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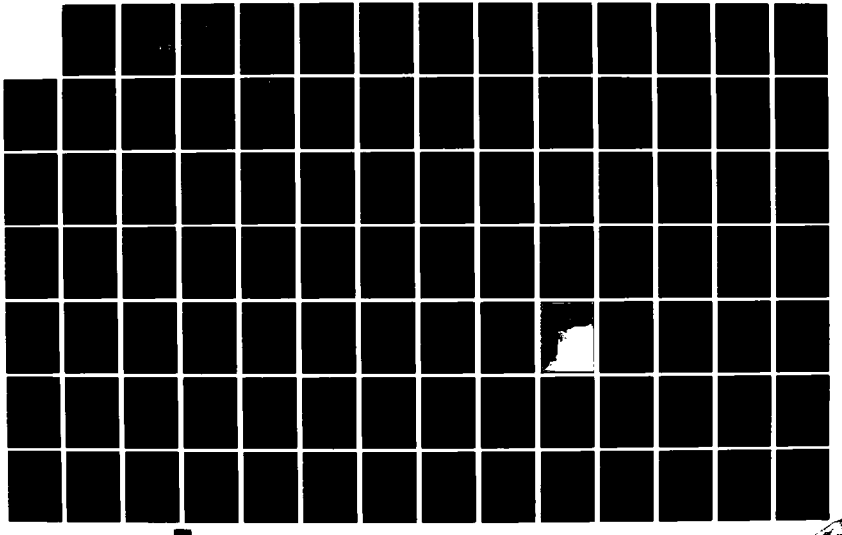

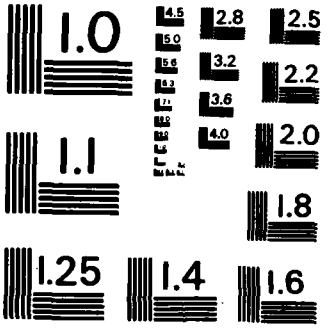

INSTALLATION RESTORATION PROGRAM PHASE II -- CONFIRMATION/QUANTIFICATION

STAGE 2

FINAL REPORT

FOR

LANGLEY AIR FORCE BASE
LANGLEY AIR FORCE BASE, VIRGINIA 23665

TACTICAL AIR COMMAND
LANGLEY AIR FORCE BASE, VIRGINIA 23665

PREPARED FOR

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (OEHL)
BROOKS AIR FORCE BASE, TEXAS 78235

JULY 1985

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

This report describes a study of groundwater conditions at Installation Restoration Program (IRP) Site 4, Langley Air Force Base (AFB), Virginia. Site 4 is a former underground fuel storage area previously identified as a possible source of fuel contaminated soil and shallow groundwater in the immediate area. Two other possible sources of fuel were identified during the present study. One is the underground distribution system associated with the former fuel storage area. The other is an underground pipeline in current use. All three remain under consideration as possible sources of leaking fuel.

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18.

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oil and grease
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benzene
toluene
ethyl benzene
xylenes

19. (Continued)

Groundwater samples collected from eight of the nine wells installed during the study contained detectable concentrations of volatile organic aromatics, principally benzene. Two of the wells contained thick (approximately 0.9 and 1.5 feet) layers of free-floating fuel products, and several other wells contained thin (approximately 0.1 foot) layers of fuel.

The horizontal groundwater flow rate was estimated at approximately 18 feet per year. At this rate, contaminated groundwater would take several decades to reach the closest surface water body (Southwest Branch of the Back River); however, fuel odors from storm sewers adjacent to Site 4 indicate fuel and/or contaminated groundwater may be seeping into the stormwater drainage system. This could route fuel contaminants to surface waters faster than by groundwater flow alone.

Recommendations for additional study at Site 4 include efforts to better define the extent of free-floating fuel product and contaminated groundwater, quantification of fuel-related contamination in stormwater drainage from the site, and testing to determine the source of fuels-related contamination at the site.

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 2

FINAL REPORT
FOR
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LANGLEY AIR FORCE BASE, VIRGINIA

TACTICAL AIR COMMAND
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JULY 30, 1985

PREPARED BY

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CONTRACT NO. F33615-81-D-4007

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TECHNICAL SERVICES DIVISION (TS)

PREPARED FOR

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY
BROOKS AIR FORCE BASE, TEXAS 78235

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PREFACE

This report has been prepared for the United States Air Force by Water and Air Research, Inc. (WAR) under Contract No. F33615-81-D-4007. It constitutes the report of the Phase II, Stage 2 Installation Restoration Program investigation for Langley Air Force Base, Virginia.

WAR's project staff consisted of:

W.D. Adams--Project Manager, Hydrogeologist;

J.H. Sullivan--Environmental Engineer; and

C.R. Fellows--Chemist.

The following U.S. Air Force (USAF) personnel contributed to the successful completion of the project:

Lt. Col. Edward S. Barnes--USAF Occupational and Environmental Health Laboratory (OEHL)/TSS

Mr. Gil Burnet--HQ TAC, Environmental Planning

Mr. Tom Wittkamp--Langley AFB, Environmental Planning

1Lt. Art Kaminski--Langley AFB, Bioenvironmental Engineering Services (BES)

MSGT Ray Monk--Langley AFB, BES

SrA Mark Conley--Langley AFB, BES

SSGT Hyde--1 SPS/SPOLT, Traffic Enforcement.

Fieldwork for the study was performed during June and July 1984. Lt. Col. Edward S. Barnes, Technical Services Division, USAF OEHL was the technical monitor.

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SUMMARY

SUMMARY

This report describes a study of groundwater conditions at Installation Restoration Program (IRP) Site 4, Langley Air Force Base (AFB), Virginia. Site 4 is a former underground fuel storage area previously identified as a possible source of fuel contaminated soil and shallow groundwater in the immediate area. Two other possible sources of fuel were identified during the present study. One is the underground distribution system associated with the former fuel storage area. The other is an underground pipeline in current use. All three remain under consideration as possible sources of leaking fuel.

Groundwater samples collected from eight of the nine wells installed during the study contained detectable concentrations of volatile organic aromatics, principally benzene. Two of the wells contained thick (approximately 0.9 and 1.5 feet) layers of free-floating fuel products, and several other wells contained thin (approximately 0.1 foot) layers of fuel.

The horizontal groundwater flow rate was estimated at approximately 18 feet per year. At this rate, contaminated groundwater would take several decades to reach the closest surface water body (Southwest Branch of the Back River); however, fuel odors from storm sewers adjacent to Site 4 indicate fuel and/or contaminated groundwater may be seeping into the stormwater drainage system. This could route fuel contaminants to surface waters faster than by groundwater flow alone.

Recommendations for additional study at Site 4 include efforts to better define the extent of free-floating fuel product and contaminated groundwater, quantification of fuel-related contamination in stormwater drainage from the site, and testing to determine the source of fuels-related contamination at the site.

1.0 INTRODUCTION

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1.1 INSTALLATION RESTORATION PROGRAM BACKGROUND

The U.S. Air Force (USAF), due to its primary mission, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. Federal, state, and local governments have developed strict regulations to require that disposers of waste identify the locations and contents of disposal sites and take action to eliminate potential hazards in an environmentally responsible manner. The primary federal legislation governing disposal of hazardous waste is the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. Under Section 6003 of RCRA, federal agencies are directed to assist EPA, and under Section 3012 disposal sites must be inventoried and the information be made available to requesting agencies. To assure compliance with hazardous waste regulations, DOD developed the Installation Restoration Program (IRP). The current DOD IRP policy is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated 11 December 1981 and implemented by USAF message dated 21 January 1982. The IRP is the basis for response actions on USAF installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as clarified by Executive Order 12316.

The IRP is implemented in four phases. Phase I, Initial Assessment/ Records Search, is designed to identify possible hazardous waste contaminated sites and potential problems that may result in contaminant migration from the installation. The Phase I report, completed for Langley AFB in June 1981 (CH2M Hill, 1981), reviews the history of base operations and waste disposal practices, the geological and hydrogeological conditions which may affect contaminant migration and the ecological setting. All hazardous waste disposal sites identified in the Phase I report are ranked on the basis of a standard evaluation system [Hazardous Assessment Rating Methodology (HARM)], which is applied to all installation record searches. The HARM model considers four aspects of the hazard posed by a specific site: the possible receptors of the

contamination, the waste and its characteristics, potential pathways for waste contaminant migration, and any efforts to contain the contaminants. Each of these categories contains a number of rating factors that are used in the overall hazard rating.

Phase II, Confirmation and Quantification, is designed to confirm or deny the presence of contaminants at waste disposal sites, and, if possible, to estimate the magnitude, extent, and direction of movement of contaminants discovered. The Phase II, Stage 1 study for Langley AFB was completed in 1982 (WAR, 1982). Phase III, Technology Base Development, is an optional phase in which appropriate technology is selected and the engineering design of corrective action options selected for implementation by the USAF is completed. Phase IV, Operations/ Remedial Action, involves construction, operation, and maintenance of the corrective action option designed under Phase III.

The Phase II, Stage 1 study for Langley AFB (WAR, 1982) was an investigation of 12 sites (4 landfills, 1 chemical leaching pit, 1 septic tank, 1 pesticide storage area, 1 transformer storage area, and 4 areas of suspected fuel contamination). The present study (Phase II, Stage 2) is an investigation of one site--a former fuel storage area.

1.2 SITE DESCRIPTION

Site 4 is a former fuel storage area (CH2M Hill, 1981) located in the southeast quadrant of Langley AFB (Figure 1). Drainage from the area is directed by storm sewer toward the Southwest Branch of the Back River which is approximately 1/4 to 1/2 mile south to southeast of Site 4. Design drawings reveal that the fuel storage area consists of twenty-four 25,000-gallon, underground, jet fuel storage tanks with associated piping and delivery pipelines; it was originally designated Storage Area B [U.S. Army Corps of Engineers (COE), 1952]. The tanks are located north of Nealy Avenue, and west of Building 764 (Figure 2), in two groups of 12. At the time of installation, three fuel pipelines ran from the area between the groups of tanks toward the flight line, and extensive control

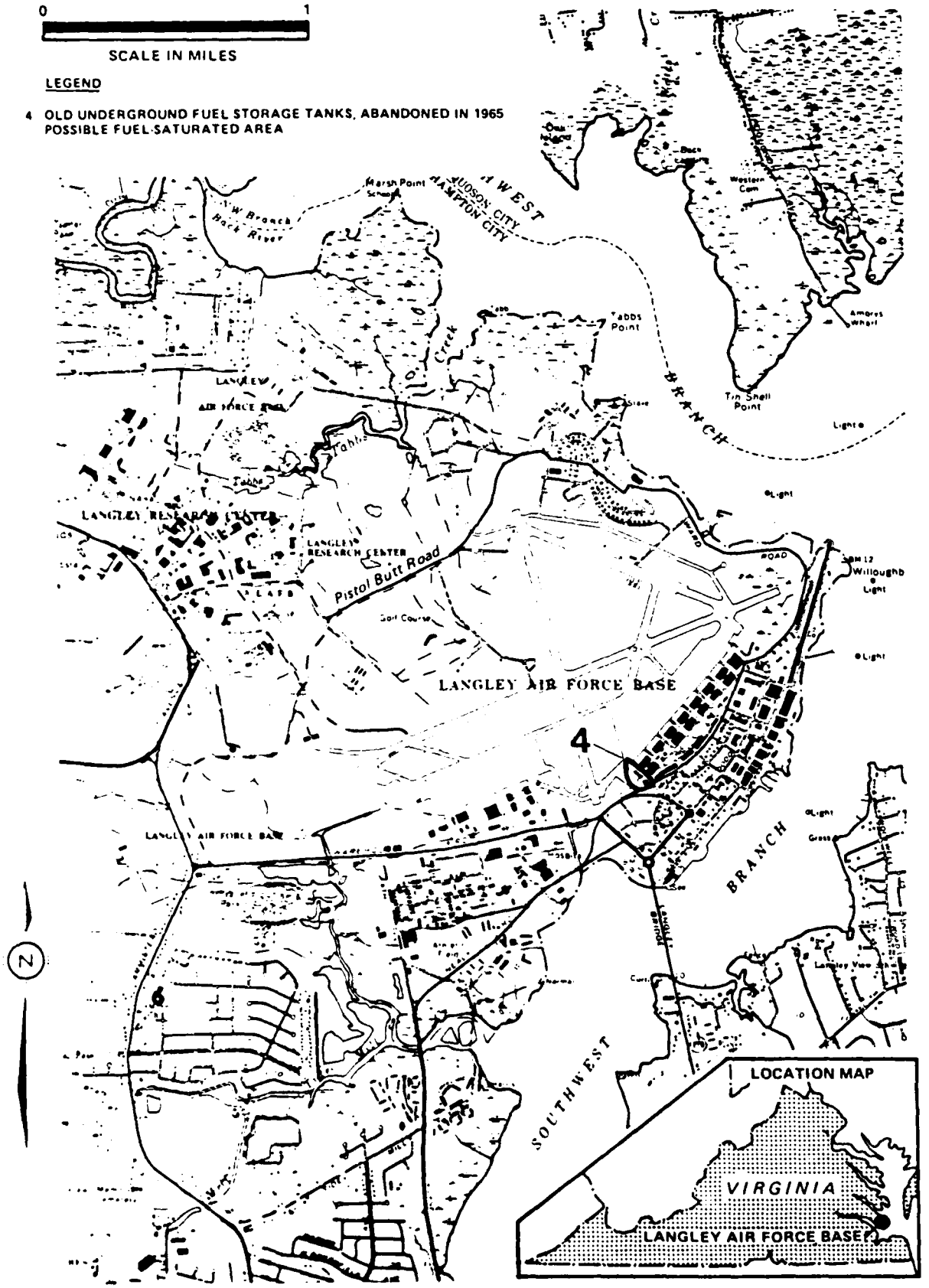

FIGURE 1. Location of Former Fuel Storage Area, Site 4, Langley AFB, Virginia

SOURCE: CH2M Hill, 1981; COE, 1952.

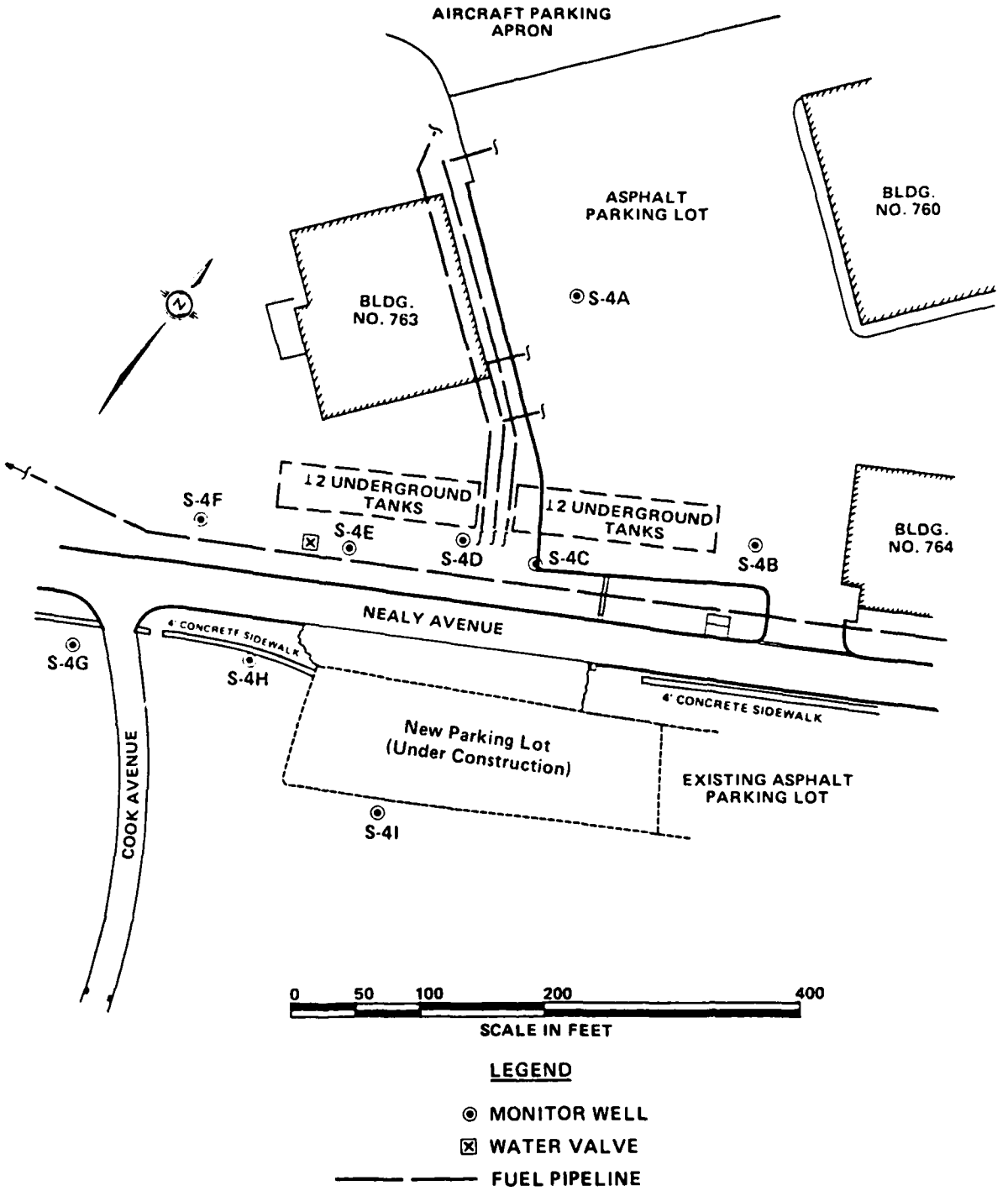

FIGURE 2. Location of Monitor Wells and Approximate Locations of Underground Fuel Storage Tanks and Fuel Pipelines, Site 4, Langley AFB, Virginia. (Source of Detail: COE, 1952; 1983.)

BASE MAP: S.J.Glass and Associates, September 1984.

piping was placed on the Nealy Avenue side of the tanks (not shown on Figure 2) (COE, 1952). It is not clear from a recent drawing (COE, 1983) whether the old pipelines and control piping are still in place; however, one of the pipelines was discovered during recent construction north of the site. The magnetometer survey conducted in this study (Section 3.2.1) verified the presence of the control piping.

A currently used fuel pipeline (Figure 2), unrelated to the former fuel storage area, parallels Nealy Avenue in the vicinity of Site 4 (COE, 1983).

1.3 PREVIOUS STUDIES

The Phase I report described Site 4 as containing old underground fuel storage tanks which were abandoned, emptied, and filled with sand in 1965. However, during the present study, WAR learned that the contractor for the new building near the site (Figure 2) was tasked to fill the western 12 tanks with sand; this indicates that the tanks may not have been filled with sand in 1965. The Phase I report noted that oil was reported to seep from the ground following heavy rains and that hydrocarbon odors had been reported in the storm sewer adjacent to Site 4. The latter phenomenon was observed during the present field investigation.

Phase I recommendations for Site 4 were to take two 6-foot soil cores from each site and to analyze soil samples from each core for volatile hydrocarbons.

Phase I recommendations were implemented in the Phase II, Stage 1 study. No significant concentrations of fuel were found in any of the soil samples; however, as discussed in Section 3.1, it is now understood that the location of Site 4 was improperly identified in the Phase I study.

1.4 PROJECT STAFF

WAR's project staff consisted of the following people whose resumes are included in Appendix B:

W.D. Adams, M.S.--Project Manager, Hydrogeologist

J.H. Sullivan, Ph.D., P.E.--Environmental Engineer

C.R. Fellows, M.S.--Chemist

The following USAF personnel contributed to the successful completion of this study. WAR appreciates their contributions:

Lt. Col. Edward S. Barnes--USAF Occupational and Environmental Health Laboratory (OEHL)/TSS

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SrA Mark Conley--Langley AFB, BES

SSGT Hyde--1 SPS/SPOLT, Traffic Enforcement

2.0 ENVIRONMENTAL SETTING

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The following discussion has been adapted from the Phase I report (CH2M Hill, 1981). It has been edited to ensure consistence of format with the present report.

2.1 PHYSIOGRAPHY/TOPOGRAPHY/DRAINAGE

The coastal plain in eastern Virginia is characterized by a series of flat plains and intervening scarps. Langley Air Force Base is located on Hampton Flat (Figure 3) between the Northwest and the Southwest Branches of the Back River. Big Bethel Scarp, occurring just west of the base, forms the western boundary of Hampton Flat. This scarp rises above Hampton Flat to Todds Flat which is approximately 25 feet above mean sea level (msl). Big Bethel Scarp is clearly visible on the topographic map illustrated on Figure 4.

The topography of the base is very flat, showing little or no relief. Most of Langley AFB occurs between elevations of 5 to 8 feet above msl. At Site 4, land surface elevations are between 5 and 10 feet msl. The land surface slopes gently away from the site toward the Southwest Branch of the Back River (Figure 1).

