analytical Task Order (ATO) and the chain-of-custody. In addition, the Laboratory certifies that the data as reported meet the Data Quality Objectives for precision, accuracy, and completeness specified for this project or as stated in EA Laboratories Quality Assurance program for other than the conditions detailed above.

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng., Sci. and Tech., Inc.**
Site: **Willowgrove N.A.S. - Fuel Farm**
Project number: **29600.09**

EA Laboratories Report: **950863**
Laboratory Project Manager: **Mary E. Asper**
Report Date: **28 June 1995**

Release of the data contained in this report has been authorized by the appropriate Laboratory Manager as verified by the following signature.

28 June 1995

Walter E. Miller, Organics Division Manager

2. CHAIN OF CUSTODY

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
(410) 771-4920
Fax (410) 771-4407

Company Name: NAVY BRAC

Project Manager or Contact: CARL RIEW DAFF

Phone:

Project No: 99600.09 TASK 3613

Project Name: Willowgrove N.A.S. Fuel Farm

Sample Storage Location: GC

ATO Number: 5510

Page 1 of 1

Job ID: 950863

Report/Deliverables: Report level IE Date Due 6/30/95

Parameters/Method Numbers for Analysis*: BTEX + NAPH (8020); TPH as JP4 (8015); Aq Gasoline

Date	Time	Water	Soil	Sample Identification 19 Characters	No. of Containers	BTEX + NAPH (8020)	TPH as JP4 (8015) Aq Gasoline	EA Labs Accession Number	Remarks
6/15/95	1215	X		BIEFIORG	4	X	X	9508902	LPM: NLA
6/15/95	1230	X		BIETWGRW	4	X	X	9508903	NORMAL TURNAROUND
6/15/95	1238	X		AATIERA	4	X	X	9508904	
									STANDARD EA REPORT
									L7227

Sampled by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Bill Pannell	6/15/95 1230	Bill Pannell	6/15/95 1530	Brian R. Stumpli	6/15 1721
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Airbill Number:	Sample Shipped by: (Circle)
Brian R. Stumpli	6/15 1630	[illegible]	6/16/95 8:30		Fed Ex Puro UPS Hand Carried Other:

Cooler Temp: 2 C pH: ☐ Yes ☒ No Comments: Custody Seals Intact ☐ Yes ☒ No none

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques.

3. ORGANIC DATA

A. TPH GRO Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9508902

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D658

Level: (low/med) LOW Date Received: 06/15/95

% Moisture: not dec. _____ Date Analyzed: 06/21/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	7400	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9508903

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D657

Level: (low/med) LOW Date Received: 06/15/95

% Moisture: not dec. _____ Date Analyzed: 06/21/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: 9508904

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D656

Level: (low/med) LOW Date Received: 06/15/95

% Moisture: not dec. _____ Date Analyzed: 06/21/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: VD4D654

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4D654

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 06/21/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

B. BTEX and Naphthalene Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: 9508902

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7C129R

Level: (low/med) LOW Date Received: 06/16/95

% Moisture: not dec. _____ Date Analyzed: 06/22/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 2

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	410	
108-88-3	TOLUENE	24	
100-41-4	ETHYLBENZENE	510	
108-38-3/106-42-3	META & PARA XYLENES	470	
95-47-6	ORTHO XYLENE	24	
91-20-3	NAPHTHALENE	290	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9508903

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7C124R

Level: (low/med) LOW Date Received: 06/16/95

% Moisture: not dec. _____ Date Analyzed: 06/22/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water)WATER Lab Sample ID: 9508904

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7C123R

Level: (low/med) LOW Date Received: 06/16/95

% Moisture: not dec. _____ Date Analyzed: 06/22/95

GC Column:RTX1 ID:0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (u)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VG7C119

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7C119R

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 06/22/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

EA Laboratories

19 Loveton Circle
Sparks, MD 21152
Telephone: 410-771-4920
Fax: 410-771-4407

November 13, 1995

Mr. Carl G. Reitenbach, Jr.
EA Engineering, Science and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

Re: Willow Grove (29600.09)

Dear Mr. Reitenbach:

Enclosed is our report on the analysis of three water samples collected for the Willow Grove project on 25 October 1995. The invoice is included.

Please contact me if you have any questions or require further information and refer to report 951698. Unless other arrangements are made, we reserve the right to dispose of your samples sixty (60) days from the date of this letter. We will retain the raw data for seven years from this date.

Sincerely,

Daniel for NKS 11/13/95

Natasha K. Sullivan
Laboratory Project Manager

enclosure

LABORATORY DATA REPORT

Prepared for:

EA Engineering, Science, and Technology, Inc.
Willow Grove

Prepared by:

EA Laboratories
19 Loveton Circle
Sparks, MD 21152

Report 951698

November 1995

TABLE OF CONTENTS
Willow Grove
Report 951698

1. NARRATIVE

2. CHAIN OF CUSTODY

3. ORGANIC DATA

   A. Aromatic Volatiles

   B. TPH Gro Data

1. NARRATIVE

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **951698**
Date: **13 November 1995**

This report contains the results of the analysis of three water samples collected on 25 October 1995 in support of the referenced project.

SAMPLE RECEIPT

The samples arrived intact by Federal Express at EA Laboratories on 26 October 1995. Upon receipt, the samples were inspected and compared with the chain-of-custody record. The samples were then logged into the laboratory computer system with assigned laboratory accession numbers and released for analysis.

Client Sample Designation	EA Lab Number
Before	9515557
Between	9515558
After	9515559

Following this narrative section are data qualifiers (Table 1) and the original chain-of-custody. Analytical results and quality control information are summarized in the appended data package which has been formatted to be consistent with the deliverable requirements of this project.

QUALITY CONTROL

The following sections are ordered as the data appears in this report. They contain observations made during sample analysis, summarize the results of quality control measurements, and address the impact on data usability based upon project Data Quality Objectives. For each fractional analysis the narrative includes:

- Sample chronology: This section summarizes the sample history by fraction including the sample preparation method and date, analytical method, and analysis date. Anything unusual about the samples, digestates, or extracts is identified. Holding time compliance is evaluated in this section.

- Laboratory method performance: All quality control criteria for method performance must be met for all target analytes for data to be reported. These criteria generally apply to instrument tune, calibration, method blanks, and Laboratory Control Samples (LCS). In some instances where method criteria fail, useable data can be obtained and are reported with client approval. The narrative will then include a thorough discussion of the impact on data quality.

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **951698**
Date: **13 November 1995**

- Sample performance: Quality control field samples are analyzed to determine any measurement bias due to the sample matrix based on evaluation of matrix spikes (MS), matrix spike duplicates (MSD), and laboratory duplicates (D). If acceptance criteria are not met, matrix interferences are confirmed either by reanalysis or by inspection of the LCS results to verify that laboratory method performance is in control. Data are reported with appropriate qualifiers or discussion.

AROMATIC VOLATILES BY GC - WATER (EA9515557-EA9515559)

Sample Chronology: The samples were analyzed for BTEX plus naphthalene on 31 October 1995 and 01 November 1995 by USEPA SW-846, Methods 5030/8020. All specified holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

VOLATILE TOTAL PETROLEUM HYDROCARBONS (VTPH) - WATER (EA9515557 - EA9515559)

Sample Chronology: Three samples were analyzed on 27 October 1995 for gasoline range organics by USEPA SW-846 methods 5030/8015-modified. All specified holding times were met.

Sample BEFORE was diluted 10X prior to analysis in order to bring the response for the gasoline range organics within the linear range of the calibration curve.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported sample.

Sample Performance: All quality control criteria were met for the reported sample.

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **951698**
Date: **13 November 1995**

CERTIFICATION OF RESULTS

The Laboratory certifies that this report meets the project requirements for analytical data as stated in the Analytical Task Order (ATO) and the chain-of-custody. In addition, the Laboratory certifies that the data as reported meet the Data Quality Objectives for precision, accuracy, and completeness specified for this project or as stated in EA Laboratories Quality Assurance program for other than the conditions detailed above. Release of the data contained in this report has been authorized by the appropriate Laboratory Manager as verified by the following signature.

_____ 13 November 1995
Walter E. Miller, Organics Division Manager

TABLE 1. ORGANIC ANALYSIS DATA QUALIFIERS

ND or U Indicates a compound on the target compound list (TCL) was analyzed for but not detected. The sample quantitation limit must be corrected for dilution and, if a soil sample, for percent moisture. For example, 10 U is used for phenol in water if the sample final volume is the protocol-specified final volume. If a 1-to-10 dilution of the extract was necessary, the reported limit is (10 x 10 U) or 100 U. For a soil sample, the value is also adjusted for percent moisture. For example, if the sample had 24% moisture and a 1-to-10 dilution factor, the soil sample quantitation limit for phenol (330 U) would be corrected as follows:

Reported limit = (330 U) x df / D

where: df = dilution factor = 10

D = (100 - % moisture) / 100 (At 24% moisture, D = (100-24) / 100 = 0.76)

Reported limit = (330 U) x 10 / 0.76 = 4300 U (rounded to two significant figures)

For soil samples subjected to gel permeation chromatography (GPC) cleanup procedures, the contract required quantitation limit (CRQL) is also multiplied by 2 to account for the fact that only half of the extract is recovered. Note: If GPC procedures are employed, the factor of 2 is not included in the dilution factor reported; a "Y" is entered for GPC (Y/N).

TR or J Indicates an estimated value. This flag is used under the following circumstances: 1) when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed, 2) when the mass spectral and retention time data indicate the presence of a compound that meets the volatile and semivolatile GC/MS identification criteria, and the result is less than the CRQL but greater than zero, 3) when the retention time data indicate the presence of a compound that meets the pesticide/Aroclor identification criteria and the result is less than the CRQL but greater than zero. Note: the "J" code is not used and the compound is not reported as being identified for pesticide/Aroclor results less than the CRQL, if the technical judgement of the pesticide residue analysis expert determines that the peaks used for compound identification resulted from instrument noise or other interferences (column bleed, solvent contamination, etc.). For example, if the sample quantitation limit is 10 ug/L but a concentration of 3 ug/L is calculated, report it as 3 J. The sample quantitation limit must be adjusted for dilution as discussed for the U flag

C This flag applies to pesticide results where the identification has been confirmed by GC/MS. Single component pesticides with concentration equal to or greater than 10 ng/uL in the final extract must be confirmed by GC/MS.

B This flag is used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. This flag is used for a TIC as well as for a positively identified TCL compound.

E This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis. This flag does not apply to pesticides/PCBs analyzed by GC/EC methods. If one or more compounds have a response greater that full scale, the sample or extract must be diluted and reanalyzed according to the specifications listed in the SOW. All such compounds with a response greater than full scale should have a concentration flagged with an "E" on Form I for the original analysis. If the dilution of the extract causes any compounds identified in the first analysis to be below the calibration range in the second analysis, then the results of both analyses are reported on separate Forms I. The Form I for the diluted sample will have the "DL" suffix appended to the sample number. NOTE: For total xylenes, where three isomers are quantified as two peaks, the calibration range of each peak is considered separately; e.g., a diluted analysis is not required for total xylenes unless the concentration of either peak separately exceeds 200 ug/L.

D This flag identifies all compounds identified in the analysis at a secondary dilution factor. If a sample or extract is reanalyzed at a higher dilution factor, as in the "E" flag above, the "DL" suffix is appended to the sample number on the Form I for the diluted sample, and all concentration values reported on that Form I are flagged with the "D" flag.

A This flag indicates that a TIC is a suspected aldol-condensation product.

X Other specific flags may be required to properly define the results. If used, they are fully described and such description attached to the Sample Data Summary Package and the Case Narrative. The flags begin by using "X". If more that one flag is required, "Y" and "Z" are used, as needed. For instance, the "X" flag might combine the "A", "B", and "D" flags for some sample.

N Indicates presumptive evidence of a compound. This flag is only used for tentatively identified compounds, where the identification is based on a mass spectral library search. It is applied to all TIC results. For generic characterization of a TIC, such as chlorinated hydrocarbon, the N code is not used.

P This flag is used for GC analyses when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported on Form 1 and flagged with a "P".

2. CHAIN-OF-CUSTODY

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
Telephone: (410) 771-4920
Fax: (410) 771-4407

Company Name: Bay Brac

Project Manager or Contact: Carl Rebinsky

Phone:

Project No. 89600.09

Project Name: Willow Grove NAS

Dept.: 6125 Task: 3613

Sample Storage Location: GC

ATO Number: 6167

Page 1 of 1

Report #: 951698

Report Deliverables: 1 2 3 4 D E

EDD: Yes No

DUE TO CLIENT: 11/16/95

Parameters/Method Numbers for Analysis: BTEX + NAPTH, TPH as Gasoline (8015), JP4

Date	Time	Water	Soil	Sample Identification 19 Characters	No. of Containers	BTEX + NAPTH	TPH as Gasoline (8015)	JP4	EA Labs Accession Number	Remarks
10/25	1536	X		BG1GARF1	3	✓	✓		9515557	LPM:
10/25	1533	X		DIGTIGGERM	3	✓	✓		9515558	
10/25	1530	X		ARTICT	3	✓	✓		9515559	Normal Turnaround
										Standard EA Rates
										L8100

Samples by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[signature]	10/27 1530	[signature]	10/25 1730	[signature]	10/26/95 1000

Relinquished by: (Signature)	Date/Time	Received by Laboratory: (Signature)	Date/Time	Airbill Number:	Sample Shipped by: (Circle)
					Fed Ex Puro. UPS Hand Carried Other:

Cooler Temp. 2 C pH: Yes No Comments: Custody Seals Intact Yes No

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques.

WHITE—EA Laboratories YELLOW—EA Laboratories PINK—Project Manager

3. ORGANIC DATA

A. Aromatic Volatiles Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract: 29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9515557

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VF6H251R

Level: (low/med) LOW Date Received: 10/26/95

% Moisture: not dec. _____ Date Analyzed: 11/01/95

GC Column: DB-624 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	260	
108-88-3	TOLUENE	10	
100-41-4	ETHYLBENZENE	450	
108-38-3/106-42-3	META & PARA XYLENES	460	
95-47-6	ORTHO XYLENE	19	
91-20-3	NAPHTHALENE	310	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9515558

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VF6H249R

Level: (low/med) LOW Date Received: 10/26/95

% Moisture: not dec. _____ Date Analyzed: 11/01/95

GC Column: DB-624 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	2.0	
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:29600.09

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9515559

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VF6H248R

Level: (low/med) LOW Date Received: 10/26/95

% Moisture: not dec. _____ Date Analyzed: 11/01/95

GC Column: DB-624 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

B. TPH Gro Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9515557

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4E566

Level: (low/med) LOW Date Received: 10/26/95

% Moisture: not dec. _____ Date Analyzed: 10/27/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 10

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	13000	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9515558

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4E565

Level: (low/med) LOW Date Received: 10/26/95

% Moisture: not dec. _____ Date Analyzed: 10/27/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	390	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9515559

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4E564

Level: (low/med) LOW Date Received: 10/26/95

% Moisture: not dec. _____ Date Analyzed: 10/27/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	150	

EA Laboratories

19 Loveton Circle
Sparks, MD 21152
Telephone: 410-771-4920
Fax: 410-771-4407

December 13, 1995

Mr. Carl G. Reitenbach, Jr.
EA Engineering, Science and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

Re: Willow Grove (29600.09)

Dear Mr. Reitenbach:

Enclosed is our report on the analysis of three water samples collected for the Willow Grove project on 21 November 1995. The invoice is included.

Please contact me if you have any questions or require further information and refer to report 951859. Unless other arrangements are made, we reserve the right to dispose of your samples sixty (60) days from the date of this letter. We will retain the raw data for seven years from this date.

Sincerely,

Natasha K. Sullivan
Laboratory Project Manager

enclosure

LABORATORY DATA REPORT

Prepared for:

EA Engineering, Science, and Technology, Inc.
Willow Grove

Prepared by:

EA Laboratories
19 Loveton Circle
Sparks, MD 21152

Report 951859

December 1995

TABLE OF CONTENTS
Willow Grove
Report 951859

1. NARRATIVE

2. CHAIN OF CUSTODY

3. ORGANIC DATA

   A. Aromatic Volatiles
   B. TPH GRO

I. NARRATIVE

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **951859**
Date: **13 December 1995**

This report contains the results of the analysis of three water samples collected on 21 November 1995 in support of the referenced project.

SAMPLE RECEIPT

The samples arrived intact by hand at EA Laboratories on 22 November 1995. Upon receipt, the samples were inspected and compared with the chain-of-custody record. The samples were then logged into the laboratory computer system with assigned laboratory accession numbers and released for analysis.

Client Sample Designation	EA Lab Number
Before	9516925
Between	9516926
After	9516927

Following this narrative section are data qualifiers (Table 1) and the original chain-of-custody. Analytical results and quality control information are summarized in the appended data package which has been formatted to be consistent with the deliverable requirements of this project.

QUALITY CONTROL

The following sections are ordered as the data appears in this report. They contain observations made during sample analysis, summarize the results of quality control measurements, and address the impact on data usability based upon project Data Quality Objectives. For each fractional analysis the narrative includes:

- Sample chronology: This section summarizes the sample history by fraction including the sample preparation method and date, analytical method, and analysis date. Anything unusual about the samples, digestates, or extracts is identified. Holding time compliance is evaluated in this section.

- Laboratory method performance: All quality control criteria for method performance must be met for all target analytes for data to be reported. These criteria generally apply to instrument tune, calibration, method blanks, and Laboratory Control Samples (LCS). In some instances where method criteria fail, useable data can be obtained and are reported with client approval. The narrative will then include a thorough discussion of the impact on data quality.

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **951859**
Date: **13 December 1995**

- Sample performance: Quality control field samples are analyzed to determine any measurement bias due to the sample matrix based on evaluation of matrix spikes (MS), matrix spike duplicates (MSD), and laboratory duplicates (D). If acceptance criteria are not met, matrix interferences are confirmed either by reanalysis or by inspection of the LCS results to verify that laboratory method performance is in control. Data are reported with appropriate qualifiers or discussion.

AROMATIC VOLATILES BY GC - WATER (EA9516925 - EA9516927)

Sample Chronology: Three samples were analyzed for BTEX plus naphthalene on 30 November through 01 December 1995 by USEPA SW-846 methods 5030/8020. All specified holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

VOLATILE TOTAL PETROLEUM HYDROCARBONS (VTPH) - WATER (EA9516925 - EA9516927)

Sample Chronology: Three samples were analyzed on 29 November 1995 for gasoline range organics (JP-4) by USEPA SW-846 methods 5030/8015-modified. All specified holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

The chromatographic pattern of field sample BEFORE was indicative of gasoline range organics as JP-4.

CERTIFICATION OF RESULTS

The Laboratory certifies that this report meets the project requirements for analytical data as stated in the Analytical Task Order (ATO) and the chain-of-custody. In addition, the Laboratory certifies

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **951859**
Date: **13 December 1995**

---

that the data as reported meet the Data Quality Objectives for precision, accuracy, and completeness specified for this project or as stated in EA Laboratories Quality Assurance program for other than the conditions detailed above. Release of the data contained in this report has been authorized by the appropriate Laboratory Manager as verified by the following signature.

_____ 13 December 1995
Walter E. Miller, Organics Division Manager

TABLE 1. ORGANIC ANALYSIS DATA QUALIFIERS

ND or U Indicates a compound on the target compound list (TCL) was analyzed for but not detected. The sample quantitation limit must be corrected for dilution and, if a soil sample, for percent moisture. For example, 10 U is used for phenol in water if the sample final volume is the protocol-specified final volume. If a 1-to-10 dilution of the extract was necessary, the reported limit is (10 x 10 U) or 100 U. For a soil sample, the value is also adjusted for percent moisture. For example, if the sample had 24% moisture and a 1-to-10 dilution factor, the soil sample quantitation limit for phenol (330 U) would be corrected as follows:

Reported limit = (330 U) x df / D

where: df = dilution factor = 10
D = (100 - % moisture) / 100 (At 24% moisture, D = (100-24) / 100 = 0.76)

Reported limit = (330 U) x 10 / 0.76 = 4300 U (rounded to two significant figures)

For soil samples subjected to gel permeation chromatography (GPC) cleanup procedures, the contract required quantitation limit (CRQL) is also multiplied by 2 to account for the fact that only half of the extract is recovered. Note: If GPC procedures are employed, the factor of 2 is not included in the dilution factor reported; a "Y" is entered for GPC (Y/N).

TR or J Indicates an estimated value. This flag is used under the following circumstances: 1) when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed, 2) when the mass spectral and retention time data indicate the presence of a compound that meets the volatile and semivolatile GC/MS identification criteria, and the result is less than the CRQL but greater than zero, 3) when the retention time data indicate the presence of a compound that meets the pesticide/Aroclor identification criteria and the result is less than the CRQL but greater than zero. Note: the "J" code is not used and the compound is not reported as being identified for pesticide/Aroclor results less than the CRQL, if the technical judgement of the pesticide residue analysis expert determines that the peaks used for compound identification resulted from instrument noise or other interferences (column bleed, solvent contamination, etc.). For example, if the sample quantitation limit is 10 ug/L but a concentration of 3 ug/L is calculated, report it as 3 J. The sample quantitation limit must be adjusted for dilution as discussed for the U flag

C This flag applies to pesticide results where the identification has been confirmed by GC/MS. Single component pesticides with concentration equal to or greater than 10 ng/uL in the final extract must be confirmed by GC/MS.

B This flag is used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. This flag is used for a TIC as well as for a positively identified TCL compound.

E This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis. This flag does not apply to pesticides/PCBs analyzed by GC/EC methods. If one or more compounds have a response greater that full scale, the sample or extract must be diluted and reanalyzed according to the specifications listed in the SOW. All such compounds with a response greater than full scale should have a concentration flagged with an "E" on Form I for the original analysis. If the dilution of the extract causes any compounds identified in the first analysis to be below the calibration range in the second analysis, then the results of both analyses are reported on separate Forms I. The Form I for the diluted sample will have the "DL" suffix appended to the sample number. NOTE: For total xylenes, where three isomers are quantified as two peaks, the calibration range of each peak is considered separately; e.g., a diluted analysis is not required for total xylenes unless the concentration of either peak separately exceeds 200 ug/L.

D This flag identifies all compounds identified in the analysis at a secondary dilution factor. If a sample or extract is reanalyzed at a higher dilution factor, as in the "E" flag above, the "DL" suffix is appended to the sample number on the Form I for the diluted sample, and all concentration values reported on that Form I are flagged with the "D" flag.

A This flag indicates that a TIC is a suspected aldol-condensation product.

X Other specific flags may be required to properly define the results. If used, they are fully described and such description attached to the Sample Data Summary Package and the Case Narrative. The flags begin by using "X". If more that one flag is required, "Y" and "Z" are used, as needed. For instance, the "X" flag might combine the "A", "B", and "D" flags for some sample.

N Indicates presumptive evidence of a compound. This flag is only used for tentatively identified compounds, where the identification is based on a mass spectral library search. It is applied to all TIC results. For generic characterization of a TIC, such as chlorinated hydrocarbon, the N code is not used.

P This flag is used for GC analyses when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported on Form 1 and flagged with a "P".

2. CHAIN-OF-CUSTODY

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
Telephone: (410) 771-4920
Fax: (410) 771-4407

Company Name: NAVY BRAC

Project Manager or Contact: CARL RABORN 3014

Phone:

Project No. 296.00.09

Project Name: WILLOWGROVE N.A.S

Dept.: 605 Task: 3613

Sample Storage Location: VOA WALK-IN

ATO Number: 6174

Page 1 of 1

Report #: 951859

Report Deliverables: 1 2 3 4 D E

EDD: Yes No

DUE TO CLIENT: 12/13/95

Parameters/Method Numbers for Analysis: BTEX + NAPTH 8020; TPH as Gasoline 8015 JP-4

Date	Time	Water	Soil	Sample Identification 19 Characters	No. of Containers	BTEX + NAPTH 8020	TPH as Gasoline 8015 JP-4	EA Labs Accession Number	Remarks
11/21/95	1218	X		BEFIOI2E	4	X	X	9516925	LPM: MEAINKS
11/21	1216	X		BISTIWEIN	4	X	X	9516926	
11/21	1212	X		AIATIEM	4	X	X	9516927	NORMAL TURNAROUND
									STANDARD EA REPORTS
									L8282

Samples by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Bill Pennell	11/21/95 1230	Bill Pennell	11/21/95 1500	Jamie McCloud	11-22-95
Relinquished by: (Signature)	Date/Time	Received by Laboratory: (Signature)	Date/Time	Airbill Number:	

Cooler Temp. N C pH: Yes No Comments: 10 A's Custody Seals Intact Yes No

Sample Shipped by: (Circle) Fed Ex. Puro. UPS Hand Carried Other:

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques.

