Draper Aden Associates

Engineering ◆ Surveying ◆ Environmental Services

ALTERNATE SOURCE DEMONSTRATION FOR TRICHLOROETHENE

HAZARDOUS WASTE MANAGEMENT UNIT 5 RADFORD ARMY AMMUNITION PLANT RADFORD, VIRGINIA

Submitted to:

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Prepared for:

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1.0 INTRODUCTION

This report presents the results of the Alternate Source Demonstration for Trichloroethene conducted for Hazardous Waste Management Unit 5 (HWMU-5) at the Radford Army Ammunition Plant (Radford AAP) in Radford, Virginia. Trichloroethene (TCE) has been detected repeatedly at concentrations exceeding the USEPA Maximum Contaminant Level (MCL) of 5 µg/l in four groundwater monitoring wells within the monitoring network for HWMU-5. In correspondence to Alliant Ammunition and Powder Company, L.L.C. (Alliant) dated September 27, 2000, the Virginia Department of Environmental Quality (VDEQ) requested that Alliant implement a Corrective Action Program at HWMU-5 to address the TCE concentrations in groundwater which exceeded the USEPA MCL. During a teleconference between the VDEQ, Alliant, and the Army on October 31, 2000, Alliant stated that, based on historical information for HWMU-5, it was believed that the wastes handled at the Unit prior to closure did not contain TCE or other organic compounds. Furthermore, TCE concentrations below the USEPA MCL had been detected in the upgradient monitoring well for the Unit during previous monitoring events. Therefore, it was believed that HWMU-5 was not the source of the TCE detected in the groundwater. In accordance with VDEQ guidance and pursuant to 40 CFR 264.99(i), Alliant has chosen to demonstrate that TCE was derived from a source other than HWMU-5. Accordingly, if it is demonstrated that TCE was derived from an alternate source, then any corrective action for the TCE would fall under the jurisdiction of Radford AAP's USEPA Region III Corrective Action Program instead of the VDEQ, and TCE would be removed from the list of the constituents of concern in the Permit for HWMU-5.

This Alternate Source Demonstration for TCE provides a description of HWMU-5, including the Unit's historic operations and the wastes processed. In addition, the facility buildings and areas in the vicinity of HWMU-5 where TCE is and/or may have been used are identified. The Demonstration describes the hydrogeologic framework of the area of concern, including karst conduits that may facilitate TCE migration in groundwater, as it relates to the potential sources of TCE. Historic detections of TCE concentrations within the monitoring well network for HWMU-5 are evaluated, along with a discussion of the analysis of groundwater samples collected on December 12-14, 2000 in support of the TCE Alternate Source Demonstration.

2.0 SITE DESCRIPTION

2.1 FACILITY DESCRIPTION

The Radford AAP is located in the mountains of southwest Virginia within Pulaski and Montgomery Counties. A Site Location Map is presented as **Figure 1**. The facility is situated in one of a series of narrow valleys typical of the Valley and Ridge physiographic province of the Appalachian Highland Region of North America. Oriented in a northeast-southwest direction, the valley is approximately 25 miles long. The valley has a width of approximately eight miles at the southwest end and narrows to approximately two miles at the northeast end. Radford AAP lies along the New River in the relatively narrow northeast corner of the valley. The maximum elevation at Radford AAP is 2,225 feet above mean sea level (amsl) in the southeast corner and the minimum elevation is approximately 1,675 feet amsl along the New River at the northern property boundary. Radford AAP is divided by the New River into two sections. The southern section, which comprises approximately two-thirds of Radford AAP, is called the "Main Plant." The remaining northern one-third section is called the "Horseshoe Area." HWMU-5 is located in the Main Plant area.

2.2 TCE AREA OF CONCERN

2.2.1 Hazardous Waste Management Unit 5

HWMU-5 is a former lined surface impoundment. As shown on the Site Location Map (**Figure 1**), HWMU-5 is located approximately 3,000 feet southwest of the New River. The Unit is located on a river terrace which slopes gently downward to the north toward the New River. The Unit was put into operation as an unlined surface impoundment in 1970, and was retrofitted with a liner in 1981. The dimensions of the Unit measured approximately 150 feet by 100 feet along the top of the berm, with a total embankment height of 10 feet above the base of the impoundment. The Unit was taken out of operation in 1986, and was closed in 1989 in accordance with the VDEQ-approved Closure Plan dated June 1985.

During operation, the Unit received runoff, spill, and washdown waters from the acid tank farm (nitric and sulfuric acids). Prior to 1983, the Unit also received process wastewater containing low concentrations of nitrocellulose. Based on historical information, the wastes handled at HWMU-5 did not contain TCE or other organic compounds.

2.2.2 Cleaning Solvents Used in Facility Operations

Several solvents are used for equipment cleaning purposes in certain areas of the Radford AAP facility. According to Alliant Procedure No. 4-27-078, Revision No. 5 (dated January 13, 1999), the following cleaning solvents are approved for use at the facility:

- Stoddard Type Solvents (clear, colorless liquids of the kerosenenaptha class; used as an oil and grease remover);

- 1,1,1-Trichloroethane (inhibited);
- DuPont Cleaning Solvent #49 (70% Stoddard Solvent, 25% methylene chloride, 5% perchloroethylene; used in electric motor cleaning);
- Acetone;
- Ethyl Alcohol;
- Inhibisol (colorless liquid of chlorinated solvents; chemical formula CCl_4);
- Nitroglycerin Remover (mixture of sodium sulfide, alcohol, acetone, and water);
- "Gunk" (degreasing-cleaning solvent; approximately 16% cresole; used in a vat or tank in the Degreasing Shop to clean and paint strip scales for overhaul);
- Butyl Alcohol (used by the Electronic Shop for strain gauge maintenance);
- Intex #8793 - Paint Stripper (used in Degreasing Shop for paint removal);
- Intex #827 - Safety Solvent (used in Degreasing Shop for paint removal and cleaning purposes);
- Lectra Clean (used in Electric Shop for cleaning and degreasing electrical equipment);
- Voltz (used in Electric Shop motor cleaning vat).

These solvents are used primarily for tasks involving operations and maintenance of motors, valves, and gauges. There is no record or operational indications that any of these solvents could have come into contact with wastewater influent to HWMU-5.

2.2.3 Potential Source Areas for TCE

As part of the TCE Alternate Source Demonstration, Alliant identified facility buildings in the vicinity of HWMU-5 where chlorinated solvents currently are used or have been used in the past. These buildings and their spatial relationships to HWMU-5 are illustrated in **Figure 2**.

Building 1549 is an Area Maintenance Shop located approximately 300 feet southeast of HWMU-5. According to Area Mechanics who worked in facility B-Line Maintenance, the cleaning of equipment in the 1960's and 1970's involved the use of Varsol and WD-40. Disposal of the used solvents consisted of pouring the solvents down the nearest floor drain. This disposal practice was later discontinued; after that time, the spent solvents were collected in a barrel to be transported by the Roads and Grounds department to a collection area for disposal.

Building 1034 formerly housed a facility laboratory. The building currently houses the Electric and Refrigeration Shop. Building 1034 is located approximately 950 feet southeast of HWMU-5. DuPont Cleaning Solvent #49, one of the solvents commonly used in electric motor cleaning, contains perchloroethylene (PCE). TCE is a daughter product of the degradation of PCE.

Building 1041 is the Degreasing Shop. The building is located approximately 980 feet southeast of HWMU-5. The building formerly contained a dip tank, which now is filled with concrete. Currently, a grate-covered pit in the floor drains to an outside underground storage tank. According to a Senior Instrument Mechanic, the Scale Shop used this building in the past for the cleaning of scales. At times, the scales would be taken outside of the building to be washed off; the wash liquids would be allowed to drain onto the ground surface. According to

the Radford AAP Sewers and Drains Atlas, a four-inch terra cotta pipe runs westward from the western end of Building 1041.

Building 2549 is another Area Maintenance Shop. The building is located approximately 450 feet southwest of HWMU-5.

Building 2570 is an Area Cleaning Station. The building is located approximately 620 feet west of HWMU-5.

Building 525 is the Tractor Steaming Station. The building is located approximately 720 feet southwest of HWMU-5.

3.0 HYDROGEOLOGIC FRAMEWORK

3.1 TOPOGRAPHY

The TCE Area of Concern is located approximately 3,000 feet southwest of the New River. The Area is located on a river terrace which slopes gently downward to the north toward the New River. Surface drainage boundaries are illustrated in **Figure 2**. As shown on **Figure 2,** a surface drainage divide separates Buildings 1034 and 1041 from the other potential source buildings in the TCE Area of Concern and HWMU-5. Surface drainage in the vicinity of Buildings 1034 and 1041 flows to the northeast, while the surface drainage in the vicinity of the other potential source buildings in the TCE Area of Concern and HWMU-5 flows to the north-northwest.

3.2 GEOLOGIC SETTING

The Valley and Ridge physiographic province consists of folded and thrust-faulted Paleozoic sedimentary rocks ranging in age from Cambrian to Mississippian. Post-deformation weathering of these thrust-faulted and overturned Paleozoic rocks has resulted in the formation of resistant sandstone and dolomite ridges separated by valleys underlain by more easily eroded shale and limestone. Well developed karst features such as sinkholes and caves are common in the Valley and Ridge.

The general geology at Radford AAP consists of limestone/dolomite bedrock covered by weathered residual deposits and/or alluvial deposits. The alluvial deposits consist of typical fluvial deposits of interbedded clay, silt, and sand/gravel deposits with cobble lenses. The thickness of the alluvial deposits ranges from a few feet to approximately 50 feet, with an average thickness of 20 feet. The residual deposits consist of clay, silt, and clasts resulting from the physical and chemical weathering of the parent bedrock. The residual deposits typically underlie the alluvium, except in locations where the residuum has been eroded to bedrock and replaced by alluvium. The thickness of the residual deposits ranges from a few feet to approximately 40 feet. Underlying the alluvium and residuum throughout most of Radford AAP is a series of dolomite, limestone and shale strata known as the Cambrian-aged Elbrook Formation. The Elbrook Formation is the major outcropping formation as well as the predominant karstic formation below the facility. Sinkholes, solution channels, pinnacled surfaces, and springs are common to the Elbrook Formation.

The Boring Logs/Well Construction Diagrams for the monitoring network at HWMU-5 are included in **Appendix A**. A Cross-Section Location Map for HWMU-5 is presented as **Figure 3**. Geologic cross-sections derived from the boring logs for the Unit's monitoring wells are presented as **Figures 4, 5,** and **6**. The area surrounding HWMU-5 is underlain by unconsolidated alluvial sediments and weathered bedrock residuum, which are in turn underlain by carbonate bedrock of the Elbrook Formation. The bedrock beneath this area is generally encountered at depths ranging from approximately 28 feet to over 56 feet below ground level, although the soil/bedrock interface is gradational. In general, the bedrock in the vicinity of

monitoring wells 5W8B, 5WC11, 5WC12, and S5W8 slopes downward to the north-northeast, while the bedrock in the vicinity of monitoring wells S5W6 and 5W9A slopes downward to the southwest. This appears to indicate the development of a karst solutional feature in the bedrock in the vicinity of monitoring wells 5W5B, 5WCA, and well cluster 5WC21, 5WC22 and 5WC23.

3.3 KARST HYDROLOGY

3.3.1 Fracture Trace Analysis

A total of 66 fracture traces were identified within and around Radford AAP in a photogeologic study conducted by the USEPA's Environmental Photographic Interpretation Center (EPIC) in 1992. Fracture traces are linear features identified in aerial photographs that represent the surface expression of primary joint sets, major fractures, and/or zones of fracturing in the subsurface. These features may be expressed as soil-tonal variations and vegetational and topographical alignments, and are significant in consideration of groundwater flow at Radford AAP. The fractures and joint sets can act as discrete conduits for groundwater flow, increasing flow rates, and in some cases, redirecting flow away from the expected flow direction. In karst terrains, such features are environmentally significant because solutionization and resulting conduits develop along bedding planes as well as fractures and joints (USEPA, 1992).

The primary fracture traces identified by the 1992 USEPA EPIC study in the vicinity of the TCE Area of Concern are illustrated in **Figure 2**. The fracture lineations appear to be oriented radially, with trends ranging from northeast-southwest to northwest-southeast in the TCE Area of Concern.

3.3.2 Sinkhole Delineation

The locations of sinkholes at Radford AAP were also mapped during the 1992 USEPA EPIC study. In the vicinity of Radford AAP, the strike of bedding in the Elbrook Formation is roughly west/southwest to east/northeast, with dips to the south/southeast. Most of the sinkholes in the vicinity of Radford AAP are oval shaped and elongated with respect to the strike of bedding planes. In some instances, the sinkholes appear to align with respect to the fracture traces. The sinkholes most likely represent bedrock units with a greater carbonate content and lower shale content within the underlying Elbrook Formation (USEPA, 1992).

As mapped by the 1992 USEPA EPIC study, the area surrounding the TCE Area of Concern is characterized by the development of sinkholes without any apparent alignment or preferred orientation (**Figure 2**). Many of these sinkholes were filled during historic site development; at present, several facility structures are now located on these historic sinkholes. It is probable that there are well developed karst conduits which connect these sinkholes and which convey groundwater as well as aerated surface water during precipitation events at relatively rapid velocities through solution-enhanced fractures and joints.

3.4 OCCURRENCE OF GROUNDWATER

The general hydrogeologic setting for Radford AAP is characterized by porous alluvial sediments overlying weathered and unweathered dolomite and limestone. In areas where the porous alluvial sediments are the uppermost water-bearing zone, groundwater flow is generally from topographically high areas to topographically low areas. In some areas of Radford AAP, the uppermost water-bearing zone is within the limestone and dolomite bedrock. The karst features within the bedrock aquifer can provide conduits for rapid transport of groundwater to the New River, which is the discharge area for regional groundwater flow.

Seasonal variations in precipitation can affect the direction of groundwater flow within the bedrock aquifer at Radford AAP. During wet seasons (high flow conditions), groundwater flow may occur in higher elevation conduits that are not normally saturated during dry seasons (low flow conditions). As a result, flow directions may change significantly as different conduits are accessed. Additionally, flow may short-circuit the predominant flow paths and be redirected, discharging in unexpected areas.

In addition to seasonal variations, groundwater levels within the bedrock aquifer may fluctuate dramatically during heavy precipitation events. Groundwater levels in the karst bedrock aquifer generally respond to heavy precipitation within approximately 14 hours, and may rise several feet in a short time (Engineering-Science, 1994). This condition exists throughout Radford AAP, especially in areas where surface water infiltrates through sinkholes. Stormwater that flows into the sinkholes travels downward rapidly through conduits into the bedrock aquifer. Because groundwater may flow very quickly through these conduits, stormwater infiltrating in the uplands of the facility may discharge to the New River in a matter of a few days following a storm event. The turbulent flow created by these conditions aerates the infiltrating water. The increased O_2 content can significantly affect the chemistry of the groundwater, increasing the concentration of many commonly occurring inorganic analytes. It is this direct connection between surface water and groundwater and the rapid movement of groundwater through the aquifer that is vital to interpreting the migration of both naturally occurring and released constituents in the groundwater at Radford AAP.

The monitoring wells at HWMU-5 are screened entirely within either weathered carbonate bedrock residuum or alluvium, or across the weathered residuum/carbonate bedrock interface. Static water levels measured during the Fourth Quarter 2000 monitoring event ranged from 1754.07 feet to 1772.49 feet above mean sea level. As shown on the Potentiometric Surface Map (**Figure 7**), groundwater movement beneath the site is generally to the northeast. The groundwater contours and the topography in this area suggest that the TCE Area of Concern is located on a river terrace that contains several karst features and drains north toward the New River.

3.5 RELATION OF HYDROGEOLOGIC FEATURES TO POTENTIAL SOURCES OF TCE

Area Maintenance Shop Building 1549 is located on a large historic sinkhole measuring approximately 430 feet by 200 feet (**Figure 2**). A smaller historic sinkhole (approximately 150 feet by 130 feet) is located approximately 80 feet north of the large sinkhole. Monitoring wells 5WCA, 5W5B, and nested wells 5WC21, 5WC22, and 5WC23 are located within this smaller sinkhole. It is likely that these two sinkholes are connected by well-developed karst conduits. According to facility personnel, past disposal practices at Building 1549 involved pouring used solvents into floor drains. Liquids released to the subsurface through floor drains or spilled on the ground surface in the vicinity of Building 1549 would percolate to the groundwater through the soil filling the large sinkhole. Karst conduits would convey groundwater from the larger sinkhole to the smaller sinkhole containing monitoring wells 5WCA, 5W5B, and nested wells 5WC21, 5WC22, and 5WC23. As discussed in Section 4.0, these are the wells that consistently exhibit TCE concentrations in exceedance of the USEPA MCL of 5 µg/l.

Electric and Refrigeration Shop Building 1034 and Degreasing Shop Building 1041 are separated from the TCE Area of Concern by a surface drainage divide. However, as shown on **Figure 2**, Buildings 1034 and 1041 are located near two fracture traces which trend through the large sinkhole upon which Building 1549 is located. As indicated by facility personnel, past practices at Building 1041 included cleaning scales by washing them outside of the building, with the wash liquids allowed to drain to the ground surface. Liquids released to the subsurface through floor drains, the UST system and/or the former dip tank associated with Building 1041, or spilled on the ground surface in the vicinity of Buildings 1034 and 1041 would flow northeastward and percolate through the soil to the groundwater. Any subsurface flow from the vicinity of these buildings possibly would be intercepted by the fracture trace located to the northeast and conveyed to the sinkhole underlying Building 1549, and be conveyed to the sinkhole containing monitoring wells 5WCA, 5W5B, and nested wells 5WC21, 5WC22, and 5WC23. Furthermore, waste solvents could be conveyed by the four-inch terra cotta pipe running westward from the western end of Building 1041, released to the subsurface and intercepted by the fracture trace located to the west of the buildings. This fracture trace also would convey any liquids to the large sinkhole underlying Building 1549.

