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CONFIRMATION/QUANTIFICATION STAGE 1 BERGSTROM AFB TEXAS

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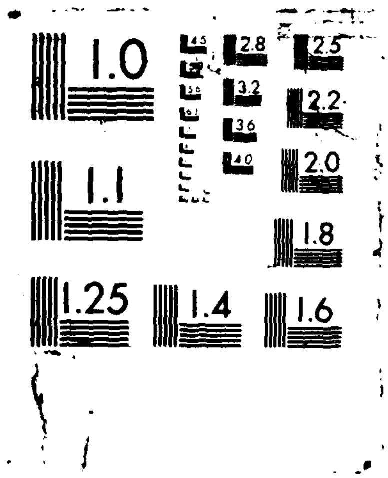
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INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE I - FINAL REPORT
VOLUME I

BERGSTROM AIR FORCE BASE, TEXAS 78743

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Post Office Box 9948
8501 Mopac Blvd.
Austin, Texas 78766-0948

April 1987

Final Report, March 1984 - August 1986

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The Department of Defense's Installation Restoration Program (IRP) is a four-phase program to identify past waste disposal practices, evaluate environmental impacts, propose mitigation measures, and remediate environmental problems. Phase I of the IRP is an initial assessment and records search to locate potential environmental problems associated with waste disposal practices. The Bergstrom AFB Phase I program was completed in July 1983. Radian Corporation of Austin, Texas performed Phase II (Confirmation/Quantification). This phase, managed by the U.S. Air Force Occupational and Environmental Health Laboratory (USAFOEHL), investigated eleven sites at Bergstrom AFB that could have potential environmental contamination due to waste disposal practices.

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The Phase II field study was conducted between March 1984 and August 1986. The investigation focused on whether environmental contamination had occurred, the magnitude and extent of the contamination, and the environmental consequences of migrating pollutants. The Phase II field study also provided recommendations for further study. Nine coreholes were drilled in order to collect and chemically analyze soils and groundwater and to assess the hydrogeologic conditions. Nine groundwater monitoring wells were ~~also~~ drilled, ~~installed,~~ and sampled. Where appropriate, two rounds of groundwater samples were collected and analyzed for parameters indicative of potential pollution.

Contaminants were detected in the soil and groundwater at most of the sites. In some cases, inorganic compounds in the groundwater exceeded regulatory standards, and in other cases, organic compounds exceeded EPA guidelines. The contaminants detected in the highest quantities in the groundwater were lead and benzene. However, the shallow groundwater at the base is not used for drinking water. Shallow groundwater use outside the base is unknown, but it is not believed to include drinking water supplies. Additionally, the existing aquifers are thin and discontinuous on the base so that no known immediate threat to human health exists.

Each of the eleven sites was categorized according to Air Force criteria: Category I - no further investigation required, Category II - additional work needed, or Category III - institute remedial action. All sites were Category II.

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INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 1

FINAL REPORT
VOLUME 1

FOR

BERGSTROM AIR FORCE BASE, TEXAS 78235

HEADQUARTERS, TACTICAL AIR COMMAND
LANGLEY AIR FORCE BASE, VIRGINIA 23665

APRIL 1987

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NOTICE

This report has been prepared for the United States Air Force by Radian Corporation, Austin, Texas, for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the United States Air Force, nor the Department of Defense.

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PREFACE

Radian Corporation is the contractor for the Installation Restoration Program, Phase II (Stage 1) investigation at Bergstrom Air Force Base, Texas. The work was performed under USAF Contract No. F33615-83-D-4001, Delivery Order 0011.

The field work consisted of the installation of nine groundwater monitoring wells; groundwater sampling from eight of the wells and air sampling from one well; groundwater sampling from one previously existing well; coring and sampling of shallow soils from six sites; air sampling of underground utilities at one site; and acoustic emission testing of a JP-4 pipeline.

The purpose of the investigation was to determine if environmental contamination had resulted from previous waste disposal practices or, in one case, from a suspected JP-4 pipeline leak. In addition, the investigation included; an estimate of the magnitude and extent of any contamination; the identification of environmental consequences of any migrating pollutants; and recommendations to mitigate any possible pollution problems.

Key Radian project personnel were:

o	Thomas W. Grimshaw	Delivery Order Manager
o	Rick A. Belan	Project Director & Co-Author
o	E. Wayne Pearce	Principal Author
o	William M. Little	Technical Reviewer
o	Peter A. Waterreus	Sampling Coordinator & Co-author
o	Jenny B. Chapman	Co-author
o	Jill P. Rossi	Cartographer

Radian would like to acknowledge the cooperation of the Bergstrom Air Force Base Bioenvironmental Engineering and Civil Engineering Staffs, especially the assistance provided by First Lieutenant Victoria Reimer.

The work was accomplished between March 1984 and August 1986. Captain Maria R. LaMagna, Technical Services Division, USAF Occupational and Environmental Health Laboratory, was the Technical Program Manager.

