

N83447.AR.000545  
NAS FORT WORTH  
5090.3a

FINAL RCRA FACILITY INVESTIGATION FOR AREA OF CONCERN 2 VOLUME 1 OF 2 NAS  
FORT WORTH TX  
11/1/2000  
CH2M HILL



**NAVAL AIR STATION  
FORT WORTH JRB  
CARSWELL FIELD  
TEXAS**

---

**ADMINISTRATIVE RECORD  
COVER SHEET**

AR File Number 651

# HQ Air Force Center for Environmental Excellence

## **Final RCRA Facility Investigation Report Area of Concern 2 NAS Fort Worth JRB, Texas**

### **Volume I of II**

Contract No.: F41624-94-D-8053-0039  
Project No.: W/O 72435



Prepared by:  
CH2M HILL, Inc.

November 2000

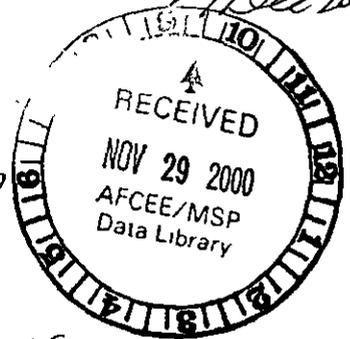
651

2 TOWNITEC  
ms McPherson,  
Fun ERB Pring  
Dec 2000

November 27, 2000

Mr Ray Risner  
Texas Natural Resource Conservation Commission  
Building D - MC127  
12100 Park 35 Circle  
Austin, Texas 78753

FYI/R/c  
+ Cor File  
TKS/O



2 Volumes  
+ Ltr of Cover

Dear Mr. Risner:

Subject: NAS Fort Worth JRB, Texas (Carswell Field)  
Area of Concern 2 RCRA Facility Investigation Report, Version 1.1

AFCEE is pleased to submit the final version of the RCRA Facility Investigation (RFI) Report for Area of Concern 2 (AOC2) at Naval Air Station Fort Worth Joint Reserve Base (NAS Fort Worth JRB).

AOC2 represents the groundwater affected by trichloroethylene (TCE) at NAS Fort Worth JRB. TCE-related contamination observed at the base generally occurs in the form of three lobes: northern, central, and southern. At the time the AOC2 RFI was being planned, only the northern lobe had not already been well-defined by previous investigative work conducted at the base, and the AOC2 RFI investigation was planned to specifically address data needs remaining for this northern lobe. The AOC2 RFI was conducted by CH2M HILL in accordance with the AOC2 RFI Workplan dated February 1998.

The attached document, designated Version 1.1, incorporates TNRCC and EPA review comments on Version 1.0 (dated January 1999), in accordance with our original response to comments provided to you in January 2000. Based on the RFI activities, the conclusions of the report describe the TCE plume at Air Force Plant 4 (AFP4) as the most likely source of TCE in the northern lobe of AOC2, and provide a description of the nature and extent of the affected groundwater, the potential for natural attenuation, and the potential risks associated with the current and potential future plume. Recommendations for continued monitoring pending the evaluation and selection of remedial alternatives are also provided.

Please let me know if you have any questions or comments

Sincerely,

Don Ficklen  
Restoration Team Chief  
Air Force Center for Environmental Excellence

DFW\138681\AOC2RFIREPORT\VER1\00Nov\_AOC2.doc

- c Ms. Luda Voskov/TNRCC
- Mr. Gary Miller/EPA Region 6
- Mr. Ruben Moya/EPA Region 6
- Mr. Charles Pringle/AFCEE
- Mr. Rafael Vasquez/AFBCA
- Ms Audrie Medina/Universe Technologies, Inc.

**CH2MHILL** TRANSMITTAL

**TO:** Ray Risner/TNRCC  
 Luda Voskov/TNRCC  
 Gary Miller/US EPA Region 6  
 Ruben Moya/US EPA Region 6

**TO:** Charles Pringle/AFCEE  
 Rafael Vasquez/AFBCA  
 Audrie Medina/Unitech  
**CC:** Don Fickler/AFCEE,  
 w/out attachment  
 Mike Dodyk/AFCEE, w/out  
 attachment  
 George Walters/ HQ ASC, w/out  
 attachment

**Date:** November 27, 2000

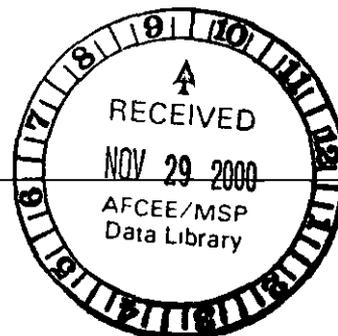
**Re:** NAS Fort Worth JRB, Area of Concern 2

**We Are Sending You:**

- |  |  |
|--|--|
| <input checked="" type="checkbox"/> Attached | Under separate cover via                               |
| Shop Drawings                                | <input checked="" type="checkbox"/> Documents Tracings |
| Prints                                       | Specifications Catalogs                                |
| Copy of letter                               | Other:   |

F411624-94-D-8053139

ITEM	Description
1.	Final RCRA Facility Investigation Report, Area of Concern 2, NAS Fort Worth JRB (Version 1.1), Volumes I and II  NOTE: This version of the report incorporates AFCEE's response to TNRCC and EPA comments on the January 1999 draft.



If material received is not as listed, please notify us at once

**NOTE to distribution recipients:**

**This copy is being provided by CH2M HILL at the request of Don Fickler/ AFCEE.**

# HQ Air Force Center for Environmental Excellence

## **Final RCRA Facility Investigation Report Area of Concern 2 NAS Fort Worth JRB, Texas**

**Volume I of II**

Contract No.: F41624-94-D-8053-0039

Project No.: W/O 72435



Prepared by:  
CH2M HILL, Inc.

November 2000

HQ Air Force Center for Environmental Excellence

**Final**  
**RCRA Facility Investigation Report**  
**Area of Concern 2**  
**NAS Fort Worth JRB, Texas**

**Volume I of II**

Contract No.: F41624-94-D-8053-0039  
Project No.: W/O 72435



November 2000

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
<small>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.</small>				
1 AGENCY USE ONLY (Leave blank)	2. REPORT DATE November 2000	3. REPORT TYPE AND DATES COVERED RCRA Facility Investigation Report January 1997 through October 1998		
4 TITLE AND SUBTITLE RCRA Facility Investigation Report, Area of Concern 2, Version 1.0 NAS Fort Worth JRB, Carswell Field, Texas		5 FUNDING NUMBERS C-F41624-94-D-8053-0039		
6. AUTHOR(S) CH2M HILL		at NAS Fort Worth JRB Carswell Field, Texas		
7 PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) CH2M HILL 5339 Alpha Road, #300 Dallas, Texas 75240		8 PERFORMING ORGANIZATION REPORT NUMBER N/A		
9 SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFCEE/ERD 3207 North Road Brooks AFB, TX 78235-5363		10 SPONSORING/MONITORING AGENCY REPORT NUMBER CDRL Nos A008A, A009A Project 72435		
11 SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for Public Release Distribution is Unlimited		12b. DISTRIBUTION CODE  A		
13 ABSTRACT (Maximum 200 words) This document represents the RCRA Facility Investigation (RFI) Report for Area of Concern 2 (AOC2) at NAS Fort Worth JRB (Carswell Field), Texas, conducted under the Defense Environmental Restoration Account (DERA). AOC2 represents the groundwater at NAS Fort Worth JRB affected by trichloroethene (TCE) contamination. The AOC2 RFI Report defines the study area addressed by the AOC2 RFI, summarizes historical activities and ongoing investigations within the study area, describes the AOC2 RFI field sampling program, presents analytical results and quality assurance/quality control information for all samples collected under the AOC2 RFI, describes the nature and extent of the AOC2 TCE plume, describes a preliminary screening assessment of natural attenuation of the TCE, and provides a risk assessment associated with the affected migration pathways.				
14. SUBJECT TERMS		15 NUMBER OF PAGES		
		16 PRICE CODE		
17 SECURITY CLASSIFICATION OF REPORT Unclassified	18 SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19 SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20 LIMITATION OF ABSTRACT Unclassified	

---

## Preface

---

This report was prepared for the Air Force Center for Environmental Excellence (AFCEE) for the purpose of documenting the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) conducted at Area of Concern 2 (AOC2) at Naval Air Station Fort Worth Joint Reserve Base (Carswell Field), Texas (NAS Fort Worth JRB).

Although AOC2 is not listed as a Solid Waste Management Unit (SWMU) in the hazardous waste permit (HW-50289) issued to NAS Fort Worth JRB (formerly Carswell Air Force Base) by the TNRCC on February 7, 1991, the RFI workplan requirements (Permit Provision VIII.A) of the permit were used as a guide in conducting the RFI. The RFI was performed in accordance with the AOC2 RFI Work Plan dated February 1998, and the Draft Basewide Quality Assurance Project Plan dated August 1996, as modified by its revision dated December 1997. This Version 1.1 of the report incorporates TNRCC and EPA Region 6 review comments on Version 1.0.

This report was prepared under Contract Number F41624-94-D-8053, Delivery Order 39, issued to CH2M HILL. Activities to be included in this contract were set forth in the Statement of Work Modification 1 dated August 19, 1996. The AFCEE Contracting Officer's Representative (COR) is Don Ficklen. CH2M HILL's Program Manager is Michael Smith, and the Project Manager is Margaret O'Hare.

# Contents

<b>1.0 Introduction .....</b>	<b>1</b>
1 1 THE USAF INSTALLATION RESTORATION PROGRAM.....	1
1.1.1 Program Origins.....	1
1.1.2 Program Objectives .....	3
1.1.3 Program Organization.....	4
1.2 SITE DESCRIPTION AND HISTORY .....	4
1.2.1 Site Description.....	4
1.2.2 Site History and Current Operations .....	5
1.2.3 Summary of Wastes Handled .. ..	6
1.2.4 Area of Concern 2 Description and Regulatory History.....	7
1 3 PREVIOUS TCE PLUME-RELATED INVESTIGATIONS .....	8
1.3.1 Air Force Plant 4 Investigations.....	8
1.3.2 NAS Fort Worth JRB Investigations.....	12
1.4 AOC2 PROJECT OBJECTIVES AND APPROACH .....	17
1.5 RFI REPORT ORGANIZATION .....	19
<b>2.0 ENVIRONMENTAL SETTING .....</b>	<b>1</b>
2.1 GEOGRAPHY.....	1
2.2.1 Land Use.....	1
2.2.2 Climate.....	1
2.2.3 Physiography .....	2
2 2 GEOLOGY AND HYDROGEOLOGY .....	2
2.2.1 Terrace Alluvium .....	3
2.2.2 Goodland Limestone/Walnut Formation Aquitard.....	4
2.2.3 Paluxy Formation Aquifer.....	5
2.3 SURFACE WATER .....	7
<b>3.0 INVESTIGATION ACTIVITIES DESCRIPTION.....</b>	<b>1</b>
3.1 RFI PROGRAM RATIONALE.....	1
3.2 RFI OBJECTIVES .. ..	2
3.3 SUMMARY OF RFI ACTIVITIES.. ..	2
3.3.1 Review of Existing Information.....	3
3.3.2 Seismic Reflection Survey .....	4
3.3.3 Direct Push Investigation.. ..	5
3.3.4 Drilling and Monitor Well Installation .....	8
3.3.5 Groundwater Sampling .....	13
3.3.6 Aquifer Testing .....	16
3.3.7 Surface Water Staff Gauge Installation .....	17
3.3.8 Investigation-Derived Waste Disposal.....	17
3.4 LABORATORY ANALYSIS AND DATA VALIDATION... ..	18
3.4.1 Analytical Procedures .. ..	18
3.4.2 Quality Assurance/Quality Control Program.....	19
3.4.3 Data Evaluation .....	22
<b>4.0 INVESTIGATION RESULTS.....</b>	<b>1</b>
4.1 IDENTIFICATION OF CONTAMINANTS OF CONCERN .....	1
4.2 SEISMIC REFLECTION SURVEY RESULTS .....	2

4.3 DIRECT PUSH INVESTIGATION RESULTS .....	4
4.3.1 Preliminary Work Plan Direct Push Investigation Results .....	4
4.3.2 RFI Direct Push Investigation Results .....	5
4.4 SUBSURFACE SOIL SAMPLE RESULTS .....	6
4.5 GROUNDWATER SAMPLE RESULTS .....	7
4.5.1 Field-Measured Natural Attenuation Parameters .....	7
4.5.2 First Groundwater Sampling Event Analytical Results (December 1997).....	8
4.5.3 Second Groundwater Sampling Event Analytical Results (February 1998).....	9
4.5.4 Third Groundwater Sampling Event Analytical Results (April 1998)..	11
4.6 STAFF GAUGE MEASUREMENT FINDINGS .....	12
4.7 AQUIFER TEST RESULTS .....	13
4.8 OVERVIEW OF STUDY AREA STRATIGRAPHIC FINDINGS .....	14
<b>5.0 NATURE AND EXTENT OF TCE-RELATED CONTAMINATION IN THE AOC2 STUDY AREA 1</b>	
5.1 TCE-RELATED CONTAMINANTS OF CONCERN .....	1
5.2 INFORMATION ON BACKGROUND LEVELS .....	2
5.3 POTENTIAL SOURCE AREAS .....	2
5.3.1 Air Force Plant 4 .....	2
5.3.2 AOC4 .....	3
5.3.3 Sanitary Sewer System (SWMU 66) .....	4
5.3.4 Other SWMUs .....	4
5.4 SOIL .....	5
5.5 GROUNDWATER .....	6
5.5.1 First Groundwater Sampling Event (December 1997) .....	6
5.5.2 Second Groundwater Sampling Event (February 1998) .....	7
5.5.3 Third Groundwater Sampling Event (April 1998) .....	9
5.6 SUMMARY .....	10
<b>6.0 FATE AND TRANSPORT OF TCE-RELATED CONTAMINANTS .....</b>	<b>1</b>
6.1 MIGRATION PATHWAYS AND HYDRODYNAMIC PROCESSES .....	1
6.1.1 Site Hydraulic Conceptual Model .....	1
6.1.2 Estimate of Future Potential West Fork Trinity River Concentrations ..	2
6.2 PRELIMINARY SCREENING OF NATURAL ATTENUATION .....	5
6.2.1 Natural Attenuation Scoring .....	5
6.2.2 Evidence of Biological Activity .....	6
6.2.3 Limitations to Reductive Dechlorination .....	7
6.2.4 Implications .....	8
<b>7.0 RISK ASSESSMENT .....</b>	<b>1</b>
7.1 CHEMICALS OF POTENTIAL CONCERN.. ..	2
7.2 EXPOSURE ASSESSMENT .....	3
7.2.1 Conceptual Site Model .....	5
7.2.2 Exposure Point Concentrations .....	5
7.3 TOXICITY ASSESSMENT .....	12
7.4 POTENTIAL THREATS TO ECOLOGICAL RECEPTORS AND RECREATIONAL USERS OF THE TRINITY RIVER	13
7.5 RISK CHARACTERIZATION .....	13
7.5.1 Soil .....	14
7.5.2 Groundwater .....	14
7.5.3 Surface Water .....	14
7.6 UNCERTAINTY ANALYSIS .....	15
7.7 CONCLUSIONS .....	16
<b>8.0 CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>1</b>

9.0 References..... 1

List of Tables

TABLE 1-1 SWMUs AND AOCs AT NAS FORT WORTH JRB ..... 20

TABLE 2-1 STRATIGRAPHIC UNITS AT AFP4 AND NAS FORT WORTH JRB . .... 10

TABLE 3-1 DATA NEEDS FOR AOC2 RFI OBJECTIVES..... . 26

TABLE 3-2 AOCs AND SWMUs LOCATED WITHIN THE AOC2 RFI STUDY AREA . .... 28

TABLE 3-3 PRELIMINARY CPT WELLS INFORMATION ..... . 32

TABLE 3-4 RFI DIRECT PUSH INVESTIGATION TEMPORARY WELL INFORMATION..... . 33

TABLE 3-5 SUMMARY OF SOIL BORING AND MONITOR WELL INFORMATION..... . 34

TABLE 3-6 GROUNDWATER SAMPLING PROGRAM . .... . 35

TABLE 3-7 STAFF GAUGE INSTALLATION INFORMATION ..... . 36

TABLE 4-1 TNRC RISK REDUCTION STANDARD NO. 2 MEDIA-SPECIFIC CONCENTRATIONS..... 16

TABLE 4-2 ONSITE GROUNDWATER ANALYTICAL DATA ... .. 17

TABLE 4-3 OFFSITE CONFIRMATION GROUNDWATER ANALYTICAL DATA .. . 18

TABLE 4-4 ONSITE GROUNDWATER ANALYTICAL DATA . .... 19

TABLE 4-5 OFFSITE CONFIRMATION GROUNDWATER ANALYTICAL DATA ... .. 20

TABLE 4-6 SOIL ANALYTICAL COC DATA ..... . 21

TABLE 4-7 DECEMBER 1997 NATURAL ATTENUATION FIELD PARAMETERS ..... 22

TABLE 4-8 APRIL 1998 NATURAL ATTENUATION FIELD PARAMETERS..... 23

TABLE 4-9 AOC2 RFI FIRST EVENT ANALYTICAL COC DATA FOR GROUNDWATER .... 24

TABLE 4-10 AOC2 RFI SECOND EVENT ANALYTICAL COC DATA FOR GROUNDWATER..... 26

TABLE 4-11 AOC2 RFI THIRD EVENT ANALYTICAL COC DATA FOR GROUNDWATER..... 28

TABLE 4-12 WATER TABLE ELEVATIONS FOR FIRST, SECOND, AND THIRD EVENTS ..... 30

TABLE 4-13 SLUG TEST HYDRAULIC CONDUCTIVITIES (JANUARY 1998)..... 32

TABLE 6-1 NATURAL ATTENUATION SCORING TABLE..... 9

TABLE 6-2 NATURAL ATTENUATION PARAMETERS (DECEMBER 1997) ..... 10

TABLE 6-3 NATURAL ATTENUATION PARAMETERS (APRIL 1998) ..... 11

TABLE 7-1 SUMMARY STATISTICS FOR SOIL AND GROUNDWATER DATA ..... 18

TABLE 7-2 COPCS DETECTED IN STUDY AREA GROUNDWATER ..... 18

TABLE 7-3 CHEMICAL EXPOSURE POINT CONCENTRATIONS IN SURFACE WATER ..... 18

TABLE 7-4 CURRENT AND FUTURE SITE CONSTRUCTION WORKER EXPOSURE FACTORS/SOIL EXPOSURE MEDIUM  
..... 18

TABLE 7-5 CURRENT AND FUTURE SITE CONSTRUCTION WORKER EXPOSURE FACTORS/GROUNDWATER  
EXPOSURE MEDIUM..... 18

TABLE 7-6 FUTURE RECREATIONAL SCENARIO EXPOSURE FACTORS/SURFACE WATER EXPOSURE MEDIUM ..... 18

TABLE 7-6A FUTURE RESIDENTIAL SCENARIO EXPOSURE FACTORS/ SURFACE WATER EXPOSURE MEDIUM..... 18

TABLE 7-7 TOXICITY VALUES AND CHEMICAL-SPECIFIC PARAMETERS FOR CHEMICALS OF CONCERN..... 18

TABLE 7-8 WATER QUALITY GOALS..... 18

TABLE 7-9 SUMMARY OF EXCESS LIFETIME CANCER RISKS AND NONCANCER HAZARD INDICES BY PATHWAY. 18

TABLE 7-10 UNCERTAINTIES ASSOCIATED WITH HUMAN HEALTH RISK ESTIMATES..... 18

LIST OF FIGURES

FIGURE 1-1 SITE LOCATION MAP ... .. 23

FIGURE 1-2 SWMU/AOC LOCATION MAP..... 24

FIGURE 1-3 GENERALIZED EXTENT OF TCE IN GROUNDWATER ... .. 25

FIGURE 1-4 EXTENT OF TCE IN GROUNDWATER AND LOCATION OF RFI STUDY AREA ..... 26

FIGURE 2-1 GENERALIZED HYDROGEOLOGIC SECTION AT AFP4 AND NAS .. . 12

FIGURE 2-2 TOP OF BEDROCK SURFACE BENEATH TERRACE ALLUVIUM..... . 13

FIGURE 2-3 BASEWIDE GROUNDWATER POTENTIOMETRIC SURFACE MAP .....	14
FIGURE 3-1 SAMPLE LOCATIONS.....	37
FIGURE 4-1 TCE CONCENTRATIONS, AOC2 RFI SAMPLING EVENTS DECEMBER 1997 – APRIL 1998.....	33
FIGURE 4-2 CIS-1,2-DCE CONCENTRATIONS, AOC2 RFI SAMPLING EVENTS DECEMBER 1997 – APRIL 1998	34
FIGURE 4-3 TRANS-1,2-DCE CONCENTRATIONS, AOC2 RFI SAMPLING EVENTS DECEMBER 1997 – APRIL 1998	35
FIGURE 4-4 1,1-DCE CONCENTRATIONS, AOC2 RFI SAMPLING EVENTS DECEMBER 1997 – APRIL 1998 .....	36
FIGURE 4-5 CROSS SECTION A .....	37
FIGURE 4-6 CROSS SECTION B .....	38
FIGURE 4-7 CROSS SECTION C .....	39
FIGURE 4-8 CROSS SECTION D .....	40
FIGURE 4-9 CROSS SECTION E.....	41
FIGURE 4-10 CROSS SECTION F.....	42
FIGURE 5-1 DISTRIBUTION OF TCE IN GROUNDWATER (DECEMBER 1997) .....	12
FIGURE 5-2 DISTRIBUTION OF TCE IN GROUNDWATER (FEBRUARY 1998). .....	13
FIGURE 5-3 DISTRIBUTION OF TCE IN GROUNDWATER (APRIL 1998).....	14
FIGURE 6-1 NATURAL ATTENUATION PARAMETER DISTRIBUTION DECEMBER 1997 . .....	12
FIGURE 6-2 NATURAL ATTENUATION PARAMETER DISTRIBUTION APRIL 1998 .....	13
FIGURE 6-3 TCE VS. DCE CONCENTRATIONS IN STUDY AREA GROUNDWATER .....	14
FIGURE 7-1 AOC2 CONCEPTUAL SITE MODEL.....	19

## LIST OF APPENDICES

APPENDIX A	GEOPHYSICAL INVESTIGATION SUBCONTRACTOR REPORT
APPENDIX B	DIRECT PUSH INVESTIGATION DATA
APPENDIX C	SOIL BORING/MONITOR WELL INSTALLATION DATA
C-1	SOIL BORING LOGS
C-2	WELL COMPLETION FORMS
C-3	WELL DEVELOPMENT FORMS
APPENDIX D	AQUIFER TEST RESULTS
APPENDIX E	FIELD SAMPLING FORMS
APPENDIX F	SAMPLE LOCATION COORDINATES
APPENDIX G	LABORATORY ANALYSIS DATA
G-1	CHAIN OF CUSTODY FORMS
G-2	SAMPLE CHRONOLOGY
G-3	RESULTS AND VALIDATION REPORTS
G-3.1	NORMAL/FIELD DUPLICATE RESULTS
G-3.2	COMPLETENESS SUMMARY
G-3.3	LCS SUMMARY
G-3.4	DETECTS SUMMARY
G-3.5	DATA QUALITY EVALUATION
G-4	STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF METHANE
APPENDIX H	INVESTIGATION DERIVED WASTE DISPOSAL REPORT
APPENDIX I	ESTIMATION OF CONCENTRATIONS IN AMBIENT AIR
APPENDIX J	DERIVATION OF THE SOIL VOLATILIZATION FACTOR AND PARTICULATE EMISSION FACTOR
APPENDIX K	HAZARD INDEX AND EXCESS LIFETIME CANCER RISK CALCULATIONS

---

## List of Acronyms and Abbreviations

---

ACOE	Army Corps of Engineers
AFB	US Air Force Base
AFBCA	Air Force Base Conversion Agency
AFCEE	Air Force Center for Environmental Excellence
AFP	Air Force Plant
AGE	Aerospace Ground Equipment
AOC	Area of Concern
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
BRAC	Base Realignment and Closure
C&ASD	Chemical & Analytical Sciences Division
CADD	computer assisted drafting and design
CAFB	Carswell Air Force Base
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/s	centimeters per second
CMS	Corrective Measures Study
COC	contaminants of concern
CPT	Cone Penetrometer Test
COR	Contracting Officer's Representative
DCE	Dichloroethene
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DERA	Defense Environmental Restoration Account
DERP	Defense Environmental Restoration Program
DO	dissolved oxygen
DoD	Department of Defense
DoE	Department of Energy
DNAPL	dense non-aqueous phase liquid
DPDO	Defense Property Disposal Office
DQO	Data Quality Objectives
EB	Ethylbenzene
EC	electrical conductivity
EDF	Electronic Data File
EPA	U.S. Environmental Protection Agency
Fe <sup>2+</sup>	ferrous iron
FHS	fuel hydrant system
ft/d	feet per day
ft/ft	feet/foot
GD	General Dynamics
GIS	geographic information system
GMI	Geo-Marine, Inc
gpd	gallons per day
HCl	hydrochloric acid
HGL	HydroGeoLogic, Inc.

---

HAS	Hollow Stem Auger
IAW	in accordance with
ID	interior diameter
IDW	investigation-derived waste
ILS	Instrument Landing System
in	inch
IRA	Interim Remedial Action
IRP	Installation Restoration Program
IRPIMS	Installation Restoration Program Information Management System
IT	IT Corporation, Inc.
ITIR	Informal Technical Information Report
JRB	Joint Reserve Base
KCl	Potassium Chloride
LAW	Law Engineering and Environmental Services, Inc.
LNAPL	light non-aqueous phase liquid
LSA	Limited Site Assessment
LTO/LTM	long-term operations/long-term monitoring
MCL	maximum contaminant level
MEK	methyl ethyl ketone
MDL	method detection limit
MGD	million gallons per day
mg/L	milligrams per liter
µg/L	micrograms per liter
MSC	media-specific concentration
MSL	Mean Sea Level
MS/MSD	matrix spike/matrix spike duplicate
NAD	North American Datum
NAS	Naval Air Station
NCP	National Contingency Plan
NFA	no further action
NIDW	noninvestigation-derived waste
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NR	not rated
NTU	nephelometric turbidity unit
OVA	organic vapor analyzer
OVM	organic vapor meter
OVS	oil/water separator
PAH	polynuclear aromatic hydrocarbon
PCE	tetrachloroethylene
PID	photoionization detector
PM	project manager
POC	Point of Contact
POTW	publicly owned treatment works
ppb	parts per billion
PPE	personal protective equipment
PR	Preliminary Review
PRP	Potentially Responsible Party
PVC	polyvinyl chloride

---

QA	quality assurance
QAL	Quality Analytical Laboratory
QAPP	Quality Assurance Project Plan
QC	quality control
RAP	Remedial Action Plan
RCRA	1976 Resource Conservation and Recovery Act
RD/RA	remedial design/remedial action
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
ROD	Record of Decision
RRS	Risk Reduction Standard
SAC	Strategic Air Command
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCAPS	Site Characterization and Analysis Penetrometer System
SCS	Site Characterization Study
SWMU	Solid Waste Management Unit
SVOC	semi-volatile organic compound
TAC	Texas Administrative Code
TCA	trichloroethane
TCE	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TL	task leader
TNRCC	Texas Natural Resource Conservation Commission
TOC	total organic carbon
TOX	total organic halogens
TPH	total petroleum hydrocarbon
TSS	Total Support Services, Inc.
TWC	Texas Water Commission
USAF	United States Air Force
USACOE	U.S. Army Corps of Engineers
USCS	United Soil Classification System
USGS	U.S. Geological Survey
UST	underground storage tank
VOC	volatile organic compound
VRP	Vertical Reflection Profile
VSI	Visual Site Inspection
WAA	Waste Accumulation Area
WSA	Weapons Storage Area
%D	percent difference

# TAB

Section 1 : Introduction

---

# 1.0 Introduction

---

This document represents the Resource Conservation and Recovery Act Facilities Investigation (RFI) Report for Area of Concern 2 (AOC2) at Naval Air Station Fort Worth Joint Reserve Base (Carswell Field), Texas (NAS Fort Worth JRB). The RFI for NAS Fort Worth JRB has been conducted under the United States Air Force (USAF) Installation Restoration Program (IRP). This section provides an overview of the IRP, and a brief description of NAS Fort Worth JRB, including a summary of activities performed there, a summary of wastes handled, an introduction to AOC2, and a brief summary of previous investigations and removal activities that directly relate to AOC2. A summary of project objectives, approach, and report organization are found at the end of this section.

## 1.1 THE USAF INSTALLATION RESTORATION PROGRAM

The objective of the IRP is to assess past hazardous waste disposal and spill sites at USAF installations and to develop remedial actions consistent with the National Contingency Plan (NCP) for sites that pose a threat to human health and welfare or the environment. This section presents background information on the program origins, objectives, and organization.

### 1.1.1 Program Origins

The 1976 Resource Conservation and Recovery Act (RCRA) is one of the primary federal laws governing the disposal of hazardous wastes (as amended by the 1984 Hazardous and Solid Waste Amendment). Sections 6001 and 6003 of RCRA require federal agencies to comply with local and state environmental regulations and provide information to the U.S. Environmental Protection Agency (EPA) concerning past disposal practices at federal sites. RCRA Section 3012 requires state agencies to inventory past hazardous waste disposal sites and provide information to the EPA concerning those sites.

---

In 1980, Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund), which outlines the responsibility for identifying and remediating contaminated sites in the United States and its possessions. The CERCLA legislation identifies the EPA as the primary policy and enforcement agency regarding contaminated sites.

The 1986 Superfund Amendments and Reauthorization Act (SARA) extends the requirements of CERCLA and modifies CERCLA with respect to goals for remediation and the steps that lead to the selection of a remedial process. Under SARA, technologies that provide permanent removal or destruction of a contaminant are preferable to action that only contains or isolates the contaminant. SARA also provides for greater interaction with public and state agencies and extends the EPA's role in evaluating health risks associated with contamination. Under SARA, early determination of Applicable or Relevant and Appropriate Requirements (ARARs) is required, and the consideration of potential remediation alternatives is recommended at the initiation of a Remedial Investigation/Feasibility Study (RI/FS). SARA is the primary legislation governing remedial action at past hazardous waste disposal sites.

Executive Order 12580, which was adopted in 1987, gave various federal agencies, including the Department of Defense (DoD), the responsibility to act as lead agencies to conduct investigations and implement remediation efforts when they are the sole contributor or co-contributor to contamination on or off their properties.

In response to Executive Order 12580, the DoD developed the IRP, under the Defense Environmental Restoration Program (DERP), to identify potentially contaminated sites, investigate these sites, and evaluate and select remedial actions for contaminated facilities. The DoD issued Defense Environmental Quality Program Policy Memorandum (DEQPPM) 80-6 regarding the IRP program in June 1980, and implemented the policies outlined in this memorandum in December 1980.

The DoD formally revised and expanded the existing IRP directives and amplified all previous directives and memoranda concerning the IRP through DEQPPM 81-5, dated

December 11, 1981. The memorandum was implemented by a USAF message dated January 21, 1982.

The IRP is the DoD's primary mechanism for response actions on USAF installations affected by the hazardous waste provisions of RCRA and SARA. Over the years, requirements of the IRP have been developed and modified to ensure that DoD compliance with federal laws, such as RCRA, NCP, CERCLA, and SARA, can be met.

### 1.1.2 Program Objectives

The objectives of the IRP include the following:

- Identification and evaluation of sites where contamination may be present on DoD property as a result of past hazardous waste disposal practices, spills, leaks, or other activities.
- Control of the migration of hazardous contaminants.
- Control of health or environment hazards that may result from past DoD disposal operations.

The alternatives that are proposed and solutions that are developed must protect public health and the environment, meet ARARs, and be technically feasible to implement at the evaluated site. To meet these objectives, the following program tasks are required:

- Development of a project database through literature search, field investigation, laboratory analysis, and data evaluation.
- Development and implementation of a Quality Assurance/Quality Control (QA/QC) program to ensure meaningful and defensible data.
- Development of, and adherence to, site and laboratory safety plans to protect the health and safety of personnel and to prevent the release of contaminants.
- Identification of data gaps and recommendations for additional data-gathering efforts to be performed during the IRP.

- 
- Use of rigorous procedures to identify, evaluate, and select appropriate solutions.
  - Performance of the IRP in compliance with applicable federal, state, and local regulations and guidance.

### 1.1.3 Program Organization

The IRP is a CERCLA-based environmental restoration program, which mimics the phases of investigation defined under Superfund, including initial assessment, confirmation/quantification, remedial action evaluation, and remedial action implementation activities. For non-NPL sites, other applicable regulatory processes, such as RCRA, apply. A RFI such as that conducted for AOC2 under the IRP, addresses the requirements of the EPA RFI process.

## 1.2 SITE DESCRIPTION AND HISTORY

This section provides a description and brief history of NAS Fort Worth JRB, its current operations, and a summary of the wastes handled. A description of SWMUs and AOCs identified at the base, with specific detail relative to AOC2, the subject of this RFI report, is also provided.

### 1.2.1 Site Description

NAS Fort Worth JRB is located on 2,555 acres of land in Tarrant County, Texas, eight miles west of Fort Worth (**Figure 1-1**). It lies between the communities of White Settlement and River Oaks, within a bend of the West Fork Trinity River that flows along the eastern boundary of the base. The river is dammed to form Lake Worth, a drinking water supply and recreation reservoir bordering NAS Fort Worth JRB to the north. To the west, NAS Fort Worth JRB is bounded by Air Force Plant 4 (AFP4) and by the community of White Settlement. AFP4 is an aircraft production plant that shares the runway and several facilities with NAS Fort Worth JRB, and is operated by Lockheed Martin for the USAF. NAS Fort Worth JRB is bordered on the east by the communities of River Oaks, Westworth Village, and other urban developments. Two off-site facilities, the Instrument Landing

---

System (ILS) marker beacon and the Weapons Storage Area (WSA), are also part of the JRB. Both are located west of the town of White Settlement, to the west of the area shown in Figure 1-1.

## 1.2.2 Site History and Current Operations

Prior to 1941, the area that is now occupied by NAS Fort Worth JRB consisted of woods and pasture in an area called White Settlement. In August 1942, the base was opened as Tarrant Field Airdrome. The original mission was to train pilots to fly the new B-24 Liberator, which was being constructed by the Consolidated Aircraft Corporation (located across the runway at what is now AFP4).

Construction at the airfield continued into 1943, extending the runway and taxiways, and erecting hangars and additional facilities. In May 1943, the field was re-designated as Fort Worth Army Air Field. The training mission continued and in January 1945, the Army Air Field began to operate a transition school for the B-32 aircraft which, like the B-24, was manufactured across the runway. The 7th Bombardment Group was assigned to the Fort Worth Army Air Field in October 1946 with B-29 aircraft.

The Strategic Air Command (SAC) assumed command of the facility in 1946, and it was renamed Carswell Air Force Base (CAFB) in 1948. The SAC mission remained at CAFB until 1992, when Air Force reductions resulted in the closure of CAFB and the Air Combat Command assumed control of the base. In October 1994, the US Navy assumed responsibility for the facility. Officers, personnel, mobile, and stationary equipment from CAFB and Naval Air Stations in Dallas, Texas, Memphis, Tennessee, and Glenview, Illinois, were combined to streamline the naval budget and place key people and equipment in one central location. The name of the facility was changed from CAFB to Naval Air Station Fort Worth Joint Reserve Base (NAS Fort Worth JRB).

At the time of initiation of this RFI, NAS Fort Worth JRB headquartered 400 officers, 1400 civil employees, and 1800 active reservists, with approximately 125 assorted aircraft and over 200 separate buildings. Temporary military reservists on base for drills were expected to increase the number of part-time personnel to over 6,000. NAS Fort Worth JRB functions

---

as a self-sustaining community, with its own fire department, police force, public works department, air terminal, medical/dental clinic, gas stations, and numerous training and service facilities.

### 1.2.3 Summary of Wastes Handled

The principal activities on the base have been maintenance and service of bombers, fuel tankers, and fighter jet aircraft. Many of the activities have been in conjunction with AFP4, which has been successively operated by Consolidated Aircraft Corporation, Consolidated Vultec Corporation, General Dynamics Corporation, and most recently, Lockheed Martin. Servicing and maintenance of the engines and equipment of the multi-engined B-52 and KC-135 aircraft generated the majority of waste liquids at the base.

Most of the liquid waste generated by the industrial operations can be categorized as waste oils, recoverable fuels, and spent solvents and cleaners. Waste oils are generally lubricating fluids, such as crankcase oils and synthetic turbine oils, and hydraulic fluids. Recoverable fuel refers to fuel drained from aircraft tanks and vehicles, such as JP-4 and MOGAS (unleaded gasoline). Spent solvents and cleaners refer to liquids used for degreasing and general cleaning of aircraft, aircraft systems, electronic components, and vehicles. This category includes PD-680 (petroleum naphtha) and various chlorinated organic compounds, such as carbon tetrachloride, trichloroethene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA).

The specific types of solvents used by the USAF have changed over the years. Carbon tetrachloride was the most commonly used solvent in the 1950s, being replaced by TCE around 1960. TCE usage decreased steadily over the years in favor of 1,1,1-TCA, although both were commonly used. Today, PD-680 (Type II), 1,1,1-TCA and, to a limited extent, TCE are in common use. Waste paint solvents or thinners and strippers are generated by corrosion control activities. Typical thinners include isobutyl acetate, toluene, methyl ethyl ketone (MEK), isopropanol, naphtha, and xylene. Paint strippers generally contain such compounds as methylene chloride, toluene, ammonium hydroxide, and phenolics.

Since 1942, most hazardous waste generated through operations and activities at the base has been disposed in landfills, reused on base, or processed through the Defense Property Disposal Office (DPDO) for off-base recycling or disposal.

## 1.2.4 Area of Concern 2 Description and Regulatory History

The IRP was initiated in 1984 at NAS Fort Worth JRB (while it was still CAFB) with a Phase 1 records search to identify past waste disposal activities that may have resulted in groundwater contamination and/or off-site migration of contaminants. Seventeen sites on the base and 5 sites at the off-site WSA were identified as requiring further evaluation (CH2M HILL, 1984). All 22 sites were ranked based on environmental setting, past waste disposal practices, and contaminant migration potential. Ten of these sites subsequently were determined not to present a significant concern for adverse human health or environmental effects.

The remaining 12 sites were selected for Phase II Confirmation/Quantification investigations (Radian, 1986 and 1989). In 1989, EPA conducted the Preliminary Review/Visual Site Inspection (PR/VSI) portions of a RCRA Facility Assessment (RFA) for the then CAFB (USEPA, 1989a). A hazardous waste permit (HW-50289) was issued to the base by the Texas Natural Resource and Conservation Commission (TNRCC) on February 7, 1991.

Sixty-eight SWMUs and 15 AOCs are currently identified at NAS Fort Worth JRB (Table 1-1). Their locations are shown on Figure 1-2. Sites that are currently considered off-base (as a result of base closure activities) are being managed by AFCEE under Base Realignment and Closure (BRAC), while the portions of the base currently used (or planned to be used) by NAS are being managed by AFCEE under the Defense Environmental Restoration Account (DERA). Table 1-1 and Figure 1-2 also show which sites are managed under each program.

Since 1990, site-specific investigations have been conducted at various SWMUs and AOCs (including landfills, fire training areas, oil/water separators, and waste accumulation areas) to support remediation and/or closure of sites. Some were determined by TNRCC to require no further action (NFA) and are currently considered closed; others are considered by AFCEE to qualify for NFA pending the results of ongoing studies. Specific SWMU investigations that are either directly or indirectly associated with AOC2 are discussed in Section 1.3.2.

AOC2 is defined as all areas on NAS Fort Worth JRB where TCE is detected in groundwater. The generalized extent of TCE contamination considered as AOC2 is shown in Figure 1-3; this plume has been generally referred to as consisting of three lobes: a southern lobe, a central lobe, and a northern lobe. Groundwater contamination within the AOC2 plume is not limited to TCE and may include other contaminants, in particular those related to activities involving fuel products (specifically benzene, toluene, ethylbenzene, and xylene [BTEX compounds]). As described in Section 1.4, based on the status of other ongoing investigations and identified data gaps, the AOC2 RFI has been focused to specifically address the northern lobe of the AOC2 TCE plume.

## 1.3 PREVIOUS TCE PLUME-RELATED INVESTIGATIONS

The following discussions describe the history of investigations related to the TCE plume at AFP4 (upgradient of NAS Fort Worth JRB), and within the AOC2 RFI study area at NAS Fort Worth JRB. (The AOC2 RFI study area encompasses the northern lobe of the TCE plume shown on Figure 1.3; this study area is described in Section 1.4.)

### 1.3.1 Air Force Plant 4 Investigations

According to the Record of Decision (ROD) for AFP4 (US Department of the Air Force, 1996), suspected contamination at AFP4 was first noted in 1982 by a private citizen. Within months, several investigations were started. The USAF investigation of groundwater contamination beneath AFP4 began in 1984. A RI/FS for AFP4 was initiated in 1990 and the completed RI/FS was approved in 1995. The proposed plan for remedial action was issued in 1995 and the ROD signed in 1996. Several interim remedial actions were implemented to mitigate the effects of contamination at the site before the final remedies were approved. These actions included removal of contaminated soil and installation of extraction wells, french drains, a pilot-scale soil-vapor extraction system, and a groundwater extraction and treatment system. A Remedial Design Investigation was completed recently. Details of previous investigations are described in the following subsections.

### 1.3.1.1 Investigation History

The IRP was initiated at AFP4 in March 1984 by the USAF. As a result of the Phase I investigation, 21 sites were identified as sources of contamination due to past waste disposal practices at the facility (CH2M HILL, 1984). Shallow groundwater contaminated with TCE beneath the East Parking Lot at AFP4 (just west of the AFP4/NAS Fort Worth JRB boundary) was one of the 21 sites identified for remediation under the IRP. This area is located west of the "southern lobe" of NAS Fort Worth JRB TCE extent shown on Figure 1-3.

Studies conducted in 1985 found the Walnut Formation (a confining unit between the Shallow Terrace Alluvial Aquifer and the deeper Paluxy Aquifer) (see Section 2 for a description of local geology/hydrogeology), to be extremely thin in areas on the east side of the facility. In addition, high concentrations of chlorinated hydrocarbons and unusually high water levels were observed in an East Parking Lot monitor well (Hargis & Associates, Inc., 1989). The report concluded that a "window" existing under the East Parking Lot might be serving as a flow path for contaminated groundwater from the Terrace Alluvial Aquifer to recharge the uppermost water-bearing unit of the Paluxy Formation.

In 1985, the USAF retained the US Army Corps of Engineers (USACOE) to further investigate the "window" area by studying geophysical logs and proposing a monitoring program for the Paluxy. They also retained Radian Corporation to begin the IRP Stage I and II Investigations to define the presence, magnitude, extent, direction, and rate of movement of any identified contaminants at AFP4, including the East Parking Lot groundwater plume.

Based on USACOE's recommendations, a "window area" investigation was conducted between November 1986 and April 1987 (Hargis & Associates, Inc., 1987). Three monitor wells were installed and monitored: one in the Terrace Alluvial Aquifer, one in the Upper Paluxy Formation, and one in the Upper Paluxy Sand (the first water-bearing unit of the Paluxy). As a result of the IRP Phase II investigation, which was completed in 1987, the extent and degree of contamination at the sites was identified (Radian, 1987). The presence of TCE, dichloroethene (DCE), and chromium in groundwater beneath the AFP4 East

Parking Lot, and the distribution of these contaminants from the site onto NAS Fort Worth JRB, was confirmed.

In July 1989, a report was prepared that summarized the conclusions and recommendations of investigations conducted at AFP4 between January 1987 and April 1989 (Hargis & Associates, Inc., 1989). The contaminants detected most often on the east side of AFP4 (chromium, TCE, and trans-1,2-DCE) were believed to have originated from various sources on AFP4. The distribution of these contaminants was believed to be influenced by groundwater flow in the basal gravel of the Terrace Alluvial Aquifer (the primary migration pathway) and an erosional channel (the "window area") in the Walnut Formation, where over a limited area contaminated groundwater could flow to the underlying Paluxy Formation. TCE detected in groundwater from wells located on NAS Fort Worth JRB (southern and central lobes) was attributed in part to AFP4 and in part to unidentified sources on NAS Fort Worth JRB. Further hydrogeologic characterization of the Paluxy, in addition to aquifer testing of the Terrace Alluvial Aquifer and the Upper and Middle Paluxy Formations, was recommended. Soon after conducting their final groundwater sampling round in January 1990, Hargis' contract expired. RI/FS activities were resumed at AFP4 in December 1990. Sampling indicated that TCE dense non-aqueous phase liquid (DNAPL) might be migrating along a paleochannel beneath the AFP4 East Parking Lot area and that TCE DNAPL might also be present elsewhere under AFP4 (US Department of the Air Force, 1996).

In March 1991, AFCEE established a groundwater monitoring program at AFP4 to aid in the implementation of the final Remedial Action Plan (RAP) under the IRP. The objectives of the sampling were to monitor changes in water quality in the Terrace Alluvial and Paluxy Aquifers and in surface waters adjacent to AFP4, and to monitor contaminant plumes and the effect of interim remedial actions on plume concentrations. This sampling has been conducted quarterly since April 1992 (Jacobs, 1996; Jacobs, 1998).

In August 1992, the USAF contracted USACOE for several tasks, including the installation of a recovery and treatment system for TCE-contaminated groundwater in the "window" area and delineation of the TCE plume on NAS Fort Worth JRB. In 1993, USACOE retained IT Corporation for the design and operation of the groundwater treatment system, and Geo-

Marine, Inc. (GMI) for the TCE plume delineation. The TCE extent boundary shown on Figure 1-3 was interpreted in part from GMI's data. General Dynamics (GD) provided support for these projects. The groundwater treatment system and others at AFP4 were installed in 1992 and 1993. Some have operated continuously, while others have operated only intermittently.

An investigation to support a remedial design for the East Parking Lot has been completed recently, and the report documenting this work is pending. Investigation activities included monitor well installation, aquifer testing, groundwater and soil sampling, and tracer studies to identify DNAPL in the East Parking Lot area (Jacobs, 1998).

### 1.3.1.2 AFP4 REGULATORY HISTORY AND RECORD OF DECISION

In August 1990, after EPA placed AFP4 on the National Priorities List (NPL), the USAF, EPA, and the Texas Water Commission (TWC, now the TNRCC) signed a Federal Facility Agreement under which the facility would conduct RI/FS activities by specified dates. In July of 1996, the Final ROD for AFP4 (US Department of the Air Force, 1996) was issued. The ROD addressed the final response actions required for remediation of soil, sediment, and groundwater in all areas of the site. Major components of the selected groundwater remedy for the Paluxy Aquifer and Upper Sand Groundwater include:

- Extracting contaminated groundwater from the Paluxy Aquifer and the Upper Paluxy Sand in the East Parking Lot area, if contaminant concentrations exceed maximum contaminant levels (MCLs).
- Treating the extracted groundwater with ultraviolet oxidation or similar technology with off-gas treatment that results in near-zero atmospheric emissions, and discharging the treated water to surface water or to a publicly owned treatment works (POTW).
- Monitoring the movement of contamination in the Paluxy Aquifer and the Upper Paluxy Sand, and installing additional monitor wells, as needed.

Major components of the selected remedy for the East Parking Lot groundwater plume (in the Terrace Alluvial Aquifer) include:

- 
- Removal of DNAPL by enhanced dissolution, followed by groundwater extraction.
  - Treatment of extracted groundwater with air stripping, followed by discharge of the treated water to surface water or POTW. Potential use of a physical or hydraulic barrier to separate the "window" area of the Terrace Alluvial Aquifer from areas upgradient of the "window."
  - Installation of soil-gas probes to monitor selected remedy performance.

A key component of the ROD related to the Paluxy Aquifer, the Upper Paluxy Sand, and the East Parking Lot plume includes prevention of migration of contaminated groundwater (above MCLs) off property controlled by AFP4 or NAS Fort Worth JRB. Another key component is prevention of excess risk in surface water. Contaminant levels established for these goals are dependent on the groundwater discharge points (Farmers Branch Creek or the West Fork Trinity River). As stated in the previous section, investigations to support preparation of a remedial design for the East Parking Lot plume have been completed recently.

### **1.3.2 NAS Fort Worth JRB Investigations**

Multiple investigations have been conducted at NAS Fort Worth JRB since the base-related SWMUs and AOCs were first identified in 1984. The following paragraphs summarize specific SWMU/AOC and other investigations that address sites or sampling locations within the area of the northern lobe of the AOC2 TCE plume, the focus of this RFI. Included are descriptions of investigations related to the Basewide Groundwater Sampling & Analysis Program, the Fuel Hydrant System (AOC4), the Sanitary Sewer System SWMU 66), Building 1628, Landfill No. 9 SWMU 30), Waste Accumulation Areas, and underground storage tanks.

#### **1.3.2.1 BASEWIDE GROUNDWATER SAMPLING AND ANALYSIS PROGRAM**

Basewide groundwater sampling has been conducted at NAS Fort Worth JRB wells since April 1995: quarterly through April 1996 (Law Engineering, 1996), and again quarterly since January 1997. Eleven sampling rounds have been conducted since the initiation of basewide groundwater sampling. The current Basewide Quarterly Groundwater Sampling

and Analysis Program (GSAP) was initiated in January 1997 (CH2M HILL, 1996a); the most recent quarterly sampling was conducted in July 1998 (HGL, 1998). The next sampling event is scheduled to be conducted in October, 1998 by HydroGeoLogic, Inc. (HGL). Quarterly groundwater monitoring has also been conducted at AFP4, which includes wells on the western portion of NAS Fort Worth JRB (Jacobs, 1996).

The purpose of the NAS Fort Worth JRB Basewide Quarterly GSAP is primarily to monitor downgradient groundwater plume extent and migration patterns while the various site investigations are ongoing. This program supplied the basewide groundwater levels presented in Section 2, and applicable analytical results were used to confirm AOC2 plume extent described in Section 5.

#### **1.3.2.2 FUEL HYDRANT SYSTEM (AREA OF CONCERN 4)**

The Fuel Hydrant System, located along the western edge of the Alert Apron (Figure 1-2), distributed fuel from the tank farms to the flight apron fueling areas since the opening of the base in the 1940s. This system was removed from operation and dismantled during various investigation phases in the early 1990s. After removal of the pump stations and associated components, direct push studies were conducted to delineate fuel-related soil contamination potentially associated with releases from the system (GMI, 1995).

AFCEE has contracted HGL to conduct a groundwater and soil investigation of BTEX-related contamination resulting from operation of the Fuel Hydrant System (known as AOC4, which includes the fueling location known as Spot-35). The field effort, described by HGL's work plan dated August 1997 (HGL, 1997), was completed in September 1998, and consisted of sampling 17 new and existing groundwater monitor wells for volatile organic compounds (VOCs), petroleum aromatic hydrocarbons (PAHs), and total petroleum hydrocarbons (TPHs). Ten soil borings were completed and soil samples collected and analyzed for VOCs, PAHs, and TPH. A report describing the findings of this investigation is expected to be submitted following data evaluation by HGL (HGL, 1998e).

### **1.3.2.3 BUILDING 1628 INVESTIGATIONS (SWMUS 5, 6, 7, 8)**

Building 1628 was formerly the Aerospace Ground Equipment (AGE) Maintenance Shop, and operations there included corrosion control activities. This building, which includes several SWMUs, is discussed individually here due to the presence of several contamination source issues. Wastes generated from the activities in the building included antifreeze and paint strippers and thinners. A Waste Accumulation Area (SWMU 5) and Wash Rack and Drain (SWMU 6) were identified during the initial records search in 1984 as being located inside Building 1628. Both of these units were reported as removed in the early 1990s (refer also to Section 1.3.2.6). An oil/water separator (SWMU 7) and a sludge collection tank (SWMU 8) located outside Building 1628, which received waste from the AGE Maintenance Shop are still in place (refer to Section 1.3.2.4). There are also several underground storage tanks (USTs) in the area, associated with a fueling system adjacent to Building 1628, and free product has historically been identified in the groundwater (refer to Section 1.3.2.7).

### **1.3.2.4 SANITARY SEWER RCRA FACILITY INVESTIGATION (SWMU 66 AND SWMUS 7, 40, AND 41)**

IT Corporation was contracted by AFCEE to perform a RFI of the Sanitary Sewer System at NAS Fort Worth JRB. The investigation was completed and the RFI report submitted in September 1997 (IT Corporation, 1997). The purpose of this investigation was to determine the nature and extent of any contamination resulting from releases into the environment from the basewide Sanitary Sewer System and connecting oil/water separators (OWS), several of which are located within the north lobe area of the AOC2 TCE plume (SWMUs 7, 40, and 41).

According to the RFI Report, low concentrations of both organic and inorganic constituents were detected in soil samples collected as part of the RFI across the base; however, there was no specific pattern of contaminants or concentrations that would indicate a point source release from the Sanitary Sewer System (IT Corporation, 1997). Groundwater sample results also showed no significant contamination in groundwater directly attributable to the Sanitary Sewer System. Detection of TCE across the base during Sanitary Sewer System RFI sampling was attributed to AOC2, and was not considered a result of any point releases

from the Sanitary Sewer System. Human health and ecological risk assessments concluded that the Sanitary Sewer System is not a source of unacceptable human health risk and projected no unacceptable overall ecological risk indicator to wildlife receptor species (IT Corporation, 1997).

OWSs at Building 1628 (SWMU 7), Building 1643 (SWMU 40), and Building 1414 (SWMU 41), which are those OWSs located within the northern lobe area of the AOC2 plume, were included in the Sanitary Sewer RFI sampling effort. The Building 1643 OWS (SWMU 40) is located along the eastern edge of the AOC2 plume; no TCE or PCE was detected in near-surface or subsurface soil samples. The Building 1628 OWS (SWMU 7) is located within the AOC2 plume extent, south of the Alert Apron; of all of the near-surface and subsurface soil samples collected there, only one detection of TCE was reported at a low (estimated below quantitation limits) value. The Building 1414 OWS (SWMU 41) is also located within the northern lobe AOC2 TCE plume extent; no detections of organic compounds were reported in either near surface or subsurface soil samples collected there (IT Corporation, 1997).

#### **1.3.2.5 WASTE ACCUMULATION AREAS (SWMUS 5, 11, 12, 13, 32, 33, 39, 42)**

Several Waste Accumulation Areas (WAAs) are located within the area of the north lobe of the AOC2 TCE plume (see Figure 1-2 for SWMU locations). Several of these sites are being addressed under a specific sampling effort being conducted to confirm the lack of significant releases from these WAAs, and to provide supporting documentation for closure. For this effort, HGL has been contracted by AFCEE to conduct confirmation soil and groundwater sampling for analysis of 40 CFR Part 264 Appendix IX VOCs, semi-volatile organic compounds (SVOCs), and metals. This effort is currently in the planning stage (HGL, 1998e), but was not scheduled when the AOC2 RFI was initiated.

