DRAFT FINAL

SITE INVESTIGATION REPORT ADDENDUM

for the

Open Burn/Open Detonation Area
Fort Riley, Kansas

Prepared for

United States Army Engineer District, Kansas City
CENWK-EP-EA
601 East 12th Street
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LIST OF ACRONYMS

AA	Atomic Absorption
amsl	above mean sea level
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
CEMRK	Corps of Engineers, Missouri River Division, Kansas City District
CENWK	Corps of Engineers, Northwest Division, Kansas City District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEH	Directorate of Engineering and Housing
DES	Directorate of Environment and Safety
DNAPL	Dense Non-Aqueous Phase Liquid
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
FFA	Federal Facility Agreement
FR	Fort Riley
HPLC	High Performance Liquid Chromatography
IAG	Interagency Agreement
ICP/MS	Inductively Coupled Plasma/Mass Spectroscopy
IDW	Investigation Derived Waste
IWSA	Installation Wide Site Assessment
J	Estimated concentration
KAR	Kansas Administrative Regulations
KDHE	Kansas Department of Health and Environment
KSWQS	Kansas Surface Water Quality Standards
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
NA	Not Analyzed
NAD 83	North American Datum of 1983
NAp	Not Applicable
ND	Not Detected
NPL	National Priorities List
OB/OD	Open Burn/Open Detonation
PAOC	Potential Areas of Concern
PCE	Tetrachloroethylene or Perchloroethylene
PID	Photoionization Detector
PP	Priority Pollutant
QCSR	Quality Control Summary Report
RCRA	Resource Conservation and Recovery Act
RDX	Cyclo-1,3,5-trimethylene-2,4,6-trinitramine
SAP	Sampling and Analysis Plan
SB	Soil Boring

LIST OF ACRONYMS (Continued)

SD	Sediment
SDWA	Safe Drinking Water Act
SI	Site Investigation
SIRA	Site Investigation Report Addendum
SS	Surface Soil
SVOCs	Semi-Volatile Organic Compounds
SW	Surface Water
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TNT	Trinitrotoluene
TPH	Total Petroleum Hydrocarbons
USC	United States Code
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
VOCs	Volatile Organic Compounds

EXECUTIVE SUMMARY

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The United States Army Corps of Engineers, Northwest Division, Kansas City District (CENWK), under contract DACA41-92-D-0001, retained Louis Berger & Associates, Inc. (Berger) in support of the Fort Riley Directorate of Environment and Safety, Installation Restoration Program, to perform an Site Investigation (SI) at the Open Burn/Open Detonation (OB/OD) Area at Fort Riley, Kansas.

The OB/OD Area is located due north of the Main Post on Range 16 on the southern part of the Impact Area, approximately 2,300 feet north of Vinton School Road. The site lies on the Fort Riley NE, Kansas USGS 7.5 minute quadrangle in the Northeast quarter, Section 33, Township 10 south, Range 6 east. Since 1941, the site was used for ordnance disposal by open detonation and open burning. Burning is no longer conducted at the site.

The High Priority Sites Site Investigation (SI) (CEMRK, 1994) was initiated in September 1993, and included the OB/OD Area as one of the High Priority Sites. A Site Investigation (SI) of the OB/OD Area, which included geophysics, soil gas sampling, and groundwater sampling, was performed in September-October 1993. Groundwater sampling was again conducted in December 1995 as part of the confirmation groundwater sampling at Multiple Sites (CEMRK, 1996a).

Based on the findings of these previous investigations at the OB/OD Area, it was determined that further site investigation (SI) activities were required based on the presence of chlorinated solvent contaminants. The objectives of these SI activities were:

- to evaluate the possible source and extent of contamination;
- to evaluate whether any other contaminants at the site are co-contaminants with the chlorinated solvent; and
- to clarify the local geology and movement of water within the different formations that underlay this site.

The approach for the SI is documented in the *Draft Final Sampling and Analysis Plan (SAP) for the Supplemental Site Investigation at the Open Burn/Open Detonation Area, Fort Riley, Kansas* (CENWK, 1997a). Access to the OB/OD Area is restricted because it is used for military training. As a result, the following SI field activities had to be conducted in a series of events during inactive periods at the site:

- a preliminary investigation (Mobilization #1) which included installation of four monitoring wells;
- a passive soil gas demonstration test;
- an investigation for further characterization of hydrogeologic conditions and extent of contamination (Mobilization #2) which included installation of five piezometer nests; and,

- groundwater monitoring, including monthly water level measurements and quarterly sampling and analysis.

The purpose of this *SI Report Addendum* (SIRA) is to supplement the *Site Investigation Report for High Priority Sites at Fort Riley, Kansas* (High Priority Sites SI) (CEMRK, 1994) by presenting a summary of previous investigations, the 1997 SI activities, and a site characterization based on the evaluation and interpretation of the results of those investigations.

To provide a preliminary basis for comparison to the identified levels of contamination at the site, the following potential ARARs were evaluated and used in this report as appropriate to provide comparative chemical-specific levels:

- The State of Kansas Surface Water Quality Standards (KSWQS) (KAR 28-16-28b);
- The Federal Safe Drinking Water Act (SDWA) (42 USC 300) and Amendments of 1996 (42 USC 201) National Primary Drinking Water Regulations (40 CFR 141); and,
- The Federal Clean Water Act (33 USC 1251-1375) and Federal Surface Water Quality Requirements (40 CFR 131).

Quantitative Maximum Contaminant Levels (MCLs) have been established pursuant to the SDWA and the National Primary Drinking Water Regulations for numerous chemicals. MCLs are sometimes used at CERCLA sites as action levels if groundwater or surface water at or near the contaminated site is reasonably expected to migrate and adversely affect a drinking water supply system in the future. This is not the case for the OB/OD Area, however, because no threatened water supply systems exist in the vicinity of the OB/OD Area. Nonetheless, because they are incorporated by reference into the KSWQS for surface waters which are designated as a current or potential future water supply source, and because they represent one of the few available and generally accepted chemical-specific standards, MCLs are used throughout this report to provide a conservative risk-based comparison and frame of reference when presenting and evaluating the identified levels of aqueous contamination associated with the OB/OD Area. This is not intended to imply, however, that MCLs have been established as the applicable numeric regulatory criteria for the OB/OD Area. The ultimate applicability of any regulatory requirements are determined subsequent to the SI stage of the CERCLA process.

The results of the environmental investigations indicate that low levels of chlorinated solvents, predominantly TCE, are present in the groundwater beneath the site. The highest concentration of TCE detected in the groundwater is two orders of magnitude below the concentration which would indicate the presence of any residual product, but does exceed the MCL for TCE (5 µg/l). Due to the long period of site use and the low levels of contamination identified, it is difficult to identify the exact location where the contaminants may have been released. The identified groundwater contaminants may be the result of several small sporadic releases which occurred at various locations within the area over the period of site activity. However, based on the distribution of the TCE and the direction of groundwater flow, the contaminants were released somewhere within the active and/or historical open burn/open detonation areas bounded by the subject investigations.

In general, the bedrock units (alternating layers of limestone and shale) beneath the OB/OD Area are flat-lying with relatively uniform thicknesses. As a result, elevation becomes a good indicator of stratigraphic position. Based on the bedrock geologic map from the investigation data and published information, the demo pits and the North Burn Pit are situated on the Blue Springs Shale while the South Burn Pit is located on the Wymore Shale. Much of what directly underlies these areas is overburden and weathered bedrock derived from these formations.

After being released to the ground, the small quantities of TCE would have migrated downward through the soil column to the water table via gravity drainage and precipitation infiltration. The concentrations were low enough that the TCE dissolved and moved with the flow of groundwater (as opposed to being dense non-aqueous phase liquid [DNAPL] that would sink).

Although some seepage through the shale formations may occur, it is considered to be of much less importance since the limestone units contain the zones which would much more readily transport groundwater. The affected limestone units beneath the OB/OD Area are the Kinney, Schroyer/Havensville, and the Threemile.

Contaminants released above the Kinney limestone were dispersed with the groundwater flow in this formation coming out of the higher land to the north. This moved some contaminants slightly to the east but also to the west via the spring at the base of the Kinney. The discharge from the spring continues to the west, infiltrating into the overburden underlying the mesic area. The contaminants dispersed in other directions in the Kinney and some also may have seeped downward through the Wymore Shale to the underlying water-bearing zone of the Schroyer limestone and upper portion of the Havensville Shale. The Schroyer/upper portion of the Havensville is also the first water-bearing zone to receive contaminants that may have been released at the South Burn Pit.

The highest concentration of TCE onsite (570 µg/l) is identified in the Schroyer/upper portion of the Havensville. In this unit, the contaminants also migrate with the primary flow of groundwater. The flow is generally towards the intermittent stream to the west. Consistent with the regional structural geology, this intermittent stream is interpreted to be the trace of a vertical joint which is providing a drainage path for the groundwater in this zone. Smaller layers within the water-bearing zone flow more to the northwest or the southwest depending on where the joint is best developed in contact with that layer. The vertical joint may also provide a potential pathway for some groundwater and contaminants to migrate down to the underlying Threemile limestone. In addition, some downward seepage through the Havensville Shale may also occur. The limited nature of this downward flow is evidenced by the TCE concentrations being one to two orders of magnitude lower in the Threemile Limestone.

Human exposure potential is minimal. Human receptors within a 1-mile radius of the site are limited to personnel of the OB/OD Area during OB/OD activities and Army personnel in areas adjacent to the OB/OD Area. These receptors are considered transient since their access is strictly controlled and they only use the areas on a limited and intermittent basis. Surrounding land use consists of military training grounds to the south, an artillery and mortar impact area to the north. There are leased croplands about three miles to the southeast and southwest, and leased haylands south of Vinton School Road. Wildlife food plots are located within one mile southwest. With rare exception, access to the OB/OD Area is restricted to EOD personnel, which only enter the area to perform disposal.

The greatest potential for exposure to the groundwater contamination at the OB/OD Area is at the spring adjacent to the North Burn Pit (Figure 1-2). This spring is flowing most of the time and the water contains concentrations of TCE in the 100 to 300 µg/l range. Exposure of the spring to potential ecological receptors is possible as footprints of various indigenous wildlife (deer, etc.) were observed onsite. It is possible that wildlife present on the OB/OD Area are drinking from this spring. The intermittent streams are dry most of the time, so this spring is usually the only surface water on the OB/OD Area.

A mesic (commonly moist, intermittently wet) area approximately 700 feet by 600 feet in size (10 acres) is located between the spring and the intermittent stream along the western side of the site. This area is not listed as a wetland on the USGS 7.5 minute topographic quadrangles, the Fort Riley installation map prepared by the Defense Mapping Agency, or the National Wetlands Inventory. This area is usually not saturated. Any water that may appear is likely to be from surface runoff. During periods of high water table, however, it is possible that some of the water may be from the groundwater in the underlying overburden (which, like the spring, may have TCE concentrations in the 100 to 300 µg/l range). When wet, this area could present another exposure potential for ecological receptors.

The intermittent streams located to the east and west of the OB/OD Area are usually dry and, therefore, do not usually pose an exposure potential to human or ecological receptors. These intermittent streams join about 1,000 feet south of the southern site boundary. This single tributary continues south another 2,000 feet where it joins Threemile Creek. From this point, Threemile Creek flows southeast and joins the Kansas River at the west side of Camp Funston. There are no perennial streams within one mile downstream of the site and no known uses of surface water as potable water within 15 miles downstream of the site.

The groundwater withdrawal well nearest to the OB/OD Area is located at Range 18 approximately 4,220 feet to the east-southeast of the site. This well is only used at the Range 18 maintenance facility for non-potable purposes. No other wells fall within the one-mile radius of the OB/OD Area. The next nearest wells are the Ogden supply wells located approximately 3 miles southeast of the site. There is no realistic potential for exposure to the site groundwater contamination via extraction from production wells.

1.0 INTRODUCTION

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The United States Army Corps of Engineers, Northwest Division, Kansas City District (CENWK), under contract DACA41-92-D-0001, retained Louis Berger & Associates, Inc. (Berger) in support of the Fort Riley Directorate of Environment and Safety, Installation Restoration Program, to perform a Site Investigation (SI) at the Open Burn/Open Detonation (OB/OD) Area at Fort Riley, Kansas.

On 14 July 1989, the United States Environmental Protection Agency (EPA) proposed inclusion of Fort Riley on the National Priorities List (NPL), and listed the installation on the NPL in August 1990, pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The U.S. Department of the Army - Fort Riley, the KDHE and the USEPA entered into a Federal Facility Agreement (FFA) (also referred to as the Interagency Agreement [IAG]) -- Docket No. VII-90-F-0015, to address environmental releases subject to CERCLA. The IAG, which became effective in June 1991, required Fort Riley to conduct a systematic site assessment to identify all potential areas of concern (PAOC) at Fort Riley. The systematic site assessment was performed in 1992, with the results presented in the Installation Wide Site Assessment (IWSA) (CEMRK, 1993a). The IWSA identified 24 groupings of PAOCs consisting of over 45 individual PAOCs. Subsequent to the IWSA, site investigations were planned for three groupings of sites. An SI for the first group, the Sensitive-Receptor lead sites, was initiated in June 1993. The Sensitive-Receptor Lead sites were later incorporated into the second group, the High Priority sites. The remaining sites identified in the IWSA as requiring further investigation, known as "Other Sites", were included in the "Other Sites" SI program which was initiated in March 1994. A Site Investigation (SI) of the OB/OD Area, which included geophysics, soil gas sampling, and groundwater sampling, was performed in September-October 1993. Groundwater sampling was again conducted in December 1995 as part of the confirmation groundwater sampling at Multiple Sites (CEMRK, 1996a).

1.1 Purpose

The finding that prompted extension of the site investigation under CERCLA at the OB/OD Area is the presence of chlorinated solvents in two of the monitoring wells (OB-93-03 and OB-93-04). The elevated levels of chlorinated solvents, along with the discovery of a somewhat complex site hydrogeology (a near-surface water table seeming to be in two independent saturated bedrock formations, with possible groundwater divides in the area), dictated that further investigations be performed to identify contaminant source location and potential migration paths. In contrast to the chlorinated solvents, the types of contaminants originally suspected to be a potential problem (e.g., traces of explosives) are not currently considered to be a problem based upon discussions held 20 July 1995 with the EPA Region VII and Kansas Department of Health and Environment (KDHE) (Berger, 1995).

Based on this information, it was decided by Fort Riley, KDHE, and EPA to further characterize the nature and extent of contamination at the OB/OD Area. The purpose of this SI Report Addendum is therefore to supplement the *Site Investigation Report for High Priority Sites at Fort Riley, Kansas* (High Priority Sites SI) (CEMRK, 1994) for the OB/OD Area in particular by presenting a summary of previous site investigations, the 1997 SI activities, and a site characterization based on the evaluation and interpretation of the results of those investigations.

1.2 Supporting Documents

Section 1.4 of the *Draft Final Site Investigation for High Priority Sites at Fort Riley, Kansas* (CEMRK, 1994) lists supporting documents, which included information or procedures that were used during the *High Priority Sites SI*. These documents, including both planning documents and those related to previous investigations, pertain to this SI Report Addendum. In addition, the following documents support these further investigations:

- *Quality Control Summary Report* (QCSR) *Confirmation Groundwater Sampling at the Multi-Sites, Fort Riley, Kansas*, February 1996 (CEMRK, 1996a).
- *Data Summary Report (DSR) for Confirmation Groundwater Sampling, OB/OD, Fort Riley, Kansas*, June 1996 (CEMRK, 1996b).
- *Draft Final Sampling and Analysis Plan for Supplemental Site Investigation at the Open Burn/Open Detonation Area, Fort Riley, Kansas*, 10 April 1997 (CENWK, 1997a)
- *Quality Control Summary Report (QCSR), Supplemental Site Investigation, Open Burn/Open Detonation Area, Fort Riley, Kansas*, November 1997 (CENWK, 1997b).
- *Technical Memorandum, Overview of Mobilization #1 Preliminary Findings and Proposed Mobilization #2 Activities Open Burn/Open Detonation Area, Fort Riley, Kansas*, 30 May 1997 (CENWK, 1997c).
- *Technical Memorandum, Mobilization #2 Activities Open Burn/Open Detonation Area, Fort Riley, Kansas*, 22 August 1997 (CENWK, 1997d).
- *Supplemental Technical Memorandum, Mobilization #2 Activities Open Burn/Open Detonation Area, Fort Riley, Kansas*, 4 November 1997 (CENWK, 1997e).
- *Quality Control Summary Report, Supplemental Site Investigation, Open Burn / Open Detonation Area, Fort Riley, Kansas*, February 1998 (CENWK, 1998a).
- *Draft Data Summary Report, Groundwater Monitoring, Open Burn/Open Detonation Area, Fort Riley, Kansas,* February 1998 (CENWK, 1998b).

1.3 Scope and Objectives

The objective of an SI is to gather information to support a site decision regarding the need for further action. To assist in making such decisions, the SI data are compared to comparative regulatory or risk-based standards as a means to evaluate the potential for adverse impact to human health or the environment. More specifically, the objectives of the SI at OB/OD Area were to:

- evaluate the possible source and extent of contamination;
- evaluate whether any other contaminants at the site are co-contaminants with the chlorinated solvent; and
- clarify the local geology and movement of water within the different formations that underlay this site.

The investigation approach for the SI is documented in the *Draft final Sampling and Analysis Plan (SAP) for the Supplemental Site Investigation at the Open Burn/Open Detonation Area, Fort Riley, Kansas* (CENWK, 1997a). Access to the OB/OD Area is highly restricted because it is used for military training. As a result, the following SI field activities were conducted in a series of events during inactive periods at the site, rather than being performed all at one time:

- a preliminary investigation (Mobilization #1) which included installation of four monitoring wells;
- a passive soil gas demonstration test;
- an investigation for further characterization of hydrogeologic conditions and extent of contamination (Mobilization #2) which included installation of five sets of vertically nested piezometers; and,
- groundwater monitoring, including monthly water level measurements and quarterly sampling and analysis.

1.4 OB/OD Area

Presented below is the site description and operations history for the OB/OD Area.

1.4.1 Site Description

The OB/OD Area is located on Range 16 on the southern part of the Impact Area, approximately 2,300 feet north of Vinton School Road, as shown in Figures 1-1 and 1-2. The site lies on the Fort Riley NE, Kansas USGS 7.5 minute quadrangle (USGS, 1992) in the Northeast quarter, Section 33, Township 10 south, Range 6 east. The location of the site based on the survey of piezometer PZ-97-11 is Universal Transverse Mercator (UTM), Zone 14, North American Datum of 1983 (NAD 83) (x=693343, y=4334939) which is approximately latitude 39° 08' 31.88" and longitude 96° 45' 46.16". The active portion of the site consists of an area approximately 1,000 feet by 350 feet. The site is located on gently sloping ground that is bordered on the north by a hill. The relief between the OB/OD Area and the top of the hill is approximately 50 feet. The land north of the OB/OD Area is part of the Impact Area for the surrounding training ranges. A mesic area is located along the western boundary of the site. Open vacant fields surround the remainder of the site. For purposes of this SI, the OB/OD Area refers to the entire area shown in Figure 1-2 bounded on the east and west by southerly flowing intermittent streams.

As shown in Figure1-2, the OB/OD Area lies between two tributaries to Threemile Creek. Both are intermittent streams. A mesic (commonly moist, intermittently wet) area approximately 700 feet by 600 feet in size (10 acres) is located between the OB/OD Area and the west tributary to Threemile Creek. This area is not listed as a wetland, however, on the USGS 7.5 minute topographic quadrangles, the Fort Riley installation wetlands map prepared by the Defense Mapping Agency, or the National Wetlands Inventory. The tributaries located to the east and west of the site join about 1,000 feet south of the southern site boundary. This single tributary continues south another 2,000 feet where it joins Threemile Creek. From this point, Threemile Creek flows southeast and joins the Kansas River at the west side of Camp Funston. of the site join about 1,000 feet south of the southern site boundary. Surface water runoff from the active area is to the south and west, towards the intermittent stream located to the west. As stated in section 4.5 of the *Draft Final Site Investigation for High Priority Sites at Fort Riley, Kansas* (CEMRK, 1994), there are no known uses of surface water as potable water within 15 miles downstream of the site.

Surrounding land use consists of military training grounds to the south, and an artillery and mortar impact area to the north. There are leased croplands about three miles to the southeast and southwest, and leased haylands south of Vinton School Road. Wildlife food plots are located within one mile to the southwest. With rare exceptions (e.g., to perform the subject site investigations), access to the OB/OD Area is constantly restricted to EOD personnel only. Even these personnel only periodically enter the area, whenever there is a requirement to perform ordnance disposals, etc. Human receptors within a 1-mile radius of the site include working personnel during OB/OD activities, and other army personnel in areas adjacent to the OB/OD Area. The potentially affected medium to which these receptors could be exposed is surface water (spring and intermittent streams) when present. These receptors are considered transient, however, since they only use the areas on a limited basis and do not regularly work or live at or near the site.

The nearest groundwater withdrawal well to the OB/OD Area is located at Range 18 approximately 4,220 feet to the east-southeast of the site. This well is only used at the Range 18 maintenance facility for non-potable purposes. No other wells fall within the 1-mile radius. The next nearest wells are the Ogden water supply wells located approximately 3 miles southeast of the site. The nearest residence lies 2.5 miles to the east of the site, on Vinton School Road. The town of Ogden lies between 3 and 4 miles to the southeast of the site (CEMRK, 1994).

1.4.2 History of Operations

The Explosive Ordnance Detachment (EOD) unit at Fort Riley recovers ordnance materials from Fort Riley and from a multi-state area for the Department of Defense and other state and federal agencies. Effective August 1991, the mission of the 74th EOD at Fort Riley, Kansas has been to provide routine and emergency EOD support to military installations, operations, and exercises, and to civilian and federal authorities within its assigned geographical area of operation. This area of operation includes Kansas, Nebraska, parts of Missouri, and parts of South Dakota.

The OB/OD Area is closely controlled. All access to the site is controlled by Range Control, and each visit to the area requires pre-screening and a full-time escort consisting of a qualified Unexploded Ordnance (UXO) contractor. The OB/OD Area includes several pits on the side of a hill, as indicated in Figure 1-2. In the past, ordnance-related materials were burned in the North and South Burn Pits, however, the burn pits are no longer active. Burning last occurred in the North Burn Pit several years ago, according to the 74th Ordnance Company (Explosive Ordnance Disposal), Fort Riley (EOD FR)(Communication with the EOD FR, 5 March 1997).

The 74th EOD Detachment currently performs ordnance disposal by open detonation, and previously by open burning at Range 16 within the Impact Area of Fort Riley. The area currently used for this purpose is approximately 1,000 feet by 350 feet, and has been in use since 1941. Open burning was conducted approximately once per year for ordnance materials containing relatively small amounts of explosives. These include small arms, pyrotechnic rounds, black powder, and phosphorous-based munitions. Open burning was performed at a specific, dedicated location within the OB/OD Area, referred to as the North Burn Pit (open burn pit). This area contained a small pit within the soil on which a metal grating rested. The pit measures approximately 3 feet by 7 feet wide and is surrounded by a horse-shoe shaped embankment extending to approximately 9 feet above the surrounding ground surface. Materials were burned by dousing them with petroleum hydrocarbons (typically diesel fuel), and then igniting them.

Open detonation is the current means of disposal. Detonation is conducted whenever a sufficient amount of materials has been received, typically on a quarterly basis. The quantity of materials to be disposed of varies, but each detonation typically includes 50 to 500 rounds of high explosive and propellant rounds; however, some detonations have included up to 2,000 rounds. The materials are destroyed by detonation. The primary material used for detonation is C4 (91% cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX) and 9% plastic desensitizer [typically wax-like thermoplastic compounds of high molecular weight]) (Davis, 1943). Other materials used for detonation include 2,4,6-trinitrotoluene (TNT) and "flexlinear" (a specific type of RDX; an elongated cutting charge). Open detonation is conducted on the open ground, and this creates crater-like pits in the natural soil of the OB/OD Area. These pits are the result of the detonations and increase in size with use. The EOD also digs pits with a high-loader and/or backhoe. The pits generally reach a maximum size of 10 to 20 feet deep and 25 feet in diameter. Open detonation pits are filled in approximately once per year by backfilling the blast-excavated soil surrounding the pits.

At the time of the SI in 1993, three active detonation pits, one active (north) burn pit, and two metal debris pits (Figure 1-2) were present. During the SI in 1993, a South Burn Pit was identified approximately 300 feet south of the North Burn Pit. No information is available pertaining to the origin or the time of formation of this pit. The pit is circular with a low (approximately 3 to 4 foot high) berm of soil. The inner diameter is approximately 40 feet and the outer diameter is approximately 70 feet.

1.5 Preliminary Evaluation of Regulatory Requirements

In accordance with CERCLA and the NCP, the need to pursue response actions at identified contaminated sites is dictated by the need to be protective of human health and the environment and/or to be in compliance with applicable or relevant and appropriate requirements (ARARs) to the extent that such compliance is practicable. The action threshold for protectiveness is typically determined by performing site-specific human and ecological receptor evaluations and by developing a quantitative baseline risk assessment for receptors which may be adversely impacted by exposure to the contamination. Such evaluations and assessments are not typically performed, however, at the SI stage. Similarly, a detailed ARAR evaluation is not typically performed at the SI stage. Nonetheless, potential ARARs which contain quantitative thresholds are often used at the SI stage (and earlier) to establish a conservative frame of reference with regard to chemical-specific levels of contamination. Based on the confirmed presence of groundwater contamination and the potential for at least transient discharges of site-related contamination to the nearby intermittent streams, the following potential ARARs were evaluated for the purpose of identifying some comparative chemical-specific levels to be used in this report:

- The State of Kansas Surface Water Quality Standards (KAR 28-16-28b);
- The Federal Safe Drinking Water Act (42 USC 300) and Amendments of 1996 (42 USC 201) National Primary Drinking Water Regulations (40 CFR 141); and,
- The Federal Clean Water Act (33 USC 1251-1375) and Federal Surface Water Quality Requirements (40 CFR 131).

The State of Kansas Department of Health and Environment (KDHE) has promulgated Surface Water Quality Standards (KSWQS) which generally provide that: (1) levels of water quality in surface waters of the state shall be maintained at levels which protect existing and designated uses; (2) permanent degradation of existing water quality shall be avoided except where otherwise approved by KDHE based on a showing of important social and economic considerations; and, (3) artificial sources of pollution will not be allowed which result in harmful effects on populations of threatened or endangered species. Numeric water quality criteria are provided for specified pollutants based upon which designated use category a given surface water is placed in, although KDHE reserves the authority to: (1) promulgate more stringent criteria if site-specific conditions warrant it; and, (2) permit temporary sources of pollution producing only ephemeral surface water quality degradation not harmful to existing or designated uses. The most stringent use category is for surface waters which represent an actual or potential drinking water supply source. The numeric water quality criteria established for this use category are the federal Maximum Contaminant Levels (MCLs) for drinking water, which are further described in the following paragraph. The least restrictive designation is found in the requirement that all classified surface water shall be designated for noncontact recreational use and one of the three categories of aquatic life support. In accordance with K.A.R. 28-16-28e(c)(2)(F) the numeric criteria for acute and chronic aquatic life is applicable to these types of surface waters. The ultimate applicability of the KSWQS to the contamination in surface waters at or near the OB/OD Area will depend on a designated use analysis, although it is noted that these surface waters are not currently used for agricultural water supply, domestic water supply, food procurement, groundwater recharge, or industrial water supply. The designated beneficial uses of Threemile Creek are aquatic life support and contact recreation.

The Safe Drinking Water Act (SDWA) is the federal statute which requires the regulation of public water supply systems, including the creation of enforcement powers and penalty provisions. Under the SDWA, a "public water supply system" is defined as a system for the provision to the public of piped water for human consumption if such system includes at least fifteen service connections or regularly serves at least 25 individuals. Based on conservative exposure assumptions and human health risk evaluations for specific chemicals, quantitative Maximum Contaminant Levels (MCLs) have been established pursuant to the SDWA and the National Primary Drinking Water Regulations for numerous chemicals. MCLs are sometimes used at CERCLA sites as action levels if groundwater or surface water at or near the contaminated site is reasonably expected to migrate and adversely affect a drinking water supply system in the future. This is not the case for the OB/OD Area, however, because no threatened water supply systems exist in the vicinity of the OB/OD Area. Nonetheless, because they are incorporated by reference into the KSWQS for surface waters which represent a current or potential future water supply source, and because they represent one of the few available and generally accepted chemical-specific standards, MCLs are used throughout this report to provide a conservative risk-based comparison and frame of reference when presenting and evaluating the identified levels of aqueous contamination associated with the OB/OD Area. This is not intended to imply, however, that MCLs have been established as the applicable numeric regulatory criteria for the OB/OD Area.

The Federal Clean Water Act (CWA) amended the Federal Water Pollution Control Act and is intended to restore and maintain the chemical, physical and biological integrity of the nation's "navigable" waters. The CWA regulates discharges of pollutants from any point source, including both direct point discharges (ditches, culverts, pipes, fill, etc.) and indirect point discharges (via waste water treatment facilities) into navigable waters of the United States. The Federal Surface Water Quality Requirements (40 CFR 131) and the numeric Ambient Water Quality Criteria (AWQC) were developed to evaluate constituents in surface waters for the protection of aquatic life and for the protection of human health from the ingestion of contaminated water and/or organisms. Under the CWA, these criteria are potentially applicable to all U.S. waters as defined therein. The AWQC for the protection of aquatic organisms are based on two types of criteria: (1) acute criteria representing the maximum concentrations permissible at any time; and (2) chronic criteria representing the maximum permissible concentration averaged over a 24-hour time period. The AWQC for the protection of human health are based on the daily ingestion of contaminated water and/or the daily ingestion of contaminated organisms from surface waters. This type of exposure does not occur in the general vicinity of the OB/OD Area.

Table 1-1 lists the relevant chemical-specific regulatory levels obtained from these regulations, to the extent that they were available for the contaminants of potential concern identified for the OB/OD Area. It is noted, however, that establishing site-specific numeric action levels and the ultimate applicability of these (or any other) regulatory requirements is to be determined subsequent to the SI stage of the CERCLA process.

TABLES

Table 1-1 Quantitative Criteria from Preliminary Evaluation of Potential ARARs Chlorinated Solvent Contaminants

Chemical	Ambient Water Quality Criteria (mg/l)				Drinking Water Standards** (mg/l)
	For Aquatic Life		For Human Health		Maximum Contaminant Levels (MCLs)
	Acute	Chronic	Water & Organisms	Organisms Only	
cis-1-2-dichloroethylene	11.6[a]	NAv	NAv	NAv	0.070
Trichloroethylene	45.0[a]	21.9[a]	0.0027[*b]	0.470[*b]	0. 005
Tetrachloroethylene	5.28[a]	0.84[a]	0.0008[*b]	0.00885[*b]	0.005

NAv Not Available.

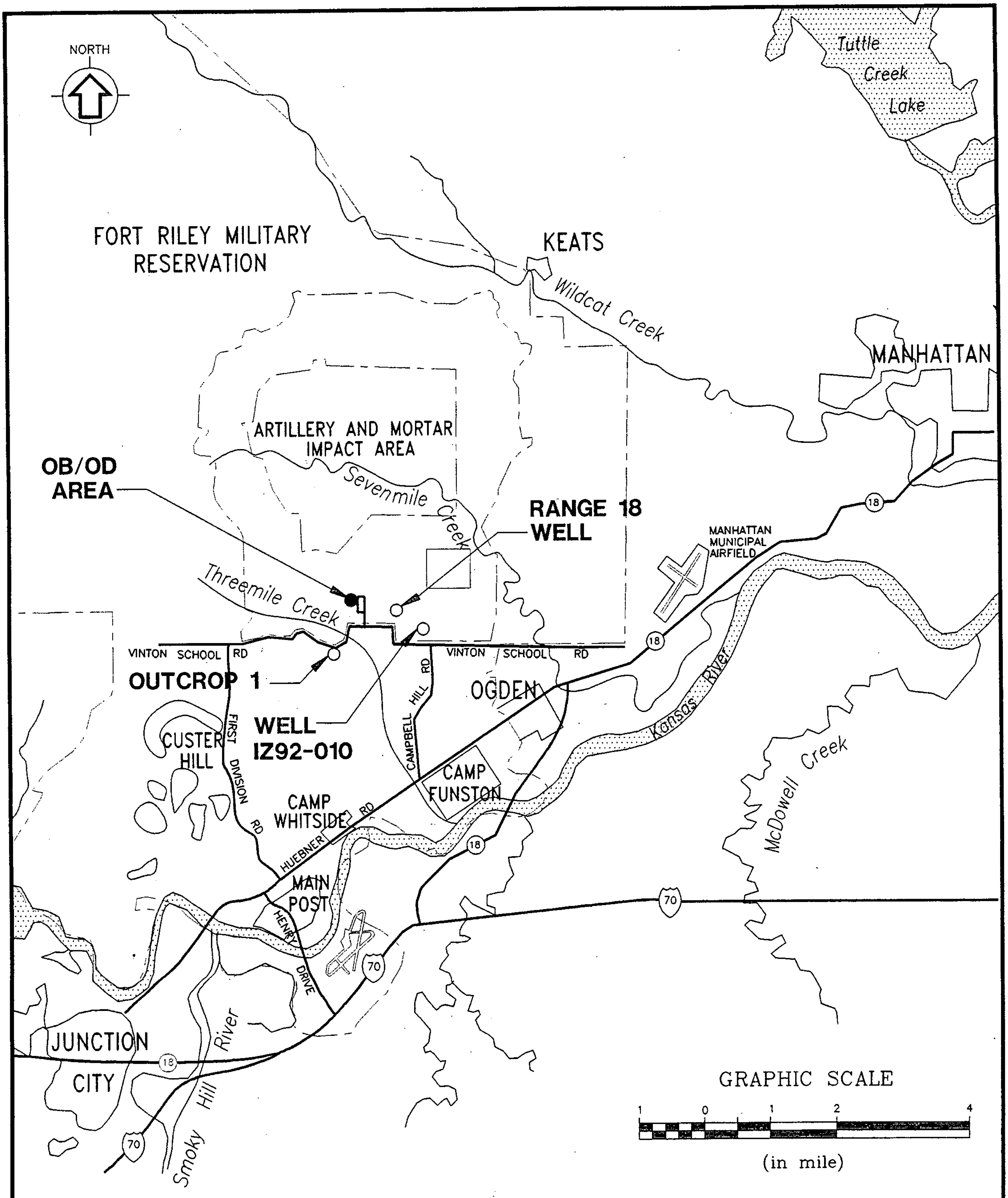
a Insufficient data to develop federal criteria. Value presented is from Kansas Department of Health and Environment, Water Pollution Regulations, adopted KAR 28.16.28e(c)(8)(d) Table 1A, January 1995.

b Federal Quality Criteria for Water - 1986. EPA 440/5-86.001, 1 May, 1987. Human health criteria for carcinogens reported for three risk levels. Value presented is the most conservative (10^{-6}) risk level and is based on conservative daily ingestion scenarios.

* 40 CFR 131.36 - Toxic Criteria for states not complying with Clean Water Act Section 303(c)(2)(B).

** Federal Maximum Contaminant Levels from Drinking Water Regulations, Office of Water, United States Environmental Protection Agency, October 1996. Also adopted as part of the State of Kansas Surface Water Quality Standards, which applies the federal MCLs to surface water bodies with a Use Designation that includes the actual or potential use of the surface waters for domestic drinking water supply purposes. Kansas Department of Health and Environment, Water Pollution Regulations, adopted KAR 28.16.28e(c)(8)(d) Table 1A, January 1995.

FIGURES



NOTE:

RANGE 18 WELL USED FOR NON-POTABLE PURPOSES.

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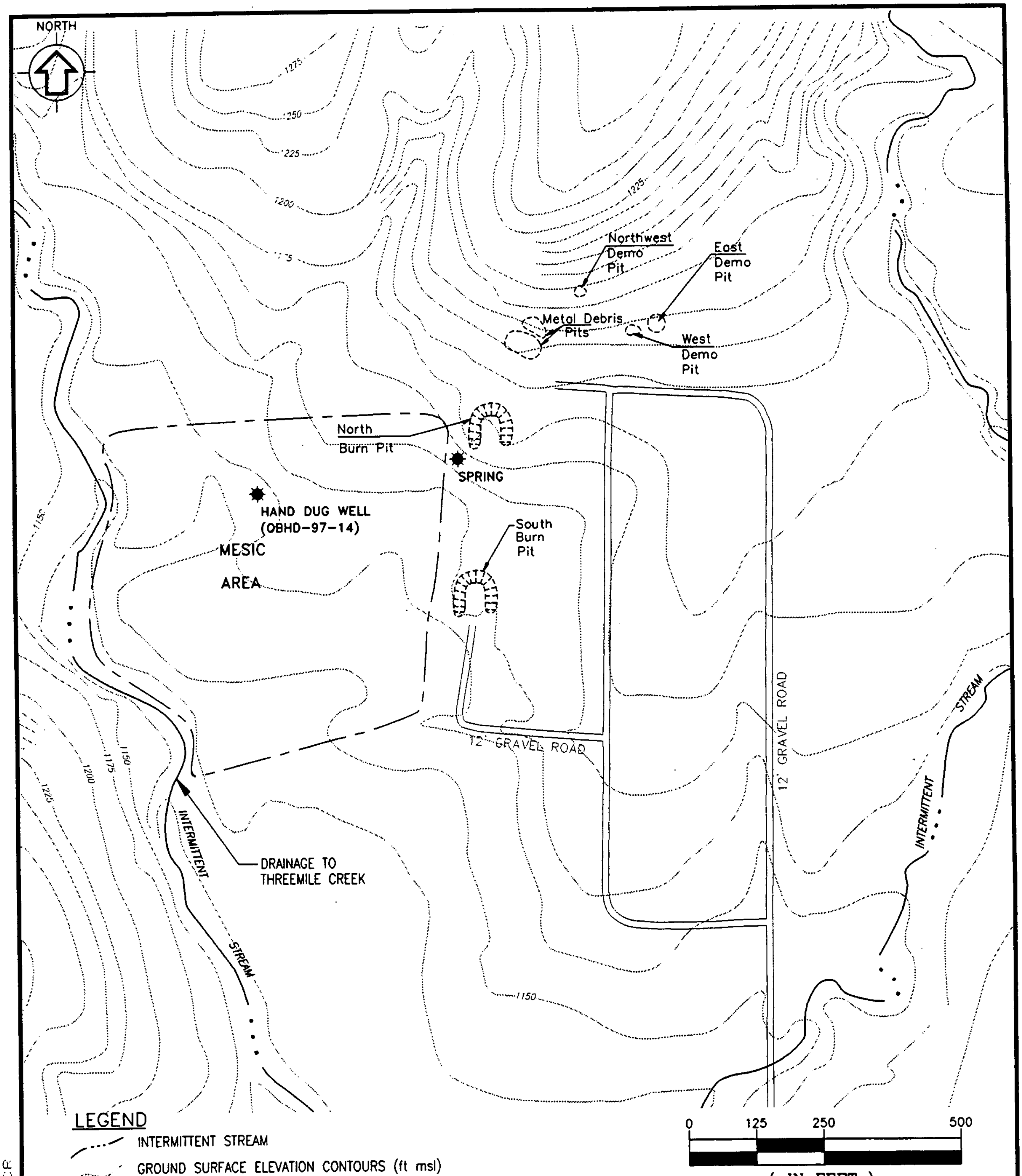
FORT RILEY MILITARY RESERVATION (OB/OD AREA–SIRA)

SITE LOCATION MAP

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 1–1

OB–ODGVM/06AUG98/U4



LEGEND

INTERMITTENT STREAM

GROUND SURFACE ELEVATION CONTOURS (ft msl)

GRAVEL ROAD

● SPRING/HAND DUG WELL

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FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

SITE MAP

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 1-2

OB-OD1/06AUG98/OB-SITE.SCR

2.0 PREVIOUS INVESTIGATIONS

2.0 PREVIOUS INVESTIGATIONS

This chapter presents a summary of the investigations conducted at the OB/OD Area prior to the SI in 1997. The previous investigations discussed in the following subsections are the Impact Area Investigation (1992), the Initial Site Investigation (1993), and the Confirmation Sampling (1995).

2.1 Impact Area Investigation (1992)

An environmental investigation was conducted for the Impact Area as a whole in 1992 (CEMRK, 1993b). The OB/OD Area is located within the Impact Area. The investigation consisted of the installation and sampling of 10 groundwater monitoring wells around the perimeter of the Impact Area and the collection of stream sediment and aqueous samples along intermittent tributaries draining the Impact Area.

The Impact Area analytical results are deemed to be representative of ambient conditions since the OB/OD Area is located within the Impact Area and any contaminants detected in the OB/OD Area may be the result of Impact Area activities. Groundwater and stream samples were collected but no soil samples were collected from the Impact Area as part of that study (Impact Area 5A).

It should be noted that the results for the 10 monitoring wells within the Impact Area cannot all be directly compared since the wells are screened in different bedrock formations, and the wells are located in different drainage basins. The only potentially hazardous substances detected in groundwater were volatile organic compounds (VOCs), and some metals. The only analytes exceeding MCLs in groundwater were sulfate and iron. The observed groundwater detections are summarized in Table 3.15 of the *Impact Area Site Assessment Report for Fort Riley, Kansas* (CEMRK, 1993b).

2.2 Initial Site Investigation (1993)

The SI program for the OB/OD Area which was conducted in September-October 1993 was designed to collect samples from within pits that were active for burning and detonation of ordnance at the time of sampling. These sampling locations were considered to be those most likely to produce the highest concentrations of explosive residues, if any were present. In addition, soil samples were collected from the surface and subsurface at locations throughout the OB/OD Area to assess whether residual contamination was present from formerly used pits. Lastly, potential migration of contaminants via surface water and groundwater was assessed at this time. Surface water migration was assessed by sampling the intermittent tributary to Threemile Creek located west of the site.

All samples (soils, groundwater, surface water and sediment) collected at the OB/OD Area were analyzed for the following analytes using SW-846 methods (USEPA, 1986):

- Explosives using EPA Method 8330 High Performance Liquid Chromatography (HPLC),
- Priority pollutant (PP) metals using EPA Method 6010/7000 Series - Furnace Atomic Absorption (AA) and Inductively Coupled Plasma (ICP), and

- Uranium using EPA Method 6020 - Inductively Coupled Plasma/Mass Spectroscopy (ICP/MS).

Other parameters were also analyzed and are discussed, by media, in the following media-specific capsule summaries for the investigation. The complete details of the investigation are reported in the *Draft Final Site Investigation for High Priority Sites at Fort Riley, Kansas* (CEMRK, 1994).

2.2.1 Surface Soil

Eight surface soil (SS) samples were collected from within pits and across the OB/OD Area as indicated on Figure 2-1.

In addition to the general parameters listed above, the one surface soil sample near the North Burn Pit was also analyzed for VOCs using EPA method 8240 and semi-volatile organic compounds (SVOCs) using EPA method 8270, because flammable liquids were acknowledged to be used at the North Burn Pit. Surface soil samples collected at the opening of the North Burn Pit were analyzed for total petroleum hydrocarbons (TPH) using EPA Method 8015, modified.

Also, two surface soil samples (SS1 and SS6) were analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals using EPA Method 1311 for digestion and EPA Method 6010/7000 Series for measurement. Selection of samples for TCLP analysis was made based on the analytical results for priority pollutant metals from samples having the highest total metals concentration.

2.2.2 Subsurface Soil

Eight soil borings (ranging in depth from 5 to 20 feet) were installed at locations indicated on Figure 2-1. The boring logs are presented in Appendix A. Soil boring SB1 was also used for installation of groundwater monitoring well OB-93-04. Three soil samples were collected from each soil boring, except SB8, where only two samples were collected due to the shallowness of bedrock at this location. A total of 23 subsurface soil samples were collected from these borings and were subsequently analyzed.

In addition, two shallow soil borings were hand-augered near the opening of the North Burn Pit. They were added during field activities because the high amount of UXO debris near the opening of the North Burn Pit prevented use of a drill rig to collect deep soil samples. These samples were designated SB10A and SB10B.

In addition to the general parameters listed above, the two subsurface soil samples collected from boring SB8 were also analyzed for VOCs using EPA method 8240 and SVOCs using EPA method 8270.

Two subsurface soil samples (SB3 from 1.0 to 3.5 ft. bgs and; SB7 from 7.5 to 8.5 ft. bgs) were analyzed for TCLP metals using EPA Method 1311 for digestion and EPA Method 6010/7000 Series for measurement. Selection of samples for TCLP analysis was made based on the analytical results for priority pollutant metals from samples having the highest total metals concentration.

2.2.3 Surface Water and Sediment

Two surface water and three sediment samples were collected along the tributary to Threemile Creek west of the OB/OD Area as this intermittent stream was flowing at the time of sampling. The sample locations are shown on Figure 2-1. Sediment samples were collected upstream from the site, due west of the site, and downstream from the site. The surface water samples were collected near the due west and downstream sediment sample locations. All samples were analyzed for the general parameters presented above.

2.2.4 Groundwater

Four groundwater monitoring wells (OB-93-01 through OB-93-04) were installed and sampled. The well locations are indicated on Figure 2-1. Coring of bedrock was performed during installation of OB-93-04. The lithological logs, construction details, well specification forms, and well development records for all four monitoring wells are presented in Appendix A.

In addition to the general parameters listed above, the groundwater samples were analyzed for VOCs and SVOCs (using EPA Methods 8240 and 8270, respectively). Also, groundwater samples were analyzed for anions, including the following: nitrate (Method 353.2), nitrite (Method 353.2), sulfate (Method 375.4), and phosphate (Method 365.1) (USEPA, 1983).

2.2.5 Findings

As discussed in the *Draft Final Site Investigation for High Priority Sites at Fort Riley, Kansas* (CEMRK, 1994), there were a few detections of explosive residues, metals, and ions in soils from the demolition pit areas. There were no detections for SVOCs or explosives in groundwater. The positive detections in groundwater include uranium, sulfate, nitrate, and one VOC (trichloroethylene [TCE]). The highest concentration for uranium was reported for OB-93-01 (0.0057 mg/l [0.0043 mg/l in the duplicate sample]). The highest uranium concentration for groundwater in the Impact Area investigation in 1992 was 0.0048 mg/l. The MCL for uranium is 0.02 mg/l. The detected uranium concentrations do not exceed regulatory standards. Nitrate was detected only in well OB-93-02 at 1.0 mg/l. Sulfate was detected in all four wells at 26 to 97 mg/l. The detections of nitrate and sulfate do not exceed their respective MCLs of 10 mg/l and 500 mg/l. The detections of TCE range from 1.3 μg/l in OB-93-03 to 29 μg/l in OB-93-04. The concentration in OB-93-04 exceeds the MCL of 5 μg/l for TCE.

There were no detections of explosives in the surface water or sediment samples. The only detection in the surface water samples was silver in the upstream sample (detected at 0.02 mg/l, which is below the secondary MCL of 0.10 mg/l) and uranium in both samples (detected at 0.0021 to 0.0024 mg/l, well below the MCL of 0.02 mg/l).

The metals detected in all three sediment samples were arsenic, beryllium, cadmium, chromium, copper, nickel, lead, zinc, and uranium. The concentrations in the upstream sediment sample were the same (and sometimes higher) than the concentrations in the downstream sediment samples. With the exception of beryllium, the detected concentrations for the OB/OD Area were below the highest reported concentration for the Impact Area investigation.

In an effort to determine past practices of the EOD and to determine the origin of TCE in the groundwater at the OB/OD Area, personnel at the DES (formerly the DEH) (Fort Riley DEH, 1994) contacted a former EOD employee who participated in OB/OD activities during the 1960s. This person stated that kerosene and diesel fuel were almost exclusively used for burning, except for the occasional use of gasoline as a fuel during demonstrations. This former employee had no knowledge of the use of TCE or the disposal of TCE at the site.

In addition, the commanding officer of the 74th EOD at Fort Riley at the time of the SI in 1993 had no knowledge of the use or disposal of TCE at the site (CEMRK, 1994). Thus, the origin of the TCE in the groundwater beneath the OB/OD Area continues to be unknown, but is considered to likely be the result of a sporadic or one-time (rather repeated) practice. This conclusion is based in large part on the fact that TCE was not detected in samples collected from other media at the site, indicating that there does not appear to be a widespread source of TCE at the site. TCE is not typically associated with munitions and ordnance or their disposal at OB/OD Area. Some TCE may have been present in waste fuels used for burning at the site. The TCE fraction of the burn agent may not have been completely combusted, leaving the TCE to migrate (via soil and surface water) into the groundwater. TCE is a volatile organic with a low octanol carbon coefficient (K_{OC}) of 126 milliliters per gram indicating that it is relatively mobile in the environment.

The surface soils in the OB/OD Area are mainly silts and clays. The overburden is 12 to 20 feet thick in the area and can be characterized as clay with occasional limestone inclusions. There were some damp zones observed in the overburden in October 1993. In the lower lying areas (e.g., well OB-93-04), dampness was noted to begin about 10 feet below ground surface and intermittent water was observed at the contact with the bedrock at approximately 20 feet below the ground surface. The regional bedrock stratigraphy consists of alternating layers of limestone and shale that dip slightly toward the west (Jewett, 1941). The shales have a much lower relative permeability than the limestones.

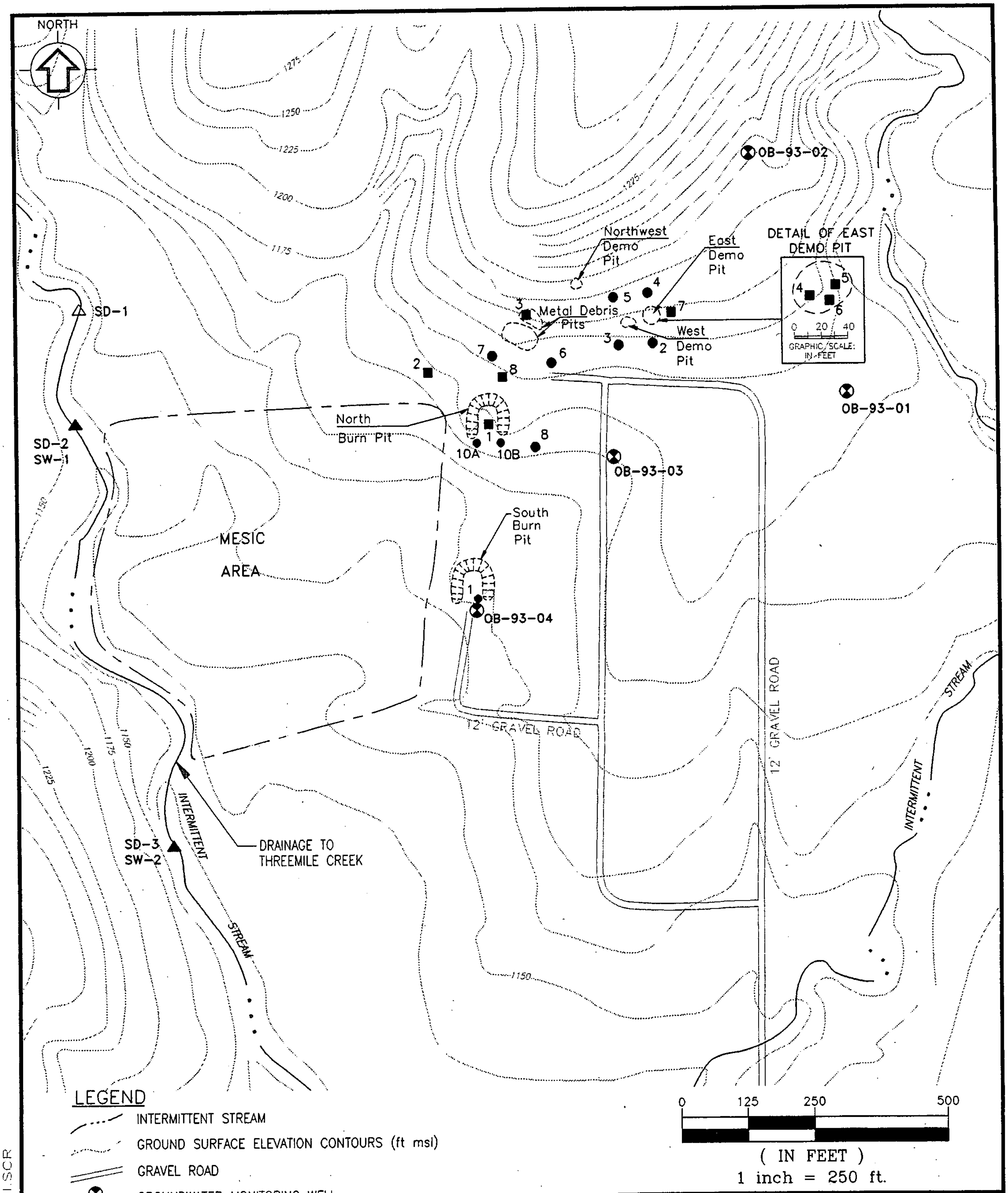
As shown in Figure 2-1, four wells were installed, surrounding the suspect sources in the OB/OD Area. Sustainable water-bearing zones were encountered during well installation activities in two different formations, and the wells were screened in those formations. Wells OB-93-01 and OB-93-02 were screened at elevations consistent with the Wymore Shale and Schroyer Limestone interface, and wells OB-93-03 and OB-93-04 were screened in the deeper Threemile Limestone.

Coring of bedrock was performed during the installation of OB-93-04. Analyses of this core and comparisons with regional stratigraphy (discussed in Chapter 4) allowed for the identification of specific formations at this location. Well OB-93-04 penetrates overburden, the Schroyer Limestone, the Havensville Shale and the Threemile Limestone. The well is screened, however, in the Threemile Limestone. The other three wells were logged based on cuttings, and correlation of stratigraphy at each location was performed with a lesser degree of confidence.

2.3 Confirmation Sampling (1995)

Pursuant to the 20 July 1995 meeting between Fort Riley, KDHE, and the EPA, Fort Riley completed a one-time round of confirmation groundwater sampling of several areas, including the OB/OD Area. This groundwater sampling and analysis was conducted to confirm results from previous rounds of sampling at these sites and to supplement the groundwater data base. Samples were collected from the four monitoring wells in the OB/OD Area in December 1995 (CEMRK, 1996a and 1996b). Groundwater samples were analyzed for VOCs, SVOCs, explosives, nitrate, nitrite, ortho-phosphate, sulfate, uranium, and PP metals. TCE was again detected in OB-93-03 (at 1.4 μg/l) and in OB-93-04 (at 17 μg/l). The concentration in OB-93-04 again exceeded the MCL of 5 μg/l for TCE. After the sampling event in December of 1995, no other site investigation activities were conducted at the OB/OD Area until the field work associated with the SI Report Addendum began in March of 1997.

FIGURES



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FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

SAMPLING LOCATIONS,
INITIAL SITE INVESTIGATIONS, 1993

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 2-1

OB-OD1/06AUG98/OB-ISI.SCR

3.0 SITE INVESTIGATION (1997)

3.0 SITE INVESTIGATION (1997)

Based on the findings of the previous investigations at the OB/OD Area, it was determined that additional site investigation (SI) activities were required. The objectives of the additional SI activities were to:

- evaluate the possible source and extent of contamination;
- evaluate whether any other contaminants at the site are co-contaminants with the chlorinated solvent; and
- clarify the local geology and movement of water within the different formations that underlay this site.

The approach for this work is documented in the *Sampling and Analysis Plan (SAP) for the Supplemental Site Investigation at the Open Burn/Open Detonation Area, Fort Riley, Kansas* (CENWK, 1997a). The following subsections present a summary of the activities conducted during the supplemental SI work performed in 1997. Evaluations and interpretations based on the results of this work (combined with the previous investigations) are presented in Chapter 4.

Access to the OB/OD Area is restricted because it, and adjacent areas, are used for military training. As a result, the SI field activities had to be conducted in a series of field events during inactive periods at the site. The following subsections thus discuss the SI activities as four different events:

- a preliminary investigation (referred to as "Mobilization #1");
- a passive soil gas demonstration test;
- an investigation for further characterization of hydrogeologic conditions and extent of contamination (referred to as "Mobilization #2"); and
- groundwater monitoring.

3.1 Mobilization #1

The objectives of Mobilization #1 were to clarify the geology and hydrogeology of the area and to screen for contamination. In particular, the assignment of observed rock units to the regional stratigraphy and the determination of the gradient of the water in each water-bearing limestone was planned. This information was to be used to guide the further evaluation of the area of contamination in Mobilization #2.

Mobilization #1 was conducted from 17 March to 2 April 1997. Prior to commencement of site activities, a UXO survey was conducted. No live UXO were encountered during the drilling operations at any of the monitoring well locations. A summary of UXO encountered is provided in Appendix B.

3.1.1 Activities Conducted

On 21 January 1997, a site visit to the OB/OD Area was conducted as part of an effort to visually inspect the geologic outcrops near the site in order to better understand the geology beneath the OB/OD Area. Based on information gathered at this time and subsequent discussions from this field trip, it was noted that the existing shallow monitoring wells (OB-93-01 and OB-93-02) intersect the Schroyer Limestone. The deeper existing shallow monitoring wells (OB-93-03 and OB-93-04) are confirmed to be screened in Threemile Limestone, as previously noted in the boring logs.

At the commencement of Mobilization #1, the ground surface elevations at the proposed monitoring well locations were surveyed. In addition, the top of the Havensville Shale was surveyed at two locations where it outcropped near the OB/OD Area; one along a streambed to the west within the EOD Range and the other along a reach of the same streambed near Vinton School road, off-site from the OB/OD Area. The results showed that the Schroyer/Havensville contact occurs at an elevation of 1138.87 feet in the streambed in the southern portion of the EOD Range, and occurs at an elevation of 1132.69 feet along Vinton School Road. This represents a change in elevation of 6.19 feet over a horizontal distance of approximately 2,400 feet in the east-west direction (along the dip of the beds). This information was used for the following purposes:

- to estimate the depths at which the formations would be encountered during drilling;
- to confirm the formations in which the existing monitoring wells were screened and installed during the initial 1993 SI; and,
- to evaluate the magnitude of the regional dip (approximately 0.26 feet per 100 feet).

To accomplish these objectives, four monitoring wells were installed at locations shown on Figure 3-1. Table 3-1 lists the well construction information for the newly installed wells during Mobilization #1, including the ground elevation at each well location, the total depth, interval cored (if applicable), screened interval, and the formation in which the well is screened. During Mobilization #1, a spring and a hand dug well were also discovered at the locations indicated on Figure 3-1. Table 3-1 presents information on the measured elevations of the spring, the hand dug well, and the Schroyer/Havensville contact (as discussed above). The lithological logs, construction details, and well specification records for the monitoring wells are presented in Appendix A.

Two of the wells (OB-97-06 and OB-97-07) were screened across the Schroyer Limestone and the upper portion of the Havensville Shale to compliment the two existing wells (OB-93-01 and OB-93-02) which were screened across the Schroyer Limestone and lower portion of the Wymore Shale. One well (OB-97-05) was screened in the Threemile Limestone to compliment the two existing wells (OB-93-03 and OB-93-04) in that zone. A fourth well (OB-97-08) was installed in the overburden and screened across the water table at a location between the OB/OD Area and the intermittent stream to the west to evaluate the potential for shallow groundwater discharges to the intermittent stream.

Two of the wells were cored to improve the understanding of the stratigraphy; one (OB-97-05) was cored into the Threemile Limestone, the other (OB-97-06) was cored into the Schroyer Limestone. During installation of the wells, geologic logs and hydrogeologic observations were made and the borings were geophysically logged (using a natural gamma technique). Geophysical logs were also obtained for all four of the existing wells on the site. Groundwater screening samples were collected from each saturated zone encountered during the installation of the new wells, and were analyzed for VOCs, including chlorinated solvents. One well (OB-97-08) was also sampled and analyzed for explosives and nitrate/nitrite since this was the well installed at the overburden/bedrock interface in a location expected to intercept groundwater flow from the area of the North Burn Pit and South Burn Pit (the suspected source areas).

Three of the four newly installed wells were developed at this time. The well development records are presented in Appendix A. Due to the heavy rain experienced during this mobilization, the development of OB-97-05 could not be completed and was delayed until Mobilization #2. No water was added to the boreholes during drilling operations. Therefore, only formation water was removed during well development. The results of the well development of OB-97-06, OB-97-07, and OB-97-08 (volume, temperature, pH, conductivity, and turbidity) are shown in Table 3-2.

Groundwater screening water samples were collected from each of the newly installed monitoring wells at discrete intervals (dependent on the existence of water) during the drilling operations: the overburden/bedrock interface (based on auger drilling refusal), the Schroyer Limestone horizon, and the Threemile Limestone horizon. Additional groundwater screening samples were collected within the Havensville Shale at OB-97-07, from the spring, and from the hand dug well. Table 3-3 lists the groundwater sample depth, formation, date of collection, and the positive detection analytical results.

Based on the analytical results shown in Table 3-3, the highest concentration of TCE (570 μg/l) was detected at the OB-97-07 well location, which is screened in the lower portion of the Schroyer Limestone and the upper portion of the Havensville Shale. VOC contaminants are also present to some extent at all other well locations installed during this mobilization; with TCE being the predominant contaminant. Concentrations of TCE were also detected in the hand dug well and spring (100 to 300 μg/l respectively).

Table 3-4 presents the groundwater elevations measured in both the existing wells and the wells installed during Mobilization #1. These elevations were measured over a 10-day period from 19 to 29 March 1997.

The types of Investigation Derived Waste (IDW) water that were generated and containerized during these field investigations included formation water from drilling, purge water from well development, and purge water from groundwater sampling. The IDW water generated during well installation was containerized daily in a tank located inside the OB/OD Area. Purge water collected during the monitoring well groundwater sampling event that followed the well installation was similarly managed.

Soil IDW was not containerized, but rather was returned to the ground at the site. This includes soil cuttings from the hollow stem auger and the air-rotary rigs.

3.1.2 Deviations from the Sampling and Analysis Plan

The following deviations from the Sampling and Analysis Plan were made during the execution of the Mobilization #1 activities:

- A spring and hand dug well were discovered to the west of the OB/OD Area during Mobilization #1. A grab sample was collected from each of these locations and analyzed for VOCs, SVOCs, explosives, and nitrate/nitrite.
- Additional elevation surveys were performed at the hand dug well, spring, and two outcrop areas near the OB/OD Area.
- OB-97-08 was installed as a permanent monitoring well because of the large amount of groundwater encountered at this location during the drilling operation.
- At OB-97-07, auger refusal did not occur until an elevation corresponding with the bottom of the Schroyer Limestone; therefore, the well was completed in the bottom of the Schroyer Limestone and top of the Havensville Shale.
- Groundwater screening samples were collected from OB-97-05 at the Schroyer Limestone and Threemile Limestone because they were the only two depths with sufficient water to sample.
- Three additional post-development samples were collected and analyzed for VOCs (Method 8260) at OB-97-06, OB-97-07, and OB-97-08 to help further characterize the groundwater.
- Geophysical logging of OB-97-05 was delayed until Mobilization #2. Impact well IZ92-010 and an outcrop were also geophysically logged (Appendix D). The location of well IZ92-010 and the outcrop are shown on Figure 1-1.
- All monitoring wells were planned to be installed using a hollow stem auger rig through the overburden material, followed by use of dual tube reverse air rotary drilling to advance the borehole through bedrock. Straight air rotary method was used instead of the dual tube reverse method for both drilling and coring. The dual tube method could have been used for the drilling (but was inadvertently omitted), however, the coring could not have been performed with the dual tube air rotary equipment. Air coring was considered advantageous over water coring to avoid the loss of water to the formation.

3.2 Passive Soil Gas Survey Demonstration Test

As part of the SI, a passive soil gas survey method was tested within the OB/OD Area. The purpose of the test was to evaluate whether this technique could be effective in delineating the pattern of VOCs in the groundwater. The survey method generally consisted of installing soil gas detectors (GORE-SORBER Screening Modules) in shallow borings and then collecting them at a later date for laboratory analysis. On 16 April 1997, a total of six detectors were installed in 1/2-inch borings at depths of 3 feet, in a radial pattern of about 20 feet to the west, north, and east of wells OB-97-07 and OB-97-05. These two wells had the highest levels of VOCs detected in Mobilization #1. The detectors were collected on 8 May 1997 and analyzed. PCE was detected in five samples at 0.03 to 0.10 μg/sorber, and TCE was detected in one sample at 0.03 μg/sorber. As these levels were just above the method detection limits (MDLs), their concentrations would be expected to decrease below the MDLs as detectors are moved away from areas of known contamination. Because the samples arrived at the laboratory at 20.6° C (above the generally accepted level for shipment of environmental samples) the results are considered qualitative. The analytical report is provided in Appendix C. It is believed that the reason for only detecting low levels of PCE in the soil gas detectors above known contaminated groundwater lies in the fact that the shale (layer of low permeability) overlying the groundwater impedes the upward migration of soil gas from the groundwater to the detector. Based on the low levels detected and this vertical barrier limitation, a more extensive deployment of passive soil gas detectors at the OB/OD area was not considered suitable and was, therefore, not recommended or pursued.

3.3 Mobilization #2

The original objectives of Mobilization #2 were to use the geologic information (confirmation of geologic profiles), hydrologic information (gradients in each of the saturated formations), and new chemical screening results obtained during Mobilization #1 to install four additional wells to evaluate the observed chlorinated solvent contamination and possible source. Secondarily, wells would be located in the interest of forming a monitoring network around the OB/OD Area.

The hypothesis upon which this supplemental investigation was based is that the chlorinated solvent contamination was originally released onto the surface of the site in the burn pits. Based on information provided by the 74th EOD-FR, the South Burn Pit is inactive and has not been in use for some time. The North Burn Pit is active, but has not been used as a burn pit at least for the past several years since open detonation is the current disposal/destruction method of choice. There are no industrial facilities in the area that might account for the contamination. No VOCs were detected in near-surface soil in or near the North Burn Pit. Samples collected near the South Burn Pit during the installation of OB-93-04 were not analyzed for VOCs. Sediment and surface water samples collected from the stream to the west were also not analyzed for VOCs. Thus, additional wells needed to be placed to further evaluate the possible source and extent of contamination.

The data collected during Mobilization #1 raised several new questions regarding the presence of VOCs at the site and their migration. Specifically, source areas were not yet identifiable and the contaminant migration pathways in groundwater were not well understood. Insufficient information was currently available to clearly establish locations for additional investigation that would be expected to provide data (in a cost-effective manner) on source areas and contaminant delineation. Therefore, the objectives of the Mobilization #2 activities were changed as follows (CENWK, 1997c):

- Gather sufficient information to predict groundwater flow patterns; this requires an understanding of the origins of the groundwater moving through the site, the formations that are serving to initiate contaminant migration from the source areas, and the movement of water within and between formations downgradient of the site.

- Gather sufficient information to assess and/or predict the migration of contaminants from the site for purposes of establishing an appropriate investigative effort in a subsequent effort (e.g., placement of additional groundwater monitoring wells) and for establishing an effective groundwater monitoring network.
- Assess potential migration pathways between surface water and groundwater through the presence of the springs and nearby intermittent streams.

Because the inter-relationship between groundwater in different formations at a given location was not well understood, vertically nested piezometers were proposed in lieu of monitoring wells. Nested piezometers represent multiple, small diameter (1-inch) piezometers screened at different elevations in the same borehole. The screened interval of each piezometer is short (1 foot) so that measured groundwater information can be correlated with a specific vertical horizon. The use of nested piezometers also allows for the long-term assessment of the presence of groundwater within different formations (e.g., the Kinney Limestone and Wymore Shale); allows for the comparison of groundwater elevations across the site within very discrete zones to better assess groundwater flow directions; allows for an assessment of vertical migration; and provides access to a specific horizon for purposes of collecting groundwater screening samples to better assess the distribution of contaminants across the site.

3.3.2 Activities Conducted

Mobilization #2 was conducted from 1 June to 5 July 1997. Activities performed during Mobilization #2 included the installation and development of five nested piezometers; geophysical logging of the five pilot boreholes and existing monitoring well OB97-05; surveying of all wells, piezometers, and sampling locations for elevation and horizontal coordinates; and, sampling. These activities were all conducted from 1 to 19 June, except for the purging of the piezometers, which was conducted on 4 to 5 July 1997. This section summarizes the field activities conducted during Mobilization #2. Additional details are provided in Technical Memorandum #2 (CENWK, 1997d and 1997e). No live UXO were encountered during the drilling operations at any of the piezometer locations. A summary of UXO encountered is provided in Appendix B.

3.3.2.1 <u>Nested Piezometer Construction</u>

Five nested piezometers were installed at the OB/OD Area during Mobilization #2 between 1 and 19 June 1997. The locations of the piezometers are shown on Figure 3-2. The lithological logs are presented in Appendix A and the piezometer construction data is presented in Table 3-5. The survey data for the eight existing wells, the five piezometers, and other site features are presented in Table 3-6.

The locations for the nested piezometers were selected to provide data while avoiding areas that would interfere with use of the range and/or be susceptible to damage due to activities at the range. A description of these locations, which are shown in Figure 3-2, is presented below:

OB-97-09PZ - Located at the top of the rise north of the OB/OD Area. The purpose of this nest is to evaluate the origins of water that may be flowing through the OB/OD Area. Specifically, this nest would evaluate the presence of water in the Florence Limestone, the Blue Springs Shale, the Kinney Limestone, the Wymore Shale, the Schroyer Limestone, and the Havensville Shale. Since the Florence Limestone was projected to occur at an elevation of 1212 to 1242 feet, the location of this PZ was selected to be well above the top of the Florence and away from the exposed edges of the Florence which may have temporal effects of recharge and discharge. This borehole was advanced to an elevation of approximately 1132 feet msl, in the Havensville Shale.

OB-97-10PZ - Located adjacent to OB-93-01 at the northeast corner of the loop road within the OB/OD Area. This location was selected to assess groundwater on the eastern portion of the site and, in conjunction with other piezometers, to assess the possible presence of a groundwater divide. This nest was to evaluate the Kinney Limestone, the Wymore Shale, the top of the Schroyer Limestone, the bottom of the Schroyer Limestone, and the Havensville Shale. This borehole was advanced to an elevation of approximately 1134 feet msl.

OB-97-11PZ - Located adjacent to the North Burn Pit on the northeastern side of the berm. The stratigraphic position, drilling depths, and formation screened are similar to those of both OB-97-10PZ and OB-97-12PZ. This nest was intended to assess whether the water flowing out of the spring on the southwest of the burn pit, which contains TCE, is being fed by the Kinney Limestone.

OB-97-12PZ - Located approximately 150 feet due north of OB-97-05. This location was selected to assess the northwestern portion of the site, north (and in the apparent upgradient direction) of the detections of TCE in the Schroyer Limestone at OB-97-05. This nest is located at a similar stratigraphic position as both OB-97-10PZ and -11PZ, and the depth drilled and the formations screened are similar. This nest, in conjunction with OB-97-10PZ and OB-97-11PZ, provides for an evaluation of groundwater across the OB/OD Area from west to east.

OB-97-13PZ - Located adjacent to wells OB-93-04 and OB-97-07. This nest is located lower in the stratigraphic column than the other nested piezometer locations. The formations to be screened include the Wymore Shale at an elevation approximately five feet above the top of the Schroyer Limestone, the top of the Schroyer Limestone, the bottom of the Schroyer Limestone, and the top and middle of the Havensville Shale. In conjunction with OB-97-10PZ and OB-97-13PZ, this nest provides data on groundwater flow from north to south across the OB/OD Area. This nest would also provides information on the potential for vertical migration from the Schroyer Limestone to the Havensville Shale. The borehole for this piezometer was drilled to an elevation of approximately 1126 feet msl.

Prior to the commencement of drilling activities for the nested piezometers, the ground surface elevations at the proposed locations were surveyed. As the proposed screen intervals for piezometers OB97-10 through OB97-12 were the same, their locations were adjusted so that the ground surface elevation for each location was within 2 feet. Accurate elevation data were important prior to drilling as the limestone formations at the site are relatively flat lying, and the elevation at which these formations might be expected to be encountered was known from previous drilling and logging activities performed at the site.

Drilling was performed using air rotary drilling techniques. Coring was performed at one piezometer location (OB-97-13PZ) from 17.4 feet below ground surface (bgs) to 26.5 feet bgs. Upon completion of each boring an 8-inch inner diameter polyvinyl chloride (PVC) casing was installed temporarily to prevent collapse of the sidewalls.

Upon completion of the five borings, downhole geophysical logging was performed using a gamma logging tool. Logging of monitoring well OB-97-05 was also performed during this mobilization. The geophysical logs, printed at a scale of 1 inch equals 10 feet, are included in Appendix D. The drilling logs and geophysical logs were used to select the screen intervals for each piezometer.

Each piezometer is constructed of 1-inch diameter schedule 80 PVC and the screen sections for each are approximately 1-foot long, with the exception of the piezometer OB97-09PZ screening the Florence Limestone. The screen interval for this piezometer is approximately 2-feet long. Six nested piezometers were installed at piezometer location OB97-09PZ and five nested piezometers were installed at the other four piezometer locations. Each piezometer was constructed in a similar fashion by first backfilling the boring with bentonite to a depth approximately 1.5 feet below the proposed depth of the lowest piezometer. Time delayed bentonite pel-plug was used to allow the bentonite time to fall through the water before hydrating. The bentonite seal was allowed three hours to hydrate before the sand/filter pack and piezometer was set. All piezometer casings at each location were cut to the same elevation and notched for identification purposes. The deepest piezometer at each location had no notches with each consecutively shallower piezometer having one more notch than the previous piezometer. For example, the deepest piezometer at OB-97-09PZ is identified as OB-97-09PZ(0), and the uppermost piezometer is identified as OB-97-09PZ(5). The well specification forms are provided in Appendix A.

3.3.2.2 Well Development

During drilling operations at piezometer OB97-13PZ, groundwater was forced from monitoring well OB97-07, located approximately 10 feet to the west. It was therefore necessary to redevelop this well. Redevelopment took place on 17 and 18 June 1997.

Monitoring well OB97-05 was also developed on 10 June 1997 during Mobilization #2 as it was not completed during Mobilization #1 due to the heavy rains. Well development records are included in Appendix A and the well development results (volume, temperature, pH, conductivity, and turbidity) of both wells are summarized in Table 3-2.

3.3.2.3 Piezometer Purging

It was planned to remove 3 well volumes from each piezometer and to collect a grab sample. Due to the narrow diameter and depths of the piezometers, conventional pumps could not be used. On

17 June 1997, purging of the piezometers commenced at OB97-13PZ using inertial (jiggle) tubes. However, purging using this method also could not be completed due to limitations of the jiggle tubes. The limitations of the jiggle tubes were the depths of the piezometers (particularly at OB97-09PZ) and the shallow head in many of the piezometers (the jiggle tubes will not lift water if there is not sufficient head in the piezometer - a water column of at least 1.5 feet). It was therefore decided to use air lift methods to purge the piezometers. The purge logs are presented in Appendix A.

On 4 July 1997 the piezometers were purged using air lift methods. Before purging, a round of groundwater level measurements and photoionization detector (PID) readings were recorded. An injection tube was used to deliver air to the bottom of each piezometer, forcing water up the piezometer casing. At each piezometer cluster, the deepest piezometer was purged first. Each piezometer was purged to dryness. Purge water from OB97-09PZ and OB97-10PZ was discharged to the ground. Purge water from OB97-11PZ, through OB97-13PZ was containerized. Table 3-7 summarizes the total purge volume collected from each piezometer.

3.3.2.4 <u>Groundwater and Surface Water Sampling</u>

As the piezometers could not be purged with inertial tubes, grab samples were not collected from all the piezometers. Only one sample from OB97-13PZ(2) was collected from the piezometer screened in the Schroyer Limestone and analyzed for VOCs. The spring and hand dug well were also sampled. These results are presented in Tables 3-8 and 3-9.

Surface water sampling was not performed as the flow in the two streams bordering the OB/OD Area had low and intermittent flow. Proposed sample locations were surveyed.

3.3.2.5 <u>IDW</u>

Drill cuttings generated during drilling operations were staged on plastic sheeting at each borehole and headspace screening using a PID was performed on samples from each interval encountered. All drill cuttings with a PID response less than 1 ppm were spread on the ground surface near each borehole. Only drill cuttings from OB97-11PZ exhibited a PID greater than 1 ppm and so these were containerized in seven 55-gallon steel drums and staged on site. Cuttings from all other boreholes were spread on the ground surface following screening. A composite sample of the soil from five of the seven drums was collected on 19 June 1997 and analyzed for VOCs.

With the exception of OB97-09PZ and OB97-10PZ, all groundwater generated during drilling activities was containerized and placed in the IDW tank with purge water from Mobilization #1. As OB97-09PZ is located in an upgradient location and VOCs have not been detected in the eastern portion of the site near OB97-10PZ, groundwater from these locations was not containerized. The contents of the IDW tank were aerated during Mobilization #2 activities and a sample of the tank contents was collected on 19 June 1997 and analyzed for VOCs. The results for the IDW analysis (CENWK, 1997b) showed that there were no detections in the soil and that all detections were below the MCLs in the water. Therefore, on 27 August 1997, the soil IDW was spread on the ground, the drums were removed, and the water IDW was discharged to the ground.

3.3.3 Deviations from the Planned Activities

The deviations from the planned activities were as follows:

- Grab samples were not collected from the piezometers as planned because of the difficulties in purging the piezometers.
- Surface water sampling of the intermittent streams was not conducted because they were dry. However, the proposed surface water sampling locations were located and surveyed. The five stream locations (and the spring) are shown in Figure 3-3. Surface water location OB-97-SW5 is at the same location as the outcrop on the east side of the intermittent stream to the south of the OB/OD Area (confluence of the two intermittent streams that bound the site on the east and west). This outcrop is identified in Table 3-1.
- The number of piezometers installed (26) was changed from the proposed number (28) based on a review of the drilling logs and geophysical logs. The number of screens completed in each nested piezometer is summarized as follows:

No. of Screens per Piezometer	Planned	Completed
OB-97-09PZ	5	6
OB-97-10PZ	6	5
OB-97-11PZ	6	5
OB-97-12PZ	6	5
OB-97-13PZ	5	5
Total	28	26

- The amount of coring conducted at OB97-13PZ was reduced from the proposed 25 feet to approximately 10 feet based on the materials encountered. The coring did however reveal the Schroyer Limestone/Havensville Shale contact, which partially fulfilled the purpose of coring. As the upper portion of the Schroyer was absent, the entire thickness could not be cored as planned.

3.4 Groundwater Monitoring

Groundwater monitoring, in the form of monthly elevation measurements and quarterly sampling and analysis, was conducted at the OB/OD Area.

3.4.1 Groundwater Elevations

After the installation of the nested piezometers, the plan was to measure groundwater elevations whenever site access can be arranged in addition to measuring the elevations as part of the sampling events. Monthly groundwater elevations were measured on 27 August and 14 October 1997, but site access was not available in November 1997. These data are presented in Table 3-10.

Concurrent with the OB/OD field activities, USGS installed remote access automatic data loggers in each piezometer in OB-97-09PZ and OB-97-13PZ on 3-4 September 1997. USGS then installed remote access automatic data loggers in OB-93-01, OB-93-02, OB-97-06, and OB-97-11PZ(1) on 2 December 1997.

3.4.2 Groundwater Sampling and Analysis

Periodic groundwater samples were to be collected from all wells at the OB/OD Area, including the existing wells installed in September-October 1993 and the new wells installed in 1997. The wells would be sampled after well development and would be dependent on coordination for access when the OB/OD Area is not reserved for training activities. Groundwater samples collected during the groundwater sampling event following the well installation mobilizations were to be analyzed for the same suite of analytes as in the initial 1993 SI (CEMRK, 1993c and CEMRK, 1994) and the December 1995 sampling (CEMRK, 1996a). The analytical method for TCL volatile organics was changed from EPA 8240 to EPA 8260 pursuant to EPA recommendations in *Test Methods for Evaluating Solid Waste* (USEPA, 1986, Update III), that the use of method 8240 be eliminated. The methods differ in the type of chromatography column employed; the analyte list and analyte quantitation limits are the same for both methods. The analytes and methods (USEPA 1986, USEPA 1983) included:

• Explosives	Method 8330/HPLC
• Target Compound List (TCL) Semi-Volatile Organics (SVOCs)	Method 8270/GC-MS (EPA Method 3510B is used for sample preparation)
• Target Compound list (TCL) Volatile Organics (VOCs)	Method 8260
• Priority Pollutant Metals (13)	Method 7000 series/AA and 6010/ICP
• Nitrate	Method 353.2 Colorimetric
• Nitrite	Method 353.2 Colorimetric
• Phosphate (ortho)	Method 365.1
• Sulfate	Method 375.4

3.4.2.1 <u>September 1997 Sampling Event</u>

The first periodic sampling event for the OB/OD Area since the installation of the wells and piezometers in 1997 was performed between 1 and 5 September 1997. Analytical results are provided in the QCSR (CENWK, 1997b) and summarized in Tables 3-8 and 3-9.

The results for samples collected from OB-97-10PZ(0), OB-97-11PZ(0), and OB-97-12PZ(0) are presented as the highest values of the original analysis and reanalysis. These samples were reanalyzed as the matrix spike/matrix spike duplicate (MS/MSD) samples in the Quality Control (QC) batch were inadvertently not spiked by the laboratory. All associated QC for the Batch were within control criteria. The samples were preserved at the recommended storage temperature (4 degrees C) following collection and reanalyzed one day beyond hold with all QC within control limits. Although two analyses were performed, any analytes detected in either analysis was reported. Therefore, as the samples affected are screening samples, the data quality objectives to determine the presence or absence of contaminants were met and no data qualifications were made.