WHITE—EA Laboratories YELLOW—EA Laboratories PINK—Project Manager Shaded Areas for Lab Use Only

3. ORGANIC DATA

A. AROMATIC VOLATILES DATA

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9516925F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D036F

Level: (low/med) LOW Date Received: 11/22/95

% Moisture: not dec. _____ Date Analyzed: 12/01/95

GC Column: RTX502.2 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	140	
108-88-3	TOLUENE	14	
100-41-4	ETHYLBENZENE	340	
108-38-3/106-42-3	META & PARA XYLENES	330	
95-47-6	ORTHO XYLENE	16	
91-20-3	NAPHTHALENE	480	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9516926F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D032F

Level: (low/med) LOW Date Received: 11/22/95

% Moisture: not dec. _____ Date Analyzed: 12/01/95

GC Column: RTX502.2 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (L)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A

VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9516927F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D030F

Level: (low/med) LOW Date Received: 11/22/95

% Moisture: not dec. _____ Date Analyzed: 11/30/95

GC Column: RTX502.2 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VG7D029F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D029F

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 11/30/95

GC Column: RTX502.2 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

B. TPH GRO DATA

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9516925

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4E735F

Level: (low/med) LOW Date Received: 11/22/95

% Moisture: not dec. _____ Date Analyzed: 11/29/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	6300	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9516926

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4E738F

Level: (low/med) LOW Date Received: 11/22/95

% Moisture: not dec. _____ Date Analyzed: 11/29/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	140	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9516927

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4E739F

Level: (low/med) LOW Date Received: 11/22/95

% Moisture: not dec. _____ Date Analyzed: 11/29/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
----------	TPH	100	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VD4E732

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4E732F

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 11/29/95

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

EA Laboratories

19 Loveton Circle
Sparks, MD 21152
Telephone: 410-771-4920
Fax: 410-771-4407

April 10, 1996

Mr. Carl G. Reitenbach, Jr.
EA Engineering, Science and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

Re: Willow Grove (29600.09)

Dear Mr. Reitenbach:

Enclosed is our report on the analysis of two water samples collected for the Willow Grove project on 27 March 1996. The invoice is included.

Please contact me if you have any questions or require further information and refer to report 960429. Unless other arrangements are made, we reserve the right to dispose of your samples sixty (60) days from the date of this letter. We will retain the raw data for seven years from this date.

Sincerely,

Daniel for NKS 4/10/96

Natasha K. Sullivan
Laboratory Project Manager

enclosure

LABORATORY DATA REPORT

Prepared for:

EA Engineering, Science, and Technology, Inc.
Willow Grove

Prepared by:

EA Laboratories
19 Loveton Circle
Sparks, MD 21152

Report 960429

April 1996

TABLE OF CONTENTS
Willow Grove
Report 960429

1. NARRATIVE

2. CHAIN OF CUSTODY

3. AROMATIC VOLATILES DATA

   A. QC Summary

      1. Laboratory Control Sample
      2. Method Blank

   B. Sample Data

      1. Data for Sample BEFORE
      2. Data for Sample AFTER

4. TPH as JET FUEL DATA

   A. QC Summary

      1. Laboratory Control Sample
      2. Method Blank

   B. Sample Data

      1. Data for Sample BEFORE
      2. Data for Sample AFTER

1. NARRATIVE

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **960429**
Date: **10 April 1996**

This report contains the results of the analysis of two water samples collected on 27 March 1996 in support of the referenced project.

SAMPLE RECEIPT

The samples arrived intact by Federal Express at EA Laboratories on 29 March 1996. Upon receipt, the samples were inspected and compared with the chain-of-custody record. The samples were then logged into the laboratory computer system with assigned laboratory accession numbers and released for analysis.

Client Sample Designation	EA Lab Number
Before	9603801
After	9603802

Following this narrative section are data qualifiers (Table 1) and the original chain-of-custody. Analytical results and quality control information are summarized in the appended data package which has been formatted to be consistent with the deliverable requirements of this project.

QUALITY CONTROL

The following sections are ordered as the data appears in this report. They contain observations made during sample analysis, summarize the results of quality control measurements, and address the impact on data usability based upon project Data Quality Objectives. For each fractional analysis the narrative includes:

- Sample chronology: This section summarizes the sample history by fraction including the sample preparation method and date, analytical method, and analysis date. Anything unusual about the samples, digestates, or extracts is identified. Holding time compliance is evaluated in this section.

- Laboratory method performance: All quality control criteria for method performance must be met for all target analytes for data to be reported. These criteria generally apply to instrument tune, calibration, method blanks, and Laboratory Control Samples (LCS). In some instances where method criteria fail, useable data can be obtained and are reported with client approval. The narrative will then include a thorough discussion of the impact on data quality.

- Sample performance: Quality control field samples are analyzed to determine any measurement

bias due to the sample matrix based on evaluation of matrix spikes (MS), matrix spike duplicates (MSD), and laboratory duplicates (D). If acceptance criteria are not met, matrix interferences are confirmed either by reanalysis or by inspection of the LCS results to verify that laboratory method performance is in control. Data are reported with appropriate qualifiers or discussion.

AROMATIC VOLATILES BY GC - WATER (EA9603801, EA9603802)

Sample Chronology: Two samples were analyzed on 1, 2 and 3 April 1996 for BTEX plus naphthalene by USEPA SW-846, Methods 5030/8020. All specified holding times were met.

The batch matrix spikes and matrix spike duplicates were analyzed on other client's samples.

Sample BEFORE required a 2X dilution in order to achieve concentrations of target analytes within calibration range.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

VOLATILE TOTAL PETROLEUM HYDROCARBONS (VTPH) by GC - WATER (EA9603801, EA9603802)

Sample Chronology: Two samples were analyzed on 2 and 3 April 1996 for Gasoline Range Organics (GRO) as JP-4 by USEPA SW-846, Methods 5030/8015-Modified. All specified holding times were met.

Sample BEFORE required a 5 dilution in order to achieve concentrations of target analytes within calibration range.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported sample.

Sample Performance: All quality control criteria were met for the reported sample.

The chromatographic pattern of sample BEFORE appears to be indicative of JP-4 fuel as well as

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Natasha K. Sullivan**
EA Laboratories Report: **960429**
Date: **10 April 1996**

---

a heavier petroleum product.

CERTIFICATION OF RESULTS

The Laboratory certifies that this report meets the project requirements for analytical data as stated in the Analytical Task Order (ATO) and the chain-of-custody. In addition, the Laboratory certifies that the data as reported meet the Data Quality Objectives for precision, accuracy, and completeness specified for this project or as stated in EA Laboratories Quality Assurance program for other than the conditions detailed above. Release of the data contained in this report has been authorized by the appropriate Laboratory Manager as verified by the following signature.

10 April 1996

Phyllis Christopher, Production Manager

2. CHAIN-OF-CUSTODY

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
Telephone: (410) 771-4920
Fax: (410) 771-4407

Company Name: BRAC NAVY

Project Manager or Contact: CARL Rewaza
Phone: 771-4950

Project No. 29600-09

Project Name: Willowgrove Pump Test

Dept.: 6025 Task: 5613

Sample Storage Location: VOA

ATO Number: 6185

Page 1 of 1

Report #: 960429

Report Deliverables: 1 2 3 4 D E

EDD: Yes/No

DUE TO CLIENT: 4/19/96

Parameters/Method Numbers for Analysis: BETX + NAPH 8030; TPH as Test Fuel 8015 JP4

Date	Time	Water	Soil	Sample Identification 19 Characters	No. of Containers	BETX+NAPH 8030	TPH as Test Fuel 8015 JP4	EA Labs Accession Number	Remarks
3/27/96	1415	X		AFTER BEFORE	4	X	X	9603801	9603797 LPM: MEA/NKS
3/27	1430	X		AFTER	4	X	X	9603802	9603798
									9603801 NORMAL TURNAROUND
									9603802 RUSH
									STANDARD EA REPORT
									BUOLE 96030242
									LS 19002

Samples by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Bill Pawlle	3/27/96 1420	Bill Pawlle	3/27/96 1700		

Relinquished by: (Signature)	Date/Time	Received by Laboratory: (Signature)	Date/Time	Airbill Number:	Sample Shipped by: (Circle)
		Kristin Jen	3/29/96 9:45	8504804921	Fed Ex Puro. UPS Hand Carried

Cooler Temp. 1.3 C pH: Yes No Comments: VOA Custody Seals Intact Yes No NONE

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques.

[redacted]

3. AROMATIC VOLATILES DATA

A. QC Summary

LCS RECOVERY REPORT

LAB NAME: EA LABORATORIES

DATA FILE: VG7D617F

INSTRUMENT: VG7

DATE: 04/02/96

SAMPLE ID: GV3063A

MATRIX: WATER

ANALYST: SSB

% MOISTURE: 0

SPIKE COMPOUND	SPIKE ADDED	SAMPLE CONC.	%REC.
Benzene	100	116.030	116
Chlorobenzene	100	128.080	128
Toluene	100	121.210	121

CURRENT VOLATILE LCS LIMITS

	WATER	SOIL
Benzene	87 - 121	87 - 119
Chlorobenzene	81 - 133	75 - 119
Toluene	81 - 125	82 - 117

If LCS is outside limits, a non-conformance form is required.

The LCS has been checked and is within/outside current limits.

Gilly Blough 4/3/96

ANALYST DATE

N.A.

Non-conformance form #

LCS RECOVERY REPORT

LAB NAME: EA LABORATORIES

DATA FILE: VG7D593F

INSTRUMENT: VG7

DATE: 04/01/96

SAMPLE ID: GV3060A

MATRIX: WATER

ANALYST: SSB

% MOISTURE: 0

SPIKE COMPOUND	SPIKE ADDED	SAMPLE CONC.	%REC.
Benzene	100	110.940	111
Chlorobenzene	100	116.180	116
Toluene	100	115.190	115

CURRENT VOLATILE LCS LIMITS

	WATER	SOIL
Benzene	87 - 121	87 - 119
Chlorobenzene	81 - 133	75 - 119
Toluene	81 - 125	82 - 117

If LCS is outside limits, a non-conformance form is required.

The LCS has been checked and is within/outside current limits.

Sherry Blough 4/3/96

ANALYST DATE

N.A.

Non-conformance form #

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VG7D595F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D595F

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 04/01/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK2

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VG7D619F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D619F

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 04/02/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (L)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

B. Sample Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9603801F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D642F

Level: (low/med) LOW Date Received: 03/29/96

% Moisture: not dec. _____ Date Analyzed: 04/03/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (L

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	150	
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	540	E
108-38-3/106-42-3	META & PARA XYLENES	570	E
95-47-6	ORTHO XYLENE	49	
91-20-3	NAPHTHALENE	600	E

1A

VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFOREDL

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9603801D

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D624F

Level: (low/med) LOW Date Received: 03/29/96

% Moisture: not dec. _____ Date Analyzed: 04/02/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 2

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	140	
108-88-3	TOLUENE	2.0	U
100-41-4	ETHYLBENZENE	420	
108-38-3/106-42-3	META & PARA XYLENES	450	
95-47-6	ORTHO XYLENE	23	
91-20-3	NAPHTHALENE	390	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9603802F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7D600F

Level: (low/med) LOW Date Received: 03/29/96

% Moisture: not dec. _____ Date Analyzed: 04/01/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

4. TPH as JET FUEL DATA

A. QC Summary

LCS RECOVERY REPORT

LAB NAME: EA LABORATORIES

DATA FILE: VD4F504

INSTRUMENT: VD4

DATE: 04/02/96

SAMPLE ID: GV3065

MATRIX: WATER

ANALYST: SSB

% MOISTURE: 0

SPIKE COMPOUND	SPIKE ADDED	SAMPLE CONC.	%REC.
TPH	500	449.000	90

CURRENT VOLATILE LCS LIMITS

	WATER	SOIL
TPH	50 - 150	50 - 150

If LCS is outside limits, a non-conformance form is required.

The LCS has been checked and is within/outside current limits.

Shirley Singh 4/4/96

ANALYST DATE

N.A.

Non-conformance form #

LCS RECOVERY REPORT

LAB NAME: EA LABORATORIES

DATA FILE: VD4F513

INSTRUMENT: VD4

DATE: 04/03/96

SAMPLE ID: GV3066

MATRIX: WATER

ANALYST: SSB

% MOISTURE: 0

SPIKE COMPOUND	SPIKE ADDED	SAMPLE CONC.	%REC.
TPH	500	426.000	85

CURRENT VOLATILE LCS LIMITS

	WATER	SOIL
TPH	50 - 150	50 - 150

If LCS is outside limits, a non-conformance form is required.

The LCS has been checked and is within/outside current limits.

Shelley Bunch 4/4/96

ANALYST DATE

N.A.

Non-conformance form #

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VD4F505

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4F505

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 04/02/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	----------TPH	100	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK2

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: VD4F514

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4F514

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 04/03/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

B. Sample Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9603801

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4F518

Level: (low/med) LOW Date Received: 03/29/96

% Moisture: not dec. _____ Date Analyzed: 04/03/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 5

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	18000	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No:

Matrix: (soil/water) WATER Lab Sample ID: 9603802

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4F506

Level: (low/med) LOW Date Received: 03/29/96

% Moisture: not dec. _____ Date Analyzed: 04/02/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	100	U

EA Laboratories

15 Loveton Circle
Sparks, MD 21152
Telephone: 410-771-4920
Fax: 410-771-4207

July 30, 1996

Mr. Carl G. Reitenbach, Jr.
EA Engineering, Science and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

Re: Willow Grove (29600.09)

Dear Mr. Reitenbach:

Enclosed is our report on the analysis of three water samples collected for the Willow Grove project on 18 July 1996. The invoice is included.

Please contact me if you have any questions or require further information and refer to report 961148. Unless other arrangements are made, we reserve the right to dispose of your samples sixty (60) days from the date of this letter. We will retain the raw data for seven years from this date.

Sincerely,

Mary E. Asper
Laboratory Project Manager

enclosure

LABORATORY DATA REPORT

Prepared for:

EA Engineering, Science, and Technology, Inc.
Willow Grove

Prepared by:

EA Laboratories
19 Loveton Circle
Sparks, MD 21152

Report 961148

July 1996

TABLE OF CONTENTS
Willow Grove
Report 961148

1. NARRATIVE

2. CHAIN OF CUSTODY

3. AROMATIC VOLATILES DATA

   A. QC Summary

      1. Laboratory Control Sample
      2. Method Blank

   B. Sample Data

      1. Data for Sample BEFORE
      2. Data for Sample BETWEEN
      3. Data for Sample AFTER

4. TPH as GAS DATA

   A. QC Summary

      1. Laboratory Control Sample
      2. Method Blank

   B. Sample Data

      1. Data for Sample BEFORE
      2. Data for Sample BETWEEN
      3. Data for Sample AFTER

I. NARRATIVE

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Mary E. Asper**
EA Laboratories Report: **961148**
Date: **30 July 1996**

This report contains the results of the analysis of three water samples collected on 18 July 1996 in support of the referenced project.

SAMPLE RECEIPT

The samples arrived intact by hand at EA Laboratories on 19 July 1996. Upon receipt, the samples were inspected and compared with the chain-of-custody record. The samples were then logged into the laboratory computer system with assigned laboratory accession numbers and released for analysis.

Client Sample Designation	EA Lab Number
Before	9610596
Between	9610597
After	9610598

Following this narrative section are data qualifiers (Table 1) and the original chain-of-custody. Analytical results and quality control information are summarized in the appended data package which has been formatted to be consistent with the deliverable requirements of this project.

QUALITY CONTROL

The following sections are ordered as the data appears in this report. They contain observations made during sample analysis, summarize the results of quality control measurements, and address the impact on data usability based upon project Data Quality Objectives. For each fractional analysis the narrative includes:

- Sample chronology: This section summarizes the sample history by fraction including the sample preparation method and date, analytical method, and analysis date. Anything unusual about the samples, digestates, or extracts is identified. Holding time compliance is evaluated in this section.

- Laboratory method performance: All quality control criteria for method performance must be met for all target analytes for data to be reported. These criteria generally apply to instrument tune, calibration, method blanks, and Laboratory Control Samples (LCS). In some instances where method criteria fail, useable data can be obtained and are reported with client approval. The narrative will then include a thorough discussion of the impact on data quality.

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Mary E. Asper**
EA Laboratories Report: **961148**
Date: **30 July 1996**

- Sample performance: Quality control field samples are analyzed to determine any measurement bias due to the sample matrix based on evaluation of matrix spikes (MS), matrix spike duplicates (MSD), and laboratory duplicates (D). If acceptance criteria are not met, matrix interferences are confirmed either by reanalysis or by inspection of the LCS results to verify that laboratory method performance is in control. Data are reported with appropriate qualifiers or discussion.

AROMATIC VOLATILES BY GC - WATER (EA9610596-EA9610598)

Sample Chronology: The samples and associated quality control were analyzed on 24 July 1996 for benzene, toluene, ethylbenzene, xylenes and naphthalene by SW-846 Methods 5030/8020. All holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

PURGEABLE TPH BY GC - WATER (EA9610596-EA9610598)

Sample Chronology: The samples and associated quality control were analyzed on 26 July 1996 for purgeable TPH as JP-4 by SW-846 Methods 5030/8015M. All holding times were met.

Laboratory Method Performance: All laboratory method performance criteria were met for the reported samples.

Sample Performance: All quality control criteria were met for the reported samples.

The chromatographic pattern for sample BEFORE was very similar to that of the JP-4 calibration standards. The pattern for sample BETWEEN was not similar to the calibration standards but did have some individual peaks which were present in the calibration standards.

CERTIFICATION OF RESULTS

The Laboratory certifies that this report meets the project requirements for analytical data as stated in the Analytical Task Order (ATO) and the chain-of-custody. In addition, the Laboratory certifies that the data as reported meet the Data Quality Objectives for precision, accuracy, and completeness

EA Laboratories
ANALYTICAL NARRATIVE

Client: **EA Eng. Science and Tech.**
Site: **Willow Grove**
Project number: **29600.09**

Laboratory Project Manager: **Mary E. Asper**
EA Laboratories Report: **961148**
Date: **30 July 1996**

---

specified for this project or as stated in EA Laboratories Quality Assurance program for other than the conditions detailed above. Release of the data contained in this report has been authorized by the appropriate Laboratory Manager as verified by the following signature.

_____ 30 July 1996
Phyllis Christopher, Production Manager

2. CHAIN-OF-CUSTODY

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
(410) 771-4920
Fax (410) 771-4407

Company Name: [illegible]

Project Manager or Contact: [illegible]

Phone:

Project No: [illegible] 3612 6125

Project Name: [illegible]

Sample Storage Location: YOA WALK-IN

ATO Number:

Page 1 of 1 Job ID: 961148

Report/Deliverables: Report Level 2E Date Due 8/9/96

Parameters/Method Numbers for Analysis*: BTEX - 8020 Pinellas; TPH as TPH Gas; Gasoline

Date	Time	Water	Soil	Sample Identification 19 Characters	No. of Containers	BTEX - 8020 Pinellas	TPH as TPH Gas	Gasoline	EA Labs Accession Number	Remarks
7/18/96	1222	X		B1E0A0A1	2	✓	✓		9610596	LPM: Randall Jones 7/19/96
7/18/96	1233	X		B1E0A0A0	2	✓	✓		9610597	
7/18/96	1239	X		A1E0A0A0	2	✓	✓		9610598	Mary C. Ayers

L976

Sampled by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[illegible]	7/18/96 1230	[illegible]	7/18/96 1439		

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Airbill Number:	Sample Shipped by (Circle)
		Janae McCloud	7/19/96 1439		Fed Ex Puro UPS Hand Carried Other

Cooler Temp: 1.3 °C pH: ☐ Yes ☒ No Comments: YOA SAMPLES Custody Seals Intact ☐ Yes ☐ No

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques

WHITE - EA Laboratories YELLOW - EA Laboratories PINK - Project Manager Shaded Areas for Lab Use Only

3. AROMATIC VOLATILES DATA

A. QC Summary

LCS RECOVERY REPORT

LAB NAME: EA LABORATORIES

DATA FILE: VG7E770F

INSTRUMENT: VG7

DATE: 07/24/96

SAMPLE ID: VL607241

MATRIX: WATER

ANALYST: SSB

% MOISTURE: 0

SPIKE COMPOUND	SPIKE ADDED	SAMPLE CONC.	%REC.
Benzene	50	47.840	96
Chlorobenzene	50	46.860	94
Toluene	50	49.310	99

CURRENT VOLATILE LCS LIMITS

	WATER	SOIL
Benzene	87 - 121	87 - 119
Chlorobenzene	81 - 133	75 - 119
Toluene	81 - 125	82 - 117

If LCS is outside limits, a non-conformance form is required.

The LCS has been checked and is within/outside current limits.

Shelly Bright 7/24/96

ANALYST DATE

N.A.

Non-conformance form #

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8020

Matrix: (soil/water) WATER Lab Sample ID: VB607241

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7E772F

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 07/24/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	1.0	U
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

B. Sample Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8020

Matrix: (soil/water) WATER Lab Sample ID: 9610596F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7E778F

Level: (low/med) LOW Date Received: 07/19/96

% Moisture: not dec. _____ Date Analyzed: 07/24/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	100	
108-88-3	TOLUENE	9.2	
100-41-4	ETHYLBENZENE	180	
108-38-3/106-42-3	META & PARA XYLENES	130	
95-47-6	ORTHO XYLENE	8.2	
91-20-3	NAPHTHALENE	180	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8020

Matrix: (soil/water) WATER Lab Sample ID: 9610597F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7E775F

Level: (low/med) LOW Date Received: 07/19/96

% Moisture: not dec. _____ Date Analyzed: 07/24/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	120	
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	13	
108-38-3/106-42-3	META & PARA XYLENES	2.3	
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8020

Matrix: (soil/water) WATER Lab Sample ID: 9610598F

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VG7E774F

Level: (low/med) LOW Date Received: 07/19/96

% Moisture: not dec. _____ Date Analyzed: 07/24/96

GC Column: DBVRX ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
71-43-2	BENZENE	3.5	
108-88-3	TOLUENE	1.0	U
100-41-4	ETHYLBENZENE	1.0	U
108-38-3/106-42-3	META & PARA XYLENES	1.0	U
95-47-6	ORTHO XYLENE	1.0	U
91-20-3	NAPHTHALENE	5.0	U

4. TPH as GAS DATA

A. QC Summary

LCS RECOVERY REPORT

LAB NAME: EA LABORATORIES

DATA FILE: VD4G310

INSTRUMENT: VD4

DATE: 07/26/96

SAMPLE ID: VL607262

MATRIX: WATER

ANALYST: SSB

% MOISTURE: 0

SPIKE COMPOUND	SPIKE ADDED	SAMPLE CONC.	%REC.
TPH	500	561.000	112

CURRENT VOLATILE LCS LIMITS

	WATER	SOIL
TPH	50 - 150	50 - 150

If LCS is outside limits, a non-conformance form is required.

The LCS has been checked and is within/outside current limits.

[illegible] 11/26/96

ANALYST DATE

N.A.

Non-conformance form #

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

VBLK1

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8015M

Matrix: (soil/water) WATER Lab Sample ID: VB607262

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4G311

Level: (low/med) LOW Date Received: / /

% Moisture: not dec. _____ Date Analyzed: 07/26/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
----------	TPH	100	U

B. Sample Data

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BEFORE

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8015M

Matrix: (soil/water) WATER Lab Sample ID: 9610596

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4G314

Level: (low/med) LOW Date Received: 07/19/96

% Moisture: not dec. _____ Date Analyzed: 07/26/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	7300	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

BETWEEN

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8015M

Matrix: (soil/water) WATER Lab Sample ID: 9610597

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4G313

Level: (low/med) LOW Date Received: 07/19/96

% Moisture: not dec. _____ Date Analyzed: 07/26/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
	TPH	690	

1A
VOLATILE COMPOUNDS ORGANICS ANALYSIS SHEET

EPA SAMPLE NO.

AFTER

Lab Name: EA LABS Contract:

Lab Code: EAENG Case No: SAS No: _____ SDG No: 8015M

Matrix: (soil/water) WATER Lab Sample ID: 9610598

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VD4G312

Level: (low/med) LOW Date Received: 07/19/96

% Moisture: not dec. _____ Date Analyzed: 07/26/96

GC Column: RTX1 ID: 0.53 (mm) Dilution Factor: 1

Soil Extract Volume: _____ (uL) Soil Aliquot Volume: _____ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS (ug/L or ug/Kg) ug/L	Q
----------	TPH	100	U

APPENDIX D

RESULTS OF SOIL VAPOR EXTRACTION TEST (April 1995)

EA Engineering, Science, and Technology

EA Mid-Atlantic
15 Loveton Circle
Sparks, MD 21152
Telephone: 410-771-4950
Fax: 410-771-4204

31 May 1995

Mr. Paul Briegel
Northern Division
Design Division (Code 4051/PB)
Naval Facilities Engineering Command
Mail Stop 82
10 Industrial Highway
Lester, Pennsylvania 19113-2090

RE: Contract No. N62472-92-D-1296, CTO No. 0009, NAS Willow Grove
Results of Soil Vapor Extraction Test

Dear Mr. Briegel:

This letter report presents the results of soil vapor extraction (SVE) testing conducted at the Naval Fuel Farm Facility, Naval Air Station Willow Grove, Horsham Township, Pennsylvania. The testing was conducted in order to evaluate the potential for SVE during high water table conditions. The testing, as outlined in the Revised Work Description dated 22 February 1995, was conducted from 4 April through 6 April 1995 and included both system head and radial influence tests on wells NFFW-4, -7, and -16. These wells were chosen to assess SVE performance in areas with varying amounts of free phase product. Product has not been observed in NFFW-4, has been present periodically in NFFW-7, and has been consistently present in NFFW-16. The well locations are indicated on the Site Plan in Figure 1. The following describes the testing and data collection methodologies and presents the testing and sample analyses results.

1.0 INTRODUCTION

Soil vapor extraction is a widely used remedial technique capable of removing volatile organic compounds (VOC) from the subsurface. In this process, a vacuum is applied to an extraction point inducing air flow through the vadose zone. As air moves through the soil, residual phase VOC are volatilized and removed from the subsurface through the extraction well.

In order to effectively assess the applicability of SVE as a remedial technology in the areas surrounding wells NFFW-4, -7, and -16, three individual SVE tests were conducted. These tests were designed to evaluate the relationships between (1) applied vacuum and extracted air flow rate and (2) applied vacuum and radial influence. VOC concentration and removal rates were also characterized as part of the radial influence test.