These sites include the WAA at Building 1628 (SWMU 5), mentioned in Section 1.3.2.3 above, which was used to stage the AGE Maintenance Shop wastes (waste paint and thinners, MEK, antifreeze, and batteries). This SWMU is included in HGL's proposed WAA sampling effort to support closure.

The SWMU 11 WAA was located in Building 1617 where printed circuit boards were produced; the process generated etchant and lacquer thinner/ink residue. The nearby

SWMU 12 WAA was located in Building 1619, a jet engine repair shop, which generated PD-680, jet fuel, and engine oil. Neither of these WAAs currently exist, but contaminant releases to the soil were suspected at the SWMU 12 WAA (CH2M HILL, 1996c). Both of these sites are currently included in HGL's proposed WAA sampling effort.

The SWMU 13 WAA was located in Building 1710, a former photographic film-developing location; spent photograph fixer would have been staged at this location. This WAA does not currently exist, and no releases were suspected based on historical records or visual observations (CH2M HILL, 1996c).

The SWMU 32 WAA was located at Building 1410, another jet engine repair shop, which generated PD-680, JP-4, engine oil, solvents, and degreasers. The SWMU 33 WAA was located in Building 1420, a maintenance and inspection location for munitions trailers; wastes generated included PD-680 Type II, hydraulic fluid, and brake fluid. Both of these WAA's are currently also included in HGL's proposed sampling effort (HGL, 1998e).

#### **1.3.2.6 LANDFILL NO. 9 (SWMU 30)**

Landfill No. 9 is located in the northeast portion of the base along the eastern boundary of the AOC2 study area boundary, and adjacent to the West Fork Trinity River. Although not situated within the TCE plume and not therefore a potential source area, this landfill is described here because it may be present within a future downgradient migration pathway of the TCE plume. The unit was reported to have been used to dispose clean construction rubble and trees. No hazardous materials are reported to be buried at the site, although materials with hazardous constituents may have been disposed there (CH2M HILL, 1996). HGL was contracted by AFCEE to conduct a soil and groundwater investigation of the site in order to close the landfill. This investigation is presently ongoing; investigation activities are described by HGL's work plan (HGL, 1997a). To-date, the landfill boundaries have been defined, and soil borings have been completed. Soil samples were submitted for Appendix IX analysis, and groundwater monitor wells are scheduled to be installed in November 1998. A report describing the findings of this investigation is pending (HGL, 1998e).

### 1.3.2.7 UNDERGROUND STORAGE TANK SITES

Fuel storage and transmission at various locations on the NAS Fort Worth JRB facility have occurred since operations began in the 1940s. Miscellaneous underground storage tanks located throughout the base have been in use over time. HGL has been contracted by AFCEE to conduct investigations of several of these UST sites on base, including four sites within the AOC2 study area. These sites are located at Buildings 1411 (UST Nos. 1411-1, 1411-2, and 1411-3), 1427 (UST No. 1427-1), 1750 (UST Nos. 1750-1 and 1750-2), and 4136 (4136-1). The work has been proposed but not yet initiated. Proposed activities at these sites include completion of multiple soil borings at each site for analysis of VOCs (8260B/5035), TPH (418.1), and PAHs (8310) (HGL, 1998e).

In 1993, following confirmation of releases from the USTs adjacent to Building 1628, the Building 1628 tanks (which contained gasoline, diesel, and JP-4) were removed and the contaminated soil was backfilled into the excavated area. In 1994, USACOE performed an investigation to determine the extent of groundwater contamination attributable to these Building 1628 USTs, collecting soil samples and installing and sampling three monitor wells (USACOE, 1994). Results indicated that soil contamination by BTEX compounds was limited to the approximate extent of the former tankhold. Groundwater contamination identified in the monitor wells (BTEX compounds as well as TCE and its degradation products) was documented downgradient, and in subsequent groundwater sampling events (Law, 1995b, and Law, 1996), two of the wells were found to contain floating free product (fuel-related). Additional soil borings and monitor well installations were performed in this area in December 1996 (Lance Key, 1997).

## 1.4 AOC2 Project Objectives and Approach

This report addresses the requirements of an RFI for AOC2 in order to support future closure of the site. The general objective of an RFI is to obtain data that support the development and evaluation of alternatives for a Corrective Measures Study (CMS). This includes characterization of the environmental setting, definition and characterization of source(s), delineation of contamination extent in all media, and identification of potential receptors.

---

More specifically, the primary objectives for the AOC2 RFI are:

1. Delineation of the potential sources of TCE and related contaminants that are contributing to the northern lobe of groundwater contamination occurring in AOC2.
2. Physical identification of primary flow paths within the Terrace Alluvial, and potentially to the Paluxy Aquifer in the northern lobe of AOC2.
3. Delineation of the nature and extent of the northern lobe of groundwater contamination by TCE and related contaminants in the AOC2 study area.
4. A fate and transport assessment which, in conjunction with the known nature and extent of contamination, will help determine the on-site and/or off-site sources responsible for the present contaminant distribution within AOC2, and the extent to which natural attenuation is occurring within the AOC2 contaminant plume.
5. A risk characterization to evaluate the risk posed to human health and the environment by the constituents encountered in soils and groundwater that define AOC2.

As described previously, the geographic boundaries of AOC2 have previously not been well defined, and the sources of contamination within AOC2 have not been definitively identified. Based on current knowledge of the relative distribution of TCE and BTEX in groundwater and potential sources (AFP4 and other areas on NAS Fort Worth JRB), RFI activities were focused in the area encompassing the Alert Apron, extending to the eastern and western property boundaries of NAS Fort Worth JRB ("study area"). The study area includes the northern lobe of TCE groundwater contamination and is shown on Figure 1-4.

Focusing the investigation activities in this area was expected to provide the data required to sufficiently delineate the as-yet unattributed TCE plume in the northern lobe, and provide data to support identification of probable source(s). To that end, the following tasks were identified: Data Evaluation and Review of Existing Data; Field Investigation; Data Management and Validation; Data Evaluation, Including Fate and Transport; Risk Characterization; and RFI Report

The results of performance of these tasks are described in this report.

## 1.5 RFI Report Organization

Section 2.0 of this report includes a discussion of the environmental setting and a summary of findings regarding the nature and extent of groundwater contamination reported in previous investigations. Section 3.0 describes the field investigation and analytical programs including the drilling, sampling, laboratory, and data evaluation activities conducted and any deviations from the work plan. Section 4.0 presents the field and analytical results from the completed RFI activities and data validation documentation. Section 5.0 presents the evaluation of the nature and extent of contamination in groundwater and soil based on AOC2 RFI results as supplemented by data collected during other investigations. The fate and transport discussion and results of a preliminary screening of the occurrence of natural attenuation is presented in Section 6.0. Section 7.0 presents the human health and ecological risk characterizations. Section 8.0 provides a summary of the AOC2 RFI findings, and Section 9.0 lists the references utilized in preparation of this report. Tables and figures for each section of the report are provided at the conclusion of each applicable section.

Provided in the Appendices are the geophysical investigation subcontractor report (Appendix A); the direct push investigation data, including cone penetrometer test logs and onsite mobile laboratory groundwater sample results (Appendix B); the soil boring and monitor well installation data, including soil boring logs, well completion forms, and well development forms (Appendix C); the aquifer test result calculations (Appendix D); the groundwater and soil field sampling forms (Appendix E); sample location coordinates (Appendix F); the offsite laboratory analysis data, including chain of custody forms, analytical results, and validation reports (Appendix G); the investigation-derived waste disposal report (Appendix H); and the risk assessment calculations, including the estimation of contaminant concentrations in ambient air (Appendix I); derivation of soil volatilization and particulate emission factors (Appendix J); and the hazard index and excess lifetime cancer risk calculations (Appendix K).

**Table 1-1**  
**SWMUs and AOCs at NAS Fort Worth JRB**

<b>SWMU No.</b>	<b>Description</b>	<b>AFCEE Office of Primary Responsibility</b>
1*	Pathological Waste Incinerator	BRAC
2*	Pathological Waste Storage Shed	BRAC
3*	Metal Cans	BRAC
4*	Facility Dumpsters	BRAC
5	Building 1628 Waste Accumulation Area	DERA
6	Building 1628 Wash Rack & Drain	DERA
7	Building 1628 Oil/Water Separator	DERA
8	Building 1628 Sludge Collection Tank	DERA
9*	Building 1628 Work Station Waste Accumulation Area	DERA
10*	Building 1617 Work Station Waste Accumulation Area	DERA
11	Building 1617 Waste Accumulation Area	DERA
12	Building 1619 Waste Accumulation Area	DERA
13	Building 1710 Waste Accumulation Area	DERA
14*	Building 1060 Bead Blaster Collection Tray	DERA
15*	Building 1060 Paint Booth Vault	DERA
16	Building 1060 Waste Accumulation Area	DERA
17	Landfill No. 7	DERA
18*	Fire Training Area No. 1	BRAC
19	Fire Training Area No. 2	BRAC
20	Waste Fuel Oil Tank	BRAC
21	Waste Oil Tank	BRAC
22	Landfill No. 4	BRAC
23	Landfill No. 5	BRAC
24	Waste Burial Area	BRAC
25	Landfill No. 8	BRAC
26	Landfill No. 3	DERA
27	Landfill No. 10	DERA
28	Landfill No. 1	DERA
29	Landfill No. 2	DERA
30	Landfill No. 9	DERA

**Table 1-1**  
**SWMUs and AOCs at NAS Fort Worth JRB**

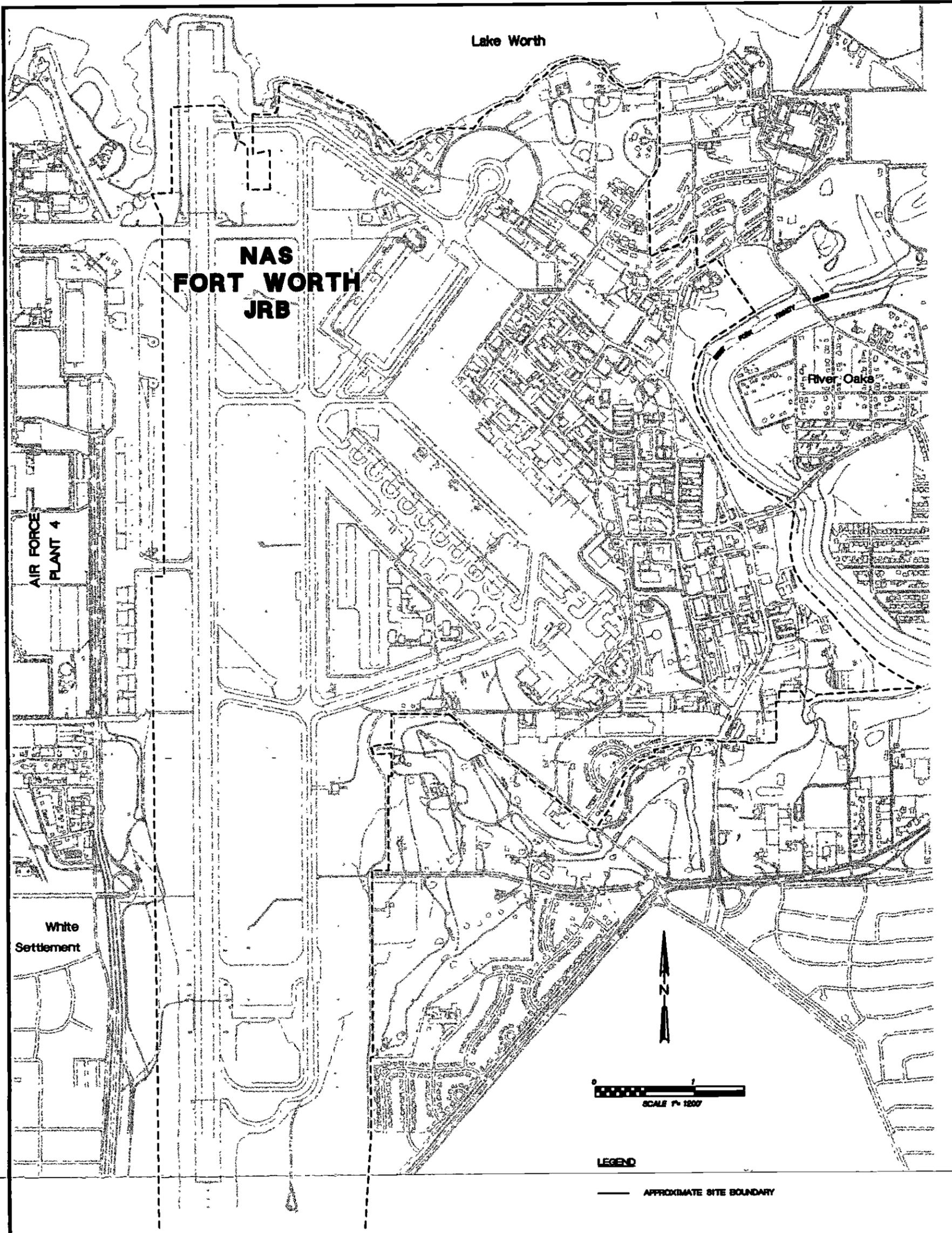
<b>SWMU No.</b>	<b>Description</b>	<b>AFCEE Office of Primary Responsibility</b>
31	Building 1050 Waste Accumulation Area	DERA
32	Building 1410 Waste Accumulation Area	DERA
33	Building 1420 Waste Accumulation Area	DERA
34	Building 1194 Waste Accumulation Area	DERA
35	Building 1194 Oil/Water Separator	DERA
36	Building 1191 Waste Accumulation Area	DERA
37	Building 1191 Oil/Water Separator	DERA
38*	Building 1269 PCB Transformers Building	DERA
39	Building 1643 Waste Accumulation Area	DERA
40	Building 1643 Oil/Water Separator	DERA
41	Building 1414 Oil/Water Separator	DERA
42	Building 1414 Waste Accumulation Area	DERA
43*	Building 1414 Non-Destructive Inspection Waste Accumulation Point	DERA
44	Building 1027 Oil/Water Separator	DERA
45	Building 1027 Waste Oil Tank	DERA
46*	Building 1027 Waste Accumulation Area	DERA
47	Building 1015 Oil/Water Separator	DERA
48*	Building 1048 Fuel Systems Shop Floor Drains	DERA
49	Aircraft Washing Area No. 1	DERA
50	Aircraft Washing Area No. 2	DERA
51	Building 1190 Waste Holding Area	DERA
52	Building 1190 Oil/Water Separator	DERA
53	Storm Water Drainage	DERA
54	Storm Water Interceptors	DERA
55	East Gate Oil/Water Separator	DERA
56*	Building 1405 Waste Accumulation Area	DERA
57*	Buildings 1432/1434 Waste Accumulation Area	DERA
58	Pesticide Rinse Area	BRAC
59	Building 8503 Weapons Storage Area Waste Accumulation Area	BRAC
60	Building 8503 Radioactive Waste Burial Site	BRAC

**Table 1-1**  
**SWMUs and AOCs at NAS Fort Worth JRB**

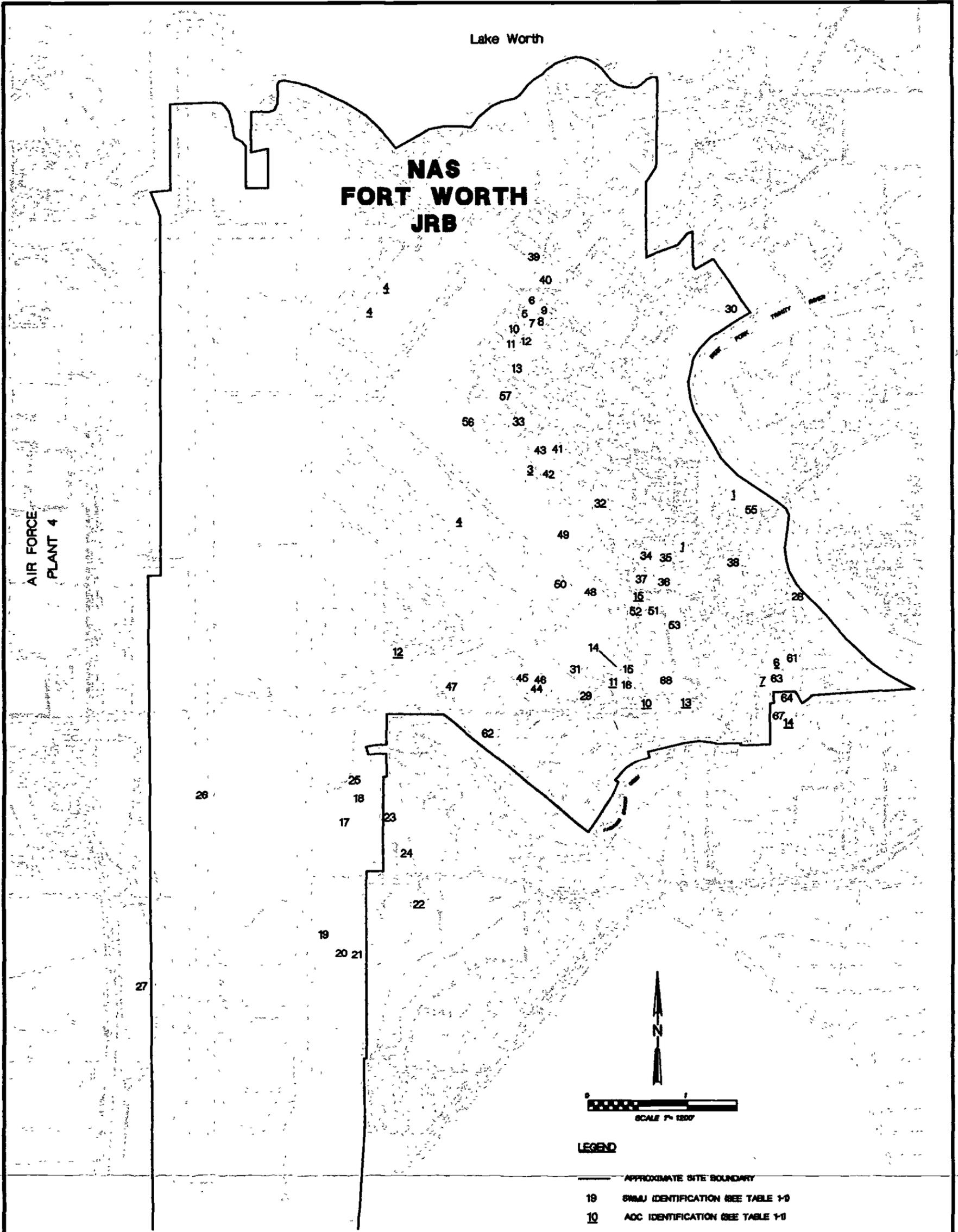
<b>SWMU</b>		<b>AFCEE Office of</b>
<b>No.</b>	<b>Description</b>	<b>Primary Responsibility</b>
61	Building 1320 Waste Accumulation Area	DERA
62	Landfill No. 6	DERA
63*	Entomology Dry Well	DERA
64	French Underdrain System	DERA
65*	Weapons Storage Area Disposal Site	BRAC
66	Sanitary Sewer System	BRAC
67	Building 134D Oil/Water Separator	DERA
68	POL Tank Farm	DERA
AOC 1	Base Service/Gas Stations	DERA
AOC 2	Airfield GW Plume	DERA
AOC 3	Waste Oil Dump	DERA
AOC 4	Fuel Hydrant System	DERA
AOC 6	RV Storage Area	DERA
AOC 7	Base Refueling Area	DERA
AOC10	Building 1064 Oil/Water Separator	DERA
AOC11	Building 1060 Oil/Water Separator	DERA
AOC12	Building 4210 Oil/Water Separator	DERA
AOC13	Building 1145 Oil/Water Separator	DERA
AOC15	Building 1190 Storage Shed	DERA

**Note:**

\* Sites for which no further action is required by TNRCC per their March 1995 letter to the USAF (TNRCC, 1995)



<b>NAS FORT WORTH JRB, CARSWELL FIELD FORT WORTH, TEXAS</b>			
<b>SITE LOCATION MAP AOC2 RFI REPORT</b>			
Reviewed by:	K SWANSON	Figure No:	FIGURE 1-1
Drawn by:	W KENAS	Project No:	135009.A2.11
		File Name:	38881109.dgn
		Date:	13-JAN-1999



**NOTE**

Below ground portion of SWMU 63 (Storm Water System) is located base-wide and is not depicted on this map. The portion shown is the flightline drainage ditch only.

SWMU 54 (Storm Water Interceptors), and SWMU 66 (Sanitary Sewer System) are located base-wide and are not depicted on this map.

AOC 2 (Airfield Groundwater) broadly defines groundwater contamination beneath NAS Fort Worth JRB; and therefore is not depicted on this map.

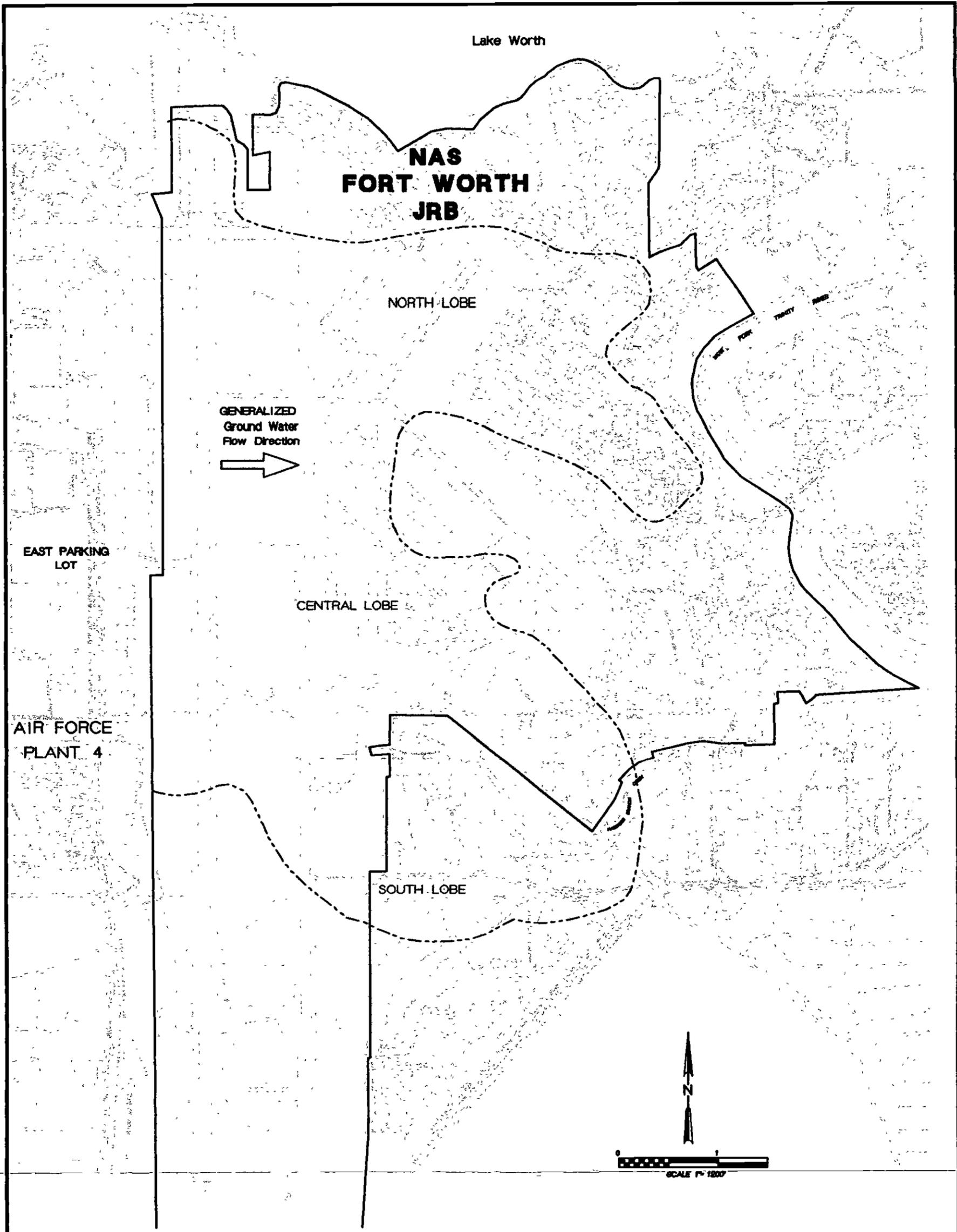
**NAS FORT WORTH JRB, CARSWELL FIELD**

**FORT WORTH, TEXAS**

**SWMU/AOC LOCATION MAP**

**AOC2 RFI REPORT**

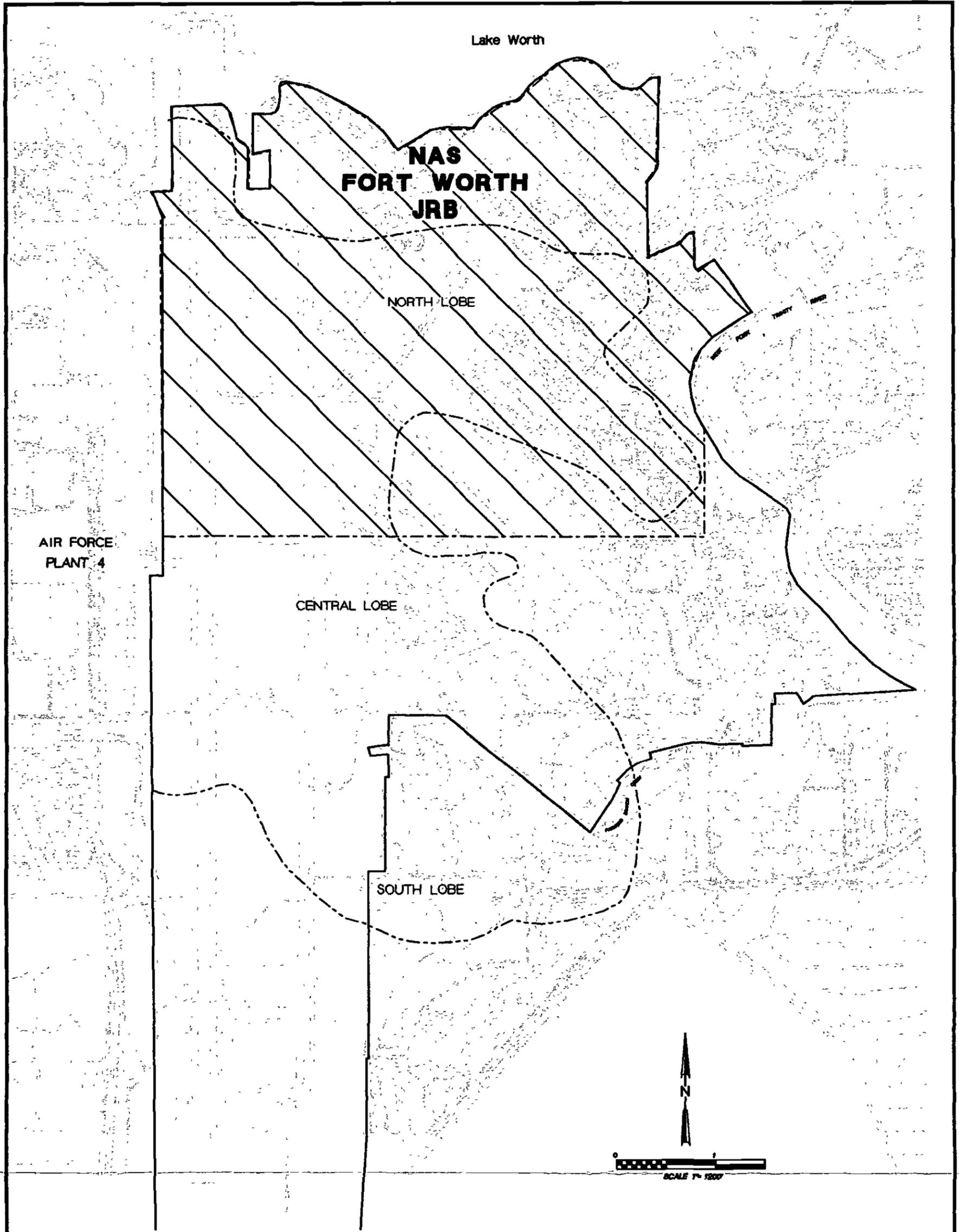
Reviewed by: <b>K SWANSON</b>	Figure No: <b>FIGURE 1-2</b>
Drawn by: <b>W KENAS</b>	Project No: <b>135009.A2.11</b>
	File Name: <b>38681110.dgn</b>
	Date: <b>13-JAN-1999</b>



**LEGEND**

- APPROXIMATE SITE BOUNDARY
- - - APPROXIMATE TRICHLOROETHENE EXTENT DETERMINED BY  
GEO-MARINE 1981, 1983, JACOBS (JACOBS, 1988), AND IT ITT, 1989

<b>NAS FORT WORTH JRB, CARSWELL FIELD</b>			
<b>FORT WORTH, TEXAS</b>			
<b>GENERALIZED EXTENT OF TCE IN GROUNDWATER</b>			
<b>AOC2 RFI REPORT</b>			
Reviewed by:	K SWANSON	Figure No:	FIGURE 1-3
Drawn by:	W KENAS	Project No:	135009.A2.11
		File Name:	36681f11.dgn
		Date:	13-JAN-1999



**LEGEND**

- APPROXIMATE SITE BOUNDARY
- - - APPROXIMATE TRICHLOROETHENE EXTENT DETERMINED BY GEO-MARINE (GMI, 1993, JACOBS (JACOBS, 1993, AND IT (IT, 1993)
- ▨ AOC2 STUDY AREA

<b>NAS FORT WORTH JRB, CARSWELL FIELD</b>	
<b>FORT WORTH, TEXAS</b>	
<b>EXTENT OF TCE IN GROUNDWATER AND LOCATION OF RFI STUDY AREA</b>	
<b>AOC2 RFI REPORT</b>	
Reviewed by: <b>K SWANSON</b>	Figure No: <b>FIGURE 1-4</b>
Drawn by: <b>W KENAS</b>	Project No: <b>135009.A2.11</b>
	File Name: <b>38681f12.dgn</b>
	Date: <b>09-SEP-1998</b>

# TAB

Section 2 Environmental Setting

---

## 2.0 Environmental Setting

---

The following sections describe the geographic setting, geology, hydrogeology, climatology, nature and extent of groundwater contamination, and contaminant transport in groundwater and surface water at NAS Fort Worth JRB and vicinity.

### 2.1 Geography

As stated in Section 1.2.1, NAS Fort Worth JRB lies within Tarrant County, Texas, eight miles west of Fort Worth. The following sections describe the geographical setting of the base.

#### 2.2.1 Land Use

Prior to 1941, the area which is now occupied by NAS Fort Worth JRB consisted of woods and pasture in an area called White Settlement. The base was opened in 1942 as Tarrant Field Airdrome. The area currently surrounding NAS Fort Worth JRB is industrial and residential/commercial to the immediate west (Air Force Plant 4 and the community of White Settlement). The West Fork Trinity River flows along part of the northeastern boundary of NAS Fort Worth JRB, and is dammed to form Lake Worth, a water supply and recreational reservoir which borders NAS Fort Worth JRB/AFP4 to the north. The residential communities of River Oaks and Westworth Village along with various urban developments lie to the east and south of the base (CH2M HILL, 1996c, 1998).

#### 2.2.2 Climate

The climate in the Fort Worth area is subhumid with mild winters and hot, humid summers. The average annual precipitation is approximately 32 inches a year, with the majority falling between April and October. The average annual temperature in the area is 66° Fahrenheit (°F). Monthly mean temperatures vary from 45°F in January to 86°F in July. The average daily minimum temperature in January is 35 °F, and the average daily maximum temperature in July and August is 95°F. Freezing temperatures occur at NAS Fort Worth JRB an average of 33 days per year (IT Corporation, 1997).

Prevailing winds are primarily southerly from March through November and northerly from December through February; the average wind speed is 8 knots. Severe thunderstorms with wind speeds of 65 knots and hailstorms are common. Climate conditions during the summer months make tornado formations possible. (IT Corporation, 1997).

### 2.2.3 Physiography

NAS Fort Worth JRB is located in the Grand Prairie section of the Central Lowlands physiographic province of Texas. The area is characterized by broad, gently rolling plains with moderately sloping terraces of sedimentary rock outcrops. These plains are covered by a variable thickness of loamy soil upon which grasslands have developed. Isolated stands of upland timber are found in areas where no agricultural activity has occurred and where re-growth is advanced.

Ground surface elevations at NAS Fort Worth JRB range from approximately 590 feet above mean sea level (MSL) along the south shore of Lake Worth to approximately 660 feet MSL in the southwest corner of the base. The existing topography of this area has been essentially controlled by two activities. Surface water erosion has created the existing topographic relief that is evident in the vicinity of Farmers Branch Creek, the West Fork Trinity River, and Lake Worth. Site development and ground surface modifications since the 1940s have resulted in other parts of the base being more uniform in elevation than what has developed naturally elsewhere. (CH2M HILL, 1996c).

## 2.2 Geology and Hydrogeology

The geologic and hydrogeologic system at NAS Fort Worth JRB consists of three primary units, beginning at the surface with the Terrace Alluvium, which is underlain in turn by the Goodland Limestone/Walnut Formation, and the Paluxy Formation. Each of these is described in the following sections; the regional stratigraphic sequence is described on Table 2-1 and illustrated on Figure 2-1. Local geologic cross-sections of the Terrace Alluvium prepared from AOC2 RFI investigation data are provided with the discussion of investigation findings in Section 4.0.

## 2.2.1 Terrace Alluvium

The Terrace Alluvium is the uppermost water-bearing stratigraphic zone beneath NAS Fort Worth JRB. This unit underlays unconsolidated fill and is composed of Quaternary alluvial deposits. The fill, deposited on the ground surface over much of the developed portions of the base since the 1940s, is generally comprised of variable mixtures of sand, silt, and gravel, and in some areas combined with general refuse, construction debris, and moderate amounts of chemical waste in landfill areas (Jacobs, 1996). The alluvium, highly heterogeneous in both the lateral and vertical directions, is comprised of interbedded clay, silt, and poorly to moderately well-sorted sand and gravel. Basal gravel and weathered limestone is frequently present at the contact between the Terrace Alluvium and the underlying Goodland/Walnut limestone bedrock/aquitard (described in Section 2.2.2).

The thickness of the fill and alluvial deposits is variable, but generally ranges from 0 to 60 feet beneath NAS Fort Worth JRB and AFP4 (USGS, 1996), and has been found as thick as 40 feet within the AOC2 study area, depending on the presence of paleochannels eroded into the underlying bedrock. The depth to the top of the bedrock is highly variable over the AOC2 study area: 11 to 20 feet below ground surface (bgs) in the eastern portion of study area (USACOE, 1994; LAW, 1995), and 30 to 40 feet bgs in the western portion of the study area (USACOE, 1992; ES&E, 1994).

The saturated thickness of the Terrace Alluvium generally is greatest along the axes of the paleochannels (USGS, 1996; Rust Geotech, 1996). Two paleochannels are believed to exist beneath AFP4 and NAS Fort Worth JRB. One of these extends southeast from the assembly building and East Parking Lot at AFP4 toward the golf course on NAS Fort Worth JRB (Rust Geotech, 1996; Parsons Engineering Science, 1996). The second one is believed to trend northeast from the East Parking Lot area at AFP4 to the NAS Fort Worth JRB flightline. Based on a bedrock map compiled by Parsons, the northeast channel appears to bifurcate along the flightline, part of it continuing north toward Lake Worth, and part of it trending east toward and beyond the Alert Apron area (Parsons, 1998). Parsons' bedrock map, based on all area well data, including the data from wells drilled during the AOC2 RFI, is illustrated in Figure 2-2, overlain by the generalized TCE plume extent.

The Terrace Alluvium groundwater flow system behaves as an unconfined aquifer. Recharge occurs locally as infiltration of precipitation onto unpaved surfaces at the base and leakage from water-supply lines, sewer lines, and fire prevention water lines (Rust Geotech, 1996). Groundwater in this system generally flows east and southeast from AFP4, and discharges as baseflow to the West Fork Trinity River, its tributary Farmers Branch Creek/King Branch Creek, and seeps from the ground surface into Lake Worth. A generalized potentiometric map of shallow groundwater flow in the Terrace Alluvial Aquifer is provided in Figure 2-3. The potentiometric surface contours shown in this map were provided by HGL in their Basewide Groundwater Sampling and Analysis Program event report for January 1998 (HGL, 1998b).

Local hydraulic gradients in the Terrace Alluvium flow system are variable, but historically have been reported to range from 0.004 to 0.2 feet/foot (ft/ft) (ES&E, 1994), reflecting variations in the lithologic character of the unconsolidated sediments and weathered bedrock, and localized recharge. Hydraulic conductivities historically obtained from slug tests conducted in areas exhibiting easterly-flowing Terrace Alluvial groundwater ranged from  $1.97 \times 10^{-2}$  to  $9.76 \times 10^{-6}$  centimeters per second (cm/s), with the mean hydraulic conductivity at  $4.52 \times 10^{-4}$  cm/s based on a sampled population of 13 monitor wells (Rust Geotech, 1996). Estimated transmissivities based on aquifer tests conducted in the Terrace Alluvial flow system on the east side of AFP4 (Intellus, 1986) range from 5 to 260 gallons per day per foot (gpd/ft), and higher in areas of greater saturated thickness. On the basis of calculated hydraulic gradients, calculated hydraulic conductivity, and assumed porosity, average linear velocities in the Terrace Alluvial flow system have been reported to range from 0.02 to 0.06 feet per day (ft/d) (Rust Geotech, 1996). Slug tests conducted as part of the AOC2 RFI on new and existing wells in the AOC2 study area support the historic hydraulic conductivity ranges; the results of these tests are described in Section 4.0.

### **2.2.2 Goodland Limestone/Walnut Formation Aquitard**

The Goodland Limestone is a white, fossiliferous, massive limestone with thin beds of clay and marl; its surface is characterized by previous erosional activity. The underlying Walnut Formation (0.5 to 30 feet thick at AFP4) consists of gray claystone and limestone containing

shell conglomerates, clay, and black fissile shale that lies disconformably over the Paluxy Formation. The Goodland and Walnut Formations are not generally distinguished from each other in lithologic logs from previous investigations at NAS Fort Worth JRB, and are present beneath most of NAS Fort Worth and AFP4. The thickness of these combined units regionally ranges from 0 to 158 feet in Tarrant County, and from 0.5 to 70 feet thick beneath NAS Fort Worth JRB and AFP4 (Environmental Science and Engineering Group (ES&E), 1994; USGS, 1996).

In the area of East Parking Lot at AFP4, the Goodland Limestone is absent and the Walnut Formation has been partially eroded, resulting in the presence of a "window" (shown conceptually on Figure 2-1). This "window" is approximately 1/2-mile long, less than 1/8-mile wide, and extends from the East Parking Lot to the far west side of NAS Fort Worth JRB (west of the flightline, outside the AOC2 study area). To help confirm the lack of a similar window in the AOC2 RFI study area, wells drilled throughout the area were used to confirm bedrock presence, and at four of the new monitor well locations, bedrock coring was accomplished from 2 to 8 feet into the competent bedrock. See Section 4.0 for a discussion of the stratigraphy observed in these cores. There has been no indication of a window area at NAS Fort Worth JRB.

The Goodland/Walnut aquitard demonstrates a lower permeability than the overlying sediments that is believed to limit the potential for vertical groundwater flow between the Terrace Alluvial flow system and the underlying Paluxy Aquifer. The logarithmic mean of vertical hydraulic conductivity values for core samples of the competent Walnut Formation measured during the AFP4 RI (Radian, 1991) was calculated to be  $7.0 \times 10^{-10}$  cm/s.

Hydrographs from paired monitor wells installed in the Terrace Alluvium and the Paluxy Formation indicate that there is minimal flow from the Terrace Alluvial flow system to the Paluxy Aquifer in areas where the Goodland/Walnut has not been significantly eroded (USGS, 1996).

### 2.2.3 Paluxy Formation Aquifer

The Paluxy Formation, the uppermost member of the Lower Cretaceous Trinity Group, underlies all of NAS Fort Worth JRB and AFP4, and outcrops along the southern and

southeastern shore of Lake Worth (USGS, 1996). The formation consists of several thick layers of sandstone (the lower section generally more coarse-grained than the upper section) that are poorly cemented to slightly indurated with sparry calcite (Caughey, 1977). The sandstone layers are separated by thin, discontinuous beds of shale and claystone. Bedding in the Paluxy Formation may be horizontally laminated, massive, or burrowed; low angle cross-bedding has been observed in core samples of the Paluxy and in Paluxy outcrops along the Lake Worth shoreline.

The overall thickness of the Paluxy Formation ranges from 130 to 190 feet and averages 160 feet in Tarrant County (Hargis & Associates, 1989; ES&E, 1994). The thickness of the Paluxy beneath NAS Fort Worth JRB and AFP4 is believed to be variable (130 to 175 feet), with individual units thin or missing locally. Only one lithologic log (for well USGS-01P, from USGS, 1995) has been found for the AOC2 study area that includes a description of the Paluxy. The Paluxy, first encountered at a depth of 47 feet bgs, was described as a greenish-gray claystone/very fine quartz sandstone, grading downwards into a well sorted/rounded fine-grained sandstone, with pyrite and coal nodules at 83 feet bgs. The base of the Paluxy had not been encountered by the end of the boring at 114 feet bgs.

The Paluxy Aquifer beneath NAS Fort Worth JRB and AFP4 is described as an unconfined to semi-confined sandstone aquifer that serves as a major municipal water supply source for the community of White Settlement and elsewhere in Tarrant County (Rust Geotech, 1996). The Paluxy historically has been described as being comprised of three separate saturated zones separated by aquitards (USGS, 1996). Most of the municipal supply wells are completed in the lower section of the aquifer, which is more coarse-grained than the upper and middle zones. Recharge to the Paluxy occurs largely as infiltration or precipitation on outcrop surfaces (which are located in Wise, Parker, Hood, and Tarrant counties), and includes infiltration from surface water bodies that are within the outcrop area (i.e., Lake Worth). Additional evidence (USGS, 1996) suggests vertical leakage from the Terrace Alluvial flow system into the Paluxy Aquifer in the window area on AFP4 and NAS Fort Worth JRB, although the potential for vertical flow is less than the potential for horizontal flow in this area.

The direction of flow within the Paluxy Aquifer generally is to the east. Local flow gradients are affected by recharge from Lake Worth and withdrawals by municipalities, which have lowered the potentiometric surface overall and created a more southeasterly groundwater flow direction beneath the base (USGS, 1996). Estimates of transmissivity for this aquifer generally range from less than 100 gpd/ft to approximately 8,000 gpd/ft for the Upper Paluxy, and between 8,000 gpd/ft and 23,000 gpd/ft for the Middle Paluxy (Hargis & Associates, 1985). Estimated ranges of hydraulic conductivity from slug testing of the Paluxy (Chem-Nuclear Geotech, 1992) are between  $1.83 \times 10^{-3}$  cm/s and  $6.63 \times 10^{-4}$  cm/s, which lead to a calculated groundwater flow rate ranging from 0.26 ft/d to 0.79 ft/day (Chem-Nuclear Geotech, 1992).

## 2.3 Surface Water

NAS Fort Worth JRB is located within the watershed of the Trinity River. Surface water features in the area of the base include Lake Worth, the West Fork Trinity River, Farmers Branch Creek (which meanders east toward the West Fork Trinity River along the southern portion of the base to Kings Branch Creek and onward to the West Fork), and two ponds located in the golf course area (IT Corporation, 1997). The locations of these are illustrated on Figure 2-2.

The amount of water the Trinity River receives is controlled by the watershed runoff, by releases and overflows from the series of man-made reservoirs along the forks and tributaries by natural runoff, and by the discharge of effluent from sewage treatment plants. Lake Worth, a man-made reservoir constructed in 1914 on the West Fork Trinity River, is located north of NAS Fort Worth JRB and is owned and operated by the City of Fort Worth. The West Fork Trinity River flows southeastward from the Lake Worth dam and spillway and flows along the eastern boundary of NAS Fort Worth JRB. These waters are used for public water supply and recreation. The Lake Worth spillway elevation is 594 feet above MSL and has a maximum discharge capacity of 55,000 cubic feet per second. Lake Worth averages 6 feet in depth, with a maximum depth of 28 feet, and covers an area of 3,558 acres. It is 12 miles long and its drainage area covers approximately 2,064 square miles. The

---

lake has a conservation storage capacity of 38,130 acre-feet (or approximately 12.4 billion gallons). (IT Corporation, 1997).

Surface water is the main source of potable water in the vicinity of NAS Fort Worth JRB. The City of Fort Worth Water Department is the primary supplier to the areas surrounding and including the base using water from Lake Worth. Water from Farmers Branch Creek is used to irrigate the on-station golf course. The communities of White Settlement and Sansom Park obtain water from groundwater wells [Paluxy Aquifer, upgradient from the base], but when required, they purchase surface water from Fort Worth to supplement their water supplies. NAS Fort Worth JRB purchased 0.93 million gallons per day (MGD), 0.77 MGD, and 0.76 MGD of water from Fort Worth in 1989, 1990, and 1991, respectively. (IT Corporation, 1997).

Surface drainage at NAS Fort Worth JRB is collected by the storm drainage system and routed into the sewer system, or as outfall into Lake Worth. An underground drainage culvert conducts surface runoff generated from areas west of the NAS Fort Worth JRB eastward to Farmers Branch Creek. After exiting the underground culvert, Farmers Branch Creek flows eastward through the on-base golf course before flowing into Kings Branch Creek and eventually discharging into the West Fork Trinity River at the southeastern part of the base. Farmers Branch is an intermittent stream that receives most of its flow from surface water runoff discharged into the creek from storm drains, culverts, and overland flow. Several springs discharge into Farmers Branch Creek as it flows through the on-base golf course. (IT Corporation, 1997).

The North Central Texas Council of Governments (NCTCOG) has implemented the Continuous Automated Monitoring (CAM) system. Two monitoring stations are located along the West Fork Trinity River, downstream from NAS Fort Worth JRB. It was reported by IT that results of analyses of water from the first CAM station downstream from the NAS Fort Worth showed that 100 percent of the samples were below the criteria value of 5.5 milligrams per liter (mg/L) for dissolved oxygen, and that measure of acidity and alkalinity (pH) values range from 6.6 to 9.8 due to the presence of substantial attached algal communities. (IT Corporation, 1997).

---

Storm water runoff from the NAS Fort Worth JRB that is not routed to the base or city sewer system is discharged into Lake Worth. The outfall is permitted under the National Pollution Discharge Elimination System (NPDES) and monitoring results document compliance with permit discharge limitations. (IT Corporation, 1997).

The water in Lake Worth is moderately hard, and contains slightly elevated salt levels during the warm summer season. Historically, Lake Worth has experienced problems with high sediment loads. Lake Worth was included in the 1990 Nonpoint Source Report for having known problems with sedimentation from agricultural and vacant lands. The sedimentation problems have been reduced by using the upstream Eagle Mountain Lake as a sediment trap. (IT Corporation, 1997).

Table 2-1  
Stratigraphic Units at Air Force Plant 4 and NAS Fort Worth JRB

3

Era	System	Series/Group	Stratigraphic Unit	Thickness (feet) <sup>1</sup>	Lithologic Characteristics <sup>2</sup>	Water-yielding Characteristics	
Cenozoic	Quaternary (1.8 mya to present)	Holocene	Fill material	0-20	Construction debris	Permeability varies, gravels and sands permeable	
			Recent alluvial deposits	0-50	Gravel, sand, silt, clay		
			Pleistocene	Terrace alluvial deposits	0-60	Gravel, sand, silt, clay	Permeability varies, gravels and sands permeable
Tertiary (1.8 to 65 mya)	Eocene/Wilcox			--	--	--	
		Paleocene/Midway			--	--	--
Mesozoic	Cretaceous (65 to 140 mya)	Gulfian		--	--	--	
			Comanchean/Washita		--	--	--
			Comanchean/Fredericksburg		--	--	--
			Goodland Limestone	0-40	White fossiliferous limestone, coarsely nodular, resistant, and dense—contains some marl	Impermeable where not weathered—considered confining unit	

Table 2-1  
Stratigraphic Units at Air Force Plant 4 and NAS Fort Worth JRB

Era	System	Series/Group	Stratigraphic Unit	Thickness (feet) <sup>1</sup>	Lithologic Characteristics <sup>2</sup>	Water-yielding Characteristics
		Walnut Formation		0.5-30	Medium to dark grey clay and limestone with shell conglomerates, fossiliferous, Gryphaea beds	Very low permeability—considered confining unit
		Cornachean/ Trinity	Paluxy Formation	130-175	Light grey to greenish-grey sandstone and mudstone; fine-grained to coarse-grained sandstone	Considered aquifer, yields small to moderate quantities of water
		Glen Rose Formation		150, range unknown at AFP4	Brownish-yellow and gray alternating limestone, marl, shale, and sand	Low permeability—considered confining unit in area of AFP4
		Twin Mountains Formation		200, range unknown at AFP4	Fine-to coarse-grained sandstone, shale and claystone, basal gravel conglomerate	Coarse sandstones and parts of formation considered aquifer, yields moderate to large quantities of water

<sup>1</sup>Thickness determined from site logs, except for Glen Rose Limestone and Twin Mountains Formation (Baker and others, 1990, figure 4)  
<sup>2</sup>Lithologic characteristics determined from field observations and from Winton and Adkins, 1919; University of Texas, Bureau of Economic Geology, 1972; U.S. Army Corps of Engineers, 1986; Baker and others, 1990; Environmental Science and Engineering, Inc., 1994.  
<sup>3</sup>This stratigraphic name does not conform to the usage of the U.S. Geological Survey.

Note: Information in table is reproduced from Kuniansky, et. al, 1996

mya - million years ago

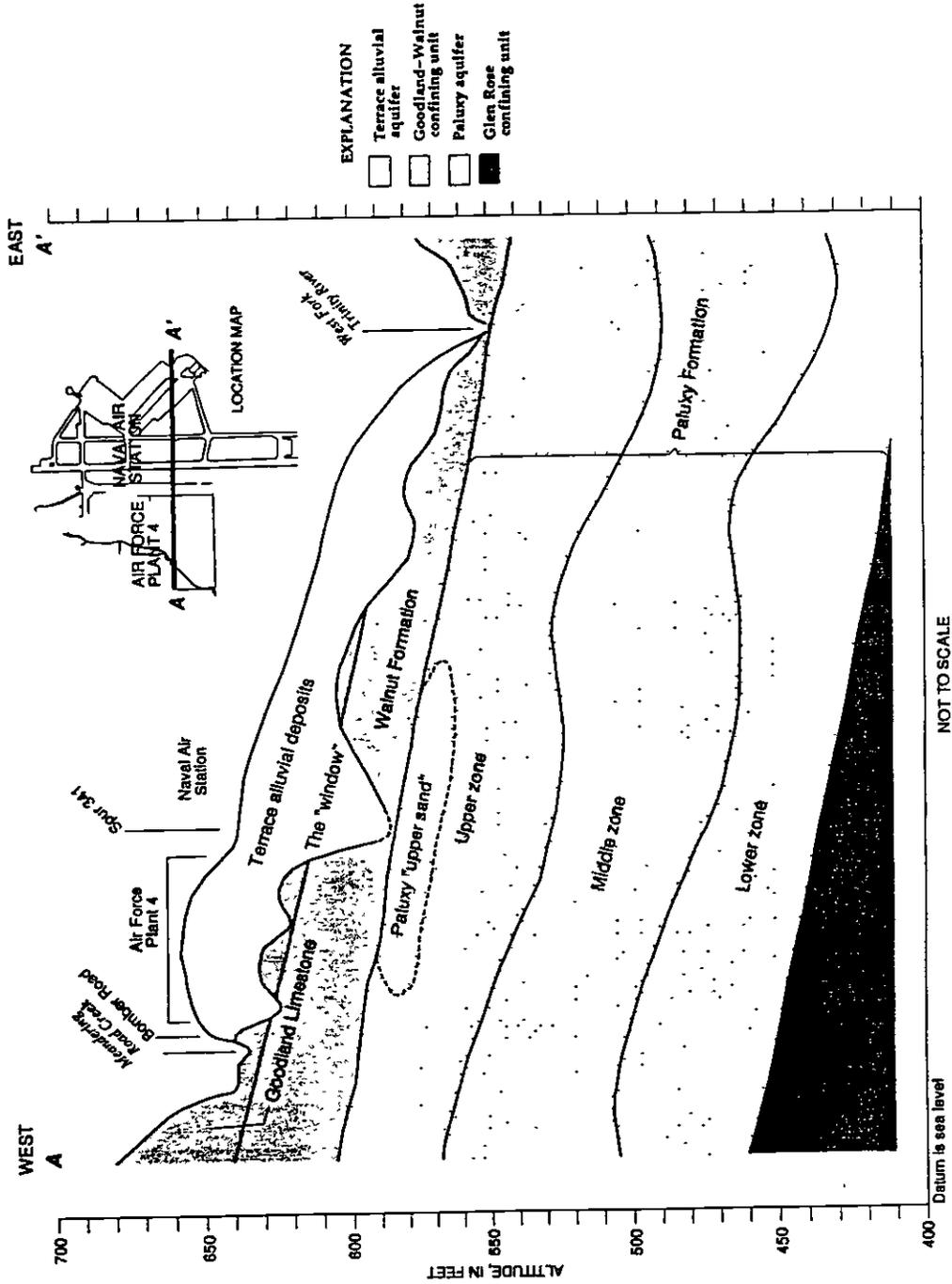
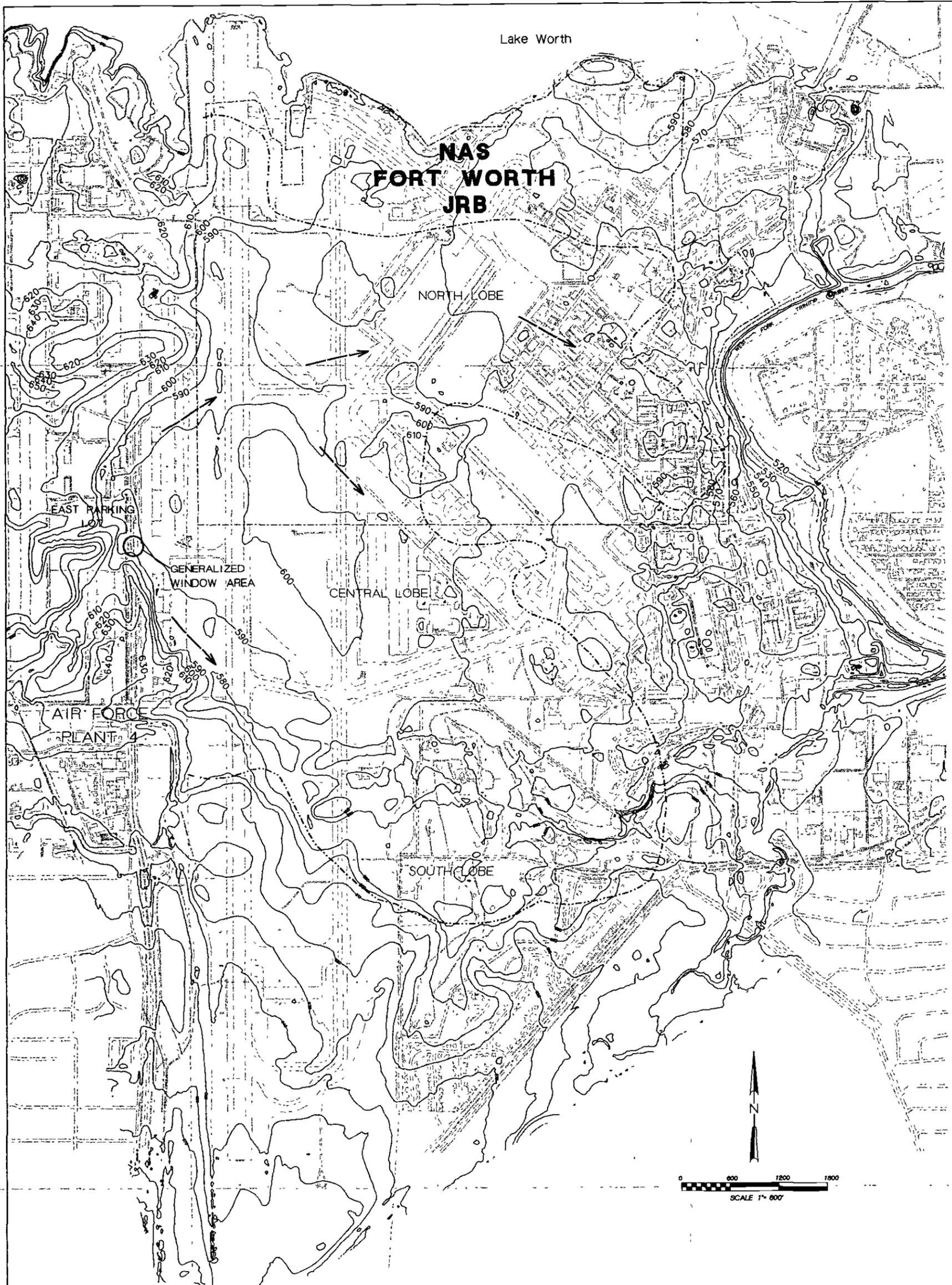
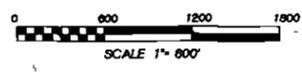


Figure 2-1 Generalized Hydrogeologic Section at AFP4 and NAS, Fort Worth, Texas (Hydrogeology at Air Force Plant 4 and Vicinity and Water Quality of the Paluxy Aquifer, Fort Worth, Texas. U.S. Geological Survey Water-Resources Investigations Report 96-4091, 1996.

