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PHASE II REMEDIAL INVESTIGATION REPORT
FOR OPERABLE UNIT II
VERTAC SITE
JACKSONVILLE, ARKANSAS

Report, Volume I

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SECTION 1

INTRODUCTION

1.1 OVERVIEW

This document is the Remedial Investigation Report (RI Report) for the second phase (Phase II) of the remediation investigation (RI) for Operable II (OPII) at the property of the Vertac Chemical Corporation, Jacksonville, Arkansas (Site). This document is an addendum to the Phase I Remedial Investigation Report for Operable Unit II (Phase I RI Report), Vertac Site, Jacksonville, Arkansas (WESTON, 1992b). This document describes performance and results of activities required in the Work Plans for the Phase II Remedial Investigation (Phase II RI Work Plan; WESTON, 1991 and Addendum to Phase II RI Work Plan; WESTON, 1993), accepted by the United States Environmental Protection (U.S. EPA) on 9 September 1991 and acknowledged by the U.S. EPA, 5 March 1993.

This document was prepared in accordance with an Administrative Order on Consent (AO) signed by Hercules Incorporated (Hercules) and the U.S. EPA[1] on 12 July 1989. The purpose of the AO, in part, was to provide for the characterization of the nature and extent of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) distribution and that of other selected substances related to manufacturing and formulation activities performed at the Vertac Chemical Corporation property Jacksonville, Arkansas. Attachment A to the AO was the original Work Plan (WESTON, 1989a) that describes site remedial investigation/feasibility study (RI/FS) activities to be performed by Hercules. Section 5 of the original Work Plan described the RI activities for natural and manmade materials at or below the land surface that were investigated in Operable Unit II. These materials included surface soil and groundwater, which are the subjects of the Phase II investigation.

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[1]It is U.S. EPA's position that under the Consent Decree entered 18 January 1982 in United States v. Vertac Chemical Corporation et al., Nos. LR-C-80-109 (E.D. Ark.), U.S. EPA retained the right to issue Administrative Orders under CERCLA against Hercules with respect to the Vertac onsite and offsite areas. Hercules disagrees with this interpretation of the Consent Decree and maintains the position that under the Consent Decree, U.S. EPA must negotiate with Hercules regarding remedial action for onsite and offsite areas. If agreement cannot be reached, U.S. EPA must petition the Court for an order. However, for the purposes of this referenced Administrative Order only, Hercules has not challenged U.S. EPA's authority and jurisdiction to issue this Administrative Order.

The overall purpose of the second phase of the remedial investigations (Phase II RI) was to resolve data gaps remaining after completion of activities described in the original Work Plan (Section 5; WESTON, 1992a). Specifically, the objectives of the Phase II RI were to:

- Assess the vertical extent of contamination in groundwater below the depth of weathering.
- Evaluate the potential presence and migration of light and dense non-aqueous-phase liquids (LNAPLs and DNAPLs) within the central process area.
- Assess the importance of fracturing and stratigraphy on potential contaminant transport.
- Evaluate groundwater quality in bedrock west of Rocky Branch Creek near the western property boundary.
- Characterize the horizontal groundwater gradient within a hydrostratigraphic bedrock unit below the depth of weathering and west of Rocky Branch Creek.
- Evaluate for potential contamination of surface soils in the area of the Regina Paint building and a small area adjacent to Marshall Road. The Phase I and Phase II RI activities are cross referenced on Table 1-1. The Phase II RI was planned to compliment available information; was based on the results of the previous studies; and was performed in a manner consistent with methods used during the previous studies.

This document, the Phase II Remedial Investigation Report (Phase II RI Report) for Operable Unit II, was prepared in accordance with the provisions of the AO, the original Phase I RI Work Plan, the Phase II RI Work Plans (WESTON, 1991 and 1993), and recommendations from the Phase I RI Report (Section 5, WESTON, 1992b). This document: (1) summarizes the field techniques used to accomplish additional Operable Unit II activities described in the Phase II RI Work Plans; (2) describes the rationale used in adapting the requirements of the Phase II RI Work Plans, where

Table 1-1

Cross-Reference of the Phase I and Phase II Activities for the Remedial Investigations Vertac Site, Jacksonville, Arkansas

Phase I Activities	Phase II Activities
Surface Soils (Subsections 2.2, 3.2 and 4.2) Soil grids, 400 through 585 Test pits, TP-1 through TP-4	Surface soils (Subsections 2.2, 3.2, and 4.2) Soil grids, 586 through 588
Subsurface Soils (Subsections 2.3, 3.3, and 4.3) At-depth and composite soil borings, SB-1 through SB-71. Stratigraphic borings, XB-2 through XB-21	Subsurface Soils (Subsection 2.3, 3.3, and 4.3) Stratigraphic boring, XB-22 Monitoring wells, MW-85 through MW-98.
Groundwater (Subsections 2.4, 3.4, and 4.4) Monitoring well installation and groundwater sampling, MW-58 through MW-84. Slug tests, MW-58 through MW-84 Packer tests, XB-4, XB-5, and XB-9	Groundwater (Subsections 2.3, 3.3, and 4.3) Monitoring well installation and groundwater sampling, MW-85 through MW-98. Slug tests, MW-95 through MW-98. Rising Head Tests, MW-85 through MW-94. Pumping tests, MW-86, MW-88, MW-91, and MW-92 Test Pits, TP-5 through TP-14
Underground Storage Tanks (Subsection 2.5, 3.5, and 4.5) Soil borings, USTs 1 through 5	NA
Underground Utilities (Subsection 2.6, 3.6, and 4.6) Utilities survey	NA

Notes:
NA = No new activity during Phase II RI.

necessary, to account for conditions encountered in the field; (3) presents the data generated during field activities for the Phase II RI; (4) Summarizes analytical data for hazardous compounds and physical parameters from samples collected during the Phase II RI field activities. The data quality objectives applicable to the Phase II RI activities are listed in Subsection 1.1 of the Phase I RI Report (WESTON, 1992b).

This document was prepared as an addendum to the Phase I RI Report for Operable Unit II; therefore, it uses a format consistent with the Phase I RI Report and references the Phase I Report, where appropriate. The format of this document was selected to be consistent with the Phase I RI Report to facilitate integrating the data into a comprehensive picture of site conditions. References to the Phase I RI Report were used to the extent practical, to minimize repetition of information presented in the aforementioned report. Selected summary graphics from the previous documents were used to illustrate aspects of site conditions that are pertinent to the focus of this document. References to the Phase II RI Work Plan (WESTON, 1991) and the Addendum to the Phase II RI Work Plan (WESTON, 1993) were combined, as Phase II RI Work Plans, where appropriate, to reduce confusion in the report. Activities described in this document were performed in accordance with the AO, the Quality Assurance Project Plan (QAPP) (WESTON, 1989b), and the Health and Safety Plan (HASP) (WESTON, 1989c). The QAPP and HASP were written in accordance with the AO and were accepted by U.S. EPA on 10 October 1989.

Data from the Phase II RI will be incorporated into the baseline risk assessment and feasibility study activities for Operable Unit II media which are being performed separately and which will be submitted to the U.S. EPA under separate covers as described in the AO.

Hercules retained Roy F. Weston, Inc. (WESTON) to assist in performing the RI/FS. WESTON acknowledges the historical data and the field logistical support provided by Hercules which facilitated the timely completion of the field activities related to the Phase II RI. WESTON also acknowledges the support provided by U.S. EPA and their oversight contractor, CH2M Hill, in the coordination of field oversight activities.

1.2 REPORT ORGANIZATION

This Phase II RI Report evaluates data collected from past and present environmental studies at the Site to provide information to support the Feasibility Study. Section 2 of this report presents an overview of the Operable Unit II field activities, including a summary of field quality control measures for field and laboratory work. Section 3 is a summary of results and laboratory quality control measures. Section 4 presents discussion of results and conceptual models for surface soil and groundwater migration. Section 5 outlines recommendations. Section 6 lists pertinent references. References to personal communications are cited in the text and supported by information contained in project notes, including field notes and meeting notes.

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SECTION 2

FIELD ACTIVITIES

2.1 INTRODUCTION

This section describes the field activities performed in accordance with the Phase II RI Work Plan which describes activities for characterizing the extent of contamination in surface soils and groundwater. These field activities complete the sampling and delineation activities described in Section 2 of the Phase II RI Work Plan and the Addendum to the Phase II RI Work Plan. The approaches used in these additional investigations were selected based on the results of previous site investigations, as described in the Phase I RI Report. The procedures used in performing these investigations were in accordance with the original Work Plan, the Phase II RI Work Plan, the Addendum to the Phase II RI Work Plan, the Phase I RI Report, and industry standards.

Field activities for the Phase II RI began on 5 October 1991 and concluded on 26 February 1992. Field activities for the Addendum to the Phase II RI began on 5 April to 23 May 1993 and 29 November to 10 December 1993. The sequence and the performance periods of the Phase II RI field activities are listed below:

- Groundwater

- Test Pits	April 1993
- Well Installation	October 1991 through February 1992, April through May 1993
- Groundwater Sampling	December 1991 and February 1992, May 1993
- Rising Head Tests	December 1991 and January 1992, May 1993
- Pumping Tests	February 1992
- Dense Non-aqueous Phase Liquid Assessment	March 1992, December 1993
- Light Non-aqueous Phase Liquid Assessment	April and December 1993

- Surface Soil
  - Regina Paint Building Area — December 1991
  - Area Adjacent to Marshall Road — December 1991 and February 1992

A unique 16-character sample identification code was assigned to each sample collected during the Phase II RI (Appendix A). The sample identification coding system was identical to that used during the first phase of the RI (Subsection 2.1 and Appendix E of the Phase I RI Report), except that an additional sample type code (08) was added to accommodate a surface soil sample collected at depths from 0 to 1-inch along Marshall Road.

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2.2 SURFACE SOILS

2.2.1 Introduction

Surface soil sampling was performed in accordance with requirements in Subsection 2.2 of the Phase II RI Work Plan and applicable sections of the QAPP and HASP. Grid location and sampling procedures were the same as those described in the Phase I RI Report (Subsection 2.2). Sampling was performed using the systematic stratified approach applied to areas inside the central process area. The areas that were sampled and the rationale for sampling them are listed below:

- Area near the Regina Paint building, for assessment of the surface soil quality adjacent to and downslope from the building, where purportedly drums that probably once contained 2,4,5-T waste are stored (WESTON, 1992a).

- A strip, along the west side of Marshall Road, east of the drainage ditch and approximately 300 feet south of the main entrance road where previous results indicated a concentration of 2,3,7,8-TCDD at 6.3 ppb.

Field tasks involved in surface soil sampling included the following:

- Establishing grids near the Regina Paint building (Grids 586 and 587) and along Marshall Road (Grid 588).

- Laying out sample nodes within the grids.

- Selecting sampling locations around the sampling nodes.

- Sampling surface soils at the sampling locations within each grid.

2.2.2 <u>Sampling Program</u>

2.2.2.1 Regina Paint Building

Two grids were constructed in the vicinity of the Regina Paint building (Figure 2-1). Grid 586 was constructed around the perimeter of the building. The grid contained a ring of eleven evenly-spaced sampling nodes around the building. One of the sampling nodes was placed at the southeast corner at the entrance to the building, as specified in the RI Phase II Work Plan. Another node was placed on the east side of the building at the loading dock entrance ramp. Grid 587 was constructed downslope and to the south of Grid 586. Sampling nodes in Grid 587 were arranged in a rectangular grid pattern, as shown in Figure 2-4 of the Phase I RI Report.

2.2.2.2 Marshall Road

Based on discussions with U.S. EPA and Hercules, the area in Grid 529, along the west side of Marshall Road, was re-sampled using the systematic stratified sampling approach (Exner, et al., 1984). The purpose of this resampling was to confirm the previous results for samples collected at 0 to 6-inches which indicated a concentration of 2,3,7,8-TCDD at 6.3 ppb (Table 3-1 of the Phase I RI Report). The grid was re-numbered as Grid 588 and was re-sampled using the 3 composite sample approach so that a 95 percent upper confidence limit could be calculated. The grid was re-measured and staked based on field notes from the Phase I RI. The sampling nodes were evenly spaced along the north-south axis of the grid (Figure 2-1). This layout was selected to evaluate the distribution of 2,3,7,8-TCDD within the grid relative to distance from Marshall Road. The 'A' sample was closest to the road, and the 'C' sample was closest to the ditch. The layout for the elongated Grid 588 was patterned after the drainage grid layout described in the Phase I RI Report (Subsection 2.2.2.3). Two samples were collected in Grid 588; one at 0 to 1-inch in depth and the other at 0 to 6-inches in depth.

2.2.2.3 Sampling Procedure for Surface Soil

Surface soil samples from Grids 586, 587, and 588 were collected from 0 to 6-inches below land surface using the U.S. EPA-approved procedure described in the Phase I RI Report (Subsection 2.2.2.5). At Grid 588, soil samples were also collected from 0 to 1-inch below land surface using the same U.S. EPA-approved procedure for the samples collected at 0 to 6-inches below land surface (Phase I RI Report, Subsection 2.2.2.5). This sample was identified by placing "08" in the

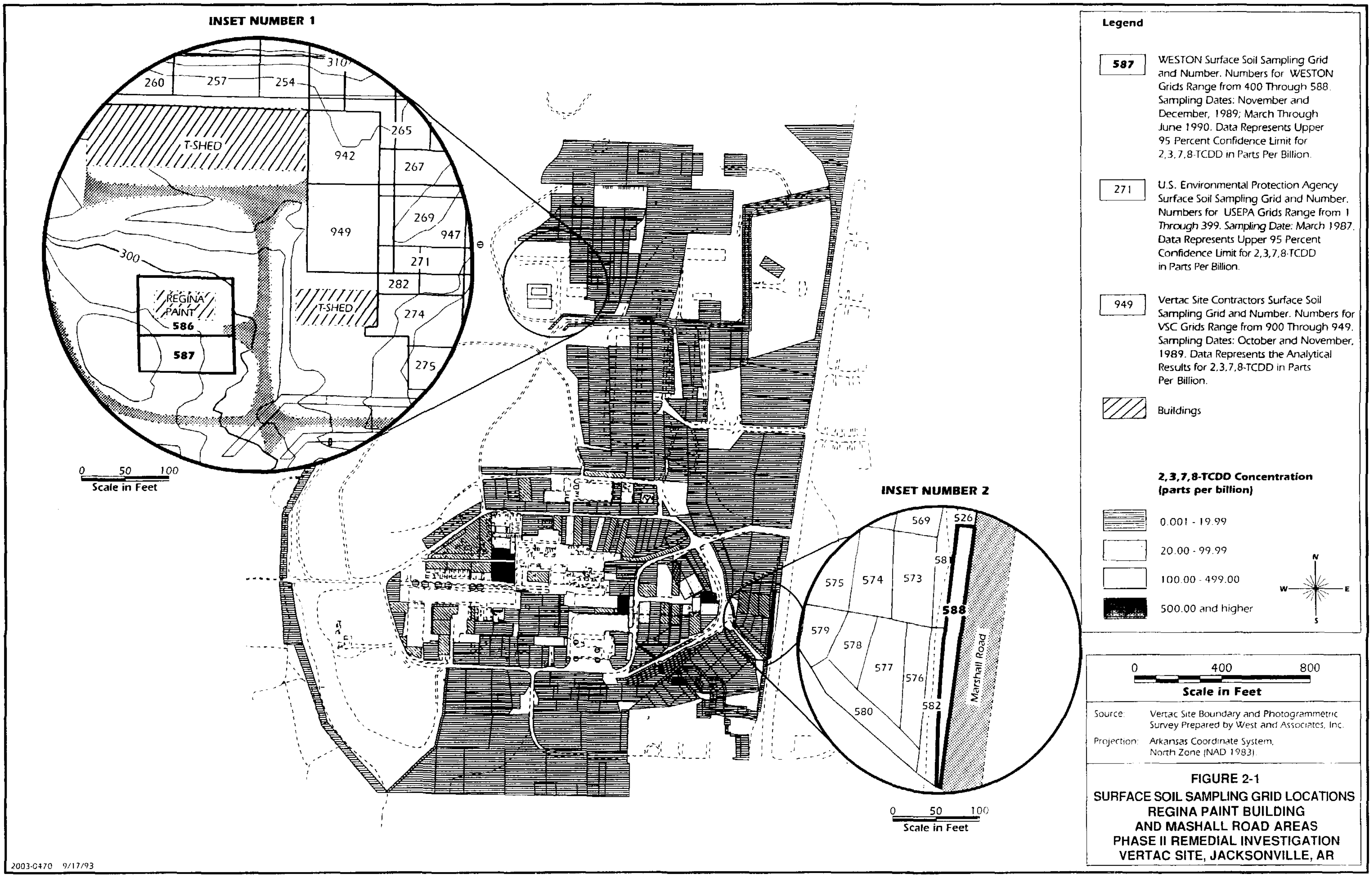


FIGURE 2-1
SURFACE SOIL SAMPLING GRID LOCATIONS
REGINA PAINT BUILDING
AND MASHALL ROAD AREAS
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

"sample type" field in the sample identification code (Appendix A). Samples from the Regina Paint building area (Grids 586 and 587) were collected for analysis of 2,3,7,8-TCDD, chlorophenols, and chlorophenoxyherbicides. Samples from the area along the west side of Marshall Road were collected for analysis of 2,3,7,8-TCDD.

2.2.2.4 Field Support Activities

Soil Grids 586 and 587 were completed with assistance from Hercules' site personnel who trimmed the vines and dense grasses prior to sampling. A pick that was used to dig small holes at the sampling locations was decontaminated using procedures described in Subsection 2.4.4. The grid corners were surveyed as described in Subsection 2.4.5.

2.3 GROUNDWATER

2.3.1 Introduction

Monitoring wells were installed, sampled, and tested to accomplish the Phase II RI objectives for groundwater. Those work objectives were as follows:

- Complete the characterization of horizontal and vertical hydraulic gradient below the depth of weathering.
- Evaluate hydraulic conductivity of the bedrock and potential for migration of the dissolved phase off-site to the east.
- Assess groundwater quality within the central processing area below the depth of weathering.
- Evaluate potential presence and migration of light and dense non-aqueous (immiscible) phase liquids (LNAPLs and DNAPLs) within the central process area.
- Assess the importance of fracturing and bedrock stratigraphy for potential contaminant transport.
- Assess groundwater quality west of Rocky Branch Creek, the horizontal groundwater gradient and the possible presence of floating product in suspect target areas.

To achieve these objectives, the following field activities were completed during the Phase II RI:

- Eleven test pits were constructed to observe the water entry zone and to evaluate the possible presence of LNAPL.
- Fourteen bedrock monitoring wells were installed.

- Groundwater samples were collected from each well and analyzed for site-related compounds.

- Synoptic groundwater levels were measured in each monitoring well.

- Four pumping tests were performed.

- Fourteen rising head tests and/or slug tests were conducted.

- Thirteen monitoring wells (Phase I and Phase II) and the Reasor-Hill well were checked for evidence of a light, non-aqueous phase liquid (LNAPL).

- Twenty-three monitoring wells (Phase I and Phase II) and the Reasor-Hill well were checked for evidence of a dense, non-aqueous phase liquid (DNAPL).

2.3.2 Assessment of Potential for Light, Non-aqueous Phase Liquids in Test Pits

2.3.2.1 Introduction

Eleven test pits were excavated to evaluate the possible presence of floating, light, non-aqueous phase liquids (LNAPLs) in selected areas of the Site. The evaluation for LNAPLs was performed because: (1) LNAPLs were observed in groundwater samples from the Reasor-Hill well where wastes were reportedly disposed; (2) the concentration of toluene in some groundwater samples was high relative to the saturation limit of toluene in water; and, (3) free-phase liquid seepage was observed by visible staining of the ditch foundation, on an historical basis, near the east end of central ditch. The potential for having toluene as an LNAPL was based on the use of toluene as a solvent in the manufacturing processes performed at the Site. Test pits were selected to evaluate the possible presence of LNAPLs because the test pits would provide a direct visual and chemical indication of whether LNAPLs were present. During excavation of the test pits, the five excavated soil samples that exhibited the highest readings of organic vapors were collected and submitted for chemical analysis. As a consequence of the results of the chemical analysis of soils for toluene (Subsection 3.3.3.2), soil and groundwater from test pits, TP-06 and TP-10, were re-evaluated by using a qualitative phase- separation test to evaluate whether or not a free phase

LNAPL was present. Excavation of the test pits and sampling of the soil was performed in accordance with the Work Plan, QAPP and HASP.

2.3.2.2 Locations

Five target areas were identified for evaluation of the possible presence of LNAPLs. These areas were selected based on: the presence of LNAPLs in some samples from the Reasor-Hill well; the concentration of toluene in groundwater samples from some wells (i.e., MW-71/MW-72, MW-80/MW-81 and MW-82) which appeared to be large in proportion to the saturation limit of toluene in water; and, stained seepage which was observed near the east end of the central ditch. Within each of the five target areas, two or three test pits were excavated. Within each area, one of the test pit locations was selected at an accessible point along strike with the location/point where an LNAPL or seepage was observed or where groundwater samples from a well had exhibited a high relative concentration of toluene. A second location was selected in an updip direction. The test pit locations were selected within about 40 feet of the reference well or seepage location. The identification numbers and rationale for each of the test pits are listed below:

- TP-05 and TP-06, excavated at accessible locations around the Reasor-Hill well to assess whether LNAPLs occur at the water table, because an LNAPL was observed in a groundwater sample from this well which was reportedly used for waste disposal (WESTON, 1992b).

- TP-07 and TP-08, excavated at accessible locations around monitoring wells MW-71 and MW-72 to assess whether LNAPLs occur at the water table because concentrations of toluene (440 parts per million (ppm) and 2.1 ppm, respectively; Table 3-13, Weston 1992b) measured in groundwater samples from these wells were large relative to the saturation limit of toluene in water.

- TP-09 and TP-10, excavated at accessible locations around monitoring wells MW-80 and MW-81 to assess whether LNAPLs occur at the water table because the concentration of toluene in MW-80 was 160 ppm (Table 3-13, Weston, 1992b) which is large relative to the saturation limit of toluene in water.

- TP-11 and TP-12, excavated at accessible locations around monitoring well MW-82 (120 ppm; Table 3-13, Weston, 1992b) to assess whether LNAPLs occur at the water table because the concentration of toluene measured in the groundwater sample from this well was large relative to the saturation limit of toluene in water.

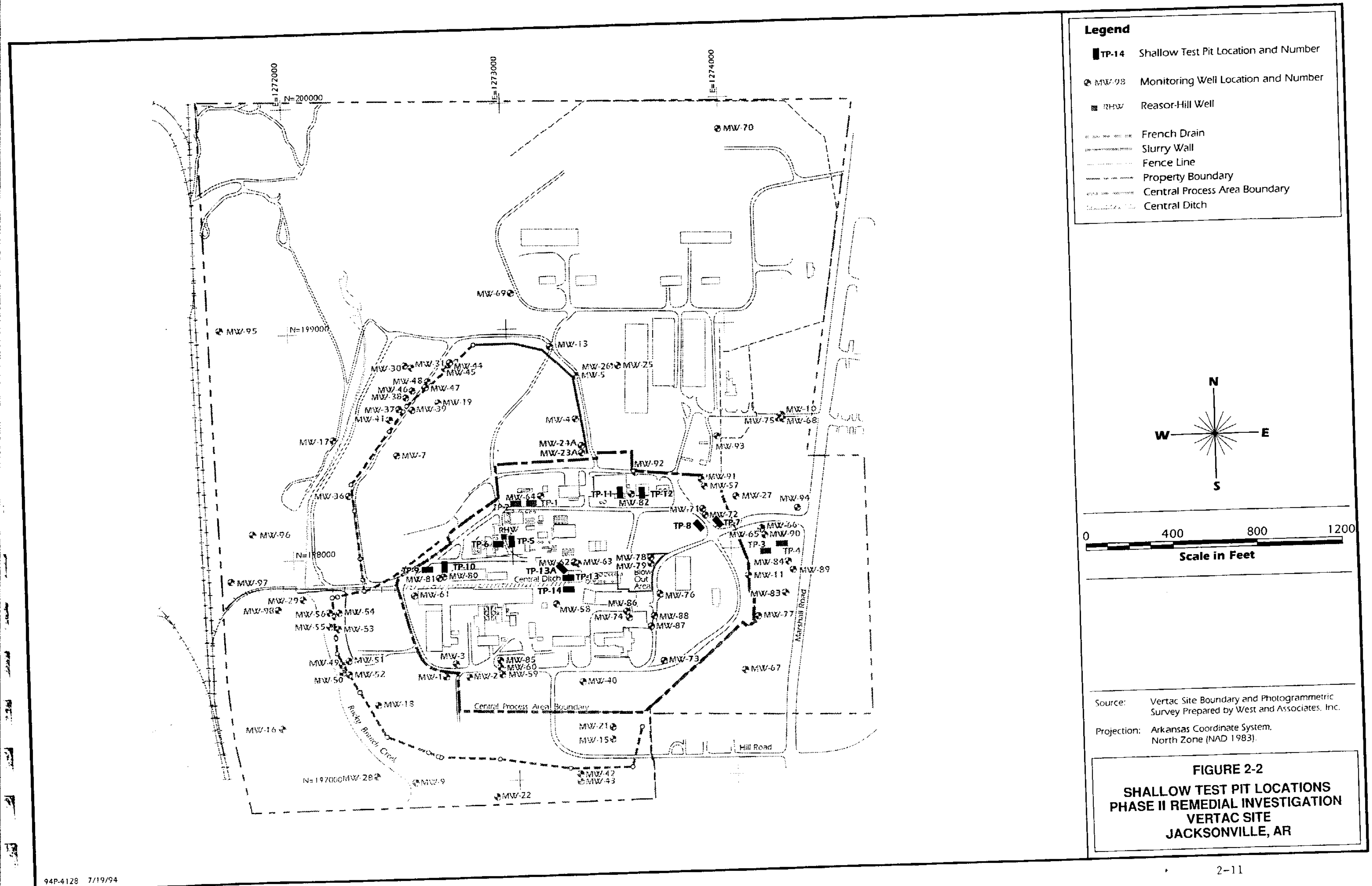
- TP-13A, TP-13, and TP-14, excavated at accessible locations near the east end of the central ditch to assess whether LNAPLs occur at the water table because stained seepage has been observed on an historical basis.

The locations of the test pits and the reference wells are shown on Figure 2-2. Prior to excavating the test pits, each location was cleared for underground utilities (Subsection 2.4.1).

2.3.2.3 Test Pit Excavation and Soil Sampling Procedure

Eleven test pits were excavated to assess whether or not LNAPLs are possibly present on the water table in the area near the Reasor-Hill well, MW-71/MW-72, MW-80/MW-81, MW-82, and the east end of central ditch. Two test pits were excavated near each of the wells, and three test pits were excavated near the east end of central ditch. A backhoe was used to excavate each test pit to a depth of about 2 feet below the level where saturated conditions or to a depth where bedrock was encountered, which ever was shallower. Excavated material was piled on plastic sheeting adjacent to the test pit. Subsurface soil samples were collected at one foot intervals below land surface down to the water entry zone. Soil samples were collected from the center of the backhoe bucket with a disposable stainless steel scoopula. The soil sample was put into a glass sample bottle, the bottle capped and shaken, then allowed to equilibrate for approximately twenty minutes. After each sample was allowed to equilibrate, the air in the headspace of the bottle was monitored for organic vapors with an organic vapor monitor (OVM). For each set of test pits, the soil sample with the highest organic vapor levels in the bottle headspace was submitted to the laboratory for analysis of toluene. During test pit excavation, particular attention was focused on water entry zones to assess whether LNAPLs could be observed as water entered the excavation. A summary of test pit locations, dimensions, and soil screening results is presented in Table 2-1. Stratigraphic logs for each of the test pits are contained in Appendix B.

Three test pits were excavated near the east end of the central ditch area. During the excavation of TP-13A near the east end of central ditch, bedrock was encountered at 6.5 feet below land



Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 2-2
SHALLOW TEST PIT LOCATIONS
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE
JACKSONVILLE, AR

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Table 2-1

Summary of Test Pit Screening Results
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Test Pit Number	Reference Location/ Relative Position/ Orientation of Test Pit[a]	Ground Surface Elevation (ft)[b][c]	Total Depth (ft)[b]	Water Entry Zone (ft)[d]	Interval Sampled (ft)[b]	Soil Headspace Reading (units)[e]	Sample Identification Number[f]	Field Obsevations 6-7 April 1993	Field Observations 12 April 1993	Field Observations 1 December 1993
TP-05	Reasor-Hill Well	286.60	5.8	4.0	0-1.0	0.0		Construction debris	Black-colored water	Gray-colored water
	SE (10)				1.0-2.0	20.0				DTW=1.4 feet[g]
	N-S				2.0-3.0	6.0		Stained soil	DTW = 2.3 feet[c]	Patch of sheen on water
					3.0-4.0	2.0				surface
					4.0-5.0	10.0				
					5.0-5.6	NA		Water entry zone		
								Bedrock refusal		
TP-06	Reasor-Hill Well	286.70	4.8	3.8	0-1.0	3.5			Oily sheen on water	
	SW (33)				1.0-2.0	45.0		Stained soil	surface	DTW=3 feet[g]
	E-W				2.0-3.0	733.0	HE-TP-006-S03-01		DTW = 3.2 feet[c]	WEZ=4 feet; light
					3.0-4.0	539.0	HE-TP-006-S03-02	Water entry zone		iridescent sheen on water
					4.0-4.8	400.0		Bedrock refusal		surface
TP-07	MW-71/MW-72	280.80	5.5	4.0	0-1.0	0.0		Conduit	Heavy, waxy,	NA
	E (25)				1.0-2.0	0.0			iridescent sheen	
	NW-SE				2.0-3.0	0.0			on water surface.	
					3.0-4.0	0.0			DTW = 0.5 feet[c]	
					4.0-5.0	0.0				
					5.0-5.5	NA		Water entry zone		
TP-08	MW-71/MW-72	280.90	7.0	4.8	0-1.0	0.0			Light, waxy,	NA
	W (50)				1.0-2.0	0.7			iridescent	
	NW-SE				2.0-3.0	0.7			sheen on water	
					3.0-4.0	2.0			surface.	
					4.0-5.0	158.0	HE-TP-008-S05-01	Water entry zone	DTW = land	
					5.0-6.0	100.0			surface.[c]	
					6.0-7.0	NA				

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Table 2-1 (Continued)

Summary of Test Pit Screening Results
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Test Pit Number	Reference Location/ Relative Position/ Orientation of Test Pit[a]	Ground Surface Elevation (ft)[b][c]	Total Depth (ft)[b]	Water Entry Zone (ft)[d]	Interval Sampled (ft)[b]	Soil Headspace Reading (units)[e]	Sample Identification Number[f]	Field Obsevations 6-7 April 1993	Field Observations 12 April 1993	Field Observations 1 December 1993
TP-09	MW-81	281.20	6.0	5.0	1.0-2.0	0.0		Asphalt cap	Oily sheen on water	
	W (10)				2.0-3.0	0.0			surface	
	E-W				3.0-4.0	2.0		Water entry zone	DTW = 3.5 feet[c]	DTW=3.2 feet[g]
					4.0-5.0	2.0		Bedrock refusal		
					5.0-6.0	5.0				
TP-10	MW-81	281.60	6.5	5.5	1.0-2.0	49.0		Asphalt cap	Oily sheen on water	Green-black-colored water
	N (20)				2.0-3.0	154.0			surface	DTW=2.3 feet[g]
	N-S				3.0-4.0	190.0			DTW = 3.3 feet[c]	WEZ=5 feet; light
					4.0-5.0	1109.0				iridescent sheen on water
					5.0-6.0	1761.0	HE-TP-010-S05-01	Water entry zone		surface
					6.0-6.5	1100.0		Bedrock refusal		
TP-11	MW-82	288.80	8.0	6.0	1.0-2.0	0.0			Oily sheen on water	NA
	W (10)				2.0-3.0	0.0			surface	
	N-S				3.0-4.0	0.0			DTW = 4.4 feet[c]	
					4.0-5.0	2.1				
					5.0-6.0	256.0				
					6.0-7.0	314.0	HE-TP-011-S06-01	Water entry zone		
					7.0-8.0	200.0				
TP-12	MW-82	288.70	7.0	5.5	1.0-2.0	0.0			Oily sheen on water	NA
	E (10)				2.0-3.0	0.0			surface	
	N-S				3.0-4.0	0.0			DTW = 4.4 feet[c]	
					4.0-5.0	0.0				
					5.0-6.0	0.0				
					6.0-7.0	0.0		Water entry zone		

Table 2-1 (Continued)

Summary of Test Pit Screening Results
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Test Pit Number	Reference Location/ Relative Position/ Orientation of Test Pit[a]	Ground Surface Elevation (ft)[b][c]	Total Depth (ft)[b]	Water Entry Zone (ft)[d]	Interval Sampled (ft)[b]	Soil Headspace Reading (units)[e]	Sample Identification Number[f]	Field Obsevations 6-7 April 1993	Field Observations 12 April 1993	Field Observations 1 December 1993
TP-13A	Central Ditch	283.90	6.5	NE	1.0-2.0	0.0			DTW = 3.8 feet[c]	NA
	N (50)				2.0-3.0	10.0				
	NW-SE				3.0-4.0	38.0				
					4.0-5.0	45.0				
					5.0-6.0	42.0				
					6.0-6.5	35.0		Bedrock refusal		
TP-13	Central Ditch	282.00	4.6	2.5	1.0-2.0	NA			Oily sheen on water	NA
	N (3)				2.0-3.0	NA			surface	
	E-W				3.0-4.0	NA			DTW = 1.6 feet[c]	
					4.0-4.6	NA				
TP-14	Central Ditch	281.70	4.5	3.5	1.0-2.0	2.0		Asphalt cap	DTW = 2.1 feet[c]	NA
	S (3)				2.0-3.0	254.0				
	E-W				3.0-4.0	366.0	HE-TP-014-S03-01	Water entry zone		
					4.0-4.5	NA		Bedrock refusal		

Notes:
- a = Approximate distance from test pit to monitoring well or other geographic reference feature (in feet) is shown in parentheses.
- b = Measured in feet below land surface.
- c = Measured in feet above mean sea level as referenced from the northeast corner of each test pit. Survey data was provided by The Mehlburger Firm.
- d = Approximate depth to groundwater measured in feet below land surface.
- e = Organic vapor concenration in sample bottle headspace. Concentration measured with a photo-ionizing detector (OVM) and reported in units above background. The sample with the highest ocncentration of organic vapors was analyzed for toluene.
- f = Refer to Appendix A for explanation of the sample identification number.
- g = Measrement was obtained prior to dewatering the test pit. Measured in feet above mean sea level as referenced from the south side of each test pit.

DTW = Depth to water.
NA = Not applicable.
NE = Not encountered.
WEZ = Water entry zone.

surface (BGS). Groundwater was not observed during the excavation of TP-13A. Groundwater was not encountered when TP-13A was excavated; however, some water eventually entered the test pit after the excavation had been open for more than a day. On 12 April, a month after TP-13A was excavated, the water level was about 3.8 feet below ground surface as a result of spring rainfall. To assess the potential for LNAPLs at the groundwater table, another test pit, TP-13, was closer to the east end of the central ditch. TP-13 was excavated on the northern slope at the east end of the central ditch, approximately 3 feet north of the axis of the central ditch. During the excavation of TP-13, flowing water was encountered at approximately 2.5 feet. The water flowed directly into the excavation from beneath the base of the concrete foundation which is situated between TP-13 and the acid building. Based on the field observations (i.e., high rate of flow and location where water entered TP-13), the water appeared to be surface water discharging from the base of the building foundation and was not groundwater. The location of the water flow at the base of the concrete and the relatively high rate of flow prohibited the collection of representative soil samples from TP-13. Soil samples were collected, however, from TP-14 which was located on the southern slope of the central ditch. The water entry zone in TP-14 was observed at 3.5 feet. It was decided that this water entry zone was more representative of groundwater conditions at the east end of the central ditch based on the slow rate of groundwater flow into the excavation relative to TP-13. The water entry zone in TP-14 was observed in the south sidewall from within the soil. Subsurface samples collected from TP-14 were screened for organic vapors. One sample was submitted for the analysis of toluene based on the level of organic vapors in the headspace of the sample bottle. TP-13 and TP-14 were excavated in soil to a depth at least two feet below the bottom of the central ditch.

2.3.2.4 Phase-Separation Test Procedure

Two test pits were re-evaluated to collect soil and groundwater samples for a qualitative phase-separation test to evaluate whether or not a LNAPL was present. The phase-separation test was adapted from the procedure described in Cohen, et al. (1992) in which soil and water samples were subjected to several qualitative tests. Test pits, TP-06 and TP-10, were chosen for the phase-separation test because analytical results of soils from test pits TP-06 (30 ppm) and TP-10 (110 ppm) indicated that toluene was present in the subsurface soils at elevated concentrations (Table 3-6, Subsection 3.3.3.2). Depth to water, presence of an iridescent or oily sheen on the water surface, and water color were noted prior to pumping water from the test pit. A sump pump was used to remove groundwater from each test pit prior to the excavating the sidewalls of the test pit to expose a fresh cut of soil. Groundwater from TP-06 was pumped into drums for transfer to the water treatment plant. Groundwater from TP-10 was pumped into the nearby surface water sump ("central sump"). A backhoe was used to expose fresh soil along the east sidewall of TP-10 and the south sidewall of TP-06. The excavations were completed to a depth of 1-foot below the water entry zone. Subsurface soil samples were collected at one-foot intervals below the surface gravel layer down to the water entry zone. Soil samples were collected from the center of the backhoe bucket with a decontaminated stainless steel scoop. The soil sample transferred to a glass bottle. A groundwater sample was collected from the water entry zone using polyethylene dipper with a 12-foot handle. Both soil and water samples were stored in the onsite sample refrigerator until the phase-separation tests were run. Initial visual observations noted at the time of sample collection included: depth of the water entry zone, presence of an iridescent or oily sheen on the groundwater surface, and presence of soil staining. The visual observations are summarized in Table 2-1.

The phase-separation test consisted of the following steps:

- Visual examination for stained soil, residual product, or free liquid product.
- Shortwave (254 nanometers (nm)) and longwave (300-400 nm) ultraviolet light fluorescence examination.
- Hydrophobic dye shake test.

The phase-separation tests were performed in the Supervisor's building where the lights could be turned off to provide a dark environment for examining the samples for fluorescence under an ultraviolet light. The samples were kept under refrigeration for two days until the initiation of the test. The following procedures were completed during the phase-separation tests:

- Allowed sample to equilibrate to room temperature.
- Screened sample bottle headspace for organic vapors using a portable organic vapor analyzer (OVA).
- Transferred a uniform volume of soil from each sample bottle to a Ziploc-type bag.

- Observed the soil and water samples under plain light, shortwave (254 nm), and longwave ultraviolet (300-400 nm) light. The ultraviolet light was produced using an UVGL-48 Multi-Band Lamp (Ultra-Violet Products, Inc.). 003311

- Transferred a uniform volume of soil from each sample bottle to a new clear, colorless glass bottle.

- Transferred a uniform aliquot of settled and agitated groundwater samples to new, clear, colorless glass bottles.

- Transferred a uniform aliquot of deionized water to each test sample.

- Added a uniform volume of Sudan IV dye (an hydrophobic dye) to each test sample and capped each bottle.

- Agitated each bottle to mix the dye with the soil or water sample.

- Observed the soil and water samples for evidence of reactions with the hydrophobic dye.

Visual examination of soil samples from TP-6 indicated that a dark gray tar-like solid was present in the soil pores from 2 to 3 feet below land surface (Table 2-2). Examination of the groundwater sample collected indicated that a light iridescent sheen was present on the water surface at the time of collection (Table 2-1) prior to testing the groundwater. A thin pale yellow liquid was observed on top of the water sample (Table 2-2). The ultraviolet light fluorescence examination indicated that only individual sand grains fluoresced under both short- and longwave ultraviolet light. No response was observed by the shake test with hydrophobic dye. The results of the phase-separation tests for TP-10 indicate that residual NAPLs may be present in some subsurface soils based on visual observations of thin films on the groundwater within the test pits, but such residual NAPLs, if present, were not observed in the phase-separation tests.

Examination of soil samples from TP-10 indicated NAPL was not present based on visual observations (Table 2-2), though an oily liquid was observed on a tree limb in the fill from 4 to 5

Table 2-2

Summary of Observations Made During the Assessment for Presence of Residual Phases in Soil[a]
December 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Sample Location/ Sample Interval[b]	Matrix	Headspace Reading[c] (units)	Visual Examination[d]	Ultraviolet Light Fluorescence Examination[e] Shortwave/Longwave	Shake Test with Hydrophobic Dye[f]
Test Pit, TP-06					
0-1	Gravel	NA	Sample was not collected.	NA/NA	NA
1-2	Soil	38	C	No[g]/No[g]	No response
2-3	Soil	200	B, Dark gray tar-like solid in soil pores.	No[g]/No[g]	No response
3-4	Soil	4	B, Sample was collected near the water entry zone.	No[g]/No[g]	No response
Groundwater	Water	720	A, Iridescent sheen on water surface at time of collection, thin pale yellow liquid on top of water sample.	NA/NA	No response
Test Pit, TP-10					
0-1	Gravel	NA	Sample was not collected.	NA/NA	NA
1-2	Soil	7	C	No/No[g]	No response
2-3	Soil	24	C	No/No[g]	No response
3-4	Soil	30	C	No/No[g]	No response
4-5	Soil	56	B, Oily liquid on tree limb found in the fill.	No/No[g]	No response
5-6	Soil	5	B, Sample was collected near the water entry zone.	No[g]/No[g]	No response
Groundwater	Water	520	A, Iridescent sheen, pale yellow-gray liquid on top of water sample.	NA/NA	No response
Background Sample No. 1[h]	Soil	NA	C	No[g]/No[g]	No response
Background Sample No. 2[i]	Soil	NA	C	No[g]/No[g]	No response

Table 2-2 (continued)

Summary of Observations Made During the Assessment for Presence of Residual Phases in Soil[a]
December 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Notes:

a = Qualitative phase separation tests were adapted from: Cohen, R.M., A.P. Bryda, S.T. Shaw, and C.P. Spalding. 1992. "Evaluation of Visual Methods to Detect NAPL in Soil and Water". Ground Water Monitoring Review, Volume 12, Number 4, pp. 132-141.

b = Measurement in feet below land surface.

c = Organic vapor concentration measured in sample bottle headspace. Concentration measured with a flame-ionizing detector (OVA) and reported in units above background.

d = Test qualifiers:
A = NAPL present based on visual observations.
B = NAPL presence suspected based on visual observations.
C = No visual evidence of NAPL.
NA = Not applicable

e = Ultraviolet light fluorescence examination was performed using an UVGL-48 Multi-Band Lamp (Ultra-Violet Products, Inc.) using a filter to produce shortwave (254 nanometers) and longwave (300-400 nanometers) ultraviolet light. This is a visual test; therefore potential exists for some subjective differences among operators.

f = Hydrophobic dye: Sudan IV, J.T. Baker Product No. V141-03.

g = Individual sand grains fluoresced a blue-white color in the presence of ultraviolet light.

h = Sample collected west of Rocky Branch Creek and north of the railroad spur. Sample depth: 0-2 inches below land surface.

i = Sample collected west of MW-95. Sample depth: 0-2 inches below land surface.

feet below land surface. Examination of the groundwater sample collected indicated that a light iridescent sheen was present on the water surface at the time of collection (Table 2-1). Prior to testing the groundwater, a thin, pale yellow-gray liquid was observed on top of the water sample (Table 2-2). The ultraviolet light fluorescence examination indicated that individual sand grains fluoresced under longwave ultraviolet light for each of the soil samples. The soil sample from 5 to 6 feet indicated individual sand grain fluorescence under shortwave ultraviolet light. No response was observed by the shake test with hydrophobic dye. The results of the phase-separation tests for TP-10 indicate that residual NAPLs may be present in some subsurface soils based on visual observations of thin films on the groundwater within the test pits, but such residual NAPLs, if present, were not observed in the phase-separation tests.

Visual observations from the phase-separation test were recorded in a project notebook and summarized in Table 2-2. Samples used to perform the phase-separation test were stored in a sample refrigerator at the Site. Photographs were taken following the excavation of the test pits and of the hydrophobic dye test samples. These photographs are maintained in WESTON's project files. The test pits were closed upon the completion of the phase-separation test. The test pits were closed by filling each excavation with the spoil material. To the extent practical, the spoil materials were returned to the test pits in the reverse order than they were excavated.

2.3.2.5 Field Support Activities

Test pits TP-5 through TP-14 were excavated and closed with assistance from Hercules' site personnel who operated the backhoe. Groundwater was evacuated from TP-6 and TP-10 with assistance from Hercules' site personnel who operated the sump pump. Utility clearances were obtained for overhead and underground utilities as described in Subsection 2.4.1. The stainless steel scoopulas and scoops that were used to collect soil samples were decontaminated using procedures described in Subsection 2.4.4. The locations of the test pits were surveyed as described in Subsection 2.4.5.

2.3.3 Drilling Program

2.3.3.1 Locations

Locations for groundwater monitoring wells were selected to achieve the Phase II groundwater objectives and were based on the specific rationale described in the Phase II RI Work Plans. To adjust for field conditions, the locations of six wells (MW-86, MW-93, MW-94, and MW-96) were moved to new locations from the locations shown in the Phase II RI Work Plans. The new locations were approved based on consultation between Hercules and U.S. EPA (personal communications, 1989, 1992 and 1993; and Subsection 1.9.3.4).

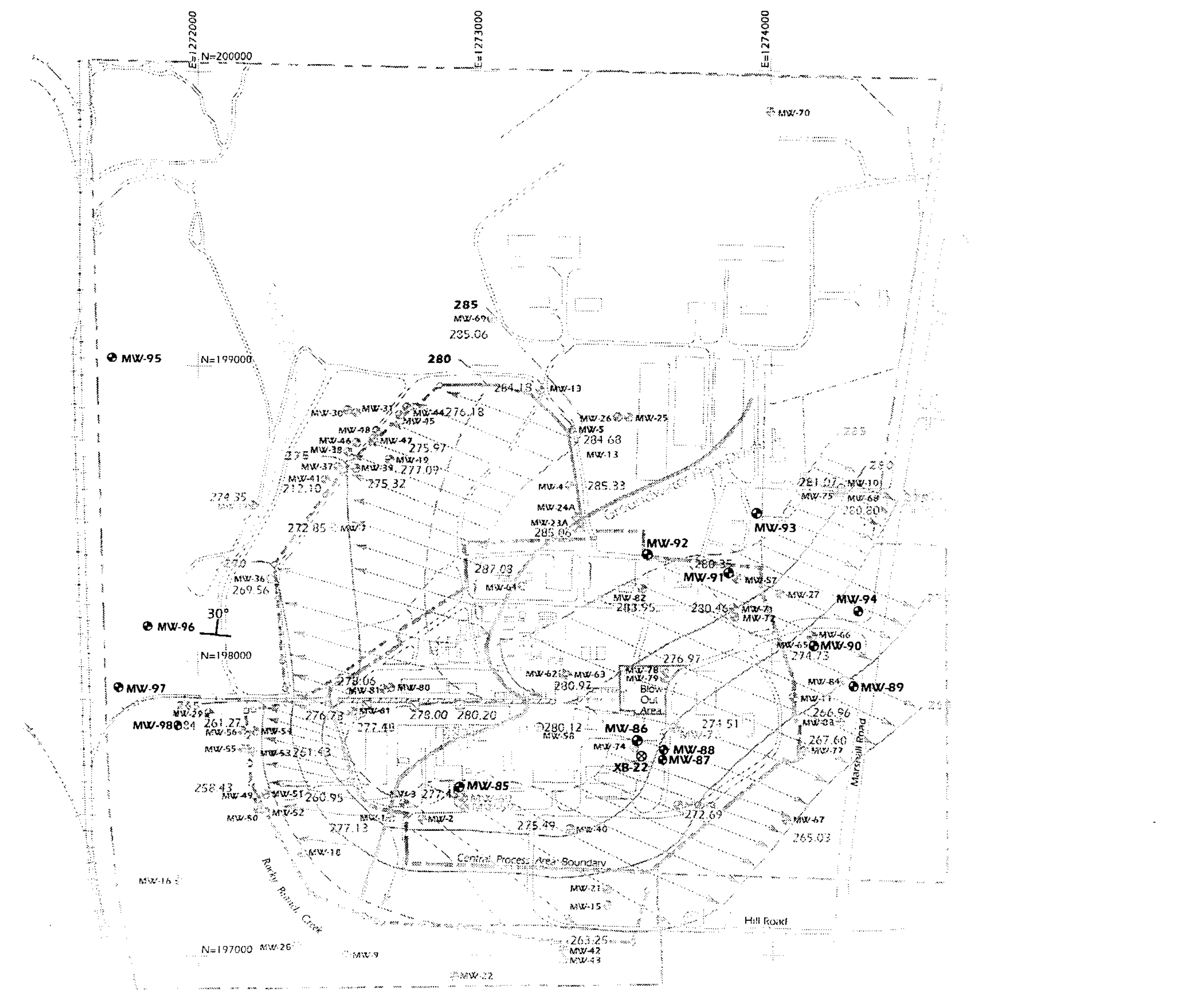
The location for MW-86 was moved about 22-feet north of the original location to be on strike with MW-88 and drilled to monitor similar stratigraphic units. The location was moved based on the detailed stratigraphic correlations developed from cores at the original location of MW-86, MW-87, and MW-88. The visual correlation indicated that strike and dip in the area of the administration building were about N85°W and 28°N. This strike and dip were used for locating the other wells installed during the Phase II RI. The original location of MW-86 was subsequently abandoned (Subsection 2.4.3) and the location was re-named stratigraphic boring XB-22.

In accordance with the initial Phase II RI Work Plan, MW-93 and MW-94 were not drilled east of Marshall Road because no evidence of contamination was observed during drilling of MW-86, MW-87, or MW-88. Based on the evidence of contamination during drilling of MW-91, however, MW-93 and MW-94 were installed at locations down dip and along strike from MW-91, respectively. These locations were selected with the concurrence of U.S. EPA.

The field locations of MW-97 and MW-98 were moved from the preliminary locations shown in the Addendum to the Phase II Work Plan, based on field conditions. The location of MW-97 was moved about 100 feet north of the railroad siding location to be on strike with the former equalization basin based on extrapolation of strata exposed in Rocky Branch Creek. The location of MW-98 was moved east 80 feet (i.e., toward Rocky Branch Creek) because wet field conditions prohibited access to the proposed location. An additional 10 feet of core was cut in MW-98 to establish the stratigraphic correlation of a sandstone encountered at the bottom of MW-98.

The locations for the fourteen monitoring wells and one stratigraphic boring that were installed during the Phase II RI are shown in Figure 2-3. The locations were based on the following rationale:

- MW-85, nested with MW-59 and MW-60 to monitor groundwater in bedrock below the depth of weathering.



Legend

- MW-85 — Monitoring Well Location and Number, Phase II Remedial Investigation
- XB-22 — Stratigraphic Boring Location and Number
- Existing Monitoring Well Location and Number
- Groundwater Elevation Contour (Measured in Feet Above Sea Level) Contour Interval: 5 Feet; Contour Dashed Where Approximate
- Land Surface Elevation (Surveyed) Along Railroad Tracks Within Central Ditch
- Groundwater Flow Line Corrected For 11.8:1 Average Anisotropy
- Groundwater Flow Divide
- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch

30°

Strike: N70°W
Dip: 30°NE

N E S W

0 400 800 1200

Scale in Feet

Note: Groundwater Elevation Data Collected on 26 November 1990 by Hercules Site Personnel. Flow Net Corrected for Anisotropic Flow. See Appendix U Phase I RI WESTON, 1992 for Derivation. Map was completed using wells in the weathered Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 2-3
MONITORING WELL AND STRATIGRAPHIC BORING LOCATIONS
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

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- MW-86, nested with MW-74 and along strike with MW-88 to monitor groundwater in bedrock below the depth of weathering.

- MW-87, located up dip from MW-88 and drilled to the depth of equivalent stratigraphic units.

- MW-88, located on strike with MW-86 and drilled to a depth of equivalent stratigraphic units.

- MW-89, nested with MW-84 to monitor groundwater in bedrock below the depth of weathering, down dip from MW-83.

- MW-90, nested with MW-65 and MW-66 to monitor groundwater in bedrock below the depth of weathering, and equivalent to the down dip projection of MW-84.

- MW-91, nested with MW-57 and along bedding strike with MW-92 to monitor groundwater in bedrock below the depth of weathering, down dip from MW-71 and MW-72.

- MW-92, located along fracture strike, southeast of the MW-23A/MW-24A well nest and along bedding strike with the MW-57/MW-91 well nest to monitor groundwater in bedrock below the depth of weathering, down dip from MW-82.

- MW-93, located down dip from MW-91.

- MW-94, located along bedding strike with MW-91.

- MW-95, located along strike with the seep in the closed cooling pond area and along fracture strike with the MW-23A/MW-24A well nest to monitor groundwater below the depth of weathering along the western property boundary.

- MW-96, located along strike with the Reasor-Hill well and along fracture strike with the central ditch to monitor groundwater below the depth of weathering along the western property boundary.

- MW-97, located along the western property boundary and along strike with the former equalization basin to monitor groundwater below the depth of weathering within the same water-bearing zone and at the same subsurface elevation as MW-98.

- MW-98, located along strike with the former equalization basin to monitor groundwater below the depth of weathering within the same water-bearing zone and at the same subsurface elevation as MW-97.

- XB-22, nested with MW-74 and used for stratigraphic control in selecting the location for MW-86.

The drilling locations were cleared for utilities (Subsection 2.4.1) and obstructions (i.e., trees and branches). Access to some of the monitoring well locations required use of SB or B grade limestone gravel, 3/4-inch plywood, and/or local "red clay" soil (borrowed from a location south of MW-97 along the western property boundary).

2.3.3.2 Procedures

2.3.3.2.1 Construction of Monitoring Wells, MW-85 through MW-94

The drilling was performed using two drilling rigs: a Gardner-Denver 500 and a Failing 1500. During the initial stage of Phase II RI fieldwork, drilling activities were performed using both rigs. The Gardner-Denver 500 was used to drill pilot-holes, core, and ream small holes. The Failing 1500 was used to ream large holes. During the later stages of field work, the Failing 1500 was used to complete coring and reaming.

The Gardner-Denver 500 was used to perform the following activities:

- Installing temporary casing.

- Collecting cuttings from the overburden and weathered bedrock.
- Coring.
- Reaming the open-hole portion at MW-85, MW-87, MW-89, MW-90, and MW-91.

The Failing 1500 was used to perform the following activities:

- Installing temporary casing at MW-92, MW-93 and MW-94.
- Collecting cuttings from the overburden and weathered bedrock at MW-92, MW-93, and MW-94.
- Reaming 7.88, 11.88, 12.5 and 17.0-inch boreholes, as appropriate.
- Installing 8 and 12-inch low carbon steel well casings.
- Coring activities at MW-92, MW-93 and MW-94 locations.
- Reaming the open-hole portion at MW-86, MW-88, MW-92, MW-93 and MW-94.

2.3.3.2.2 Construction of Monitoring Wells, MW-95 through MW-98

One drilling rig was used to perform drilling and well installation during the second stage of the Phase II RI fieldwork. A Failing 1500 was used to perform the following activities:

- Installing temporary casing.
- Collecting cuttings from the overburden.
- Coring.
- Reaming 6.13-inch boreholes.
- Installing 4-inch, low carbon steel well casing.
- Coring the open-hole portion of MW-95, MW-96, MW-97, and MW-98.
- Air surging the new wells, to develop them.

2.3.3.3 Coring

Coring was completed to obtain a visual rock record at the well locations. At well locations near a borehole that was cored previously, coring was performed below the depth of the previous coring and a cross-reference to the description of the previous core was provided in the log. The cores were inspected to evaluate the degree of fracturing which was one of the criteria used to select the depth of casings and wells. Cores within weathered bedrock were used to identify the base of the weathered zone, delineated by the absence of orange staining on bedding planes and fractures. Borehole completion information, including the depths of the cored intervals and orange staining, is listed in Table 2-3.

Coring was performed for monitoring well locations, MW-85 through MW-94 using NX (3-inch O.D.) coring apparatus, fitted with a 10-foot solid sleeve. Water-wash drilling techniques were used to lubricate the coring apparatus. Coring was performed inside a temporary, low-carbon steel surface casing. The temporary casing was used to prevent caving of the unconsolidated sediments and highly fractured, weathered bedrock and to facilitate water circulation during coring activities. The temporary casing was placed at depths ranging from 14.5 to 80-feet below land surface with casing stick-ups from 0.5 to 1.5 feet above land surface. The temporary surface casing was removed prior to reaming the borehole and installing the wells.

Monitoring wells MW-95, MW-96, MW-97, and MW-98 were cored using a NX (3.88 inch O.D.) coring apparatus, fitted with a 5- or 10-foot length split inner sleeve. Air or water-wash drilling techniques were used to lubricate the coring apparatus. Water-wash coring was used above the water table to minimize dust. Coring was performed inside a 6-inch, Schedule 40, PVC, temporary surface casing. The casing was used to prevent caving of the unconsolidated sediments and highly fractured weathered bedrock, and to facilitate circulation during coring activities. The temporary casing was placed at 16 feet below land surface. The temporary surface casing was removed prior to reaming the borehole. Upon recovery, the cores and rock fractures were scanned for organic vapors by using a portable organic vapor analyzer (OVA) with a flame ionizing detector (FID) and/or a photoionizing detector (PID). The readings were recorded in units above background on the logging forms and in the field logbook. The cores were rinsed with water, visually described, and placed in wooden core boxes while preserving the orientation, to the extent practical. The core boxes were labeled with the monitoring well or stratigraphic boring identification number, depth interval, and top of the core. The core for MW-91 interval 80.4 to 101.4 feet was spilled on 28 January 1992. The core was returned to the storage box as best possible. The cores were photographed and were stored on-site. The cuttings and drilling fluid generated from the core holes for monitoring wells MW-95 through MW-98 were not contained, since the photoionizing detector did not record any positive organic vapor readings from the cores, cuttings, or fluid during drilling.

