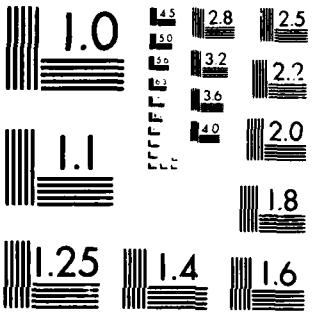
AD-A195 524 INSTALLATION RESTORATION PROGRAM (IRP) PHASE 2 1/6
CONFIRMATION/QUANTIFICATIO..(U) SCIENCE APPLICATIONS
INTERNATIONAL CORP MCLEAN VA R EADES ET AL. 10 JUN 86
UNCLASSIFIED F33615-80-D-4002 F/G 24/4 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

DTIC FILE COPY

AD-A195 524

Installation Restoration Program
Phase II — Confirmation/Quantification
Stage 1

McEntire Air National Guard Base
Eastover, South Carolina 29044

Science Applications International Corporation
8400 Westpark Drive, McLean, VA 22102

June 1986

Final Report 2/85 to 6/86

Approved for Public Release;
Distribution Is Unlimited

DTIC
ELECTE
MAY 16 1988
S D
E

Prepared for
Headquarters Air National Guard
Command Surgeon's Office, (HQ ANGSC/SGPB)
Bioenvironmental Engineering Division
Andrews Air Force Base, MD 20331

United States Air Force
Occupational and Environmental Health Laboratory (USAFOEHL)
Brooks Air Force Base, TX 78235-5501

88 5 13 097

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION Unclassified	1b RESTRICTIVE MARKINGS N/A
2a SECURITY CLASSIFICATION AUTHORITY N/A	3 DISTRIBUTION / AVAILABILITY OF REPORT Distribution is unlimited
2b DECLASSIFICATION / DOWNGRADING SCHEDULE N/A	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) N/A	5 MONITORING ORGANIZATION REPORT NUMBER(S) N/A
6a NAME OF PERFORMING ORGANIZATION Science Applications International Corporation 6b OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION USAF OEHL/TSS
6c ADDRESS (City, State, and ZIP Code) 8400 Westpark Drive McLean, Virginia 22102	7b ADDRESS (City, State, and ZIP Code) Brooks AFB, Texas 78235-5500
8a NAME OF FUNDING / SPONSORING ORGANIZATION USAF OEHL/TSS 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Contract No. F33615-80-D-4002 Delivery Order 60
8c ADDRESS (City, State, and ZIP Code) Brooks AFB, Texas 78235-5500	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)

IRP Phase II McEntire ANG Base, South Carolina

12 PERSONAL AUTHOR(S)

Eades R., Lapins A., Nothwanger, C., Zafran F., Mentz J.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM 2/85 TO 6/86	1986, June 10	

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

See Attached

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL 1 Lt. Maria R. LaMagna	22b TELEPHONE (Include Area Code) 512-536-2158 22c OFFICE SYMBOL USAF OEHL/TSS

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

A

Abstract

Seven sites were investigated for contamination at McEntire ANGB during the Installation Restoration Program (IRP) Phase II Stage 1. Sites examined included two fire training areas (Sites 1 and 2), a sanitary landfill (Site 2), a liquid waste storage area (Site 3), an oil dump site (Site 4), a C-141 spill trench (Site 5), an unofficial dump site (Site 6), and a drainage pond/swamp area (Site 7).

The Stage 1 field investigation involved the installation of 23 groundwater monitoring wells and the collection of numerous soil, sediment, surface water, and groundwater samples. Samples were analyzed for volatile organic compounds (VOC), total organic halogens (TOX), total organic carbon (TOC), arsenic and trace metals, oil and grease, total phosphorous, and nitrates. Field measurements of pH, specific conductance, and temperature were also made. Quality Assurance/Quality Control (QA/QC) sampling and analysis, both in the field and in the laboratory, were integral parts of this effort.

Elevated levels for contaminants were identified at 5 of the sites investigated. Contaminants were elevated in groundwater at 4 of the 6 sites where groundwater was examined. Elevated contaminant levels in soil and sediment samples were found at 4 of the 6 sites where these media were sampled. Two sites were without contamination in the media investigated. Elevated contaminant levels were found but not confirmed at the base water supply well W-1.

The Phase II Stage 1 investigation at McEntire ANGB identified the presence of contaminants at several sites but did not determine the rate or extent of substance migration. Further examination is recommended at those sites where contaminant levels were elevated: Sites 1, 2, 3, 4, and 6. Additional investigation is also recommended for the base water supply well W-1 to confirm the presence or absence of contaminants at the tap and of the water supply system.

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 1

FINAL REPORT

FOR

MCENTIRE AIR NATIONAL GUARD BASE
EASTOVER, SOUTH CAROLINA 29044

HEADQUARTERS AIR NATIONAL GUARD
COMMAND SURGEON'S OFFICE (HQ ANGSC/SGB)
BIOENVIRONMENTAL ENGINEERING DIVISION
ANDREWS AIR FORCE BASE, MARYLAND 20331

JUNE 1986

PREPARED BY

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
8400 WESTPARK DRIVE
MCLEAN, VA 22102

USAF CONTRACT NO. F33615-80-D-4002 DELIVERY ORDER NO. 60

CONTRACTOR CONTRACT NO. 2-827-06-182 DELIVERY ORDER NO. 60

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION IS UNLIMITED

USAFOEHL TECHNICAL PROGRAM MANAGER

MARIA R. LAMAGNA, 1 LT., USAF BSC

USAF OCCUPATIONAL & ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

NOTICE

This report has been prepared for the United States Air Force by Science Applications International Corporation of McLean, Virginia, for the purpose of aiding in the implementation of the Air Force Installation Restoration Program (AFIRP). It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the United States Air Force, nor the Department of Defense.

Copies of this report may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with Defense Technical Information Center should direct requests for copies of this report to:

Defense Technical Information Center
Cameron Station
Alexandria, Virginia 22314

Accession For	
NTIS GRA&I	X
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



PREFACE

On 21 February 1985, SAIC was contracted by the U.S. Air Force to perform an IRP Phase II Stage 1 Field Evaluation at McEntire Air National Guard (ANG) Base, South Carolina. The objectives of the field evaluation were to determine if environmental contamination had resulted from past waste disposal practices, fuel spills, and fire training activities at the base; to provide estimates of the magnitude and extent of contamination (if found present); to identify the potential environmental consequences of migrating pollutants; and to identify additional monitoring efforts to meet these objectives, if needed. To these ends, groundwater, surface water, soil and sediment samples were obtained for analysis from seven sites having a high potential for environmental contamination, a base water supply well, and Cedar Creek. This report presents the activities and findings of the IRP Phase II Stage 1 Field Evaluation, as well as, provides recommendations for additional studies at McEntire ANG Base.

Andris Lapins was project manager for this Phase II Stage 1 study. Members of the field investigation team and technical support staff included Andris Lapins, Fred Zafran, Christopher Manikas, Richard Eades, and Candace Nothwanger. Senior technical review was provided by Dr. Edward Repa, Dr. William Ellis, and John Mentz.

The support and assistance given by TSgt Mitchel Brochman of the 169th TAC Clinic and Cpt. Zollie Green of the 169th CEF during the performance of the Phase II Stage 1 field activities at McEntire ANG Base is greatly appreciated.

This work was accomplished between February 1985 and February 1986. Lt. Maria R. Lamagna, Technical Services Division, USAF Occupational Enironmental Health Laboratory (USAF OEHL) was the technical monitor.

TABLE OF CONTENTS

	Page
List of Figures	v
List of Tables	viii
SUMMARY	S-1
1.0 INTRODUCTION	1-1
1.1 BACKGROUND	1-1
1.2 BASE HISTORY AND ORGANIZATION	1-2
1.3 HISTORY OF WASTE MANAGEMENT ACTIVITIES	1-6
1.4 PHASE II (STAGE 1)	1-9
2.0 ENVIRONMENTAL SETTING	2-1
2.1 PHYSICAL GEOGRAPHY	2-1
2.2 REGIONAL GEOLOGY	2-5
2.3 REGIONAL HYDROGEOLOGY	2-13
2.4 LOCAL GEOLOGY AND HYDROGEOLOGY	2-15
2.4.1 Local Geology	2-16
2.4.2 Local Hydrogeology	2-18
2.4.2.1 Aquifer Characteristics	2-18
2.4.2.2 Aquifer Testing	2-20
2.4.2.3 Aquifer Recharge	2-24
2.4.2.4 Local Water Use	2-25
2.4.2.5 Summary of Local Hydrogeology	2-28
2.5 SITE HISTORIES AND HYDROGEOLOGY	2-29
2.5.1 Site No. 1: No. 5 Fire Training Area	2-29
2.5.2 Site No. 2: No. 1 Fire Training Area/ Sanitary Landfill	2-33
2.5.3 Site No. 3: Y-Storage Area	2-38
2.5.4 Site No. 4: Oil Dump Site	2-41
2.5.5 Site No. 5: C-141 Spill Trench	2-45
2.5.6 Site No. 6: Unofficial Dump Site	2-49
2.5.7 Site No. 7: Drainage Pond/Swamp	2-53
2.6 BASE WATER SUPPLY SYSTEM	2-55

TABLE OF CONTENTS (Continued)

		Page
3.0	FIELD PROGRAM	3-1
3.1	MONITORING PLAN DEVELOPMENT	3-1
3.2	MONITORING PLAN IMPLEMENTATION	3-4
3.2.1	Monitoring Well Installation	3-13
3.2.2	Sampling Program/Procedures	3-20
3.2.2.1	Groundwater Sampling	3-20
3.2.2.2	Surface Water, Sediment and Soil Sampling	3-35
3.2.2.3	Resampling for Second Column Confirmation	3-28
3.2.2.4	Field Quality Assurance/Quality Control	3-29
3.2.3	Aquifer Testing	3-29
4.0	DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS	4-1
4.1	QUALITY ASSURANCE/QUALITY CONTROL PROGRAM	4-1
4.1.1	Laboratory Duplicates and Matrix Spikes	4-1
4.1.2	Field Blanks, Bailer Washes and Duplicate Samples	4-2
4.1.3	Drilling Water Source	4-5
4.2	EVALUATION OF THE RESULTS OF SAMPLING AND ANALYSIS	4-10
4.2.1	Identification of Background Contaminant Levels	4-11
4.2.2	Identification of Federal Criteria and Standards for Evaluation of Analytical Data	4-12
4.3	SITE-SPECIFIC RESULTS AND FINDINGS	4-14
4.3.1	Site No. 1: No. 5 Fire Training Area	4-14
4.3.2	Site No. 2: No. 1 Fire Training Area and Sanitary Landfill	4-18
4.3.3	Site No. 3: Y-Storage Area	4-23
4.3.4	Site No. 4: Oil Dump Site	4-24
4.3.5	Site No. 5: C-141 Spill Trench	4-29
4.3.6	Site No. 6: Unofficial Dump Site	4-29
4.3.7	Site No. 7: Drainage Pond/Swamp	4-34
4.3.8	Cedar Creek and Tributary Drainage Swale	4-37
4.3.9	Base Supply Well	4-41
5.0	ALTERNATIVE MEASURES	5-1
5.1	ANALYTICAL ALTERNATIVES APPLICABLE TO MORE THAN ONE SITE	5-1
5.2	SITE SPECIFIC MONITORING ALTERNATIVES	5-2

TABLE OF CONTENTS (Continued)

		Page
5.2.1	Site No. 1: No. 5 Fire Training Area	5-2
5.2.2	Site No. 2: No. 1 Fire Training Area/ Sanitary Landfill	5-4
5.2.3	Site No. 3: Y-Storage Area	5-5
5.2.4	Site No. 4: Oil Dump Site	5-7
5.2.5	Site No. 5: C-141 Spill Trench	5-7
5.2.6	Site No. 6: Unofficial Dump Site	5-8
5.2.7	Site No. 7: Drainage Pond/Swamp	5-9
5.2.8	Cedar Creek and Tributary Drainage Swale	5-10
5.2.9	Base Water Supply Well W-1	5-12
6.0	RECOMMENDATIONS	6-1
6.1	CATEGORY II SITES	6-1
6.1.1	Base Water Supply Well W-1	6-1
6.1.2	No. 5 Fire Training Area: Site No. 1	6-5
6.1.3	No. 1 Fire Training Area and Sanitary Landfill: Site No. 2	6-9
6.1.4	Y-Storage Area: Site No. 3	6-10
6.1.5	Oil Dump Site: Site No. 4:	6-14
6.1.6	Unofficial Dump Site: Site No. 6:	6-16
6.2	CATEGORY I SITES	6-18
6.2.1	C-141 Spill Trench: Site No. 5	6-18
6.2.2	The Drainage Pond/Swamp: Site No. 7	6-18
6.3	CEDAR CREEK AND TRIBUTARY DRAINAGE SWALE	6-19

APPENDICES

A. Glossary of Abbreviations and Terminology
B. Measuring Unit Conversions
C. Scope of Work
D. Monitoring Well and Sample Numbering System
E. Well Construction Summaries and Boring Logs
F. Aquifer Test Data
G. Analytical Data
H. Quality Control Report
I. Chain of Custody Forms
J. State Correspondence
K. References
L. Resumes

LIST OF FIGURES

Figure		Page
1-1	Location Map for McEntire ANG Base	1-3
1-2	Map of McEntire ANG Base	1-4
1-3	Location of Map of Phase II Stage 1 Study Sites	1-12
1-4	Location of Map of Phase II Stage 1 Study Sites Showing site Numbering System Implemented	1-15
1-5	Site No. 1: No. 5 Fire Training Area	1-16
1-6	Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site	1-17
1-7	Site No. 3: Y-Storage Area	1-18
1-8	Site No. 4: Oil Dump Site	1-19
1-9	Site No. 5: C-141 Spill Trench	1-20
1-10	Site No. 6: Unofficial Dump Site	1-21
1-11	Site No. 7: Drainage Pond/Swamp Site	1-22
2-1	Physiographic Provinces of South Carolina	2-2
2-2	Physiographic and Topographic Cross-Section of the Northeast Side of the Congaree River Valley from Brown's Chapel to Madison Church, South Carolina	2-4
2-3	Geologic Cross Section of South Carolina	2-7
2-4	Surficial Geology of South Carolina Coastal Plain	2-8
2-5	Schematic Block Diagram Showing Relative Position of Terrace Complexes Overlying Tuscaloosa Formation on Northeast Side of Congaree River Valley (Adapted from Colquhoun, 1965)	2-11
2-6	General Geologic Cross-Section of McEntire ANG Base	2-17
2-7	Isopach Map of the Hazelhurst (Terrace) Formation at McEntire ANG Base	2-19
2-8	Potentiometric Surface Map McEntire Air National Guard Base	2-22

LIST OF FIGURES (Continued)

Figure		Page
2-9	Map Showing the Location of Water Supply Wells at McEntire ANG Base	2-27
2-10	Site No. 1: No. 5 Fire Training Area	2-30
2-11	Geologic Cross Sections For Site No. 1: No. 5 Fire Training Area	2-32
2-12	Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site	2-34
2-13	Geologic Cross Sections for Site No. 2: No. 1 Fire Training Area/Sanitary Landfill	2-37
2-14	Site No. 3: Y-Storage Area	2-39
2-15	Geologic Cross-Section for Site No. 3: Y-Storage Area	2-40
2-16	Site No. 4: Oil Dump Site	2-42
2-17	Geologic Cross Sections for Site No. 4: Oil Dump Site	2-44
2-18	Site No. 5: C-141 Spill Trench	2-46
2-19	Fence Diagram for Site No. 5: C-141 Spill Trench	2-48
2-20	Site No. 6: Unofficial Dump Site	2-50
2-21	Fence Diagram for Site No. 6: Unofficial Dump Site	2-51
2-22	Site No. 7: Drainage Pond/Swamp Site	2-54
3-1	Monitoring Well and Sampling Locations: Site No. 1: No. 5 Fire Training Area	3-5
3-2	Monitoring Well Locations: Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site	3-6
3-3	Monitoring Well and Sampling Locations: Site No. 3: Y-Storage Area	3-7
3-4	Monitoring Well and Sampling Locations: Site No. 4: Oil Dump Site	3-8
3-5	Monitoring Well and Sampling Locations: Site No. 5: C-141 Spill Trench	3-9

LIST OF FIGURES (Continued)

Figure		Page
3-6	Monitoring Well and Sampling Locations: Site No. 6: Unofficial Dump Site	3-10
3-7	Sampling Locations: Site No. 7: Drainage Pond/Swamp Site	3-11
3-8	Sampling Locations: Cedar Creek and Tributary Drainage Swale	3-12
3-9	Sieve Analysis for Sand Pack	3-16
3-10	Schematic Diagram of Monitoring Well	3-18
4-1	Monitoring Well and Sampling Locations; Site No. 1: No. 5 Fire Training Area	4-17
4-2	Monitoring Well Locations; Site No. 2: No. 1 Fire Training Area/Sanitary Landfill	4-22
4-3	Monitoring Well and Sampling Locations; Site No. 3: Y-Storage Area	4-26
4-4	Monitoring Well and Sampling Locations; Site No. 4: Oil Dump Site.	4-28
4-5	Monitoring Well and Sampling Locations; Site No. 5: C-141 Spill Trench	4-30
4-6	Monitoring Well and Sampling Locations: Site No. 6: Unofficial Dump Site	4-33
4-7	Sampling Locations: Site No. 7: Drainage Pond/Swamp Site	4-36
4-8	Sampling Locations: Cedar Creek and Tributary Drainage Swale	4-38
4-9	Base Supply Wells Monitoring Locations	4-44
6-1	Proposed Soil Sampling Plan for Site No. 1: No. 5 Fire Training Area	6-7
6-2	Proposed Monitoring Well Location for Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site.	6-11
6-3	Proposed Soil Sampling Plan for Site No. 3: Y-Storage Area	6-13

LIST OF FIGURES (continued)

Figure		Page
6-4	Proposed Soil Sampling Plan for Site No. 4: Oil Dump Site . .	6-15
6-5	Proposed Soil Sampling Plan for Site No. 6: Unofficial Dump Site	6-17
6-6	Proposed Sampling Plan for Cedar Creek and Tributary Drainage Swale	6-20

LIST OF TABLES

Table		Page
1-1	McEntire ANG Base Host and Tenants	1-6
1-2	Materials With Hazardous Properties Used and Disposed by Various Base Operations	1-7
1-3	Summary of Results IRP Phase I HARM Site Ratings	1-8
1-4	History of Contamination of Phase II Study Sites	1-10
1-5	Brief Summary of IRP Phase II Stage 1 Sampling and Analysis Plan	1-13
2-1	Physical Properties at Soils of Study Sites	2-6
2-2	Geologic Formations Which Outcrop in the South Carolina Coastal Plain	2-9
2-3	Formations and Terraces Found in the Congaree River Valley	2-12
2-4	Groundwater Levels at McEntire ANG Base	2-21
2-5	Aquifer Test Results	2-23
2-6	Summary of Well Construction Data for Base Water Supply Wells	2-26
3-1	Brief Summary of IRP Phase II Stage 1 Sampling and Analysis Plan	3-2
3-2	Well Construction Summary	3-19
3-3	Horizontal Coordinates and Elevations of Monitoring Wells Installed at McEntire ANG Base	3-21
3-4	Groundwater Sample Analysis Plan Implemented for IRP Phase II Stage 1 - McEntire ANG Base	3-23
3-5	Sample Preservation and Storage	3-24
3-6	Surface Water Sample Analysis Plan Implemented for IRP Phase II Stage 1 - McEntire ANG Base	3-26
3-7	Soil/Sediment Sample Analysis Plan Implemented for IRP Phase II Stage 1 - McEntire ANG Base	3-27
3-8	Field QA/QC Sample Analysis Plan Implemented for IRP Phase II Stage 1 - McEntire ANG Base	3-30

LIST OF TABLES (continued)

Table		Page
4-1	Analytical Results Field Blanks and Bailer Washes.	4-3
4-2	Analytical Results for Sample Duplicates	4-6
4-3	Analytical Results for Drilling Water Source	4-9
4-4	Federal Human Health Criteria, Standards and Guidelines. . . .	4-13
4-5	Analytical Results for Site No. 1: No. 5 Fire Training Area	4-15
4-6	Analytical Results for Site No. 2: No. 1 Fire Training Area/Sanitary Landfill	4-20
4-7	Analytical Results for Site No. 3: Y-Storage Area	4-25
4-8	Analytical Results for Site No. 4: Unofficial Dump Site . . .	4-27
4-9	Analytical Results for Site No. 5: C-141 Spill Trench	4-31
4-10	Analytical Results for Site No. 6: Unofficial Dump Site . . .	4-32
4-11	Analytical Results for Site No. 7: Drainage Pond/Swamp. . . .	4-35
4-12	Analytical Results for Cedar Creek and Tributary Drinage Swale	4-39
4-13	Analytical Results for Base Supply Well W-1.	4-43
6-1	Summary of Recommended Monitoring at McEntire ANG Base	6-2

SUMMARY

A total of 6 sites at McEntire Air National Guard (ANG) Base were identified during Phase I Record Search activities as warranting Phase II investigation. These sites included the No. 1 Fire Training Area, No. 5 Training Area, Sanitary Landfill, Y-Storage Area, and C-141-Spill Trench. Based upon the findings of a Phase II presurvey and at the request of OEHL, 2 additional sites were identified for further Phase II study - the Unofficial Dump Site and the Drainage Pond/Swamp Site. Two of the original Phase I sites, the Sanitary Landfill and the No. 5 Fire Training Area, were also combined into a single study site based on their close proximity to one another. Therefore, the resultant number of sites ultimately investigated during Phase II was 7. In addition, one of the base's water supply wells and Cedar Creek, the primary discharge point for surface waters from McEntire ANG Base, were also studied during the Phase II effort.

Twenty-three 2-inch diameter groundwater monitoring wells were installed in the upper Tuscaloosa water table aquifer during Phase II Stage 1. These, along with the base water supply well W-1, were sampled by both OEHL and ERG (the Phase II contract lab) laboratories. Soil/sediment samples were collected at six sites, and sediment and surface water samples were collected along Cedar Creek. Analyses of these soil and water samples were keyed to known or suspected contaminants at each sampling location or site. The analytical suites were:

- Total organic halogens (TOX), total organic carbon (TOC) and oil and grease - two sites
- All the above plus volatile organic compounds - two sites
- All the above plus metals - one site
- TOX, TOC, oil and grease and metals - one site
- TOX, oil and grease, nitrate nitrogen and total phosphorus - one site.

Analyses for TOX, TOC, oil and grease and volatile organic compounds were performed on the base well (W-1) sample. Analyses for all of the above parameters and for metals were performed on sediment and surface water samples from

Cedar Creek and the tributary swale. The pH, temperature and specific conductance at the time of sampling were measured at each surface water and groundwater sampling point.

In addition, local aquifer characteristics were determined using water level information to establish hydraulic gradients, and slug tests to find hydraulic conductivities. Available standards were compiled for comparison to analyses; however, these standards apply only to contaminant concentrations in water, not in soils or sediment. No formal standards have been set for general scan analyses for contaminants such as oil and grease, TOX and TOC. For analytes and media for which standards are lacking, the range of background values published for the study area were used to set levels of significance. Where these data were also unavailable, levels of significance were established based on past experience.

Following is a general summary of the Phase II Stage 1 sampling/analtyical findings:

- Contaminants were identified in samples from 5 of the 7 investigated sites, in Cedar Creek and its tributary, and in the base supply well W-1;
- Groundwater contamination was found at 4 of the 6 investigated sites;
- One well was found to contain chromium at levels slightly exceeding Federal and state drinking water standards, with one other well found to have contamination that slightly exceeded the Federal and state standards for carbon tetrachloride;
- Soil/sediment contamination was found at 4 of 6 sites investigated;
- Surface waters and sediments in Cedar Creek and the tributary swale were found to be contaminated; and
- Two sites, the C-141 Spill Trench and Drainage Pond/Swamp, were without contamination in the media investigated, although at the Drainage Pond/Swamp, contamination not attributable to the site was found beyond the extent of site influence.

The Stage 1 results fulfill the Phase II goal of confirming the presence or absence of contamination at the sites investigated. They do not, however,

satisfy the Phase II goals of determining the specific contaminants involved at most sites, nor do the results provide sufficient data to determine the extent of contaminant migration from the sites. Consequently, additional monitoring is recommended for 5 of the Stage 1 sites, as well as for Cedar Creek and its tributary swale, and the base supply well W-1.

Following is a brief summary of the additional Stage 2 monitoring recommended, prioritized according to significance and magnitude of contaminants identified to date:

- Base Supply Wells
  - Sample both base wells W-1 and W-2
  - Sample tap water at three high occupancy locations
  - Analyze all samples for volatile organics
- No. 5 Fire Training Area
  - Resample four Stage 1 monitoring wells at three discrete depths in each well for volatile organics
  - Collect 25 surficial soil samples and analyze for volatile organics and base/neutral and acid extractables
  - Conduct a soil boring, collect soil samples at 3 foot intervals to a minimum of 25 feet in depth, and analyze for volatile organics and base/neutral and acid extractables
- No. 1 Fire Training Area/Sanitary Landfill
  - Install one additional monitoring well
  - Sample new (one) and existing (five) wells at three discrete depths for volatile organics and metals
- Y-Storage Area
  - Resample groundwater at four Stage 1 monitoring wells and analyze for volatile organics
  - Collect 17 surficial soil samples and analyze for volatile organics and base/neutral and acid extractables in 10 samples and TOX and oil and grease in the other seven
  - Conduct a soil boring, collect soil samples at three foot intervals to a minimum of 25 feet in depth, and analyze for volatile organics and base/neutral and acid extractables

- Oil Dump Site

  - Collect seven surficial soil samples, analyze four samples for volatile organics and base/neutral and acid extractables and analyze for TOX and oil and grease in the remaining three samples

  - Conduct a soil boring, collect soil samples at three foot intervals to a minimum depth of 25 feet, and analyze for volatile organics and base/neutral and acid extractables

  - Resample groundwater at four Stage 1 monitoring wells and analyze for volatile organics

- Unofficial Dump Site

  - Collect seven surficial soil samples, analyze four samples for volatile organics and base/neutral and acid extractables, and analyze the remaining three samples for TOX and oil and grease

  - Conduct a soil boring, collect soil samples at three foot intervals to a minimum depth of 25 feet, and analyze for volatile organics and base/neutral and acid extractables

- Cedar Creek and Tributary Drainage Swale

  - Collect eight surface water and eight sediment samples

  - Analyze two surface water and two sediment samples for all priority pollutants

  - Analyze remaining six surface water and six sediment samples for volatile organics and metals.

It is felt that data generated by these additional monitoring recommendations, when examined in conjunction with previously collected information, will enable definitive characterization of extent and magnitude of specific contaminants at the designated sites (and ancillary areas/wells mentioned above) at McEntire ANG Base.

1.0 INTRODUCTION

1.1 BACKGROUND

Federal, state, and local governments have developed strict regulations that require disposers of toxic and hazardous wastes to identify the location and content of waste disposal sites and to implement actions to eliminate any hazards to public health or to the environment. The Department of Defense (DOD) answered this challenge by issuing Defense Environmental Quality Program Policy Memorandum 81-5. This memorandum requires the identification and evaluation of past hazardous material disposal sites on DOD property, the control of hazardous contaminant migration, and the control of hazards to the public health and to the environment from past waste disposal activities. The program that was implemented by the Air Force (AF) under this memorandum was the Installation Restoration Program (IRP). The IRP serves as the basis for response actions at AF and Air National Guard (ANG) installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

The AF IRP has been developed as a four-phased program with each phase having distinct objectives and outputs. These phases are:

Phase I - Installation Assessment (Records Search)
To identify and prioritize past disposal sites posing a hazard to public health or the environment.

Phase II - Confirmation/Quantification
To define and quantify the presence or absence of contamination that may have an adverse impact on public health or the environment.

Phase III - Technology Base Development (if needed)
To develop a sound data base upon which to prepare a comprehensive contaminant control plan.

Phase IV - Operations/Remedial Actions
To execute the contaminant control plan and implement remedial actions.

The Phase I - Installation Assessment of the IRP for McEntire ANG Base was completed by the Hazardous Materials Technical Center (HMTC) in January 1984. This phase identified and prioritized past waste sites on the base which may pose a hazard to public health or the environment.

Phase II activities were initiated at McEntire ANG Base in May 1984. This report, prepared by Science Applications International Corporation (SAIC), presents the results of the IRP Phase II Stage 1 Field Evaluation and details the activities performed. Stage 1 of the Phase II program is designed to confirm the presence or absence of contamination, with subsequent efforts (i.e., Stage 2 if required) intended to further define the levels and areal extent of contamination.

1.2 BASE HISTORY AND ORGANIZATION

McEntire ANG Base encompasses an area of 2,387 acres in Richland County, South Carolina, approximately 12 miles east-southeast of Columbia (Figures 1-1 and 1-2).

The land area presently known as McEntire ANG Base was initially purchased by the Federal Government in 1941. Congaree Army Air Field, as it was then designated, was constructed in 1941-42, primarily for use as an attack fighter training field for the U.S. Army Air Corps. The field was transferred to the Department of the Navy on July 1, 1944, and was designated Congaree Air Base. The base was operated by the U.S. Marine Corps as an advanced fighter training base until the spring of 1946 when the field was placed on inactive status. The Department of the Navy issued the State of South Carolina an operator's permit in October 1946. The South Carolina Air National Guard (SCANG) has had control of the base since that time. The base was formally transferred by the Department of the Navy to the U.S. Air Force on November 8, 1955. The air field was renamed Congaree Air National Guard Base in April 1960 and redesignated McEntire Air National Guard Base on October 16, 1961.

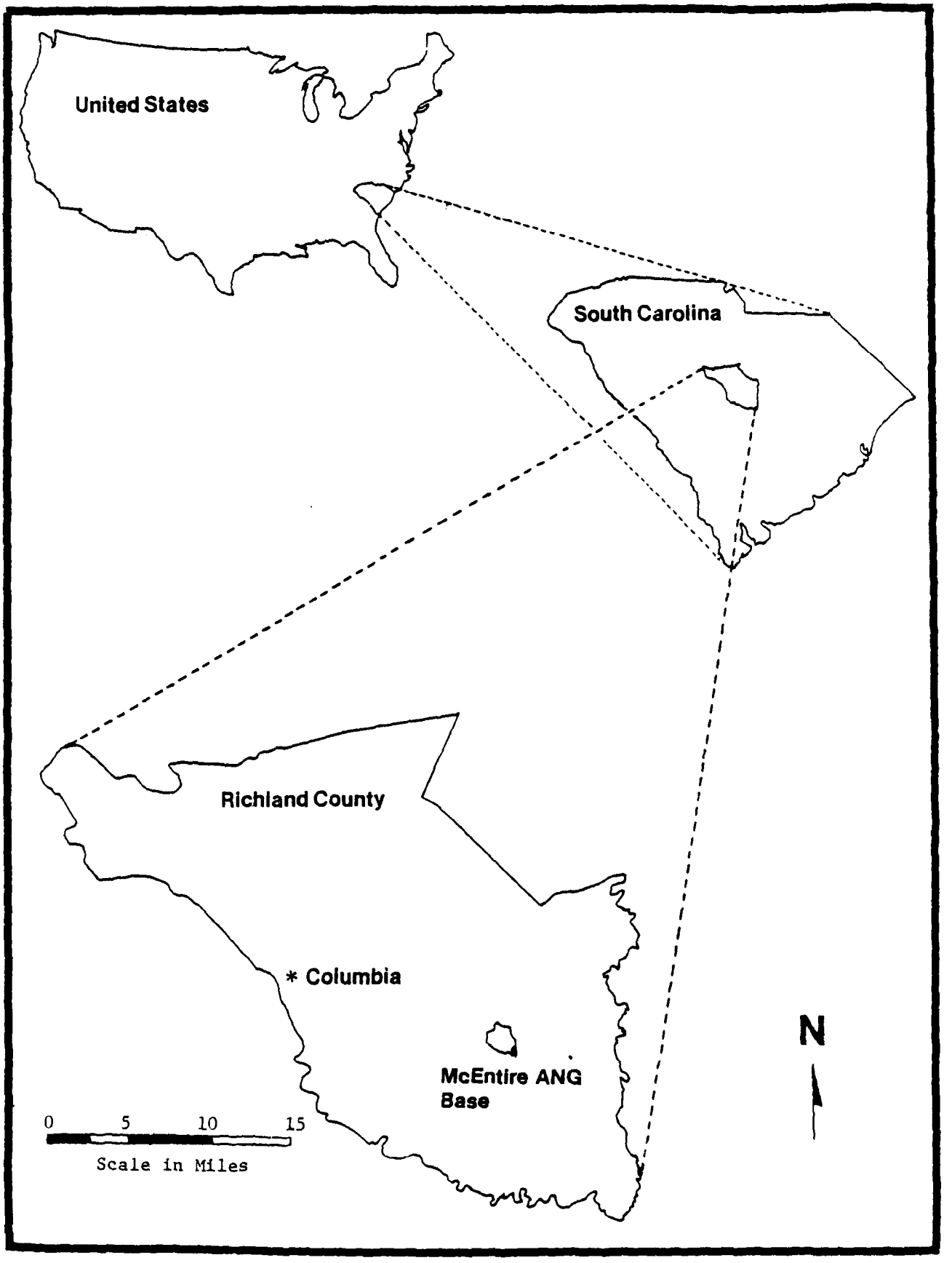


Figure 1-1. Location Map for McEntire ANG Base.

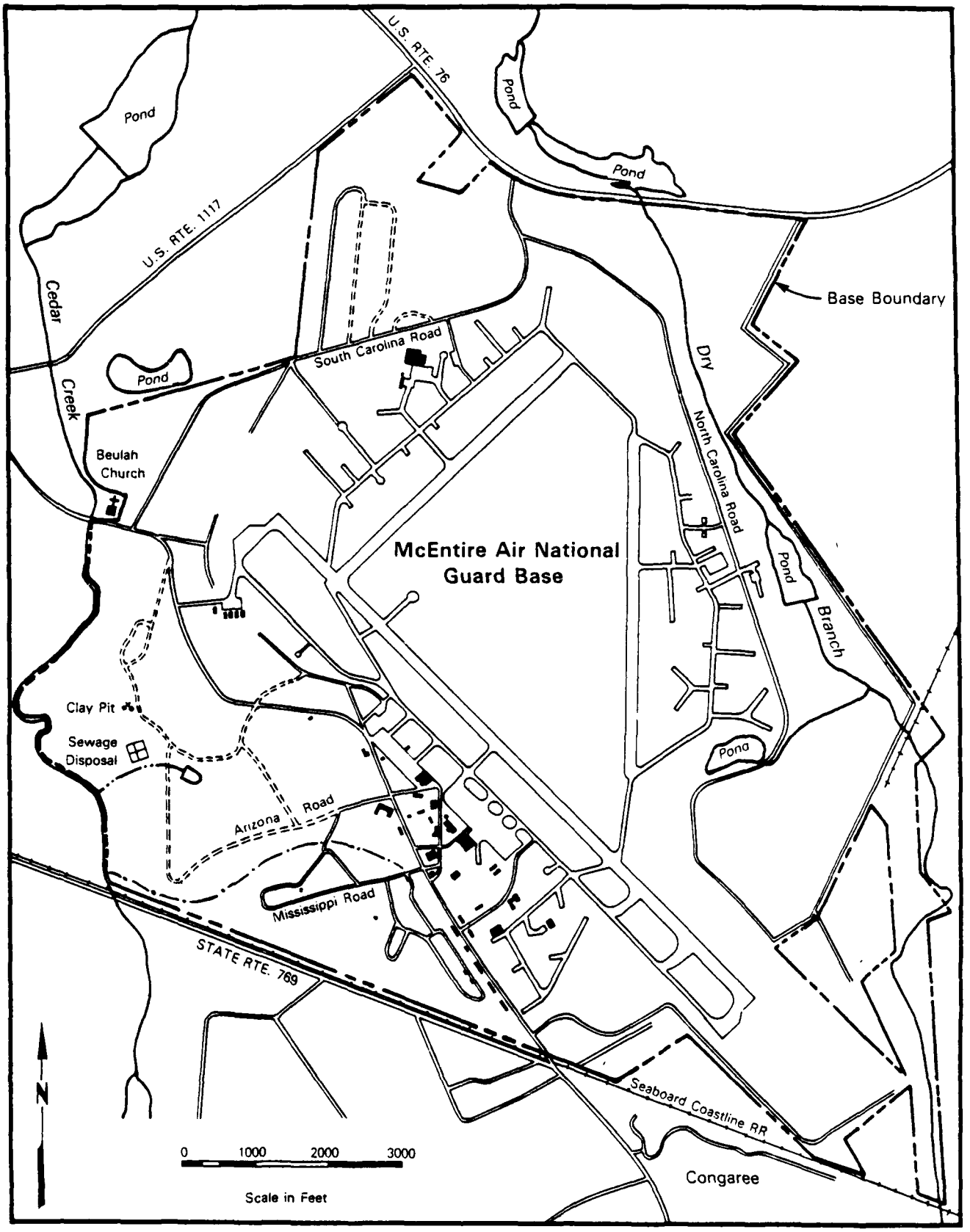


Figure 1-2. Map of McEntire ANG Base.

The base currently serves as host to a variety of small tenant units (Table 1-1). The host unit, which operates and maintains the installation, is the 169th Tactical Fighter Group. The mission of this unit is to train a tactical fighter squadron and associated units to readiness for recall and immediate deployment in a Tactical Air Command fighter-bomber combat role. The unit is also on call to the State of South Carolina in the event of an emergency. The base supports a normal contingent of 24 assigned tactical fighters and has recently converted its primary mission aircraft from the A-7 Corsair II to the F-16 Fighting Falcon.

The airfield complex at McEntire consists of three runways; one is 9,000 feet in length and two are 4,500 feet in length (Figure 1-2). Original structures and newly constructed facilities at the base are used for operations, maintenance, or training purposes. The base does not have community support facilities, base housing, or full-time messing or billeting facilities.

1.3 HISTORY OF WASTE MANAGEMENT ACTIVITIES

Training and maintaining the 169th Tactical Fighter Group at a combat readiness level commensurate with the needs of the Tactical Air Command necessitated that the South Carolina ANG be engaged in a wide variety of operations which involved the use of materials with toxic and hazardous properties. Hazardous wastes were generated as a result of these operations. A summary of the type and quantity of hazardous materials used and wastes generated by various base operations is provided in Table 1-2.

The Phase I - Installation Assessment, completed in January 1984 by the Hazardous Materials Technical Center (HMTC), identified 12 waste disposal and or spill sites as potentially containing hazardous materials. Six of the 12 sites were eliminated from further consideration when it was determined that the potential for contaminant migration did not exist. The remaining 6 sites were determined by HMTC to have the potential for contaminant migration and were further evaluated and prioritized using the Air Force's Hazardous Assessment Rating Methodology (HARM). Table 1-3 lists the six sites and their associated HARM scores. These sites were recommended for investigation as part of the Phase II - Confirmation/Quantification effort.

TABLE 1-1. McENTIRE ANG BASE HOST AND TENANTS

Host

169th Tactical Fighter Group

Tenants

Headquarters, South Carolina Air National Guard (SCANG): Approval of overall policies and training for all organizations of SCANG.

240th Air Traffic Control Flight: To attain and maintain an optimum effective capability to install, operate, and maintain air traffic control and navigational aid facilities in support of USAF operations, according to gaining command plans for utility in a national emergency.

240th Combat Communications Flight: To attain and maintain effective capability to install, operate, and maintain mobile communications in support of USAF operations, according to gaining command plans for utility in a national emergency.

Det 4 OLA 3rd Weather Squadron: To provide continuous meterological watch service 24 hours/day, 7 days/week for weather observations and weather warning service to McEntire ANG Base.

Army Aviation Support Facility: Provides flight operation and maintenance support for all Army National Guard aircraft and provides proficiency training for Army National Guard aircrews.

51st Aviation Assault Company: Trains aircrews in operational support of Army units upon mobilization.

Fort Jackson Aero Club: Provides flight training for all members of a certified aero club. Provides maintenance on all club aircraft.

Other Installation Users

Shaw Air Force Base: U.S. Air Force aircraft use base as transition field for practice landings and takeoffs.

SCANG Clinic McEntire ANG.

TABLE 1-2.
MATERIALS WITH HAZARDOUS PROPERTIES USED AND DISPOSED
BY VARIOUS BASE OPERATIONS (modified from HMTC, 1984)

Shop Name	Bldg. No.	Hazardous Waste/Used Hazardous Material	Estimated Quantity	Method* of Treatment/Storage/Disposal ----1950----1960----1970----1980----Present
Pneudraulic Shop	253	PD-680	15 gal/mo	FIRE TR → DPDO
		Hydraulic Fluid	20 gal/mo	
Corrosion Control	60	Paint	4 gal/mo	LAND FL → CNTRCT
Machine Shop		Paint Strippers	4 gal/mo	
Structural Repair		Paint Thinners	4 gal/mo	SSTP
Welding		Cutting Fluid/Coolant	1/2 gal/mo	
Engine Shop	253	PD-680	1 gal/mo	FIRE TR → DPDO
		Aircraft Oil	12 gal/mo	
		JP-4	8 gal/mo	
NDI	60	Fixer	7 gal/mo	SSTP → RECOVERY
		Developer	10 gal/mo	SSTP
		Kerosene	1 gal/mo	
		Penetrant	2 gal/mo	
		Emulsifier	2 gal/mo	FIRE TR → DPDO
		Waste Lube Oil	10 gal/mo	
		Methylethylketone	1 gal/mo	
		Trichloroethane	1 gal/mo	
Flightline/ Base Flight	253/ 60	Aircraft Oil	50 gal/mo	FIRE TR → DPDO
		Hydraulic Fluid	10 gal/mo	
		PD-680	25 gal/mo	STORM DR
		Aircraft Cleaner	9 gal/mo	
Tire Repair and Reclamation	253	Paint Stripper (B & B)	18 gal/mo	LAND FL → CNTRCT
		PD-680	35 gal/mo	FIRE TR → DPDO
Paint Shop		Chromic Acid	1 gal/mo	LAND FL → CNTRCT
		Epoxy Paint	1 gal/mo	
		Polyurethane Paint	1 gal/mo	
		Thinner	1/4 gal/mo	
		Aldoine	1 gal/mo	
		Toluene	3 gal/mo	
		Methylethylketone	6 gal/mo	
AGE	200	PD-680/Varsol/Gunk	76 gal/mo	OWS/STDR
		JP-4/MOGAS[a]/AVGAS[b]	4 gal/mo	FIRE TR
		Hydraulic Fluid	20 gal/mo	FIRE TR → DPDO
		Engine Oil	20 gal/mo	
		Aircraft Oil	2 gal/mo	
		Transmission Fluid	1 gal/mo	
		Battery Acid	3 gal/mo	NEUTRL & OWS/STDR
Motor Pool	210/ 200	PD-680/Varsol/Gunk	10 gal/mo	OWS/STDR → SSTP
		Methylethylketone	5 gal/mo	FIRE TR → DPDO
		Paint Thinner	1 gal/mo	
		JP-4	3 gal/mo	FIRE TR
		Engine Oil	40 gal/mo	FIRE TR → DPDO
		Brake Fluid	1 gal/mo	
		Antifreeze	120 gal/mo	OWS/STDR → SSTP
		Paint	1/2 gal/mo	LAND FL → CNTRCT
		Battery Acid	2 gal/mo	NEUTRL & OWS/STDR → NEUTRL & SSTP
POL	183	JP-4/AVGAS	300 gal/mo	FIRE TR → DPDO
Army Aviation	165	Waste Oil	65 gal/mo	CNTRCT
		Hydraulic Fluid	2 gal/mo	
		Gunk/Varsol	50 gal/mo	
		Trichloroethane	25 gal/mo	OWS/STDR
		Battery Acid	1 gal/mo	
		JP-4/AVGAS	20 gal/mo	FIRE TR

*RECOVERY - Precious metal recovery.
STDR/OWS - Storm drain to Oil/Water separator to Cedar Ck.
SSTP - Sanitary Sewage Treat Plant to Cedar Ck.
FIRE TR - Fire Dept. Training Exercises.
DPDO - Defense Property Disposal Office.

[a]MOGAS - Automobile gasoline
[b]AVGAS - Aviation gasoline

LANDFL - On-base Landfill.
NEUTRL - Neutralization and to drain.
CNTRCT - Outside Service Contract to off-base facility

TABLE 1-3. SUMMARY OF RESULTS: IRP PHASE I HARM SITE RATINGS

Priority	Phase I Site No.	Site Description	HARM Score
1	2	No. 5 Fire Training Area	69
2	1	No. 1 Fire Training Area	67
3	3	Sanitary Landfill	57
4	4	Y-Storage Area	56
5	5	Oil Dump Site	56
6	6	C-141 Spill Trench	54

Source: Phase I Report (HMTC, 1984).

During the Phase II initiation meeting and site survey conducted at McEntire ANG Base in May 1984, two additional sites were identified as potential sources of off-base contaminant migration: an unofficial dump site located north of the Sanitary Landfill site and approximately 500 feet from Cedar Creek, and a drainage pond/swamp area located along the south-central base boundary line near the petroleum, oils, and lubricants (POL) storage area. As the result of discussions with, and at the request of, McEntire ANG Base officials and the Air Force's Occupational and Environmental Health Laboratory (OEHL), these two sites were included as part of the Phase II - Confirmation/Quantification effort. Table 1-4 presents a brief summary of suspected contamination for the six prioritized sites, as well as, the two unprioritized sites. The location of the sites is shown in Figure 1-3.

1.4 IRP PHASE II STAGE 1

On the basis of the Phase I and Phase IIa presurvey findings, the Air Force's Occupational and Environmental Health Laboratory (OEHL) developed a scope of work (Appendix C) for the Phase II Stage 1 - Confirmation/ Quantification effort for McEntire ANG Base. The objectives of this stage were to investigate the eight sites previously identified in order to:

- Determine if environmental contamination had resulted from past waste disposal practices, fuel spills, or fire training activities
- Provide estimates of the magnitude and the extent of contamination, if present
- Identify potential environmental consequences of migrating pollutants, if confirmed
- Identify additional investigations that may be necessary to properly define the magnitude and the extent of contaminants.

The exact location of the No. 1 Fire Training Area could not be delineated in the field by base personnel. Because of the fire training area's reported close proximity with the Sanitary Landfill site (Figure 1-3), these two sites were combined and investigated as one site area. The combination of these two sites and the addition of two previously unidentified sites necessitated reorganization of the numbering system previously established by the Phase I effort (Table 1-3). Table 1-5 presents the site

TABLE 1-4. HISTORY OF CONTAMINATION AT PHASE II STUDY SITES

Site Name	HARM Score	Date or Period of Existence	Waste Disposal/Contamination Activity
No. 5 Fire Training Area	69	1970-Present	Approximately 63,000 gallons of liquid waste were disposed at the site. An estimated 80 percent of these materials were burned, leaving approximately 12,600 gallons remaining in the environment. Wastes disposed included: kerosene, JP-4, waste oil, PD-680, battery acid, paint thinners, emulsifiers, aircraft cleaners, methylethyl ketone, trichloroethane, waste trash, airplane parts, and transmission, hydraulic, and brake fluids.
No. 1 Fire Training Area	67	1947-1955	Approximately 16,000 gallons of combustible waste were disposed and burned at this site during fire training exercises. An estimated 3,200 gallons remain unburned. Wastes were of the same type as those disposed of in the No. 5 Fire Training Area (above).
Sanitary Landfill	57	1947-1980	Waste materials disposed at this site include: construction rubble, domestic refuse, pesticide cans, paint, solvents, paint thinner and stripper, motor oil and antifreeze containers. Open burning was practiced, during which, approximately 5 to 30 gallons of combustible liquid waste were disposed of weekly.
Y- Storage Area	56	1947-1974	Drums of waste oil, solvents, gasoline, JP-4 and other combustible liquids were stored at this site prior to being transported to fire training areas. Chronic minor spillage, throughout it's history of use, had saturated the concrete pad and the soil surrounding it.

TABLE 1-4. HISTORY OF CONTAMINATION AT PHASE II STUDY SITES (continued)

Site Name	HARM Score	Date or Period of Existence	Waste Disposal/Contamination Activity
Oil Dump Site	56	unknown	A visible oil patch which emits a distinct hydrocarbon odor comprises this site. The volume and the full nature of the liquid disposed at this site are unknown. Plant growth has been stunted in the immediate area.
C-141 Spill Trench	54	3/7/82	An estimated 9,000 gallons of JP-4 spilled from a burning C-141 and entered the trench. An estimated 450 gallons remained in the trench following clean up operations.
Unofficial Dump Site	--	unknown	General debris, scrap metal, roofing shingles, empty paint cans, tar residues and stained soils were observed at the site. The type and volume of liquid materials disposed at the site are unknown.
Drainage Pond/Swamp	--	Intermittant	This site receives surface drainage from a large portion of the base. A light oil film was observed near a drain pipe entering the pond. The pond discharges directly off-base and therefore has a high potential for off-base contaminant migration.

Source: Phase I Report (HMTC, 1984) and Phase IIa site survey.

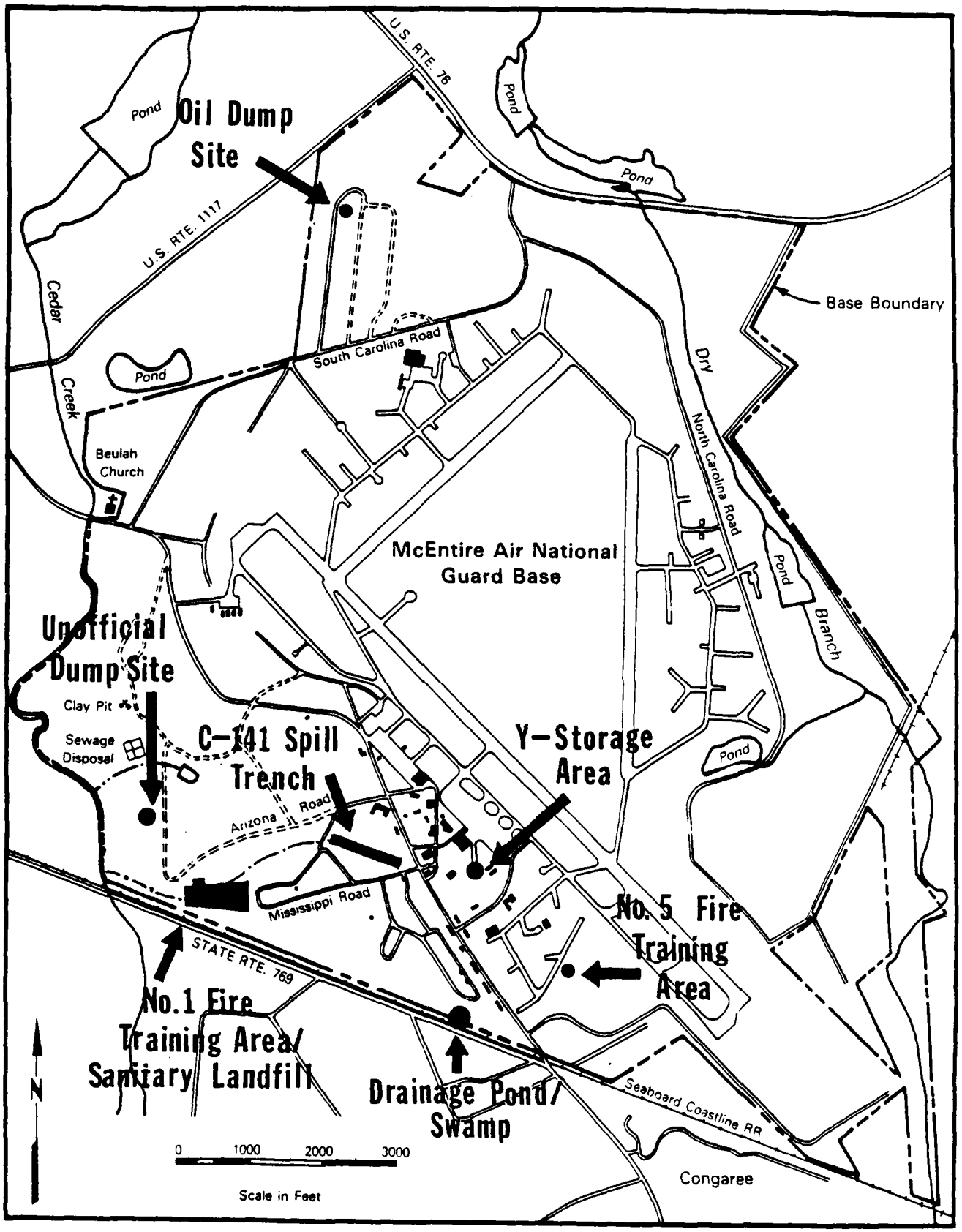


Figure 1-3. Location Map of Phase II Stage 1 Study Sites.

TABLE 1-5. BRIEF SUMMARY OF IRP PHASE II STAGE 1 SAMPLING AND ANALYSIS PLAN

Phase II Site No.	Phase I Site No.	Site Name	HARM Score	Monitoring/Sampling Plan	Analyses List*
1	2	No. 5 Fire Training Area	69	Install and sample 4 shallow monitoring wells; obtain 1 sediment sample from burn pit and 3 samples from overflow swale.	Groundwater: TOX, TOC, O&G, VOA Sediment: TOX, O&G, VOA
2	1	No. 1 Fire Training Area/ Sanitary Landfill	67	Install and sample 5 shallow monitoring wells.	TOX, TOC, O&G, VOA, Metals
	3		57		
3	4	Y-Storage Area	56	Install and sample 4 shallow monitoring wells; obtain 3 soil samples.	Groundwater: TOX, TOC, O&G Soil: TOX, O&G
4	5	Oil Dump Site	56	Install and sample 4 shallow monitoring wells; obtain 1 surface soil sample and 3 samples at 5 foot depth intervals at center of site.	Groundwater: TOX, TOC, O&G Soil: TOX, O&G
5	6	C-141 Spill Trench	54	Install and sample 3 shallow monitoring wells; obtain 4 sediment samples.	Groundwater: TOX, TOC, O&G Soil: TOX, O&G
6	--	Unofficial Dump Site	--	Install and sample 3 shallow monitoring wells; obtain 1 surface soil sample.	Groundwater: TOX, TOC, O&G, Soil: TOX, O&G, VOA
7	--	Drainage Pond/ Swamp	--	Obtain 6 sediment samples.	TOX, O&G, nitrates, phosphorous (total)
--	--	Cedar Creek & Tributary Drainage Swale	--	Obtain 4 surface water and sediment samples from Cedar Creek, and 2 sediment samples from drainage swale.	Surface water: TOX, TOC O&G, VOA, Metals Sediment: TOX, O&G, VOA, Metals
--	--	Supply Well (W-1)	--	Obtain 1 sample.	VOA

* TOX: Total Organic Halogens
TOC: Total Organic Carbon
O&G: Oil and Grease by IR
VOA: Volatile Organics Analysis by EPA methods 601-602 (water), 846/8010-8020 (soil/sed.)
Metals: As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn

numbering system developed and implemented for the Phase II Stage 1 effort and provides a brief summary of the sampling and analysis plan for each of the sites. The location of the site areas with their assigned numbers is shown in Figure 1-4. Site scale maps are provided in Figures 1-5 through 1-11. Detailed descriptions of each of the sites are provided in Chapter 2.0.

The field program was coordinated and implemented by SAIC personnel. The field team as well as the personnel involved in the preparation of this report are identified in Appendix L. Borehole drilling and well installation were contracted to Soil and Materials Engineers, Inc. of Columbia, South Carolina, and supervised by SAIC/JRB personnel. Sampling activities were performed by SAIC/JRB personnel. The samples collected were split, with one set sent for analysis to SAIC/JRB's subcontracted laboratory, Environmental Research Group (ERG) Laboratories of Ann Arbor, Michigan, and a duplicate set sent to OEHL's laboratory in San Antonio, Texas.

The remainder of the report is divided into five chapters which are briefly outlined below:

2.0 Environmental Setting - An overview of regional and local geology and hydrology, including aquifer systems and detailed disposal histories.

3.0 Field Program - The field activities and procedures associated with the monitoring well installation program, aquifer tests, and sampling procedures.

4.0 Discussion of Results and Significance of Findings - Field sampling results, extent of contamination, and evaluation of contamination.

5.0 Alternative Measures - The proposed options by site for future monitoring efforts or studies.

6.0 Recommendations - Conclusions of the study and recommendations for future IRP stages.

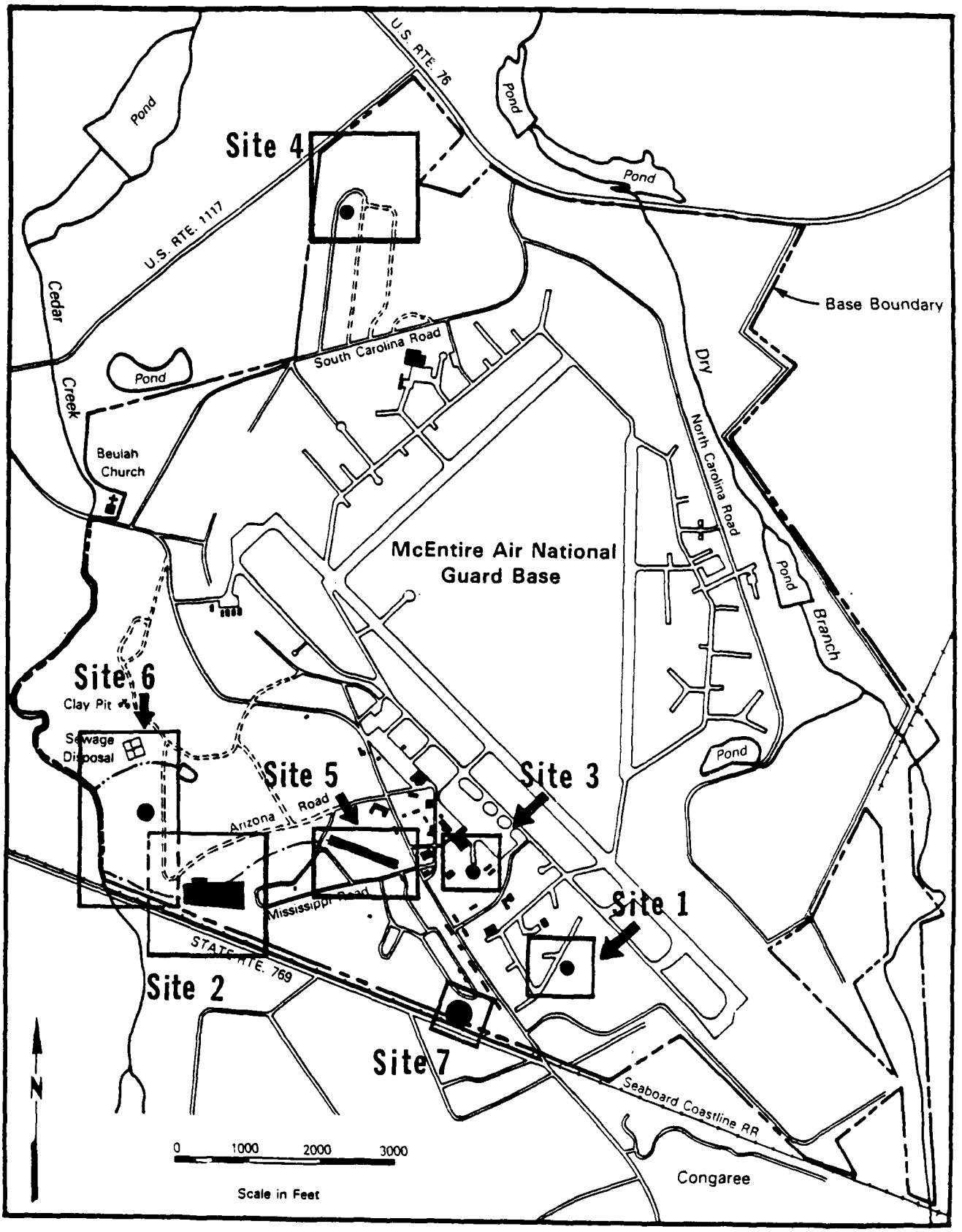


Figure 1-4. Location Map of Phase II Stage 1 Study Sites Showing Site Numbering System Implemented.

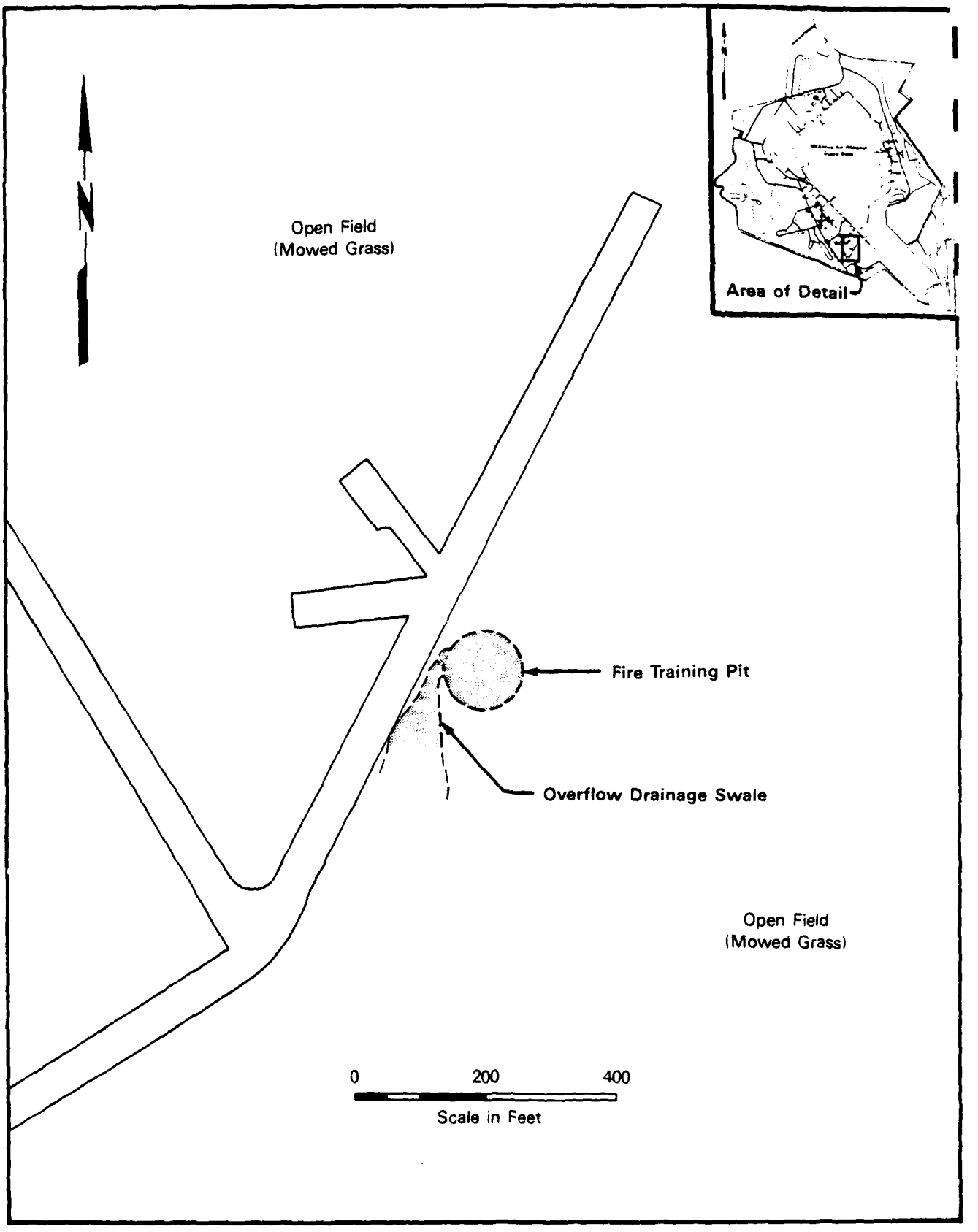


Figure 1-5. Site No. 1: No. 5 Fire Training Area.

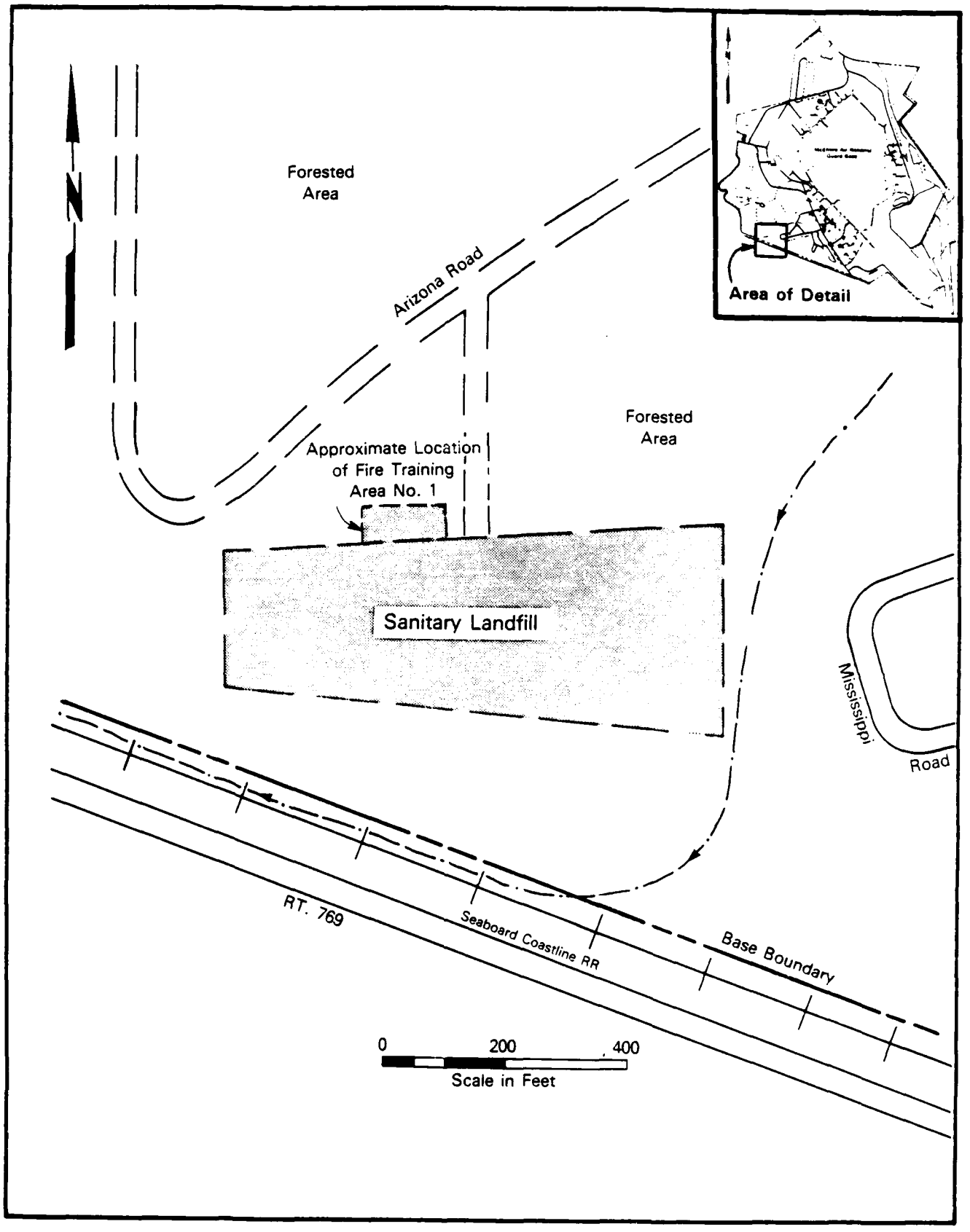


Figure 1-6. Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site.

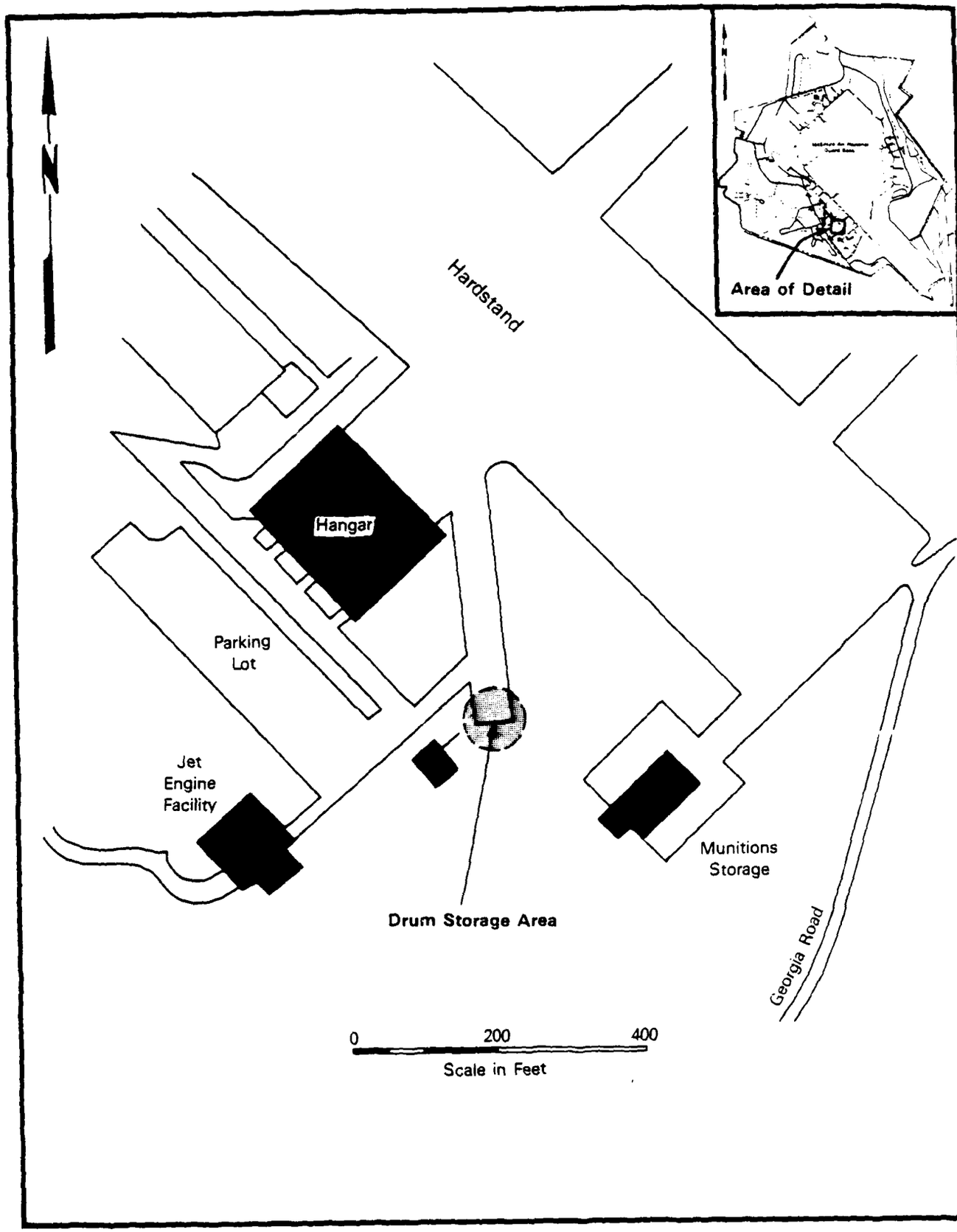


Figure 1-7. Site No. 3: Y-Storage Area.

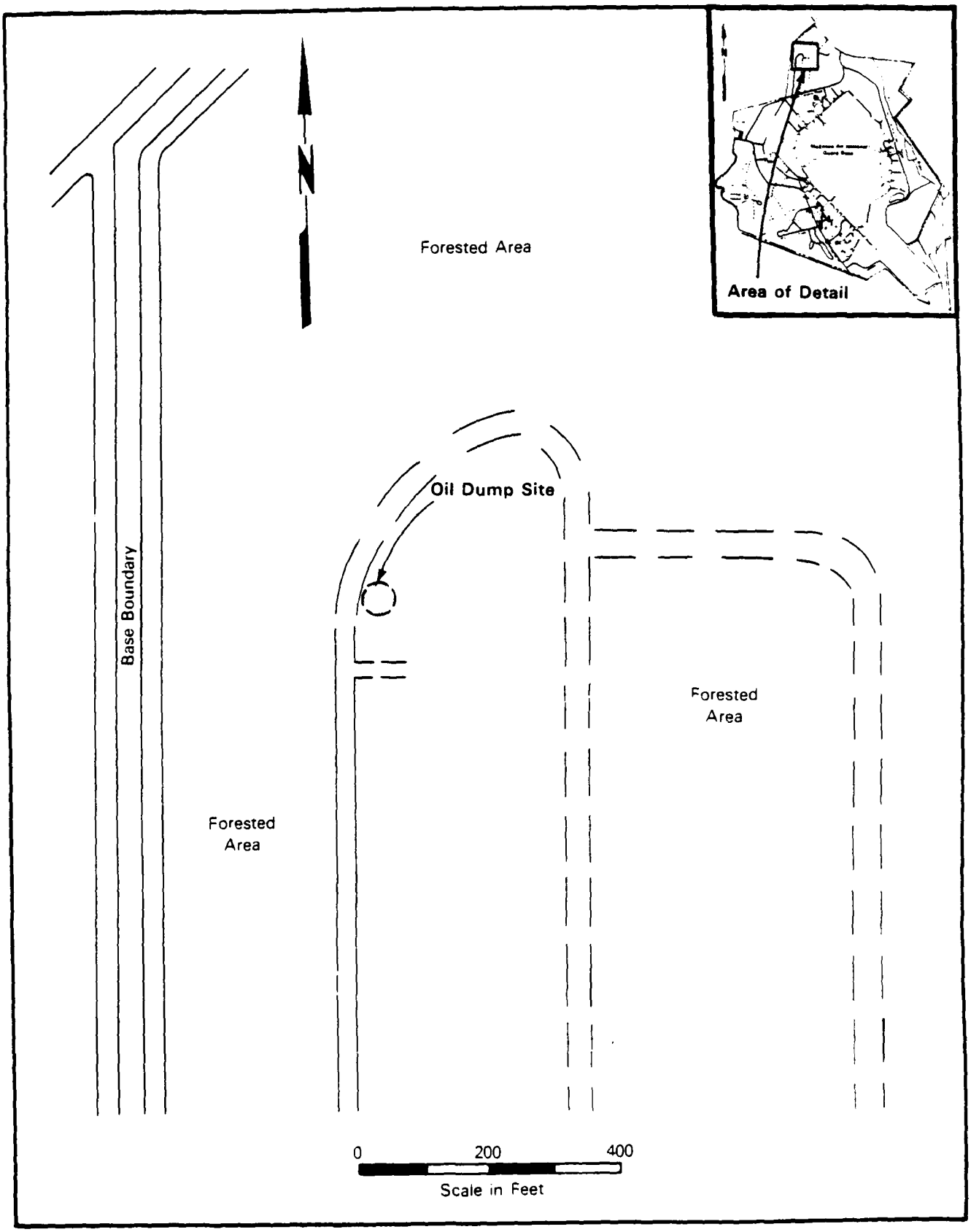


Figure 1-8. Site No. 4: Oil Dump Site.

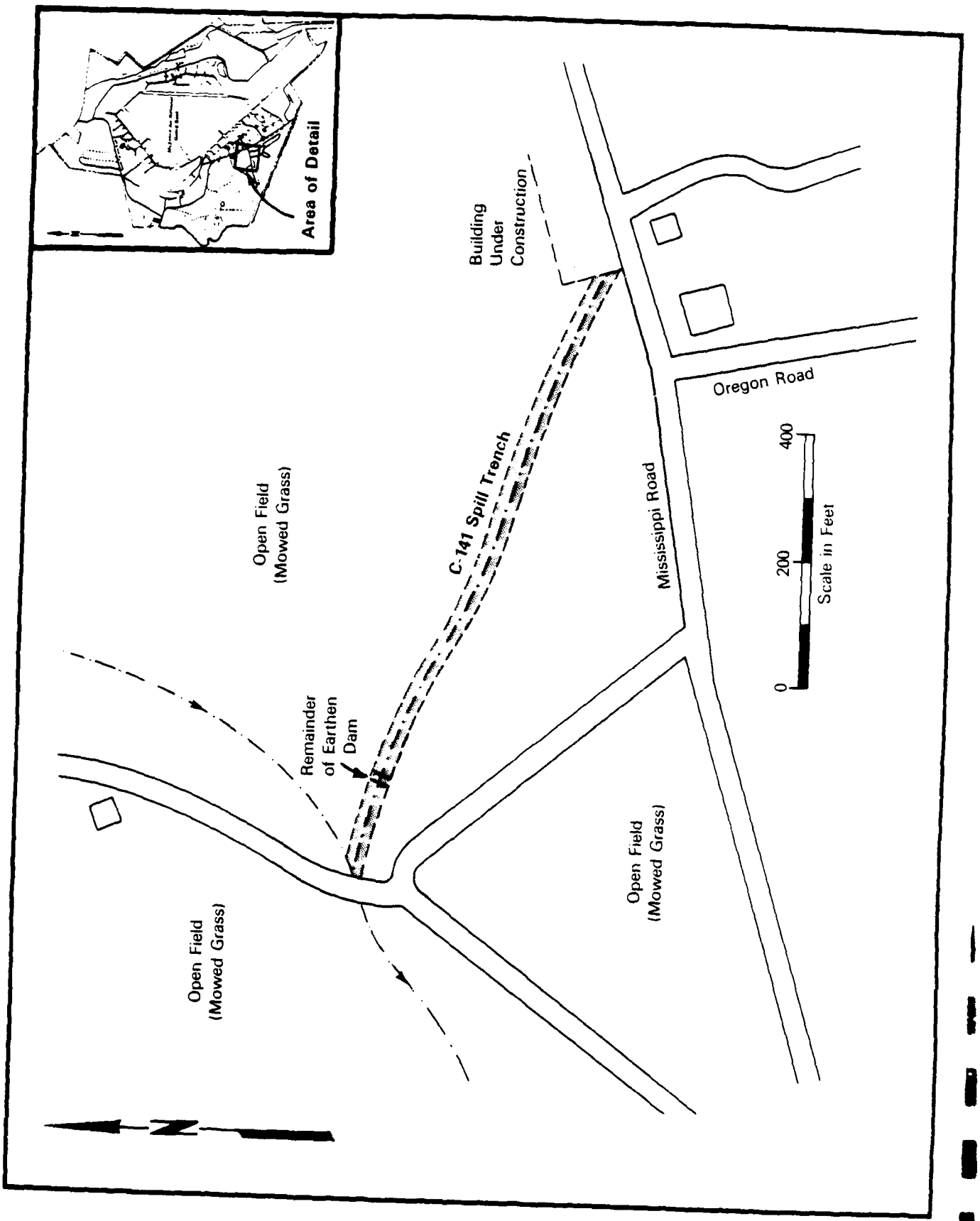


Figure 1-9. Site No. 5: C-141 Spill Trench.

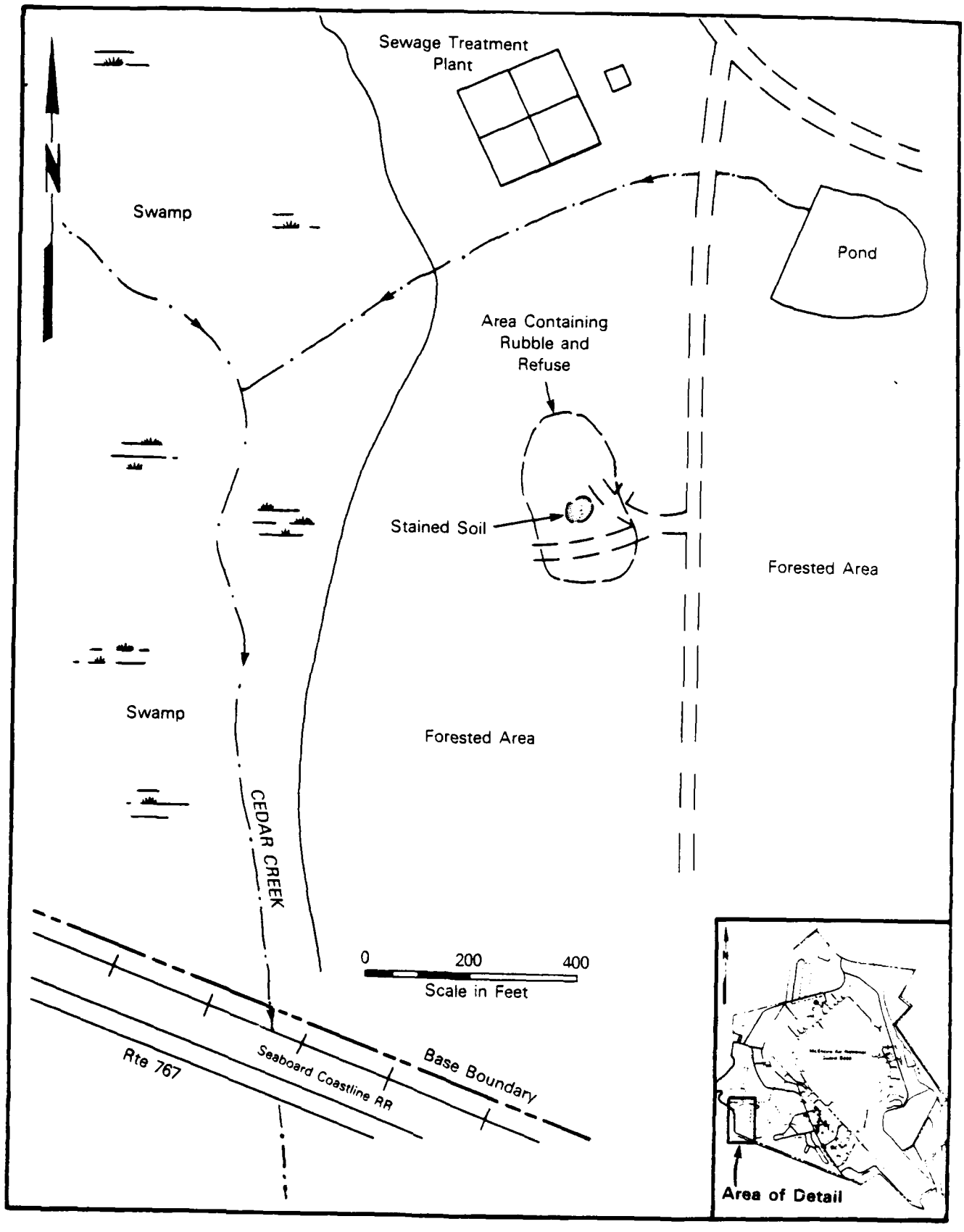


Figure 1-10. Site No. 6: Unofficial Dump Site.

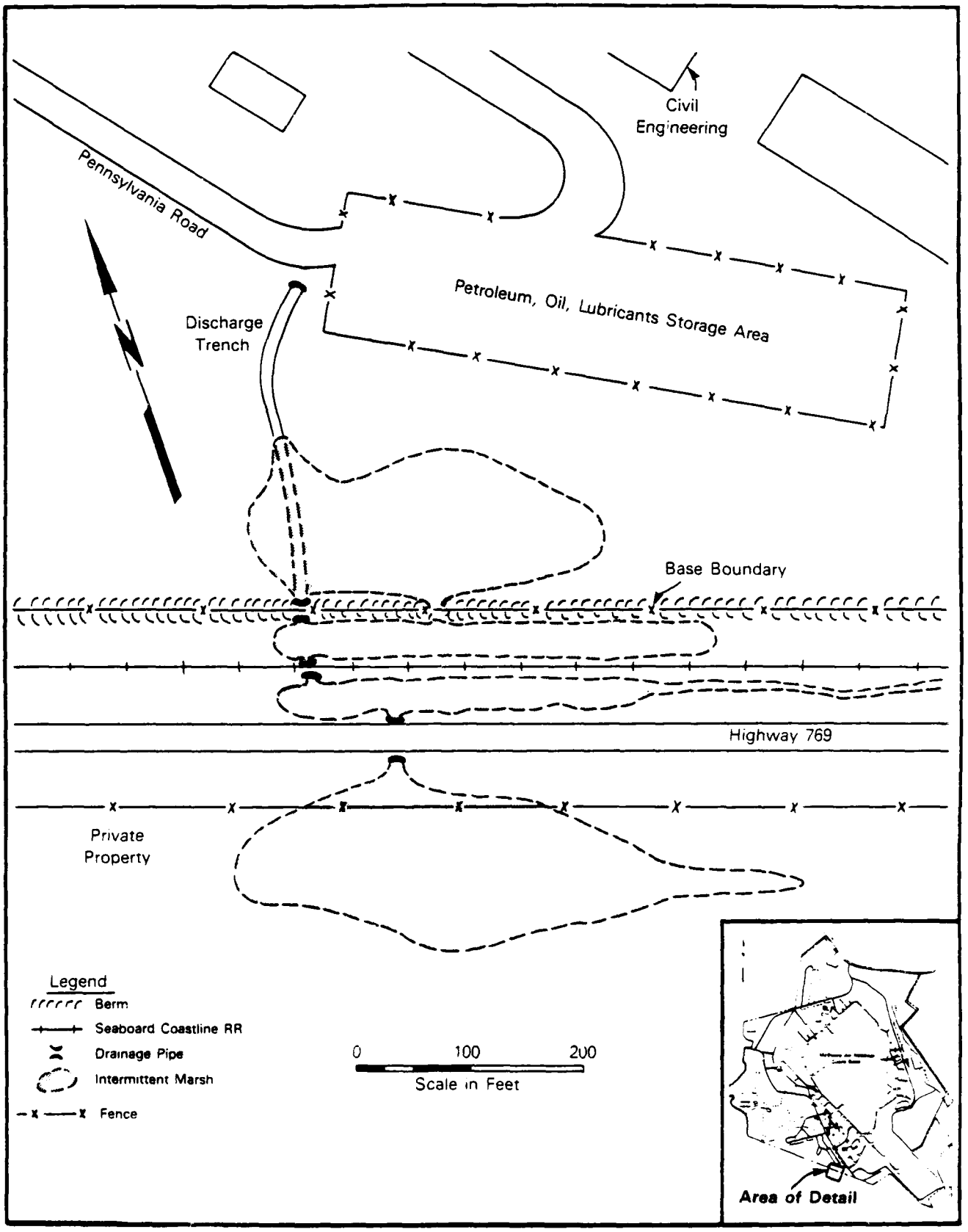


Figure 1-11. Site No. 7: Drainage Pond/Swamp Site.

2.0 ENVIRONMENTAL SETTING

2.1 PHYSICAL GEOGRAPHY

McEntire ANG Base lies within the Lower Coastal Plain subprovince of the Atlantic Coastal Plain Physiographic Province (Figure 2-1), between the northeast valley wall and the floodplain of the Congaree River. This portion of the Lower Coastal Plain is characterized by very low relief and a number of flat to gently inclined terraces separated by scarps that are topographically recognizable between the elevations of 270 and 110 feet mean sea level (MSL). The terraces and associated scarps have been identified by Cooke (1936) and regionally correlated by Colquhoun (1965) as follows:

Elevation of Toe of Northwest Bounding Scarp(feet MSL)	Terrace Name
300-320	Un-named
270-250	Hazelhurst
220-210	Coharie
180-170	Sunderland
150-140	Okefenokee
125-110	Wicomico

According to Colquhoun (1965), these terraces and scarps represent the terminal geomorphic surfaces of transgressive - regressive stratigraphic units which were deposited during fluctuations in sea level. Their state of preservation is variable. The highest terrace is not noticeable on topographic maps of the area and is interpreted to be present on the basis of stratigraphy (Colquhoun, 1965). The remaining terraces are less dissected by erosion and are more apparent physiographically. Ground surface elevations at McEntire ANG Base (excluding flood plains) grade gradually from approximately 200 feet MSL, near the southwest base boundary, to approximately 270 MSL along the northern boundary, within the limits designated by Cooke (1936) for the Hazelhurst terrace. The land area directly north of the base lies within the Upper Coastal Plain. Relief of several hundred feet is common within this

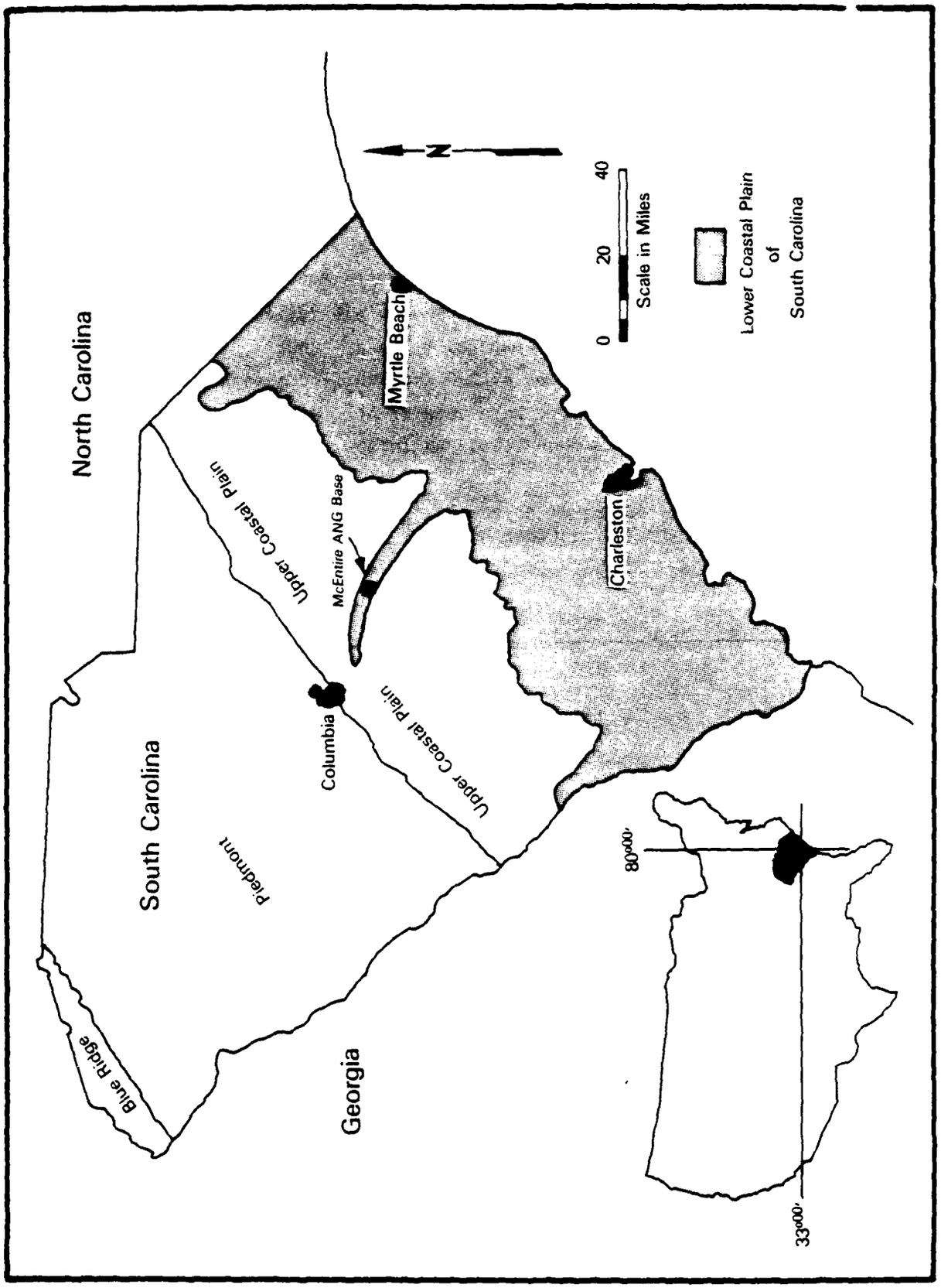
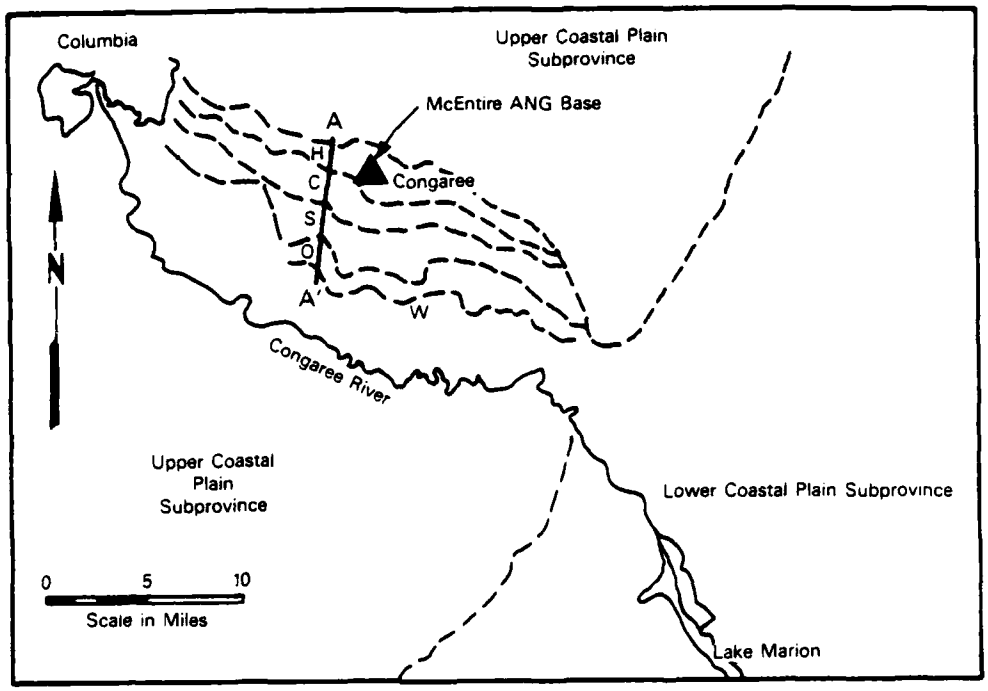


Figure 2-1. Physiographic Provinces of South Carolina

subprovince and plain surfaces are rare. Complex dendritic stream patterns thoroughly drain the region and natural lakes and swamps are almost absent. The Upper Coastal Plain has been subdivided into two regions, the Red Sand Hills and the White Sand Hills, based largely on characteristic soils (Colquhoun, 1965). A topographic cross section of the northeast side of the Congaree River Valley illustrating the Upper and Lower Coastal Plain subprovinces is provided in Figure 2-2.

The majority of streams which flow across the northeast valley wall of the Congaree River are fed by groundwater and originate in the Sand Hills region of the Upper Coastal Plain. They flow in a southeasterly direction toward the Congaree River across the Lower Coastal Plain in narrow valleys that are separated by relatively smooth, broad stream divides (SCS, 1978). McEntire ANG Base is situated between two such streams; Cedar Creek, which flows along the west side of the base and forms the southwest base boundary, and Dry Branch which flows along the eastern base boundary (Figure 1-2). With the exception of a drainage outfall located near the Petroleum, Oil and Lubricants (POL) area in the extreme southern portion of the base (Site No. 7: Drainage Pond/Swamp), rainfall runoff at McEntire ANG Base flows directly, or is captured and diverted via the base's stormwater drainage system, into Cedar Creek and Dry Branch. All of the sites being investigated as part of the Phase II Stage 1 effort lie within the drainage area of Cedar Creek. Cedar Creek flows in a southeasterly direction for approximately 14 miles and empties into the Congaree River. Dry Branch, a tributary to Cedar Creek, joins Cedar Creek approximately six miles due south of McEntire ANG Base. The Congaree River is joined by the Wateree River approximately 24 miles southeast of the base. Their confluence marks the origin of the Santee River which in turn, flows southeasterly and eventually empties into Lake Marion.

Water quality data are not available for either Cedar Creek or Dry Branch, however, both streams have been classified as Class A streams under the South Carolina Stream Classification System. Class A refers to those streams suitable for a drinking water supply after conventional treatment, primary contact recreation, fishing, survival and propagation of fish, and for industrial and agricultural purposes (HMTC, 1984).



Legend

— — Top of Scarp (Landward Extent of Terrace)

A-A' Cross-section Line

H Hazelhurst Terrace

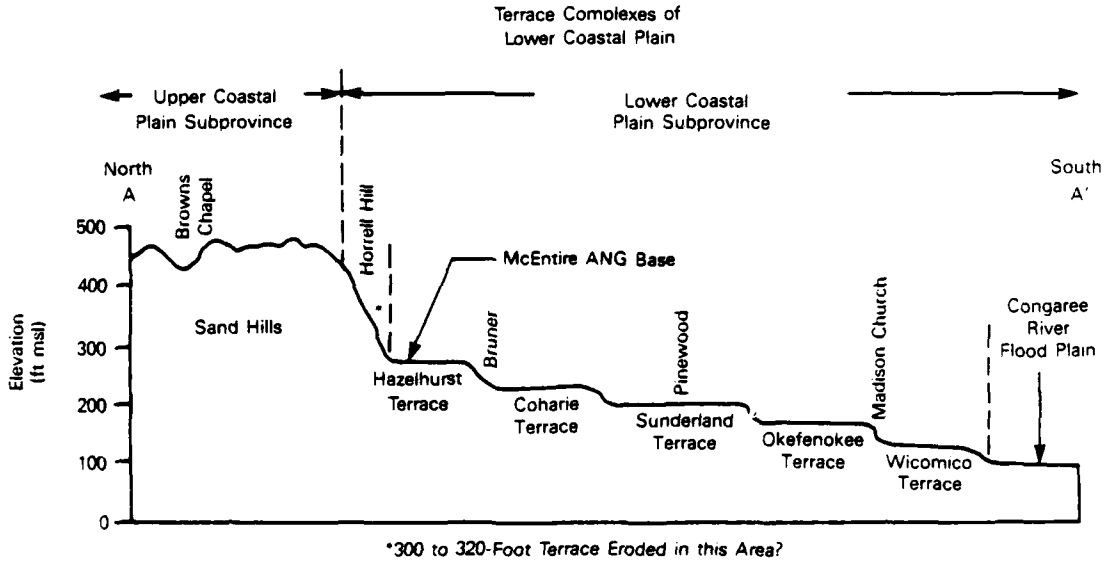
C Coharie Terrace

S Sunderland Terrace

O Okefenokee Terrace

W Wicomico Terrace

(Source: Colquhoun, 1965)



*300 to 320-Foot Terrace Eroded in this Area?

(Source: Modified from Colquhoun, 1965.)

Figure 2-2. Physiographic and Topographic Cross-Section of the Northeast Side of the Congaree River Valley from Brown's Chapel to Madison Church, South Carolina.

Soils mapped by the U.S.D.A., Soil Conservation Service (1978) at McEntire ANG Base are of the Orangeburg-Norfolk-Marlboro soil association. This map unit consist of deep, nearly level to sloping, well drained soils that were formed in the loamy and clayey sediments of the Coastal Plain terraces. The majority of the soils of this map unit which are present at the sites under investigation are of the Orangeburg, Norfolk, and Coxville soil series. Table 2-1 summarizes the physical properties of these soils.

2.2 REGIONAL GEOLOGY

The geology of South Carolina has been characterized by several authors including Tuomey (1848), Cooke (1936), Siple (1957), and Colquhoun (1965). The regional geologic setting provided in this report is based largely on their findings and is presented to provide background information so that correlations of site-specific information can be related to regional trends.

The Coastal Plain of South Carolina is characterized by a wedge-shaped body of complexly interbedded unconsolidated or semiconsolidated sedimentary formations, of Late Cretaceous to Quaternary Age, which overlie crystalline basement rock of the Piedmont Province (Figure 2-3). These Coastal Plain formations generally strike northeast-southwest, dip to the southeast at 8 to 30 feet per mile, and thicken downdip (Siple, 1957). Because of their simple homoclinal structure, they outcrop at the surface along the inner margin of the Coastal Plain, and do so in an oldest to youngest sequence from west to east. This effect is illustrated in the regional geologic map of the South Carolina Coastal Plain (Figure 2-4). Table 2-2 provides a description of the formations identified in Figure 2-4.

As is shown in Figure 2-4, McEntire ANG Base is underlain by the Tuscaloosa formation of Late Cretaceous Age. This formation is composed of tan, buff, red and white crossbedded, micaceous, feldspathic, quartz sand and gravel interbedded with red, brown, gray and purple impure clay and white kaolin (Siple, 1957). The Tuscaloosa is the oldest and lowermost of the sedimentary formations, and is continuous throughout the Coastal Plain of South Carolina (Callahan, 1975). Because the Tuscaloosa formation dips to the

TABLE 2-1. PHYSICAL PROPERTIES OF SOILS AT STUDY SITES

Soil Series	Sites Where Found	Permeability Change With Depth (in/hr)[1]	Depth (in)	Erosion Factor (by water)	Hydrologic Group[2]	Mean Overall Permeability (in/hr)[1]
Orangeburg Loamy Sand	1,2,3,5,6	2.00-6.00 2.00-6.00 2.00-6.00 2.00-6.00	0-12 12-18 18-57 57-90	Slight	B	1.30-4.00
Norfolk Loamy Sand	4	2.00-6.00 0.60-2.00	0-17 17-75	Slight	B	1.30-4.00
Coxville Fine Sandy Loam	7	0.60-2.00 0.20-0.60	0-9 9-65	Slight	D	0.40-1.30

[1] - Permeability factors refer to vertical water movement in saturated soils.

[2] - Group A. Soils having a high infiltration rate (low runoff potential) when throughly wet. These consist chiefly of deep, well-drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well-drained or well-drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water or soils that have moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

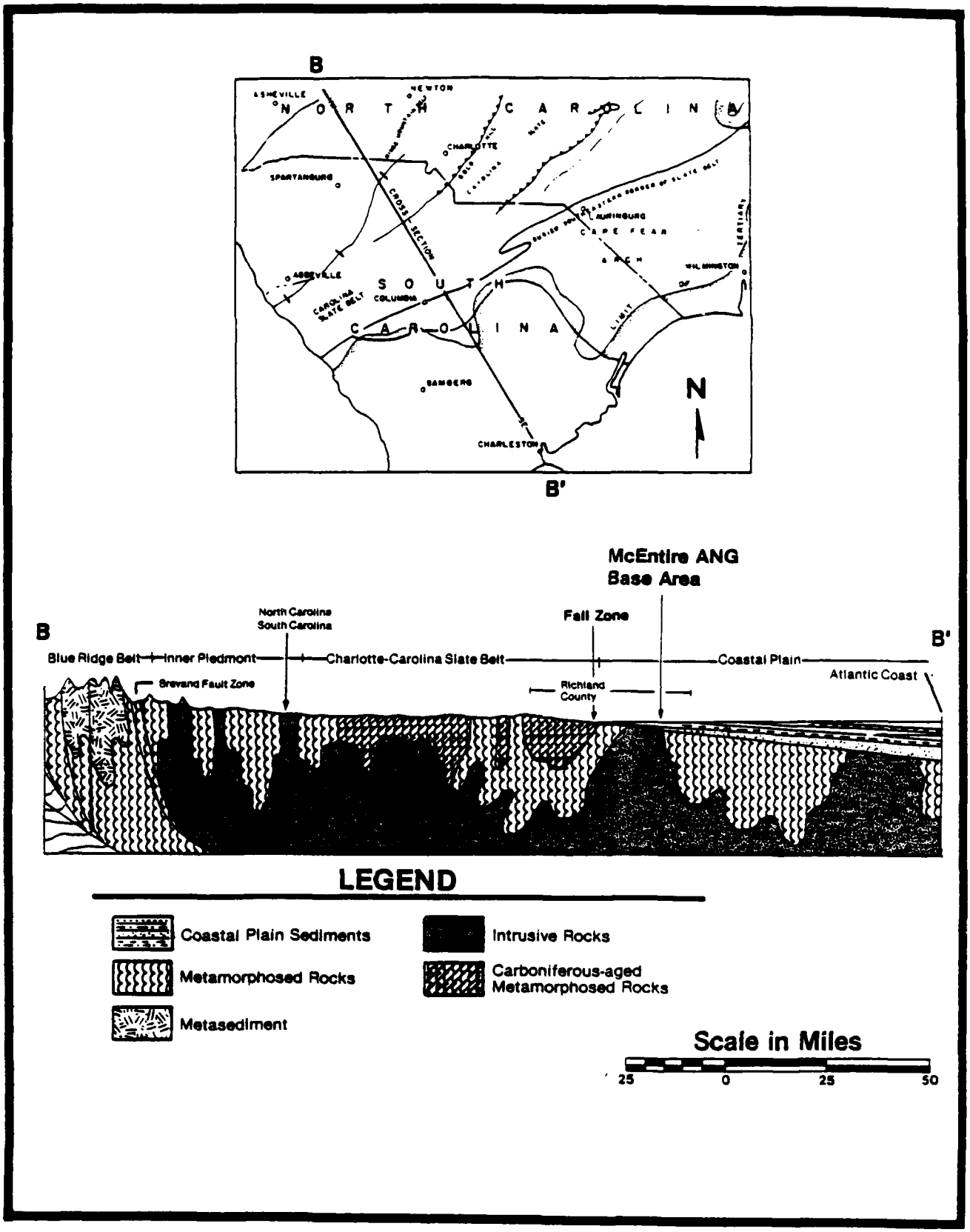


Figure 2-3. *Geologic Cross Section of South Carolina.*

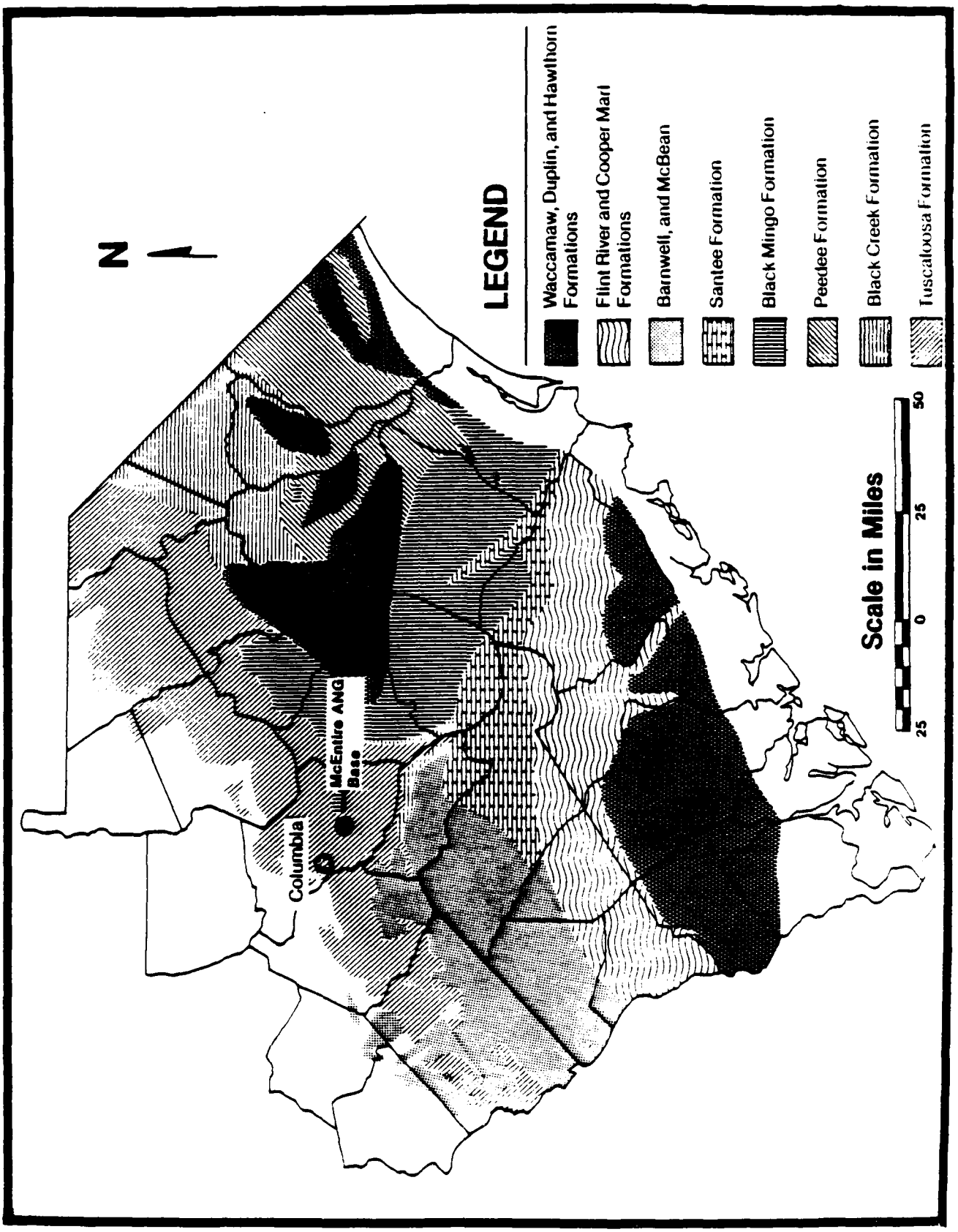


Figure 2-4. Surficial Geology of South Carolina Coastal Plain.

TABLE 2-2.
GEOLOGIC FORMATIONS WHICH OUTCROP IN THE SOUTH CAROLINA COASTAL PLAIN

System	Formation	Approximate Thickness (ft.)	Description
Tertiary	Waccamaw	25	Interbedded layers of sand and marine shells.
	Duplin	20	Shell marl.
	Hawthorn	160	Sandy phosphatic marl and soft limestone with interbedded brittle shale.
	Flint River	50	Reddish yellow sand, inclusions of yellow vitreous chert.
	Cooper Marl	100-200	Greyish-green marl commonly 75 percent lime carbonate and 2-5 percent lime phosphate.
	Barnwell	100	Fine to coarse reddish pebbly sand, generally massive, cross-bedded, and mottled with grey in places.
	McBean	100	Fine to medium grained, light greenish glauconitic marl, laminated flakey clay, fuller's earth, lenses of silicified limestone.
	Santee	180-230	Pure white to creamy yellow, soft, homogeneous limestone containing few bedding planes.
	Black Mingo	100	Yellow-red, fossiliferous, laminated sandy shale, interbedded dark clay, shale, fuller's earth.
Cretaceous	Peedee	800	Grey sandy marl interbedded with thin ledges of hard marlstone.
	Black Creek	450	Unctuous black shaley clays enclosing interlaminations of extremely thin seams and occasional fine-grained sand.
	Tuscaloosa	250-300	Light-grey, white, or buff, cross-bedded sand with interfingering lenses of white, pink, or purplish clay.

Source: Phase I Report (HMTC, 1984).

southeast, it crops out at the surface in a belt 10 to 40 miles wide along the extreme northwestern border of the Coastal Plain, where McEntire ANG Base is situated (Figure 2-4). According to Siple (1957), the Tuscaloosa formation has a smaller dip (15 to 20 feet per mile) in this portion of the Coastal Plain than it does across the Coastal Plain as a whole (30 feet per mile). Thickness of the Tuscaloosa ranges from a feather edge along its westernmost border, in the vicinity of Columbia, to approximately 950 feet in wells near the coast (Callahan, 1964). At McEntire ANG Base, the Tuscaloosa formation is estimated to be approximately 300 feet thick (HMTC, 1984).

Along the northwest valley wall of the Congaree River, where McEntire ANG Base is situated, the Tuscaloosa formation is overlain by a series of marine terrace deposits of Tertiary Age. These terraces and the stratigraphic units which comprise them were formed by a complex series of erosional and depositional cycles brought about by successive transgressive and regressive fluctuations in sea level (Colquhoun, 1965). Figure 2-2 shows the mapped extent of the terraces along the northeast valley wall of the Congaree River, based on the scarps that differentiate them. The oldest terrace found in the vicinity of the base is the Hazelhurst terrace, followed sequentially in age by the Coharie, Sunderland, Okefenokee, and Wicomico terraces. Each of these terraces were deposited on an erosional unconformity on the underlying Tuscaloosa formation. The relationship between the terraces and the underlying Tuscaloosa formation is schematically illustrated in Figure 2-5. The terraces are geomorphically and geologically congruous (i.e., the deposits which form a terrace comprise a formation having the same name as the terrace). The elevation, thickness, and lithology of individual terraces are summarized in Table 2-3. The Hazelhurst (terrace) formation directly underlies the majority of McEntire ANG Base. Geologic information obtained during monitoring well installation suggests that the southwesternmost portion of the base may be underlain by the Coharie (terrace) formation.

The Hazelhurst (terrace) formation, like the Coharie and other terrace formations, generally consists of basal cross-bedded sands and gravels which grade upward to sandy, silty clay. The thickness of the formation ranges from 40 to 50 feet along northeasternmost extent to 0 feet at the scarp that

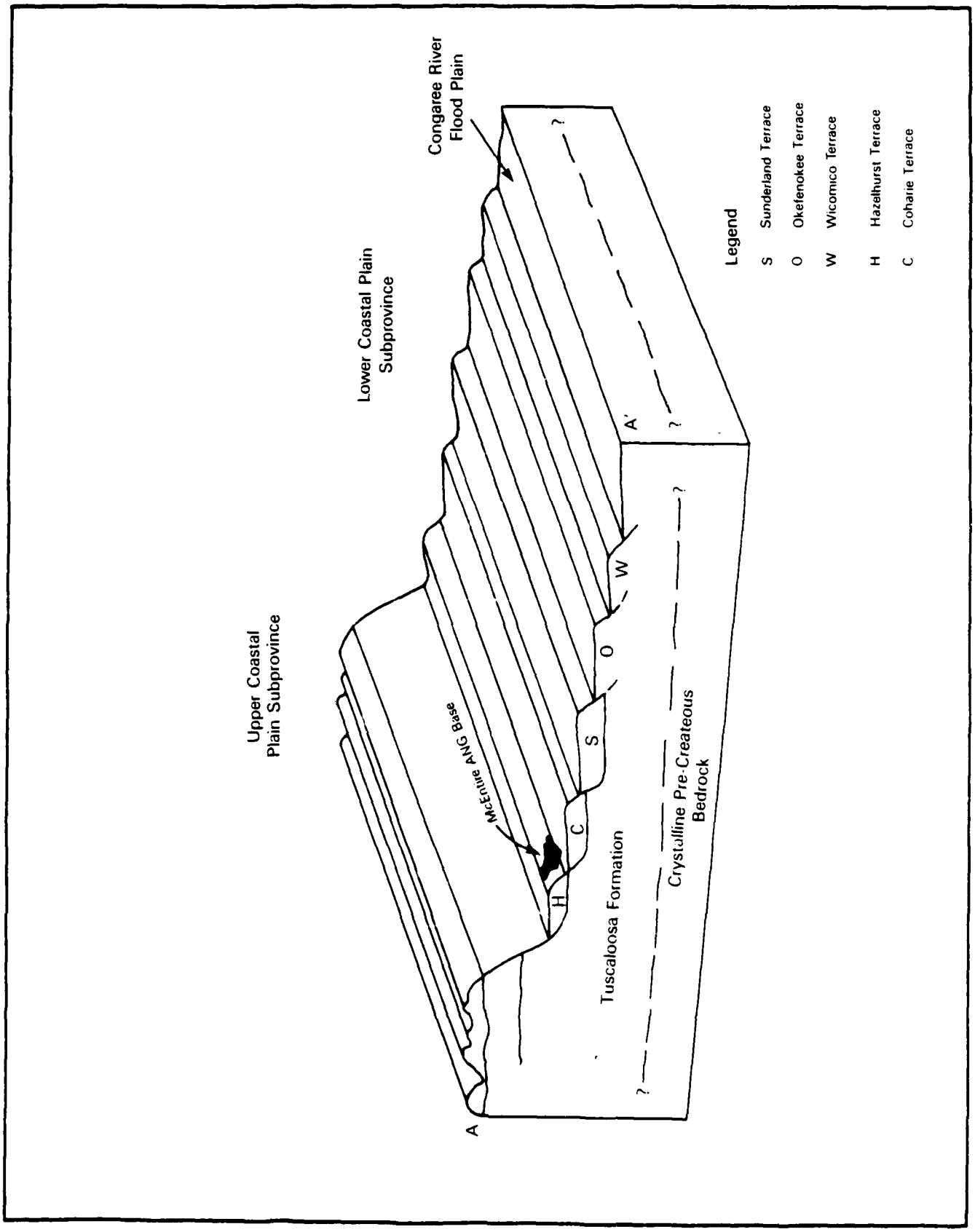


Figure 2-5. Schematic Block Diagram Showing Relative Position of Terrace Complexes Overlying Tuscaloosa Formation on Northeast Side of Congaree River Valley (Adapted from Colquhoun, 1965).