The scope of work was modified such that during this initial round of sampling, the wells, piezometers, and surface water locations would only be analyzed for VOCs. In future events, the wells and surface water locations would be analyzed for only VOCs and SVOCs. The piezometers would only be sampled once as a baseline as they were primarily installed to provide groundwater elevation data and not to be periodic sampling points.

The static water levels were first measured on 2 September 1997 at all the groundwater monitoring wells, the five nested piezometers, the hand dug well, and the spring. The groundwater levels are presented in Table 3-10. For the monitoring wells and piezometers, the field parameters; temperature, pH, conductivity, and turbidity were measured for each well volume purged. In addition, for the hand dug well, the same four field parameters were measured before sample collection. The groundwater monitoring wells were sampled with dedicated bladder pumps. In addition, the hand dug well was sampled using a surface water sampler. A field blank was collected from the sampling equipment used to collect the hand dug well sample. For the monitoring wells, three well volumes were purged following methodologies outlined in the *Comprehensive Basic Documents for Site Investigations at Fort Riley, Kansas* (CEMRK, 1995) prior to collection of each sample. The following piezometers were purged dry prior to removal of one well volume and were allowed to recharge prior to sampling without further purging: OB97-10PZ(0), (1), and (3); OB-97-11PZ(0); OB-97-12PZ(0) and (3); and OB-97-13PZ(0), (1), and (3).

No surface water samples were collected as the spring and the five planned surface water sampling locations were all dry. However, on 26 September 1997, a sample was collected from OB-97-SW2, the only surface water location with water in it. The results were non-detect for VOCs. All the groundwater and surface water samples were analyzed for only VOCs.

No samples were collected from 8 of the 26 piezometers as they were dry [OB-97-09PZ(2), and (5); OB-97-10PZ(4); OB-97-11PZ(2), (3), and (4); and OB-97-12PZ(2) and (4)]. Due to previously observed effervescence caused by reaction of the calcium carbonate in the groundwater originating from the limestone with the acid preservative in the sample container, VOC samples collected from OB-97-09PZ(0), (3), and (4); OB-97-10PZ(0), (1), (2), and (3); OB-97-11PZ(0) and (1); OB-97-12PZ(0); OB-97-13PZ(0), (1), (2), (3), and (4) were not preserved with acid. This corrective action was implemented to mitigate the effect of the acid, but necessitated an expedited holding time of seven days.

In this September 1997 event, wells OB-97-07 and OB-97-08 have the highest and second highest concentrations of TCE, at 400 μg/l and 200 μg/l, respectively. The concentration of TCE decreased from 570 to 400 μg/l at OB-97-07 while the concentration of TCE increased from 99 to

200 μg/l at OB-97-08. The concentrations of TCE in hand dug well increased from 100 to 260 μg/l while the concentration of TCE in the spring decreased from 300 to 190 μg/l. These values all exceed the MCL of 5 μg/l for TCE. Tetrachloroethylene (PCE) was also detected at 14 μg/l in OB-97-07 and at 8.0 μg/l in OB-97-08, which also exceeds its MCL of 5 μg/l.

The groundwater levels were remeasured on 5 September 1997 to compare electric water level meter measurements to chalked steel tape measurements. These results are presented in Table 3-11.

3.4.2.2 December 1997 Sampling Event

The second periodic sampling event for the OB/OD Area since the installation of the wells and piezometers in 1997 was performed between 1 and 5 December 1997. Samples were analyzed for VOCs and SVOCs. Analytical results are provided in the QCSR (CENWK, 1998a) and are discussed in the DSR (CENWK, 1998b). The results are summarized in Table 3-12.

Groundwater elevation data were collected on 1 December 1997 at eight monitoring wells and five nested piezometers. There were eight dry piezometers [OB-97-09PZ(2), and (5); OB-97-10PZ(4); OB-97-11PZ(3), and (4); OB-97-12PZ(2) and (4); and OB-97-13PZ(4)]. In addition, surface water elevations were measured at two surface water locations and the spring. The hand dug well was sampled on 1 December 1997 using a surface water sampler. After monitoring well OBHD-97-14 (also referred to as FPHD-97-14) was constructed at the hand dug well for safety reasons, the groundwater level was measured on 5 December 1997 and this new well was sampled. The groundwater elevation data are presented in Table 3-10. Well construction information for OBHD-97-14 is provided in Appendix A.

VOCs were detected above the Sample Quantitation Limits (SQLs) at 4 of the 9 monitoring wells, the hand dug well, and the spring. There were no detections of SVOCs in any of the groundwater or surface water samples.

TCE exceeded the MCL of 5 μg/l in four wells (OB-93-04, OB-97-07, OB-97-08, the hand dug well) and the spring. The highest total concentration of VOCs was detected in monitoring well OB-97-07. TCE was detected at 530 μg/l and tetrachloroethylene (PCE) was detected at 14 μg/l. These levels exceed the 5 μg/l MCL for both PCE and TCE. The spring had the second highest concentration of PCE at 3.1 μg/l. Monitoring well OB-97-08, the spring, and the hand dug well had the second highest concentration of TCE at 110 μg/l. The concentration of TCE in the field duplicate of OB-97-08 was higher at 120 μg/l. PCE was also detected in the field duplicate of OB-97-08 at 3.3 μg/l, although it was not detected in the record sample. The highest concentration of cis-1,2-DCE was in OBHD-97-14 at 82 μg/l, which exceeds its MCL of 70 μg/l. Wells OB-93-04 and OBHD-97-14 also had detections of TCE above the MCL of 5 μg/l at 15 μg/l and 63 μg/l, respectively.

The results of the hand dug well and monitoring well OBHD-97-14 were compared. The concentrations of 1,2-DCE (total) doubled from 46.4 μg/l to 88 μg/l, while the concentration of 1,1,2,2-tetrachloroethane decreased by one-half from 33 μg/l to 15 μg/l, and the concentration of TCE decreased also by one-half from 110 μg/l to 63 μg/l. 1,2-DCE is the total of cis-1,2-DCE and trans-1,2-DCE.

3.4.2.3 Comparison of December 1997 to September 1997 Sampling Events

While the PCE concentration (14 μg/l) in well OB-97-07 in December 1997 remained the same as in September 1997 sampling event, the concentration for TCE increased (530 μg/l) compared to the concentration previously detected in September 1997 (400 μg/l).

The PCE concentration in well OB-97-08 decreased from 8.0 μg/l in September 1997 to non-detect in December 1997. The TCE concentration in well OB-97-08 decreased from 200 μg/l in September 1997 to 110 μg/l in December 1997.

The TCE concentration remained about the same for OB-93-04 at 15 μg/l for December 1997 sampling event compared to the September 1997 (17 μg/l) sampling event.

The TCE concentration (110 μg/l) in the hand dug well in December 1997 decreased compared to the concentration detected in September 1997 (260 μg/l). The concentration of TCE detected in the water after the hand dug well was made into a monitoring well decreased to 63 μg/l in December 1997.

The spring was not sampled during the September 1997 mobilization due to insufficient water. Comparison of the December 1997 results to those obtained for June 1997 show a decrease in concentrations of TCE (from 190 to 110 μg/l), PCE (from 4.9 to 3.1 μg/l) and 1,1,2,2-tetrachloroethane (from 67 to 42 μg/l).

TABLES

Table 3-1 Well Construction Data for Mobilization #1

Well ID	Dates of Drilling (1997)	Ground Surveyed Elevation (ft.amsl)	Total Depth (ft.bgs)	Interval Cored (ft.bgs)	Screened Interval (ft.amsl)	Formation Screened
OB-97-05	3/20-3/30	1178.39	73	32.5-73	1115-1105	Three Mile Limestone
OB-97-06	3/19-3/23	1173.44	36.5	27.5-42*	1126.5-1136.5	Schroyer Limestone
OB-97-07	3/21-3/23	1158.59	30	NAp	1140-1130	Schroyer Limestone/ Havensville Shale
OB-97-08	3/21-3/24	1157.97	18	NAp	1149-1139	Wymore Shale
Hand Dug Well (top of angle iron)	NAp	1155.28	NAp			
Hand Dug Well (top of water)	NAp	1145.98	NAp			
Spring (top of water)	NAp	1163.47	NAp			
Bottom of Rock Ledge on East Side of Creek[+]	NAp	1138.87	NAp			
Bottom of Rock Ledge South of Vinton School Road Bridge	NAp	1132.69	NAp			

NAp - Not Applicable; ft.amsl - feet above mean sea level; ft.bgs - feet below ground surface

* - OB-97-06 was cored to the top of the Havensville Shale (42 feet bgs). The borehole was grouted to the base of the Schroyer Limestone designated at 36.5 feet bgs based on geologic logging information collected during the drilling operation. A monitor well was installed at this depth.

[+] - OB-97-SW05 (surface water sampling location) was later located at the bottom of this rock ledge.

Table 3-2 Well Development Results for Mobilization #1 and #2

Well ID	Development Dates (1997)	Mobilization	Development Volume (gal)	Measurements at End			
				Temp (°F/°C)	pH	Cond (μmhos/ cm)	Turbidity (NTU)
OB-97-05	6/10	2	55	73.0/22.8	7.02	1184	22.6
OB-97-06	3/26	1	50	65.7/18.2	7.43	1548	13.1
OB-97-07	3/26-3/28	1	480	62/17	9.88	690	10.8
OB-97-07	6/17-6/18	2	65	54.3/12.4	6.70	520	25.4
OB-97-08	3/27-3/28	1	82	53.5/11.9	9.36	580	11.6

Table 3-3 Groundwater Results for Mobilization #1, March 1997

Positive Detections Only

Well	OB-97-05		OB-97-06			OB-97-07		OB-97-08		Dug Well	Spring	MCL and KSWQS
Sample Type	Grab	Grab	Grab	Grab	Post-Development	Grab	Post-Development	Grab	Post-Development	Grab	Grab	
Collection Date	3/25/97	3/29/97	3/19/97	3/22/97	3/28/97	3/22/97	3/28/97	3/23/97	3/29/97	3/23/97	3/23/97	
Sample Depth (feet below ground surface)	42	73	27.5	35.5	35.5	20	30	18	18	8	Ground Surface	
Formation	Schroyer Limestone	Three Mile Limestone	Overburden Interface	Schroyer Limestone	Schroyer Limestone	Overburden Interface	Schroyer/ Havensville	Wymore Shale	Wymore Shale	NAp	NAp	
Other Parameters (mg/l)												
Nitrate/Nitrite	NA	NA	NA	NA	NA	NA	NA	**0.1J**	NA	**0.1J**	**0.1J**	10
Volatile Organic Compounds in micrograms per liter (µg/l)												
Benzene	ND(<0.4)	ND(<0.4)	**0.5**	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	**1.2**	ND(<0.4)	ND(<0.4)	ND(<0.4)	5
Bromodichloromethane	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	**1.2**	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	100 (a)
cis-1,2-Dichloroethylene	**0.8**	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	**3.6**	**5.4**	**0.6**	ND(<0.5)	**5.2**	**1.4**	70
trans-1,2-Dichloroethylene	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	**1.8**	**2.7**	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	100
Dichloromethane	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	5
1,1,2,2-Tetrachloroethane	**9.7**	ND(<0.6)	**3.8**	ND(<0.6)	ND(<0.6)	**14**	**14**	**25**	**39**	**26**	**99**	NAv
Tetrachloroethylene	**1.8**	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	**9.9**	**11**	**2.5**	**2.2**	**2.6**	**6.3**	5
Toluene	**1.2**	**0.7**	**0.4**	ND(<0.4)	**1.2**	ND(<0.4)	ND(<0.4)	**0.5**	ND(<0.4)	ND(<0.4)	ND(<0.4)	1000
Trichloroethylene	**140**	ND(<0.6)	**61**	**0.7**	**0.9**	**490**	**570**	**86**	**99**	**100**	**300**	5
Trichloromethane	**1.1**	ND(<0.5)	ND(<0.5)	**0.8**	**2.2**	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	100 (a)

Bold values represent positive detections of analytes for which standards are available; Shaded values represent concentrations that are equal to or exceed the MCL and the KSWQS

KSWQS: Kansas Surface Water Quality Standard. From: Kansas Register, Department of Health and Environment, Volume 13, No. 28, July 14, 1994.

MCL: Federal Maximum Contaminant Level. From Drinking Water Regulations and Health Advisories, Office of Water, US Environmental Protection Agency, October 1996.

NAv: Not Available

NA: Not Analyzed

NAp: Not Applicable

ND(): Not Detected (Sample Quantitation Limit).

J: Estimated concentration

(a) For MCL, total for all trihalomethanes combined cannot exceed 80 ug/l.

There were no detections of semi-volatile organic compounds or explosives in OB-97-08, the spring, or dug well collected on 3/23/97.

For a complete list of analytes from March 1997, see CEMRK 1997b.

Table 3-4 Groundwater Elevations Measured in Mobilization #1

Well ID	Ground Elevation (ft.amsl)	Depth to Groundwater (Date Collected 1997) (ft.bgs)	Groundwater Elevation (ft.amsl)	Screened Formation
OB-93-01	1181	31.75 (3/19)	1149.25	Wymore/Schroyer
OB-93-02	1207	58.15 (3/19)	1148.88	Wymore/Schroyer
OB-93-03	1172	51.66 (3/19)	1120.34	Three Mile Limestone
OB-93-04	1158	35.45 (3/19)	1122.55	Three Mile Limestone
OB-97-05	1178	54.50 (3/29)	1123.50	Three Mile Limestone
OB-97-06	1173	21.57 (3/26)	1152.80	Schroyer Limestone
OB-97-07	1158	11.60 (3/22)	1146.40	Schroyer Limestone/ Havensville Shale
OB-97-08	1158	11.50 (3/22)	1146.50	Wymore Shale

Notes: ft.amsl - feet above mean sea level; ft.bgs - feet below ground surface

Table 3-5. Piezometer Construction Data in Mobilization #2

Well ID	Dates of Drilling	Surveyed Elevation -Grd (ft.amsl)	Surveyed Elevation - TOC (ft.amsl)	Total Depth (ft.bgs)	Interval Cored (ft.bgs)	Screened Interval Elevation (ft. amsl)	Formation Screened
OB-97-09PZ	6/6/97- 6/7/97	1242.81	1245.70	114.5	NAp	1133.81 - 1132.81 1140.72 - 1139.81 1156.81 - 1155.81 1168.81 - 1167.81 1191.81 - 1190.81 1216.79 - 1214.81	Havensville Shale Schroyer Limestone Wymore Shale Kinney Limestone Blue Springs Shale Florence Limestone
OB-97-10PZ	6/8/97	1183.28	1185.52	58.0	NAp	1134.18 - 1133.28 1141.28 - 1140.28 1147.30 - 1146.28 1154.28 - 1153.28 1167.28 - 1166.28	Havensville Shale Schroyer Limestone (lower) Schroyer Limestone (upper) Wymore Shale Kinney Limestone
OB-97-11PZ	6/9/97	1182.21	1184.43	58.0	NAp	1132.21 - 1131.21 1138.21 - 1137.21 1146.21 - 1145.21 1153.21 - 1152.21 1169.21 - 1168.21	Havensville Shale Schroyer Limestone (lower) Schroyer Limestone (upper) Wymore Shale Kinney Limestone
OB-97-12PZ	6/5/97	1183.24	1185.65	58.0	NAp	1133.24 - 1132.24 1139.24 - 1138.24 1147.24 - 1146.24 1154.24 - 1153.24 1169.24 - 1168.24	Havensville Shale Schroyer Limestone (lower) Schroyer Limestone (upper) Wymore Shale Kinney Limestone
OB-97-13PZ	6/3/97- 6/4/97	1157.92	1160.15	38.0	17.4-26.5	1127.92 - 1126.92 1131.92 - 1130.92 1136.92 - 1135.92 1141.42 - 1140.42 1146.92 - 1145.92	Havensville Shale (lower) Havensville Shale (upper) Schroyer Limestone (lower) Schroyer Limestone (upper) Overburden

Notes: NAp - Not Applicable, not cored; ft. amsl - feet above mean sea level; ft.bgs - feet below ground surface; TOC - top of casing; Grd. - ground surface

Table 3-6 Survey Data

Survey Point	Ground Elevation (ft.amsl)	Top of Casing Elevation (ft.amsl)	NAD 27 Coordinates		NAD 83 Coordinates	
			Latitude/ Easting	Longitude/ Northing	Latitude/ Easting	Longitude/ Northing
OB93-01	1182.07	1183.72	2351617.00	297014.00	1663860.43	297017.70
OB93-02	1208.44	1210.08	2351430.00	297455.00	1663673.43	297458.70
OB93-03	1172.88	1174.84	2351178.00	296891.00	1663421.43	296894.70
OB93-04	1158.32	1160.09	2350915.00	296603.00	1663158.43	296606.70
OB97-05	1178.23	1180.12	2350827.53	297143.29	1663070.96	297146.99
OB97-06	1173.36	1175.37	2351177.15	296903.05	1663420.58	296906.75
OB97-07	1158.72	1160.37	2350918.19	296614.14	1663161.62	296617.84
OB97-08	1158.25	1160.11	2350704.07	296753.03	1662947.50	296756.73
OB97-09PZ	1242.81	1245.70	2351194.18	297646.11	1663437.61	297649.81
OB97-10PZ	1183.28	1185.52	2351567.81	296982.44	1663711.24	296986.14
OB97-11PZ	1182.21	1184.43	2350973.70	296987.18	1663217.13	296990.88
OB97-12PZ	1183.24	1185.65	2350811.13	297281.66	1663054.56	297285.36
OB97-13PZ	1157.92	1160.15	2350926.34	296598.84	1663169.77	296602.54
Dug Well	1155.28	NAp	2350548.60	296813.88	1662792.03	296817.58
Spring	1162.48	1163.66	2350873.72	296885.77	1663117.15	296889.47
OB97-SW1	1168.74	1169.94	2351710.83	297304.08	1663954.26	297307.78
OB97-SW2	1132.01	1132.92	2351041.69	295273.69	1663285.12	295277.37
OB97-SW3	1145.30	1145.97	2350180.08	296664.68	1662423.51	296668.38
OB97-SW4	1130.10	1131.65	2350911.84	295132.88	1663155.27	295136.56
OB97-SW5	1128.99	1130.96	2351195.15	294895.91	1663438.58	294899.59

Notes:

Elevation for dug well is the top of the angle iron adjacent to well.
Elevations for the spring are ground elevation (1162.48 ft amsl) and the top of the iron bar (1163.66 ft amsl) placed at the head of the spring by the surveyor.
Elevations for surface water sample locations are the ground surface along the centerline of each stream and the top of the iron bar placed at each location by the surveyor.
NAp - Not Applicable; ft.amsl - feet above mean sea level; ft.bgs - feet below ground surface

Table 3-7 Piezometer Purging Data for Mobilization #2

Piezometer ID	Initial Condition 4 July 1997	Volume Purged (Gals)
OB97-09PZ(0)	Water Present	1.5
OB97-09PZ(1)	Water Present	Blown dry - water not recoverable
OB97-09PZ(2)	Dry	Dry
OB97-09PZ(3)	Water Present	Blown dry - water not recoverable
OB97-09PZ(4)	Water Present	Blown dry - water not recoverable
OB97-09PZ(5)	Water Present	Blown dry - water not recoverable
OB97-10PZ(0)	Water Present	1
OB97-10PZ(1)	Water Present	3
OB97-10PZ(2)	Water Present	0.5
OB97-10PZ(3)	Water Present	3
OB97-10PZ(4)	Dry	Dry
OB97-11PZ(0)	Water Present	3
OB97-11PZ(1)	Water Present	2.5
OB97-11PZ(2)	Water Present	Blown dry - water not recoverable
OB97-11PZ(3)	Water Present	0.25
OB97-11PZ(4)	Dry	Dry
OB97-12PZ(0)	Water Present	1
OB97-12PZ(1)	Water Present	0.2
OB97-12PZ(2)	Dry	Dry
OB97-12PZ(3)	Water Present	0.6
OB97-12PZ(4)	Dry	Dry
OB97-13PZ(0)	Water Present	1.5
OB97-13PZ(1)	Water Present	Blown dry - water not recoverable
OB97-13PZ(2)	Water Present	(Was purged when sampled on 6/19/97)
OB97-13PZ(3)	Water Present	0.8
OB97-13PZ(4)	Water Present	Blown dry - water not recoverable

Table 3-8 Groundwater and Surface Water Data, Mobilization #2, June and September 1997

Positive Detections Only

Well	OB-93-01	OB-93-02	OB-93-03	OB-93-04	OB-97-05	OB-97-06	OB-97-07	OB-97-08	Dug Well		Spring	OB-97-SW2	MCL and KSWQS
Sample Event	09/97	09/97	09/97	09/97	09/97	09/97	09/97	09/97	06/97	09/97	06/97	09/97	
Field Parameters													
pH (Standard Units)	7.01	7.05	7.01	6.79	7.04	7.01	6.81	6.99	6.48	7.05	6.72	7.61	NAv
Conductivity (umhos/cm)	610	700	900	890	750	620	840	670	480	380	460	540	NAv
Temperature (C)	12.9	14.1	15.0	14.0	15.0	15.0	14.0	16.0	14.0	15.2	13.0	14.4	NAv
Turbidity (NTU)	2.76	4.54	26.2	5.23	4.0	6.52	22.6	2.38	1.15	6.34	20.5	251	NAv
Volatile Organic Compounds in micrograms per liter (µg/l)													
cis-1,2-Dichloroethylene	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<5.0)	**6.4**	**7.1**	**19**	**0.8**	ND(<0.5)	70
trans-1,2-Dichloroethylene	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<5.0)	ND(<2.5)	**1.1**	ND(<5.0)	ND(<0.5)	ND(<0.5)	100
Dichloromethane	ND(<0.9)	ND(<0.9)	ND(<0.9)	1.2B	ND(<0.9)	1.5B	14B	ND(<4.5)	ND(<0.9)	14B	1.1B	1.5B	5
Tetrachloroethylene	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	**14**	**8.0**	**4.9**	ND(<11)	**4.9**	ND(<1.1)	5
1,1,2,2-Tetrachloroethane	ND(<0.6)	ND(<0.6)	ND(<0.6)	**0.8**	ND(<0.6)	ND(<0.6)	**21**	**58**	**56**	**78**	**67**	ND(<0.6)	NAv
Toluene	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<4.0)	ND(<2.0)	ND(<0.4)	ND(<4.0)	ND(<0.4)	ND(<0.4)	1000
Trichloroethylene	ND(<0.6)	ND(<0.6)	**1.9**	**17**	ND(<0.6)	**1.2**	**400**	**200**	**230**	**260**	**190**	ND(<0.6)	5
m/p-Xylene	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<6.0)	**5.0**	ND(<0.6)	ND(<6.0)	ND(<0.6)	ND(<0.6)	10000

Bold values represent positive detections of analytes for which standards are available; Shaded values represent concentrations that are equal to or exceed the MCL and the KSWQS

KSWQS: Kansas Surface Water Quality Standard. From: Kansas Register, Department of Health and Environment, Volume 13, No. 28, July 14, 1994.

MCL: Federal Maximum Contaminant Level. From Drinking Water Regulations and Health Advisories, Office of Water, US Environmental Protection Agency, October 1996.

B: Compound detected in sample is less than 10X the amount detected in the method blank. Result is estimated.

NAv: Not Available

ND(): Not Detected (Sample Quantitation Limit).

While there were no detections in OB93-01 and OB93-02, the field parameters are provided on this table.

No sample was collected from the spring in 9/97, the surface water locations in 6/97, or the four other surface water locations in 9/97 as they were dry.

For a complete list of analytes for June and September 1997, see CEMRK 1997b.

Table 3-9 Groundwater Data for Piezometers, Mobilization #2, June and September 1997

Positive Detections Only

Sample Location	OB97-09PZ(0)	OB97-09PZ(1)	OB97-09PZ(3)	OB97-09PZ(4)	OB97-10PZ(0)*	OB97-10PZ(1)	OB97-10PZ(2)	OB97-10PZ(3)	OB97-11PZ(0)*	OB97-11PZ(1)	OB97-12PZ(0) *	OB97-12PZ(1)	OB97-12PZ(3)	OB97-13PZ(0)	OB97-13PZ(1)	OB97-13PZ(2)	OB97-13PZ(2)	OB97-13PZ(3)	OB97-13PZ(4)	MCL and KSWQS
Sample Event	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Sep-97	Jun-97	Sep-97	Sep-97	Sep-97	
Field Parameters																				
pH (Standard Units)	7.18	7.18	7.12	7.09	6.64	6.62	7.00	7.39	7.21	7.29	7.27	7.15	7.33	6.72	7.78	6.68	6.52	7.64	7.01	NAv
Conductivity (umhos/cm)	1980	1180	1270	1180	4100	1150	940	970	1040	810	1710	830	620	1200	750	660	660	1800	990	NAv
Temperature (C)	16.2	16.2	15.5	15.8	14.8	15.8	15.2	15.4	17.4	21.8	20.7	15.3	16.4	21.2	20.8	20.0	25.1	>200	>200	NAv
Turbidity (NTU)	>200	101.9	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	17.8	18.6	NAv
Volatile Organic Compounds in micrograms per liter (µg/l)																				
Acetone	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	**100**	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	NAv
Benzene	ND(<0.4)	ND(<0.4)	**2.0**	ND(<0.4)	**1.2**	ND(<0.4)	ND(<0.4)	ND(<0.4)	**1.1**	ND(<0.4)	**1.1**	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	**0.8**	5
Bromodichloromethane	ND(<0.5)	ND(<0.5)	**1.2**	**1.1**	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	100(a)
Bromomethane	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	**1.9**	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	ND(<1.2)	**2.0**	NAv
2-Butanone	**210**	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	**110**	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	ND(<100)	NAv
Carbon Disulfide	**65**	**5.2**	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	**5.4**	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	ND(<5.0)	NAv
Chlorobenzene	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	**0.4**	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	ND(<0.4)	NAv
cis-1,2-Dichloroethylene	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	**2.2**	**0.8**	ND(<0.5)	ND(<0.5)	ND(<0.5)	**0.9**	**1.0**	**2.3**	**2.2**	**1.0**	**1.8**	70
trans-1,2-Dichloroethylene	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	**1.0**	**1.2**	ND(<0.5)	**0.6**	100
1,4-Dichlorobenzene	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	**2.7**	ND(<1.0)	ND(<1.0)	ND(<1.0)	ND(<1.0)	75
Dichloromethane	6.5B	1.9B	1.4B	1.0B	10B	14B	2.6B	3.1B	3.4B	1.6B	9.3B	ND(<0.9)	3.6B	1.3B	8.3B	1.3B	1.3B	1.3B	2.2B	5
1,1,2,2-Tetrachloroethane	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	**2.4**	**2.0**	**2.8**	ND(<0.6)	ND(<0.6)	**1.1**	**2.2**	**7.2**	**6.2**	**3.1**	ND(<0.7)	NAv
Tetrachloroethylene	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	**3.6**	**4.1**	ND(<1.1)	ND(<1.1)	5
Tribromomethane	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	**1.6**	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	ND(<1.5)	100(a)
Toluene	**2.0**	**1.6**	**1.8**	ND(<0.4)	**2.4**	**3.1**	**1.6**	**3.0**	**0.8**	ND(<0.4)	**0.9**	ND(<0.4)	**2.3**	ND(<0.4)	**0.8**	**0.8**	ND(<0.4)	**1.7**	**0.8**	1000
1,1,1-Trichloroethane	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	**0.9**	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	ND(<0.7)	200
1,1,2-Trichloroethane	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	**0.8**	ND(<0.6)	**0.8**	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	5
Trichloroethylene	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	**1.8**	**0.7**	ND(<0.6)	**5.3**	**10**	**54**	**2.2**	**9.1**	ND(<0.6)	**38**	**18**	**170**	**200**	**62**	**13.3**	5
Trichloromethane	**1.4**	ND(<0.5)	**1.0**	**0.7**	**39**	**1.7**	**2.4**	ND(<0.5)	**1.0**	ND(<0.5)	**2.5**	**0.5**	ND(<0.5)	ND(<0.5)	**1.1**	**0.7**	ND(<0.5)	**0.6**	**0.8**	100(a)
m/p-Xylene	ND(<0.6)	ND(<0.6)	ND(<0.6)	**0.7**	**0.6**	ND(<0.6)	ND(<0.6)	ND(<0.6)	**1.3**	ND(<0.6)	ND(<0.6)	ND(<0.6)	**0.8**	ND(<0.6)	**0.8**	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	10000

Bold values represent positive detections of analytes for which standards are available; Shaded values represent concentrations that are equal to or exceed the MCL and the KSWQS

KSWQS: Kansas Surface Water Quality Standard. From: Kansas Register, Department of Health and Environment, Volume 13, No. 28, July 14, 1994.

MCL: Federal Maximum Contaminant Level. From Drinking Water Regulations and Health Advisories, Office of Water, US Environmental Protection Agency, October 1996.

B: Compound detected in sample is less than 10X the amount detected in the method blank. Result is estimated.

NAv: Not Available

ND(): Not Detected (Sample Quantitation Limit).

No samples were collected from OB97-09PZ(2), -09PZ(5); -10PZ(4); -11PZ(2), -11PZ(3), and -11PZ(4); -12PZ(2) and -12PZ(4), which were dry.

(a) For MCL, total for all trihalomethanes combined cannot exceed 80 ug/l.

For a complete list of analytes for June and September 1997, see CEMRK, 1997b.

* Results reported as maximum detections of record sample and reanalysis.

Table 3-10 Summary of Groundwater Elevation Data at OB/OD Area

Well ID	Formation Screened	Top of Screen Elev. (ft.amsl)	Bottom of Screen Elev. (ft.amsl)	Ground Elevation (ft.amsl)	Measuring Point Elev. (ft.amsl)	Groundwater Elevation (ft.amsl)													
						Date													
						19-Dec-95	1-Jun-97	4-Jun-97	5-Jun-97	6-Jun-97	7-Jun-97	9-Jun-97	10-Jun-97	11-Jun-97	14-Jun-97	16-Jun-97	17-Jun-97	18-Jun-97	20-Jun-97
OB93-01	Wymore/Schroyer	1155	1140	1182.07	1183.72	1152.28	1155.41	1154.91	1154.87	1154.84	1154.59	1154.35	1154.32	1154.39	1154.11	1153.85	1153.65	1153.47	1153.37
OB93-02	Wymore/Schroyer	1151	1136	1208.44	1210.08	1152.13	1155.40	1154.89	1154.86	1154.85	1154.59	1154.34	1154.33	1154.39	1154.11	1153.88	1153.70	1153.51	1153.39
OB93-03	Threemile Limestone	1111	1096	1172.88	1174.84	1121.22	1124.03	1123.86	1123.85	1123.84	1123.79	1123.73	1123.67	1123.67	1123.53	1123.46	1123.38	1123.31	1123.24
OB93-04	Threemile Limestone	1116	1101	1158.32	1160.09	1122.19	1125.01	1124.89	1124.90	1124.88	1124.84	1124.78	1124.74	1124.74	1124.62	1124.53	1124.42	1124.34	1124.23
OB97-05	Threemile Limestone	1115	1105	1178.23	1180.12		1124.10	1123.95	1123.96	1123.94	1123.89	1123.83	1123.77	1123.78	1123.62	1123.56	1123.48	1123.40	1123.34
OB97-06	Schroyer Limestone	1146.5	1136.5	1173.36	1175.37		1155.39	1154.90	1154.86	1154.86	1154.59	1154.39	1154.34	1154.40	1154.13	1153.87	1153.67	1153.49	1153.38
OB97-07	Schroyer/Havensville	1140	1130	1158.72	1160.37		1146.66	1146.93	1147.00	1147.15	1147.05	1146.77	1146.76	1146.68	1146.46	1146.32	1146.25	1146.17	1146.03
OB97-08	Overburden	1149	1139	1158.25	1160.11		1145.94	1145.62	1145.51	1145.44	1145.28	1145.05	1144.98	1144.92	1144.74	1144.53	1144.45	1144.36	1144.18
OB97-09PZ(0)	Havensville Shale	1133.81	1132.81	1242.81	1245.70	Wells/Piezometers Not Installed												1158.44	1156.21
OB97-09PZ(1)	Schroyer Limestone	1140.72	1139.81	1242.81	1245.70													1146.52	1146.51
OB97-09PZ(2)	Wymore Shale	1156.81	1155.81	1242.81	1245.70													1158.43	1156.21
OB97-09PZ(3)	Kinney Limestone	1168.81	1167.81	1242.81	1245.70													1168.83	1168.73
OB97-09PZ(4)	Blue Springs Shale	1191.81	1190.81	1242.81	1245.70													1191.96	1192.00
OB97-09PZ(5)	Florence Limestone	1216.79	1214.81	1242.81	1245.70													1216.28	1215.73
OB97-10PZ(0)	Havensville Shale	1134.18	1133.28	1183.28	1185.52													1138.54	1140.01
OB97-10PZ(1)	Schroyer Limestone-bottom	1141.28	1140.28	1183.28	1185.52													1151.28	1151.18
OB97-10PZ(2)	Schroyer Limestone-top	1147.30	1146.28	1183.28	1185.52													1153.47	1153.44
OB97-10PZ(3)	Wymore Shale	1154.28	1153.28	1183.28	1185.52													1164.71	1164.50
OB97-10PZ(4)	Kinney Limestone	1167.28	1166.28	1183.28	1185.52													**1166.24 R**	**1166.24 R**
OB97-11PZ(0)	Havensville Shale	1132.21	1131.21	1182.21	1184.43													1154.52	1153.62
OB97-11PZ(1)	Schroyer Limestone-bottom	1138.21	1137.21	1182.21	1184.43													1146.67	1146.66
OB97-11PZ(2)	Schroyer Limestone-top	1146.21	1145.21	1182.21	1184.43													1146.59	1146.54
OB97-11PZ(3)	Wymore Shale	1153.21	1152.21	1182.21	1184.43													1154.56	1153.59
OB97-11PZ(4)	Kinney Limestone	1169.21	1168.21	1182.21	1184.43													1168.39	1168.39
OB97-12PZ(0)	Havensville Shale	1133.24	1132.24	1183.24	1185.65													1147.57	1136.52
OB97-12PZ(1)	Schroyer Limestone-bottom	1139.24	1138.24	1183.24	1185.65													1146.43	1146.43
OB97-12PZ(2)	Schroyer Limestone-top	1147.24	1146.24	1183.24	1185.65													1146.56	1146.65
OB97-12PZ(3)	Wymore Shale	1154.24	1153.24	1183.24	1185.65													1160.22	1160.11
OB97-12PZ(4)	Kinney Limestone	1169.24	1168.24	1183.24	1185.65													dry	dry
OB97-13PZ(0)	Havensville Shale-middle	1127.92	1126.92	1157.92	1160.15													1145.33	1132.33
OB97-13PZ(1)	Havensville Shale-top	1131.92	1130.92	1157.92	1160.15													1146.20	1145.69
OB97-13PZ(2)	Havensville Shale-top	1136.92	1135.92	1157.92	1160.15													1146.04	1146.05
OB97-13PZ(3)	Schroyer Limestone-bottom	1141.42	1140.42	1157.92	1160.15													1147.19	1141.32
OB97-13PZ(4)	Overburden	1146.92	1145.92	1157.92	1160.15													1149.83	1147.39
OBHD-97-14	NAp	1143.26	1138.26	1154.21	1156.81	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp
Dug Well	NAp	NAp	NAp	1155.28	1155.28	NAp	NM	1144.88	1144.73	1144.63	1144.58	1144.58	1144.50	1144.52	1144.03	1143.83	1143.74	1143.67	1143.50
Spring	NAp	NAp	NAp	1162.48	1163.66	NM													
OB97-SW1	Above Schroyer	NAp	NAp	1168.74	1169.94	Dry													
OB97-SW2	Below Schroyer	NAp	NAp	1132.01	1132.92														
OB97-SW3	Above Schroyer	NAp	NAp	1145.30	1145.97														
OB97-SW4	Below Schroyer	NAp	NAp	1130.10	1131.65														
OB97-SW5	Below Schroyer	NAp	NAp	1128.99	1130.96														

R- Rejected, based on the bottom of screen
NAp - Not Applicable
NM - Not Measured
J - Estimated value, measured within 0.1 foot of bottom of screen.
R - Rejected elevation, measured below bottom of screen.
a - OBHD-97-14 was measured on 5 December 1997.
* - Measured by United States Geologic Survey
+ - The piezometers were purged using air lift method on 4 July 1997 after the water elevations were measured, and water elevations were measured again on 5 July 1997.
(ft.amsl) - feet above mean sealevel

Table 3-10 Summary of Groundwater Elevation Data at OB/OD Area

Well ID	Formation Screened	Top of Screen Elev. (ft.amsl)	Bottom of Screen Elev. (ft.amsl)	Ground Elevation (ft.amsl)	Measuring Point Elev. (ft.amsl)	Groundwater Elevation									
						Date									
						4-Jul-97 +	5-Jul-97 +	27-Aug-97	2-Sep-97	5-Sep-97	14-Oct-97		1-Dec-97		19-Jan-98
OB93-01	Wymore/Schroyer	1155	1140	1182.07	1183.72	1151.95	1152.11	1151.01	1150.80	1151.00	1149.96		1150.70	*	1155.33
OB93-02	Wymore/Schroyer	1151	1136	1208.44	1210.08	1151.96	1152.16	1151.03	1150.81	1150.97	1149.96		1150.47	*	1155.33
OB93-03	Threemile Limestone	1111	1096	1172.88	1174.84	1122.48	1122.53	1121.37	1121.31	1121.32	1120.97		1121.95		1123.21
OB93-04	Threemile Limestone	1116	1101	1158.32	1160.09	1123.17	1123.16	1121.39	1121.36	1121.35	1120.97		1122.54		1124.56
OB97-05	Threemile Limestone	1115	1105	1178.23	1180.12	1122.51	1122.57	1121.33	1121.28	1121.27	1120.91		1121.96		1123.30
OB97-06	Schroyer Limestone	1146.5	1136.5	1173.36	1175.37	1151.97	1152.17	1151.13	1150.80	1150.94	1149.96		1150.46	*	1155.25
OB97-07	Schroyer/Havensville	1140	1130	1158.72	1160.37	1145.27	1145.26	1144.90	1144.86	1144.78	1144.59		1145.22		1149.63
OB97-08	Overburden	1149	1139	1158.25	1160.11	1142.98	1142.92	1142.45	1142.50	1142.43	1141.55		1143.91		1149.56
OB97-09PZ(0)	Havensville Shale	1133.81	1132.81	1242.81	1245.70	1155.68	1150.20	1154.73	1154.78	1142.14	1153.18	*	1153.01	*	1153.80
OB97-09PZ(1)	Schroyer Limestone	1140.72	1139.81	1242.81	1245.70	1145.21	Dry	1145.32	1145.24	1145.39	1143.60	*	1144.34	*	1148.19
OB97-09PZ(2)	Wymore Shale	1156.81	1155.81	1242.81	1245.70	1156.05	Dry	Dry	Dry	Dry	Dry	*	Dry	*	Dry
OB97-09PZ(3)	Kinney Limestone	1168.81	1167.81	1242.81	1245.70	1168.58	Dry	1168.41	1168.48	1168.41	1168.39	*	1168.73	*	1169.47
OB97-09PZ(4)	Blue Springs Shale	1191.81	1190.81	1242.81	1245.70	1191.93	Dry	1191.71	1191.73	1191.69	1191.54	*	1191.80	*	1192.35
OB97-09PZ(5)	Florence Limestone	1216.79	1214.81	1242.81	1245.70	**1214.91 J**	Dry	Dry	Dry	Dry	Dry	*	Dry	*	1215.54
OB97-10PZ(0)	Havensville Shale	1134.18	1133.28	1183.28	1185.52	1146.31	1136.65	1149.01	1148.92	1140.01	1148.17		1148.61		1152.12
OB97-10PZ(1)	Schroyer Limestone-bottom	1141.28	1140.28	1183.28	1185.52	1150.78	1150.33	1149.56	1149.35	1149.44	1148.66		1149.01		1152.85
OB97-10PZ(2)	Schroyer Limestone-top	1147.30	1146.28	1183.28	1185.52	1151.99	1151.95	1151.16	1151.10	1150.96	1149.97		1150.49		1155.19
OB97-10PZ(3)	Wymore Shale	1154.28	1153.28	1183.28	1185.52	1164.69	1157.52	1163.79	1163.74	1158.68	1164.03		1164.70		1165.30
OB97-10PZ(4)	Kinney Limestone	1167.28	1166.28	1183.28	1185.52	Dry	Dry	Dry	Dry	Dry	Dry		Dry		1166.66
OB97-11PZ(0)	Havensville Shale	1132.21	1131.21	1182.21	1184.43	1152.96	1152.41	1148.42	1148.52	1138.17	1147.24		1149.12		1152.41
OB97-11PZ(1)	Schroyer Limestone-bottom	1138.21	1137.21	1182.21	1184.43	1145.29	1145.70	1145.36	1145.20	1145.40	1143.90		1144.55	*	1148.73
OB97-11PZ(2)	Schroyer Limestone-top	1146.21	1145.21	1182.21	1184.43	**1145.21 J**	1145.29	Dry	Dry	**1145.12 R**	Dry		1145.59		1149.93
OB97-11PZ(3)	Wymore Shale	1153.21	1152.21	1182.21	1184.43	1152.95	1152.41	Dry	Dry	Dry	Dry		Dry		1152.39
OB97-11PZ(4)	Kinney Limestone	1169.21	1168.21	1182.21	1184.43	**1167.76 R**	Dry	Dry	Dry	Dry	Dry		Dry		1168.49
OB97-12PZ(0)	Havensville Shale	1133.24	1132.24	1183.24	1185.65	1147.79	1135.29	1143.87	1144.14	1133.71	1142.46		1147.48		1151.12
OB97-12PZ(1)	Schroyer Limestone-bottom	1139.24	1138.24	1183.24	1185.65	1145.12	1145.53	1145.34	1145.07	1145.30	1143.40		1143.88		1147.83
OB97-12PZ(2)	Schroyer Limestone-top	1147.24	1146.24	1183.24	1185.65	**1146.21 R**	Dry	Dry	Dry	Dry	Dry		Dry		1148.45
OB97-12PZ(3)	Wymore Shale	1154.24	1153.24	1183.24	1185.65	1158.91	1158.85	1157.31	1156.52	1156.41	1155.46		1157.99		1165.75
OB97-12PZ(4)	Kinney Limestone	1169.24	1168.24	1183.24	1185.65	**1168.18 R**	Dry	Dry	Dry	Dry	Dry		Dry		1169.74
OB97-13PZ(0)	Havensville Shale-middle	1127.92	1126.92	1157.92	1160.15	1132.18	1131.69	1131.50	1131.60	1129.25	1135.07	*	1136.98	*	1142.58
OB97-13PZ(1)	Havensville Shale-top	1131.92	1130.92	1157.92	1160.15	1145.23	1143.91	1144.58	1144.61	1144.07	1143.84	*	1144.49	*	1149.66
OB97-13PZ(2)	Havensville Shale-top	1136.92	1135.92	1157.92	1160.15	1145.30	1145.28	1144.96	1144.88	1144.83	1144.56	*	1145.25	*	1149.70
OB97-13PZ(3)	Schroyer Limestone-bottom	1141.42	1140.42	1157.92	1160.15	1143.79	1144.24	1143.68	1143.69	1141.07	1143.36	*	1144.39	*	1149.20
OB97-13PZ(4)	Overburden	1146.92	1145.92	1157.92	1160.15	1146.35	1146.60	1146.20	1146.11	**1145.92 J**	**1145.84R**	*	Dry	*	1147.72
OBHD-97-14	NAp	1143.26	1138.26	1154.21	1156.81	NAp	NAp	NAp	NAp	NAp	NAp	a	1143.40		1147.41
Dug Well	NAp	NAp	NAp	1155.28	1155.28	1142.40	1141.98	1140.93	1141.02	1141.03	1139.96		1142.98		NAp
Spring	NAp	NAp	NAp	1162.48	1163.66	NM	NM	NM	Dry	Dry	NM		NM		1162.66
OB97-SW1	Above Schroyer	NAp	NAp	1168.74	1169.94	Dry	Dry	Dry	Dry	Dry	Dry		Dry		1168.99
OB97-SW2	Below Schroyer	NAp	NAp	1132.01	1132.92	Dry	Dry	Dry	Dry	Dry	Dry		NM		1132.12
OB97-SW3	Above Schroyer	NAp	NAp	1145.30	1145.97	Dry	Dry	Dry	Dry	Dry	Dry		Dry		1145.75
OB97-SW4	Below Schroyer	NAp	NAp	1130.10	1131.65	Dry	Dry	Dry	Dry	Dry	Dry		Dry		1130.95
OB97-SW5	Below Schroyer	NAp	NAp	1128.99	1130.96	Dry	Dry	Dry	Dry	Dry	Dry		NM		1129.61

R- Rejected, based on the bottom of screen
NAp - Not Applicable
NM - Not Measured
J - Estimated value, measured within 0.1 foot of bottom of screen.
R - Rejected elevation, measured below bottom of screen.
a - OBHD-97-14 was measured on 5 December 1997.
* - Measured by United States Geologic Survey
+ - The piezometers were purged using air lift method on 4 July 1997 after the water elevations were measured, and water elevations were measured again on 5 July 1997.
(ft.amsl) - feet above mean sealevel

Table 3-11 Groundwater Elevation Data Measurement Comparison, 5 September 1997

Well ID	Formation Screened	Top of Screen Elev. (ft amsl)	Bottom of Screen Elev. (ft amsl)	Ground Elevation (ft amsl)	Measuring Point Elev. (ft amsl)	5-Sep-97						
						Electronic Tape		Steel Tape & Chalk				
						DTW (ft.bmp)	GW Elev (ft.amsl)	Sounded (ft.bmp)	Held (ft.bmp)	Water Mark *	DTW (ft.bmp)	GW Elev. (ft.amsl)
OB93-01	Wymore / Schroyer	1155	1140	1182.07	1183.72	32.72	1151.00	42.14	33.50	0.78	32.72	1151.00
OB93-02	Wymore / Schroyer	1151	1136	1208.44	1210.08	59.11	1150.97	73.88	60.00	0.94	59.06	1151.02
OB93-03	Threemile Limestone	1111	1096	1172.88	1174.84	53.52	1121.32	79.30	54.00	0.53	53.47	1121.37
OB93-04	Threemile Limestone	1116	1101	1158.32	1160.09	38.74	1121.35	58.27	39.00	0.29	38.71	1121.38
OB97-05	Threemile Limestone	1115	1105	1178.23	1180.12	58.85	1121.27	73.03	59.50	0.65	58.85	1121.27
OB97-06	Schroyer Limestone	1146.5	1136.5	1173.36	1175.37	24.43	1150.94	38.53	25.00	0.56	24.44	1150.93
OB97-07	Schroyer / Havensville	1140	1130	1158.72	1160.37	15.59	1144.78	31.99	17.00	1.42	15.58	1144.79
OB97-08	Overburden	1149	1139	1158.25	1160.11	17.68	1142.43	20.40	18.00	0.35	17.65	1142.46
OB97-09PZ(0)	Havensville Shale	1133.81	1132.81	1242.81	1245.70	103.56	1142.14	113.13	104.00	0.49	103.51	1142.19
OB97-09PZ(1)	Schroyer Limestone	**1140.72**	**1139.81**	1242.81	1245.70	100.31	1145.39	107.35	101.00	0.73	100.27	1145.43
OB97-09PZ(2)	Wymore Shale	**1156.81**	**1155.81**	1242.81	1245.70	Dry	Dry	89.89	89.89	0.10	89.79	1155.91
OB97-09PZ(3)	Kinney Limestone	1168.81	1167.81	1242.81	1245.70	77.29	1168.41	78.19	78.00	0.75	77.25	1168.45
OB97-09PZ(4)	Blue Springs Shale	1191.81	1190.81	1242.81	1245.70	54.01	1191.69	55.05	54.50	0.53	53.97	1191.73
OB97-09PZ(5)	Florence Limestone	**1216.79**	**1214.81**	1242.81	1245.70	Dry	Dry	31.26	31.26	0.15	31.11	1214.59
OB97-10PZ(0)	Havensville Shale	**1134.18**	1133.28	1183.28	1185.52	45.51	1140.01	53.48	46.00	0.53	45.47	1140.05
OB97-10PZ(1)	Schroyer Limestone-bottom	1141.28	1140.28	1183.28	1185.52	36.08	1149.44	45.61	36.50	0.45	36.05	1149.47
OB97-10PZ(2)	Schroyer Limestone-top	**1147.30**	1146.28	1183.28	1185.52	34.56	1150.96	39.68	35.00	0.48	34.52	1151.00
OB97-10PZ(3)	Wymore Shale	1154.28	1153.28	1183.28	1185.52	26.84	1158.68	32.41	27.50	0.72	26.78	1158.74
OB97-10PZ(4)	Kinney Limestone	1167.28	1166.28	1183.28	1185.52	Dry	Dry	19.56	19.56	0.25	19.31	1166.21
OB97-11PZ(0)	Havensville Shale	1132.21	1131.21	1182.21	1184.43	46.26	1138.17	53.41	47.00	0.81	46.19	1138.24
OB97-11PZ(1)	Schroyer Limestone-bottom	1138.21	1137.21	1182.21	1184.43	39.03	1145.40	47.59	39.50	0.51	38.99	1145.44
OB97-11PZ(2)	Schroyer Limestone-top	1146.21	1145.21	1182.21	1184.43	39.31	1145.12	39.62	39.62	0.37	39.25	1145.18
OB97-11PZ(3)	Wymore Shale	1153.21	1152.21	1182.21	1184.43	Dry	Dry	32.56	32.56	0.13	32.43	1152.00
OB97-11PZ(4)	Kinney Limestone	1169.21	1168.21	1182.21	1184.43	Dry	Dry	16.94	16.94	0.11	16.83	1167.60
OB97-12PZ(0)	Havensville Shale	1133.24	1132.24	1183.24	1185.65	51.94	1133.71	53.63	52.50	0.61	51.89	1133.76
OB97-12PZ(1)	Schroyer Limestone-bottom	1139.24	1138.24	1183.24	1185.65	40.35	1145.30	47.58	41.00	0.69	40.31	1145.34
OB97-12PZ(2)	Schroyer Limestone-top	1147.24	1146.24	1183.24	1185.65	Dry	Dry	39.76	39.76	0.13	39.63	1146.02
OB97-12PZ(3)	Wymore Shale	1154.24	1153.24	1183.24	1185.65	29.24	1156.41	32.62	30.00	0.79	29.21	1156.44
OB97-12PZ(4)	Kinney Limestone	1169.24	1168.24	1183.24	1185.65	Dry	Dry	17.73	17.73	0.00	Dry	Dry
OB97-13PZ(0)	Havensville Shale-middle	1127.92	1126.92	1157.92	1160.15	30.90	1129.25	33.35	31.00	0.16	30.84	1129.31
OB97-13PZ(1)	Havensville Shale-top	1131.92	1130.92	1157.92	1160.15	16.08	1144.07	29.55	17.00	0.98	16.02	1144.13
OB97-13PZ(2)	Schroyer Limestone-top	1136.92	1135.92	1157.92	1160.15	15.32	1144.83	24.42	16.00	0.68	15.32	1144.83
OB97-13PZ(3)	Schroyer Limestone-bottom	1141.42	1140.42	1157.92	1160.15	19.08	1141.07	19.92	18.50	-0.56	19.06	1141.09
OB97-13PZ(4)	Overburden	1146.92	1145.92	1157.92	1160.15	14.23	1145.92	14.71	13.50	-0.74	14.24	1145.91
Dug Well	NAp	NAp	NAp	NM	1155.28	14.25	1141.03	19.20	NM	MM	NM	NM

Notes:

Bolded values are revisions to screen elevations based on review of field notes and well construction information.

NAp - Not applicable

NM - Not measured

(ft.amsl) - feet above mean sea level

(ft.bmp) - feet below measuring point

* - Length of water mark on chalked tape

Table 3-12 Groundwater and Surface Water Data - Open Burn / Open Detonation Area - December 1997

Positive Detections Only

Sample Location	OB93-01	OB93-02	OB93-03	OB93-04	OB97-05	OB97-06	OB97-07	OB97-08	OB97-14(b)	Dug Well	OBHD-97-14 a	Spring	OB97-SW2	OB97-SW5	MCL or KSWQS
Sample Event	12/97	12/97	12/97	12/97	12/97	12/97	12/97	12/97	12/97	12/97	12/97	12/97	12/97	12/97	
Field Parameters															
pH (Standard Units)	7.10	7.07	7.04	7.09	7.55	7.12	7.11	7.04		7.00	8.00	7.26	8.06	8.22	NAv
Conductivity (umhos/cm)	718	660	1080	1220	630	800	870	1260		7.0	946	1090	229	259	NAv
Temperature (C)	12.8	13.5	13.7	13.3	9.6	13.5	13.5	13.9		9.3	10.9	11.9	9.0	6.2	NAv
Turbidity (NTU)	9.84	3.49	8.66	8.47	4.14	6.11	16.20	6.14		8.92	1.58	23.20	3.69	11.26	NAv
Volatile Organic Compounds in micrograms per liter (µg/l)															
cis-1,2-Dichloroethylene	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	**5.4**	ND(<2.5)	1.5	**43**	**82**	ND(<1.0)	ND(<0.5)	ND(<0.5)	70
trans-1,2-Dichloroethylene	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<0.5)	ND(<5.0)	ND(<2.5)	ND(<1.0)	**3.4**	**6.0**	ND(<1.0)	ND(<0.5)	ND(<0.5)	100
Dichloromethane	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<0.9)	ND(<9.0)	ND(<4.5)	ND(<1.8)	ND(<4.5)	ND(<1.8)	2.8B	1.3B	1.0B	100
Tetrachloroethylene	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	ND(<1.1)	**14**	ND(5.5)	3.3	ND(<5.5)	ND(<2.2)	**3.1**	ND(<1.1)	ND(<1.1)	5
1,1,2,2-Tetrachloroethane	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	ND(<0.6)	23	37	36	33	15	42	ND(<0.6)	ND(<0.6)	NAv
Trichloroethylene	ND(<0.6)	ND(<0.6)	**1.7**	**15**	ND(<0.6)	**0.7**	**530**	**110**	**120**	**110**	**63**	**110**	ND(<0.6)	ND(<0.6)	5

NOTES:

Bold values represent positive detections of analytes for which standards are available; Shaded values represent concentrations that are equal to or exceed the MCL and the KSWQS

KSWQS: Kansas Surface Water Quality Standard. From: Kansas Register, Department of Health and Environment, Volume 13, No. 28, July 14, 1994.

MCL: Federal Maximum Contaminant Level. From Drinking Water Regulations and Health Advisories, Office of Water, US Environmental Protection Agency, November 1995.

B: Compound detected in sample is less than 10X the amount detected in the method blank. Result is estimated.

NAv: Not Available

ND(): Not Detected (Sample Quantitation Limit).

a: A monitoring well was constructed at Dug well on December 1-3, 1997. Groundwater samples were collected prior to construction of the well and after development of the monitoring well.

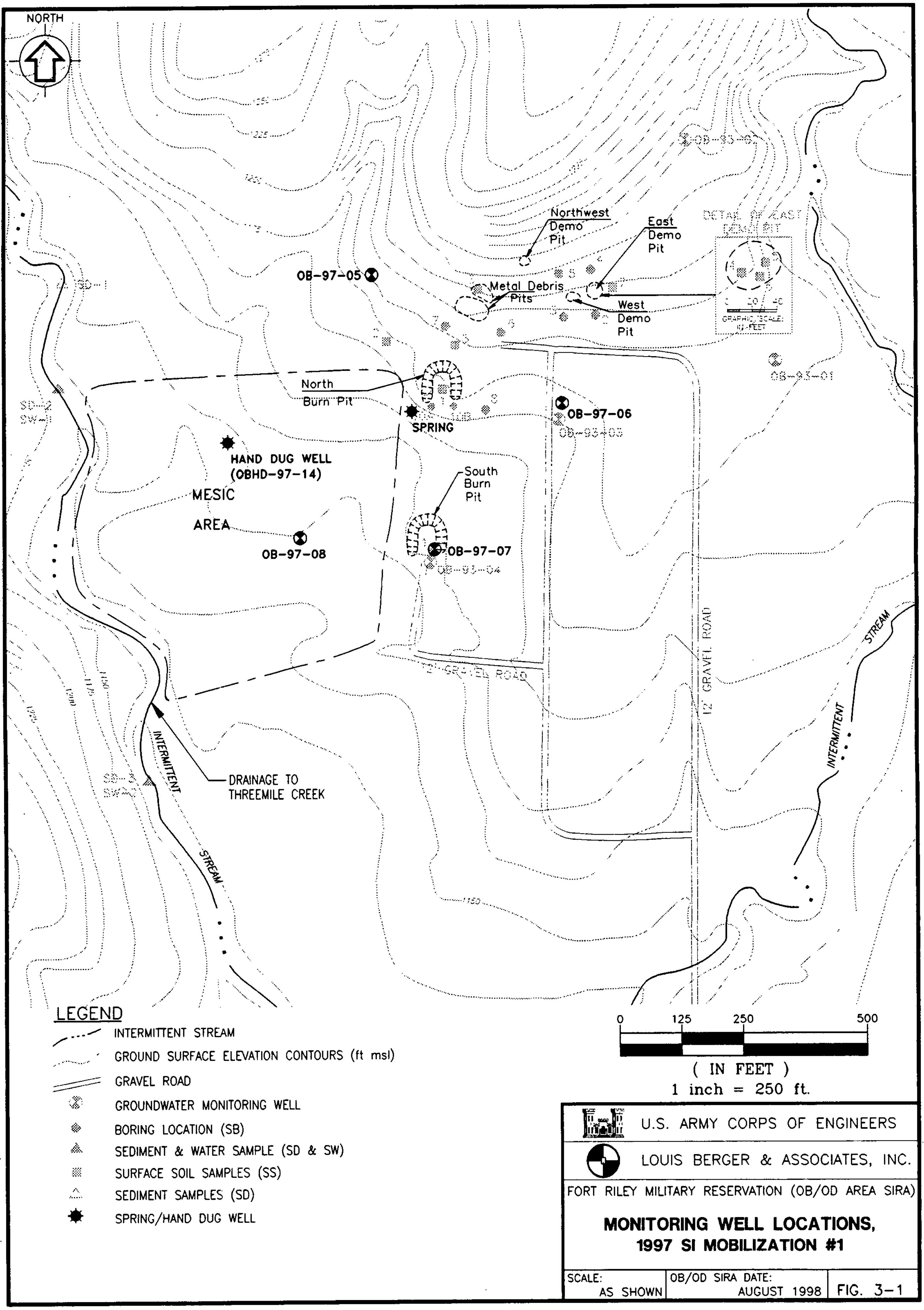
b: Duplicate of OB-97-08

There were no detections of semi-volatile organic compounds in any samples.

While there were no detections in OB93-01, OB93-02, and OB93-05, the field parameters are provided on this table.

For a complete list of analyte from December 1997, see CENWK 1998.

FIGURES



U.S. ARMY CORPS OF ENGINEERS

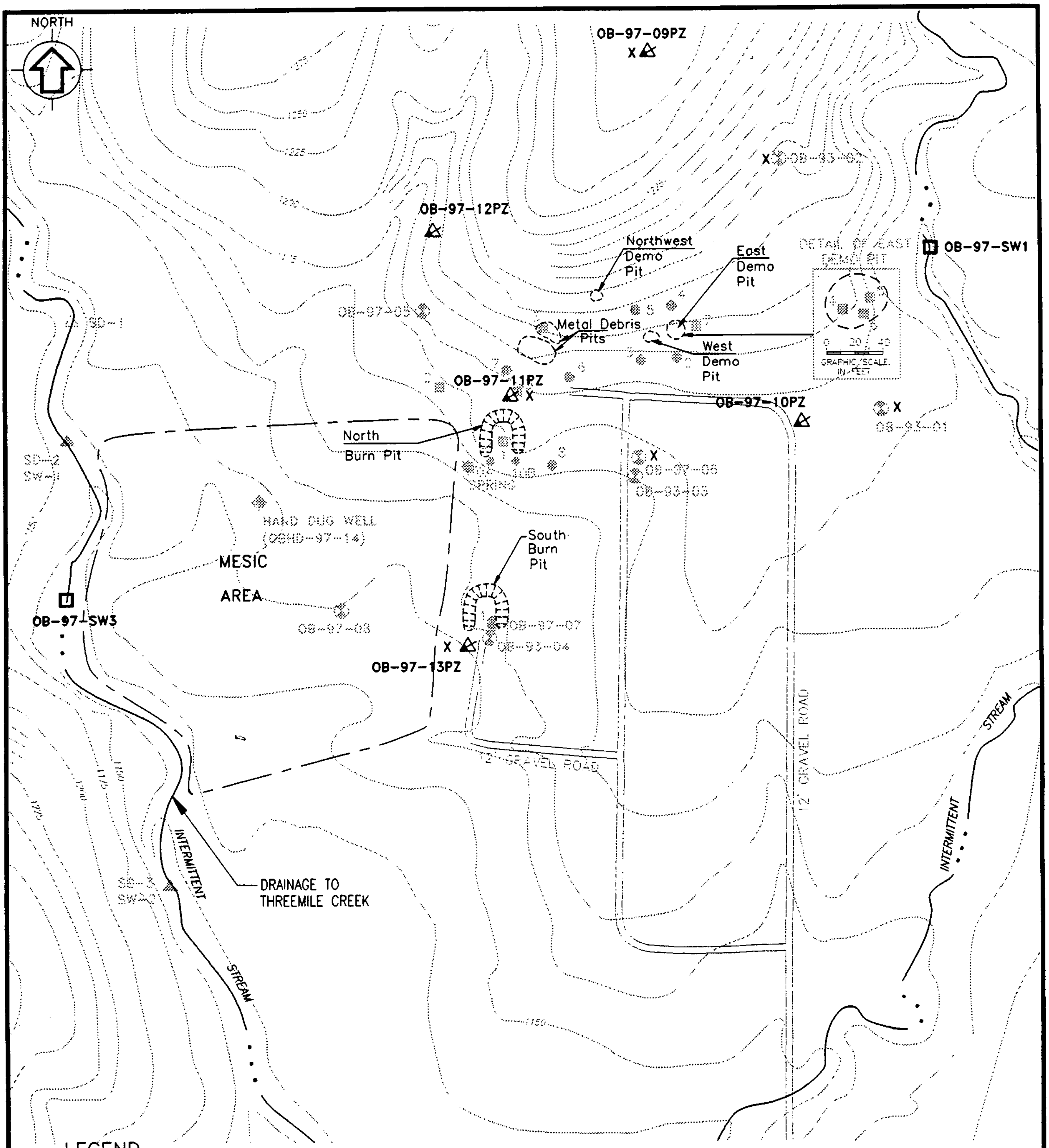
LOUIS BERGER & ASSOCIATES, INC.

FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

MONITORING WELL LOCATIONS, 1997 SI MOBILIZATION #1

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 3-1

OB-OD1/06AUG98/OB-MWMOB.SCF



0 125 250 500

(IN FEET)
1 inch = 250 ft.

LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- GROUNDWATER MONITORING WELL
- BORING LOCATION (SB)
- SEDIMENT & WATER SAMPLE (SD & SW)
- SURFACE SOIL SAMPLES (SS)
- SEDIMENT SAMPLES (SD)
- SPRING/HAND DUG WELL
- NESTED PIEZOMETER
- ☐ SURFACE WATER SAMPLING LOCATIONS
- X USGS DATA PLATFORM

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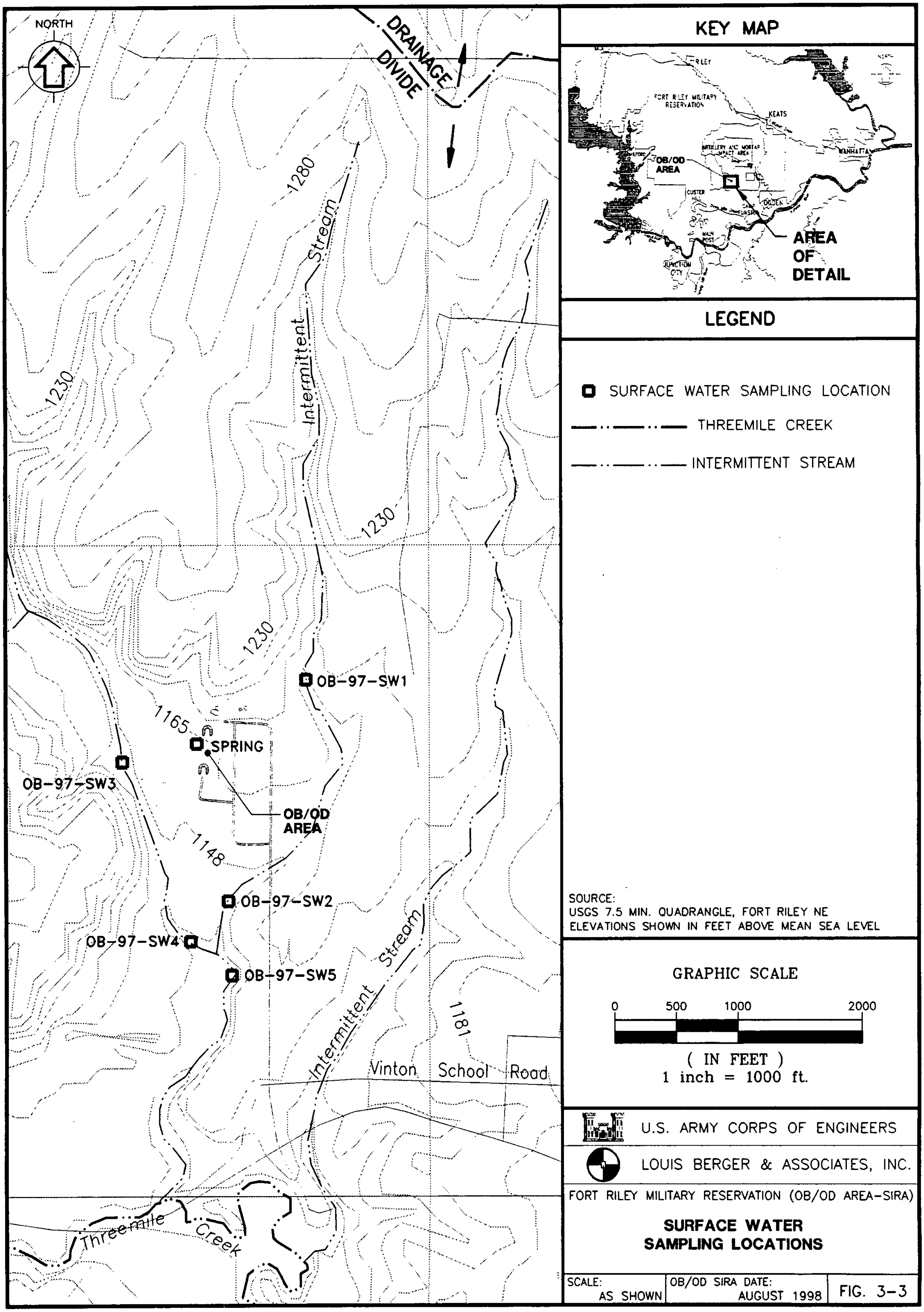
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

**NESTED PIEZOMETER LOCATIONS,
1997 SI MOBILIZATION #2**

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 3-2

OB-OD1/06AUG98/OB-PZMOB.SCR



LEGEND

- ▣ SURFACE WATER SAMPLING LOCATION
- —··—·· THREEMILE CREEK
- —·—·— INTERMITTENT STREAM

SOURCE:
USGS 7.5 MIN. QUADRANGLE, FORT RILEY NE
ELEVATIONS SHOWN IN FEET ABOVE MEAN SEA LEVEL

GRAPHIC SCALE
0 500 1000 2000
(IN FEET)
1 inch = 1000 ft.

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FORT RILEY MILITARY RESERVATION (OB/OD AREA–SIRA)

SURFACE WATER SAMPLING LOCATIONS

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 3-3

OB- ODCM/OC..JG98/OB-SWSL.SCR

4.0 SITE CHARACTERIZATION SUMMARY

4.0 SITE CHARACTERIZATION SUMMARY

This chapter presents a summary of the characterization of the OB/OD Area based on the results of the investigations conducted, and supplemented by pertinent information from published references. A general overview of the site characterization is presented in the form of a conceptual site model, followed by subsections which provide supportive detail for the model.

4.1 Conceptual Site Model

Figure 4-1 depicts the various elements of the conceptual site model developed for the OB/OD Area.

4.1.1 Sources

Since 1941, the site was used for ordnance disposal by open detonation and open burning. Burning is no longer conducted at the site. Groundwater investigations have detected the presence of some dissolved chlorinated solvents; predominantly TCE, with lesser detections of PCE, 1,2-DCE (total) and 1,1,2,2-tetrachloroethane. Investigations did not, however, identify problems associated with other potential site-related contaminants such as explosives by-products or petroleum hydrocarbons from past open burning practices.

The highest concentration of TCE detected in the groundwater is two orders of magnitude below the concentration which would indicate the presence of any residual product or DNAPL. According to *Estimating Potential for Occurrence of Dense Non-Aqueous Phase Liquids (DNAPL) at Superfund Sites* (USEPA, 1992), the concentrations of DNAPL-related chemicals in groundwater would have to be greater than 1% of the pure phase solubility of the DNAPL to indicate the presence of residual product at the site. The pure phase solubility of TCE is approximately 1,100 mg/l. One percent of this concentration is 11 mg/l or 11,000 μg/l. The highest concentration of TCE detected at the site is 570 μg/l in OB-97-07, which is between one and two orders of magnitude below the threshold.

Due to the long period of site use and the low levels of contamination identified, it is difficult to identify an exact location where the contaminants may have been released. The identified groundwater contaminants may even be the result of several sporadic and/or small releases which occurred at various locations within the OB/OD Area over the period of site activity. It is apparent, however, that based on the distribution of the TCE and the direction of groundwater flow, that the contaminants were originally released somewhere within the active and/or historical open burn/open detonation areas, that no residual product or source exists, and that the area investigated has bounded the likely originating point of the contamination. Thus, pinpointing a discrete contamination source appears to not only be difficult to impossible, but also appears to be unnecessary based on the results of this investigation.

4.1.2 Pathways

After being released to the ground, the small quantities of solvents migrated downward through the soil column to the water table via gravity drainage and precipitation infiltration. The concentrations were low enough that the TCE was dissolved and moved with the flow of groundwater (as opposed to being DNAPL that would sink). Contaminants released above the Kinney Limestone were dispersed with the flow in this formation coming out of the higher land to the north. This moved some contaminants slightly to the east but also to the west via the spring at the base of the Kinney. The discharge from the spring continues to the west, infiltrating into the overburden underlying the mesic area. The contaminants dispersed in other directions in the Kinney and some also seeped downward through the Wymore Shale to the underlying water-bearing zone of the Schroyer Limestone and upper portion of the Havensville Shale. The Schroyer/upper portion of the Havensville is also the first water-bearing zone to receive contaminants that may have been released at the South Burn Pit.

The highest concentration of TCE onsite (570 μg/l) is identified in the Schroyer/upper portion of the Havensville. In this unit, the contaminants also migrate with the primary flow of groundwater; generally towards the intermittent stream to the west. Consistent with regional geology, this intermittent stream is interpreted to be the trace of a vertical joint, which is providing a potential vertical drainage path for the groundwater in this zone. Smaller layers within the water-bearing zone may flow more to the northwest or the southwest, depending on where the joint is best developed in contact with that layer. Depending on how open it is, the vertical joint may provide a potential pathway for some groundwater and contaminants to migrate down to the underlying Threemile Limestone. In addition, some limited downward seepage through the relatively less permeable Havensville Shale may also occur. This is consistent with the TCE concentrations being one to two orders of magnitude lower in the Threemile Limestone.

4.1.3 Receptors

Human exposure potential is minimal and well controlled. Human receptors within a 1-mile radius of the site are limited to personnel of the OB/OD Area during OB/OD activities and Army personnel in areas adjacent to the OB/OD Area. These receptors are considered transient since their access is strictly controlled and they only use the areas on a limited and intermittent basis. Surrounding land use consists of military training grounds to the south, an artillery and mortar impact area to the north, and some wheat and grass farmlands to the southeast. With rare exception, access to the OB/OD Area is restricted to EOD personnel, which only enter the area to perform disposal.

The greatest potential for exposure to the groundwater contamination at the OB/OD Area is at the spring adjacent to the North Burn Pit (Figure 4-1). This spring is flowing most of the time and the water contains concentrations of TCE in the 100 to 300 μg/l range. Exposure of the spring to potential ecological receptors is possible as footprints of various indigenous wildlife (deer, etc.) were observed onsite. The intermittent streams are dry most of the time, so this spring is usually the only surface water on the OB/OD Area. It is possible that wildlife present on the OB/OD Area are drinking from this spring.

A mesic (commonly moist, intermittently wet) area approximately 700 feet by 600 feet in size (10 acres) is located between the spring and the intermittent stream along the western side of the site (Figure 4-1). This area is not listed as a wetland on the USGS 7.5 minute topographic quadrangles, the Fort Riley installation map prepared by the Defense Mapping Agency, or the National Wetlands Inventory. This area is usually not saturated and any water that may appear might be from surface runoff. During periods where the water table is high, however, it is possible that some of the water may come from groundwater seeps originating in the underlying overburden (which, like the spring, may have TCE concentrations in the 100 to 300 μg/l range). Thus, when wet, this area could also present an exposure potential for ecological receptors.

The intermittent streams located to the east and west of the OB/OD Area are usually dry and, therefore, do not usually pose an exposure threat to potential human or ecological receptors. These intermittent streams join about 1,000 feet south of the southern site boundary. When flowing, this single tributary continues south another 2,000 feet where it joins Threemile Creek. From this point, Threemile Creek flows southeast and joins the Kansas River at the west side of Camp Funston. There are no perennial streams within one mile downstream of the site and no known uses of surface water as potable water exist within 15 miles downstream of the site.

The groundwater withdrawal well nearest to the OB/OD Area is located at Range 18, approximately 4,220 feet to the east-southeast of the site. This well is only used at the Range 18 maintenance facility for non-potable purposes. No other wells fall within a one-mile radius of the OB/OD Area. The next nearest wells are the Ogden supply wells located approximately 3 miles southeast of the site. There is no realistic potential for exposure to the site groundwater contamination via extraction from production wells.

4.2 Regional Setting

The open burn/open detonation (OB/OD) area is located on Range 16 on the southern part of the Impact Area, approximately 2,300 feet north of Vinton School Road. The site lies on the Fort Riley NE, Kansas USGS 7.5 minute quadrangle in the Northeast quarter, Section 33, Township 10 south, Range 6 east, latitude 39° 08' 31.88" and longitude 96° 45' 46.16". The site location is indicated on Figure 1-1.

"Physiographically, the site is located on the slopes of the Flint Hills section of the Osage Plains. The Flint Hills section consists of a series of roughly parallel cuestas. Escarpments formed on the cherty limestones, which are separated by somewhat thicker shales, dominate the topography" (Hattin, 1957). To the north of the site, is the great flat-topped area capped by the Fort Riley Limestone. "Strata below the Fort Riley Limestone weather to steeply terraced slopes, and it is principally these strata that form the slopes of the Flint Hills in this part of Kansas. The shale units are slope-formers and rarely are completely exposed naturally. The hills capped by Fort Riley Limestone and the knobs capped by Florence Limestone, however, are part of the general Flint Hills region" (Jewett, 1941).

4.2.1 Geology

The area of the OB/OD Area is underlain by Permian aged shales and limestones encompassing the Chase and Council Grove Groups within the Wolfcamp Series of the Permian System. Regionally, this sequence of rocks dips gently (0.5 to 1.0 degree) to the west-northwest as a monocline, with local variations in dip resulting from smaller scale syn- and anticlinal structures. Fort Riley lies between the Abiline and Nemaha anticlines and due to this position, the bedrock units underlying the OB/OD Area are generally flat lying with a uniform thickness. Due to the uniformity of the bed thicknesses and the generally horizontal nature of the local structure, elevation is a good indicator of stratigraphic position. The information gathered from the site investigations and from published references were used to generate a bedrock geologic map (Figure 4-2) and a stratigraphic column (Figure 4-3) for the OB/OD Area and adjacent area.

These rocks form a sequence of alternating limestone and shale units. The sequence exhibits repetition of lithologies and faunas that is attributed to cyclic sedimentation. Some units have gradational characteristics (e.g. shaley limestone, calcareous shale). Also, some limestones are cherty, and some shale units contain gypsum and/or anhydrite stringers. The shales vary in color, having hues of gray, green, and red. Surface materials over the area consist of loess, soil, and highly weathered shale that typically make up the upper 20 feet of substrate in the Fort Riley area.

Structural features, such as joints, are important factors in the movement of groundwater and contaminants in bedrock. Chelikowsky (1972) described the regional geologic structure as follows:

> The regional joint pattern in the Manhattan area consists principally of two major sets trending nearly at right angles to each other. The northerly trending set generally parallels the regional strike, the westerly trending set, the regional dip. At any given site other joints with different trends may occur, but such joints do not persist regionally. For the area as a whole, neither set dominates. Most of the joints dip vertically, but in thick shale sections some may be inclined. Except for master joints which cut across all of the layers in an outcrop, both the spacing and orientation of minor joints may vary from layer to layer.
>
> There are significant regional as well as more local deflections from straight-line trends. The northerly trending strike set of joints swing in a broad arc from a N35°W direction in the south to a N5°W direction in the north. The westerly trending dip set maintains a general 90-degree transverse relationship to the broad arc and changes in direction accordingly.

Chelikowsky (1972) also discussed the inter-relationship between the regional joint system and drainage as follows:

> The relationship between drainage and the regional joint system is revealed by the pronounced angular pattern of upland drainage, particularly where joint development is good. Another peculiarity in local drainage as noted from a study of topographic maps is

the asymmetrical shape of watersheds of some upland streams. The asymmetry is probably a reflection of the westerly regional dip of the rock layers.

The estimated location and orientation of vertical joint fractures relevant to the OB/OD Area are indicated on Figure 4-4. The northerly trending strike set is oriented at N20°W and located on portions of the intermittent stream beds (interpreted to be lineaments of vertical joint fractures). This orientation is within the regional range of N35°W and N5°W as presented by Chelikowsky (1972), and is consistent with the joint orientation (N22°W) depicted closest to the Fort Riley site (Chelikowsky 1972, Figure 3). The westerly trending dip set is oriented 90 degrees to the strike set and is aligned with abrupt changes in stream bed direction.

4.2.2 Hydrogeology

Typically, carbonate rocks (limestone and dolomite) have primary permeability values less than 10^{-7} meters per second. Many carbonate strata, however, have appreciable secondary permeability as the result of joints, fractures or openings along bedding planes (Freeze and Cherry, 1979). Observations in quarries and other excavations in flat-lying carbonate rocks indicate that solution openings along vertical joints generally are wide spaced. Openings along bedding planes are more important from the point of view of water yield from wells (Walker, 1956; Johnson, 1962 *in* Freeze and Cherry, 1979). In nearly horizontal carbonate rocks with regular vertical fractures and horizontal bedding planes, there is usually a much higher probability of wells encountering horizontal openings than vertical fractures. In fractured carbonate rocks, successful and unsuccessful wells can exist in close proximity, depending on the frequency of encounter of fractures by the well bore. Seasonally, the water levels in shallow wells can vary greatly because the bulk fracture porosity is a few percent or less (Freeze and Cherry, 1979). Figure 4-5 is from Freeze and Cherry (1979), and attempts to depict this relationships between fractures and bedding to help explain the response of groundwater to these features and to wells intersecting none or some of these flow conduits.

In some carbonate rocks, lineations of concentrated vertical fractures provide zones of high permeability. Zones in which fractures are concentrated are the zones of most rapid groundwater flow. Dissolution may cause the permeability of such zones to increase (Freeze and Cherry, 1979). Intensive studies of lineaments in carbonate rock have shown that the probability of obtaining successful wells is greatly enhanced if drilling sites are located along lineaments or at their intersections (Lattman and Parizek, 1964; Parizek and Drew, 1966 *in* Freeze and Cherry, 1979). In some areas, however, excessive thicknesses of overburden prevent recognition of bedrock lineaments. Figure 4-6 is from Freeze & Cherry 1979, and illustrates a situation where fracture intersections and lineaments are reflected in the morphology of the land surface.

Figure 4-7 presents an estimation of the general flow of the water table. The estimated water table elevation contours were created by connecting streambeds of the same elevation on the USGS topographic map. The site is located within the drainage basin of Threemile Creek. Based on this estimated flow, the recharge area for the site is located to the north. The upper boundary of the basin relevant to the site is interpreted to be along the ridge located approximately a mile north of the site. Much of this area to the north is underlain by the Fort Riley Limestone and Florence

Limestone. Precipitation infiltration into these upgradient limestone units provides recharge to the water table. The water which enters the Fort Riley Limestone will migrate horizontally through permeable zones (i.e., bedding planes).

It is thus interpreted that groundwater primarily flows horizontally along bedding planes and solutioned zones in the limestone units. The interbedded shales have relatively low permeability and tend to prevent or at least severely limit flow between the limestone units; however, when an open vertical joint or fracture is encountered, some water will potentially migrate downward and provide recharge to the underlying formation. The amount of water flowing downward versus continuing horizontally will depend on the relative openness of the joints and fractures, and/or the relative permeability of the bedrock units. This potential supply of recharge from above will also sometimes cause an artesian condition locally in an underlying formation.

4.3 Site-Specific Conditions

The site-specific conditions are summarized below based on the results of the investigations conducted at the OB/OD Area and information in published references. Discussed are the geology and hydrogeology, the fate and transport of the contaminants, and the potential exposure pathways.