Table 2-3

Summary of Borehole Completion Information
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well or Soil Boring Number	Well Completion Date	Ground Surface Elevation[a,b]	Total Well Depth[c]	Cored Interval[c,d]	Drilled Interval[c]	Base of Orange Staining[c]	Borehole Diameter[e]	Bottom of Casing[c]	Casing Diameter[e]	Casing Type[f]	Surface Coordinates[b,g] Northing	Easting
MW-85	10-24-91	283.00	101.2	40.0-101.2	0-80.0	NR	12.5	78.7	8	LCS	197522.80	1272904.48
					80.0-101.2		7.88					
MW-86	11-24-91	282.14	131.0	60.4-130.9	0-101.0	81.7[h]	12.5	100.4	8	LCS	197719.71	1273526.47
					101.0-131.0		7.88					
MW-87	11-06-91	280.14	100.5	29.3-99.5	0-80.0	53.4[h]	12.5	78.3	8	LCS	197657.26	1273604.35
					80.0-100.5		7.88					
MW-88	11-22-91	280.57	131.6	14.5-131.2	0-102.0	31.0[h]	12.5	100.8	8	LCS	197706.96	1273627.32
					102.0-131.6		7.88					
MW-89	11-11-91	271.60	94.9	25.3-95.3	0-61.0	85.0[h,i]	12.5	60.9	8	LCS	197928.90	1274266.05
					61.0-94.9		7.88					
MW-90	11-08-91	277.00	101.8	40.6-99.8	0-80.0	53.0[h]	12.5	80.0	8	LCS	198076.50	1274145.39
					80.0-101.8		7.88					
MW-91	11-07-91	283.40	114.1	60.5-110.8	0-80.0	NR	12.5	79.4	8	LCS	198286.47	1273880.27
					80.0-114.1		7.88					
MW-92	01-31-92	287.50	126.4	20.0-38.5	0-38.5	22.4[j]	17.5	38.5	12	LCS	198360.13	1273599.17
				40.5-79.8	38.5-80.4		11.9	80.3	8	LCS		
				79.8-100.0	80.4-126.4		7.88					
				100.5-125.0								
MW-93	01-29-92	286.10	242.0	162.0-192.5.0	0-18.5	NR	12.5	18.5	6	GALV	198496.76	1273934.72
				192.5-241.4	18.5-189.0		7.88	189.5	4	GALV		
					189.0-242.0		3.88					
MW-94	01-12-92	277.80	101.5	65.0-82.5	0-18.5	30.0[j]	12.5	18.5	6	GALV	198183.05	1274314.06
				82.5-100.5	18.5-80.0		7.88	80.5	4	GALV		
					80.0-100.5		3.88					
MW-95	04-27-93	302.5	109.22	6-80[k]	0-6	31.0[h]	6.13	80	4	LCS	199013.54	1271640.16
				80-110[k]			3.88					
MW-96	04-23-93	294.5	100.5	6-80[k]	0-6	29.2[h]	6.13	80	4	LCS	198085.18	1271724.21
				80-100[k]			3.88					

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Table 2-3 (continued)

Summary of Borehole Completion Information
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well or Soil Boring Number	Well Completion Date	Ground Surface Elevation[a,b]	Total Well Depth[c]	Cored Interval[c,d]	Drilled Interval[c]	Base of Orange Staining[c]	Borehole Diameter[e]	Bottom of Casing[c]	Casing Diameter[e]	Casing Type[f]	Surface Coordinates[b,g] Northing	Easting
MW-97	05-04-93	288.8	99.87	16-80[k] 80-100[k]	0-16	33.8[h]	6.13 3.88	80	4	LCS	197881.12	1271660.61
MW-98	05-06-93	274.7	92.19	12-65[k] 65-93[k]	0-12	30.6[h]	6.13 3.88	63	4	LCS	197791.99	1271959.76
XB-22	10-18-91	281.50	100.2	30.3-100.2	0-53.0	86.2[h]	12.5	NA	NA	NA	197698.81	1273525.17

Notes:

NA – Not applicable.
NR – Not reported.

a = Measurement in feet above mean sea level.
b = Survey data provided by West and Associates, Inc., Jacksonville, Arkansas for monitoring wells MW-85 through MW-94 and stratigraphic boring XB-22. Survey data provided by The Mehlburger Firm, Little Rock, Arkansas for monitoring wells MW-95 through MW-98.
c = Measurement in feet below land surface.
d = Corehole diameter was 3.0 inches.
e = Measurement in inches.
f = Casing Type:
GALV = Galvanized steel.
LCS = Low carbon steel.
g = Arkansas Coordinate System, North Zone (NAD, 1983).
h = Noted in the core.
i = Staining was yellow.
j = Noted in the cuttings.
k = Corehole diameter was 4.0 inches

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2.3.3.4 Drilling

Drilling was performed using mud, air, and/or water wash rotary drilling techniques. Drilling was used to cut a pilot-hole for coring, to ream the core holes for well casing installation, and to ream the open-hole portion of the wells. Standard tri-cone rotary bits, including mill tooth and button bits, were used to drill the rock. A drag bit was commonly used to bore a pilot-hole through the unconsolidated sediments and highly fractured, weathered bedrock.

Cuttings of the unconsolidated sediments, weathered bedrock and fresh rock were caught at regular intervals (1 foot or 5 foot intervals) near the top of the borehole and above the top of the core. The cuttings were washed with potable water and visually described. The drill cuttings were transferred to clear glass bottles or plastic Ziploc-type bags that were marked with the appropriate depths and placed in a core box. The cuttings and drilling fluid generated from each borehole were contained, when the OVA or PID showed positive organic vapor readings from the cuttings or drilling fluid.

The boreholes were drilled to a diameter about 4-inches larger than the diameter of the casing that was to be installed so that grout could be injected into the annular space. For example, where an 8-inch casing was to be installed for a single-cased well, the borehole was reamed with a 12.5-inch button bit. At MW-92, which was a double-cased well, a 17-inch button bit was used to ream the borehole for installation of the 12-inch, low carbon steel surface casing. The intermediate borehole was reamed with a 11.88-inch button bit and the 8-inch, low carbon steel, inner casing was grouted in place. At monitoring well locations MW-95, MW-96, MW-97 and MW-98, a 6.13-inch button bit was used to ream the boreholes for installing a of 4-inch, low carbon steel casing which was pressure grouted in place.

The subassemblies for the bits included stabilizers to provide additional vertical weight to maintain a plumb borehole (Driscoll, 1986). For mud rotary drilling, bentonite powder was added to the mud pit to form a viscous drilling fluid (mud) to facilitate circulation of the cuttings from the borehole. Potable water from the public water system was used during drilling.

2.3.3.5 Logging

The stratigraphy of the boreholes was evaluated using two methods: visual logging and geophysical logging. Visual logging of samples was accomplished by describing the drill cuttings and cores. Geophysical logging included natural gamma-ray logs at each monitoring well location and single point resistivity and spontaneous potential (SP) logs at MW-95, MW-96, MW-97, and MW-98.

2.3.3.5.1 Visual Description

Visual logging included a description of the sediments and rocks at depth based on texture, color bedding characteristics, degree of weathering, and fractures. Visual descriptions were entered into WESTON's proprietary Geologic Logging and Interpretation System (GEOLIS™). The GEOLIS logs are presented in Appendix C.

2.3.3.5.2 Borehole Geophysical Logging

Borehole geophysical logs were completed at each well location to provide a continuous record of the bedrock at depth below the Site; thereby, allowing enhanced interpretation of the Site stratigraphy. The natural gamma-ray response was used to provide information for correlating the sandstone and shale units across the Site. Natural gamma logging was performed in the cased boreholes (monitoring wells) as the natural gamma ray from the bedrock penetrates through the well casing. Single-point resistivity and spontaneous potential logs (SP) were completed in addition to natural gamma-ray logs in monitoring wells MW-95, MW-96, MW-97, and MW-98. These tools were performed prior to setting the well casings as the single-point resistance and SP responses are not transmitted through the well casing.

A portable geophysical logging unit with either a gamma-ray probe or a combined gamma-ray/single point resistivity/spontaneous potential probe attachment were used according to the methods recommended by the manufacturer (COLOG, 1993, and COLOG, personal communications, 1990 and 1993). For the electrical logs (resistivity and SP), the borehole was filled with potable water, which acted as a conducting medium. Between boreholes, the logging cable and probe were wiped with a methanol and/or deionized water-soaked cloth to minimize the potential for cross-contamination between wells. Upon completion of the geophysical logging, the logging probe and cable were steam-cleaned prior to returning them to COLOG.

Borehole gamma-ray log output for monitoring wells MW-85 through MW-94 was recorded on an analog printout at the well head. In some parts of the borehole, the gamma-ray response indicated subdued response due to the diameter of the well and filtering effects of the grout and casing. An increase in natural gamma-ray response was observed in the open-hole portion of these monitoring wells where the borehole diameter was smaller and grout and casing were not present.

The geophysical logs for MW-95, MW-96, MW-97, and MW-98 were recorded with an MGX digital logger that stored electronic responses from the borehole to a portable computer which was used to process the digital data. The geophysical logs were printed out at a later date using the COLOG software program "LOGSHELL". Copies of the borehole geophysical logs, including instrument settings, are presented in Appendix D.

2.3.3.6 Monitoring Well Installation

Monitoring wells were installed in the fresh bedrock. The casing depth was determined by the stratigraphy relative to other monitoring wells and to obtain high relative flow rates. The length of open-hole interval was based on the presence of fractures in the core, the amount of water lost to the bedrock during coring operations, and/or, the well yield during well development. Due to the competent nature of the bedrock, monitoring wells were completed as open holes. Single casings were used, except for MW-92, which was completed using a double-casing because elevated organic vapor readings indicated shallow contamination at that location. In this well, a 12-inch diameter surface casing was installed at a depth of 38.5 feet in fresh bedrock and then a 6-inch inner casing was installed to a depth of 80.3 feet. Well casings were constructed of low carbon steel, with the exception of MW-93 and MW-94, which were constructed with galvanized steel. The decision to use galvanized steel was based on materials availability at the time the wells were drilled. The upper portions of MW-93 and MW-94 were constructed with 6-inch diameter pipe to a depth of 18.5 feet BGS to accommodate the 4-inch diameter kelly bar used to core and ream below the well casing. In these two wells, the diameter of the casings below 18.5 feet was 4-inches, except for the base of the casings which was fitted with a float shoe for pressure grouting. The float shoe was reamed to a diameter of 3.88 inches, the same diameter as the completed open-hole portion of the wells. Casings were grouted with a pumpable mixture of three to four percent bentonite/Portland cement that was pumped through a Tremie pipe. Casings for monitoring wells, MW-93, MW-94, MW-95, MW-96, MW-97, and MW-98 were installed by pressure grouting. A lockable aluminum or stainless steel cap was placed on each well casing. Well completion information is summarized on Table 2-4. Well completion diagrams are presented in Appendix E.

Table 2–4

Completion Information for Groundwater Monitoring Wells
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number[a]	Well Completion Date	Total Well Depth[b]	Ground Surface Elevation[c,d]	Top of Casing Elevation[c,d]	Casing Diameter[e]	Monitored Interval[b] Top	Monitored Interval[b] Bottom	Monitored Interval Elevation[c] Top	Monitored Interval Elevation[c] Bottom	Base of Orange Staining[b]	Surface Coordinates[b,f] Northing	Surface Coordinates[b,f] Easting
MW–85	10–24–91	101.2	283.00	286.28	8	78.7	101.2	204.3	181.8	NR	197522.80	1272904.48
MW–86	11–24–91	131.0	282.14	285.24	8	100.4	131.0	181.7	151.1	81.7[g]	197719.71	1273526.47
MW–87	11–06–91	100.4	280.14	283.13	8	78.3	100.5	201.8	179.6	53.4[g]	197657.26	1273604.35
MW–88	11–22–91	131.6	280.57	283.18	8	100.8	131.6	179.8	149.0	31.0[g]	197706.96	1273627.32
MW–89	11–11–91	94.9	271.60	273.72	8	60.9	94.9	210.7	176.7	85.0[g,h]	197928.90	1274266.05
MW–90	11–08–91	101.8	277.00	279.37	8	80.0	101.8	197.0	175.2	53.0[g]	198076.50	1274145.39
MW–91	11–07–91	114.1	283.40	285.29	8	79.4	114.1	204.0	169.3	NR	198286.47	1273880.27
MW–92	01–31–92	126.4	287.50	289.27	8	80.3	126.4	207.2	161.1	22.4[i]	198360.13	1273599.17
MW–93	01–29–92	242.0	286.10	288.42	6 to 4	189.5	242.0	96.6	44.1	NR	198496.76	1273934.72
MW–94	01–12–92	101.9	277.80	281.17	6 to 4	80.5	101.5	197.3	176.3	30.0	198183.05	1274314.06
MW–95	04–27–93	109.10	302.50	304.62	4	80.0	109.22	222.50	193.4	31.0	199013.54	1271640.16
MW–96	04–23–93	100.50	294.50	296.60	4	80.0	100.50	214.50	194.0	29.2	198085.18	1271724.21
MW–97	05–04–93	99.9	288.80	290.48	4	80.0	99.87	208.80	188.9	33.8	197881.12	1271660.61
MW–98	05–06–93	92.2	274.70	282.61	4	63.0	92.19	211.70	182.50	30.6	197791.99	1271959.76

Notes:

a = All monitoring wells completed in fresh rock below the depth of weathering as indicated by the absence of orange staining.
b = Measurement in feet below land surface.
c = Measurement in feet above mean sea level.
d = Survey data provided by West and Associates, Inc., Jacksonville, Arkansas for monitoring wells MW–85 through MW–94.
Survey data provided by The Mehlburger Firm, Little Rock, Arkansas for monitoring wells MW–95 through MW–98.
e = Measurement in inches.
f = Arkansas Coordinate System, North Zone (NAD, 1983).
g = Noted in the core.
h = Staining was yellow.
i = Noted in the cuttings.
NR = Not reported.

Monitoring well MW-92 was originally drilled to a depth of 101.4 feet BGS; however, the slow rate of water level rise during well development indicated that the yield was low. After a review of available data, it was decided to drill deeper with the objective of encountering a more productive zone. The well was cored and reamed for an additional 25 feet to a depth of 126.4 feet. Examination of the cores indicated that two sandstone layers were encountered while drilling deeper. Water level recovery measurements made during development of the well indicated that the sandstone layers were more productive.

Upon completion of drilling, monitoring wells MW-85, MW-88, MW-89, MW-90 MW-91, MW-92, and MW-93 were backflushed with potable water until return water was clear and free of cuttings. MW-86, MW-87, MW-94, MW-95, MW-96, MW-97, and MW-98 were surged with air from rig-mounted, air compressors to facilitate back-flushing and to evaluate the yield of the newly completed monitoring wells. The practice was sporadic because it was difficult to contain the volumes of water produced from the wells during the air surging. Groundwater generated from monitoring wells MW-86, MW-87, and MW-94 was contained in the mud pit. Groundwater generated during back-flushing monitoring wells MW-95, MW-96, MW-97, and MW-98 was not contained because the photoionizing organic vapors were not detected during drilling or back-flushing.

2.3.3.7 Well Development

Development of groundwater monitoring wells MW-85 through MW-94 was accomplished by purging the well using 2 or 4-inch diameter submersible pumps. Each well was developed by purging at least three well volumes of water. In monitoring wells where the recharge rate was low, the well was pumped dry and allowed to recover before purging additional volumes of water. Temperature, pH, and specific conductance were measured after each casing volume was purged. These measurements were collected to assess the characteristics of the water and the freshness of the water entering the well.

MW-95 through MW-98 were developed using air surging the well to blow water out of the hole. Each well was developed for 25 to 90 minutes. Groundwater was removed until the water was clear; typically 4 to 10 well volumes were removed during well development. Temperature, pH, and specific conductance were measured after each casing volume was purged.

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2.3.4 Groundwater Sampling Program

2.3.4.1 Introduction

Groundwater samples were collected from each of the groundwater monitoring wells installed during the Phase II RI (MW-85 through MW-98). In addition, groundwater monitoring well MW-69, which was installed downgradient from the Regina Paint building during the Phase I RI, was re-sampled to assess the potential for solvents being released during painting operations. The purpose of groundwater sampling was to obtain a representative sample of water from the wells that could be used to evaluate groundwater quality. One set of samples was collected from each well installed during the Phase II RI. In addition, a second set of samples were collected from MW-85, MW-87, MW-89, MW-92, MW-93, and MW-94. Pre-purge samples were taken from MW-93 and MW-94 to assess the extent to which the water quality in the open-hole interval could be considered to be representative under flow through conditions (i.e., without purging). The second sample from MW-94, indicated that the concentration of silvex in the groundwater at MW-94, which is located near the eastern boundary of the Site, exceeded the 50 ppb Federal maximum contaminant level (MCL) for drinking water. A long-term, pilot groundwater recovery test was initiated, in large part, to assess whether the contaminant concentrations in MW-94 could be reduced by pumping groundwater from MW-92. After pumping nearly a million gallons from MW-92 during the pilot recovery test, a third sample was collected from MW-94 for analysis of chlorophenoxyherbicides, including silvex. The groundwater samples were collected in accordance with the Phase II RI Work Plan and the Addendum, QAPP, and HASP. Sampling procedures and materials were consistent with U.S. EPA guidance (U.S. EPA, 1985). Samples were collected for the following analytes:

- Chlorophenols.
- Chlorophenoxyherbicides.
- Tetrachlorobenzene.
- 2,3,7,8-TCDD (MW-85 through MW-94, first sampling round only).
- Target Compound List (TCL) volatile organic compounds.
- Chloride.
- Total organic carbon.

Groundwater samples from MW-69 and MW-85 through MW-92 were collected in December 1991; samples for analysis of chlorophenols and tetrachlorobenzene were re-collected in February 1992 because of difficulties during analysis of the original samples collected in December 1991. Samples from MW-92, MW-93, and MW-94 were collected in February 1992, when these wells were completed. MW-92 was re-sampled after the well was deepened to 126.4 feet (Subsection 2.3.2.6). During the Phase I RI, MW-69 was originally sampled for toluene which was the only volatile compound reported to be site-related. The well was re-sampled for the full suite of TCL volatile organic compounds to assess whether painting activities, not related to Vertac's site operations, had impacted groundwater quality in the area of the Regina Paint building.

Groundwater samples from MW-95 through MW-98 and the second set of samples from MW-85, MW-87, MW-89, MW-92, MW-93, and MW-94 were collected in May 1993. The purpose of the second set of samples was to confirm the concentrations of site-related contaminants at those locations. In accordance with the provisions in the Addendum to the Phase II RI Work Plan, groundwater samples from MW-95 through MW-98 were not collected for analysis of 2,3,7,8-TCDD because organic vapors were not detected during drilling. As described in Subsection 2.3.4.1, a third sample was collected from MW-94 to evaluate whether or not concentrations of silvex, detected in the May 1993 sampling round, exceeded the MCL of 50 ppb for drinking water. A fourth sample was collected from MW-94 to evaluate whether or not silvex and chlorophenols were still present in the groundwater since the December 1993 sampling round.

In addition to the groundwater samples collected for quantitative chemical analyses, qualitative samples were also collected for an assessment of whether or not dense non-aqueous phase liquids (DNAPLs) or light non-aqueous phase liquids (LNAPLs) were present as immiscible phases in the wells. Each of the Phase II wells within or adjacent to the central process area was checked for visual evidence of DNAPLs in March 1992. As a follow-up, selected wells on the northeast side of the Site were re-sampled in December 1993 for evidence of DNAPLs and LNAPLs. The wells were selected based on the results of previous analyses, particularly where the level of toluene was high relative to the saturation limit of toluene in water. The following central process area wells were evaluated: MW-23A, MW-24A, MW-61, MW-62, MW-63, MW-64, MW-71, MW-72, MW-78, MW-79, MW-80, MW-81, MW-82, and the Reasor-Hill well. The evaluation for the possible presence of DNAPLs and LNAPLs was performed in accordance with provisions in the Phase II Work Plan (WESTON, 1992) and its addendum (WESTON, 1993).

2.3.4.2 Purging

Each monitoring well was purged to provide groundwater that was representative of the hydrogeologic zone where the well is completed. Measurements made during purging are listed in Table 2-5. The wells were purged using the following sequential steps.

- Depth to water was measured from the surveyed reference mark at the top of the inner casing. The water level probe was decontaminated before use and between monitoring wells.

- Wells were purged in order of increasing potential for contamination based on organic vapor readings measured during drilling or results of previous sampling.

- Purging was performed by using a submersible pump, except for MW-69 which was purged with a dedicated Teflon® bailer. Pumps were fitted with dedicated, 3/4-inch ID polypropylene and polyethylene tubing that was discarded after purging was completed. Between wells, the purging pumps were decontaminated by sequentially pumping an Alconox solution through the pump, pumping approximately 50-gallons of potable water through the pump, and rinsing the pump and electrical cable with deionized water.

- A minimum of three well volumes was evacuated from each well during the December 1991 and February 1992 sampling, except for MW-69 which was bailed dry. The volume of water in each well was calculated by subtracting the measured depth to water level, in feet, from the total depth of the well and multiplying the difference by the number of gallons per foot which is a function of the casing diameter. For MW-93 and MW-94 adjustments were made to account for the column of water in the shallow section where 6-inch casing was used (Subsection 2.3.2.5). Only one volume was purged from each well during the May 1993 sampling event in order to minimize the potential for redistributing dissolved-phase contaminants due to low bedrock storativity. A minimum of three well volumes was purged from MW-94 during the December 1993 sampling event.

Table 2-5

Summary of Measurements and Observations During the Purging of Groundwater Monitoring Wells
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[a]	Ground Surface Elevation[b,c]	Casing Stick-up (feet)	Top of Casing Elevation[b,c]	Depth to Water[d]	Water Level Elevation[e]	Well Purging Date	pH	Specific Conductance (μmhos/cm)	Temperature (°C)	Dissolved Oxygen	Odor	Color	Turbidity
MW-85	101.2	283.00	3.28	286.28	19.33	266.95	02/01/92	6.2	120	20	NA	Yes	NR	Yes
					16.45	269.83	05/19/93	7.4	140	18	2	No	Clear	No
MW-86	131.0	282.14	3.10	285.24	16.23	269.01	02/02/92	5.6	100	19	NA	NR	NR	Yes
MW-87	100.4	280.14	2.99	283.13	11.04	272.09	02/01/92	6	85	18	NA	Yes	NR	NR
					10.95	272.18	05/19/93	5.5	100	18.5	1.6	No	Clear	No
MW-88	131.6	280.57	2.61	283.18	32.90	250.28	02/02/92	6.9	130	19	NA	Yes	Dark Gray	Yes
MW-89	94.9	271.60	2.12	273.72	2.74	270.98	02/03/92	6.8	215	19	NA	No	NR	Yes
					1.58	272.14	05/20/93	6	310	17.5	1.4	No	Clear	No
MW-90	101.8	277.00	2.37	279.37	6.78	272.59	02/03/92	7.2	190	19	NA	Yes	NR	Yes
MW-91	114.1	283.40	1.89	285.29	7.25	278.04	11/21/91	7	625	18	NA	Yes	NR	NR
MW-92	126.4	287.50	1.77	289.27	11.55	277.72	02/04/92	5.8	875	17.5	NA	Yes	NR	NR
					8.44	280.83	05/21/93	5.5	1150	20	0.1	Yes	Clear	No
MW-93	242.0	286.10	2.32	288.42	9.44	278.98	02/04/92	7.2	600	19	NA	NR	NR	Yes
					8.48	279.94	05/21/93	6	900	19.5	0.1	Yes	Pale Gray	Yes
MW-94	101.9	277.80	3.37	281.17	3.26	277.91	02/03/92	6	750	15	NA	Yes	NR	Yes
					2.76	278.41	05/20/93	5.5	1000	18	2.4	Yes	Clear	No
					12.00	270.61	12/07/93	8	750	22	21	Yes	Light Gray	Yes
MW-95	109.1	302.50	2.12	304.62	6.48	298.14	05/18/93	6.3	170	18	0.2	No	Clear	No
MW-96	100.5	294.50	2.10	296.6	12.33	284.27	05/19/93	6.6	90	18	0.2	No	Clear	No
MW-97	99.9	288.80	1.68	290.48	12.88	277.60	05/19/93	6.8	150	20	0	No	Clear	No
MW-98	92.2	274.70	7.91	282.61	4.75	277.86	05/19/93	7	150	19	0.2	No	Clear	No

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Table 2–5 (continued)

Summary of Measurements and Observations During the Purging of Groundwater Monitoring Wells
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Notes:
NR = Not reported.
NA = Not Applicable.
a = Depth in feet below land surface.
b = Measurement in feet above mean sea level.
c = Survey data provided by West and Associates, Inc., Jacksonville, Arkansas for MW–85 thru MW–94.
Survey data provided by The Mehlburger Firm, Inc., Little Rock, Arkansas for MW–95 thru MW–98.
d = Measurement in feet below top of casing.
e = Measurement in feet above mean sea level with reference to the top of casing.

- Pre-purge samples were collected using dedicated bailers from MW-93 and MW-94 to assess whether purging is necessary to obtain representative groundwater samples from the open-hole interval of the wells.

- The flow rate in gallons per minute was measured by gauging the length of time needed to fill a 5-gallon, plastic bucket. The length of purging was established so that the purge volume exceeded the established number of well volumes. The flow rate was checked periodically and adjustments were made, as necessary.

- Purge water was discharged to either one of the surface water sumps, to the water treatment plant, or to 85-gallon drums which were used to transfer purge water to be disposed at the onsite waste water treatment plant. Water in the sumps was pumped to the water treatment plant during purging activities.

- Temperature, pH, and specific conductance were measured after purging each casing volume. Data for MW-69 was not included in Table 3-4 as the fieldbook containing the data was lost during the 1992 sampling event. During the 1993 sampling event, temperature, pH, specific conductance and dissolved oxygen concentration were measured every 10 minutes, (about every 1/6 volume). Temperature, pH, and specific conductance measurements were measured in samples at the land surface. Dissolved oxygen concentration was measured in-situ above the submersible pump. These measurements were collected to indicate the characteristics of the water and to assess the freshness of the water in the well.

2.3.4.3 Sampling

Groundwater samples were collected following the sample procedure specified in the Phase I RI Report (Subsection 2.4.4.6.3). The procedure followed U.S. EPA-approved guidelines in the original Work Plan (WESTON, 1989a) and QAPP to provide a high level of confidence in the results obtained. The samples for analysis of volatile organic compounds were collected first.

2.3.4.4 Assessment of Non-Aqueous Phase Liquids in Groundwater

2.3.4.4.1 Introduction

Samples were collected from each of the Phase II wells and from selected previously existing wells to assess the possible presence of non-aqueous phase liquids (NAPLs) in the wells. The assessment involved collecting samples from the top of the water column to check for LNAPLs and collecting sample from the bottom of the water column to check for DNAPLs. The assessment of NAPLs was performed in two steps. As a first step each of the wells installed during the Phase II RI was checked for the possible presence of DNAPLs. As a second step, wells where samples had indicated a high proportion of toluene relative to the saturation of toluene in water were checked for the possible presence of both LNAPLs and DNAPLs. The decision to check wells for LNAPLs and DNAPLs was based on observation of a floating, non-aqueous phase liquid in the Reasor-Hill well after sediments were removed from the casing (Subsection 4.4.5; WESTON 1992b). Observation of the floating phase, after the casing was flushed, raised the possibility that the floating phase had separated from waste materials that were previously disposed in the well (Subsection 3.3.6). To assess the potential for DNAPL fractionation into separate phases each of the wells was checked for LNAPLs, even though most of the wells were cased below the water table. The methods used during the assessment are described in the following subsections.

2.3.4.4.2 Phase II Wells

A sample was collected from the bottom of the water column in each of the Phase II wells to assess the possible presence of DNAPLs in accordance with the Phase II Work Plan. The samples were collected on 26 and 27 March 1992 using a bailer that contained upper and lower (double) check valves (Huling and Weaver, 1991). Each sample was collected by lowering a clean, bailer with dedicated nylon or polypropylene rope to the bottom of each Phase II monitoring well. A few minutes were allowed for the bottom check valve to settle prior to lifting the bailer from the well. At the surface, each bailer was observed for density currents and/or suspended chemical droplets in the water, turbidity, odor, color, and presence of rock fragments and/or mud. The bailer contents were transferred from the bottom of the bailer to a clear, colorless glass bottle. The glass bottle was placed in an inaccessible location. Each bottle was observed for density currents or organic droplets. DNAPLs were not observed in any of the samples. Observations made during the assessment are summarized in Table 2-6.

Table 2-6

Summary of Observations Made During the Dense, Non-aqueous Phase Liquid Assessment
April 1992
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Date Sampled	Dense Phase Present	Density Currents Present	Turbidity	Odor	Color	Time Elapsed Since Removal of Bailer from the Well[a]
MW-85	4-26-92	No	No	Yes	No	Gray	NA
MW-86	4-26-92	No	No	Yes	No	Black	0.4
MW-87	4-26-92	No	No	No	No	Light Orange	1.4
MW-88	4-26-92	No	No	Yes	No	Gray	1.2
MW-89	4-26-92	No	No	Yes	No	Orange-gray	2.3
MW-90	4-26-92	No	No	Yes	No	Black	2.2
MW-91	4-27-92	No	No	Yes	Yes	Orange-gray	18.3
MW-92	4-27-92	No	No	Yes	Yes	Orange-gray	NA
MW-93[b]	4-27-92	No	No	No	No	Colorless	18.0
MW-94	4-26-92	No	No	No	No	Light Orange	NA

Notes:
NA = Not applicable, bailer was removed from the monitoring well prior to arrival at the site.
a = Measured in hours.
b = Unable to descend the bailer below 198 feet below land surface.

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2.3.4.4.3 Selected Previously Existing Wells

Samples were collected at the top and bottom of the water column in selected monitoring wells in or adjacent to the central process area to assess the possible presence of LNAPLs or DNAPLs, in accordance with the Addendum to the Phase II Work Plan. Samples were collected form 3 through 7 December 1993 for simple visual observations and subjected to a qualitative phase-separation test on 8 December 1993. Samples were collected from the following monitoring wells: MW-23A, MW-24A, MW-61, MW-62, MW-63, MW-64, MW-71, MW-72, MW-78, MW-79, MW-80, MW-81, MW-82, and the Reasor-Hill well. These wells were selected based largely on the results of previous sampling which indicated high concentrations of toluene in the samples relative to the saturation of toluene in water.

Prior to collecting samples, the water column in each was checked for possible oil/water interfaces using an oil/water indicator probe from Oil Recovery Systems, Inc. The probe did not audibly indicate the presence of NAPLs in any of the wells.

Each sample was collected using a double check valve bailer. The sample for assessing the possible presence of LNAPLs was collected from the top of the water column by lowering a decontaminated bailer with dedicated polypropylene rope to the air/groundwater interface and allowing the bailer to submerge about one-foot into the groundwater. The bottom check valve was allowed to settle for about a minute before lifting the bailer to the well head. At the surface, each bailer was visually checked for density currents and/or suspended chemical droplets in the water, turbidity, color, sheens, floating particles, sand grains, and/or mud. The bailer contents were transferred from the bottom of the bailer to a clear, colorless glass bottle.

The sample for assessing the possible presence of DNAPLs was collected from the bottom of the water column using a double check valve bailer. To collect the sample, the bailer was lowered to the bottom of each monitoring well, Upon reaching the bottom of the well, the bailer was raised a few inches and again lowered to the bottom of the well in order to collect additional basal sample. A few minutes were allowed for the bottom check valve to settle prior to lifting the bailer from the well. At the surface, each bailer was observed for density currents and/or suspended chemical droplets in the water, turbidity, color, sheens, floating particles, rock fragments, and/or mud. The contents of the bailer were transferred from the bottom of the bailer to a separate clear, colorless glass bottle designated for the DNAPL sample.

The glass bottles containing the water samples were placed in a sample refrigerator onsite to minimize volatilization of possible colorless NAPL and to allow the particles in the water sample to settle before conducting the fluorescence and phase-separation tests. After settling, each sample was exposed to shortwave (254 nanometer) and longwave (300-400 nanometer) ultraviolet light and was observed for evidence of fluorescence. The ultraviolet light source was directed through the sidewalls and through the top of the bottle. Visual examination and ultraviolet fluorescence methods did not show evidence of NAPLs. A phase-separation test was then performed on the groundwater sample. The phase-separation test performed was similar to that used for soil samples in evaluating the possible presence of NAPLs in test pits (Subsection 2.3.2.4). The phase-separation test was performed by adding a small amount of the non-volatile hydrophobic dye, Sudan IV, to each sample bottle, replacing the bottle lid and agitating the sample bottle to stain possible colorless NAPL that may have been present in each groundwater sample. Results of visual examination of the samples, the fluorescence test, and the phase-separation test for assessing the possible presence of LNAPLs and DNAPLs are presented in Tables 2-7 and 2-8.

The results indicate that samples collected from the surface of the water in MW-23A, MW-64, MW-71, MW-82, and the Reasor-Hill well showed evidence of some thin sheens that could be related to the presence of NAPLs. The volume of material was insufficient to sample for analysis. A separate DNAPL was found at the bottom of MW-23A. The material was a black, tar-like liquid. The sample was collected by dropping the double check valve bailer to the bottom of the well several times. The sample was transferred to the sample vials by gravity flow from the bottom of the bailer. This sample was submitted to the laboratory for analysis of specific gravity, viscosity, and qualitative gas chromatograph purge and trap analysis.

Dense oily leachate is collected in the french drains constructed downslope and downgradient from the Reasor-Hill burial area, northern burial area and the closed equilization basin. The french drain oily leachate consisted of product and sediments that were collected in the french drain system and settled out of the aqueous leachate stream in a settling tank prior to water treatment (Subsection 2.1.3.2; WESTON, 1992a). Samples of the oily leachate were collected and analyzed for volatile organic compounds, base/neutral-acid extractable compounds, pesticides/PCBs, 2,3,7,8-TCDD, incinerability metals, and physical incinerability parameters (Subsection 3.2.3; WESTON, 1992a).

2.3.5 Water Level Measurements

Water level measurements were collected during the Phase II RI as part of the groundwater

Table 2-7

Summary of Observations Made During Assessment for Presence of Light, Non-Aqueous Phase Liquids in Wells[a]
December 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[b]	Depth to Water	Visual Examination					Ultraviolet Light Fluorescence[d] (Shortwave/Longwave)	Shake Test with Hydrophobic Dye[e]
			Density Currents	Turbidity	Headspace Reading[c] (units)	Water Color	Comments		
MW-23A	42.79	30.83	No	Low	>1000	Light Gray	Black floating particles; separate visual phase	No/No	Red film on the interior wall of the bottle
MW-24A	28.75	14.56	No	Low	>1000	Light Gray	Black and orange floating particles	No/No	No response
MW-61	18.16	3.90	No	Low	4	Orange	Black floating particles	No/No	No response
MW-62	17.37	6.25	No	Low	4	Orange	Iridescent sheen on water surface; oily substance on water surface	No/No	No response
MW-63	10.96	4.48	No	Low	200	Orange	Iridescent sheen on water surface; sudsy water; black floating particles	No/No	No response
MW-64	30.89	13.43	No	Low	>1000	Gray	No comment	No/No	Light red film on the interior wall of the bottle
MW-71	23.69	5.00	No	Low	200	Orange	Gray floating particles	No/No	No response
MW-72	55.09	13.95	No	Low	200	Colorless	Gray floating particles	No/No	No response
MW-78	25.33	7.78	No	Low	>1000	Orange	Sudsy water; orange floating particles	No/No	No response
MW-79	49.78	9.70	No	Low	>1000	Orange	Orange floating particles	No/No	No response
MW-80	14.06	5.99	No	Low	>1000	Orange	Sudsy water; orange floating particles	No/No	No response
MW-81	28.31	6.70	No	Low	14	Colorless	Orange floating particles	No/No	No response
MW-82	25.11	7.50	No	Low	>1000	Orange	No comment	No/No	No response
Reasor-Hill Well	81.40	7.40	No	No	>1000	Colorless	Black floating particles	No/No	No response

Table 2-7 (continued)

Summary of Observations Made During Assessment for Presence of Light, Non-Aqueous Phase Liquids in Wells[a]
December 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Notes:

a = Qualitative phase separation tests were adapted from: Cohen, R.M., A.P. Bryda, S.T. Shaw, and C.P. Spalding. 1992. "Evaluation of Visual Methods to Detect NAPL in Soil and Water". Ground Water Monitoring Review, Volume 12, Number 4, pp. 132-141.

b = Measurement in feet with reference to top of casing.

c = Organic vapor concentration measured in sample bottle headspace. Concentration measured with a flame-ionizing detector (OVA) and reported in units above background.

d = Ultraviolet light fluorescence examination was performed using an UVGL-48 Multi-Band Lamp (Ultra-Violet Products, Inc.) using a filter to isolate shortwave (254 nanometers) and longwave (300-400 nanometers) ultraviolet light.

e = Hydrophobic dye: Sudan IV, J.T. Baker Product No. V141-03.

f = LNAPL (light, non-aqueous phase liquids) observed as a distinct floating phase in sample bottle. NAPL thickness: thin film on top of water surface.

g = Thin iridescent coating on the interior of sample bottle did not react with the hydrophobic dye.

Table 2-8

Summary of Observations Made During Assessment for Presence of Dense, Non-Aqueous Phase Liquids in Wells[a]
December 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[b]	Depth to Water[b]	Visual Examination					Ultraviolet Light Fluorescence [d] (Shortwave/Longwave)	Shake Test with Hydrophobic Dye[e]
			Density Currents	Turbidity	Headspace Reading[c] (units)	Water Color	Comments		
MW-23A	42.79	30.83	No	High	>1000	Dark Gray	Black, tar-like substance with some fine-grained sand; silty water	No/No	Red film on water surface and the interior wall of the bottle.
MW-24A	28.75	14.56	No	High	>1000	Dark Gray	Sudsy, silty water	No/No	No response
MW-61	18.16	3.90	No	High	5	Orange-brown	Silty water	No/No	No response
MW-62	17.37	6.25	No	High	0	Orange	Very fine-grained black sand	No/No	No response
MW-63	10.96	4.48	No	Medium	>1000	Orange-brown	Iridescent sheen on water surface; silty water with orange and black floating particles	No/No	No response
MW-64	30.89	13.43	No	High	>1000	Dark Gray	Silty water	No/No	No response
MW-71	23.69	5.00	No	Medium	>1000	Orange-brown	Sudsy, silty water	No/No	Red tinge on top of the settled sediments, red film on the interior wall of the bottle.
MW-72	55.09	13.95	No	High	40	Dark Gray	Black floating particles; black sand grains	No/No	No response
MW-78	25.33	7.78	No	High	>1000	Orange-brown	Silty water	No/No	No response

Table 2-8 (continued)
Summary of Observations Made During Assessment for Presence of Dense, Non-Aqueous Phase Liquids in Wells[a]
December 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[b]	Depth to Water[b]	Visual Examination					Ultraviolet Light Fluorescence [d] (Shortwave/Longwave)	Shake Test with Hydrophobic Dye[e]
			Density Currents	Turbidity	Headspace Reading[c] (units)	Water Color	Comments		
MW-79	49.78	9.70	No	High	>1000	Dark-Gray	Silty water	No/No	No response
MW-80	14.06	5.99	No	High	>1000	Light Orange-brown	Sudsy, silty water	No/No	No response
MW-81	28.31	6.70	No	Medium	>1000	Orange-Gray	Orange floating particles; black sand grains	No/No	No response
MW-82	25.11	7.50	No	Medium	>1000	Orange-Brown	Black and buff sand grains	No/No	No response
Reasor-Hill Well	81.40	7.40	No	Medium	>1000	Orange	Dark brown floating globules of possible organic liquid; black irregularly-shaped particles	No/No	Red film on the interior wall of the bottle; globules had a pink overcast.

Notes:

a = Qualitative phase separation tests were adapted from: Cohen, R.M., A.P. Bryda, S.T. Shaw, and C.P. Spalding. 1992. "Evaluation of Visual Methods to Detect NAPL in Soil and Water". Ground Water Monitoring Review, Volume 12, Number 4, pp. 132-141.
b = Measurement in feet with reference to top of casing.
c = Organic vapor concentration measured in sample bottle headspace. Concentration measured with a flame-ionizing detector (OVA) and reported in units above background.
d = Ultraviolet light fluorescence examination was performed using an UVGL-48 Multi-Band Lamp (Ultra-Violet Products, Inc.) using a filter to isolate shortwave (254 nanometers) and longwave (300-400 nanometers) ultraviolet light.
e = Hydrophobic dye: Sudan IV, J.T. Baker Product No. V141-03.
f = NAPL (non-aqueous phase liquid) observed as a distinct floating phase in sample collected for DNAPL assessment. NAPL depth and thickness were indeterminate.
g = DNAPL (dense, non-aqueous phase liquids), observed at the bottom of the monitoring well. Approximate DNAPL thickness: 3 inches.
h = NAPL observed in mid-water column. NAPL depth and thickness were indeterminate.
i = NAPL observed in mid-water column. Approximate NAPL depth: 25 feet below the top of casing. NAPL thickness was indeterminate.

monitoring program. The depth to water in each monitoring well was measured by inserting an electronic water level probe to the water table surface and then acquiring a measurement from the probe tape using the top of the inner casing as a reference point. The depth to water was measured to within about one hundredth of a foot. Water level measurements were made prior to well evacuation and during the set-up of individual pumping test observation well networks. The probe was decontaminated between wells using a sequential rinse of methanol or hexane, and deionized water. The water level measurements were used to evaluate horizontal and vertical groundwater flow potential as described in Subsection 3.3.4.

A compilation of monthly water level measurements for the period January 1991 through May 1993 is located in Appendix F.

2.3.6 <u>Rising Head Tests</u>

2.3.6.1 Introduction

In accordance with Subsection 2.1.5 of the Phase II RI Work Plan, short-term yield tests and recovery tests were performed. The purpose of the tests was to provide an empirical, qualitative basis for selection of extraction rates to be used during the pumping tests and to estimate the well-bore hydraulic conductivity of the monitoring wells that were unlikely to respond to the pumping tests. The short-term yield tests were performed by varying the discharge rate from the pump and measuring the recovery that could be expected during the pumping test. Hydraulic conductivity was calculated based on the rate of water level recovery after the pump was shut off. The rate of recovery was used to provide an estimate of the near well-bore conductivity, particularly for wells such as MW-85, MW-89, and MW-90, where drawdown during the pumping tests was considered unlikely. The field methods were selected due to identification of vertical permeability in previous packer tests (Subsection 3.4.3.4; WESTON, 1992b), short monitored interval lengths, and bulk hydrologic characteristic testing of the rock. The methods and results of these tests are further described in the next two subsections.

2.3.6.2 Short-Term Yield Tests

Short-term yield tests were performed in the Phase II RI wells to estimate well yields, particularly where wells were to be pump tested. Pump discharge rates were adjusted as drawdown increased in the well in an attempt to achieve a steady discharge rate. 003433

Short-term yield tests were performed using a 2-inch or 4-inch submersible pump, a water level probe, a 5-gallon PVC bucket, and a watch. Short-term yield tests were conducted using the following sequential steps:

- The static water level in the pumping well was measured with a decontaminated water level probe. Depth to water in the well was measured from the top of the inner casing and recorded in the field logbook.

- The decontaminated pump, electric cable, and dedicated tubing assembly was lowered to the bottom of the well, raised approximately 5 feet off the bottom of the well, and secured to prevent damage to the electrical cable.

- The pump was turned on and the starting time was noted in the field logbook.

- The water level probe was inserted in the well for periodic measurements of the water level during well evacuation.

- The pump discharge rate was estimated periodically by measuring the time required to fill a 5-gallon bucket.

- An attempt was made to evacuate as much water as possible from the pumping well without going below the pump intake. Once this point was achieved, the gate valve at the discharge point was adjusted in an attempt to maintain a constant water level.

- After the measurements were completed, the recovery test commenced as described in Subsection 2.3.6.3.

2.3.6.3 Rising Head Test Method

Rising head (recovery tests) tests were performed in eight of the ten Phase II wells to estimate the hydraulic conductivity of the rocks near the wells. After the pump was shut-off, the depth to water (rising head) was measured periodically with a manual probe as the water level recovered. Results of the are described in Subsection 3.3.3.2.

Testing was performed using a water level probe and a watch with a second hand. Recovery testing was conducted using the following sequential steps:

- The initial water level in the pumping well was measured with a decontaminated water level probe. Depth to water in the well was measured from the top of the inner casing and recorded in the field logbook.

- The pump was shut off and the time was noted. The rising water levels were recorded at one minute intervals from the time the pump was shut off. If time permitted, 15-second and 30-second measurements were recorded for the first several minutes after the pump was shut off.

- After the measurements were completed, the water level probe and pump were removed from the wall and decontaminated as described in Subsection 2.4.4.

- The accumulated records of water level change were transferred from the field notebook to a computer spreadsheet program for additional calculations.

2.3.6.4 Slug Testing of Monitoring Wells

2.3.6.4.1 Introduction

As described in the Phase II RI Work Plan (Weston, March 1993), slug testing was performed on each of the 4 groundwater monitoring wells (MW-95, MW-96, MW-97, and MW-98) installed west of Rocky Branch Creek. The purpose of conducting the slug tests was to measure the hydraulic conductivity of the strata monitored by the wells. (Hydraulic conductivities calculated from the slug test results were used to determine possible contaminant transport rates.)

2.3.6.4.2 Slug Test Method

A slug test measures the rate of change in water level in a well due to the injection or withdrawal of a slug. The method of slug testing used involved inserting and withdrawing a solid cylinder of material. The almost instantaneous rise in water level that occurred when the slug was submerged was followed by a gradual drop in water level that continued until the water reached equilibrium. This is referred to as a "falling-head slug test." The slug was then withdrawn. The almost instantaneous drop in water levels that occurred when the slug was withdrawn was followed by a gradual rise in water level that continued until the water returned to an equilibrium level. This is referred to as a "rising-head slug test." Water level changes were recorded using a pressure transducer and digital datalogger.

Slug tests were performed following groundwater sampling activities. The order in which the wells from each stage were slug tested was based on the level of vapor readings noted during drilling of the wells. Wells where vapor readings were at background levels were tested first. Wells where vapor readings were above background levels were tested in order of increasing vapor levels. Slug testing was performed using the equipment listed in Table 2-9 and following the sequential steps:

- The initial water level in the well was measured with the water level probe. Depth to water in the well was measured from the top of the inner casing and recorded in the field logbook.

- The pressure transducer was lowered to within approximately 1 foot above the bottom of the well, and the transducer cable was taped to the well casing to hold the transducer at the appropriate level.

- The required test parameters were entered into the datalogger (i.e., test number, transducer scale factors, water level sampling rate, and the well identification number). These parameters were also noted in the field logbook.

- The slug was lowered into the well casing until it was just above the groundwater surface in the well, using a new length of polypropylene rope.

- To begin the falling-head test, the datalogger was started and water levels were recorded using a logarithmic sampling increment as the slug was lowered below

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Table 2-9

Summary of Equipment Used
During Slug Test Field Activities
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Equipment	Number, Length, or Quantity
PVC slug 3-feet long, 3-inch diameter O.D.	1
In-Situ Inc. pressure transducer, 20 psi	1
In-Situ Inc. SE1000 Data Loggers	1
Water level indicator	1
Nylon rope, 0.25-inch diameter	100
Laptop computer	1
Decontamiantion equipment including brushes and tubs	---
Duct tape	1 roll

the water surface.

- Water levels were monitored until an equilibrium level was achieved.

- To begin the rising-head test, the data recording was set to a logarithmic sampling interval and the slug was withdrawn from the well.

- Water levels were recorded until an equilibrium level was achieved.

- After the end of the rising-head test, the slug, transducer, cables, and water level indicator were removed and decontaminated as described in Subsection 2.7.4.

- The accumulated records of water level change stored in the datalogger were transferred to an IBM-compatible field computer using a program from the data-logger manufacturer (In-Situ) called Hermit-DM.

2.3.7 Pumping Tests

2.3.7.1 Introduction

Pumping tests were performed in accordance with the Phase II RI Work Plan. Monitoring wells within the central process area were assessed to determine which ones could be pumped and which ones could be monitored as observation wells.

Based upon the number and locations of the wells, two areas were selected and four wells were selected for pumping. Pumping tests were completed in the following areas and wells:

- Administration building area (MW-86 and MW-88).

- Dalapon production area (MW-91 and MW-92).

The approach was to monitor water levels in nearby observation wells while pumping one of the selected pumping wells. The set-up for the pumping tests is described in Subsection 2.3.7.2. Pumping tests for each area are described separately in Subsections 2.3.7.3 and 2.3.7.4.

In each area, background water level fluctuations were monitored continuously for 2 to 3 days before pumping began. Those wells that were monitored during the background testing in each area were also monitored during the pump tests in that area.

Throughout the period of the tests, rainfall was monitored daily through measurements from an on-site rain gauge. Barometric pressure data for the area during the time of testing was obtained form the weather station at the Little Rock Air Force Base, located about a mile north of the Site. Hercules' site personnel assisted in the setup and daily operation of the equipment during the pumping tests.

2.3.7.2 Pumping Test Set-up

2.3.7.2.1 Test Equipment and Logistics

Equipment and supplies used during the hydrologic evaluation are listed in Table 2-10. WESTON was responsible for acquiring, setting-up and running the equipment. The transducers and data loggers were leased from In-Situ, Inc. Hercules provided the collection tanks and drop tubes. The extension cables and portable computer were leased from WESTON.

2.3.7.2.2 Pressure Transducer Placement

The pressure transducer used to monitor changes in water levels was placed directly in wells that had shown either low or non-detectable levels of organic compounds, based on available analytical results. The transducers were placed at a depth below the level of the anticipated drawdown for each well. The transducer cables were held to the well casing by tape that was wrapped around the outside of the casing and around the cable. The water levels in the wells were allowed to equilibrate before the data logger was set to zero. A transducer was also placed in the bottom of the water containment tank (Subsection 2.3.7.2.4) to measure the rate at which water was collected in the tank during pumping. The transducer cables were kept above ground to minimize potential contact with soils and minimize decontamination. The cables were secured to trees, fences and metal poles by polyethylene cable ties.

The transducers and cables were placed in protective drop tubes in wells exhibiting substantial levels of organic compounds to protect them from potential chemical attack and to facilitate decontamination. The drop tubes were constructed by Hercules' site personnel using 1-inch, threaded PVC pipe and end fittings purchased from In-Situ, Inc. The tubes were cut to a length

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Table 2-10

Summary of Equipment Used For Pumping Tests
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Equipment	Number, Length, or Quantity
PVC drop tubes with transducer fittings, Schedule 40, 1-inch O.D.	5
In-Situ, Inc. pressure transducers, 10 psi	11
In-Situ, Inc. pressure transducer, 30 psi (Grundfos Redi-Flo 2 compatible)	1
In-Situ, Inc. pressure transducers, 50 psi	2
Extension cables for pressure transducers, 500-foot reels	5
In-Situ, Inc. SE 2000, 16 channel data logger	2
Grundfos Redi-Flo 2, variable speed, electric submersible pump, 2-inch O.D.	1
Polyethylene Tubing, 3/4" O.D., feet	500
Check valve, 1/2" I.D.	1
Portable computer, Zenith	1
Centrifugal pump, 4 horsepower	1
NIBCO Bail valve, discharge valve	1
M-scope water level probe	1
RECORDALL Totalizer, flow meter	1
Polyethylene tank, 500 gallon capacity	2
Polyethylene cable ties	

that would place the transducers to a sufficient depth below the anticipated drawdown in each well. A fitting consisting of a brass tube filled with a chemically inert silicon compound was threaded into the bottom of the drop tube. The purpose of the silicon compound was to provide a flexible media that would allow the transducer to sense water level fluctuations while protecting the transducer from contact with organic compounds in the water. The tubes with the transducers inside were placed into the wells and suspended from the top of the casing by metal rods that were placed in holes drilled through the tubes. The tubes were filled with potable water to a height above the level of the groundwater in the well to provide a slightly positive pressure within the drop tube. The water level within the well was allowed to equilibrate before the data logger was reset to zero. The water level in the well was measured to the nearest 0.01 foot using a M-Scope water level probe immediately before the data logger was reset to zero.

Due to potential interference between the pump and the transducer, a shielded cable with a 50 psi transducer was used in the pumping well. Transducers in most of the observation wells were 10 psi except for transducers in the two observations wells that were most likely to respond to pumping which were 50 psi and 30 psi.

The transducer in the pumping well was placed in a stilling tube during the pumping test at MW-86. Flexible polyethylene tubing was used as the stilling tube. Stilling tubes were not used in the other tests because of the relatively low pumping rates (1 to 5 gallons per minute (gpm)) and the large volume of water in the wells which minimized any turbulence. Before starting each pumping test, each transducer was checked to ensure proper operation. Each transducer was raised approximately one-foot from the top of casing while in the water column and checked on the data logger to ensure a one-foot difference in head. After each transducer was checked, the water level in the observation wells was allowed to equilibrate before the pumping test began.

2.3.7.2.3 Pump Placement and Operation

A Grundfos® Redi-flo, submersible, variable-speed, electric pump was placed near the bottom of each well selected for pumping. The depth of the pump was determined by lowering it to the bottom of the well then raising it about 3 feet from the bottom. The pump was secured by tieing the control cable and discharge tubing to the well casing. The discharge line was 3/4-inch polyethylene tubing. At the conclusion of the drawdown test, the pump was shut off. A check valve located directly above the pump prevented water from running back into the well and affecting the water level in the pumping well. A new length of polyethylene tubing was used for each well.

Within each area, the pump was placed in one of the selected pumping wells before the background data was measured. The transducer was also placed in the pumping well as described in Subsection 2.3.7.2.2. The transducer was placed as near as possible to the top of the pump to allow as continuous a measurement of water levels as was practical given the low yield of the wells. The water level was allowed to equilibrate within each pumping well before the pump was started. The rate of pumping was monitored by a flow meter with a continuous flow readout and a flow totalizer. In addition, the pumping rate was monitored with a water level transducer placed in the bottom of the water containment tank, described in Subsection 2.3.7.2.4.

2.3.7.2.4 Water Containment and Monitoring of Flow Rate

Water removed from the well by the pump was contained in two 500-gallon, translucent, polyethylene water containment tanks that were joined near the base with a 6-inch PVC pipe containing a discharge valve. The total storage volume of the joined tanks was about 1,000 gallons. The polyethylene tubing carried the water to the tank from the pump in the well. The polyethylene tubing was secured to the tank with tape. The water in the tanks was emptied periodically during individual tests as necessary and between each of the pumping tests. A pump was used to transfer the water from the tank to the on-site water treatment plant for treatment.

The flow rate for each test was established based on pumping rates and water levels measured during well development. To achieve the desired flow rate on a nearly constant basis, an in-line gate valve was used to maintain back pressure on the pump thereby minimizing the effect of the decrease in static head during pumping. The amount of back pressure was calculated based on the amount of head loss that was anticipated in the pumping well. The flow rate was monitored using an in-line flow meter which provided cumulative totalized volume measurements. As a backup, a transducer was placed in the bottom of the water containment tank (Subsection 2.3.7.2.2), to measure the fill rate of the tank, thereby monitoring the discharge rate of the pump under operating conditions. A schematic drawing showing the set-up for pumping test is presented in Figure 2-4.

2.3.7.2.5 Data Loggers

Two SE-2000 digital data loggers were connected to the transducer cables. Connection and operation of the data logger were performed in accordance with the manufacturer's specifications. During the tests in the administration building area, the data loggers were placed in the parking lot

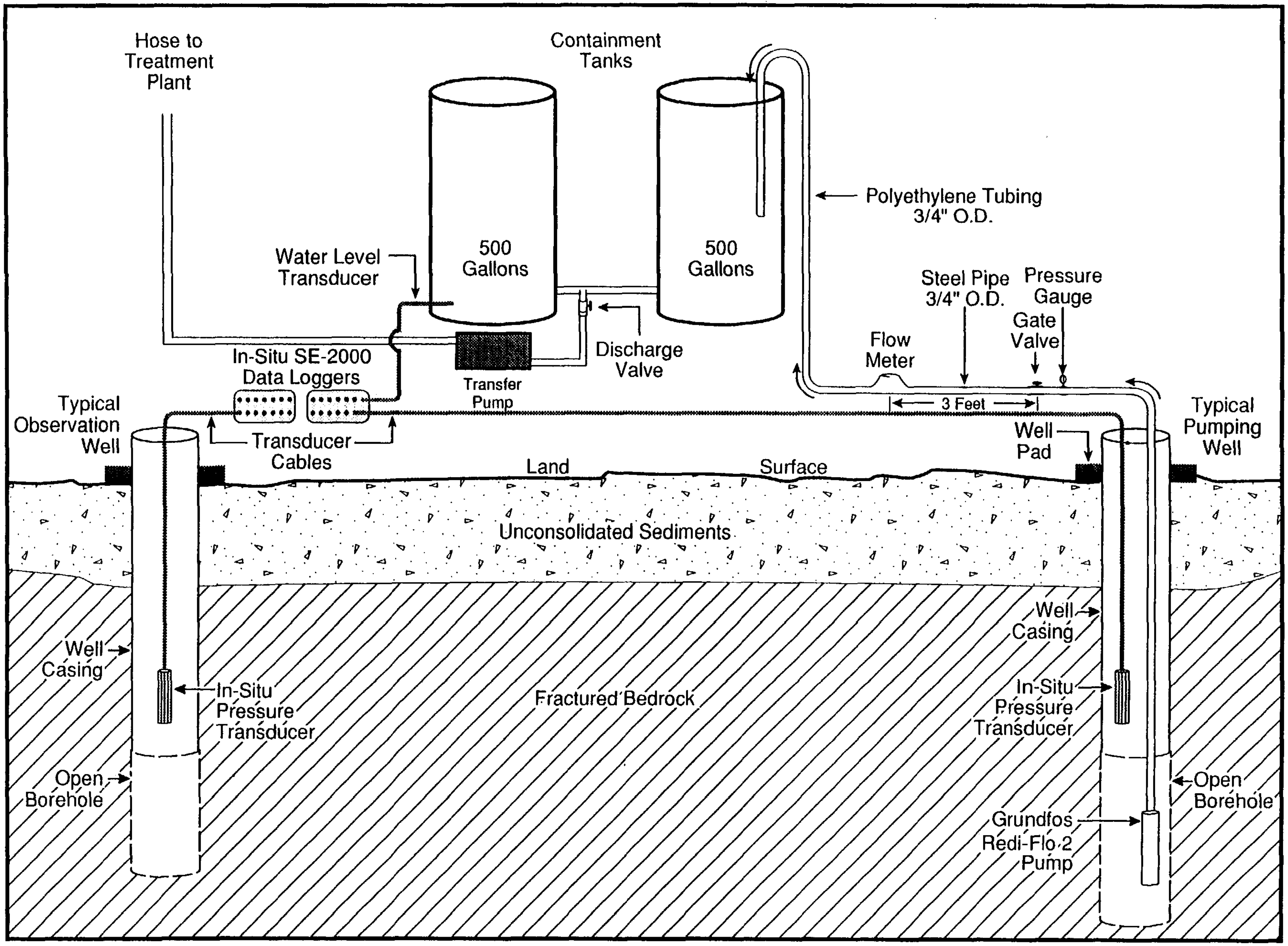

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FIGURE 2-4 SCHEMATIC DIAGRAM OF PUMPING TEST PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

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near MW-86, which was the first well to be tested. During the tests in the dalapon production area, the data loggers were placed in the area of MW-91. Data in the loggers were periodically downloaded in the field using a Zenith portable computer. The data was graphed in the field and evaluated to establish when drawdown had stabilized and when recovery was completed. 0035[?]

The elapsed time between water level measurements in wells close to the pumping well during drawdown and recovery tests started at 0.0083 minutes (i.e., 0.5 second) and gradually increased on a logarithmic scale until it reached a maximum of once every 30 minutes. The measurement interval for more distant wells was a constant 30 minutes.

2.3.7.3 Administration Building Area Pumping Tests

Hydrogeologic testing completed in the administration building area included background testing, pumping tests of MW-86 and MW-88, and monitoring nearby wells with transducers. Two additional wells were monitored with hand measurements during the first pumping test (Table 2-11 and Figure 2-5). A two-day period of background data was recorded to ascertain the trends of water levels in the wells prior to pumping. Water level changes during the background period fluctuated up to 0.3 foot. A chronology of pumping test activities in the administration building area is shown in Figure 2-5.

MW-86 was pumped first for a period of 2650 minutes at a constant rate of 2-gpm. The rate was selected based on drawdown data gathered during well development. To minimize flow rate fluctuations resulting from the drop in static head in the pumping well, a pump setting of 250 hertz and a back pressure of 28 to 32 psi were used. Throughout the course of the test, 1 minor adjustment to the flow rate was made to maintain a constant rate of 2 gpm. The water level in the pumping well stabilized at about 30-feet of drawdown after 2000 minutes of pumping at 2 gpm. During pumping, water levels dropped by more than one-half foot in four observation wells (MW-87, MW-88, MW-73 and MW-67, in decreasing order of water level drop). The drawdown in these observation wells stabilized after about 2000 minutes. The recovery test was started after 2650 minutes of pumping because of the forecast for rain. A light rain began to fall during the night. A total of 0.94 tenths of an inch of rain fell over approximately a 48 hour period. The recovery test lasted about 2860 minutes and was completed after the water levels in the wells had recovered to more than 90 percent of the original water level. At the end of the MW-86 recovery test, the pump and the transducer with the shielded cable were decontaminated and moved to MW-88. The transducer from MW-88 was decontaminated and moved to MW-86.