TABLE 2-3. FORMATIONS AND TERRACES FOUND IN THE CONGAREE RIVER VALLEY

Formation Name	Terrace Name	Elevation (ft. MSL)	Lithology	Geologic Time Period
Wicomico	Wicomico	100-125	Cross-bedded sand, grades upward to sandy clay	Pleistocene
Okefenokee	Okefenokee	140-150	Cross-bedded sand and gravel, grades upward to sandy clay	Post-Late Miocene or Late Miocene
Indefinite	Sunderland	170-180	Basal cross-bedded sands and coarse gravels, grades upwards to sandy clay	Post-Late Miocen or Late Miocene
Coharie	Coharie	210-220	Basal gravel grades upwards to sandy clay	Post-Late Miocene or Late Miocene
Hazelhurst	Hazelhurst (or Brandywine)	250-270	Basal cross-bedded sands and coarse gravels, grades upwards to silt, sand, and clay	Post Median Eocene to Pre-Late Miocene

Source: Colquhoun (1965).

differentiates it from the lower-lying Coharie (terrace) formation. The gravel facies at the base of the Hazelhurst constitutes the contact between the Hazelhurst and the underlying Tuscaloosa formation. However, the interbedded nature of gravel and sand in the lowermost horizon of the Hazelhurst suggests that the gravel is not a continuous unit. Where the gravel layer is absent, the contact between the Hazelhurst and Tuscaloosa formation is difficult to determine, because of their similiar lithologic characteristics. Because the terrace deposits and Tuscaloosa formation are contiguous and have similar lithologic and stratigraphic characteristics, they can be viewed as one hydrogeologic unit.

2.3 REGIONAL HYDROGEOLOGY

The primary water bearing formation in the McEntire ANG Base area is the Tuscaloosa formation. This formation is composed of complexly interbedded unconsolidated to semiconsolidated sand, silt and clay deposits. Sufficient yields of water for supply purposes occur within the sandy beds of the formation.

Groundwater in the Tuscaloosa formation, in the region where McEntire ANG Base is situated, occurs under both water table and artesian conditions. Within the uppermost units of the formation groundwater occurs under water table conditions. Within the deeper sandy beds of the formation, groundwater is confined by relatively impermeable clay and silt beds and hydrostatic pressure causes the water to rise above the confining bed when the aquifer is penetrated by a well. Because the deeper sand aquifers of the Tuscaloosa formation are generally higher yielding, the shallow water table aquifer is not extensively utilized for water supply purposes. Wells which are installed into the Tuscaloosa for supply purposes generally are drilled into the deeper confined sand aquifers of the formation, where groundwater exists under artesian conditions (Siple, 1957).

As a hydrogeologic unit, the Tuscaloosa formation is one of the principal aquifers in the Coastal Plain of South Carolina, because of its yield and utilization (Siple, 1957). Wells within the Tuscaloosa have been reported to

yield as much as 2,000 gallons per minute (gpm), with a large portion of municipal and industrial wells yielding 300 gpm or more (McGuinness, 1963). Siple (1960) estimated the transmissivity of the Tuscaloosa along the inner margin of the Coastal Plain to be as high as 450,000 gallons per day (gpd) and to average 200,000 gpd. The high yields of the Tuscaloosa aquifer are largely the result of its occurrence as a thick, predominantly sandy formation with an extensive outcrop area available for recharge.

Precipitation falling directly on the outcrop area of the Tuscaloosa formation provides the primary source of recharge to the aquifer. Annual precipitation over the outcrop averages 48 inches, of which, approximately 15 inches per year occurs as surface runoff and an estimated 10 inches per year recharges the aquifer (Callahan, 1964). Thomson and Carter (1955) determined that streams in the outcrop region of the Tuscaloosa formation have minimum flows not much less than their average flows, indicating a steady flow of groundwater from the aquifer to the streams. Callahan (1964) reported that most of the water that is recharged to the Tuscaloosa in its outcrop area is actually discharged to streams and rivers which incise the formation.

Groundwater which is not discharged to surface water bodies in the outcrop region moves in a general southeasterly direction down the dip of bedding (or, more accurately, down the hydraulic gradient which, locally, may be in a different direction from the dip) to discharge into overlying strata in areas where its head is lower, between the outcrop area and the coast, beyond the coast, or both (Siple, 1957). Callahan (1964) reports the average hydraulic gradient for the Tuscaloosa to be 2.5 feet per mile over the extent of the aquifer. However, Siple (1960) computed a hydraulic gradient of 14 feet per mile from the recharge area at Aiken, South Carolina, to the discharge area in the Savannah River south of Augusta, Georgia. Because the hydraulic gradient appears to be less than 1 foot per mile over the last 80 miles to the coast (Callahan, 1964) and the average takes this into account, hydraulic gradients in the westernmost portion of the aquifer probably exceed the average. Consequently, the hydraulic gradient of the Tuscaloosa formation is probably greater than 2.5 feet per mile in the vicinity of McEntire ANG Base.

A regional report addressing the quality of groundwater within the Tuscaloosa is currently being prepared by the South Carolina Water Resources Commission (SCWRC), however, this report has not yet been published and similar reports are currently unavailable (Clymer, 1985). A review of available literature pertaining to the Tuscaloosa formation has provided the following information regarding groundwater quality:

- As groundwater in the Tuscaloosa moves toward the east, it tends to become harder and more alkaline because of chemical interaction with the sediments through which it flows (HMTC, 1984).
- Excessive concentrations of iron, chloride, hydrogen sulfide, and fluoride, low pH and hard water can occur in groundwater of the South Carolina Coastal Plain (Cederstrom, et al., 1979).
- The iron content is generally 0.35 ppm or more in Cretaceous sand aquifers in a belt 15 to 20 miles southeast of the Columbia, SC (McGuinness, 1963).
- The Tuscaloosa possibly contains usable fresh water for as much as 100 miles southeast of Columbia, SC (Callahan, 1964).
- The Tuscaloosa has yielded water containing about 1,200 ppm dissolved solids from a well at Parris Island, SC, some 110 miles southeast of Columbia, SC (Callahan, 1964).

From these sources, groundwater quality within the Tuscaloosa can generally be assumed to be good, with the exception of potentially high concentrations of iron, fluoride, chloride, and hydrogen sulfide.

2.4 LOCAL GEOLOGY AND HYDROGEOLOGY

The regional geologic and hydrogeologic setting for McEntire ANG Base presented in the previous sections were provided to serve as an overview and to aid in the interpretation of site-specific data gathered during this investigation. Local geologic and hydrogeologic data obtained during the field program for the Phase II Stage 1 effort generally agrees with regional trends. The few elements that appear anomalous result from localized geomorphic controls, not observed by previous authors, whose work formed the basis of the regional brief. This section summarizes the local geologic and hydrogeologic data that were acquired during the field effort at McEntire ANG Base and presents it in light of regional trends.

2.4.1 Local Geology

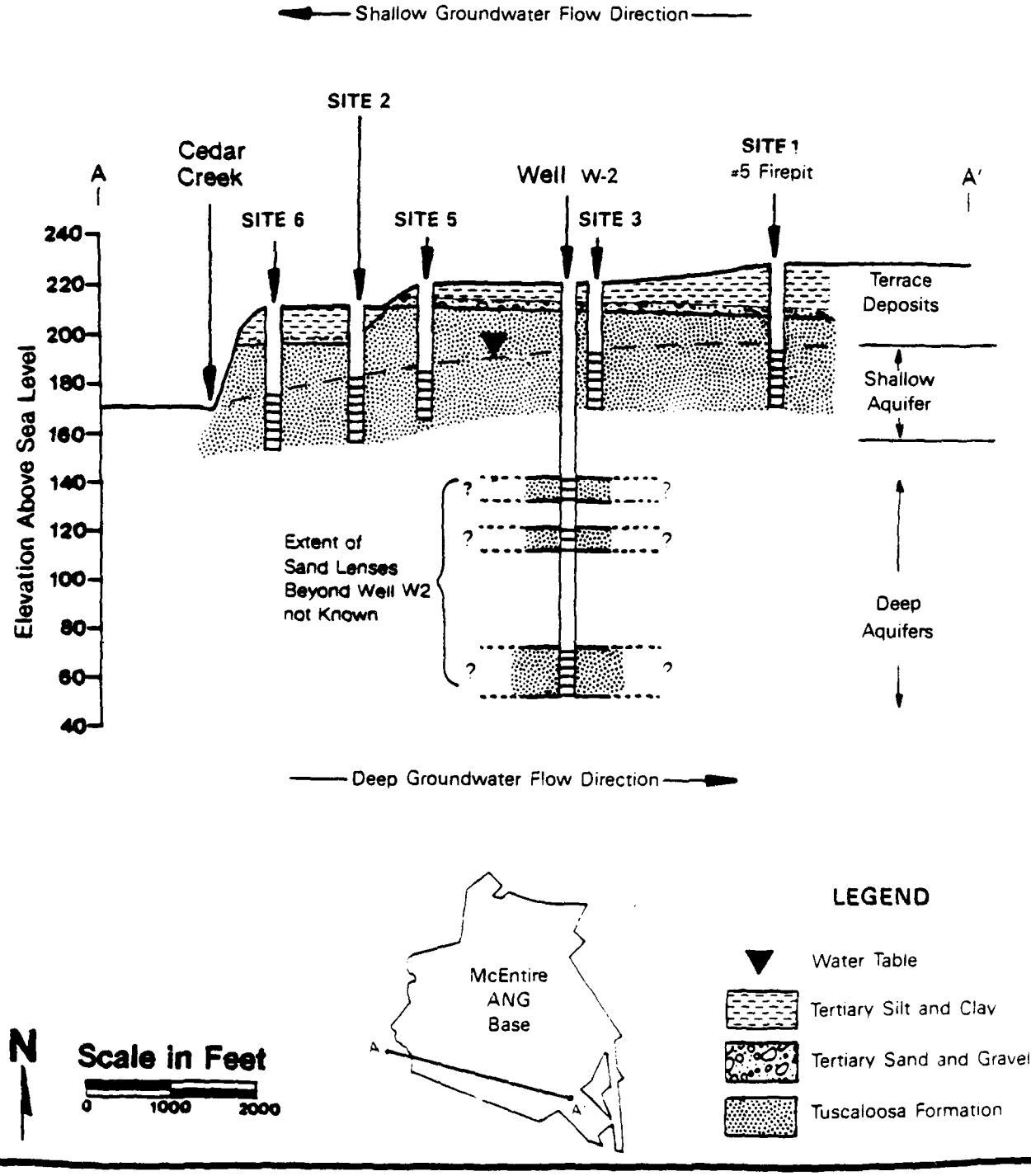
Subsurface materials at McEntire ANG Base were characterized through the visual examination of split spoon samples collected during borehole drilling at each of the 23 monitoring well locations. Lithologic descriptions for the subsurface materials encountered at each of the well locations is provided in the drilling logs contained in Appendix E.

Generally, two regional stratigraphic units were encountered through the depth of each borehole: 1) an upper unit which generally consisted of a basal layer of light to heavy gravel and sand grading upward to relatively stiff to very stiff tan to red sandy clays or silts, characteristic of the terrace deposits which encompass the general area and 2) a lower unit generally consisting of light yellow, buff to white, micaceous to kaolinitic sands interbedded with silt and clay (kaolin), typical of the Tuscaloosa formation. These units are illustrated in the cross section shown in Figure 2-6.

In many cases the basal gravels of the terrace deposits were disseminated in a sand matrix or absent and the contact between the terrace deposits and Tuscaloosa formation was gradational rather than sharp. In addition, because of the lenticular and discontinuous nature of bedding, the thickness and extent of individual layers within the terrace deposits and Tuscaloosa formation varied greatly within site areas and between site locations at the base.

Based on the elevation intervals delineated by Colquhoun (1964) for the terraces in the general area, the terrace deposits which encompass approximately 90% of the base (where sites 1, 3, 4 and 5 are located) are interpreted as being equivalent to the Hazelhurst (terrace) formation. The southwest corner of the base is interpreted to be of the Coharie (terrace) formation. The spatial relationship of the terraces and the underlying Tuscaloosa formation is schematically illustrated in Figure 2-5.

Figure 2-6.
General Geologic Cross-Section of
McEntire ANG Base



An isopach map illustrating the estimated thickness of the Hazelhurst terrace formation at McEntire ANG Base was constructed from the well boring logs at Site Nos. 1, 3, 4, and 5. As is shown in Figure 2-7 the Hazelhurst thickens from 0 feet at its approximate southwesternmost extent to over 40 feet in the northeastern portion of the base. The formation thickness and extent are consistent with that offered by Colquhoun (1965). In general, sand and gravel occupy the lowermost 5 to 15 feet of the formation, with silts and clays occupying the uppermost 5 to 35 feet of the formation. At Sites 2 and 6, the contact between the Coharie and Tuscaloosa formations is gradational. The estimated thickness of the Coharie formation ranges from 20 to 30 feet, with silt and clay comprising the majority of the interval.

Surface soils which formed in the terrace deposits were noted to extend to an approximate depth of 2 to 3 feet and consisted generally of soft to firm tan to slightly silty fine and medium sandy clays or clayey sands.

2.4.2 Local Hydrogeology

2.4.2.1 Aquifer Characteristics

The upper-most sandy layers of the Tuscaloosa formation comprise the zone of saturation of the prevailing water table aquifer at McEntire ANG Base. All 23 monitoring wells installed at the various study sites were screened into this interval. The basal gravel layer of the terrace deposits, recommended for monitoring in the Phase I report (HMTC, 1984), was found not to be a water bearing unit nor part of the water table aquifer during well installation. Therefore, the gravel layer was not monitored as part of the Phase II Stage 1 investigation.

Groundwater level data for McEntire ANG Base was obtained during monitoring well installation. The data revealed the shallow water table aquifer to occur at an average depth of approximately 35 feet below land surface (BLS), ranging from 45 feet BLS along the southcentral portion of the base (in the vicinity of Site No. 3) to 26 feet BLS in the southwest corner of the base (near Site No. 2), depending largely upon differences in surficial topography.

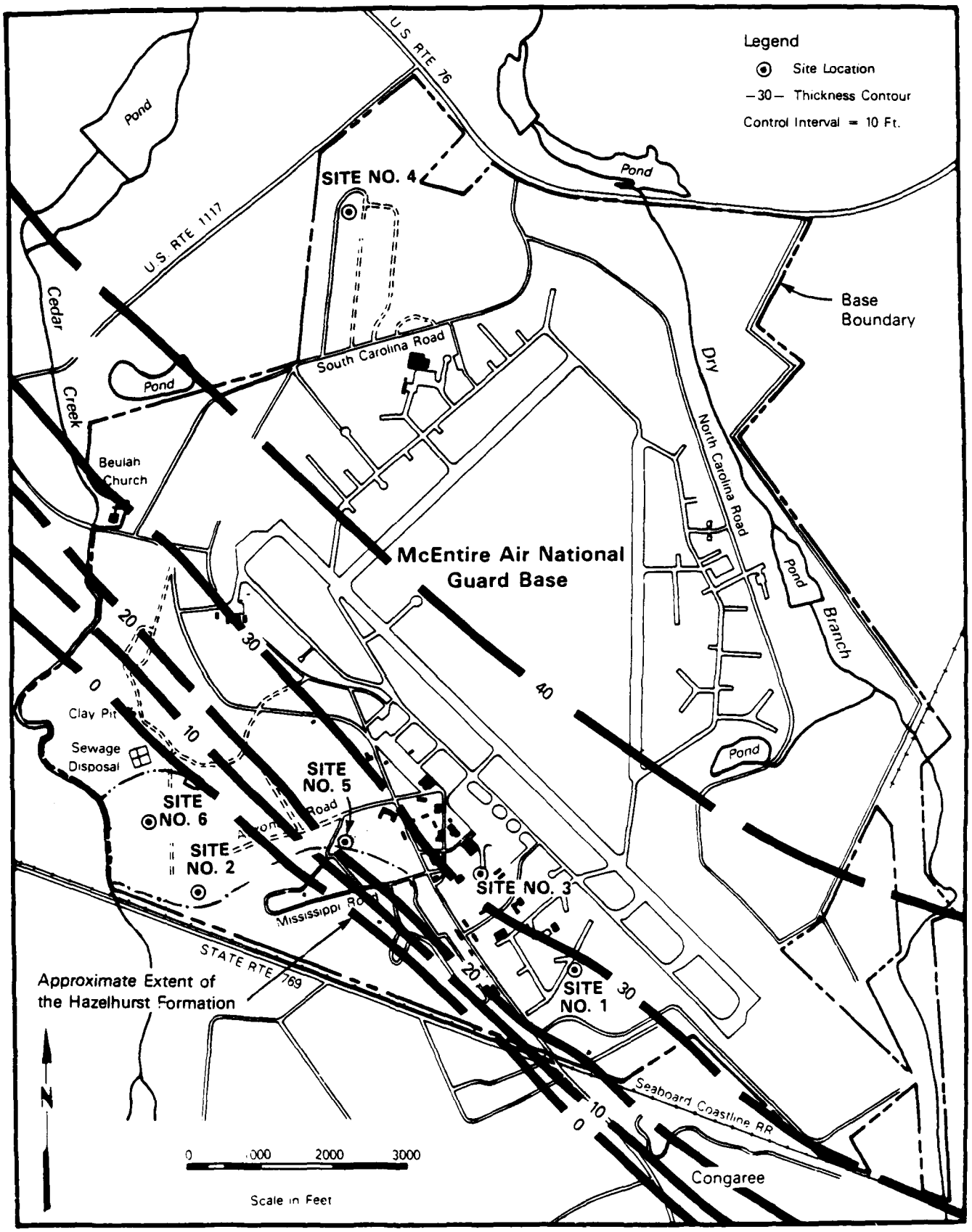


Figure 2-7. Isopach Map of the Hazelhurst (Terrace) Formation at McEntire ANG Base.

Table 2-4 provides a summary of static water level measurements obtained during the field program. These data were used to map the potentiometric surface of the water table aquifer (Figure 2-8). Because of the relative location of the sites and well clusters, and the overall sparsity of data points at the base, a water table aquifer potentiometric surface map for the entire base could not be constructed. Data from wells at Site No. 4 (Oil Dump Site) were not included on the map because that site's distance from the other sites could inaccurately skew the equi-potential lines generated. As Figure 2-8 shows, the prevailing direction of groundwater flow within the water table aquifer is southwesterly, toward Cedar Creek. The maximum head differential for the area shown in Figure 2-8 (roughly between Sites 2 and 3) is approximately 25 feet, yielding a hydraulic gradient of approximately 0.625%. The map also suggests that the water table aquifer is discharging to Cedar Creek, since its potentiometric surface along the southwestern portion of the base occurs within the elevation range for the creek.

2.4.2.2 Aquifer Testing

Aquifer tests were performed on two downgradient wells at each site using the slug test method developed by Hvorslev (1951) for partially penetrating wells under unconfined conditions (see Appendix F). Hydraulic conductivities calculated from the field results are shown in Table 2-5. As they show, the upper sands of the Tuscaloosa formation at the base had hydraulic conductivities ranging from 1.1×10^{-4} ft/sec (3.4×10^{-3} cm/sec) to 1.1×10^{-3} ft/sec (3.5×10^{-2} cm/sec). Using an average hydraulic conductivity of 6×10^{-3} ft/sec and average hydraulic gradient of 0.00625, the average velocity of groundwater movement can be calculated using Darcy's equation:

$$v = KI/n$$

where

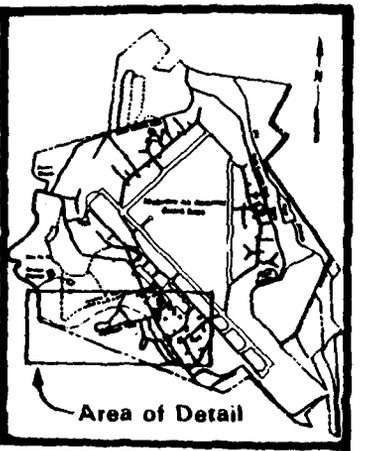
v = groundwater velocity (ft/sec),
K = hydraulic conductivity (ft/sec),
I = hydraulic gradient (dimensionless), and
n = effective porosity (dimensionless).

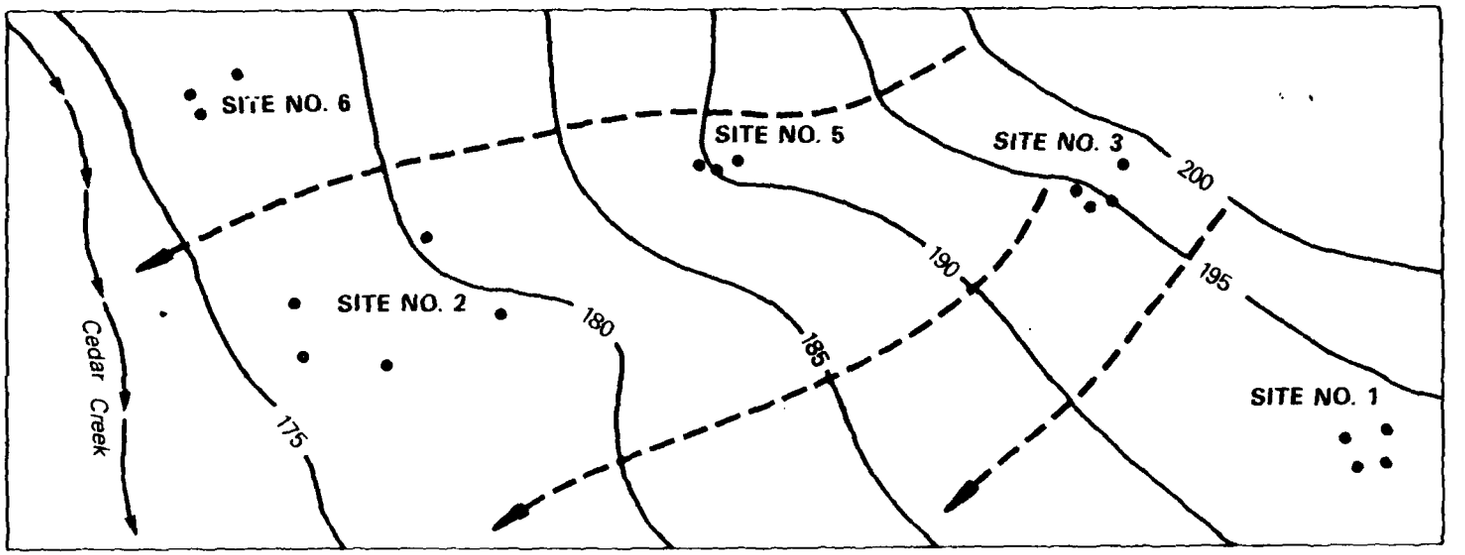
TABLE 2-4. GROUNDWATER LEVELS AT McENTIRE ANG BASE

Well Number	Water Level					
	Drilling Program 3/27 - 4/18/85		Sampling Program 5/15/85		Aquifer Testing 6/11/85	
	Depth (FT BLS)[1]	Elevation (FT MSL)[2]	Depth (FT BTR)[3]	Elevation (FT MSL)	Depth (FT BTR)	Elevation (FT MSL)
MW 1-1	40.4	194.21	43.00	193.61	43.54	193.07
MW 1-2	40.5	192.90	42.75	192.55	43.30	192.00
MW 1-3	40.2	192.89	42.65	192.39	43.21	191.83
MW 1-4	41.4	193.88	44.40	192.80	44.94	192.26
MW 2-1	33.3	179.57	35.50	179.12	35.90	178.72
MW 2-2	26.6	180.06	27.82	180.84	28.20	180.46
MW 2-3	26.2	177.55	28.35	177.40	28.76	176.99
MW 2-4	26.4	176.23	28.55	175.93	28.91	175.57
MW 2-5	38.0	177.27	40.50	176.57	40.84	176.23
MW 3-1	43.5	196.61	45.25	199.86	45.67	196.44
MW 3-2	46.0	193.92	45.90	195.97	46.32	195.55
MW 3-3	43.0	194.98	45.90	194.18	45.35	194.73
MW 3-4	48.5	192.11	45.80	196.81	47.12	195.49
MW 4-1	43.6	220.68	45.42	220.86	45.80	220.48
MW 4-2	42.8	220.86	45.25	220.41	45.64	220.02
MW 4-3	43.1	220.17	44.60	220.65	44.85	219.97
MW 4-4	46.0	218.41	45.45	220.92	45.81	220.56
MW 5-1	33.3	192.69	35.55	192.24	35.98	191.81
MW 5-2	32.9	190.70	35.30	190.30	35.72	189.88
MW 5-3	30.8	190.29	33.20	189.84	33.64	189.40
MW 6-1	41.7	178.41	43.20	178.83	43.54	178.49
MW 6-2	33.0	177.40	34.55	177.60	34.95	177.20
MW 6-3	28.6	178.38	31.10	177.98	31.45	177.63

[1] FT BLS - Feet Below Land Surface
[2] FT MSL - Feet Mean Sea Level
[3] FT BTR - Feet Below Top of Riser

Figure 2-8.
Potentiometric Surface Map
McEntire Air National Guard Base





0 1,000 2,000

Scale in Feet

Contour Interval = 5 Feet

Legend

- Monitoring Well Location
- 185 Equal Elevation Contours of Water Table (Equipotential Line)
- Flow Line

TABLE 2-5. AQUIFER TEST RESULTS

Site No.	Well No.	Hydraulic Conductivity (K)	
		(ft/sec)	(cm/sec)
1	MW 1-2	4.8×10^{-4}	1.4×10^{-2}
	MW 1-3	1.2×10^{-4}	3.6×10^{-3}
2	MW 2-4	4.9×10^{-4}	1.5×10^{-2}
	MW 2-5	3.8×10^{-4}	1.1×10^{-2}
3	MW 3-2	4.8×10^{-4}	1.4×10^{-2}
	MW 3-3	1.1×10^{-3}	3.5×10^{-2}
4	MW 4-2	1.9×10^{-4}	5.7×10^{-3}
	MW 4-3	1.1×10^{-4}	3.4×10^{-3}
5	MW 5-2	2.3×10^{-4}	7.1×10^{-3}
	MW 5-3	4.9×10^{-4}	1.5×10^{-2}
6	MW 6-2	4.4×10^{-4}	1.3×10^{-2}
	MW 6-3	3.2×10^{-4}	9.7×10^{-3}

See Appendix F for a detailed description of the aquifer test method used.

As effective porosity was not measured, a value of 35% was assumed based upon existing data on similar sands. The resultant calculated horizontal velocity of groundwater movement in the area shown in Figure 2-8 averages approximately 9.25 ft/day or approximately 3,378 ft/yr.

2.4.2.3 Aquifer Recharge

Recharge to the water table aquifer at McEntire ANG Base occurs through the direct infiltration of precipitation over the areal extent of the base and adjacent lands. Callahan (1964) estimated 10 inches of precipitation recharges the aquifers of the Tuscaloosa formation in its outcrop area per year (see Section 2.3). However, the Tuscaloosa at the base is overlain by terrace deposits with high silt and clay contents that tend to reduce the amount of infiltration, increase surface runoff, and therefore decrease the amount of water available to recharge the aquifer system. In addition, temporary or "perched" water table conditions commonly develop over the silt and clay layers within the upper surface soils and terrace deposits during periods of heavy rainfall (McNair, Johnson & Associates, 1983). In these instances, the direction of groundwater movement would likely be in the dip direction of the confining clay or silt layer, or in the general downhill direction of surface topography. Because of the prevailing dry weather conditions, perched water table conditions were not encountered at the time of well installation.

Vertical movement of water downward into the water table aquifer beneath the base is also probably severely restricted by the relatively thick, near surface clay and silt unit within the terrace deposits. Because the permeability of this unit is not known, its effectiveness as a barrier to surface infiltration and groundwater recharge cannot be evaluated with certainty. However, using conservative assumptions, calculations of travel time through the clay and silt unit can be made by again using Darcy's Law.

Based on the following assumptions, $K = 2.8 \times 10^{-2}$ ft/day (Freeze and Cherry, 1979), $I = 1$ (EPA, 1983), $n = 0.50$ (Freeze and Cherry, 1979), the

calculated velocity (v) of flow through the clay unit would be 5.6×10^{-2} ft/day. Travel time may then be computed by using:

$$t = l/v$$

where

t = travel time, and
l = length of flow path (thickness of the unit in feet).

The clay and silt unit of the terrace formation averages approximately 20 feet in thickness beneath the sites at the base, ranging from 12 feet at Site No. 5 (C-141 Spill Trench) to approximately 35 feet at Site No. 4 (Oil Dump Site). Using the above formula, calculated travel times through the unit would range from 214 days (0.59 yrs) to 625 days (1.71 yrs), and would average approximately 1 year. In a worse case analysis, groundwater would move through the clay and silt unit in the time intervals indicated. However, these travel time estimates do not consider such factors as chemical characteristics (e.g., viscosity, density) and various attenuation processes (e.g., soil adsorption, chemical degradation). Therefore, chemical constituents being carried by the groundwater at any of the sites would likely increase the water's migration time through the clay and silt unit.

2.4.2.4 Local Water Use

Water used by McEntire ANG Base and surrounding residences is acquired from wells that penetrate deeper confined sand layers within the Tuscaloosa formation (HMTC, 1984). Definitive information regarding the extent and hydraulic characteristics of the deeper sand aquifers and the confining units in the vicinity of McEntire ANG Base is lacking. A well boring log (Appendix E), well construction data (Table 2-6) for the base's water supply wells (Figure 2-9), and the Phase I report, provide the only source of definitive local information available. A report is presently being prepared by the South Carolina Water Resources Commission (SCWRC) that will characterize the quality, depth, and direction of groundwater movement in the area of McEntire

TABLE 2-6. SUMMARY OF WELL CONSTRUCTION DATA
FOR BASE WATER SUPPLY WELLS

Well Number	Depth to Bottom of the Well (ft. BLS)	Elevation of Top of Well (ft. MSL)	Elevation of Static Water Level (ft. MSL/Date)	Depth of Screened Interval (ft. BLS)
W-1	120	220	175/unknown	70-170
W-2	160	220	175/12-5-42 12-10-42	80-85 100-105 150-160

Source: Phase I report (HMTC, 1984)

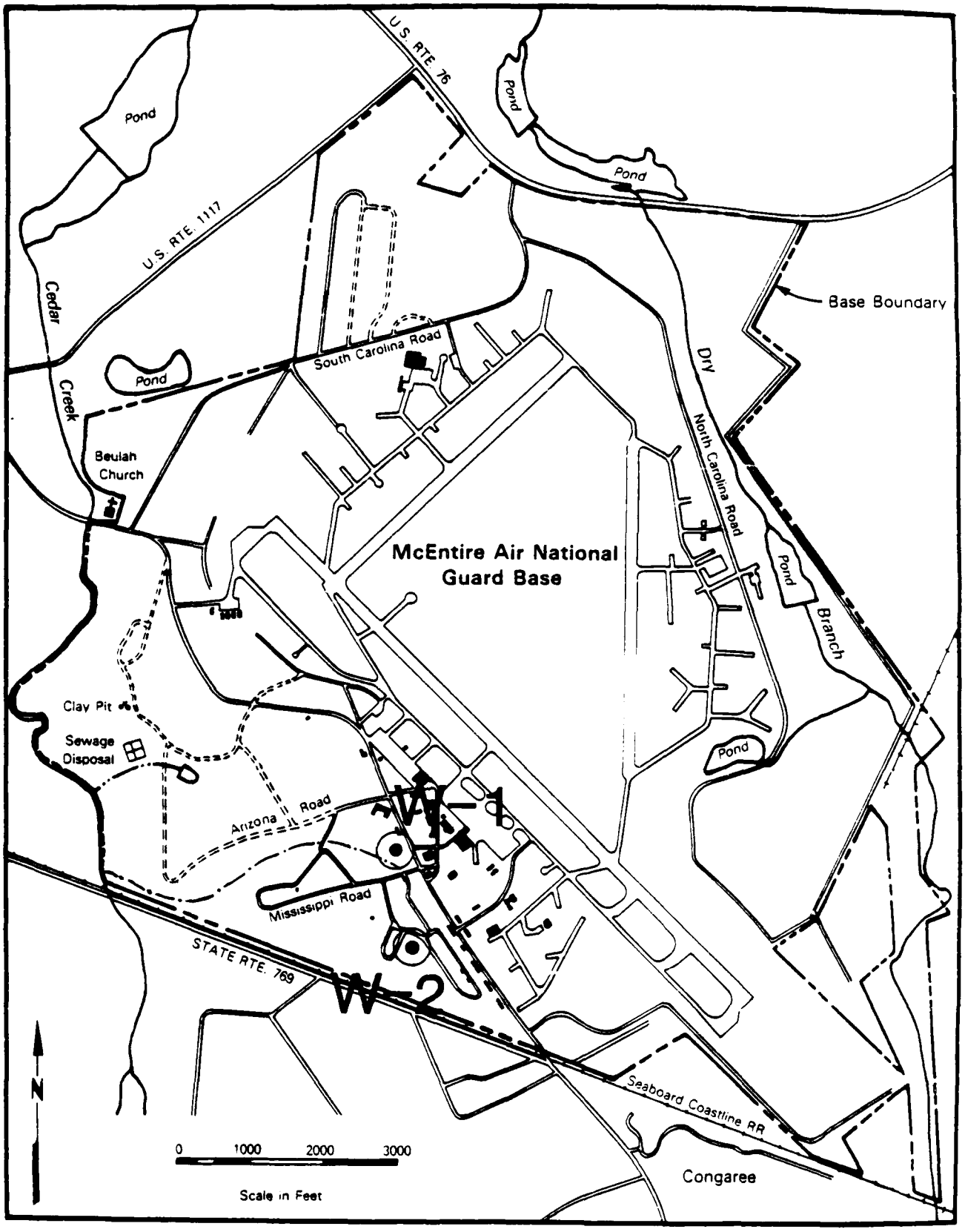


Figure 2-9. Map Showing the Location of Water Supply Wells at McEntire ANG Base.

ANG Base; unfortunately, this report has not yet been published and similar reports are not currently available.

2.4.2.5 Summary of Local Hydrogeology

According to the Phase I report (HMTC, 1984) the elevation of the sand layers which comprise the deep aquifers at McEntire ANG Base vary throughout the interval from 60 to 140 feet above mean sea level (MSL), which is approximately 90 to 160 feet below land surface (BLS). The static water elevations recorded in the base wells, whose screened intervals are coincident with the sandy layers (Table 2-6), varies from 175 to 203 feet above MSL, or from 45 to 30 feet BLS. These data indicate that the sandy layers are hydraulically pressurized as evidenced by the fact that the static water elevations in the wells (whose screened intervals are coincident with the sandy zones), occurs at a higher elevation than that of the top of the sand layers. These sand layers, therefore, may appropriately be classified as artesian aquifers.

Based on the regional hydrogeologic setting (see Section 2.3) the direction of groundwater flow within the deep aquifers at the base is probably from west to east in response to an eastwardly decline in the hydraulic head within the Tuscaloosa formation. Local fluctuations of this flow direction in response to heavy pumping of wells, such as the base supply wells, is likely, in which case groundwater movement would be toward the pumped wells. Because of the prevailing southeasterly dip of bedding for the Tuscaloosa formation, recharge to the deeper aquifers probably occurs northwest of the base where the formation outcrops at the surface and where the deeper sand layers become surficially exposed.

Whether the shallow water table aquifer and the deep aquifers at McEntire ANG Base are in hydraulic communication cannot be ascertained with certainty, based on available hydrogeologic information. However, the probability of such communication is low because available information indicates the deeper aquifers are confined by relatively impermeable clay and silt layers and the natural vertical hydraulic gradient within the deep aquifers is upward. The installation of deep aquifer observation wells and the performance of pump

tests on the base supply wells would be necessary in order to more fully evaluate the hydraulic characteristics of the deep aquifers. Local discontinuities with the confining layers and changes in the vertical component of groundwater flow due to heavy pumping of the base's supply wells may also facilitate the downward migration of groundwater and contaminants.

Groundwater quality data for the deep aquifer takes the form of a single sample obtained from the base's water supply well W-1 (Figure 2-9) on 5/17/83 by the SCWRC. The results of the water quality analysis are summarized below:

pH = 5.6 std. units
Chloride = 3.46 mg/l
Fluoride = 0.02 mg/l
Sulfate = 2.89 mg/l
Calcium (total) = 0.92 mg/l
Iron (total) = 219 ug/l
Magnesium (total) = 0.45 mg/l
Potassium (total) = 0.27 mg/l
Silica (dissolved) = 5.56 mg/l
Silicon (dissolved) = 2.60 mg/l
Sodium (total) = 3.9 mg/l
Specific Conductance = 25 umhos/cm

Neither the shallow water table aquifer or the deep confined aquifers of the Tuscaloosa formation have been classified as sole source aquifers.

2.5 SITE HISTORIES AND HYDROGEOLOGY

The following sections provide descriptions of the waste disposal activities and the hydrogeologic conditions at each of the sites investigated for the Phase II Stage 1 effort at McEntire ANG Base.

2.5.1 Site No. 1: No. 5 Fire Training Area

This site is the current location of the base's fire department training area. The site consists of an unlined oval shaped pit, approximately 1 foot in depth and 60 x 75 feet in dimension, located in a relatively flat open area in the southern portion of the base (Figure 2-10). An estimated 63,000 gallons (gals) of waste oil, solvents, JP-4, brake fluid, transmission fluid, paint thinner or strippers, hydraulic fluid and other combustible waste materials were disposed and ignited at this site for fire training purposes since 1970. An estimated 12,600 gals of waste liquids still remain at the site (HMTC, 1984). Standing water, scrap metal, and floating fuel residues,

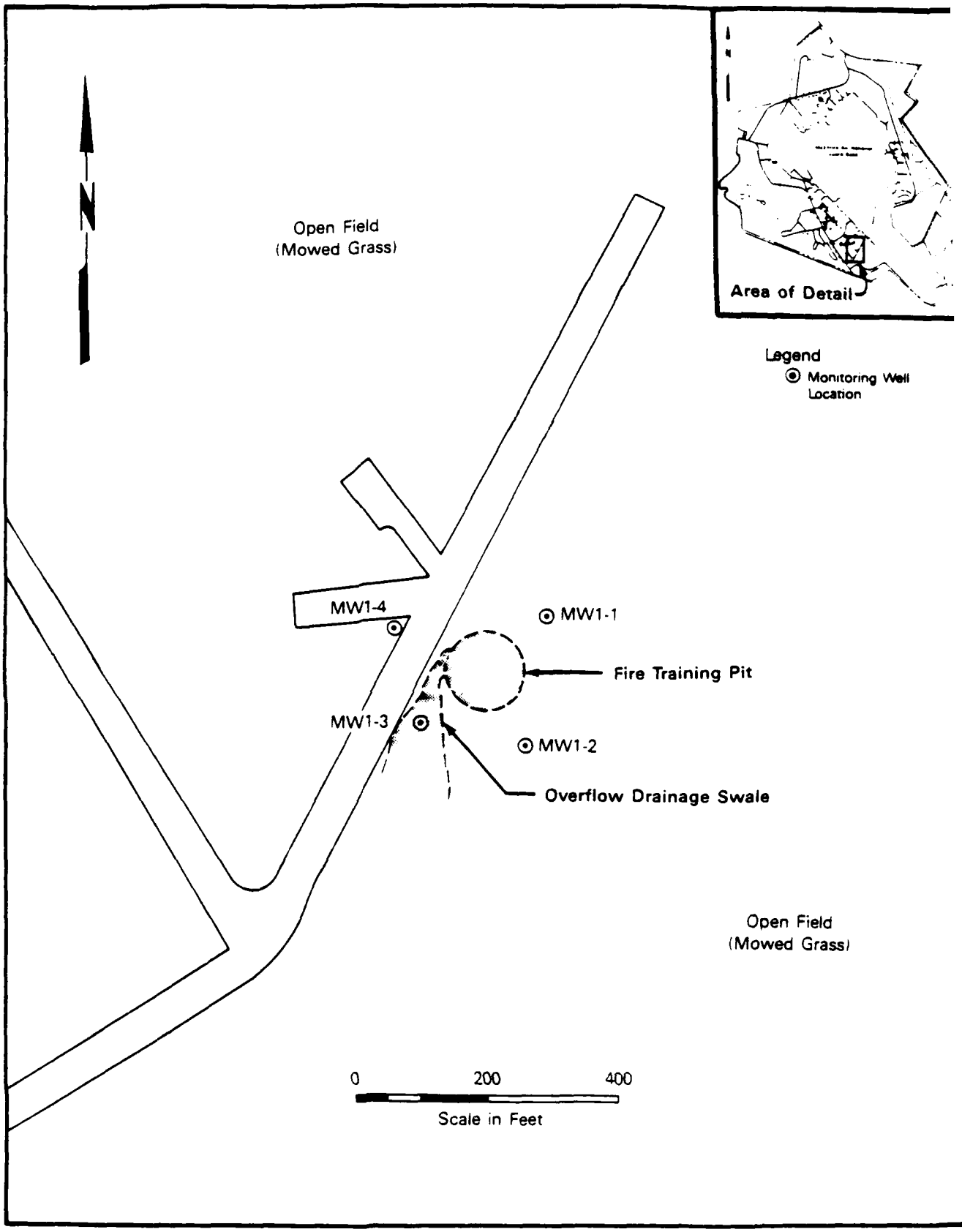


Figure 2-10. Site No. 1: No. 5 Fire Training Area.

which imparted a pronounced hydrocarbon odor downwind of the site, were observed during the initial Phase II survey of the site. Also observed were discolored soils extending 2 to 3 feet beyond the limits of the pit and a natural breach in the western rim of the pit (caused by rainfall overflow), which allowed its contents to spill into a slight depression in the surrounding field. The site received an overall HARM Score of 69.

Four water table aquifer monitoring wells were installed around this site to investigate groundwater quality and movement and to obtain site-specific geologic and hydrogeologic data. The stratigraphy of the interbedded unconsolidated Coastal Plain deposits beneath the site, as interpreted from these wells' logs, is depicted in Figure 2-11. Surface soils at the site extend to a depth of approximately 3 feet and consist of brown, soft, slightly silty to clayey, fine to medium sands. Below these surface soils, to a depth of approximately 20 feet, extend less permeable, stiff to very stiff reddish brown sandy clays and silts which grade to an additional 10 feet of coarse sands and gravel. This uppermost 30 feet of material is characteristic of the Hazelhurst (terrace) formation, which encompasses the general area. This is exemplified by the datum elevation of the gravel layer present in MW1-1 and MW1-2 (approximately 210 and 215 feet MSL, respectively), and the gradational sequence (fining upward) of the overlying materials at the site. The basal gravel layer of the Hazelhurst (terrace) formation which appeared in wells MW1-1 and MW1-2 did not appear in wells MW1-3 and MW1-4. From approximately 30 feet below land surface to the terminal depth of the borings (approximately 65 feet below land surface), extended white to buff fine to medium kaolinitic sands interbedded with thin layers of clay or kaolin. In addition, very thin gravel layers (approximately 2 to 3 inches in thickness) occur within these sediments at well MW1-3. This lower 30 to 35 feet of material penetrated was consistent with the regional descriptions of the Tuscaloosa formation (see Section 2.2).

The presence or absence of individual layers between well locations at this site is indicative of the lenticular and discontinuous nature of bedding which is characteristic of these Coastal Plain formations.

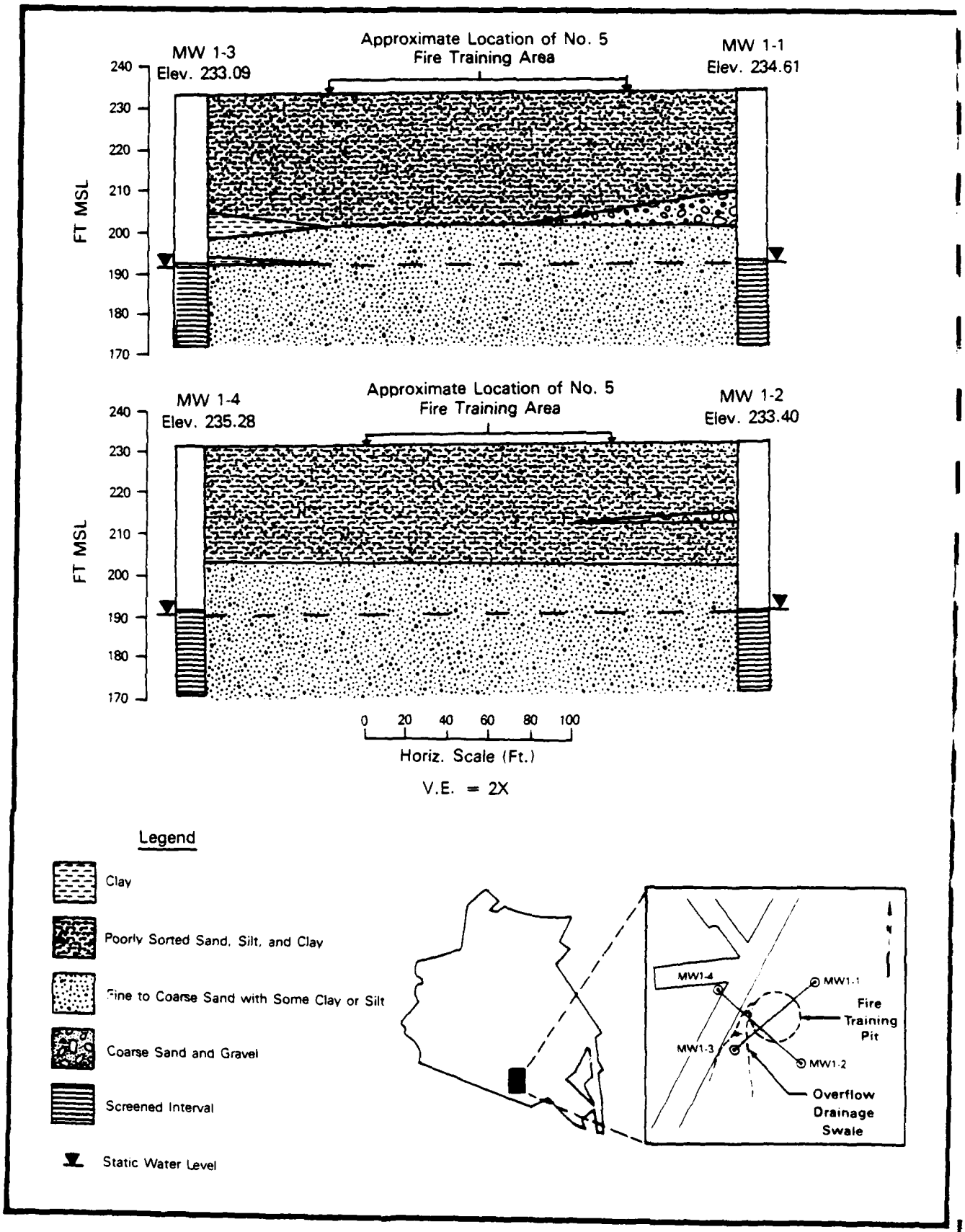


Figure 2-11. Geologic Cross Sections For Site No. 1: No. 5 Fire Training Area.

The zone of saturation of the water table aquifer at Site No. 1 occurs within the upper sands of the Tuscaloosa formation. The water table lies approximately 42 feet beneath the site and is relatively flat. The maximum range in static water elevations (193.07 to 191.83 feet MSL), between wells MW1-1 and MW1-3, respectively, yields a maximum head differential of 1.24 feet and a hydraulic gradient of approximately 0.5%. The direction of groundwater flow within this aquifer is southwesterly, toward Cedar Creek. The hydraulic conductivity of these Tuscaloosa sands, as determined from aquifer tests at wells MW1-2 and MW1-3, ranges from 4.8×10^{-2} ft/sec (1.4×10^{-2} cm/sec) to 1.2×10^{-4} ft/sec (3.6×10^{-3} cm/sec), respectively (see Section 3.2.3). Assuming an effective porosity of 35%, the calculated horizontal velocity of groundwater flow would at Site No. 1 ranges from 0.15 ft/day (54 ft/yr) to 0.6 ft/day (216 ft/yr).

2.5.2 Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site

The No. 1 Fire Training Area, of which no visible traces remain (HMTC, 1984), consisted of a shallow, airplane-shaped trench in a forested area adjacent to the base's sanitary landfill (Figure 2-12). Visible traces of this training area do not remain (HMTC, 1984). Firefighting exercises took place two or three times monthly at this site from 1947 until the mid-1950's. According to the Phase I report, an estimated 16,000 gallons of liquid waste material were disposed in this area during this period. Typically, one 55-gallon drum of mixed hydrocarbon solvents, waste motor oils, and contaminated 100-octane fuel was ignited during such exercise. Of the 16,000 gallons disposed at the site, an estimated 80% was consumed by fire; therefore, 3,200 gallons are estimated to have remained at the site. This site received a HARM Score of 67. Because visible traces of this training area do not remain and because of its reported close proximity to the Sanitary Landfill, the No. 1 Fire Training Area was included with the Sanitary Landfill as a single monitoring site area.

The adjacent Sanitary Landfill comprises an area of approximately 2 acres at the end of Arizona Road near the railway forming the southern boundary of the base (Figure 2-12). The landfill was operated from 1947 until its closure in 1980.

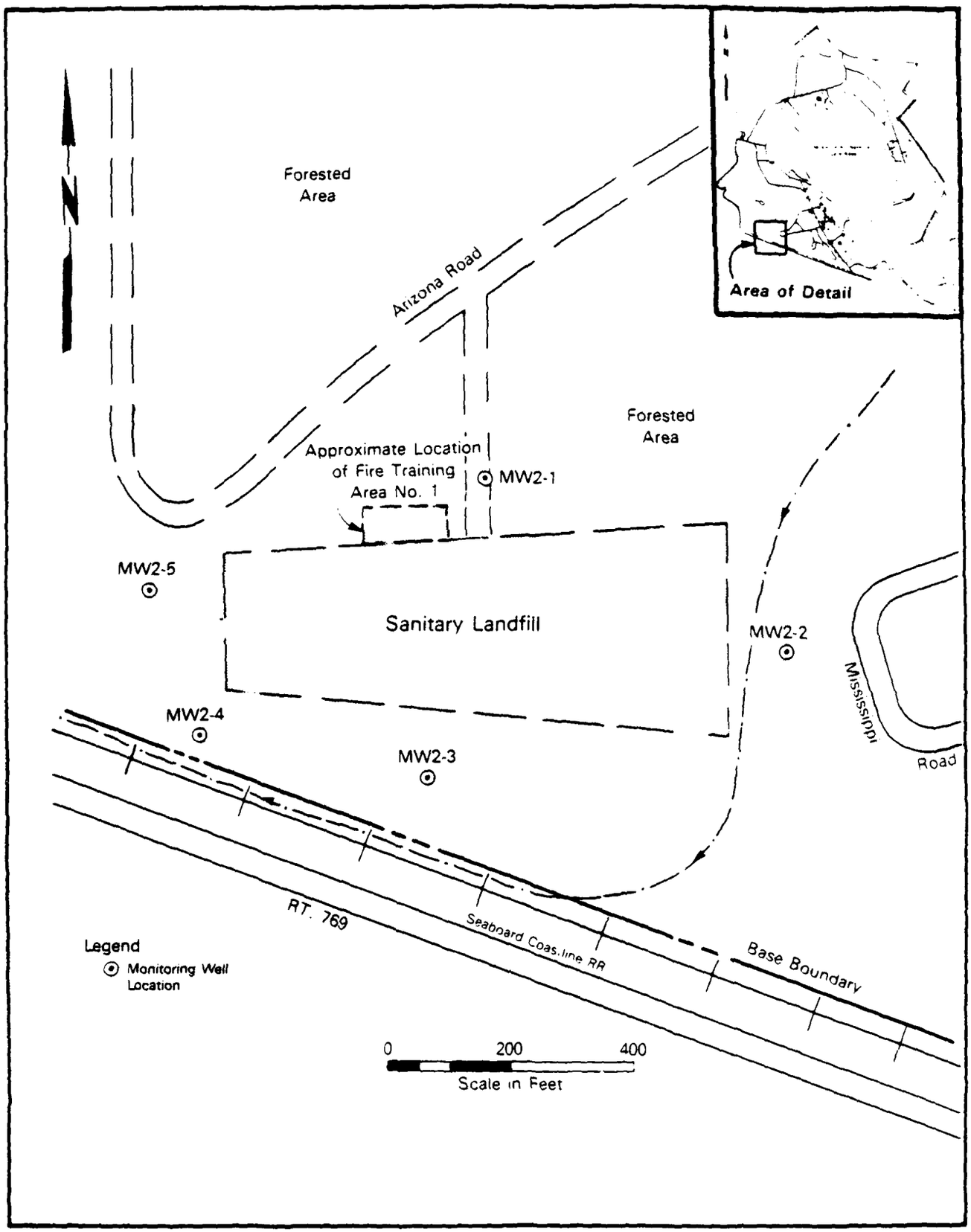


Figure 2-12. Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site.

The predominant solid wastes disposed at this site were paper and domestic refuse, old wood from demolished structures, general construction rubble, and a variety of empty or partially filled small (5 to 20 gallon) containers. Disposed containers were mostly empty solvent, paint and pesticide cans, although many contained hardened paint or polyurethane. For an undetermined period (from at least 1960 until 1970) approximately 15 gallons per year of used paints, strippers, and thinners from the Motor Pool were packaged in 5-gallon containers and placed in the landfill.

Open burning of trash was a standard procedure at the landfill for two decades, with 5 to 30 gallons of waste motor oil, lubricating oils, and fuel routinely added to the refuse each week to stimulate and maintain the fires. Ninety percent of this liquid waste is assumed to have been destroyed by fire, as compared to only 80% consumption for the fire department training areas because attempts were not made to extinguish the fires. Assuming an average liquid disposal volume of 15 gallons per week during the 20-year duration of burning at the landfill, and the probability that at least 90% of this waste was destroyed by fire, a total waste residual of approximately 1,600 gallons may have remained at this site.

The practice of burning was discontinued in 1967 when burial procedures were instituted. Two parallel trenches (14 feet wide, 8 feet deep, and several hundred feet long) were excavated, and trash was unloaded from dumpsters and compacted and covered with dirt using heavy equipment until the trenches were gradually filled. A few incidents of spontaneous combustion reportedly occurred during the initial period of landfilling operation, but there is no evidence that any other unusual events took place in subsequent years. Landfilling operations ceased in 1980 when trash removal services were procured from a private contractor.

Visual inspection of the area revealed that the site had been used infrequently for minor dumping since closure. Items scattered in localized areas on the landfill surface included an empty 5-gallon paint thinner can, several small motor oil and antifreeze containers, a refrigerant filter canister, several dozen 50-ml vials filled with an organidinn dry solution,

and several small piles of waste runway seam-sealing strips. No visible contamination of the soil or reduced plant growth was observed in any portion of this former landfill site. There was no visual evidence that any empty or full 55-gallon drums, battery casings, or radioactive wastes of any kind were ever placed in the landfill. The bottoms of the trenches are reportedly red clay, and groundwater was apparently never encountered during landfilling operations. Surface runoff from the site drains in an easterly direction into a drainage swale located along the eastern border of the site (Figure 2-12). The site received a total HARM Score of 57.

Five shallow aquifer monitoring wells were installed around the No. 1 Fire Training/Sanitary Landfill area (Site No. 2) to investigate the potential subsurface movement of contaminants and to obtain site-specific geologic and hydrogeologic information. Figure 2-13 illustrates the stratigraphy beneath Site No. 2 in cross section. An estimated thickness of 20 to 30 feet of the Coharie (terrace) formation, predominantly reddish yellow to reddish brown, poorly sorted, stiff, sandy silty clay, was penetrated during well installation at this site. The upper sands of the Tuscaloosa formation occur as buff to yellow kaolinitic sands, and helped to define the Coharie-Tuscaloosa formation interface at approximately 190 ft MSL beneath the site. Interbeds of kaolin several inches in thickness were observed in the lowermost portion of the Tuscaloosa formation at each of the monitoring well locations.

Static water levels in the wells installed around the site ranged from 26.35 ft BLS at well MW2-3 to 38.50 feet BLS at well MW2-5. The observed variations in depth to static water are largely the result of differences in topography rather than variations in potentiometric surface. Water table elevations at the two previously mentioned well locations were 175.9 and 189.8 feet above MSL, respectively. This yields a maximum head differential of 4.9 feet and a hydraulic gradient of 0.43%. The horizontal hydraulic conductivity of the upper sands of the Tuscaloosa formation beneath the site, as determined from aquifer tests performed on downgradient wells MW2-4 and MW2-5, ranges from 4.9×10^{-4} ft/sec (1.5×10^{-2} cm/sec) to 3.8×10^{-4} ft/sec (1.1×10^{-2} cm/sec), respectively (see Section 3.2.3). Assuming an effective porosity of 35% for the sands of the Tuscaloosa formation, the calculated horizontal

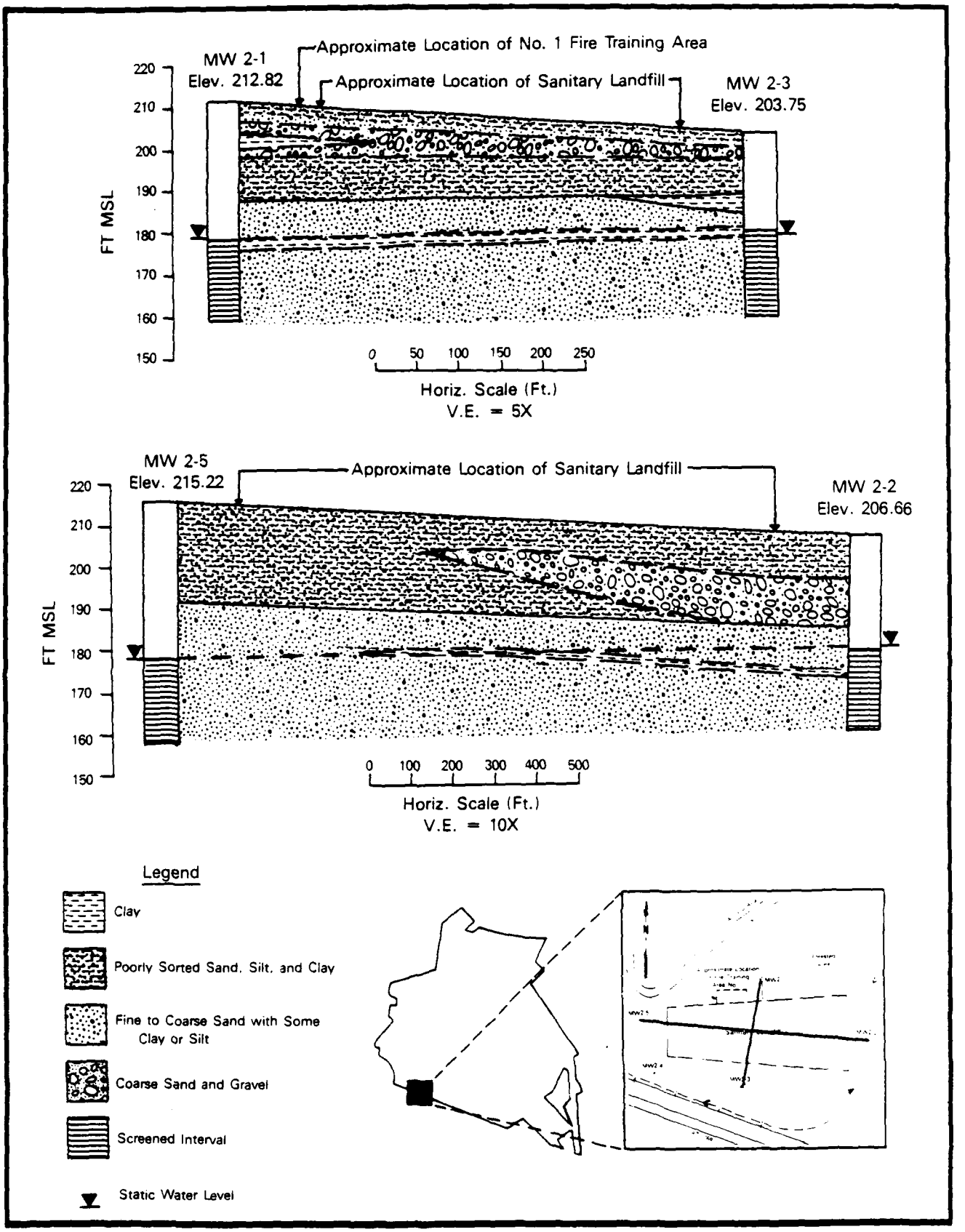


Figure 2-13. Geologic Cross Sections For Site No. 2: No. 1 Fire Training Area/Sanitary Landfill.

velocity of groundwater flow would range from 0.40 ft/day (147 ft/yr) to 0.52 ft/day (190 ft/yr).

2.5.3 Site No. 3: Y-Storage Area

The Y-Storage Area is located adjacent to the main hanger, building No. 253 (Figure 2-14), and has been in use since 1974. The site consists of a concrete pad approximately 40 feet wide where drums containing flammable liquid waste materials were stored prior to their use/disposal at Site No. 1 (No. 5 Fire Training Area) for fire training purposes. The concrete pad and the ground immediately adjacent to the pad have been saturated with chemicals as a result of chronic minor spillage. The total volume of liquid waste materials spilled at the site is not known, and no large spill incidents were ever reported at this site. Vegetative growth in the chemically saturated zones is sparse. The land area surrounding the site is relatively flat, with no obvious pathways for runoff to enter a nearby drainage ditch. The site received a total HARM Score of 56.

Four water table aquifer monitoring wells were installed around this site to investigate the potential subsurface movement of contaminants. Boring logs for these wells appear in Appendix E. Cross sections (Figure 2-15) constructed from those logs illustrate the subsurface geology at the site. As the cross sections show, a coarse sand and gravel layer, approximately 7 feet in thickness, underlies the site at a depth of 20 to 25 feet BLS. This layer represents the basal unit of the Hazelhurst (terrace) formation. Above the gravel unit lies a stiff to very stiff reddish yellow to reddish brown clay and silt layer.

Below the Hazelhurst gravel layer are the buff to white sands of the Tuscaloosa formation. These Tuscaloosa sands grade to include an increasing percentage of kaolinitic clay and clayey silt with depth. At well locations MW3-2 and MW3-3, approximately 8 feet of stiff kaolinitic clay (kaolin) was encountered at the bottom of the penetrated interval. Subsequently, less than 20 feet of screen was installed for these wells (Figure 2-15). Because this clay layer was not encountered in wells MW3-1 and MW3-4, the clay layer appears to be laterally discontinuous to the north.

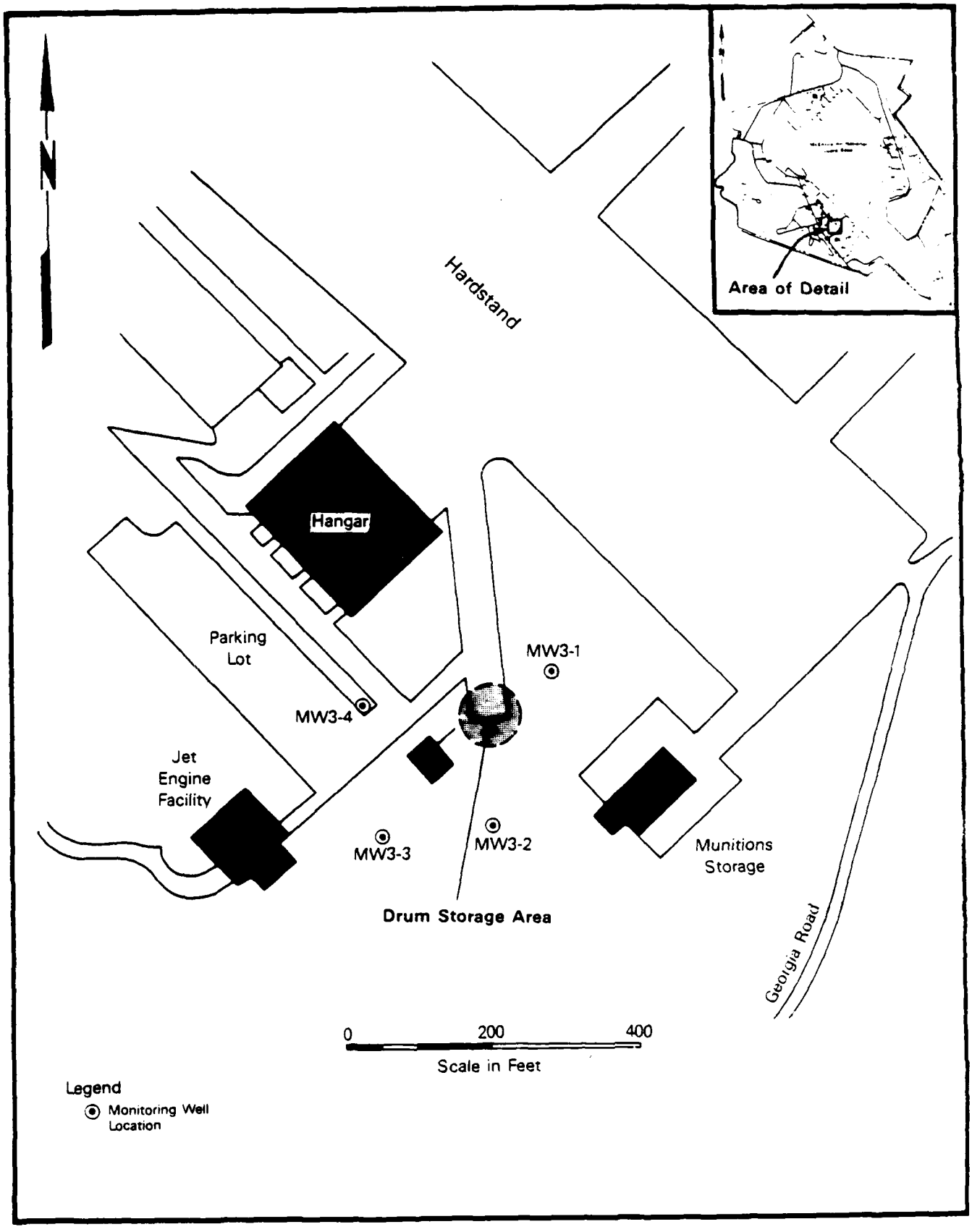


Figure 2-14. Site No. 3: Y-Storage Area.

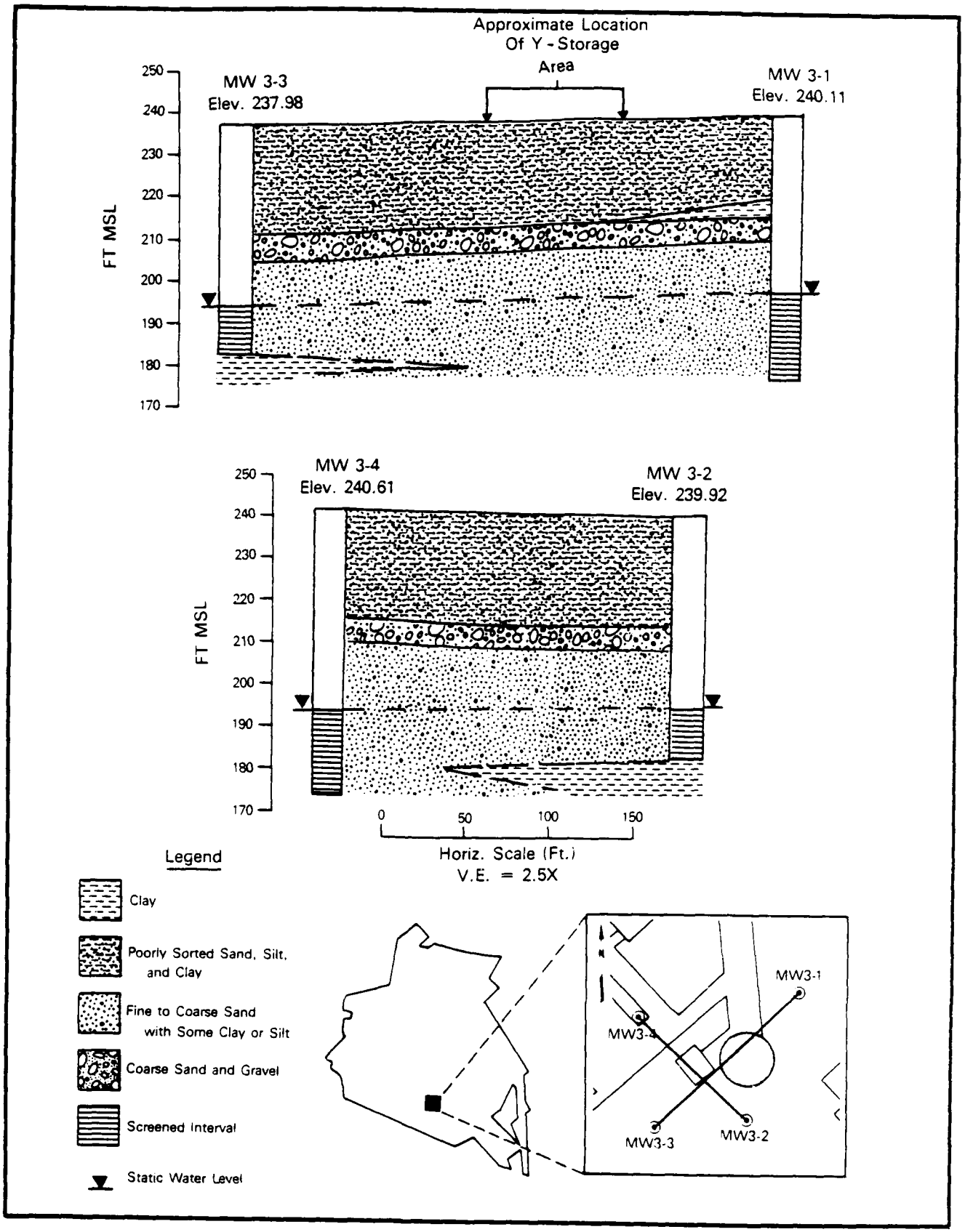


Figure 2-15. Geologic Cross Sections For Site No. 3: Y-Storage Area.

The upper sands of the Tuscaloosa formation comprise the water table aquifer at the site. The water table occurs at an average depth of approximately 44 feet BLS and ranges in elevation from 194.73 feet MSL at MW3-3 to 196.44 feet MSL at MW3-1. This maximum head differential is thus 1.71 feet and the hydraulic gradient is 0.46%. The horizontal hydraulic conductivity of the upper sands of the Tuscaloosa formation beneath the site, as determined from aquifer tests performed on downgradient wells MW3-2 and MW3-3, ranges from 4.8×10^{-4} ft/sec (1.4×10^{-2} cm/sec) to 1.10×10^{-3} ft/sec (3.5×10^{-2} cm/ sec), respectively (see Section 3.2.3). Assuming an effective porosity of 35% for the sands of the Tuscaloosa formation, the calculated horizontal velocity of groundwater flow would range from 0.55 ft/day (199 ft/yr) to 1.25 ft/day (456 ft/yr). The direction of groundwater movement beneath the site is southwest toward Cedar Creek.

2.5.4 Site No. 4: Oil Dump Site

This site consists of a visible oil patch on the ground surface at the end of an abandoned road near the northern base boundary (Figure 2-16). The visible oil patch measures approximately 30 feet in width and 50 feet in length and is not vegetated although stunted plant growth was observed around the periphery of the area. The oily substance was consolidated with sand throughout the greater portion of the area and is most obvious in saturated leaf litter. A distinct hydrocarbon odor is apparent in the immediate area. Erosion of the flat surface appears minimal and there is no obvious pathway for runoff to exit the area in a concentrated flow. Surface soils at the site are comprised predominantly of sand; therefore, the material disposed at this site probably percolated directly into the ground.

This was once the site of the officers' quarters when the Army Air Corps controlled the base, but the structures were removed before 1947 and this portion of the base was never further developed. Whether liquid wastes other than oil were disposed at this site is not known. In addition, neither the total volume of liquid waste materials disposed, or the period of existence of the site are known. The site received a total HARM Score of 56.

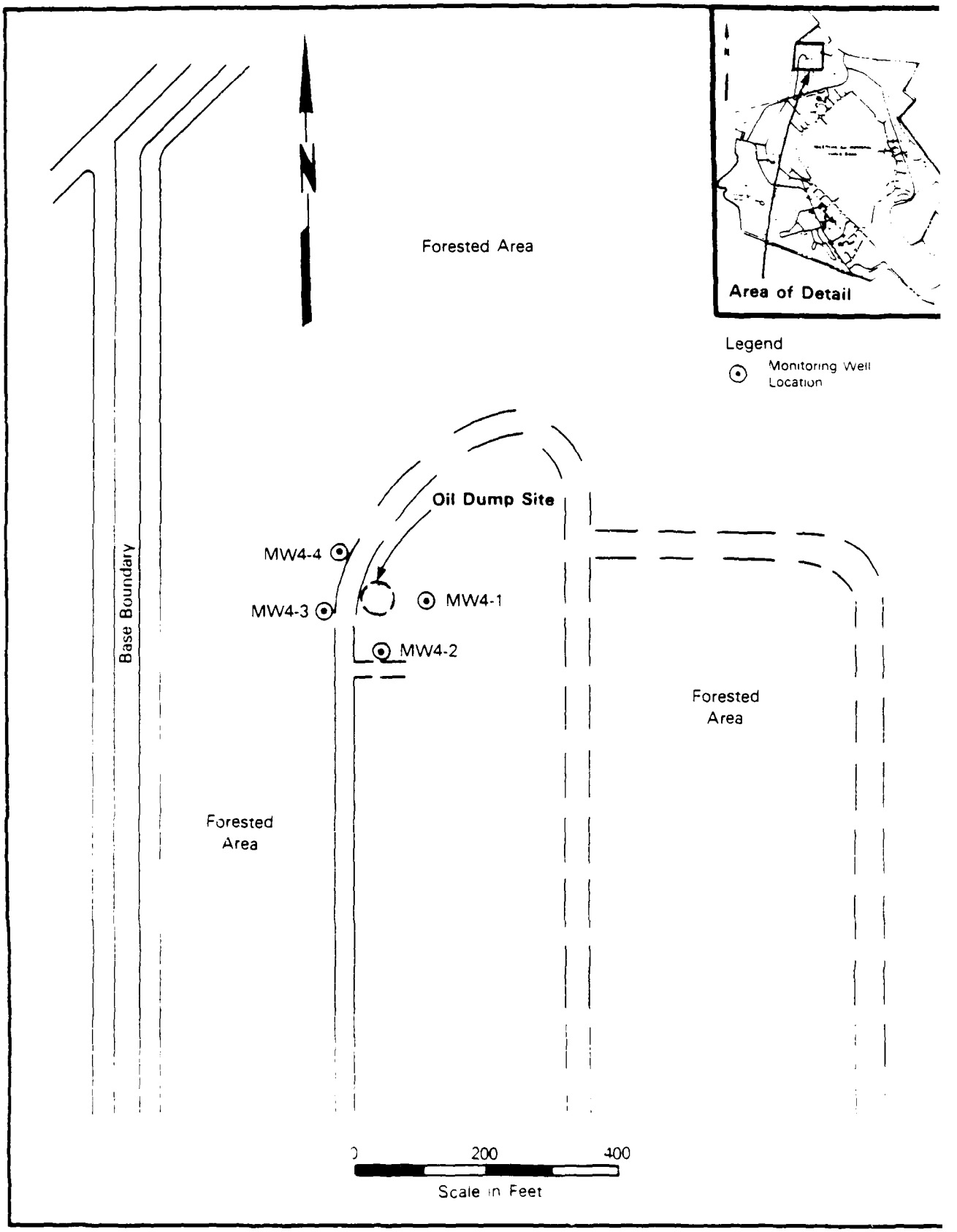


Figure 2-16. Site No. 4: Oil Dump Site.

Four shallow water table aquifer monitoring wells were installed around the site to investigate the potential subsurface movement of contaminants and to obtain site-specific geologic and hydrogeologic information. Cross sections (Figure 2-17) constructed from the boring logs for those monitoring wells (Appendix E) illustrate the subsurface geology at the site.

In general, surface soils at the site extend to a depth of 2 to 3 feet and consist of tan, soft, slightly silty, fine to medium sand. Below the surface soils, to a depth of approximately 40 feet, extend less permeable, stiff, reddish brown, sandy clay or sandy silt, which grade with depth to clay. Below the clay extends generally loose, brownish yellow to white, slightly silty or slightly clayey medium to coarse sands containing thin (1 inch or less) kaolinitic clay (kaolin) layers.

The extensive (40 to 45 feet thick) near surface silt and clay unit which underlies the site is characteristic of the Hazelhurst (terrace) formation. In the lowermost portion of these reddish brown silts and clays, a coarse sand lense approximately 4 feet in thickness was observed in wells MW4-1, MW4-2, and MW4-4. The basal sands and gravels of the Hazelhurst (terrace) formation observed elsewhere on the base were not present at this site. Two possible explanations exist for this anomaly: either the thin sand lense previously mentioned is equivalent to the coarse basal fraction of the Hazelhurst seen elsewhere, or the paleoslope (surface of the Tuscaloosa formation) upon which the Hazelhurst was deposited prevented coarser grained deposition in the more landward extent of the terrace.

Sandy deposits underlying the silt and clay deposits (from approximately 220 feet MSL to the terminal depth of each boring) are characteristic of the Tuscaloosa formation. Those upper sands of the Tuscaloosa formation comprise the water table aquifer at the site. The water table occurs at an average depth of approximately 44 feet BLS and is relatively flat. Static water level elevations ranged from 220.56 feet MSL in MW4-4 to 219.97 feet MSL in MW4-3, yielding a maximum head differential of approximately 0.6 feet and a hydraulic gradient of approximately 0.4%. The horizontal hydraulic conductivity of the unit, as determined from site aquifer tests performed on wells MW4-2 and

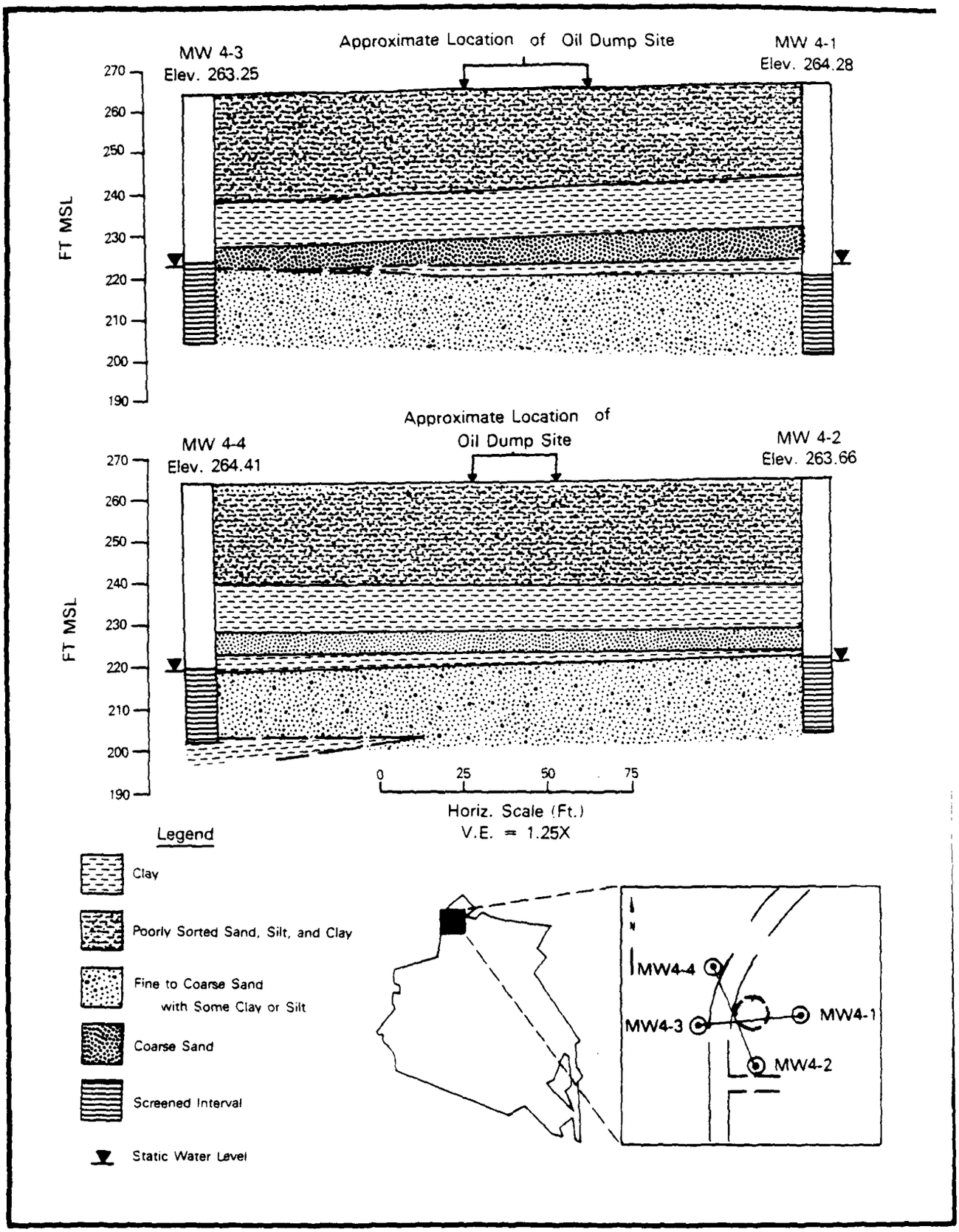


Figure 2-17. Geologic Cross Sections For Site No. 4: Oil Dump Site.

MW4-3, ranges from 1.9×10^{-4} ft/sec (5.7×10^{-3} cm/sec) to 1.1×10^{-4} ft/sec (3.4×10^{-3} cm/sec), respectively (see Section 3.2.3). Assuming an effective porosity of 35% for the sands of the Tuscaloosa formation, the calculated horizontal velocity of groundwater flow would range from 0.11 ft/day (40 ft/yr) to 0.19 ft/day (69 ft/yr). The direction of groundwater flow is to the southwest, toward Cedar Creek.

2.5.5 Site No. 5: C-141 Spill Trench

Contamination at this site occurred as the result of the only major hazardous liquid spill on record at McEntire ANG Base. According to the Phase I report (HMTC, 1984), the spill occurred on the afternoon of 7 March 1982, when an estimated 9,000 gallons of JP-4 was released from a burning C-141 aircraft. Most of the fuel was consumed in the fire on the ramp, but some entered the underground storm conduits and flowed into an open drainage ditch running parallel to Mississippi Road (Figure 2-18). As the fuel burned, an earthen dam was constructed approximately one-half mile from the spill site immediately upstream of the confluence with a second drainage ditch. The fires were extinguished that evening. On the following day, the residual amounts of fuel observed downstream of the dam and a portion of the fuel behind the dam were collected using absorbent pads. After consultation with the South Carolina Department of Health and Environmental Control (SCDHEC), the majority of the remaining fuel was burned and the rest absorbed. Less than 5% (450 gallons) of the original 9,000 gallons was estimated to remain at this site subsequent to the burning and cleanup efforts. An inspection performed by an SCDHEC representative confirmed that fuel had not left the base. After the temporary earthen dam was broken, a straw dike was constructed and remained in place for several weeks to absorb any remaining fuel. No visible traces of hydrocarbon contamination in the water, sediments, or adjacent vegetation were observed during the initial Phase II survey of the site. The site received an overall HARM Score of 54.

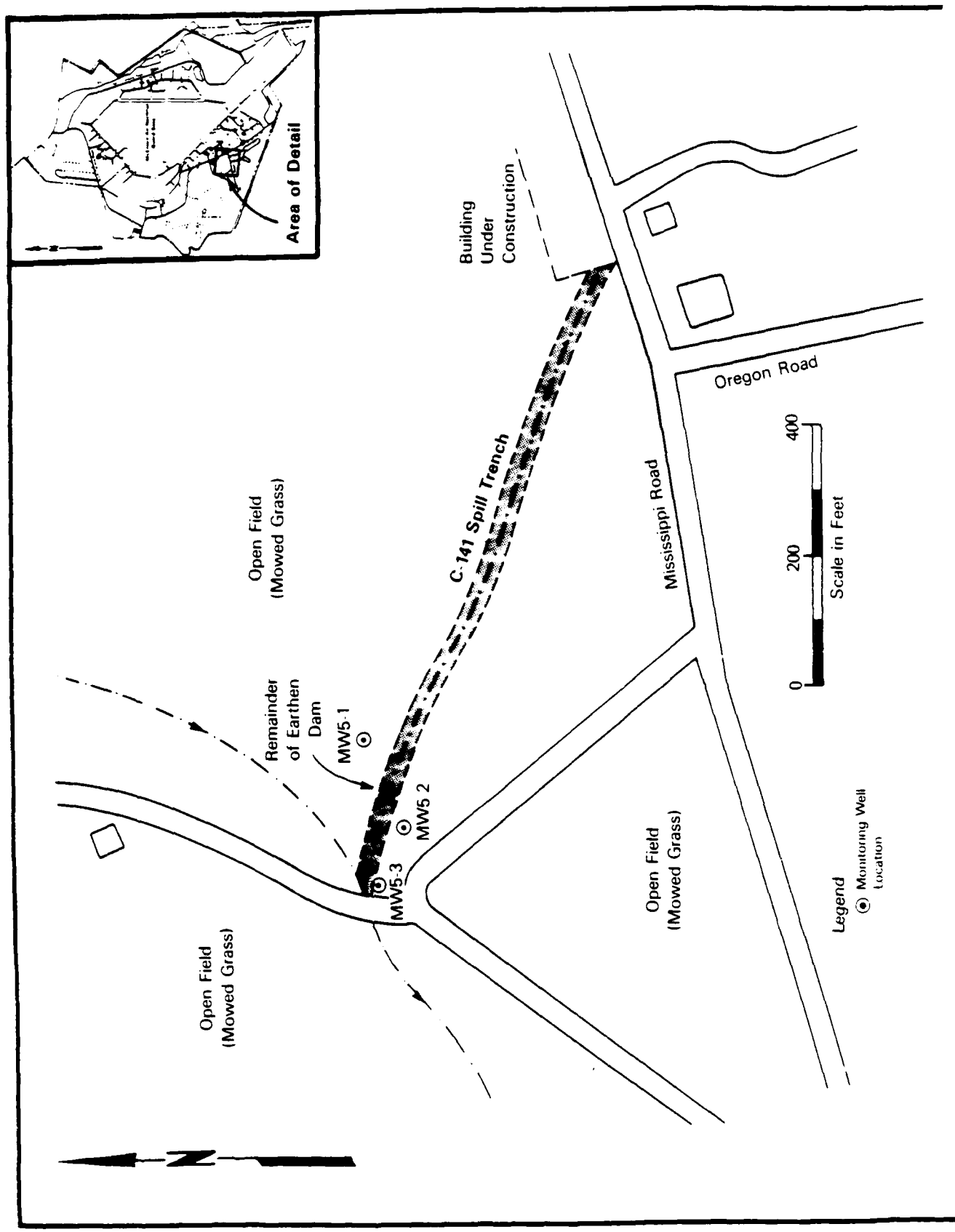


Figure 2-18. Site No. 5: C-141 Spill Trench.

Three shallow water table aquifer monitoring wells were installed at the downgradient end of the trench near the temporary dam location (where the greatest concentration of the fuel was assumed to have collected) to investigate the potential subsurface movement of contaminants and to obtain site-specific geologic and hydrogeologic information. Cross sections (Figure 2-19) constructed from the boring logs for the monitoring wells (Appendix E) illustrate the subsurface geology of the site.

In general, surface soils at the site extend to a depth of approximately 2 to 3 feet and consist of yellowish red, slightly silty to clayey fine to medium sand. Below the surface soils, to a depth of 10 to 15 feet, extend less permeable, stiff to very stiff, reddish brown, sandy to silty clay. Below the clay layer extends a coarse sand and heavy gravel layer, varying in thickness from approximately 7 feet in well MW5-3 to 12 feet in well MW5-1. Below the gravel layer generally extends yellow to white silty to kaolinitic, medium to coarse sands containing thin clay layers. Based on Colquhoun (1965), the heavy gravel layer and overlying silt and clay deposits are interpreted to be of the Hazelhurst (terrace) formation. The underlying sands are characteristic of the Tuscaloosa formation (see Section 2.2).

The clay content (primarily kaolinite) of the sands of the Tuscaloosa formation increased with depth at well locations MW5-2 and MW5-3 to a depth of approximately 44 feet BLS, where a relatively thick layer of kaolin was encountered. To determine the potential thickness of this layer and to evaluate whether the installation of 20 feet of screen at these well locations (as specified in the Work Scope) would be appropriate, the borings were extended approximately 7 to 10 feet into the layer. However, changes in lithology were not observed, consequently, the bore hole for each of these was backfilled with bentonite pellets to the top of the kaolin layer to reseal the layer and avoid any potential for the downward migration of contaminants. The wells were then installed to the top of the kaolin layer (see Figure 2-19). The kaolin layer encountered in the borings for wells MW5-2 and MW5-3 was not encountered in MW5-1, indicating this layer to be horizontally discontinuous (in a northward direction) beneath the site. The extent of this layer in a southwesterly (downgradient) direction cannot be determined from the data available.

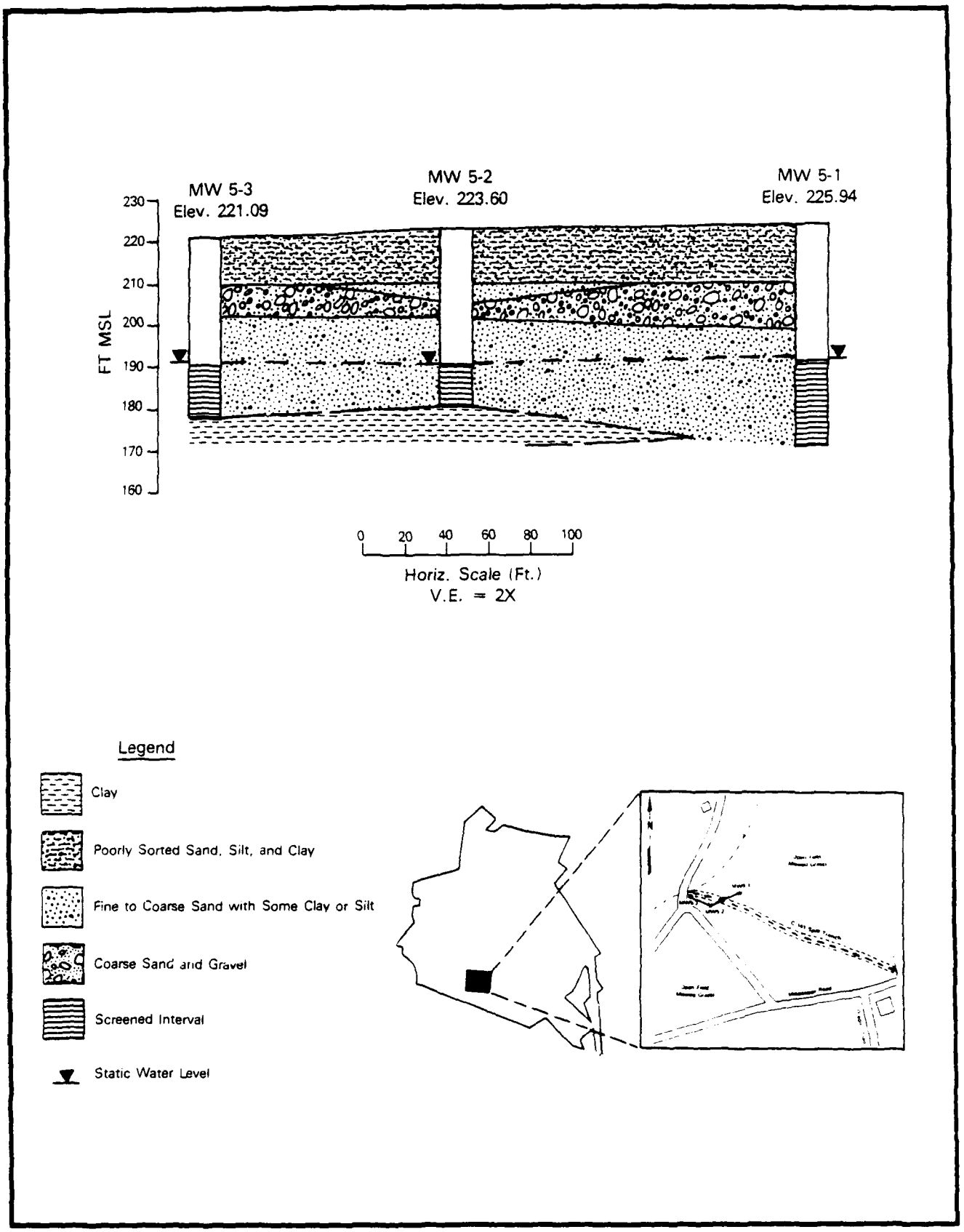


Figure 2-19. Fence Diagram For Site No. 5: C-141 Spill Trench.

The upper sands of the Tuscaloosa formation comprise the zone of saturation of the prevailing water table aquifer beneath the site. The water table occurs at an average depth of approximately 34 feet BLS, and ranges in elevation from 189.4 feet MSL at MW5-3 to 191.8 feet MSL at MW5-1, yielding a maximum head differential of 2.4 feet and a hydraulic gradient of 1.07%. The hydraulic conductivity of the sands of the Tuscaloosa formation beneath the site, as determined from aquifer tests performed on downgradient wells MW5-2 and MW5-3, ranges from 2.3×10^{-4} ft/sec (7.1×10^{-3} cm/sec) to 4.9×10^{-4} ft/sec (1.5×10^{-2} cm/sec), respectively (see Section 3.2.3). Assuming an effective porosity of 35% for the sands of the Tuscaloosa formation, the calculated horizontal velocity of groundwater flow would range from 0.6 ft/day (322 ft/yr) to 1.29 ft/day (472 ft/yr). The direction of groundwater flow is to the southwest, toward Cedar Creek.

2.5.6 Site No. 6: Unofficial Dump Site

An unofficial dump site, situated in a brushy upland area near the base's wastewater treatment plant at the western base boundary (Figure 2-20), was also examined during the Phase IIa site survey. Waste materials observed at the site included construction debris, waste wood, scrap metal, roofing shingles, empty paint cans and brush cuttings. Patches of discolored soils, paint residues, and a tar like substance were also observed at this site. The period of existence and the full contents of the site are unknown. Because this site is located approximately 500 feet from Cedar Creek off-base contaminant migration could readily and rapidly occur. Thus, McEntire ANG Base officials and OEHL requested inclusion of this site in the Phase II, Stage 1 investigative effort.

Three shallow water table aquifer monitoring wells were installed around the site (one upgradient and two downgradient) to investigate the potential subsurface movement of contaminants and to obtain site-specific geologic and hydrogeologic information. A fence diagram (Figure 2-21) constructed from the boring logs for the monitoring wells (Appendix E) illustrates the subsurface geology at the site.

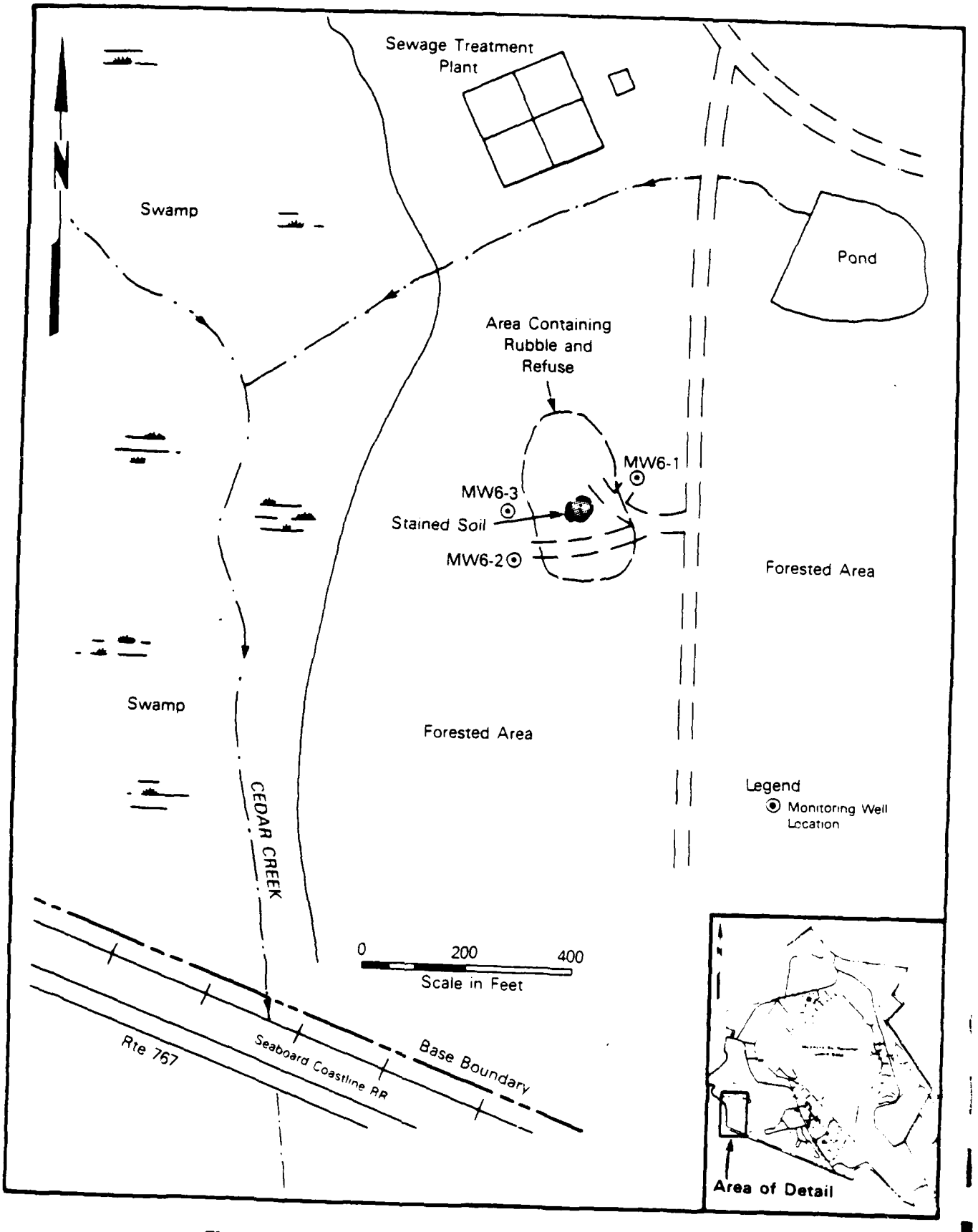


Figure 2-20. Site No. 6: Unofficial Dump Site.

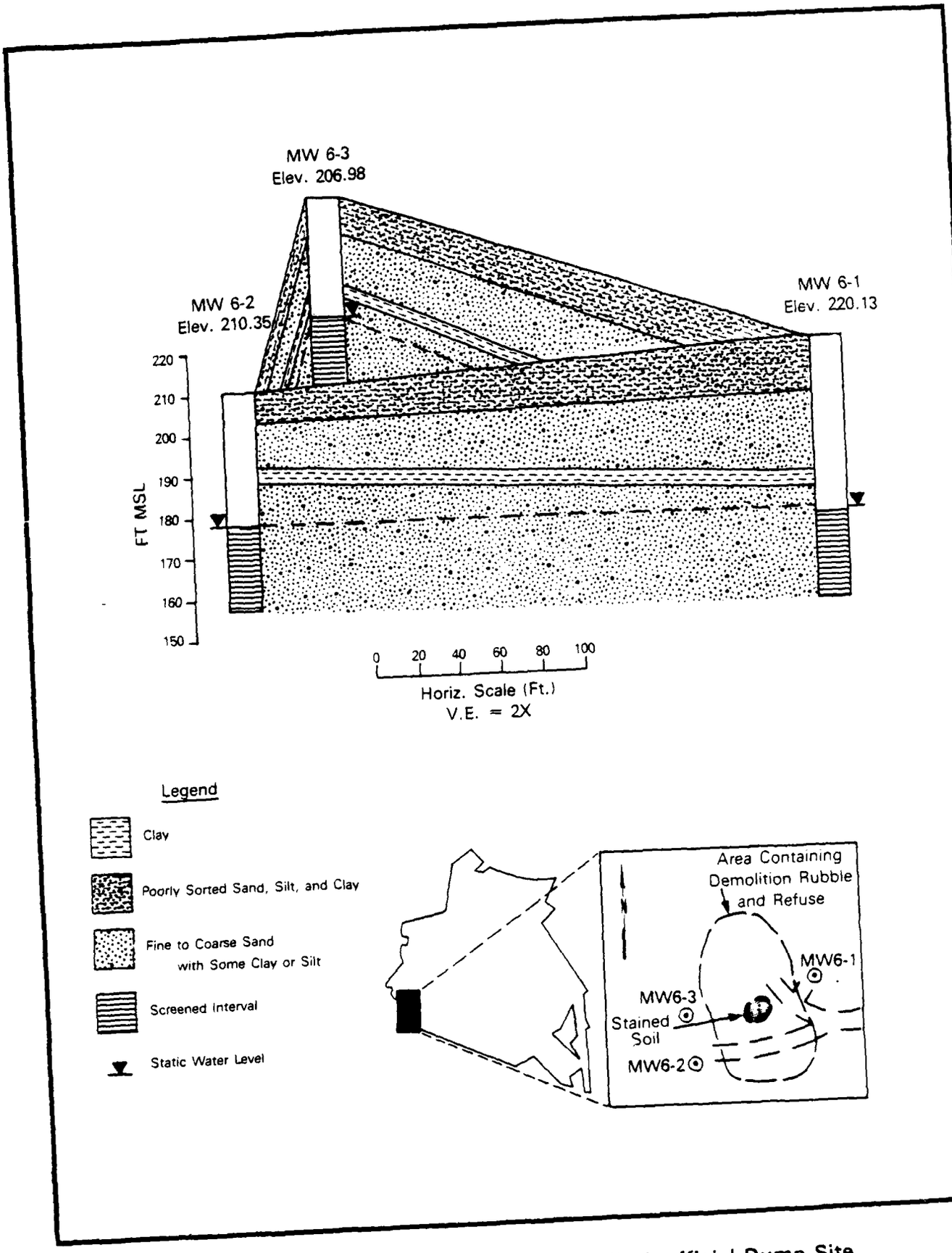


Figure 2-21. Fence Diagram For Site No. 6: Unofficial Dump Site.

In general, surface soils at the site consist of light yellow brown slightly silty medium sand. The surface soils generally grade to a reddish brown sandy silt or clay, which in turn, grades to a light yellow brown, fine to medium silty sand to a depth of approximately 25 feet. Below the silty sands, at an elevation of approximately 185 to 190 feet MSL, extends a thin layer of white clay (kaolin), of approximately 3 feet in thickness. Beneath this clay layer to the terminal depth of the borings generally extend yellowish brown to buff fine to medium sands, containing some light gravel and clay (kaolinite). Based on Colquhoun (1965) the deposits occupying the interval from approximately 195 feet MSL to land surface are considered to be of the Coharie (terrace) formation. This determination is based largely on the topographic interval delineated by Colquhoun (1965) for the Coharie terrace (210 to 220 feet MSL) and the general coarsening gradation of the deposits with depth through this interval. The underlying unconsolidated materials are consistent with regional descriptions of the Tuscaloosa formation (see Section 2.2).

The zone of saturation of the prevailing water table aquifer at the site occurs within the upper sands of the Tuscaloosa formation. The water table ranges in depth from 41.5 to 29.5 feet BLS at wells MW6-1 and MW6-3, respectively. The range in depths to the water table is principally caused by variations in surface topography. Water table elevations range from 178.5 in MW6-1 to 177.2 feet MSL in MW6-2, with a maximum head differential of 1.3 feet and a hydraulic gradient of 0.47%. The horizontal hydraulic conductivity of the upper sands of the Tuscaloosa formation beneath the site, as determined from aquifer tests performed on downgradient wells MW6-2 and MW6-3, ranges from 4.4×10^{-4} ft/sec (1.3×10^{-2} cm/sec) to 3.2×10^{-4} ft/sec (9.7×10^{-3} cm/sec), respectively (see Section 3.2.3). Assuming an effective porosity of 35% for the sands of the Tuscaloosa formation, the calculated horizontal velocity of groundwater flow would range from 0.37 ft/day (136 ft/yr) to 0.51 ft/day (186 ft/yr). The direction of groundwater flow is to the southwest, toward Cedar Creek.

2.5.7 Site No. 7: Drainage Pond/Swamp

This site is located in an open field along the south-central boundary line of the base, near the base's petroleum, oils, and lubricants (POL) storage area (Figure 2-22). The site consists of a slight topographic depression covering approximately 2 acres, into which surface runoff from the southern portion of the base is discharged. A light oil film was observed near the drain pipe entering the area, during the Phase IIa site survey. A drainage pipe beneath a small berm along the base boundary line directs surface runoff off from the base into a series of small swampy areas, which are interconnected by drain pipes (Figure 2-22). Discharge waters from a small commercial fertilizer mixing plant, located east of the site along highway 769, also flows into this site via a roadside drainage ditch. Dense algal growth was observed in each of the swampy areas depicted in Figure 2-22 during the Phase II survey of the site. Because this site provides obvious potential for direct off-base contaminant migration, McEntire ANG Base officials and OEHL requested that this site be investigated as part of the Phase II, Stage 1 effort.

Groundwater monitoring wells were not installed at this site, consequently site specific geologic and hydrologic information for the site are not available. Based on the U.S.D.A. Soil Conservation Service Soil Survey Report for Richland County (1978), the site soils are of the Coxville series, and are characteristically deep, nearly level, poorly drained, slow to moderately permeable, and formed from thick beds of clayey marine sediment. Generally, these soils occupy shallow, elliptical depressions on broad, smooth, interstream divides. Typically, the surface layer is dark gray, fine sandy loam about 7 inches thick. The subsurface layer is light brownish-gray fine sandy loam about 2 inches thick. The subsoil typically consists of 56 inches of gray sandy clay that has brownish and reddish mottles and 15 inches of gray sandy clay loam that has yellowish-red mottles. This soil is strongly acidic throughout. Organic matter content is medium. Permeability is moderately slow and available water capacity is medium.

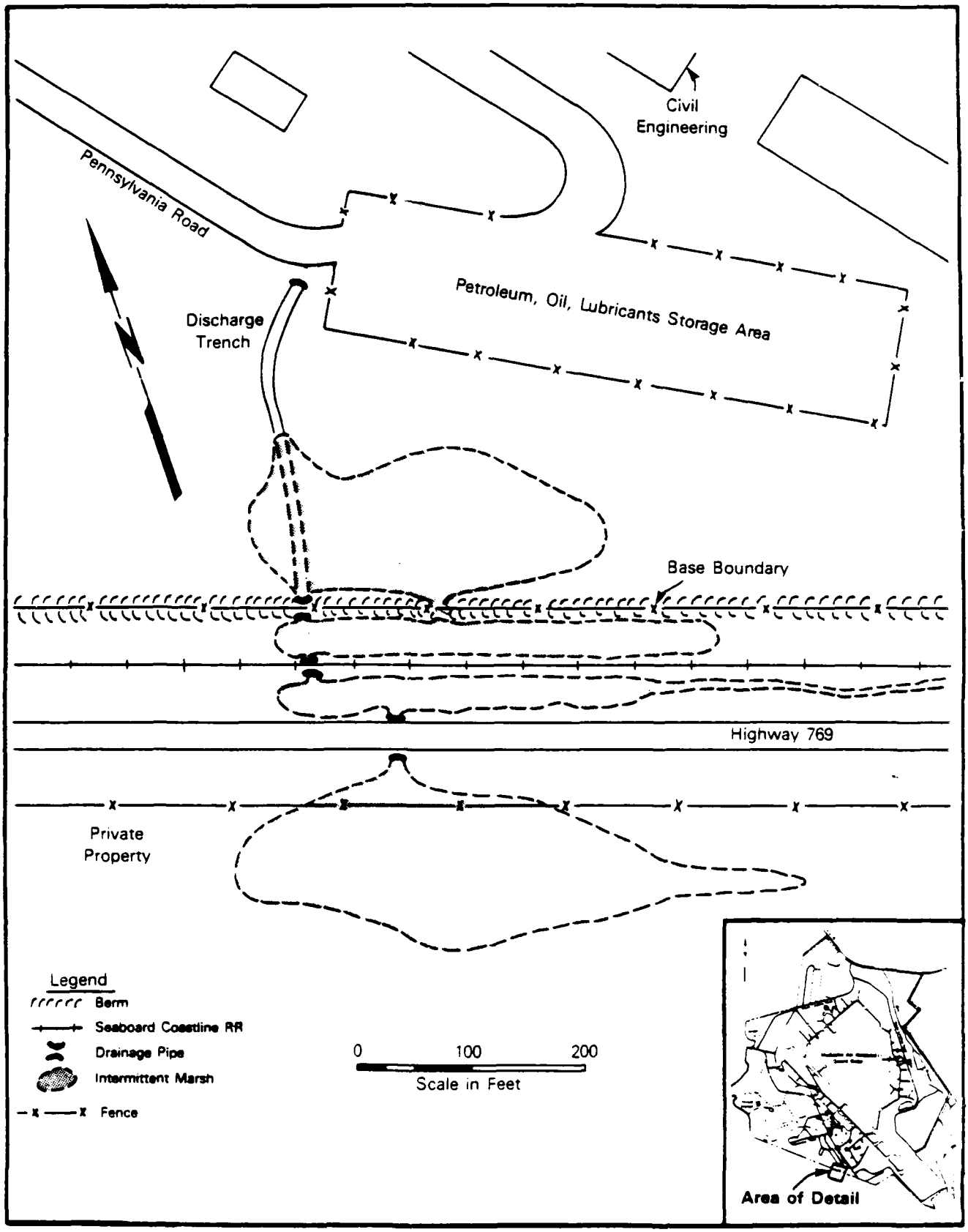


Figure 2-22. Site No. 7: Drainage Pond/Swamp Site.

Interpretation of topographic data and subsurface geologic and hydrologic information (previously presented for the base) suggest that the site is probably underlain by the unconsolidated sand, silt and clay deposits of the Hazelhurst and Tuscaloosa formations. The prevailing water table aquifer probably occurs within the upper sands of the Tuscaloosa formation at a depth of approximately 35 to 40 feet BLS. The direction of groundwater flow is likely to be southwesterly, toward Cedar Creek.

2.6 BASE WATER SUPPLY SYSTEM

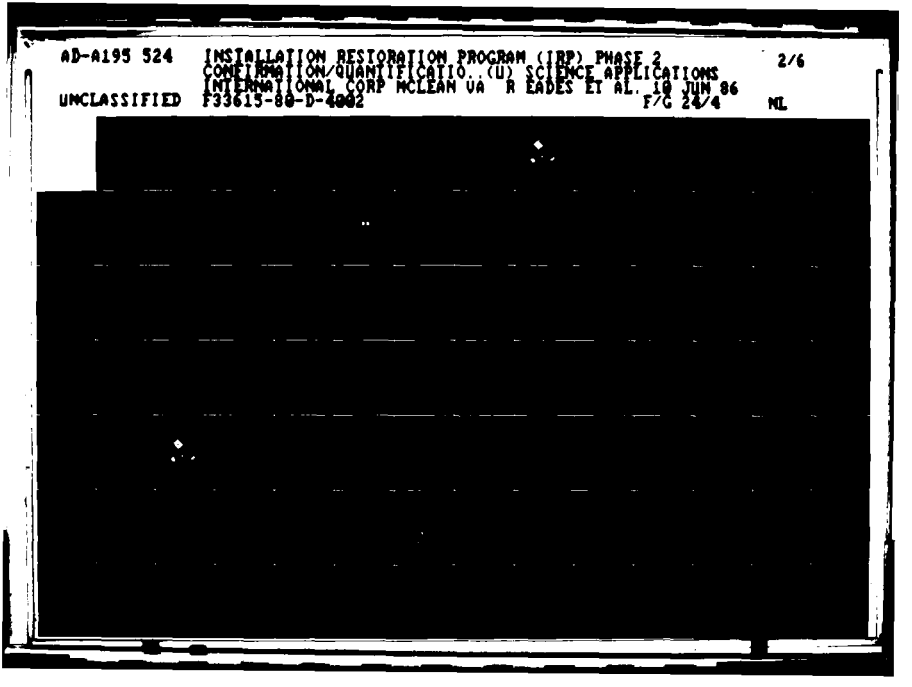
McEntire ANG Base's water supply system is owned and operated by the South Carolina ANG. The system was originally installed in 1942 and consists of two 4-inch diameter wells, which are screened within deep confined (artesian) sand aquifers of the Tuscaloosa formation, a 5,000 gallon pneumatic storage tank and three booster pumps. The location of the wells is shown in Figure 2-9. Specification data for the wells is provided in Table 2-6.

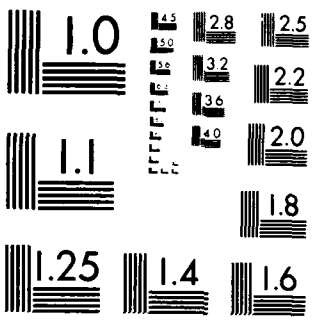
The two wells feed to an 8-inch header pipe which flows to the three booster pumps, which in turn pump directly into the distribution system. The booster pumps are 15 horsepower centrifugal pumps rated at 210 gpm. The pumps are turned on by a drop in the pressure in the distribution system, with one pump being turned on at a time. Chlorine gas, used to disinfect the system, is injected before the suction side of each booster pump. In addition to feeding water to a 5,000 gallon pneumatic storage tank the system also feeds a 500,000 gallon ground storage tank used for fire protection at the main hanger (Building No. 253). Water from this storage tank is prevented from flowing back into the system by a single check valve. The system has emergency power capability.

A survey of the water supply system on 20 November 1979, by the South Carolina Department of Health and Environmental Control (SCDHEC) revealed that the wells were improperly sealed. The South Carolina ANG has since rectified the problem.

Other wells (supply or monitoring) have not been installed or currently exist at McEntire ANG Base.

AD-A195 524 INSTALLATION RESTORATION PROGRAM (IRP) PHASE 2 2/6
CONFIRMATION/QUANTIFICATIO..(U) SCIENCE APPLICATIONS
INTERNATIONAL CORP MCLEAN VA R EADES ET AL. 10 JUN 86
UNCLASSIFIED F33615-80-D-4002 F/G 24/4 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3.0 FIELD PROGRAM

3.1 MONITORING PLAN DEVELOPMENT

The field program designed for McEntire ANG Base was based on the following: 1) a review of the Phase I Records Search, 2) a review of aerial photographs, maps, and available literature pertaining to the base, and 3) observations made during the Phase II presurvey. The Phase II presurvey was initiated at McEntire ANG Base in May 1984 and consisted of a meeting with base and OEHL personnel, a site survey, and the sampling of base water supply wells. Based largely on the Phase I and Phase II presurvey findings and recommendations, OEHL developed the Description of Work (DOW) for the Phase II Stage 1 Field Evaluation for McEntire ANG Base (Appendix C). The overall field/monitoring program for the base is provided in the DOW. The final field monitoring program implemented at McEntire ANG Base was modified on-site as appropriate due to unanticipated field conditions. Modifications to the DOW were accomplished and approved through communication with the OEHL task monitor.

The monitoring program was developed in order to determine whether environmental contamination had occurred at each of the designated sites and to provide for a preliminary evaluation of the movement of any contaminants found. Table 3-1 provides a summary of the monitoring program developed for the base and each of the sites. Monitoring well, soil, sediment, and surface water sampling locations were selected to maximize data acquisition while minimizing cost. As specified in the DOW, a total of 23 monitoring wells were installed at sites number 1 through 6 at depths designed to monitor the upper 20 feet of the water table aquifer only. Depths were limited in this manner because of the lack of definitive geologic and hydrogeologic information for the base. The installation of deep aquifer monitoring wells without adequate geologic and hydrogeologic information opens potential conduits for the downward migration of contaminants into the deeper confined aquifers which are utilized as a water supply source by the base and surrounding communities (see Section 2.0). In addition, installing deep wells at a site which may not have been contaminated groundwater would be an unnecessary capital expenditure.

TABLE 3-1. BRIEF SUMMARY OF IRP PHASE II STAGE 1 SAMPLING AND ANALYSIS PLAN

Phase II Site No.	Phase I Site No.	Site Name	HARM Score	Monitoring/Sampling Plan	Analyses List*
1	2	No. 5 Fire Training Area	69	Install and sample 4 shallow monitoring wells; obtain 1 sediment sample from burn pit and 3 samples from overflow swale.	Groundwater: TOX, TOC, O&G, VOA Sediment: TOX, O&G, VOA
2	1	No. 1 Fire Training Area/ Sanitary Landfill	67	Install and sample 5 shallow monitoring wells.	TOX, TOC, O&G, VOA, Metals
	3		57		
3	4	Y-Storage Area	56	Install and sample 4 shallow monitoring wells; obtain 3 soil samples.	Groundwater: TOX, TOC, O&G Soil: TOX, O&G
4	5	Oil Dump Site	56	Install and sample 4 shallow monitoring wells; obtain 1 surface soil sample and 3 samples at 5 foot depth intervals at center of site.	Groundwater: TOX, TOC, O&G Soil: TOX, O&G
5	6	C-141 Spill Trench	54	Install and sample 3 shallow monitoring wells; obtain 4 sediment samples.	Groundwater: TOX, TOC, O&G Soil: TOX, O&G
6	--	Unofficial Dump Site	--	Install and sample 3 shallow monitoring wells; obtain 1 surface soil sample.	Groundwater: TOX, TOC, O&G, Soil: TOX, O&G, VOA
7	--	Drainage Pond/ Swamp	--	Obtain 6 sediment samples.	TOX, O&G, nitrates, phosphorous (total)
--	--	Cedar Creek & Tributary Drainage Swale	--	Obtain 4 surface water and sediment samples from Cedar Creek, and 2 sediment samples from drainage swale.	Surface water: TOX, TOC O&G, VOA, Metals Sediment: TOX, O&G, VOA, Metals
--	--	Supply Well (W-1)	--	Obtain 1 sample.	VOA

* TOX: Total Organic Halogens
TOC: Total Organic Carbon
O&G: Oil and Grease by IR
VOA: Volatile Organics Analysis by EPA methods 601-602 (water), 846/8010-8020 (soil/sed.)
Metals: As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn

The monitoring program proposed for McEntire ANG Base was designed to meet the following objectives:

- Determine whether a site is contributing to groundwater contamination, and if so, the degree of contamination;
- Determine subsurface geologic and hydrogeologic conditions;
- Define the direction and rate of groundwater movement; and
- Determine the need for additional investigations.