2.0 TESTING METHODOLOGY

The testing was conducted utilizing a mobile vent trailer. The trailer consists of a vacuum pump equipped with a moisture separator, activated carbon treatment canisters, flow and vacuum gauges, and sample ports. The vacuum extraction system is shown schematically in Figure 2.

2.1 System Head Test

Individual system head tests were conducted on each of the three test wells in order to develop site specific relationships between applied vacuum and extracted air flow rate. The tests were conducted by applying 5 different vacuums to the extraction well in a decreasing stepped manner. Each vacuum was applied until the corresponding flow rate stabilized, this occurred within approximately 20 minutes in each case. Once the flow rate stabilized, a different vacuum was applied and the test was repeated. System head tests were conducted before radial influence tests.

2.2 Radial Influence Test

Radial influence tests were used to measure the radial distance influenced by the applied vacuum at the extraction well and to assess VOC removal rates. The radius of influence was measured by installing six soil vapor probes into the subsurface at various distances in two directions from the extraction well. The distances and orientation of the probes are indicated on Figures 3, 4, and 5, for the tests conducted from wells NFFW-4, -7, and -16, respectively. The 0.75-inch diameter soil vapor probes were driven to a depth of approximately 5 to 8 feet below grade and fitted with gauges capable of sensing changes in soil air pressure. During each test a constant vacuum was applied to the extraction well for approximately two hours and the induced vacuum on the soil vapor probes was recorded regularly. Vapor flow rate and temperature were also recorded throughout the test.

To assess VOC removal rates, samples of extracted soil vapor were collected approximately every 30 minutes and analyzed for petroleum range and chlorinated hydrocarbons. The samples were analyzed onsite with EA's mobile field gas chromatograph. The analysis results and the extraction air volume flow rate were utilized to assess the VOC mass removal rates associated with each test well.

3.0 RESULTS

3.1 System Head Test

The results of the system head test are contained and displayed graphically in Attachment A. The individual tests produced relationships between applied vacuum and observed flow rate consistent with the nature of the subsurface at the Naval Fuel Farm Facility. In general, the results indicate the area is characterized by a low permeability subsurface resulting in a high vacuum - low flow rate relationship. Applied vacuums ranged from 2 to 14.8 inches mercury (Hg) while observed flow rates ranged from 2.18 to 43.6 cubic feet per minute (cfm). In general, the three wells responded similarly to the range of vacuums applied and no significant differences were observed.

3.2 Radial Influence Test

The radial influence tests produced varying results. Relationships between applied vacuum and radial influence for each test are summarized on Table 1. The results indicate that preferential pathways may exist in the subsurface. The tests on wells NFFW-4, -7, and -16 were conducted at vacuums of approximately 7, 9, and 10 inches Hg, respectively, with corresponding average flow rates of 33, 33, and 26 cfm. In general, the greatest radial influence was observed from well NFFW-16 and the least radial influence was present in the vicinity of well NFFW-4. The inconsistent nature of the results does not allow the determination of an effective radius of influence about each well. However, it should be noted that vacuum influence was observed during each test at distances of up to 25 feet from the extraction well.

The analytical results of petroleum and chlorinated hydrocarbon analyses along with corresponding vacuum, flow rate, and influent air stream temperature readings are summarized on Tables 2 and 3, respectively. Table 2 also includes the estimated VOC removal rates. Removal rates in pounds per day were calculated for each sample collected based on total petroleum hydrocarbons (TPH) as toluene equivalents; the equation used is given in Table 2. Extraction from well NFFW-7 produced the highest average hydrocarbon removal rate (28.46 pounds per day) while extraction from wells NFFW-4 and NFFW-7 resulted in lower average removal rates of 0.74 and 11.46 pounds per day, respectively. Tables 2 and 3 also include the results of one treated effluent sample per test; this sample is labeled "After Carbon".

The results of the chlorinated hydrocarbon analysis indicated the presence of several target compounds in samples from each of the three test wells. Chlorinated hydrocarbons were most prevalent in the extracted air samples from well NFFW-4 where methylene chloride was present at a maximum of 19.18 parts per million by volume (ppmv). The occurrence of chlorinated hydrocarbons is not consistent with the occurrence of free product as NFFW-4 is in an area where free product has not been detected. As noted above, the complete results of chlorinated hydrocarbon analysis are summarized on Table 3.

4.0 DISCUSSION

The results of the system head tests on each of the three test wells indicate that high vacuum low flow rate conditions persist throughout the areas tested. This is not a limitation to potential remediation as equipment capable of operating in the required vacuum and flow range is readily available. However, the radial influence tests indicate the presence of preferential pathways about each test well and as a result, an estimate of the effective radius could not be determined. As noted in Section 3.2, the radial influence test results may be characteristic of the subsurface environment. The tests did indicate influence up to at least 25 feet in one direction from each well.

Petroleum hydrocarbon removal rates were greatest during extraction from wells NFFW-7 and NFFW-16 indicating remedial action in these areas including soil vapor extraction may be effective. Soil vapor extraction utilizing well NFFW-4 is not recommended at this time. However, it should be noted that the tests were conducted during times of seasonally high water table and increased hydrocarbon removal rates (for each well) may be attainable when low water table conditions predominate.

Please contact us at (410) 771-4950 if you have any questions or would like to discuss the testing results further.

Sincerely,

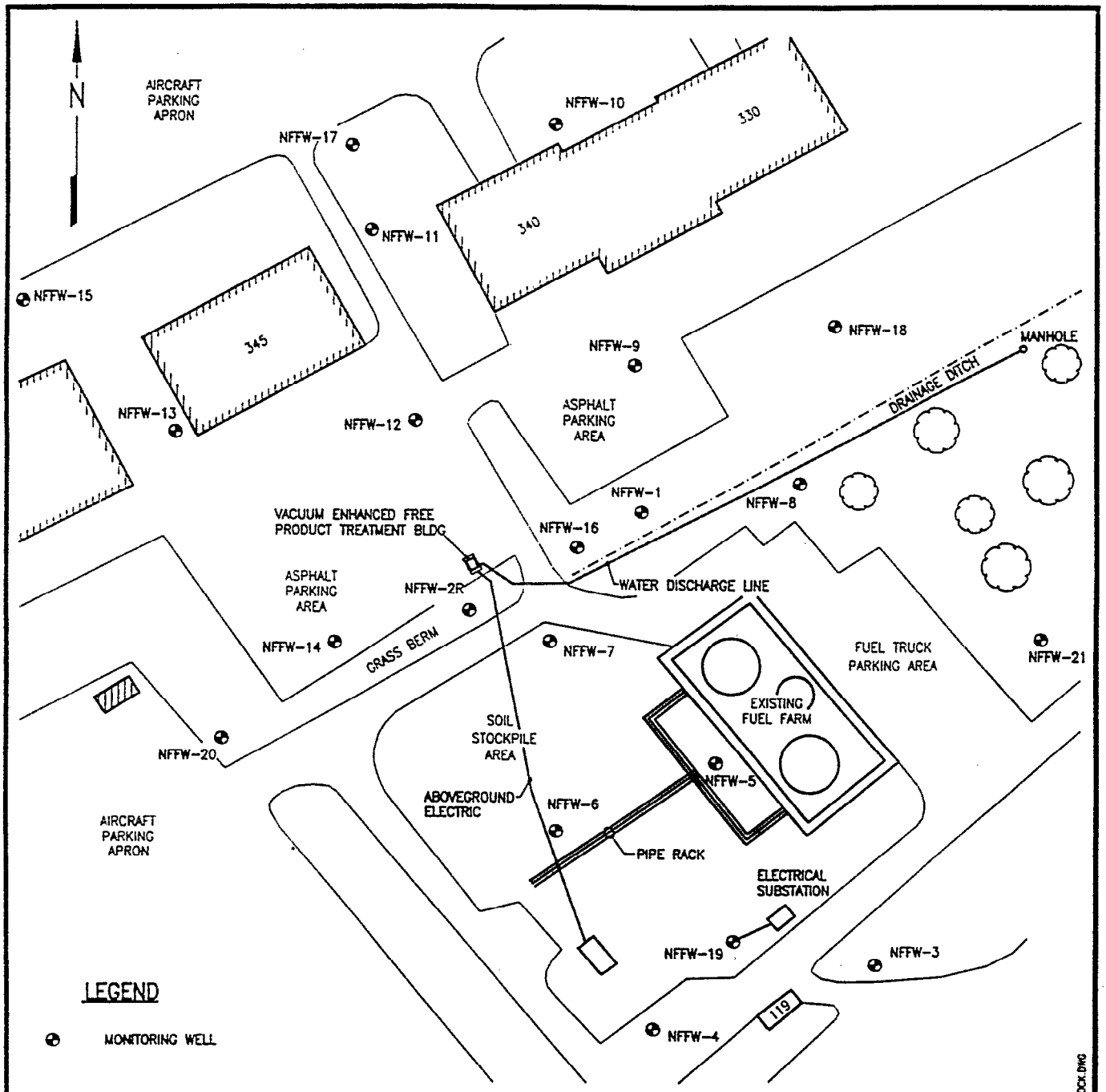
Brian R. Stempowski

Brian R. Stempowski
Project Engineer

Brian R. Stempowski for

Carl G. Reitenbach, P.E.
CTO Manager

cc: P. Greco (NAS-Willow Grove)
J. Colter (NORTHDIV)
C. Houlik (EA)



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

150 75 0 150

GRAPHIC SCALE IN FEET

APPROXIMATE SCALE

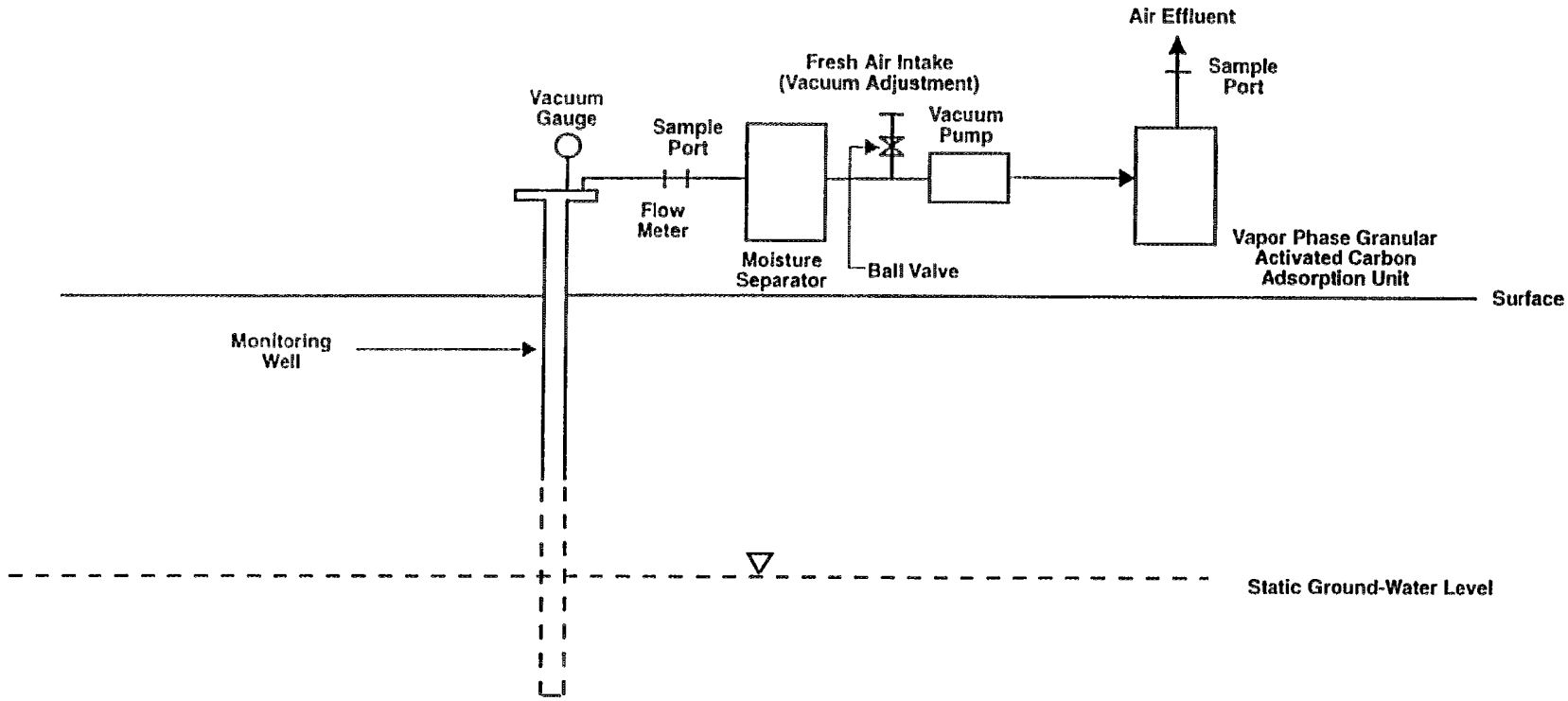
FILE: F:\29600009\DWGZ\BEDROCK.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

SITE PLAN

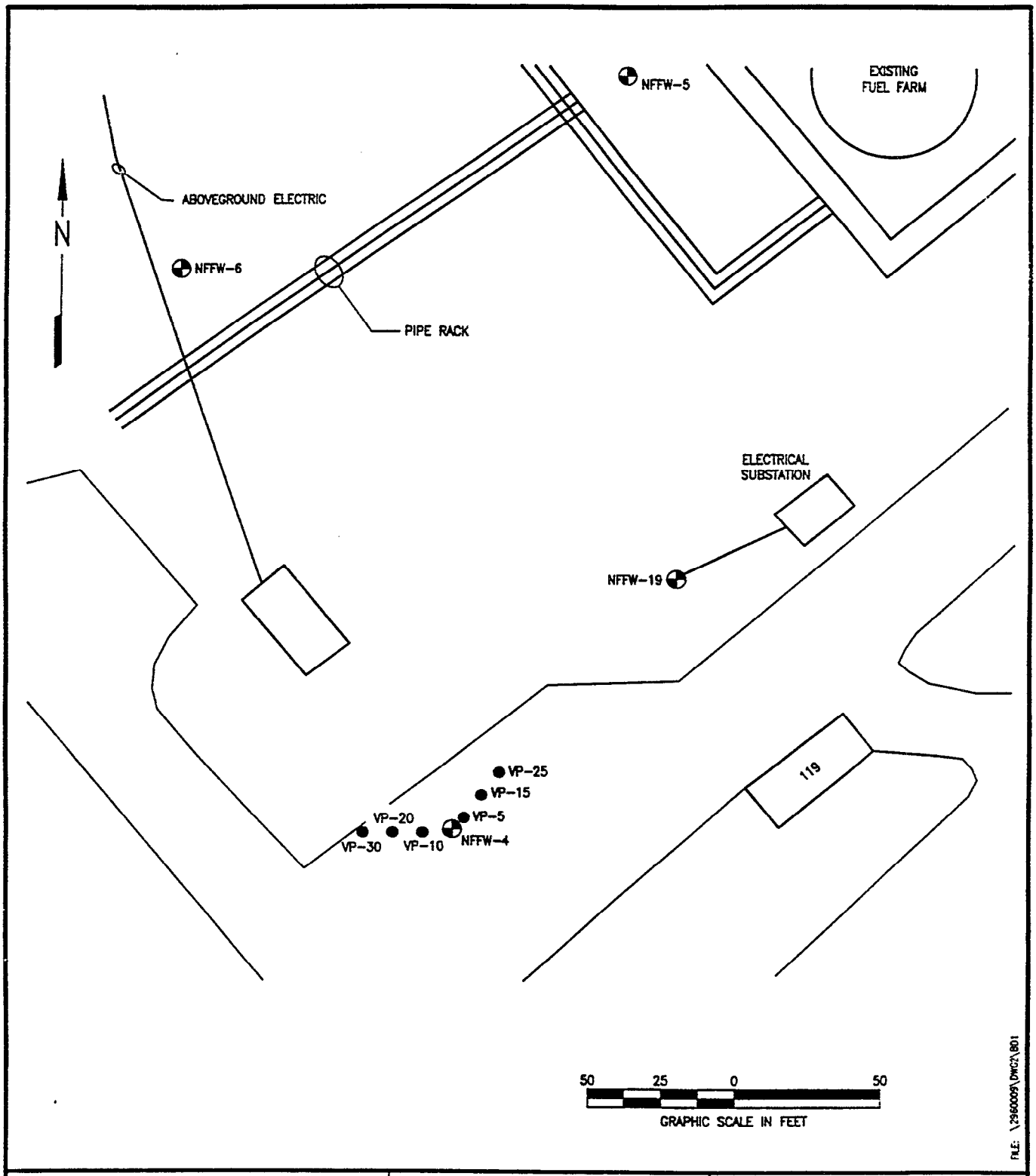
PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	BS	1"=150'	4-27-95	29600.09	1



Naval Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

Figure 2. Soil vapor extraction test equipment schematic.

F:\2960009\Reports\Fig2.cdr

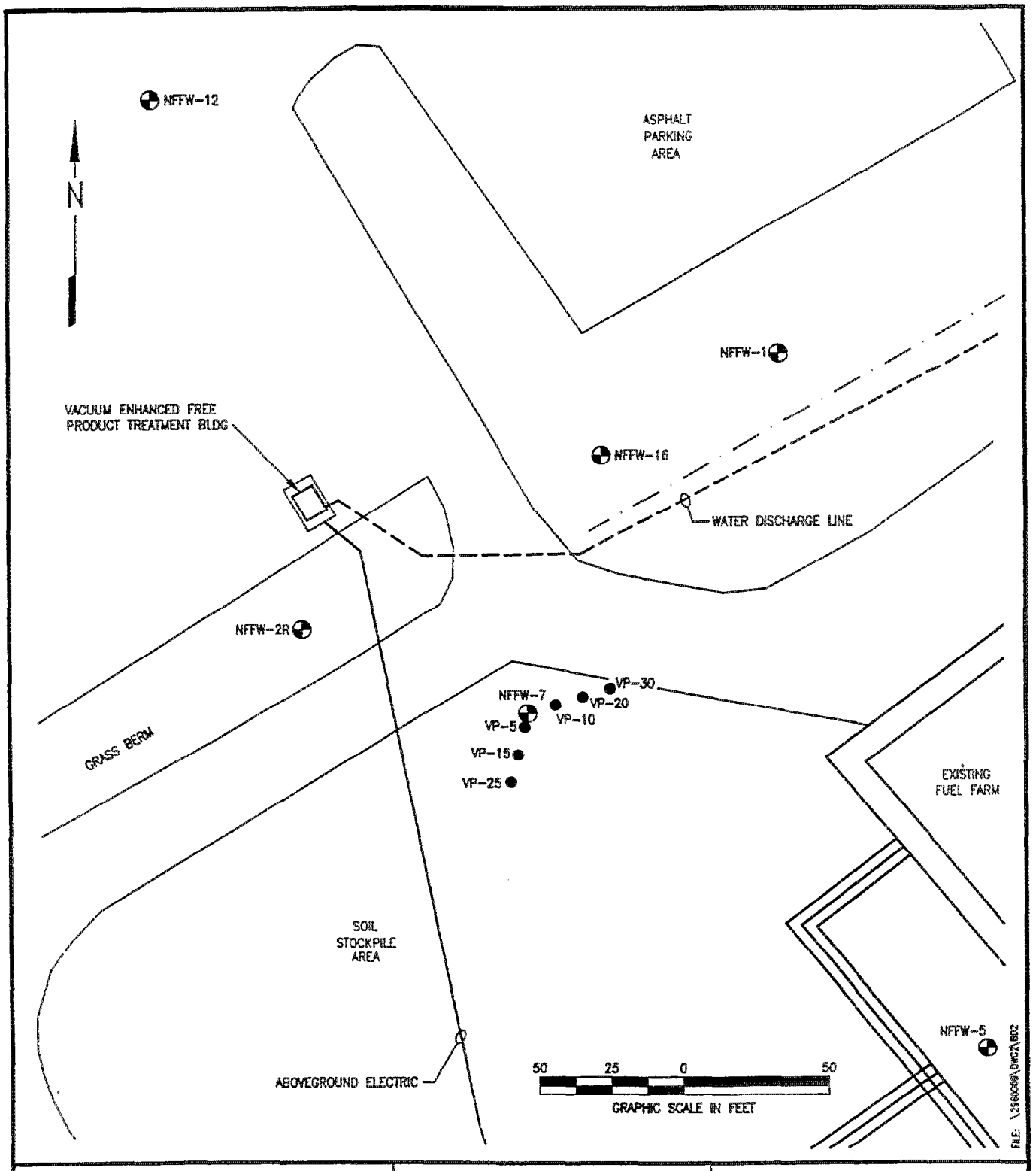


EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

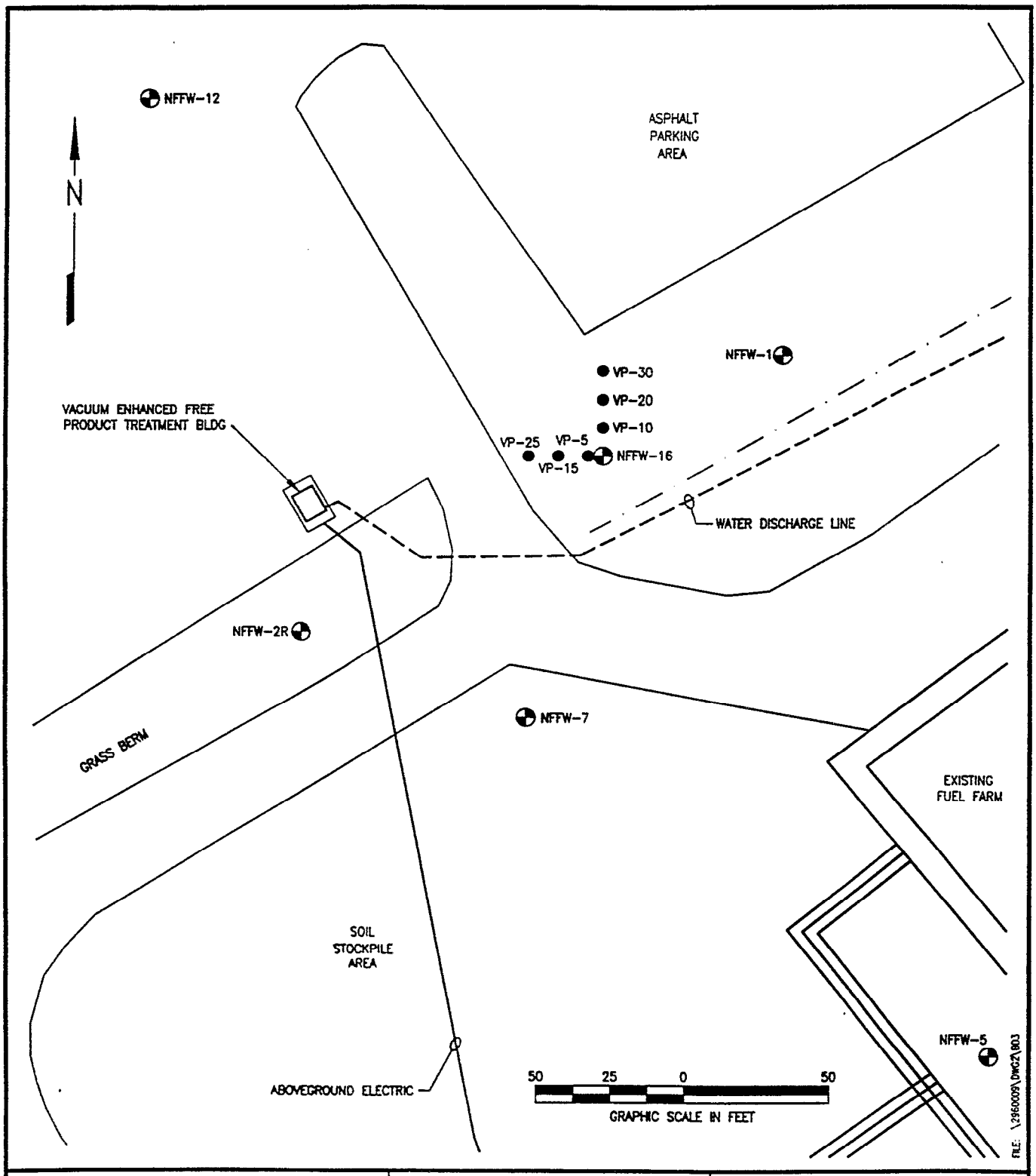
NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

LOCATION OF MONITORING POINTS DURING SVE TEST, FROM WELL NFFW-4 6 APRIL 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	AMP	BS	1"=50'	5-30-95	29600.09	3



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.			NAVY FUEL FARM FACILITY NAVAL AIR STATION WILLOW GROVE HORSHAM TOWNSHIP, PENNSYLVANIA			LOCATION OF MONITORING POINTS DURING SVE TEST, FROM WELL NFFW-7 5 APRIL 1995	
PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	AMP	BS	1"=50'	5-31-95	29600.09	4



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	NAVY FUEL FARM FACILITY NAVAL AIR STATION WILLOW GROVE HORSHAM TOWNSHIP, PENNSYLVANIA	LOCATION OF MONITORING POINTS DURING SVE TEST, FROM WELL NFFW-16 5 ABRIL 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	AMP	BS	1"=50'	5-31-95	29600.09	5