Approved:

Francis J. Smith, P.E.
Contract Program Manager

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SUMMARY

Background and Purpose

The Department of Defense (DOD) is conducting a nationwide program to evaluate waste disposal practices on DOD property, to control the migration of hazardous contaminants, and to control hazards that may result from waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Records Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Remedial Actions. The United States Air Force (USAF) in March 1984 initiated an IRP investigation at Bergstrom Air Force Base near Austin, Texas. USAF contracted with Radian Corporation to conduct the Phase II (Stage 1) Field Evaluation for Bergstrom Air Force Base (AFB) under Contract No. F33615-83-D-4001, Delivery Order 0011.

Phase I studies for the Bergstrom AFB Installation Restoration Program were completed in July 1983. The purpose of the Phase I study was to conduct a records search for the identification of past waste disposal activities which may have caused groundwater contamination and the migration of contaminants off-base.

Twenty-six disposal or spill sites were identified as possibly containing hazardous waste during the Phase I study. Of these sites twenty-four were selected for environmental rating. The potential for adverse environmental consequences at each site was then evaluated and rated using the USAF Hazard Assessment Rating Methodology (HARM). The rating was based on the potential environmental contamination and migration of contaminants. This system took into account such factors as the site environmental setting, the nature of the wastes present, past waste disposal practices, and the potential for contaminant migration.

Ten of the twenty-four Phase I sites were selected for Phase II (Stage 1) studies. In addition, an eleventh site was added when an Air Force corrosion team discovered a possible leak at a JP-4 pipeline. The IRP Phase II studies are for contaminant confirmation and quantification, which is executed in a staged approach. Stage 1 is the initial part of the investigation to confirm a contamination problem. Based upon the results of the Stage 1 activities, additional investigations may be needed for quantification of contaminants, which may require one or more successive stages.

The purpose of the Phase II (Stage 1) investigation was to determine if environmental contamination had resulted from waste disposal and other activities at Bergstrom AFB. In addition, the purpose of the investigation included an estimate of the magnitude and extent of contamination, the identification of environmental consequences of migrating pollutants, and the recommendation of additional investigations to identify the magnitude, extent, and direction of movement of discovered contaminants.

Authorization for conducting the Phase II (Stage 1) program was provided in the Delivery Order dated 22 February 1984. Field activities were conducted from 19 March to 11 April 1984 and from 9 to 15 January 1985. The field work consisted of coring and sampling of soil; installation of groundwater monitoring wells; sampling from permanent and temporary monitoring wells; ambient air sampling from underground utilities; and acoustic emission testing along a JP-4 pipeline.

Location and Site Descriptions

Bergstrom AFB is located on approximately 4,000 acres of land in Travis County, Texas, 7 miles southeast of the center of the city of Austin (Figure 1). The base is bordered to the north and east by State Highway 71, to the west by U.S. Highway 183, and to the south and southeast by used and unused cropland.