Monitoring wells were located to provide both upgradient and downgradient data at each site. Well placement was complicated because the exact direction of groundwater flow in the surficial aquifer was not known. The direction of flow was assumed to be controlled by site and base topography. Where topography did not provide definitive clues, the lack of information concerning the direction of groundwater flow necessitated that wells be placed to surround a site. In addition, since rates of groundwater movement had not been previously determined, wells were placed relatively close to sites to assure identification of any contaminants that were being generated.

Elevated levels of chlorinated organics (as measured by TOX) were detected in McEntire ANG Base's water supply well (W-1) during the Phase II presurvey sampling. To identify the compound(s) present their well was also resampled as part of the Phase II Stage 1 Field Evaluation program.

Surface water, soil, and sediment sampling points were located to detect any residual contamination at spill or waste disposal sites, and to identify off-site contaminant movement through surface drainage. Where surface water samples were collected, sediment samples were also obtained from the same location. Surface water and sediment sampling along Cedar Creek and its tributary drainage swale were recommended to evaluate the potential movement of contaminants off-base. Sampling points were located above and below the drainage areas of the individual sites and upstream and downstream of the base itself. This allowed evaluation of surface water and sediment quality changes as surface water flowed through the base and past individual sites of

concern. A soil boring was performed at Site No. 4 (Oil Dump Site) in order to determine the depth of residual contamination within the soil beneath the site.

The sampling program was developed to provide representative samples for laboratory analysis within allowable holding times for analytes. The wells were completed according to predetermined specifications and purged prior to sampling to yield representative results. Quality Assurance/Quality Control (QA/QC) provisions were included in the sampling program to ensure the integrity of the samples.

3.2 MONITORING PLAN IMPLEMENTATION

The field program for the Phase II Stage 1 Field Evaluation was initiated at McEntire ANG Base on March 6, 1985. A reconnaissance of the disposal/spill sites and Cedar Creek was conducted and locations of groundwater monitoring wells, and surface water, soil and sediment sampling points were staked. Each of the staked markers was painted fluorescent orange, flagged with surveying tape, and labeled to facilitate resampling, if required. The well identification and sampling location/sample identification numbering system implemented is provided in Appendix D. The location of the monitoring wells and sampling points for each of the sites is shown in Figures 3-1 through 3-8.

A number of modifications to the original DOW were implemented during this phase of the field program. Because of the limited extent of visible contamination (approximately 750 ft^2) at Site No. 6 (Unofficial Dump Site), three monitoring wells rather than four were determined to provide adequate site coverage. Conversely, because of the relatively large area of Site No. 2 (No. 1 Fire Training Area/Sanitary Landfill Site) and ambiguity with respect to direction of groundwater flow, five monitoring wells rather than four were installed to provide adequate monitoring coverage.

As a result of unseasonably dry weather, no surface water was present at Site numbers 1, 5, and 7 or in the tributary drainage swale to Cedar Creek from Site No. 2 during implementation of the sampling program. Consequently,

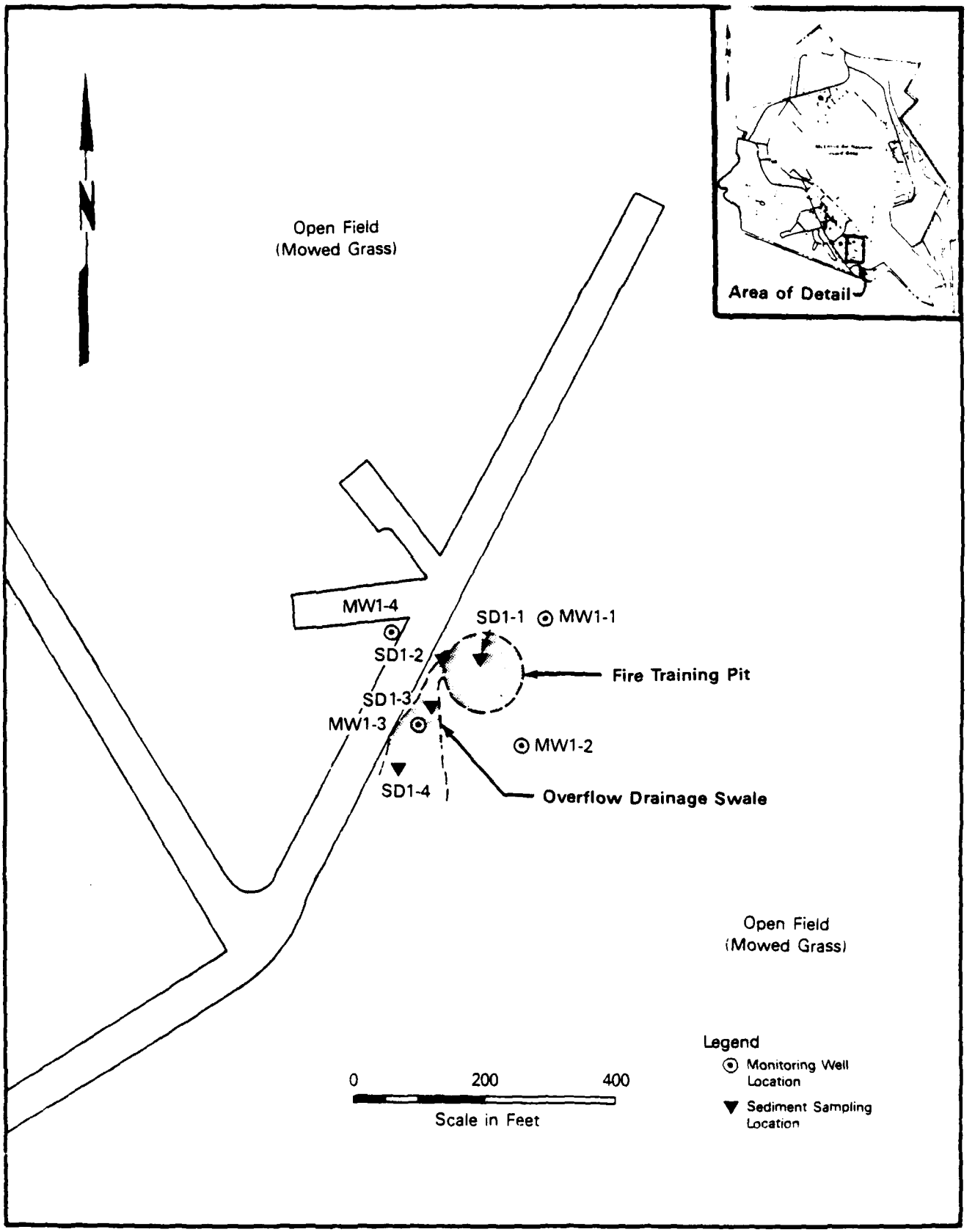


Figure 3-1. Monitoring Well and Sampling Locations; Site No. 1: No. 5 Fire Training Area.

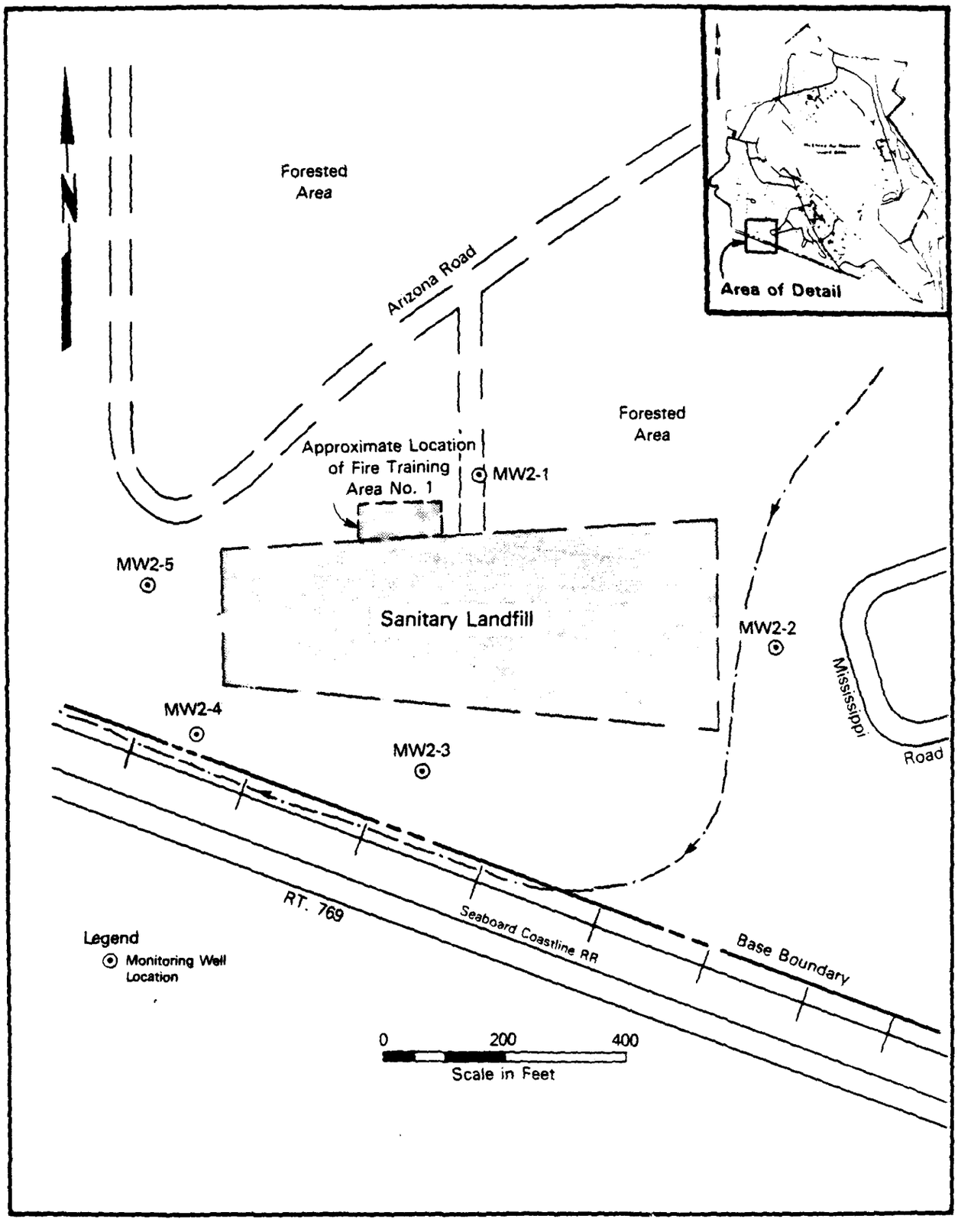


Figure 3-2. Monitoring Well Locations; Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site.

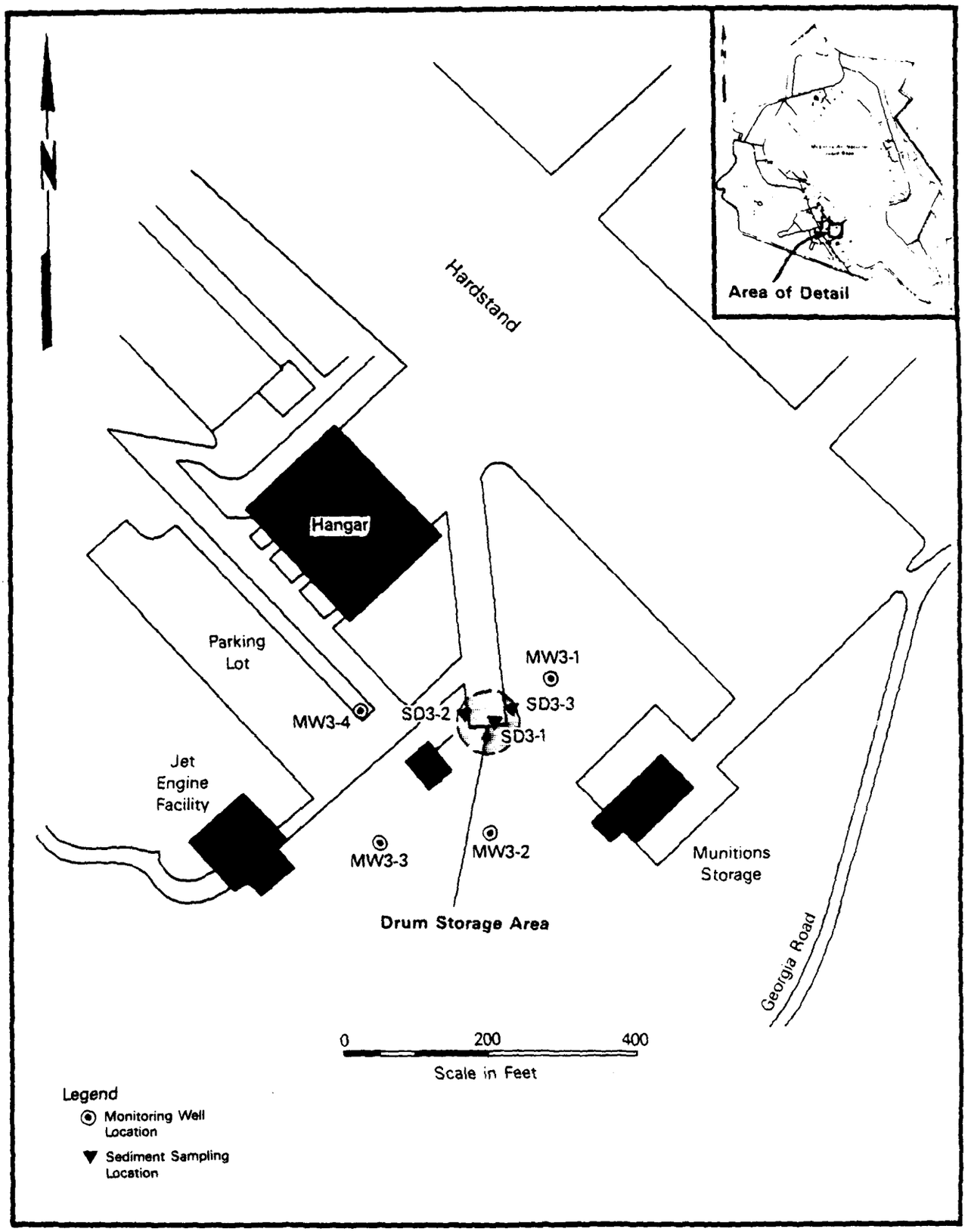


Figure 3-3. Monitoring Well and Sampling Locations; Site No. 3: Y-Storage Area.

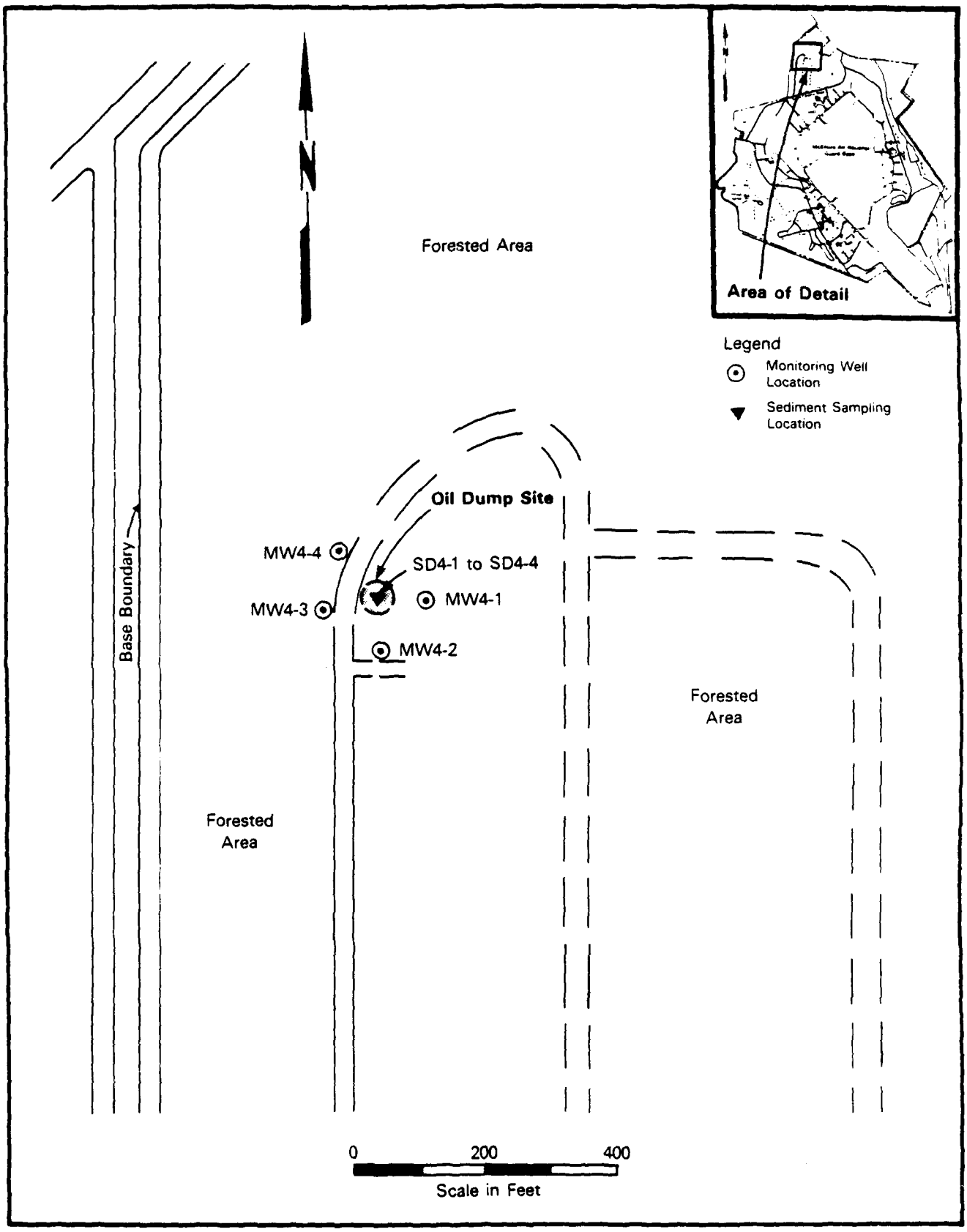


Figure 3-4. Monitoring Well and Sampling Locations; Site No. 4: Oil Dump Site.

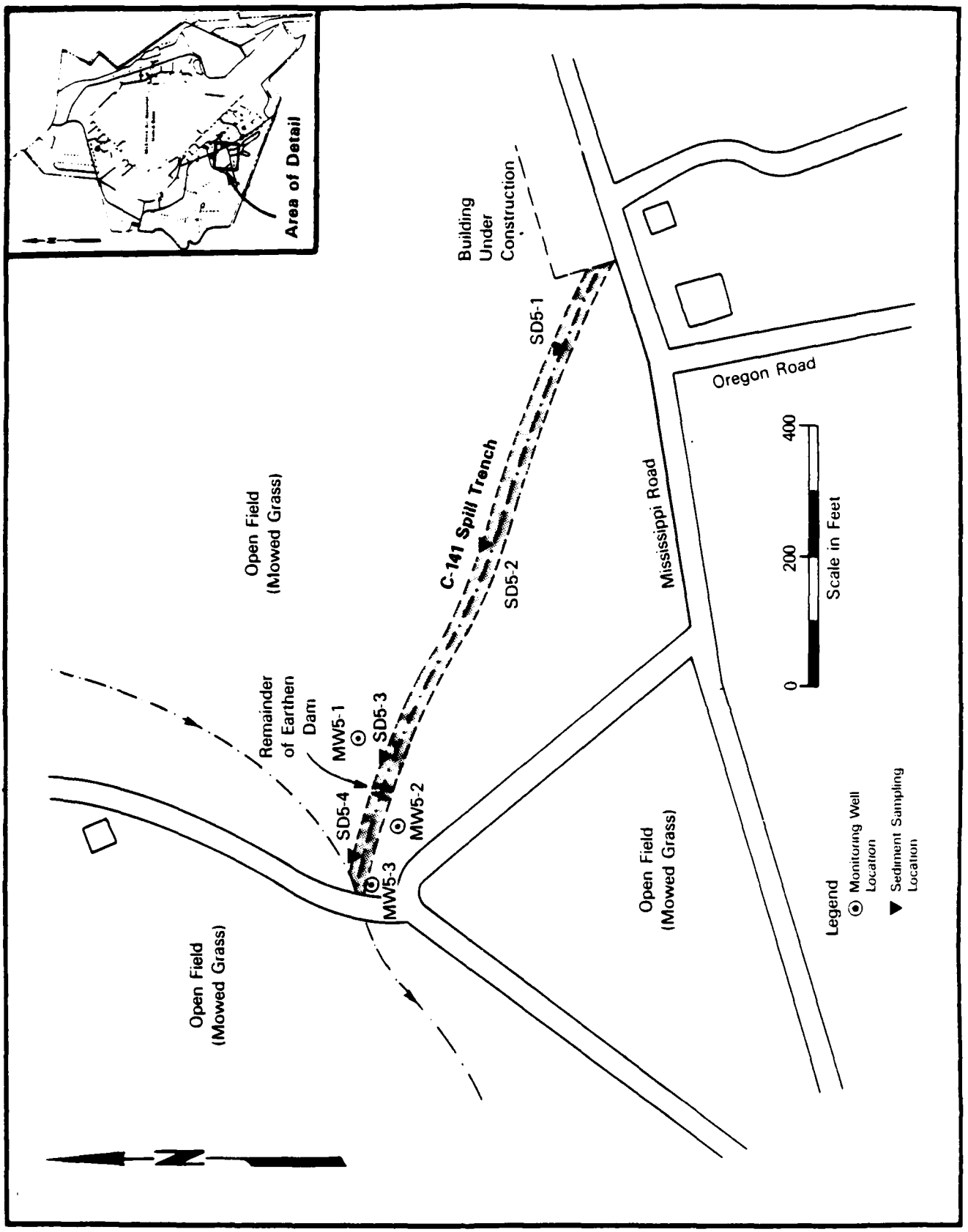


Figure 3-5. Monitoring Well and Sampling Locations; Site No. 5: C-141 Spill Trench.

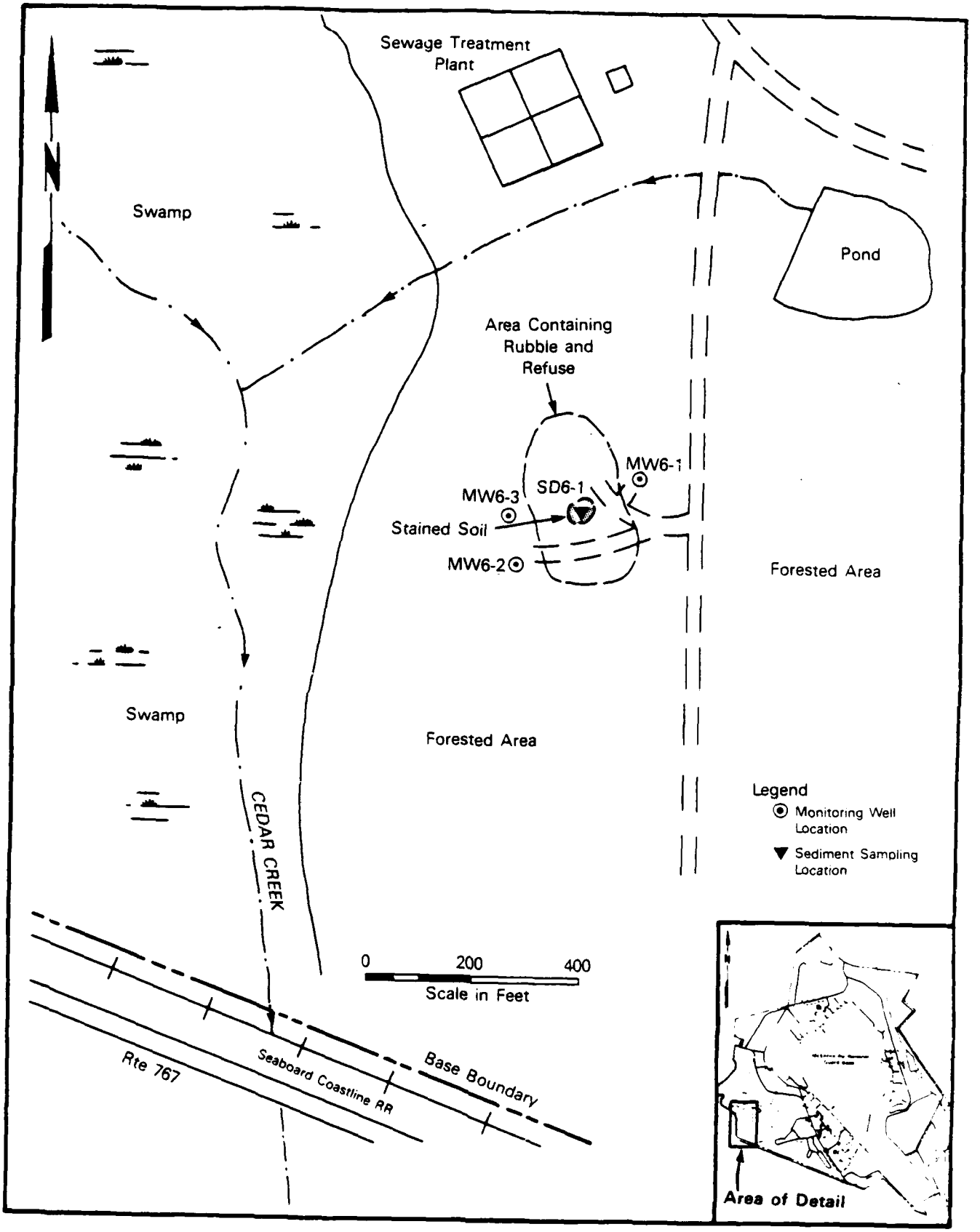


Figure 3-6. Monitoring Well and Sampling Locations; Site No. 6: Unofficial Dump Site.

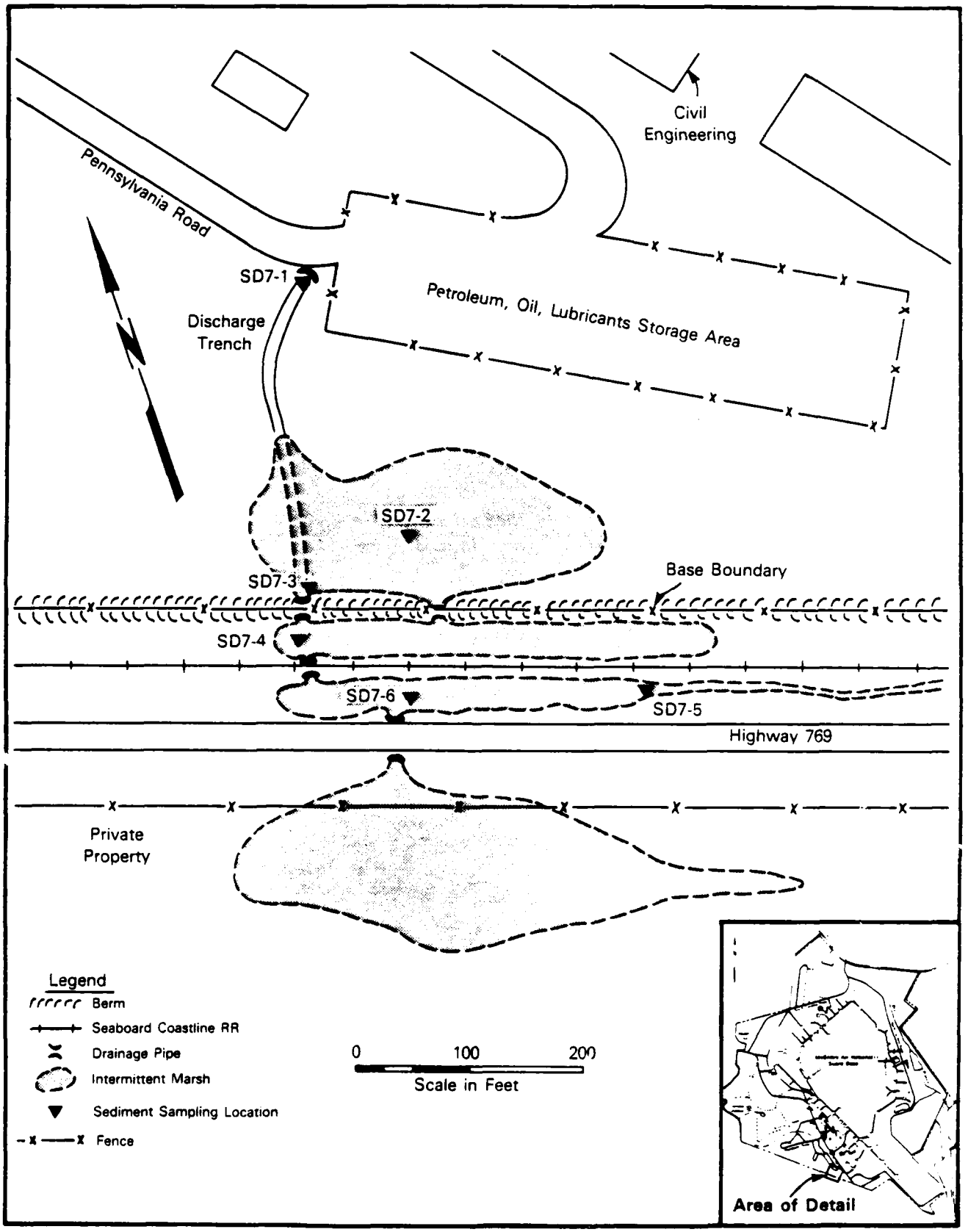


Figure 3-7. Sampling Locations; Site No. 7: Drainage Pond/Swamp Site.

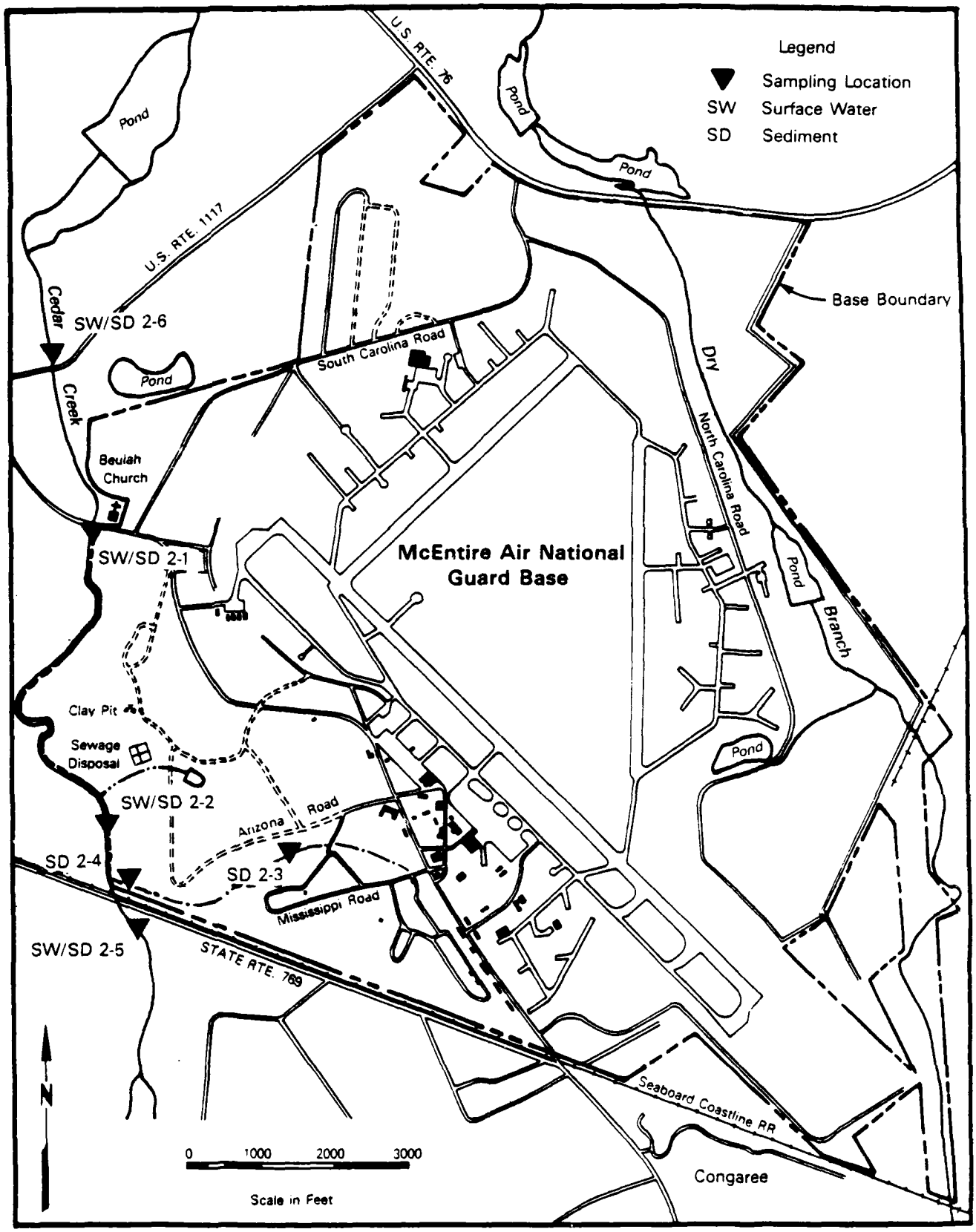


Figure 3-8. Sampling Locations: Cedar Creek and Tributary Drainage Swale.

surface water sampling points were not established at these sites. Sediment sampling points were, however, established.

The lack of surface water at Site No. 7 also exposed a drainage pipe that had not been visible during the Phase II presurvey of the site. The drain pipe discharges directly off-base from the site, providing a conduit for the potential rapid movement of contaminants directly off-base. Three additional sediment sampling points were, therefore, located at this site (SD7-4, SD7-5, SD7-6) to evaluate potential off-base contaminant migration in this pathway.

The specific location of the temporary earthen dam reportedly constructed at Site No. 5 (C-141 Spill Trench) could not be determined. For this reason, and because of the trench's length (approximately 1,200 feet), one additional sediment sampling point was located near the reported dam site to aid in the evaluation of contaminant movement away from the site.

As noted in Section 2 discussions, stained soils and a pronounced hydrocarbon odor were noted at Site No. 6 (Unofficial Dump Site). Therefore, one sediment sampling point was added to the monitoring program for this site. An additional sediment sampling point was also located near the mouth of the tributary drainage swale to Cedar Creek to aid in the analysis of potential off-base contaminant migration from the sites and the base as a whole.

The sampling phase of the field program at McEntire ANG Base was initiated on March 6, 1985.

The following sections discuss the sampling and analysis program, as implemented, and the procedures that were used in installing monitoring wells and obtaining samples.

3.2.1 Monitoring Well Installation

Well installation was initiated at the base on March 27, 1985. Borehole drilling and well installation was conducted under subcontract by Soil and Material Engineers, Inc. of Columbia, South Carolina, and was supervised by

SAIC personnel. Boreholes for all 23 monitoring wells were drilled with CME-550 all-terrain drill rigs. Twenty-one of the boreholes were drilled using 6-inch (OD), 3 1/2-inch (ID) hollow stem augers. Two of the boreholes were drilled using hydraulic rotary drilling methods and a 6-inch drill bit. Drilling began in all cases by advancing the borehole 3.5 feet below land surface. A 1.5 foot split spoon sample was then obtained and described in accordance with ASTM Standard 1586. The following information was recorded by the supervising geologist:

- Sample Interval
- Blow Count
- Amount of Recovery
- Sample Color (using Munsell Soil Color Charts)
- Texture
- Moisture Content
- Density
- Any unusual and distinguishing characteristics.

In addition, all cuttings were characterized similarly. This drilling and sampling cycle was repeated at 5 foot depth intervals until the borehole was advanced 20 feet into the water table aquifer. Boring logs for each well are provided in Appendix E. To ensure worker health and safety, ambient air monitoring was performed with an HNU® photoionization organic vapor analyzer during drilling.

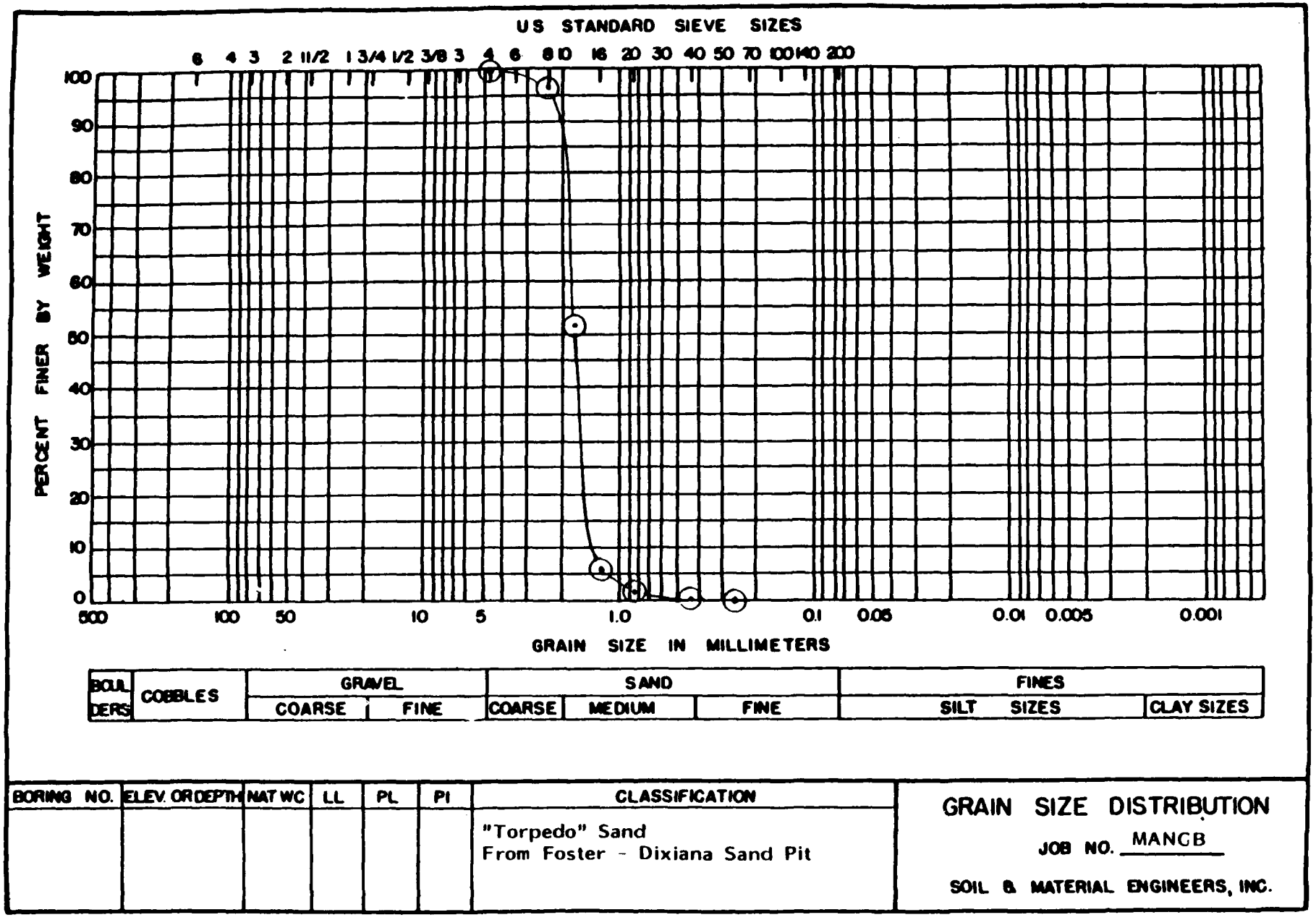
The DOW specified use of auger drilling methods for well installation. During auger drilling at Site Nos. 2, 5, and 6, however, the unconsolidated sands of the surficial aquifer tended to flow under hydrostatic pressure into the hollow stem augers once the water table was encountered. This phenomena, referred to as "heaving sands", made split spoon sampling and well installation more difficult and time consuming. In an effort to expedite the drilling and well installation process, conversion to mud rotary drilling was requested by SAIC and approved by OEHL. The base's water supply well (W-2) was used as a water source and two wells (MW1-4 and MW4-3) were drilled using hydraulic rotary drilling methods. Although hydraulic rotary drilling

prevented the sands from heaving, near-surface silt and clay units (see Chapter 2.0) slowed the drilling rate using this method. Since a time saving was not realized, hydraulic rotary drilling was terminated and auger drilling, as specified in the DOW, was resumed through the remainder of the program.

Physical evidence of contamination was not detected during borehole drilling at any of the sites, based on color, odor or organic vapor monitoring with HNU® meters. Therefore, drill cuttings were not containerized and no testing for EP Toxicity and Ignitability was performed.

Upon completion of drilling, wells were installed using the following procedures. Twenty (20) feet (or less, where dictated by site conditions) of 2-inch (ID) flush-joint PVC screen, with five (5) slots per inch at 0.015 inches per slot, and an appropriate length of 2-inch (ID) Schedule 40 PVC riser were assembled and threaded together. A threaded flush plug was installed at the bottom of each well screen. The screen and riser pipe were then lowered down through the hollow stem augers or open borehole. A riser stick-up of two feet above ground level was retained to facilitate sampling. A sand pack of uniform size (Figure 3-9) was then added to the annulus until it extended two to three feet above the top of the well screen. A layer of bentonite pellets, at least two feet in thickness, was added above the sand pack. Water was then applied to the bentonite pellets to promote swelling and the formation of a proper seal. After approximately 30-45 minutes elapsed, ensuring proper bentonite sealing, grout was added to the annulus from the top of the bentonite to ground surface. The grout mixture was composed of water, bentonite, and Type 1 Portland Cement in a 0.44:9.5:10 ratio. For auger drilled wells all materials (sand pack, bentonite, grout) were added through the hollow stem augers as the augers were raised at increments of 2.5 feet or less. In the hydraulic rotary drilled wells, the sand pack and bentonite were placed directly through the open borehole.

In all wells, the grout was allowed to set for a minimum of 24 hours before installing and setting with concrete a 5 foot length of protective steel casing over the PVC riser. Three two-inch diameter steel guard posts, 5 feet in length, were then installed at a distance of 2.5 feet radially from



BORING NO.	ELEV. OR DEPTH	NAT WC	LL	PL	PI	CLASSIFICATION
						"Torpedo" Sand From Foster - Dixiana Sand Pit

GRAIN SIZE DISTRIBUTION

JOB NO. MANGB

SOIL & MATERIAL ENGINEERS, INC.

Figure 3-9. Sieve Analysis for Sand Pack.

all wells to prevent damage to the wells. The guard posts and protective steel casings were painted fluorescent orange for ease of visibility. Monitoring well identification numbers were stenciled on the steel casings, and marked on vented PVC slip covers which were placed over the top of the PVC riser pipe. A schematic diagram for a completed well is shown in Figure 3-10.

Well specifications outlined in the DOW (Appendix C) required "each well to be screened 20 feet into the shallow groundwater aquifer." However, the presence of clay units within the uppermost 20 feet of the shallow groundwater aquifer precluded the installation of 20 feet of screen in some instances. A well construction summary for all the wells installed is presented in Table 3-2. Detailed well construction summaries for each of the wells are provided in Appendix E.

Prior to initiating the drilling program, following the completion of each borehole, and after drilling the final borehole, all drilling and measuring equipment was steam cleaned, washed with a low-residue detergent (Alconox), and rinsed with clean water. This procedure was used to prevent cross-contamination between boreholes. In addition, well construction materials (screen and casing) were also decontaminated prior to installation. A portable kerosene-burning steam generator was used to steam clean the rigs and equipment on wash racks located off Mississippi Road, near Building No. 225. Water from a base fire hydrant at this location was used for steam cleaning purposes.

Wells were developed by both air surging and pumping to remove any particles obstructing the screen. Each well was surged with an air compressor for a minimum of one hour prior to pumping. At least 5 casing volumes and 5 times the estimated volume of water introduced during drilling were then pumped from each well using a 1.7 inch PVC Brainard/Kilman hand pump. Additional pumping was performed when required until the wells produced sediment free water. All equipment employed in developing the wells was decontaminated prior to use at each well to prevent cross-contamination.

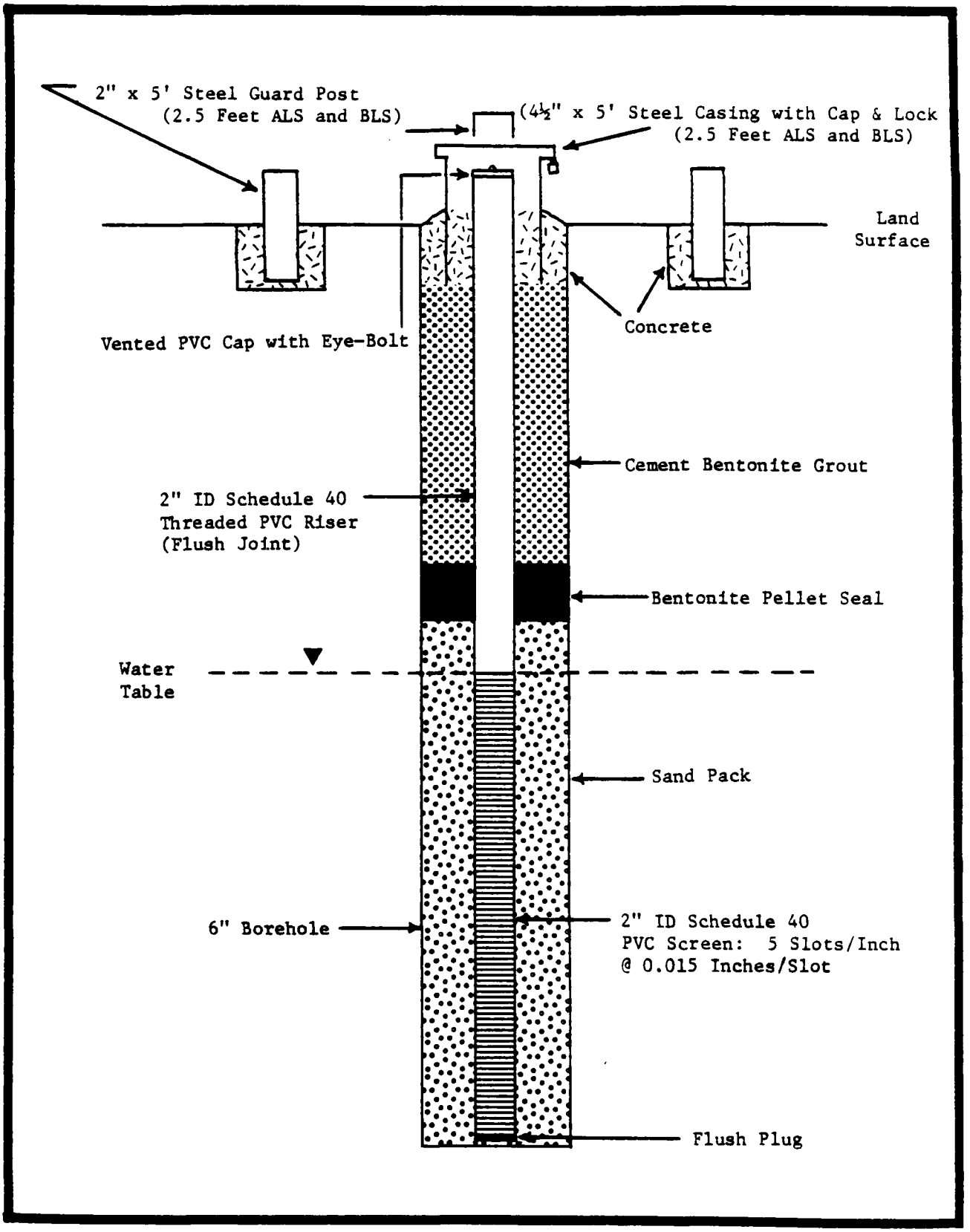


Figure 3-10. Schematic Diagram of Monitoring Well.

TABLE 3-2. WELL CONSTRUCTION SUMMARY

Well Number	Date Drilled and Installed (1985)	Depth (ft. BLS[1])	Drilling Method[2]	Screened Interval (ft. BLS)	Sand Pack (ft. BLS)	Bentonite Seal (ft. BLS)	Riser Stickup (ft. ALS[3])
MW 1-1	4/11-12	60.0	A/MR	40.4-60.0	38.4-60.0	36.4-38.4	2.0
MW 1-2	4/11-12	60.1	A/MR	40.5-60.1	38.5-60.0	36.5-38.5	1.9
MW 1-3	4/12-13	60.0	A	40.4-60.0	38.4-60.0	36.4-38.4	1.9
MW 1-4	4/12-13	61.0	MR	41.0-61.0	34.0-61.0	32.0-34.0	1.9
MW 2-1	4/4-5	53.0	A	33.0-53.0	31.0-53.0	29.0-31.0	1.8
MW 2-2	4/3-4	47.0	A	27.0-47.0	25.0-47.0	23.0-25.0	2.0
MW 2-3	4/10-11	43.3	A	23.7-43.3	21.7-43.3	19.7-21.7	2.0
MW 2-4	4/10	46.0	A	26.0-46.0	24.0-46.0	22.0-24.0	1.9
MW 2-5	4/8-9	58.0	A	38.0-58.0	36.0-58.0	34.0-36.0	1.8
MW 3-1	4/16-17	63.5	A	43.5-63.5	41.4-63.5	39.4-41.4	2.0
MW 3-2	4/17	58.5	A	46.0-58.5	43.5-58.5	41.5-43.5	1.9
MW 3-3	4/16	54.7	A	43.0-54.7	41.0-54.7	39.0-41.0	2.1
MW 3-4	4/18	68.1	A	48.5-68.1	45.5-68.1	43.5-45.5	2.0
MW 4-1	4/13-14	65.6	A	46.0-65.6	45.0-65.6	41.0-45.0	2.0
MW 4-2	4/15-16	63.0	A	43.0-61.0	41.0-63.0	39.0-41.0	2.0
MW 4-3	4/13-14	60.0	MR	40.0-60.0	38.0-60.0	36.0-38.0	2.0
MW 4-4	4/15	62.0	A	45.0-62.0	45.0-62.0	43.0-45.0	1.9
MW 5-1	3/27-28	54.0	A	34.0-54.0	32.0-55.0	28.0-32.0	1.8
MW 5-2	3/29	42.5	A	32.4-42.5	29.8-42.8	25.8-27.8	2.0
MW 5-3	4/1-2	44.0	A	31.0-44.0	28.3-46.3	25.2-28.3	1.9
MW 6-1	4/4-5	62.7	A	42.7-62.7	40.9-65.0	38.9-40.9	1.9
MW 6-2	4/9-10	53.2	A	33.2-53.2	30.7-53.2	28.7-30.7	1.8
MW 6-3	4/8-9	49.0	A	29.0-49.0	25.9-49.0	23.9-25.9	2.1

[1] BLS - Below Land Surface
[2] A - Auger
MR - Mud Rotary
[3] ALS - Above Land Surface

At the completion of drilling operations, the horizontal coordinates and vertical elevations of all wells were surveyed. Surveying was subcontracted to Ralph O. Vanadore, RLS, of Lexington, South Carolina. Well locations were established using the State Plane Coordinate System. Table 3-3 provides a list of the elevations and horizontal coordinates for the 23 monitoring wells installed at the base.

3.2.2 Sampling Program/Procedures

Groundwater samples were collected from each of the monitoring wells installed and the base's water supply well, W-1. Surface water, sediment, and soil samples were obtained from each of the previously staked locations. All samples collected by SAIC personnel were split, with one suite of samples sent for analysis to SAIC's contracted laboratory (ERG) and a duplicate suite of samples sent to OEHL's laboratory. The following sections detail the methods, procedures, and equipment used in performing the sampling phase of the field program at McEntire ANG Base.

3.2.2.1 Groundwater Sampling

Prior to purging and sample collection, static water level measurements were taken at each well using a Keck electronic water level indicator (Model WLI-82). The water level indicator was attached to a tape measure and lowered down the well until it produced a tone indicating contact with the surface of the standing water in the well. The total distance from the top of the PVC riser to static water was measured and recorded. The tape and instrument were then extracted and decontaminated. Static water level measurements were obtained for all wells within a 24-hour period and used to calculate the volume of standing water in each well and to generate a water table contour map of the surficial aquifer (Section 2.0).

Prior to collecting groundwater samples, at least five casing volumes of water were purged from each well to ensure that a representative sample of the aquifer (i.e., not stagnant water) would be collected (EPA, 1977). A 1.7 inch PVC Brainard/Kilman hand pump was used to purge the wells. The pump and water level indicator were decontaminated between each well by scrubbing with an

TABLE 3-3.
HORIZONTAL COORDINATES AND ELEVATIONS OF
MONITORING WELLS INSTALLED AT McENTIRE ANG BASE

Well No.	Elevation (ft.MSL)		State Plane Coordinates (ft.)	
	Top of Riser	Land Surface	North	East
MW 1-1	236.61	234.61	331,675.4886	2,061,376.0823
MW 1-2	235.30	233.40	331,480.7669	2,061,327.1277
MW 1-3	235.04	233.09	331,510.1229	2,061,179.7910
MW 1-4	237.20	235.28	331,660.3656	2,061,146.7316
MW 2-1	214.62	212.82	332,459.0151	2,057,061.9748
MW 2-2	208.66	206.66	332,825.4351	2,057,045.7775
MW 2-3	205.75	203.75	332,262.2504	2,056,493.3164
MW 2-4	204.48	202.58	332,324.2197	2,056,101.9256
MW 2-5	217.07	215.22	332,574.0808	2,056,042.8854
MW 3-1	242.11	240.11	333,020.6724	2,060,184.3808
MW 3-2	241.87	239.92	332,843.0003	2,060,093.5280
MW 3-3	240.08	237.98	332,815.8281	2,059,953.3647
MW 3-4	242.61	240.61	332,955.5289	2,059,910.5605
MW 4-1	266.28	264.28	341,814.5816	2,058,095.1091
MW 4-2	265.66	263.66	341,740.2417	2,058,008.9759
MW 4-3	265.25	263.25	341,845.9792	2,057,924.3583
MW 4-4	266.37	264.41	341,914.3259	2,058,004.6433
MW 5-1	227.79	225.94	333,164.4151	2,058,300.9057
MW 5-2	225.60	223.60	333,108.0621	2,058,159.5448
MW 5-3	223.04	221.09	333,151.6410	2,058,065.4298
MW 6-1	222.03	220.13	333,691.8391	2,055,864.6288
MW 6-2	212.15	210.35	333,535.3098	2,055,645.2333
MW 6-3	209.08	206.98	333,617.8990	2,055,625.1306

Alconox/water solution and then rinsing with distilled water (de Vera et al., 1980).

Sample collection was performed within a 24-hour period after purging each well. Samples were retrieved from each monitoring well with a point source teflon bailer and dispensed directly into an appropriate prelabeled sample bottle containing the required preservative for the analyte to be tested (Table 3-4 and Table 3-5). Each sample container was then wrapped in packing material (bubble pack) and placed in a cooler containing blue ice to maintain a temperature of 4°C.

When volatile organics were included in a sampling suite, they were collected first. Care was taken to minimize agitation when retrieving the sample and when placing it in the sample container. Oil and grease samples were collected second. These samples were retrieved from the upper five feet of the screened interval of the well to ensure collection of oil and grease. Total organic halogen (TOX) and total organic carbon (TOC) samples were collected next and metal samples were collected last. With the exception of oil and grease samples, all samples were obtained from the mid-point of the saturated column.

One sample was collected from the base's water supply well, W-1. The sample was obtained from a spigot in a discharge pipe from the well head located in Building No. 145. Flow from the spigot was minimized to ensure minimal sample agitation and release (loss) of volatile organic compounds, if present.

Upon retrieving the final water sample at each sampling point, field measurements for temperature, pH, and specific conductance were obtained. A Hach digital pH/temperature meter (Model No. 19000-00) and Hach digital conductivity/temperature meter (Model 16300) were used in measuring these parameters. The measuring probes for each of these meters were rinsed with distilled water before and after each measurement.

TABLE 3-4.
GROUNDWATER SAMPLE ANALYSIS PLAN IMPLEMENTED
FOR IRP PHASE II STAGE 1 McENTIRE ANG BASE

SAIC/JRB Sample No.	Air Force Sample No.	TOX[1]	TOC[2]	Oil & Grease	VOA[3]	Metals[4]
GW1-1	GN-85-0019	X	X	X	X	
GW1-2	GN-85-0020	X	X	X	X	
GW1-3	GN-85-0021	X	X	X	X	
GW1-4	GN-85-0022	X	X	X	X	
GW2-1	GN-85-0010	X	X	X	X	X
GW2-2	GN-85-0011	X	X	X	X	X
GW2-3	GN-85-0012	X	X	X	X	X
GW2-4	GN-85-0013	X	X	X	X	X
GW2-5	GN-85-0014	X	X	X	X	X
GW3-1	GN-85-0031	X	X	X		
GW3-2	GN-85-0032	X	X	X		
GW3-3	GN-85-0033	X	X	X		
GW3-4	GN-85-0034	X	X	X		
GW4-1	GN-85-0027	X	X	X		
GW4-2	GN-85-0028	X	X	X		
GW4-3	GN-85-0029	X	X	X		
GW4-4	GN-85-0030	X	X	X		
GW5-1	GN-85-0005	X	X	X		
GW5-2	GN-85-0006	X	X	X		
GW5-3	GN-85-0009	X	X	X		
GW6-1	GN-85-0015	X	X	X		X
GW6-2	GN-85-0016	X	X	X		X
GW6-3	GN-85-0017	X	X	X		X.
W-1	GP-85-0018				X	

[1]TOX - Total Organic Halogens

[2]TOC - Total Organic Carbon

[3]VOA - Volatile Organics Analysis - EPA Method 601-602

[4]As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn.

TABLE 3-5. SAMPLE PRESERVATION AND STORAGE

Media	Parameter	Container	Preservative*	Special Instruction
Aqueous	TOX[1]	2-125 ml. amber glass with teflon septa cap	None	No air space
	TOC[2]	125 ml. plastic	HNO_3 (0.5 mls)	Fill 90% full
	O&G[3]	750 ml. glass	H_2SO_4 (2 mls)	Fill 90-95% full
	VOC[4]	40 ml. glass with teflon septa cap	None	No air space
	Metals[5]	1000 ml. plastic	HNO_3 (4 mls)	Fill 90% full
Soil/ Sediments	TOX[1]	125 ml. widemouth glass	None	Fill container a full as possible
	O&G[3]	750 ml. glass	None	Fill container a full as possible
	VOC[4]	40 ml. glass with teflon septa cap	None	Fill container a full as possible
	Metals[5]	1000 ml. widemouth plastic	None	Fill container as full as possible
	Nitrates	125 ml. widemouth plastic	None	Fill container as full as possible
	Phosphorous (total)	125 ml. widemouth plastic	None	Fill containers as full as possible

* All samples cooled to 4°C.

1 TOX - Total Organic Halogens.

2 TOC - Total Organic Carbon.

3 O&G - Oil & Grease by IR.

4 VOC - Volatile Organic Compounds, Analysis by EPA methods 601-602 (water), 846/8010-8020 (soil/sed.).

5 Metals - As, Cd, Dr, Cu, Pb, Hg, Ni, Se, Ag, Zn.

Each sample collected during the sampling phase of the field program was recorded on a chain-of-custody form (Appendix I), which was placed in the coolers containing the samples, for tracking purposes. The coolers were then shipped via overnight carrier to the respective laboratories to ensure delivery of the samples within 24 hours of sample collection.

3.2.2.2 Surface Water, Sediment, and Soil Sampling

Surface water samples were obtained from Cedar Creek. Soil/sediment samples were obtained from Site Nos. 1, 3, 4, 5, 6, Cedar Creek, and a tributary drainage swale to Cedar Creek (see Figures 3-1 through 3-8). Tables 3-6 and 3-7 list the sampling points and the analytes to be tested for at each sampling point. Each sample bottle was prelabeled and contained the appropriate preservative for the analyte to be tested (Table 3-5). Handling, packaging, and transporting procedures were the same as previously described for groundwater sampling. Field measurements for temperature, pH, and conductivity were also obtained for water samples.

Surface water quality samples for Cedar Creek were obtained using grab sampling techniques (USGS, 1977). In this method, sample bottles are used to directly collect samples from the surface water body. Sample bottles were filled with water by holding the container below the surface of the body of water. Cedar Creek water levels were low at the time of sampling, consequently samples were taken at the deepest locations. When obtaining samples in this manner, care was taken not to disturb the bottom sediments and incorporate them into the water sample. Typically this was achieved by sampling the furthest downstream point first and working upstream. When wading into the stream was necessary, samples were collected upstream from the disturbance made during wading.

Sediment and soil samples were collected with a stainless steel hand trowel. The upper four to six inches of soil or sediment at each sampling point was collected and placed directly into sample containers. If vegetation was present at a designated sampling point it was removed prior to sampling. Cobbles and debris were also removed from the sample prior to placing into the

TABLE 3-6.
SURFACE WATER SAMPLE ANALYSIS PLAN IMPLEMENTED
FOR IRP PHASE II, STAGE 1, McENTIRE ANG BASE

SAIC/JRB Sample Identification No.	Air Force Sample Identification No.	TOX[1]	TOC[2]	Oil & Grease	VOA[3]	Metals[4]
SW2-1	GN-85-0054	X	X	X	X	X
SW2-2	GN-85-0052	X	X	X	X	X
SW2-5	GN-85-0049	X	X	X	X	X
SW2-6	GN-85-0057	X	X	X	X	X

[1] TOX - Total Organic Halogens

[2] TOC - Total Organic Carbon

[3] VOA - Volatile Organic Analysis (EPA Method 601-602)

[4] As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn.

TABLE 3-7. SOIL/SEDIMENT SAMPLE ANALYSIS PLAN IMPLEMENTED FOR IRP PHASE II, STAGE 1, McENTIRE ANG BASE

SAIC/JRB Sample Identification No.	Air Force Sample Identification No.	TOX[1]	Oil & Grease	VOA[2]	Metals[3]	Nitrate Nitrogen	Phosphorous (Total)
SD1-1	GS-85-0036	X	X	X			
SD1-2	GS-85-0037	X	X	X			
SD1-3	GS-85-0038	X	X	X			
SD1-4	GS-85-0039	X	X	X			
SD2-1	GS-85-0055	X	X	X	X		
SD2-2	GS-85-0053	X	X	X	X		
SD2-3	GS-85-0056	X	X	X	X		
SD2-4	GS-85-0051	X	X	X	X		
SD2-5	GS-85-0050	X	X	X	X		
SD2-6	GS-85-0058	X	X	X	X		
SD3-1	GS-85-0046	X	X				
SD3-2	GS-85-0047	X	X				
SD3-3	GS-85-0048	X	X				
SD4-1	GS-85-0001	X	X				
SD4-2	GS-85-0002	X	X				
SD4-3	GS-85-0003	X	X				
SD4-4	GS-85-0004	X	X				
SD5-1	GS-85-0023	X	X				
SD5-2	GS-85-0024	X	X				
SD5-3	GS-85-0025	X	X				
SD5-4	GS-85-0026	X	X				
SD6-1	GS-85-0035	X	X	X			
SD7-1	GS-85-0040	X	X			X	X
SD7-2	GS-85-0041	X	X			X	X
SD7-3	GS-85-0042	X	X			X	X
SD7-4	GS-85-0043	X	X			X	X
SD7-5	GS-85-0044	X	X			X	X
SD7-6	GS-85-0045	X	X			X	X

[1] TOX - Total Organic Halogens

[2] VOA - Volatile Organics Analysis (EPA Method 946/8010-8020)

[3] As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn.

sample container. The trowel was decontaminated with an Alconox/ distilled water solution and rinsed with distilled water before and after collecting each sample.

A soil boring was performed at Site No. 4 (Oil Dump Site) with a CME-550 Drill Rig equipped with 6-inch OD, 3 1/2-inch ID augers. One sample (SD4-1) was collected from the upper four to six inches of soil at the boring location with a stainless steel hand trowel. Three additional samples (SD4-2, 3, and 4) were obtained at 5 foot depth intervals, to a total depth of 15 feet, with a 3-inch diameter split spoon sampler. The samples obtained were removed from the split spoon with a stainless steel hand trowel and placed directly into prelabeled sample containers. The sample containers were wrapped in packaging material, placed in coolers containing blue ice, and shipped according to the procedures previously outlined. The hand trowel and split spoon were washed with an Alconox/distilled water solution and rinsed with distilled water before and after each use. A boring log which provides a description of each sample is provided in Appendix E.

3.2.2.3 Resampling for Second Column Confirmation

Following the completion of sampling and sample analysis, OEHL requested that analysis for volatile organic compounds [EPA methods 601-602 (water); 846/8010-8020 (soil/sediment)] include second column confirmation. The original DOW for the Phase II Stage 1 Field Evaluation for McEntire ANG Base was then modified by OEHL to require second column confirmation for volatile organic compound analysis (see Appendix C). On September 11 and 12, 1985, the sampling locations requiring analysis for volatile organic compounds were resampled and laboratory analysis was performed to include second column confirmation. At the direction of OEHL, the analytical results for volatile organic compounds obtained from the initial round of sampling were not evaluated and are not included as part of this study.

3.2.2.4 Field Quality Assurance/Quality Control

To ensure the quality and integrity of the samples, numerous Quality Assurance/Quality Control (QA/QC) procedures were implemented in the field. These procedures are summarized below:

- Cleaning all equipment used in drilling and sampling before and after use by washing with a laboratory grade solution and rinsing clean with distilled water. This procedure was used to ensure that contaminants were not transferred between monitoring points (USEPA, 1977).
- Maintenance of chain-of-custody forms for all samples. Copies of these forms are included in Appendix I.
- Collection of the following QA samples (Table 3-8) for each day of sampling:
  - One field blank collected prior to the start of sampling. This sample consisted of pouring distilled water into the sample containers and carrying these samples while collecting media samples in the field. Field blanks are utilized to evaluate the field sampling procedure.
  - One bailer wash was collected early in the day. This sample consisted of distilled water poured through the bailer and into the sample containers immediately after the bailer had been decontaminated. Bailer washes are utilized during groundwater sampling to verify the effectiveness of the decontamination procedure.
  - One replicate each day at a pre-selected monitoring point. These samples were collected at the same time and in the same manner as the normal laboratory sample. The results of the duplicate analysis are used to evaluate the reproducibility of laboratory results.

3.2.3 Aquifer Testing

In situ hydraulic conductivities were determined for two downgradient wells at each study site using a bail-down test method described by Hvorslev (1951) in Freeze and Cherry (1979).

The test, as performed, was accomplished by rapidly withdrawing a known volume of water from the well for the purpose of changing the head level. The rate of recovery was monitored by measuring head level rise over time. The test was completed when the head level approached the initial level which existed prior to the withdrawal of water. Semi-logarithmic plots were then

TABLE 3-8. FIELD QA/QC SAMPLE ANALYSIS PLAN IMPLEMENTED FOR IRP PHASE II, STAGE 1, McENTIRE ANG BASE

SAIC/JRB Sample Identification No.	TOX[1]	TOC[2]	Oil & Grease	VOA[3]	Metals[4]	Nitrate Nitrogen	Phosphorous (Total)
FB-1	X	X	X		X		
BW-1	X	X	X		X		
FB-2	X	X	X		X		
BW-2	X	X	X		X		
FB-3	X	X	X		X		
BW-3	X	X	X		X		
FB-4	X	X	X				
BW-4	X	X	X				
FB-5	X		X			X	X
FB-6	X	X	X		X		
FB-7				X			
BW-7				X			
FB-8				X			
GW1-1D				X			
GW3-4D	X	X	X				
GW6-2D	X	X	X		X		
SW2-1D				X			
SW2-6D	X	X	X		X		
SD1-1D				X			
SD1-2D	X		X				
SD2-6D	X		X		X		
SD3-1D	X		X				
WS-1	X	X	X	X	X		

[1]TOX: Total Organic Halogen.

[2]TOC: Total Organic Carbon.

[3]VOA: Volatile Organics Analysis by EPA Methods 601-602 (water), 846/8010-3020 (soil/sediment).

[4]As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn.

FB = Field Blank.

BW = Bailer Wash.

D = Duplicate sample.

constructed to show head change (log scale) versus time (linear scale). By reading pre-determined intercepts from these plots, an estimate of hydraulic conductivity was then calculated. Appendix F contains a detailed description of this method, and the results of field testing.

The tests at McEntire ANG Base were performed using an 18 feet by 1.25 inch I.D. PVC bailer. The bailer, when filled, contained 1.17 gallons. When placed within a 2-inch I.D. well, this amount of water instantaneously withdrawn results in a negative head change of 7.12 feet. The rise in head following the removal of water was measured with a Keck electronic water level indicator (Model WLI-82) which was attached to a tape measure. The rise in head was recorded at measured intervals, and the time (in seconds) noted. The results of the test are contained within Appendix F. Aquifer testing was not performed after all initial groundwater quality sampling had been completed. This ensured the collection of representative groundwater quality samples. All equipment used during testing was washed with an Alconox/distilled water solution and rinsed with distilled water before and after testing at each well.

4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

In order to determine whether environmental contamination has occurred as the result of past waste management activities at McEntire ANG Base and to define the nature, magnitude, and extent of contamination that may have an adverse impact on public health or the environment, samples of groundwater, surface water, soil, and sediment were obtained for analysis from seven waste site areas, Cedar Creek, and a base water supply well. Samples were analyzed for total organic carbon (TOC), total organic halogens (TOX), volatile organic halogens, volatile aromatic compounds, arsenic and trace metals, oil and grease, pH, temperature and conductivity. A listing of detection limits as defined by the level of concern is presented in the SOW (Appendix C). This section summarizes the analytical results for the sampling program implemented (Section 3.0) and discusses the significance of the findings.

4.1 QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The field sampling and laboratory analyses were conducted using standard procedures for ensuring the quality of the analytical data. A variety of Quality Assurance/Quality Control (QA/QC) procedures were implemented including analysis of duplicate samples, matrix spikes, field blanks, bailer washes and the drilling water source. The laboratory analytical results of these QC checks on the McEntire ANG Base field activities are presented and discussed in this section.

4.1.1 Laboratory Duplicates and Matrix Spikes

The QC results for laboratory duplicate and matrix spike analysis are presented in Appendix H. The duplicate analysis consisted of samples split by the laboratory, their analysis and relative differences between the split samples, which indicate the precision of the analytical instruments. The matrix analysis, with spike amounts and recoveries indicates the accuracy of the analytical method.

4.1.2 Field Blanks, Bailer Washes and Duplicate Samples

Analysis of field blanks and bailer washes provides a QC check on the effectiveness of QA efforts during field sampling and sample transport. Field blanks consisted of commercially available distilled water poured directly into sample containers. These were then handled and transported in the same manner as the normal samples. The field blanks were analyzed to determine if samples had been contaminated during collection in the field or shipment to the laboratory.

Bailer washes consist of distilled water that has been poured into the decontaminated bailer and then into sample containers. Analysis of bailer washes enables one to verify whether bailer decontamination procedures were adequate and have prevented cross-contamination of samples between wells. Duplicate analysis consists of double sampling at one or more points, and serve as a check for the precision of the combined sampling and analytical procedure.

As shown in Table 4-1, levels of organic contaminants in all field blanks and bailer washes [including oil and grease, and total organic carbon (TOC)] were low or undetected. Low levels of organic chloride compounds (0.02 mg/l) were found in field blanks FB-2 and FB-5. Only two purgeable organic compounds tetrachloroethylene and 1,1,2,2-tetrachloroethane were detected at low levels (0.08 to 0.14 ug/l range) in field blanks FB-7, FB-8 and in bailer wash BW-8. Note that these two compounds co-eluted and it was not possible to resolve at the low levels observed whether one or both compounds were present in a given sample. No methylene chloride, organic bromine or iodine compounds were detected in any samples (detection limits 0.01 mg/l for the organic halogens, and 0.001 mg/l for the purgeable compounds). TOC was also undetected in all samples (detection limit 2 mg/l). Concentrations of oil and grease were less than 1.0 mg/l in all field blanks and bailer washes.

Inorganic contaminants such as arsenic and trace metals were either not detected or measured at very low levels (i.e., below Federal drinking water standards). Only field blank FB-5 was analyzed for nitrate and phosphorus,

TABLE 4-1. ANALYTICAL RESULTS FIELD BLANKS AND BAILER WASHES

Parameter*	FB-1 05-07-85	BW-1 05-07-85	FB-2 05-08-85	BW-2 05-08-85	FB-3 05-09-85	BW-3 05-09-85	FB-6 05-14-85
Total Organic Halogens:							
Organic Chloride	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Organic Bromide	ND	ND	ND	ND	ND	ND	ND
Organic Iodide	ND	ND	ND	ND	ND	ND	ND
Total Organic Carbon:	ND	ND	ND	ND	ND	ND	4
Oil & Grease by IR:	<1	<1	<1	<1	<1	<1	<1
Metals:							
Arsenic	0.004	ND	<0.001	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND
Chromium	<0.05	<0.05	<0.05	<0.05	ND	<0.05	<0.05
Copper	ND	ND	ND	ND	ND	ND	ND
Lead	ND	ND	ND	ND	ND	ND	<0.02
Mercury	0.0002	<0.0002	0.0002	0.0004	<0.0002	<0.0002	<0.0002
Nickel	ND	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Selenium	0.003	<0.001	0.001	<0.001	0.001	<0.001	<0.001
Silver	ND	ND	ND	<0.02	ND	ND	ND
Zinc	<0.02	<0.02	<0.02	ND	<0.02	ND	<0.02

*Units are mg/l.
< = Positive result but at unquantifiable concentration below indicated level.
FB = Field Blank.
BW = Bailer Wash.
ND = Not detected.

TABLE 4-1. ANALYTICAL RESULTS FIELD BLANKS AND BAILER WASHES (Continued)

Parameter*	FB-4 05-10-85	BW-4 05-10-85	FB-5 05-13-85	FB-7 09-11-85	FB-8 09-12-85	BW-8 09-12-85
Total Organic Halogens:						
Organic Chloride	<0.01	0.02	0.02	--	--	--
Organic Bromide	ND	ND	ND	--	--	--
Organic Iodide	ND	ND	ND	--	--	--
Total Organic Carbon:	ND	ND	--	--	--	--
Oil & Grease by IR:	<1	<1	<1	--	--	--
Nitrate Nitrogen:	--	--	0.02	--	--	--
Phosphorous (Total):	--	--	0.34	--	--	--
Purgeable Aromatics:	--	--	--	ND	ND	ND
Purgeable Halocarbons:						
Tetrachloroethane, 1,1,2,2	--	--	--	UR(0.14)	UR(0.12)	UR(0.08)
Tetrachloroethylene	--	--	--	UR(0.14)	UR(0.12)	UR(0.08)

*Units are ug/l for volatile organic compounds, and mg/l for all others. Volatile organic analysis by EPA method 601-602. Only those compounds for which results were at or above detection limits are listed. See Appendix G for complete listing of analytes.
< = Positive result but at unquantifiable concentration below indicated level.
-- = Not analyzed for.
ND = Not detected.
FB = Field Blank.
BW = Bailer Wash.
UR = Unresolved

with reported levels at 0.02 and 0.34 mg/l respectively. Since the level of nitrate in the blank is just above the EPA method detection limit (0.01 mg/kg) and well below the lowest level of nitrate found in any sample (1.6 mg/kg in sample SD7-5), the blank value is quite acceptable. The blank value for total phosphorus is well below the lowest sample value found (99 mg/kg), and is therefore considered acceptable.

QC analytical results for field duplicates are presented in Table 4-2. Overall, the results indicate good agreement between the duplicate samples.

4.1.3 Drilling Water Source

All drilling equipment that came into contact with potentially contaminated soil/sediments or water during well installation was decontaminated by steam cleaning with a low residue laboratory grade detergent (Alconox) followed by rinsing. Equipment was washed before drilling the first well and after drilling each consecutive well. SAIC follows this procedure in order to prevent cross-contamination between wells.

The wash water used for this decontamination procedure was drawn from a fire hydrant located along Mississippi Road near building no. 225. Samples of water from this hydrant (WS-1) were evaluated for levels of contamination as part of the study's QC effort. As shown in Table 4-3, levels of detected inorganic contaminants were below Federal drinking water standards (see Table 4-4). A number of purgeable halocarbons were identified however: chloroform (1.3 ug/l); bromodichloromethane (0.94 ug/l); co-elution/w-occurence of dibromochloromethane, trichloroethane, and cis-1,3-dichloropropene (unresolved at 0.61 ug/l); bromoform (0.22 ug/l); and co-elution/co-occurence of tetrachloroethylene and 1,1,2,2-tetrachloroethane (unresolved at 1.5 ug/l).

Despite the observation of these contaminants in the drilling water source, it is considered unlikely that water from the hydrant used for equipment decontamination would be a source of contamination of water and soil samples. The observed levels of contaminants in water from the hydrant would tend to decrease with use of the water in decontamination operations. In use

TABLE 4-2. ANALYTICAL RESULTS FOR SAMPLE DUPLICATES

Parameter	Groundwater (mg/l)				Surface Water (mg/l)	
	MW3-4 05-10-85	MW3-4D 05-10-85	MW6-2 05-08-85	MW6-2D 05-08-85	SW2-6 05-14-85	SW2-6D 05-14-85
Total Organic Halogens:						
Organic Chloride	<0.01	0.03	0.01	0.05	<0.01	<0.01
Organic Bromide	ND	ND	ND	ND	ND	ND
Organic Iodide	<0.01	ND	0.01	ND	ND	<0.01
Total Organic Carbon:	4	6	2	ND	6	4
Oil & Grease by IR:	<1	<1	<1	<1	<1	<1
Metals:						
Arsenic	--	--	0.004	0.002	ND	ND
Cadmium	--	--	ND	ND	<0.01	ND
Chromium	--	--	<0.05	<0.05	ND	<0.05
Copper	--	--	0.02	0.02	ND	ND
Lead	--	--	0.05	<0.05	<0.05	<0.05
Mercury	--	--	0.0002	0.0003	<0.0002	ND
Nickel	--	--	<0.05	ND	<0.05	<0.05
Selenium	--	--	<0.001	<0.001	<0.001	<0.001
Silver	--	--	<0.02	<0.02	ND	<0.02
Zinc	--	--	<0.02	0.04	<0.02	<0.02

< = Positive result but at unquantifiable concentration below indicated level.
-- = Not analyzed for.
ND = Not detected.

TABLE 4-2. ANALYTICAL RESULTS FOR SAMPLE DUPLICATES (Continued)

Parameter	Soil/Sediment (mg/kg)					
	SD1-2 05-13-85	SD1-2D 05-13-85	SD2-6 05-14-85	SD2-6D 05-14-85	SD3-1 05-13-85	SD3-1D 05-13-85
Total Organic Halogens:						
Organic Chloride	<1.0	<1.0	<1.0	<1.0	2.3	1.7
Organic Bromide	<0.1	<0.1	<0.1	<0.1	0.86	0.44
Organic Iodide	<0.05	<0.05	0.06	<0.05	0.07	<0.05
Oil & Grease by IR:	2.9	3.1	2.2	2.0	10	450
Metals:						
Arsenic	--	--	<0.25	ND	--	--
Cadmium	--	--	<2	<2	--	--
Chromium	--	--	<4	<4	--	--
Copper	--	--	<4	<4	--	--
Lead	--	--	<10	<10	--	--
Mercury	--	--	ND	ND	--	--
Nickel	--	--	<10	<10	--	--
Selenium	--	--	<0.25	<0.25	--	--
Silver	--	--	ND	ND	--	--
Zinc	--	--	<4	6	--	--

< = Positive result but at unquantifiable concentration below indicated level.
-- = Not analyzed for.
ND = Not detected.

TABLE 4-2. ANALYTICAL RESULTS FOR SAMPLE DUPLICATES (Continued)

Parameter	Groundwater (ug/l)		Surface Water (ug/l)		Soil(ug/kg)	
	MW1-1 09-12-85	MW1-1D 09-12-85	SW2-1 09-12-85	SW2-1D 09-12-85	SD1-1 09-11-85	SD1-1D 09-11-85
Purgeable Aromatics:						
Benzene	ND	ND	ND	ND	23 [2.7]	45 [1.2]
Toluene	ND	ND	ND	ND	15 [6.0]	30 [0.84]
Purgeable Halocarbons:						
Dibromochloromethane	ND	UR(0.08)	ND	ND	ND	ND
Trichloroethane, 1,1,2-	ND	UR(0.08)	ND	ND	ND	ND
Cis-1,3-Dichloropropene	ND	UR(0.08)	ND	ND	ND	ND
Tetrachloroethane 1,1,2,2	ND	UR(0.03)	UR(0.66)	UR(0.28)	ND	ND
Tetrachloroethylene	ND	UR(0.03)	UR(0.66)	UR(0.28)	ND	ND

*Analysis by EPA methods 601-602 (water), 846/8010-8020 (soil). Only those compounds for which results were at or above detection limits are listed. See Appendix G for complete listing of analytes.
[ ] = Second column confirmation result.
UR = Unresolved at level indicated.
ND = Not detected.

TABLE 4-3. ANALYTICAL RESULTS FOR DRILLING WATER SOURCE

Parameter	WS-1 05-08-84	WS-1 09-12-85
Total Organic Halogens (mg/l):		
Organic Chloride	<0.01	--
Organic Bromide	ND	--
Organic Iodide	ND	--
Total Organic Carbon (mg/l):	ND	--
Oil & Grease by IR (mg/l):	<1	--
Metals:		
Arsenic	ND	--
Cadmium	ND	--
Chromium	<0.05	--
Copper	ND	--
Lead	ND	--
Mercury	<0.0002	--
Nickel	ND	--
Selenium	<0.001	--
Silver	ND	--
Zinc	<0.02	--
*Purgeable Aromatics (ug/l):	--	ND
*Purgeable Holocarbons (ug/l):		
Chloroform	--	1.3
Bromodichloromethane	--	0.94
Dibromochloromethane	--	UR(0.61)
Trichloroethane	--	UR(0.61)
Cis-1,3-Dichloropropene	--	UR(0.61)
Bromoform	--	0.22
Tetrachloroethane, 1,1,2,2-	--	UR(1.5)
Tetrachloroethylene	--	UR(1.5)
Field Parameters:		
Temperature (°C)	22.2	--
pH (std. units)	6.43	--
Conductivity (umhos/cm)	73.0	--

*Analysis by EPA Method 601-602. Only those compounds for which results were at or above detection limits are listed. See Appendix G for complete listing of analytes.
UR = Unresolved at level indicated.
< = Positive result but at unquantifiable concentration below indicated level.
-- = Not analyzed for.
ND = Not detected.

of the steam for cleaning equipment, much of the volatile organic compounds would be removed by air stripping. The small fraction of any residual organic which might remain on the equipment afterwards would be removed through additional volatilization during equipment transport to well sites and/or physically removed during well development.

Overall, the analytical results for the QA/QC program, both for field and laboratory work, are within normal acceptable limits for conducting environmental sampling.

4.2 EVALUATION OF THE RESULTS OF SAMPLING AND ANALYSIS

This section presents a discussion and interpretation of the analytical results as reported by the laboratory. Background levels and levels of contaminants reported in field blanks have not been subtracted from these results at the request of the Air Force. Where these values are important to site-specific discussions, however, they are considered.

The evaluation of results at McEntire ANG Base is accomplished by a series of assessments:

- Examination of QA/QC data (as described in Section 4.1);
- Comparison with background levels;
- Comparison with appropriate Federal Criteria and standards; and
- Examination of trends in observed site concentrations (e.g., upgradient vs. downgradient wells

As noted previously, samples obtained at McEntire ANG Base were analyzed for total organic carbon (TOC), total organic halogens (TOX), volatile organic halogens, volatile aromatic compounds, arsenic and trace metals, and oil and grease. Field measurements of temperature, pH and conductivity were also obtained for aqueous samples. Note that the TOC, TOX and oil and grease analyses are not compound-specific and provide data on the total level of a given class of compounds. These analyses are conducted for screening and preliminary assessment of a site, and provide only general estimates of

concentrations of contaminants. Lacking specific concentrations of individual compounds, this information has only limited use in evaluating human health risks associated with a given disposal site.

4.2.1 Identification of Background Contaminant Levels

Background contaminant levels are reported concentrations observed in environmental media in the absence of identified sources of contamination. SAIC contacted the South Carolina Department of Health and Environmental Control (SCDHEC), the U.S. Geological Survey, the State Geological Survey, and the South Carolina Water Resources Commission (SCWRC) to obtain background groundwater quality information on the region in which McEntire ANG Base is located. SAIC learned that a report is presently being prepared by the SCWRC in which will be characterized the quality, depth, and direction of movement of groundwater in the area of McEntire ANG Base. This report has not yet been published, however, and no similar reports are currently available. However, in order to obtain groundwater quality data for inclusion in their report, the SCWRC sampled the base water supply well W-1. A summary of the groundwater chemistry observed for well W-1 on 5/17/83, as reported by SCWRC in HMTC (1984) is as follows:

pH = 5.6	Magnesium (total) = 0.45 mg/l
Chloride = 3.64 mg/l	Potasium (total) = 0.27 mg/l
Fluoride = 0.02 mg/l	Silica (dissolved) = 5.56 mg/l
Sulfate = 2.89 mg/l	Silicon (dissolved) = 2.60 mg/l
Calcium (total) = 0.92 mg/l	Sodium (total) = 3.9 mg/l
Iron (total) = 219 ug/l	Specific Conductance = 25 umhos/cm

These data provide at least some background against which to compare analytical water quality information at McEntire ANG Base.

In addition to this analytical data, the following were estimated as background concentrations:

- Oil and Grease = 1 mg/l (water)
  10 mg/l (soil sediment)
- Total organic halogens = 0.02 mg/l
- Volatile organic compounds = 0.01 mg/l.

Background levels for oil and grease and total organic halogens were established based on the past experience and judgment in similar circumstances, of SAIC senior staff. The background concentration of volatile organic compounds in groundwater was established using data from the EPA Office of Drinking Water. In 1982, EPA conducted a survey of 466 randomly selected sites (Ground Water Supply Survey) for 29 non-trihalomethane volatile organic contaminants (Sec 49 FR Number 114, Tuesday, June 12, 1984). Ninety-seven percent of the ground water supplies monitored had levels of volatile organic contaminant less than 10 ug/l. (Approximately 79% of the systems had levels below quantitation limits. None had measured levels above 100 ug/l). Thus 10 ug/l can be supported as an estimated background level.

4.2.2 Identification of Federal Criteria and Standards for Evaluation of Analytical Data

Table 4-4 summarizes Federal human health criteria, standards, and guidelines used in the assessment of compounds detected during the Stage 1 effort at McEntire ANG Base. Groundwater levels are most appropriately evaluated using EPA Drinking Water Standards-Maximum Contaminant Limits (MCLs). If MCLs are not available, EPA Carcinogen Assessment Group (CAG) Cancer Risk Estimates for contaminants in drinking water are used for evaluating the significance of potentially carcinogenic compounds in groundwater. Recommended maximum contaminant levels (RMCLs) and Safe Drinking Water Act Health Advisories are used in the absence of MCLs for evaluating non-carcinogenic compounds in groundwater. In the absence of other guidelines, the Clean Water Act Ambient Water Quality Control (AWQC) may be used as an approximate indicator of contaminant levels of concern in groundwater.

The Clean Water Act (AWQC) are most appropriately used in evaluating concentrations of contaminants in surface water. However, if the surface water is clearly used as a drinking water source, comparison of a drinking water standard (i.e., MCL) to tap water concentrations should take precedence over comparison of surface water concentrations with AWQC. No published criteria or standards are currently available for compounds in sediments or soil.

TABLE 4-4. FEDERAL HUMAN HEALTH CRITERIA, STANDARDS AND GUIDELINES

Chemical	Applicable or Relevant Requirements: Safe Drinking Water Act, MCLs (mg/L unless otherwise noted)	Applicable or Relevant Requirements: Safe Drinking Water Act RMCLs[a] (mg/L)	Other Criteria, Advisories, and Guidelines: Clean Water Act, Water Quality Criteria for Human Health--Fish and Drinking Water	Other Criteria, Advisories, and Guidelines: Cancer Risk Estimates[b] For Volatile Organic Compounds (ug/L) CAG	Other Criteria, Advisories, and Guidelines: Safe Drinking Water Act, Health Advisories (mg/L) 1-day	10-day	Chronic (weeks or months)
Arsenic	0.05		0 (2.2 ng/L)[d]				
Benzene		0	0 (0.66 ug/L)	0.67		0.23	0.07
Cadmium	0.01		10 ug/L				
Carbon Tetrachloride		0	0 (0.4 ug/L)	0.27	0.2	0.02	
Chlorinated Ethanes						Insufficient data	
1,2-Dichloroethane		0	0 (0.94 ug/L)	0.5			
1,1,1-Trichloroethane		0.2	18.4 mg/L	21.7			1.07
1,1,2-Trichloroethane			0 (0.6 ug/L)				
1,1,2,2-Tetrachloroethane			0 (0.17 ug/L)				
1,1-Dichloroethane			Insufficient data				
Chloroform	0.1[c]		0 (0.19 ug/L)				
Chromium Cr+6	0.05		50 ug/L				
Cr+3			170 mg/L				
Copper			1 mg/L (organoleptic)[e]				
Dichloroethylene, 1,2-		0	Insufficient data		2.7	0.27	
Dichloromethane			See Halomethanes		13	1.3	0.15
Dichloropenes			87 ug/L				
Ethylbenzene			1.4 mg/L				
Halomethanes			0 (0.19 ug/L)				
Lead	0.05		50 ug/L				
Mercury	0.002		144 ng/L				
Nickel			13.4 ug/L[f]				
Nitrate (as N)	10.0		10.0 mg/L				
Selenium	0.01		10 ug/L				
Silver	0.05		50 ug/L				
Tetrachloroethylene		0	0 (0.8 ug/L)	1.0	2.3	0.175	0.02
Trichloroethylene		0	0 (2.7 ug/L)	18	2.02	0.2	0.075
Trihalomethanes (total)[c]	0.1				21.5	2.2	0.34
Toluene			14.3 mg/L				
Zinc			5 mg/L (organoleptic)[e]				

[a] Recommended Maximum Contaminant Levels (RMCLs) are non-enforceable health goals or levels of exposure proposed by the EPA Office of Drinking Water. RMCLs are exposure levels that would result in no known or anticipated health effects, and which incorporate an adequate margin of safety. RMCLs are an initial stage in rulemaking for the establishment of primary (enforceable) drinking water standards (MCLs). RMCLs for nine volatile (purgeable) synthetic organic chemicals were proposed by EPA June 12, 1984 (49 FR, Number 114, 24330-24355).

[b] Projected upper limit lifetime cancer risk estimates for volatile organic compounds (Source: 49 FR, Number 114, 24340). Risk estimates developed by the EPA Carcinogen Assessment Group (CAG). Values noted are concentrations in drinking water associated with a cancer risk level of 10^{-6}.

[c] Criteria designated as organoleptic are based on taste and odor effects, not toxicological effects. Human health-based ambient water quality criteria are not available for these chemicals.

[d] Concentrations in parenthesis are ambient water quality criteria for carcinogens. These are estimates associated with consumption of contaminated fish and drinking water, corresponding to risk levels of 10^{-6}.

[e] Chloroform is one of four trihalomethanes whose sum concentration must be less than 0.1 mg/L. Total trihalomethanes refers to the sum concentration of chloroform, bromodichloromethane, dibromochloromethane, and bromoform.

[f] [illegible]

4.3 SITE-SPECIFIC RESULTS AND FINDINGS

In this section an evaluation is presented of the results of sampling and analysis at McEntire ANG Base. For each site and environmental medium sampled, the significance of observed chemical constituent levels is considered with regard to potential impacts on human health.

4.3.1 Site No. 1: No. 5 Fire Training Area

Site No. 1 has been used since 1970 for fire training procedures. During these activities, waste oil, solvent, JP-4, brake and transmission fluids, paint thinners and strippers, hydraulic fluid and other combustible materials were disposed. Analytical results for Site No. 1 are summarized in Table 4-5. Location of sampling sites are shown in Figure 4-1.

The results of soil sampling can be summarized as follows:

- o Elevated levels of oil and grease were observed
- o Benzene and toluene were detected at elevated levels of 23 and 15 ug/kg respectively
- o Levels of all organic halogens were less than 1.0 mg/kg in all samples
- o No purgeable halocarbons were detected.

The low levels of TOX and the detection of benzene and toluene suggest that contamination in soils of Site No. 1 is related to the presence of petroleum products (e.g., JP-4).

The results of groundwater sampling are as follows:

- o No detectable levels of oil and grease or purgeable aromatics were observed in groundwater.
- o Several purgeable halocarbons were identified: carbon tetrachloride; dibromochloropropane, 1,1,2-trichloroethane, and/or cis-1,3-dichloropropene (co-elution/co-occurrence); 1,1,2,2-tetrachloroethane and/or tetrachloroethylene (co-elution/co-occurence).

TABLE 4-5. ANALYTICAL RESULTS FOR SITE NO. 1: NO. 5 FIRE TRAINING AREA

Parameter	Groundwater (mg/l)				Soil (mg/kg)			
	MW1-1 05-08-85	MW1-2 05-08-85	MW1-3 05-08-85	MW1-4 05-08-85	SD1-1 05-13-85	SD1-2 05-13-85	SD1-3 05-13-85	SD1-4 05-13-85
Total Organic Halogens:								
Organic Chloride	<0.01	0.01	0.01	<0.01	<1.0	<1.0	<1.0	<1.0
Organic Bromide	ND	ND	ND	ND	0.50	<0.1	<0.1	<0.1
Organic Iodide	ND	ND	ND	ND	<0.50	<0.05	<0.05	<0.05
Total Organic Carbon:	ND	ND	ND	2	--	--	--	--
Oil & Grease by IR:	<1	<1	<1	<1	460	2.9	2.7	25
Field Parameters:								
Temperature (°C)	19.2	19.1	18.8	19.3	--	--	--	--
pH (std. units)	6.21	4.83	4.67	5.55	--	--	--	--
Conductivity (umhos/cm)	60	25	32.5	40	--	--	--	--

-- = Not analyzed for.
ND = Not detected.
< = Positive result but at unquantifiable concentration below indicated level.

TABLE 4-5. ANALYTICAL RESULTS FOR SITE NO. 1: NO. 5 FIRE TRAINING AREA (Continued)

Parameter*	Groundwater (ug/l)				Soil (ug/kg)			
	MW1-1 05-08-85	MW1-2 05-08-85	MW1-3 05-08-85	MW1-4 05-08-85	SD1-1 05-13-85	SD1-2 05-13-85	SD1-3 05-13-85	SD1-4 05-13-85
Purgeable Aromatics:								
Benzene	ND	ND	ND	ND	23 [2.7]	ND	ND	ND
Toluene	ND	ND	ND	ND	15 [6.0]	ND	ND	ND
Purgeable Halocarbons:								
Carbon tetrachloride	ND	ND	ND	0.98	ND	ND	ND	ND
Dibromochloromethane	ND	UR(0.03)	ND	ND	ND	ND	ND	ND
Trichloroethane,1,1,2-	ND	UR(0.03)	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	ND	UR(0.03)	ND	ND	ND	ND	ND	ND
Tetrachloroethane,1,1,2,2	ND	UR(0.15)	UR(0.09)	UR(0.06)	ND	ND	ND	ND
Tetrachloroethylene	ND	UR(0.15)	UR(0.09)	UR(0.06)	ND	ND	ND	ND

*Analysis by EPA methods 601-602 (water), 846/8010-8020 (soil). Only those compounds for which results were at or above detection limits are listed. See Appendix G for complete listing of analytes.

[ ] = Second column confirmation result.

UR = Unresolved at level indicated.

ND = Not detected.

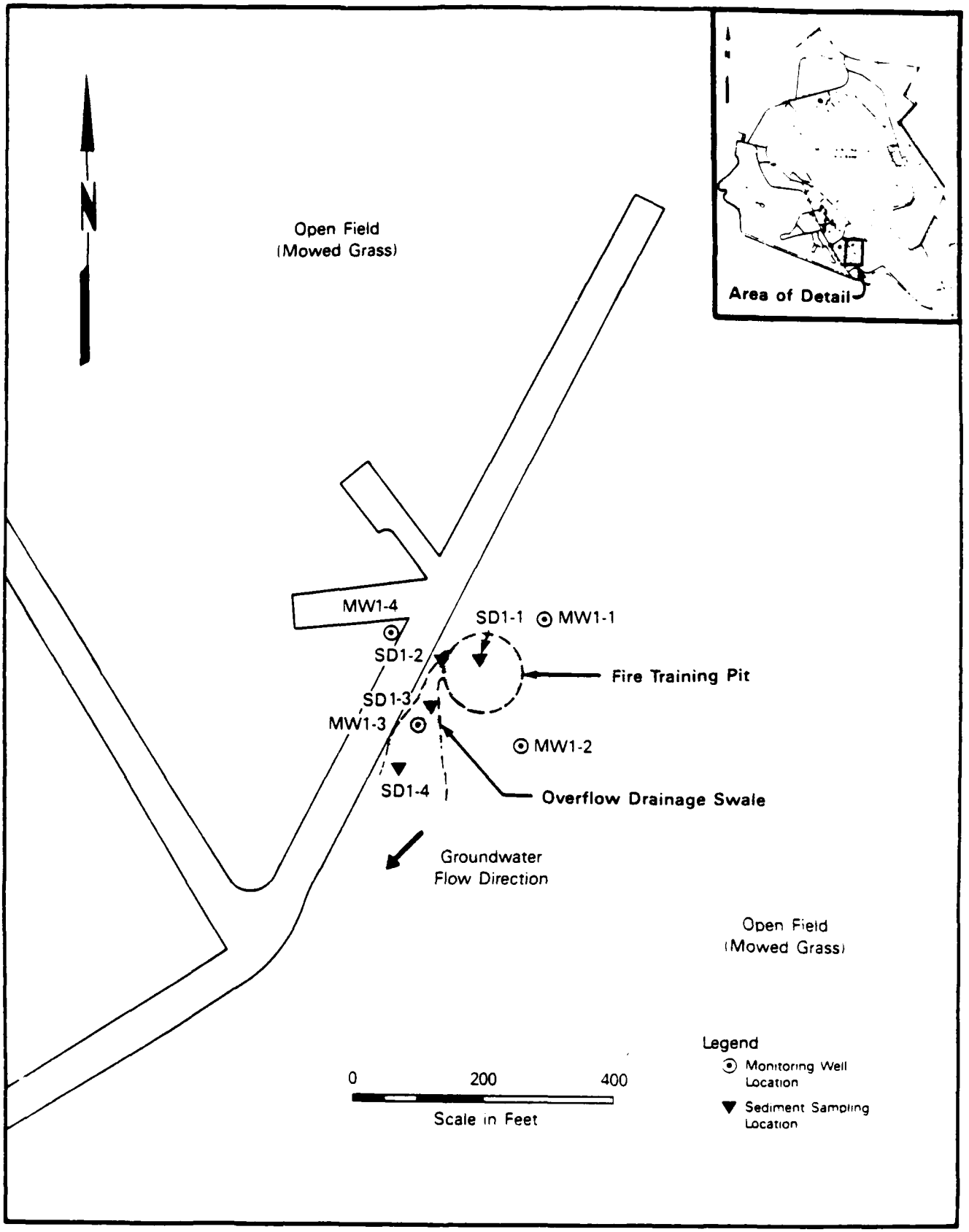


Figure 4-1. Monitoring Well and Sampling Locations; Site No. 1: No. 5 Fire Training Area.

- The observed concentration of carbon tetrachloride in MW1-4 (0.98 ug/l) exceeds the EPA CAG risk estimate of 10^{-6} for exposure to 0.27 ug/l in drinking water.

One plausible explanation for the observed levels of volatile aromatic compounds and volatile halocarbon compounds detected in the sediment sample but absent in groundwater samples could be stratification of the compounds in the aquifer. Volatile organic compounds have differing specific gravities which cause them to sink or float in an aquifer under certain conditions. Although soluble to a sufficient degree to spread throughout the water column by diffusion, they may concentrate within a certain aquifer zone because of specific gravity differences and aquifer heterogeneities. During the Stage 1 sampling effort, groundwater in each well was only sampled from the approximate midpoint of the screened interval. If compound stratification were occuring within the aquifer, only a select group of compounds would have been collected by the sampling method employed.

It is significant to note that MW1-4, the well in which the carbon tetrachloride concentration was significantly elevated, as noted above, does not appear to be directly hydrologically downgradient from the site. As a result, without more definitive data, the observed contaminant cannot be positively linked to the site. Since this compound was not confirmed by second column confirmation, a possibility exists that interferences may be responsible for the level found in MW1-4.

The Stage 1 program results for Site No. 1 do indicate that low levels of contaminants exist in both soil and groundwater, and point to past site activities as the possible contaminant source. The extent to which the contaminants exist within the soil and groundwater at the site is uncertain, and will require additional Phase II, Stage 2 sampling to ascertain.

4.3.2 Site No. 2: No. 1 Fire Training Area and Sanitary Landfill

The No. 1 Fire Training Area was used for disposal of liquid combustibles such as solvents, paint thinners, gasoline, JP-4, etc. The sanitary landfill received domestic refuse, paint thinner and stripper, empty pesticide

containers, demolished structures and other materials. Groundwater samples were taken at Site No. 2. The analytical results are presented in Table 4-6 and the location of the monitoring wells as depicted in Figure 4-2. The key results of these groundwater analyses are as follows:

- Levels of total organic chloride and total organic iodide (0.04 and 0.06 mg/l, respectively) were slightly above the anticipated background level of 0.02 mg/l total organic halogen
- Halogenated organic compounds were detected in groundwater. Observed maximums levels of tetrachloroethylene or 1,1,2,2-tetrachloroethane (these compounds co-eluted/co-occured), 7.0 ug/l (second column confirmation of 1.6 ug/l), exceed the EPA CAG 10^{-6} risk level of 1.0 ug/l (for tetrachloroethylene)
- Concentration of chromium 0.07 mg/l (MW2-1) exceeds the MCL for this metal.
- Oil and grease, while detected in the samples, was present in unquantifiably low concentrations
- No purgeable aromatic compounds were detected

In addition to tetrachloroethylene and 1,1,2,2-tetrachloroethane, a number of other halogenated organic compounds were detected in groundwater and are likely associated with the disposal of solvents at Site No. 2. The following additional compounds were detected:

- Chloromethane (8.0 ug/l, MW2-4);
- Methylene chloride (0.51 ug/l, MW2-4);
- 1,1-dichloroethane (0.52 ug/l, MW2-4);
- Trans-1,2-dichloroethylene (1.5 ug/l, MW2-4);
- Chloroform (0.11 ug/l, MW2-4);
- 1,1,1-trichloroethane (0.62 ug/l, MW2-4);
- Trichloroethylene (0.3, 1.2 and 0.27 ug/l in MW2-1; MW2-4, and MW2-5, respectively;
- Co-elution/co-occurence of dibromochloroemethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene (0.03 ug/l, MW2-4 and MW2-5); and
- Bromoform (1.1 ug/l in GW2-5).

TABLE 4-6. ANALYTICAL RESULTS FOR SITE NO. 2: NO. 1 FIRE TRAINING AREA/SANITARY LANDFILL

Parameter	Groundwater (mg/l)				
	MW2-1 05-07-85	MW2-2 05-07-85	MW2-3 05-07-85	MW2-4 05-07-85	MW2-5 05-07-85
Total Organic Halogens:					
Organic Chloride	0.04	<0.01	<0.01	0.02	<0.01
Organic Bromide	ND	ND	ND	ND	ND
Organic Iodide	ND	ND	0.02	0.06	ND
Total Organic Carbon:	ND	ND	ND	ND	ND
Oil & Grease by IR:	<1	<1	<1	<1	<1
Metals:					
Arsenic	0.002	<0.001	<0.001	0.001	<0.001
Cadmium	ND	ND	ND	ND	ND
Chromium	0.07	ND	<0.05	<0.05	<0.05
Copper	0.03	<0.02	<0.02	<0.02	<0.02
Lead	<0.05	ND	ND	ND	ND
Mercury	0.0011	0.0002	0.0004	0.0003	0.0002
Nickel	<0.05	ND	ND	ND	ND
Selenium	ND	<0.001	<0.001	0.001	<0.001
Silver	<0.02	ND	ND	<0.02	<0.02
Zinc	0.03	<0.02	<0.02	<0.02	<0.02
Field Parameters:					
Temperature (°C)	22.8	23	22	22	20.5
pH (std. units)	5.02	4.91	4.43	4.04	4.43
Conductivity (umhos/cm.)	42	35	59	68	37.5

ND = Not detected.
< = Positive result but at unquantifiable concentration below indicated level.

TABLE 4-6. ANALYTICAL RESULTS FOR SITE NO. 2: NO. 1 FIRE TRAINING AREA/SANITARY LANDFILL (Continued)

Parameter*	Groundwater (ug/l) MW2-1 09-12-85	MW2-2 09-12-85	MW2-3 09-12-85	MW2-4 09-12-85	MW2-5 09-12-85
Purgeable Aromatics:	ND	ND	ND	ND	ND
Purgeable Halocarbons:					
Chloromethane	ND	ND	ND	8.0 [7.0]	ND
Methylene Chloride	ND	ND	ND	0.51	ND
Dichloroethane, 1,1-	ND	ND	ND	0.52	ND
Trans-1,2-Dichloroethylene	ND	ND	ND	1.5	ND
Chloroform	ND	ND	ND	0.11	ND
Trichloroethane,1,1,1-	ND	ND	ND	0.62	ND
Trans-1,3-Dichloropropene	ND	ND	ND	ND [0.9]	ND
Trichloroethylene	0.3	ND	ND	1.2	0.27
Dibromochloromethane	ND	ND	ND	UR(0.03)	UR(0.03
Trichloroethane,1,1,2-	ND	ND	ND	UR(0.03)	UR(0.03)
Cis-1,3-Dichloropropene	ND	ND	ND	UR(0.03)	UR(0.03)
Bromoform	ND	ND	ND	ND	1.1
Tetrachloroethane,1,1,2,2-	UR(0.09)	UR(2.7)	UR(0.14)	UR(3.6) [UR(5.9)]	UR(7.0) [UR(1.6)]
Tetrachloroethylene	UR(0.09)	UR(2.7)	UR(0.14)	UR(3.6) [UR(5.9)]	UR(7.0) [UR(1.6)]

* = Analysis by EPA method 601-602. Only those compounds for which results were at or above detection limits are listed. See Appendix G for complete listing of analytes.
[ ] = Second column confirmation result.
UR = Unresolved at level indicated.
ND = Not detected.

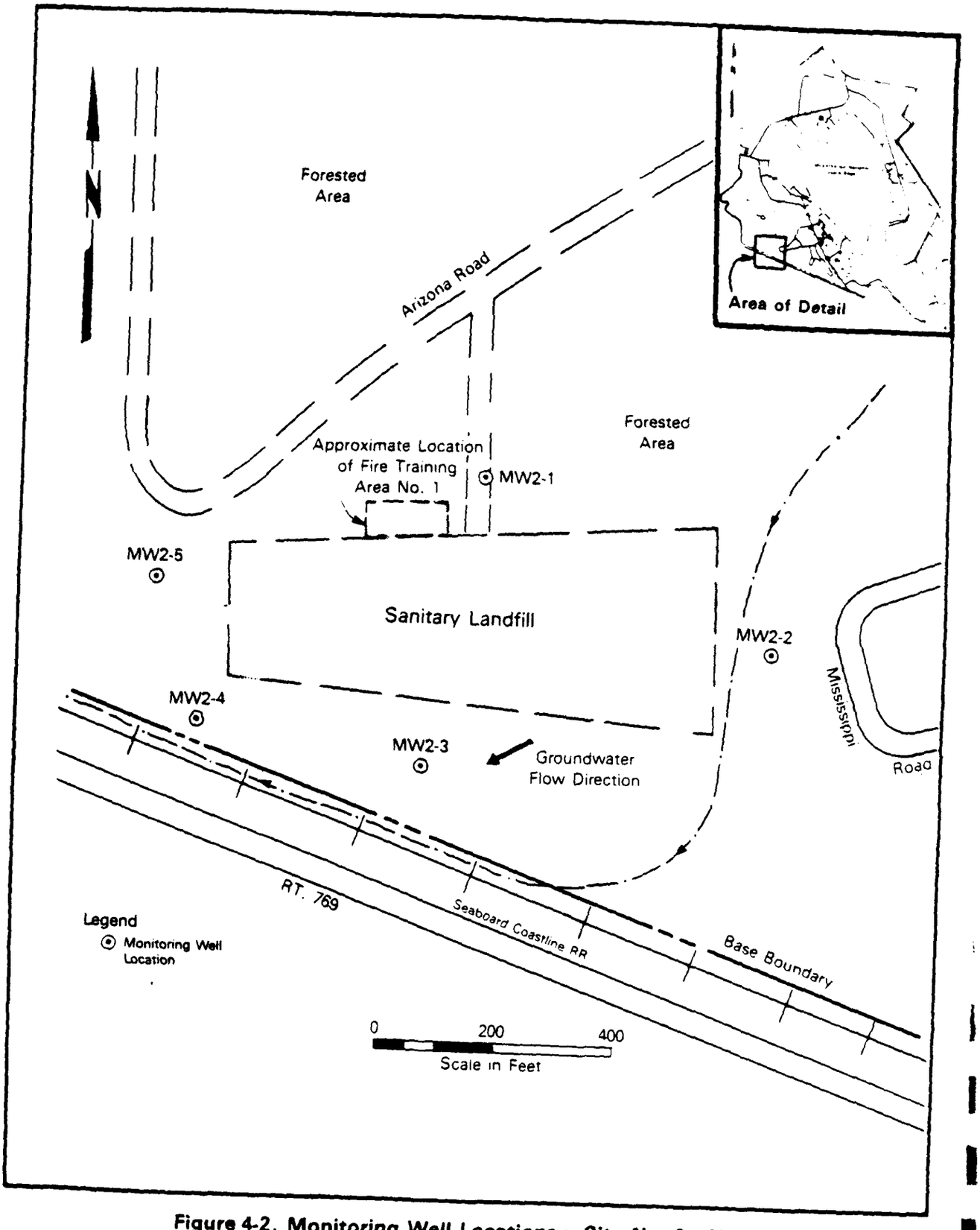


Figure 4-2. Monitoring Well Locations; Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site.

Tetrachloroethylene and 1,1,2,2-tetrachloroethane were detected in the field blank and bailer wash (FB-8 and BW-8 9/12/85) but at levels nearly two orders of magnitude less than the maximum observed concentrations in MW2-5. The observed maximum concentration of 7.0 ug/l is 7 times greater than the exposure level for tetrachloroethylene associated with a cancer risk level of 10^{-6}, although it should be noted that the second column confirmation value was only 1.6 ug/l. Although none of the other purgeable halocarbons individually exceeded the 10^{-6} risk levels, or other National criteria or standards, it is important to recognize the significant of combined exposure to the mixture of contaminants, several of which are potential carcinogens. Other potential carcinogens detected in groundwater at Site No. 2 include 1,1,1-trichloroethane, 1,1,2-trichloroethane, and trichloroethylene. Concentrations of these contaminants correspond to risk levels $\leq 10^{-7}$.

Detection of elevated levels of chromium is at this point somewhat anomalous, since the metal was measured in an upgradient well only. Further sampling and analysis will be required to confirm this Phase II, Stage 1 finding and, if necessary, to evaluate potential sources for this contaminant.

A second anomaly of the Site No. 2 data exists in the fact that low levels of trichloroethylene, 1,1,2,2-tetrachloroethane and tetrachloroethylene (PCE) were also detected in upgradient well sample MW2-1. In addition, the total organic chloride level measured (0.04 mg/l) was in excess of the anticipated background level (0.02 mg/l). The detected presence of the previously mentioned compounds in upgradient well sample MW2-1 cannot be explained with certainty. Because of its close positioning with the approximated location for the No. 1 Fire Training area, the observed results are possibly due to this source.

4.3.3 Site No. 3: Y-Storage Area

Site No. 3 was a storage area from 1947 to 1974 for flammable waste liquids used in fire training procedures. Groundwater and soil samples at the

site were analyzed for TOX, TOC, oil and grease, temperature, pH, and conductivity. The analytical results are presented in Table 4-7, and the monitoring locations are depicted in Figure 4-3. From the available data, groundwater at Site No. 3 does not appear to be contaminated. Analytical results are as follows:

- Levels of total organic chloride in soil ranged from 1.3 to 4.6 mg/kg, and levels of all total organic halogens in soil were well above expected background levels.
- Concentration of total organic chloride in groundwater (0.05 mg/l) were slightly elevated above expected background levels.

Since analysis has not been conducted to date for specific organic contaminants, it is not possible to further evaluate the significance of these observed levels. Results for TOC, oil and grease, temperature, pH and conductivity however, are not indicative of groundwater contamination.

4.3.4 Site No. 4: Oil Dump Site

Site No. 4 is a visible oil patch, 30 x 50 feet, at which liquid wastes were disposed. Soil and groundwater samples were collected at the site. The analytical results are summarized in Table 4-8. Figure 4-4 depicts the monitoring locations. The key results are as follows:

- Soil samples were contaminated with high levels of oil and grease
- Levels of organic chloride in groundwater are above expected background levels.

As shown in Table 4-8, the surface soil sample (SD4-1) contained 8000 mg/kg oil and grease. Analysis of soil samples taken at 5, 10 and 15 feet intervals did indicate some possible migration of the oil and grease downward through the soil column, with oil and grease concentration of 98, 140 and 55 mg/kg at 5, 10 and 15 feet, respectively. It is possible, however, that some or all of this subsurface oil and grease could be attributed to caving of highly contaminated surface soils into the borehole during sample collection. Because analysis was not conducted for specific organic compounds, it is not possible to identify contaminants of concern.

TABLE 4-7. ANALYTICAL RESULTS FOR SITE NO. 3: Y-STORAGE AREA

Parameter	Groundwater (mg/l)				Soil (mg/kg)		
	MW3-1 05-10-85	MW3-2 05-10-85	MW3-3 05-10-85	MW3-4 05-10-85	SD3-1 05-13-85	SD3-2 05-13-85	SD3-3 05-13-85
Total Organic Halogens:							
Organic Chloride	0.05	<0.01	0.05	<0.01	2.3	1.3	4.6
Organic Bromide	ND	ND	ND	ND	0.86	0.14	<0.10
Organic Iodide	ND	ND	ND	<0.01	0.07	0.06	<0.05
Total Organic Carbon:	ND	ND	4	4	--	--	--
Oil & Grease by IR:	<1	<1	<1	<1	10	8.0	4.8
Field Parameters:							
Temperature (°C)	23.2	21.8	21.5	22.7	--	--	--
pH (std. units)	5.05	5.38	4.62	5.22	--	--	--
Conductivity (umhos/cm)	40	55	40	40	--	--	--

-- = Not analyzed for.
ND = Not detected.
< = Positive result but at unquantifiable concentration below indicated level.