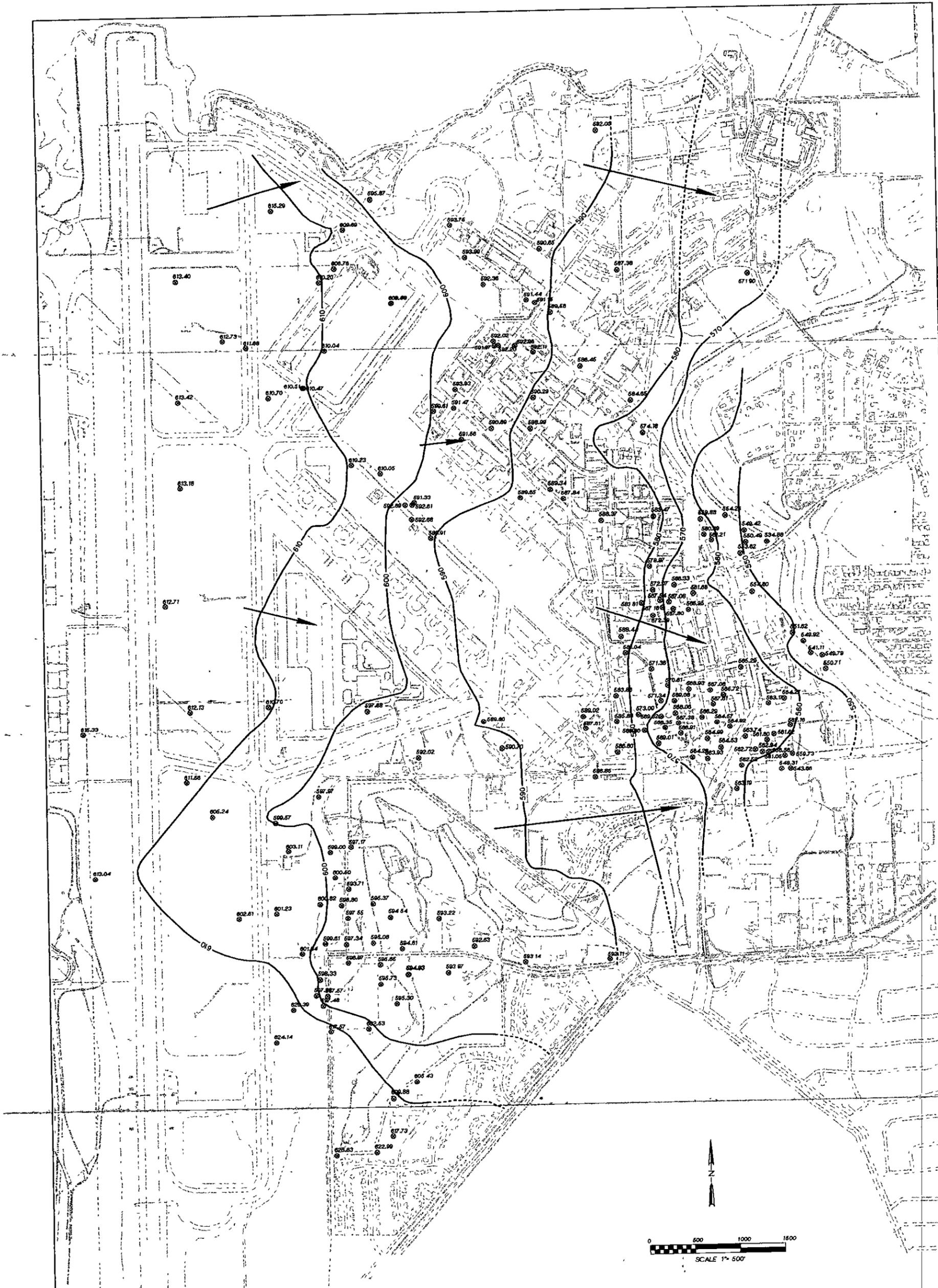


LEGEND

- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
- AOC2 STUDY AREA BOUNDARY
- - - - APPROXIMATE TRICHLOROETHENE EXTENT DETERMINED BY GEO-MARINE (GMI, 1996), JACOBS (JACOBS, 1996), AND IT (IT, 1998)
- BEDROCK SURFACE CONTOUR (PARSONS 1998) (IN ELEVATION ABOVE MEAN SEA LEVEL)
- > GENERALIZED PALEOCHANNEL TREND



<b>NAS FORT WORTH JRB</b>	
TEXAS	
TOP OF BEDROCK SURFACE BENEATH TERRACE ALLUVIUM (BEDROCK SURFACE FROM PARSONS, 1998) AOC2 RFI REPORT	
Reviewed by: K SWANSON	Figure No: FIGURE 2-2
Drawn by: W KENAS	Project No: 136009 A2 11
	File Name: 38681F27.DGN
	Date: 13-JAN-1999



- LEGEND**
- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
  - ⊙ GROUNDWATER ELEVATION IN MONITOR WELL (FEET ABOVE MEAN SEA LEVEL)
  - 550— GROUNDWATER ELEVATION CONTOUR (FEET ABOVE MEAN SEA LEVEL)
  - GROUNDWATER FLOW DIRECTION

**NOTE**  
 GROUNDWATER ELEVATIONS AND POTENTIOMETRIC SURFACE INTERPRETATION TAKEN FROM JANUARY 1998 GROUNDWATER SAMPLING AND ANALYSIS PROGRAM REPORT HYDROGEOLOGIC 1998

<b>NAS FORT WORTH JRB, CARSWELL FIELD</b> <b>FORT WORTH, TEXAS</b>	
<b>BASEWISE GROUNDWATER POTENTIOMETRIC SURFACE MAP</b> (TERRACE ALLUVIAL AQUIFER - JANUARY 1998 GSAP) AOC2 RFI REPORT	
Reviewed by: <b>K SWANSON</b>	Figure No: <b>FIGURE 2-3</b>
Drawn by: <b>W KENAS</b>	Project No: <b>135009 A1 01</b>
File Name: <b>38681118.dgn</b>	Date: <b>13-JAN-1999</b>

# TAB

Section 3 : Investigation Activities Description

---

## 3.0 Investigation Activities Description

---

This section provides the rationale for the focused AOC2 RFI based on the project objectives, and summarizes the AOC2 RFI field activities (along with any deviations from the original work plan), including the geophysical investigation, direct push investigation, drilling and well installation activities, aquifer testing, soil and groundwater sampling, and the laboratory analytical program. Investigation findings and analytical results from these activities are summarized in Section 4.0; evaluation of these results in terms of the nature and extent of contamination is described in Section 5.0.

### 3.1 RFI Program Rationale

As described in Section 1, TCE-related contamination at AOC2 occurs in the form of three lobes: the northern, central, and southern lobes. Of these three, only the northern lobe had not been well-defined relative to its source through investigations prior to the AOC2 RFI.

Based on existing data, the southern lobe of the plume has been attributed to documented AFP4 activities and specific NAS Fort Worth JRB sources. These sources include the East Parking Lot at AFP4, and former landfills and fire training areas at NAS Fort Worth JRB. These sources are being addressed under other investigations. Regarding the central lobe of TCE-related contamination, no known onsite sources of TCE exist within that area of NAS Fort Worth JRB. Based on the documented groundwater flow patterns from west to east (from AFP4 to NAS Fort Worth JRB), and the consistency of historic GMI direct push data with the data from existing monitor wells in the area, it has been generally accepted that upgradient sources from AFP4 are responsible for the TCE distribution in the central lobe.

Because the central and southern lobes of the AOC2 plume were documented previously in terms of extent and source, a decision was made during the development of the RFI investigation work plan (CH2M HILL, 1998) to focus activities on the northern lobe of the AOC2 contaminant plume (the AOC2 study area is shown on each report figure). This decision was based on the known nature and extent of contamination in the area and

existing information regarding possible TCE sources. The objectives related to investigation of the northern lobe of AOC2 were defined on this basis, and are described in the following section.

## 3.2 RFI Objectives

The primary RFI objectives, as originally presented in the AOC2 RFI Workplan, were:

- Delineation of the potential sources of TCE that are contributing to the northern lobe of groundwater contamination occurring at AOC2.
- Physical identification of primary flow paths within the Terrace Alluvial Aquifer, and potentially to the Paluxy aquifer in the northern lobe of AOC2.
- Delineation of the nature and extent of the northern lobe of TCE groundwater contamination in AOC2.
- Development of a fate and transport assessment which, in conjunction with the known nature and extent of contamination, will help determine the onsite and/or offsite sources responsible for the present contaminant distribution within AOC2, and the extent to which natural attenuation may be occurring within the AOC2 contaminant plume.
- Development of a risk characterization to evaluate the risk posed to human health and the environment by the constituents encountered in soils and groundwater within the AOC2 study area.

Table 3-1 lists these objectives, and the RFI work task designed to address each objective. The RFI work tasks conducted are described in the next section, along with identification of deviations from the work plan.

## 3.3 Summary of RFI Activities

Table 3-1 provides a description of data needs for each primary and secondary AOC2 RFI objective. RFI activities completed in support of these objectives are also listed in Table 3-1. These activities included a records review, geophysical investigation, direct push

investigation, drilling and well installation activities, hydraulic conductivity testing, soil and groundwater sampling, and laboratory analysis. The final locations from which data were obtained under each of these activities are shown on **Figure 3-1**. A detailed description of the activities conducted under each work task is provided in the following sections. All location survey coordinates are provided in **Appendix F**.

### **3.3.1 Review of Existing Information**

A records review was completed prior to the initiation of field work and throughout the performance of the remaining activities to refine the investigation approach and field sampling activity scope of work, and to supplement data evaluation. The majority of relevant information was obtained through review of the recently-conducted IT investigation of the Sanitary Sewer System (SWMU 66) (IT Corporation, 1997), the Site Characterization Summary Informal Technical Information Report (SCS ITIR) (CH2M HILL, 1996), Basewide Groundwater Sampling and Analysis Program data, and documentation from other prior and ongoing investigations concerning the NAS Fort Worth JRB and AFP4 subsurface conditions and SWMUs/AOCs located within the AOC2 study area.

Review of the new well locations installed during the Sanitary Sewer RFI led to their use to supplement the AOC2 new well network and reduce the need for new AOC2 wells. For example, IT well WITCTA010 was sampled to provide analytical information concerning the western boundary of the northern lobe, and well WITCTA016 was sampled to further delineate the southern boundary of the northern lobe.

Soil analytical information from the IT investigation was also reviewed to assist in the evaluation of the need for confirmatory soil borings at possible source locations within the AOC2 study area. This information, along with historical information regarding the SWMUs and AOCs described in the SCS ITIR, was used to determine the placement of two AOC2 RFI soil boring locations to screen and preliminarily evaluate the likelihood of potential onsite sources. **Table 3-2** lists the SWMUs and AOCs located within the AOC2 RFI study area, the wastes managed as reported in the original site assessment (CH2M HILL, 1984), and each unit's investigation status as reported in the Site Characterization Summary ITIR (CH2M HILL, 1996), supplemented by information regarding recent and ongoing

investigations obtained from the various contractors as part of this records review. The comments column indicates the conclusions of the records review in terms of each unit's potential as a source and/or other the status of other ongoing investigations. Based on historic information, three SWMUs were identified as suitable for screening as potential minor TCE sources; soil borings were scheduled at these areas (see Section 3.3.4.2).

### 3.3.2 Seismic Reflection Survey

A geophysical investigation, consisting of a seismic reflection survey, was conducted at the site during October 1997. The investigation was conducted along the flightline and Alert Apron area of the base to evaluate the thickness of the Terrace Alluvial Aquifer, the top of bedrock, and the thickness of rock units in areas where paleochannels were suspected. The data obtained aided in the final selection of the locations of the confirmatory rock corings (see Section 3.3.4.5).

Six transects (three lines oriented north-south and three lines oriented east-west were identified based on previous top of bedrock interpretations (Parsons, 1996; Rust Geotech, 1996), and a seismic reflection survey was conducted along those transects. Figure 3-1 shows the layout of those transects; note two of the east/west lines are lined up end to end, resulting in one longer line. The report prepared by the geophysical contractor is provided in whole in Appendix A. The surveyed shot points are shown in Figure 3-1; not all shot points were surveyed, but rather a sampling of data points sufficient to define the transects (the surveyed points are shown as circled x's on the figure).

The seismic data was acquired in four phases; a single velocity check shot survey, field data acquisition, data processing, and data interpretation. A single velocity check shot was conducted at monitoring well SPOT 35-04 (see Figure 3-1). A velocity check shot provides for ground-truthing of the reflection seismic data. A down-hole geophone was installed in the well at a depth of 19 ft. Shots were recorded at two foot vertical intervals, then the time/depth interpretation was compared to the borehole log available for SPOT 35-4.

The seismic data was acquired on 20 foot and 30 foot station spacings along the six transects using a single-source, single-geophone "Vertical Reflection Profile" (VRP). A minimum of

six shots were taken at each station and recorded. The sum of the six shots was acquired to increase the signal to noise ratio.

Data interpretation was conducted using several methods. The velocity check shot survey provided interval velocities where rock properties were known. Where a monitoring well was near or crossed a transect, a velocity check shot survey was conducted. The velocities and the rock properties were generalized. If velocities were not known an average velocity of 1600 ft/sec was used. In some instances a seismic synthetic was used for the velocity. The seismic synthetic used was for the first five feet. The seismic synthetic used in this case was 1000 ft/sec. See **Appendix A** for a complete description of these activities in the subcontractor report.

### **3.3.3 Direct Push Investigation**

CH2M HILL conducted a preliminary direct-push investigation at NAS Fort Worth JRB AOC2 between October 27 and November 8, 1996, during the work planning stage of the RFI. An additional investigation was also performed during the remaining RFI field activities, as outlined in the work plan, between October 29 through November 3, 1997. CH2M HILL utilized the services of the US Army Corps of Engineers (USACOE) Site Characterization and Analysis Penetrometer System (SCAPS) unit and the Department of Energy's (DOE) Chemical & Analytical Sciences Division (C&ASD) mobile laboratory for this investigation. The purpose of the direct-push activities was to support the evaluation of potential sources of TCE at NAS Fort Worth JRB, confirm TCE migration patterns and evaluate the bifurcation of TCE plume associated with the AOC2 area, and to supplement well data in the area.

#### **3.3.3.1 Preliminary Work Plan Direct Push Investigation**

The initial objective of the preliminary investigation was to take advantage of the availability of the USACOE direct push rig and the C&ASD mobile laboratory in order to clarify data obtained during previous investigations conducted by Geo-Marine Inc. (GMI, 1995), Jacobs Engineering (Jacobs, 1996), and LAW Engineering (LAW, 1996), as well as to help determine the final direct push and monitor well locations for the AOC2 RFI work conducted in 1997. Forty temporary PowerPunch wells were installed at various locations

through the study area during this investigation. Figure 3-1 shows these locations (locations with labels beginning "AGA"). Total depth, depth to water, installation date, and screened interval information for these temporary points is provided in Table 3-3. A full description of this investigation is provided in Appendix B of the AOC2 RFI Workplan (CH2M HILL, 1998).

### **3.3.3.2 RFI Direct Push Investigation**

Six north-south transects (A through F) were identified during the 1997 preliminary work planning direct push investigation for further direct push and well installation activities. These transects were located perpendicular to groundwater flow, across the width of the north lobe plume (Figure 3-1). These locations were determined following an evaluation of data from previous direct push and soil boring/well installation investigations. The six transects provide data for determining the flow of the groundwater and the migration of the TCE. Direct push locations were sited along these transects where existing data from wells or direct push investigations were lacking. A total of 22 temporary PowerPunch wells were installed along the six transects, as shown in Figure 3-1.

#### **3.3.3.2.1 Direct Push Location Identification**

Direct push locations were chosen to fill in data gaps along the work plan-defined north-south transects where data from previous soil borings/wells or future soil borings/wells were not available. The locations were chosen in an attempt to provide true north-south transects while allowing safe access by the direct push rig. Utility clearance and digging permits were obtained prior to the completion of any intrusive activities. The proposed locations were field-marked by CH2M HILL; the utilities lines were cleared by the individual shops at NAS Fort Worth JRB, and communications lines were cleared by an independent contractor, SM&P.

#### **3.3.3.2.2 Collection of Stratigraphic Data**

A Cone Penetrometer Test (CPT) probe was pushed to the refusal depth in order to obtain stratigraphic data from each direct push point. The soil classifications were determined by the resistance on the tip of the probe and the friction exerted on the sleeve of the probe. A microcomputer logged the depth the probe was pushed, the cone resistance, and the sleeve friction and classified the soil according to the readings. The readings were logged on the

computer and printed out at the end of each day for review. Stratigraphic information was not obtained at points PCHMHTA0E1 and PCHMHTA0F3 due to mechanical difficulties with the CPT probe. Stratigraphic information was not obtained at the PCHMHTA0B5 location because the probe encountered refusal at approximately three feet below ground surface (bgs) following three separate attempts. The stratigraphic information collected at the rest of the direct push locations is described in Section 4; the logs are provided in Appendix B.

#### **3.3.3.2.3 Direct Push Temporary Well Installation**

The USACOE direct push rig was utilized to advance a 2-5/8-inch hollow rod to a refusal depth. In the hollow rod was a 3/4-inch inside diameter (ID), 3-foot polyvinyl chloride (PVC) screen with 3/4-inch ID 3-foot PVC risers above. Once the refusal depth was obtained, the rods were pulled up 3 feet, thereby exposing the screened length. A 4-inch long annular seal was installed at the first break in the hollow rod. The temporary wells were then allowed time to stabilize, and a groundwater sample was collected via the screen and hollow rod. Temporary well installation could not be completed at location PCHMHTA0B5 as the probe hit refusal at three feet bgs (see also Section 3.3.3.2.2). Although a temporary well was installed at location PCHMHTA0E5, groundwater was not encountered and no sample could be collected. After sampling was completed, the temporary wells were removed and the holes grouted to the surface. Total depth, depth to water, installation date, and screened-interval information is provided in Table 3-4.

#### **3.3.3.2.4 Groundwater Sampling and Analysis**

Groundwater samples were collected from all temporary direct push wells except the one at location PCHMHTA0E5 (see Section 3.3.3.2.3). To collect each groundwater sample, an insitu sparge probe was inserted into the completed well, and at least 8 inches into the groundwater collecting in the well. The well water was sparged with helium gas and returned to the instrument. The gases were then passed through a portable ion mass spectrometer and each sample analyzed for TCE, perchloroethene (PCE), dichloroethene (DCE), trichloroethane (TCA), and hydrocarbons. Following the analysis, the probe was removed, rinsed and placed in a known concentration solution (standard) to confirm that the instrument was functioning properly. Following the standard, the probe was rinsed and

placed in a blank sample to clear the tubing of any residuals. The data was stored in a computer on the COE direct push rig to be quantified at a later date. An estimation of TCE concentrations were reported immediately to the field team leader.

At 10 percent of the temporary wells installed, an additional groundwater sample was also collected for offsite laboratory analysis for confirmation of onsite results. These additional samples were collected using conventional techniques via a 3/4-inch dedicated bailer lowered into the temporary well. The samples were packed in a cooler with ice and submitted to Paragon Analytics, Inc., in Fort Collins, Colorado for analysis of volatile organic compounds using EPA Method 8260. Sample analysis was performed in accordance with the Draft Basewide Quality Assurance Project Plan (CH2M HILL, 1996); data analysis and validation is described in Section 3.4. All direct push analytical results are summarized in Section 4; onsite mobile laboratory reports are provided in Appendix B, and the offsite laboratory analytical results are included along with other offsite laboratory analytical results in Appendix G.

### **3.3.4 Drilling and Monitor Well Installation**

CH2M HILL conducted a drilling and well installation program in the AOC2 study area from November 17, 1997 to December 10, 1997. CH2M HILL utilized Total Support Services, Inc. (TSS) for the drilling and rock coring activities and Paragon Analytics, Inc. for offsite laboratory analytical services. The objective of the investigation was to obtain data for: additional stratigraphic characterization of the Terrace Alluvial Aquifer and confirmation of the top of bedrock; analytical characterization of areas where PCE and/or TCE may have been released to soils or groundwater; evaluation of the bifurcation of TCE plume in the north lobe of the AOC2 plume; and lithologic information for vertical profiling. Rock cores were collected at four of the well locations for evaluation of the competency of the bedrock. Soil boring and well completion information is summarized in Table 3-5; soil boring logs and well completion information are provided in Appendix C.

#### **3.3.4.1 Drilling Location Identification**

The soil boring/monitoring well locations were confirmed and finalized following the historical records review, the geophysical investigation, and the direct push investigation.

The locations were selected in order to meet the RFI objectives while providing safe access by the drill rig.

Utility clearance was obtained prior to any subsurface activities. The locations were field-marked by CH2M HILL and utilities lines cleared by the individual shops at the base. The communication lines were cleared by SM&P personnel.

#### **3.3.4.2 Soil Borings**

Eleven soil borings were advanced to the top of bedrock for the installation of monitor wells in the Terrace Alluvial Aquifer (locations illustrated in **Figure 3-1**). Continuous soil cores were reviewed in the field at each of the eleven locations and all soil cores were screened with a photoionization detector (PID) for the presence of volatile organics. In accordance with the work plan, soil samples were collected for laboratory analysis from the cores with the highest PID reading in each boring, and from the core collected from immediately above the water table in each boring. If no elevated PID readings were observed in a soil boring, only one sample was collected from the area above the water table. All soil samples collected were submitted for analysis of VOCs and/or total organic carbon (TOC), a natural attenuation parameter (see **Section 3.3.4.3**).

Two additional soil borings were advanced to screen the possibility of potential contaminant source areas in the AOC2 study area. The locations of these borings were determined following the records review at sites where information suggested historical related contamination releases could have occurred (see also **Section 3.3.1**), and subsequent to evaluation of the preliminary results of the direct push investigation activities. These boring locations are shown on **Figure 3-1**. Continuous soil cores were reviewed in the field at each of the two locations and all soil cores were screened with a photoionization detector (PID) for the presence of volatile organics. In accordance with the work plan, soil samples were collected for laboratory analysis from each boring at a minimum of every 5 feet bgs. Three soil samples were obtained from each boring between the ground surface and twelve feet below ground surface for analysis of VOCs (see **Section 3.3.4.4**).

All soil borings were advanced using 8-1/4-inch hollow stem augers (HSA) and 2-inch-diameter by 2 foot-long split spoon samplers. The split spoons were driven through the

HSA by dropping a 140 pound hammer from a height of 30 inches (blow counts). The number of times that were required to drive the split spoon six inches was recorded. This was done three times to a depth of eighteen inches and the blow counts recorded on the boring log.

The split spoon was removed from the hole, opened, screened with a PID as described above, and the core was described using the United Soil Classification System (USCS). The boring was logged until refusal was encountered. This was when the blow counts exceeded 50 counts for 6 inches. Confirmation of bedrock was determined by a visual assessment.

All soil cuttings and other associated investigation-derived waste (IDW) were transferred to 55 gallon drums, labeled with the date and contents of the drum, and staged in the designated storage area (see Section 3.3.8 for a description of IDW disposal).

#### **3.3.4.3 Laboratory Analysis**

All soil samples collected during the soil boring activities were submitted to Paragon Analytics, Inc., for analysis of VOCs using EPA method 8260A. Samples were also collected at six of the soil boring locations for total organic carbon (TOC) analysis. These samples were sent to Paragon Analytics, Inc. for analysis using EPA method SW9060. Sample analysis was performed in accordance with the Draft Basewide Quality Assurance Project Plan (CH2M HILL, 1996c); data analysis and validation is described in Section 3.4.

#### **3.3.4.4 Rock Coring**

At four of the eleven monitor well locations (Wells WCHMHTA004, 006, 010, and 012), approximately ten feet of rock coring was performed to confirm the top of bedrock and further characterize the top of the bedrock lithology. The locations of these confirmatory rock corings are shown on Figure 3-1; they were selected to verify the bedrock elevation in suspected paleochannel areas reported during other investigations. Cores were collected using an air rotary method. The method involved connecting an air compressor to the rock core barrel and rotating the barrel into the rock. The air blew the rock fragments out of the hole and the rock core was collected in the barrel. The barrel was opened and the core was removed. It was measured, logged, labeled, and placed in a wooden core box for storage.

The rock core logs are presented in **Appendix C**. Results of this activity are discussed in **Section 4**.

#### **3.3.4.5 Monitor Well Installation**

Fourteen Terrace Alluvial Aquifer monitor wells were installed in the study area at the eleven monitor well boring sites (at 3 of the well boring locations, two wells were installed, one shallow and one deep). The location and number of monitor wells were finalized following completion of the records review, geophysical survey, and direct push investigation work tasks. Locations are illustrated on **Figure 3-1**. These wells were installed to verify results obtained from previous and/or planned screening-level investigations and to provide permanent locations for subsequent groundwater sampling and analysis. Modifications to well designations and locations proposed in the work plan are described in **Section 3.3.5.1**.

**Table 3-5** summarizes the monitor well construction data. Lithologic logs and monitor well completion diagrams are included in **Appendix C**. All of the wells installed were constructed of PVC risers with 0.010 inch slot PVC screen. The depth of the saturated zone was used to determine the length of the screened interval. The screen length was usually selected as 5 foot to 10 feet, but at 3 locations the screen length used was 20 feet. This length was used to provide the opportunity to address the thick sands at these locations; the low-flow sampling method employed (see **Section 3.3.5**) enabled focused sampling near the bottom of this screened interval without compromising the discreteness of the sampled horizon.

At three of the locations (wells WCHMHTA004, WCHMHTA006, and WCHMHTA010) where the depth of the saturated zone exceeded 20 feet, both a deep and shallow well were installed. The deep well was screened from ten feet above bedrock to bedrock, and the shallow well was screened from the saturated zone to ten feet below the saturated zone. These were installed to determine if a variance existed in the contamination concentration in the upper portion and lower portion of the aquifer. A 20/40 silica sand was used as the screen filter. The seal was bentonite holeplug and the grout was Portland/powder bentonite slurry. The wells were fitted with a 2-inch locking cap for security and finished with four-

foot by four-foot steel reinforced concrete pad. The wells were protected with a steel 12-inch length flush mount manhole with an 8-inch cover.

After installation, the wells were surveyed for northing, easting, and elevation. The elevations were surveyed from the top of the casing at the measuring point and from the top of the manhole lid. The survey data is included in Table 3-5.

#### **3.3.4.6 Well Development**

Following installation of the monitor wells, well development was conducted from December 1, 1997, through December 10, 1997. Each of the fourteen newly installed fourteen monitor wells were developed utilizing the overpumping method described in the AOC2 RFI Work Plan. Two of the wells, WCHMHTA013 and WCHMHTA014, did not contain sufficient water to perform well development with the pump and had to be bailed. Well development forms can be found in Appendix C.

In the work plan it states that wells will be developed until "the turbidity remains within a 5 nephelometric turbidity unit (NTU) range, when possible given the nature of the geologic unit the well is screened in, for at least 30 minutes (EPA has acknowledged that turbidity requirements may be difficult to achieve and notes that natural turbidity levels in groundwater may exceed 10 NTUs (EPA, 1996)). If the turbidity requirement of 5 NTUs can not be achieved within a reasonable amount of time, the Task Leader will be alerted and detailed documentation recorded in the logbook." The majority of the wells developed were purged until the turbidity was within the 5 NTU range. Two exceptions occurred at WCHMHTA004 (which due to an equipment failure, was last measured at 18 NTUs), and WCHMHTA011 (last measured at 19 NTUs after 370 gallons had been purged). At WCHMHTA011, it was deemed excessive to continue purging the well.

All other groundwater parameters, including pH, electrical conductivity, and temperature, stabilized fairly rapidly for all wells developed by the overpumping method. A total of 2,842 gallons of water were purged from the 14 wells that were developed. All purge water was transferred to 55 gallon drums, labeled with the date and contents of the drum, and staged with the soil cuttings generated from the drilling task (see Section 3.3.8 for a description of IDW disposal).

### 3.3.5 Groundwater Sampling

The groundwater sampling of new and existing wells was conducted in three phases at intervals of approximately two months: the first event was completed in December 1997, the second in February 1998, and the third in April 1998. The sampling was performed in order to further delineate the northern lobe of the contaminant plume and provide data to assist with the preliminary screening of the occurrence of natural attenuation in this area.

A total of 37 wells were sampled, including 14 newly installed and 23 existing wells. The field sampling forms are found in Appendix E. All groundwater samples were submitted to Paragon Analytics for VOC analysis. Samples collected from 11 of the 37 wells were also submitted for analysis of natural attenuation-related parameters during the first and third events.

Groundwater purging and sampling procedures outlined in the AOC2 RFI Work Plan were followed where possible; exceptions to these procedures are noted in the following subsections. All groundwater analytical data is provided in Appendix G; analysis procedures and data validation is described in Section 3.4.

#### 3.3.5.1 Well Location Selection

Several adjustments to the well selection proposed in the work plan were made following the completion of the drilling task. The modified sampling program is described on Table 3-6. Changes made to the initial work plan selection were as follows:

- Well WCHMHTA002 was not installed due to poor weather conditions rendering the site inaccessible to the drill rig. Monitor well HM-96, located approximately 500 feet southwest of the chosen site, was chosen to be sampled as a replacement.
- Because Well WCHMHTA002 was not installed, the well designations proposed in the work plan were reassigned as follows:

Original Designation (AOC2 RFI Workplan)	Current Designation
WCHMHTA003	WCHMHTA002
WCHMHTA005	WCHMHTA003

WCHMHTA016  
WCHMHTA014  
WCHMHTA015

WCHMHTA005  
WCHMHTA013  
WCHMHTA014

- Well WCHMHTA013 was originally planned to be a couplet well with WCHMHTA012, however, well 12 contained only a five-foot water column and the couplet was installed at WCHMHTA006 instead.
- Wells WCHMHTA013, WCHMHTA014, and WCHMHTA015 were initially chosen for sampling of natural attenuation parameters. However, WCHMHTA013 (formerly WCHMHTA014) and WCHMHTA014 (formerly WCHMHTA015) had less than two feet of water (which would strictly limit the volume of water that could be collected for sampling), and the former well WCHMHTA013 was not drilled (see previous bullet). The wells that were chosen as replacement natural attenuation wells were HM-120, MW-3, and WCHMHTA012.
- Existing well MW-59 demonstrated only 0.29 feet of water in the casing and could not be sampled (well MW-58, located near MW-59, was considered as a replacement but it also demonstrated only a small amount of water (only 0.41 feet of water)). Well WITCTA016 was sampled in lieu of MW-59.

### 3.3.5.2 Groundwater Sampling Activities

A total of 37 wells were sampled in three sampling events spaced at two-month intervals: December 1997, February 1998, and April 1998. The 37 wells included 15 newly installed and 22 existing wells. Decontamination procedures dictated by the work plan were followed. All groundwater samples collected were analyzed for VOCs, samples collected from the wells selected for natural attenuation screening were also analyzed for anions, cations, TOC, alkalinity, and methane. All samples, with the exception of the methane samples, were sent to Paragon Analytics in Fort Collins, Colorado. The methane samples were sent to QAL in Corvallis, Oregon. All laboratory analytical data for the groundwater samples collected during December 1997 are listed in Appendix G; copies of field sampling forms are provided in Appendix E.

The following bullets describe any deviations from the work plan:

- A low-flow sampling technique consistent with that outlined in the workplan was utilized during this sampling event wherever possible. Several wells had to be purged and sampled via bailers due to the minimal amount of water in the wells and very slow recovery rates. Wells WCHMHTA013, WCHMHTA014, and MW-57 were sampled in this manner. Two of the three wells that had to be bailed, WCHMHTA013 and MW-57, contained approximately 2 feet of water. The field crew attempted to pump these wells at very low flow rates, however, the water column would rapidly drop below the pump intake and both were extremely slow to recover. The third bailed well, WCHMHTA014, contained less than a foot of water and could not be pumped.
- During several days of sampling, The dissolved oxygen (DO) sensor on the Horiba multi-meter used to collect groundwater purging parameter measurements was not functioning properly. When this occurred, a HACH DR 2000 spectrophotometer was used to collect initial and final DO readings.

The majority of the wells sampled met the purge/stabilization criteria outlined in the AOC2 Field Sampling Plan (temperature +/- 0.2°C, pH +/- 0.1 units, EC +/- 3% full scale range, DO +/- 0.10 mg/L or 10% of value - whichever is greater, Eh +/- 10 %, and turbidity +/- 10%). In general, groundwater DO concentrations at the time of sampling were equal to or lower than DO concentrations at the beginning of the purge, indicating that artificial aeration did not occur during purging. The following exceptions to the purge criteria were observed:

- The temperature criteria (+/-0.2°C) was not always met due to the nature of the submersible pumps. These pumps will heat up during purging, causing an increase in the water temperature. Based on a literature review, there does not appear to be conclusive evidence indicating increased sampling pump temperatures affect the concentration of chlorinated solvents. The "Comparison of Ground-Water Sampling Devices Based on Equilibration of Water Quality Indicator Parameters" (National Groundwater Sampling Symposium Proceedings, November 30, 1992), states "the only disadvantage of the low speed submersible pump appears to be the increased heat

generated, which might affect certain volatiles, but even with this possibility, however, it gave the highest recoveries for TCE of any of the tested devices [in the study].”

- Well SPOT-35-4 has historically not met low-flow purge parameters (see GSAP, CH2M HILL, 1997). Even at low flow rates the water level will drop. The well surged and turbidity values fluctuated constantly. The samples collected during the three events were collected after purging over 5 well volumes.

### 3.3.6 Aquifer Testing

Slug testing was performed at 22 newly installed and existing monitor wells in the AOC2 study area from January 19, 1998 to January 23, 1998. The testing was conducted on eleven new wells installed by CH2M HILL in December 1997, and eleven wells previously installed by other contractors. Figure 3-1 shows the location of these wells. The objectives of the testing were to provide an estimation of hydraulic conductivity and to supplement existing data on the physical properties of the Terrace Alluvial Aquifer in the AOC2 study area.

#### 3.3.6.1 Monitoring Well Selection

The criteria used to select wells for slug testing were: (1) newly installed wells with a water column greater than four feet; (2) previously installed wells spaced evenly over the AOC2 area with a water column greater than four feet; and (3) wells exhibiting little to no contamination, if possible, to reduce exposure and cross-contamination concerns. Decontamination was performed between wells.

#### 3.3.6.2 Data Acquisition

The aquifer testing was conducted utilizing the slug test method. The water column in the well was determined by measuring the water level and total depth of the well with an electronic water level indicator. A transducer was lowered into the well and placed six inches to one foot above the bottom of the well. The well was allowed to equilibrate and a head pressure reading was noted. The depth from the top of the casing to the water level was entered into the instrument as the reference number. This converted the instrument to reading the actual water level instead of the head pressure. Once the water level stabilized, the data logger began recording data. A slug (sealed PVC pipe filled with sand) was lowered below the water table displacing the water in the well. The data logger recorded the

rise of the water level in the well over time (in fractions of a second). The depth to water was checked on the data logger, when the water level returned to equilibrium the recording was stopped. This portion of the test was labeled slug in. The data logger was restarted and the slug removed. Again the data was recorded at fractions of a second and the well was allowed to equilibrate. This was labeled the slug out portion of the test. These sets of tests were performed two to three times at each well.

The slug, the water level indicator and the transducer/cable were decontaminated with a methanol wipe followed by a DI water rinse between each well tested.

### **3.3.6.3 Data Processing**

The data logger was downloaded into a portable computer at the end of each day or when the data logger was limited on memory space. The data was converted to an Excel format and the time versus water level change was graphed to ensure representativeness. If the data appeared unusable the well was scheduled to be re-tested.

The data and well construction information was entered into a software program that calculated the hydraulic conductivity of the aquifer in the vicinity of the tested well. Slug test analyses are presented in **Appendix D**, results are summarized in **Section 4**.

### **3.3.7 Surface Water Staff Gauge Installation**

Two surface water staff gauges were installed in January 1998, one along the Trinity River at the eastern boundary of the AOC2 study area, and one along the shore of Lake Worth at the northern boundary of the study area. The locations of the gauges are shown on **Figure 3-1** and described on **Table 3-7**. The gauges were installed to provide surface water elevation data at these locations for comparison with monitor well groundwater elevation data in order to evaluate horizontal groundwater flow. This data is presented in **Section 4**.

### **3.3.8 Investigation-Derived Waste Disposal**

All IDW generated during the AOC2 RFI field effort was contained in 55-gallon drums and placed in a designated staging area at the west end of White Settlement Road. In August 1998, Safewater Technologies, Inc., was contracted by CH2M HILL to remove and properly dispose all soil, water, and personal protective equipment (PPE) generated during the AOC2

RFI from the site. Following confirmation sampling, approximately 2,389 gallons of non-hazardous purge water and decontamination water was discharged to the NAS Fort Worth JRB Sanitary Sewer System on September 2, 1998. Approximately 12 tons of non-hazardous soil and PPE were disposed of at the CSC Landfill in Avalon Texas on September 3, 1998. Copies of the waste manifest forms and analytical results can be found in **Appendix H**.

## **3.4 Laboratory Analysis and Data Validation**

All laboratory analysis and data validation activities were performed under the guidelines of the Draft Basewide Quality Assurance Program Plan (CH2M HILL, 1996b, as modified by HGL, 1997c). This section describes the analytical procedures and data validation activities.

### **3.4.1 Analytical Procedures**

Soil and groundwater samples were collected and analyzed for selected parameters as described in **Section 3.3**. This section describes the laboratories and methods employed.

#### **3.4.1.1 Laboratories**

The offsite analytical activities conducted for this RFI were performed by Paragon Analytics, Inc. (Fort Collins, CO) and CH2M Hill Applied Sciences Laboratory (Corvallis, OR).

#### **3.4.1.2 Parameters for Analysis, References to Analytical Methods, and Specifications of Methods for Establishing Control Limits for Each Laboratory**

The parameters analyzed and analytical methods used by each laboratory are described in this section. The methods utilized are listed on **Table 3-6**; these methods are also specified in **Table 7.2.1** of the Basewide QAPP (HydroGeoLogic, 1997c). They are from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition, Updates I and II*, and from *Methods for Chemical Analysis of Water and Waste, 1979*, with the exception of method RSK-175. The CH2M Hill - Corvallis Applied Sciences Laboratory Standard Operating Procedure (SOP) for Methane, Ethane, and Ethene in Water by GC-FID with Headspace Generation was used in the analysis for methane, ethane, and ethene by method RSK-175. This method involves headspace generation followed by gas chromatography using flame ionization detector. The SOP is provided in **Appendix G-4**.

The quality control (QC) requirements followed by the laboratories, including QC type, frequency of analysis, control limits, and corrective action, are those specified in Sections 6.0 and 7.0 of the Basewide QAPP, as listed below. These requirements were modeled after those specified in the Air Force Center for Environmental Excellence Model QAPP, February 1996.

#### Analytical Methods and Quality Control Requirements

Method	Parameter	QC Reference (QAPP Table No.)	Laboratory
SW-8260A	Volatile Organics	7.2.13-2; 7.2.13-3	Paragon Analytics
SW-6010A	Trace Metals by ICP	7.2.18-2, 7.2.18-3	Paragon Analytics
SW-9056	Common Anions	7.2.31-2; 7.2.31-3	Paragon Analytics
SW-9060	Total Organic Carbon	7.2.34-2; 7.2.34-3	Paragon Analytics
E310.1	Alkalinity	6.2.1	Paragon Analytics
RSK-175	Methane, Ethane, and Ethene	7.2.33-2; 7.2.33-3	CH2M Hill Applied Sciences Laboratory

#### 3.4.1.3 Chronology of Laboratory Analyses

Samples were collected and shipped by overnight carrier to the laboratories. Copies of Chain of Custody forms are provided in **Appendix G-1**. The samples and analysis dates are listed in chronological order in the Sample Chronology table provided in **Appendix G-2**.

#### 3.4.2 Quality Assurance/Quality Control Program

This section discusses the program that was required to be in place to ensure that the data collected were of known quality. It describes the types of QC samples that were generally required the analysis frequency, and the actions to be taken when the acceptance criteria were exceeded. The use of QC results to measure completeness is also addressed.

##### 3.4.2.1 Types of QC Samples by Method

The types of QC samples specified are a function of the method and the data quality parameters that they were supposed to measure.

Calibration verification standards were required to ensure that the initial instrument calibration was valid and that the calibration was maintained throughout each analysis sequence.

Matrix spike/matrix spike duplicates (MS/MSD) and field duplicates were used to evaluate analytical and field precision. The relative percent differences between the MS and MSD results and those between the field duplicate results were calculated. Results of field duplicates are summarized in **Appendix G-3.1**.

Accuracy of analytical results is a function of the performance of each method and that of the laboratory. Matrix spikes, surrogates (used for organics analyses only), and laboratory control samples (LCS) were used to evaluate accuracy. Matrix spike and surrogate recoveries provide an indication of the performance of the method relative to the specific matrix. They are, however, susceptible to matrix interference, and do not always provide an indication of the laboratory's performance. Laboratory control samples are more useful in this respect, since they do not suffer from matrix effects. LCS summaries are presented in **Appendix G-3.3**.

Method and field blanks were specified in order to monitor for contaminants. Method blanks were used to provide an indication of the presence of contaminants in the laboratory. Ambient blanks and trip blanks were used to monitor for volatile contaminants during sample handling and transport. Equipment blanks were used to assess the effectiveness of equipment decontamination procedures in the field.

The types of QC samples required for each method are listed in the QAPP tables referenced above.

#### **3.4.2.2 Frequency of QC Sample Analysis**

The analysis frequency varies with the type of QC samples and the purpose for which they were intended.

Where the purpose of the QC sample was to monitor the state of control of the laboratory, the frequency of analysis was based on the number of samples analyzed or the analysis time elapsed. Calibration verification standards, method blanks, and laboratory control samples are in this category.

MS/MSDs, field duplicates, and field blanks, on the other hand, were intended to monitor for variabilities arising from the sample matrix or sampling events. Since this was the case, the analysis frequency was based on the sampling frequency.

The QAPP tables referenced above list the analysis frequency for each type of QC sample for each method.

#### **3.4.2.3 QC Acceptance Criteria**

The QAPP tables referenced above list the acceptance criteria for each type of QC sample for each method and matrix. These criteria were based on AFCEE specifications, and reflect the data quality goals for the project.

#### **3.4.2.4 Out-of-Control Conditions and Other Problems Detected During Laboratory Analysis**

The QAPP specifies how each out-of-control condition is to be handled by the laboratory when identified during the analysis of samples. The expected corrective action usually involves re-preparation and/or reanalysis of all samples implicated. Each analyst is required to review 100% of definitive data to ensure that problems identified subsequent to analysis are corrected. An independent review of 100% of definitive data by a senior analyst or supervisor is also required. In addition, review of 10% of completed data packages by the QA section is specified.

#### **3.4.2.5 Corrective Actions Taken to Correct Problems**

The QAPP tables referenced above specify the corrective action to be taken when the acceptance criteria for each type of QC are not met. They also specify qualification of data when acceptance criteria are not met, and corrective action was not successful or was not taken.

#### **3.4.2.6 Calculations of Completeness of Analytical Results**

The results of completeness calculations for each parameter and each analyte and matrix are listed in the Completeness Summary table provided in Appendix G-3.2. Analytical completeness is defined by the QAPP as the percentage of valid results (no "R" flags) compared to the total possible number of results for all normal and field duplicate samples

irrespective of the reason for the rejection of data. Contractor completeness, however, takes into consideration rejections resulting from the contractor's non-compliances, through error or omission, with the QAPP requirements. The criteria for completeness are 90% for soil samples and 95% for water samples.

The results of completeness calculations are summarized in Appendix G-3.2.

#### 3.4.2.7 QA Activities

No audits of the participating laboratories have been performed for this project.

### 3.4.3 Data Evaluation

This section describes the evaluation of the data received from the laboratories.

#### 3.4.3.1 Methodology for Data Quality Assessment

The methodologies that were followed were consistent with those specified in the Basewide QAPP. The laboratories were required to qualify data according to the requirements specified in the QAPP tables referenced above for each method. A comment explaining each qualifier was to be included. When data were affected by multiple qualifiers, the laboratories were required to apply a final qualifier which reflected the most severe one according to the following hierarchy listed in the order of most severe to least severe: R, M, F, J, B, and U. The qualifiers are defined below:

Qualifier	Description
R	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
M	A matrix effect was present.
F	The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
J	The analyte was positively identified; the quantitation is an estimation.
B	The analyte was found in an associated blank, as well as in the sample.
U	The analyte was analyzed for, but not detected. The associated numerical value is at or below the method detection limit (MDL)
UB	Same as "U", and a matrix effect was present.
UM	Same as "U", and the analyte was found in an associated blank.
UJ	Same as "U", but the detection limit was estimated

During data validation all data were reviewed for compliance with the acceptance criteria for each method to determine the usability of each result. Where multiple results were submitted for a given sample, the data validators identified the best result using professional judgment, and excluded the rest of the results. The included results were then evaluated against the data qualification requirements, and the most severe qualifier was applied where appropriate. Data qualification was applied to normal and field duplicate samples only.

Data validation was done using a semi-automated program that utilizes both laboratory hard copies and electronic data. Final data qualifiers and the reason for each qualification were entered into the project database. Validation reports were generated from the database. Final validation qualifiers for global issues, such as matrix interference, were added to the database following each round of data validation. These are annotated as global qualifiers in the database.

#### **3.4.3.2 Data Evaluation Results**

Results of data evaluation for each of the methods utilized are listed below, including Method SW8260A, Method SW6010A, Method SW9056, Method SW9060, Method E310.1, and Method RSK-175.

##### **Method SW8260A**

The most common problems that were identified during data evaluation were associated with the VOC analyses from Paragon Analytics, Inc. The laboratory had a significant problem particularly with Methylene Chloride. All observed problems and their impact on the data are discussed below:

- **Methylene Chloride contamination.** This compound was reported above the RL in the method blanks for all sample delivery groups. This resulted in adjustment of the results reported for the associated field samples. In most cases, however, the results had to be rejected due to deviations associated with calibration or laboratory control sample analyses.

- **Initial calibration deviations.** Some compounds failed to meet the %RSD criteria. This resulted in rejection of the associated results. Table G-3.2 lists all rejected data. Rejected data were not considered as usable.
- **Calibration verification deviations.** Several compounds were not recovered within the acceptance limits from the second-source calibration verification standards and/or the continuing calibration standards. From two to seven compounds at a time were also missing from the second-source calibration verification standards. The QAPP specifications required rejection of the results associated with these deviations. Due to the critical need for information for some of these compounds, when calibration exceedances were observed an increased level of effort was given to determining the usability of data over and above the flagging criteria stated in the QAPP. On further review of the data, the project team decided to re-consider the rejection of results for 5 compounds (1,1-Dichloroethene, trans-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene, and Vinyl Chloride). The guidelines from the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, February 1994* were used as the basis for the rationale for this decision. There is no specification for second-source calibration verification standard in this referenced document, and its criteria for the use of "J" and "UJ" qualifiers for continuing calibration percent difference (%D) deviations are consistent with the application of these qualifiers to the five compounds listed above. The application of the "UJ/J" flags was advisory to the data users to indicate that the second source information was missing from the quality control review. Specifically, the following adjustments were made: a) When the %D for continuing calibration verifications was outside of control limits, the "R" flag was replaced with "J" for detects and "UJ" for non-detects. This is in line with the USEPA guidance document referenced above if the analyte response factor (RF) meets the minimum level specified in that document. b) When these compounds were missing from the second source calibration standard, the "R" flag was removed and the data were flagged as "J" for detects and "UJ" for non-detects. In this instance, the reviewers feel that recovery of the laboratory control sample (LCS) along with the RF and %D for CCV were good indicators that the analytical system was under control.

- **Laboratory control sample deviations.** In most, if not all cases, these deviations involved low recoveries of Methylene Chloride. There were a few cases of low recoveries for other compounds as well. These deviations resulted in rejection of results since these compounds were, in most cases, not detected in the associated samples. A number of compounds that were recovered above the control limits were also noted. In most cases, these compounds were not detected in the associated samples, and the impact of the deviation was therefore minimal.

**Method SW6010A**

No significant problems were identified except occasional detections of certain analytes in laboratory or field blanks above the RL. This required adjustment of associated sample results.

**Method SW9056**

No analytical problems were noted.

**Method SW9060**

No analytical problems were noted.

**Method E310.1**

No analytical problems were noted.

**Method RSK-175**

No analytical problems were noted.

A validation report has been prepared for each sample delivery group. The text of each report describes the deviations found for each QC sample type, and the flags applied to associated sample results. A summary of the results of each sample and any qualifications resulting from the data validation is found at the end of each report. An explanation for the data qualification is also provided in each case.

Copies of the validation reports are found in Appendix G-3.5. A quantitative summary of all detections is provided in Appendix G-3.4.

**Table 3-1  
Data Needs for AOC2 RFI Objectives  
NAS Fort Worth JRB, Texas**

	Primary Project Objective	Secondary Project Objective	Data Need	RFI Activity
1	Delineate the potential sources of TCE that are contributing to the northern lobe of groundwater contamination occurring in AOC2	N/A	The history of TCE use, including the quantities and locations of use	Record reviews
2	Physically identify primary flow paths within the Terrace Alluvial Aquifer, and potentially to the Paluxy Aquifer in the northern lobe of AOC2	Evaluate the occurrence of transmissive zones within the AOC2 study area and the likelihood of potential thin zones within the Goodland and Walnut formations, particularly along possible paleochannels.	Stratigraphic profile between the western property boundary and the alert apron to investigate the feasibility of preferential flow paths that may explain the distribution of TCE east of this area  Depth to bedrock between the alert apron and western property boundary	Direct-push screening transects  Seismic refraction geophysical survey
3	Delineate the nature and extent of TCE groundwater contamination in the northern lobe of AOC2	Evaluate the feasibility of a relationship between the known occurrence of TCE in the alert apron and flightline areas, and the western property boundary of NAS Fort Worth JRB  Define the nature and extent of TCE contamination along the north west portion of the runway  Evaluate bifurcation of the TCE plume east of the control tower near  Evaluate presence of other possible sources east of the control tower to potentially explain cause of apparent "hot spots" in this area  Evaluate the downgradient extent of TCE groundwater contamination near the West Fork Trinity River	Top of rock characterization at selected locations within possible paleochannels to determine presence of Walnut/Goodland Limestones  Horizontal plume delineation between the known APP 4 plume and the isolated TCE plume west of the alert apron and near the control tower, vertical plume delineation within the Terrace Alluvium including the upper zone and the basal gravel, particularly in the alert apron area and along the western property boundary  Horizontal plume delineation in the northwestern corner of the runway  Horizontal and vertical contaminant delineation in this area, hydrostratigraphic delineation (see above).  Additional horizontal contaminant delineation, historical waste management information  Horizontal plume delineation in this area	Confirmatory rock borings (at locations WCHMHTA004, 006, 010, and 012)  Direct-push screening transects, single and couplet monitor well installations (at locations WCHMHTA003, 004, 005, 006, 009, and 010), and soil and groundwater sampling.  Monitor well installations (WCHMHTA014), groundwater sampling of existing wells  Direct-push screening transects, monitor well couplet (at location WCHMHTA009 and 010)  Records review Direct-push screening transects, groundwater sampling of existing wells, soil borings  Monitor well installation (WCHMHTA013) and sampling of existing wells

**Table 3-1  
Project Objectives, Data Needs, and Proposed Work Tasks  
NAS Fort Worth JRB, Carswell Field, TX**

	<b>Primary Project Objective</b>	<b>Secondary Project Objective</b>	<b>Data Need</b>	<b>RFI Activity<sup>1</sup></b>
4	Perform a fate and transport assessment	Evaluate the potential occurrence of natural attenuation  Perform a fate and transport assessment to evaluate possible contaminant source locations and to estimate the concentration and time of travel associated with groundwater discharges to the West Fork Trinity River	Obtain natural attenuation parameter analytical data.  Contaminant fate and transport properties, aquifer properties, nature and extent of TCE contamination	Groundwater sampling, natural attenuation screening assessment  Soil borings, well installations, hydrogeologic testing, groundwater sampling, time of travel assessment
5	Evaluate the risk posed to human health and the environment by the constituents encountered in soils and groundwater that define AOC 2	Based on requirements established by the TNRCC, evaluate complete exposure pathways including but not limited to ingestion, inhalation, and dermal contact with contaminated soil and/or groundwater by human receptors, and the potential ecological receptors and effects associated with AOC 2 media	Soil and groundwater analytical data	Soil and groundwater sampling, Risk characterization

**Notes**

<sup>1</sup> Borings, monitor wells, and direct-push screening transects are shown on Figure 3-1.