4.3.1 Geology and Hydrogeology

The information gathered from the site investigations (including lithological and geophysical logs) were used to generate geologic cross sections of the OB/OD Area. The cross section locations are shown on Figure 4-8 and the cross sections are presented on Figure 4-9.

The soils found at the OB/OD Area generally have a high available water capacity and, in general, readily transmit water. Surface run-off is moderate and infiltration of precipitation would move downward through the soil layer. The soils at the site are depicted on Figure 4-10. As shown, the soils in the area of the OB/OD Area are characterized as silt loams and silty clay loams.

In general, the bedrock units beneath the OB/OD Area are flat-lying with relatively uniform thicknesses and, as a result, elevation becomes a good indicator of stratigraphic position. Based on the bedrock geologic map, the demo pits and the North Burn Pit are situated on the Blue Springs Shale and the South Burn Pit is located on the Wymore Shale. Much of what directly underlies these areas is overburden and weathered bedrock derived from these formations.

Although some seepage through the shale formations may occur, it is interpreted to be relatively limited based on the low permeability of these types of formations. The limestone units are therefore assumed to contain the zones which most readily transport groundwater. The affected limestone units beneath the OB/OD Area are the Kinney, Schroyer/Havensville, and the Threemile. These units are discussed in greater detail below.

4.3.1.1 Kinney Limestone

The flow of groundwater in the Kinney (under a horizontal gradient of approximately 0.004 ft/ft) is depicted on Figure 4-11. Aside from direct precipitation infiltration, this would be the first groundwater to contact and transport contaminants deposited in the demo pits and the North Burn Pit. The flowing spring adjacent to the North Burn Pit is a surface exposure of groundwater from the Kinney. This is most likely due to a high permeability feature (near, or slightly below, the contact with the underlying Wymore Shale) intersecting the ground surface. This spring provides recharge to the downgradient "mesic area" (an overburden-filled area where the underlying Schroyer Limestone has apparently been eroded). During seasonal high water conditions (e.g., January 1998), groundwater from the Kinney discharges to and flows in the intermittent stream along the eastern side of the site.

In addition to the primary horizontal movement, some groundwater in the Kinney may also move downward via vertical pathways (i.e., vertical joints, fractures). The potential for this migration is documented by the downward gradient (approximately 0.5 ft/ft) between the Kinney and the Schroyer/Upper Havensville (the next underlying limestone unit); although it is noted that downward gradients do not necessarily translate into significant downward flows, depending on the existence of vertical flow pathways such as joints and fractures. The occurrence of some downward seepage of groundwater on this downward potential may be documented by the presence of some dissolved contaminants in the underlying formations.

4.3.1.2 Schroyer Limestone/Havensville Shale

The South Burn Pit is underlain by the Schroyer Limestone and upper portion of the Havensville Shale (limestone and shale), downgradient from the demo pits and the North Burn Pit. The flow of groundwater in the Schroyer/upper Havensville is depicted on Figures 4-12 through 4-15. This would be the first limestone unit to receive and transport contaminants deposited in the South Burn Pit. On average, the general flow direction within this unit (under a horizontal gradient of approximately 0.01 ft/ft) is consistent with the estimated flow direction for the water table in this portion of the Threemile Creek drainage basin (Figure 4-7). In looking at the individual layers within the unit, as indicated on Figures 4-12 through 4-15, there is a component of horizontal flow towards the intermittent stream bed on the western side of the site, as well as to the north-northwest. As discussed above, in some carbonate rocks, lineations of concentrated vertical fractures provide zones of high permeability and these lineaments can be reflected in the morphology of the land surface. Also as stated above, the relationship between drainage and the regional joint system is revealed by the pronounced angular pattern of upland drainage, particularly where joint development is good.

It is interpreted that a portion of the intermittent stream bed is a lineament of a vertical joint, portions of which may be developed well enough to locally provide drainage and influence the flow direction of groundwater in that unit. The orientation and location of these interpreted vertical joint fractures are indicated on Figure 4-4. The strike of the lineament is approximately N20°W which is, as discussed above, consistent with published values for the northerly trending strike set in this area. Likewise, a vertical joint fracture of the westerly trending dip set (90 degrees to the strike set) (Figure 4-4) could explain the north-northwest component, even though a lineament is not obvious. As stated above, excessive thicknesses of overburden can prevent recognition of bedrock lineaments. This flow component appears weaker than the west-southwest flow, indicating that such a vertical joint fracture may not be as well developed here.

The nested piezometers (OB97-09PZ, OB97-11PZ, and OB97-12PZ) document an artesian condition at the base of the water bearing unit in the upper portion of the Havensville. This condition indicates that this zone has the highest permeability in the unit and the best hydraulic connection with the overlying groundwater. When the water table is high enough (e.g., January 1998), groundwater from this unit is exposed in the intermittent stream along the western side of the site.

In addition to the primary horizontal movement, some groundwater in this unit may also move downward via vertical pathways (i.e., vertical joints, fractures). The potential for this migration is documented by the downward gradient (approximately 0.9 ft/ft) between this unit and the Threemile Limestone (the next underlying limestone unit). The occurrence of at least some localized downward seepage of groundwater on this potential may be documented by the presence of some lower levels of contaminants in the Threemile Limestone.

4.3.1.3 Threemile Limestone

The flow of groundwater in the Threemile Limestone cannot be fully interpreted from the existing information. Three monitoring wells are screened in the Threemile Limestone (OB-93-03, OB-93-04, and OB-97-05), however, so a simple three-point solution can be prepared. Using the groundwater elevations recorded from these wells, a horizontal flow to the northeast is indicated, which is the opposite direction of the flow in the overlying formations.

While this interpretation may prove to be correct (likely attributable to preferential drainage via structural features), such a solution may also present a potentially incorrect or misleading interpretation, especially if vertical gradients are present. This is because the three point solution is based on wells which are not all consistently screened in the vertical plane. To avoid distortion when interpreting horizontal gradients in the presence of vertical gradients, it is important to use groundwater elevations from wells screened in the same vertical plane. Two of the Threemile Limestone wells have 15-foot screens (OB-93-03 and OB-93-04), and one has a 10-foot screen (OB-97-05). Although there is some overlap, all three wells screen different elevation ranges. If a vertical gradient is present within the unit (either upward or downward), a distorted interpretation of horizontal gradient could thus result. For this reason, interpretation of the groundwater flow direction in the Threemile Limestone must be deferred until additional and more definitive information becomes available.

4.3.2 Contaminant Fate and Transport

The predominant contaminant detected in the groundwater at the OB/OD Area is trichloroethylene (TCE), a common chlorinated solvent and volatile organic compound. Based on the distribution of TCE (from monitoring well sample analytical results) and the flow direction of the groundwater (discussed above), this common solvent was most likely released in the area of the burn pits and/or demo pits. The time and location of the release (or releases) is unknown. Several small releases may have occurred, over time, at various locations within these areas. Whatever the scenario, the magnitude of the release (or releases) was evidently minor and/or well in the past because there is no indication of any residual product currently existing at the site. According to *Estimating Potential for Occurrence of Dense Non-Aqueous Phase Liquids (DNAPL) at Superfund Sites*(USEPA, 1992), the concentrations of DNAPL-related chemicals in groundwater would have to be greater than 1% of the pure phase solubility of the DNAPL to indicate the presence of residual product at the site. The pure phase solubility of TCE is approximately 1,100 mg/l. One percent of this concentration is 11 mg/l or 11,000 μg/l. The highest concentration of TCE detected at the site is 570 μg/l in OB-97-07 (December 1997), which is between one and two orders of magnitude below the threshold.

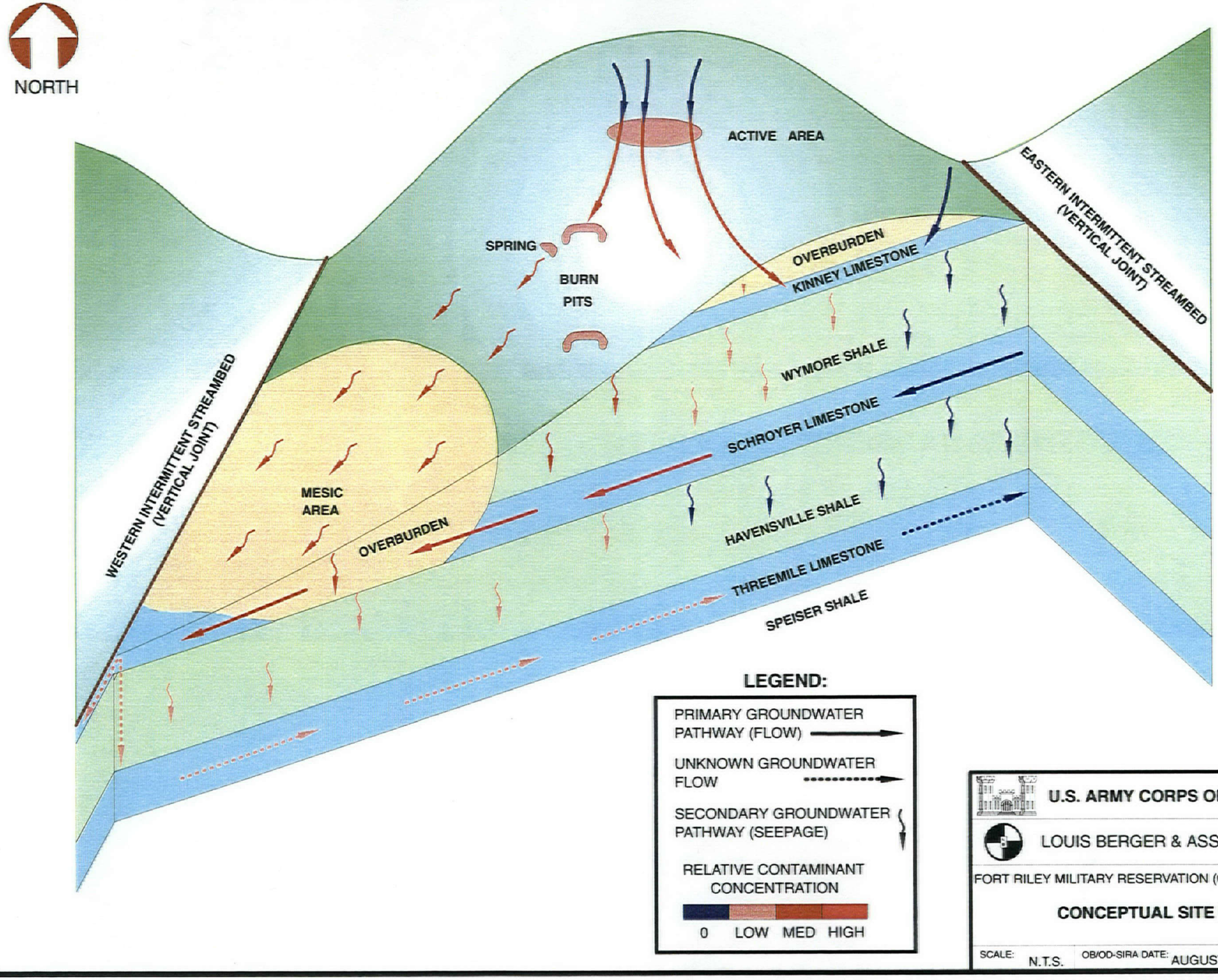
After being released to the ground, the TCE was transported downward through the soil by infiltration of precipitation. It then entered the first occurrence of groundwater within the Kinney formation and was transported with the primary flow in that unit. Contaminants migrated to the east with this flow, as well as to the west, via the flowing spring. The water flowing from the spring shows the highest concentration of contamination in this unit. This spring provides recharge to the downgradient mesic area (an overburden-filled area where the underlying Schroyer Limestone has apparently been eroded). Some of the dissolved contaminants may have also seeped downward to some extent (as discussed above), ultimately reaching the Schroyer/Upper Havensville.

In the Schroyer/Upper Havensville, the contaminants also migrate with the primary flow of groundwater (as discussed above). Figure 4-16 depicts the distribution of TCE in this unit. Again, the highest concentrations are detected in the most permeable zone (OB-97-07[570 μg/l] and OB-97-13PZ(2)[200 μg/l]). The cores for OB-93-04, OB-97-05 and OB-97-06 indicate a solutioned zone at approximately elevation 1135 ft msl. This zone is intersected by the screens of monitoring well OB-97-07 and piezometer OB-97-13PZ(2). Another permeable area in this unit is the overburden underlying the mesic area, where the bedrock of the unit has apparently been eroded. The wells located there (hand dug well/OBHD-97-14 and OB-97-08) show concentrations of TCE around 100 μg/l. This is approximately the same concentration detected at the spring, which provides recharge to this overburden area. Some of the dissolved contaminants may have also seeped downward to some extent (as discussed above), ultimately reaching the underlying Threemile Limestone.

In the Threemile Limestone, the contaminants would also migrate with the primary horizontal flow of groundwater (which is presently undetermined, as discussed above). Figure 4-17 depicts the distribution of TCE in the Threemile Limestone based on the limited data available. Some dissolved contaminants appear to have seeped downward, likely via vertical joints or fractures connecting with the overlying shale of the Havensville. Contaminant levels in this unit are much lower than in the overlying units. This reduction in concentration has likely occurred during movement from the Schroyer/Upper Havensville to the Threemile Limestone. The highest concentration in the Threemile Limestone, 17 μg/l in OB-93-04, is an order of magnitude less than the highest levels in the overlying unit.

FIGURES

OB-CSM.PRE



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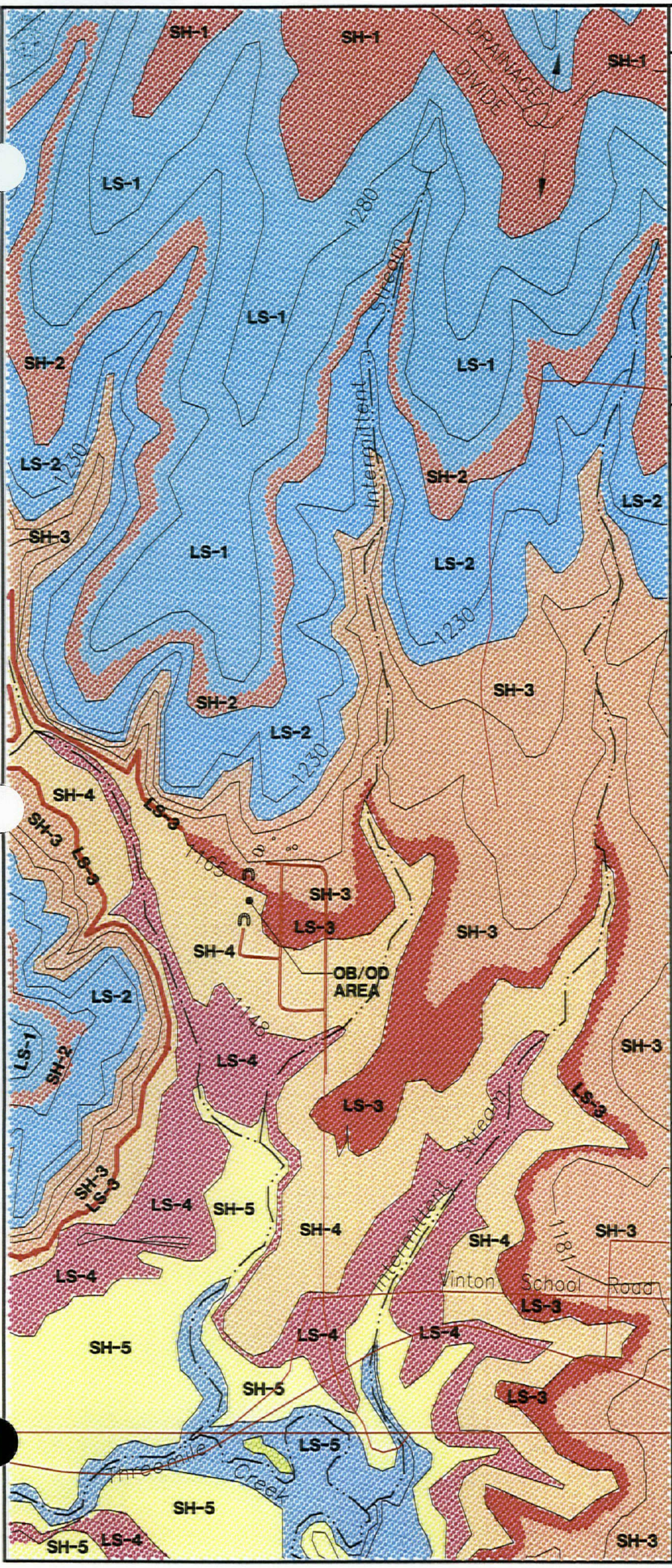
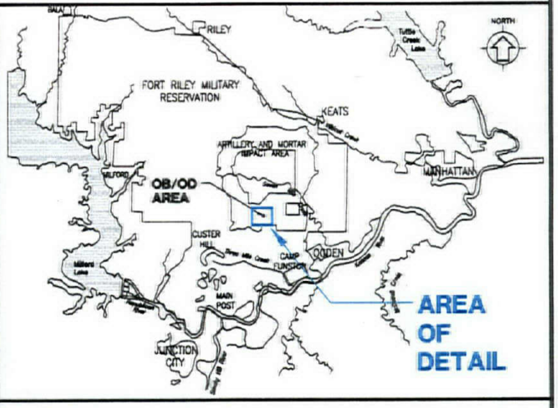
FORT RILEY MILITARY RESERVATION (OB/OD AREA -SIRA)

CONCEPTUAL SITE MODEL

SCALE:	N.T.S.	OB/OD-SIRA DATE:	AUGUST 1998	FIG. 4-1



KEY MAP



LEGEND

SH-1	▨	HOLMESVILLE SHALE
LS-1	▨	FORT RILEY LIMESTONE
SH-2	▨	OKETO SHALE
LS-2	▨	FLORENCE LIMESTONE
SH-3	▨	BLUE SPRINGS SHALE
LS-3	▨	KINNEY LIMESTONE
SH-4	▨	WYMORE SHALE
LS-4	▨	SCHROYER LIMESTONE
SH-5	▨	HAVENSVILLE SHALE
LS-5	▨	THREEMILE LIMESTONE

SOURCE:
USGS 7.5 MIN. QUADRANGLE, FORT RILEY NE
ELEVATIONS SHOWN IN FEET ABOVE MEAN SEA LEVEL

GRAPHIC SCALE

0 500 1000 2000

(IN FEET)
1 inch = 1000 ft.

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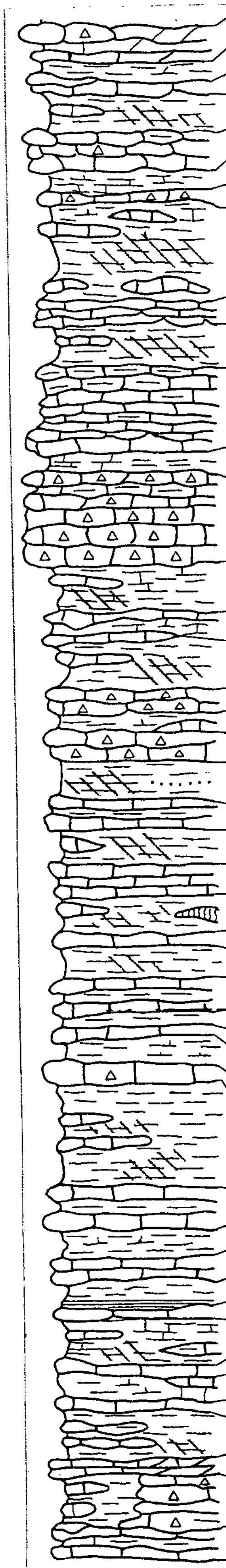
FORT RILEY MILITARY RESERVATION (OB/OD AREA–SIRA)

GEOLOGIC MAP

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4–2

OB–GEOL UG98/OB–GEOL2.SCR



Herington Ls. Mbr.	Nolans Limestone	Chase Group	GEARYAN STAGE	LOWER PERMIAN SERIES	PERMIAN SYSTEM
Paddock Shale Member					
Krider Limestone Mbr.					
	Odell Shale				
Cresswell Ls. Mbr.	Winfield Limestone				
Grant Shale Member					
Stovall Limestone Mbr.					
Gage Shale Member	Doyle Shale				
Towanda Limestone Mbr.					
Holmesville Sh. Mbr.					
Fort Riley Ls. Mbr.	Barneston Limestone				
Oketo Shale Member					
Florence Ls. Mbr.					
Blue Springs Sh. Mbr.	Matfield Shale				
Kinney Limestone Mbr.					
Wymore Shale Member					
Schroyer Ls. Mbr.	Wreford Limestone				
Havensville Shale Mbr.					
Threemile Ls. Mbr.					
	Speiser Shale	Council Grove Group			
	Funston Limestone				
	Blue Rapids Shale				
	Crouse Limestone				
	Easly Creek Shale				
Middleburg Ls. Mbr.	Bader Limestone				
Hooser Shale Member					
Eiss Limestone Member					
	Stearns Shale				
Morrill Limestone Mbr.	Beattie Limestone				
Florena Shale Member					
Cottonwood Ls. Mbr.					
	Eskridge Shale				
Neva Limestone Mbr.	Grenola Limestone				
Salem Point Shale Mbr.					
Burr Limestone Mbr.					
Legion Shale Member					
Sallyards Ls. Mbr.					
	Roca Shale				
Howe Limestone Member	Red Eagle Limestone				
Bennett Shale Member					
Glenrock Ls. Mbr.					
	Johnson Shale				
Long Creek Ls. Mbr.	Foraker Limestone				
Hughes Creek Sh. Mbr.					
Americus Ls. Mbr.					

SOURCE: ZELLER, DORIS E., 1968. "THE STRATIGRAPHIC SUCCESSION IN KANSAS"
STATE GEOLOGICAL SURVEY OF KANSAS, BULLETIN 189, PLATE 1.

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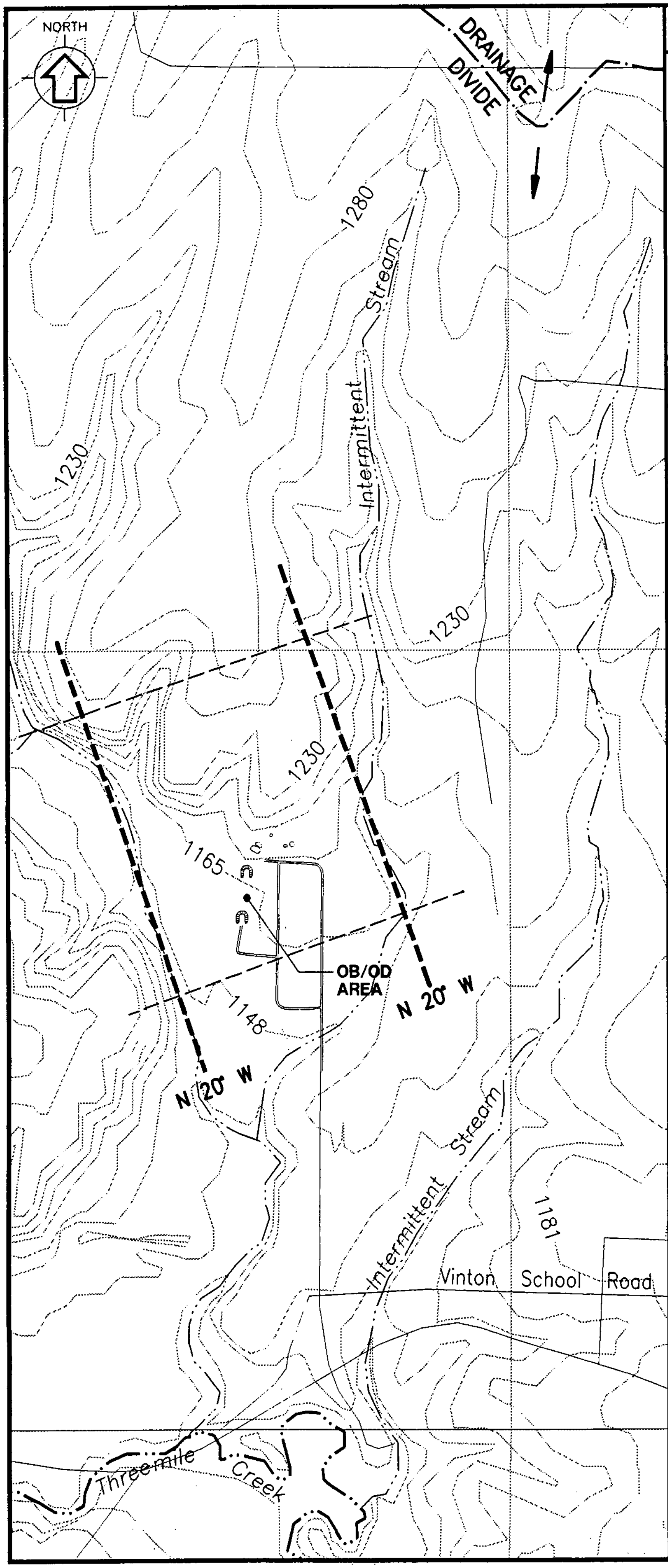
FORT RILEY MILITARY RESERVATION (OB/OD AREA-SIRA)

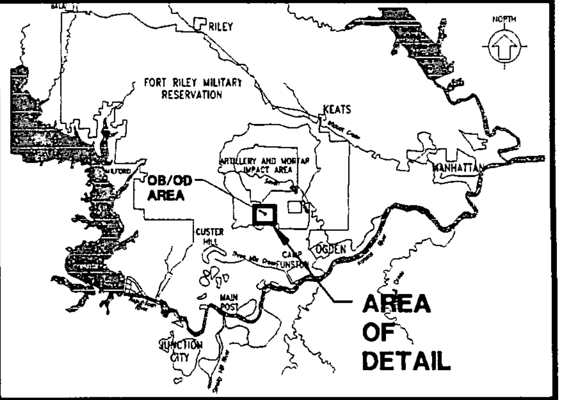
STRATIGRAPHIC COLUMN

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-3

OB-GSSR/06AUG98/U4



KEY MAP



LEGEND

━ ━ ━ ━ INTERPRETED STRIKE SET JOINT

- - - - - INTERPRETED DIP SET JOINT

SOURCE:
USGS 7.5 MIN. QUADRANGLE, FORT RILEY NE
ELEVATIONS SHOWN IN FEET ABOVE MEAN SEA LEVEL

GRAPHIC SCALE
0 500 1000 2000
(IN FEET)
1 inch = 1000 ft.

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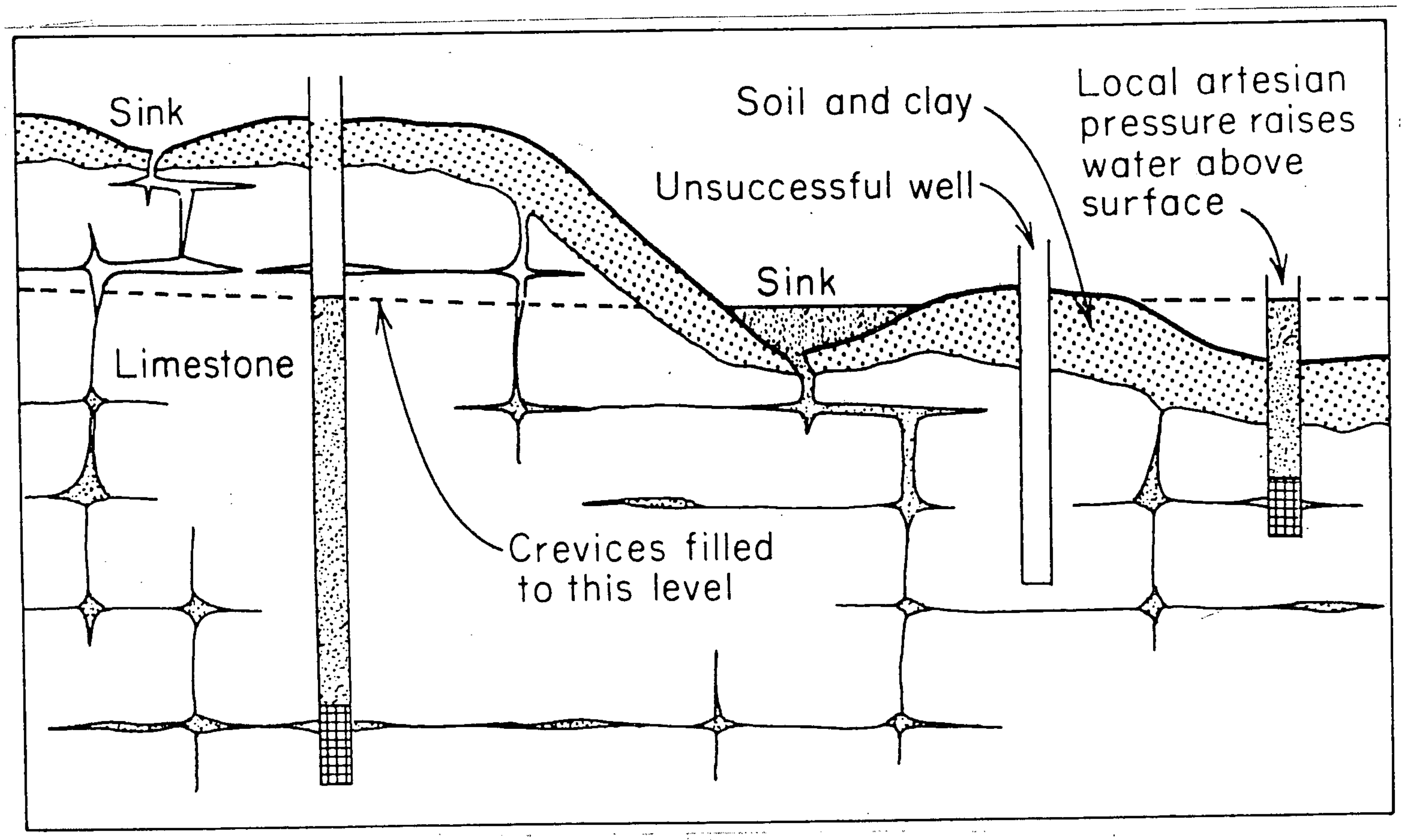
FORT RILEY MILITARY RESERVATION (OB/OD AREA-SIRA)

INTERPRETED JOINT LOCATIONS

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-4

OB-ODCM/06AUG98/OB-INVJ.SCR



SCHEMATIC ILLUSTRATION OF THE OCCURRENCE OF GROUNDWATER IN CARBONATE ROCK IN WHICH SECONDARY PERMEABILITY OCCURS ALONG ENLARGED FRACTURES AND BEDDING PLANE OPENINGS (AFTER WALKER, 1956; DAVIS AND DeWIEST, 1966).

SOURCE: FREEZE AND CHERRY, 1979.

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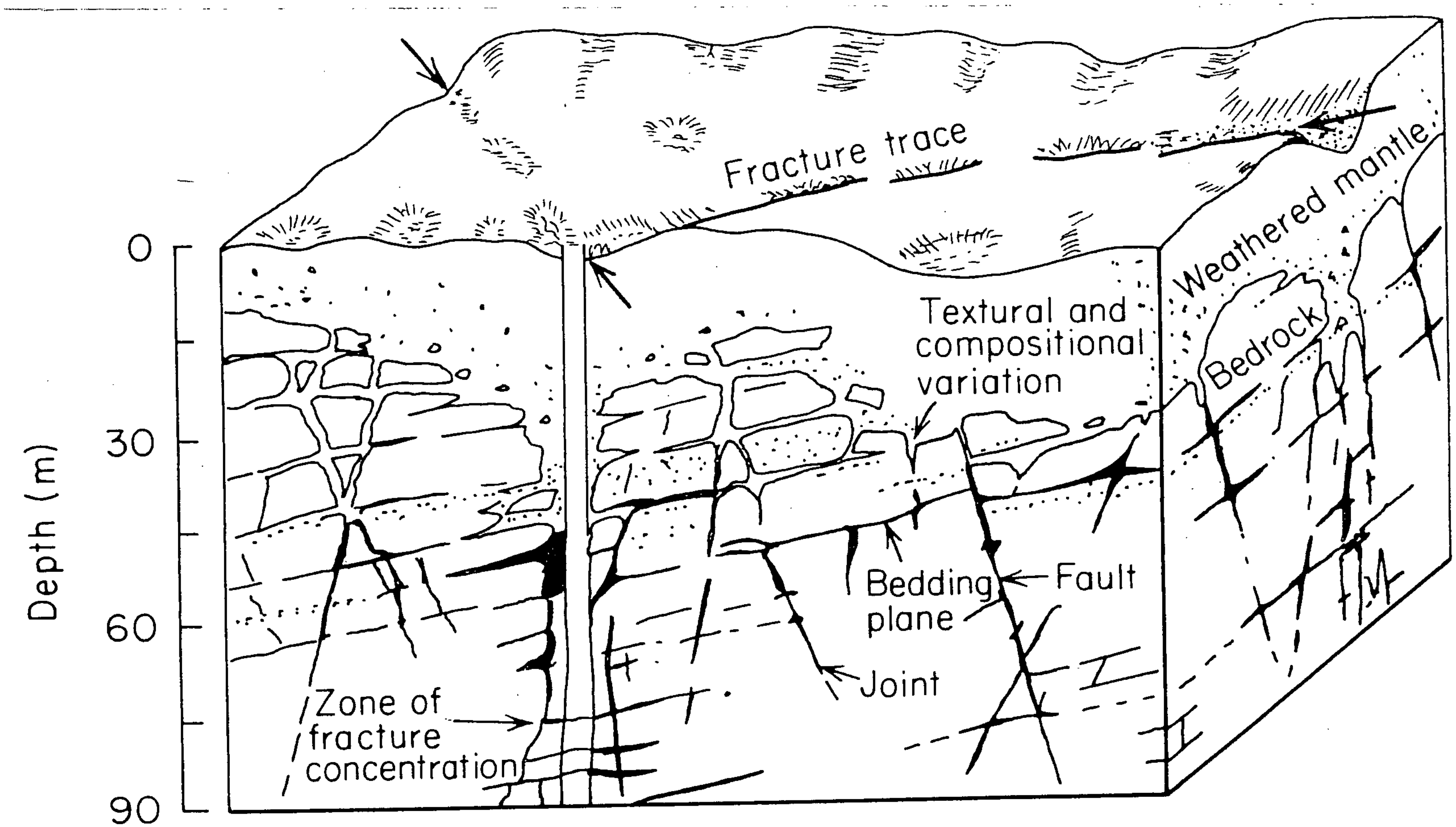
FORT RILEY MILITARY RESERVATION (OB/OD AREA-SIRA)

OCCURRENCE OF GROUNDWATER IN CARBONATE ROCKS

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-5



OCCURRENCE OF PERMEABILITY ZONES IN FRACTURED CARBONATE ROCK. HIGHEST WELL YIELDS OCCUR IN FRACTURE INTERSECTION ZONES (AFTER LATTMAN AND PARIZEK, 1964).

SOURCE: FREEZE AND CHERRY, 1979.

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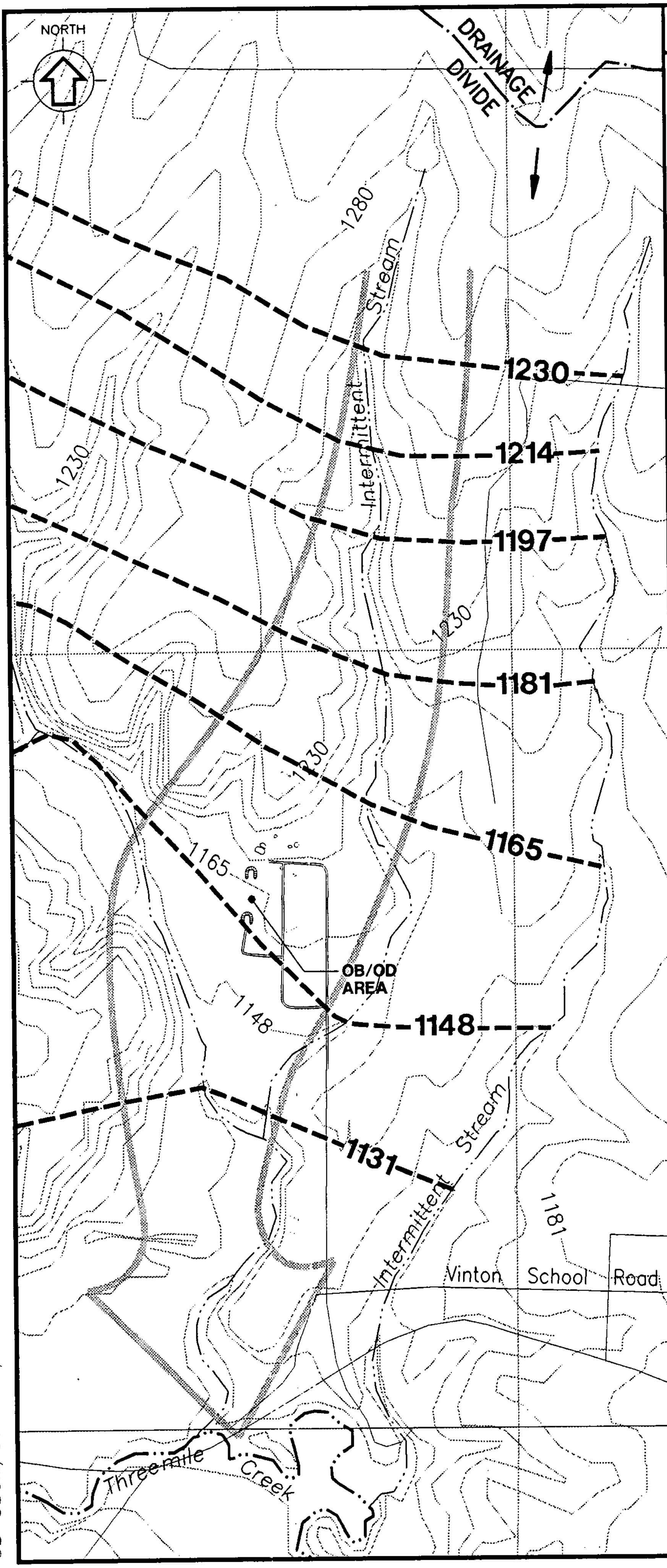
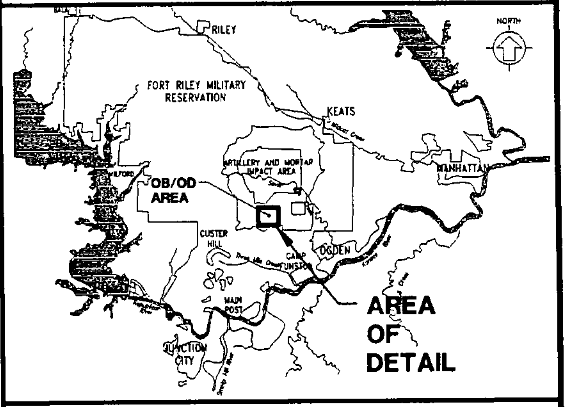
FORT RILEY MILITARY RESERVATION (OB/OD AREA-SIRA)

OCCURRENCE OF PERMEABILITY ZONES IN FRACTURED CARBONATE ROCKS

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-6



KEY MAP



LEGEND

– – – – – INTERPRETED WATER TABLE ELEVATION CONTOUR (FEET ABOVE MSL)

NOTE:
CONTOURS BASED ON CONNECTION OF STREAMBEDS OF SAME ELEVATION

SOURCE:
USGS 7.5 MIN. QUADRANGLE, FORT RILEY NE
ELEVATIONS SHOWN IN FEET ABOVE MEAN SEA LEVEL

GRAPHIC SCALE

0 500 1000 2000

(IN FEET)
1 inch = 1000 ft.

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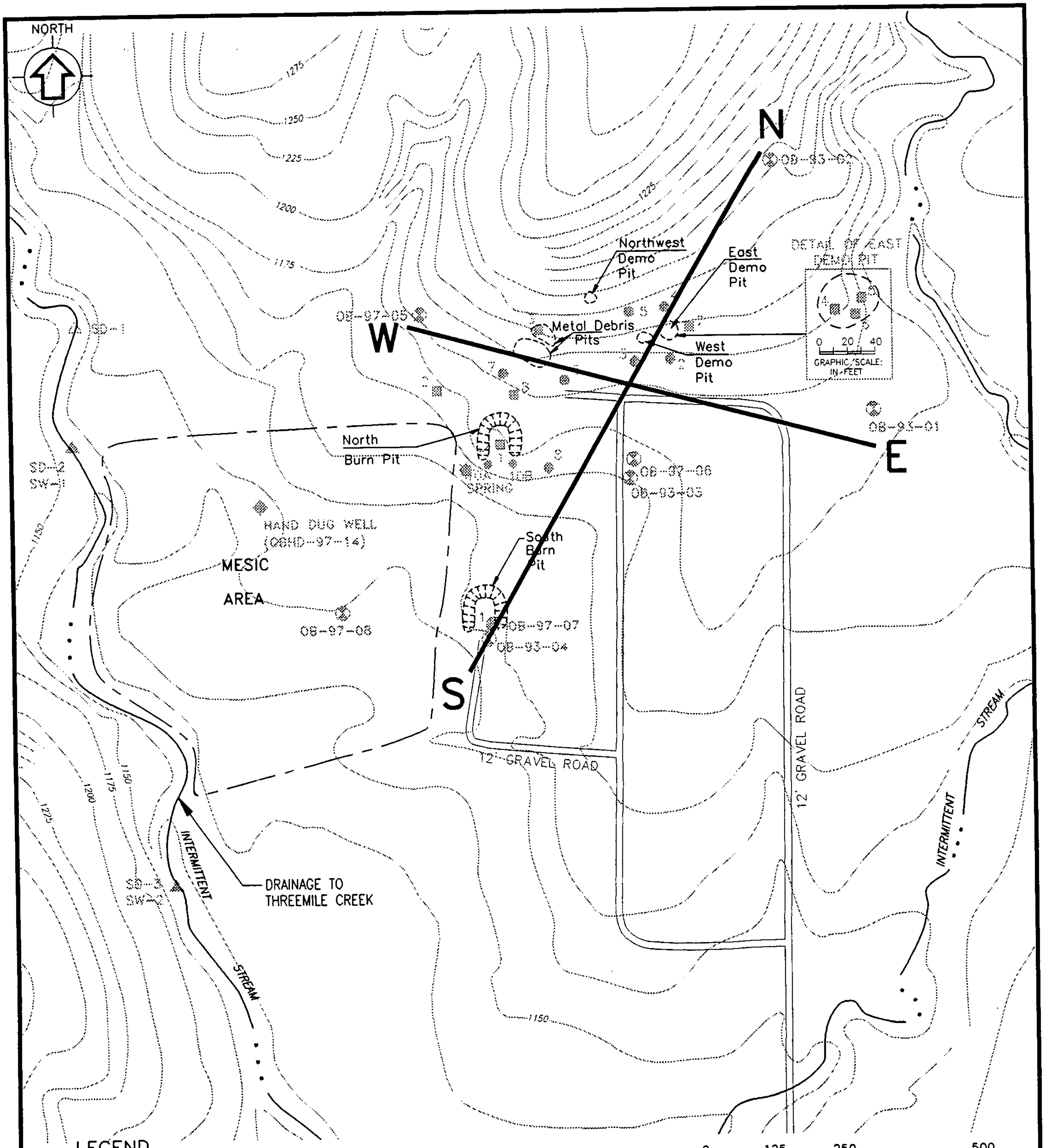
FORT RILEY MILITARY RESERVATION (OB/OD AREA–SIRA)

GENERAL WATER TABLE FLOW

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4–7

OB–ODCM/06AUG98/OB–GWTF.SCR



0 125 250 500

(IN FEET)
1 inch = 250 ft.

LEGEND

-·-·-	INTERMITTENT STREAM
·····	GROUND SURFACE ELEVATION CONTOURS (ft msl)
═	GRAVEL ROAD
⊛	GROUNDWATER MONITORING WELL
●	BORING LOCATION (SB)
▲	SEDIMENT & WATER SAMPLE (SD & SW)
▨	SURFACE SOIL SAMPLES (SS)
△	SEDIMENT SAMPLES (SD)
◆	SPRING/HAND DUG WELL
⛛	NESTED PIEZOMETER
☐	SURFACE WATER SAMPLING LOCATIONS
━	CROSS SECTION LINE

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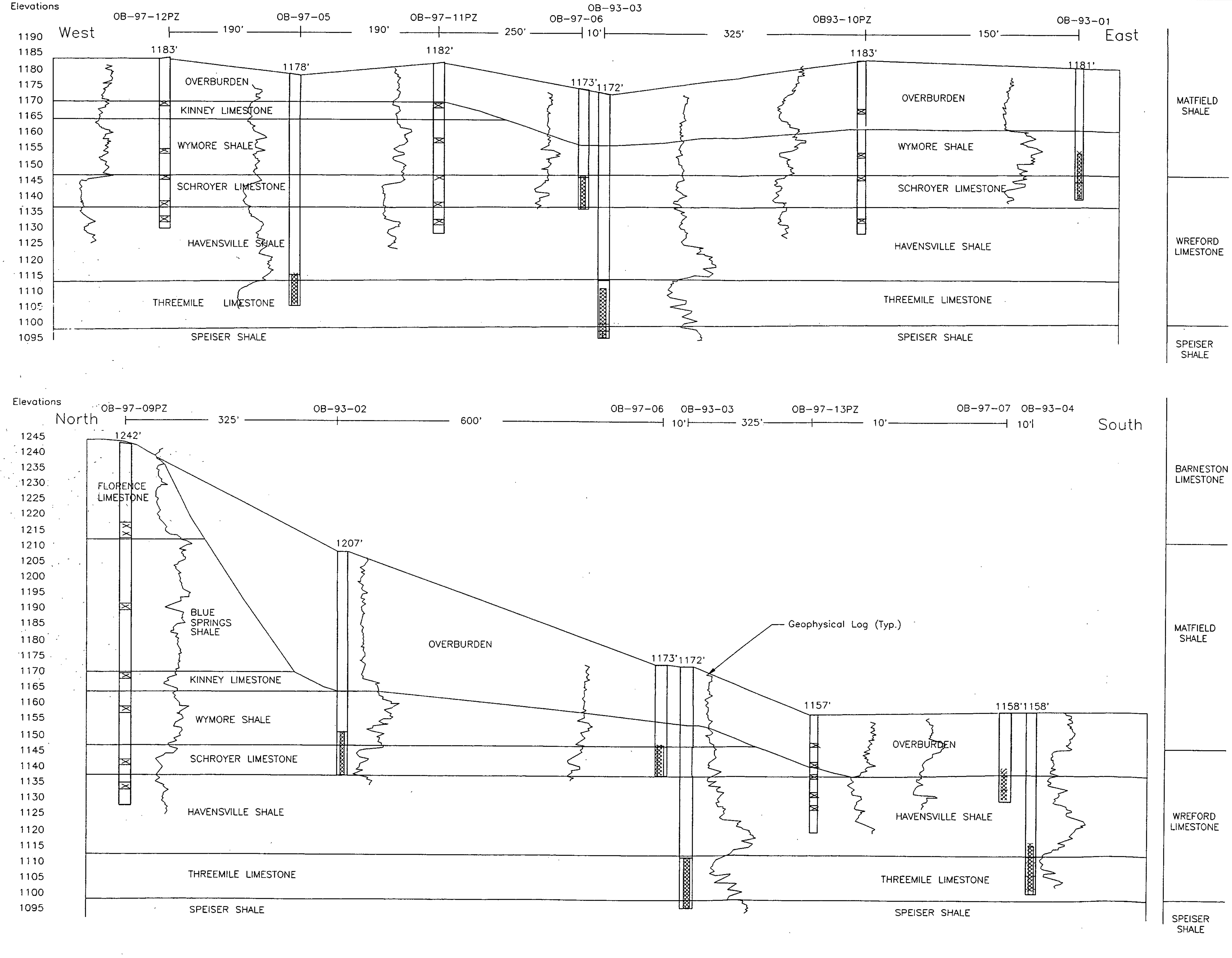
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

CROSS SECTIONS LOCATION MAP

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-8

OB-OD1/06AUG98/OB-SECTL.SCR



NOTE:

CROSS SECTIONS CONSTRUCTED BASED ON LITHOLOGICAL AND GEOPHYSICAL LOGS.

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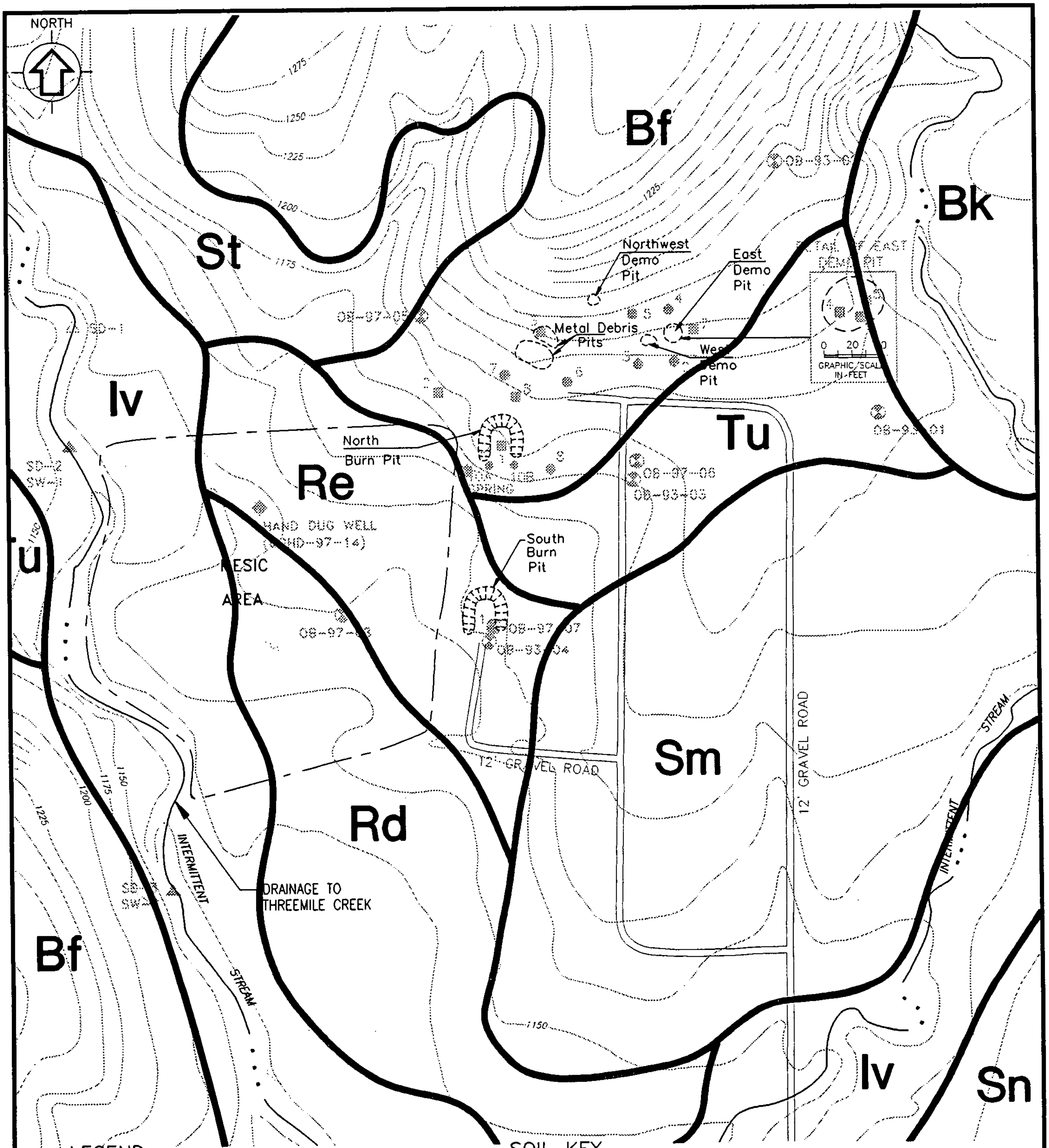
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

GEOLOGIC CROSS SECTIONS

SCALE: N.T.S.	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-9

OB-GEOX2/06AUG98/U4



LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- GROUNDWATER MONITORING WELL
- BORING LOCATION (SB)
- SEDIMENT & WATER SAMPLE (SD & SW)
- SURFACE SOIL SAMPLES (SS)
- SEDIMENT SAMPLES (SD)
- SPRING/HAND DUG WELL
- NESTED PIEZOMETER
- SURFACE WATER SAMPLING LOCATIONS
- SOIL BOUNDARY

SOIL KEY

Iv –	Ivan and Kennebec Silt Loams
Rd–	Reading Silt Loam, 0 to 1% Slopes
Re–	Reading Silt Loam, 1 to 3% Slopes
Sm–	Smolan Silt Loam 1 to 4% Slopes
Tu–	Tully Silty Clay Loam 4 to 8% Slopes
St–	Stony Steep Land
Bk–	Breaks–Alluvial Land Complex
Bf–	Benfield–Florence Complex 5 to 20% Slopes
Sn–	Smolan Silt Loam 4 to 8% Slopes

0 125 250 500

(IN FEET)

1 inch = 250 ft.

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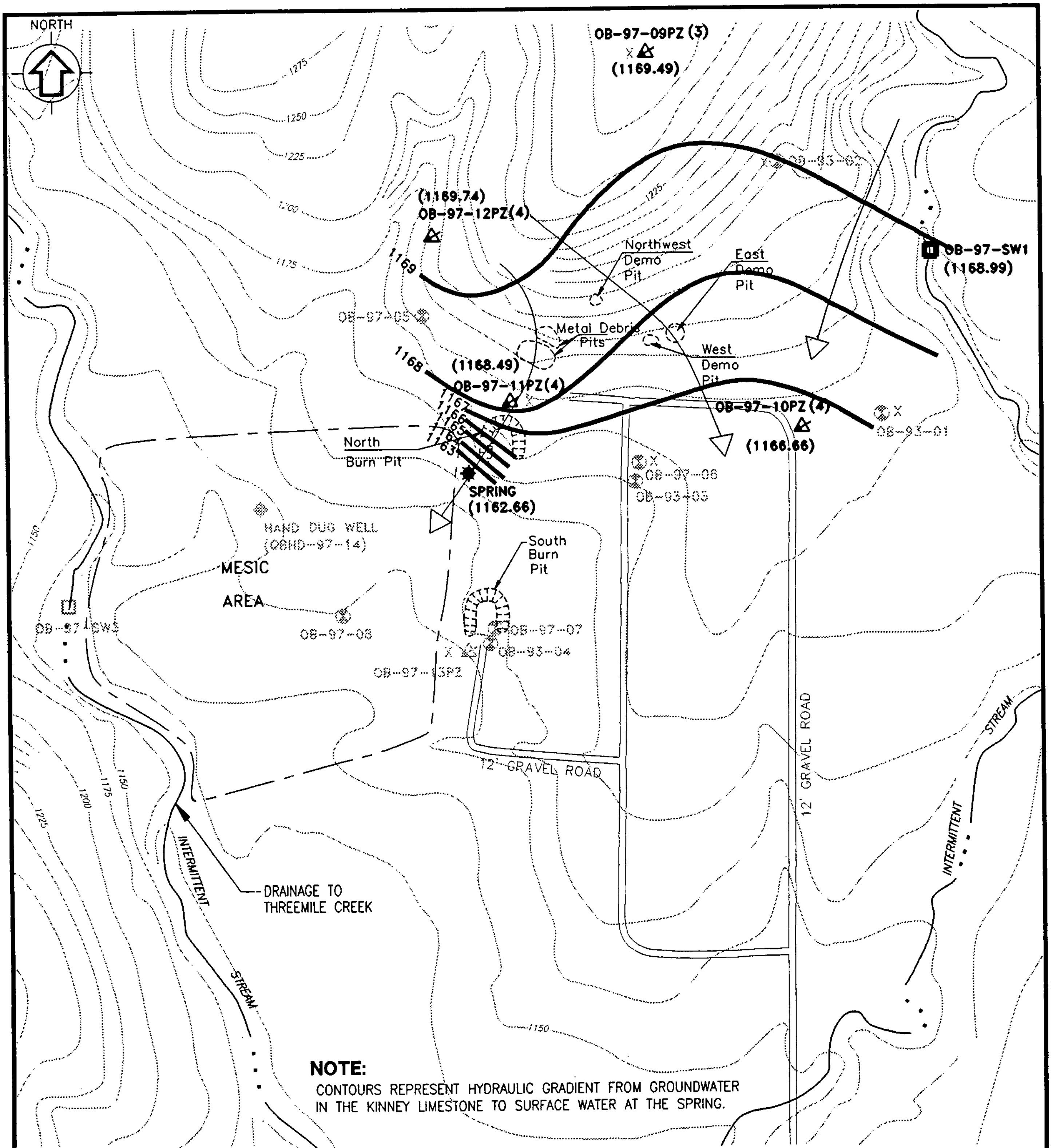
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

SOILS TYPES

SCALE:	OB/OD SIRA DATE:	
AS SHOWN	AUGUST 1998	FIG. 4–10

OB–OD1/06AUG98/OB–SOIL.SCR



NOTE:
CONTOURS REPRESENT HYDRAULIC GRADIENT FROM GROUNDWATER IN THE KINNEY LIMESTONE TO SURFACE WATER AT THE SPRING.

LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- ⊗ GROUNDWATER MONITORING WELL
- △ NESTED PIEZOMETER
- (1169.49) GROUNDWATER ELEVATION (ft msl)
- ▣ SURFACE WATER SAMPLING LOCATIONS
- ◁— GROUNDWATER FLOW DIRECTION
- GROUNDWATER ELEVATION CONTOUR (ft msl)
- ✸ SPRING/HAND DUG WELL
- x USGS DATA PLATFORM

0 125 250 500

(IN FEET)
1 inch = 250 ft.

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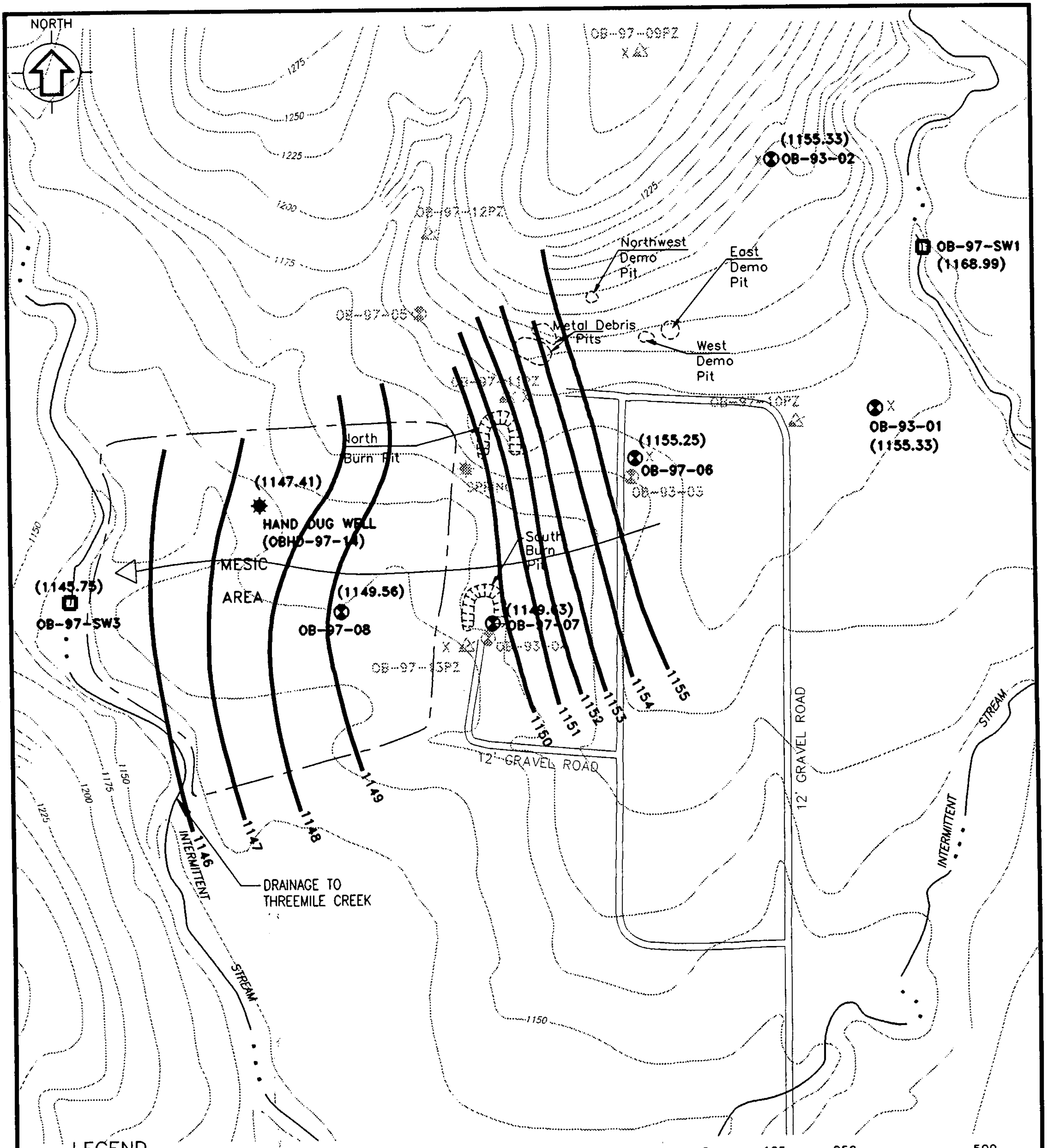
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

GROUNDWATER ELEVATION CONTOURS KINNEY LIMESTONE PIEZOMETERS 19 JANUARY 1998

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-11

OB-OD2/06AUG98/OB-GEC1.SCR



(IN FEET)
1 inch = 250 ft.

LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- ⊗ GROUNDWATER MONITORING WELL
- △ NESTED PIEZOMETER
- (1169.49) GROUNDWATER ELEVATION (ft msl)
- ▣ SURFACE WATER SAMPLING LOCATIONS
- ◁— GROUNDWATER FLOW DIRECTION
- GROUNDWATER ELEVATION CONTOUR (ft msl)
- ✸ SPRING/HAND DUG WELL

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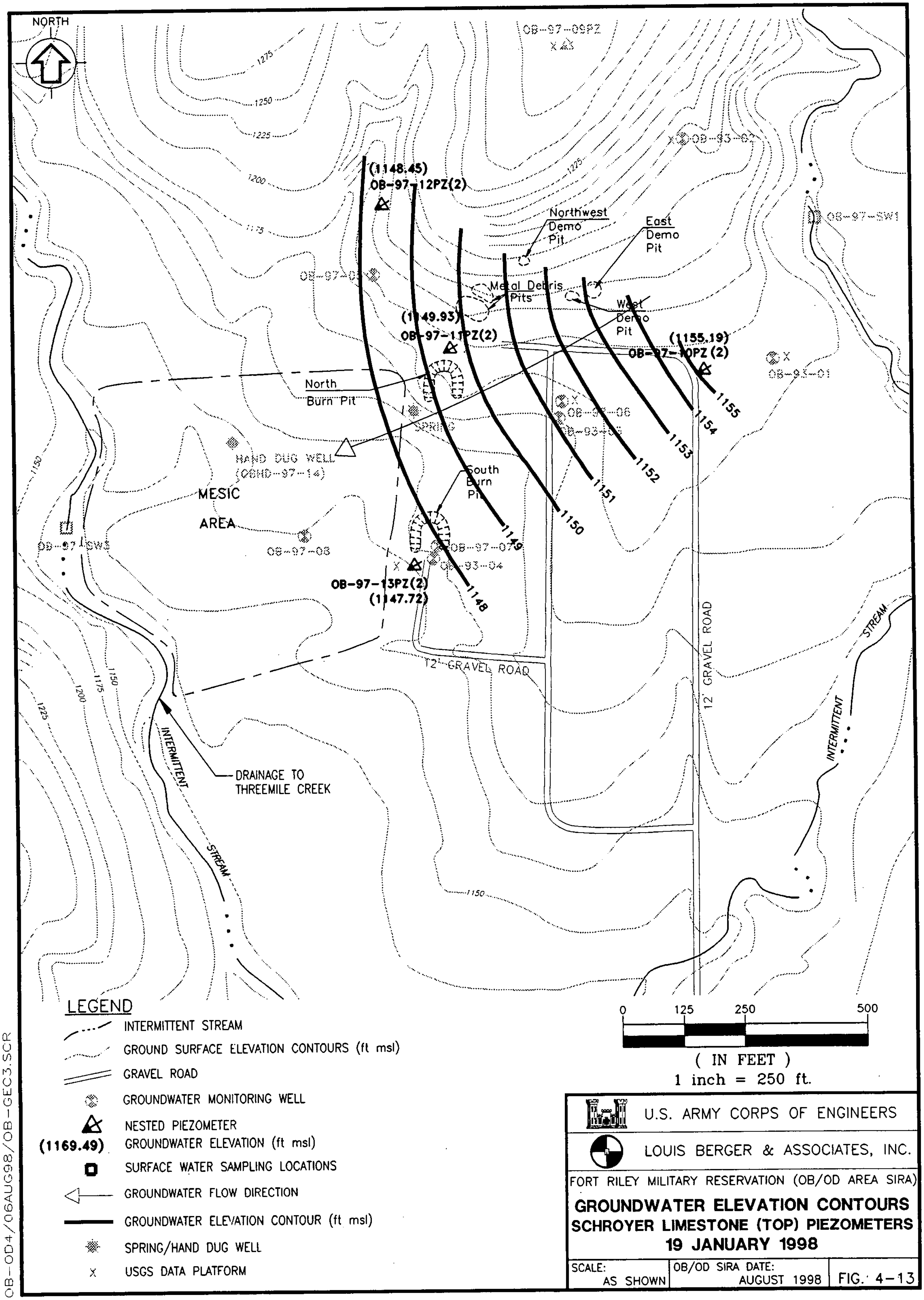
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

GROUNDWATER ELEVATION CONTOURS
WYMORE SHALE/SHROYER LIMESTONE
WELLS - 19 JANUARY 1998

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-12

OB-OD3/06AUG98/OB-GEC2.SCR



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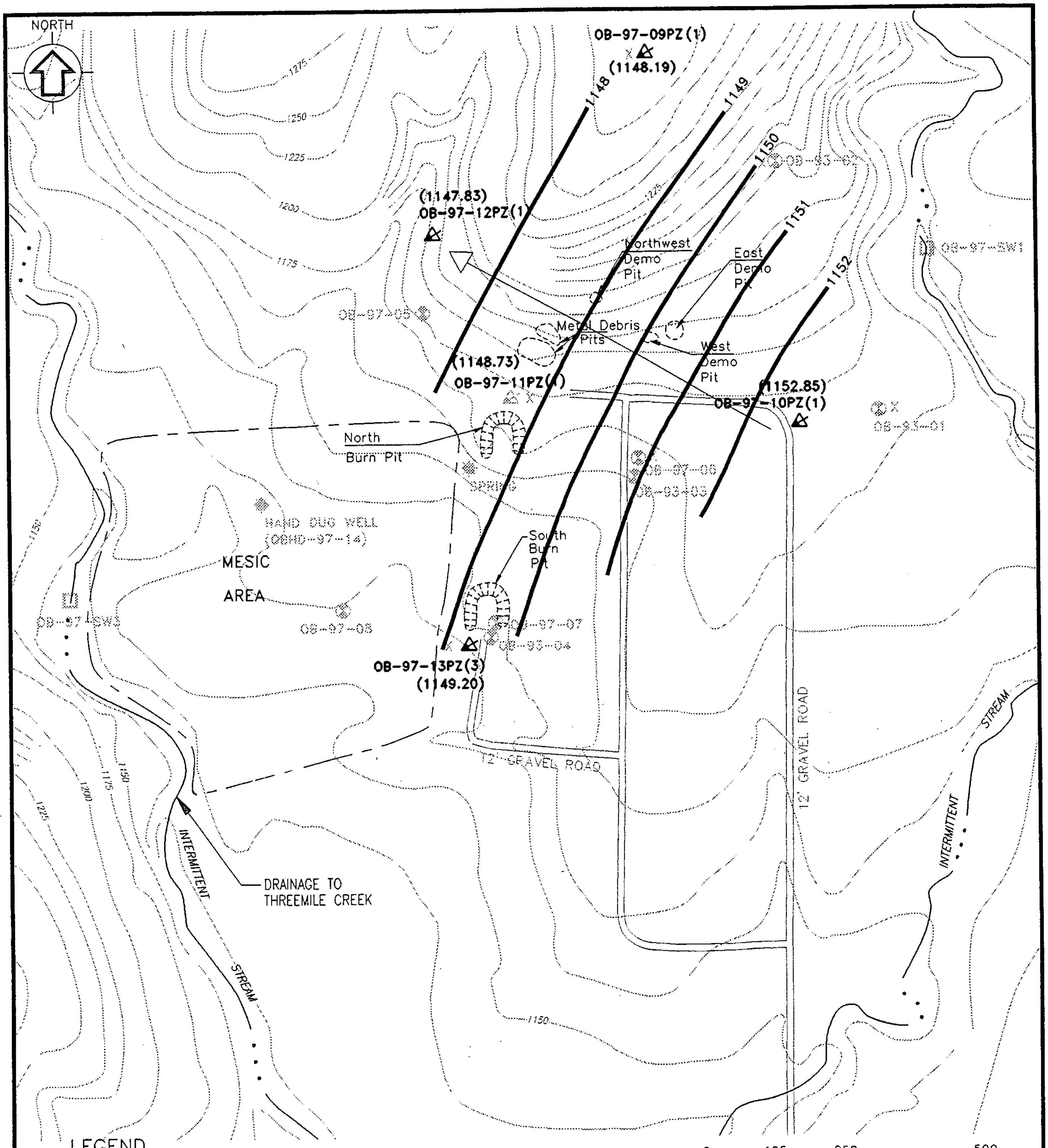
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

GROUNDWATER ELEVATION CONTOURS
SCHROYER LIMESTONE (TOP) PIEZOMETERS
19 JANUARY 1998

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-13

OB-OD4/06AUG98/OB-GEC3.SCR



0 125 250 500

(IN FEET)
1 inch = 250 ft.

LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- GROUNDWATER MONITORING WELL
- NESTED PIEZOMETER
- (1169.49) GROUNDWATER ELEVATION (ft msl)
- SURFACE WATER SAMPLING LOCATIONS
- GROUNDWATER FLOW DIRECTION
- GROUNDWATER ELEVATION CONTOUR (ft msl)
- SPRING/HAND DUG WELL
- USGS DATA PLATFORM

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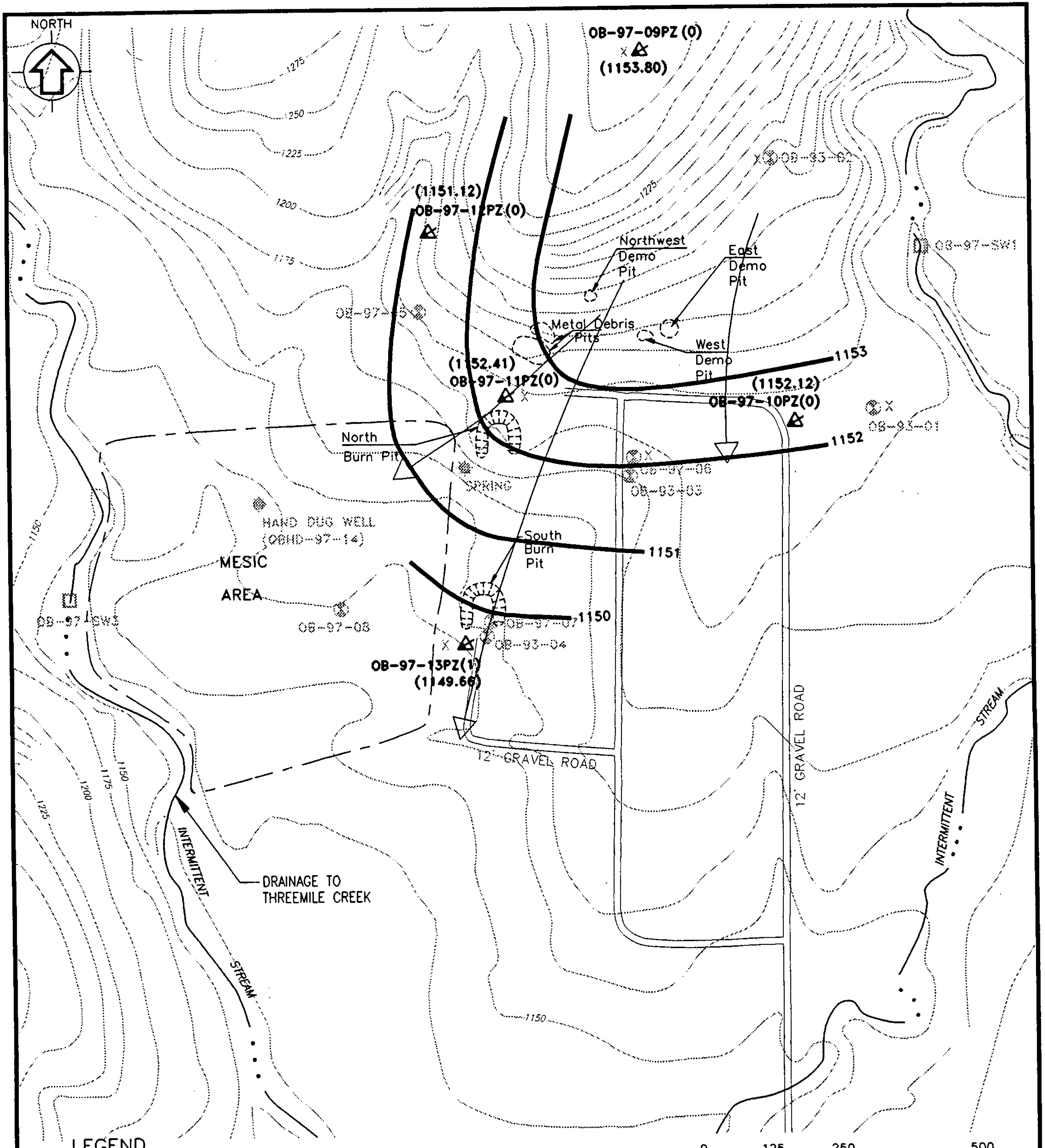
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

GROUNDWATER ELEVATION CONTOURS
SCHROYER LIMESTONE (BOTTOM) PIEZOMETERS
19 JANUARY 1998

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-14

OB-OD5/06AUG98/OB-GEC4.SCR



LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- GROUNDWATER MONITORING WELL
- NESTED PIEZOMETER
- (1169.49) GROUNDWATER ELEVATION (ft msl)
- ☐ SURFACE WATER SAMPLING LOCATIONS
- ◁— GROUNDWATER FLOW DIRECTION
- GROUNDWATER ELEVATION CONTOUR (ft msl)
- SPRING/HAND DUG WELL
- x USGS DATA PLATFORM

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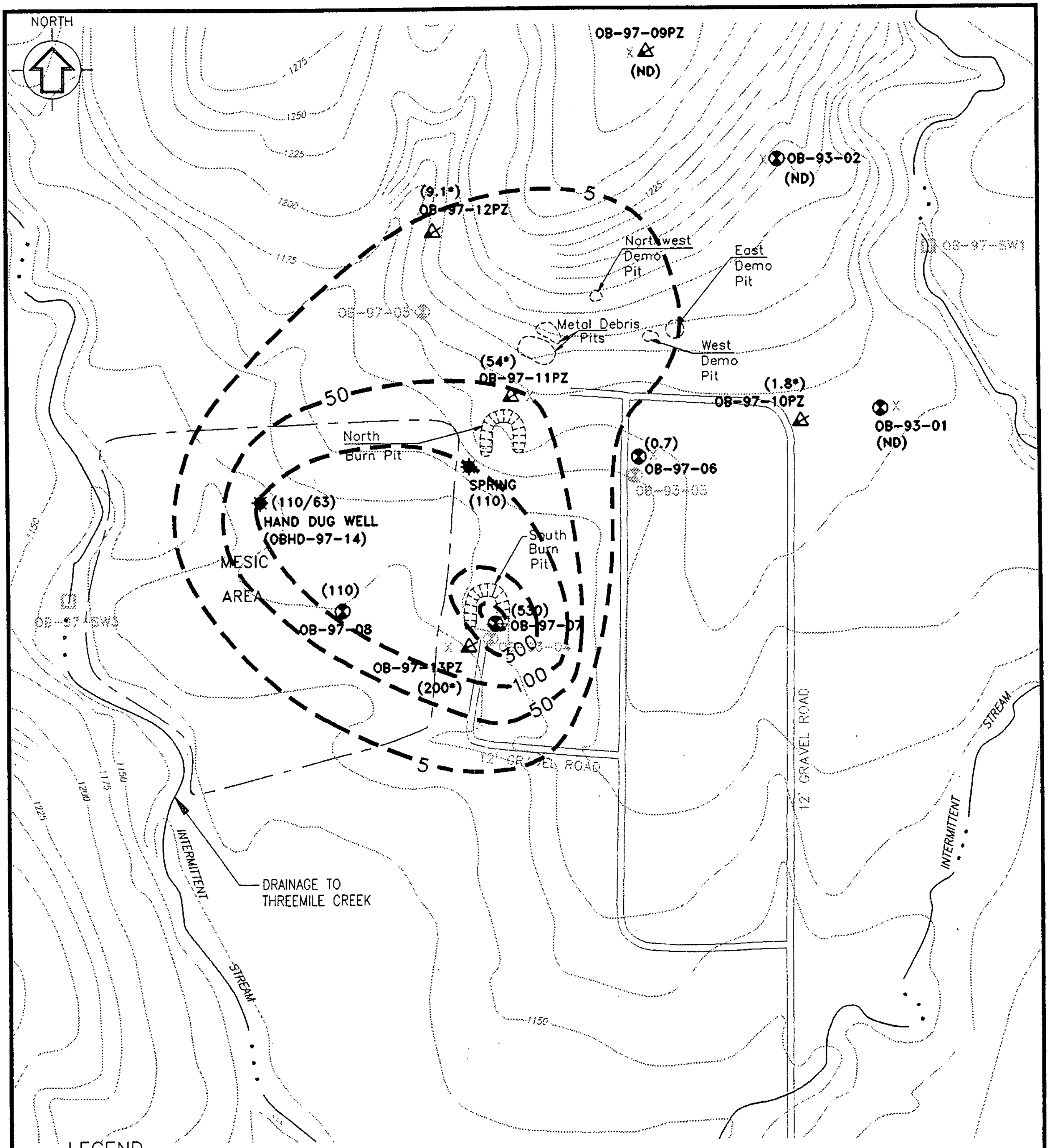
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

GROUNDWATER ELEVATION CONTOURS
HAVENSVILLE (TOP) PIEZOMETERS
19 JANUARY 1998

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-15

OB-OD6/06AUG98/OB-GEC5.SCR



LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- GROUNDWATER MONITORING WELL
- NESTED PIEZOMETER
- (100) TCE CONCENTRATION (ug/l)
- ☐ SURFACE WATER SAMPLING LOCATIONS
- INTERPRETED TCE CONCENTRATION CONTOUR (ug/l)
- ✸ SPRING/HAND DUG WELL
- X USGS DATA PLATFORM

* – HIGHEST TCE CONCENTRATIONS DETECTED IN THIS PIEZOMETER NEST WITHIN THIS WATER-BEARING ZONE.

0 125 250 500

(IN FEET)
1 inch = 250 ft.