Table 1

Results of Radial Influence Test

Navy Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

NFFW-4

Time (min)	Applied Vacuum (inches Hg)	Flow rate (cfm)	Observed Vacuum (inches water) at Radial Distance (ft) 5	10	15	20	25	30
10	7	30.5	0	2.85	0	0.005	0.005	0
20	7	30.5	0	2.87	0	0.005	0.005	0
35	6.8	33	0	3	0.01	0.01	0.005	0
50	6.8	33	0	3	0.01	0.005	0.005	0
65	6.6	33	0	3	0	0	0.005	0
80	6.6	33	0	3.1	0	0	0.002	0
110	6.6	33	0.02	3.1	0.01	0.015	0	0
140	6.6	33	0.025	3.1	0.005	0.005	0	0

NFFW-7

Time (min)	Applied Vacuum (inches Hg)	Flow rate (cfm)	Observed Vacuum (inches water) at Radial Distance (ft) 5	10	15	20	25	30
3	8.8	33	0	6.3	0	0.02	0	0.02
9	9	33	0	6.4	0	0	0	0
12	9	33	0	6.4	0	0.005	0	0.005
15	9.25	33	0	6.5	0	0.005	0	0.01
25	10	30.5	0	6	0	0.01	0	0.025
35	10.5	30.5	0	5.7	0	0.01	0.01	0.03
60	11	30.5	0.01	5.4	0	0.01	0.015	0.03
75	11	30.5	0.01	5.2	0	0.015	0.015	0.035
105	10.25	33	0.025	5	0	0.045	0.015	0.045
135	10.25	33	0.045	5	0	0.062	0.015	0.045
155	10.25	33	0.05	5	0	0.065	0.012	0.05

NFFW-16

Time (min)	Applied Vacuum (inches Hg)	Flow rate (cfm)	Observed Vacuum (inches water) at Radial Distance (ft) 5	10	15	20	25	30
1	10	26	1.8	2.8	1.65	0.23	0	0.19
2	10	26	1.8	2.8	1.65	0.23	0	0.23
5	10	26	1.8	2.8	1.65	0.23	0.005	0.25
10	10	26	1.7	2.65	1.65	0.23	0	0.05
15	10	26	1.6	2.65	1.6	0.22	0	0.14
25	10.1	26	1.6	2.55	1.55	0.215	0	0.31
35	10.1	26	1.58	2.55	1.5	0.215	0	0.58
50	10.2	26	1.5	2.45	1.5	0.22	0	0.44
65	10.2	26	1.5	2.5	1.5	0.22	0	0.445
85	10.2	26	1.5	2.4	1.5	0.215	0	0.445
100	10.2	26	1.5	2.45	1.5	0.22	0	0.45
115	10.2	26	1.5	2.45	1.5	0.21	0.005	0.46
165	10.2	26	1.5	2.45	1.5	0.21	0.005	0.44

Table 2

Soil Vapor Contaminant Assessment Results Summary - Petroleum Hydrocarbons

Navy Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

Sample	Date	Time	Vacuum ("Hg)	Flow Rate (cfm)	Influent Temperature (C)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	M&P -Xylenes (ppmv)	O-Xylenes (ppmv)	TPH as Toluene Equivalents (ppmv)	TPH Removal Rate as Toluene Equivalents (pounds/day)	TPH Emission Rate as Toluene Equivalents (pounds/day)	Total VOC Emission Rate (b) (pounds/day)
NFFW-4	6-Apr-95	1100	8	44	54	ND	ND	ND	ND	ND	4.6	0.06	NA	NA
NFFW-4	6-Apr-95	1135	8.8	41	55	ND	ND	ND	ND	ND	57	0.72	NA	NA
NFFW-4	6-Apr-95	1205	7	30	56	0.56	ND	ND	ND	ND	61	0.56	NA	NA
NFFW-4	6-Apr-95	1235	6.8	33	58	ND	ND	ND	ND	ND	95	0.96	NA	NA
NFFW-4	6-Apr-95	1335	6.6	33	59	ND	ND	ND	ND	ND	140	1.41	NA	NA
NFFW-4 After Carbon	6-Apr-95	1235	6.8	33	58	ND	ND	ND	ND	ND	ND	NA	0.00	0.00
NFFW-7	5-Apr-95	1458	8.8	33	48	299	155	9.5	1.9	3	4000	41.62	NA	NA
NFFW-7	5-Apr-95	1538	10.5	30	49	167	96	6	1.7	6	3000	28.29	NA	NA
NFFW-7	5-Apr-95	1615	11	30	49	98	53	1.3	ND	0.8	1800	16.97	NA	NA
NFFW-7	5-Apr-95	1645	10.25	33	49	(a)	86	6.2	2.1	0.5	2600	26.97	NA	NA
NFFW-7 After Carbon	5-Apr-95	1615	11	30	49	1.9	4.5	ND	ND	ND	130	NA	1.23	1.23
NFFW-16	5-Apr-95	1132	10	26	48	56	444	15	ND	35	1600	13.12	NA	NA
NFFW-16	5-Apr-95	1215	10.1	26	48	44	375	4	ND	41	1300	10.66	NA	NA
NFFW-16	5-Apr-95	1238	10.2	26	50	48	394	5	ND	22	1300	10.59	NA	NA
NFFW-16 After Carbon	5-Apr-95	1215	10.1	26	48	ND	ND	ND	ND	ND	25	NA	0.20	0.20

Note: ND - Not Detected
(a) - unable to quantify
(b) - includes total petroleum and chlorinated hydrocarbons
TPH emission rates calculated as follows:

$$\text{Emission Rate(pounds/day)} = \frac{Q(cfm) \times C(ppmv) \times P(atm) \times V(L) \times 0.4719(L/sec) \times 86400(sec/day) \times 92.1(g/mol) \times 0.0022(pound/g)}{R(L\text{-}atm/mol\text{-}K) \times T(K)}$$

$$= \frac{Q(cfm) \times C(ppmv) \times 0.0083}{0.082 \times T(K)}$$

Where:
Q = Vapor volume flow rate
C = TPH concentration as toluene equivalents
P = Vapor pressure of 1 ppm toluene (1EE-6 atm)
V = Volume (1 Litre)
R = Ideal gas constant (0.082 L-atm/mol-K)
T = Vapor influent temperature

Table 3

Soil Vapor Contaminant Assessment Results Summary - Chlorinated Hydrocarbons

Navy Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

Sample	Date	Time	Vacuum ("Hg)	Flow Rate (cfm)	Influent Temperature (C)	Trichloroethane (ppmv)	Carbon Tetrachloride (ppmv)	Trichloroethene (ppmv)	Tetrachloroethylene (ppmv)	Methylene Chloride (ppmv)	Trans-1,2-Dichloroethene (ppmv)	Cis-1,2-Dichloroethene (ppmv)	Chlorinated Hydrocarbon Removal Rate (pounds/day)	Chlorinated Hydrocarbon Emission Rate (pounds/day)
NFFW-4	6-Apr-95	1100	8	44	54	0.001	ND	ND	ND	4.82	ND	ND	0.06	NA
NFFW-4	6-Apr-95	1135	5.8	41	55	0.005	ND	ND	ND	19.18	ND	ND	0.22	NA
NFFW-4	6-Apr-95	1206	7	30	56	0.004	ND	ND	0.002	17.8	ND	0.04	0.15	NA
NFFW-4	6-Apr-95	1235	6.8	33	58	0.005	ND	ND	0.002	17.67	ND	0.03	0.16	NA
NFFW-4	6-Apr-95	1335	6.6	33	59	0.004	ND	ND	0.002	18.18	ND	ND	0.17	NA
NFFW-4 After Carbon	6-Apr-95	1235	6.8	33	58	0.002	ND	ND	ND	ND	ND	ND	NA	0.00
NFFW-7	5-Apr-95	1458	8.8	33	48	ND	ND	ND	ND	3.1	0.42	ND	0.03	NA
NFFW-7	5-Apr-95	1538	10.5	30	49	0.005	ND	0.004	ND	3.1	0.61	ND	0.03	NA
NFFW-7	5-Apr-95	1615	11	30	49	ND	ND	ND	ND	3.3	0.54	ND	0.03	NA
NFFW-7	5-Apr-95	1645	10.25	33	49	ND	ND	ND	ND	3.8	ND	0.4	0.04	NA
NFFW-7 After Carbon	5-Apr-95	1615	11	30	49	0.001	ND	ND	ND	ND	ND	ND	NA	0.00
NFFW-16	5-Apr-95	1132	10	26	48	ND	ND	ND	0.003	0.46	ND	ND	0.00	NA
NFFW-16	5-Apr-95	1215	10.1	26	48	ND	ND	ND	0.005	0.19	ND	ND	0.00	NA
NFFW-16	5-Apr-95	1238	10.2	26	50	0.001	ND	ND	0.004	0.14	ND	ND	0.00	NA
NFFW-16 After Carbon	5-Apr-95	1215	10.1	26	48	ND	ND	ND	ND	ND	ND	ND	NA	0.00

Note: ND - Not Detected

Chlorinated hydrocarbon removal/emission rates calculated as follows:

$$\text{Emission Rate(pounds/day)} = \frac{Q(\text{cfm}) \times C(\text{ppmv}) \times P(\text{atm}) \times V(L) \times 0.4719(\text{L/sec}) \times 86400(\text{sec/day}) \times 84.94(\text{g/mol}) \times 0.0022(\text{pound/g})}{R(\text{L-atm/mol-K}) \times T(K)}$$

$$= \frac{Q(\text{cfm}) \times C(\text{ppmv}) \times 0.0076}{0.082 \times T(K)}$$

Where:
- Q = Vapor volume flow rate
- C = Methylene chloride concentration
- P = Vapor pressure of 1 ppm methylene chloride (1EE-6 atm)
- V = Volume (1 Litre)
- R = Ideal gas constant (0.082 L-atm/mol-K)
- T = Vapor influent temperature

ATTACHMENT A

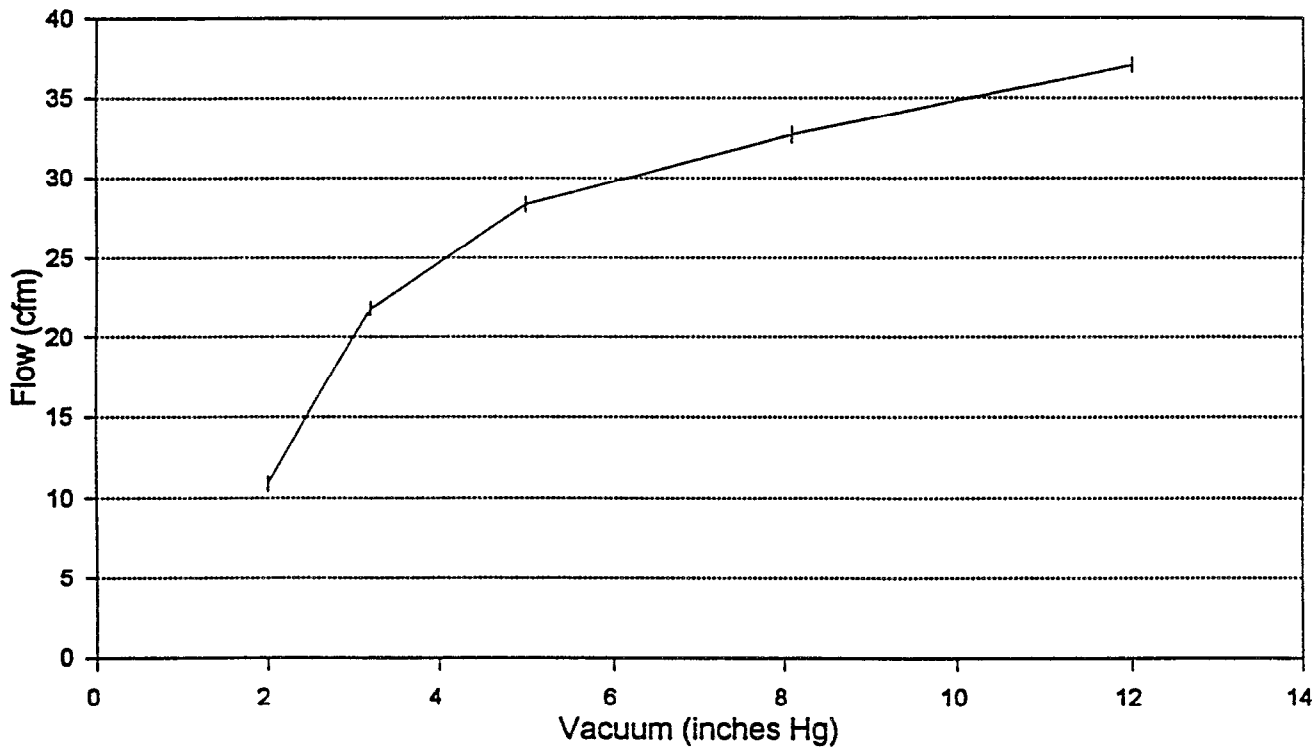
System Head Test Data and Graphs

System Head Test - NFFW-4

Navy Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

VACUUM (in Hg)	Velocity (fpm)	Flow Rate (cfm)
12	1700	37.06
8.1	1500	32.70
5	1300	28.34
3.2	1000	21.80
2	500	10.90

Naval Air Station Willow Grove
System Head Test - NFFW-4



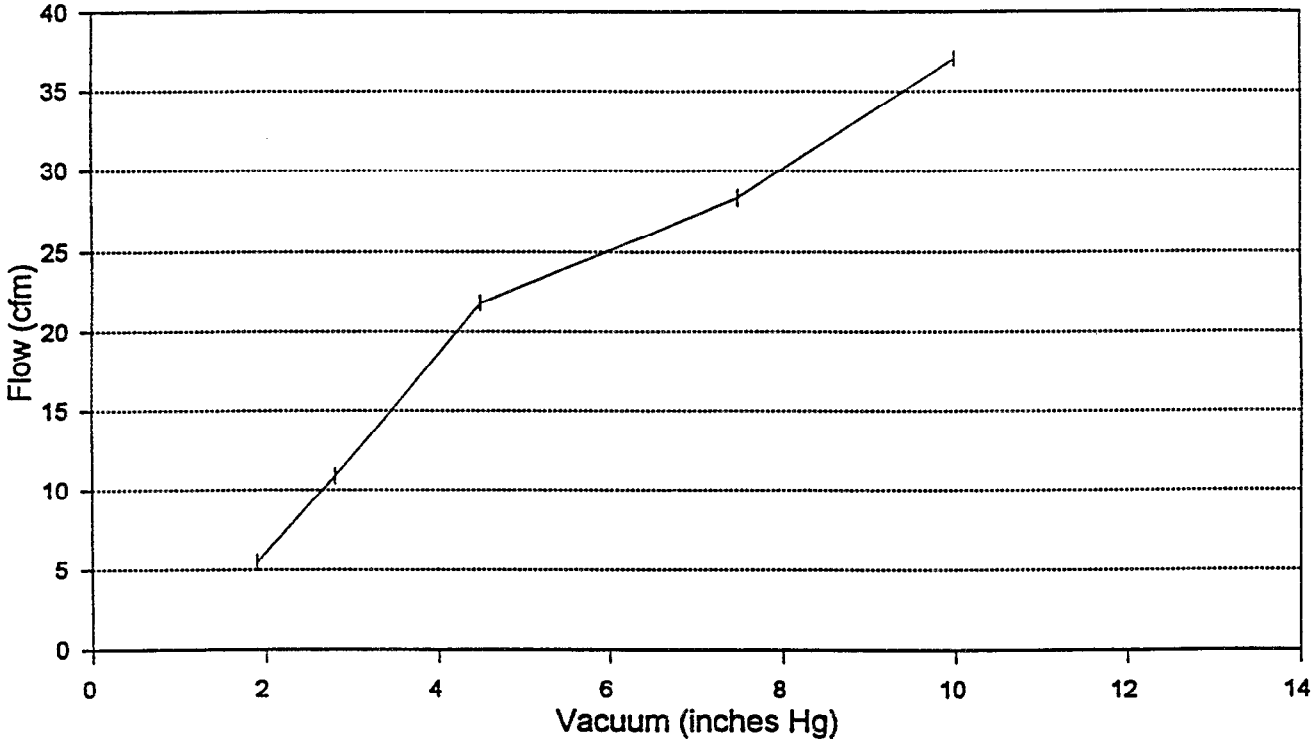
System Head Test - NFFW-7

Navy Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

VACUUM (in Hg)	Velocity (fpm)	Flow Rate (cfm)
10	1700	37.06
7.5	1300	28.34
4.5	1000	21.80
2.8	500	10.90
1.9	250	5.45

Naval Air Station Willow Grove

System Head Test - NFFW-7

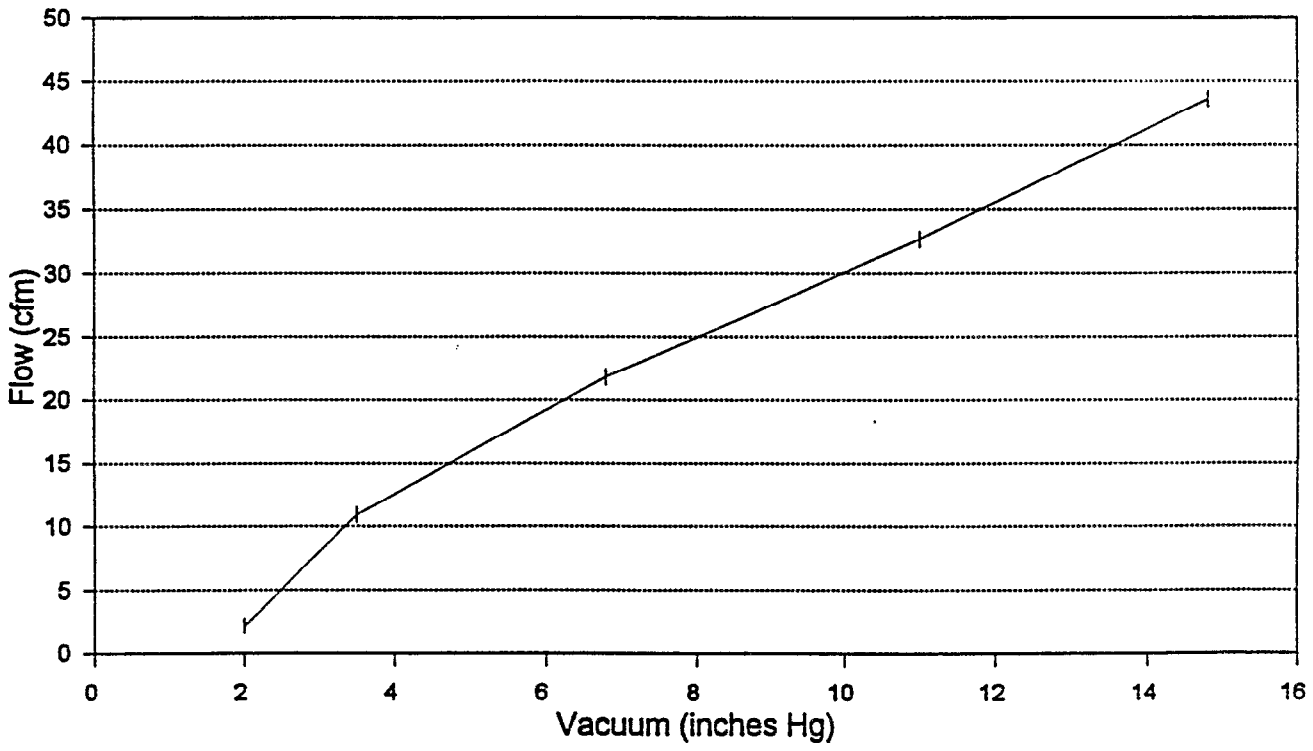


System Head Test - NFFW-16

Navy Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

VACUUM (in Hg)	Velocity (fpm)	Flow Rate (cfm)
14.8	2000	43.60
11	1500	32.70
6.8	1000	21.80
3.5	500	10.90
2	100	2.18

Naval Air Station Willow Grove
System Head Test - NFFW-16



APPENDIX E

RESULTS OF SOIL VAPOR EXTRACTION TEST (July 1995)

RESULTS OF SOIL VAPOR EXTRACTION TESTS - 6 JULY 1995

1.0 INTRODUCTION

This report presents the results of the second soil vapor extraction (SVE) tests conducted 6 July 1995 at the Naval Fuel Farm Facility, Naval Air Station Willow Grove, Horsham Township, Pennsylvania. These tests were conducted during a period of low water table elevation. The first SVE tests were performed on 6 April 1995 during high water table conditions. Results of the April 1995 testing were issued in a letter report dated 31 May 1995. The second tests were conducted in order to evaluate the potential for SVE during low water table conditions. The tests, as outlined in the Revised Work Description dated 22 February 1995, included both system head and radial influence tests on wells NFFW-4 and NFFW-16. NFFW-7, which was tested in April 1995, was not tested a second time because it had been damaged during the removal of the soil piles from the surrounding area. The well casing had been cracked and would allow ambient air to enter the well from the surface when a vacuum was applied. NFFW-4 and NFFW-16 were chosen to assess SVE performance in areas with varying amounts of free phase product. Product has not been observed in NFFW-4 and has been consistently present in NFFW-16. The well locations are indicated on the Site Plan in Figure 1. The following describes the testing and data collection methodologies and presents the testing and sample analyses results.

Soil vapor extraction is a widely used remedial technique capable of removing volatile organic compounds (VOC) from the subsurface. In this process, a vacuum is applied to an extraction well inducing air flow through the vadose zone. As air moves through the soil, residual phase VOC are volatilized and removed from the subsurface through the extraction well.

In order to effectively assess the applicability of SVE as a remedial technology in the areas surrounding wells NFFW-4 and NFFW -16, two separate SVE tests were conducted. These tests were designed to evaluate the relationships between (1) applied vacuum and extracted air flow rate and (2) applied vacuum and radial influence. VOC concentration and removal rates were also characterized as part of the radial influence test.

2.0 TESTING METHODOLOGY

The testing was conducted utilizing a mobile vent trailer. The trailer consists of a vacuum pump equipped with a moisture separator, activated carbon treatment canisters, flow and vacuum gauges, and sample ports. The vacuum extraction system is shown schematically in Figure 2.

2.1 System Head Test

Individual system head tests were conducted on each of the two test wells in order to develop site specific relationships between applied vacuum and extracted air flow rate. The tests were conducted by applying different extraction vacuums to the well in a increasing stepped manner. Each vacuum was applied until the corresponding flow rate stabilized, this occurred within approximately 15 minutes in each case. Once the flow rate stabilized, a different vacuum was applied and the test was repeated. System head tests were conducted before radial influence tests.

2.2 Radial Influence Test

Radial influence tests were used to measure the radial distance influenced by the applied vacuum at the extraction well and to assess VOC removal rates. The radius of influence was measured by installing six soil vapor probes into the subsurface at various distances in two directions from the extraction well. The distances and orientation of the probes are indicated in Figures 3 and 4, for the tests conducted from wells NFFW-4 and NFFW-16, respectively. The 0.75-inch diameter soil vapor probes were driven to a depth of approximately 5 to 8 feet below grade and fitted with gauges capable of sensing changes in soil air pressure. During each test a constant vacuum, determined from the system head test, was applied to the extraction well for approximately two hours and the induced vacuum on the soil vapor probes was recorded regularly. Vapor flow rate, extraction pressure and temperature were also recorded throughout the test.

To assess VOC removal rates, samples of extracted soil vapor were collected approximately every 30 minutes and analyzed for petroleum range and chlorinated hydrocarbons. The samples were analyzed onsite with EA's mobile field gas chromatograph. The analysis results and the extraction air volume flow rate were utilized to assess the VOC mass removal rates associated with each test well.

3.0 RESULTS

3.1 System Head Test

The results of the system head test are contained and displayed graphically in Attachment A. The individual tests produced relationships between applied vacuum and observed flow rate consistent with the nature of the subsurface at the Naval Fuel Farm Facility. In general, the results indicate the area is characterized by a low permeability subsurface resulting in a high vacuum - low flow rate relationship. Applied vacuums ranged from 1 to 5 inches mercury (Hg) while observed flow rates ranged from 8.7 to 37.6 cubic feet per minute (cfm). In general, a higher flow rate was achieved in NFFW-4 than in NFFW-16 for the same applied extraction pressures.

3.2 Radial Influence Test

The radial influence tests produced varying results. Relationships between applied vacuum and radial influence for each test are summarized in Tables 1 and 2 for wells NFFW-4 and NFFW-16, respectively. The tests on wells NFFW-4 and NFFW-16 were conducted at extraction pressures of 4 inches Hg with corresponding average flow rates of 37 and 16 cfm respectively. In general, the greater radial influence was observed from well NFFW-16 and minimal radial influence was present in the vicinity of well NFFW-4. The effective zone of radial influence about each well, which is defined as the area within a differential pressure of 0.10 inches of water (Brown *et al.* 1991; Keech 1989), is approximately 5 ft for NFFW-4 and 25 ft for NFFW-16. This estimate is based on an observed vacuum of 0.1 inches of water in the monitoring points.

The analytical results of petroleum and chlorinated hydrocarbon analyses, along with corresponding vacuum, flow rate, and influent air stream temperature readings, are summarized on Tables 3 and 4, respectively. Table 3 also includes the estimated petroleum and total VOC removal rates while Table 4 also includes the estimated chlorinated VOC removal rates. Tables 3 and 4 also include the results of one treated (after carbon) effluent sample per test. The results of this sample were non detect. The effluent sample was collected to demonstrate effective treatment of the air emissions was attained during the SVE tests.