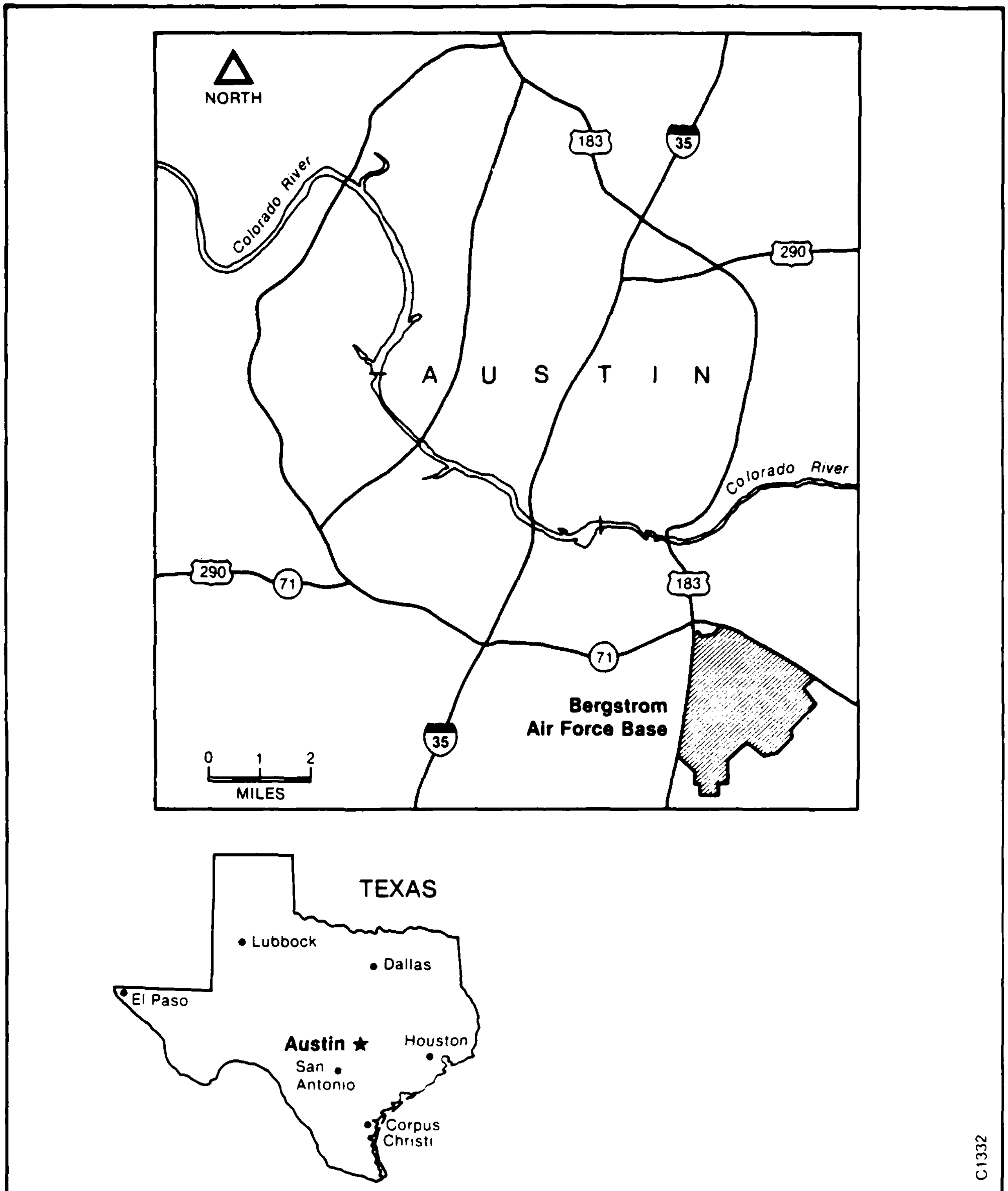

Figure 1. General Location of Bergstrom AFB, Texas

Phase II (Stage 1) work at Bergstrom AFB focused on the eleven sites shown in Figure 2. These sites consist of landfills, a drainage ditch, a road oiling area, a fire training area, and spill sites. The following paragraphs, which are based on the Phase I report (CH2M Hill, 1983), are brief descriptions of the Phase II sites. The descriptions are presented in the order used in the statement of work.

Site 17. South Fork Drainage Ditch

The South Fork Drainage Ditch has provided major drainage for Apron A, the fuel hydrant area of Apron B, and some of the industrial shop areas since the construction of the base in 1942. Prior to the installation of an oil/water separator near the head of the ditch in 1981, fuels and oils could flow through the ditch and off-base, soak into the ground along the ditch, or evaporate. The oil/water separator has prevented the escape of fuel and oil from the base and reduced the ground area subject to potential contamination.

Site 13. MOGAS Spill at Motor Pool

MOGAS (motor gas) spills occurred periodically in the Motor Pool area from 1974 to 1978. The spills were located between vehicle fueling stands 1803 and 1804 and occurred during the filling of two underground storage tanks. The spills ceased in 1978 when a proper connection was established between the fill lines and filler pipes. Previously, each time a tank was filled, fuel was lost through a connection. All spills soaked into the gravel-covered ground and no known attempts were made to recover the fuel. Total spillage from 1974 to 1978 was estimated to be 1,600 to 3,200 gallons.

Site 23. Fire Training Area

The Fire Training Area is located at the south end of the base next to Taxiway 9. Based on available information, training activities have always been conducted at the present Site No. 23. Fire training activities have been