Buildings 525, 2549, and 2570 are not expected to have contributed to the TCE concentrations detected at the site. The anticipated groundwater flow direction in the vicinity of these three buildings is to the north-northeast, away from HWMU-5. As shown on **Figure 2**, there are no karst conduits interpreted to be in the vicinity that would intercept groundwater flow from the area of these buildings.

4.0 GROUNDWATER ANALYTICAL RESULTS

4.1 HISTORIC TCE CONCENTRATIONS

Graphs of the historic TCE concentrations detected in the monitoring network for HWMU-5 are presented in **Appendix B**. The graphs were compiled using quarterly groundwater monitoring data from First Quarter 1995 through Fourth Quarter 2000. As shown on the graphs, TCE has been detected repeatedly at concentrations exceeding the USEPA MCL of 5 µg/l in downgradient monitoring wells 5W5B, 5WC21, 5WC22, and 5WC23. During First Quarter 1999, TCE was detected at a concentration of 7.4 µg/l in downgradient well 5W10A; however, this detection is considered to be an anomaly, as TCE has never been detected in well 5W10A at any other time. Minor detections of TCE at concentrations less than 1 µg/l have been observed occasionally in upgradient well 5W8B and in downgradient wells 5W7B and 5W9A. TCE has never been detected in monitoring wells S5W5, S5W7, or 5W11A; it should be noted that these three wells are located on the opposite sides of fracture traces from the remaining wells in the monitoring network (**Figure 2**).

4.2 DECEMBER 12-14, 2000 GROUNDWATER SAMPLING EVENT

On December 12-14, 2000, groundwater samples were collected from nine (9) monitoring wells at HWMU-5 in support of the TCE Alternate Source Demonstration. Five of the monitoring wells sampled (upgradient well 5W8B, downgradient well 5W5B, and nested wells 5WC21, 5WC22, and 5WC23) are part of the current monitoring network for the Unit. In addition, four observation wells (upgradient wells 5WC11, 5WC22, and S5W8 and sidegradient well 5WCA) were also sampled. These observation wells were included in this sampling event as part of the effort to determine whether the TCE concentrations detected in wells 5W5B, 5WC21, 5WC22, and 5WC23 were from a source upgradient and/or sidegradient from HWMU-5.

The groundwater samples were submitted to REI Consultants Inc. (REIC) in Beaver, West Virginia for analysis for volatile organic compounds using SW846 Method 8260B. Validation of the laboratory data by Draper Aden Associates revealed that the laboratory failed to meet mandatory instrument tuning and calibration requirements. The laboratory's failure to identify and address these deficiencies resulted in compromised data for the sampling event. As a result, the analytical data had to be rejected. Alliant plans to resample the nine wells in support of the TCE Alternate Source Demonstration in March 2001; the validated data from that event will be forwarded to the VDEQ when it becomes available.

Although the analytical results for the December 12-14, 2000 sampling event were rejected, it was determined that the data could be used to provide a non-quantitative determination of the presence or absence of volatile organic compounds. Of the volatile compounds for which the samples were analyzed, only TCE was detected. TCE was detected in monitoring wells 5WCA, 5W5B, and nested wells 5WC21, 5WC22, and 5WC23, all of which

are located in a historic sinkhole. TCE was not detected in upgradient wells 5W8B, 5WC11, 5WC12, and S5W8.

5.0 CONCLUSIONS

Historic information regarding operations at HWMU-5 prior to closure indicates that the wastes processed through the Unit did not contain TCE. A review of Radford AAP cleaning and maintenance practices in the vicinity of HWMU-5 has identified areas in which chlorinated solvents have been used. An evaluation of historic waste disposal practices in these areas indicates the potential for groundwater impact from these operations. Hydrogeologic features such as fracture traces and sinkholes in this area would be conducive to the transport of impacted groundwater from these potential source areas to certain monitoring wells within the groundwater monitoring network for HWMU-5. Only these certain monitoring wells (5W5B, 5WC21, 5WC22, and 5WC23) consistently exhibit TCE concentrations in exceedance of the USEPA MCL of 5 µg/l.

Based on these factors, it is Alliant's conclusion that the detected TCE concentrations are derived from a source other than HWMU-5. As a result, Alliant respectfully requests that TCE be removed from the list of constituents of concern in the Post-Closure Permit for HWMU-5. Remediation of TCE in groundwater in this area will fall under the jurisdiction of Radford AAP's USEPA Region III Corrective Action Program. With this TCE Alternate Source Demonstration, Alliant hereby provides USEPA Region III with notice of a new Area of Concern at Radford AAP.

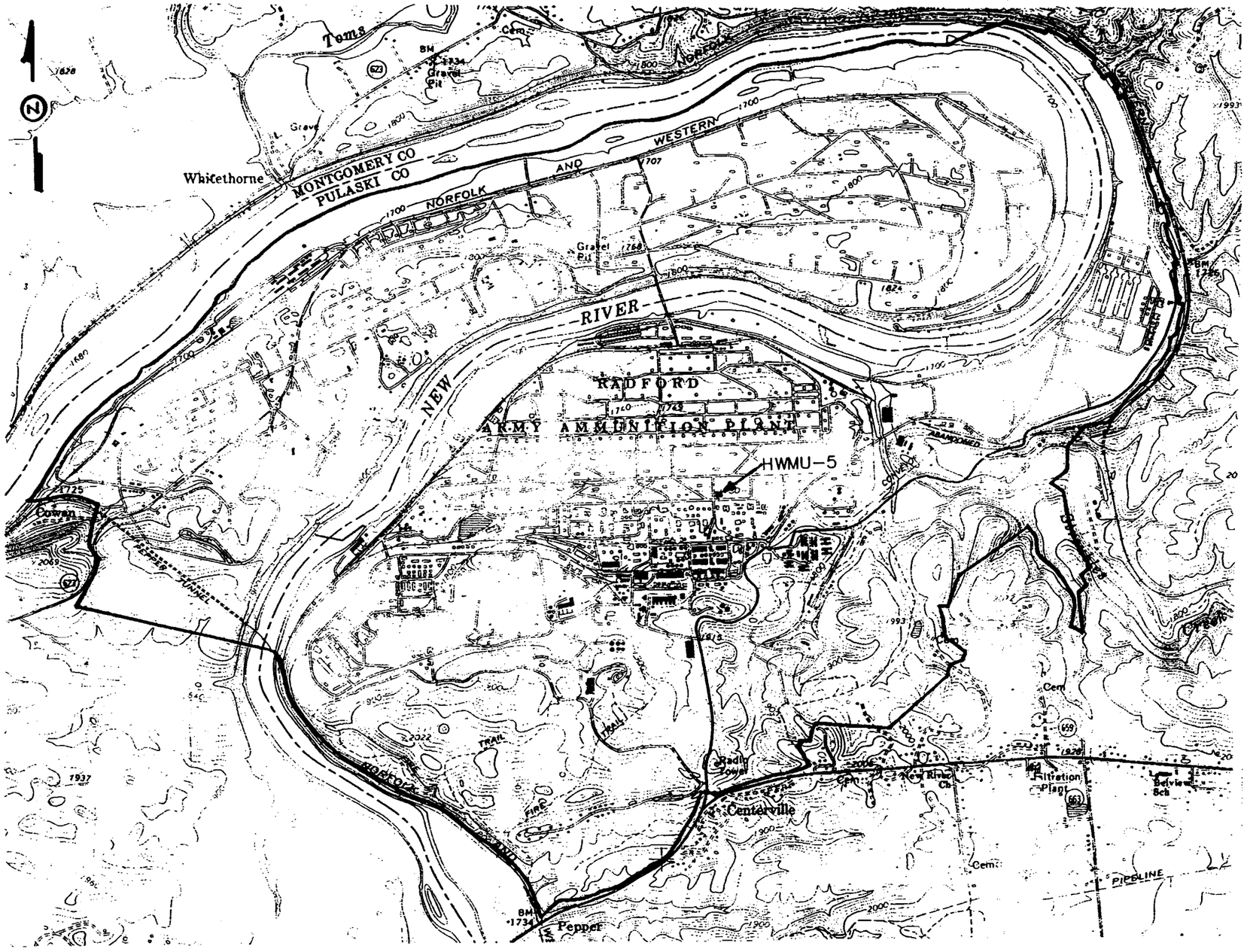
6.0 REFERENCES

Engineering-Science, Inc. March 1994. Dye-Tracing Study Report, Radford Army Ammunition Plant. Prepared for the U.S. Army Environmental Center.

Radford North, Virginia 7.5-minute topographic quadrangle map. 1984. USGS. Reston, VA.

U.S. Environmental Protection Agency (USEPA). 1992. Installation Assessment, Radford Army Ammunition Plant, Radford, Virginia. Environmental Photographic Interpretation Center.

FIGURES



LEGEND

——— PROPERTY LINE

APPEND.DWG

Draper Aden Associates CONSULTING ENGINEERS Blacksburg, Virginia – Richmond, Virginia – Nashville, Tennessee	DESIGNED RGM DRAWN JFF CHECKED AEK DATE 6-11-97	SITE LOCATION MAP RADFORD ARMY AMMUNITION PLANT MONTGOMERY COUNTY, VIRGINIA	SCALE: 1" = 2000' PLAN NO. B00316	FIGURE 1

LEGEND

- HWMU 5 — HAZARDOUS WASTE MANAGEMENT UNIT 5
- DEGREASING BUILDING 1041
- FORMER LABORATORY BUILDING 1034
  EXISTING ELECTRIC REFRIGERATION SHOP
- CLEANING RELATED BUILDINGS 525, 2570
- MAINTENANCE RELATED BUILDINGS 2549, 1549
- HISTORIC SINKHOLE LOCATIONS MAPPED BY THE USEPA ENVIRONMENTAL PHOTOGRAPHIC ITERPPRETATION CENTER (1992)
- FRACTURE TRACES MAPPED BY THE USEPA ENVIRONMENTAL PHOTOGRAPHIC INTERPPRETATION CENTER (1992)
- 5W10A ◎ — MONITORING WELL
- SURFACE DRAINAGE BOUNDARIES

NOTE: MAP AREA IS UNDERLAIN BY THE CAMBRIAN AGED ELBROOK FORMATION

5W11A 5W10A 5W9A S5W5 S5W6 5WC21 5WC22 5WC23 5W7B 5W5B 5WCA STA 5 S5W7 S5W8 5WC11 5WC12 5W8B HWMU 4 SWMU "D" SWMU 75 BLDGS 1022 REMOVED

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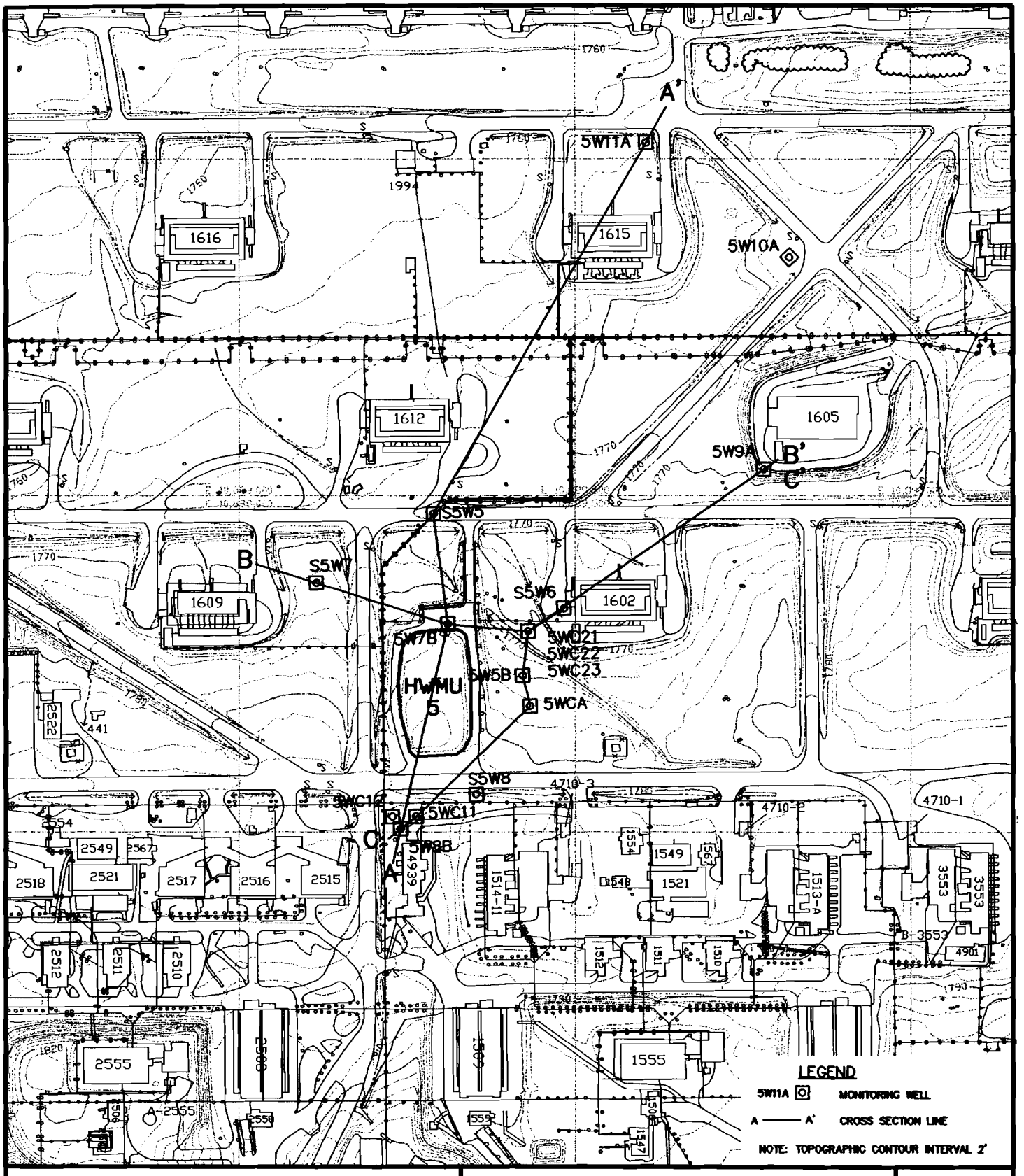
SITE MAP / GEOLOGICAL FEATURES MAP
HWMU-5 TCE ALTERNATE SOURCE DEMONSTRATION
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