Table 2-11

List of Pumping and Observation Wells
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Pumping Well MW-86 Pumping Test No. 1	Pumping Well MW-88 Pumping Test No. 2	Pumping Well MW-91 Pumping Test No. 3	Pumping Well MW-92 Pumping Test No. 4
	Observation Wells		
MW-58	MW-58	MW-10[b]	MW-23A[a]
MW-62[b]	MW-67	MW-23A[a]	MW-24A[a]
MW-63[b]	MW-73	MW-24A[a]	MW-27[b]
MW-67	MW-74	MW-27[b]	MW-57
MW-73	MW-76	MW-57	MW-64[b]
MW-74	MW-77	MW-64[b]	MW-66
MW-76	MW-78	MW-66	MW-71[a]
MW-77	MW-79	MW-68[b]	MW-72[a]
MW-78[a]	MW-83	MW-71[a]	MW-82
MW-79[a]	MW-86	MW-72[a]	MW-89
MW-83	MW-87	MW-75[b]	MW-90
MW-87		MW-82	MW-91
MW-88		MW-84	MW-93
		MW-89	MW-94
		MW-90	
		MW-92	
		MW-93	
		MW-94	

Notes:
a = Pressure transducer was installed in a drop tube.
b = Water levels in the observation well were measured using a water level probe.

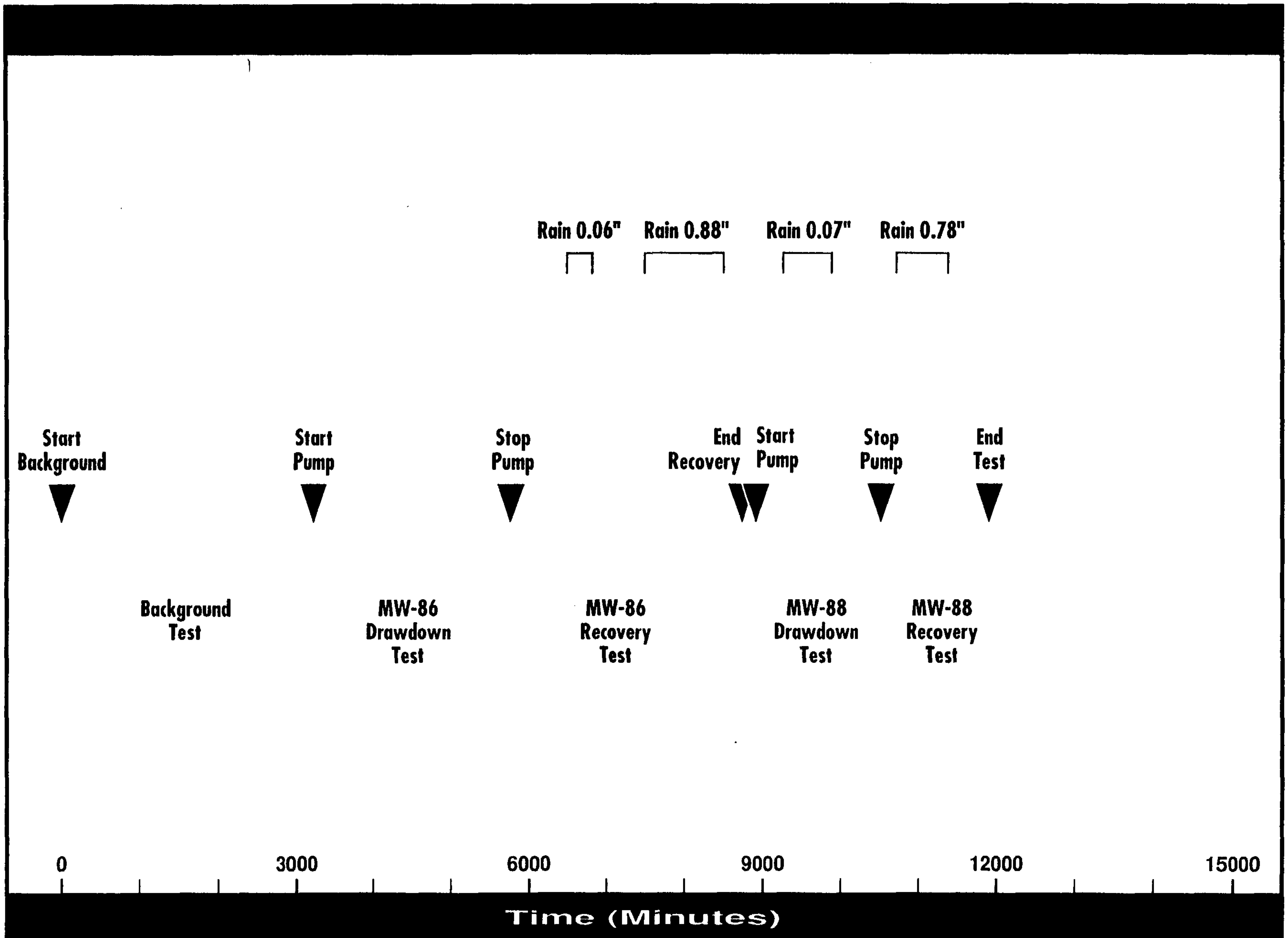

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FIGURE 2-5 TIMELINE OF PUMPING TEST ACTIVITIES, ADMINISTRATION BUILDING AREA
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

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After the equipment was in place, a short flow rate test (several minutes) was performed at MW-88 to set the gate valve to a point where the flow rate would be about 1 gpm. The water level was then allowed to equilibrate for about 2-hours, before starting the drawdown test at MW-88.

MW-88 was pumped for a period of 1720 minutes at a constant rate of 1 gpm. The rate was selected based on a short term yield test performed during well development. To minimize flow rate fluctuations resulting from the drop in static head in the pumping well, a pump setting of 250 hertz and a backpressure of 15 to 20 psi were used. Throughout the duration of the test, 9 minor flow rate adjustments were made. The second adjustment was made to clear some sediment that had fouled the paddles in the flow meter. The water level in the pumping well stabilized at about 69-feet of drawdown after approximately 1200 minutes of pumping at 1 gpm. During the pumping, water levels dropped by more than one-half foot in four observation wells (MW-86, MW-88, MW-73, and MW-67 in decreasing order of water level drop). The water levels in MW-87 and MW-86 stabilized after about 1200 minutes. The recovery test was started after 1720 minutes of pumping because of the forecast for rain. Rain began to fall during the night. A total of 0.78 inches of rain fell over a 12 hour period. The recovery test was stopped after about 1360 minutes when the water levels had recovered to more than 90 percent of the pre-pumping levels. After the recovery test, the equipment was decontaminated (Subsection 2.4.4) and was moved to the dalapon production house area for additional pumping tests. The drawdown data and recovery data for the pumping test MW-88 are presented in Subsection 3.3.3.4.

2.3.7.4 Dalapon Production House Area Pumping Tests

Hydrogeologic testing completed in the dalapon production area included background testing, pumping tests of MW-91 and MW-92, and monitoring of nearby wells with transducers and manual measurements. A two-day period of background data was recorded to ascertain the trends in water levels in wells prior to pumping. Water level changes during the background period were slight and tended to be increasing due to the rain which occurred during the recovery period after pumping MW-88 (Subsection 2.3.7.3). A chronology of testing in the dalapon production area is shown on Figure 2-6.

MW-91 was pumped for a period of 3190 minutes at a constant rate of 1 gpm. There were 13 observation wells monitored by transducers and 5 additional wells were monitored with hand measurements (Table 2-8 and Figure 2-6). The rate was selected based on short term yield data gathered during well development. To minimize flow rate fluctuations resulting from a drop in static head in the pumping well, a pump setting 250 hertz and a back pressure of 31 to 44 psi were

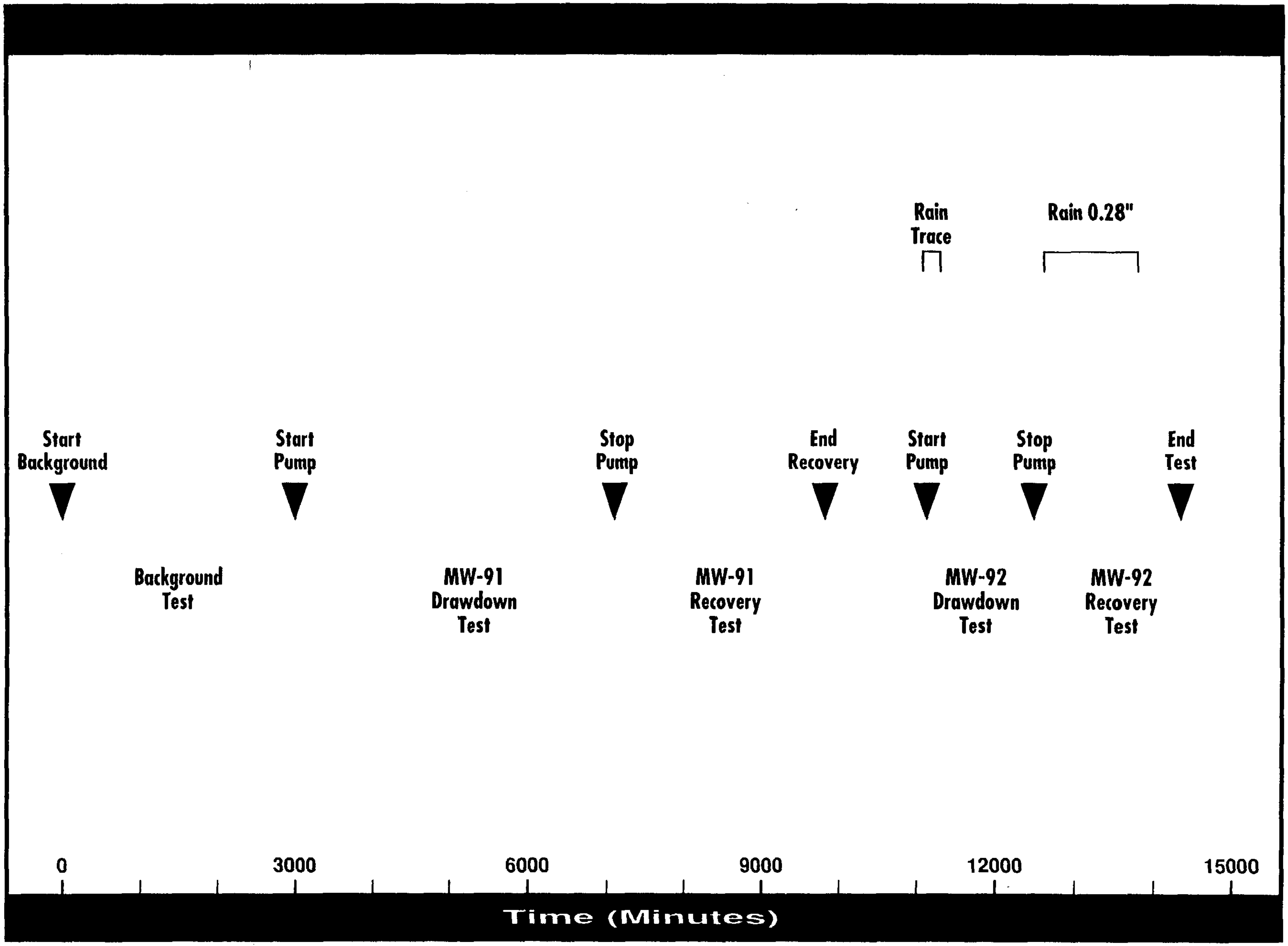

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FIGURE 2-6 TIMELINE OF PUMPING TEST ACTIVITIES, DALAPON BOILER AREA
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

used. Throughout the test, four minor adjustments to the flow rate were made to maintain a constant flow rate. The water level in the pumping well stabilized at about 33 feet of drawdown after 1000 minutes of pumping at 1 gpm. During pumping, water levels dropped by more than one-half foot in six observation wells (MW-92, MW-93, MW-94, MW-23A, MW-72, and MW-57 in decreasing order water level drop). The water levels in these observation wells stabilized after about 1000 minutes. There was no rainfall during the drawdown test. The recovery test was started after the water level drawdown in the observation wells stabilized. The recovery test lasted 2770 minutes and was completed after the water levels in the wells reached 90 percent or more of the pre-pumping level. The total rainfall monitored during recovery test was 0.2-inches.

After the recovery test, the pump and transducer with shielded cable were decontaminated and moved to MW-92. The transducer from MW-92 was decontaminated and removed to MW-91. After the equipment was in place, a short flow rate test (several minutes) was preformed to set the gate value to a point where the flow rate would be about 5 gpm to begin the test. The water level was then allowed to equilibrate for about 105 minutes before starting the drawdown test at MW-92.

MW-92 was pumped for a period of 1450 minutes of a rate of 5 gpm. The rate was selected based on results of draw-down measured during development and a desire to minimize the potential for drawing water from beneath the north landfill. To minimize flow rate fluctuations resulting from the drop in static head in the pumping well, a pump setting of 350 hertz and a pack pressure of 36 to 38 psi were used. Throughout the test, four minor adjustments to the flow rate were maintain a constant flow rate. The water level in the pumping well stabilized at about 17 feet of drawdown after 800 minutes of pumping at 5 gpm. There were 12 wells monitored by transducers and 2 additional wells by hand measurements (Table 2-8 and Figure 2-6). During pumping, water levels dropped by more than one-half foot in six observation wells (MW-23A, MW-93, MW-91, MW-57A, MW-72, and MW-94, in decreasing order of water level drop). The water levels in the observation wells stabilized after about 800 minutes. The recovery test was started after the water level drawdown in the observation wells had stabilized. The recovery test lasted 1810 minutes and was completed after the water levels in the wells reached 90 percent or more of their pre-pumping level.

Rain began to fall approximately 106 minutes into recovery test. A total of 0.28 tenths of an inch fell over approximately a 19 hour period and did not seem to impact results of the recovery.

After the recovery test, the pump and transducers were decontaminated as described in Subsection 2.4.4.

2.4 FIELD SUPPORT ACTIVITIES

2.4.1. Utility Clearances

Prior to intrusive activities, such as surface soil sampling excavations or well drilling activities, utility clearance was obtained to minimize hazards which might have jeopardized the health and safety of personnel. Underground and overhead utilities for which clearance were obtained included:

- Electric (overhead and subsurface).
- Industrial (chemical) sewer.
- Sanitary sewer.
- Domestic water.
- Natural gas (overhead and subsurface).
- Overhead pipe racks.

The location of underground piping was delineated as described in the Phase I RI Report (Subsection 2.6 and Figure 2-15). Utility clearances were obtained from Hercules' site personnel for drilling and test pit locations. Clearances obtained from public utility personnel during the Phase I RI also were considered prior to drilling at the MW-89 and MW-94 locations. At MW-93, clearance also was obtained from Riedel Environmental Services relating to a trailer labeled for DOT class 1A explosives and associated underground electrical conduits. Where necessary, electrical power to parts of the central process area was shut off and electrical boxes were locked out and tagged during intrusive activities and were returned to service when the intrusive activities were completed.

2.4.2 Subcontractor Support

Drilling activities were completed by Layne-Western Company, Inc. and The Winnek Companies who were selected after discussions with Hercules and US. EPA prior to commencement of Site activities. The identities of the subcontractor that performed boring or drilling are shown on the borehole logs, and the well completion summaries in Appendices C and E.

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2.4.3 Borehole Closure

Borehole closure was completed for intrusive activities as specified in Subsection 2.7.3 of the Phase I RI Report. Stratigraphic boring XB-22 was abandoned in the following manner:

- Backflushing of the borehole from 100.2 feet (base of the corehole).
- Grouting the hole from 100.2 to 48 feet using galvanized steel tremie pipe.
- Grouting the hole from 48 feet to land surface using flexible hose.
- Collecting liquids and cuttings from drilling and closure activities and placing the waste in drums, to the extent practical.

2.4.4 Decontamination

Prior to intrusive activities, decontamination of field and drilling equipment was performed in accordance with methodologies specified in Section 3.3 of the QAPP and Subsection 2.7.4 of the Phase I RI Report.

The pump and transducers/cables were decontaminated between areas by scrubbing with a strong detergent solution and rinsing with potable water. Decontamination was performed because the cables and data loggers were used in portions of the Site which may have contained some contaminated soils. After the equipment was decontaminated at the end of the test, the equipment was returned to its owners.

2.4.5 Surveying

Surveying was performed using panel and traverse points designated during the Vertac Boundary and Photogrammetric Survey (Walker and Associates, 1989), which was prepared for Hercules. West and Associates, Inc., an Arkansas-licensed surveying firm was subcontracted to survey the new monitoring wells (MW-85 through MW-94) and surface soil grid (586, 587 and 588) corner locations. The Mehlburger Firm, an Arkansas-licensed surveying firm was subcontracted to survey the additional monitoring well (MW-95 through MW-98) and test pit (TP-5 through TP-14) corner locations. All land surface and top of casing elevations were surveyed to the nearest one hundredth of a foot.

2.5 PROJECT QUALITY ASSURANCE AND QUALITY CONTROL

2.5.1 Introduction

The primary objective of the project quality assurance and quality control (QA/QC) program was to provide a high level of confidence that the environmental data obtained during performance of the Phase II RI were of known quality and suitable to address the objectives for which the data were collected. The scope of the QA/QC program provided appropriate quality assurance procedures and quality control measures to be applied throughout the project, including:

- Sample collection, handling and preservation.
- Laboratory analysis of samples.
- Data transfer and interpretation.
- Data presentation.

2.5.2 Field Quality Control

2.5.2.1 Field Quality Control Samples

Each Operable Unit II field sample was collected, handled, and preserved as prescribed in the QAPP (WESTON, 1989b). Field samples were segregated by media for shipment to the laboratory. QC samples were collected to ensure that the quality control measures described in the QAPP were attained. The following field QC samples were collected during the Phase II RI:

- Duplicate Field Sample - One duplicate field sample was collected for each batch of 20 or fewer field samples. At least one duplicate field sample was collected for each media and/or soil geographic location. Field duplicate samples were not collected for each node location.

- Sampling Equipment Field Blank - A sampling equipment field blank consisted of laboratory-grade (HPLC) water, poured through an unused bailer. This blank provided a check on the cleanliness of the sampling equipment. One sampling equipment field blank was collected during each groundwater sampling round during the Phase II RI. Sampling equipment field blanks were not collected for soil sampling equipment because the equipment was disposable. The sampling equipment field blanks were analyzed for the same chemical compounds as the field samples.

- Trip Blank - A trip blank was a sample of laboratory-grade water that was placed in the appropriate sample bottle in the laboratory and accompanied the sample container (cooler) from the time it was shipped to the field until the sample was returned to the laboratory for analysis. The trip blank monitored the cleanliness of conditions during the period of sample collection and shipment. A trip blank was included with each sample shipment in the cooler containing samples to be analyzed for volatile organic compounds. The trip blanks were analyzed for the same VOCs as the field samples.

- Matrix Spikes - Sufficient sample volume was collected so that for each batch of 20 or fewer field samples for each matrix, matrix spike(s) and if required by the method, matrix spike duplicate(s), could be set up and chemically analyzed in accordance with appropriate analytical methods.

A breakdown of the QC samples collected for each matrix shows that more than the requisite number and percent of the field duplicate samples were collected for analysis (Table 2-12). A list of all the field QC samples collected during the Phase II RI is presented in Table 2-12.

2.5.2.2 Sample Custody

WESTON personnel followed the chain-of-custody procedures specified in Section 4 of the QAPP to ensure preservation of the integrity of each sample. Chain-of-custody records were used for sample manifesting. The chain-of-custody records were initiated in the field at the time of sample collection and followed each bottle through completion of chemical analysis.

2.5.3 Laboratory Quality Control

Analyses were performed in accordance with the QAPP and the appropriate methods identified therein. The analytical results were validated in accordance with U.S. EPA Functional Guidelines for reporting organic analyses. Each Phase II RI sample was submitted to WESTON laboratories, who performed the analyses. A summary of quality control results for each media are discussed in Appendix G.

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Table 2-12

Summary of Field Quality Control Samples
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Media/Sample Type	Analyte	Field Samples	Field Duplicates	Trip Blanks	Field Blanks
Surface Soils					
Composite Samples	Chlorophenols	2	1 [50%]	0	0
	Chlorophenoxyherbicides	2	1 [50%]	0	
	2,3,7,8-TCDD	12	3 [25%]	0	0
Subsurface Soils					
Discrete Samples	Toluene	5	1 [20%]	1	0
Groundwater					
	TCL Volatiles	23	2 [9%]	5	3
	Chlorophenols	22	3 [14%]	0	2
	Chlorophenoxyherbicides	25	3 [12%]	0	4
	Chlorobenzenes	22	3 [14%]	0	2
	2,3,7,8-TCDD	11	1 [9%]	0	2
	Chloride	24	3 [13%]	0	3

Data validation reports for each batch of samples are contained in Appendix F. Appropriate data qualifiers were placed on the results, where applicable. The U.S. EPA did not split surface soil or groundwater samples during the Phase II RI.

SECTION 3

RESULTS

3.1 INTRODUCTION

This section summarizes the results of activities performed during the Phase II RI. Particular emphasis is placed on the results of laboratory analyses of samples collected during field activities and results of evaluations and calculations using measurements collected during field activities. Results are presented in summary tables and/or maps for each medium and are discussed in the same order that the media are presented in Section 2. To the extent practical, the results are presented in formats similar to those in the Phase I RI Report.

Samples were analyzed in accordance with the standard analytical methods identified in Table 6-2 of the QAPP and Method 8240 for volatile organic compounds. Analytical results are shown in a summary table for each medium. Results shown include:

- Reported concentrations.
- Quantitation limits.
- Data qualifiers.

The analytical data were validated using the U.S. EPA Contract Laboratory Program (CLP) data validation procedures, or equivalent protocols where CLP procedures are unavailable. Validation report summaries are contained in Appendix G. Statistical analyses for calculating confidence limits for surface soils were performed using software from SAS Institute, Inc. Evaluations and calculations based on measurements made during field activities were completed in accordance with standard procedures, and the results were checked prior to finalization of this report. References are provided for procedures used. Analytical data are reported in the following standard units:

- Soils: Milligrams per kilogram (mg/kg) or parts per million (ppm), except for 2,3,7,8-TCDD which is reported as nanogram per gram (ng/g) or parts per billion (ppb).

- Groundwater: Milligrams per liter (mg/L) or parts per million (ppm) except for 2,3,7,8-TCDD, which is reported in nanograms per liter (ng/L) or parts per trillion (ppt).

For purposes of simplicity, analytical data in the text is discussed in terms of ppm, ppb, or ppt rather than mass/mass or mass/volume units, which are used in the tables.

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3.2 SURFACE SOILS

3.2.1 Introduction

Each surface soil sample collected using the systematic stratified sampling approach described in Subsection 2.2.2 was analyzed for 2,3,7,8-TCDD. A representative sample from each grid near the Regina Paint building was also analyzed for chlorophenols and chlorophenoxyherbicides. The analytical results are summarized in Table 3-1.

The 2,3,7,8-TCDD concentration at the upper 95 percent confidence limit was calculated for three samples in each grid in accordance with the approach used by Exner (1984). The concentration of 2,3,7,8-TCDD at the upper 95 percent confidence limit for each grid is shown in the right-hand column of Table 3-1.

3.2.2 Regina Paint Building Area

Coverage of surface soil grids in the Regina Paint building area included two 5,000-square foot grids. Results for 2,3,7,8-TCDD at the upper 95 percent confidence limit were as follows:

- Grid 586 - $[2,3,7,8\text{-TCDD}]_{95\%}$ = 10.4 ppb
- Grid 587 - $[2,3,7,8\text{-TCDD}]_{95\%}$ = 1.2 ppb

A map showing the coverage and analytical results for existing and Phase II RI surface soil samples for grids in the Regina Paint building area was prepared and is shown in Figure 3-1. The upper 95 percent confidence limit concentrations for 2,3,7,8-TCDD listed in Table 3-1 are shown on the map. Results posted for the U.S. EPA and Vertac Site Contractors surface soil grids were obtained from Appendix A of the Phase I RI Report.

The results of the sampling indicate that 2,3,7,8-TCDD is present in surface soils around and downslope from the Regina Paint building. The distribution of the results indicates that the source of 2,3,7,8-TCDD was probably related to the historical use of the Regina Paint building for storage of drums that reportedly had contained 2,4,5-T waste. The distribution of results shows that the concentration decreases with distance from the Regina Paint building. For example, on an overall basis, the concentration of 2,3,7,8-TCDD at the upper 95 percent confidence limit decreases by an order of magnitude between Grid 586, (10.4 ppb) which encircles the Regina Paint building, and

Table 3-1

Summary of Surface Soil Analytical Results
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Grid Number/ Sample Type	Chlorophenol		Dichlorophenol		Trichlorophenol			Chlorophenoxyherbicide			2,3,7,8-TCDD (a)			95% Confidence Limit
	2-	4-	2,4-	2,6-	2,3,6-	2,4,5-	2,4,6-	2,4-D	Silvex	2,4,5-T	A	B	C	
Units--->	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
586 (0-6")	ND	ND	0.055 J	ND	ND	0.033 J	ND	0.074 J	ND	ND	2.4 J	2.2 J	8.5 J	10.4
586 (0-6",Dup)	ND	ND	0.060 J	ND	ND	0.038 J	ND	0.076 J	ND	0.074 J	NR	4.3 J	NR	NA
587 (0-6")	ND	ND	0.046 J	ND	ND	0.150 J	ND	0.048 J	0.089 J	0.089 J	0.9 J	0.3 J	0.7 J	1.2
588 (0-1")	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	1.2	1.2	3.4	4.1
588 (0-6")	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	3.0 J	3.4 J	5.0 J	5.6
588 (0-6",Dup)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	3.1 J	NR	NR	NA

Notes:

a = TCDD-A --> Surface soil composite sample collected from the "A" locations.
TCDD-B --> Surface soil composite sample collected from the "B" locations.
TCDD-C --> Surface soil composite sample collected from the "C" locations.

Analytical Data Qualifiers:
J = Quantitation estimated below quantitation limit.

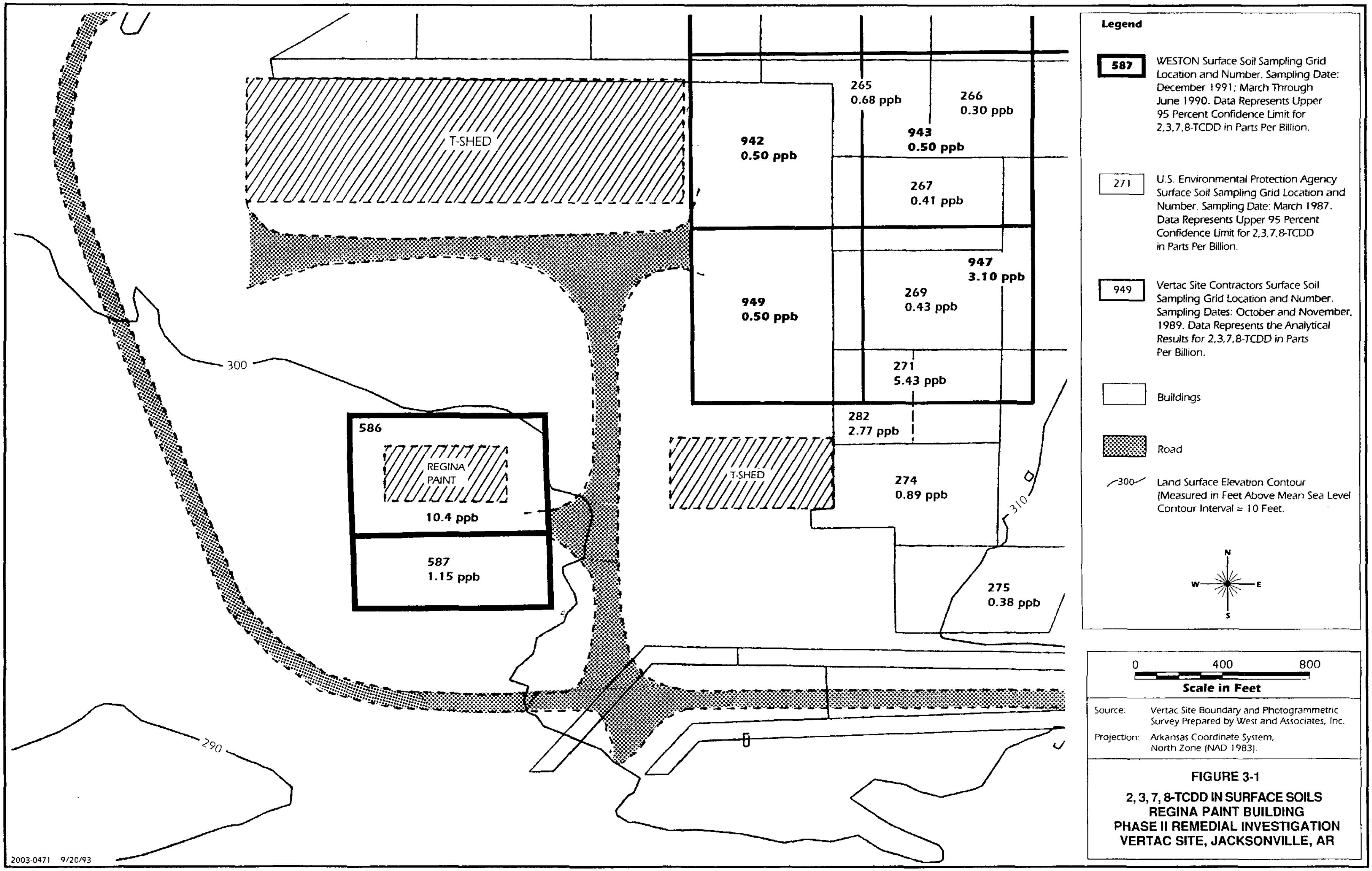

FIGURE 3-1
2, 3, 7, 8-TCDD IN SURFACE SOILS REGINA PAINT BUILDING PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

Grid 587 (1.2 ppb), which is located down slope to the south of the Regina Paint building. In addition, at a smaller scale, the distribution of the results for the three individual samples from Grid 587 also shows a decrease with distance from the Regina Paint building. For example, the highest concentration of 2,3,7,8-TCDD was reported for the "C" sample (8.5 ppb) which was located closest to the building. The concentration of 2,3,7,8-TCDD decreased in the "B" sample (4.3 ppb), which was located about 10 feet from the building, and decreased further in the "A" sample (2.4 ppb), which was located about 15 feet from the building. The results indicate that some chlorophenols and chlorophenoxyherbicides are also present at low concentrations in the surface soils adjacent and downslope from the Regina Paint building. For example, 2,4-dichlorophenol, 2,4,5-trichlorophenol, 2,4-D, and 2,4,5-T were found in the samples from Grid 586 and Grid 587 (Table 3-1). Silvex was also reported in the results for the sample from Grid 587. There was no apparent trend in the concentrations of the chlorophenols or chlorophenoxyherbicides that were found. The presence and distribution of the 2,3,7,8-TCDD and the presence of some chlorophenols and chlorophenoxyherbicides appear to be consistent with the historical use of the Regina Paint building for storage of drums that had contained 2,4,5-T waste. At present, the building contains an estimated 1,100 empty metal drums (Subsection 3.2.4.1, WESTON, 1992a).

Historical data (Appendix A; WESTON, 1992b) show that 2,3,7,8-TCDD was also found at elevated concentrations, relative to surrounding soil grids, in U.S. EPA soil Grids 271 (5.43 ppb) and 282 (2.77 ppb) and Vertac Site Contractors soil Grid 947 (3.1 ppb). These grids are located northeast of the T-Shed (Figure 3-1). The presence and distribution of 2,3,7,8-TCDD in these grids is probably related to drum storage activities in the T-shed and is probably not related to the activities at the Regina Paint building. This is based on the fact that, although the T-shed is upslope from the Regina Paint building, a road topographically separates the T-shed from the Regina Paint building.

3.2.3 Marshall Road Area

Results for 2,3,7,8-TCDD at the upper 95 percent confidence limit for Grid 588 were as follows:

- Grid 588 (0-1") - [2,3,7,8-TCDD]$_{95\%}$ = 4.1 ppb
- Grid 588 (0-6") - [2,3,7,8-TCDD]$_{95\%}$ = 5.6 ppb

These results indicate that the surface soils in the area along the west side of Marshall Road contain 2,3,7,8-TCDD at concentrations of 4.1 (0 to 1-inch) to 5.6 ppb (0 to 6-inches) at the upper 95 percent confidence limit.

A map showing the coverage and analytical results for Phase I and Phase II RI surface soil sample grids in the vicinity of Marshall Road was prepared and is shown in Figure 3-2. The upper 95 percent confidence limits for 2,3,7,8-TCDD are shown on the map (Table 3-1 and Table 3-1 of the Phase I RI Report).

A review of the distribution of 2,3,7,8-TCDD in surface soils at Grid 588 indicates that the 2,3,7,8-TCDD probably was deposited on the eastern side of the ditch as a result of run-off from the central process area. This is indicated by the trends in the analytical results for both the 0 to 1-inch and 0 to 6-inch intervals, which show a decrease in the concentration of 2,3,7,8-TCDD toward Marshall Road (composite "A") eastward from the drainage ditch (composite "C"). The source of the 2,3,7,8-TCDD in Grid 588 is presumed to be related to the presence of 2,3,7,8-TCDD in surface soils west of the drainage ditch, where concentrations ranged from about 0.06 ppb to 98 ppb at the upper 95 percent confidence limit (Table 3-1, WESTON, 1992b). The results of the 0 to 6-inch sample are similar to but slightly higher than results for the 0 to 1-inch sample (Table 3-1).

The analytical results for surface soil Grid 588 (4.1 ppb 0 to 1-inch and 5.6 ppb 0 to 6-inch sample) were comparable to the original sample for Grid 529 (6.3 ppb, Table 3-1, Phase I RI Report). As explained in the Phase II Work Plan, the area originally included in Grid 529 was re-sampled during the Phase II RI as Grid 588 using the systematic stratified sampling method. The decision to re-sample the surface soils in the area was based on desirability of confirming the original result that was obtained from a single sample, collected using a screening approach. The results for the samples collected during the Phase II RI, appear to confirm the results for the screening sample collected from Grid 529 during the Phase I RI.

FIGURE 3-2

2, 3, 7, 8-TCDD IN SURFACE SOILS NEAR MARSHALL ROAD PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

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3.3 GROUNDWATER

3.3.1 Introduction

Results of activities performed during the groundwater investigation (Subsection 2.3) are presented in this subsection. The results include information on the geologic framework, hydrogeologic framework, and groundwater quality for the fourteen monitoring wells and one stratigraphic boring completed in fresh bedrock during the Phase II RI. This information was collected to attempt to complete the definition of the horizontal and vertical extent of contamination, and refine the conceptual model for contaminant transport potential. Data from existing fresh bedrock monitoring wells are incorporated into this evaluation.

3.3.2 Geologic Framework

3.3.2.1 Introduction

The geologic framework was based on the integration activities from Phase I RI (Section 2 of the Phase I RI Report) and Phase II RI (Section 2.3). Information gathered during the Phase II RI focused on the geology of the Pennsylvanian Atoka Formation (Atoka Formation) below the depth of weathering in the following areas:

- Administration building area southeast of the central process area.
- North and east of the dalapon production area (along the northern perimeter of the central process area).
- Area west of Rocky Branch Creek.

The Atoka Formation is overlain by Tertiary Coastal Plain deposits of the Wilcox Group and the Midway Formation. The geology of these deposits was discussed in Subsections 3.4.2.2.2 and 3.4.2.2.3 of the Phase I RI Report. The geologic framework is discussed from the perspective of providing sufficient information to select a remedy for groundwater, if necessary.

3.3.2.2 Stratigraphic Framework of the Atoka Formation

The rocks of the Atoka Formation have a regional presence in the vicinity of the Site. The interbedded siltstone, shale, and sandstone lithologies of the Atoka Formation are exposed near the western boundary of Site along Rocky Branch Creek. The formation is exposed along a northwest-southeast trend with northerly dipping beds. The Atoka Formation is overlain by the younger Midway Formation and the Wilcox Group on the eastern boundary of the Site. The Atoka Formation also crops out south of the Site in the bed of Rocky Branch Creek upstream from the confluence with an east tributary just north of Main Street and east of Rebel Drive in the bed of the east tributary.

The bedrock observed along Rocky Branch Creek changes from mostly shale at the southern end of the Site to massive sandstone beds, and interbedded sandstone, shale, and siltstone packages near the northern most bedrock exposure in the creek. The rocks observed in the creek are correlated to the rocks observed in the deep stratigraphic borings drilled during the Phase I and Phase II Remedial Investigations. A correlation chart of the natural gamma logs from the stratigraphic borings and monitoring wells constructed during the Phase I and Phase II Remedial Investigations to the Atoka Formation outcrop in Rocky Branch Creek is presented in Plate 3-1.

The Site bedrock stratigraphy is best described using the concept of packages. A package would consist of rocks of similar lithology, structure, and water-bearing capacity. This concept was used for determining which water-bearing units would be subjected to hydraulic conductivity testing.

The stratigraphic correlation chart (Plate 3-1) indicates that rock units can be traced laterally across the Site. The stratigraphic correlations were made based largely on the similarities of the natural gamma logs that were compared among boreholes and observations made along the outcrop in Rocky Branch Creek. As a result of their relatively high continuity, the shale units were used to select the top or bottom of the stratigraphic packages. The shale units are informally designated by the letters "A" through "G" on Plate 3-1. The response of monitoring wells constructed in the same bedrock package to pumping tests also indicates that the bedrock packages are of similar lithologic and structural character.

3.3.2.3 Structural Framework

The structural framework of the site geology is summarized in this subsection. In this report, emphasis is focused on the Atoka Formation because groundwater in the Atoka Formation was found to be contaminated with site-related compounds. Additional information about the structural framework of the Wilcox Group, Midway Formation, and the Atoka Formation are described in Subsection 3.4.2.2 of the Phase I RI Report.

Visual evaluation of the cores from monitoring wells, MW-87 and MW-88 and stratigraphic boring, XB-22 (Subsection 2.3.3.1), indicated that the strike and dip of the Atoka Formation on the east side of the Site were N80° to 85°W and 28°N, respectively. These strike and dip values were used to locate MW-86, the remainder of the Phase II wells and to select the depth of the wells on the east side of the Site, where the objective was to drill into strata that were correlative with strata in nearby wells. Correlation of strata based on gamma-ray logs that were run in the wells indicated that the strike and dip are N75°W, and 30°N, respectively. These latter values for strike and dip are similar to those measured west of the central process area, where the strike is about N70°W with a maximum dip of 35°N, based on the Atoka Formation where beds are exposed in outcrop along Rocky Branch Creek (Subsection 3.4.2.2.4, WESTON, 1992b).

The primary fracture set was N50°W to N70°W, subparallel to the strike of bedding. The dip of the primary fracture set was to the southwest. The strike of the secondary fracture set was N30°E to N50°E. The dip of the secondary fracture set was to the southeast at steep angles. Fractures associated with the primary fracture set were more penetrative than the secondary fracture directions based on the Atoka formation subcrop exposed in Rocky Branch Creek (Subsection 2.4.3.3, WESTON, 1992b). The secondary fractures did not penetrate more than 1 or 2 beds.

The structural relationship of the Wilcox Group, Midway Formation, and the Atoka Formation are shown in Figure 3-3 which was updated from Figure 3-29 of the Phase I RI Report. The cross-section was constructed parallel to the dip direction (i.e., north-south) with a five-fold vertical exaggeration. The vertical exaggeration resulted in the steep apparent dip. The bend in the line of the cross-section resulted in the changes in the apparent dip angle shown on Figure 3-3. It should be noted that the apparent fold on Figure 3-3 is an artifact of the line of section and does not occur in the rocks. The orientation of the bedrock is shown on Figure 3-4.

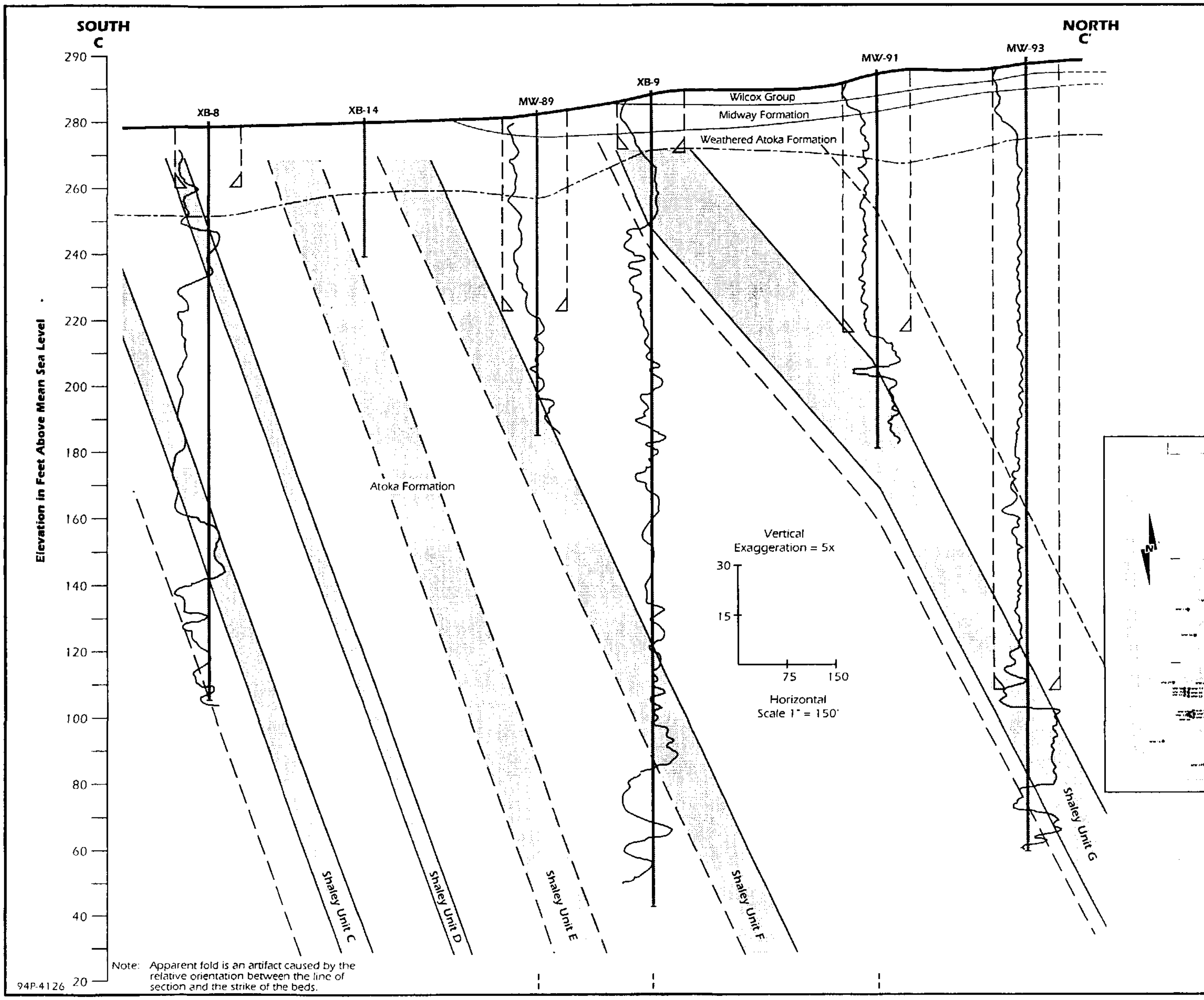

FIGURE 3-3
GEOLOGIC CROSS SECTION C-C'
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE
JACKSONVILLE, AR

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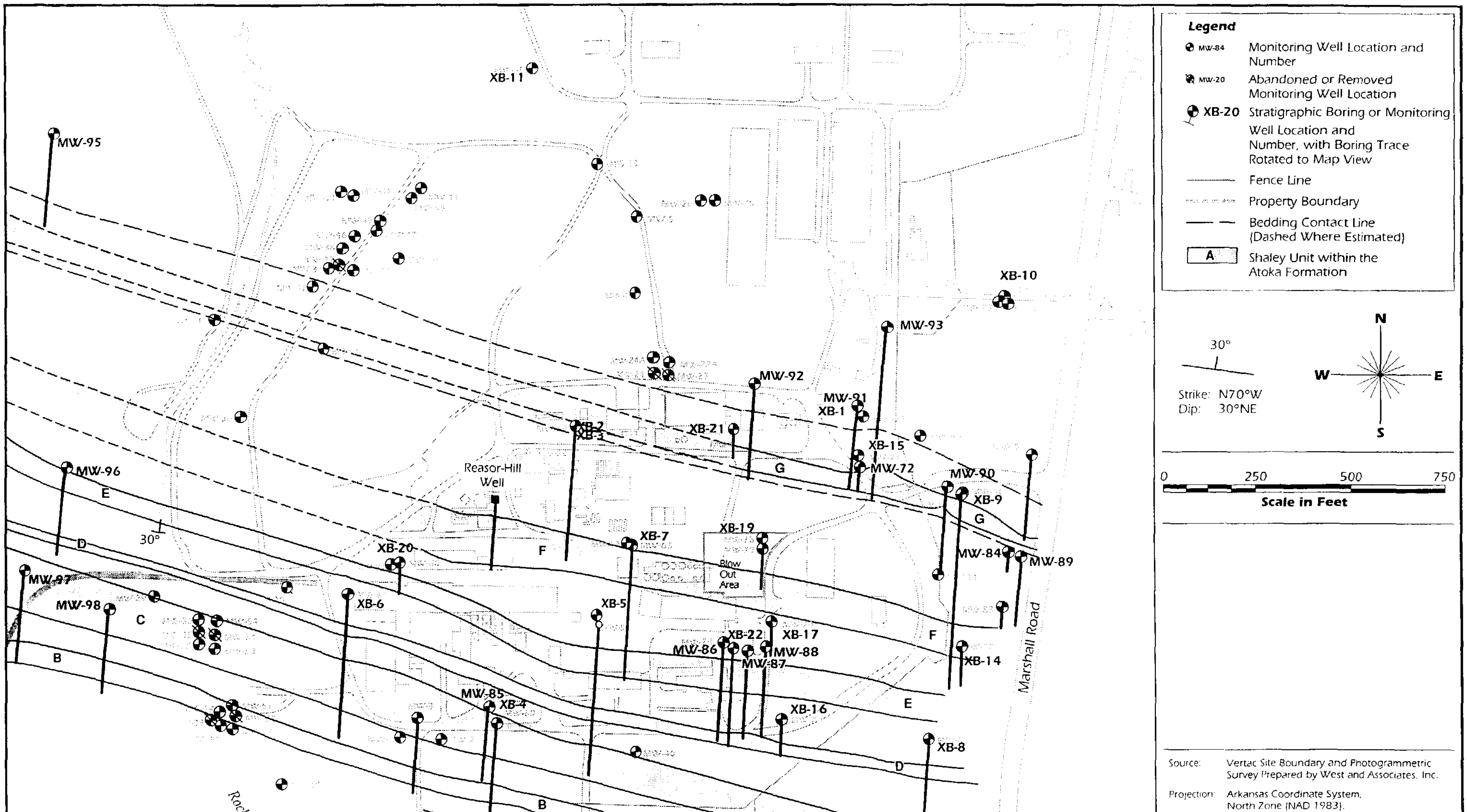

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-4

BEDROCK SUBCROP GEOLOGIC MAP ATOKA FORMATION PHASE II REMEDIAL INVESTIGATON VERTAC SITE, JACKSONVILLE, AR

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The bedrock subcrop map (Figure 3-4) was updated to include information from the Phase II monitoring wells, including the strike, dip, and revised stratigraphic information for the area west of Rocky Branch Creek. The map was constructed to provide a guide to the shallow bedrock and to indicate dominant rock types in different areas of the central process area. The map shows the projected locations and orientations of the strata that would be seen if the overlying unconsolidated sediments were removed. The map shows the pattern of the major sandstone and shale packages within the Atoka Formation. Plate 3-1 provides additional stratigraphic correlation of the natural gamma logs with the Atoka Formation subcrop in Rocky Branch Creek.

3.3.2.4 Weathering of Atoka Formation

Effects of weathering are superimposed on top of the stratigraphic and structural features of the Atoka Formation. The effects of the weathering are most significant near land surface where the rock has been weathered to a residual soil. The extent of the weathering decreases downward from the land surfaces and the competency of the rock increases with depth. On the basis of weathering, the Atoka Formation was divided into three zones as described in Subsection 2.4.3.5, Phase I RI Report:

- Unconsolidated weathered bedrock.
- Consolidated weathered bedrock.
- Fresh bedrock.

The unconsolidated weathered bedrock is characterized by the common occurrence of orange-stained sediments and fractures (Subsection 3.4.2.2.4 of the Phase I RI Report). The thickness of the unconsolidated weathered bedrock ranged from 2 to 18 feet in thickness based on the depth of auger/split-spoon refusal (WESTON, 1992b).

The consolidated weathered bedrock is below the unconsolidated weathered bedrock and is characterized based on competence of the strata and the prevalence of orange-stained fractures. The orange staining typically occurred to depths of about 34 feet BGS (Table 2-3). In cores from MW-86, MW-87, MW-89 and MW-90, a few orange-stained fractures were observed at depths of 53 to 85 feet. Orange-stained fractures at such depths were not previously recognized and may be indicative of individual fractures where groundwater flow was more active than adjacent fractures.

The unweathered (fresh) bedrock zone is the deepest of the three zones in the Atoka Formation. The fresh bedrock is characterized by the general absence of orange-stained fractures (and altered rock color). Weathering at the Site was a progressive chemical process that over time dissolved the more soluble minerals in the rock and disaggregated the rock. Shales were weathered to clays; siltstones weathered into silts; and sandstones weathered into sands. The minerals which were most soluble were dissolved first leaving less soluble minerals as a residual soil. As a results of the presence of different minerals, and their relative proportions in the rock, shales, siltstones, and sandstones weathered differently. On a relative basis the shales were more deeply weathered than the sandstones. The relative resistance of the sandstones to weathering is reflected in the topography of the central process area where several sandstone layers were observed.

3.3.3 Hydrogeologic Framework

Hydrostratigraphic units were delineated on the Site based on stratigraphy, structural geology, piezometric mapping, porosity, packer testing, slug testing, and pump testing. The units are consistent with Seaber's (1988) definition that considers a hydrostratigraphic unit as a body of rock distinguished and characterized on the basis of its observable hydrogeologic characteristics, such as lithology, porosity, and permeability. Delineation of these units is intended to facilitate explanation of the Site hydrogeology. Within 250 feet of the land surface (based on the depth of existing monitoring wells), three major hydrostratigraphic units were identified at the Site:

- Wilcox Group.
- Midway Formation.
- Atoka Formation.

The Wilcox Group and Midway Formation, which consist of unconsolidated sands, silts and clays, are regionally present as two distinct hydrostratigraphic units (Counts, 1957). In the area of the Site, these units are located north and east of the central process area where they unconformably overlie the older bedrock of the Atoka Formation. The characteristics of the Wilcox Group in the area of the Site indicate that it is a water-bearing unit based on the presence of silty sands and high relative hydraulic conductivity of about 10^{-3} cm/sec (10^{-5} ft/sec). Such characteristics are exemplified by monitoring wells MW-68 and MW-70. In contrast, the Midway Formation is an aquitard (i.e., not a water producing unit) based upon the amount of clay and the low relative hydraulic conductivity. Such characteristics are exemplified by monitoring well MW-65 where attempts to perform hydraulic conductivity testing were unsuccessful because of the slow recharge. The low hydraulic conductivity of the Midway Formation at the Site is consistent with confining conditions that are characteristic of the formation across the Gulf Coastal Plain physiographic province (Counts, 1957, and Davis, 1988). Hydraulic characteristics of these two hydrostratigraphic units were evaluated as part of the Phase I RI. These characteristics are discussed here to provide a background for describing the hydrostratigraphic characteristics of the Atoka Formation which is discussed in the remainder of this subsection. It should be noted that additional description of the Wilcox and Midway hydrostratigraphic units is limited because site-related compounds have not been found in these units. These formations may have shallow water table conditions to the north and east of the Site, but appear to be separated from the Atoka Formation which acts as a semi-confined hydrostratigraphic unit.

The Atoka Formation is a complex hydrostratigraphic unit that is present as bedrock throughout the Site area. As discussed in Subsection 3.3.2, the geology of the Atoka Formation in the Site area is characterized by northward dipping, interbedded sandstone, siltstone, and shale beds that are overlain unconformably by the Wilcox Group and the Midway Formation. The hydrogeology of the Atoka Formation is complex due to variations in geological features such as lithology and structural fracturing. The hydrogeology of the Atoka Formation is further complicated by influences related to differential weathering of the bedrock. Based on the degree of weathering, the Atoka Formation can be subdivided into three distinct hydrogeologic zones: (1) unconsolidated weathered bedrock; (2) consolidated weathered bedrock; and, (2) fresh bedrock. Hydrologic characteristics of these zones are described in the following paragraphs.

The unconsolidated weathered bedrock is exposed throughout the southern, central, and western parts of the Site. The hydrogeologic characteristics of the unconsolidated weathered bedrock include:

- Residual soils ranging from clay to coarse sand depending on the nature of the parent bedrock. Characteristics of the soil tend to be similar to the underlying bedrock, except where the soils were disturbed during plant construction or operations, particularly in the central process area.

- High intergranular porosity but relatively low hydraulic conductivity.

- Low hydraulic connection with the underlying consolidated weathered bedrock, based on results of pumping tests in the North Landfill area (WESTON, 1990b) where drawdown in water levels in the consolidated weathered bedrock did not result in drawdown in water levels in the unconsolidated weathered bedrock.

- Potential occurrence of a seasonal perched water table based on test pit observations (Table 2-1).

The consolidated weathered bedrock is present across the Site. Hydrogeologic characteristics of the consolidated weathered bedrock, which includes confining and water-bearing units, are as follows:

- Northward dipping, interbedded sandstone, siltstone, and shale lithologies.

- Water table conditions.

- Highly fractured.

- Moderate to low intergranular porosity and moderate to low hydraulic conductivity.

- Hydraulically connected to the fresh bedrock.

- Similar hydraulic conductivity values across stratigraphic units.

The fresh bedrock is present across the entire Site. The hydrogeologic characteristics of the confining and water-bearing units which comprise the fresh bedrock zone include:

- Northerly dipping, interbedded sandstone, siltstone, and shale lithologies.

- Semi-confined or leaky groundwater conditions.

- Fracture porosity and permeability with low intergranular porosity and permeability.

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- Variable fracture percentage; sandstone tends to have open, continuous fractures compared to shale as viewed at the Atoka Formation subcrop in Rocky Branch Creek (Subsection 2.4.3.3, WESTON 1992b).

- Number and frequency of the fractures appeared to decrease with depth based on observations of cores and the borehole television logs (Subsections 2.4.5.2 and 3.4.3.4; WESTON, 1992b).

Within the Atoka Formation, the primary water-bearing units are layers of consolidated sandstone that are characterized by the persistence of relatively open fractures, high effective fracture porosity, and low intergranular porosity. The water-bearing units may be confined (Pump Tests 1 and 2) or semi-confined (Pump Tests 3 and 4) by adjacent confining units across the Site (Subsections 3.3.5.3.4, 3.3.5.3.5, 3.3.5.3.7, 3.3.5.3.8, and 3.3.5.3.9). Groundwater flow potential in water-bearing units is higher than in confining units.

The confining units are comprised mostly of shale and are defined by high intergranular porosity, low fracture connectivity, low effective porosity and some persistence of fracturing at lithologic boundaries. The confining units may act as a complete or partial barrier to groundwater flow due to low effective porosity of the unit.

3.3.4 Water Level Measurements

3.3.4.1 Introduction

Water level measurements were used to calculate water level elevations in previously existing monitoring wells (MW-1 through MW-84) and in monitoring wells (MW-85 through MW-98) which were installed during the Phase II RI. Water level elevations were calculated by subtracting the depth to water as measured from the top of casing, from the elevation of the top of casing as determined by surveying. The water level elevations were used to assess horizontal and vertical groundwater gradients and to evaluate seasonal variations in groundwater levels. Water level elevations prior to the pumping tests are listed in Table 3-2. Historical groundwater level elevations are listed in Appendix F. These water level elevations were used to evaluate horizontal and vertical groundwater flow as described in the following subsections.

Table 3-2

Static Groundwater Measurements in the Fresh Bedrock
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth (a)	Top of Casing Elevation (b)	Depth to Groundwater (c,d)	Groundwater Elevation (e)	Monitored Interval Elevation (e)
MW-85	101.2	286.28	19.02	267.26	204.28-181.80
MW-86	131.0	285.24	13.87	271.37	181.73-151.14
MW-87	100.4	283.13	11.77	271.36	201.80-179.74
MW-88	131.6	283.18	11.78	271.40	179.78-148.97
MW-89	94.9	273.72	2.05	271.67	210.72-176.70
MW-90	101.8	279.37	16.19[f]	273.18	197.04-175.20
MW-91	114.1	285.29	6.04	279.25	203.97-169.30
MW-92	126.4	289.27	8.15	281.12	207.17-161.10
MW-93	242.0	288.42	8.68	279.74	96.60-44.10
MW-94	101.9	281.17	2.70	278.47	197.34-175.90

Notes:

a = Measurement in feet below land surface.

b = Measurement in feet above mean sea level. Survey data provided by West and Associates, Jacksonville, Arkansas.

c = Measurements were collected by Hercules site personnel on 18 and 19 February 1992, as part of the monthly water level rounds.

d = Measurement in feet below top of casing.

e = Measurement in feet above mean sea level relative to the top of casing elevation.

f = Measurement was collected by WESTON on 16 February 1992. Monitoring well MW-90 was not measured during the monthly water round of 18 and 19 February 1992.

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3.3.4.2 Horizontal Groundwater Flow

3.3.4.2.1 Unconsolidated and Consolidated Weathered Bedrock

The horizontal component of the groundwater gradient in the weathered bedrock (weathered bedrock) was evaluated by constructing piezometric maps using water level data collected on 20 October 1992 and 24 May 1993. These dates were selected to represent horizontal groundwater flow during two different seasons. The October date was selected to be representative of groundwater levels during the Fall which is a period of low precipitation and recharge. The May date was selected to be representative of groundwater levels during the spring which is a period of high precipitation and recharge. The water level elevations are listed in Table 3-3 and the piezometric levels are shown in Figures 3-5 and 3-6. Piezometric maps were constructed using the elevations of groundwater in the weathered rock in the Atoka Formation, assuming that the wells and piezometers are hydrologically connected. Supplementary field observations, such as known seepage points along the central ditch and along Rocky Branch Creek, were also used in constructing the piezometric maps. The piezometric maps were constructed assuming horizontal, isotropic groundwater flow conditions in accordance with methods described by Freeze and Cherry (1979).

The two piezometric maps (Figures 3-5 and 3-6) exhibit consistent features. The major maps are summarized below:

- A broad low gradient area occurs along a groundwater high located north of the central process area which indicates horizontal flow toward the east and west and to a lesser extent, toward the south.

- A second isolated groundwater high exists south of the central ditch and exhibits radial flow in that area.

- The pattern of groundwater elevation contours parallel the trend of the surface topography (Plate 1, WESTON 1992b).