Runoff from Site 4 is directed by storm sewer to the Southwest Branch of the Back River which is approximately 1/4 to 1/2 mile south to southeast of Site 4 (Figure 1).

2.2 GEOLOGY

Surficial deposits occurring at Langley AFB consist of alluvial sediments, primarily sandy, silty clay or silty, clayey sand. The alluvium or river-deposited sediments had an upland origin but were transported by the James, York, and Back Rivers and deposited within their floodplains during a higher stand of sea level. Locally on the base there are deposits of organic rich soil having an estuarine or lagoonal depositional environment. Figure 5 illustrates surface and near-surface deposits in the Langley area. Tables 1 and 2 describe the geologic units

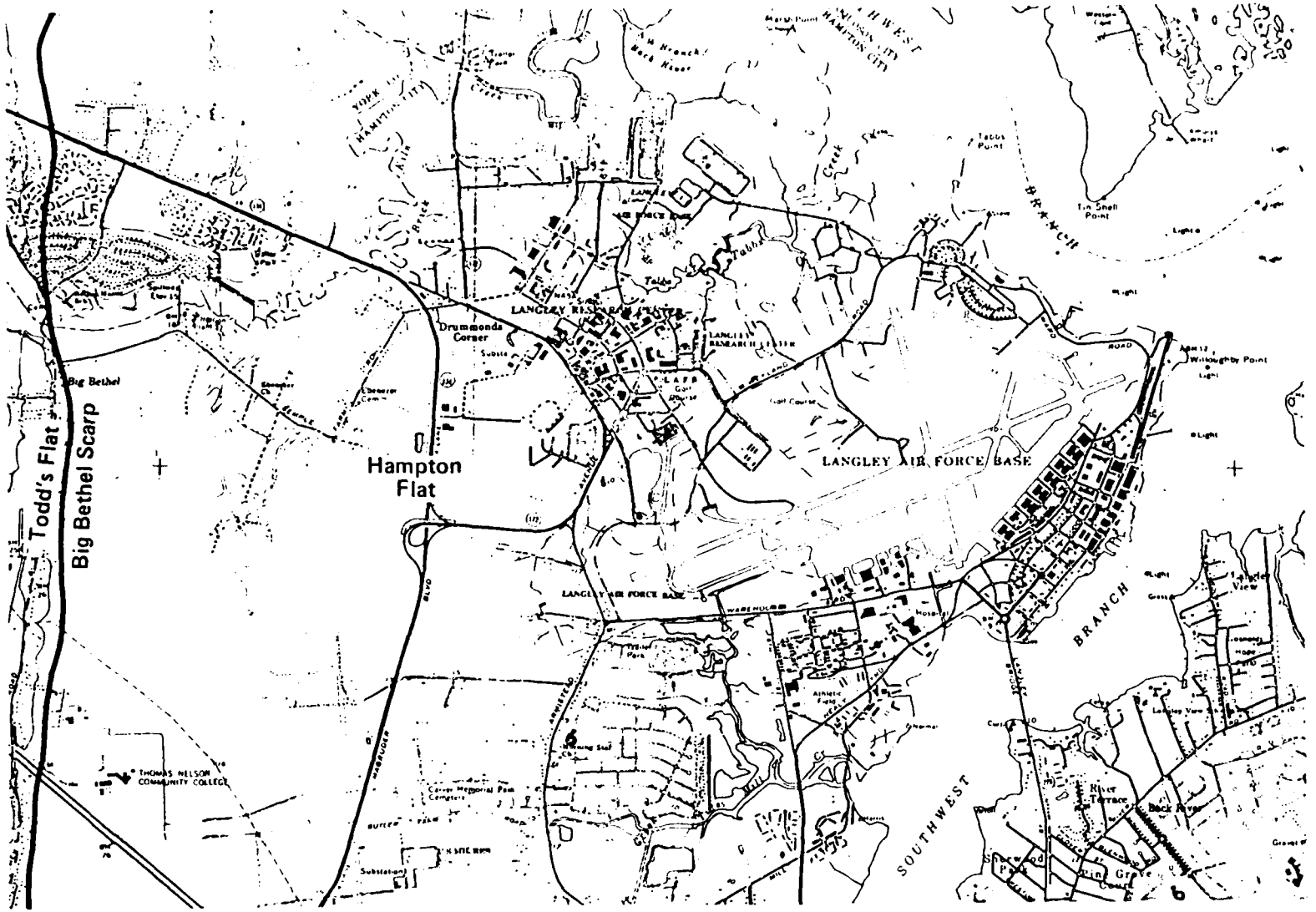


FIGURE 3. Physiographic Map of Langley AFB, Virginia

SOURCE: Johnson, 1976.

BASE MAP: USGS, 1965, Newport News North 7½ min. Quadrangle; USGS, 1965, Hampton 7½ min. Quadrangle.

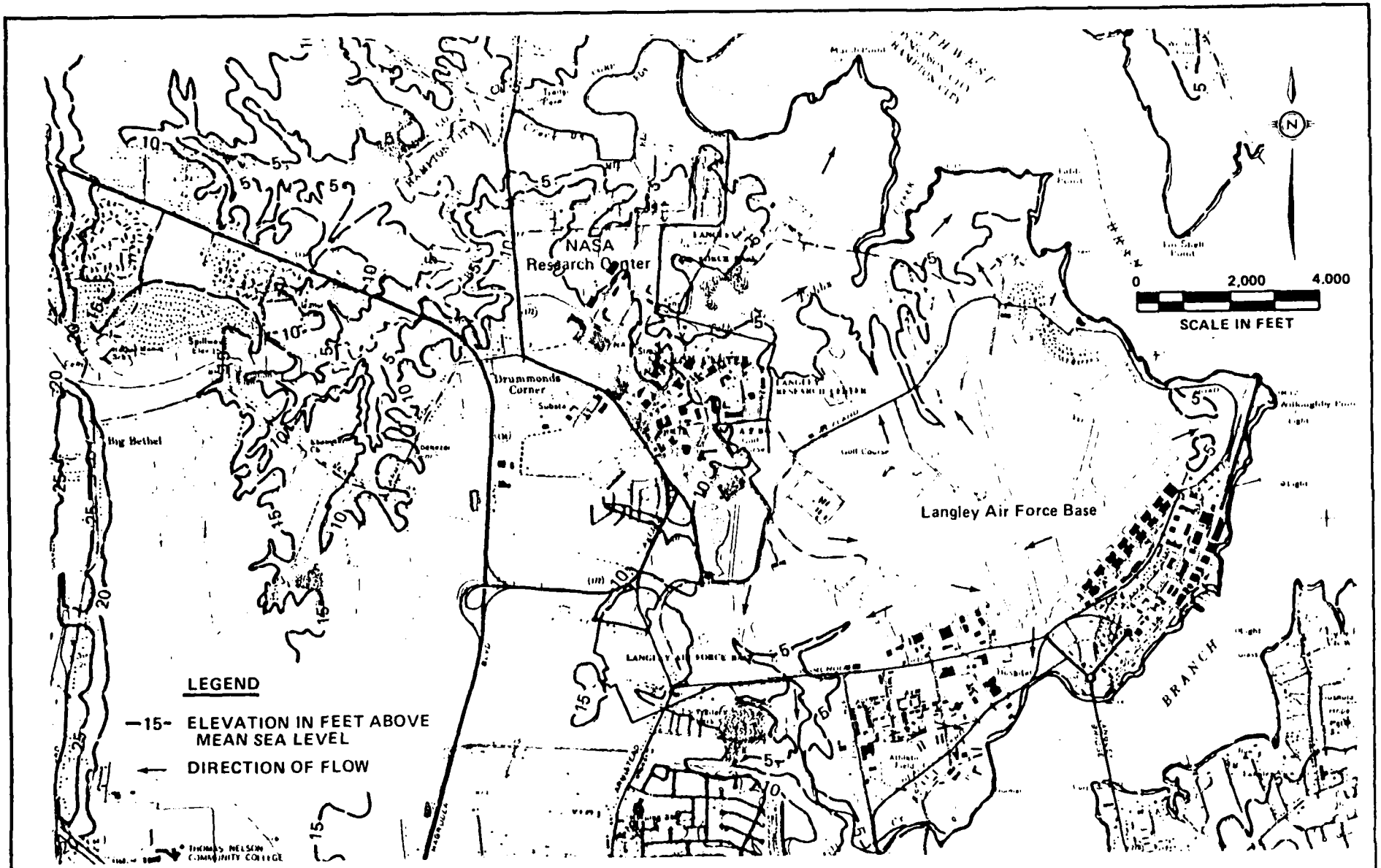


FIGURE 4. Topographic and Drainage Map of Langley AFB, Virginia

SOURCE: CH2M Hill, 1981

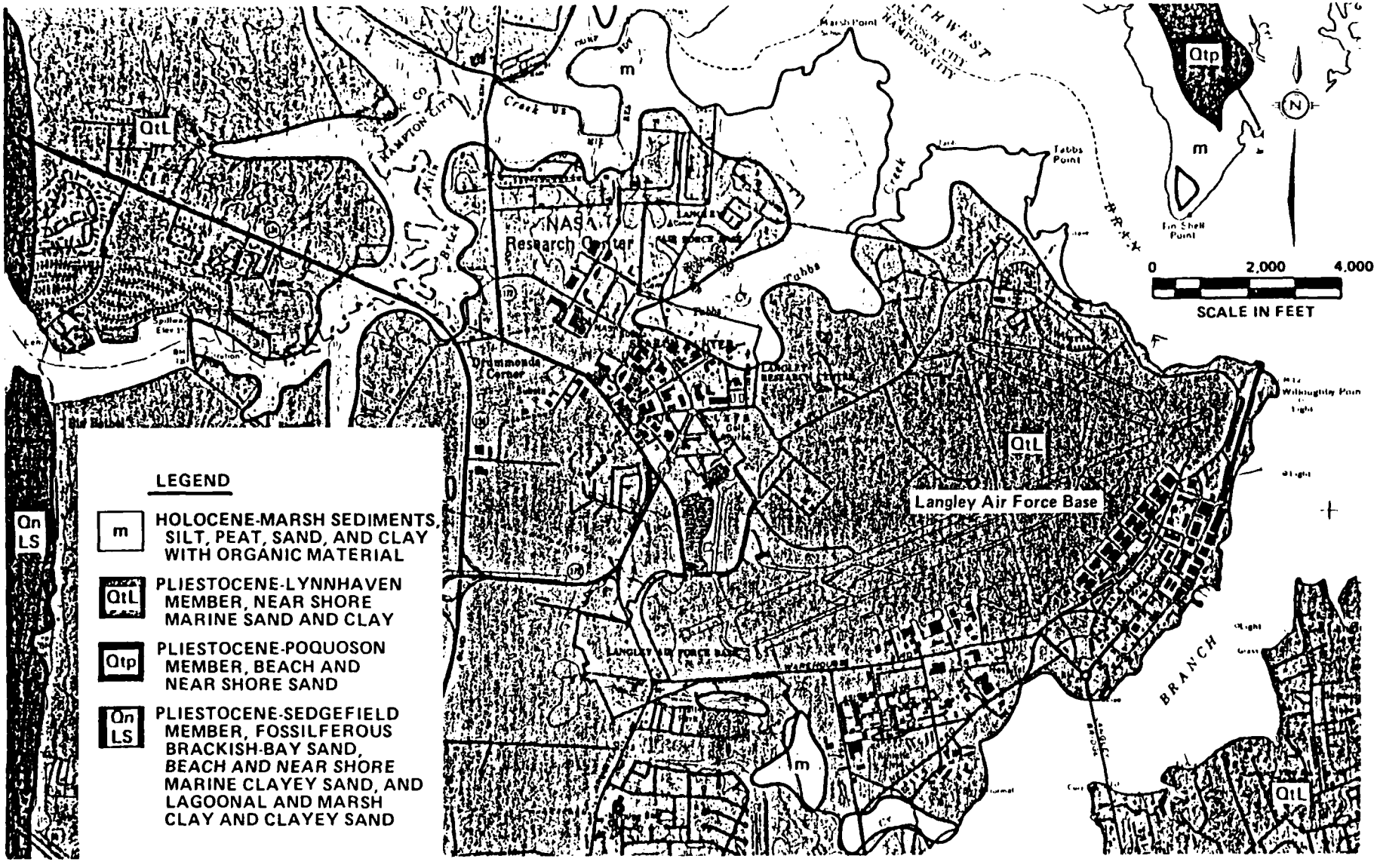


FIGURE 5. Geologic Map of Langley AFB, Virginia Area (After Johnson)

SOURCE: CH2M Hill, 1981.

Table 1. Geologic Units and Their Water-Bearing Characteristics (Page 1 of 2)

System	Series	Age	Formation	Approximate Thickness (feet)	Lithologic Character	Hydrologic Comments
Quaternary			See Table 2	20-100	Mostly sands and gravels of fluvial and terrace deposits.	Supplies groundwater to low yield water-table wells throughout the area.
Tertiary	Pliocene		Yorktown	0-125	Fossiliferous sands, marls, and coquinas.	Supplies groundwater to water-table wells in parts of the area.
	Miocene	Late Miocene Middle Miocene	St. Marys	0-150	Dark-colored sands, silts, and clays; often referred to as "blue sand" and "blue clay."	Acts as a confining bed for the upper artesian aquifer system.
	Miocene	Late Miocene Middle Miocene	Calvert	0-60	Fossiliferous silts and sands, occasionally glauconitic.	Upper artesian aquifer; yields sufficient water for domestic subdivision and light agricultural and industrial purposes.
	Eocene	Jackson	Chickahominy	0-30	Fine- to medium-grained sands, poorly to moderately sorted, occasionally glauconitic.	Upper artesian aquifer; yields sufficient water for domestic, subdivision, and light agricultural and industrial purposes.
	Eocene	Claiborne	Nanjemoy (Claiborne Age)	0-80	Fine- to medium-grained sands, poorly to moderately sorted, occasionally glauconitic.	Upper artesian aquifer; yields sufficient water for domestic, subdivision, and light agricultural and industrial purposes.

Table 1. Geologic Units and Their Water-Bearing Characteristics (Page 2 of 2)

System	Series	Age	Formation	Approximate Thickness (feet)	Lithologic Character	Hydrologic Comments
Tertiary	Paleocene	Midway	Nanjemoy (Wilcox Age) Aquia Mattaponi	0-100	Highly glauconitic sands, silts and clays; often referred to as "greensand" or "black sand."	Generally confining layer for principal aquifer system; basal sand is part of principal aquifer system.
Cretaceous	Lower Cretaceous	F G H	Mattaponi (lower) Potomac Group	0-1500	Interbedded sands, silts, and clays of fluvial and detaic origin; some thin marginal marine beds; unit F dominantly silts and clays of interdelta region in extreme eastern part of the area.	Capable of high yields with proper development in most areas of York-James Peninsula; mostly undeveloped at present time.
Triassic					Predominantly soft red and brown shales; some thin beds of hard red shale and sandstone.	Supplies groundwater to a few low-yield water-table wells in Ashland area.
Pre-Triassic Crystalline Rock					Highly variable rock types.	Supplies moderate quantities of groundwater to deep wells near Fall Zone.

Source: CH2M Hill, 1981.

Table 2. Post-Miocene Geologic Formations in the Newport News North and Hampton Area (Page 1 of 2)

Age	Formation	Name	Character	Thickness in feet (m)
Holocene		Alluvium	Fluvial and fluvial-estuarine sand, silt, and clay, locally organic-rich and gravelly.	0-125 (0-38)
		Marsh sediment	Organic-rich clay, silt, and sand; peat.	0-12 (0-4)
		Sand	Beach and dune sand.	0-10 (0-4)
Pleistocene	Tabb Formation	Poquoson Member	Beach and nearshore marine and fluvial estuarine fine to medium sand and sandy clay; basal gravelly sand.	0-9 (0-3)
	Tabb Formation	Lynnhaven Member	Nearshore marine clayey sand, sandy clay, and gravel, beach sand, and cobbly gravel.	0-9 (0-3)
	Tabb Formation	Sedgefield Member	Brackish-bay sand and nearshore marine clayey sand; lagoonal marsh clay and clayey sand; basal fossiliferous gravelly and clayey sand.	0-11 (0-3)
	Sand Bridge Formation Upper Member	Silty-sand facies	Fluvial and lagoonal silty sand.	0-8 (0-2)

Table 2. Post-Miocene Geologic Formations in the Newport News North and Hampton Area (Page 2 of 2)

Age	Formation	Name	Character	Thickness in feet (m)
Pleistocene	Sand Bridge Formation Upper Member	Clayey-sand facies	Fluvial-estuarine and nearshore marine clayey sand; silt.	0-25 (0-8)
	Sand Bridge Formation Upper Member	Silty-clay facies	Marsh and tidal-flat silty clay; tidal channel clayey sand.	0-7 (0-2)
	Norfolk Formation Upper Member	Silty-sand facies	Brackish marine clayey medium sand, fine sandy silt, and clayey silt.	0-15 (0-5)
	Norfolk Formation Upper Member	Sand facies	Beach and nearshore marine fine to coarse sand; clayey silt.	0-35 (0-11)
	Norfolk Formation Upper Member	Clayey-sand facies	Fluvial and estuarine fossiliferous clayey sand, organic-rich clay, silt, and peat.	0-85 (0-26)
	Windsor Formation		Marine and lagoonal fine to coarse sand, silty and clayey sand, and silt.	0-15 (0-5)
Pliocene	Yorktown Formation		Marine sand, silt, and coquina.	0-125 (0-38)

Source: CH2M Hill, 1981.

of Tidewater, Virginia. Table 2 describes the many post-Miocene geologic units which are related to glacio-eustatic changes in sea level.

The stratigraphic sequence at Langley AFB consists of sediments ranging in age from early Cretaceous (approximately 135 million years ago) to Holocene (recent).

The pre-Cretaceous (older than 135 million years) basement rock complex consists of consolidated sedimentary rocks and various crystalline rocks, including granite and diorite. The basement rock at Langley AFB is approximately 2,200 feet below land surface (bls).

The Cretaceous deposits at Langley AFB consist of discontinuous sand layers interbedded with silts and clays. These deposits occur as two units, the lower Cretaceous, Potomac group, and the upper Cretaceous Mattaponi Formation and extend from approximately 700 to 2,200 feet bls. Both formations were deposited as channel deposits from a meandering stream or further to the east as estuarine deposits. The Cretaceous formations form the principal aquifer in the coastal plain of Virginia.

Paleocene sediments overlie the Cretaceous materials in the vicinity of Langley AFB and consist of fine- to medium-grained sands interbedded with silty clays. Three formations, the Nanjemoy, Aquia, and Mattaponi (glauconitic member) occur as the Paleocene unit. Farther to the west, some of the sands are composed largely of dark green to black glauconitic sands. Paleocene strata form the aquitard or confining bed above the lower Cretacous aquifer.

The Eocene strata are divided into the Nanjemoy and Chickahominy formations. Farther to the east but in the vicinity of Langley, the Eocene units are thin or absent.

Miocene deposits in the study area are divided into two formations: the Calvert and St. Marys. Miocene deposits extend from approximately

40 feet bls to 600 to 700 feet bls in the Langley area. The top part of the Miocene consists of shells and shell fragments cemented with calcite. This unit grades downward to a fine-grained quartz sand with a gradual decrease in shell. Traces of biotite and glauconite occur in the sand. Miocene sediments, having been deposited in a shallow marine environment, are fairly consistent and have a wide areal extent.

Post-Miocene deposits in the Langley area consist of marine, brackish, beach, fluvial, and marsh deposits. Table 2 lists the post-Miocene formations and their characteristics in the Langley area.

The Pliocene Yorktown Formation consists of marine sand, silt, and coquina.

The Pleistocence strata consist of the Norfork, Sand Bridge, and Tabb Formations, which range from estuarine clay and silt deposits to beach deposits consisting of sand and gravel.

Holocene materials consist of sand, marsh sediments, and alluvium.

Figures 6 and 7 illustrate east-west and north-south geologic cross sections in the Langley area.

The uppermost stratigraphic unit at Site 4 is the Lynnhaven Member of the Tabb Formation (Johnson, 1976). This member consists primarily of clayey sand or sandy clay deposited in a nearshore marine environment during late Pleistocene time. Sea level at this time was approximately 20 feet higher than at present. According to Johnson (1976), the Lynnhaven Member is 9 feet thick or less.