REVISIONS

DESIGNED BY:	RGM
DRAWN BY:	JFF
CHECKED BY:	AEK
SCALE:	1" = 100'
DATE:	02-06-01
PROJECT NUMBER:	B00316

FIGURE 2

B00316_WSTUNITSLDWG

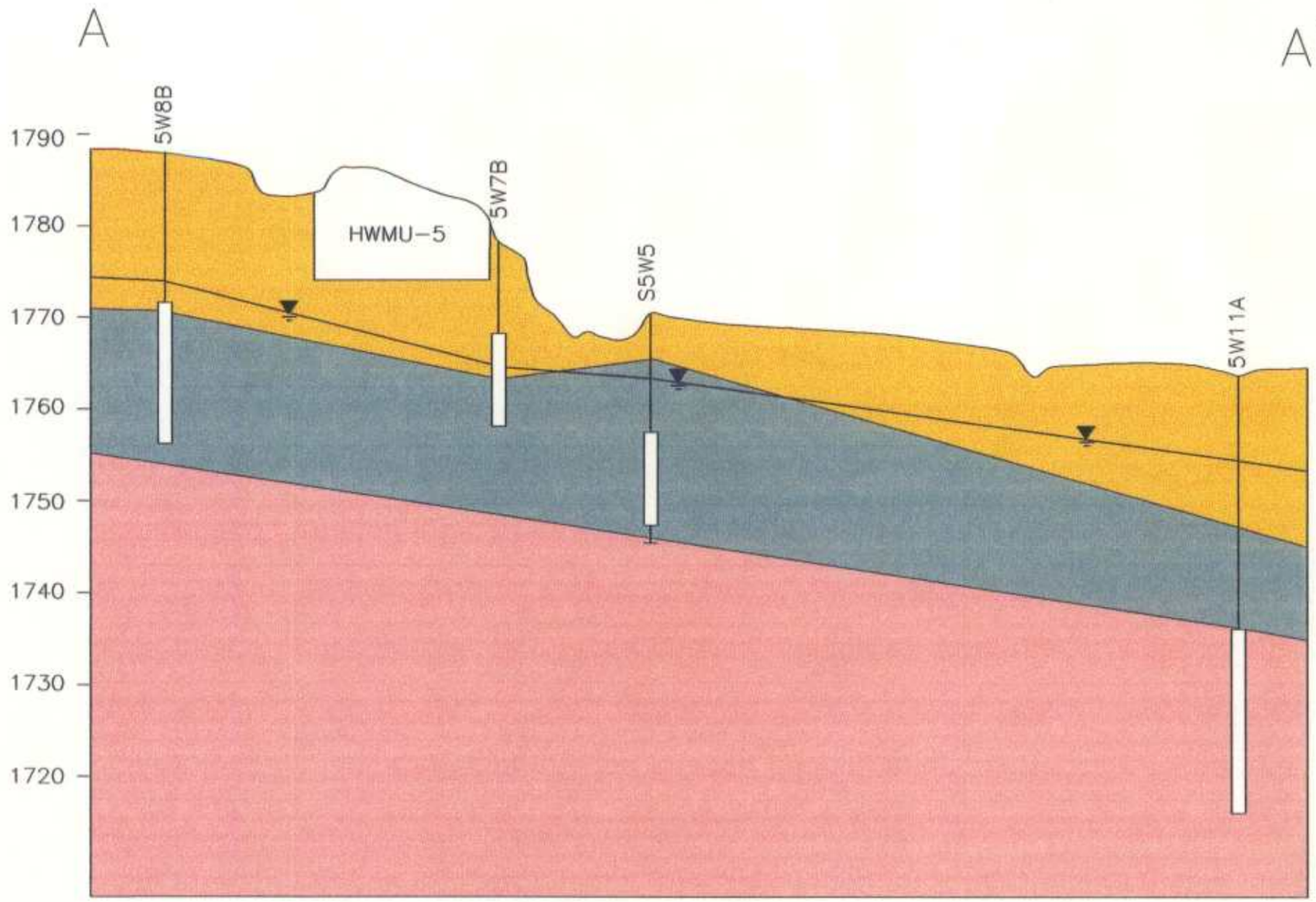


CROSS SECTION LOCATION MAP
HWMU–5 TCE ALTERNATE SOURCE DEMONSTRATION

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, VA – Richmond, VA

JOB No.	DATE:	SCALE:	FIGURE
B00316	02–06–01	1" = 200'	3



LEGEND

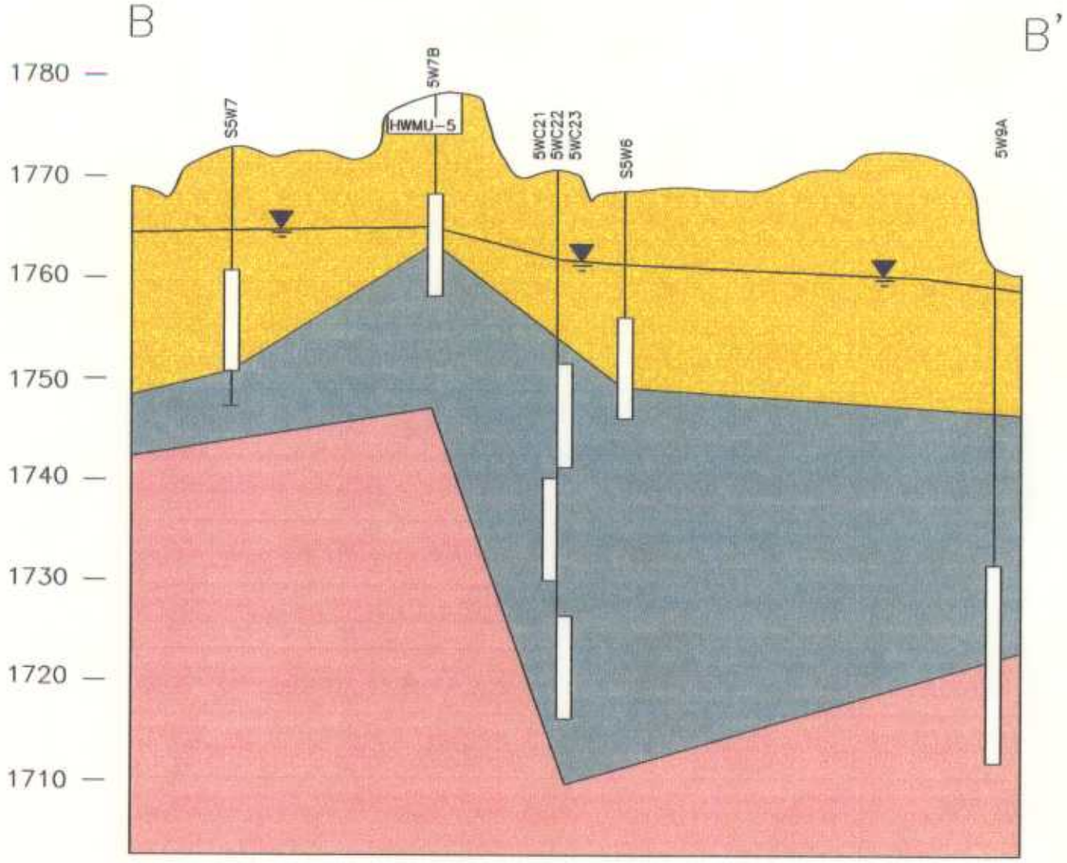
- ALLUVIUM (SILT, SAND, AND GRAVEL)
- WEATHERED BEDROCK (SANDY SILT AND CLAY, RELICT ROCK TEXTURE)
- ELBROOK FORMATION (LIMESTONE AND SHALE, BRECCIATED)
- GROUNDWATER MONITORING WELL
  - SCREENED INTERVAL
  - BOTTOM OF WELL
  - BORING TERMINATION
- POTENTIOMETRIC SURFACE

VERTICAL EXAGGERATION = 10X

NOTE: 5WC21, 5WC22, AND 5WC23 ARE THREE NESTED WELLS

B00316-CRS-X2.DWG

Draper Aden Associates CONSULTING ENGINEERS Blacksburg, Virginia – Richmond, Virginia	DESIGNED RGM DRAWN BTM CHECKED AEK DATE 02-10-01	GEOLOGIC CROSS-SECTION A-A' – HWMU 5 TCE ALTERNATE SOURCE DEMONSTRATION RADFORD ARMY AMMUNITION PLANT RADFORD, VIRGINIA	SCALE: H:1"=150' V:1"=15' PLAN NO. B00316	FIGURE 4



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- ALLUVIUM (SILT, SAND, AND GRAVEL)
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  - SCREENED INTERVAL
  - BOTTOM OF WELL
  - BORING TERMINATION
- POTENTIOMETRIC SURFACE

VERTICAL EXAGGERATION = 10X

NOTE: 5WC21, 5WC22, AND 5WC23 ARE THREE NESTED WELLS

B00316-CRS-X1.DWG

Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, Virginia – Richmond, Virginia

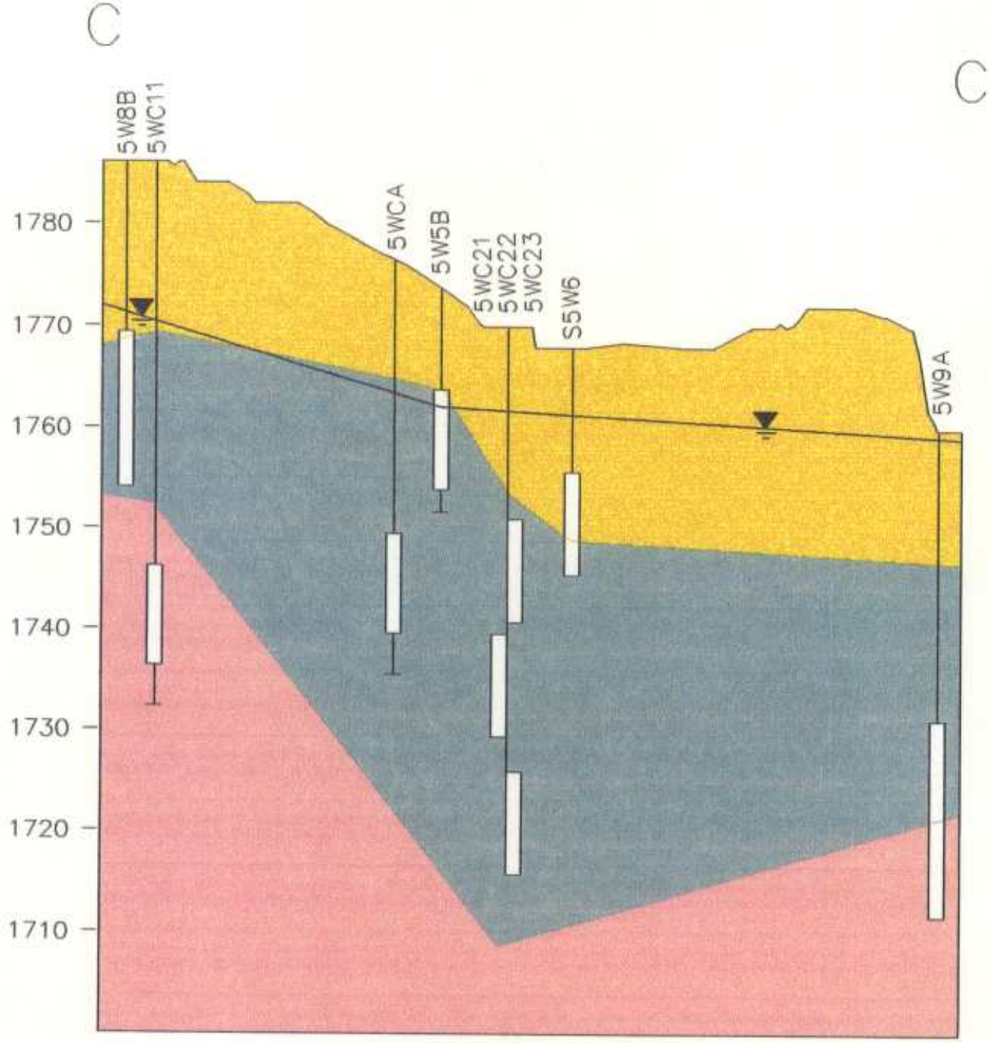
DESIGNED	RGM
DRAWN	BTM
CHECKED	AEK
DATE	02-10-01

GEOLOGIC CROSS-SECTION B-B' -HWMU 5 TCE ALTERNATE SOURCE DEMONSTRATION
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

SCALE: H:1"=150' V:1"=15'

PLAN NO. B00316

FIGURE 5



LEGEND

- ALLUVIUM (SILT, SAND, AND GRAVEL)
- WEATHERED BEDROCK (SANDY SILT AND CLAY, RELICT ROCK TEXTURE)
- ELBROOK FORMATION (LIMESTONE AND SHALE, BRECCIATED)
- GROUNDWATER MONITORING WELL
  - SCREENED INTERVAL
  - BOTTOM OF WELL
  - BORING TERMINATION
- POTENTIOMETRIC SURFACE

VERTICAL EXAGGERATION = 10X

NOTE: 5WC21, 5WC22, AND 5WC23 ARE THREE NESTED WELLS

Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, Virginia – Richmond, Virginia

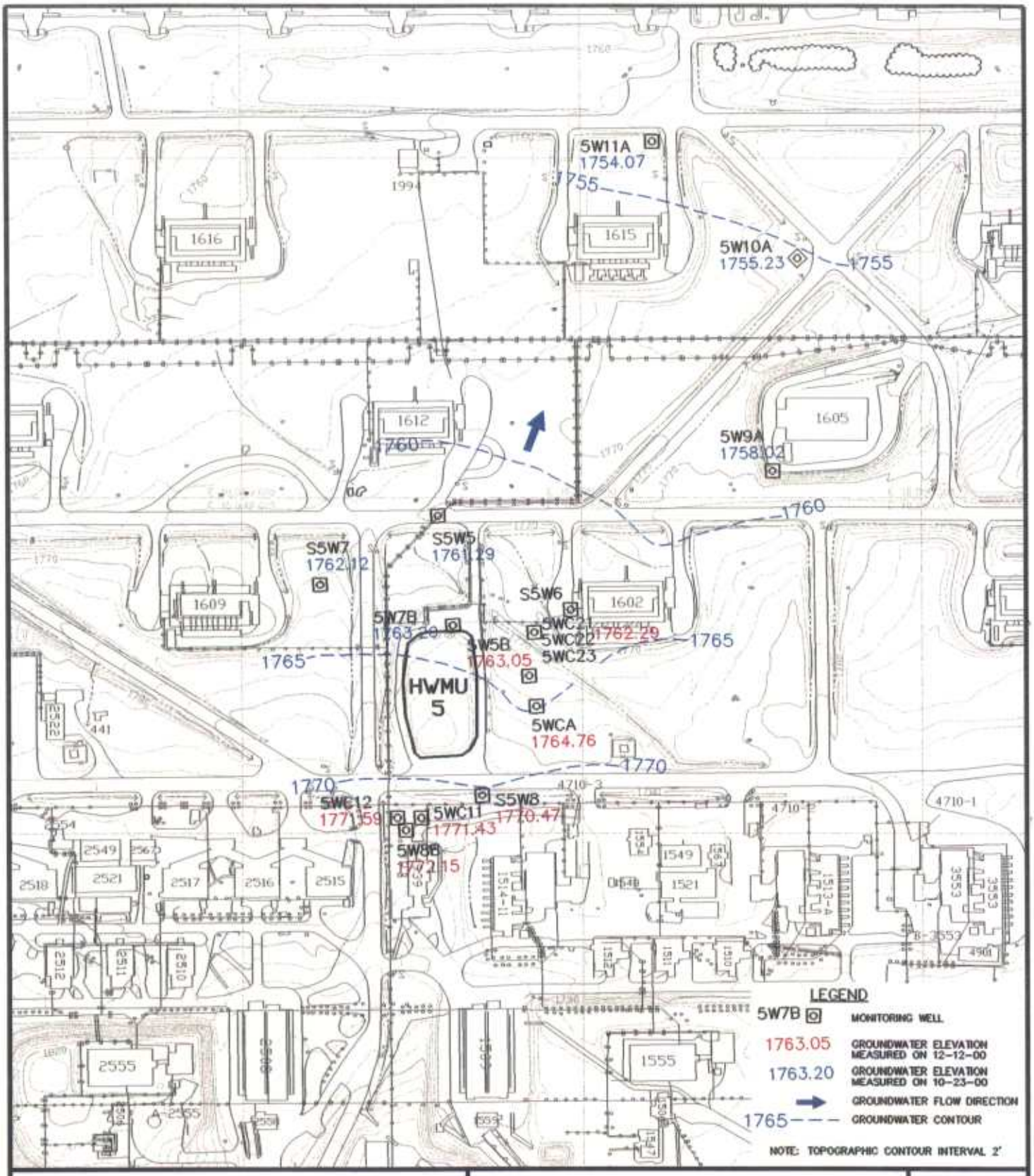
DESIGNED	RGM
DRAWN	BTM
CHECKED	AEK
DATE	02-07-01

GEOLOGIC CROSS-SECTION C-C" – HWMU 5 TCE ALTERNATE SOURCE DEMONSTRATION
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

SCALE: H:1"=150' V:1"=15'

PLAN NO. B00316

FIGURE 6



POTENTIOMETRIC SURFACE MAP HWMU–5 TCE ALTERNATE SOURCE DEMONSTRATION	RADFORD ARMY AMMUNITION PLANT RADFORD, VIRGINIA	
Draper Aden Associates CONSULTING ENGINEERS Blacksburg, VA – Richmond, VA	JOB No. B00316	DATE: 02–06–01
	SCALE: 1" = 200'	FIGURE 7

APPENDIX A

MONITORING WELL BORING LOGS/CONSTRUCTION DIAGRAMS

HWMU 5

RAAP

UNIT 5

02/07/95

WELLS	TYPE	STATUS	TD	DATE DRILLED	BORING LOG	COMPLETIO DIAGRAM	DATUM		SCREEN			
							G.L.	T.O.C.	LENGTH	SIZE	SLOT	TYPE
W8-B	UP/BG	ACTIVE	31.50	02/16/83	YES	YES	1787.58	1789.55	15.00	2.00	0.01	PVC
5WC2-1	POC	ACTIVE					1772.10	1774.43				
W6-B	POC	ACTIVE			YES	YES	1773.13	1775.08	10.00	2.00	0.01	PVC
W7-B	POC	ACTIVE	20.00		YES	YES	1772.78	1774.90	10.00	2.00	0.01	PVC
5WC2-2	ASMT	ACTIVE					1771.99	1774.45				
5WC2-3	ASMT	ACTIVE					1771.28	1773.84				
S5W-5	ASMT	ACTIVE	25.00	04/05/81	YES	YES	1769.81	1771.74	10.00	2.00	PVC40	
S5W-6	ASMT	ACTIVE					1769.42	1771.43				
S5W-7	ASMT	ACTIVE	26.00	04/05/81	YES	YES	1773.08	1775.06	10.00	2.00	PVC40	
W10-A	ASMT	ACTIVE			YES		1768.42	1770.79	20.00			TEFLON
W11-A	ASMT	ACTIVE			YES		1764.70	1765.90				
W9-A	ASMT	ACTIVE			YES		1761.07	1761.82				
5WC1-2		SWL					1787.43	1789.89				
5WCA	POC	SWL					1777.37	1779.96				
5WC1-1	UP	SWL					1787.55	1789.99				
S5W-8	UP	SWL	34.00	04/05/81	YES		1783.51	1784.77	5.00	2.00	PVC40	
S5W-8	UP	SWL					1787.02	1785.28				

RAAP

UNIT 5

WELLS			GROUT		ANNULAR SEALANT		FILTER PACK		hydraulic conductivity	
	TOP	BASE	TOP	BASE	TOP	BASE	TOP	BASE	K (ft/sec)	K (cm/sec)
W6-B	16.50	31.50							3.84E-04	1.17E-02
5WC2-1	(1749.80)								3.14E-06	9.58E-05
W5-B	10.00	20.00	0.00	6.00	8.00	10.00	8.00	20.00		
W7-B	10.00	20.00								
5WC2-2	(1749.80)								2.52E-05	7.69E-04
5WC2-3	(1725.39)								2.76E-05	8.42E-04
S5W-5	13.00	23.00								
S5W-6	(1755.42)									
S5W-7	12.00	22.00								
W10-A	(1745.77)									
W11-A	(1735.90)									
W9-A	(1729.85)									
5WC1-2	(1721.63)								1.10E-06	3.36E-05
5WCA	(1747.27)								2.37E-07	7.23E-06
5WC1-1	(1745.25)								9.60E-06	2.93E-04
S5W-8	29.00	34.00								
S5W-8	(1757.52)									