- Deflection of the water level elevation contours adjacent to the central ditch indicates the ditch controls the elevation of groundwater in the central process area adjacent to the central ditch. This influence was observed in the field based

Table 3–3

Groundwater Measurements Used to Construct Piezometric Maps and Cross Sections
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Well Depth[a]	Top of Casing[b,c]	Groundwater Elevation[b] 20 October 1992	Groundwater Elevation[b] 24 May 1993	Monitored Interval Elevation[b]		Base of Orange Staining[a]
					Top	Bottom	
MW–01	29.0	286.68	271.60	277.99	259.50	252.50	30
MW–04	21.0	303.28	282.32	286.62	282.80	279.80	18
MW–05	28.5	302.28	281.94	286.41	273.90	270.90	23
MW–17	9.7	280.35	273.02	274.04	276.70	268.70	10
MW–24A	26.0	298.36	281.14	286.01	276.60	269.60	24
MW–26	28.7	294.87	282.25	287.09	271.50	265.30	24.5
MW–41	8.5	275.40	270.59	271.82	269.00	264.50	NA
MW–42	34.0	279.69	261.37	266.06	251.80	242.71	29
MW–43	23.0	279.32	262.98	266.68	259.31	253.31	29
MW–45	17.0	288.46	275.80	276.43	274.60	268.60	15
MW–46	18.0	285.06	274.56	276.03	270.60	264.60	16
MW–51	20.0	269.85	260.08	262.15	254.40	246.40	12
MW–53	25.0	271.43	260.72	262.11	254.40	244.40	15
MW–57	23.5	286.53	276.43	280.92	266.88	259.88	23.5
MW–60	30.0	285.35	273.39	278.31	261.47	252.97	31
MW–61	15.3	281.53	274.72	277.47	270.27	263.37	29
MW–62	14.6	287.47	280.49	282.13	276.11	270.11	40
MW–64	28.0	294.33	280.17	284.43	272.74	263.44	30
MW–66	19.7	279.63	270.70	275.81	263.48	257.08	17.5
MW–67	18.0	271.49	261.57	266.01	257.42	250.42	28
MW–71	21.0	284.82	277.12	280.76	267.13	261.13	30

Table 3–3 (continued)

Groundwater Measurements Used to Construct Piezometric Maps and Cross Sections
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Well Depth[a]	Top of Casing[b,c]	Groundwater Elevation[b] 20 October 1992	Groundwater Elevation[b] 24 May 1993	Monitored Interval Elevation[b] Top	Monitored Interval Elevation[b] Bottom	Base of Orange Staining[a]
MW–73	33.7	279.99	270.03	273.29	251.96	244.46	29
MW–75	31.5	288.33	276.21	282.17	260.19	254.19	31
MW–76	33.6	283.32	272.32	275.69	254.88	248.16	33
MW–77	20.3	273.40	264.50	269.24	257.18	250.08	22
MW–78	23.0	285.75	275.41	278.87	266.42	260.42	23
MW–81	25.2	285.01	277.56	278.71	263.00	256.70	19
MW–82	22.1	292.20	280.10	284.79	273.29	267.09	21
MW–83	28.7	274.74	264.74	268.85	249.99	243.39	28.2
MW–84	27.0	275.50	261.10	269.59	252.65	245.65	25
PZ–142	27.8	286.76	NA	281.38	263.90	256.70	28
PZ–143	22.76	288.08	NA	284.02	271.04	263.04	23
PZ–144	25.01	290.38	NA	282.83	269.69	262.49	25
PZ–145	22.81	291.29	NA	284.21	273.19	266.29	23.2
PZ–146	25.94	292.81	NA	285.33	271.66	264.66	28.5
PZ–147	25.83	288.09	NA	282.27	267.17	259.97	26
PZ–148	22.95	287.28	NA	277.01	269.45	262.25	23
PZ–149	35.25	297.03	NA	286.14	266.95	259.75	NE

Notes:

Data points represent monitoring wells and piezometers screened in weathered bedrock. (Atoka Formation).

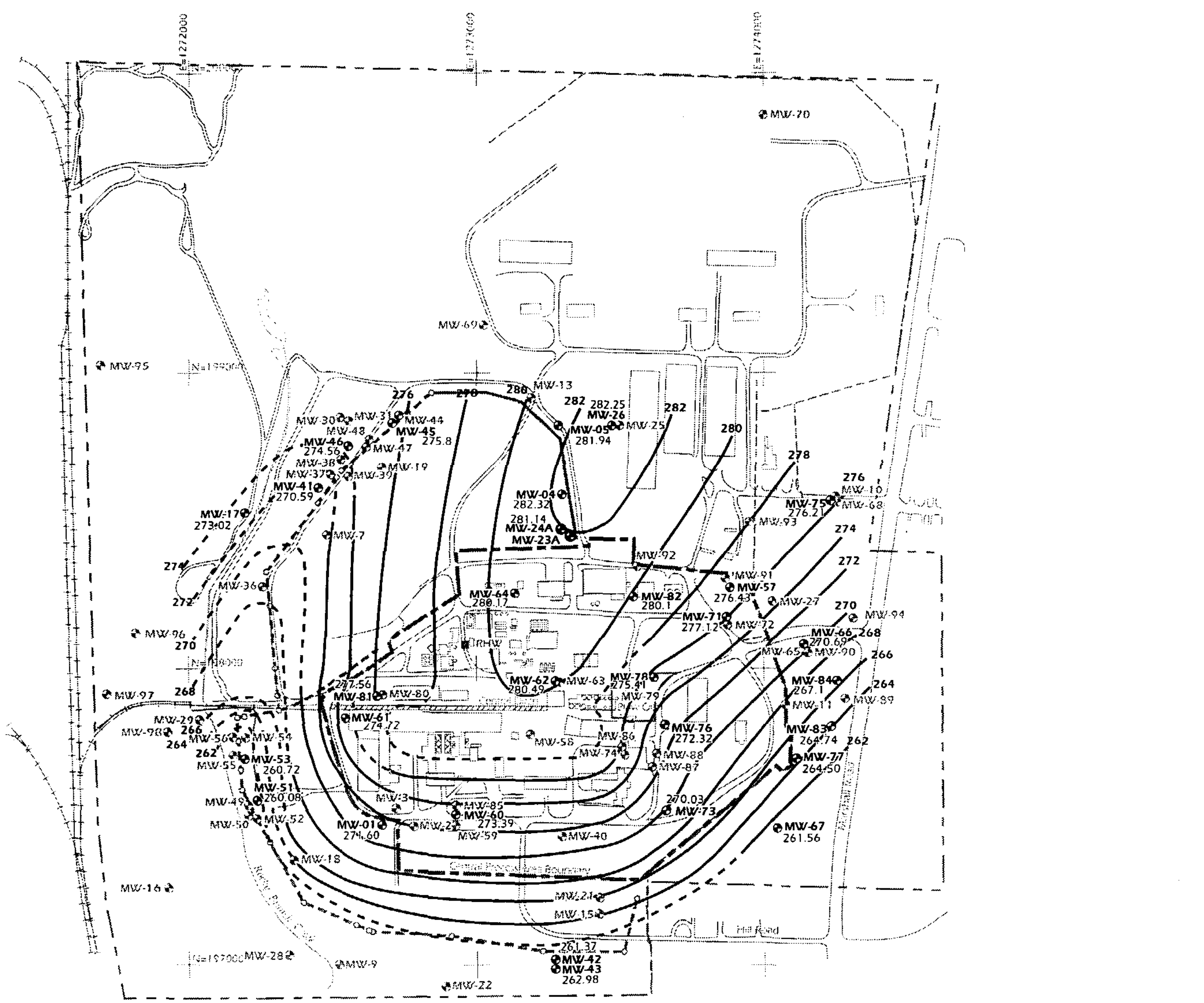
a = Measurement in feet below land surface.

b = Measurement in feet above mean sea level.

c = Survey data provided by West and Associates, Inc., Jacksonville, Arkansas and The Mehlburger Firm, Little Rock, Arkansas.

NA = Not Applicable.

NE = Not Encountered.



Legend

- PZ-149 Piezometer Location and Number
- MW-84 Monitoring Well Location and Number
- 280 Groundwater Elevation Contour (Measured in Feet Above Mean Sea Level) Contour Interval: 2 feet; Contour Dashed Where Approximate
- RHW Reasor-Hill Well
- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch

0 400 800 1200

Scale in Feet

Note: Groundwater elevation data collected on 20 October 1992 by Hercules site personnel. Map was constructed using wells completed in the weathered Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-5
PIEZOMETRIC SURFACE MAP
WEATHERED ATOKA FORMATION
20 OCTOBER 1992
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

94P-4131 7/19/94

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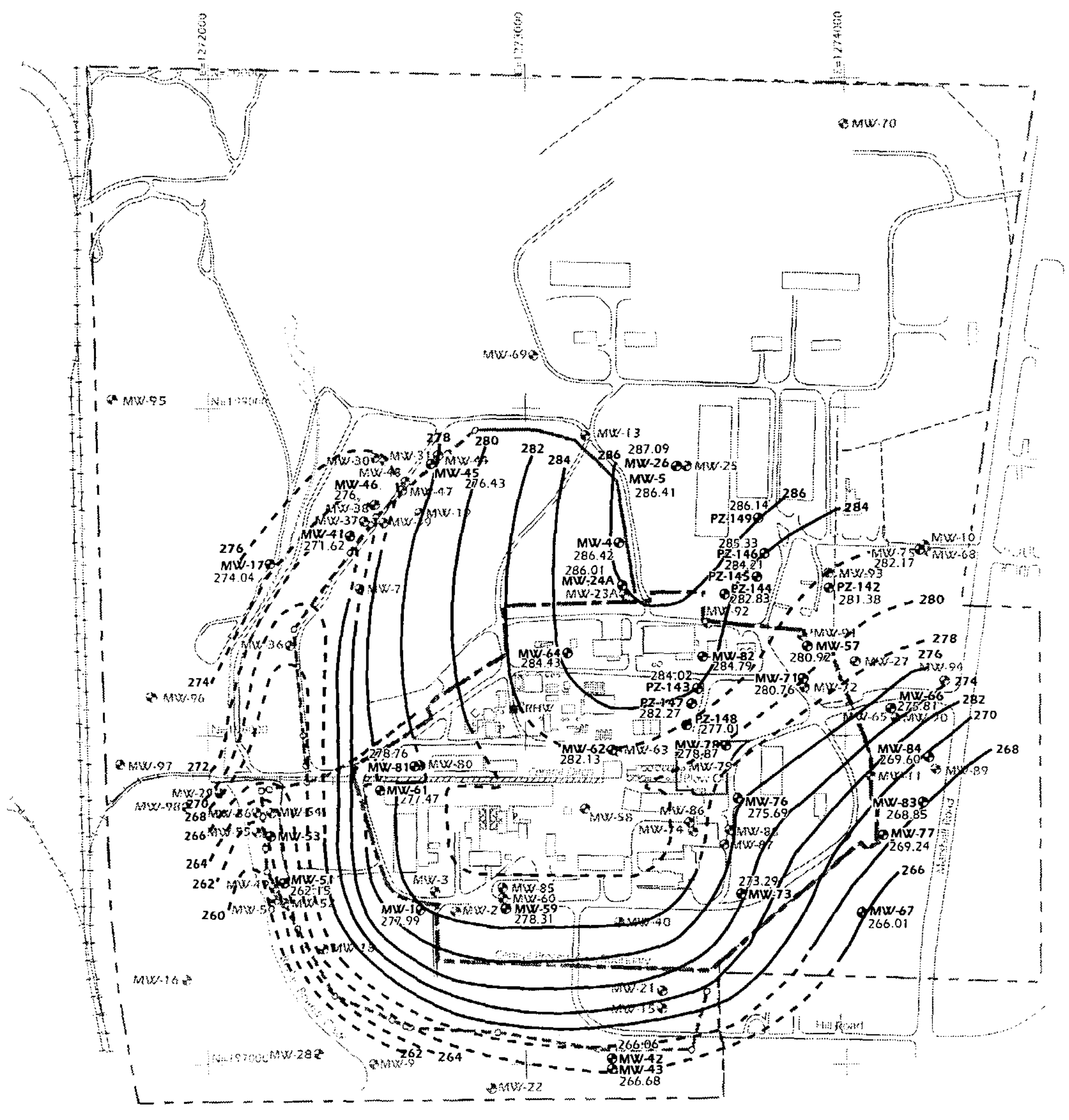


Legend

PZ-149 Piezometer Location and Number

MW-84 Monitoring Well Location and Number

280 Groundwater Elevation Contour
(Measured in Feet Above Mean Sea Level)
Contour Interval: 2 feet;
Contour Dashed Where Approximate

RHW *Reasor-Hill Well*

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800 1200

Scale in Feet

Note: Groundwater elevation data collected on 24 May 1993 by Hercules site personnel. Map was constructed using wells completed in the weathered Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-6
PIEZOMETRIC SURFACE MAP
WEATHERED ATOKA FORMATION
24 MAY 1993
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

94P-4132 7/19/94

000390

on water levels in test pits TP-13 and TP-14 (Table 2-1), which were above the elevation of the adjacent ditch, and the occurrence of seepage along the floor of the central ditch.

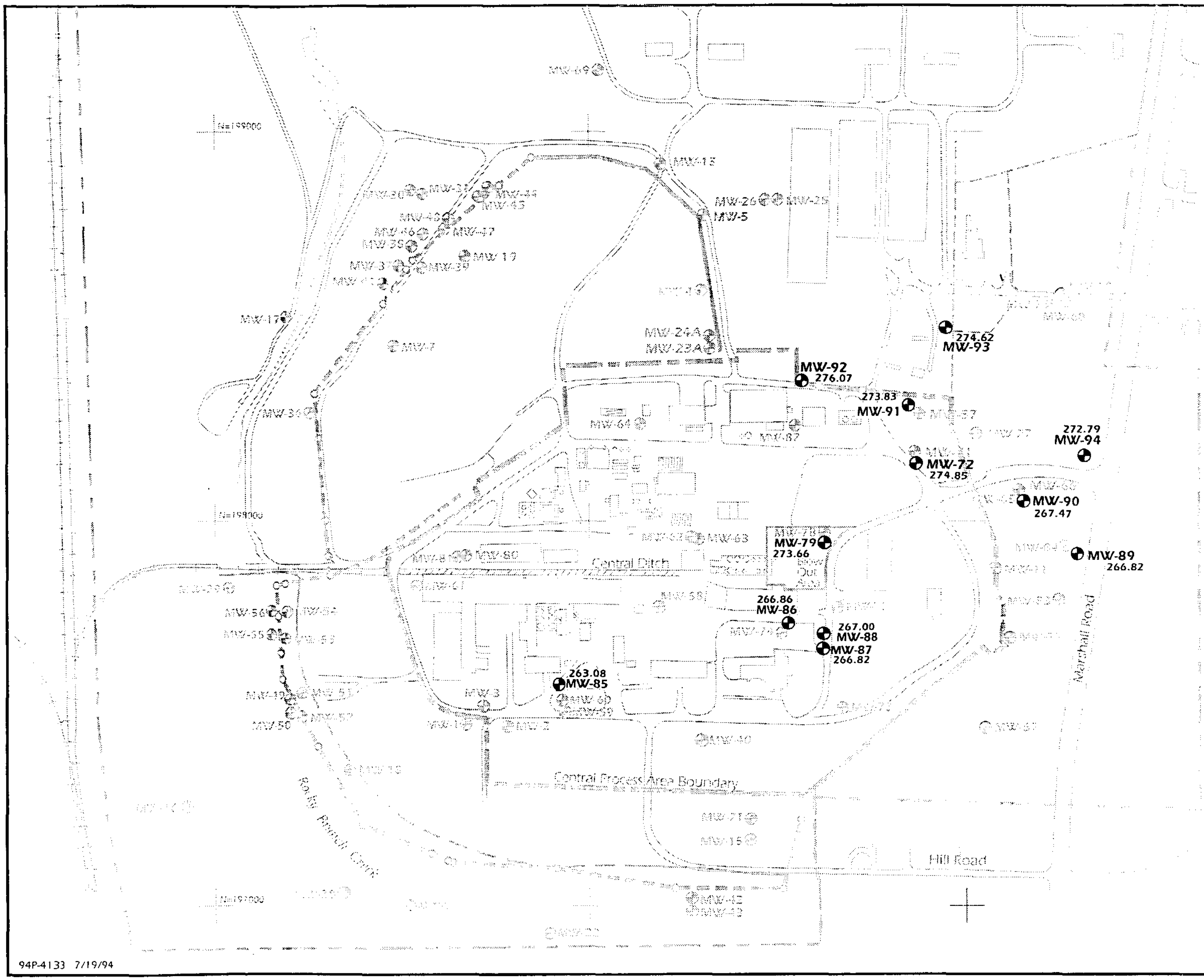
- Groundwater elevations appear to decrease westward toward the french drain and eastward toward Rocky Branch Creek, which is a perennial stream on the western side of the Site; therefore the french drain and creek appear to be the ultimate receptor of shallow, horizontal groundwater flow on the west side of the Site.

The pattern of water level elevation contours shown on these maps are parallel to the trends shown on piezometric maps presented in the Phase I RI (Subsection 3.4.3.2.4). A comparison of the trends in the contours indicates that the hydraulic control exerted by the central ditch is less during drier months, such as October (Figure 3-5) when flow is concentrated at the east end of the ditch relative to the control exerted during the wetter months, such as May (Figure 3-6).

A compilation of groundwater elevations in Site monitoring wells and associated hydrographs for the period 25 September 1990 through 24 May 1993 are presented in Appendix F. Monitoring well MW-25 did not exhibit a similar water level response pattern to other site monitoring wells, owing to possible failure of the well construction. The seasonal response of water levels indicate a maximum water level occurring during the months of April and May, followed by a minimum water level in the months of August, September, and October. The seasonal response of precipitation is evident in the water level elevation maps for weathered bedrock and fresh bedrock. Water level changes were similar in paired wells without discrimination among weathering zones, i.e., monitoring well constructed in fresh bedrock exhibited the same response to precipitation as did weathered bedrock wells. Short term (seasonal) changes in water level were observed in most wells.

3.3.4.2.2 Fresh Bedrock

The horizontal component of groundwater gradient in the fresh bedrock was evaluated by water level elevation data collected on 24 May 1993 (Table 3-3) following the installation of additional bedrock wells west of Rocky Branch Creek. The water level elevations are plotted on Figures 3-7 and 3-8. The maps were constructed using available water level data for site monitoring wells



Legend

MW-85	Monitoring Well Completed in Fresh Deep Bedrock
MW-84	Monitoring Well Completed in Unconsolidated Sediments or Weathered Bedrock
263.08	Groundwater Elevation Measured in Feet Above Mean Sea Level
	French Drain
	Slurry Wall
	Fence Line
	Property Boundary
	Central Process Area Boundary
	Central Ditch

N
W E
S

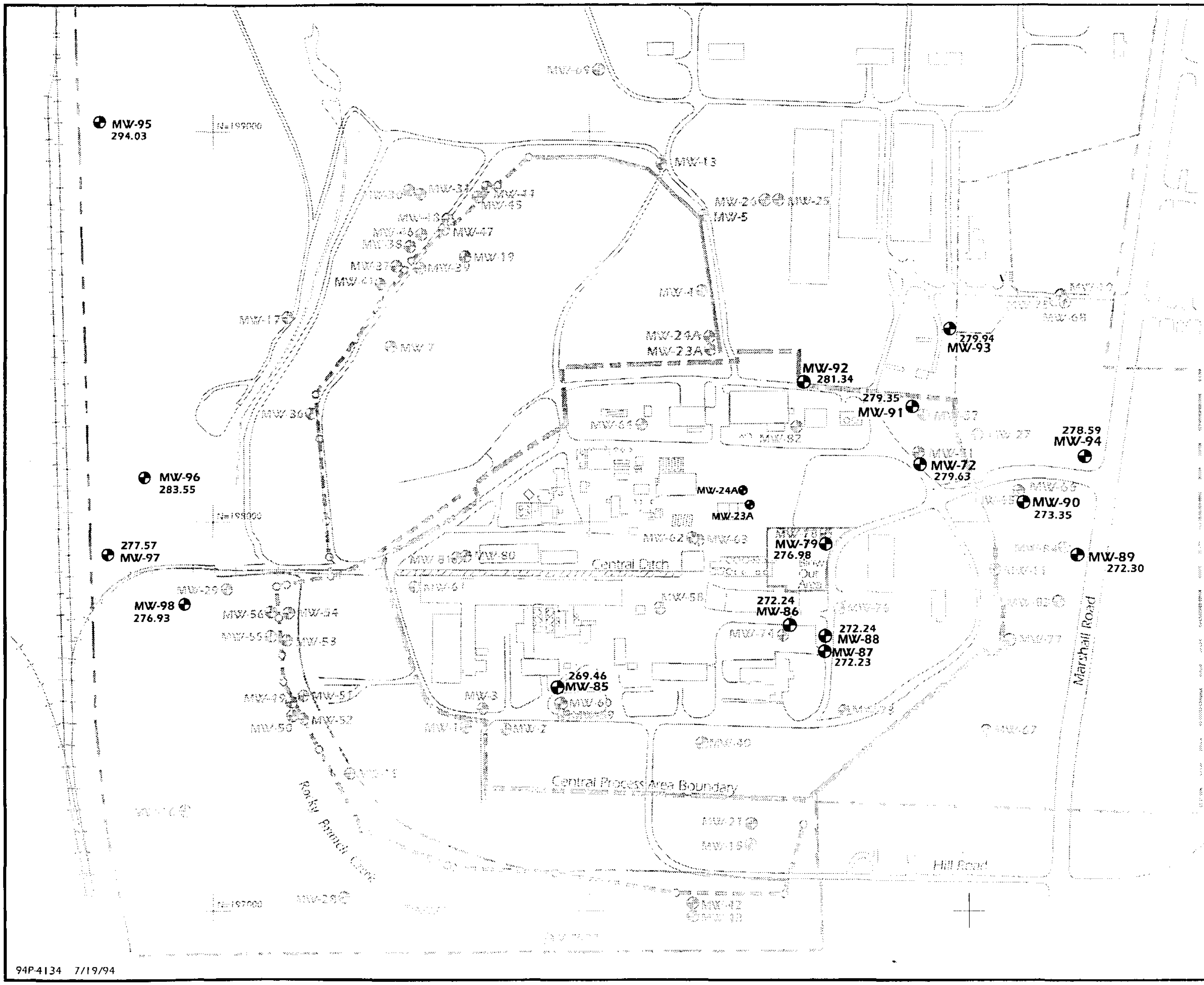
0 400 800
Scale in Feet

Note: Groundwater Elevation Data Collected on 20 October 1992 by Hercules Site Personnel. Map was completed using wells in the Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-7
PIEZOMETRIC ELEVATION MAP
DEEP BEDROCK WELLS
20 OCTOBER 1992
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR



Legend

MW-85	Monitoring Well Completed in Fresh Deep Bedrock
MW-84	Monitoring Well Completed in Unconsolidated Sediments or Weathered Bedrock
269.46	Groundwater Elevation Measured in Feet Above Mean Sea Level

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800
Scale in Feet

Note: Groundwater Elevation Data Collected on 24 May 1992 by Hercules Site Personnel. Map was completed using wells in the Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

**FIGURE 3-8
PIEZOMETRIC ELEVATION MAP
DEEP BEDROCK WELLS
24 MAY 1992
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR**

constructed in the Atoka Formation below the depth of weathering. The water level elevations were not contoured due to the spacing among wells completed in the fresh bedrock.

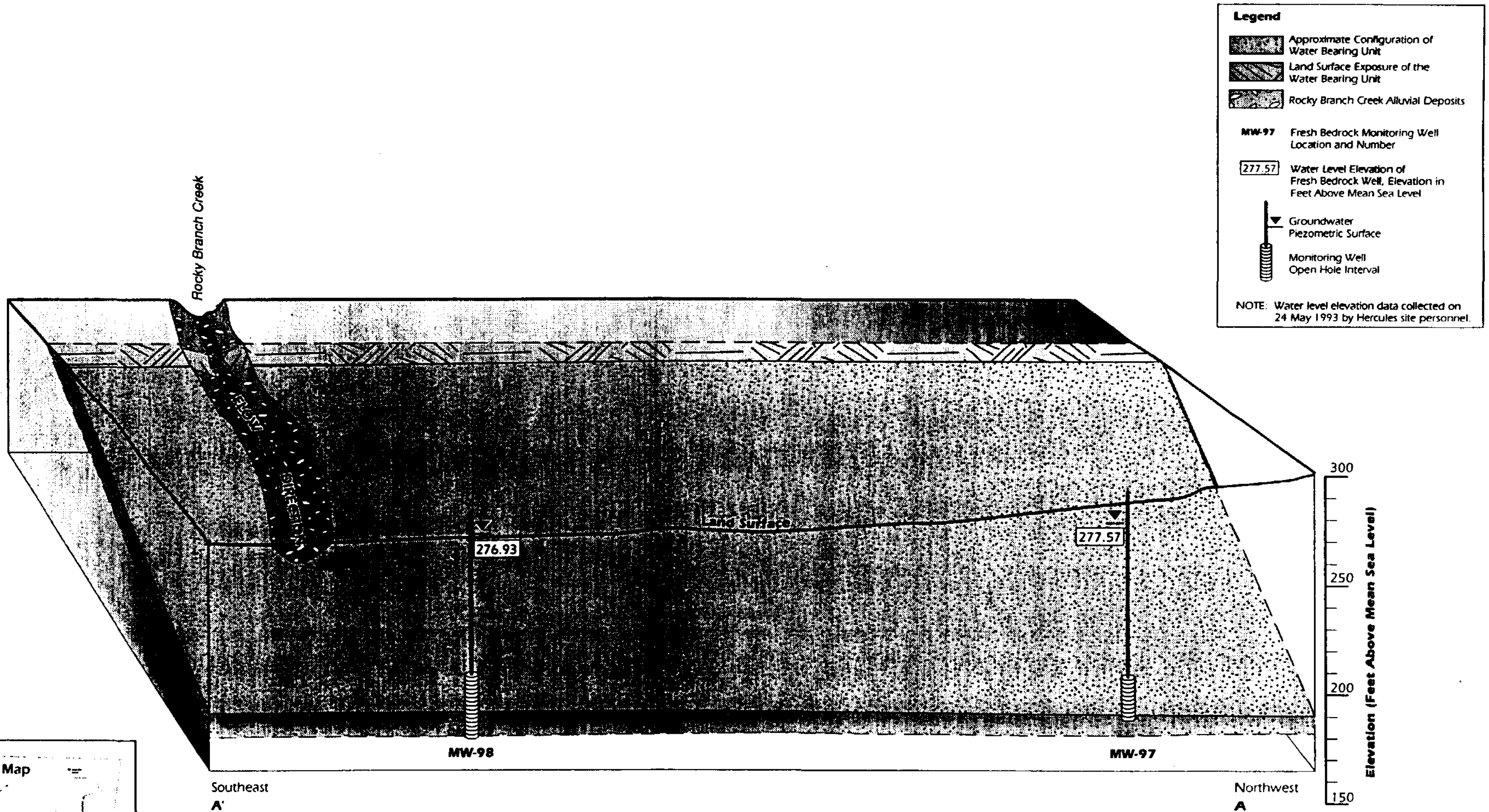
Monitoring wells MW-97 and MW-98 were constructed to characterize the horizontal groundwater gradient in the fresh bedrock between the western property boundary and Rocky Branch Creek. Figure 3-9 presents a 3-dimensional perspective of the potentiometric surface in fresh bedrock between monitoring wells MW-97 and MW-98. Both wells were constructed along strike with the location of the former equalization basin. The figure shows a shallow gradient 0.002 ft/ft) between the two monitoring wells. The groundwater elevation at MW-98 is about 2.2 feet above land surface, which implies that the fresh bedrock is contributing groundwater to the base flow of Rocky Branch Creek. The eastward directed flow observed between MW-97 is expected to be representative of each water-bearing unit west of Rocky Branch Creek.

Groundwater elevations for wells completed in fresh bedrock and measured in May 1993 exhibit the following consistent features:

- A broad low gradient and across the central process area.
- Gradient reflects a regional trend of groundwater flow from the northwest to the southeast, rather than mimicking the surface topography.
- Groundwater elevation of MW-98 is about 2.2 feet above land surface (276.93 feet, 24 May 1993), thereby implying contribution of groundwater from the fresh bedrock to the base flow of Rocky Branch Creek, a perennial stream.
- Possible constriction of piezometric elevations between MW-90 and MW-94, as well as MW-96 and MW-97, due to stratigraphy, low density of bedrock fractures, lower effective porosity, and slow recharge.

3.3.4.3 Vertical Groundwater Flow

Vertical components of hydraulic gradient were evaluated through a comparison of water level elevations among nested monitoring wells (Tables 3-4 and 3-5). A comparison of the water levels at most of the nested monitoring wells showed a downward (negative) vertical hydraulic gradient



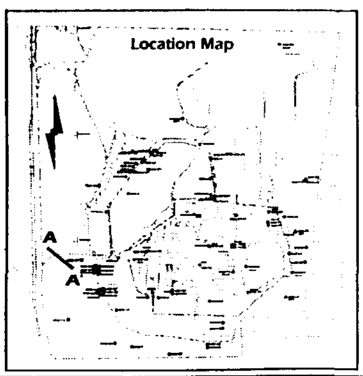


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FIGURE 3-9
POTENTIOMETRIC SURFACE WEST OF ROCKY BRANCH CREEK ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

Table 3-4

Vertical Hydraulic Gradient Variations in Paired Monitoring Wells
18 February 1992
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[a]	Top of Casing Elevation[b]	Depth to Groundwater[c]	Groundwater Elevation[d]
MW-23A	40.0	298.39	16.96	281.40
MW-24A	26.0	298.36	11.48	286.88
				Difference = -5.48
MW-25	43.4	295.04	16.01	279.03
MW-26	28.7	294.87	7.41	287.46
				Difference = -8.43
MW-72	52.0	285.05	5.16	279.89
MW-71	21.0	284.82	3.72	281.10
				Difference = -1.21
MW-79	47.4	285.76	9.73	276.03
MW-78	23.0	285.75	7.84	277.91
				Difference = -1.88
MW-85	101.2	286.28	19.02	267.26
MW-59	10.0	285.92	7.35	278.57
				Difference = -11.31
MW-85	101.2	286.28	19.02	267.26
MW-60	30.0	285.35	6.69	278.66
				Difference = -11.4
MW-86	131.00	285.24	13.87	271.37
MW-74	13.00	284.23	5.76	278.47
				Difference = -7.1
MW-89	94.9	273.72	2.05	271.67
MW-84	27.0	275.5	5.26	270.24
				Difference = +1.43
MW-90	101.8	279.37	7.95	271.42
MW-65	8.9	278.67	2.86	275.81
				Difference = -4.39
MW-90	101.8	279.37	6.19[e]	273.18
MW-66	19.7	279.63	3.17	276.46
				Difference = -3.28

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00397

TABLE 3-4 (continued)

Vertical Hydraulic Gradient Variations in Paired Monitoring Wells
18 February 1992
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[a]	Top of Casing Elevation[b]	Depth to Groundwater[c]	Groundwater Elevation[d]
MW-91	114.1	285.29	6.04	279.25
MW-57	23.5	286.53	5.06	281.47
				Difference = -2.22

Notes:

a = Measurement in feet below land surface.

b = Measurement in feet above mean sea level. Survey data provided by West and Associates, Jacksonville, Arkansas.

c = Measurement in feet below top of inner casing. Water level measurements were collected by Hercules onsite personnel on 18 February 1992.

d = Measurement in feet above mean sea level relative to the top of casing elevation.

e = Measurement was collected by WESTON on 16 February 1992.

Difference = Elevation difference of water levels between the deeper and shallower monitoring wells. A negative difference number denotes a downward component of hydraulic gradient.

Table 3–5

Vertical Hydraulic Gradient Variations in Paired Monitoring Wells
24 May 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

00398

Monitoring Well Number	Total Well Depth[a]	Top of Casing Elevation[b]	Depth to Groundwater[c]	Groundwater Elevation[d]
MW–21	33.30	279.35	8.83	270.52
MW–15	10.70	277.35	5.68	271.67
			Difference=	–1.15
MW–23A	40.00	298.39	16.81	281.58
MW–24A	26.00	298.36	12.35	286.01
			Difference=	–4.43
MW–25	43.40	294.04	11.30	282.74
MW–26	28.70	294.87	7.78	287.09
			Difference=	–4.35
MW–31	22.50	281.00	5.15	275.85
MW–30	10.50	281.15	5.33	275.82
			Difference=	0.03
MW–46	18.00	285.06	9.03	276.03
MW–38	10.50	283.99	8.83	275.16
			Difference=	0.87
MW–42	34.00	279.69	13.63	266.06
MW–43	23.00	279.32	12.64	266.68
			Difference=	–0.62
MW–44	21.00	288.63	12.35	276.28
MW–45	17.00	288.46	12.03	276.43
			Difference=	–0.15
MW–47	21.00	288.92	12.80	276.12
MW–48	15.00	289.28	12.62	276.66
			Difference=	–0.54
MW–51	20.00	269.85	7.70	262.15
MW–52	8.50	268.85	7.46	261.39
			Difference=	0.76
MW–53	25.00	271.43	9.32	262.11
MW–54	13.00	271.41	8.61	262.8
			Difference=	–0.69
MW–55	25.00	270.92	4.92	266
MW–56	13.00	270.77	8.84	261.93
			Difference=	4.07
MW–60	30.00	285.35	7.04	278.31
MW–59	10.00	285.92	7.58	278.34
			Difference=	–0.03

Table 3–5 (continued)

Vertical Hydraulic Gradient Variations in Paired Monitoring Wells
24 May 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[a]	Top of Casing Elevation[b]	Depth to Groundwater[c]	Groundwater Elevation[d]
MW–85	101.2	286.28	16.82	269.46
MW–59	10.00	285.92	7.58	278.34
			Difference=	–8.88
MW–85	101.2	286.28	16.82	269.46
MW–60	30.00	285.35	7.04	278.31
			Difference=	–8.85
MW–62	14.60	287.47	5.34	282.13
MW–63	8.00	287.59	4.28	283.31
			Difference=	–1.18
MW–66	19.70	279.63	3.82	275.81
MW–65	8.90	278.67	2.44	276.23
			Difference=	–0.42
MW–90	101.8	279.37	6.02	273.35
MW–65	8.90	278.67	2.44	276.23
			Difference=	–2.88
MW–90	101.8	279.37	6.02	273.35
MW–66	19.70	279.63	3.82	275.81
			Difference=	–2.46
MW–75	31.50	288.33	6.16	282.17
MW–68	14.00	286.86	5.16	281.70
			Difference=	0.47
MW–72	52.00	285.05	5.42	279.63
MW–71	21.00	284.82	4.06	280.76
			Difference=	–1.13
MW–79	47.40	285.76	8.78	276.98
MW–78	23.00	285.75	6.88	278.87
			Difference=	–1.89
MW–81	25.20	285.01	6.3	278.71
MW–80	11.00	285.28	6.5	278.78
			Difference=	–0.07
MW–86	131	285.24	13	272.24
MW–74	13	284.23	5.8	278.43
			Difference=	–6.19

000400

Table 3-5 (continued)

Vertical Hydraulic Gradient Variations in Paired Monitoring Wells
24 May 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Total Well Depth[a]	Top of Casing Elevation[b]	Depth to Groundwater[c]	Groundwater Elevation[d]
MW-89	94.9	273.72	1.42	272.3
MW-84	27	275.5	5.91	269.59
			Difference=	2.71
MW-91	114.1	285.29	5.94	279.35
MW-57	23.50	286.53	5.61	280.92
			Difference=	-1.57
MW-93	242	288.42	8.48	279.94
PZ-142	27.80	286.76	5.38	281.38
			Difference=	-1.44
MW-98	92.2	282.61	5.68	276.93
MW-29	25.50	272.29	4.49	267.8
			Difference=	9.13

Notes:

a = Measurement in feet below land surface.

b = Measurement in feet above mean sea level.
Survey data provided by West and Associates, Jacksonville, Arkansas and The Mehlburger Firm, Little Rock, Arkansas.

c = Measurement in feet below top of inner casing. Water level measurements were collected by Hercules onsite personnel on 24 May 1993.

d = Measurement in feet above mean sea level relative to the top of casing elevation.

Difference = Elevation difference of water levels between the deeper and shallower monitoring wells. A negative difference number denotes a downward component of hydraulic gradient.

that is indicative of recharge areas. A comparison of the water levels in the MW-84/MW-89 well pair was the exception, indicating an upward (positive) hydraulic gradient of 1.93 feet in fresh bedrock near the eastern side of the Site. The upward hydraulic gradient is indicative of a discharge area consistent with the Phase I RI findings at stratigraphic borings XB-8 and XB-9 plus monitoring well pair MW-68/MW-75 (Table 3-9, Subsections 3.4.3.2.4, 3.4.3.4.5, and 3.4.3.4.6; WESTON, 1992b).

Water levels measured on 24 May 1993 were used to construct a hydrogeologic cross section (Figure 3-10) for the weathered bedrock and fresh bedrock. Water level elevations in the weathered bedrock during the Phase II RI were similar to those measured during the Phase I RI (Figure 3-33, WESTON, 1992a). The hydrogeologic cross section (Figure 3-10) for the weathered and fresh bedrock indicates:

- The water table is within 5 feet of land surface in most areas of the Site.
- Groundwater is about 2.2 feet above the land surface at monitoring well MW-98. This indicates that the fresh bedrock may contribute groundwater to the weathered bedrock at this location.
- The groundwater is under semi-confined (leaky) conditions between water-bearing and confining units in both the weathered and fresh bedrock.
- A downward vertical hydraulic gradient may exist over most of the central process area.
- Upward vertical hydraulic gradient exists in limited areas adjacent to Rocky Branch Creek (west of the central process area) and Marshall Road (east of the central process area).
- Westward flow of shallow groundwater is captured by the french drain.
- Eastward flow of groundwater contributes to the base flow of Rocky Branch Creek.

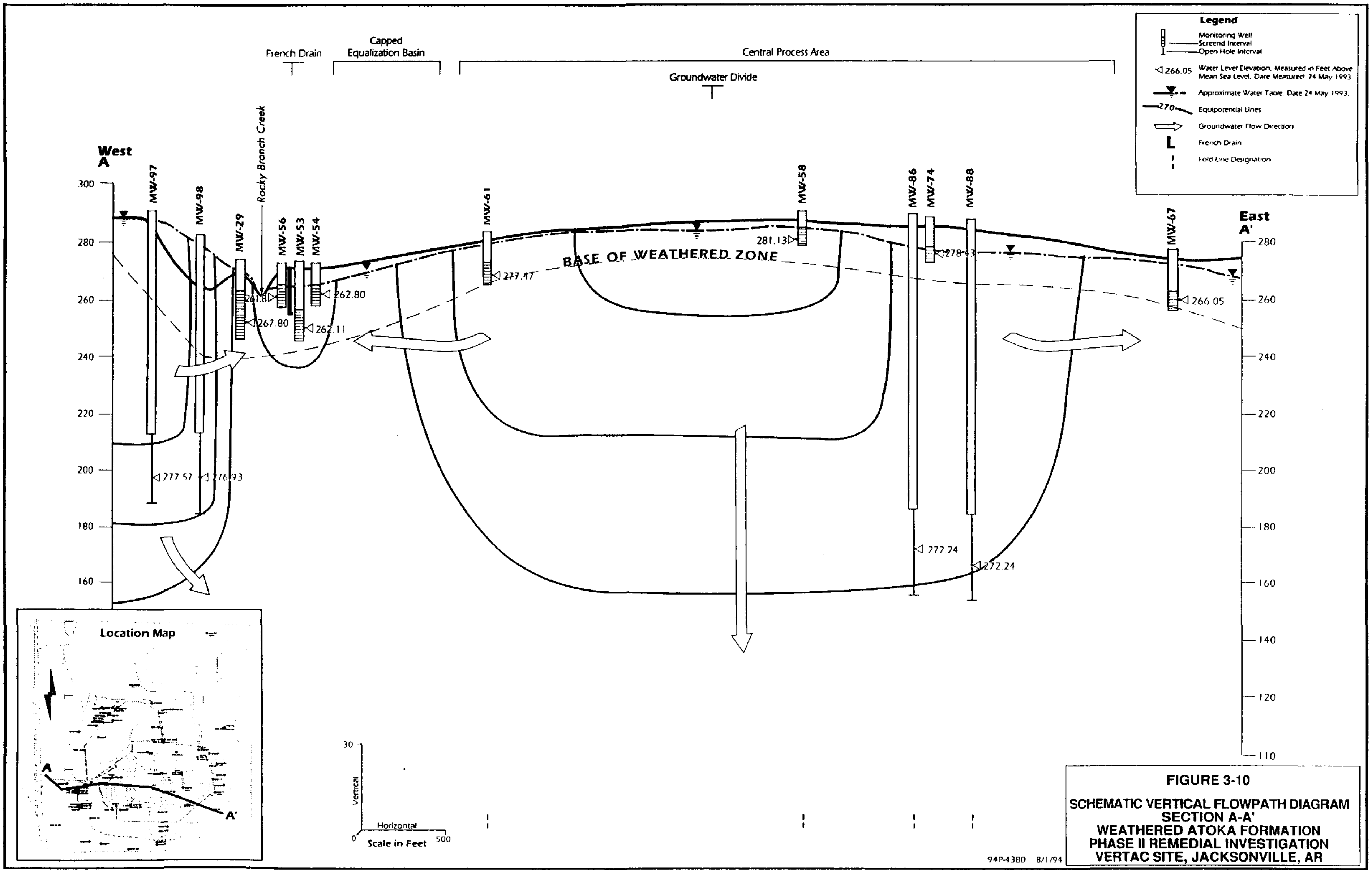


FIGURE 3-10

SCHEMATIC VERTICAL FLOWPATH DIAGRAM
SECTION A-A'
WEATHERED ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

The water levels used to create the cross sections are shown in Table 3-3 and tabulated in Appendix F. A summary of the completion information for monitoring well used in the hydrogeologic cross section is presented in Appendix H. The midpoint of the monitored interval was used to plot the equipotential lines. The distortion in the equipotential lines is related to the apparent folds in the cross-section and the segregation of the water bearing unit tested for Pumping Tests 1 and 2.

Vertical groundwater flow is expected to be complex and follow the path of least resistance. Within the weathered bedrock, vertical head potential is expected to be controlled by intergranular processes with increasing amounts of fracture control toward the base of weathering. Within the fresh bedrock which dips north at about 30°, vertical groundwater flow is expected to occur only along fractures, because of low intergranular porosity. As described in Subsection 3.3.2.3, the density and length of fractures are related to the rock type. Groundwater flowing in response to the vertical gradient would tend to be directed northward along bedding-plane fractures, but vertical flow would tend to be re-directed southward where cross-cutting, open fractures penetrate across beds. Therefore, vertical groundwater flow, particularly in the fresh bedrock, is expected to occur in a stepwise progression among bedding plane fractures and cross-cutting fractures. The extent to which vertical groundwater flow is controlled by bedding-plane fractures versus cross-cutting fractures is not known and may differ across the Site. It is anticipated that the fracture number and frequency decreases with depth (Subsection 2.4.5.2 and 3.4.3.4; Weston, 1992b). The ultimate discharge point of the Atoka Formation is unknown.

3.3.5 Hydraulic Conductivity Testing

3.3.5.1 Rising Head Tests

Rising head tests were performed for eight of the ten Phase II fresh bedrock monitoring wells (Subsection 2.3.6.1) in the form of 1.5 hour pumping tests. Drawdown and recovery data were analyzed using the Jacob Method (Cooper and Jacob, 1946) as interpreted in Krusemann and deRidder (1991). This method was used to evaluate the hydraulic conductivity at monitoring wells MW-85, MW-89, and MW-90, because these wells did not respond to the pumping tests (Subsection 3.3.5.3.3). Porous rather than fractured media evaluation methods were used under the assumption that the fracture distribution and density were similar to that of an unconsolidated aquifer (Subsection 3.3.5.3.2.1) Evaluation of the drawdown data for monitoring wells, MW-85, MW-89, and MW-90 indicated that each well was not pumped for a sufficient period of time to stress the water-bearing unit associated with the monitored interval of each well. The drawdown data still reflected the effects of casing storage. Semi-log plots of the data for these wells are contained in Appendix I.

000404

3.3.5.2 Slug Tests

3.3.5.2.1 Introduction

Slug tests were conducted on wells installed during Phase II (MW-95, MW-96, MW-97, and MW-98) to evaluate saturated hydraulic conductivities (Subsection 2.3.6.4). Table 3-6 presents the results of the slug test data. Slug data evaluations are presented in Appendix J.

3.3.5.2.2 Slug Test Analysis Method

The rate of water level change during the period of recovery in a monitoring well was used to calculate the hydraulic conductivity of the slug test interval using the method of Bouwer and Rice (1976). In accordance with this method, the data were plotted on a semi-logarithmic scale graph, and linear segments of the water level recovery curve were chosen as those representative of conditions in the bedrock. Evaluation of the slug test data was completed using the methodology described in Subsection 2.4.5.2.6 of the Phase I RI report.

Datalogger records from each slug test were graphed using microcomputer software in a semi-logarithmic scale. Following the convention used by the datalogger manufacturer (In-Situ), an increasing (or positive) transducer reading is a decreasing water level elevation, while a decreasing (or negative) transducer reading is an increasing water level elevation.

Using the graphs produced for each well, the rate of water level change was evaluated during the slug test. In each case, the graph of water level change was evaluated to locate the portion of the slug test data curve that was linear, as described by Bouwer and Rice (1976). Results of the slug test analysis are summarized in Table 3-6.

3.3.5.2.3 Discussion of Slug Test Analysis

The hydraulic conductivities calculated from slug test analysis ranged from a maximum calculated permeability of 2.05×10^{-3} cm/sec in well MW-95, to the lowest calculated permeability was 4.6×10^{-4}

Table 3-6

Summary of Slug Test Evaluations
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number	Screen Length (ft) L_e	Borehole Diameter (ft) r_w	Effective Filter Pack Porosity n	Effective Borehole Radius (ft) r_c	Effective Water Column (ft) L_w	Radius of Influence of Slug Test (ft) R_e	Maximum Water Level Change (Linear Segment) (ft) h_o	Water Level Change after t Minutes Linear Segment) (ft) h_t	Elapsed Time Between h_o and h_t (min) t	Interval Hydraulic Conductivity(a) (cm/sec) K
MW-95	29.22	0.16667	NA	0.16667	98.96	21.2	1.783	0.362	0.9467	2.05×10^{-3}
MW-96	20.50	0.16667	NA	0.16667	87.46	17.7	2.076	0.134	9.95	4.6×10^{-4}
MW-97	19.92	0.16667	NA	0.16667	86.94	18.0	1.67	0.534	0.9734	2.0×10^{-3}
MW-98	29.65	0.16667	NA	0.16667	86.97	19.7	1.606	0.287	4.367	4.65×10^{-4}

Notes:

a = Hydraulic conductivity measurements were calculated from rising head slug test evaluation.
NA = Not applicable, open hole well completion.

cm/sec in MW-96. As described in Subsection (2.3), each of these Phase II wells were completed in sandstone units. A calculation summary for each slug test is presented in Appendix J. 00406

3.3.5.3 Pumping Tests

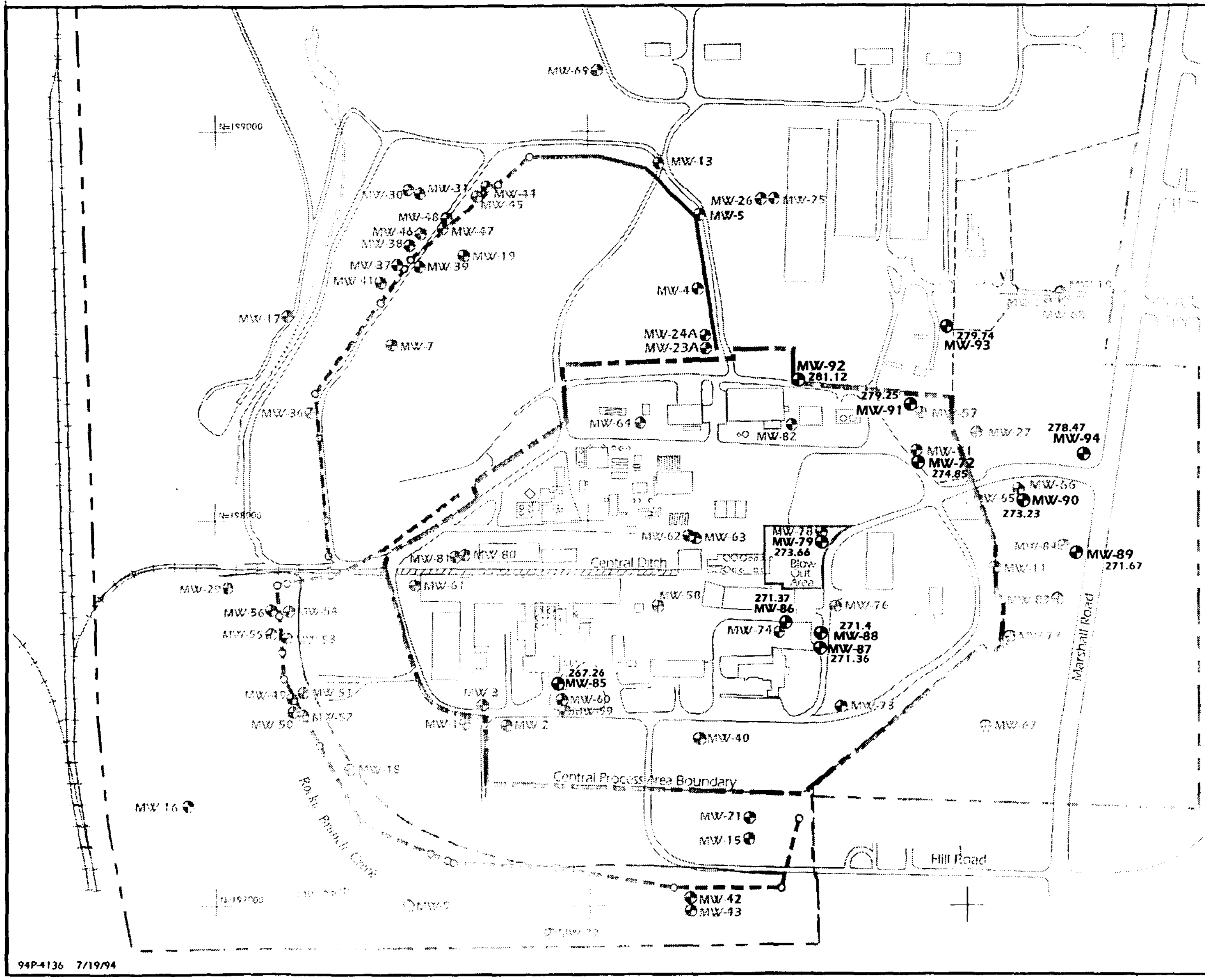
3.3.5.3.1 Introduction

Pumping tests were used to provide additional hydrogeologic information regarding the relationships between stratigraphy, fractures, and weathering. Two areas were chosen for pumping tests based on their proximity to major process areas:

- Administration Building Area.
- Dalapon Production Area

Two pumping wells were selected for testing within each area. Observation wells were selected along strike, dip, and fractures relative to the pumping well to observe water level changes within unconsolidated materials, consolidated weathered rock, and fresh bedrock. Pressure transducers were hung in the observation wells and in the pumping well to measure changes in water levels. Water levels were monitored during background (prior to pumping), drawdown (during pumping), and recovery (after pumping). The water elevations prior to pumping test 1 are listed in Table 3-2. A plot of static water level elevations in the fresh bedrock is shown in Figure 3-11.

After collection of data from the four pumping tests (Subsection 2.3.7), the electronic datalogger records were transferred at the Site to magnetic storage disks and loaded into a microcomputer for analysis at the office. Initial review of the data was performed by plotting the changes in water level versus time for each of the background, drawdown, and recovery tests. These plots were used to evaluate whether or not the water level in an observation well responded to a pumping test. The evaluation was based on a comparison of the magnitude and direction of water level changes during the background phase relative to the water level changes during the drawdown and recovery phases. The net change in water level for each well during the drawdown and recovery phases was calculated from the minimum and maximum responses plotted on the water level versus time graphs contained in Appendix K. A summary of the water level changes is presented in Table 3-7. Where water levels appeared to respond, the data was further evaluated to assess whether the data could be used to calculate hydrogeologic parameters, such as transmissivity, storativity, and hydraulic conductivity. The decision to calculate hydrogeologic parameters was



Legend

MW-85 Monitoring Well Completed in Fresh Deep Bedrock

MW-84 Monitoring Well Completed in Unconsolidated Sediments or Weathered Bedrock

267.26 Groundwater Elevation Measured in Feet Above Mean Sea Level

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800
Scale in Feet

Note: Groundwater Elevation Data Collected on 18 and 19 February 1992 by Hercules Site Personnel. Groundwater Elevation Measurement for MW-90 was Collected on 16 February 1992. Map was completed using wells in the Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-11
STATIC GROUNDWATER ELEVATION MAP
DEEP BEDROCK WELLS
18 AND 19 FEBRUARY 1992
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

Table 3-7

Summary of Maximum Water Level Responses to Pumping Tests
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

a. Administration Building Area

Observation Well Number	Maximum Water Level Response (feet)					Data Usage
	Background Test	Pumping Test Number 1		Pumping Test Number 2		
		Drawdown	Recovery	Drawdown	Recovery	
MW-58	-0.1	+0.3	-0.9	-0.6	-0.9	a
MW-67	-0.3	+0.86	-0.6	-0.5	-0.35	b
MW-73	+0.05	+4.8	-4.0	+1.3	-1.3	b
MW-74	+0.2	-0.2	-0.2	-0.3	-0.25	a
MW-76	+0.15	+0.35	-0.15	-0.2	-0.25	a
MW-77	-0.2	-0.18	-0.4	-0.3	-0.25	a
MW-78	-0.3	+0.20	-0.2	-0.3	-0.3	a
MW-79	-0.3	+0.25	-0.2	-0.2	-0.35	a
MW-83	-0.25	+0.15	-0.3	-0.25	-0.28	a
MW-86	+0.2	+33	-29	+10.3	-10.0	T, S, K, d
MW-87	+0.25	+29	-26	+10.3	-10.0	T, S, K, d
MW-88	+0.2	+28	-25	+69	-69	T, S, K, d

b. Dalapon Boiler Area

Observation Well Number	Maximum Water Level Response (feet)					Data Usage
	Background Test	Pumping Test Number 3		Pumping Test Number 4		
		Drawdown	Recovery	Drawdown	Recovery	
MW-23A	+0.2	+1.5	-1.5	+8.4	-8.4	b
MW-24A	+0.5	+0.4	+0.25	+0.5	-0.45	a
MW-57	+0.25	+1.3	-0.9	+5.4	-5.4	b
MW-66	-0.15	+0.55	-0.15	+0.25	-0.1	a
MW-71	+0.6	+0.25	+0.3	+0.12	0.3[(d)]	a
MW-72	+0.3	+1.8	-1.5	+5.3	-4.5	b
MW-82	+0.5	+0.25	+0.3	+0.13	+0.15	a
MW-84	0.23[(d)]	+0.15	-0.1	NA	NA	a
MW-89	-0.35	-0.1	-0.15	+0.06	+0.13	a
MW-90	-0.25	+0.25	-0.13	+0.23	-0.1	T, S, K, d
MW-91	0.2[d]	+33	-33	+6.3	-5.8	T, S, K, d
MW-92	-0.3	+1.8	-1.5	+16.8	-16.8	T, S, K, d
MW-93	-0.25	+3.1	-2.8	+6.8	-6.5	T, S, K, d
MW-94	+0.4	+3.4	-3.3	+4.8	-4.8	T, S, K, d

Sign Designations:

Plus and minus signs are specified in accordance with the convention used by the data logger.
+ = decrease in water level elevation.
- = increase in water level elevation.
Absence of +/- sign indicates constant water level fluctuations.

Data Usage:

Maximum water level responses were calculated from the minimum and maximum responses plotted on the water level versus time graphs contained in Appendix G.
NA = Water level was measured manually with a water level indicator probe during the pumping test.
T = Transmissivity.
S = Storativity.
K = Hydraulic conductivity.
a = No response.
b = Partial penetrating well.
c = T and S calculated for observation wells only.
d = Water level fluctuations did not show a net trend.

based on the degree to which the assumptions for the evaluation method were met (Subsection 3.3.5.3.2). The plots of the water level changes versus time for each well monitored with a pressure transducer are shown in Appendix K. The plots are organized as follows:

- Administration Building Area
  - Background Data Pumping Tests MW-86 and MW-88 (Tests #1 and #2).
  - Drawdown Pumping Test MW-86 (Test #1).
  - Recovery Pumping Test MW-86 (Test #1).
  - Drawdown Pumping Test MW-88 (Test #2).
  - Recovery Pumping Test MW-88 (Test #2).
- Dalapon Production Area
  - Background Data Pumping Tests MW-91 and MW-92 (Tests #3 and #4).
  - Drawdown Pumping Test MW-91 (Test #3).
  - Recovery Pumping Test MW-91 (Test #3).
  - Drawdown Pumping Test MW-92 (Test #4).
  - Recovery Pumping Test MW-92 (Test #4).

3.3.5.3.2 Evaluation Method

3.3.5.3.2.1 Introduction

Drawdown and recovery data for the administration building and dalapon production area pumping tests were analyzed to estimate the hydrogeologic characteristics of the fresh bedrock. Test methods for porous rather than fractured media were used to describe groundwater flow generated by each of the pumping tests. According to Kruseman and deRidder (1991), if the fractures were numerous enough and evenly distributed through the rock, it could be assumed that fluid flow will only occur through the fractures and will be similar to that in an unconsolidated homogeneous aquifer. The data were analyzed using the Jacob Method (Cooper and Jacob, 1946) and the Theis Recovery Method (Theis, 1935). These methods were chosen based on the degree to which the assumptions for each evaluation method were met. Drawdown and recovery data from each test were analyzed using semi-logarithmic plots to calculate transmissivity and storativity. Both the drawdown and recovery data were interpreted because the data were consistent. In general, recovery data are considered to be more reliable than drawdown data because well recovery occurs at a constant rate, and maintaining a constant pumping rate (hence, consistent drawdown data) is often difficult to achieve in the field. These data are tabulated in Table 3-7. The semi-logarithmic plots are presented in Appendix K.

3.3.5.3.2.2 Jacob Method

The drawdown data were analyzed by using the Cooper and Jacob (1946) straight line approximation (Jacob Method) of the Theis (1935) equation to estimate transmissivity (T) and storativity (S). The Jacob Method (as interpreted by Kruseman and deRidder (1991)) are considered to provide a satisfactory estimate of T and S (within 5 percent) of the Theis curve matching technique as long as the following assumptions and stability criteria are met:

- Confined water-bearing unit.
- Infinite areal extent of the water-bearing unit.
- Homogeneous, isotropic, and uniformly thick water-bearing unit throughout the test area.
- Horizontal static piezometric surface.
- Constant pump discharge rate.
- Full penetration of the water-bearing unit by the pumping well.
- Flow to the well is in unsteady state.
- Theis well function, u, is less than 0.1.

The extent to which the assumptions were met for the pumping tests are described in the remainder of this subsection.

The confined nature of the water-bearing units is generally defined by:

- Layered stratigraphy of the Atoka Formation, which consists of sandstone, siltstone, and shale.

- Lack of response of observation wells constructed in the fresh bedrock wells to recharge events over the duration of the testing.

- Lack of response of observation wells monitoring the fresh bedrock at the same depth as the pumping well, but constructed in another water-bearing or confining unit down or up section.

Water-bearing units of the Atoka Formation cover a laterally continuous area across the Interior Highlands physiographic province and underlie the unconsolidated marine sediments of the Gulf Coastal Plain physiographic province of northern Arkansas (Counts, 1957). The stratigraphy observed in Rocky Branch Creek and in the RI stratigraphic borings indicate that the rocks are laterally continuous across the Site along strike, and down dip (Figure 3-4). Graphical representations of the drawdown and recovery curves from each pumping test indicated lateral continuity and lack of boundary conditions within the fresh bedrock based on the smooth and regular appearance of the curves during the tests. Additional regional and local hydrogeologic information regarding the Atoka Formation is discussed in Subsections 1.7, 2.4 and 3.4 of the Phase I RI (WESTON, 1992b).

The water-bearing unit is reasonably homogeneous, isotropic, and of uniform thickness in the fresh bedrock with respect to each pumping test area. The water-bearing units tested in the fresh bedrock are characterized by:

- A reasonable degree of lateral continuity along strike and downdip.

- Cross-cutting fractures within the unit.

- Wells drilled along strike or downdip to test stratigraphically equivalent rocks.

The piezometric surface of each water-bearing unit was nearly horizontal prior to the onset of each pumping test. The maximum gradient among observation wells was characterized by:

- Administration Building Area, Pumping Tests 1 and 2:
  - maximum gradient of 0.009 ft/ft between MW-86 and MW-67.