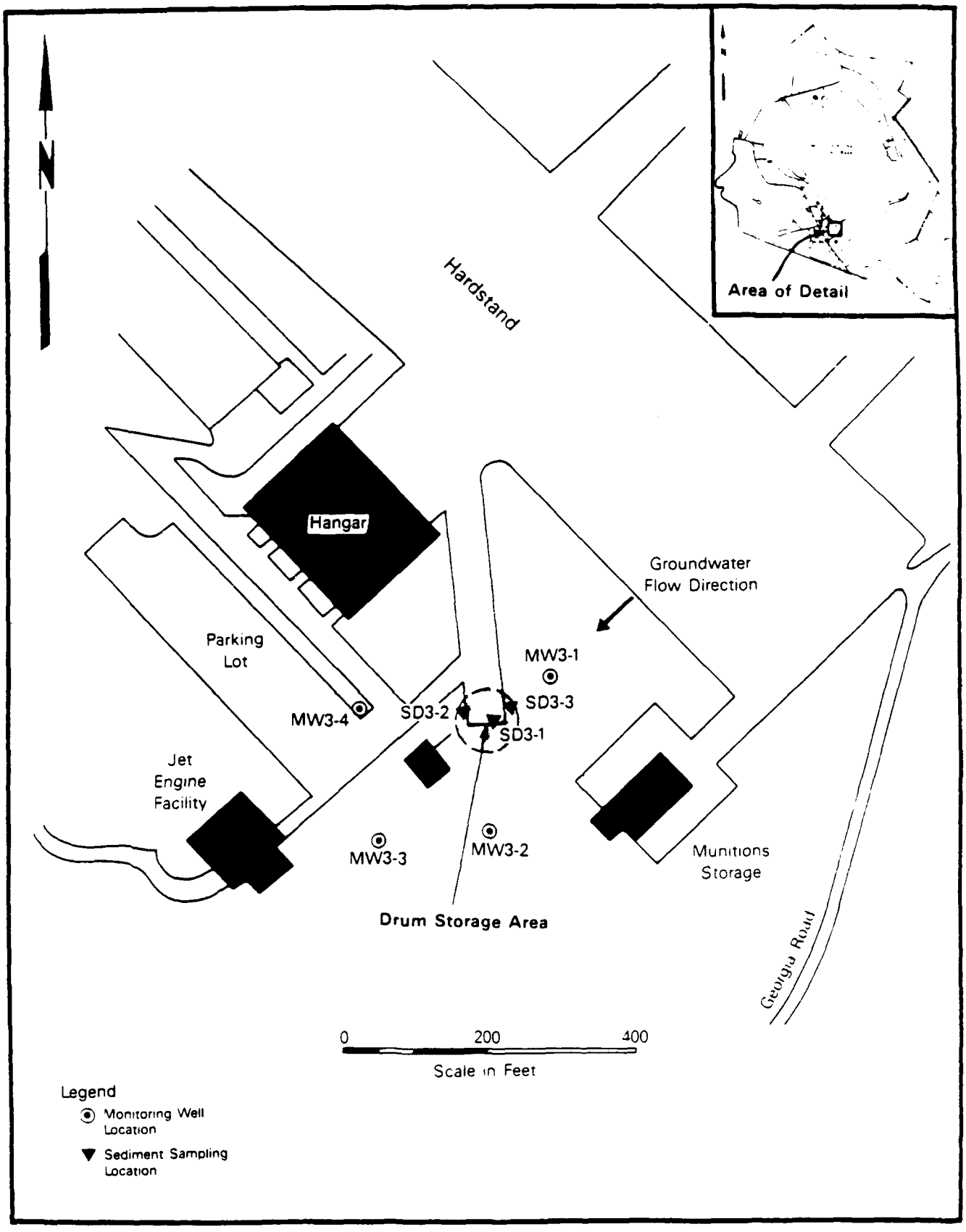


Figure 4-3. Monitoring Well and Sampling Locations; Site No. 3: Y-Storage Area.

TABLE 4-8. ANALYTICAL RESULTS SITE NO. 4: UNOFFICIAL OIL DUMP SITE

Parameter	Groundwater (mg/l)				Soil (mg/kg)			
	MW4-1 05-10-85	MW4-2 05-10-85	MW4-3 05-10-85	MW4-4 05-10-85	SD4-1 04-18-85	SD4-2 04-18-85	SD4-3 04-18-85	SD4-4 04-18-85
Total Organic Halogens:								
Organic Chloride	<0.01	<0.01	0.11	0.05	3.1	<1.0	<1.0	<1.0
Organic Bromide	ND	ND	ND	ND	ND	ND	ND	ND
Organic Iodide	ND	ND	ND	ND	<0.05	<0.05	<0.05	ND
Total Organic Carbon:	2	ND	ND	ND	--	--	--	--
Oil & Grease by IR:	<1	<1	<1	<1	8000	98	140	55
Field Parameters:								
Temperature (°C)	19.9	19.5	19.6	19.5	--	--	--	--
pH (std. units)	5.05	4.78	5.09	10.09	--	--	--	--
Conductivity (umhos/cm)	30	49	30	55	--	--	--	--

-- = Not analyzed for.
ND = Not detected.
< = Positive result but at unquantifiable concentration below indicated level.

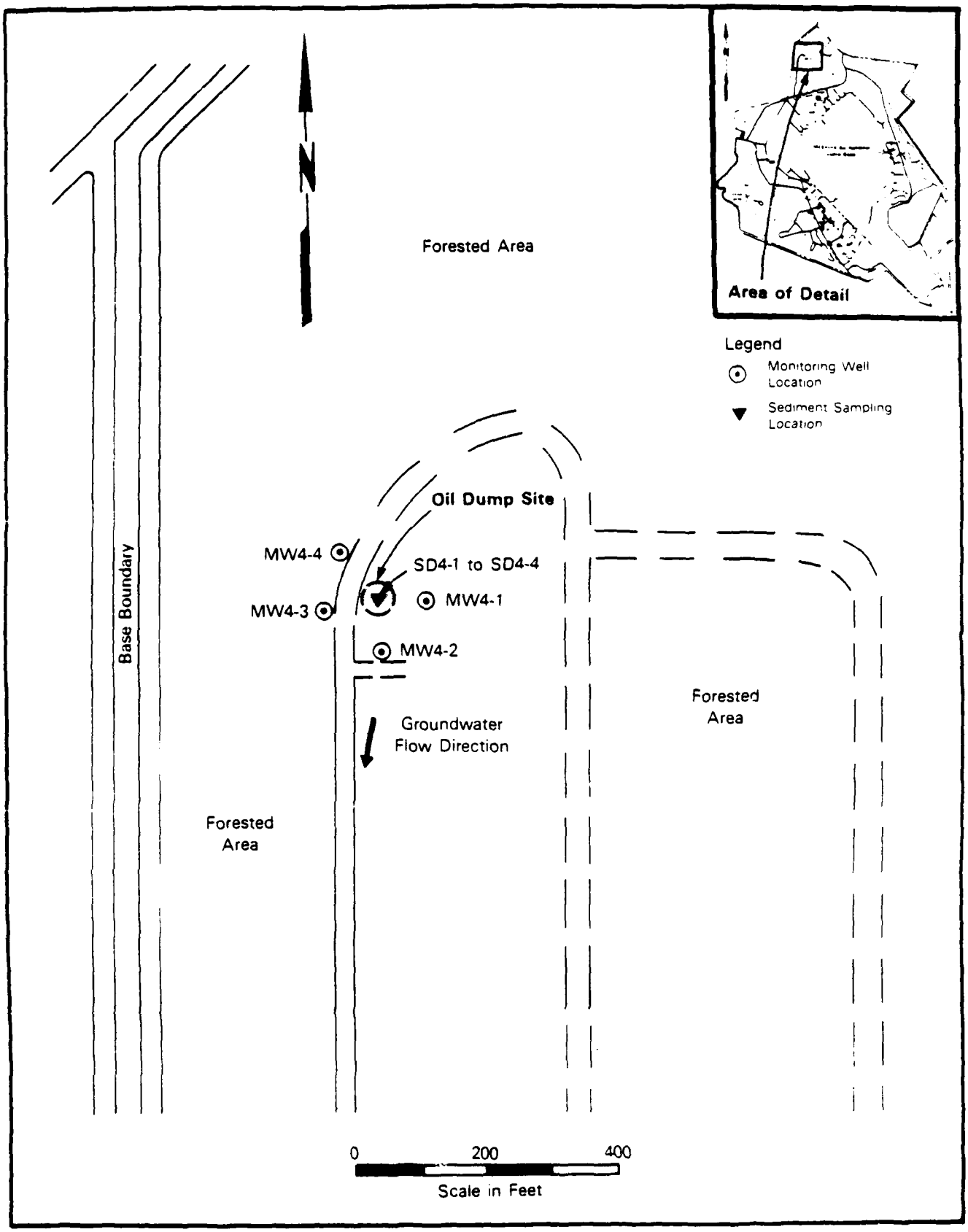


Figure 4-4. Monitoring Well and Sampling Locations; Site No. 4: Oil Dump Site.

The results of groundwater sampling for oil and grease do not indicate that contamination of the aquifer has occurred. Measurements for conductivity, pH and temperature for samples MW4-1, MW4-2, and MW4-3 are not indicative of groundwater contamination. Levels of total organic chloride, however, (0.11 and 0.05 mg/l for samples MW4-3, and MW4-4) are above the expected background level of 0.02 mg/l. Although concentrations of TOX, TOC and oil and grease in MW4-4 do not point to contamination of groundwater, elevated levels of conductivity and pH are suspect. The pH of sample MW4-4 was 10.09, and the conductivity was 155 (3 to 5 times higher than for the other samples). These high values may possibly be attributed to grout contamination during well installation.

4.3.5 Site No. 5: C-141 Spill Trench

In 1982, a large quantity of JP-4 was released from a burning aircraft and transported via a drain pipe into the drainage trench comprising Site No. 5. The majority of the fuel was absorbed or burned off. Sediment and groundwater at Site No. 5 (Figure 4-5) were sampled and analyzed for TOX, TOC, oil and grease and conductivity, pH and temperature. The results are summarized in Table 4-9. As shown, there is no indication of contamination of either sediment or groundwater at this site. It is important to note however, that sediment sample SD2-3 (Figure 4-8 and Table 4-12), obtained directly downstream of the spill trench, was contaminated with ethylbenzene and inorganic contaminants (arsenic and metals). The relationship between these observed levels and activity at Site No. 5 should be examined in greater detail.

4.3.6 Site No. 6: Unofficial Dump Site

Site No. 6 is an unofficial dump site which currently contains waste wood, scrap metal, roofing shingles and empty paint cans. Soil and groundwater samples were analyzed at the site. The analytical results are presented in Table 4-10, and the location of the monitoring wells and soil sampling point are indicated in Figure 4-6. The key results are as follows:

- Oil and grease levels were elevated in soil (170 mg/kg), but no volatile organic contaminants were detected
- Groundwater samples did not exhibit contamination.

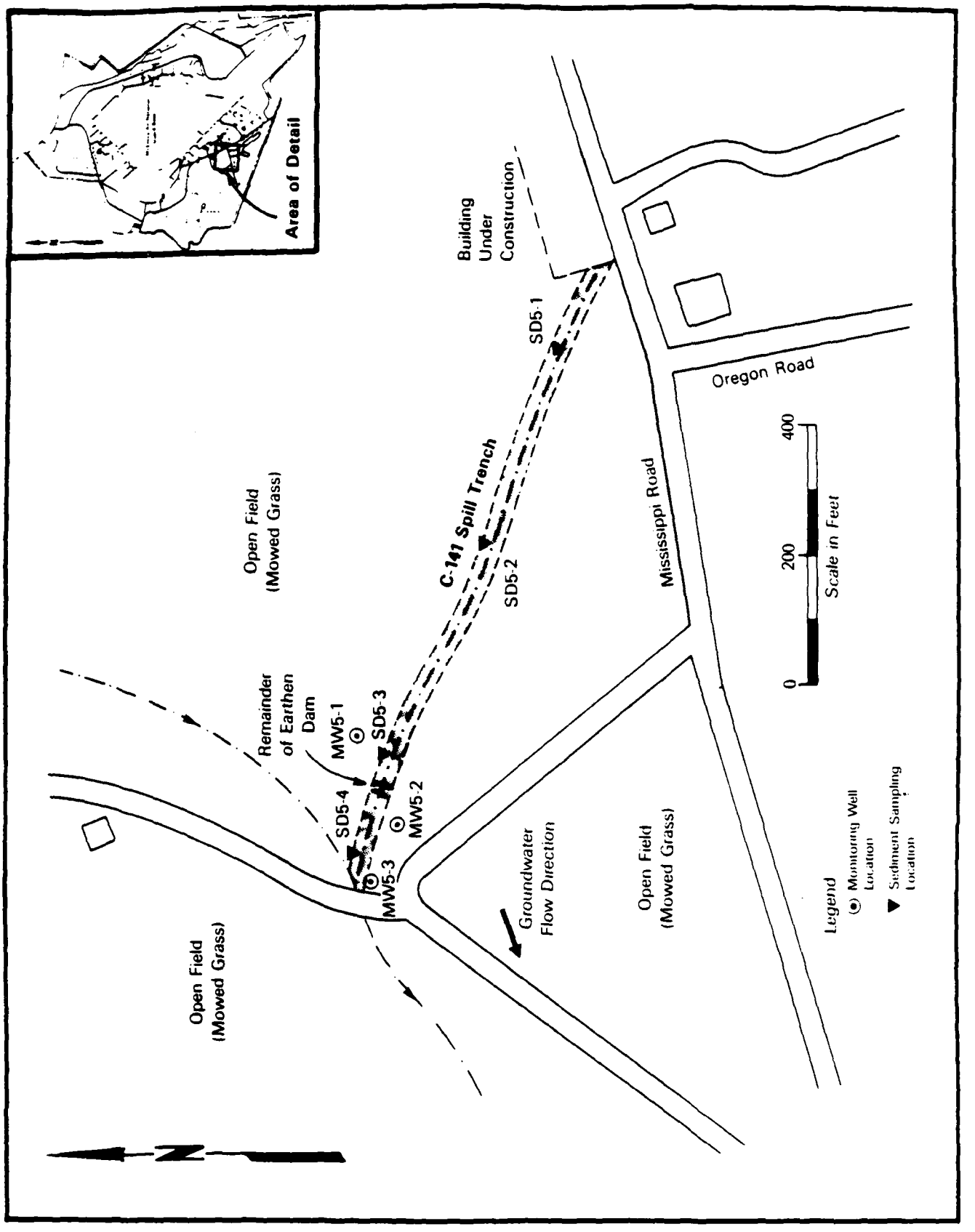


Figure 4-5. Monitoring Well and Sampling Locations; Site No. 5: C-141 Spill Trench.

TABLE 4-9. ANALYTICAL RESULTS FOR SITE NO. 5: C-141 SPILL TRENCH

Parameter	Groundwater (mg/l)			Sediment (mg/kg)			
	MW5-1 05-07-85	MW5-2 05-07-85	MW5-3 05-07-85	SD5-1 05-09-85	SD5-2 05-09-85	SD5-3 05-09-85	SD5-4 05-09-85
Total Organic Halogens:							
Organic Chloride	<0.01	<0.01	<0.01	<1.0	<1.0	<1.0	<1.0
Organic Bromide	ND	ND	ND	ND	ND	ND	ND
Organic Iodide	ND	ND	<0.01	ND	ND	ND	ND
Total Organic Carbon:	3	ND	ND	--	--	--	--
Oil & Grease by IR:	<1	<1	<1	1.5	0.8	<1	<1
Field Parameters:							
Temperature (°C)	23	21.4	22.3	--	--	--	--
pH (std. units)	4.86	6.31	5.36	--	--	--	--
Conductivity (umhos/cm)	25	66	40	--	--	--	--

< = Positive result but at unquantifiable concentration below indicated level.
-- = Not analyzed for.
ND = Not detected.

TABLE 4-10. ANALYTICAL RESULTS FOR SITE NO. 6: UNOFFICIAL DUMP SITE

Parameter	Groundwater (mg/l)			*Soil (mg/kg)
	MW6-1 05-08-85	MW6-2 05-08-85	MW6-3 05-08-85	SD6-1 05-13-85
Total Organic Halogens:				
Organic Chloride	<0.01	<0.01	<0.01	2.6
Organic Bromide	ND	ND	ND	0.32
Organic Iodide	<0.01	<0.01	ND	<0.05
Total Organic Carbon:	ND	2	ND	--
Oil & Grease by IR:	<1	<1	<1	170
Metals:				
Arsenic	<0.001	0.004	ND	--
Cadmium	ND	ND	ND	--
Chromium	<0.05	<0.05	ND	--
Copper	<0.02	0.02	<0.02	--
Lead	ND	<0.05	ND	--
Mercury	0.0003	0.0002	<0.0002	--
Nickel	ND	<0.05	<0.05	--
Selenium	<0.001	<0.001	<0.001	--
Silver	<0.02	<0.02	ND	--
Zinc	<0.02	<0.02	<0.02	--
Field Parameters:				
Temperature (°C)	18.6	17.8	18.5	--
pH (std. units)	5.26	4.88	4.96	--
Conductivity (umhos/cm)	48	20	17	--

*Note: Soil sample SD6-1 also analyzed for Volatile Organic Compounds (EPA method 846 /8010-8020). None were detected.
< = Positive result but at unquantifiable concentration below indicated level.
-- = Not analyzed for.
ND = Not detected.

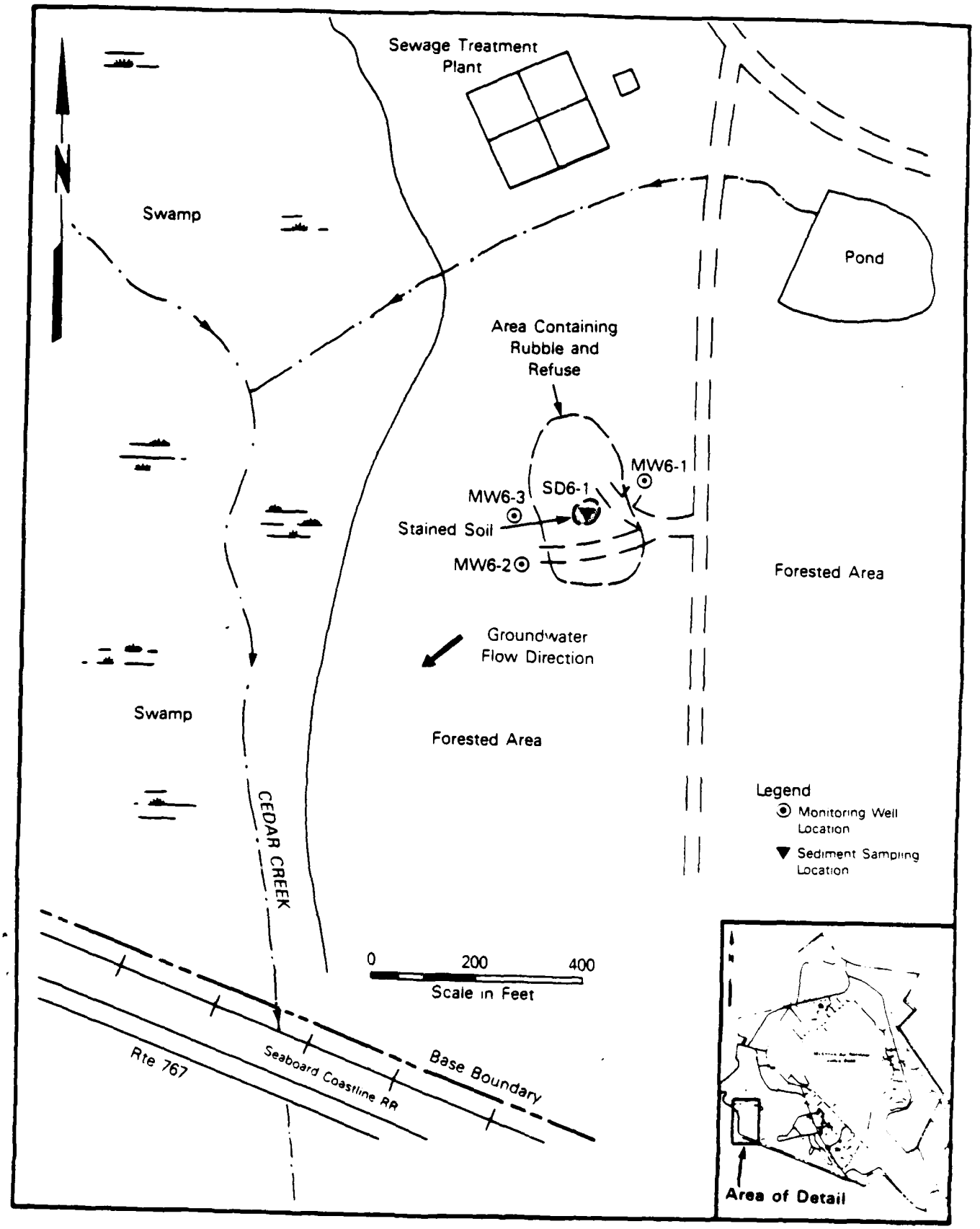


Figure 4-6. Monitoring Well and Sampling Locations; Site No. 6: Unofficial Dump Site.

Paint, tar-like residues, and discolored soils were apparent at the site. The one soil sample taken from the center of Site No. 6 (SD6-1) revealed elevated levels of oil and grease consistent with the visually observed contamination at the surface. No analysis was conducted for TOC in soil. Levels of organic chloride were 2.6 mg/kg but no volatile organic compounds were detected in soil. The results of the groundwater monitoring do not indicate that surface contamination by oil and grease has migrated to groundwater.

Groundwater at Site No. 6 was also monitored for inorganic contaminants. As shown in Table 4-10, none of the measured levels of these compounds are indicative of groundwater contamination. All concentrations of these contaminants are below Federal criteria and standards. Temperature, pH and conductivity are within expected ranges.

4.3.7 Site No. 7: Drainage Pond/Swamp

The drainage pond/swamp comprising Site No. 7 receives drainage from a large portion of McEntire ANG Base as well as discharge water from an off-base commercial fertilizer plant. Samples of sediments from the drainage pond/swamp were obtained and evaluated for levels of contamination. The analytical results are summarized in Table 4-11. Figure 4-7 indicates the monitoring locations. Key results are as follows:

- o Very high levels of phosphorous are observed in sediments
- o Levels of nitrates are elevated
- o Levels of oil and grease were elevated.

Of greatest concern at Site No. 7 are the very high levels of phosphorous in the sediments. Concentrations ranged from 99 to 24,000 mg/kg (sample SD7-6). Highest levels of nitrate (170 mg/kg) were observed in sample SD7-6. The observed phosphorous and nitrate contamination of sediments at Site no. 7 however, does not appear to be associated with activities on base. Looking at the distribution of concentration profile, phosphate contamination is likely to originate off-site.

TABLE 4-11. ANALYTICAL RESULTS FOR SITE NO. 7: DRAINAGE POND/SWAMP

Parameter	Sediment (mg/kg)					
	SD7-1 05-13-85	SD7-2 05-13-85	SD7-3 05-13-85	SD7-4 05-13-85	SD7-5 05-13-85	SD7-6 05-13-85
Total Organic Halogens:						
Organic Chloride	1.0	<1.0	<1.0	<1.0	3.4	2.0
Organic Bromide	<0.1	<0.1	<0.1	<0.1	<0.1	0.26
Organic Iodide	<0.05	<0.05	0.05	<0.05	<0.05	<0.05
Oil & Grease by IR:	110	2.4	8.3	3.0	8.6	21
Nitrate Nitrogen:	ND	19	19	1.6	54	170
Phosphorus (total):	310	99	680	680	4,100	24,000

ND = Not detected.
< = Positive result but at unquantifiable concentration below indicated level.

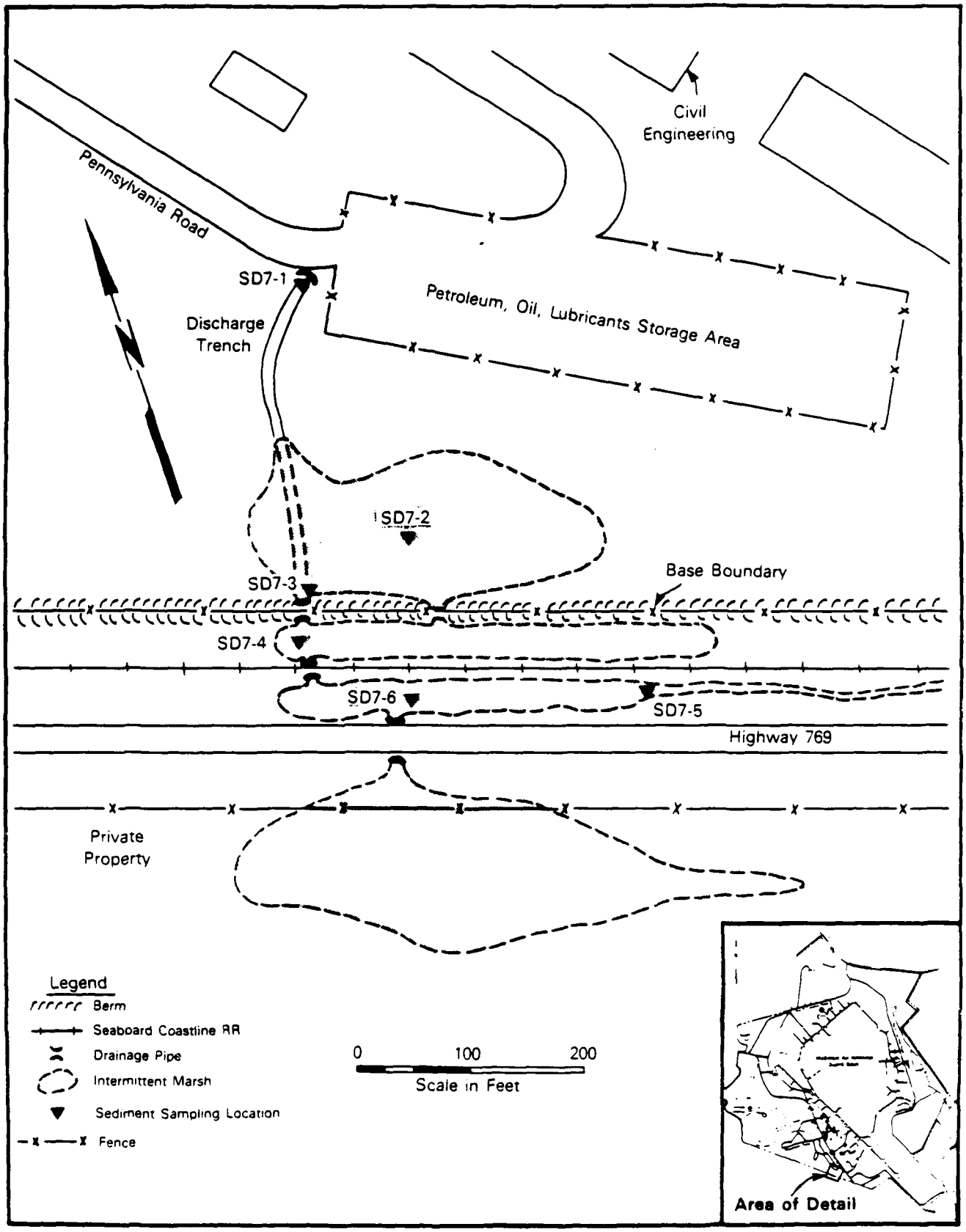


Figure 4-7. Sampling Locations; Site No. 7: Drainage Pond/Swamp Site.

Oil and grease, organic chloride, and organic bromide were also observed in sediments at Site No. 7. Highest levels of total organic chloride were measured in samples SD7-5 and SD7-6; 3.4 and 2.0 mg/kg, respectively. Concentrations of total organic bromide were highest (0.26 mg/kg) in SD7-6. From the available data it appears that the contamination of samples SD7-5 and SD7-6 by organic halogens may be more likely associated with proximity to Highway 76 and the Seaboard Coastline Railroad, than discharge from McEntire ANG Base. This is supported by the lower concentration observed in the samples collected on the base. Levels of oil and grease were elevated in sample SD7-1 (110 mg/kg) and most likely originate from the petroleum, oil, and lubricants (POL) storage area. The reasons for the elevated oil and grease concentration in SD7-6 cannot be pinpointed with the data available.

4.3.8 Cedar Creek and Tributary Drainage Swale

To evaluate the impacts of potential contaminant movement from the various sites identified at McEntire ANG Base on Cedar Creek as it flows through and drains the base area, the study's sampling effort included the creek and a tributary drainage swale. Surface water and sediment samples were obtained from Cedar Creek and a tributary drainage swale, and evaluated for levels of contamination. Four samples were taken on base and two samples off base (one north and one south of McEntire ANG Base boundaries). Figure 4-8 shows the locations of the sampling points, and analytical data are summarized in Table 4-12.

The key results are as follows:

- Tetrachloroethylene and 1,1,2,2-tetrachloroethane were detected in all surface water samples (co-eluted/co-occurrence). The maximum observed concentration (0.66 ug/l) exceeds the 10^{-6} risk level (EPA AWQC) of 0.17 ug/l for 1,1,2,2-tetrachloroethane
- Sediment samples were found to contain arsenic and trace metals.

The maximum observed concentration of tetrachloroethylene and 1,1,2,2-tetrachloroethane (0.66 ug/l SW2-1), is below the exposure concentration (EPA Ambient Water Quality Criterion) associated with a cancer risk level of 10^{-6}

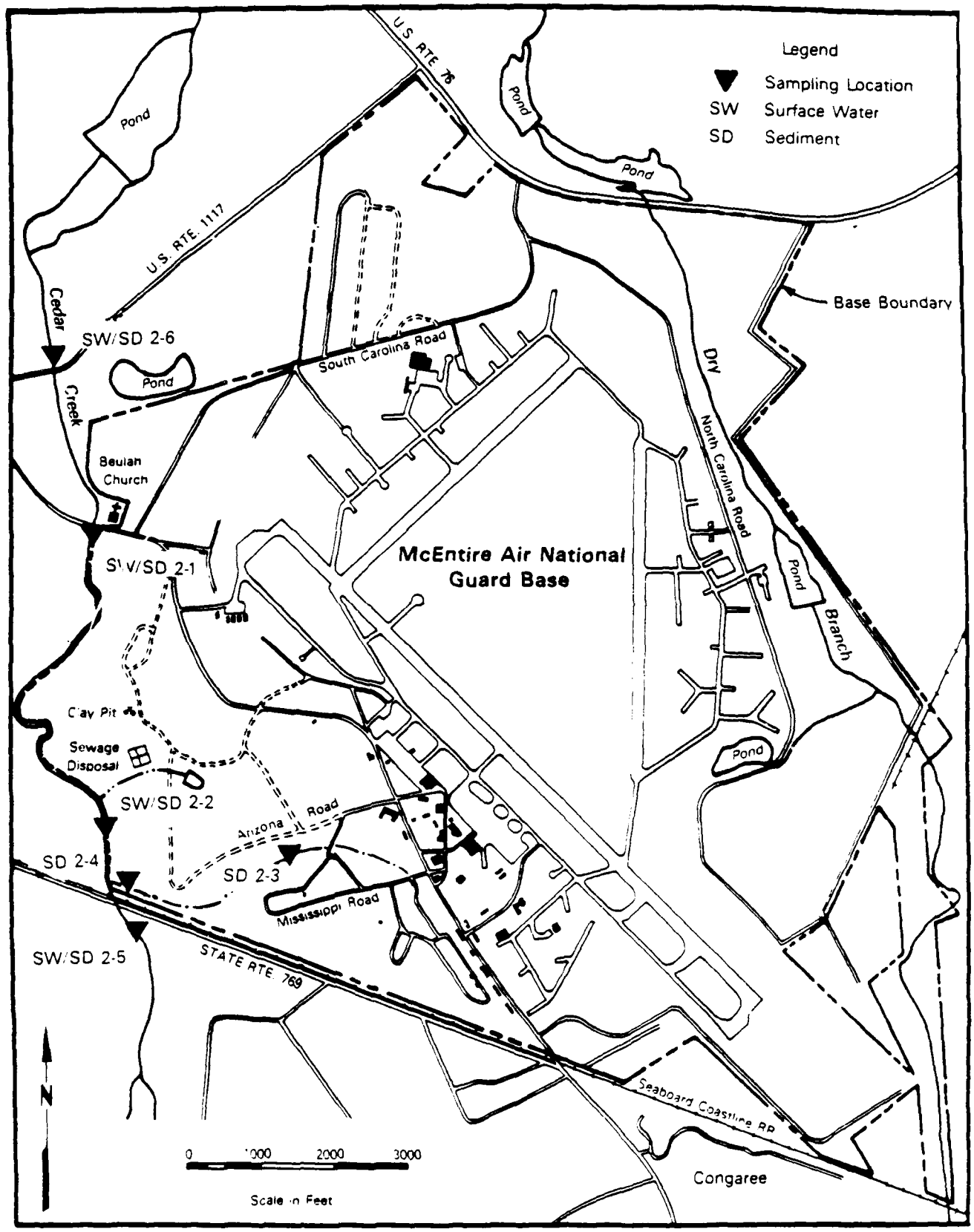


Figure 4-8. Sampling Locations: Cedar Creek and Tributary Drainage Swale.

TABLE 4-12. ANALYTICAL RESULTS FOR CEDAR CREEK AND TRIBUTARY DRAINAGE SWALE

Parameter	Surface Water (mg/l)				Sediment (mg/kg)					
	SW2-1 05-14-85	SW2-2 05-14-85	SW2-5 05-14-85	SW2-6 05-14-85	SD2-1 05-14-85	SD2-2 05-14-85	SD2-3 05-14-85	SD2-4 05-14-85	SD2-5 05-14-85	SD2-6 05-14-85
Total Organic Halogens:										
Organic Chloride	<0.01	0.05	0.03	<0.01	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Organic Bromide	ND	ND	ND	ND	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Organic Iodide	ND	ND	ND	ND	<0.05	<0.05	<0.05	0.1	<0.005	0.06
Total Organic Carbon:	4	5	6	6	--	--	--	--	--	--
Oil & Grease by IR:	<1	<1	<1	<1	3.2	2.5	2.9	2.9	2.8	2.2
Metals:										
Arsenic	ND	ND	ND	ND	<0.25	<0.25	0.79	4	<0.25	<0.25
Cadmium	<0.01	ND	<0.01	<0.01	<2	<2	<2	<2	<2	<2
Chromium	<0.05	ND	<0.05	ND	6	4	31	21	5	<4
Copper	ND	ND	<0.02	ND	<4	<4	8	<18	<4	<4
Lead	ND	<0.05	ND	<0.05	<10	<10	11	19	ND	<10
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Nickel	<0.05	<0.05	ND	<0.05	<10	<10	<10	<10	<10	<10
Selenium	<0.001	0.001	<0.001	<0.001	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Silver	ND	ND	ND	ND	ND	<4	ND	<4	<4	ND
Zinc	ND	0.18	<0.02	<0.02	4	4	30	30	4	<4
Field Parameters:										
Temperature (°C)	24.0	22.8	21.8	24.9	--	--	--	--	--	--
pH (std. units)	6.19	6.30	5.82	6.25	--	--	--	--	--	--
Conductivity (umhos/cm)	27.5	30.0	50.0	30.0	--	--	--	--	--	--

-- = Not analyzed for.
ND = Not detected.
< = Positive result but at unquantifiable concentration below indicated level.

TABLE 4-12. ANALYTICAL RESULTS FOR CEDAR CREEK AND TRIBUTARY DRAINAGE SWALE (Continued)

Parameter	Surface Water (ug/l)				Sediment (ug/kg)					
	SW2-1 09-12-85	SW2-2 09-12-85	SW2-5 09-12-85	SW2-6 09-12-85	SD2-1 09-12-85	SD2-2 09-12-85	SD2-3 09-12-85	SD2-4 09-12-85	SD2-5 09-12-85	SD2-6 09-12-85
Purgeable Aromatics:	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Purgeable Halocarbons:										
Tetrachloroethane, 1,1,2,2-	UR(0.66)	UR(0.09)	UR(0.17)	UR(0.08)	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	UR(0.66)	UR(0.09)	UR(0.17)	UR(0.08)	ND	ND	ND	ND	ND	ND

*Analysis by EPA methods 601-602 (water), 846/8010-8020 (sediment). Only those compounds for which results were at or above detection limits are listed. See Appendix G for complete listing of analytes.

UR = Unresolved at level indicated.

ND = Not detected.

for tetrachloroethylene (0.8 ug/l) but exceeds the 10^{-6} level for 1,1,2,2-tetrachloroethane (0.17 ug/l) by more than 4 times. In addition, levels in sample SW2-5 are equal to the 10^{-6} risk level for 1,1,2,2-tetrachloroethane. Note that the concentration in sample SW2-1 is more than 5 times the levels detected in the field blank (FB-8, 9/12/85). Given the observed levels of contamination by the purgeable halocarbons, surface waters of Cedar Creek should be considered to pose a potential risk to human health. Additional sampling and analysis is also warranted here to determine whether the observed levels of these compounds are emanating from the northwestern corner of the base or from an off-base source. The results of surface water sampling do not indicate contamination by inorganic compounds.

Analysis of sediment samples from Cedar Creek and the drainage swale did not indicate contamination of this substrate by purgeable organic compounds. Only ethylbenzene was detected (single sample, SD2-3) at a concentration of 0.92 ug/kg. Levels of oil and grease ranged from 2.2 to 3.2 mg/kg. Concentration of total organic halogens were 0.1 mg/l or less for all samples. However, metals were observed with the highest concentrations for arsenic, chromium, copper, lead, nickel and zinc. Highest levels of metals were observed in samples SD2-3 and SD2-4. These were obtained downstream from the drainage swale which originates in Site No. 5 and passes through Site No. 2. Site Nos. 5 and 2 are thus implicated as possible sources of metals concentrations in the drainage swale.

From the limited data available, no clear trend is apparent in results of off base versus on-base sampling and analysis, or in upstream versus downstream values.

4.3.9 Base Supply Well

During the Phase IIa presurvey visit to McEntire ANG Base, two water supply production wells (W-1 and W-2) that draw water from underlying deep aquifers were sampled. Results of analysis of the presurvey samples indicated that the groundwater in the vicinity of well number W-1 may be contaminated by organic halogen compounds. Levels of total organic chloride measured were

0.03 and 0.003 mg/l for wells W-1 and W-2, respectively. Because well W-1 is a source of drinking water at the base, it was, at SAIC's suggestion, resampled and analyzed for volatile organic compounds (EPA 601-602). The analytical data are presented in Table 4-13. Locations of the monitoring wells are depicted in Figure 4-9. As the data show, tetrachloroethylene and 1,1,2,2-tetrachloroethane were detected in the well sample (co-eluted/ co-occurrences) at a concentration of 5.1 ug/l. It should be noted that the field blank and bailer wash contained low levels of these compounds (0.12 ug/l and 0.08 ug/l, respectively), as shown in Table 4-1. There is currently no Maximum Contaminant Limit (MCL) for either compound. Both compounds are considered potential carcinogens, however, by both the EPA Office of Drinking Water and Office of Water Regulations and Standards. A projected upper limit excess lifetime cancer risk of 10^{-6} has been estimated for exposure to 1.0 ug/l tetrachloroethylene and 0.17 ug/l 1,1,2,2-trichloroethane in surface water (AWQC).

TABLE 4-13. ANALYTICAL RESULTS FOR BASE SUPPLY WELL W-1

Parameter	W-1 05-07-84	W-1 09-12-85
Total Organic Halogens (mg/l):		
Organic Chloride	0.03	--
Organic Bromide	ND	--
Organic Iodide	0.002	--
Total Organic Carbon (mg/l):	ND	--
Oil & Grease by IR (mg/l):	ND	--
*Purgeable Aromatics (ug/l):	--	ND
*Purgeable Holocarbons (ug/l):		
Chloroform	--	ND
Bromodichloromethane	--	ND
Dibromochloromethane	--	ND
Trichloroethane	--	ND
Cis-1,3-Dichloropropene	--	ND
Bromoform	--	ND
Tetrachloroethane, 1,1,2,2-	--	UR(5.1) [UR(1.3)]
Tetrachloroethylene	--	UR(5.1) [UR(1.3)]
Field Parameters:		
Temperature (°C)	21.0	20.5
pH (std. units)	5.0	4.9
Conductivity (umhos/cm)	26.5	26.0

*Analysis by EPA Method 601-602. Only those compounds for which results were at or above detection limits are listed. See Appendix G for complete listing of analytes.
[] = Second column confirmation result.
UR = Unresolved at level indicated.
ND = Not detected.
- = Not analyzed for.

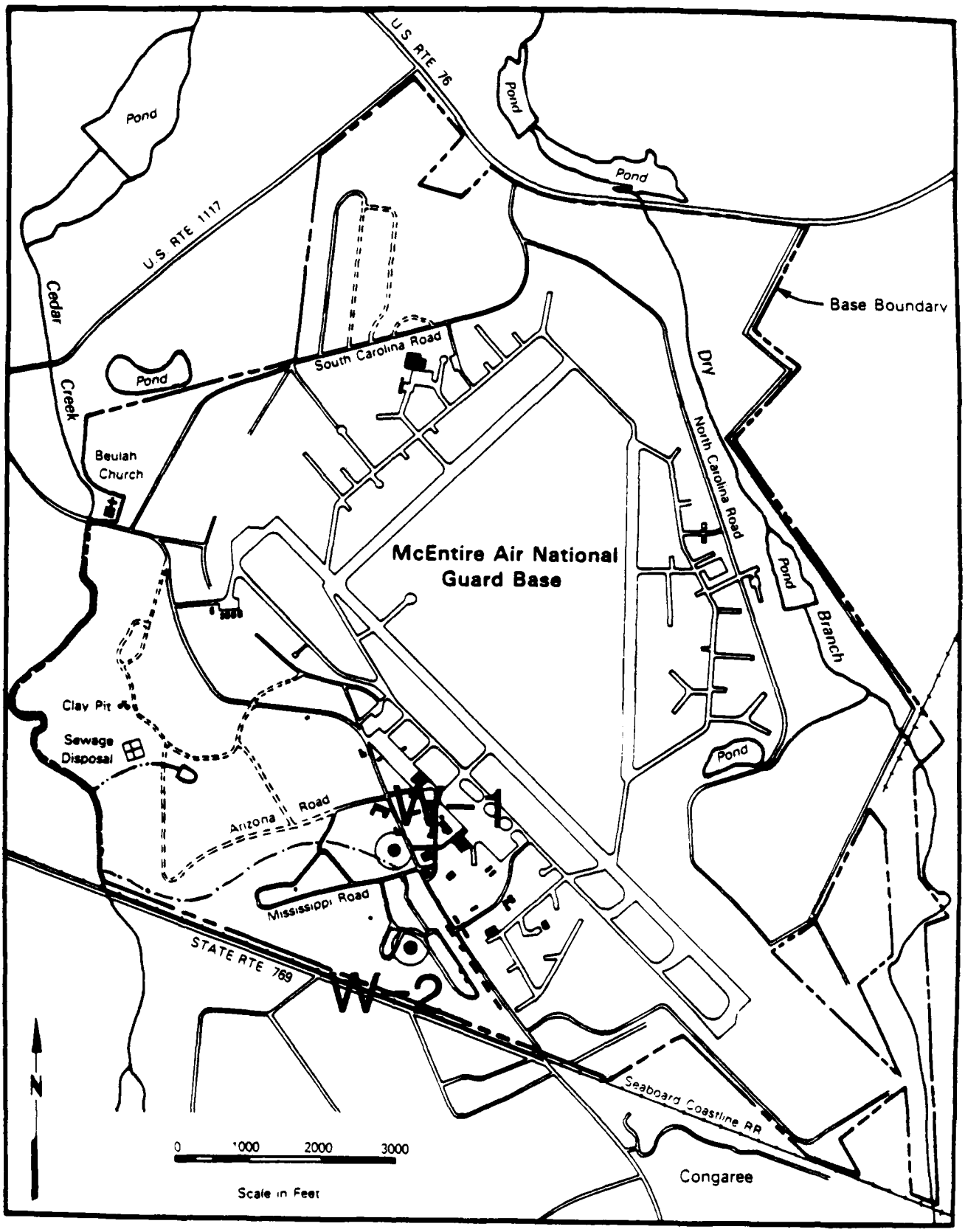


Figure 4-9. Base Supply Wells Monitoring Locations.

5.0 ALTERNATIVE MEASURES

Findings summarized in Section 4.0 indicate the need for additional monitoring at several McEntire ANG Base sites where the full extent of contamination could not be determined with available data. This section discusses options available to obtain the necessary data and permit characterization of the extent, magnitude, and direction of movement of contamination at certain base sites. Section 5.1 deals with the analytical alternatives that must be considered in planning future work at the site. These analytical alternatives are similarly applicable to the monitoring programs proposed for each of McEntire's sites. Section 5.2 presents the specific monitoring alternatives that are available to fill observed data gaps at each of the base sites. Recommendations for further study at each site, which address in detail both analytical and monitoring considerations, are then presented in Section 6.

5.1 ANALYTICAL ALTERNATIVES APPLICABLE TO MORE THAN ONE SITE

The analytical alternatives available for the site specific monitoring alternatives proposed in Section 5.2 are as follows:

1. Analysis for indicator parameters (TOX, oil and grease). A monitoring program implemented using this analysis would provide a cost-effective means of evaluating the extent to which compounds may have migrated within the soils at the site, but would not identify the specific compounds present.

2. Analysis using a modified EPA Method 624. The detected presence of benzene and toluene, and the elevated level of oil and grease, suggests the material detected in the sediment samples from a number of sites was JP-4. A monitoring program implemented using this alternative would identify JP-4 and its major constituents.

3. Analysis for base/neutral and acid extractable organics groups from the Priority Pollutant list using EPA Method 8250 (soil/sediment) and volatile organic compound analysis using EPA Methods 601-602 (water) and 846/8010-8020 (soil/sediment). The elevated total organic bromide and oil and grease levels measured in the sediment samples from several sites may be due to organic solvents known to have been disposed there. A monitoring program implemented using this alternative would characterize a range of organic compounds suspected to be present at these sites. This program would also analyze for

non-volatile chlorinated organic compounds. Because a number of years have elapsed since possible contamination occurred at the base sites, the likeliness that volatile organic compounds would still exist in some of the surface soils is low. However, volatile organic compounds may have migrated through the soils to the water table and may still persist in the underlying aquifer at low levels. Therefore, groundwater analysis would include volatile organic compound analysis using EPA Methods 601-602.

4. Analysis for complete Priority Pollutant list. A wide range of waste liquids were disposed at several of the sites, and Stage 1 analysis was somewhat limited. A monitoring program implemented using this analytical alternative would check for a wider range of compounds which may be present at the sites. This method of analysis would be most costly if applied to all samples. However, if applied to one or several samples obtained from strategic site locations, this alternative would provide a list of compounds present, from which decisions could be made as to which group of compounds (or compound) should be targeted for analysis and what analytical method(s) would be best suited for implementation with subsequent monitoring programs.

5.2 SITE SPECIFIC MONITORING ALTERNATIVES

5.2.1 Site No. 1: No. 5 Fire Training Area

As noted earlier in this report, Site No. 1 was a disposal area for waste oil, solvent, JP-4, brake and transmission fluids, paint thinners and strippers, hydraulic fluid and other combustibles. Phase II sampling and analysis indicated elevated levels of oil and grease, benzene, and toluene in site soils, particularly in samples from the fire pit itself. Groundwater samples showed elevated purgeable halocarbon levels, with carbon tetrachloride in particular, exceeding EPA CAG's cancer risk estimate value. Given these elevated levels of contaminants, a "no further action" alternative is not viable at this site.

The following data needs have been identified for better defining the soil and groundwater contamination problems at Site No. 1:

- Additional data is required to better define the areal extent of contamination and to determine whether contaminant concentrations are limited to the fire pit itself, as this study tentatively suggests;

- Additional data is required in the fire pit area, where the highest contaminant levels have been identified, to evaluate their extent of vertical movement;

- Additional data is required to confirm the presence of the identified groundwater contaminants and identify the extent of their movement downgradient from the site.

Alternatives for acquiring soils data to fill identified gaps are discussed below.

1. Establish a sampling grid and obtain surface soil samples from within the fire pit and at increasing distances away from the perimeter of the fire pit. Every effort should be made to ensure that one arm of this grid lies in the swale through which the site drains, to permit additional sampling there. This will provide information on the areal extent of soil contamination, but will not provide information on depths of contamination.

2. Obtain soil samples at incremental depths. This alternative would provide information on the depth and levels to which the compounds exist in the soils beneath the site. Two options can be implemented as part of this alternative:

   - Obtain soil samples at incremental depths at the center of the fire pit; and

   - Obtain soil samples at incremental depths in conjunction with Alternative 1.

   The first option would provide information on the depth and levels to which the compounds exist within the soil directly beneath the fire pit, but would not further define the areal extent of the compounds in the soil beyond the pit. This option can, however, be implemented prior to implementing the second option to provide for a preliminary assessment of the target depth to which incremental depth sampling should be performed. The latter option would characterize both the areal extent and the depth to which chemical compounds occur within the soil, providing both a horizontal and vertical chemical concentration profile of the site.

Alternatives for acquiring required additional groundwater data for this site include the following.

1. Perform depth-discrete sampling at existing monitoring wells. This would identify whether chemical compound stratification is occurring in the aquifer beneath the site, and, if occurring, would characterize both the vertical and horizontal extent of the compounds in the water table aquifer.

2. Install an additional monitoring well approximately 500 feet hydraulically downgradient of the site. The Stage 1 results revealed the presence of purgeable halocarbon compounds at levels in excess of state and Federal drinking water and health standards in the groundwater downgradient from the site. Implementing this monitoring alternative would enable an evaluation of whether the chemical compounds are being attenuated in the groundwater system and their potential extent of migration.

3. Establish the vertical and horizontal extent of contamination at this site using soil gas analysis techniques. Soil gas investigations involve analyzing soil pore gas to detect the underground presence of volatile chemicals such as solvents, cleaning fluids, and hydrocarbons. This monitoring alternative can be implemented to collect additional data on the areal extent of volatile organic compounds within the soil at this site and can be used to characterize their presence and level in groundwater (i.e., define a potential plume). It is also useful as an additional information source in the siting of additional monitoring wells, and would be valuable from that standpoint if Alternative 2 were implemented. However, this technique cannot be used to detect nonvolatile compounds (which may also be present at this site) and their potential extent of migration.

5.2.2 Site No. 2: No. 1 Fire Training Area/Sanitary Landfill

As noted in previous sections, this site reportedly received significant volumes of mixed hydrocarbon solvents, waste motor oils, and contaminated 100-octane fuel. Groundwater analyses for this site revealed very slightly elevated TOX levels and elevated organic halogen concentrations, with one compound exceeding the EPA CAG 10^{-6} risk level. A chromium concentration exceeding the MCL was identified in a well which appears to hydrologically upgradient from the site itself. In addition, low levels of purgeable aromatics were detected in a second well which also appears to be upgradient.

Based on this data, the existence of groundwater contamination in the vicinity of this site has been established and a no action alternative is not considered viable. Stage 1 data clearly indicates that low level groundwater contamination is occurring in this area and that the likely source is Site No. 2. However, hydraulic gradients are very slight in this section of the base, and it is uncertain whether a true upgradient monitoring well has been established at this site. Thus, it cannot be confirmed at this point that Site No. 2 is in fact, the contaminant source. To fill this data gap at Site No. 2, several alternatives could be instituted:

1. Re-sample existing wells. This alternative could be implemented with any of the several analytical sub-options noted in Section 5.1, but regardless of the sub-option selected or the new and more definitive analytical data generated, the mentioned uncertainty in site hydrology would still make it difficult to be certain that the site was in fact the source of any contaminants observed.

2. Install an additional monitoring well further from the site in the tentatively established upgradient direction (to generate better site background data) and resample/reanalyze all wells. This would permit confirmation of groundwater contamination in the area and a better definition of the contaminant source as per the objectives of the Phase II IRP. At a minimum, sample analysis should be performed for those analytes tested during Stage 1.

The Stage 1 results for this site suggest that the predominant waste types detected are organic solvents known to have been disposed in this area (measured TOC and oil and grease levels were below their respective detection limits). As an analytical alternative, additional sample analysis for base/neutral and acid extractable organics groups from the Priority Pollutant list could be performed to assess the likely presence of nonvolatile organic compounds.

5.2.3 Site No. 3: Y-Storage Area

As noted in earlier sections of this report, Site No. 3 was a pad storage area for waste oil, solvents, gasoline, JP-4, and other combustible liquids. Analytical data generated to date shows somewhat elevated levels of total organic chloride in both soils and groundwater, and total organic halogen levels significantly higher than expected background levels in the site's

soil. As a result of this data, a no action alternative is not considered viable at Site No. 3.

The TOX levels measured in the samples obtained during the Stage 1 effort are suggestive of environmental contamination resulting from past activities which occurred at this site. However, the identity, magnitude, toxicity and potential extent of the compound(s) detected are unknown. In order to meet the objectives of Phase II of the IRP, additional monitoring is warranted for this site.

The following monitoring and analytical alternatives should be considered to more thoroughly characterize the identify and magnitude of the compound(s) present and the extent to which they occur at Site No. 3.

1. Resample the Stage 1 groundwater and surface soil monitoring locations and perform analysis to determine the identity of the compound(s) present. This would provide information on the identify, magnitude, and toxicity of the chemical compound(s) present in soils and groundwater. However, additional information on the potential extent of contaminant migration would not be gained.

2. Obtain soil samples at incremental depths at a Stage 1 surface soil sampling location. This alternative would provide information on the depth to which the compounds may have migrated beneath the site and would aid in determining whether the compounds in the soil have migrated, or are migrating, toward the water table aquifer. This alternative would not, however, further define the areal extent of the compounds in the soil at the site.

3. Establish a sampling grid and obtain surface soil samples at increasing distances from the site. This would further define the areal extent of the compounds in the soil at Site No. 3, but would not provide information on the depth to which the compounds may have migrated. However, this alternative can be implemented prior to implementing Alternative 4 in order to establish the areal limits within which soil borings should be performed.

4. Obtain soil samples at incremental depths in conjunction with Alternative 3. This alternative would characterize both the areal extent and the depth to which chemical compounds occur within the soil, permitting remedial measures for Site No. 3 to be evaluated, if necessary.

5.2.4 Site No. 4: Oil Dump Site

Site No. 4 consists of a sizable visible patch of oil, evidence of past oil disposal of undetermined extent. As would be expected, soil samples in the area showed extremely high oil and grease levels. Levels of organic chloride in groundwater were also above the anticipated background. The following gaps have been identified in the data generated to data for Site No. 4:

- Although analytical data reflected some oil and grease contamination extending vertically beneath the oil dump site, possible sampling problems (contaminated surface soils may have been sloughing into the hole during collection of deeper samples) render that data suspect. Thus, extent of contaminants beneath the site is still unclear.
- Specific compounds occurring in both the contaminated soils and groundwater should be identified.
- Areal extent of contamination should be established.

The following alternatives should be considered to address these data needs:

1. Resample Stage 1 groundwater and soil monitoring locations and perform analysis to determine the identity of the compounds present. This would provide information on the identity, magnitude, and toxicity of the chemical compounds present. However, additional information on the potential extent of migration would not be gained.
2. Establish a sampling grid and obtain surface soil samples at the center of the site, along its periphery, and at increasing distances away from the site. This would further define the areal extent of the compounds in the soil at the site and can be implemented prior to implementing Alternative 3 in order to establish the areal limits within which soil borings should be performed.
3. Obtain soil samples at incremental depths in conjunction with Alternative 2 to characterize both the areal extent and depth to which chemical compounds occur within the soil.

5.2.5 Site No. 5: C-141 Spill Trench

As noted earlier, this site represents the flow path taken, prior to clean-up, by a large quantity of JP-4 released from a burning C-141 aircraft. The Stage 1 results do not indicate the presence of chemicals which may be

hazardous to human health or the environment in the sediment or groundwater at Site No. 5. However, ethylbenzene, chromium, and lead were detected in sediment sample SD2-3, obtained approximately 300 feet downstream from Site No. 5 in the tributary drainage swale to Cedar Creek (see Table 4-12 and Figure 4-8). Because the sediment samples obtained from Site No. 5 were analyzed for TOX and oil and grease only, the presence of ethylbenzene, chromium, and lead may have gone undetected. Alternatively, the source of these substances may be from another drainage ditch which joins Site No. 5 just upstream of SD2-3. This represents a data gap that should be addressed during the course of Phase II, Stage 2 follow-on work at McEntire ANG Base. Given that Site No. 5 itself showed no contaminants of any kind based upon the program conducted, however, the no action alternative is considered viable for the site itself and is recommended in Section 6.0. The issue of the contaminants that were evident in the drainage swale some distance downstream from Site No. 5 does warrant further investigation, however, and appropriate discussion/alternatives for that aspect of the investigation are presented in Section 5.2.8, which deals specifically with Cedar Creek and the tributary drainage swale.

5.2.6 Site No. 6: Unofficial Dump Site

This unofficial dump site contains a typical array of scrap wood, metal, construction materials, and empty paint cans, and showed somewhat elevated oil and grease, total organic chloride, and total organic bromide levels in the soils sampled. The analytical results for the groundwater samples obtained during Stage 1 show no indication that chemicals which may be hazardous to human health or the environment are present.

The Stage 1 results suggest hazardous compounds may be present in the soil at this site and that the compounds have not yet migrated to the water table aquifer. The identity, magnitude and toxicity of the compounds present and their extent within the soils have not been determined, and thus represent a data gap. Areal extent of contamination within the soils is also unknown at this point.

The following represent monitoring/analytical alternatives that could be applied to Site No. 6 during a Phase II, Stage 2 follow-on investigation:

1. A no action alternative is viable for consideration here since data available indicate that no contaminants are leaving the site via groundwater. However, without a more concise definition of the specific contaminants present in the site soil, it cannot be assured that contaminants will not in the future migrate into the groundwater beneath the site.

2. Obtain a surface soil sample at the Stage 1 monitoring location and perform analysis to determine the identity of the compounds present. This would not, however, provide information on either areal extent or depth of contamination.

3. Obtain soil samples at incremental depths at the Stage 1 surface soil sampling location. This would provide information on vertical contaminant migration, but again would provide no areal information.

4. Establish a sampling grid and obtain surface soil samples at increasing distances from the site to further define the areal extent of the compounds in the soil at Site No. 6. This approach would not provide information on the depth to which the compounds may have migrated. However, this alternative can be implemented prior to implementing Alternative 5 to establish the areal limits within which soil borings should be performed.

5. Obtain soil samples at incremental depths in conjunction with Alternative 4. This would finalize the required data on vertical and areal extent of contaminant migration at the site.

5.2.7 Site No. 7: Drainage Pond/Swamp

As noted in previous sections of this report, Site No. 7 receives drainage from both a significant portion of the base and an off-base commercial fertilizer plant. Analytical data for sediments sampled here showed extremely high levels of phosphorous, as well as elevated levels of nitrates and oil and grease. Review of sampling locations and analytical data suggests that phosphorous and nitrate concentrations in the sediments are probably attributable to an off-base source, possibly the nearby commercial plant. However, levels of phosphorous observed in samples SD 7-1 and SD 7-3, which cannot be attributed to off-site sources, warrant additional investigation. In addition, the oil and grease concentrations noted, particularly in sample SD 7-1, upstream from the site and adjacent to a POL Area, do not appear to

emanate from this site. Additional data would be required to better understand and account for these values.

Given the analytical findings summarized above, a no action alternative is considered viable for Site No. 7, since available data does not point to significant contaminant levels in the drainage pond/swamp itself. Questions raised particularly by the oil and grease levels in the drainage ditch upstream from the site do, it is felt, require clarification. To provide the needed information, several soil monitoring alternatives are available:

1. Resample at the three on-base points included in the previous program and analyze samples for the same suite of parameters designated in Phase II Stage 1 efforts. This may confirm the previous stage's general findings, but will not help to define/quantify specific contaminants or their potential sources, if any, on the base.

2. Resample at the three on-base points included in the previous program and analyze samples for an expanded suite of parameters to identify and quantify specific contaminants present. This procedure will provide some valuable data, but again will not help pinpoint potential sources.

3. Conduct alternative 2 sampling and expand number of sampling points to include: at least one of the previously sampled downstream, off-base points to serve as a control; several points along the drainage trench from the POL area to the swamp/marsh area, including a point where the trench empties into the marsh; and the upstream end of the drainage pipe that dischages at point SD7-1. This alternative would provide additional information on specific contaminants present and, hopefully, sufficient data to pinpoint a source for any contaminants that are observed upstream from the site.

5.2.8 Cedar Creek and Tributary Drainage Swale

As described in Section 4.3.8, Cedar Creek and a tributary drainage swale were sampled (water and sediments) as part of the McEntire ANG Base Phase II, Stage 1 program because they receive drainage from a significant portion of the base. The objective of this program was to ensure that the creek was not receiving contaminants from on-base sources other than those identified in Phase I and investigated in this Phase II effort. Analytical results of this effort, with regard to water quality, are somewhat intriguing, however. Tetrachloroethylene and 1,1,1,2-tetrachloroethane were detected in all surface

water samples upstream, adjacent to, and downstream from the base, with the highest concentrations (exceeding EPA AWQC 10^{-6} risk levels) at the station farthest upstream. While at first glance, the data suggests a significant upstream, off-base source for these contaminants, available information does not suggest that any potential sources exist upstream from this point, as there are no known industrial facilities that would generate such contaminants, for instance. In addition, there is a portion of the base upstream from this point that drains to Cedar Creek. It is felt that, while no known potential on-base sources exist for these contaminants, the existing data base is inadequate to definitely state that the contaminant source is off-base. Additional data is deemed necessary to fill this data gap.

Sediment samples collected during this effort also showed contamination by ethylbenzene, arsenic, and trace metals (chromium and zinc). These data show a trend opposite to that described for the purgeable halocarbons in the stream itself - the upstream sediment sample SD2-6 is clean with respect to all parameters evaluated. The downstream sample (SD2-5), which reflects Cedar Creek's quality (in terms of its impact on sediments) as it leaves the base, shows slightly elevated levels of zinc and chromium. The drainage swale which leads from Site No. 5 to the creek, however, shows significantly elevated arsenic, chromium, level, zinc, and ethylbenzene concentrations. This condition, although only minimally reflected in Cedar Creek below the mouth of this drainage swale, certainly is significant, and will necessitate additional data collection to better focus on the occurrence and potential source of contaminants in this area.

Given the existence of the sediment and stream contaminants noted above, a no action alternative is not considered viable for Cedar Creek even though it is not a specifically designated Phase II site. Additional data collection is definitely warranted to fill noted gaps. Alternatives for that sediment and water oriented data collection include:

1. Resampling/analysis as per Phase II, Stage 1 effort documented in this report. This would not contribute to better definition of contaminant sources.

2. Resampling/analysis (for Phase II, Stage 1 suite of parameters) with expansion of sampling (water/sediment) locations to include the following: several points in Cedar Creek upstream from SW2-1; walking stream and site boundary upstream from SW2-1 to assure that no previously unidentified discharges emanating from the base exist; and additional points within the drainage swale both upstream and downstream from SD2-2.

3. Alternative 2 as noted above with full Priority Pollutant Analysis for all samples. This analytical alternative would certainly provide ample data for the sites sampled, but might not be cost effective, given the magnitude of problems/contamination at this site.

4. Alternative 2 as noted above, with select samples at critical locations (from a data acquisition standpoint) analyzed for Priority Pollutants. Critical points for such expanded analysis would be those first upstream and downstream in Cedar Creek from the drainage swale. This would optimize data collection from a cost standpoint and provide definitive information on: 1) the contaminant contribution/impact on Cedar Creek from the drainage swale; and 2) the precise nature of contaminants, if any, leaving McEntire ANG Base via Cedar Creek.

These additional points, with the same analytical program implemented in the current study, should fill the data gaps identified with regard to Cedar Creek and the subject drainage swale.

5.2.9 Base Water Supply Well W-1

The level of total organic chloride (0.03 mg/l) measured in a sample obtained from the base's water supply well W-1, during the initial Phase II sampling effort, was above the anticipated background level (0.02 mg/l). In an attempt to identify the compound(s) present, resampling of the well and analysis for volatile organic compounds (EPA method 601-602) was performed as part of the Phase II Stage 1 Field Evaluation for McEntire ANG Base.

Either 1,1,2,2-tetrachloroethane or tetrachloroethylene (PCE), or both, were measured in the sample obtained during the Stage 1 effort at an unresolved level (gc/ms peaks co-eluted, i.e., did not separate) of 5.1 ug/l and was second column confirmed at an unresolved level of 1.3 ug/l. Both compounds are considered potential carcinogens by the EPA Office of Drinking Water and Office of Water Regulations and Standards. A projected upper limit

lifetime cancer risk of 10^{-6} has been estimated for exposure to 1.0 ug/l PCE and 0.17 ug/l 1,1,2,2-tetrachloroethane.

Because of the health risks associated with these compounds and the high potential for direct exposure to base personnel through consumption a no-action alternative with regard to this water supply is not viable. Even though the well does not constitute a potential contaminant source area or site originally designated for study in Phase II, Stage 1, measures should be taken to fill these critical data gaps:

- Determine whether base personnel are being exposed to these compounds.
- Determine the source for the measured levels of these compounds at well W-1.
- Determine their extent of migration.

To meet these additional data needs, the following alternatives should be considered:

1. Obtain and analyze samples from high occupancy locations at the base. This would provide information as to whether base personnel are being exposed to these compounds and whether they are at risk, so proper precautionary measures can be implemented, if necessary.

2. For well W-1, obtain well water samples at points before and after it enters the treatment and distribution system. The presence of these compounds in the sample obtained from well W-1 may be due to impurities in the chlorine gas used in the treatment system. Alternative 2 would provide information to confirm either: 1) the existence of these compounds in the deep aquifer at McEntire ANG Base; or 2) their artificial introduction at some point in the treatment process.

3. Obtain samples from base supply well W-2 as described in Alternative 2. This procedure would, if conducted in conjunction with Alternative 2, provide verification of the presence or abscence of those compounds in the deep aquifer and some information on the extent of migration. This information would aid in the evaluation of potential contaminant sources impacting these base water supply wells.

Sample analysis for volatile organic compounds should be performed using EPA method 601-602, as was implemented during Stage 1.

6.0 RECOMMENDATIONS

This section presents the recommendations for Stage 2 work, based on the findings of Stage 1. The recommendations are presented by category as defined in the IRP Phase II Report Format. Two sites, the C-141 Spill Trench and the Drainage Pond/Swamp, which are not considered to pose a threat to human health or the environment based on Stage 1 findings, are assigned to Category I and no further IRP-related acivities are recommended. All other sites studied, unless otherwise noted, are Category II sites and will require additional monitoring activities to confirm and quantify contaminants and their extent. None of these sites have been sufficiently characterized by Stage 1 activities to permit initiation of Phase IV; thus, there are no Category III sites. The sites and pertinent Stage 2 recommendations for each are presented in order of recommended priority. It should be noted that recommendations have been developed for additional data collection at Cedar Creek and its tributary drainage swale. Since this area does not formally fall under the heading of a site, it is presented last in the following discussion. This does not reflect the priority of recommendations for Cedar Creek relative to other studied sites, as the text for that area will discuss. Table 6-1 presents a summary of recommended monitoring at McEntire ANG Base.

6.1 CATEGORY II SITES

The following monitoring sites at McEntire ANG Base are assigned to Category II. These are sites for which additional Phase II work is recommended to determine the need for subsequent IRP Phases. These are presented in order of priority according to the severity of contamination the Stage 1 results revealed.

6.1.1 Base Water Supply Well W-1

The level of total organic chloride (0.03 mg/l) measured in a sample obtained from the base's water supply well W-1 during Phase II presurvey sampling was above the anticipated background level (0.02 mg/l). In an attempt to identify the compound(s) present, resampling of the well and analysis for volatile organic compounds (EPA method 601-602) was performed as part of the

TABLE 6-1. SUMMARY OF RECOMMENDED FUTURE MONITORING AT McENTIRE ANG BASE

No.	Site Description	Groundwater	Surface Water	Soils	Analyses
-	Base Water Supply Well W-1	• At least 3 tap water samples from high usage locations • Sample W-1 water upstream and downstream from treatment system • Sample base water supply well W-2 as per W-1 above	Not Applicable	Not Applicable	• Field: pH, conductivity, temperature • Laboratory: Volatile organics (EPA 601-602)
1	No. 5 Fire Training Area	• Resample existing monitoring wells at 3 discrete depths each (4 wells, 3 samples each)	Not Applicable	• Sampling at 25 points on grid pattern, including 4 Stage I points • Depth discrete sampling, 3 foot intervals to 25 feet below surface or base of visible contamination at 1 point	• Field (wells): pH, conductivity, temperature, head level • Laboratory (soils): Volatile organics (EPA 8010-8020); Base/neutral and acid extractable organics (EPA 8250) • Laboratory (Water): Volatile organics (EPA 601-602)
2	No. 1 Fire Training Area/Sanitary Landfill	• Install and sample additional upgradient well • Resample existing monitoring wells at 3 discrete depths each (5 wells, 3 samples each)	Not Applicable	No Action	• Field: pH, conductivity, temperature, head level • Laboratory: Priority Pollutant metals; Volatile organics (EPA 601-602)
3	Y-Storage Area	• Resample existing monitoring wells (4 wells)	Not Applicable	• Sample at 17 points on grid pattern, including 3 Stage I points • Depth discrete sampling, 3 foot intervals to 25 feet below surface or base or visible contamination at 1 point	• Field (wells): pH, conductivity, temperature, head level • Laboratory (soils): Base/neutral and acid extractable organics (EPA 8250) - 10 samples; Volatile organics (EPA 8010, 8020) - 10 samples; TOX, oil and grease - 7 samples • Laboratory (water): Volatile organics (EPA 602, 602)

TABLE 6-1. SUMMARY OF RECOMMENDED FUTURE MONITORING AT McENTIRE ANG BASE (Continued)

No.	Site Description	Groundwater	Surface Water	Soils	Analyses
4	Oil Dump Site	• Resample existing monitoring wells (4 wells)	Not Applicable	• Sampling at 7 points in and around site, including Stage 1 point • Depth discrete sampling, 3 foot intervals to 25 feet below surface or base of visible contamination at 1 point	• Field (wells): pH, conductivity, temperature, head level • Laboratory (soils): Volatile organics (EPA 8010, 8020) - 4 points including depth discrete samples; Base/neutral and acid extractable organics (EPA 8250) - 4 points including depth discrete samples; TOX, oil and grease - 3 samples • Laboratory (Water): Volatile organics (EPA 601, 602)
6	Unofficial Dump Site	No Action	Not Applicable	• Sampling at 7 points in and around site, including Stage 1 point • Depth discrete sampling, 3 foot intervals to 25 feet below surface or base of visible contamination at 1 point	• Field (wells): pH, conductivity, temperature, head level • Laboratory (soils): Volatile organics (EPA 8010, 8020) - 4 points including depth discrete samples; Base/neutral and acid extractable organics (EPA 8250) - 4 points including depth discrete samples; TOX, oil and grease - 3 samples • Laboratory (Water): Volatile organics (EPA 601, 602)
5	C-141 Spill Trench	No Action	Not Applicable	No Action	No Action
7	Drainage Pond/Swamp	No Action	Not Applicable	No Action	No Action
	Cedar Creek and Tributary Drainage Swale	Not Applicable	• Sampling at 8 points, including 6 Stage 1 points	• Sampling (stream sediments) at 8 surface water sampling points	• Field (water): pH, conductivity, temperature, flow rate • Laboratory (water): Full Priority Pollutant analysis - 2 samples; Volatile organics (EPA 601, 602) - 6 samples • Laboratory (sediment): Full Priority Pollutant analysis - 2 samples; Volatile organics (EPA 8010, 8020) - 6 samples

Phase II Stage 1 Field Evaluation. Either 1,1,2,2-tetrachloroethane or tetrachloroethylene (PCE), or both, were detected in this Stage 1 sample at an unresolved level (gc/ms peaks co-eluted, i.e., did not separate) of 5.1 ug/l with second column confirmation at an unresolved level of 1.3ug/l. As noted earlier, both compounds are considered potential carcinogens by the EPA Office of Drinking Water and Office of Water Regulations and Standards, with a projected upper limit lifetime cancer risk of 10^{-6} estimated for exposure to 1.0 ug/l tetrachloroethylene (PCE) and 0.17 ug/l 1,1,2,2-tetrachloroethane.

Because of the health risks associated with these compounds and the high potential for direct exposure to base personnel through consumption, the base water supply well W-1 was given the highest priority ranking for Stage 2 actions. It is recommended that measures should be taken to:

- Determine whether base personnel are being exposed to these compounds;
- Determine the source for the measured levels of these compounds at well W-1; and
- Determine their extent of migration.

Samples from base supply well W-1 were collected directly from the well head and therefore do not confirm the presence of contaminants in the tap water. In order to determine whether base personnel are being exposed to harmful compounds, a minimum of 3 tap water samples, from high occupancy/usage locations, should be collected and analyzed for the presence of volatile organic compounds using EPA method 601-602. Should the presence of organic compounds be confirmed, an alternate water source such as bottled water, may be necessary.

Determining the source for the measured compound levels found during Stage 1 can be accomplished by obtaining water samples at points before and after the water from W-1 enters the base's treatment and distribution system. Compounds identified (at unresolved levels) in well W-1 may be due to impurities in the chlorine gas used for disinfection in the treatment system. It is recommended that samples upstream and downstream of the treatment system be

analyzed for volatile organic compounds using EPA Method 601-602. These analytical data can be used to determine whether any compounds, if present, originate in the deep aquifer beneath McEntire ANG Base (and thus appear in the influent to the treatment system) or whether they have been artificially introduced in the treatment process.

To meet the third objective, determining the extent of contamination, it is recommended that base supply well W-2 also be sampled. Sampling of water from well W-2 should be conducted before and after it reaches the treatment and distribution system. Volatile organic compound anaysis is again recommended using the previously stated method. This monitoring should identify any volatile organic compounds present at well W-2, any possible connection to the water treatment system, and the extent of contamination, if any, in the deep aquifer at McEntire ANG Base.

Implementation of the recommended monitoring program will provide verification of the presence or absence of volatile organic compounds in the deep aquifer, provide information on the extent of migration, aid in the evaluation of potential sources, and identify whether human exposure through consumption of the base water supply is occurring.

6.1.2 No. 5 Fire Training Area: Site No. 1

Soil at all four Stage 1 monitoring locations was found to be contaminated with oil and grease (a non-compound specific analyte). In addition, soil sampled within the fire training pit contained elevated levels of benzene and toluene. Of the purgeable halocarbons found in groundwater, the most elevated occurrence of a single compound was in well MW1-4 (carbon tetrachloride at 0.98 mg/l). Given the toxic nature of the contaminants found, additional Stage 2 monitoring is recommended to determine the following:

- The identity and areal extent of contaminants in soils;
- The vertical extent of contaminant migration in soils; and
- The presence, magnitude and extent of purgeable halocarbon compounds in groundwater.

The first objective can be met by sampling surficial soils at the existing Stage 1 monitoring locations in addition to the 21 proposed soil sampling locations shown in Figure 6-1. The soil sampling points are located in a modified grid pattern which should provide adequate monitoring to determine the extent of soils contamination.

Specifically, the grid sampling pattern allows for:

- Two additional sampling points within the fire training pit, providing additional coverage to determine contaminant distribution within the pit;
- Four additional points (2 to the north, 2 to the east) around the pit, where no breach in the berm exists. The points are equally spaced and at an approximate distance of 25 feet from the pit boundary;
- Seven additional points within and to an approximate distance of 25 feet from the overflow drainage swale; and
- Eight additional points peripherally located away from the site. One of these points is purposely located near well MW1-4, where purgeable halocarbons were found in groundwater during Stage 1.

It is recommended that soil samples at all locations be analyzed for volatile organic compounds using EPA Methods 8010 and 8020 and for base/neutral and acid extractable organics using EPA Method 8250. These analyses are recommended to identify specific compounds which are related to fuels, solvents, and waste oils reportedly disposed of at the site. Volatile organics analysis is recommended based on the occurrence of benzene and toluene in the pit, base/neutral and acid extractable analysis is recommended to allow oil and grease levels (non-compound specific) to be related to these specific compounds.

To establish the vertical extent of soils contamination, a soil boring is proposed at Stage 1 sampling location SD1-1, where the highest contaminant levels were found. It is recommended that samples be taken at 3-foot intervals to a minimum depth of 25 feet below land surface, or to a depth of at least 1 foot below any obvious signs of contamination (i.e., discolored soils or positive readings on the Hr. ® meter). Given the high oil and grease levels

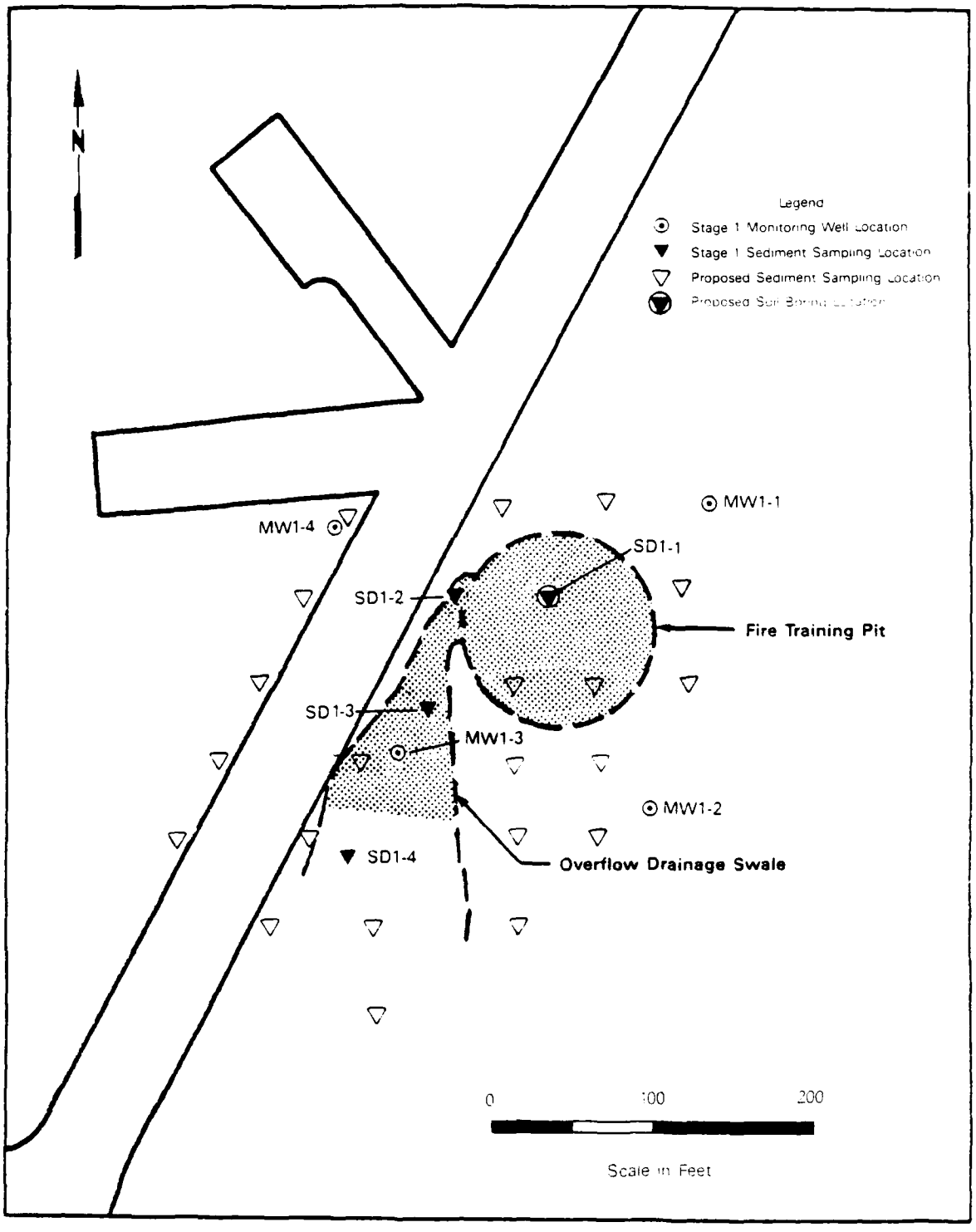


Figure 6-1. Proposed Soil Sampling Plan for Site No. 1: No. 5 Fire Training Area.

identified during Stage 1, and the possibility that base/neutral and acid extractable compounds may contribute to those levels, analysis of boring samples for these specific compounds using EPA Method 8250 is recommended. Samples should also be analyzed for volatile organics (EPA Methods 8010 and 8020) since toluene and benzene have been identified in the pit.

Should contaminants be identified to appreciable depths in the site soils, additional borings and subsurface sampling should be performed where surficial soils have been shown to be contaminated, thus establishing depth of soils contamination across the site. If required, additional borings should be sampled and analyzed using the previously stated methods. At this time, contaminant levels of other Stage 1 sampling locations do not justify borings.

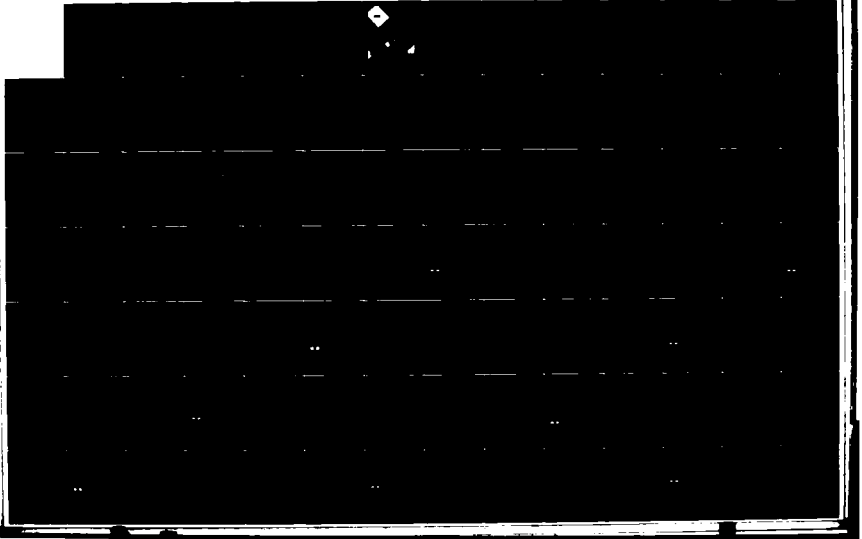
Additional groundwater monitoring is recommended to identify the specific compounds present in groundwater and their magnitude. However, the installation of an additional monitoring well is not justified at this time since definition of an appropriate location cannot be accomplished based on existing data. The occurrence of carbon tetrachloride in well MW1-4, hydraulically along-gradient from the site, generates some doubt as to the relationship between contaminant migration and hydraulic gradient (note: carbon tetrachloride was not detected in downgradient well MW1-3).

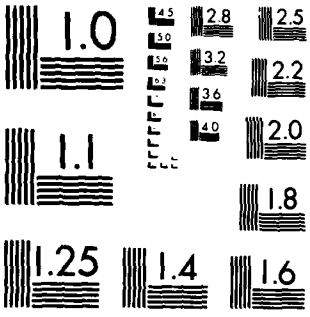
Soil gas testing, although considered, will, it is felt, have little utility in the environmental setting present at the site (see Secton 2.0). The water table occurs at a depth of approximately 40 feet below land surface, and discrete stratigraphic changes (see Figure 2-11) in the overlying units may alter upward gas migration. Thus, inaccuracy would be likely to occur in soil gas testing results relative to contaminants as they occur in the groundwater. This is particularly true given the generally low contaminant concentrations, excluding carbon tetrachloride, present at the site.

On the basis of these considerations, recommended groundwater monitoring is as follows:

- Resample the 4 existing wells at a minimum of 3 discrete depths in the water column; and

AD-A195 524 INSTALLATION RESTORATION PROGRAM (IRP) PHASE 2 3/6
CONFIRMATION/QUANTIFICATIO..(U) SCIENCE APPLICATIONS
INTERNATIONAL CORP MCLEAN VA R EADES ET AL. 10 JUN 86
UNCLASSIFIED F33615-80-D-4002 F/G 24/4 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

- Analyze samples for volatile organic compounds using EPA Method 601-602.

This approach should identify any effects of compound stratification in the aquifer and better characterize the vertical and horizontal extent of the compounds in the water table aquifer. In addition, water level data generated during Stage 2 work will be used to better assess the hydraulic gradient around the site, in the event that additional monitoring wells would be sited at some point in the future.

6.1.3 No. 1 Fire Training Area/Sanitary Landfill: Site No. 2

Stage 1 analytical results for groundwater revealed that upgradient well MW2-1 contained chromium (0.07 mg/l) and trichloroethylene (0.3 ug/l). Tetrachloroethylene and 1,1,2,2-tetrachloroethane were identified at unresolved levels in downgradient well MW2-5, where the unresolved level for each compound (7.0 ug/l), when combined, exceeds the CAG. The occurrence of these contaminants may thus pose a threat to human health and the environment, and additional monitoring is warranted. The recommended Stage 2 monitoring for this site is directed to meet the following objectives:

- Determine the quality of groundwater upgradient of the site (since MW2-1 is contaminated and considered unrepresentative of background water quality), and thereby better establish the source and extent of contamination; and
- Better define the occurrence and extent of contaminants in groundwater as related to their vertical position in the aquifer.

To accomplish these goals it is recommended that:

- An additional groundwater monitoring well be installed at an approximate distance of 300 feet directly upgradient (as established during Stage 1) from the site;
- Sampling be conducted at the 5 existing monitoring wells, as well as the newly installed well, at a minimum of three discrete depths in the water column; and
- Analyses be performed on all samples for Priority Pollutant metals and for volatile organics compounds using EPA Method 601-602.

This monitoring plan would provide data on upgradient groundwater quality at a point assumably beyond the influence of the No. 1 Fire Training Area/ Sanitary Landfill site (see Figure 6-2). Such data is needed to determine the source for contamination found in well MW2-1 during Stage 1. The stratified sampling plan proposed will better define the identity and vertical occurrence of contaminants in groundwater. In addition, such a sampling plan will provide potential identification of contamination which may have gone undetected in Stage 1 (i.e., chromium, which due to its specific gravity will sink in the water column and may be occurring at depths greater than those sampled during Stage 1). Water level data acquired from the wells during Stage 2 work will also be used to better define the hydraulic gradient at the site.

6.1.4 Y-Storage Area: Site No. 3

Soils at all three Stage i sampling locations were found to contain oil and grease and TOX, with organic iodide and organic bromide also measured at concentrations above anticipated background levels. Oil and grease were measured at 4.8 to 10 mg/kg, and TOX levels of 1.3 to 4.6 mg/1 were found. Although these indicator parameters identify the presence of compounds in soils, the specific compounds occurring and their areal extent are not known. In addition, total organic chloride levels in groundwater samples from wells MW3-1 and MW3-3 were above expected background levels. For these reasons, additional monitoring of this site is recommended.

The recommended Stage 2 monitoring effort at this site is intended to determine:

- The specific compounds in soil;
- The areal extent of the compounds in soil and the depth to which they occur; and
- The specific compounds present in the groundwater.

The first goal can be achieved by sampling at Stage 1 surface soil sampling locations and analyzing for base/neutral and acid extractable organic groups from the Priority Pollutant list and for volatile organic compounds

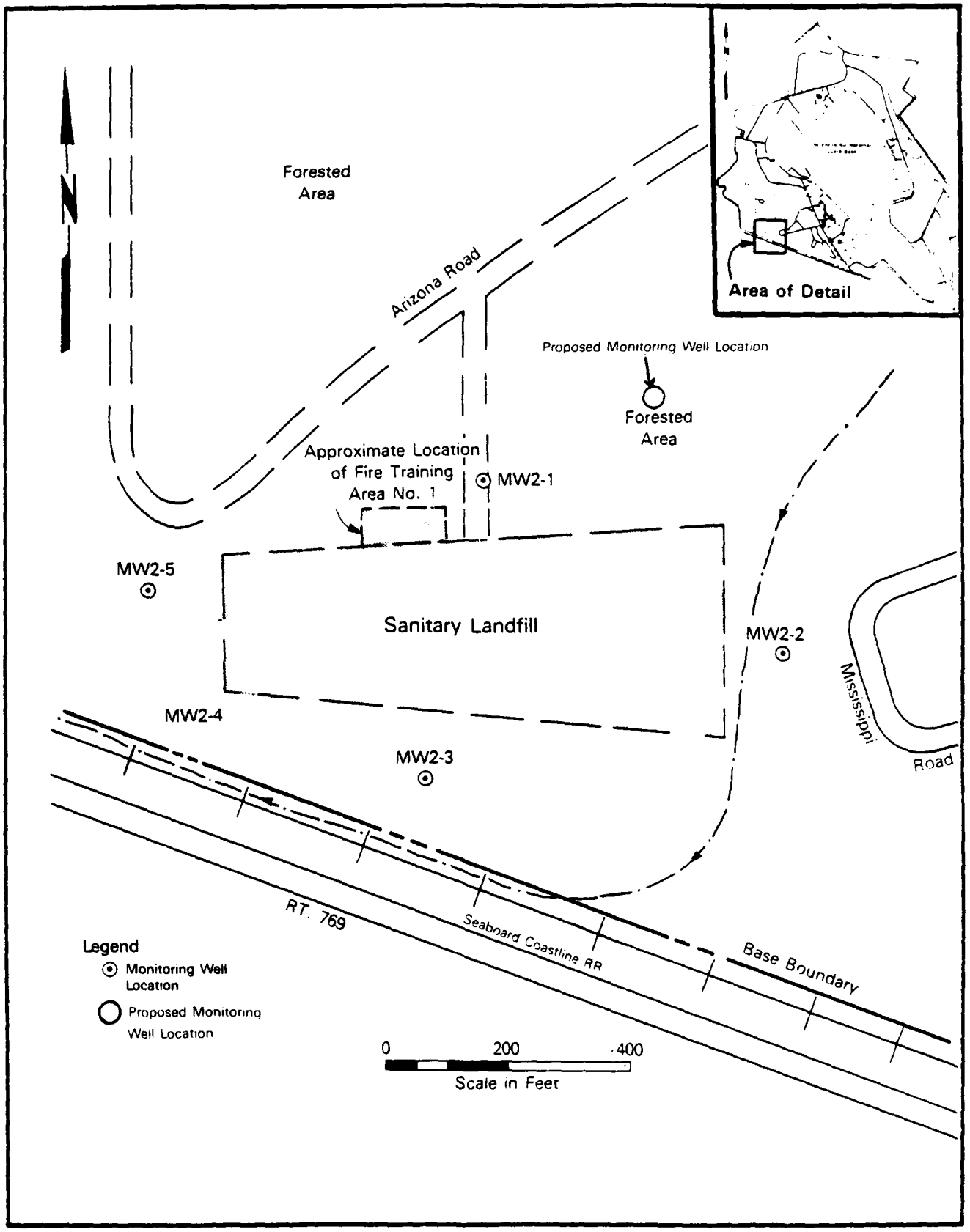


Figure 6-2. Proposed Monitoring Well Location for Site No. 2: No. 1 Fire Training Area/Sanitary Landfill Site.

using EPA Methods 8250, 8010 and 8020. This process will permit identification of the specific compounds of concern at the site and selection of target parameters for use in subsequent monitoring efforts.

The second goal, determination of the extent of compounds in soils both areally and at depth, will also require additional soil sampling. Surficial soil sampling at the locations shown in Figure 6-3 is recommended to establish the areal extent of compounds in soil at Site No. 3. Of the 14 additional proposed soil sampling locations, 7 are radially located within 15 feet of the approximate perimeter of the spill area. Samples collected at the 3 Stage 1 locations and these 7 additional locations should be analyzed for volatile organics and base/neutral and acid extractables using EPA Methods 8250, 8010, and 8020. The remaining 7 sampling locations lie approximately 50 feet from the spill area. It is recommended that, in the interest of cost savings, these 7 samples be initially analyzed for TOX and oil and grease. Those locations where TOX or oil and grease levels exceed expected background levels should be resampled and analyzed for base/neutral and acid extractable organic groups and volatile organic compounds.

To establish the depth to which compounds have migrated below the site, a soil boring is recommended at Stage 1 sampling location SD3-1 (see Figure 6-3). Samples should be collected at 3 foot intervals to a minimum of 25 feet below land surface or to a depth of at least 1 foot below the deepest obvious signs of contamination (i.e., discoloration or positive reading on the Hnu® meter). Boring sample analyses are recommended for base/neutral and acid extractable groups and volatile organic compounds using EPA Methods 8250, 8010 and 8020.

Contingent upon the identification of specific compounds occurring at depth beneath the site, additional borings and subsurface sampling should be conducted at locations where surficial soil contamination occurs to determine the vertical extent of migration throughout the site area. Any additional borings would also be sampled at 3 foot intervals to depths determined from the initial boring and from on-site observations during actual boring.

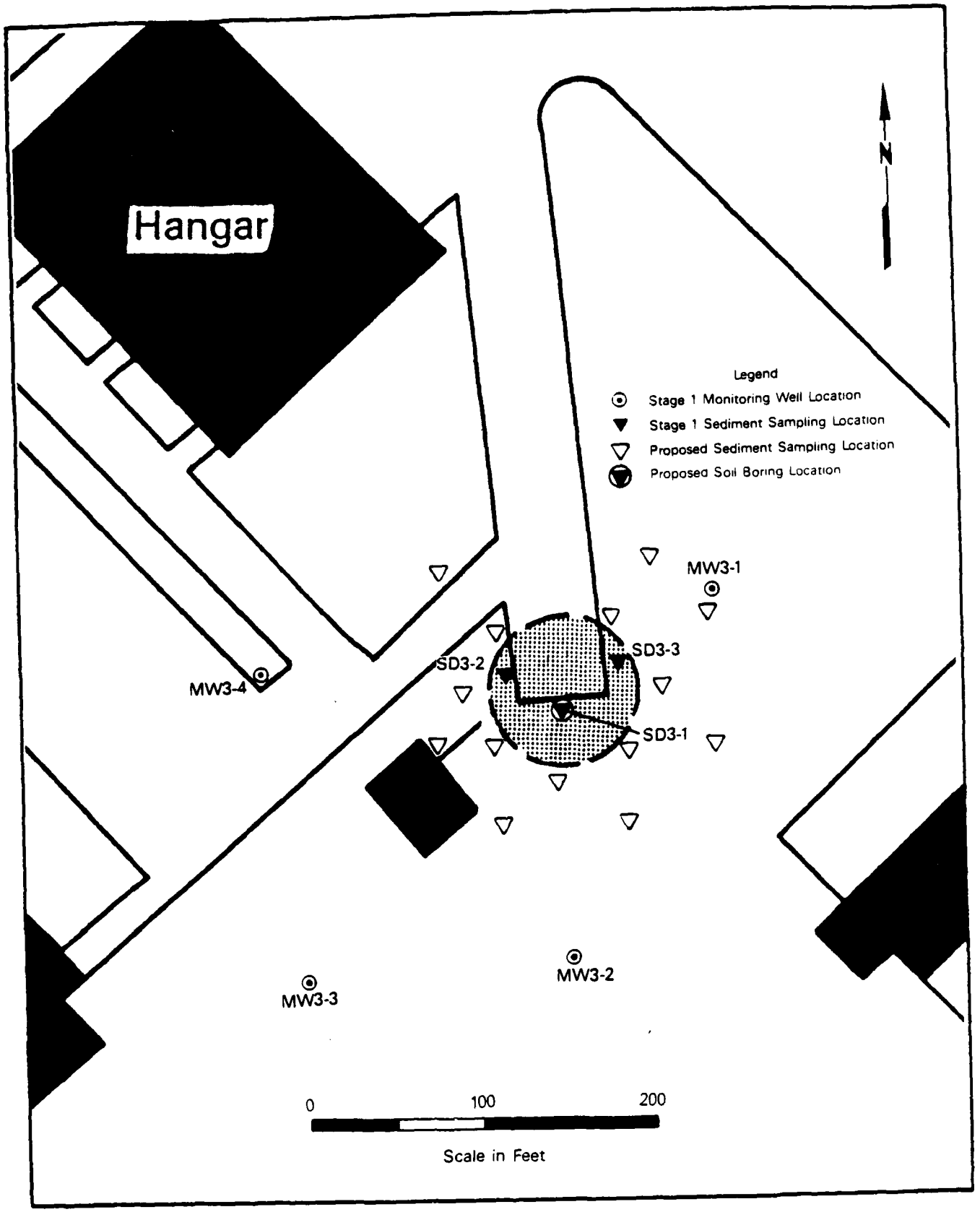


Figure 6-3. Proposed Soil Sampling Plan for Site No. 3: Y-Storage Area.

The third goal, determining the specific compounds occurring in groundwater, will necessitate resampling of the 4 Stage 1 groundwater monitoring locations (see Figure 6-3). Analysis of the groundwater for volatile organic compounds by EPA Method 601-602 is recommended. These analyses will allow for a determination of specific contaminant levels (suggested as occurring by TOX levels from Stage 1) in groundwater at the site. Water level data collected during Stage 2 activities will also be useful in further clarifying the hydraulic gradient at the site.

6.1.5 Oil Dump Site: Site No. 4

Stage 1 analytical results revealed high levels of oil and grease in soils at the Oil Dump Site, with up to 8000 mg/kg found at SD4-1. TOX levels, organic chloride specifically, were above anticipated background levels in site soils at SD4-1, and in groundwater in wells MW4-3 and MW4-4. Although contamination is confirmed, the specific contaminants involved and their areal extent are not known. Consequently, Stage 2 monitoring is recommended at this site to detemine:

- The specific compounds occurring in soils, their magnitude and their extent; and
- The specific compounds in groundwater.

The first goal can be met by:

- Sampling surficial soil at the Stage 1 sampling location and at 6 proposed locations shown in Figure 6-4;
- Performing a soil boring to a minimum depth of 25 feet below land surface, or until no obvious signs of contamination occur, with samples taken at 3-foot intervals;
- Analyzing samples from SD4-1, the 3 proposed sampling locations closest in proximity to the site, and the above-referenced soil boring for volatile organic compounds using EPA Method 8010-8020 and for base/neutral and acid extractable organic compounds using EPA Method 8250;
- Analyzing samples from the 3 proposed locations peripherally located at a greater distance from the site for indicator parameters TOX and oil and grease.

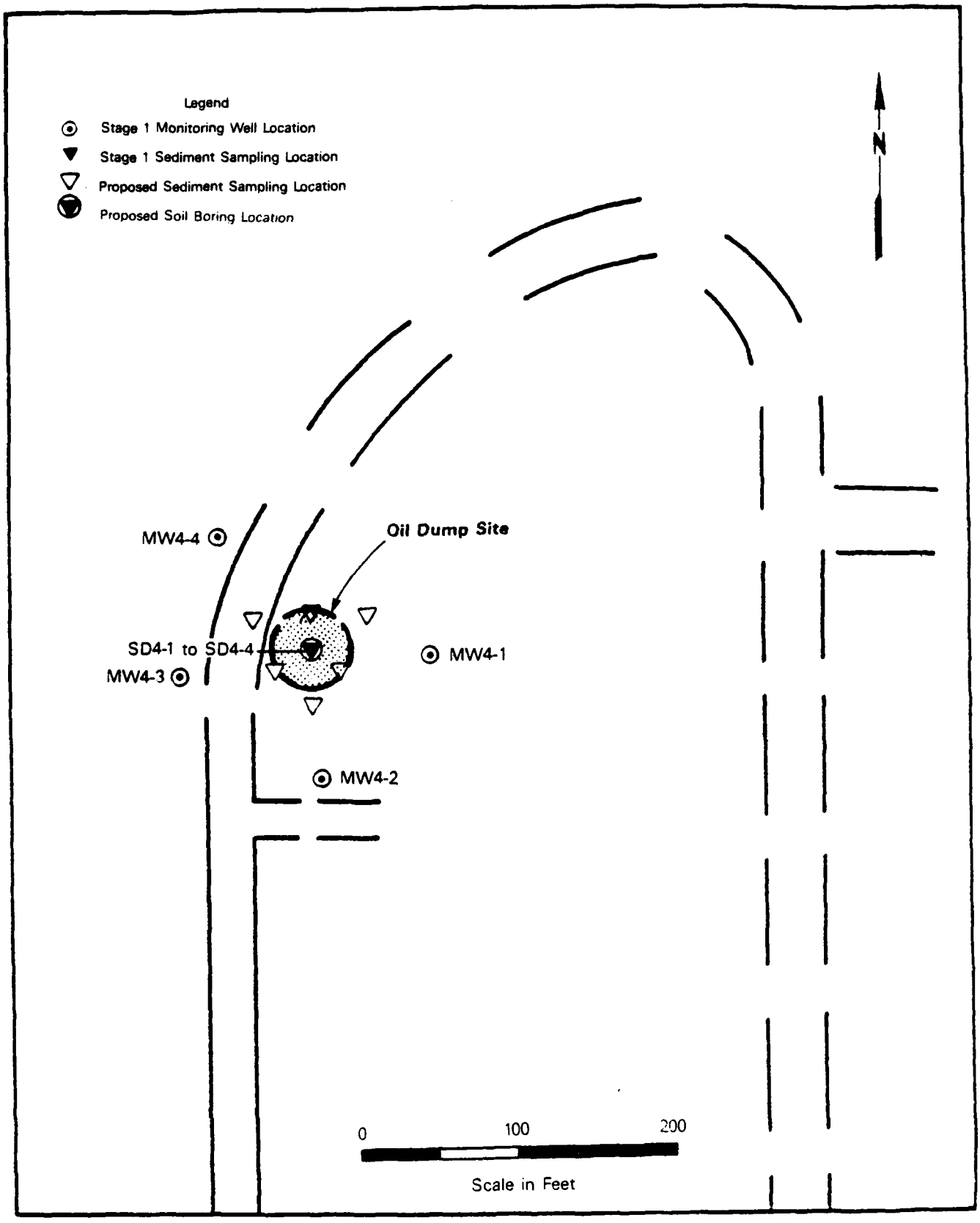


Figure 6-4. Proposed Soil Sampling Plan for Site No. 4: Oil Dump Site.

This soil monitoring scheme provides compound specific analysis at locations areally and at depth, while providing a cost savings for contaminant indicator analysis of samples at a greater distance from the site. The information obtained from the recommended soil monitoring will permit contaminants and their extent in soils at the site to be better defined.

From Stage 1 data, it cannot be determined what specific contaminants occur in groundwater at the site. Therefore, to meet the second goal of identifying compounds in groundwater, resampling of the 4 Stage 1 monitoring wells should be considered. It is recommended that these samples be analyzed for volatile organic compounds according to EPA Method 601-602. This recommendation should confirm the presence or absence of specific contaminants suggested by elevated Stage 1 TOX levels in groundwater at the site.

6.1.6 Unofficial Dump Site: Site No. 6

Groundwater sample analyses indicated no contamination of this media at the Unofficial Dump Site. However, in the single soil sample analyzed during Stage 1, oil and grease was found at 170 mg/kg. Although this elevated level of oil and grease indicates soil contamination, the specific identity of contaminants and their areal extent are not known. Consequently, Stage 2 soil monitoring is recommended to determine the specific compounds in soil and the areal extent of those compounds.

To accomplish these objectives, it is recommended that:

- Surficial soils be sampled at the Stage 1 monitoring location and at 6 additional proposed locations shown in Figure 6-5;
- A soil boring should be performed to a minimum depth of 25 feet below land surface, or until no obvious signs of contamination occur, with samples taken at 3 foot intervals;
- Samples at SD6-1, the 3 proposed locations closest in proximity to the site, and the soil boring should be analyzed for volatile organic compounds using EPA Method 8010-8020 and for base/neutral and acid extractable compounds using EPA Method 8250; and
- Analyses should be performed for TOX and oil and grease on the surficial soil sampled at the 3 proposed locations peripherally at a greater distance from the site.

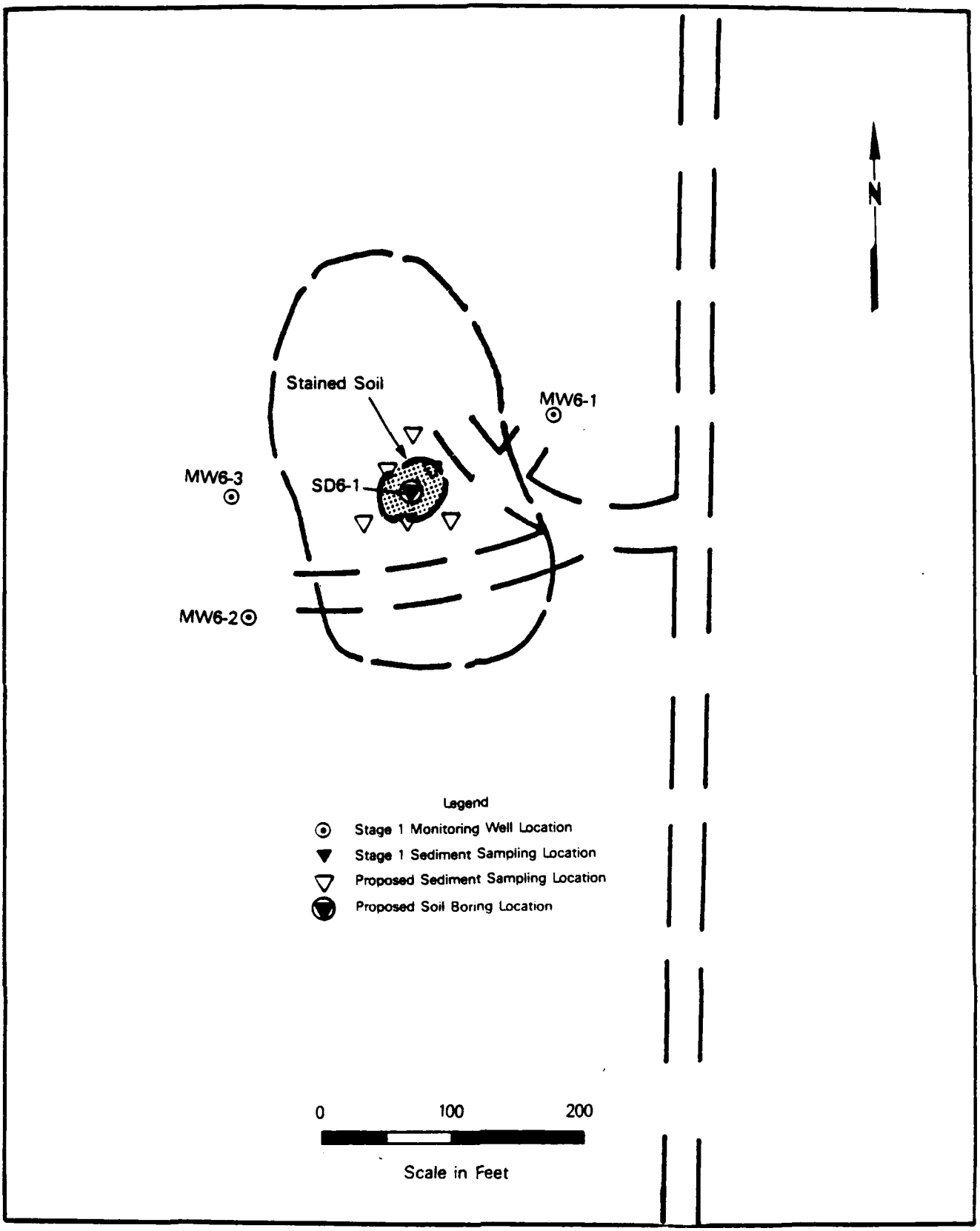


Figure 6-5. Proposed Soil Sampling Plan for Site No. 6: Unofficial Dump Site.

As recommended, this soil monitoring plan should provide sufficient information to confirm the levels of specific contaminants and their extent in soils at the site.

6.2 CATEGORY I SITES

6.2.1 C-141 Spill Trench: Site No. 5

No contamination at levels of concern (i.e. above anticipated background levels) was found in either groundwater or sediment samples analyzed during Stage 1 at this site. The three monitoring wells and four sediment sampling points were located such that any contamination would certainly have been detected. Consequently, this site is assigned to Category I, and no further IRP-related monitoring is recommended.

However, as described in sections 4.0 and 5.0 of this report, ethylbenzene and inorganic contaminants have been found in sediment sample SD2-3, obtained directly downstream from the spill trench. Since no Stage 1 findings suggest the spill trench to be a source of this type of contamination, this problem will be addressed subsequently in monitoring recommendations for Cedar Creek and its tributary drainage swale (see Section 6.1.9).

6.2.2 The Drainage Pond/Swamp: Site No. 7

From Stage 1 data there is no indication that the Drainage Pond/Swamp is in itself a source of contamination. The contaminants found in sediments off-base at locations SD7-5 and SD7-6 do not appear to be a result of discharge from the site. Consequently, this site is assigned to Category I, and no further IRP-related work is recommended for the drainage pond/swamp.

However, upstream sediment sample analysis at SD7-1 indicated high levels of oil and grease (110 mg/kg). Although not strictly a Phase II activity, consideration should be given to confirming this elevated oil and grease value and, if necessary, to determining via sampling at additional points the source, identity, and specific compounds responsible for the elevated oil and grease levels. Sampling should be considered for sediment (and surface waters, if present) above and below any drainage from the petroleum, oil, and

lubricant area to evaluate whether contamination exists, and if so, what compounds are present and to what extent they are present. Specific additional sampling, if given future consideration, should also be conducted at SD7-1, the upstream end of the drainage pipe that discharges at SD7-1, and the point in the swale (below SD7-1) where it discharges to Site No. 7. Such samples, if collected, would require analysis for volatile organic compounds, (EPA Method 8010-8020) and for base/neutral and acid extractable compounds (EPA Method 8250).

6.3 CEDAR CREEK AND TRIBUTARY DRAINAGE SWALE

Surface water and sediment samples from Cedar Creek and a major tributary drainage swale were analyzed during Stage 1 to evaluate any potential contaminant movement off-base from the study sites at McEntire ANG Base. Surface waters within Cedar Creek were found to contain tetrachloroethylene and 1,1,2,2-tetrachloroethane, with potentially harmful concentrations noted at one upstream station (SD2-1). Sediment samples were found to contain metals, and at sampling location SD2-3 within the tributary drainage swale, ethylbenzene was detected. Based on Stage 1 findings, no conclusive correlation exists between the contaminants noted in the stream and swale and the specific sites studies. However, to confirm definitively that study sites at McEntire ANG Base have not contributed to this contamination, additional monitoring is strongly recommended.

The recommended monitoring is primarily an extension of the Stage 1 effort and is directed toward providing a definitive understanding of the contaminants in Cedar Creek and the tributary drainage swale as they relate to the study sites. Monitoring for Stage 2, if implemented, should include surface water and sediment sampling at the 8 locations shown in Figure 6-6. Six of the proposed locations generally correspond to the Stage 1 sample points: samples should be collected specifically at points SW/SD 2-1, SD2-3, and SW/SD2-6; SW/SD2-2 and SW/SD2-5 should be slightly adjusted from their Stage 1 locations to points on Cedar Creek immediately upstream and downstream from the mouth of the drainage swale; and SD2-4 should be moved to a point slightly farther upstream from the mouth of the drainage swale. Two

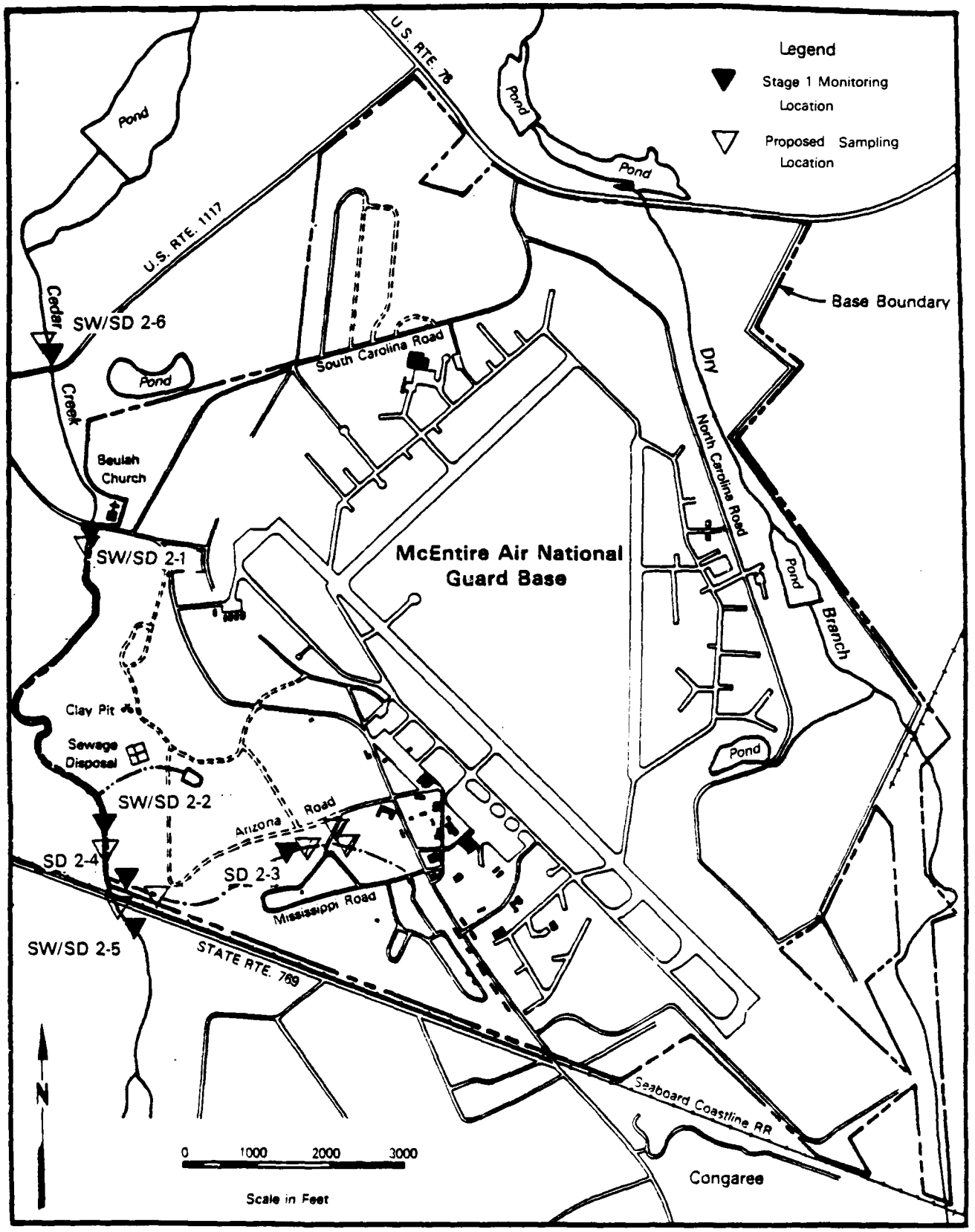


Figure 6-6. Proposed Sampling Plan for Cedar Creek and Tributary

additional sampling locations are proposed upstream from point SD2-3, as shown, to better define the occurrence of the contaminants observed at SD2-3. These points are in the previously examined C-141 Spill Trench (at its downstream end) and at the mouth of an adjacent tributary or swale that joins the spill trench at its downstream end.

Given the toxicity of the contaminants found and the threat they pose to human health and the environment, a full Priority Pollutant Scan is recommended to further clarify and identify compounds present at the two sampling points on Cedar Creek immediately upstream and downstream from the drainage swale/tributary's mouth. Although costly, this analytical recommendation would permit determination of whether Phase II study sites are contributing to Cedar Creek contamination. Specifically, the change in priority pollutant levels between the aforementioned points would identify any previously undetected contaminant migration from the study sites at the base. Although this method alone will not confirm the source of any contamination, it would allow for better parameter definition to do so.

The remaining 6 recommended surface water and sediment sampling locations should all be analyzed for volatile organics (EPA Methods 601-602 for water, 8010-8020 for sediment) and for metals from the Priority Pollutant list.

A second aspect of the Phase II, Stage 2 monitoring recommendation for Cedar Creek addresses that portion of the stream from Stage 1 sampling location SW/SD2-1 upstream. This point showed, as noted in Sections 4.0 and 5.0 of this report, potentially harmful levels of tetrachloroethylene and 1,1,2,2-tetrachloroethane in the creek's surface waters. While this point is upstream from much of McEntire ANG Base, there is a portion of the base's northwest corner that does drain to Cedar Creek upstream from this sampling point. It is strongly recommended that, in order to definitively confirm that these seriously high contaminant levels are not emanating from the base, both Cedar Creek itself and the base boundary be walked from sampling point SW/SD2-1 upstream to the farthest point of possible base drainage into Cedar Creek to assure that there are no previously unidentified, overlooked, or intermittent discharges from base property that might contribute to these contaminant

levels. Should any such discharges be identified during this suggested effort, sampling locations and analytical requirements would have to be formulated at that time. As noted, this recommendation is viewed as being precautionary, since there is no reason to believe, based on available data, that the contaminants in Cedar Creek originate on the designated sites at McEntire ANG base.