Betz-Converse-Murdoch-Inc. BCM

UNITS
W-9B

Drilling Log

Well Number W-8-B

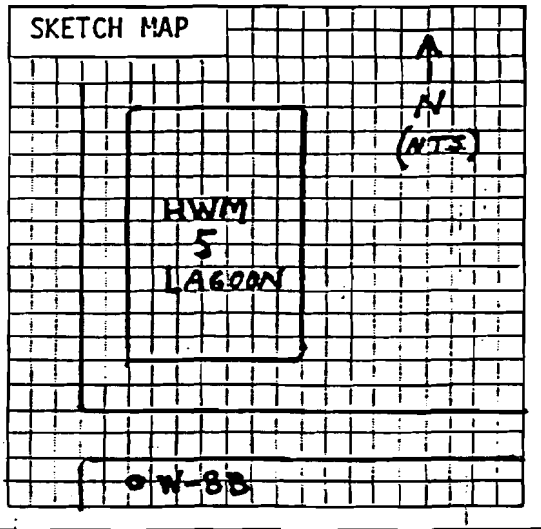
Client Corps of Engineers/Radford AAP
Project No. 00-0008-01
Well Location upgradient from lagoon No. 5
Driller/Company Dean/Cunningham
Drilling Method NX core
Hole Diameter nominal 4"
Date(s) Drilled 2/15 - 16/83
Sample Type split spoon/core
Sample Interval 5' spoon
No. Samples Retained 7
Surface Elevation 1787.58'
Casing Top Elevation 1789.55'
Total Well Depth 31.5
Casing Material and Size 2" ID PVC threaded couples
Cased Interval(s) 0 - 16.5 (+2's
Grouting Type sand cement
Grouted Interval 0-15.5 incl. 1'
Screening Material and Size 2" ID PVC 0.010" slots
Screened Interval(s) 16.5 - 31.5
Packing Material and Size No. 1 sand
Packed Interval 15.5 - 31.5
Depth to Static Water 17'4"*
Date 2/18/83
Approx Well Yield <0.25 gpm
Development Method air
Development Time 3 hours
Logged by: Peter R. Jacobson

Comments

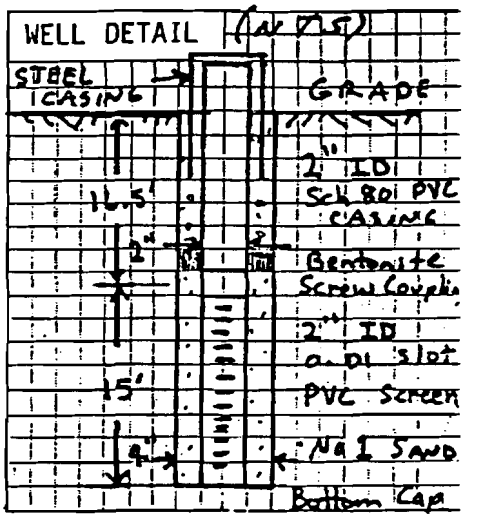
no core recovery

* measured from top of casing

SKETCH MAP



WELL DETAIL (Not to Scale)



Depth Scale	Sample	Spoon Blows	Description of Materials
0 - 1.5	spoon	1-5-6	medium brown to orange brown silty clay with angular pebbles
5 - 6.5	spoon	1-2-2	medium orange brown silty clay with minor fine sand
10 - 11.5	spoon	3-6-14	slightly moist mottled orange brown clay, minor silt and fine sand
14'4"			coarse sand and gravel layer
15 - 16.5	spoon	11-17-45	poorly sorted mix of sand silt gravel clay; coarsening downward; gravel ends at 17.5'
20 - 21.5	spoon	5-5-8	mottled orange/red brown clay, moist
25 - 26.5	spoon	1-2-2	wet soft brown clay with silt and fine sand
30 - 31.5	spoon	1-3-2	wet medium orange brown silty clay, minor sand
end of hole at 31.5'			

Betz-Converse-Murdoch-Inc. BCM

UNIT 5
W-5B

Drilling Log

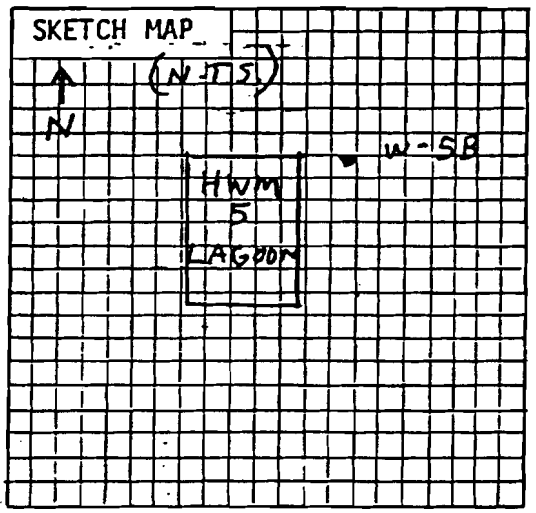
Well Number W-5B

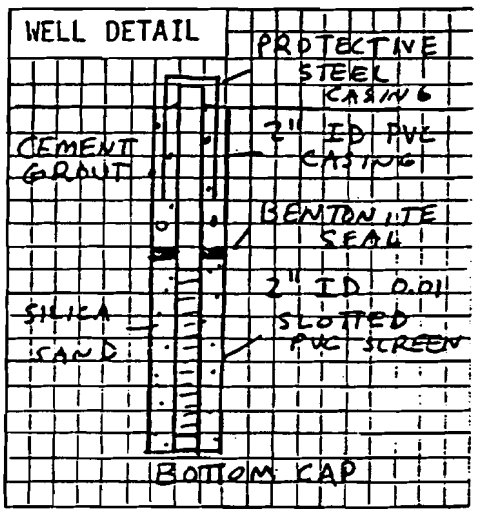
Client Corps of Engineers, RAAP, Radford, VA — Project No. 00-0008-01
Well Location East of HWM 5 Lagoon
Driller/Company M. Dean, Cunningham Core Drilling and Grouting Corp, Salem, VA
Drilling Method Fishtail — Hole Diameter 4.5" — Date(s) Drilled 8/17-18/83
Sample Type Split Spoon — Sample Interval 5' — No. Samples Retained 4
Surface Elevation 1773.13 — Casing Top Elevation 1775.08'* — Total Well Depth 22'
Casing Material and Size 2" ID Sch. 80 PVC — Cased Interval(s) 0-10'
Grouting Type Portland Cement with Sand — Grouted Interval 0-6'
Screening Material and Size 2" ID 0.01 Slotted PVC — Screened Interval(s) 10-20'
Packing Material and Size Fine to Coarse Silica Sand — Packed Interval 8-20'
Depth to Static Water 14.31 (T.O.C.) Date 8/19/83 — Approx Well Yield < 1 gpm
Development Method Air — Development Time 4 hours
Logged by: D. J. Varner

Comments

1) Drilling water obtained from RAAP hydrants
2) Replaces well W-5
3) Bentonite pellet seal in the 8-10' annular interval
4) Depth to water table measured from the top of the steel casing

*Top of steel casing





Depth Scale	Sample	Spoon Blows	Description of Materials
5-6.5	Spoon	2-3-4	Somewhat mottled buff to orange-brown fine sandy and silty clay
10-11.5	Spoon	4-7-9	Tan Clay with fine to coarse sand
15-16.5	Spoon	4-5-7	Tan clay with scattered sand
20-21.5	Spoon	2-2-4	Brown sandy clay
22			End of hole

Betz-Converse-Murdoch-Inc. BCM

UNIT 5
W-7B

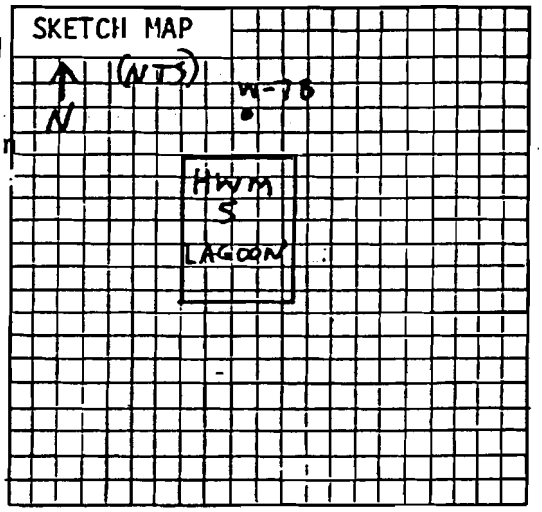
Drilling Log

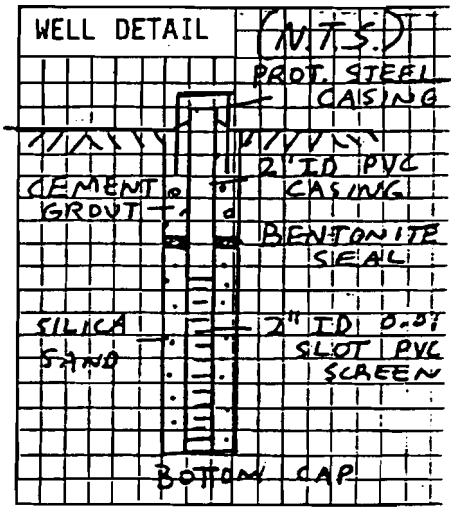
Well Number W-7B

Client Corps of Engineers, RAAP, Radford, VA — Project No. 00-0008-01
Well Location North of HWM5 Lagoon
Driller/Company M. Dean, Cunningham Core Drilling and Grouting Corp, Salem, VA
Drilling Method Fishtail/Core — Hole Diameter 4.5" — Date(s) Drilled 8/18/83
Sample Type Split Spoon — Sample Interval 5' — No. Samples Retained 4
Surface Elevation 1772.78 — Casing Top Elevation 1774.90'* — Total Well Depth 20'
Casing Material and Size 2" ID Sch. 80 PVC — Cased Interval(s) 0-10'
Grouting Type Portland Cement with Sand — Grouted Interval 0-6'
Screening Material and Size 2" ID 0.01 Slotted PVC — Screened Interval(s) 10-20'
Packing Material and Size Fine to coarse silica sand — Packed Interval 8-20'
Depth to Static Water 13.58'(T.O.C.) Date 8/19/83 — Approx Well Yield < 1 gpm
Development Method Air — Development Time 4 hours
Logged by: D. J. Varner

Comments
1) Drilling water obtained from RAAP hydrants
2) Replaces well W-7
3) Bentonite pellet seal in the 6-8' annular interval
4) Depth to water table measured from the top of the steel casing
5) Core size: HW

*Top of steel casing





Depth Scale	Sample	Spoon Blows	Description of Materials
5-6.5	Spoon	5-7-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
10-11.5	Spoon	2-3-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
15-16.5	Spoon	6-9-19	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite
20-21.5	Spoon	5-2-4	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite.
20			End of hole.

W-7B

Betz-Converse-Murdoch-Inc. BCM

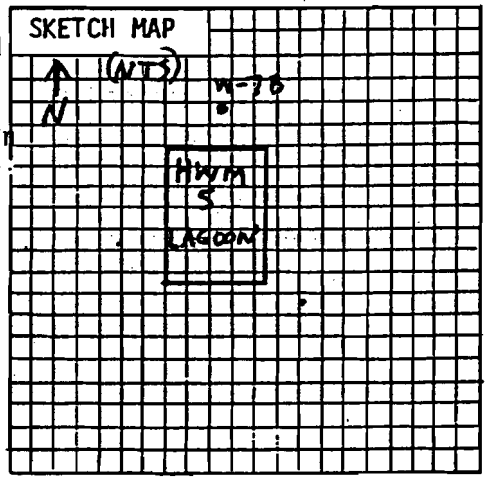
Drilling Log

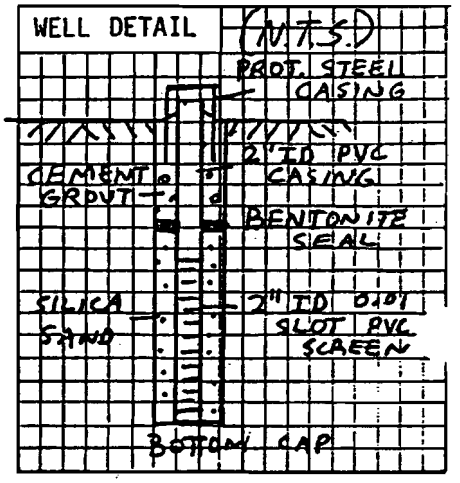
Well Number W-7B

Client Corps of Engineers, RAAP, Radford, VA — Project No. 00-0008-01
Well Location North of HWM5 Lagoon
Driller/Company M. Dean, Cunningham Core Drilling and Grouting Corp, Salem, VA
Drilling Method Fishtail/Core — Hole Diameter 4.5" — Date(s) Drilled 8/18/83
Sample Type Split Spoon — Sample Interval 5' — No. Samples Retained 4
Surface Elevation 1772.78 — Casing Top Elevation 1774.90'* — Total Well Depth 20'
Casing Material and Size 2" ID Sch. 80 PVC — Cased Interval(s) 0-10'
Grouting Type Portland Cement with Sand — Grouted Interval 0-6'
Screening Material and Size 2" ID 0.01 Slotted PVC — Screened Interval(s) 10-20'
Packing Material and Size Fine to coarse silica sand — Packed Interval 8-20'
Depth to Static Water 13.58' (T.O.C.) Date 8/19/83 — Approx Well Yield < 1 gpm
Development Method Air — Development Time 4 hours
Logged by: D. J. Varner

Comments
1) Drilling water obtained from RAAP hydrants
2) Replaces well W-7
3) Bentonite pellet seal in the 6-8' annular interval
4) Depth to water table measured from the top of the steel casing
5) Core size: HW

*Top of steel casing





Depth Scale	Sample	Spoon Blows	Description of Materials
5-6.5	Spoon	5-7-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
10-11.5	Spoon	2-3-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
15-16.5	Spoon	6-9-19	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite
20-21.5	Spoon	5-2-4	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite.
20			End of hole.

55W5
MW-5

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of MOnitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, north of lagoon next to building SR 1612 DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight auger BORE HOLE MW 5

TD= 25ft.

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	REMARKS (water level initial 7' 5" 24 hr. 8' 10")	
		Brown sandy silt with some gravel wet, plastic	10 ft of Concrete grout	13 ft of schedule 40, 2 in ID PVC casing
		Perched lense of water		
5 ft.	MB 5-10	Yellowish brown silty clay w/ some mica flakes		
10 ft			Bentonite	
	MB 10-15	same material	sand pack	
				screen
15 ft				

USAEHA Form 95, 12 Aug 74

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81

DATE 5 April 81

LOCATION Site 5, north of lagoon next to building S.R.1612

DRILLERS Smithson, Hoddinott
Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight auger

BORE HOLE MW 5

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	REMARKS
	MB 10-20		10 ft of slotted 2 in ID, schedule 40, PVC screen (0.008-0.01")
20 ft		water at 20 ft yellow coarse medium sand - saturated	
		change in engine pitch Elbrook FM	2 ft of trap
25 ft		TD 25 feet	Depth of well 25 ft
30 ft			

USAEHA Form 95, 12 Aug 74

55W6
MW-6

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81

DATE 5 April 81

LOCATION Site 6, northwest of lagoon next to building S.R. 1602

DRILLERS Smithson, Hoddinott
Craig, Gates (logger)

DRILL RIG Acker II w/ 4 in continuous flight auger

BORE HOLE MW 6

TD= 25.5 ft

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	Water level initial 9.5 ft 24 hr. 9' 7" REMARKS	
		Brown silty clay, damp plastic	7 ft of concrete grout	13.5 ft of schedule 40, 2 in ID PVC casing
5 ft	MB 5-10	Reddish brown silty clay--slightly damp, tight drilling	4.5 ft of Bentonite (may have a void above sand next to water table)	
10 ft		softer drilling, same material, getter wetter	11.5 ft of sand pack	
		saturated		screen
15 ft				

HSE-ES Form 78, 1 Jun 80

Replaces USAEHA Form 95, 12 Aug 74, which will be used.

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5,northeast : of lagoon next to building S.R. 1602 DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 6

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	REMARKS	
		Reddish brown silty coarse to medium sand, saturated (water is flowing)	Sand pack	10 ft of slotted schedule 40, 2 in ID PVC screen (0.008-0.010")
20 ft		Weathered Elbrook FM (red gray clay residuum over dolomite)		
				2 ft of sediment trap
25 ft		25.5 ft TD		Bottom of well 25.5 ft
30 ft				

USAEHA Form 95, 12 Aug 74

5507

MW-7

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, west of lagoon next to building S.R. 1603 DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 7 TD=26 ft

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	water level initial=14'10" 24 hr =10'10" REMARKS	
		Reddish brown silty clay dampmed plastic	Concrete	
			Bentonite	12 ft of schedule 40, 2 in ID PVC casing
5ft			24.5 ft of sand pack	
	MB 5-10	same material getting damper and more plastic		
10 ft				
		saturated silty medium coarse sand return on Auger- may have hit a lense of gravel		10 ft of slotted 2 in ID schedule 40 PVC screen
15 ft				

USAEHA Form 95, 12 Aug 74

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, west of lagoon next to building S.R. 1603 DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 7

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	REMARKS
	MB 15-20	same material saturated	screen
20 ft			
			3 ft of sediment trap
25 ft		Elbrook FM (weathered gray clay residuum)	depth of well 26 feet
		26 ft TD	
30 ft			

USAEHA Form 95, 12 Aug 74

5508

MW-8

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, Background well, south of lagoon DRILLERS Smithson Hoddinott, Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 8, TD= 34ft

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	water level initial=24 ft, 24 hr.=14'11" REMARKS	
		gravel fill for road		
		Reddish brown sandy clay with some small gravels	8 ft of concrete grout	29 ft of schedule 40, 2 in ID PVC casing
5 ft				
		same material, wet, med plastic	5 ft of Bentonite	
10 ft				
		same material, getting wetter & sticky	sand pack	
15 ft				

HSE-ES Form 78, 1 Jun 80

Replaces USAEHA Form 95, 12 Aug 74, which will be used.