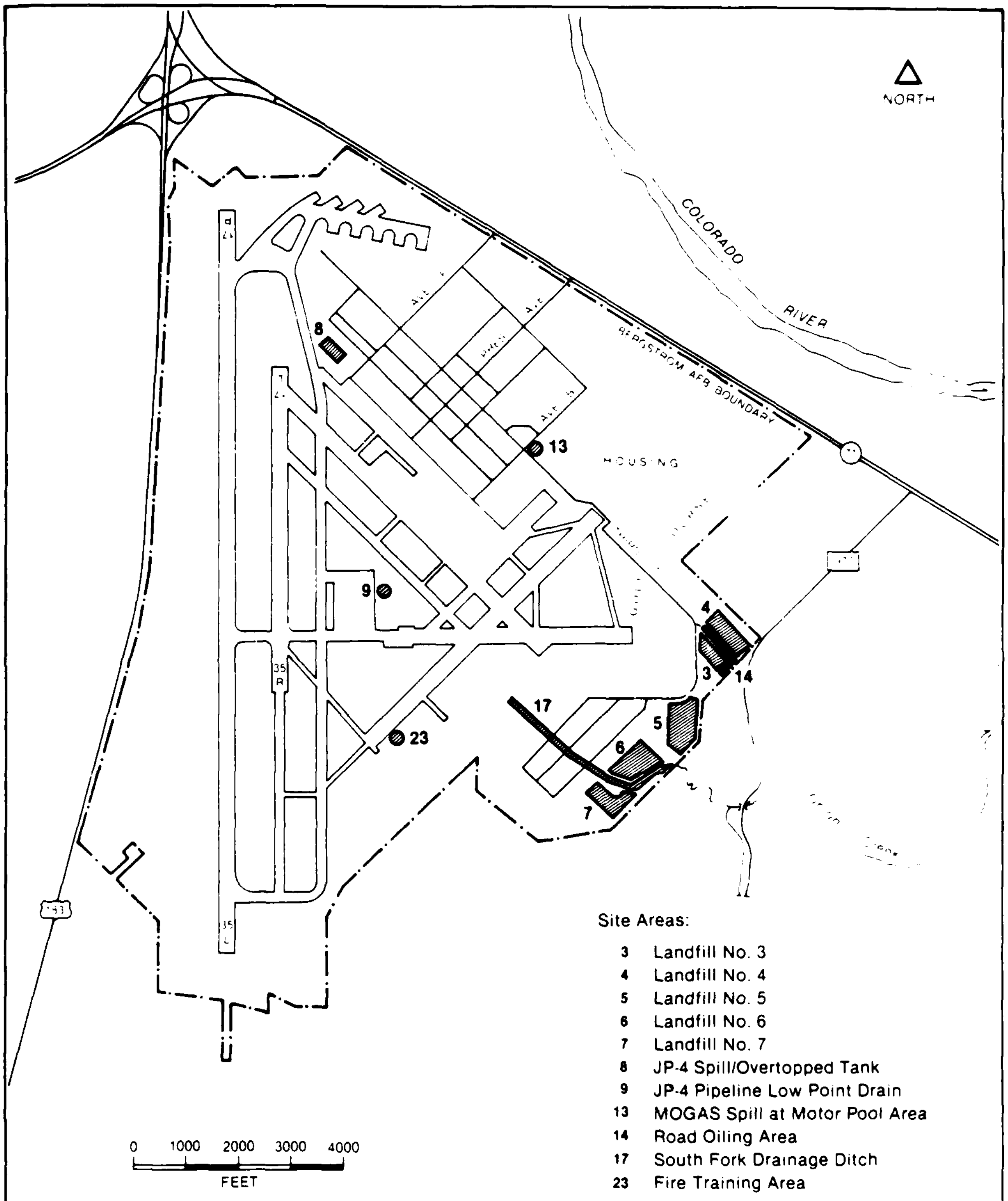

Figure 2. Location of IRP Phase II (Stage 1) Study Sites, Bergstrom AFB, Texas

Source: Base records

common since the activation of the Base in the 1940s. The active fire pit is an unlined circular pit, 120 feet in diameter, surrounded by a dirt berm. In 1982, a new limestone base was installed and a drain and oil/water separator were connected to the sanitary sewer to collect and pre-treat runoff. Most potential contaminants would have been consumed in the fires. However, some direct infiltration of fuels, waste oils and spent solvents into the ground is assumed, especially before the practice of water presaturation of the ground was begun in 1982.

Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

The site consists of Landfill Nos. 3, 4, 5, 6, and 7. All of these landfills are located on the southeast side of Bergstrom AFB in the area of the South Fork Drainage Ditch. These areas are considered a single site because of the proximity of the landfills to each other and the similarity in the type of waste disposed of at each landfill. The individual landfills were operational for 4 to 8 years each. The time interval that the Combined Southeast Landfill was active was 1957 to 1980. The landfills received primarily domestic solid waste and construction rubble. Rinsed and punctured pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents are also suspected of having been buried at these sites. Also included in the combined Southeast Landfill area is site No. 14, an old road oiling area, described below.

Site 14 was a road oiling area which was active from the mid-1950s to 1962. The road is a one-half mile extension of Third Street between Landfill Nos. 3 and 4 along the southeast side of Landfill No. 3. The waste oils came from the industrial shops located in the flightline areas. Oil was dispensed from a spreader bar on the back of a 150- to 500-gallon bowser. Reportedly, two times per year up to 300 gallons of waste oil may have been spread on the road. Over an approximate seven year period, 4,200 gallons would have been spread over the unimproved road.

Site 8. JP-4 Spill/Overtopped Tank Area

Site No. 8, at the POL (petroleum, oils and lubricants) bulk storage area (Facility No. 513), was the site of a tank-filling accident in 1975 that resulted in the loss of 2,000 to 8,000 gallons of JP-4 (jet propulsion) fuel. The spill occurred when the floating top was allowed to exceed its maximum height, permitting JP-4 fuel to escape and overflow the top of the tank. The lost fuel soaked into the gravel base of the POL storage area. No attempts to recover the spilled fuel are known.

Site 9. JP-4 Suspected Underground Line Leak

An Air Force corrosion team conducting gas-line testing at Bergstrom AFB in early 1984 discovered evidence of a pipeline leak in the JP-4 transmission system. The evidence was water with a sheen noted at the bottom of a pit dug around a JP-4 low-flow valve in the vicinity of Bldg. 4544. A study was initiated under the IRP program to confirm and investigate the suspected leak in the JP-4 pipeline.