**Table 3-2  
Results of Evaluation of Potential SWMU/AOC Sources in AOC2 Study Area  
NAS Fort Worth JRB, Texas**

<b>SWMU/AOC<sup>1</sup></b>	<b>Description<sup>2</sup></b>	<b>Status as of 1996<sup>3,4</sup></b>	<b>Wastes Managed [Release Potential]<sup>2</sup></b>	<b>Comments</b>
5. Building 1628 WAA	Outdoor container storage area within roofed metal shed with concrete base	No Investigations	antifreeze, MEK, epoxy paint stripper, epoxy paint thinner, lead acid batteries, recyclable oil / HIGH	Not a concern as a potential AOC2 source. Included in a proposed investigation of multiple WAAs (HGL, 1998b).
6 Building 1628 Wash Rack & Drain	Wash rack and drain located inside the building.	No Investigations	wastewater containing fractions of aircraft engine hydraulic fluid, aircraft engine oil, PD-680 (a petroleum naphtha solvent / HIGH	Addressed indirectly by other Building 1628 area investigations. Not a concern as a potential AOC2 source.
7 Building 1628 Oil/Water Separator	Below-ground L-shaped concrete structure, receives wastes from the wash rack and drain (SWMU 6)	No Investigations	wastewater containing fractions of aircraft engine hydraulic fluid, aircraft engine oil, PD-680 (a petroleum naphtha solvent [UNKNOWN])	Addressed by Sanitary Sewer RFI (IT Corporation, 1997) Not a concern as a potential AOC2 source.
8. Building 1628 Sludge Collection Tank	Below ground steel tank installed in concrete connected to the adjacent oil/water separator (SWMU 7)	No Investigations	sludge containing fractions of aircraft engine hydraulic fluid, aircraft engine oil, PD-680 (a petroleum naphtha solvent) [UNKNOWN]	Addressed indirectly by Sanitary Sewer RFI (IT Corporation, 1997). Not a concern as a potential AOC2 source.
9 Building 1628 Work Station WAA	5-gallon metal can	No Further Action	rags containing MEK, epoxy stripper, aircraft engine hydraulic fluid and/or engine oil [LOW]	Not a concern as a potential AOC2 source
10. Building 1617 Work Station WAA	two 5-gallon metal cans	No Further Action	lacquer thinner/fnk residue, rags containing lacquer thinner and ink / LOW	Not a concern as a potential AOC2 source
11. Building 1617 WAA	outdoor container storage area with a concrete base surrounded by a wooden fence	No Investigations	spent etchant, lacquer thinner/fnk residue [LOW]	Include screening soil boring in RFI to assess this as a possible TCE-related contamination source (share soil boring with SWMU 12). This WAA is now included in a proposed investigation of multiple WAAs (HGL, 1998d)
12. Building 1619 WAA	container storage area, not fenced, with a partial concrete pad base (located outside Building 1619 at edge of parking lot)	No Investigations	waste jet fuel, waste jet engine oil, PD-680 [HIGH]	Include screening soil boring in RFI to assess as a possible TCE-related contamination source (share soil boring with SWMU 11). This WAA is now included in a proposed investigation of multiple WAAs (HGL, 1998d)

Table 3-2

Results of Evaluation of Potential SWMU/AOC Sources in AOC2 Study Area  
NAS Fort Worth JRB

SWMU/AOC <sup>1</sup>	Description <sup>2</sup>	Status as of 1996 <sup>3,4</sup>	Wastes Managed [Release Potential] <sup>2</sup>	Comments
13. Building 1710 WAA	plastic containers within Building 1710 plumbed to film processing equipment and sanitary sewer drain	No Investigations	waste photo fixer which may contain a phenolic compound, an alkaline compound, sodium sulfite, potassium bromide [LOW]	Not a concern as a possible AOC2 source.
30 Landfill No. 9	Located in the northeast area of the base, along the West Fork Tnnity River	No Investigations	Clean construction rubble and trees, no reported hazardous materials, although materials with hazardous constituents may have been disposed [MODERATE]	This landfill is located downgradient of the documented TCE plume extent. HGL is performing a separate RFI of this landfill (HGL, 1997a). Not a concern as a potential AOC2 source.
32. Building 1410 WAA	Outside TCE plume boundary / outdoor, uncovered storage area with concrete base and 500 gallon tank	No Investigations	7808 engine oil, carbon and fingerprint removers, PD-680, waste JP-4 fuel, solvent designated SE 377E [MODERATE TO HIGH]	Not a concern as a potential AOC2 source. This WAA is now included in a proposed investigation of multiple WAAs (HGL, 1998d)
33. Building 1420 WAA	outdoor uncovered container storage area with wooden fence on 3 sides and partial concrete, partial asphalt base	No Investigations	hydraulic fluids, brake fluid, PD-690 [HIGH]	Include screening soil boring in RFI to assess as a possible TCE-related contamination source. This WAA is now included in a proposed investigation of multiple WAAs (HGL, 1998d)
39 Building 1643 WAA	200 gallon waste oil trailer, 55-gallon drum and smaller container with 25-gallon containers in locked cage, ground paved with asphalt	No Investigations	waste engine oil, hydraulic fluid, waste jet fuel, carbon remover containing complex hydrocarbons [LOW]	Not a concern as a potential AOC2 source.
40. Building 1643 Oil/Water Separator	Two oil/water separators; unit includes floor drains in the building and underground conduits to the separators	No Investigations	wastewater contaminated with chemicals used in aircraft maintenance (PD-680, jet fuel, hydraulic fluid, engine oil, carbon remover) / UNKNOWN	Addressed by Sanitary Sewer RFI (IT Corporation, 1997). Not a concern as a potential AOC2 source.

Table 3-2  
Results of Evaluation of Potential SWMU/AOC Sources in AOC2 Study Area  
NAS Fort Worth JRB

SWMU/AOC <sup>1</sup>	Description <sup>2</sup>	Status as of 1996 <sup>3,4</sup>	Wastes Managed [Release Potential] <sup>2</sup>	Comments
41. Building 1414 Oil/Water Separator	Inactive oil/water separator, unit includes floor drains in the building and underground conduits to o/w separator located just outside NW side of building.	Investigated by Law, 1995a, some metals contamination documented. Confirmation sampling recommended (CH2M HILL, 1996)	wastewater contaminated with hydraulic fluid, antifreeze, jet fuel, engine oil and grease, citri-kleen (a degreasing solvent), other chemical cleaning agents [UNKNOWN]	Addressed by Sanitary Sewer RFI (IT Corporation, 1997) Not a concern as a potential AOC2 source.
42. Building 1414 WAA	outdoor container storage area on asphalt paved base with 500-gallon waste oil bowser	No Investigations	waste oil, hydraulic fluid, antifreeze, jet fuel [LOW]	Not a concern as a potential AOC2 source.
43. Building 1414 Non-Destructive Inspection Waste Accumulation Point	two metal carboys inside Bldg 1414	No Further Action	waste oil, 1,1,1-trichloroethane contaminated rags / LOW	Not a concern as a potential AOC2 source
49. Aircraft Washing Area No. 1	Rectangular space paved with asphalt sloped toward center drain	No Investigations	PD-680, soaps [LOW]	Outside TCE plume boundary; not a concern as a potential AOC2 source.
56. Building 1405 WAA	One 55-gallon drum inside Building 1405	No Investigations	polyurethane waste paint and thinners / LOW	Outside TCE plume boundary; not a concern as a potential AOC2 source.
57. Buildings 1432/1434 WAA	Outdoor uncovered and non-barn-caded container storage area with concrete pad base	No Further Action	diethylene glycol, waste hydraulic oil, antifreeze, cleaner and degreaser	Not a concern as a potential AOC2 source.
66. Sanitary Sewer System	A base-wide network of underground pipes. Collects sanitary wastewater as well as some industrial wastewater. Effluent is pumped to the City of Fort Worth for treatment. System has been in place throughout base history.	No Investigations	Mostly sanitary wastewater, some industrial wastewater	IT Corporation has completed a RCRA Facility Investigation (IT Corporation, 1997). Not a concern as a potential AOC2 source
AOC 3 Waste Oil Dump	Area reportedly used as a disposal pit for used oil filters and other items used in routine vehicle maintenance	Subsurface soil/groundwater investigation in 1993 (USCOE, 1993) No Further Action	Automobile maintenance waste, including used oil filters	Not a concern as a potential AOC2 source

Table 3-2  
Results of Evaluation of Potential SWMU/AOC Sources in AOC2 Study Area  
NAS Fort Worth JRB

SWMU/AOC <sup>1</sup>	Description <sup>2</sup>	Status as of 1996 <sup>3,4</sup>	Wastes Managed [Release Potential] <sup>2</sup>	Comments
AOC 4. Fuel Hydrant System	Inactive fuel hydrant system used to performed aircraft refueling (includes "Spot-35")	Previous investigation, initial remedial actions have been performed.	Aircraft fuel	A site investigation to supplement previous work at AOC4 has recently been completed (HGL, 1997.). Not a concern as a potential AOC2 source

Notes.

Refer to Figure 1-1 for SWMU/AOC locations

1. SWMU = Solid Waste Management Area;  
AOC = Area of Concern
2. WAA = Waste Accumulation Area
3. Unit description, wastes managed, and release potential from Site Characterization Summary ITIR (CH2M HILL, 1996c)
4. "No Investigations" based on investigation summary provided in Site Characterization Summary ITIR (CH2M HILL, 1996c)  
"No Further Action" is an official designation from TNRCC, based on March 1995 TNRCC letter (TNRCC, 1995), and September 1993 TNRCC letter (TNRCC, 1993).

**Table 3-3  
 Preliminary Work Plan Direct Push Temporary Well Information  
 NAS Fort Worth JRB, Texas**

Well ID	Date Installed	Northing	Easting	Ground Elevation	Total Depth (ft)	Depth to Water (ft bgs)	Screened Interval (ft bgs)
AGA-001	10/30/96	6965958.695	2299497.306	596.590	14.1	11.1	11.1-14.1
AGA-002	10/31/96	6966482.495	2299483.493	588.445	8.3	7.3	5.3-8.3
AGA-003	10/31/96	6966839.676	2299470.734	581.391	10.1	8.1	7.1-10.1
AGA-006	10/31/96	6967145.378	2299092.760	586.110	10.5	7.5	7.5-10.5
AGA-007	10/31/96	6966085.340	2299038.883	604.316	18.7	17.6	15.7-18.7
AGA-009	11/3/96	6968226.047	2298925.102	601.742	20.2	17.7	17.2-20.2
AGA-010	11/3/96	6968549.295	2299004.752	602.377	21.8	17.3	18.8-21.8
AGA-011	11/1/96	6968613.748	2298441.847	600.575	16.4	12.4	13.4-16.4
AGA-012	10/31/96	6967360.926	2298498.923	597.428	16.9	9	13.9-16.9
AGA-014	11/1/96	6967438.195	2297810.959	601.781	16.5	12.4	13.5-16.5
AGA-015	11/1/96	6968097.395	2297626.604	604.729	19.1	13.8	16.1-19.1
AGA-016	11/3/96	6966824.206	2297371.921	612.193	26.4	22.8	23.4-26.4
AGA-018	11/5/96	6966824.858	2295750.835	623.336	20.8	14	17.8-20.8
AGA-019	11/1/96	6967050.941	2295689.228	624.690	20.8	15.8	17.8-20.8
AGA-020	11/1/96	6967196.674	2295789.419	623.113	16.6	14.5	13.6-16.6
AGA-021	11/1/96	6967308.059	2295397.694	626.984	25.3	18.4	22.3-25.3
AGA-022	11/3/96	6967101.041	2295225.724	629.156	26.4	20.2	23.4-26.4
AGA-023	11/3/96	6967131.306	2295210.503	629.326	26.4	17.9	23.4-26.4
AGA-024	11/3/96	6967348.800	2295209.120	629.238	31.9	20.1	28.9-31.9
AGA-024S	11/4/96	6967349.487	2295210.684	629.175	23	21.1	21.0-23.0
AGA-025	11/3/96	6967650.317	2295376.915	625.703	21.9	16.7	18.9-21.9
AGA-026	11/3/96	6967845.934	2295425.681	623.951	19.8	14.8	16.8-19.8
AGA-027	11/4/96	6968068.673	2295689.360	620.657	21.8	12.3	18.8-21.8
AGA-028	11/3/96	6968286.400	2295636.944	620.362	19.9	12.5	16.9-19.9
AGA-035	11/5/96	6967351.466	2294058.901	633.585	27.8	22.7	24.8-27.8
AGA-036	11/5/96	6967673.873	2294269.166	632.253	27.1	19.7	24.1-27.1
AGA-037	11/5/96	6967895.296	2294060.557	632.325	30	24.4	27.0-30.0
AGA-038	11/4/96	6967498.299	2294936.858	628.918	26.8	20.3	23.8-26.8
AGA-039	11/4/96	6967399.002	2294553.860	631.674	31.8	22.4	28.8-31.8
AGA-040	11/4/96	6967230.620	2294941.388	629.745	32.8	22.6	29.8-32.8
AGA-040S	11/4/96	6967232.630	2294941.350	629.810	24	20.3	21.0-24.0
AGA-041	11/4/96	6966665.716	2294928.042	631.027	28.5	21.5	25.5-28.5
AGA-042	11/5/96	6966776.470	2294060.196	633.156	36	23.5	33.0-36.0
AGA-043	11/5/96	6966426.429	2294071.512	632.876	26.2	23	23.2-26.2
AGA-050	11/4/96	6966128.624	2294909.760	629.867	27.5	19.9	24.5-27.5
AGA-071	11/5/96	6967147.368	2294428.753	633.508	37.9	23.6	34.9-37.9
AGA-071A	11/5/96	6967147.368	2294428.753	633.508	34	28.6	31.0-34.0
AGA-071B	11/5/96	6967147.368	2294428.753	633.508	27	23	24.0-27.0
AGA-072	11/5/96	6967302.446	2294278.019	634.117	28.2	25.4	25.2-28.2
AGA-073	11/5/96	6967154.588	2294124.364	633.698	24	23.2	21.0-24.0

Note: bgs = below ground surface

651 90

**Table 3-4**  
**RFI Direct Push Investigation Temporary Well Information**  
**NAS Fort Worth JRB, Texas**

Well ID	Date Installed	Northing	Eastng	Ground Elevation	Total Depth (ft)	Depth to Water (ft)	Approximate Sreened Interval (ft)
PCHMHTA0A1	11/01/97	6968847 867	2295695 701	617 130	20 2	8 5	17 9-20 9
PCHMHTA0A2	11/01/97	6968264 751	2295731 486	619 049	18 5	10 6	15 4-18 4
PCHMHTA0A3	11/01/97	6967589 359	2295619 047	623 454	25 5	13 9	26 3-28 3
PCHMHTA0A4	11/03/97	6966486 822	2295885 674	622 585	18 4	12 1	15 0-18 0
PCHMHTA0B1	11/01/97	6968193 823	2296824 520	608 773	24 4	15 8	22 0-25 0
PCHMHTA0B2	11/01/97	6967925 824	2296618 566	612 236	21 2	4 1	18 4-21 4
PCHMHTA0B3	11/03/97	6966964 238	2296347 452	618 577	17 9	9 6	15 1-18 1
PCHMHTA0B4	11/01/97	6966612 754	2296238 241	618 268	28 1	12 9	27 7-30 7
PCHMHTA0B5	10/30/97	6966260 166	2296266 667	618 898	3 2*	dry	Not Sampled
PCHMHTA0C1	11/01/97	6968187.460	2297711.038	602 459	15 0	11 0	12 0-15 0
PCHMHTA0C2	10/31/97	6967028 928	2297356 302	607 100	20 4	16 2	17 2-20 2
PCHMHTA0C3	11/01/97	6966456 178	2297362 362	610 070	26 1	10.7	23 1-26 1
PCHMHTA0D1	10/31/97	6968772 049	2298414.232	600.460	18.4	12 3	15.3-18 3
PCHMHTA0D2	10/31/97	6967703 030	2298262 703	594 849	15 2	NA	12 5-15 5
PCHMHTA0D3	10/31/97	6966699 139	2298109 294	604 947	22 4	17 2	19.3-22 3
PCHMHTA0E1	10/29/97	6968717 889	2298912 074	601 676	19 7	13 3	16 7-19 7
PCHMHTA0E2	10/31/97	6967206 118	2298693 872	593 721	15 7	NA	12 4-15 4
PCHMHTA0E3	10/31/97	6966972 831	2298771 113	601 548	17 9	14 8	15 1-18 1
PCHMHTA0E4	10/31/97	6966634 120	2298682 284	603 814	20 1	16 9	17 3-20 3
PCHMHTA0E5	10/31/97	6966161 103	2298670 425	605 112	19 0	dry	Not Sampled
PCHMHTA0E6	10/31/97	6965817.253	2298688 293	598 599	16 2	12 0	13 7-16 7
PCHMHTA0F1	10/29/97	6968091.195	2299394 997	598 120	19 6	13 7	16 7-19 7
PCHMHTA0F2	10/29/97	6967621 356	2299430 266	595 077	16 8	11 5	13 8-16 8
PCHMHTA0F3	11/03/97	6965424 023	2299304 242	590 135	7 5	4 0	4 5-7 5

\* ng hit refusal at 3 2', well not installed

NA - not available

**Table 3-5  
Summary of Soil Boring and Monitor Well Information  
NAS Fort Worth JRB, Texas**

Well ID	Date Drilled	Easting	Northing	Top of Casing Elevation	Surface Elevation	Depth (ft)	Borehole Diameter (Inches)	Well Inside Diameter (in)	Well Depth (ft)	Well, Portland Grout Seal (ft bgs)	Well Bentonite Seal Interval (ft bgs)	Well Sand Interval (ft bgs)	Well Screened Interval (ft bgs)	Rock Coring Conducted Y or N?
WCHMHTA001	11/20/97	2293437.600	6965828.172	639.57	639.08	46	8.25	2	46	2-22	22-24	24-46	26-46	N
WCHMHTA002	12/6/97	2294553.414	6966740.532	631.83	631.32	42	8.25	2	42	2-18	18-20	20-42	22-42	N
WCHMHTA003	12/2/97	2294774.144	6967153.875	631.69	631.00	28	8.25	2	28	2-14	14-16	16-26	18-28	N
WCHMHTA004	12/1/97	2294776.099	6967144.605	631.68	631.25	38	8.25	2	38	2-24	24-26	26-38	28-38	Y
WCHMHTA005	11/26/97	2295397.821	6966691.185	627.39	626.95	26	8.25	2	26	2-12	12-14	14-26	16-26	N
WCHMHTA006	11/26/97	2295406.968	6966690.112	627.22	626.73	36.5	8.25	2	36.5	2-22.5	22.5-24.5	24.5-36.5	26.5-36.5	Y
WCHMHTA007	11/18/97	2295645.387	6967105.885	624.54	623.93	32.5	8.25	2	32.5	2-8.5	8.5-10.5	10.5-32.5	12.5-32.5	N
WCHMHTA008	11/19/97	2295597.480	6967889.887	623.15	622.85	25	8.25	2	25	2-6	6-8	8-25	10-25	N
WCHMHTA009	11/25/97	2296395.012	6967635.292	615.73	615.55	12	8.25	2	12	0	1-2.5	2.5-12	4.5-12	N
WCHMHTA010	12/3/97	2296398.796	6967640.077	615.74	615.35	25.5	8.25	2	25	2-11	11-13	13-25	15-25	Y
WCHMHTA011	11/17/97	2297063.014	6968490.507	606.32	605.80	22	8.25	2	22	2-8	8-10	10-22	12-22	N
WCHMHTA012	11/21/97	2297425.824	6967840.863	606.18	605.85	18.5	8.25	2	18.5	2-4.5	4.5-6.5	6.5-18.5	8.5-18.5	Y
WCHMHTA013	11/17/97	2299786.181	6966251.256	578.76	578.26	18.5	8.25	2	18.5	2-9.5	9.5-11.5	11.5-18.5	13.5-18.5	N
WCHMHTA014	11/20/97	2294072.809	6970403.901	619.43	619.11	12.5	8.25	2	12.5	0	1-5.5	5.5-12.5	7.5-12.5	N
*BCHMHTA001	12/10/97	2297641.370	6967602.983	--	--	--	--	--	--	--	--	--	--	--
*BCHMHTA002	12/10/97	2297653.124	6966692.266	--	--	--	--	--	--	--	--	--	--	--

\* Locations are approximate

**Table 3-6  
AOC2 RFI Groundwater Sampling Program  
NAS Fort Worth JRB, Texas**

ID	MATRIX	RATIONAL	CHEMICAL PARAMETER <sup>(1)</sup> /METHOD <sup>(2)</sup>								
			CONTAMINANTS OF CONCERN		NATURAL ATTENUATION PARAMETERS (collected during the December 1997 and April 1998 events)						
			BTEX	TCE	DO <sup>(3)</sup>	Anions	Cations	Alkalinity	Eh <sup>(4)</sup>	CH4	TOC
SW8260A		E360 1	SW9056	SW3005A/ SW6010 and HACH 8146 <sup>(5)(6)</sup>	E310.1	ASTM D1498 or A2580B	SW 6211M	9060			
<b>EXISTING WELLS</b>											
LSA1628-3*	GW	Plume	X	X	X	X	X	X	X	X	X
SPOT-35-4*	GW	Sentry	X	X							
USGS04T*	GW	Perimeter	X	X							
GMI-22-02M*	GW	Upgradient	X	X	X	X	X	X	X	X	X
GMI-22-03M	GW	Plume	X	X							
GMI-22-04M*	GW	Plume	X	X							
GMI-22-05M*	GW	Perimeter	X	X	X	X	X	X	X	X	X
GMI-22-06M	GW	Plume	X	X							
GMI-22-07M*	GW	Sentry	X	X	X	X	X	X	X	X	X
HM-96	GW	Upgradient	X	X							
HM-116	GW	Upgradient	X	X							
HM-117	GW	Upgradient	X	X							
HM-118	GW	Upgradient	X	X							
HM-119	GW	Upgradient	X	X							
HM-120	GW	Sentry	X	X	X	X	X	X	X	X	X
HM-121	GW	Plume	X	X	X	X	X	X	X	X	X
HM-125	GW	Plume	X	X							
MW-3	GW	Perimeter	X	X	X	X	X	X	X	X	X
MW-49	GW	Sentry	X	X							
MW-57	GW	Plume	X	X							
MW-57B	GW	Sentry	X	X	X	X	X	X	X	X	X
WITCTA010	GW	Sentry	X	X	X	X	X	X	X	X	X
WITCTA016	GW	Perimeter	X	X							
<b>PROPOSED WELLS</b>											
WCHMHTA001	GW	Upgradient	X	X	X	X	X	X	X	X	X
WCHMHTA002	GW	Upgradient	X	X							
WCHMHTA003 <sup>(4)</sup>	GW	Upgradient	X	X							
WCHMHTA004 <sup>(4)</sup>	GW	Upgradient	X	X							
WCHMHTA005 <sup>(4)</sup>	GW	Upgradient	X	X							
WCHMHTA006 <sup>(4)</sup>	GW	Upgradient	X	X							
WCHMHTA007	GW	Upgradient	X	X							
WCHMHTA008	GW	Upgradient	X	X							
WCHMHTA009 <sup>(4)</sup>	GW	Plume	X	X							
WCHMHTA010 <sup>(4)</sup>	GW	Plume	X	X							
WCHMHTA011	GW	Plume	X	X							
WCHMHTA012	GW	Plume	X	X	X	X	X	X	X	X	X
WCHMHTA013	GW	Sentry	X	X							
WCHMHTA014	GW	Perimeter	X	X							

**Notes:**

- \* wells included in quarterly groundwater monitoring program
- <sup>(1)</sup>Chemical Parameters
  - BTEX benzene, toluene, ethylbenzene, and xylene
  - TCE Trichloroethylene (includes degradation products of TCE)
  - DO dissolved oxygen
  - Cations aluminum, calcium, iron, lead, magnesium, potassium, sodium
  - Anions bromide, chloride, fluoride, nitrate, nitrite, phosphate, sulfate
  - TOC total organic carbon
  - CH4 methane (also includes ethane and ethene)
  - Eh oxidation-reduction potential

<sup>(2)</sup>CH2M HILL, 1996c, APCEE, 1995

<sup>(3)</sup>Field parameters

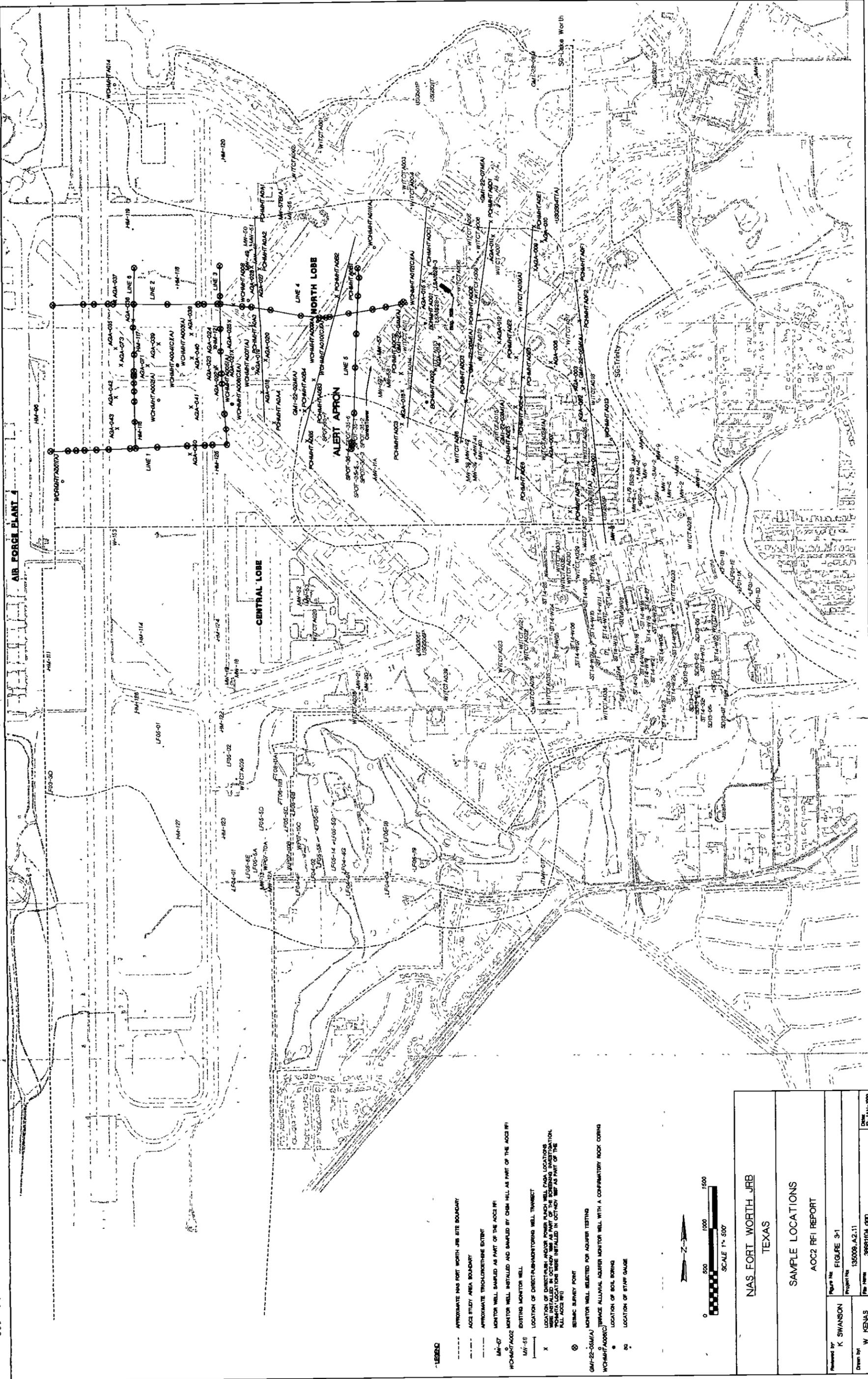
<sup>(4)</sup>Potential monitor well couplet

<sup>(5)</sup>Ferrous iron only

**Table 3-7**  
**Staff Gauge Installation Information**  
**NAS Fort Worth JRB, Texas**

<b>Location</b>	<b>Date Installed</b>	<b>Northing</b>	<b>Easting</b>	<b>Elevation* (ft above sea level)</b>
Staff Gauge, Lake Worth	2/4/98	6970870.104	2299390.649	593.10
Staff Gauge, Trinity River	2/4/98	6966941.064	2299917.801	528.92

\* Elevation at base of staff gauge (0.00 feet)



**LEGEND**

- APPROXIMATE 1000 FOOT NORTH JRB SITE BOUNDARY
- APPROXIMATE STUDY AREA BOUNDARY
- APPROXIMATE TRICHLORETHYLENE EXHAUST
- MW-07 MONITOR WELL SAMPLED AS PART OF THE AOC2 RFI
- WCHMNTA002C MONITOR WELL INSTALLED AND SAMPLED BY OSM HILL AS PART OF THE AOC2 RFI
- EXISTING MONITOR WELL
- MW-69 LOCATION OF DIRECT-READING MONITORING WELL TRAMMERT
- X LOCATION OF INTERFERING MONITORING WELL FROM LOCATIONS IDENTIFIED IN OCTOBER 1987 AS PART OF THE EXHAUST INVESTIGATION. MONITOR LOCATIONS WERE INSTALLED IN OCTOBER 1987 AS PART OF THE AOC2 RFI
- ⊙ SEISMIC SURVEY POINT
- GMW-22-55M(A) MONITOR WELL SELECTED FOR ADQUIER TESTING
- WCHMNTA002C TRIMBLE ALLIANCE MONITOR WELL WITH A COMPENSATORY ROCK CORING
- LOCATION OF SOIL BORING
- ⊙ LOCATION OF STAFF GAUGE



<b>NAS FORT WORTH JRB</b> TEXAS	
<b>SAMPLE LOCATIONS</b> AOC2 RFI REPORT	
Reviewed by <b>K. SWANSON</b>	Figure No. <b>FIGURE 3-1</b>
Drawn by <b>W. KENAS</b>	Project No. <b>135008-A2.11</b>
	File Name <b>3882104.dgn</b>
	Date <b>13-JAN-1988</b>

# TAB

Section 4 Investigation Results Description

---

## 4.0 Investigation Results

---

This section presents and summarizes the investigation findings and analytical results from the field investigation tasks described in Section 3.0, including the seismic survey, the direct push investigation, the soil and groundwater sampling, the surface water staff gauge measurements, and the aquifer testing. The data is presented chronologically in the order it was collected, and a general summary of conclusions related to stratigraphic information collected via the various field tasks is presented in Section 4.7. For an evaluation of the nature and extent of contamination, refer to Section 5, which takes the results presented below and applicable results from other investigations and describes the nature and extent of the AOC2 contamination as a whole.

### 4.1 Identification of Contaminants of Concern

The contaminants of concern (COCs) for AOC2 groundwater include trichloroethene (TCE) and compounds related to TCE as degradation products. Included is the parent to TCE, tetrachloroethene (PCE), which is observed in AFP4 groundwater and in AOC2 groundwater along with TCE. Degradation products of TCE are, in order, dichloroethene (1,1-DCE, cis-1,2-DCE, trans-1,2-DCE), vinyl chloride, ethene, and ethane. Throughout this section, levels of the contaminants of concern detected within AOC2 groundwater and soil are presented in comparison to their corresponding TNRCC Risk Reduction Standard 2 (RRS2) media-specific concentrations (which are listed in Table 4-1). These values are chemical-specific cleanup levels established according to health-based criteria pursuant to TNRCC regulations, 30 Texas Administrative Code (TAC) 335.551 – 335.569; they are presented here only for comparison to the observed contaminant levels. In addition to contaminants of concern, field-measured parameters, natural attenuation parameters, and other organic compounds if detected are mentioned.

## 4.2 Seismic Reflection Survey Results

As described in Section 3.3.2, the geophysical investigation consisted of setting up and shooting seismic reflection lines across suspected paleochannel locations. The locations of these lines are illustrated in Figure 3-1. The complete report submitted by CH2M HILL subcontractor SeisPulse, Inc., is provided as Appendix A. At the time the location of the seismic lines were planned, available data included borings drilled at various points in the area and direct push results (some of which did not reach bedrock). The bedrock map prepared by Parsons, Inc., which was prepared utilizing all available boring data, including that generated during the AOC2 RFI, was not yet available (Figure 2-2).

The investigation resulted in the acquisition of 6 seismic reflection survey lines, two of which were set up end to end (Lines 2 and 4 shown on Figure 3-1). The depth to bedrock accuracy of the investigation proved to be useful in supporting the proposed placement of the monitor wells and the direct push/cone penetrometer test (CPT) locations, although a few discrepancies in depth between the seismic reflection investigation and the soil borings were noted. Most noticeably at WCHMHTA12, where the monitor well boring encountered rock at 19 feet while the nearby seismic reflection investigation location indicated the depth to bedrock was 34 feet. The distance between the seismic line and this boring is approximately 75 feet apart, and it is possible that an escarpment in that area between the two locations contributed to the discrepancy; alternatively the discrepancy could be attributed to a disturbance experienced while acquiring the data point.

The report provided in Appendix A shows depth to bedrock profiles along each seismic survey line. As stated above, when planning the locations of these lines the basewide bedrock map was not available; since that time, one has been prepared by Parsons, Inc. (see Section 2.2 and Figure 2-2).

In general, the Line 1 profile, which cuts across the flightline from AFP4 east, shows a shallow dip, or channel, along the flightline which could correspond to the dip in bedrock elevation illustrated in this area in the bedrock map prepared by Parsons (see Figure 2-2). This dip appears on the seismic survey line to be about 5-7 feet; the bedrock map shows it to be more shallow. The Line 2 profile, which parallels Line 1 about 1,000 feet to the north,

does not show a dip, but shows only a shallow decrease in elevation from west to east, which is also consistent with that specific area on the bedrock map.

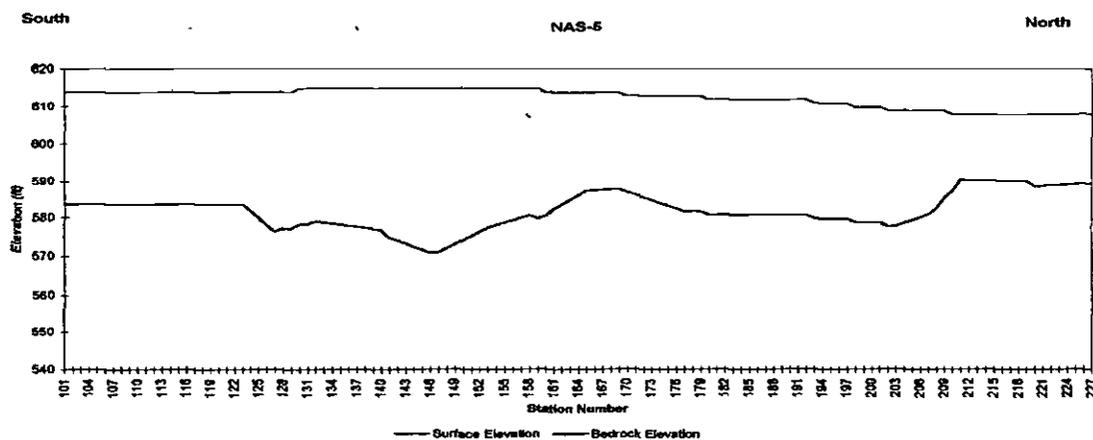
Line 4 is an eastward continuation of Line 2, and this seismic line shows the bedrock elevation continuing to drop across the Alert Apron, with no specific channels in evidence. This is also consistent with that area of the bedrock map.

Lines 6, 3, and 5 cut across the area north to south, increasing with distance from the AFP4 property line, respectively (see Figure 3-1). The Line 6 seismic survey profile shows several sharp but shallow (less than 10 feet) changes in bedrock surface; the Line 3 survey profile shows similar variations in the bedrock surface.

The Line 5 profile, further east, shows the most distinct evidence of channeling. This profile is reproduced below (all profiles are included in Appendix A). Line 5 cuts across the AOC2 plume at the Alert Apron, perpendicular to groundwater flow, and shows two dips in the bedrock which correspond to possible paleochannels trending east. The presence of these two dips is supported by the bedrock surface map.

In summary, the seismic survey lines support the findings illustrated in the bedrock surface map prepared since the seismic survey was conducted, and particularly Line 5, confirm the presence of paleochannels in the study area. Overall stratigraphy based on the various AOC2 RFI activities is described in Section 4.8.

#### Seismic Survey Line 5:



## 4.3 Direct Push Investigation Results

As described in Section 3.3.3, direct push activities were conducted first during the work planning stage of the RFI, and then again during the main RFI investigation. The following paragraphs summarize the results of each of these efforts.

### 4.3.1 Preliminary Work Plan Direct Push Investigation Results

As stated in the AOC2 RFI work plan (CH2M HILL, 1998), the preliminary direct push investigation conducted in 1996 was performed to address preliminary data gaps in the northern lobe, which originally appeared to consist of two distinct plumes. The rig utilized for this work proved able to achieve greater push depths than had been achieved in GMI's previous direct push effort, and it appeared that the lack of TCE detections reported in GMI locations between the flightline area and the Alert Apron (which supported the idea of a separation between the AFP4 TCE and the TCE observed east of the Alert Apron) was a result of the lack of penetration depth rather than a break in the presence of TCE detections.

Although cone penetrometer testing (CPT) to evaluate stratigraphy was planned for this portion of the investigation, the CPT portion of the rig was not operational in the field and could not be used.

Onsite analytical data for this portion of the investigation are presented in Table 4-2, offsite laboratory confirmation data is presented in Table 4-3. For this event, the onsite lab used a direct sampling ion trap mass spectrometer. There is no prior separation of compounds before the sample hits the mass spectrometer, as there is with a GC/MS. Therefore, compounds with similar ion fragmentation patterns (like TCA and DCE) are difficult to distinguish. In this instance, it was not known with the degree of certainty necessary to report the two compounds separately. See Figure 4-1 for direct push locations along with the more recent direct push/monitor well offsite lab TCE results (for consistency, the 1996 data are not included on this 1997/1998 figure).

The onsite reported TCE concentrations in 1996 varied from below-detection to 2,318 ug/L at AGA-024. Fourteen of the 40 wells sampled exhibited elevated TCE concentrations. With one exception (AGA-015), all of these higher detections occurred in the area between the

Alert Apron and western property boundary. Toluene, TCE, TCA/DCE (total), PCE, and ethylbenzene/xylene were also detected. Toluene was detected in all samples analyzed and may reflect potential cross contamination of field instruments; although occasionally detected, toluene is not typically found in study area groundwater. As shown on **Table 4-2**, the onsite analytical methods utilized did not permit differentiation between several of the compounds listed.

In general, comparable TCE results were reported by the offsite laboratory. However, the reported TCE result from AGA-024 was 690 ug/L and is significantly lower than the 2,318 ug/L reported by the onsite laboratory. The reason for the disparity is unknown, though the variation in sampling method (direct vs. bailer) may be the cause. Toluene, DCE, and PCE (total) were detected in at least one of the four groundwater samples analyzed offsite. It appears that detections of TCA/DCE reported by the onsite laboratory are actually detections of DCE (total).

#### **4.3.2 RFI Direct Push Investigation Results**

The follow-up direct push investigation work performed after the seismic survey and prior to RFI well installation involved the use of cone penetrometer testing (CPT) as well as water quality sampling. The direct push locations were placed along north-south transects (designated A through F from west to east) designed to provide cross-sectional views of the AOC2 TCE plume (see **Figure 3-1**).

The cone penetrometer portion of this effort provided usable soil data to a depth of approximately 20 feet at the majority of the direct push locations where CPT was employed. The instrument experienced difficulty achieving greater depths due to the condition of the alluvial materials encountered at the site, and the CPT stratigraphic profiles did not extend to bedrock at any of the tested locations (the CPT profiles are provided in **Appendix B**). A summary of stratigraphic interpretations from all field tasks is provided in **Section 4.8**, along with stratigraphic cross-sections along the direct push transects. It was concluded that the push depth was at bedrock or near to it, based on nearby well data.

Onsite analytical data from the groundwater samples collected during this effort are presented in **Table 4-4**, and the laboratory confirmation data are presented in **Table 4-5**. See

Figure 4-1 for direct push locations along with the monitor well TCE results (for consistency, the onsite mobile lab results are not included on this figure, just the confirmation offsite lab results). The onsite mobile lab-reported TCE concentrations varied from below-detection to 1,800 µg/L at PCHMHTA0B1. Direct push groundwater samples from points along the northern-most transects indicate TCE does not appear to be present outside the plume extent defined by previous investigations. Direct push groundwater data from Transects C and E (which were sited to extend south beyond the previously-defined TCE extent) demonstrated TCE detections at their southern-most points, PCHMHTA0C3 (310 µg/L) and PCHMHTA0E6 (5.2 µg/L). Direct push groundwater data from the eastern-most transect, Transect F, showed no detection of TCE.

Comparable TCE results were reported in the offsite laboratory confirmation samples, though these results were typically slightly lower than those achieved with the onsite mobile lab. This disparity is expected due to the different sample collection technique employed (sparging versus bailing). It appears that detections of TCA/DCE reported by the onsite laboratory are actually detections of DCE (total).

Onsite mobile lab results from the direct push analysis also show an elevated concentration of PCE at location PCHMHTA0E3 (250 µg/L).

## 4.4 Subsurface Soil Sample Results

Soil samples were collected from each monitor well location during drilling and at two additional soil boring locations sited to address the potential for onsite sources of TCE. As stated in Section 3.3.4.2, soil samples were scheduled to be collected from each monitor well boring in the areas with the highest PID reading and from the area above the water table. The two confirmatory soil borings drilled in areas of potential TCE release were sampled a minimum of every 5 feet per the work plan; 3 soil samples were collected for analysis from each of these borings. Elevated PID readings were detected in the monitor well borings only at wells WCHMHTA001 and WCHMHTA008, and two soil samples each were collected at these locations per the work plan. At the remaining monitor well borings, only one sample was collected just above the water table (no elevated PID readings detected).

Soil analytical results from samples collected during the soil boring and monitor well installation task are presented in Table 4-6 (COCs only). All soil analytical data is presented in Appendix G. Soil TCE results were below detection limits for all samples. Concentrations of TCE degradation products, cis-1,2-DCE, trans-1,2-DCE and vinyl chloride, were also below detection limits in all soil samples.

Detected compounds included 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, ethylbenzene, m,p-xylene, n-propylbenzene, and sec-, tert-, and n-butylbenzene. These detected compounds were all found in samples collected from WCHMHTA008. M,p-xylene was also detected in the sample collected from WCHMHTA002 at a low estimated concentration (0.0023F mg/kg). These compounds are associated with fuel-related contamination, which has been documented in the well WCHMHTA008 area as AOC4. AOC4 is being addressed by HGL in a separate investigation (HGL, 1997b).

## 4.5 Groundwater Sample Results

AOC2 RFI groundwater samples were collected in three sampling events at two month intervals: December 1997, February 1998, and April 1998. Refer to the description of the groundwater sampling activity in Section 3.3.5 for details regarding samples collected and analyses conducted. The following subsections present the results of field measurements and analytical results. Figures 4-1, 4-2, 4-3, and 4-4 present the TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,1-DCE results, respectively, over each groundwater sampling event. Plume distribution maps are presented in Section 5 along with the evaluation of the nature and extent of the AOC2 contamination.

### 4.5.1 Field-Measured Natural Attenuation Parameters

Eleven samples collected from wells selected for natural attenuation parameter sampling were analyzed on-site for ferrous iron ( $\text{Fe}^{2+}$ ) via HACH method 8146 during the first and third groundwater sampling events. Field-measured parameters collected at the 11 wells selected for evaluation of the occurrence of natural attenuation, including temperature, pH, Eh, conductivity, and ferrous iron, are presented in Table 4-7 (December 1997 event) and

Table 4-8 (February 1998 event). Evaluation of these and other natural attenuation screening results is provided in Section 6.

#### **4.5.2 First Groundwater Sampling Event Analytical Results (December 1997)**

The first groundwater sampling event was conducted in December 1997. This event included collection of samples for natural attenuation parameter analysis. Results for COCs and other detected compounds are described below. An evaluation of the nature and extent of contamination related to these compounds is presented in Section 5.

##### **4.5.2.1 Trichloroethene**

TCE was detected in 26 of the 37 groundwater monitoring locations. As shown on Figure 4-1, which also presents the offsite laboratory direct push results collected during October and November 1997, the TCE concentrations detected in wells in samples collected in December ranged from 1J  $\mu\text{g}/\text{L}$  (at MW-57) to 1,100J  $\mu\text{g}/\text{L}$  (at WCHMHTA010). The highest concentrations occur near the Alert Apron. All December 1997 monitor well sample TCE results are listed on Table 4-9. All but two of the TCE detections in wells in the AOC2 study area exceed the Risk Reduction Standard 2 (RRS2) of 5  $\mu\text{g}/\text{L}$ .

##### **4.5.2.2 cis-1,2-Dichloroethene**

Cis-1,2-DCE was detected in 21 of the 37 groundwater monitoring locations. As shown on Figure 4-2, which also presents the offsite laboratory direct push results, detections of this TCE degradation product are highest east of the Alert Apron area, downgradient from the highest TCE concentrations. Some elevated concentrations were also detected across the flightline extending back to AFP4. Concentrations of cis-1,2-DCE range from 0.48F  $\mu\text{g}/\text{L}$  (at WCHMHTA003) to 250J  $\mu\text{g}/\text{L}$  (at WCHMHTA012). Cis-1,2-DCE results are listed on Table 4-9. Only three of the detections exceed the RRS2 for cis-1,2-DCE of 70  $\mu\text{g}/\text{L}$ .

##### **4.5.2.3 1,1-Dichloroethene and trans-1,2-Dichloroethene**

1,1-DCE and trans-1,2-DCE are additional isomers of dichloroethene and sequential degradation products of TCE. Trans-1,2-DCE, shown on Figure 4-3, was detected in ten of the 37 groundwater monitoring locations; 1,1-DCE, shown on Figure 4-4, was not detected

during the December 1997 event. Trans-1,2-DCE and 1,1-DCE concentrations are listed on **Table 4-9**.

Concentrations of trans-1,2-DCE range from 0.5 F  $\mu\text{g/L}$  (at MW-57) to 85  $\mu\text{g/L}$  (at WITCTA016). The distribution of trans-1,2-DCE shows the highest concentrations are located outside of the Alert Apron area, east (downgradient) of where the highest TCE concentrations were detected. Trans-1,2-DCE was not detected west of the Alert Apron. None of the trans-1,2-DCE detections exceeded the RRS2 value of 100  $\mu\text{g/L}$ .

#### **4.5.2.4 Vinyl Chloride**

A list of vinyl chloride analytical results from the December 1997 event are listed on **Table 4-9**. Vinyl chloride, the sequential degradation product of cis-1,2-DCE and 1,1-DCE, was not detected during this event.

#### **4.5.2.5 Tetrachloroethene**

Tetrachloroethene (PCE) was detected in 6 of the 37 groundwater monitoring locations. Concentrations ranged from 0.36F  $\mu\text{g/L}$  (at WCHMHTA003) to 36  $\mu\text{g/L}$  (at HM-96). PCE results for the first event are listed on **Table 4-9**. Four results exceeded the RRS2 value for PCE of 5  $\mu\text{g/L}$ .

### **4.5.3 Second Groundwater Sampling Event Analytical Results (February 1998)**

The second groundwater sampling event was conducted in February 1998. Results for COCs and other detected compounds are described below. An evaluation of the nature and extent of contamination related to these compounds is presented in **Section 5**.

#### **4.5.3.1 Trichloroethene**

TCE was detected in 27 of the 37 groundwater monitoring locations. As shown on **Figure 4-2**, the TCE concentrations range from 0.85F  $\mu\text{g/L}$  (at WCHMHTA013) to 1,200  $\mu\text{g/L}$  (at WCHMHTA011). February 1998 TCE concentrations are listed on **Table 4-10**. All but three of the TCE detections in the AOC2 study area exceed the Risk Reduction Standard (RRS2) of 5  $\mu\text{g/L}$ .

#### 4.5.3.2 cis-1,2-Dichloroethene

Cis-1,2-DCE was detected in 24 of the 37 groundwater monitoring locations. As shown on Figure 4-2, the February 1998 distribution of cis-1,2-DCE is similar to the December 1997 distribution: cis-1,2-DCE concentrations are highest east of the Apron area, downgradient from the highest TCE concentrations. Some elevated concentrations were also detected across the flightline extending back to AFP4. Concentrations of cis-1,2-DCE range from 0.82F $\mu$ g/L (at WITCTA010) to 160  $\mu$ g/L (at WCHMHTA012). Cis-1,2-DCE results are listed on Table 4-10. Only four of the detections exceed the RRS2 for cis-1,2-DCE of 70  $\mu$ g/L.

#### 4.5.3.3 1,1-Dichloroethene and trans-1,2-Dichloroethene

Trans-1,2-DCE, shown on Figure 4-3, was detected in seven of the 37 groundwater monitoring locations. 1,1-DCE, shown on Figure 4-4, was detected at two locations during the February 1998 event. Trans-1,2-DCE and 1,1-DCE concentrations are listed on Table 4-10. One of the two 1,1-DCE detections exceeded the RRS2 value of 7  $\mu$ g/L (8.2F  $\mu$ g/L at well HM-96).

Trans-1,2-DCE concentrations range from 0.84  $\mu$ g/L (at WITCTA010) to 130  $\mu$ g/L (at WITCTA016). The distribution of trans-1,2-DCE shows the highest concentrations are located outside of the Alert Apron area, east (downgradient) of where the highest TCE concentrations were detected. The compound was not detected west of the Alert Apron. One trans-1,2-DCE detection exceeded the RRS2 value of 100  $\mu$ g/L.

#### 4.5.3.4 Vinyl Chloride

Vinyl chloride was detected during the February 1998 event at two locations, WITCTA016 (2.6J  $\mu$ g/L) and GMI-22-06M (3J  $\mu$ g/L). Both results exceed the RRS2 value for vinyl chloride of 2  $\mu$ g/L. Vinyl Chloride results for the second event are listed on Table 4-10.

#### 4.5.3.5 Tetrachloroethene

Tetrachloroethene (PCE) was detected in 7 of the 37 groundwater monitoring locations. Concentrations ranged from 0.82F  $\mu$ g/L (at WCHMHTA003) to 63  $\mu$ g/L (at HM-96). PCE results for the second event are listed on Table 4-10. Four results exceeded the RRS2 value for PCE of 5  $\mu$ g/L.

#### 4.5.4 Third Groundwater Sampling Event Analytical Results (April 1998)

The third groundwater sampling event was conducted in April 1998. This event included collection of samples for natural attenuation parameter analysis. Results for COCs and other detected compounds are described below. An evaluation of the nature and extent of contamination related to these compounds is presented in Section 5.

##### 4.5.4.1 Trichloroethene

TCE was detected in 26 of the 37 groundwater monitoring locations. As shown on Figure 4-1, the TCE plume extends down from AFP4 into the AOC2 study area at concentrations ranging from 0.61F µg/L (at WCHMHTA014) to 1,100J µg/L (at WCHMHTA010). April 1998 TCE results are listed on Table 4-11. All but two of the TCE detections in the AOC2 study area exceed the Risk Reduction Standard (RRS2) of 5 µg/L.

##### 4.5.4.2 cis-1,2-Dichloroethene

Cis-1,2-DCE was detected in 21 of the 37 groundwater monitoring locations. As shown on Figure 4-2, similar to the December 1997 and February 1998 distribution, cis-1,2-DCE concentrations are highest east of the Apron area, downgradient from the highest TCE concentrations. Some elevated concentrations were also detected across the flightline extending back to AFP4. Concentrations of cis-1,2-DCE range from 1.3 µg/L (at HM-119) to 180 µg/L (at WCHMHTA012). Cis-1,2-DCE results are listed on Table 4-11. Five of the detections exceed the RRS2 for cis-1,2-DCE of 70 µg/L.

##### 4.4.4.3 1,1-Dichloroethene and trans-1,2-Dichloroethene

Trans-1,2-DCE, shown on Figure 4-3, was detected in nine of the 37 groundwater monitoring locations. Low concentrations of 1,1-DCE, shown on Figure 4-4, were detected at three locations during the April 1998 event. Trans-1,2-DCE and 1,1-DCE concentrations are listed on Table 4-11. One of the three 1,1-DCE detections exceeded the 7 µg/L RRS2 value (9.8J at well HM-96).

Trans-1,2-DCE concentrations range from 0.67J µg/L (at WCHMHTA004) to 130 µg/L (at WITCTA016). The distribution of trans-1,2-DCE shows the highest concentrations are located outside of the Alert Apron area, east (downgradient) of where the highest TCE

concentrations were detected. The only trans-1,2-DCE detections west of the Alert Apron occurred at wells WCHMHTA004 (0.67J  $\mu\text{g/L}$ ) and HM-96 (1.8J  $\mu\text{g/L}$ ), near AFP4. One trans-1,2-DCE detection exceeded the RRS2 value of 100  $\mu\text{g/L}$ .

#### 4.5.4.4 Vinyl Chloride

Vinyl Chloride was detected at well WCHMHTA012 only (13J  $\mu\text{g/L}$ ) during the April 1998 event. The detection exceeds the RRS2 value for vinyl chloride of 2  $\mu\text{g/L}$ . Vinyl Chloride results for the third event are listed on Table 4-11.