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, background south of lagoon DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 8

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	REMARKS
	MB 15-20	same material	21 ft of sandpack; PVC casing
20 ft			
		same material	
25 ft			
30 ft			

HSE-ES Form 78, 1 Jun 80

Replaces USAEHA Form 95, 12 Aug 74, which will be used.

Army Pollution Abatement Program Study, Installation of MOnitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 Apr 81

LOCATION Site 5, background south of lagoon DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II. w/ 4 in continuous flight Auger BORE HOLE MW 8

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	REMARKS
		same material	5 ft of slotted schedule 40, 2 in ID PVC screen
35 ft		Refusal Elbrook FM Note: ran short of screen, therefore, 5 ft of screen was installed in the saturated zone instead of 10 feet.	bottom of well 34 ft.
40 ft			

HSE-ES Form 78, 1 Jun 80

Replaces USAEHA Form 95, 12 Aug 74, which will be used.

W9A
HWMU-5

Form No 500

BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No. ROM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No: W-9-A | Total Depth: 49.0' | Elevation: --- | Location: See plan

Type of Boring: Hollow stem auger | Started: 11-6-85 | Completed: 11-6-85 | Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	Asphalt and crushed stone				GROUNDWATER DATA
	1.5	Loose to medium dense brown fine sandy SILT little clay				
		-ALLUVIUM-	5 7 9	4.5 6.0		
			3 8	8.5 10.0		
	13.0	Soft orange-brown silty CLAY to clayey SILT (CL/ML) Relict structure	2 1 1	13.5 15.0		Water level @ 16.0'
		-RESIDUUM-				Development Data: Sloshed for 2 hrs. Bailed down to 21'. Water level re-established at 16.0' after 1.5 hrs.
	39.0			39.0		Auger refusal @ 39.0'
	40.0					

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Form No 500

BORING LOG

SINCE 1881

FROEHLING & ROBERTSON, INC.

EARTH LABORATORIES • ENGINEERING CHEMICAL

"ONE HUNDRED YEARS OF SERVICE"

Report No ROM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No.: W-9-A cont. | Total Depth: 49.0' | Elevation: --- | Location: See plan

Type of Boring: Hollow stem auger | Started: 11-6-85 | Completed: 11-6-85 | Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
	40.0	Brown fine to medium grained SANDSTONE, changing to blue-gray fractured saccharoidal LIMESTONE and DOLOMITE			20%	0%	GROUNDWATER DATA
				44.0			
					30%	0%	
	49.0			49.0			
		Coring terminated @ 49.0'					

- 20' TEFLON SCREEN
- 10' PVC. 80
- ADAPTER
- 25' PVC. (2 3' CUTOFF)

*No. of blows req'd for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N

Scale 1"=5' unless otherwise noted

W10A
HWMU-5

Form No 500

BORING LOG

SINCE 1881

FROEHLING & ROBERTSON, INC.

ENGINEERS • ENVIRONMENTAL SCIENTISTS

"ONE HUNDRED YEARS OF SERVICE"

Report No ROM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No.: W-10-A | Total Depth: 45.0' | Elevation: --- | Location: See plan

Type of Boring: Hollow stem auger | Started: 11-6-85 | Completed: 11-6-85 | Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
	0.0	Brown fine sandy SILT; roots, organics					GROUNDWATER DATA
	1.0	Loose to medium-dense red brown fine sandy SILT with occasional cobble layers (ML) -ALLUVIUM-					
			5 10 10	4.5 6.0			
			7 5 5	8.5 10.0			
			12 11 12	13.5 15.0			Water level @ 14.8'
	17.0	Medium-stiff gray-brown silty CLAY to clayey SILT, shale fragments, relict structure -RESIDUUM-					Development Data: Sloshed for 2 hrs. Bailed down for 1/2 hr. No change in water level.
			3 3 3	18.5 20.0			
			30 * *	28.5 30.0	28.5		* 50/0.5'
	30.0	Gray green brecciated LIMESTONE and DOLOMITE, numerous calcite-healed fractures			20%	0%	
				35.0	12%	0%	
	40.0			40.0			

*No. of blows req'd for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N

Scale 1"=5' unless otherwise noted

Form No 500

BORING LOG

SINCE 1881

FROEHLING & ROBERTSON, INC.

ONE HUNDRED YEARS OF SERVICE

Report No ROM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No. W-10-A cont | Total Depth: 45.0' | Elevation: --- | Location: See plan

Type of Boring: Hollow stem auger | Started: 11-6-85 | Completed: 11-6-85 | Driller W. Simmons, Sr.

Elevation	Depth 40.0	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
		Gray sandy LIMESTONE (Calcarenite)			42%	GROUNDWATER DATA 16%
	45.0			45.0		
		Boring terminated @ 45.0'				

- 20' TEFLON SCREEN
- 10' PVC-80
- ADAPTER
- 15' PVC-40

*No of blows req'd for a 140 lb hammer dropping 30 in to drive 2 in O.D., 1.375 in I.D. sampler a total of 18 inches in three 6 in increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N

Scale 1"=5' unless otherwise noted

W11A
HWMU-5

Form No 500

BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No ROM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No.: W-11-A | Total Depth: 48.0' | Elevation: --- | Location: See plan

Type of Boring: Hollow stem auger | Started: 11-6-85 | Completed: 11-6-85 | Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
	0.0	Brown fine sandy SILT; roots, organics					GROUNDWATER DATA
	1.0	Medium-dense to dense brown fine sandy SILT to silty fine SAND (ML/SM) -ALLUVIUM-		4.5			
			9 11 11	6.0			
				8.5			
			4 9 22	10.0			
				13.5			
			12 7 11	15.0	▽		Water level @ 14.8'
	17.0	Very soft yellow-brown coarse to fine sandy CLAY, some silt (CL) relict structure -RESIDUUM-					Development Data: Sloshed 2 hours. Bailed down to 19.0'. Recovered to 14.8' after 1.5 hrs.
				18.5			
			1 1 1	20.0			
	28.0	Gray-brown vuggy LIMESTONE, calcite healed fractures interbedded with gray-green -FAULT BRECCIA-		28.0			
					72%	30%	
				33.0			
					33%	7%	
				38.0			
	40.0						

*No. of blows req'd for a 140 lb. hammer dropping 30 in. to drive 2 in O.D. (1.375 in I.D.) sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Form No 500

BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No ROM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No W-11-A cont. Total Depth: 48.0' Elevation: --- Location: See plan

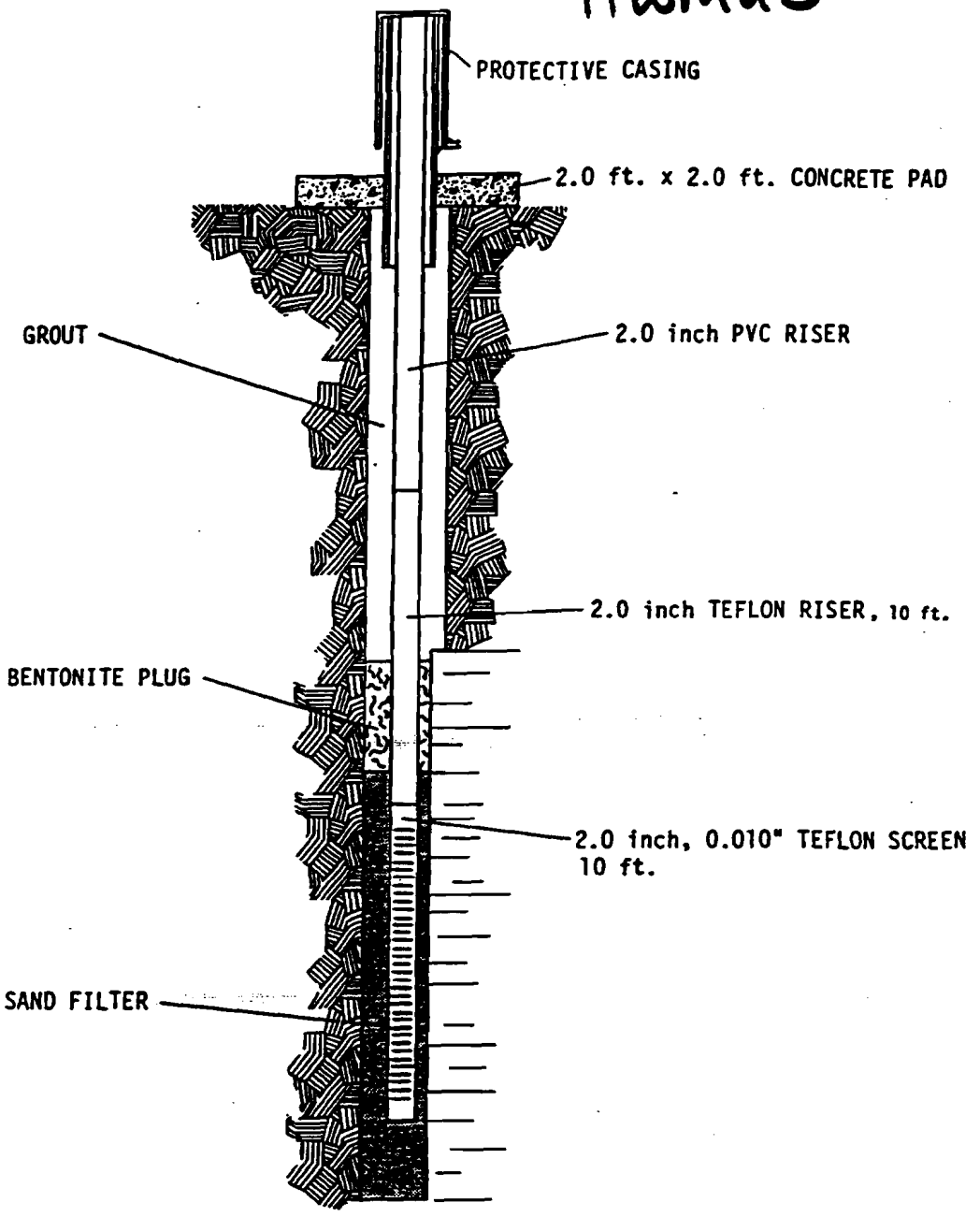
Type of Boring: Hollow stem auger Started: 11-6-85 Completed: 11-6-85 Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
	40.0				23%	0%	GROUNDWATER DATA
		Oark gray saccharoidal LIMESTONE		43.0			
					53%	0%	
	48.0			48.0			
		Coring terminated @ 48.0'					
		• 20' PVC Screen					
		• 30' PVC Riser					

*No of blows req'd for a 140 lb hammer dropping 30 in to drive 2 in O D 1 375 in I D sampler a total of 18 inches in three 6 in increments The sum of the last two increments of penetration is termed the standard penetration resistance, N

Scale 1"=5' unless otherwise noted

HWMU5



SINCE F&R 1881 FROEHLING & ROBERTSON, INC. FULL SERVICE LABORATORIES • ENGINEERS • CHEMISTS	DATE: May, 1987 SCALE: Not to Scale DRWN: CJS	
RADFORD ARMY AMMUNITION PLANT HERCULES, INC. RADFORD, VIRGINIA	TYPICAL WELL CONSTRUCTION DIAGRAM	DWG. NO. 3

FORM NO. 103

HWMU 5\5-WC1-1

Form No. 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICA
"ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No: 5-WC1-1 | Total Depth: 53.5 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/5/87 | Completed: 5/5/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	40.0				45.0	GROUNDWATER DATA
		5-WC1-1 continued		43.5		RQD = 23
					36.7	RQD = 7
				48.5		
					61.7	RQD = 0
	53.5			53.5		
		Boring terminated at 53.5 ft.				

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Form No. 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMIC.
"ONE HUNDRED YEARS OF SERVICE"

Report No. Q-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: 5-WC1-1 | Total Depth: 53.5 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/5/87 | Completed: 5/5/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted, see S-WC1-2 for subsurface conditions				GROUNDWATER DATA
		Cobbles encountered at 13.0 ft. and 17.0 ft.				
	33.5	Auger refusal at 33.5 ft.		33.5		
		Hard light gray dolomite, fractured and vuggy abundant calcareous infill, occasional shale infill: dolomite clasts in calcareous matrix: Probable slump structure		38.5	21 7	RQD - 0

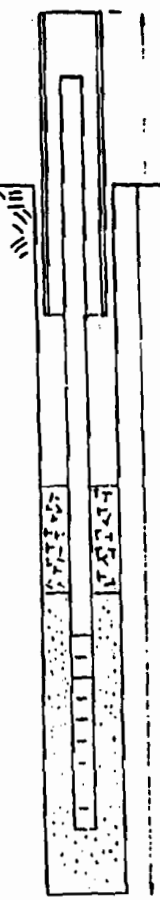
*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherw se noted

Project: Radford Army Ammunition Plant	Driller: Simmons	WELL No. 5-WC1-1
Location: Radford, Virginia	Inspector: Smith	
Client: Hercules Inc.	Date Installed: 5/5/87	
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen @10'	Sand Size: D(10)= 0.45-0.55 mm	
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser	Bore/ Core Size: 6 inch/ NX	

Subsurface Conditions Summary

See 5-WC1-2 for Conditions
Cobbles encountered at; 13.0 ft, 16.0 ft.



Casing Stickup (ft.)= 3.0 ft.

Elev. = _____

Riser Stickup (ft.) = 3.0 ft.

Elev. = _____

Ground Elev.= _____

Depth to Bentonite (ft.)= ---------

Elev. = _____

Depth to Sand Filter(ft.)= ---------

Elev. = _____

Depth to Well Bottom(ft.)= 49.3 ft.

Elev. = _____

Depth of Hole (ft.) = 53.5 ft.

Elev. = _____

HWMU 5 WC1-1

4

HWMU 5\ 5-WC1-2

Form No. 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICA
"ONE HUNDRED YEARS OF SERVICE"
1881

Report No. 0-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: S-WC1-2 | Total Depth: 76.8 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/1/87 | Completed: 5/1/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0					GROUNDWATER DATA
		Very loose yellow brown silty medium to fine SAND (SM)				
		-to-	1 1	4.5		
		Loose tan to red brown clayey medium to fine SAND, trace rounded coarse sand (SC)		6.0		
			2 2 7	8.5		
		-ALLUVIUM-		10.0		
			11 13 16	13.5		
				15.0		
	16.5					
		Loose orange brown medium to fine sandy SILT, trace angular coarse sand (rock fragments), manganese stains (ML)	6 7 3	18.5		
				20.0		
		-to-		23.5		
		Medium stiff orange brown clayey SILT, little medium to fine sand (rock fragments) (ML/MH)	2 1 3	25.0		
		-RESIDUUM-	15 4	28.5		
				30.0		
				33.5		
			1 1 2	35.0		Subsurface water at 34.5 ft. depth at 11:30 a.m. on May 1, 1987
	39.3	Auger refusal at 39.3 ft.		39.3		

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Form No. 500

BORING LOG

SINCE 1881

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICA
"ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: S-WC1-2 | Total Depth: 76.8 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/1/87 | Completed: 5/1/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	40.0	Hard light gray dolomite, vuggy, fractured, with calcareous infilling, some with moderately developed crystals, occasional shale infill: occasional dolomite clasts in a calcareous matrix: probable flow structure		44.3	35.8	GROUNDWATER DATA RQD = 0
				49.3	46.7	RQD = 7
				54.8	34.9	RQD = 0
				59.8	33.3	RQD = 0
				64.8	25.8	RQD = 0
				69.8	19.2	RQD = 0
				74.8	88.3	RQD = 10
	76.8	Boring terminated at 76.8 ft.		76.8	33.3	RQD = 0

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Project: Radford Army Ammunition Plant	Driller: Simmons	WELL No.
Location: Radford, Virginia	Inspector: Smith	5-WC1-2
Client: Hercules Inc.	Date Installed: 5/1/87	
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen	Sand Size: D(10)= 0.45-0.55 mm	
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser	Bore/ Core Size: 6 inch/ NX	

Subsurface Conditions Summary

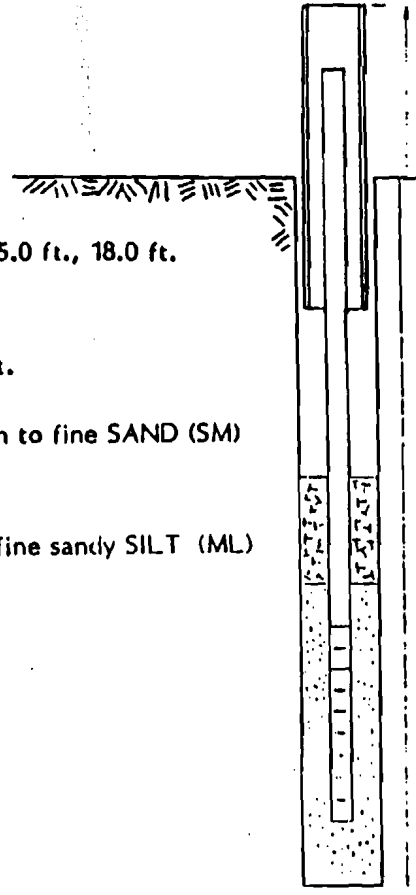
Cobbles encountered at; 15.0 ft., 18.0 ft.

Subsurface water at 34.5 ft.

Yellow Brown silty medium to fine SAND (SM)

to

Orange Brown medium to fine sandy SILT (ML)



Casing Stickup (ft.)= 3.0 ft.

Elev. = _____

Riser Stickup (ft.) = 3.0 ft.

Elev. = _____

Ground Elev.= _____

Depth to Bentonite (ft.)= --------

Elev. = _____

Depth to Sand Filter(ft.)= --------

Elev. = _____

Depth to Well Bottom(ft.)= 72.8 ft.