Sampling and Analytical Program

The sampling program at Bergstrom AFB consisted of the collection of surface and subsurface sediments and groundwater. Surface sediments and selected shallow subsurface sediments were collected with a hand auger. Deeper subsurface soils were collected either with a split-spoon sampler or a Shelby tube during drilling activities. All soil samples were placed in individual glass jars and frozen. Groundwater samples were collected from temporary wells installed in coreholes and from alluvial monitoring wells using a Teflon bailer. The existing on-base well at the Golf Course was sampled with the electric pump installed in that well. All water samples were chilled to 4°C. The schedule of analyses is summarized in Table 1.

TABLE 1. ANALYTICAL SCHEDULE FOR AIR, SOIL AND WATER SAMPLES, BERGSTROM AFB, TEXAS

Parameter	Sites[1]						
	CSL*	8	9	13	17	23	Existing Well at Golf Course
Total Organic Carbon	W	W		W		W	W
Total Organic Halogen	W						W
Oil and Grease	W	W,S		S,W	S	S,W	W
Lead		W		S,W	S	S,W	
Cadmium, Chromium, Nickel		W		S,W	S	S,W	
Heavy Metals	W						W
Purgeable Halocarbons						W	
Purgeable Hydrocarbons		W	S,W	W		W	
Phenols	W						W
Pesticides	W						W
Herbicides	W						W
Dibrom	W						
PCBs	S						
Ambient Hydrocarbons			A				

[1] W = Water, S = Soil, A = Air.

* Combined Southeast Landfill Sites 3, 4, 5, 6, 7, and 14.

Field Program

The following paragraphs contain descriptions of the various field activities in the Bergstrom AFB Phase II (Stage 1) investigation. The field program included hollow-stem auger drilling; monitoring well installation; hand augering; acoustic emission testing; and soil, water, and air sampling.

Drilling Techniques

Drilling at Bergstrom AFB was accomplished using a hollow-stem auger drilling rig. The hollow-stem method allowed for an accurate examination of soil conditions, identification of the position of the water table, and recovery of soil samples. The holes were drilled dry; no drilling fluids or additives were used. Samples of soil were collected either with a split-spoon sampler or a Shelby tube at intervals of about two and one-half feet or five feet. Selected samples were carried to Radian's laboratory and frozen until chemical analyses were conducted.

Monitoring Well Installation

Monitoring wells at the Combined Southeast Landfill area were drilled to approximately 15 feet below the water table. Upon reaching final depth, 4-inch diameter wells were installed using stainless steel screens and PVC casing. The annulus was completed using a sand pack and bentonite seal, followed by cement grout to the land surface. The monitor wells located in the area of the suspected JP-4 pipeline leak were constructed of 2-inch diameter stainless steel screen and PVC casing and were also completed with sand, bentonite and cement.

Acoustic Emissions Testing

Acoustic emissions (AE) testing was performed on a JP-4 pipeline suspected of leaking. To conduct AE testing, a portion of the pipeline is exposed and sensors are attached to it. The basic concept of AE testing is that the AE sensors are able to pick up high-frequency noise that can result from small leaks in a pipeline or connections. In principle, the louder the noise signal, the closer the leak source is to the sensor. To ensure that a leak can be detected, it is best to pressurize a pipeline above normal working pressures. Once the pipeline is pressurized, readings are taken with the sensors and the data are analyzed for signal strength, which is directly related to the distance to a detected leak. In general, the sensors can be used to bracket a suspected leak area on a pipeline.

Other Sampling

As noted, soil samples were collected during drilling using a split-spoon sampler or a Shelby tube. Additional soil samples were collected using a hand auger with a 3-inch diameter bucket. Groundwater samples were collected from the monitoring wells and from temporary wells installed in coreholes using a Teflon bailer. Air samples were collected from underground utilities and one monitoring well in the JP-4 pipeline area.

Results of Analysis

The Phase II (Stage 1) investigation has documented the presence of organic contamination (primarily oil and grease and benzene) in the soil and groundwater at several sites. Concentrations of heavy metals were found to be elevated in the soil and occasionally elevated in the groundwater. The following summarizes the analytical results by site. Analytical values or ranges of values discussed are shown in parentheses.

Site 17. South Fork Drainage Ditch

Soil from the South Fork Drainage Ditch contained oil and grease (<100-1990 ug/g) as well as chromium (0.74-79 ug/g), copper (1.9-240 ug/g), nickel (1.5-17), and lead (4.5-250 ug/g).

Site 13. MOGAS Spill at Motor Pool

Soil from the MOGAS spill area contained oil and grease (280-400 ug/g). Analysis of groundwater from the motor pool area indicated the presence of lead (1.5 mg/L) and organic compounds. The organic species detected in the highest concentration was benzene (1040 ug/L).

Site 23. Fire Training Area

Soil at the Fire Training Area contained oil and grease and heavy metals (<0.55-35 ug/g). One of two groundwater samples had a lead content (0.090 mg/L) exceeding the primary drinking water standard, but the other heavy metal contents were low (<0.001-0.090 mg/L) in the groundwater. Benzene (8-196 ug/L) and trichlorofluoromethane (2.3-2.4 ug/L) were detected in the groundwater in amounts in excess of EPA guidelines.

Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

The only soil samples collected at the Combined Southeast Landfill area were taken from the road oiling area (Site 14). The samples were analyzed for PCBs, none of which were detected. Chemical analysis of groundwater from the area detected no evidence of contamination.

Site 8. JP-4 Spill/Overtopped Tank Area

The soil samples from the Overtopped Tank Area contained concentrations of oil and grease (280-600 ug/g) that increase with depth. No purgeable hydrocarbons were detected in the groundwater; however, lead (0.190 ug/L) was present in amounts in excess of federal drinking water standards.

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Site 9. JP-4 Suspected Underground Line Leak

A pipeline leak was confirmed at the old valve and flange at the low point drain box. No organic compounds were detected in the soil samples. The analysis of ambient air from a monitoring well located near the drain box and from a storm drain revealed vapor concentrations of compounds typical of JP-4 fuel. The highest vapor concentrations (1,350-499,000 ug/m^3) were found in the sample obtained closest to the low point drain.

Categorization

Each site was categorized according to Air Force criteria and has been assigned to one of the following categories:

Category I - Sites where no further action is required

Category II - Sites requiring additional monitoring or work to assess the extent of current or future contamination

Category III - Sites that require and are ready for remedial action

The site classifications were based on Radian's assessment of the impact of each site on environmental media and the likelihood of contaminants entering drinking water supplies or having an impact on the health of plant and/or ani- mal communities. Although evidence of soil contamination was present at every site and groundwater contamination was noted at some sites, the absence of local use of the shallow groundwater reduces potential impacts. Off-base shallow groundwater uses are undefined.

All sites have been classified as Category II, sites requiring additional characterization. They are so classified because of the relative ease with which potential contaminants could move off-base.

Recommendations

Based on the findings of this study, follow-up investigations for Category II sites are recommended to resolve issues defined by the Phase II (Stage 1) work. These recommendations and issues addressed are listed in Table 2.

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Table 2. Recommended IRP Phase II (Stage 2) Sites and Actions

Site(s)	Rationale	Summary of Recommended Actions
Site 17. South Fork Drainage Ditch	Presence of organic compounds and metals in the soil.	Collect and analyze waste samples from the ditch, especially at peak flow times, to determine the water quality.
Site 13. MOGAS Spill at Motor Pool	Presence of organic compounds and metals in groundwater.	Install 3 monitoring wells to define flow directions, groundwater chemistry, and background conditions.
Site 23. Fire Training Area	Presence of organic compounds in the groundwater, metals in the soil, proximity to base boundary, and age of site.	Install 3 monitoring wells to define flow directions, groundwater chemistry, and background conditions. Conduct a well inventory within one-half mile of the base boundary adjacent to the site.
Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill	Proximity to base boundary and large size of disposal areas.	Install 2 additional monitoring wells and conduct 2 rounds of sampling. Conduct a well inventory within one-half mile of the base boundary adjacent to the site.
Site 8. JP-4 Spill/ Overtopped Tank Area	Confirm presence of lead and/or organic compounds in the subsurface.	Drill 4 boreholes to collect soil samples and install 1 monitoring well. Analyze soil and groundwater samples to confirm subsurface chemistry.

(Continued)

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Table 2. (Continued)

Site(s)	Rationale	Summary of Recommended Actions
Site 9. JP-4 Suspected Underground Line Leak	Confirmation of fuel leak. Observations by base personnel of fuel in utility vaults.	Conduct groundwater sampling and possibly install another well, depending on analytical results. Collect another air sample from a utility vault.

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1.0 INTRODUCTION

The Department of Defense (DOD) is conducting a nationwide program to evaluate waste disposal practices on DOD property, to control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Records Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Remedial Actions. The United States Air Force has initiated an IRP investigation at Bergstrom Air Force Base near Austin, Texas; Radian Corporation has performed the Phase II (Stage 1) Field Evaluation under USAF Contract No. F33615-83-D-4001, Delivery Order 11.

1.1 Purpose of the Investigation

The purpose of the Phase II (Stage 1) investigation was to determine if environmental contamination has resulted from waste disposal practices at Bergstrom AFB. In addition, the investigation included an estimate of the magnitude and extent of contamination, the identification of environmental consequences of migrating pollutants, and the recommendation of additional investigations to identify the magnitude, extent, and direction of movement of any discovered contaminants.

1.2 Duration of Program

Authorization for conducting activities at Bergstrom AFB Phase II (Stage 1) program was provided in the delivery order dated 22 February 1984. Field activities took place in two stages: the base-wide investigation was conducted from 19 March to 11 April 1984, and a suspected JP-4 fuel line leak was investigated from 9 to 15 January 1985. The field work consisted of coring and sampling of soil at several locations, installation of groundwater monitor wells, sampling of groundwater from completed monitor wells and from temporary wells installed in coreholes, and acoustic emission testing along a JP-4 pipeline.

1.3 Location and Site Descriptions

Bergstrom AFB is located on approximately 4,000 acres of land in Travis County, Texas, 7 miles southeast of the center of the city of Austin. The base is bordered to the north and east by State Highway 71, to the west by U.S. Highway 183, and to the south and southeast by used and unused cropland.