#### 4.5.4.5 Tetrachloroethene

Tetrachloroethene (PCE) was detected in 10 of the 37 groundwater monitoring locations. Concentrations ranged from 0.83J  $\mu\text{g/L}$  (at WCHMHTA003) to 68  $\mu\text{g/L}$  (at HM-96). PCE results for the third event are listed on Table 4-11. Six results exceeded the RRS2 value for PCE of 5  $\mu\text{g/L}$ .

## 4.6 Staff Gauge Measurement Findings

Two staff gauges were installed to check surface water elevations in Lake Worth and the West Fork Trinity River against Terrace Alluvial Aquifer groundwater elevations and support a conceptual flow model in terms of potential downgradient receptors. Staff gauge and groundwater level data collected during the groundwater sampling events are presented in Table 4-12). The staff gauges are made of steel covered in porcelain. The locations are shown on Figure 3-1. SG-01 was installed along the southern shore of Lake Worth. Proceeding north on Carswell Avenue to the pavilion at the end of the road, it can be found mounted on a 2 foot x 6 foot board against several logs in the lake. SG-02 is located along the western shore of the West Fork Trinity River. This gauge can be found mounted on the north side of the drainage inlet from the base on the concrete structure at the river's edge.

It was decided not to create groundwater potentiometric surface maps for this report with the AOC2 groundwater elevation data, which is based on a limited number of wells in the area; instead the surface water staff gauge data was compared to the basewide Terrace

Alluvial Aquifer potentiometric surface map prepared for the GSAP sampling event in January 1998 (presented in Figure 2-3). Referring to this figure, the Lake Worth surface water staff gauge is located at the northeast corner of the AOC2 study area (and the NAS Fort Worth JRB boundary). This staff gauge demonstrated surface water elevations of about 593 feet MSL in three measurement events from January through April 1998. The West Fork Trinity River staff gauge, located in the curve of the river on the east side of the study area, demonstrated surface water elevations of about 530 feet MSL in the three measurement events.

Based on these data and the potentiometric surface demonstrated by the basewide map, it appears that the Terrace Alluvial aquifer provides flow to Lake Worth along the northwestern edge of the base, and receives flow from Lake Worth toward the northeastern edge of the base. To the east, the Terrace Alluvial Aquifer serves as a source of flow to the West Fork Trinity River.

## 4.7 Aquifer Test Results

As described in Section 3.3.6, slug testing was performed in 22 newly installed and existing monitor wells in the AOC2 study area from January 19, 1998 to January 23, 1998. The testing was conducted on eleven new wells installed by CH2M HILL in December 1997, and eleven wells previously installed by other contractors. Figure 3-1 shows the location of these wells (indicated with "A" next to their designation). The objectives of the testing were to provide an estimation of hydraulic conductivity and to supplement existing data on the physical properties of the Terrace Alluvial Aquifer in the AOC2 study area.

A summary of the results of the slug testing is presented in Table 4-13, grouped by geographic location within the study area (runway area, Alert Apron area, and east of the Alert Apron area). As shown on this table, the slug test results indicate an average hydraulic conductivity within the study area of about 0.0083 centimeter per second (cm/s). The average hydraulic conductivity measured in wells in the runway area is 0.00385 cm/s; the average hydraulic conductivity measured in wells in the Alert Apron area is 0.00851 cm/s; the average hydraulic conductivity measured in wells east of the Alert Apron area is 0.0175 cm/s.

The average hydraulic conductivity appears to increase slightly toward the east; the minimum was measured in well WCHMHTA004 in the runway area (0.00172 cm/s), and the maximum was measured in well WCHMHTA011 at the northern edge of the Alert Apron (0.0807 cm/s). One of the lowest measured hydraulic conductivities was in well WCHMHTA010 (0.00401 cm/s), which also typically demonstrates the highest TCE concentrations in the study area.

For comparison, the average hydraulic conductivity measured by IT during the Sanitary Sewer RFI was 0.00129 cm/s (IT Corporation, 1997).

## 4.8 Overview of Study Area Stratigraphic Findings

Several field investigation activities conducted during the RFI contributed stratigraphic information useful in helping to refine the interpretation of the Terrace Alluvial Aquifer within the AOC2 study area, including the seismic reflection survey, the direct push and CPT investigations, and the monitor well and soil boring drilling and rock coring activities. Cross-sections along the direct push transects A through F have been prepared using available boring/direct push information along those lines (both current and existing) to illustrate the stratigraphy in sections perpendicular to the orientation of the TCE plume. These cross-sections are illustrated in Figures 4-5 through 9. The orientation of the transects A through F are initially illustrated on Figure 3-1 and also on all subsequent figures that show the plan view.

The stratigraphic conditions of the Terrace Alluvial Aquifer previously determined within the AOC2 study area were supported by the AOC2 RFI activity results, with some refinements, particularly in terms of the bedrock highs observed at PCHMHTA0B5, and within the plume bifurcation east of the Alert Apron area.

**Table 4-1  
TNRCC Risk Reduction Standard No. 2 Media-Specific Concentrations  
(Updated 9-18-98)**

Contaminant	CAS	GW-Res (mg/l)	GW-Ind (mg/l)	GWP-Res (mg/kg)	GWP-Ind (mg/kg)	SAI-Res (mg/kg)	SAI-Ind (mg/kg)
Benzene	71-43-2	5.00E-03	5.00E-03	5.00E-01	5.00E-01	8.60E-01	1.50E+00
Bromodichloromethane	75-27-4	1.00E-01	1.00E-01	1.00E+01	1.00E+01	1.00E+01	9.20E+01
Bromoform	75-25-2	1.00E-01	1.00E-01	1.00E+01	1.00E+01	3.40E+01	8.50E+01
Bromomethane	74-83-9	5.10E-02	1.40E-01	5.10E+00	1.40E+01	3.50E+00	4.90E+00
Carbon tetrachloride	56-23-5	5.00E-03	5.00E-03	5.00E-01	5.00E-01	3.50E-01	6.30E-01
Chlorobenzene	108-90-7	1.00E-01	1.00E-01	1.00E+01	1.00E+01	3.10E+02	4.50E+02
Chloroethane	75-00-3	1.50E+01	4.10E+01	1.50E+03	4.10E+03	1.10E+04	1.70E+04
Chloroform	67-66-3	1.00E-01	1.00E-01	1.00E+01	1.00E+01	3.10E-01	5.10E-01
Chloromethane	74-87-3	6.60E-02	2.20E-01	6.60E+00	2.20E+01	2.30E+00	3.80E+00
Dibromo-3-chloropropane, 1,2-	96-12-8	2.00E-04	2.00E-04	2.00E-02	2.00E-02	3.50E-01	2.00E+00
Dibromochloromethane	124-48-1	1.00E-01	1.00E-01	1.00E+01	1.00E+01	7.60E+01	6.80E+02
Dichlorobenzene, 1,2-	95-50-1	6.00E-01	6.00E-01	6.00E+01	6.00E+01	2.60E+03	3.90E+03
Dichlorobenzene, 1,4-	106-46-7	7.50E-02	7.50E-02	7.50E+00	7.50E+00	2.70E+02	2.40E+03
Dichlorodifluoromethane	75-71-8	7.30E+00	2.00E+01	7.30E+02	2.00E+03	2.20E+03	3.10E+03
Dichloroethane, 1,1-	75-34-3	3.70E+00	1.00E+01	3.70E+02	1.00E+03	8.90E+02	1.30E+03
Dichloroethane, 1,2-	107-06-2	5.00E-03	5.00E-03	5.00E-01	5.00E-01	2.70E-01	4.70E-01
Dichloroethylene, 1,1-	75-35-4	7.00E-03	7.00E-03	7.00E-01	7.00E-01	6.00E-01	1.10E+00
Dichloroethylene, cis-1,2-	156-59-2	7.00E-02	7.00E-02	7.00E+00	7.00E+00	1.20E+03	2.50E+03
Dichloroethylene, trans-1,2	156-60-5	1.00E-01	1.00E-01	1.00E+01	1.00E+01	1.40E+03	2.40E+03
Dichloropropane, 1,2-	78-87-5	5.00E-03	5.00E-03	5.00E-01	5.00E-01	9.40E+00	2.50E+01
Ethylbenzene	100-41-4	7.00E-01	7.00E-01	7.00E+01	7.00E+01	4.30E+03	6.90E+03
Hexachlorobutadiene	87-68-3	7.30E-03	2.00E-02	7.30E-01	2.00E+00	1.60E+01	3.20E+01
Methylene chloride	75-09-2	5.00E-03	5.00E-03	5.00E-01	5.00E-01	8.70E+00	1.60E+01
Naphthalene	91-20-3	7.30E-01	2.00E+00	7.30E+01	2.00E+02	1.80E+02	2.70E+02
Styrene	100-42-5	1.00E-01	1.00E-01	1.00E+01	1.00E+01	1.30E+04	2.30E+04
Tetrachloroethane, 1,1,1,2-	630-20-6	3.30E-02	1.10E-01	3.30E+00	1.10E+01	5.20E+01	1.00E+02
Tetrachloroethane, 1,1,2,2-	79-34-5	4.30E-03	1.40E-02	4.30E-01	1.40E+00	5.10E+00	9.80E+00
Tetrachloroethylene	127-18-4	5.00E-03	5.00E-03	5.00E-01	5.00E-01	6.00E+00	1.70E+01
Toluene	108-88-3	1.00E+00	1.00E+00	1.00E+02	1.00E+02	1.70E+03	2.40E+03
Trichlorobenzene, 1,2,4-	120-82-1	7.00E-02	7.00E-02	7.00E+00	7.00E+00	1.40E+03	6.10E+03
Trichloroethane, 1,1,1-	71-55-6	2.00E-01	2.00E-01	2.00E+01	2.00E+01	2.30E+03	3.40E+03
Trichloroethane, 1,1,2-	79-00-5	5.00E-03	5.00E-03	5.00E-01	5.00E-01	9.70E+00	1.70E+01
Trichloroethylene	79-01-6	5.00E-03	5.00E-03	5.00E-01	5.00E-01	3.70E+00	6.60E+00
Trichlorofluoromethane	75-69-4	1.10E+01	3.10E+01	1.10E+03	3.10E+03	2.60E+03	3.80E+03
Trichloropropane, 1,2,3-	96-18-4	1.20E-05	4.10E-05	1.20E-03	4.10E-03	9.10E-02	8.20E-01
Vinyl chloride	75-01-4	2.00E-03	2.00E-03	2.00E-01	2.00E-01	4.10E-03	7.00E-03
Xylene, m-	108-38-3	1.00E+01	1.00E+01	1.00E+03	1.00E+03	2.30E+03	3.30E+03
Xylene, o-	95-47-6	1.00E+01	1.00E+01	1.00E+03	1.00E+03	3.30E+04	4.80E+04
Xylene, p-	106-42-3	1.00E+01	1.00E+01	1.00E+03	1.00E+03	2.70E+03	3.80E+03
Xylenes	1330-20-7	1.00E+01	1.00E+01	1.00E+03	1.00E+03	2.60E+03	3.60E+03

**Updated Examples of Standard No. 2, Appendix II Medium-Specific Concentrations (MSCs) (Last update September 18, 1998)**

**Definitions**

MSC - Media-Specific Concentration

GWP-Res - Soil MSC for Residential Use Based on Groundwater Protection

GW-Ind - Groundwater MSC for Industrial Use

GW-Res - Groundwater MSC for Residential Use

CAS # - Chemical Abstracts Service number

GWP-Ind - Soil MSC for Industrial Use Based on Groundwater Protection

SAI-Ind - Soil MSC for Industrial Use Based on Inhalation, Ingestion, and Dermal Contact

SAI-Res - Soil MSC for Residential Use Based on Inhalation, Ingestion, and Dermal Contact

Downloaded from the TNRCC Website on 9/24/98, reformatted by J. Coffey

**Table 4-2**  
**Onsite Groundwater Analytical Results**  
**Preliminary Work Plan Direct Push Investigation**  
**October/November 1996**  
**NAS Fort Worth JRB, Texas**

Well ID	Date Sampled	Toluene	TCE	TCA & DCE <sup>2</sup>	Tetrachloroethene	EB or Xyl <sup>1</sup>
AGA001	10/31/96	500				
AGA002	10/31/96	100	15			TR
AGA003	10/31/96	120				
AGA006	10/31/96	30	5			TR
AGA007	10/31/96	30		TR	TR	TR
AGA009	11/03/96	30	11	54		
AGA010	11/03/96	4				
AGA011	11/01/96	20	10	5	2	TR
AGA012	10/31/96	40	TR	80		TR
AGA014	11/01/96	15	TR	500		
AGA015	11/01/96	40	400	60		
AGA016	11/03/96	30	35	116		
AGA018	11/05/96	36	162	105		
AGA019	11/01/96	8	50	10		
AGA020	11/01/96	5	5			
AGA021	11/01/96	10	200	TR	TR	
AGA022	11/03/96	38	178			
AGA023	11/03/96	38	35			
AGA024	11/03/96	31	2318			
AGA024S	11/04/96	28	319			
AGA025	11/03/96	15	493			
AGA026	11/03/96	28	37			
AGA027	11/04/96	9	13			
AGA028	11/04/96	4	8			
AGA035	11/05/96	25	44			
AGA036	11/05/96	13	46			
AGA037	11/05/96	8	47			
AGA038	11/04/96	17	346		18	
AGA039	11/04/96	19	396			
AGA040	11/04/96	6	686		18	
AGA040S	11/04/96	5				
AGA041	11/04/96	28	361	78		
AGA042	11/05/96	12	345			
AGA043	11/05/96	17	7			
AGA050	11/04/96	25	32			
AGA071	11/05/96	21	595		79	
AGA071A	11/05/96	13	488			
AGA071B	11/05/96	12				
AGA072	11/05/96	4				
AGA073	11/05/96	14				

Notes: All concentrations in micrograms per liter (ug/L)  
<sup>1</sup> EB or Xyl - Ethylbenzene or Xylene  
<sup>2</sup> TCA & DCE - Trichloroethane and/or Dichloroethene (total)  
Blank space - Denotes concentration below detection limits  
TR - Denotes concentration below reporting limits

**Table 4-3**  
**Offsite Confirmation Groundwater Analytical Results**  
**Preliminary Work Plan Direct Push Investigation**  
**NAS Fort Worth JRB, Texas**  
**October/November, 1996**

	<b>Date Sampled</b>	<b>Toluene</b>	<b>TCE</b>	<b>DCE</b>	<b>Tetrachloroethene</b>
AGA-001	10/31/96	21	3	13	1
AGA-010	11/03/96	24			
AGA-024	11/03/96	140	690	11	
AGA-039	11/04/96	440	93		

Notes: All concentrations in micrograms per liter (ug/L)  
Blank space denotes concentration below detection limit

**Table 4-4**  
**Onsite Groundwater Analytical Results**  
**Direct Push Screening Investigation**  
**NAS Fort Worth JRB, Texas**  
**October/November, 1997**

Well ID	Date Sampled	TCE	Tetrachloroethene	DCE & TCA	Hydrocarbons
PCHMHTA0A1	11/01/97	<5	<5	<5	
PCHMHTA0A2	11/01/97	36	<5	<5	
PCHMHTA0A3	11/01/97	550	23	<5	
PCHMHTA0A4	11/03/97	<5	<5	<5	20
PCHMHTA0B1	11/01/97	1800	10	<5	
PCHMHTA0B2	11/01/97	860	<5	<5	
PCHMHTA0B3	11/03/97	570	<5	160	
PCHMHTA0B4	11/01/97	<5	<5	<5	
PCHMHTA0C1	11/01/97	1400	<5	<5	
PCHMHTA0C2	10/31/97	460	<5	82	
PCHMHTA0C3	11/01/97	310	<5	220	
PCHMHTA0D1	10/31/97	<5	<5	<5	
PCHMHTA0D2	11/01/97	<5	<5	27	
PCHMHTA0D3	10/31/97	340	<5	45	
PCHMHTA0E1	10/29/97	<5	<5	<5	
PCHMHTA0E2	11/01/97	<5	<5	19	
PCHMHTA0E3	10/31/97	23	250	360	
PCHMHTA0E4	10/31/97	340	<5	51	
PCHMHTA0E6	10/31/97	5.2	<5	11	
PCHMHTA0F1	10/29/97	<5	<5	<5	
PCHMHTA0F2	10/31/97	<5	<5	<5	
PCHMHTA0F3	11/03/97	<5	<5	<5	

Notes: All concentrations in micrograms per liter (ug/L)  
TCA & DCE - Tnchlorothane and/or Dichloroethene (total)  
Blank space - Denotes concentration below detection limits

**Table 4-5**  
**Offsite Confirmation Groundwater Analytical Results**  
**Direct Push Screening Investigation**  
**NAS Fort Worth JRB, Texas**  
**October/November, 1997**

	TCE	Tetrachloroethene	DCE & TCA*	Hydrocarbons		
				sec- butylbenzene	1,2,4- trimethylbenzene	Isopropylbenzene
PCHMHTA0A4				11F	350	7.2F
PCHMHTA0B3			95			
PCHMHTA0C2	200		56			
PCHMHTA0C3	180J		161			
PCHMHTA0D1						
PCHMHTA0D3	230		40.5			

Notes. All concentrations in micrograms per liter (ug/L)

Blank space denotes concentration below detection limit

\* Normally this column is used to report indistinguishable dichloroethene and/or trichloroethane, in this instance it was observable that only cis-1,2-DCE and trans-1,2-DCE isomers were detected, no TCA was present

Table 4-6  
Soil Analytical Results  
NAS Fort Worth JRB, Texas

Location	Begin Depth	End Depth	Sample Date	PCE (mg/kg)	TCE (mg/kg)	Cis-1,2-DCE (mg/kg)	trans-1,2-DCE (mg/kg)	1,1-DCE (mg/kg)	Vinyl Chloride (mg/kg)
BCHMHTA001	1	3	10-Dec-97	0.007 U	0.01 U	0.006 U	0.003 U	0.006 U	0.009 U
BCHMHTA001	5	7	10-Dec-97	0.007 U	0.01 U	0.006 U	0.003 U	0.006 U	0.009 U
BCHMHTA001	10	12	10-Dec-97	0.007 U	0.01 U	0.006 U	0.003 U	0.006 U	0.009 U
BCHMHTA002	1	3	10-Dec-97	0.007 U	0.01 U	0.006 U	0.003 U	0.006 U	0.009 U
BCHMHTA002	5	7	10-Dec-97	0.007 U	0.01 U	0.006 U	0.003 U	0.006 U	0.009 U
BCHMHTA002	10	12	10-Dec-97	0.007 U	0.01 U	0.006 U	0.003 U	0.006 U	0.009 U
WCHMHTA001	6	8	20-Nov-97	0.008 U	0.011 UJ	0.0069 U	0.0034 U	0.0069 U	0.01 UJ
WCHMHTA001	26	28	20-Nov-97	0.0082 U	0.012 UJ	0.007 U	0.0035 U	0.007 U	0.011 UJ
WCHMHTA002	18	20	06-Dec-97	0.0078 U	0.011 U	0.0066 U	0.0033 U	0.0066 UJ	0.01 UJ
WCHMHTA004	17	18	01-Dec-97	0.008 U	0.011 U	0.0069 U	0.0034 U	0.0069 UJ	0.01 UJ
WCHMHTA006	12	16	26-Nov-97	0.0087 U	0.012 UJ	0.0075 U	0.0037 U	0.0075 U	0.011 UJ
WCHMHTA007	12	14	18-Nov-97	0.0079 U	0.011 UJ	0.0068 U	0.0034 U	0.0068 U	0.01 UJ
WCHMHTA008	12	14	19-Nov-97	0.0083 U	0.012 UJ	0.0071 U	0.0035 U	0.0071 U	0.011 UJ
WCHMHTA008	14	16	19-Nov-97	0.041 U	0.059 UJ	0.035 U	0.018 U	0.035 U	0.053 UJ
WCHMHTA009	6	8	25-Nov-97	0.0079 U	0.011 UJ	0.0068 U	0.0034 U	0.0068 U	0.01 UJ
WCHMHTA011	12	14	17-Nov-97	0.008 U	0.011 UJ	0.0068 U	0.0034 U	0.0068 U	0.01 UJ
WCHMHTA012	12	14	21-Nov-97	0.04 U	0.057 UJ	0.034 U	0.017 U	0.034 U	0.052 UJ
WCHMHTA013	14	16	17-Nov-97	0.0073 U	0.01 UJ	0.0063 U	0.0031 U	0.0063 U	0.0094 UJ
WCHMHTA014	10	12	20-Nov-97	0.0091 U	0.013 UJ	0.0078 U	0.0039 U	0.0078 U	0.012 UJ

Notes: All concentrations in milligrams/kilogram (mg/kg)  
Data qualifiers are described on page 3-22

**Table 4-7  
December 1997 Natural Attenuation Field Parameter Results  
NAS Fort Worth JRB, Texas**

Well ID	Ferrous Iron (mg/L)	pH	Temp (C)	Conductivity (mS/cm)	ORP (mV)	DO (mg/L)
GMI-22-02M	0.01	7.05	20.8	0.355	140.8	2.08
GMI-22-05M	0.31	7.08	19.4	0.669	124.3	2.4
GMI-22-07M	0.72	6.72	25.3	0.623	170.3	2.71
HM-120	0.09	6.1	20.7	1.2	52.1	1.11
HM-121	0.56	6.95	18.8	1.53	147.5	1.74
LSA1628-3	0.02	6.8	27	1.22	-24.2	0.8
MW-3	0.11	6.77	23.9	0.665	143.3	2.01
MW-57B	0.01	6.39	20.8	8.03	124	1.1
WCHMHTA001	0.68	7.01	25.2	0.739	139.6	1.08
WCHMHTA012	2.35	6.76	28.1	1.42	-58.5	0.4
WITCTA010	0.96	6.9	25.5	0.569	-72.5	0.05

Note All natural attenuation parameters, laboratory and field-measured, are presented on Table 6-2 and 6-3.  
 mg/L milligram/liter  
 mS/cm milliSiemens per centimeter  
 mV millivolts

**Table 4-8**  
**April 1998 Natural Attenuation Field Parameter Results**  
**NAS Fort Worth JRB, Texas**

Well ID	Ferrous Iron (mg/L)	pH	Temp (C)	Conductivity (mS/cm)	ORP (mV)	DO (mg/L)
GMI-22-02M	0.09	6.76	22.1	0.459	34	0.6
GMI-22-05M	0.04	6.76	27.3	1.65	260	1.4
GMI-22-07M	0.57	6.78	27.8	0.551	179	3.16
HM-120	0.00	6.52	20.5	1.14	-133.9	0.2
HM-121	0.03	6.67	24	1.36	-116.8	0.8
LSA1628-3	0.00	6.84	24.4	0.789	48.7	0.15
MW-3	0.01	6.78	23	0.611	66.5	0.7
MW-57B	0.01	6.56	22	6.09	69.3	3.78
WCHMHTA001	0.03	6.69	25.4	0.651	121	1.27
WCHMHTA012	2.88	6.81	26.1	1.00	-89.4	0.45
WITCTA010	1.47	7.08	26.3	0.498	-122.9	0.37

Note: All natural attenuation parameters, laboratory and field-measured, are presented on Table 6-2 and 6-3.  
 mg/L milligram/liter  
 mS/cm milliSiemens per centimeter  
 mV millivolts

Table 4-9  
 First Event Groundwater Analytical Results  
 NAS Fort Worth JRB, Texas

Location	Date Sampled	PCE (ug/L)	TCE (ug/L)	Cis-1,2-DCE (ug/L)	trans-1,2-DCE (ug/L)	1,1-DCE (ug/L)	Vinyl chloride (ug/L)
GMI-22-02M	16-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
GMI-22-03M	18-Dec-97	13	70	45	51	2.4 U	2.2 U
GMI-22-04M	18-Dec-97	28 U	520	56	11 F	24 U	22 U
GMI-22-05M	23-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
GMI-22-06M	18-Dec-97	7 U	120	22	30	6 U	5.5 U
GMI-22-07M	16-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
HM-116	19-Dec-97	28 U	530 J	33 J	12 U	24 U	22 U
HM-117	19-Dec-97	8.1	150 J	3.7 J	3 U	6 U	5.5 U
HM-118	19-Dec-97	7 U	120 J	2 J	3 U	6 U	5.5 U
HM-119	19-Dec-97	1.8	26 J	0.71 J	0.6 U	1.2 U	1.1 U
HM-120	16-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
HM-121	17-Dec-97	35 U	400 J	30 U	15 U	30 U	28 U
HM-125	22-Dec-97	1.4 U	35	2.7	0.6 U	1.2 U	1.1 U
HM-96	22-Dec-97	36	520	54	12 U	24 U	22 U
LSA1628-3	16-Dec-97	35 U	540 J	75 J	53 J	30 U	28 U
MW-3	23-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
MW-49	17-Dec-97	1.4 U	3.8 J	1.2 U	0.6 U	1.2 U	1.1 U
MW-57	19-Dec-97	1.4 U	1 J	14 J	0.5 F	1.2 U	1.1 U
MW-57B	16-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
PCHMHTA0A4	3-Nov-97	28 U	20 U	24 U	12 U	24 U	22 U
PCHMHTA0B3	3-Nov-97	28 U	320 J	89	12 U	24 U	22 U
PCHMHTA0C2	31-Oct-97	14 U	200	40	16	12 U	11 U
PCHMHTA0C3	3-Nov-97	28 U	180 J	94	67	24 U	22 U
PCHMHTA0D1	31-Oct-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
PCHMHTA0D3	31-Oct-97	14 U	230	33	7.5	12 U	11 U
SPOT-35-4	22-Dec-97	5.6 U	4 U	4.8 U	2.4 U	4.8 U	4.4 U

**Table 4-9**  
**First Event Groundwater Analytical Results**  
**NAS Fort Worth JRB, Texas**

Location	Date Sampled	PCE (ug/L)	TCE (ug/L)	Cis-1,2-DCE (ug/L)	trans-1,2-DCE (ug/L)	1,1-DCE (ug/L)	Vinyl chloride (ug/L)
USGS04T	18-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
WCHMHTA001	17-Dec-97	35 U	400 J	60	15 U	30 UJ	28 UJ
WCHMHTA002	19-Dec-97	35 U	620 J	34 J	15 U	30 U	28 UJ
WCHMHTA003	22-Dec-97	0.36 F	23	0.48 F	0.6 U	1.2 U	1.1 UJ
WCHMHTA004	22-Dec-97	8.2 F	380	8.9 F	6 U	12 U	11 UJ
WCHMHTA005	22-Dec-97	2.8 U	59	1.2 F	1.2 U	2.4 U	2.2 UJ
WCHMHTA006	22-Dec-97	28 U	500	100	12 U	24 U	22 UJ
WCHMHTA007	19-Dec-97	35 U	660 J	9.5 J	15 U	30 U	28 UJ
WCHMHTA008	17-Dec-97	14 U	59 J	12 U	6 U	12 UJ	11 UJ
WCHMHTA009	22-Dec-97	28 U	480	7.4 F	12 U	24 U	22 UJ
WCHMHTA010	17-Dec-97	70 U	1100 J	60 U	30 U	60 UJ	55 UJ
WCHMHTA011	17-Dec-97	70 U	420 J	60 U	30 U	60 UJ	55 UJ
WCHMHTA012	16-Dec-97	35 U	620 J	250 J	69 J	30 UJ	28 UJ
WCHMHTA013	18-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
WCHMHTA014	22-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
WITCTA010	23-Dec-97	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
WITCTA016	22-Dec-97	7 U	13	57	85	6 U	5.5 UJ

Notes: All concentrations in micrograms per liter (ug/L).  
 Data qualifiers are described on page 3-22.

Table 4-10  
Second Event Groundwater Analytical Results  
NAS Fort Worth JRB, Texas

Location	Date Sampled	PCE (ug/L)	TCE (ug/L)	Cis-1,2-DCE (ug/L)	trans-1,2-DCE (ug/L)	1,1-DCE (ug/L)	Vinyl chloride (ug/L)
GMI-22-02M	23-Feb-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
GMI-22-03M	19-Feb-98	23 J	57	39	33 J	2.4 UJ	2.2 UJ
GMI-22-04M	19-Feb-98	28 UJ	450	53	8.8 J	24 UJ	22 UJ
GMI-22-05M	19-Feb-98	1.4 UJ	1 U	1.2 U	0.6 UJ	1.2 UJ	1.1 UJ
GMI-22-06M	20-Feb-98	14 U	190	31	47	12 U	3 J
GMI-22-07M	18-Feb-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
HM-116	24-Feb-98	28 U	410	32	12 U	24 U	22 UJ
HM-117	24-Feb-98	8.5	140	4.4 F	3 U	6 U	5.5 UJ
HM-118	24-Feb-98	7 U	120	2.8 F	3 U	6 U	5.5 UJ
HM-119	24-Feb-98	3.6	43	1.4 F	1.2 U	2.4 U	2.2 UJ
HM-120	23-Feb-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
HM-121	23-Feb-98	14 U	230	3.1 F	6 U	12 U	11 UJ
HM-125	24-Feb-98	1.4 U	26	2.6	0.6 U	1.2 U	1.1 UJ
HM-96	24-Feb-98	63	670	73	12 U	8.2 F	22 UJ
LSA1628-3	18-Feb-98	14 U	180	35	23	12 U	11 UJ
MW-3	18-Feb-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
MW-49	23-Feb-98	1.4 U	1.1	1.2 U	0.6 U	1.2 U	1.1 UJ
MW-57	24-Feb-98	1.4 U	1 U	5	0.6 U	1.2 U	1.1 UJ
MW-57B	23-Feb-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
SPOT-35-4	23-Feb-98	2.8 U	2 U	2.4 U	1.2 U	2.4 U	2.2 UJ
USGS04T	19-Feb-98	1.4 UJ	1 U	1.2 U	0.6 UJ	1.2 UJ	1.1 UJ
WCHMHTA001	24-Feb-98	14 U	220	54	6 U	12 U	11 UJ
WCHMHTA002	24-Feb-98	28 U	360	29	12 U	24 U	22 UJ
WCHMHTA003	20-Feb-98	0.82 F	45	1.3 F	1.2 U	2.4 U	2.2 UJ
WCHMHTA004	20-Feb-98	9 F	410	12 F	12 U	24 U	22 UJ
WCHMHTA005	24-Feb-98	2.8 U	53	2 F	1.2 U	2.4 U	2.2 UJ

Table 4-10  
 Second Event Groundwater Analytical Results  
 NAS Fort Worth JRB, Texas

Location	Date Sampled	PCE (ug/L)	TCE (ug/L)	Cis-1,2-DCE (ug/L)	trans-1,2-DCE (ug/L)	1,1-DCE (ug/L)	Vinyl chloride (ug/L)
WCHMHTA006	24-Feb-98	28 U	360	81	12 U	24 U	22 UJ
WCHMHTA007	20-Feb-98	28 U	550	11 F	12 U	24 U	22 UJ
WCHMHTA008	23-Feb-98	7 U	22	6 U	3 U	6 U	5.5 UJ
WCHMHTA009	19-Feb-98	2.2 J	320	7.9	0.6 UJ	1.2 UJ	1.1 UJ
WCHMHTA010	19-Feb-98	28 UJ	330	24 U	12 UJ	24 UJ	22 UJ
WCHMHTA011	19-Feb-98	70 U	1200	28 F	30 U	60 U	55 UJ
WCHMHTA012	18-Feb-98	28 U	410	160	28	24 U	22 UJ
WCHMHTA013	19-Feb-98	1.4 UJ	0.85 F	1.2 U	0.6 UJ	1.2 UJ	1.1 UJ
WCHMHTA014	24-Feb-98	1.4 U	0.97 F	1.2 U	0.6 U	1.2 U	1.1 UJ
WITCTA010	18-Feb-98	1.4 U	1 U	0.82 F	0.84	1.2 U	1.1 UJ
WITCTA016	23-Feb-98	1.4 U	33	84	130	0.42 F	2.6 J

Notes: All concentrations in micrograms/liter (ug/L).  
 Data qualifiers are described on page 3-22.

Table 4-11  
Third Event Groundwater Analytical Results  
NAS Fort Worth JRB, Texas

Location	Date Sampled	PCE (ug/L)	TCE (ug/L)	cis-1,2-DCE (ug/L)	trans-1,2-DCE (ug/L)	1,1-DCE (ug/L)	Vinyl chloride (ug/L)
GMI-22-02M	22-Apr-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
GMI-22-03M	21-Apr-98	18	53	38	32	24 U	2.2 U
GMI-22-04M	21-Apr-98	28 U	520	59	9.4 F	24 U	22 U
GMI-22-05M	23-Apr-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
GMI-22-06M	21-Apr-98	7 U	170	36	56	6 U	5.5 U
GMI-22-07M	22-Apr-98	1.4 U	1 U	1.2 UJ	0.6 UJ	1.2 U	1.1 UJ
HM-116	24-Apr-98	8.2 F	500	50	12 U	24 U	22 U
HM-117	24-Apr-98	11 F	160	4.9 F	6 U	12 U	11 U
HM-118	24-Apr-98	7 U	110	2.5 F	3 U	6 U	5.5 U
HM-119	25-Apr-98	3.6 J	40	1.3	0.6 UJ	1.2 UJ	1.1 UJ
HM-120	22-Apr-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 UJ
HM-121	22-Apr-98	5.5 F	370	5.9 F	6 U	12 U	11 UJ
HM-125	24-Apr-98	1.4 U	27	2.8	0.6 U	12 U	1.1 U
HM-96	25-Apr-98	68 J	600	75	1.8 J	9.8 J	1.1 UJ
LSA1628-3	22-Apr-98	14 U	250 J	43 J	33 J	12 U	11 UJ
MW-3	20-Apr-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
MW-49	24-Apr-98	1.4 U	4.7	1.2 U	0.6 U	1.2 U	1.1 U
MW-57	21-Apr-98	1.4 U	1 U	3.2	0.6 U	1.2 U	1.1 U
MW-57B	23-Apr-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
SPOT-35-4	23-Apr-98	7 U	5 U	6 U	3 U	6 U	5.5 U
USGS04T	20-Apr-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
WCHMHTA001	23-Apr-98	14 U	310	74	6 U	12 U	11 U
WCHMHTA002	24-Apr-98	28 U	470	37	12 U	24 U	22 U
WCHMHTA003	25-Apr-98	0.83 J	45	14	0.6 UJ	1.2 UJ	1.1 UJ
WCHMHTA004	25-Apr-98	12 J	420	15	0.67 J	1.1 J	1.1 UJ
WCHMHTA005	24-Apr-98	7 U	69	2.3 F	3 U	6 U	5.5 U

Table 4-11  
Third Event Groundwater Analytical Results  
NAS Fort Worth JRB, Texas

Location	Date Sampled	PCE (ug/L)	TCE (ug/L)	cis-1,2-DCE (ug/L)	trans-1,2-DCE (ug/L)	1,1-DCE (ug/L)	Vinyl chloride (ug/L)
WCHMHTA006	24-Apr-98	28 U	490	95	12 U	24 U	22 U
WCHMHTA007	24-Apr-98	28 U	670	12 F	12 U	24 U	22 U
WCHMHTA008	24-Apr-98	7 U	22	6 U	3 U	6 U	5.5 U
WCHMHTA009	21-Apr-98	2.5	450 J	7.7 J	0.6 U	1.2 U	1.1 U
WCHMHTA010	24-Apr-98	70 U	1100	60 U	30 U	60 U	55 U
WCHMHTA011	24-Apr-98	28 U	360	6.2 F	12 U	24 U	22 U
WCHMHTA012	22-Apr-98	1.2 J	580	180	34 J	1.4	13 J
WCHMHTA013	21-Apr-98	1.4 U	1 U	1.2 U	0.6 U	1.2 U	1.1 U
WCHMHTA014	21-Apr-98	1.4 U	0.61 F	1.2 U	0.6 U	1.2 U	1.1 U
WITCTA010	23-Apr-98	1.4 U	1 UU	1.3	1.6	1.2 U	1.1 U
WITCTA016	24-Apr-98	14 U	26	86	130	12 U	11 U

Notes. All concentrations in micrograms/liter (ug/L).  
Data qualifiers are described on page 3-22.

Table 4-12  
Groundwater Elevations Measured During Groundwater Sampling Events  
NAS Fort Worth JRB, Texas

Well	Coordinates		Top of Casing		Groundwater Elevations		
	Easting	Northing	Elevation		First Event	Second Event	Third Event
GMI-22-02M	2296187.4	6966632.9	619.13		609.71	610.33	610.59
GMI-22-03M	2298539.4	6966219.9	608.03		587.43	587.63	587.67
GMI-22-04M	2297340.5	6967250.5	610.70		591.05	591.22	591.36
GMI-22-05M	2299432.1	6966940.3	584.28		573.72	572.83	572.84
GMI-22-06M	2298186.6	6967004.5	606.84		588.47	588.59	588.72
GMI-22-07M	2298322.5	6969018.7	605.66		590.06	590.54	590.88
HM-96	2293169.07	6966507.836	--		--	--	--
HM-116	2294283.7	6966411.4	634.06		611.59	613.22	613.51
HM-117	2294274.3	6967355.4	633.32		611.90	613.67	613.76
HM-118	2294780.5	6968035.2	626.23		611.07	612.93	612.56
HM-119	2294271.8	6968726	625.04		611.94	613.44	613.56
HM-120	2295343.2	6969489	616.84		611.95	615.86	613.03
HM-121	2295279.2	6967390.2	627.66		609.97	610.75	611.10
HM-125	2295220.29	6965893.458	629.37		611.91	612.87	613.32
LSA1628-3	2297791.257	6967993.079	601.73		591.88	592.11	592.25
MW-3	2299750.342	6965242.674	576.48		566.18	565.48	565.33
MW-49	2295623.167	6968470.498	--		--	--	--
MW-57	2297112.98	6967217.16	613.37		601.44	599.87	599.92
MW-57B	2296034.177	6968836.004	613.78		606.42	606.69	605.83
SPOT35-4	2296777.882	6966174.924	612.74		592.30	592.74	592.99
USGS04T	2299178.7	6968773	604.92		586.69	586.97	587.32
WCHMHTA001	2293437.6	6965828.172	639.57		612.37	613.90	614.04
WCHMHTA002	2294553.414	6966740.532	631.83		611.65	612.82	613.13
WCHMHTA003	2294774.144	6967153.875	631.69		611.55	612.12	612.59
WCHMHTA004	2294776.099	6967144.605	631.68		611.32	611.86	612.34

Table 4-12  
Groundwater Elevations Measured During Groundwater Sampling Events  
NAS Fort Worth JRB, Texas

Well	Coordinates		Top of Casing		Groundwater Elevations		
	Easting	Northing	Elevation	First Event	Second Event	Third Event	
WCHMHTA005	2295397.821	6966691.185	627.39	610.41	611.02	611.39	
WCHMHTA006	2295406.968	6966690.112	627.22	610.41	611.04	611.04	
WCHMHTA007	2295645.387	6967105.885	624.54	610.08	610.69	611.11	
WCHMHTA008	2295597.48	6967889.887	623.15	609.70	610.41	610.77	
WCHMHTA009	2296395.012	6967635.292	615.73	609.19	609.69	610.05	
WCHMHTA010	2296398.796	6967640.077	615.74	609.39	609.90	610.28	
WCHMHTA011	2297063.014	6968490.507	606.32	593.98	594.27	594.48	
WCHMHTA012	2297425.824	6967840.863	606.18	592.48	592.73	592.84	
WCHMHTA013	2299786.181	6966251.256	578.76	561.78	562.52	562.42	
WCHMHTA014	2294072.809	6970403.901	619.43	608.18	609.48	609.38	
WITCTA010	2298752.182	6967693.534	600.31	586.20	585.86	587.21	
WITCTA016	2298061.326	6966238.285	607.85	589.32	589.50	589.55	
Staff Gauge Lake Worth	6971675.036	2299656.162	593.84	593.84	593.85	593.80	
Staff Gauge Trinity River	6967745.542	2300183.374	529.90	529.90	530.00	529.92	

Notes. -- TOC Elevation not available

**Table 4-13**  
**Slug Test Hydraulic Conductivities (January 1998)**  
**NAS Fort Worth JRB, Texas**

Well	Screen Length (ft)	Well Depth (ft)	Hydraulic Conductivity (cm/s)
<b>Runway area wells</b>		<b>geometric mean:</b>	<b>3.85E-03</b>
WCHMHTA001	20	46	2.27E-03
WCHMHTA002	20	42	3.04E-03
WCHMHTA 003	10	28	1.85E-02
WCHMHTA004	10	38	1.72E-03
<b>Alert Apron area wells</b>		<b>geometric mean:</b>	<b>8.51E-03</b>
WCHMHTA005	10	26	1.89E-03
WCHMHTA006	10	36.5	5.61E-03
WCHMHTA007	20	32.5	1.81E-02
WCHMHTA009	7.5	12	4.01E-03
WCHMHTA010	10	25	1.37E-02
WCHMHTA011	10	22	8.07E-02
GMI-22-02M	25	30.5	3.79E-03
<b>Off-Flightline area wells</b>		<b>geometric mean:</b>	<b>1.75E-02</b>
WCHMHTA012	10	18.5	1.36E-02
GMI-22-03M	20	32	1.35E-02
GMI-22-04M	10	23	1.19E-02
GMI-22-05M	5	10.5	1.65E-02
GMI-22-06M	10	23.5	1.66E-02
GMI-22-07M	10	20.5	1.97E-02
WITCTA010	7.25	19	7.61E-02
WITCTA024	9.75	23.7	6.48E-03
USGS04T	10	25.5	2.59E-02
<b>AOC2 Study Area Horizontal Hydraulic Conductivity (geometric mean):</b>			<b>8.30E-03</b>

**Well locations:**

Runway area wells. located west of Taxiway F

Alert Apron area wells. located within Alert Apron, east of Taxiway F

Off-flightline area wells: located east of Alert Apron

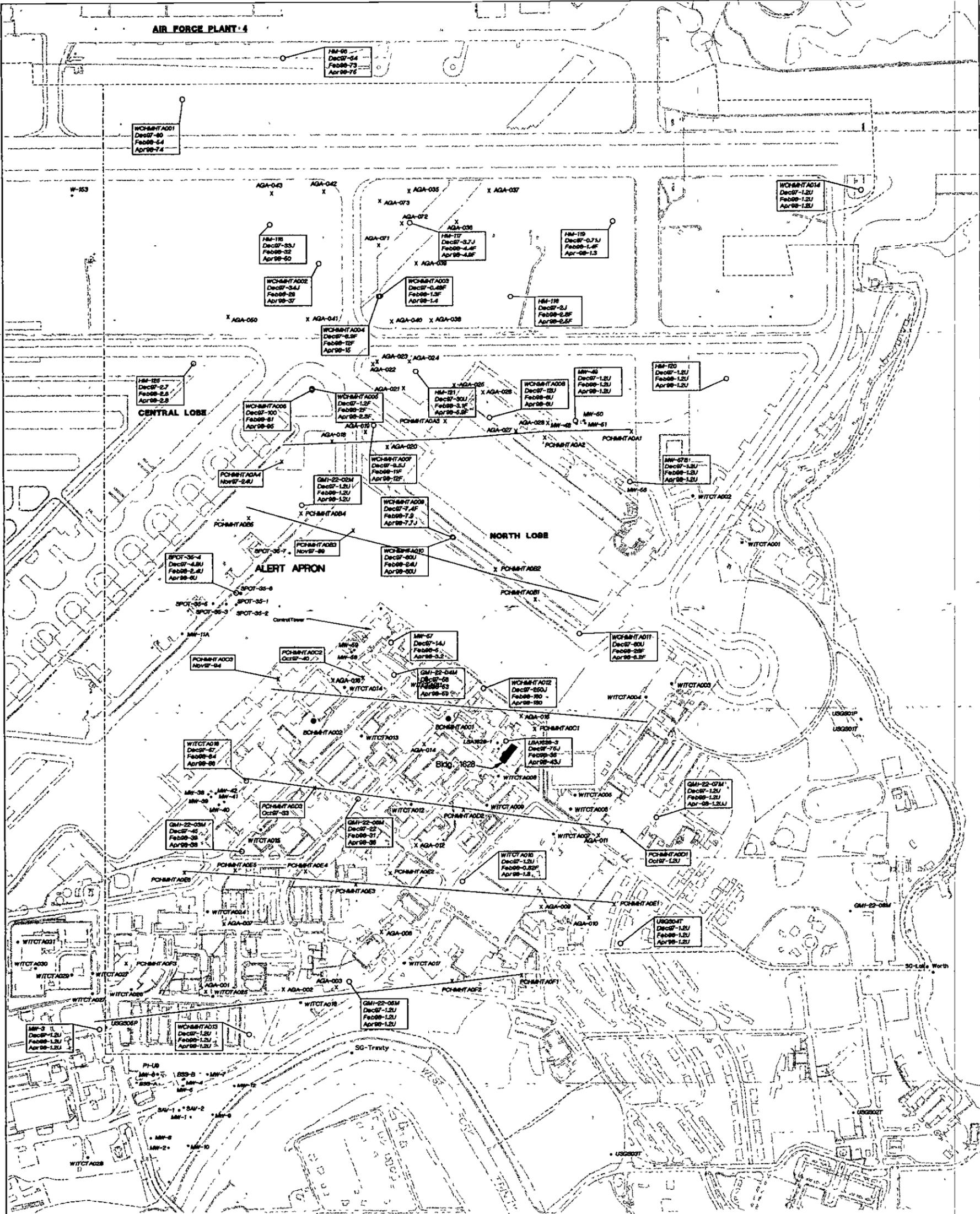
**Method of analysis: Bouwer & Rice**

Well 8 not tested due to presence of strong odors

Wells 13 and 14 not tested due to lack of water

**NAS Wells Hydraulic Conductivity (geometric mean) calculated by IT (Sanitary Sewer RFI, Sep-97):**  
**1.29x10<sup>-3</sup> cm/s**





**LEGEND**

--- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY

--- AOC2 STUDY AREA BOUNDARY

cis-1,2-DCE CONCENTRATIONS IN ug/L IN GROUNDWATER SAMPLES COLLECTED FROM MONITOR WELLS

cis-1,2-DCE CONCENTRATIONS IN ug/L IN GROUNDWATER SAMPLES COLLECTED FROM DIRECT-PUSH LOCATIONS (SQUARE SYMBOLS) (OFFSITE LABORATORY CONFIRMATION DATA)

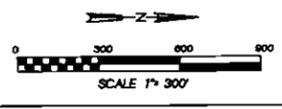
EXISTING MONITOR WELL

LOCATION OF DIRECT-PUSH/MONITORING WELL TRANSECT

LOCATION OF DIRECT-PUSH AND/OR POWER FLUSH WELL (X) (X) LOCATIONS WERE INSTALLED IN OCT-NOV 1998 AS PART OF THE SCREENING INVESTIGATION. (PCHMHTA) LOCATIONS WERE INSTALLED IN OCT-NOV 1997 AS PART OF THE FULL AOC2 RFI

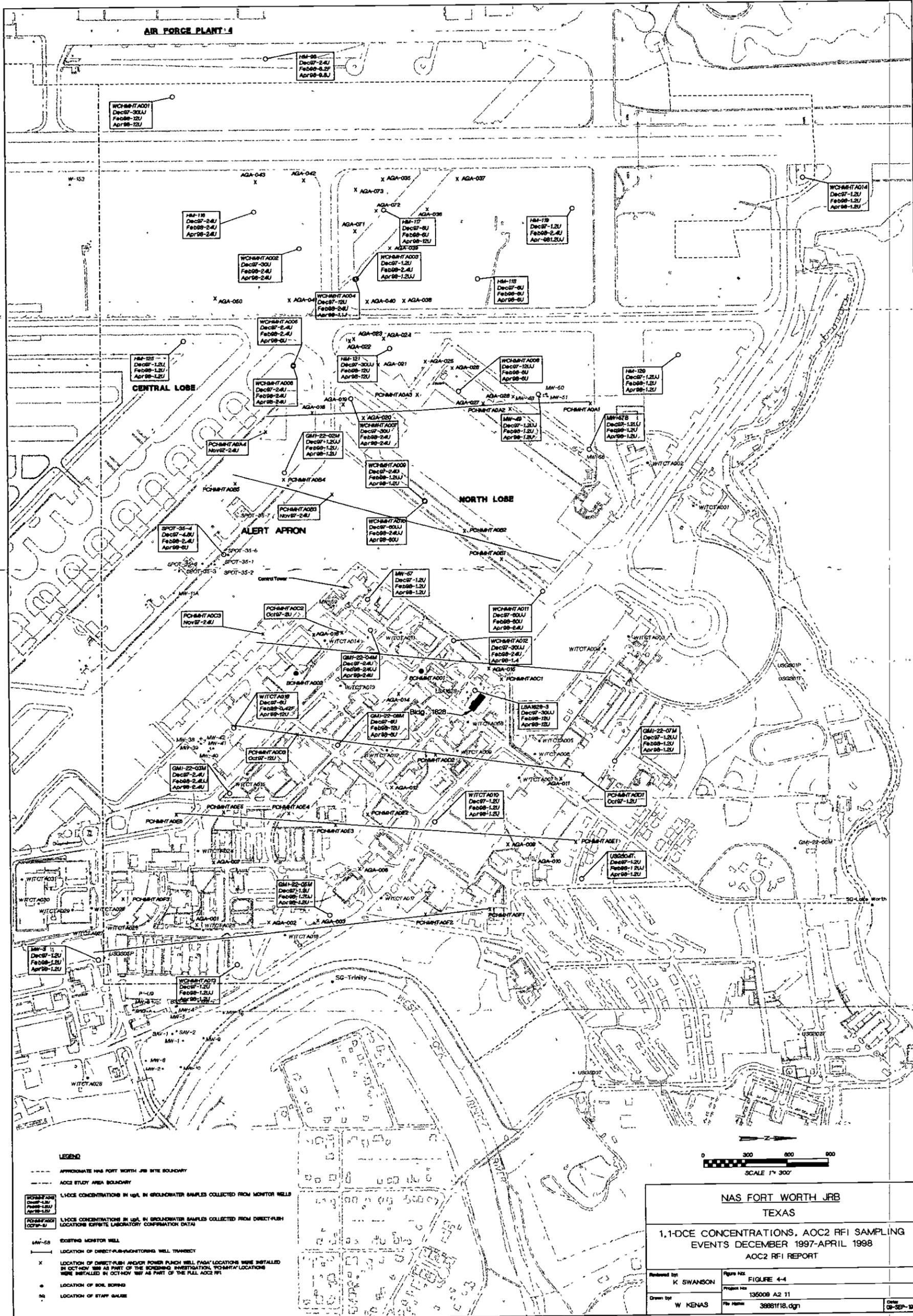
LOCATION OF SOIL BORINGS

LOCATION OF STAFF GAUGE



<b>NAS FORT WORTH JRB</b>	
TEXAS	
cis-1,2-DCE CONCENTRATIONS, AOC2 RFI SAMPLING EVENTS DECEMBER 1997-APRIL 1998 AOC2 RFI REPORT	
Reviewed by <b>K SWANSON</b>	Figure No. <b>FIGURE 4-2</b>
Drawn by <b>W KENAS</b>	Project No. <b>136009.A2.11</b>
File Name <b>38681120.dgn</b>	Date <b>10-NOV-2000</b>





**LEGEND**

--- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY

--- AOC2 STUDY AREA BOUNDARY

□ 1,1-DCE CONCENTRATIONS IN UG/L IN GROUNDWATER SAMPLES COLLECTED FROM MONITOR WELLS

□ 1,1-DCE CONCENTRATIONS IN UG/L IN GROUNDWATER SAMPLES COLLECTED FROM DIRECT-PUSH LOCATIONS (RFP) LABORATORY CONFIRMATION DATA

MW-58 EXISTING MONITOR WELL

--- LOCATION OF DIRECT-PUSH/MONITORING WELL TRANSECT

X LOCATION OF DIRECT-PUSH AND/OR PUNCH WELL (PAG) LOCATIONS WERE INSTALLED IN OCTOBER 1998 AS PART OF THE SCREENING INVESTIGATION. PCHMHTA LOCATIONS WERE INSTALLED IN OCTOBER 1997 AS PART OF THE FULL AOC2 RFI

• LOCATION OF SOIL BORING

SA LOCATION OF STAFF GAUGE

0 300 600 900  
SCALE 1" = 300'

**NAS FORT WORTH JRB  
TEXAS**

**1,1-DCE CONCENTRATIONS, AOC2 RFI SAMPLING  
EVENTS DECEMBER 1997-APRIL 1998  
AOC2 RFI REPORT**

Revised by: K SWANSON  
Drawn by: W KENAS

Figure No: FIGURE 4-1  
Project No: 135008 A2 11  
File Name: 388118.dgn

Date: 09-SEP-1998

Facing West

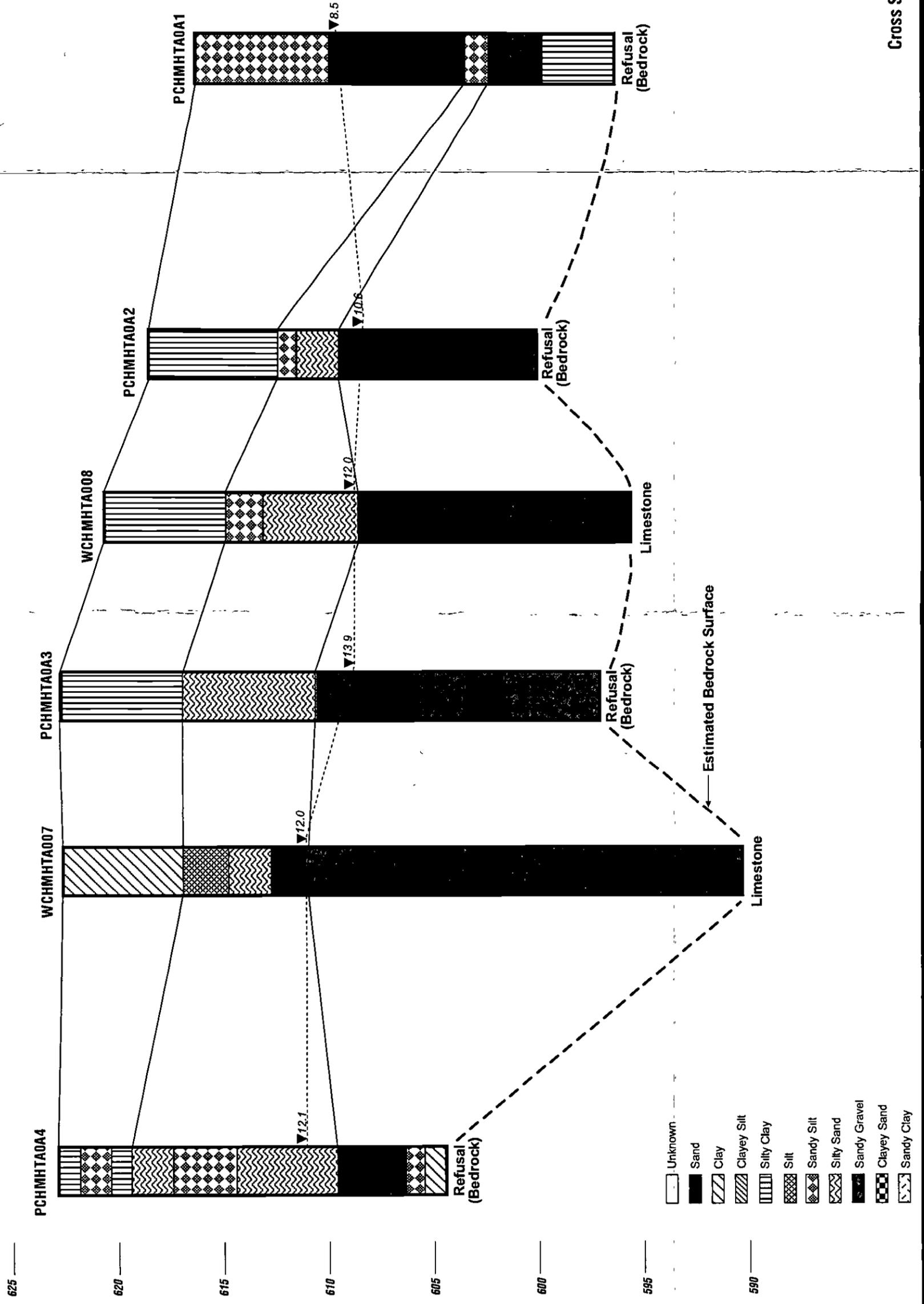


Figure 4-5  
 AOC 2 RFI Report  
 Cross Section A (Transect A)  
 NAS Fort Worth JRB, Texas