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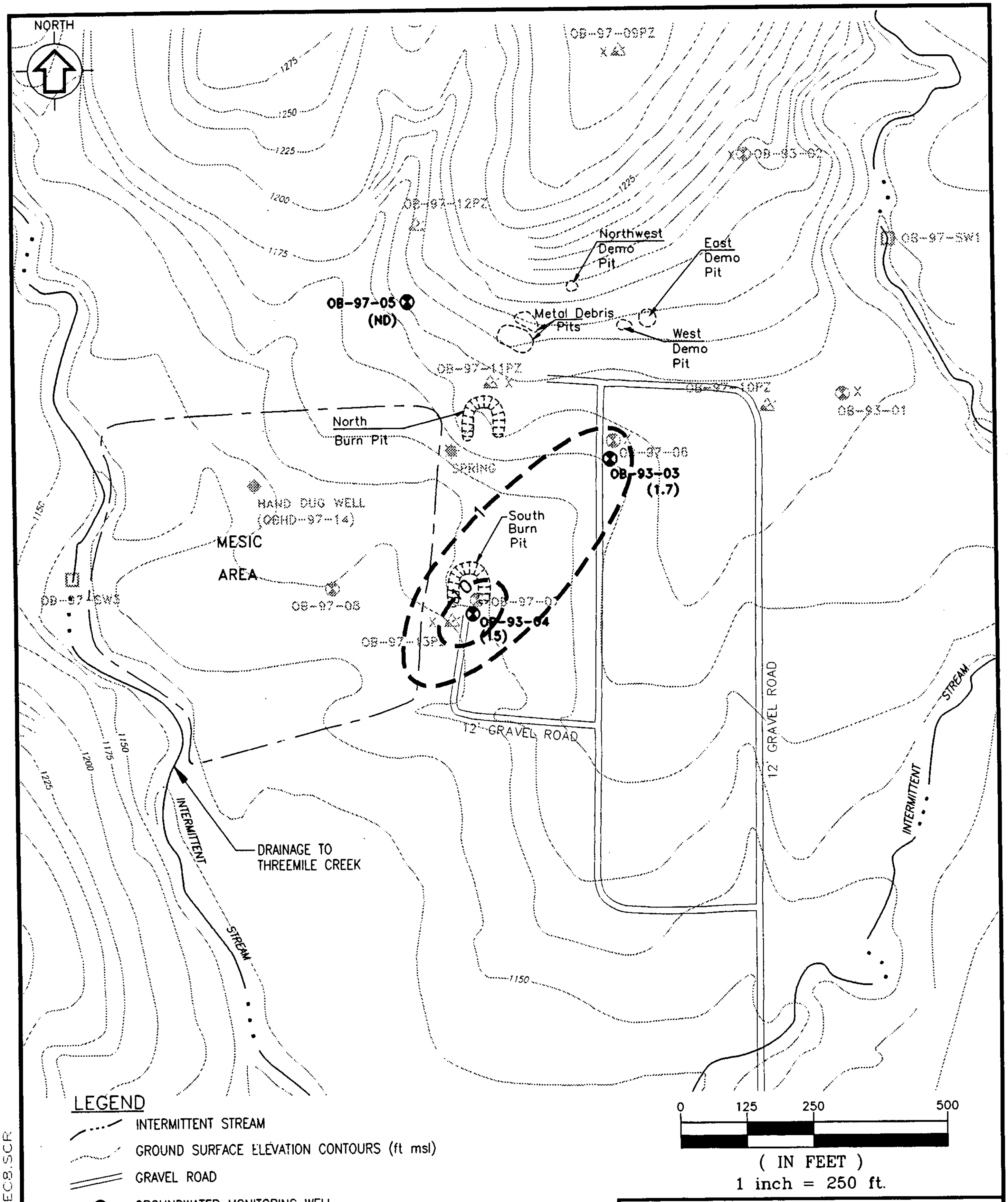
FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

TRICHLOROETHYLENE (TCE)
CONCENTRATIONS-SCHROYER-UPPER HAVENSVILLE
DECEMBER 1997

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-16

OB-OD7/06AUG98/OB-GEC7.SCR



LEGEND

- INTERMITTENT STREAM
- GROUND SURFACE ELEVATION CONTOURS (ft msl)
- GRAVEL ROAD
- ⊗ GROUNDWATER MONITORING WELL
- △ NESTED PIEZOMETER
- (15) TCE CONCENTRATION (ug/l)
- ☐ SURFACE WATER SAMPLING LOCATIONS
- — — INTERPRETED TCE CONCENTRATION CONTOUR (ug/l)
- ✱ SPRING/HAND DUG WELL
- x USGS DATA PLATFORM

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FORT RILEY MILITARY RESERVATION (OB/OD AREA SIRA)

TRICHLOROETHYLENE (TCE)
CONCENTRATIONS - THREEMILE LIMESTONE
DECEMBER 1997

SCALE: AS SHOWN	OB/OD SIRA DATE: AUGUST 1998	FIG. 4-17

OB-OD8/06AUG98/OB-GEC8.SCR

5.0 SUMMARY AND CONCLUSIONS

5.0 SUMMARY AND CONCLUSIONS

Since 1941, the OB/OD Area was used for ordnance disposal by open detonation and open burning. Burning is no longer conducted at the site. The results of the environmental investigations indicate that low levels of chlorinated solvents, predominantly TCE, are present in the groundwater beneath the site. The highest concentration of TCE detected in the groundwater is one to two orders of magnitude below the concentration which would indicate the presence of any residual product. Review of available information and testimony regarding past practices at the site did not identify a discrete source or practice related to the potential release of solvents at the site. Due to the long period of site use and the low levels of dissolved contamination identified, it is difficult to identify the exact location where the contaminants may have been released. In fact, there may actually have been several small, sporadic releases in the past at different locations within the OB/OD Area. However, based on the distribution of the TCE and the direction of groundwater flow, the contaminants were released somewhere within the active and/or historical open burn/open detonation areas bounded by the subject investigations.

After being released to the ground, the small quantities of TCE would have migrated downward through the soil column to the water table via gravity drainage and precipitation infiltration. The concentrations were low enough that the TCE was dissolved and moved with the flow of groundwater (as opposed to being DNAPL, that would sink and persist as residual product and give rise to much higher detections of contamination in the monitoring wells).

In general, the bedrock units beneath the OB/OD Area are flat-lying with relatively uniform thicknesses. As a result, elevation becomes a good indicator of stratigraphic position. Based on the bedrock geologic map, the demo pits and the North Burn Pit are situated on the Blue Springs Shale, while the South Burn Pit is located on the Wymore Shale. Much of what directly underlies these areas is overburden and weathered bedrock derived from these formations.

Although some limited seepage through the shale formations might ultimately occur, it is considered to be of much less importance since the limestone units contain the zones which would much more readily transport groundwater. The affected limestone units beneath the OB/OD Area are the Kinney, Schroyer/Havensville, and the Threemile.

Contaminants released above the Kinney Limestone were dispersed with the primary groundwater flow in this formation coming out of the higher land to the north. This moved some contaminants slightly to the east, but also to the west via the spring at the base of the Kinney. The discharge from the spring continues to the west, infiltrating into the overburden underlying the mesic area. The contaminants dispersed in other directions in the Kinney and some also may have seeped downward through the Wymore Shale to the underlying water-bearing zone of the Schroyer Limestone and upper portion of the Havensville Shale. The Schroyer/upper portion of the Havensville is also the first water-bearing zone to receive contaminants that may have been released at the South Burn Pit.

The highest concentration of TCE onsite (570 µg/l) is identified in the Schroyer/upper portion of the Havensville. For comparison purposes, the federal drinking water MCL for TCE is 5 µg/l.

In this unit, the contaminants also migrate with the flow of groundwater. The flow in this unit is generally towards the intermittent stream to the west. Consistent with the regional geology, this intermittent stream is interpreted to be the trace of a vertical joint which is providing a drainage path for the groundwater in this zone. Smaller layers within the water-bearing zone flow more to the northwest or the southwest depending on where the joint is best developed in contact with that layer. The vertical joint also provides a potential pathway for some groundwater and contaminants to migrate down to the underlying Threemile Limestone. In addition, some downward seepage through the Havensville Shale may also occur. The interpretation that vertical seepage through the shale units does not readily occur is evidenced by the TCE concentrations being one to two orders of magnitude lower in the Threemile Limestone.

Human exposure potential is minimal. Human receptors within a 1-mile radius of the site are limited to military personnel or contractors working at the OB/OD Area during OB/OD activities and/or in areas immediately adjacent to the OB/OD Area. These receptors are considered transient since their access is strictly controlled and they only use the areas on a limited and intermittent basis. Surrounding land use consists of military training grounds to the south, an artillery and mortar impact area to the north, and some wheat and grass farmlands to the southeast. With rare exception, access to the OB/OD Area is restricted to EOD personnel, which only enter the area to perform disposal.

The greatest potential for exposure to the groundwater contamination at the OB/OD Area is at the spring adjacent to the North Burn Pit (Figure 4-1). This spring is flowing most of the time and the water contains concentrations of TCE in the 100 to 300 μg/l range. Exposure of the spring to potential ecological receptors is possible as footprints of various indigenous wildlife (deer, etc.) were observed onsite. The intermittent streams are dry most of the time, so this spring is usually the only surface water on the OB/OD Area. It is possible that wildlife present on the OB/OD Area are drinking from this spring.

A mesic (commonly moist, intermittently wet) area approximately 700 feet by 600 feet in size (10 acres) is located between the spring and the intermittent stream along the western side of the site. This area is not listed as a wetland on the USGS 7.5 minute topographic quadrangles, the Fort Riley installation map prepared by the Defense Mapping Agency, or the National Wetlands Inventory. This area is usually not saturated. Any water that may appear is likely to be from surface runoff. During periods of high water table, however, it is possible that some of the water may be from the groundwater in the underlying overburden (which, like the spring, may have TCE concentrations in the 100 to 300 μg/l range). When wet, this area could present an additional exposure potential for ecological receptors.

The intermittent streams located to the east and west of the OB/OD Area are usually dry and, therefore, do not usually pose an exposure potential to human or ecological receptors. These intermittent streams join about 1,000 feet south of the southern site boundary. This single tributary continues south another 2,000 feet where it joins Threemile Creek. From this point, Threemile Creek flows southeast and joins the Kansas River at the west side of Camp Funston. There are no perennial streams within one mile downstream of the site, and there are no known uses of surface water as potable water within 15 miles downstream of the site.

The groundwater withdrawal well nearest to the OB/OD Area is located at Range 18 approximately 4,220 feet to the east-southeast of the site. This well is only used at the Range 18 maintenance facility for non-potable purposes. No other wells fall within the one-mile radius of the OB/OD Area. The next nearest wells are the Ogden supply wells located approximately 3 miles southeast of the site. There is no realistic potential for exposure to the site groundwater contamination via extraction from production wells.

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REFERENCES

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APPENDICES

APPENDIX A

Boring Logs, As-Built Diagrams, Well Specification Forms, Well Development Records, and Purge Logs

APPENDIX A

Initial SI - September-October 1993 (Wells OB93-01 through OB93-04 and SB1 through SB8)

Drilling Logs
As-Built Diagrams
Well Specification Forms
Well Development Records

Mobilization #1 - March/April 1997 (Wells OB97-05 through OB93-08)

Drilling Logs
As-Built Diagrams
Well Specification Forms
Well Development Records

Mobilization #2 - June/July 1997 (Piezometers OB97-09 through OB93-13)

Drilling Logs
Well Specification Forms
Purge Logs -
    OB93-01 through OB93-04, OB97-05 through OB97-13 and FPHD-14

FPHD-97-14 (Former Dug Well)

As-Built Diagrams

Initial SI -
September-October 1993
(Wells OB93-01 through OB93-04
and SB1 through SB8)

HTW DRILLING LOG

HOLE NO. OB-93-01

SHEET 1 OF 7 SHEETS

1. COMPANY NAME
Louis Berger & Associates, Inc.

2. DRILLING SUBCONTRACTOR
Layne Western – Witchita, KS

3. PROJECT
High Priority Site Investigation , Fort Riley, KS

4. LOCATION
EOD Range, OB/OD area, Fort Riley, KS

5. NAME OF DRILLER
Randy Smith and Ed Roe

6. MANUFACTURER'S DESIGNATION OF DRILL
Acker Soil Max 90

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
8.25" by 12" augers O.D.
18" spoons
Schram Rota Drill T66 OH
Dual tube drill using air and water

8. HOLE LOCATION
East Downgradient Well

9. SURFACE ELEVATION
1181.05

10. DATE STARTED
25 September 1993

11. DATE COMPLETED
27 September 1993

12. OVERBURDEN THICKNESS
18'

15. DEPTH GROUNDWATER ENCOUNTERED
35.0'

13. DEPTH DRILLED INTO ROCK
33'

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED. 21.9' at 15 minutes

14. TOTAL DEPTH OF HOLE
50.8'

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
N.A.						

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
		X		ED WIELAND E Wieland

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨	Split Spoon	**0 - 3' CL** Clay, silty, low plasticity, reddish brown. 5YR/4/4, firm, damp.	0.1 ppm	N.A.	N.A.	5-5-4	
▨	1						
▨	2 Split Spoon						
▨	3 Split Spoon	**3 - 5'** No recovery. Sloughing. Cuttings: Clay, silty, low plasticity.					
▨	4						
▨	5						

HTW DRILLING LOG

HOLE NO.
OB-93-01

PROJECT
High Priority Site Investigation , Fort Riley. KS

INSPECTOR
Ed Wieland

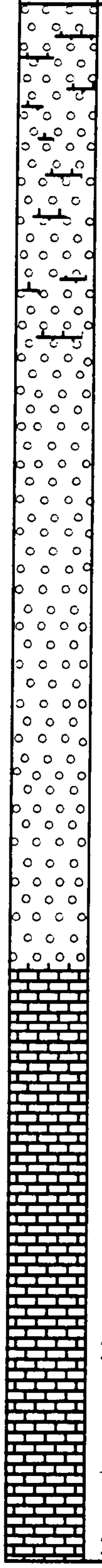
SHEET 2
OF 7 SHEETS

LITH.	DEPTH		DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	6 7	Split Spoon	**5 - 8' SM** Sand, with silt, some clay, reddish brown. Sand is fine, well-sorted, reddish brown to yellowish red. 5YR/5/8, soft, damp.	0.1 ppm				Slightly damp.
	8 9	Split Spoon Split Spoon	**8 - 10'** Sand, fine, well-sorted, some silt, slightly damp.		N.A.	N.A.	2-3-2	
	10 11 12 13	Split Spoon Split Spoon	**10 - 13' SM, GM** Sand, with silt, some clay, contains pieces of limestone, gray-white, soft, moist to wet.					10 - 15' samples moist to wet.

0.3 ppm

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. OB-93-01 SHEET 3 OF 7 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	14	Split Spoon **13 - 15' SM, GM** Sand, fine to medium grade, yellow 10 YR/7/6 with chunks of limestone -- gray-white, moist to wet.		N.A.	N.A.	16-15-17	10 - 15' samples moist to wet.
	15 16 17	Split Spoon **15 - 18' SC, GC** Sand, fine to medium grain, yellow/white, with pebbles of limestone and other little fragments. Some clay as matrix, wet. Split Spoon					15 - 20' samples moist to wet. Note: On 26 September 1993 at 08:35 water level 16.0' bgs -- draw down to 18 bgs with bailing 6.5 gallons. At 09:20, water level was 16'. Clay reacts with hydrochloric acid. Wet.
	18 19	Split Spoon **18 - 20'** Limestone, weathered, olive 5Y/4/4.	0.4 ppm	N.A.	N.A.	50/4 refusal	Reacts with hydrochloric acid. 20.5' End of auger drilling. 6" surface casing set to 20.5'. 78 gallons of water used in grout for setting surface casing. 25 September
	20 21	Grey limestone with interbedded maroon weathered shale. Limestone is well indurated.					27 September: Begin dual tube drilling.

C3

HTW DRILLING LOG

HOLE NO.
OB-93-01

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 4
OF 7 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		Grey limestone with interbedded maroon weathered shale. Limestone is well indurated.					Logged from air rotary cuttings.
	22		0.1 ppm	N.A.	N.A.		Approximately 19 gals. of water used while dual tube drilling.
	23						
	24						
	25	**25 - 28'** Brownish gray shale. Interbedded clay lenses. Moderately consolidated. Not indurated.					
	26						
	27						
	28	**28 - 32'** Tan grey shale.					
	29						

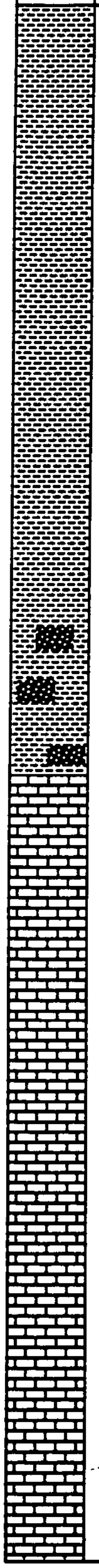
HTW DRILLING LOG

HOLE NO.
OB-93-01

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 5
OF 7 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	30						
	31						
	32	**32.0 - 33.0'** Dark brownish gray shale with interbedded clay lenses.					
	33	**33.0 - 38.0'** Gray limestone. Well indurated.					Very hard to drill.
	34						
	35		0.1 ppm				First water.
	36						
	37						

frly\drillog.prs

PROJECT
Fort Riley High Priority Site Investigations – Marshall Army Air Field

HOLE NO.
OB-93-01

HTW DRILLING LOG

HOLE NO.
OB-93-01

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 6
OF 7 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
							End of water. Hard to drill.
	38	**38.0 - 45.0'** Black well indurated shale.	0.1 ppm				
	39						
	40						
	41						
	42						
	43						
	44						
	45						

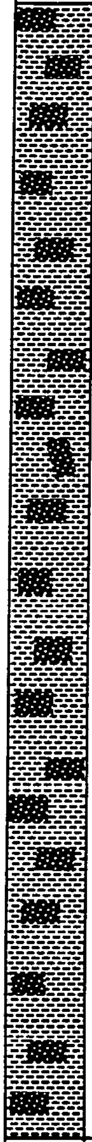
HTW DRILLING LOG

HOLE NO.
OB-93-01

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 7
OF 7 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	46 47 48 49 50	**45.0 - 50.8'** Dark gray shale. Poorly indurated. Interbedded clay lenses.	0.1 ppm				Easy to drill. Total Depth = 50.8'. 108 gallons of water used in well construction. Approximately 50 gallons of water used while drilling. Source of non-chlorinated water was BLDG. 2000, Well No. 7, at Camp Forsyth, on McCormick Rd.
	51 52 53	Bottom of hole.					

LOUIS BERGER & ASSOCIATES, INC.

Client: U. S. Army Corps of Engineers
Project No.: High Priority SI
Project: Ft. Riley High Priority SI
Page: Page 1 of 1
Prepared by: Ed Wieland
Date: 3-OCT-93
Checked by: Peter Li
Date: 18-FEB-94

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Well No.: OB-93-01
Drilling Method: 8.25"x8" augers, 18" spoon to refusal, air rotary dual tube to TD.
Date Installed: 28-SEP-93

Location: OB/OD Are

Elevations:
Ground Surface 1181.05'
Top of PVC 1182.67'

Ground Elevation: 0

Depth from Ground Surface

Outer Casing
20.5'

Surface Seal Material
5% Bentonite Grout

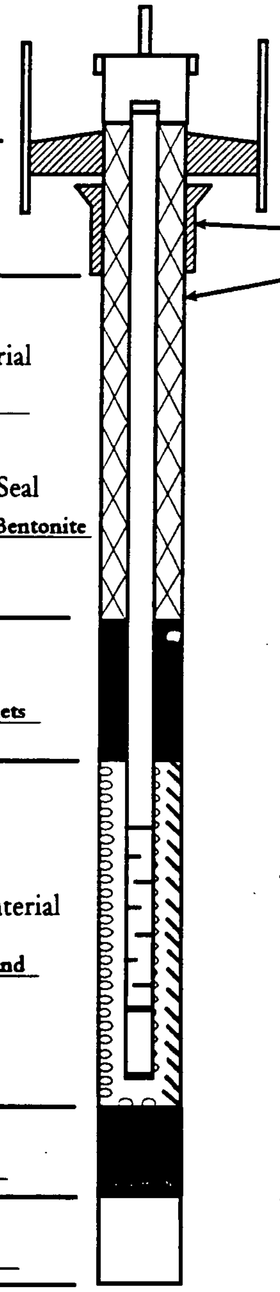
Type of Annular Seal
Cement Grout w/5% Bentonite
17.6'

Type of Seal
1/4" Bentonite Pellets
21.25'

Type of Filter Material
Clean Washed Sand
40.8'

Type of Seal
None at Base
NA

Type of Backfill
Clean Washed Sand
50.8'



SURFACE CASING:
Size: 6"
Material: Steel
Depth: 20.5'

Drill Hole Diameter:
8" (0' - 20.5')
5.25" (20.5' - 50.8')

Riser:
Diameter: 2"
Material: PVC
Sch.: 40
Type of Joints: Flush Thread
Length: 27.8'
Stick- Up: 2.33'

Screen:
Diameter: 2"
Material: PVC
Slot Size: 0.02
Length: 15'
Screened Interval: 40.5' - 25.5'

Sump:
Length: 4" Cap
Type of Cap: Threaded PVC

Centralizer: Used X
Not Used ____
Depths: 25.8' & 40.8'

Depth to Water From Top of Riser at Completion: 21.95'

Form: ftrly\mwdiagrm.prs

Note: Not to Scale

WELL SPECIFICATION FORM

CLIENT: Louis Berger & Associates, Inc.

JOB NUMBER: High Priority SI

WELL OWNER: Fort Riley & HQ 1st Division

ADDRESS:

CITY, STATE, ZIP CODE: Fort Riley, Kansas

PHONE: (913) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-93-01

WELL INSTALLATION DATE: 28 September 1993

GEOLOGIST SUPERVISING INSTALLATION: Mike Miles (SAIC)

GROUND SURFACE ELEVATION (FT): 1181.05'

TOP OF CASING ELEVATION (FT): 1182.67'

WELL STICK-UP (FT): 2.33'

TOTAL BORING DEPTH (FT): 50.8'

BORING DIAMETER (IN): 0' TO 20.5' = 8", 20.5' TO 50.8' = 5.25"

TOTAL DEPTH OF OUTER CASING (FT): 20.5'

OUTER CASING MATERIAL: Steel

OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): Total Length = 27.8'; From Surface = 25.5'

INNER CASING MATERIAL: PVC

INNER CASING DIAMETER (IN): 2" SCREENED INTERVAL (FT): 40.5' - 25.5'

TOTAL LENGTH OF WELL SCREEN (FT): 15'

WELL SCREEN MATERIAL: PVC

WELL SCREEN DIAMETER (FT): 0.167

SCREEN SLOT SIZE (IN): 0.020"

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-93-01

BACKFILL MATERIAL AROUND SCREEN: Clean Washed Silica Sand (10-20)

DEPTH RANGE OF BACKFILL (FT): 50.8 TO 21.25'

SEAL MATERIAL ABOVE SCREEN: 1/4" Bentonite Pellets

DEPTH RANGE OF SEAL (FT): 21.25' TO 17.6'

BACKFILL MATERIAL AROUND CASING: Cement Grout with 5% Bentonite Grout

DEPTH RANGE OF BACKFILL (FT): 17.6' TO 0'

DESCRIPTION OF TOP SEAL: Cement grout topped by a 3' diameter pad and 8" of 3/4" gravel.

DESCRIPTION OF WELL COVER: 6" steel cover, embedded 2' into grout and concrete with secure locking cap.

OTHER ADDITIONAL INFORMATION: Backfilled hole with sand from 50.8' to 40.8' before setting well.

WELL DEVELOPMENT RECORD

CLIENT: Fort Riley - High Priority Sites JOB NO: High Priority SI

FIELD PERSONNEL: Mike Miles (SAIC), Ray Weakly and Randy Smith (Layne Western) SHEET: 1 OF: 1

1. WELL NUMBER: OB-93-01

2. DATE OF INSTALLATION: 27 September 1993

3. DATE OF DEVELOPMENT: 1 October 1993

4. STATIC WATER LEVEL: BEFORE DEVELOPMENT (FT): 23.4' 24 HOURS AFTER (FT):

5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED (GAL): 50 gal.

6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT (GAL): 8 gal.

	START	DURING		END
7. PHYSICAL APPEARANCE	cloudy	clear	clear	clear
SPECIFIC CONDUCTANCE (μmhos/cm)	420	442	442	442
TEMPERATURE (°C)	15.5	14.1	14.1	14.1
pH (s.u.)	6.83	7.10	6.55	6.64
TURBIDITY (NTU)	-	6.22	2.11	1.25

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL (FT): 53.1'

9. SCREEN LENGTH (FT): 15'

10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT (FT): 42.1' AFTER DEVELOPMENT (FT): 49.4'

11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: 1 7/8" Surge block, 1 1/2" x 3 ' bailer, and 2" Grundfos Pump.

12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge, bail, and pump.

13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE (FT): 1.8

14. QUANTITY OF WATER REMOVED (GAL): 1100 gal TIME OF REMOVAL (HR:MIN): 4:05

HTW DRILLING LOG

HOLE NO. OB-93-02

1. COMPANY NAME Louis Berger & Associates, Inc.

2. DRILLING SUBCONTRACTOR Layne Western – Witchita, KS

SHEET 1 OF 10 SHEETS

3. PROJECT High Priority Site Investigation , Fort Riley, KS

4. LOCATION EOD Range, OB/OD area, Fort Riley, KS

5. NAME OF DRILLER John Gornick and Ed Roe

6. MANUFACTURER'S DESIGNATION OF DRILL

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
- Mobile B57 4.25 x 8" auger
- Schram Rota Drill T66 OH
- Dual tube drill using air and water

8. HOLE LOCATION Upgradient monitoring Well

9. SURFACE ELEVATION approximately 1207.49'

10. DATE STARTED 26 September 1993

11. DATE COMPLETED 29 September 1993

12. OVERBURDEN THICKNESS 37.3'

15. DEPTH GROUNDWATER ENCOUNTERED 62.0'

13. DEPTH DRILLED INTO ROCK 34.7'

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED. 49.26' at 15 minutes

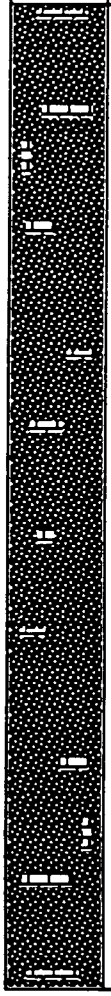
14. TOTAL DEPTH OF HOLE 72.0'

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
N.A.						

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
		X		

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	1 2 3 4 5 Continuous Core Sampler C.C.S.	**0.0 - 4.5'** Tight, moist clay, medium brown, plastic, minor limestone fragments, moist.	0 ppm 0 ppm				0 - 14.5': Moist.

PROJECT Fort Riley High Priority Site Investigations

HOLE NO. OB-93-02

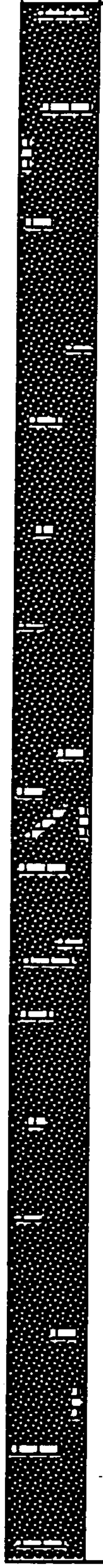
HTW DRILLING LOG

HOLE NO.
OB-93-02

PROJECT
High Priority Site Investigation . Fort Riley. KS

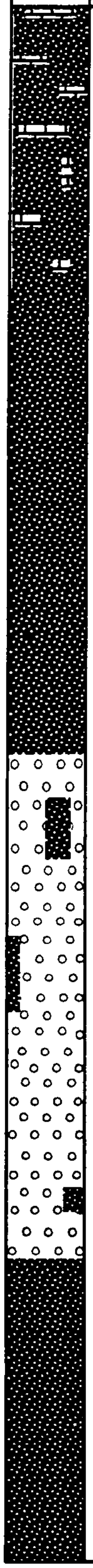
INSPECTOR
Steve Keller and Mike Miles

SHEET 2
OF 10 SHEETS

LITH.	DEPTH		DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	6 7 8	Continuous Core Sampler	**4.5 - 9.0'** Tight, moist clay, medium brown, plastic, minor limestone fragments.					0-14.5': Moist.
	9		**9.0 - 9.5'** Clay with abundant limestone fragments, limestone cream-white, well indurated, moist.					
	10 11 12 13	Continuous Core Sampler	**9.5 - 14.5'** Clay grades to light tan-brown with minor limestone fragments. Moist.	0 ppm (9.5- 14.5')				

HTW DRILLING LOG

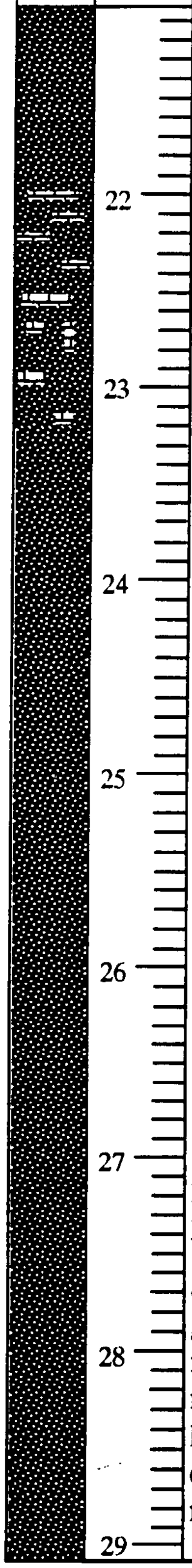
PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keller and Mike Miles	HOLE NO. OB-93-02 SHEET 3 OF 10 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	14	CCS					
	15 16	Continuous Core Sampler **14.5 - 16.8' CL/ML** Silty clay, light tan, weak and plastic, moist, with well-sorted silt/very fine sand fraction.	0 ppm				14.5 - 16.8' Moist.
	17	Interval 16.8 - 16.9' partially saturated. Lower contact gradational.					
	18 19	**16.9 - 19.5' SC** Clayey sand, dry very well sorted, minor clay content, some plasticity..					Approximately 2' lost in run. No sample from 19.5 - 22.0'.
	20 21	CCS	0 ppm 19.5 - 24.5'				

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keller and Mike Miles	HOLE NO. OB-93-02 SHEET 4 OF 10 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	21.0 - 22.0	Continuous Core Sampler		☒			
	22.0 - 23.2	**22.0 - 23.2' CL** Clay, light brown, moist, with abundant limestone fragments.					22.0 - 23.2' Moist. At 23.2', it was the end of moisture in all samples; all below (to 62') were dry.
	23.2 - 24.5	**23.2 - 24.5'** Light green gray clay with thin bedding or lamination, and minor angular granules. Dry, non-plastic, and weakly indurated. Possibly lacustrine as opposed to colluvial-looking clay from 22.0 - 23.2'.					
	24.5 - 27.0			☒			24.5 - 27.0' No sample .
	27.0 - 29.0	**27.0 - 29.5' CL** Light green gray with thin bedding or lamination, and minor angular granules. Dry, non-plastic, and weakly indurated. Possibly lacustrine as opposed to colluvial-looking clay from 22.0 - 23.2'.					

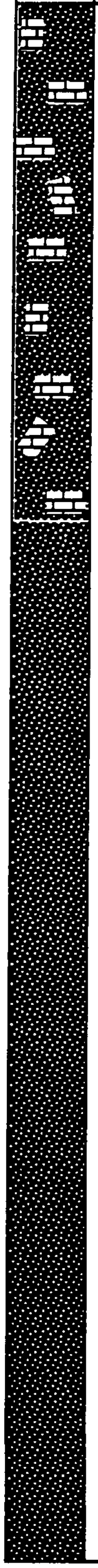
HTW DRILLING LOG

HOLE NO.
OB-93-02

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Steve Keller and Mike Miles

SHEET 5
OF 10 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	30 31	**29.5 - 31.7' CL** Clay. Color is light to medium olive brown, minor angular limestone fragments, dry and blocky with no laminae, moderately indurated, and becomes silty at base.					
	32 33 34 35 36 37	**31.7 - 37.3' CL** Clay. Light green-gray, minor to no silt, minor orange-brown oxidation mottles. Laminated and slightly fissile, but less fissile and more blocky towards base.	0 ppm				

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keller and Mike Miles	HOLE NO. OB-93-02 SHEET 6 OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	38	**37.3 - 39.3'** Shale, bedrock, dry. Light grayish green, well indulated with interbedded lenses of weathered shales with oxidation stains.					
	39						26 September
	40	**40.0 - 45.0'** Dark gray shale, poorly indulated. Dry.	0 ppm				27 September Dual tube drilling began. Logged from air rotary cuttings.
	41						
	42						
	43						
	44						
	45						

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keiler and Mike Miles	HOLE NO. OB-93-02 SHEET 7 OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨		**4[illegible].0 - 53.0'** Light gray shale. Soft, dry.					Easy to drill.
	46						
	47						
	48	Light gray shale. Dry.					
	49						
	50						
	51	Light gray shale. Dry.					
	52						
	53						

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keller and Mike Miles	HOLE NO. OB-93-02 SHEET 8 OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨		**53.0 - 60.0'** Gray shale. Well indurated. Interbedded lenses of stiff-very stiff clay. Dry.	0 ppm				Hard to drill.
▨	54						
▨	55						
▨	56	Gray shale, as above.					
▨	57						
▨	58	Gray shale, as above.					
▨	59						
▨	60	**60.0 - 61.0'** Gray weathered shale. Dry. Soft. Poorly indurated.					Very easy to drill.
▨	61						

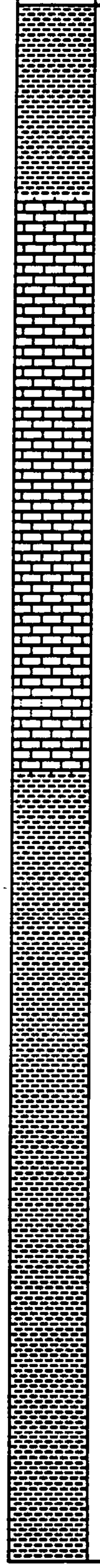
HTW DRILLING LOG

HOLE NO.
OB-93-02

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Steve Keller and Mike Miles

SHEET 9
OF 10 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
			0 ppm				Very hard to drill.
	62	**62.0 - 65.0'** Light gray limestone.					Water.
	63						
	64						
	65	**61.0 - 72.0'** Grayish black shale. Hard. Dry.	0 ppm				End of water bearing unit.
	66						
	67						
	68						
	69						

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keller and Mike Miles	HOLE NO. OB-93-02 SHEET 10 OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨	70 71 72	**72.0'** Dark gray shale with interbedded blackish-gray clay lenses.	0 ppm				End of boring. Total depth = 72'. Used approximately 55 gallons of water while drilling. 120 gallons of water in grout for surface casing.
	73 74 75 76 77	Bottom of hole.					Note: Water source for drilling fluid: Bldg. 3200, Well No. 7, Camp Forsyth on McCormick Rd.

LOUIS BERGER & ASSOCIATES, INC.

Client: U. S. Army Corps of Engineers
Project No.: High Priority SI
Project: Ft. Riley High Priority SI
Page: Page 1 of 1
Prepared by: Ed Wieland
Date: 3-OCT-93
Checked by: Peter Li
Date: 18-FEB-94

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Well No.: OB-93-02
Drilling Method: 8.25"x8" auger with CME continuous sampler to refusal, air rotary dual tube to TD.
Date Installed: 29-SEP-93

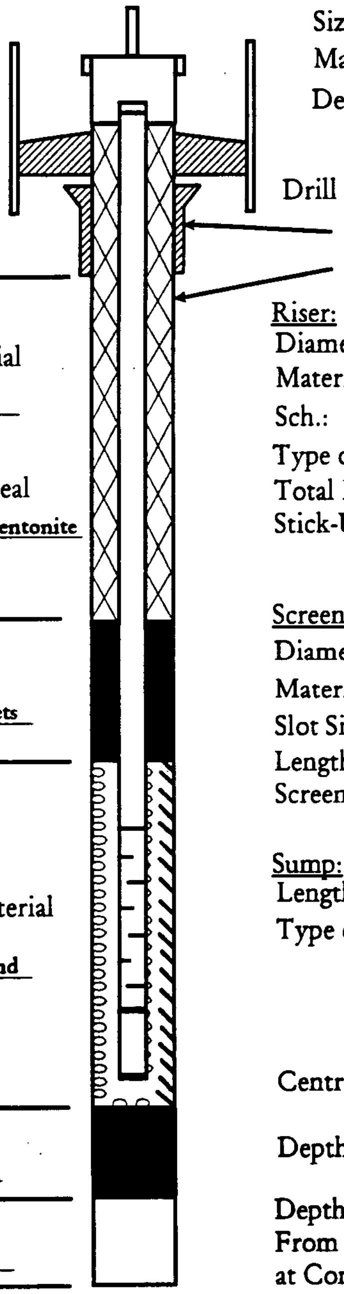
Location: OB/OD Area

Elevations:
Ground Surface 1207.49'
Top of PVC 1209.11'

Ground Elevation: 0

Depth from Ground Surface

0	
	Outer Casing
37.3'	
	Surface Seal Material 5% Bentonite Grout
	Type of Annular Seal Cement Grout w/5% Bentonite
43.9'	
	Type of Seal 1/4" Bentonite Pellets
53.2'	
	Type of Filter Material Clean Washed Sand
72.0'	
	Type of Seal None at Base
NA	
	Type of Backfill Clean Washed Sand
72.0'	



SURFACE CASING:
Size: 6"
Material: Steel
Depth: 37.3'

Drill Hole Diameter:
8" (0' - 37.3')
5.25" (37.3' - 72')

Riser:
Diameter: 2"
Material: PVC
Sch.: 40
Type of Joints: Flush Thread
Total Length: 58.2'
Stick-Up: 1.53'

Screen:
Diameter: 2"
Material: PVC
Slot Size: 0.02
Length: 15'
Screened Interval: 71.7' - 56.7'

Sump:
Length: 4" Cap
Type of Cap: Threaded PVC

Centralizer: Used X
Not Used
Depths: 37' & 72'

Depth to Water From Top of Riser at Completion: 49.3'

Note: Not to Scale

Form: ftrly\mwdiagrm.prs

WELL SPECIFICATION FORM

CLIENT: Louis Berger & Associates, Inc.

JOB NUMBER: High Priority SI

WELL OWNER: Fort Riley & HQ 1st Division

ADDRESS:

CITY, STATE, ZIP CODE: Fort Riley, Kansas

PHONE: (913) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-93-02

WELL INSTALLATION DATE: 29 September 1993

GEOLOGIST SUPERVISING INSTALLATION: Mike Miles (SAIC)

GROUND SURFACE ELEVATION (FT): 1207.49'

TOP OF CASING ELEVATION (FT): 1209.11'

WELL STICK-UP (FT): 1.53'

TOTAL BORING DEPTH (FT): 72'

BORING DIAMETER (IN): 0' TO 37.3' = 8", 37.3 TO 72.0' = 5.25"

TOTAL DEPTH OF OUTER CASING (FT): 37.3'

OUTER CASING MATERIAL: Steel

OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): Total Length = 58.2'; From Surface = 56.7'

INNER CASING MATERIAL: PVC

INNER CASING DIAMETER (IN): 2"

TOTAL LENGTH OF WELL SCREEN (FT): 15' SCREENED INTERVAL (FT): 71.7' - 56.7'

WELL SCREEN MATERIAL: PVC

WELL SCREEN DIAMETER (FT): 0.167

SCREEN SLOT SIZE (IN): 0.020"

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-93-02

BACKFILL MATERIAL AROUND SCREEN: Clean Washed Silica Sand

DEPTH RANGE OF BACKFILL (FT): 72' TO 53.2'

SEAL MATERIAL ABOVE SCREEN: 1/4" Bentonite Pellets

DEPTH RANGE OF SEAL (FT): 53.2' TO 43.9'

BACKFILL MATERIAL AROUND CASING: 5% Bentonite Grout

DEPTH RANGE OF BACKFILL (FT): 43.9' TO O'

DESCRIPTION OF TOP SEAL: 5% Bentonite grout capped by 8" of 3/4" gravel and 6" of concrete.

DESCRIPTION OF WELL COVER: 6" Steel Casing with locking cap, embedded 2' into the concrete.

OTHER ADDITIONAL INFORMATION:

WELL DEVELOPMENT RECORD

CLIENT: Fort Riley - High Priority Sites JOB NO: High Priority SI

FIELD PERSONNEL: Ed Wieland (SAIC), Brian Meier (Layne Western) SHEET: 1 OF: 1

1. WELL NUMBER: OB-93-02
2. DATE OF INSTALLATION: 29 September 1993
3. DATE OF DEVELOPMENT: 2 October 1993
4. STATIC WATER LEVEL: BEFORE DEVELOPMENT (FT): 50.11' 24 HOURS AFTER (FT): -
5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED (GAL): 55 gal.
6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT (GAL): 8.5 gal.

	START	DURING		END
7. PHYSICAL APPEARANCE	cloudy (milky)	clear	clear	clear
SPECIFIC CONDUCTANCE (μmhos/cm)	448	448	445	445
TEMPERATURE (°C)	15.2	15.9	15.9	15.9
pH (s.u.)	7.02	6.63	6.72	6.73
TURBIDITY (NTU)	-	34.9	9.08	5.31

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL (FT): 73.5'
9. SCREEN LENGTH (FT): 15'
10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT (FT): 73' AFTER DEVELOPMENT (FT): 73.2'
11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: 1 7/8" Surge block, 1 1/2" x 3 ' bailer, and 2" Grundfos Pump.
12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge, bail, and pump.
13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE (FT): 2.0'
14. QUANTITY OF WATER REMOVED (GAL): 360 gal TIME OF REMOVAL (HR:MIN): 4:18

HTW DRILLING LOG

HOLE NO. OB-93-03

SHEET 1 OF 10 SHEETS

1. COMPANY NAME Louis Berger & Associates, Inc.
2. DRILLING SUBCONTRACTOR Layne Western – Witchita, KS
3. PROJECT High Priority Site Investigation . Fort Riley, KS
4. LOCATION EOD Range, OB/OD area, Fort Riley, KS
5. NAME OF DRILLER John Gornick and Ed Roe
6. MANUFACTURER'S DESIGNATION OF DRILL Mobile drill B-57
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
   - 4.25 x 8" Hollow Stem Auger
   - CME continuous core sampler
   - Schram dual tube rota drill T66OH
8. HOLE LOCATION Central downgradient well
9. SURFACE ELEVATION 1172.88'
10. DATE STARTED 26 September 1993
11. DATE COMPLETED 28 September 1993
12. OVERBURDEN THICKNESS 28.5'
13. DEPTH DRILLED INTO ROCK 48.5'
14. TOTAL DEPTH OF HOLE 77.0'
15. DEPTH GROUNDWATER ENCOUNTERED 67.0'
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED. 49.2' at 15 minutes
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES N.A.	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS N.A.	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
		X		ED WIELAND

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨	1 2 3 4 5 Continuous Core Sampler	0 - 5' CL Clay, silty, grayish brown, firm, dry. 10YR/5/2.	0.4 ppm	N.A	N.A.		0 - 10' dry.

PROJECT Fort Riley High Priority Site Investigations

HOLE NO. OBOD-93-02

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. OBOD-93-03 SHEET 2 OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	6 7 8 9	Continuous Core Sampler **5 - 10' CL** Clay, silty, soft, brown, firm, dry. 10YR4/3.	0.4 ppm	N.A	N.A.		0 - 10' dry.
	10 11 12 13	Continuous Core Sampler **10 - 14.5' CL** Clay: brown, soft, moist, with limestone fragments (white), firm.	0.4 ppm	N.A.	N.A.		10 -15' moist.

HTW DRILLING LOG

HOLE NO. OBOD-93-03	SHEET 3 OF 10 SHEETS
PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland

LITH.	DEPTH		DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	14	Continuous Core Sampler	**10 - 14.5'** (cont.) Clay: brown, soft, moist, with limestone fragments (white).	0.4 ppm	N.A.	N.A.		10 - 15' moist.
	15		**14.5 - 15.0' CL** Clay: gray to light olive brown, fissile. firm.					
	16	Continuous Core Sampler	**15.0 - 17.0'** Shale, grayish brown.	0.2 ppm	N.A.	N.A.		Shale is soft, clayey and fissile, not weathered. Recovered 4' in the 15 - 20' interval.
	17 18 1(20		**17.0 - 20.0'** Shale, dark reddish brown and dark olive brown.					
		Continuous Core Sampler	**20.0 - 20.5'** Shale, gray.					Recovered 3.5' in the 20 -25' interval.
	21		**20.5 - 21.5'** Limestone lense, wet, gray.					

HTW DRILLING LOG

PROJECT High Priority Site Investigation . Fort Riley, KS	INSPECTOR Ed Wieland
HOLE NO. OBOD-93-03	SHEET 4 OF 10 SHEETS

LITH.	DEPTH		DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		Continuous Core Sampler	**20.5 - 21.5'** Limestone lense, wet, gray.					From 20.5 - 21.5' -- wet. Water came up to 14.6' bgs at 16:55. Bailed at a rate of approximately 1 gallon per minute with slight drawdown.
	22		**21.5 - 22.5'** Shale, reddish brown.					
	23 24		**22.5 - 23.5'** Shale, dark greenish gray, mottled red.		☒			Recovered 3.5' in the 20 -25' interval. 23.5 - 25.0': Lost core.
	25 26 27 28 29	Continuous Core Sampler	**25 - 34.0'** Shale, dark gray, fissile, hard, becomes olive with depth.	0.1 ppm	N.A.	N.A.		Becoming difficult to auger. Stopped augers. Begin dual tube drilling after setting surface casing. Surface casing set to 28.4'. Used 100 gals. of water in grout for setting surface casing. 26 September 28 September

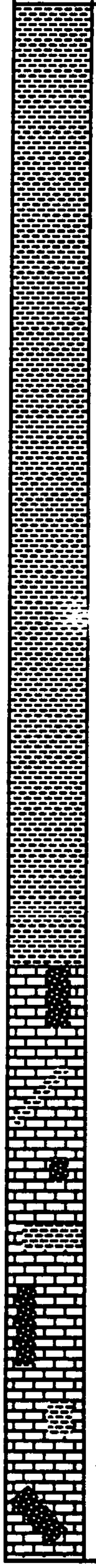
HTW DRILLING LOG

HOLE NO.
OBOD-93-03

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

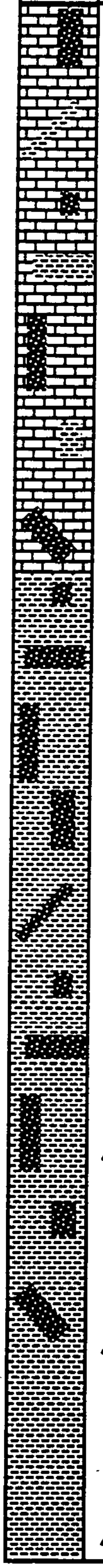
SHEET 5
OF 10 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		Shale, dark gray, fissile, hard, becomes olive with depth.					
	30						
	31						
	32						
	33						
	34	**34.0 - 40.0'** Dark gray limestone with interbedded clay and shale. Shale is well indurated.	0.1 ppm	N.A.	N.A.		Very hard to drill.
	35						
	36						
	37						

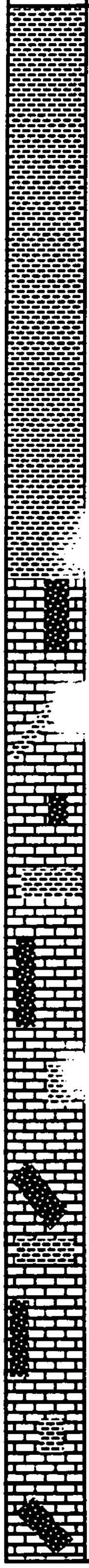
HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. OBOD-93-03 SHEET 6 OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	38						
	39						
	40	**40.0 - 44.0'** Light gray shale with interbedded clays. Shale is well indurated.	0.1 ppm	N.A.	N.A.		Begin to see an organic material in the cuttings.
	41						
	42						
	43						
	44	**44.0 - 48.0'** Yellowish gray clayey shale.					
	45						

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. OBOD-93-03 SHEET 7 OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	46						
	47						
	48	**48.0 - 67.0'** Dark gray limestones with interbedded clays and shales.	0.1 ppm	N.A.	N.A.		Very hard. Started to drill with water injection.
	49						
	50						
	51						
	52						
	53						

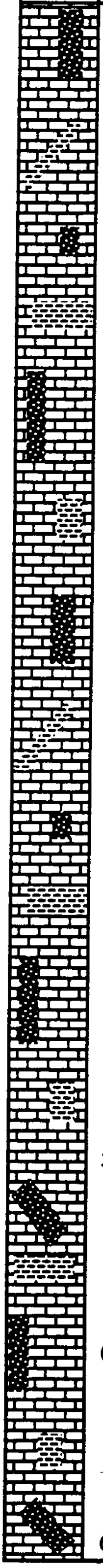
HTW DRILLING LOG

HOLE NO.
OBOD-93-03

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 8
OF 10 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	54						
	55						
	56						
	57						
	58						
	59						
	60						
	61						

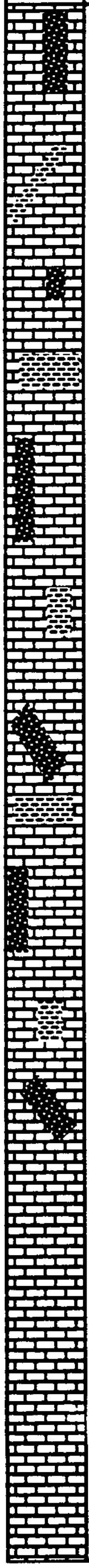
HTW DRILLING LOG

HOLE NO.
OBOD-93-03

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 9
OF 10 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	62						
	63						
	64						
	65						Becoming very hard to drill.
	66						
	67	**67.0 - 74.0'** Gray limestone, hard.	0.1 ppm	N.A.	N.A.		Water.
	68						
	69						

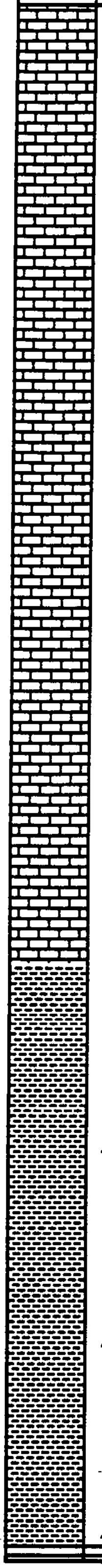
HTW DRILLING LOG

HOLE NO.
OBOD-93-03

PROJECT
High Priority Site Investigation . Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 10
OF 10 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	70						
	71						
			0.1 ppm	N.A.	N.A.		
	72						
	73						
							End of water bearing unit.
	74	**74.0 - 77.0** Reddish brown shales and clays, moderately hard.	0.1 ppm	N.A.	N.A.		Stopped drilling. Total depth = 77'. Used 100 gallons of water in setting surface casing (grout). Used 140 gallons of water in well construction. Used approximately 60 gallons of water in dual tube drilling. Non-chlorinated drilling source used: Bldg. 3200, Well 7, at Forsyth on McCormick Rd.
	75						
	76						
	77	Bottom of hole.					

LOUIS BERGER &
ASSOCIATES, INC.

Client: U. S. Army Corps of Engineers Project No.: High Priority SI
Project: Ft. Riley High Priority SI Page: Page 1 of 1
Prepared by: Ed Wieland Date: 3-OCT-93
Checked by: Peter Li Date: 18-FEB-94

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Well No.: OB-93-03
Drilling Method: 8.25"x 8" auger with CME continuous sampler to refusal, air rotary dual tube to TD.
Date Installed: 28-SEP-93

Location: OB/OD Area

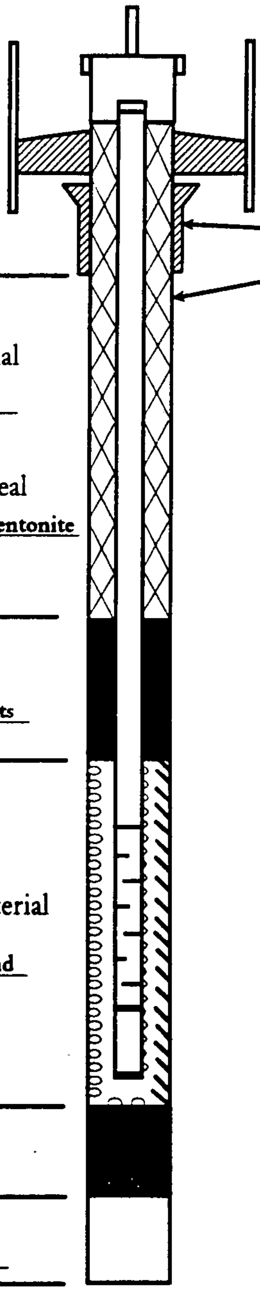
Elevations:
Ground Surface 1172.88'
Top of PVC 1174.82'

SURFACE CASING:
Size: 6"
Material: Steel
Depth: 28.5'

Ground Elevation: 0

Depth from Ground Surface

0 – 28.5'	Outer Casing
28.5' – 51.8'	Surface Seal Material: 5% Bentonite Grout Type of Annular Seal: Cement Grout w/5% Bentonite
51.8' – 58.7'	Type of Seal: 1/4" Bentonite Pellets
58.7' – 77.0'	Type of Filter Material: Clean Washed Sand
NA	Type of Seal: None at Base
NA	Type of Backfill: Clean Washed Sand



Drill Hole Diameter:
8" (0' - 28.5')
5.25" (28.5' - 77')

Riser:
Diameter: 2"
Material: PVC
Sch.: 40
Type of Joints: Flush Thread
Total Length: 64'
Stick-Up: 2.33'

Screen:
Diameter: 2"
Material: PVC
Slot Size: 0.02
Length: 15'
Screened Interval: 76.7' - 61.7'

Sump:
Length: 4" Cap
Type of Cap: Threaded PVC

Centralizer: Used X
Not Used
Depths: 62' - 77'

Depth to Water From Top of Riser at Completion: 47.0'

Form: ftrly\mwdiagrm.prs

Note: Not to Scale

WELL SPECIFICATION FORM

CLIENT: Louis Berger & Associates, Inc.

JOB NUMBER: High Priority SI

WELL OWNER: Fort Riley & HQ 1st Division

ADDRESS:

CITY, STATE, ZIP CODE: Fort Riley, Kansas

PHONE: (913) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-93-03

WELL INSTALLATION DATE: 9-28-93

GEOLOGIST SUPERVISING INSTALLATION: Mike Miles (SAIC)

GROUND SURFACE ELEVATION (FT): 1172.88'

TOP OF CASING ELEVATION (FT): 1174.82'

WELL STICK-UP (FT): 2.33'

TOTAL BORING DEPTH (FT): 77.0'

BORING DIAMETER (IN): 0' TO 28.5' = 8", 28.5' TO 77' = 5.25"

TOTAL DEPTH OF OUTER CASING (FT): 28.5'

OUTER CASING MATERIAL: Steel

OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): Total Length = 64'; From Surface = 61.7'

INNER CASING MATERIAL: PVC

INNER CASING DIAMETER (IN): 2"

TOTAL LENGTH OF WELL SCREEN (FT): 15' SCREENED INTERVAL (FT): 76.7' -61.7'

WELL SCREEN MATERIAL: PVC

WELL SCREEN DIAMETER (FT): 0.167

SCREEN SLOT SIZE (IN): 0.020"

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-93-03

BACKFILL MATERIAL AROUND SCREEN: Clean Washed Silica Sand

DEPTH RANGE OF BACKFILL (FT): 77' TO 58.7'

SEAL MATERIAL ABOVE SCREEN: 1/4" Bentonite Pellets

DEPTH RANGE OF SEAL (FT): 58.7' TO 51.8'

BACKFILL MATERIAL AROUND CASING: 5% Bentonite Grout

DEPTH RANGE OF BACKFILL (FT): 51.8' TO 0'

DESCRIPTION OF TOP SEAL: 5% Bentonite Grout capped with a concrete pad.

DESCRIPTION OF WELL COVER: steel casing embedded in the concrete with a locking cap.

OTHER ADDITIONAL INFORMATION:

WELL DEVELOPMENT RECORD

CLIENT: Fort Riley - High Priority Sites　JOB NO: High Priority SI

FIELD PERSONNEL: Ed Wieland (SAIC), Brian Meier (Layne Western)　SHEET: 1 OF: 1

1. WELL NUMBER: OB-93-03
2. DATE OF INSTALLATION: 29 September 1993
3. DATE OF DEVELOPMENT: 2 October 1993
4. STATIC WATER LEVEL: BEFORE DEVELOPMENT (FT): 50.34'　24 HOURS AFTER (FT):
5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED (GAL): 60 gal.
6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT (GAL): 9.3 gal.

		START	DURING		END
7.	PHYSICAL APPEARANCE	muddy	cloudy	clear	clear
	SPECIFIC CONDUCTANCE (μmhos/cm)	900	590	590	590
	TEMPERATURE (°C)	15.0	15.9	16.0	16.0
	pH (s.u.)	8.15	6.87	6.95	6.95
	TURBIDITY (NTU)	-	42.0	11.3	11.8

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL (FT): 79.3'
9. SCREEN LENGTH (FT): 15'
10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT (FT): 79.4'　AFTER DEVELOPMENT (FT): 79.4'
11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: 1 7/8" Surge block, 1 1/2" x 3 ' bailer, and 2" Grundfos Pump.
12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge, bail, and pump.
13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE (FT): 1.8
14. QUANTITY OF WATER REMOVED (GAL): 553 gal　TIME OF REMOVAL (HR:MIN): 4:00

HTW DRILLING LOG

HOLE NO. OB-93-04; SB1

SHEET 1 OF 8 SHEETS

1. COMPANY NAME
Louis Berger & Associates, Inc.

2. DRILLING SUBCONTRACTOR
Layne Western -- Witchita, KS

3. PROJECT
High Priority Site Investigation , Fort Riley, KS

4. LOCATION
EOD Range, OB/OD area, Fort Riley, KS

5. NAME OF DRILLER
John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL
Mobile drill B-57, Schram Rotodrill T-660H Dual Tube

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
4.25 x 8" Hollow Stem Auger
CME continuous core sampler
NX Core
5.25 tricone-reverse circulation

8. HOLE LOCATION
South of burn pit

9. SURFACE ELEVATION
1158.32

10. DATE STARTED
27 September 1993

11. DATE COMPLETED
1 October 1993

12. OVERBURDEN THICKNESS
20.5'

13. DEPTH DRILLED INTO ROCK
36.5'

14. TOTAL DEPTH OF HOLE
57.0'

15. DEPTH GROUNDWATER ENCOUNTERED
47.0 - 48.0"

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED. 23.1 after 10 minutes

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			Three

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
		Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
		X		ED WIELAND

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	1 2 3 4 5 Continuous Core Sampler	**0 - 5' CL** Clay, brown to reddish brown, firm to hard, dry.	0.2 ppm	N.A	N.A. OBOD-SB1-001 disturbed		0 - 5' dry. 2.5' of recovery (hard piece caught in barrel).

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. OB-93-04; SB1 SHEET 2 OF 8 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	6 Continuous Core Sampler	**5 - 10' CL** Clay, brown to light reddish brown, firm to hard, dry to damp.	0.9 ppm	N.A	N.A.		5 - 10' dry to damp.
	7 8				OBOD-SB1-002 undisturbed		Sample from 7 - 9' appears undisturbed.
	9						
	10 11 Continuous Core Sampler	**10 - 15' CL** Clay, dark brown to brown, soft to hard, damp.	0.4 ppm	N.A	N.A.		10 - 15' damp.
	12				OBOD-SB1-003 undisturbed		
	13						

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. OB-93-04; SB1 SHEET 3 OF 8 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	14	Continuous Core Sampler **10 - 15'** (cont.) Clay, dark brown to brown, soft to hard, damp.	0.4 ppm	N.A.	N.A.		10 - 15' damp.
	15 16 17 18	Continuous Core Sampler **15 - 19' CL** Clay, light brown, firm, damp.	0.4 ppm	N.A.	N.A.		15 - 19' damp (moist).
	19 20	**19 - 20' CL, GC** Clay, as above, with limestone fragments, white, 0.5-1.5" diameter cherty, light gray.	0.2 ppm	N.A.	N.A.		Limestone is wet, has chemical bonding. End of auger; refusal. 27 September
	21			Core Box 1			30 September Start NX Core.

HTW DRILLING LOG

HOLE NO.
OB-93-04; SB1

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 4
OF 8 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▦	22	**20.5 - 22.7'** Limestone, shaley limestone, locally cherty, also vuggy limestone at 21.8', white to gray where shaley. Chert is light gray.		Core Box 1			Core Run 1: 9/30/93, 15:25 - 16:00 hours. Recovered 2' of 4' in the 20.58 - 24.1' interval.
▤	23 24	**22.7 - 24.1'** Shale, light brown.					Wet shale at 22.7'.
▤	25	**24.1 - 25.3'** Shale, yellowish brown with white calcite vugs and calcite (5%) -- low permeability.					Core Run 2: 9/30/93, 16:00 - approximately 16:45 hours. 24.1 - 29.1': 100 percent recovery.
▤	26 27 28	**25.3 - 28.3'** Shale, black.					
▦	29	**28.3 - 29.1'** Gradational contact limestone, gray fossil forms.		Core Box 1			

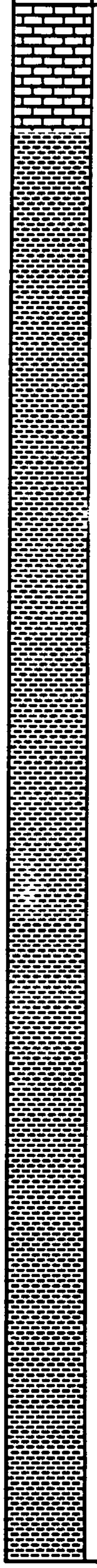
HTW DRILLING LOG

HOLE NO.
OB-93-04; SB1

PROJECT
High Priority Site Investigatio. . Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 5
OF 8 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		29.1 - 29.7' Limestone as above, grading to limy shale.					
	30	**29.7 - 34.1'** Shale, limy, dark gray to olive gray.		Core Box 1			Core Run 3: 9/30/93, from approximately 17:00 - 18:45 hours. Cut 29.1 - 34.1': Recovered 4.1'.
	31						
	32	Massive gypsum up to 1" diameter at 32.3'.					
	33						
	34						
		34.1 - 39.1' Shale, dark gray, limy.		Core Box 1			
	35						
	36						
	37						

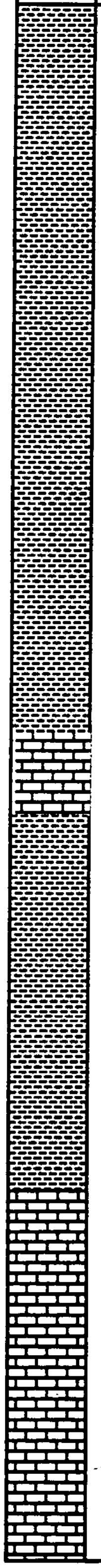
HTW DRILLING LOG

HOLE NO.
OB-93-04; SB1

PROJECT
High Priority Site Investigation, Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 6
OF 8 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	38 39	**34.1 - 39.1' (cont.)** Shale, dark gray, limy.		Core Box 1			Core Run 4: 10/1/93, 9:05 - 9:44 hours. Recovered 4.1'. Used 475 gallons of water from 20.5 - 39.1'. September 30
	40	**39.1 - 40.8'** Shale, dark gray.		Core Box 2			October 1 Core Run 5: 10/1/93, 10:00 - 10:18 hours. 39.1 - 44.1': Recovered 5', 100 percent.
	41	Limestone, very shaley, gray to light gray.					
	42 43	**41.2 - 43.2'** Shale dark gray with gypsum. White to pinkish white, up to 2" across as massive concentrations.					
	44	**43.2 - 44.1'** Limestone, shaley, very fossiliferous, fossil hash - shell fragments and whole					
	45	**44.1 - 44.8'** Limestone, shaley, very fossiliferous, fossil hash.					

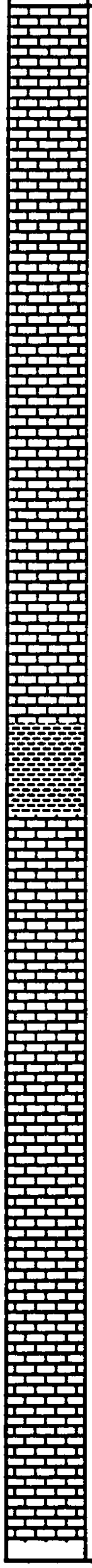
HTW DRILLING LOG

HOLE NO.
OB-93-04; SB1

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

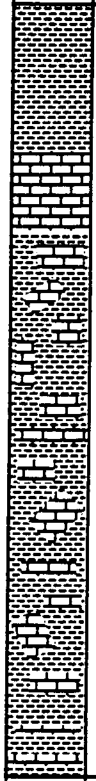
SHEET 7
OF 8 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		44.8 - 46' Limestone soft, yellowish brown with dark bluish gray chert blebs.		Core Box 2			
	46 47 48	**46 - 48.8'**. Limestone, light brown, slightly yellowish, vuggy, fossiliferous. Lost core 47.8 - 48.35' in vuggy section. Vugs are present across the full horizontal cross-section of core.					Driller reported soft zone here with hard section below.
	49	**48.8 - 49.2'** Shale, dark gray, wavy bedding with fossil hash.					Core Run 6: 10/1/93, 10:48 -11:19 hours. 49.1- 54.1': 100 percent recovery.
		49.2 - 49.7' Limestone, yellowish brown, vuggy, up to 0.25" diameter.					
	50	**49.7 - 50.2'** Chert, light gray cuts across fossils.					
		50.2 - 50.9' Limestone, yellowish brown, minor vugs, 0.0625' diameter.					
	51	**50.9' - 51.9'** Limestone, shaley, dark gray to locally black, wavy bedding with fossil hash.					
	52 53	**51.9' - 53'** Limestone, light gray, hard, slightly fossiliferous.		Core Box 2 Core Box 3			

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. OB-93-04: SB1 SHEET 8 OF 8 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	54 55 56 57	**53 - 53.8'** Shale, ivory, fossiliferous, dark gray. **53.8 - 54.2'** Limestone, dark gray fossiliferous. **54.2 - 57'** Limy shale and shaley limestone.		Core Box 3			275 gallons drilling water. End of Core, drilling. Begin dual tube rig drilling. Stopped drilling. Total depth = 57'. 750 gallons of water used for core drilling; 20 gallons of water to ream; 60 gallons to aid in well construction. 830 gallons total added to well.
	58 59 60 61	Bottom of hole.					NOTE ON WATER PRIOR TO CORE DRILLING: On 1 October 1993 at 08:30 water level was 9.6'. Bailed approximately 3 minutes, and drew water level down 1'. After 3 additional minutes water level came up 0.25'. Water source for drilling fluid: Bldg. 3200, Well No. 7 (non-chlorinated), McCormick Rd., Camp Forsyth.

LOUIS BERGER &
ASSOCIATES, INC.

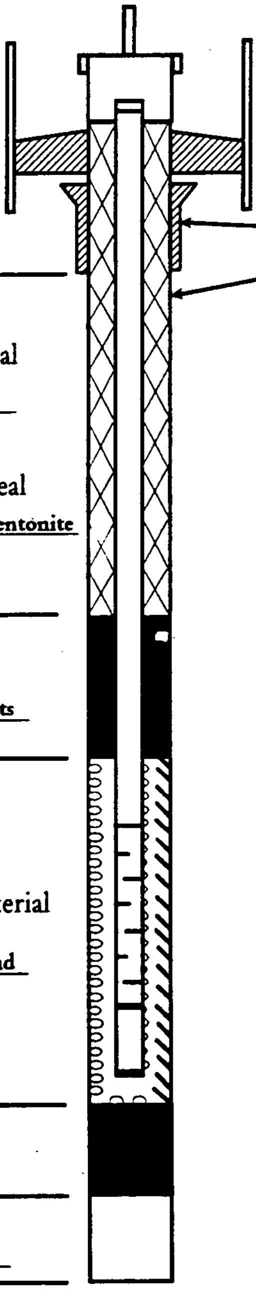
Client: U. S. Army Corps of Engineers
Project No.: High Priority SI
Project: Ft. Riley High Priority SI
Page: Page 1 of 1
Prepared by: Ed Wieland
Date: 3-C .93
Checked by: Peter Li
Date: 18-FEB-94

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Well No.: OB-93-04
Drilling Method: 8.25"x 8" auger with CME continuous sampler to refusal, air rotary dual tube to TD.
Date Installed: 01-OCT-93

Location: OB/OD Area

Elevations:
Ground Surface 1158.32'
Top of PVC 1160.07'



Depth from Ground Surface

Ground Elevation: 0

Outer Casing
20.0'

Surface Seal Material
5% Bentonite Grout

Type of Annular Seal
Cement Grout w/5% Bentonite
31.8'

Type of Seal
1/4" Bentonite Pellets
37.0'

Type of Filter Material
Clean Washed Sand
57'

Type of Seal
None at Base
NA

Type of Backfill
Clean Washed Sand
NA

SURFACE CASING:
Size: 6"
Material: Steel
Depth: 20'

Drill Hole Diameter:
8" (0' - 20')
5.25" (20' - 56.8')

Riser:
Diameter: 2"
Material: PVC
Sch.: 40
Type of Joints: Flush Thread
Total Length: 43.8'
Stick-Up: 2.1'

Screen:
Diameter: 2"
Material: PVC
Slot Size: 0.02
Length: 15'
Screened Interval: 56.7' - 41.7'

Sump:
Length: 4"
Type of Cap: Threaded PVC

Centralizer: Used X
Not Used
Depths: 41.7' & 56.7'

Depth to Water
From Top of Riser
at Completion: 23.1'

Note: Not to Scale

Form: ftrly\mwdiagrm.prs

C48

WELL SPECIFICATION FORM

CLIENT: Louis Berger & Associates, Inc.

JOB NUMBER: High Priority SI

WELL OWNER: Fort Riley & HQ 1st Division

ADDRESS:

CITY, STATE, ZIP CODE: Fort Riley, Kansas

PHONE: (319) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-93-04

WELL INSTALLATION DATE: 1 October 1993

GEOLOGIST SUPERVISING INSTALLATION: Mike Miles (SAIC)

GROUND SURFACE ELEVATION (FT): 1158.32'

TOP OF CASING ELEVATION (FT): 1160.07'

WELL STICK-UP (FT): 2.33'

TOTAL BORING DEPTH (FT): 56.8'

BORING DIAMETER (IN): 0.0' TO 20.0' = 8, 20.0' TO 56.8' = 5.25"

TOTAL DEPTH OF OUTER CASING (FT): 20.0'

OUTER CASING MATERIAL: Steel

OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): Total Length = 43.8'; From Surface = 41.7'

INNER CASING MATERIAL: PVC

INNER CASING DIAMETER (IN): 2"

TOTAL LENGTH OF WELL SCREEN (FT): 15' SCREENED INTERVAL (FT): 56.7' - 41.7'

WELL SCREEN MATERIAL: PVC

WELL SCREEN DIAMETER (FT): 0.167

SCREEN SLOT SIZE (IN): 0.020"

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-93-04

BACKFILL MATERIAL AROUND SCREEN: Clean Washed Silica Sand

DEPTH RANGE OF BACKFILL (FT): 56.8' TO 37'

SEAL MATERIAL ABOVE SCREEN: 1/4" Bentonite Pellets

DEPTH RANGE OF SEAL (FT): 37' TO 31.8'

BACKFILL MATERIAL AROUND CASING: 5% Bentonite Grout

DEPTH RANGE OF BACKFILL (FT): 31.8' TO 0'

DESCRIPTION OF TOP SEAL: Grout to surface with a 3' concrete pad placed around well.

DESCRIPTION OF WELL COVER: 6" steel casing with locking cap, embedded into the grout and concrete pad.

OTHER ADDITIONAL INFORMATION:

WELL DEVELOPMENT RECORD

CLIENT: Fort Riley - High Priority Sites JOB NO: High Priority SI

FIELD PERSONNEL: Steve Keller (SAIC) SHEET: 1 of 1

1. WELL NUMBER: OB-93-04
2. DATE OF INSTALLATION: 1 October 1993
3. DATE OF DEVELOPMENT: 9 October 1993
4. STATIC WATER LEVEL: BEFORE DEVELOPMENT (FT): 32.87' 24 HOURS AFTER (FT):
5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED (GAL): 750 gal.
6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT (GAL): 49 gal.

		START	DURING		END
7.	PHYSICAL APPEARANCE	cloudy	slightly cloudy	clear	clear
	SPECIFIC CONDUCTANCE (μmhos/cm)	455	560	550	550
	TEMPERATURE (°C)	13.0	14.1	15.4	15.6
	pH (s.u.)	6.60	6.76	7.0	6.93
	TURBIDITY (NTU)	-	46.2	6.2	5.4

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL (FT): 59.1'
9. SCREEN LENGTH (FT): 15'
10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT (FT): 58.25' AFTER DEVELOPMENT (FT): 58.8'
11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: 1 7/8" Surge block, 1 1/2" x 3 ' bailer, and 2" Grundfos Pump.
12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge, bail, and pump.
13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE (FT): 1.45
14. QUANTITY OF WATER REMOVED (GAL): 1025 gal TIME OF REMOVAL (HR:MIN): 3:45

HTW DRILLING LOG

HOLE NO.
SB2

SHEET 1
OF 3 SHEETS

1. COMPANY NAME
Louis Berger & Associates, Inc.

2. DRILLING SUBCONTRACTOR
Layne Western -- Witchita, KS

3. PROJECT
High Priority Site Investigation , Fort Riley, KS

4. LOCATION
EOD Range, OB/OD area, Fort Riley, KS

5. NAME OF DRILLER
John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL
Mobile drill B-57

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
4.25 x 8" Hollow Stem Auger
CME continuous core sampler

8. HOLE LOCATION
South of east pit

9. SURFACE ELEVATION
1185'(topo)

10. DATE STARTED
28 September 1993

11. DATE COMPLETED
28 September 1993

12. OVERBURDEN THICKNESS
N.A.

15. DEPTH GROUNDWATER ENCOUNTERED
N.A.

13. DEPTH DRILLED INTO ROCK
N.A.

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED.

14. TOTAL DEPTH OF HOLE
20.0'

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOV
		Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	X		Grouted	ED WIELAND

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨	1 2	Continuous Core Sample **0 - 3' CL** Clay, dark yellowish brown, firm, dry, disturbed soils.					Dry to 14.7'.
▨	3 4 5	**3 - 5' CL** Clay, dark yellowish brown, firm with fragments that are white, angular to subrounded, dry, disturbed.			OBOD-SB2-001 disturbed		

HTW DRILLING LOG

HOLE NO.
SB2

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 2
OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	6 7	Continuous Core Sample **5 - 8.5' CL** Clay, reddish brown, firm to hard, dry.					
	8				OBOD-SB2-002 disturbed		Boundary between disturbed and undisturbed soils based on appearance.
	9	**8.5 - 10' CL** Clay, yellowish red, and very hard, undisturbed, dry.					
	10	Continuous Core Sample **10 - 14.7' CL** Clay, yellowish red, firm to hard, dry.			OBOD-SB2-003 undisturbed		
	11 12 13						

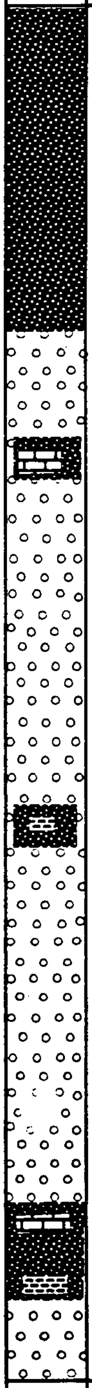
HTW DRILLING LOG

HOLE NO.
SB2

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 3
OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	14	Continuous Core Sampler **10 - 14.7' CL** (cont.) Clay, yellowish red, firm to hard, dry.					
	15 16 17 18 19 20	Continuous Core Sampler **14.7 - 20' SC** Sand, medium-fine, with clay (5-10%), yellowish red, moist, soft. Limestone and shale fragments in clay, angular to subangular up to 2" diameter.					14.7 - 20' moist. Stopped drilling. Total depth = 20'.
	21	Bottom of hole.					

HTW DRILLING LOG

HOLE NO. SB3

1. COMPANY NAME: Louis Berger & Associates, Inc.
2. DRILLING SUBCONTRACTOR: Layne Western – Witchita, KS

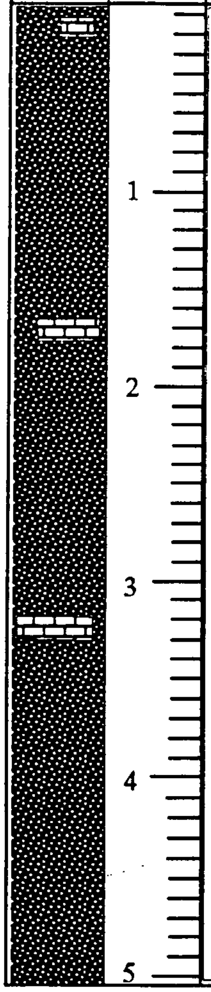
SHEET 1 OF 3 SHEETS

3. PROJECT: High Priority Site Investigation , Fort Riley, KS
4. LOCATION: EOD Range, OB/OD area, Fort Riley, KS
5. NAME OF DRILLER:
6. MANUFACTURER'S DESIGNATION OF DRILL: Mobile drill B-57
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4.25 x 8" Hollow Stem Auger
CME continuous core sampler
8. HOLE LOCATION: South of west pit. Approximately 125' east of SB2.
9. SURFACE ELEVATION: 1185'(topo)
10. DATE STARTED: 29 September 1993
11. DATE COMPLETED: 29 September 1993
12. OVERBURDEN THICKNESS: N.A.
13. DEPTH DRILLED INTO ROCK: N.A.
14. TOTAL DEPTH OF HOLE: 20.0'
15. DEPTH GROUNDWATER ENCOUNTERED: N.A.
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
		Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	X		Grouted	ED WIELAND



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	0	Continuous Core Sample **0 - 4' CL** Clay, dark yellowish brown, firm, dry to slightly moist. Also scattered limestone fragments up to 0.5" diameter in the clay. Disturbed.	3.5 ppm		OBOD-SB3-001 disturbed		0 - 20' dry.
	4	**4 - 7.7' CL** Clay, reddish brown, firm, with some gray shale streaks, dry.	0.6 ppm		OBOD-SB3-003 undisturbed (4.5 - 6.0')		Disturbed soils. Undisturbed soils.

PROJECT: Fort Riley High Priority Site Investigations

HOLE NO. SB3

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HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. SB3	SHEET 2 OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	6 7 Continuous Core Sample	**4 - 7.7' CL** (cont.) Clay, reddish brown, firm, with some gray shale streaks, dry.	0.6 ppm		OBOD-SB3-003 undisturbed (4.5 - 6.0')		
	8	**7.7 - 8.0' CL** Clay, silty, reddish brown, undisturbed, dry.					
	9	**8.0 - 9.2' CL** Clay, reddish brown, firm, dry.					
	10	**9.2 - 10' CL** Clay, reddish brown, firm, with small limestone granules.					
	11 12 13 Continuous Core Sample	**10 - 15' CL** Clay, reddish brown, firm with small pieces of dark brown shale up to 0.5" diameter, dry.	0.4 ppm		OBOD-SB3-003 undisturbed (12 - 13.5')		

HTW DRILLING LOG

HOLE NO.
SB3

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Ed Wieland

SHEET 3
OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS		FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨	14	Continuous Core Sample	**10 - 15' CL** (cont.) Clay, reddish brown, firm with small pieces of dark brown shale up to 0.5" diameter, dry, locally fissile.	0.4 ppm		OBOD-SB3-003 undisturbed (12 - 13.5')		
▨	15 16 17 18 19	Continuous Core Sample	**15 - 20' CL** Clay, reddish brown, firm with small pieces of dark brown shale up to 0.5" diameter. Locally contains limestone fragments, angular to subangular. 1-2" diameters. Dry.					Stopped drilling. Total depth = 20'.
	20 21		Bottom of hole.					

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PROJECT
Fort Riley High Priority Site Investigations

HOLE NO.
SB3

HTW DRILLING LOG

1. COMPANY NAME Louis Berger & Associates, Inc.	2. DRILLING SUBCONTRACTOR Layne Western – Witchita, KS	HOLE NO. SB4 SHEET 1 OF 3 SHEETS

3. PROJECT High Priority Site Investigation . Fort Riley, KS	4. LOCATION EOD Range, OB/OD area, Fort Riley, KS
5. NAME OF DRILLER John Gornick	6. MANUFACTURER'S DESIGNATION OF DRILL Mobile drill B-57
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 4.25 x 8" Hollow Stem Auger CME continuous core sampler	8. HOLE LOCATION North of East pit. 9. SURFACE ELEVATION 1193'(topo) 10. DATE STARTED 29 September 1993 11. DATE COMPLETED 29 September 1993
12. OVERBURDEN THICKNESS N.A.	15. DEPTH GROUNDWATER ENCOUNTERED N.A.
13. DEPTH DRILLED INTO ROCK N.A.	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED.
14. TOTAL DEPTH OF HOLE 20.0'	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES N.A.	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
		Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	X		Grouted	ED WIELAND

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▒		Continuous C[illegible] Sample **0 - 1' CL/OH** Clay. Dark. brown organic matter, firm, dry, disturbed.					0 - 15' Dry.
▒	1	**1 - 4' CL** Clay. Reddish brown with white fragments, dry, disturbed.					
▒	2				OBOD-SB4-001 (2'-5')		
▒	3						
▒	4	**4 - 6' CL** Clay. Reddish brown with white fragments, dry, disturbed.					
▒	5						

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HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. SB4 SHEET 2 OF 3 SHEETS

LITH.	DEPTH		DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		Continuous Core Sample	**4 - 6' CL** (Cont.) Clay.			OBOD-SB4-002 disturbed (5'-6')		Disturbed soils.
	6 7		**6 - 8' CL** Clay. Reddish brown with angular white fragments, dry. At 6', 30% less fragments. Appears undisturbed below 6'.					Undisturbed soils.
	8 9		**8 - 10' CL** Clay. As above with less fragments, firm, dry.					
	10 11	Continuous Core Sample	**10 - 15' CL** Clay. Reddish brown, firm limestone fragments throughout, dry.					Recovered 4' from 10 - 15'.
	12 13					OBOD-SB4-003 undisturbed (12'-13.5')		

PROJECT Fort Riley High Priority Site Investigations – OB/OD Area	HOLE NO. SB4

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Ed Wieland	HOLE NO. SB4 SHEET 3 OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▨	14 Continuous Core Sample	**10 - 15' CL** (Cont.) Clay.					
▨	15 16 17 18 19 Continuous Core Sample	**15 - 20' CL** Clay. Light yellowish brown, soft to firm, slightly moist.					15 - 20' Moist. 20' Stopped drilling.
	20 21	Bottom of hole.					

HTW DRILLING LOG

HOLE NO. SB5

1. COMPANY NAME: Louis Berger & Associates, Inc.

2. DRILLING SUBCONTRACTOR: Layne Western -- Witchita, KS

SHEET 1 OF 3 SHEETS

3. PROJECT: High Priority Site Investigation , Fort Riley, KS

4. LOCATION: EOD Range, OB/OD area, Fort Riley, KS

5. NAME OF DRILLER: John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL: Mobile drill B-57

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4.25 x 8" Hollow Stem Auger; CME continuous core sampler

8. HOLE LOCATION: North of West pit.

9. SURFACE ELEVATION: 1194'(topo)

10. DATE STARTED: 29 September 1993

11. DATE COMPLETED: 29 September 1993

12. OVERBURDEN THICKNESS: N.A.

15. DEPTH GROUNDWATER ENCOUNTERED: N.A.

13. DEPTH DRILLED INTO ROCK: N.A.

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED.