An unconformity separates the Lynnhaven Member of the Tabb Formation from the underlying silty-sand facies of the Yorktown Formation (Johnson, 1976). Typically, this formation consists of bluish-gray to greenish-gray, fossiliferous, fine sand and silt with localized shell beds and

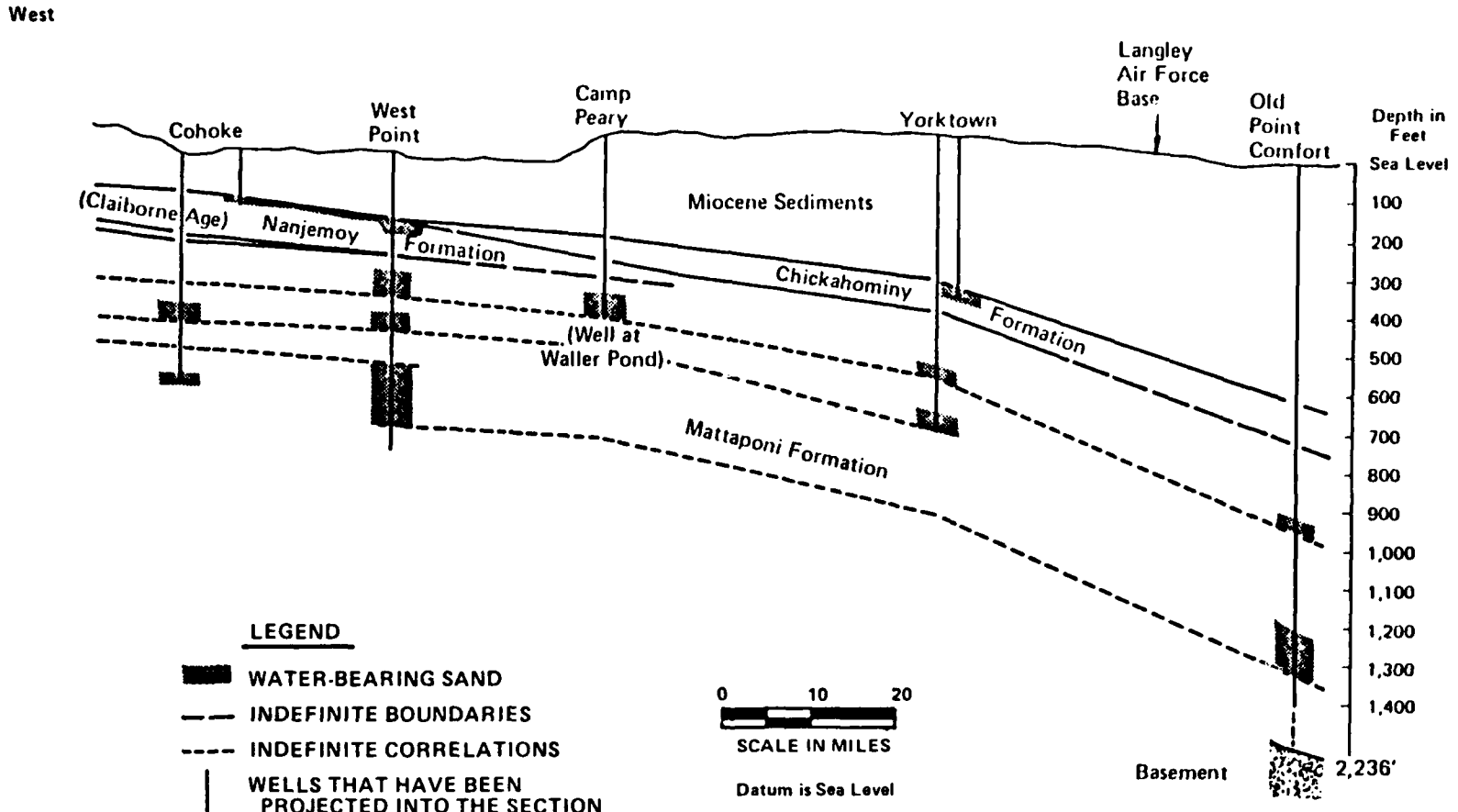


FIGURE 6. Geologic Cross-Section of Langley AFB, Virginia Area (East-West Trend) (After Johnson)

SOURCE: CH2M Hill, 1981.

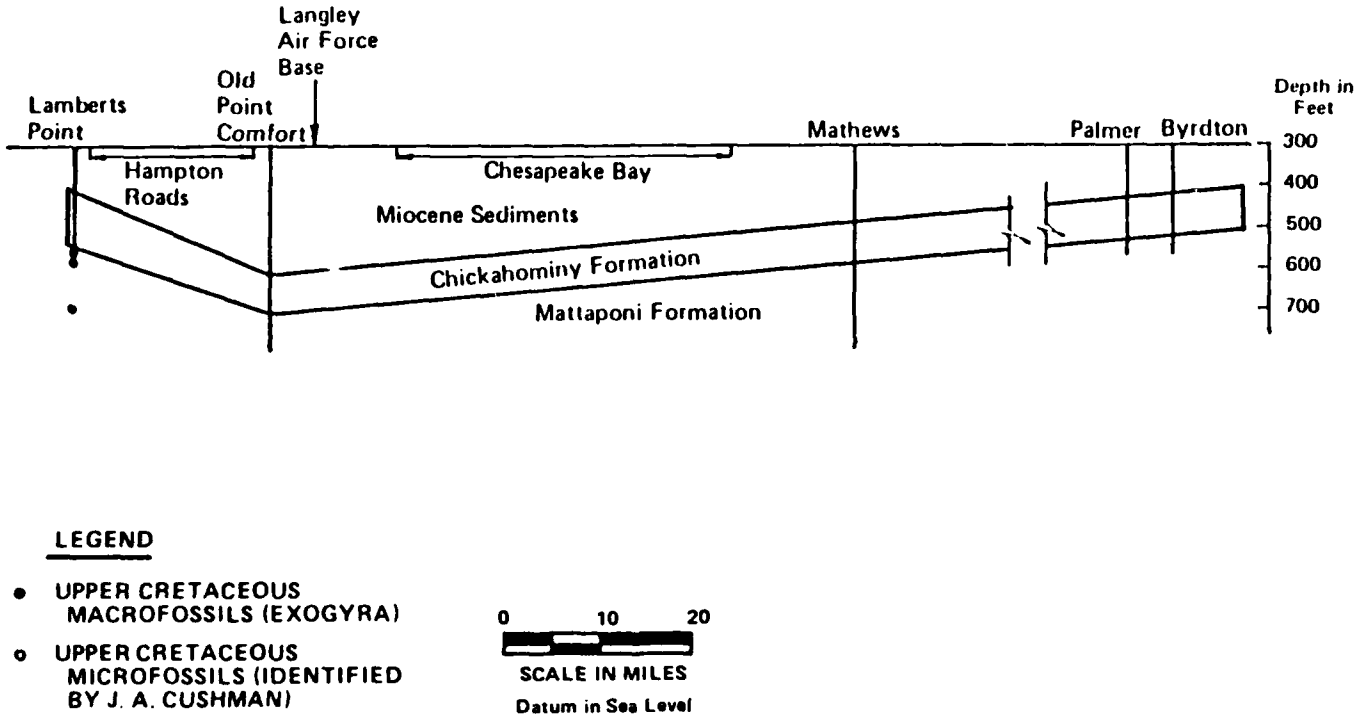


FIGURE 7. Geologic Cross-Section of Langley AFB, Virginia Area (North-South Trend) (After Cedarstrom)

SOURCE: CH2M Hill, 1981

clayey silt lenses. The Yorktown Formation was deposited during Pliocene time. According to Johnson (1976), the Yorktown Formation is 125 feet thick or less.

Lithologic logs for wells installed at Site 4 (Appendix E) indicate that the upper 10 feet of sediments at the site are predominantly silty sand, clayey sand, and sandy clay which were deposited in a nearshore marine environment.

2.3 GROUNDWATER

The water supply for Langley AFB is obtained from surface water sources, primarily Big Bethel Reservoir approximately 2 miles west of the base.

Groundwater occurs in three aquifer systems at Langley AFB: the shallow water-table aquifer, the upper artesian aquifer system, and the principal artesian aquifer system. None of these aquifers is used to provide drinking water at Langley AFB since all three aquifers beneath the base produce water with high chloride concentrations.

The water-table aquifer is an important source of domestic water supply farther to the west in King Williams, Charles City, New Kent, James City, and York Counties. In parts of Newport News and Hampton, there are areas where domestic groundwater is supplied by shallow wells ranging in depth from 50 to 100 feet. These wells are probably completed in the water-table aquifer which occurs from approximatley 5 feet bls to a depth of approximately 100 feet bls. The water-table aquifer occurs within the fine sands, silts, and shell beds of Pleistocene and Pliocene age and surficial sands of recent or Holocene age. This aquifer produces rather small quantities of water in most places. Some homes and small farms west of Langley AFB have reported yields from shallow wells of 5 to 15 gpm. These deposits, having marine origin, are lenticular in cross section and occasionally a well is reported to yield as much as 40 gpm. Such wells are probably completed within a locally thick section of shell. Permeability within the water-table aquifer probably ranges from 1×10^{-3} to 1×10^{-5} cm/sec.

Water quality from shallow wells varies according to proximity to salt water bodies. Some wells have been reported to yield fresh water initially but quickly turn salty. This is due to the fact that fresh water floats on top of the denser salt water. However, tidal action keeps the interface in a constant state of change. The thickness of fresh water overlying the salt water is very small, and thus pumpage quickly removes the fresh water from the water table in the vicinity of the pumped well. Recharge to the water-table aquifer is direct from rainfall.

The upper artesian aquifer system consists of glauconitic quartz sands and marls of Eocene Age, and shell, sand, silt, and clay beds of Miocene Age. This aquifer is of little importance in the Langley area since yields are very low and water quality is poor. Wells completed in the upper artesian aquifer in the vicinity of Langley can be expected to be of poor quality and contain as much as 950 parts per million (ppm) chlorides, with hardness of approximately 230 ppm.

The principal artesian aquifer consists of coarse sand, gravel, and boulders of Cretaceous Age. West of Langley AFB the aquifer has the potential to yield large quantities of water. Recharge to this aquifer occurs many miles west, approximately at the fall line. Water quality in the principal artesian aquifer in the Williamsburg area is of good enough quality to permit development of large amounts of potable water.

Test wells have been drilled in the vicinity of Langley, and logs from these wells indicate that yields should be high at depths below 600 feet. Although yields would be high from this aquifer in the Langley area, water quality is very poor. Chlorides could be expected to be in the range of 4,000 to 5,000 ppm. There is the possibility that locally within some Cretaceous strata water may be of better quality. One well in Newport News completed in this aquifer was reported to have chlorides of 600 ppm. This is still unfit for most uses, but significantly better than expected from this area.

Figure 8 illustrates the 1972 potentiometric surface of the principal artesian aquifer. Groundwater withdrawals in the Williamsburg area have caused a cone of depression to form around Williamsburg (not shown on map) such that groundwater flow from all directions is toward Williamsburg.

2.4 GEOLOGICAL ASPECTS OF POTENTIAL MIGRATION

Surface and near-surface strata at Langley AFB are of moderate to low hydraulic conductivity (permeability) due to the occurrence of clay and silt with the sand. Past disposal practices could result in the movement of some leachate radially away from the disposal sites; however, travel time would be extremely slow due to the low permeability and the low hydraulic gradient. The shallow water-table aquifer would be the only water-bearing formation affected by this contamination since the upper artesian and principal artesian aquifer systems are hydraulically separated from the water-table aquifer by clay confining beds. Therefore, contamination from past disposal sites would probably be limited to the immediate vicinity of the disposal site.

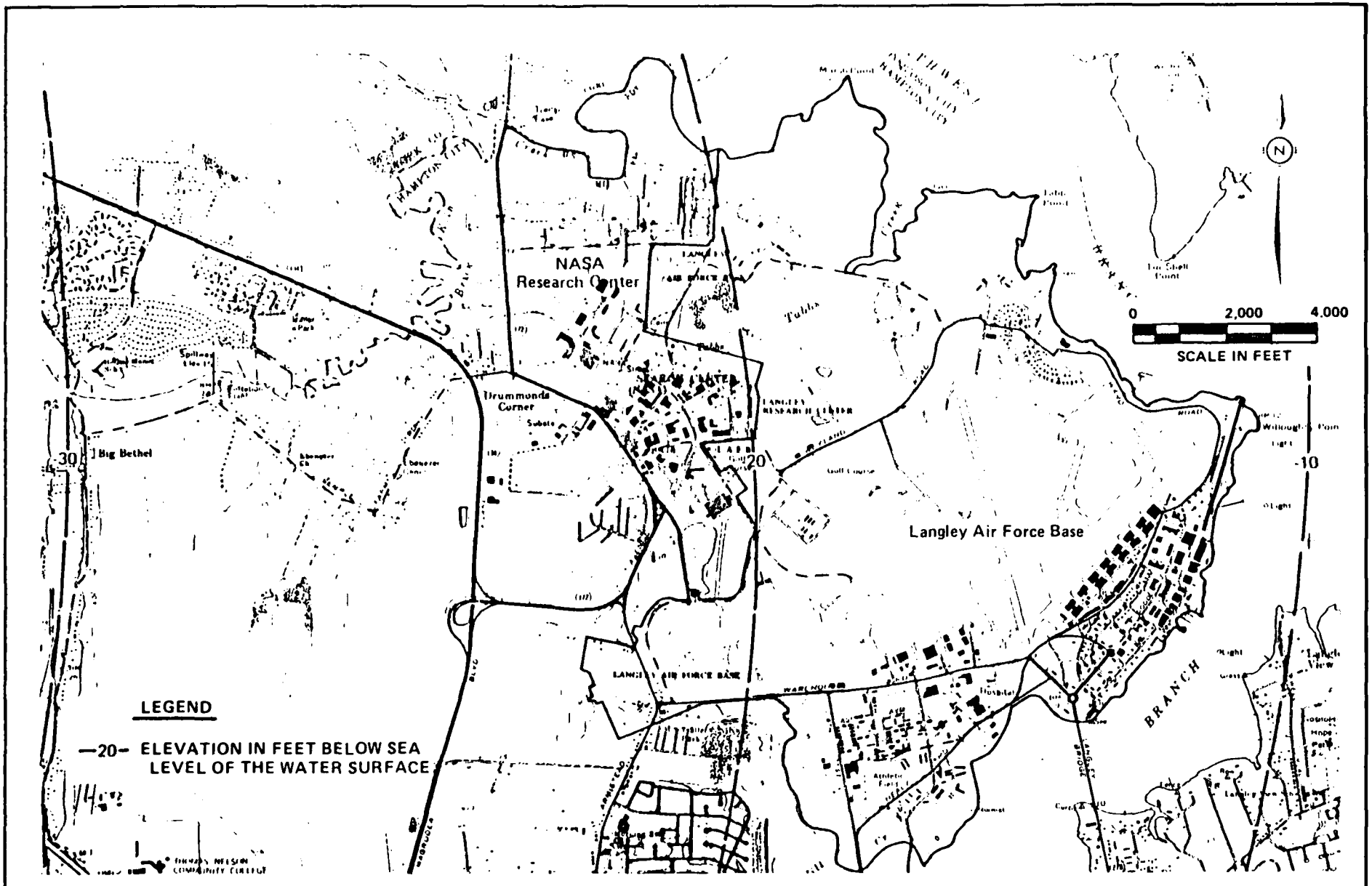


FIGURE 8. Potentiometric Surface of the Principal Aquifer System of Langley AFB, Virginia Area, December 1972 (After Virginia Water Control Board)

SOURCE: CH2M Hill, 1981.

3.0 FIELD PROGRAM

3.0 FIELD PROGRAM

3.1 DEVELOPMENT OF THE SCOPE OF WORK

Following the Phase II, Stage 1 effort, it became apparent that the Phase I evaluation had imprecisely defined the location of Site 4. The Phase I study reported the Site 4 area to be larger than it is and also improperly positioned Site 4 to the north and east of the subsequently confirmed location of the underground tanks (Figure 1). Consequently, the Phase II, Stage 1 soil borings missed Site 4.

According to design drawings, the construction contractor for Building 763, north of Site 4 (Figure 2), was initially tasked to remove the western group of tanks (COE, 1983). At some point, this task was modified, and the construction contractor was tasked to stabilize the western group of tanks by filling them with sand. However, according to BES personnel, the construction contractor encountered fuel in the soil upon excavating the tanks, and potentially explosive vapors prevented him from filling the tanks with sand. The construction contractor also encountered an old fuel line between the two groups of tanks (Figure 2). The Chief BES, based upon his belief that jet fuel had been stored at Site 4, reported that the fuel line contained JP-4 and that JP-4 was also encountered at the water valve shown in Figure 2 (Pontier, 1984).

Upon consideration of the foregoing information, personnel from OEHL, Langley AFB, and WAR developed the Stage 2 scope of work (Appendix C) which was designed to better define the nature and extent of contamination at Site 4. The field program incorporated four elements:

1. A magnetometer sweep of each well location to detect subsurface utilities.
2. Installation and development of nine wells (one upgradient).
3. Measurement and mapping of water levels. Measurement of floating fuel thickness, if present, in wells.
4. Sampling and analysis of groundwater from the wells for pH, specific conductance, oil and grease, dissolved lead, and volatile organic aromatics (VOA).

3.2 IMPLEMENTATION OF THE FIELD PROGRAM

WAR mobilized to the job site on June 24, 1984 and began selecting monitor well locations. Since previous experience at Langley AFB during Phase II, Stage 1 verified the general rule that the water-table gradient follows the land surface gradient, WAR assumed that hydraulically downgradient would be toward the nearest surface water body.

The principal investigator arrived following a heavy rain and did not observe oil seeping from the ground as was reported in the Phase I study, nor was this observed following several other heavy rainfalls during the Stage 2 field study. However, fuel odors were noted in storm sewers adjacent to and downgradient of Site 4.

All fieldwork was performed in compliance with the safety plan (Appendix D).

3.2.1 Magnetometer Survey

WAR retained a subcontractor, Law Engineering Testing Company (LETCO), for the magnetometer survey and for monitor well installation; these services were performed under the supervision of the WAR principal investigator.

The magnetometer survey proved effective in locating subsurface utilities within a depth of approximately 5 to 6 feet. The presence of control piping [not shown on the design drawing (COE, 1983) used in developing the scope of work] south of the eastern group of tanks required that well S-4C (Figure 2) be placed adjacent to, instead of in, the parking lot; this still placed well S-4C immediately downgradient of the underground tanks as required by the scope of work (Appendix C).

During the magnetometer survey, portions of the parking lot were cleared of vehicles to avoid magnetic interferences.

3.2.2 Monitor Well Installation

WAR had originally planned to use the hollow-stem auger drilling method at Site 4 to avoid introducing drilling fluids which might alter the chemistry of the groundwater, but at the request of the Langley AFB Fire Prevention Office, the drilling method was changed to the hydraulic rotary method to minimize potential fire hazards. The only drilling fluid used was clean, potable water.

Monitor well installation took place in the following sequence:

1. Drilling (6-inch roller-cone bit) and soil sampling (ASTM D-1586-67) to a depth of approximately 10 feet below land surface (bls).
2. Installation of 10 feet of flush-joint, threaded, Schedule 40, polyvinyl chloride (PVC) well screen (0.010-inch slots). Wells in the parking lot (S-4A and S-4B) were finished below grade to minimize their impact on parking conditions, but enough solid, flush-joint, threaded Schedule 40 PVC casing was used on the other wells to give 1.3 to 1.4 feet of stick up.
3. Installation of a filter pack of fine-to-medium sand to approximately 1.8 feet bls.
4. Installation of bentonite pellets to approximately 1.5 feet bls.
5. Installation and grouting in place (sakrette) of either a lockable iron security casing (wells S-4C through S-4I) or an iron valve box (wells S-4A and S-4B).
6. Well development to ensure removal of drilling fluids and a hydraulic connection between the well and the water-table aquifer. Well development involved pumping water from the well at approximately 1 gallon per minute until the well produced clear water.
7. All drilling equipment was thoroughly rinsed with clean, potable water between wells to prevent cross contamination.

A portable combustible-gas detector (Gas Tech Model 1314) was used frequently during well installation. The highest reading was 2 percent

of the lower explosive limit measured in the casing of well S-4B during sample collection.

All drill cuttings, including fuel contaminated soils, were containerized in new steel drums (US DOT 17H) for disposal by Langley AFB.

Monitor well installation and development were completed by June 30, 1984. Well logs are included as Appendix E.

Survey of the wells was performed under subcontract by S.J. Glass and Associates. Well locations were determined by Virginia State Planar Coordinates, and top of casing elevations were referenced to mean sea level (see Well Logs, Appendix E).

3.2.3 Sample Collection

WAR sampled all wells at Site 4 on July 3, 1984. Collection of a groundwater sample followed these steps:

1. Measurement of the depth to the top of the fluid surface (noted visually) and the depth to water (noted with an electronic sensor), referenced to the top of the casing.
2. Determination of the volume of water contained in the well screen (the well volume).
3. Removal of at least three well volumes with a peristaltic pump. The suction hose was cleaned with nitric acid (0.1 N) and deionized water between wells.
4. Sample collection according to procedures described in Appendix F [Laboratory Methods and Quality Assurance/Quality Control (QA/QC) Plan]. A separate, precleaned PVC bailer was used to sample each well.