APPENDICES

A. GLOSSARY OF ABBREVIATIONS AND TERMINOLOGY

B. MEASURING UNIT CONVERSIONS

C. SCOPE OF WORK

D. MONITORING WELL AND SAMPLE NUMBERING SYSTEM

E. WELL CONSTRUCTION SUMMARIES AND BORING LOGS

F. AQUIFER TEST DATA

G. ANALYTICAL DATA

H. QUALITY CONTROL REPORT

I. CHAIN OF CUSTODY FORMS

J. STATE CORRESPONDENCE

K. REFERENCES

L. RESUMES

APPENDIX A

GLOSSARY OF ABBREVIATIONS AND TERMINOLOGY

ABBREVIATIONS

AF	Air Force
Ag	Silver
ALS	Above Land Surface
AMSL	Above Mean Sea Level
ANG	Air National Guard
As	Arsenic
ATV	All Terrain Vehicle
AVGAS	Aviation Gasoline
BLS	Below Land Surface
BTR	Below Top of Riser
BW	Bailer Wash
C	Cuttings
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
CN	Cyanide
Cr	Chromium
Cu	Copper
DOD	Department of Defense
DOW	Description of Work
DRMO	Defense Reutilization Marketing Office
EDM	Electronic Distance Meter
EPA	Environmental Protection Agency
ERG	Environmental Research Group
FB	Field Blank
Fe	Iron
FIT	Field Investigation Team
ft	feet
ft/day	feet per day
ft/sec	feet per second
ft/year	feet per year
gals	gallons
gpd	gallons per day
gpm	gallons per minute

HARM	Hazard Assessment Rating Methodology
Hg	Mercury
HMTC	Hazardous Materials Technical Center
ID	Inside diameter
IRP	Installation Restoration Program
JP-4	Jet Propulsion Fuel No. 4
K	Hydraulic Conductivity
MGD	Million gallons per day
mg	milligrams
mg/l	milligrams per liter
ml	milliters
MOGAS	automobile gasoline
MSL	Mean Sea Level
Ni	Nickel
No_3	Nitrate Nitrogen
OD	Outside Diameter
OEHL	Occupational & Environmental Health Laboratory
O&G	Oil & Grease
Pb	Lead
POL	Petroleum, Oils & Lubricants
ppb	parts per billion (equivalent to micrograms per liter-ug/l)
ppm	parts per million (equivalent to milligrams per liter-mg/l)
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RE	Recovery
SAIC	Science Applications International Corporation
SCANG	South Caroline Air National Guard
Se	Selenium
SI	Sample Interval
SS	Split Spoon
TAC	Tactical Air Command
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TOX	Total Organic Halogens
ug/l	Micrograms per liter

USAF	United States Air Force
USGS	United States Geological Survey
v	Velocity
VOA	Volatile Organics Analysis - EPA Methods 601-602
Zn	Zinc

TERMINOLOGY

Air Surging	A procedure for developing wells whereby compressed air is pumped down a well and allowed to bubble up through the water column in the well.
Alconox	A low residue detergent utilized for decontamination procedures.
Anisotropic	Having physical properties that vary in different directions.
Annular Space	The space between a borehole and the outside of a well screen or casing.
Aquifer	A geologic formation, group of formations, or part of a formation that is capable of yielding water to a well or spring.
Auger	A screwlike boring tool resembling a carpenter's anger bit but much larger, usually motor-driven, designed for use in clay, soil, and other relatively unconsolidated near-surface materials.
Bed	Any tabular body of rock lying in a position essentially parallel to the surface or surfaces on or against which it was formed, whether these be a surface of weathering and erosion, planes of stratificaton, or inclined fractures.
Bedding	The arrangement of rock in layers, strata, or beds.
Bedrock	The more or less solid, undisturbed rock in place either at the surface or beneath surficial deposits of gravel, sand, or soil.
Bentonite	Rock composed of any of the montmorillonite-beidellite group of clay minerals.
Berm	Relatively narrow, horizontal or gently sloping man-made bench or shelf.
Blow Count	The total number of strikes with a free-falling weight needed to drive a sampler a given distance into the ground.
Boring Log	Systematic and sequential record of geologic data obtained from a soil boring.
Clay	Fine-grained aggregate consisting wholly or dominantly of microscopic and submicroscopic mineral particles.
Coastal Plain	Physiographic province of the Eastern United States characterized by a gently seaward sloping surface formed over exposed, unconsolidated, stratified marine fluvial sediments. Typical coastal plain features

Coastal Plain (continued)	include low hills and ridges, organic deposits, floodplains and high water tables.
Cone of Depression	The depression, roughly conical in shape, produced in a water table or potentiometric surface by pumping or artesion flow.
Confining bed, layer, or unit	Body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers.
Cretaceous	The third and latest period of the mesozoic era.
Cross-section	Geologic diagram or actual field exposure showing the geologic formations and structures transected by a given plane.
Diffusion	The spreading out of molecules, atoms, or ions into a porous medium in a direction tending to equalize concentrations in all parts of the system.
Dip	Angle at which a stratum or any planar feature is inclined from the horizontal.
Discharge	Rate of flow at a given instant in terms of volume per unit of time.
Downgradient	In the direction of decreasing hydraulic static head; the direction in which groundwater flows.
Drawdown	A lowering of the water table or potentiometric surface caused by pumping of groundwater from wells.
Effective Porosity	The amount of interconnected pore space through which fluids can pass.
EPA Method 601	GC test method for the determination of 29 purgeable halocarbons.
EPA Method 602	GC test method for the determination of 7 purgeable aromatics.
Evapotranspiration	A term embracing that portion of the precipitation returned to the air through direct evaporation or by transpiration of vegetation, no attempt being made to distinguish between the two.
Facies	A stratigraphic body as distinguished from other bodies of different appearance or composition.
Fluvial	Of or pertaining to rivers or river action.
Flow Path	The direction or movement of groundwater as governed principally by the hydraulic gradient.

Friable	Easily crumbled, pulverized, or reduced to powder.
Gravel	Loose or unconsolidated coarse granular material, larger than sand grains, resulting from erosion of rock by natural agencies.
Groundwater	Subsurface water in a zone of saturation.
Hard Stand	Parking area or ramp adjacent to taxiway where aircraft are parked or stored.
Hazardous Waste	A solid waste or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness, or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.
Heterogeneous	Differing in kind, having unlike properties, possessed of different characteristics.
Hydraulic Conductivity	A coefficient of proportionality describing the rate at which water can move through a permeable medium.
Hydraulic Gradient	The change in total head with a change in distance in a given direction. The direction is that which yields a maximum rate of decrease in head.
Impermeable	Not permitting passage, as a fluid through a solid.
Leachate	A solution resulting from the separation or dissolving of soluble or particulate constituents from solid waste or other man-placed medium by percolation of water.
Leaching	The process by which soluble materials in the soil, such as nutrients, pesticide chemicals or contaminants, are washed into a layer of soil or are dissolved and carried away by water.
Lens	Body of rock material bounded by converging surfaces, at least one of which is curved.
Lithology	Study of stones or rocks.
Miocene	The fourth of the five epochs of the Tertiary period, occurring between 12 and 26 million years ago.
Monitoring Well	A well used to measure groundwater levels and to obtain samples.
Net Precipitation	The amount of annual precipitation minus annual evaporation.

Organic	Being, containing, or relating to carbon compounds, especially in which hydrogen is attached to carbon.
Outcrop	Part of a body of rocks that appears bare and exposed at the surface of the ground.
Overland Flow	The flow of water over a land surface due to direct precipitation, generally occurring when the precipitation rate exceeds the infiltration capacity of the soil and depression storage is fuller.
Period	Fundamental unit of the geologic time scale.
Permeability	The capacity of a porous rock, soil, or sediment for transmitting a fluid without damage to the structure of the medium.
pH	Negative logarithm of hydrogen ion concentration.
Piezometric Surface	An imaginary surface that everywhere coincides with the static water level in the aquifer.
Pleistocene	First epoch of the Quaternary period, in general including the time and deposits of the last great glacial epoch.
Potentiometric Surface	A surface that represents the level to which water will rise in tightly cased wells. The water table is a particular potentiometric surface for an unconfined aquifer.
Porosity	Property of a rock containing interstices without regard to size, shape, intercommunication, or arrangement of openings.
Recharge	Intake, the process by which water is absorbed and is added to the zone of saturation, either directly into a formation, or indirectly by way of another formation. Also, the quantity of water that is added to the zone of saturation.
Regression	The retreat of water from a land surface and the consequent evidence of this retreat in the character and relations of the newer and older strata.
Riser	Length of PVC casing stickup above land surface.
Sand	An aggregation of unlithified mineral or rock particles the diameters of which are usually considered to be less than 2mm and greater than 1/16mm.
Scarp	A straight slope of any height, generally no steeper than 45 degrees.
Silt	Muddy sediment, coarser than clay, but finer than sand, which has been carried or deposited by a body of water.

Sorting	Separation and segregation of rock fragments according to size or specific gravity by natural processes, mainly by the action of running water.
Specific Capacity	An expression of the productivity of a well, obtained by dividing the rate of discharge of water from the well by the drawdown of the water level in the well.
Specific Gravity	The ratio of the mass of a body to the mass of an equal volume of water at 4°C or other specified temperatures.
Specific Yield	The ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of the rock or soil.
Split Spoon	A type of soil sampler consisting of a length of hollow tubing split lengthwise and threaded at both ends. A drive head and a coupling hold the two halves together. The sampler is pounded into the soil a set distance. The sample is examined by removing the drive head and coupling and opening the split barrel.
Stratified	Arranged or formed in layers.
Stratum	Single layers of homogeneous gradational lithology deposited parallel to the original dip of the formation.
Strike	The direction or bearing of the outcrop of an inclined bed or structure on a level surface, perpendicular to the direction of the dip.
Terrace	A natural or artificial plain with the surface ascending on one side and descending on the other, may be formed by sediment deposition by water, wave cutting action, or crustal movements.
Tertiary	The first period of the Cenozoic era.
Transgression	The gradual spread of water over a land surface and the consequent evidence of this invasion shown in the character and relations of newer and older strata.
Transmissivity	The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit of hydraulic gradient. Transmissivity can be calculated by multiplying the hydraulic conductivity by the aquifers saturated thickness.
Upgradient	In the direction of increasing hydraulic static head; the direction opposite to the prevailing flow of groundwater.

Water Table	Upper surface of a zone of saturation except where that surface is formed by an impermeable body.
Well Log	Systematic and sequential record of geologic data obtained from a well.

APPENDIX B

MEASURING UNIT CONVERSIONS

MEASURING UNIT CONVERSION TABLE

S.I. UNITS	LENGTH	METRIC
inch (in)	x 2.54	= centimeter (cm)
foot (ft)	x 0.3048	= meter (m)
mile (mi)	x 1.608	= kilometer (km)
	VOLUME	
U.S. gallon (gal)	x 0.0038	= cubic meter (m^3)
cubic feet (ft^3)	x 0.0283	= cubic meter
acre-foot (ac. ft)	1233.48	= cubic meter
	AREA	
square inch (in^2)	x 6.452	= square centimeter (cm^2)
square foot (ft^2)	x 0.09	= square meter (m^2)
acre (ac)	x 0.4047	= hectare (ha)
	MASS	
ounce (oz)	X 28	= gram (g)
pound (lb)	x 0.45	= kilogram (kg)
short ton	x 0.9	= metric ton (t)
	DENSITY	
Pounds per cubic foot (pcf)	x 0.016	= grams per cubic centimenter (g/cm^3)
	HYDRAULIC CONDUCTIVITY	
gallons per day per square foot (gpd/ft^2)	x 4.72×10^{-5}	= centimeters per second (cm/sec)
Darcy	x 8.58×10^{-4}	= centimeters per second
	TRANSMISSIVITY	
gallons per foot per day (gpd/ft)	x 0.012	= square meters per day (m^2/d)
square feet per day (ft^2/dy)	X 0.093	= square meters per day (m^2/d)

APPENDIX C

SCOPE OF WORK

Installation Restoration Program
Phase II Field Evaluation
McEntire Air National Guard Base SC*

I. Description of Work

The purpose of this task is to determine if environmental contamination has resulted from waste disposal practices, fuel spills and fire training activities at McEntire Air National Guard Base SC; to provide estimates of the magnitude and extent of contamination, should contamination be found; to identify potential environmental consequences of migrating pollutants; to identify any additional investigations and their attendant costs necessary to properly evaluate the magnitude, extent, and direction of movement of discovered contaminants.

Ambient air monitoring of hazardous and/or toxic material for the protection of contractor and Air Force personnel shall be accomplished when necessary, especially during the drilling operation.

The presurvey report (mailed under separate cover) and Phase I IRP report (mailed under separate cover) incorporated background and description of the sites for this task. To accomplish the survey effort, the contractor shall take the following steps:

A. General

1. Determine the aerial extent of each site by reviewing available aerial photos of the base, both historical and most recent panchromatic and infrared, and by field reconnaissance.

2. Locations where surface water, sediment, and core samples are collected shall be marked with an easily identifiable and retraceable marker, and the location recorded on a site map.

3. A total of 23 ground-water monitoring wells shall be installed. The exact location of wells shall be determined in the field.

4. Ground-Water Monitoring Well Installation: Ground-water monitoring wells shall be drilled using 6-inch hollow-stem augers. Split-spoon samples wil be taken and described in accordance with ASTM Standard 1586. Each well shall be constructed of 2-inch I.D. Schedule 40 flush joint PVC casing and screen. Each well shall be an average of 50 feet in depth. The screened interval in each well shall consist of 0.01 inch slotted PVC screen, depending upon the geologic findings during the drilling operation. Each well shall be screened 20 feet into the shallow groundwater table aquifer. A gravel pack or sand pack, as determined in the field as suitable for the soil formation, shall be emplaced around the well screen. The gravel pack shall extend 2 feet above the top of the screen. A 2-foot layer of bentonite pellets shall be placed above the gravel pack to seal the screened interval, and the seal shall be completed using a bentonite grout mixture to the surface. Each well shall be provided with a surface grout seal and protective, 5-foot steel casing with locking cap. All wells shall be developed until they produce clear, sand-free water. Each well shall be clearly numbered with exterior paint and be provided with three guard posts

*Highlights of Modification are underscored

placed radially away from each well. Each well installed around Site 3, Y-Area Storage Site, shall be provided with four protective steel guard posts since Site 3 is located in a high traffic area. All guard posts and steel casings shall be painted fluorescent orange for easy visibility.

5. Ground-water monitoring wells shall comply with U.S. EPA publication 330/9-81-002 NEIC Manual for Groundwater/Subsurface Investigations at Hazardous Waste Sites, and State of South Carolina requirements for monitoring well installation. All wells shall be developed, water levels measured, and locations surveyed and recorded on a site map. Only screw type joints shall be used. Glue fittings are not permitted.

6. All water samples shall be analyzed on site by the contractor for pH, temperature, and specific conductance. Sampling, maximum holding time, and preservation of samples shall comply strictly with the following references: Standard Methods for the Examination of Water and Wastewater, 15th Ed. (1980), pp 35-42; ASTM, Section 11, Water and Environmental Technology; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp xiii to xix (1979). All water samples shall be analyzed using minimum detection levels, as specified in Attachment 1.

7. The contractor shall split all water and soil samples. One set of samples shall be analyzed by the contractor and the other set of samples shall be forwarded for analysis through overnight delivery to:

USAF OEHL/SA
Bldg 140
Brooks AFB TX 78235

The samples sent to the USAF OEHL/SA shall be accompanied by the following information:

(a) Purpose of sample (analyte)

(b) Installation name (base)

(c) Sample number (on containers)

(d) Source/location of sample

(e) Contract Task Numbers and Title of Project

(f) Method of collection (bailer, suction pump, air-lift pump, etc.)

(g) Volumes removed before sample taken

(h) Special Conditions (use of surrogate standard, special nonstandard preservations, etc.)

(i) Preservatives used

This information shall be forwarded with each sample by properly completing an AF Form 2752 (copy of form and instructions on proper

completion mailed under separate cover). In addition, copies of field logs documenting sample collection should accompany the samples. Chain-of Custody records for all samples, field blanks, and quality control duplicates shall be maintained. All contractor QA/QC program analysis results shall be included in the analytical results of draft final report (as specified in Item VI below).

8. Second-column confirmation shall be required when detection limits exceed values identified in Attachment 1, for EPA Methods 8010, 8020, 601 and 602. Conduct second-column confirmation on a maximum of 50% of the samples collected for these analyses. Total number of samples for Methods 8010, 8020, 601 and 602 in Attachment 1 include these confirmation analyses. Report concentrations as non-detected where the second column does not confirm the analyte to be present. Report the first column result where the second cloumn does provide confirmation of the analyte. Report all procedures and conditions used. Also report the different retention times for major components.

. Field data collected for each site shall be plotted and mapped. The nature of contamination and the magnitude and potential for contaminant flow within each site to receiving streams and ground waters shall be determined or estimated. Upon completion of the sampling and analysis, the data shall be tabulated in the next R&D Status report, as specified in Item VI below.

B. In addition to items delineated in A above, conduct the following specific actions at sites identified on McEntire Air National Guard Base SC:

1. Resampling of Base Well W1

Collect one ground-water sample from base water supply production well W1. The ground-water sample shall be analyzed for the purgeable compounds specified in U.S. EPA Methods 601 and 602.

2. Site 1. Fire Training Area 5

a. Install 4 ground-water monitoring wells in the immediate vicinity of the site. One well shall be placed upgradient of the site and three wells shall be placed downgradient of the site. All wells shall be positioned to surround the site to detect any contaminants which may be present and to supply head levels from which groundwater flow direction can be determined. Each well shall be an average of 50 feet in depth; total footage drilled shall not exceed 280 feet.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for Volatile Organic Compounds (VOC), Oil and Grease-Infrared Method (O&G/IR), Total Organic Carbon (TOC), and Total Organic Halogens (TOX).

d. Collect surface water and sediment samples from one location within the burn area. The surface water and sediment samples shall be collected with a malgene scoop having a 9-10 foot extension handle. One surface water and one sediment sample shall be analyzed.

e. The surface water sample shall be analyzed for VOC, O&G/IR, TOC, and TOX. The sediment sample shall be analyzed for VOC, O&G/IR, and TOX.

f. Collect three near-surface soil samples with a hand auger along the overflow drainage swale leading from the site. Each soil sample shall be collected to a depth of approximately 1 foot.

g. Each soil sample shall be analyzed for VOC, O&G/IR, and TOX.

3. Site 2. Fire Training Area 1 and Sanitary Landfill

a. Install 4 ground-water monitoring wells in the immediate vicinity of the site. One well shall be placed upgradient of the site and three wells shall be placed downgradient of the site. Each well shall be an average of 50 feet in depth; total footage drilled shall not exceed 280 feet.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for VOC, O&G/IR, TOC, TOX and the heavy metals specified in Attachment 1.

d. Collect surface water and sediment samples from four sampling locations along Cedar Creek. In addition, collect a surface water and sediment sample from one sampling location in the tributary drainage ditch that enters Cedar Creek near the site, downgradient of the temporary dam location at Site 5, C-141 Spill Trench. A maximum of 5 surface water and 5 sediment samples shall be analyzed.

e. Each surface water sample shall be analyzed for VOC, O&G/IR, TOC, TOX, and the heavy metals specified in Attachment 1. Each sediment sample shall be analyzed for VOC, O&G/IR, TOX, and the heavy metals specified in Attachment 1.

4. Site 3. Y-Area Storage Site

a. Install 4 ground-water monitoring wells in the immediate vicinity of the site. One well shall be placed upgradient of the site and three wells shall be placed downgradient of the site. All wells shall be positioned so as to surround the site. Each well shall be an average of 50 feet in depth; total footage drilled shall not exceed 280 feet.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for O&G/IR, TOC, and TOX.

d. Collect three near-surface samples with a hand auger along the periphery of the concrete pad. Each soil sample shall be collected to a depth of approximately 1 foot.

e. Each soil sample shall be analyzed for O&G/IR and TOX.

5. Site 4. Oil Dump Site

a. Install 4 ground-water monitoring wells in the immediate vicinity of the site. One well shall be placed upgradient of the site and three wells shall be placed downgradient of the site. Each well shall be an average of 50 feet in depth; total footage drilled shall not exceed 280 feet.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for O&G/IR, TOC, and TOX.

d. One soil boring shall be drilled at the center of the site. Boring shall be advanced to the groundwater table. Soil boring shall be completed utilizing hollow stem augers. Upon withdrawal of the augers, the borehole shall be grouted with a bentonite cement mixture from the bottom of the borehole to the ground surface to avoid downward percolation of contaminated material. Soil samples shall be retained for analysis at 5-foot intervals from the surface to 30 feet below the surface (BLS), and at the saturated/unsaturated zone interface. A maximum of 7 soil samples shall be analyzed.

e. Each soil sample shall be analyzed for O&G/IR and TOX.

6. Site 5. C-141 Spill Trench

a. Install 3 ground-water monitoring wells in the immediate vicinity of the site. One well shall be placed upgradient of the site and two wells shall be placed downgradient of the site. All wells shall be positioned at the downgradient end of the trench near the temporary dam location. Each well shall be an average of 50 feet in depth; total footage drilled shall not exceed 210 feet.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for O&G/IR, TOC, and TOX.

d. Collect surface water and sediment samples from three locations along the trench. The sampling points shall be located one at each end of the trench and one from the center of the trench. A maximum of three surface water and three sediment samples shall be analyzed.

e. Each surface water sample shall be analyzed for O&G/IR, TOC, and TOX. Each sediment sample shall be analyzed for O&G/IR, and TOX.

7. Site 6. Unofficial Dump Site

a. Install 4 ground-water monitoring wells in the immediate vicinity of the site. One well shall be placed upgradient of the site and three wells shall be placed downgradient of the site. Each well shall be an average of 50 feet in depth; total footage drilled shall not exceed 280 feet.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for O&G/IR, TOC, TOX. and the heavy metals specified in Attachment 1.

8. Site 7. Drainage Pond/Swamp

a. Collect surface water and sediment samples from three locations in the vicinity of the site. One sampling location shall be near the discharge pipe, the second sampling location shall be along the boundary line of the base near the site, and the third sampling location shall be approximately midway between these two points. A maximum of three surface water and three sediment samples shall be analyzed.

b. Each surface water sample shall be analyzed for O&G/IR, TOC, TOX, nitrates and phosphates. Each sediment sample shall be analyzed for O&G/IR and TOX.

C. Well Installation and Clean-up

The well and boring area shall be cleaned following the completion of each well and boring. The contractor shall determine those drill cuttings suspected as being hazardous waste based upon discoloration, odor, or organic vapor detection instrument. If hazardous waste is suspected in the process of well installation, the contractor shall be responsible for proper containerization of drill cuttings for eventual government disposal. The contractor shall test four samples of the suspected hazardous waste for EP Toxicity and Ignitability as specified in Attachment 1. Disposal of drill cuttings is not the responsibility of the contractor.

D. Results of all sampling and analysis shall be tabulated and incorporated in the Informal Technical Information report (Sequence 3, Atch 1 and Sequence 2, Atch 3 as specified in Item VI below) and forwarded to USAF OEHL/TS for review.

E. Reporting

1. A draft report delineating all findings of this field investigation shall be prepared and forwarded to the USAF OEHL, as specified in Item VI below, for Air Force review and comment. This report shall include a discussion of the regional site specific hydrogeology, well and boring logs, data from water level surveys, water quality and soil analysis results, available geohydrologic cross sections, groundwater and gradient vector maps and laboratory quality assurance information. The report shall follow the USAF OEHL format (mailed under separate cover).

2. The recommendation section will address each site and list them by categories. Category I will consist of sites where no further action, including remedial action, is required. Data for these sites are considered sufficient to rule out unacceptable health or environmental risks. Category II sites are those requiring additional monitoring or work to quantify or further assess the extent of current or future contamination. Category III sites are sites that will require remedial actions (ready for IRP Phase IV actions). In each case the contractor will summarize or present the results of field data, environmental or regulatory criteria, or other pertinent information supporting these conclusions.

F. Cost Estimates

The contractor shall provide cost estimates for all additional work recommended to permit proper determination of contaminants. The recommendations provided shall include all efforts required to determine the magnitude and direction of movement of discovered contaminants along with an estimate of the time required to accomplish the proposed effort. This information shall be provided in a separately bound appendix to the final report.

G. Meetings

The contractor's project leader shall attend one meeting with Air Force officials and regulatory agency representatives to present and discuss results of this investigation. This meeting shall take place at McEntire Air National Guard Base SC for eight hours at a time to be specified by the USAF OEHL.

II. Site Location and Dates:

McEntire Air National Guard Base SC
Time and Dates
To be established

III. Base Support: None

IV. Government Furnished Property: None

V. Government Points of Contact:

1. 1Lt Maria R. LaMagna
USAF OEHL/TS
Brooks AFB TX 78235
(512) 536-2158
AV 240-2158

2. TSgt Mitch Brockman
169 TAC Clinic/SGPB
McEntire ANG Base, Eastover SC 29044
(803) 776-5121, Ext 396
AV 583-8396

3. 1Lt Zollie Green
169 Civil Engineering Flight
McEntire ANG Base, Eastover SC 29044
(803) 776-5121, Ext 291
AV 583-8291

4. Lt Col Michael C. Wasbeleski
ANGSC/SGB
Andrews AFB MD 20331
(301) 981-5926
AV 858-5926

VI. In addition to sequence numbers 1, 5 and 11 which are applicable to all orders, the reference numbers below are applicable to this order. Also shown are data applicable to this order:

Sequence No.	Block 10	Block 11	Block 12	Block 13	Block 14
Atch 1					
4	ONE/R	85AUG05	85 ~~OCT~~ NOV 05	86 ~~JAN~~ FEB 05	*
3	O/TIME	**	**		2
Atch 5					
2	O/TIME	**	**		2

*Two draft reports will be required. After incorporating Air Force comments concerning the first draft report, the contractor shall supply the USAF OEHL with one copy of the second draft report. Upon USAF OEHL acceptance of the second draft report, the contractor shall distribute the remaining copies per a USAF OEHL prepared distribution list. The contractor shall supply the USAF OEHL with 20 copies of each draft report and 50 copies plus the original camera-ready copy of the final report.

**Upon completion

Attachment 1

Levels of Detection Required

Levels of Detection are for water unless shown otherwise:

Analyte	Analytical Method	Detection Limit	No. Samples
Oil and Grease (IR)	EPA 413.2	100 µg/L (water); 100 µg/g (soil)	35W; 25S
*Total Organic Carbon (TOC)	EPA 415.1	1000 µg/L	35W
*Total Organic Halogens (TOX)	EPA 9020	5 µg/L (water); 5 µg/g (soil)	35W; 25S
Volatile Organic Compounds (VOC)	EPA 601-602W ** EPASW-846/8010-8020S		27[a] 16[b] 27W; 14S
pH	EPA 150.1	±0.1 unit	36W
Specific Conductance	EPA 120.1	1 µmho/cm	36W
Arsenic (1)	EPA 206.2 or 206.3	10 µg/L	13W; 5S
Cadmium (1)	EPA 213.2	10 µg/L	13W; 5S
Chromium (1)	EPA 218.1	50 µg/L (water); 5 µg/g (soil)	13W; 5S
Copper (2)	EPA 220.1	20 µg/L	13W; 5S
Lead (1)	EPA 239.2	20 µg/L (water); 2 µg/g (soil)	13W; 5S
Mercury (1)	EPA 245.1 and EPA 245.5 (soil)	1 µg/L (water); 0.1 µg/g (soil)	13W; 5S
Nickel	EPA 249.1	100 µg/L	13W; 5S
Selenium (1)	EPA 270.3	10 µg/L	13W; 5S
Silver (1)	EPA 272.2	10 µg/L	13W; 5S
Zinc (2)	EPA 289.1	50 µg/L	13W; 5S
Nitrates	EPA 353.3	0.1 µg/L	3W
Phosphates	EPA 365.1	0.1 µg/L	3W
EP Toxicity	40 CFR 261.24	***	4
Ignitability	40 CFR 261.21	****	4

*Detection levels for TOX and TOC must be three times the noise level of the instrument. Laboratory distilled water must show no response. If so, corrections of positive results must be made.

••Determine limits for Volatile Organic Compounds as specified for the compounds by EPA Methods 601-602, for water samples and EPA Methods 8010 and 8020 for sediment and soil samples. Method: Federal Register, Vol. 44, No. 233, pp 69468-69473. this method should be strictly followed including these items:

Item 1.4 - This method is recommended by EPA for use only by experienced residue analysts or under the close supervision of such qualified persons.

Item 2.2 - This is most important. If interferences are encountered (as in early peaks such as vinyl chloride), the method provides a secondary gas chromatographic column that will be helpful in resolving the compounds of interest from interferences. This must be done in the case of vinyl chloride and so noted in analysis report.

Item 3.3 - 7.1-7.3 - These sections on interferences, contamination and QC should be strictly followed.

Item 8.3 - All samples must be analyzed within the recommended holding times. This must be followed without exception.

Second-column confirmation is required when values exceed:

Benzene	0.7 ug/L
Carbon Tetrachloride	4.0 ug/L
1,2 Dichloroethane	0.1 ug/L
Methylene Chloride	4.0 ug/L
Tetrachloroethylene	4.0 ug/L
Trichloroethylene	1.0 ug/L
Vinyl Chloride	1.0 ug/L
Dichlorobenzene isomers	Sum greater than 10 ug/L
Any other organics	Greater than 10 ug/L

Retention times on both columns must match before reporting positive value. If no match, it will be considered an interference.

If questions are encountered about certain contaminants, the contractor may be asked to show both chromatograms used to rule out possible interferences.

Detection limits for halogenated and aromatic volatile organics shall be as specified for compounds by EPA Methods 8010-8020. If the analytes analyses exceed 10 ug/g in soil, second-column confirmation is required.

***Metal	mg/L of Solution
As	10
Ba	200
Cd	10
Cr	50
Pb	20
Hg	1
Se	10
Ag	10

****Find if sample is ignitable at 140 degrees F or below. If so, it is a hazardous waste.

(1) = Primary Drinking Water Standard, 40 CFR 141.11.

(2) = Secondary Drinking Water Standard, 40 CFR 143.3.

a Total of 27 includes second-column confirmation for 50% of the samples.

b Total of 16 includes second-column confirmation for 50% of the samples.

APPENDIX D

MONITORING WELL AND SAMPLE NUMBERING SYSTEM

McENTIRE ANG BASE IRP PHASE II STAGE 1
MONITORING WELL AND SAMPLE IDENTIFICATION SYSTEM

Location	Monitoring Well No.	Groundwater Sample No.	Surface Water Sample No.	Soil/Sediment Sample No.
Site No. 1:	MW1-1	GW1-1		SD1-1
No. 5 Fire	MW1-2	GW1-2		SD1-2
Training Area	MW1-3	GW1-3		SD1-3
	MW1-4	GW1-4		SD1-4
Site No. 2:	MW2-1	GW2-1	SW2-1	SD2-1
No. 1 Fire	MW2-2	GW2-2	SW2-2	SD2-2
Training Area/	MW2-3	GW2-3	--	SD2-3
Sanitary	MW2-4	GW2-4	--	SD2-4
Landfill	MW2-5	GW2-5	SW2-5	SD2-5
			SW2-6	SD2-6
Site No. 3:	MW3-1	GW3-1		SD3-1
Y-Storage	MW3-2	GW3-2		SD3-2
Area	MW3-3	GW3-3		SD3-3
	MW3-4	GW3-4		
Site No. 4:	MW4-1	GW4-1		SD4-1
Oil Dump	MW4-2	GW4-2		SD4-2
Site	MW4-3	GW4-3		SD4-3
	MW4-4	GW4-4		SD4-4
Site No. 5:	MW5-1	GW5-1		SD5-1
C-141 Spill	MW5-2	GW5-2		SD5-2
Trench	MW5-3	GW5-3		SD5-3
				SD5-4
Site No. 6:	MW6-1	GW6-1		SD6-1
Unofficial	MW6-2	GW6-2		
Dump Site	MW6-3	GW6-3		
Site No. 7:				SD7-1
Drainage				SD7-2
Pond/Swamp				SD7-3
				SD7-4
				SD7-5
				SD7-6
Bldg. 145:	W-1	W-1		
Supply Well				
Bldg. 144:	W-2	W-2		
Supply Well				

Note: Sample No. = sample location.
-- = water not present for sampling.

McENTIRE ANGB - IRP PHASE II, STAGE I

MONITORING WELL AND SAMPLE IDENTIFICATION GUIDELINES

Monitoring wells will be designated by the letter "MW" followed by a digit for the site number. A second digit will be assigned, sequentially and in a clockwise manner (starting with the number (1) for the designated up-gradient well), to indicate location within a site. For example, MW1-1 = monitoring well, site number 1, location number 1.

Sampling locations and sample identification numbers will be designated by sample medium followed by two digits indicating site number and location within the site. The following codes will be used to designate the sample medium: GW = Groundwater; SW = Surface Water; SD = Soil/Sediment. For example, GW1-1 = groundwater sample, site number 1, location number 1. A minimum of four drill cutting samples will also be taken and tested for EP Toxicity and Ignitability. The letter "C" will be used to designate these samples, which will also be followed by the site and well number identifiers (e.g., C1-2 = cutting sample, site number 1, well number 2). Sampling location numbers will correlate with sample identification numbers. Use of this system will facilitate the addition of sampling points during later stages of the IRP Phase II site investigation program, if necessary, and will serve to eliminate potential miscorrelation of sample identification (and analytical results) with sample location.

For field QA/QC purposes a field blank and bailer wash will be prepared for each day of sampling. In addition, a duplicate sample will be obtained of approximately every tenth sample taken per medium. Field blanks and bailer washes will be designated by the letters "FB" and "BW," respectively, and will be followed by a digit indicating day of sampling. For example, FB-1 = field blank, day 1; BW-1 = bailer wash, day 1. Duplicate samples will be identified by placing the letter "D" after the identification number assigned for that point (e.g., GW3-2D = groundwater sample, site number 3, location number 2, duplicate). Because weather and site conditions will influence the order in which samples will be obtained, identification of duplicate sampling points cannot be made at this time. Sample identification numbers will be assigned at the time of sampling. Similarly, the location of cutting samples to be taken for EP Toxicity and Ignitability testing will be determined in the field. An appropriate sample identification number will also be assigned at that time.

ESE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 3-2

Site Sketch

Location: Y Area Storage Yard
Field Book No.: 3 pp 114-121
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 65.0'
Reference Point Elevation: 239.92

	Date	Time
Drilling Started:	4/17/85	0730hr
Drilling Completed	4/17/85	1053hr
Water Level: 46'BLS	4/17/85	1000hr

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-10%
Little 10-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Brown silty sand, some clay
2'			SI: 3.5 - 5.0' BLS RE: 1.5'
	SS #1	1	0.5' - Brown (10yr 4/4) sandy silt, some clay
		2	1.0' - Red (2.5yr 4/8) sandy clayey silt, firm
		8	
	C		Red sandy clayey silt
8'			SI: 8.5 - 10.0' BLS RE: 1.5'
	SS #2	5	1.5' - Red (2.5yr 4/8) sand clayey silt, firm
		9	
10'		11	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-2 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (BB)	DESCRIPTION
10'			
	C		Same as above
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	11	1.4' - Light red (2.5yr 5/8) sandy clayey silt,
		16	firm
		18	
	C		
16'			Cuttings becoming more reddish yellow and coarsening
			downward to sandy silt, some clay
18'			SI: 18.5 - 20.0' BLS RE: 1.4'
	SS #4	7	1.4' - Mottled red (2.5yr 5/8) red yellow (7.5yr 7/8 and
		9	5yr 7/6) very tight sandy silt, some clay,
20'		13	firm to stiff
22'			
24'	SS #5	3	SI: 23.5 - 25.0' BLS RE: 1.5'
		4	1.5' - Light red yellow (10yr 7/6) grading down to
		3	pinkish white (7.5yr 7/2) fine to coarse sand,
			some silt, trace gravel, loose
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
400 Westbury Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-2 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (/6)	DESCRIPTION
26'	C		
			Hit gravel layer at about 27.0'
28'			SI: 28.5 - 30.0' BLS RE: 1.3'
	SS #6	6	1.3' - Red yellow (7.5yr 7/6) to pink white (7.5yr 7/2)
		6	coarse to medium sand and gravel, little
30'		5	clay, firm
	C		
32'			Lithology changed from gravelly sand to clayey sand at about 32.0'
			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	4	1.5' - White (10yr 8/1) highly micaceous, clayey
		8	sand, loose to firm, dry
		9	
	C		
36'			Hit thin gravel layer from 36.5 - 37.5'
38'			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	7	1.5' - White (10yr 8/1) with thin red (2.5yr 6/6)
		12	interbeds, fine to medium sand, clayey,
40'		13	loose to firm
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-2 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
42'	C		Same as above
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	10	1.4' - White (10yr 8/1) clayey sand, firm, wet
		15	0.1' - White (10yr 8/1) clay, moist
		14	
46'	C		Same as above, clayey sand, white
48'			SI: 48.5 - 50.0' BLS RE: 0.9'
	SS #10	10	0.6' - White (10yr 8/1) clayey sand, firm
		11	0.3' - Red yellow (2.5yr 5/4) medium to coarse
50'		13	sand, some silt
52'	C		White clayey sand
			SI: 53.5 - 55.0' BLS RE: 1.1'
54'	SS #11	9	1.1' - White (10yr 8/1) clayey sand, firm
		17	
		29	
56'	C		White sandy clay, clayey sand
58'			

JRB ASSOCIATES
Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

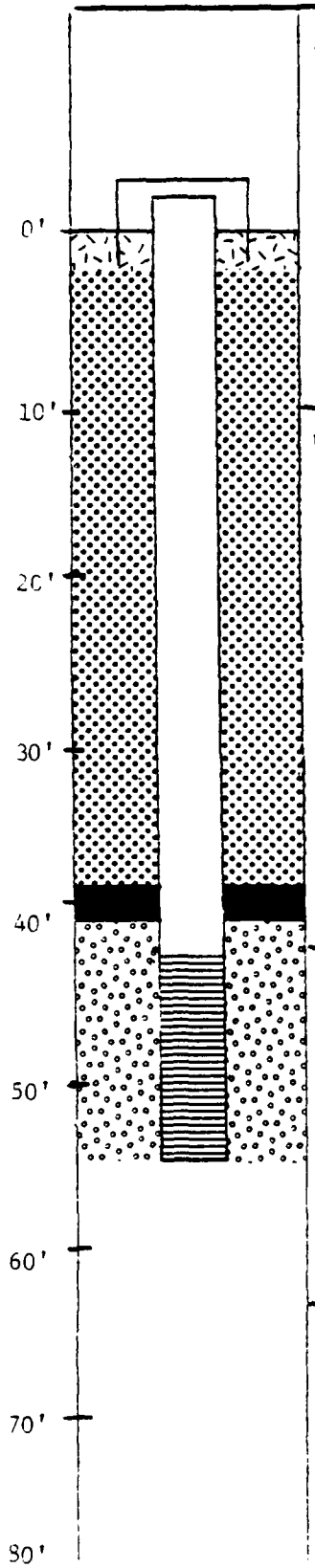
MW 3-2 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (BC)	DESCRIPTION
58'			SI: 58.5 - 60.0' RE: 1.5'
	SS #12	7	1.5' - White (10yr 8/1) clayey silt, firm
		6	dry to moist
60'		12	
	C		
62'			Firm silt became stiff at about 61.5'
			SI: 63.5 - 65.0' RE: 1.5'
64'	SS #13	5	1.5' - White (10yr 8/1) kaolinitic clayey silt,
		9	stiff, dry
		16	
66'			Note: Since clayey silt encountered at 58.5' was fine grained, dry to moist layer, screening the interval below was determined inappropriate.
68'			
70'			
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW 3-3



Drilling Summary:

Total Depth: 54.7'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 237.98
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 106-113
Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): Hollow Stem Auger
Drilling Fluid Type: water
Amount Use: 10 gallons
Water Level: 43.0' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD
Length: 45'
Filter: Material: Torpedo Sand
Setting: 41.0 - 54.7' BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.5 - 39.0' BLS
Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 43.0 - 54.7' BLS
Seals: Type: Bentonite Pellets
Setting: 39.0 - 41.0' BLS
Surface Casing: Steel(4½"OD x 5'Lt.
Other: Total drilled depth - 60' BLS. Interval between 54.7 - 60.0' composed of silty clay; therefore, no screen was deemed appropriate for this interval and well bottom was set at 54.7' BLS.

Time Log:

	Started	Completed
Drilling:	4/16/85 0724hr	4/16/85 0931hr
Installation:	4/16/85 1039hr	4/16/85 1450hr
Water Level Reading:	4/16/85 0853hr (43'BLS)	4/16/85 1510hr (44.7'B
Development		

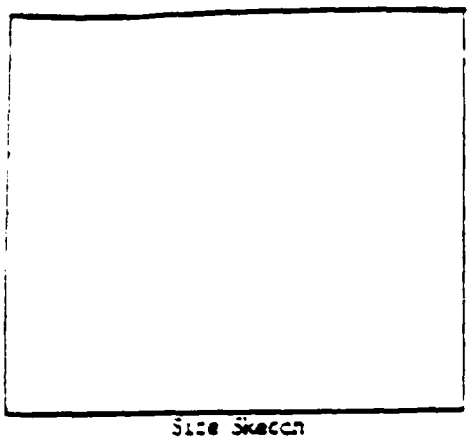
Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 43.0'
Pumping Depth to Water: 54.0'
Pumping Rate: ? 1 gal/min.
Volume Pumped: 100 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 3-3



Site Sketch

Location: Y Area Storage Yard
Reference Point: Land Surface
Reference Point Elevation: 237.98

Field Book No.: 3 pp 106-110
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Total Depth: 60.0'

	Date	Time
Drilling Started:	4/16/85	0724hr
Drilling Completed:	4/16/85	0931hr
Water Level:	43'BLS 4/16/85	0853hr

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-10%
Little 10-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
2'	C		Red brown, clayey, sandy silt
			SI: 3.5 - 5.0' BLS RE: 1.4'
4'	SS #1	5	1.4' - Red (2.5yr 4/8) sandy, clayey silt, stiff
		5	to firm
		13	
6'	C		Same as above
8'			SI: 8.5 - 10.0' BLS RE: 1.3'
	SS #2	5	1.3' - Red (2.5yr 4/8) sandy, clayey silt , firm to
		7	stiff
10'		10	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-3 (cont.)

Depth (feet)	Sample type and Number	Blow Counts (BI)	DESCRIPTION
10'			
	C		Same as above
12'			
			SI: 13.5 - 15.0' BLS RE: 1.3'
14'	SS #3	4	1.3' - Red (2.5yr 4/8) sandy silt, some clay,
		9	firm to stiff
		14	
	C		
16'			Same as above
18'			SI: 18.5 - 20.0' BLS RE: 1.1'
	SS #4	8	1.1' -Mottled red yellow (5yr 6/8, 5yr 8/2,
		10	2.5yr 4/8, and 10yr 7/8) poorly sorted
20'		13	fine to coarse sand, silt, and clay, firm
	C		
22'			Same as above
24'	SS #5	8	SI: 23.5 - 25.0' BLS RE: 1.4'
		10	0.3' - Red yellow (2.5yr 5/8) silty sand, little clay
		9	0.6' - " " fine sand and gravel, some clay
			0.5' - " " silty sand, some clay, firm
26'			

JRB ASSOCIATES
Company of Science Applications, Inc.
400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-3 (cont.)

Depth (feet)	Sample type and Number	Blow Count (N)	DESCRIPTION
26'			
	C		Same as above
	C		Hit gravel layer at about 27.0 - 28.0'
28'			
			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	6	0.4' - Red (2.5yr 5/8) silty sand and gravel, some clay, loose
		7	1.1' - Light gray (10yr 7/2) silty clay, trace sand, stiff
30'		6	
	C		
32'	C		Hit top of sandy layer at about 32.0'
			SI: 33.5 - 35.0' BLS RE: 1.4'
34'	SS #7	10	1.4' - Light gray (10yr 7/2 and thin reddish (2.5yr 5/8)
		17	streaks, fine to coarse sand and silt, little
		16	kaolinitic clay, loose to firm
36'	C		Same as above
38'			
			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	6	1.5' - White (10yr 8/1) fine to coarse sand, silty,
		8	some clay, loose, dry
40'		10	
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-3 (cont.)

Depth (feet)	Sample type and Number	Blow Count (N)	DESCRIPTION
42'	C		Same as above
			SI: 43.5 - 45.0' BLS RE: 1.1'
44'	SS #9	5	1.1' - White (10yr 7/2) silty clayey sand, loose
		9	wet
		10	
46'	C		Same as above
48'			SI: 48.5 - 50.0' BLS RE: 0.9'
	SS #10	5	0.9' - White (10yr 8/1) silty clayey sand, highly
		7	micaceous, loose, wet
50'		11	
52'	C		Same as above
			SI: 53.5 - 55.0' BLS RE: 1.4'
54'	SS #11	6	1.1' - White (10yr 8/1) with light red laminae
		6	(2.5yr 6/8) clayey sand, some very
		8	thin clay interbeds, loose, wet
56'	C		0.3' - White (10yr 8/1) clayey silt, firm, moist to dry
58'			White clayey silt grading down to silty clay at about 58.0'

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

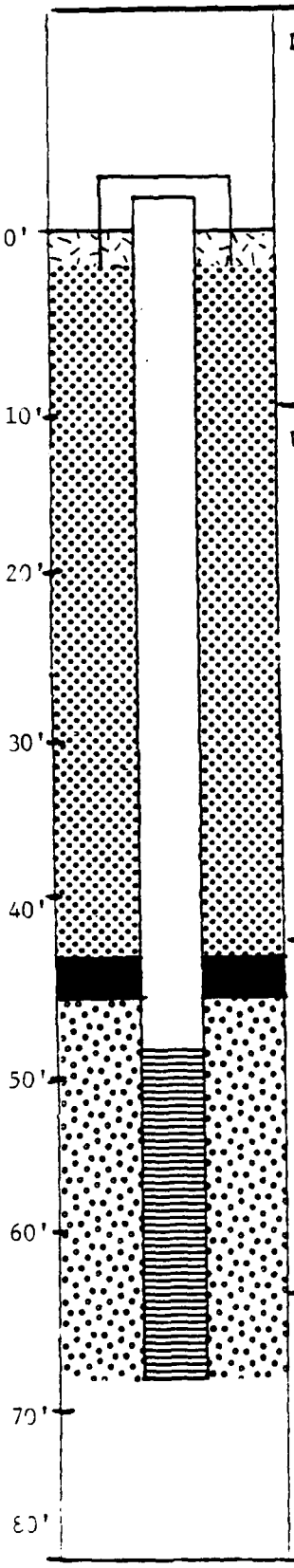
MW 3-3 (cont.)

Depth (feet)	Sample type and Number	Blow Counts (BI)	DESCRIPTION
58'			SI: 58.5 - 60.0' RE: 1.5'
	SS #12	0	1.5' - White (10yr 8/1) silty clay, tight, firm,
		8	dry to moist
60'		11	
			Note: Although drilled to desired completion depth clayey silt encountered at 54.7' to depth was determined poor material to screen through and bottom of screen terminated at 54.7'.
62'			
64'			
66'			
68'			
70'			
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 3-4



Drilling Summary:

Total Depth: 68.1'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 240.61
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 123-129
Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): Hollow Stem Auger
Drilling Fluid Type: water
Amount Use: 5 gallons
Water Level: 48.5' BLS 4/18/85

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2¼" OD
Length: 50.5'
Filter: Material: Torpedo Sand
Setting: 45.5 - 69.8' BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.5 - 43.5' BLS
Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 48.5 - 68.1' BLS
Seals: Type: Bentonite Pellets
Setting: 43.5 - 45.5' BLS
Surface Casing: Steel(4½"OD x 5'Lt.
Other: Steel casing cemented from 2.5' BLS to land surface.

Time Log:

	Started	Completed
Drilling:	4/18/85 0720hr	4/18/85 1000hr
Installation:	4/18/85 1002hr	4/18/85 1425hr
Water Level Reading:	4/18/85 0920 (48.5'BLS)	4/18/85 1430hr (47.6'B
Development:		

Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 48.5'
Pumping Depth to Water: 67.5'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 100 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 3-4

Site Sketch

Location: Y Area Storage Yard
Reference Point: Land Surface
Reference Point Elevation: 240.61

Field Book No.: 3 pp 123-129
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Total Depth: 70'

	Date	Time
Drilling Started:	4/18/85	07?
Drilling Completed:	4/18/85	100
Water Level: 48.5' BLS	4/18/85	

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Brown sandy silt
2'			SI: 3.5 - 5.0' BLS RE: 1.5'
	SS #1	1	0.5' - Yellow red (7.5yr 5/6) sandy silt, loose
		3	1.0' - Red (2.5yr 4/8) clayey sand silt,
		8	firm
6'	C		Same as above
8'			SI: 8.5 - 10.0' BLS RE: 1.5'
	SS #2	6	1.5' - Red (2.5yr 4/2) clayey sandy silt
		9	
10'		12	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-4 (cont.)

Depth (feet)	Sample type and Number	Blow Counts (N)	DESCRIPTION
10'			
	C		Same as above
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	9	1.4' - Red (2.5yr 5/8) clayey sand and silt,
		11	yellow red streaks (5yr 6/8), firm
		13	
	C		
16'			
			Texture coarsening downward, becoming more yellow in color
18'			SI: 18.5 - 20.0' BLS RE: 1.2'
			1.2' - Mottled red (2.5yr 4/8) yellow (10yr 8/8)
	SS #4	8	and white (10yr 8/1) silty clayey sand,
		11	little gravel, firm to stiff
20'		14	
	C		
22'			Yellow red sand, trace gravel
24'	SS #5	5	SI: 23.5 - 25.0' BLS RE: 1.5'
		4	1.5' - Light red (2.5yr 5/8) medium to very
		4	coarse sand, some silt and clay, trace
			gravel, loose, dry
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-4 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (/ft)	DESCRIPTION
26'	C		Same as above
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	4 5 7	1.5' - Pink (7.5yr 6/4) medium to very coarse sand, little fines (silt/clay) loose, dry
30'	C		Hit loose sand at about 31.0'
32'			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	8 7 9	1.5' - White (10yr 8/1) clayey sand, trace silt, loose, dry
36'	C		Same as above
38'			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	6 5 12	1.3' - White (10yr 8/1) clayey sand 0.2' - Red (2.5yr 4/8) fine to coarse sand, some fines (silt/clay), firm
40'			
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westbury Drive, McLean, Virginia 22102

DRILLING LOG

MW 3-4 (cont.)

Depth (feet)	Sample type and Number	Blow Count (#)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	11	0.2' - White (10yr 8/1) clay
		9	1.0' - White (10yr 8/1) and red (2.5yr 4/8)
		10	fine to medium sand
	C		0.3' - White (10yr 8/1) clayey silt
46'			
			White clayey sand
48'			
			SI: 48.5 - 50.0' BLS RE: 1.3'
	SS #10	5	1.3' - White (10yr 8/1) clayey sands, loose,
		6	wet
50'		7	
	C		
			Same as above
52'			
			SI: 53.5 - 55.0' BLS RE: 0.9'
54'	SS #11	8	0.9' - White (10yr 8/1) clayey sand, loose,
		10	wet
		14	
56'	C		
			Same as above
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

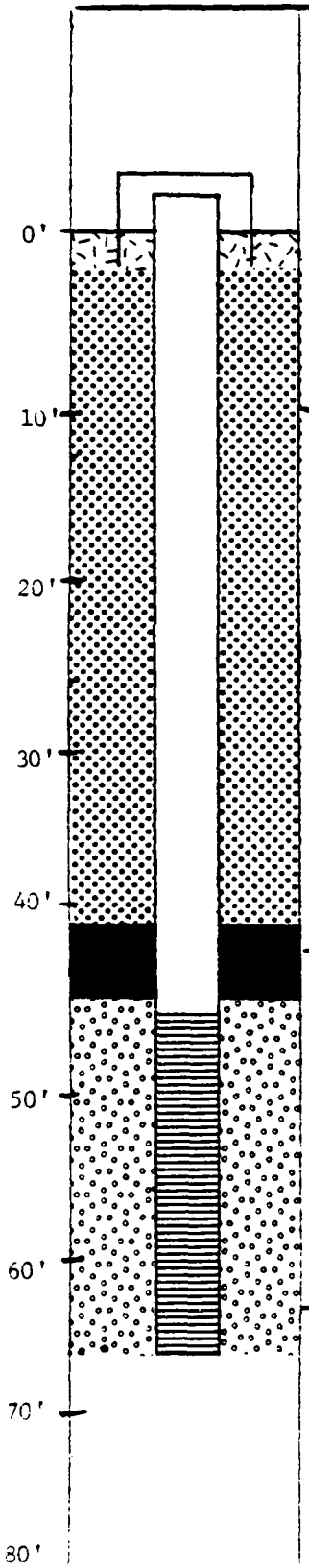
MW 3-4 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (bl)	DESCRIPTION
58'			SI: 58.5 - 60.0' RE: 1.4'
	SS #12	8	0.2' - White (10yr 8/1) clayey sand, loose
		10	0.2' - White (10yr 8/1) clay firm
60'		18	1.0' - White (10yr 8/1) clayey sand, loose
	C		
62'			White clayey sand
	SS #13	4	SI: 63.5 - 65.0' RE: 1.5'
		5	0.1' - White (10yr 8/1) sand
		7	1.4' - Gray (10yr 8/1) and pink (5yr 7/4) laminated silty clay, firm
66'	C		
			Yellow sand, some clay
68'			SI: 68.5 - 70.0' RE: 1.5'
	SS #14	6	0.8' - Yellow (10yr 7/8) sand, loose
		9	0.7' - White (10yr 7/2) coarse sand, some clay
70'		14	
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 4-1



Drilling Summary:

Total Depth: 65.6' Drillers: Earl Moseley
Borehole Diameter(s): 6½" Soil & Material Engineers
Rig Type: CME 550
Elevation: Land Surface: 264.28 Bit(s): Hollow Stem Auger
Top of Casing: Drilling Fluid Type: water
Supervisory Geologist: Rick Eades Amount Use: 10 gallons
Log Book No. 3 pp. 84-95 Water Level: 42.8' BLS (4/14/85 1458hr)

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD Diameter: 2"
Length: 48' Slot: .015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 46.0 - 65.6' BLS
Setting: 45.0 ' 65.6' BLS Seals: Type: Bentonite Pellets
Grout: Type: Port. Cement/Bentonite Setting: 41.0 - 45.0' BLS
Setting: 2.5 - 41.0' BLS Surface Casing: Steel(4½"OD x 5'Lt.
Other: Set screen at 46' BLS because clay occupied interval immediately above 46' and wanted to screen sand interval only. Steel casing cemented from 2.5' BLS to land surface.

Time Log:

	Started	Completed
Drilling:	4/13/85 1509hr	4/14/85 0910hr
Installation:	4/14/85 0915hr	4/14/85 1204hr
Water Level Reading:	4/13/85 1727hr (43.6'BLS)	4/14/85 1458hr (42.8'BL
Development:		

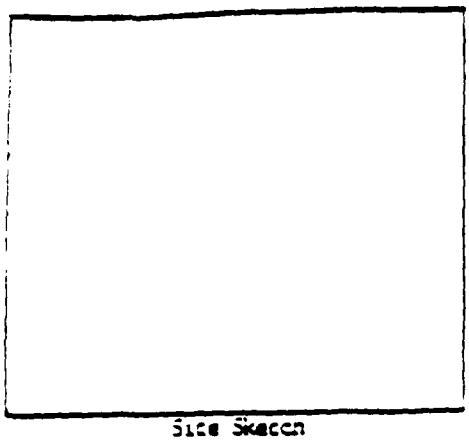
Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 42.7'
Pumping Depth to Water: 65.0'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 1000 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 4-1



Site Sketch

Location: Oil Dump Site Field Book No.: 3 pp 84-95
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Reference Point: Land Surface Total Depth: 70'
Reference Point Elevation: 264.28

	Date	Time
Drilling Started:	4/13/85	1509hr
Drilling Completed:	4/14/85	0910hr
Water Level:	43.6'BLS 4/13/85	1727

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Red yellow clayey silt
2'			
			SI: 3.5 - 5.0' BLS RE: 1.3'
	SS #1	3	1.3' - Red (2.5yr 4/8) clayey silt, little fine
		7	sand, stiff to firm
4'		12	
	C		Same as above
6'			
			SI: 8.5 - 10.0' BLS RE: 1.2'
8'	SS #2	5	1.2' - Red (2.5yr 4/8) silty clay, little sand,
		7	firm
10'		10	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westbury Drive, McLean, Virginia 22102

DRILLING LOG

MW 4-1 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (BB)	DESCRIPTION
10'			
	C		Same as above
12'			
			SI: 13.5 - 15.0' BLS RE: 1.1'
14'	SS #3	5	1.1' - Red yellow (2.5yr 5/8) silt, some fine
		8	sand, trace clay, firm
		12	
	C		
16'			Yellow red silt, fine sand
			SI: 18.5 - 20.0' BLS RE: 1.1'
18'			0.7' - Yellow gray (2.5yr 5/8) and red yellow
	SS #4	7	(5yr 6/8) sandy silt, trace clay, firm
		6	0.4' - Pink (2.5yr 6/6) clayey silt, trace sand,
20'		7	firm
	C		
22'			Hit top of pink clay layer at about 22.0'
24'	SS #5	6	SI: 23.5 - 25.0' BLS RE: 1.4'
		9	1.4' - Mottled grayish pink (5yr 7/1) and
		13	yellow (10yr 6/8) clay, trace silt
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
100 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 4-1 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (#)	DESCRIPTION
26'	C		Same as above
28'			SI: 28.5 - 30.0' BLS RE: 1.3'
	SS #6	4	1.3' - Mottled gray (5yr 7/1) pink (5R 5/3) yellow
		7	(10yr 6/8) and red (5R 3/8) clay, trace silt
30'		7	firm
	C		Same as above
32'			SI: 33.5 - 35.0' BLS RE: 1.4'
34'	SS #7	7	0.3' - Mottled (5R 6/3) clay, trace sand and silt
		9	0.6' - Yellow (10yr 6/8) loose silty sand, some clay
		12	0.5' - Pink (5R 6/3) mottled silty, sandy clay, firm
36'	C		Same as above
38'			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	15	0.5' - Mottled yellow red (5yr 5/8) silty clay,
		27	firm to stiff
40'		31	1.0' - Light yellow (2.5Y 8/4) loose fine sand,
			same silt
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 4-1 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
42'	C		Hit top of clay layer at about 42.5'
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	2	1.5' - Mottled yellow (10yr 6/8) and reddish
		3	brown (5yr 5/4) soft clay
		6	
46'	C		Hit top of sand layer at about 46.0'
48'			SI: 48.5 - 50.0' BLS RE: 1.5'
	SS #10	0	1.5' - Yellow (10yr 6/8) fine to very coarse sand,
		0	trace silt, very loose and wet
50'		3	
52'	C		Same as above
			SI: 53.5 - 55.0' BLS RE: 0.7'
54'	SS #11	3	0.7' - Yellow (10yr 6/8) coarse sand and
		7	gravel, loose
		10	
56'	C		Same as above
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

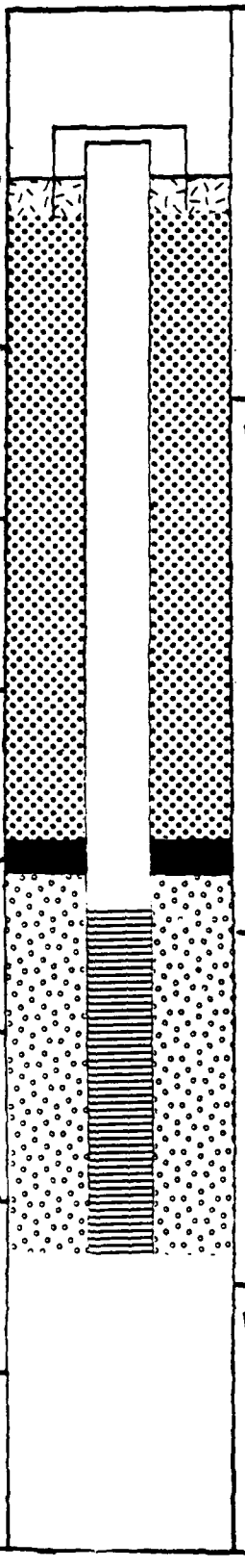
MW 4-1 (cont.)

Depth (feet)	Sample type and Number	Blow Count (BI)	DESCRIPTION
58'			SI: 58.5 - 60.0' RE: 1.3'
	SS #12	12	1.3' - Light yellow (10yr 7/8) coarse sand,
		12	trace silt and clay, little gravel, loose
60'		13	
	C		
62'			Same as above
			SI: 63.5 -65.0' RE: 1.5'
64'	SS #13	0	1.5' - Light yellow (10yr 7/8) fine to medium sand,
		0	little kaolinitic clay, trace silt, loose
		4	
66'	C		Since heaving sands encountered, overdrilled to 68.5'
			Same as above
68'			SI: 68.5 - 70.0' RE: 0.9'
	SS #14	0	0.9' - Yellow (10yr 6/8) coarse to medium
		10	sand with thin clay interbeds, firm
70'		15	
72'			
74'			

ARE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW4-2



Drilling Summary:

Total Depth: 65' BLS Drillers: Harris Howard
Borehole Diameter(s): 6½" Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 263.66 Bit(s): Auger
Top of Casing: Drilling Fluid Type:
Supervisory Geologist: Candace Nothwanger Amount Use:
Log Book No. 4 pp. 151-159 Water Level: 43' BLS

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16"OD Diameter: 2"
Length: 45' Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 43' - 63' BLS
Setting 41' - 63' BLS Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite Setting: 39' - 41' BLS
Setting: 2.5'- 39' BLS Surface Casing: Steel (4½" OD x 3'
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	4/15/85	0848 hrs	4/16/85	1130 hrs
Installation:	4/16/85	1130 hrs	4/16/85	1500 hrs
Water Level Reading:	4/16/85	43' BLS	4/17/85	45' BLS
Development:				

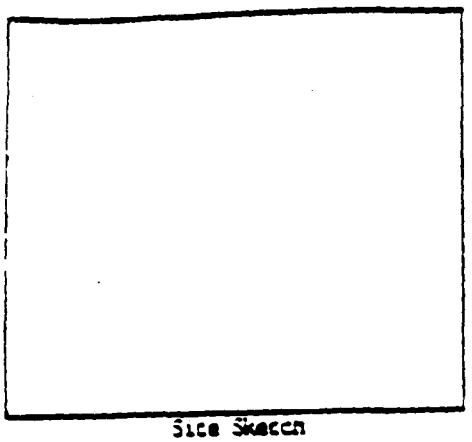
Well Development:

Method/Equipment: Air surge (1 hr.)/ 1.7" Brainard-Kilman hand pump.
Static Depth to Water: 42.9'
Pumping Depth to Water: 60.5'
Pumping Rate: @ 1 gal/min
Volume Pumped: 65 gals

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base
Owner: U.S. Air Force
Well No.: MW4-2



Site Sketch

Location: Site 4
Oil Dump Site
Field Book No.: 4 pp 151-159
Log By: Candace Northwanger
Driller: Harris Howard
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 65' BLS
Reference Point Elevation: 263.66

	Date	Time
Drilling Started:	4/15/85	0848 hrs
Drilling Completed:	4/16/85	1130 hr
Water Level:	4/16/85	43' BLS

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (ft)	DESCRIPTION
0'			
	C		Sandy clay.
2'			
			SI: 3.5 - 5.0' BLS RE: 1.0'
4'	SS #1	5	Sandy clay, some silt; red (2.5YR 4/8); stiff.
		9	dense; moist.
		14	
6'	C		Same as above.
8'			SI: 8.5 - 10.0' BLS RE: 1.4'
	SS #2	6	Sandy clay, some silt; mottled, red (2.5YR 5/8) and
		8	very pale brown (10YR 8/4); firm; moist.
10'		10	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (/6")	DESCRIPTION
10'			
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	6	Sandy clay, some silt, trace fine gravel;
		8	mottled, red (2.5YR 5/8), red (2.5YR 5/6) and
		11	very pale brown (10YR 8/4); firm; moist to dry.
16'			
	C		Sandy clay, red.
18'			
			SI: 18.5 - 20.0' BLS RE: 1.4'
	SS #4	6	Sandy clay, some silt; mottled, red (10R 5/6)
		7	and red (2.5YR 5/8); firm; dry.
20'		11	
			Clayey sand layer extends from @ 21 - 25' BLS.
22'			
			SI: 23.5 - 25.0' BLS RE: 0.8'
24'	SS #5	20	Clayey sand, some silt; brownish yellow
		20	(10YR 6/8); loose; dry.
		12	
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbary Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (N)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 1.4'
	SS #6	5	Clay, some silt; mottled yellow (10YR 7/8) to
		9	brownish yellow (10YR 6/8), red (2.5YR 4/8) and
30'		11	white (10YR 8/1); dense; dry.
	C		
			Same as above.
32'			
			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	6	Clay, trace silt; mottled, yellowish brown
		9	(10YR 5/8)., brownish yellow (10YR 6/8), and light
		13	grey (2.5YR 7/2); stiff; dense; dry.
36'			
			Sand layer from @ 36.5 - 41.0' BLS.
38'			
			SI: 38.5 - 40.0' BLS RE: 1.0'
	SS #8	15	Fine to medium sand; yellow (10YR 8/8),
		49	reddish yellow (7.5YR 6/8), and very pale
40'		49	brown (10YR 8/3); loose; dry.
			Clay layer from @ 41 - 42' BLS.
			Sand layer begins at @ 42' BLS.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (ft)	DESCRIPTION
42'			Water Table at @ 42.8' BLS.
			SI: 43.5 - 45.0' BLS RE: 1.4'
44'	SS #9	9	Medium clayey sand; yellow (10YR 8/8),
		5	reddish yellow (7.5YR 6/8), and very pale
		6	brown (10YR 8/3); loose; wet.
46'	C		
			Same as above.
48'			
			SI: 48.5 - 50.0' BLS RE: 1.4'
	SS #10	2	Medium sand, trace clay; brownish yellow
		5	(10YR 6/8); loose; wet.
50'		6	
52'			
			SI: 53.5 - 55.0' BLS RE: 0.3
54'	SS #11	11	0.4' - Same as SS#10.
		11	0.4' - Medium. Kaolinitic sand, some gravel; white
		11	(10YR 8/1); loose; wet.
56'			
			Clayey sand and gravel begins at @ 54.6' BLS.
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

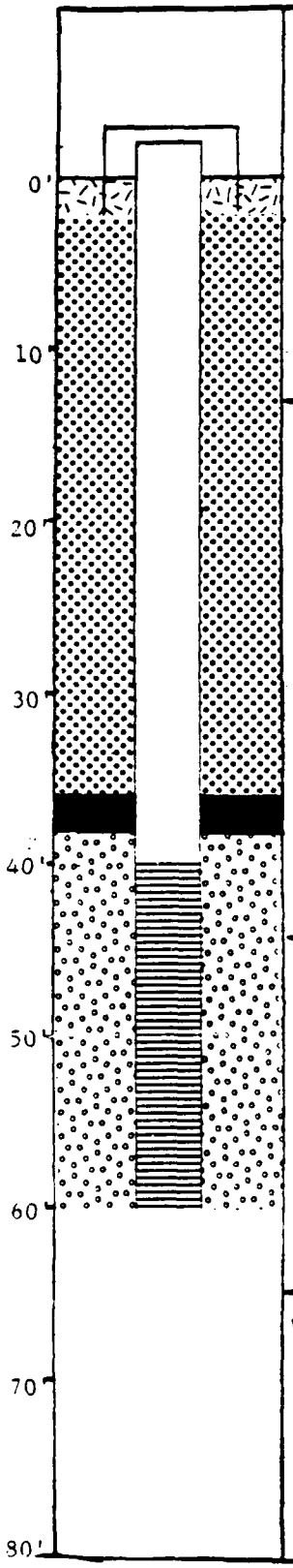
DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (ft)	DESCRIPTION
58'			SI: 58.5 - 60/0' BLS RE: 1.0'
	SS #12	9	Medium kaolinitic sand, some gravel; yellow
		21	(10YR 8/6) to brownish yellow (10YR 6/8);
60'		50	loose; wet.
62'			SI: 63.5 - 65.0' BLS RE: 1.4'
64'	SS #13	14	1.3' - Medium sand; very pale brown (10YR 8/4);
		16	loose; wet.
		12	0.1' - Clay, some gravel; white (10YR 8/1);
66'			loose to firm; wet.
68'			
70'			
72'			
74'			

ERE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW4-3



Drilling Summary:

Total Depth: 60.0' BLS
Drillers: Harris Howard
Borehole Diameter(s): 6¼"
Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 263.25
Bit(s): Tri- Cone Roller Bit
Top of Casing:
Drilling Fluid Type: Bentonite/Water
Supervisory Geologist: Candace Nothwanger
Amount Use: 280 gals.
Log Book No. 4 pp. 129-150
Water Level: 40' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD
Diameter: 2"
Length: 42.08'
Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand
Setting: 40' - 60' BLS
Setting 38' - 60' BLS
Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite
Setting: 36 - 38' BLS
Setting: 2.5'- 36' BLS
Surface Casing: Steel (4½" OD x 5'
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	4/13/85	1532 hrs	4/14/85	1015 hrs
Installation:	4/14/85	1253 hrs	4/14/85	1425 hrs
Water Level Reading:	4/14/85	40.08' BLS	4/15/85	42.5' BLS
Development:				

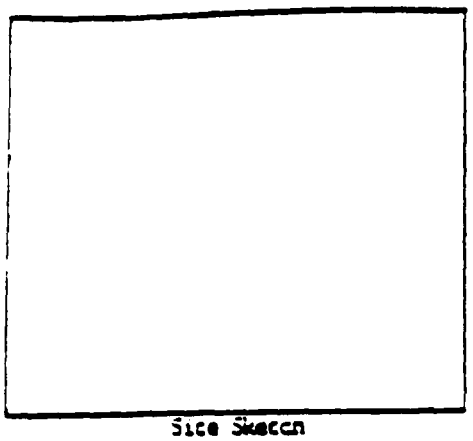
Well Development:

Method, Equipment: Air surge (1 hr.)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 40.1'
Pumping Depth to Water: 59.5'
Pumping Rate: @ 1 gal/min
Volume Pumped: 1500 gals

ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base | Owner: U.S. Air Force | Well No.: MW4-3



Site Sketch

Location: Site 4
Oil Dump Site

Field Book No.: 4 pp 129-146
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550

Reference Point: Land Surface
Total Depth: 60' BLS

Reference Point Elevation: 263.25

	Date	Time
Drilling Started:	4/13/85	1532 h
Drilling Completed:	4/14/85	1015
Water Level:	4/14/85	40.08'

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (ft)	DESCRIPTION
0'			
	C		Trace gravel at @ 1 - 2' BLS.
2'			SI: 3.5 - 5.0' BLS RE: 1.1'
4'	SS #1	6	Sandy clay, some silt; red (2.5YR 4/6); stiff;
		8	moist.
		14	
6'			
8'			SI: 8.5 - 10.0' BLS RE: 1.2'
	SS #2	6	Sandy clay, some silt, trace gravel; red (2.5YR 4/8)
		9	with brownish yellow (10YR 6/8); laminations;
10'		9	stiff; moist.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (N)	DESCRIPTION
10'			
	C		Sandy clay, some silt, trace gravel.
12'			
			SI: 13.5 - 15.0' BLS RE: 1.1'
14'	SS #3	6	Sandy clay, some silt; mottled, red (2.5YR 4/8)
		9	and very pale brown (10YR 8/3); stiff; moist.
		8	
16'			
18'			SI: 18.5 - 20.0' BLS RE: 0.9'
	SS #4	8	Sandy clay; mottled, red (10R 4/6), pale
		7	red (10R 6/3), and white (10YR 8/1); stiff; moist.
20'		10	
22'			
			SI: 23.5 - 25.0' BLS RE: 1.0'
24'	SS #5	6	Sandy clay, some silt; mottled, red (10R 4/6),
		5	pale red (10R 6/3), white (10 YR 8/1); and
		17	yellow (10YR 7/8), to brownish yellow (10 YR 6/8);
			stiff; moist.
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
1400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Count (#)	DESCRIPTION
26'			Clay layer begins at @ 26' BLS.
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	7	Clay trace sand and silt; mottled red
		9	(10R 4/6), weak red (7.5YR 5/2 to 7.5YR 4/2),
30'		13	reddish yellow (5YR 6/8), yellow (2.5YR 8/6),
			and white (10YR 8/1); stiff; dense; dry.
32'			
			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	5	Same as SS#6.
		8	
		14	
36'			
38'			
			SI: 38.5 - 40.0' BLS RE: 1.0'
	SS #8	20	0.4' - Same as SS#6.
		43	0.6' - Fine to medium sand; brownish yellow
40'		64	(10YR 6/8); loose; wet.
			Water Table at @ 40.08' BLS.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (/ft)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.1'
44'	SS #9	20	Same as SS#8.
		43	
		50	
46'			
48'			SI: 48.5 - 50.0' BLS RE: 0.9'
	SS #10	8	Fine to medium micaceous sand, some clay;
		9	very pale brown (10YR 8/3) to brownish yellow
50'		13	(10YR 6/8); loose; wet.
	C		
			Same as above.
52'			
			SI: 53.5 - 55.0' BLS RE: 1.2'
54'	SS #11	7	Medium to coarse sand, coarser with depth;
		8	trace gravel; brownish yellow (10YR 6/8);
		12	loose; wet.
56'			Gravel layer from @ 56 - 57' BLS.
58'			

JRB ASSOCIATES
Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

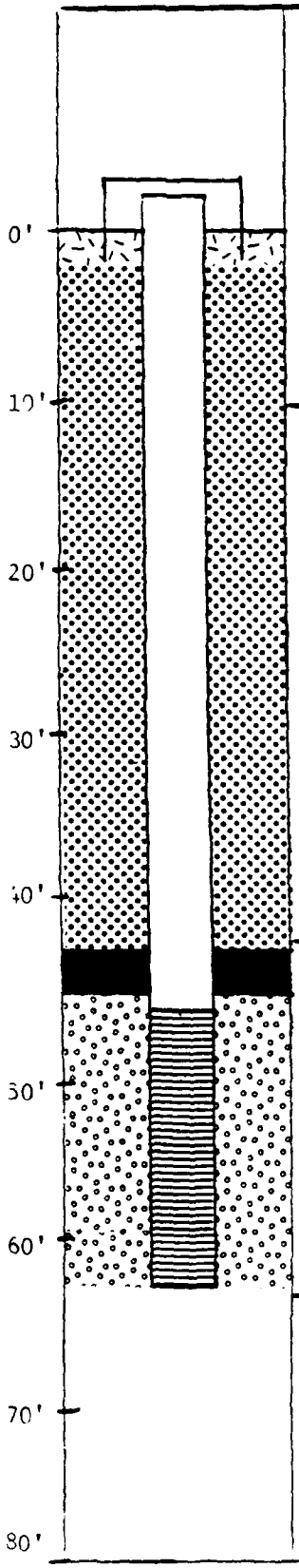
DRILLING LOG

Depth (feet)	Sample type and number	Blow Counts (BI)	DESCRIPTION
58'			SI: 58.5 - 60.0' BLS RE: 1.2'
	SS #12	6	Medium sand, some clay; brownish yellow
		10	(10YR 6/8); loose; wet.
60'		3	
62'			
64'			
66'			
68'			
70'			
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW 4-4



Drilling Summary:

Total Depth: 62.0'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 264.41
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 97-104

Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): Hollow Stem Auger
Drilling Fluid Type: none
Amount Use:
Water Level: 46.0' BLS (4/15/85 0912hr)

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD
Length: 48'
Filter: Material: Torpedo Sand
Setting: 45.0 - 62.0' BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.5 - 43.0' BLS
Other: Steel casing cemented from 2.5'BLS to land surface.

Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 46.0 - 62.0' BLS
Seals: Type: Bentonite Pellets
Setting: 43.0 - 45.0' BLS
Surface Casing: Steel(4½"OD x 5'Lt.)

Time Log:

	Started	Completed
Drilling:	4/15/85 0727hr	4/15/85 1012hr
Installation:	4/15/85 1029hr	4/15/85 1427hr
Water Level Reading:	4/15/85 0912hr (46'BLS)	4/15/85 1440hr (48'BLS
Development:		

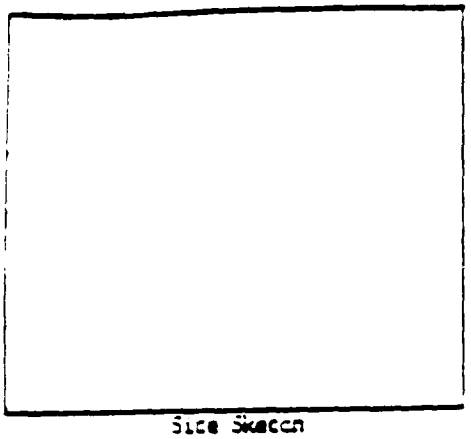
Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 46.0'
Pumping Depth to Water: 61.5'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 50 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 4-4



Site Sketch

Location: Oil Dump Site Field Book No.: 3 pp 97-104

Log By: Rick Eades

Driller: Earl Moseley

Rig Type: CME 550

Reference Point: Land Surface Total Depth: 65.0'

Reference Point Elevation: 264.41

	Date	Time
Drilling Started:	4/15/85	0727hr
Drilling Completed:	4/15/85	1012hr
Water Level: 46' BLS	4/15/85	0912hr

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-10%
Little 10-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Red yellow silt, some clay
2'			SI: 3.5 - 5.0' BLS RE: 1.3'
4'	SS #1	3	1.3' - Red (2.5yr 4/8) clayey silt, little fine silt,
		8	firm to stiff
		12	
	C		Same as above
6'			
8'			SI: 8.5 - 10.0' BLS RE: 1.3'
	SS #2	6	1.3' - Red (2.5yr 4/8) clayey, sandy silt,
		9	firm
10'		11	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 4-4 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (#)	DESCRIPTION
10'	C		Same as above
12'			SI: 13.5 - 15.0' BLS RE: 1.0'
14'	SS #3	7	1.0' - Mottled yellow red (5yr 6/8) clayey silt,
		9	some sand, very firm
		10	
16'	C		Clayey, sandy silt, red yellow
18'			SI: 18.5 - 20.0' BLS RE: 0.8'
	SS #4	5	0.8' - Red (5yr 5/8) sandy silt, little clay,
		6	firm
20'		9	
22'	C		Same as above
24'	SS #5	5	SI: 23.5 - 25.0' BLS RE: 1.5'
		7	0.2' - Red (5yr 5/8) sandy, clayey silt
		12	1.3' - Mottled yellow (7.5yr 6/8) clay, trace
26'			sand and silt, firm

JRB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbarr Drive, McLean, Virginia 22102

DRILLING LOG

MW 4-4 (cont.)

Depth (feet)	Sample type and Number	Blow Count (#)	DESCRIPTION
26'	C		Stiff yellow clay
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	5	1.5' - Mottled yellow (10yr 7/6) white (7.5yr N8/0)
		7	and red (5R 6/3) clay, trace silt and
30'		10	fine sand, firm
	C		Same as above
32'			
			SI: 33.5 - 35.0' BLS RE: 1.4'
34'	SS #7	7	1.4' - Gray (5Y 7/1) and red (5R 6/3) clay,
		8	trace silt, fine sand, firm
		11	
36'	C		Hit top of sand at about 37.0'
38'			
			SI: 38.5 - 40.0' BLS RE: 1.2'
	SS #8	16	1.2' - Yellow (10yr 7/6) fine to coarse sand,
		24	trace silt, loose, dry
40'		27	
42'	C		Hit top of clay layer at about 41.5'

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 4-4 (cont.)

Depth (feet)	Sample type and Number	Blow Count (BC)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	3	1.5' - Mottled red (5R 6/3) and gray (5Y 7/1)
		4	clay, trace sand
		3	
46'	C		Hit top of sand layer at about 46'
48'			SI: 48.5 - 50.0' BLS RE: 1.4'
	SS #10	1	1.2' - Yellow (10yr 6/8) fine to coarse sand,
		2	very loose, wet
50'		2	0.2' - Interbedded sand (as above) and thin
	C		clay lenses
52'			Yellow fine to coarse sand
			SI: 53.5 - 55.0' BLS RE: 1.1'
54'	SS #11	4	0.3' - Yellow (10yr 6/8) fine to coarse sand, some silt
		3	0.2' - Gray (5Y 7/1) kaolinitic clay
		4	0.6' - Yellow (10yr 6/8) fine to coarse sand, some gravel
56'			
58'	C		Hit sand and gravel layer at about 57.0'

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

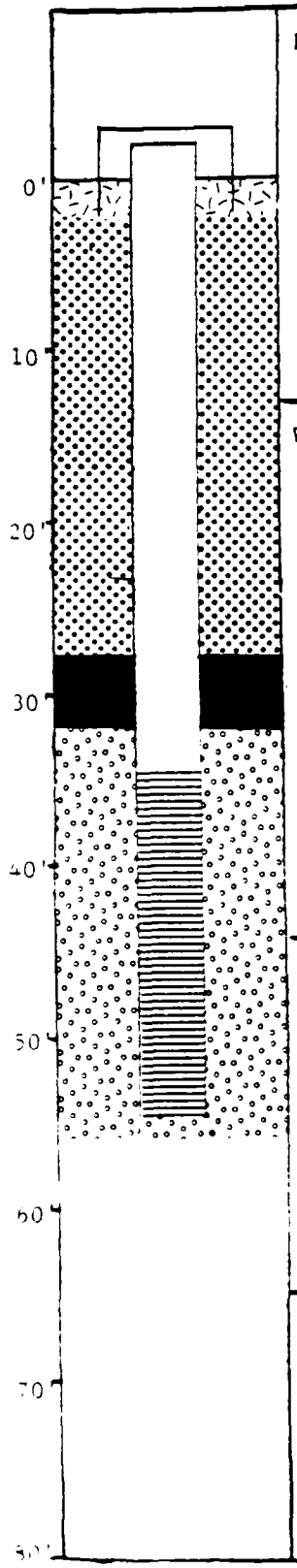
MW 4-4 (cont.)

Depth (feet)	Sample type and Number	Blow Count (N)	DESCRIPTION
58'			SI: 58.5 - 60.0' RE: 1.2'
	SS #12	3	1.2' - Yellow (10yr 7/8) fine to medium sand
		5	and gravel, some silt and kaolinitic clay
60'		8	
	C		Same as above
62'	C		Hit clayey silt at about 62.0'
			SI: 63.5 - 65.0' RE: 1.4'
64'	SS #13	9	1.4' - Kaolinitic silty clay, white (10yr 8/1)
		15	stiff
		28	
69'			
75'			

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW5 1



Drilling Summary:

Total Depth: 55' BLS Drillers: Harris Howard
Borehole Diameter(s): 6½" Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 225.94 Bit(s): Auger
Top of Casing: 2' ALS Drilling Fluid Type: Water
Supervisory Geologist: Candace Nothwanger Amount Use: 50 gals
Log Book No. 2 pp. 4-35 Water Level: 33.25' BLS

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD Diameter: 2"
Length: 36' Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 34' - 54' BLS
Setting 32' - 55' ALS Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite Setting: 28' - 32' BLS
Setting: 2.5' - 28' BLS Surface Casing: Steel (4⅜" OD x [illegible]
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	3/27/85	0820 hrs	3/28/85	1035 hrs
Installation:	3/28/85	1100 hrs	3/28/85	1520 hrs
Water Level Reading:	3/27/85	33.25' BLS	4/1/85	33.11' BLS
Development:				

Well Development:

Method, Equipment: Air surge (1 hr.) 1.7" Brainard-Kilman hand pump.
Static Depth to Water: 33.15'
Pumping Depth to Water: 53.5'
Pumping Rate: [illegible] gal/min
Volume Pumped: [illegible] gals

A Company of SSOCI. s Associates.
3400 Westbark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW5-1

Site Sketch

Location: Site 5
C-141 Spill Trench

Field Book No.: 2 pp: 4-26
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550

Reference Point: Land Surface
Reference Point Elevation: 225.94

Total Depth: 55' BLS

	Date	Time
Drilling Started:	3/27/85	0820 h
Drilling Completed:	3/28/85	1035
Water Level:	3/27/85	33.25

Legend
SI: Sampling Interval
RE: Recovery
SS: Solit Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Sandy clay, some silt; yellowish red (5YR 4/6); moist.
2'			
			SI: 3.5 - 5.0' BLS RE: 1.3'
4'	SS #1	7	Sandy clay, some silt, trace gravel; red
		9	(10R 4/8); firm; dense; moist.
		12	
6'			
8'			SI: 8.5 - 10.0' BLS RE: 1.2'
	SS #2	8	Sandy clay, some gravel, trace silt; red (10R 4/8);
		10	firm; dry.
10'		16	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (#)	DESCRIPTION
10'			
	C		Same as above.
12'			
			SI: 13.5 - 15.0' BLS RE: 1.1'
14'	SS #3	7	0.2' - Same as SS#2
		9	0.9' - Medium to coarse sandy clay, some gravel; mottled, white (5YR 8/1) and yellowish red (5YR 5/6); firm to stiff; dense.
		11	
16'	C		Gravel layer begins at @ 15.0' BLS
18'			
			SI: 18.5 - 20.0' BLS RE: 1.5'
	SS #4	22	0.4' - Fine gravel, some silt; yellowish brown (10YR 5/8); dry.
		21	
20'		23	1.1' - Heavy gravel, some sand, white (7.5YR 8/1) and yellowish red (5YR 5/8); dry.
	C		dry.
			Heavy gravel, some sand.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.5'
24'	SS #5	14	Coarse sandy gravel, little silt; trace kaolinitic clay; reddish yellow (5YR 6/8) and white (5YR 8/1); loose; dry.
		10	
		12	
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
400 Westbury Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Count (BI)	DESCRIPTION
26'			
			Sand layer begins at @ 27' BLS.
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	9	Fine to medium kaolinitic sand; white
		10	(5YR 8/1); firm; dry
30'		12	
	C		Same as above.
32'			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	8	Medium kaolinitic sand; white (10YR 8/1);
		10	loose to firm; wet.
		15	
36'			Water Table at @ 33.25' BLS.
38'			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	8	0.4' - Coarse kaolinitic sand; white (10YR 8/1);
		15	loose; saturated.
40'		34	1.1' - Fine to very fine kaolinitic sand; white
			(10YR 8/1) with pale red lamination (5YR 6/4);
			loose to firm; saturated.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

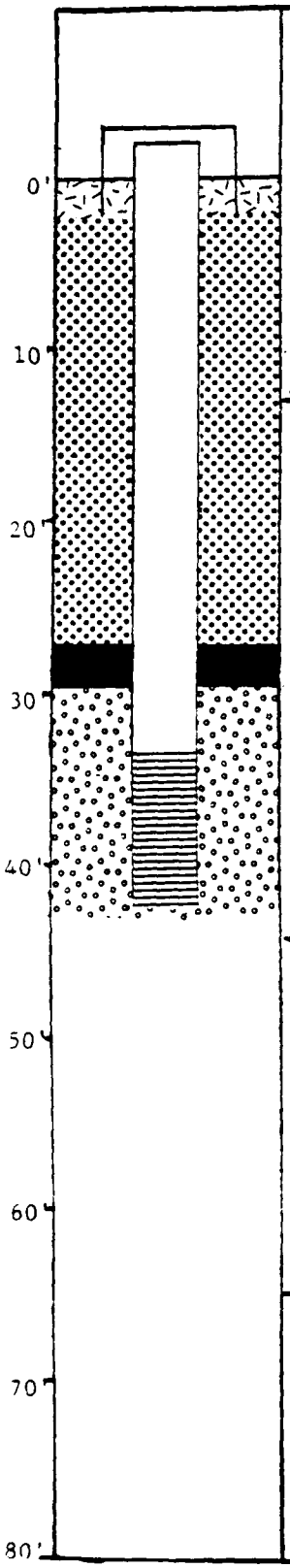
DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (BH)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	9 18 25	Fine to very fine kaolinitic sand, some silt; white (10YR 8/1) with pale red laminations (5R 6/4); loose; saturated.
46'	C		Same as above.
48'			SI: 48.5 - 50.0' BLS RE: 1.5'
	SS #10	8 13 25	Medium kaolinitic sand; white (10YR 8/1) with pale red (5R 6/4) laminations; loose; saturated.
50'	C		Same as above.
52'			SI: 53.5 - 55.0' BLS RE: 1.1'
54'	SS #11	10 15 18	Fine micaceous kaolinitic sand; gradational colour pale red (5R 6/4) to white (10YR 8/1) and light red (2.5YR 6/6); loose to firm; wet.
56'			
58'			

ESE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW5-2



Drilling Summary:

Total Depth: 55' BLS Drillers: Harris Howard
Borehole Diameter(s): 6¼" Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 223.60 Bit(s): Auger
Top of Casing: 2' ALS Drilling Fluid Type: Water
Supervisory Geologist: Candace Nothwanger Amount Use: 30 gals
Log Book No. 2 pp. 37-63 Water Level: 33' BLS

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD Diameter: 2"
Length: 35' Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 32.4' to 42.5' BLS
Setting 29.8' to 42.8' BLS Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite Setting: 27.8 - 29.8' BLS
Setting: 2.5'- 25.8' BLS Surface Casing: Steel (4½" OD x 3'
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	3/29/85	0810 hrs	3/29/85	1112 hrs
Installation:	3/29/85	1120 hrs	3/29/85	1603 hrs
Water Level Reading:	3/29/85	32.9' BLS	4/1/85	32.52' BLS
Development:				

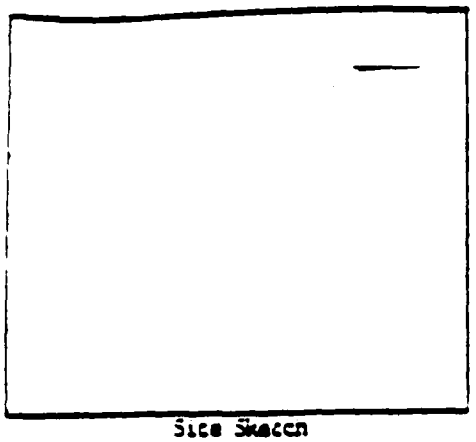
Well Development:

Method/Equipment: Air surge (1 hr.)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 32.6'
Pumping Depth to Water: 42.0'
Pumping Rate: @ 1 gal.min
Volume Pumped: 700 gals

ESE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base
Owner: U.S. Air Force
Well No.: MW5-2



Site Sketch

Location: Site 5
C-141 Spill Trench
Field Book No.: 2 pp 37-52
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 55' BLS
Reference Point Elevation: 223.60

	Date	Time
Drilling Started:	3/29/85	0810
Drilling Completed:	3/29/85	1112
Water Level:	3/29/85	32.9'

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Sandy clay, red.
2'			
			SI: 3.5 - 5.0' BLS RE: 1.3'
4'	SS #1	7	Sandy clay, some silt; red (2.5YR 4/8); firm; moist.
		10	
		15	
6'			
8'			SI: 8.5 - 10.0' BLS RE: 1.2'
	SS #2	7	Sandy silt; yellow (10YR 7/8) to
		11	yellowish red (5YR 5/8); firm; moist.
10'		17	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (BPF)	DESCRIPTION
10'			
	C		Fine to medium sand, some silt; reddish brown (5YR 4/4).
12'			
			SI: 13.5 - 15.0' BLS RE: 1.5'
14'	SS #3	11	Medium sand, trace silt; mottled,
		11	red (2.5YR 5/8), brownish yellow
		13	(10R 6/8), and white (10YR 8/2); loose
	C		to firm; moist to dry.
16'			Medium sand, some silt, trace gravel.
			Gravel layer from @ 18 - 22' BLS.
18'			SI: 18.5 - 20.0' BLS RE: 1.5'
	SS #4	12	Coarse sand, some gravel; mottled, white
		12	(10YR 8/1) and reddish yellow (5YR 7/6);
20'		24	loose; dry.
	C		Sand and gravel.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.5'
24'	SS #5	8	Medium to coarse sand; white (5YR 8/1);
		9	and light reddish brown (2.5YR 6/4);
		6	loose; moist.
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (#)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 1.4'
	SS #6	4	Coarse micaceous, kaolinitic sand;
		14	white (10YR 8/1) with light red (7.5YR 6/6)
30'		14	laminations; loose to firm; moist.
			Water Table at @ 33' BLS.
32'			
			SI: 33.5 - 35.0' BLS RE: 1.0'
34'	SS #7	11	Coarse micaceous, kaolinitic sand;
		11	white (10YR 8/1) with light red (7.5YR 6/6)
		10	laminations; loose; wet.
36'	C		
			Same as above.
38'			
			SI: 38.5 - 40.0' BLS RE: 1.6'
	SS #8	5	Same as SS#7.
		7	
40'		13	
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
1400 Westpark Drive, McLean, Virginia 22102

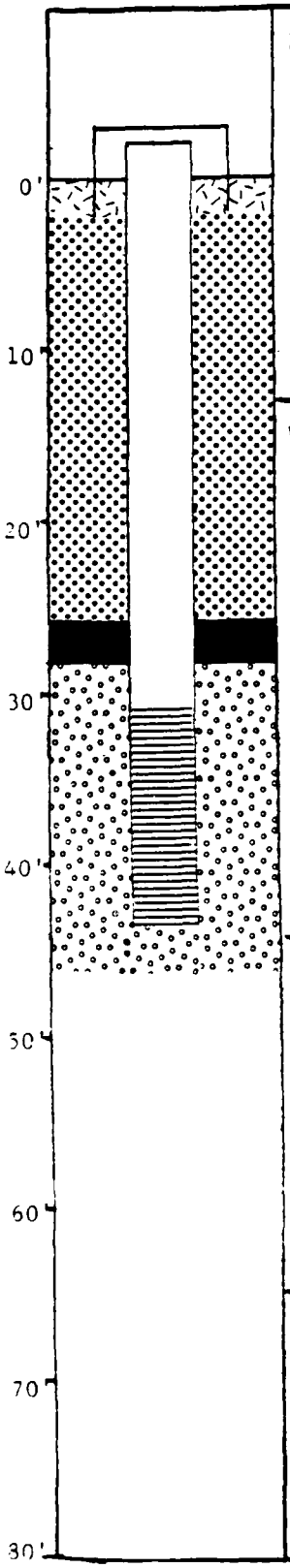
DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (BB)	DESCRIPTION
42'			Clay layer begins at @ 43' BLS.
			SI: 43.5 - 45.0' BLS RE: 1.4'
44'	SS #9	10	Clay; mottled, white (5YR 8/1) and
		14	light brown (7.5YR 6/4); firm to stiff;
		20	moist to dry.
46'	C		Clay, some sand.
48'			SI: 48.5 - 50.0' BLS RE: 1.3'
	SS #10	10	Clay; white(5YR 8/1); stiff; dry.
		14	
50'		23	
	C		Clay, little sand.
52'			SI: 53.5 - 55.0' BLS RE: 1.3'
54'	SS #11	10	Same as SS#10.
		13	
		15	
56'			
58'			

ESE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW5-3



Drilling Summary:

Total Depth: 50' BLS
Drillers: Harris Howard
Borehole Diameter(s): 6¼"
Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 221.09
Bit(s): Auger
Top of Casing:
Drilling Fluid Type:
Supervisory Geologist: Candace Nothwanger
Amount Use:
Log Book No. 2 pp. 65-97
Water Level: 30.8' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD
Diameter: 2"
Length: 33'
Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand
Setting: 31'-44' BLS
Setting 28.3' - 46.3' BLS
Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite
Setting: 25.2' to 28.3' BLS
Setting: 2.5'- 25.2' BLS
Surface Casing: Steel (4½" OD x
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	4/1/85	0937 hrs	4/2/85	1200 hrs
Installation:	4/2/85	1318 hrs	4/2/85	1516 hrs
Water Level Reading:	4/2/85	30.8' BLS	4/2/85	30.5' BLS
Development:				

Well Development:

Method/Equipment: Air surge (1 hr.)/1.7" Brainard- Kilman hand pump.
Static Depth to Water: 30.7'
Pumping Depth to Water: 43.5'
Pumping Rate: 1 gal/min
Volume Pumped: 550 gals

SOCIATES
A Company of Science Applications, Inc.
100 Westpark Drive, McLean Virginia 22102

DRI... G LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW5-3

Site Sketch

Location: Site 5 Field Book No.: 2 pp 65-97
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550
Reference Point: Land Surface Total Depth: 50' BLS
Reference Point Elevation: 221.09

	Date	Time
Drilling Started:	4/1/85	0937 hr
Drilling Completed:	4/2/85	1200 hr
Water Level:	4/2/85	30.8' BLS

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

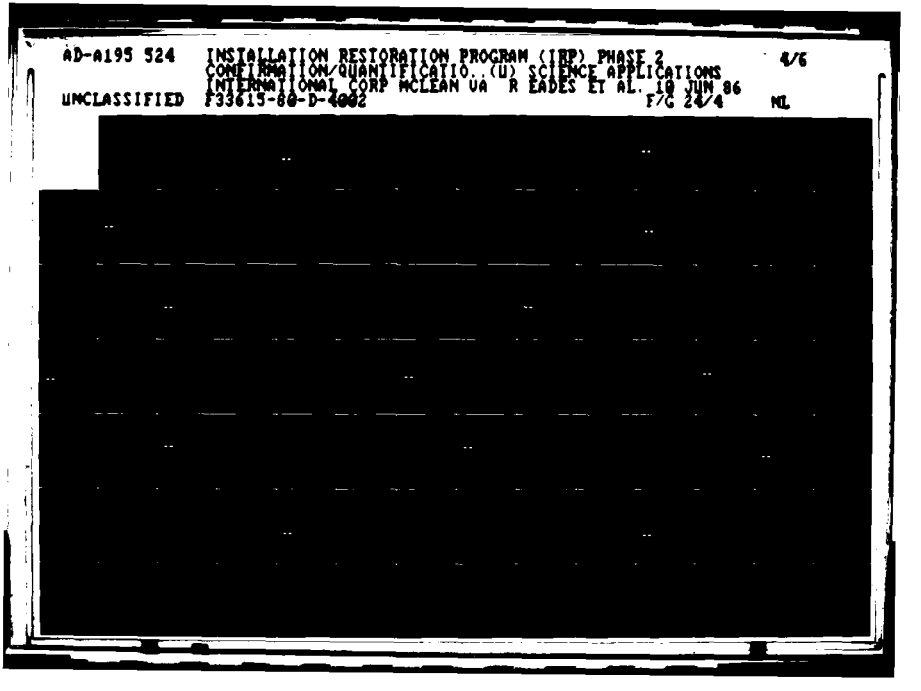
Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Sandy clay; red (2.5YR 4/6).
2'			SI: 3.5 - 5.0' BLS RE: 1.0
4'	SS #1	5	Sandy clay, some silt, trace,
		8	gravel; red (2.5YR 4/6); firm to stiff;
		13	moist.
6'			
8'			SI: 8.5 - 10.0' BLS RE: 1.4'
	SS #2	6	Sandy clay, some silt, trace gravel;
		8	yellowish red (5YR 5/8); firm; moist.
10'		13	

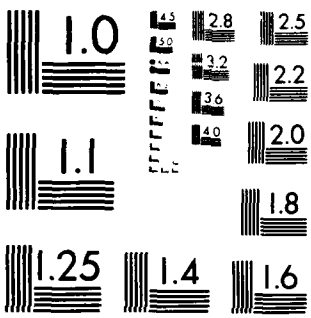
JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample & Type and Number	Blow Counts (/6")	DESCRIPTION
10'			
			Gravel layer begins at @ 11.5' BLS.
12'			
			SI: 13.5 - 15.0' BLS RE: 1.3'
14'	SS #3	17	Medium silt sand, some gravel; red (2.5 YR 4/8)
		16	to yellow (10YR 7/8); loose; dry.
		18	
16'	C		Medium to coarse silty sand and gravel.
			Gravel layer ends at @ 18.0' BLS.
18'			SI: 18.5 - 20.0' BLS RE: 1.4'
	SS #4	9	Medium micaceous, kaolinitic sand, some
		15	silt; mottled reddish yellow (7.5YR 6/8);
20'		17	reddish yellow (5YR 6/8), and white
	C		(5YR 8/1); loose to firm; moist to dry.
			Kaolin beads.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.4'
24'	SS #5	8	Medium to coarse, micaceous, kaolinitic
		10	sand; light reddish brown (2.5YR 6/4)
		18	and white (10YR 8/1); loose to firm; moist.
26'			

AD-A195 524 INSTALLATION RESTORATION PROGRAM (IRP) PHASE 2 4/6
CONFIRMATION/QUANTIFICATIO..(U) SCIENCE APPLICATIONS
INTERNATIONAL CORP MCLEAN VA R EADES ET AL. 10 JUN 86
UNCLASSIFIED F33615-80-D-4002 F/G 24/4 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

JRB ASSOCIATES
A Company of Science Applications, Inc.
400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (#)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 1.2'
	SS #6	11	Medium to coarse sand, coarser with
		12	depth; mottled, yellow (2.5YR 8/6) and
30'		12	white (10YR 8/1); loose; moist to wet.
	C		
			Medium to coarse sand.
32'			Water Table at @ 30.8' BLS.
			SI: 33.5 - 35.0' BLS RE: 1.3'
34'	SS #7	7	Medium to coarse sand, some clay;
		10	white (10YR 8/1); loose; wet.
		14	
36'			
38'			
			SI: 38.5 - 40.0' BLS RE: 1.0'
	SS #8	9	Coarse sand; white (10YR 8/1) with
		16	pale red (5R 6/4) laminations; loose;
40'		21	saturated.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

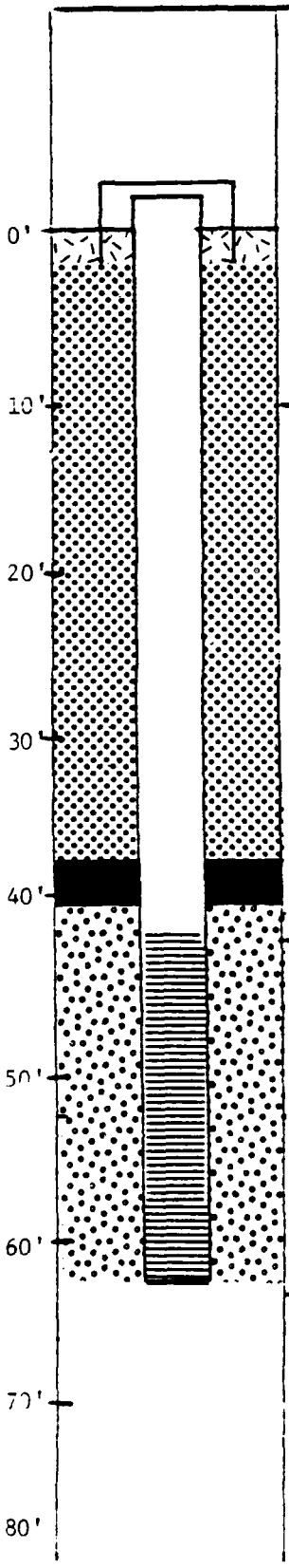
DRILLING LOG

Depth (feet)	Sample type and Number	Blow Count (N)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	9	0.5' - Coarse sand; white (5YR 8/1); wet.
		6	0.5' - Medium sand; pale red (10R 6/4); moist.
		13	0.4' - Clay; reddish yellow (7.5YR 6/8); stiff; dry.
46'			0.1' - Clay; white (5YR 8/1); stiff; dense; dry.
			Clay layer from @ 44.5 - 48' BLS.
48'			SI: 48.5 - 50.0' BLS RE: 1.0'
	SS #10	8	Medium to coarse sand; white (10YR 8/1)
		13	and grey (2.5YR 5/0); wet.
50'		16	
52'			
54'			
56'			
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW 6-1



Drilling Summary:

Total Depth: 65.0'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 220.13
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 1-23

Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): 6"OD/3¼ID Hollow Stem Auger
Drilling Fluid Type: water
Amount Use: 80 gallons
Water Level: 41.72' BLS (4/5/85 0820hr

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2¼" OD
Length: 44.7'
Filter: Material: Torpedo Sand
Setting: 40.9 - 65.0' BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.5 - 38.0' BLS

Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 42.7 - 62.7' BLS
Seals: Type: Bentonite Pellets
Setting: 38.0 - 40.9' BLS
Surface Casing: Steel(4½"OD x 5'Lt.)

Other: Steel casing cemented from 2.5' BLS to land surface.

Time Log:

	Started	Completed
Drilling:	4/4/85 1305hr	4/4/85 1750hr
Installation:	4/5/85 0920hr	4/5/85 1530hr
Water Level Reading:	4/5/85 0820hr (41.72'BLS)	4/8/85 (41.6'BLS)
Development:		

Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 41.7'
Pumping Depth to Water: 62.2'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 310 gals. & 100 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 6-1

Site Sketch

Location: Unofficial Dump Site
Field Book No.: 3 pp 1-23
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 65.0'
Reference Point Elevation: 220.13

	Date	Time
Drilling Started:	4/4/85	1305 hr
Drilling Completed:	4/4/85	1750 hr
Water Level:	4/5/85	0820 hr

Legend
SI: Sampling Interval
RE: Recovery
SS: Solit Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
2'			SI: 3.5 - 5.0' BLS RE: 1.5'
4'	SS #1	3	1.5' - Reddish yellow (7.5 yr 5/8) fine to medium sand,
		6	clayey, some silt, loose, poorly sorted.
		3	
6'	C		Reddish brown silty, clayey sand
8'			SI: 8.5 - 10.0' BLS RE: 1.5'
	SS #2	8	1.5' - Reddish yellow (10 yr 6/8 to 10 yr 5/8) clayey
		13	silt, some sand, loose to slightly firm,
10'		16	poorly sorted

JRB ASSOCIATES
Company of Science Applications, Inc.
400 Westbury Drive, McLean, Virginia 22102

DRILLING LOG

MW 6-1 (Cont.)

Depth (feet)	Sample Type and Number	Blow Count (BB)	DESCRIPTION
10'	C		Same as above
12'			SI: 13.5 - 15.0' BLS RE: 1.5'
14'	SS #3	12	1.5' - Reddish yellow (7.5 yr 6/8 to 7.5 yr 5/8)
		18	fine to medium sand, silty, firm
		11	
16'	C		Light brown silty sand, little clay.
18'			SI: 18.5 - 20.0' BLS RE: 1.5'
	SS #4	14	1.5' - Mottled reddish brown (5 yr 4/6) and light yellow (10 yr 7/6) silty sand, little clay
		16	firm to stiff
20'		19	
22'	C		Silty sand, trace gravel
			SI: 23.5 - 25.0' BLS RE: 1.5'
24'	SS #5	14	1.5' - Yellow brown (10yr 6/6) fine to medium sand,
		16	some silt, trace clay, loose
		17	
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 6-1 (Cont.)

Depth (feet)	Sample Type and Number	Blow Count (#)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	9	1.5' - Light yellow (10 yr 7/8) fine to medium sand,
		13	trace silt, trace coarse sand, loose
30'		14	
	C		Light yellow sand
32'			
			SI: 33.5 - 35.0' BLS RE: 1.5'
	SS #7	3	1.5' - Laminated light yellow (10 yr 7/8) and
34'		4	pinkish brown (5 yr 5/4) clayey silt, trace sand,
		7	loose
	C		
36'			Light yellow sand
38'			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	3	1.5' - Light yellow brown (10 yr 6/8) medium sand,
		3	some fine sand, trace silt, loose, moist
40'		5	
42'			

JRB ASSOCIATES
Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 6-1 (Cont.)

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	4	6.5' - Light yellow (10 yr 6/8) medium to coarse sand,
		3	trace silt and clay, loose, wet
		6	
	C		
46'			Same as above
48'			
			SI: 48.5 - 50.0' BLS RE:
	SS #10	4	1.0' - Light yellow (10 yr 7/8) coarse to medium sand
		5	some fine sand, trace silt, loose, wet
50'		7	
	C		
			Same as above
52'			
			SI: 53.5 - 55.0' BLS RE:
54'	SS #11	4	1.2' - Light brown (10 yr 6/6) medium sand,
		6	some fine sand, trace gravel up to
		7	1" in diameter, wet, loose
56'	C		Same as above
	C		Gravel layer approximately 1.0' thick (57.0 - 58.0')
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

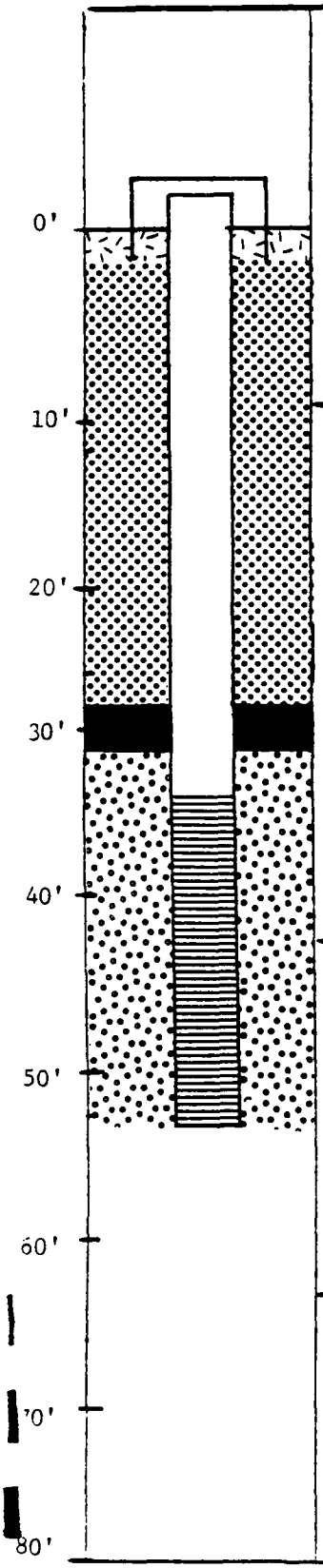
MW 6-1 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (#)	DESCRIPTION
58'			
			No split spoon sample attempted since sands heaved up
			3' into augers
60'	C		Light yellow brown sands, trace gravel
			Note: Since heaving sands encountered, overdrilled to
62'			63.5' to allow for ease in well installtion.
			SI: 63.5 - 65.0' BLS RE: 0.0'
64'	SS #12	4	No recovery, considered interval to be composed of
		7	loose sands with trace gravel
		11	
66'			
68'			
70'			
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW 6-2



Drilling Summary:

Total Depth: 53.2' Drillers: Earl Moseley
Borehole Diameter(s): 6½" Soil & Material Engineers
Rig Type: CME 550
Elevation: Land Surface: 210.35 Bit(s): Hollow Stem Auger
Top of Casing: Drilling Fluid Type: water
Supervisory Geologist: Rick Eades Amount Use: 7 gallons
Log Book No. 3 pp. 37-49 Water Level: 32.9' BLS (4/9/85 1601hr

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD Diameter: 2"
Length: 35.2' Slot: .015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 33.2 - 53.2' BLS
Setting: 30.7 - 53.2' BLS Seals: Type: Bentonite Pellets
Grout: Type: Port. Cement/Bentonite Setting: 28.7 - 30.7' BLS
Setting: 2.5 - 28.7' BLS Surface Casing: Steel(4½"OD x 5'Lt.)
Other: Water used during installation to hydrate bentonite pellets. Steel casing cemented from 2.5'BLS to land surface.

Time Log:

	Started	Completed
Drilling:	4/9/85 1440hr	4/9/85 1745hr
Installation:	4/10/85 0740hr	4/10/95 1212hr
Water Level Reading:	4/9/85 1601hr (32.95'BLS)	4/10/85 1211hr (32.4'BL
Development:		

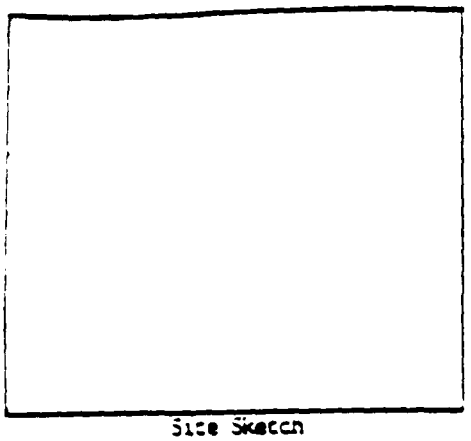
Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 32.8'
Pumping Depth to Water: 52.8'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 300 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbarx Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 6-2



Site Sketch

Location: Unofficial Dump Site
Field Book No.: 3 pp 37-69
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 58'
Reference Point Elevation: 210.35

	Date	Time
Drilling Started:	4/9/85	1440 hr
Drilling Completed:	4/9/85	1745 hr
Water Level: 32.9' BLS	4/9/85	1601 hr

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-10%
Little 12-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
2'			
			SI: 3.5 - 5.0' BLS RE: 1.3'
4'	SS #1	8	0.4' - Brown (7.5 yr 4/4) silt, trace clay
		8	0.5' - Mottled brown (7.5 yr 6/8) clay
		10	0.4' - Pink (5 yr 5/4) clayey silt, firm
6'			
	C		Pinkish brown silt, some sand
8'			
			SI: 8.5 - 10.0' BLS RE: 1.5'
	SS #2	19	1.5' - Reddish brown (5 yr 5/8) silty sand, some
		19	coarse sand, trace angular quartzitic gravel,
10'		18	firm

JRB ASSOCIATES
A Company of Science Applications, Inc.
100 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 6-2 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (bpf)	DESCRIPTION
10'			
	C		Light yellow brown silt and sand
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
	SS #3	5	1.4' - Reddish brown (5 yr 5/6) grading downing color
14'		6	to pale yellow (7.5 yr 7/6) silty sand, loose
		10	
	C		Pale yellow silty sand
16'	C		Pinkish brown clay
			SI: 18.5 - 20.0' BLS RE: 1.4'
18'	SS #4	4	1.4' - Mottled pinkish brown (5yr 6/3) clay, some silt, trace sand, stiff
		6	
20'		6	
	C		Pinkish brown clay
	C		Redish brown silt and sand
22'			SI: 23.5 - 25.0' BLS RE: 1.5'
			0.8' - Reddish brown (5 yr 5/6) silt and silty sand loose
			0.7' - Yellow brown (10 yr 6/8) fine to medium
24'	SS #5	2	sand, loose, slightly moist
		3	
		2	
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 6-2 (Cont.)

Depth (feet)	Sample type and Number	Blow Counts (N)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	1	1.5' - Light yellow brown (10 yr 7/8) fine sand,
		3	some silt, very loose, moist
30'		3	
	C		Same as above.
32'			
			SI: 33.5 - 35.0' BLS RE: 1.4'
	SS #7	4	1.4' - Pale yellow (10 yr 7/6) medium to very coarse
34'		12	sand, some gravel, loose, wet
		14	
36'	C		Same as above
	C		Hit top of clay layer at approximately 38.0'
38'			SI: 38.5 - 40.0' BLS RE: 1.4'
	SS #8	6	1.4' - White (7.5 yr 7/2) kaolonitic clay, firm
		13	
40'		19	
	C		Hit top of sand layer at approximately 41.0'
42'			

JRB ASSOCIATES
Company of Science Applications, Inc.
100 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

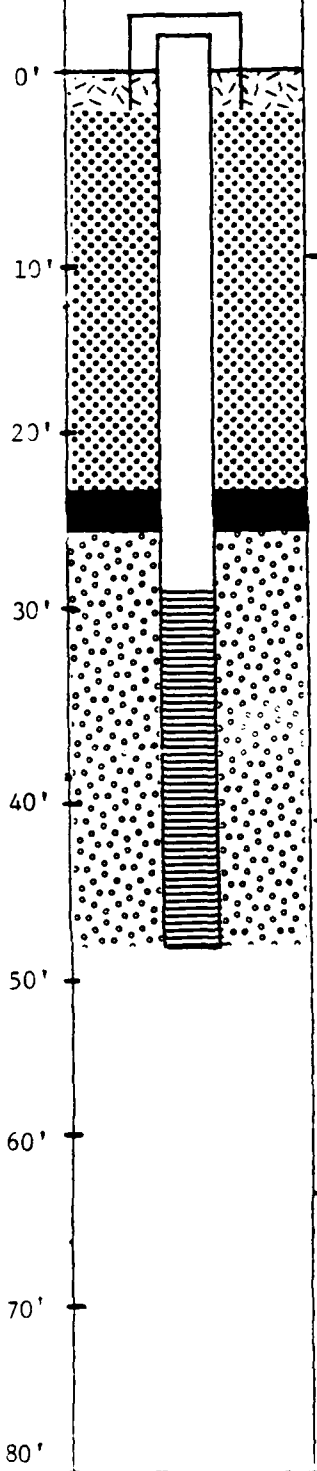
MW 6-2 (Cont.)

Depth (feet)	Sample type and Number	Blow Counts (No)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 0.7'
44'	SS #9	6	0.7' - Medium yellow brown (10 yr 6/8) coarse to
		7	medium sand
		21	
46'	C		Light to medium brown coarse sand
48'			Heaving sands prevented split spoon sample attempt at 48.5'
50'	C		Brown coarse to medium sand
52'			Heaving sands prevented split spoon sample attempt at 53.5'; decided to overdrill 5' to allow for easier well installation.
54'	C		Brown coarse to medium sand
56'			
58'			Heaving sands also occurred at 58', and no sample could be taken

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW 6-3



Drilling Summary:

Total Depth: 49.0'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 206.98
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 23-37

Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): Hollow Stem Auger
Drilling Fluid Type: water
Amount Use: 2.5 gallons
Water Level: 28.6' BLS (4/8/85)

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2⅜" OD
Length: 31.0'
Filter: Material: Torpedo Sand
Setting: 25.9' - 49.0'BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.5- 23.9' BLS

Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 29.0 - 49.0' BLS
Seals: Type: Bentonite Pellets
Setting: 23.9 - 25.9' BLS
Surface Casing: Steel(4½"OD x 5'Lt

Other: Used 2.5 gallon of water to hydrate bentonite pellets.
Steel casing cemented from 2.5' BLS to land surface.