- Dalapon Production Area, Pumping Tests 3 and 4:
  - maximum gradient of 0.004 ft/ft between MW-92 and MW-94.

A constant pump discharge rate was maintained during each pumping test (Subsection 2.3.7.2.4). The discharge rate from each test was monitored by:

- Use of an in-line flow meter (totalizer) which provided instantaneous and cumulative total volume measurements. Flow meter readings were recorded approximately every one-half hour throughout each test.

- Use of a transducer in the water containment tank to measure the rate at which the tank was filled, thus monitoring the pump discharge rate under operating conditions.

- Pump discharge rates were confirmed based on periodic measurements of the height of the water in the tank. Results of these measurements were comparable with the flow meter readings.

- Timed measurement of direct discharge of groundwater into a one-gallon container during each pumping test.

The graphs representing continuous pump discharge to the containment tank over the length of each pumping test are presented in Appendix G. The minor fluctuation in fill rate of the tank was either related to freezing conditions (pumping test no. 1) or minor adjustments to the pump discharge rate (pumping test no. 3). During pumping test no. 1, the water surrounding the transducer tip froze approximately 700 minutes into the test. Heat tracing was placed around the transducer to keep the tip from freezing. At the onset of pumping test no. 3, there were some mechanical difficulties with an open gate valve and a nonresponsive transducer in the containment tank. The difficulties were resolved approximately 250 minutes into pumping test no. 3 (Appendix K).

Hydrogeologic parameters were calculated assuming that each pumping well fully penetrated equivalent strata within their respective water-bearing unit at the depth of the fresh bedrock. The value for aquifer thickness was estimated based on the length of the open-hole interval in the pumping well of each pumping test. For the dalapon production area pumping tests an average of the open-hole intervals for MW-91 and MW-92 (40 ft) was used for hydrogeologic calculations. The open-hole intervals in each pumping and observation well were fully saturated.

In each pumping test there were some observation wells, which were shallower and screened in the consolidated weathered bedrock, where the water level also responded to pumping (Table 3-8). The locations of these wells were in the up-dip direction from the bedrock wells that were being pumped. Hydrogeologic parameters were not calculated for these wells because they did not penetrate the entire water-bearing zone that was used to estimate aquifer thickness. Well completion information for the shallow wells is listed in the Phase I RI Report (Appendices B and M).

After plotting drawdown and recovery data from each test (time and drawdown on semilog plots), values of transmissivity and storativity were calculated. Equations used in the analyses are shown in Appendix K. The results of these calculations are listed on Table 3-9.

3.3.5.3.2.3 Theis Recovery Method

The recovery data were analyzed using the Theis recovery method (Theis, 1935) to estimate T and S. The Theis recovery method provided a satisfactory estimate of T and S using the assumptions outlined in Subsection 3.3.5.3.2.2 with emphasis on the following assumptions and stability criteria:

- Confined water-bearing unit.
- Full penetration of the water-bearing unit by the pumping well.
- Constant pump discharge rate prior to onset of the recovery period.
- Theis well function, u is less than 0.01.

The equations which were used to estimate transmissivity and storativity, were in accordance with the Theis recovery method and are presented in Appendix K. Semi-logarithmic plots of the recovery data are presented in Appendix K. Calculated transmissivities for fully penetrating observation wells are presented in Table 3-9.

Table 3-8

Summary of Responding Shallow Weathered Bedrock Observation Wells Phase II Remedial Investigation Vertac Site, Jacksonville, Arkansas

Pumping Test Number	Observation Well[a]	Drawdown[b]
1	MW-67	0.8
	MW-73	4.8
2	MW-73	1.0
3	MW-23A	1.5
	MW-57	1.2
	MW-72	1.8
4	MW-23A	8.4
	MW-57	5.4
	MW-72	5.3

Notes:
a = Observation wells whose drawdown was greateer than 0.6 feet.
b = Measurement in feet.

Table 3-9

Summary of Pumping Test Results
Phase II Remedial Investigation
Vertac Site, Jacksonville Arkansas

Pumping Well Number	Well Discharge (gpm) Q	Duration of Pumping Test (minutes)	Observation Well Number	Radius from Pumping Well (feet)	Maximum Drawdown (feet)	Change in Drawdown (ft/log cycle) Δs	Transmissivity (Drawdown) (ft^2/day) T[a]	Storativity (Drawdown) (dimensionless) S[b]	Aquifer Thickness (feet) b	Hydraulic Conductivity (Drawdown) (ft/day)[c] K	Hydraulic Conductivity (Drawdown) (cm/s)[c] K	Transmissivity (Recovery) (gpd/ft)[d] T	Hydraulic Conductivity (Recovery) (ft/day)[e] K	Hydraulic Conductivity (Recovery) (cm/s)[e] K
MW-86 (Pumping Test 1)	2.0	2650			33.4				30					
			MW-67	586.53	0.86									
			MW-73	256.35	4.8									
			MW-87	99.83	28.5	20	3.52	4.1×10^{-5}		0.117	4.14×10^{-5}	28	0.094	3.3×10^{-5}
			MW-88	101.66	27.7	20	3.52	4.8×10^{-5}		0.117	4.14×10^{-5}	25	0.084	2.96×10^{-5}
MW-88 (Pumping Test 2)	1.0	1720			69				30					
			MW-73	256.35	1.0									
			MW-86	101.66	10.3	7.8	4.52	6.2×10^{-5}		0.151	5.3×10^{-5}	27	0.090	3.2×10^{-5}
			MW-87	54.74	10.3	8.2	4.3	2.1×10^{-4}		0.14	5.1×10^{-5}	27	0.090	3.2×10^{-5}
MW-91 (Pumping Test 3)	1.0	3190			33.5				40					
			MW-92	290.6	1.8	1.6	22.02	7.16×10^{-5}		0.55	1.9×10^{-4}	252	0.842	2.97×10^{-4}
			MW-93	217.21	3.1	1.9	18.55	3.7×10^{-5}		0.46	1.6×10^{-4}	275	0.92	3.2×10^{-4}
			MW-94	445.94	3.4	2.2	16.02	5.08×10^{-5}		0.40	1.4×10^{-4}	168	0.561	1.97×10^{-4}
MW-92 (Pumping Test 4)	5.0	1450			16.7				40					
			MW-23A	255.9	8.4									
			MW-57	292.98	5.4									
			MW-72	343.19	5.3									
			MW-91	290.6	6.3	5.4	32.63	5.99×10^{-5}		0.82	2.9×10^{-4}	198	0.661	2.3×10^{-4}
			MW-93	362.3	6.8	5.2	33.9	2.8×10^{-5}		0.85	3.0×10^{-4}	198	0.661	2.3×10^{-4}
			MW-94	736.5	4.8	4.5	39.15	1.01×10^{-5}		0.98	3.5×10^{-4}	244	0.82	2.89×10^{-4}

Notes:
Units:
cm/s - Centimeters per second.
gpm - Gallons per minute.

a - Drawdown transmissivity calculated using the method Cooper and Jacob, 1946.
b - Drawdown storativity calculated using the method (Cooper and Jacob, 1946.
c - Hydraulic conductivity calculated using the drawdown transmissivity data.
d - Recovery transmissivity calculated using the method of Theis (1935).
e - Hydraulic conductivity calculated using the recovery transmissivity data.

The Theis recovery method was used to analyze the recovery data collected during the recovery phase for each of the four pumping tests and to calculate the hydrogeologic parameters. The results of the recovery testing were used as a check on the drawdown results. Equations used into calculate transmissivity from recovery data are listed in Appendix K.

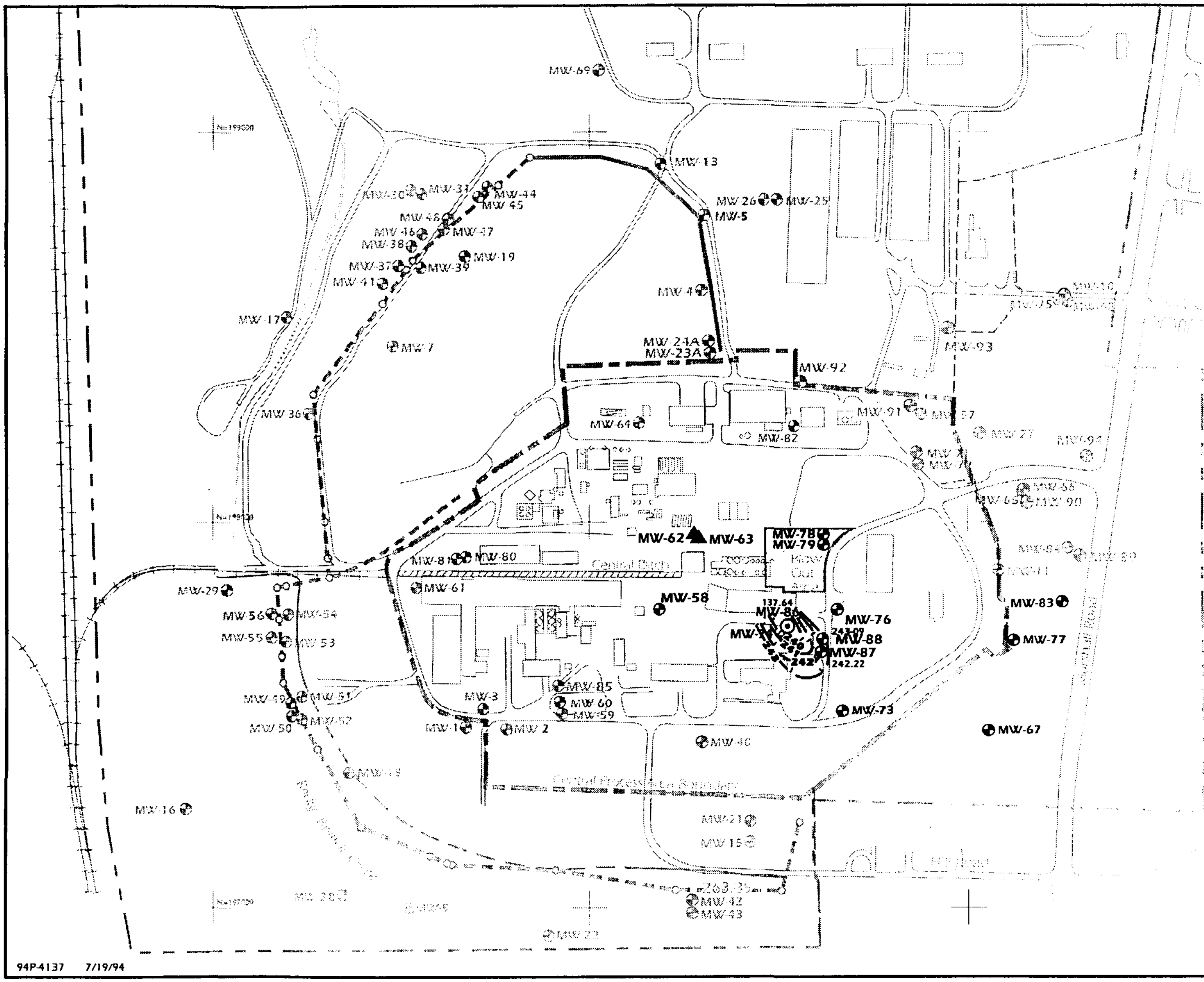
3.3.5.3.3 Background Test Results (Administration Building Area)

Background data collected from the administration building area showed a decrease in water levels of 0.25 feet or less in observation wells MW-86, MW-87 and MW-88 (Table 3-6). Background water level data in shallow observation wells (MW-58, MW-74, MW-76, MW-73, MW-67, MW-77, MW-83, MW-78, and MW-79) showed a variation in water levels of 0.3 feet or less (Appendix K).

3.3.5.3.4 MW-86 Pumping Test Results (Pumping Test No. 1, Administration Building Area)

As a result of pumping at MW-86 (Subsection 2.3.7.3), significant drawdown was observed in observation wells MW-87, MW-88, MW-73 and MW-67 (Table 3-7) during the period of the test. Drawdown and recovery data for observation wells MW-87 and MW-88 were used to calculate transmissivity, storativity, and hydraulic conductivity values (Table 3-9). In addition, recovery data from observation wells MW-87 and MW-88 were used to calculate transmissivity as a check on drawdown data (Table 3-9). The groundwater level elevations in bedrock wells at maximum drawdown are shown on Figure 3-12. Although a decrease in water level was observed in MW-73 (4.8 feet) and MW-67 (0.8 feet), values of transmissivity and storativity were not calculated because of uncertainty about whether the wells were fully penetrating in the same unit as was being pumped. Also, the stability criteria for the evaluation method, (i.e., the Theis well function, μ, less than 0.1) was not met for data from MW-67.

Water levels in the other observation wells monitored during the test did not appear to respond in a significant manner to pumping at MW-86. The responses measured in observation wells MW-74, MW-76, MW-78, MW-79, MW-83, MW-62, and MW-63 were less than the variation observed during the background period. Water levels in shallow observation wells MW-74 and MW-76 indicated no response during the drawdown phase. Observation wells MW-77, MW-78, MW-79, MW-83 showed a maximum decrease in water levels of 0.15 feet throughout the test. Monitoring wells MW-62 and MW-63 showed fluctuations of less than 0.3 feet throughout the drawdown phase of



Legend

MW-86 Pumping Well

MW-74 Observation Well, Water Levels Monitored by Pressure Transducer

MW-62 Observation Well, Water Levels Measured Manually Using a Water Level Probe

—240— Groundwater Elevation Contour (Measured in Feet Above Mean Sea Level) Contour Interval: 1 Foot; Contour Dashed Where Approximate

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N W E S

0 400 800
Scale in Feet

Note: Map was completed using wells in the weathered Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-12

GROUNDWATER ELEVATIONS IN BEDROCK WELLS AT MAXIMUM DRAWDOWN PUMPING TEST NUMBER 1 PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

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the pumping test. Water levels in MW-74, MW-76, MW-77, MW-78, MW-79 and MW-83 did not appear to respond to the 0.9-inch rainfall that began approximately 1,500 minutes into the recovery test.

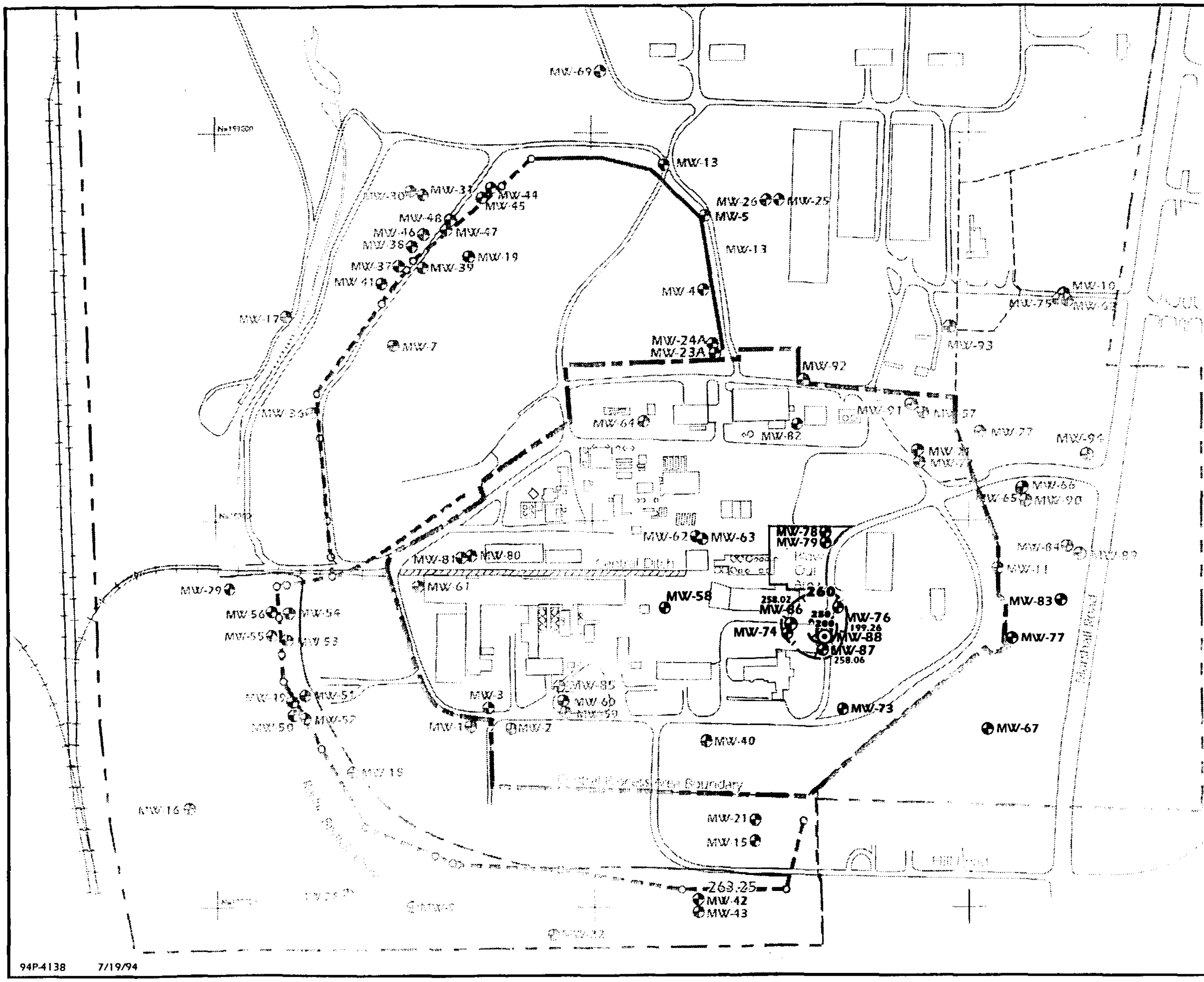
Water levels in MW-67 dropped (0.35 feet) until approximately 1,500 minutes into the recovery test, when the rain began to fall and the water levels began to rise. Water levels in MW-58 did not respond to pumping at MW-86 but did appear to rise 0.8-foot in response to the 0.9-inch rainfall that began at approximately 1500 minutes into the recovery test.

3.3.5.3.5 MW-88 Pumping Test Results (Pumping Test No. 2, Administration Building Area)

As a result of pumping at MW-88 (Subsection 2.3.7.3) significant drawdown was observed in the following observation wells in order of decreasing drawdown: MW-87, MW-86, and MW-73 (Table 3-7) during the period of the test. Drawdown data for observation wells MW-86 and MW-87 were used to calculate transmissivity, storativity, and hydraulic conductivity values (Table 3-9). The groundwater level elevations in bedrock wells at maximum drawdown are shown on Figure 3-13. In addition, recovery data were used to calculate transmissivity for these same wells as a check on the drawdown data (Table 3-9).

Values of transmissivity and storativity were not calculated for observation well MW-73 because of uncertainty that the well was fully penetrating in the same unit that was being pumped; therefore, one of the evaluation criteria was not met. Data for MW-67, which responded to pumping at MW-86, showed delayed effects of drawdown during pumping of MW-88. The interference may have resulted from a delayed drawdown to pumping MW-86 or a delayed infiltration effect of precipitation reaching the saturated zone of consolidated weathered bedrock.

The water levels in other shallow observation wells were rising throughout the drawdown portion of the pumping test. This could be attributed to the 0.9-inch rainfall that fell during the recovery portion of the MW-86 pumping test and 0.07-inch rainfall that fell during the drawdown portion of MW-88 pumping test. The precipitation during the testing did not appear to affect the water levels in the bedrock wells (MW-86, MW-87, and MW-88).



Legend

MW-92 Pumping Well

MW-57 Observation Well, Water Levels Monitored by Pressure Transducer

MW-27 Observation Well, Water Levels Measured Manually Using a Water Level Probe

250 Groundwater Elevation Contour (Measured in Feet Above Mean Sea Level) Contour Interval: 10 Feet; Contour Dashed Where Approximate

French Drain

Slurry Wall

Fence Line

Property Boundary

Central Process Area Boundary

Central Ditch

N
W E
S

0 400 800

Scale in Feet

Note:	Map was completed using wells in the weathered Atoka Formation.
Source:	Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.
Projection:	Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-13

GROUNDWATER ELEVATIONS IN BEDROCK WELLS AT MAXIMUM DRAWDOWN PUMPING TEST NUMBER 2 PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

During the recovery test, the water level in MW-58 (a shallow observation well) showed an increase of 0.6 feet of head that may have been related to the 0.78 inches of precipitation that fell over a 12-hour period during the recovery test.

3.3.5.3.6 Background Test Results (Dalapon Production Area)

The background data collected from the dalapon production area showed fluctuations of less than 0.4 feet in the bedrock wells MW-91, MW-92, MW-93, and MW-94 (Table 3-7). Water levels in bedrock wells MW-89 and MW-90 rose less than 0.35 feet throughout the duration of the background test. The water levels in the shallow observation wells MW-23A, MW-24A, MW-57, MW-66, MW-71, MW-72, MW-82, and MW-84 showed fluctuations of 0.6 feet or less over the duration of background testing.

3.3.5.3.7 MW-91 Pumping Test Results (Pumping Test No. 3, Dalapon Production Area)

As a result of pumping at MW-91 (Subsection 2.3.7.4), significant drawdown was observed in wells MW-94, MW-93, MW-92, MW-72, MW-57, and MW-23A. Drawdown data for observation wells MW-92, MW-93, and MW-94 were used to calculate transmissivity, storativity, and hydraulic conductivity values (Table 3-8). In addition, recovery data were used to calculate transmissivity for these same wells as a check on drawdown values (Table 3-9). The groundwater level elevations in bedrock wells at maximum drawdown are shown on Figure 3-14.

Although there was significant drawdown in observation wells MW-23A, MW-57, and MW-72 (Table 3-9), values of transmissivity and storativity were not calculated because of uncertainty about whether the wells are fully penetrating the same water-bearing unit that was pumped.

There was no significant drawdown observed in the shallow observation wells MW-24A, MW-71, MW-82, or MW-84. There was also no significant drawdown observed in the deep bedrock wells MW-89 and MW-90. Although observation well MW-66 showed a decrease in water level during the drawdown test of 0.55 feet; the hydrogeologic parameters were not calculated because the magnitude of the response was limited and there is some uncertainty about whether the well is fully penetrating the same water-bearing unit that was pumped.

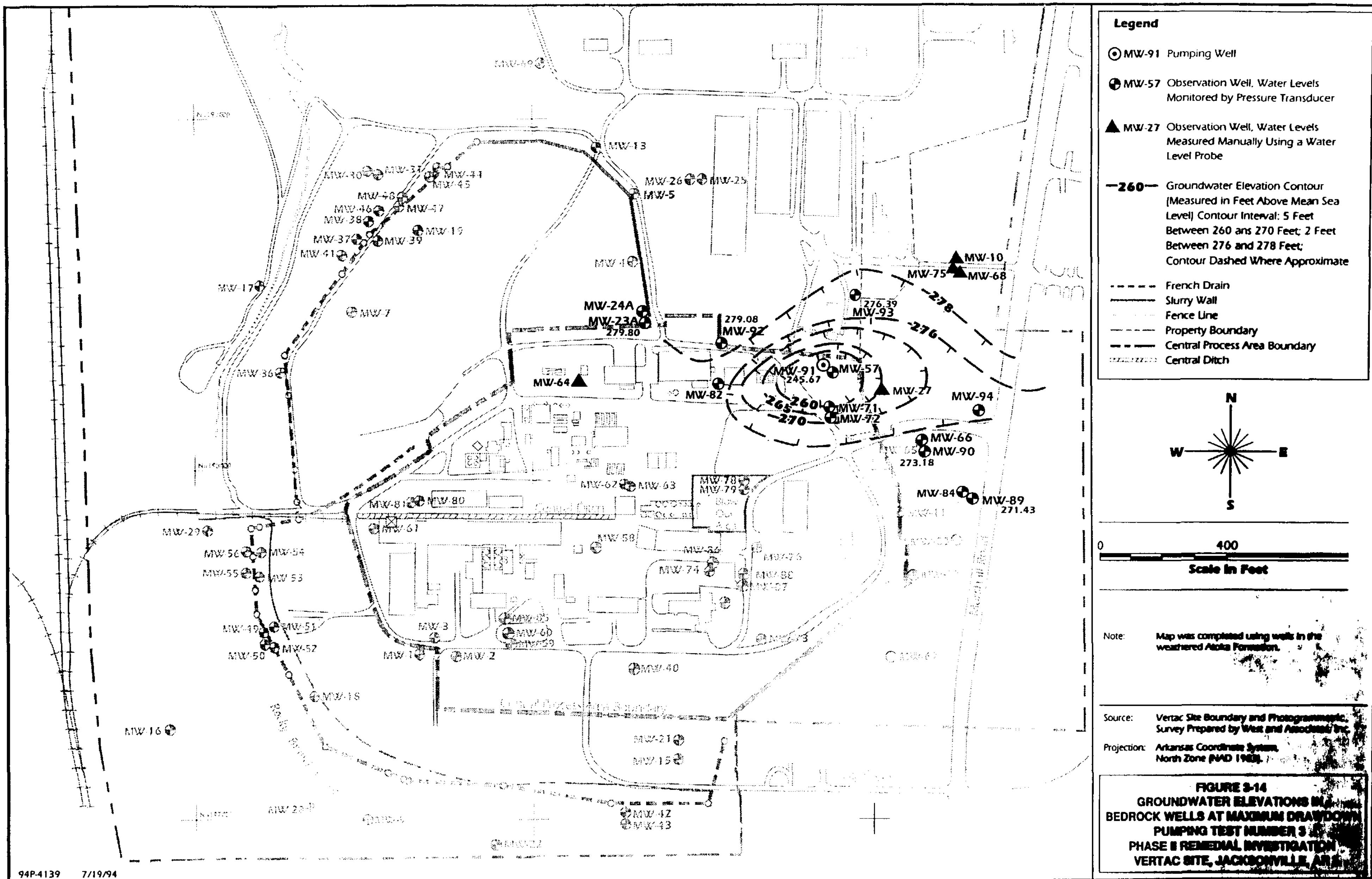


FIGURE 3-14
GROUNDWATER ELEVATIONS IN BEDROCK WELLS AT MAXIMUM DRAWDOWN PUMPING TEST NUMBER 3
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

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3.3.5.3.8 MW-92 Pumping Test Results (Pumping Test No. 4, Dalapon Production Area)

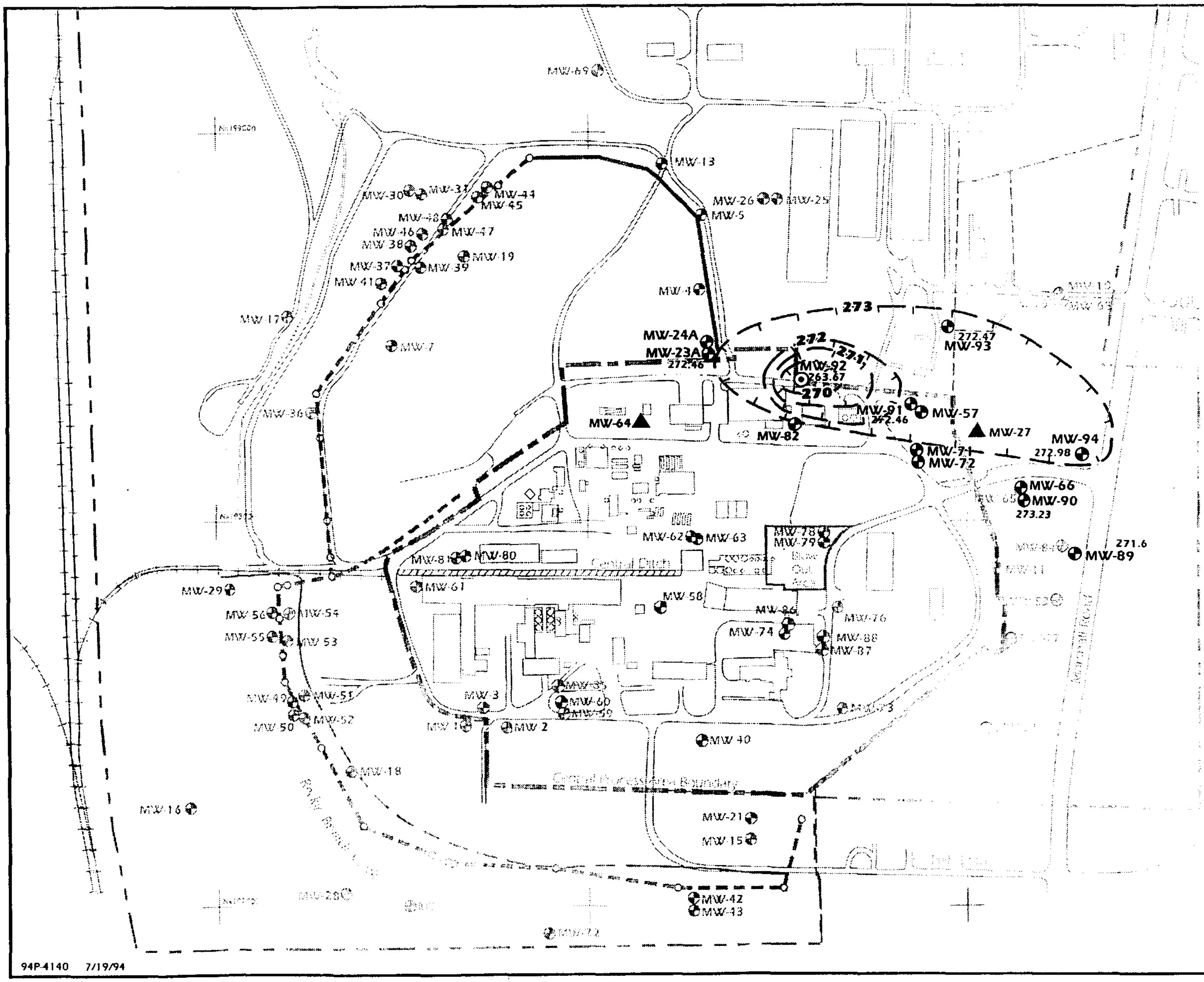
As a result of pumping MW-92 (Subsection 2.3.7.4) significant drawdown was observed in the following observation wells (in order of decreasing drawdown): MW-93, MW-91, MW-94, MW-23A, MW-57, and MW-72. Drawdown data for observation wells MW-91, MW-93, and MW-94 were used to calculate transmissivity, storativity, and hydraulic conductivity values (Table 3-9). In addition, recovery data were used to calculate transmissivity for these same wells as a check on drawdown (Table 3-9). The groundwater level elevations in bedrock wells at maximum drawdown are shown in Figure 3-15.

Although there was significant drawdown in observation wells MW-23A, MW-57 and MW-72 (Table 3-9), values of transmissivity and storativity were not calculated because of uncertainty about whether the wells were fully penetrating in the same unit that was being pumped; therefore, one of the evaluation criteria was not met. There was no significant drawdown in the shallow observation wells MW-82, MW-71, nor in the deep well MW-89. There was a decrease in water levels in MW-66 of 0.25 feet in MW-24A of 0.4 feet and the deep bedrock well MW-90 of 0.25 feet.

3.3.5.3.9. Summary of Pumping Test Results

Water levels in consolidated weathered bedrock and fresh bedrock responded to pumping over large areas along strike, up-dip and down-dip within general water-bearing units. Water levels in wells completed at similar depths, but, within different water-bearing units did not respond to pumping. The water level data in the pumping and bedrock observation wells showed smooth and systematic drawdown during pumping tests and rise during recovery tests. The lengths of pumping (i.e., one to two days), the amount of drawdown in the pumping wells (i.e., 16.7 to 69.0 feet), and the large area of influence indicate that the pumping tests sufficiently stressed the hydraulic capacity of the water-bearing units. The hydraulic characteristics (i.e., storativity, transmissivity, and conductivity) were calculated based on pumping a well at a known discharge rate, and measuring drawdown in observation wells at known distances from the pumping well. The graphs of the data generated from these tests indicated that the pumping wells responded in an expected manner; therefore, the measurements of time, drawdown, and distance were used to calculate the hydraulic characteristics of the water-bearing units.

The range of hydraulic characteristics was small. The storativity values were within an order of magnitude and ranged from 1×10^{-5} to 2.1×10^{-4} (unitless). For confined aquifers, S may be



Legend

- MW-92 Pumping Well
- MW-57 Observation Well, Water Levels Monitored by Pressure Transducer
- MW-27 Observation Well, Water Levels Measured Manually Using a Water Level Probe
- —273— Groundwater Elevation Contour (Measured in Feet Above Mean Sea Level) Contour Interval: 1 Foot; Contour Dashed Where Approximate; Only Bedrock Wells That Responded to the Pumping Well Were Contoured.
- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch

N
W E
S

0 400 800
Scale in Feet

Note: Map was completed using wells in the weathered Atoka Formation.

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-15
GROUNDWATER ELEVATIONS IN BEDROCK WELLS AT MAXIMUM DRAWDOWN
PUMPING TEST NUMBER 4
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

interpreted as the amount of water in storage released from a column of aquifer with a specified cross sectional area and a specified decline in head (Davis and DeWiest, 1966). The transmissivity values for both drawdown and recovery were within about an order of magnitude. For example, the transmissivity for drawdown data ranged from 3.5 to 39.2 ft^2/day gpd/ft. The hydraulic conductivities were within an order of magnitude and ranged from 2.96 x 10^{-5} to 3.5 x 10^{-4} cm/s 0.084 to 9.98 ft/day. The values for the hydraulic conductivities are relatively low, which shows that bedrock will transmit water at a low rate. The low storativity indicates that the bedrock has limited capacity to store water.

The hydraulic characteristics measured in the two different areas of the Site were similar. The hydraulic characteristics in the administration building area were slightly lower than those in the dalapon production area on a consistent basis. The cause of the slight differences is not known at this time.

3.3.6 Assessments of Non-Aqueous Phase Liquids

As described in Subsections 2.3.2 and 2.3.4.4, assessments were conducted to observe the presence of non-aqueous phase liquids in soils and groundwater within and adjacent to the central process area. Assessments were conducted by excavating shallow test pits and by collecting samples from the top and bottom of the water column in groundwater monitoring wells.

Results from assessment indicated that some residual NAPLs are present in subsurface soils in some areas within the central process area. This is based on observations of some stained soils, thin films floating on water within the test pits, and results for chemical analyses for toluene. Test pits TP-6, TP-9, TP-10, TP-11, TP-12, TP-13 and TP-14 showed evidence of thin (less than 0.5 inch), oily films floating on the water in the test pits. In addition, re-evaluation of TP-6 confirmed a residual tar-like solid in some of the soil pores at the depth where the sample was collected for analysis based on screening of the head space in the sample bottle. Re-evaluation of TP-10 uncovered a tree limb that exhibited an oil-like sheen when it was uncovered in the fill materials. Soil samples from the two test pits also tested positive for toluene (Table 3-10). Results of the analysis of the soil sample from TP-6 showed that the sample contained toluene at a concentration of 30 ppm at a depth of 2 to 3 feet below land surface. Similarly, results of the analysis of the soil sample from TP-10 showed that the sample contained toluene at a concentration of 110 ppm at a depth of 5 to 6 feet below land surface. If fluorescence is used as a screening tool in the future,

Table 3-10

Summary of Test Pit Analytical Results
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Test Pit Number/ Sample Type (Units)	Sample Depth (feet)	Toluene (mg/kg)
TP-06	2.0-3.0	30
TP-06(Dup)	2.0-3.0	4.6
TP-08	4.0-5.0	0.0012u
TP-10	5.0-6.0	110
TP-11	6.0-7.0	0.0014u
TP-14	3.0-4.0	0.0014u

Notes:
Units:
Sample depth is measured in feet below ground surface.
Analytical data concentration is presented in milligrams per kilogram (mg/kg) of soil or parts per million.

Sample Type:
Dup = Field duplicate (quality control) sample.

Analytical Data Qualifier:
u = Not detected at the quantitation limit.

perhaps a recording spectrofluorometer could be used to remove potential for operator subjectivity inherent in visual observation.

Observation of samples collected from the top and bottom of the wells also indicated that NAPLs are present within the soils and rock beneath the central process area. Specifically, DNAPLs were observed in samples collected from the bottom of MW-23A and disseminated NAPLs were observed at mid-water column in MW-71 and the Reasor-Hill well. Also, thin films of organic liquids were observed on the top of water samples collected from the top of MW-23A and MW-64. Results of the assessment of NAPLs are presented in Table 3-11. The LNAPL observed on the sample from the bottom of MW-23A may have separated from the DNAPL after the sample was collected. The thickness of DNAPL in MW-23A was estimated to be about 3-inches thick based on the suction created when the bailer was lifted from the bottom of the well. Presence of NAPLs in MW-23A are considered to be related to wastes that were disposed in the North Landfill. A sample of the DNAPL was submitted for a qualitative analysis of volatile organic compounds, density and viscosity analyses (Table 3-12). The analysis of the sample for volatile organics indicated that the sample contained 2,300 ppm toluene. Chemical characterization of the French drain oily leachate samples showed high concentrations of toluene, chlorophenols, chlorobenzene, and chlorophenoxyherbicides (Subsection 3.2.3; WESTON, 1992a). The DNAPL sample from MW-23A showed a similar concentration of toluene as found in the French drain oily leachate samples (Table 3-9; WESTON, 1992a). The substance has a viscosity of 521.8 cps (centipoises) and a specific gravity of 1.443 which indicates that the substance in the bottom of MW-23A is more viscous and heavier than water. The presence of DNAPL at the bottom of MW-23A (42.8 ft) also suggests that the DNAPL is in the fresh rock. MW-23A is located in the North Burial area (i.e. west of the slurry wall and within the capped area) where waste materials were reported to be buried. The presence of DNAPLs was observed when the original well (MW-23) was drilled in this area in 1984. The source of the DNAPL is assumed to be burial of the waste in the area of the well.

The thin film observed in the water sample collected from the top of MW-64 was undetectable prior to the shake test with hydrophobic dye. Subsequent samples collected from the top of the water column did not test positive for NAPLs; therefore, the LNAPL must be present as a thin discontinuous film. It is possible that the thin film has separated from DNAPLs in the area of the well (Fetter, 1993). This is based on the proximity of the well to an area where wastes were buried. In addition, MW-64 would not be expected to contain any extent of LNAPL because the well was designed to test the conditions at the base of the weathered zone; therefore, the casing extends below the water table. Previous investigations in the area of MW-64 also indicated the

Table 3-11

Results of Assessment for Presence of Light and Dense, Non-Aqueous Phase Liquids in Wells [a]
December 1993
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

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Monitoring Well Number	Total Well Depth[b]	Light Phase Observed	Dense Phase Observed
MW-23A	42.79	Yes[c]	Yes[e,f]
MW-24A	28.75	No	No
MW-61	18.16	No	No
MW-62	17.37	Maybe[d]	No
MW-63	10.96	Maybe[d]	No
MW-64	30.89	Yes[c]	No
MW-71	23.69	No	Yes[g]
MW-72	55.09	No	No
MW-78	25.33	No	No
MW-79	49.78	No	No
MW-80	14.06	No	No
MW-81	28.31	No	No
MW-82	25.11	No	No
Reasor-Hill Well	81.40	No	Yes[h]

Notes:

a = Qualitative phase separation tests were adapted from: Cohen, R.M., A.P. Bryda, S.T. Shaw, and C.P. Spalding. 1992. "Evaluation of Visual Methods to Detect NAPL in Soil and Water". Ground Water Monitoring Review, Volume 12, Number 4, pp. 132-141.

b = Measurement in feet with reference to top of casing.

c = LNAPL (light, non-aqueous phase liquids) observed as a distinct floating phase in sample bottle. NAPL thickness: thin film on top of water surface.

d = Thin iridescent coating on the interior of sample bottle did not react with the hydrophobic dye.

e = NAPL observed as a distinct floating phase in sample collected for DNAPL assessment. NAPL depth and thickness were indeterminate.

f = DNAPL observed at the bottom of the monitoring well. Approximate DNAPL thickness: 3 inches.

g = NAPL observed in mid-water column. NAPL depth and thickness were indeterminate.

h = NAPL observed in mid-water column. Approximate NAPL depth: 25 feet below the top of casing. NAPL thickness was indeterminate.

Table 3-12

Summary of MW-23A Analytical Results
Assessment of Dense, Non-aqueous Phase Liquid
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Analysis/Compound	Result	
GC/FID VOA Analysis		
Toluene	2,300	ppm
Density	1.443	
Viscosity	521.8	cps

possible presence of NAPLS. For example, several patches of a pink-brown liquid were noted on the water surface in TP-1/TP-2 when these test pits were excavated to assess the dimensions of the tetrachlorobenzene spill (Subsection 2.3.2.4; WESTON, 1992b) during the Phase I RI.

Mid-water column NAPLs were observed while collecting the basal water column samples for MW-71 and the Reasor-Hill well. Samples of the Reasor-Hill well during the Phase I RI (Subsection 3.4.4; WESTON, 1992b) indicated that there was at least 1 foot of LNAPL in the upper water column. Recent sampling indicated that the mid-water column NAPL was situated at about 25 feet below land surface based on presence of product globules and a stained bailer rope. The presence of a mid-water column NAPL is consistent with the injection of wastes into the Reasor-Hill well and fractionation of DNAPL into separate phases of intermediate densities. The geographic distribution of the mid-water column NAPL is not known. TP-5 and TP-6, which were excavated across the water table, near the Reasor-Hill well, show evidence only of a thin iridescent sheen.

The presence of mid-water column NAPL in MW-71 is consistent with the presence of toluene at near saturation limits in water at that location. The occurrence of a mid-water column NAPL suggests that the substance is of an intermediate density between an LNAPL and a DNAPL. The exact location within the water column was indeterminate during re-sampling of MW-71. In summary, thin, discontinuous, iridescent sheens are present in MW-23A, MW-24A, and possibly MW-62 and MW-63. These wells are constructed in consolidated weathered rock with the exception of MW-23A which is constructed in fresh bedrock. DNAPLs and mid-water column NAPLs are present in MW-23A, MW-71, and the Reasor-Hill well. MW-71 is constructed in the consolidated weathered bedrock. Mid-water column NAPLs in MW-71 may move along bedrock fractures. The construction of the Reasor-Hill well is unknown. The bottom of the well is in fresh bedrock at 81.4 feet below top of casing. Based on discussions with Hercules' site personnel, a few drums of waste liquids were reportedly dumped into the Reasor-Hill well. The DNAPL present at MW-23A is still present in the bedrock system of the associated North Landfill.

3.3.7 Groundwater Quality Data

The results of analyses of the groundwater samples for sampling rounds 1 and 2 are summarized in Table 3-13. The following parameters were analyzed:

- TCL volatile organic compounds.

Table 3-13

Summary of Groundwater Analytical Data
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number/ Sample Type (units)	Sampling Date	Chlorophenol 2- (mg/L)	Chlorophenol 4- (mg/L)	Dichlorophenol 2,4- (mg/L)	Dichlorophenol 2,6- (mg/L)	Trichlorophenol 2,3,6- (mg/L)	Trichlorophenol 2,4,5- (mg/L)	Trichlorophenol 2,4,6- (mg/L)	Chlorophenoxyherbicides 2,4-D (mg/L)	Chlorophenoxyherbicides Silvex (mg/L)	Chlorophenoxyherbicides 2,4,5-T (mg/L)
MW-69	12/16/91	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
MW-85	12/14/91, 2/2/92	0.011 u	0.011 u	0.011 u	0.011 u	0.011 u	0.055 u	0.011 u	0.012 uJ	0.0058 uJ	0.0058 uJ
	5/21/93	0.011 u	0.011 u	0.011 u	0.011 u	0.011 u	0.005 u	0.011 u	0.001 u	0.00052 u	0.00052 u
MW-86	12/15/91, 2/2/92	0.011 u	0.011 u	0.011 u	0.011 u	0.011 u	0.055 u	0.011 u	0.011 uJ	0.0054 uJ	0.0054 uJ
MW-87	12/15/91, 2/2/92	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	0.05 u	0.01 u	0.011 uJ	0.0057 uJ	0.0057 uJ
	5/21/93	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	0.05 u	0.01 u	0.001 u	0.00052 u	0.00052 u
MW-88	12/15/91, 2/2/92	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	0.05 u	0.01 u	0.011 uJ	0.0055 uJ	0.0055 uJ
MW-89	12/16/91, 2/3/92	0.003 J	0.01 u	0.01 u	0.003 J	0.01 u	0.05 u	0.01 u	0.021 J	0.0058 uJ	0.0058 uJ
	5/22/93	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	0.05 u	0.01 u	0.0011 u	0.00053 u	0.00053 u
MW-90	12/16/91, 2/3/92	0.011 u	0.011 u	0.011 u	0.011 u	0.011 u	0.055 u	0.011 u	0.011 uJ	0.0054 uJ	0.0054 uJ
MW-91	12/16/91, 2/5/92	0.47 J	0.94	0.13	0.12 J	0.002 J	0.027	0.006 J	0.011 uJ	0.0056 uJ	0.0096 J
(duplicate)	12/16/91, 2/5/92	0.4 J	0.68	0.11	0.14 J	0.003 J	0.036	0.007 J	0.012 u	0.006 u	0.006 u
MW-92	12/16/91, 2/5/92	2.1	3.9	1.3	1.1	0.22 u	0.31	0.14 J	14	0.44 J	1.1
	5/22/93	3.8	42	1.5	0.51	0.28 u	0.096 J	0.058 J	9.2	0.65	0.94
MW-93	2/4/92	0.06 u	1.2	0.06 u	0.06 u	0.06 u	0.3 u	0.06 u	0.0011 u	0.00056 u	0.00013 u
(duplicate)	2/4/92	0.055 u	1.6	0.055 u	0.055 u	0.055 u	0.28 u	0.055 u	0.0011 u	0.00053 u	0.00017 u
	5/22/93	0.039 J	2.7	0.11 u	0.11 u	0.11 u	0.55 u	0.11 u	0.0026	0.0059	0.00053 u
(pre-purge)	5/22/93	0.019 J	2.7	0.2 u	0.2 u	0.2 u	1 u	0.2 u	0.0025	0.0017	0.00056 u
MW-94	2/3/92	0.025 J	1	0.055 u	0.006 J	0.055 u	0.28 u	0.055 u	0.027 u	0.015	0.0066 u
	5/22/93	1.3	7.4	0.82 u	0.82 u	0.82 u	4.1 u	0.82 u	0.0029	0.11	0.00048 J
(pre-purge)	5/22/93	0.015 J	0.37	0.025 u	0.025 u	0.025 u	0.12 u	0.025 u	0.001 u	0.01	0.0005 u
	12/7/93	NR	NR	NR	NR	NR	NR	NR	0.001 u	0.0038	0.0012 J
(duplicate)	12/7/93	NR	NR	NR	NR	NR	NR	NR	0.0012 u	0.0036	0.00059 u
(pre-purge)	12/7/93	NR	NR	NR	NR	NR	NR	NR	0.0011 u	0.0063	0.00054 u
	6/14/94	0.009 J	0.1	0.01 u	0.002 J	0.01 u	0.05 u	0.01 u	0.0011 u	0.0049	0.00053 u
(duplicate)	6/14/94	0.01	0.12	0.01 u	0.003 J	0.01 u	0.05 u	0.01 u	0.0011 u	0.0049	0.00055 u
(pre-purge)	6/14/94	0.01	0.1	0.01 u	0.002 J	0.01 u	0.05 u	0.01 u	0.0011 u	0.0046	0.00053 u
MW-95	5/21/93	0.01 uJ	0.01 uJ	0.01 uJ	0.01 uJ	0.01 uJ	0.05 uJ	0.01 uJ	0.001 uJ	0.00052 uJ	0.00052 uJ
MW-96	5/21/93	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	0.05 u	0.01 u	0.0012 u	0.00059 u	0.00059 u
MW-97	5/21/93	0.011 u	0.011 u	0.011 u	0.011 u	0.011 u	0.055 u	0.011 u	0.0011 u	0.00054 u	0.00054 u
MW-98	5/21/93	0.011 u	0.011 u	0.011 u	0.011 u	0.011 u	0.055 u	0.011 u	0.00059 u	0.00052 u	0.00052 u
(duplicate)	5/21/93	0.011 u	0.011 u	0.011 u	0.011 u	0.011 u	0.055 u	0.011 u	0.00059 u	0.00053 u	0.00053 u

Notes:
Units are reported in milligrams per liter (mg/L) or in parts per million (ppm).
Analytical Data Qualifiers:
J = Concentration estimated below quantitation limit.
NR = Not Reported
u = Not detected at the quantitation limit.
uJ = Estimated quantitation limit.

Sample Type:
Duplicate = Field duplicate of the groundwater sample.
Pre-purge = Groundwater sample collected prior to purging the monitoring well

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Table 3-13

Summary of Groundwater Analytical Data
Phase II Remedial Investigation
Vertac Site, Jacksonville, Arkansas

Monitoring Well Number/ Sample Type	Sampling Date	Tetra-chloro-Benzene (mg/L)	2,3,7,8-TCDD (ng/L)	Volatile Organic Compounds: Toluene (mg/L)	Chloroform (mg/L)	Acetone (mg/L)	Methylene Chloride (mg/L)	Chloromethane (mg/L)	Chloride (mg/L)	Total Organic Carbon (mg/L)
MW-69	12/16/91	NR	NR	0.005 u	0.005 u	0.01 u	0.01 u	0.01 u	NR	NR
MW-85	12/14/91 , 2/2/92	0.011 u	1 u	0.005 u	0.008	0.013 u	0.005 u	0.01 u	8	27
	5/21/93	0.011 u	NR	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	9.6	0.5 u
MW-86	12/15/91 , 2/2/92	0.011 u	1.3 u	0.005 u	0.002 J	0.0021 u	0.006 u	0.01 u	5.9	1.8
MW-87	12/15/91 , 2/2/92	0.010 u	1.4 u	0.005 u	0.005 u	0.0021 u	0.007 u	0.01 u	6.2	1.1
	5/21/93	0.01 u	NR	0.01 u	0.01 u	0.01 u	0.011 u	0.01 u	7.6	0.91
MW-88	12/15/91 , 2/2/92	0.010 u	0.9 u	0.005 u	0.005 u	0.01 u	0.005 u	0.01 u	6.6	0.55
MW-89	12/16/91 , 2/3/92	0.010 u	1.4 u	0.014	0.005 u	0.018 u	0.005 u	0.01 u	30.1	1.5
	5/22/93	0.01 u	NR	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	78.4	1.8
MW-90	12/16/91 , 2/3/92	0.011 u	1.4 u	0.005 u	0.005 u	0.013 u	0.005 u	0.01 u	8	0.55
MW-91	12/16/91 , 2/5/92	0.010 u	1.3 u	0.006	0.005 u	0.022 u	0.009 u	0.01 u	159	2.4
MW-91 (dup)	12/16/91 , 2/5/92	0.012 u	1.7 u	0.007	0.005 u	0.023 u	0.01 u	0.01 u	155	4.4
MW-92	12/16/91 , 2/5/92	0.220 u	1.8 u	0.72	0.027	0.025	0.1 J	0.01 u	114	NR
	5/22/93	0.28 u	NR	2.9	0.05 u	0.11 u	0.063 u	0.05 u	356	125
MW-93	2/4/92	0.055 u	0.9 uJ	0.002 J	0.005 u	0.01 u	0.022	0.01 u	68.5	6.8
MW-93 (dup)	2/4/92	0.400 u	0.4 uJ	0.002 J	0.005 u	0.01 u	0.025	0.01 u	75.2	6.7
	5/22/93	0.11 u	NR	0.008 J	0.01 u	0.01 u	0.01 u	0.01 u	126	16.1
(pre-purge)	5/22/93	0.2 u	NR	0.01 u	0.01 u	0.01 u	0.01 u	0.003 J	116	14.9
MW-94	2/3/92	0.055 u	1.4 uJ	0.005 u	0.005 u	0.012 u	0.006 u	0.01 u	290	7.6
	5/22/93	0.82 u	NR	0.009 J	0.01 u	0.014	0.01 u	0.01 u	367	37.3
(pre-purge)	5/22/93	0.025 u	NR	0.01 u	0.01 u	0.047	0.01 u	0.01 u	241	4.8
	12/7/93	NR	NR	NR	NR	NR	NR	NR	212	NR
(duplicate)	12/7/93	NR	NR	NR	NR	NR	NR	NR	NR	NR
(pre-purge)	12/7/93	NR	NR	NR	NR	NR	NR	NR	NR	NR
	6/14/94	NR	NR	NR	NR	NR	NR	NR	NR	NR
(duplicate)	6/14/94	NR	NR	NR	NR	NR	NR	NR	NR	NR
(pre-purge)	6/14/94	NR	NR	NR	NR	NR	NR	NR	NR	NR
MW-95	5/21/93	0.01 uJ	NR	0.01 u	0.01 u	0.01 u	0.01 u	0.01 u	18.7	3
MW-96	5/21/93	0.01 u	NR	0.01 u	0.01 u	0.013	0.011 u	0.01 u	5 u	1.4
MW-97	5/21/93	0.011 u	NR	0.01 u	0.01 u	0.009 J	0.013 u	0.01 u	12.2	1.4
MW-98	5/21/93	0.011 u	NR	0.01 u	0.01 u	0.013	0.011 u	0.01 u	10.5	0.53
MW-98 (dup)	5/21/93	0.011 u	NR	0.01 u	0.01 u	0.013	0.011 u	0.01 u	11.9	0.5 u

Notes:

Units are reported in milligrams per liter (mg/L) or in parts per million (ppm).
Analytical Data Qualifiers:
J = Concentration estimated below quantitation limit.
NR = Not Reported
u = Not detected at the quantitation limit.
uJ = Estimated quantitation limit.

Sample Type:
Duplicate = Field duplicate of the groundwater sample.

Pre-purge = Groundwater sample collected prior to purging the monitoring well

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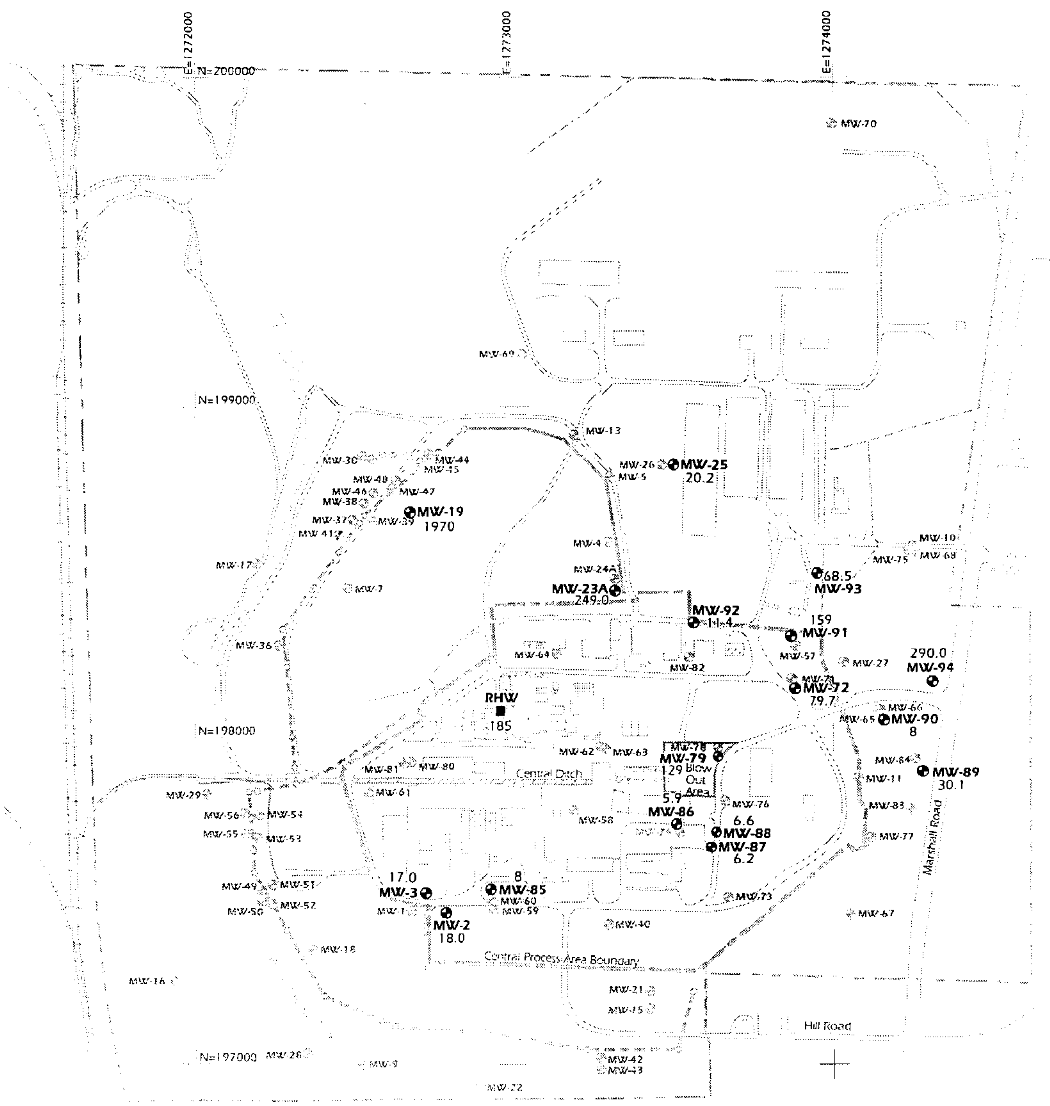
- Chlorophenols.
- Chlorophenoxyherbicides.
- 2,3,7,8-TCDD.
- Tetrachlorobenzene.
- Chloride.
- Total organic carbon.

The results of analyses of groundwater samples are listed in Table 3-13 and are shown on maps. The fresh bedrock water quality data for sampling round 1 are shown in Figures 3-16 through 3-27. The fresh bedrock water quality data for sampling round 2 are shown in Figures 3-28 through 3-39. Historical analytical data for other bedrock wells (Table 3-13 and Appendix D of the Phase I RI Report) are also shown on Figures 3-16 through 3-27. Some historical data are shown on the maps even though they were collected at different times and some of the data were not validated (Hercules, personal communications, 1989, and Subsection 1.9.3.4, WESTON, 1992b. These historical results were used to provide the best picture of Site conditions. Isopleth maps were not constructed for the bedrock wells because contouring implies, at least to some extent, that the results of samples from one well may be related to results from other wells; therefore, contouring suggests a degree of interconnection among wells. The interconnection among bedrock wells appears to exist in wells along strike and dip, as indicated in Subsection 3.3.2.3. Therefore, drawing contours among wells in different hydrologic zones creates a perception of interconnection that probably does not exist.