14. TOTAL DEPTH OF HOLE: 18.0'

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES: N.A.

DISTURBED	UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS

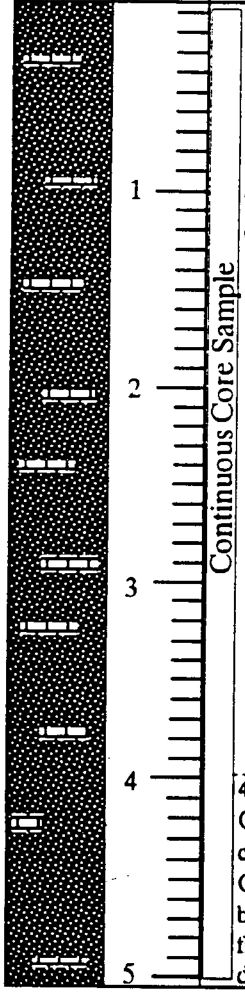
VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)
	Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC		

21. TOTAL CORE RECOVERY

22. DISPOSITION OF HOLE

BACKFILLED	MONITORING WELL	OTHER (SPECIFY)
X		Grouted

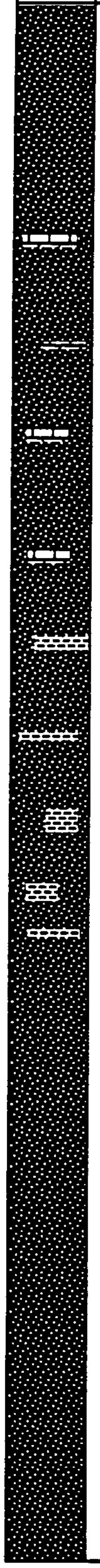
23. SIGNATURE OF INSPECTOR



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	0 - 4'	**0 - 4' CL** Clay. Dark brown, silty, with limestone fragments. Well consolidated. Some organics.	0.1 ppm (0 - 4')		OBOD-SB5-001 disturbed (3'-4')		Recovery 20".
	4 - 8'	**4 - 8'** Clay. Dark gray, silty, with calcareous nodules. Grading to clay, light brown, silty, with limestone fragments below, dry, disturbed.	0.1 ppm (4 - 8')				Recovery 4'.

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Mike Miles	HOLE NO. SB5 SHEET 2 OF 3 SHEETS



LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		Continuous Core Sample **4 - 8' Clay. (Cont.)**	0.2 ppm		OBOD-SB5-002 (5'-6')		
	6						Disturbed soils. Undisturbed soils.
	7						
	8	**8 - 10' CL** Clay. Light brown, silty with calcareous shale and limestone fragments. Consolidated and undisturbed, dry.	0.2 ppm				Recovery 2'.
	9				OBOD-SB5-003 (9'-10')		
	10	Continuous Core Sample **10 - 14' CL** Clay. Light brown, silty no fragments Well consolidated, dry.	0.1 ppm				
	11						
	12						
	13						

HTW DRILLING LOG

PROJECT High Priority Site Investigation . Fort Riley, KS	INSPECTOR Mike Miles	HOLE NO. SB5 SHEET 3 OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▓		Continuous Core Sample **10 - 14'** Clay. (Cont.)					
░	14	**14 -15' ML** Silt, light gray, clayey with some very fine sand.					
░	15	Continuous Core Sample **15 - 16' ML** Silt, reddish brown, clayey with some very fine sand and some limestone fragments.					
▓	16	**16 - 18' CL** Clay, silty, olive green. No fragments. Well consolidated.					
▓	17	Bottom of hole					18' Stopped drilling.
	18						
	19						
	20						
	21						

HTW DRILLING LOG

HOLE NO. SB6

1. COMPANY NAME: Louis Berger & Associates, Inc.
2. DRILLING SUBCONTRACTOR: Layne Western – Witchita, KS

SHEET 1 OF 3 SHEETS

3. PROJECT: High Priority Site Investigation , Fort Riley, KS
4. LOCATION: EOD Range, OB/OD area, Fort Riley,KS
5. NAME OF DRILLER: John Gornick
6. MANUFACTURER'S DESIGNATION OF DRILL: Mobile drill B-57
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4.25 x 8" Hollow Stem Auger; CME continuous core sampler
8. HOLE LOCATION: Northeast of pit.
9. SURFACE ELEVATION: 1185'(topo)
10. DATE STARTED: 1 October 1993
11. DATE COMPLETED: 1 October 1993
12. OVERBURDEN THICKNESS: N.A.
13. DEPTH DRILLED INTO ROCK: N.A.
14. TOTAL DEPTH OF HOLE: 18.0'
15. DEPTH GROUNDWATER ENCOUNTERED: N.A.
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
		Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	X		Grouted	

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	0	**0 - 2.4'** No Recovery.	0.1 ppm				0 - 18' Dry.
	1						
	2	Continuous Core Sample					
		2.4 - 3.4' CL Clay. (disturbed zone) Dry, moderately consolidated, abundant gravel fragments.					
	3						
		3.4 - 8.4' CL Clay. (disturbed zone) Gravel fragments less than or equal to 1", clay moist, dark brown.					
	4						
	5		–		OBOD-SB6-001 (disturbed)		

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keller	HOLE NO. SB6 SHEET 2 OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	6 7 8 Continuous Core Sample	**3.4 - 8.4' CL** (Cont.) Clay. (disturbed zone) Gravel fragments less than or equal to 1", clay moist, dark brown.	0.2 ppm		Cont. OBOD-SB6-001 disturbed (4.5'-8')		Disturbed soils. Undisturbed soils. Dry.
	9 10	**8.4 - 9.5'** Weathered shale. (undisturbed) Poorly indurated, semi-plastic, partings contain white powdery carbonate mineral. Dry and overall color medium yellow-green.	0.1 ppm (9.5'-13.5')				**9.5 - 10.7'** No Recovery.
	11 12 13 Continuous Core Sample	**10.7 - 13.5' ML** Siltstone. Medium yellow-green, well sorted, dry, poorly indurated. Grades downward to unlaminated clay with some blocky fracturing, minor orange oxidation mottles, dry.			OBOD SB6-002 (11.5'-12.5')		Dry.

HTW DRILLING LOG

HOLE NO.
SB6

PROJECT
High Priority Site Investigation , Fort Riley, KS

INSPECTOR
Steve Keller

SHEET 3
OF 3 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	14 15 16 17 18 Continuous Core Sample Continuous Core Sample	**10.7 -13.5'** (Cont.) Silt **13.5 - 15.5'** Siltstone. Highly indurated medium gray-green, well sorted siltstone, calcareous, one possible shell fragment. Trace coarse-grained calcite crystals. Dry, "pops" in fingers, calcareous. **15.5 - 18'** No Recovery.	0.1 ppm (13.5'-18')				18' Stopped drilling.
	19 20 21	Bottom of hole.					

HTW DRILLING LOG

HOLE NO. SB7

1. COMPANY NAME Louis Berger & Associates, Inc.

2. DRILLING SUBCONTRACTOR Layne Western – Witchita, KS

SHEET 1 OF 2 SHEETS

3. PROJECT High Priority Site Investigation , Fort Riley, KS

4. LOCATION EOD Range, OB/OD area, Fort Riley, KS

5. NAME OF DRILLER John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL Mobile drill B-57

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
4.25 x 8" Hollow Stem Auger
CME continuous core sampler

8. HOLE LOCATION North of pit.

9. SURFACE ELEVATION 1190'(topo)

10. DATE STARTED 2 October 1993

11. DATE COMPLETED 2 October 1993

12. OVERBURDEN THICKNESS N.A.

15. DEPTH GROUNDWATER ENCOUNTERED N.A.

13. DEPTH DRILLED INTO ROCK N.A.

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED.

14. TOTAL DEPTH OF HOLE 9.5'

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
		Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	X		Grouted	

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
		Continuous Core Sampler **0 - 0.5' OH** Soil black, moist, organic clayey soil	0.2 ppm (0'-4.5')				Moist.
	1 2	**0.5 - 3' CL** Clay. Medium brown, plastic, moist, disturbed zone material, minor angular granules and pebbles.			OBOD SB7-001 (1'-3')		
	3 4	**3 - 4.5' CL** Clay. Highly disturbed, moist, plastic, with abundant angular granules and pebbles.					
	5	**4.5 - 4.7' CL** Clay. (Same as 0.5'-3'). **4.7 - 6.1'** Clay. (Continued on next pg.)	0.2 ppm (4.5'-9.5')		OBOD- SB7-002 (4.5'-5.5')		Disturbed soils.

PROJECT Fort Riley High Priority Site Investigations – OB/OD Area

HOLE NO. SB7

HTW DRILLING LOG

PROJECT High Priority Site Investigation , Fort Riley, KS	INSPECTOR Steve Keller	HOLE NO. SB7 SHEET 2 OF 2 SHEETS

LITH.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
▩		**4.7 - 6.1' CL** (Cont.) Clay. Intercalcated light brown and olive-yellow, fissile, minor silt content. Blocky, nearly dry.			(cont.) SB7-002		5' Undisturbed Soils, nearly dry.
░	6	**6.1 - 9.5' CL** Clayey Silt. Light yellow-green, highly fissile, ochre oxidation patches, dry, highly laminated, weakly indurated, with trace black fracture coatings. Continuous Core Sample					6' Intercalcated because horizontal color layering is not necessarily stratigraphic bedding.
	7						
	8				OBOD SB7-003 (8.5'-9.5')		
	9						9.5' Stopped Drilling.
		Bottom of hole.					
	10						
	11						
	12						
	13						

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PROJECT
Fort Riley High Priority Site Investigations – OB/OD Area

HOLE NO.
SB7

HTW DRILLING LOG

HOLE NO. SB8

1. COMPANY NAME Louis Berger & Associates, Inc.

2. DRILLING SUBCONTRACTOR Layne Western – Witchita, KS

SHEET 1 OF 1 SHEETS

3. PROJECT High Priority Site Investigation , Fort Riley, KS

4. LOCATION EOD Range, OB/OD area, Fort Riley,KS

5. NAME OF DRILLER John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL Mobile drill B-57

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
- 4.25 x 8" Hollow Stem Auger
- CME continuous core sampler

8. HOLE LOCATION Southeast of pit.

9. SURFACE ELEVATION 1180'(topo)

10. DATE STARTED 2 October 1993

11. DATE COMPLETED 2 October 1993

12. OVERBURDEN THICKNESS 4.5'

13. DEPTH DRILLED INTO ROCK 0.5'

14. TOTAL DEPTH OF HOLE 5'

15. DEPTH GROUNDWATER ENCOUNTERED N.A.

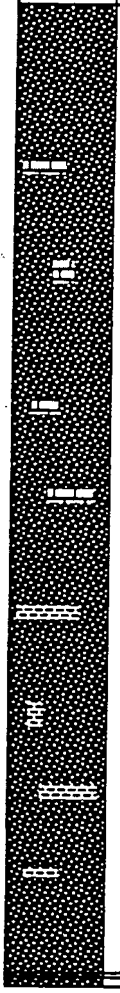
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMMENCED.

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
N.A.			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
		Priority Pollutant Metals	EPA 6020 ICP/MC EPA 8330 HPLC			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	X		Grouted	

LITH.	DEPTH	DESRIPTION OF MATERIALS	FIELD SCREEN RESULTS	CORE BOX NO.	SAMPLE NO.	BLOW COUNTS	REMARKS
	1 2 3 4 5 Continuous core sampler	**0 - 2.8' OH** Disturbed zone material. Clay. Medium to dark brown, moist, plastic, with minor angular limestone fragments. Sharp lower contact.	0.2 ppm (0'-4.5')		OBOD SB8-001 (2'-3')		2' Disturbed soils. Moist.
		2.8 - 4.5' CL Clay. (Undisturbed) Light gray-green, moist, plastic, undisturbed, with minor silt content. Possibly weathered shale. Thincoarse-grained sand lens at approximately 4', approximately 0.5' thick. Abundant carbonaceous material 4'-4.5'. Residuum.			OBOD SB8-002 (3'-4')		3' Undisturbed. Moist.
		Bottom of hole.	0.2 ppm (4.5'-9.5')				5' Stopped Drilling.

PROJECT Fort Riley High Priority Site Investigations – OB/OD Area

HOLE NO. SB7

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Mobilization #1 - March/April 1997

(Wells OB97-05 through OB93-08)

HTW DRILLING LOG

HOLE NO. OB-97-05

SHEET 1 OF 4 SHEETS

1. COMPANY NAME: Louis Berger & Associates
2. DRILLING SUBCONTRACTOR: Layne Western

PROJECT: OB/OD Area

4. LOCATION: FT. Riley, KS

5. NAME OF DRILLER: John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL: ATV Hollow Stem Auger Rig/Dual Tube Air Rotary

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:
Dual Tube Air Rotary Rig
ATV Hollow Stem Auger Rig
10" bit for reaming

8. HOLE LOCATION: ≈ 300' NW of the North Burn Pit

9. SURFACE ELEVATION: 1178.39'

10. DATE STARTED: 3-20-97
11. DATE COMPLETED: 3-30-97

12. OVERBURDEN THICKNESS: 8' (Weathered)

15. DEPTH GROUNDWATER ENCOUNTERED: 20.5' (wet in Fractures)

13. DEPTH DRILLED INTO ROCK: 65'

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 54.5' (16 hours)

14. TOTAL DEPTH OF HOLE: 73'

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
Yes			4

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
Yes	X					>98 %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Yes		X		Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		10YR 3/4, Dark yellowish brown Massive, medium plasticity, medium dilatancy, trace fine to coarse gravel-chert					0-5' recovery 58" roots, moist
	1						
	2						
	3						
	4						
	5						

MRK FORM JUN 89 55

PROJECT OB/OD Area

HOLE NO. OB-97-05

HTW DRILLING LOG

HOLE NO. OB-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 2 OF 9 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		2.5Y6.4 Light yellowish brown, medium plasticity medium dilatancy, medium strength, CL					5-10' 22" recovery
	6						
	7						
	8	LS: 2.5Y 6/4 Light Yellowish brown, fine crystalline, weathered, some chert 8'-9', fossiliferous					8' Hard Drilling
	9						
	10	LS: 2.5Y 6/4 Light Yellowish brown, fine crystalline, some weathered shale					10-15' recovery 17"
	11						
	12						
	13						
	14						

HTW DRILLING LOG

HOLE NO. OB-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 9 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	15	LS: 2.5Y 6/4 Light yellowish brown, fine crystalline, weathered					15-17' 20" recovery dry
	16	Shale 10YR 5/1 Gray, Crumbly, weathered, fine texture					
	17						17'-20' recovery 24" moist
	18	Shale 5BG 4/1 Dark greenish gray, fine texture, blocky to sub-platy					
	19						
	20	Shale 5BG 4/1 Dark greenish gray, fine texture, sub-platy					20-22' recovery 22" 20.5' wet in fracture
	21						
	22	Shale 5BG 4/1 Dark greenish gray, A/A					22'-24' recovery 22" 22.5' wet in fracture
	23						

HTW DRILLING LOG

HOLE NO. OB-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 4 OF 9 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	24	Shale 5BG 4/1 Dark greenish gray, fine texture, weathered					24-26' recovery 24"
	25						
	26						26-30' recovery 32"
	27						
	28	Shale 5B 4/1 Dark greenish gray, fine texture, weathered					28' moist
	29						
	30						
	31	LS. 5Y 7/2 Light Gray, fine crystalline, weathered					wet
	32						

HTW DRILLING LOG

HOLE NO. OB-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 5 OF 9 SHEETS

V.	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		LS: Pale yellowish orange 10YR 8/6, pitted, vuggy, microcrystalline, hard, dense					auger refusal 32.5'-36.5 recovery 46"
	33						
							dry
	34	LS: 10YR6/2 Pale yellowish brown, pitted, vuggy, weathered, hard, dense, Microcrystalline, chert and gypsum throughout					moist
	35						
	36						saturated 36.5-41.5 recovery 36"
		LS: 5PB 3/2 Dusky blue pitted, vuggy, hard dense, microcrystalline, very cherty					
	37						
		Gypsum 2" lense					
	38	LS: 10YR 6/2 Pale yellow brown, pitted, vuggy, microcrystalline, hard, dense, with chert and gypsum					
	39						
	40						
	41						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-05

HTW DRILLING LOG

HOLE NO. 0B-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 6 OF 9 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		Shale: 5Y5/2 olive green massive, fine texture, gypsum					Havensville 41'2"
	42	10Y 6/2 Pale olive, Limestone, microcrystalline, hard, dense, argilleaous, shalely					42-44' recovery 21"
	43	shale: 5B 5/1 Medium bluish gray, fine texture, massive, blocky ½" Gypsum lense					moist
	44	LS: N5 medium gray, fine crystalline, hard, dense, argillaceous, shaley, fossiliferous					44-46'3" recovery 23" dry, ~~set~~ om
	45						
	46	LS: 5B 7/1 Light bluish gray, microcrystalline, hard, dense, argillaceous, Shalely, massive fossiliferous					46'3"-49.5' recovery 34" dry
	47						
	48						
	49	LS: A/A					49.5-50.5 recovery 12"
	50						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-05

HTW DRILLING LOG

HOLE NO. OB-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 7 OF 9 SHEETS

V.	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	51	LS: 5G 4/1 Dark greenish gray, microcrystalline, hard, dense, argillaceous, Shalely					51.5-56.5 56" recovery dry
	52						
		Shale: 5PB 3/2 Dusky blue, fine texture, blocky, firm					
	53						
	54						
	55						
	56						
		Shale: A/A					56.5-61.5' recovery 53" dry
	57						
	58						
	59						

HTW DRILLING LOG

HOLE NO. OB-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 8 OF 9 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		LS: 5G 4/1 Dark greenish gray microcrystalline, hard, dense argillaceous, shalely Shale: 5PB 3/2 Dusky blue, fine texture, blocky, firm					59'3"-59'6"
	60						
	61						61.5-66.5' recovery 60"
	62	LS: 5G 8/1 Light greenish gray, fine crystalline, hard, dense, argillaceous, very fossiliferous crinoids					~~Saturated~~ dry
	63	5B 7/1 Light bluish gray, 9" Chert					
	64	LS: 10YR 6/2, Pale yellowish brown, fine to microcrysalline vuggy, pitted, chalky					Saturated
	65						
	66	LS: 10YR 6/2, Pale yellowish brown, fine to microcrystalline, pitted, vuggy, fossiliferous, chalky					66.5-68.75 recovery 26"
	67	Chert: 5B7/1 light bluish gray 3"					
	68						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB/97-05

HTW DRILLING LOG

HOLE NO. OB-97-05

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 9 OF 9 SHEETS

EV.	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
							68' drill bit drop 4"
		LS:10YR6/2 Pale Yellowish brown, fine to microcrystalline vuggy, pitted, chalky, fossiliferous					
	69	Chert:5B 7/1 Light bluish gray 3" lense @ 68'9"					68'9"-73.0' recovery 54"
	70	LS: 5GY4/1, Dark greenish gray, fine crystalline, hard, dense, argillaceous, very fossiliferous					
	71						
	72	Shale: 5GY2/1 Greenish black, fine texture, blocky massive, very limy, fossiliferous					TD 73.0'
	73						
	74						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-05

LOUIS BERGER & ASSOCIATES, INC.
100 Halsted Street
East Orange, N.J.

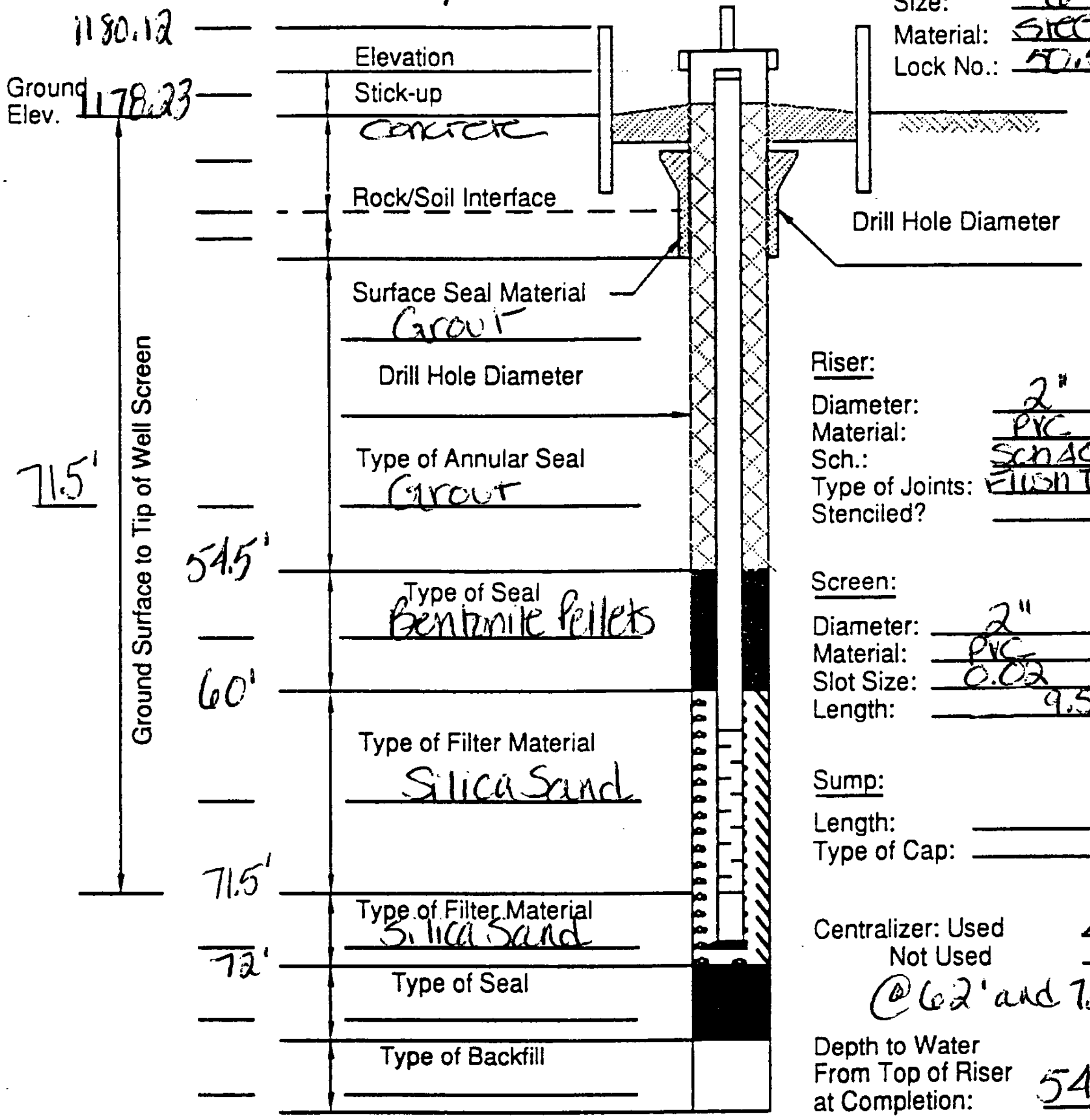
Client: US Army Corps of Engineers Project No.: JH1124D
Project: OB/OD Page: 1 of 1
Prepared by: Samantha Bennett Date: 2/24/98
Checked by: Date:

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Drilling Method: ATV Hollow Stem Auger Rig / Dual Tube Air Rotary
Well No.: 06-97-05
Date Installed: 3-30-97

Coordinates: 1163070.96 E / 297146.99 N

PROTECTOR CASING
Size: 6"
Material: Steel
Lock No.: 50.5'



Concrete
Surface Seal Material: Grout
Drill Hole Diameter:
Type of Annular Seal: Grout
Type of Seal: Bentonite Pellets
Type of Filter Material: Silica Sand
Type of Filter Material: Silica Sand
Type of Seal:
Type of Backfill:

Riser:
Diameter: 2"
Material: PVC
Sch.: Sch 40
Type of Joints: Flush Threaded
Stenciled?

Screen:
Diameter: 2"
Material: PVC
Slot Size: 0.02
Length: 9.5'

Sump:
Length:
Type of Cap:

Centralizer: Used X
Not Used
@ 62' and 72'

Depth to Water From Top of Riser at Completion: 54.50'

FORM: *LBAMONW.DRW/Feb.1992*

NOTE: Not to Scale

WELL SPECIFICATION FORM

CLIENT: US ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH112AD

WELL OWNER: FORT RILEY - DES

ADDRESS: BUILDING A07 MAIN POST

CITY, STATE, ZIP CODE: Fort Riley, Kansas 66442-6016

PHONE: (785)239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-97-05

WELL INSTALLATION DATE: 3-30-97

GEOLOGIST SUPERVISING INSTALLATION: Darryl Morgan

GROUND SURFACE ELEVATION (FT): 1178.23

TOP OF CASING ELEVATION (FT): 1180.12

WELL STICK-UP (FT): 1.89'

TOTAL BORING DEPTH (FT): 72'

BORING DIAMETER (IN): 8.25"

TOTAL DEPTH OF OUTER CASING (FT): 50.5'

OUTER CASING MATERIAL: Steel

OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): 62' = From Surface 64' = Total

INNER CASING MATERIAL: PVC

INNER CASING DIAMETER (IN): 2"

TOTAL LENGTH OF WELL SCREEN (FT): 9.5'

WELL SCREEN MATERIAL: PVC

WELL SCREEN DIAMETER (FT): 2"

SCREEN SLOT SIZE (IN): 0.02

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-97-05

BACKFILL MATERIAL AROUND SCREEN: Silica Sand

DEPTH RANGE OF BACKFILL (FT): 60' TO 72'

SEAL MATERIAL ABOVE SCREEN: Bentonite Pellets

DEPTH RANGE OF SEAL (FT): 54.5' TO 60'

BACKFILL MATERIAL AROUND CASING: Grout

DEPTH RANGE OF BACKFILL (FT):

DESCRIPTION OF TOP SEAL: Grout Capped With Concrete.

DESCRIPTION OF WELL COVER: 6" Diameter Steel.

OTHER ADDITIONAL INFORMATION:

WELL DEVELOPMENT RECORD

CLIENT: Army Corp of Engineers-Kansas City JOB NO: JG-1270

FIELD PERSONNEL: Darryl Morgan SHEET: 1 OF: 1

1. WELL NO.: 0B-97-05
2. DATE OF INSTALLATION: 3-29-97
3. DATE OF DEVELOPMENT: 6-10-97
4. STATIC WATER LEVEL: BEFORE DEVELOPMENT 56.35 FT. 24 HOURS AFTER ~~18.30~~ 56.34 FT.
5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED 0.0 GAL.
6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT 18.30 GAL.

	START	DURING		END
7. PHYSICAL APPEARANCE	Gray	lt gray	clear	clear
SPECIFIC CONDUCTANCE (umhos/cm)	1248	1194	1151	1184
TEMPERATURE (°C)	76.8°F (24.9)	75.9°F (24.4)	75.3°F (24.0)	73.0°F (22.8)
pH (s.u.)	7.41	7.00	7.54	7.02

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL 73.0 FT.
9. SCREEN LENGTH 10 FT.
10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT 72.94 FT. AFTER DEVELOPMENT 72.98 FT.
11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: stainless steel bailer
12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge with stainless steel bailer
13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE: 1.89 FT.
14. QUANTITY OF WATER REMOVED 55.0 GAL. TIME OF REMOVAL 4 hrs 50 min HR./MIN.
15. TURBIDITY IN NEPHELOMETRIC UNITS 22.6 NTUs

HTW DRILLING LOG

HOLE NO. OB-97-06

1. COMPANY NAME: Louis Berger & Associates

2. DRILLING SUBCONTRACTOR: Layne Western

SHEET 1 OF 6 SHEETS

3. PROJECT: OB/OD Area

4. LOCATION: Ft. Riley KS

5. NAME OF DRILLER: John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL: ATV Hollow Stem Auger Rig / Dual Tube Air Rotary

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:
Dual Tube Air Rotary Rig
ATV Hollow Stem Auger Rig
10" bit for reaming

8. HOLE LOCATION: 10' N of OB-93-03

9. SURFACE ELEVATION: 1173.44

10. DATE STARTED: 3-19-97

11. DATE COMPLETED: 3-23-97

12. OVERBURDEN THICKNESS: 14.5'

13. DEPTH DRILLED INTO ROCK: 27.5'

14. TOTAL DEPTH OF HOLE: 42' (Grouted to 36.5' and set well)

15. DEPTH GROUNDWATER ENCOUNTERED: 24'

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 15.20' (1 hour)

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
Yes			2

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
Yes	X					>98 %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Yes		X		Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		10YR 4/3 Brown, med plasticity, med strength, med dilatancy, mostly clay, trace silt, CL					0-5' 52" recovery 100% fines Some Fe stain
	1						
	2						
	3						
	4						
	5						

MRK FORM JUN 89 55 | PROJECT OB/OD Area | HOLE NO. OB-97-06

HTW DRILLING LOG

HOLE NO.	OB-97-06
PROJECT	OB/OD Area
INSPECTOR	Darryl Morgan
SHEET	2 OF 5 SHEETS

EV.	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		10YR 4/3 - Brown, low plasticity, med dilatancy, low strength, Some silt, some clay, ML					5-10' 27" recovery 100% fines Some Fe stain mottle, dry
	6						
	7						
	8						
	9						
	10	10YR 4/3 - Brown, med plasticity, med dilatancy, med strength, mostly clay, little silt, CL					10-15' 33" recovery 100% fines moist
	11						
	12						
	13						
	14						

HTW DRILLING LOG

HOLE NO. OB-97-06

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 5 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		5Y/4 olive, weathered shale Calcareous, friable					100% fines
	15	5Y/4 olive, weathered shale Calcareous, friable					15-20' 32" recovery 100% fines
	16						
	17						
	18						
	19						
		10R 3/3 - Dusky Red, weathered shale, calcareous, ~~mas~~ friable					
	20	10YR5/1 - Gray, weathered Shale, friable					20-25' 29" recovery 100% fines
	21						
	22						Hard drilling @ 22'
	23						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-06

HTW DRILLING LOG

HOLE NO. OB-97-06

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 4 OF 6 SHEETS

ELEV.	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	24	10R 3/3; Dusky Red, weathered Shale, crumbly					very moist to wet
	25	Shale 5GY 4/1; Dark greenish gray, weathered,					25-27.5' 32" recovery
	26						
	27						
		LS. 10GY 7/2; Pale Yellowish Green, microcrystalline, hard, dense, argillaceous					core 27.5-30'
	28						
	29	LS. 5Y 8/1, Yellowish gray microcrystalline, soft-crumbly, Vuggy, pitted, weathered					29.0'-29.5' Lost core Sample in Vuggy zone Saturated
		Shale: 5G 3/2 Dusky green, very fine texture, platy, firm, calcareous					
	30	LS: 10GY 5/2 Grayish green, microcrystalline, hard, dense, argillaceous					
	31						
		LS: A/A with quartz inclusion					
	32	LS: A/A, slightly fossilferous					

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-06

HTW DRILLING LOG

HOLE NO. OB-97-06

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 5 OF 6 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	33						
	34	5G 3/2 Dusky green, platy, weathered Shale, 2"					
		LS: 5Y 8/1 yellowish graygreen, microcrystalline, hard, dense, vuggy, pitted					
	35						35.5'-38.0' recovery 31"
	36	LS: 5Y 8/1 yellowish gray green hard, dense, microcrystalline, argillaceous, 2" chert layer					
		Shale: 10GY 5/2 Greenish gray, platy, fine texture, with gypsum inclusions					36.5' to 38.0 limy and calcaeous Havensville Shale @ 36.5'
	37						
	38	Shale: 5G 3/2 Dusky green, platy, fine texture					38.0'-41.8" recovery 44"
							38'10" to 39' Gypsum layer
	39	Shale: 5G 3/2 Dusky green, platy, fine texture					
		LS: 5Y 8/1 yellavish gray, hard, dense, microcrystalline, argillaceous, shaley, with gypsum inclusions					
	40						
	41						

HTW DRILLING LOG

HOLE NO. OB-97-06

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 6 OF 6 SHEETS

EV.	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		LS: 5Y 8/1 yellowish gray, hard, dense, microcrystalline, argillaceous, shalely, with gypsum inclusions.					TD@ 41'8" Grout hole up to 36.5'
	42						

PROJECT

HOLE NO.

MRK FORM JUN 89 55-2

LOUIS BERGER & ASSOCIATES, INC.
100 Halsted Street
East Orange, N.J.

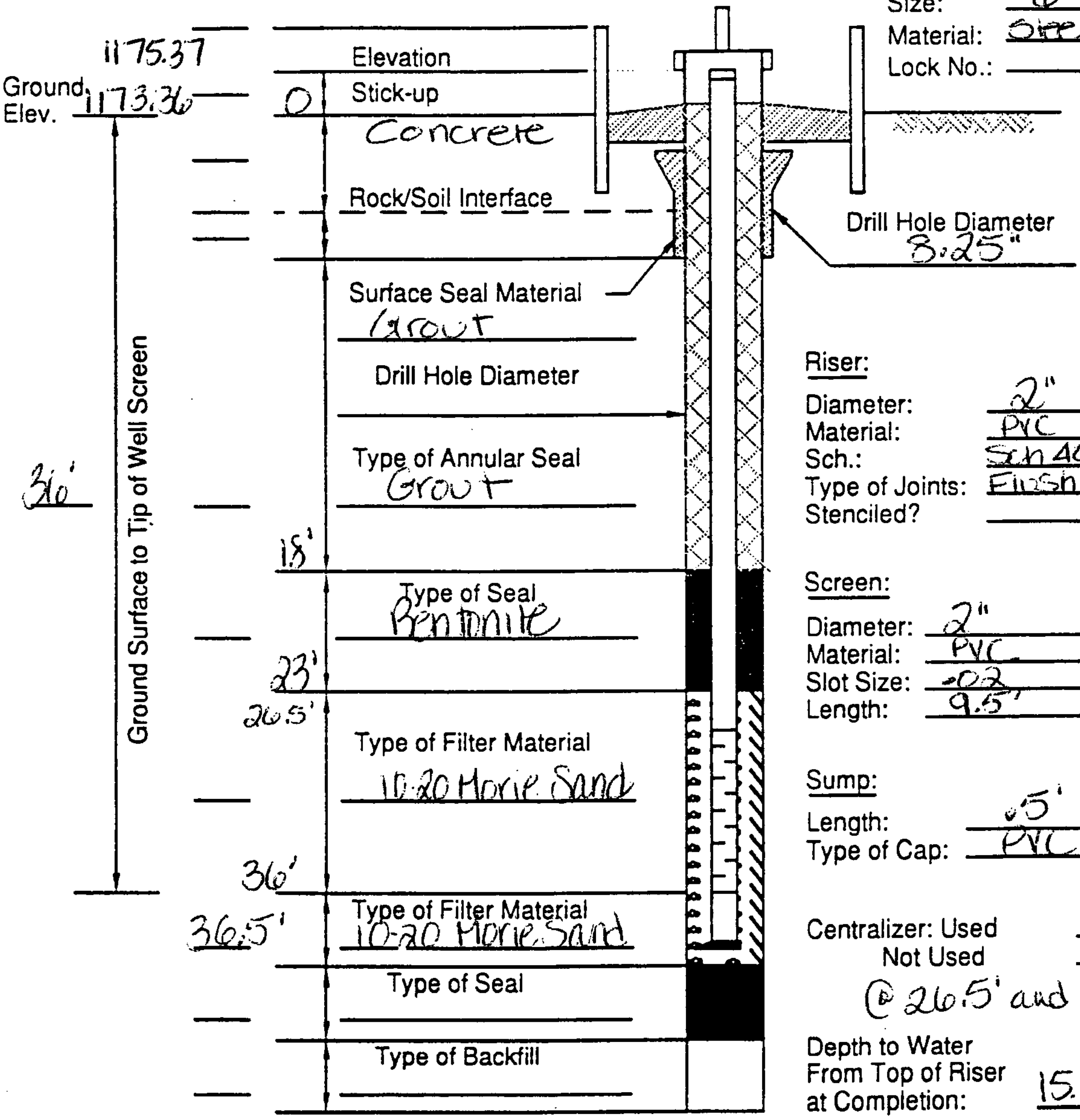
Client: US Army Corps of Engineers Project No.: JH1124D
Project: OB/OD Page: 1 of 1
Prepared by: Samantha Bennett Date: 2/23/98
Checked by: ______ Date: ______

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Drilling Method: ATV Hollow Stem Auger Rig / Dual Tube Air Rotary
Well No.: OB-97-06
Date Installed: 3-23-97

Coordinates: 1663420.58E/296906.75N

PROTECTOR CASING
Size: 6"
Material: Steel
Lock No.: ______



1175.37 Elevation
Ground Elev. 1173.36
0 Stick-up
Concrete
Rock/Soil Interface
Drill Hole Diameter 8.25"
Surface Seal Material Grout
Drill Hole Diameter ______
36' Type of Annular Seal Grout
18'
Type of Seal Bentonite
23'
26.5'
Type of Filter Material 10-20 Morie Sand
36'
36.5' Type of Filter Material 10-20 Morie Sand
Type of Seal ______
Type of Backfill ______

Riser:
Diameter: 2"
Material: PVC
Sch.: Sch 40
Type of Joints: Flush Threaded
Stenciled? ______

Screen:
Diameter: 2"
Material: PVC
Slot Size: .02
Length: 9.5'

Sump:
Length: .5'
Type of Cap: PVC

Centralizer: Used X
Not Used ______
@ 26.5' and 36.5'

Depth to Water From Top of Riser at Completion: 15.20'

FORM: *LBAMONW.DRW/Feb.1992*

NOTE: Not to Scale

WELL SPECIFICATION FORM

CLIENT: US ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH1124D

WELL OWNER: FORT RILEY - DES

ADDRESS: BUILDING 407 MAIN POST

CITY, STATE, ZIP CODE: Ft. Riley, Kansas 66442-6016

PHONE: (785)239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-97-06

WELL INSTALLATION DATE: 3-23-97

GEOLOGIST SUPERVISING INSTALLATION: Darryl Morgan

GROUND SURFACE ELEVATION (FT): 1173.36

TOP OF CASING ELEVATION (FT): 1175.37

WELL STICK-UP (FT): 2.01'

TOTAL BORING DEPTH (FT): 36.5'

BORING DIAMETER (IN): 8.25"

TOTAL DEPTH OF OUTER CASING (FT): 18.0'

OUTER CASING MATERIAL: Steel

OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): 26.5' = FromSurface 28.5' = Total

INNER CASING MATERIAL: PVC

INNER CASING DIAMETER (IN): 2"

TOTAL LENGTH OF WELL SCREEN (FT): 9.5'

WELL SCREEN MATERIAL: PVC

WELL SCREEN DIAMETER (FT): 2"

SCREEN SLOT SIZE (IN): .02"

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-97-06

BACKFILL MATERIAL AROUND SCREEN: 10-20 Morie Sand

DEPTH RANGE OF BACKFILL (FT): 23' TO 36.5'

SEAL MATERIAL ABOVE SCREEN: Bentonite

DEPTH RANGE OF SEAL (FT): 18' TO 23'

BACKFILL MATERIAL AROUND CASING: Grout

DEPTH RANGE OF BACKFILL (FT):

DESCRIPTION OF TOP SEAL: Grout Capped With Concrete

DESCRIPTION OF WELL COVER: 6" Diameter Steel

OTHER ADDITIONAL INFORMATION:

WELL DEVELOPMENT RECORD

CLIENT: US Army Corps of Engineers JOB NO. JH1124D

FIELD PERSONNEL: David Stein SHEET: 1 OF: 1

1. WELL NO.: OB-97-06
2. DATE OF INSTALLATION: 3/23/97
3. DATE OF DEVELOPMENT: 3/26/97
4. STATIC WATER LEVEL: BEFORE DEVELOPMENT 21.55 TOC FT. 24 HOURS AFTER 21.57 FT. immediately After Development
5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED None used GAL.
6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT ______ GAL.

	Total gallons removed	26gal	35gal		50gal
		START	DURING		END
7.	PHYSICAL APPEARANCE NTU	13.12	11.30	-	13.10
	SPECIFIC CONDUCTANCE (umhos/cm)	1548	1541	-	1536
	TEMPERATURE °F	65.7	63.9	-	63.2
	pH (s.u.)	7.43	6.65	-	7.62

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL ______ FT.
9. SCREEN LENGTH ______ FT.
10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT ______ FT. AFTER DEVELOPMENT ______ FT.
11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT:
    Layne 2" Submersible Pump
12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge & Pump
13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE: ______ FT.
14. QUANTITY OF WATER REMOVED 50 GAL. TIME OF REMOVAL 2hr 5min HR./MIN.
15. TURBIDITY IN NEPHELOMETRIC UNITS 13.10 NTUs

HTW DRILLING LOG

HOLE NO. OB-97-07

1. COMPANY NAME: Louis Berger & Associates
2. DRILLING SUBCONTRACTOR: Layne Western

SHEET 1 OF 4 SHEETS

3. PROJECT: OB/OD Area
4. LOCATION: 10' N of OB-93-04 - FT. Riley, KS
5. NAME OF DRILLER: John Gornick
6. MANUFACTURER'S DESIGNATION OF DRILL: ATV Hollow Stem Auger Rig/Dual Tube Air Rotary
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:
   - Dual Tube Air Rotary Rig
   - ATV Hollow Stem Auger Rig
   - 10" bit for Boring.
8. HOLE LOCATION: 10' N of OB-93-04
9. SURFACE ELEVATION: 1158.59
10. DATE STARTED: 3-21-97
11. DATE COMPLETED: 3-23-97
12. OVERBURDEN THICKNESS: 20'
13. DEPTH DRILLED INTO ROCK: 10'
14. TOTAL DEPTH OF HOLE: 30'
15. DEPTH GROUNDWATER ENCOUNTERED: 13.5'
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 11.60 (16 hours)
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
NO			None - 0

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
Yes	X					

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Yes		X		Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		10YR4/3 Brown, med plasticity med strength, med dilarancy mostly clay, few silt, CL					0-5' recovery 56" moist
	1						
	2						
	3						
	4						
	5						

MRK FORM JUN 89 55

PROJECT OB/OD Area

HOLE NO. OB-97-07

HTW DRILLING LOG

HOLE NO. OB-97-07

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 2 OF 4 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	5	2.5Y 4/3 olive Brown, med-plasticity, med strength, med dilatancy, mostly clay, little silt, CL					5-10' 52" recovery dry
	6						
	7						
	8						
	9						
	10	5YR 4/3 Reddish brown, high plasticity, med strength, med dilatancy, mostly clay, trace silt, CL					10-15' 55" recovery Mottle, moist
	11						
	12						
	13						13.5' saturated
	14						

HTW DRILLING LOG

HOLE NO. OB-97-07

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 4 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	15	5YR 4/3, Reddish brown, medium plasticity, medium strength, medium dilatancy, little fine to coarse chert gravel, CL					15-20' recovery 57" Saturated
	16						
	17						
	18						
	19						
	20	Shale 5G 3/2 Dusky green platy, fine texture, firm					20-20.2' refusal @ 20.2' Havensville Shale @ 20.2'
	21						
	22						
	23						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-07

HTW DRILLING LOG

HOLE NO. OB-97-07

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 4 OF 4 SHEETS

V.	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		Shale 5G 3/2 Dusky green, platy, firm					
	24						
	25						
	26						
	27						
		LS: 5B 7/1 Light Bluish gray, micro crystalline, hard, dense, argillaceous, Shalely, 4" thick					27'6" to 27'10"
	28	Shale 5G 3/2 Dusky green, platy, firm					
	29						TD 30'
	30						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-07

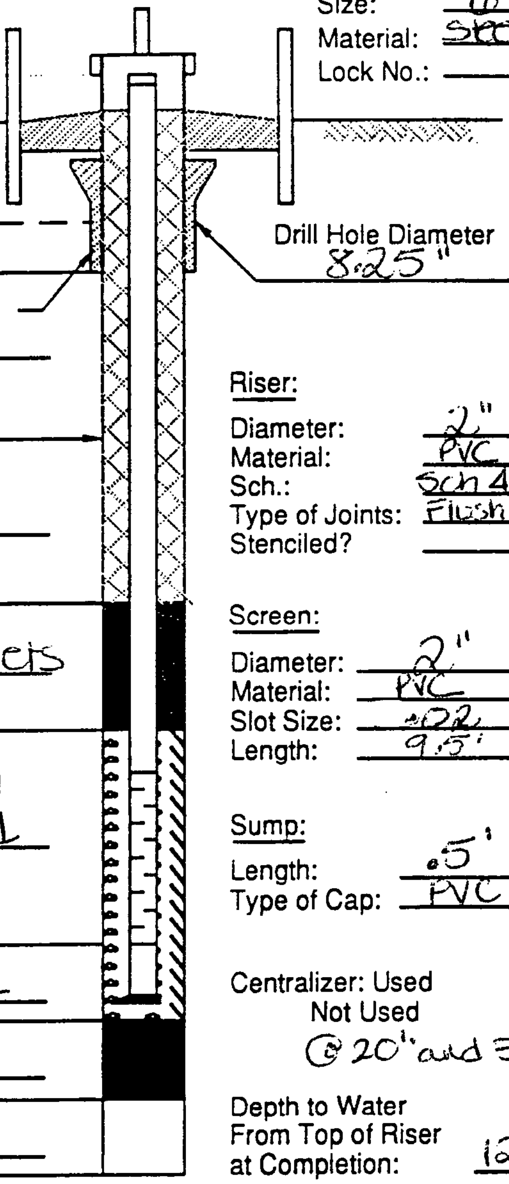
LOUIS BERGER & ASSOCIATES, INC.
100 Halsted Street
East Orange, N.J.

Client: US Army Corps of Engineers
Project No.: JH1124D
Project: OB/OD
Page: 1 of 1
Prepared by: Samantha Bennett
Date: 2/23/98
Checked by:
Date:

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Well No.: OB-97-07
Drilling Method: ATV Hollow Stem Auger Rig/ Dual Tube Air Rotary
Date Installed: 3-23-97

Coordinates: 1663161.62 E / 296617.84 N



1160.37 Elevation
Ground Elev. 1158.54
0 Stick-up
Concrete
Rock/Soil Interface
Surface Seal Material: Grout
Drill Hole Diameter
Type of Annular Seal: Grout
8'
Type of Seal: Bentonite Pellets
18'
Type of Filter Material: Silica Sand
29.5'
Type of Filter Material: Silica Sand
30'
Type of Seal:
Type of Backfill:

Ground Surface to Tip of Well Screen: 29.5'

PROTECTOR CASING
Size: 6"
Material: Steel
Lock No.:

Drill Hole Diameter: 8.25"

Riser:
Diameter: 2"
Material: PVC
Sch.: Sch 40
Type of Joints: Flush Threaded
Stenciled?

Screen:
Diameter: 2"
Material: PVC
Slot Size: .02
Length: 9.5'

Sump:
Length: .5'
Type of Cap: PVC

Centralizer: Used X
Not Used
@ 20' and 30'

Depth to Water From Top of Riser at Completion: 12.7'

FORM: *LBAMONW.DRW/Feb.1992*

NOTE: Not to Scale

WELL SPECIFICATION FORM

CLIENT: US ARMY CORPS. OF ENGINEERS - KANSAS CITY DISTRICT
JOB NUMBER: JH1124D

WELL OWNER: FORT RILEY - DES
ADDRESS: BUILDING 407 MAIN POST
CITY, STATE, ZIP CODE: Fort Riley, Kansas 66442-6016
PHONE: (785) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-97-07
WELL INSTALLATION DATE: 3-23-97
GEOLOGIST SUPERVISING INSTALLATION: Darryl Morgan

GROUND SURFACE ELEVATION (FT): 1158.59
TOP OF CASING ELEVATION (FT): 1160.37
WELL STICK-UP (FT): 1.78'

TOTAL BORING DEPTH (FT): 30'
BORING DIAMETER (IN): 8.25"

TOTAL DEPTH OF OUTER CASING (FT): 18'
OUTER CASING MATERIAL: Steel
OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): 20' = From Surface 22' = Total
INNER CASING MATERIAL: PVC
INNER CASING DIAMETER (IN): 2"
TOTAL LENGTH OF WELL SCREEN (FT): 9.5'
WELL SCREEN MATERIAL: PVC
WELL SCREEN DIAMETER (FT): 2"
SCREEN SLOT SIZE (IN): .02"

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-97-07

BACKFILL MATERIAL AROUND SCREEN: Silica Sand

DEPTH RANGE OF BACKFILL (FT): 18' TO 30'

SEAL MATERIAL ABOVE SCREEN: Bentonite Pellets

DEPTH RANGE OF SEAL (FT): 8' TO 18'

BACKFILL MATERIAL AROUND CASING: Grout

DEPTH RANGE OF BACKFILL (FT):

DESCRIPTION OF TOP SEAL: Grout Capped With Concrete.

DESCRIPTION OF WELL COVER: 6" Diameter Steel.

OTHER ADDITIONAL INFORMATION:

WELL DEVELOPMENT RECORD

CLIENT: US Army Corps of Engineers JOB NO. JH1124D

FIELD PERSONNEL: David Stein SHEET: 1 OF: 1

1. WELL NO.: OB-97-07

2. DATE OF INSTALLATION: 3-23-97

3. DATE OF DEVELOPMENT: 3-27-97

4. STATIC WATER LEVEL: BEFORE DEVELOPMENT 15.15' FT. 24 HOURS AFTER 17.91' FT. immediately after development

5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED — GAL.

6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT ~1.78 GAL.

Total removed (gallons)	58	62	190	200	268	410	470	—
	START			DURING			END	
7. PHYSICAL APPEARANCE NTU	105.3	102.3	69.9	59.9	67.1	69.8	45.9	10.8
SPECIFIC CONDUCTANCE (umhos/cm)	960	670	1040	680	740	640	650	690
TEMPERATURF (°F)	57.0	55.9	70.5	63.1	63.3	64.5	63.2	62.0
pH (s.u.)	8.17	8.28	8.06	8.13	8.06	8.16	8.30	9.88

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL 32 FT.

9. SCREEN LENGTH 9.5' FT.

10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT ______ FT. AFTER DEVELOPMENT ______ FT.

11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: Layne 2" Submersible Pump

12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge and pump.

13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE: 1.78' FT.

14. QUANTITY OF WATER REMOVED 470 GAL. TIME OF REMOVAL 6/05 HR./MIN.

15. TURBIDITY IN NEPHELOMETRIC UNITS 10.8 NTUs

WELL DEVELOPMENT RECORD

CLIENT: Army Corp of Engineers - KANSAS CITY JOB NO: JG-1170

FIELD PERSONNEL: DAN KEOHANE SHEET: 1 OF: 1

1. WELL NO.: OB97-07
2. DATE OF INSTALLATION: 3-23-97
3. DATE OF DEVELOPMENT: 6-17-97 - Redevelopment & 6-18-97
4. STATIC WATER LEVEL: BEFORE DEVELOPMENT 14.12 FT. 24 HOURS AFTER 14.34 FT.
5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED N/A GAL.
6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT 11 GAL.

	START	DURING		END
7. PHYSICAL APPEARANCE	Turbid	156	58.1	25.4
SPECIFIC CONDUCTANCE (umhos/cm)	785	791	580	520
TEMPERATURE (°C)	80°F (26.6)	82°F (27.8)	12.2°C 53.9°F	12.4°C 54.3°F
pH (s.u.)	7.42	7.41	6.71	6.70

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL 28.3 FT.
9. SCREEN LENGTH 10 FT.
10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT 28.3 FT. AFTER DEVELOPMENT 28.4 FT.
11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: 2-inch Stainless Steel bailer & 2-inch PVC bladder Pump.
12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: 2-inch Stainless steel bailer.
13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE: 1.65 FT.
14. QUANTITY OF WATER REMOVED 65 GAL. TIME OF REMOVAL 4 hr/20 min HR./MIN.
15. TURBIDITY IN NEPHELOMETRIC UNITS 25.4 NTUs

HTW DRILLING LOG

HOLE NO. OB-97-08

SHEET 1 OF 3 SHEETS

1. COMPANY NAME: Louis Berger & Associates

2. DRILLING SUBCONTRACTOR: Layne Western

3. PROJECT: OB/OD Area

4. LOCATION: FT. Riley, KS

5. NAME OF DRILLER: John Gornick

6. MANUFACTURER'S DESIGNATION OF DRILL: ATV Hollow Stem Auger Rig

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:
ATV Hollow Stem Auger Rig
6 1/4" OD Augers

8. HOLE LOCATION: ≈ 500 feet West of South Burn Pit

9. SURFACE ELEVATION: 1157.97

10. DATE STARTED: 3-21-97

11. DATE COMPLETED: 3-24-97

12. OVERBURDEN THICKNESS: 18'

13. DEPTH DRILLED INTO ROCK: 0

14. TOTAL DEPTH OF HOLE: 18'

15. DEPTH GROUNDWATER ENCOUNTERED: 15'

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 11.50 (16 hours)

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES: 0

DISTURBED	UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES:

20. SAMPLES FOR CHEMICAL ANALYSIS: Yes

VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)
X		Explosives	SVOC	Nitrate/Nitrite

21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE: Yes

BACKFILLED	MONITORING WELL	OTHER (SPECIFY)
	X	

23. SIGNATURE OF INSPECTOR: Darryl D. Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		5YR 3/1 very dark gray, non plastic, medium dilatancy, friable, low strength; ML					0-5' recovery 40"
	1						
	2	10YR 4/2; Dark grayish brown medium plasticity, medium dilatancy, medium strength, CL					
	3						
	4						
	5						

HTW DRILLING LOG

HOLE NO. OB-97-08

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		10YR4/3; Brown, medium plasticity, medium dilatancy, med strength, CL					5'-10' recovery 46" moist
	6						
	7						
	8						
	9						
	9						
	10	10YR 3/2; very dark grayish brown, low plasticity, low to medium dilatancy, low strength, dry, ML					10'-15' recovery 60"
	11						
	12						
	13						
	14						

HTW DRILLING LOG

HOLE NO. OB-97-08

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	15	Saturated					15'-18' recovery 36"
	16						
	17	7.5YR 4/3; Brown, weathered relic bedding, fine to coarse chert fragments, low plasticity, low strength; low dilatancy, ML					
	18	LS: 2.5Y 8/3 Pale yellow; weatherd, crumbly, trace chert					TD- 18.0'
	19						

LOUIS BERGER & ASSOCIATES, INC.
100 Halsted Street
East Orange, N.J.

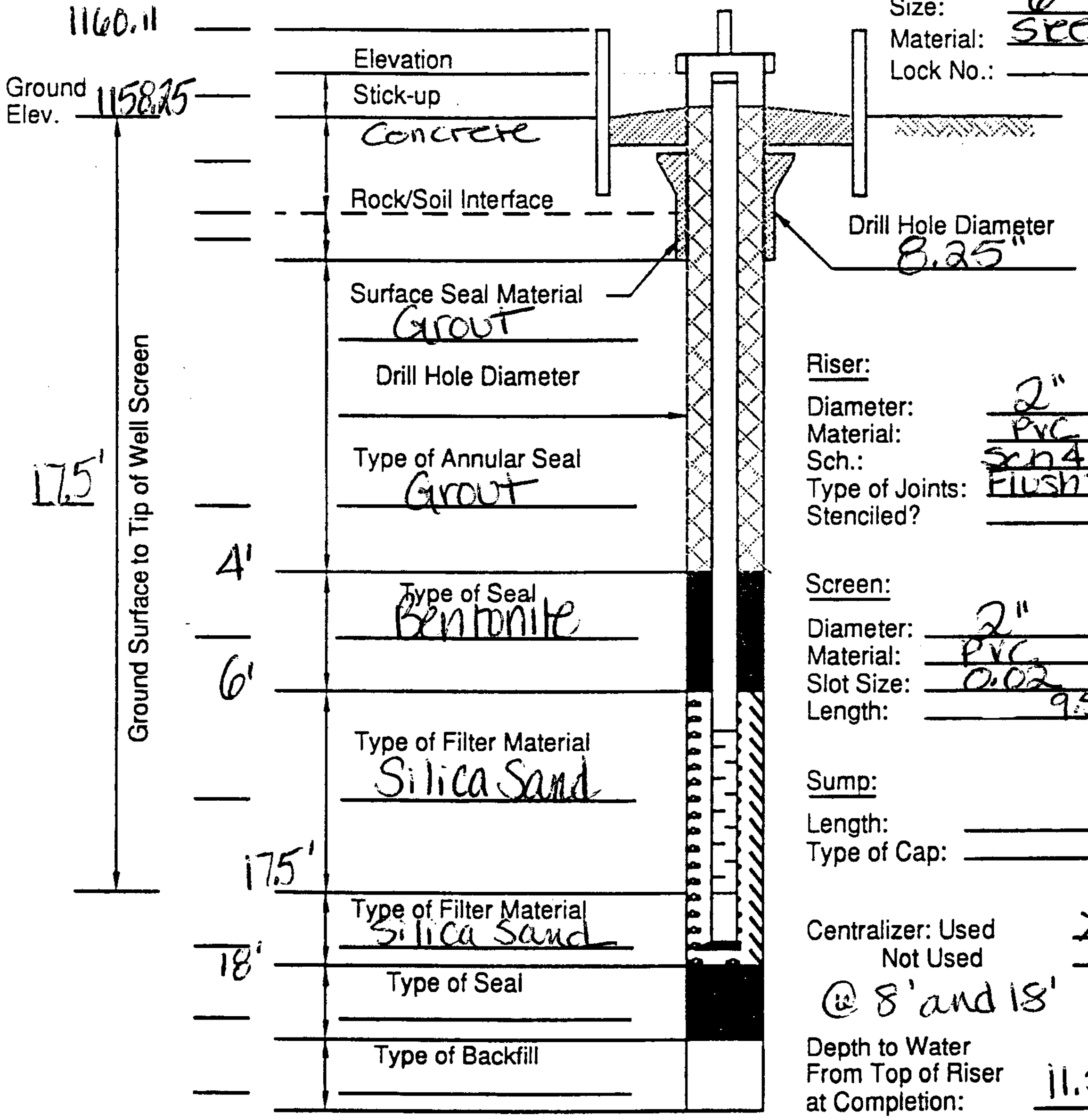
Client: US Army Corps of Engineers Project No.: JH1124D
Project: OB/OD Page: 1of1
Prepared by: Samantha Bennett Date: 2/24/98
Checked by: ______ Date: ______

MONITORING WELL AS-BUILT DIAGRAM

Driller: Layne Western
Drilling Method: ATV Hollow Stem Auger Rig / Dual Tube Air Rotary
Well No.: OB-97-08
Date Installed: 3-24-97

Coordinates: 1662947.50E/296756.73N

PROTECTOR CASING
Size: 6"
Material: Steel
Lock No.: ______



Riser:
Diameter: 2"
Material: PVC
Sch.: Sch 40
Type of Joints: Flush Threaded
Stenciled? ______

Screen:
Diameter: 2"
Material: PVC
Slot Size: 0.02
Length: 9.5'

Sump:
Length: ______
Type of Cap: ______

Centralizer: Used X
Not Used ______
@ 8' and 18'

Depth to Water From Top of Riser at Completion: 11.50'

FORM: *LBAMONW.DRW/Feb.1992*

NOTE: Not to Scale

WELL SPECIFICATION FORM

CLIENT: US ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH112AD

WELL OWNER: FORT RILEY - DES

ADDRESS: BUILDING 407 MAIN POST

CITY, STATE, ZIP CODE: Fort Riley, Kansas 66442-6016

PHONE: (785) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB-97-08

WELL INSTALLATION DATE: 3-24-97

GEOLOGIST SUPERVISING INSTALLATION: Darryl Morgan

GROUND SURFACE ELEVATION (FT): 1158.25

TOP OF CASING ELEVATION (FT): 1160.11

WELL STICK-UP (FT): 1.86'

TOTAL BORING DEPTH (FT): 18'

BORING DIAMETER (IN): 2"

TOTAL DEPTH OF OUTER CASING (FT): 18"

OUTER CASING MATERIAL: Steel

OUTER CASING DIAMETER (IN): 6"

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): 8' = FROM GROUNDSURFACE 10' - TOTAL

INNER CASING MATERIAL: PVC

INNER CASING DIAMETER (IN): 2"

TOTAL LENGTH OF WELL SCREEN (FT): 9.5'

WELL SCREEN MATERIAL: PVC

WELL SCREEN DIAMETER (FT): 2"

SCREEN SLOT SIZE (IN): .02

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB-97-08

BACKFILL MATERIAL AROUND SCREEN: Silica Sand

DEPTH RANGE OF BACKFILL (FT): 6' TO 18'

SEAL MATERIAL ABOVE SCREEN: Bentonite

DEPTH RANGE OF SEAL (FT): 4' TO 6'

BACKFILL MATERIAL AROUND CASING: Grout

DEPTH RANGE OF BACKFILL (FT):

DESCRIPTION OF TOP SEAL: Grout Capped With Concrete.

DESCRIPTION OF WELL COVER: 6" Diameter Steel

OTHER ADDITIONAL INFORMATION:

WELL DEVELOPMENT RECORD

CLIENT: US Army Corps of Engineers JOB NO: JH112AD

FIELD PERSONNEL: David Stein SHEET: 1 OF: 1

1. WELL NO.: OB-97-08
2. DATE OF INSTALLATION: 3-24-97
3. DATE OF DEVELOPMENT: 3-28-97
4. STATIC WATER LEVEL: BEFORE DEVELOPMENT 13.52' FT. 24 HOURS AFTER ______ FT.
5. QUANTITY OF WATER LOSS DURING DRILLING, IF USED ______ GAL.
6. QUANTITY OF STANDING WATER IN WELL AND ANNULUS BEFORE DEVELOPMENT ______ GAL.

	Total Removed (gallons)	30	45	47	52
		START	DURING		END
7.	PHYSICAL APPEARANCE	200+	62.5	47.8	11.6
	SPECIFIC CONDUCTANCE (umhos/cm)	550	480	500	580
	TEMPERATURE (°F)	59.6	56.2	55.8	53.5
	pH (s.u.)	9.73	9.26	9.26	9.36

8. DEPTH FROM TOP OF WELL CASING TO BOTTOM OF WELL 20 FT.
9. SCREEN LENGTH 9.5' FT.
10. DEPTH TO TOP OF SEDIMENT: BEFORE DEVELOPMENT ______ FT. AFTER DEVELOPMENT ______ FT.
11. TYPE AND SIZE OF WELL DEVELOPMENT EQUIPMENT: Layne 2" Submersible Pump
12. DESCRIPTION OF SURGE TECHNIQUE, IF USED: Surge and pump
13. HEIGHT OF WELL CASING ABOVE GROUND SURFACE: 1.86' FT.
14. QUANTITY OF WATER REMOVED 52 GAL. TIME OF REMOVAL 1/19 HR./MIN.
15. TURBIDITY IN NEPHELOMETRIC UNITS 11.6 NTUs

Mobilization #2 -
June/July 1997
(Piezometers OB97-09 through OB93-13)

HTW DRILLING LOG

HOLE NO. 0B-97-9 PZ

SHEET 1 OF 14 SHEETS

1. COMPANY NAME: Louis Berger & Associates, Inc

2. DRILLING SUBCONTRACTOR: Layne

3. PROJECT: OB/OD Area

4. LOCATION: OB/OD AREA, RANGE 16 Ft. RILEY KANSAS

5. NAME OF DRILLER: Bob Knopf

6. MANUFACTURER'S DESIGNATION OF DRILL: TH-60 INGERSOll-RAND AIR RIG

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:
5 7/8" bit air rotary to 114'
Sampleng air cuttings
ream with 9 7/8" bit to
114.5'

8. HOLE LOCATION: NORTH END OF OB/OD ON TOPOGRAPHIC HIGH

9. SURFACE ELEVATION: 1241.74 feet above mean sea level

10. DATE STARTED: 6-6-97

11. DATE COMPLETED: 6-7-97

12. OVERBURDEN THICKNESS: 3.5 feet

13. DEPTH DRILLED INTO ROCK: 111 Feet

14. TOTAL DEPTH OF HOLE: 114.5

15. DEPTH GROUNDWATER ENCOUNTERED: Moisture At 15 Ft / 26 Ft / 72 Ft / 78 Ft / 90 Ft / 94 / wet @ 96.5

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 96.32 Ft b.g.s / 2 days

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): 96.33 Ft b.g.s / 6-10-97

18. GEOTECHNICAL SAMPLES: N/A

DISTURBED	UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES: N/A

20. SAMPLES FOR CHEMICAL ANALYSIS: N/A

VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)

21. TOTAL CORE RECOVERY: N/A %

22. DISPOSITION OF HOLE

BACKFILLED	MONITORING WELL	OTHER (SPECIFY)
		nested Piezometer

23. SIGNATURE OF INSPECTOR: Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1242	0	Limestone (light gray (N7/) fine crystalline, medium hard, slightly chalky, abundant Chert, Dry	hnu 0				Begin drilling @ 1030hrs 6-6-97 with 5 7/8" bit air rotary
1241	1						
1240	2	Shale: (pale yellow, (5Y7/4) fine texture, sft, calcaeous, HCL reaction, 50% fines, 50% limestone and chert fragments (0.5cm to 3.0cm) Dry	0				
1239	3	Florence Limestone: pale yellow (5Y 8/2) fine crystalline, sft, slightly weathered, some chert, Dry					torque up slow drilling
1238	4		0				
1237	5						

HTW DRILLING LOG

HOLE NO. 0B-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 2 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1237	5		hnu				
			0				
1236	6	~~Shale: pale yellow (5Y7/4), fine texture, Cateacus, HCL reaction~~ DM					
1235	7	Shale: pale yellow (5Y7/4), fine texture, Cateacus, HCL reaction, 50% fines, 50% Limestone and chert fragments (0.5cm to 3.0cm) dry					smooth dilling
1234	8	Limestone: pale yellow (5Y8/2) fine crystalline, medium hard, slightly chalky, some chert dry	0				
1233	9						
1232	10						torque up
							smooth out
1231	11		0				
							torque up
1230	12	Limestone: A/A abundant chert, dry					
1229	13	DM ~~Limestone~~ Shale: yellow (5Y8/6 fine texture, soft, 50% fines, 50% Limestone fragments (0.5cm to 3.0cm					smooth out
1228	14						

HTW DRILLING LOG

HOLE NO. OB-97-09 PZ

PROJECT OB/OD Area

INSPECTOR Darrell Morgan

SHEET 3 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1228	14	Limestone: A/A, dry	hnu 0				
1227	15	Strong brown 5YR 5/6), medium plasticity, medium dilatancy CL (100% fines) dry Limestone: A/A, abundant Chert, dry					smooth out moisture at 15-16' torque up
1226	16		0				
1225	17	Limestone: A/A, abundant chert, dry					
1224	18	~~Limestone: A/A, abundant chert~~ brn	0				smooth out torque up
1223	19	Limestone: olive yellow (2.5Y6/8) fine crystalline, medium hard to soft, slightly chalky, some chert, slightly weathered, dry	0				
1222	20						
1221	21						
1220	22	Limestone: A/A, dry					
1219	23						

PROJECT OB/OD Area

HOLE NO. OB-97-09 PZ

MRK FORM JUN 89 55-2

HTW DRILLING LOG

HOLE NO. OB-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 4 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1219	23		hnu 0				
1218	24	Limestone: white (N8/) fine crystalline, hard, dense, fossillerous, slightly Chalky, abundant chert, dry					compressor on rig froze up @ 1130hrs fixed compressor resumed drilling @ 1100hrs 6-7-97
1217	25	Shale. pale olive (5Y 6/4) subplaty, firm to hard, HCL Reaction, very calceacus Limestone: A/A dry					
1216	26	Shale: light greenish gray (5G7/1) blocky, fine texture, firm to hard, HCL reaction, very calcaecus; dry	0				drilling rate increased moisture at 26-29'
1215	27						
1214	28		0				
1213	29	Shale: dark green gray (5G4/1) fine texture, blocky, slight HCL reaction, slightly calceous,					
1212	30		0				
1211	31	Shale: light greenish gray (5GY7/1) moist, fine texture, blocky to subplaty, firm, weak HCL reaction, slightly Calceaous					
1210	32						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09PZ

HTW DRILLING LOG

HOLE NO. OB-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 5 OF 14 SHEETS

EV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1210	32	Shale: dark greenish gray (5GY4/1) fine texture, firm to hard, non calcareous, No reaction HCL, dry	hnu 0				
1209	33						
1208	34		0				
1207	35						
1206	36		0				
1205	37	Shale: dark reddish gray (5YR4/2), fine texture, soft to firm, subplaty, weak reaction HCL, slightly calcareous, dry					
1204	38	Shale: dark reddish brown, (5YR 3/3) A/A, reaction HCL calcareous, dry	0				
1203	39						
1202	40						
1201	41						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09PZ

HTW DRILLING LOG

HOLE NO. OB-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 6 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1204	41	Shale: greenish gray (5G 6/1), fine texture, subplaty, soft, strong HCL reaction, very calceaeous. dry	hnu 0				
1200	42	shale: dark reddish brown (5YR 3/3), fine texture, subblocky, strong HCL reaction, very calcaeous, dry					
1198	43	shale: light greenish gray (5GY 7/1) A/A, dry					
1198	44		0				
1198	45						
1196	46	Shale: dark greenish gray (5GY 4/1), fine texture, subplaty, soft, weak HCL reaction, slightly calceaous dry					
1195	47		0				
1194	48		0				
1193	49						
1192	50						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09PZ

HTW DRILLING LOG

HOLE NO. OB-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 7 OF 14 SHEETS

EV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1192	50	Limestone: light gray (N7/) fine crystalline, medium hard, dry	hnu 0				Water @ 50ft [illegible] while drilling ? torque up drill rate slowed
1191	51						
1190	52	Shale: greenish gray (5GY/) fine texture, subplaty, soft, No HCL reaction, noncalcareous dry	0				smooth out drill rate increased
1189	53						
88	54						
1187	55		0				
1186	56	shale: very dark gray (N3/) fine texture, platy, laminated soft, no HCL reaction, non calcareous, dry					
1185	57		0				
1184	58	shale very dark gray (N/3) fine texture, subplaty, hard, strong HCL reaction, very calcareous, dry					torque up drill rate slowed
1183	59						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09 PZ

HTW DRILLING LOG

HOLE NO. 0B-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 8 **OF** 14 **SHEETS**

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1183	59		hnu				smooth out drill rate increase
1182	60	Shale: very dark gray (N/3) fine texture, subplaty, Soft, strong HCL reaction, very calcaeous, dry	0				
1181	61						
1180	62		0				
1179	63						
1178	64						
1177	65	Shale: A/A, dry	0				torque up drilling rate slowed
1176	66						
1175	67						
1174	68						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. 0B-97-09-PZ

HTW DRILLING LOG

HOLE NO. OB-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 9 OF 14 SHEETS

EV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
74	68'		hnu 0				
1173	69	Shale: A/A					
1172	70		0				[illegible] water @ 70' while reaming 70'-114.5' ~ 400 gals added was recovered
1170	71						
1169	72	**Kinney** Limestone: pale yellow(5Y7/4), fine crystalline, medium hard, slightly weathered, some chert, moist	0				torque up drill rate slowed
1168	73						
1168	74						
1167	75	Wet @ 75	0				
1165	76	**Wymore** Shale: gray(N5/), fine texture, platy, soft, strong HCL reaction, calcareous					
1165	77						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09PZ

HTW DRILLING LOG

HOLE NO. OB-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 10 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1165	77		hnu 0				
1164	78	Shale. A/A, wet zone dry					
1163	79		0				
1162	80						
1161	81	Shale: gray(N/3), fine texture, platy, firm, strong HCL reaction, calcaeous, wet zone	0				
1160	82	Shale: light greenish gray (5G 7/1) fine texture, blocky, firm, strong HCL reaction, calcaeous, dry					
1159	83		0				
1158	84						
1157	85						
1156	86	Shale: A/A, dry					

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09-PZ

HTW DRILLING LOG

HOLE NO. OB-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 11 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1156	86		hnu				
		shale A/A, dry	0				
1155	87						
1154	88						
1153	89		0				
152	90	Shale: A/A, moist zone					
1151	91						
1150	92						
1149	92		0				
1148	93						
1147	94	Shale: greenish gray (5DC 5/1)					

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09-PZ

HTW DRILLING LOG

HOLE NO. 0B-97-09-PZ

SHEET 12
OF 14 SHEETS

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1147	94	blocky, fine texture, soft, slight HCL reaction, wet zone	hnu 0				
1146	95						DM ~~torque up~~
1145	96	Schrover Limestone: pale yellow (2.5Y 7/4), fine crystalline, medium hard, weathered wet.					torque up drill rate slowed
1144	97		0				
1143	98						smooth out
1142	99	Shale: gray (N5/) fine texture subplaty, firm, strong HCL reaction, calcaeous	0				
1141	100	Limestone: Light gray (N7/) fine crystalline, hard, dense, wet					torque up drillrate slowed
1140	101	Limestone gray (N6/) fine crystalline, hard, dense, abundant chert, wet					
1139	102						
1138	103						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. 0B-97-09 PZ

HTW DRILLING LOG

HOLE NO. 0B-97-09-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 13 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1138	~~104~~ 103		hnu 0				
1137	104 ~~105~~						
1136	105 ~~106~~	Havensville Shale: dark gray (N4/), fine texture, subplaty, soft, calcite, strong HCL reaction, calceaous, dry	0				
1135	106 ~~107~~						
1134	107 ~~108~~		0				torque up
1133	108 ~~109~~	Shale: A/A, dry					DM ~~ended drilling @ 1238hrs~~ ~~[illegible]~~
1132	109 ~~110~~						
1131	110	Shale: darkgray (N4/) fine texture, subplaty soft to firm, strong HCL reaction, calcaeous, dry	0				
1130	111 ~~112~~						
1129	112 ~~113~~						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-09PZ

HTW DRILLING LOG

HOLE NO. 0B-97-09PZ

PROJECT 0B/0D Area

INSPECTOR Darryl Morgan

SHEET 14 OF 14 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1129	112						
		Shale: A/A, dry					Set 8" ID temporary casing to 114.5'
1128	113						reamed hole with @ 9 7/8" bit to 114.5' finished reaming @ 1130 6-8-97 ended drilling @ 1235 hrs 6-9-97
	1'						
1127	114	TD 114					

MRK FORM JUN 89 55-2

PROJECT 0B/0D Area

HOLE NO. 0B-97-09-PZ

WELL SPECIFICATION FORM

CLIENT: U.S. ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH-1124 D

WELL OWNER: FORT RILEY - DEH

ADDRESS: BUILDING 407 MAIN POST

CITY, STATE, ZIP CODE: FORT RILEY, KANSAS 66442-6016

PHONE: (973) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB97-09 PZ [0-5] NEST OF 6 Piezometers

WELL INSTALLATION DATE: START 6/6/97 : FINISH 6/17/97

GEOLOGIST SUPERVISING INSTALLATION: DANIEL KEOHANE /DARRYL MORGAN

GROUND SURFACE ELEVATION (FT): 1242.81 (SURVEYOR'S DISC)

TOP OF CASING ELEVATION (FT): 1245.~~06~~ 70 (TOP PVC CASING)

WELL STICK-UP (FT): 2.89 ~~3.25~~ FEET

TOTAL BORING DEPTH (FT): 114 FEET (b.g.s)

BORING DIAMETER (IN): 9 7/8 - INCH

TOTAL DEPTH OF OUTER CASING (FT): 114 FEET (TEMPORARY)

OUTER CASING MATERIAL: SCHEDULE 80 PVC

OUTER CASING DIAMETER (IN): 8 - INCH

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): 109 102.09 87 74 51 26.02 (b.g.s)

INNER CASING MATERIAL: SCHEDULE 80 PVC

INNER CASING DIAMETER (IN): 1 INCH

TOTAL LENGTH OF WELL SCREEN (FT): 1 0.91 1 1 1 2

WELL SCREEN MATERIAL: SCHEDULE 80 PVC

WELL SCREEN DIAMETER (FT): 1 INCH

SCREEN SLOT SIZE (IN): All 0.020 INCH

LOUIS BERGER AND ASSOCIATES, INC.
WELL SPECIFICATION FORM

JANUARY 1992

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB97-09 PZ

BACKFILL MATERIAL AROUND SCREEN: COARSE SAND

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW TO

SEAL MATERIAL ABOVE SCREEN: BENTONITE (PEL PLUG OR CHIPS)

DEPTH RANGE OF SEAL (FT): SEE TABLE BELOW TO

BACKFILL MATERIAL AROUND CASING: ~~SEE TABLE BELOW~~ BENTONITE

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW.

DESCRIPTION OF TOP SEAL: BENTONITE TO GROUND SURFACE; PLACED AFTER STEEL PROTECTIVE CASING SET.

DESCRIPTION OF WELL COVER: 10-INCH DIAMETER STEEL PROTECTIVE CASING

OTHER ADDITIONAL INFORMATION: TOP OF PZ'S NOTCHED: THE DEEPEST (HAVENSVILLE) HAS 0 NOTCHES; THE NUMBER OF NOTCHES INCREASES WITH DECEASING DEPTH B.G.S.