Time Log:

	Started	Completed
Drilling:	4/8/85 1330hr	4/8/85 1618hr
Installation:	4/9/85 0714hr	4/9/85 1131hr
Water Level Reading:	4/8/85 1435hr (28.6'BLS)	4/9/85 0935 (28.6'BLS)
Development:		

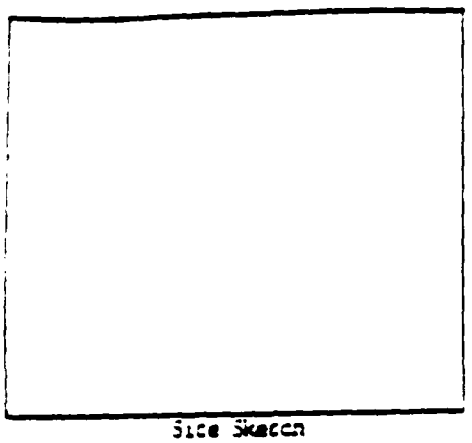
Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 28.6'
Pumping Depth to Water: 48.5'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 130 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 6-3



Site Sketch

Location: Unofficial Dump Site
Reference Point: Land Surface
Reference Point Elevation: 206.98

Field Book No.: 3 pp 23-61
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Total Depth: 53.5'

	Date	Time
Drilling Started:	4/8/85	1330hr
Drilling Completed:	4/8/85	1618hr
Water Level 28.6' BLS	4/8/85	1435hr

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" 30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Light brown sandy silt
2'			SI: 3.5 - 5.0' BLS RE: 1.5'
4'	SS #1	2	0.9' - Light brown (10yr 6/6) sandy silt, loose
		8	0.6' - Reddish brown (7.5yr 5/8) silty clay, some
		16	Medium to coarse sand, firm
6'	C		Same as above
8'			SI: 8.5 - 10.0' BLS RE: 1.5'
	SS #2	7	0.5' - Brownish gray (10yr 5/2) silt, some clay
		10	0.4' - Reddish brown (5yr 5/4) fine sand, some coarse sand
10'		10	0.6' - Yellow (10yr 7/8) fine to medium sand

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 6-3 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (/6")	DESCRIPTION
10'			
	C		Same as above
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	4	0.8' - Yellow brown (10yr 6/8) fine to coarse sand, trace silt
		2	0.6' - Mottled pink (7.5yr 6/2) and tan (7.5yr 8/6)
		4	kaolinitic clay, some sand, firm
16'	C		Tan to pink fine to coarse sand
18'			SI: 18.5 - 20.0' BLS RE: 1.5'
	SS #4	3	0.6' - Yellow brown (10yr 6/8) fine sand and silt, trace clay
		4	0.9' - Pinkish brown (5yr 6/8) fine sand, loose
20'		4	
	C		Pinkish brown sand
22'			
			SI: 23.5 - 25.0' BLS RE: 1.4'
24'	SS #5	2	0.3' - Mottled yellow brown (7.5yr 7/6) clayey silt, trace sand
		4	1.1' - Yellow (10yr 6/6) fine to coarse sand, trace gravel
		2	
26'			

JRB ASSOCIATES
Company of Science Applications, Inc.
400 Westbury Drive, McLean, Virginia 22102

DRILLING LOG

MW 6-3 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (#)	DESCRIPTION
26'			
	C		Light yellow, fine to coarse sand, trace gravel
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	2	0.2' - Reddish yellow (7.5yr 6/8) fine sand, some silt
		2	trace clay, dry
30'		2	1.3' - Light yellow (10yr 7/8) fine to coarse sand, wet
	C		
			Same as above
32'			
			SI: 33.5 - 35.0' BLS RE: 1.1'
34'	SS #7	1	1.1' - Yellow (10yr 6/6) coarse to medium sand,
		2	some gravel, semi-rounded quartz pebbles,
		5	very loose
	C		Gravel layer from 35.0-36.0'
36'	C		Coarse to medium sand
38'			SI: 38.5 - 40.0' BLS RE: 1.1'
	SS #8	6	0.2' - White (10yr 8/2) kaolintic clay, some sand
		6	0.8' - Yellow (10yr 6/8) coarse sand and gravel, some clay
40'		15	0.1' - White (10yr 8/2) kaolintic clay, some sand
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

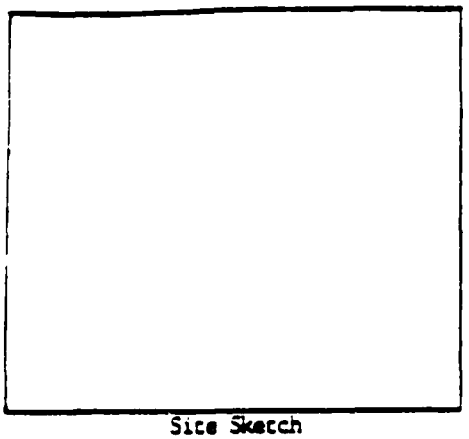
MW 6-3 (cont.)

Depth (feet)	Sample type and Number	Blow Count (#)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.0'
44'	SS #9	12	1.0' - White (10yr 8/2) coarse sand, trace fine sand and
		12	silt, loose
		14	
46'	C		Same as above
48'			SI: 48.5 - 50.0' BLS RE: 1.0'
	SS #10	6	1.0' - Same as above (with approximately 1' heave
		10	above sample
50'		16	
	C		Since heaving sands encountered, overdrilled to 53.5' to allow for ease in well installation.
52'			Same as above
54'			No split spoon attempted, since heaving sands came into auger when plug pulled; therefore, terminated drilling in sand.
56'			
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

BORING LOG

Project: McEntire ANG Base **Owner:** U.S. Air Force



Site Sketch

Location: Site 4 Oil Dump Site

Field Book No.: 5 pp 18-22

Log By: Candace Nothwanger

Driller: Harris Howard

Rig Type: CME 550

Total Depth: 15.0' BLS

	Date	Time
Boring Started:	4/18/85	0808hrs
Boring Completed:	4/18/85	0900hrs

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation

Trace	1-12%
Little	12-20%
Some	20-30%
Add "Y"	>30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			SI: 0.0-2.5'BLS
			0.0-0.5'-Silty sand; black; hydrocarbon odor
			0.5-2.5'-Sandy silt, some clay; red(2.5YR 4/8)
2'			Red clay layer begins at approximately 2.5'BLS.
4'			SI: 4.0-5.0'BLS RE: 1.0'
	SS #1		Sandy clay, some silt; red(2.5YR 4/8); firm; moist.
6'	C		Same as above.
8'			SI: 9.5-10.0'BLS RE: 0.5'
			Clay, some sand and silt; major color is red(2.5YR 4/8) but mottled yellow(10YR 7/8) to brownish yellow(10YR 7/8);
10'	SS#2		moist to dry.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Count (#)	DESCRIPTION
10'			
12'			
	C		Sand layer begins at approximately 14.4' BLS.
14'			
			SI: 14.5-15.0' BLS RE: 0.5'
	SS#3		Sand, some clay and silt; color grades from red(2.5YR 4/8)
			to yellow(10YR 7/8) and brownish yellow(10YR 6/8); loose;dry.
16'			
18'			
20'			
22'			
24'			
26'			

APPENDIX E

WELL CONSTRUCTION SUMMARIES AND BORING LOGS

WELL W2

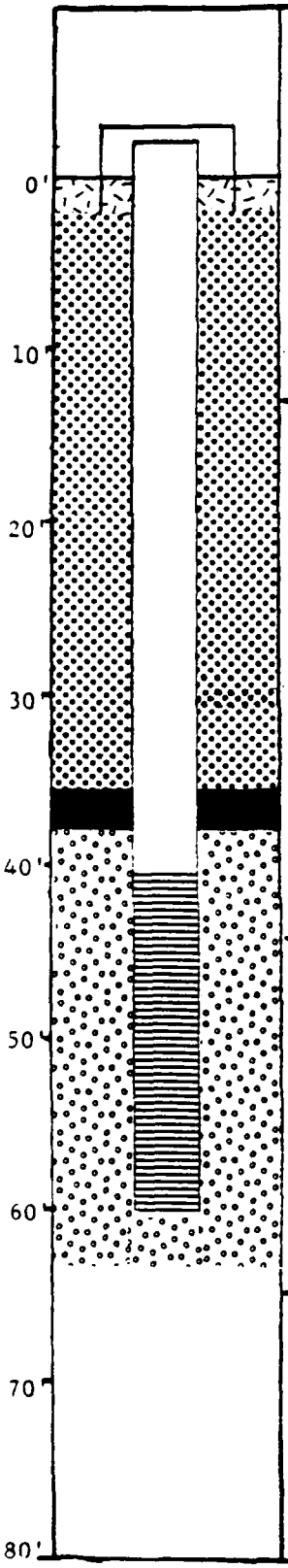
Depth Below Surface (ft.)	Description of Subsurface[a]
0-20	Sandy red clay
20-50	White clay
50-60	Hard red sandrock
60-65	Red sandy clay
65-70	White sand, some clay
70-80	Red sand, some clay
80-85	Red clay, traces of sand
85-90	Red sand, traces of clay
90-110	Fine reddish sand
110-120	Hard red clay
120-145	Dark brown clay
145-149	White clay and sand
149-160	Soft white sand

a - Description from Layne Atlantic Company, drillers.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW1-1



Drilling Summary:

Total Depth: 63.5' BLS
Drillers: Harris Howard
Borehole Diameter(s): 6¼"
Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 234.61
Bit(s): Auger, Tricone Roller Bit
Top of Casing:
Drilling Fluid Type: Bentonite/Wate
Supervisory Geologist: Candace Nothwanger
Amount Use: 200 gals.
Log Book No. 4 pp. 63-100
Water Level: 40.4' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD
Diameter: 2"
Length: 42'
Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand
Setting: 40.4' - 60' BLS
Setting 38.4' - 60' BLS
Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite
Setting: 36.4' - 38.4' BLS
Setting: 2.5'- 36.4' BLS
Surface Casing: Steel (4¾" OD x
Other: Steel casing concreted from 2.5' BLS to land surface. Drilled down to 60' BLS using augers and completed well using mud rotary.

Time Log:

	Started	Completed
Drilling:	4/11/85 0734 hrs	4/12/85 0945 hrs
Installation:	4/12/85 0947 hrs	4/12/85 1208 hrs
Water Level Reading:	4/12/85 40.4' BLS	4/17 85 41' BLS
Development:		

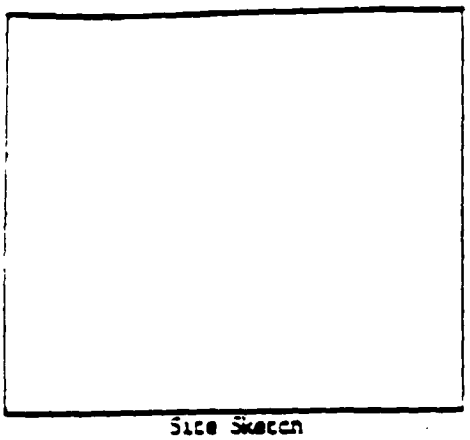
Well Development:

Method/Equipment: Air surge (1 hr.)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 40.3'
Pumping Depth to Water: 59.5'
Pumping Rate: @ 1 gal/min
Volume Pumped: 1050 gals

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbark Drive, McLean Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW1-1



Site Sketch

Location: Site 1
Fire Training Area

Field Book No.: 4 pp 63-96
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550

Reference Point: Land Surface
Total Depth: 63.5' BLS

Reference Point Elevation: 234.61

	Date	Time
Drilling Started:	4/11/85	0734hrs
Drilling Completed:	4/12/85	0945hrs
Water Level:	4/11/85	1200hrs
	40.4' BLS	

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace: 1-12%
Little: 12-20%
Some: 20-30%
Add "Y": >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Silty clay, some sand; red.
2'			
			SI: 3.5 - 5.0' BLS RE: 1.1'
4'	SS #1	7	Silty clay, some sand; red (10R 4/8); stiff;
		12	dense; dry.
		14	
6'	C		Same as above.
8'			SI: 8.5 - 10.0' BLS RE: 1.4'
	SS #2	9	Silty clay, some sand; red (10R 4/8); stiff; dense;
		8	dry.
10'		8	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (#/ft)	DESCRIPTION
10'			
			Sandy clay layer begins at @ 13.0' BLS
12'			
			SI: 13.5 - 15.0' BLS RE: 1.1'
14'	SS #3	10	Sandy clay; some silt; trace gravel; mottled,
		12	yellow (10YR 7/8) and red (2.5YR 5/8); firm to
		11	stiff; dry.
16'			
			SI: 18.5 - 20.0' BLS RE: 1.5'
18'	SS #4	7	Sandy clay, some silt; mottled, red (2.5YR 5/8),
		5	yellow (10YR 7/8); firm; dry.
20'		5	
	C		Clay, some sand, trace silt and gravel; dry.
			Gravel layer begins at @ 24' BLS.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.5'
24'	SS #5	6	0.5' - Clayey sand; brownish yellow (10YR 6/8); loose to firm; moist.
		6	0.5' - Clayey sand; white (10YR 8/1) with light red
		15	(2.5YR 6/8) laminations; loose to firm; moist.
			0.5' - Micaceous sand, some gravel, trace clay; white
26'			(10YR 8/1); loose; moist.

JRB ASSOCIATES
A Company of Science Applications, Inc.
1400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (BH)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 0.7'
	SS #6	9	Medium to coarse sand, some gravel and clay;
		12	white (10YR 8/1) and light red (2.5YR 6/8); loose
30'		10	to firm; moist.
32'			
			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	3	Clayey sand, some gravel; white (10YR 8/1) and
		3	light red (2.5YR 6/8) with red (2.5YR 5/8)
		3	laminations; loose to firm; moist.
36'			Gravel layer ends at @ 35.0' BLS
			Very fine sand layer begins at @ 38' BLS
38'			
			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	6	Very fine micaceous sand, some clay; white
		12	(10YR 8/1); loose to firm; moist.
40'		17	
			Water Table at @ 40.4' BLS.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (#)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 0.8'
44'	SS #9	10	Medium micaceous sand, some clay; white (10YR 8/1)
		16	with red (2.5YR 5/8 to 2.5YR 4/8) laminations;
		20	loose; saturated.
46'			
48'			SI: 48.5 - 50.0' BLS RE: 1.5'
	SS #10	11	Medium micaceous sand, some clay; white (10YR 8/1);
		21	loose; wet; grading into fine to medium micaceous
50'		32	sand, some clay; white (10YR 8/1) with pale red
			(10R 6/4) laminations; loose to firm; moist.
52'			SI: 53.5 - 55.0' BLS RE: 1.5'
54'	SS #11	13	Fine to medium micaceous sand, some clay;
		25	yellow (2.5YR 7/8); loose to firm; moist to wet.
		50	
56'			
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

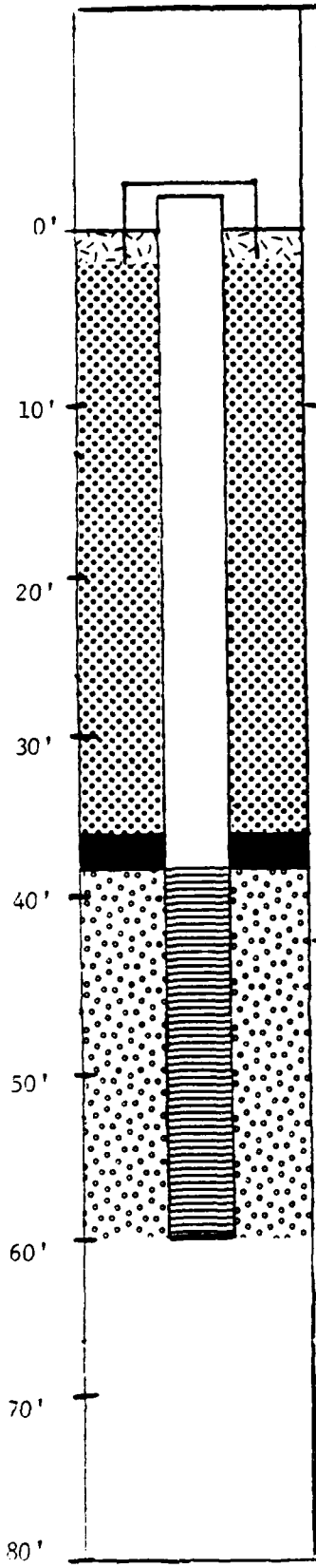
DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (ft)	DESCRIPTION
58'			SI: 58.5 - 60.0' BLS
	SS #12		Unable to take sample due to heaving sand. (Fill in augers same as SS #17).
60'	C		Fine to medium sand, some clay; wet.
62'			SI: 62 - 63.5' BLS RE: 1.4'
	SS #13	7 8 14	Very fine micaceous kaolinitic sand; white (10YR 8/1); loose to firm; moist.
64'			Note - Overdrilled @ 2' to allow room for sands to heave.
66'			
68'			
70'			
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 1-2



Drilling Summary:

Total Depth: 60'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 233.40
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 61-72
Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): Drag and Hollow Stem Auger
Drilling Fluid Type: water
Amount Use: 140 gallons
Water Level: 40.5' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD
Length: 42.5'
Filter: Material: Torpedo Sand
Setting: 38.5 - 60.1' BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.5 - 36.5' BLS
Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 40.5' - 60.1' BLS
Seals: Type: Bentonite Pellets
Setting: 36.5 - 38.5' BLS
Surface Casing: Steel(4½"OD x 5'Lt
Other: Drilled to 24' using mud rotary method, drilled from 28' to depth using auger method, steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started	Completed
Drilling:	4/11/85 1616hr	4/12/85 0949hr
Installation:	4/12/85 1000hr	4/12/85 1240hr
Water Level Reading:	4/12/85 0901hr (40.5'BLS)	4/12/85 1250hr(40. BL
Development:		

Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 42.2'
Pumping Depth to Water: 59.6'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 725 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 1-2

Location: No.5 Fire Training Area Field Book No.: 3 pp 61-72
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Reference Point: Land Surface Total Depth: 65.5'
Reference Point Elevation: 233.40

	Date	Time
Drilling Started:	4/11/85	1616hr
Drilling Completed:	4/12/85	0949hr
Water Level:	40.5' BLS 4/12/85	0901hr

Site Sketch

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
2'	C		Dark reddish brown silty clay
			SI: 4.0 - 5.5' BLS RE: 1.3'
4'			1.3' - Red (2.5YR 3/6) clay, trace silt, fine sand,
	SS #1	5	firm
		10	
		14	
6'	C		
			Same as above
8'			
			SI: 9.0 - 10.5' BLS RE: 0.9'
	SS #2	5	0.9' - Red (2.5YR 3/6) clay, trace silt, fine sand,
10'		6	firm

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 1-2 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (BB)	DESCRIPTION
10'	SS #2	8	
	C		Same as above
12'			
14'			SI: 14.0 - 15.5' BLS RE: 0.9'
	SS #3	7	0.9' - Mottled red (5YR 7/8) clayey silt with
		9	disseminated yellow (10YR 7/6) coarse sand,
		13	firm
16'	C		Same as above
	C		Hit gravel layer form 18.0 - 19.0'
18'			SI: 19.0 - 20.5' BLS RE: 1.0'
	SS #4	5	0.2' - Red (5YR 7/8) silt and clay
20'		6	0.2' - White (10YR 8/1) coarse sand and gravel
		8	0.6' - Yellow red (5YR 7/8) coarse to medium sand, some silt, firm
22'	C		Red silt and clay
	C		Gravel layer at 23.0'
24'			SI: 24.0 - 25.5' BLS RE: 0.8'
	SS #5	6	0.4' - Red (5YR 6/8 to 5YR 7/6) silty clay with
		3	gravel, firm
		4	0.4' - Red (5YR 5/6) silty sand, some clay, firm
26'			

JRB ASSOCIATES
Company of Science Applications, Inc.
400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 1-2 (cont.)

Depth (feet)	Sample type and Number	Blow Counts (N#)	DESCRIPTION
26'	C		Reddish brown silt and clay
28'			SI: 29.0 - 30.5' BLS RE: 1.4'
30'	SS #6	10 9 7	0.5' - Reddish brown (5YR 5/8) clayey silt, firm 0.9' - Yellow brown (10YR 7/8) coarse to medium sand and angular gravel, loose
32'	C		Yellow coarse to medium sand and gravel
34'			SI: 34.0 - 35.5' BLS RE: 1.4'
	SS #7	5 7 4	1.4' - Pinkish yellow (5YR 7/6) fine to medium sand, some gravel, little clay in matrix, loose to firm
36'	C		Gravel layer form 37.0 - 37.0', otherwise interval composed of pink sand, little clay
38'			SI: 39.0 - 40.5' BLS RE: 1.4'
40'	SS #8	12 18 22	1.4' - Pinkish white (5YR 8/2) fine to medium sand with some kaolinitic clay in matrix, firm, slightly damp
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 1-2 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
42'			Fine to medium sand and silt
			SI: 44.0 - 45.5' BLS RE: 1.5'
44'		5	0.4' - Pinkish red (5YR 7/6) fine to medium sand
	SS #9	7	some silt, trace clay, loose to firm, moist
		12	1.1' - White (10YR 8/1) clayey silt, some fine
			sand, firm
46'			
	C		Pinkish white fine sand and silt, clayey
48'			
			SI: 49.0 - 50.5' BLS RE: 1.5'
		8	0.5' - Pinkish white (5YR 7/4) silty clayey sand
50'	SS #10	10	1.5' - Yellow brown (10YR 8/4) silty sand, little
		14	clay, firm, wet
52'	C		Yellow silty fine sand, trace clay
54'			SI: 54.0 - 55.5' BLS RE: 1.3'
		5	0.5' - Whitish brown (10YR 8/4) silty clay
	SS #11	12	0.8' - Yellow (10YR 6/8) poorly graded coarse
		16	to medium sand, some fine sand, silt and
56'			clay, firm
	C		Yellow brown silty sand, little clay
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

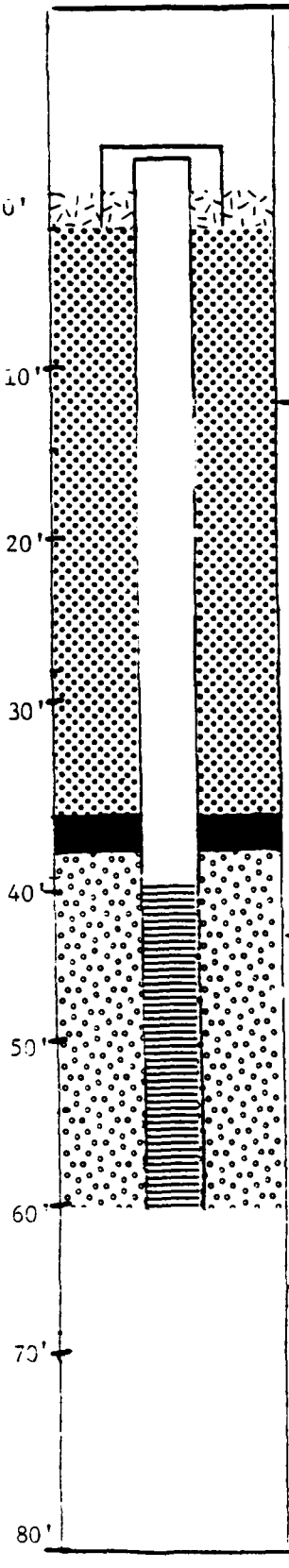
MW 1-2 (cont.)

Depth (feet)	Sample type and Number	Blow Counts (BI)	DESCRIPTION
58'			
			SI: 59.0 - 60.5' BLS RE: 1.1'
	SS #12	9	0.2' - Interbedded thin clay lenses and coarse
60'		13	sand, light yellow (10YR 7/6)
		20	0.9' - Yellow (10YR 7/6) coarse to fine sand, some
			silt and clay, firm
			Since heaving sands encountered, overdrilled to 64.0'.
62'			Same as above
64'			SI: 64.0 - 65.5' BLS RE: 0.8'
	SS #13	8	0.8' - Light yellow (10YR 6/8) silty, clayey,
		16	fine sands, firm
		27	
66'			
68'			
70'			
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW 1-3



Drilling Summary:

Total Depth: 60' Drillers: Earl Moseley
Borehole Diameter(s): 6½" Soil & Material Engineers
Rig Type: CME 550
Elevation: Land Surface: 233.09 Bit(s): Hollow Stem Auger
Top of Casing: Drilling Fluid Type: water
Supervisory Geologist: Rick Eades Amount Use: 10 gallons
Log Book No. 3 pp. 73-83 Water Level: 40.2' 4/13/85 (0702hr)

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD Diameter: 2"
Length: 42.4' Slot: .015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 40.4 - 60.0' BLS
Setting: 38.4 - 60.0' BLS Seals: Type: Bentonite Pellets
Grout: Type: Port. Cement/Bentonite Setting: 36.4 - 38.4' BLS
Setting: 2.5 - 36.4' BLS Surface Casing: Steel(4½"OD x 5'Lt.
Other: Steel casing cemented from 2.5' BLS to land surface.

Time Log:	Started	Completed
Drilling:	4/12/85 1622hr	4/13/85 0756hr
Installation:	4/13/85 0802hr	4/13/85 1100hr
Water Level Reading:	4/13/85 0702hr (40.2'BLS)	4/13/85 1127hr (40.2'B
Development:		

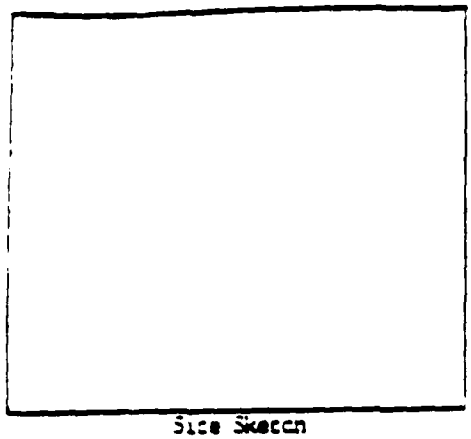
Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 42.15'
Pumping Depth to Water: 59.5'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 80 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 1-3



Site Sketch

Location: No.5 Fire Training Area
Reference Point: Land Surface
Reference Point Elevation: 233.09

Field Book No.: 3 pp 73-83
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Total Depth: 64.5'

	Date	Time
Drilling Started:	4/12/85	1622hr
Drilling Completed:	4/13/85	0756hr
Water Level:	40.2' BLS 4/13/85	0702

Legend
SI: Sampling Interval
RE: Recovery
SS: Solit Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
2'	C		Dark brown to dark red clayey silt
			SI: 3.5 - 5.0' BLS RE: 1.4'
4'	SS #1	3	1.4' - Red (2.5yr 4/8) clayey silt, some fine
		9	sand, firm
		10	
6'	C		Same as above
8'			
			SI: 8.5 - 10.0' BLS RE: 1.5'
	SS #2	4	1.5' - Red (2.5yr 4/8) clayey silt, some fine
		7	sand, firm
10'		9	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 1-3 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (N)	DESCRIPTION
10'			
	C		Same as above
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	7	0.4' - Red (2.5yr 4/8) silty clay with some
		11	sand, firm
		14	1.0' - Yellowred (5yr 5/8) sandy silt, some
	C		clay, firm
16'			
			Yellow red clayey, sandy silt
18'			SI: 18.5 - 20.0' BLS RE: 1.3'
			0.4' - Yellow red (5yr 5/8) sandy silt, some clay
	SS #4	7	0.4' - Pink yellow (7.5yr 6/8) mottled clayey sand
		12	0.5' - Mottled pink (5yr 7/4) and yellow (7.5yr 6/8)
20'		14	clayey sand, trace silt, stiff
	C		
22'			Clayey silt, some sand
24'	SS #5	5	SI: 23.5 - 25.0' BLS RE: 1.4'
		6	1.4' - Pinkish white (5yr 8/2) sandy silt,
		9	trace clay and coarse sand, stiff
26'			

ASSOCIATES
A Company of Science Applications, Inc.
400 Westbury Drive, McLean, Virginia 22102

DRILLING LOG

MW 1-3 (cont.)

Depth (feet)	Sample Type and Number	Blow Count (#)	DESCRIPTION
26'			
	C		Hit top of clay at about 28.0'
28'			SI: 28.5 - 30.0' BLS RE: 1.2'
	SS #6	6	0.8' - Mottled gray (7.5yr 8/2) and reddish yellow
		10	(5yr 6/8) clay, stiff
30'		22	0.4' - Interbedded clay (see above) and yellow
			(7.5yr 6/8) clayey sand, firm
	C		Pink to gray clay, silty
32'			
			SI: 33.5 - 35.0' BLS RE: 1.4'
34'	SS #7	5	0.4' - Pinkish gray (5yr 8/2) sandy silt, stiff
		8	0.5' - Pink (5yr 7/4) silty clay, firm
		8	0.5' - Yellow (7.5yr 8/6) well graded sand, loose, dry
36'			
	C		Yellow fine to medium sand
38'			
			SI: 38.5 - 40.0' BLS RE: 1.4'
	SS #8	5	1.0' - Pink (5yr 8/2) to yellow (10yr 6/8) fine
		6	to medium sand, loose, dry
40'		5	0.4' - Pink (5yr 7/4) mottled clay
	C		Hit top of silty sand layer at about 41.0'
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbary Drive, McLean, Virginia 22102

DRILLING LOG

MW 1-3 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (BC)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.4'
44'	SS #9	3	1.4' - Pink (5yr 7/4) to red (2.5yr 5/8) silty sand
		3	with thin clay interbeds, firm, wet
		5	
46'	C		Hit interbedded gravel and sand from 47.0 - 48.0'
48'			SI: 48.5 - 50.0' BLS RE: 1.0'
	SS #10	2	0.7' - Yellow red (5yr 6/6) coarse sand, some
		4	silt, loose
50'		5	0.3' - Yellow red (5yr 6/6) coarse sand and gravel,
	C		trace silt, loose
52'			Wet, yellow sand
			SI: 53.5 - 55.0' BLS RE: 0.5'
54'	SS #11	5	0.5' - Yellow red (5yr 7/8) silty sand, loose, wet
		17	
		23	
56'	C		Wet, yellow red sand
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

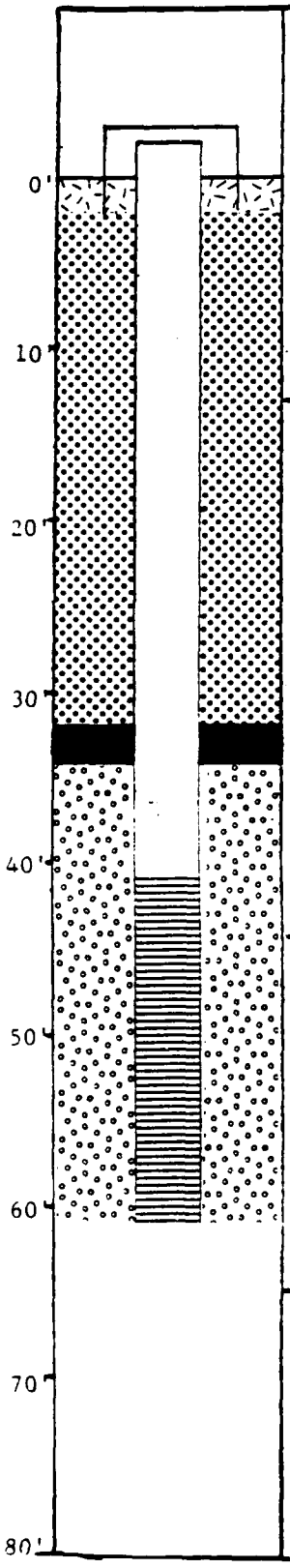
MW 1-3 (cont.)

Depth (feet)	Sample type and Number	Blow Count (N)	DESCRIPTION
58'			
	SS #12	8	SI: 58.5 - 60.0' RE: 1.1'
		14	0.3' - White (7.5yr N8) medium to coarse sand,
		19	clayey, loose
60'			0.6' - Red yellow (5yr 6/8) fine to coarse sand
			with thin clay interbeds, firm
			0.2' - Pale pink (5yr 8/3) silty sand, loose
62'			Since heaving sands encountered, overdrilled to 63.5'
	SS #13	8	SI: 63.5 - 64.5' RE: 0.6'
64'		18	0.6' - White (7.5yr N8) silty sand, trace
			clay and coarse sand, firm
66'			
68'			
70'			
72'			
74'			

ERB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW1-4



Drilling Summary:

Total Depth: 65' BLS Drillers: Harris Howard
Borehole Diameter(s): 6½" Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 235.28 Bit(s): Tricone Roller Bit
Top of Casing: Drilling Fluid Type: Bentonite/Water
Supervisory Geologist: Candace Nothwanger Amount Use: 300 gals
Log Book No. 4 pp. 101-127 Water Level: 41.4' BLS

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD Diameter: 2"
Length: 43' Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 41' - 61' BLS
Setting 34' - 61 BLS Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite Setting: 32' - 34' BLS
Setting: 2.5'- 32' BLS Surface Casing: Steel (4½" OD x 3'
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	4/12/85	1428 hrs	4/13/85	1019 hrs
Installation:	4/13/85	1104 hrs	4/13/85	1309 hrs
Water Level Reading:	4/13/85	41.4' BLS	4/14/85	41.3' BLS
Development:				

Well Development:

Method/Equipment: Air surge (1hr.)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 41.49'
Pumping Depth to Water: 60.5'
Pumping Rate: @ 1 gal/min
Volume Pumped: 1100 gals

ERB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW1-4

Location: Site 1
Fire Training Area

Field Book No.: 4 pp 101-122
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550

Reference Point: Land Surface
Total Depth: 65' BLS

Reference Point Elevation: 235.28

	Date	Time
Drilling Started:	4/12/85	1428 hr
Drilling Completed:	4/13/85	1019 hr
Water Level:	4/13/85	0859 hr
	41.4' BLS	

Site Sketch

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Sandy clay, some silt.
2'			
			SI: 3.5 - 5.0' BLS RE: 1.2'
4'	SS #1	4	Sandy clay, some silt; red (2.5YR 4/6); firm;
		6	moist.
		9	
6'			
8'			SI: 8.5 - 10.0' BLS RE: 1.3'
	SS #2	8	Sandy clay, trace silt; red (2.5YR 4/6); firm;
		8	moist.
10'		12	

JRB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbary Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (bl)	DESCRIPTION
10'			
12'			
			SI: 13.5 - 15.0' BLS RE: 1.1'
14'	SS #3	6	Sandy clay, trace silt; red (2.5YR 4/6); firm;
		7	moist.
		8	
16'			
18'			
			SI: 18.5 - 20.0' BLS RE: 1'
	SS #4	7	Sandy clay; mottled white (10YR 8/1), red
		11	(2.5YR 4/8) and yellow (10YR 7/8); firm to
20'		15	stiff; dry.
	C		
			Sandy clay to clayey sand @ 22' BLS
22'			
			SI: 23.5 - 25.0' BLS RE: 1.1'
24'	SS #5	6	Medium sand, some clay; white (10YR 8/1), and
		6	red (2.5YR 5/8); loose to firm; dry.
		7	
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (#)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 0.6'
	SS #6	9	Medium to coarse sand, some gravel and clay;
		9	red (2.5YR 5/6) and yellow (10YR 7/8); loose;
30'		8	moist to dry.
			Gravel layer begins at @ 29.0' BLS.
32'			
			SI: 33.5 - 35.0' BLS RE: 1'
34'	SS #7	9	Medium to coarse sand, some clay; white
		9	(10YR 8/1) with pale red (10R 6/4) laminations;
		9	loose; moist.
36'			Gravel layer ends at @ 36' BLS.
38'			
			SI: 38.5 - 40.0' BLS RE: 0.8'
	SS #8	17	Medium micaceous sand, some clay; white (10YR 8/1); loose;
		22	moist to wet.
40'		24	
			Water Table at @ 41' BLS.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Count (/ft)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 0.9'
44'	SS #9	13	Medium micaceous kaolinitic sand; white (10YR 8/1);
		15	loose; saturated.
		21	
46'			
48'			
			SI: 48.5 - 50.0' BLS RE: 1.0'
	SS #10	19	Same as sample SS#9.
		19	
50'		22	
	C		Same as above.
52'			
			SI: 53.5 - 55.0' BLS RE: 1.0'
54'	SS #11	19	Same as sample SS#9.
		25	
		32	
56'	C		Same as above.
58'			

JRB ASSOCIATES
– Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

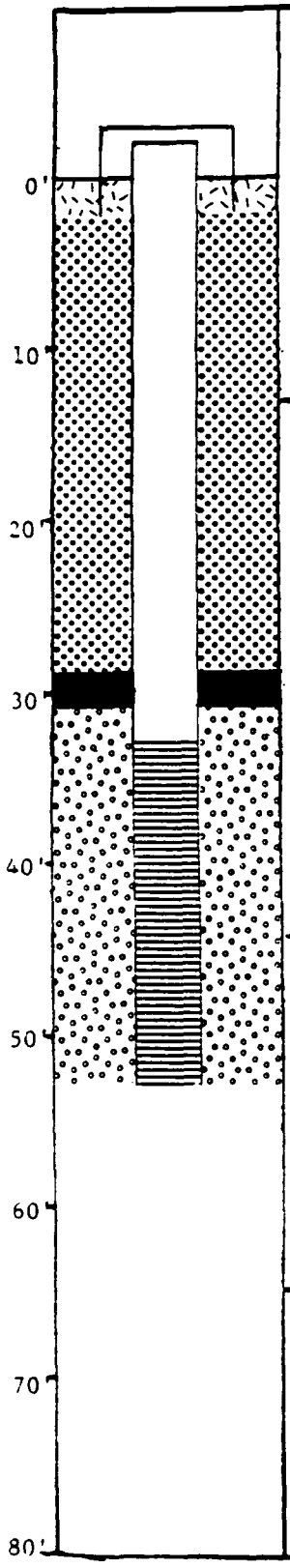
DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (/6")	DESCRIPTION
58'			SI: 58.5 - 60.0' BLS RE: 1.2'
	SS #12	26	Medium micaceous sand; some clay; white
		36	(10YR 8/1); loose; saturated.
60'		50	
	C		Same as above.
62'			
			SI: 63.5 - 65.0' BLS RE: 0.9'
64'	SS #13	18	0.7' - medium micaceous sand, some clay; white
		24	(10YR 8/1); loose; saturated.
		32	0.2' - Clay lens; white (10YR 8/1) with red
			(2.5YR 5/8) laminations; stiff;
66'			moist.
68'			
70'			
72'			
74'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW2-1



Drilling Summary:

Total Depth: 55' BLS
Drillers: Harris Howard
Borehole Diameter(s): 6½"
Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 212.82
Bit(s): Auger
Top of Casing: 2'
Drilling Fluid Type: Water/Mixture Mud
Supervisory Geologist: Candace Nothwanger
Amount Use: 27 gals/30 gals
Log Book No. 2 pp. 135-160
Water Level: 33.25' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD
Diameter: 2"
Length: 35'
Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand
Setting: 33' - 53' BLS
Setting 31' - 53' BLS
Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite
Setting: 29'-31' BLS
Setting: 2.5'- 29' BLS
Surface Casing: Steel (4½" OD x 3
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	4/4/85	1048 hrs	4/4/85	1655 hrs
Installation:	4/5/85	0824 hrs	4/5/85	1624 hrs
Water Level Reading:	4/4/85	33.25' BLS	4/8/85	33.10' BLS
Development:				

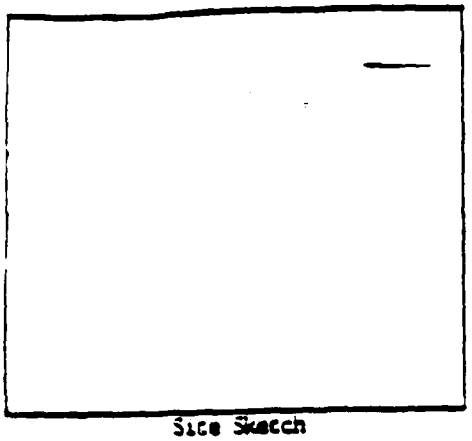
Well Development:

Method/Equipment: Air surge (1 hr)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 33.2'
Pumping Depth to Water: 52.5'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 280 gals

JRB ASSOCIATES
Company of Science Applications, Inc.
30 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 2-1



Site Sketch

Location: Site 2
Sanitary Landfill

Field Book No.: 2 pp 135-153
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550

Reference Point: Land Surface
Total Depth: 55' BLS

Reference Point Elevation: 212.82

	Date	Time
Drilling Started:	4/4/85	1048hrs.
Drilling Completed:	4/4/85	1655hrs.
Water Level:	4/4/85	33.1'BLS

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (#)	DESCRIPTION
0'			
2'			SI: 3.5 - 5.0' BLS RE: 1.2'
4'	SS #1	4 5 7	Fine to medium sandy silt, trace clay; red (2.5YR 4/6); firm; moist.
6'	C		Same as above.
8'			SI: 8.5 - 10.0' BLS RE: 1.4'
10'	SS #2	5 5 8	0.1' - Same as SS#1 1.3' - Medium to coarse sand, some clay; strong brown (7.5YR 5/6); firm to loose; moist.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (/6")	DESCRIPTION
10'			
			Gravel layer begins at @ 13.0' BLS.
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	7 8 8	Fine to medium clayey sand, trace gravel; gradation; mottled pink (7.5YR 7/4), reddish yellow (7.5YR 6/8), and white (2.5YR 8/2); firm to stiff (becomes stiff towards 15.0' BLS); moist to dry.
16'			Gravel layer ends at 16.0' BLS.
18'			SI: 18.5 - 20.0' BLS RE: 1.4'
	SS #4	2 2 3	Very fine sand, some silt; colour grades from reddish yellow (2.5YR 6/8) into yellow (10YR 7/6); loose to firm; moist.
20'			
22'			SI: 23.5 - 25.0' BLS RE: 1.5'
24'	SS #5	5 7 10	0.8' - Medium to coarse sand; white (10YR 8/1); loose; dry. 0.3' - Fine to medium sand; yellow (10YR 7/8); loose; moist to dry.
26'			0.4' - Fine to medium sand, trace clay; pale brown (10YR 7/4) to yellow (10YR 7/6); loose; moist.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (#)	DESCRIPTION
26'			
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	5	Fine to medium sand; very pale brown (10YR 8/4);
		5	loose; dry.
30'		7	
32'			Water Table at 33.25' BLS
			SI: 33.5 - 35.0' BLS RE: 0.8'
34'	SS #7	2	0.7' - Fine micaceous kaolinitic sand; white
		2	(10YR 8/1); loose; moist to wet.
		4	0.1' - Clay; mottled red (10R 4/8), pale red (10R 6/4),
			and yellow (10YR 7/8); stiff; dense; moist.
36'			
			Sand layer represented in SS#8 began at 36.0' BLS.
38'			
			SI: 38.5 - 40.0' BLS RE: 0.4'
	SS #8		Fine to medium grained sand, some silt, trace
			gravel and clay; brownish yellow (10YR 6/8);
40'			loose; wet.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

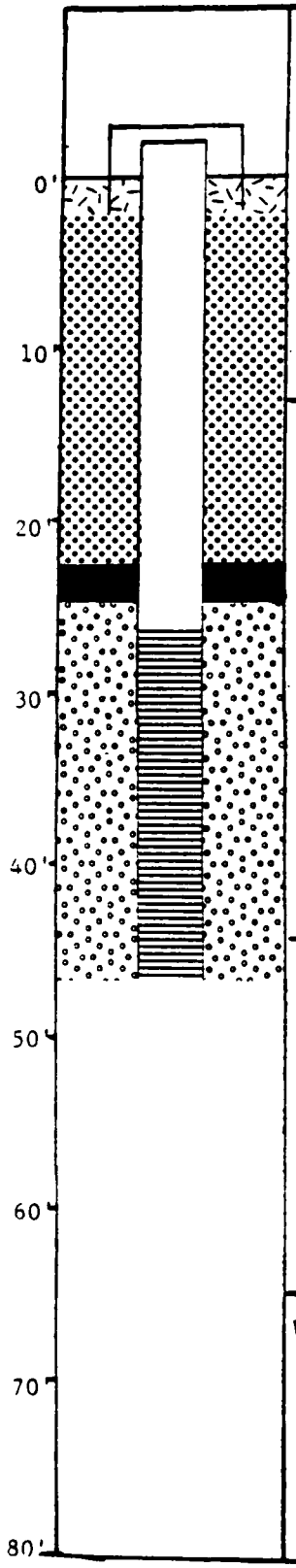
DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (N)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 0.0'
44'	SS #9		SS#9 not taken due to heaving sands.
			Sand believed to be of same type as sample SS#8.
46'			Sands becoming coarser with depth.
48'			SI: 48.5 - 50.0' BLS RE: 0.0'
	SS #10		Unable to take sample due to heaving sands
50'			Sands believed to be of same type as SS#8.
52'	C		Coarse sand, trace gravel; brownish yellow; loose; wet.
			SI: 53.5 - 55.0' BLS RE: 0.0'
54'	SS #11		Unable to take proper sample due to heaving sands.
			Sands believed to be of same type as SS#8.
56'			Overdilled @ 2' to allow for heaving sands.
58'			

ERE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base **Owner:** U.S. Air Force **Well No.:** MW2-2



Drilling Summary:

Total Depth: 48' BLS
Borehole Diameter(s): 6¼"
Elevation: Land Surface: 206.66
Top of Casing: 2' ALS
Supervisory Geologist: Candace Nothwanger
Log Book No. 2 pp. 103-125
Drillers: Harris Howard
Soil & Material Engineers, Inc.
Rig Type: CME 550
Bit(s): Auger
Drilling Fluid Type: Water
Amount Use: 25 gals
Water Level: 26.6' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD
Length: 29'
Filter: Material: Torpedo Sand
Setting 25'- 47' BLS
Grout: Type: Cement/Bentonite
Setting: 2.5'-23' BLS
Other: Steel casing concreted from 2.5' BLS to land surface.
Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: 0.015, 5 slot/inch
Setting: 27' - 47' BLS
Seals: Type: Bentonite Pellets
Setting: 23' - 25' BLS
Surface Casing: Steel (4½" OD x 5')

Time Log:

	Started		Completed	
Drilling:	4/3/85	0806 hrs	4/3/85	1136 hrs
Installation:	4/3/85	1259 hrs	4/4/85	0900 hrs
Water Level Reading:	4/3/85	26.6' BLS	4/5/85	24.0' BLS
Development:				

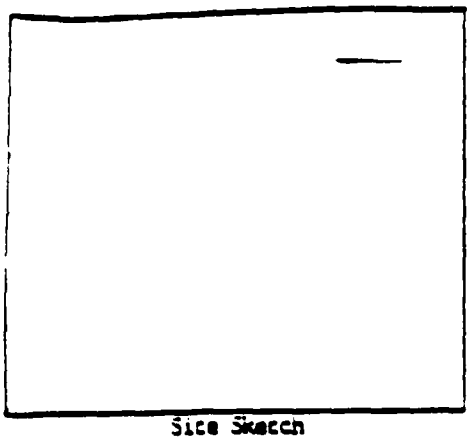
Well Development:

Method/Equipment: Air surge (1 hr)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 25.85'
Pumping Depth to Water: 46.5'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 125 gals

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base
Owner: U.S. Air Force
Well No.: MW2-2



Site Sketch

Location: Site 2
Sanitary Landfill
Field Book No.: 2 pp 103-125
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 48' BLS
Reference Point Elevation: 206.66

	Date	Time
Drilling Started:	4/3/85	0806hrs
Drilling Completed:	4/3/85	1150hrs
Water Level:	4/3/85	26.6' BLS

Legend
SI: Sampling Interval
RE: Recovery
SS: Solit Spoon
C: Cuttings

Gradation
Trace: 1-12%
Little: 12-20%
Some: 20-30%
Add "Y": >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
	C		Sandy clay; moist.
2'			SI: 3.5 - 5.0' BLS RE: 0.4'
4'	SS #1	8	Sandy clay, some silt; mottled; red (2.5YR 4/8)
		11	and strong brown (7.5YR 5/8); firm; moist.
		19	
	C		Medium to coarse sand, some silt and gravel; hot.
6'			
8'			SI: 8.5 - 10.0' BLS RE: 1.4'
	SS #2	11	Medium to coarse sand, some clay; mottled;
		10	white (5YR 8/1), pale red (10R 6/4), and yellow
10'		16	(10YR 7/8) to brownish yellow (10YR 6/8); firm; moist.

A Company of Science Applications, Inc.
1400 Westpark Drive, McLean, Virginia 22102

Depth (feet)	Sample Type and Number	Blow Counts (/6")	DESCRIPTION
10'			
			Medium to coarse sand, some gravel.
	C		
12'			Gravel layer from 11' - 14' BLS
			SI: 13.5 - 15.0' BLS RE: 1.3'
14'	SS #3	9	Fine to coarse clayey sand, some gravel;
		8	mottled, white (5YR 8/1) and pale red (10YR 6/4);
		10	firm, moist.
	C		
16'			Medium to coarse sand, some gravel; very hot.
18'			
			SI: 18.5 - 20.0' BLS RE: 1.4'
	SS #4	6	0.7' - Clay, trace sand; mottled, red (10YR 6/4)
		6	and white (5YR 8/1); stiff; dense; dry.
20'		8	0.7' - Medium sand, some clay and gravel;
			mottled, pale red (10YR 6/4) and white
			(5YR 8/1); loose to firm; moist.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.4'
24'	SS #5	3	Medium micaceous, kaolinitic sand;
		2	white (5YR 8/1); loose; moist to wet.
		7	
26'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (/6")	DESCRIPTION
26'			Medium to coarse sand and gravel; kaolin beads.
	C		Water Table at 26.6' BLS
28'			SI: 28.5 - 30.0' BLS RE: 1.2'
	SS #6	4	1.0' - Coarse sand; white (5YR 8/1); loose; wet.
		8	0.2' - Coarse sand; yellow (2.5 YR 7/8); loose; wet.
30'		15	
32'			SI: 33.5 - 35.0' BLS RE: 1.5
34'	SS #7	7	1.3' - Medium to coarse micaceous sand; brownish yellow
		14	(10YR 6/8); loose; wet.
		18	0.2' - Clay; mottled; white (5YR 8/1) and pale red
36'			(10R 6/4); loose; wet.
38'			SI: 38.5 - 40.0' BLS RE: 1.2'
	SS #8	6	0.3' - Coarse sand; white (5YR 8/1); loose; wet.
		13	0.9' - Clay and .1' sand; mottled; brownish yellow
40'		20	(10YR 6/8), and dark reddish brown (5YR 3/3);
			contains small dark red beads (7.5YR 3/6);
42'			dense; stiff; dry.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

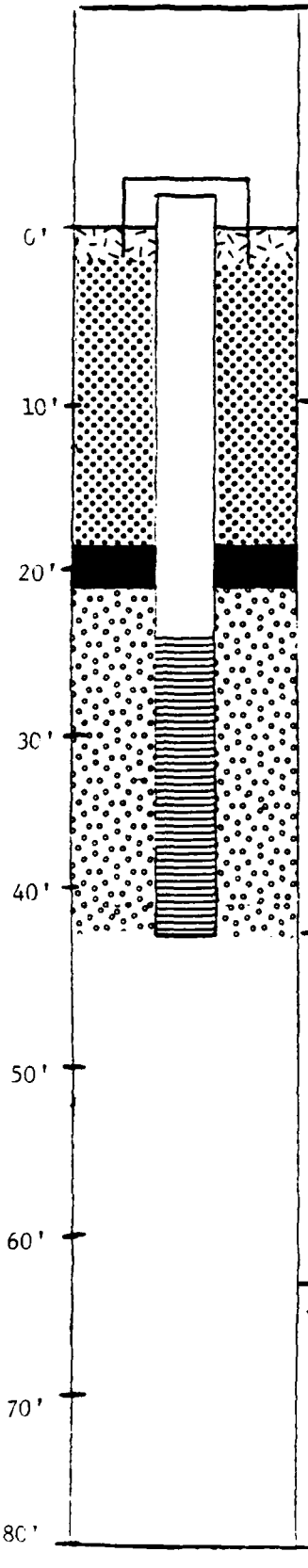
DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (#)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 0.9'
44'	SS #9	Wt. of Rods	Medium to coarse, micaceous sand; brownish yellow (10YR 6/8); loose; wet.
			SI: 45.5 - 47.0' BLS RE: 1.5'
46'	SS #10	4 7 13	Medium to coarse micaceous sand some clay; white (5YR 8/1).
48'			
50'			
52'			
54'			
56'			
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 2



Drilling Summary:

Total Depth: 43.3'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 203.75
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 49-60
Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): Hollow Stem Auger
Drilling Fluid Type: water
Amount Use: 10 gallons
Water Level: 26.0' BLS (4/10/85 165

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD
Length: 25.7'
Filter: Material: Torpedo Sand
Setting: 21.7 - 43.3' BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.0 - 29.7' BLS
Other: Steel casing cemented from 2.0' BLS to land surface.
Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 23.7 - 43.3' BLS
Seals: Type: Bentonite Pellets
Setting: 19.7 - 21.7' BLS
Surface Casing: Steel(4½"OD x 5'Lt.

Time Log:

	Started	Completed
Drilling:	4/10/85 1550hr	4/11/85 0818hr
Installation:	4/11/85 0823hr	4/11/85 1148hr
Water Level Reading:	4/11/85 1651hr (26.0"BLS)	4/11/85 1145hr(26.2"BI
Development:		

Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 26.0'
Pumping Depth to Water: 43.0'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 125 gals.

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 2-3

Site Sketch

Location: No.1 Fire Training Area/Sanitary Landfill
Field Book No.: 3 pp 49-60
Log By: Rick Eades
Driller: Earl Moseley
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 50'
Reference Point Elevation: 203.75

	Date	Time
Drilling Started:	4/10/85	1550h
Drilling Completed:	4/11/85	0818h
Water Level 26'BLS	4/10/85	1651h

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
			Legend: SI: Sampling Interval; RE: Recovery; SS: Split Spoon; C: Cuttings. Gradation: Trace 1-10%; Little 10-20%; Some 20-30%; Add "Y" 30%
0'			
			SI: 3.5 - 5.0' BLS RE: 1.5'
2'	SS #1	11	1.5' - Yellowish red (5yr) silt, some fine
		16	sand, reace clay, firm
		20	
6'	C		Reddish silty sand
			SI: 8.5 - 10.0' BLS RE: 1.5'
8'	SS #2	10	1.5' - Yellow red (5yr 5/8) medium to coarse sand,
		14	some silt, loose to firm
10'		18	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 2-3 (cont.)

Depth (feet)	Sample Type and Number	Meas Chrom (ppm)	DESCRIPTION
10'			
	C		Yellow brown fine to medium sand
12'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	5	0.7' - Pinkish brown (5yr 7/2) coarse to medium sand,
		6	some silt
		7	0.4' - Yellow brown (10yr 7/8) coarse to fine sand
	C		0.3' - Pinkish brown (5yr 5/4) clay
16'			
			Hit top of yellow sand, occurred from about 17.0-18.0'
18'			SI: 18.5 - 20.0' BLS RE: 1.4'
			1.4' - Mottled light gray (5yr 8/1) and pink (2.5yr 7/4)
	SS #4	2	clay, some silt, trace sand, firm to stiff
		4	
20'		6	
	C		Yellow silty sand lense from approximatley 20.0-22.0'
22'	C		Pinkish white clay
24'	SS #5	2	SI: 23.5 - 25.0' BLS RE: 1.5'
		2	1.3' - Pink (7.5yr 6/8) and white (5yr 8/1) laminated
		2	clay, stiff, moist at bottom
			0.2' - Red(7.5yr 4/8) silt, some sand and clay,
26'			poorly graded, firm

JRB ASSOCIATES
A Company of Science Applications, Inc.
400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

MW 2-3 (cont.)

Depth (feet)	Sample type and Number	Blow Counts (#/ft)	DESCRIPTION
26'	C		Reddish yellow silty sand
28'			SI: 28.5 - 30.0' BLS RE: 1.3'
	SS #6	2	1.3' - Yellow brown (10yr 6/8) coarse to medium
		4	sand, some silt, loose, wet
30'		5	
	C		Same as above
32'			SI: 33.5 - 35.0' BLS RE: 1.0'
	SS #7	1	1.0' - Light yellow (7.5yr 6/8) coarse to fine sand,
34'		3	trace silt, loose
		8	
36'	C		Same as above
38'			SI: 38.5 - 40.0' BLS RE: 0.9'
	SS #8	12	0.9' - Yellow (10yr 8/6) fine sand, some silt
		4	and clay, with disseminated muscovite mica,
40'		7	very loose
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

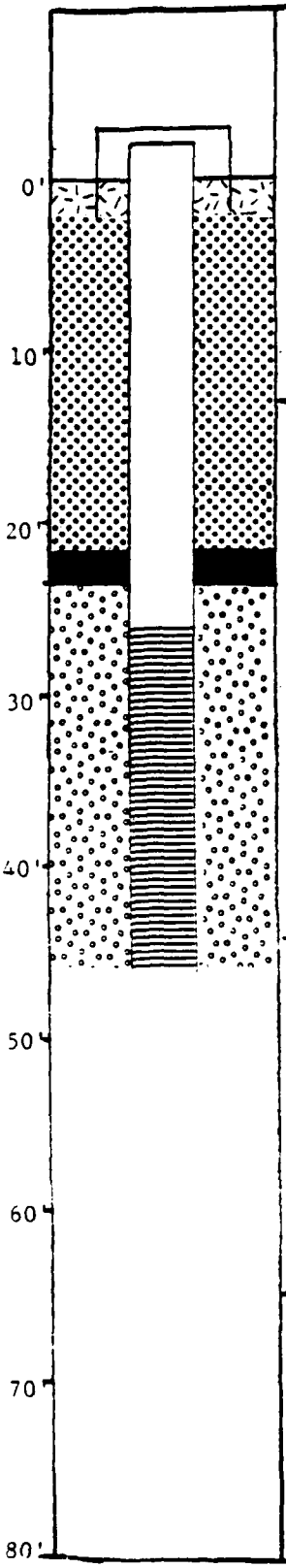
MW 2-3 (cont.)

Depth (feet)	Sample Type and Number	Blow Counts (N)	DESCRIPTION
42'	C		Same as above
			SI: 43.5 - 45.0' BLS RE: 0.7'
44'	SS #9	5	0.7' - Light yellow (10yr 8/6) coarse to very coarse
		8	sand, some silt and clay, loose to firm
		13	
			Decided to overdrill to 48.5' to ease well installation
46'			inside augers, since heaving sand encountered.
	C		Same as above
48'			SI: 48.5 - 50.0' BLS RE: 1.3'
	SS #10	8	1.3' - Yellow (10yr 8/6) coarse sand, with some
		13	silt, thin (less than ½") clay lenses
50'		19	in sample interval
52'			
54'			
56'			
58'			

ARB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW2-4



Drilling Summary:

Total Depth: 50' BLS Drillers: Harris Howard
Borehole Diameter(s): 6¼" Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 202.58 Bit(s): Auger
Top of Casing: Drilling Fluid Type:
Supervisory Geologist: Candace Nothwanger Amount Use:
Log Book No. 4 pp. 35-62 Water Level: 26'

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD Diameter: 2"
Length: 27.7' Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 26' - 46' BLS
Setting 24' - 46' BLS Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite Setting: 22' - 24' BLS
Setting: 2.5' - 22' BLS Surface Casing: Steel (4⅜" OD x 5'
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	4/10/85	0814 hrs	4/10/85	1115 hrs
Installation:	4/10/85	1300 hrs	4/10/85	1817 hrs
Water Level Reading:	4/10/85	26' BLS	4/17/85	26.3' BLS
Development:				

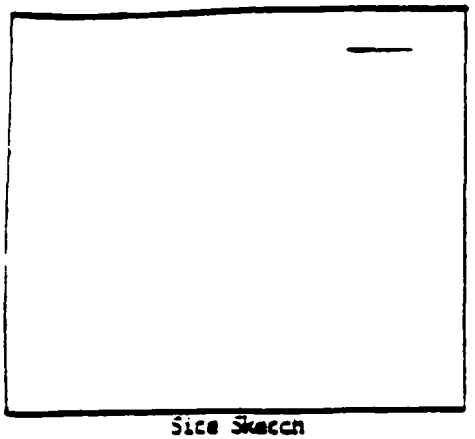
Well Development:

Method/Equipment: Air surge (1 hr.)/1/7" Brainard-Kilman hand pump.
Static Depth to Water: 26.1'
Pumping Depth to Water: 45.5'
Pumping Rate: @ 1 gal/min
Volume Pumped: 100 gals

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 2-4



Site Sketch

Location: Site 2
Sanitary Landfill

Field Book No.: 4 pp 35-52
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550
Total Depth: 50' BLS
Reference Point: Land Surface
Reference Point Elevation: 202.58

	Date	Time
Drilling Started:	4/10/85	0814hrs
Drilling Completed:	4/10/85	1115 hrs
Water Level:	4/10/85	26'BLS

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
			Sandy clay.
2'	C		
			SI: 3.5 - 5.0' BLS RE: 1.3'
4'	SS #1	4	Sandy clay, trace silt; mottled strong brown
		7	(7.5YR 5/6); yellowish brown (10YR 5/8); and red
		9	(2.5YR 4/6); firm; moist.
6'			Sandy clay layer ends at 6' BLS.
			Sand layer extends from 6 - 10' BLS.
8'			SI: 8.5 - 10.0' BLS RE: 0.7'
			Very fine sand, trace clay and gravel; mottled
	SS #2	12	white (10YR 8/1), very pale brown (10YR 8/3), reddish
		12	yellow (5YR 7/6), red (2.5YR 5/8), and yellow
10'		14	(10YR 7/8); loose; moist.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (/6")	DESCRIPTION
10'			
			Clay layer from 10.5 - 14.0' BLS
12'			
			SI: 13.5 - 15.0' BLS RE: 1.3'
14'	SS #3	4	0.5' - Clay; mottled white (10YR 8/1) and yellow (10YR 7/8);
		20	stiff; dense; dry.
		25	0.8' - Very fine sand; mottled white (10YR 8/1), very
			pale brown (10YR 8/3), red (2.5YR 5/8), and
16'			yellow (10YR 7/8); loose; dry.
			Sand layer from @ 14.0 - 21.0' BLS.
			Clay layer from @ 21.0 - 22.5' BLS.
18'			
			SI: 18.5 -20.0' BLS RE: 1.3'
	SS #4	3	0.3' - Clay, some sand; colours same as SS3;
		5	firm; dry.
20'		4	1.0' - Very fine sand; mottled white (10YR 8/1), and
			red (10R 5/8) to light red (10R 6/8);
			loose; dry.
			Sand layer begins at @ 22.5' BLS.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.5'
24'	SS #5	3	1.2' - Fine to medium sand; laminated red (7.5YR 5/8)
		4	and white (10YR 8/1); loose; dry to moist.
		3	0.3' - Fine to medium sand; colour grades from light red
			(5YR 6/8) to reddish yellow (7.5YR 8/6) to brownish
26'			yellow (10YR 6/8); loose; dry to moist.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (N#)	DESCRIPTION
26'			
			Water Table at 26.35' BLS
28'			SI: 28.5 - 30.0' BLS RE: 1.5'
	SS #6	2	Fine to medium sand; brownish yellow (10YR 6/8);
		3	loose; saturated.
30'		3	
	C		Same as above.
32'			SI: 33.5 - 35.0' BLS RE: 0.7'
34'	SS #7	Wt.	Medium to coarse sand, some gravel, trace clay; yellow
		of	(2.5Y 7/6); loose; saturated.
		Rods	
36'	C		Same as above.
38'			SI: 38.5 - 40.0' BLS RE: 0.0'
	SS #8		Unable to take SS#8 due to heaving sands.
			Fill in augers same as SS#7.
40'			
			Kaolinitic sand layer begins at ± 41' BLS.
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
1400 Westbury Drive, McLean, Virginia 22102

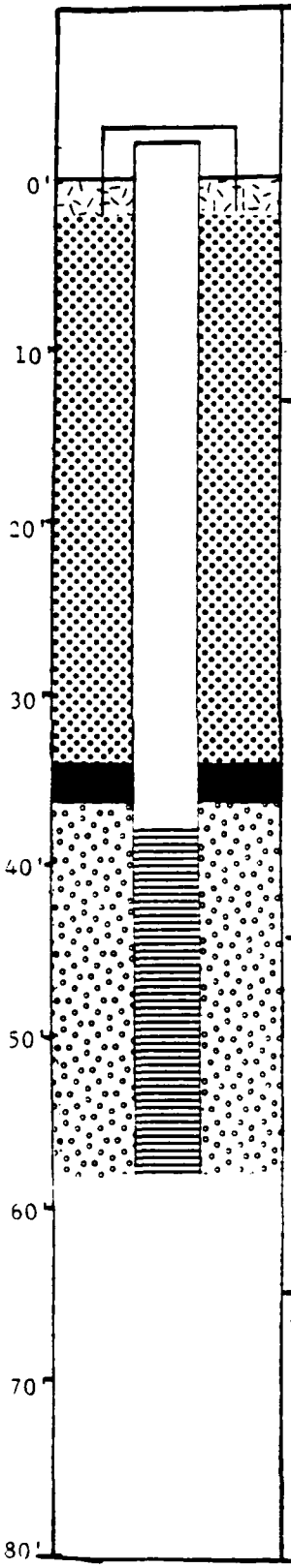
DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (/ft)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	3	Micaceous kaolinitic sand; mottled white
		6	(10YR 8/1) to yellow (10YR 7/8), very dark grey
		12	(10YR 3/1) and black (10YR 2/1); loose to firm;
			wet to moist.
46'	C		Same as above.
48'			SI: 48.5 - 50.0' BLS RE: 1.5'
	SS #10	5	Fine to medium micaceous kaolinitc sand;
		14	laminated, white (10YR 8/1) and yellow (10YR 7/8)
50'		19	to brownish yellow (10YR 6/8); loose to firm;
			moist to wet.
52'			
54'			
56'			
58'			

ASSOCIATES
A Company of Science Applications, Inc.
3400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW2-5



Drilling Summary:

Total Depth: 60' BLS
Borehole Diameter(s): 6¼"
Elevation: Land Surface: 215.22
Top of Casing:
Supervisory Geologist: Candace Nothwanger
Log Book No. 4 pp. 2-33
Drillers: Harris Howard
Soil & Material Engineers, Inc.
Rig Type: CME 550
Bit(s): Auger
Drilling Fluid Type: Mud mixture
Amount Use: 30 gals water, 95 lbs. bentonite
Water Level: 38' BLS

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD
Length: 40'
Filter: Material: Torpedo Sand
Setting 36'-58' BLS
Grout: Type: Cement/Bentonite
Setting: 2.5'- 34' BLS
Other: Steel casing concreted from 2.5' BLS to land surface.
Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: 0.015, 5 slot/inch
Setting: 38' - 58' BLS
Seals: Type: Bentonite Pellets
Setting: 34'-36' BLS
Surface Casing: Steel (4⅝" OD x 3'

Time Log:

	Started		Completed	
Drilling:	4/8/85	0833 hrs	4/9/85	0828 hrs
Installation:	4/9/85	0839 hrs	2/9/85	1541 hrs
Water Level Reading:	4/8/85	38' BLS	4/17/85	37.8' BLS
Development:				

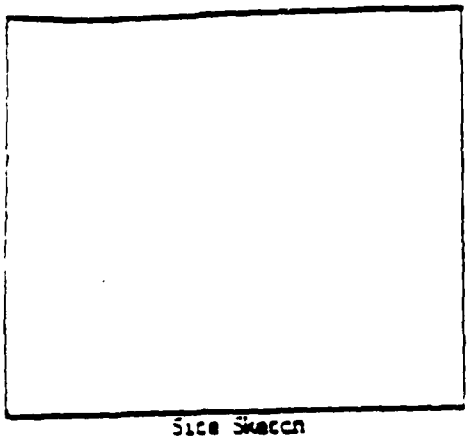
Well Development:

Method/Equipment: Air surge (1 hr.)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 38'
Pumping Depth to Water: 52.5'
Pumping Rate: @ 1 gal/min
Volume Pumped: 250 gals

A Company of Science Applications, Inc.
3400 Westbark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW2-5



Site Sketch

Location: Site No. 2
Sanitary Landfill

Field Book No.: 4 pp 2-27
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550

Reference Point: Land Surface
Total Depth: 60' BLS

Reference Point Elevation: 215.22

Date Time
Drilling Started: 4/8/85, 0833 hr.
Drilling Completed: 4/9/85, 0828 h
Water Level: 4/8/85, 38' BLS

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
			Legend: SI: Sampling Interval; RE: Recovery; SS: Split Spoon; C: Cuttings. Gradation: Trace 1-12%; Little 12-20%; Some 20-30%; Add "Y" >30%
0'	C		
			Fine to medium sand and clay.
2'			
			SI: 3.5 - 5.0' BLS RE: 1.3'
4'	SS #1	4	Sandy clay; mottled; colour grades from red (10R 4/6) to
		4	brownish yellow (10YR 6/6); firm; moist.
		9	
6'			
			SI: 8.5 - 10.0' BLS RE: 1.4'
8'	SS #2	6	Same as SS1; also contains light grey laminations
		10	(10YR 7/2).
10'		18	

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample # type and Number	Blow Counts (/6")	DESCRIPTION
10'			
12'			
			SI: 13.5 - 15.0' BLS RE: 1.2'
14'	SS #3	16	0.2' - Same as SS1 and SS2
		18	1.0' - Clayey sand; light red (2.5 YR 6/6) and light grey
		18	(10YR 7/2); firm to loose; dry.
16'			
18'			
			SI: 18.5 - 20.0' BLS RE: 1.4'
	SS #4	10	Medium to coarse sand, trace clay; reddish yellow (5YR 6/8)
		13	to yellowish red (5YR 5/8) with very pale brown laminations
20'		16	(10YR 8/3); moist to dry; loose.
	C		Sand, some clay, trace gravel; hot.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.4'
			0.1' - Medium sand, some clay; red (2.5YR 5/8); moist; loos
24'	SS #5	9	0.5' - Clay; laminated white (10YR 8/1), light reddish brow
		15	(2.5YR 6/4) and light red (2.5YR 6/6); stiff; dense;
		15	dry.
			0.8' - Very fine sand; laminated white (5YR 8/1), reddish
26'			yellow (7.5YR 7/6) and light red (2.5YR 6/8); moist.

JRB ASSOCIATES
A Company of Science Applications, Inc.
1400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (/6")	DESCRIPTION
26'			
			Very fine sand layer from @ 24 to 29' BLS
28'			SI: 28.5 - 30.0' BLS RE: 1.3'
	SS #6	6	0.4' - Very fine sand; reddish yellow, (5YR 7/6);
		6	loose; moist.
30'		6	0.5' - Very fine sand; pale red (10R 6/4); loose;
			moist.
			0.4' - Fine to medium sand, trace clay and gravel,
			mottled red (10R 5/8) and reddish yellow
			(7.5YR 6/8); loose; moist.
32'			
			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	2	0.2' - Clay; reddish grey, (10R 6/1); stiff; dense; dry.
		2	0.7' - Medium sand; laminated white (10YR 8/1) and
		4	reddish yellow (5YR 7/6); loose; moist.
			0.6' - Medium sand; brownish yellow (10YR 6/8);
36'			loose; moist.
			Water Table at @ 38' BLS
38'			
			SI: 38.5 - 40.0' BLS RE: 1.5'
	SS #8	3	Medium sand; brownish yellow (10YR 6/8) to
		3	strong brown (7.5YR 5/8); loose; wet.
40'		5	
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbart Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (BH)	DESCRIPTION
42'			
			SI: 43.5 - 45.0' BLS RE: 1.5'
44'	SS #9	Wt. of Rods	Medium to coarse sand; some gravel, reddish yellow (7.5YR 6/8); loose; wet.
46'	C		Same as above.
48'			SI: 48.5 - 50.0' BLS RE: 0.0'
	SS #10		SS #10 could not be taken due to heaving sands. Sands believed to be of same type as SS #9.
50'	C		Same as above.
52'			SI: 53.5 - 55.0' BLS RE: 0.0'
54'	SS #11		SS #11 could not be taken due to heaving sands. Sands believed to be of same type as SS #9.
56'	C		Same as above.
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

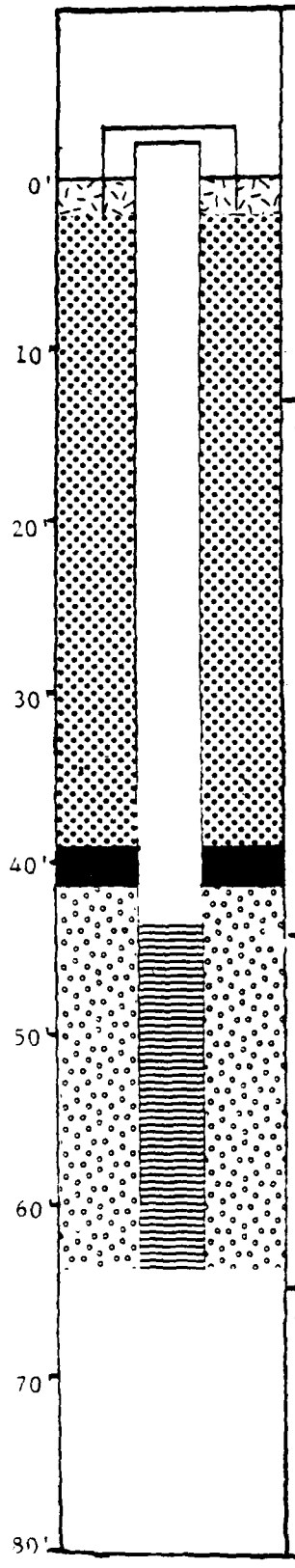
DRILLING LOG

Depth (feet)	Sample type and Number	Blow Count (#)	DESCRIPTION
58'			SI: 58.5 - 60.0' BLS RE: 1.2'
	SS #12	Wt. of Rods	Same as SS #9.
60'			
62'			
64'			
66'			
68'			
70'			
72'			
74'			

ESE ASSOCIATES
A Company of Science Applications, Inc.
3400 Westbank Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW3-



Drilling Summary:

Total Depth: 65' BLS Drillers: Harris Howard
Borehole Diameter(s): 6¼" Soil & Material Engineers, Inc.
Rig Type: CME 550
Elevation: Land Surface: 240.11 Bit(s): Auger
Top of Casing: Drilling Fluid Type:
Supervisory Geologist: Candace Nothwanger Amount Use:
Log Book No. 5 pp. 2-14 Water Level: 43.5' BLS

Well Design:

Casing: Material: Schedule 40 PVC Screen: Material: Schedule 40 PVC
Diameter: 2" ID 2 5/16" OD Diameter: 2"
Length: 45.5' Slot: 0.015, 5 slot/inch
Filter: Material: Torpedo Sand Setting: 43.5' - 63.5' BLS
Setting 41.4' - 63.5' BLS Seals: Type: Bentonite Pellets
Grout: Type: Cement/Bentonite Setting: 39.4' - 41.4' BLS
Setting: 2.5'- 39.4' BLS Surface Casing: Steel (4½" OD x
Other: Steel casing concreted from 2.5' BLS to land surface.

Time Log:

	Started		Completed	
Drilling:	4/16/85	1752 hrs	4/17/85	0945 hrs
Installation:	4/17/85	0951 hrs	4/17/85	1410 hrs
Water Level Reading:	4/17/85	43.5' BLS	4/18/85	41.9' BLS
Development:				

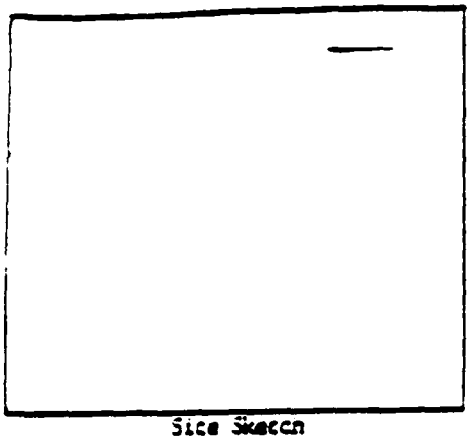
Well Development:

Method/Equipment: Air surge (1 hr.)/1.7" Brainard-Kilman hand pump.
Static Depth to Water: 43.6'
Pumping Depth to Water: 63.0'
Pumping Rate: @ 1 gal/min
Volume Pumped: 75 gals

SAIC ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Project: McEntire ANG Base
Owner: U.S. Air Force
Well No.: MW3-1



Site Sketch

Location: Site 3
Storage Facility
Field Book No.: 5 pp2-14
Log By: Candace Nothwanger
Driller: Harris Howard
Rig Type: CME 550
Reference Point: Land Surface
Total Depth: 65' BLS
Reference Point Elevation: 240.11

	Date	Time
Drilling Started:	4/16/85	1752
Drilling Completed:	4/17/85	0945
Water Level:	4/17/85	43.5'

Legend
SI: Sampling Interval
RE: Recovery
SS: Split Spoon
C: Cuttings

Gradation
Trace 1-12%
Little 12-20%
Some 20-30%
Add "Y" >30%

Depth (feet)	Sample Type and Number	Blow Count (N)	DESCRIPTION
0'			
2'			SI: 3.5 - 5.0' BLS RE: 1.1'
4'	SS #1	4 7 12	Sandy clay, some silt; red (2.5YR 4/8); firm; moist.
6'	C		Same as above.
8'			SI: 8.5 - 10.0' BLS RE: 1.3'
10'	SS #2	7 11 17	Sandy clay, some silt; red (2.5YR 5/8) to red (2.5YR 4/8); firm; moist to dry.

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (6")	DESCRIPTION
10'			
			SI: 13.5 - 15.0' BLS RE: 1.4'
14'	SS #3	7 11 16	Silty sand, some clay; mottled, red (2.5YR 4/8) and white (10YR 8/1); firm; dry.
16'			
18'			SI: 18.5 - 20.0' BLS RE: 1.3'
20'	SS #4	8 11 12	Silty sand, some clay, trace gravel; mottled, red (2.5YR 4/8), light red (2.5YR 6/8), and white (10YR 8/1); firm; dry.
			Sand layer begins at 21.5' BLS.
22'			
			SI: 23.5 - 25.0' BLS RE: 1.4'
24'	SS #5	5 5 4	Sand, some silt, little clay; reddish yellow (7.5YR 6/8) and strong brown (7.5YR 5/8); loose; moist.
26'			

JRB ASSOCIATES
Company of Science Applications, Inc.
400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (BI)	DESCRIPTION
26'			
			Sand and gravel layer begins at 26.0' BLS.
28'			
			SI: 28.5 - 30.0' BLS RE: 1.3'
	SS #6	3	Sand, some gravel, trace silt and clay;
		9	light red (10YR 6/8) and white (10YR 8/1);
30'		14	loose; moist.
32'			Micaceous sand layer begins at 31.5' BLS.
			SI: 33.5 - 35.0' BLS RE: 1.5'
34'	SS #7	10	Very fine micaceous sand; yellow (10YR 8/8),
		9	white (10YR 8/1) and white (10YR 8/2);
		11	loose; moist.
36'			
38'			
			SI: 38.5 - 40.0' BLS RE: 1.4'
	SS #8	10	Fine micaceous sand; white (10YR 8/1);
		10	loose; moist.
40'		13	
42'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

DRILLING LOG

Depth (feet)	Sample type and Number	Blow Counts (/ft)	DESCRIPTION
42'			Water Table at 43.5' BLS.
			SI: 43.5 - 45.0' BLS RE: 1.7'
44'	SS #9	13	Fine micaceous sand; white (10YR 8/1) to white
		11	(10YR 8/2); loose; wet.
		17	
46'			
48'			SI: 48.5 - 50.0' BLS RE: 1.4'
	SS #10	6	Medium to coarse micaceous sand;
		10	white (10YR 8/1); loose; saturated.
50'		23	
52'			Same as above.
			SI: 53.5 - 55.0' BLS RE: 0.5'
54'	SS #11	10	Medium micaceous sand, some clay; white
		20	(10YR 8/2); loose; saturated.
		32	
56'			Sand and clay layer began at 54.5' BLS.
58'			

JRB ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

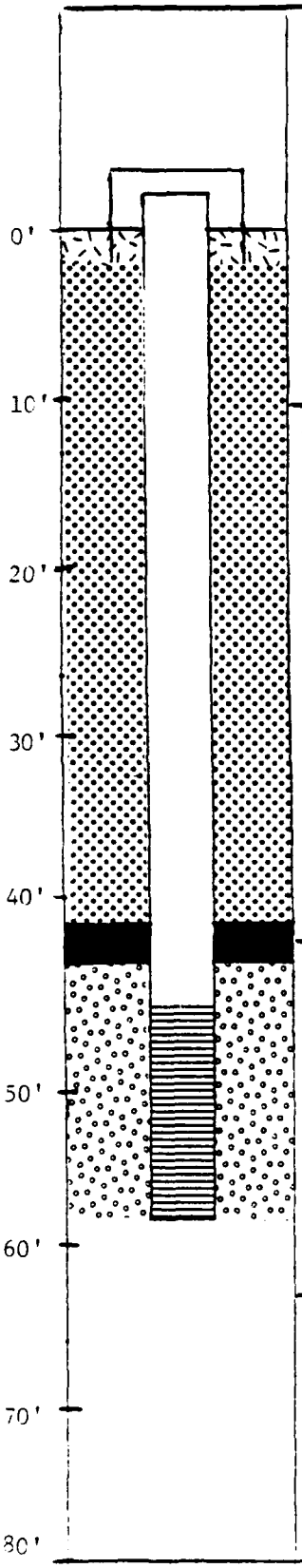
DRILLING LOG

Depth (feet)	Sample Type and Number	Blow Counts (#)	DESCRIPTION
58'			SI: 58.5-60.0' BLS RE: 1.4'
	SS #12	10	Fine micaceous sand, trace clay; white (10YR 8/2); loose;
		17	wet.
60'		24	
	C		Same as above.
62'			
			SI: 63.5 - 65.0' BLS RE: 1.0'
64'	SS #13	4	0.5' - Medium micaceous sand; white (10YR 8/1);
		9	loose; wet.
		14	0.5' - Medium micaceous kaolinitic sand; white
			(10YR 8/2); loose; wet.
66'			
68'			
70'			
72'			
74'			

ASSOCIATES
A Company of Science Applications, Inc.
8400 Westpark Drive, McLean, Virginia 22102

WELL CONSTRUCTION SUMMARY

Project: McEntire ANG Base Owner: U.S. Air Force Well No.: MW 3-2



Drilling Summary:

Total Depth: 58.5'
Borehole Diameter(s): 6½"
Elevation: Land Surface: 239.92
Top of Casing:
Supervisory Geologist: Rick Eades
Log Book No. 3 pp. 114-121

Drillers: Earl Moseley
Soil & Material Engineers
Rig Type: CME 550
Bit(s): Hollow Stem Auger
Drilling Fluid Type: water
Amount Use: 10 gallons
Water Level: 46' BLS (4/17/85 1510hr)

Well Design:

Casing: Material: Schedule 40 PVC
Diameter: 2" ID 2½" OD
Length: 45.4'
Filter: Material: Torpedo Sand
Setting: 43.5 - 58.5' BLS
Grout: Type: Port. Cement/Bentonite
Setting: 2.5 - 41.5' BLS

Screen: Material: Schedule 40 PVC
Diameter: 2"
Slot: .015, 5 slot/inch
Setting: 46.0 - 58.5' BLS
Seals: Type: Bentonite Pellets
Setting: 41.5 - 43.5' BLS
Surface Casing: Steel(4½"OD x 5'Lt.

Other: Encountered clayey silt(dry) @ 58.5' BLS to 65' BLS and determined screening in that interval inappropriate.

Time Log:

	Started	Completed
Drilling:	4/17/85 0730hr	4/17/85 1053hr
Installation:	4/17/84 1059hr	4/17/85 1500hr
Water Level Reading:	4/17/85 1000hr (46'BLS)	4/17/85 1510hr (46'BLS)
Development:		

Well Development:

Method/Equipment: Air Surge(1hr)/1.7" Brainard-Kilman Hand Pump.
Static Depth to Water: 45.9'
Pumping Depth to Water: 58.0'
Pumping Rate: @ 1 gal/min.
Volume Pumped: 65 gals.

APPENDIX F

AQUIFER TEST DATA

Hvorslev (1951) Well Test Method
(Freeze and Cherry, 1979)

The simplest interpretation of piezometer-recovery data is that of Hvorslev (1951). His initial analysis assumed a homogeneous, isotropic, infinite medium in which both soil and water are incompressible. With reference to the bail test of Figure 8.20(a), Hvorslev reasoned that the rate of inflow, q, at the piezometer tip at any time t is proportional to the hydraulic conductivity, K, of the soil and to the unrecovered head difference, $H - h$, so that

$$q(t) = \pi r^2 \frac{dh}{dt} = FK(H - h) \tag{8.31}$$

where F is a factor that depends on the shape and dimensions of the piezometer intake. If $q = q_0$ at $t = 0$, it is clear that $q(t)$ will decrease asymptotically toward zero as time goes on.

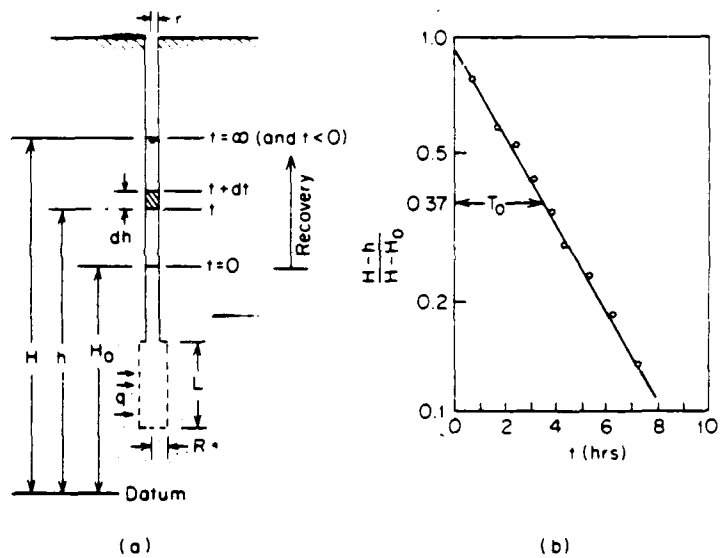


Figure 8.20 Hvorslev piezometer test. (a) Geometry; (b) method of analysis.

Hvorslev defined the *basic time lag*, T_0, as

$$T_0 = \frac{\pi r^2}{FK} \tag{8.32}$$

When this parameter is substituted in Eq. (8.31), the solution to the resulting ordinary differential equation, with the initial condition, $h = H_0$ at $t = 0$, is

$$\frac{H - h}{H - H_0} = e^{-t/T_0} \tag{8.33}$$

A plot of field recovery data, $H - h$ versus t, should therefore show an exponential decline in recovery rate with time. If, as shown on Figure 8.20(b), the recovery is normalized to $H - H_0$ and plotted on a logarithmic scale, a straight-line plot results. Note that for $H - h/H - H_0 = 0.37$, $\ln (H - h/H - H_0) = -1$, and from Eq. (8.33), $T_0 = t$. The basic time lag, T_0, can be defined by this relation; or if a more physical definition is desired, it can be seen, by multiplying both top and bottom of Eq. (8.32) by $H - H_0$, that T_0 is the time that would be required for the complete equalization of the head difference if the original rate of inflow were maintained. That is, $T_0 = V/q_0$, where V is the volume of water removed or added.

To interpret a set of field recovery data, the data are plotted in the form of Figure 8.20(b). The value of T_0 is measured graphically, and K is determined from Eq. (8.32). For a piezometer intake of length L and radius R [Figure 8.20(a)], with $L/R > 8$, Hvorslev (1951) has evaluated the shape factor, F. The resulting expression for K is

$$K = \frac{r^2 \ln (L/R)}{2LT_0} \tag{8.34}$$

Pump Test Data and Analysis

Well No.: MW 1-2

H: 42.83 ft.

H_o: 50.00 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	42.87	.005	30
h_3			
h_4			
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -1

Slope : -.03

Intercept : 1

T_o : 18.9

$K=(r^2)\ln(LR)/2LT_o$: 4.8×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 1-3

H: 42.75 ft.

H_o: 49.50 ft.

		$H-h_2/H-H_o$	t(sec)
h_1		1	0
h_2	43.16	.060	33
h_3	42.79	.005	156
h_4	42.76	.001	284
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.647

Slope : -2.4×10^{-3}

Intercept : 55

T_o : 76

$K=(r^2)\ln(LR)/2LT_o$: 1.2×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 2-4

H: 27.90 ft.

H_o: 35.02 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	28.00	.014	21
h_3	27.95	.007	32
h_4	27.91	.001	39
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.904

Slope : -.026

Intercept : .86

T_o : 18.6

$K=(r^2)\ln(LR)/2LT_o$: 4.9×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 2-5

H: 39.91 ft.

H_o: 47.03 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	40.00	.012	30
h_3	39.87	.005	45
h_4			
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.946

Slope : -.023

Intercept : .930

T_o : 23.6

$K=(r^2)\ln(LR)/2LT_o$: 3.8×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 3-2

H: 45.72 ft.

H_o: 50.78 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	47.00	.252	29
h_3	46.66	.185	39
h_4	46.33	.120	46
h_5	46.25	.104	48
h_6	46.16	.086	52
h_7	46.08	.071	59
h_8	46.00	.055	65
h_9	45.91	.037	80
h_{10}	45.83	.021	120
h_{11}	45.76	.007	200
h_{12}	45.75	.005	266
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.506

Slope : 1.8×10^{-3}

Intercept : .313

T_o : -31.4

$K=(r^2)\ln(LR)/2LT_o$: 4.8×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 3-3

H: 44.76 ft.

H_o: 48.68 ft.

		$H-h_2/H-H_o$	t(sec)
h_1		1	0
h_2	45.25	.125	27
h_3	45.08	.081	35
h_4	45.00	.061	37
h_5	44.91	.038	40
h_6	44.83	.017	50
h_7	44.79	.007	124
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.577

Slope : -.005

Intercept : .432

T_o : 11.48

$K=(r^2)\ln(LR)/2LT_o$: 1.1×10^{-3} ft/sec

Pump Test Data and Analysis

Well No.: MW 4-2

H: 45.03 ft.

H_o: 52.18 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	45.20	.023	30
h_3	45.08	.006	111
h_4	45.04	.001	130
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.734

Slope : -5.8×10^{-3}

Intercept : .650

T_o : 48.3

$K=(r^2)\ln(LR)/2LT_o$: 1.89×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 4-3

H: 44.68 ft.

H_o: 50.45 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	46.26	.273	46
h_3	46.00	.278	55
h_4	45.91	.213	104
h_5	45.75	.185	120
h_6	45.66	.169	123
h_7	45.58	.155	129
h_8	45.50	.142	136
h_9	45.41	.126	143
h_{10}	45.33	.112	152
h_{11}	45.25	.098	201
h_{12}	45.16	.083	213
h_{13}	45.08	.069	227
h_{14}	45.00	.055	244
h_{15}	44.91	.039	309
h_{16}	44.83	.025	343
h_{17}	44.75	.012	450
h_{18}	44.70	.003	600
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.525

Slope : -7.8×10^{-4}

Intercept : .307

T_o : 80

$K=(r^2)\ln(LR)/2LT_o$: 1.14×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 5-2

H: 35.08 ft.

H_o: 37.88 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	35.37	.103	76
h_3	35.25	.060	94
h_4	35.16	.028	131
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.933

Slope : -7.9×10^{-3}

Intercept : .895

T_o : 66.15

$K=(r^2)\ln(LR)/2LT_o$: 2.3×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 5-3

H: 32.95 ft.

H_o: 37.25 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	33.20	.058	20
h_3	33.08	.030	38
h_4	33.03	.018	510
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.409

Slope : -8×10^{-4}

Intercept : .39

T_o : 25.5

$K=(r^2)\ln(LR)/2LT_o$: 4.9×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 6-2

H: 34.08 ft.

H_o: 41.20 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	34.16	.011	32
h_3			
h_4			
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -1.0

Slope : -.03

Intercept : 1

T_o : 20.38

$K=(r^2)\ln(LR)/2LT_o$: 4.4×10^{-4} ft/sec

Pump Test Data and Analysis

Well No.: MW 6-3

H: 30.50 ft.

H_o: 37.62 ft.

		$H-h_z/H-H_o$	t(sec)
h_1		1	0
h_2	30.58	.011	29
h_3	30.54	.005	61
h_4			
h_5			
h_6			
h_7			
h_8			
h_9			
h_{10}			
h_{11}			
h_{12}			
h_{13}			
h_{14}			
h_{15}			
h_{16}			
h_{17}			
h_{18}			
h_{19}			
h_{20}			

Regression Analysis

Correlation : -.854

Slope : -.016

Intercept : .819

T_o : 28.0

$K=(r^2)\ln(LR)/2LT_o$: 3.2×10^{-4} ft/sec

APPENDIX G

ANALYTICAL DATA

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.
117 N. FIRST ST.
ANN ARBOR, MI 48104 (313) 662-3104

Report Date: 10/09/85

Results by Sampl

Prepared for:
SCIENCE APPLICATIONS INTERNATIONAL COR
8400 WESTPARK DRIVE
MC LEAN, VA 22102
Attention: ANDRE LAPINS

Client P.O.: 16-862007-10
Report #: 246
Samples Rec'd: 05-08-85

Approved: Barbara Jackson
Refer Questions to:
CAROLYN NOACK

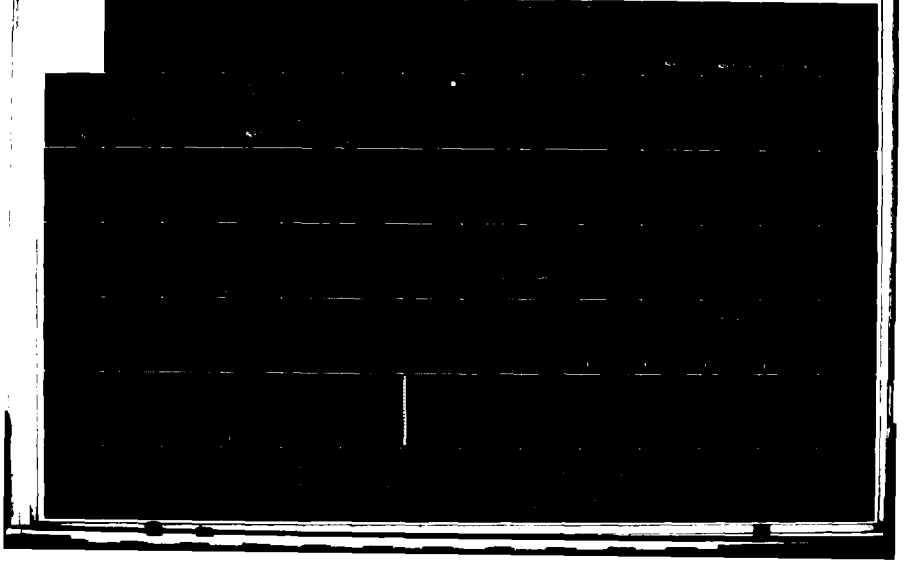
**
Residual Samples Will Be Held
For Two Weeks
**

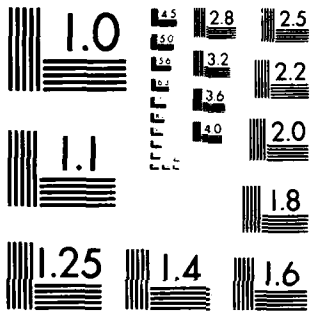
Client ID	GW-2-1	GW-2-2	GW-2-3	GW-2-4	GW-2-5	BW-1
Collected	05-07-85	05-07-85	05-07-85	05-07-85	05-07-85	05-07-
ERG Sample Number	05/129643	05/129644	05/129645	05/129646	05/129647	05/1296
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL W
Parameter						
ARSENIC, TOTAL mg/L	0.002	<0.001	<0.001	0.001	<0.001	ND (0.0
CADMIUM, TOTAL mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.0
ORGANIC CARBON, TOTAL mg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
CHROMIUM, TOTAL mg/L	0.07	ND (0.05)	<0.05	<0.05	<0.05	<0.0
COPPER, TOTAL mg/L	0.03	<0.02	<0.02	<0.02	<0.02	ND (0.0
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	-	-	-	-	-	-
ORGANIC BROMIDE mg/L	-	-	-	-	-	-
ORGANIC IODIDE mg/L	-	-	-	-	-	-
HALOSCAN - T						
ORGANIC CHLORINE mg/L	0.04	<0.01	<0.01	0.02	<0.01	<0.0
ORGANIC BROMINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.0
ORGANIC IODINE mg/L	ND (0.01)	ND (0.01)	0.02	0.06	ND (0.01)	ND (0.0
LEAD, TOTAL mg/L	0.02	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.0
MERCURY mg/L	0.0011	0.0002	0.0004	0.0003	0.0002	<0.0
NICKEL, TOTAL mg/L	<0.05	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	<0.0
NITRATE NITROGEN mg/L	-	-	-	-	-	-
OIL AND GREASE BY IR mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	-
SELENIUM, TOTAL mg/L	ND (0.001)	<0.001	<0.001	0.001	<0.001	<0.0
SILVER, TOTAL mg/L	<0.01	ND (0.01)	ND (0.01)	<0.01	<0.01	ND (0.0
ZINC mg/L	0.03	<0.02	<0.02	<0.02	<0.02	<0.0

Client ID	FB-1	GW-5-1	GW-5-2	GW-5-3	FB-2	BW-
Collected	05-07-85	05-07-85	05-07-85	05-07-85	05-08-85	05-08
ERG Sample Number	05/129649	05/129650	05/129651	05/129652	05/129930	05/129
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL
Parameter						
ARSENIC, TOTAL mg/L	0.004	-	-	-	<0.001	ND (0.
CADMIUM, TOTAL mg/L	ND (0.01)	-	-	-	ND (0.01)	ND (0.
ORGANIC CARBON, TOTAL mg/L	ND (1)	3	ND (1)	ND (1)	ND (1)	ND (1)
CHROMIUM, TOTAL mg/L	<0.05	-	-	-	<0.05	<0.
COPPER, TOTAL mg/L	ND (0.02)	-	-	-	ND (0.02)	ND (0
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	-	-	-	-	-	-
ORGANIC BROMIDE mg/L	-	-	-	-	-	-
ORGANIC IODIDE mg/L	-	-	-	-	-	-
HALOSCAN - T						
ORGANIC CHLORINE mg/L	<0.01	<0.01	<0.01	<0.01	0.02	<0.
ORGANIC BROMINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.
ORGANIC IODINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	<0.01	ND (0.01)	ND (0.
LEAD, TOTAL mg/L	ND (0.02)	-	-	-	ND (0.02)	ND (0.
MERCURY mg/L	0.0002	-	-	-	0.0002	0.

 See last page for explanation of symbols

AD-A195 524 INSTALLATION RESTORATION PROGRAM (IRP) PHASE 2 5/6
CONFIRMATION/QUANTIFICATIO..(U) SCIENCE APPLICATIONS
INTERNATIONAL CORP MCLEAN VA R EADES ET AL. 10 JUN 86
UNCLASSIFIED F33615-80-D-4002 F/G 24/4 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A3002

Report Date: 09 OCT 1985

Client ID	FB-1	GW-5-1	GW-5-2	GW-5-3	FB-2	BW-2
Collected	05-07-85	05-07-85	05-07-85	05-07-85	05-08-85	05-08-85
ERG Sample Number	05/129649	05/129650	05/129651	05/129652	05/129930	05/129931
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
NICKEL, TOTAL mg/L	ND (0.05)	-	-	-	<0.05	<0.05
NITRATE NITROGEN mg/L	-	-	-	-	-	-
OIL AND GREASE BY IR mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	-
SELENIUM, TOTAL mg/L	0.003	-	-	-	0.001	<0.001
SILVER, TOTAL mg/L	ND (0.01)	-	-	-	ND (0.01)	0.01
ZINC mg/L	<0.02	-	-	-	<0.02	ND (0.02)

Client ID	GW-6-1	GW-6-2	GW-6-2D	GW-6-3	WB-1	W-1
Collected	05-08-85	05-08-85	05-08-85	05-08-85	05-08-85	05-08-85
ERG Sample Number	05/129932	05/129933	05/129934	05/129935	05/129936	05/129937
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
ARSENIC, TOTAL mg/L	<0.001	0.004	0.002	ND (0.001)	ND (0.001)	
CADMIUM, TOTAL mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	
ORGANIC CARBON, TOTAL mg/L	ND (1)	2	ND (1)	ND (1)	ND (1)	
CHROMIUM, TOTAL mg/L	<0.05	<0.05	<0.05	ND (0.05)	<0.05	
COPPER, TOTAL mg/L	<0.02	0.02	0.02	<0.02	ND (0.02)	
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	-	-	-	-	-	
ORGANIC BROMIDE mg/L	-	-	-	-	-	
ORGANIC IODIDE mg/L	-	-	-	-	-	
HALOSCAN - T						
ORGANIC CHLORINE mg/L	<0.01	<0.01	0.05	<0.01	<0.01	
ORGANIC BROMINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	
ORGANIC IODINE mg/L	<0.01	<0.01	ND (0.01)	ND (0.01)	ND (0.01)	
LEAD, TOTAL mg/L	ND (0.02)	<0.02	0.03	ND (0.02)	ND (0.02)	
MERCURY mg/L	0.0003	0.0002	0.0003	<0.0002	<0.0002	
NICKEL, TOTAL mg/L	ND (0.05)	<0.05	ND (0.05)	<0.05	ND (0.05)	
NITRATE NITROGEN mg/L	-	-	-	-	-	
OIL AND GREASE BY IR mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	
SELENIUM, TOTAL mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
SILVER, TOTAL mg/L	<0.01	<0.01	<0.01	ND (0.01)	ND (0.01)	
ZINC mg/L	<0.02	<0.02	0.04	<0.02	<0.02	

Client ID	GW-1-1	GW-1-2	GW-1-3	GW-1-4	FB-3	BW-3
Collected	05-08-85	05-08-85	05-08-85	05-08-85	05-09-85	05-09-85
ERG Sample Number	05/129938	05/129939	05/129940	05/129941	05/129942	05/129943
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
ARSENIC, TOTAL mg/L	-	-	-	-	ND (0.001)	ND (0.001)
CADMIUM, TOTAL mg/L	-	-	-	-	ND (0.01)	ND (0.01)
ORGANIC CARBON, TOTAL mg/L	ND (1)	ND (1)	ND (1)	2	ND (1)	ND (1)
CHROMIUM, TOTAL mg/L	-	-	-	-	ND (0.05)	<0.05
COPPER, TOTAL mg/L	-	-	-	-	ND (0.02)	ND (0.02)
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	-	-	-	-	-	-
ORGANIC BROMIDE mg/L	-	-	-	-	-	-
ORGANIC IODIDE mg/L	-	-	-	-	-	-

 See last page for explanation of symbols

ANALYTICAL REPORT
ENVIRONMENTAL RESEARCH GROUP, INC.

Report Date: 09 OCT 1985

Client ID	QW-1-1	QW-1-2	QW-1-3	QW-1-4	FB-3	BW-3
Collected	05-08-85	05-08-85	05-08-85	05-08-85	05-09-85	05-09-85
ERG Sample Number	05/129938	05/129939	05/129940	05/129941	05/129942	05/129943
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
HALOSCAN - T						
ORGANIC CHLORINE mg/L	<0.01	0.01	0.01	<0.01	<0.01	<0.01
ORGANIC BROMINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
ORGANIC IODINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
LEAD, TOTAL mg/L	-	-	-	-	ND (0.02)	ND (0.02)
MERCURY mg/L	-	-	-	-	<0.0002	<0.0002
NICKEL, TOTAL mg/L	-	-	-	-	<0.05	<0.05
NITRATE NITROGEN mg/L	-	-	-	-	-	-
OIL AND GREASE BY IR mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	-
SELENIUM, TOTAL mg/L	-	-	-	-	0.001	<0.001
SILVER, TOTAL mg/L	-	-	-	-	ND (0.01)	ND (0.01)
ZINC mg/L	-	-	-	-	<0.02	ND (0.02)

Client ID	SD-5-1	SD-5-2	SD-5-3	SD-5-4	FB-4	BW-4
Collected	05-09-85	05-09-85	05-09-85	05-09-85	05-10-85	05-10-85
ERG Sample Number	05/129944	05/129945	05/129946	05/129947	05/129948	05/129949
Matrix	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	NATURAL WATER	NATURAL WATER
Parameter						
ARSENIC, TOTAL mg/L	-	-	-	-	-	-
CADMIUM, TOTAL mg/L	-	-	-	-	-	-
ORGANIC CARBON, TOTAL mg/L	-	-	-	-	ND (1)	ND (1)
CHROMIUM, TOTAL mg/L	-	-	-	-	-	-
COPPER, TOTAL mg/L	-	-	-	-	-	-
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	<1.0 #	<1.0 #	<1.0 #	<1.0 #	-	-
ORGANIC BROMIDE mg/L	ND (0.10) #	ND (0.10) #	ND (0.10) #	ND (0.10) #	-	-
ORGANIC IODIDE mg/L	ND (0.05) #	ND (0.05) #	ND (0.05) #	ND (0.05) #	-	-
HALOSCAN - T						
ORGANIC CHLORINE mg/L	-	-	-	-	<0.01	0.02
ORGANIC BROMINE mg/L	-	-	-	-	ND (0.01)	ND (0.01)
ORGANIC IODINE mg/L	-	-	-	-	ND (0.01)	ND (0.01)
LEAD, TOTAL mg/L	-	-	-	-	-	-
MERCURY mg/L	-	-	-	-	-	-
NICKEL, TOTAL mg/L	-	-	-	-	-	-
NITRATE NITROGEN mg/L	-	-	-	-	-	-
OIL AND GREASE BY IR mg/L	1.5 #	0.8 #	<0.2 #	<0.2 #	<0.2	<0.2
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	-
SELENIUM, TOTAL mg/L	-	-	-	-	-	-
SILVER, TOTAL mg/L	-	-	-	-	-	-
ZINC mg/L	-	-	-	-	-	-

 See last page for explanation of symbols

CONTINUED

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A3002

Report Date: 09 OCT 1985

Client ID	GW-4-1	GW-4-2	GW-4-3	GW-4-4	GW-3-1	GW-3-2
Collected	05-10-85	05-10-85	05-10-85	05-10-85	05-10-85	05-10-85
ERG Sample Number	05/129950	05/129951	05/129952	05/129953	05/129954	05/129955
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
ARSENIC, TOTAL mg/L	-	-	-	-	-	-
CADMIUM, TOTAL mg/L	-	-	-	-	-	-
ORGANIC CARBON, TOTAL mg/L	2	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
CHROMIUM, TOTAL mg/L	-	-	-	-	-	-
COPPER, TOTAL mg/L	-	-	-	-	-	-
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	-	-	-	-	-	-
ORGANIC BROMIDE mg/L	-	-	-	-	-	-
ORGANIC IODIDE mg/L	-	-	-	-	-	-
HALOSCAN - T						
ORGANIC CHLORINE mg/L	<0.01	<0.01	0.11	0.05	0.05	<0.01
ORGANIC BROMINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
ORGANIC IODINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
LEAD, TOTAL mg/L	-	-	-	-	-	-
MERCURY mg/L	-	-	-	-	-	-
NICKEL, TOTAL mg/L	-	-	-	-	-	-
NITRATE NITROGEN mg/L	-	-	-	-	-	-
OIL AND GREASE BY IR mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	-
SELENIUM, TOTAL mg/L	-	-	-	-	-	-
SILVER, TOTAL mg/L	-	-	-	-	-	-
ZINC mg/L	-	-	-	-	-	-

Client ID	GW-3-3	GW-3-4	GW-3-4D	FB-5	SD-6-1	SD-1-1
Collected	05-10-85	05-10-85	05-10-85	05-13-85	05-13-85	05-13-85
ERG Sample Number	05/129956	05/129957	05/129958	05/129959	05/129960	05/129961
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	SEDIMENT	SEDIMENT
Parameter						
ARSENIC, TOTAL mg/L	-	-	-	-	-	-
CADMIUM, TOTAL mg/L	-	-	-	-	-	-
ORGANIC CARBON, TOTAL mg/L	4	4	6	-	-	-
CHROMIUM, TOTAL mg/L	-	-	-	-	-	-
COPPER, TOTAL mg/L	-	-	-	-	-	-
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	-	-	-	-	2.6 #	<1.0 #
ORGANIC BROMIDE mg/L	-	-	-	-	0.32 #	0.50 #
ORGANIC IODIDE mg/L	-	-	-	-	<0.05 #	<0.05 #
HALOSCAN - T						
ORGANIC CHLORINE mg/L	0.05	<0.01	0.03	0.02	-	-
ORGANIC BROMINE mg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	-	-
ORGANIC IODINE mg/L	ND (0.01)	<0.01	ND (0.01)	ND (0.01)	-	-
LEAD, TOTAL mg/L	-	-	-	-	-	-
MERCURY mg/L	-	-	-	-	-	-
NICKEL, TOTAL mg/L	-	-	-	-	-	-
NITRATE NITROGEN mg/L	-	-	-	0.02	-	-
OIL AND GREASE BY IR mg/L	<0.2	<0.2	<0.2	<0.2	170 #	460 #
PHOSPHORUS, TOTAL mg/L	-	-	-	0.34	-	-
SELENIUM, TOTAL mg/L	-	-	-	-	-	-
SILVER, TOTAL mg/L	-	-	-	-	-	-
ZINC mg/L	-	-	-	-	-	-

 See last page for explanation of symbols

CONTINUED

ANALYTICAL REPORT
ENVIRONMENTAL RESEARCH GROUP, INC.

Report Date: 09 OCT 1985

Client ID	SD-1-2	SD-1-2D	SD-1-3	SD-1-4	SD-7-1	SD-7-2
Collected	05-13-85	05-13-85	05-13-85	05-13-85	05-13-85	05-13-85
ERG Sample Number	05/129962	05/129963	05/129964	05/129965	05/129966	05/129967
Matrix	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
Parameter						
ARSENIC, TOTAL mg/L	-	-	-	-	-	-
CADMIUM, TOTAL mg/L	-	-	-	-	-	-
ORGANIC CARBON, TOTAL mg/L	-	-	-	-	-	-
CHROMIUM, TOTAL mg/L	-	-	-	-	-	-
COPPER, TOTAL mg/L	-	-	-	-	-	-
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	<1.0 #	<1.0 #	<1.0 #	<1.0 #	1.0 #	<1.0 #
ORGANIC BROMIDE mg/L	<0.1 #	<0.1 #	<0.1 #	<0.1 #	<0.1 #	<0.1 #
ORGANIC IODIDE mg/L	<0.05 #	<0.05 #	<0.05 #	<0.05 #	<0.05 #	<0.05 #
HALOSCAN - T						
ORGANIC CHLORINE mg/L	-	-	-	-	-	-
ORGANIC BROMINE mg/L	-	-	-	-	-	-
ORGANIC IODINE mg/L	-	-	-	-	-	-
LEAD, TOTAL mg/L	-	-	-	-	-	-
MERCURY mg/L	-	-	-	-	-	-
NICKEL, TOTAL mg/L	-	-	-	-	-	-
NITRATE NITROGEN mg/L	-	-	-	-	ND (0.1) #	19 #
OIL AND GREASE BY IR mg/L	2.9 #	3.1 #	2.7 #	25 #	110 #	2.4 #
PHOSPHORUS, TOTAL mg/L	-	-	-	-	310 #	99 #
SELENIUM, TOTAL mg/L	-	-	-	-	-	-
SILVER, TOTAL mg/L	-	-	-	-	-	-
ZINC mg/L	-	-	-	-	-	-

Client ID	SD-7-3	SD-7-4	SD-7-5	SD-7-6	SD-3-1	SD-3-1D
Collected	05-13-85	05-13-85	05-13-85	05-13-85	05-13-85	05-13-85
ERG Sample Number	05/129968	05/129969	05/129970	05/129971	05/129972	05/129973
Matrix	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
Parameter						
ARSENIC, TOTAL mg/L	-	-	-	-	-	-
CADMIUM, TOTAL mg/L	-	-	-	-	-	-
ORGANIC CARBON, TOTAL mg/L	-	-	-	-	-	-
CHROMIUM, TOTAL mg/L	-	-	-	-	-	-
COPPER, TOTAL mg/L	-	-	-	-	-	-
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	<1.0 #	<1.0 #	3.4 #	2.0 #	2.3 #	1.7 #
ORGANIC BROMIDE mg/L	<0.1 #	<0.1 #	<0.1 #	0.26 #	0.86 #	0.44 #
ORGANIC IODIDE mg/L	<0.05 #	<0.05 #	<0.05 #	<0.05 #	0.07 #	<0.05 #
HALOSCAN - T						
ORGANIC CHLORINE mg/L	-	-	-	-	-	-
ORGANIC BROMINE mg/L	-	-	-	-	-	-
ORGANIC IODINE mg/L	-	-	-	-	-	-
LEAD, TOTAL mg/L	-	-	-	-	-	-
MERCURY mg/L	-	-	-	-	-	-
NICKEL, TOTAL mg/L	-	-	-	-	-	-
NITRATE NITROGEN mg/L	19 #	1.6 #	54 #	170 #	-	-
OIL AND GREASE BY IR mg/L	8.3 #	3.0 #	8.6 #	21 #	10 #	450 #
PHOSPHORUS, TOTAL mg/L	680 #	680 #	4100 #	24000 #	-	-
SELENIUM, TOTAL mg/L	-	-	-	-	-	-
SILVER, TOTAL mg/L	-	-	-	-	-	-
ZINC mg/L	-	-	-	-	-	-

 See last page for explanation of symbols

CONTINUED

Client ID	SD-3-2	SD-3-3	FB-6	SW-2-5	SD-2-5	SD-2-4
Collected	05-13-85	05-13-85	05-14-85	05-14-85	05-14-85	05-14-85
ERG Sample Number	05/129974	05/129975	05/129976	05/129977	05/129978	05/129979
Matrix	SEDIMENT	SEDIMENT	NATURAL WATER	NATURAL WATER	SEDIMENT	SEDIMENT
Parameter						
ARSENIC, TOTAL mg/L	-	-	ND (0.001)	ND (0.001)	<0.25 #	4.0 #
CADMIUM, TOTAL mg/L	-	-	ND (0.01)	<0.01	<2 #	<2 #
ORGANIC CARBON, TOTAL mg/L	-	-	4	6	-	-
CHROMIUM, TOTAL mg/L	-	-	<0.05	<0.05	5 #	21 #
COPPER, TOTAL mg/L	-	-	ND (0.02)	<0.02	<4 #	<18 #
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	1.3 #	4.6 #	-	-	<1.0 #	<1.0 #
ORGANIC BROMIDE mg/L	0.14 #	<0.10 #	-	-	<0.1 #	<0.10 #
ORGANIC IODIDE mg/L	0.06 #	<0.05 #	-	-	<0.005 #	0.10 #
HALOSCAN - T						
ORGANIC CHLORINE mg/L	-	-	<0.01	0.03	-	-
ORGANIC BROMINE mg/L	-	-	ND (0.01)	ND (0.01)	-	-
ORGANIC IODINE mg/L	-	-	ND (0.01)	ND (0.01)	-	-
LEAD, TOTAL mg/L	-	-	<0.02	ND (0.02)	ND (10) #	19 #
MERCURY mg/L	-	-	<0.0002	<0.0002	<0.1 #	<0.1 #
NICKEL, TOTAL mg/L	-	-	ND (0.05)	ND (0.05)	<10 #	<10 #
NITRATE NITROGEN mg/L	-	-	-	-	-	-
OIL AND GREASE BY IR mg/L	8.0 #	4.8 #	<0.2	<0.2	2.8 #	2.9 #
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	-
SELENIUM, TOTAL mg/L	-	-	<0.001	<0.001	<0.25 #	<0.25 #
SILVER, TOTAL mg/L	-	-	ND (0.01)	ND (0.01)	<4 #	<4 #
ZINC mg/L	-	-	<0.02	<0.02	4 #	30 #

Client ID	SW-2-2	SD-2-2	SW-2-1	SD-2-1	SD-2-3	SW-2-6
Collected	05-14-85	05-14-85	05-14-85	05-14-85	05-14-85	05-14-85
ERG Sample Number	05/129980	05/129981	05/129982	05/129983	05/129984	05/129985
Matrix	NATURAL WATER	SEDIMENT	NATURAL WATER	SEDIMENT	SEDIMENT	NATURAL WATER
Parameter						
ARSENIC, TOTAL mg/L	ND (0.001)	<0.25 #	ND (0.001)	<0.25 #	0.79 #	ND (0.001)
CADMIUM, TOTAL mg/L	ND (0.01)	<2 #	<0.01	<2 #	<2 #	<0.01
ORGANIC CARBON, TOTAL mg/L	5	-	4	-	-	6
CHROMIUM, TOTAL mg/L	ND (0.05)	4 #	<0.05	6 #	31 #	ND (0.05)
COPPER, TOTAL mg/L	ND (0.02)	<4 #	ND (0.02)	<4 #	8 #	ND (0.02)
HALOSCAN - E						
ORGANIC CHLORIDE mg/L	-	<1.0 #	-	<1.0 #	<1.0 #	-
ORGANIC BROMIDE mg/L	-	<0.1 #	-	<0.1 #	<0.1 #	-
ORGANIC IODIDE mg/L	-	<0.05 #	-	<0.05 #	<0.05 #	-
HALOSCAN - T						
ORGANIC CHLORINE mg/L	0.05	-	<0.01	-	-	<0.01
ORGANIC BROMINE mg/L	ND (0.01)	-	ND (0.01)	-	-	ND (0.01)
ORGANIC IODINE mg/L	ND (0.01)	-	ND (0.01)	-	-	ND (0.01)
LEAD, TOTAL mg/L	<0.02	<10 #	ND (0.02)	<10 #	11 #	<0.02
MERCURY mg/L	<0.0002	<0.1 #	<0.0002	<0.1 #	<0.1 #	<0.0002
NICKEL, TOTAL mg/L	<0.05	<10 #	<0.05	<10 #	<10 #	<0.05
NITRATE NITROGEN mg/L	-	-	-	-	-	-
OIL AND GREASE BY IR mg/L	<0.2	2.5 #	<0.2	3.2 #	2.9 #	<0.2
PHOSPHORUS, TOTAL mg/L	-	-	-	-	-	-
SELENIUM, TOTAL mg/L	0.001	<0.25 #	<0.001	<0.25 #	<0.25 #	<0.001
SILVER, TOTAL mg/L	ND (0.01)	<4 #	ND (0.01)	ND (4) #	ND (4) #	ND (0.01)
ZINC mg/L	0.18	4 #	ND (0.02)	4 #	30 #	<0.02

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

RECEIVED OCT 1 6 1985

Report Date: 09 OCT 1985

Client ID	SW-2-6D	SD-2-6	SD-2-6D
Collected	05-14-85	05-14-85	05-14-85
ERG Sample Number	05/129986	05/129987	05/129988
Matrix	NATURAL WATER	SEDIMENT	SEDIMENT
Parameter			
ARSENIC, TOTAL mg/L	ND (0.001)	<0.25 #	ND (0.25) #
CADMIUM, TOTAL mg/L	ND (0.01)	<2 #	<2 #
ORGANIC CARBON, TOTAL mg/L	4	-	-
CHROMIUM, TOTAL mg/L	<0.05	<4 #	<4 #
COPPER, TOTAL mg/L	ND (0.02)	<4 #	<4 #
HALOSCAN - E			
ORGANIC CHLORIDE mg/L	-	<1.0 #	<1.0 #
ORGANIC BROMIDE mg/L	-	<0.1 #	<0.1 #
ORGANIC IODIDE mg/L	-	0.06 #	<0.05 #
HALOSCAN - T			
ORGANIC CHLORINE mg/L	<0.01	-	-
ORGANIC BROMINE mg/L	ND (0.01)	-	-
ORGANIC IODINE mg/L	<0.01	-	-
LEAD, TOTAL mg/L	<0.02	<10 #	<10 #
MERCURY mg/L	ND (0.0002)	ND (0.1) #	ND (0.1) #
NICKEL, TOTAL mg/L	<0.05	<10 #	<10 #
NITRATE NITROGEN mg/L	-	-	-
OIL AND GREASE BY IR mg/L	<0.2	2.2 #	2.0 #
PHOSPHORUS, TOTAL mg/L	-	-	-
SELENIUM, TOTAL mg/L	<0.001	<0.25 #	<0.25 #
SILVER, TOTAL mg/L	<0.01	ND (4) #	ND (4) #
ZINC mg/L	<0.02	<4 #	6 #

Project Comments:

Comments about sample 05/129644
MERCURY - REPORTED RESULTS ARE CALCULATED AVERAGE OF DUPLICATES.
Comments about sample 05/129931
TOTAL SELENIUM - AVERAGE OF DUPLICATE RUNS
Comments about sample 05/129943
MERCURY - REPORTED RESULTS ARE CALCULATED AVERAGE OF DUPLICATES.
Comments about sample 05/129979
TOTAL ARSENIC - AVERAGE OF DUPLICATE RUNS
Comments about sample 05/129981
MERCURY - REPORTED RESULTS ARE CALCULATED AVERAGE OF DUPLICATES.
Comments about sample 05/129985
TOTAL ARSENIC - AVERAGE OF DUPLICATE RUNS
TOTAL SELENIUM - AVERAGE OF DUPLICATE RUNS

Note Results indicated by '#' are in mg/Kg instead of mg/L
FR = See field report for result
NA = Not applicable to test requested
ND = Nondetected, detection limit in ()
SD = Sample damaged
SR = See attached report for result
< = Positive result but at unquantifiable concentration below inicated level
- = Test not requested for this sample

RECEIVED JUN 07 1985

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A2947
Report Date: 05-22-85

117 N. FIRST
ANN ARBOR, MICHIGAN 48104 (313) 662-3104

Client P.O. 16-862007-10
Report: 13527

Samples Recvd: 04-19-85
Refer Questions To:
CAROLYN SCHNEIDER

Client:
JRB ASSOCIATES, INC.
8400 WESTPARK DRIVE
MC LEAN, VA 22102
Attention. ANDRE LAPINS

Approved: Fred D. Stevens

***
Residual Samples Will Be Held
TWO WEEKS
***

Client I.D.: SD4-1
ERG Sample No.: 04/128534
Matrix: SOIL
Date Sampled: 04-18-85

Parameter	Result	Units
LOSCAN - E		
ORGANIC CHLORIDE	3.1	mg/Kg
ORGANIC BROMIDE	ND (0.10)	mg/Kg
ORGANIC IODIDE	<0.05	mg/Kg
MOISTURE, PERCENT	9	%
OIL AND GREASE BY IR	8000	mg/Kg

Client I.D.: SD4-2
ERG Sample No.: 04/128535
Matrix: SOIL
Date Sampled: 04-18-85

Parameter	Result	Units
LOSCAN - E		
ORGANIC CHLORIDE	<1.0	mg/Kg
ORGANIC BROMIDE	ND (0.10)	mg/Kg
ORGANIC IODIDE	<0.05	mg/Kg
MOISTURE, PERCENT	14	%
OIL AND GREASE BY IR	98	mg/Kg

Client I.D.: SD4-3
ERG Sample No.: 04/128536
Matrix: SOIL
Date Sampled: 04-18-85

Parameter	Result	Units
LOSCAN - E		
ORGANIC CHLORIDE	<1.0	mg/Kg
ORGANIC BROMIDE	ND (0.10)	mg/Kg
ORGANIC IODIDE	<0.05	mg/Kg
MOISTURE, PERCENT	14	%
OIL AND GREASE BY IR	140	mg/Kg

See last page for explanation of symbols

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A2947
Report Date: 05-22-85

Client I.D.: SD4-4
ERG Sample No.: 04/128537
Matrix: SOIL
Date Sampled: 04-18-85

Parameter	Result	Units
HALOSCAN - E		
ORGANIC CHLORIDE	<1.0	mg/Kg
ORGANIC BROMIDE	ND (0.10)	mg/Kg
ORGANIC IODIDE	ND (0.05)	mg/Kg
MOISTURE, PERCENT	9	%
OIL AND GREASE BY IR	55	mg/Kg

SD-Sample damaged
SR-See field report for result
SR-See attached report
NA-Result not applicable to test

ND-Nondetected, Detection limit in ()
<-Positive result at an unquantifiable concentration below indicated level

Thank you for your business.