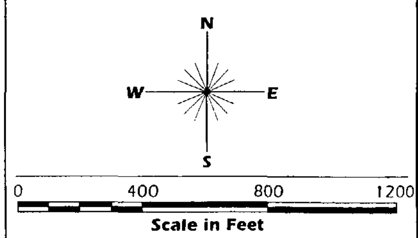
Water quality results from the second round of sampling indicated an increase in the concentrations from previous sampling for the following compounds: 2,4-D, Silvex, 2,4,5-T, and toluene. Because of the low storativity of the bedrock, the increase in concentration of the organic compounds may be due to gradients induced during prior well purging and pumping test activities, thereby drawing contamination toward MW-94. Silvex was found in the sample from MW-94, which is located near the eastern site boundary at concentration above the maximum contaminant level for that compound (MCL = 0.050 ppm). As a result, a long-term groundwater recovery pilot test was started. One of the primary objectives of the test was to pull contaminants toward the central process area and away from the eastern boundary of the Site. In December 1993, after the pilot recovery test had pumped about 1 million gallons of groundwater from MW-92, a third set of samples was collected from MW-94 to assess the concentration of silvex in the area of the well. The results of the third set of samples from MW-94 showed that the concentration silvex was about



94P-4141 7/19/94

Legend

- MW-85 — Monitoring Well Completed in Fresh Bedrock
- RHW — Reasor-Hill Well
- Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
- 8.0 — Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)
- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch



Sampling Dates and Sources of Analytical Data:

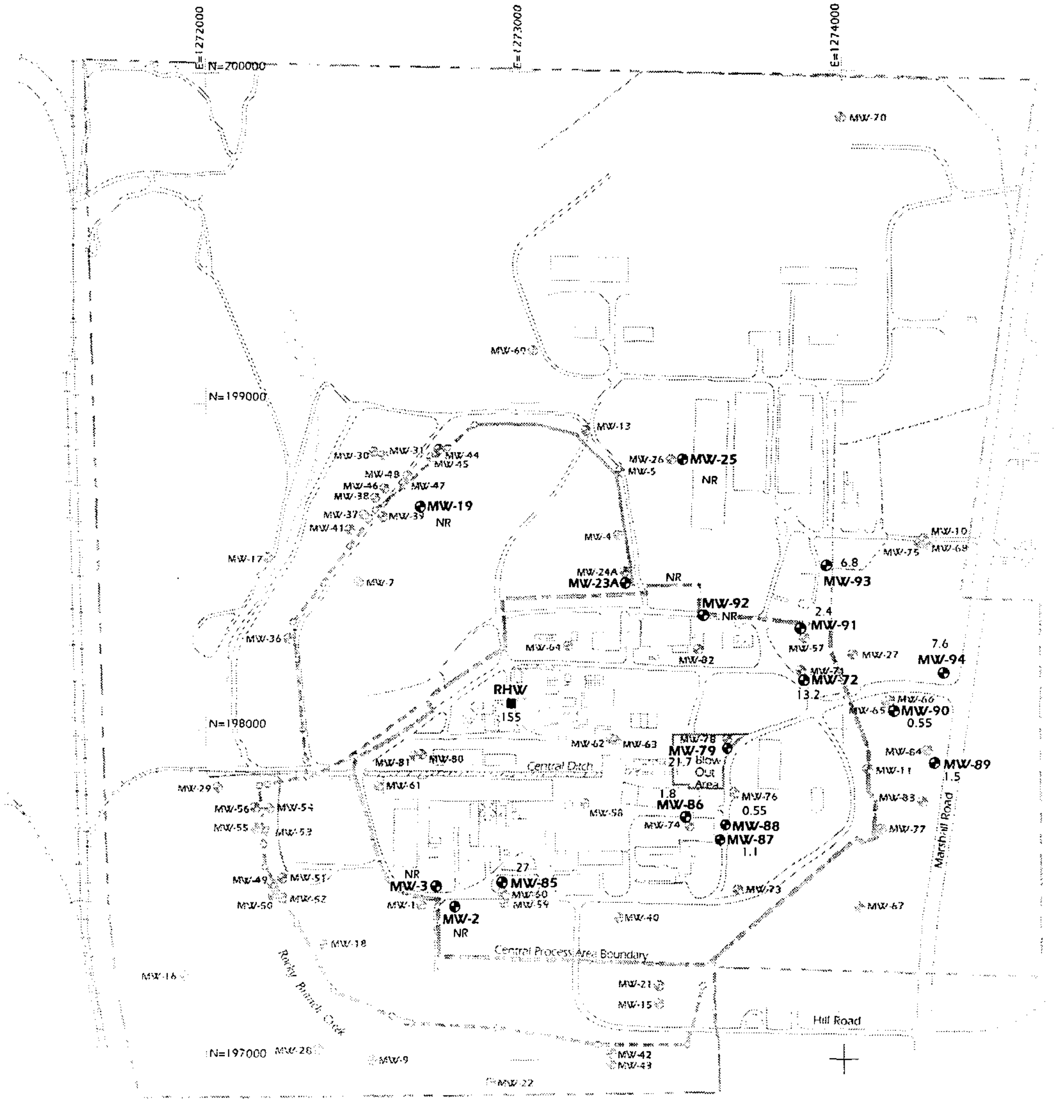
1. Hercules Incorporated: (PHASE I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (PHASE I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-16
CHLORIDE
GROUNDWATER QUALITY MAP
SAMPLING ROUND 1
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

000433



Legend

MW-85 Monitoring Well Completed in *Fresh Bedrock*

RHW Reasor-Hill Well

Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

27 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
NR - Analyte Not Requested.

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:

1. Hercules Incorporated: Wells 2, 3 - 10 October 1989
   (Phase I RI, Appendix B) Well 19 - 3 April 1989
   Well 23A - 13 October 1989
   Well 25 - 11 October 1989
2. WESTON RI Data: Wells 72, 79 - 14 November 1990
   (Phase I RI, Appendix R) Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: Wells 85 through 94 -
   (Phase II RI, Appendix G) 14 December 1991 through 5 February 1992

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-17
TOTAL ORGANIC CARBON GROUNDWATER QUALITY MAP SAMPLING ROUND 1 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

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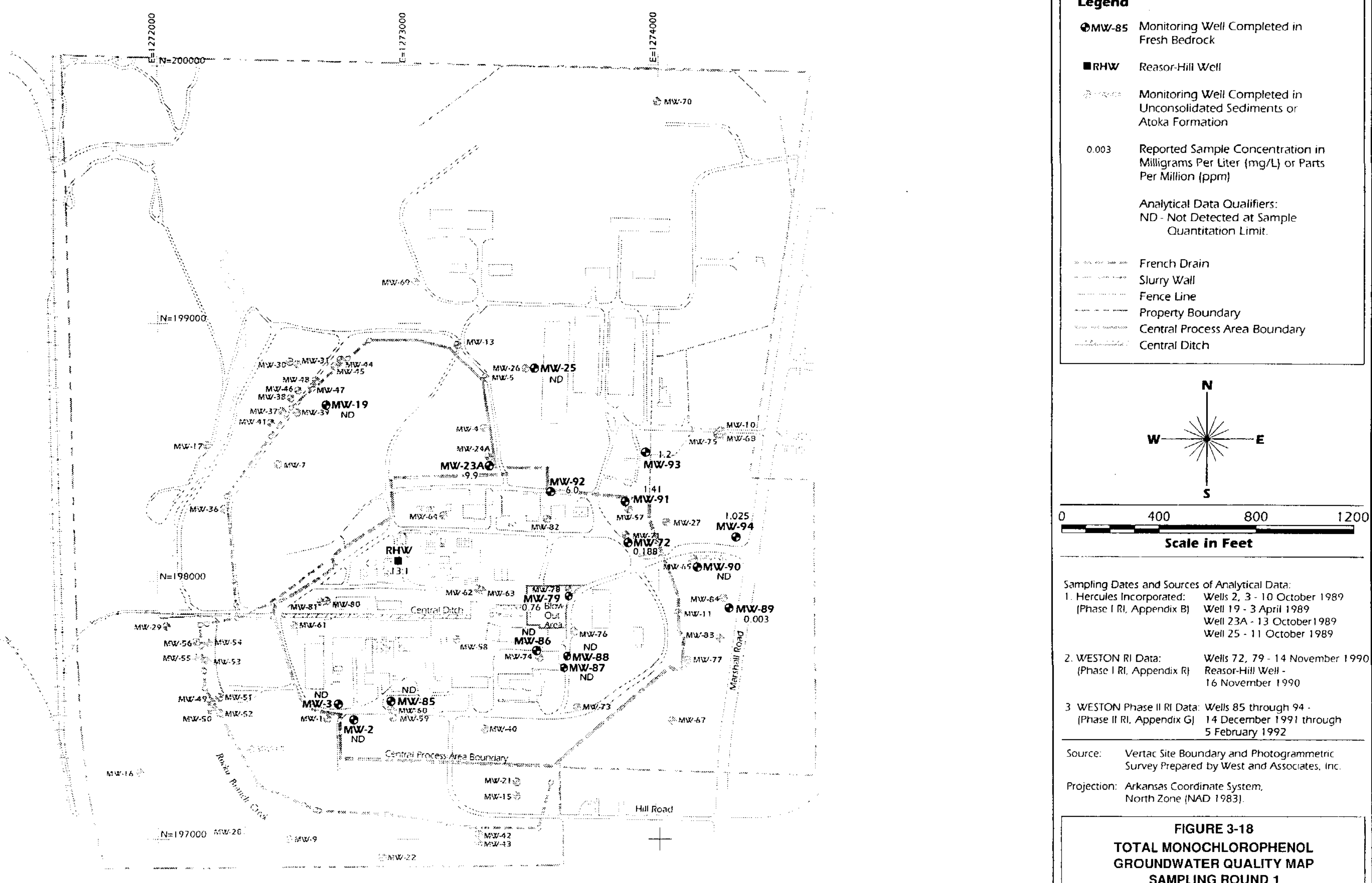

Legend

MW-85 Monitoring Well Completed in Fresh Bedrock

RHW Reasor-Hill Well

Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

0.003 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

Sampling Dates and Sources of Analytical Data:

1. Hercules Incorporated: (Phase I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-18
TOTAL MONOCHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 1 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

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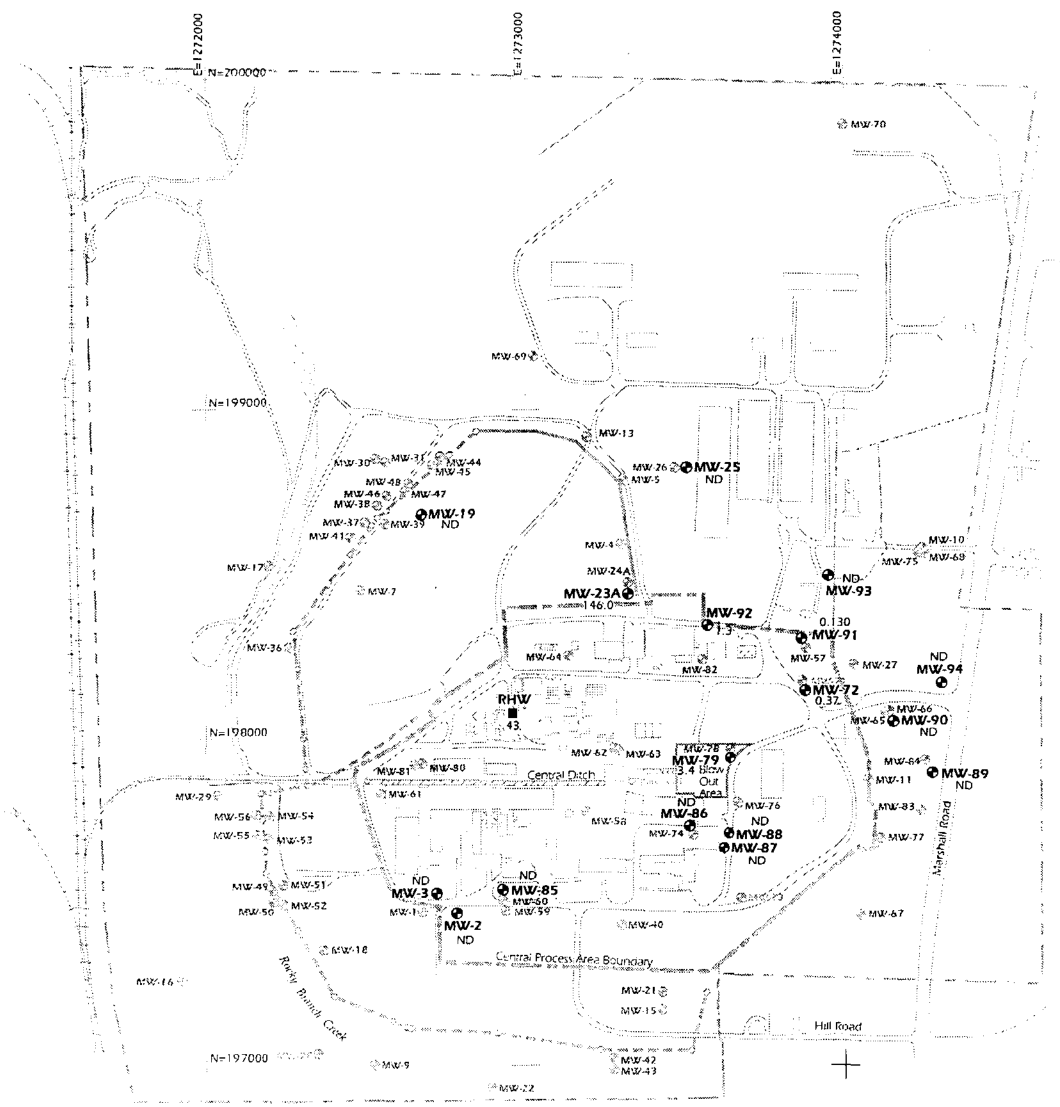


Legend

MW-85	Monitoring Well Completed in Fresh Bedrock
RHW	Reasor-Hill Well
	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
0.130	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)
	Analytical Data Qualifiers: ND - Not Detected at Sample Quantitation Limit.
	French Drain
	Slurry Wall
	Fence Line
	Property Boundary
	Central Process Area Boundary
	Central Ditch

N S W E

0 400 800 1200

Scale in Feet

Sampling Dates and Sources of Analytical Data:

1. *Hercules Incorporated:* (Phase I RI, Appendix B) — *Wells 2, 3 - 10 October 1989*; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

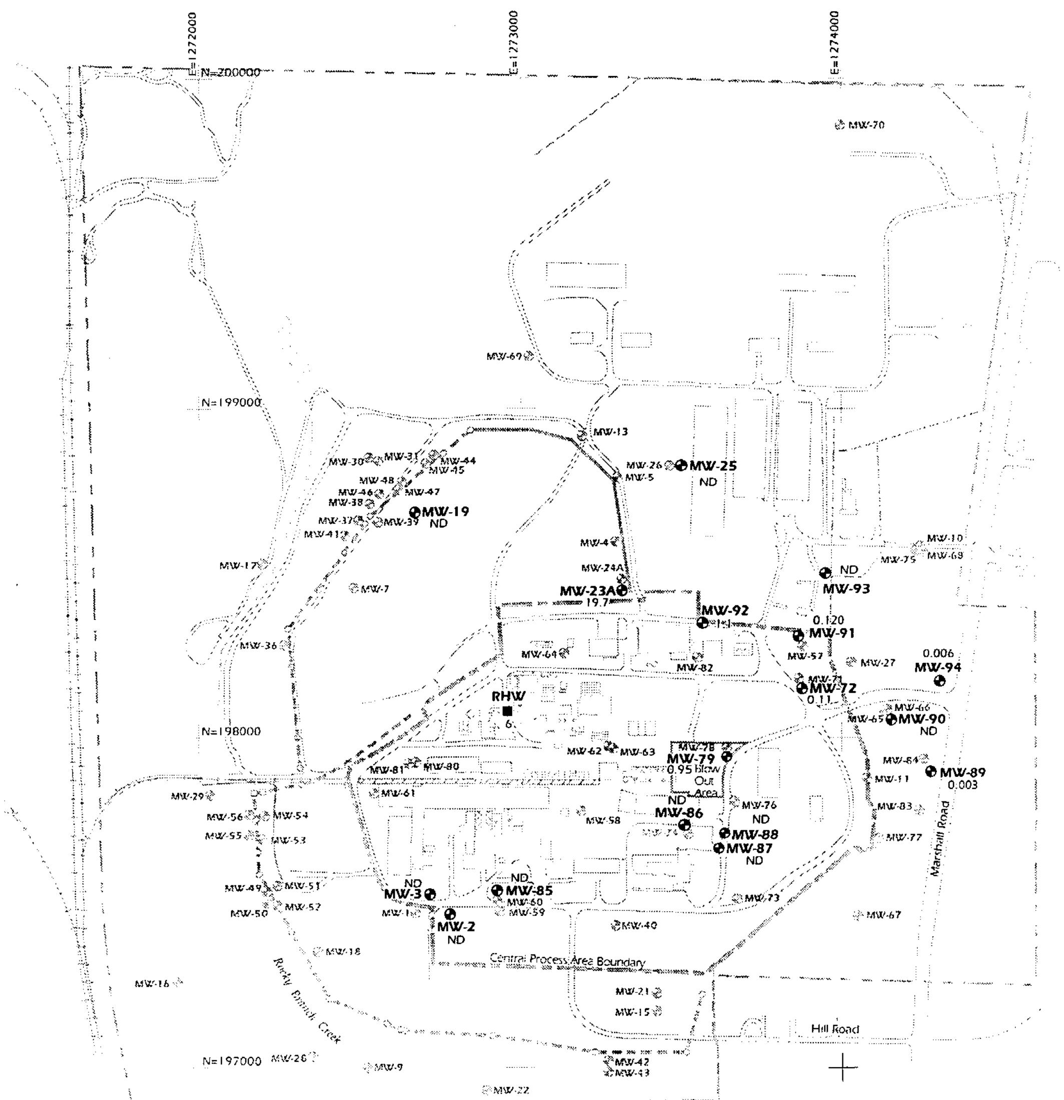
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-19

2,4–DICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 1 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

C00436



Legend

- MW-85 — Monitoring Well Completed in Fresh Bedrock
- RHW — Reasor-Hill Well
- Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
- 0.003 — Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.

- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch

N
W E
S

0 400 800 1200

Scale in Feet

Sampling Dates and Sources of Analytical Data:

1. Hercules Incorporated: (Phase I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

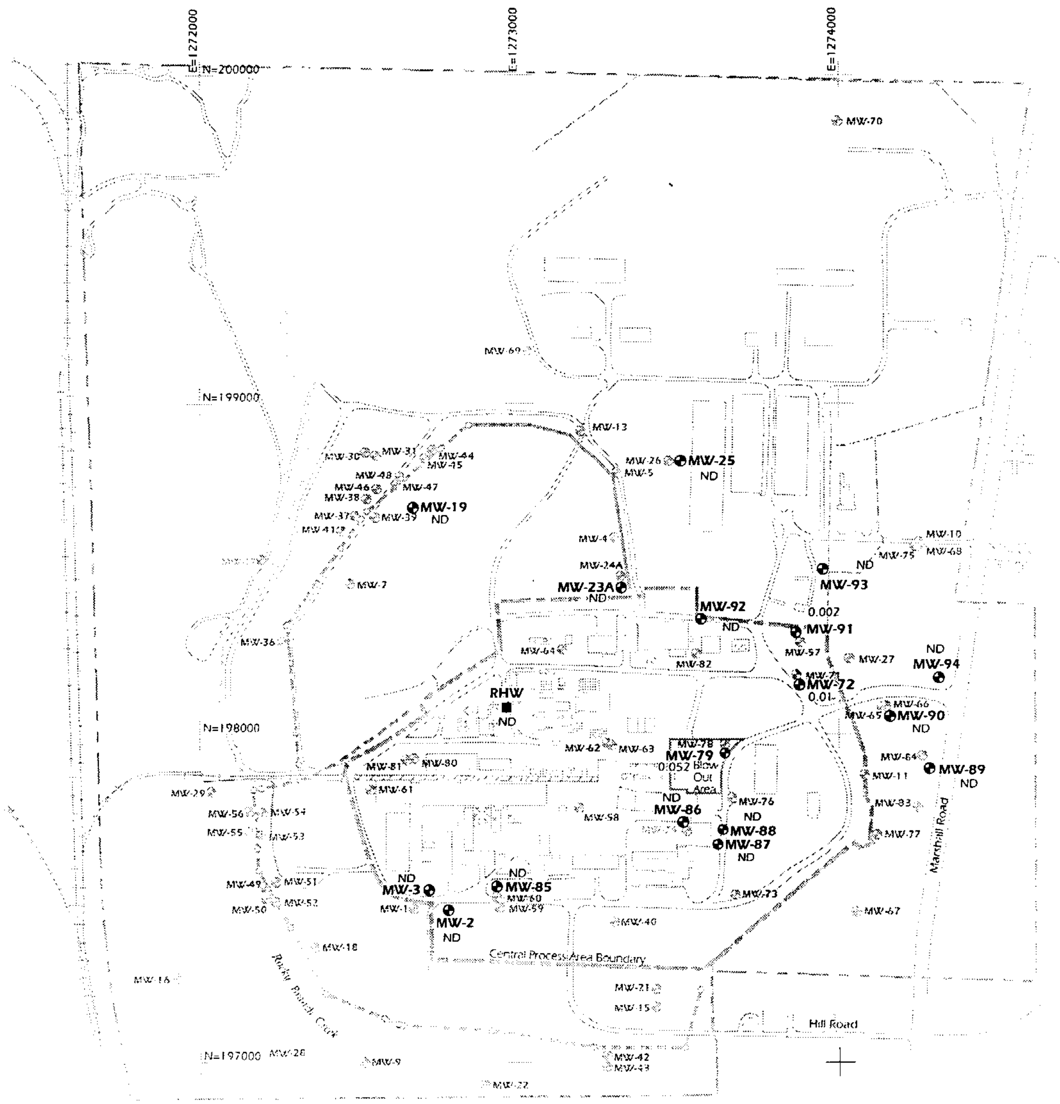
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-20
2, 6–DICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 1 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4145 7/19/94

C00437



Legend

MW-85 Monitoring Well Completed in Fresh Bedrock

RHW Reasor-Hill Well

Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

0.002 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

Sampling Dates and Sources of Analytical Data:

1. Hercules Incorporated: (Phase I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

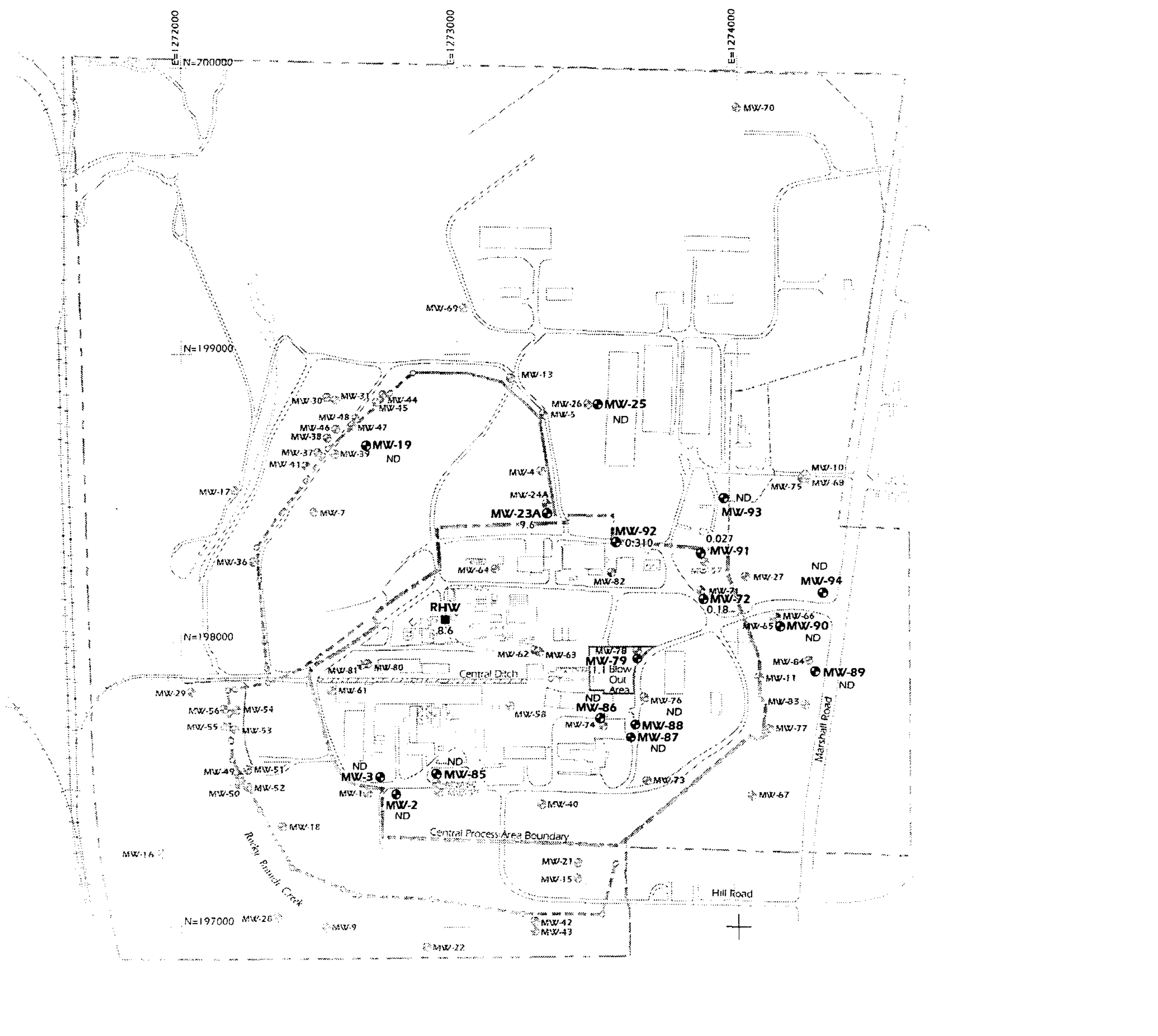
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-21
2,3,6–TRICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 1 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4146 7/19/94

00438



Legend

MW-85 Monitoring Well Completed in Fresh Bedrock

RHW Reasor-Hill Well

Monitoring Well Completed in Unconsolidated Sediments or *Atoka Formation*

0.027 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N W E S

0 400 800 1200

Scale in Feet

Sampling Dates and Sources of Analytical Data:

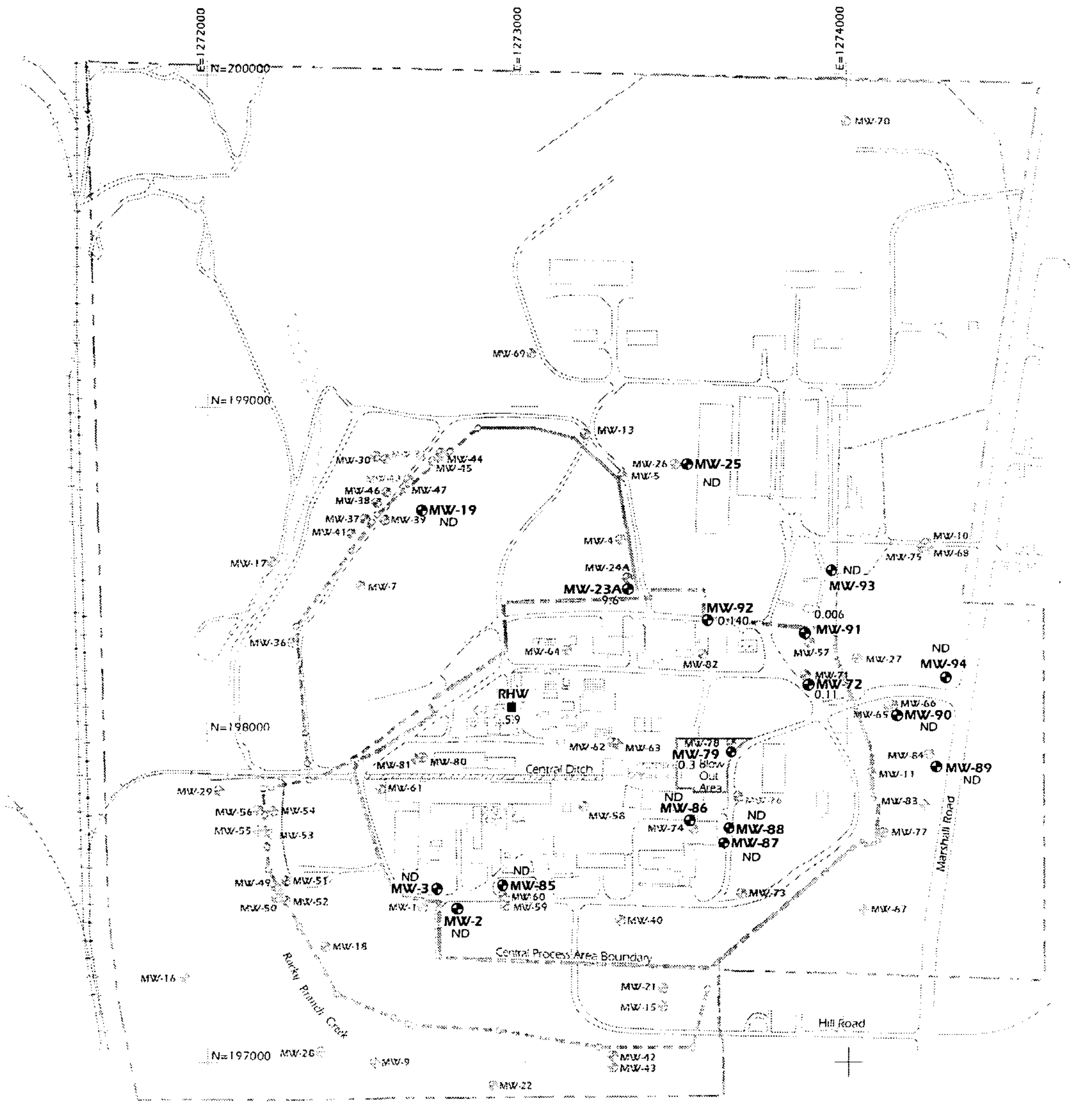
1. Hercules Incorporated: (Phase I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: *Arkansas Coordinate System, North Zone (NAD 1983).*

FIGURE 3-22
2, 4, 5–TRICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 1 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

000439



Legend

MW-85	Monitoring Well Completed in Fresh Bedrock
RHW	Reasor-Hill Well
	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
0.006	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)
	Analytical Data Qualifiers: ND - Not Detected at Sample Quantitation Limit.
	French Drain
	Slurry Wall
	Fence Line
	Property Boundary
	Central Process Area Boundary
	Central Ditch

N
W
E
S

0 400 800 1200

Scale in Feet

Sampling Dates and Sources of Analytical Data:

1.	Hercules Incorporated: (Phase I RI, Appendix B)	Wells 2, 3 - 10 October 1989 Well 19 - 3 April 1989 Well 23A - 13 October 1989 Well 25 - 11 October 1989
2.	WESTON RI Data: (Phase I RI, Appendix R)	Wells 72, 79 - 14 November 1990 Reasor-Hill Well - 16 November 1990
3.	WESTON Phase II RI Data: (Phase II RI, Appendix G)	Wells 85 through 94 - 14 December 1991 through 5 February 1992

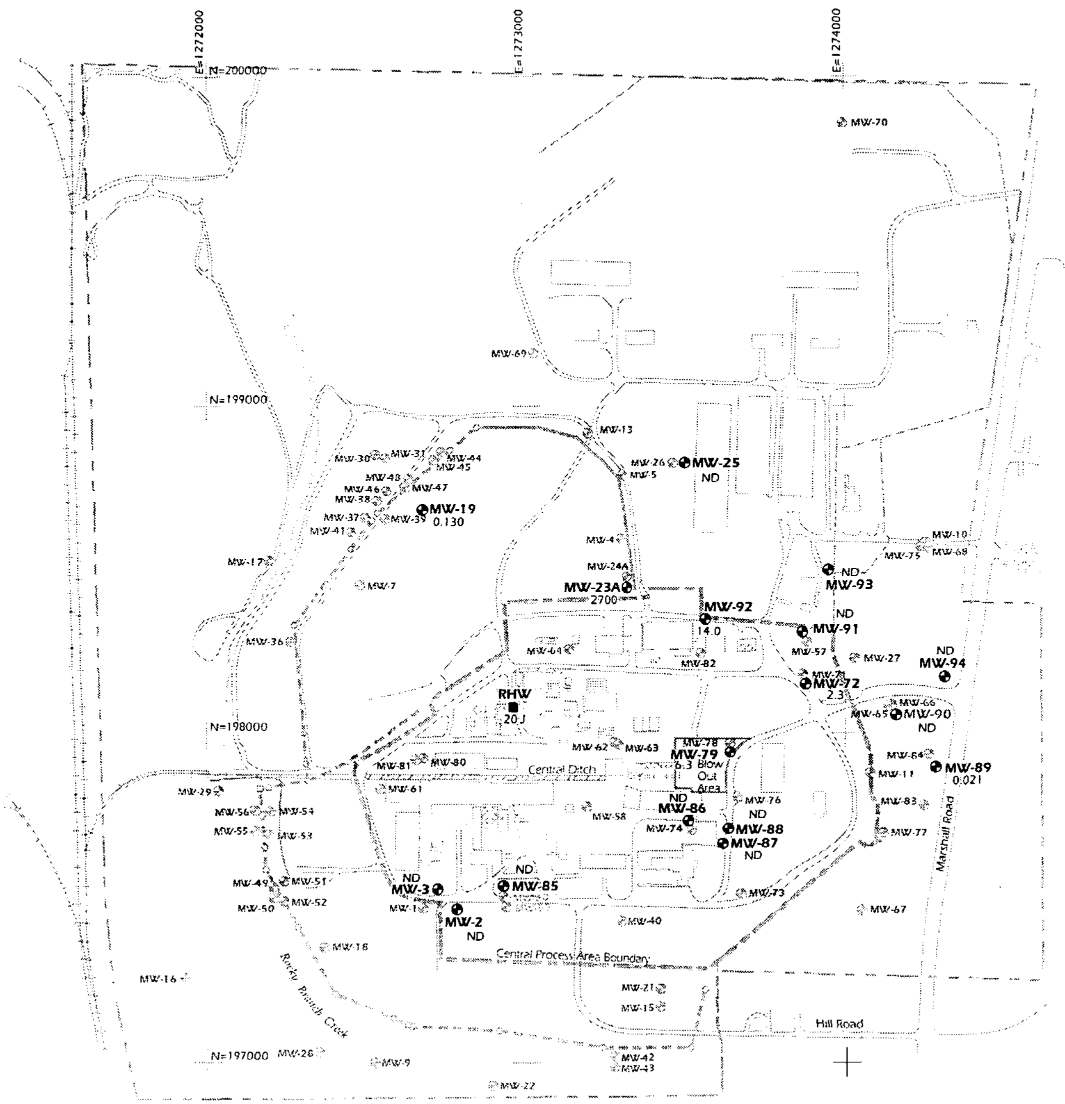
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-23
2, 4, 6–TRICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 1 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4148 7/19/94

000440



Legend

MW-85 Monitoring Well Completed in Fresh Bedrock

RHW Reasor-Hill Well

Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

0.021 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
J - Quantitation Estimated Below Sample Quantitation Limit.
ND - Not Detected at Sample Quantitation Limit.

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:

1. Hercules Incorporated: (Phase I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

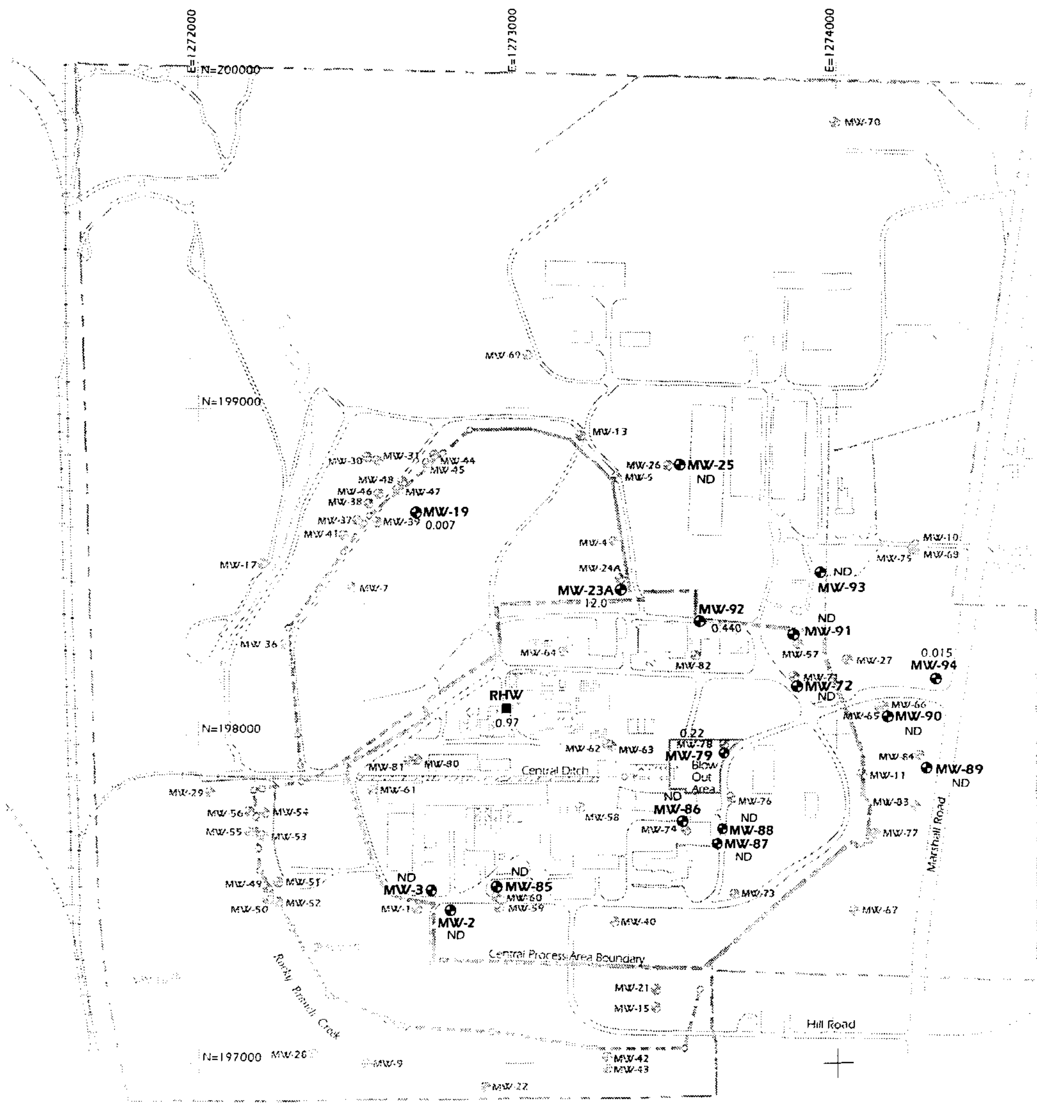
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-24
2,4–D
GROUNDWATER QUALITY MAP
SAMPLING ROUND 1
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

94P-4149 7/19/94

c00441



Legend

MW-85	Monitoring Well Completed in Fresh Bedrock
RHW	Reasor-Hill Well
	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
0.007	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)
	Analytical Data Qualifiers: ND - Not Detected at Sample Quantitation Limit.
	French Drain
	Slurry Wall
	Fence Line
	Property Boundary
	Central Process Area Boundary
	Central Ditch

N W E S

0 400 800 1200

Scale in Feet

Sampling Dates and Sources of Analytical Data:

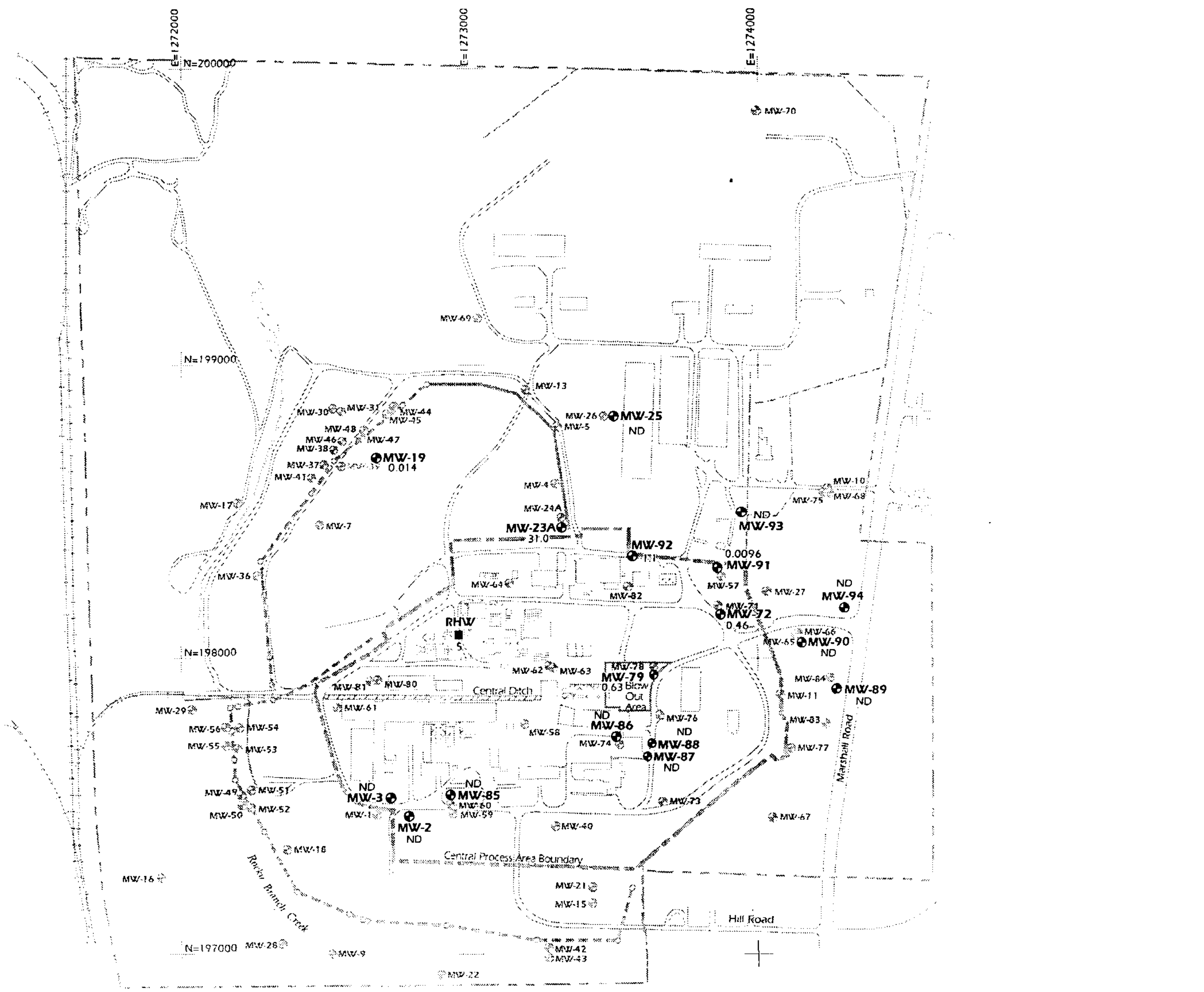
1. Hercules Incorporated: (Phase I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data. (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-25
SILVEX
GROUNDWATER QUALITY MAP
SAMPLING ROUND 1
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

94P-4150 7/19/94



Legend

MW-85	Monitoring Well Completed in Fresh Bedrock
■ RHW	Reasor-Hill Well
	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
0.096	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)
	Analytical Data Qualifiers: ND - Not Detected at Sample Quantitation Limit.
	French Drain
	Slurry Wall
	Fence Line
	Property Boundary
	Central Process Area Boundary
	Central Ditch

N
W E
S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:

1. Hercules Incorporated: (Phase I RI, Appendix B)	Wells 2, 3 - 10 October 1989 Well 19 - 3 April 1989 Well 23A - 13 October1989 Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R)	Wells 72, 79 - 14 November 1990 Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G)	Wells 85 through 94 - 14 December 1991 through 5 February 1992

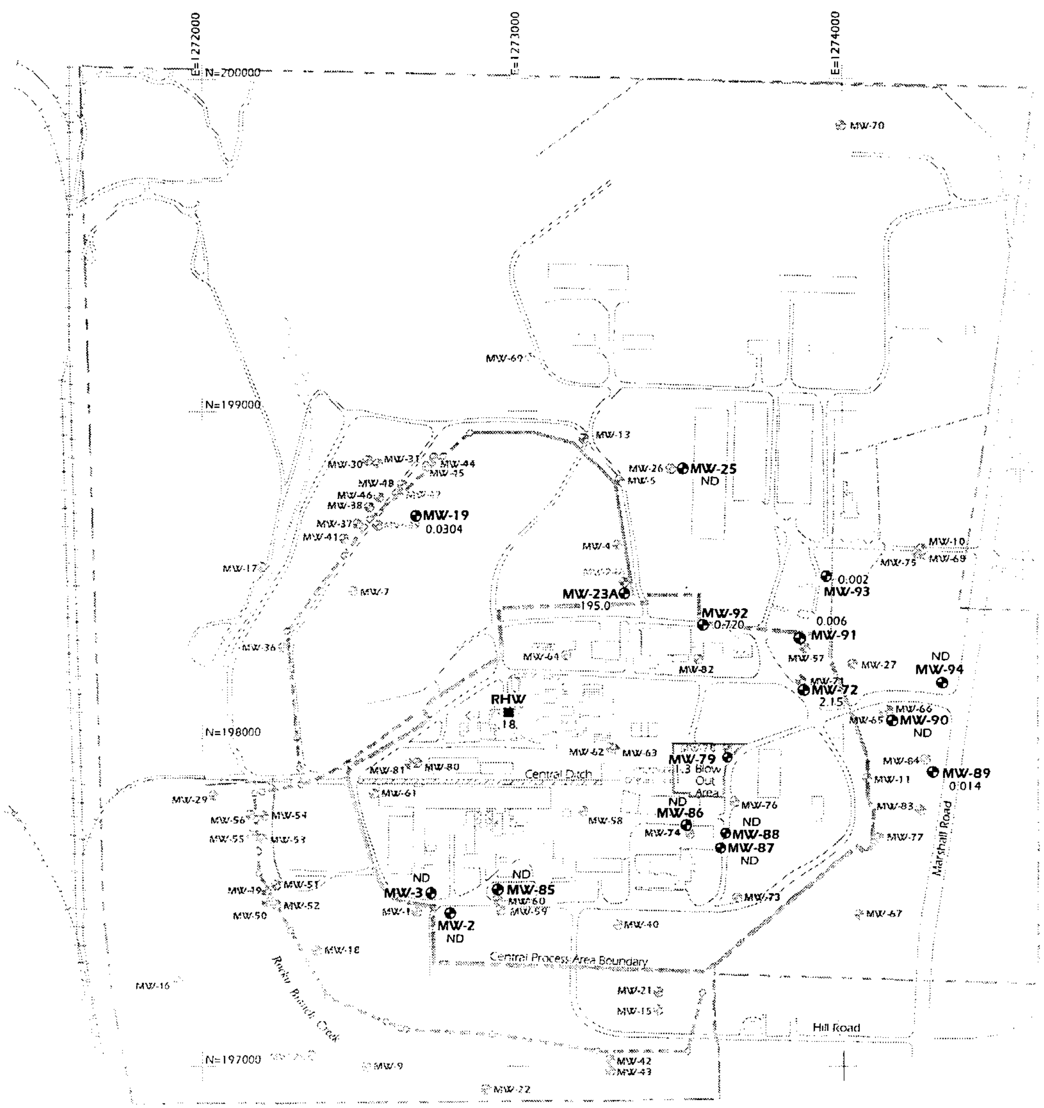
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-26
2,4,5–T
GROUNDWATER QUALITY MAP
SAMPLING ROUND 1
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

94P-4151 7/19/94

00443



Legend

MW-85 Monitoring Well Completed in Fresh Bedrock

RHW Reasor-Hill Well

Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

0.002 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800 1200

Scale in Feet

Sampling Dates and Sources of Analytical Data:

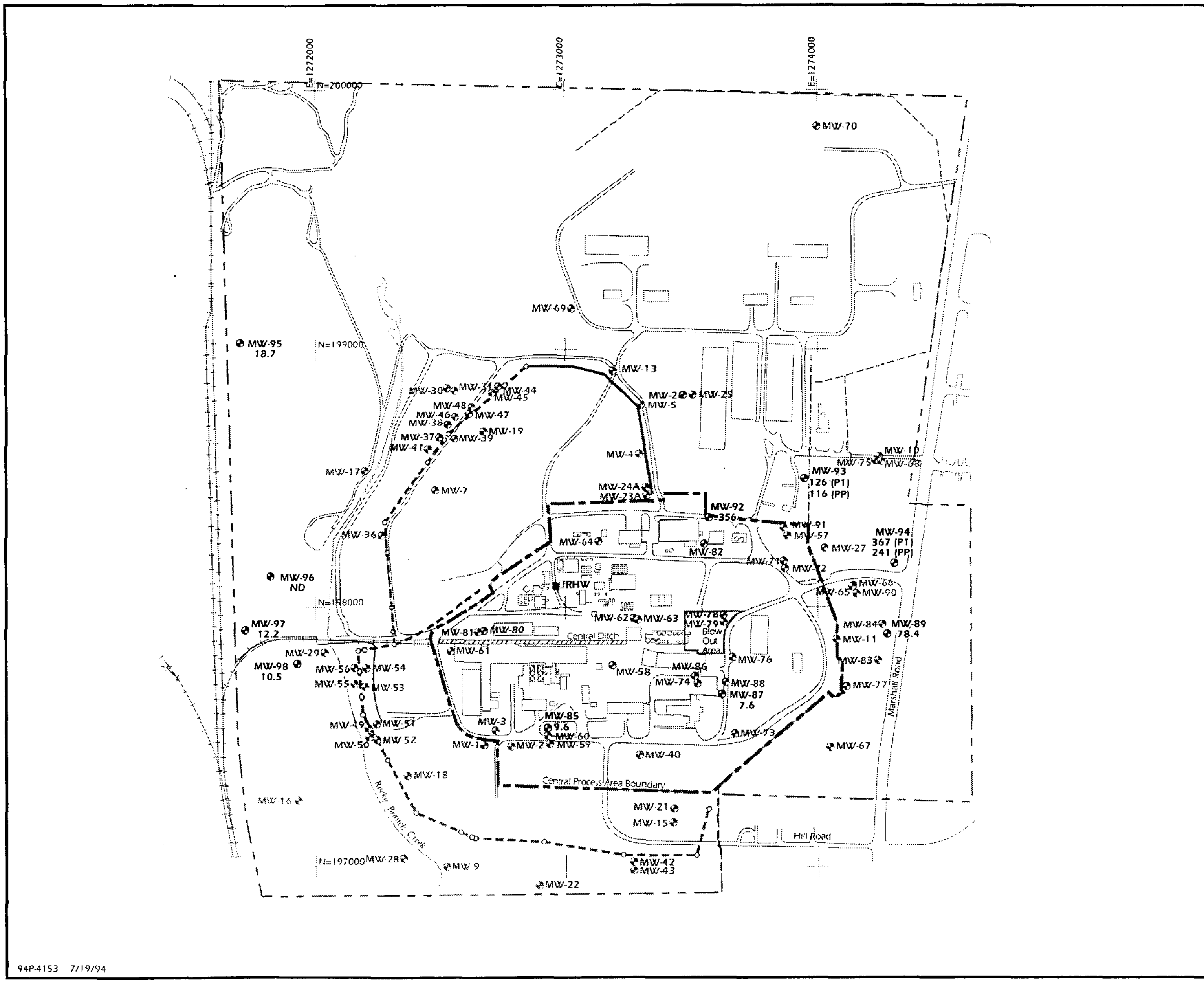
1. Hercules Incorporated: (Phase I RI, Appendix B) — Wells 2, 3 - 10 October 1989; Well 19 - 3 April 1989; Well 23A - 13 October 1989; Well 25 - 11 October 1989
2. WESTON RI Data: (Phase I RI, Appendix R) — Wells 72, 79 - 14 November 1990; Reasor-Hill Well - 16 November 1990
3. WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85 through 94 - 14 December 1991 through 5 February 1992

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-27
TOLUENE
GROUNDWATER QUALITY MAP
SAMPLING ROUND 1
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

94P-4152 7/19/94



Legend

MW-98 Monitoring Well Completed in Fresh Bedrock

RHW Reasor-Hill Well

MW-84 Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

10.5 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

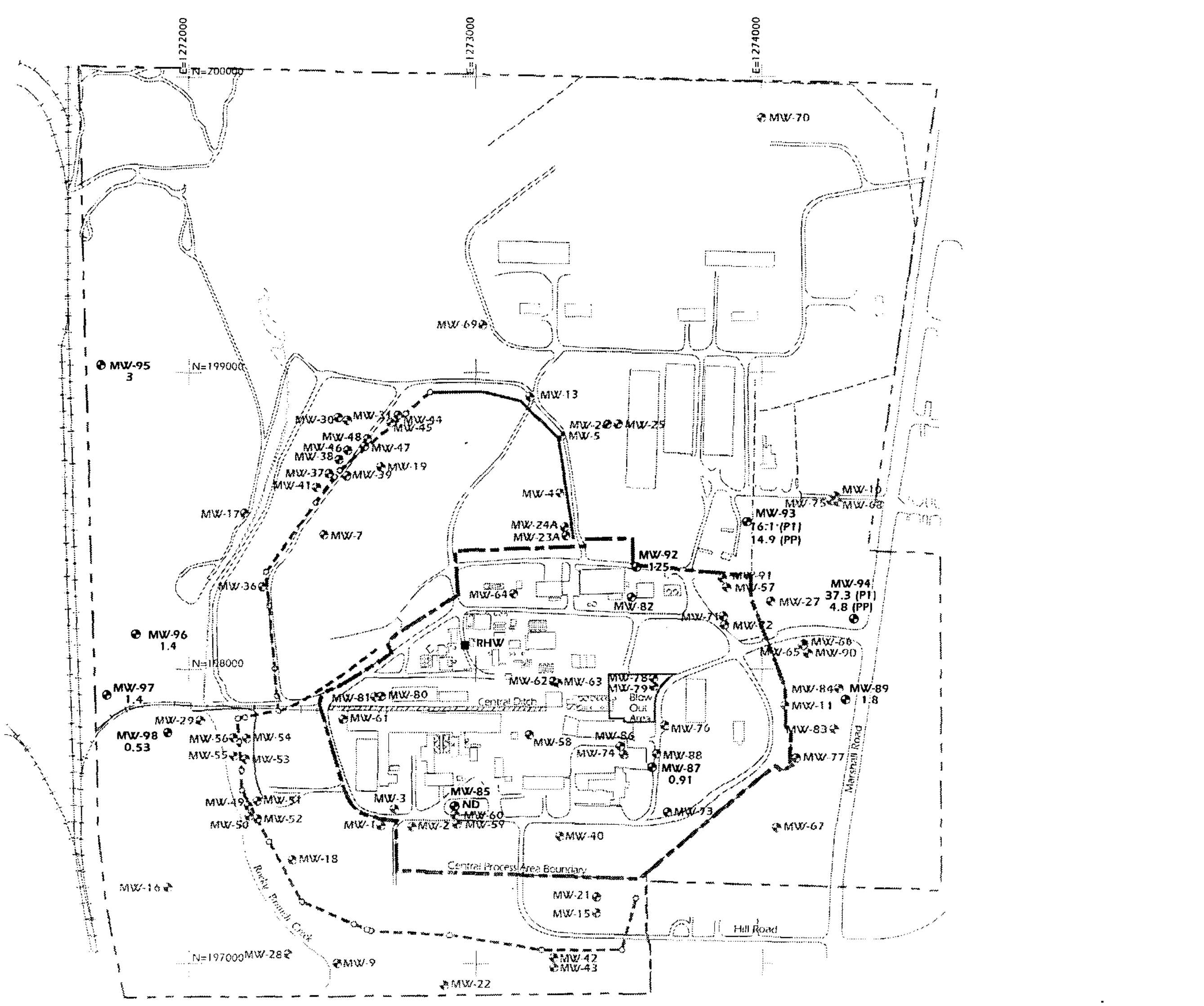
0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: (Phase II RI, Appendix G) *Wells 85, 87, 89, 92 through 98* - 21, 22 May 1993

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: *Arkansas Coordinate System, North Zone (NAD 1983).*

FIGURE 3-28
CHLORIDE
GROUNDWATER QUALITY MAP
SAMPLING ROUND 2
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR



Legend

MW-98 Monitoring Well Completed in Fresh Bedrock

RHW Reasor-Hill Well

MW-84 Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

0.53 Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800 1200
Scale in Feet

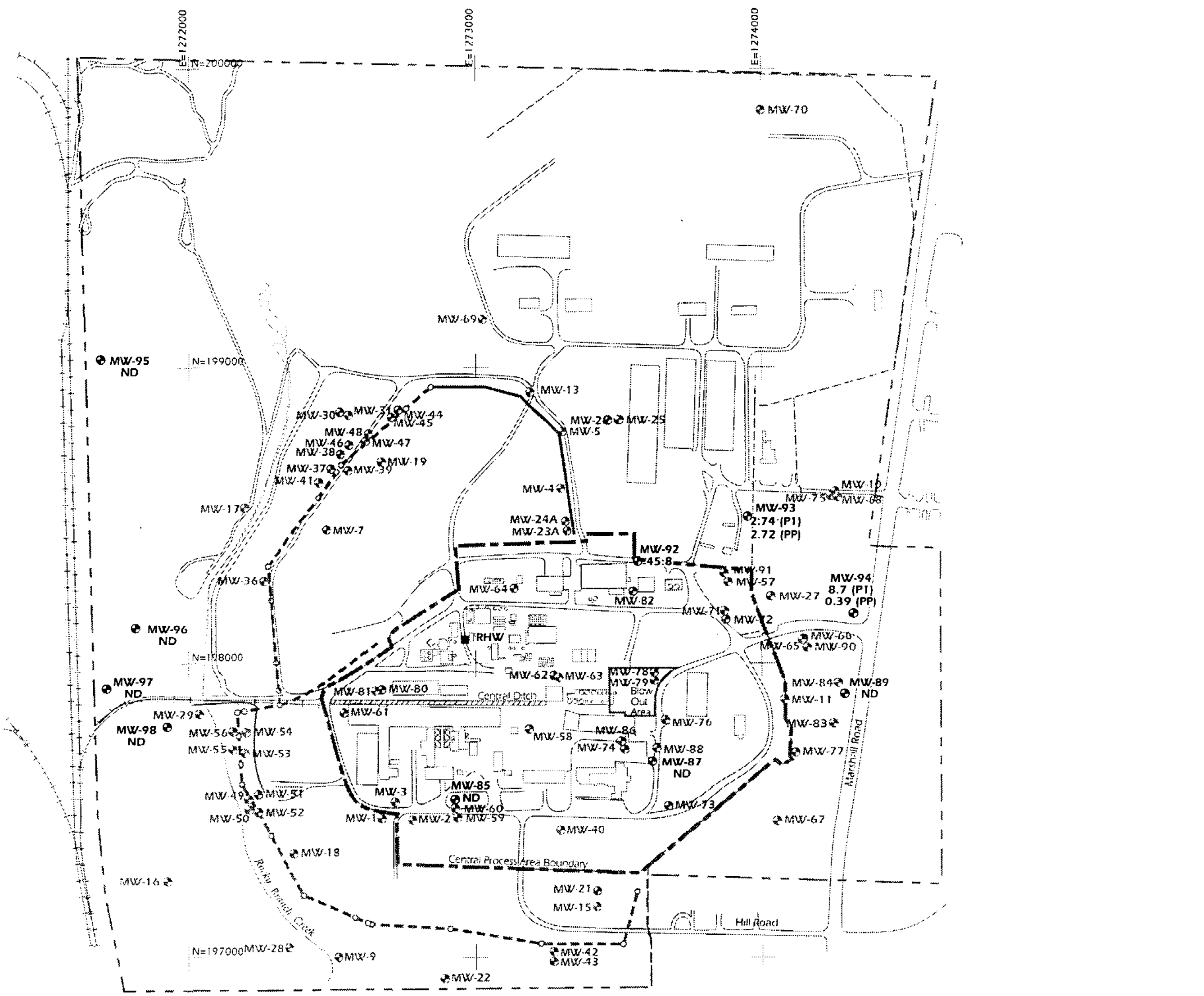
Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: (Phase II RI, Appendix G) Wells 85, 87, 89, 92 through 98 – 21, 22 May 1993

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-29
TOTAL ORGANIC CARBON GROUNDWATER QUALITY MAP SAMPLING ROUND 2 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

00446



Legend

MW-98	Monitoring Well Completed in Fresh Bedrock
RHW	Reasor-Hill Well
MW-54	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
45.8	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: (Phase II RI, Appendix G) Wells 85, 87, 89, 92 through 98 – 21, 22 May 1993