- Unknown
- Sand
- Clay
- Clayey Silt
- Silty Clay
- Silt
- Sandy Silt
- Silty Sand
- Sandy Gravel
- Clayey Sand
- Sandy Clay
- Shale
- Limestone

Facing West

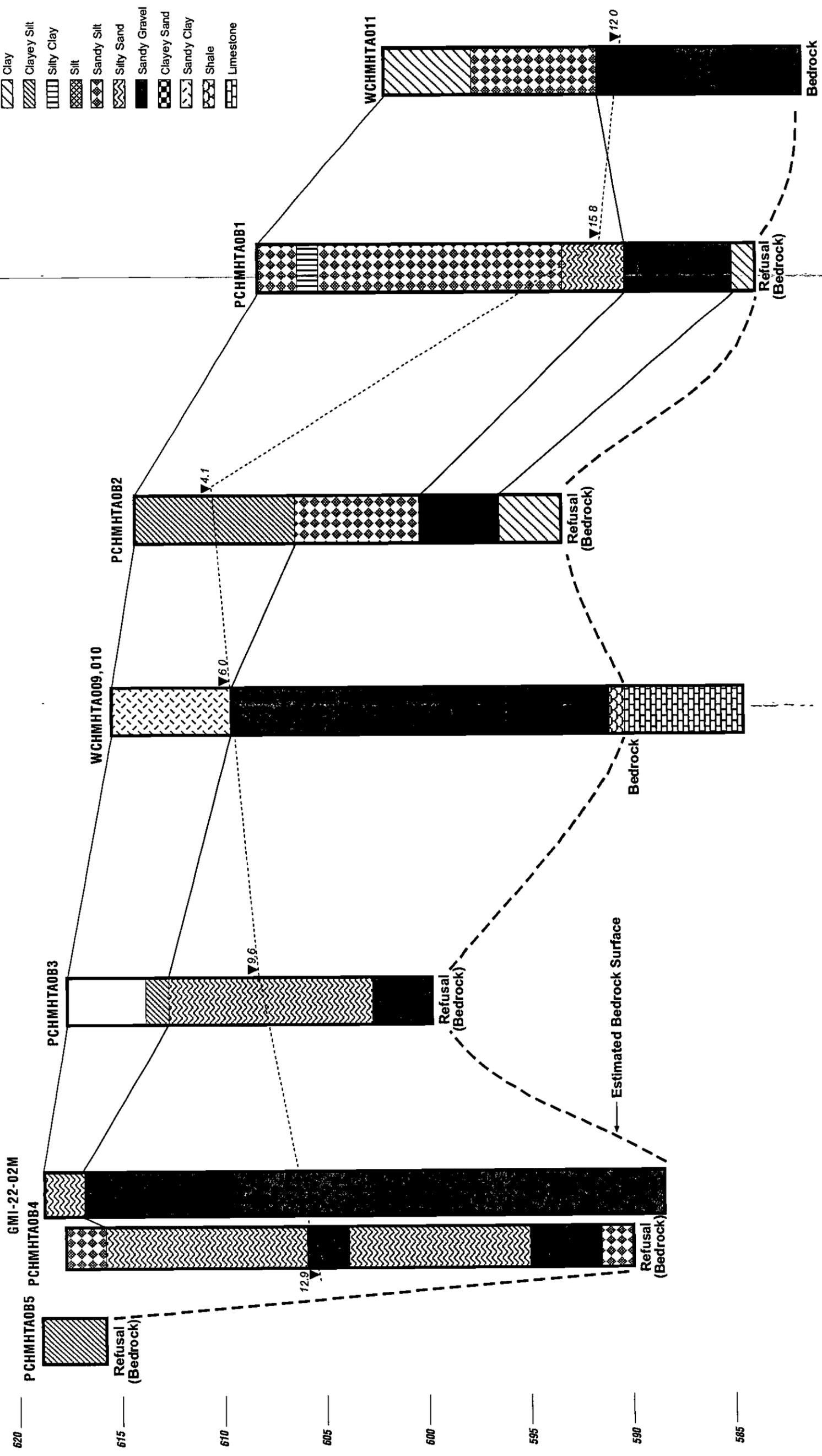


Figure 4-6  
 AOC 2 RFI Report  
 Cross Section B (Transect B)  
 IAS Fort Worth JRB, Texas

Facing West

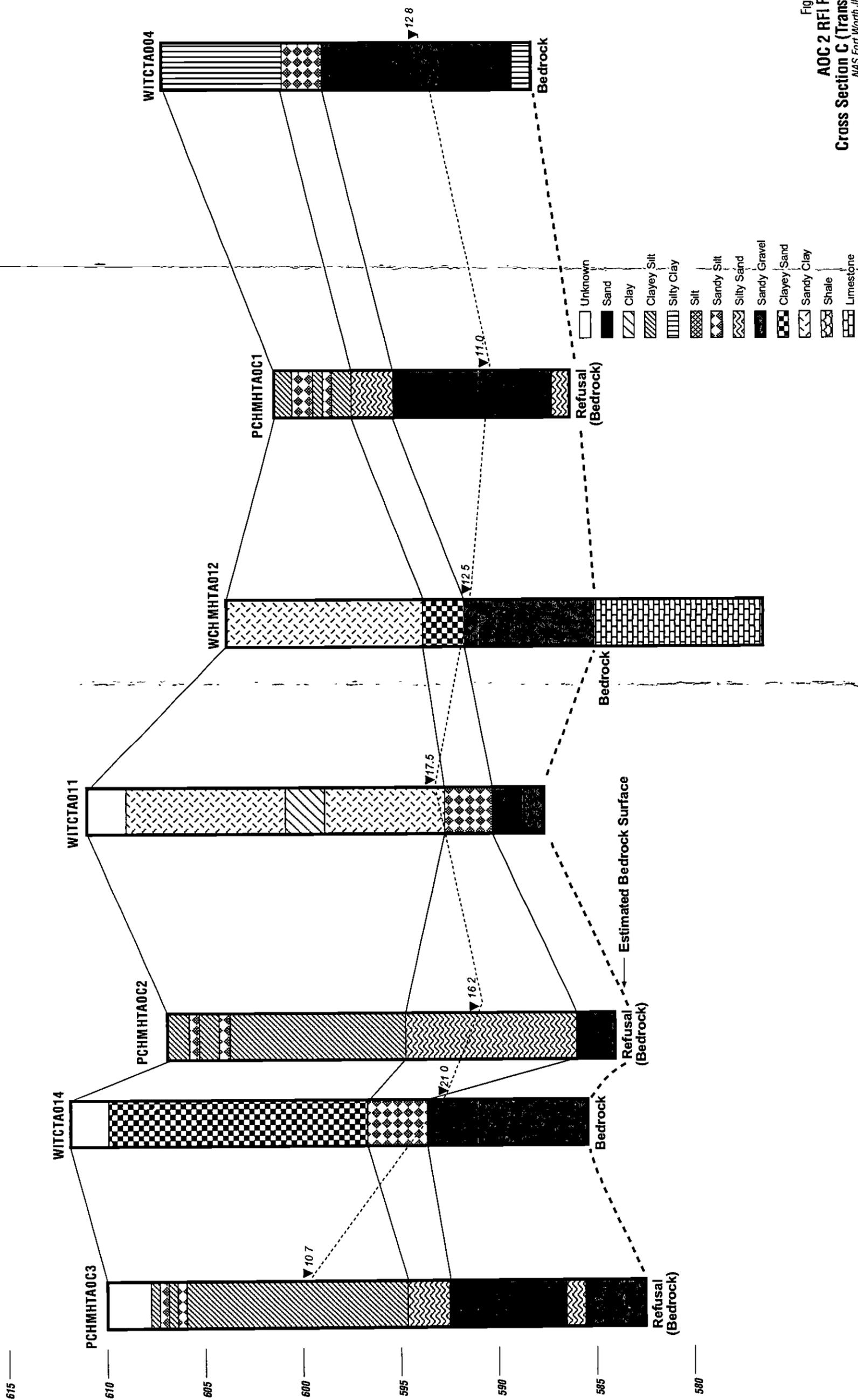
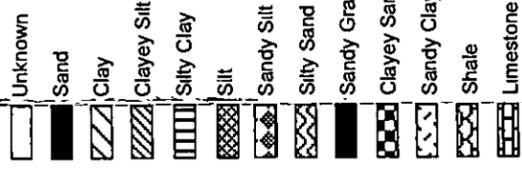


Figure 4-7  
AOC 2 RFI Report  
Cross Section C (Transect C)  
NAS Fort Worth JRB, Texas



PCHMHTA0A4

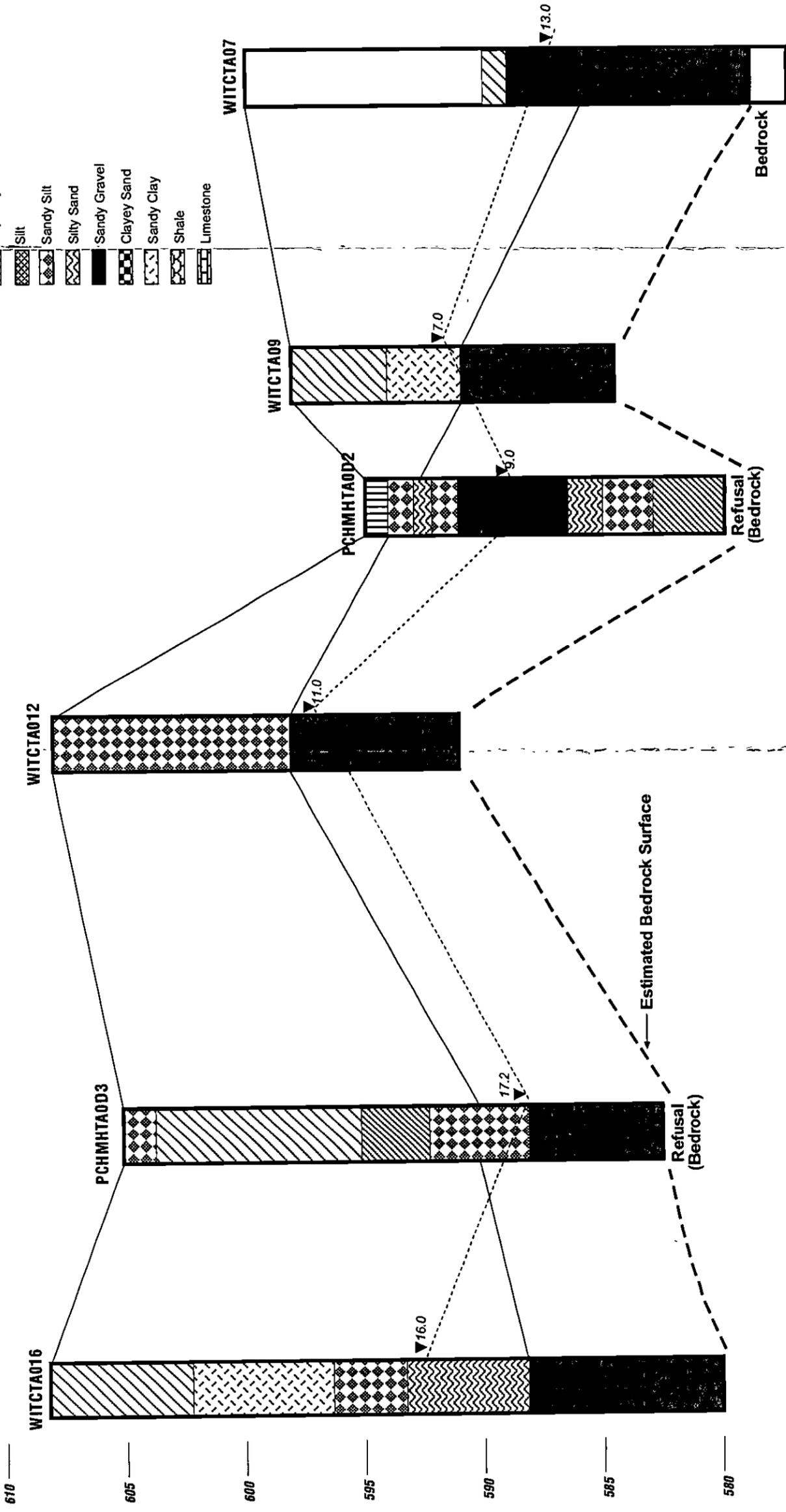


Figure 4-8  
AOC 2 RFI Report  
Cross Section D (Transect D)  
NAS Fort Worth JRB, Texas

605

600

595

590

585

580

575

Facing West

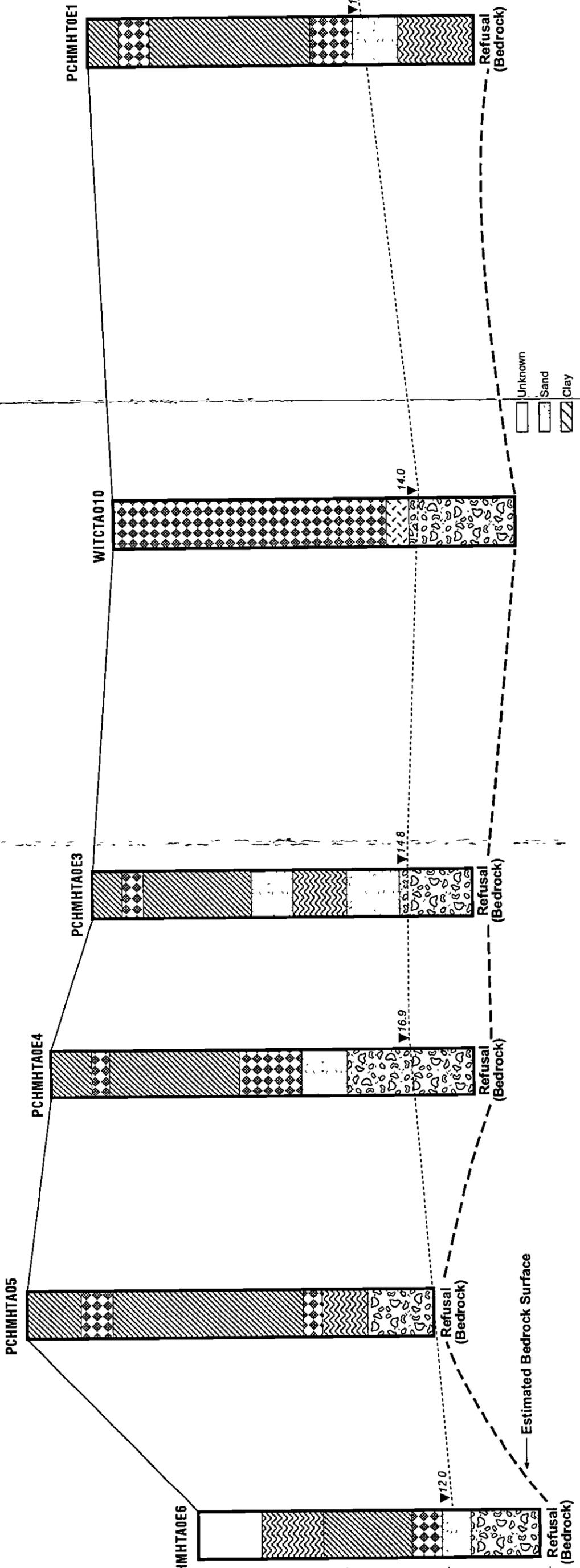


Figure 4-9  
 AOC 2 RFI Report  
 Cross Section E (Transect E)  
 NAS Fort Worth JRB, Texas

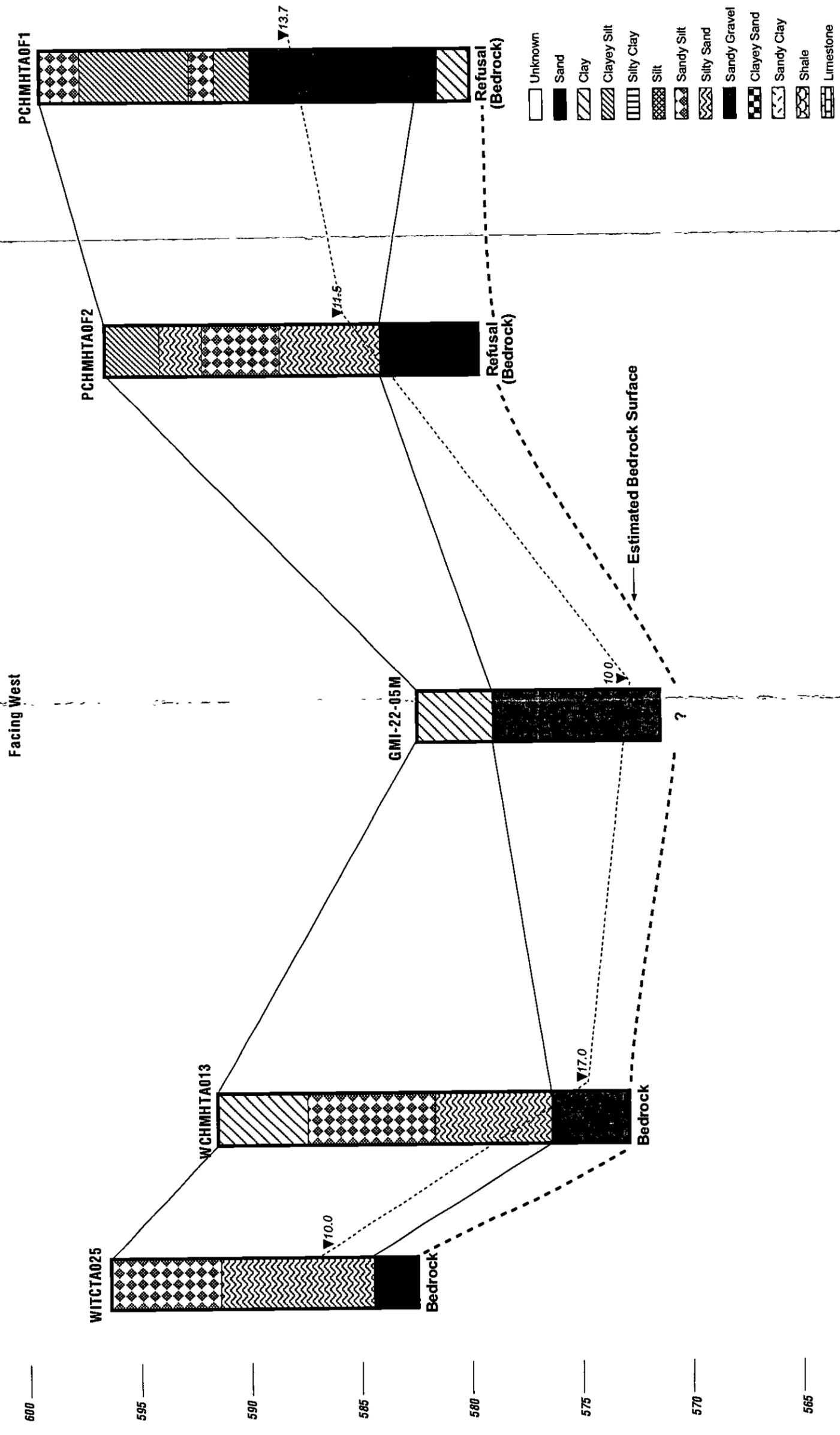


Figure 4-10  
**AOC 2 RFI Report**  
**Cross Section F (Transect F)**  
 NAS Fort Worth JRB, Texas

# TAB

Section 5  
Nature and Extent of TCE-Related Contamination

---

## 5.0 Nature and Extent of TCE-Related Contamination in the AOC2 Study Area

---

AOC2 is defined as contamination related to the presence of TCE in groundwater. For this RFI, therefore, the main focus has been on TCE-related compounds in the AOC2 study area groundwater. Although some fuel-related constituents have been detected (see Section 4), they are being addressed under the AOC4 investigation currently being conducted (HGL, 1997b, 1998e). This section therefore describes the nature and extent of the TCE-related contamination found in the AOC2 study area. Known background levels for these contaminants are discussed as well as potential source areas for AOC2. Contaminant distribution is presented by media sampled (soil and groundwater). All analytical results are provided in Appendix G.

### 5.1 TCE-Related Contaminants of Concern

As discussed in Section 1.4, one of the primary objectives of this investigation is delineation of the potential sources of TCE that are contributing to the northern lobe of groundwater contamination referred to as AOC2. In light of this objective, the primary contaminants of interest in the AOC2 area are TCE and degradation products (cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and vinyl chloride). Tetrachloroethene (PCE), a parent compound of TCE, is also of interest due to its presence within the AFP4 plume, as well as some AOC2 study area groundwater. All soil and groundwater samples collected during the RFI investigation were analyzed for VOCs. Selected samples were also analyzed for natural attenuation parameters (see Section 3) including methane, TOC, alkalinity, cations, anions, and field parameters including dissolved oxygen, ferrous iron, and oxidation-reduction potential. Section 4 provides a listing of AOC2 RFI analytical results; these data and other study area data from recent investigations are used to describe the nature and extent of TCE-related contamination below.

## 5.2 Information on Background Levels

A basewide background study was conducted by Jacobs Engineering (Jacobs, 1997) to establish background concentrations of inorganic constituents in various site media.

Background concentrations for 24 inorganic constituents were established for surface soil, subsurface soil, groundwater, surface water, and sediment.

VOCs and SVOCs (including PCE, TCE, and TCE degradation products) were included for analysis in the background study, but were not intended for use in determining background concentrations. Unlike metals, TCE-related compounds are not naturally occurring. VOCs and SVOCs were included for analysis as an indicator of potential impacts on a sample location due to previous site activities.

Several organic compounds were detected in the background study samples collected; however, no TCE or TCE-related compounds were detected. The majority of the detected organic compounds were either determined to be common laboratory contaminants, found in blank samples and therefore were qualified as non-detects, or were "F" qualified as the value was above the detection limit but below the practical quantitation limit.

For the AOC2 RFI, background groundwater concentrations of contaminants of interest were assumed to be those demonstrated at the upgradient edge of the property, along the boundary with AFP4, where the East Parking Lot plume is documented as consisting of TCE-related contamination.

## 5.3 Potential Source Areas

As described in Section 1, potential source areas of contamination within the AOC2 study area include AFP4, AOC4, and several SWMUs, including the Sanitary Sewer System.

### 5.3.1 Air Force Plant 4

TCE contamination has been well-documented at AFP4, located upgradient of NAS Fort Worth JRB, since 1982. Past spills of TCE have reportedly occurred within the Chemical Process Facility at AFP4 (US Department of the Air Force, 1996). The direction of

groundwater flow underlying the facility has resulted in three separate plumes on AFP4, the East Parking Lot Plume, the West Plume, and the North Plume. The East Parking Lot plume is documented as spreading east, southeast, and northeast across the eastern property boundary to NAS Fort Worth JRB. The central and southern lobes of the AOC2 plume at NAS Fort Worth JRB have been attributed to this AFP4 contamination, as well as other NAS Fort Worth JRB sources in the southern flightline area (as previously stated, the focus of this current AOC2 RFI is the northern lobe, not previously attributed to AFP4 due to the collection of previous data which showed a gap in TCE concentrations between the flightline and downgradient in the northern lobe).

The volume of the TCE release at AFP4 is not known, however the size of the East Parking lot plume indicates multiple releases of organic solvents may have occurred at this location over the history of the facility (about 40 years).

Previous investigations conducted at AFP4 are described in Section 1.3.1. Data from quarterly sampling being conducted, including the last documented sampling event in April 1998 by Jacobs Engineering at AFP4 and at locations on NAS Fort Worth JRB continue to show elevated concentrations of TCE and TCE degradation products in wells located immediately upgradient from the northern lobe of AOC2.

### 5.3.2 AOC4

AOC4, defined as areas of fuel-related contamination associated with the operation of the former Fuel Hydrant System at NAS Fort Worth JRB, is located within the AOC2 study area along the edges of the Alert Apron. This jet fuel delivery system consisted of approximately 20,000 feet of steel pipeline with five pumping stations. The system was removed from operation in the early 1990s.

Numerous investigations of the Fuel Hydrant System have been conducted since 1988 (see Section 1.3.2). The piping and USTs of the system were not used to store or dispense TCE, thus these investigations focused on potential BTEX and total petroleum hydrocarbon (TPH) contamination as a result of jet fuel leaks in the area. In 1995, Geo-Marine, Inc., concluded a groundwater survey and subsurface soil delineation study in the area of the Fuel Hydrant

System (GMI, 1995). Analyses were performed to define the extent of the TCE plume as well as the extent of hydrocarbon contamination from the Fuel Hydrant System. No correlation was made between the Fuel Hydrant System and observed TCE groundwater contamination. In addition, the data showed a lack of TCE contamination between the Alert Apron and the flightline, leading to the conclusion that the northern lobe of AOC2 was not directly attributable to AFP4 TCE contamination documented upgradient.

As described in Section 1.3.2, AFCEE has contracted HydroGeoLogic, Inc. to conduct a site investigation for AOC4 in an effort to obtain closure of the unit in accordance with the TNRCC's LPST Plan A site evaluation, as required by Title 30 Texas Administrative Code and the Texas Water Code. According to the work plan submitted for this investigation (HGL, 1997), VOC analyses, as well as BTEX and TPH, are included in this investigation. Sixteen groundwater samples and three soil samples were scheduled for analysis.

### **5.3.3 Sanitary Sewer System (SWMU 66)**

As described in Section 1.3.2, IT Corporation was contracted by AFCEE to perform an RFI of the Sanitary Sewer System to determine the nature and extent of contamination resulting from releases from this unit. Basewide sampling of the system was conducted and it was concluded that TCE detected in samples collected for the RFI investigation was not attributable to the Sanitary Sewer System (IT Corporation, 1997). This investigation included sampling at several related SWMUs within the AOC2 study area, including oil/water separators designated SWMUs 7, 40, and 41.

### **5.3.4 Other SWMUs**

As described in Section 1.3.2, SWMUs located in the AOC2 study area include Building 1628 SWMUs 5, 6, 7, and 8, as well as WAA SWMUs 11, 12, 13, 32, 33, 39, and 42 and OWSs 40 and 41. SMWUs 10, 43, 56, 57 and AOC3 are also located within the study area but have been declared No Further Action (NFA) by the TNRCC (TNRCC, 1995). AFCEE has contracted HGL to conduct sampling efforts to confirm a lack of significant releases in order to close SWMUs 5, 11, 12, 32, 33, 39 and 42. Of the remaining SWMUs in the AOC2 Study Area (6, 7, 8, 40 and 41), SWMUs 7, 40, and 41 were investigated under the Sanitary Sewer

RFI and no significant TCE contamination was found (refer to Section 1.3.2.4 and 5.3.3). SWMU 6 (Wash Rack and Drain) is located inside Building 1628, and not considered to be a concern, and SWMU 8 (sludge collection tank) is adjacent to SWMU 7 and therefore addressed in the Sanitary Sewer RFI sampling effort of SWMU 7.

As described in Section 3, 3 SWMUs not previously declared NFA were identified as being worthy of consideration as potential sources of TCE. These were SWMUs 11, 12, and 33. Two soil borings were conducted to screen these areas for soil contamination (see Section 5.4).

## 5.4 Soil

A total of 19 soil samples were collected during the AOC2 RFI field effort. Thirteen soil samples were collected from 11 of the borings installed for the new monitor wells (soil samples were not collected from the three borings for the shallow couplet wells), and six samples were collected from the soil borings installed to check for the presence of possible unsaturated zone soil contamination in the vicinities of SWMU 11 WAA and SWMU 33 WAA, which had not been previously investigated. As described in Section 3, soil samples were to be collected just above the saturated zone and wherever there were PID detections. PID readings registered at borings for WCHMHTA001 and WCHMHTA008 only.

As stated in Section 4, no TCE-related compounds were detected in the soil samples collected as part of this RFI. Soil sampling for the Sanitary Sewer RFI showed only one TCE detection within the AOC2 study area (0.0094] mg/kg) near SWMU 40.

Nearly all of the soil analytical results were non-detects; compounds that were detected exhibited very low concentrations and none of the detects were TCE or TCE-related compounds. This data, in conjunction with the lack of TCE detections from the extensive soil sampling conducted for the Sanitary Sewer RFI, indicates that soil in the AOC2 study area has not been contaminated with TCE-related compounds from onsite sources.

## 5.5 Groundwater

Groundwater from a total of 37 monitor wells and 22 direct-push locations were sampled during this RFI. The permanent wells were sampled over 3 separate events, in December 1997, February 1998, and April 1998. In addition, groundwater was sampled from forty direct push locations installed during October/November 1996 under the work plan screening investigation. Groundwater samples have also recently been collected within the AOC2 study area as part of the GSAP quarterly sampling and as part of the Sanitary Sewer RFI conducted in 1997. In this section, the distribution of TCE-related constituents detected in groundwater during the 3 AOC2 RFI groundwater sampling events is described; the interpretations of plume distribution has been supplemented by data from the direct push locations and the other investigations, although these data have not been directly correlated due to the different time frames and data collection methods.

### 5.5.1 First Groundwater Sampling Event (December 1997)

TCE was detected in 26 of the 37 monitor wells sampled at a maximum of 1100J  $\mu\text{g}/\text{L}$ , and 12 of the 22 direct-push locations, including 4 direct push confirmation samples analyzed by the offsite laboratory. These offsite laboratory TCE results are shown on Figure 5-1, and the data has been contoured to show the TCE plume extent. The plume's outer extent (shown by the dashed 5  $\mu\text{g}/\text{L}$  contour line) is based on data from the AOC2 RFI investigation (direct push as well as monitor well sampling), Sanitary Sewer System RFI data (IT Corporation, 1997), and recent quarterly GSAP data (HGL, 1998a, b, and c). The higher concentration contour lines interior to the TCE plume extent shown on this figure were contoured based on December 1997 AOC2 monitor well sampling results only, to reflect concentration distribution based on consistent sample method and time frame.

Comparison of the extent of contamination contour on Figure 5-1 to GMI data collected in 1995 (GMI, 1995) shows the extent of the northern lobe has not changed significantly since that time. The southern edge of the plume in the AOC2 study area appears to be widening somewhat, as evidenced by the TCE concentrations found at PCHMHTA0E6 and PCHMHTA0C3. The highest concentrations are near the Alert Apron, with contamination

now documented with the new direct push and monitor well locations as extending back to AFP4.

Cis-1,2-DCE and trans-1,2-DCE were also detected within the groundwater. As discussed in Section 4.5, the highest concentrations of cis-1,2-DCE in the AOC2 study area were found east of the flightline area, downgradient from the highest TCE detections, and across the flightline extending from AFP4. Trans-1,2-DCE was detected east of the flightline only. Concentrations of cis-1,2-DCE were significantly lower near the Alert Apron, where TCE concentrations were highest.

TCE degradation products vinyl chloride and 1,1-DCE were not detected during the first event.

PCE was found at a high concentration at direct push location PCHMHTA0E3 (250 µg/L via onsite mobile lab analysis), east of the flightline area (see Figure 5-1). Concentrations of (PCE) were also detected during the December 1997 groundwater monitor well sampling; however, these occurred in wells near the AFP4 boundary, with the highest concentration found at HM-96 (36 µg/L). Elevated concentrations of PCE have been documented in the East Parking Lot Plume (AOC2) at AFP4 (GMI, 1996 and US Department of the Air Force, 1996).

In terms of vertical distribution of contaminants, 3 monitor well locations provide a shallow vs. deeper view of water quality within the Terrace Alluvial Aquifer. These locations are represented by wells WCHMHTA003/004, WCHMHTA005/006, and WCHMHTA009/010. In every instance, groundwater concentrations measured in samples from these locations are higher in the deeper strata by a significant amount (23 vs. 380 µg/L TCE, 59 vs. 500 µg/L TCE, and 480 vs. 1100 µg/L TCE, respectively). In each instance, only four feet defines the vertical distance between these samples.

### 5.5.2 Second Groundwater Sampling Event (February 1998)

TCE was detected in 27 of the 37 monitor wells sampled at a maximum of 1,200 µg/L.

Figure 5-2 shows the TCE distribution, with the outer extent of contamination remaining unchanged from the first event.

As shown on this plume map, the highest TCE concentrations were demonstrated in the Alert Apron area, similar to the first event, but in a different well located further east. The eastward shift of the highest TCE from well WCHMTA010 to well WCHMHTA011 appears to be anomalous, especially when the data from the April 1998 event is considered, which confirms the first event results (see below).

Cis-1,2-DCE and trans-1,2-DCE were also detected within the plume with similar distribution as in the first event. As discussed in Section 4.5, the highest concentrations of cis-1,2-DCE in the study area were found east of the flightline area, downgradient of the highest TCE detections, and across the flightline to AFP4. Trans-1,2-DCE was detected east of the flightline only. Concentrations of cis-1,2-DCE were again significantly lower near the Alert Apron, where TCE concentrations were highest.

Isolated hits of sequential TCE degradation products 1,1-DCE and vinyl chloride were both detected during the second event. Concentrations of 1,1-DCE were detected at two locations, at 0.42F µg/L (WITCTA016) and 8.2F µg/L (HM-96). Vinyl chloride was also detected at two locations, at 3J µg/L (GMI-22-06M) and 2.6J µg/L (WITCTA016). Neither constituent was found during the first event. Although both 1,1-DCE and vinyl chloride have been reported in the East Parking Lot plume (US Department of the Air Force, 1996), widespread contamination of these constituents is not observed in the northern lobe of AOC2.

PCE was again detected during the second event, with the majority of detections in wells near the AFP4 boundary. The highest concentration was found in well HM-96 (63 µg/L). Elevated concentrations of PCE have been documented in the East Parking Lot Plume (AOC2) at AFP4 (US Department of the Air Force, 1996).

In terms of vertical distribution of contaminants, the 3 monitor well locations that provide a shallow vs. deeper view of groundwater quality within the Terrace Alluvial Aquifer (WCHMHTA003/004, WCHMHTA005/006, and WCHMHTA009/010) demonstrated similar results as in the first event, with one exception (45 vs. 410 µg/L TCE, 53 vs. 360 µg/L TCE, and 320 µg/L vs. 330 µg/L TCE). The last result is at the location where anomalous results were observed in terms of previous and subsequent TCE levels as described above.

### 5.5.3 Third Groundwater Sampling Event (April 1998)

TCE was detected in 26 of the 37 monitor wells sampled at a maximum of 1,100J  $\mu\text{g}/\text{L}$  during the third event. Figure 5-3 shows the TCE distribution during the first and third events is almost identical.

Cis-1,2-DCE and trans-1,2-DCE distribution is similar to that of the first and second events. Elevated concentrations of cis-1,2-DCE were found east of the flightline and west of the Alert Apron. Trans-1,2-DCE results show the majority of the elevated concentrations are east of the flightline, with only one hit west of the Alert Apron area. Similar to the first and second events, concentrations of cis-1,2-DCE were significantly lower near the Alert Apron, where TCE concentrations were highest.

Isolated hits of sequential TCE degradation products 1,1-DCE and vinyl chloride were both detected during the third event. Concentrations of 1,1-DCE were detected at three locations, at 9.8J  $\mu\text{g}/\text{L}$  (HM-96), 1.1J  $\mu\text{g}/\text{L}$  (WCHMHTA004), and 1.4  $\mu\text{g}/\text{L}$  (WCHMHTA012). Vinyl chloride was also detected at one location at a concentration of 13J  $\mu\text{g}/\text{L}$  (WCHMHTA012). Although both 1,1-DCE and vinyl chloride have been reported in the East Parking Lot plume (US Department of the Air Force, 1996), based on results from the three events, widespread contamination of these constituents is not present in the northern lobe of AOC2.

PCE was again detected during the third event, again with the majority of detections in wells near the AFP4 boundary. The highest concentration was found in well HM-96 (68J  $\mu\text{g}/\text{L}$ ). Elevated concentrations of PCE have been documented in the East Parking Lot at AFP4 (US Department of the Air Force, 1996).

In terms of vertical distribution of contaminants, the 3 monitor well locations that provide a shallow vs. deeper view of groundwater quality within the Terrace Alluvial Aquifer (WCHMHTA003/004, WCHMHTA005/006, and WCHMHTA009/010) demonstrated similar results as in the first event (45 vs. 420  $\mu\text{g}/\text{L}$  TCE, 69 vs. 490  $\mu\text{g}/\text{L}$  TCE, and 450J vs. 1100  $\mu\text{g}/\text{L}$  TCE). These results indicate the higher TCE contamination is migrating along the bedrock surface, in the gravel zone observed in numerous borings.

## 5.6 Summary

Based on the data from the AOC2 RFI investigation and past investigations conducted in the area, the extent of TCE contamination has not changed significantly over the last few years. A slight increase in the width of the plume to the north and east is observed, as well as a slight extension at the downgradient limit near the West Fork Trinity River. It is important to note these increases in plume dimension may simply be due to the new data points in these areas rather than a significant increase in plume extent. The only difference in TCE distribution between the 3 events was in the well demonstrating the highest concentration (well WCHMHTA010 in December 1997 and April 1998, and nearby well WCHMHTA011 in February 1998). When reviewed in sequence, as shown below, the data are suggestive of a possible switch of the samples or analytical results. Although these samples were collected the same day, no evidence of a possible switch was found in a review of field log books or analytical data packages, although the possibility is not precluded.

Date	Well WCHMHTA010 TCE Concentration ( $\mu\text{g/L}$ )	Well WCHMHTA011 TCE Concentration ( $\mu\text{g/L}$ )
December 1997	1100	420
February 1998	330	1200
April 1998	1100	360

Note: December concentrations were estimated below the practical quantitation limit (J-flag)

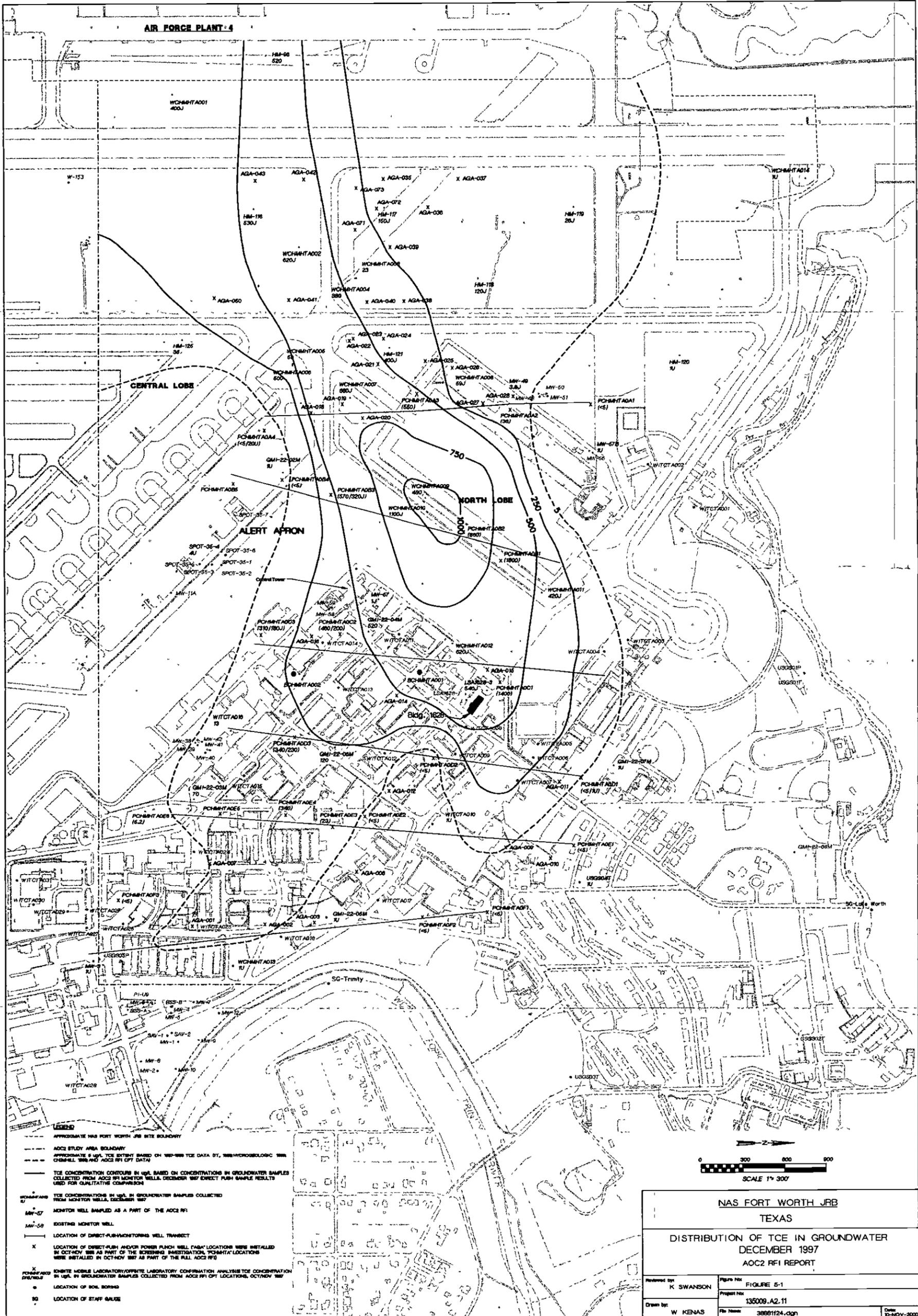
Regardless of this one incident of anomalous results, both wells are in the Alert Apron area, and as such, the highest TCE concentrations in the northern lobe of the AOC2 plume have remained in the Alert Apron area, which could suggest the existence of a point source in the area. However, as stated in Section 5.5.1, no evidence of soil contamination or operational history information related to SWMUs and other AOCs in the study area supports the existence of an onsite point source near the Alert Apron. In addition, the adjacent wells screened at different depths of the Terrace Alluvial Aquifer support an upgradient source of TCE, with the shallow wells consistently demonstrating significantly lower concentrations

than the deeper wells. This distribution pattern could potentially be a result of a slug of higher-level contamination having migrated from upgradient sources, and then encountering possible stratigraphic conditions and conditions unfavorable to TCE degradation (refer to Section 6) that may keep concentrations in this area higher than other areas of the plume.

In terms of TCE degradation products, cis-1,2-DCE contamination is more widespread within the plume than the other DCE isomers (trans-1,2-DCE and 1,1-DCE), which makes sense in terms of degradation (the cis-1,2-DCE isomer is the more likely degradation product). Both cis-1,2-DCE and trans-1,2-DCE concentrations are consistently higher east of the Alert Apron area, downgradient from the highest TCE concentrations. Concentrations of both constituents were lower or not detected in the Alert Apron area. This may be due to conditions unfavorable to TCE degradation. A discussion of TCE degradation is provided in Section 6.

With the exception of well GMI-22-03M and well WCHMHTA012, PCE detections in the AOC2 Study area occurred west of the Alert Apron. Elevated concentrations of PCE have been documented in the East Parking Lot at AFP4 (US Department of the Air Force, 1996), and PCE concentrations in the AOC2 study area are highest along the AFP4 boundary at well HM-96. In addition, except for the single groundwater sample collected from well GMI-22-03M, PCE results decrease with distance from AFP4.

In terms of downgradient extent, the presence of WCHMHTA013 provides a monitor point between the furthest downgradient extent of the plume and the West Fork Trinity River. This well remains unaffected, as do samples collected at the other downgradient extent of the plume further north (on the other side of the plume bifurcation). The bifurcation is explained by the elevated bedrock and the lack of groundwater demonstrated in wells within the bifurcation.



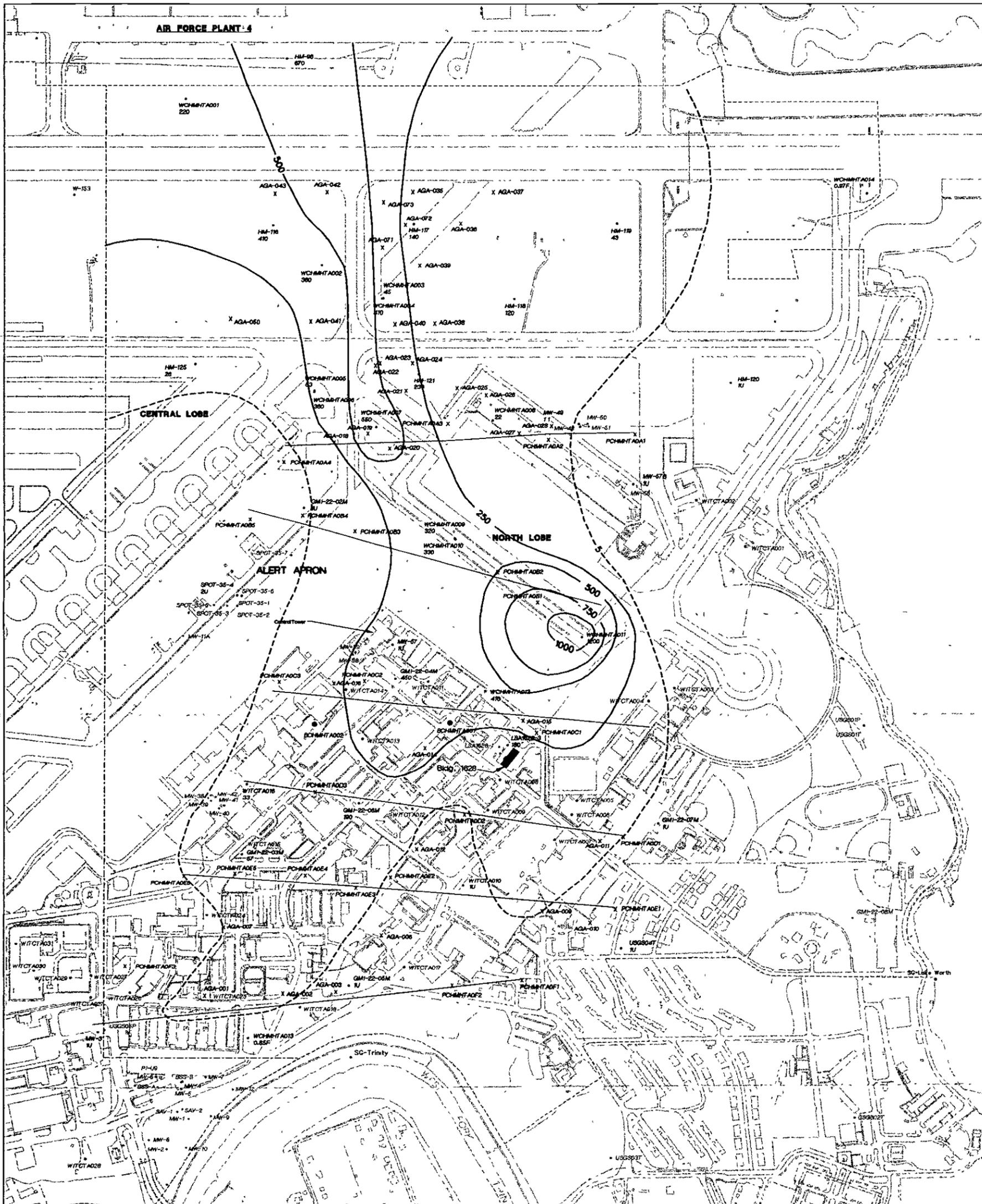
**LEGEND**

- - - APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
- - - AOC2 STUDY AREA BOUNDARY
- - - APPROXIMATE 6 ug/L TCE ISOTOPE RATIO DATA DT, 1988 HYDROGEOLOGIC 1988 CHANNEL, 1988 AND AOC2 RFI CPT DATA
- - - TCE CONCENTRATION CONTOURS IN ug/L BASED ON CONCENTRATIONS IN GROUNDWATER SAMPLES COLLECTED FROM AOC2 RFI MONITOR WELLS, DECEMBER 1997 DIRECT PUSH SAMPLE RESULTS USED FOR QUALITATIVE COMPARISON
- TCE CONCENTRATIONS IN ug/L IN GROUNDWATER SAMPLES COLLECTED FROM MONITOR WELLS, DECEMBER 1997
- MW-07 MONITOR WELL SAMPLED AS A PART OF THE AOC2 RFI
- MW-08 EXISTING MONITOR WELL
- LOCATION OF DIRECT-PUSH/RECOVERY WELL TRANSECT
- LOCATION OF DIRECT-PUSH AND/OR POWER PUNCH WELL PUMP LOCATIONS WERE INSTALLED IN OCTOBER 1997 AS PART OF THE SCREENING INVESTIGATION, "POMHTA" LOCATIONS WERE INSTALLED IN OCTOBER 1997 AS PART OF THE FULL AOC2 RFI
- IN-SITE MOBILE LABORATORY/OFF-SITE LABORATORY CONFIRMATION ANALYSIS TCE CONCENTRATION IN ug/L IN GROUNDWATER SAMPLES COLLECTED FROM AOC2 RFI CPT LOCATIONS, OCTOBER 1997
- LOCATION OF SOIL BORING
- 80 LOCATION OF STAFF GAUGE

**NAS FORT WORTH JRB  
TEXAS**

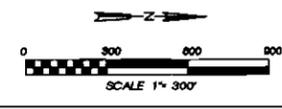
**DISTRIBUTION OF TCE IN GROUNDWATER  
DECEMBER 1997  
AOC2 RFI REPORT**

Prepared by: K SWANSON	Figure No: FIGURE 5-1
Drawn by: W KENAS	Project No: 135009.A2.11 File Name: 38681124.dgn
Date: 10-NOV-2000	

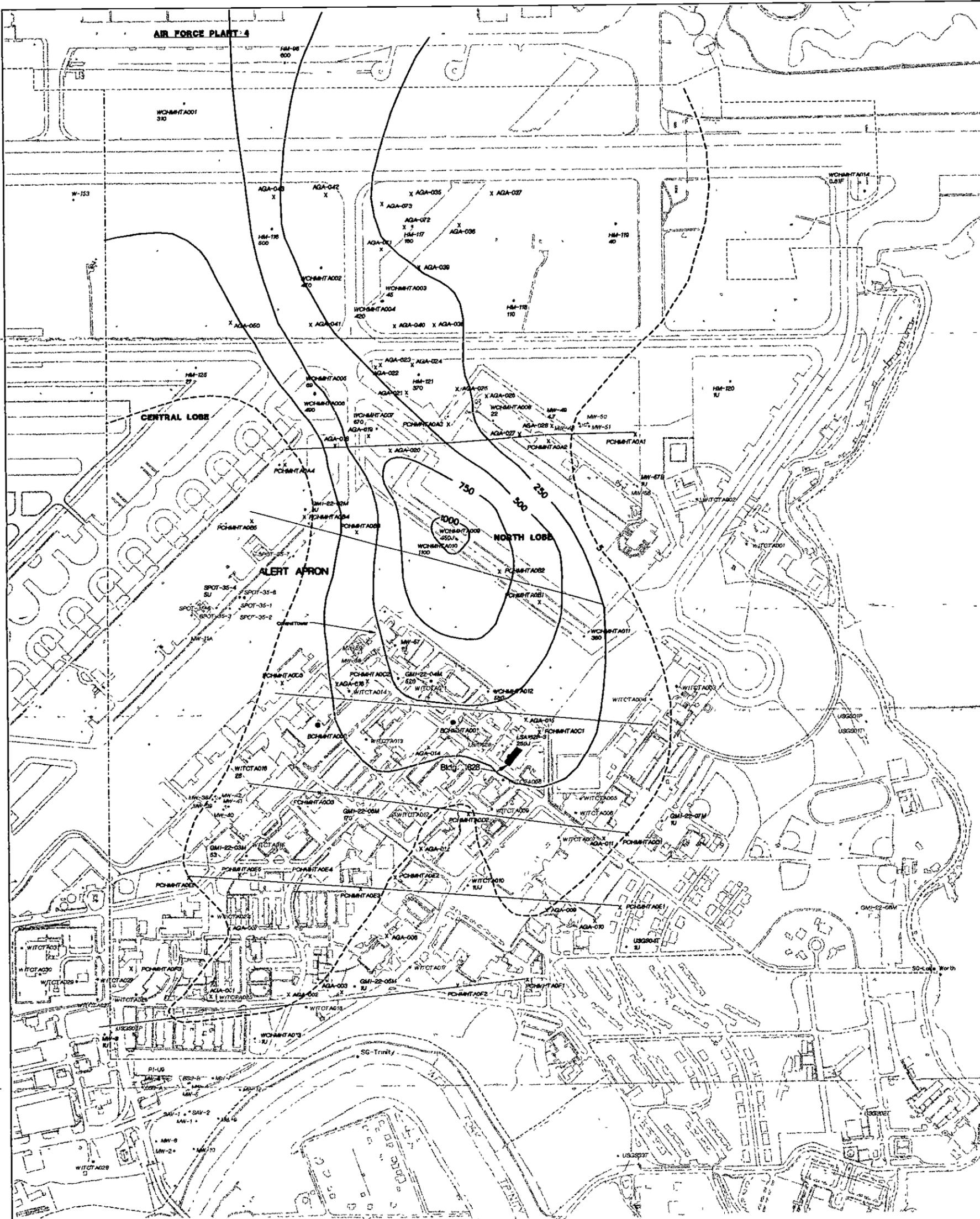


**LEGEND**

- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
- AOC2 STUDY AREA BOUNDARY
- APPROXIMATE 6 ug/L TCE EXISTENT BASED ON 1980-1986 TCE DATA AT 188 HYDROGEOLOGIC, 188 OBSERVATION WELLS AND AOC2 RFI DATA
- TCE CONCENTRATION CONTOURS IN ug/L BASED ON CONCENTRATIONS IN GROUNDWATER SAMPLES COLLECTED FROM AOC2 RFI MONITOR WELLS, FEBRUARY 1998
- TCE CONCENTRATIONS IN ug/L IN GROUNDWATER SAMPLES COLLECTED FROM MONITOR WELLS, FEBRUARY 1998
- MW-01 MONITOR WELL SAMPLED AS A PART OF THE AOC2 RFI
- MW-02 EXISTING MONITOR WELL
- LOCATION OF DIRECT-PUSH/NOVOTRONS WELL TRAMMETS
- X LOCATION OF DIRECT-PUSH AND/OR POWER PUNCH WELL PANA LOCATIONS WERE INITIATED IN OCTOBER 1988 AS PART OF THE SCREENING INVESTIGATION. PCHMTA LOCATIONS WERE INITIATED IN OCTOBER 1987 AS PART OF THE FULL AOC2 RFI
- LOCATION OF SOIL BORINGS
- SA LOCATION OF STAFF GAUGE

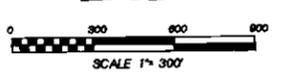


<b>NAS FORT WORTH JRB TEXAS</b>	
<b>DISTRIBUTION OF TCE IN GROUNDWATER FEBRUARY 1998 AOC2 RFI REPORT</b>	
Reviewed by: K SWANSON	Figure No: FIGURE 6-2
Drawn by: W KENAS	Project No: 135009.A2.11
	File Name: 38881125.dgn
	Date: 13-NOV-2000



**LEGEND**

- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
- AOC2 STUDY AREA BOUNDARY
- APPROXIMATE 6 UG/L TCE EXTENT BASED ON 1987-1988 TCE DATA ST. 1988 HYDROGEOLOGIC, 1988 CHEMICAL 1988 AND AOC2 RFI DATA
- TCE CONCENTRATION CONTOURS IN UG/L BASED ON CONCENTRATIONS IN GROUNDWATER SAMPLES COLLECTED FROM AOC2 RFI MONITOR WELLS, APRIL 1998
- TCE CONCENTRATIONS IN UG/L IN GROUNDWATER SAMPLES COLLECTED FROM MONITOR WELLS, APRIL 1988
- MW-07 MONITOR WELL SAMPLED AS A PART OF THE AOC2 RFI
- MW-08 EXISTING MONITOR WELL
- LOCATION OF DIRECT-PUSH/MONITORING WELL TRANSECT
- X LOCATION OF DIRECT-PUSH AND/OR FORCE PLANCH WELL PUMP LOCATIONS WERE INSTALLED IN OCTOBER 1988 AS PART OF THE SCREENING INVESTIGATION. PUMP/TA LOCATIONS WERE INSTALLED IN OCTOBER 1988 AS PART OF THE FULL AOC2 RFI
- LOCATION OF SOIL BOMBING
- SG LOCATION OF STAFF GAUGE



<b>NAS FORT WORTH JRB TEXAS</b>	
<b>DISTRIBUTION OF TCE IN GROUNDWATER APRIL 1998 AOC2 RFI REPORT</b>	
Reviewed by: K SWANSON	Figure No: FIGURE 5-3
Drawn by: W KENAS	Project No: 136009 A2 11
	File Name: 38861126.dgn
	Date: 20-NOV-2000

# TAB

Section 6  

---

Fate and Transport of TCE-Related Contaminants

## 6.0 Fate and Transport of TCE-Related Contaminants

As described in Sections 4 and 5, the presence of TCE and related compounds has been demonstrated in AOC2 study area groundwater. Evaluation of the transport and fate of these constituents is provided in this section, first in terms of migration pathways, and then in terms of the possibility of natural attenuation via reductive dechlorination.