Well purging and sampling techniques described above (Steps 3 and 4) were selected to provide the best combination of sample collection effectiveness and cost effectiveness. A recently published study (Barcelona, 1984) which evaluated the performance of groundwater sampling mechanisms for purgeable and gas-sensitive parameters (e.g., VOA) found that bailers

(typical cost = $12.00 each) were the second best sampling mechanism. Positive displacement (bladder) submersible pumps received the highest rating, but these devices cost much more (approximately $600.00 to $1,000.00 per well). Suction (peristaltic) pumps were determined to be unsuitable for sampling VOAs, but were rated as suitable for purging wells at depths to approximately 20 feet.

After each well was purged by removal of at least three well volumes, samples were collected for laboratory analysis of oil and grease, dissolved lead, and VOAs (benzene, toluene, ethyl benzene, and xylenes). Each sample fraction was placed in a sample container appropriate to the specific analysis, as indicated on the field data sheets (Appendix G). Samples for VOA analysis were collected in two 40-ml glass vials to provide a sample for confirmation analysis if first column analysis exceeded 0.7 ug/l for benzene or 10 ug/l for other VOAs (OEHL, 1984). Each sample container was identified with a WAR sample number (16031 through 16041) which was also recorded on the field data sheet for the appropriate well. Field duplicate samples (oil and grease; VOAs) and a field triplicate sample (lead) were collected from well S-4A for QA/QC purposes (see discussion in Appendix F). Duplicate and triplicate samples are identified by separate WAR sample numbers (see field data sheet for well S-4A, page G-1). Temperature, specific conductance, and pH were measured in the field, and the data were recorded on the field data sheets.

All samples were delivered by the sampling team to the subcontractor for analytical services [The Bionetics Corporation (TBC)] on the day of collection. TBC shipped the VOA samples by Federal Express to a second laboratory [Lancaster Laboratories, Inc. (LLI)] for analysis. Five VOA containers were broken in shipment. Three were duplicates collected for second column confirmation purposes (wells S-4E, S-4F, and S-4H), and two containers were for well S-4G. None of the broken containers were the field duplicates collected from well S-4A for quality control purposes. The affected wells were resampled on July 16, 1984 according to guidance given by OEHL (Rodriguez, 1984) which was to replace only the five broken containers.

4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

4.1 VIRGINIA GROUNDWATER STANDARDS

The state of Virginia has established groundwater quality standards (Virginia Water Quality Standards, 1980) for a variety of chemical parameters. Standards applicable to this study include those for pH (standard of 6.5 to 9.0), petroleum hydrocarbons (1 milligram per liter [mg/l]), and lead (50 micrograms per liter [ug/l]). The petroleum hydrocarbons standard is applicable to both VOAs and oil and grease. These standards apply to all groundwater occurring at or below the uppermost seasonal limits of the water table.

In addition to numeric standards, Virginia's groundwater standards (Virginia Water Quality Standards, 1980) also contain an antidegradation policy for groundwater. This policy states:

> "If the concentration of any constituent in groundwater is less than the limit set forth by groundwater standards, the natural quality for the constituent shall be maintained; natural quality shall also be maintained for all constituents, including temperature, not set forth in groundwater standards. If the concentration of any constituent in groundwater exceeds the standard for that constituent, no addition of that constituent to the naturally occurring concentration shall be made."

4.2 RESULTS

Analytical results and fuel thickness measurements for this study are summarized in Table 3. The two columns of data for well S-4A are for field duplicate samples collected for quality control purposes. Comparison of data for the duplicate samples indicate good precision for all analyses except benzene. The poorer precision for benzene is probably attributable to this compound being three to ten times more volatile than the other VOAs (Mackison et al., 1978) which makes it more difficult to compare analytical results of duplicate samples. Duplicate sample results, lead spike recovery, confirmation column results, and other QA/QC issues are further discussed in Appendix F.

Table 3. Results of Analyses of Groundwater Samples Collected in the Vicinity of Site 4, Langley AFB, Virginia, July 1984

Parameter	Well Number/WAR Sample Number									
	S-4A* 16039	S-4A* 16032	S-4B 16036	S-4C 16035	S-4D 16033	S-4E 16037	S-4F 16038	S-4G 16040	S-4H 16031	S-4I 16034
pH	7.2	NA	6.2	7.7	6.9	7.0	6.9	7.3	7.3	7.1
Sp. cond. @ 25°C, umhos/cm	250	NA	440	425	770	690	575	450	485	450
Lead, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Oil and grease, mg/l	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzene, ug/l	0.5	17.5†	6,180†	99.4†	0.2	19.7**	428**	0.2	7.4**	<0.2
Toluene, ug/l	1.4	3.3	6,700†	4.1	<0.2	1.8**	122**	<0.2	3.6††	<0.2
o-Xylene, ug/l	2.1	5.7	1,660†	8.9†	<0.2	0.9**	56.7**	<0.2	3.0**	<0.2
m-Xylene, ug/l	<0.2	<0.2	<10	<0.2	0.3	<0.2	121**	<0.2	1.5**	<0.2
p-Xylene, ug/l	<0.2	1.2	4,190†	75.6†	<0.2	10.2**	108**	<0.2	2.8**	<0.2
Ethyl benzene, ug/l	<0.2	<0.2	1,020†	<0.2	<0.2	<0.2	16.2**	<0.2	0.6**	<0.2
Free-floating fuel, ft	ND	ND	±0.9	±0.1	±0.1	ND	±1.5	ND	ND	ND

*Field duplicate samples.
†Chromatographic difficulties on the second column precluded confirmation, as discussed in Appendix F.
**Confirmed by second GC column. Confirmation samples for wells S-4E, S-4F, and S-4H were collected July 16, 1984, as discussed in Section 3.2.3.
††Not observed on second column.

NA = Not analyzed.
ND = No free-floating fuel product detected.
Note 1: Second column was used if benzene exceeded 0.7 ug/l or if other volatile aromatics exceeded 10 ug/l (OEHL, 1984).
Note 2: As discussed in Section 3.2.3, all wells were sampled July 3, 1984. Five VOA samples were broken in shipment to LLI. The replacement samples (see Section 3.2.3) were collected July 16, 1984.

In spite of benzene's greater volatility, it was the most persistent fuel-related compound detected in these samples. If any of the fuel-related compounds were detected, benzene was also present, and in one well (S-4G), benzene was the only parameter detected. This is probably due to benzene's higher solubility in water as compared to other VOAs tested. Benzene concentrations in groundwater are shown by the appropriate well in Figure 9. Only groundwater from well S-4I, approximately 220 feet from the tanks (Figure 2), contained no detectable fuel-related compounds. Lead was not detected in any sample, and oil and grease was below detection limits in all samples except the sample from well S-4B.

The highest concentrations of VOAs and the thickest accumulations of free-floating fuel product were measured in wells S-4B and S-4F. Total VOAs for well S-4B were 19,750 ug/l; fuel thickness at this well was approximately 0.9 feet. At well S-4F, total VOAs were 851.9 ug/l, and fuel thickness was approximately 1.5 feet.

It should be emphasized that the fuel thickness measured in a well is not the thickness of fuel in the soil surrounding the well. The free-floating (phase-separated) fuel product in the soil floats on the capillary fringe (Shepherd, 1983) which is the soil zone in which groundwater fills all pores but is held by capillary forces (i.e., the pressure head is less than atmospheric pressure). Thus, the phase-separated fuel product in the soil is separated from the water table (a surface defined by saturated conditions and at which pressure head equals atmospheric pressure) by the capillary fringe. Laboratory models (Shepherd, 1983) have determined that typical thickness of the mobile fuel product layer varies with soil type and ranges from 4 mm for coarse gravel to 40 mm (1.6 inches) for fine sand to silt. The latter soils are similar to those encountered at Site 4. From this, one may infer that a mobile fuel product layer of approximately 1.6 inches is in the soil surrounding wells S-4B and S-4F and that the thickness of fuel in these wells is equivalent to the thickness of the capillary fringe plus the mobile fuel product layer.

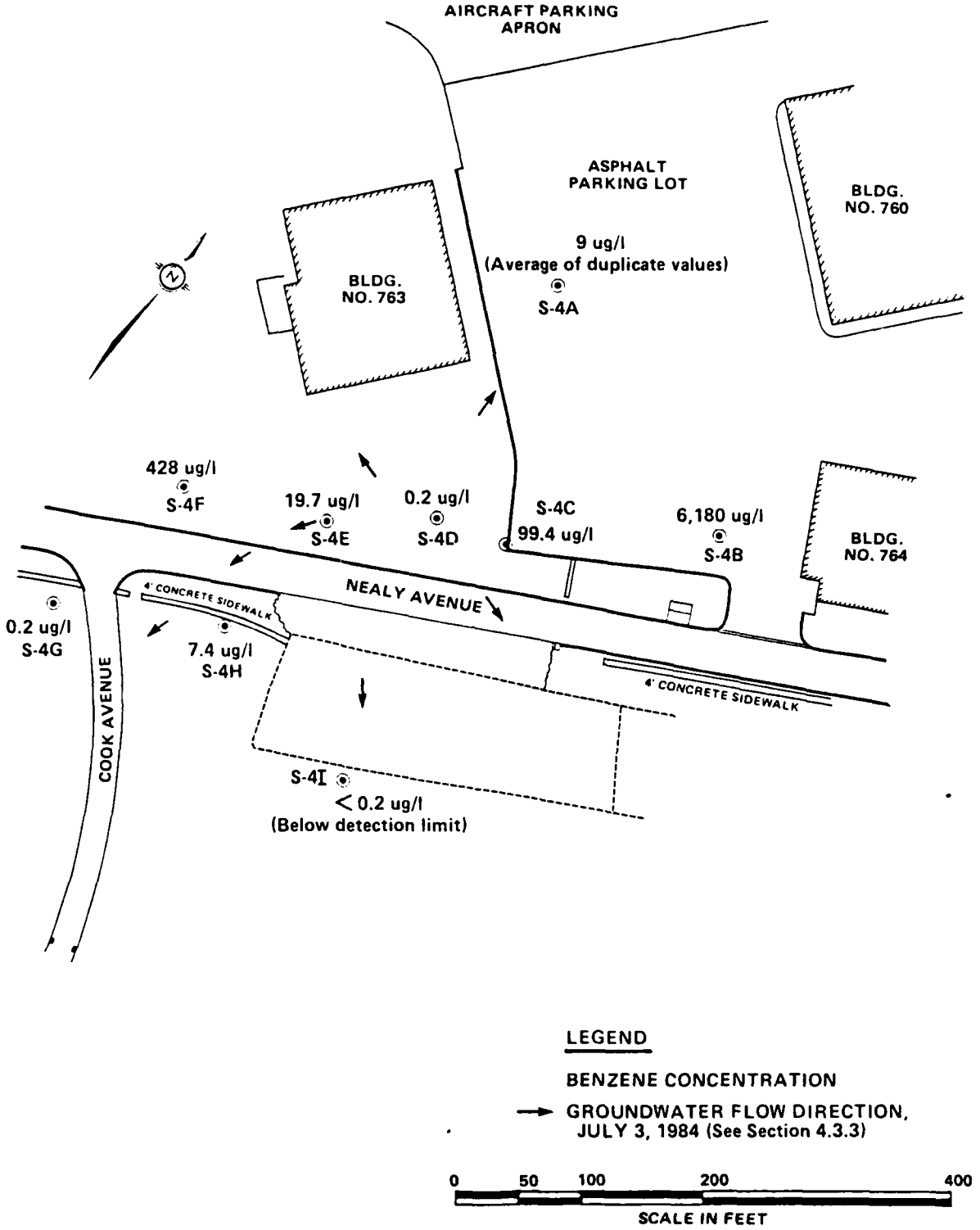


FIGURE 9. Concentrations of Benzene in Groundwater Samples Collected from Monitor Wells in the Vicinity of Site 4, Langley AFB, Virginia, July 1984

BASE MAP: S.J. Glass and Associates, September 1984.

It may seem that there is a discrepancy between the thick fuel accumulations and low measured concentrations of oil and grease at wells S-4B and S-4F; however, this apparent discrepancy is resolved by realizing that the samples for laboratory analysis were collected after the wells were purged by removing at least three well volumes of fluid. This presampling purge would remove the free-floating accumulation of fuel product before the sample was collected; therefore, most of the oil and grease, which has low solubility in water, was removed prior to sampling. Since phase-separated fuel product flows through soil at approximately half the rate of groundwater flow, the wells were recharged with water (flowing into the well from a zone approximately 5 feet thick) much more quickly than they were recharged with fuel (flowing into the well from a zone approximately 1.6-inches thick).

Comparison of the data in Table 3 to the Virginia numeric groundwater standards reveals that water from well S-4B exceeds the petroleum hydrocarbons standard of 1 mg/l with total VOAs of 19.75 mg/l and oil and grease of 0.2 mg/l. The pH of water from this well (6.2) is below the minimum pH standard of 6.5, but a pH of 6.2 may be within the range of natural background for shallow groundwater in the study area since the range of pH for all samples from the site (6.2 to 7.7) is not wide. Groundwater from wells S-4A through S-4H could be interpreted as violating the antidegradation policy of the Virginia groundwater standards. Since VOAs are synthetic organic compounds, natural groundwater would contain none of these parameters.

4.3 SIGNIFICANCE OF FINDINGS

4.3.1 Extent of Contamination

Petroleum-derived fuels are mixtures of many compounds which generally include, but are not limited to benzene, toluene, ethyl benzene, and xylenes. Of the contaminants measured in this study, benzene appears to be the best indicator of fuel-related contamination of groundwater since it was the most persistent contaminant detected. Compared to the other VOAs, benzene is more soluble in water and elutes faster in

chromatographic media; consequently, benzene might reasonably be expected to migrate farther in groundwater in a given period than other VOAs. Water from well S-4I contained no detectable benzene or other evidence of contamination (Figure 9 and Table 3), and it is farthest downgradient from Site 4 (Figure 10). Therefore, well S-4I is apparently beyond the limit of contamination (as of July 1984) attributable to Site 4. By similar reasoning, it may be concluded that well S-4G was at the approximate downgradient limit of contamination at the time of sampling and field measurements. From this information, it is possible to extrapolate an approximate downgradient limit of groundwater contamination (Figure 11). The approximate downgradient limit depicted on Figure 11 should be regarded as a first approximation which defines a region of interest for subsequent investigation.

The presence of fuel-related compounds (benzene, toluene, and xylenes) at the upgradient well (S-4A) makes it impossible to approximate an upgradient limit of groundwater contamination in the vicinity of Site 4.

There may be two zones of free-floating fuel product since free- floating fuel was detected in wells S-4B, S-4C, S-4D, and S-4F but was not detected in S-4E (Table 3); however, the number of wells are too few to delineate the precise extent of free-floating fuel.

4.3.2 Possible Sources of Contamination at Site 4

There are three possible sources for the fuel-related contamination encountered in this study (Figure 2). One, of course, is the former fuel storage area. A second potential source is the currently-used fuel main that parallels Nealy Avenue. The former fuel distribution lines running from the former fuel storage area to the flight line is the third potential source.

Contamination of groundwater at well S-4A may be attributable to leakage from the former fuel distribution system since this is the closest potential source.

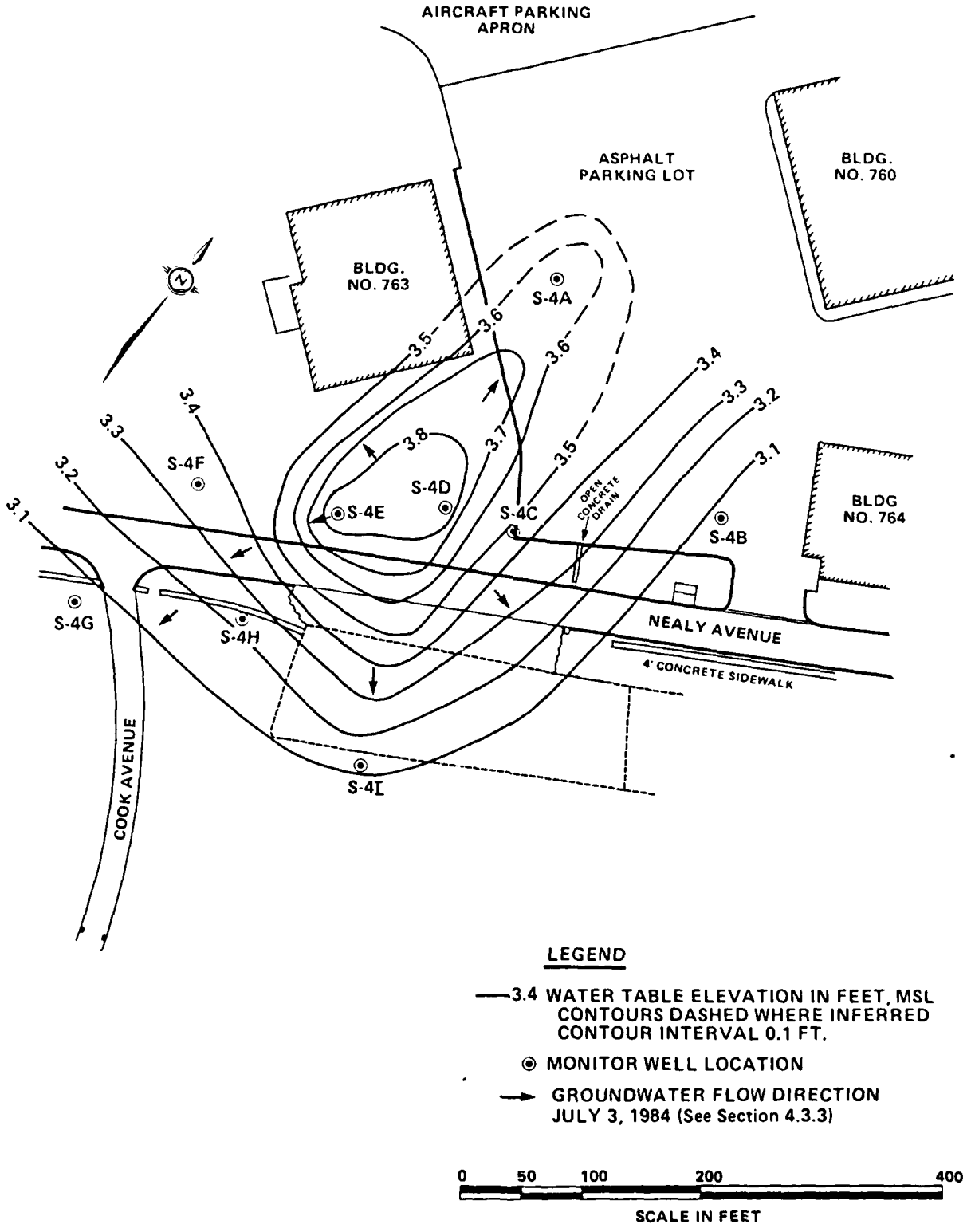


FIGURE 10. Water Table Elevations in the Vicinity of Site 4, Langley AFB, Virginia, July 3, 1984

BASE MAP: S.J.Glass and Associates, September 1984.

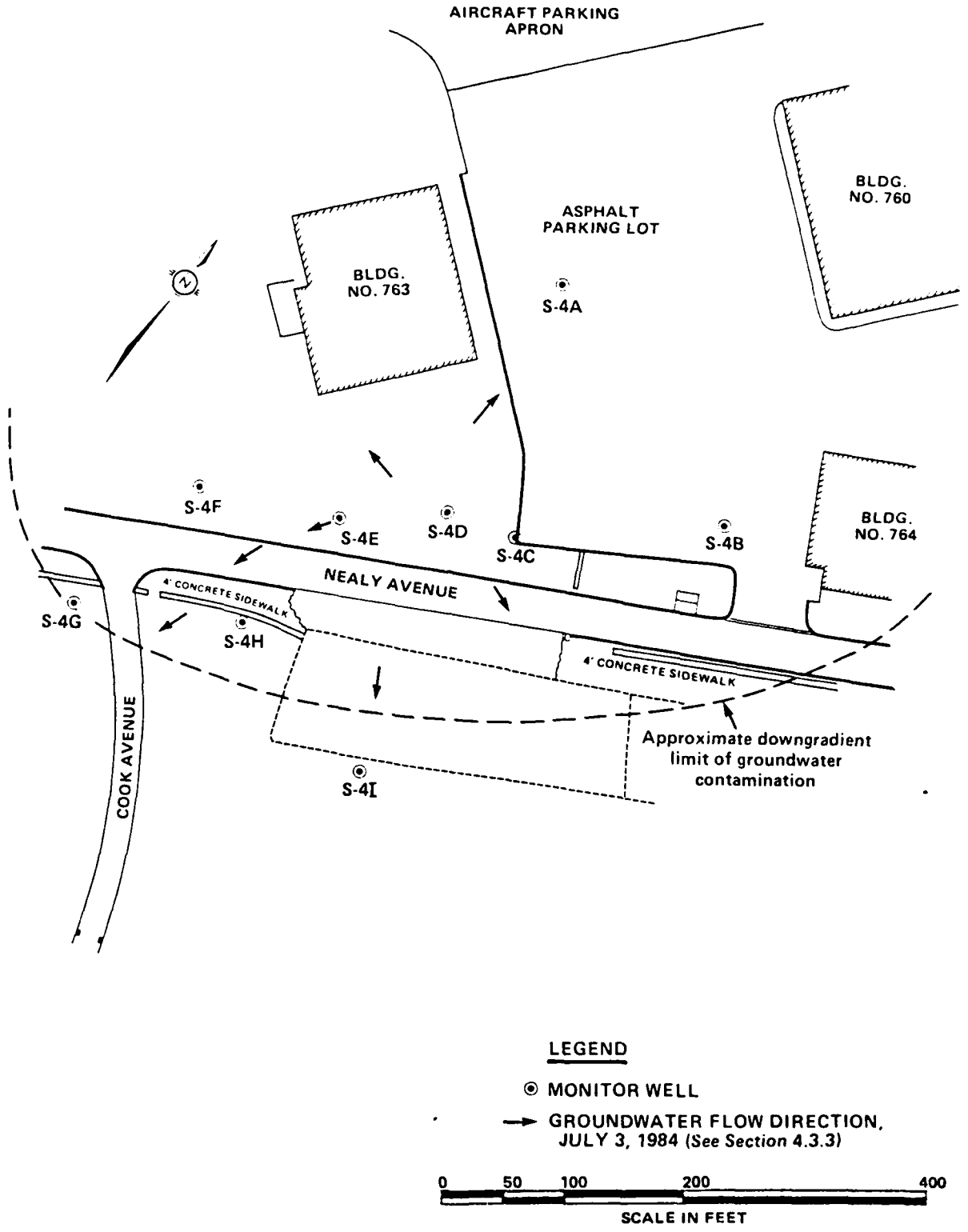


FIGURE 11. Approximate Downgradient Limit of Groundwater Contamination, Site 4, Langley AFB, Virginia, July 1984

BASE MAP: S.J.Glass and Associates, September 1984.