INTERVAL SCREENED	DEPTH RANGE OF BACKFILL (Ft.bgs)	DEPTH RANGE OF SEAL	INTERVAL SCREENED (Ft.bgs) APPROX
HAVENSVILLE	111.95 - 108.15	108.15 - 104.1	109 - 110
SCHROYER	104.1 - 100.93	100.93 - 89.29	102.09 - 103
WYMORE	89.29 - 85.96	85.96 - 76.10	86 - 87
KINNEY	76.10 - 72.69	72.69 - 53.78	74 - 75
BLUE SPRINGS	53.76 - 49.90	49.90 - 29.58	51 - 52
FLORENCE	29.58 - 25.00	25.00 - 4.01	28.0 - 26.02

HTW DRILLING LOG

HOLE NO. OB-97-10PZ

SHEET 1 OF 7 SHEETS

1. COMPANY NAME Louis Berger & Associates
2. DRILLING SUBCONTRACTOR Layne

PROJECT OB/OD Area

4. LOCATION OB/OD Area Range 16-Ft Riley
5. NAME OF DRILLER Bob Knopf
6. MANUFACTURER'S DESIGNATION OF DRILL TH-60 INGERSOLL-RAND AIR RIG
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT air rotary 5⅞" bit to 58/logged from air cuttings ream hole with 9⅞" bit
8. HOLE LOCATION Approx. 100 Ft West of OB93-01
9. SURFACE ELEVATION 1183.01 feet mean sea level
10. DATE STARTED 6-8-97
11. DATE COMPLETED 6-8-97
12. OVERBURDEN THICKNESS 20 Feet (Residual SOIL)
13. DEPTH DRILLED INTO ROCK 38 feet
14. TOTAL DEPTH OF HOLE 58 Feet
15. DEPTH GROUNDWATER ENCOUNTERED 19.5 feet
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED 27.94/6-10-97
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) 29.91/6-11-97
18. GEOTECHNICAL SAMPLES N/A — DISTURBED — UNDISTURBED
19. TOTAL NUMBER OF CORE BOXES N/A
20. SAMPLES FOR CHEMICAL ANALYSIS N/A — VOC — METALS — OTHER (SPECIFY) — OTHER (SPECIFY) — OTHER (SPECIFY)
21. TOTAL CORE RECOVERY N/A %
22. DISPOSITION OF HOLE — BACKFILLED — MONITORING WELL — OTHER (SPECIFY) 5 NESTED PIEZOMETERS
23. SIGNATURE OF INSPECTOR Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1183		very dark brown (10YR 2/2) medium plasticity, medium dilatancy, Limestone and chert fragments (0.5cm to 4.0 cm) CL, moist (50% fines, 50% gravel) — Blue Springs SHALE	hnu 0				roots drilling commenced @ 1443 hrs 6-8-97 with 5⅞" bit, air rotary Ream w/ 9⅞" bit/air rotary @ 1420 6-9-97 Finish reaming @ 1640 6-9-97 and set 58.25 ft temporary 8" PVC casing.
1182	1						
1181	2		0				
1180	3						
1179	4	dark grayish brown (2.5Y 4/2) medium plasticity, medium dilatancy, trace limestone fragments, 95% fines 5% fragments, CL	0				
1178	5						

MRK FORM 55

PROJECT OB/OD Area

HOLE NO. OB-97-10PZ

HTW DRILLING LOG

HOLE NO. OB-97-10PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET OF 2 SHEETS 7

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1178	5		hnu 0				
1177	6	Brown(10YR4/3) medium plasticity, medium dilatancy 100% fines, non calcaeous no reaction HCL, CL, moist					
1176	7		0				
1175	8	dark reddish brown (5YR3/3) medium plasticity medium dilatancy, 100fines non calcaeous, no reaction HCL, CL, moist					
1174	9		0				
1173	10	dusky red(2.5YR 3/4) medium plasticity, medium dilatancy, 100% fines, non calcaeous, no reaction HCL, CL, moist					
1172	11		0				
1171	12						
1170	13						
1169	14	A/A with limestone and chert					

PROJECT OB/OD Area

HOLE NO. OB-97-10PZ

MRK FORM JUN 89 55-2

HTW DRILLING LOG

HOLE NO. 0B-97-10PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1169	14	fragments 90% fines, 10% fragments, moist	hnu 0				
1168	15						
1167	16	dusky red (2.5YR 3/4) medium dilatancy, medium plasticity, 75% fines, 20% Limestone and chert fragments 5% sand, CL, (Limestone and chert 0.1 to 2cm), moist	0				
1166	17	KINNEY LIMESTONE					
65	18						
1164	19	Yellow (10YR 8/4) sand, fine unconsolidated, non calcareous subrounded to rounded, wet	0				
1163	20	Shale pale yellow (5Y 7/3) fine texture, firm, blocky, strong reaction HCL, very calcareous, moist					
1162	21	WYMORE SHALE	0				
1161	22						
1160	23						

PROJECT OB/OD Area

HOLE NO. 0B-97-10PZ

MRK FORM JUN 89 55-2

HTW DRILLING LOG

HOLE NO. 0B-97-10PZ

PROJECT 0B/0D Area

INSPECTOR Darryl Morgan

SHEET 4 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1160	23		hnu 0				
1159	24	Shale: light greenish gray (5BG 7/1), fine texture, blocky, Soft, noncalcaeous, no reaction HCL, dry, 100%					
1158	25		0				
1157	26	Shale: greenish gray (5BG 6/1) fine texture, sub-platy, firm, strong reaction HCL, 100% fines, dry					
1156	27		0				
1155	28	Shale: dusky red (2.5YR4/3) fine texture, sub-blocky, moderately firm, calcaeous, Strong reaction HCL, 100% fines, dry					
1154	29		0				
1153	30	DM ~~Shale: dusky red (2.5YR4/3)~~ Shale: light greenish gray, (5G7/1) fine texture, blocky, firm, very calcaeous, Strong HCL reaction, 100% fines					
1152	31						
1151	32						

MRK FORM 55-2

PROJECT 0B/0D Area

HOLE NO. 0B-97-10PZ

HTW DRILLING LOG

HOLE NO. OB-97-10PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 5 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1151	32	Shale: weak red (10R4/4) fine texture, blocky, soft, no reaction HCL, 100% fines, dry	hnu 0				
1150	33						
1149	34	Shale: bluish gray (5B6/1) fine texture, sub platy, soft, very strong reaction HCL, 100% fines, dry	0				
1148	35		0				
1147	36	A/A					
1146	37	Schroyer LIMESTONE Limestone: greenish gray (5GY6/1) fine crystalline, medium hard, wet to saturated, weathered	0				torque up
1145	38						
1144	39		0				
1143	40	Limestone: white (N8/) fine to microcrystalline, hard, dense, wet to saturated					
1142	41						

HTW DRILLING LOG

HOLE NO. OB-97-10PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 6 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1142	41		hnu				
1141	42	Limestone: dark gray (N4/) fine crystalline, hard, dense saturated, abundant chert	0				
1140	43						
1139	44	A/A with white (N8/) limestone, saturated	0				
1138	45	Havensville SHALE					
		Shale: gray (N5/), fine texture, platy, moderately firm, strong HCL reaction, Calcarous, 100% fines, dry					
1137	46		0				
1136	47						
1135	48						
	dm ~~49~~	Shale: A/A, dry	0				
1134	49						
1133	50						

PROJECT OB/OD Area

HOLE NO. OB-97-10PZ

MRK FORM 55-2

HTW DRILLING LOG

HOLE NO. 0B-97-10PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 7 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1133	50		hnu 0				
1132	51	shale: A/A, dry					torque up
1131	52		0				
1130	53	shale: gray (N5/), fine texture, platy, moderate firm, strong reaction HCL, calcareous, some gypsum, 100% fines, dry					
1129	54						
1128	55	Limestone: gray (N 5/) fine crystalline, hard, dense, very argillaeous, dry	0				torque up
1127	56						
1126	57		0				TD 58' @ 1600hrs 6-8-97
1125	58	Shale: black (N2.5/) fine texture, platy, Sd+, 100% fines, slight reaction HCL dry					
1124	59						

PROJECT OB/OD Area

HOLE NO. 0B-97-10PZ

WELL SPECIFICATION FORM

CLIENT: U.S. ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH-1124D

WELL OWNER: FORT RILEY - DES

ADDRESS: BUILDING 407 MAIN POST

CITY, STATE, ZIP CODE: FORT RILEY, KANSAS 66442-6016

PHONE: (913) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB97-10PZ [0-4] NEST OF 5 PIEZOMETERS

WELL INSTALLATION DATE:

GEOLOGIST SUPERVISING INSTALLATION: DANIEL KEOHANE / DARRYL MORGAN

GROUND SURFACE ELEVATION (FT): 1183.28 (SURVEYOR'S DISC)

TOP OF CASING ELEVATION (FT): 1185.52 (TOP PVC CASING)

WELL STICK-UP (FT): 2.24 Feet

TOTAL BORING DEPTH (FT): 58 FEET

BORING DIAMETER (IN): 9 7/8 - INCHES

TOTAL DEPTH OF OUTER CASING (FT): 58 FEET (TEMPORARY)

OUTER CASING MATERIAL: SCHEDULE 80 PVC

OUTER CASING DIAMETER (IN): 8-INCH

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): 49.1 42.0' 35.98' 29.0' 16.01'

INNER CASING MATERIAL: SCHEDULE 80 PVC

INNER CASING DIAMETER (IN): 1-INCH

TOTAL LENGTH OF WELL SCREEN (FT): 0.9' 1.0' 1.02' 0.9' 0.89

WELL SCREEN MATERIAL: SCHEDULE 80 PVC

WELL SCREEN DIAMETER (FT): 1-INCH

SCREEN SLOT SIZE (IN): 0.020-INCH

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB97-10PZ

BACKFILL MATERIAL AROUND SCREEN: COARSE SAND

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW TO

SEAL MATERIAL ABOVE SCREEN: BENTONITE (PEL PLUG OR CHIPS)

DEPTH RANGE OF SEAL (FT): SEE TABLE BELOW TO

BACKFILL MATERIAL AROUND CASING: BENTONITE

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW

DESCRIPTION OF TOP SEAL: BENTONITE TO GROUND SURFACE; PLACED AFTER PROTECTIVE CASING SET

DESCRIPTION OF WELL COVER: 10-INCH DIAMETER STEET PROTECTIVE CASING

OTHER ADDITIONAL INFORMATION: INTERVAL SCREENED IS IDENTIFIED BY NUMBER OF NOTCHES - NUMBER OF NOTCHES INCREASE WITH DECREASING DEPTH SCREENED

FORMATION SCREENED	DEPTH RANGE OF BACKFILL (Ft b.g.s)	DEPTH RANGE OF SEAL (Ft b.g.s)	SCREENED INTERVAL (Ft bgs-approx)
HAVENSVILLE	52.2 — 48.5	48.5 — 44.15	49.1 - 50
LOWER SCHROYER	44.15 — 41.0	41.0 — 38.0	42 - 43
UPPER SCHROYER	38.8 - 35.01	35.01 — 31.1/30.9	35.98 - 37
WYMORE	30.9 - 26.9	26.9 — 18.5	29 - 30
KINNEY	18.5 — 15.0	15.0 — 4.0	16 - 17

HTW DRILLING LOG

HOLE NO. OB-97-11 PZ

SHEET 1 OF 7 SHEETS

1. COMPANY NAME: Louis Berger & Associates

2. DRILLING SUBCONTRACTOR: Layne

3. PROJECT: OB/OD Area

4. LOCATION: OB/OD Range 16 Ft Riley

5. NAME OF DRILLER: Bob Knopf

6. MANUFACTURER'S DESIGNATION OF DRILL: TH-60 INGERSOLL-RAND AIR RIG

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:
air rotary 5 7/8" bit to 58'
logged from air cuttings
ream hole with 9 7/8" bit

8. HOLE LOCATION: IMMEDIATELY NORTH OF NORTH BURN PIT

9. SURFACE ELEVATION: 1182.14 feet mean sea level

10. DATE STARTED: 6-9-97

11. DATE COMPLETED: 6-9-97

12. OVERBURDEN THICKNESS: 12 Feet (RESIDUAL SOIL)

13. DEPTH DRILLED INTO ROCK: 46 Feet

14. TOTAL DEPTH OF HOLE: 58 Feet

15. DEPTH GROUNDWATER ENCOUNTERED: 14.5 Feet

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 33.61 / 6-10-97

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): 33.48 / 6-11-97 35' / 6-14-97

18. GEOTECHNICAL SAMPLES: N/A

DISTURBED	UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES: N/A

20. SAMPLES FOR CHEMICAL ANALYSIS: N/A

VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)

21. TOTAL CORE RECOVERY: N/A %

22. DISPOSITION OF HOLE

BACKFILLED	MONITORING WELL	OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR: Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1182		Very dark gray (10YR 3/1) medium plasticity, medium dilatancy, 50% fines 50% Limestone gravel (0.5cm to 3.6cm) moist, CL, no HCL reaction	hnu 0				Begin drilling with 5 7/8" bit air rotary @ 0740hrs 6-9-97
1181	1	Blue Springs SHALE					Ream w/ 9 7/8" bit air rotary @ 0950 6-9-97 Finish reaming @ 1145 6-9-97 & set 58.25 ft temporary 8" PVC casing
1180	2	grayish brown (10YR 5/2) medium plasticity, medium dilatancy, 50% fines, 50% limestone gravel (0.5cm to 3.5cm) CL, moist, no HCL reaction	0				
1179	3		0				
1178		Yellowish brown (10YR 5/6) medium plasticity, medium dilatancy, 80% fines, 20% Limestone gravel (1.0cm to 4.0cm) CL, moist calcareous					
1177	5						

MRK FORM 55

PROJECT OB/OD Area

HOLE NO. OB-97-11PZ

HTW DRILLING LOG

HOLE NO. OB-97-11-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 2 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1177	5	Slight HCL reaction	hnu				
1176	6		0				
1175	7						
1174	8	Yellowish brown (10YR 5/6) medium plasticity, medium dilatancy, 100% fines, Slight HCL reaction, Calcaeous, CL moist	0				
1173	9						
1172	10	Pale olive (5Y 6/4) medium Plasticity, medium dilatancy, 100% fines Slight HCL reaction, clcaeous, CL, dry	0				
1171	11						
1170	12	shale. Pale olive, (5Y 6/4) fine texture, blocky, soft, Strong HCL reaction, very Calcaeous, dry	0				
1169	13	Dm ~~Lime Sto~~ Kinney Limestone: Pale olive (5Y 6/3) fine to medium crystalline, hard, dense, some chert, dry					
1168	14						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-11PZ

HTW DRILLING LOG

HOLE NO. OB-97-11-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1168	14		hnu				
		Limestone: A/A, wet	0				
1167	15						
1166	16	Limestone: A/A, wet					
1165	17		0				
		Wymore					
1164	18	Shale: Light olive gray (5Y6/2) fine texture, subplaty, soft, slight HCL reaction, calcaeous, Some Fe stain, dry	0				
1163	19						
1162	20	Shale: gray (N5/) fine texture, blocky, firm, Strong HCL reaction, calcaeous, dry	0				
1161	21						
1160	22	Shale: greenish gray (5GY5/1) fine texture, blocky, firm, Strong HCL reaction, Calcaeous dry					
159	23						

HTW DRILLING LOG

HOLE NO. 0B-97-11-PZ

PROJECT 0B/0D Area

INSPECTOR Darryl Morgan

SHEET 4 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1159	23		hnu				
1158	24	Shale: A/A, dry	0				
1157	25						
1156	26	Shale A/A, dry	0				torque up
1155	27						
1154	28	Shale: dark reddish gray (2.5YR4/1) fine texture, blocky, firm, HCL reaction dry	0				
1153	29						
1152	30	Shale: grayish green (5G6/1) fine texture, blocky, firm, HCL reaction, dry	0				
1151	31						
1150	32	Shale dark reddish gray					

MRK FORM JUN 89 55-2

PROJECT 0B/0D Area

HOLE NO. 0B-97-11 PZ

HTW DRILLING LOG

HOLE NO. OB-97-11-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 5 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1150	32	(5YR 4/2) fine texture, blocky, firm, no HCL reaction, dry	hnu 0				
1149	33						
1148	34	Shale: dark greenish gray (5G4/1) fine texture, platy soft, Strong HCL reaction, calcareous, slightly moist	0				
1147	35						
1146	36	Shale: light greenish gray (5G7/1) fine texture, blocky, moderately firm, weak HCL reaction, Slightcalcaeous, dry	0 Schroyer				
1145	37	Limestone: pale yellow (2.5Y 7/4), fine crystalline, soft weathered, moist					torque up
1144	38	Limestone: A/A wet	0				
1143	39						
1142	40	Limestone: light gray (2.5Y 7/2) fine to micro crystalline, hard, dense, abundant chert, Saturated	0				
1141	41						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-11-PZ

HTW DRILLING LOG

HOLE NO. OB-97-11-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 6 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1141	41		hnu 0				
1140	42	Limestone: light gray (2.5Y7/2) fine to microcrystalline, hard, dense, with calcite, abundant chert, saturated	0				torque up drilling slowed
1139	43						
1138	44	Limestone A/A saturated	0				
1137	45						
1136	46	Limestone: A/A no chert Saturated	Havensville				smooth out
		Shale: dark gray (N4/) fine texture, platy, soft, weak HCL reaction, slightly calcareous; moist	0				
1135	47						
	4						
1134	48		0				
1133	49	Shale: A/A, no HCL reaction, dry					
1132	50						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-11-PZ

HTW DRILLING LOG

HOLE NO. 0B-97-11-PZ

PROJECT 0B/0D Area

INSPECTOR Darryl Morgan

SHEET 7 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1132	50		hnu				
			0				torque up
1131	51						smooth out
			0				
1130	52	shale: gray (N6/) fine texture, blocky, firm to hard, Strong HCL reaction, Very calcaeous, dry					
1129	53						
1128	54	Shale: gray (N6/) fine texture, blocky, firm, modrate HCL reaction, calcaeous, moist	0				torque up for 4" possible Limestone Lense smooth out
1127	55						
1126	56	Shale: gray (N6/) fine texture, blocky, firm to hard, Strong HCL reaction very calcaeous					torque up moist
1125	57		0				Set 8"ID temporary casing to 58'
1124	58	Shale: very dark gray (N3/) fine texture, platy, soft, very week HCL reaction, dry					smooth out Total Deph 58'
							finish drilling @ 0852 hrs 6-9-97

MRK FORM JUN 89 55-2

PROJECT 0B/0D Area

HOLE NO. 0B-97-11-PZ

WELL SPECIFICATION FORM

CLIENT: US ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH - 1124 D

WELL OWNER: FORT RILEY - DES

ADDRESS: BUILDING 407 MAIN POST

CITY, STATE, ZIP CODE: FORT RILEY, KANSAS 66442-6016

PHONE: (913) 239 - 3343

WELL NUMBER OR OTHER IDENTIFICATION: OB97-11PZ [0-4] NEST OF 5 PIEZOMETERS

WELL INSTALLATION DATE:

GEOLOGIST SUPERVISING INSTALLATION: DANIEL KEOHANE / DARRYL MORGAN

GROUND SURFACE ELEVATION (FT): 1182.21 (SURVEYOR'S DISC)

TOP OF CASING ELEVATION (FT): 1184.43 (TOP PVC CASING)

WELL STICK-UP (FT): 2.22 FEET

TOTAL BORING DEPTH (FT): 58 FEET

BORING DIAMETER (IN): 9 7/8 - INCH

TOTAL DEPTH OF OUTER CASING (FT): 58.25 FEET (TEMPORARY)

OUTER CASING MATERIAL: SCHEDULE 80 PVC

OUTER CASING DIAMETER (IN): 8 - INCH

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): - bgs to 1st slot - 50.02' 44.01' 36.0' 29.0' 13.0'

INNER CASING MATERIAL: SCHEDULE 80 PVC

INNER CASING DIAMETER (IN): 1 INCH

TOTAL LENGTH OF WELL SCREEN (FT): 1st - last slot - 0.88' 0.89' 0.9' 0.9' 0.9'

WELL SCREEN MATERIAL: SCHEDULE 80 PVC

WELL SCREEN DIAMETER (FT): 1 INCH

SCREEN SLOT SIZE (IN): 0.020 INCH

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB97-11 PZ

BACKFILL MATERIAL AROUND SCREEN: COARSE SAND

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW TO

SEAL MATERIAL ABOVE SCREEN: BENTONITE (PEL PLUG OR CHIPS)

DEPTH RANGE OF SEAL (FT): SEE TABLE BELOW TO

BACKFILL MATERIAL AROUND CASING: BENTONITE

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW

DESCRIPTION OF TOP SEAL: BENTONITE TO GROUND SURFACE; PLACED AFTER PROTECTIVE CASING SET

DESCRIPTION OF WELL COVER: 10-INCH DIAMETER STEEL PROTECTIVE CASING

OTHER ADDITIONAL INFORMATION: INTERVAL SCREENED IS IDENTIFIED BY NUMBER OF NOTCHES - NUMBER OF NOTCHES INCREASE WITH DECREASING DEPTH SCREENED

FORMATION SCREENED	DEPTH RANGE OF BACKFILL (Ft. bgs)	DEPTH RANGE OF SEAL (Ft bgs)	INTERVAL SCREENED (Ft bgs)
HAVENSVILLE	~~48~~ 53.1 — 49.0	49.0 - 46.2	50 - 51
LOWER SCHROYER	46.2 — 42.9	42.9 — 38.3/38.1	44 - 45
UPPER SCHROYER	38.1 — 35.0	35.0 — 31.0/30.9	36 - 37 ~~29 - 30~~
WYMORE	30.9 — 27.9	27.9 — 15.3	29 - 30
KINNEY	15.3 — 12.0	12.0 - 4.0	13 - 14

HTW DRILLING LOG

HOLE NO. OB-97-12PZ

1. COMPANY NAME: Louis Berger & Associates
2. DRILLING SUBCONTRACTOR: Layne

SHEET 1 OF 7 SHEETS

3. PROJECT: OB/OD Area
4. LOCATION: OB/OD Area Range 16 Ft Riley
5. NAME OF DRILLER: Bob Knopf
6. MANUFACTURER'S DESIGNATION OF DRILL: TH-60 INGERSOLL-RAND AIR RIG
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: air rotary 5 7/8" bit to 58'
Logged hole from air cuttings
ream hole with 9 7/8" bit
8. HOLE LOCATION: ~150 FEET NORTH OF OB97-05
9. SURFACE ELEVATION: 1183.07
10. DATE STARTED: 6-5-97
11. DATE COMPLETED: 6-5-97
12. OVERBURDEN THICKNESS: 14 Feet (residual soil)
13. DEPTH DRILLED INTO ROCK: 44 Feet
14. TOTAL DEPTH OF HOLE: 58'
15. DEPTH GROUNDWATER ENCOUNTERED: 20 Feet
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 37.10 feet / 6-9-97
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): 37.10 Feet / 6-10-97 & 36.38 Feet / 6-11-97
18. GEOTECHNICAL SAMPLES: N/A — DISTURBED: — UNDISTURBED:
19. TOTAL NUMBER OF CORE BOXES: N/A
20. SAMPLES FOR CHEMICAL ANALYSIS: N/A — VOC: — METALS: — OTHER (SPECIFY): — OTHER (SPECIFY): — OTHER (SPECIFY):
21. TOTAL CORE RECOVERY: N/A %
22. DISPOSITION OF HOLE — BACKFILLED: — MONITORING WELL: — OTHER (SPECIFY): Nested piezometer
23. SIGNATURE OF INSPECTOR: Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1183		Black (2.5Y 2.5/1) moist, medium plasticity, medium dilatancy, CL - Loam 100% fines	hnu 0				Drilling with 5 7/8" bit 6-5-97 1215hrs air rotary
1182	1						
1181	2	Blue Springs Shale very dark grayish brown (10YR 3/2) moist, medium plasticity, medium dilatancy, CL, 100% fines					
1180	3						
1179	4		0				
1178	5						

PROJECT: OB/OD Area

HOLE NO. OB-97-12 PZ

MRK FORM 55

HTW DRILLING LOG

HOLE NO. OB-97-RRZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 2 OF [illegible] SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
[illegible]			mdl 0				
1177	6	very dark grayish brown, (10YR 3/2) dry, medium plasticity, medium dilatancy, CL, 90% fines, 10% limestone fragments (0.5cm to 1cm)					
1176	7						
1175	8		0				
1174	9	Dusky Red (2.5YR 3/2) [illegible] medium plasticity, medium dilatancy, CL (60% fines, 40% limestone and chert fragments (0.5cm to 2cm)					
1173	10		0				
1172	11						
1171	12						
1170	13		0				
[illegible]	14	[illegible] Limestone — [illegible]					

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-RRZ

HTW DRILLING LOG

HOLE NO. 0B-97-12PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1169	14	fine texture, soft, calraceous HCL reaction, 100% fines	hnu 0				
1168	15						
1167	16		0				
1166	17	WYMORE SHALE					
1165	18	gray (N5/) dry, fine texture blocky, soft to firm, weak HCL reaction, 100% fines, dry					
1164	19		0				
1163	20	pale green (5G 7/2) moist, fine texture, soft, HCL reaction, 100% fines,	0				
1162	21						
1161	22						
1160	23						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-12PZ

HTW DRILLING LOG

HOLE NO. OB-97-12 PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 4 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1160	23		hnu 0				
1159	24						
1158	25	Shale: dark gray (4/N4/) dry fine texture, blocky, firm, HCL reaction, Calcaeous, 100% fines, dry	0				
1157	26						
1156	27		0				
1155	28	A/A					
1154	29		0				
1153	30						
1152	31	Limestone: (N7/) light gray, fine crystalline, weathered, firm, moist	0				torque up
1151	32						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-12 PZ

HTW DRILLING LOG

HOLE NO. OB-97-12PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 5 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1151	32	Shale: light gray (7N7/), fine texture, firm, blocky 100% fines	hnu 0				
1156	33						
1149	34		0				
1148	35		0				
1147	36	Schroyer Limestone: light gray (7/N7/), wet, fine crystalline, hard, dense,					drilling slower
1146	37						
1145	38	A/A: saturated @ 38'	0				
1144	39						
1143	40	Limestone: Very dark gray, (N3/) fine to micro crystalline, hard, dense, abundant chert	0				Torque up drilling slower
1142	41						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-12PZ

HTW DRILLING LOG

HOLE NO. OB97-12PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 6 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1142	41	saturated	hnu 0				
1141	42						
1140	43	Limestone: (N/7/) Light gray, fine to microcrystalline hard, dense, some gypsum saturated	0				
1139	44						
1138	45	Havensville Shale: very dark gray (N/3) fine texture, blocky, firm, Caleeaous, HCL reaction. dry	0				drilling smooth out
1137	46						
1136	47		0				
1135	48						
1134	49		0				
1133	50	Limestone: Very dark gray					torque up

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-12PZ

HTW DRILLING LOG

HOLE NO. OB-97-12-PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 7 OF 7 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1133	50	fine crystalline, hard, dense, argilleaous, moist	hnu 0				
1132	51						
1131	52	Shale: very dark gray (N/3) fine texture, blocky, firm, calcaeous, HCL reaction dry	0				drilling smooth out
1130	53						
1129	54		0				
1128	55						Torque up
1127	56	Limestone: very dark gray (N/3), fine crystalline, hard, dense, argilleaous, moist Shale: very dark gray (N/3) fine texture, blocky, firm, calcaeous, HCL reaction dry	0				drilling smooth out
1126	57						ream hole with 9 7/8" bit to 58' Stared@1400hrs Ended@ 1620hrs set 8" ID PVC temporary casing to 58' Ended 1715hrs end drilling @ 1330 hrs 6-5-9
1125	58	Total Depth	0				While reaming Sticking in ho' 31 to 25'

PROJECT OB/OD Area

HOLE NO. OB-97-12PZ

MRK FORM JUN 89 55-2

WELL SPECIFICATION FORM

CLIENT: U.S. ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH- 1124 D

WELL OWNER: FORT RILEY -DEH

ADDRESS: BUILDING 407 MAIN POST

CITY, STATE, ZIP CODE: FORT RILEY, KANSAS 66442-6016

PHONE: (913) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB97-12PZ (0-4) NEST OF 5 PIEZOMETERS

WELL INSTALLATION DATE:

GEOLOGIST SUPERVISING INSTALLATION: DANIEL KEOHANE / DARRYL MORGAN

GROUND SURFACE ELEVATION (FT): 1183.24 (SURVEYORS DISC)

TOP OF CASING ELEVATION (FT): 1185.65 (TOP PVC CASING)

WELL STICK-UP (FT): 2.41 FEET

TOTAL BORING DEPTH (FT): 58 FEET

BORING DIAMETER (IN): 9 7/8 - INCH

TOTAL DEPTH OF OUTER CASING (FT): 58.3 (TEMPORARY)

OUTER CASING MATERIAL: SCHEDULE 80 PVC

OUTER CASING DIAMETER (IN): 8-INCH

b.g.s to 1st slot

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): 49.99 44.0 35.99 29.0' 14.0'

INNER CASING MATERIAL: SCHEDULE 80 PVC

INNER CASING DIAMETER (IN): 1 INCH

TOTAL LENGTH OF WELL SCREEN (FT): [1st-last slot] 0.91' 0.9' 0.91' 0.9' 0.9'

WELL SCREEN MATERIAL: SCHEDULE 80 PVC

WELL SCREEN DIAMETER (FT): 1 -INCH

SCREEN SLOT SIZE (IN): 0.020 INCH

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB97-12 PZ

BACKFILL MATERIAL AROUND SCREEN: COARSE SAND (10-20)

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW TO

SEAL MATERIAL ABOVE SCREEN: BENTONITE (PEL PLUG & CHIPS)

DEPTH RANGE OF SEAL (FT): SEE TABLE BELOW. TO

BACKFILL MATERIAL AROUND CASING: BENTONITE

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW.

DESCRIPTION OF TOP SEAL: BENTONITE TO GROUND SURFACE; PLACED AFTER PROTECTIVE CASING SET

DESCRIPTION OF WELL COVER: 10-INCH DIAMETER STEEL PROTECTIVE CASING.

OTHER ADDITIONAL INFORMATION: INTERVAL SCREENED IS IDENTIFIED BY NUMBER OF NOTCHES - NUMBER OF NOTCHES INCREASE WITH DECREASING DEPTH SCREENED.

FORMATION SCREENED	DEPTH RANGE OF BACKFILL (Ft b.g.s)	DEPTH RANGE OF SEAL (Ft b.g.s)	INTERVAL SCREENED (Ft b.g.s) - APPROX
HAVENSVILLE	53.5 — 49.0	49.0 - 46.4'/46.3	50 - 51
LOWER SCHROYER	46.3 — 43.0	43.0 - 38.5'/38.45'	44 - 45
UPPER SCHROYER	38.45 — 35.0	35.0 — 31.3'/31.2'	36 - 37
WYMORE	31.2' — 27.9	27.9 — 16.5/16.3'	29 - 30
KINNEY	16.3' — 12.8'	12.8 - 4.0	14 - 15

HTW DRILLING LOG

HOLE NO. 0B-97-13PZ

1. COMPANY NAME Louis Berger & Associates
2. DRILLING SUBCONTRACTOR Layne

SHEET 1 OF 5 SHEETS

3. PROJECT OB/OD Area
4. LOCATION 0B-97-13PZ, OB/OD Area Range 16 Ft Riley
5. NAME OF DRILLER Bob Knoof
6. MANUFACTURER'S DESIGNATION OF DRILL TH-60 INGERSOL-RAND AIR RIG
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT
air rotary 5 7/8" bit to [illegible]
logged from air cuttings
ream hole with 9 7/8" bit
Core from 17.4' to 26.5'
~~[illegible]~~ DM
8. HOLE LOCATION ADJACENT TO 0B95-04 & 0B97-07
9. SURFACE ELEVATION 1157.69 feet mean sea level
10. DATE STARTED 6-3-97
11. DATE COMPLETED 6-4-97
12. OVERBURDEN THICKNESS 17.5 Feet (RESIDUAL SOIL)
13. DEPTH DRILLED INTO ROCK 20.5 Feet
14. TOTAL DEPTH OF HOLE 38'
15. DEPTH GROUNDWATER ENCOUNTERED 15 feet
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED 37.58 Feet / 6-7-97
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) 37.57 / 6-9-97 37.51 / 6-10-97
18. GEOTECHNICAL SAMPLES N/A

DISTURBED	UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES 4
20. SAMPLES FOR CHEMICAL ANALYSIS N/A

VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)

21. TOTAL CORE RECOVERY 50 %
22. DISPOSITION OF HOLE

BACKFILLED	MONITORING WELL	OTHER (SPECIFY)
		nested piezometer

23. SIGNATURE OF INSPECTOR Darryl Morgan

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1158		0.0 - 4.8' very dark grayish brown (10 YR 3/2) (100% fine) (moist) medium plasticity, medium dilatancy. CL	hnu 0				1730 hrs 6/3/97 Begin drilling w/ 5 7/8" bit air rotary
DM ~~1159~~ 1157	1						
DM ~~1160~~ 1156	2						
DM ~~1161~~ 1155	3						
DM ~~1162~~ 1154	4						
		Wymore Shale ~~Blue Springs Shale~~ or					
1153 DM ~~1163~~	5	4.8 - 6.5 continued on next page					

MRK FORM JUN 89 55

PROJECT OB/OD Area

HOLE NO. 0B-97-13PZ

HTW DRILLING LOG

HOLE NO. 0B-97-13 PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 2 OF 5 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		4.8-6.5 dusky red (2.5YR 3/3) (100% fine) dry, medium plasticity, medium dilantancy, CL			17.5'		
1152 DM ~~1166~~	6						
		6.5-7.2 light greenish gray (5GY7/1) 85% fines 15% fine gravel Limestone (weathered) angular (0.5cm to 1cm) Dusky red (2.5YR 3/2) 85% fines, dry, medium plasticity medium dilantanty, CL					
1151 DM ~~1167~~	7						
1150 DM ~~1168~~	8						
1149 DM ~~1169~~	9						
1148 DM ~~1170~~	10						
1147 DM ~~1171~~	11						
1146 DM ~~1172~~	12.	12.0-14.0 dark reddish gray (2.5YR4/1) 85% fines 15% fine to coarse gravel (Limestone-weathered) CL-medium plasticity, medium dilatancy, fragments-angular (0.5 to 2.0cm) wet @ 13.0'					
1145 DM ~~1173~~	13						wet @ 13.0' Hand auger @13.5' @ 1215hrs
1144 DM ~~1174~~	14	Saturated @ 14.0'					saturated @ 14.0'

HTW DRILLING LOG

HOLE NO. OB-97-13PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 3 OF 5 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
			hnu 0				
1143 DM ~~1175~~	15						
1142 DM ~~1176~~	16	Dark reddish gray (2.5YR 4/4) 75% fines 25% (fine to coarse gravel - Limestone) medium dilatancy, medium plasticity - CL fragments - angular (0.5cm to 2.0 cm)	0				Ream hole with 5 7/8" bit set temporary 4" PVC casing to 17' Hand auger refusal @ 17.4' @ 1245 hrs
1141 DM ~~1177~~	17	Schroyer Limestone Light gray (2.5Y 7/2) fine crystalline, hard, dense, argillaceous, cherty, Very fossiliferous @ 18' (shell fragments)		begin run #1 @ 1406 hrs @ 17.4'			coring begin @1405 6-9-97 @ 17.4'; 1 7/8" core barrel, rubble zone encounter @ 18.5' communication between OB-97-13PZ and OB-97-07 air forcing water out of OB-97-07 casing
1140 DM ~~1178~~	18						
1139 DM ~~1179~~	19	A/A Vuggy zone @ 18.5' to 19.0'	0	RQD=8%			
1138 DM ~~1180~~	20			~~recovery=2.1'~~ DM ~~end run #1~~ ~~[illegible]~~ ~~begin run #2~~ ~~@ 1455hrs~~ ~~@ 22.2'~~			
1137 DM ~~1181~~	21						
1136 DM ~~1182~~	22	5Y 7/3 (pale yellow) fine crystalline, hard, dense, gypsum nodules	Hnu 0	recovery 2.4' end run #1 @ 1425 hrs begin run #2 @ 1455 @ 22.2' RQD = 42%			
1135 DM ~~1183~~	2.5						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-13PZ

HTW DRILLING LOG

HOLE NO. OB-97-13PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 4 OF 5 SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
	23		hnu 0	recovery 0.9 end run #2 23.4' @ 1505 begin run #3 @ 1530h @ 23.4'			
1134	24	Havensville Shale Verydarkgray(N3/) dry,					Lost 1.5' of core on 4 core damaged lost core retieved core ream hole with 5 7/8" bit set temporary casing to 26.5'
1133	25		0				
1132	26			recovery 1.5' end run #3 @ 1655 hrs Begin run #4 @ 1130 hrs 6-4/97 End run 1140 No recovery Stop coring			ream hole with 9 7/8" bit, logged hole from Cuttings from 26.5'
1131	27	Shale: dark gray (4N4/) fine texture, blocky, firm, calcaeous					
1130	28		0				
1129	29						
1128	30	Shale: A/A					
1127	31		0				
1126	32						

MRK FORM JUN 89 55-2

PROJECT OB/OD Area

HOLE NO. OB-97-13PZ

HTW DRILLING LOG

HOLE NO. OB-97-15PZ

PROJECT OB/OD Area

INSPECTOR Darryl Morgan

SHEET 5 **OF** 5 **SHEETS**

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
			hnu				
			0				
125	33						
124	34		0				
123	35'	Shale: dark gray (4/N4/) fine texture, blocky, soft-firm, slightly calcaeous					
122	36		0				
121	57						
120	38	Total Depth	0				Set temporary ID casing to 38.' (finished reaming) finished 6-4-97

PROJECT OB/OD Area

HOLE NO. OB-97-15PZ

MRK FORM JUN 89 55-2

WELL SPECIFICATION FORM

CLIENT: US ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

JOB NUMBER: JH - 1124 D

WELL OWNER: FORT RILEY - DEH

ADDRESS: BUILDING 407 MAIN POST

CITY, STATE, ZIP CODE: FORT RILEY, KANSAS 66442-6016

PHONE: (913) 239-3343

WELL NUMBER OR OTHER IDENTIFICATION: OB97-13PZ (0-4) NEST OF 5 PIEZOMETERS

WELL INSTALLATION DATE:

GEOLOGIST SUPERVISING INSTALLATION: DANIEL KEOHANE / DARRYL MORGAN

GROUND SURFACE ELEVATION (FT): 1157.92 (SURVEYORS DISC)

TOP OF CASING ELEVATION (FT): 1160.15 (TOP PVC CASING)

WELL STICK-UP (FT): 2.23 FEET

TOTAL BORING DEPTH (FT): ~~37.8 FEET (TEMPORARY)~~ 38 FEET

BORING DIAMETER (IN): 9 7/8 INCH

TOTAL DEPTH OF OUTER CASING (FT): 37.8 Feet (TEMPORARY).

OUTER CASING MATERIAL: SCHEDULE 80 PVC

OUTER CASING DIAMETER (IN): 3 - INCH

TOTAL DEPTH OF INNER CASING (FT. EXCLUDING SCREEN): b.g.s to 1st Slot - 30' 25.99' 20.99' 16.5' 10.99'

INNER CASING MATERIAL: SCHEDULE 80 PVC

INNER CASING DIAMETER (IN): 1 - INCH

TOTAL LENGTH OF WELL SCREEN (FT): 1st - last Slot : 0.91' 0.91' 0.91' 0.9' 0.91'

WELL SCREEN MATERIAL: SCHEDULE 80 PVC

WELL SCREEN DIAMETER (FT): 1 - INCH

SCREEN SLOT SIZE (IN): 0.020 INCH

WELL SPECIFICATION FORM (Cont'd)

WELL NUMBER: OB97 - 13PZ

BACKFILL MATERIAL AROUND SCREEN: COARSE SAND (10-20)

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW TO

SEAL MATERIAL ABOVE SCREEN: BENTONITE (PEL PLUG OR CHIPS)

DEPTH RANGE OF SEAL (FT): SEE TABLE BELOW TO

BACKFILL MATERIAL AROUND CASING: BENTONITE

DEPTH RANGE OF BACKFILL (FT): SEE TABLE BELOW

DESCRIPTION OF TOP SEAL: BENTONITE TO GROUNDSURFACE: PLACED AFTER PROTECTIVE CASING SET.

DESCRIPTION OF WELL COVER: 10-INCH DIAMETER STEEL PROTECTIVE CASING

OTHER ADDITIONAL INFORMATION: INTERVAL SCREENED IS IDENTIFIED BY NUMBER OF NOTCHES - NUMBER OF NOTCHES INCREASE WITH DECREASING DEPTH SCREENED.

FORMATION SCREENED	DEPTH RANGE OF BACKFILL (Ft bgs)	DEPTH RANGE OF SEAL (Ft bgs)	INTERVAL SCREENED (Ft bgs)-APPROX
LOWER HAVENSVILLE	32.0 - 29.5	29.5 - 27.7	30 - 31
UPPER HAVENSVILLE	27.7 - 25.0	25.0 - 23.2/23.1	26 - 27
LOWER SCHROYER	23.1 - 20.0	20.0 - 18.1/17.9	21 - 22
UPPER SCHROYER	17.9 - 15.5	15.5 - 13.3/13.1	16.5 - 17.5
OVERBURDEN	13.1 - 9.8	9.8 - 4.0	11 - 12

WELL NUMBER OB93-01

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA Ft RILEY

Project Number JH-1124 D

DATE 9-4-97

Sampler(s) DAN KEOHANE/Darryl Morgan/Tim Berry

Date Well Installed

Elapsed Time since grouting N/Ap

~~**Development**~~/[✓ **Purge**] **Method** Bladder Pump

VOLUME OF CASING

1. Depth of Well: 42.14 ft
2. Depth to Top of Water 33.01 ft
3. Height of Water 9.13 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. **One Casing Volume** 1.6 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 2 in

1. Height of Water 9.13 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ ~20% x 020 % porosity
4. **One Annulus Volume** 7.3 gal

ONE TOTAL WELL VOLUME 8.9 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		9	18				27
Time (24 hr)	0841	0855	0910				0926
Conductivity (µS/cm)	610	600	600				610
Dissolved Oxygen (ppm)	—	—	—				—
Eh (mV)	—	—	—				—
pH (S.U.)	6.83	7.00	7.02				7.01
Temperature (°C)	13.2	13.0	12.9				12.9
Turbidity (NTU)	34.8	7.42	3.14				2.76

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 33.03 (after sampling)

NOTES: Sample collected @ 0926 for VOA analysis
HCL Preserved
PID = 0.0 ppm

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER 0893-02

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD Area Ft Riley

Project Number JH-1124D

DATE 9-4-97

Sampler(s) Dan Keohane / Darryl Morgan / Tim Berry

Date Well Installed

Elapsed Time since grouting N/Ap

~~Development~~ / [✓ Purge] Method Bladder Pump

VOLUME OF CASING

1. Depth of Well: 73.88 ft
2. Depth to Top of Water 59.41 ft
3. Height of Water 14.47 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. One Casing Volume 2.5 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 2 in

1. Height of Water 14.47 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ 20% x 0.20 % porosity
4. One Annulus Volume 11.5 gal

ONE TOTAL WELL VOLUME 14 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		14	28				~~1022~~
Time (24 hr)	0847	0916	0944				1022
Conductivity (µS/cm)	710	740	710				700
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (Ft)	59.41	60.25	60.30				60.25
pH (S.U.)	6.39	7.03	7.06				7.05
Temperature (°C)	15.0	14.0	14.1				14.1
Turbidity (NTU)	7200	60.25	5.45				4.54

42

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 60.25 (after sampling)

NOTES: Sample was collected @ 1022 for VOA Analysis - HCL Preserved. PID - 0.0 ppm.

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-03

WELL ~~DEVELOPMENT~~ [✓ PURGE] LOG

Project Name OB/OD AREA Ft. RiLEY

Project Number JH-1124D

DATE 9-3-97

Sampler(s) Dan KEOHANE / Darryl Morgan
Tim BERRY

Date Well Installed

Elapsed Time since grouting N/Ap

~~Development~~ [✓ Purge] Method Bladder Pump

VOLUME OF CASING

1. Depth of Well: 79.30 ft
2. Depth to Top of Water 53.53 ft
3. Height of Water 25.77 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. **One Casing Volume** 4.4 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 2 in

1. Height of Water 17 ft (15' screen + 2' sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ ~~30~~20% x 0.20 % porosity
4. **One Annulus Volume** 13.6 gal

ONE TOTAL WELL VOLUME 18 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		18	36				54
Time (24 hr)	0919	1004	1118				1154
Conductivity (µS/cm)	—	—	—				—
~~issolved Oxygen (ppm)~~	4200	930	910				900
~~h (mV)~~ DTW (Ft)	53.53	53.65	53.65				53.60
pH (S.U.)	7.09	7.04	7.02				7.01
Temperature (°C)	15.0	15.0	15.0				15.0
Turbidity (NTU)	7200	39.5	33.0				26.2

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/A

Sounded Depth After Development N/Ap

Water Level After Purging 53.60 (after sample)

NOTES: Collect Sample @ 1154 For VOA analysis - HCL Preserved.
PID-0ppm

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB93-04

WELL ~~DEVELOPMENT~~ /[✓ PURGE] LOG

Project Name OB/OD AREA Ft Riley

Project Number JH-1124D

DATE 9-3-97

Sampler(s) Dan Keohane / Darryl Morgan
Tim Berry

Date Well Installed

Elapsed Time since grouting N/Ap

~~Development~~/[✓ Purge] Method Bladder Pump

VOLUME OF CASING

1. Depth of Well: 58.27 ft
2. Depth to Top of Water 38.73 ft
3. Height of Water 19.54 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. One Casing Volume 3.3 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 2 in

1. Height of Water 17 ft (15' screen + 2' sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ ~20% x 0.20 % porosity
4. One Annulus Volume 13.6 gal

ONE TOTAL WELL VOLUME 16.9 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons	[redacted]	17	34				51
Time (24 hr)	1253	1323	1410				1441
Conductivity (µS/cm)	2100	910	900				870
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (Ft)	38.76	38.76	38.82				38.79
pH (S.U.)	6.76	6.82	6.81				6.79
Temperature (°C)	14	14	14				14
Turbidity (NTU)	>200	29.4	7.37				5.23

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 38.79 (after sampling)

NOTES: PID - 0.0. Collect Sample @ 1441 for VOA analysis - HCL Preserved.

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	*3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-05

WELL ~~DEVELOPMENT /~~ [✓ PURGE] LOG

Project Name OB/OD AREA Ft RILEY

Project Number JH-1124 D

DATE 9-3-97

Sampler(s) Dan Keohane / Darryl Morgan
Tim Berry

Date Well Installed MARCH 97

Elapsed Time since grouting N/Ap

~~Development/~~ [✓ Purge] Method Bladder Pump

VOLUME OF CASING

1. Depth of Well: 71.94 ft
2. Depth to Top of Water 58.84 ft
3. Height of Water 13.10 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. **One Casing Volume** 2.2 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 2 in

1. Height of Water 12 ft (10 Ft screen + 2 Ft Sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 9.6 gal

ONE TOTAL WELL VOLUME 11.80 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		12	24				36
Time (24 hr)	1543	1617	1640				1705
Conductivity (µS/cm)	970	750	770				750
)issolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (Ft)	58.84	58.85	58.85				58.85
pH (S.U.)	7.16	7.02	7.04				7.04
Temperature (°C)	15	15	15				15
Turbidity (NTU)	181.7	17.2	6.07				4.34

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 58.85 (after sampling)

NOTES: Collect Sample @ 1706 FOR VOA analysis ~~[illegible]~~ - HCL-Preserved - PID - 0.0 ppm.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-06

WELL ~~DEVELOPMENT~~ [✓ PURGE] LOG

Project Name OB/OD AREA Ft Riley **Project Number** JH-1124D **DATE** 9-3-97

Sampler(s) Dan Keohane Daryl Morgan Tim Berry **Date Well Installed** MARCH 97

Elapsed Time since grouting N/Ap **~~Development~~/[✓ Purge] Method** Bladder Pump

VOLUME OF CASING

1. Depth of Well: 38.53 ft
2. Depth to Top of Water 24.75 ft
3. Height of Water 13.78 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. **One Casing Volume** 2.3 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 2 in

1. Height of Water 13.78 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 11 gal

ONE TOTAL WELL VOLUME 13.3 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		14	28				42
Time (24 hr)	1000	1036	1136				1204
Conductivity (µS/cm)	1260	610	620				620
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (Ft)	24.75	24.79	24.79				24.77
pH (S.U.)	11.02	7.01	7.00				7.01
Temperature (°C)	15	15	15				15
Turbidity (NTU)	130.9	15.60	7.46				6.52.

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 24.77 (after sampling)

NOTES: PID: 0.0ppm Sample collected @ 120 for VOA analysis HCL preserved.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-~~05~~07 DK

WELL ~~DEVELOPMENT~~ [✓ PURGE] LOG

Project Name OB/OD Area Ft Riley Project Number JH-1124 D DATE 9-3-97

Sampler(s) Dan Keohane Darryl Morgan Tim Berry Date Well Installed March 97

Elapsed Time since grouting N/Ap ~~Development~~/[✓ Purge] Method Bladder Pump

---

VOLUME OF CASING

1. Depth of Well: 31.99 ft
2. Depth to Top of Water 15.57 ft
3. Height of Water 16.42 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. **One Casing Volume** 2.8 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 2 in

1. Height of Water 12 ft (10 Ft screen + 2 Ft sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ 30% x 0.30 % porosity
4. **One Annulus Volume** 9.6 gal

ONE TOTAL WELL VOLUME 12.4 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		13	26				39
Time (24 hr)	1243	1306	1345				1415
Conductivity (µS/cm)	690	860	840				840
ssolved Oxygen (ppm)	—	—	—				—
~~a (mV)~~ DTW (Ft)	15.58	15.60	15.72				15.63
pH (S.U.)	6.86	6.82	6.80				6.81
Temperature (°C)	14	14	14				14
Turbidity (NTU)	7200	104.2	30.4				22.6

Photo Taken YES ☐ NO ☑ Photo No. N/Ap

Water Level After Development N/Ap Sounded Depth After Development N/Ap

Water Level After Purging 15.63 (after sampling)

NOTES: Collect sample @ 1415 For VOA analysis - HCL Preserved also collect MS/MSD, MRD and Duplicate labelled OB97-04 time 1445 PID - 0.0 ppm.

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-08

WELL-~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA Ft Riley

Project Number JH-1124D

DATE 9-3-97

Sampler(s) Dan Keohane / Darryl Morgan Tim Berry

Date Well Installed MARCH 97

Elapsed Time since grouting N/Ap

~~Development~~ / [✓ Purge] Method Bladder Pump

VOLUME OF CASING

1. Depth of Well: 20.40 ft
2. Depth to Top of Water 17.61 ft
3. Height of Water 2.79 ft

Casing Diameter: 2 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.17 gal
5. One Casing Volume 0.5 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 2 in

1. Height of Water 2.79 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.06 gal
3. Porosity @ 30% x 0.30 % porosity
4. One Annulus Volume 2.2 gal

ONE TOTAL WELL VOLUME 2.7 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		3	6				7
Time (24 hr)	1558	1645	1720				1749
Conductivity (µS/cm)	1400	530	670				670
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (Ft)	17.61	—	—				—
pH (S.U.)	7.04	7.04	6.97				6.99
Temperature (°C)	15.7	16.0	16.0				16.0
Turbidity (NTU)	137.5	7.56	4.40				2.38

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging NM (after sampling) - below pump.

NOTES: PID - 0.0 ppm. : Unable to measure water level during pumping as water level was below top of pump. Collect Sampled @ 1750 FOR VOA analysis - HCL Preserved.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-09P2(0)

WELL ~~DEVELOPMENT~~ PURGE LOG

Project Name OBJOD AREA, Ft RILEY
Project Number JH-1124D
DATE 9-5-97

Sampler(s) DAN KEOHANE Daryl Morgan TIM BERRY
Date Well Installed June 97

Elapsed Time since grouting NAp
~~Development~~ Purge Method Disposable bailer

VOLUME OF CASING

1. Depth of Well: 113.10 ft
2. Depth to Top of Water 91.24 ft
3. Height of Water 21.86 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.9 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~ 4.1 gal
3. Porosity @ 20% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 2.5 gal

PARAMETER	INITIAL	~~1 VOL.~~	~~2 VOL.~~	~~3 VOL.~~	~~4 VOL.~~	1 ~~5~~VOL.	FINAL
Gallons	▨	0.25	0.75	1.25	1.5	2	2.1
Time (24 hr)	0910	0925	0955	1045	1107	1145	1205
Conductivity (µS/cm)	1160	—	—	—	—	—	1980
Dissolved Oxygen (ppm)	91.24	95.40	99.28	104.51	107.05	110.09	110.88
~~Eh (mV)~~ (DTW (Ft)	~~91.24~~	—	—	—	—	—	—
pH (S.U.)	6.62	—	—	—	—	—	7.16
Temperature (°C)	15.1	—	—	—	—	—	16.2
Turbidity (NTU)	13.06	—	—	—	—	—	7200

Photo Taken ☐ YES ☑ NO
Photo No. N/Ap

Water Level After Development N/Ap
Sounded Depth After Development N/Ap

Water Level After Purging 110.88 (after Sample

NOTES: Sample Collected @ 1150 - VOA analysis - unpreserved
PID 0.0ppm
Well was going dry - so collected sample after ~ 1 ~~well~~ purge vol.

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-09PZ(1)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD Area Ft Riley **Project Number** JH-1124D **DATE** 9-5-97

Sampler(s) Dan Keohane Daryl Morgan Tim Berry **Date Well Installed** June 97

Elapsed Time since grouting N/Ap ~~Development~~/[✓ Purge] **Method** Jiggle tube

VOLUME OF CASING

1. Depth of Well: 107.30 ft
2. Depth to Top of Water 100.40 ft
3. Height of Water 6.9 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.3 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~41 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 1.9 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons	▨	2	4				6
Time (24 hr)	0955	1032	1110				1216
Conductivity (µS/cm)	1170	1590	1330				1180
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (ft)	100.4	—	—				—
pH (S.U.)	7.09	7.01	7.04				7.18
Temperature (°C)	17.9	16.3	16.8				16.2
Turbidity (NTU)	86.3	2200	116.8				101.9.

Photo Taken ☐ YES ☑ NO Photo No. N/Ap

Water Level After Development N/Ap Sounded Depth After Development N/Ap

Water Level After Purging 100.40 (after sample

NOTES: Collect sample @ 1212 - VOA analyis - HCL Preserved.
PID - 0.0 ppm.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-09PZ(3)

WELL ~~DEVELOPMENT~~ / PURGE LOG

Project Name OB/OD Area Ft Riley
Project Number JH-1124D
DATE 9-5-97
Sampler(s) Dan Keehane / Darryl Morgan
Time Berry
Date Well Installed June 97
Elapsed Time since grouting N/Ap
~~Development~~/Purge Method Disposable Bailer

VOLUME OF CASING

1. Depth of Well: 78.13 ft
2. Depth to Top of Water 77.29 ft
3. Height of Water 0.84 ft
Casing Diameter: 1 in.
4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. One Casing Volume 0.03 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in
1. Height of Water 0.84 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. One Annulus Volume 0.69 gal

ONE TOTAL WELL VOLUME 0.72 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1250						
Conductivity (µS/cm)	1270						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft)	77.29						
pH (S.U.)	7.12						
Temperature (°C)	15.5						
Turbidity (NTU)	>200						

Photo Taken ☐ YES ☑ NO
Photo No. N/Ap

Water Level After Development N/Ap
Sounded Depth After Development N/Ap

Water Level After Purging 77.63 (after sample)

NOTES: Sample collect @ 1300 - VOA analysis Unpreserved
PID - 0.0
Sample collected immediately after parameters taken as piezometer running dry.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-09 PZ(4)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD Area Ft Riley

Project Number JH-1124 D

DATE 9-5-97

Sampler(s) Dan Keohane Darryl Morgan
Tim BERRY

Date Well Installed June 97

Elapsed Time since grouting N/Ap

~~Development~~/[✓ Purge] Method Disposable Bailer

VOLUME OF CASING

1. Depth of Well: 55.10 ft
2. Depth to Top of Water 54.01 ft
3. Height of Water 1.09 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.04 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 1.09 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 0.89 gal

ONE TOTAL WELL VOLUME 0.93 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1330						
Conductivity (µS/cm)	1180						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft)	54.01						
pH (S.U.)	7.09						
Temperature (°C)	15.8						
Turbidity (NTU)	>200						

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 54.71 (after sampling)

NOTES: Sample Collected @ 1335 - VOA analysis - Unpreserved. PID-0.0ppm. Sample collected immediately after parameters taken as piezometer running dry.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-10PZ (c)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA Ft Riley **Project Number** JH-1124 D **DATE** 9-4-97

Sampler(s) Dan Keohane, Darryl Morgan, Tim Berry **Date Well Installed** May 97

Elapsed Time since grouting N/Ap **~~Development~~/[✓ Purge] Method** Jiggle tube

---

VOLUME OF CASING

1. Depth of Well: 53.40 ft
2. Depth to Top of Water 36.71 ft
3. Height of Water 16.69 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.7 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft (1 ft screen + sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 2.3 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1005						
Conductivity (µS/cm)	4100						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft)	16.69						
pH (S.U.)	6.64						
Temperature (°C)	14.8						
Turbidity (NTU)	>200						

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 51.39 (after Sampling)

NOTES: Well ~~well~~ went dry after ~0.25 gal. Strong H_2SO_4 odor from water - PID -0 in well but >2000 ppm headspace. Water contaminated. Collect sample @ 1240 for VOA analysis - unpreserved.

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-10PZ(i)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA Ft RILEY

Project Number JH-1124 D

DATE 9-4-97

Sampler(s) Dan Keohane Darryl Morgan Tim BeRRY

Date Well Installed ~~MAY~~ June 97

Elapsed Time since grouting N/Ap

~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 45.63 ft
2. Depth to Top of Water 36.20 ft
3. Height of Water 9.43 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.4 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 1 in

1. Height of Water 2 ft (1 ft screen + sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~30% x 0.30 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 2.0 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1117						
Conductivity (µS/cm)	1150						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft)	36.20						
pH (S.U.)	6.62						
Temperature (°C)	15.8						
Turbidity (NTU)	>200						

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 38.55 (after sampling).

NOTES: Well goes dry after ½ gallon. Strong H_2SO_4 odor water is black.
Sample @ 12:25 for VOA analysis - unpreserved.
PID - 0 ppm

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-1072(2)

WELL ~~DEVELOPMENT~~ (PURGE) LOG

Project Name OB/OD AREA Ft Riley

Project Number JH-1124D

DATE 9-4-97

Sampler(s) Dan Keohane Darryl Morgan Tim Berry

Date Well Installed ~~May~~ June 97

Elapsed Time since grouting N/Ap

~~Development~~ (Purge) Method ~~Jiggle~~ tube

VOLUME OF CASING

1. Depth of Well: 39.70 ft
2. Depth to Top of Water 34.66 ft
3. Height of Water 5.04 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. One Casing Volume 0.2 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 1 in

1. Height of Water 2 ft (1 Ft screen + sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~ 4.1 gal
3. Porosity @ ~30% x 0.30 % porosity
4. One Annulus Volume 1.6 gal

ONE TOTAL WELL VOLUME 1.8 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		2	4				6
Time (24 hr)	1120	1135	1145				1155
Conductivity (µS/cm)	2100	960	960				940
ssolved Oxygen (ppm)	—	—	—				—
~~h (mV)~~ DTW (Ft)							
pH (S.U.)	6.68	6.99	7.04				7.00
Temperature (°C)	17.0	15.5	15.2				15.2
Turbidity (NTU)	>200	>200	>200				>200

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 34.84 (after sampling)

NOTES: Water brown - no H_2SO_4 odor. Sample @ 1200 for VOA analysis - Unpreserved. PID - 0.0ppm

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-10PZ(3)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA Ft Riley

Project Number JH-1124D

DATE 9-4-97

Sampler(s) Dan Keohane / Darryl Morgan
Tim Berry

Date Well Installed ~~May~~ June 1997

Elapsed Time since grouting N/Ap

~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 32.43 ft
2. Depth to Top of Water 21.81 ft
3. Height of Water 10.62 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.4 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft (1 Ft screen + sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 2 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1127						
Conductivity (µS/cm)	970						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft)	21.81						
pH (S.U.)	7.39						
Temperature (°C)	15.4						
Turbidity (NTU)	7200						

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 31.18 (after sampling)

NOTES: Well goes dry after 1/4 gal. Sample @ 1232 for VOA analysis - Unpreserved
PID - 0 ppm

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-11P2(O)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA Ft. Riley

Project Number JA-1124 D

DATE 9-4-97

Sampler(s) Dan Keohane Darryl Morgan Tim Berry

Date Well Installed ~~May~~ June 1997

Elapsed Time since grouting N/Ap

~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 53.47 ft
2. Depth to Top of Water 36.04 ft
3. Height of Water 17.43 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.7 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 1 in

1. Height of Water 2 ft (1 Ft screen + sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 2.3 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons	[redacted]						
Time (24 hr)	1314						
Conductivity (µS/cm)	1040						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (ft)	36.04						
pH (S.U.)	7.21						
Temperature (°F)	17.4						
Turbidity (NTU)	2200						

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 50.81 (after sampling)

NOTES: PID-0 ppm Sampled collected @ 1345 for VOA analysis-Unpreserved

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-11PZ(1)

WELL ~~DEVELOPMENT~~/[✓ PURGE] LOG

Project Name OB/OD Area Ft Riley
Project Number JH-1124D
DATE 9-3-97
Sampler(s) Dan Keohane / Darryl Morgan / Tim Berry
Date Well Installed ~~May~~ June 97
Elapsed Time since grouting N/Ap
~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 47.60 ft
2. Depth to Top of Water 39.44 ft
3. Height of Water 8.16 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.3 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft (1 Ft screen + sand pack)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) 4.1 gal
3. Porosity @ ~30% x 0.30 % porosity
4. One Annulus Volume 1.6 gal

ONE TOTAL WELL VOLUME 1.9 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		2	4				6
Time (24 hr)	1318	1328	1335				1342
Conductivity (µS/cm)	850	690	900				810
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (Ft)	39.44	—	—				—
pH (S.U.)	7.24	7.48	7.34				7.29
Temperature (°F)	22.4	22.1	21.9				21.8
Turbidity (NTU)	>200	>200	>200				>200

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 39.45 (after sample)

NOTES: PID-0 Collected sample @ 1350 For VOA analysis - Unpreserved also collect MS/MSD, & MRD plus Duplicate labelled 'OB97-11PZ(5) @ 1315. MS/MSD was cancelled for analysis

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-12P2(O)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD Area Ft Riley
Project Number
DATE 9-4-97

Sampler(s) Dan Keohane / Darryl Morgan
Tim Berry
Date Well Installed June 97

Elapsed Time since grouting N/Ap
~~Development~~ / [✓ Purge] **Method** Jiggle tube

VOLUME OF CASING

1. Depth of Well: 53.68 ft
2. Depth to Top of Water 41.50 ft
3. Height of Water 12.18 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.5 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~20% x 0.30 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 2.1 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1500						
Conductivity (µS/cm)	1710						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft)	53.63						
pH (S.U.)	7.27						
Temperature (°C)	20.7						
Turbidity (NTU)	7200						

Photo Taken ☐ YES ☑ NO
Photo No. N/Ap

Water Level After Development N/Ap
Sounded Depth After Development N/Ap

Water Level After Purging 52.73 (after sampling)

NOTES: Collected Sample @ 1534 ~~HCL~~ for VOA analysis HCL - Preserved. PID - 0.0ppm. Well went dry after ~½ gallon water has odor

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-12PZ(1)

WELL DEVELOPMENT / PURGE LOG

Project Name OB/OD AREA Ft Riley

Project Number JH-1124D

DATE 9-4-97

Sampler(s) Dan Keohane/Daryl Morgan Tim Berry

Date Well Installed June 97

Elapsed Time since grouting N/Ap

~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 47.63 ft
2. Depth to Top of Water 40.51 ft
3. Height of Water 7.12 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.28 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 1.9 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		2	4				6
Time (24 hr)	1453	1507	1519				1525
Conductivity (µS/cm)	1220	830	830				830
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (FT)							
pH (S.U.)	6.73	7.15	7.18				7.15
Temperature (°C)	19.5	15.5	15.3				15.3
Turbidity (NTU)	7200	7200	7200				7200

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 40.55 (after sampling)

NOTES: PID - 0.8 ppm Collect sample @ 1530 VOA analysis - HCL Preserved. Water has H_2SO_4 ODOR - very turbid; sediment allowed to settle out before sample enabling sample to be HCL preserved.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97 -12P2(3)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD Area Ft Riley **Project Number** JH-1124D **DATE** 9-4-97

Sampler(s) Dan Keohane Darryl Morgan Tim Berry **Date Well Installed** June 97

Elapsed Time since grouting N/Ap ~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 32.65 ft
2. Depth to Top of Water 29.22 ft
3. Height of Water 3.43 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.14 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 1 in

1. Height of Water 2 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~30% x 030 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 1.75 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons	▨						
Time (24 hr)	1445						
Conductivity (µS/cm)	620						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW(ft)	29.22						
pH (S.U.)	7.33						
Temperature (°C)	16.4						
Turbidity (NTU)	>200						

Photo Taken ☐ YES ☑ NO Photo No. N/Ap

Water Level After Development N/Ap Sounded Depth After Development N/Ap

Water Level After Purging 30.94 (after sampling)

NOTES: PID - 0 : Collect Sample @ 1545 for VOA analysis - HCL Preserved (water had cleared).
Well went dry after 1/4 gallon - allowed to recharge

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole	Volume per Linear Foot		Casing	Volume per Linear Foot	
Diameter	Gal.	Cu.Ft.	Diameter	Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97 – 13 PZ (c)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OD/OD Area, Ft Riley

Project Number JH-1124D

DATE 9-3-97

Sampler(s) Dan Keohane Daryl Morgan Tim Berry

Date Well Installed ~~May~~ June 97

Elapsed Time since grouting N/Ap

~~Development~~ / [✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 33.38 ft
2. Depth to Top of Water 28.58 ft
3. Height of Water 4.80 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.2 gal

VOLUME OF ANNULUS

Hole Diameter 10" in

Casing Diameter 1 in

1. Height of Water 2 ~~4.80~~ DK ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~ 4.1 gal
3. Porosity @ 30% x 0.30 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 1.8 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1052						
Conductivity (µS/cm)	1200						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft	28.58						
pH (S.U.)	6.72						
Temperature (°C)	21.2						
Turbidity (NTU)	7200						

Photo Taken ☐ YES ☒ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 32.47 (after sampling)

NOTES: Piezometer goes dry after ~ 0.25 gals : Collect sample @ 1130
Reaction w/ HCL - must use unpreserved vials.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97 - 13PZ(i)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA Ft RiLEY

Project Number JH-1124 D

DATE 9-3-97

Sampler(s) Dan KEOHANE Darryl Morgan Tim BERRY

Date Well Installed ~~MAY~~ June 97.

Elapsed Time since grouting N/Ap

~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 29.33 ft
2. Depth to Top of Water 15.52 ft
3. Height of Water 13.81 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. One Casing Volume 0.5 gal

VOLUME OF ANNULUS

Hole Diameter 10 in

Casing Diameter 1 in

1. Height of Water 2 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ 30% x 0.30 % porosity
4. One Annulus Volume 1.6 gal

ONE TOTAL WELL VOLUME 2.1 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons	[redacted]						~~1044~~ 2
Time (24 hr)	1027						1044
Conductivity (µS/cm)	950						750
issolved Oxygen (ppm)	—						—
~~Eh (mV)~~ DTW (Ft)	15.52						—
pH (S.U.)	7.51						7.78
Temperature (°C)	20.9						20.8
Turbidity (NTU)	7200						7200

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 28.72 (after sampling)

NOTES: Piezometer goes dry after ~2 gals. Collect sample @ 1120 for VOA analysis - unpreserved. Also collect MS/MSD, MRD and duplicate labelled OB97-13PZ(5) @ 1145. Odor of H_2SO_4

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Volume per Linear Foot Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

WELL NUMBER OB97-13PZ(2)

WELL ~~DEVELOPMENT~~ / [✓ PURGE] LOG

Project Name OB/OD AREA, Ft RILEY

Project Number JH-1124D

DATE 9-3-97

Sampler(s) DAN KEOHANE

Date Well Installed ~~MAY~~ June 97

Elapsed Time since grouting N/Ap

~~Development~~ [✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 24.45 ft
2. Depth to Top of Water 15.32 ft
3. Height of Water 9.13 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.4 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft (Screen Section plus 1 ft sand pack above screen)
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~~30~~% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 2 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons		2	4				6
Time (24 hr)	1149	1201	1210				1218
Conductivity (µS/cm)	560	1100	960				1050
Dissolved Oxygen (ppm)	—	—	—				—
~~Eh (mV)~~ DTW (Ft)	15.32	—	—				—
pH (S.U.)	7.34	7.47	7.50				7.75
Temperature (°C)	21.9	20.6	19.5				20.8
Turbidity (NTU)	>200	>200	>200				>200

Photo Taken ☐ YES ☑ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging 15.41 (After Sampling)

NOTES: Collect Sample from OB97-13PZ(2) @ 1228 for VOA analysis - unpreserved.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-13 PZ (3)

WELL DEVELOPMENT / PURGE LOG

Project Name OB/OD Area Ft. Riley   Project Number JH-1124 D   DATE 9-3-97

Sampler(s) DAN KEOHANE Darryl Morgan TIM BERRY   Date Well Installed ~~May~~ June 97

Elapsed Time since grouting N/Ap   ~~Development~~/[✓ Purge] Method Jiggle tube

VOLUME OF CASING

1. Depth of Well: 19.94 ft
2. Depth to Top of Water 16.51 ft
3. Height of Water 3.43 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.14 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 2 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~ 4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. **One Annulus Volume** 1.6 gal

ONE TOTAL WELL VOLUME 1.8 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons	[illegible]						1
Time (24 hr)	1158						1206
Conductivity (µS/cm)	1950						1800
ssolved Oxygen (ppm)	—						—
~~Eh (mV)~~ DTW (Ft	16.51						—
pH (S.U.)	7.39						7.64
Temperature (°C)	19.4						17.8
Turbidity (NTU)	>200						>200

Photo Taken ☐ YES ☒ NO   Photo No. N/Ap

Water Level After Development N/Ap   Sounded Depth After Development N/Ap

Water Level After Purging 19.42 (after sampling)

NOTES: Collect sample @ 1238 For VOA analysis - Unpreserved.
well went dry after 1 gallon.

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER OB97-13PZ(4)

WELL ~~DEVELOPMENT~~/PURGE LOG

Project Name OB/OD AREA Ft RILEY **Project Number** JH-1124 D **DATE** 9-4-97

Sampler(s) Dan Keohane Darryl Morgan Tim Berry **Date Well Installed** ~~MAY~~ June 97

Elapsed Time since grouting N/Ap **~~Development/~~Purge Method** Disposable bailer

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VOLUME OF CASING

1. Depth of Well: 14.70 ft
2. Depth to Top of Water 14.11 ft
3. Height of Water 0.59 ft

Casing Diameter: 1 in.

4. Vol/Lin Ft. of Casing (see Table 1) 0.04 gal
5. **One Casing Volume** 0.02 gal

VOLUME OF ANNULUS

Hole Diameter 10 in
Casing Diameter 1 in

1. Height of Water 0.59 ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ~4.1 gal
3. Porosity @ ~20% x 0.20 % porosity
4. One Annulus Volume 0.48 gal

ONE TOTAL WELL VOLUME 0.5 gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							0.1
Time (24 hr)	1605						1635
Conductivity (µS/cm)	—						990
Dissolved Oxygen (ppm)	—						—
~~Eh (mV)~~ DTW (Ft)	14.11						14.19
pH (S.U.)	—						7.01
Temperature (°C)	—						18.6
Turbidity (NTU)	—						>200

Photo Taken ☐ YES ☑ NO Photo No. N/Ap

Water Level After Development N/Ap Sounded Depth After Development N/Ap

Water Level After Purging 14.33 (after sampling)

NOTES: Sample @ 1620 for VOA analysis - this sample was recorded. Piezometer was resampled @ 1730 after purging 0.1 gallons

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

Hole Diameter	Volume per Linear Foot Gal.	Cu.Ft.	Casing Diameter	Volume per Linear Foot Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

WELL NUMBER Dug well

WELL ~~DEVELOPMENT~~/ [✓ PURGE] LOG

Project Name OB/OD AREA Ft Riley

Project Number JH-1124D

DATE 9-4-97

Sampler(s) Dan Keohane/Darryl Morgan
Tim Berry

Date Well Installed N/Ap

Elapsed Time since grouting N/Ap

Development/[✓ Purge] Method N/Ap

VOLUME OF CASING N/Ap - No purge

1. Depth of Well: ______ ft
2. Depth to Top of Water ______ ft
3. Height of Water ______ ft

Casing Diameter: ______ in.

4. Vol/Lin Ft. of Casing (see Table 1) ______ gal
5. **One Casing Volume** ______ gal

VOLUME OF ANNULUS N/Ap - No Purge

Hole Diameter ______ in
Casing Diameter ______ in

1. Height of Water ______ ft
2. Vol/Lin. Ft. of Annulus between casing & hole (see Table 2) ______ gal
3. Porosity @ ~30% x 0.30 % porosity
4. **One Annulus Volume** ______ gal

ONE TOTAL WELL VOLUME ______ gal

PARAMETER	INITIAL	1 VOL.	2 VOL.	3 VOL.	4 VOL.	5VOL.	FINAL
Gallons							
Time (24 hr)	1340						
Conductivity (µS/cm)	380						
Dissolved Oxygen (ppm)	—						
~~Eh (mV)~~ DTW (Ft)	14.29						
pH (S.U.)	7.05						
Temperature (°C)	15.2						
Turbidity (NTU)	6.34						

Photo Taken ☐ YES ☒ NO

Photo No. N/Ap

Water Level After Development N/Ap

Sounded Depth After Development N/Ap

Water Level After Purging N/Ap

NOTES: Grab sample collected at 1340 for VOA analysis - HCL Preserved. No purge conducted. Use Kimbler sampler. Sample grabed from ~16 Ft below measuring point i.e. ~2 Ft below top of water
Collect Field blank @ 1340

TABLE 1. Volume of Schedule 40 PVC Pipe

DIAMETER	O.D. (in)	I.D. (in)	Volume (gal / lin ft.)
1.25"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

TABLE 2. Volume of Open Borehole and Annulus between Casing and Hole

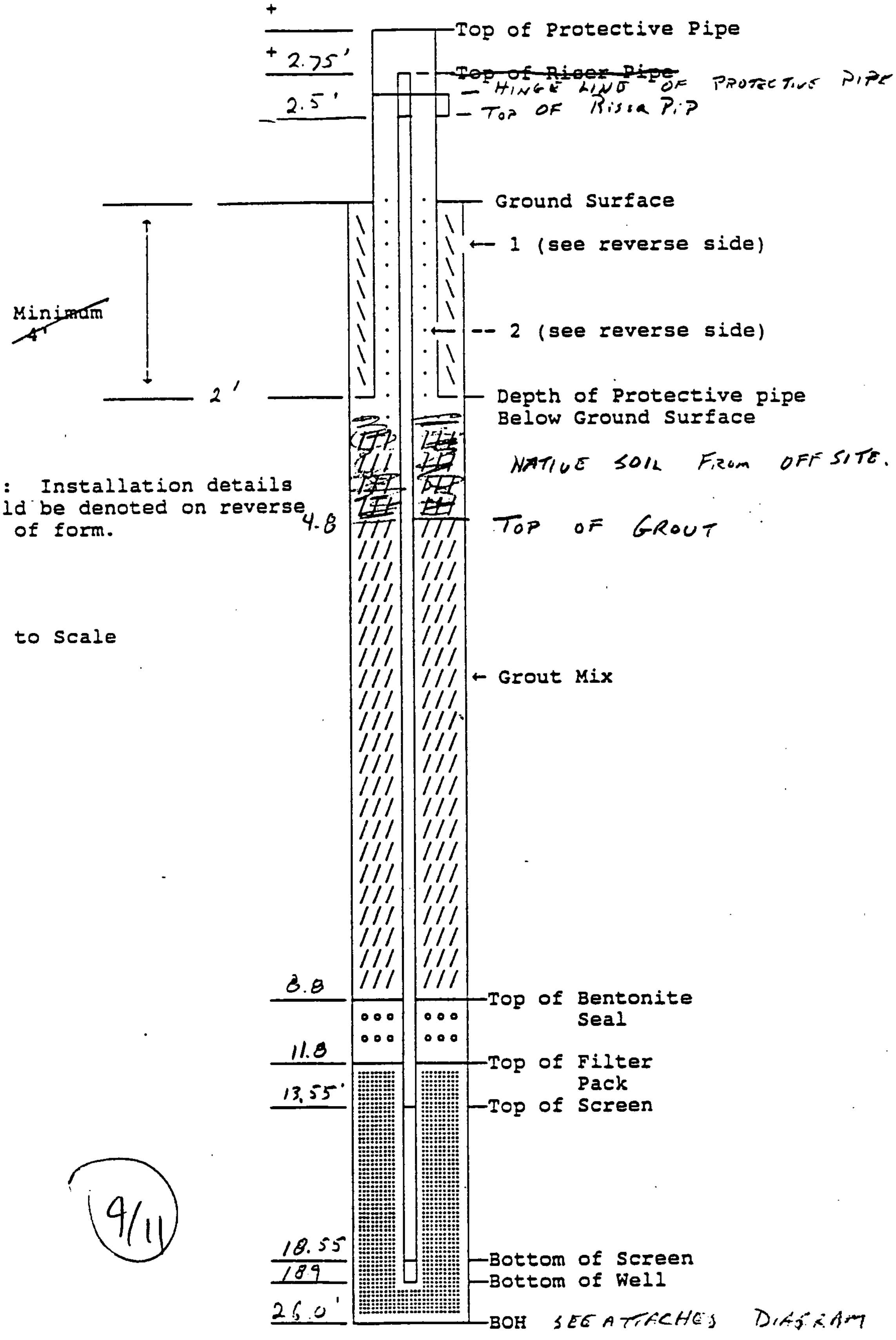
Hole Diameter	Volume per Linear Foot		Casing Diameter	Volume per Linear Foot	
	Gal.	Cu.Ft.		Gal.	Cu.Ft.
7.25 in	2.14	0.29	1.25	2.03	0.27
7.25 in	2.14	0.29	2	1.91	0.26
7.75 in	2.45	0.33	2	2.22	0.3
8.25 in	2.78	0.37	2	2.55	0.34
10.25 in	4.29	0.57	2	4.06	0.54
8.25 in	2.78	0.37	3	2.28	0.30
10.25 in	4.29	0.57	3	3.79	0.51
12.25 in	6.13	0.82	3	5.62	0.75
8.25 in	2.78	0.37	4	1.95	0.26
10.25 in	4.29	0.57	4	3.46	0.46
12.25 in	6.13	0.82	4	5.30	0.71
12.25 in	6.13	0.82	6	4.33	0.58

FPHD-97-14 (Former Dug Well)

MONITORING WELL INSTALLATION DIAGRAM

Project Ft Riley Well Abandonment **Well Number** FP-HD-97-14

Boring Number OLD HAND Dug Well **Date Installed** 12/2/97



NOTE: Installation details should be denoted on reverse side of form.