Elev. = _____

Depth of Hole (ft.) = 76.8 ft.

Elev. = _____

HWMU 5\ S-WC2-1

Form No. 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMIC
"ONE HUNDRED YEARS OF SERVICE"
1881

Report No. 0-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: S-WC2-1 | Total Depth: 31.8 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/5/87 | Completed: 5/5/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	Medium dense red brown silty fine SAND, trace mica (SM)	3 6 10	1.5		GROUNDWATER DATA
				3.0		
				4.5		
			4 5 9			
		-to-		6.0		
		Very loose to medium dense yellow brown silty medium to fine SAND (SM)		8.5		
			2 2 2			
				10.0		
		-ALLUVIUM-				
				13.5		
			2 14 6			
				15.0		
	16.5					
		Medium dense to very loose yellow brown silty coarse to fine SAND (angular rock Fragments) (SM)		18.5		
			9 14 8			
				20.0		Subsurface water at: 22 ft. May 5, 1987 at 4:00 p.m. 29 ft, May 5, 1987 4:10 p.m.
		-RESIDUUM-		23.5		
			*1			*Weight of hammer
				25.0		
				28.5		
			1 2 3			
				30.0		
	31.8					
		Boring terminated at 31.8 ft.				

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted

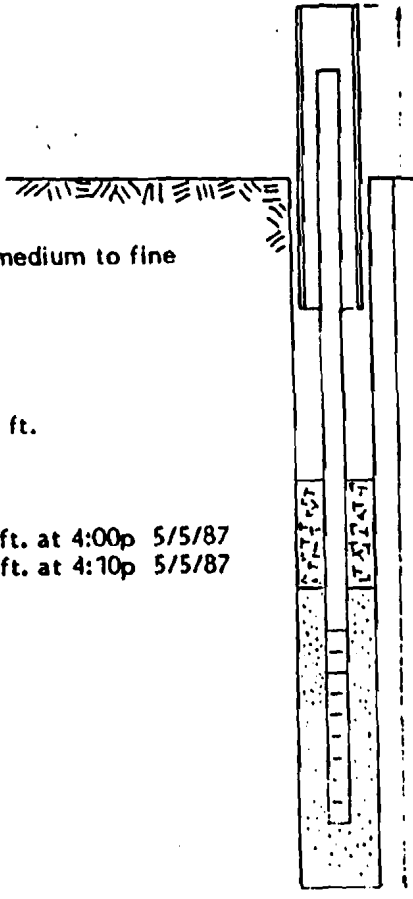
Project: Radford Army Ammunition Plant	Driller: Simmons	WELL No. 5-WC2-1
Location: Radford, Virginia	Inspector: Smith	
Client: Hercules Inc.	Date Installed: 5/6/87	
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen	Sand Size: D(10)= 0.45-0.55 mm	
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser	Bore/ Core Size: 6 inch/ NX	

Subsurface Conditions Summary

Yellow to Red Brown silty medium to fine SAND (SM)

Cobbles encountered at 8.0 ft.

Subsurface water at; 22.0 ft. at 4:00p 5/5/87
29.0 ft. at 4:10p 5/5/87



Casing Stickup (ft.)= 3.0 ft.
Elev. =
Riser Stickup (ft.) = 3.0 ft.
Elev. =
Ground Elev.=

Depth to Bentonite (ft.)= 14.8 ft.
Elev. =
Depth to Sand Filter(ft.)= .....
Elev. =

10' Screen

Depth to Well Bottom(ft.)= 29.3 ft.
Elev. =
Depth of Hole (ft.) = 31.8 ft.
Elev. =

HWMU 5\ 5-WC2-2

Form No. 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICA
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1881

Report No. 0-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: 5-WC2-2 | Total Depth: 43.5 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/6/87 | Completed: 5/6/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted, see 5-WC2-1 for subsurface condictions				GROUNDWATER DATA
		Cobbles encountered at 15 ft.				
		Difficult augering at 35 ft. - 40 ft.				
		Boring terminated at 43.5 ft.				

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

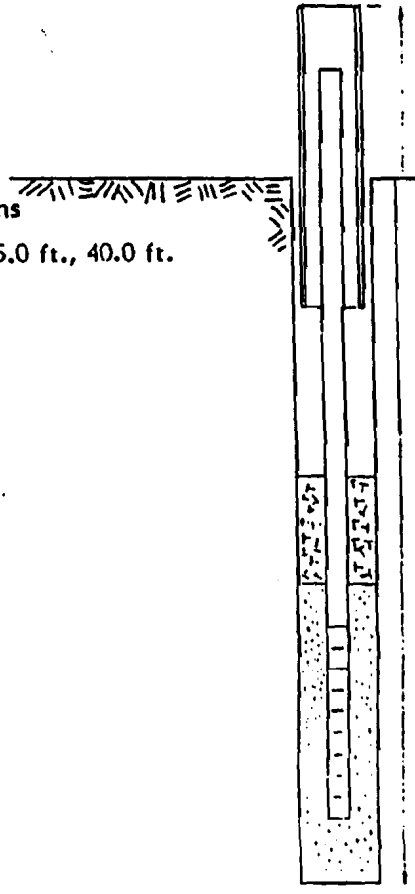
Scale 1"=5' unless otherwise noted

Project: Radford Army Ammunition Plant	Driller: Simmons	WELL No. 5-WC2-2
Location: Radford, Virginia	Inspector: Smith	
Client: Hercules Inc.	Date Installed: 5/6/87	
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen	Sand Size: D(10)= 0.45-0.55 mm	
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser	Bore/ Core Size: 6 inch/ NX	

Subsurface Conditions Summary

See 5-WC2-1 for Conditions

Cobbles encountered at; 15.0 ft., 40.0 ft.



Casing Stickup (ft.)= 3.0 ft.

Elev. =

Riser Stickup (ft.) = 3.0 ft.

Elev. =

Ground Elev.=

Depth to Bentonite (ft.)= 28.0 ft.

Elev. =

Depth to Sand Filter(ft.)= -------

Elev. =

Depth to Well Bottom(ft.)= 40.5 ft.

Elev. =

Depth of Hole (ft.) = 43.5 ft.

Elev. =

HWMU 5 \ 5-WC2-3

Form No 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICA
"ONE HUNDRED YEARS OF SERVICE"

Report No. Q-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: 5-WC2-3 | Total Depth: 55.3 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/6/87 | Completed: 5/6/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0					GROUNDWATER DATA
		No sampling conducted, see S-WC2-1 for subsurface conditions				
		Cobbles encountered at 15.0 ft.				
		Difficult augering at 53.0 ft. - 55.0 ft.				
		Boring terminated at 55.3 ft.				

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

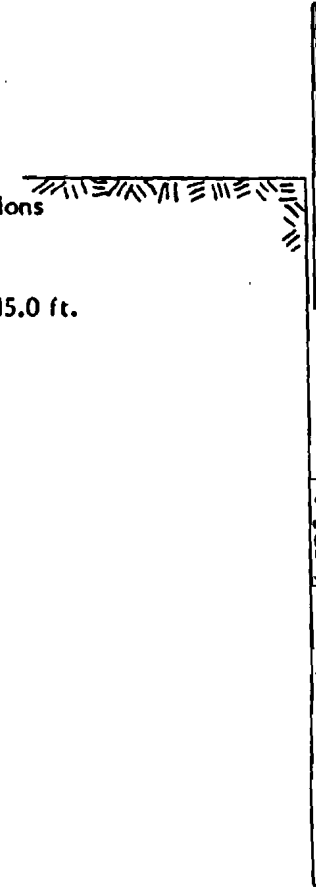
Scale 1"=5' unless otherwise noted

Project: Radford Army Ammunition Plant	Driller: Simmons	WELL No.
Location: Radford, Virginia	Inspector: Smith	5-WC2-3
Client: Hercules Inc.	Date Installed: 5/6/87	
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen	Sand Size: D(10)= 0.45-0.55 mm	
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser	Bore/ Core Size: 6 inch/ NX	

Subsurface Conditions Summary

See 5-WC2-3 for Conditions

Cobbles encountered at 15.0 ft.



Casing Stickup (ft.)= 3.0 ft.

Elev. =

Riser Stickup (ft.) = 3.0 ft.

Elev. =

Ground Elev.=

Depth to Bentonite (ft.)= --------

Elev. =

Depth to Sand Filter(ft.)= --------

Elev. =

10' SCREEN

Depth to Well Bottom(ft.)= 53.6 ft.

Elev. = ~~55.3 ft.~~

Depth of Hole (ft.) = 55.3ft

Elev. =

HWMU 5\5-WCA

Form No 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CHEMICA
"ONE HUNDRED YEARS OF SERVICE"
1881

Report No. G-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: 5-WCA | Total Depth: 40 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/7/87 | Completed: 5/11/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0					GROUNDWATER DATA
		Very loose gray brown medium to fine sandy SILT, trace coarse subrounded sand (ML)	3_2	1.5		
				3.0		
				4.5		
		Very loose gray braown fine sandy SILT (ML)	2_1	6.0		
		-ALLUVIUM-				
			2_4	8.5		
				10.0		
	11.5					
				13.5		
		Medium stiff gray to tan clayey SILT, manganese stains (ML)	2_4	15.0		
				18.5		
			2_3	20.0		
		Medium stiff to stiff mottled to gray silty fine SAND (SM) manganese stains		23.5		
			2_6	25.0		
		-grading to-				
		Stiff mottled to gray silty CLAY/clayey SILT (CL/ML)		28.5		
			3_7	30.0		
		-RESIDUUM-				
				33.5		
			3_9	35.0		
				38.5		
			***			
	40.0	Boring terminated at 40.0 ft.		40.0		*Weight of Hammer

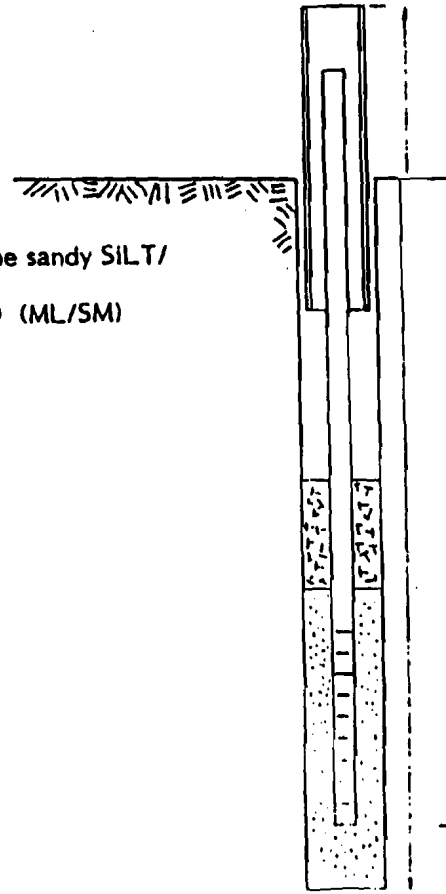
*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Project: Radford Army Ammunition Plant	Driller: Simmons	WELL No.
Location: Radford, Virginia	Inspector: Smith	S-WCA
Client: Hercules Inc.	Date Installed: 5/11/87	
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen	Sand Size: D(10)= 0.45-0.55 mm	
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser	Bore/ Core Size: 6 inch/ NX	

Subsurface Conditions Summary

Gray Brown medium to fine sandy SILT/ silty medium to fine SAND (ML/SM)



Casing Stickup (ft.)= 3.0 ft.

Elev. = _____

Riser Stickup (ft.) = 3.0 ft.

Elev. = _____

Ground Elev.= _____

Depth to Bentonite (ft.)= 4.0 ft.

Elev. = _____

Depth to Sand Filter(ft.)= 25.8 ft.

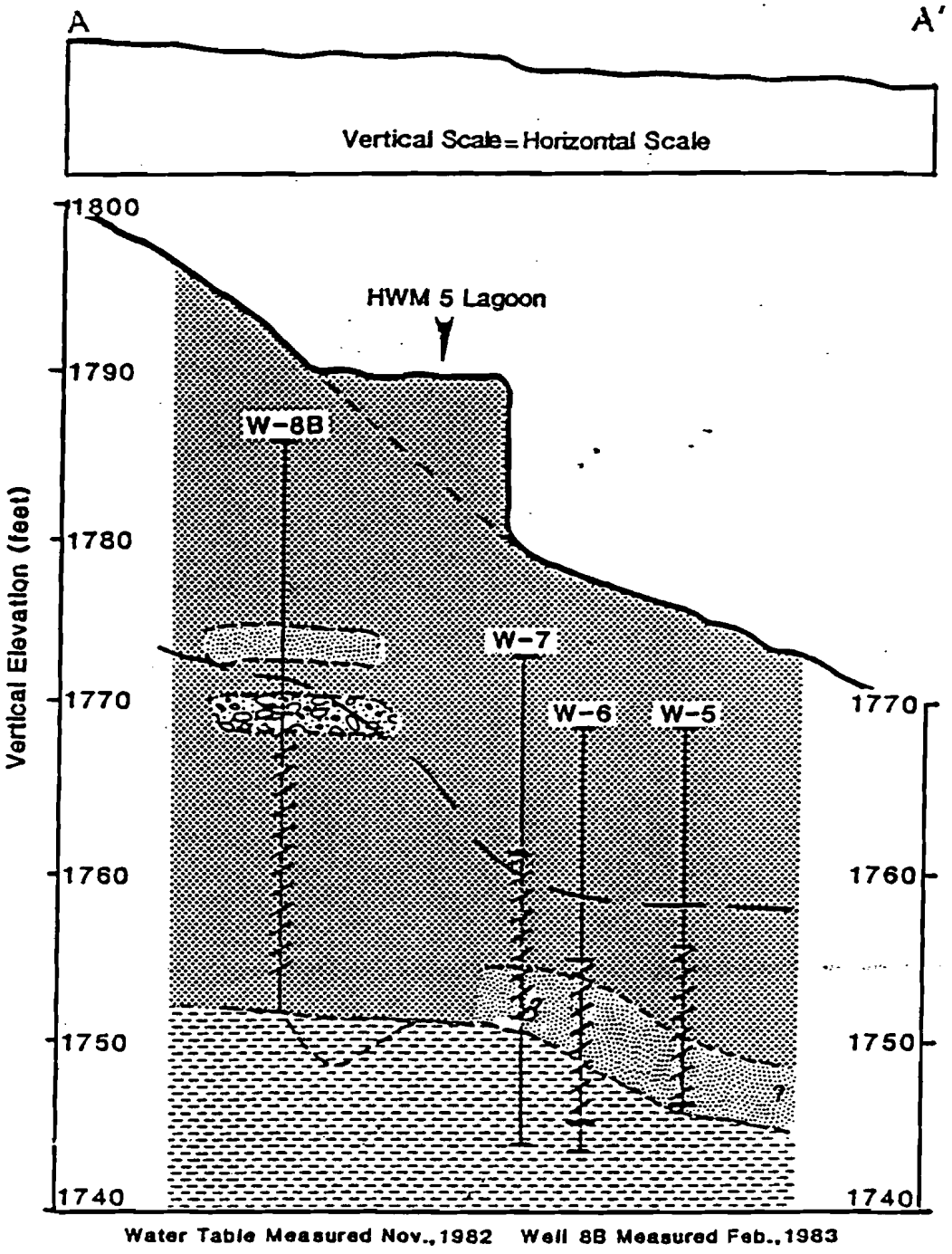
Elev. = _____

Depth to Well Bottom(ft.)= 37.1 ft.

Elev. = _____

Depth of Hole (ft.) = 40.0 ft.