The other two potential sources are close to each other which makes it difficult to differentiate the source of contamination at a given well. Since the age of fuel in these potential sources differs, personnel from BES attempted to obtain age analyses of the fuels from wells S-4B and S-4F by sending samples to the fuels lab at MacDill AFB, but apparently, the analyses do not yield valid results on samples that have been contaminated with water (Kaminski, 1984). Therefore, the present data require that both the former fuel storage area and the present fuel pipeline adjacent to Nealy Avenue remain under consideration as potential sources. The age (30+ years) and composition (steel) of the tanks makes it probable that they have developed leaks, and the proximity of well S-4F to the pipeline suggests that it may also be leaking.

4.3.3 Groundwater Hydrology

Water-table elevations in the vicinity of Site 4 (Figure 10) indicate that the general flow of shallow groundwater is toward the south and southeast. There is a localized high in the water table in the vicinity of wells S-4D and S-4E which places these wells, at least temporarily, upgradient of well S-4A. The slightly lower water-table elevations at S-4A are probably a result of diversion of potential recharge (rainfall) by the asphalt covered parking lot surrounding well S-4A. Heavy rains in late June and early July would have exaggerated this tendency by recharging the open area near wells S-4D and S-4E.

The hydraulic gradient, at the time of water level measurements, to the south and southeast is approximately 0.004, but the hydraulic gradient towards well S-4A is lower (0.001). Higher gradients to the south and southeast support the interpretation that the localized high at wells S-4D and S-4E is a temporary feature.

The horizontal average linear velocity (v) of groundwater at the study site may be estimated from the relation:

$v = KI/n$ (Freeze and Cherry, 1979),

where: K = hydraulic conductivity,

I = hydraulic gradient, and

n = effective porosity (or specific yield).

By selecting a hydraulic conductivity representative of silty sand (1×10^{-5} M/S [Freeze and Cherry, 1979]) and a specific yield representative of fine sand (0.23 [Todd, 1980]), the average linear velocity may be estimated as 5.5 m/yr or 18 ft/year. This is probably on the right order of magnitude since the approximate downgradient limit of groundwater contamination at well S-4G is 140 to 190 feet from either suspected source of fuel. This velocity is such that it would take contaminated groundwater several decades to reach the Southwest Branch of the Back River. However, the fuel odors in storm sewers noted previously (Section 3.2) indicated that seepage of fuel and/or contaminated groundwater into storm sewers may be short-circuiting the groundwater flow path.

The foregoing estimate applies only to groundwater and does not apply to free-floating fuels since fluid velocities in porous media are related to the fluid's viscosity and density as well as the previously described factors (Freeze and Cherry, 1979). Velocity is directly proportional to density and inversely proportional to a fluid's viscosity. The ratios of density to viscosity of fuels and water (Vennard and Street, 1975) are such that fuels flow at a slower rate than water, as would be expected from this study's data.

5.0 ALTERNATIVE MEASURES

5.0 ALTERNATIVE MEASURES

Three alternatives are possible for the sites investigated:

1. Mitigate the contamination;
2. Conduct an additional investigation; or
3. Take no further action.

Alternative 1 is appropriate where there is clear indication that present or future human or environmental problems will exist. The priority for actions would depend on the magnitude of the threat and whether that threat was current or future.

Alternative 2 is appropriate where insufficient evidence exists to place a site in either the Alternative 1 or 3 categories, or where additional information is needed for design of mitigative measures. Continued monitoring may be performed to better define the nature and areal extent of contamination and to define the migration potential of the contaminant plume. The goal should be to gather enough evidence in a timely manner to resolve the question of whether or not the site should be cleaned up.

Alternative 3 is appropriate for sites where there is little, if any, evidence to indicate that the site is or will ever be a source of significant contamination.

5.1 MITIGATIVE MEASURES

Recommendations concerning mitigative measures are beyond the scope of the present study (OEHL, 1983) and, if necessary, will be developed by a future study.

5.2 CONTINUED MONITORING

Options for continued monitoring of Site 4 include:

1. Further define the extent of free-floating fuel product;
2. Further define the extent of contaminated groundwater both upgradient and downgradient of Site 4;

3. Determine whether the present pipeline which parallels Nealy Avenue is leaking; and
4. Quantify fuels-related contamination in storm sewers draining the study area.

5.3 NO FURTHER ACTION

This alternative is not appropriate since contamination has been confirmed, and its significance is not yet fully understood.

6.0 RECOMMENDATIONS

6.0 RECOMMENDATIONS

The following recommendations are listed in order of descending priority.

1. Further define the extent of free-floating fuel product. Suitable initial search areas would be within 75 feet of wells S-4B and S-4F. Other areas to search would be the area of the former fuel transmission lines and the upgradient side of the former fuel storage tanks. It may be possible to define the extent of free-floating fuel product by performing an in situ organic vapor survey of soil gas in the vadose (unsaturated) zone. This would involve hand augering shallow (4- to 5-feet deep) holes within the study area, letting them equilibrate overnight, and then sampling soil vapors in each hole with a portable organic vapor analyzer (OVA). The results of an OVA survey should be confirmed by the installation of fully-screened wells.
2. Quantify fuel-related contamination in the storm sewers adjacent to and downgradient of Site 4 by collecting samples of storm water from several points following at least two rainfall events. For comparison, collect samples of storm water from an area which contains no potential source of leaking fuel.
3. Determine if the pipeline which parallels Nealy Avenue is leaking. One option would be to pressure test the pipeline to check it for leaks. A second option would be to compare the chemical signatures of fuel from the monitor wells, from the underground tanks at Site 4, and from the present bulk storage area which feeds the pipeline which parallels Nealy Avenue (Figure 2) by performing complete GC/MS scans of these fuel samples.
4. Further define the downgradient limit of groundwater contamination by installing two additional wells at the approximate downgradient limit shown in Figure 11. One well should be

southeast of well S-4B, and the other should be southwest of well S-4F. Sample all wells to monitor groundwater quality variations.

5. It may be impossible to define an upgradient limit of fuels-related groundwater contamination since one potential source, the former fuel distribution lines, extends throughout the flight line (COE, 1952). However, there is no apparent need to attempt this task since upgradient contamination poses no reported or foreseeable threat to human health or the environment.

Any continued monitoring of groundwater should include measurement of free-floating fuel and depth to water, plus analysis of groundwater for pH, specific conductance, oil and grease, and VOA. Storm water samples should be analyzed for pH, specific conductance, oil and grease, and VOA.

7.0 REFERENCES

7.0 REFERENCES

Barcelona, M.J., J.A. Helfrich, E.E. Garsko, and J.P. Giff. 1984. A Laboratory Evaluation of Ground Water Sampling Mechanisms. Ground Water Monitoring Review. Volume 4, No. 2, pp. 32-41.

Cederstrom, D.J. 1957. Geology and Groundwater Resources of the York-James Peninsula, Virginia. U.S. Geological Survey Water-Supply Paper, 1361.

CH2M Hill. 1981. Installation Restoration Program Records Search for Langley Air Force Base, Virginia. Prepared for Air Force Engineering and Services Center, Tyndall AFB, Florida. Contract No. F08367-80-G0010-0001. Gainesville, Florida.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey. 604 pp.

Johnson, G.H. 1976. Geology of the Mulberry Island, Newport News North, and Hampton Quadrangles, Virginia. Virginia Division of Mineral Resources. Report of Investigations 41. Charlottesville, Virginia. 72 pp.

Kaminski, A. 1984. Personal communication. Bioenvironmental Engineering Services, Langley AFB, Virginia.

Mackison, F.W., R.S. Stricoff, and L.J. Partridge, Jr. 1978. NIOSH/OSHA Pocket Guide to Chemical Hazards. U.S. Department of Health, Education, and Welfare. U.S. Department of Labor. 191 pp.

Occupational and Environmental Health Laboratory (OEHL). 1983. Installation Restoration Program (IRP) Phase IIB and IIC Report Format. Brooks Air Force Base, Texas.

Occupational and Environmental Health Laboratory (OEHL). 1984. Letter regarding second column confirmation requirements.

Pontier, J. 1984. Personal communication. Bioenvironmental Engineering Services, Langley AFB, Virginia.

Rodriguez. 1984. Personal communication. Occupational Environmental Health Laboratory, Brooks AFB, Texas.

Shepherd, W.D. 1983. Practical Geohydrological Aspects of Groundwater Contamination. Shell Oil Company, Houston, Texas.

Todd, D.K. 1980. Groundwater Hydrology. John Wiley and Sons, New York, New York. 535 pp.

U.S. Army Corps of Engineers (COE). 1952. Plans and Details, Liquid Fuel Storage and Dispensing Facilities, Langley AFB, Hampton, Virginia. Norfolk District File No. LF152-1.8. Drawing No. 78-09-01. Sheet 8 of 13.

U.S. Army Corps of Engineers (COE). 1983. Squadron Operations/Aircraft Maintenance Unit Building. Langley AFB, Virginia. Norfolk District File No. LF353-1.3. Drawing No. 30-10-04/35-32-09. Sheet No. C-1.

U.S. Environmental Protection Agency (EPA). 1979. Safety Manual for Hazardous Waste Site Investigations--Draft Copy. National Enforcement Investigation Center. Denver, Colorado.

U.S. Environmental Protection Agency (EPA). 1980. Field Health and Safety Manual. Region 4. Atlanta, Georgia. 65 pp.

U.S. Environmental Protection Agency (EPA). 1982. Technical Additions to Methods for Chemical Analysis of Water and Wastes, Table 1. EPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA-600/4-82-055, December 1982.

Vennard, J.K. and R.L. Street. 1975. Elementary Fluid Mechanics. John Wiley and Sons, Inc., New York, New York. 740 pp.

Virginia Water Quality Standards. 1980. In: Bureau of National Affairs, Inc. March 6, 1981. Environmental Reporter, State Water Laws, Vol. 3, Washington, D.C.

Water and Air Research, Inc. (WAR). 1982. Installation Restoration Program for Langley AFB, Virginia, Phase II--Field Evaluation. Prepared for Occupational and Environmental Health Laboratory, Brooks AFB, Texas. Contract No. F33615-81-D-4007.

APPENDIX A

LIST OF ABBREVIATIONS/ACRONYMS

LIST OF ABBREVIATIONS/ACRONYMS

AFB	Air Force Base
bls	Below land surface
bsl	Below sea level
BES	Bioenvironmental Engineering Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DOD	Department of Defense
ft	Feet
GC	Gas chromatrograph
HARM	Hazardous Assessment Rating Methodology
HQ	Headquarters
IRP	Installation Restoration Program
LETCO	Law Engineering Testing Company
LLI	Lancaster Laboratories, Inc.
msl	Mean sea level
m/yr	Meters per year
ug/l	Micrograms per liter
umhos/cm	Micromhos per centimeter
mg/l	Milligrams per liter
ml	Milliliter
mm	Millimeter
OEHL	Occupational and Environmental Health Laboratory
PVC	Polyvinyl chloride
QA/QC	Quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
TAC	Tactical Air Command
TBC	The Bionetics Corporation
COE	U.S. Army Corps of Engineers
USAF	United States Air Force
EPA	U.S. Environmental Protection Agency
VOA	Volatile aromatics
WAR	Water and Air Research, Inc.

APPENDIX B

RESUMES OF PROJECT STAFF

WILLIAM D. ADAMS

HYDROGEOLOGIST
WATER AND AIR RESEARCH, INC.

Relevant Experience

Mr. Adams is an environmental geologist who specializes in engineering applications of hydrogeology. His practical experience is strongly oriented toward solving problems of pollutant transport in the subsurface environment.

He works on environmental contamination assessments and hazardous waste management/ permitting. He has conducted hydrogeologic work at abandoned hazardous waste sites at DOD installations in Alabama, Florida, North Carolina, Georgia, Virginia, Missouri, and Arizona. At some of these bases, chemical agent disposal was investigated and elaborate health and safety precautions were used.

His project responsibilities have included: assembling and reviewing geologic and geohydrologic literature; quantifying pollutant movement potential using published documents and/or field test data; supervising monitoring well installation; selecting well sites, depths, and casing requirements; specifying rig cleanup procedures; and drafting reports of findings for DOD and regulatory staffs. Mr. Adams has also participated in staff briefings detailing interim and final findings.

He conducted a comprehensive hazardous waste inspection and survey at Pensacola Naval Air Station. Industrial facilities which generate substantial quantities of various wastes were visited and associated personnel debriefed to determine waste generation and handling practices. This information was used in two ways. First, Mr. Adams and his team developed a complete hazardous waste management plan for the entire complex. This ensured compliance with 40 CFR 260-265. A Part B permit application, including revised Part A, was then filed. Facilities permitted included container storage buildings, surface impoundments, and treatment in drying beds. A preliminary design for additional container storage was reviewed and concept design modifications made to ensure RCRA compliance (40 CFR 264). Although numerous tanks were used, all tank usage was reviewed and recommendations were made to alter hazardous waste storage practices. This eliminated the need to permit any tank.

Mr. Adams has directed field work for installation restoration confirmation studies (Phase II) at five Air Force Bases (three in Florida), and one Army Ammunition Plant. In these studies, he researched site geology, sited all wells, supervised well installation and development, and collected samples for inorganic and organic constituent analyses.

In another DOD study, Mr. Adams compared two potential depleted uranium burial sites. He planned and supervised the field work, lab work, and report preparation. An important aspect of this study was assessing potential routes of contaminant migration. This work included extensive field and laboratory soils testing and analysis.

Education

M.S.	Geology	University of Florida
B.S.	Geology	University of Florida

Professional Registrations and Societies

Certified Professional Geologist--Indiana
National Water Well Association
American Water Resources Association (Florida Section)

Publications

Author and co-author of several articles and numerous technical reports.

JAMES H. SULLIVAN, JR., Ph.D., P.E.

CHEMICAL ENGINEER
WATER AND AIR RESEARCH, INC.

Relevant Experience

Dr. Sullivan has played major roles in projects involving technical work directly related to groundwater monitoring and assessment at hazardous wastes sites. His recent experience includes work for a paper manufacturer, a phosphate plant, a landfill, and a cement manufacturer.

Dr. Sullivan directed preparation of Part A and Part B permit applications for the U.S. Navy. He has also worked directly on other projects related to RCRA groundwater monitoring and assessment programs and the permitting process. He is familiar with the DOD Hazardous Materials Information System which he has used to assess chemical/physical properties of DOD compounds. He directed a team of scientists and engineers working at two installations on initial assessment studies (IASs) for the Naval Energy and Environmental Support Activity. Potential for contamination from past hazardous waste disposal was determined for approximately 80 candidate disposal sites. Recommendations for confirmation or remedial action were developed.

At U.S. Air Force bases he conducted Phase II confirmation studies of potential contamination from past hazardous waste disposal activities. He participated in fieldwork and used field data to assess pollutant movement and severity of contamination. He recommended remedial measures and specified additional data needs for remedial design.

He directed a series of studies for the U.S. Army in which impacts of munitions wastes at several ammunition plants were defined. Siting of a new munitions plant was the objective of another study, and developing water quality criteria for hazardous substances using field and laboratory data was accomplished in another study. He conducted fieldwork, data reduction, report preparation, and briefings.

At a U.S. Army installation (Redstone Arsenal), Dr. Sullivan directed a nationally prominant study of environmental contamination from DDT. He was responsible for devising and evaluating engineering techniques for remedial action. The project involved several public agencies, with field data collected by four separate groups. He was responsible for reducing and interpreting all field data. Again he participated directly in field reconnaissance, records research, data compilation, data reduction, report writing, and briefings, including those before Congressional staffs.

Dr. Sullivan studied three solid waste disposal sites near Charleston, South Carolina and monitored groundwater impacts. In addition to gathering chemical data on groundwater and soils, fluorescent dye was used to trace groundwater movement. Evidence of hazardous substances in leachate was found and remedial action recommended.

Education

Ph.D.	Environmental Engineering	University of Florida
M.S.	Environmental Engineering	University of Florida
B.S.	Chemical Engineering	Georgia Institute of Technology

Professional Registrations and Society Memberships

Professional Engineer--Florida
Member of 8 professional societies

Publications

Author and co-author of approximately 10 publications and 45 technical reports in water chemistry, potable water treatment, wastewater renovation, and environmental impact assessment.

CHARLES R. FELLOWS

ENVIRONMENTAL CHEMIST
WATER AND AIR RESEARCH, INC.

Relevant Experience

Mr. Fellows is an environmental chemist trained in both field studies and formal laboratory chemistry.

As a member of hazardous waste site investigation teams, Mr. Fellows has conducted interviews regarding past disposal practices, past and present industrial/chemical processes, and the chemical and physical nature of disposed materials. On several occasions he has identified waste sites that posed an immediate concern to human health.

Mr. Fellows is familiar with and has used various appropriate safety procedures and techniques while sampling sites that have received hazardous wastes. He has collected groundwater, surface water, sediment, and leachates for a wide variety of organic, inorganic, and physical analyses. He is experienced in applying site assessment models to evaluate migration and health-threatening potential of chemical wastes at specific disposal sites.

In addition to the procedures mentioned above for collection, preservation, and analysis of various types of samples, he is familiar with the RCRA EP Toxicity Test Procedure, the U.S. Army Corps of Engineers Elutriate Test Procedure, and groundwater monitoring procedures for arsenic, heavy metals and other toxicants.

Mr. Fellows is directly responsible for inorganic chemical analyses. He performs quality assurance checks and often participates in actual laboratory water quality analyses. He recently worked with an industry generating hazardous wastes to develop suitable extraction methods for assessing waste toxicity. He helped to develop wastewater analysis protocols which mitigated interferences from chemicals in battery manufacturing wastes.

He directs sampling of groundwater monitoring wells and participates in developing field sampling networks for both surface waters and groundwaters.

Education

M.S.	Water Chemistry	University of Florida
B.S.	Biology	Eckerd College

Publications

Author and co-author of several articles and technical reports

APPENDIX C

SCOPE OF WORK

10 MAY 1984

INSTALLATION RESTORATION PROGRAM
Phase II Stage 2 Field Evaluation
Langley AFB, Virginia

I. DESCRIPTION OF WORK

The purpose of this task is to determine if environmental contamination has resulted from fuel handling and storage practices at Langley AFB VA; to provide estimates of the magnitude, extent and direction of contaminant movement should contamination be found; and to identify potential environmental consequences of migrating pollutants.

The Phase I IRP Report (mailed under separate cover) and the Phase II IRP Report (mailed under separate cover) incorporate background and description of the site for this task. To accomplish the survey effort, the contractor should take the following action:

A. General

1. All water samples collected shall be analyzed on site by the contractor for pH, temperature and specific conductance. Sampling, maximum holding time and preservation of samples shall strictly comply with the following references: Standard Methods for The Examination of Water and Wastewater, 15th Ed. (1980), pp. 35-42; ASTM, Part 31, pp. 76-86, (1980), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix (1979).

2. Standard penetration tests and split spoon sampling shall be accomplished on all monitor well borings. All wells shall be developed, water levels measured and locations surveyed and recorded on a project map and a specific site map. Groundwater monitoring wells shall, as a minimum, comply with Environmental Protection Agency Guidelines and State of Virginia requirements for monitoring well installation. Only screw type joints shall be used. Glued fittings are not permitted.