### 6.1 Migration Pathways and Hydrodynamic Processes

This section provides a description of the migration pathways determined for AOC2 northern lobe groundwater, and a summary of a simple calculation performed to assess future conditions of the plume in terms of impact with the West Fork Trinity River.

#### 6.1.1 Site Hydraulic Conceptual Model

Groundwater in the Terrace Alluvial Aquifer migrates along preferred migration pathways within the varied strata. This strata consists of the typical alluvial deposits of sands, silts, and silty clays, in addition to a basal gravel/weathered bedrock zone often demonstrated at the base of the Terrace Alluvium.

This basal zone seems to provide the most-preferred pathway for migration of groundwater through the AOC2 study area. Slug test data from adjacent wells installed at different depths (wells WCHMHTA003/004, WCHMHTA005/006 and WCHMHTA009/010) confirm that higher hydraulic conductivities (K) are typically present in the lower zone, although the 3 / 4 location did demonstrate a somewhat higher K in the shallower well.

Terrace Alluvial Aquifer Wells	Shallow	Deep
WCHMHTA003/004 (runway area)	0.0185 cm/s	0.00172 cm/s
WCHMHTA005/006 (between runway/Alert Apron)	0.00189 cm/s	0.00561 cm/s
WCHMHTA009/010 (Alert Apron)	0.00401 cm/s	0.0137 cm/s

In addition, the groundwater flow within the AOC2 study area appears to occur along the trend of paleochannels defined in the underlying bedrock, which may be characterized by thicker high conductivity zones. A paleochannel has been defined to extend from AFP4 east; this paleochannel broadens in the runway area north toward Lake Worth, and narrows as it continues east toward the Alert Apron. Well WCHMHTA014, which demonstrates little groundwater, illustrates the northern extent of the broad area. The main paleochannel heads east and then bifurcates beyond the Alert Apron, causing a similar bifurcation in the AOC2 plume as it approaches the West Fork Trinity River.

The hydrodynamic processes that affect the migration of the TCE-related compounds are dictated by these preferential flowpaths within the Terrace Alluvial Aquifer, as well as the processes of dispersion and dilution. Although the plume has not yet reached the West Fork Trinity River, it is likely to do so at some time in the future. In the following section, a quick calculation to estimate the worst-case scenario in terms of interaction of the plume with the West Fork is described. Migration downward through the Goodland-Walnut is not considered a migration pathway of concern in the AOC2 study area.

### **6.1.2 Estimate of Future Potential West Fork Trinity River Concentrations**

The potential future concentration distribution of TCE from NAS Fort Worth JRB to the West Fork Trinity River was calculated using a GMS ModFlow groundwater flow model and GMS MT3D fate and transport simulation, with significant simplifying assumptions. The purpose of this calculation was to estimate the worst case situation in terms of TCE plume effects on the West Fork Trinity River water quality. It is important to note that these calculations did not take into account the local variation in groundwater flow direction and magnitude that is demonstrated by the current character of the TCE plume configuration and stratigraphic conditions.

The flow model simulations were based on the following assumptions:

- Model Grid – 6000 ft. by 5000 ft (Alert Apron to beyond West Fork Trinity River)
- Model Cells – 100 ft x 100 ft
- Constant head cells are simulated along the east and west boundaries of the model.

- Groundwater flow is simulated from west to east with a constant gradient of 0.03 ft/ft
- Hydraulic Conductivity - constant at 23.5 ft/day
- Saturated thickness – constant at 20 ft

The cell by cell flux generated from the flow model was then incorporated into a simple MT3D fate and transport simulation.

The following inputs were used for the MT3D fate and transport simulation:

- Advection was simulated using a hybrid of the Method of Characteristics and Modified Method of Characteristics solution schemes
- Tracking Algorithm defined for the Method of Characteristics scheme is fourth order Runge-Kutta at or near sources and first order Euler elsewhere
- Concentration weighting factor was set at 0.5
- Particles were randomly placed in cells, 16 particles per cell
- Longitudinal Dispersivity = 50
- Ratio of transverse to longitudinal dispersivity = 0.3
- Ratio of vertical to longitudinal dispersivity =  $1.0 \times 10^{-5}$  (negligible)
- Effective molecular diffusion coefficient = 0
- Saturated thickness = 20 ft
- Top of the model was set at 10 feet above the potentiometric surface
- No point sources or sinks were initialized
- No sorption or biodegradation was simulated
- No constant sources were simulated

The initial TCE distribution was mapped according to the April 1998 contour distribution (Figure 5-3). The initial concentration for each cell was calculated by assuming a logarithmic

decline in concentration between each of the mapped contour values. Cells between the 5 and 250 (ug/L) contour were given an initial concentration of 37 (ug/L); 250 to 500 were set equal to 355 (ug/L); 500 to 750 were set equal to 617 (ug/L); 750 to 1000 were set equal to 871 (ug/L); and cells inside the 1000 (ug/l) contour were set at 1000 (ug/L). The simulation was then run for ten years. The resulting TCE concentration distribution was contoured every two years up to ten years to estimate when the maximum concentration of TCE might reach the river.

In this simplified model, the highest concentrations of TCE intercepted the West Fork Trinity in approximately four years (again, this model did not account for variations in groundwater flow and magnitude resulting from the stratigraphic variations observed in the aquifer which control groundwater flow or other affects on discharge such as evaporation, adsorption, or degradation). A cross-section of the largest (diameter and concentration) portion of the plume at 4 years was used to calculate the maximum contaminant mass that could potentially intercept the river. The average TCE concentration per model cell in this simulated plume cross-section was 260 (ug/L). The total width of the simulated plume at the cross-section was 3700 feet. The groundwater flux per cell is 1361 ft<sup>3</sup>/day for a total flux of 50,357 ft<sup>3</sup>/day.

Historical flow records in the West Fork Trinity River were compiled for US Geological Survey Gaging Station number 08048000 (USGS, 1998). This station is located near downtown Fort Worth and includes daily flow records for the period from October 1, 1920 through September 30, 1997. A gauging station (08045500) located at the dam of Lake Worth was maintained from October 1, 1924 through September 30, 1934, but may not reflect river flows since the lake was built. The portion of the Gauging Station record from January 1, 1940, through September 30, 1997 was reviewed for river flow variations.

Based on the model flux calculation, and assuming there is negligible TCE already present in the river water, flow in the river must be at least 55.6 cfs to not exceed a TCE concentration of 2.7 ug/L in the river water after the peak plume concentration intercepts the river in accordance with the simulation. The value of 2.7 ug/L was chosen for comparison based on the risk assessment results described in Section 7. Based on the

historical flow record, the flow in the river was less than 55.6 cfs on 12,144 days since January 1, 1940, or approximately 58 % of the time.

Again, this simple model simulation likely represents a worst case scenario, and does not take into account the complicated flowpath demonstrated within the Terrace Alluvial Aquifer. The model assumes the plume is headed directly east toward the West Fork Trinity River; actual conditions suggest the plume is essentially cutoff from the river directly east due to the presence of the paleochannels, and will likely intercept the West Fork Trinity further downstream (and at a farther distance from its current extent) than demonstrated by the model.

## 6.2 Preliminary Screening of Natural Attenuation

A preliminary screening assessment of the occurrence of natural attenuation (reductive dechlorination) within the AOC2 plume was performed using data collected from wells selected for natural attenuation analysis (refer to Table 3-6). These data were collected during the first and third groundwater sampling events (December 1997 and April 1998, respectively). The results of the screening assessment are presented in this section.

### 6.2.1 Natural Attenuation Scoring

A qualitative method of scoring the potential for natural attenuation of chlorinated solvents was developed originally by the EPA and has been published in various forms by AFCEE (AFCEE, 1996) and EPA Region 4 (EPA, 1997). Table 6-1 summarizes the scoring performed for two wells in the AOC2 study area (WCHMHTA012 and LSA1628-3). These wells were selected due to the availability of sufficient supporting data and the presence of significant levels of TCE contamination.

This assessment resulted in the calculation of scores of 11 and 6 for the two wells selected. Based on accepted procedures in the literature, scores in this range can be classified as having "limited evidence for biodegradation of chlorinated solvents." A score of 15 to 20 is required to classify the site as having "adequate evidence for biodegradation of chlorinated solvents." A more detailed discussion of the reasons behind achieving a score in these wells

which concludes "limited evidence" and the implications behind this score are presented in the following sections.

### 6.2.2 Evidence of Biological Activity

The data from AOC2 suggest that there is some biological activity and reductive dechlorination taking place in the subsurface. Figure 6-1 (December 1997) and Figure 6-2 (April 1998) present the distribution of the key natural attenuation parameters collected to support this screening assessment. Tabular presentations of this data are shown in Table 6-2 (December 1997 data) and Table 6-3 (April 1998 data).

General biological activity is suggested by the low dissolved oxygen concentrations (less than 1 mg/L) at 7 locations, and low ORP conditions (less than 100 mV) in 3 locations. Biodegradation of some type of organic compound is probably taking place with use of oxygen as the electron acceptor. Elevated ferrous iron concentrations (greater than 1 mg/L) were also noted in 2 wells, and small amounts of methane (from 300 to 450 ug/L) were measured in two wells. Ferrous iron and methane are byproducts from the use of ferric iron and carbon dioxide as electron acceptors. These parameters are indicative of a limited amount of biodegradation of some type of organic compounds, but not necessarily chlorinated solvents. For a very biologically active site, these parameters would have been more extreme (i.e. lower dissolved oxygen, lower ORP, higher ferrous iron, and higher methane). For example, methane levels up to 10,000 ug/L can be found at some sites.

Evidence of some reductive dechlorination is obvious in the concentrations of cis-1,2-DCE demonstrated in many of the wells. Cis-1,2-DCE is a byproduct of reductive dechlorination of TCE. If it is assumed that only PCE and/or TCE was spilled at the source, which is reasonable considering the available documentation of releases, the presence of cis-1,2-DCE provides evidence that some reductive dechlorination has occurred. Figure 6-3 presents a graph of the TCE and corresponding cis-1,2-DCE in each well measured for natural attenuation parameters in December 1997 and April 1998. One sample had a DCE concentration as high as 250 ug/L, while a number of wells had concentrations between 50 and 100 ug/L. TCE concentrations ranged from 200 to 650 ug/L in the corresponding samples.

### 6.2.3 Limitations to Reductive Dechlorination

Although some reductive dechlorination has occurred, as demonstrated by the presence of DCE in the plume, it also appears to have been limited in extent. This is also demonstrated by the graph of TCE versus DCE introduced in the previous section (Figure 6-3). If reductive dechlorination was extremely active, the DCE concentrations could be greater than TCE concentrations. Vinyl Chloride and ethene, the ultimate products of dechlorination of TCE, would also be present if reductive dechlorination were very active. Vinyl chloride was detected in only one of the wells selected for natural attenuation screening, and ethene was not present in any of the wells.

Further evidence of the limited extent of reductive dechlorination is in the size of the TCE plume. Figure 5-1 presents the TCE data from December of 1997, and Figure 5-3 presents the TCE data from April 1998. The TCE plume is approximately 5,500 ft long (approximately one mile). This is an extensive plume compared to most BTEX hydrocarbon plumes that undergo very active natural attenuation, which typically would be less than 1,000 ft long in the type of soil observed in the AOC2 study area.

Reductive dechlorination is likely being limited by the lack of electron donors, as is evidenced by low TOC concentrations. The electron donors are typically organic carbon compounds. TOC concentrations in wells in AOC2 were all less than 6 mg/L, with the exception of well HM-120, which had concentrations of 10 mg/L in December 1997, and 11 mg/L in April 1998. TOC concentrations of around 20 mg/L are typically indicative of a significant level of organic carbon source. The low concentrations of TOC also correlated with low BTEX compound concentrations. Benzene was detected in only one well selected for natural attenuation analysis, WCHMHTA012, at a concentration of 0.63 ug/L during the April 1998 sampling.

Reductive dechlorination might also be limited by high nitrate and sulfate concentrations. Both nitrate and sulfate will preferentially serve as electron acceptors compared to TCE. It is interesting to note that the wells with significant levels of nitrate also had significant TCE concentrations, including wells WCHMHTA001, HM-121, WCHMHTA012, and LSA1628-3. As noted in Section 5.5, cis-1,2-DCE concentrations are elevated east and west of the Alert

---

Apron, but not in the Alert Apron area itself, where the highest TCE concentrations are seen (refer to Figure 4-2). A possible explanation for this could be high nitrate or sulfate levels in the area are inhibiting reductive dechlorination. However, definitive natural attenuation screening data was not specifically collected in this area.

#### **6.2.4 Implications**

The implications of this natural attenuation screening assessment are that although some natural attenuation in the form of reductive dechlorination seems to be occurring, biologically-mediated natural attenuation mechanisms should not be considered significant fate processes for the chlorinated solvents demonstrated in AOC2 groundwater.

**Table 6-1**  
**Natural Attenuation Scoring Table**  
 Screen for Biodegradation of TCE  
 Suggested Values and Associated Scoring  
**NAS Fort Worth JRB, Texas**

Analysis	Concentration in most contaminated Zone	Value	Concentration at WCHMHTA012	Value	Concentration at LSA 1628-3	Value
Oxygen	<0.5 mg/L	3	0.4	3	0.8	3
	>1 mg/L	-3				
Nitrate	<1 mg/L	2	4.8J mg/L	0	4	0
Iron II	>1 mg/L	3	2.35 mg/L	2	0.02	0
Sulfate	<20 mg/L	2	65 mg/L	0	65	0
Sulfide	>1 mg/L	3	?			
Methane	>0.1 mg/L	2	194 ug/L	1	4.6	0
	>1	3				
	<1					
ORP	<50 mV	1	-58.5	1	48	1
	<-100	2				
pH	5<pH<9		6.76			
TOC	>20 mg/L	2	4		5	0
Temperature	>20 C	1	28.1	1	24	1
Carbon Dioxide	>2x background	1	?			
Alkalinity*	>2x background	1	440S mg/L	0	350	0
Chloride*	>2x background	2	120 mg/L	1	?	0
Hydrogen	>1 nM	3	?			
Volatile Fatty Acids	>0.1 mg/L	2	?			
BTEX	>0.1 mg/L	2	Benzene = 10U Ethylbenzene = 15U M-P-Xylene = 33U O-P-Xylene = 28U Toluene = 14F Total = 57 ug/L	0		0
PCE			35U			
TCE		2	620J	0	500	
DCE		2	1,1-DCE = 30R CIS-1,2-DCE = 250J TRANS-1,2-DCE = 28R Total = 250 ug/L	2	50	1
Vinyl Chloride		2	28R	0		0
Ethane/Ethene	>0.1 mg/L	3	?			
	>0.01 mg/L	2				
Chloroethane		2	25R	0		
chlorobenzene		2	10U	0		
			<b>Total Score</b>	<b>11</b>		<b>6</b>

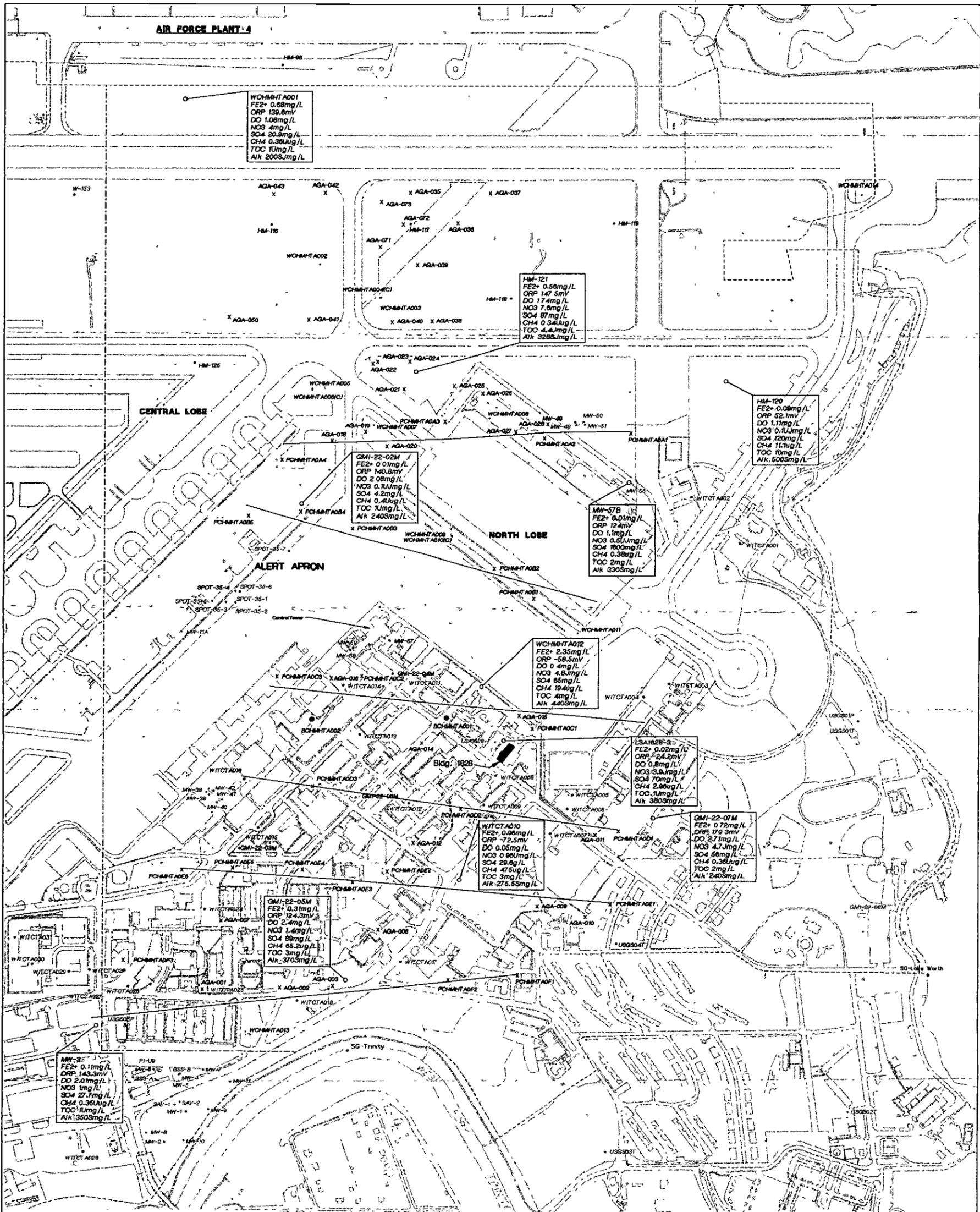
\* No background values established, concentrations compared to levels at MW-3 and GMI-22-05 located outside of the contaminant plume

**Table 6-2**  
**Natural Attenuation Parameters-December 1997**  
**NAS Fort Worth JRB, Texas**

Location ID	TCE (ug/L)	Ferrous Iron (mg/L)	ORP (mV)	DO (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	Methane (ug/L)	TOC (mg/L)	Total Alkalinity (mg/L)
GMI-22-02M	1 U	0.01	140.8	2.08	0.1 UJ	4.2	0.4 U	1 U	240S
GMI-22-05M	1 U	0.31	124.3	2.4	1.4	89	65.2	3	370S
GMI-22-07M	1 U	0.72	170.3	2.71	4.7 J	56	0.36 U	2	240S
HM-120	1 U	0.09	52.1	1.11	0.1 UJ	120	11.1	10	500S
HM-121	400 J	0.56	147.5	1.74	7.6	87	0.34 U	4.4 J	328SJ
LSA1628-3	540 J	0.02	-24.2	0.8	3.9 J	70	2.96	1 U	380S
MW-3	1 U	0.11	143.3	2.01	1	27.7	0.35 U	1 U	350S
MW-57B	1 U	0.01	124	1.1	0.5 UJ	1600	0.38	2	330S
WCHMHTA001	400 J	0.68	139.6	1.08	4	20.9	0.36 U	1 U	200SJ
WCHMHTA012	620 J	2.35	-58.5	0.4	4.8 J	65	194	4	440S
WITCTA010	1 U	0.96	-72.5	0.05	0.96 U	29.6	475	3	275.5S

**Table 6-3**  
**Natural Attenuation Parameters-April 1998**  
**NAS Fort Worth JRB, Texas**

Location ID	TCE (ug/L)	Ferrous Iron (mg/L)	ORP (mV)	DO (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	Methane (ug/L)	TOC (mg/L)	Alkalinity (mg/L)
GMI-22-02M	1 U	0.09	34	0.6	0.28	12	11	2	330
GMI-22-05M	1 U	0.04	260	1.4	0.1 U	580	33.8	4	1100
GMI-22-07M	1 U	0.57	179	3.16	8.4	130	0.36 U	4	200
HM-120	1 U	0.00	-133.9	0.2	0.1 U	88	22.2	11	540
HM-121	230	0.03	-116.8	0.8	5.6	82	0.38 U	4	370
LSA1628-3	180	0.00	48.7	0.15	4.2	62	4.76	5	380
MW-3	1 U	0.01	66.5	0.7	1.8	40	0.39 U	1	370
MW-57B	1 U	0.01	69.3	3.78	0.1 U	1000	0.51	5	400
WCHMHTA001	220	0.03	121	1.27	2.9	21	0.44 U	1	330
WCHMHTA012	410	2.88	-89.4	0.45	4.9	60	454	4	450
WITCTA010	1 U	1.47	-122.9	0.37	0.1 U	40	367	4	290



**LEGEND**

--- APPROXIMATE NAS FORT WORTH JOB SITE BOUNDARY

--- ACC2 STUDY AREA BOUNDARY

**TABLE 1: NATURAL ATTENUATION PARAMETER RESULTS IN GROUNDWATER SAMPLES COLLECTED FROM MONITOR WELLS SELECTED FOR NATURAL ATTENUATION EVALUATION.**

Well ID	FE2+ (mg/L)	ORP (mv)	DO (mg/L)	NO3 (mg/L)	SO4 (mg/L)	CH4 (ug/L)	TOC (mg/L)	Alk (mg/L)
WCHMHTA001	0.69	139.6	1.08	4	20.8	0.39	10	2005
WCHMHTA002	0.58	147	17.4	7.6	87	0.34	4.4	3285
WCHMHTA003	0.08	52	1.1	0.11	120	11.7	10	5003
WCHMHTA004	0.01	140.8	2.08	0.11	4.2	0.4	10	2403
WCHMHTA005	2.35	68.3	0.4	4.8	65	19.4	4	4403
WCHMHTA006	0.02	12	0.8	3.9	70	2.96	1.0	3803
WCHMHTA007	0.12	179	2.7	4.7	66	0.36	2	2403
WCHMHTA008	0.31	124.3	2.4	1.4	89	65.2	3	3703
WCHMHTA009	0.98	72.5	0.05	0.96	29	47.5	3	275.5
WCHMHTA010	0.11	143.3	2.0	1.7	27	0.35	10	3503

**TABLE 2: MONITOR WELL INFORMATION**

Well ID	Well Type
MW-57	MONITOR WELL SAMPLED AS A PART OF THE ACC2 RFI
MW-58	EXISTING MONITOR WELL

**TABLE 3: MONITORING AND LOCATION INFORMATION**

Symbol	Description
X	LOCATION OF DIRECT-PUSH MONITORING WELL TRANSECT
X	LOCATION OF DIRECT-PUSH AND/OR PNEUMATIC WELL FROM LOCATIONS WERE INSTALLED IN OCT-NOV 1998 AS PART OF THE SCREENING INVESTIGATION. WCHMHTA LOCATIONS WERE INSTALLED IN OCT-NOV 1997 AS PART OF THE FULL ACC2 RFI
o	LOCATION OF SOIL BORING
*	LOCATION OF STAFF GAUGE

**TABLE 4: PARAMETER ABBREVIATIONS**

Abbreviation	Parameter Name
FE2+	FERRIC IRON
ORP	OXIDATION REDUCTION POTENTIAL
DO	DISSOLVED OXYGEN
NO3	NITRATE
SO4	SULFATE
CH4	METHANE
TOC	TOTAL ORGANIC CARBON
Alk	TOTAL ALKALINITY

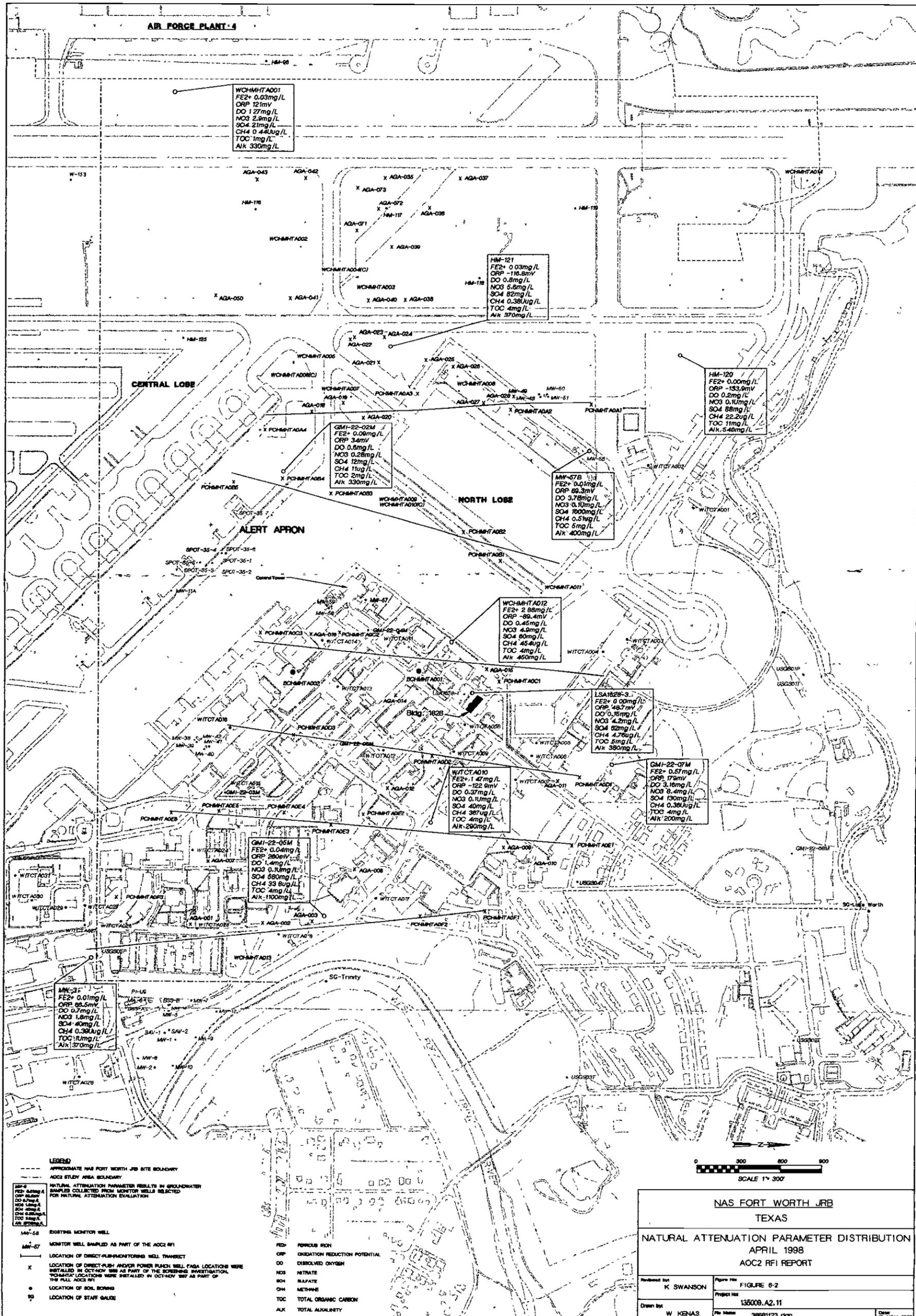
**NAS FORT WORTH JRB TEXAS**

**NATURAL ATTENUATION PARAMETER DISTRIBUTION**  
DECEMBER 1997  
ACC2 RFI REPORT

Reviewed by: **K SWANSON**      Figure No: **FIGURE 6-1**

Drawn by: **W KENAS**      Project No: **135006.A2.11**

Date: **10-NOV-2000**



WCHMHTA001  
 FE2+ 0.03mg/L  
 ORP 121mv  
 DO 1.27mg/L  
 NO3 2.9mg/L  
 SO4 2.1mg/L  
 CH4 0.44ug/L  
 TOC 1mg/L  
 Alk 330mg/L

HM-121  
 FE2+ 0.03mg/L  
 ORP -116.8mv  
 DO 0.8mg/L  
 NO3 5.6mg/L  
 SO4 82mg/L  
 CH4 0.38ug/L  
 TOC 4mg/L  
 Alk 370mg/L

HM-120  
 FE2+ 0.00mg/L  
 ORP -133.0mv  
 DO 0.2mg/L  
 NO3 0.10mg/L  
 SO4 88mg/L  
 CH4 22.2ug/L  
 TOC 11mg/L  
 Alk 540mg/L

GMI-22-02M  
 FE2+ 0.09mg/L  
 ORP 3.4mv  
 DO 0.6mg/L  
 NO3 0.28mg/L  
 SO4 12mg/L  
 CH4 11ug/L  
 TOC 2mg/L  
 Alk 330mg/L

MW-57B  
 FE2+ 0.01mg/L  
 ORP 89.3mv  
 DO 3.78mg/L  
 NO3 0.10mg/L  
 SO4 1000mg/L  
 CH4 0.57ug/L  
 TOC 5mg/L  
 Alk 400mg/L

WCHMHTA012  
 FE2+ 2.88mg/L  
 ORP -89.4mv  
 DO 0.45mg/L  
 NO3 4.0mg/L  
 SO4 60mg/L  
 CH4 45.4ug/L  
 TOC 4mg/L  
 Alk 450mg/L

LSA1826-3-1  
 FE2+ 0.00mg/L  
 ORP 48.7mv  
 DO 0.35mg/L  
 NO3 4.2mg/L  
 SO4 62mg/L  
 CH4 4.78ug/L  
 TOC 5mg/L  
 Alk 380mg/L

GMI-22-07M  
 FE2+ 0.07mg/L  
 ORP 179mv  
 DO 3.18mg/L  
 NO3 8.4mg/L  
 SO4 130mg/L  
 CH4 0.38ug/L  
 TOC 4mg/L  
 Alk 200mg/L

GMI-22-05M  
 FE2+ 0.04mg/L  
 ORP 280mv  
 DO 1.4mg/L  
 NO3 0.10mg/L  
 SO4 580mg/L  
 CH4 33.8ug/L  
 TOC 4mg/L  
 Alk 1100mg/L

WITCTA010  
 FE2+ 1.47mg/L  
 ORP -122.9mv  
 DO 0.37mg/L  
 NO3 0.10mg/L  
 SO4 40mg/L  
 CH4 387ug/L  
 TOC 4mg/L  
 Alk 290mg/L

MW-3F  
 FE2+ 0.01mg/L  
 ORP 86.5mv  
 DO 0.7mg/L  
 NO3 1.8mg/L  
 SO4 40mg/L  
 CH4 0.38ug/L  
 TOC 11mg/L  
 Alk 370mg/L

- LEGEND**
- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
  - - - AOC2 STUDY AREA BOUNDARY
  - NATURAL ATTENUATION PARAMETER RESULTS IN GROUNDWATER SAMPLES COLLECTED FROM MONITOR WELLS SELECTED FOR NATURAL ATTENUATION EVALUATION
  - EXISTING MONITOR WELL
  - MONITOR WELL SAMPLED AS PART OF THE AOC2 RFI
  - LOCATION OF DIRECT-FLOW/MONITORING WELL TRINEXET
  - X LOCATION OF DIRECT-PUSH AND/OR PNEUMATIC WELL. PAGA LOCATIONS WERE INSTALLED IN OCTOBER 1988 AS PART OF THE SCREENING INVESTIGATION. POCBATA LOCATIONS WERE INSTALLED IN OCTOBER 1987 AS PART OF THE FULL AOC2 RFI
  - LOCATION OF SOIL BORING
  - LOCATION OF STAFF GAUGE
  - FeD FERRIC IRON
  - ORP OXIDATION REDUCTION POTENTIAL
  - DO DISSOLVED OXYGEN
  - NO3 NITRATE
  - SO4 SULFATE
  - CH4 METHANE
  - TOC TOTAL ORGANIC CARBON
  - Alk TOTAL ALKALINITY

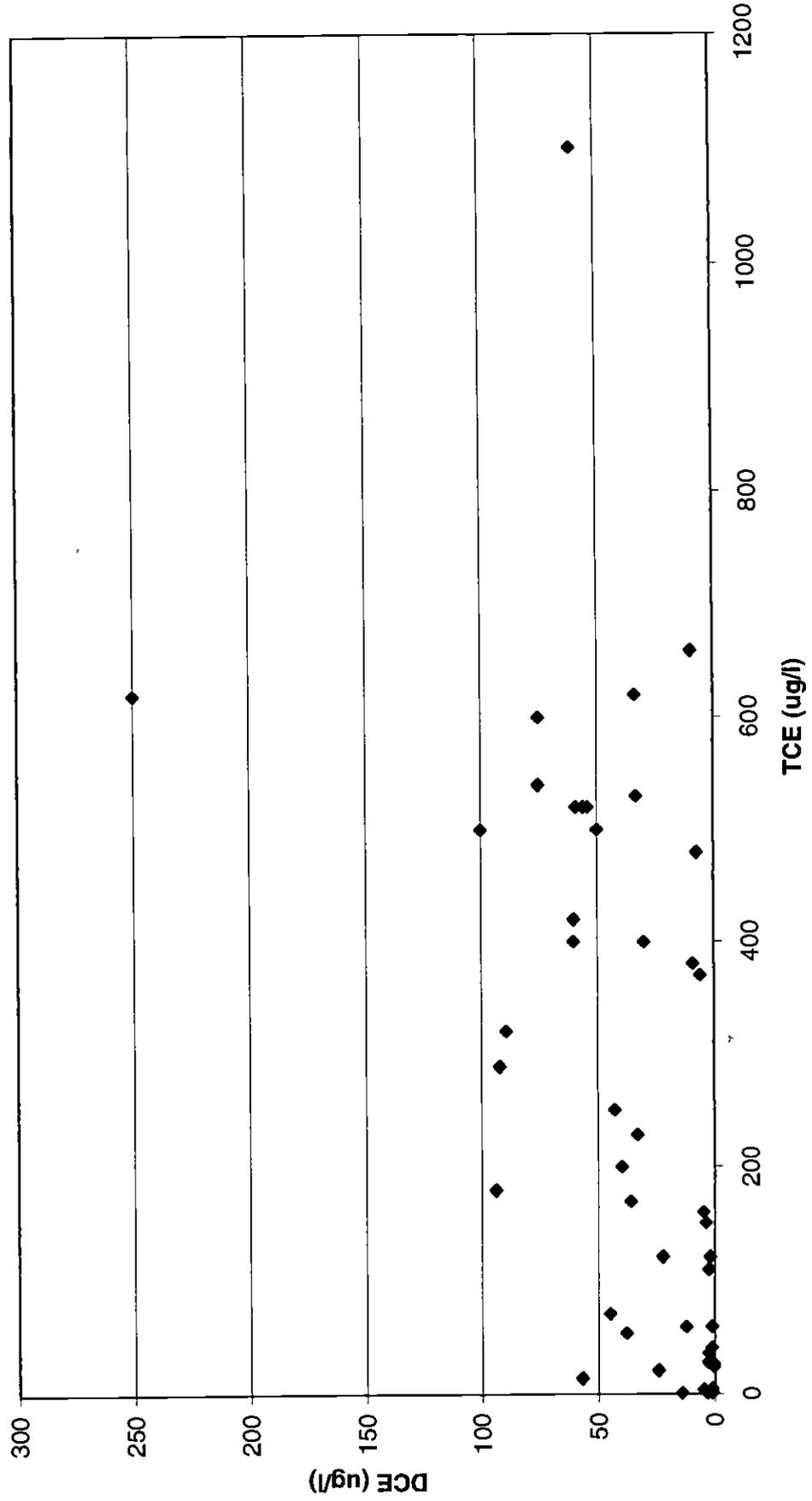
0 300 600 900  
 SCALE 1" = 300'

NAS FORT WORTH JRB  
 TEXAS

NATURAL ATTENUATION PARAMETER DISTRIBUTION  
 APRIL 1998  
 AOC2 RFI REPORT

Prepared by K SWANSON	Figure File FIGURE 6-2
Drawn by W KENAS	Project No. 135009.A2.11
File Name 38651123.dgn	Date 10-NOV-2000

Figure 6-3  
TCE vs. DCE Concentrations in AOC2 Study Area Groundwater  
NAS Fort Worth JRB, Texas



# TAB

Section 7 Risk Assessment

---

## 7.0 Risk Assessment

---

A baseline risk assessment was conducted for NAS Fort Worth JRB AOC2 in accordance with the requirements under Risk Reduction Standard No. 3 (30 TAC 335). RRS3 provides for employing a baseline risk assessment to assess risk using site-specific data, rather than simply applying the default values under RRS1 or RRS2. This baseline risk assessment includes evaluations of potential exposure for human and ecological receptors. The purpose of this risk assessment is to estimate current and future risks associated with exposure to site contaminants in the absence of any remedial actions.

Risks associated with exposure to soil and groundwater were evaluated for current and future land use conditions. This human health risk assessment includes the following components:

- **Identification of Chemicals of Potential Concern (COPCs):** This step involves identifying and selecting for inclusion into the risk assessment those chemicals at the site that are of greatest potential health concern.
- **Exposure assessment:** An exposure assessment is conducted to estimate the magnitude of potential human exposures, the frequency and duration of these exposures, and the pathways through which humans are potentially exposed to COPCs detected at the site. The exposure assessment involves evaluating chemical releases from the site, identifying potentially exposed populations and pathways of exposure, estimating exposure point concentrations for specific pathways, and estimating chemical intake rates in humans.
- **Toxicity assessment:** This step involves the characterization of the toxicology properties and health effects of COPCs with special emphasis on defining their dose-response relationships. From these dose-response relationships, toxicity values are derived that can be used to evaluate the potential occurrence of adverse health effects at different levels of exposure.

- Risk characterization: This section summarizes and combines the results of the exposure and toxicity assessments to characterize health risks, both in numerical expressions and qualitative statements.
- Uncertainty analysis: The uncertainties in the risk assessment process, and how these uncertainties influence the characterization of health risks, are discussed in this step.

The following guidance has been used in preparing this risk assessment:

- *Implementation of the Existing Risk Reduction Rule (Consistency Document). Texas Natural Resource Conservation Commission. July 23, 1998.*
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A. Interim Final. December, 1989 (EPA, 1989b)*
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Supplemental Guidance, "Standard Default Exposure Factors". Interim Final, March, 1991 (EPA, 1991).*
- *ASTM E1739-95. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. November 1995. (ASTM 1995)*

## 7.1 Chemicals of Potential Concern

Soil and groundwater data collected during the AOC2 RFI were evaluated for use in this risk assessment. Off-site laboratory-analyzed groundwater samples collected using the direct push method as well as groundwater samples collected from monitoring wells were used for the evaluation of groundwater concentrations. With the exception of essential nutrients (i.e., calcium, iron, magnesium, potassium, and sodium) and water quality parameters (i.e., bromide, chloride, nitrate, and orthophosphate and sulfate), all detected chemicals were evaluated in this risk assessment (including those that may be attributed to sources other than AOC2). Essential nutrients and water quality parameters are not expected to contribute significantly to estimated site risks because of low toxicity, and were eliminated from the HHRA in accordance with EPA guidance (EPA, 1989).

Appendix G-3 provides the laboratory analytical results of all samples collected during the AOC2 RFI. A summary of the chemicals detected in soil and groundwater, including the number of samples detected, the number of samples analyzed, the range of detection limits for nondetects, the minimum and maximum detected value, and the average and standard deviation, are presented in Table 7-1. Averages were calculated using a concentration equal to ½ the sample quantitation limit for non-detected contaminants when the contaminant was detected in some samples but not others.

None of the VOCs analyzed were detected in the two surface soil (1 to 3 feet below ground surface) samples collected for the AOC2 RFI. Eight compounds were detected in the 17 collected subsurface soil samples; these are classified as chemicals of potential concern (COPCs). Refer to Section 5.4 for a description of additional soil samples collected in the study area under other investigations which support these results. The subsurface soil COPCs include ethylbenzene, m,p-xylene, n-butylbenzene, n-propylbenzene, sec-butylbenzene, tert-butylbenzene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene. Total petroleum hydrocarbons (TPHs) were also detected in subsurface soils. These compounds were detected in soil samples ranging in depth from 14 to 16 feet below ground surface to 18 to 20 feet.

In three rounds of groundwater monitoring from 43 wells, seven metals (including the 5 essential nutrients listed above) and 22 organic compounds were detected. The metals and organic compounds detected are listed in Table 7-2 (not including the 5 essential nutrients listed above). These detected constituents were considered as COPCs.

## 7.2 Exposure Assessment

Exposure refers to the potential contact of an individual with a chemical. Exposure assessment is the estimation of the magnitude, frequency, duration and routes of exposure to a chemical. Human exposure to chemicals is typically evaluated by estimating the amount of a chemical that could come into contact with the lungs, gastrointestinal tract, or skin during a specified period of time.

An exposure pathway describes how a receptor makes contact with a contaminant source. This risk assessment includes a subsurface soil exposure pathway and a groundwater exposure pathway. Potential receptors include current and future on-site construction (trench) workers who may come into direct contact with soil and inhale vapors emanating from groundwater.

Since there were no COPCs found in the surface soil, there will be no exposure to current and future on-site workers through incidental ingestion, inhalation of fugitive dust, or dermal contact with surface soil. Residential scenarios were not considered in this risk assessment for soil pathways as the site is expected to remain industrial.

Current and future on-site construction workers may come in contact with contaminated subsurface soil. These construction workers could be exposed to COPCs in subsurface soil through the following exposure routes:

- Incidental ingestion of soil,
- Inhalation of resuspended particulates (i.e., resuspended by wind or construction activities),
- Inhalation of chemicals volatilizing from the soil and groundwater, and
- Dermal contact with soil.

Onsite (and offsite) shallow groundwater is not currently being used for agricultural, industrial, or domestic purposes. Construction workers could be exposed to groundwater through inhalation of chemicals volatilizing from the water, through the soil, and into the worker's breathing zone.

Since the groundwater flows in the direction of the West Fork Trinity River, there is potential for the COPCs to contaminate the surface water. Additional receptors that may be exposed to the COPCs in surface water include an offsite resident who may use the surface water for drinking or recreational uses (swimming and fishing) or aquatic organisms. Since the West Fork Trinity River is designated for use as a public domestic water supply, the potential future offsite resident scenario is also considered. This potential future offsite resident may be exposed to the surface water through ingestion. A swimmer may be

exposed to contaminants in the surface water through dermal absorption, incidental ingestion of the water while swimming, and ingestion of contaminated fish.

### 7.2.1 Conceptual Site Model

The conceptual site model aids in determining the potential exposure pathways to people, plants, or animals from the site. An exposure pathway is the means by which a person (receptor) may come in contact with one or more COPCs. A complete chemical exposure pathway consists of the following elements:

- Chemical source (e.g., chemical residues in soil or groundwater)
- Release mechanisms (e.g., dispersion, infiltration)
- Transport mechanism (e.g., resuspension of particulates)
- Feasible route of exposure (e.g., ingestion)
- Potential receptors (e.g., onsite construction worker)

The potential exposure pathways and routes are summarized in the Conceptual Site Model presented in Figure 7-1.

### 7.2.2 Exposure Point Concentrations

Exposure point concentrations of the COPCs are required as one of the variables within the exposure assessment calculations to estimate potential chemical intake. Exposure point concentrations estimates do not include physical, chemical, or biological processes that could result in the reduction of chemical concentrations over time. The exposure point concentrations are assumed to remain constant at levels reflected in the analytical results. This general assumption of steady state conditions also applies to sources and contaminant release mechanisms. This assumption may result in a conservative evaluation of long-term exposure conditions.

The maximum concentration for each COPC in soil was used as the exposure point concentration (see Table 7-1) for the current and future on-site construction worker scenario. For exposure point concentrations in air as a result of volatilization of compounds in groundwater, the maximum concentration of each COPC was multiplied by a chemical-specific volatilization factor. This volatilization factor was calculated using an equation

from the ASTM RBCA standard. The RBCA equation and assumptions used in this model are presented in **Appendix I**.

In surface water, the exposure point concentration was calculated using a dilution factor of 0.26 applied to the maximum concentration detected in groundwater. This dilution factor was calculated based on modeling of the groundwater movement toward the surface water as described in Section 6.0. The reduction in concentrations predicted by the model over that distance is based on dilution and dispersion influences only. Because surface water flows in the West Fork Trinity River are sometimes non-existent, it was assumed that the maximum groundwater concentration intercepting the river would be the surface water exposure concentration (ie. no dilution associated with mixing of surface water with the groundwater was assumed). The exposure point concentrations used in the surface water exposure pathways are presented in **Table 7-3**.

#### **7.2.2.1 Chemical Intakes**

Exposure (or intake) is defined as the contact of an organism with a chemical or physical agent. Intake is normalized for time and body weight and is expressed as milligrams of chemical per kilogram of body weight per day (mg/kg-day). Six basic factors are used to estimate intake: chemical concentration, contact rate, exposure frequency, exposure duration, body weight, and averaging time.

Intake can be described by the following general equation:

$$\text{Intake} = \frac{\text{Concentration} \times \text{Contact Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}}{\text{Body Weight} \times \text{Averaging Time}}$$

The intake of chemicals evaluated for noncarcinogenic health effects is estimated over an averaging time dependent on the assessed toxic effect (i.e., health effect). This assessment evaluates chronic exposure to chemicals on the basis of systemic toxic effects and the estimated period of exposure.

The intake of a chemical evaluated for carcinogenic health effects is referred to as the lifetime average chemical intake. The lifetime average chemical intake is calculated by prorating the total cumulative dose of the chemical over an averaging time of an entire life

span (assumed to be 70 years) (EPA, 1989b). The selection of an averaging time that spans a lifetime is based on EPA guidance: "The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime" (EPA, 1989b).

EPA guidance states that actions at Superfund sites should be based on an estimate of the "reasonable maximum exposure" (RME). The RME is defined as the "highest exposure that is reasonably expected to occur at a site" (EPA, 1989b). The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possibilities. Each exposure factor has a range of possible values. To the extent possible, the risk assessment has selected values for the exposure factors that result in an estimate of the RME scenario.

#### 7.2.2.2 Soil Pathway

Chemical intakes were calculated for exposure to chemicals in soil through incidental ingestion, inhalation of resuspended particulates and volatiles, and dermal contact. A conservative, screening-level approach was used for the intake calculations. Standard default exposure parameters were used and the maximum detected concentration for each COPC was used as the exposure point concentration. The exposure parameters used to calculate the chemical intakes for the on-site construction worker are summarized in Table 7-4. The formulas used to calculate the intakes for all COPCs are provided below.

##### 7.2.2.2.1 Intake from the Soil Ingestion Pathway

The following formula was used to calculate intake from the soil ingestion pathway:

$$Intake = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

Where:

- Intake = Intake from ingestion of soil (mg/kg-day)
- C = Concentration in soil (mg/kg)
- IR = Intake rate for soil (mg/day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- CF = Conversion factor (10<sup>-6</sup> kg/mg)
- BW = Body weight (kg)
- AT = Averaging time (ED x 365 days/year)

**7.2.2.2 Intake from the Inhalation Pathway**

The following formula was used to calculate intake from the inhalation pathway:

$$Intake = \frac{C x ([1/PEF] + [1/VF]) x IR x EF x ED}{BW x AT}$$

Where:

Intake = Intake from inhalation pathway (mg/kg-day)

C = Concentration in soil (mg/kg)  
 PEF = Particulate Emissions Factor (m<sup>3</sup>/kg)  
 VF = Volatilization Factor (m<sup>3</sup>/Kg)  
 CF = Conversion factor (10<sup>9</sup> kg/ug)  
 IR = Intake rate for air (m<sup>3</sup>/day)  
 EF = Exposure frequency (days/year)  
 ED = Exposure duration (years)  
 BW = Body weight (Kg)  
 AT = Averaging time (ED x 365 days/year)

The derivation of the volatilization factor (VF) and particle emission factor (PEF) can be found in Appendix J.

**7.2.2.3 Intake from the Dermal Contact Pathway**

The soil COPCs have an ABS value of zero (0), so the dermal pathway is not applicable.

**7.2.2.3 Groundwater Pathway**

Chemical intakes were calculated for exposure to chemicals in groundwater through inhalation of chemicals volatilizing from the groundwater and traveling through the soil to a worker's breathing zone. The chemical specific volatilization factor was calculated using the RBCA model (see Appendix I). A conservative, screening-level approach was used for the intake calculations. Standard default exposure parameters were used and the maximum detected concentration for each COPC was used as the exposure point concentration. The exposure parameters used to calculate the chemical intakes for the on-site construction worker are summarized in Table 7-5. The formulas used to calculate the inhalation intakes are provided below.

The following formula was used to calculate intake from the groundwater inhalation pathway:

$$Intake = \frac{C \times VF \times IR \times EF \times ED}{BW \times AT}$$

Where:

Intake = Intake from inhalation of volatiles in groundwater (mg/kg-day)  
 C = Concentration in groundwater (mg/L)  
 VF = Volatilization factor (L/m<sup>3</sup>)  
 CF = Conversion factor (10<sup>-3</sup> mg/ug)  
 IR = Intake rate for air (m<sup>3</sup>/day)  
 EF = Exposure frequency (days/year)  
 ED = Exposure duration (years)  
 BW = Body Weight (Kg)  
 AT = Averaging time (ED x 365 days/year)

#### 7.2.2.4 Surface Water Pathway for a Resident and Recreational User

Chemical intakes were calculated for exposure to chemicals in surface water by a resident through ingestion and a recreational user through dermal contact, incidental ingestion while swimming and through ingestion of contaminated fish. A conservative approach was used for the intake calculations. Standard default exposure parameters were used for a recreational scenario and the concentrations of COPCs at the point of exposure (West Fork Trinity River) were derived from a groundwater model. The exposure parameters used to calculate the chemical intakes for the recreational user are summarized in Table 7-6. The exposure parameters used to calculate the chemical intake for residential ingestion of surface water are summarized in Table 7-6a. The formulas used to calculate the intakes are provided below.