Petroleum VOC removal rates in pounds per day were calculated for each sample collected based on total petroleum hydrocarbons (TPH) as toluene equivalents; the equation used is given in Table 3. Extraction from well NFFW-16 produced the highest average petroleum hydrocarbon removal rate (1.0 pound per day) while extraction from well NFFW-4 resulted in a minimal average removal rate of less than 0.05 pounds per day.

The results of the chlorinated hydrocarbon analysis indicated the presence of several target compounds in samples from NFFW-4 while samples from NFFW-16 contained no detectable

level of chlorinated hydrocarbons. The occurrence of chlorinated hydrocarbons in NFFW-4 is not consistent with the occurrence of free product as NFFW-4 is in an area where free product has not been detected. The most prevalent chlorinated hydrocarbon present in the extracted air samples from NFFW-4 was methylene chloride which was detected at a maximum concentration of 25 parts per million by volume (ppmv). The maximum total VOC removal rate at NFFW-4, which includes both petroleum and chlorinated VOCs, was 0.26 pounds per day..

4.0 DISCUSSION

The results of the second SVE test are summarized below followed by a comparison of the first and second SVE test results. Recommendations based on the second SVE test are also presented.

The results of the second SVE test are summarized as follows:

- Applied vacuums during the system head test from NFFW-4 ranged from 1 to 4 inches Hg at observed flow rates of 17.5 to 37.6 cfm while applied vacuums during the system head test from NFFW-16 ranged from 1 to 5 inches Hg at observed flow rates of 8.7 to 18.5 cfm (NFFW-16).

- The effective zone of radial influence about each well was estimated at approximately 5 ft for NFFW-4 and 25 ft for NFFW-16.

- Extraction from well NFFW-4 resulted in an average petroleum hydrocarbon removal rate of less than 0.05 pounds per day while extraction from well NFFW-16 resulted in an average removal rate of 1.0 pound per day.

- Chlorinated hydrocarbons, mainly methylene chloride, were detected in samples from NFFW-4 while samples from NFFW-16 contained no detectable level of chlorinated hydrocarbons.

A comparison of the two SVE tests is presented below:

- Flow rates for NFFW-4 were consistent with those found in April but extraction pressures were significantly less to achieve the same flow rate, 12 in. Hg in April and 4 in. Hg in July to achieve the same flow of 37 cfm. NFFW-16 exhibited significantly lower flow rates in July (18.5 cfm) than in April (44 cfm). Noting that the same vacuum extraction blower was utilized during both tests, the maximum achievable extraction pressure was also significantly less during July (4 in. Hg) than in April (18 in. Hg).

- The radial influence tests indicate a significant difference in radial influence between NFFW-4 (5 ft) and NFFW-16 (25 ft). These results are similar to those found during the April vent test with the exception of these results were more symmetrical for the two axis. The results of the April investigation indicate that the radial influence was not symmetrical.

- Average petroleum hydrocarbon removal rates (<1 pounds per day) were minimal during this testing event for both wells tested. These removal rates were also less than those found during the April, (high water) testing event,

where the average petroleum hydrocarbon removal rate was 28 pounds per day.

The following presents recommendations based on the SVE testing results:

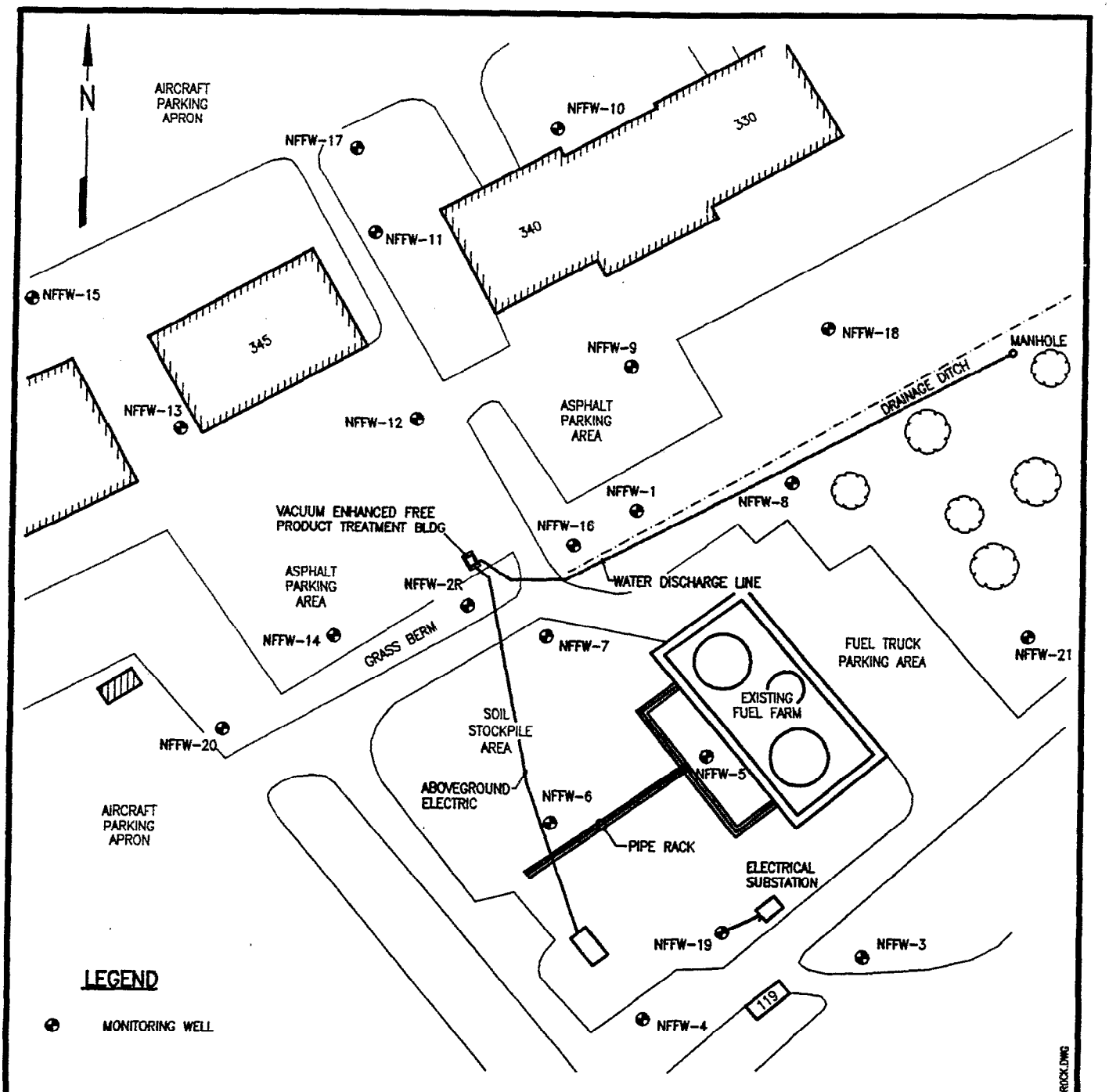
- The results of the second SVE test, as summarized above, indicate that SVE is not favorable during low water table conditions. As a result SVE from NFFW-4 and NFFW-16 for the sole purpose of soil vapor recovery during low water table conditions is not feasible and is therefore not recommended.

REFERENCES

Brown, R., C. Herman, and E. Henry. 1991. The Use of Aeration in Environmental Clean-Ups. HazTech International Pittsburgh Waste Conference. 14-16 May. Pittsburgh, Pennsylvania.

Keech, D.A. 1989. Surface Venting Research and Venting Manual by the American Petroleum Research Institute. Presented at the Workshop on Soil Vacuum Extraction, R.S. Kerr Environmental Research Laboratory. 27-28 April. Ada, Oklahoma.

FIGURES



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

150 75 0 150

GRAPHIC SCALE IN FEET

APPROXIMATE SCALE

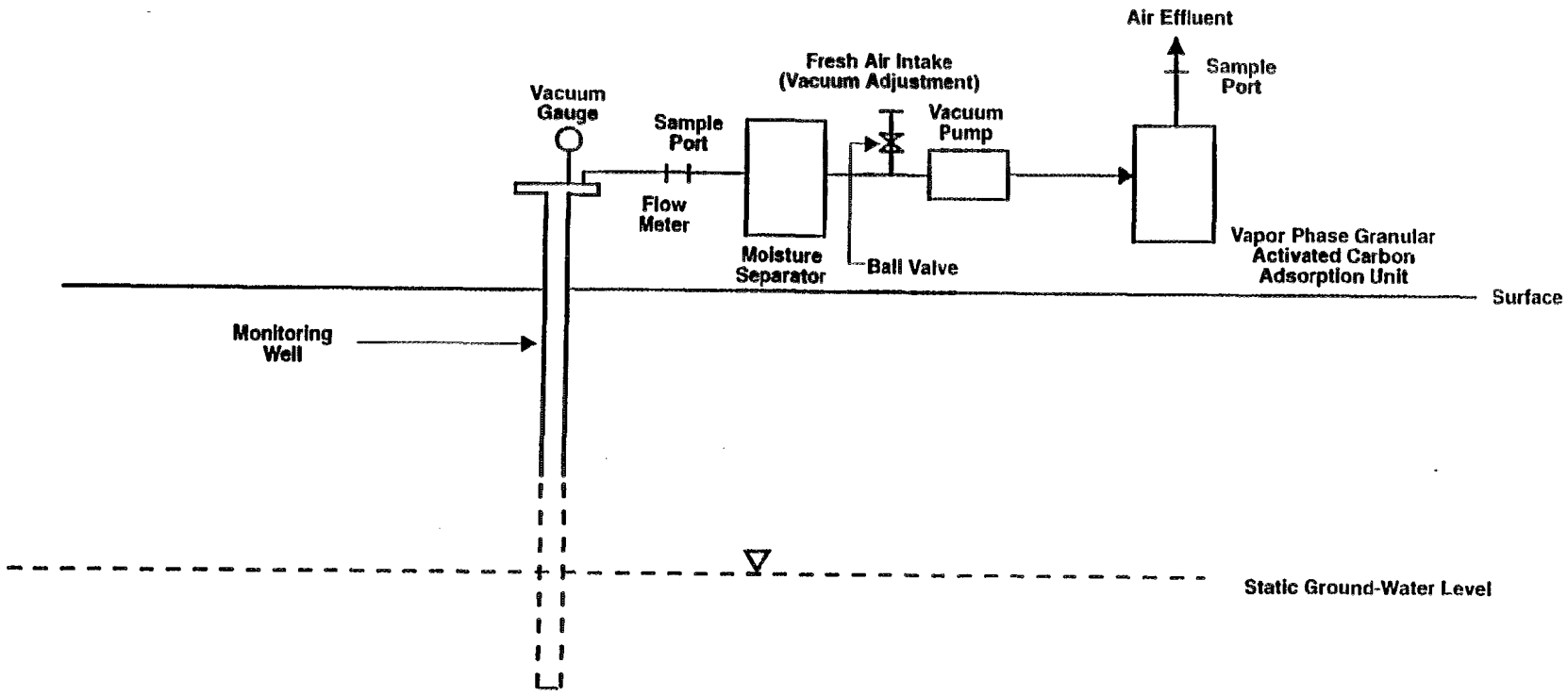
FILE: F:\29600.09\DWG2\BEDROCK.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

SITE PLAN

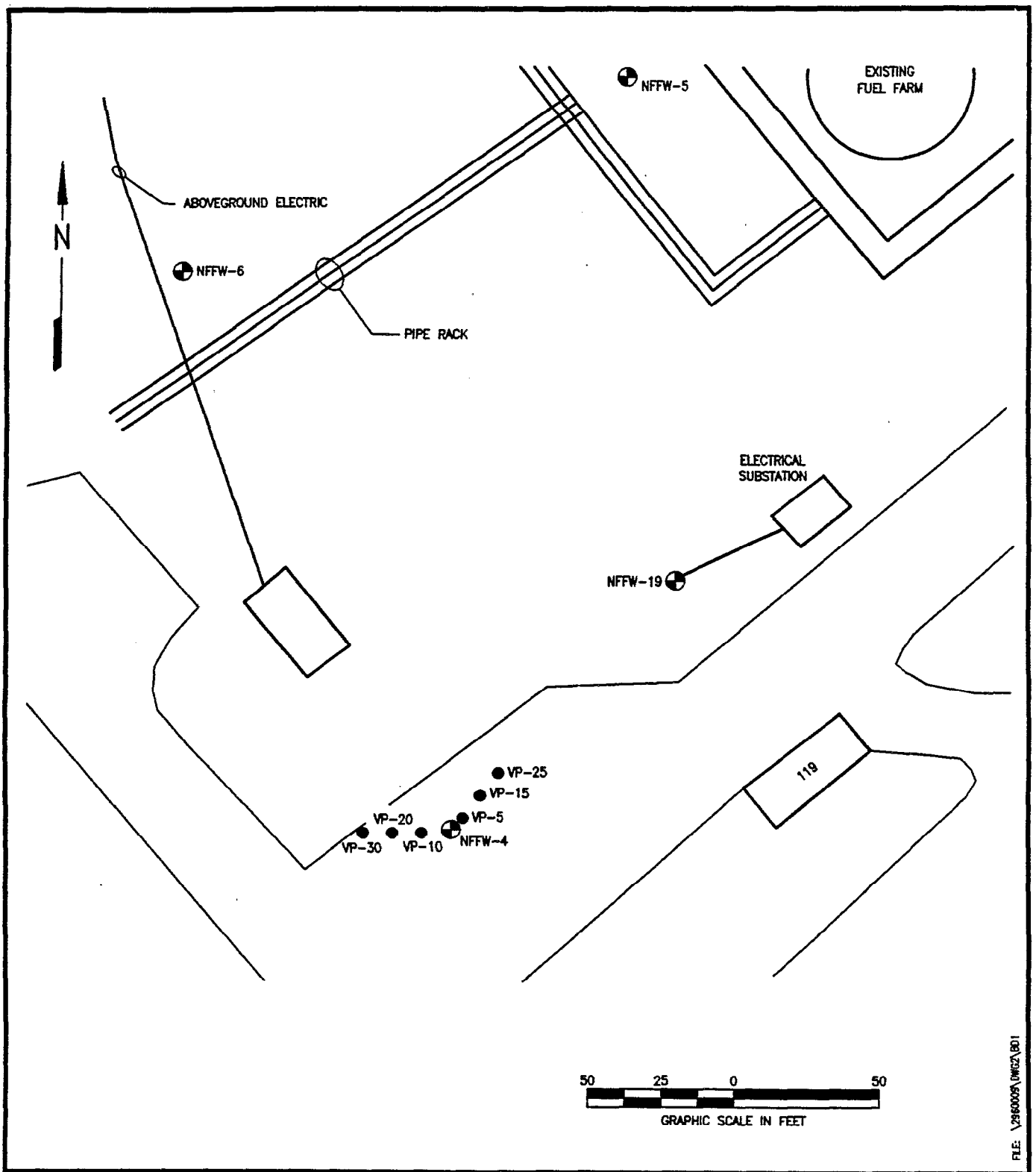
PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	BS	1"=150'	4-27-95	29600.09	1



Naval Fuel Farm Facility
Naval Air Station Willow Grove
Horsham Township, Pennsylvania

Figure 2. Soil vapor extraction test equipment schematic.

F:\2960009\Reports\Fig2.cdr

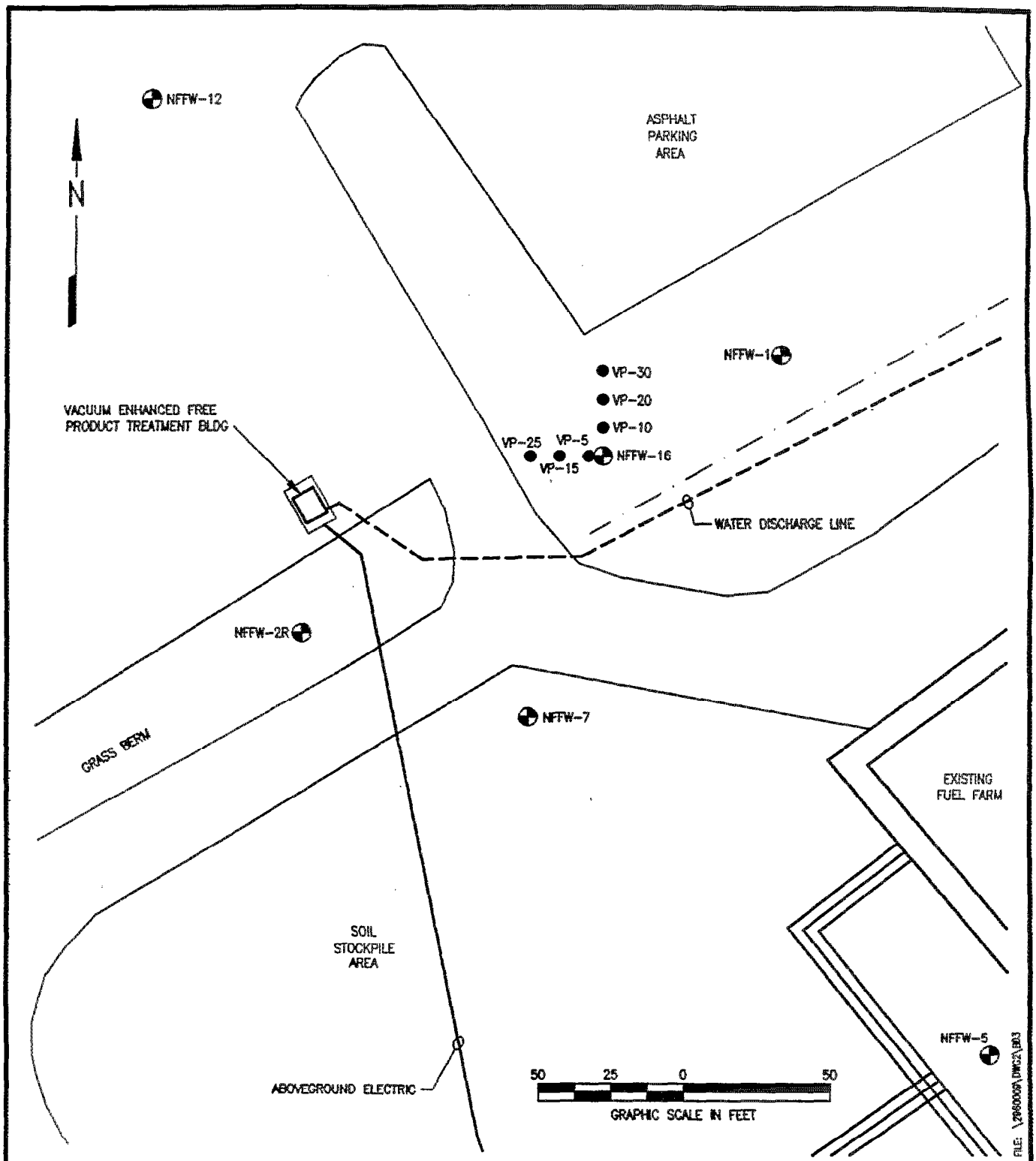


EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

LOCATION OF MONITORING POINTS DURING SVE TEST, FROM WELL NFFW-4 6 JULY 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	AMP	BS	1"=50'	5-30-95	29600.09	3



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

LOCATION OF MONITORING POINTS DURING SVE TEST, FROM WELL NFFW-16 6 JULY 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	AMP	BS	1"=50'	5-31-95	29600.09	4

TABLES

Table 1 - Radial Influence Test Results for NFFW-4. Observed Vacuums (in. H_2O) at Radial Distances (ft) During the SVE Test Performed on 6 July 1995, Navy Fuel Farm Facility, NAS Willow Grove.

Time (min)	Applied Vacuum (in. Hg)	Flow Rate (cfm)	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft
15	4	37	0.05	0.01	0.01	0.03	0.02	0.05
30	4	37	0.05	0.01	0.01	0.03	0.02	0.05
45	4	37	0.13	0.04	0.03	0.04	0.02	0.06
60	4	37	0.26	0.07	0.05	0.04	0.02	0.09
75	4	37	0.30	0.05	0.05	0.05	0.02	0.09
90	4	37	0.32	0.04	0.09	0.05	0.02	0.09
105	4	37	0.32	0.04	0.10	0.05	0.02	0.09
120	4	37	0.32	0.04	0.10	0.05	0.02	0.09
135	4	37	0.32	0.04	0.10	0.05	0.02	0.09

Table 2 - Radial Influence Test Results for NFFW-16. Observed Vacuums (in. H_2O) at Radial Distances (ft) During the SVE Test Performed on 6 July 1995, Navy Fuel Farm Facility, NAS Willow Grove.

Time (min)	Applied Vacuum (in. Hg)	Flow Rate (cfm)	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft
15	4	16.3	0.50	0.40	0.30	0.10	0.00	0.00
30	4	16.3	2.1	1.8	1.2	0.8	0.2	0.03
45	4	16.5	2.2	1.8	1.3	0.5	0.15	0.02
60	4	16.3	2.1	2.0	1.2	0.7	0.2	0.01
75	4	16.3	2.3	2.0	1.1	0.7	0.2	0.02
90	4	16.3	2.3	2.0	1.2	0.7	0.2	0.02
105	4	16.3	2.3	2.0	1.2	0.7	02	0.02
120	4	16.3	2.3	2.0	1.2	0.7	0.2	0.03
135	4	16.3	2.3	2.0	1.2	0.7	0.2	0.03

Table 3 - Summary of Petroleum Hydrocarbon Analyses of Extracted Soil Vapor During SVE Tests, 6 July 1995, Navy Fuel Farm Facility, NAS Willow Grove

Sample	Date	Time	Vacuum ("Hg)	Flow Rate (cfm)	Influent Temperature (C)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	M&P -Xylenes (ppmv)	O-Xylenes (ppmv)	TPH as Toluene Equivalents (ppmv)	TPH Removal Rate as Toluene Equivalents (pounds/day)	TPH Emission Rate as Toluene Equivalents (pounds/day)	Total VOC Emission Rate (b) (pounds/day)
NFFW-4	6-July -95	1047	4	37	82	ND	ND	ND	ND	ND	ND	0.00	NA	0.14
NFFW-4	6-July -95	1112	4	37	82	ND	ND	ND	ND	ND	ND	0.00	NA	0.23
NFFW-4	6-July -95	1142	4	37	82	ND	ND	ND	ND	ND	2	0.02	NA	0.26
NFFW-4	6-July -95	1220	4	37	82	ND	ND	ND	ND	ND	5	0.05	NA	0.26
NFFW-16	6-July -95	1440	4	16	84	9.9	23	8	ND	8.5	165	0.75	NA	0.75
NFFW-16	6-July -95	1534	4	16	84	15	54	ND	ND	7.8	234	1.06	NA	1.06
NFFW-16	6-July -95	1600	4	16	84	12	52	ND	ND	6.5	253	1.15	NA	1.15
NFFW-16	6-July -95	1635	4	16	84	19	61	ND	ND	8.3	220	1.00	NA	1.00
NFFW-16 After Carbon	6-July -95	1700	4	16	120	ND	ND	ND	ND	ND	ND	NA	0.00	0.00

Note *ND - Not Detected*

(a) - unable to quantify

(b) - includes total petroleum and chlorinated hydrocarbons

TPH emission rates calculated as follows

$$\text{Emission Rate(pounds/day)} = \frac{Q(\text{cfm}) \times C(\text{ppmv}) \times P(\text{atm}) \times V(L) \times 0.4719(L/\text{sec}) \times 86400(\text{sec/day}) \times 92.1(\text{g/mol}) \times 0.0022(\text{pound/g})}{R(\text{L-atm/mol-K}) \times T(K)}$$

$$= \frac{Q(\text{cfm}) \times C(\text{ppmv}) \times 0.0083}{0.082 \times T(K)}$$

Where Q = vapor volume flow rate

C = TPH concentration as toluene equivalents

P = Vapor pressure of 1 ppm toluene (1EE-6 atm)

V = Volume (1 Litre)

R = Ideal gas constant (0.082 L-atm/mol-K)

T = Vapor influent temperature

Table 4 - Summary of Chlorinated Hydrocarbon Analyses of Extracted Soil Vapor During SVE Tests, 6 July 1995, Navy Fuel Farm Facility, NAS Willow Grove

Sample	Date	Time	Vacuum ("Hg)	Flow Rate (cfm)	Influent Temperature (C)	Trichloroethane (ppmv)	Carbon Tetrachloride (ppmv)	Trichloroethene (ppmv)	Tetrachloroethylene (ppmv)	Methylene Chloride (ppmv)	Trans-1,2-Dichloroethene (ppmv)	Cis-1,2-Dichloroethene (ppmv)	Chlorinated Hydrocarbon Removal Rate (pounds/day)	Chlorinated Hydrocarbon Emission Rate (pounds/day)
NFFW-4	6-July -95	1047	4	37	82	ND	ND	ND	0.004	14	ND	ND	0.14	NA
NFFW-4	6-July -95	1112	4	37	82	ND	ND	ND	0.004	24	ND	ND	0.23	NA
NFFW-4	6-July -95	1142	4	37	82	ND	ND	ND	0.005	25	ND	0.04	0.24	NA
NFFW-4	6-July -95	1220	4	37	82	ND	ND	ND	0.002	22	ND	0.03	0.21	NA
NFFW-16	6-July -95	1440	4	16	84	ND	ND	ND	ND	ND	ND	ND	0.00	NA
NFFW-16	6-July -95	1534	4	16	84	ND	ND	ND	ND	ND	ND	ND	0.00	NA
NFFW-16	6-July -95	1600	4	16	84	ND	ND	ND	ND	ND	ND	ND	0.00	NA
NFFW-16	6-July -95	1635	4	16	84	ND	ND	ND	ND	ND	ND	ND	0.00	NA
NFFW-16 After Carbon	6-July -95	1700	4	16	120	ND	ND	ND	ND	ND	ND	ND	NA	0.00