*Not to Scale

9/11

COMMENTS ON MONITORING WELL INSTALLATION

Diameter and type of well pipe 2" PVC

Schedule of well pipe 40 Screen slot size .010

Measurements:

Length of riser pipe 16.05

Length of Screen 5.0'

Length of end blank .35'

Total length of well installation 21.4

Bottom depth of well '26' ESTIMATED

Length of riser pipe stickup above ground surface 2.5

Centralizers:

Total number of centralizers NONE

Depth(s) of centralizer(s) below ground surface —

Protective Pipe:

Size and type of protective pipe 4" BOX

Number of weep holes drilled in protective pipe 1

Well Pad:

Dimensions of well pad 3'x3'x4"

Number and size of protective posts around well 4 ea 3"

Filter Pack:

Type and grain size of filter pack material 12/20 – 18.9 - 13.8'
LOCALLY PROCURED FILTER, SAND 14.0 - 11.8'

Grout Mix(es):

Type of grout mix(es) and locations used in the well installation
READY MIX 3000

Amount and type of grout materials used for each mix N/A

Portland

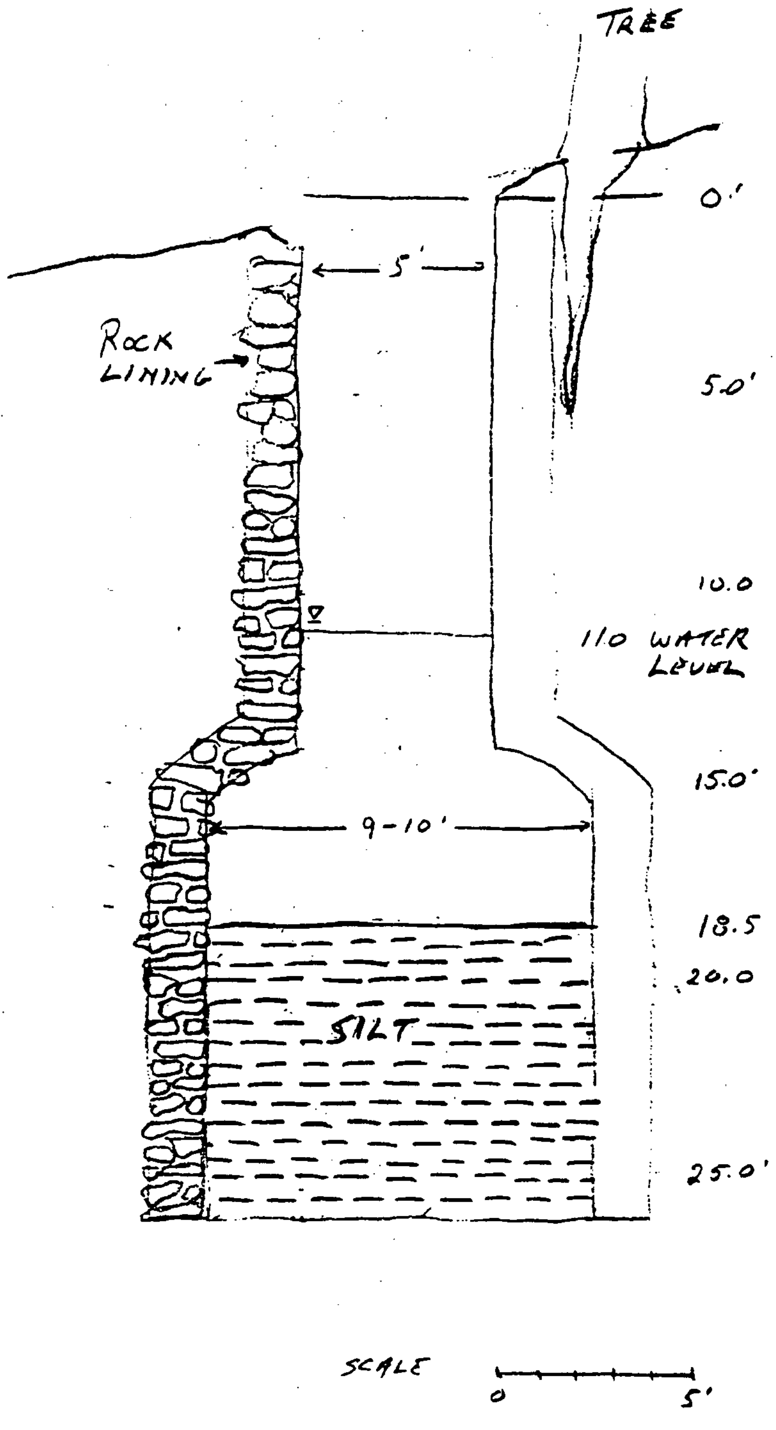
Bentonite (specify type)

water

1. Material used to fill annular space between borehole and protective pipe
   Cement
2. Material used to fill void between protective pipe and well riser pipe
   Fine Sand

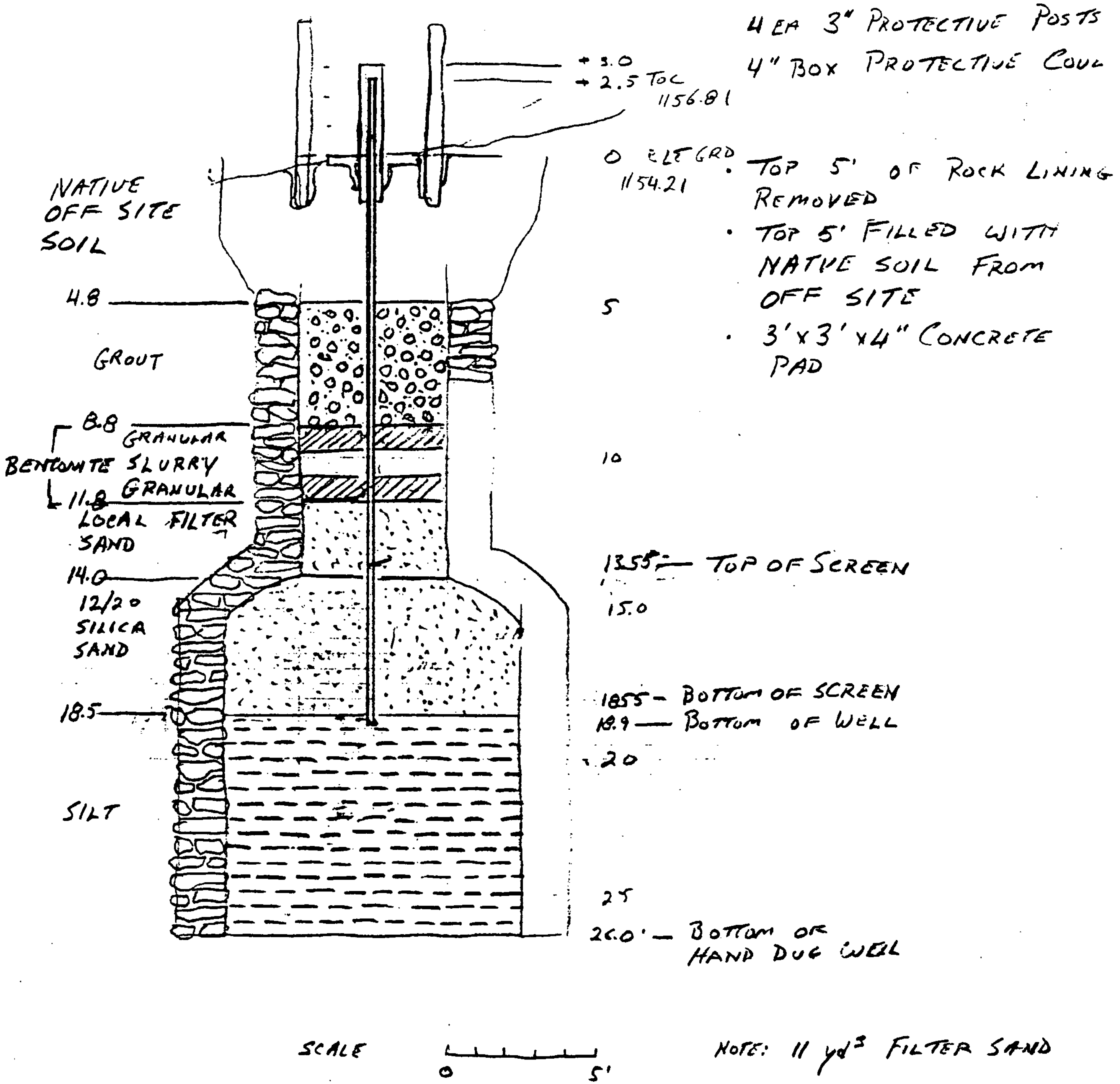
5/11

FP-HD-97-14



- MEASURED DEPTH OF WELL 18.5'
- ORIGINAL DEPTH OF 26' DETERMINED BY LENGTH OF PUMP REMOVED FROM WELL.
- WATER LEVEL 11.0'
- LOWER DIAMETER OF WELL ESTIMATED USING THE VOLUME OF FILTER SAND PLACED.
- ROCK LINING 1-1.5' THICK

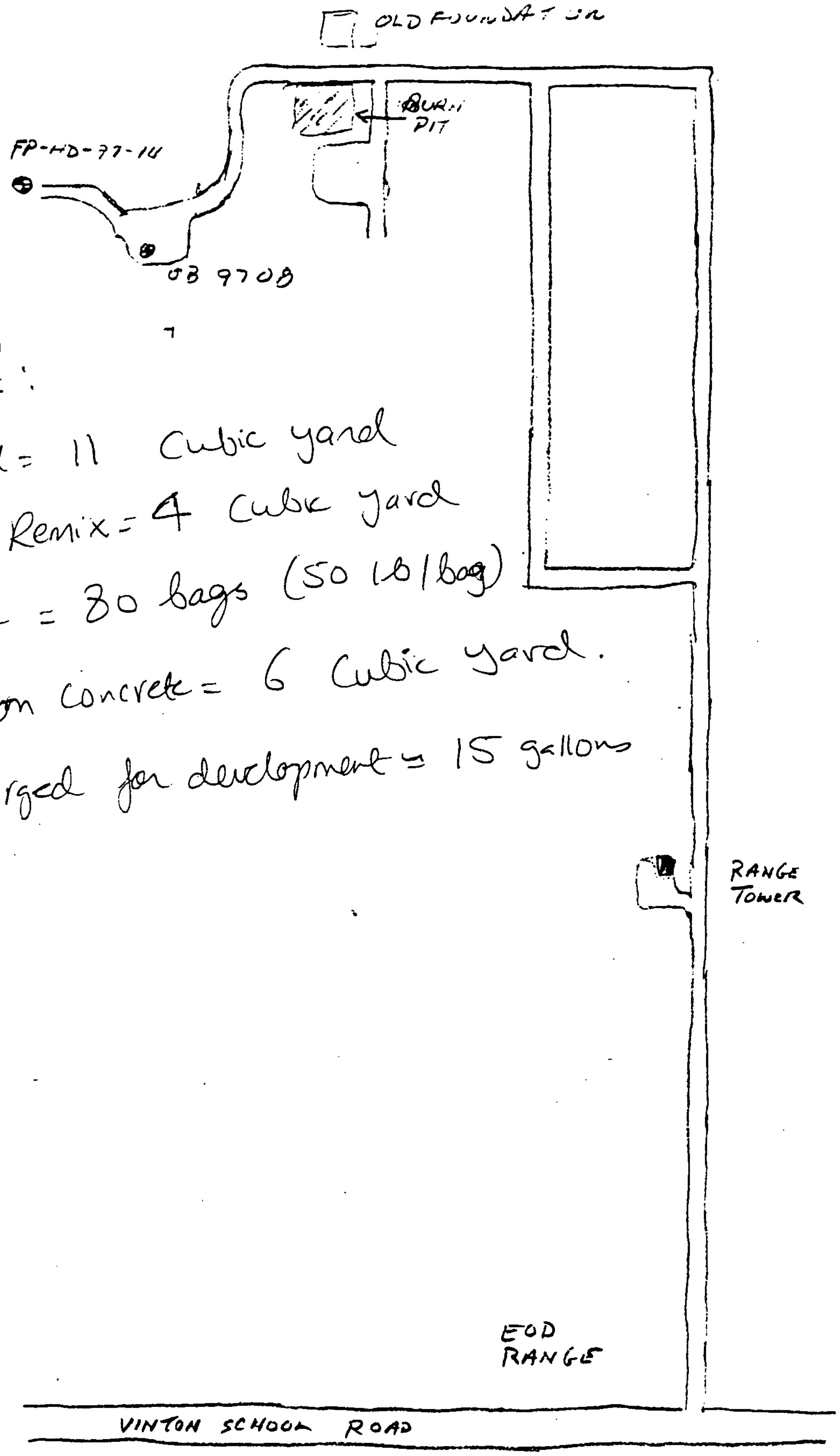
FP-HD-97-14



4 EA 3" PROTECTIVE POSTS
4" BOX PROTECTIVE COWL

- TOP 5' OF ROCK LINING REMOVED
- TOP 5' FILLED WITH NATIVE SOIL FROM OFF SITE
- 3'x3'x4" CONCRETE PAD

NOTE: 11 yd³ FILTER SAND INSTALLED



Material Used:

Filter Sand = 11 Cubic yard
Concrete Remix = 4 Cubic yard
Bentonite = 80 bags (50 lb/bag)
Top Soil on concrete = 6 Cubic yard.
Volume purged for development = 15 gallons

APPENDIX B

Unexploded Ordnance (UXO) Report

Final Report for Ft. Riley, Kansas

First Mobilization

UXB Team completed mobilization to Ft Riley on March 16, 1997 to start on the 17th. A group meeting was held at the USACE office Monday morning and then we departed for the EOD Range (Range 16) to conduct a UXO clearance for personnel and equipment entry. On March 19, 1997 the UXO clearance was completed for present and equipment and personnel started arriving. Escort duties started and we also provided assistance to the client when and where needed to assist in tasks completion. Split shifts were originally discussed to keep hours down, but, would not have worked due to the many people on site with different places to be escorted. We located a spring on the site and notified the client of such, then dug a sump in it to assist in sampling. A dug well was also located in an old homestead site within the range. This also required sampling. Layne Western had 2 drill rigs on site most of the time to escort. EOD had a accidental range fire on march 14, 1997 and then on the 17th the fire department burned off additional area to ease in the UXO clearance. The burning of the range made the UXO clearance and also the escorting of personnel and equipment into the well site much easier. March 29, the last well was installed, then the decon of equipment started along with site clean up. Clean up and equipment removal was completed on March 30. March 31 was a stand by day as well logging was scheduled but the client had the equipment returned to rental company so the task was delayed. Equipment from the Funston Landfill area was shipped out, vehicle cleaned and all reports caught up to date.

LIST OF TASKS COMPLETED

Well Installation - escort and assistance	4 wells
Well Development - escort and assistance	4 wells
Well Logging - escort and assistance	4 wells
Road ways - cleared	all permanent
Path ways & work areas for wells cleared	4 wells
Staging area cleared	2 sites
Escort to Spring location	Numerous
Escort to sample spring	1
Escort to dug well	Numerous
Escort to sample dug well	1
Escort of survey crew	2 days
Mapped location of wells, spring & dug well	1 day
Army EOD assistance required to detonate UXOs	2

Second Mobilization

Arrived on April 15, 1997. On April 16 we cleared and hand augered 2 soil samples in the Funston Landfill area, then went to the OBOD and cleared and installed 6 passive soil gas tubes around wells 7 and 5. No ordnance item encountered.

Third Mobilization

Arrived on May 31,1997. Met with Louis Berger & Associates on site manager at their office at 9AM, June 1, 1997 to go over the planned activities during this mobilization. Went to the EOD range to conduct a walk of the area to show us the projected locations of the wells to be installed and the areas requiring clearance. Exact locations could not be set until the USACE representative picks them on the 2nd. Started ordnance operations after the meeting. Had to rent a brush cutting machine to clear weeds and brush to facilitate ordnance clearance and safety. Well locations surveyed in for exact location. Started Drilling operations on June 3, 1997. Clearance operations continued along with escort duties and brush cutting. June 12 and 13, 1997, operations shut down due to range going hot and no one allowed in area, on standby. June 14 operations resumed after we provided a surface clearance of all roadways and pathways. 5 piezometer wells installed with pads and bumper posts. Escorted survey crew to provide the exact location and altitude for all wells(13), sample locations, springs, well logging and dug well. Assisted the drill crew and client in marking of all wells along with the installation of pads and bumper posts. June 19, 1997 team of 12 regulators were on site and escorted to several locations. All operations were completed on the morning of June 20, 1997 including demobilization of equipment and personnel.

LIST OF TASKS COMPLETED

Piezometer wells installed - escort and assistance	5
Well development - escort and assistance	2
Well logging - escort and assistance	6
Roadways cleared - all permanent	2 occasions
Pathways & work areas for all wells cleared	13
Pathways to sample areas cleared	9
Staging areas cleared	2 sites
Escort of survey crew	2 days
Escort to conduct water levels or sample	everyday
Escort of regulators	1 day

During all mobilizations numerous expended UXO items were removed from work areas. 83 UXO items (live or suspected to be live) were removed from work areas and access routes, 2 of these UXO items had to be detonated in place by the base EOD Team. 33 ounces of bulk propellant was recovered. All UXO items or material was staged near the blow hole for Army EOD action. The Army EOD Team was notified of the UXO items being staged near their blow hole for later disposal by them.

Robert L. Diekmann
Senior UXO Supervisor

LIST OF LIVE UXO ITEMS LOCATED DURING SITE CLEARING OPERATIONS

DATE	ITEM	ACTION	COMMENTS	QUANITY	TOTALS
3-17-97	75MM Projectile	EOD Disposed of	Detonated in place by EOD	1	1
	50 Cal. Round	Removed	Stockpiled for later disposal by EOD	1	2
	30-06 Round	Removed	Stockpiled for later disposal by EOD	1	3
3-18-97	38 Cal. Round	Removed	Stockpiled for later disposal by EOD	1	4
	20MM TPT Projec	Removed	Stockpiled for later disposal by EOD	5	9
	40MM Practice Round	EOD Disposed of	Detonated in place by EOD	1	10
	105MM Smoke Cannister	Removed	Stockpiled for later disposal by EOD	1	11
	2.36 Rocket Warhead	Removed	Stockpiled for later disposal by EOD	1	12
	30MM Practice Round	Removed	Stockpiled for later disposal by EOD	1	13
	20MM Round	Removed	Stockpiled for later disposal by EOD	2	15
3-19-97	20MM Round	Removed	Stockpiled for later disposal by EOD	1	16
	20MM TPT Projec	Removed	Stockpiled for later disposal by EOD	1	17
	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	8 oz.	8 oz.
3-20-97	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	2 oz.	10 oz.
3-21-97	40MM Round	EOD Disposed of	Detonated in place by EOD	1	18
	75MM Projectile	EOD Disposed of	Detonated in place by EOD	1	19
	2.36 Rocket Warhead	Removed	Stockpiled for later disposal by EOD	1	20
	20MM TPT Projec	Removed	Stockpiled for later disposal by EOD	1	21
	7.62 Round	Removed	Stockpiled for later disposal by EOD	2	23
3-22-97	5.56 Round	Removed	Stockpiled for later disposal by EOD	1	24
3-23-97	7.62 Round	Removed	Stockpiled for later disposal by EOD	1	25
	20MM TPT Projec	Removed	Stockpiled for later disposal by EOD	1	26
	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	5 oz.	15 oz.
3-24-97	20MM Round	Removed	Stockpiled for later disposal by EOD	1	27
	20MM TPT Projec	Removed	Stockpiled for later disposal by EOD	1	28
	38 Auto Round	Removed	Stockpiled for later disposal by EOD	1	29
3-25-97	50 Cal. Round	Removed	Stockpiled for later disposal by EOD	1	30
	20MM TPT Projec	Removed	Stockpiled for later disposal by EOD	1	31
	5.56 Round	Removed	Stockpiled for later disposal by EOD	1	32
	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	1 oz.	16 oz.
3-26-97	M120 Bomb Fuze	Removed	Stockpiled for later disposal by EOD	1	33
	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	7 oz.	23 oz.
3-27-97	20MM TPT Projec	Removed	Stockpiled for later disposal by EOD	1	34
	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	2 oz.	25 oz.
all days	Expended UXO Items	Removed	Stockpiled for later disposal/action by EOD	Numerous	
TOTALS	**Bulk Propellent**		**Stockpiled for later disposal by EOD**		**25 oz.**
	UXO Items		**Stockpiled for EOD Disposal/Disposed of already**		**34**
6-1-97	20MM Projectile	Removed	Stockpiled for later disposal by EOD	11	11

	20MM Round	Removed	Stockpiled for later disposal by EOD	1	12
	30MM Round	Removed	Stockpiled for later disposal by EOD	6	18
	30MM Projectile	Removed	Stockpiled for later disposal by EOD	1	19
	M117 Booby Trap Simulator	Removed	Stockpiled for later disposal by EOD	1	20
	Booby Trap Firing Device	Removed	Stockpiled for later disposal by EOD	1	21
6-3-97	50 Cal. Round	Removed	Stockpiled for later disposal by EOD	2	23
	50 Cal. Blank Round	Removed	Stockpiled for later disposal by EOD	1	24
	20MM Projectile	Removed	Stockpiled for later disposal by EOD	1	25
	38 Special Round	Removed	Stockpiled for later disposal by EOD	1	26
	38 Auto Round	Removed	Stockpiled for later disposal by EOD	1	27
	2.36 Rocket Warhead	Removed	Stockpiled for later disposal by EOD	1	28
6-5-97	20MM Projectile	Removed	Stockpiled for later disposal by EOD	4	32
6-6-97	25MM Projectile	Removed	Stockpiled for later disposal by EOD	1	33
6-7-97	25MM Projectile	Removed	Stockpiled for later disposal by EOD	1	34
6-9-97	20MM Projectile	Removed	Stockpiled for later disposal by EOD	1	35
6-10-97	50 Cal. Blank Round	Removed	Stockpiled for later disposal by EOD	1	36
6-14-97	50 Cal. Blank Round	Removed	Stockpiled for later disposal by EOD	1	37
	20MM Projectile	Removed	Stockpiled for later disposal by EOD	8	45
	30MM Projectile	Removed	Stockpiled for later disposal by EOD	1	46
	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	4oz.	4 oz.
6-15-97	20MM Projectile	Removed	Stockpiled for later disposal by EOD	1	47
6-18-97	20MM Projectile	Removed	Stockpiled for later disposal by EOD	2	49
	Bulk Propellent	Removed	Stockpiled for later disposal by EOD	4oz.	8 oz.
all days	Expended UXO items	Removed	Stockpiled for later disposal/action by EOD	Numerous	
This MOB	**Bulk Propellent**		**Stockpiled for later disposal by EOD**		**8 oz.**
Totals	**UXO Items**		**Stockpiled for later disposal by EOD**		**49**
Totals For	**Bulk Propellent**		**Stockpiled for later disposal by EOD**		**33 oz.**
Project	**UXO Items**		**Stockpiled for EOD Disposal/Disposed of already**		**83**

APPENDIX C

Passive Soil Gas Survey Analytical Report

GORE
Creative Technologies Worldwide

W. L. GORE & ASSOCIATES, INC.

101 LEWISVILLE ROAD • P.O. BOX 1100 • ELKTON, MARYLAND 21922-1100 PHONE: 410/392-3300
FAX: 410/996-3325 • TELEX 467637 GORE FB ELKT

ENVIRONMENTAL PRODUCTS GROUP

1 of 5

GORE-SORBER^{SM} Screening Survey Final Report

Firing Range
Kansas

May 13, 1997

Prepared For:
Louis Berger and Associates, Inc.
295 Promenade Street,
Providence, RI 02908

W.L. Gore & Associates, Inc.
Written/Submitted by

Ray F. Fenstermacher, P.G.
Associate

W.L. Gore & Associates, Inc.
Reviewed/Approved by

Jay W. Hodny

Jay W. Hodny, M.S.
Associate

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FORM 11 R.3
Rev 10/25/96

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GORE-SORBER Screening Survey is a registererd service mark of W. L. Gore & Associates, Inc.

GORE-SORBER^{sm} Screening Survey
Final Report

REPORT DATE: May 13, 1997 **AUTHOR:** RFF

SITE INFORMATION

Site Reference: Firing Range, Kansas
Customer Purchase Order Number: Verbal
Gore Production Order Number: 072808 **Gore Site Code:** AAH

FIELD PROCEDURES

 # Modules shipped: 7
Installation Date(s): April 16, 1997 **# Modules Installed:** 6
Field work performed by: Louis Berger and Associates, Inc.

Retrieval date(s): May 8, 1997 **Exposure Time:** 22 **[days]**
 # Modules Retrieved: 6 **# Trip Blanks Returned:** 1
 # Modules Lost in Field: 0 **# Unused Modules Returned:** 0

Date/Time Received by Gore: May 9, 1997, 12:40 PM **By:** TS
Recorded Cooler/Water Temperature Control Blank temperature: 20.6 [°C]
Chain of Custody Form attached: √
Chain of Custody discrepancies: The installation/retrieval form was not included with the chain of custody.
Comments: The temperature of the water control blank exceeded the generally-accepted level for shipment of environmental samples (2.0 ± 4.0° C.)

✓

GORE-SORBER^{sm} Screening Survey
Final Report

ANALYTICAL PROCEDURES

W.L. Gore & Associates' Screening Module Laboratory operates under the guidelines of its Quality Assurance Manual, Operating Procedures and Methods. The quality assurance program is consistent with Good Laboratory Practices (GLP) and ISO Guide 25, "General Requirements for the Competence of Calibration and Testing Laboratories", third edition, 1990. The Laboratory is audited regularly by a quality system design, development and auditing company.

Instrumentation consists of Hewlett-Packard 5890 gas chromatographs and 5971 mass selective detectors, as well as Perkin-Elmer ATD 400 automated thermal desorption units. Sample preparation simply involves cutting the tip off the bottom of the sample module and transferring one or more exposed sorbent containers (sorbers, each containing 40mg of a suitable granular adsorbent) to a thermal desorption tube for analysis. Sorbers remain clean and protected from dirt, soil, and ground water by the insertion/retrieval cord, and require no further sample preparation.

Screening Method Quality Assurance:

Before each run sequence, two instrument blanks, a sorber containing 5µg BFB (Bromofluorobenzene), and a method blank are analyzed. The BFB mass spectra must meet the criteria set forth in our methods before samples can be analyzed. A sorber containing BFB is also analyzed after every 30 samples and/or trip blanks, as is a method blank. Standards containing the selected target compounds at three calibration levels of 5, 20, and 50µg are analyzed at the beginning of each run. The criterion for each target compound is less than 35% RSD (relative standard deviation). If this criterion is not met for any target compound, the analyst has the option of generating second- or third-order standard curves, as appropriate. A second-source reference standard, at a level of 20µg per target compound, is analyzed after every ten samples and/or trip blanks, and at the end of the run sequence. Positive identification of target compounds is determined by the presence of the target ion and at least two secondary ions, retention time versus reference standard, and the analyst's judgment.

NOTE: **All data have been archived. Any replicate sorbers not used in the initial analysis will be discarded fifteen (15) days from the date of analysis.**

Laboratory analysis: thermal desorption, gas chromatography, mass selective detection
Quality Assurance Level: 2 (ANA-4/A1)
Instrument ID: # 3 **Chemist:** JW **Data Subdirectory:** 072808
Compounds/mixtures requested: Gore Standard VOC/SVOC Compound List (A3)
Deviations from Standard Method: None
Comments: Soil vapor analytes and abbreviations are tabulated in the Data Table Key (page 5).

GORE-SORBER^{sm} Screening Survey
Final Report

DATA TABULATION

 # CONTOUR MAPS ENCLOSED: No maps were generated from this data

NOTE: All data values presented in Appendix A represent masses of compound(s) desorbed from the GORE-SORBER Screening Modules received and analyzed by W.L. Gore, as identified in the Chain of Custody (Appendix A). The measurement traceability and instrument performance are reproducible and accurate for the measurement process documented. Semi-quantitation of the compound mass is based on either a single-level (QA Level 1) or three-level (QA Level 2) standard calibration.

Comments:

- Stacked total ion chromatograms (TIC's) are included in Appendix A. The last three digits of each module number are incorporated into the TIC identification (e.g.: AAH503TC.D represents module #136503).
- Low levels of target analytes (particularly PCE) were detected in most of the modules with the exception of module location 136504.

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GORE-SORBER^{sm} Screening Survey
Final Report

KEY TO DATA TABLE
Firing Range, Kansas

UNITS	
µg	micrograms (per sorber), reported for compounds for which we run external standards.
MDL	method detection limit
ANALYTES	
t12DCE	trans-1,2-dichloroethene
11DCA	1,1-dichloroethane
c12DCE	cis-1,2-dichloroethene
111TCA	1,1,1-trichloroethane
12DCA	1,2-dichloroethane
TCE	trichloroethene
PCE	tetrachloroethene
BLANKS	
TBn	unexposed trip blanks, which traveled with the exposed modules

APPENDIX A:

1. CHAIN OF CUSTODY
2. DATA TABLE
3. STACKED TOTAL ION CHROMATOGRAMS

GORE-SORBER® Screening Survey Chain of Custody

For W.L. Gore & Associates use only
Production Order # 72908

W. L. Gore & Associates, Inc., Environmental Products Group
101 Lewisville Road • Elkton, Maryland 21921 • Tel: (410) 392-3300 • Fax (410) 996-3325

Instructions: Customer must complete ALL shaded cells

Customer Name: LOUIS BERGER + ASSOC INC
Address: 295 PROMENADE ST
PROVIDENCE RI 02908
Phone: 401 521 5980
FAX: 401 331 8956

Site Name: FIRING RANGE
Site Address:
KANSAS
Project Manager: DAVE EGAN
Customer Project No.:
Customer P.O. #: N/A
Quote #:

Serial # of Modules Shipped
136499 through # 136505
through
through
through
through
through
through

of Modules for Installation 6 # of Trip Blanks 1
Total Modules Shipped: 7 Pieces
Total Modules Received: 7 Pieces
Total Modules Installed: 6 Pieces
Serial # of Trip Blanks (*Client Decides*) # 136505 ✓

#	#	#
#	#	#
#	#	#

Installation Performed By:
Name (*please print*): DAVID STEIN
Company/Affiliation: Louis Berger & Associates

Installation Method(s) (*circle those that apply*):
Slide Hammer Hammer Drill [✓ Auger]
Other:

Installation Start Date and Time: 4/16/97 11:00 [✓ AM] PM
Installation Complete Date and Time: 4/16/97 12:05 AM [✓ PM]

Retrieval Performed By:
Name (*please print*): DAVID STEIN
Company/Affiliation: Louis Berger & Associates

Total Modules Retrieved: 6 Pieces
Total Modules Lost in Field: 0 Pieces
Total Unused Modules Returned: 0 Pieces

Retrieval Start Date and Time: 5/8/97 1:00 AM [✓ PM]
Retrieval Complete Date and Time: 5/8/97 2:00 AM [✓ PM]

Target Analytes to be Mapped (*Check Options or List as appropriate*):
To Be Determined Pending Completion of Lab Analysis [ ] or write "None", if applicable.
Analyte #1: PCE
Analyte #2: TCE
Analyte #3: DCE
Other Instructions, if any: BTEX

	Date	Time		Date	Time
Relinquished By C J Fordun Affiliation: W.L. Gore & Associates, Inc.	4/14/97	15:00	Received By: David Stein Affiliation: Louis Berger	4/13/97	1:00pm
Relinquished By David Stein Affiliation: Louis Berger	5/8/97	2:47pm	Received By: FED EX Affiliation: 3325217641		
Relinquished By Affiliation			Received By: Affiliation: W.L. Gore & Associates, Inc.	5/9/97	12:40

Temperature of Samples When Received By Gore 20.6 °C

TWC # 1

FORM 8R.2

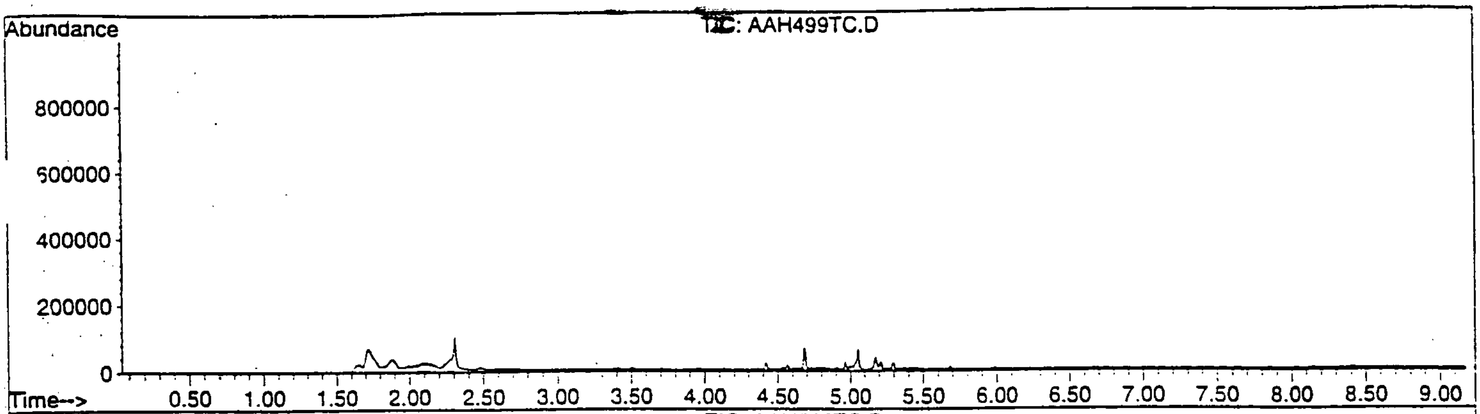
GORE-SORBER ® Screening Survey is a registered service mark of W.L. Gore & Associates, Inc.

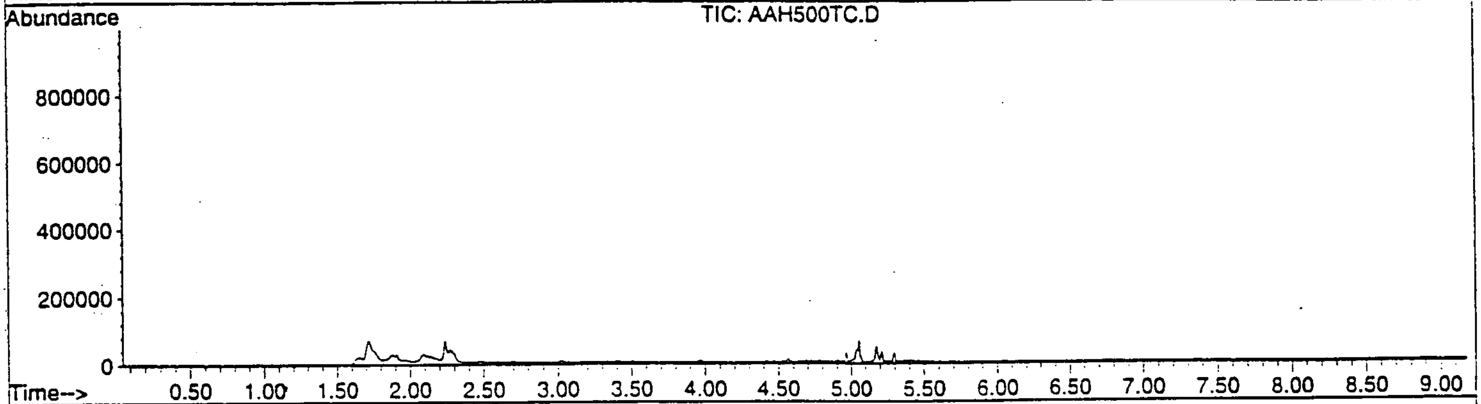
No second page

GORE SORBER SCREENING SURVEY ANALYTICAL RESULTS

LOUIS BERGER AND ASSOCIATES, PROVIDENCE, RI
SELECTION OF ANY EIGHT COMPOUNDS FROM GORE STANDARD TARGET VOCs/SVOCs (A3)
FIRING RANGE, KS
SITE AAH - PRODUCTION ORDER #072808

MODULE NUMBER	DATE ANALYZED	t12DCE, ug	11DCA, ug	c12DCE, ug	111TCA, ug	12DCA, ug	TCE, ug	PCE, ug
MDL =		0.16	0.05	0.03	0.08	0.02	0.01	0.03
136499	05/12/97	0.00	0.00	0.00	0.00	0.00	0.00	0.05
136500	05/12/97	0.00	0.00	0.00	0.00	0.00	0.00	0.03
136501	05/12/97	0.00	0.00	0.00	0.00	0.00	0.03	0.10
136502	05/12/97	0.00	0.00	0.00	0.00	0.00	0.00	0.10
136503	05/12/97	0.00	0.00	0.00	0.00	0.00	0.00	0.05
136504	05/12/97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
136505	05/12/97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Max. Detected	0.00	0.00	0.00	0.00	0.00	0.03	0.10


TIC: AAH499TC.D
Abundance
800000
600000
400000
200000
0
Time-->
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
7.50
8.00
8.50
9.00


TIC: AAH500TC.D
Abundance
800000
600000
400000
200000
0
Time-->
0.50
1.00
1.50
2.00
2.50
3.00
3.50
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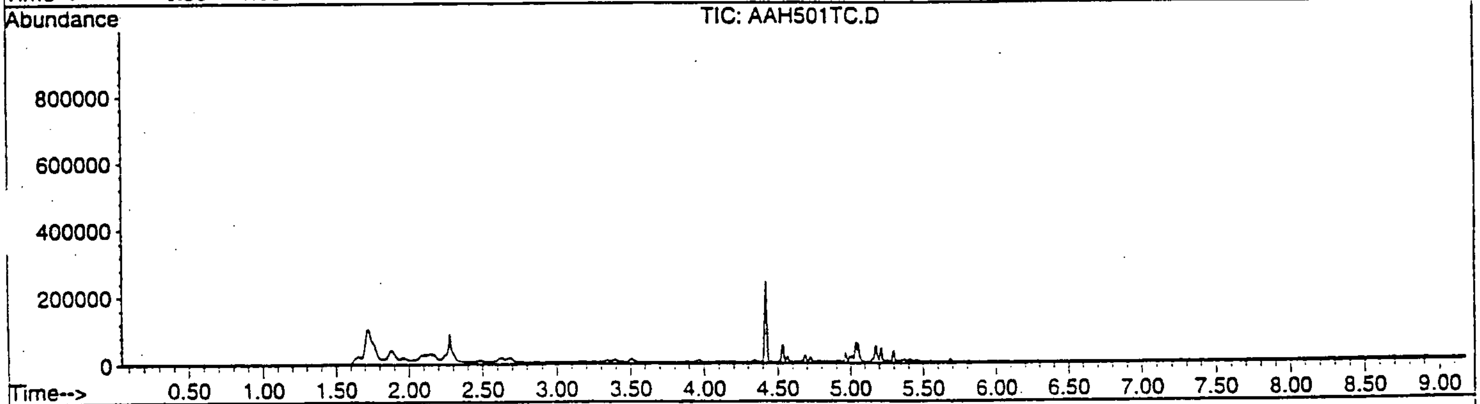
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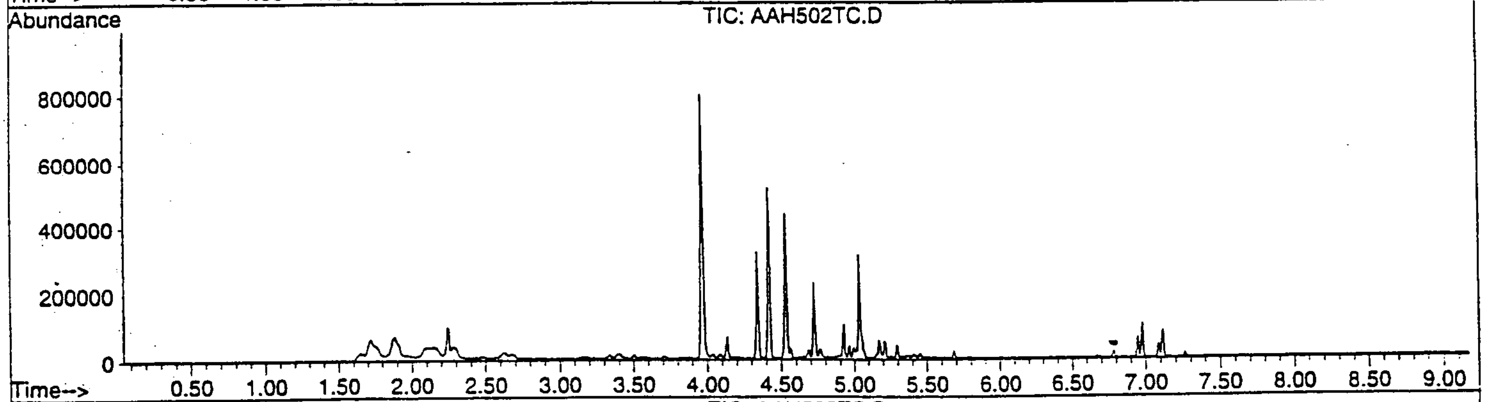
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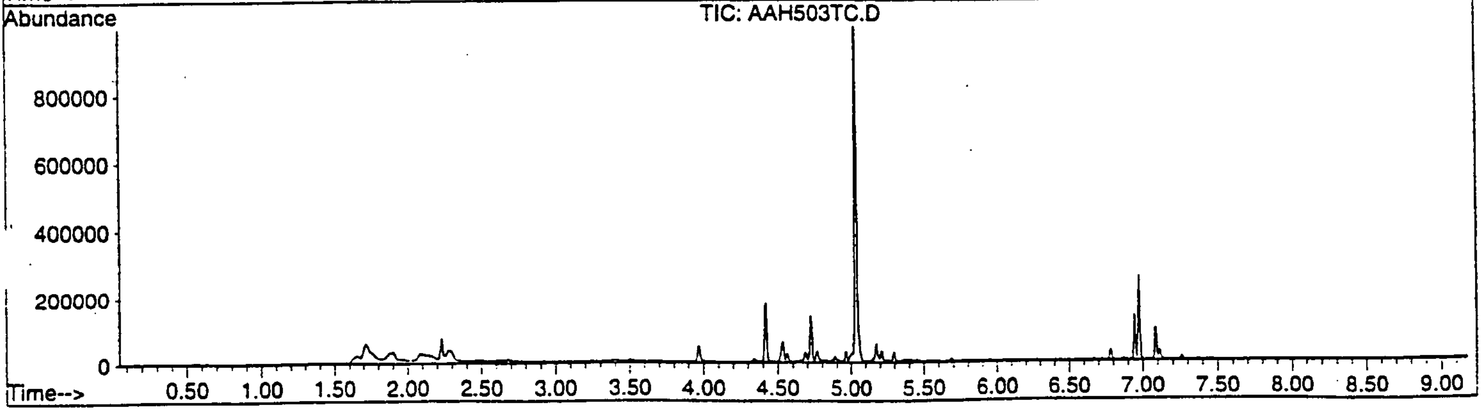
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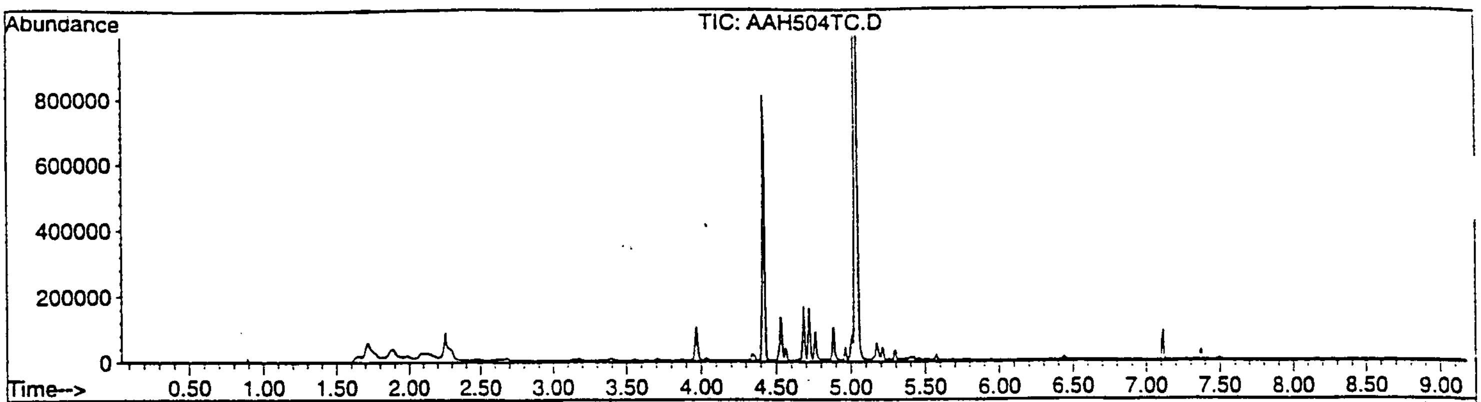
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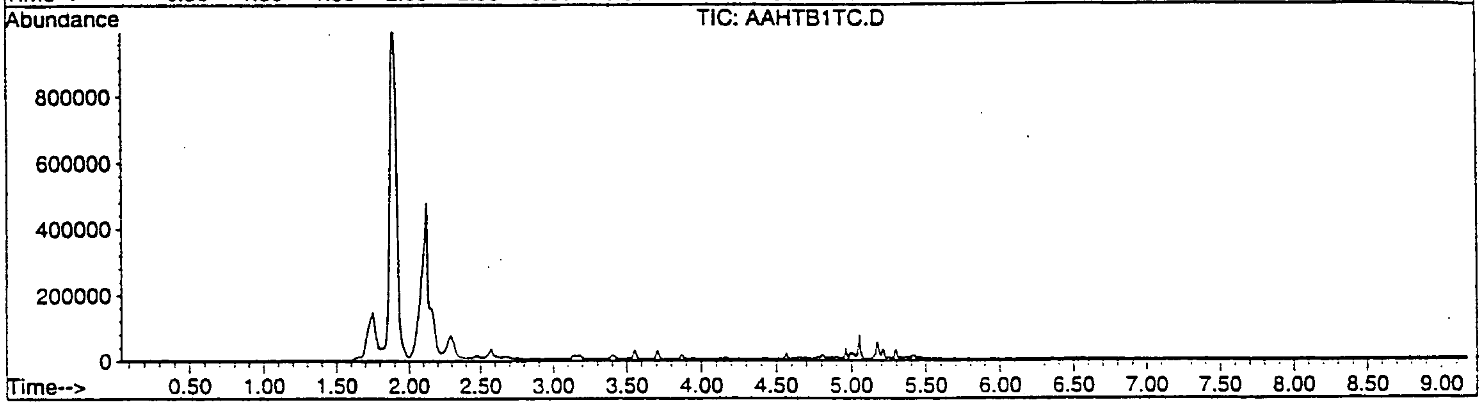
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5.00
5.50
6.00
6.50
7.00
7.50
8.00
8.50
9.00

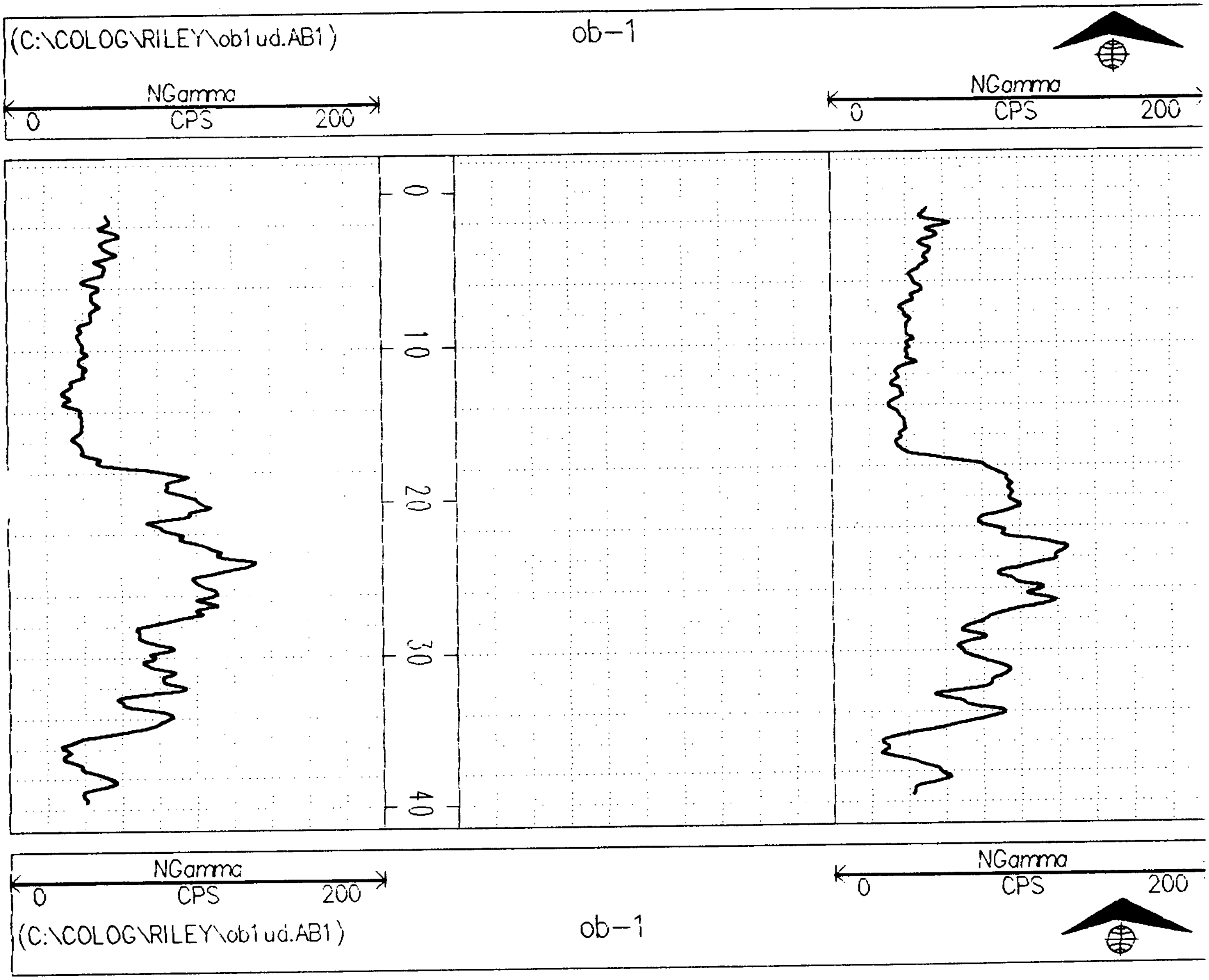
APPENDIX D

Geophysical Logs

APPENDIX D

Geophysical Logs (Gamma Logs - Scale : 1" = 10')

OB-93-01
OB-93-02
OB-93-03
OB-93-04
OB-97-05
OB-97-06
OB-97-07
OB-97-08
OB-97-09PZ
OB-97-10PZ
OB-97-11PZ
OB-97-12PZ
OB-97-13PZ
IZ-92-010
Outcrop 1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CPS
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NGamma
0
CPS
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0
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20
30
40
NGamma
0
CPS
200
NGamma
0
CPS
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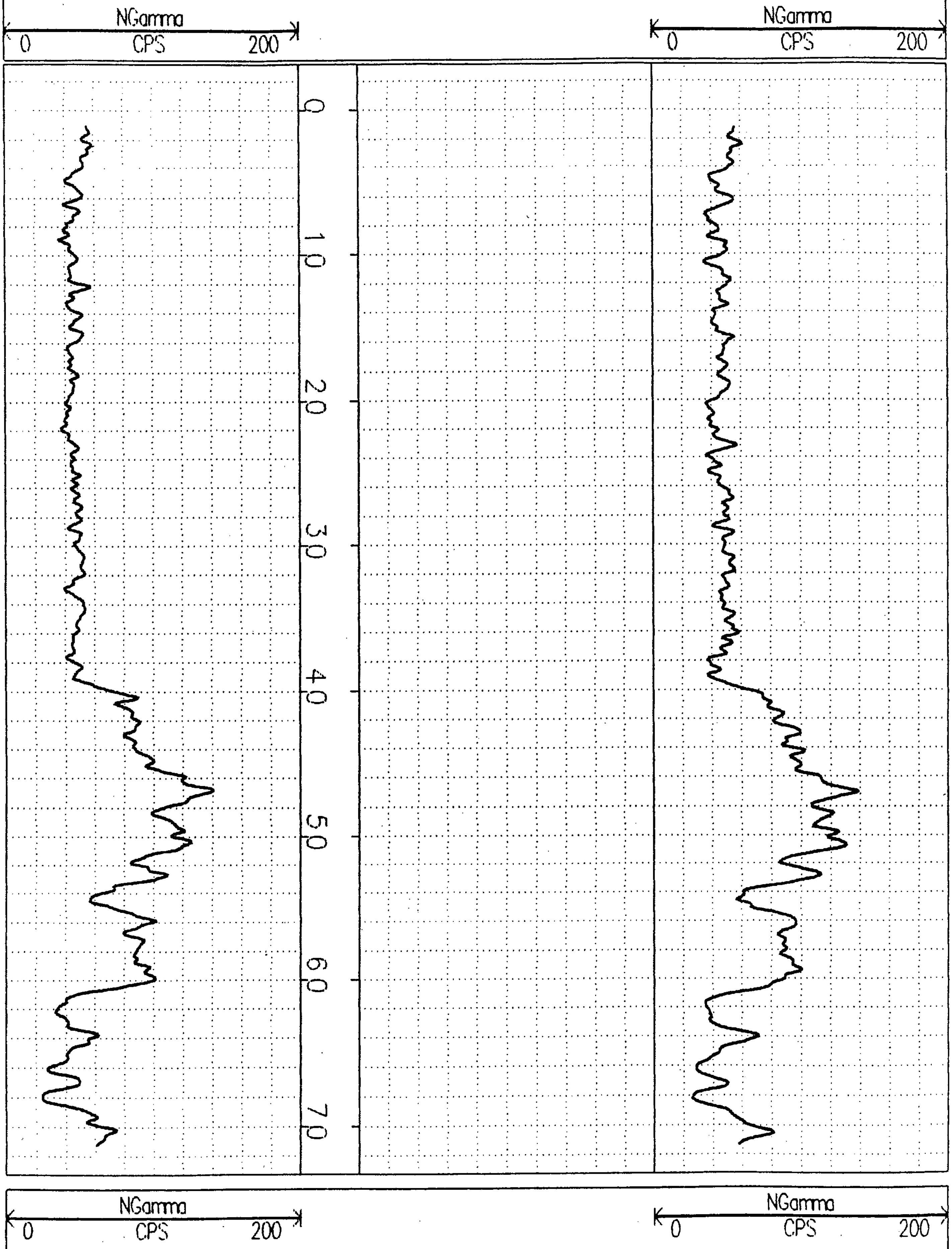
ob-1

(C:\TEMP\ob-2t.AB1) ob-2



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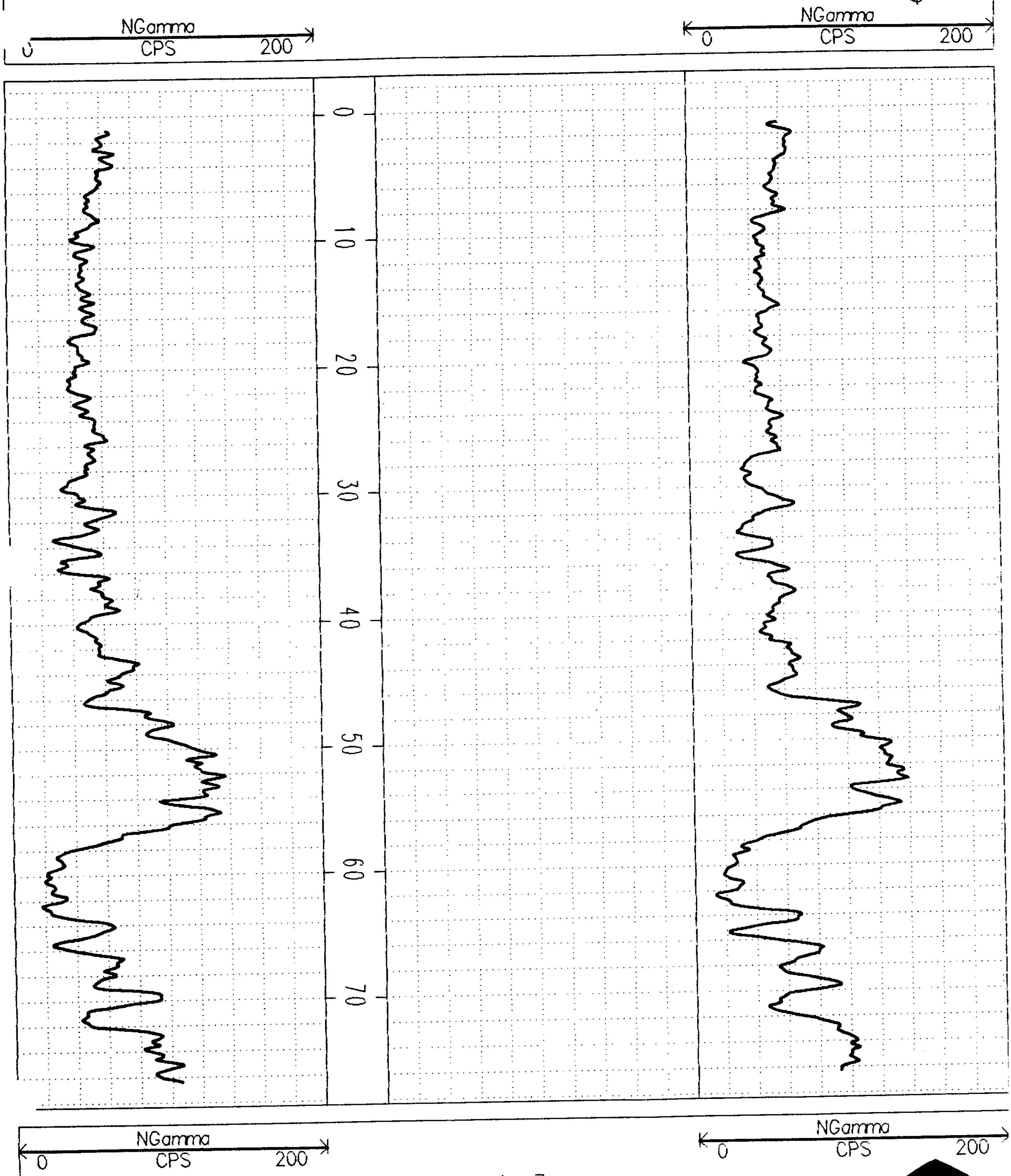
(C:\COLOG\RILEY\ob3ud.AB1)

ob-3



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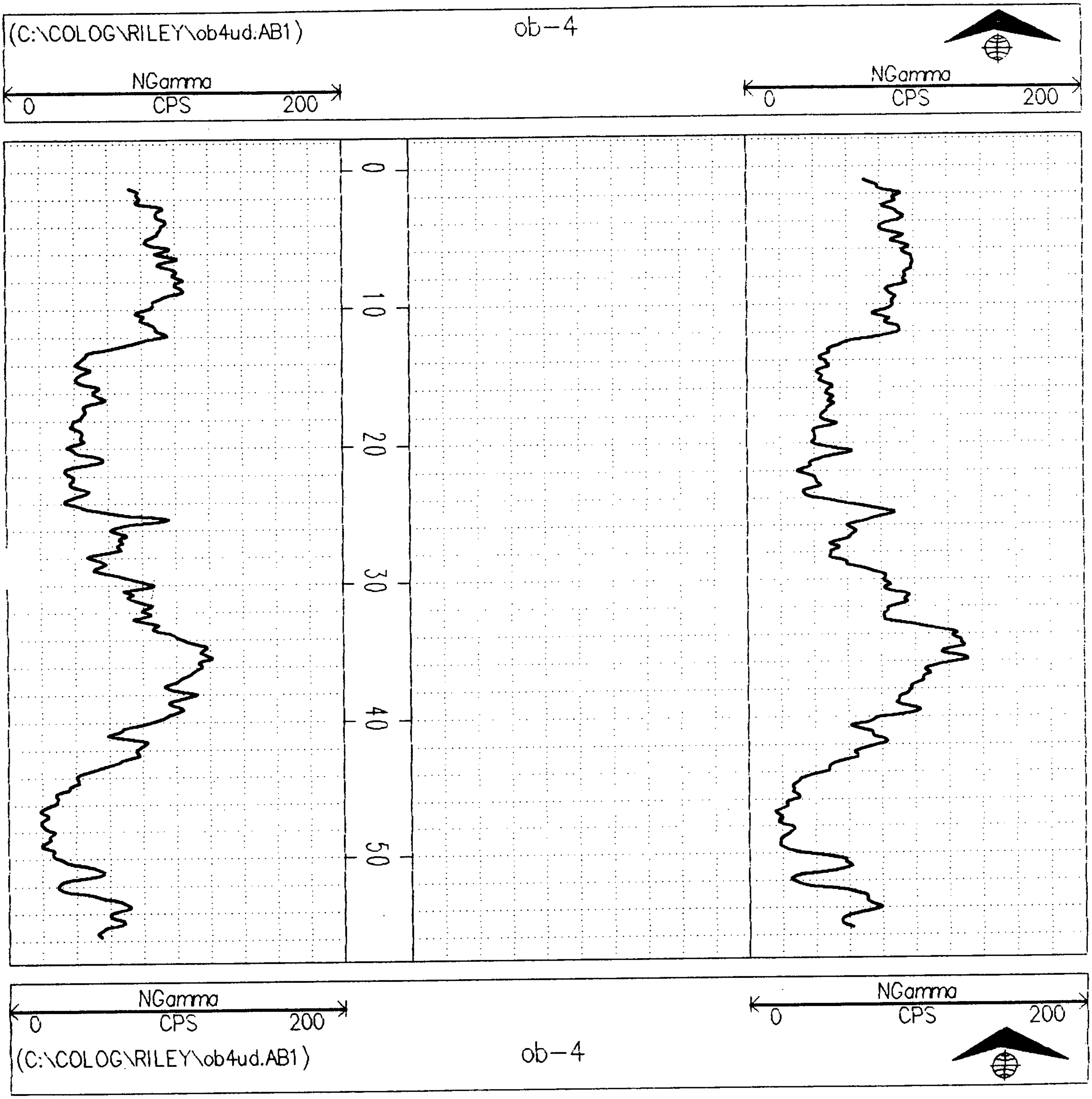
ob-3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CPS
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20
30
40
50
NGamma
0
CPS
200
NGamma
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CPS
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ob-4

(A:\OB9705.XDO)

OB9705

NGamma

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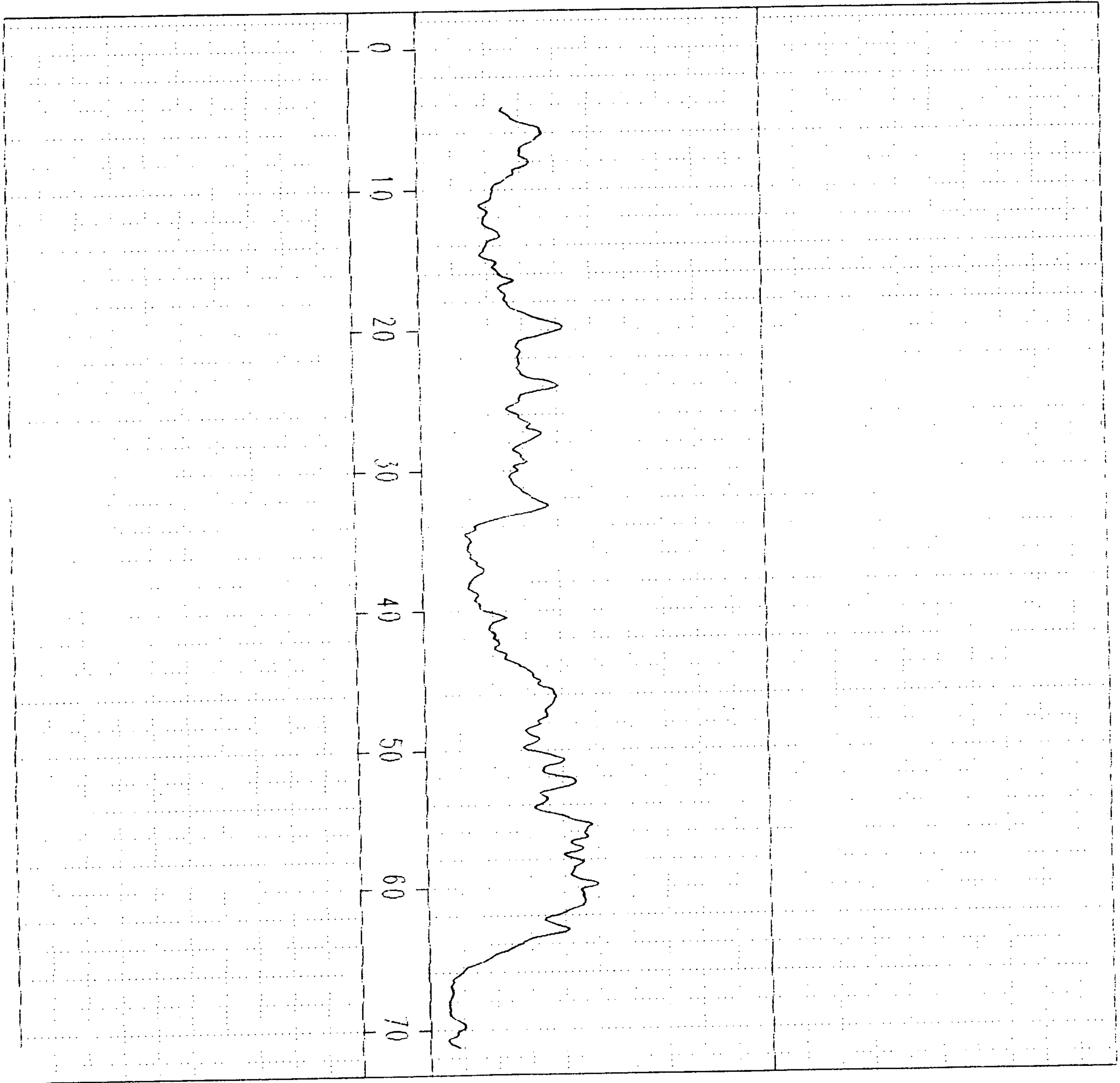

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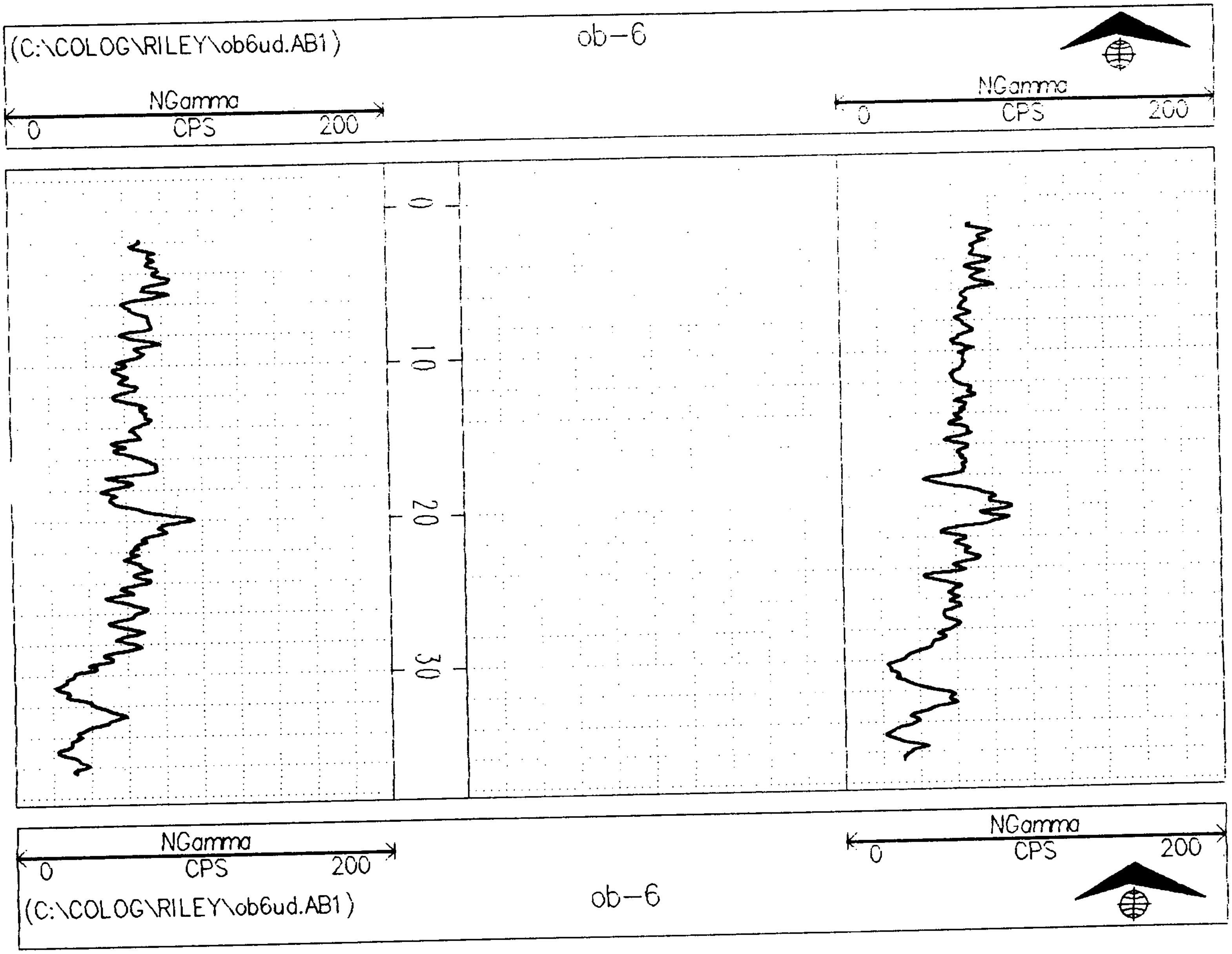
(A:\OB9705.XDO)

OB9705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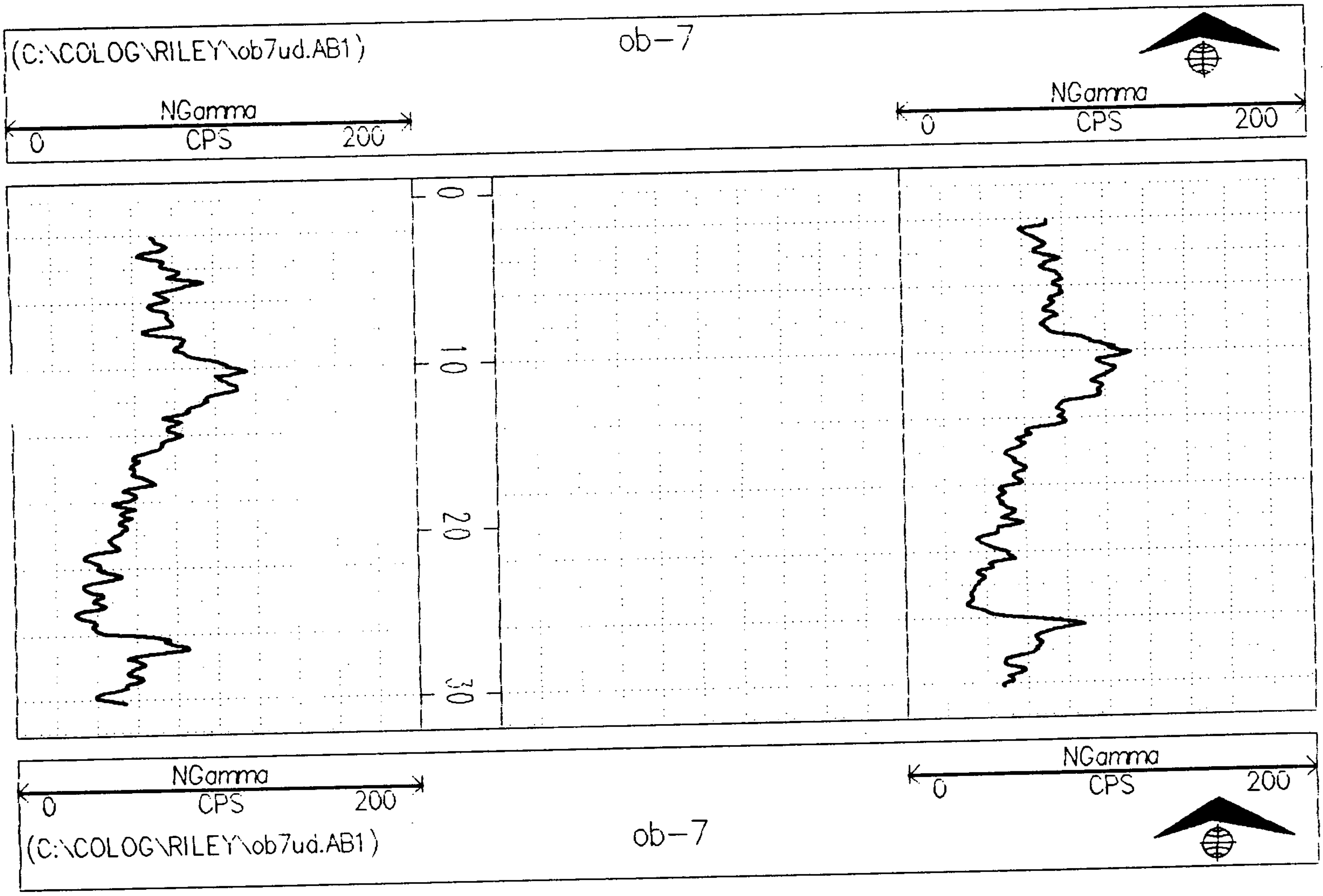
ob-6

(C:\COLOG\RILEY\ob6ud.AB1)

ob-6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CPS
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CPS
0
200
NGamma
CPS
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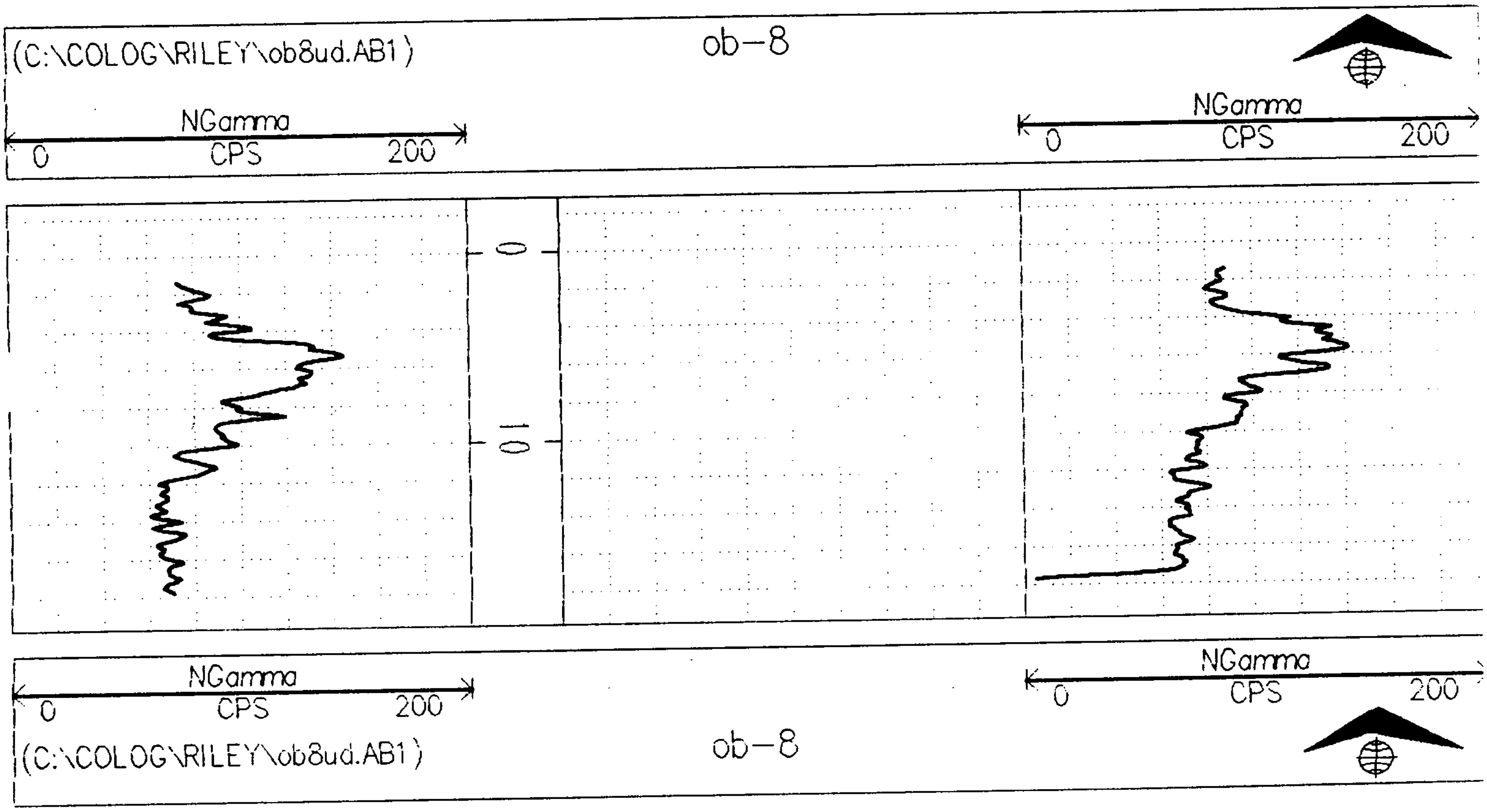
ob-7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CPS
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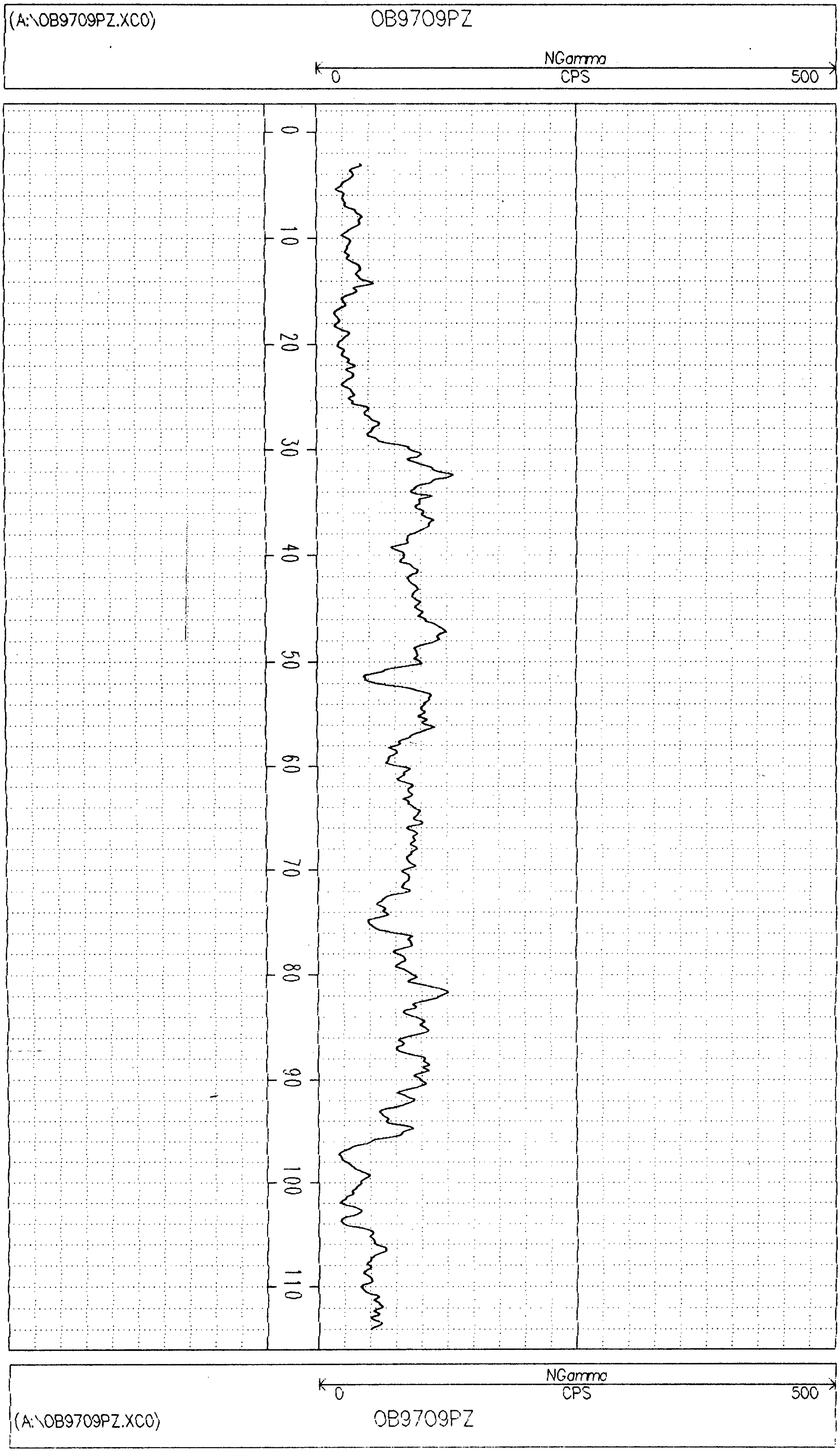
ob-8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CPS
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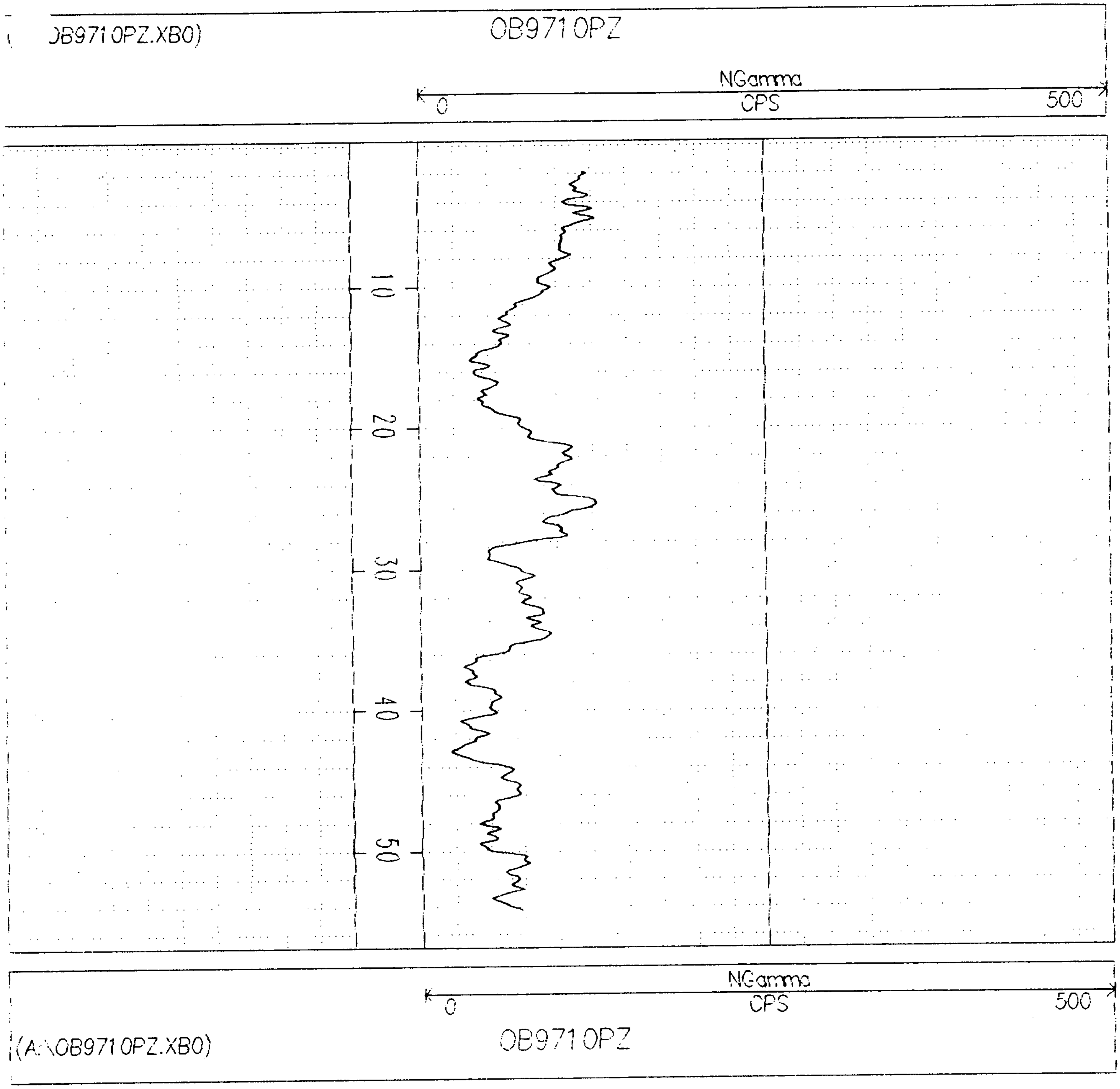
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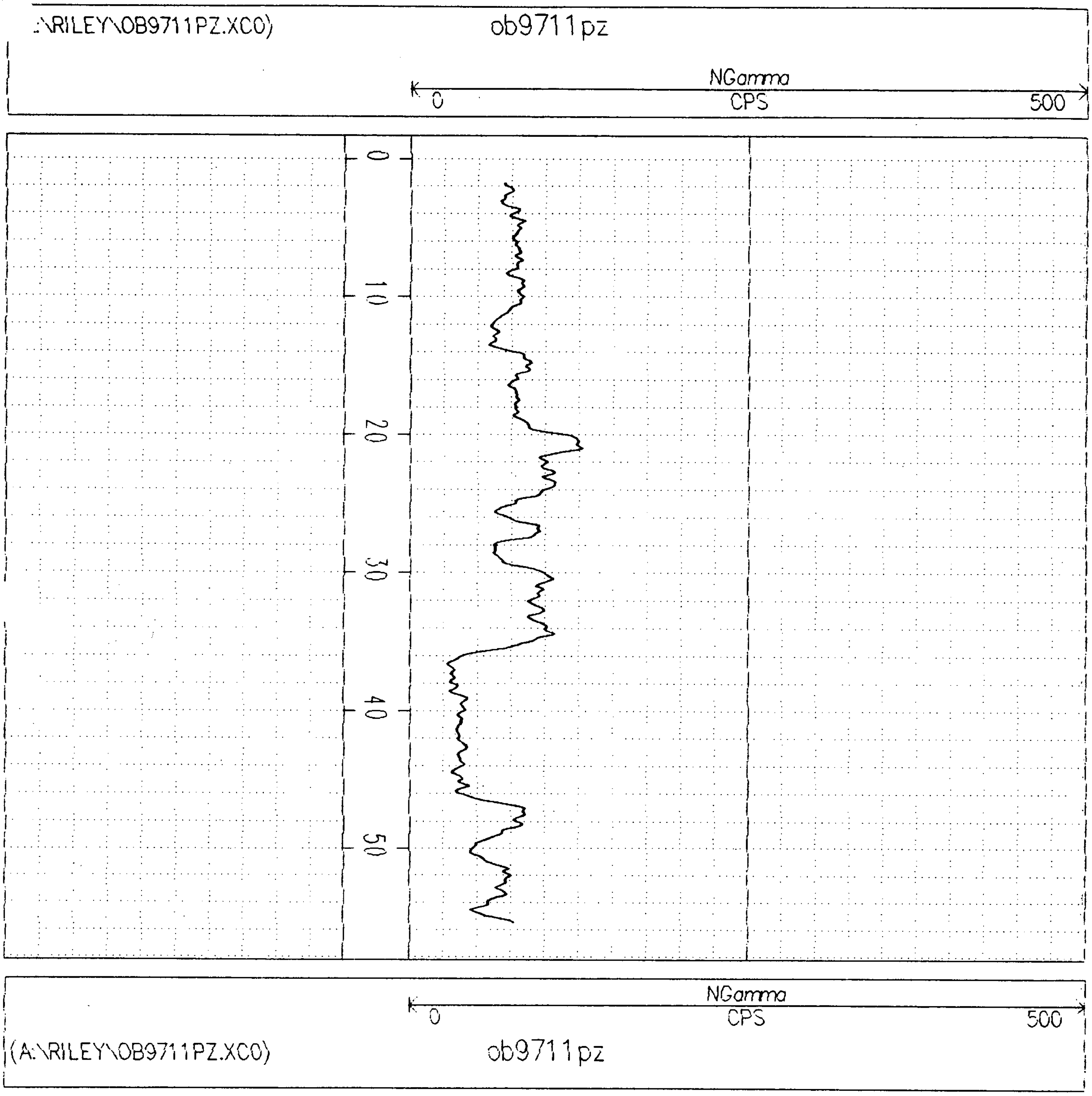
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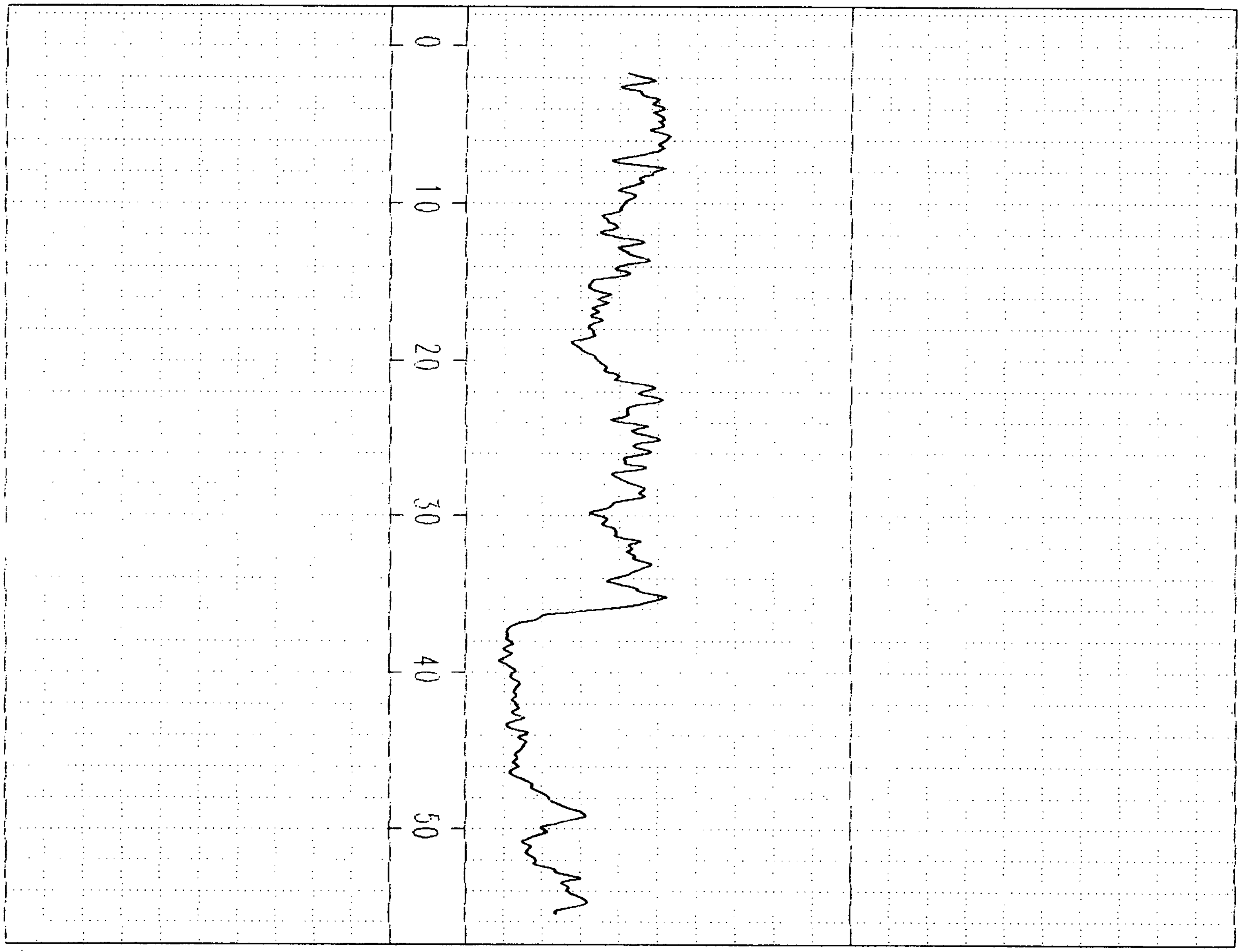
ob9711pz