RECEIVED OCT - 3 1985

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.
117 N. FIRST ST.
ANN ARBOR, MI 48104 (313) 662-3104

Project: A3383

Report Date: 10/02/85

Results by Sample

Prepared for:
SCIENCE APPLICATIONS INTERNATIONAL COR
8400 WESTPARK DRIVE
MC LEAN, VA 22102
Attention: ANDRIS LAPINS

Client P.O.: LETTER
Report #: 236
Samples Rec'd: 09-13-85

Approved: [signature]
Refer Questions to:
ROBYN WOOLEY

**
Residual Samples Will Be Held
For Two Weeks
**

Client ID ERG Sample Number Matrix Parameter	FB-1 09/136542 NATURAL WATER	SD1-1 09/136543 SEDIMENT	SD1-2 09/136544 SEDIMENT	SD1-3 09/136545 SEDIMENT	SD1-4 09/136546 SEDIMENT	SD6-1 09/136547 SEDIMENT
PURGEABLE AROMATICS						
BENZENE mg/L	ND (0.0002)	0.023 #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #
DICHLOROBENZENE, 1,2- mg/L	ND (0.00015)	ND (0.0015) #	ND (0.00015) #	ND (0.00015) #	ND (0.00015) #	ND (0.00015) #
DICHLOROBENZENE, 1,3- mg/L	ND (0.00032)	ND (0.0032) #	ND (0.00032) #	ND (0.00032) #	ND (0.00032) #	ND (0.00032) #
DICHLOROBENZENE, 1,4- mg/L	ND (0.00024)	ND (0.0024) #	ND (0.00024) #	ND (0.00024) #	ND (0.00024) #	ND (0.00024) #
ETHYLBENZENE mg/L	ND (0.0002)	ND (0.002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #
TOLUENE mg/L	ND (0.0002)	0.015 #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #
CHLOROBENZENE mg/L	ND (0.00025)	ND (0.0025) #	ND (0.00025) #	ND (0.00025) #	ND (0.00025) #	ND (0.00025) #
PURGEABLES, 601						
CHLOROMETHANE mg/L	ND (0.00008)	ND (0.0008) #	ND (0.00008) #	ND (0.00008) #	ND (0.00008) #	ND (0.00008) #
BROMOMETHANE mg/L	ND (0.0012)	ND (0.012) #	ND (0.0012) #	ND (0.0012) #	ND (0.0012) #	ND (0.0012) #
DICHLORODIFLUOROMETHANE mg/L	ND (0.0018)	ND (0.018) #	ND (0.0018) #	ND (0.0018) #	ND (0.0018) #	ND (0.0018) #
VINYL CHLORIDE mg/L	ND (0.00018)	ND (0.0018) #	ND (0.00018) #	ND (0.00018) #	ND (0.00018) #	ND (0.00018) #
CHLOROETHANE mg/L	ND (0.00052)	ND (0.0052) #	ND (0.00052) #	ND (0.00052) #	ND (0.00052) #	ND (0.00052) #
METHYLENE CHLORIDE mg/L	ND (0.00025)	ND (0.0025) #	ND (0.00025) #	ND (0.00025) #	ND (0.00025) #	ND (0.00025) #
TRICHLOROFLUOROMETHANE mg/L	ND (0.0005)	ND (0.005) #	ND (0.0009) #	ND (0.0005) #	ND (0.0005) #	ND (0.0009) #
DICHLOROETHYLENE, 1,1- mg/L	ND (0.00013)	ND (0.0013) #	ND (0.00013) #	ND (0.00013) #	ND (0.00013) #	ND (0.00013) #
DICHLOROETHANE, 1,1- mg/L	ND (0.00007)	ND (0.0007) #	ND (0.00007) #	ND (0.00007) #	ND (0.00007) #	ND (0.00007) #
TRANS-1,2-DICHLOROETHYLENE mg/L	ND (0.0001)	ND (0.001) #	ND (0.0001) #	ND (0.0001) #	ND (0.0001) #	ND (0.0001) #
CHLOROFORM mg/L	ND (0.00005)	ND (0.0005) #	ND (0.00005) #	ND (0.00005) #	ND (0.00005) #	ND (0.00005) #
DICHLOROETHANE, 1,2- mg/L	ND (0.00003)	ND (0.0003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #
TRICHLOROETHANE, 1,1,1- mg/L	ND (0.00003)	ND (0.0003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #
CARBON TETRACHLORIDE mg/L	ND (0.00012)	ND (0.0012) #	ND (0.00012) #	ND (0.00012) #	ND (0.00012) #	ND (0.00012) #
BROMODICHLOROMETHANE mg/L	ND (0.0001)	ND (0.001) #	ND (0.0001) #	ND (0.0001) #	ND (0.0001) #	ND (0.0001) #
DICHLOROPROPANE, 1,2- mg/L	ND (0.00004)	ND (0.0004) #	ND (0.00004) #	ND (0.00004) #	ND (0.00004) #	ND (0.00004) #
TRANS-1,3-DICHLOROPROPENE mg/L	ND (0.00034)	ND (0.0034) #	ND (0.00034) #	ND (0.00034) #	ND (0.00034) #	ND (0.00034) #
TRICHLOROETHYLENE mg/L	ND (0.00012)	ND (0.0012) #	ND (0.00012) #	ND (0.00012) #	ND (0.00012) #	ND (0.00012) #
DIBROMOCHLOROMETHANE mg/L	ND (0.00009)	ND (0.0009) #	ND (0.00009) #	ND (0.00009) #	ND (0.00009) #	ND (0.00009) #
TRICHLOROETHANE, 1,1,2- mg/L	ND (0.00002)	ND (0.0002) #	ND (0.00002) #	ND (0.00002) #	ND (0.00002) #	ND (0.00002) #
CIS-1,3-DICHLOROPROPENE mg/L	ND (0.0002)	ND (0.002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #
CHLOROETHYLVINYL ETHER, 2- mg/L	ND (0.00013)	ND (0.0013) #	ND (0.00013) #	ND (0.00013) #	ND (0.00013) #	ND (0.00013) #
BROMOFORM mg/L	ND (0.0002)	ND (0.002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #
TETRACHLOROETHANE, 1,1,2,2- mg/L	*	ND (0.0003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #
TETRACHLOROETHYLENE mg/L	*	ND (0.0003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #

 See last page for explanation of symbols

CONTINUED

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Report Date: 02 OCT 1985

Client ID	SD1-1D	FB-2	GW1-1	GW1-1D	GW1-2	GW1-3
ERG Sample Number	09/136548	09/136549	09/136550	09/136551	09/136552	09/136553
Matrix	SEDIMENT	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
PURGEABLE AROMATICS						
BENZENE mg/L	0.045 #	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
DICHLOROBENZENE, 1,2- mg/L	ND (0.0015) #	ND (0.00015)	ND (0.00015)	ND (0.00015)	ND (0.00015)	ND (0.00015)
DICHLOROBENZENE, 1,3- mg/L	ND (0.0032) #	ND (0.00032)	ND (0.00032)	ND (0.00032)	ND (0.00032)	ND (0.00032)
DICHLOROBENZENE, 1,4- mg/L	ND (0.0024) #	ND (0.00024)	ND (0.00024)	ND (0.00024)	ND (0.00024)	ND (0.00024)
ETHYLBENZENE mg/L	ND (0.002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
TOLUENE mg/L	0.03 #	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
CHLOROBENZENE mg/L	ND (0.0025) #	ND (0.00025)	ND (0.00025)	ND (0.00025)	ND (0.00025)	ND (0.00025)
PURGEABLES, 401						
CHLOROMETHANE mg/L	ND (0.0008) #	ND (0.00008)	ND (0.00008)	ND (0.00008)	ND (0.00008)	ND (0.00008)
BROMOMETHANE mg/L	ND (0.012) #	ND (0.0012)	ND (0.0012)	ND (0.0012)	ND (0.0012)	ND (0.0012)
DICHLORODIFLUOROMETHANE mg/L	ND (0.018) #	ND (0.0018)	ND (0.0018)	ND (0.0018)	ND (0.0018)	ND (0.0018)
VINYL CHLORIDE mg/L	ND (0.0018) #	ND (0.00018)	ND (0.00018)	ND (0.00018)	ND (0.00018)	ND (0.00018)
CHLOROETHANE mg/L	ND (0.0052) #	ND (0.00052)	ND (0.00052)	ND (0.00052)	ND (0.00052)	ND (0.00052)
METHYLENE CHLORIDE mg/L	ND (0.0025) #	ND (0.00025)	ND (0.00025)	ND (0.00025)	ND (0.00025)	ND (0.00025)
TRICHLOROFLUOROMETHANE mg/L	ND (0.005) #	ND (0.0005)	ND (0.0005)	ND (0.0005)	ND (0.0005)	ND (0.0005)
DICHLOROETHYLENE, 1,1- mg/L	ND (0.0013) #	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)
DICHLOROETHANE, 1,1- mg/L	ND (0.0007) #	ND (0.00007)	ND (0.00007)	ND (0.00007)	ND (0.00007)	ND (0.00007)
TRANS-1,2-DICHLOROETHYLENE mg/L	ND (0.001) #	ND (0.0001)	ND (0.0001)	ND (0.0001)	ND (0.0001)	ND (0.0001)
CHLOROFORM mg/L	ND (0.0005) #	ND (0.00005)	ND (0.00005)	ND (0.00005)	ND (0.00005)	ND (0.00005)
DICHLOROETHANE, 1,2- mg/L	ND (0.0003) #	ND (0.00003)	ND (0.00003)	ND (0.00003)	ND (0.00003)	ND (0.00003)
TRICHLOROETHANE, 1,1,1- mg/L	ND (0.0003) #	ND (0.00003)	ND (0.00003)	ND (0.00003)	ND (0.00003)	ND (0.00003)
CARBON TETRACHLORIDE mg/L	ND (0.0012) #	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
BROMODICHLOROMETHANE mg/L	ND (0.001) #	ND (0.0001)	ND (0.0001)	ND (0.0001)	ND (0.0001)	ND (0.0001)
DICHLOROPROPANE, 1,2- mg/L	ND (0.0004) #	ND (0.00004)	ND (0.00004)	ND (0.00004)	ND (0.00004)	ND (0.00004)
TRANS-1,3-DICHLOROPROPENE mg/L	ND (0.0034) #	ND (0.00034)	ND (0.00034)	ND (0.00034)	ND (0.00034)	ND (0.00034)
TRICHLOROETHYLENE mg/L	ND (0.0012) #	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)
DIBROMOCHLOROMETHANE mg/L	ND (0.0009) #	ND (0.00009)	ND (0.00009)	*	*	ND (0.00009)
TRICHLOROETHANE, 1,1,2- mg/L	ND (0.0002) #	ND (0.00002)	ND (0.00002)	*	*	ND (0.00002)
CIS-1,3-DICHLOROPROPENE mg/L	ND (0.002) #	ND (0.0002)	ND (0.0002)	*	*	ND (0.0002)
CHLOROETHYLVINYL ETHER, 2- mg/L	ND (0.0013) #	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)
BROMOFORM mg/L	ND (0.002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
TETRACHLOROETHANE, 1,1,2,2- mg/L	ND (0.0003) #	*	ND (0.00003)	**	**	*
TETRACHLOROETHYLENE mg/L	ND (0.0003) #	*	ND (0.00003)	**	**	*

Client ID	GW1-4	BW-1	GW2-4	GW2-3	GW2-2	SD2-3
ERG Sample Number	09/136554	09/136555	09/136556	09/136557	09/136558	09/136559
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	SEDIMENT
Parameter						
PURGEABLE AROMATICS						
BENZENE mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002) #
DICHLOROBENZENE, 1,2- mg/L	ND (0.00015)	ND (0.00015)	ND (0.00015)	ND (0.00015)	ND (0.00015)	ND (0.00015) #
DICHLOROBENZENE, 1,3- mg/L	ND (0.00032)	ND (0.00032)	ND (0.00032)	ND (0.00032)	ND (0.00032)	ND (0.00032) #
DICHLOROBENZENE, 1,4- mg/L	ND (0.00024)	ND (0.00024)	ND (0.00024)	ND (0.00024)	ND (0.00024)	ND (0.00024) #
ETHYLBENZENE mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	0.00092 #

See last page for explanation of symbols

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A3383

Report Date: 02 OCT 1985

Client ID	GW1-4	BW-1	GW2-4	GW2-3	GW2-2	SD2-3
ERG Sample Number	09/136554	09/136555	09/136556	09/136557	09/136558	09/136559
Matrix	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	NATURAL WATER	SEDIMENT
Parameter						
TOLUENE mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002) #
CHLOROBENZENE mg/L	ND (0.00025)	ND (0.00025)	ND (0.00025)	ND (0.00025)	ND (0.00025)	ND (0.00025) #
PURGEABLES, 601						
CHLOROMETHANE mg/L	ND (0.00008)	ND (0.00008)	0.008	ND (0.00008)	ND (0.00008)	ND (0.00008) #
BROMOMETHANE mg/L	ND (0.0012)	ND (0.0012)	ND (0.0012)	ND (0.0012)	ND (0.0012)	ND (0.0012) #
DICHLORODIFLUOROMETHANE mg/L	ND (0.0018)	ND (0.0018)	ND (0.0018)	ND (0.0018)	ND (0.0018)	ND (0.0018) #
VINYL CHLORIDE mg/L	ND (0.00018)	ND (0.00018)	ND (0.00018)	ND (0.00018)	ND (0.00018)	ND (0.00018) #
CHLOROETHANE mg/L	ND (0.00052)	ND (0.00052)	ND (0.00052)	ND (0.00052)	ND (0.00052)	ND (0.00052) #
METHYLENE CHLORIDE mg/L	ND (0.00025)	ND (0.00025)	0.00051	ND (0.00025)	ND (0.00025)	ND (0.00025) #
TRICHLOROFLUOROMETHANE mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	ND (0.0005)	ND (0.0005)	ND (0.0005) #
DICHLOROETHYLENE, 1,1- mg/L	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013) #
DICHLOROETHANE, 1,1- mg/L	ND (0.00007)	ND (0.00007)	0.00052	ND (0.00007)	ND (0.00007)	ND (0.00007) #
TRANS-1,2-DICHLOROETHYLENE mg/L	ND (0.0001)	ND (0.0001)	0.0015	ND (0.0001)	ND (0.0001)	ND (0.0001) #
CHLOROFORM mg/L	ND (0.00005)	ND (0.00005)	0.00011	ND (0.00005)	ND (0.00005)	ND (0.00005) #
DICHLOROETHANE, 1,2- mg/L	ND (0.00003)	ND (0.00003)	ND (0.00003)	ND (0.00003)	ND (0.00003)	ND (0.00003) #
TRICHLOROETHANE, 1,1,1- mg/L	ND (0.00003)	ND (0.00003)	0.00062	ND (0.00003)	ND (0.00003)	ND (0.00003) #
CARBON TETRACHLORIDE mg/L	0.00098	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012)	ND (0.00012) #
BROMODICHLOROMETHANE mg/L	ND (0.0001)	ND (0.0001)	ND (0.0001)	ND (0.0001)	ND (0.0001)	ND (0.0001) #
DICHLOROPROPANE, 1,2- mg/L	ND (0.00004)	ND (0.00004)	ND (0.00004)	ND (0.00004)	ND (0.00004)	ND (0.00004) #
TRANS-1,3-DICHLOROPROPENE mg/L	ND (0.00034)	ND (0.00034)	ND (0.00034)	ND (0.00034)	ND (0.00034)	ND (0.00034) #
TRICHLOROETHYLENE mg/L	ND (0.00012)	ND (0.00012)	0.0012	ND (0.00012)	ND (0.00012)	ND (0.00012) #
DIBROMOCHLOROMETHANE mg/L	ND (0.00009)	ND (0.00009)	*	ND (0.00009)	ND (0.00009)	ND (0.00009) #
TRICHLOROETHANE, 1,1,2- mg/L	ND (0.00002)	ND (0.00002)	*	ND (0.00002)	ND (0.00002)	ND (0.00002) #
CIS-1,3-DICHLOROPROPENE mg/L	ND (0.0002)	ND (0.0002)	*	ND (0.0002)	ND (0.0002)	ND (0.0002) #
CHLOROETHYLVINYL ETHER, 2- mg/L	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013)	ND (0.00013) #
BROMOFORM mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002) #
TETRACHLOROETHANE, 1,1,2,2- mg/L	*	*	**	*	*	ND (0.00003) #
TETRACHLOROETHYLENE mg/L	*	*	**	*	*	ND (0.00003) #

Client ID	BW2-1	BW2-1D	SD2-1	SD2-5	BW2-5	BW2-2
ERG Sample Number	09/136560	09/136561	09/136562	09/136563	09/136564	09/136565
Matrix	NATURAL WATER	NATURAL WATER	SEDIMENT	SEDIMENT	NATURAL WATER	NATURAL WATER
Parameter						
PURGEABLE AROMATICS						
BENZENE mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)
DICHLOROBENZENE, 1,2- mg/L	ND (0.00015)	ND (0.00015)	ND (0.00015) #	ND (0.00015) #	ND (0.00015)	ND (0.00015)
DICHLOROBENZENE, 1,3- mg/L	ND (0.00032)	ND (0.00032)	ND (0.00032) #	ND (0.00032) #	ND (0.00032)	ND (0.00032)
DICHLOROBENZENE, 1,4- mg/L	ND (0.00024)	ND (0.00024)	ND (0.00024) #	ND (0.00024) #	ND (0.00024)	ND (0.00024)
ETHYLBENZENE mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)
TOLUENE mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)
CHLOROBENZENE mg/L	ND (0.00025)	ND (0.00025)	ND (0.00025) #	ND (0.00025) #	ND (0.00025)	ND (0.00025)
PURGEABLES, 601						
CHLOROMETHANE mg/L	ND (0.00008)	ND (0.00008)	ND (0.00008) #	ND (0.00008) #	ND (0.00008)	ND (0.00008)
BROMOMETHANE mg/L	ND (0.0012)	ND (0.0012)	ND (0.0012) #	ND (0.0012) #	ND (0.0012)	ND (0.0012)
DICHLORODIFLUOROMETHANE mg/L	ND (0.0018)	ND (0.0018)	ND (0.0018) #	ND (0.0018) #	ND (0.0018)	ND (0.0018)

See last page for explanation of symbols

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A3383

Report Date: 02 OCT 1985

Client ID	SW2-1	SW2-1D	SD2-1	SD2-3	SW2-3	SW2-2
ERG Sample Number	09/136560	09/136561	09/136562	09/136563	09/136564	09/136565
Matrix	NATURAL WATER	NATURAL WATER	SEDIMENT	SEDIMENT	NATURAL WATER	NATURAL WATER
Parameter						
VINYL CHLORIDE mg/L	ND (0.00018)	ND (0.00018)	ND (0.00018) #	ND (0.00018) #	ND (0.00018)	ND (0.00018)
CHLOROETHANE mg/L	ND (0.00052)	ND (0.00052)	ND (0.00052) #	ND (0.00052) #	ND (0.00052)	ND (0.00052)
METHYLENE CHLORIDE mg/L	ND (0.00025)	ND (0.00025)	ND (0.00025) #	ND (0.00025) #	ND (0.00025)	ND (0.00025)
TRICHLOROFLUOROMETHANE mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005) #	ND (0.0005) #	ND (0.0005)	ND (0.0005)
DICHLOROETHYLENE, 1,1- mg/L	ND (0.00013)	ND (0.00013)	ND (0.00013) #	ND (0.00013) #	ND (0.00013)	ND (0.00013)
DICHLOROETHANE, 1,1- mg/L	ND (0.00007)	ND (0.00007)	ND (0.00007) #	ND (0.00007) #	ND (0.00007)	ND (0.00007)
TRANS-1,2-DICHLOROETHYLENE mg/L	ND (0.0001)	ND (0.0001)	ND (0.0001) #	ND (0.0001) #	ND (0.0001)	ND (0.0001)
CHLOROFORM mg/L	ND (0.00005)	ND (0.00005)	ND (0.00005) #	ND (0.00005) #	ND (0.00005)	ND (0.00005)
DICHLOROETHANE, 1,2- mg/L	ND (0.00003)	ND (0.00003)	ND (0.00003) #	ND (0.00003) #	ND (0.00003)	ND (0.00003)
TRICHLOROETHANE, 1,1,1- mg/L	ND (0.00003)	ND (0.00003)	ND (0.00003) #	ND (0.00003) #	ND (0.00003)	ND (0.00003)
CARBON TETRACHLORIDE mg/L	ND (0.00012)	ND (0.00012)	ND (0.00012) #	ND (0.00012) #	ND (0.00012)	ND (0.00012)
BROMODICHLOROMETHANE mg/L	ND (0.0001)	ND (0.0001)	ND (0.0001) #	ND (0.0001) #	ND (0.0001)	ND (0.0001)
DICHLOROPROPANE, 1,2- mg/L	ND (0.00004)	ND (0.00004)	ND (0.00004) #	ND (0.00004) #	ND (0.00004)	ND (0.00004)
TRANS-1,3-DICHLOROPROPENE mg/L	ND (0.00034)	ND (0.00034)	ND (0.00034) #	ND (0.00034) #	ND (0.00034)	ND (0.00034)
TRICHLOROETHYLENE mg/L	ND (0.00012)	ND (0.00012)	ND (0.00012) #	ND (0.00012) #	ND (0.00012)	ND (0.00012)
DIBROMOCHLOROMETHANE mg/L	ND (0.00009)	ND (0.00009)	ND (0.00009) #	ND (0.00009) #	ND (0.00009)	ND (0.00009)
TRICHLOROETHANE, 1,1,2- mg/L	ND (0.00002)	ND (0.00002)	ND (0.00002) #	ND (0.00002) #	ND (0.00002)	ND (0.00002)
CIS-1,3-DICHLOROPROPENE mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)
CHLOROETHYLVINYL ETHER, 2- mg/L	ND (0.00013)	ND (0.00013)	ND (0.00013) #	ND (0.00013) #	ND (0.00013)	ND (0.00013)
BROMOFORM mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)
TETRACHLOROETHANE, 1,1,2,2- mg/L	*	*	ND (0.00003) #	ND (0.00003) #	*	*
TETRACHLOROETHYLENE mg/L	*	*	ND (0.00003) #	ND (0.00003) #	*	*

Client ID	SD2-2	SD2-4	SD2-6	SW2-6	OW2-1	OW2-5
ERG Sample Number	09/136566	09/136567	09/136568	09/136569	09/136570	09/136571
Matrix	SEDIMENT	SEDIMENT	SEDIMENT	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
PURGEABLE AROMATICS						
BENZENE mg/L	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)
DICHLOROBENZENE, 1,2- mg/L	ND (0.00015) #	ND (0.00015) #	ND (0.00015) #	ND (0.00015)	ND (0.00015)	ND (0.00015)
DICHLOROBENZENE, 1,3- mg/L	ND (0.00032) #	ND (0.00032) #	ND (0.00032) #	ND (0.00032)	ND (0.00032)	ND (0.00032)
DICHLOROBENZENE, 1,4- mg/L	ND (0.00024) #	ND (0.00024) #	ND (0.00024) #	ND (0.00024)	ND (0.00024)	ND (0.00024)
ETHYLBENZENE mg/L	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)
TOLUENE mg/L	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)
CHLOROBENZENE mg/L	ND (0.00025) #	ND (0.00025) #	ND (0.00025) #	ND (0.00025)	ND (0.00025)	ND (0.00025)
PURGEABLES, 601						
CHLOROMETHANE mg/L	ND (0.00008) #	ND (0.00008) #	ND (0.00008) #	ND (0.00008)	ND (0.00008)	ND (0.00008)
BROMOMETHANE mg/L	ND (0.0012) #	ND (0.0012) #	ND (0.0012) #	ND (0.0012)	ND (0.0012)	ND (0.0012)
DICHLORODIFLUOROMETHANE mg/L	ND (0.0018) #	ND (0.0018) #	ND (0.0018) #	ND (0.0018)	ND (0.0018)	ND (0.0018)
VINYL CHLORIDE mg/L	ND (0.00018) #	ND (0.00018) #	ND (0.00018) #	ND (0.00018)	ND (0.00018)	ND (0.00018)
CHLOROETHANE mg/L	ND (0.00052) #	ND (0.00052) #	ND (0.00052) #	ND (0.00052)	ND (0.00052)	ND (0.00052)
METHYLENE CHLORIDE mg/L	ND (0.00025) #	ND (0.00025) #	ND (0.00025) #	ND (0.00025)	ND (0.00025)	ND (0.00025)
TRICHLOROFLUOROMETHANE mg/L	ND (0.0005) #	ND (0.0005) #	ND (0.0005) #	ND (0.0005)	ND (0.0005)	ND (0.0005)
DICHLOROETHYLENE, 1,1- mg/L	ND (0.00013) #	ND (0.00013) #	ND (0.00013) #	ND (0.00013)	ND (0.00013)	ND (0.00013)
DICHLOROETHANE, 1,1- mg/L	ND (0.00007) #	ND (0.00007) #	ND (0.00007) #	ND (0.00007)	ND (0.00007)	ND (0.00007)

See last page for explanation of symbols

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A3383

Report Date: 02 OCT 1985

Client ID	SD2-2	SD2-4	SD2-6	SW2-6	QW2-1	QW2-5
ERG Sample Number	09/136566	09/136567	09/136568	09/136569	09/136570	09/136571
Matrix	SEDIMENT	SEDIMENT	SEDIMENT	NATURAL WATER	NATURAL WATER	NATURAL WATER
Parameter						
TRANS-1,2-DICHLOROETHYLENE mg/L	ND (0.0001) #	ND (0.0001) #	ND (0.0001) #	ND (0.0001)	ND (0.0001)	ND (0.0001)
CHLOROFORM mg/L	ND (0.00005) #	ND (0.00005) #	ND (0.00005) #	ND (0.00005)	ND (0.00005)	0.0059
DICHLOROETHANE, 1,2- mg/L	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003)	ND (0.00003)	ND (0.00003)
TRICHLOROETHANE, 1,1,1- mg/L	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	ND (0.00003)	ND (0.00003)	ND (0.00003)
CARBON TETRACHLORIDE mg/L	ND (0.00012) #	ND (0.00012) #	ND (0.00012) #	ND (0.00012)	ND (0.00012)	ND (0.00012)
BROMODICHLOROMETHANE mg/L	ND (0.0001) #	ND (0.0001) #	ND (0.0001) #	ND (0.0001)	ND (0.0001)	ND (0.0001)
DICHLOROPROPANE, 1,2- mg/L	ND (0.00004) #	ND (0.00004) #	ND (0.00004) #	ND (0.00004)	ND (0.00004)	ND (0.00004)
TRANS-1,3-DICHLOROPROPENE mg/L	ND (0.00034) #	ND (0.00034) #	ND (0.00034) #	ND (0.00034)	ND (0.00034)	ND (0.00034)
TRICHLOROETHYLENE mg/L	ND (0.00012) #	ND (0.00012) #	ND (0.00012) #	ND (0.00012)	0.0003	0.00027
DIBROMOCHLOROMETHANE mg/L	ND (0.00009) #	ND (0.00009) #	ND (0.00009) #	ND (0.00009)	ND (0.00009)	*
TRICHLOROETHANE, 1,1,2- mg/L	ND (0.00002) #	ND (0.00002) #	ND (0.00002) #	ND (0.00002)	ND (0.00002)	*
CIS-1,3-DICHLOROPROPENE mg/L	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)	*
CHLOROETHYLVINYL ETHER, 2- mg/L	ND (0.00013) #	ND (0.00013) #	ND (0.00013) #	ND (0.00013)	ND (0.00013)	ND (0.00013)
BROMOFORM mg/L	ND (0.0002) #	ND (0.0002) #	ND (0.0002) #	ND (0.0002)	ND (0.0002)	0.0011
TETRACHLOROETHANE, 1,1,2,2- mg/L	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	*	*	**
TETRACHLOROETHYLENE mg/L	ND (0.00003) #	ND (0.00003) #	ND (0.00003) #	*	*	**

Client ID	W-1	WS-1
ERG Sample Number	09/136572	09/136573
Matrix	NATURAL WATER	NATURAL WATER
Parameter		
PURGEABLE AROMATICS		
BENZENE mg/L	ND (0.0002)	ND (0.0002)
DICHLOROBENZENE, 1,2- mg/L	ND (0.00015)	ND (0.00015)
DICHLOROBENZENE, 1,3- mg/L	ND (0.00032)	ND (0.00032)
DICHLOROBENZENE, 1,4- mg/L	ND (0.00024)	ND (0.00024)
ETHYLBENZENE mg/L	ND (0.0002)	ND (0.0002)
TOLUENE mg/L	ND (0.0002)	ND (0.0002)
CHLOROBENZENE mg/L	ND (0.00025)	ND (0.00025)
PURGEABLES, 601		
CHLOROMETHANE mg/L	ND (0.00008)	ND (0.00008)
BROMOMETHANE mg/L	ND (0.0012)	ND (0.0012)
DICHLORODIFLUOROMETHANE mg/L	ND (0.0018)	ND (0.0018)
VINYL CHLORIDE mg/L	ND (0.00018)	ND (0.00018)
CHLOROETHANE mg/L	ND (0.00052)	ND (0.00052)
METHYLENE CHLORIDE mg/L	ND (0.00025)	ND (0.00025)
TRICHLOROFLUOROMETHANE mg/L	ND (0.0005)	ND (0.0005)
DICHLOROETHYLENE, 1,1- mg/L	ND (0.00013)	ND (0.00013)
DICHLOROETHANE, 1,1- mg/L	ND (0.00007)	ND (0.00007)
TRANS-1,2-DICHLOROETHYLENE mg/L	ND (0.0001)	ND (0.0001)
CHLOROFORM mg/L	ND (0.00005)	0.0013
DICHLOROETHANE, 1,2- mg/L	ND (0.00003)	ND (0.00003)
TRICHLOROETHANE, 1,1,1- mg/L	ND (0.00003)	ND (0.00003)
CARBON TETRACHLORIDE mg/L	ND (0.00012)	ND (0.00012)

See last page for explanation of symbols

Client ID	W-1	WB-1
ERG Sample Number	09/136572	09/136573
Matrix	NATURAL WATER	NATURAL WATER
Parameter		
BROMODICHLOROMETHANE mg/L	ND (0.0001)	0.00094
DICHLOROPROPANE, 1,2- mg/L	ND (0.00004)	ND (0.00004)
TRANS-1,3-DICHLOROPROPENE mg/L	ND (0.00034)	ND (0.00034)
TRICHLOROETHYLENE mg/L	ND (0.00012)	ND (0.00012)
DIBROMOCHLOROMETHANE mg/L	ND (0.00009)	**
TRICHLOROETHANE, 1,1,2- mg/L	ND (0.00002)	**
CIS-1,3-DICHLOROPROPENE mg/L	ND (0.0002)	**
CHLOROETHYLVINYL ETHER, 2- mg/L	ND (0.00013)	ND (0.00013)
BROMOFORM mg/L	ND (0.0002)	0.00022
TETRACHLOROETHANE, 1,1,2,2- mg/L	*	*
TETRACHLOROETHYLENE mg/L	*	*

Project Comments:

Comments about sample 09/136542
PURGEABLES, 601 - *UNRESOLVED AT 0.14 ug/L.
Comments about sample 09/136549
PURGEABLES, 601 - *UNRESOLVED AT 0.12 ug/L.
Comments about sample 09/136551
PURGEABLES, 601 - *UNRESOLVED AT 0.08 ug/L; **UNRESOLVED AT 0.30 ug/L.
Comments about sample 09/136552
PURGEABLES, 601 - *UNRESOLVED AT 0.03 ug/L; **UNRESOLVED AT 0.15 ug/L.
Comments about sample 09/136553
PURGEABLES, 601 - *UNRESOLVED AT 0.09 ug/L.
Comments about sample 09/136554
PURGEABLES, 601 - *UNRESOLVED AT 0.06 ug/L.
Comments about sample 09/136555
PURGEABLES, 601 - *UNRESOLVED AT 0.08 ug/L.
Comments about sample 09/136556
PURGEABLES, 601 - *UNRESOLVED AT 0.03 ug/L; **UNRESOLVED AT 3.6 ug/L.
Comments about sample 09/136557
PURGEABLES, 601 - *UNRESOLVED AT 0.14 ug/L. AVERAGE OF DUPLICATE RUNS
PURGEABLE AROMATICS - AVERAGE OF DUPLICATE RUNS
Comments about sample 09/136558
PURGEABLES, 601 - *UNRESOLVED AT 2.7 ug/L.
Comments about sample 09/136560
PURGEABLES, 601 - *UNRESOLVED AT 0.66 ug/L.
Comments about sample 09/136561
PURGEABLES, 601 - *UNRESOLVED AT 0.28 ug/L.
Comments about sample 09/136564
PURGEABLES, 601 - *UNRESOLVED AT 0.17 ug/L.
Comments about sample 09/136565
PURGEABLES, 601 - *UNRESOLVED AT 0.09 ug/L.
Comments about sample 09/136569
PURGEABLES, 601 - *UNRESOLVED AT 0.08 ug/L.
Comments about sample 09/136570
PURGEABLES, 601 - *UNRESOLVED AT 0.09 ug/L.
Comments about sample 09/136571
PURGEABLES, 601 - *UNRESOLVED AT 0.03 ug/L; **UNRESOLVED AT 7.0 ug/L.

Comments about sample 09/136572
PURGEABLES, 601 - *UNRESOLVED AT 5.1 ug/L.
Comments about sample 09/136573
PURGEABLES, 601 - *UNRESOLVED AT 1.5 ug/L. **UNRESOLVED AT 0.61 ug/L.

Note Results indicated by '#' are in mg/Kg instead of mg/L
FR = See field report for result
NA = Not applicable to test requested
ND = Nondetected, detection limit in ()
SD = Sample damaged

SR = See attached report for result
< = Positive result but at unquantifiable concentration below inicated level
- = Test not requested for this sample

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.
117 N. FIRST ST.
ANN ARBOR, MI 48104 (313) 662-3104

Project: A3365.1

Report Date: 10/02/85

Results by Sample

Prepared for:
SCIENCE APPLICATIONS INTERNATIONAL COR
8400 WESTPARK DRIVE
MC LEAN, VA 22102
Attention: ANDRIS LAPINS

Client P.O.: LETTER
Report #: 238
Samples Rec'd: 09-13-85

Approved: [signature]
Refer Questions to:
ROBYN WOOLEY

**
Residual Samples Will Be Held
For Two Weeks
**

Client ID ERG Sample Number Matrix Parameter	SD1-1 09/136575 SEDIMENT	SD1-1D 09/136580 SEDIMENT	GW2-4 09/136588 NATURAL WATER	GW2-5 09/136603 NATURAL WATER	W-1 09/136604 NATURAL WATER
PURGEABLE AROMATICS					
BENZENE mg/L	0.0027 #	0.0012 #	ND (0.0002)	ND (0.0002)	ND (0.0002)
DICHLOROBENZENE, 1,2- mg/L	ND (0.0015) #	ND (0.0015) #	ND (0.00015)	ND (0.00015)	ND (0.00015)
DICHLOROBENZENE, 1,3- mg/L	ND (0.0032) #	ND (0.0032) #	ND (0.00032)	ND (0.00032)	ND (0.00032)
DICHLOROBENZENE, 1,4- mg/L	ND (0.0024) #	ND (0.0024) #	ND (0.00024)	ND (0.00024)	ND (0.00024)
ETHYLBENZENE mg/L	ND (0.002) #	ND (0.002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)
TOLUENE mg/L	0.006 #	0.00084 #	ND (0.0002)	ND (0.0002)	ND (0.0002)
CHLOROBENZENE mg/L	ND (0.0025) #	ND (0.0025) #	ND (0.00025)	ND (0.00025)	ND (0.00025)
PURGEABLES, 601					
CHLOROMETHANE mg/L	ND (0.0008) #	ND (0.0008) #	0.007	ND (0.00008)	ND (0.00008)
BROMOMETHANE mg/L	ND (0.012) #	ND (0.012) #	ND (0.0012)	ND (0.0012)	ND (0.0012)
DICHLORODIFLUOROMETHANE mg/L	ND (0.018) #	ND (0.018) #	ND (0.0018)	ND (0.0018)	ND (0.0018)
VINYL CHLORIDE mg/L	ND (0.0018) #	ND (0.0018) #	ND (0.00018)	ND (0.00018)	ND (0.00018)
CHLOROETHANE mg/L	ND (0.0052) #	ND (0.0052) #	ND (0.00052)	ND (0.00052)	ND (0.00052)
METHYLENE CHLORIDE mg/L	ND (0.0025) #	ND (0.0025) #	ND (0.00025)	ND (0.00025)	ND (0.00025)
TRICHLOROFLUOROMETHANE mg/L	ND (0.005) #	ND (0.005) #	ND (0.0005)	ND (0.0005)	ND (0.0005)
DICHLOROETHYLENE, 1,1- mg/L	ND (0.0013) #	ND (0.003) #	ND (0.00013)	ND (0.00013)	ND (0.00013)
DICHLOROETHANE, 1,1- mg/L	ND (0.0007) #	ND (0.0013) #	ND (0.00007)	ND (0.00007)	ND (0.00007)
TRANS-1,2-DICHLOROETHYLENE mg/L	ND (0.001) #	ND (0.001) #	ND (0.0001)	ND (0.0001)	ND (0.0001)
CHLOROFORM mg/L	ND (0.0005) #	ND (0.0005) #	ND (0.00005)	ND (0.00005)	ND (0.00005)
DICHLOROETHANE, 1,2- mg/L	ND (0.0003) #	ND (0.0003) #	ND (0.00003)	ND (0.00003)	ND (0.00003)
TRICHLOROETHANE, 1,1,1- mg/L	ND (0.0003) #	ND (0.0003) #	ND (0.00003)	ND (0.00003)	ND (0.00003)
CARBON TETRACHLORIDE mg/L	ND (0.0012) #	ND (0.0012) #	ND (0.00012)	ND (0.00012)	ND (0.00012)
BROMODICHLOROMETHANE mg/L	ND (0.001) #	ND (0.001) #	ND (0.0001)	ND (0.0001)	ND (0.0001)
DICHLOROPROPANE, 1,2- mg/L	ND (0.0004) #	ND (0.0004) #	ND (0.00004)	ND (0.00004)	ND (0.00004)
TRANS-1,3-DICHLOROPROPENE mg/L	ND (0.0034) #	ND (0.0034) #	0.0009	ND (0.00034)	ND (0.00034)
TRICHLOROETHYLENE mg/L	ND (0.0012) #	ND (0.0012) #	ND (0.00012)	ND (0.00012)	ND (0.00012)
DIBROMOCHLOROMETHANE mg/L	ND (0.0009) #	ND (0.0009) #	ND (0.00009)	ND (0.00009)	ND (0.00009)
TRICHLOROETHANE, 1,1,2- mg/L	ND (0.0002) #	ND (0.0002) #	ND (0.00002)	ND (0.00002)	ND (0.00002)
CIS-1,3-DICHLOROPROPENE mg/L	ND (0.002) #	ND (0.002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)
CHLOROETHYLVINYL ETHER, 2- mg/L	ND (0.0013) #	ND (0.0013) #	ND (0.00013)	ND (0.00013)	ND (0.00013)
BROMOFORM mg/L	ND (0.002) #	ND (0.002) #	ND (0.0002)	ND (0.0002)	ND (0.0002)
TETRACHLOROETHANE, 1,1,2,2- mg/L	ND (0.0003) #	ND (0.0003) #	*	*	*
TETRACHLOROETHYLENE mg/L	ND (0.0003) #	ND (0.0003) #	*	*	*

 See last page for explanation of symbols

CONTINUED

erg

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: A3383.1

Report Date: 02 OCT 1985

Project Comments:

Comments about sample 09/136388
PURGEABLES, 601 - *UNRESOLVED AT 5.9 ug/L.
Comments about sample 09/136403
PURGEABLES, 601 - *UNRESOLVED AT 1.6 ug/L.
Comments about sample 09/136404
PURGEABLES, 601 - *UNRESOLVED AT 1.3 ug/L.

Note - Results indicated by '@' are in mg/Kg instead of mg/L
FR = See field report for result
NA = Not applicable to test requested
ND = Nondetected, detection limit in ()
SD = Sample damaged

SR = See attached report for result
< = Positive result but at unquantifiable concentration below inicated level
- = Test not requested for this sample

APPENDIX H

QUALITY CONTROL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

117 N. First Ann Arbor, Michigan 48104 (313) 662-3104

November 5, 1985

Mr. Andres Lapins
SAIC-JRB Associates
8400 Westpark Drive
McLean, VA 22102

Dear Mr. Lapins:

Enclosed please find the additional information relating to Project SAIC/JRB McEntire #A3383 which you requested.

We are sorry this information is late getting to you. In the future, I will take all the steps necessary to ensure all the data gets to you on a timely basis.

If you have any further questions, please do not hesitate to call.

Very truly yours,

Arthur Czabaniuk
Laboratory Director

AC/m

Encl.

QUALITY CONTROL REPORT

Submitted to:	JRB Associates, Inc. 8400 Westpark Drive McLean, VA 22102
Attention:	Andra Lapins
Project Number:	A3383 Reference: JRB McEntire
Date Samples Received:	September 13, 1985
Date Samples Extracted:	No Extraction
Date Samples Analyzed:	September 17 - 20, 1985
Methodology Employed:	Purgeable Halocarbon EPA Method 601 and purgeable aromatics EPA Method 602.
Sample Quality Control:	ERG's QA/QC requires a duplicate, method spike and blank with each group of samples or with every 10 samples, whichever is larger.
Validity of Quality Control Results:	Overall the results of the method spikes and the relative differences of the duplicates were within EPA Method 601 and 602 acceptability limits.

Sample Analysis/Positive Identifications
on Purgeable 601/602 Compounds

SAIC/JRB McEntire A3383

Client I.D./Matrix	Compounds Identified	Results	Primary Column Retention Times	Confirmation Column Retention Times
FB-1 (ug/L)	1,1,2,2-Tetrachloroethane	0.14*	23.19	(2)
	Tetrachloroethylene	0.14*	23.19	(2)
SD1-1 (ug/Kg)	Benzene	23	16.68	14.28
	Toluene	15	23.45	16.31
SD1-1D(ug/Kg)	Benzene	45	16.71	14.45
	Toluene	30#	23.46	17.44
FB-2 (ug/L)	1,1,2,2-Tetrachloroethane	0.12*	23.20	(2)
	Tetrachloroethylene	0.12*	23.20	(2)
GW1-1D(ug/L)	Dibromochloromethane	0.08*	18.42	(2)
	1,1,2-Trichloroethane	0.08*	18.42	(2)
	Cis-1,3-Dichloropropene	0.08*	18.42	(2)
	1,1,2,2-Tetrachloroethane	0.38**(4)	23.38	(2)
	Tetrachloroethylene	0.38**(4)	23.38	(2)
GW1-2 (ug/L)	Dibromochloromethane	0.03*	18.38	(2)
	1,1,2-Trichloroethane	0.03*	18.38	(2)
	Cis-1,3-Dichloropropene	0.03*	18.38	(2)
	1,1,2,2-Tetrachloroethane	0.15**	23.36	(2)
	Tetrachloroethylene	0.15**	23.36	(2)
GW1-3 (ug/L)	1,1,2,2-Tetrachloroethane	0.09*	23.46	(2)
	Tetrachloroethylene	0.09*	23.46	(2)
GW1-4 (ug/L)	Carbon Tetrachloride	0.98	14.96	(2)
	1,1,2,2-Tetrachloroethane	0.06*	23.48	(2)
	Tetrachloroethylene	0.06*	23.48	(2)

Sample Analysis (Continued)

SAIC/JRB McEntire A3383

Client I.D./Matrix	Compounds Identified	Results	Primary Column Retention Times	Confirmation Column Retention Times
SW2-2 (ug/L)	1,1,2,2-Tetrachloroethane	0.09*	23.47	(2)
	Tetrachloroethylene	0.09*	23.47	(2)
SW2-6 (ug/L)	1,1,2,2-Tetrachloroethane	0.08*	23.54	(2)
	Tetrachloroethylene	0.08*	23.54	(2)
GW2-1 (ug/L)	Trichloroethylene	0.3	17.94	(2)
	1,1,2,2-Tetrachloroethane	0.09*	23.67	(2)
	Tetrachloroethylene	0.09*	23.67	(2)
GW2-5 (ug/L)	Chloroform	5.9	12.14	7.16
	Trichloroethylene	0.27	17.07	9.94
	Dibromochloromethane	0.03*	17.95	14.69
	1,1,2-Trichloroethane	0.03*	17.95	(2)
	Cis-1,3-Dichloropropene	0.03*	17.95	(2)
	Bromoform	1.1	20.62	(2)
	1,1,2,2-Tetrachloroethane	7.0**	22.91	ND
	Tetrachloroethylene	7.0**	22.91	11.89
W1 (ug/L)	1,1,2,2-Tetrachloroethane	5.1*	23.29	11.80
	Tetrachloroethylene	5.1*	23.29	11.80
WS-1 (ug/L)	Chloroform	1.3	12.04	(2)
	Bromodichloromethane(1)	0.94	15.00	(2)
	Dibromochloromethane(1)	0.61**	17.81	(2)
	1,1,2-Trichloroethane(1)	0.61**	17.81	(2)
	Cis-1,3-Dichloropropene(1)	0.61**	17.81	(2)
	Bromoform	0.22	20.61	(2)
	1,1,2,2-Tetrachloroethane(1)	1.5*	22.95	(2)
	Tetrachloroethylene(1)	1.5*	22.95	(2)

#*The zero is not significant
**Compounds not resolvable on this column. The result is the product of all compounds added together
(1)Compounds not resolvable on this column. The result is the product of all compounds added together
(2)Average of duplicate runs
(3)Second-column confirmation not required
(4)Second-column confirmation not apparent
ND Original result reported as 0.30, but is 0.38
Not determinable in confirmation column

Sample Analysis (Continued)

SAIC/JRB McEntire A3383

Client I.D./Matrix	Compounds Identified	Results	Primary Column Retention Times	Confirmation Column Retention Times
BW-1 (ug/L)	1,1,2,2-Tetrachloroethane	0.08*	23.42	(2)
	Tetrachloroethylene	0.08*	23.42	(2)
GW2-4 (ug/L)	Chloromethane	8	2.17	(2)
	Methylene Chloride	0.51	7.17	(3)
	1,1-Dichloroethane	0.52	11.12	9.35
	Trans-1,2-Dichloroethylene	1.5	11.83	8.89
	Chloroform	0.11	12.41	6.96
	1,1,1-Trichloroethane	0.62	14.5	9.78
	Trichloroethylene	1.2	17.68	9.78
	Dibromochloromethane	0.03*	18.42	(2)
	1,1,2-Trichloroethane	0.03*	18.42	(2)
	Cis-1,3-Dichloropropene	0.03*	18.42	(2)
	1,1,2,2-Tetrachloroethane	3.6**	23.48	ND
	Tetrachloroethylene	3.6**	23.48	11.66
GW2-3 (ug/L)	1,1,2,2-Tetrachloroethane[1]	0.14*	23.44	(2)
	Tetrachloroethylene[1]	0.14*	23.44	(2)
GW2-2 (ug/L)	1,1,2,2-Tetrachloroethane	2.7*	23.44	(2)
	Tetrachloroethylene	2.7*	23.44	(2)
SW2-1 (ug/L)	1,1,2,2-Tetrachloroethane	0.66*	23.64	(2)
	Tetrachloroethylene	0.66*	23.64	(2)
SW2-1D (ug/L)	1,1,2,2-Tetrachloroethane	0.28*	23.53	(2)
	Tetrachloroethylene	0.28*	23.53	(2)
SW2-5 (ug/L)	1,1,2,2-Tetrachloroethane	0.17*	23.50	(2)
	Tetrachloroethylene	0.17*	23.50	(2)

QUALITY CONTROL REPORT

Submitted to:	JRB Associates, Inc. 8400 Westpark Drive McLean, VA 22102
Attention:	Andra Lapins
Project Number:	A3383 Reference: JRB McEntire
Date Samples Received:	September 13, 1985
Date Samples Extracted:	No Extraction
Date Samples Analyzed:	September 17 - 20, 1985
Methodology Employed:	Purgeable Halocarbon EPA Method 601 and purgeable aromatics EPA Method 602.
Sample Quality Control:	ERG's QA/QC requires a duplicate, method spike and blank with each group of samples or with every 10 samples, whichever is larger
Validity of Quality Control Results:	Overall the results of the method spikes and the relative differences of the duplicates were within EPA Method 601 and 602 acceptability limits.

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spiked Sample	Spike Added	Percent Recovery
	mg/l	mg/l	%	mg/l	mg/l	%
1,3 - Dichlorobenzene	ND(0.00032)	ND(0.00032)	0	0.0064	0.0080	80
1,2 - Dichlorobenzene	ND(0.00015)	ND(0.00015)	0	0.00065	0.0080	81
1,4 - Dichlorobenzene	ND(0.00024)	ND(0.00024)	0	0.0070	0.0080	88
Benzene	ND(0.00020)	ND(0.00020)	0	0.0038	0.0040	94
Toluene	ND(0.00020)	ND(0.00020)	0	0.0034	0.0040	85
Ethyl Benzene	ND(0.00020)	ND(0.00020)	0	0.0035	0.0040	87

This QC report covers the following sample numbers: 136542, 136549-136557

RECEIVED OCT - 3 1985

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
SAIC/JRB McENTIRE A3383

Parameter	DUPLICATE Sample A	DUPLICATE Sample B	DUPLICATE Relative Difference	MATRIX SPIKE Spiked Sample	MATRIX SPIKE Spike Added	MATRIX SPIKE Percent Recovery
	mg/L	mg/L	%	mg/L	mg/L	%
Chloromethane	ND(0.00008)	ND(0.00008)	0	---	---	---
Bromomethane	ND(0.0012)	ND(0.0012)	0	---	---	---
Dichlorodifluoromethane	ND(0.0018)	ND(0.0018)	0	---	---	---
Vinyl Chloride	ND(0.00018)	ND(0.00018)	0	---	---	---
Chloroethane	ND(0.00052)	ND(0.00052)	0	---	---	---
Methylene Chloride	ND(0.00025)	ND(0.00025)	0	---	---	---
Trichlorofluoromethane	ND(0.00050)	ND(0.00050)	0	---	---	---
1,1 - Dichloroethylene	ND(0.00013)	ND(0.00013)	0	---	---	---
1,1 - Dichloroethane	ND(0.00007)	ND(0.00007)	0	---	---	---
Trans - 1,2 - dichloroethylene	ND(0.00010)	ND(0.00010)	0	---	---	---
Chloroform	ND(0.00005)	ND(0.00005)	0	0.0040	0.0040	100
1,2 - Dichloroethane	ND(0.00003)	ND(0.00003)	0	---	---	---
1,1,1 - Trichloroethane	ND(0.00003)	ND(0.00003)	0	---	---	---
Carbon Tetrachloride	ND(0.00012)	ND(0.00012)	0	---	---	---
Bromodichloromethane	ND(0.00010)	ND(0.00010)	0	0.0040	0.0040	100
1,2 - Dichloropropane	ND(0.00004)	ND(0.00004)	0	0.0040	0.0040	100
Trans - 1,3 - dichloropropane	ND(0.00034)	ND(0.00034)	0	0.0038	0.00040	95
Trichloroethylene	ND(0.00013)	ND(0.00013)	0	0.011	0.012	92
Dibromochloromethane	ND(0.00009)	ND(0.00009)	0	---	---	---
1,1,2 - Trichloroethane	ND(0.00002)	ND(0.00002)	0	---	---	---
Cis - 1,3 dichloropropane	ND(0.00020)	ND(0.00020)	0	---	---	---
2 - Chloroethylvinylether	ND(0.00013)	ND(0.00013)	0	0.0040	0.0040	100
Bromoform	ND(0.00020)	ND(0.00020)	0	---	---	92
1,1,2,2, - Tetrachloroethane	0.00013	0.00016	21	0.0068	0.012	57
Tetrachloroethylene	ND(0.00003)	ND(0.00003)	0	---	---	---
Chlorobenzene	ND(0.00025)	ND(0.00025)	0	0.0066	0.0080	82

This QC report covers the following sample numbers: 136542, 136549-136557

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
SAIC / JRB-McENTIRE A3383

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spiked Sample	Spike Added	Percent Recovery
	mg/kg	mg/kg	%	mg/kg	mg/kg	%
1,3 - Dichlorobenzene	ND(0.00032)	---	---	0.0053	0.0064	83
1,2 - Dichlorobenzene	ND(0.00015)	---	---	0.013	0.016	81
1,4 - Dichlorobenzene	ND(0.00024)	---	---	---	---	---
Benzene	ND(0.0002)	---	---	0.0053	0.0044	120
Toluene	ND(0.0002)	---	---	0.0032	0.0043	74
Ethyl Benzene	ND(0.0002)	---	---	0.0041	0.0043	95

This QC report covers the following sample numbers: 136543-136548, 136559, 136562, 136563, 136566-136568

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spiked Sample	Spike Added	Percent Recovery
	mg/l	mg/l	%			
1,3 - Dichlorobenzene	ND(0.00024)	ND(0.00024)	0	0.010	0.0080	125
1,2 - Dichlorobenzene	ND(0.00032)	ND(0.00032)	0	0.0088	0.0080	110
1,4 - Dichlorobenzene	ND(0.00024)	ND(0.00024)	0	0.0098	0.0080	122
Benzene	ND(0.00020)	ND(0.00020)	0	0.0050	0.0040	125
Toluene	ND(0.00020)	ND(0.00020)	0	0.0048	0.0040	120
Ethyl Benzene	ND(0.00020)	ND(0.00020)	0	---	---	---

This QC report covers the following sample numbers:

[redacted]

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
JRB McEntire A3002

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spike Sample	Spike Added	Percent Recovery
	mg/L	mg/L	%	mg/L	mg/L	%
Nitrates	0.06	0.06	0	0.32	0.25	104
	N.D.(0.01)	N.D.(0.01)	0	0.25	0.25	100
	N.D.(0.01)*	N.D.(0.01)*	0	0.27*	0.25*	108
Total Phosphorus	N.D.(0.02)	N.D.(0.02)	0	0.61	0.50	122
	0.50	0.46	8.3	0.90	0.50	25
	280*	340*	19	spike diluted out		
TOC	N.D.(2)	N.D.(2)	0	20	20	100
	N.D.(2)	N.D.(2)	0	20	20	100
	48*	45*	6	61*	20*	80
	4*	3*	25	21*	20*	90
Oil and Grease(IR)	<1	<1	0			
	<1	<1	0			
	<1	<1	0			
	<1	<1	0			
	<1	<1	0			

This QC report covers the following sample numbers:

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
SAIC / JRB McENTIRE A3383

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spiked Sample	Spike Added	Percent Recovery
	mg/kg	mg/kg	%	mg/kg	mg/kg	%
Chloromethane	ND(0.00008)	---	---	---	---	---
Bromomethane	ND(0.0012)	---	---	---	---	---
Dichlorodifluoromethane	ND(0.0018)	---	---	---	---	---
Vinyl Chloride	ND(0.00018)	---	---	---	---	---
Chloroethane	ND(0.00052)	---	---	---	---	---
Methylene Chloride	ND(0.00025)	---	---	0.0058	0.0056	104
Trichlorofluoromethane	ND(0.0005)	---	---	0.0042	0.0051	82
1,1 - Dichloroethylene	ND(0.00013)	---	---	---	---	---
1,1 - Dichloroethane	ND(0.00007)	---	---	0.0052	0.0059	88
Trans - 1,2 - dichloroethylene	ND(0.0001)	---	---	0.0052	0.0063	83
Chloroform	ND(0.00005)	---	---	0.0061	0.0074	82
1,2 - Dichloroethane	ND(0.00003)	---	---	0.0061	0.0067	91
1,1,1 - Trichloroethane	ND(0.00003)	---	---	---	---	---
Carbon Tetrachloride	ND(0.00012)	---	---	0.0071	0.0076	93
Bromodichloromethane	ND(0.0001)	---	---	---	---	---
1,2 - Dichloropropane	ND(0.0004)	---	---	---	---	---
Trans - 1,3 - dichloropropane	ND(0.00009)	---	---	---	---	---
Trichloroethylene	ND(0.00012)	---	---	0.009	0.0073	81
Dibromochloromethane	ND(0.00009)	---	---	---	---	---
1,1,2 - Trichloroethane	ND(0.00002)	---	---	---	---	---
Cis - 1,3 dichloropropane	ND(0.0002)	---	---	---	---	---
2 - Chloroethylvinylether	ND(0.00013)	---	---	---	---	---
Bromoform	ND(0.0002)	---	---	---	---	---
1,1,2,2, - Tetrachloroethane	ND(0.00003)	---	---	---	---	---
Tetrachloroethylene	ND(0.00003)	---	---	0.0066	0.0081	93
Chlorobenzene	ND(0.00025)	---	---	0.0052	0.0055	95

This QC report covers the following sample numbers: 136543-136548, 136559, 136562, 136563, 136566-136568

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS

JRB McEntire A3002

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spike Sample	Spike Added	Percent Recovery
	mg/L	mg/L	%	mg/L	mg/L	%
Arsenic	<0.001	<0.001	0	0.223	0.200	112
	N.D.(0.001)	N.D.(0.001)	0	0.024	0.020	120
	1.1*	1.1*	0	2.3*	1.2*	101
Cadmium	<0.01	<0.01	0	0.03	0.03	100
	N.D.(0.01)	N.D.(0.01)	0	0.03	0.03	100
	<2.0*	<2.0*	0	9.6*	9.0*	107
Chromium	0.81	0.82	1.2	0.88	0.05	120
	N.D.(0.02)	N.D.(0.02)	0	0.05	0.05	100
	18*	20*	10	62*	40*	108
Copper	0.02	0.02	0	0.07	0.05	100
	<0.02	<0.02	0	0.07	0.05	100
Iron	18*	22*	20	38*	20*	90
Mercury	<0.0002	<0.0002	0	0.0010	0.0010	100
	0.003	0.003	0	0.0010	0.0010	70
	<0.1*	<0.1*	0	0.16*	0.20*	80

This QC report covers the following sample numbers: 129643 - 129652, 129930 - 129988

*units are mg/kg

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
JRB McEntire A3002

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spike Sample	Spike Added	Percent Recovery
	mg/L	mg/L	%	mg/L	mg/L	%
Lead	0.06	0.06	0	0.18	0.10	120
	<0.05	<0.05	0	0.11	0.10	110
	60*	48*	22	91*	40*	92
Nickel	0.62	0.61	1.6	0.72	0.10	100
	0.06	0.06	0	0.17	0.10	110
	<25*	<25*	0	102*	100*	102
Selenium	0.003	0.003	0	0.022	0.020	95
	<0.001	<0.001	0	0.010	0.010	100
	<0.25*	<0.25*	0	0.010*	0.007*	70
Silver	N.D.(0.02)	N.D.(0.02)	0	0.10	0.03	30
	N.D.(0.02)	N.D.(0.02)	0	0.10	0.03	30
	<4*	<4*	0	10*	40*	25
Zinc	0.04	0.05	5	0.09	0.05	100
	0.02	0.02	0	0.06	0.05	80
	79	93	16			

This QC report covers the following sample numbers:
* units are mg/kg

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
SAIC/JRB McENTIRE A3383

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spiked Sample	Spike Added	Percent Recovery
	mg/l	mg/l	%	mg/l	mg/l	%
Chloromethane	ND(0.00008)	ND(0.00008)	0	---	---	---
Bromomethane	ND(0.0012)	ND(0.0012)	0	---	---	---
Dichlorodifluoromethane	ND(0.0018	ND(0.0018)	0	---	---	---
Vinyl Chloride	ND(0.00018)	ND(0.00018)	0	---	---	---
Chloroetnane	ND(0.00052)	ND(0.00052)	0	---	---	---
Methylene Chloride	ND(0.00025)	ND(0.00025)	0	---	---	---
Trichlorofluoromethane	ND(0.00050)	ND(0.00050)	0	---	---	---
1,1 - Dichloroethylene	ND(0.00013)	ND(0.00013)	0	0.0038	0.0040	45
1,1 - Dichloroethane	ND(0.00007)	ND(0.00007)	0	0.0041	0.0040	102
Trans - 1,2 - dichloroethylene	ND(0.00010)	ND(0.00010)	0	0.0041	0.0040	102
Chloroform	0.0010	0.0013	25	0.0056	0.0040	108
1,2 - Dichloroethane	ND(0.00003)	ND(0.00003)	0	0.0045	0.0040	113
1,1,1 - Trichloroethane	ND(0.00003)	ND(0.00003)	0	0.0044	0.0040	110
Carbon Tetrachloride	ND(0.00012)	ND(0.00012)	0	0.0045	0.0040	112
Bromodichloromethane	0.00078	0.00094	21	0.0065	0.0040	139
1,2 - Dichloropropane	ND(0.00004)	ND(0.00004)	0	0.0044	0.0040	110
Trans - 1,3 - dichloropropane	ND(0.00034)	ND(0.00034)	0	0.0055	0.0040	138
Trichloroethylene	ND(0.00012)	ND(0.00012)	0	0.0013	0.0012	108
Dibromochloromethane	ND(0.00009)	ND(0.00009)	0	0.0052	0.0040	130
1,1,2 - Trichloroethane	0.00070	0.00052	29	---	---	---
Cis - 1,3 dichloropropane	ND(0.00020)	ND(0.00020)	0	---	---	---
2 - Chloroethylvinylether	ND(0.00013)	ND(0.00013)	0	0.0048	0.0040	120
Bromoform	0.00069	0.00022	103	---	---	---
1,1,2,2, - Tetrachloroethane	0.0019	0.0012	45	---	---	---
Tetrachloroethylene	ND(0.00003)	ND(0.00003)	0	---	---	---
Chlorobenzene	ND(0.00025)	ND(0.00025)	0	---	---	---

This QC report covers the following sample numbers: 136558, 136560, 136561, 136564, 136565, 136569-136573

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS

JRB - McEntire A2947

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spike Sample	Spike Added	Percent Recovery
	mg/L	mg/L	%	mg/L	mg/L	%
TOH: Chlorine	<1.0	<1.0	0	43	48	90
Bromine	ND(0.10)	ND(0.10)	0			
Iodine	ND(0.05)	ND(0.05)	0			
Oil & Grease	54	48	12			

This QC report covers the following sample numbers: 128534 - 128537

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
JRB McEntire A3002

	DUPLICATE			MATRIX SPIKE		
Parameter	Sample A	Sample B	Relative Difference	Spike Sample	Spike Added	Percent Recovery
	mg/L	mg/L	%	mg/L	mg/L	%
Chlorine	<0.01	<0.01	0	0.76	0.96	79
Bromine	N.D.(0.01)	N.D.(0.01)	0			
Iodine	N.D.(0.01)	N.D.(0.01)	0			

This QC report covers the following sample numbers:

Sample Analysis/Positive Identifications
on Purgeable 601/602 Compounds

SAIC/JRB McEntire A3383

Client I.D./Matrix	Compounds Identified	Results	Primary Column Retention Times	Confirmation Column Retention Times
FB-1 (ug/L)	1,1,2,2-Tetrachloroethane	0.14*	23.19	(2)
	Tetrachloroethylene	0.14*	23.19	(2)
SD1-1 (ug/Kg)	Benzene	23	16.68	14.28
	Toluene	15	23.45	16.31
SD1-1D(ug/Kg)	Benzene	45	16.71	14.45
	Toluene	30#	23.46	17.44
FB-2 (ug/L)	1,1,2,2-Tetrachloroethane	0.12*	23.20	(2)
	Tetrachloroethylene	0.12*	23.20	(2)
GW1-1D(ug/L)	Dibromochloromethane	0.08*	18.42	(2)
	1,1,2-Trichloroethane	0.08*	18.42	(2)
	Cis-1,3-Dichloropropene	0.08*	18.42	(2)
	1,1,2,2-Tetrachloroethane	0.38**(4)	23.38	(2)
	Tetrachloroethylene	0.38**(4)	23.38	(2)
GW1-2 (ug/L)	Dibromochloromethane	0.03*	18.38	(2)
	1,1,2-Trichloroethane	0.03*	18.38	(2)
	Cis-1,3-Dichloropropene	0.03*	18.38	(2)
	1,1,2,2-Tetrachloroethane	0.15**	23.36	(2)
	Tetrachloroethylene	0.15**	23.36	(2)
GW1-3 (ug/L)	1,1,2,2-Tetrachloroethane	0.09*	23.46	(2)
	Tetrachloroethylene	0.09*	23.46	(2)
GW1-4 (ug/L)	Carbon Tetrachloride	0.98	14.96	(2)
	1,1,2,2-Tetrachloroethane	0.06*	23.48	(2)
	Tetrachloroethylene	0.06*	23.48	(2)

Sample Analysis (Continued)

SAIC/JRB McEntire A3383

Client I.D./Matrix	Compounds Identified	Results	Primary Column Retention Times	Confirmation Column Retention Times
BW-1 (ug/L)	1,1,2,2-Tetrachloroethane	0.08*	23.42	(2)
	Tetrachloroethylene	0.08*	23.42	(2)
GW2-4 (ug/L)	Chloromethane	8	2.17	(2)
	Methylene Chloride	0.51	7.17	(3)
	1,1-Dichloroethane	0.52	11.12	9.35
	Trans-1,2-Dichloroethylene	1.5	11.83	8.89
	Chloroform	0.11	12.41	6.96
	1,1,1-Trichloroethane	0.62	14.5	9.78
	Trichloroethylene	1.2	17.68	9.78
	Dibromochloromethane	0.03*	18.42	(2)
	1,1,2-Trichloroethane	0.03*	18.42	(2)
	Cis-1,3-Dichloropropene	0.03*	18.42	(2)
	1,1,2,2-Tetrachloroethane	3.6**	23.48	ND
	Tetrachloroethylene	3.6**	23.48	11.66
GW2-3 (ug/L)	1,1,2,2-Tetrachloroethane(1)	0.14*	23.44	(2)
	Tetrachloroethylene(1)	0.14*	23.44	(2)
GW2-2 (ug/L)	1,1,2,2-Tetrachloroethane	2.7*	23.44	(2)
	Tetrachloroethylene	2.7*	23.44	(2)
SW2-1 (ug/L)	1,1,2,2-Tetrachloroethane	0.66*	23.64	(2)
	Tetrachloroethylene	0.66*	23.64	(2)
SW2-1D (ug/L)	1,1,2,2-Tetrachloroethane	0.28*	23.53	(2)
	Tetrachloroethylene	0.28*	23.53	(2)
SW2-5 (ug/L)	1,1,2,2-Tetrachloroethane	0.17*	23.50	(2)
	Tetrachloroethylene	0.17*	23.50	(2)

Sample Analysis (Continued)

SAIC/JRB McEntire A3383

Client I.D./Matrix	Compounds Identified	Results	Primary Column Retention Times	Confirmation Column Retention Times
SW2-2 (ug/L)	1,1,2,2-Tetrachloroethane	0.09*	23.47	(2)
	Tetrachloroethylene	0.09*	23.47	(2)
SW2-6 (ug/L)	1,1,2,2-Tetrachloroethane	0.08*	23.54	(2)
	Tetrachloroethylene	0.08*	23.54	(2)
GW2-1 (ug/L)	Trichloroethylene	0.3	17.94	(2)
	1,1,2,2-Tetrachloroethane	0.09*	23.67	(2)
	Tetrachloroethylene	0.09*	23.67	(2)
GW2-5 (ug/L)	Chloroform	5.9	12.14	7.16
	Trichloroethylene	0.27	17.07	9.94
	Dibromochloromethane	0.03*	17.95	14.69
	1,1,2-Trichloroethane	0.03*	17.95	(2)
	Cis-1,3-Dichloropropene	0.03*	17.95	(2)
	Bromoform	1.1	20.62	(2)
	1,1,2,2-Tetrachloroethane	7.0**	22.91	ND
	Tetrachloroethylene	7.0**	22.91	11.89
W1 (ug/L)	1,1,2,2-Tetrachloroethane	5.1*	23.29	11.80
	Tetrachloroethylene	5.1*	23.29	11.80
WS-1 (ug/L)	Chloroform	1.3	12.04	(2)
	Bromodichloromethane	0.94	15.00	(2)
	Dibromochloromethane(1)	0.61**	17.81	(2)
	1,1,2-Trichloroethane(1)	0.61**	17.81	(2)
	Cis-1,3-Dichloropropene(1)	0.61**	17.81	(2)
	Bromoform	0.22	20.61	(2)
	1,1,2,2-Tetrachloroethane(1)	1.5*	22.95	(2)
	Tetrachloroethylene(1)	1.5*	22.95	(2)

#* The zero is not significant
** Compounds not resolvable on this column. The result is the product of all compounds added together
(1) Compounds not resolvable on this column. The result is the product of all compounds added together
(2) Average of duplicate runs
(3) Second-column confirmation not required
(4) Second-column confirmation not apparent
Original result reported as 0.30, but is 0.33
ND Not determinable in confirmation column

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
SAIC/JRB McENTIRE A3383

Parameter	DUPLICATE			MATRIX SPIKE		
	Sample A	Sample B	Relative Difference	Spiked Sample	Spike Added	Percent Recovery
	mg/l	mg/l	%	mg/l	mg/l	%
Chloromethane	ND(0.00008)	ND(0.00008)	0	No spike.		
Bromomethane	ND(0.0012)	ND(0.0012)	0	No spike.		
Dichlorodifluoromethane	ND(0.0018)	ND(0.0018)	0	No spike.		
Vinyl Chloride	ND(0.00018)	ND(0.00018)	0	No spike.		
Chloroethane	ND(0.00052)	ND(0.00052)	0	No spike.		
Methylene Chloride	ND(0.00025)	ND(0.00025)	0	No spike.		
Trichlorofluoromethane	ND(0.00050)	ND(0.00050)	0	No spike.		
1,1 - Dichloroethylene	ND(0.00013)	ND(0.00013)	0	No spike.		
1,1 - Dichloroethane	ND(0.00007)	ND(0.00007)	0	No spike.		
Trans - 1,2 - dichloroethylene	ND(0.00010)	ND(0.00010)	0	No spike.		
Chloroform	ND(0.00005)	ND(0.00005)	0	0.0040	0.0040	100
1,2 - Dichloroethane	ND(0.00003)	ND(0.00003)	0	No spike.		
1,1,1 - Trichloroethane	ND(0.00003)	ND(0.00003)	0	No spike.		
Carbon Tetrachloride	ND(0.00012)	ND(0.00012)	0	No spike.		
Bromodichloromethane	ND(0.00010)	ND(0.00010)	0	0.0040	0.0040	100
1,2 - Dichloropropane	ND(0.00004)	ND(0.00004)	0	0.0040	0.0040	100
Trans - 1,3 - dichloropropane	ND(0.00034)	ND(0.00034)	0	0.0038	0.0040	95
Trichloroethylene	ND(0.00013)	ND(0.00013)	0	0.011	0.012	92
Dibromochloromethane	ND(0.00009)	ND(0.00009)	0	No spike.		
1,1,2 - Trichloroethane	ND(0.00002)	ND(0.00002)	0	No spike.		
Cis - 1,3 dichloropropane	ND(0.00020)	ND(0.00020)	0	No spike.		
2 - Chloroethylvinylether	ND(0.00013)	ND(0.00013)	0	0.0040	0.0040	100
Bromoform	ND(0.00020)	ND(0.00020)	0	No spike.		
1,1,2,2 - Tetrachloroethane	0.00013	0.00016	21	0.0068	0.012	57
Tetrachloroethylene	ND(0.00003)	ND(0.00003)	0	No spike.		
Chlorobenzene	ND(0.00025)	ND(0.00025)	0	0.0066	0.0080	82
1,3 - Dichlorobenzene	ND(0.00032)	ND(0.00032)	0	0.0064	0.0080	80
1,2 - Dichlorobenzene	ND(0.00015)	ND(0.00015)	0	0.0065	0.0080	81
1,4 - Dichlorobenzene	ND(0.00024)	ND(0.00024)	0	0.0070	0.0080	88
Benzene	ND(0.00020)	ND(0.00020)	0	0.0038	0.0040	94
Toluene	ND(0.00020)	ND(0.00020)	0	0.0034	0.0040	85
Ethyl Benzene	ND(0.00020)	ND(0.00020)	0	0.0035	0.0040	88

COMMENTS : This QC report covers sample numbers 136542, 136549-136557

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
SAIC/JRB McENTIRE A3383

Parameter	DUPLICATE Sample A mg/kg	DUPLICATE Sample B mg/kg	DUPLICATE Relative Difference %	MATRIX SPIKE Spiked Sample mg/l	MATRIX SPIKE Spike Added mg/l	MATRIX SPIKE Percent Recovery %
Chloromethane	ND(0.00008)	No duplicated sample run.		No spike.		
Bromomethane	ND(0.0012)			No spike.		
Dichlorodifluoromethane	ND(0.0018)			No spike.		
Vinyl Chloride	ND(0.00018)			No spike.		
Chloroethane	ND(0.00052)			No spike.		
Methylene Chloride	ND(0.00025)			0.0058	0.0056	104
Trichlorofluoromethane	ND(0.0005)			0.0042	0.0051	82
1,1 - Dichloroethylene	ND(0.00013)			No spike.		
1,1 - Dichloroethane	ND(0.00007)			0.0052	0.0059	88
Trans - 1,2 - dichloroethylene	ND(0.0001)			0.0052	0.0063	83
Chloroform	ND(0.00005)			0.0061	0.0074	82
1,2 - Dichloroethane	ND(0.00003)			0.0061	0.0067	91
1,1,1 - Trichloroethane	ND(0.00003)			No spike.		
Carbon Tetrachloride	ND(0.00012)			0.0071	0.0070	93
Bromodichloromethane	ND(0.0001)			No spike		
1,2 - Dichloropropane	ND(0.00004)			No spike.		
Trans - 1,3 - dichloropropane	ND(0.00034)			No spike.		
Trichloroethylene	ND(0.00012)			0.0059	0.0073	81
Dibromochloromethane	ND(0.00009)			No spike.		
1,1,2 - Trichloroethane	ND(0.00002)			No spike.		
Cis - 1,3 dichloropropane	ND(0.0002)			No spike.		
2 - Chloroethylvinylether	ND(0.00013)			No spike.		
Bromoform	ND(0.0002)			No spike.		
1,1,2,2 - Tetrachloroethane	ND(0.00003)			No spike.		
Tetrachloroethylene	ND(0.00003)			0.0066	0.0081	93
Chlorobenzene	ND(0.00025)			0.0052	0.0055	95
1,3 - Dichlorobenzene	ND(0.00032)			0.0053	0.0064	83
1,2 - Dichlorobenzene	ND(0.00015)			0.013	0.016	81
1,4 - Dichlorobenzene	ND(0.00024)			No spike.		
Benzene	ND(0.0002)			0.0053	0.0044	120
Toluene	ND(0.0002)			0.0032	0.0043	74
Ethyl Benzene	ND(0.0002)			0.0041	0.0043	95

COMMENTS : This QC report covers sample numbers 136543-136548, 136559, 136562, 136563, 136566-136568.

QUALITY CONTROL REPORT
DUPLICATE AND MATRIX SPIKE ANALYSIS
SAIC/JRB McENTIRE A3383

Parameter	DUPLICATE			MATRIX SPIKE		
	Sample A	Sample B	Relative Difference	Spiked Sample	Spike Added	Percent Recovery
	mg/l	mg/l	%	mg/l	mg/l	%
Chloromethane	ND(0.00008)	ND(0.00008)	0	No spike.		
Bromomethane	ND(0.0012)	ND(0.0012)	0	No spike.		
Dichlorodifluoromethane	ND(0.0018)	ND(0.0018)	0	No spike.		
Vinyl Chloride	ND(0.00018)	ND(0.00018)	0	No spike.		
Chloroethane	ND(0.00052)	ND(0.00052)	0	No spike.		
Methylene Chloride	ND(0.00025)	ND(0.00025)	0	No spike.		
Trichlorofluoromethane	ND(0.00050)	ND(0.00080)	0	No spike.		
1,1 - Dichloroethylene	ND(0.00013)	ND(0.00013)	0	0.0038	0.0040	95
1,1 - Dichloroethane	ND(0.00007)	ND(0.00007)	0	0.0041	0.0040	102
Trans - 1,2 - dichloroethylene	ND(0.00010)	ND(0.00010)	0	0.0041	0.0040	102
Chloroform	0.0010	0.0013	25	0.0056	0.0040	108
1,2 - Dichloroethane	ND(0.00003)	ND(0.00003)	0	0.0045	0.0040	112
1,1,1 - Trichloroethane	ND(0.00003)	ND(0.00003)	0	0.0044	0.0040	110
Carbon Tetrachloride	ND(0.00012)	ND(0.00012)	0	0.0045	0.0040	112
Bromodichloromethane	0.00078	0.00094	21	0.0065	0.0040	139
1,2 - Dichloropropane	ND(0.00004)	ND(0.00004)	0	0.0044	0.0040	110
Trans - 1,3 - dichloropropane	ND(0.00034)	ND(0.00034)	0	0.0055	0.0040	138
Trichloroethylene	ND(0.00012)	ND(0.00012)	0	0.0013	0.0012	108
Dibromochloromethane	ND(0.00009)	ND(0.00009)	0	0.0052	0.0040	130
1,1,2 - Trichloroethane	0.00070	0.00052	29	No spike.		
Cis - 1,3 dichloropropane	ND(0.00020)	ND(0.00020)	0	No spike.		
2 - Chloroethylvinylether	ND(0.00013)	ND(0.00013)	0	0.0048	0.0040	120
Bromoform	0.00069	0.00022	103	No spike.		
1,1,2,2 - Tetrachloroethane	0.0019	0.0012	45	No spike.		
Tetrachloroethylene	ND(0.00003)	ND(0.00003)	0	No spike.		
Chlorobenzene	ND(0.00025)	ND(0.00025)	0	No spike.		
1,3 - Dichlorobenzene	ND(0.00024)	ND(0.00024)	0	0.010	0.0080	125
1,2 - Dichlorobenzene	ND(0.00032)	ND(0.00032)	0	0.0088	0.0080	110
1,4 - Dichlorobenzene	ND(0.00024)	ND(0.00024)	0	0.0098	0.0080	122
Benzene	ND(0.00020)	ND(0.00020)	0	0.0050	0.0040	125
Toluene	ND(0.00020)	ND(0.00020)	0	0.0048	0.0040	120
Ethyl Benzene	ND(0.00020)	ND(0.00020)	0	No spike.		

COMMENTS : This QC report covers sample numbers 136558, 136560, 136561, 136564, 136565, 136569-136573.

DEAR MR. LAPINS

I'M SORRY BUT THIS LAST PAGE OF THE GC REPORT WAS NOT DONE IN TIME TO MAIL WITH THE REST OF THE REPORT YESTERDAY. WE APOLOGIZE AGAIN FOR THE LATENESS OF THIS REPORT.

Sincerely Yours,

Joe Foster

JOE FOSTER
ENG. TECH

QUALITY CONTROL REPORT

Submitted to:	JRB Associates, Inc. 8400 Westpark Drive McLean, VA 22102
Attention:	Andra Lapins
Project Number:	A3383 Reference: JRB McEntire
Date Samples Received:	September 13, 1985
Date Samples Extracted:	No Extraction
Date Samples Analyzed:	September 17 - 20, 1985
Methodology Employed:	Purgeable Halocarbon EPA Method 601 and purgeable aromatics EPA Method 602.
Sample Quality Control:	ERG's QA/QC requires a duplicate, method spike and blank with each group of samples or with every 10 samples, whichever is larger.
Validity of Quality Control Results:	Overall the results of the method spikes and the relative differences of the duplicates were within EPA Method 601 and 602 acceptability limits.

APPENDIX I

CHAIN OF CUSTODY FORMS

Pg. 1 of 2

Shipment No. 12

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE
Name: SAIC / SRB
No., Street: 8400 WEST PARK DR.
City, State, Zip: MCLEAN VA. 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis	Sediment Core Date	Remarks
FB-1	9/11/89	1700	2	FIELD BLANKS			X	X	X																				
SD1-1	" "	"	"	SEDIMENT			X	X	X																				
SD1-2	" "	"	"	"			X	X	X																				
SD1-3	" "	"	"	"			X	X	X																				
SD1-4	" "	"	"	"			X	X	X																				
SD6-1	" "	"	"	"			X	X	X																				
SD1-1D	" "	"	"	"			X	X	X																				
FB2-2	9/12/89	"	"	FIELD BLANK			X	X	X																				
GW1-1	" "	"	"	GROUNDWATER			X	X	X																				
GW1-1D	" "	"	"	"			X	X	X																				
GW1-2	" "	"	"	"			X	X	X																				
GW1-3	" "	"	"	"			X	X	X																				
GW1-4	" "	"	"	"			X	X	X																				
BW-1	" "	"	"	BAILER WASH			X	X	X																				

Total No. Containers

CHAIN OF CUSTODY

	Date	Time		Date	Time
Received By (sign)	9/12	1730	Received By Courier (sign)		
Courier From Airport (sign)			Received By Contract Lab (sign)		

SAMPLE SHIPPING RECORD

Shipment No. 12

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: SAIC / JRB
No., Street: 8400 WESTPARK DR.
City, State, Zip: McLEAN, VA 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis	Sediment Core Date	Remarks
GW2-4	9/12/85	1700	2	GROUNDWATER			X																						
GW2-3	" "	4	2	" "			X																						
GW2-2	" "	"	2	" "			X																						
SD2-3	" "	"	2	" SEDIMENT "			X																						
SW2-1	" "	"	2	SURFACE WATER			X																						
SW2-1D	" "	"	2	" "			X																						
SD2-1	" "	"	2	SEDIMENT			X																						
SD2-5	" "	"	2	" "			X																						
SW2-5	" "	"	2	SURFACE WATER			X																						
SW2-2	" "	"	2	" "			X																						
SD2-2	" "	"	2	SEDIMENT			X																						
SD2-4	" "	"	2	" "			X																						
SD2-6	" "	"	2	" "			X																						
SW2-6	" "	"	2	SURFACE WATER			X																						
	Total No. Containers																												

SHIPPING CHAIN OF CUSTODY

SAI (by) (sign)	Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
[signature] [signature]	9/12/85	1730						
Shipping Method:	Shipped By (sign):		Courier from Airport (sign)	Date	Time	Received by Contract Courier (sign)	Date	Time

SAMPLE SHIPPING RECORD

Pg. 3-25

Shipment No. 12

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: SAIC/SRA

No., Street: 8400 WESTPARK DR.

City, State, Zip: MCLEAN, VA. 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
GW2-1	9/12/85	1700	2	GROUNDWATER
GW2-5	9/12/85	"	2	GROUNDWATER
~~SW2-1~~	~~9/12/85~~	~~"~~	~~2~~	~~SURFACE WATER~~
W-1	" "	"	2	WATER SOURCE
WS-1	" "	"		
		Total No. Containers	64	

SAMPLE ANALYSIS

Sample No.	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GW2-1			X																						
GW2-5			X																						
W-1			Y																						
WS-1			X																						

SHIPPING CHAIN OF CUSTODY

		Date	Time
SAI (sign)	Received By (sign)		
Courier From Airport (sign)	Received By Courier (sign)		
Received By (sign)	Received By Contract Lab (sign)		

	Date	Time
SAI (sign) Received By (sign)	9/12/85	1730
Courier From Airport (sign)		
Received By Courier (sign)		
Received By Contract Lab (sign)		

CHAIN OF CUSTODY RECORD

Page 1 of 2

PROJ NO.	PROJECT NAME
A3383	SAIC / JRB McEntire

SAMPLERS (Signature)

STA NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO OF CONTAINERS	40ml VOA vile							REMARKS
	9/14	9 am			1 FB-1	2	2							
	"	"			2 FB-2	2	2							
	"	"			3 GW1-1	2	2							
	"	"			4 GW1-1D	2	2							
	"	"			5 GW1-2	2	2							
	"	"			6 GW1-3	2	2							
	"	"			7 GW1-4	2	2							
	"	"			8 BW-1	2	2							
	"	"			9 GW2-4	2	2							
	"	"			10 GW2-3	2	2							
	"	"			11 GW2-2	2	2							
	"	"			12 SW2-1	2	2							
	"	"			13 SW2-1D	2	2							
	"	"			14 SW2-5	2	2							
	"	"			15 SW2-2	2	2							

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[illegible]	9/15/95 1730	Federal Express 4116811 #4958511234			Marcella S. Tappe
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	
				Request [illegible]	

[redacted] Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

CHAIN OF CUSTODY RECORD

Page 1 of 2

PROJ NO.	PROJECT NAME
A3383	SAIC/JRB McEntire

SAMPLERS: (Signature)

STA. NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO OF CONTAINERS	40ml VOA vile	REMARKS
	7/14	9am			16 SGW2-6	2	2	
	"	"			17 GW2-1	2	2	
	"	"			18 GW2-5	2	2	
	"	"			19 W-1	2	2	
	"	"			20 WS-1	2	2	
	21							
	22							

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[illegible]	7/15/96 17:30	Federal Express Airbill # 455911237			
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

CHAIN OF CUSTODY RECORD

Page 1 of 2

PROJ NO: A3333

PROJECT NAME: SAIC/JRB McEntire

SAMPLERS (Signature):

STA NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO OF CONTAINERS	40ml VOA vile							REMARKS
					SW2-6	2	2							
					GW2-1	2	2							
					GW2-5	2	2							
					W-1	2	2							
					WS-1	2	2							

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[signature]	7/15/99 1130	Federal Express Airbill # 435 811 234			
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	
				Shipment of 11 samples to [illegible]	

White Accompanies Shipment, Copy to Coordinator Field Files

CHAIN OF CUSTODY RECORD

Page 1 of 2

PROJ NO: A3383 | PROJECT NAME: SAIC / JRB McEntire

SAMPLERS: (Signature)

STA NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO OF CONTAINERS	40ml VOA vial						REMARKS
					FB-1	2	2						
					FB-2	2	2						
					GW1-1	2	2						
					GW1-1D	2	2						
					GW1-2	2	2						
					GW1-3	2	2						
					GW1-4	2	2						
					BW-1	2	2						
					GW2-4	2	2						
					GW2-3	2	2						
					GW2-2	2	2						
					SW2-1	2	2						
					SW2-1D	2	2						
					SW2-5	2	2						
					SW2-2	2	2						

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[signature]	2/13/95 1730	Federal Express Airbill # 4588 8117 32			
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	
				Shipment of the samples to the lab	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

Project Sheet - Page 2

Project #:

8.

Sample ID	Date Collected	Matrix Code *	Accession Number	Test Name	601	602	QC	AD SERVICES
	X	X	136	Test Code	3214	3211	QCRPT	
1. SD2-1		20	560					
2. SD2-5		↓	563					
3. SW2-5		01	564					
4. SW2-2		↓	565					
5. SD2-2		20	566					
6. SD2-4		↓	567					
7. SD2-6		↓	568					
8. SW2-6		01	569					
9. GW2-1		↓	570					
10. GW2-5		↓	571					
11. W-1		↓	572					
12. WS-1		↓	573				X	
13.								
14.								
15.								
16.								
17.								
18.				* Waters = 110.00/sx X 20 = 2200.00				> FOR 601/602
19.				* Sediments = 130.00/sx X 12 = 1560.00				
20.								
9. Spec. Fee/Sample							75	150
Tot. Spls/Test							1	1
Total Fee							75	150

10. Sample Comments: (i.e., storage area, preservative notes, problems, etc.)

* All sediments, sludges, soils must be logged-in for percent moisture

SAMPLE SHIPPING RECORD

Shipment No. 1

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Andris Lapins JRB/SAIC
No., Street: 8400 Westpark Dr.
City, State, Zip: McLean, VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
304-1	4/18/85	8:10	1	Soil - 0 to .5' BLS
304-2	"	8:35	1	Soil - 4' to 5' BLS
304-3	"	8:45	1	Soil - 9.5 to 10' BLS
304-4	"	9:05	1	Soil - 14.5 to 15' BLS

SAMPLE SHIPPING RECORD

Shipment No. 1

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE
Name: Andris Lapins JRB/SAIC
No., Street: 8400 Westpark Dr.
City, State, Zip: McLean, VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
35-85-0001	4/16/85	8:10	1	Soil - 0 to 5' BLS
35-85-0002	"	8:35	1	Soil - 4' to 5' BLS
35-85-0003	"	8:45	1	Soil - 9.5 to 10' BLS
35-85-0004	"	9:07	1	Soil - 14.5 to 15' BLS
		Total No Containers	4	

SAMPLE ANALYSIS

Sample No.	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS 704	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
35-85-0001																	X	X			X	X	X	X	
35-85-0002																									
35-85-0003																									
35-85-0004																									

SHIPPING CHAIN OF CUSTODY

		Date	Time
SAI (sign)	Received By (sign)		
Shipped By (sign)	Courier From Airport (sign)	4/16/85	10:20

Canary Lab Representative — Pink Contract Lab

	Date	Time
Received By Courier (sign)		
Received By Contract Lab (sign)		

Goldenrod Lab Returns to SAI

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

Shipment No: 1

CONSIGNEE

Name: ANDRIS LAPINS
No., Street: 8400 WESTPARK DRIVE
City, State, Zip: McLean, Va. 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics EPA 601/602	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS	TDS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GW5-1	5/7/85	1035	4	GROUNDWATER															X		X				X				
GW5-2	"	1115	4	"															X		X				X				
GW5-3	"	1230	4	"															X		X				X				
GW-2-1	"	1415	7	"			X		X										X		X				X				
FB-1	"	1115	7	FIELD BLANK			X		X										X		X				X				
BW-1	"	1115	7	BAILER WASH			X		X										X		X				X				
	Total No. Containers		33																										

SHIPPING CHAIN OF CUSTODY

Sent (by) (sign)	Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
[signature]	5.7.85	7:35						
Shipping Method	**Shipped By (sign)**		**Courier From Airport (sign)**	**Date**	**Time**	**Received By Contract Lab (sign)**	**Date**	**Time**
Fed X	Frank A Chemello							

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

Shipment No. 1

CONSIGNEE

Name: Andris Lapens
No., Street: 8400 Westpark Drive
City, State, Zip: Mclean, Va 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics GC/MS/60	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS	~~TSC~~ TDX	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GW-85-005	5/7/85	1035	4	GROUNDWATER															X		X			X					
GW-85-006	"	1115	4	"															X		X			X					
GW-85-009	"	1230	4	"															X		X			X					
GW-85-010	"	1415	7	"			X		X										X		X			X					
GW-85-008	"	1115	7				X		X										X		X			X					
GW-85-007	"	1415	7				X		X										X		X			X					
	Total No. Containers		33																										

SHIPPING CHAIN OF CUSTODY

SAI (by) (sign)	Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
Andris Kapens	5/8/85	7:3[illegible]						
Shipping Method	**Shipped By (sign)**		**Courier From Airport (sign)**	**Date**	**Time**	**Received By Contract Lab (sign)**	**Date**	**Time**
Fedex								

White SAI Canary Lab Representative Pink Contract Lab Goldenrod Lab Returns to SAI

SAMPLE SHIPPING RECORD

Shipment No. 2

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Andris Lapens
No. Street: 8400 Westpark Drive
City, State, Zip: McLean, Va. 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics EPA 601/624	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS	TOX	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GW-2-2	5/7/85	1540	7	GROUNDWATER			X	X	X	X									X			X	X		X				
GW-2-3	"	1615	7	"			X	X	X	X									X			X	X		X				
GW-2-4	"	1700	7	"			X	X	X	X									X			X	X		X				
GW-2-5	"	1730	7				X	X	X	X									X			X	X		X				

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

Shipment No. 2

CONSIGNEE

Name: ANDRIS LAPINS
No. Street: 8400 WESTPARK DRIVE
City, State, Zip: MCLEAN, VA 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	~~TOX~~	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
SW-85-011	5/7/85	1540	7	GROUNDWATER			X	X	X										X	X				X					
SW-85-012	"	1615	7	"			X	X	X										X	X				X					
SW-85-013	"	1700	7	"			X	X	X										X	X				X					
SW-85-014	"	1730	7	"			X	X	X										X	X				X					

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

Shipment No. 3

CONSIGNEE

Name: ANDRIS LAPINS
No., Street: 8400 Westpark Drive
City, State, Zip: McLean, Virginia 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics EPA 601/602	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TCLX	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GN-85-015	5-8-85	1000	5	GROUNDWATER					X										X		X				X				
GN-85-016	"	1055	5	"					X										X		X				X				
GN-85-017	"	1130	5	"					X										X		X				X				
GN-85-018	"	1330	2	"			X												X										
GN-85-019	"	1345	6	"			X												X		X				X				
GN-85-020	"	1535	6	"			X												X		X				X				
GN-85-021	"	1555	6	"			X												X		X				X				
GN-85-022	"	1620	6	"			X												X		X				X				
	Total No. Containers		41																										

SHIPPING CHAIN OF CUSTODY

SAI Transmitted		Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
Shipping Method: Fed X	Shipped By (sign): [signature]			Courier From Airport (sign)	Date	Time	Received By Contract Lab (sign)	Date	Time

White SAI Canary Lab Representative Pink Contract Lab Goldenrod Lab Returns to SAI

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

Shipment No. 3

CONSIGNEE

Name: ANDRIS LAPINS
No., Street: 8400 WESTPARK, DRIVE
City, State, Zip: McLEAN, VIRGINIA 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics EPA 601-603	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	~~TOX~~ TOX	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
FB-2	5/8/85	1000	7	FIELD BLANK			X	X	X										X	X				X					
BW-2	5/8/85	1010	7	BAILER WASH			X	X	X										X	X				X					
MW6-1	5/8/85	1020	5	GROUNDWATER				X	X										X	X				X					
MW6-2	5/8/85	1055	5	"				X	X										X	X				X					
MW6-2D	5/8/85	1100	5	"				X	X										X	X				X					
MW6-3	5/8/85	1130	5	"				X	X										X	X				X					
	Total No. Containers		34																										

SHIPPING CHAIN OF CUSTODY

SAI (sign)	Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
[signature]	5/9/85	1154						
Shipping Method	**Shipped By (sign)**		**Courier From Airport (sign)**	**Date**	**Time**	**Received By Contract Lab (sign)**	**Date**	**Time**
FEDEX	[signature]							

SAMPLE SHIPPING RECORD

Shipment No. 4

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

ENDRIS LAPINS

Street: 8400 WESTPARK DRIVE

City, State, Zip: MCLEAN, VA. 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
WS-1	5/8/85	1320	7	Water Source (Fire Hydrant)
W-1	"	1330	2	Supply Well (W-1)
MW1-1	"	1345	6	Groundwater
MW1-2	"	1535	6	"
MW1-3	"	1555	6	"
MW1-4	"	1620	6	"

SAMPLE SHIPPING RECORD

Shipment No. 4

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Hydrix Logistics

No., Street: 8400 Westpark Dr.

City, State, Zip: McLean, VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
G3-85-0023	5/4/85	1400	2	Sediment - C-141 Spill Trench
G3-85-0024	"	1430	2	"
G3-85-0025	"	1505	2	"
G3-85-0026	"	1520	2	"

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

Shipment No. 5

CONSIGNEE

Name: Andris Lapins
No., Street: 8400 Westpark Dr.
City, State, Zip: McLean VA 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics (EPA 624-601)	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	TOC	BOD	TSS	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GW6-3	5/9/85	12:25		Groundwater					X								X	X						X				
GW1-1	"	12:50		"			X										X	X						X				
FB-3	"	12:55		Field Blank			X		X								X	X						X				
BW-3	"	1:00		Buiter Wash			X		X								X	X						X				
GW5-1	"	2:45		Groundwater													X	X						X				
SD5-1	"	2:00	2	Sediment													X							X				
SD5-2	"	2:30	2	"													X							X				
SD5-3	"	3:05	2	"													X							X				
SD5-4	"	3:20	2	"													X							X				
	Total No. Containers																											

SHIPPING CHAIN OF CUSTODY

Sampled By (sign)	Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
[signature]	5/9/85	1721	[signature]					
Shipping Method	**Shipped By (sign)**		**Courier From Airport (sign)**	**Date**	**Time**	**Received By Contract Lab (sign)**	**Date**	**Time**
Fed-X	Frank A Chan							

SAMPLE SHIPPING RECORD

Shipment No. 5

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Andris Lapins
No. Street: 8400 Westpark Dr.
City, State, Zip: McLean, VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
GN-85-0027	5/10/85	0945	4	Groundwater - Site No 4
GN-85-0028	"	1010	4	"
GN-85-0029	"	1025	4	"
GN-85-0030	"	1045	4	Groundwater - Site No 3
GN-85-0031	"	1305	4	"
GN-85-0032	"	1330	4	"
GN-85-0033	"	1345	4	"
GN-85-0034	"	1410	4	"
			Lab	
		Total No. Containers	32	

SAMPLE ANALYSIS

Sample No.	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS Tot	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GN-85-0027															X		X				X	X			
GN-85-0028															X		X	X				X			
GN-85-0029															X		X	X				X			
GN-85-0030															X		X	X				X			
GN-85-0031															X		X	X				X			
GN-85-0032															X		X	X				X			
GN-85-0033															X		X	X				X			
GN-85-0034															X		X	X				X			

SHIPPING CHAIN OF CUSTODY

	Date	Time
Relinquished By (sign)	5/16/85	6:10
Courier From Airport (sign)		
Pick Contract Lab Representative		

	Date	Time
Received By (sign)		
Received By Courier (sign)		
Received By Contract Lab (sign)		

Goldenrod Lab Returns to SAI

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Hydros Logics JRB/SAIC
No. Street: 8400 Westpark Dr.
City, State, Zip: McLean VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
FB-4	5/10/85	9:30	4	Field Blank
BW-4	"	9:35	4	Bailer Wash
GW4-1	"	9:45	4	Groundwater
GW4-2	"	10:10	4	"
GW4-3	"	10:25	4	"
GW4-4	"	10:45	4	"
GW3-1	"	1:05	4	"
GW3-2	"	1:30	4	"
GW3-3	"	1:45	4	"
GW3-4	"	2:10	4	"
GW3-4D	"	4:00	4	Duplicate

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY

476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

SAMPLE SHIPPING RECORD

Shipment No. 6

CONSIGNEE

Name: Andris Kapins

No., Street: 8460 Westpark Dr.

City, State, Zip: McLean VA 22102

SAMPLE ANALYSIS

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	TOX	NO3	TSS	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
GS-BS-0035	5/13/85	0925	4	Sediment - Site No 6.			X											X	[redacted]						X					
GS-BS-0036	"	0955	4	" " No. 1			X											X							X					
GS-BS-0037	"	1010	4	" " " "			X											X							X					
GS-BS-0038	"	1020	4	" " " "			X											X							X					
GS-BS-0039	"	1040	4	" " " "			X											X							X					
GS-BS-0040	"	1110	3	" " " 7														X	X	X					X					
GS-BS-0041	"	1125	3	" " " "														X	X	X					X					
GS-BS-0042	"	1140	3	" " " "														X	X	X					X					
GS-BS-0048	"	1425	2	" " " 3														X	[redacted]						X					
GS-BS-0043	"	1155	3	" " " 7														X	X	X					X					
GS-BS-0044	"	1315	3	" " " "														X	X	X					X					
GS-BS-0045	"	1330	3	" " " "														X	X	X					X					
GS-BS-0046	"	1355	2	" " " 3														X							X					
GS-BS-0047	"	1410	2	" " " "														X							X					
	Total No Containers		[redacted]	44																										

SHIPPING CHAIN OF CUSTODY

SAI (by) (sign)	Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
[signature]	5/13/85	5:00	(TOU)					
Shipping Method	**Shipped By (sign)**		**Courier From Airport (sign)**	**Date**	**Time**	**Received By Contract Lab (sign)**	**Date**	**Time**
[illegible]	[signature]							

White SAI — Canary Lab Representative — Pink Contract Lab — Goldenrod Lab Returns to SAI

SAIC

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

SAMPLE SHIPPING RECORD

Shipment No. 7

CONSIGNEE

Name: Andras Lapins
No., Street: 8400 West Park Dr.
City, State, Zip: McLean, VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
FB-5	5/13/85	0910	4	Field Blank
SD6-1	"	0925	4	Sediment
SD1-1	"	0955	4	"
SD1-2	"	1010	4	"
SD1-2D	"	1020	4	"
SD1-3	"	1040	4	"
SD1-4	"	1110	3	"
SD7-1	"	1125	3	"
SD7-2	"	1140	3	"
SD7-3	"		3	"

SAMPLE SHIPPING RECORD

Shipment No. 8

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Andris Lapins
No., Street: 8400 Westpark Dr.
City, State, Zip: McLean VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
SD7-4	5/13/85		3	Sediment
SD7-5	"		3	"
SD7-6	"		2	"
SD3-1	"		2	"
SD3-1D	"		2	"
SD3-2	"		2	"
SD3-3	"			

Total No. Containers

SAMPLE ANALYSIS

Sample No.	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Bromide	Chloride	pH	TOC	BOD	TSS	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis	Sediment Core Date	Remarks
SD7-4												X	X		X						X				
SD7-5												X	X		X						X				
SD7-6												X	X		X						X				
SD3-1															X						X				
SD3-1D															X						X				
SD3-2															X						X				
SD3-3															X						X				

SHIPPING CHAIN OF CUSTODY

Sample(s) Shipped By (sign): Andris Lapins — Date: 5/13/85 — Time: 5:00
Shipped By (sign): [illegible] — Received By (sign): [illegible] — Date: 5/14/85 — Time: 1700
Courier From Airport (sign): [illegible] — Date: — Time: — Received By Courier (sign): — Date: — Time:
Canary Lab Representative — Pink Contract Lab — Received By Contract Lab (sign): — Date: — Time:
Goldenrod Lab Return to SAI

SAMPLE SHIPPING RECORD

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

Shipment No. 7

CONSIGNEE

Name: Andris Lapins
No., Street: 8400 Westpark A.
City, State, Zip: McLean VA 22102

SAMPLE ANALYSIS

Sample No	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	~~TSS~~ TCH	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis.	Sediment Core Date	Remarks
[illegible]N-85-0049	5/14/85	0915	7	Surface water			X	X											X	X					X				
[illegible]S-85-0050	"	0930	5	Sediment			X	X												X					X				
[illegible]S-85-0051	"	1020	5	"			X	X												X					X				
[illegible]N-85-0052	"	1100	7	Surface water			X	X											X	X					X				
[illegible]S-85-0053	"	1110	5	Sediment			X	X												X					X				
[illegible]N-85-0054	"	1255	7	Surface water			X	X											X	X					X				
[illegible]85-0055	"	1305	5	Sediment			X	X												X					X				
~~[illegible]S-85-0056~~	~~"~~	~~1545~~	~~5~~	~~"~~			X	X												X					X				
~~[illegible]N-85-0057~~	~~"~~	~~1625~~	~~7~~	~~Surface water~~			X	X											X	X					X				
~~[illegible]S-85-0058~~	~~"~~	~~1635~~	~~5~~	~~Sediment~~			X	X												X					X				
	Total No Containers		41																										

Shipment No 8

SHIPPING CHAIN OF CUSTODY

SAI (by) (sign)	Date	Time	Received By (sign)	Date	Time	Received By Courier (sign)	Date	Time
Shipping Method: FX	Shipped By (sign): [illegible]		Courier From Airport (sign)	Date	Time	Received By Contract Lab (sign)	Date	Time

SAMPLE SHIPPING RECORD

Shipment No 8

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE
Name: Arctis Logistics
No., Street: 8400 Westpark Dr
City, State, Zip: McLean, VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description	Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS TOT	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis	Sediment Core Date	Remarks
~~BB-00265~~	~~5/14/85~~	~~1545~~																										
BB-00265	5/14/85	1545	5	Sediment					X	X											X					X		
SS-85-0056	11	1625	7	Surface Water					X	X											X	X				X		
SN-85-0057	11	1635	5	Sediment					X	X												X						
SS-85-0058																												

Total No Containers: 17

	Date	Time
Relinquished By (sign)		
Courier From Airport (sign)		
Received By (sign)		
Received By Courier (sign)		
Received By Contract Lab (sign)		

SAMPLE ANALYSIS

SAMPLE SHIPPING RECORD

Shipment No 9

SCIENCE APPLICATIONS, INC.
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Hydrolis Laboratories
No. Street: 8400 Westpark Dr.
City, State, Zip: McLean VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
FB-6	5/14/85	9:00	7	Field Blank
SW2-5	"	9:15	7	Surface Water
SD2-5	"	9:30	5	Sediment
SD2-4	"	10:20	7	"
SW2-2	"	11:00	5	Surface Water
SD2-2	"	11:10	7	Sediment
SW2-1	"	12:55	5	Surface Water
SD2-1	"	1:05	5	Sediment
~~SD2~~	"	3:45	5	"
			Total No Containers	48

SAMPLE ANALYSIS

Ext. Organics	Surv. Ext. Organics	Vol. Organics	Surv. Vol. Organics	Trace Metals	Other Inorganics	Pesticides	Herbicides	LMWHC	HMWHC	Radionuclides	Drugs	Cyanide	pH	TOC	BOD	TSS — TDS	VSS	DOC	POC	Oil and Grease	Lipids	Part. Size Dis	Sediment Core Date	Remarks
		X		X										X		X				X				
		X		X										X		X				X				
		X		X										X		X				X				
		X		X										X		X				X				
		X		X										X		X				X				
		X		X										X		X				X				
		X		X		X								X		X				X				
		X		X		X								X		X				X				
		X		X		X								X		X				X				
		X		X		X								X		X				X				
		X		X		X								X		X				X				
		X		X		X								X		X				X				
		X		X		X								X		X				X				

	Date	Time
Relinquished By (sign)	5/14/85	6:50
Courier From Airport (sign)		

	Date	Time
Received By (sign)		
Received By Courier (sign)		
Received By Contract Lab (sign)		

SAMPLE SHIPPING RECORD

Shipment No: 10

SAIC

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
DIVISION OF ENVIRONMENTAL CHEMISTRY AND GEOCHEMISTRY
476 PROSPECT STREET, LA JOLLA, CA 92038 • (619) 456-2791

CONSIGNEE

Name: Andris Lupins
No., Street: 8400 Westpark Dr
City, State, Zip: Mclean VA 22102

Sample No.	Sample Date	Packed Time	No. Containers	Sample Description
SD2-3	5/14/85	3:45	5	Sediment
~~SD2-D~~	"			Surface Water
SW2-6	"	4:25	7	"
SW2-6D	"	4:30	7	"
SD2-6	"	4:35	5	Sediment
SD2-6D	"	4:40	5	"

APPENDIX J

STATE CORRESPONDENCE

South Carolina Department of Health and Environmental Control

RECEIVED JAN 10 1985

2600 Bull Street
Columbia, S.C. 29201

Commissioner
Robert S. Jackson, M.D.

Board
Moses H. Clarkson, Jr., Chairman
Leonard W. Douglas, M.D., Vice-Chairman
Gerald A. Kaynard, Secretary
Barbara P. Nuessle
Oren L. Brady, Jr.
James A. Spruill, Jr.
William H. Hester, M.D.

January 4, 1985

Mr. Andris Lapins
J.R.B. Associates
8400 Westpark Drive
McLean, VA 22102

Dear Mr. Lapins:

As requested during our conversation on January 3, 1985 concerning the proposed monitoring wells to be installed at McEntire National Guard Air Base, Richland County, please find enclosed a copy of the SCDHEC publication Ground-Water Monitor Wells: Location and Construction Methods.

I trust this information will be of assistance to you. If you should have any questions concerning this matter, please do not hesitate to call me at (803) 758-5213.

The Department requests that a copy of the final report outlining the well locations, construction and hydrogeologic data derived from the drilling and initial sampling be submitted upon completion of the project. Although the monitoring well data reporting requirement is not mandatory at this time, the requested information will enhance the Department's knowledge of the hydrogeology of this area and serve as reference for any future discussions which may arise between the facility and SCDHEC.

If the Ground-Water Protection Division may lend any technical assistance during the course of this project, please feel free to call.

Sincerely,

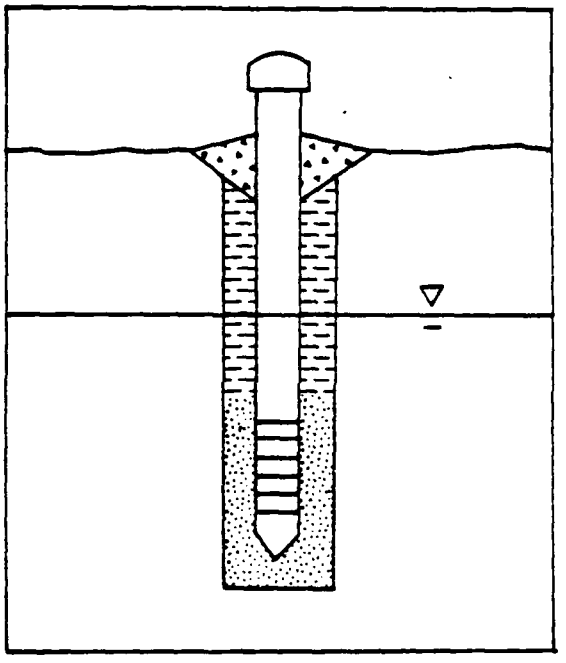
Charles R. Clymer, Geologist
Ground-Water Protection Division

CRC/km

RECEIVED JAN 1 0 1985

GROUND-WATER MONITOR WELLS:

LOCATION AND CONSTRUCTION METHODS



By
Mark A. Williams
Clyde M. Livingston
Charles R. Clymer

PREPARED BY
GROUND-WATER PROTECITON DIVISION
BUREAU OF WATER SUPPLY AND SPECIAL PROGRAMS
SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

November 1982

CONTENTS

	Page
Introduction	1
Laws Governing Protection of Ground Water	3
Purpose for Monitoring Land Treatment Facilities	4
Location of monitor wells	4
Areal Location	5
Depth Location	5
Contaminant Characteristics	8
Hydrogeologic Conditions	12
Construction methods	12
Selection of Well Construction Materials	15
Drilling Methods	20
Well Grouting	20
Well Development	23
Well Disinfection	25
Selected references	28

ILLUSTRATIONS

Figure 1. Diagram of a typical ground-water monitor well in unconsolidated sediments 2

2. Diagramatic relationship between soil moisture, saturation and the water table 7

3. Diagramatic effect of contaminant density on plume migration 9

4. Diagram of a hydrocarbon contaminant plume in water-table aquifer 10

5. Generalized diagram of a monitor well-piezometer cluster 11

6. Generalized diagram of hydrogeologic conditions affecting contaminant plume migration suggesting deep screen placement 13

7. Generalized diagram of hydrogeologic conditions affecting contaminant plume migration, suggesting shallow screen placement 14

8. Generalized diagram of an "open hole" monitor well . . 19

9. Diagram of a surge block developing tool 24

TABLES

		Page
Table 1.	Common types of land treatment/disposal facilities and the recommended minimum number of monitor wells	6
2.	Common types of land treatment/disposal facilities and the recommended miminum monitoring parameters . . .	16-17
3.	Basic well drilling methods	21-22
4.	Chlorine compound required to dose 100 feet of water filled well at 100 ppm	27

INTRODUCTION

Good quality ground water is one of South Carolina's major attractions for industry and urban development. Conversely, South Carolina's ground waters are increasingly being threatened by the development which it attracts through the associated practice of land disposal of wastes. Presently, the South Carolina Department of Health and Environmental Control reviews an average of fifteen (15) applications for land treatment/disposal facilities per month.