Note: ND - Not Detected

Chlorinated hydrocarbon removal/emission rates calculated as follows:

$$\text{Emission Rate(pounds/day)} = \frac{Q(\text{cfm}) \times C(\text{ppmv}) \times P(\text{atm}) \times V(L) \times 0.4719(\text{L/sec}) \times 86400(\text{sec/day}) \times 84.94(\text{g/mol}) \times 0.0022(\text{pound/g})}{R(\text{L-atm/mol-K}) \times T(K)}$$

$$= \frac{Q(\text{cfm}) \times C(\text{ppmv}) \times 0.0076}{0.082 \times T(K)}$$

Where
- Q = Vapor volume flow rate
- C = Methylene chloride concentration
- P = Vapor pressure of 1 ppm methylene chloride (1EE-6 atm)
- V = Volume (1 Litre)
- R = Ideal gas constant (0.082 L-atm/mol-K)
- T = Vapor influent temperature

ATTACHMENT A

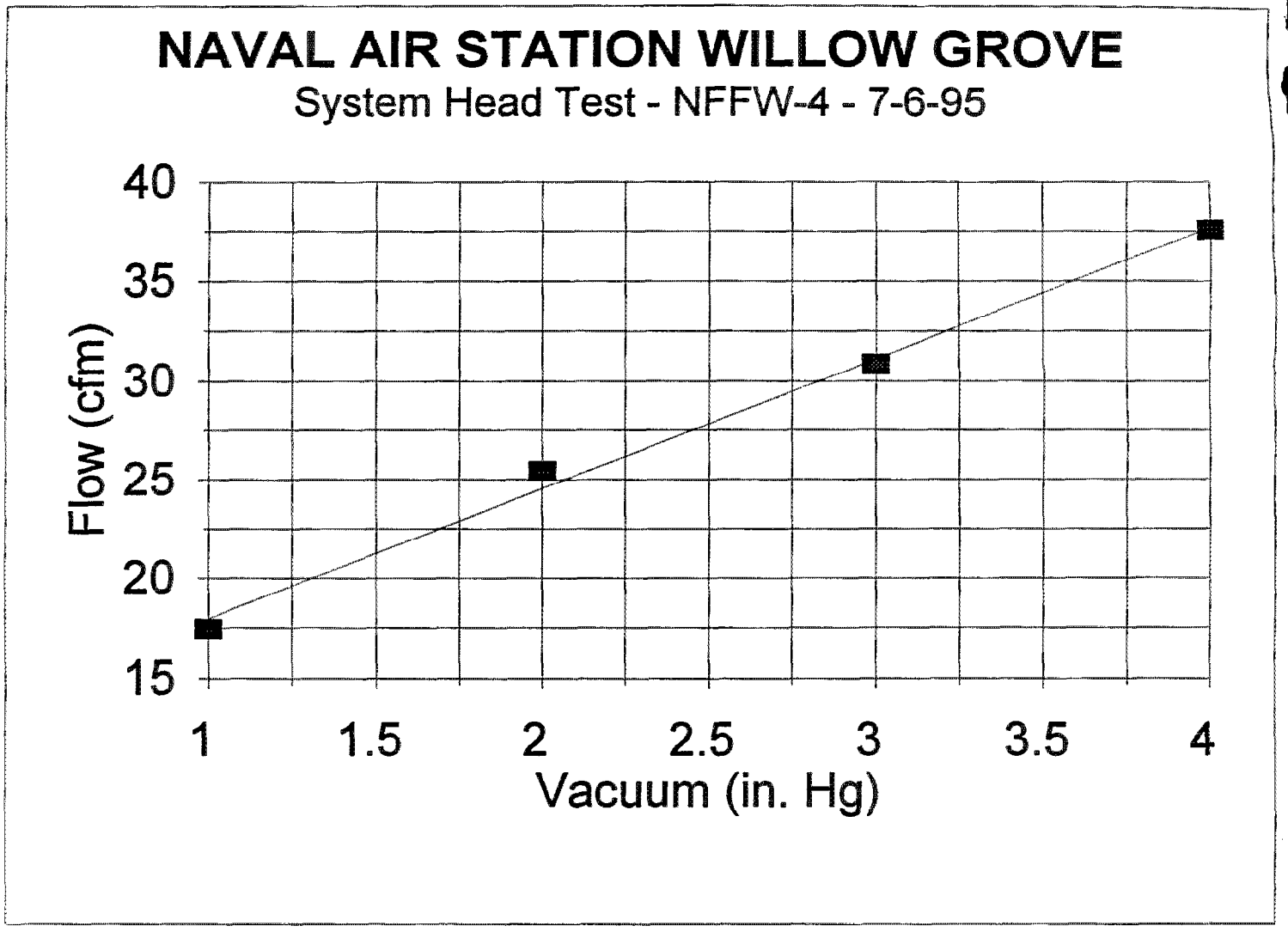
System Head Test Data and Graphs

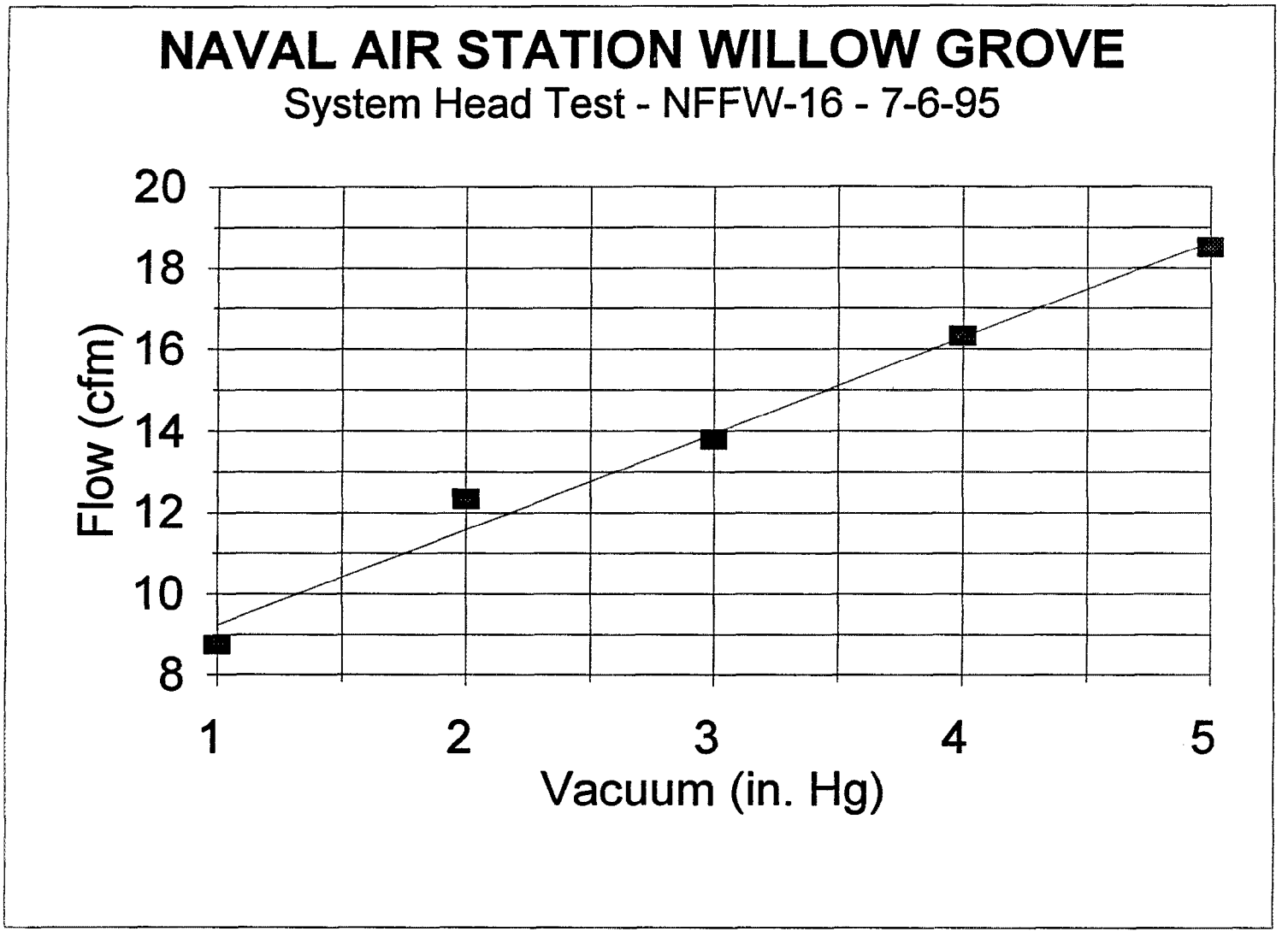
Results of System Head Test Performed on 6 July 1995 on NFFW-4. Navy Fuel Farm Facility, NAS Willow Grove.

Vacuum (in. Hg)	Velocity (fpm)	Flow Rate (cfm)
4	1723	37.6
3	1416	30.9
2	1168	25.5
1	801	17.5

Results of System Head Test Performed on 6 July 1995 on NFFW-16. Navy Fuel Farm Facility, NAS Willow Grove.

Vacuum (in. Hg)	Velocity (fpm)	Flow Rate (cfm)
5	849	18.5
4	749	16.3
3	633	13.8
2	566	12.3
1	401	8.7


NAVAL AIR STATION WILLOW GROVE
System Head Test - NFFW-4 - 7-6-95
Flow (cfm)
40
35
30
25
20
15
1
1.5
2
2.5
3
3.5
4
Vacuum (in. Hg)


NAVAL AIR STATION WILLOW GROVE
System Head Test - NFFW-16 - 7-6-95
Flow (cfm)
20
18
16
14
12
10
8
1
2
3
4
5
Vacuum (in. Hg)

APPENDIX F

HYDROGEOLOGICAL REPORT - 31 March 1995

EA Engineering, Science, and Technology

31 March 1995

Mr. Paul Briegel
c/o Commanding Officer, Northern Division
Naval Facilities Engineering Command
Mail Stop 82, Attn.: Code 4051/PB
10 Industrial Highway
Lester, Pennsylvania 19113-2090

RE: Contract No. N62472-92-D-1296, CTO No. 0009, NAS Willow Grove

Dear Mr. Briegel:

The primary purpose of this letter is to explain why EA feels it is not prudent to deepen well NFFW-2R by 20 ft. Secondly, it serves to present hydrogeological site conditions based on the data collected over the past year.

Issue of Deepening NFFW-2R

In EA's letter of 22 February 1995 which presented a revised work plan description, it was proposed that well NFFW-2R be deepened. At the time of this proposition EA requested additional hydrogeological information regarding the Naval Air Station from the Navy. The reports received were reviewed in conjunction with Fuel Farm data collected by EA to assess whether or not deepening NFFW-2R would create a possible cross-contamination situation. Based upon review of the RI report prepared by Halliburton NUS (Remedial Investigation Report for Sites 1, 2, 3, and 5, Naval Air Station, Willow Grove, Pennsylvania, February 1993, Vols. I and II), and the hydrogeology report prepared by Earth Data (Hydrogeologist's Report, Potable Water Treatability Study, Willow Grove Naval Air Station, August 1985); EA believes that if NFFW-2R is deepened approximately 20 ft, there would be the possibility of cross-contaminating the lower portion of the Stockton Formation which is utilized for onsite water supply. Following are pertinent geological and hydrological details about the Willow Grove site which aided in the determination.

NAS Willow Grove is underlain by the middle member of the Stockton Formation, which consists of interbedded shale, siltstone, and sandstone. Competent bedrock typically begins at depths ranging from 6 to 35 ft below ground surface. The overburden consists mainly of fill material, silt, and clay. The regional dip of the bedrock strata is approximately 12 degrees to the northwest.

The middle member is the most productive aquifer in the Stockton Formation. Two aquifer systems are present in the middle member - the water-table aquifer and the confined, artesian aquifer. Literature reports that the water table aquifer extends to a depth between 75 and 100 ft below ground surface at NAS Willow Grove. The water-table aquifer is capable of storing water which infiltrates from the surface and it acts as a reservoir that supplies the underlying artesian aquifer. Fully developed artesian conditions are generally encountered below 150 ft. A semi-artesian or semi-confining unit exists between the two. A drop in pressure in the artesian aquifer will induce a release of water from water-table storage through the semi-artesian zone. Water supply wells installed in the Stockton Formation in the vicinity of Willow Grove are generally set between 300 and 600 ft below ground surface. The two Navy water supply wells onsite at NAS Willow Grove are set at 398 ft (NW-1) and 352 ft (NW-2), respectively. Fractures within the bedrock are the primary providers of ground water. Due to fracture irregularity (in number, size, orientation, and connectedness), exactly determining ground-water conditions at depth is difficult.

Navy Fuel Farm well NFFW-2R is 35.5 ft deep. Deepening this well 20 additional feet would place it approximately 55 ft below ground surface. There are no wells at the Fuel Farm deeper than approximately 38 ft and therefore lithological logs are only available to that depth deeper. In order to determine likely lithological and hydrogeological conditions at roughly 55 ft, sources other than EA reports were reviewed.

The RI report prepared by Halliburton NUS in 1993 was reviewed. Although this report does not include any investigations at the Fuel Farm, work was conducted at the Privet Road site located approximately 0.25 miles northeast of the Fuel Farm. In addition to existing site wells, Halliburton installed intermediate wells at depths between 85 and 92 ft (10 ft screens), and shallow wells between 28 and 40 ft (20 ft screens). Under standard supply well pumping operations (which tend to be cyclical) of NW-1 and NW-2, the shallow water-table aquifer at the site flows toward the northwest and the deeper "confined" portion of the aquifer flows toward the east southeast or toward the production wells. Cyclical drawdown, mimicking supply well pumping, was observed in the intermediate wells. Minor fluctuations were noted in the shallow wells but did not coincide with the pumping cycles. During pumping tests conducted in production wells NW-1 and NW-2, a very strong response was observed in the intermediate wells. No observable drawdown in shallow wells was noted during the NW-2 test but a subdued response was noted in shallow wells during the NW-1 test. In one exception, a direct drawdown response was observed in one shallow well (PRW-4) while pumping NW-1. The subdued drawdown observed in most shallow wells indicates that some restricted inter-connection between the shallow and deeper portions of the aquifer exists. The direct drawdown response in PRW-4 indicates that in some cases significant transmissivity exists between the shallow and deeper aquifer zones. This occurrence, coupled with the fact that intermediate wells closer to the pumping wells did not always show the greatest drawdown, is indicative of an anisotropic fracture system.

The Hydrogeologist's Report prepared by Earth Data in 1985 was also reviewed. Earth Data conducted pumping tests on production wells which showed responses similar to the Halliburton aquifer testing - with the deeper wells being strongly influenced and the shallow wells showing subdued responses to the pumping. One exception to this was a strong response exhibited in MW-4, a shallow well (31.5 ft deep with 10 ft of screen) installed by Earth Data. Earth Data's conclusion was "This would indicate that the shallow aquifer is hydraulically interconnected with the deep aquifer".

As a result of this review, EA's assessment is that well NFFW-2R should not be deepened because of the possible risk of introducing contamination into the lower portion of the aquifer. The key reasons for this recommendation are:

1. There is no lithological information deeper than approximately 40 ft at the Fuel Farm. As a result, the lithology which will be encountered at approximately 55 ft is unknown. If the Halliburton logs are utilized, and a 55 ft depth at the Fuel Farm is correlated to the Privet Road site, the lithology encountered would most likely be sandstone/siltstone. Unfortunately at the Privet Road site, this is the same lithology logged from beneath the overburden to the depth of the intermediate wells (set approximately between 80 and 90 ft) which show a strong response to aquifer pumping. There is no way of knowing where the lithological transition zone from the water-table aquifer to the confined aquifer lies between these depths. Even if the lithology was known, there is no way of knowing the fractures which may or may not be encountered.

2. The Halliburton intermediate wells screened between 80 and 90 feet show a strong response to production well pumping, and the shallow wells, screened to depths between 20 and 40 feet generally showed only subdued responses (with a few exceptions showing stronger responses). The Earth Data report presented similar findings. Without additional investigative drilling/coring, there is no way to know where in the 40 ft to 80 ft interval, the transition to a direct response to supply well pumping would occur. At any rate, a subdued response in the shallow wells is reason enough to believe that there is some communication between the water-table aquifer and the confined aquifer.

3. Again, fractures pose a problem. Regardless of knowing the exact lithology and the depth of the "transition zone"; the irregularity of fractures and fracture systems (size , number, interconnectedness), would not allow one to state definitely that a well set to 55 ft would not be a conduit for contamination to lower depths via fractures.

Hydrogeological Site Conditions

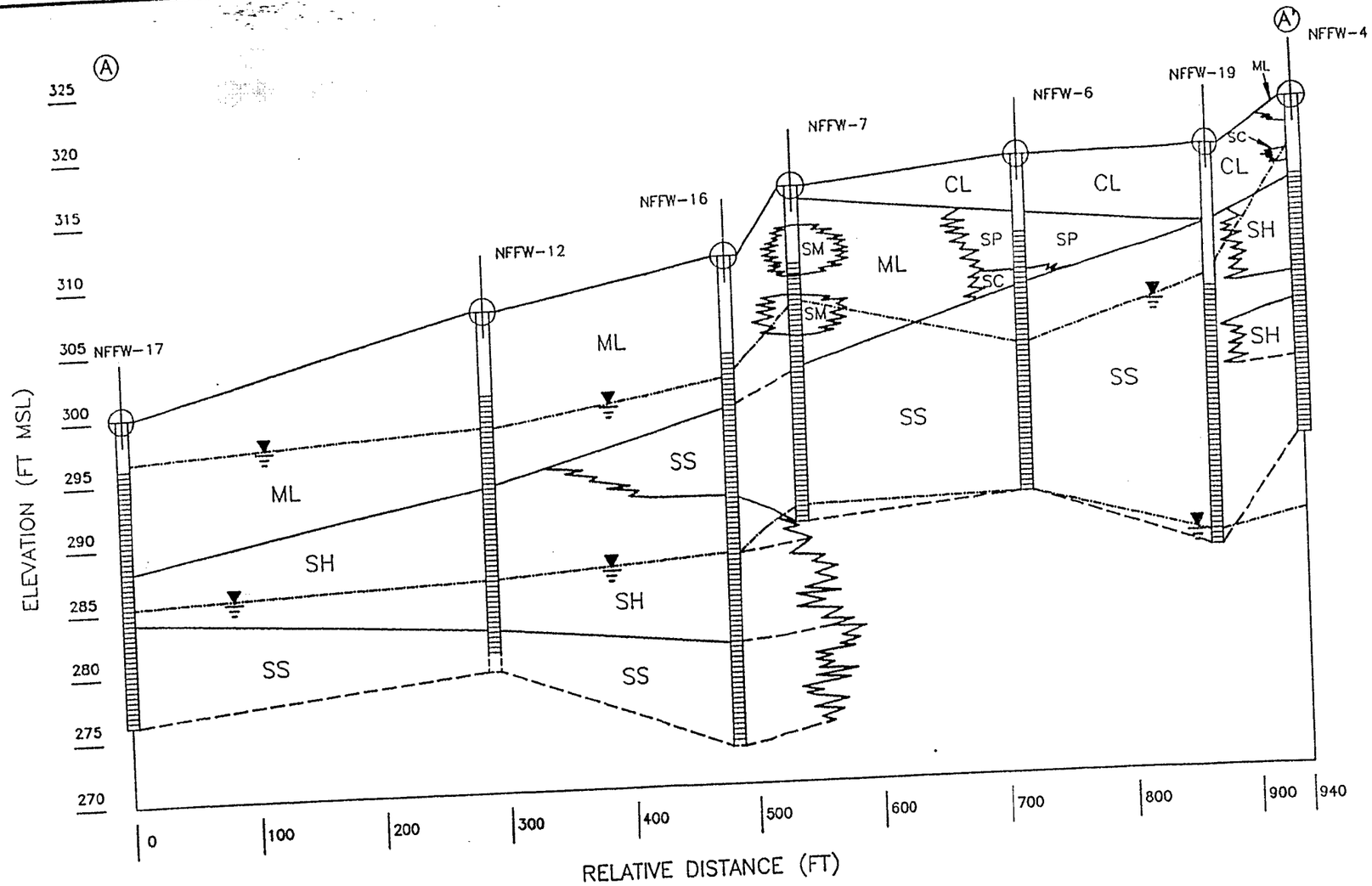
In order to characterize geological conditions at the Fuel Farm, two cross-sections were constructed. Figure 1 is a site map which shows the lines of section. Figures 2 and 3 represent cross-sections A-A' and B-B', respectively. An overburden isopach map (Figure 4) was also constructed to visually present the approximate thickness of unconsolidated sediment overlying the bedrock at the site.

Figures 5 through 14 represent potentiometric and product isopach maps for the dates of gauging ranging from 4 April 1994 to 4 January 1995. Each gauging date is represented by two maps. The first map is the potentiometric or ground-water elevation map, and the second is the product thickness or isopach map. These maps present a picture of the hydrogeological nature of the site. As evidenced from the maps, when the water-table elevation falls, the areal extent of product measurable in wells and the product thickness in wells increases at the site. During periods of low water-table elevation, product occurs over much of the site (NFFW wells 1, 2R, 6, 7, 12, 14, 16, 19, and 20). When the water-table elevation is high, as shown for example on the 4 April 1994 gauging event maps (Figures 5 and 6), fewer wells (in this case only NFFW-6) have an occurrence of product.

In summary, the hydrogeologic data indicate that as the water-table elevation decreases, the amount of free-phase product increases; both in aerial extent and in thickness of the product layer observed in individual wells. Furthermore, during very dry periods, the water table drops below the bottom of the recovery well. Based on the evaluation of pumping test data as presented above, we cannot rule out the possibility that deepening well NFFW-2R has the potential to cross-contaminate the lower portion of the aquifer which serves as the drinking water supply. As a result, deepening NFFW-2R is not recommended.

Continued Recovery Activities

Although taking the conservative approach of not deepening NFFW-2R reduces the potential of separate phase recovery during dry/low water-table elevation periods; the addition of the thermal oxidizer will allow continued recovery during those periods. The installation of the thermal oxidizer, as outlined in the revised work description letter dated 22 February 1995, will allow the vacuum-enhanced recovery system at NFFW-2R to be put back into operation in a more cost-efficient manner than with carbon absorption as previously used. The thermal oxidizer will enable the vacuum-enhanced recovery of petroleum hydrocarbons from the subsurface to continue even when the water table falls below the bottom of well NFFW-2R. As a result, remediation of the site can continue even during periods of low water-table elevation.



LEGEND

GP	GRAVEL/SAND
SP	POORLY GRADED SANDS/LITTLE FINES
SM	SAND
SC	CLAYEY SANDS
ML	SILT
CL	CLAY
SH	SHALE/SILT STONE
SS	SAND STONE

——— INTERPRETED LITHOLOGIC BOUNDARY (DASHED WHERE INFERRED)

- - - - INTERPRETED WATER-TABLE ELEVATIONS UNDER HIGH AND LOW WATER CONDITIONS.

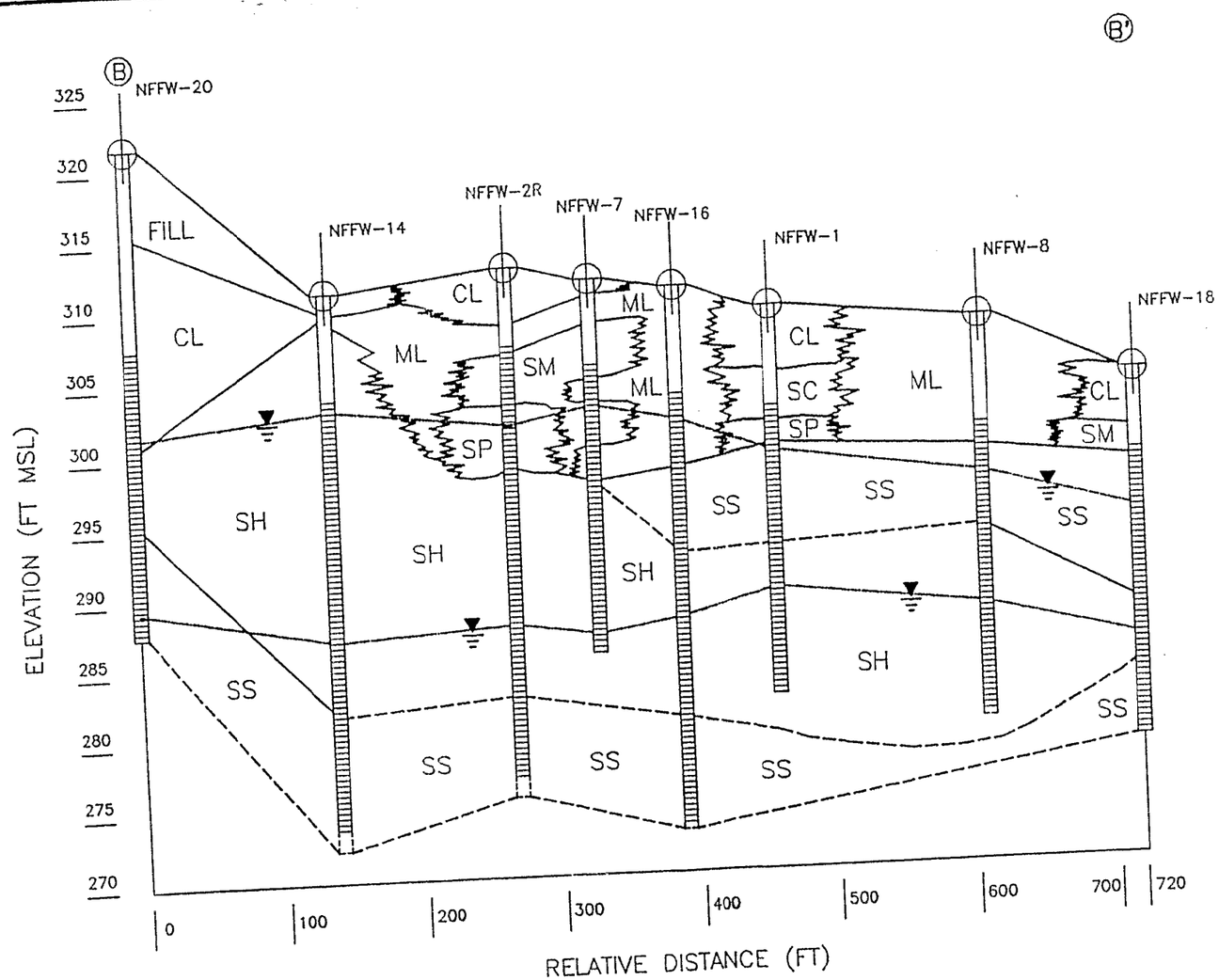
NOTE: HIGH WATER-TABLE ELEVATIONS BASED ON 04 APRIL 1994 GAUGING DATA.
LOW WATER-TABLE ELEVATIONS BASED ON 25 OCTOBER 1994 GAUGING DATA.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

INTERPRETED GEOLOGIC CROSS-SECTION
FOR TRANSECT LINE A-A'

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
SC	CJV/PMH	12-21-94	29600.09	XSECTAA
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
CR	CR	NONE	-	2



LEGEND

GP	GRAVEL/SAND
SP	POORLY GRADED SANDS/LITTLE FINES
SM	SAND
SC	CLAYEY SANDS
ML	SILT
CL	CLAY
SH	SHALE/SILT STONE
SS	SAND STONE

——— INTERPRETED LITHOLOGIC BOUNDARY (DASHED WHERE INFERRED)

——— INTERPRETED WATER-TABLE ELEVATIONS UNDER HIGH AND LOW WATER CONDITIONS.