Phase II (Stage 1) work at Bergstrom AFB has focused on the eleven sites shown on Figure 1-1. These sites consist of landfills, a drainage ditch, a road oiling area, a fire training area, and spill sites. The following paragraphs, based upon the Phase I study (CH2M Hill, 1983), provide brief descriptions of the locations and features of the Phase II sites.

1.3.1 Site 17. South Fork Drainage Ditch

The South Fork Drainage Ditch has provided major drainage for Apron A, the fuel hydrant area of Apron B, and some of the industrial shop areas since the construction of the base in 1942. Prior to the installation of an oil/water separator near the head of the ditch in 1981, fuels and oils could either flow through the ditch and off-base, soak into the ground along the ditch, or evaporate. The oil/water separator has prevented the escape of fuel and oil from the base and reduced the ground area subject to potential contamination.

1.3.2 Site 13. MOGAS Spill at Motor Pool

MOGAS (motor gas) spills occurred periodically in the Motor Pool area from 1974 to 1978. The spills were located between vehicle fueling stands 1803 and 1804 and occurred during the filling of two underground storage tanks. The spills ceased in 1978 when a proper connection was established between the fill lines and filler pipes. Each time a tank was filled, fuel was lost through a connection. All spills soaked into the gravel-covered ground and no known attempts were made to recover the fuel. Total spillage from 1974 to 1978 was estimated to be 1,600 to 3,200 gallons.