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

B. In addition to items delineated in A above, conduct the following specific actions at Site No. 4 Tank Farm (Underground POL) identified on Langley AFB.

1. A magnetometer sweep of each proposed well location shall be conducted in order to verify the location of subsurface facilites.

2. The contractor shall install nine 10-foot groundwater monitoring wells around the site to monitor contaminant migration: Two wells in the grassed area immediately downgradient of the assumed locations of the underground POL tanks, four wells in grassed areas farther downgradient, two wells in the asphalt parking lot adjacent to Building 764 and one well upgradient. A maximum of 90 linear feet of wells shall be installed. These wells shall be

constructed of 2-inch inside diameter schedule 40 PVC well screen, .010 inch slots. The base of the screen shall be set approximately 10 feet below the ground surface with the top of the screens extending above the water table to intercept floating fuel products.

3. All contractor installed wells shall be developed, water levels measured and locations recorded on the site map.

4. All contractor installed wells shall be surveyed for location (Virginia State Planar coordinates) and elevation (feet above mean sea level) of the top of each well casing.

5. After the monitoring wells have stabilized for at least 48 hours, groundwater samples shall be recovered from each of the 9 wells. Prior to sampling, each well shall be purged of the equivalent of 3 or more casing volumes of water standing in the well. Floating fuel product thickness, if present, shall be measured. The samples shall be analyzed for the parameters shown in Attachment 1. Number of analysis are also shown in Attachment 1.

6. A water table contour map shall be developed in the field for the site from the above data, and the groundwater gradient and direction of flow around the site shall be identified.

C. Well Installation and Cleanup

Monitor wells shall be completed with the installation of an iron security casing equipped with a lockable cap. The exact locations of wells at each site shall be determined by the contractor in the field. Drill cuttings shall be removed and the general area cleaned. If hazardous waste is generated in the process of well installations, the contractor shall be responsible for proper containerization (according to local Civil Engineering Office requirements) for eventual government disposal. Drill cuttings shall be disposed of in area designated by the Base Civil Engineer.

D. Data Review:

Results of sampling and analysis shall be tabulated and incorporated into the monthly R&D Status Reports and forwarded to the USAF OEHL for review as soon as they become available as specified in Item VI below.

E. Reporting

1. A draft report delineating all findings of this field investigation shall be prepared and forwarded to the USAF OEHL as specified in Item VI below for Air Force review and comment. This Report shall be prepared in the format of Addendum No. 1 to the existing IRP Phase II Report for Langley Air Force Base. This report shall include a discussion of the site hydrogeology, well logs of all project wells, data from water level surveys, water quality analysis result, available geohydrologic cross sections, groundwater surface and flow maps, and laboratory quality assurance information and quality control data.

2. Estimates shall be made of the magnitude, extent and direction of movement of contaminants discovered. Potential environmental consequences of discovered contamination, where known, must be identified.

3. Specific requirements, if any, for future groundwater and surface water monitoring must be identified.

II. SITE LOCATION AND DATES

Langley AFB VA
USAF HOSP/SGPB
Dates to be established

III. BASE SUPPORT: Langley AFB will provide the following:

A. Designation of site for disposal of drill cuttings.

B. Use of a holding tank (bowser) and designation of disposal site for contaminated groundwater generated during well development.

C. Temporary construction barriers and parking/traffic control support for wells sited in parking lots and/or roadways.

IV. GOVERNMENT FURNISHED PROPERTY: None

V. GOVERNMENT POINTS OF CONTACT

1. Maj Edward Barnes
USAF OEHL/TS
Brooks AFB TX 78235
(512) 536-2158
AV 240-2158

2. Col Jerry Dougherty
HQ TAC/SGPB
Langley AFB VA 23665
(804) 764-2180
AV 432-5857

3. Maj John Pontier / Lt. Art Kaminski
USAF Hospital/SGPB
Langley AFB VA 23665
(804) 764-7060
AV 432-7060

VI. In addition to sequence numbers 1, 5 and 10 which are applicable to all orders, the reference numbers below are applicable to this order. Also shown are data applicable to this order.

Sequence No.	Block 10	Block 11	Block 12	Block 13	Block 14
Attachment 1					
4	ONE/R	84 OCT 30	84 OCT 30	85 FEB 28	*

*A minimum of two draft reports will be required. After incorporating Air Force comments concerning the first draft report, the contractor shall supply the USAF OEHL with a second draft report. Contractor shall supply the USAF OEHL with 25 copies of each draft report and 50 copies plus the original camera ready copy of the final report.

Attachment I

Analytical Parameters, Methods and Required Detection Limits

Parameter	Method	Detection Limit	Number of Samples*
Volatile organic aromatics	EPA Method 602	**	10
Oils and Greases	EPA Method 413.2	0.1 mg/L	10
Lead	EPA Method 239.2	20 µg/L	10

*Includes one field QA duplicate for each analysis.

**Detection limits for Volatile Organic aromatics shall be as specified for the compounds by EPA Method 602: Federal Register, Vol. 44, No. 233, pp. 69474-69478. This method should be strictly followed including these items:

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

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

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

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

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

APPENDIX D

SAFETY PLAN

APPENDIX D
SAFETY PLAN

D-1.0 GENERAL

The safety plan presented herein gives guidelines for basic safety procedures and equipment utilized by Water and Air Research, Inc. (WAR) during the course of IRP Phase II surveys. Samples collected during Phase II surveys are typically environmental water and sediment samples as opposed to hazardous waste samples and normally do not require unusual levels of personnel protection. Detailed procedures and equipment required to minimize exposure to specific hazardous wastes or conditions requiring higher levels of protection are beyond the scope of this plan. References are provided from which waste-specific information on equipment and procedures can be obtained on a case-by-case basis.

D-2.0 INFORMATION REVIEW

Prior to initiating Phase II survey fieldwork, the Phase I records search is reviewed in detail to identify hazardous wastes or conditions that may be encountered at each site. Available toxicological data on materials suspected of being present at the sites are reviewed to determine if the base level of personnel protection outlined in Section D-5.0 is adequate. Hazards such as the presence of highly toxic or incompatible chemicals, toxic gases, radioactive material, or explosives may require more extensive precautionary measures than the base level of protection. Safety hazards requiring special attention are addressed on an individual basis using appropriate assessment methods, and equipment and procedure recommendations given in the EPA Field Health and Safety Manual (EPA, 1980) and the EPA Safety Manual for Hazardous Waste Site Investigations (EPA, 1979). Hazardous conditions can be clarified or confirmed on preliminary site visits.

D-3.0 MEDICAL MONITORING PROGRAM

The person responsible for Phase II survey fieldwork will determine whether a medical monitoring program is necessary, based on results of the information review. If hazard levels are judged high enough to

warrant this procedure, all field personnel will participate in a medical monitoring program. Guidelines for the program are given in Appendix I of the EPA Field Health and Safety Manual (EPA, 1980).

D-4.0 FIELD PERSONNEL INDOCTRINATION

All field personnel will be informed by the project field supervisor of required safety equipment and procedures prior to on-site work. Subjects covered will include personal safety gear, general and site-specific safety procedures, and incident notification procedures.

D-5.0 PERSONNEL PROTECTION GEAR

The following items will be available on-site, if needed, for all field personnel:

- o Tyvek® disposable coveralls,
- o Rubber boots,
- o Rubber gloves,
- o Hard hats, and
- o Eye protection (safety glasses or face shields).

Hearing protection (disposable ear plugs) will be provided for all work in the vicinity of the flight line or other noise hazards. Cartridge-type respirators will be available on-site for protection against inhalation of dust or vapors. If strong vapors are encountered, respirators will be utilized to facilitate evacuation of personnel and equipment from the site until the situation can be assessed or corrected.

An Enmet CGS-18M portable gas detector will be used to monitor combustible or toxic gas concentrations during fieldwork. For Phase II fieldwork, normal alarm calibrations will be for methane (20 percent of the lower explosive limit) and methyl chloride (200 ppm).

Personal equipment described above will offer adequate protection for most situations encountered during the course of Phase II survey fieldwork. When conditions are identified that require a higher level of

personal protection, the EPA Safety Manual for Hazardous Waste Site Investigations will be referred to for guidance.

D-6.0 SAFETY PROCEDURES

Hard hats and eye protection will be worn when appropriate, as directed by the project field supervisor. Protective clothing (boots, gloves, and coveralls) will be worn at all times while working on-site. Coveralls will be changed a minimum of once daily.

The project field supervisor will consult with the base environmental coordinator or other responsible contact regarding site-specific hazards prior to entering sites. Special procedures for entering and working at particular sites will be clarified and conveyed to all field personnel. Examples of areas requiring strict procedures are active runways or taxiways, fuel handling or storage areas, and secure areas.

Prior to any drilling or digging on the sites, USAF Form 103 must be routed to all applicable base organizations for a clearance review. Circulation of this form is required to avoid contact with underground or overhead utilities, conflict with base activities, or breaches of security.

Additional safety procedures will be implemented, if warranted by the information review or conditions encountered at the site. Site-specific safety procedures will be based on guidelines given in the EPA Field Health and Safety Manual and the EPA Safety Manual for Hazardous Waste Site Investigations.

D-7.0 INCIDENT/ACCIDENT NOTIFICATION PROCEDURES

As a minimum, the following emergency phone numbers should be available on-site:

1. Ambulance or medical assistance,
2. Base fire department (or other if off-site), and
3. USAF contact for project.

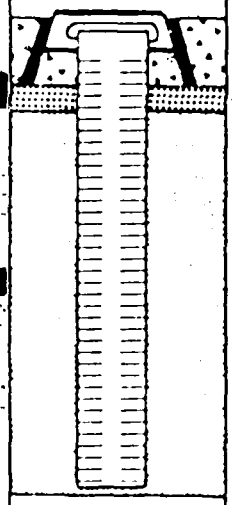
After contacting appropriate emergency services, or in nonemergency incidents, the USAF project contact should be notified of the incident or accident so that it can be dealt with according to base policies and procedures.

APPENDIX E

WELL LOGS

SHEET 1 OF 1

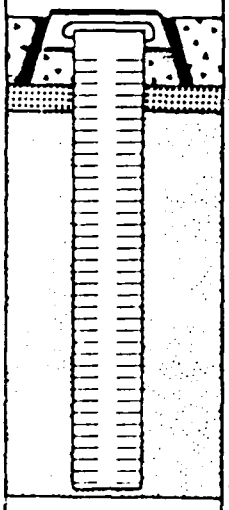
Boring No. 4-A
Location Coordinates 278,395 N
2,626,523 E
Hole Size 6"x 10' Slot 0.010"
Screen Size 2"x 10' Mat'l SCH 40 PVC
Filter Materials F-M SAND
Casing Size N.A. Mat'l N.A.
Grout Type SAKRETTE
Geologist W. D. ADAMS
Protective Casing VALVE BOX
Date Start 28 JUNE 84 Finish 30 JUN 84
Static Water Level 4.56 FT TOC
Contractor WAR/LETCO
Top of Well Elevation 8.22 FT MSL
Driller CHUCK YIGNERON
Drill Type 6" RCB ; MAYHEW

Sketch	Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0 FT	0 - 1 FT	ASPHALT & CONCRETE	N.A.	N.A.
		1 - 2	CLAY, SANDY. CLAY ≅ ~10%. VF QTZ & H.M. SD & SLT, SOFT, MOIST, OLIVE (5Y 5/4) TO GRAY (N 6/).	CL	5
		2 - 4	FUEL ODOR IN 2-4FT SAMPLE	CL	2
	1.5 FT	4 - 6	4-5: AS ABOVE EXCEPT FOR THIN STREAK OF VC, ROUND, QTZ, SD.	CL	2
	1.8 FT		5-6: CLAY, SANDY. CL, ≅ VF - F QTZ SD, SOFT, DRY, RED-YEL (7.5YR6/8), ABUNT SHELL FRAGS IN LOWER INCH, YELLOW (2.5Y 8/6).	CL	
		6 - 8	CLAY, SANDY. CL ≅ ~30% VF-F, QTZ, & H.M., ANG SD & SLT, ~10% SHELL FRAGS, MOIST, YELLOW (2.5Y 8/6) IN UPPER 6", LT GRAY (N7/) IN LOWER 1½ FT.	CL	32
		8 - 10	AS ABOVE	CL	30
	10 FT				

SHEET 1 OF 1

Boring No. S-4B
Hole Size 6" x 10' Slot 0.010"
Screen Size 2" x 10' Mat'l SCH 40 PVC
Casing Size — Mat'l —
Geologist W. D. ADAMS
Date Start 28 JUN 84 Finish 30 JUN 84
Contractor WAR / LETCO
Driller CHUCK VIGNERON

Location Coordinates 278,319 N
2,626,749 E
Filter Materials F-M SAND
Grout Type SAKRETTE
Protective Casing VALVE BOX
Static Water Level 5.10 FT TOC
Top of Well Elevation 8.18 FT MSL
Drill Type 6" R.C.B.; MAYHEW

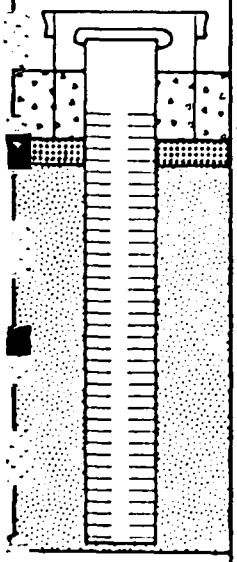


Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0-0.5	ASPHALT	N.A.	N.A.
	0.5-1	SUB GRADE.		
	1-2	CLAY, SANDY. CL ~ ~ 30% VF-F QTZ SD & SLT, SOFT, DRY, V. DK. GRAY (5Y 3/1).	CL	17
	2-4	CLAY, SANDY. AS ABOVE EXCEPT TR QTZ GRAVEL, MOIST, FUEL ODOR, V. DK. GRAY (5Y3/1).	CL	8
	4-6	4-5: AS ABOVE, STRONG FUEL ODOR	CL	3
		5-6: CLAY, SANDY. CL ~ ~ 30% SHELL FRAGS, SOFT, SAT, GRAY (N5/).	CL	
	6-8	6-7: A S ABOVE. STRONG FUEL ODOR	CL	25
		7-8: CLAY, SANDY. CL ~ ~ 30% SHELL FRAGS & VF-F QTZ. SD. & SLT., SOFT, MOIST, OLIVE YEL (2.5 Y 6/6). NO ODOR.	CL	
	8-10	CLAY, SANDY. CL ~ ~ 30% VF-F SD & SLT, ~ 5% SHELL FRAGS, MOIST, SOFT, NO ODOR, BL. GRAY (5B 5/1).	CL	26

SHEET 1 OF 1

Boring No. S-4C
Hole Size 6"×10' Slot 0.010"
Screen Size 2"×10' Mat'l SCH 40 PVC
Casing Size 2"×1.3' Mat'l SCH 40 PVC.
Geologist W. D. ADAMS
Date Start 29 JUN 84 Finish 30 JUN 84
Contractor WAR/LETCO
Driller CHUCK VIGNERON.

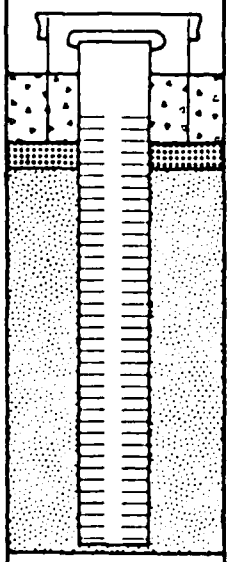
Location Coordinates 278,205 N
2,626,619 E
Filter Materials F-M SAND
Grout Type SAKRETTE
Protective Casing 4"×3' B.I.P.
Static Water Level 5.98 FT TOC
Top of Well Elevation 9.45 FT MSL
Drill Type 6" R.C.B. ; MAYHEW.

Sketch	Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0 FT 1.5 FT 1.8 FT 10 FT	0-2	CLAY, SANDY. CL ≈ ~30% VF-F ANG, QTZ SD & SLT, ~10% SHELL FRAG, SOFT, BR. YEL. (10YR 6/6).	CL	15
		2-4	CLAY, SANDY. CL ≈ ~30% VF-F ANG, QTZ & H.M. SD & SLT, SOFT, FUEL ODOR, MOIST, OLIVE GRAY (5 Y 5/2).	CL	6
		4-6	CLAY, SANDY. AS ABOVE, SAT., FAINT FUEL ODOR.	CL	2
		6-8	CLAY, SANDY. AS ABOVE, V. SOFT. FAINT FUEL ODOR.	CL	2
		8-10	CLAY, SANDY. CL ≈ ~30% VF-F ANG, QTZ & H.M. SD & SLT, ~10% SHELL FRAGS, V. SOFT, SAT, NO ODOR, GRAY (5Y 5/1).	CL	14

SHEET 1 OF 1

Boring No. S-4D
Hole Size 6" x 10' Slot 0.010"
Screen Size 2" x 10' Mat'l SCH 40 PVC
Casing Size 2" x 1.4' Mat'l SCH 40 PVC
Geologist W. D. ADAMS
Date Start 29 JUN 84 Finish 30 JUN 84
Contractor WAR/LETCO
Driller CHUCK VIGNERON

Location Coordinates 278,186 N
2,626,563 E
Filter Materials F-M SAND
Grout Type SAKRETTE
Protective Casing 4" x 3' BGP.
Static Water Level 5.39 ~~FT~~ TOC
Top of Well Elevation 9.24 ~~FT~~ MSL
Drill Type 6" RCB; MAYHEW.

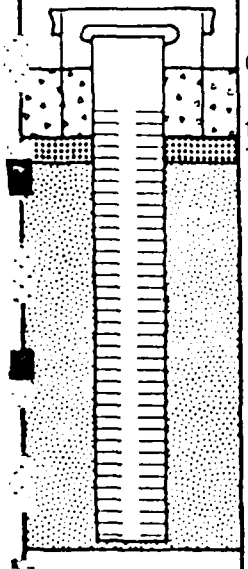


Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0-2 FT	SAND, SILTY. SD, VF-C, QTZ, ANG, ~40% SLT & CL, MOIST, TR SH FRAGS, BRN (10YR 4/3).	SM	7
	2-4	AS ABOVE.		~~2~~ 5
	4-6	SAND, CLAYEY. SD, VF-F, QTZ, ANG ~30% CL & SLT, WET, ABNDNT SH FRAGS, OLIVE YEL. (2.5Y 6/6).	SC	3
0 FT	6-8	CLAY, SANDY. CL & ~40% VF SD & SLT, ~10% SH. FRAGS, WET, PALE YEL (2.5Y 7/4) & LT GRAY (5Y 6/1).	CL-SC	3
1.5 FT 1.8 FT	8-10	SAND, SILTY & GRAVELLY. SD, VF, QTZ, ~30% SLT, ~20% GRAVEL, WET, TR SH. FRAGS., LT. YEL. BRN. (2.5Y 6/4).	SM-SC	2
10 FT				

SHEET 1 OF 1

Boring No. S-4E
Hole Size 6" x 10' Slot 0.010"
Screen Size 2" x 10' Mat'l SCH 40 PVC
Casing Size 2" x 1.4' Mat'l SCH 40 PVC
Geologist W. D. ADAMS
Date Start 30 JUN 84 Finish 30 JUN 84
Contractor WAR/LETCO
Driller CHUCK VIGNERON

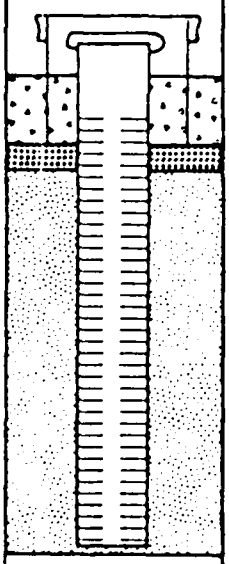
Location Coordinates 278,129 N
2,626,494 E
Filter Materials F-M SAND
Grout Type SAKRETTE
Protective Casing 4" x 3' B.G.P.
Static Water Level 5.30 FT TOC
Top of Well Elevation 9.20 FT MSL
Drill Type 6" R.C.B.; MAYHEW.



Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0-2 FT	SAND, SILTY. SD, VF-F, QTZ, ~40% SLT & CL, ~10% SH. FRAGS, MOIST, BRN (7.5YR 4/4).	SM-SC	12
	2-4	SAND, CLAYEY & GRAVELLY. SD, VF-F, QTZ, ~20% CLAY, ~30% QTZ GRAVEL, WET, ~10% SH. FRAGS, BRN. YEL.	SC-SG	3
	4-6	CLAY, SANDY. CL, ~30% VF SD & SLT, ~10% SH FRAGS, FUEL ODOR, WET, RED. YEL. (7.5YR 6/8) & RED. GRAY (10R 5/1).	CL-SC	6
	6-8	SAND, CLAYEY. SD, VF-F, ~20% SLT & CL, ~20% SH FRAGS, SAT., BRN. YEL. & GRAY (5Y 5/1).	SC-SM	24
	8-10	SAND, SILTY. SD, VF-F, ~30% SLT & CL, ~20% SHELLS & SH. FRAGS., SAT, GRAY (N 5/).	SM	34

SHEET 1 OF 1

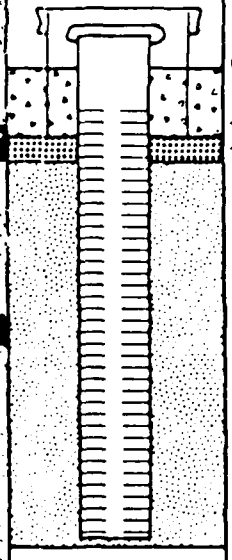
Boring No. S-4F
Location Coordinates 278,079 N
2,626,386 E
Hole Size 6" x 10' Slot 0.010"
Screen Size 2" x 10' Mat'l SCH 40 PVC
Filter Materials F-M SAND
Casing Size 1.4' x 2" Mat'l SCH 40 PVC
Grout Type SAKRETTE
Geologist W. D. ADAMS
Protective Casing 4" x 3' BEP.
Date Start 30 JUNE 84 Finish 30 JUN 84
Static Water Level 5.47 FT TOC
Contractor WAR/LETCO
Top of Well Elevation 8.83 FT MSL
Driller CHUCK VIGNERON.
Drill Type 6" R.C.B.; MAYHEW

Sketch	Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0 FT 1.5 FT 1.8 FT 10 FT	0 - 2 FT	SAND, SILTY. SD, VF-F, ~20% SLT & CL., DRY, LT. GRAY (N 7/).	SM	17
		2 - 4	CLAY, SANDY. CL, ~30% VF SD & SLT, TR SH FRAGS, ST. BRN (7.5YR 5/6)	SC	11
		4 - 6	SAND, SILTY. SD, VF-F, ~30% SLT & CL, ~10% SH. FRAGS, WET, RED. YEL. (7.5 YR 6/8).	SM	8
		6 - 8	SAND, SILTY. SD, VF-M, ANG, ~20% SH. FRAGS, ~10% SLT, WET, GRAY (N 5/).	SP-SM	29
		8 - 10	SAND, SILTY. SD, VF-F, ANG, ~30% SH. FRAGS & SHELLS, ~20% SLT & CL, WET, GRAY (N 5/).	SM	18

SHEET 1 OF 1

Boring No. S-46
Hole Size 6" x 10' Slot 0.010"
Screen Size 2" x 10' Mat'l PVC
Casing Size 1.4' x 2" Mat'l PVC
Geologist W. D. ADAMS
Date Start 30 JUN 84 Finish 30 JUN 84
Contractor HAR/LETCO
Driller CHUCK VEGNERON

Location Coordinates 277,939 N
2,626,362 E
Filter Materials F-M SAND
Grout Type SAKRETTE
Protective Casing 4" x 3' B.E.P.
Static Water Level 5.86 FT TOC
Top of Well Elevation 8.93 FT MSL
Drill Type 6" RCB; MAYHEW

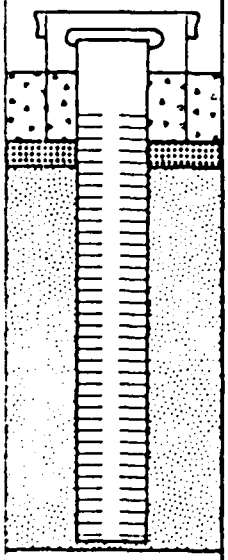


Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0-2FT	SAND, SILTY. SD, VF-F, QTZ, ANG, ~ 20% SLT, DRY, GRAY.	SM	16
	2-4	CLAY, SANDY. CL, ~20% VF QTZ SD, TR GRAVEL, WET, RED. GRAY.	CL	7
	4-6	SAND, CLAYEY. SD, VF-F, QTZ, ~20% CL & SLT, ~20% SH. FRAGS, WET, YEL (10YR 7/6).	SC-SM	11
	6-8	SAND, SILTY, SD, VF-F, QTZ, ~20% SLT & CL, ~20% SH. FRAGS, SAT, GRAY (N 6/).	SM	19
	8-10	SAND, SILTY., SD, VF-F, QTZ, ~20% SLT & CL, ~20% SH FRAGS, SAT, GRAY (N 6/).	SM	20

SHEET 1 OF 1

Boring No. S-4H
Hole Size 6" x 10' Slot 0.010"
Screen Size 2" x 10' Mat'l PVC
Casing Size 2" x 1.4' Mat'l PVC
Geologist W. D. Adams
Date Start 30 Jun 84 Finish 30 Jun 84
Contractor WAR/LETCO
Driller Chuck Vigneron

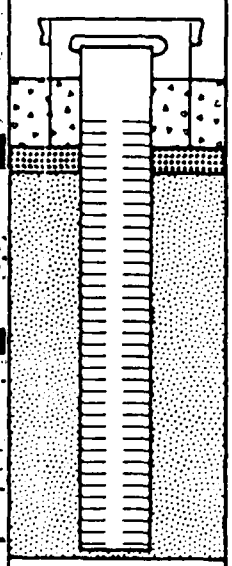
Location Coordinates 278,011 N
2,626,483 E
Filter Materials F-M SAND
Grout Type SAKRETTE
Protective Casing 4" x 3' B.D.P.
Static Water Level 5.95 Ft MSL
Top of Well Elevation 9.19 Ft MSL
Drill Type 6" RCB; MAYHEW

Sketch	Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
		0-2 FT	CLAY, SANDY. CL, ~20% VF QTZ SD, TR GRAVEL, DRY, YEL. RED (5 YR 5/8).	CL-SC	6
		2-4	CLAY, SANDY. As Above.	CL-SC	4
		4-6	SAND, SILTY. SAND, VF-F, QTZ, ~10% SLT, ~40% SH FRAGS, WET, YGL (2.5 Y 7/6).	SM	3
	0 FT	6-8	SAND, SILTY. As Above.	SM	24
	1.5 FT 1.8 FT	8-10	SAND, SILTY. As Above, EXCEPT GRAY (N5/).	SM	25
	10 FT				

SHEET 1 OF 1

Boring No. S-4I
Hole Size 6" x 10' Slot 0.010"
Screen Size 2" x 10' Mat'l PVC
Casing Size 2" x 1.4' Mat'l PVC
Geologist W. D. ADAMS
Date Start 30 JUN 84 Finish 30 JUN 84
Contractor WAR/LETCO
Driller CHUCK VEGNERON

Location Coordinates 277,972 N
2,626,635 E
Filter Materials F-M SAND
Grout Type SAKRETTE
Protective Casing 4" x 3' B.G.P.
Static Water Level 6.38 FT TOC
Top of Well Elevation 9.50 FT MSL
Drill Type 6" RCB; MAYHEW

Sketch	Depth (Feet)	Sample	Lithology	USCS	SPT (BL/FT)
	0 FT	0-2 FT	SAND, SILTY. SD, VF-F, QTZ, ~40% SLT & CL, MOIST, BRN (7.5 YR 4/4).	SM-SC	24
		2-4	CLAY, SANDY. CL, ~40% VF-F, QTZ SD, TR GRAVEL, WET, LT. GRAY (N 7/).	CL-SC	15
		4-6	CLAY, SANDY. AS ABOVE EXCEPT RED. YEL. (7.5 YR 6/8).	CL-SC	3
	1.5 FT	6-8	SHELLS, SANDY. SHELLS & SD. FRAGS, ~40% SILTY SAND. YELL.	N.A.	27
	1.8 FT	8-10	SAND, SILTY. SD, VF-F, QTZ, ~20% SLT & CL, ~20% SH. FRAGS, TR GRAVEL, WET, GRAY (N 5/).	SM-SC	27
	10 FT				

APPENDIX F

QA/QC PLAN

APPENDIX F

QA/QC PLAN

F-1.0 ANALYTICAL QUALITY CONTROL

All quality control spiking was performed by WAR. All sample analyses were performed by TBC and LLI. Each of the above organizations maintains strict QA/QC plans which are outlined in separate documents but were not appended in this report due to their length. This appendix outlines QA/QC procedures directly relevant to the Langley AFB Phase II, Stage 2 survey.

Accuracy of analytical techniques is assured by strict adherence to the methods listed in Table F-1. Integrity and representativeness of the samples are assured by sampling procedures described in Section F-2.0. A check on analytical quality control was provided by duplicating a minimum of 10 percent of the samples in each analysis lot. An additional sample was collected to provide for spiking 10 percent of the lead samples. Samples for oil and grease and VOAs were not spiked.

Duplicate and spike samples were labeled in such a way that the analytical laboratory could not identify them as duplicate or spiked samples. Results of duplicate and spike analyses are discussed in the following sections.

F-1.1 OIL AND GREASE

Duplicates--<0.1, <0.1 mg/l Mean--<0.1 mg/l

No spike

Accuracy of duplication was satisfactory for this parameter.

F-1.2 VOLATILE AROMATICS

	Duplicates	Mean
Benzene	0.5, 17.5 ug/l	9 ug/l
Toluene	1.4, 3.3	2.4
o-Xylene	2.1, 5.7	3.9

Table F-1. Analytical Chemistry Methods for Water Samples, Langley AFB, Virginia

Parameter	Method	Ref.	Detection Limit
pH*	EPA 150.1	1	--
Specific conductance*	EPA 120.1	1	--
Temperature*	EPA 170.1	1	--
Oil and grease	EPA 413.2	1	0.1 mg/l
Metals			
Lead	EPA 239.2	1	20 ug/l
Purgeable Organics			
Volatile organic aromatics	EPA 602	2	†

*Measured in the field.
†See Table 3 for detection limits (reported as "less than" values).
1--EPA "Methods for Chemical Analysis of Water and Wastes," March 1979 - method number.
2--EPA "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," July 1982 - method number.

	Duplicates	Mean
m-Xylene	<0.2, <0.2	<0.2
p-Xylene	<0.2, 1.2	0.6
Ethyl benzene	<0.2, <0.2	<0.2

With the exception of benzene, the accuracy of duplication was satisfactory for this analysis. In-house spiking procedures by the subcontracting laboratory showed recoveries of 88 and 100 percent, respectively, for the above listed replicates. Confirmation analyses were conducted per the 8 March 1984 letter from OEHL. The results of these second column analyses were, for the most part, inconclusive due to the poor separation characteristics of the second gas chromatograph (GC) column specified in EPA method 602. Presence of compounds not specified in the method (the xylenes) increased the problem of qualitative and quantitative analysis of the VOAs. As discussed in previous Phase II reports, field replication of volatile components is perhaps the most difficult task in any sampling effort.

F-1.3 LEAD

Duplicates--<0.02, <0.02 mg/l Mean--<0.02 mg/l

Spike recovery--108 percent at 0.071 mg/l

Duplication and spike recovery were satisfactory for this parameter.

F-2.0 SAMPLING INSTRUCTIONS FOR LANGLEY AFB

Descriptions of sample containers, preservation methods, and holding times are given in Table F-2. Sampling procedures are outlined below for each analysis group.

F-2.1 VOLATILE AROMATICS

This sample should come from the first aliquot of a bailer to prevent the loss of any volatiles. Avoid excess turbulence (e.g., bubbling) when filling these bottles for the same reason. Fill bottle to an inverted meniscus, cap, and refrigerate immediately. A small convex dimple in the top of the septum indicates that the bottle is properly filled. There

Table F-2. Sample Containers, Preservation Methods, and Holding Times

Parameter	Sample Type	Container/ Volume	Method of Preservation (Filtration, pH, etc.)	Holding Time
Oil and grease	W*	Glass, 1 qt. Teflon liner in cap	Conc. H_2SO_4 to pH <2, chill to 4°C	28 days
Metals (diss.)	W	Plastic, 250 ml	Filter, conc. HNO_3 to pH <2	6 months
Purgeables	W	Glass, 40 ml (4) Teflon septa	No headspace in vial, chill to 4°C	14 days

*W = Water.

Source: U.S. Environmental Protection Agency (EPA). 1982. Technical Additions to Methods for Chemical Analysis of Water and Wastes, Table 1. EPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA-600/4-82-055, December 1982.

should be no air bubbles present in the bottle. This sample is taken in duplicate in 40 milliliter (ml) glass, screw-cap vials with Teflon™ septa. Preservation is by refrigeration.

F-2.2 METALS

Metal samples from the wells should be from the first bailer following collection of VOA samples. The bottle should be filled to the very top if dissolved metals are desired and filtration is not performed immediately.

Filtration should be as follows:

1. Rinse a glass fiber filter with 20 to 30 ml of 0.5 N HNO_3 after placing the filter in the suction apparatus. Discard the rinsate.
2. Rinse the filter with 20 to 30 ml of sample. Discard the rinsate.
3. Filter the sample and return it to the bottle after rinsing the bottle with deionized water.
4. For membrane filtration, place the filter in the filtration apparatus with the gridded side up and follow Steps 1 through 3; preserve the sample with concentrated HNO_3.
5. Samples must be filtered through the 0.45-micrometer filter for analytes to be considered dissolved. Filtration through a glass fiber filter reduces "binding" of the membrane filter but may not be needed for samples with little turbidity.

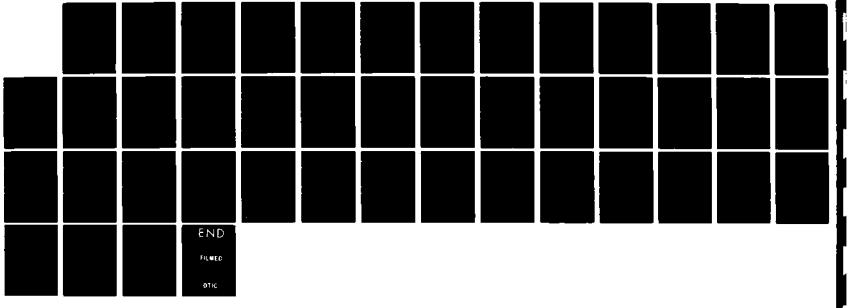
After filtration, preserve metal samples by adding 2 ml of HNO_3 per liter of sample. Mix thoroughly and check the pH by pouring a small amount of the sample on a pH test strip. If the pH is not less than 2, add more HNO_3. Refrigeration of preserved metals samples is not necessary.

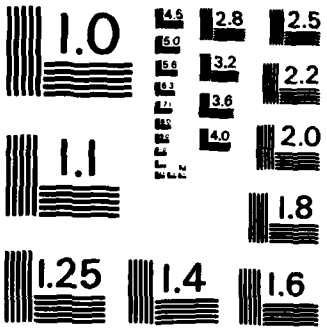
F-2.3 OIL AND GREASE

Due to the nature of the analyte, do not fill sample bottles completely. Bottles are 1-quart glass with foil-lined caps. Preserve oil and grease samples by adjusting the pH below 2 with concentrated HCl and refrigerating the sample.

AD-A161 201 INSTALLATION RESTORATION PROGRAM (IRP) PHASE II -- CONFIRMATION/QUANTIFIC..(U) WATER AND AIR RESEARCH INC GAINESVILLE FL W D ADAMS ET AL. 30 JUL 85 2/2

UNCLASSIFIED F33615-81-D-4007 F/G 13/2 NL





should be no air bubbles present in the bottle. This sample is taken in duplicate in 40 milliliter (ml) glass, screw-cap vials with Teflon™ septa. Preservation is by refrigeration.

F-2.2 METALS

Metal samples from the wells should be from the first bailer following collection of VOA samples. The bottle should be filled to the very top if dissolved metals are desired and filtration is not performed immediately.

Filtration should be as follows:

1. Rinse a glass fiber filter with 20 to 30 ml of 0.5 N HNO_3 after placing the filter in the suction apparatus. Discard the rinsate.
2. Rinse the filter with 20 to 30 ml of sample. Discard the rinsate.
3. Filter the sample and return it to the bottle after rinsing the bottle with deionized water.
4. For membrane filtration, place the filter in the filtration apparatus with the gridded side up and follow Steps 1 through 3; preserve the sample with concentrated HNO_3.
5. Samples must be filtered through the 0.45-micrometer filter for analytes to be considered dissolved. Filtration through a glass fiber filter reduces "binding" of the membrane filter but may not be needed for samples with little turbidity.

After filtration, preserve metal samples by adding 2 ml of HNO_3 per liter of sample. Mix thoroughly and check the pH by pouring a small amount of the sample on a pH test strip. If the pH is not less than 2, add more HNO_3. Refrigeration of preserved metals samples is not necessary.

F-2.3 OIL AND GREASE

Due to the nature of the analyte, do not fill sample bottles completely. Bottles are 1-quart glass with foil-lined caps. Preserve oil and grease samples by adjusting the pH below 2 with concentrated HCl and refrigerating the sample.

APPENDIX G
FIELD DATA SHEETS

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA / LBA
Date: 3 July 84
Time: 14:35

Well No.: S-4A

Sampling Location Description: Upgradient well in middle of asphalt (set flush).

Groundwater Samples

Depth to fuel product N/A

Thickness of fuel product 0

Depth to water surface 4' 6 3/4"

Height of water column ~ 5 1/2 FT

pH 7.2

Sp. cond. 260 umhos/cm @ 27.2 °C 81° F 250 µmhos/cm @ 25°C

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16039, 16032
250 ml plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos	16041,	16039, 16032*
40 ml glass (2)	VOA	Chill to 4°C	14 days		16039, 16032

Comments and additional observations: Water initially clear, then slightly turbid. No odor.

* SPIKED 16032 @ 200 µl of Pb-SPIKING SOLN.

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA / LBA
Date: 3 July 84
Time: 15:10

Well No.: S-4B

Sampling Location Description: In asphalt parking lot (set flush) closest to Bldg. 764.

Groundwater Samples

Depth to fuel product 4' 3 1/4"

Thickness of fuel product ~0.91'

Depth to water surface 5' 1 1/4"

Height of water column ~5 FT

pH 6.2

Sp. cond. 460 umhos/cm @ 27.2°C 81°F 440 umhos @ 25°C

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16036
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16036
40 ml glass (2)	VOA	Chill to 4°C	14 days		16036

Comments and additional observations: Strong fuel smell; sample included droplets of fuel.

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA / LBA
Date: 3 3/4 84
Time: 1615

Well No.: S-4C

Sampling Location Description: West edge of old parking lot.

Groundwater Samples

Depth to fuel product 5'11"

Thickness of fuel product ~ 3/4"

Depth to water surface 5' 11 3/4"

Height of water column ~ 5 1/2 FT

pH 7.1

Sp. cond. 420 umhos/cm @ 24.4°C 76°F 425 µmhos/cm @ 25°

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16035
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16035
40 ml glass (2)	VOA	Chill to 4°C	14 days		16035

Comments and additional observations: Clear, odorless.

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA / LBA
Date: 3 July 94
Time: 1650

Well No.: S-4D

Sampling Location Description: Second well west of old parking lot.

Groundwater Samples

Depth to fuel product 5' 3 1/2"

Thickness of fuel product ~ 1"

Depth to water surface 5' 4 1/2"

Height of water column ~ 6 FT

pH 6.9

Sp. cond. 720 umhos/cm @ 21.7 °C 71° F 770 umhos/cm @ 25°C

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16033
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16033
40 ml glass (2)	VOA	Chill to 4°C	14 days		16033

Comments and additional observations: Water moderately turbid, brown, odorless. Recharged slowly.

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA/LBA
Date: 3 July 84
Time: 1729

Well No.: S-48E

Sampling Location Description: Third well west of old packing lot.

Groundwater Samples

Depth to fuel product 5' 3 1/4"

Thickness of fuel product ~ 3/8" (?)

Depth to water surface 5' 3 5/8"

Height of water column ~ 6 1/2 FT

pH 7.0

Sp. cond. 690 umhos/cm @ 25 °C 77° F 690 um-hos/cm

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16037
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16037
40 ml glass (2)	VOA	Chill to 4°C	14 days		16037

Comments and additional observations: Water slightly turbid, brown, odorless. Fast recharge.

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA / LBA
Date: 3 July 94
Time: 1906

Well No.: S-4F

Sampling Location Description: Fourth well west of old parking lot.

Groundwater Samples

Depth to fuel product 4' 0 1/4"

Thickness of fuel product ~1' 5 3/8"

Depth to water surface 5' 5 5/8"

Height of water column ~6 1/2 FT

pH 6.9

Sp. cond. 570 umhos/cm @ 24.4 °C 76°F 575 umhos/cm

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16039
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16038
40 ml glass (2)	VOA	Chill to 4°C	14 days		16038

Comments and additional observations: Water slightly turbid, brown, strong fuel odor

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA/LBA
Date: 3 July 84
Time: 1340

Well No.: S-4G

Sampling Location Description: Southwest corner of Nealy Ave. & _____ St.

Groundwater Samples

Depth to fuel product N. A.