NOTE: HIGH WATER-TABLE ELEVATIONS BASED ON 04 APRIL 1994 GAUGING DATA.
LOW WATER-TABLE ELEVATIONS BASED ON 25 OCTOBER 1994 GAUGING DATA.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

INTERPRETED GEOLOGIC CROSS-SECTION
FOR TRANSECT LINE B-B'

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
SC	CJV/PMH	12-21-94	29600.09	XSECTBB
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
CR	CR	NONE	-	3

Please contact either of the undersigned at (410) 771-4950 if you have any questions or comments regarding this letter.

Sincerely,

Terri B. Lindsay

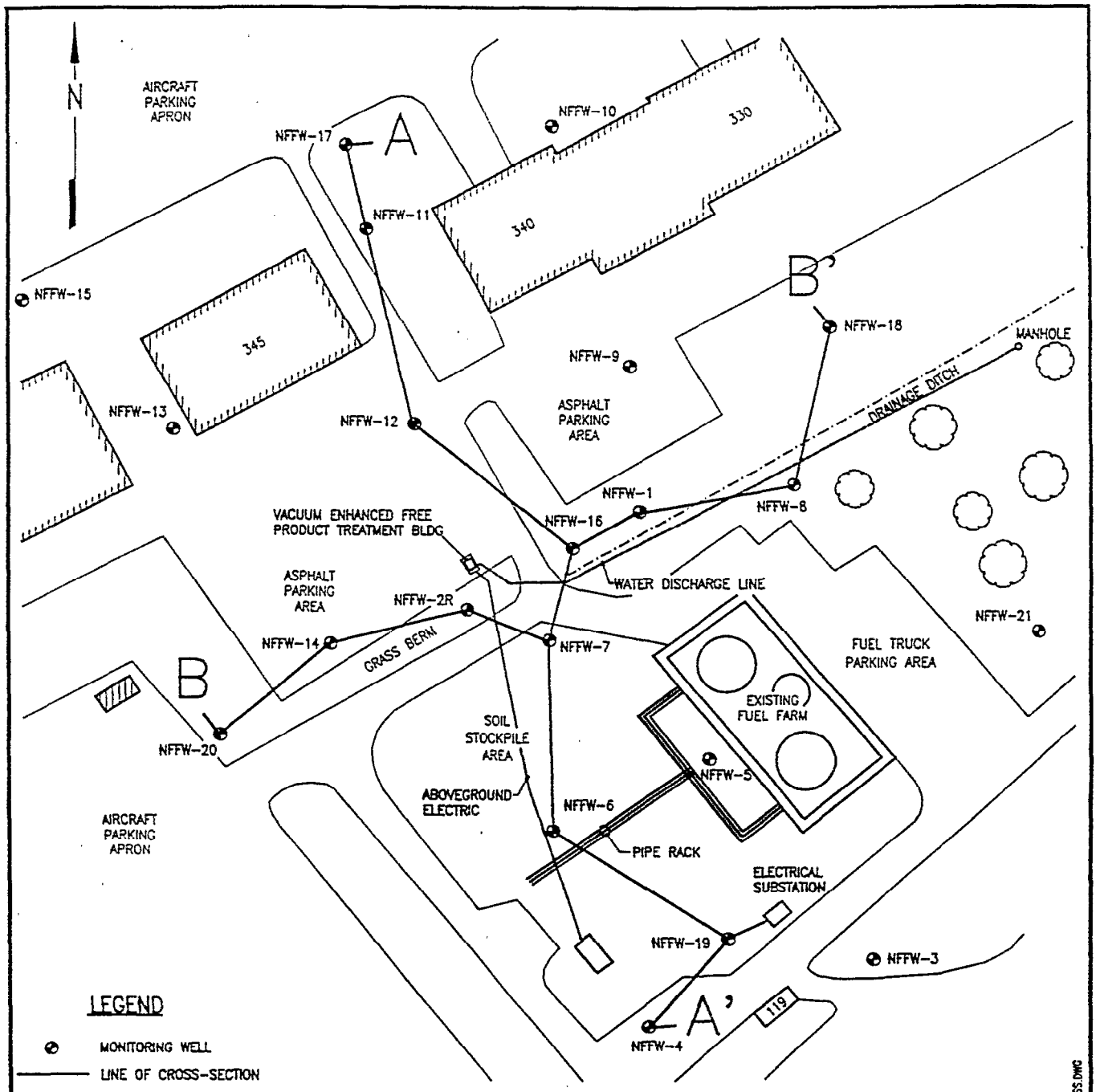
Terri B. Lindsay
Geologist

Carl G. Reitenbach

Carl G. Reitenbach, P.E.
CTO Manager

cc: P. Greco, NAS Willow Grove
J. Colter, North Div
C. Houlik, EA
S. Morekas, EA
B. Parnella, EA

f:\2960009\letters\Briegel.395



NOTE:

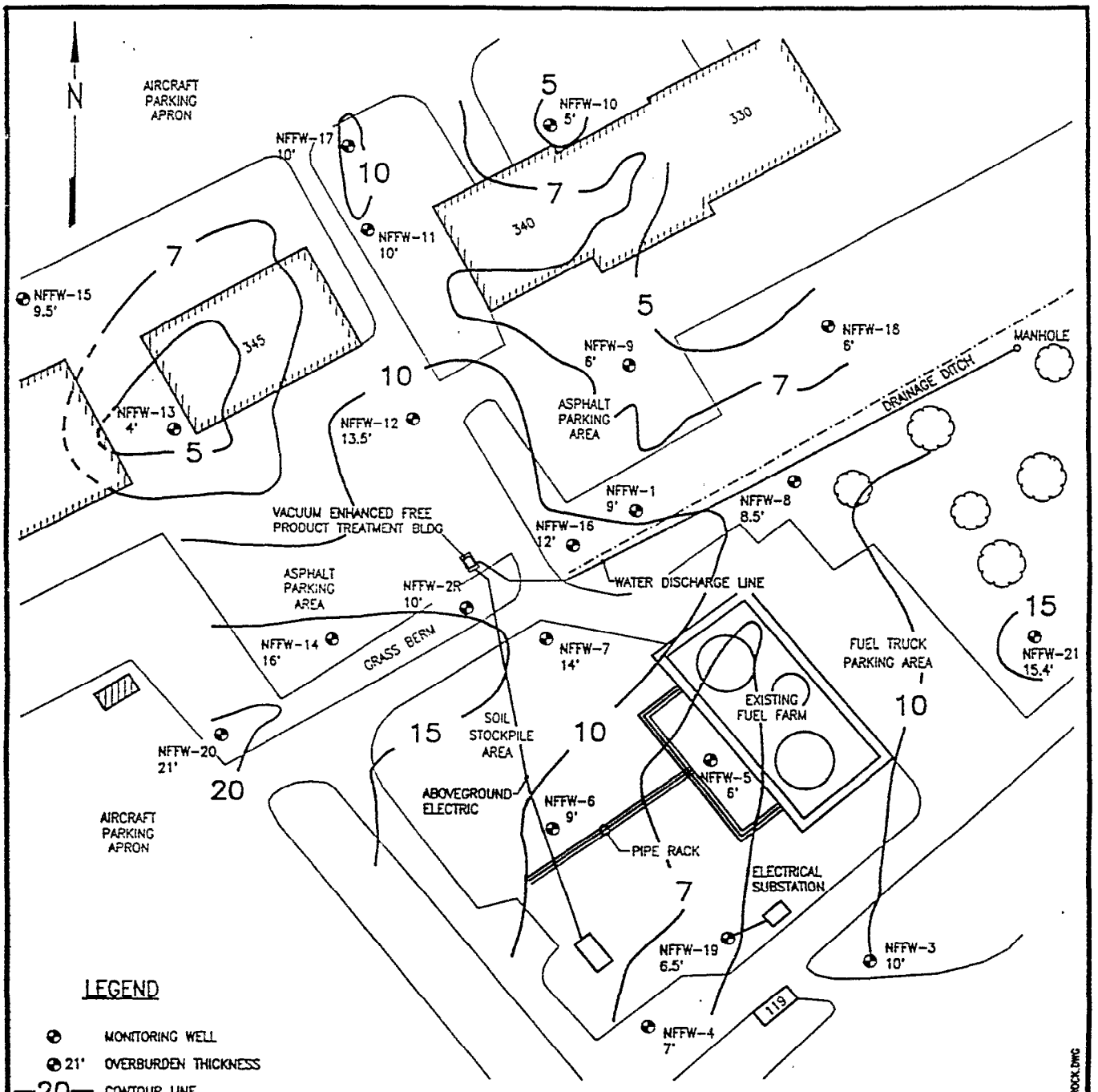
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

150 75 0 150

GRAPHIC SCALE IN FEET
APPROXIMATE SCALE

FILE: F:\29600.09\DWG2\CROSS.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.			NAVY FUEL FARM FACILITY NAVAL AIR STATION WILLOW GROVE, PENNSYLVANIA			LINES OF GEOLOGIC CROSS SECTION	
PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	12-21-94	29600.09	1



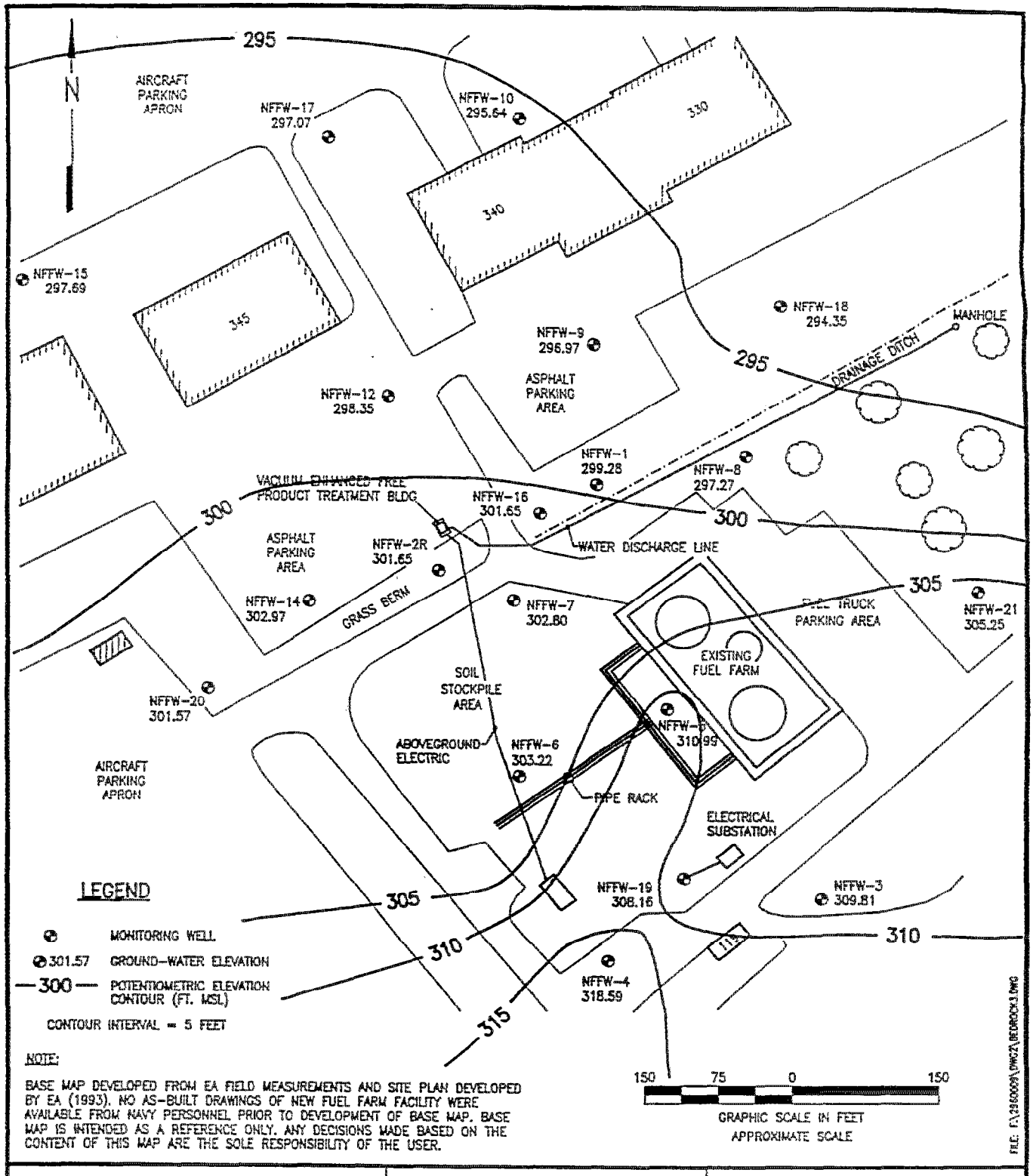
NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

FILE: F:\29600009\DWG2\BEDROCK.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	NAVY FUEL FARM FACILITY NAVAL AIR STATION WILLOW GROVE, PENNSYLVANIA	OVERBURDEN THICKNESS

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	4



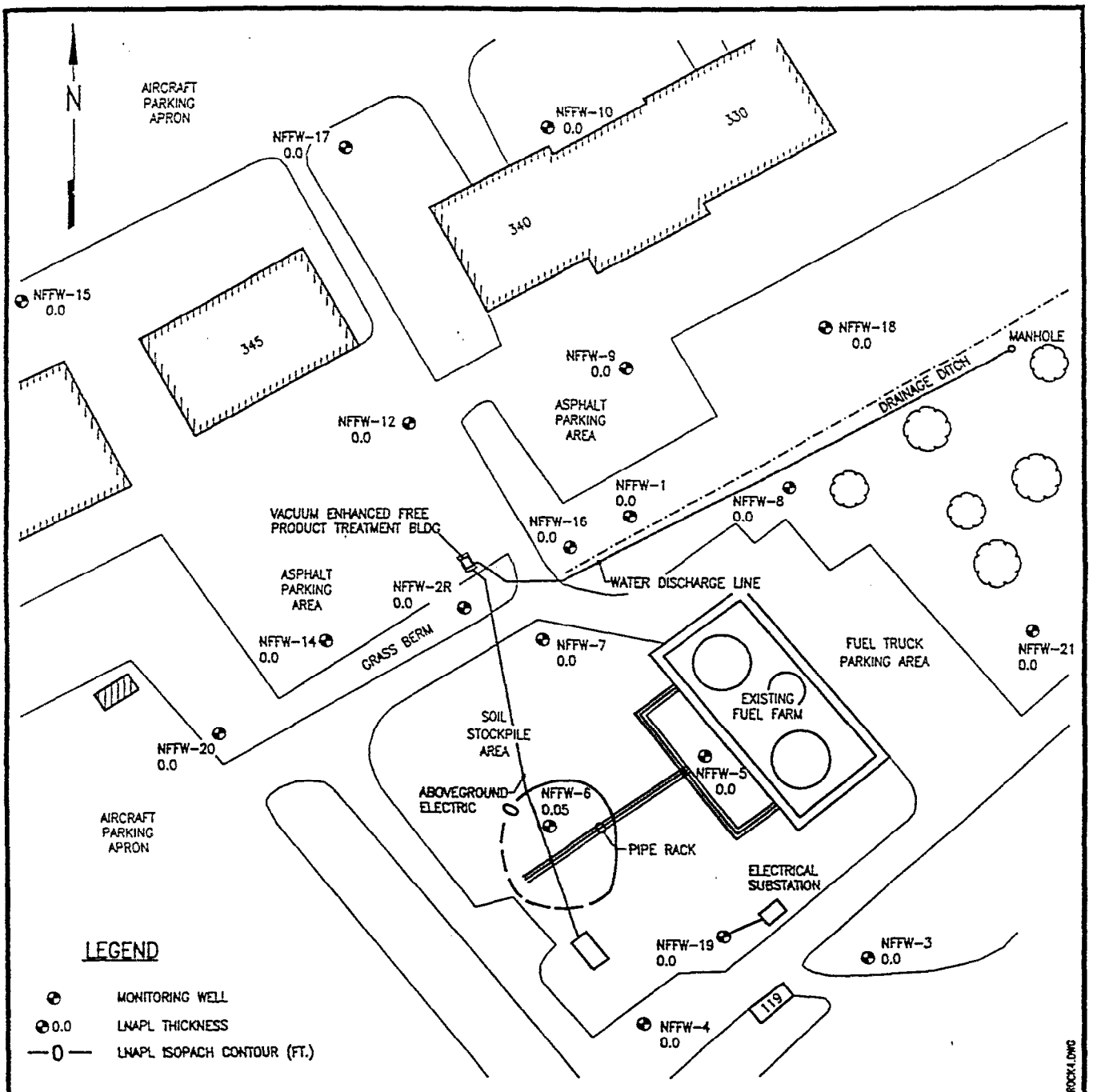
NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

FILE: F:\29600009\DWG2\BEDROCK3.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	NAVY FUEL FARM FACILITY NAVAL AIR STATION WILLOW GROVE, PENNSYLVANIA	POTENTIOMETRIC SURFACE 4 APRIL 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	5



NOTE:

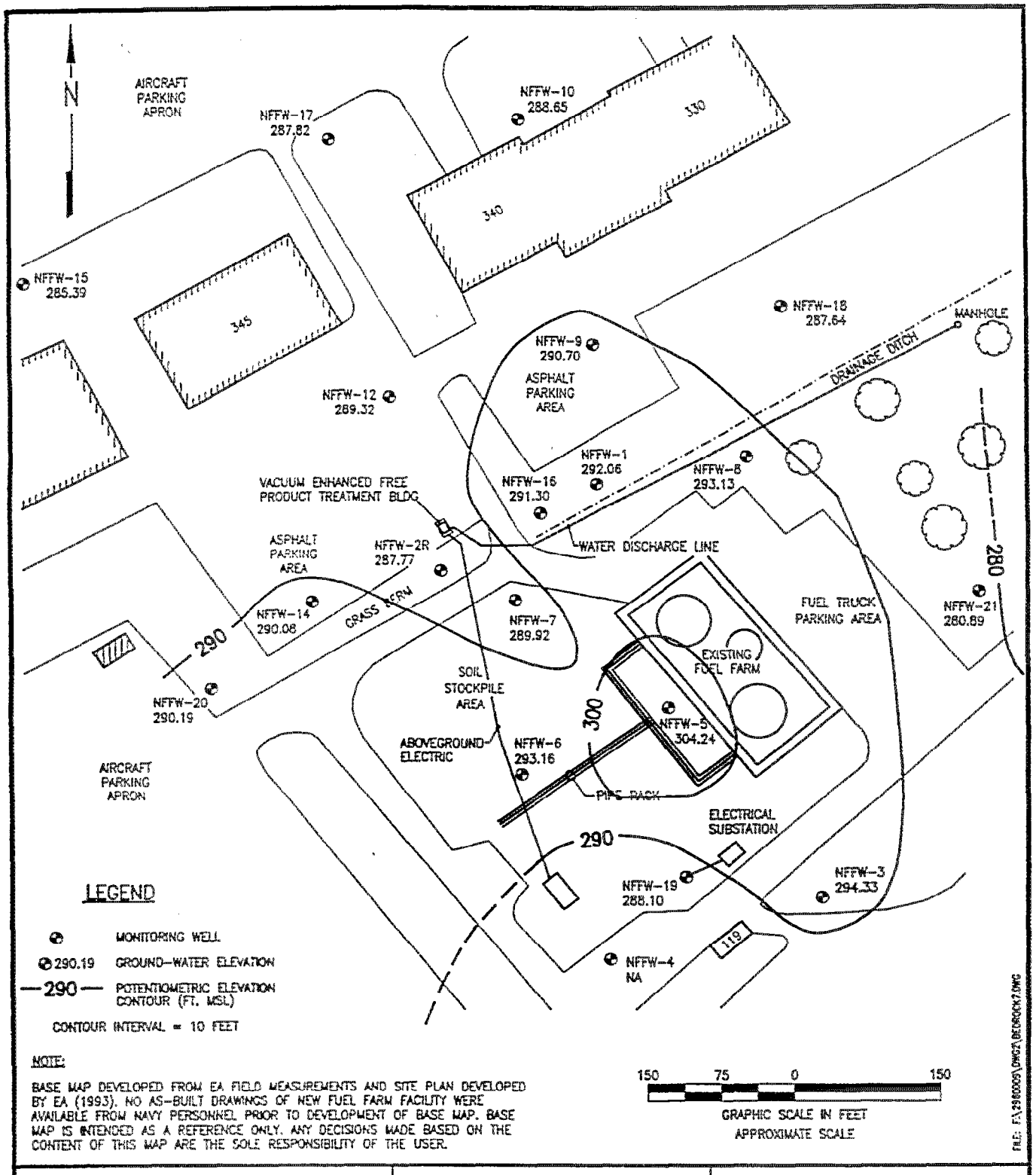
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
4 APRIL 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	6



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

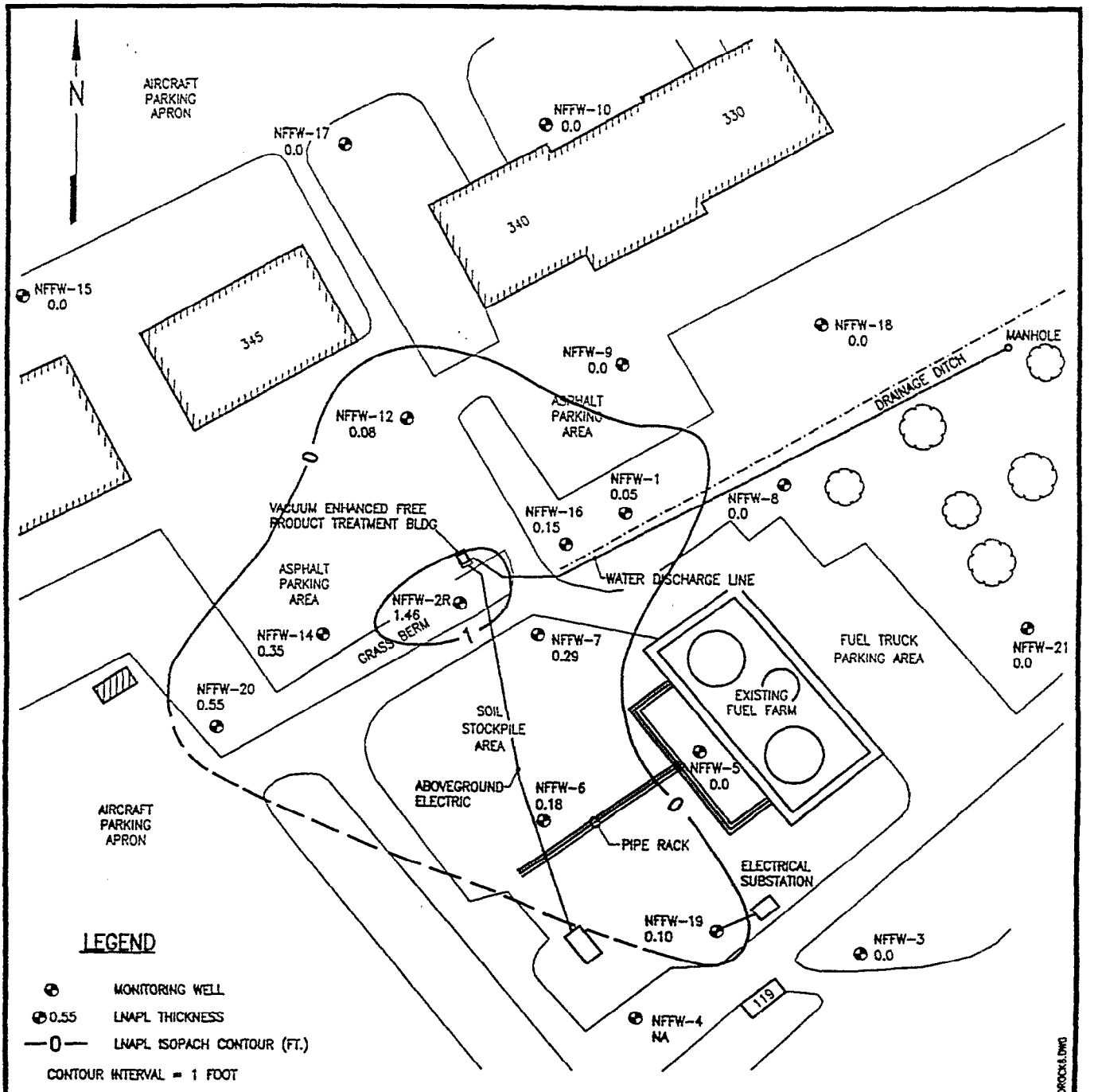
FILE: F:\29600009\DWGS\BEDROCK1.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