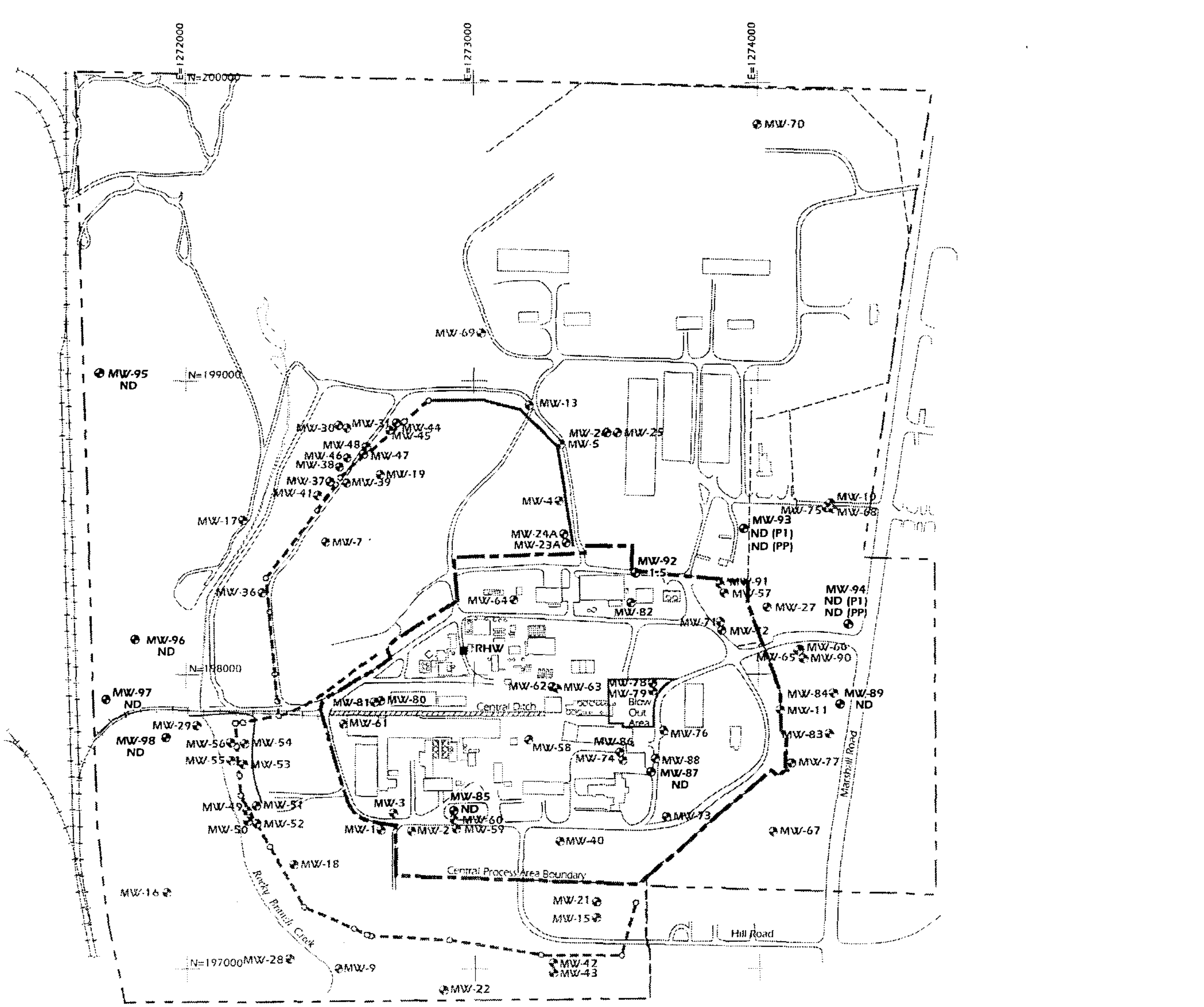
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-30
TOTAL MONOCHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 2 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4155 7/19/94

00447



Legend

- MW-98 — Monitoring Well Completed in Fresh Bedrock
- RHW — Reasor-Hill Well
- MW-84 — Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
- 1.5 — *Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)*

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

- French Drain
- Slurry Wall
- Fence Line
- *Property Boundary*
- Central Process Area Boundary
- Central Ditch

N
W — E
S

0 400 800 1200

Scale in Feet

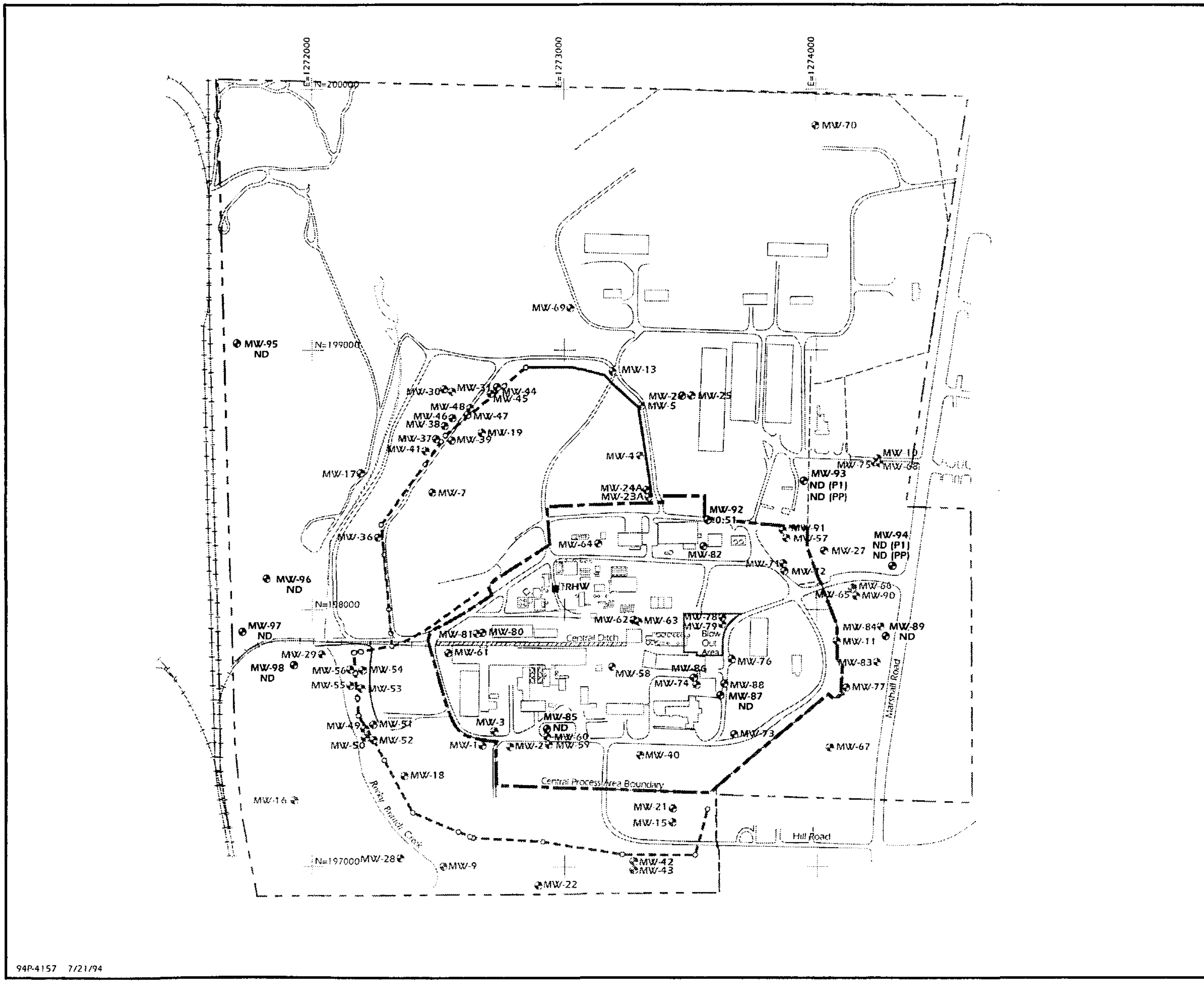
Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: - *Wells 85, 87, 89, 92 through 98*
(Phase II RI, Appendix G) - 21, 22 May 1993

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, *North Zone (NAD 1983).*

FIGURE 3-31
2,4-DICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 2 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4156 7/19/94



Legend

- MW-98 — Monitoring Well Completed in Fresh Bedrock
- RHW — Reasor Hill Well
- MW-84 — Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
- 0.95 — Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch

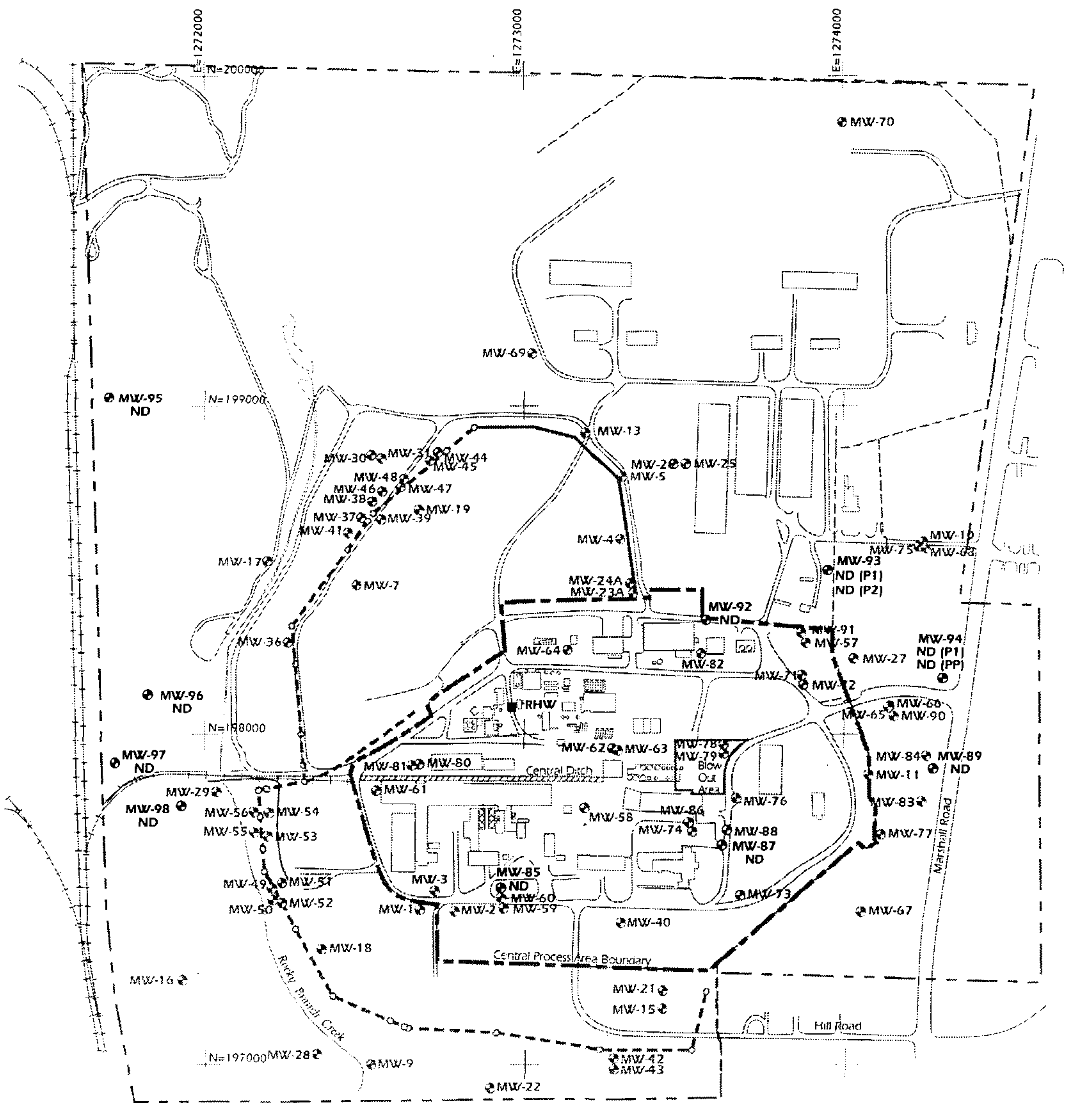
N
W
E
S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: (Phase II RI, Appendix G) — Wells 85, 87, 89, 92 through 98 – 21, 22 May 1993

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.
Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-32
2,6-DICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 2 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR



Legend

MW-98	Monitoring Well Completed in Fresh Bedrock
RHW	Reasor-Hill Well
MW-84	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
0.95	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N
W E
S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: Wells 85, 87, 89, 92 through 98
(Phase II RI, Appendix G) – 21, 22 May 1993

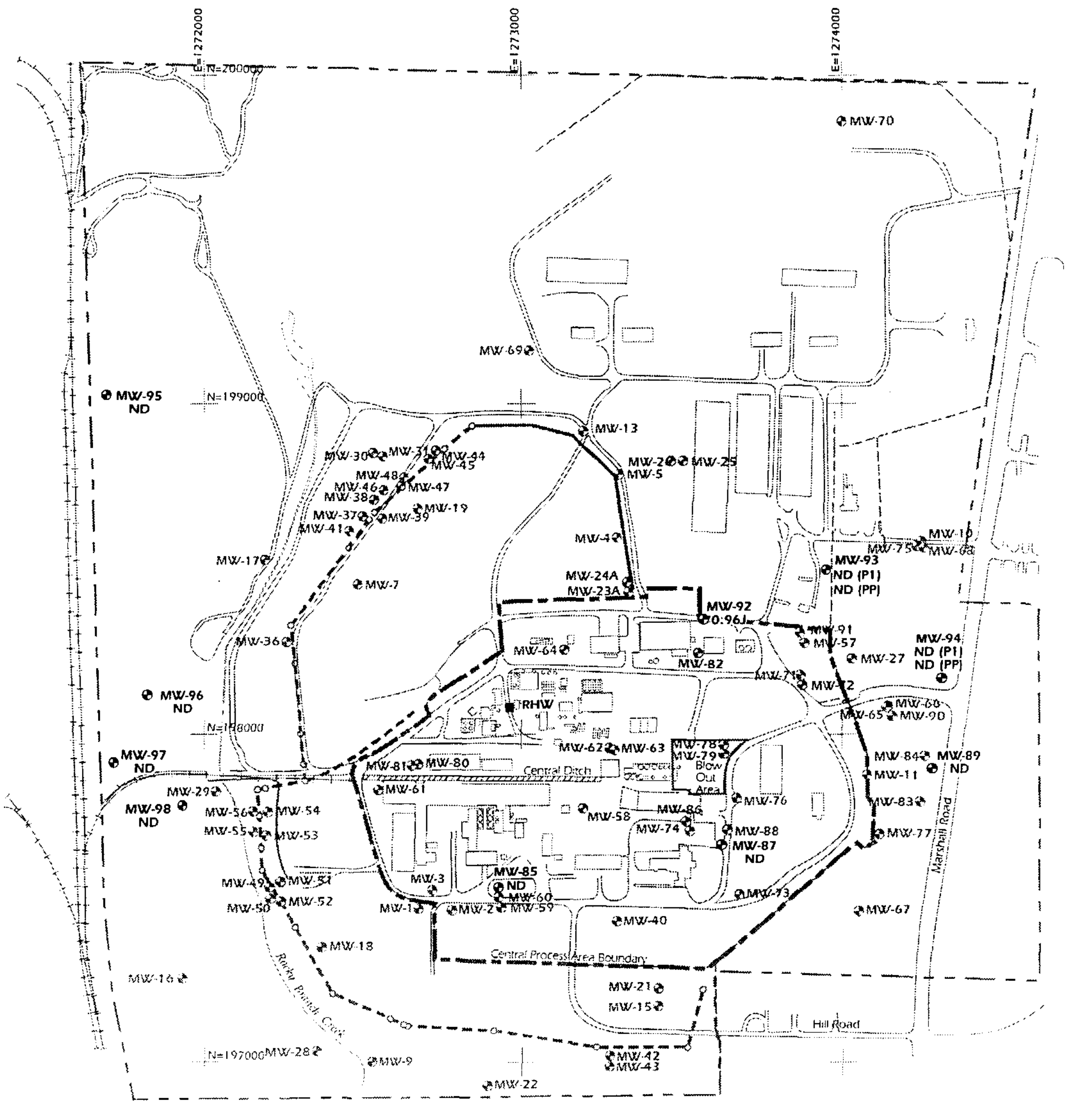
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-33
2,3, 6-TRICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 2 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4158 7/21/94

000450



Legend

- MW-98 — Monitoring Well Completed in Fresh Bedrock
- RHW — Reasor-Hill Well
- MW-84 — Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
- 0.96J — Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
J - Quantitation Estimated Below Sample Quantitation Limit.
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: Wells 85, 87, 89, 92 through 98
(Phase II RI, Appendix G) - 21, 22 May 1993

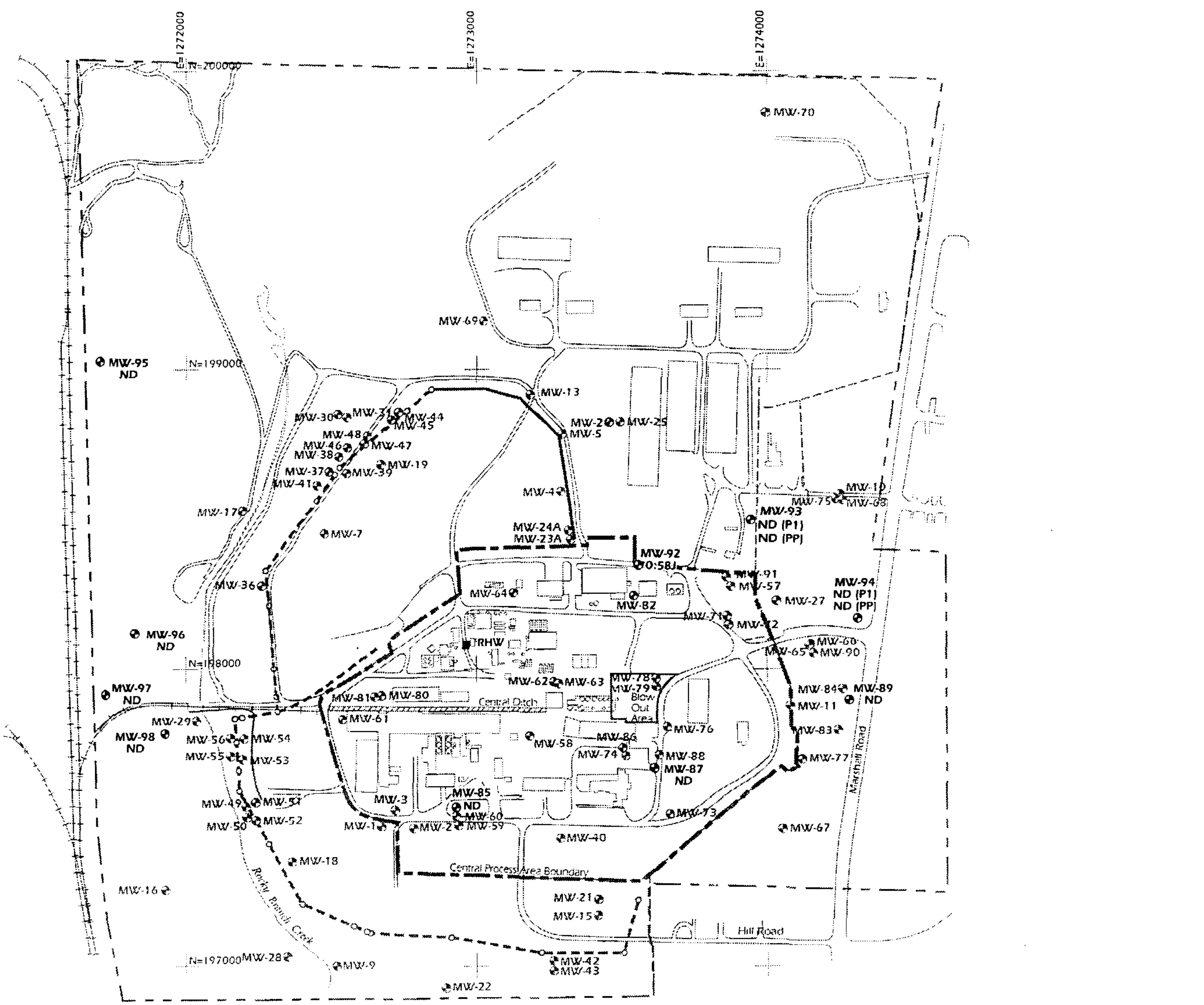
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-34
2,4,5-TRICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 2 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4159 7/21/94

°00451



Legend

MW-98 Monitoring Well Completed in Fresh Bedrock

RHW Reasor Hill Well

MW-84 Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation

0.58J Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
J - Quantitation Estimated Below Sample Quantitation Limit.
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N W E S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: (Phase II RI, Appendix G) Wells 85, 87, 89, 92 through 98 - 21, 22 May 1993

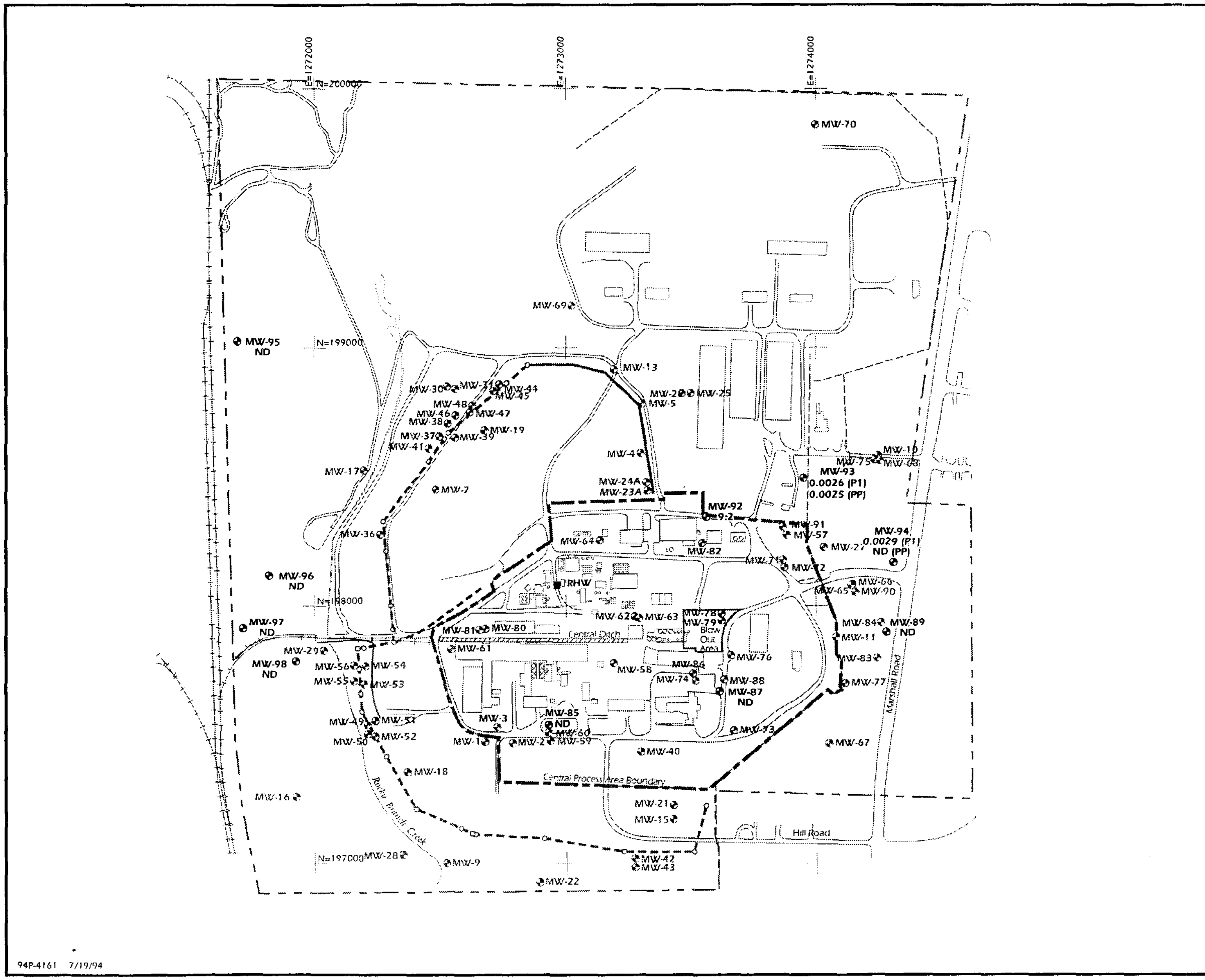
Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-35
2,4,6-TRICHLOROPHENOL GROUNDWATER QUALITY MAP SAMPLING ROUND 2 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4160 7/21/94

000452



Legend

MW-98	Monitoring Well Completed in Fresh Bedrock
RHW	Reasor-Hill Well
MW-84	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
9.2	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch

N, W, E, S

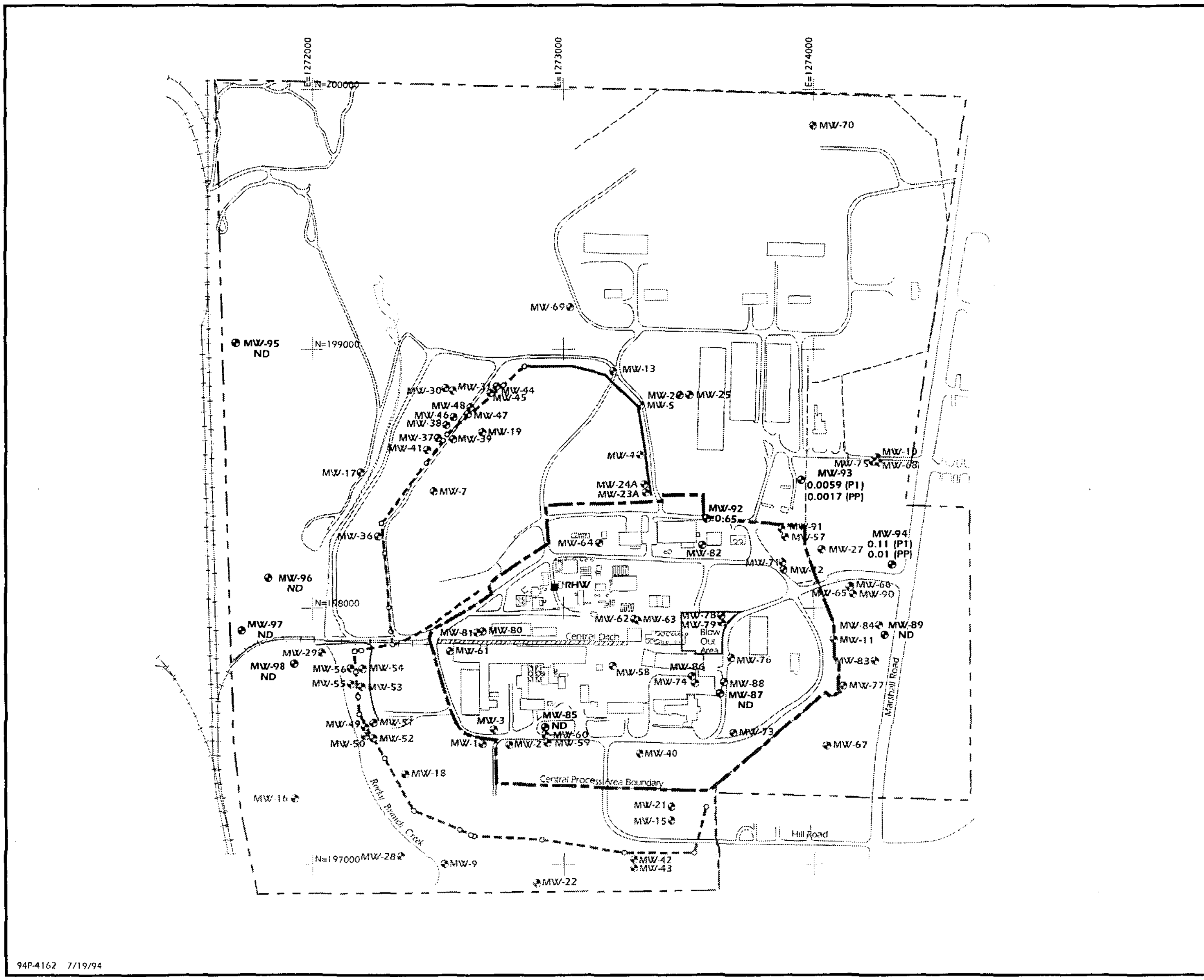
0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: (Phase II RI, Appendix G) Wells 85, 87, 89, 92 through 98 - 21, 22 May 1993

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.
Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-36
2,4-D
GROUNDWATER QUALITY MAP
SAMPLING ROUND 2
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

00453



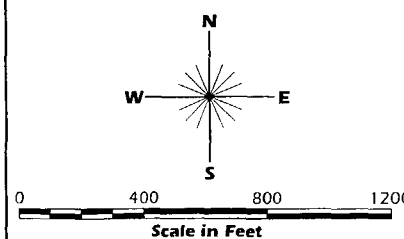
94P-4162 7/19/94

Legend

MW-98	Monitoring Well Completed in Fresh Bedrock
RHW	Reasor-Hill Well
MW-64	Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
0.65	Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

French Drain
Slurry Wall
Fence Line
Property Boundary
Central Process Area Boundary
Central Ditch



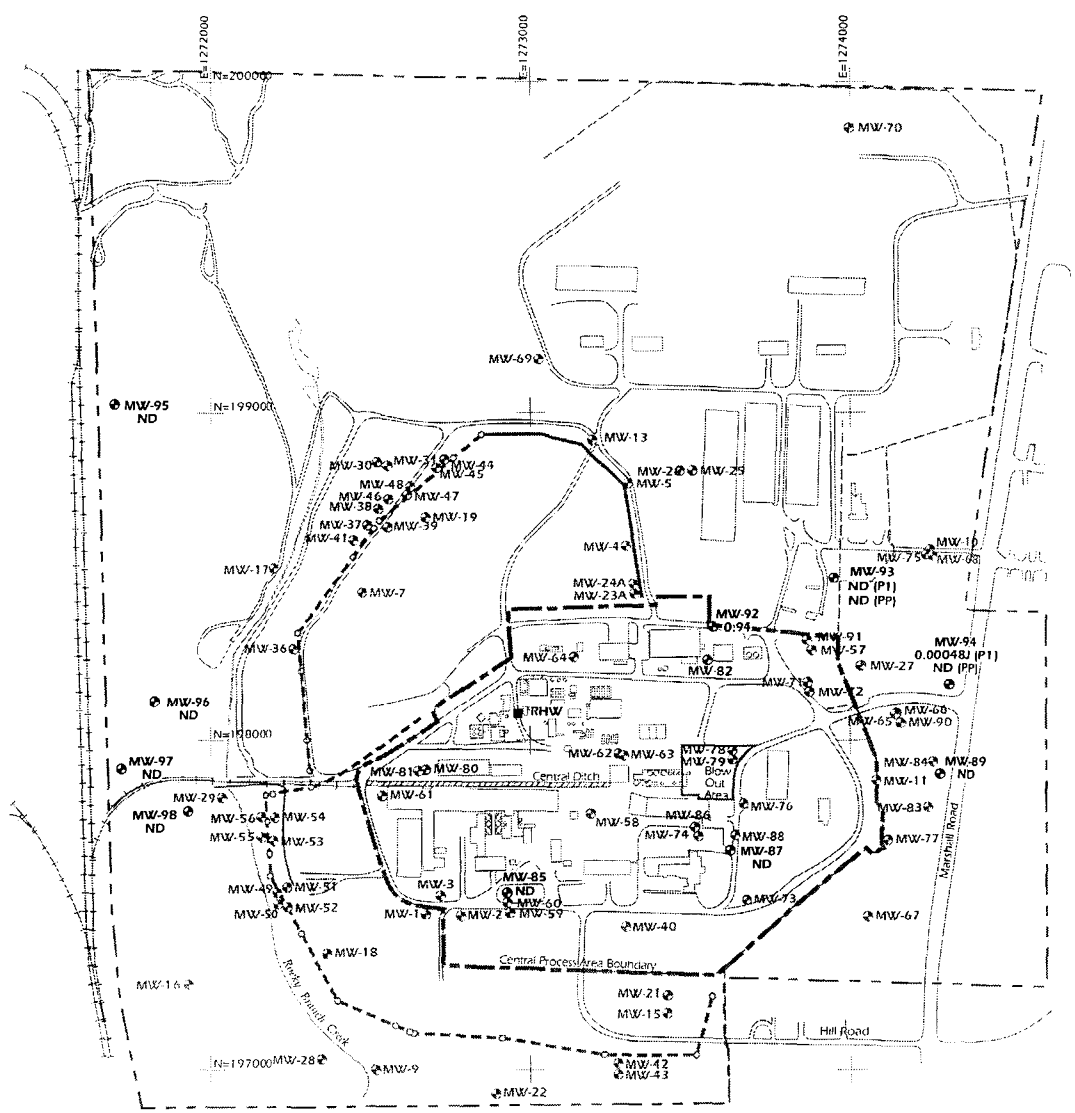
Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: Wells 85, 87, 89, 92 through 98
(Phase II RI, Appendix G) - 21, 22 May 1993

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-37
SILVEX
GROUNDWATER QUALITY MAP
SAMPLING ROUND 2
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

000454

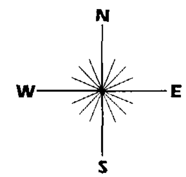


Legend

- MW-98 — Monitoring Well Completed in Fresh Bedrock
- RHW — Reasor-Hill Well
- MW-84 — Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
- 0.94 — *Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)*

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging *One Well Volume*

- French Drain
- Slurry Wall
- Fence Line
- *Property Boundary*
- Central Process Area Boundary
- Central Ditch



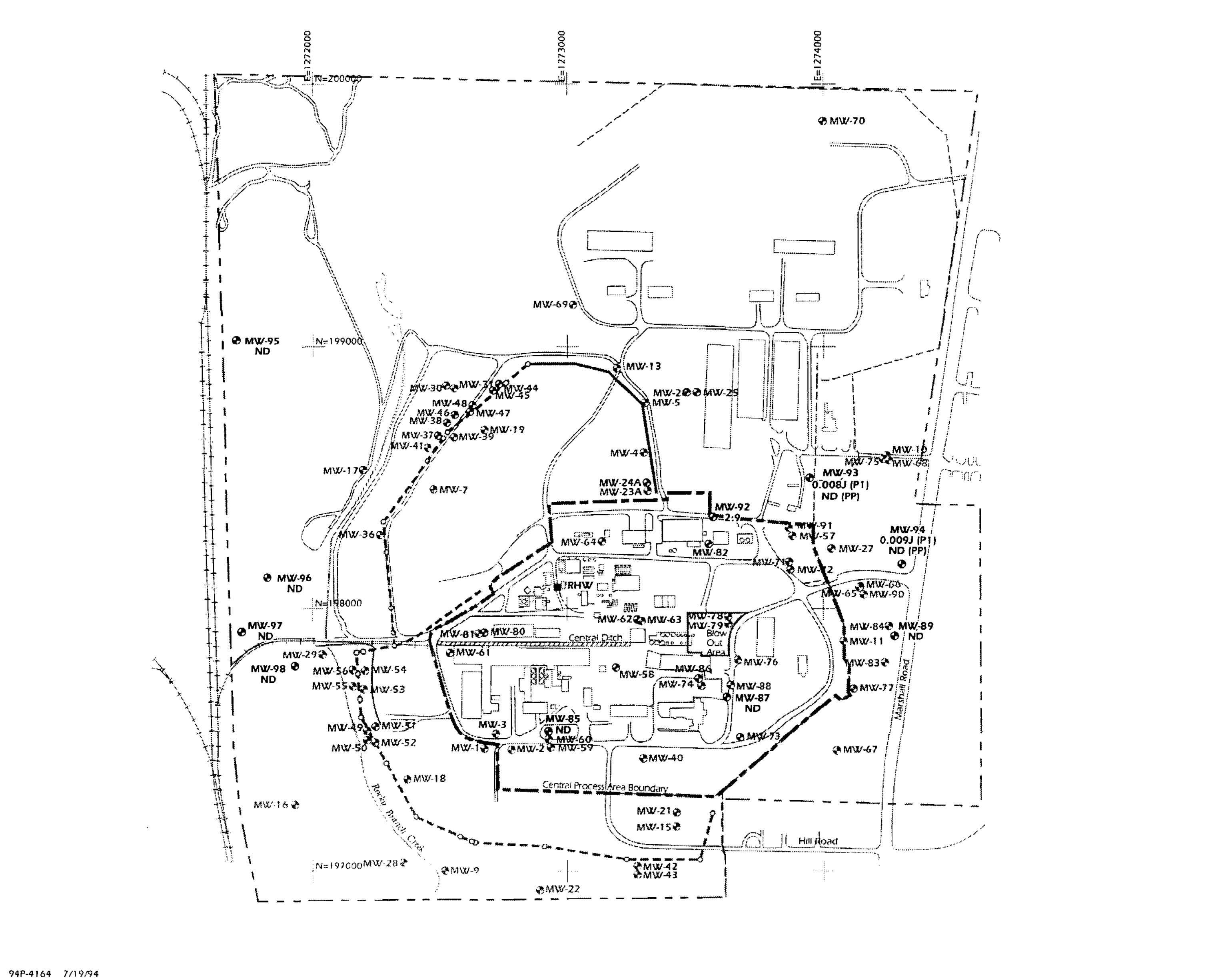
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: Wells 85, 87, 89, 92 through 98
(Phase II RI, Appendix G) - 21, 22 May 1993

Source: *Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.*
Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-38
2,4,5-T
GROUNDWATER QUALITY MAP
SAMPLING ROUND 2
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

00455



Legend

- MW-98 — Monitoring Well Completed in Fresh Bedrock
- RHW — Reasor-Hill Well
- MW-84 — Monitoring Well Completed in Unconsolidated Sediments or Atoka Formation
- 2.9 — Reported Sample Concentration in Milligrams Per Liter (mg/L) or Parts Per Million (ppm)

Analytical Data Qualifiers:
ND - Not Detected at Sample Quantitation Limit.
PP - Sample Collected Prior to Purging the Well
P1 - Sample Collected After Purging One Well Volume

- French Drain
- Slurry Wall
- Fence Line
- Property Boundary
- Central Process Area Boundary
- Central Ditch

N
W E
S

0 400 800 1200
Scale in Feet

Sampling Dates and Sources of Analytical Data:
WESTON Phase II RI Data: (Phase II RI, Appendix G) Wells 85, 87, 89, 92 through 98 - 21, 22 May 1993

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.
Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 3-39
TOLUENE
GROUNDWATER QUALITY MAP
SAMPLING ROUND 2
ATOKA FORMATION
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

3.8 ppb, a concentration lower than the initial Phase II RI sample concentration (15 ppb, 3 February 1992, Table 3-13). In June 1994, a fourth set of samples was collected from MW-94 to assess the concentration of silvex and the presence of chlorophenols. The results of the fourth set of samples show that the concentration of silvex was about 4.9 ppb. Analysis for chlorophenols indicated that 2-chlorophenol (10 ppb), 4-chlorophenol (120 ppb), and 2-6-dichlorophenol (3 ppb) were present but at lower concentrations than the initial Phase II RI groundwater sampling round (3 February 1992, Table 3-13).

Site-related compounds were not found in any of the monitoring wells west of Rocky Branch Creek. Absence of contaminants in the fresh bedrock monitoring wells west of Rocky Branch Creek is consistent with the eastward horizontal groundwater flow (Figure 3-10 and Subsection 3.3.4.2.2). The eastward groundwater flow acts as a barrier and prevents migration of contaminants to the west of Rocky Branch Creek.

A comparison of the concentrations of organic compounds and chloride ion in shallow and deep wells in well clusters for sampling round 1 is shown in Table 3-14. The comparison indicates that generally the concentrations of organic compounds and chloride decrease between the shallow and deep wells. This generalization is based on a comparison of 153 analytical results for paired wells (i.e., 12 paired wells and 13 analytes minus three wells where tetrachlorobenzene was not analyzed in one of the wells). Of the 153 pairs of analytical results, 131 pairs showed higher concentrations of analytes in the shallower of the paired wells and only 22 pairs show higher concentrations in the deeper of the paired wells for any analyte. The exceptions to the generally lower concentrations at depth are listed below:

Chloride	-	MW-59/MW-60, MW-57/MW-91, MW-84/MW-89
Toluene	-	MW-65/MW-66, MW-84/MW-89
2-chlorophenol	-	MW-78/MW-79, MW-84/MW-89
4-chlorophenol	-	MW-57/MW-91
2,4-dichlorophenol	-	MW-57/MW-91
2,6-dichlorophenol	-	MW-57/MW-91, MW-78/MW-79,
	-	MW-84/MW-89
2,3,6-trichlorophenol	-	MW-78/MW-79
2,4,5-trichlorophenol	-	MW-57/MW-91, MW-78/MW-79
2,4,6-trichlorophenol	-	MW-57/MW-91, MW-78/MW-79
2,4-D	-	MW-84/MW-89

Table 3-14

Comparison of Concentration of Selected Compounds in Samples From Nested Wells Phase II Remedial Investigation Vertac Site, Jacksonville, Arkansas

Analyte Group/ Compound	Well Nest Shallower/Deeper	Shallow Well(a)	Intermediate Well(b)	Deep Well(c)
Chloride (mg/L)				
	MW-57/ MW-91		8.0	159.0
	MW-59/ MW-60/ MW-85	18.4	22.4	8.0
	MW-63/ MW-62	381	216	
	MW-65/ MW-66/ MW-90	39.4	14.3	8.0
	MW-68/ MW-75	8.6	5 U	
	MW-71/ MW-72		405	79.7
	MW-74/ MW-86	67.1		5.9
	MW-78/ MW-79		237	128
	MW-80/ MW-81		446	15.4
	MW-84/ MW-89		23.4	30.1
Toluene (mg/L)				
	MW-57/ MW-91		0.066	0.006
	MW-59/ MW-60/ MW-85	0.001 U	0.001 U	0.005 U
	MW-63/ MW-62	0.040	0.001 U	
	MW-65/ MW-66/ MW-90	0.001 U	0.0032	0.005 U
	MW-68/ MW-75	0.001 U	0.001 U	
	MW-71/ MW-72		440 J	2.1 J
	MW-74/ MW-86	0.0049		0.005 U
	MW-78/ MW-79		19 J	1.3 J
	MW-80/ MW-81	160	0.001 UJ	
	MW-84/ MW-89		0.001 U	0.014
Chlorophenols				
2-Chlorophenol (mg/L)				
	MW-57/ MW-91		ND	0.470
	MW-59/ MW-60/ MW-85	0.014 U	0.011 U	0.011 U
	MW-63/ MW-62	0.021	0.010 U	
	MW-65/ MW-66/ MW-90	0.010 U	0.010 U	0.011 U
	MW-68/ MW-75	0.010 U	0.010 U	
	MW-71/ MW-72		16	0.068
	MW-74/ MW-86	0.010 R		0.011 U
	MW-78/ MW-79		0.280	0.600
	MW-80/ MW-81	0.590	0.012 R	
	MW-84/ MW-89		0.012 U	0.003 J

Table 3-14 (Continued)

Analyte Group/ Compound	Well Nest Shallower-Deeper	Shallow Well(a)	Intermediate Well(b)	Deep Well(c)
4-Chlorophenol (mg/L)				
	MW-57/ MW-91		0.0020	0.940
	MW-59/ MW-60/ MW-85	0.014 U	0.011 U	0.011 U
	MW-63/ MW-62	0.010 U	0.010 U	
	MW-65/ MW-66/ MW-90	0.010 U	0.010 U	0.011 U
	MW-68/ MW-75	0.010 U	0.010 U	
	MW-71/ MW-72		15	0.120
	MW-74/ MW-86	0.010 R		0.011 U
	MW-78/ MW-79		0.830	0.160 J
	MW-80/ MW-81	7.5	0.012 R	
	MW-84/ MW-89		0.012 U	0.010 U
Dichlorophenols				
2,4-Dichlorophenol (mg/L)				
	MW-57/ MW-91		0.0012	0.130
	MW-59/ MW-60/ MW-85	0.014 U	0.011 U	0.011 U
	MW-63/ MW-62	0.020	0.010 U	
	MW-65/ MW-66/ MW-90	0.010 U	0.010 U	0.011 U
	MW-68/ MW-75	0.010 U	0.010 U	
	MW-71/ MW-72		35	0.370
	MW-74/ MW-86	0.010 R		0.011 U
	MW-78/ MW-79		0.640	3.4
	MW-80/ MW-81	4.1	0.004 J	
	MW-84/ MW-89		0.012 U	0.010 U
2,6-Dichlorophenol (mg/L)				
	MW-57/ MW-91		ND	0.120 J
	MW-59/ MW-60/ MW-85	0.014 U	0.011 U	0.011 U
	MW-63/ MW-62	0.020	0.010 U	
	MW-65/ MW-66/ MW-90	0.010 U	0.010 U	0.011 U
	MW-68/ MW-75	0.010 U	0.010 U	
	MW-71/ MW-72		8.1	0.110
	MW-74/ MW-86	0.010 R		0.011 U
	MW-78/ MW-79		0.580	0.950
	MW-80/ MW-81	0.750	0.001 J	
	MW-84/ MW-89		0.012 U	0.003 J

Table 3-14 (Continued)

Analyte Group/ Compound	Well Nest Shallower-Deeper	Shallow Well(a)	Intermediate Well(b)	Deep Well(c)
<u>Trichlorophenols</u>				
2,3,6-Trichlorophenol (mg/L)				
	MW-57/ MW-91		0.003	0.002 J
	MW-59/ MW-60/ MW-85	0.014 U	0.011 U	0.011 U
	MW-63/ MW-62	0.010 U	0.010 U	
	MW-65/ MW-66/ MW-90	0.010 U	0.010 U	0.011 U
	MW-68/ MW-75	0.010 U	0.010 U	
	MW-71/ MW-72		0.710	0.010 J
	MW-74/ MW-86	0.010 R		0.011 U
	MW-78/ MW-79		0.016 J	0.052 J
	MW-80/ MW-81	0.099 J	0.012 R	
	MW-84/ MW-89		0.012 U	0.010 U
2,4,5-Trichlorophenol (mg/L)				
	MW-57/ MW-91		ND	0.027
	MW-59/ MW-60/ MW-85	0.014 U	0.011 U	0.055 U
	MW-63/ MW-62	0.004 J	0.010 U	
	MW-65/ MW-66/ MW-90	0.051 U	0.010 U	0.055 U
	MW-68/ MW-75	50 U	52 U	
	MW-71/ MW-72		130	0.180
	MW-74/ MW-86	0.005 J		0.055 U
	MW-78/ MW-79		0.052 J	1.1
	MW-80/ MW-81	3	0.062 R	
	MW-84/ MW-89		0.060 U	0.050 U
2,4,6-Trichlorophenol (mg/L)				
	MW-57/ MW-91		0.002	0.006 J
	MW-59/ MW-60/ MW-85	0.070 U	0.055 U	0.011 U
	MW-63/ MW-62	0.003 J	0.050 U	
	MW-65/ MW-66/ MW-90	0.010 U	0.050 U	0.011 U
	MW-68/ MW-75	0.010 U	0.010 U	
	MW-71/ MW-72		4.6	0.110
	MW-74/ MW-86	0.010 R		0.011 U
	MW-78/ MW-79		0.140	0.300 J
	MW-80/ MW-81	1.7	0.012 R	
	MW-84/ MW-89		0.012 U	0.010 U

Table 3-14 (Continued)

Analyte Group/ Compound	Well Nest Shallower-Deeper	Shallow Well(a)	Intermediate Well(b)	Deep Well(c)
Chlorophenoxyherbicides				
2,4-D (mg/L)				
	MW-57/ MW-91		0.003	0.011 UJ
	MW-59/ MW-60/ MW-85	0.0012 U	0.0011 U	0.012 UJ
	MW-63/ MW-62	0.092	0.023	
	MW-65/ MW-66/ MW-90	0.0011 U	0.0014 U	0.011 UJ
	MW-68/ MW-75	0.0010 U	0.0010 U	
	MW-71/ MW-72		200	2.3
	MW-74/ MW-86	0.015 U		0.011 UJ
	MW-78/ MW-79		9.3	6.3
	MW-80/ MW-81	31	7.2 U	
	MW-84/ MW-89		0.0002 J	0.021 J
Silvex (mg/L)				
	MW-57/ MW-91		ND	0.0056 UJ
	MW-59/ MW-60/ MW-85	0.00072 U	0.00054 U	0.0058 UJ
	MW-63/ MW-62	0.011	0.0065	
	MW-65/ MW-66/ MW-90	0.00054 U	0.00051 J	0.0054 UJ
	MW-68/ MW-75	0.00050 U	0.00050 U	
	MW-71/ MW-72		3.1 J	0.540 U
	MW-74/ MW-86	0.0037 J		0.0054 UJ
	MW-78/ MW-79		1.8	0.220 J
	MW-80/ MW-81	0.570	0.320 J	
	MW-84/ MW-89		0.0005 U	0.0058 UJ
2,4,5-T (mg/L)				
	MW-57/ MW-91		0.002	0.0096 J
	MW-59/ MW-60/ MW-85	0.00042 U	0.00054 U	0.0058 UJ
	MW-63/ MW-62	0.018	0.00011 U	
	MW-65/ MW-66/ MW-90	0.00054 U	0.00048 U	0.0054 UJ
	MW-68/ MW-75	0.00050 U	0.00050 U	
	MW-71/ MW-72		23	0.460 J
	MW-74/ MW-86	0.0055 U		0.0054 UJ
	MW-78/ MW-79		1.3 U	0.630 U
	MW-80/ MW-81	4.7	3.1 U	
	MW-84/ MW-89		0.0002 J	0.0058 UJ

Table 3-14 (Continued)

Analyte Group/ Compound	Well Nest Shallower-Deeper	Shallow Well(a)	Intermediate Well(b)	Deep Well(c)
<u>2,3,7,8-TCDD</u> (mg/L)				
	MW-57/ MW-91		NR	1.3 U
	MW-59/ MW-60/ MW-85	0.5 U	0.1 U	1.0 U
	MW-63/ MW-62	0.06 U	0.08 U	
	MW-65/ MW-66/ MW-90	0.06 U	0.1 U	1.4 U
	MW-68/ MW-75	0.2 U	0.1 U	
	MW-71/ MW-72		75	3.0
	MW-74/ MW-86	0.4 U		1.3 U
	MW-78/ MW-79		0.1 U	0.3 U
	MW-80/ MW-81	0.95	0.1 U	
	MW-84/ MW-89		0.2 U	1.4 U
<u>Tetrachlorobenzene</u> (mg/L)				
	MW-57/ MW-91		NR	0.010 U
	MW-59/ MW-60/ MW-85	NR	NR	0.011 U
	MW-63/ MW-62	NR	NR	
	MW-65/ MW-66/ MW-90	0.010 U	NR	0.011 U
	MW-68/ MW-75	0.010 U	0.010 U	
	MW-71/ MW-72		0.720	0.011 U
	MW-74/ MW-86	0.01		0.011 U
	MW-78/ MW-79		0.022 U	0.021
	MW-80/ MW-81	0.1 U	0.012	
	MW-84/ MW-89		0.012 U	0.010 U

Notes:
Units are reported in milligrams per liter (mg/L) or in parts per million (ppm), except 2,3,7,8-TCDD which are reported in nanograms per liter (ng/L) or parts per trillion (ppt)
a = Sediment/rock type - unconsolidated sediments
b = Base of weathered bedrock.
c = Fresh/fractured bedrock.

Analytical Data Qualifiers:
J = Quantitation estimated below quantitation limit.
NR = Analysis not requested.
R = Rejected analytical data.
U = Not detected at the quantitation limit.
UJ = Estimated quantitaion limit.

Source:
Data for MW-1 through MW-57 are presented in Phase I RI Report (Appendix D).
Data for MW-58 through MW-84 are presented in Phase I RI Report (Subsection 3.4.4 and Table 3-13).

Silvex	-	MW-65/MW-66
2,4,5-T	-	MW-57/MW-91
Tetrachlorobenzene	-	MW-80/MW-81, MW-78/MW-79

A comparison of wells and analytes shows that there is not a consistent pattern of higher concentrations at depth in the paired wells. Also, the well pairs where higher concentrations were observed in the deeper wells are geographically distributed across the site. Most of the situations where a higher analyte concentration was found in the deeper well occurred at the following well pairs: MW-57/MW-91, MW-78/MW-79, and MW-84/MW-89.

Results for samples from wells completed in the Wilcox Group, Midway Formation or weathered Atoka Formation were not shown on maps in this report because they were discussed in the Phase I RI Report. The Wilcox Group, Midway Formation and the weathered Atoka Formation represent separate groundwater regimes (Subsection 3.3.3).

SECTION 4

DISCUSSION OF RESULTS

4.1 INTRODUCTION

This section describes the conceptual model for the Site. The purpose of this model is to organize the technical data within a unified theory of contaminant distribution and transport. The model was developed by integrating results from the Phase I RI and other Site investigations with results of the Phase II RI. The primary application of the conceptual model is to provide a basis for evaluating potential risks and selecting remedial technologies for the onsite areas with particular focus on groundwater which was the primary medium of interest during the Phase II RI.

Activities described in this Phase II RI Report were completed in accordance with Work Plan requirements. As described in Sections 2 and 3, requirements of the Work Plan were completed with minor modifications approved by U.S. EPA. The minor modifications, where they were made, were necessitated because of conditions encountered during field work. The results of the Phase II RI are to be incorporated into the baseline risk assessment for the soil and groundwater and used to formulate feasible remedial alternatives for the onsite areas. Uncertainties in the conceptual models will be discussed in baseline risk assessment and in the feasibility study.

4.2 COMPOUNDS OF POTENTIAL CONCERN

Hazardous compounds of potential concern was based on reported historical Site operations which focused on the manufacturing of 2,4-D and 2,4,5-T (Subsection 1.5, Phase I RI). Preliminary compounds of potential concern were selected based on: the historical list of products and intermediates in Table 2-1 of the original Work Plan; compounds identified in the historical groundwater data (Subsection 1.9.3.4, Phase I RI). Compounds reported in available groundwater data are expected to represent a comprehensive list because the wells are located within and around landfills that were used for disposal of wastes from manufacturing processes; some of the wastes were in liquid form. Samples collected from these wells were reportedly analyzed for the full range of organic compounds on the U.S. EPA hazardous substances list (U.S. EPA, personal communications, 1989). Petroleum hydrocarbons were not carried into the Phase II RI as compounds of potential concern because there was no evidence that they were released from the underground storage tanks and were not found in the groundwater samples at levels of potential concern.

The following compounds or groups of compounds were selected as compounds of potential concern based on the results of available analyses:

- Chloride.
- Toluene.
- Chlorophenols.
- Chlorophenoxyherbicides.
- Tetrachlorobenzene.
- 2,3,7,8-TCDD.

Toluene is the primary solvent used on the site and is on the U.S. EPA's target compounds list of volatile organic compounds. This compound, when present as a pure phase, is a liquid that is less dense than water; therefore, it will float on water as a light non-aqueous phase (LNAPL).

Chlorinated compounds, for example, chlorophenols, chlorophenoxyherbicides, 2,3,7,8-TCDD, and tetrachlorobenzene, are manmade substances on the U.S. EPA's target compounds list of semivolatile compounds. These compounds, when present as pure phases, are solids under ambient conditions, except for 2-chlorophenol which is a liquid. When present as liquids, these compounds are more dense than water; therefore, they will sink through water as a dense non-aqueous phase (DNAPL). Volatile organic compounds and semivolatile organic compounds can be present as dissolved phases up to their solubility limits in the media (i.e., soils or water). The more chlorinated compounds typically tend to adhere most strongly to soil particles.

Chlorinated compounds are also soluble in other organic (solvent) compounds, such as toluene which was used as a solvent in some processes at the site. In the presence of a solvent, like toluene, chlorinated compounds, such as 2,3,7,8-TCDD, are less likely to partition onto soil particles. In water or non-aqueous phase liquids, the presence of some organic compounds may increase the solubility of other organic compounds. Physical characteristics for compounds identified as potential substances of concern, based on results of the RI, are listed on Table 4-1.

Table 4 - 1

Summary of Physical Characteristics of Selected Substances
Vertac Site, Jacksonville, Arkansas

Substance	Moleular Weight[a]	Melting Point[a] (°C)	Boiling Point[a] (°C)	Vapor Pressure[b] (mm Hg;25°C)	Solubility in Water[b] (mg/l; °C)	Log Octanol/Water Partition Coefficient[b] (Kow)	Henry's Law Constant[a][c]	Specific Gravity	Log Sorption Coefficient[b] (Koc)
Chloride	35.45					Very High			
Toluene	92.14	-95	110.6	28	515;20	2.69	5.92E-3;25	0.867[d]	2.69[e]
2-Chlorophenol	128.56	9.0	174.9	2.2[e]	28,500;20[e]	2.15	1.03E-5;20	1.241[e]	2.17[e]
4-Chlorophenol	128.56	43.5	220	0.10[d]	27,100;20[d]	2.39	NA	NA	2.39[d]
2,4-Dichlorophenol	163.0	45	210	0.12	4,500:25[e]	2.75	2.8E-6;20	1.383[f]	2.75[e]
2,6-Dichlorophenol	163.0	65 to 68	218 to 220	NA	NA	2.88	4E-5;NA	NA	NA
2,4,5-Trichlorophenol	197.45	67	253	1;72	1,200;25	3.72	NA	1.678[f]	3.7[e]
2,4,6-Trichlorophenol	197.45	69.5	246	0.03	800;25[d]	3.69	4E-6;25	NA	3.38[e]
2,4-D	221.04	138	NA	<10E-5	620;25	2.81	NA	NA	2.5
Silvex	269.51	181.6	NA	<1	180;25	2.44	NA	1.640[f]	4
2,4,5-T	255.48	153	NA	<8.4E-6	250;25	NA	NA	NA	3 [g]
2,3,7,8-TCDD	321.96	303 to 305	NA	1.4E-9[h]	1.4E-5;20[h]	6.64	1.3E-6;NA	NA	6.52[i]

Notes:

NA = Information not available.
a = U.S. EPA RREL Treatability Database, Rev. No.4.
b = U.S. EPA, 1985a
c = atm x m3 Mole^{-1}, °C
d = Verschueren, 1989
e = U.S. EPA, 1979
f = Clement Associates, 1985
g = U.S. EPA, 1988
h = ATSDR, 1989
i = U.S. EPA, 1986

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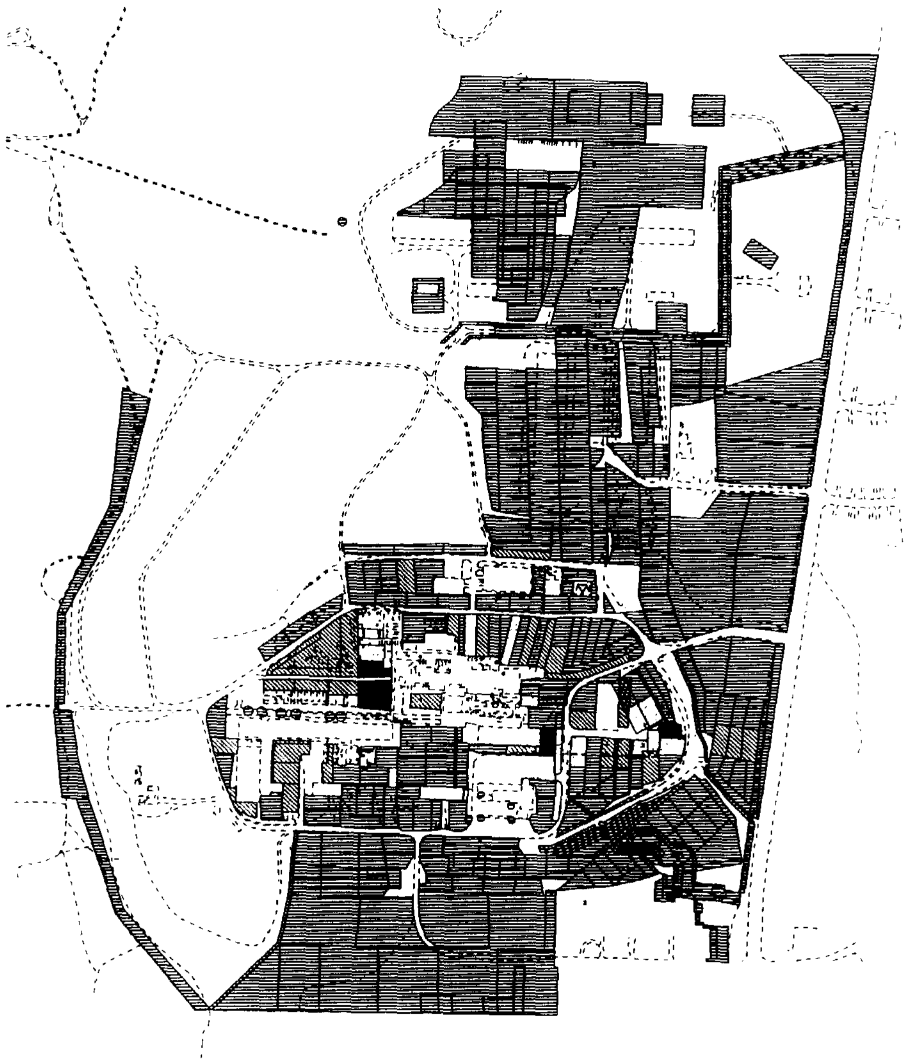
4.3 SURFACE SOILS

4.3.1 Introduction

As described in the Phase I RI Report (Subsection 4.2.1), the conceptual model for surface soils focuses primarily on the potential for migration of organic compounds adsorbed onto soil particles and transported via surface drainages. Particular emphasis is placed on the concentrations and distribution of 2,3,7,8-TCDD, because of the toxicity of this compound. The concentrations and distribution of 2,3,7,8-TCDD in surface soils is shown in Figure 4-1. The results of the Phase II RI surface soils are consistent with the conceptual model presented in the Phase I RI and with historical information provided by Hercules' site personnel. The conceptual model for surface soils focuses primarily on the potential for migration of organic compounds adsorbed onto sediments and transported via surface water runoff along drainages and away from source areas (Subsection 4.2.1, WESTON 1992b).