##### 7.2.2.4.1 Intake from Dermal Contact with Surface Water

The following formula was used to calculate surface water intake from the dermal contact pathway:

$$Intake = \frac{C \times Kp \times SA \times ET \times EF \times ED \times CF \times 0.001 L / cm^3}{BW \times AT}$$

Where:

Intake = Dermal intake of surface water (mg/kg-day)  
 C = Concentration in water (ug/L)  
 Kp = Dermal permeability coefficient (cm/hour)

---

SA	= Skin surface area (cm <sup>2</sup> )
ET	= Exposure time (hours/day)
EF	= Exposure frequency (days/year)
ED	= Exposure duration (years)
CF	= Conversion factor (10 <sup>3</sup> mg/μg)
BW	= Body weight (Kg)
AT	= Averaging time (ED x 365 days/year)

#### 7.2.2.4.2 Intake from Ingestion of Surface Water for a Recreational User

The following formula was used to calculate intake from the surface water ingestion pathway:

$$Intake = \frac{C \times IR \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

Intake	= Intake from incidental ingestion of water (mg/kg-day)
C	= Concentration in water (μg/L)
IR	= Intake rate for water while swimming (L/hour)
ET	= Exposure time (hours/day)
EF	= Exposure frequency (days/year)
ED	= Exposure duration (years)
CF	= Conversion factor (10 <sup>3</sup> mg/μg)
BW	= Body weight (Kg)
AT	= Averaging time (ED x 365 days/year)

#### 7.2.2.4.3 Intake from Ingestion of Surface Water for a Potential Future Resident

The following formula was used to calculate intake from the surface water ingestion pathway:

$$Intake = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

Where:

Intake	= Intake from incidental ingestion of water (mg/kg-day)
C	= Concentration in water (μg/L)
IR	= Intake rate for water (L/day)
EF	= Exposure frequency (days/year)
ED	= Exposure duration (years)
CF	= Conversion factor (10 <sup>3</sup> mg/μg)

BW = Body weight (kg)  
AT = Averaging time (ED x 365 days/year)

#### 7.2.2.4.3 Estimation of Concentrations in Fish

Bioconcentration from water to aquatic organisms was estimated using bioconcentration factors (BCF). The BCF is defined as the ratio of the concentration of chemical in an organism to the concentration in water at equilibrium (Lyman et al., 1990), and was used to estimate concentrations accumulated into fish from water as follows:

$$C_f = C_{sw} \times BCF \times 0.001 \text{ mg/ug}$$

Where:

$C_f$  = chemical concentration in fish (mg/kg)

$C_{sw}$  = chemical concentration in surface water (ug/L)

BCF = bioconcentration factor (L/kg)

Exposure point concentrations of the surface water COPCs, BCFs, and the resulting concentrations in fish are documented in **Appendix K, Table K-1**.

#### 7.2.2.4.4 Intake from Ingestion of Contaminated Fish

The following formula was used to calculate intake from ingestion of contaminated fish:

$$\text{Intake} = \frac{C_f \times IR \times FI \times EF \times ED}{BW \times AT}$$

Where:

Intake = Intake from ingestion of contaminated fish (mg/kg-day)

$C_f$  = Concentration in fish (mg/kg)

IR = Intake rate for fish (kg/meal)

FI = Fraction ingested

EF = Exposure frequency (meals/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (ED x 365 days/year)

The portion size of a fish meal is assumed to range from 4 ounces (114 grams) to 8 ounces (227 grams). The parameter "fraction ingested from source" describes the number of fish

meals per year caught from surface water in the West Fork Trinity River (essentially, they do not fish at other locations). The exposure scenario assumes that 17 fish meals are consumed per month. The frequency of 17 meals per month is considered by EPA to represent "unlimited" fish consumption in its guidelines for developing fishing advisories (EPA, 1994).

### 7.3 Toxicity Assessment

Toxicity values (reference dose [RfD] and cancer slope factors [CSFs]) are presented in Table 7-7. For the inhalation pathways, unit risk factors (URFs) and reference concentrations (RfCs) are used in lieu of the inhalation slope factors (SFis) and reference doses (RfDis). The primary source of toxicity values used in this risk assessment is EPA's Integrated Risk Information Systems database (IRIS) (EPA, 1998). The IRIS database contains up-to-date health risk and EPA regulatory information. IRIS contains only those RfDs and CSFs that have been verified by EPA work groups and is considered by EPA to be the preferred source of toxicity information. If a toxicity value was not available through IRIS, the next data source used is the most recently available Health Effects Assessment Summary Tables (HEAST) issued by the EPA's Office of Research and Development (EPA, 1997a). HEAST summarizes interim (and some verified) RfDs and CSFs. Several chemical toxicity values came from EPA's National Center for Environmental Assessment (NCEA, formerly ECAO) because they were not available from IRIS or HEAST.

Toxicity values for cumene were used as a surrogate for p-isopropyltoluene.

Methane was not evaluated quantitatively in the human health risk assessment since it is most likely an artifact of chemical analysis.

TPH presently has no published health criteria (i.e., cancer slope factor or reference dose). Therefore, risks from exposure to TPH are addressed by evaluating the individual constituents of greatest toxicological concern and greatest mobility (i.e., benzene, ethylbenzene, toluene and xylene).

## 7.4 Potential Threats to Ecological Receptors and Recreational Users of the Trinity River

As demonstrated in Section 7.1, volatile organic compounds and metals were detected in groundwater at AOC2. The vertical and horizontal extent of contamination in groundwater has been determined using a network of monitoring wells, obtaining subsurface geological data, and a collection of depth specific groundwater samples. Table 7-8 is a compilation of current Texas Water Quality Standards for the protection of human health and welfare and freshwater and marine aquatic life for COPCs detected in groundwater associated with AOC2. The concentrations presented in Table 7-8 would serve as future potential surface water quality criteria in the event that groundwater should impact the West Fork Trinity River.

## 7.5 Risk Characterization

This section summarizes the risk estimates (i.e., Hazard Indices [HIs] for noncarcinogenic COPCs and Excess Lifetime Cancer Risk [ELCR] for carcinogenic COPCs) for a potential current and future construction worker exposure scenario.

ELCR were estimated for carcinogenic chemicals having CSFs. Cancer risks for each COPC were calculated as the product of intake for the chemical (mg/kg-day) and the CSF for that chemical (mg/kg-day)<sup>-1</sup>. Based on the EPA risk assessment guidelines for carcinogens, cancer risks from exposure to multiple carcinogens via multiple exposure routes were assumed to be additive. Therefore, estimated ELCR for all carcinogens and exposure routes were summed to yield a single estimated cancer risk.

Noncancer risks were estimated by comparing the intake for each noncarcinogenic COPC for each exposure route to its reference dose (RfD). The ratio of the intake to the RfD is described as the Hazard Quotient (HQ). The HQs for the COPCs were combined to estimate the Hazard Index (HI) for each exposure route. HIs for the three exposure routes were combined to give an overall HI for the future worker scenario. Media cleanup requirements for RRS No. 3 state the HI for multiple chemicals and multiple exposure pathways shall not exceed 1 (30 TAC 335.563).

### 7.5.1 Soil

The risk characterization results for the current and future construction worker scenario as a result of exposure to subsurface soil are shown in Table 7-9. As the exposure point concentrations and exposure parameters are the same for both the current and future construction worker, the risk characterization results are the same.

Since the COPCs detected in soil are not considered carcinogenic, cancer risk was not calculated for the soil exposure route. The estimated hazard index for the Construction Worker scenario is well below 1 (i.e., 0.05) and therefore no adverse noncancer health effects are predicted to result from exposure of a construction worker to soils at AOC2.

Appendix K, Table K-2, contains the chemical specific ELCRs calculation and HQ spreadsheets for the soil exposure pathway.

### 7.5.2 Groundwater

The risk characterization results for the current and future construction worker scenario as a result of exposure to groundwater are shown in Table 7-9.

The estimated lifetime cancer risk from inhalation of volatiles in groundwater for a potential commercial/industrial exposure is  $1 \times 10^{-11}$ . This risk estimate is below the cancer risk criteria of  $10^{-6}$ .

The estimated hazard index for a construction worker inhaling volatile compounds from the groundwater is below 1 (i.e., <0.001). This result demonstrates that adverse noncancer health effects are not predicted to occur from exposure of a construction worker to volatile emissions from groundwater at AOC2.

Appendix K, Table K-3, contains the chemical specific ELCR and hazard quotient calculation spreadsheets for the groundwater exposure pathway.

### 7.5.2 Surface Water

The risk characterization results for the future potential resident and recreational user scenario are shown in Table 7-9. These are both hypothetical scenarios since the contaminants in the groundwater have not yet reached the Trinity River. The estimated

lifetime cancer risk to a potential future resident who takes their drinking water directly from the river (without treatment) is  $4 \times 10^{-4}$ . The estimated hazard index for the same receptor is 0.5.

The estimated lifetime cancer risk to a future recreational user from dermal contact with surface water while swimming, ingestion of surface water while swimming, and ingestion of fish caught from the West Fork Trinity River is  $2 \times 10^{-4}$ . The estimated hazard index for the recreational user for the same exposure pathway is 2.

Appendix K, Tables K-4 and K-5, provide the chemical-specific ELCR and hazard quotient calculation spreadsheets for the surface water exposure pathway.

## 7.6 Uncertainty Analysis

Simplifying assumptions were made to estimate the risks for AOC2. Uncertainties in this risk evaluation (and risk assessment in general) are due to uncertainties in the methodologies used to estimate risks, uncertainties in characterizing the site, and uncertainties describing exposure.

The estimates of risk presented above are subject to uncertainty from a variety of sources including:

- Sampling, analysis, and data evaluation
- Fate and transport estimation
- Exposure estimation
- Toxicological data
- Risk estimation methods

General and site-specific uncertainties are summarized in Table 7-10. Uncertainty associated with sampling and analysis include the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. The quality assurance/quality control program used in the investigation

serves to reduce these errors; it cannot eliminate all errors associated with sampling and analysis. The degree to which sample collection and analyses reflect real exposure point concentrations will determine the reliability of the resulting risk estimates.

This risk assessment makes simplifying assumptions about the environmental fate and transport of the COPCs, specifically, that no chemical loss or transformation has occurred over time. This assessment also assumes that the chemical concentrations detected in surface soil and groundwater remain constant during the assessed exposure duration.

Risk estimation required numerous assumptions to describe potential exposure situations. Several uncertainties exist regarding likelihood of exposure, frequency of contact with contaminated soil and groundwater, the concentration of chemicals at exposure points, and the time period of exposure. Assumptions used in this risk assessment tend to simplify and approximate actual site conditions.

The toxicological database is also a source of uncertainty. These uncertainties include extrapolation from high to low dose and from animals to humans; species, gender, age, and strain differences in uptake, metabolism, organ distribution, and target site susceptibility; and human population variability with respect to diet, environment, activity patterns, and cultural factors.

## 7.7 Conclusions

Data from the data evaluation, exposure assessment, and toxicity assessment were compiled in the risk characterization to yield expressions of potential carcinogenic risk to human health and the likelihood of noncarcinogenic outcomes in humans as well. Risk and hazard were computed according to current and future land use for each applicable receptor.

Carcinogenic risks resulting from exposure to volatile compounds in groundwater yielded a risk of  $1 \times 10^{-11}$ . Noncancer health hazard resulting from exposure of a construction worker to contaminants in soil and groundwater yield a total hazard index less than 0.1. Based on this quantitative risk assessment, exposure to a current or future construction worker to soil or groundwater at AOC2 is below the EPA standard level of concern ( $10^{-6}$ ).

---

Carcinogenic risk to a potential future resident who takes their drinking water directly from the river (without treatment) is  $4 \times 10^{-4}$ . The estimated hazard index for the same receptor is 0.5. Carcinogenic risk resulting from exposure to surface water while swimming and eating contaminated fish is  $2 \times 10^{-4}$ . The noncancer hazard index for the same receptor is 2. These last two scenarios are hypothetical since groundwater contamination has not reached the Trinity River.

**Table 7-1  
Summary Statistics for Soil and Groundwater Data  
NAS Fort Worth JRB, Texas**

Chemical	Units	Number of Detects	Number of Samples	Frequency of Detection	Range of Detection Limits for NonDetects	Range of Concentrations for Detected Values	Arithmetic Mean <sup>a</sup>	Standard Deviation <sup>a</sup>
<b>Groundwater Data</b>								
<b>Inorganics</b>								
BROMIDE	MG/L	21	22	95.45%	0.1 - 0.1	0.18 - 8.6	1.25	1.76
CHLORIDE	MG/L	22	22	100.00%		1.2 - 2600	256.28	619.08
FLUORIDE	MG/L	21	22	95.45%	0.2 - 0.2	0.23 - 6.4	0.82	1.30
NITRATE	MG/L	14	22	63.64%	0.1 - 0.96	0.28 - 8.4	2.57	2.65
ORTHOPHOSPHATE	MG/L	4	22	18.18%	0.1 - 0.1	0.1 - 2.6	0.19	0.54
SULFATE	MG/L	22	22	100.00%		4.2 - 1600	194.75	387.23
TOTAL ALKALINITY	MG/L	11	11	100.00%		200 - 500	332.14	90.29
TOTAL ORGANIC CARBON	MG/L	18	22	81.82%	1 - 1	1 - 11	3.43	2.77
<b>Metals</b>								
ALUMINUM	UG/L	17	22	77.27%	44.2 - 184	57.3 - 7190	817.00	1507.80
CALCIUM	UG/L	22	22	100.00%		89,800 - 926,000	203872.73	206245.58
IRON	UG/L	21	22	95.45%	8 - 8	108 - 18,100	2377.45	3984.41
LEAD	UG/L	1	22	4.55%	0.7 - 31.2	4 - 4	11.61	6.71
MAGNESIUM	UG/L	22	22	100.00%		2900 - 57,000	15367.73	14614.54
POTASSIUM	UG/L	22	22	100.00%		740 - 20,600	3467.55	4383.94
SODIUM	UG/L	22	22	100.00%		2930 - 1,090,000	164115.00	283036.63
<b>Volatile Organic Compounds</b>								
1,1-DICHLOROETHENE	UG/L	5	117	4.27%	1.2 - 60	0.42 - 9.8	5.54	6.76
1,2,4-TRIMETHYLBENZENE	UG/L	4	106	3.77%	1.3 - 65	67 - 350	11.67	36.46
1,2-DICHLOROETHANE	UG/L	1	110	0.91%	0.6 - 30	3.5 - 3.5	2.81	3.44
1,3,5-TRIMETHYLBENZENE	UG/L	3	105	2.86%	0.5 - 25	8.9 - 44	3.00	5.07
BENZENE	UG/L	5	117	4.27%	0.4 - 20	0.31 - 130	4.23	15.44
CHLOROFORM	UG/L	7	117	5.98%	0.3 - 15	0.49 - 10	1.55	2.08
CIS-1,2-DICHLOROETHENE	UG/L	73	117	62.39%	1.2 - 60	0.48 - 250	24.38	39.27
ETHYLBENZENE	UG/L	3	117	2.56%	0.6 - 30	32 - 45	3.69	6.73
1-METHYLETHYLBENZENE	UG/L	5	75	6.67%	0.5 - 25	7.2 - 39	3.77	6.69
M,P-XYLENE	UG/L	3	113	2.65%	1.3 - 65	35 - 73	7.31	10.47
METHANE	UG/L	13	22	59.09%	0.34 - 0.44	0.38 - 475	74.71	152.35
NAPHTHALENE	UG/L	9	102	8.82%	0.4 - 20	0.33 - 97	4.66	14.07
N-BUTYLBENZENE	UG/L	6	117	5.13%	1.1 - 55	0.41 - 7.6	5.15	6.24
N-PROPYLBENZENE	UG/L	6	113	5.31%	0.4 - 20	6.3 - 50	3.34	7.66
P-ISOPROPYLTOLUENE	UG/L	2	117	1.71%	1.2 - 60	1.5 - 3.4	5.45	6.80

**Table 7-1**  
**Summary Statistics for Soil and Groundwater Data**  
**NAS Fort Worth JRB, Texas**

Chemical	Units	Number of Detects	Number of Samples	Frequency of Detection	Range of Detection Limits for NonDetects	Range of Concentrations for Detected Values	Arithmetic Mean <sup>a</sup>	Standard Deviation <sup>a</sup>
SEC-BUTYLBENZENE	UG/L	8	113	7.08%	0.46 - 65	0.45 - 17	6.43	7.57
TERT-BUTYLBENZENE	UG/L	3	113	2.65%	1.4 - 70	2.5 - 3.5	6.62	7.98
TETRACHLOROETHENE	UG/L	23	117	19.66%	1.4 - 70	0.36 - 68	8.21	11.31
TOLUENE	UG/L	1	117	0.85%	1.1 - 55	1.4 - 14	5.04	6.24
TRANS-1,2-DICHLOROETHENE	UG/L	26	117	22.22%	0.6 - 30	0.5 - 130	10.33	22.28
TRICHLOROETHENE	UG/L	83	117	70.94%	1 - 20	0.61 - 1,200	204.95	259.86
VINYL CHLORIDE	UG/L	3	117	2.56%	1.1 - 55	2.6 - 13	5.15	6.27
<b>Soil Data</b>								
1,2,4-TRIMETHYLBENZENE	MG/KG	1	19	5.26%	0.007 - 0.04	0.15 - 0.15	0.012	0.034
1,3,5-TRIMETHYLBENZENE	MG/KG	1	19	5.26%	0.003 - 0.017	0.05 - 0.05	0.005	0.011
ETHYLBENZENE	MG/KG	1	19	5.26%	0.003 - 0.017	0.032 - 0.032	0.004	0.007
M,P-XYLENE	MG/KG	2	19	10.53%	0.007 - 0.04	0.0023 - 0.12	0.011	0.027
N-BUTYLBENZENE	MG/KG	1	19	5.26%	0.005 - 0.029	0.015 - 0.015	0.004	0.004
N-PROPYLBENZENE	MG/KG	1	13	7.69%	0.0021 - 0.011	0.019 - 0.019	0.003	0.005
SEC-BUTYLBENZENE	MG/KG	1	19	5.26%	0.007 - 0.04	0.012 - 0.012	0.005	0.004
TERT-BUTYLBENZENE	MG/KG	1	19	5.26%	0.007 - 0.04	0.014 - 0.014	0.005	0.004
TOTAL ORGANIC CARBON	MG/KG	5	6	83.33%	60 - 60	1060 - 5150	2158.333	1868.469

Note a: To calculate the arithmetic mean and standard deviation, a value of one-half the limit of detection was used for samples where the analyte was not detected

**Table 7-2**  
**COPCs Detected in Study Area Groundwater**  
**NAS Fort Worth JRB, Texas**

---

ALUMINUM	N-PROPYLBENZENE
BENZENE	P-ISOPROPYLTOLUENE
CHLOROFORM	SEC-BUTYLBENZENE
1,2-DICHLOROETHANE	TERT-BUTYLBENZENE
1,1-DICHLOROETHENE	TETRACHLOROETHENE
CIS-1,2-DICHLOROETHENE	TOLUENE
ETHYLBENZENE	TRANS-1,2-DICHLOROETHENE
ISOPROPYLBENZENE (CUMENE)	TRICHLOROETHENE
FLUORIDE	1,2,4-TRIMETHYLBENZENE
LEAD	1,3,5-TRIMETHYLBENZENE
METHANE	M,P-XYLENE
NAPHTHALENE	VINYL CHLORIDE
N-BUTYLBENZENE	

---

**Table 7-3**  
**Chemical Exposure Point Concentrations in Surface Water**  
**NAS Fort Worth JRB, Texas**

COPC in Groundwater	Maximum Concentration Detected in Groundwater (ug/L)	Dilution Factor	Exposure Point Concentration in Surface Water (ug/L)
<b>Organic Compounds</b>			
1,2,4-TRIMETHYLBENZENE	350	0.26	91
1,3,5-TRIMETHYLBENZENE	44	0.26	11.44
N-BUTYLBENZENE	7.6	0.26	1.98
N-PROPYLBENZENE	50	0.26	13
NAPHTHALENE	97	0.26	25.22
SEC-BUTYLBENZENE	17	0.26	4.42
METHANE	475	0.26	123.5
P-ISOPROPYLTOLUENE	3.4	0.26	0.884
TERT-BUTYLBENZENE	3.5	0.26	0.91
1,1-DICHLOROETHENE	9.8	0.26	2.548
1,2-DICHLOROETHANE	3.5	0.26	0.91
1-METHYLETHYLBENZENE	39	0.26	10.14
BENZENE	130	0.26	33.8
CHLOROFORM	10	0.26	2.6
CIS-1,2-DICHLOROETHENE	250	0.26	65
ETHYLBENZENE	45	0.26	11.7
M,P-XYLENE	73	0.26	18.98
TETRACHLOROETHENE	68	0.26	17.68
TOLUENE	14	0.26	3.64
TRANS-1,2-DICHLOROETHENE	130	0.26	33.8
TRICHLOROETHENE	1200	0.26	312
VINYL CHLORIDE	13	0.26	3.38
<b>Inorganic Compounds</b>			
ALUMINUM	7190	0.26	1869
LEAD	4	0.26	1.04
FLUORIDE	6.4	0.26	1.66

**Table 7-4**  
**Current and Future Site Construction Worker Exposure Factors/Soil Exposure Medium**  
**NAS Fort Worth JRB, Texas**

Exposure Factor	Workers
Soil Ingestion Rate (mg/kg)	480
Inhalation Rate (m <sup>3</sup> /day)	20
Volatilization Factor(m <sup>3</sup> /Kg)	Chemical specific (see Table 7-8)
Conversion Factor (kg/mg)	1 x 10 <sup>-6</sup>
Particulate Emission Factor (m <sup>3</sup> /kg)	4.63 x 10 <sup>9</sup>
Skin Surface Area (cm <sup>2</sup> /day)	3,300
Absorption Factor (fraction) for Organics	0.1
Soil-to-Skin Adherence Factor (mg/cm <sup>2</sup> )	0.2
Exposure Frequency (days/year)	40 (a)
Exposure Duration (years)	
Noncancer	1
Body Weight (kg)	70
Averaging Time (days)	
Noncancer	365

References:

30 TAC 335 Subpart S, except where noted.  
(a) EPA, 1991

**Table 7-5**  
**Current and Future Site Construction Worker Exposure Factors/Groundwater Exposure Medium**  
**NAS Fort Worth JRB, Texas**

Exposure Factor	Workers
Inhalation Rate (m <sup>3</sup> /day)	20
Volatilization Factor (mg/m <sup>3</sup> )	Calculated using RBCA model (ASTM 1995) (See Appendix I)
Exposure Frequency (days/year)	40 (a)
Exposure Duration (years)	1
Body Weight (kg)	70
Averaging Time (days)	
Noncancer	365
Cancer	25,550

References.

30 TAC 335 Subpart S, except where noted.

(a) EPA 1991

**Table 7-6**  
**Future Recreational Scenario Exposure Factors/Surface Water Exposure Medium**  
**NAS Fort Worth JRB, Texas**

Exposure Factor	Recreational Scenario
<b>Swimmer</b>	
Skin Surface Area (cm <sup>2</sup> )	23,000
Dermal Permeability Coefficient (cm/hour)	Chemical specific (see Table 7-8)
Exposure Time (hours/day)	2.6
Water Ingestion Rate (L/hour)	0.05
Exposure Frequency (days/year)	7
Exposure Duration (years)	
Cancer – Lifetime	70
Noncancer – National Upper-bound time at one residence	30
Conversion Factor 1 (mg/ug)	0.001
Conversion Factor 2 (L/cm <sup>3</sup> )	0.001
Body Weight (kg)	70
Averaging Time (days)	
Noncancer	10,950
Cancer	25,550
<b>Fish Eater</b>	
Intake rate for fish (kg/meal)	0.227 (a)
Fraction Ingested	1
Exposure Frequency (meals/year)	204 (a)
Exposure Duration (years)	
Cancer	70
Noncancer	30
Body Weight (kg)	70
Averaging Time (days)	
Noncancer	10,950
Cancer	25,550

**References:**

30 TAC 335 Subpart S

(a) Guidance for Assessing Chemical Contamination Data for Use in Fish Advisories (EPA 1994)

**Table 7-6a**  
**Future Residential Scenario Exposure Factors/Surface Water Exposure Medium**  
**NAS Fort Worth JRB, Texas**

<b>Exposure Factor</b>	<b>Residential Scenario</b>
Water Ingestion Rate (L/day)	2
Exposure Frequency (days/year)	350
Exposure Duration (years)	
Cancer – Lifetime	70
Noncancer – National Upper-bound time at one residence	30
Conversion Factor 1 (mg/ug)	0.001
Body Weight (kg)	70
Averaging Time (days)	
Noncancer	10,950
Cancer	25,550

**Table 7-7**  
**Toxicity Values and Chemical-Specific Parameters**  
**for Chemicals of Concern**  
**NAS Fort Worth JRB, Texas**

Chemical Name	Oral RfD (mg/kg-day)	Inhal RfD (mg/kg-day)	Weight of Evidence Classification	Oral SF (kg-day/mg)	Inhal SF (kg-day/mg)	RfC (mg/m <sup>3</sup> )	URF (µg/m <sup>3</sup> ) <sup>-1</sup>	Soil VF (m <sup>3</sup> /kg)	Ground water VF (mg/m <sup>3</sup> per mg/L)	Dermal Permeability Coefficient (cm/hour) (a)	ABS (for soil COPCs only)
<b>Volatiles</b>											
Benzene		0.0017 (b)	A	0.029	0.027 (b)	0.006 (b)	7.8E-06	8.81E-05	2.56E-05	0.021	
n-Butylbenzene	0.01 (b)							3.98E-05	3.98E-05	0.045 (g)	0.01
sec-Butylbenzene	0.01 (b)							1.20E-04	5.33E-05	0.045 (g)	0.01
tert-Butylbenzene	0.01 (b)							9.90E-05	3.86E-05	0.045 (g)	0.01
Chloroform	0.01	0.028 (e)	B2	0.0061	0.08 (e)	0.097 (e)	2.3E-05 (e)		2.22E-05	0.0089	
1,2-Dichloroethane		0.23 (e)	B2	0.091	0.091	0.81 (e)	2.6E-05 (e)		1.14E-05	0.0053	
1,1-Dichloroethene	0.009		C	0.6	0.18		5.0E-05		8.66E-05	0.016	
cis-1,2-Dichloroethene	0.01 (c)	0.23 (d)	D			0.79 (d)			2.05E-05	0.001	
trans-1,2-Dichloroethene	0.02	0.23 (d)	NA			0.79 (d)			3.34E-05	0.01	
Ethylbenzene	0.1	0.29	D			1 (d)		2.41E-04		0.074	0.01
p-Isopropyltoluene	0.1	0.11				0.4				0.045 (g)	
Methane (f)											
1-Methylethylbenzene (Cumene)	0.1	0.11	D			0.4			2.81E-03	0.045 (g)	
Naphthalene	0.02	0.00086	D			0.003			5.26E-06	0.069	
n-Propylbenzene	0.01 (a)							8.81E-05	3.98E-05	0.045 (g)	0.01
Tetrachloroethylene	0.01	0.011 (a)	B2	0.052 (b)	0.077 (e)	0.27 (e)	5.8E-07 (b)		5.13E-05	0.048	
Toluene	0.2	0.11 (b)	D			0.4			2.74E-05	0.045	
Trichloroethylene			B2	0.011 (b)	0.006 (b)		1.7E-06 (b)		3.56E-05	0.016	
1,2,4-Trimethylbenzene	0.05 (b)	0.0017 (b)				0.006 (b)		5.08E-05	2.10E-05	0.08 (f)	0.01
1,3,5-Trimethylbenzene	0.05 (b)	0.0017 (b)				0.006 (b)		1.24E-04	2.59E-05	0.08 (f)	0.01
Vinyl chloride			A	1.9 (c)	0.29 (c)		8.4E-05 (c)		9.34E-05	0.0073	
m,p-Xylene	2		D			0.43 (d)		1.99E-04	2.46E-05	0.08	0.01
<b>Metals</b>											
Aluminum	1 (a)									0.001	
Lead (f)										0.001	

**Table 7-7  
Toxicity Values and Chemical-Specific Parameters  
for Chemicals of Concern  
NAS Fort Worth JRB, Texas**

Chemical Name	Oral RfD (mg/kg- day)	Inhal RfD (mg/kg- day)	Weight- of- Evidence Classification	Oral SF (kg- day/mg)	Inhal SF (kg- day/mg)	RfC (mg/m <sup>3</sup> )	URF (µg/m <sup>3</sup> ) <sup>-1</sup>	Soil VF (m <sup>3</sup> /kg)	Ground water VF (mg/m <sup>3</sup> per mg/L)	Dermal Permeability Coefficient (cm/hour) (a)	ABS (for soil COPCs only)
<b>Inorganics</b>											
Bromide (f)											
Fluoride	0.06	0.00057				0.0002				0.001	
Nitrate	1.6										
Orthophosphate (f)											

References All Toxicity Values from EPA's IRIS database unless otherwise noted

- (a) Dermal Exposure Assessment: Principles and Applications. EPA 1992
- (b) EPA's National Center for Environmental Assessment (NCEA)
- (c) Health Effects Assessment Summary Tables (HEAST)
- (d) RSL-ESL = TNRCC Chronic Remediation - Specific Effects Screening Levels
- (e) ATSDR Minimal Risk Level
- (f) No published toxicity values

Dermal Permeability Coefficients are not available for several chemicals so  
 (f) Dermal Permeability Coefficient for xylenes substituted for this chemical  
 (g) Dermal Permeability Coefficient for toluene substituted for this chemical

**Table 7-8**  
**Water Quality Goals <sup>a</sup>**  
**NAS Fort Worth JRB, Texas**

Chemicals	Human Health Protection (Water and Fish) (µg/L)	Freshwater Aquatic Life Protection (µg/L)
ALUMINUM	50 <sup>c</sup>	991 <sup>d</sup>
BENZENE	5 <sup>b</sup>	5,300 <sup>e</sup>
CHLOROFORM	100 <sup>f</sup>	1,240 <sup>e</sup>
1,2-DICHLOROETHANE	5 <sup>b</sup>	20,000 <sup>e</sup>
1,1-DICHLOROETHENE	7 <sup>b</sup>	11,600 <sup>e</sup>
CIS-1,2-DICHLOROETHENE	70 <sup>c</sup>	11,600 <sup>e</sup>
ETHYLBENZENE	700 <sup>c</sup>	NA
ISOPROPYLBENZENE	NA	NA
LEAD	15 <sup>h</sup>	3 182 <sup>g</sup>
NAPHTHALENE	NA	620 <sup>e</sup>
N-BUTYLBENZENE	NA	NA
N-PROPYLBENZENE	NA	NA
P-ISOPROPYLTOLUENE	NA	NA
SEC-BUTYLBENZENE	NA	NA
TERT-BUTYLBENZENE	NA	NA
TETRACHLOROETHENE	5 <sup>b</sup>	840 <sup>e</sup>
TOLUENE	1,000 <sup>c</sup>	17,500 <sup>e</sup>
TRANS-1,2-DICHLOROETHENE	100 <sup>c</sup>	224,000 <sup>e</sup>
TRICHLOROETHENE	5 <sup>b</sup>	45,000 <sup>e</sup>
1,2,4-TRIMETHYLBENZENE	NA	NA
1,3,5-TRIMETHYLBENZENE	NA	NA
M,P-XYLENE	NA	NA
VINYL CHLORIDE	2 <sup>b</sup>	NA

- <sup>a</sup> Source: Texas Water Quality Standards (if Texas criteria not available, federal criteria provided)
- <sup>b</sup> Based on MCL - Maximum contaminant levels specified in 30 TAC 290 (relating to Water Hygiene)
- <sup>c</sup> Federal MCL
- <sup>d</sup> Texas Freshwater Acute Criteria
- <sup>e</sup> Federal acute lowest observable effects level
- <sup>f</sup> Concentration for sum of total trihalomethanes
- <sup>g</sup> Chronic
- <sup>h</sup> Indicates the criteria is for the dissolved fraction in water
- NA Not available

**Table 7-9**  
**Summary of Excess Lifetime Cancer Risks and Noncancer Hazard Indices for**  
**Exposure to Soil, Groundwater, and Surface Water**  
**NAS Fort Worth JRB, Texas**

<b>Summary of Noncancer Hazard Indices by Pathway - Soil</b>			
<b>Current and Future Construction Worker Scenario</b>			
	<b>Ingestion</b>	<b>Inhalation</b>	<b>Total</b>
Noncancer HI	0.004	0.04	0.05

<b>Summary of Excess Lifetime Cancer Risks and Noncancer Hazard Indices by Pathway - Groundwater</b>	
<b>Current and Future Construction Worker Scenario</b>	
	<b>Inhalation of Volatiles</b>
Cancer Risk	$1 \times 10^{-11}$
Noncancer HI	0.0003

<b>Summary of Excess Lifetime Cancer Risks and Noncancer Hazard Indices by Pathway - Surface Water</b>	
<b>Future Residential User</b>	
	<b>Ingestion of Surface Water</b>
Cancer Risk	$4 \times 10^{-4}$
Noncancer HI	0.5

<b>Summary of Excess Lifetime Cancer Risks and Noncancer Hazard Indices by Pathway - Surface Water</b>				
<b>Future Recreational User</b>				
	<b>Ingestion of Surface Water</b>	<b>Dermal Contact with Surface Water</b>	<b>Ingestion of Fish from the Trinity River</b>	<b>Total</b>
Cancer Risk	$5 \times 10^{-7}$	$3 \times 10^{-7}$	$2 \times 10^{-4}$	$2 \times 10^{-4}$
Noncancer HI	$6 \times 10^{-4}$	$8 \times 10^{-3}$	2.3	2.3

**Table 7-10  
Uncertainties Associated with Human Health Risk Estimates  
NAS Fort Worth JRB, Texas**

<b>Uncertainty Factor</b>	<b>Effects of Uncertainty</b>	<b>Comment</b>
<b>Exposure Assessment</b>		
Exposure assumptions	May overestimate risk	Assumptions regarding media intake, population characteristics (e.g., bodyweight, lifespan), and exposure patterns may not characterize actual exposures.
Dermal contact with chemicals of concern	May overestimate risk	Assumes sufficient time of contact for chemical to desorb from soil and absorb in skin
Contaminant loss during sampling	May underestimate risk	May underestimate VOCs present.
Use of delivered dose to estimate risks	May under- or overestimate risk	Assumes that the absorption of the chemical is the same as it was in the study that derived the toxicity value
Intake	May underestimate risks	Assumes all intake of contaminants is from the exposure medium being evaluated (no relative source contribution)
Population characteristics	May under- or overestimate risk	Assumes weight, lifespan, ingestion rate, etc., are potentially representative for a potentially exposed population.
<b>Toxicity Assessment</b>		
Cancer Slope Factor	May overestimate risks	Slope factors are upper 95 <sup>th</sup> percent confidence limits derived from a linearized model. Considered unlikely to underestimate risk, especially for low doses.
Toxicity values derived from animal studies	May under- or overestimate risk	Extrapolation from animal to humans may induce error because of differences in pharmacokinetics, target organs, and population variability

**Table 7-10**  
**Uncertainties Associated with Human Health Risk Estimates**  
**NAS Fort Worth JRB, Texas**

<b>Uncertainty Factor</b>	<b>Effects of Uncertainty</b>	<b>Comment</b>
Toxicity values derived primarily from high doses; most exposures are at low doses	May under- or overestimate risk	Assumes linear dose-response relationship at low doses. Tends to have conservative exposure assumptions
Toxicity values	May under- or overestimate risk	Not all values represent the same degree of certainty. All are subject to change as new evidence becomes available
Toxicity values derived from homogeneous animal populations	May under- or overestimate risk	Human population may have a wide range of sensitivities to a chemical
Not all chemicals at the site have toxicity values	May underestimate risks	These chemicals are not addressed quantitatively.
<b>Risk Estimation</b>		
Estimation of risks across exposure routes	May under- or overestimate risk	Some exposure routes have greater uncertainty associated with their risk estimates than others
Cancer risk estimates – no threshold assumed	May overestimate risks	Possibility that some thresholds do exist.
Cancer risk estimate – low dose linearity	May overestimate risks	Response at low doses is not known

Source      Release Mechanism      Transport Mechanism      Exposure Route      Receptor

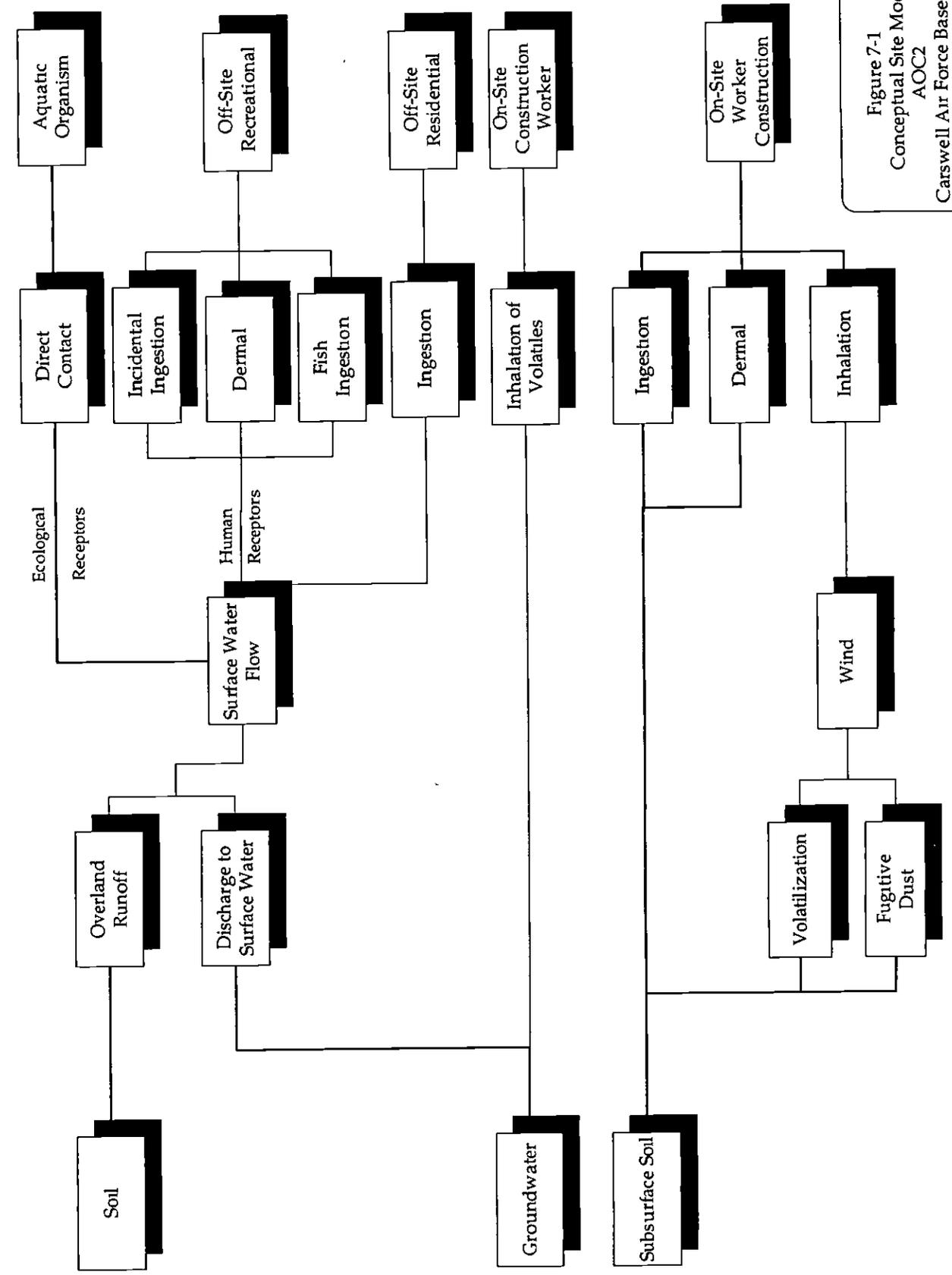


Figure 7-1  
Conceptual Site Model  
AOC2  
Carswell Air Force Base, Texas

# TAB

Section 8 Summary and Conclusions

---

## 8.0 Conclusions and Recommendations

---

This RFI report describes the activities conducted between late 1996 and 1998 to define the source, nature, and extent of the northern lobe of AOC2 TCE groundwater contamination and assess the risk to human health and the environment resulting from that contamination, presents all results from these activities, and describes the current and potential future conditions of the northern lobe plume.

Activities conducted and described include a seismic reflection survey, a direct push investigation, a drilling and monitor well installation program, soil and groundwater sampling and analysis, evaluation of the hydrogeologic and stratigraphic conditions dictating migration pathways, a baseline risk assessment, and an evaluation of the fate and transport characteristics of the plume, including a preliminary screening of the occurrence of natural attenuation.

Based on the results of these activities, the following conclusions can be made:

1. The West Fork Trinity River has not yet been impacted by TCE contamination associated with the AOC2 northern lobe. Wells located between the known plume and the West Fork Trinity River are unaffected by TCE-related constituents.
2. The extent of the AOC2 plume is slightly wider and slightly longer than that previously documented. This change is based on new well data, so whether or not an actual increase in plume extent has occurred is not known.
3. There is no evidence to support sources of TCE within the AOC2 study area other than the AFP4 plume migrating from the flightline area. This is supported by the following:
  - A review of previously uninvestigated SWMUs/AOCs within the AOC2 study area indicated only 3 SWMUs with minor potential as TCE sources; soil borings performed in the area of these SWMUs demonstrated no soil contamination.
  - No TCE soil detections (other than one low detection below practical quantitation limits in an area at the edge of the plume) were reported, in either AOC2 RFI soil samples or Sanitary Sewer RFI soil samples across the study area.

- At adjacent shallow/deep monitor well locations, groundwater concentrations of TCE and related compounds are typically significantly higher in samples from the deeper well, even in the higher concentration Alert Apron area.
  - Rather than being due to a local point source, higher concentrations of TCE in the Alert Apron area may be due to various reasons, including (1) a lower hydraulic conductivity in this area, causing a stagnant zone and (2) lower TCE degradation rates than in other areas of the plume due to geochemical conditions
  - An AFP4 source is further supported by considering the northern lobe plume length (~5500 feet from the NAS/AFP4 boundary) versus potential flow rates. If the AFP4 plume originated 50 years ago and traveled about 5500 feet, average velocity would have to have been about 0.3 feet per day. Assuming an average gradient of 0.005 to 0.01 and an average porosity of 30%, hydraulic conductivities would be expected to be between  $6 \times 10^{-3}$  cm/s to  $3 \times 10^{-2}$  cm/s. This range is within that observed in AOC2 study area wells.
4. The groundwater in the Terrace Alluvial Aquifer flows east/northeast from AFP4 across the study area, with preferred flow along basal gravel and weathered bedrock at the bottom of the aquifer. The bifurcation of the northern lobe of TCE contamination from the central lobe is due to a bedrock high west of the Spot-35 area, as demonstrated by direct push location PCHMHTA0B5. The bifurcation within the northern lobe is explained by the presence of a bifurcation in the paleochannel trending east from the flightline area toward the West Fork Trinity (demonstrated by seismic profile Line 5). Inhibition of flow directly toward the West Fork Trinity River is accomplished by a widening of this bifurcation in the paleochannel; the area along the West Fork immediately between the plume and the river demonstrates very little groundwater, and downgradient flow of the plume appears to trend toward the south rather than toward the river at that point.
5. A preliminary screening of the occurrence of natural attenuation shows that although some natural attenuation in the form of reductive dechlorination seems to be occurring, biologically-mediated natural attenuation mechanisms should probably not be considered significant fate processes for the chlorinated solvents demonstrated in AOC2 groundwater.

- 6 The risk assessment shows no adverse cancer or noncancer health effects are predicted to result from exposure of a construction worker to AOC2 study area soils, and the estimated lifetime cancer risk inhalation of volatiles in groundwater for a potential commercial/industrial exposure is  $1 \times 10^{-8}$ , well below the cancer risk criteria of  $10^{-6}$ , and adverse noncancer health effects are not predicted to occur from exposure of a construction worker to volatile emissions from groundwater at AOC2.
7. A maximum TCE concentration of 2.7 ug/L in the West Fork Trinity River would be protective of human health and the environment. Should the West Fork Trinity River be impacted by AOC2 groundwater in the future, it is possible that river flows would not be sufficient all of the time to keep concentrations always below this level.

Based on these conclusions, the following recommendations for further data gathering and monitoring prior to completion of the evaluation and selection of remedial alternatives for AOC2 groundwater is recommended:

1. To verify lack of impact to the West Fork Trinity River, add to the GSAP surface water quality monitoring in the West Fork Trinity River downstream of the AOC2 northern lobe area. Review the west bank of the river for the presence of springs and seeps in the area downgradient of AOC2 and consider adding those springs/seeps to the GSAP.
2. Add to the GSAP water elevation monitoring of the AOC2 RFI surface water gauging stations installed at Lake Worth and the West Fork Trinity River to assist with and refine Terrace Alluvial Aquifer potentiometric flow interpretations.
3. Add to the GSAP sampling of selected AOC2 RFI wells to monitor the downgradient extent of the AOC2 plume, including at a minimum, wells WCHMHTA013 and WITCTA026 (downgradient limit - southern bifurcation of plume), wells WITCTA010 and USGS04T (downgradient limit - northern bifurcation of plume), wells WCHMHTA014 and WITCTA003 (plume limit - north/northwestern extent to Lake Worth).

# TAB

Section 9      References

---

## 9.0 References

---

- American Society for Testing and Materials (ASTM), 1984. *Standard Method for Penetration Test and Split-Barrel Sampling of Soils*. D1586-84, (Vol. 4.08), ASTM, Philadelphia, PA.
- American Society for Testing and Materials (ASTM), 1995. *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. E1739-95. November 1995.
- Bureau of Reclamation, 1967. *Water Measurement Manual*.
- Carter & Burgess, 1995. *Environmental Constraints Report for NAS Fort Worth JRB*. January.
- Caughey, C.A., 1977. *Depositional Systems in the Paluxy Formation (Lower Cretaceous), Northeast Texas—Oil, Gas, and Ground-Water Resources*: Austin, University of Texas, Bureau of Economic Geology, Geological Circular 77-8, 59p.
- CH2M HILL, 1984. *Installation Restoration Program Records Search*. February.
- CH2M HILL, 1996a. *Basewide Quality Assurance Project Plan, NAS Fort Worth JRB, Carswell Field, Texas*. June.
- CH2M HILL, 1996b. *Draft Groundwater Sampling and Analysis Plan, NAS Fort Worth JRB, Carswell Field, Texas*. August.
- CH2M HILL, 1996c. *Draft Site Characterization Summary Informal Technical Information Report*. September.
- CH2M HILL, 1996d. *Direct Push Screening Investigation Technical Memorandum, NAS Fort Worth JRB, Carswell Field, Texas*. December.
- CH2M HILL, 1998. *RCRA Facility Investigation Work Plan for Area of Concern 2 (TCE Groundwater Plume)*. February.
- Chem-Nuclear Geotech, Inc., 1992. *Draft Final Groundwater Quality Monitoring Report*. Volumes I-V. January.
- Environmental Science and Engineering Group, Inc., 1994. (ES&E) *Final Report - Summary of Hydrologic and Chemical Characterization Studies. Volume III; Air Force Plant 4, Fort Worth, Texas*.
- Geo-Marine, Inc (GMI), 1995. (GMI) *Phase I & II Report, Groundwater Survey & Subsurface Soil Delineation, Hydrant Fueling System, Carswell Air Force Base, Fort Worth, Texas*. February.

- Hargis & Associates, Inc., 1985. *Phase II Investigation of Subsurface Conditions at U.S. Air Force Plant No. 4, Fort Worth, Texas*. September.
- Hargis & Associates, Inc., 1987. *Summary Report, Window Area Investigation, U.S. Air Force Plant No. 4, Fort Worth, Texas*. April.
- Hargis & Associates, Inc., 1989. *Summary of Interim Remedial Investigations January 1987 to April 1989, U.S. Air Force Plant No. 4, Fort Worth, Texas*. Vol. I, II, and III. July.
- HydroGeoLogic, Inc., 1997a. *Draft Final Work Plan, RCRA Facility Investigation of Landfills, NAS Fort Worth JRB, Texas*. June.
- HydroGeoLogic, Inc., 1997b. *Draft Work Plan, Site Investigation of Area of Concern 4, NAS Fort Worth JRB, Texas*. August.
- HydroGeoLogic, Inc., 1997c. *Draft Basewide Quality Assurance Project Plan, NAS Fort Worth JRB, Texas*. December.
- HydroGeoLogic, Inc., 1998a. *Final Basewide Groundwater Sampling and Analysis Program 1997 Annual Report*. April.
- HydroGeoLogic, Inc., 1998b. *Final Basewide Groundwater Sampling and Analysis Program Quarterly Monitoring Report, January 1998 Event*. July.
- HydroGeoLogic, Inc., 1998c. *Draft Basewide Groundwater Sampling and Analysis Program Quarterly Monitoring Report, April 1998 Event*. July.
- HydroGeoLogic, Inc., 1998d. *Draft Work Plans, RCRA Facility Investigation of Waste Accumulation Areas, NAS Fort Worth JRB, Texas*. August.
- HydroGeoLogic, Inc., 1998e. Direct communication. September 25.
- Intellus Corporation, 1986. *Interim Report for Ten-Site Field Investigation, Air Force Plant 4, Fort Worth, Texas*. November.
- IT Corporation, Inc., 1997. *Draft RCRA Facility Investigation Report, Sanitary Sewer System, NAS Fort Worth JRB, Texas*. September.
- Jacobs Engineering, 1995. *Removal/Closure of the Fuel Hydrant System, NAS Fort Worth JRB*. December.
- Jacobs Engineering, 1996. *Installation Restoration Program (IRP) Comprehensive Sampling Letter Report, Air Force Plant 4, Fort Worth, Texas*. May.
- Jacobs Engineering, 1998. Direct communication. October.
- Key, Lance (USAF), 1997. Direct communication. January.

- LAW, 1995a. *Installation Restoration Program (IRP) Oil/Water Separator Assessment Report, Naval Air Station Fort Worth, Joint Reserve Base, Carswell Field, Fort Worth, Texas.* August; revised November.
- LAW, 1995b. *Final-Revised Site-Specific Groundwater Analyses Letter Report Base-wide Quarterly Groundwater Monitoring, NAS Fort Worth, Carswell Field, Texas, in Final Scope of Documents,* March.
- LAW, 1996. *Installation Restoration Program (IRP) Base-wide Quarterly Groundwater Monitoring Second Semiannual Report, NAS Fort Worth, Carswell Field, Texas.* April.
- Ohio EPA, 1993. *Ohio EPA Technical Guidance Manual for Hydrogeologic Investigations and Groundwater Monitoring Programs.* June.
- Parsons Engineering Science, Inc. (Parsons), 1996. *Final Evaluation Report, Historical Data, Carswell Field Air Force Base, Fort Worth, Texas.* October.
- Parsons Engineering Science, Inc. (Parsons), 1998. *Draft Technical Report - The Geology of Air Force Plant 4 And Naval Air Station Fort Worth Joint Reserve Base, Fort Worth, Texas.* August.
- Perry Williams, Inc., 1994. *Petroleum Storage Tank Removal and Site Assessment at the Fuel Hydrant System.* Prepared for the U.S. Army Corps of Engineers.
- Radian Corporation, 1986. *Phase II Stage 1, Confirmation/Quantification Report.* Vol. I, II, and III. October.
- Radian Corporation, 1987. *Phase II Stage 2, Confirmation/Quantification Report, Health and Safety Plan.* October.
- Radian Corporation, 1989. *RI/FS, Stage 2, Draft Final Technical Report.* Vol. I-IX. April.
- Radian Corporation, 1991. *RI/FS, Stage 2, Final Report, Flightline Area.* October.
- Rust Geotech, 1996. *Assessment of Intrinsic Bioremediation, Air Force Plant 4.* September.
- Texas Natural Resource Conservation Commission, 1993. Letter, to Olen Long of Air Force Base Disposal Agency, Carswell Air Force Base. Subject: NFA Approval [of Waste Oil Dump St-17 AOC3] with Modifications. September 22.
- Texas Natural Resource Conservation Commission, 1995. Letter, to Olen Long of Air Force Base Disposal Agency, Carswell Air Force Base. Subject: Determination of a Need for an RFI and Current Condition Report. March 2.
- US Army Corps of Engineers (USACOE), 1992. *Spot 35, Carswell AFB, Results of Contamination Investigations.* November.
- US Army Corps of Engineers (USACOE), 1993. *Site Investigation, St-17, Waste Oil Dump [AOC3].* Fort Worth District. May.

- 
- US Army Corps of Engineers (USACOE), 1994. *Limited Site Assessment Report for UST Facility ID No. 1628, LPST ID No. 106684*. February.
- US Department of the Air Force, 1996. Final Record of Decision, Air Force Plant 4, Tarrant County, Texas. Prepared by Rust Geotech for the US Air Force. Signed by the USEPA Regional Administrator on August 26, 1996. July.
- US Environmental Protection Agency (USEPA), 1989a. RCRA Facility Assessment for Carswell Air Force Base. A.T. Kearney, Inc. March.
- US Environmental Protection Agency (USEPA), 1989b. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A. Interim Final. December.
- US Environmental Protection Agency (USEPA), 1991. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Supplemental Guidance, "Standard Default Exposure Factors". Interim Final. March.
- US Environmental Protection Agency (USEPA), 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. Ground Water Issue. EPA/540/5-95/504. April.
- US Environmental Protection Agency (USEPA), 1997. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. Draft Interim Final. September.
- US Environmental Protection Agency, 1997a. Health Effects Assessment Summary Tables. Office of Research and Development. Cincinnati, Ohio.
- US Environmental Protection Agency, 1998. Integrated Risk Information System Database, Office of Research and Development. Cincinnati, Ohio.
- US Geological Survey (USGS), 1995. Progress Memorandum. *Monitoring Well Completion Logs and Locations of Well Surveyed by U.S. Geological Survey at Air Force Plant 4 and Carswell Air Force Base*. October.
- US Geological Survey (USGS), 1996. Kuniarsky, E.L., Jones, S.A., Brock, R.D., and Williams, M.D., 1996. *Hydrogeology at Air Force Plant 4 and Vicinity and Water Quality of the Paluxy Aquifer Fort Worth, Texas*. United States Geological Survey, Water-Resources Investigation Report 96-4091. 41 p.
- US Geological Survey (USGS), 1998. West Fork Trinity River Surface Water Data for Gauging Station 08048000. Obtained from: [HTTP://WATERDATA.USGS.GOV/NWIS-W/TX/DATA.COMPONENTS/NMDMAP.CGI?STATNUM=08048000](http://WATERDATA.USGS.GOV/NWIS-W/TX/DATA.COMPONENTS/NMDMAP.CGI?STATNUM=08048000)
- Wiedemeier, T.H., Swanson, M.A., Moutoux, D.E., Gordon, E.K., Hansen, J.E., Hass, Wilson, J.T., Kampbell, D.H., and Chapelle, D.H., 1996. *Draft Technical Protocol for Natural Attenuation of Chlorinated Solvents in Groundwater*. Air Force Center for Environmental Excellence, Technology Transfer Division, Brooks Air Force Base.

**FINAL PAGE**

**ADMINISTRATIVE RECORD**

**FINAL PAGE**