Clean-up of contaminated ground water is extremely costly and if allowed to occur naturally can take centuries. Therefore, at land disposal facilities, it is necessary to monitor ground-water quality for the purpose of providing a check on the effectiveness of waste renovation and to serve as an early warning system to aid in prevention of continued pollution of ground water.

Ground-water monitoring is best accomplished through the proper installation of permanent wells (monitor wells), constructed solely for the purpose of monitoring water-level fluctuations and obtaining ground-water samples for analysis. Figure 1 illustrates a typical ground-water quality monitor well. This report deals with: State authority to require ground-water monitoring; where and how monitor wells should be located at the disposal site; type(s) of materials used for monitor well construction; and methods for monitor well installation.

The monitor well location and construction methods are presented in this report as guidelines since each monitoring site is variable in geohydrologic conditions affecting pollution plume migration and detection. Also, through aquisition and evaluation of more detailed

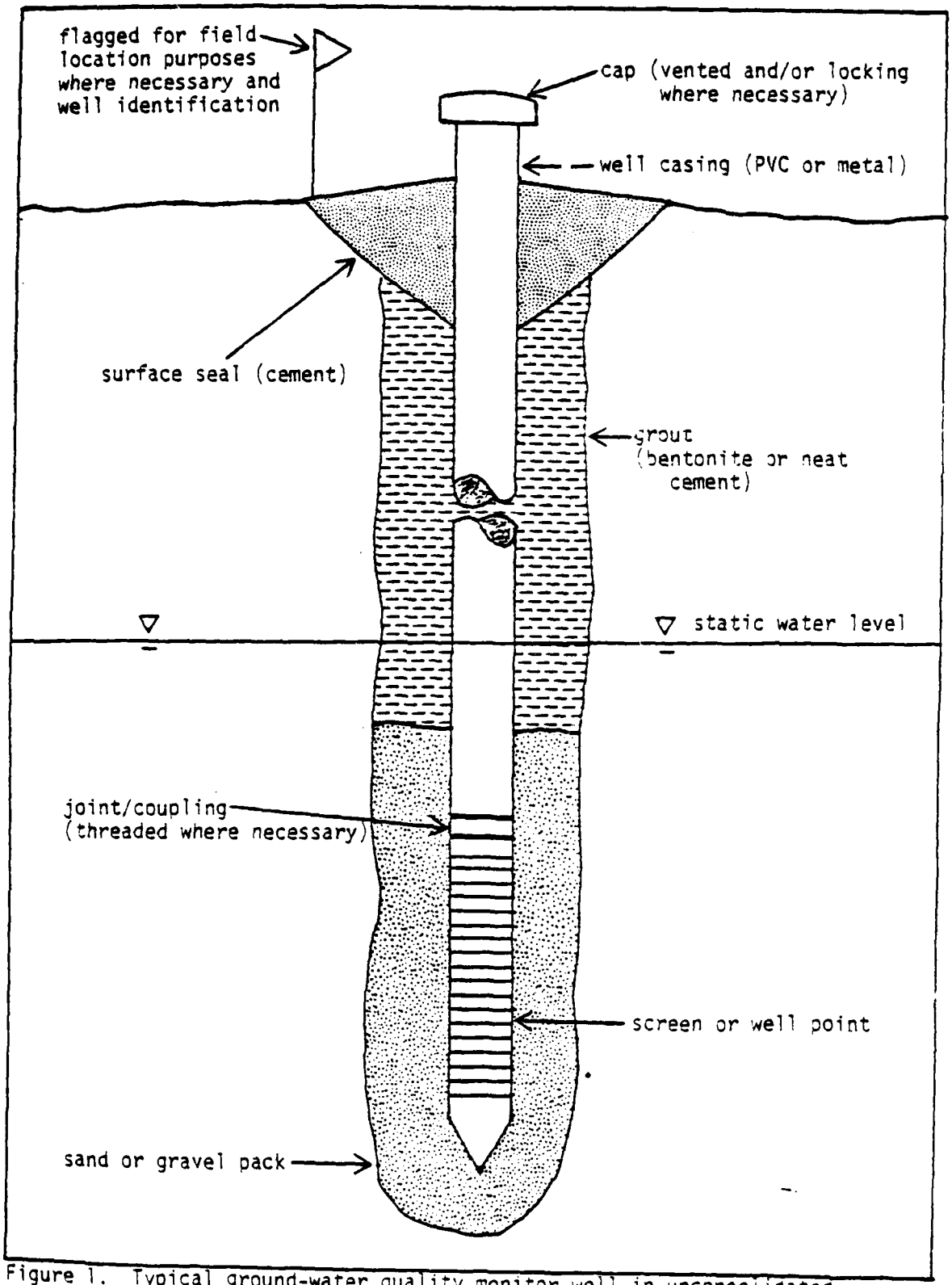


Figure 1. Typical ground-water quality monitor well in unconsolidated sediments.

site information, i.e., drill cuttings and monitoring data, well location and construction can, and should, be modified to more accurately achieve the objective of detecting any subsequent ground-water alteration.

Due to the complexity and expense involved in developing a proficient ground-water monitoring program, qualified ground-water consultants should be utilized for the determination of well locations and the interpretation of measured data, and a qualified driller should be used for actual well construction.

Laws Governing Protection of Ground Water

Two state laws, the S.C. Pollution Control Act and the S.C. Hazardous Waste Management Act, empower the S.C. Department of Health and Environmental Control (SCDHEC) to protect South Carolina's ground water from pollution by:

1. requiring persons proposing new discharges, disposal systems or increasing existing systems to submit sufficient hydrologic and environmental information to enable SCDHEC to determine that ground-water quality standards will not be violated (48-1-100 and R.61-79.10 D, Code of Laws of South Carolina, 1976, as amended).
2. requiring the owner/operator of any waste disposal system to install, use, and maintain monitoring equipment or methods and to sample and analyze discharges in accordance with prescribed methods, at locations, intervals, and procedures as SCDHEC shall prescribe (48-1-50(22) and R.61-79.8L, Code of Laws of South Carolina, 1976, as amended).

Purpose for Monitoring Land Treatment Facilities

The overall purpose of monitoring ground-water quality at land treatment/disposal sites is to provide a check on the land renovative performance and to provide an early warning system for ground-water contamination, which would allow corrective action to be taken to prevent further degradation and insure that a health hazard does not arise.

Specifically, the ground-water monitoring program may be designed to:

1. provide background water-quality data prior to disposal site use;
2. demonstrate the presence or absence of ground-water contamination;
3. protect present and future ground-water users;
4. collect data to implement a ground-water clean-up program;
5. collect data to develop design criteria for future land-disposal sites.

LOCATION OF MONITOR WELLS

Prior to designing a ground-water monitoring program, a geohydrologic evaluation of the area to be monitored is necessary. The evaluation should consist of: a review of existing hydrologic data, review of site history, soil maps, aerial photographs, available water-well data within a quarter mile, and a field investigation to determine site-specific hydrological conditions. The geohydrologic evaluation should provide detailed information about the depths and types of sediment or rock, relative permeabilities, depth to the water table, any confining strata, and relative ground-water gradients.

The location of a monitor well in relation to the pollutant source(s) determines its effectiveness in providing adequate information as to ground-water quality.

Areal Location

A ground-water monitoring program should generally consist of one background well (located hydraulically) upgradient from the disposal site and a minimum of three wells (located hydraulically) downgradient from the disposal site. Table 1 identifies the most common types of land treatment/disposal facilities along with the recommended minimum number of monitor wells.

To enable early detection of contamination, downgradient monitor wells should be located in the direction of ground-water flow and adjacent to the potential pollution source. However, if the purpose of the ground-water monitoring program is to evaluate the extent and concentration of an existing pollution plume (as in the case of enforcement monitoring), a network of monitor wells should be installed both perpendicular and parallel to ground-water flow direction(s).

The monitor wells should be installed in areas easily located, readily accessible, and guarded against destruction by land disposal activities.

Depth Location

It is important that monitor wells are constructed to be depth-discrete and sample from one specific saturated zone without interconnection with other saturated zones. Figure 2 illustrates the

TABLE 1. Common Types of Land Treatment/Disposal Facilities and the Recommended Minimum Number of Monitor Wells

Type Site	Minimum # of Monitor Wells	Special Conditions that may require additional ground-water monitor wells
Spray Irrigation *	3	1) large or irregular shaped area (golf course); 2) aquifer recharge area; 3) more than one direction of ground-water flow; 4) wastewater characteristics and hydraulic loading rates; 5) proximity of water supply wells.
Rapid Infiltration Basin *	3	1) areal extent of basins; 2) aquifer recharge area; 3) more than one direction of ground-water flow; 4) wastewater characteristics and hydraulic loading rates; 5) proximity of water supply wells.
Overland Flow *	3	1) areal extent of treatment area; 2) manufactured site (fill material); 3) proximity of water supply wells.
Absorption Field *	3	1) large flow rates; 2) aquifer recharge area; 3) more than one direction of ground-water flow; 4) wastewater characteristics; 5) proximity of water supply wells.
Landfill Sanitary	3	1) areal extent of disposal area; 2) characteristics of liner material; 3) aquifer recharge area; 4) more than one direction of ground-water flow; 5) waste characteristics; 6) proximity of water supply wells.
Hazardous Waste Facility	4	
Lagoon	3	1) unlined lagoon(s); 2) areal extent of lagoon(s); 3) more than one direction of ground-water flow; 4) industrial wastewater; 5) proximity of water supply wells.

* Only biodegradable wastes should be considered for this method of treatment and disposal.

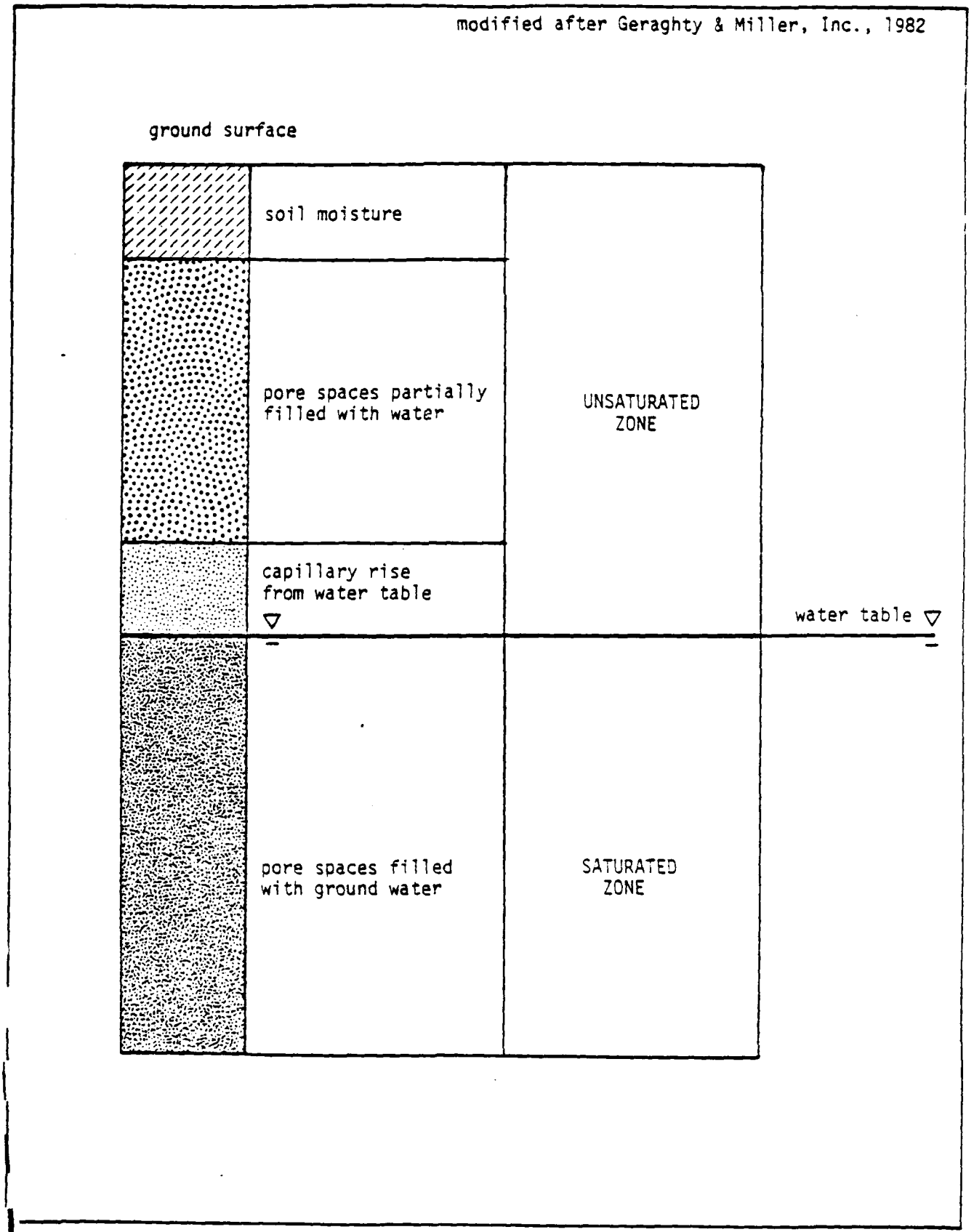


Figure 2. Diagramatic relationship between soil moisture, saturation and the water table.

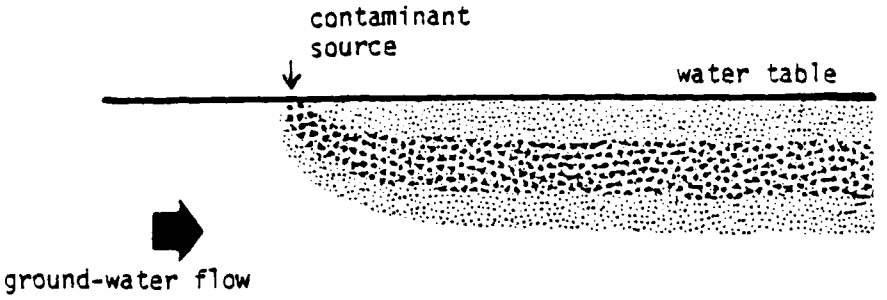
relationship between soil moisture, saturation and the water table. The depth selection of the screened interval of the monitor well requires consideration of hydrogeologic conditions and contaminant characteristics.

Contaminant Characteristics

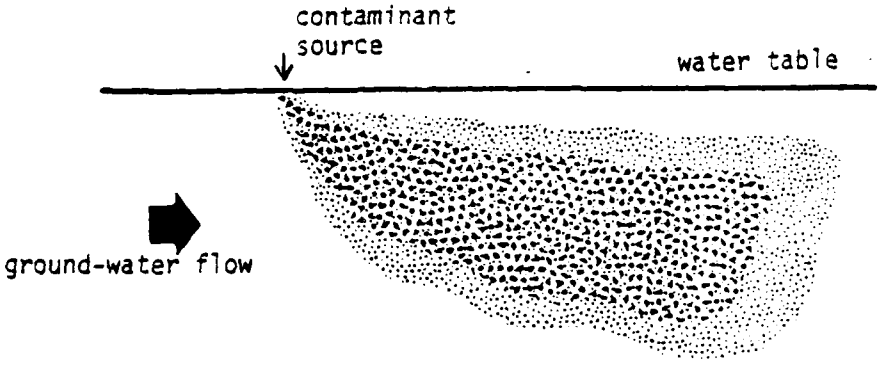
When ground-water contamination from land disposal activities occurs, pollutants commonly tend to be more concentrated in the upper zone of saturation (depending upon the pollutant density) and migrate in the direction of ground-water flow, as indicated in Figure 3. In order to provide an early warning of contamination the screened interval should be within the upper portion of the water-table aquifer (generally, 5 ft. below the water table is sufficient). When sampling for contaminants lighter than water (such as hydrocarbons), it is desirable to sample at the water table or top of the saturated zone. Lighter pollutants such as hydrocarbons tend to "float" and concentrate near the top of the saturated zone as indicated in Figure 4. The screen or intake part of the well should then extend from a few feet above to a few feet below the mean water table elevation to allow for seasonal water-table fluctuations. If the purpose of the monitoring program is to determine the vertical extent and contaminant concentration of an existing leachate plume, it is necessary to construct a well cluster (multiple wells, closely spaced, at varying depths) as shown in Figure 5. The well cluster is commonly utilized when ground water is to be monitored for a dense pollutant, such as chloride, which tends to migrate downward toward the base of the aquifer.

modified after Geraghty & Miller, Inc., 1982

A. Contaminate density slightly greater than ground-water density.



B. Contaminate density greater than ground-water density.



C. Contaminate density much greater than ground-water density.

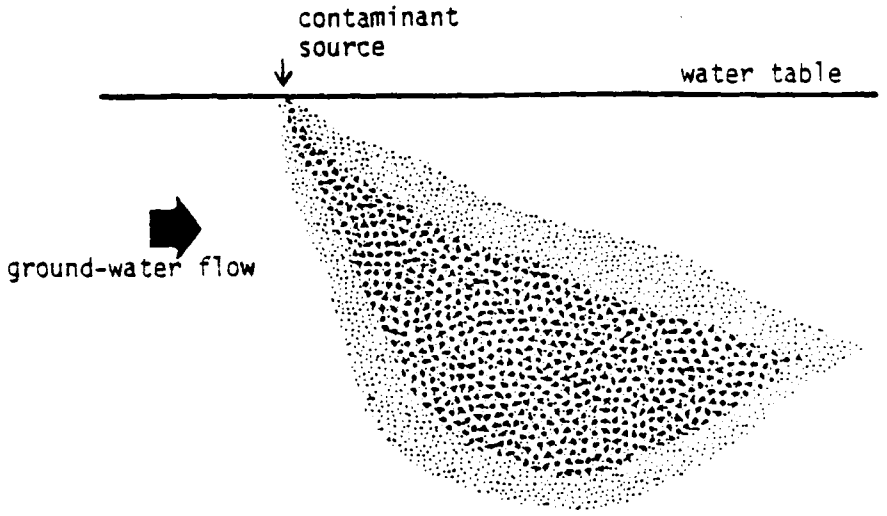


Figure 3. Diagramatic effect of contaminate density on plume migration.

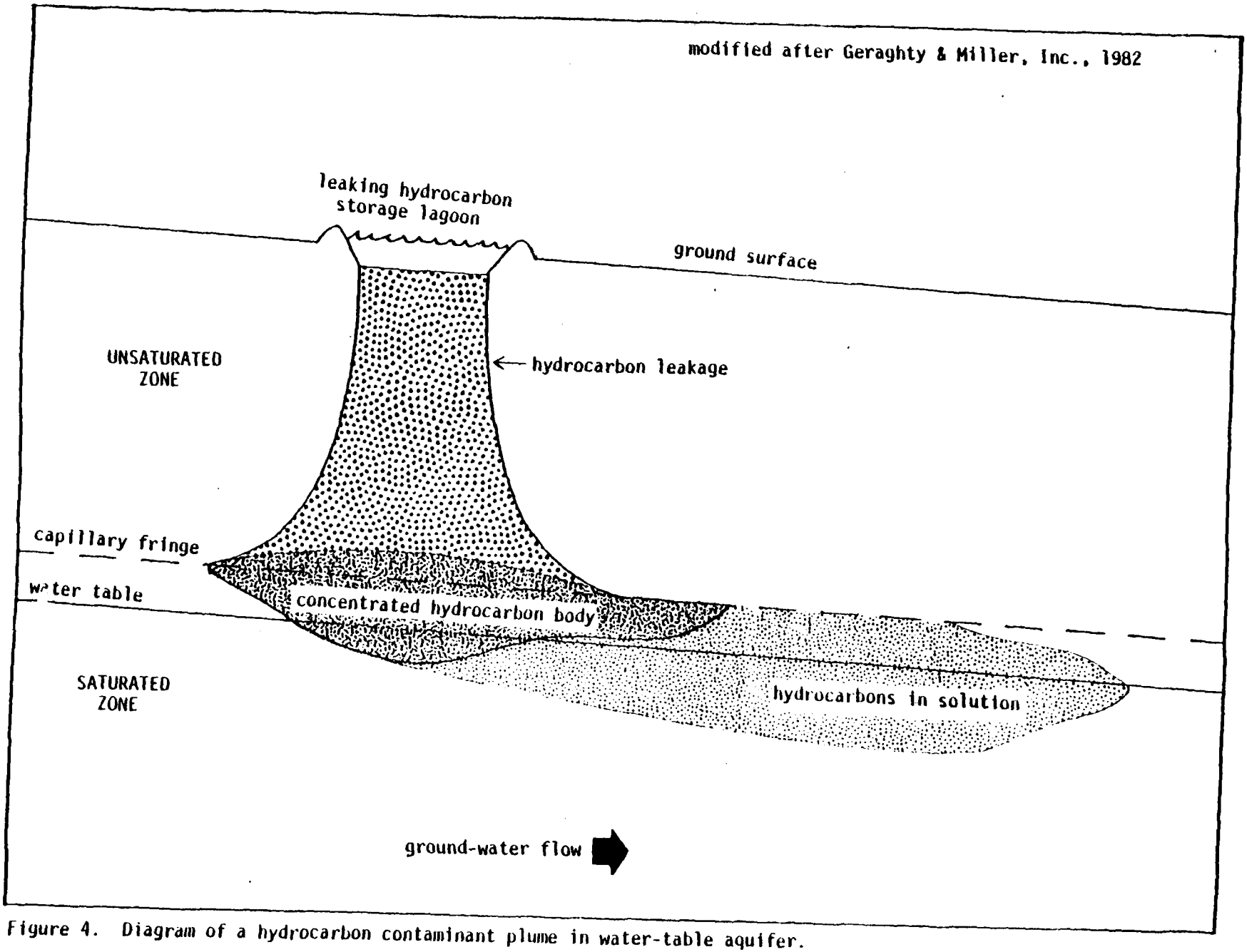


Figure 4. Diagram of a hydrocarbon contaminant plume in water-table aquifer.

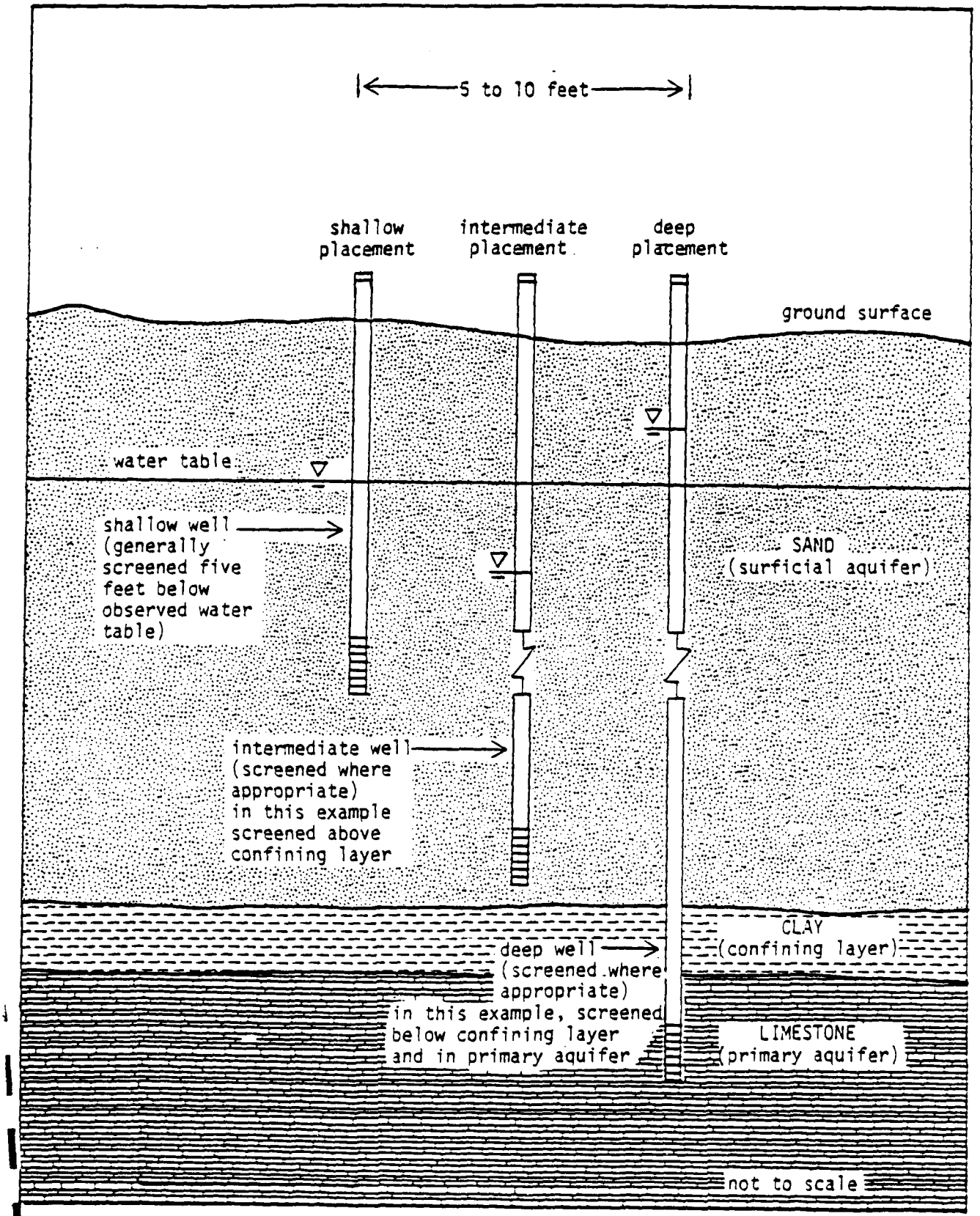


Figure 5. Generalized diagram of a monitor well-piezometer cluster.

Hydrogeologic Conditions

The hydrogeologic conditions that may affect movement of a contaminant plume and hence vertical location of the screened interval include: depth to water table, aquifer thickness, soil permeability, site lithology, and relative hydrostatic pressures. Figures 6 & 7 indicate how these conditions combine to govern plume migration. The following conditions would indicate the need for deep screen placement and/or utilization of well clusters:

1. potential aquifer recharge area (fig. 6);
2. down-gradient monitor well distant from potential pollution source (fig. 6);
3. highly permeable soils;
4. deep depth to water table.

The following conditions would indicate the need for shallow screen placement:

1. ground water discharge area (fig. 7);
2. presence of shallow confining beds (fig. 7);
3. shallow depth to water table.

CONSTRUCTION METHODS

The success of a ground-water monitoring program depends on the location, design, and construction of the monitor wells. Hence, after determination of proper well locations, it is extremely important that well design and construction be accomplished properly.

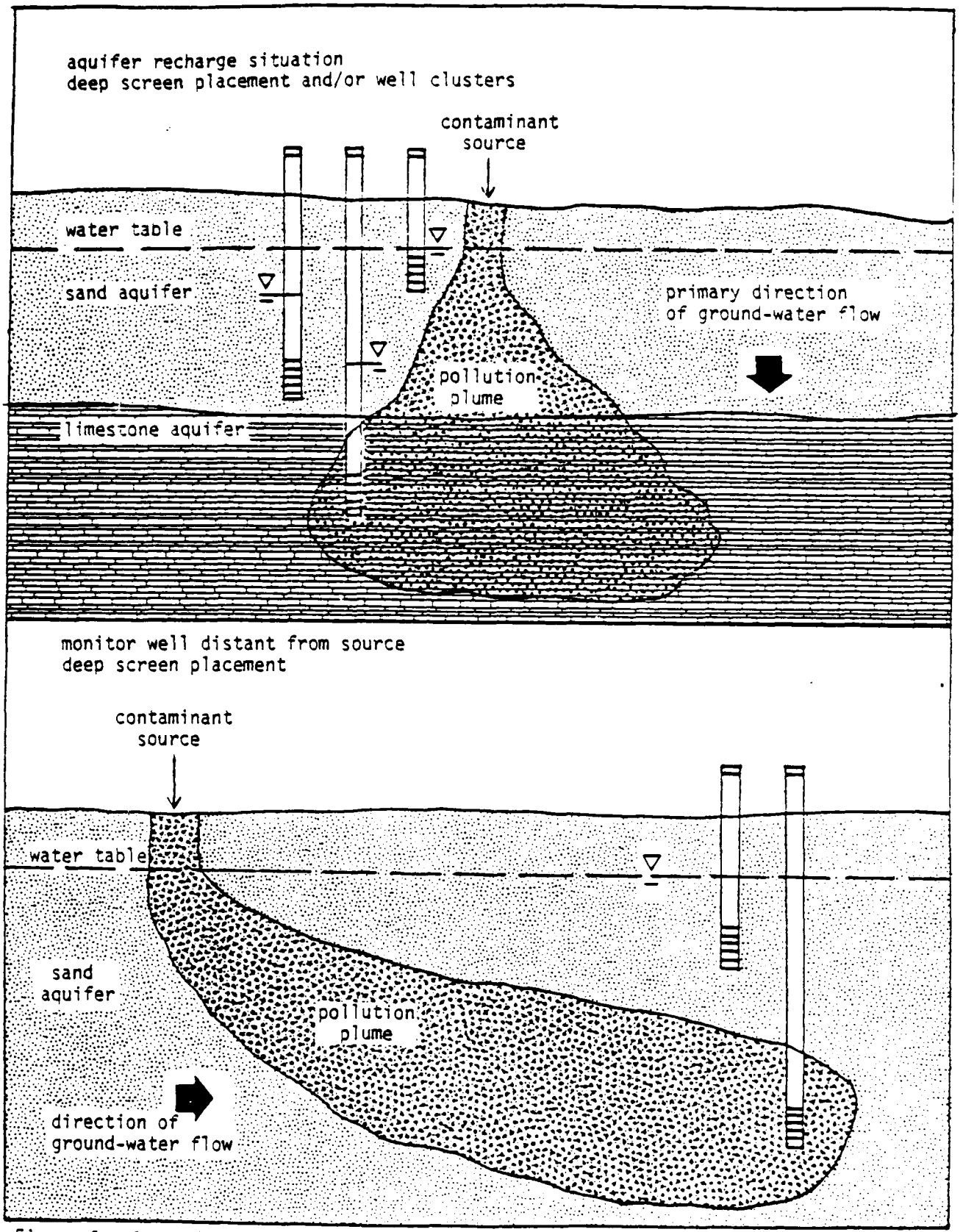


Figure 6. Generalized diagram of hydrogeologic conditions affecting contaminant plume migration, suggesting deep screen placement.

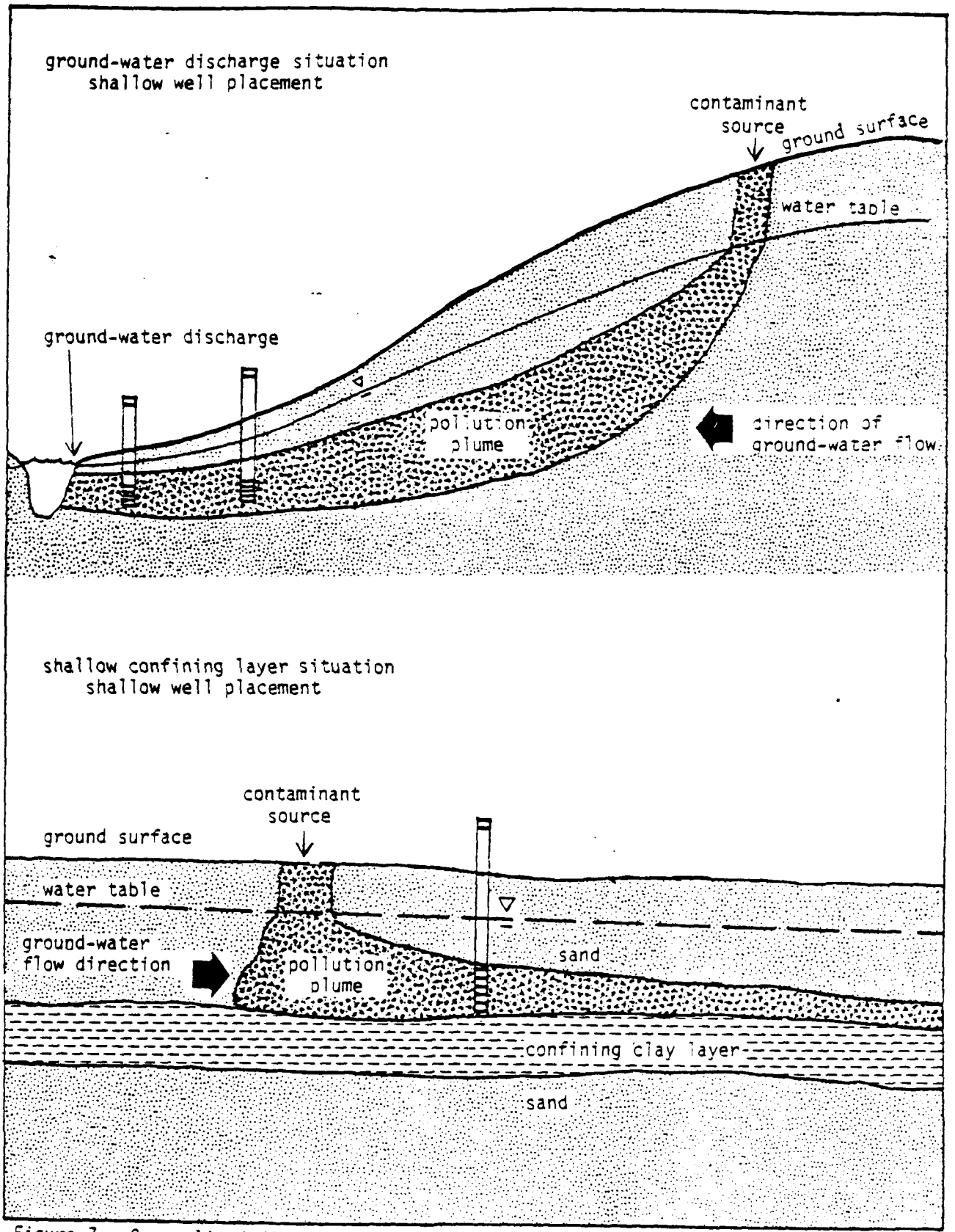


Figure 7. Generalized diagram of hydrogeologic conditions affecting contaminant plume migration, suggesting shallow screen placement.

Selection of Well Construction Materials

Ground-water monitor wells should be constructed of materials having the least potential for affecting the parameters to be sampled.

The well design should assure that casing, screen materials, and gravel pack be compatible with the:

1. monitoring program --

   If the purpose of the monitoring program is limited to monitoring ground-water elevations, small diameter PVC wells (piezometers) are sufficient.

2. monitoring parameters --

   In most cases, PVC (polyvinyl chloride) casing and screen is preferable to other materials (Teflon, metal and fiberglass) due to its relative low cost, wide availability, and relative chemical inertness. PVC is a nonconductor and will not be involved in electrochemical reactions as will metallic casing and well screens. However, PVC may be unsuitable when sampling for certain organics, as chemical interactions and absorption can affect the quality of the samples. To specifically avoid interference from PVC joint cement, it is advisable to utilize screw-type connections when joining PVC screens and casing lengths. Table 2 identifies the most common types of land treatment/disposal facilities along with the recommended minimum monitoring parameters.

TABLE 2. Common Types of Land Treatment/Disposal Facilities and the Recommended Minimum Monitoring Parameters.

Type Site	Minimum Sampling Frequency	Minimum Monitoring Parameters*
Spray Irrigation	1) Prior to start-up for background determination; 2) Quarterly for 1st year of operation; 3) Biannually after 1st year of operation;	total phosphorus (as P); chloride; ammonia (as NH_3); nitrate (as N); alkalinity; pH; sodium; total dissolved solids (TDS); fecal coliform.
Rapid Infiltration	1) Prior to start-up for background determination; 2) Quarterly for 1st year of operation; 3) Biannually after 1st year of operation;	total phosphorus (as P); chloride; ammonia (as NH_3); nitrate (as N); alkalinity; pH; sodium; total dissolved solids (TDS); fecal coliform.
Overland Flow	1) Prior to start-up for background determination; 2) Quarterly for 1st year of operation; 3) Biannually after 1st year of operation;	total phosphorus (as P); chloride; ammonia (as NH_3); nitrate (as N); alkalinity; pH; sodium; total dissolved solids (TDS); fecal coliform.
Absorption Field	1) Prior to start-up for background determination; 2) Quarterly for 1st year of operation; 3) Biannually after 1st year of operation;	total phosphorus (as P); chloride; ammonia (as NH_3); nitrate (as N); alkalinity; pH; sodium; total dissolved solids (TDS); fecal coliform.
Landfills	Quarterly for 1 year or baseline water quality;	pH (field and laboratory); specific conductance (field); total organic carbon (TOC); water level; chloride; sulfate; nitrate (NO_3-N); arsenic; barium; cadmium; chromium; fluoride; lead; mercury; selenium; silver; Endrin; Lindane; Methoxychlor; Toxaphene; 2,4,-D; 2,4,5 TP Silvex.
	Semi-annually (after 1st year);	pH (field and laboratory), specific conductance (field), total organic carbon (TOC); water level.
	Annually (after 1st year);	pH (field and laboratory); specific conductance (field), total organic carbon (TOC); water level; chloride; sulfate; nitrate (as NO_3-N).

* Dependent upon the characteristics of the wastes to be treated and/or disposed of - parameters may be deleted and/or added.

TABLE 2. (cont.)

Type Site	Minimum Sampling Frequency	Minimum Monitoring Parameters*
Lagoons	1) Prior to start-up for background determination; 2) Quarterly for 1st year of operation; 3) Biannually after 1st year of operation;	total phosphorus (as P); chloride; ammonia (as NH_3); nitrate (as N); alkalinity; pH; sodium; total dissolved solids (TDS); fecal coliform.
Hazardous Waste Facility	1) 3-months prior to facility usage; 2) Quarterly for 1st year of operation; 3) Quarterly after 1st year of operation;	as listed in S.C. Hazardous Wastes Management Regulations R.61-79.8L.

* Dependent upon the characteristics of the wastes to be treated and/or disposed of - parameters may be deleted and/or added.

3. sampling techniques --

Consideration should be given to the method of sample retrieval prior to selection of casing diameters. Large diameter casing (4 inch) is generally necessary when submersible pumps are utilized. Generally, 2 inch diameter casing is sufficient when sample retrieval is accomplished by bailing, suction lift, or gas lift devices. For information concerning sampling techniques refer to Ground-Water Sampling Methods: SCDHEC, October 1981.

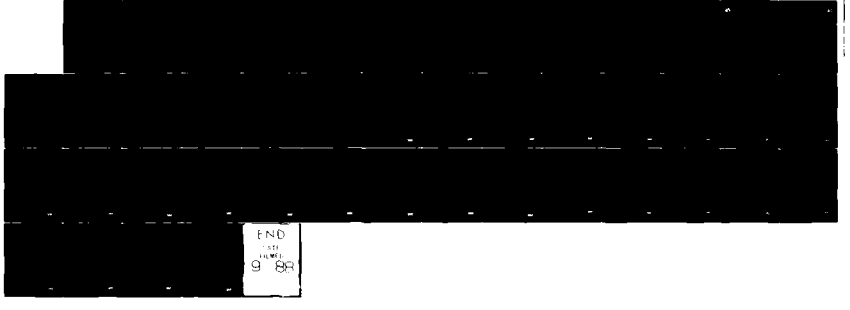
4. aquifer characteristics --

The casing and screen materials should be of ample strength to withstand normal forces encountered during and after well installation. Normally, when not sampling for organics, shallow monitor wells (less than 50 ft. deep) are constructed utilizing schedule 40 PVC casing. Deeper installations may require schedule 80 PVC casing to prevent collapse or distortion of the well casing. When down-hole pressure is required to install casing (or drive point), metallic casing is necessary.

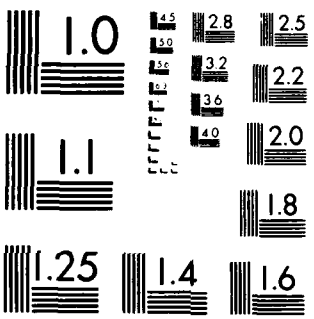
5. well screens --

Well screens should have sufficient length and open area to permit the inflow of formation water. The slot openings should be small enough to keep most of the natural formation out. Any sand or "gravel pack" utilized around the screen to reduce sample turbidity or to increase well yield should not adversely affect the quality of the sampling parameters. In some consolidated formations i.e., limestone or hard rock, well screens are not needed and "open hole" monitor wells may be utilized (fig. 8).

AD-A195 524 INSTALLATION RESTORATION PROGRAM (IRP) PHASE 2 6/6
CONFIRMATION/QUANTIFICATIO..(U) SCIENCE APPLICATIONS
INTERNATIONAL CORP MCLEAN VA R EADES ET AL. 10 JUN 86
UNCLASSIFIED F33615-80-D-4002 F/G 24/4 NL



END
DTIC
9 88



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

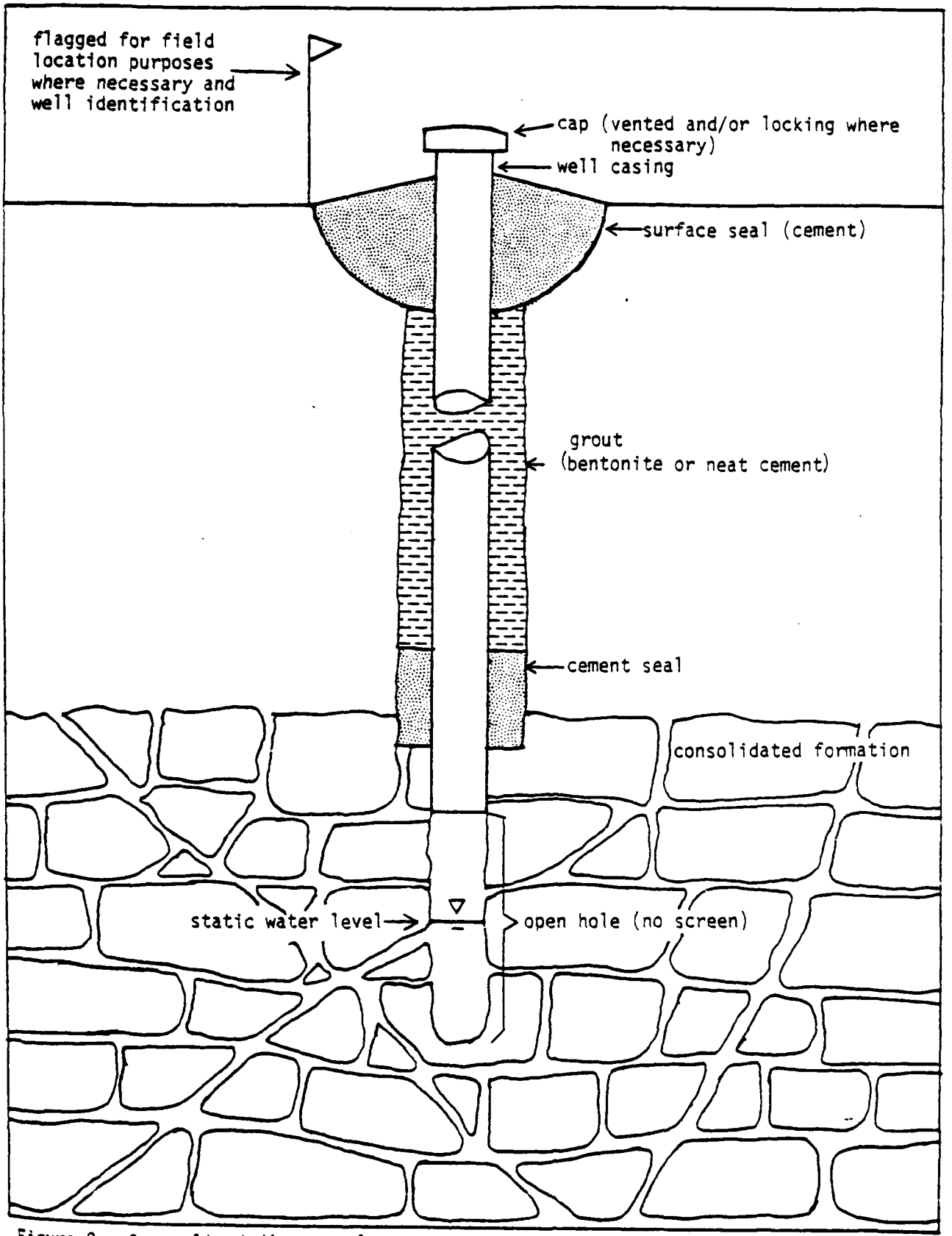


Figure 8. Generalized diagram of an "open hole" monitor well.

Drilling Methods

The drilling method best suited for a particular site is based on the following:

1. hydrogeology --
   a) formation characteristics;
   b) desired screen depth below the water table;
2. parameters to be sampled;
3. accessibility of the site;
4. monitor well design;
5. availability of drilling equipment.

The principles of operation, advantages, and disadvantages of the more common drilling techniques suitable for constructing ground-water monitor wells are listed in Table 3. A detailed discussion of various well drilling methods is given in Ground Water and Wells, 1980, published by Johnson, UOP Incorporated.

Well Grouting

Grouting consists of filling the annular space between the bore hole wall and the well casing with an impervious material. Grouting is necessary to secure the casing in place and to protect the well against entry of unwanted water from the surface or subsurface so as to ensure depth discrete sampling.

In general, positive emplacement of grout by tremie, pumping, or pressure is necessary for all wells when the grout is to be placed below the water table or where the annular space to be filled is not easily accessible from the surface. The basic grouting procedure entails

TABLE 3. Basic well drilling methods (from API, 1980)

DRILL TYPE	NORMAL HOLE DIAM.	NORMAL MAX. DEPTH	AVERAGE TIME PER HOLE	RELATIVE EXPENSE	ADVANTAGES	DISADVANTAGES
1. Rotary (fluid or air)	4"-20"	Unlimited	Fast	Expensive to moderate	1. Available throughout the U.S. 2. Capable of drilling all formations, hard or soft. 3. Capable of drilling to any depth desired for monitoring. 4. Casing not required during drilling. 5. Formation logging (sampling) is fairly reliable in most formations.	1. Drilling fluids including bentonite and organic additives can interfere with metal, bacteriological and organic analyses. 2. Limited water level information during drilling. 3. Circulates contaminants unless casing advanced during drilling.
2. Spiral Auger	4"-8"	30-50 ft.	Fast under suitable soil conditions	Inexpensive to moderate	1. Widely available. 2. Very mobile. 3. Soil samples easily obtained.	1. Sometimes difficult to set screen below water table. 2. Cannot penetrate large stones, boulders or bed rock. 3. Soil samples are disturbed.
3. Hollow Stem Auger	4"-8"	30-50 ft.	Fast under suitable conditions	Inexpensive to moderate	1. Good for sandy soil. 2. Can set casing thru hollow stem. 3. Very mobile. 4. Can obtain undisturbed soil samples while drilling.	1. Casing diameter normally limited to 2"-3" o.d. 2. Cannot penetrate large rock, boulders or bed rock.
4. Bucket Auger	12"-72"	90 ft.	Fast	Moderate to expensive	1. Can obtain good soil samples. 2. Can install large diameter wells.	1. Hard to control caving. 2. At times must use drilling fluid. 3. Normally very large operating area required.

TABLE 3. (cont.)

DRILL TYPE	NORMAL HOLE DIAM.	NORMAL MAX. DEPTH	AVERAGE TIME PER HOLE	RELATIVE EXPENSE	ADVANTAGES	DISADVANTAGES
6. Cable Tool	4"-16"	Unlimited	Slow	Inexpensive to moderate	1. Widely available. 2. Can be used in consolidated or uncolsolidated formations.	1. Slow drilling. 2. Hole often crooked. 3. May require casing while drilling.
7. Air Rotary	4"-12"	Unlimited	Fast	Expensive	1. Fast penetration in consolidated rock.	1. Inefficient in unconsolidated formations. 2. Control of dust/air release. 3. Excessive water inflow could limit use.
8. Casing Driving (well point)	2"-3"	20 ft.	Slow to moderate	Inexpensive	1. Very portable. 2. Readily available.	1. Limited to unconsolidated soil--cannot penetrate large rocks or consolidated sediment. 2. Cannot obtain soil samples.
9. Jetting	1"-2"	30 ft.	Fast	Inexpensive	1. Fast. 2. Small amount of equipment required. 3. Easily installed.	1. Fluid introduced into formation to be sampled. 2. Generally not possible to place a grout seal above the screen to assure depth-discrete sampling. 3. Sampling method limited to small diameter casing. 4. Limited to shallow unconsolidated formations. 5. Large quantities of water generally needed unless using fluid additives.

placing a column of low permeability material (usually bentonite or neat cement) above the well screen between the borehole wall and the well casing and then placing a cement collar around the casing at the surface to prevent surface water from entering the borehole.

Well Development

During some drilling processes the sides of the borehole become smeared and sealed with formation clays and drilling muds. Well development is the process of cleaning the face of the borehole and the formation around the outside of the well screen to permit ground water to flow readily into the monitor well and to remove foreign substances introduced during drilling.

Development is essential for the following reasons:

1. to increase the permeability of the formation adjacent to the borehole to permit the formation water to flow into the screen easily;
2. to remove clay, silt and other fines from the formation so that during subsequent sampling the water will not be turbid or contain suspended matter which can interfere with parameter analysis.

Some typical devices used for the development of monitor wells are:

1. surge block --

   A surge block is a round plunger with pliable edges such as belting that will not catch on the well screen as shown in Figure 9. Moving the surge block forcefully up and down inside

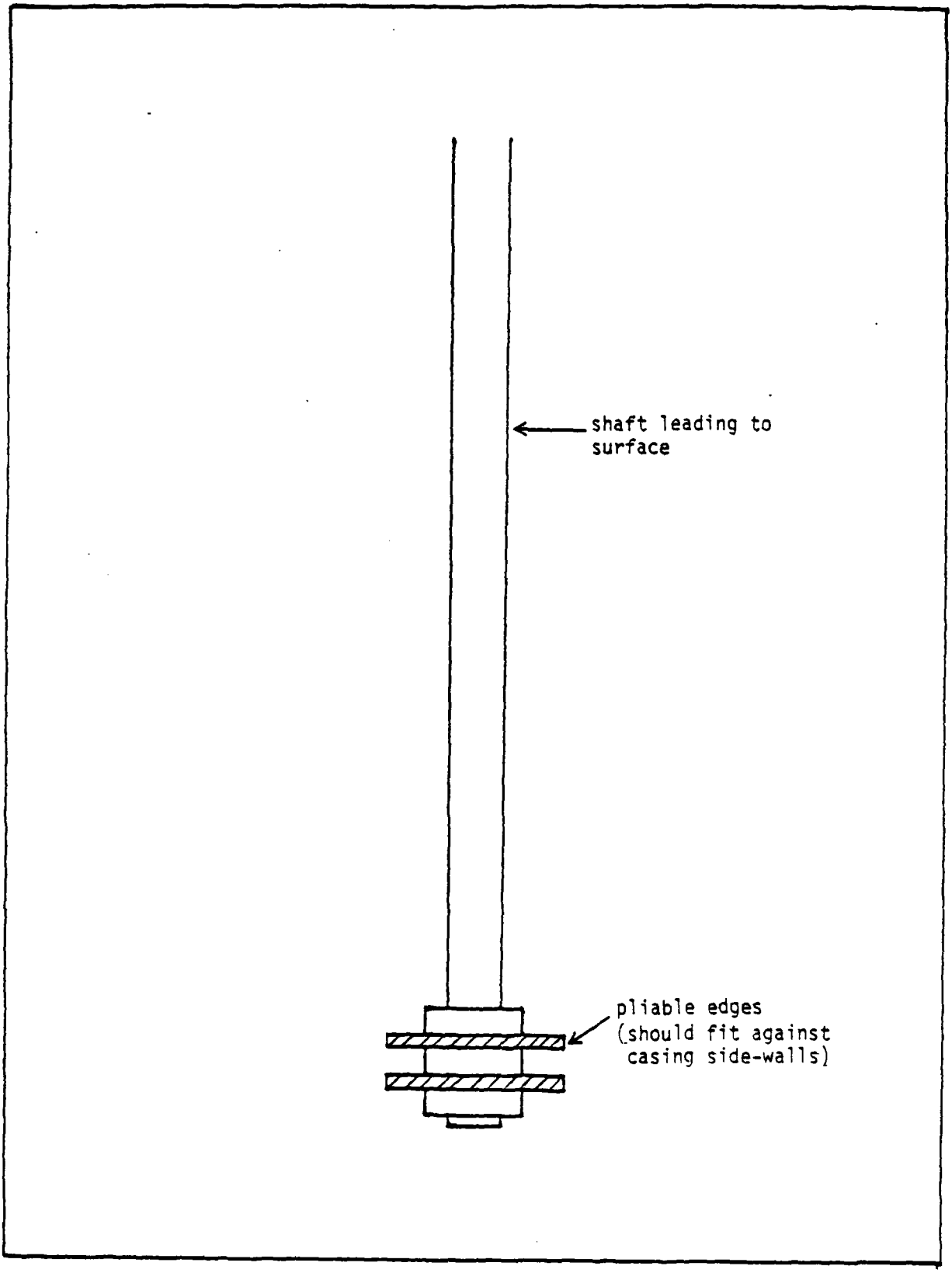


Figure 9. Diagram of a surge block developing tool.

the well screen causes the water to surge in and out through the screen accomplishing the desired cleansing action.

A surge block is commonly hand operated or used with cable-tool drilling equipment.

2. compressed air --

In this method, air is applied to the well intermittently and the water is alternately raised and lowered inside the casing, producing the desired agitation. Finally, blowing the water out of the casing removes the fines brought into the screen by the agitating action.

3. pumping --

In formations which are sufficiently permeable to allow continuous pumping, extensive pumping for removal of fines from the formation and the monitor well is suitable.

Well Disinfection

Ground-water monitor wells should be disinfected when the sample parameters include bacteriological analyses. Disinfection is accomplished by pouring an appropriate quantity of chlorine solution (table 4) into the well and mixing the solution in the well with a bailer type device. Agitation by the bailer will force some of the solution into the water bearing formation around the well to remove contaminants introduced during well construction. The bailer should then be filled in the well and the chlorine solution poured along the inside walls of the casing to disinfect that part of the well above the static water level.

The chlorine solution should be allowed to stay in the well at least 12 hours prior to removal. During removal of the chlorine solution,

chlorine residual should be checked and well evacuation continued until no residual is detected. After removal of the chlorine solution, the well(s) should be allowed to stabilize for at least two weeks prior to sampling for bacteria.

TABLE 4 -- Chlorine Compound Required to Dose 100 Feet of Water-Filled Well at 100 ppm** (from USEPA, 1976)

1	2	3	4	5
		Chlorine Compounds		
Casing diameter (inches)	Volume 100 ft. (gals.)	70% HTH, Perchloron, (dry weight)*	25% Chloride of Lime (dry weight)*	5.25% Purex, Clorox, etc. (liquid measure)
2	16.3	1/2 oz.	1 oz.	4 oz.
4	65.3	2 oz.	4 oz.	18 oz.
6	146.9	4 oz.	8 oz.	40 oz.
8	261.1	6 oz.	14 oz.	4 1/4 pts.
10	408.0	8 oz.	22 oz.	7 pts.
12	587.5	12 oz.	2 lbs.	10 pts.
16	1,044.5	20 oz.	3 1/2 lbs.	2 gals.
20	1,632.0	2 lbs.	6 lbs.	3 1/3 gals.
24	2,350.1	3 lbs.	8 lbs.	4 2/3 gals.

Note: Liquid sodium hypochlorite in a 12 percent solution is often sold for water and wastewater treatment plant use, as a commercial bleach, or for use with swimming pools. Utilizing a solution of this nature would call for a liquid measure equal to one-half the volumes presented in Column 5.

*Where a dry chemical is used it should be mixed with water to form a chlorine solution prior to placing it into the well.

**EPA recommends a minimum concentration of 100 ppm available chlorine.

SELECTED REFERENCES

American Petroleum Institute, 1980, Underground spill cleanup manual, 1st Edition, API Publication 1628.

Geraghty & Miller, Inc., 1982, The fundamentals of ground-water quality protection: handbook prepared for the American Ecology Services, Inc., professional seminar, Atlanta, GA., 1982.

Johnson, UOP Incorporated, 1980, Ground Water and Wells.

South Carolina Hazardous Waste Management Act, Code of Laws of Soutn Carolina, 1976, as amended.

South Carolina Pollution Control Act, Code of Laws of South Carolina, 1976, as amended.

U.S. Environmental Protection Agency, 1976, Manual of water well construction practices: EPA-570/9-75-001.



SOUTH CAROLINA

Classification–Within the South Carolina Pollution Control Act, "water" is defined to include underground water. Within the South Carolina Water Classification Standards, ground water is defined to mean "any water occurring below the water table within the zone of saturation." Currently there is no ground-water classification system in effect. The Department of Health and Environmental Control is developing a classification system which is based on water quality.

Quality Standards–South Carolina has not adopted numerical quality standards that are applied specifically to ground water. The South Carolina Water Classification Standards provide that existing high quality ground waters are protected through a non-degradation approach. The ground-water classification system which is currently being developed is expected to be referenced to the state drinking water standards.

Drinking Water Standards–The Department of Health and Environmental Control has adopted drinking water standards that are identical to the federal primary and secondary drinking water standards. These standards are applicable to all potable ground water uses except for individual domestic use.

Appropriation–There is no statewide permit system for appropriation of ground water and, at present, the Supreme Court of South Carolina has not decided the common law as to appropriation of ground water. The Ground Water Use Act of 1969, through provisions for the designation of Capacity Use Areas (see Controlled Use Areas) and regulations applicable within these Capacity Use Areas, represents the only statement of law with regard to appropriation and use of ground water in the state.

Regulations to implement the Water Use Reporting and Coordination Act (Section 49–4–10, et seq. South Carolina Code of Laws, 1976, as amended) are currently before the South Carolina General Assembly for approval. While this statute does not create a regulatory program with regard to ground water use per se, the Act requires periodic reporting of all water use in excess of 100,000 gallons per day, including ground water use. Information to be reported includes well siting, depth, amounts of water used, and purpose of use. In addition, well drillers' logs are required to be submitted to the Commission for any water well drilled which has a casing diameter of four inches or greater.

Controlled Use Areas–The Ground Water Use Act of1969 provides for the establishment of Capacity Use Areas. Currently two such areas have been designated; both are located in coastal areas. Within Capacity Use Areas, all ground-water withdrawals greater than 100,000 gallons per day must be permitted by the Water Resources Commission. All other ground-water uses other than individual domestic uses are required to submit well and pumpage data to the Water Resources Commission.

Well Construction–The Department of Health and Environmental Control has adopted a well construction permitting system and well construction standards for all potable supply wells other than individual domestic uses. Also, the Department is currently developing construction standards which will be applicable to all wells.

Underground Injection Control–South Carolina is seeking primacy for the federal UIC program. The Department of Health and Environmental Control is developing regulations which it intends to submit for EPA approval. These regulations provide for a proposed ban on Class I and IV wells. Pursuant to statutes governing exploration, drilling, production, and transportation of oil and natural gas within the state (Section 48–43–10 et seq. Code of Laws of South Carolina 1976, as amended), the Water Resources Commission has promulgated regulations concerning enhanced recovery of oil and natural gas. These regulations are codified as R.121–8 et seq. Code of Laws of South Carolina, 1976, as amended. While the Commission has issued permits for oil and natural gas exploration, to date no actual drilling or oil production has been commenced.

Waste Management Facilities–Solid and hazardous waste programs are administered by the Bureau of Solid and Hazardous Waste Management within the Department of Health and Environmental Control.

Solid Waste–The South Carolina Landfill Regulation does not set forth minimum ground-water monitoring requirements. It provides within-facility siting requirements that disposal location sites shall "prevent water pollution." It also states that the site design engineering report should indicate "observation test wells which will reveal reliable data or ground-water contamination where deemed necessary by the State Board of Health" and "prevent leachate from entering the surface or ground-water."

Hazardous Waste–South Carolina has received interim status authorization for RCRA Phase I and is seeking Phase II authority. The South Carolina Hazardous Waste Management Regulations' ground-water monitoring requirements stipulate that after baseline ground-water quality has been established, samples shall be comprehensively analyzed annually and a minimum analysis conducted quarterly. In addition to specific parameters which are presented, these regulations provide the requirement for determining the



presence of volatile organic constituents as determined by a gas chromatography scanning for the comprehensive analysis, and two principal metals (ones found in the largest quantities or which best serve as indicators) for the minimum analysis.

Sole Source Aquifers–There are none at this time.

Geological Surveys–

Geological Survey
Budget and Control Board
Harbison Forest Road
Columbia, SC 29210
803-758-6431
State Geologist:
Mr. Norman K. Olson

Water Resources Division
U.S. Geological Survey
Strom Thermond Federal Bldg.,
Suite 658
1835 Assembly St.
Columbia, SC 29210
803-765-5966
District Chief:
R.N. Cherry

References–

South Carolina Ground-Water Use Act. 1969

South Carolina Water Use and Reporting Act. 1976
(Code of Laws of S.C. 49–4–10)

South Carolina Pollution Control Act
(Code of Laws of S.C. 48–1–10)

South Carolina Water Classification Standards
(S.C. Code of Regulations, Ch. 61 and 68)

South Carolina Landfill Regulation
(PC–SW Regulation 1)

South Carolina Hazardous Waste Management
Regulations
(DHEC, Regulations 61–79)

Contacts–

Mr. Donald A. Duncan
Ground Water Protection Division
Department of Health and
Environmental Control
2600 Bull St.
Columbia, SC 29201
803-758-5213

Mr. Camille Ransom
Division of Hydrology
Water Resources Commission
P.O. Box 50506
Columbia, SC 29250
803-758-2514

Comments provided by Paul S. League, Legal Counsel to South Carolina Water Resources Commission, in a letter dated 6 April 1983.

SOUTH CAROLINA

Parameter (mg/l unless noted)	Drinking Water Standards		Quality Standards	Monitoring Requirements	
	Federal	State		Solid Waste	Hazardous Waste
Arsenic	0.05	0.05			M
Barium	1.0	1.0			M
Cadmium	0.010	0.010			M
Chromium	0.05	0.05			M
Lead	0.05	0.05			M
Mercury	0.002	0.002			M
Selenium	0.01	0.01			M
Silver	0.05	0.05			M
Fluoride	1.4–2.4	1.4–2.4			M
Nitrate (as N)	10.0	10.0			M
Endrin	0.0002	0.0002			M
Lindane	0.004	0.004			M
Methoxychlor	0.1	0.1			M
Toxaphene	0.005	0.005			M
2,4-D	0.1	0.1			M
2,4,5-TP Silvex	0.01	0.01			M
Trihalomethanes	0.10	0.10			
Turbidity (TU)	1 or 5*	1 or 5*			
Coliform bacteria — membrane filter test (#/100 ml)	1 or 4	1 or 4			M
Gross alpha (pCi/l)	15	15			M(R)
Combined Radium 226 and Radium 228	5	5			M(R)
Beta and photon particle activity (mrem/yr)	4	4			M(R)
Chloride	250	250			
Color (units)	15	15			M
Copper	1	1			M
Corrosivity	Noncorrosive	Noncorrosive			M
Foaming agents	0.5	0.5			M
Iron	0.3	0.3			M
Manganese	0.05	0.05			M
Odor (threshold no.)	3	3			M
pH (units)	6.5–8.5	6.5–8.5			M
Sulfate	250	250			M
Total dissolved solids	500	500			M
Zinc	5	5			M
Specific conductance (μmhos/cm)					M
Temperature (C)					M
Dissolved organic carbon					M
Beryllium					M
Cyanide					M
Nickel					M
Phenol					M
Organic constituents					M

Note: (*) denotes surface water only.
"M" denotes monitoring requirement. See text and Section 4.3.
"M(R)" denotes monitoring not required if the facility does not treat, store, or dispose of waste containing radioactive substances.

APPENDIX K

REFERENCES

REFERENCES

Billingsley, G.A., 1956. Chemical Character of Surface Waters of South Carolina 1945 - 1955. Geological Survey Bulletin No. 16B.

Callahan, Joseph T., 1964. The Yield of Sedimentary Aquifers of the Coastal Plain Southeast River Basins. Geological Survey Water Supply Paper 1669-W.

Cederstrom, D. J., E. H. Boswell, and G. R. Tarver., 1979. Summary Appraisals of the Nation's Ground-Water Resources - South Atlantic-Gulf Region. Geological Survey Professional Paper 813-O. U.S. Government Printing Office.

Clymer, C., 1985. South Carolina Department of Health and Environmental Control, Groundwater Protection Division. Personal Communications.

Colquhoun, Donald J., 1965. Terrace Sediment Complexes in Central South Carolina. Geological Association Field Conference 1965. University of South Carolina, Columbia.

Cooke, C. Wythe, 1936. Geology of the Coastal Plain of South Carolina. Geological Survey Bulletin No. 867.

de Vera, E. R., B. P. Simmons, R. D. Stephens, and D. L. Storm, 1980. Samplers and Sampling Procedures for Hazardous Waste Streams. EPA-600/2-80-018, USEPA, Cincinnati, OH 45268.

EPA, 1983. RCRA Permit Writer's Manual - Groundwater Protection, 40 CFR Part 264 Subpart F. Prepared by GeoTrans, Inc.

EPA, 1977. Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities. USEPA SW-611, Washington, D.C.

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice Hall, Inc. Englewood Cliffs, New Jersey.

Greaney, Theresa, 1985. Personal Communication. South Carolina Water Resources Commission. Columbia, South Carolina.

Hazardous Materials Technical Center. 1984. Installation Restoration Program Records Search. McEntire ANG Base, Eastover, South Carolina.

McGuinness, C. L., 1963. The Role of Ground Water in the National Water Situation. Geological Survey Water Supply Paper 1800. U.S. Government Printing Office.

Siple, G. E., 1960. Some Geologic and Hydrologic Factors Affecting Limestone Terranes of Tertiary Age in South Carolina: Southeastern Geology, V. 2, No. 1, 11 p.

Siple, George E., 1959. Guidebook for the South Carolina Coastal Plain Field Trip of the Carolina Geological Society. Geological Survey Bulletin No. 24.

Siple, George E., 1957. Ground Water in the South Carolina Coastal Plain Reprinted from Journal American Water Works Association 49.

Soil Conservation Service, 1978. Soil Survey of Richland County, South Carolina. U.S. Department of Agriculture.

Stone, Peter. 1985. Personal Communication. Groundwater Protection Agency, Columbia, South Carolina.

Thompson, M. T. and R. F. Carter, 1955. Surface-Water Resources of Georgia during the Drought of 1954: Georgia Department of Mines, Mining and Geology. Inf. Circ. 17.

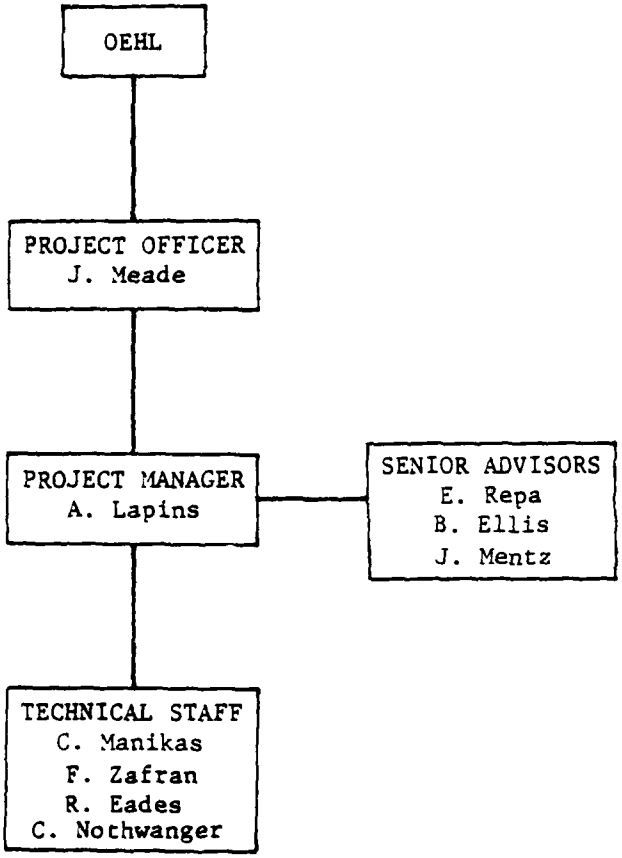
Tuomey, M., 1848. Report on the Geology of South Carolina. A.S. Johnston, Columbia, South Carolina.

USGS, 1977. National Handbook of Recommended Methods for Water-Data Acquisition-Office of Data Coordination. Geological Survey, Reston, Virginia.

APPENDIX L

RESUMES

PROJECT MANAGEMENT STRUCTURE



Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

JOHN P. MEADE

EDUCATION

Manhattan College: B.C.E., Civil Sanitary Engineering (1955)

SUMMARY

Mr. Meade has 26 years of experience in sanitary, industrial hygiene, and bioenvironmental engineering, and is certified as an Associate Public Health Engineer in the State of New York. He is a Senior Project Manager at SAIC, working as a senior technical reviewer for a multi-task contract for remedial actions on uncontrolled hazardous waste sites. He joined SAIC as the Project Manager of a Department of Labor (DOL) contract to provide OSHA with on-site consultation services to assist small businesses in Pennsylvania.

Mr. Meade, under the terms of an EPA contract addressing the investigation of remedial actions of uncontrolled hazardous waste sites, has functioned as one of SAIC's senior technical reviewers. One of his assigned tasks is to review the majority of twenty detailed case study analyses selected from an inventory of nationwide remedial actions. The sites were selected based upon their overall priority and the remedial actions were evaluated from both their effectiveness in meeting the objectives of the site action and also from a cost standpoint. He is also the Project Officer for 6 task orders under this contract, involving various hazardous waste research & development studies.

Mr. Meade is presently supporting the Manager for the Waste Management Department and shares in the responsibility for monitoring and administering a $4 million EPA R & D mission contract that has 29 tasks. He also manages two additional tasks that address the design and monitoring of protective covers for hazardous waste lagoons, and design of decontamination equipment and procedures for use at hazardous waste sites. Mr. Meade was the Program Manager for SAIC's Basic Ordering Agreement with Tyndall AFB to perform Phase 1, 3, and 4 Installation Restoration Program tasks at Military installations throughout the country. Mr. Meade is also the Program Manager for a large multi-task contract with the U.S. Air Force Occupational & Environmental Health Laboratory (USAFOEHL) for Phase II Installation Restoration Program confirmation studies. He is presently responsible for concurrent Phase II efforts at 6 Air Force installations. In addition, he has responsibility for performing Quality Assurance/Quality Control and functions as Senior Health and Safety Advisor at many of SAIC's field efforts, such as the #1 rated Superfund site in Glosgow, New Jersey.

Prior to joining SAIC, Mr. Meade was an Air Force Colonel and Vice Commander of the USAF Occupational and Environmental Health Laboratory. He directed and monitored the daily efforts of 150 professional and support personnel, including assisting the AIHA certified laboratory to ensure compliance with applicable Federal, State, and local standards. In addition, as Chief of the Consultants

Verified for accuracy by: John P. Meade Date: 7/29/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Division, he had the responsibility for managing almost fifty environmental projects for the Air Force. This included field investigations of Air Force installations to identify potential health and environmental effects from pollutants as well as making recommendations for corrective actions.

Verified for accuracy by: John P. Meade Date: 7/29/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

ANDRIS LAPINS

EDUCATION

University of Pennsylvania: M.R.P., Environmental Planning (1980)
University of Pennsylvania: Coursework toward M.S., Geology
Franklin and Marshall College: B.A., Geology (1978)

EXPERIENCE

Mr. Lapins is a project geologist with SAIC's Waste Management Department. His project involvement has included: project and task management, coordinating and conducting field investigations at controlled and uncontrolled hazardous waste sites including, supervising the installation of groundwater monitoring wells and groundwater, soil and sediment sampling; data analysis; contaminant transport assessment; hydrogeologic and geomechnical evaluation; and alternative site remediation analysis.

Mr. Lapins is currently a Project Manager for a Department of Defense (DoD), Installation Restoration Program (IRP), Phase II hazardous materials site investigation at McEntire Air National Guard Base, S.C. The project involves investigating and determining the magnitude and extent of contaminant migration from seven disposal sites; involving the installation of twenty-three groundwater monitoring wells and the sampling of contaminated groundwater, surface water and soils. Mr. Lapins was responsible for developing all phases of this investigation from investigatory approach at each site including: monitoring network design, drilling, well specification and sampling plan preparation to costing, scheduling and staffing.

Mr. Lapins recently managed a task for EPA's Emergency Response Division which involved updating EPA's "Acceptance List" for dispersants and other chemical countermeasures for oil spills, and reformatting technical test data for each product, for inclusion in Subpart H of the National Contingency Plan as Appendix C of 40 CFR 300. The "Acceptance List" and reformatted technical product test data bulletins will serve to facilitate an expeditious selection of appropriate chemical countermeasures by On-scene Coordinators in EPA Regional offices and U.S. Coast Guard Districts in the event of a spill.

Mr. Lapins also managed a task involving the preparation of a Federal Register Notice publishing a Final Rule amending subpart H of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) (40 CFR Part 300) specifying a process in which dispersants, surface collecting agents, and biological additives may be added to EPA's NCP Product Schedule. As well as preparing the text, Mr. Lapins compiled, evaluated, and addressed public comments to the proposed regulation for inclusion in the Final Rule.

Verified for accuracy by: Andris Lapins Date: 9/8/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Mr. Lapins has had considerable experience supervising the drilling and installation of groundwater monitoring wells, and with conducting groundwater sampling and soil/sediment sampling. Collectively, he has played a supervisory role in projects which involved the installation of more than drilling methods, and has performed groundwater sampling of more than 90 wells for county and federal clients.

For the U.S. Army, Mr. Lapins investigated and evaluated soil, sediment, and groundwater contamination resulting from munitions manufacturing activities at two Army depots in Illinois and Tennessee. His involvement in these DoD IRP projects included: developing novel sampling and health and safety procedures for sampling reactive wastes, coordinating field sampling activities with laboratory activities in accordance with the analytical requirements of samples to insure accurate analytical results, supervising the drilling and installation of groundwater monitoring wells, obtaining core and grab samples of sediments containing high concentrations of explosives, groundwater sampling, geotechnical and hydrogeologic data analysis, remedial action evaluation, and final report preparation.

Mr. Lapins also participated in an IRP Phase II hazardous materials site investigation at Hancock Field, N.Y., for the U.S. Air Force. His involvement in this project included supervising the installation of groundwater monitoring wells, evaluating analytical results for sampling activities conducted at the base, preparation of recommendations for additional site investigatory and remedial measures needed and final report preparation.

For the EPA, Mr. Lapins supervised the drilling and installation of groundwater monitoring wells at the Lipari Superfund Site in New Jersey. His responsibilities included overseeing well drilling and installation operations, enforcement of health and safety protocol (Level A Protection), collection and characterization of core samples and the maintenance of daily logs. Mr. Lapins also participated in a study of groundwater contamination from an active hazardous waste disposal site in Anne Arundel County, Maryland, where he performed groundwater sampling and data analysis. His involvement with groundwater sampling and monitor well installation has given him a good working knowledge of EPA and U.S. Army Toxic and Hazardous Materials Agency quality control/quality assurance and chain of custody procedures.

Mr. Lapins has participated in two IRP Phase I investigations at Olmsted AFB (Harrisburg International Airport) and Air Force Plant PJKS near Denver, CO for the U.S. Air Force. For these projects Mr. Lapins conducted record searches and investigated past hazardous materials management practices at each of the bases; conducted site surveys, identifying hazardous material disposal sites, rated sites using the HARM rating methodology, and prepared recommendations for future site investigatory measurers.

Verified for accuracy by: Andris Lapins Date: 9/6/05

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

For EPA's Office of Policy Analysis (OPA), Mr. Lapins provided technical support for a national groundwater contamination modelling effort. For this project, Mr. Lapins developed a data base for examining and evaluating the risk of groundwater contamination and health effects associated with the use of road salts for highway deicing purposes. The results of his analysis will be compared with other sources of groundwater contamination for relative risk assessment to aid EPA in developing groundwater protection policy for the nation.

Mr. Lapins participated in an EPA project to evaluate the validity and accuracy of statistical test procedures specified in 40 CFR 265.93 of RCRA for monitoring groundwater quality at Interim Status facilities. His role in this project included: reviewing site information and groundwater analytical data for facilities throughout the country, providing hydrogeologic evaluations, and data coding for computer analysis.

For the EPA's Office of Solid Waste, Mr. Lapins has taken part in the development of a large computerized data base for characterizing wastes and assessing waste management practices within several segments of the Organic Chemical Manufacturing Industry. The data base which characterizes and tracks manufacturing processes, residual streams, and waste management practices will provide technical support to EPA for the development of industry specific guidelines (RCRA Phase III regulations) for hazardous waste management. Mr. Lapins' role in the project has included reviewing RCRA 3007 Questionnaires and sampling and analysis data, and coding manufacturing processes, process products, residual streams, and waste management practices for chlorinated organic, industrial organic, dye and pigment, and plastic and resin manufacturing industries. Mr. Lapins also aided in the establishment of a computerized status matrix for the EPA to track the progress of RCRA delisting petitions through regulatory review.

Prior to joining SAIC, Mr. Lapins was employed as an environmental scientist by Ecolsciences, Inc., where he managed task assignments and prepared report elements for EIS's and environmental assessments specializing in the inventory, analysis, and evaluation of geologic, pedologic, and hydrologic conditions with special emphasis on groundwater impact assesments. A large segment of his responsibilities included performing siting and site suitability/feasibility analysis for municipal wastewater treatment facilities, deep well wastewater injection and land application of municipal wastewater and sludge at sites in Pennsylvania, Maryland, and Delaware. In addition, Mr. Lapins participated in the development of environmentally sensitive growth management plans for Stafford Township, Ocean County, New Jersey.

Verified for accuracy by: Andris Lapins Date: 8/8/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

PUBLICATIONS

Installation Restoration Program Phase I - Records Search, Final, Air Force Plant PJKS Waterton, Colorado. U.S. Air Force AFESL/DEV, Tyndal AFB, Florida and ASD/PMD Wright-Patterson AFB, Ohio. September, 1984.

Installation Restoration Program Phase I - Records Search, Harrisburg International Airport (Formerly Olmsted Air Force Base) Middletown, Pennsylvania. U.S. Air Force AFESL/DEV, Tyndall AFB, Florida. April, 1984.

Installation Restoration Program Phase II - Confirmation/Quantification, Stage I, Final Report, for Hancock Field, New York. U.S. Air Force, OEHL, Brooks AFB, Texas. December, 1984.

Draft Environmental Impact Statement, Currituck County, North Carolina Outer Banks Access. Department of Transportation, Raleigh North Carolina. March, 1981.

Environmental Assessment of Construction Grants Projects (revisions). U.S. Environmental Protection Agency, Office of Water Program Operations, Washington, D.C. January, 1979.

Draft Environmental Impact Statement, Little Patuxent Water Quality Management Center (Savage Plant), Howard County, Maryland. U.S. Environmental Protection Agency, Philadelphia, Pennsylvania. October, 1981.

Draft Environmental Impact Statement, Leola Sewer Authority Facilities Plan, Upper Leacock Township, Pennsylvania. U.S. Environmental Protection Agency, Philadelphia, Pennsylvania. October, 1981.

Draft Environmental Impact Statement, Wastewater Management Facilities, City of Rehoboth Beach, Sussex County, Delaware. U.S. Environmental Protection Agency, Philadelphia, Pennsylvania. January, 1982.

Draft Environmental Impact Statement, Wastewater Management Facilities, City of Lewes, Sussex County, Delaware. U.S. Environmental Protection Agency, Philadelphia, Pennsylvania. October, 1981.

Verified for accuracy by: Andris Lapins Date: 9/6/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

EDWARD W. REPA

EDUCATION

West Virginia University, Ph.D. Hydrology (1981)
West Virginia University, M.S.F. Hydrology (1977)
Baldwin-Wallace College, B.S. Biology (1975)

EXPERIENCE

Dr. Repa is currently a Program Manager in the Applied Technologies Division of the Waste Management Department. In this capacity, he directs the efforts of geologists, hydrologists, soil scientists and environmental scientists on projects directed at resolving hazardous waste management, technical and policy issues. Dr. Repa is currently managing approximately $1.5 million in tasks under the Air Force's Installation Restoration Program and $1.0 million in tasks under a task order contract with EPA's Office of Research and Development.

Dr. Repa is currently Project Manager (PM) and Principal Investigator (PI) on two Superfund research and development programs. One program is being performed at the Lipari Landfill in Pitman, NJ (Superfund Site Number 1) to assess the performance of the slurry wall and surface cap installed as the remedial action. The other program is being performed at the Western Processing Site in Kent, WA (Superfund Site Number 48) to assess the effectiveness of the asphalt surface cap in minimizing groundwater recharge.

Dr. Repa is the PM for an EPA project that is developing a manual on proven and innovative technologies for controlling the migration of hazardous waste leachate plumes. He led and developed one of the chapters of this manual entitled Groundwater Pumping. This chapter dealt with all aspects of well systems for plume control including well theory, design, installation, and costs. He is also serving as a Senior Technical Reviewer for the other chapters: Plume Dynamics, Plume Delineation, Control Technology Selection, Subsurface Drains, Impermeable Barriers, and Innovative Technologies.

Dr. Repa is also managing or has managed numerous projects under the Air Force's Installation Restoration Program (IRP). These include both Phase I-Records Search and Phase II-Confirmation/Quantification projects. IRP projects that he has participated in include: Phase I--Olmsted AFB, Harrisburg, PA; Air Force Plant PJKS, Waterton, CO; Air Force Plant 44, Tucson, AZ; and Phase II--Hancock Field, Syracuse, NY; Niagara Falls AFB, Niagara Falls, NY; Dover AFB, Dover, DE; Homested AFB, Homested, FL; Charleston AFB, Charleston, SC; McEntire ANG, Columbia, SC. In the role of PM/PI on these projects, Dr. Repa has developed groundwater monitoring plans, supervised the installation of monitoring wells and the collection of water quality samples, and coordinated the interpretation of hydrogeologic data.

Verified for accuracy by: _____ Date: 29 Jul 85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

In addition to these current projects, he has also served as PM/PI on over thirty hydrogeologic impact assessments for the coal mining industry. In this role, he also supervised the installation of many monitoring wells, participated in the collection of groundwater, surface water and biotic samples, and coordinated the data interpretation and prediction of the probable hydrologic impacts from the mining operations.

Dr. Repa has also served as a Project Manager or Principal Investigator on a number of projects including:

- o A theoretical evaluation of subsurface drains for use in landfills that are partially or fully located below the groundwater table.
- o A review, evaluation, and critique of existing numerical and analytical groundwater models for their possible application to risk assessments associated with hazardous waste sites.
- o The development of a specification manual on engineering systems that can be used to accelerate stabilization of hazardous waste piles or deposits.
- o The development of groundwater monitoring plans and protocols for a Part B applicant at a hazardous waste site.

PUBLICATIONS

Repa, E.W. and C. Kufs. 1985. Leachate Plume Management. United States Environmental Protection Agency (in publication).

Repa, E.W., E.F. Tokarski, and R.T. Eades. 1985. Evaluation of the Asphalt Cover at the Western Processing, Inc. Superfund Site. EPA/ORD (in publication).

Kufs, C. and E. Repa. 1984. Leachate Plume Management. United States Environmental Protection Agency, MERL, Cincinnati, OH. EPA-600/9-84-007.

Repa, E., A. Wickline, N. DeSalvo and A. Lapins. 1984. Installation Restoration Program, Phase II-Confirmation/Quantification, Stage 1, Hancock Field, New York. USAF, OEHL, Brooks AFB, Texas.

Bramlett, J., E. Repa, J. Margolis, C. Furman, and S. Mahmud. 1985. Installation Restoration Program, Phase I - Records Search, Air Force Plant 44, Tuscon, AZ. USAF, AFESC/DEV, Tyndall AFB, FL.

Burgher, B., E. Repa, A. Lapins, R. Eades, and J. Margolis. 1984. Installation Restoration Program Phase I-Records Search, Air Force Plant PJKS, Waterton, CO. USAF, AFESC/DEV, Tyndall AFB, FL.

Verified for accuracy by: _____ Date: 29 July 85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Repa, E., B. Burgher, A. Lapins, C. Furman, and W. Ellis. 1984. Installation Restoration Program Phase I - Harrisburg International Airport (Formerly Olmsted Air Force Base), Middletown, PA. USAF, AFESC/DEV, Tyndall AFB, FL.

Kufs, C., P. Rogoshewski and E. Repa. 1982. Alternatives to Groundwater Pumping for Controlling Hazardous Waste Leachates. National Conference on Management of Uncontrolled Hazardous Waste Sites, Washington, D.C. p. 146-149.

Kufs, C., K. Wagner, P. Rogoshewski, M. Kaplan, and E. Repa. 1983. Procedures and Techniques for Controlling the Migration of Leachate Plumes. Ninth Annual Research Symposium, Land Disposal, Incineration and Treatment of Hazardous Waste. USEPA, Cincinnati, May 2-4.

Repa, E., E. Tokarski, and E. McNicolas. 1982. The Establishement of Guidelines for Modeling Groundwater Contamination from Hazardous Waste Facilities. EPA-OSW, Washington, D.C.

Repa, E., R. Fithian, H. Hefner, and J. Hoffman. 1981. Prediction of the Probable Hydrologic Consequences of Mining by the Demotto Peerless Coal Company, WV SOAP #001. Division of Reclamation, Department of Natural Resources, State of West Virginia.

Fithian, R., E. Repa, J. Meeks, and N. DeSalvo. 1981. Prediction of the Probable Hydrologic Consequences of Mining by the Winsor-Pittman Coal Company, WV SOAP 012. Division of Reclamation, Department of Natural Resources, State of West Virginia.*

Repa, E.W. 1981. Rainfall Catch Errors Associated with Circumambient Obstructions. Dissertation, West Virginia University.

Tajachman, S.J., R. Lee, and E.W. Repa. 1978. Rainfall Additaments to Subsurface Water in a Young Pine Plantation. Water Resource Bulletin 15(2):381-6.

Lee, R., S. Tajachman, D.G. Boyer, and E.W., Repa. 1977. Normal Precipitation in West Virginia, West Virginia Agriculture and Forestry 7(2):12-8.

*Numerous other hydrologic assessments performed; full listing available upon request.

Verified for accuracy by: _____ Date: 25 July 85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

WILLIAM D. ELLIS, Ph.D.

EDUCATION

Johns Hopkins University: Ph.D., Organic Chemistry (1981)
Johns Hopkins University: M.A., Organic Chemistry/Biochemistry (1977)
Johns Hopkins University: B.A., Chemistry (1969)

SUMMARY

Dr. Ellis is a senior environmental scientist for SAIC, certified in comprehensive practice of industrial hygiene by the American Board of Industrial Hygiene. He has 11 years of experience in environmental science and occupational health, including risk assessment, development of criteria for health standards, characterization and treatment of hazardous wastes, and environmental transport of chemicals in soil and water. Dr. Ellis has investigated the environmental risk from waste management practices of small generators, and assessed the risk from industrial hazardous waste management practices. He is managing a task for EPA to develop chemical countermeasures for in situ treatment of contaminated soil. Dr. Ellis managed the development of NIOSH criteria documents on aliphatic polyamines and chlorinated hydrocarbon wastes. This work involved assessing the literature on toxic effects of substances on workers, and recommending engineering, work practice, and personal protective equipment techniques for controlling exposure. As a Compliance Officer for the Maryland Occupational Safety and Health Program and a field industrial hygienist for SAIC, he has performed all phases of industrial hygiene field work, including sampling for exposures to toxic substances and recommending exposure control methods at industrial plants and construction sites.

EXPERIENCE

November 1978 to present: SAIC

Dr. Ellis is providing senior technical support on several tasks under the EPA Municipal Environmental Research Laboratory's Technical Management Support (TMS III) contract. Presently, Dr. Ellis is providing senior technical support to a task on the laboratory use of asphalt or Portland cement to stabilize dioxin contaminated soil to prevent environmental transport of dioxin and toxic effects to humans.

Dr. Ellis is also managing the Chemical Countermeasures Task of SAIC's TMS III contract with the EPA. This task, which addresses the safe use of chemicals to treat or remove toxic wastes and spills without harming human health, involves three phases: 1) Gathering information on chemical methods for in situ treatment of soil contaminated by leachates from hazardous waste disposal sites and of hazardous material spills to quiescent water bodies; 2) Performing bench and pilot scale laboratory tests of promising in situ soil treatment methods: and

Verified for accuracy by: William D. Ellis Date: 7/30/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

3) Providing technical support to EPA field tests of in situ soil treatment methods. The methods Dr. Ellis is helping to develop are the use of aqueous surfactants to remove hydrophobic chemicals from soil, and the use of acids, bases, and chelating agents to remove heavy metals.

Dr. Ellis is also the senior scientist on an EPA task on the decontamination of the EPA Environmental Emergency Response Unit's mobile treatment units, such as the mobile incinerator. He is providing guidance on the toxic materials to be expected at Superfund sites, and methods for chemically degrading them or cleaning them from equipment surfaces. He is also providing technical guidance to SAIC's laboratory and field task on in situ bioreclamation of chlorinated organics at a hazardous waste site.

Dr. Ellis was recently assessing the risk to human health and the environment from releases of toxic, ignitable, reactive, and corrosive wastes, as part of the regulatory impact analysis of hazardous waste storage regulations for the EPA Office of Solid Waste. The effects of the physical and chemical characteristics upon the probability of release and the extent of environmental transport, and the potential toxicologic impact on human health and to environmental receptors was assessed. For the same project, Dr. Ellis has also assisted in evaluation of current technology and practices for hazardous waste storage, in terms of preventing releases and minimizing adverse environmental effects if releases occur. Dr. Ellis has also assessed the relative risk to human health and the environment from the hazardous waste management practices of small non-consumptive end users of chlorinated organics. This task, which covers such end use processes as dry cleaning and metal degreasing, is part of the Industry Studies program with the Office of Solid Waste.

Previously, Dr. Ellis was the document manager for a criteria document on the safe handling of chlorinated hydrocarbon wastes. This document described the best techniques available for protecting workers from exposure to toxic constituents of chlorinated hydrocarbon residues. It also summarized the toxic effects of 25 chlorinated hydrocarbons on workers. Dr. Ellis was also the manager for a NIOSH document on aliphatic polyamines. He prepared an innovative assessment using computer data bases of the size and occupational health impact of the categories of polyamines to assist NIOSH in defining the scope of the document. He wrote the section assessing the toxic effects of polyamines on animals.

In addition, Dr. Ellis has worked in several other areas of environmental protection and occupational safety and health. Dr. Ellis assisted in the preparation of a document for EPA assessing human exposures to phthalate esters in the environment. For the Louisiana On-site Consultation contract with OSHA, he was the senior industrial hygienist responsible for helping small businesses identify, evaluate, and control toxic exposures in the workplace.

Verified for accuracy by: William D. Ellis Date: 7/30/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

February 1974 to October 1978: Maryland Occupational Safety and Health Program

Prior to joining SAIC, Dr. Ellis was an assistant to the Commissioner for Technical Services of the Maryland Occupational Safety and Health Program. He supervised and trained junior industrial hygienists and served as coordinator with the public and the media on occupational health problems. He performed extensive industrial hygiene field work, such as sampling for exposures to asbestos, silica, halogenated hydrocarbons, and heavy metals at 60 commercial and industrial plants. As an occupational health consultant for Maryland, Dr. Ellis counselled businesses on occupational safety and health standards and methods for control of toxic chemicals.

1970 to 1980: Johns Hopkins University

Dr. Ellis conducted graduate research on the dinitroso-hydrazide deamination reaction. His research involved synthesis of optically active hydrazine analogs of nitrosamines; determination of the fate of isotopically labeled nitroso groups by mass spectrometry; separation of reaction products by gas chromatography; and identification and quantitation of organic compounds by nuclear magnetic reasonance, infrared, and ultraviolet spectrophotometry.

1969 to 1982: U.S. Army Reserves

Dr. Ellis was an Army-trained medic in the 309th Medical Group of the U.S. Army Reserves. His duties included the formal training of the 309th in emergency medical treatment and in the prevention of disease in military environments.

PROFESSIONAL AFFILIATIONS

American Industrial Hygiene Association
American Academy of Industrial Hygiene

PUBLICATIONS, PAPERS, AND REPORTS

McGirk, R., Cyr, D., Ellis, W., and White, E. 1974. Application of the Nitrosamide Reaction to Hydrazones. Journal of Organic Chemistry 39:3851.

Ellis, W. 1980. Application of the Nitrosamide Reaction to Alkyl Hydrazines, Doctoral Thesis, Johns Hopkins University, Baltimore, Maryland.

Verified for accuracy by: William D. Ellis Date: 7/30/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

JOHN W. MENTZ

EDUCATION

Pennsylvania State University: B.S., Geology (1972)

EXPERIENCE

During his 13 year consulting career, Mr. Mentz has gained progressively responsible experience in a variety of geotechnical areas, including: soil, surface water, and groundwater hazardous and mining waste contamination identification and remediation; geological investigations to assess/predict groundwater conditions, evaluate mining problems, and define coal and other mineral resouces; underground well injection; inventories of various mining related features with potential adverse health, safety, and environmental consequences; regulatory assessment and compliance; and impact assessments. As a Senior Program Manager in SAIC's Technical Services Division, Mr. Mentz's responsibilities include administration of a technical staff with varied backgrounds as well as management of a variety of contaminant assessment/characterization/clean-up studies.

Current project responsibilities include management of a study aimed at determining the compositions of leachates from various hazardous waste landfills across the Nation, and assessing the feasibility of formulating synthetic leachates with which to test the effectiveness of proposed liner materials and configurations. Such synthetic leachates would be formulated to reflect distinctions in geographic/climatic site conditions and the proposed hazardous wastes to be landfilled.

Mr. Mentz is managing a technical support contract to provide specialized hazardous waste related studies and program development and support activities to the State of New Jersey. This contract includes risk assessment; health effects, toxicological, and specialized lab studies; regulatory, guidelines, procedural, and data base development; and computerized MIS.

Mr. Mentz has also managed studies conducted at several Superfund sites, including an RI/FS for a site in Winslow Township, New Jersey. Included in this study were design and implementation of a surface geophysical monitoring program (resistivity, electromagnetics, magnetics); construction of groundwater monitoring wells; and a sampling/analysis program covering shallow and deep soils, surface and groundwater, and abandoned lagoons and tankers. At an industrial facility/Superfund site in southeastern Pennsylvania, Mr. Mentz managed a hydrogeologic testing program that generated data necessary for implementation of a groundwater recovery/treatment program.

Verified for accuracy by: John W. Mentz Date: 8/19/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Other similar studies managed by Mr. Mentz include:

- Evaluation of the feasibility of various alternatives for clean-up of TCE-contaminated soils and groundwater at an abandoned solvent recovery facility near Dover, Delaware (recommendations currently being implemented).
- Clean-up of TCE-contaminated soils via excavation and removal in one case, excavation and soil aeration (shredding) in another case. Both projects included pre-and post-remediation groundwater monitoring.
- Design and completion of a groundwater monitoring program at an industrial research facility to identify the presence and movement of contaminants towards two adjacent municipal pumping wells.
- Planning and initiation of an environmental audit (soils and ground water) at a decommissioned paint manufacturing facility in northern New Jersey.
- Evaluation of a subsurface gasoline spill and subsequent implementation of a recovery program.

As a Program Manager for a U.S. Environmental Protection Agency technical support contract, Mr. Mentz gained valuable experience with that agency's underground injection control program, which was initiated to assure proper regulation of underground injection of both hazarduos and non-hazardous wastes. That contract provided technical and training support to EPA headquarters and a number of that agency's regional offices. Mr. Mentz coordinated: a number of abandoned gas and oil well inventories; presentation of the EPA's oil and gas injection well regulatory program to industry in many states; evaluations of injection well abandonment practices and the environmental consequences (general and site-specific); development and organization of technical guidance methodology for implementing surface and borehole injection well mechanical integrity tests.

Mr. Mentz participated in a study for a major central Pennsylvania limestone producer to identify and recommend measures to abate major sources of groundwater inflow into an active quarry to reduce excessive pumping operations. Field investigations, aerial photo interpretations, and a variety of subsurface investigations were conducted.

He also was responsible for a study to develop a dewatering system to control fracture-dominated inflow into active underground mines. This effort included development of a site specific borehole dewatering plan that, when implemented in advance of advancing mine workings, would reduce water inflow into those workings.

A broad range of studies designed and conducted by Mr. Mentz were aimed at assessing surface water and groundwater resources to quantify mining-related pollutants (chemical and sediment) and pinpoint sources of those pollutants,

Verified for accuracy by: John W. Mentz Date: 5/19/95

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

to project pollution production potential, and to recommend pollution abatement/control strategies. These studies have been conducted throughout Appalachia and have ranged from individual sites, streams, or pollution sources to major drainage basins.

In a related area, Mr. Mentz has extensive experience in mining pollution control technology analyses, particularly at-source abatement, aimed at improvement of discharge water quality from both active and inactive mines. He has conducted or participated in a wide range of studies, including the following:

- Investigation of methods to improve performance of surface mine sedimentation basins;
- Technical and economic evaluation of available mine closure alternatives;
- Assessment of partial inundation of abandoned sections of underground mines to reduce pollution formation;
- Chapters 5 and 6 of the Office of Surface Mining's "Abandoned Mined Lands Reclamation Control Technology Handbook," dealing with mine drainage control and sealing of underground openings.

Mr. Mentz has extensive experience in planning and conducting inventories of various active and inactive mining-related features. He has conducted inventories of abandoned surface and underground mines and resultant pollution, waste piles, subsidence, and other hazardous features in five distinct watersheds in Pennsylvania, the North Branch Potomac River Basin in Pennsylvania, West Virginia, and Maryland; three major coal-mining counties in Pennsylvania and West Virginia, western Colorado (non-coal mines); and the statewide coal fields of Ohio and Kentucky.

In the active mining arena, Mr. Mentz managed an inventory of active coal waste embankments in West Virginia, Maryland, Virginia, and Eastern Kentucky. He also coordinated a nationwide assessment of off-site coal-handling facilities and a number of other mining-related studies.

Mr. Mentz also led the team that developed content requirements and format guidelines for state abandoned mined land reclamation plans for the U.S. Office of Surface Mining in compliance with 30 CFR 884.13. That effort included development of a model state plan to guide state reclamation agencies in the preparation of their state plans for OSM submission.

Mr. Mentz has extensive experience in the area of mineral resource evaluation. He has conducted or participated in many site specific coal resource evaluations:

- Pennsylvania anthracite: 3 studies
- Pennsylvania bituminous: 11 studies
- Western Maryland : 7 studies
- West Virginia : 1 study
- Alabama : 1 study
- Texas lignite : 6 studies

Verified for accuracy: John W. Mentz Date: 8/19/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Other mineral resource evaluations of much broader scope managed by Mr. Mentz include several analyses of all four Pennsylvania anthracite fields and a 3,700-square mile portion of central Pennsylvania's bituminous coal fields. In addition, he has managed or participated in numerous non-coal resource evaluations at specific sites for limestone, sandstone, and uranium.

He has also conducted a variety of other geologic studies pertinent t assessing groundwater problems, pollution production, mining feasibility, and technical issues.

Verified for accuracy by: John W. Mentz Date: 8/19/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

CHRISTOPHER S. MANIKAS

EDUCATION

The George Washington University, M.S., Geology (anticipated May, 1985)
Virginia Polytechnic Institute and State University, B.S., Geology, 1979
Northern Virginia Community College, A.S., Science, 1977

EXPERIENCE

Mr. Manikas is a geologist with SAIC's Waste Management Department, where he has participated in multi-media sampling for USAF Installation Restoration Program (IRP) tasks and was an active participant in sample collection for a USEPA research project to determine the chemical characteristics of landfill leachates. Mr. Manikas is currently investigating a contaminated well field for the New Jersey Department of Environmental Protection (NJDEP) and is a member of a project team which is preparing a Part B permit application for facilities at the Idaho National Engineering Laboratory (INEL).

Prior to joining SAIC, Mr. Manikas worked as a geologist with Woodward-Clyde Consultants where, through diverse project exposure, he accrued extensive experience in field mapping and characterization of surficial and subsurface geology. He has been the principal field investigator in numerous geotechnical engineering and siting studies for a variety of structures, including high-rise complexes in Virginia and Maryland, an extensive research facility at Fort Meade, Maryland, and a soft-ground tunnel alignment in Prince George's County, Maryland. He has been an active participant in field investigations for a 90-foot high earth embankment dam, a resource utilization study for the West Virginia Department of Highways, evaluation of landslide potential in Cretaceous-aged clays in Fairfax County, Virginia, and several foundation studies initiated for the Washington Suburban Sanitary Commission (WSSC), the Washington Metropolitan Area Transit Authority (WMATA), Montgomery County, Maryland, and Fairfax County, Virginia. Studies of this nature typically involved preliminary geologic site assessment, sampling and description of soil/rock materials, installation of groundwater monitoring wells, and in-situ special testing. He was also the principal field investigator on several subsurface investigations which utilized applications of quasi-static cone penetration techniques to characterize in-situ materials.

Mr. Manikas has been actively involved in mapping geological structure during construction on portions of the Washington, D.C. METRO subway system, and for water diversion tunnels in Bethesda, Maryland and Germantown, Maryland. Additionally, he has instrumented and monitored several tunnels, shafts, and deep excavations utilizing single, double, and multiple-point borehole extensometers, vibrating-wire strain gages, load cells, and inclinometers. He was also a member of a two-man team assigned to map the bedrock geology in the vicinity of Boyds, Maryland prior to construction of a large earth dam.

Verified for accuracy by: Christopher S. Manikas Date: 8-27-85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

As a member of two quality assurance teams, Mr. Manikas has inspected compaction grouting operations at the Davis-Besse Nuclear Power Station, Oak Harbor, Ohio, and has actively participated in a review of construction documentation at the South Texas Project Nuclear Power Station at Bay City, Texas.

During separate investigations of shallow bedrock, karstic terrains, and hazardous waste sites, Mr. Manikas has applied geophysical techniques including seismic refraction and electrical terrain conductivity methods toward subsurface delineation of rock surfaces, solution features, and migrating waste plumes.

While pursuing his graduate degree in geology, he investigated the sedimentologic aspects of the Lower Cretaceous deposits in northeastern Virginia utilizing scanning electron microscopy (SEM) and x-ray diffraction techniques among his research methods.

AFFILIATIONS

American Association of Petroleum Geologists
Geological Society of America
Society of Economic Paleontologists and Mineralogists

CERTIFICATION

Certified Professional Geologist, Virginia #000327

Verified for accuracy by: Christopher S. Manikas Date: 8-29-95

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

FREDERIC A. ZAFRAN

EDUCATION

Drexel University, M.S., Environmental Science (1979)
Michigan State University, B.S., Zoology (1973)
University of Pennsylvania, Limnology (1978)
Temple University, Biochemistry and Physiology (1973)

SUMMARY

Mr. Zafran is an environmental scientist with expertise in the assessment of impacts of toxic substances and hazardous waste on environmental and biological systems. He is experienced in conducting exposure, hazard and risk assessments of contaminants released to all environmental media, evaluating impacts to both human and non-human receptors. Mr. Zafran's experience includes the assessment (fate and effects) of non-conventional, conventional and priority toxic pollutants (CWA Section 307a.1 compounds); drinking water additives; pesticides; industrial solvents; synfuels and synfuel products; dredge and fill materials; sewage sludge; coal ash; and complex hazardous wastes. Mr. Zafran's background encompasses work in aquatic chemistry, ecology and toxicology, as well as water quality planning and management.

PROFESSIONAL EXPERIENCE

Mr. Zafran was recently involved in the development of a water quality management plan for the Grand Calumet River/Industrial Harbor Canal (state of Indiana). He conducted a critical evaluation of the state's water quality criteria and standards program, developed a method for evaluating the existing sediment contamination problem, and used this method to identify and rank sediment contaminants of concern to aquatic life and human health.

As Work Assignment Manager on several projects for the EPA Office of Water Regulations and Standards, Mr. Zafran was responsible for: (1) developing hazard assessments (aquatic ecological effects and mammalian/human health effects) for 20 non-priority pollutants found to be incompatible with the workings of POTWs; (2) preparing a background and review document on methods for the derivation of sediment criteria and their application under CWA, MPRSA, RCRA and CERCLA; and (3) the review and update of the "Red Book".

For the Municipality of Metropolitan Seattle, Mr. Zafran evaluated the impacts of combined sewer overflow and storm drain effluents on Lake Washington. Through statistical analyses of benthic biological, chemical and geological sampling data (e.g. multivariate classification and pattern analysis techniques), Mr. Zafran and two other scientists were able to assess the

Verified for Accuracy by: Frederic A. Zafran Date: 2/25/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

relationships between sediment contamination and macroinfaunal community structure, and to draw conclusions concerning impacts of discharged materials.

Mr. Zafran conducted a study of the impact of coal liquefaction and shale oil products on aquatic systems. This work for the Office of Toxic Substances involved the assessment of the toxicity of compounds characteristic of synfuels that are responsible for major environmental effects: polycyclic aromatic hydrocarbons, polynuclear heterocyclic aromatic bases, water soluble aliphatic and aromatic hydrocarbons and trace metals.

Mr. Zafran was technical contributor to an Environmental Impact Statement on the disposal of coal ash in the waters of the New York Bight. He evaluated the toxic impact to marine species associated with direct exposure to waste ash or contaminants released therefrom, and the potential for effects on human health and welfare.

Mr. Zafran was recently involved in the development of a field guide for EPA and the Coast Guard, on responding to the spill of sinking chemicals in aquatic systems. On the effort, Mr. Zafran outlined an approach to the following evaluations: (1) characterization of discharged materials and the environmental setting; (2) determination of the extent of contaminant transport; (3) evaluating environmental impacts; (4) assessment of the need for response; and (5) establishing response objectives.

For the Office of Analysis and Evaluation, Mr. Zafran conducted a study of environmental quality problems of the Narragansett Bay estuary. This included the physical/chemical characterization of the estuarine system, an examination of uses of the Bay and an evaluation of water quality problems, wetland loss, and shoreline erosion. Also for this office, Mr. Zafran assisted in developing a five year estuarine quality and protection program plan. He identified and evaluated research needs in the following six topical areas: estuarine characterization, site-specific criteria development, use attainability analyses, wasteload allocation techniques, monitoring and benefit-cost assessment.

Mr. Zafran was Work Assignment Manager on a project for the EPA Office of Federal Activities to assess the extent to which the 404 Program (Dredge or Fill Program) addresses and supports research essential to the protection of sensitive aquatic resources. Analysis of existing research and future needs facilitated the development of a broad-based program plan for 404-related research activities.

Mr. Zafran conducted a review of the available scientific literature on physical transport processes of the Alaskan Outer Continental Shelf to determine adequacy of data for ocean discharge criteria evaluation. This work assisted EPA in the NPDES permitting process for oil and gas exploration, development and production activities.

Verified for Accuracy by: _____ Date: _____

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Mr. Zafran has assisted the EPA Office of Solid Waste (OSW) in evaluating petitions submitted by industry for exclusion of waste generated at specific facilities, from listing under RCRA as hazardous waste. Review of these "delisting peititions" includes the evaluation of data on waste stream character, monitoring design, sampling and the results of analysis, EP toxicity, and disposal planning. Also for OSW, Mr. Zafran developed a method for estimating the concentration of polycyclic aromatic hydrocarbons in leachate from landfarmed waste, or waste disposed in landfill. The approach involved predicting the equilibrium partitioning of contaminants between aqueous and solid phases of soil-water systems.

Mr. Zafran conducted a comparative assessment of risks to human health of sources of groundwater contamination. In this work for the EPA Office of Policy Analysis, he assisted in refining the approach to comparative risk analysis and in characterizing the release, transport and transformation of indicator compounds from selected sources.

Mr. Zafran has been extensively involved in the development of regulatory support documents for Toxic Substances Control Act Section 4, priority chemicals (Office of Pesticides and Toxic Substances). He was responsible for the analysis of information on pollutant emission, environmental transport, and transformation as it relates to occupational and general population exposures. Also for OPTS, Mr. Zafran has prepared numerous Chemical Hazard Information Profiles, providing background health and exposure data in support of risk assessment and test rules development processes.

As Work Assignment Manager on a project for the EPA Office of Drinking Water (ODW), Mr. Zafran, was responsible for the review and evaluation of 25 years of compiled information on direct and indirect additives to drinking water. The assessment conducted by JRB scientists enabled ODW to reevaluate products previously approved in light of current health effects data. Also for ODW, Mr. Zafran has: (1) conducted a study of chemical leaching tests to determine the extent of release of pollutants from surfaces in contact with potable water; (2) evaluated the potential for groundwater contamination by pesticides; and (3) assessed the environmental transport and transformation of synthetic organic chemicals and their occurrence in air, water, soil and food.

Mr. Zafran was technical reviewer of the EPA report "Health Assessment Document for Nickel". Prepared by the Office of Research and Development, the report serves as a source document for Agency-wide use.

For ARCO Chemical Company, Mr. Zafran prepared an evaluation of mammalian toxicology and human health effects of exposure to Stoddards Solvents.

Mr. Zafran conducted a preliminary study of the impacts of incineration of sewage sludge on human health and the environment. Specifically, he provided the EPA Sludge Task Force with an assessment of contaminants likely to be emitted to the atmosphere, a quantification of emissions factors and an identification of pollutants of major concern.

Verified for Accuracy by: _____ Date: _____

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Prior to working for JRB, Mr. Zafran was employed by the Krusen Center for Biomedical Research and Engineering, and was involved in the study of neuromuscular function in human locomotion. While in graduate school, Mr. Zafran worked as consultant (health systems planner) to the Pennsylvania Department of Health, representing the Drexel University Environmental Studies Institute.

PROFESSIONAL AFFILIATION

Society of Environmental Toxicology and Chemistry

Verified for Accuracy by: _____ Date: 2/2/95

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

RICHARD T. EADES

EDUCATION

West Virginia University, B.S., Geology (1982)

EXPERIENCE

Mr. Eades is a geologist with the Applied Technologies Group of SAIC. He is diversely experienced in regard to studies involving hazardous waste site investigation, characterization and remediation. He is currently involved in a confirmation/characterization study of groundwater and surface water contamination at Dover Air Force Base under a Phase II investigation of the U.S. Air Force's Installation Restoration Program. Under this program he has been responsible for development of well installation, sampling and monitoring plans, subcontracts procurement, supervision of drilling operations, assistance in soils, surface water, and ground water sampling, interpretation of geologic, hydrologic, and chemical analytical data, and report preparation. In addition, Mr. Eades recently completed another Phase II effort at McEntire ANG Base, Columbia; South Carolina, where he supervised drilling and installation of 11 groundwater monitoring wells.

Mr. Eades also assisted in the design of a parallel Phase II drilling and sampling program at Niagara Falls Air Force Reserve Facility by inputting to technical and cost proposals, scheduling, staffing and subcontractor coordination. In addition, Mr. Eades served as a team member on the Phase I investigation at Air Force Plant PJKS in Waterton, Colorado. His responsibilities included performing a site investigation to determine past and current waste handling practices, record searches and interviews to identify the environmental conditions present at the site, an evaluation of the potential for environmental contamination, recommendation for future groundwater and surface water monitoring and final report preparation.

Mr. Eades has a wide range of experience under a variety of Environmental Protection Agency studies. He has served in numerous capacities during an ongoing evaluation of the effectiveness of an asphalt cap as a remedial action at the Western Processing Company Superfund Site in Kent, Washington. Under this program Mr. Eades was responsible for assisting in the design of asphalt, soils and groundwater sampling and analysis plans, supervision of asphalt coring operations, adherence to health and safety protocol, coordination of laboratory permeability and percent air voids testing, interpretations of test results, and making recommendations on hydraulic asphalt mix and paving designs for future remedial applications. He has recently completed a separate case study on the history to date of remedial actions and their effectiveness at the dioxin contaminated Denney Farm Site in Aurora, Missouri. During this case study, Mr. Eades was solely responsible for coordination with EPA Region VII to access files and records and conduct interviews to document remedial design, execution and performance. Evaluation included determining the effectiveness of waste exhumation, site closure, on site storage and microbiological degradation.

Verified for accuracy by: Richard T. Eades Date: 7/29/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Mr. Eades was also a key team member under an EPA program to solicit and evaluate offers to test emerging technologies to clean up hazardous waste sites and spills. This involvement included Request for Proposal development, design of evaluation criteria, proposal scoring and recommendations on various proposed technologies including sorbents, in situ vitrification, and circulating bed incineration. Under various other EPA programs, Mr. Eades has provided:

- Confirmation of hydrogeologic data at the Vertac Site in Jacksonville, Arkansas.
- Description of concepts and test results for permeable treatments beds and block displacement as methods to clean up or contain contaminated groundwaters.
- And technical and cost proposals for expanding the computer data base of remedial action case histories.

Mr. Eades served under a DOE sponsored project in review and document preparation capacities for the Nuclear Waste Management Program at the Nevada Test Site. He evaluated state-of-the-art technologies and documents regarding the regulation of borehole shaft sealing of experimental wells to insure the integrity of the host medium in which hazardous waste disposal sites could be located.

Mr. Eades also has a variety of experience in the oil and gas industry in drilling, coring, completion and well testing capacities. Prior to transferring to SAIC/McLean, Mr. Eades completed a project for Gas Research Institute under which he had the responsibility of generating a geologic framework for Meigs County, Ohio, testing the relationship between gas production and photolineaments and sampling and analyzing core to determine matrix properties, fracture occurrences and offgassing data. He was responsible for providing production decline curve analyses and geologic mapping efforts, including structure contour and isopach maps incorporating data on over 300 producing wells. This work assisted in determining reservoir characteristics such as directionality of flow within a naturally fractured reservoir as well as quantifying fracture occurrences through the use of core analysis, mini-hydraulic fracturing treatments and downhole camera surveys.

Mr. Eades served as a field geologist during drilling, completion and well testing operations under the previously mentioned program and under the Department of Energy's Offset Well Test Program. He was also responsible for installing and monitoring data acquisition systems, conducting flow tests, sampling gases, placement of downhole tools (packers and pressure monitoring probes), well log interpretations and assisting in well cleanup operations.

Verified for accuracy by: Richard T. Eades Date: 7/29/85

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

Mr. Eades also has experience in the coal mining industry with regard to defining hydrologic impacts for existing and proposed mines. He conducted field investigations, and geotechnical evaluations of over 80 surface and underground mining operations in three Appalachian coal mining states. These evaluations involved field data acquisition, overburden sampling and analysis, water monitoring station data analysis and geologic and hydrologic interpretations regarding known or predicted environmental impacts from mining operations in West Virginia, Virginia and Kentucky. Mr. Eades was responsible for proposing groundwater and surface water monitoring stations for proposed sites and identifying shortcomings of monitoring station locations for existing sites.

PUBLICATIONS

Installation Restoration Program Phase I - Records Search Air Force Plant PJKS Waterton, Colorado, 1984, USAF, AFESC/DEV, Tyndall AFB, Florida and ASD/PMD, Wright-Patterson AFB, Ohio.

Multiple Well Transient Test Program in Meigs County, Ohio, Gas Research Institute 5081-213-0605.

Evaluation of the Asphalt Cover at the Western Processing, Inc., Superfund Site (Draft Final Report) EPA 68-03-3113.

Verified for accuracy by: Richard T. Eades Date: 7/24/87

SAIC

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal or quotation

J. CANDACE NOTHWANGER

EDUCATION

B.S. Geology University of Rochester (1984)

EXPERIENCE

Ms. Nothwanger is a geologist with the Applied Technologies Division of the Waste Management Department. Primary responsibilities involve conducting field investigations at hazardous waste sites including soil and sediment sampling, analysis of data, core sample collection and characterization, and daily log write up.

Ms. Nothwanger is currently involved in investigating the nature and degree of environmental contamination resulting from previous disposal activities at designated areas under Phase II of the United States Air Forces' Installation Restoration Plan (IRP). In this capacity, she is responsible for ground water and surface water sampling, soil sampling, and the supervision of monitoring well installation.

Prior to joining SAIC, Ms. Nothwanger worked as a research assistant with Everett & Associates. In this position she conducted literature search and plotted geologic data for an asbestos contaminant project. She also compiled data on acid percipitation, and fracturing and deep well disposal for the American Petroleum Institute (API).

Professional Societies and Service Organizations

Geological Society of America
American Association for the Advancement of Science

Verified for accuracy By: J Candace Nothwanger Date: 8/5/85

SAIC


DAT
ILM