Elev. = _____


A
A'
Vertical Scale = Horizontal Scale
1800
1790
1780
1770
1760
1750
1740
Vertical Elevation (feet)
HWM 5 Lagoon
W-8B
W-7
W-6
W-5
Water Table Measured Nov., 1982
Well 8B Measured Feb., 1983
HORIZONTAL SCALE
0
200'
LEGEND
Sandy Silt
Sand with Silt and Gravel
Sand, Gravel and Cobbles
Bedrock
Water Table
Monitoring Well Profile
Screened Interval
BCM
Betz·Converse·Murdoch·Inc.
Engineers, Planners and Scientists
RAAP HWM 5
Geology and Groundwater Profile
FIGURE 2

RA-152 (Rev. 7/85)

ENGINEERING DEPARTMENT FILE

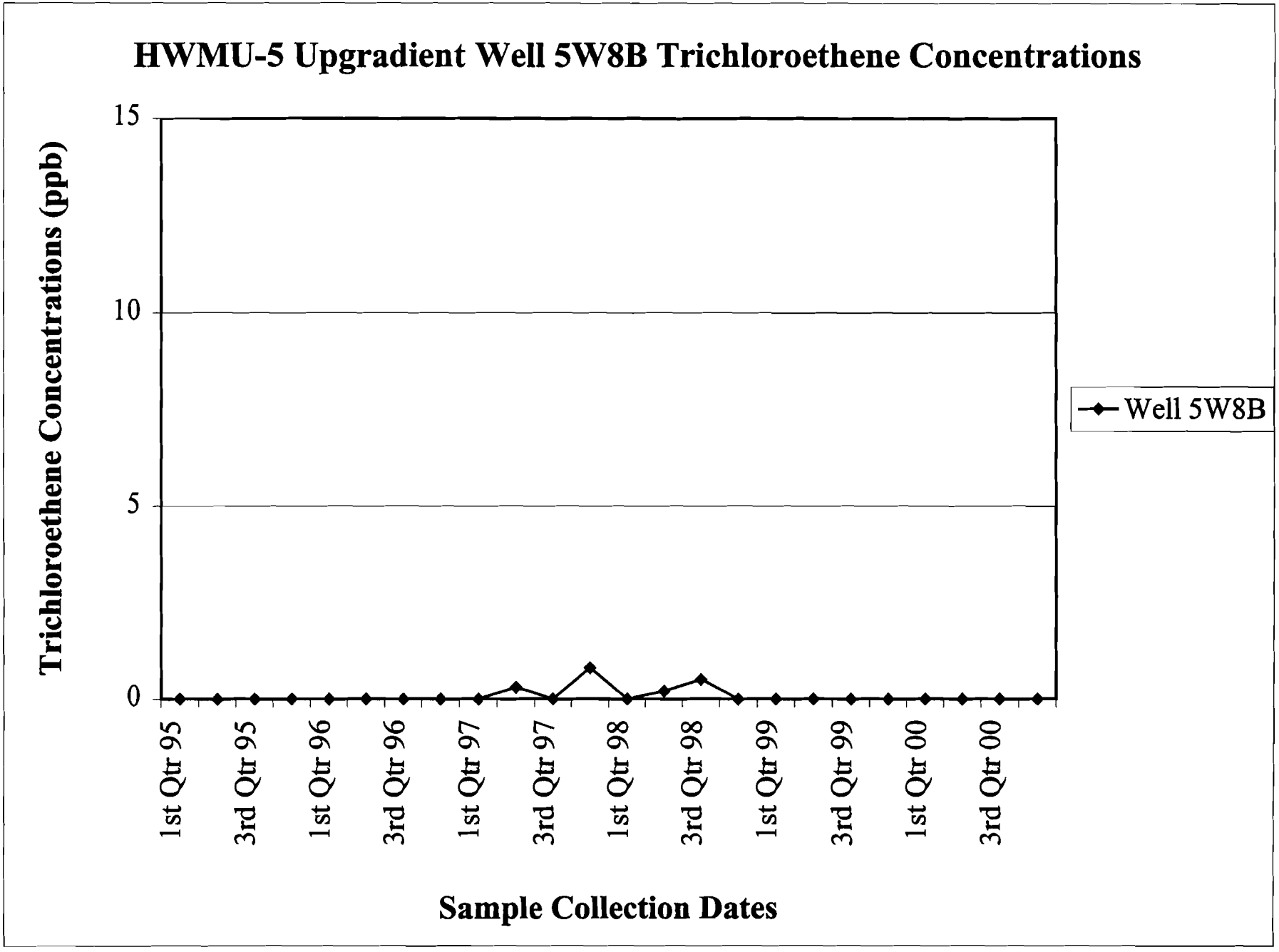
PLANT RAAD PROJECT No. _____ DATE 6/13/[illegible] AUTHOR R. C. Wed[illegible]

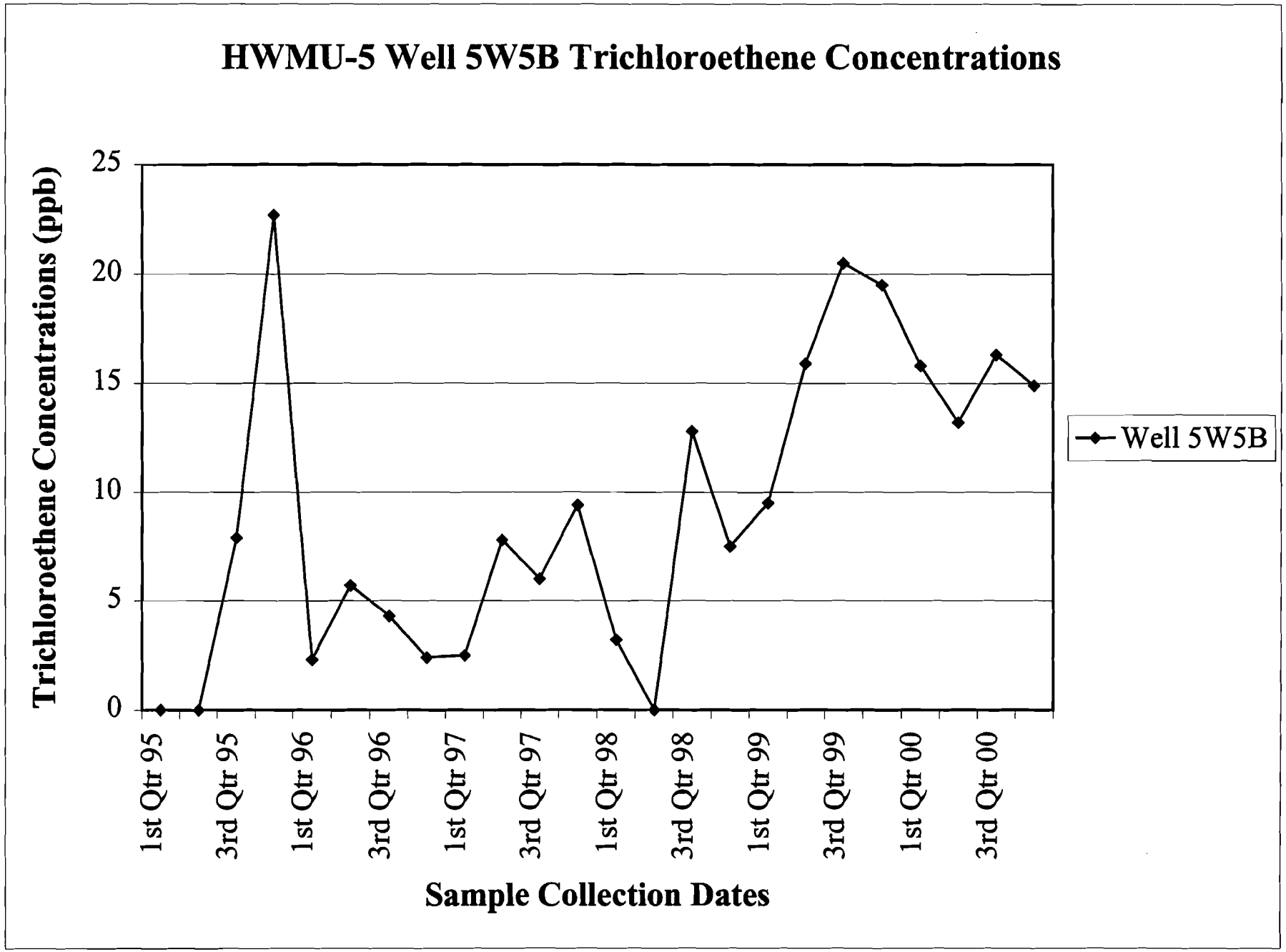
TITLE Survey Information - Groundwater Monitori[illegible] Wells at HWM 5

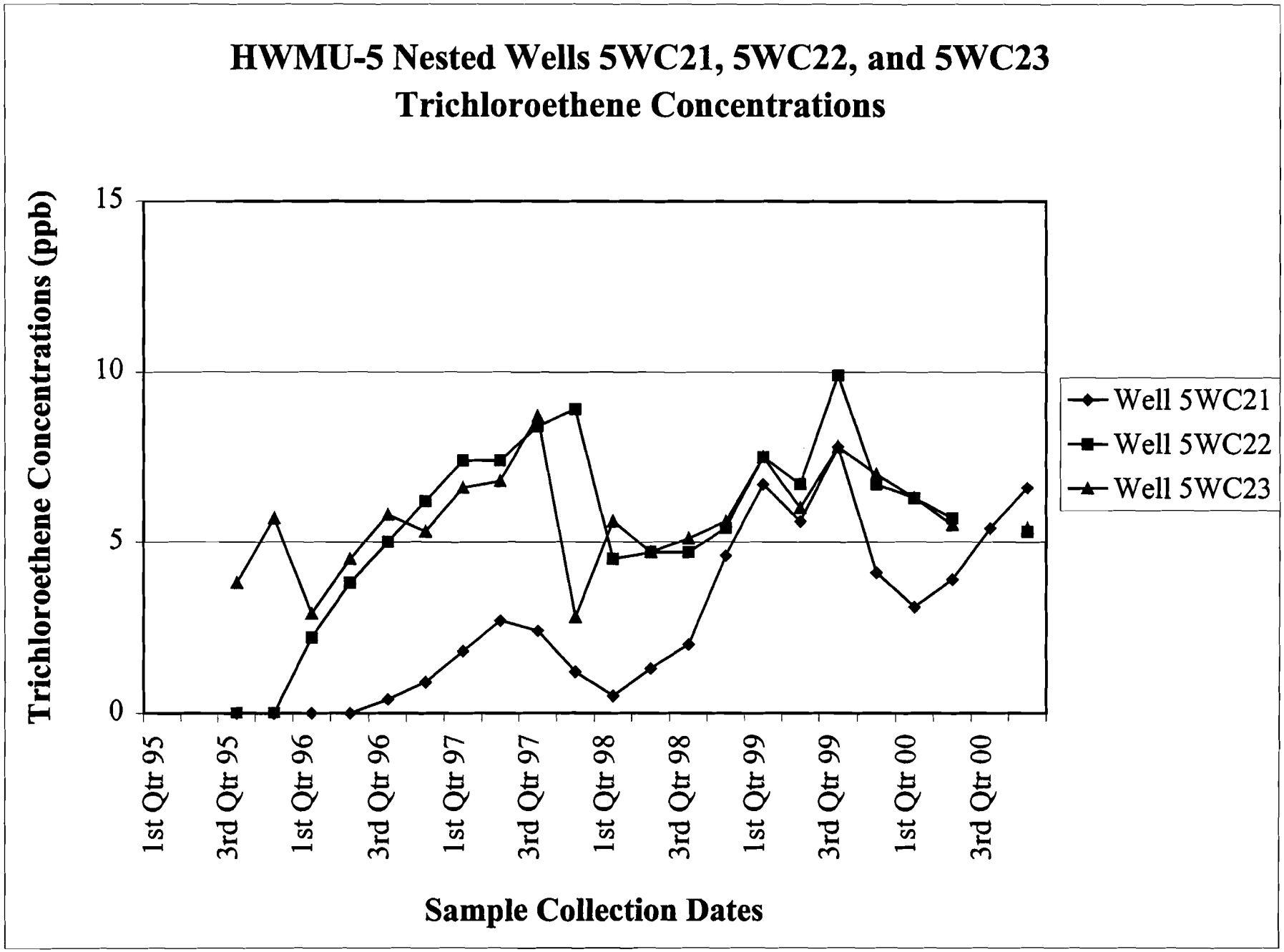
Well No.	Plant Coordinates North	Plant Coordinates West	Monitoring Well Elevations Conc. Pad	Monitoring Well Elevations Top of Casing	Ground Water Elevation	Date G. Water E. Measu[illegible]
W-6	1078.8	592.7	1772.93	1774.98	1766.6	8/2[illegible]
5WC2-3	1001.0	641.7	1771.28	1773.88		
5WC2-2	1006.1	652.7	1771.99	1778.85		
5WC2-1	1010.9	663.9	1772.10	1778.83		
W5B	951.5	658.6	1772.88	1778.80	1766.0	8/2[illegible]
5WCA	865.6	650.0	1777.37	1779.96		
W-8	713.9	726.7	1787.02	1788.28	1796.0	8/2[illegible]
W-7	1032.5	917.1	1776.59	1778.59	1765.0	8/2[illegible]
W-7B	1006.5	717.9	1772.59	1778.86	1765.0	8/2[illegible]
W-5	1153.9	776.0	1773.32	1775.25		
5WC1-2	671.7	773.2	1787.83	1789.89		
5WC1-1	685.1	782.6	1787.55	1789.99		
W8B	671.7	783.7	1787.58	1789.55	1738.35	8/2[illegible]
W9A	1190	231	1761.07	1761.82	1760.3	8/2[illegible]
W10A	1518	223	1768.82	1770.75	1758.8	8/20[illegible]
W11A	1678	835	1768.70	1765.90	1756.7	8/20[illegible]