Thickness of fuel product Ø

Depth to water surface 5' 10 3/8"

Height of water column ~6 1/2 FT

pH 7.3

Sp. cond. 430 umhos/cm @ 22.5 °C 72.5° F 450 µmhos/cm @ 25°C

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		#16040
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16040
40 ml glass (2)	VOA	Chill to 4°C	14 days		16040

Comments and additional observations: Water is moderately turbid, brown, & odorless.

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA/LBA
Date: 3 July 94
Time: 13:00

Well No.: S-4H

Sampling Location Description: 50 ft. west of new parking lot, south of Healy Ave.

Groundwater Samples

Depth to fuel product 5 FT 3 7/8 IN + ~ 1/4 IN

Thickness of fuel product 0 1/2 IN (?)

Depth to water surface 5FT 11 5/8 IN

Height of water column ~6 1/2 FT

pH 7.3

Sp. cond. 460 umhos/cm @ 22.5 °C 72.5° F 485 umhos/cm @ 25°C

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16031
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16031
40 ml glass (2)	VOA	Chill to 4°C	14 days		16031

Comments and additional observations: Water clear then moderately turbid, brown; no odor.

LANGLEY AFB FIELD SAMPLE SHEET

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, FL 32602
Phone: 904/372-1500

Project: Langley AFB IRP, STAGE II
Project No.: 7166-150
Sampled by: WDA / LBA
Date: 3 July 84
Time: 11:37

Well No.: S-41

Sampling Location Description: South of new parking lot.

Groundwater Samples

Depth to fuel product N/A

Thickness of fuel product 0

Depth to water surface 6 FT 4½ IN

Height of water column ~5 FT

pH 7.1

Sp. cond. 420 umhos/cm @ 21.4 °C 70.5° F 1450 [illegible]

Container	Parameters to be Analyzed	Preservation Method	Holding Times	Container No.	Sample No.
1 qt. glass	Oil & Grease	H_2SO_4 to pH<2,4°C	28 days		16034
1 l plastic	Lead	Filter, then HNO_3 to pH<2,4°C	6 mos		16034
40 ml glass (2)	VOA	Chill to 4°C	14 days		16034

Comments and additional observations: Water clear, no odor.

NOTICE

As discussed in Section 3.2.3, wells S-4E, S-4F, S-4G, and S-4H were resampled on July 16, 1984 to replace five broken VOA containers. Resampling was performed by The Bionetics Corporation (TBC) of Hampton, Virginia, which at this time, was relocating its laboratory offices. The files containing field data sheets and chain of custody records for the July 16, 1984 resampling were misplaced during the move; consequently, those records are not available for inclusion in this report.

APPENDIX H

CHAIN OF CUSTODY RECORD

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, Florida 32602

CHAIN OF CUSTODY RECORD

CLIENT: Langley AFB
PROJECT: 7166-150

SAMPLERS: (Signature)
Wm. D. Adams

Station Number	Station Location	Date	Time	Sample Type and No.			WAR Sample No.	Analysis Required
				Water	Air	Sediment		
314672	Two 40-ml vial samples each No.	3 Jul 91		X			16031	EPA Method 602 Volatile org. aromatics
673		"		X			16032	" " "
674		"		X			16033	" " "
675		"		X			16034	" " "
676		"		X			16035	" " "
677		"		X			16036	" " "
678		"		X			16037	" " "
679		"		X			16038	" " "
680		"		X			16039	" " "
[redacted]		"		X	BROKEN		16040	" " "
	* Holding time 7 days							

Relinquished by: Wm. D. Adams Organization: W.A.R.	Received by: Robert O'Rourke Organization: THE BIONETICS CORP	Date/Time 7/3 1929
Relinquished by: Robert O'Rourke Organization: THE BIONETICS CORP	Received by: Beth Monarch Organization: LANCASTER LAB	Date/Time 7/6 1030
Relinquished by: Organization:	Received by: Organization:	Date/Time
Relinquished by: Organization:	Received by: Organization:	Date/Time
Relinquished by: Organization:	Received for Laboratory by:	Date/Time

Method of Shipment:

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, Florida 32602

CHAIN OF CUSTODY RECORD

CLIENT: Langley AFB
PROJECT: 7166-150

SAMPLERS: (Signature)
Wm. D. Adams

Station Number	Station Location	Date	Time	Sample Type and No.			WAR Sample No.	Analysis Required
				Water	Air	Sediment		
		3 Jul 84		X			16031	EPH Method Lead 239.2
		"		X			16032	"
		"		X			16033	"
		"		X			16034	"
		"		X			16035	"
		"		X			16036	"
		"		X			16037	"
		"		X			16038	"
		"		X			16039	"
		"		X			16040	"
		"		X			16041	"
	* Holding time 6 months							

Relinquished by: Wm. D Adams Organization: W.A.R.	Received by: Organization: THE BIONETICS CORP.	Date/Time 7/3 1929
Relinquished by: Organization:	Received by: Organization:	Date/Time
Relinquished by: Organization:	Received by: Organization:	Date/Time
Relinquished by: Organization:	Received by: Organization:	Date/Time
Relinquished by: Organization:	Received for Laboratory by:	Date/Time
Method of Shipment:		

Water and Air Research, Inc.
6821 S.W. Archer Road
P.O. Box 1121
Gainesville, Florida 32602

CHAIN OF CUSTODY RECORD

CLIENT: Langley AFB
PROJECT: 7166-150

SAMPLERS: (Signature) Wm. D. Adams

Station Number	Station Location	Date	Time	Sample Type and No.			WAR Sample No.	Analysis Required
				Water	Air	Sediment		
		3 Jul 84		X			16031	[illegible] Method 413.0 Oil + Grease
		"		X			16032	" " "
		"		X			16033	" " "
		"		X			16034	" " "
		"		X			16035	" " "
		"		X			16036	" " "
		"		X			16037	" " "
		"		X			16038	" " "
		"		X			16039	" " "
		"		X			16040	" " "
				X				
	* Holding time	28 days						

Relinquished by / Organization	Received by / Organization	Date/Time
Relinquished by: Wm. D. Adams Organization: W.A.R.	Received by: [illegible] Organization: [illegible] Corp.	7/3 | 1929
Relinquished by: Organization:	Received by: Organization:	
Relinquished by: Organization:	Received by: Organization:	
Relinquished by: Organization:	Received by: Organization:	
Relinquished by: Organization:	Received for Laboratory by:	

Method of Shipment:

NOTICE

As discussed in Section 3.2.3, wells S-4E, S-4F, S-4G, and S-4H were resampled on July 16, 1984 to replace five broken VOA containers. Resampling was performed by The Bionetics Corporation (TBC) of Hampton, Virginia, which at this time, was relocating its laboratory offices. The files containing field data sheets and chain of custody records for the July 16, 1984 resampling were misplaced during the move; consequently, those records are not available for inclusion in this report.

APPENDIX I

LABORATORY REPORTS

the bionetics corporation

20 RESEARCH DRIVE
HAMPTON, VIRGINIA 23666
TELEPHONE: (804) 865-0880

REPORT OF ANALYSIS

TO: Water & Air Research, Inc.
6821 S. W. Archer Rd.
P.O. Box 1121
Gainesville, FL 32602
ATTN: Bill Adams

DATE: July 18, 1984

SAMPLE OF Water SAMPLE RECEIVED July 3, 1984

MARKED Langley AFB Project 7166-150

Sample I.D.	Code	Oil & Grease, mg/l*
16031	33674	<0.1
16032	33673	<0.1
16033	33672	<0.1
16034	33675	<0.1
16035	33676	<0.1
16036	33677	0.2
16037	33678	<0.1
16038	33679	<0.1
16039	33680	<0.1
16040	33681	<0.1

*Analysis was performed according to EPA method 413.2

LABORATORY ANALYSIS NO. _____

RESPECTFULLY SUBMITTED,
LABORATORY MANAGER

the bionetics corporation

20 RESEARCH DRIVE
HAMPTON, VIRGINIA 23666
TELEPHONE: (804) 865-0880

REPORT OF ANALYSIS

TO: Water & Air Research, Inc.
6821 S. W. Archer Rd.
P.O. Box 1121
Gainesville, FL 32602
ATTN: Bill Adams

DATE: July 18, 1984

SAMPLE OF Water SAMPLE RECEIVED July 3, 1984

MARKED Langley AFB Project 7166-150

Sample I.D.	Code	Lead,mg/l*
16031	33657	<0.02
16032	33658	0.077
16033	33668	<0.02
16034	33659	<0.02
16035	33669	<0.02
16036	33660	<0.02
16037	33670	<0.02
16038	33671	<0.02
16039	33661	<0.02
16040	33662	<0.02
16041	33663	<0.02

*Analysis was performed according to EPA method 239.2

LABORATORY ANALYSIS NO. _____

RESPECTFULLY SUBMITTED,
LABORATORY MANAGER

07:57:33- 76863 - 9 - 1 Y D WK2 108

ANALYSIS REPORT

S-4A

Lancaster Laboratories, Incorporated

LLI Sample No. WW 314673

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

16032 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0700(
Ethyl Benzene	< 0.0002	ppm	999-049-0050(
BTEX 2nd Column Confirm.	see below		999-070-0000(

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

The American Association for Laboratory Accreditation Chemical & Biological Fields of testing

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656 2301

FRANKLIN DIVISION

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Environmental Prog.

REP

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No WW 314673

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16032 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED	
ortho-Xylene		0.0057 ppm
meta-Xylene	<	0.0002 ppm
para-Xylene		0.0012 ppm
Benzene		0.0175 ppm
Toluene		0.0033 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

Due to chromatographic difficulties on the confirmation column, the data obtained precluded drawing meaningful conclusions as to the presence of purgeable aromatic compounds.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

The American Association for Laboratory Accreditation
Chemical & Biological fields of testing

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
5424 Butler Pike East Whitehall Pa 18052 • (215) 264-[illegible]

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

07:57:52- 76863 - 9 - 1 Y D WK2 108

ANALYSIS REPORT

S-4A

Lancaster Laboratories

LLI Sample No. WW 314680

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16039 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0700(
Ethyl Benzene	< 0.0002	ppm	999-049-0050(
			999-070-0000(

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

Reviewed and Approved by:
Nelson H. Risser, B.A.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301
FRANKLIN DIVISION

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No WW 314680

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

16039 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED	
ortho-Xylene		0.0021 ppm
meta-Xylene	<	0.0002 ppm
para-Xylene	<	0.0002 ppm
Benzene		0.0005 ppm
Toluene		0.0014 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • [illegible]

FRANKLIN DIVISION
[illegible]

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

07:57:44- 76863 - 9 - 1 Y D WK2 108

ANALYSIS REPORT

S-4B

Lancaster Laboratories

LLI Sample No. WW 314677

Bionetics Corporation
20 Research Drive
Hamptron, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

16036 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0700
Ethyl Benzene	1.02	ppm	999-049-0050
BTEX 2nd Column Confirm.	see below		999-070-0000

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-
FRANKLIN DIVISION

Reviewed and Approved by:
Nelson H. Risser, D.A.

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No WW 314677

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

16036 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED	
ortho-Xylene	1.66	ppm
meta-Xylene	< 0.01	ppm
para-Xylene	4.19	ppm
Benzene	6.18	ppm
Toluene	6.70	ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

Due to chromatographic difficulties on the confirmation column, the obtained data precluded drawing meaningful conclusions as to the presence of purgeable aromatic compounds.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

MAIN LABORATORY
2425 New Holland Pike, Lancaster, Pa. 17601 • (717) 656-2301
FRANKLIN DIV...

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

07:57:42- 76863 - 9 - 1 Y D WK2 10B

ANALYSIS REPORT

S-4C

Lancaster Laboratories

LLI Sample No. WW 314676

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

16035 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0700
Ethyl Benzene	< 0.0002	ppm	999-049-0050
BTEX 2nd Column Confirm.	see below		999-070-0000

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301
FRANKLIN DIVISION
5134 B[illegible] Pike East Wagontown Pa 19382 • (215) [illegible]

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prep

REP

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No WW 314676

Date Reported 7/27/84
Date Submitted 7/ 6/84
Discard Date 8/ 3/84
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16035 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED	
ortho-Xylene		0.0089 ppm
meta-Xylene	<	0.0002 ppm
para-Xylene		0.0756 ppm
Benzene		0.0994 ppm
Toluene		0.0041 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

Due to chromatographic difficulties on the confirmation column, the obtained data precluded drawing meaningful conclusions as to the presence of purgeable aromatic compounds.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

The American Association for Laboratory Accreditation
Chemical & Biological Tests of Texas

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
[illegible]

Member American [illegible]

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

07:57:36- 76863 - 8 - 1 Y D WK2 108

ANALYSIS REPORT

S-4D

Lancaster Laboratories, INCORPORATED

LLI Sample No. WW 314674

Biomedics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

16033 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0700(
Ethyl Benzene	< 0.0002	ppm	999-049-0050(

1 COPY TO Biomedics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

The American Association for Laboratory Accreditation
Chemical & Biological Testing

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
5424 Brambleton Ave. East Waynesboro Pa 17268 • (717) 762-2181

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No WW 314674

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16033 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED	
ortho-Xylene	<	0.0002 ppm
meta-Xylene		0.0003 ppm
para-Xylene	<	0.0002 ppm
Benzene		0.0002 ppm
Toluene	<	0.0002 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

MAIN LABORATORY
2425 New Holland Pike, Lancaster, Pa. 17601 • (717) 656-2301
FRANKLIN DIVISION

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prod.

ANALYSIS REPORT

S-4E

Lancaster Laboratories

LLI Sample No. WW 316552

Date Reported 7/30/84
Date Submitted 7/17/84
Discard Date 8/ 6/84
P. O. No.
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16037 Water Sample
Collected 7/16/84

ANALYSIS	AS RECEIVED	LAB CODE
BTEX 2nd Column Confirm.	see below	999-070-0750(

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics. See comments on LLI Report 316551.

Compound	Observed on 2nd Column
Benzene	yes
Toluene	yes
Ethyl Benzene,p-Xylene,m-Xylene	yes
o-Xylene	yes

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171

Respectfully submitted
Lancaster Laboratories, Inc.

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301
FRANKLIN DIVISION
5403 Buchanan Trail East Waynesboro Pa 17268 • (717) 762-2181

07:57:48- 76863 - 9 - 1 Y D WKP 108

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No. WW 314678

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

16037 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-070-0
Ethyl Benzene	0.0002	ppm	999-049-00500
			999-070-00030

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301
FRANKLIN DIVISION
5424 B... Pa ... Wyndmoor Pa ... •

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

ANALYSIS REPORT

Lancaster Laboratories, INCORPORATED

LLI Sample No WW 314678

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

16037 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED
ortho-Xylene	0.0009 ppm
meta-Xylene	< 0.0002 ppm
para-Xylene	0.0102 ppm
Benzene	0.0197 ppm
Toluene	0.0018 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

The American Association for Laboratory Accreditation
Chemical & Biological Tests of Clothing

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
[illegible]

Member [illegible]

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

ANALYSIS REPORT

S-4F

Lancaster Laboratories

LLI Sample No. WW 316553

Date Reported 7/30/84
Date Submitted 7/17/84
Discard Date 8/ 6/84
P. O. No.
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16038 Water Sample
Collected 7/16/84

ANALYSIS	AS RECEIVED	LAB CODE
BTEX 2nd Column Confirm.	see below	999-070-075

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics. See comments on LLI Report 316551.

Compound	Observed on 2nd column
Benzene	yes
Toluene	yes
Ethyl Benzene,p-Xylene,m-Xylene	yes
o-Xylene	yes

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171

Respectfully submitted
Lancaster Laboratories, Inc.

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
[illegible]

07:57:50- 76863 - 9 - 1 Y D WK2 108

ANALYSIS REPORT

Lancaster Laboratories, Incorporated

LLI Sample No. WW 314679

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16038 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0700
Ethyl Benzene	0.016	ppm	999-049-0050
			999-070-0000

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
5424 Bochanan Trail East Waynesboro Pa 17268 • (717) 762-7191

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prep

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No WW 314679

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

16038 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED
ortho-Xylene	0.0567 ppm
meta-Xylene	0.121 ppm
para-Xylene	0.108 ppm
Benzene	0.428 ppm
Toluene	0.122 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
[illegible] Pa 17268 • [illegible]

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Proc.

08:15:33- 77591 - 4 - 1 Y D WLK 429

ANALYSIS REPORT

S-46

Lancaster Laboratories

LLI Sample No. WW 316554

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/27/84
Date Submitted 7/17/84
Discard Date 8/ 3/84
P. O. No.
Collected by Client

16040 Water Sample
Collected 7/16/84

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-070-0700(
Ethylbenzene	< 0.0002	ppm	999-070-0050(

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171

Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
[illegible]

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

ANALYSIS REPORT

Lancaster Laboratories, Inc.

LLI Sample No WW 316554

Date Reported 7/27/84
Date Submitted 7/17/84
Discard Date 8/ 3/84
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16040 Water Sample
Collected 7/16/84

BTX Scan	AS RECEIVED
ortho-Xylene	< 0.0002 ppm
meta-Xylene	< 0.0002 ppm
para-Xylene	< 0.0002 ppm
Benzene	0.0002 ppm
Toluene	< 0.0002 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 1760[illegible]

FRANKLIN DIVISION
[illegible]

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

09:20:59- 77591 - 1 - 0 Y D WLK 429 REP

ANALYSIS REPORT

S-4H

Lancaster Laboratories

LLI Sample No. WW 316551

Date Reported 7/30/84
Date Submitted 7/17/84
Discard Date 8/ 6/84
P. O. No.
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16031 Water Sample
Collected 7/16/84

ANALYSIS	AS RECEIVED	LAB CODE
BTEX 2nd Column Confirm.	see below	999-070-0750(

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics. The confirmation column used is the second column recommended in the above method. Method 602 does not include xylene as one of the test parameters. It was observed that ethyl benzene, meta-xylene, and para-xylene elute too closely to make qualitative evaluations of a peak eluting in a sample chromatogram at their retention time. The observed peaks are also broader which leads to higher detection limits than those obtainable on the primary analytical column. The following table indicates which compounds were detected on the confirmation column.

Compound	Observed on 2nd Column
Benzene	yes
Toluene	no
Ethyl Benzene,p-Xylene,m-Xylene	yes
o-Xylene	yes

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171

Respectfully submitted
Lancaster Laboratories, Inc.

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

07:57:31- 76863 - 9 - 1 Y D WK2 108

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No. WW 314672

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

16031 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0760
Ethyl Benzene	0.0006	ppm	999-049-0050
			999-070-0000

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

The American Association for Laboratory Accreditation
Chemical & Biological Tests of Testing

Prep 0.00 Total 75.00 2171 Respectfully submitted
Lancaster Laboratories, Inc.

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656 2301

FRANKLIN DIVISION
5424 Baltimore Pike East Avondale Pa 19311 • (215) 268-2301

Member American Council of Independent Laboratories

Reviewed and Approved by:
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prep

ANALYSIS REPORT

Lancaster Laboratories, INCORPORATED

LLI Sample No WW 314672

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

16031 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED
ortho-Xylene	0.0030 ppm
meta-Xylene	0.0015 ppm
para-Xylene	0.0028 ppm
Benzene	0.0074 ppm
Toluene	0.0036 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
5424 Baltimore Pike Philadelphia Pa 19143 • (215) 727-2000

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

14:08:45- 76863 - 1 - 1 Y D WK2 108 REP

ANALYSIS REPORT

S-4I

Lancaster Laboratories INCORPORATED

LLI Sample No. WW 314675

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
P. O. No.
Collected by Client

16034 Collected on 6/3/84
Water Sample

ANALYSIS	AS RECEIVED		LAB CODE
BTX Scan		attached	516-049-0700(
Ethyl Benzene	< 0.0002	ppm	999-049-0050(

1 COPY TO Bionetics Corporation Attn: Peter T. Poherence

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Prep 0.00 Total 75.00 2171

Respectfully submitted
Lancaster Laboratories, Inc.

Reviewed and Approved by:
Nelson H. Risser, B.A.

REP

ANALYSIS REPORT

Lancaster Laboratories INCORPORATED

LLI Sample No WW 314675

Date Reported 7/26/84
Date Submitted 7/ 6/84
Discard Date 8/ 2/84
Collected by Client

Bionetics Corporation
20 Research Drive
Hampton, VA 23666

16034 Collected on 6/3/84
Water Sample

BTX Scan	AS RECEIVED	
ortho-Xylene	<	0.0002 ppm
meta-Xylene	<	0.0002 ppm
para-Xylene	<	0.0002 ppm
Benzene	<	0.0002 ppm
Toluene	<	0.0002 ppm

The conditions of the BTX analysis are according to EPA Method 602 - Purgeable Aromatics.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

MAIN LABORATORY
2425 New Holland Pike Lancaster Pa 17601 • (717) 656-2301

FRANKLIN DIVISION
5424 Buchanan Trail East Waynesboro Pa 17268 • (717) 762-2181

Respectfully submitted,
Lancaster Laboratories, Inc.

Reviewed and Approved by
Nelson H. Risser, B.A.
Tech. Assoc. Instrumental Prog

END

FILMED

12-85

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