\OB971 2PZ.XC2)

OB971 2PZ

NGamma

0 CPS 500



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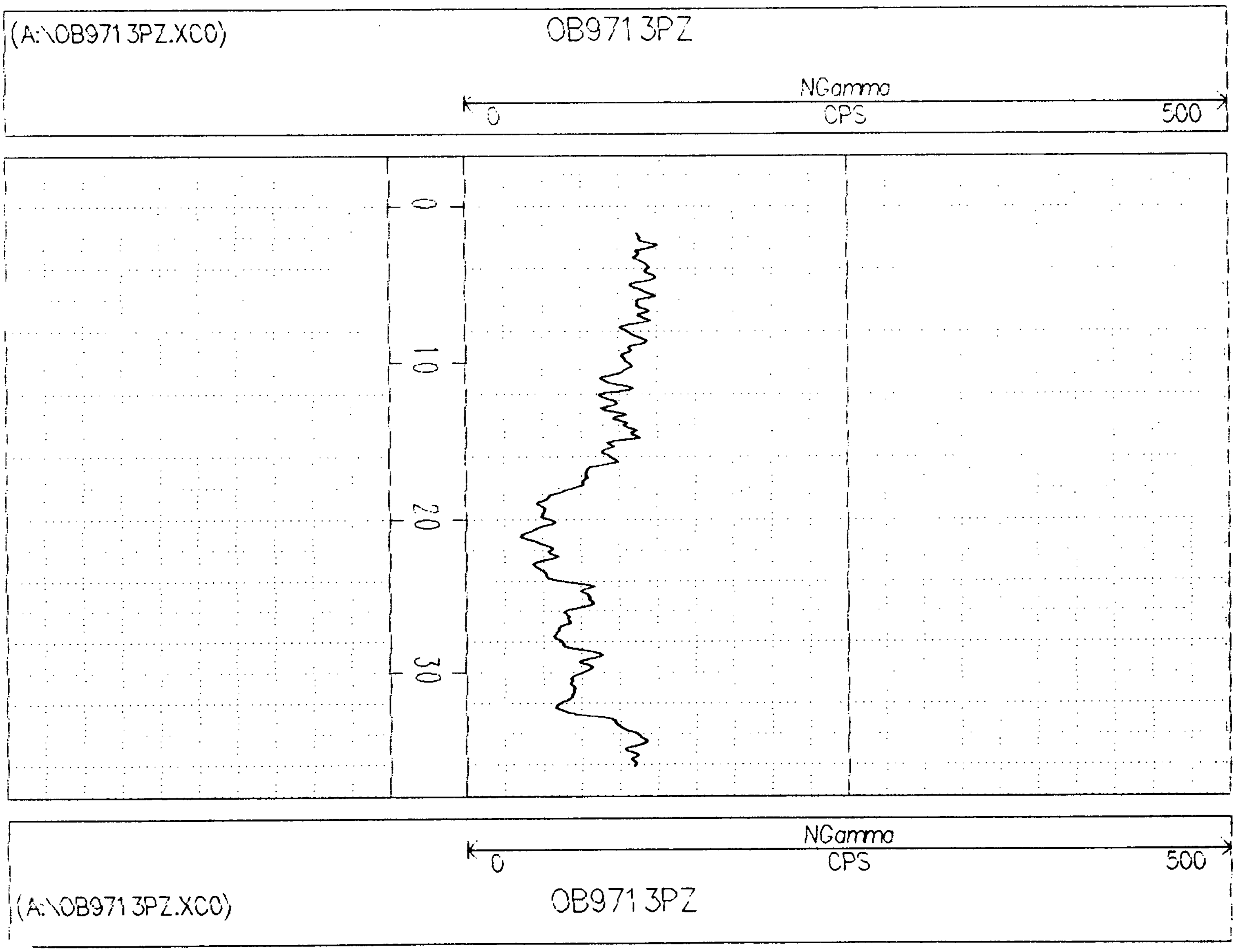
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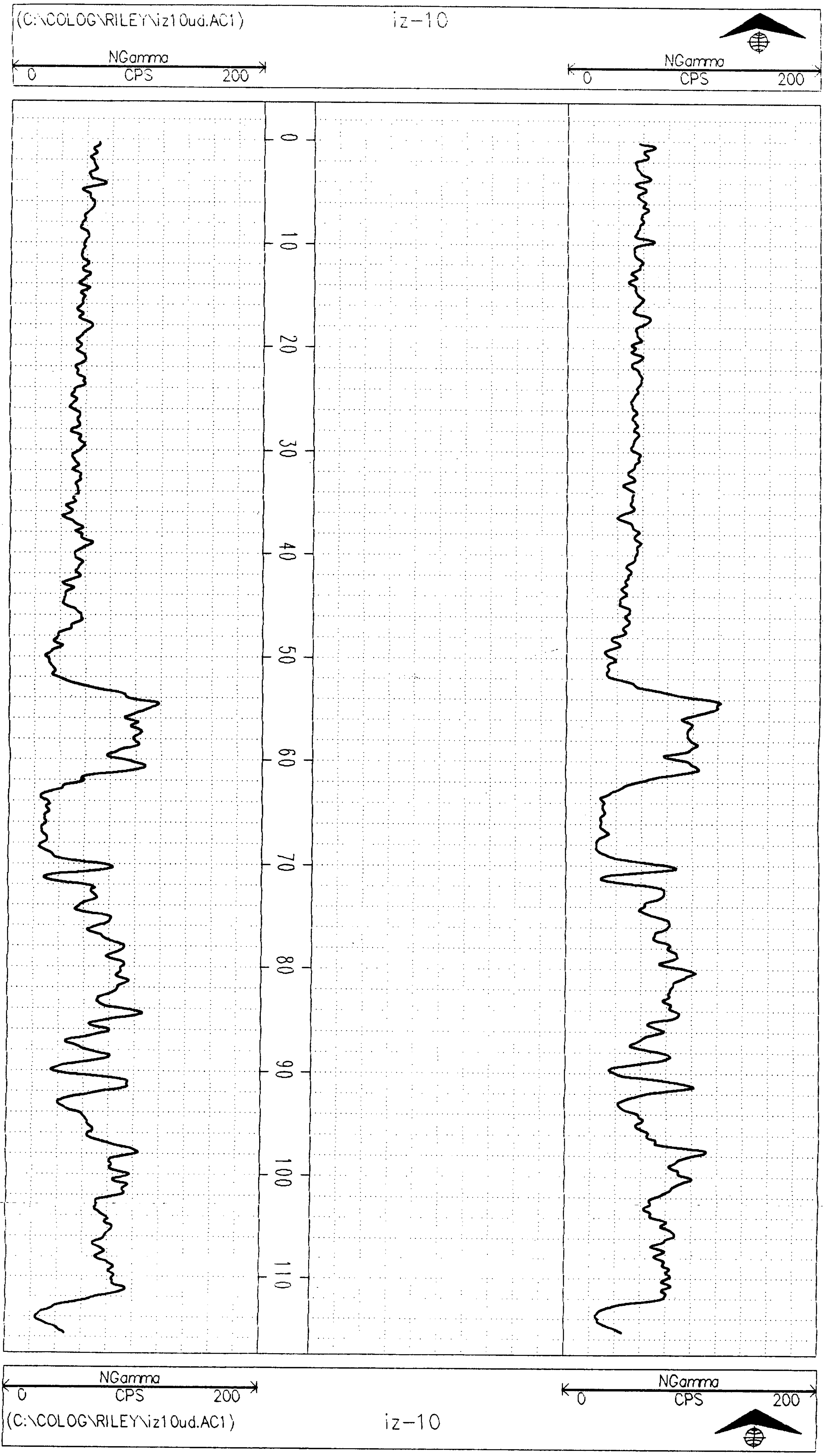
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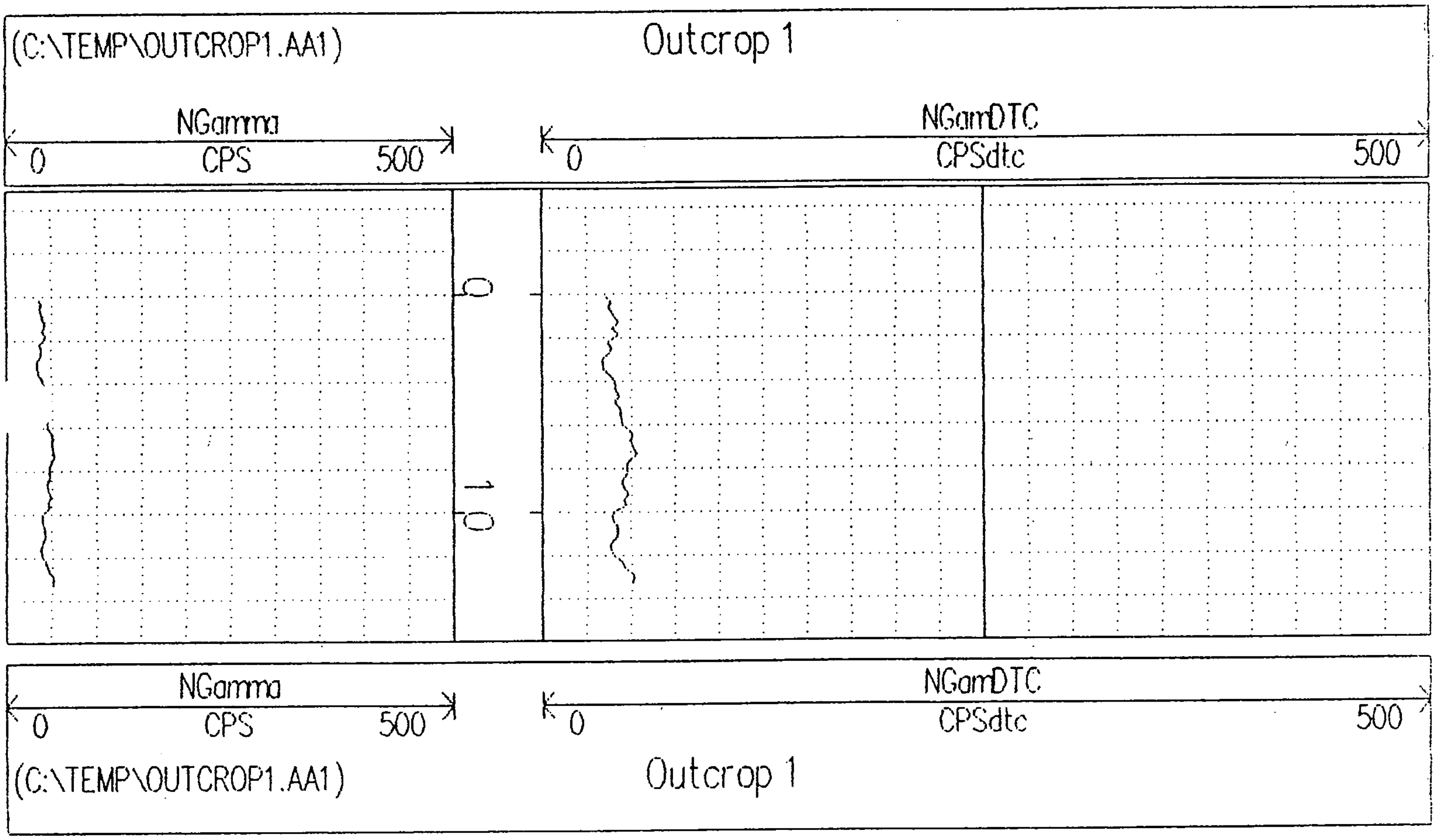
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Outcrop 1

SUPPLEMENTAL

TECHNICAL MEMORANDUM

MOBILIZATION #2 ACTIVITIES OPEN BURN/OPEN DETONATION AREA FORT RILEY, KANSAS

4 November 1997

Prepared for:

United States Army Engineer District, Kansas City
CENWK-EP-EA
601 East 12th Street
Kansas City, Missouri 64106-2896
Contract No. DACA41-92-D-0001

Prepared by:

Louis Berger & Associates, Inc.
1819 H Street, NW, Suite 900
Washington, DC 20006

Louis Berger & Associates, Inc.
1819 H Street, NW, Suite 900, Washington, DC 20006
Tel 202.331.7775 • Fax 202.293.6224

A MEMBER OF THE BERGER GROUP

ENGINEERS • PLANNERS • SCIENTISTS • ECONOMISTS • ARCHAEOLOGISTS

4 November 1997

Mr. Glen Shonkwiler
U.S. Army Engineer District, Kansas City
Attn: CENWK-EP-EA
601 East 12th Street
Kansas City, Missouri 64106-2896

RE: Supplemental Technical Memorandum Mobilization #2, Open Burn/Open Detonation Area, Fort Riley, Kansas
Contract No. DACA41-92-D-0001

Dear Glen:

Enclosed are four copies of the Supplemental Technical Memorandum for Mobilization #2 at the Open Burn/Open Detonation Area. This memo supplements the Technical Memorandum that was submitted on 22 August 1997.

We included figures showing the locations of the wells, piezometers, and surface water locations. We also included groundwater contours using data collected on 2 September 1997 since we do not believe that the wells were fully recovered when we evaluated earlier rounds of groundwater data. We also updated the cross-section to include the geophysical logging of the piezometers and the screened intervals of the piezometers.

If you have any questions, please do not hesitate to call me.

Sincerely,

LOUIS BERGER & ASSOCIATES, INC.

Barry Millman

Barry Millman, P.E.
Program Manager

Enclosures

cc: Mike Greene, CENWK (1 copy)
John Cook, Dynamac (5 copies)
Dave Egan, Berger (1 copy)
Susan Knauf, Berger (1 copy)
Harris Cheema, Berger (1 copy)
File (DO32/JH1124D)

Table of Contents

List of Figures

List of Tables

Overview of Mobilization #2 Activities
Open Burn/Open Detonation Area

1.0 Introduction

This report presents supplemental information to be used in conjunction with the Technical Memorandum for Mobilization #2, which was submitted on 22 August 1997. The groundwater elevation data collected soon after the piezometers were installed were evaluated. It is not believed that the wells had enough time to fully recover and thus it would not be appropriate to use that data to draw groundwater contours. Therefore the groundwater elevation data collected on 2 September 1997 was selected to draw groundwater contours. Table 5 was updated to include that round of data. Table 2 was also revised to correct the survey data elevations for the surface water locations. Included in this report are the following figures to aid in reviewing the data presented in the Technical Memorandum:

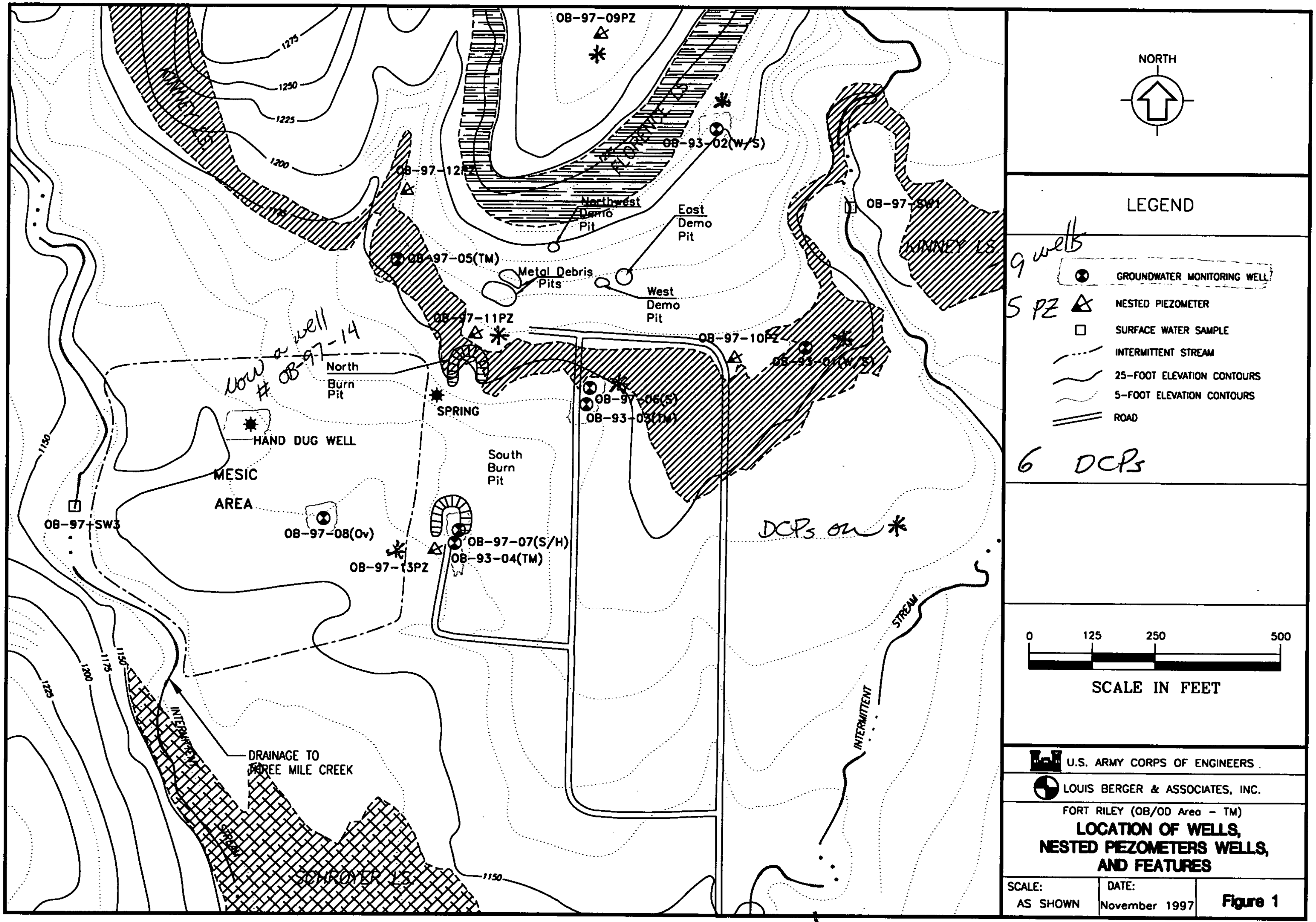
- Site map showing all the well and piezometer locations
- Site map showing location of surface water sampling locations (to date, only OB97-SW2 has been sampled)
- Groundwater elevation contours using the wells in the Schroyer Limestone and the piezometers screened in the Schroyer Limestone bottom
- Groundwater elevation contours using only the piezometers screened in the Schroyer Limestone bottom
- Groundwater elevation contours using the piezometers screened in the Havensville Shale
- A map showing the cross-section cuts
- A cross section that overlays the drilling log information with the geophysical log information and shows the elevation of the screens in the wells and piezometers

2.0 Groundwater Contours

The groundwater contours for 2 September 1997 is in the westerly direction using both the wells and piezometers screened in the Schroyer Limestone bottom (Figure 3) or just the piezometers screened in the Schroyer Limestone bottom (Figure 4). The groundwater contours for 2 September 1997 in the Havensville Shale is in the southwesterly direction (Figure 5).

There are no contours drawn for the Threemile Limestone, the Kinney Limestone, the Wymore Shale, or the Schroyer Limestone top as either there were insufficient elevations measured (i.e., wells were dry) or the gradient was too small to infer a direction.

FIG1.DWG



U.S. ARMY CORPS OF ENGINEERS

LOUIS BERGER & ASSOCIATES, INC.

FORT RILEY (OB/OD Area – TM)

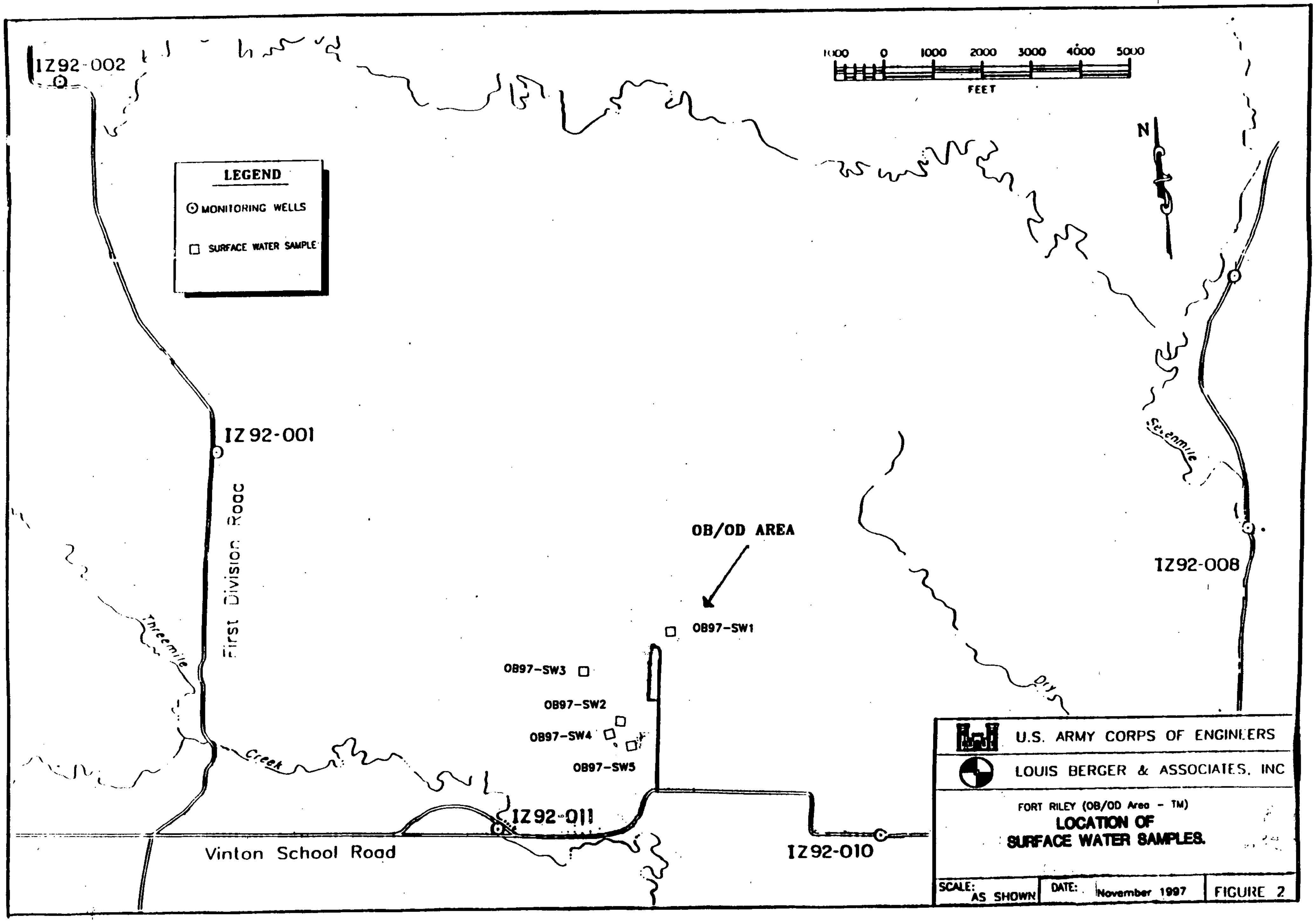
**LOCATION OF WELLS,
NESTED PIEZOMETERS WELLS,
AND FEATURES**

SCALE:	DATE:	
AS SHOWN	November 1997	**Figure 1**

TB = 1,2 6 ~~[illegible]~~ 11 PZ

1
2
6
11 9
13

Should list
Datum



U.S. ARMY CORPS OF ENGINEERS

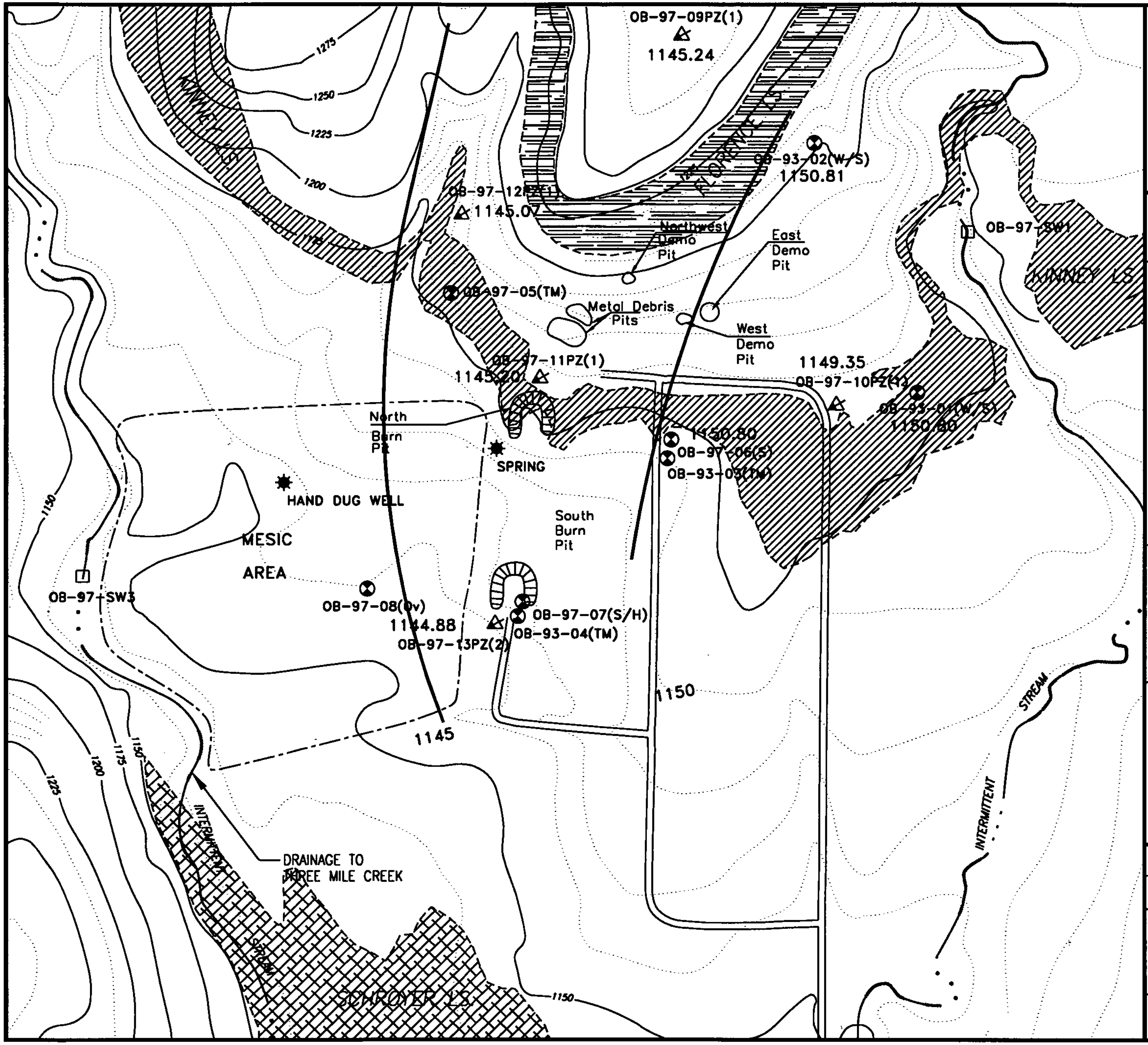
LOUIS BERGER & ASSOCIATES, INC

FORT RILEY (OB/OD Area - TM)

LOCATION OF SURFACE WATER SAMPLES

SCALE: AS SHOWN | DATE: November 1997 | FIGURE 2

FIG3.DWG



NORTH

LEGEND

- ⊗ GROUNDWATER MONITORING WELL
- △ NESTED PIEZOMETER
- ☐ SURFACE WATER SAMPLE
- INTERMITTENT STREAM
- 25-FOOT ELEVATION CONTOURS
- 5-FOOT ELEVATION CONTOURS
- ROAD
- GROUNDWATER ELEVATION CONTOUR

Note:

The Schroyer Limestone-bottom groundwater elevation was used for PZs to draw contour.

0 125 250 500

SCALE IN FEET

U.S. ARMY CORPS OF ENGINEERS

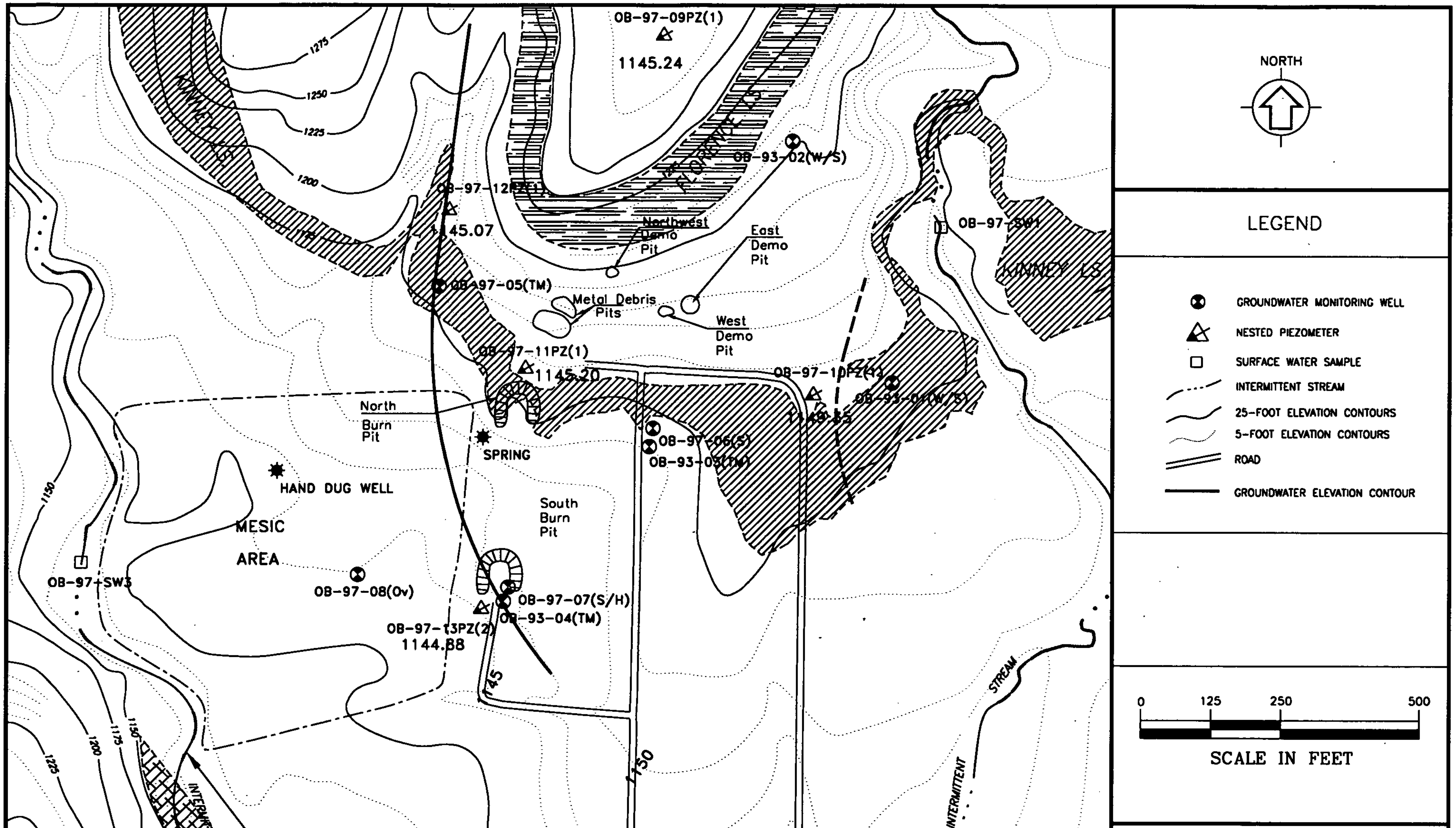
LOUIS BERGER & ASSOCIATES, INC.

FORT RILEY (OB/OD Area - TM)

GROUNDWATER ELEVATIONS CONTOUR - SCHROYER LIMESTONE, 2 SEPTEMBER 1997

SCALE:	DATE:	
AS SHOWN	November 1997	**Figure 3**

FIG5.DWG



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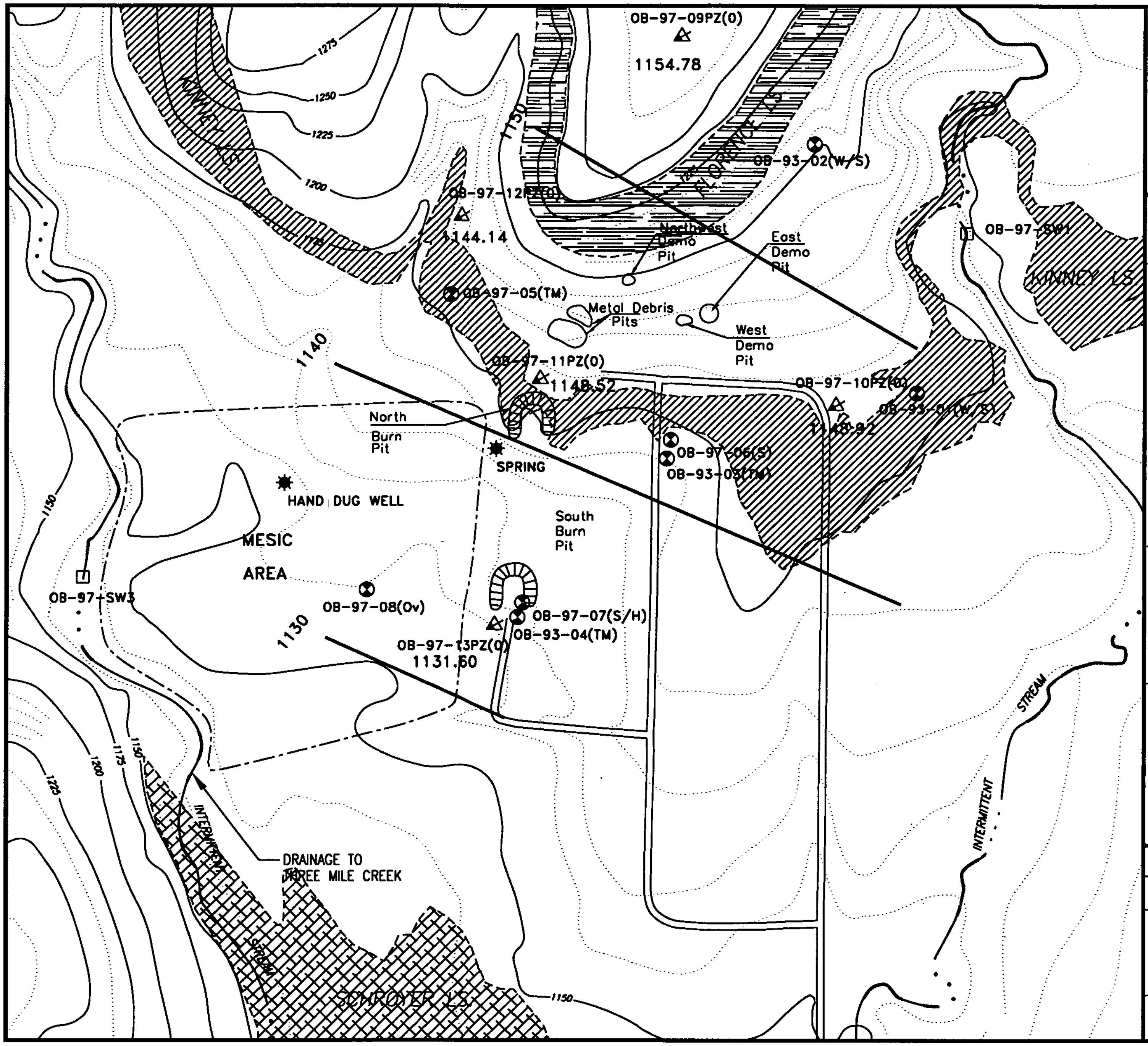
LOUIS BERGER & ASSOCIATES, INC.

FORT RILEY (OB/OD Area – TM)

GROUNDWATER ELEVATIONS CONTOUR - SCHROYER LIMESTONE BOTTOM, 2 SEPTEMBER 1997

SCALE:	DATE:	
AS SHOWN	November 1997	**Figure 4**

FIG4.DWG



NORTH

LEGEND

- GROUNDWATER MONITORING WELL
- NESTED PIEZOMETER
- ☐ SURFACE WATER SAMPLE
- INTERMITTENT STREAM
- 25-FOOT ELEVATION CONTOURS
- 5-FOOT ELEVATION CONTOURS
- ROAD
- GROUNDWATER ELEVATION CONTOUR

0 125 250 500

SCALE IN FEET

U.S. ARMY CORPS OF ENGINEERS

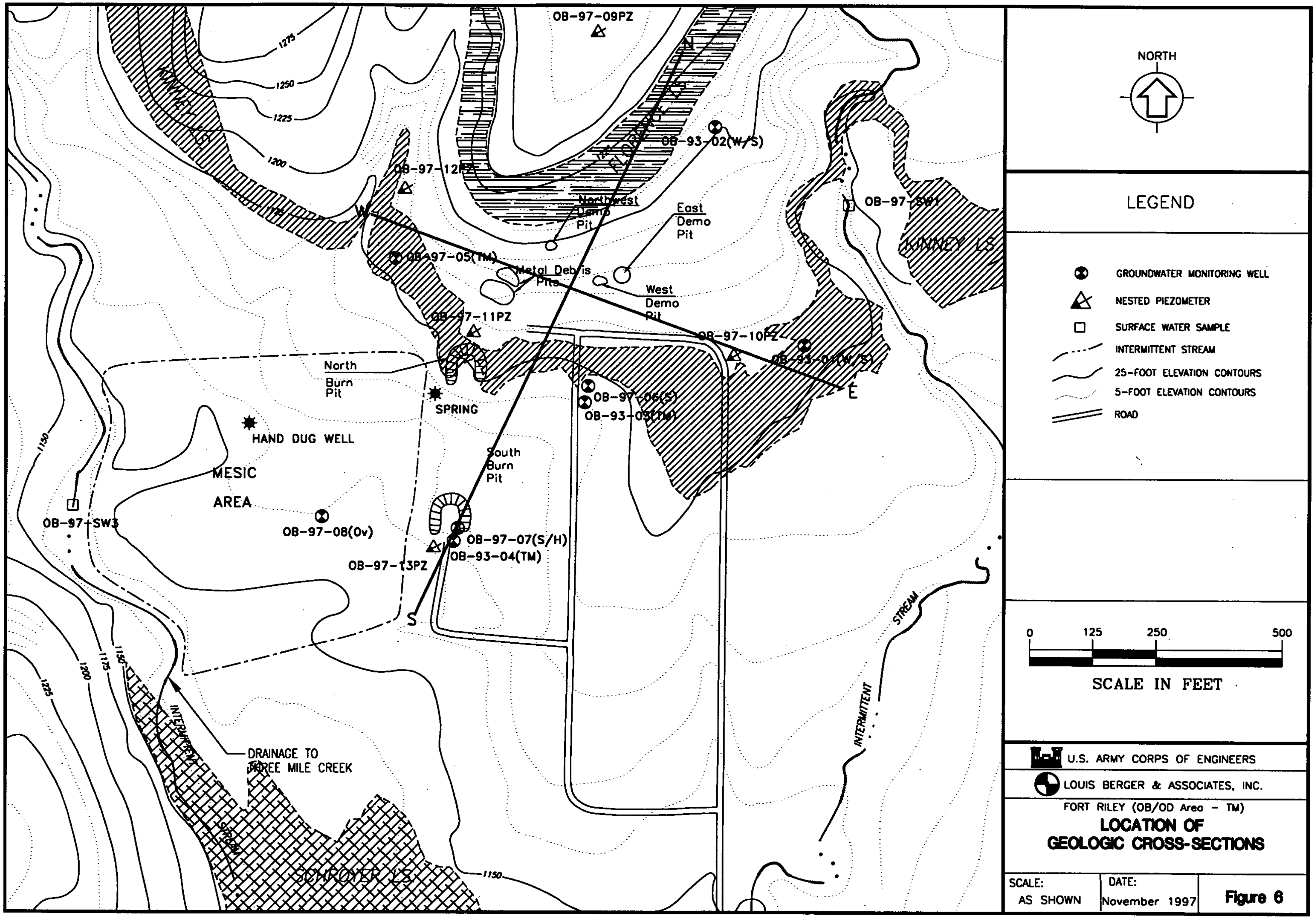
LOUIS BERGER & ASSOCIATES, INC.

FORT RILEY (OB/OD Area – TM)

GROUNDWATER ELEVATIONS CONTOUR - HAVENSVILLE SHALE 2 SEPTEMBER 1997

SCALE:	DATE:	
AS SHOWN	November 1997	**Figure 5**

97-6A.DWG



U.S. ARMY CORPS OF ENGINEERS

LOUIS BERGER & ASSOCIATES, INC.

FORT RILEY (OB/OD Area – TM)

LOCATION OF GEOLOGIC CROSS-SECTIONS

SCALE: AS SHOWN

DATE: November 1997

Figure 6

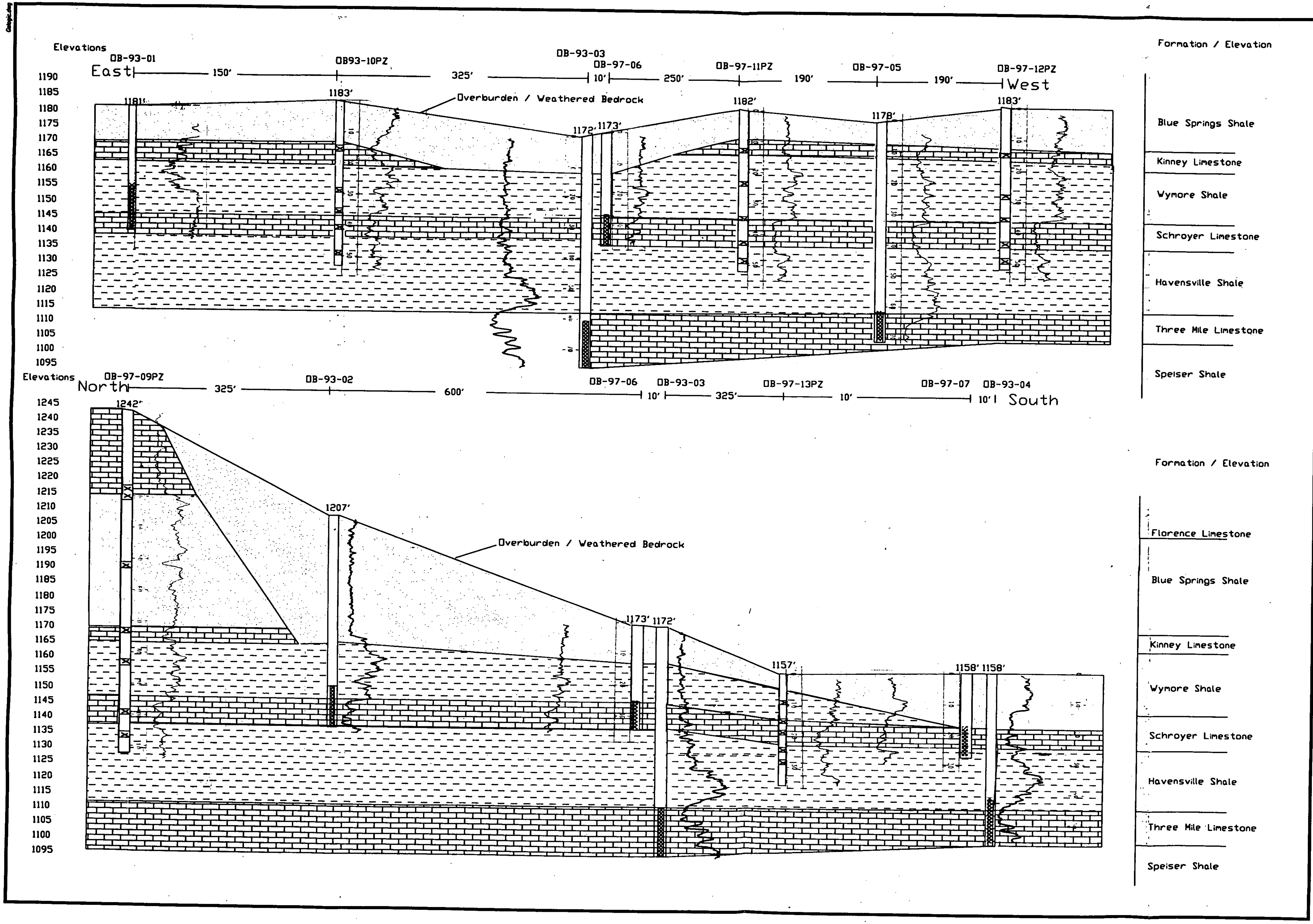


Figure 7: Well Elevations / Composition

November 1997

LOUIS BERGER & ASSOCIATES, INC.

Table 2 Survey Data - Revised

Survey Point	Elevation Ground - ft msl	Elevation TOC - ft msl	NAD 27 Coordinates		NAD 83 Coordinates	
			Latitude/ Easting	Longitude/ Northing	Latitude/ Easting	Longitude/ Northing
OB93-01	1182.07	1183.72	2351617.00	297014.00	1663860.43	297017.70
OB93-02	1208.44	1210.08	2351430.00	297455.00	1663673.43	297458.70
OB93-03	1172.88	1174.84	2351178.00	296891.00	1663421.43	296894.70
OB93-04	1158.32	1160.09	2350915.00	296603.00	1663158.43	296606.70
OB97-05	1178.23	1180.12	2350827.53	297143.29	1663070.96	297146.99
OB97-06	1173.36	1175.37	2351177.15	296903.05	1663420.58	296906.75
OB97-07	1158.72	1160.37	2350918.19	296614.14	1663161.62	296617.84
OB97-08	1158.25	1160.11	2350704.07	296753.03	1662947.50	296756.73
OB97-09PZ	1242.81	1245.70	2351194.18	297646.11	1663437.61	297649.81
OB97-10PZ	1183.28	1185.52	2351567.81	296982.44	1663711.24	296986.14
OB97-11PZ	1182.21	1184.43	2350973.70	296987.18	1663217.13	296990.88
OB97-12PZ	1183.24	1185.65	2350811.13	297281.66	1663054.56	297285.36
OB97-13PZ	1157.92	1160.15	2350926.34	296598.84	1663169.77	296602.54
Dug Well	NAp	1155.28	2350548.60	296813.88	1662792.03	296817.58
Spring	1162.48	1163.66	2350873.72	296885.77	1663117.15	296889.47
OB97-SW1	1168.74	1169.94	2351710.83	297304.08	1663954.26	297307.78
OB97-SW2	1132.01	1132.92	2351041.69	295273.69	1663285.12	295277.37
OB97-SW3	1145.30	1145.97	2350180.08	296664.68	1662423.51	296668.38
OB97-SW4	1130.10	1131.65	2350911.84	295132.88	1663155.27	295136.56
OB97-SW5	1128.99	1130.96	2351195.15	294895.91	1663438.58	294899.59

Notes:
msl - mean sea level;
TOC - Top of Casing
Elevation for dug well is the top of the angle iron adjacent to well.
Elevations for the spring are ground elevation (1162.48 ft msl) and the top of the iron bar (1163.66 ft msl) placed at the head of the spring by the surveyor.
Elevations for surface water sample locations are the ground surface along the centerline of each stream and the top of the iron bar placed at each location by the surveyor.
NAp - Not Applicable

Table 5 Summary of Groundwater Elevation Data - Revised

Well ID	Formation Screened	Top of Screen Elev.	Bottom of Screen Elev.	Grd. Elev.	Measuring Point Elev.	Total depth (ft)	Groundwater Elevation																
							Date																
						5-Jul-97	1-Jun-97	4-Jun-97	5-Jun-97	6-Jun-97	7-Jun-97	9-Jun-97	10-Jun-97	11-Jun-97	14-Jun-97	16-Jun-97	17-Jun-97	18-Jun-97	20-Jun-97	4-Jul-97	5-Jul-97	27-Aug-97	2-Sep-97
OB93-01	Wymore/Schroyer	1155.00	1140.00	1182.07	1183.72	NM	1155.41	1154.91	1154.87	1154.84	1154.59	1154.35	1154.32	1154.39	1154.11	1153.85	1153.65	1153.47	1153.37	1151.95	1152.11	1151.01	1150.80
OB93-02	Wymore/Schroyer	1151.00	1136.00	1208.44	1210.08	NM	1155.40	1154.89	1154.86	1154.85	1154.59	1154.34	1154.33	1154.39	1154.11	1153.88	1153.70	1153.51	1153.39	1151.96	1152.16	1151.03	1150.81
OB93-03	Threemile Limestone	1111.00	1096.00	1172.88	1174.84	NM	1124.03	1123.86	1123.85	1123.84	1123.79	1123.73	1123.67	1123.67	1123.53	1123.46	1123.38	1123.31	1123.24	1122.48	1122.53	1121.37	1121.31
OB93-04	Threemile Limestone	1116.00	1101.00	1158.32	1160.09	NM	1125.01	1124.89	1124.90	1124.88	1124.84	1124.78	1124.74	1124.74	1124.62	1124.53	1124.42	1124.34	1124.23	1123.17	1123.16	1121.39	1121.36
OB97-05	Threemile Limestone	1115.00	1105.00	1178.23	1180.12	72.94	1124.10	1123.95	1123.96	1123.94	1123.89	1123.83	1123.77	1123.78	1123.62	1123.56	1123.48	1123.40	1123.34	1122.51	1122.57	1121.33	1121.28
OB97-06	Schroyer Limestone	1146.50	1136.50	1173.36	1175.37	38.49	1155.39	1154.90	1154.86	1154.86	1154.59	1154.39	1154.34	1154.40	1154.13	1153.87	1153.67	1153.49	1153.38	1151.97	1152.17	1151.13	1150.80
OB97-07	Schroyer/Havensville	1140.00	1130.00	1158.72	1160.37	32.94	1146.66	1146.93	1147.00	1147.15	1147.05	1146.77	1146.76	1146.68	1146.46	1146.32	1146.25	1146.17	1146.03	1145.27	1145.26	1144.90	1144.86
OB97-08	Overburden	1149.00	1139.00	1158.25	1160.11	20.39	1145.94	1145.62	1145.51	1145.44	1145.28	1145.05	1144.98	1144.92	1144.74	1144.53	1144.45	1144.36	1144.18	1142.98	1142.92	1142.45	1142.50
OB97-09PZ(0)	Havensville Shale	1133.81	1132.81	1242.81	1245.70	113.01	Wells not installed											1158.44	1156.21	1155.68	1150.20	1154.73	1154.78
OB97-09PZ(1)	Schroyer Limestone	1139.81	1138.81	1242.81	1245.70	107.19												1146.52	1146.51	1145.21	dry	1145.32	1145.24
OB97-09PZ(2)	Wymore Shale	1155.81	1154.81	1242.81	1245.70	89.85												1158.43	1156.21	1156.05	dry	dry	dry
OB97-09PZ(3)	Kinney Limestone	1168.81	1167.81	1242.81	1245.70	78.08												1168.83	1168.73	1168.58	dry	1168.41	1168.48
OB97-09PZ(4)	Blue Springs Shale	1191.81	1190.81	1242.81	1245.70	55.06												1191.96	1192.00	1191.93	dry	1191.71	1191.73
OB97-09PZ(5)	Florence Limestone	1216.81	1215.81	1242.81	1245.70	31.24												1216.28	1215.73	1214.91	dry	dry	dry
OB97-10PZ(0)	Havensville Shale	1134.28	1133.28	1183.28	1185.52	53.35												1138.54	1140.01	1146.31	1136.65	1149.01	1148.92
OB97-10PZ(1)	Schroyer Limestone-bottom	1141.28	1140.28	1183.28	1185.52	45.59												1151.28	1151.18	1150.78	1150.33	1149.56	1149.35
OB97-10PZ(2)	Schroyer Limestone-top	1147.28	1146.28	1183.28	1185.52	40.67												1153.47	1153.44	1151.99	1151.95	1151.16	1151.10
OB97-10PZ(3)	Wymore Shale	1154.28	1153.28	1183.28	1185.52	32.62												1164.71	1164.50	1164.69	1157.52	1163.79	1163.74
OB97-10PZ(4)	Kinney Limestone	1167.28	1166.28	1183.28	1185.52	19.55												1166.24	1166.24	dry	dry	dry	dry
OB97-11PZ(0)	Havensville Shale	1132.21	1131.21	1182.21	1184.43	53.40												1154.52	1153.62	1152.96	1152.41	1148.42	1148.52
OB97-11PZ(1)	Schroyer Limestone-bottom	1138.21	1137.21	1182.21	1184.43	47.55												1146.67	1146.66	1145.29	1145.70	1145.36	1145.20
OB97-11PZ(2)	Schroyer Limestone-top	1146.21	1145.21	1182.21	1184.43	39.60												1146.59	1146.54	1145.21	1145.29	dry	dry
OB97-11PZ(3)	Wymore Shale	1153.21	1152.21	1182.21	1184.43	32.53												1154.56	1153.59	1152.95	1152.41	dry	dry
OB97-11PZ(4)	Kinney Limestone	1169.21	1168.21	1182.21	1184.43	16.93												1168.39	1168.39	1167.76	dry	dry	dry
OB97-12PZ(0)	Havensville Shale	1133.24	1132.24	1183.24	1185.65	53.60												1147.57	1136.52	1147.79	1135.29	1143.87	1144.14
OB97-12PZ(1)	Schroyer Limestone-bottom	1139.24	1138.24	1183.24	1185.65	47.56												1146.43	1146.43	1145.12	1145.53	1145.34	1145.07
OB97-12PZ(2)	Schroyer Limestone-top	1147.24	1146.24	1183.24	1185.65	39.67												1146.56	1146.65	1146.21	dry	dry	dry
OB97-12PZ(3)	Wymore Shale	1154.24	1153.24	1183.24	1185.65	32.60												1160.22	1160.11	1158.91	1158.85	1156.81	1156.52
OB97-12PZ(4)	Kinney Limestone	1169.24	1168.24	1183.24	1185.65	17.72												dry	dry	1168.18	dry	dry	dry
OB97-13PZ(0)	Havensville Shale-bottom	1127.92	1126.92	1157.92	1160.15	33.34												1145.33	1132.33	1132.18	1131.69	1131.50	1131.60
OB97-13PZ(1)	Havensville Shale-top	1131.92	1130.92	1157.92	1160.15	29.54												1146.20	1145.69	1145.23	1143.91	1144.58	1144.61
OB97-13PZ(2)	Schroyer Limestone-bottom	1136.92	1135.92	1157.92	1160.15	24.42												1146.04	1146.05	1145.30	1145.28	1144.96	1144.88
OB97-13PZ(3)	Schroyer Limestone-top	1141.42	1140.42	1157.92	1160.15	19.86												1147.19	1141.32	1143.79	1144.24	1143.68	1143.69
OB97-13PZ(4)	Overburden	1146.92	1145.92	1157.92	1160.15	14.67												1149.83	1147.39	1146.35	1146.60	1146.20	1146.11
Dug Well	NAp	NAp	NAp	NM	1155.28	20.29	NM	1144.88	1144.73	1144.63	1144.58	1144.58	1144.50	1144.52	1144.03	1143.83	1143.74	1143.67	1143.50	1142.40	1141.98	1140.93	1141.02

Notes:
NAp - Not applicable
NM - Not measured

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A MEMBER OF THE BERGER GROUP

August 5, 1998

Commander
U. S. Army Engineer District, Kansas City
ATTN: CENWK-EP-EA (Glen Shonkwiler)
601 E. 12th Street
Kansas City, MO 64106-2896

RE: DACA41-92-0001 Indefinite Delivery Contract for Various Military Hazardous Waste
Cleanup Projects at Fort Riley, Kansas
Draft Final Site Investigation (SI) for the Open Burn/Open Detonation Area
Delivery Order 32 (JH1124F/JG1270)

Dear Mr. ~~Shonkwiler~~: Glen

Louis Berger & Associates, Inc. is pleased to submit 5 copies of the Draft Site Investigation Addenda for the Open Burn/Open Detonation at Fort Riley, Kansas. Also included in this submission are the responses to the comments. As identified in the text of the responses to several comments, there will be a separate letter submission directly from the Army to the regulators regarding proposed future activities at the site.

This document has been subjected to Berger's internal Quality Control process prior to release.

Copies have been distributed according to the list found at the bottom of this letter.

Should you have any questions or comments regarding this submission, please contact either Tom Lewis at (973) 678-1960, extension 755 or me at the same number, extension 737.

Sincerely,

LOUIS BERGER & ASSOCIATES, INC.

Susan E. Knauf
Program Director

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Responses to KDHE Review Comments
Draft SI Addendum OB/OD dated 20 April 1998
Fort Riley, KS

No.	Reference	Comment	Response
General Comments by Randall Carlson, Ph.D., KDHE/BER, 16 June 1998			
1	General	Recommendations should accompany the OB/OD report, either as part of the report or in a separate letter. Discussions within the report concerning the installation of wells state that quarterly groundwater monitoring is planned for the site. The monitoring program should be described in the Executive Summary and in Section 5, Summary and Conclusions.	Agree. A letter outlining recommendations for future work at the site will be prepared and submitted by the Army under separate cover after submittal of the Draft Final SI Addendum. Plans for monitoring will specifically be included in this letter. The monitoring program will be referred to as "periodic" instead of "quarterly" because of the restricted access to the OB/OD Area.
2	General	Three of the planned surface water samples from the east and west intermittent streams were not collected because the streams were dry when the field work was conducted. These samples should be collected during the next sampling effort.	Agree. Surface water samples were collected from all five intermittent stream locations on 5 April 1998. The results indicate very low levels (i.e., all below MCLs) of TCE at locations SW-4 (3.7 ug/l) and SW-5 (3.1 ug/l) downgradient of the OB/OD Area. These results are included in the DSR.

Responses to KDHE Review Comments, Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
3	General	The extent of groundwater contamination has not been defined by the investigation, as shown on the enclosed map of total VOCs. The general direction of groundwater flow from the north and south burn pits is toward the south-southwest (Figure 4-7), however, the most downgradient wells, OB-97-08 and OB97-13PZ have 110 and 200 ug/L TCE, respectively, well above the MCL of 5 ug/L for TCE. Additional monitoring wells should be installed west of OBHD97-14, southwest of the southern burn pit between the western intermittent stream and wells OB-97-08 and OB97-13PZ and south of the southern burn pit. The highest concentrations of VOCs have been found in the Schroyer Limestone and this unit should be the main focus of further investigations. The Threemile Limestone also has TCE above the MCL and should be investigated further as well. There is a greater potential for contamination in the Threemile Limestone south of the southern burn pit where TCE may have reached greater depths because it is further from the main source areas. Structural dip of the rock layers can be a major control on the direction of groundwater flow. To aid in our understanding of the geology at the OB/OD site and its relationship to groundwater flow direction and contaminant migration, I prepared maps of the tops	As mentioned above in response to general comment 1, a letter outlining recommendations for future characterization and delineation work at the site will be prepared and submitted under separate cover after submittal of the Draft Final SI Addendum. The rationale, quantity and location for any additional monitoring wells will be addressed in that letter. It should be noted that a risk screening evaluation is being conducted for the site and the results will be presented in a separate report. Based on initial risk screening information, the impacted groundwater is not a current or likely future potable water source and meeting drinking water source quality (i.e., MCLs) at this site is not anticipated to be necessary for protection of human health and the environment. It is agreed that the Schroyer Limestone has the highest concentrations of VOCs. However, horizontal movement (along bedding planes) is interpreted to be much greater than any downward vertical movement. Therefore, these highest concentrations of VOCs are believed to discharge to the intermittent streams downgradient of the site, and not migrate down to the Threemile Limestone. The TCE concentration in the intermittent streams receiving groundwater from the Schroyer Limestone is only 3 ug/l. The much lower

No.	Reference	Comment	Response
3	General (Continued)	of the Schroyer Limestone and the Havensville Shale (enclosed) from the information in the drillers logs and gamma logs. The groundwater flow direction in the Schroyer Limestone shows some similarity to the slope of the top of the Schroyer Limestone. The groundwater flow direction at the top of the Schroyer Limestone is west-southwest (Figure 4-13). The Schroyer limestone is higher to the northeast where the demo pits are present and forms an east-west trending erosional low between the north and south burn pits, where overburden soils lie in contact with the top of the Schroyer. The direction of groundwater flow at the top of the Havensville Shale is to the south-southwest (Figure 4-15) and corresponds well with the slope of the top of the Havensville Shale. The Havensville Shale probably acts as an aquitard, thus, the dip of the Havensville should correspond with the direction of groundwater flow at the top of the unit.	TCE concentrations detected in the Threemile Limestone would likewise migrate predominantly horizontally and eventually discharge to Threemile Creek further downgradient of the site. Based on the ratio of TCE concentration observed in the Schroyer to the concentration observed in the receiving surface water, any TCE reaching Threemile Creek via the Threemile Limestone would be at nondetectable concentrations. The proposed future investigation work will help to further confirm this premise. The association of the orientation of the top of formations to the direction of groundwater flow in these zones is noted. However, care must be taken in generalizing the effects of the tops of the formations because variations in lithology at these contacts has been observed. For example, the top of the Schroyer Limestone is much more clearly defined on the eastern side of the site but is significantly eroded, blending with the overburden, on the western side of the site. There are likely a variety of factors which contribute to the observed flow directions in the various zones screened beneath the site.

Responses to KDHE Review Comments, Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
4	General	The report states that identifying source areas is very difficult to impossible and that identifying sources may not be necessary given that the dissolved phase concentrations are not high enough to indicate the presence of free product at the site. However, the downgradient extent of groundwater contamination has not been defined. Therefore, the potential for migration has not been assessed, and the conclusion is not justified at this time. Please refer to the enclosed map of total VOCs. The highest concentrations of VOCs stem from the northern and southern burn pits. There appear to have been smaller releases at the Metal Debris pits and the West Demo Pit. There are no obvious sources near or upgradient of the relatively high concentrations of 2-butanone and carbon disulfide in well OB-97-09PZ. Although not mentioned, 2-butanone is a common laboratory contaminant; carbon disulfide, however, is not. The northern and southern burn pits, although not the only source areas, appear to be the predominant source areas for the release of chlorinated volatile organic compounds to groundwater.	It is agreed that the downgradient extent of groundwater contamination has not been fully defined. As mentioned above in response to general comment 1, a letter outlining recommendations for future work at the site will be prepared and submitted under separate cover after submittal of the Draft Final SI Addendum. Any additional delineation activities will be addressed in that letter. The fact remains, however, that the relatively low dissolved concentrations identified near the suspected source areas do not indicate the presence of any residual free product at the source areas. It is agreed that the majority of the chlorinated solvents were historically released in or near the North and South Burn Pit areas with possibly smaller releases at the Metal Debris pits and the west Demo Pit. The 2-butanone as well as the carbon disulfide identified in OB-97-09PZ are not believed to be contaminants released to the site. As mentioned, the 2-butanone is a common laboratory contaminant. Carbon disulfide is not a common laboratory contaminant, but it is a naturally-occurring compound. It is particularly common in anaerobic environments, such as the dark gray shale in which OB-97-09PZ(0) is screened.

Responses to KDHE Review Comments, Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
4	General (Continued)	A Gore Sorber screening survey of six points was conducted during the initial investigations, however, it was not successful in delineating the extent of groundwater contamination. This was probably because so few points were screened. A passive soil gas survey laid out on a grid with numerous screening points may be more successful in defining the distribution of groundwater contamination and accurately locating all the source areas.	The soil gas survey conducted at the site was only a demonstration test to evaluate its potential effectiveness as an investigation tool at the site. The sorbers were placed in the vadose zone three feet below ground surface above areas of highest known groundwater contamination. Only low levels of VOC contaminants were detected in analysis of the sorbers. As stated in the report, it is believed that the reason for only detecting low levels in the soil gas detectors above known contaminated groundwater lies in the fact that the shale (layer of low permeability) overlying the groundwater impedes the upward migration of soil gas from the groundwater to the detector. Based on the low levels detected and this vertical barrier limitation, a more extensive deployment of passive soil gas detectors at the OB/OD area was not considered suitable and was, therefore, not recommended or pursued.
Specific Comments by Randall Carlson, Ph.D., KDHE/BER, 16 June 1998			
1	Section 1.4.1 Paragraph 1 Page 1-3	Mentioning the latitude and longitude coordinates would improve the description of the site.	Agree. The latitude of 39° 08' 31.88" and longitude of 96° 45' 46.16" (based on survey of piezometer PZ-97-11) will be added to the text.
2	Section 1.4.1 Paragraph 2 Page 1-4	Although the mesic area is not listed as a wetland, if its characteristics qualify it as a wetland, it should be treated as such.	The mesic area will be evaluated to determine if it should be treated as a wetland. The results of this evaluation will be presented in the Risk Screening and Ecological Assessment Report.

Responses to KDHE Review Comments, Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
3	Section 1.4.1 Paragraph 2 Page 1-4	Statements in the middle of the paragraph where the tributaries are discussed need improvements in sentence structure.	Agree. A portion of a sentence is missing from this paragraph. The sentence fragment currently reads "The tributaries located to the east and west" and will be completed with "of the site join about 1,000 feet south of the southern site boundary."
4	Section 1.5 Paragraph 2 Page 1-6	The discussion should mention that the designated beneficial uses of Threemile Creek are aquatic life support and contact recreation.	Agree. A sentence was added to the end of the first paragraph stating that the designated beneficial uses of Threemile Creek are aquatic life support and contact recreation.
5	Section 2.2.1 Paragraph 2 page 2-2	Which pit is referred to in this paragraph?	This paragraph refers to the North Burn Pit. The text was revised to clarify this.
6	Section 2.2.2 Paragraph 2 Page 2-2	For clarity in referring to the maps, the open burn pit should be referred to as the northern burn pit.	Agree. The text was revised to refer to the open burn pit as the North Burn Pit.
7	Section 2.2.5 Paragraph 1 Page 2-3	The text should also mention the secondary MCL for sulfate of 250 mg/L.	The primary MCLs are included in this paragraph for evaluation purposes. The secondary MCLs could also be included, but they would be unnecessary. No change to the text was made.
8	Section 3.3.2.1 OB-97-12PZ Page 3-7	This well is upgradient, rather than downgradient, of well OB-97-05 as stated in the text.	Agree. The text was revised to state that OB-97-12PZ is upgradient of OB-97-05.

Responses to KDHE Review Comments, Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
9	Section 4.1.1 Paragraph 3 Page 4-1	Comments concerning the necessity of further actions should be contained in the Executive Summary and the chapter on Summary and Conclusions. As stated in general comment 4 above, the main source areas already are evident. Further definition of the source areas may be accomplished through a passive soil gas survey followed by confirmatory soil borings and monitoring wells.	As mentioned above in response to general comment 1, a letter outlining recommendations for future work at the site will be prepared and submitted under separate cover after submittal of the Draft Final SI Addendum. It is agreed that the main source areas are already evident. No change to the text was made.
10	Figure 4-9 Geologic Cross- Sections	The gamma logs on the north to south cross-section are flipped 180 degrees from their proper orientation, such that the limestones appear to have the highest readings and the shales the lowest readings. Please orient the gamma logs correctly.	Agree. The gamma logs presented on the north to south cross-section will be flipped 180 degrees so that they are in their proper orientation.

No.	Reference	Comment	Response
11	Figure 4-9 Geologic Cross-Sections	The lithologic descriptions in the cross-section do not appear to have accounted for the lithologic interpretations that can be made from the gamma logs. The depth measurements of the gamma logs are probably more accurate than the driller's logs and gamma logs are sensitive to shales. The driller's logs are based on grab samples whose depth of origin during the drilling is less certain. Thus, the gamma logs should be relied on to pick the tops and bottoms of the alternating limestone and shale units. Some examples of the discrepancies between the gamma and driller's logs are as follows. The driller's logs for well OB-97-12PZ shows the Kinney Limestone as approximately 4 feet thick, whereas the gamma log indicates it is approximately six feet thick. Also, the base of the Schroyer Limestone in well OB-97-12PZ appears to be about two feet lower than shown. The top of the Schroyer on wells OB-97-05 and OB-97-11PZ appears to be about two feet lower than shown. The base of the Schroyer Limestone on well OB-97-11PZ appears to be about four feet lower than shown.	It should be noted that the formation contacts are not always identified by contacts between limestones and shales. For example, the base of the Schroyer Limestone is interpreted to be the bottom of a chert-bearing limestone. A non-chert-bearing limestone located beneath this point would be considered the top of the Havensville Shale. For this reason, it would be misleading to define the formation contacts based strictly on gamma logs which indicate more significant lithological changes (such as from limestone to shale). This is in agreement with regional geologic references/interpretations by others. The driller's logs and the gamma logs were reviewed and the cross sections revised appropriately. The lithological symbols defining each formation were removed leaving the contact lines with the formation names placed within the cross sections. The previous depiction of the formations using the conventional lithological symbols (bricks for limestone, dashes for shale) may have been misleading. For example, the Schroyer Limestone is not comprised completely of limestone, but rather intervals of limestone and shale. Likewise, the Havensville Shale is not comprised completely of shale, but rather intervals of shale and limestone.

Responses to KDHE Review Comments, Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
12	Figure 4-11	The very steep gradient shown on the figure appears unrealistic. The elevation of the spring probably does not correspond to the piezometric head of the groundwater, but rather corresponds to a bedding plane or fracture within the Kinney Limestone.	While we agree that the spring corresponds with a bedding plane or fracture actually located slightly below the base of the Kinney Limestone, the spring is flowing and the water supporting this flow is the groundwater in the Kinney Limestone. The contours represent the hydraulic gradient between the spring and the supporting head in the Kinney Limestone. If the flow of the spring could be captured in a riser, the water level in the riser would likely reach an elevation that would be more comparable to those in the Kinney and depict a less steep gradient.
13	Figures 4-14 and 4-15	The base of the Schroyer Limestone makes contact with the top of the Havensville Shale. How is it that groundwater can flow northwest at the base of the Schroyer and south-southwest at the top of the Havensville?	Disagree. The bottom of Schroyer and top of Havensville, as depicted on the groundwater contour maps, are not intervals in direct contact. These approximate one-foot thick intervals are vertically separated by six to ten feet. The factors influencing the flow direction of the approximate one-foot intervals can change within that six to ten foot separation.
14	Figure 4-16	Well OB-97-09PZ did not contain TCE as shown on the map.	Agree. The detection of 0.7 ug/l will be removed from the figure and replaced with ND.
15	Appendix C	A gamma log for well OB-93-3 is not present as indicated in the Table of Contents for the appendix.	The gamma log for OB-93-3 is present in the appendix but is out of place, appearing after OB-97-4. This will be corrected.

Responses to KDHE Review Comments,
Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
16	Appendix C	A gamma log for well IZ-92-10 is included here but is not shown on the maps accompanying the report. Where is well IZ-92-10?	Well IZ-92-10 is shown on Figure 1-1, Site Location Map. Reference to this figure was also added to the seventh bullet under Section 3.1.2 on page 3-4.

Responses to CENWK Review Comments
Draft SI Addendum OB/OD dated 20 April 1998
Fort Riley, KS

No.	Reference	Comment	Response
Comments by Becker, CENWO-HX-G			
1	General	Overall, I would say that the report provides a good overview of the conditions found and does a fair appraisal of the complicated hydrogeology at the site. It is clear to me that additional data would probably be required before the site risks can be fully evaluated to the satisfaction of the regulators. In particular, the full extent of the chlorinated compounds is not yet known. I would suggest that any additional monitoring/investigation consider obtaining data necessary to evaluate the potential for natural attenuation, including concentrations of electron receptors, redox, and organic carbon content.	Agree. A letter outlining recommendations for future work at the site will be prepared and submitted under separate cover after submittal of the Draft Final SI Addendum. A risk screening study is currently being conducted and the results will be presented in a separate report. Obtaining data necessary to evaluate the potential for natural attenuation will certainly be given consideration in any recommended further action.
2	Section 3.2 Page 3-4	Identify the type of passive soil gas device/product - was it Geosorber?	As stated in the report presented in Appendix C, GORE-SORBER Screening Modules were used in the soil gas survey demonstration test. A similar reference was added to Section 3.2.

Responses to CENWK Review Comments,
Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
Comments by Becker, CENWO-HX-G			
3	Figure 3-2	It is apparent that we do not yet have adequate well coverage in the west, south and northwest directions to fully define the extent of the plume.	Agree. As mentioned above in response to general comment 1, a letter outlining recommendations for future work at the site will be prepared and submitted under separate cover after submittal of the Draft Final SI Addendum. The rationale, quantity and location for any additional monitoring wells will be addressed in that letter.
4	Section 4.1.1 Page 4-1	I would say that there are not enough data to definitively say that there is no discrete source area remaining - there has not been adequate sampling of soils in the pits, particularly in the south pit. I would recommend that sampling be conducted there, if safety concerns will allow. Removing any source may be key to getting regulatory acceptance of natural attenuation or no action on ground water.	As mentioned above in response to general comment 1, a letter outlining recommendations for future work at the site will be prepared and submitted under separate cover after submittal of the Draft Final SI Addendum. Any additional investigation of the source areas will be addressed in that letter. Investigation within the pits is problematic due to UXO issues. In addition, the groundwater contaminant concentrations adjacent to these areas are relatively low and do not indicate the presence of any residual free product. The results of the current risk screening study may help to guide any future activities.
5	Section 4.3.1.3 Page 4-8	Is it possible that there is a divide between well MW OB-93-04 and the other two wells?	A wide range of interpretations is possible with so little data. More data from this interval would be necessary to formulate an interpretation with any confidence.

Responses to CENWK Review Comments,
Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
Comments by Becker, CENWO-HX-G			
6	Figure 4-14	Note that OB-97-13PZ(3) should probably be OB-97-13PZ(2) on this figure.	OB-97-13PZ(3) is the correct interval to be depicted on this figure (screened from elevation 1140.42 to 1141.42 ft amsl). The "Formation Screened" indicated on Table 3-10 was corrected from "Schroyer Limestone-top" to "Schroyer Limestone-bottom".
END OF COMMENTS			

Responses to CENWK Review Comments
Draft SI Addendum OB/OD dated 20 April 1998
Fort Riley, KS

No.	Reference	Comment	Response
Comments by Carol Bottjer, CENWK-EP-ES, 3 June 1998			
1	Section ES Paragraph 2 Page ES-4	Figure 1-2 does a better job of showing the position of the spring relative to the North Burn Pit than referenced Figure 4-1 does. Change reference.	Agree. The reference to Figure 4-1 was changed to 1-2.
2	Section 1.4.1 Paragraph 1 Page 1-4	5th-7th sentences - Correct grammar.	Agree. A portion of a sentence was missing from this paragraph. The sentence fragment previously read "The tributaries located to the east and west" and was completed with "of the site join about 1,000 feet south of the southern site boundary."
3	Section 1.5 Paragraph 2 Page 1-7	3rd sentence - "USEPA 1988b" is missing from the reference section. Add missing information.	Agree. The sentence referencing the EPA document has been removed from the text.
4	Sections 2.2.1, 2.2.2 Page 2-2	Previous Comment 11 - Change "Method 6010 Series" references to "Method 6010/7000 series" or something similar.	Agree. "Method 6010 Series" references were changed to "Method 6010/7000 Series".
5	Section 3.4.2 Page 3-11	Previous Comment 11 - Two analytical methods are still shown for sulfate. Delete Method 9038 reference, per A-E's comment response.	Agree. Method 9038 were deleted.

Responses to CENWK Review Comments, Draft SI Addendum OB/OD (Continued)

No.	Reference	Comment	Response
Comments by Carol Bottjer, CENWK-EP-ES, 3 June 1998			
6	Section 3.4.2.1 Paragraph 1 Page 3-12	Previous Comment 16 - The 5th and 6th lines indicate that there were discrepancies in analyte identities. As such, it seems questionable whether the project objective (per last line of paragraph) "...to determine the presence or absence of contaminants..." was met. Rewrite paragraph for clarity.	Agree. The paragraph was rewritten for clarity.
7	Section 3.4.2.3 Tables 3-3 & 3-8 Page 3-14	Section title and last sentence - The tables show that the spring was sampled in 3/97 and 6/97. Additionally, the 08 May 98 Data Summary Report (DSR) compares the 6/97 and 12/97 sampling events' results. Update SI Report Addendum to be consistent with its tables and with the DSR.	Agree. The references to the spring sampling was updated to be consistent with the tables and the DSR.
END OF COMMENTS			

Responses to CENWK Review Comments
Draft SI Addendum OB/OD dated 20 April 1998
Fort Riley, KS

No.	Reference	Comment	Response
Comments by Cathy Forget, CENWO-HX-H			
1	Section 5.0	Even though the water supply at Range 18 is not potable, risk to human receptors should be evaluated via all other exposure pathways. This is especially important due to the high volatility of TCE, and high concentrations. Similarly, potentially complete pathways for irrigation should be evaluated on the surrounding farmlands.	A risk screening study is currently being conducted and the results will be presented in a separate report. Even though the data for the site are not complete, there is enough groundwater flow direction information to know that the contaminants released at the OB/OD area would not impact the non-potable well at Range 18. The surrounding farmlands are even less likely receptors due to their distance from the site. Any contaminants migrating via groundwater would discharge to surface water long before reaching these sites. The concentration of TCE discharging from the Schroyer Limestone (the most highly contaminated interval beneath the OB/OD Area) to the intermittent stream just south of the site results in a surface water concentration of only 3 µg/l, based on the results of the surface water sampling conducted in May 1998 and presented in the DSR.
END OF COMMENTS			