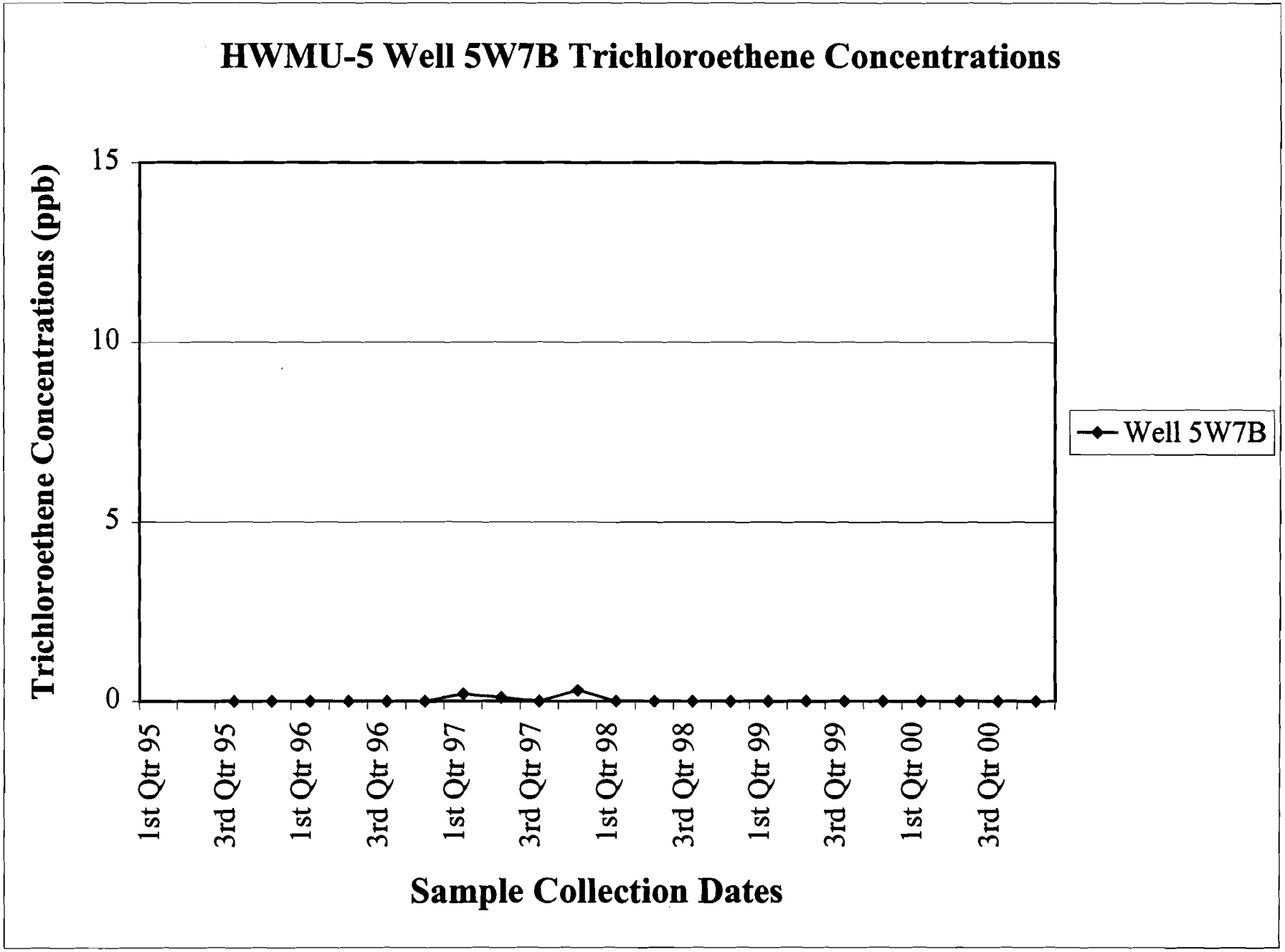
APPENDIX B

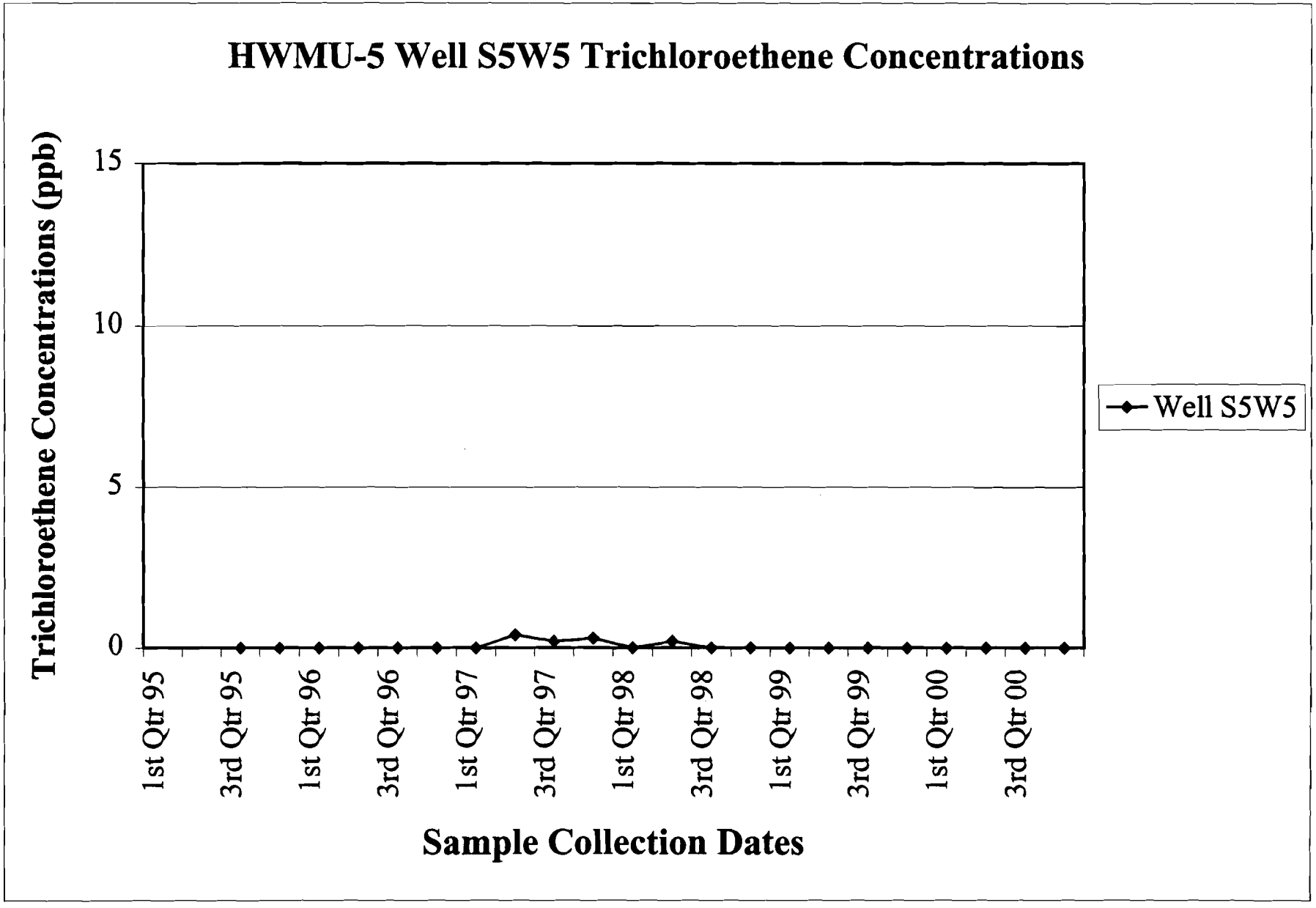
TRICHLOROETHENE HISTORIC CONCENTRATION GRAPHS

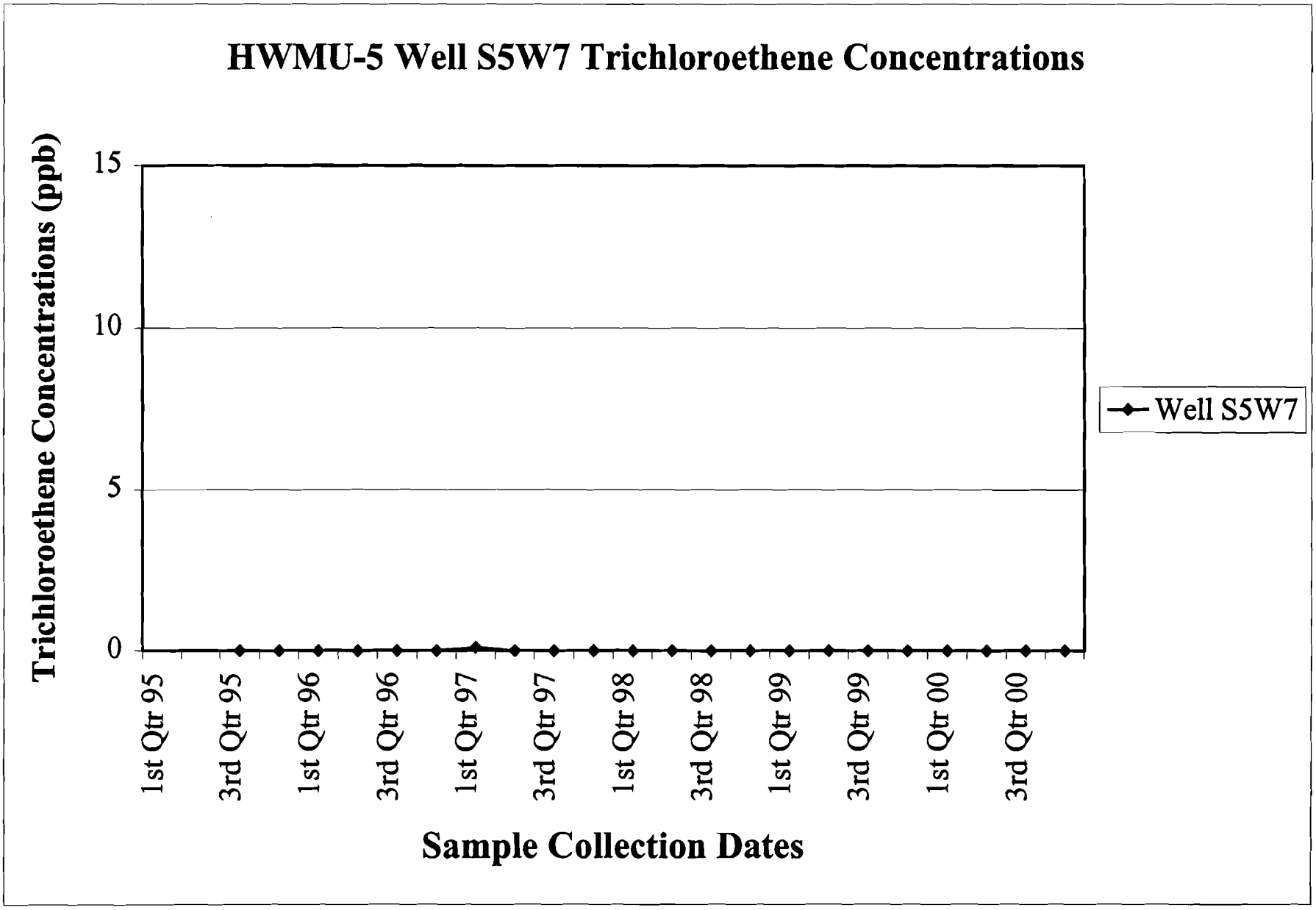

HWMU-5 Upgradient Well 5W8B Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well 5W8B

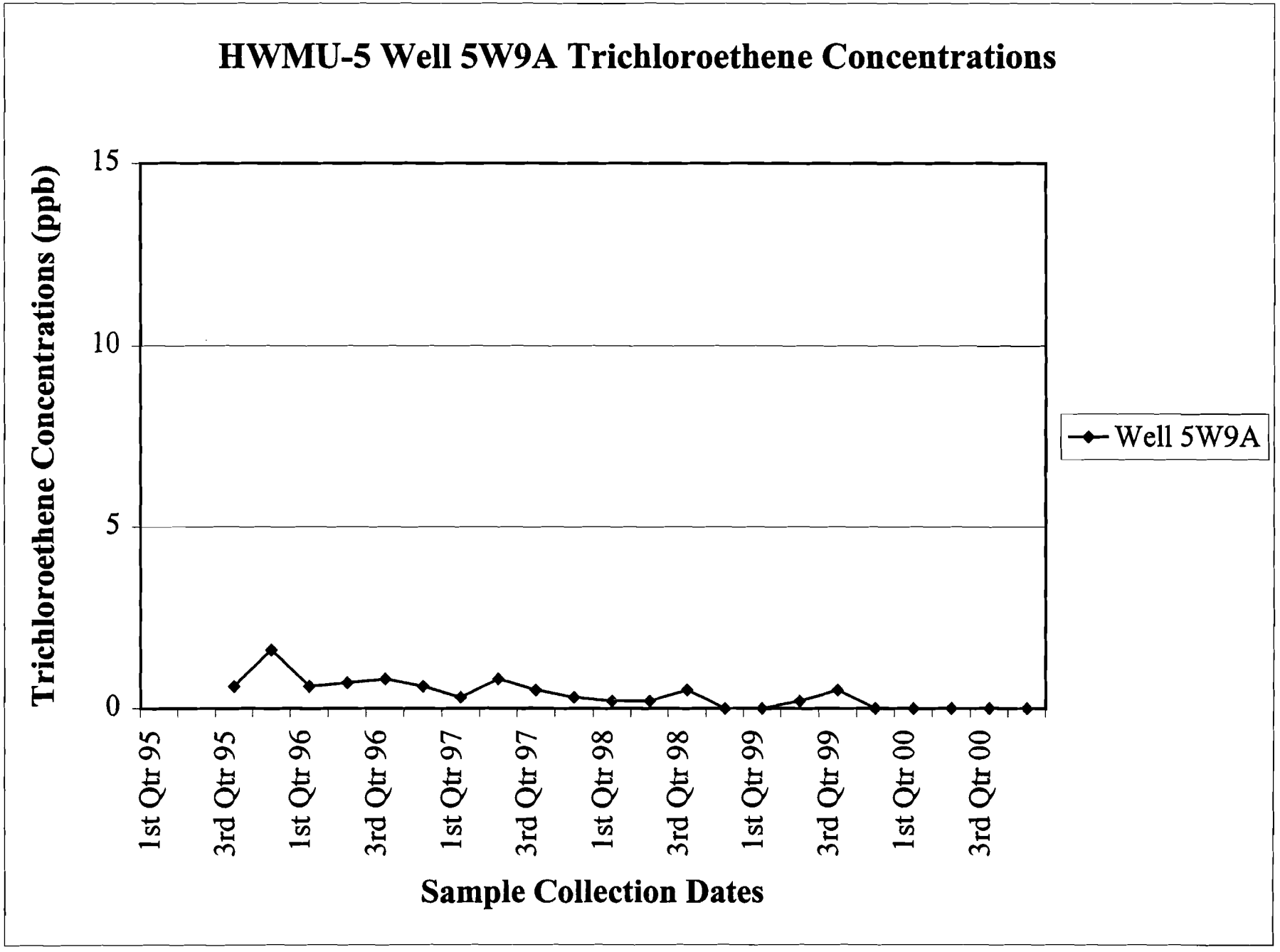

HWMU-5 Well 5W5B Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
25
20
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well 5W5B

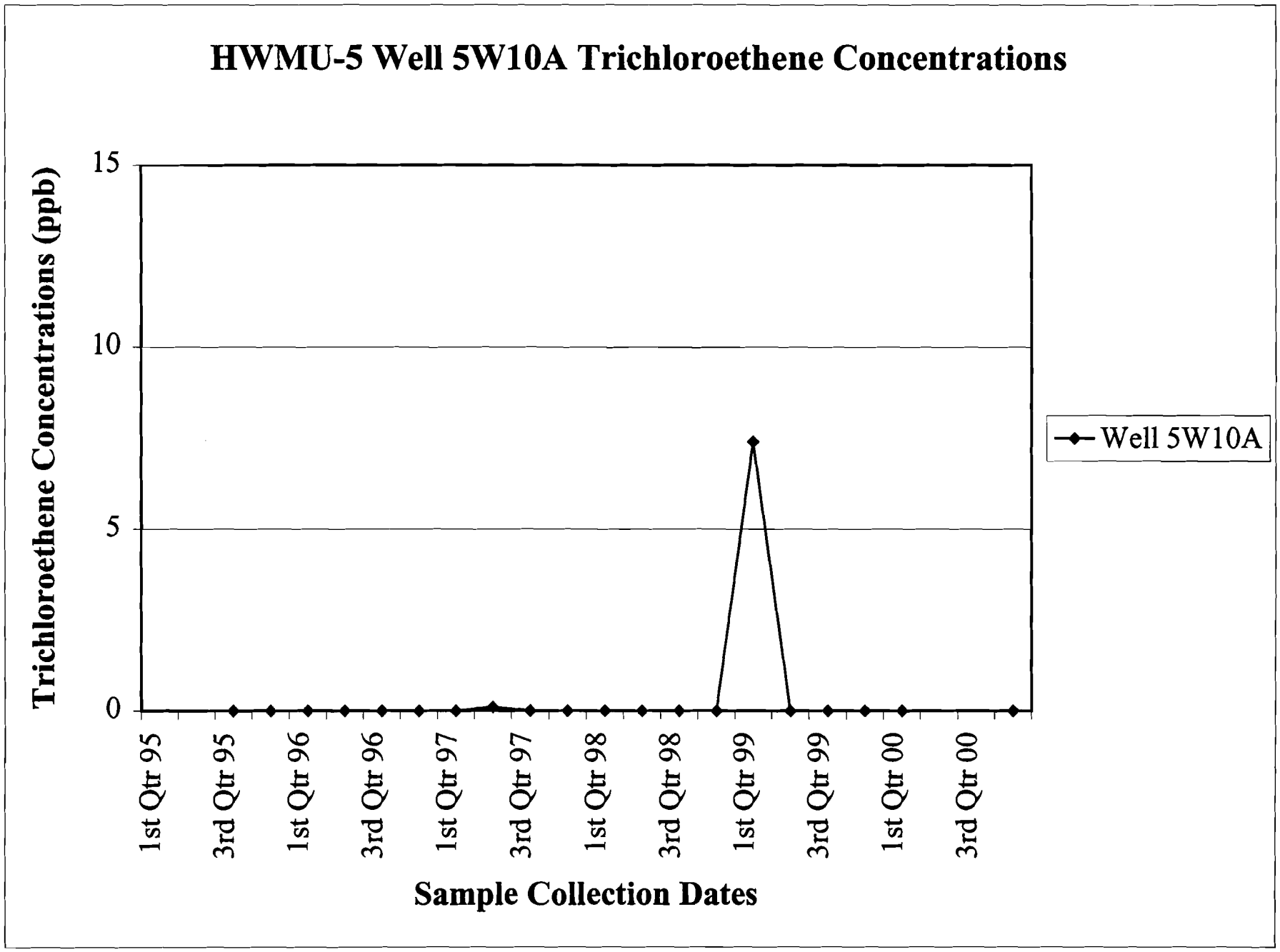

HWMU-5 Nested Wells 5WC21, 5WC22, and 5WC23
Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well 5WC21
Well 5WC22
Well 5WC23

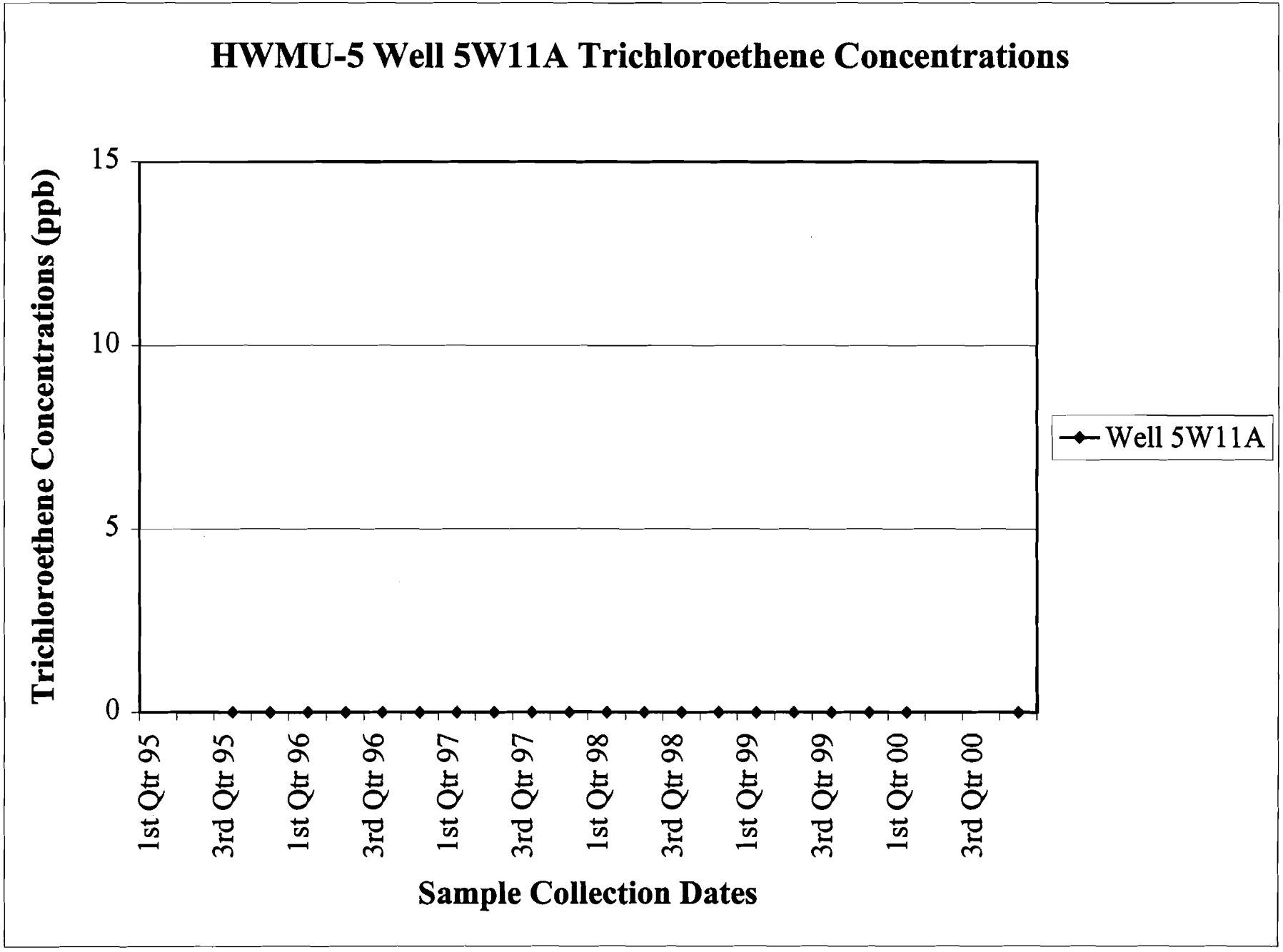

HWMU-5 Well 5W7B Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well 5W7B


HWMU-5 Well S5W5 Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well S5W5


HWMU-5 Well S5W7 Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well S5W7


HWMU-5 Well 5W9A Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well 5W9A


HWMU-5 Well 5W10A Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well 5W10A


HWMU-5 Well 5W11A Trichloroethene Concentrations
Trichloroethene Concentrations (ppb)
15
10
5
0
1st Qtr 95
3rd Qtr 95
1st Qtr 96
3rd Qtr 96
1st Qtr 97
3rd Qtr 97
1st Qtr 98
3rd Qtr 98
1st Qtr 99
3rd Qtr 99
1st Qtr 00
3rd Qtr 00
Sample Collection Dates
Well 5W11A