4.3.2 Regina Paint Building

The source of 2,3,7,8-TCDD found in surface soil samples from the area of the Regina Paint building appears to be related to the handling and storage of empty drums that had previously contained 2,4,5-T (Hercules, personal communications, 1989). This is supported by results of sediment (soil) and wipe samples collected from empty drums stored inside the Regina Paint building during the Operable Unit I RI (WESTON, 1991). These samples showed the following concentrations of 2,3,7,8-TCDD: sediment (10.4 ppb) and wipe sample (121,000 ng/m^2). In addition, the results of surface soil samples collected during the Phase II RI showed a progressive increase in concentrations toward the building (Subsection 3.2.2). Samples collected from Grid 587 located downslope from the Regina Paint building, indicated a concentration of 1.2 ppb 2,3,7,8-TCDD at the upper 95 percent confidence limit. By comparison, within Grid 586, the 'B' and 'A' samples were collected at distances of 10 feet and 15 feet from the building and showed comparable concentrations 2.2 ppb and 2.4 ppb, respectively. The 'C' sample was collected closest to the building and showed the highest concentration (8.5 ppb). As described in Subsection 3.2, low concentrations of some chlorophenols and some chlorophenoxyherbicides were also reported in the soil samples. The progressive increase in the concentration of 2,3,7,8-TCDD and presence of low levels of other site-related compounds is consistent with historical use of the Regina Paint building to store empty drums that had previously contained 2,3,7,8-TCDD.



Legend

2,3,7,8-TCDD Concentration (parts per billion)

- 0.001 - 19.99
- 20.00 - 99.99
- 100.00 - 499.00
- 500.00 and higher

N
W E
S

Note: Individual surface soil grid numbers are identified in Figures 1-6, 2-2, and 2-3 of this report.

0 400 800

Scale in Feet

Source: Vertac Site Boundary and Photogrammetric Survey Prepared by West and Associates, Inc.

Projection: Arkansas Coordinate System, North Zone (NAD 1983).

FIGURE 4-1

2, 3, 7, 8-TCDD IN SURFACE SOILS
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

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4.3.3 Marshall Road

The source of the 2,3,7,8-TCDD in samples from Grid 588 along the west side of Marshall Road appears to be related to sediment migrating from soil grids east of the main boiler house area where surface soil samples showed concentrations of 2,3,7,8-TCDD ranging from non-detectable to 98 ppb at the upper 95 percent confidence limit (Subsection 4.2.3.5, Phase I RI Report). The individual sample results from Grid 588 show a consistent decrease in the concentration toward the ditch that separates Marshall Road from the main plant area (Subsection 3.2.3). The lowest concentration was found closest to the road (0 to 1 inch, 1.2 ppb) and (0 to 6 inches, 3.0 ppb). The highest concentration was found closest to the ditch (0 to 1 inch of 3.4 ppb and 0 to 6-inch of 5.0 ppb). These results are consistent with a conceptual model based on sediment transport from the central process area via surface water drainages.

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4.4 GROUNDWATER

4.4.1 Introduction

The conceptual model for groundwater focuses on the potential for site-related compounds to migrate in a dissolved state or as an immiscible-phase liquid within the bedrock of the Atoka Formation. Site-related compounds were found in groundwater in the Atoka Formation but were not found in the Midway Formation nor Wilcox Group, (Subsection 4.4.1 of the Phase I RI Report). The conceptual model for groundwater is based on the available data for site-specific factors, including geology, hydrogeology, and groundwater quality. Parameters for each of these factors are integrated into the conceptual model subsections.

4.4.2 Conceptual Model

The conceptual model for groundwater is that site-related compounds were released as DNAPLs into the soils and fractured bedrock of the Atoka Formation within the central process area. The migration pathway for DNAPLs depends on the immiscible phase, the characteristics of the bedrock, and on gravity. In contrast, the migration pathway for contaminants in the dissolved phase depends largely on the direction and rate of groundwater flow. LNAPLs were found only as thin oily sheens on groundwater in test pits excavated in the areas where the highest concentrations of site-related compounds were found in the groundwater. Observations at the Reasor-Hill well, where some waste was disposed, indicated that the DNAPLs may fractionate into separate phases exhibiting different densities (Fetter, 1993). Hydraulic gradients indicate that organic compounds, which dissolved from the NAPLs, have the potential to migrate toward the offsite areas as a dissolved phase. This conceptual model is based on the potential for migration of site-related compounds in the bedrock based on the hydrogeologic characteristics described in Subsection 3.3.

The conceptual model focuses on the Atoka Formation because site-related compounds were found in samples collected from monitoring wells that are completed in this formation. The samples indicated that site-related compounds were present in the Atoka Formation as an immiscible phase and as a dissolved phase. As discussed previously (WESTON, 1992b), site-related compounds were not found in groundwater samples collected in monitoring wells completed in the Wilcox Group or the Midway Formation; therefore, they were excluded from further discussions on groundwater in this document.

The conceptual model for groundwater focuses on the Atoka Formation within the central process area because it is a source area where contaminants were released into the soil and groundwater, and because it is a groundwater recharge area which exhibits a gradient for outward migration of dissolved contaminants in groundwater toward offsite areas. The potential for outward, lateral groundwater flow is based on the water level elevations in the weathered bedrock which decrease away from a groundwater divide that trends in a north/south direction and bisects the central process area (Figures 3-5 and 3-6). These piezometric maps show the same trends as the qualitative flow nets in Figures 3-31 and 3-32 in the Phase I RI Report (Subsection 3.4.3.2.3; WESTON, 1992b).

Groundwater within the central process area also exhibits a downward vertical flow potential, based on a comparison of water level elevations in nested monitoring wells (Table 3-5) and observed decreases in head values in packer-tested intervals (to a depth of about 100 feet) in stratigraphic borings XB-4 and XB-5 (Subsections 3.4.3.4.3 and 3.4.3.4.4; WESTON, 1992b). On a regional basis, water level elevations in the fresh bedrock appear to exhibit a regional gradient toward the south and east, which parallels the surface topography and the water level elevations in the weathered bedrock, where there are a larger number of monitoring wells. Water levels elevations within a representative water-bearing unit on the west side of Rocky Branch Creek show that groundwater flows eastward toward Rocky Branch Creek, which appears to be the receptor for groundwater discharge on the west side of the Site (Figure 3-9). This is also supported by water level elevations on the east side of the creek (Figure 3-35; WESTON, 1992b) which indicate an upward gradient typical of a discharge area. During periods of recharge, groundwater may flow northward along bedding plane fractures, particularly in the unsaturated zone and the shallow flow system near the base of weathering.

The water level elevations within a representative water-bearing unit on the east side of the Site indicate the presence of a shallow groundwater gradient toward the east-southeast. Pumping tests performed in the fresh bedrock on the eastern side of the Site indicated that hydraulic gradients were induced along strike over long distances and that the fresh and weathered bedrock hydrologic zones are hydraulically connected. Based on the interconnected nature of the weathered bedrock and the fresh bedrock, it appears that the groundwater divide, which is present at the base of weathering, is also present in the fresh bedrock, although the number and locations of the monitoring wells were not specifically selected to evaluate the location or depth of influence of the groundwater divide that is observed in the weathered rock.

Proposed water-bearing units are shown on Figure 4-2. The water-bearing units are based upon the positive response of the weathered and fresh bedrock wells to hydrologic testing. The proposed water-bearing unit for pumping tests 1 and 2 is based on drawdown responses in wells MW-86, MW-87, MW-88, and MW-67. These wells are constructed in shaley unit "D" and the overlying sandstone unit east of the groundwater divide. The water-bearing unit for pumping tests 3 and 4 is based on drawdown responses from wells MW-23A, MW-57, MW-91, MW-92, MW-93, and MW-94. These wells are constructed across shaley unit "G" and two underlying sandstone beds ("bedding contact lines") shown on Figure 4-2. This water-bearing unit extends west of the groundwater divide based on the positive response of MW-23A to pumping tests 3 and 4.

Five additional water-bearing units are proposed based on the rhythmic pattern of the stratigraphic packages within the Atoka Formation. The locations of these water-bearing units are on Figure 4-2. They were delineated based on the area of influence that would be anticipated based on future pumping of a well completed near the base of the weathering. These proposed water-bearing units have not been verified by hydrologic testing.

On a seasonal basis, areas along Rocky Branch Creek appear to be discharge areas, as indicated by the occurrence of seep a on the eastern bank of the creek and upward flow potential, based on higher water elevations in deeper of nested wells located near the creek. In addition, some groundwater is assumed to discharge to Rocky Branch Creek along fractures that subcrop in the creek bed (Figure 3-9). Except for the small seep area in the former cooling pond area, shallow groundwater flowing (to the base of the french drain) from the western part of the central process area (west of the groundwater divide) is captured by the existing french drain system that was installed in accordance with the 1984 Court Order. This is supported by the relationship between the groundwater contour and the french drain system as discussed in the last paragraph of this subsection.

Areas along Marshall Road also exhibit upward flow potential based on higher water level elevations in the deeper of nested monitoring wells located near the road. Seeps were not observed on the eastern side of the Site near Marshall Road. The Midway Formation, which is present in the area near Marshall Road, may act as a confining layer in this area which precludes upward flow of groundwater near Marshall Road. The confining nature of the Midway Formation is indicated by its composition and on its low hydraulic conductivity. The formation is composed of soft, plastic clay that failed to yield sufficient water during slug testing of MW-65 (Subsection

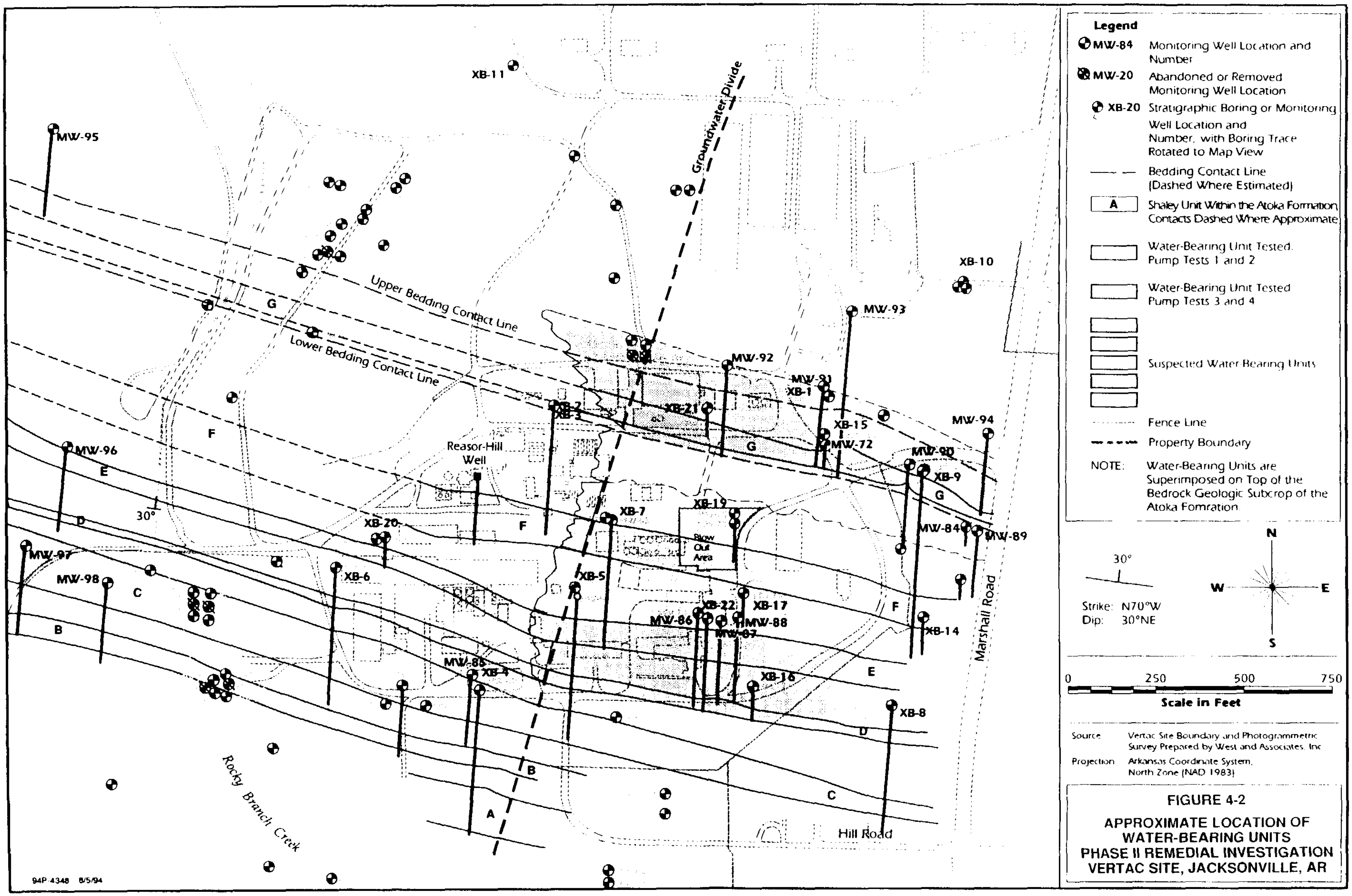

FIGURE 4-2
APPROXIMATE LOCATION OF WATER-BEARING UNITS
PHASE II REMEDIAL INVESTIGATION
VERTAC SITE, JACKSONVILLE, AR

3.4.3.3; WESTON, 1992b). MW-65 also did not respond in pumping tests 3 and 4. These data suggest that the Midway Formation may be a confining unit on the east side of the Site.

The Midway Formation and Wilcox Group were excluded from further discussions on groundwater because site-related organic compounds were not detected in samples from wells MW-65, MW-68, and MW-70 which were completed in these formations (Appendix M and Table 3-13, WESTON, 1992b). The decision to exclude the Midway Formation is further supported by field observations that the hydrostratigraphic unit has very low hydraulic conductivity. The nature and thickness of these strata are described in Subsections 3.2.2.2 and 3.4.3.3 (WESTON, 1992b). The Midway Formation therefore may act as a vertical aquitard isolating the overlying Wilcox Formation from the underlying Atoka Formation. Furthermore, the Wilcox Group is present only in the northeastern part of the Site where no contamination was found and upslope from the central process area (Figures 2-10, 3-29, 3-43 through 3-49; WESTON, 1992b).

The quantitative effects of the existing french drains and the slurry wall on the groundwater flow were not evaluated because these features are located in areas that were outside the focus of this RI (Subsections 1.1 and 1.9.1; WESTON, 1992). Some qualitative indications of the effects can be seen in the trend of shallow groundwater contours where they intersect the french drains and slurry wall (Figures 1-8, 3-31, 3-32 and 4-2; WESTON, 1992b and Figures 3-5 and 3-6, Subsection 3.3.3.4). These figures indicate that the french drains depress the adjacent water level elevations and that the slurry wall appears to flatten the gradient within the north landfill area.

4.4.3 Influences of Stratigraphy and Geologic Structure

The stratigraphic (Subsection 3.3.2.2) and structural features (Subsection 3.3.2.3) of the Atoka Formation are consistent across the Site based on the surficial geology and correlation of borehole geophysical logs. Based on available data, the stratigraphic framework and structural framework appear to exert strong influences on flow of groundwater at the Site. The stratigraphic layering of shales, siltstones, and sandstones exerts a primary influence on groundwater flow by imposing an initial bias that was followed by the subsequent fracturing and weathering of the bedrock. The rocks are arranged in relatively consistent stratigraphic packages that can be correlated across the Site (Figure 4-2). The correlation shows that the rocks exhibit a high degree of homogeneity within a stratigraphic package and a high degree of heterogeneity among packages. Based on the results of pumping tests, it appears that these stratigraphic packages exert an overall influence on the direction of groundwater flow along strike and dip. On a small scale, however, some of the rocks are closely interlayered and the degree of interlayering of the different rock types is expected to complicate local groundwater flow patterns.

In addition to stratigraphy, the structure of the Atoka Formation exerts a strong influence on flow of groundwater in the Atoka Formation. The structural influences include the strike and dip of bedding and the presence of two (cross-cutting) directions of fractures. Large scale structural folding resulted in tilting and fracturing the bedrock. The strike of the beds is about N70°W as mapped on a regional basis (Stone, 1984) and measured along Rocky Branch Creek (WESTON, 1992). Two fracture directions were measured in the bedrock outcrop along the creek. The strike of the primary fractures measured along Rocky Branch Creek is N60°W and the dip of the primary fractures is to the southwest at high angles (Subsection 2.4.3.3, WESTON, 1992b). The strike of the secondary fractures measured along Rocky Branch Creek is N40°E and the dip of the secondary fractures is to the southeast at high angles (Subsection 2.4.3.3, WESTON, 1992b). The impact of the fracturing was to provide an interconnected network for groundwater flow paths within stratigraphic packages. The interconnectedness of the network is expected to be greatest with stratigraphic packages that contain primarily sandstone units and to be least in packages that contain primarily shale units. In addition, the fractures formed preferential pathways for weathering as indicated by the orange-staining along fractures. The strike of the primary and secondary fractures is sub-parallel to the trends of some regional photo-lineations as described in the Fracture Trace Survey (WESTON, 1990a).

The cumulative influence of stratigraphy and structure within the Atoka Formation depend on the scale of observation. At a general level, which is expected to be the most important, the stratigraphy displays a high degree of consistency as indicated by the degree of correlation of strata across the Site. The structure also exhibits a high degree of consistency as evidenced by the similarity of strike and dip in the outcrop of the Atoka Formation northeast of the central process area (Subsection 3.3.2.3), the consistent trends shown in the subcrop map (Subsection 3.4.2.3), and trends in outcrops observed in offsite areas to the northeast and south of the Site. The trend of the fracture strike also seems to be consistent across the Site. At a local scale, the degree of fracturing varies among rock types and, perhaps in different areas of the Site, based on the occurrence of the photo-lineations, the slope of the land surface, and the localization of Rocky Branch Creek.

On a very large scale there is evidence that two generally north/south trending regional fractures may bound the central process area on the west and on the east. Evidence for such a fracture on the west is based on the north/south trend of Rocky Branch Creek which flows almost perpendicular to strike and cuts across some very hard sandstone layers. Evidence for such a fracture on the east is based on a photo-lineation observed on a historical aerial photograph presented in the Fracture Trace Survey (WESTON,1990). There is also some direct evidence for this latter fracture which is based on the drawdown of water levels in MW-57 to pumping groundwater from MW-91 and MW-92 (Subsections 3.3.5.3.7 and 3.3.5.3.8). Drawdown in MW-57 to pumping at MW-91 and MW-92 (pumping tests 3 and 4) indicates that the pumping impacted a thicker volume of rock than was impacted during pumping tests 1 and 2. Drawdown within a thicker volume of rock would be consistent with the influence that would be expected from the presence of a north/south trending regional fracture in the area of these wells.

Cores of the fresh bedrock were fractured, particularly at shallow depths. The number and spacing of the fractures decreased with depth. Cores of the fresh bedrock exhibited little primary porosity. Therefore, it appeared that groundwater flow within the fresh bedrock is primarily along fractures. The extent of fracturing was observed to be related to the type of rock. The spacing and openness of the fractures depended on the thickness of the beds and the competence of the rock. A consistent relationship between bedding thickness and fracture intensity was observed, such that the thicker beds tended to have more broadly spaced fractures. Sandstones typically exhibited thicker beds and a greater proportion of open fractures (Nelson, 1988) than shales. Shales tended to have thinner beds and are more ductile (Nelson, 1988); therefore observations along Rocky Branch Creek indicated that the secondary fractures usually did not penetrate between beds, particularly where rock types were closely interlayered. These observations indicated that continuous fractures were more commonly associated with the primary fracture direction (N60°W) than with the secondary fracture direction (N30°E).

4.4.4 Influences of Weathering

Influences of long-term weathering are superimposed on top of the influences of stratigraphy and geologic structure. Near land surface, the bedrock of the Atoka Formation was chemically weathered to a residual soil and is referred to as unconsolidated weathered bedrock. At depth, the extent of weathering is less severe. For example, at depths between about 10 and 40 feet, the bedrock was partially weathered and is referred to as consolidated weathered rock. The consolidated weathered rock is characterized by the relative competence of the rock and the prevalence of orange-stained fractures. Below depths of about 40 feet, where orange-stained fractures are rare, the effects of weathering diminish and the bedrock below that depth is referred to as fresh. The extent of weathering resulted in three hydrogeologic zones: (1) unconsolidated weathered bedrock, (2) consolidated weathered bedrock, and (3) fresh bedrock. The hydrogeologic characteristics of these zones are summarized in Subsection 3.3.2.4.

The weathering progressively disaggregated the bedrock into soil near the land surface. As a result, the residual soils exhibited physical characteristics that are consistent with the underlying bedrock. The residual soils differ from the underlying bedrock in that they now have a relatively high intergranular porosity and low to moderate hydraulic conductivity. The water levels in wells completed in the unconsolidated weathered bedrock tended to show relatively rapid responses to precipitation as compared to the water levels in wells completed in the consolidated bedrock. They did not respond to pumping groundwater from the fresh bedrock. In contrast, the consolidated weathered bedrock exhibited characteristics of some intergranular porosity and some fracture porosity. The water level in wells in the consolidated weathered bedrock tended to respond to pumping of groundwater from wells completed in the fresh bedrock. For example, water level responses were observed in wells completed in the weathered zone (i.e., MW-73, MW-67, MW-72, and MW-57). Based on the responses, it appears that the weathered bedrock is hydraulically connected to the fresh bedrock. In addition, it was apparent that the magnitude of the water level change, in response to pumping, was always less in the weathered rock than in the fresh rock. The inverted response was considered to be a function of high storativity due to the presence of some intergranular porosity related to the weathering.

Lateral groundwater flow at the Site occurs primarily in the weathered and fresh bedrock units. Within a water-bearing unit, lateral groundwater flow potential behaves in an isotropic manner. Across water-bearing units, groundwater flow is anisotropic in a direction at a high angle to the strike of the beds, as shown by the shape of the cone of influence on the capture zone maps (Figures 3-11, 3-12, 3-13, and 3-14). The potential effects of anisotropy are addressed in Subsections 4.4.2.2 and 4.4.3 in the Phase I RI (WESTON, 1992b).

4.4.5 Hydraulic Characteristics of the Bedrock

The effects of pumping groundwater from the fresh bedrock were observed over a large area which is consistent with pumping a semi-confined unit with low storativity. For example, while pumping MW-86 at 2-gpm, drawdown was observed in MW-73 and MW-67, at distances from the pumping well of 256 and 586.5-feet, respectively. Another example of the large area impacted by pumping is the distance along strike and dip where drawdown was observed while pumping MW-91 at 1 gpm. During that test, drawdown was observed along strike for more than 992-feet between MW-23A and MW-94 and more than 350-feet down dip between MW-72 and MW-93 (Subsection 3.3.5.3).

During pumping, water level responses were observed in wells completed in the fresh bedrock and, to a somewhat lesser extent, in wells completed in the weathered zone. Based on the responses, the weathered bedrock is hydraulically connected to the fresh bedrock. Pumping test results within each water-bearing unit confirm the field observations and indicate low storativity values ($3.6x10^{-5}$ to $1.7x10^{-4}$ (unitless)) and low transmissivity values (25 to 275 gpd/ft) within the fresh bedrock (Table 3-9). As discussed previously, the magnitude of water level changes in response to pumping was more subdued in the wells completed in the weathered zone, probably because of a higher storativity due to the presence of some intergranular porosity formed as a result of weathering.

The conformance of the pumping test results to analytical methods of Theis (1935) indicates that groundwater flow within the water-bearing unit tends to be semi-confined, isotropic, and homogeneous, at the scales and durations of the pumping tests.

The rate at which the water level in fresh bedrock adjusted to gradients induced by the pumping tests were rapid. For example, during the pumping test at MW-92, drawdown at MW-93, and MW-94 began within 20 to 30 minutes of pumping, despite their distances of 362.3 and 736 feet from the pumping well (Subsection 3.3.5.3.8), respectively. Similar rapid responses were observed in pumping tests at MW-91 (Subsection 3.3.5.3.7). In addition, rapid responses were also observed in pumping tests at MW-86 and MW-88, where the wells were closer together. Under non-pumping conditions, induced stresses are limited to recharge events that appear to dissipate within the weathered zone based on the little or no response of the water levels in the fresh bedrock wells to the precipitation during the recovery phases of the pumping tests.

4.4.6 <u>Sources of Groundwater Contamination</u>

4.4.6.1 Introduction

This subsection describes the nature and extent of non-aqueous phase liquids and the distribution of residual soil contamination at the Vertac Site. The purpose of this section is to present a synopsis of the primary and secondary source areas of organic contaminants that might migrate and contribute to the degradation of groundwater in an integrated, concise framework. The source areas were compiled by integrating the results from the Phase I RI (WESTON, 1992b) with the results of the Phase II RI. The perspective of this section is to evaluate and identify potential sources of the contaminants at the Site. A map identifying the principal source areas is presented in Figure 4-3.

4.4.6.2 Nature and Distribution of Non-Aqueous Phase Liquids

Non-aqueous phase liquids (NAPLs) are the primary source of groundwater contamination at the Site. These organic liquids are classified as either light (LNAPL) or dense (DNAPL) with respect to the density of water. LNAPLs have a specific gravity less than 1, whereas DNAPLs have a specific gravity greater than 1. The viscosity of LNAPLs tend to be lower (more mobile) than that of DNAPLs. LNAPLs float on top of the water table and are expected to migrate in the direction of groundwater flow. DNAPLs are expected to migrate to the bottom of a water-bearing unit via gravity flow and independent of the groundwater flow potential. The migration of NAPLs is dependent on the type of bedrock, extent of bedrock fracturing, the degree of bedrock weathering, the size of soil pores and rock fractures, and the physico-chemical characteristics of the contaminant, such as the partitioning coefficient for organic carbon (K_{oc}) and the portioning coefficient for octanol/water (K_{ow}).

NAPLs were observed in some parts of the central process area and appear to be limited to areas north of the central ditch. A map identifying the principal NAPL source areas is presented in Figure 4-3. Specific locations where NAPLs were observed include the following:

- Reasor-Hill well (Subsection 2.4.3.4; WESTON, 1992b).
- Tetrachlorobenzene spill area
    - TP-1 and TP-2 (Subsection 2.2.6.1, WESTON 1992b).
    - XB-3 (Subsection 2.4.3.5.6; WESTON, 1992b).
- MW-23A (Subsection 3.3.6; IT, 1988).
- XB-19 (Table 2-3 and Appendix H; WESTON 1992b).
- French drain system (Subsection 1.9; WESTON, 1992b).
- Central ditch (Subsection 1.3; WESTON, 1992b).

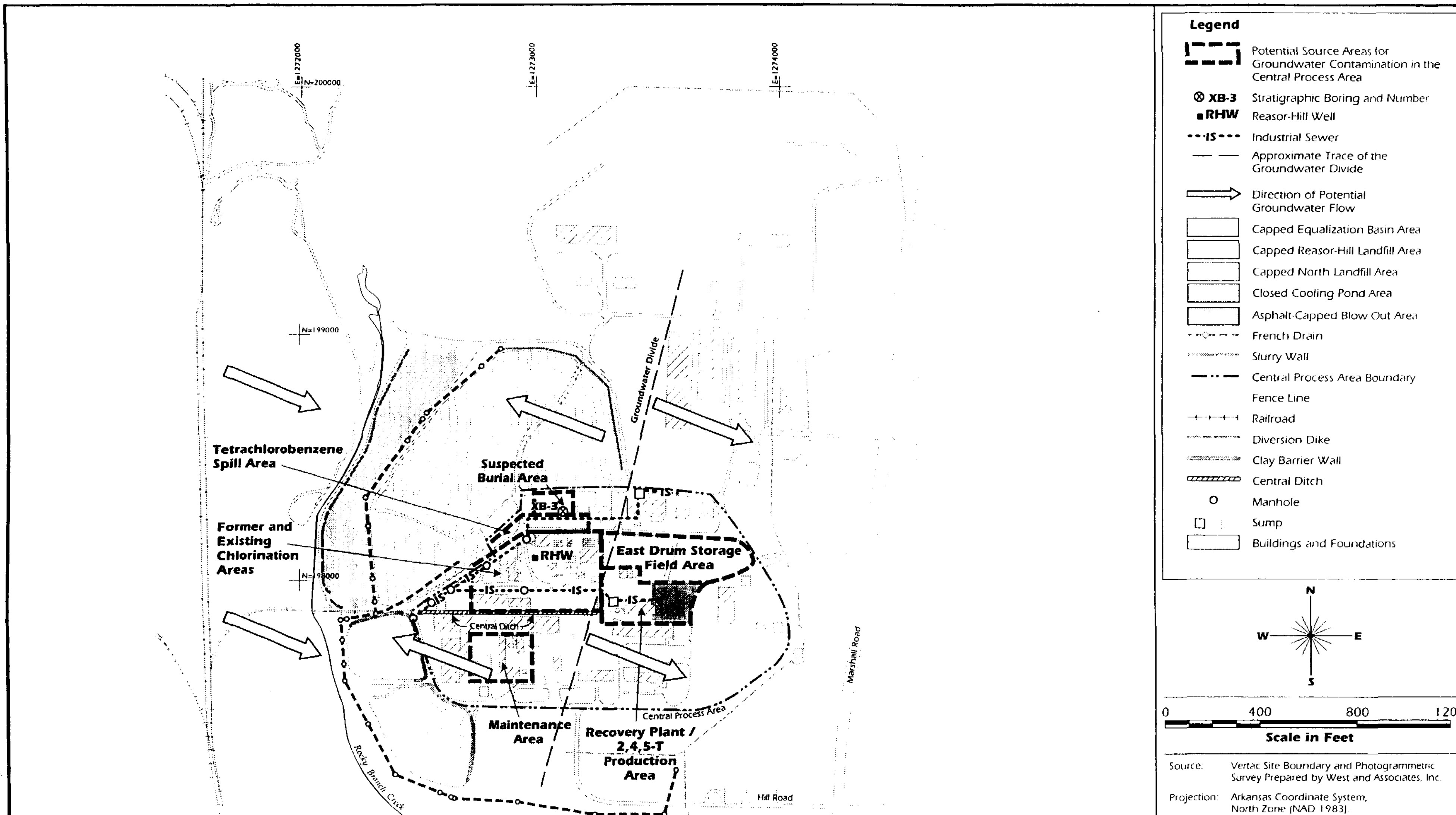

FIGURE 4-3
POTENTIAL SOURCE AREAS FOR GROUNDWATER CONTAMINATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

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Only at the Reasor-Hill well, XB-3, and MW-23A were NAPLs visually observed in quantities where NAPLs might be recoverable (i.e., thickness greater than about 1 inch) (Subsection 3.3.6). Thin sheens were observed at several of the test pits, which may indicate that some residual NAPLS are present in soils. During the several months that the test pits were open, the thickness of the sheens was not sufficient for the NAPL to be recovered. NAPLs were not observed at other locations.

The presence of NAPLs at the Site indicates that during operation of the facility, NAPLs were spilled onto the land surface or were injected into the Atoka Formation. NAPLs were contained in the raw materials, intermediate products, or waste which were released to soil, bedrock, or groundwater within the central process area (Subsection 1.3; WESTON, 1992b). Based on operations, releases may have occurred through the following mechanisms:

- Raw material releases, such as the tetrachlorobenzene spill along railroad tracks.
- Intermediate releases, such as through blow-outs from the reactor.
- Product releases, such as discharge of off-specification material into the central ditch or through leakage from the industrial sewer.
- Burial of waste materials.
- Injection of waste materials into the bedrock at the Reasor-Hill well.
- Storage of waste drums.
- Spills, material transfers, and tank overfills.

The presence of a NAPL indicates that the substance is present above its saturation limit in water. The NAPL is observed near the source area within the central process area and were not observed outside of the central process area. The continued presence of NAPLs will remain a primary contributor to residual soil contamination and dissolved-phase contamination in groundwater.

The horizontal extent of NAPLs within the central process area appears to be limited to some areas north of the central ditch. The vertical extent of DNAPL migration is not known; however, the multi-phased nature of the waste materials may have helped to minimize the depth of migration. For example, the waste material in the 2,4-D drums stored in the east drum field was reported to be crystalline in the cool months and liquid in hot weather. Liquids were released when drums would bulge and fail in hot weather. Once the liquids would penetrate into the ground, they would cool and begin to solidify as observed in the drums; thereby, helping to limit their depth of penetration as the waste became more viscous or crystallized. The physical and chemical characteristics of pure organic compounds of potential concern that might be components of the waste material, i.e., toluene, phenoxyherbicides, 2,3,7,8-TCDD, tetrachlorobenzene, and chlorophenols, are listed in Table 4-1. These compounds, except for toluene and 2-chlorophenol, are solids under ambient conditions (Subsection 1.5; WESTON, 1992b). Organic compounds present in mixtures will crystallize at lower temperatures, than when present as pure phases. The compounds will remainin a dissolved state when present below the saturation point in a solvent.

Chemical characterization of the oily leachate, which is a DNAPL collected by the French drain, showed high concentration of toluene, chlorophenols, chlorobenzene, and chlorophenoxy herbicides (Subsection 3.2.3, WESTON, 1992a). The concentration of toluene in the samples of the French drain leachate was similar to the concentration measured in the DNAPL sample collected from MW-23A (Subsection 3.3.6).

4.4.6.3 Nature and Distribution of Residual Soil Contamination

The distribution of soil contamination is important because they act as secondary sources of contaminants that might migrate and contribute to the degradation of groundwater quality. The migration of contaminants from the soil pore spaces is related to the type of soil, effective porosity, soil pore pressure, presence of preferential pathways of water movement, and the physico-chemical characteristics of the contaminant, such as K_{oc} and K_{ow}.

Contaminants identified in soils include chlorophenols, chlorophenoxyherbicides, 2,3,7,8-TCDD, and tetrachlorobenzene. The areal distribution of contaminants is associated with the distribution of NAPL releases to the land surface (Figure 4-3). The areas of highest soil contamination identified during the Phase I RI include:

- Former and existing chlorination areas.
- Suspected burial area (just north of existing chlorination area).
- North railroad siding area.
- East drum storage field area.
- Boiler house area.
- Blow-out area.
- Central ditch.
- Industrial sewer.
- Maintenance area.

Analytical and physical evidence from soil samples and test pits indicate that residual contamination exists above and within the weathered Atoka Formation. The presence of residual contamination at most of these locations indicate that raw, finished, or waste materials percolated into the environment from the surface via preferential pathways in the soils, direct infiltration of contaminants into the weathered Atoka Formation along the central ditch or chemical sewer, or movement through vadose zone soils. Physical evidence of soil contamination was observed in test pits and soil borings. Residual soil contamination was observed in the form of:

- Black-mottled or black-stained soils.
- Raw and product material-filled soil pores.
- Thin films on bedding surfaces or regional fracture surfaces.
- Elevated organic vapor readings from portable flame and photoionization instruments.

The presence of thin films on bedding surfaces in unconsolidated weathered bedrock (SB-32) indicates that residual contamination may exist in the central process area below the water table. The presence of residual soil contamination in the central process area is important in that the residual contaminants contribute to dissolved groundwater contamination. Subsurface soil contaminants are transported to the groundwater by the following transport mechanisms:

- Surface water and groundwater movement (which includes the movement of dissolved and suspended contaminants).

- Facilitated transport (which includes co-solvency).

- Leaching by dissolution or desorption.

- Gravity migration of NAPLs, above the saturated zone.

4.4.7 Groundwater Quality

Dissolved organic substances were found in groundwater samples from several monitoring wells. A review of isopleth (Figures 3-42 through 3-49, WESTON, 1992b) and point-plot maps, (Figures 3-15 through 3-38), indicates that groundwater in weathered and fresh bedrock hydrologic zones in onsite areas has been affected. Specific areas of contamination have been identified within the central process area, and are as follows:

- MW-80/MW-81 near chemical (industrial) sewer and downdip from the central ditch.

- Southern margin of north landfill north of the existing chlorination plant (near MW-64) and west of the product storage building, where suspected burial areas were reported.

- MW-71/MW-72, area downgradient from the east drum field.

- MW-78/MW-79 area within blow out area and along strike and downgradient from the recycle liquor basin.

- Reasor-Hill well area where waste was reportedly disposed in the well.

Other potential sources of groundwater contamination include the following areas, which were remediated in accordance with the 1984 Court Order and are subject to continuing operations and maintenance at the site:

- North burial area.
- Equalization basin.
- Reasor-Hill burial area.
- Cooling water pond.

Available groundwater data for the waste management units are included in the RI, but is not specifically discussed in this document because these units were excluded from the RI as described in the Work Plan (Attachment A to the AO). The following list summarizes the data from the waste management units and provides a cross-reference to the data:

• Well Location Map	Figure 1-7 (WESTON, 1992b)
• Well Completion Information	Appendix H
• Groundwater Analytical Data	Appendix D (WESTON, 1992b)
• Groundwater Level Elevation	Appendix F

Based on available data, it appears that groundwater quality is being impacted on a continuing basis by NAPLs. Although present, they were not found in recoverable quantities (Subsection 4.4.6.2). Some organic substances dissolve from the NAPLs. As discussed in Subsection 4.3.5.2, the migration of dissolved-phase substances in these areas is expected to be in the direction of groundwater flow (Figure 4-3). The migration of the dissolved substances to the west of the groundwater divide is expected to be westward, toward the french drain, which is designed to be a discharge point for shallow groundwater. Assessment of groundwater quality in fresh bedrock on the western perimeter of the Site does not indicate presence of contamination to a depth of one hundred feet (depth of monitoring wells west of Rocky Branch Creek) of the land surface for the water-bearing units at those locations. The upward hydraulic gradient in the area of Rocky Branch Creek, coupled with the occurrence of higher surface elevations farther west, indicates that Rocky Branch Creek is acting as an hydraulic barrier to westward migration of site-related contaminants. Migration of dissolved substances to the east of the groundwater divide is expected to be southeastward toward Marshall Road. Although there is an upward hydraulic gradient in the area adjacent to Marshall Road, there is no evidence of discharge, and the Midway Formation forms an aquitard to upward flow. A purported seep near Marshall Road was investigated during the Phase I RI, but there was no evidence of organic seepage, burial, or groundwater discharge (Subsections 2.2.6.2 and 3.2.2.2, WESTON, 1992b). Analysis of groundwater samples indicates that some organic compounds are present as a dissolved phase within the fresh bedrock below the depth of weathering. These compounds include: chlorophenols, chlorophenoxyherbicides, and toluene. Some other volatile compounds (acetone, methylene chloride, and chloroform) were also reported in a few of the samples; however, these volatile compounds are not discussed further because the compounds are considered common laboratory contaminants and they were reported at low concentrations.

Some site-related compounds were detected at low levels in samples collected from MW-89 and MW-94 which are located near the eastern side of the Site. The concentrations of site-related compounds in samples from the wells located near the eastern side of the Site were lower than the concentrations reported in samples from wells located inside the central process area (Subsection 3.4.4 of the Phase I RI report). The profiles of the compounds reported in the samples from wells near the boundary show a rapid decrease in the concentrations. The concentrations for herbicides, tetrachlorobenzene, and 2,3,7,8-TCDD decrease by more than two orders of magnitude between the wells in the central process area and those near the eastern boundary. Transport potential for non-aqueous and dissolved phases is discussed in Subsections 4.4.8.3 and 4.4.8.4, respectively.

4.4.8 Contaminant Transport Potential

4.4.8.1 Introduction

The characteristics of both the contaminants and the media affect the potential for contaminants to migrate. Contaminants can migrate in either dissolved phase or an immiscible (nonaqueous) phases, including phases less dense than water (floaters) and phases more dense than water (sinkers). The potential for migration depends on whether the form of the contaminant (solid or liquid) and on the density of the contaminant relative to the groundwater. The direction and rate of migration depend on the property of the saturated medium. The concentration of a contaminant depends on the solubility and the presence of other soluble compounds.

4.4.8.2 Properties of the Saturated Medium

The properties of the saturated medium at the Site which influence the transport of groundwater contamination include:

- Degree of saturation.
- Hydraulic conductivity, storativity, and transmissivity (Subsection 4.4.5).
- Hydraulic gradient (Subsection 4.4).
- The organic carbon content of the medium.
- The effective porosity of the medium.
- Capillaries of the medium.

  - void ratio.
  - natural rock porosity (fractured).
  - soil properties.

The organic carbon content of the medium influences the contaminant adsorption onto the medium. The black shales which are common at the Site likely contain a high organic carbon content. The levels of organic carbon in the bedrock at the Site would be expected to slow the migration of organic molecules by increasing the potential for adsorption. As described by Dragun (1988), the relationship between the distribution coefficient (K_d) and the organic carbon content of the saturated material is governed by the relationship $K_d = K_{oc}$ x oc, where oc is the organic carbon content of the medium. For a given contaminant, the K_{oc} is fixed and the K_d for the soil/contaminant combination increases as the organic carbon content of the soil increases.

The effective porosity of the saturated material exerts an important influence on the transport of NAPLs and dissolved substances. The effective porosity of a material is the connected porosity through which water or contaminants can flow. The greater the effective porosity, the greater the volume of groundwater/contaminant flow in a material. The smaller the effective porosity, the lower the fracture interconnectivity and the greater for groundwater/contaminant flow. Although little information is available regarding the porosity of saturated material at the Site, Freeze and Cherry (1979) indicate the effective porosity of fractured rocks varies widely; 5 to 30 percent for sandstone and 0 to 10 percent for shale. Empirical relationships between porosity and intrinsic permeability, such as that discussed by Chilingar (1963) for silty, clayey sandstones, indicates that a total porosity of between 15 and 17 percent would be expected for permeabilities between 77 and 100 milliDarcies (calculated from pumping test hydraulic conductivities between 7.4×10^{-7} and 9.7×10^{-7} meters per second (m/sec) with a water pore fluid).

Fractures in the saturated medium may decrease the adsorption of dissolved-phase substances, relative to the organic carbon content in the rock, because of the reduced surface areas available for adsorption reactions. The low effective porosity and potential for fracture flow suggest that some saturated materials at the Site may have a low exposed surface area for adsorption/desorption reactions with organic molecules; therefore, the effective retardation within the bedrock at the Site, would be expected to be less than in more porous medium having comparable organic carbon concentrations. This tends to narrow a contaminant front (Freeze and Cherry, 1979).

Capillaries are connected pore spaces (i.e., intergranular porosity or fracture porosity) that control migration of NAPLs, particularly under saturated conditions, where the NAPL must displace the water from the capillary if it is to migrate. When the "NAPL pressure head" or entry pressure exceeds the capillary pressure of the water, the NAPL can move through the capillary. If the entry pressure is not exceeded, then the NAPL will be trapped within the capillary, where it may stay for an indefinite period. Capillary pressure is a measure of the ability of the rock to pull in the wetting fluid (water) and to repel the non-wetting fluid (NAPL). The greater the capillary pressure, the greater the potential for residual saturation (i.e., trapped NAPL). The smallest pores have the highest capillary pressure and the largest pores have the lowest capillary pressure. As a result, the capillary pressure increases as the grain size decreases (i.e., sand, silt, clay) or as the openness of the fractures decreases (i.e., sandstone, siltstone, shale). The soils and bedrock at the Site exhibit a heterogeneous, irregular distribution of grain size within the unconsolidated residual soils and the weathered bedrock, and fractures within the weathered bedrock and the fresh bedrock. As discussed previously (Subsection 4.4.4), the weathered bedrock is saturated and appeared to have a higher storativity that the fresh bedrock; therefore, it is anticipated that most of the contaminant mass will be concentrated in the weathered bedrock. This does not preclude the possibility that some NAPLs may have migrated into the fresh bedrock.

4.4.8.3 Non-Aqueous Phase Transport

Transport mechanisms for non-aqueous phase liquids depend on whether or not the liquids are lighter or denser than water. Light non-aqueous phase liquids (LNAPL) float on top of the water table. LNAPLs are expected to migrate in the direction of groundwater flow potential, but at a rate slower than groundwater flow. Dense nonaqueous-phase liquids (DNAPL) are heavier than water and are expected to migrate downward through the saturated medium toward the bottom of an aquifer or water-bearing unit. DNAPL migration is based on gravity, total mass of fluid and available pathway, and is independent of the groundwater flow potential.

4.4.8.4. Dissolved-Phase Transport

Each of the organic substances reported in Site groundwater dissolves in water to some extent (Table 4-1). Water containing dissolved-phase substances are expected to migrate in the direction of groundwater flow potential, but at a rate slower than groundwater flow. The differences between the rate of dissolved-phase migration and groundwater flow are related to the organic carbon sorption coefficients (K_{oc}), which range from 2.17 to 6.52 (Table 4-1). Migration of compounds with low K_{oc} values such as 2-chlorophenol (K_{oc} = 2.17), will be more similar to the groundwater flow than will be migration of compounds with high K_{oc} values such as 2,3,7,8-TCDD (K_{oc} = 6.52). As described in Subsection 4.2, the presence of some organic compounds in the dissolved phase will increase the solubility of some other less soluble compounds. The extent of this type of co-solvency is not known for conditions or compounds at this site; however, this is only expected to be significant when there are high concentrations of dissolved-phase organic compounds.

Some site-related compounds were reported in samples collected from MW-89 and MW-94 which are located near the eastern side of the Site. The concentrations of site-related compounds in samples from the wells located near the eastern side of the Site were much lower than the concentrations reported in samples from wells located inside the central process area (Subsection 3.4.4 of the Phase I RI report). The profiles of the dissolved-phase compounds reported in the samples from wells near the boundary show a selective, rapid decrease in concentration. The concentrations for herbicides, tetrachlorobenzene, and 2,3,7,8-TCDD appear to decrease the most and drop by more than two orders of magnitude between the wells in the central process area and those near the eastern boundary. The decrease in concentrations is systematic such that the concentrations are most attenuated for the compounds with the highest molecular weights and lowest solubilities. This attenuation is consistent with that expected from flow of dissolved-phase compounds through a porous or complexly fractured medium (e.g., the elution order of a gas chromatographic analysis). The rapid decrease in concentrations of site-related compounds in areas along strike with areas in the central process area is consistent with the low transmissivities and low hydraulic gradients within water-bearing and confining units (Subsection 3.3.4.3). This suggests that horizontal contaminant migration occurs at a low rate and that the concentration gradient near the migration front is sharp. A comparison of the results for samples collected from MW-93 with results for MW-91, MW-92, and MW-94 also shows a similar reduction in concentrations of high molecular weight, low solubility compounds. Because these wells penetrate similar strata (Subsections 2.3.2.1 and 3.3.2.3; WESTON, 1992b) and are hydraulically connected (Subsections 2.3.6.4 and 3.3.3.3.7; WESTON, 1992b), it appears that the vertical migration front is also sharp. A schematic diagram showing the relationships among MW-91, MW-92, and MW-93 is presented in Figure 4-4. The hydrogeologic aspects of this model are representative of other water-bearing units at this Site, based on available data.

4.4.9 Groundwater Summary

The hydrogeology of the contaminated groundwater at the Vertac Site is complex because of the varying lithologies of the Atoka Formation rocks and hydraulic conductivities of the water-bearing and confining units of the Atoka Formation and the geographic distribution of contamination. Most contamination at the Site originated within the central process area. The bulk of the groundwater contamination exists within the unconsolidated and consolidated weathered bedrock hydrologic zones within the central process area. NAPL and dissolved phase contamination also exists within the fresh bedrock hydrologic zone. Contamination has the potential to migrate from central process area, away from the groundwater divide (Figure 4-3).

To the east of the groundwater divide, groundwater in the water-bearing and confining units of the Atoka Formation has the potential to move to the eastward along the line of formation strike. This may be a potential problem as silvex is present in MW-94 at a concentration of about 0.0038 ppm, which is, however, below the federal drinking water maximum contaminant level for that compound (0.050 ppm). These concentrations were measured in samples collected from MW-94 during pumping of MW-92. These results are expected to be representative of current groundwater conditions in the area of MW-94. It should be noted that a survey of groundwater use (Subsection 2.4.2.2; WESTON, 1992b) did not identify any users of water from the Atoka Formation within 2 miles east of the Site. Based on these data, it appears that some contaminated groundwater may have migrated beyond MW-94, which is about 250 feet west of the Vertac property line. Current data indicate that the contamination in this area exists only in the dissolved phase. The contaminant concentrations are relatively low and are below U.S. EPA's primary maximum contaminant levels in drinking water.

MW- 72	
2-Chlorophenol	0.068 ppm
4-Chlorophenol	0.12 ppm
2,4-Dichlorophenol	0.37 ppm
2,6-Dichlorophenol	0.11 ppm
2,3,6-Trichlorophenol	0.01J ppm
2,4,5-Trichlorophenol	0.18 ppm
2,4,6-Trichlorophenol	0.11 ppm
2,4-D	2.3 ppm
2,4,5-T	0.46J ppm
Toluene	2.1J ppm
2,3,7,8-TCDD	3 ppt
Total Organic Carbon	13.2 ppm

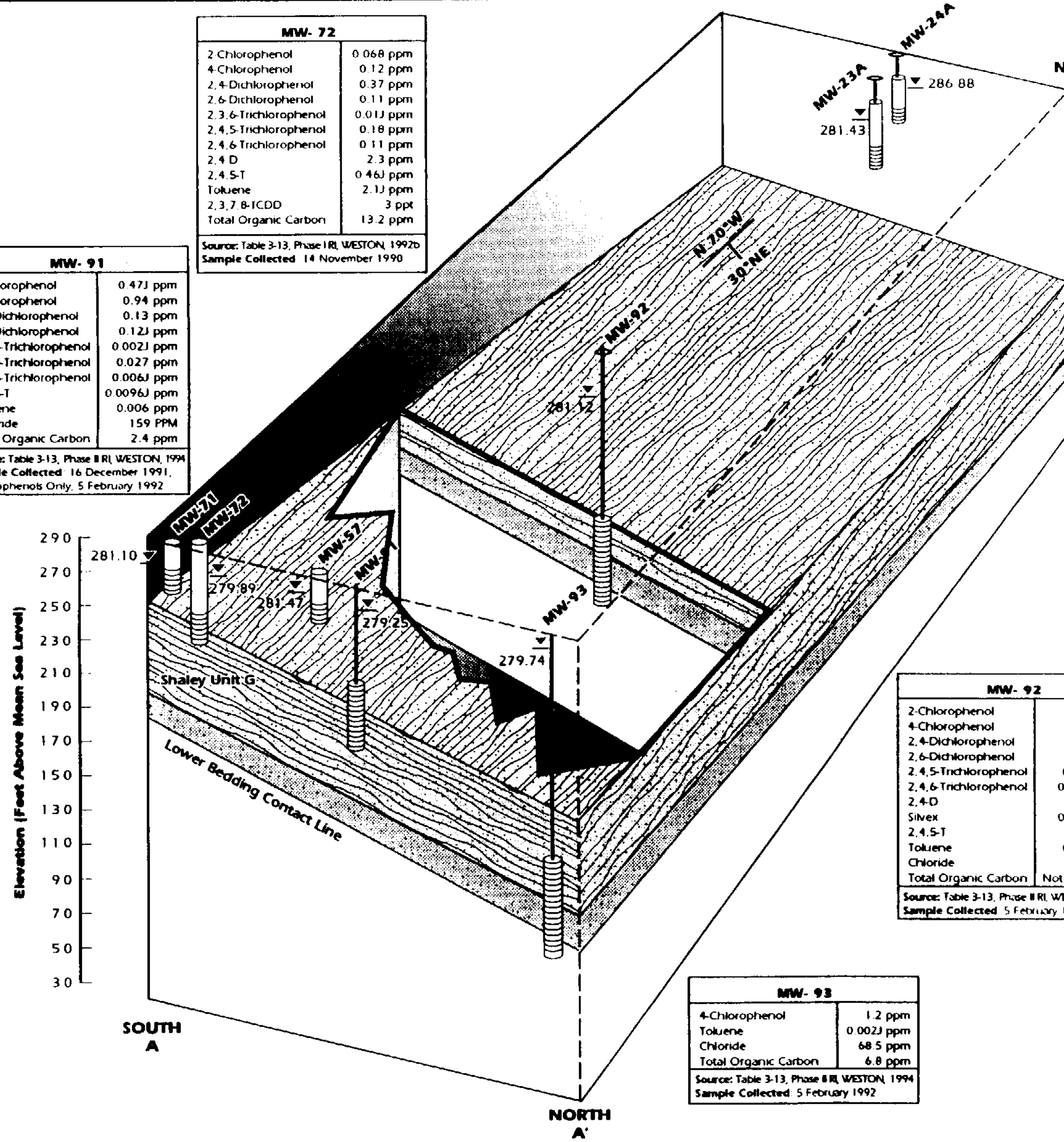
Source: Table 3-13, Phase I RI, WESTON, 1992b
Sample Collected 14 November 1990

MW- 91	
2-Chlorophenol	0.47J ppm
4-Chlorophenol	0.94 ppm
2,4-Dichlorophenol	0.13 ppm
2,6-Dichlorophenol	0.12J ppm
2,3,6-Trichlorophenol	0.002J ppm
2,4,5-Trichlorophenol	0.027 ppm
2,4,6-Trichlorophenol	0.006J ppm
2,4,5-T	0.0096J ppm
Toluene	0.006 ppm
Chloride	159 PPM
Total Organic Carbon	2.4 ppm

Source: Table 3-13, Phase II RI, WESTON, 1994
Sample Collected 16 December 1991, Chlorophenols Only, 5 February 1992

MW- 23A	
Phenol	0.82 ppm
2-Chlorophenol	5.94 ppm
4-Chlorophenol	3.96 ppm
2,4-Dichlorophenol	146 ppm
2,6-Dichlorophenol	19.7 ppm
2,4,5-Trichlorophenol	43.8 ppm
2,4,6-Trichlorophenol	9.6 ppm
2,4-D	270 ppm
2,6-D	320 ppm
Silvex	12 ppm
2,4,5-T	31 ppm
2,4,6-T	78 ppm
Toluene	195 ppm

Source: Hercules Incorporated, Personal Communications, 1990; Appendix D, Phase I RI, WESTON 1992b
Sample Collected 13 October 1993



MW- 92	
2-Chlorophenol	2.1 ppm
4-Chlorophenol	3.9 ppm
2,4-Dichlorophenol	1.3 ppm
2,6-Dichlorophenol	1.1 ppm
2,4,5-Trichlorophenol	0.31 ppm
2,4,6-Trichlorophenol	0.14J ppm
2,4-D	14 ppm
Silvex	0.44J ppm
2,4,5-T	1.1 ppm
Toluene	0.72 ppm
Chloride	114 ppm
Total Organic Carbon	Not Reported

Source: Table 3-13, Phase II RI, WESTON, 1994
Sample Collected 5 February 1992

MW- 93	
4-Chlorophenol	1.2 ppm
Toluene	0.002J ppm
Chloride	68.5 ppm
Total Organic Carbon	6.8 ppm

Source: Table 3-13, Phase II RI, WESTON, 1994
Sample Collected 5 February 1992

Legend

Interbedded Siltstone, Shale and Sandstone (Shaley Unit G)

Sandstone

Monitoring Well Construction

Screened Interval
Open Hole Interval

MW-71 Monitoring Well Location and Number

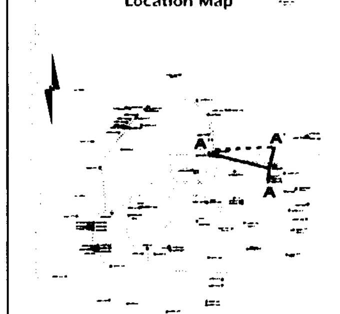
279.94 Water Level Elevation, Elevation in Feet Above Mean Sea Level

N 70°W 30°NE Strike and Dip of the Atoka Formation

NOTE: Water Level Elevation Data Collected on 19 February 1992 by Hercules Site Personnel. Analytical Data From Round 1, 16 December 1991 and 5 February 1992. Concentrations Reported in Parts Per Million (ppm) or Parts Per Trillion (ppt)

J = Estimated Concentration

Location Map



60 Vertical 0 Horizontal 100
Scale in Feet

FIGURE 4-4
SCHEMATIC DIAGRAM OF THE WATER-BEARING UNIT TESTED, PUMPING TESTS 3 AND 4 ATOKA FORMATION PHASE II REMEDIAL INVESTIGATION VERTAC SITE, JACKSONVILLE, AR

94P-4459 8/4/94

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West of the groundwater divide, the groundwater flow potential is westward toward Rocky Branch Creek. Shallow groundwater west of the divide is intercepted by the french drain system. On the west side of Rocky Branch Creek, the eastward directed hydraulic gradients prevent any westward migration of site-related contaminants. The groundwater divide that bisects the central process area is related to topography. The divide may dissipate at an unknown depth beneath the Site. Groundwater monitoring wells completed at the Site provide sufficient geographic coverage to assess the horizontal extent of target organic compounds in the shallow and intermediate depth groundwater zones on the site. These wells indicate that target organic compounds found in the weathered Atoka Formation within the central process area are contained on the Site and have affected onsite groundwater quality. Some low levels of dissolved-phase contaminants were found in boundary monitoring wells in the weathered and fresh bedrock. These indicate that some low levels of contamination may have migrated to the eastern property line. The vertical profile of target organic compounds suggests that concentrations are generally lower at depth. The vertical extent of contamination has not been fully determined particularly within the central process area where some DNAPLs may be present. It is anticipated, however, that the eastward migration of dissolved phase contamination, even at a substantial depth below land surface, would be detected by the current boundary monitoring network.

SECTION 5

RECOMMENDATIONS

This section recommends specific activities that would further minimize potential for exposure or migration of site-related contaminants:

Activities recommended here are considered interim remedial measures (IRMs) and are as follows:

- Continue the long-term groundwater extraction pilot test in either MW-23A or MW-92 to establish hydraulic control within a selected stratigraphic package. Attempts will be made to minimize the amount of drawdown in areas where DNAPLs potentially could be mobilized to minimize the potential for further migration.

- Evaluate "low-purge" techniques in selected boundary wells to minimize potential for migration of dissolved-phase or non-aqueous phase liquids as a result of purging the wells prior to collecting groundwater samples.

- Conduct a long-term groundwater extraction pilot test in MW-78 or MW-63 to establish hydraulic control within a selected stratigraphic package.

SECTION 6

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