POTENTIOMETRIC SURFACE
1 JULY 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	7



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

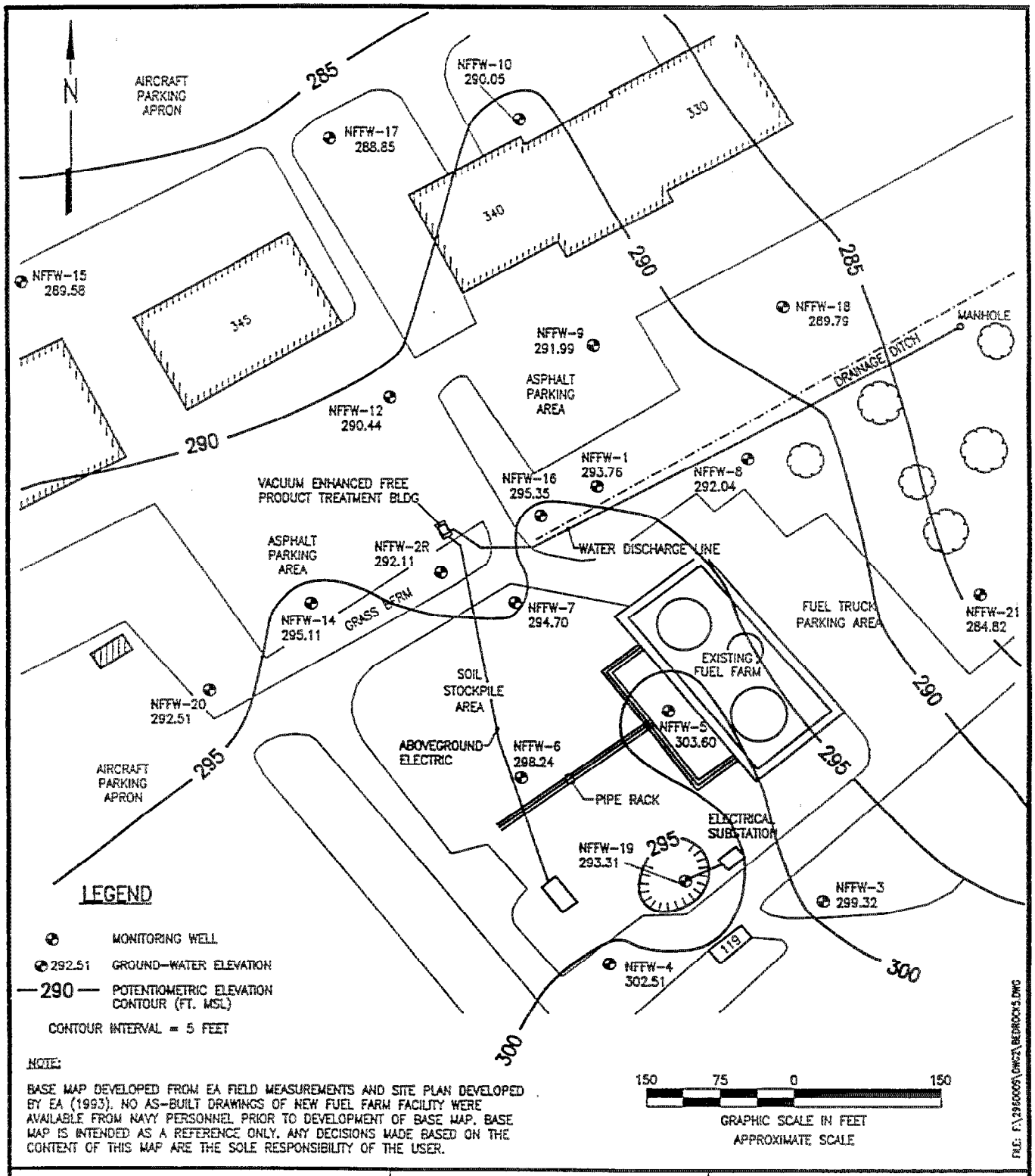
FILE: F:\29600009\DWGS\BEDROCK6.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
1 JULY 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	8



NOTE:

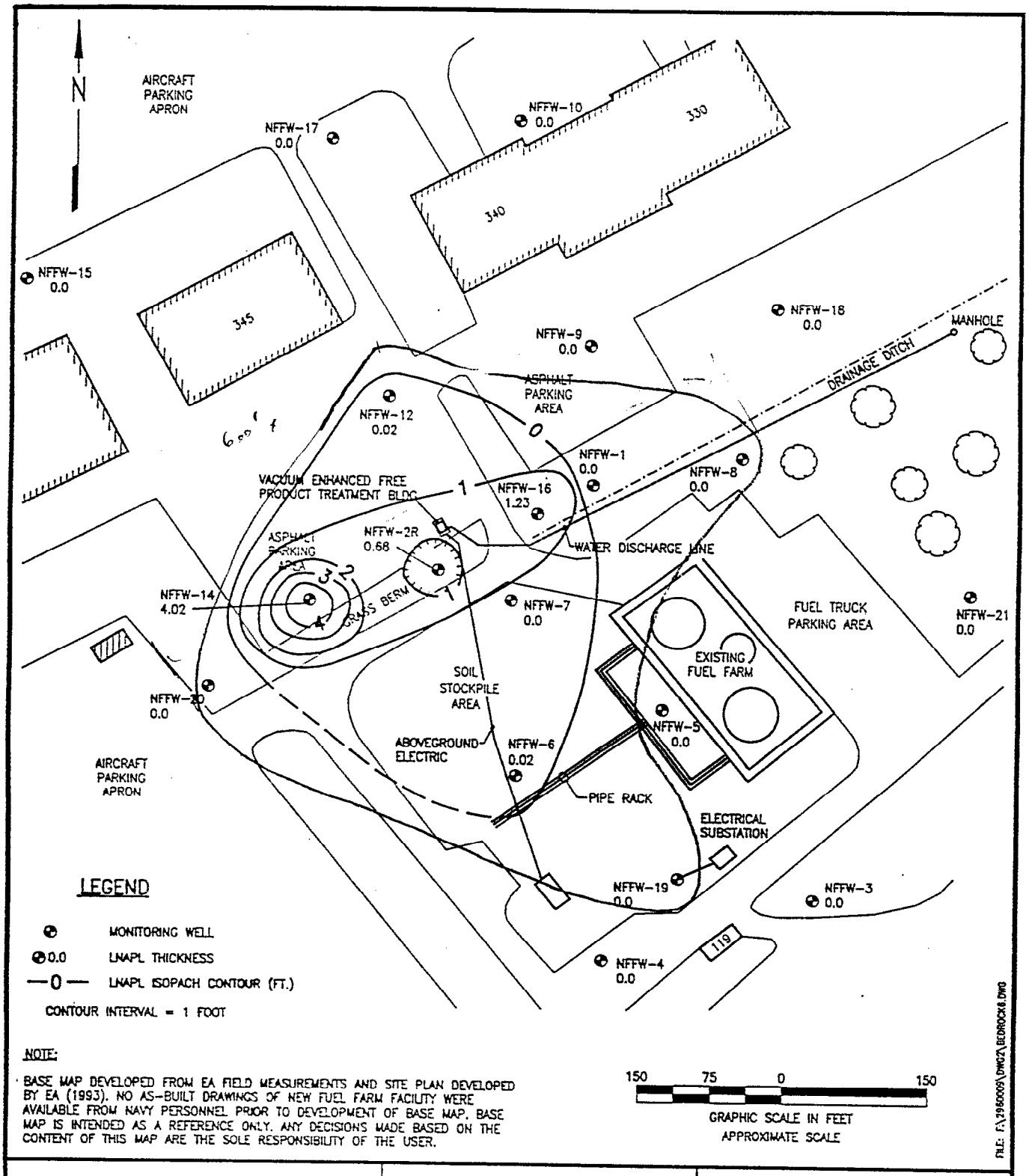
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

POTENTIOMETRIC SURFACE
5 AUGUST 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	9



NOTE:

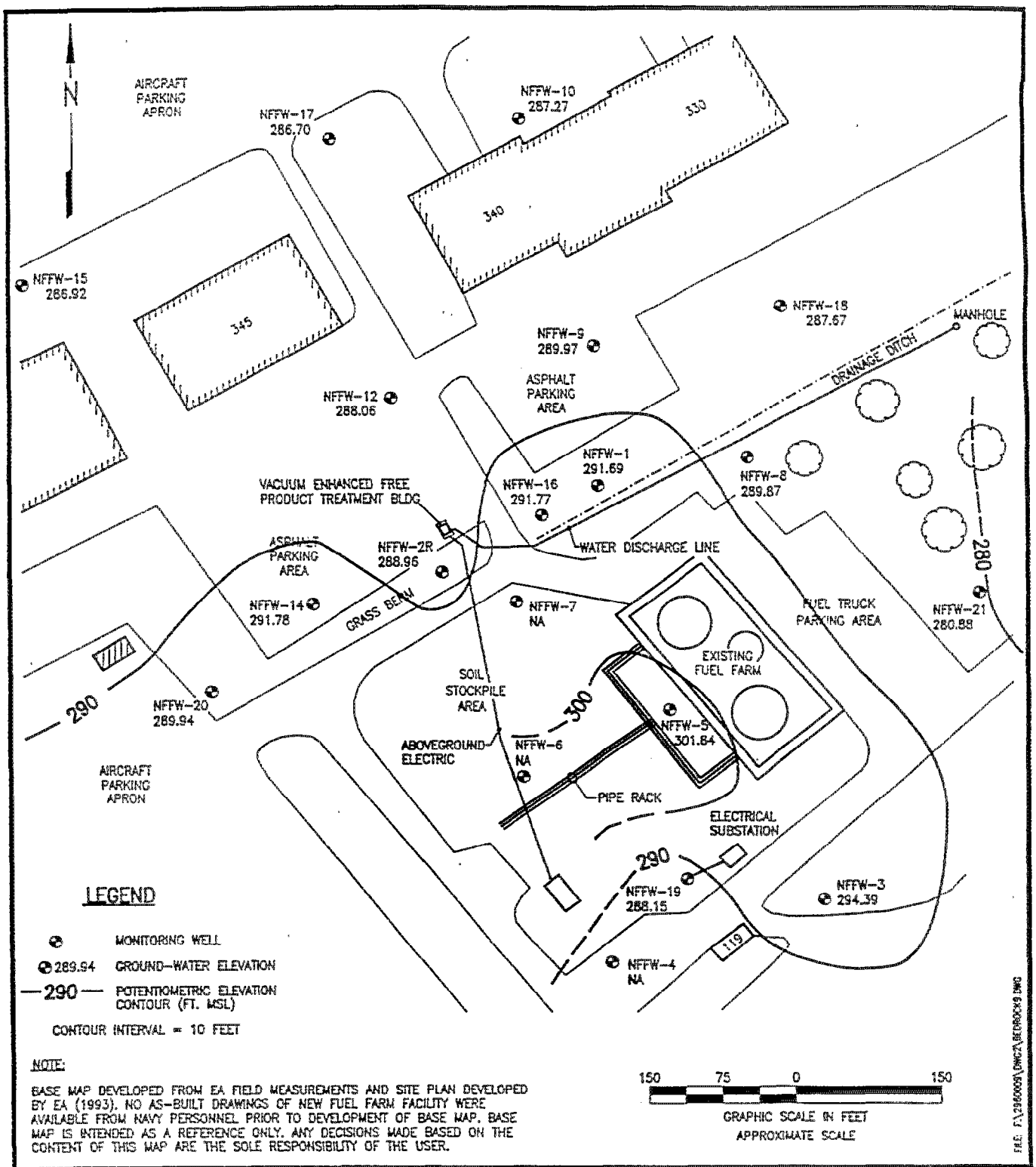
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
5 AUGUST 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	10



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

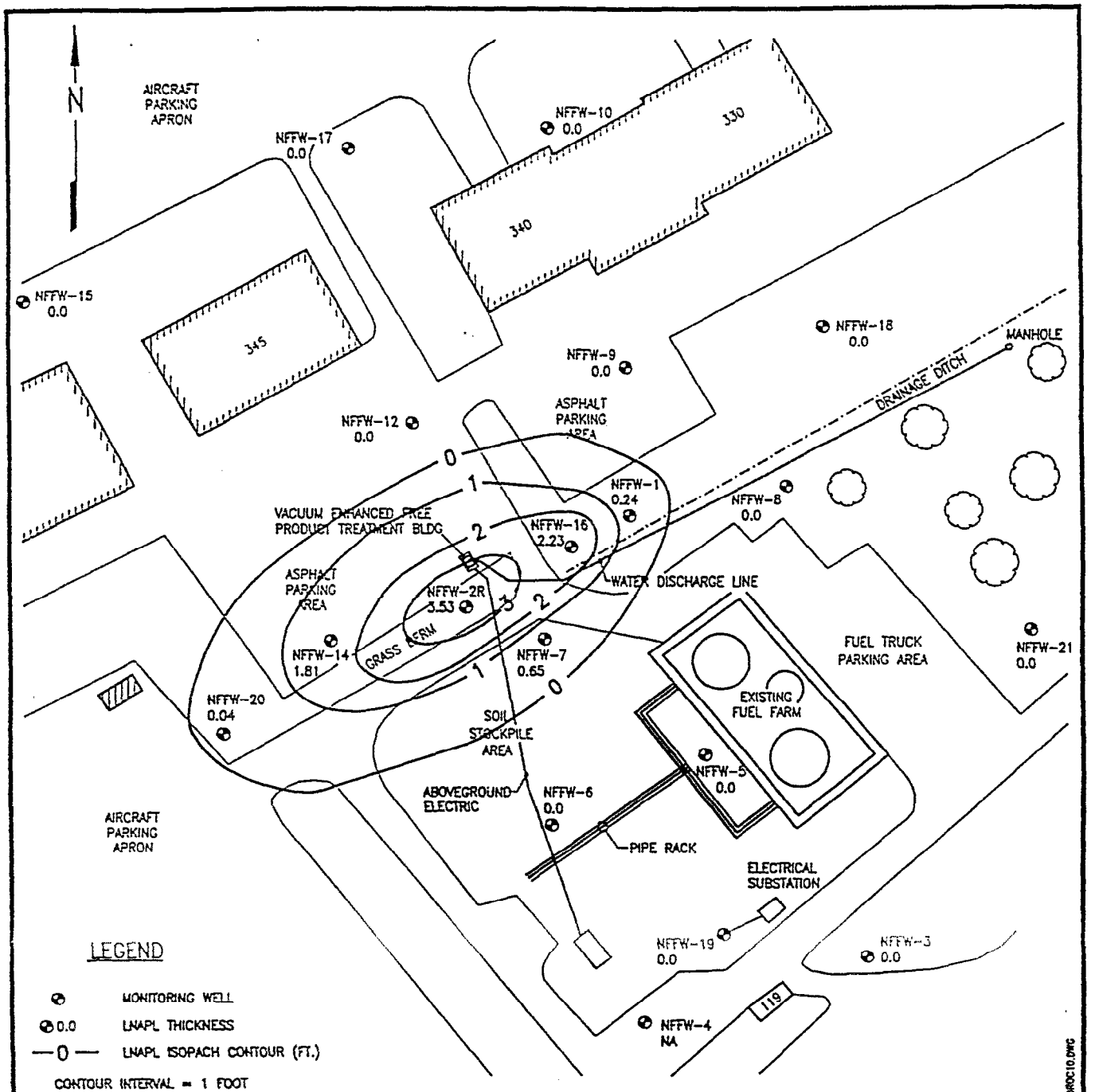
FILE: F:\29600.09\DWG\BEDROCK9.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

POTENTIOMETRIC SURFACE
21 DECEMBER 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	11



NOTE:

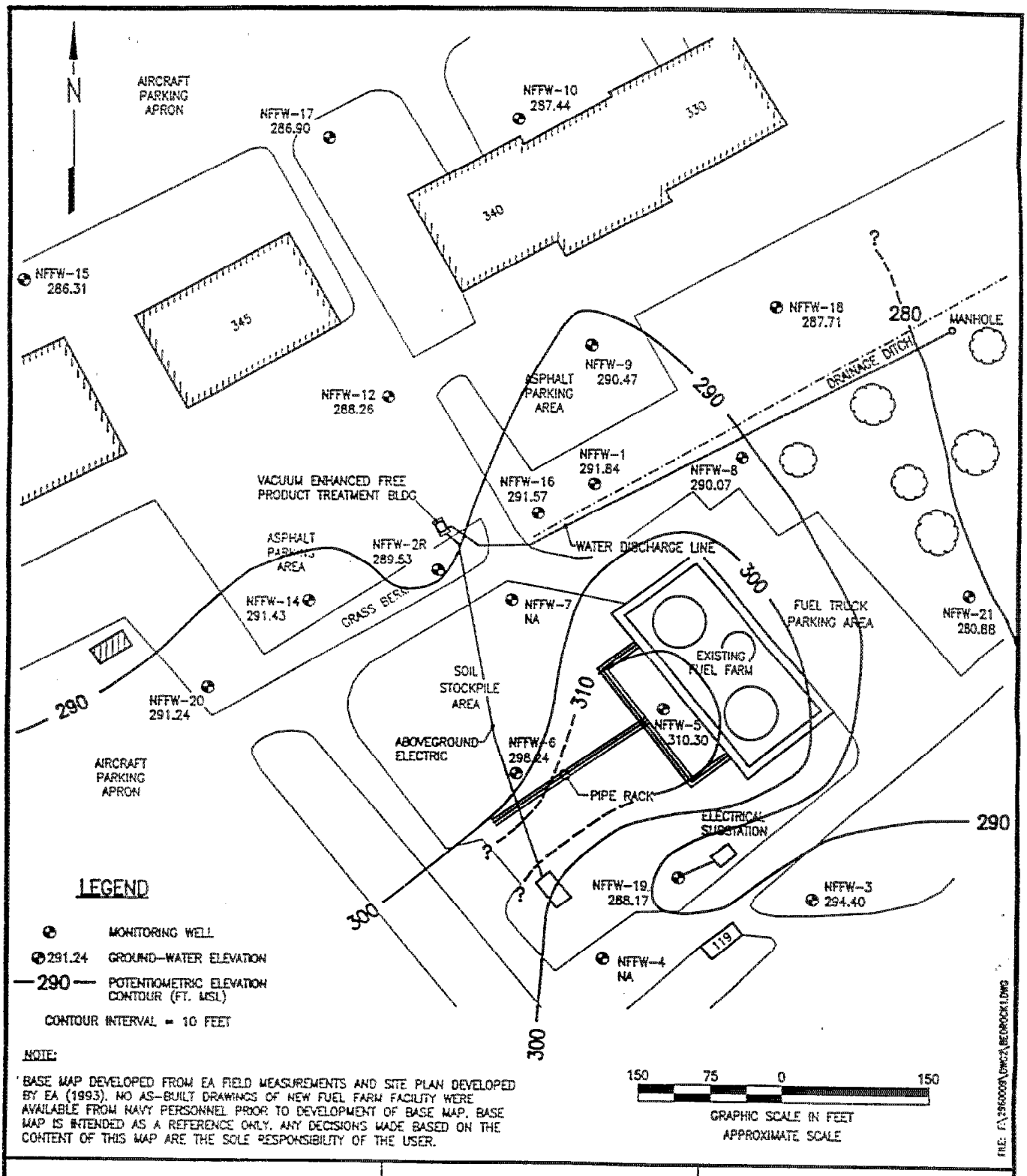
BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

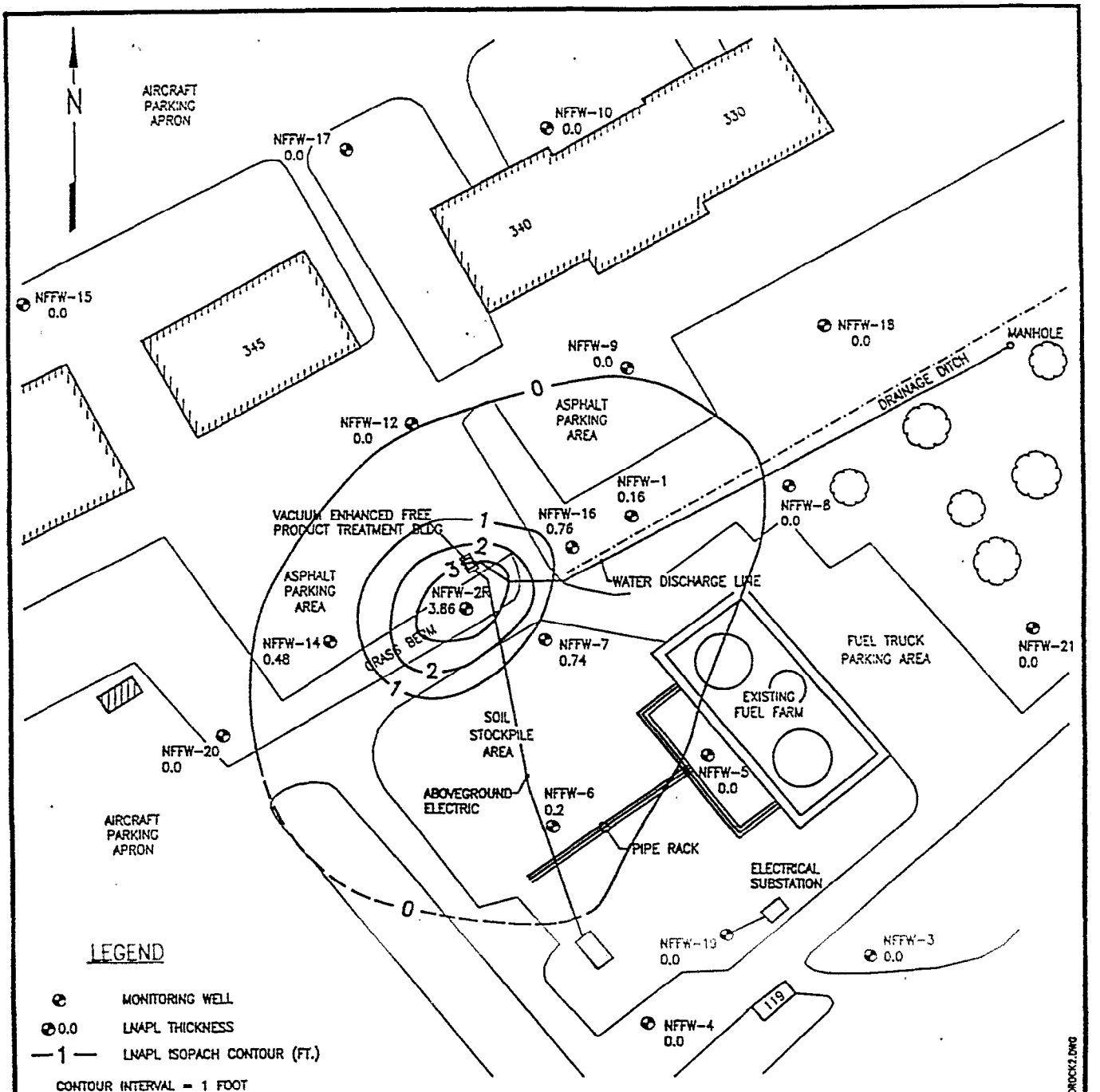
ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
21 DECEMBER 1994

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	12



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	NAVY FUEL FARM FACILITY NAVAL AIR STATION WILLOW GROVE, PENNSYLVANIA	POTENTIOMETRIC SURFACE 4 JANUARY 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29600.09	13



NOTE:

BASE MAP DEVELOPED FROM EA FIELD MEASUREMENTS AND SITE PLAN DEVELOPED BY EA (1993). NO AS-BUILT DRAWINGS OF NEW FUEL FARM FACILITY WERE AVAILABLE FROM NAVY PERSONNEL PRIOR TO DEVELOPMENT OF BASE MAP. BASE MAP IS INTENDED AS A REFERENCE ONLY. ANY DECISIONS MADE BASED ON THE CONTENT OF THIS MAP ARE THE SOLE RESPONSIBILITY OF THE USER.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVY FUEL FARM FACILITY
NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

ISOPACH MAP OF LNAPL MEASURED IN MONITORING WELLS
4 JANUARY 1995

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CR	TBL	CJV/PMH	CR	1"=150'	3-21-95	29500.09	14