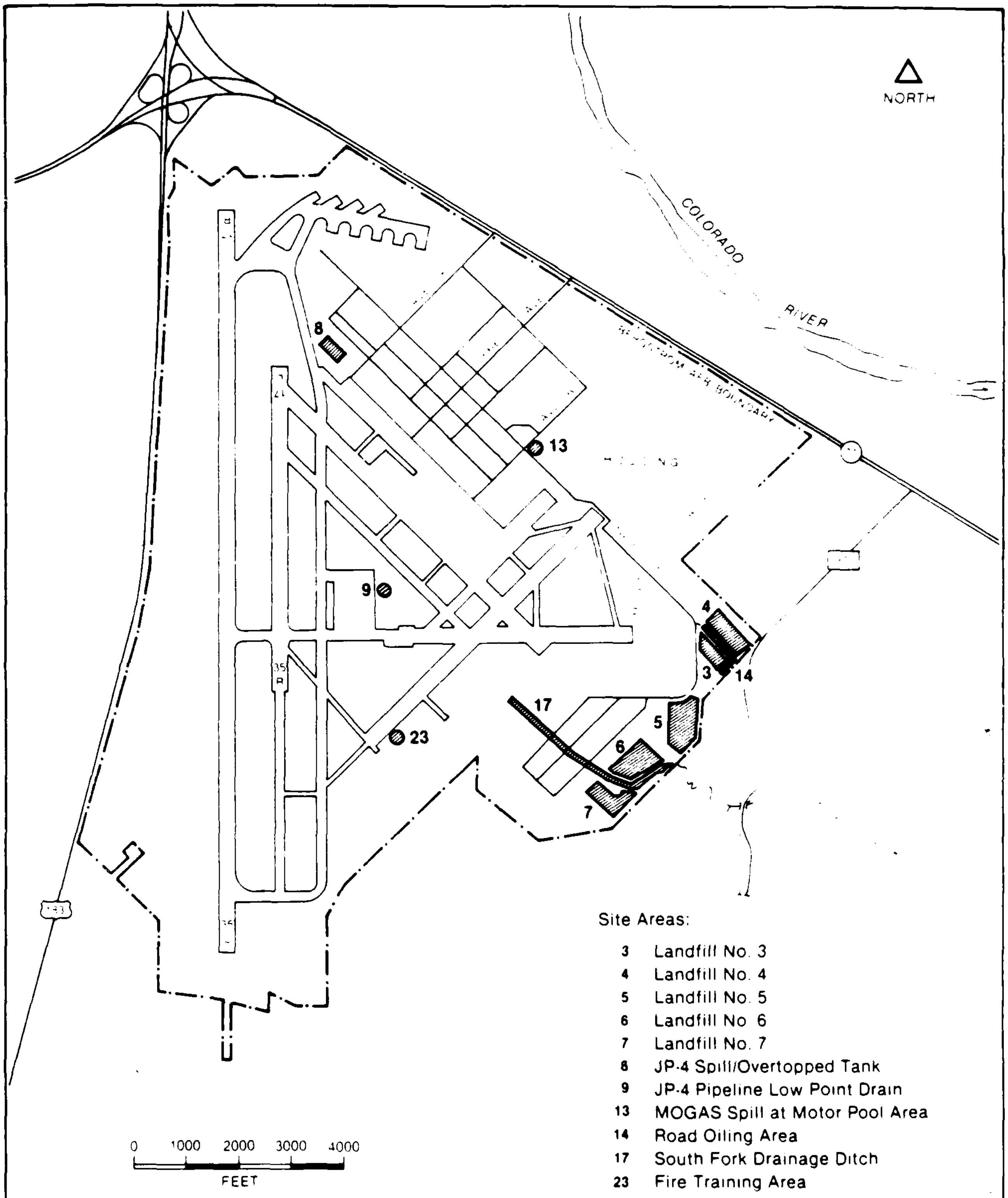

Figure 1-1. Location of IRP Phase II (Stage 1) Study Sites, Bergstrom AFB, Texas

Source: Base records

1.3.3 Site 23. Fire Training Area

The Fire Training Area is located at the south end of the base next to Taxiway 9. The active fire pit is an unlined circular pit, 120 feet in diameter, surrounded by a dirt berm. In 1982, a new limestone base was installed and a drain and oil/water separator were connected to the sanitary sewer to collect and pretreat runoff. Most potential contaminants would have been consumed in the fires. However, some percolation of fuels, waste oils and spent solvents into the ground is assumed, especially before the practice of water presaturation of the ground was begun in 1972.

1.3.4 Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

The Combined Southeast Landfill consists of Landfill Nos. 3, 4, 5, 6, 7, and 14. All of these landfills are located on the southeast side of Bergstrom AFB in the area of the South Fork Drainage Ditch. Also included in this composite site is an old road oiling area (Site No. 14) located between Landfill Nos. 3 and 4. These areas are considered a single site because of the proximity of the landfills to each other and the similarity in the type of waste disposed of at each landfill. General features for the individual landfills and the road oiling area are given below.

Site 3. Landfill No. 3 - Landfill No. 3 was operated from 1952 to 1957. It is located along the south side of Third Street, southeast of the senior officers Military Family Housing (Facility Nos. 4402 through 4428). This landfill received primarily domestic solid waste and construction rubble. Other materials that may have been disposed of at this site include empty pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents from the industrial shop areas.

Site 4. Landfill No. 4 - Landfill No. 4 was operated from 1957 to 1965. It is located southeast of the senior officers' Military Family Housing and across Third Street from Landfill No. 3. Landfill No. 4 received the same type of waste as Landfill No. 3: primarily domestic solid waste and construction rubble. Rinsed and punctured pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents are also suspected of having been buried at this site.

Site 5. Landfill No. 5 - Landfill No. 5 was operated from 1965 to 1971. It is bordered on the east and southeast by the reservation boundary and on the west and southwest by a deep drainage ditch. Domestic solid waste and construction rubble were disposed at this landfill. Rinsed and punctured pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents are also suspected of having been buried at the site.

Site 6. Landfill No. 6 - Landfill No. 6 was operated from 1971 to 1976. It is located between Landfill Nos. 5 and 7, along the north side of the South Fork Drainage Ditch. The landfill received primarily domestic solid waste and construction rubble. In the early 1970s, seven 55-gallons drums of DDT were found abandoned at this landfill. One of the drums was corroded and had leaked its contents into the ground. It is not known whether or not the drum was full prior to leaking. A leaking drum marked "PD-680" was also discovered at the site and subsequently removed. The remaining six drums were given to the city of Austin. Other material suspected of having been disposed of at this site include rinsed and punctured pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents.

Site 7. Landfill No. 7 - Landfill No. 7 was operated from 1976 to 1980. It is located in the southeast corner of the base, south of Landfill No. 6. Materials received at this landfill include domestic solid waste and construction rubble. Other materials suspected of being present at the site include empty pesticide containers, paint cans, and incidental quantities of antifreeze, waste paints, thinners, strippers, oils, and solvents.

Site 14. Road Oiling Area - Road oiling occurred at this site from the mid-1950's to 1962. The road is a 1/2 mile extension of Third Street between Landfill Nos. 3 and 4 and along the southeast side of Landfill No. 3. The waste oils came from the industrial shops located in the flightline areas. Oil was dispensed from a spreader bar on the back of a 150- to 500-gallon bowser. Reportedly, two times per year up to 30 gallons of waste oil may have been spread on the road. Over an approximate 7-year period, 4,200 gallons would have been spread over the unimproved road.

1.3.5 Site 8. JP-4 Spill/Overtopped Tank

Site No. 8, at the POL (petroleum, oil and lubricants) bulk storage area (Facility No. 513), was the site of a tank-filling accident in 1975 that resulted in the loss of 2,000 to 8,000 gallons of JP-4 fuel. The spill occurred when the floating top was allowed to exceed its maximum height, permitting JP-4 to escape and overtop the tank walls. The lost fuel soaked into the gravel base of the POL storage area. No attempts to recover the spilt fuel are known.

1.3.6 Site 9. JP-4 Suspected Underground Line Leak

An Air Force corrosion team conducting gas-line testing at Bergstrom AFB in early 1984 discovered evidence of a pipeline leak from the JP-4 transmission system. The evidence was water with a sheen noted at the bottom of a pit dug around a JP-4 low-flow valve in the vicinity of Bldg. 4544. A study was initiated under the IRP program to confirm and investigate the suspected leak in the JP-4 pipeline.

1.4 Waste Disposal Practices

The Phase I report (CH2M Hill, 1983) contains an account of the history of waste generation and disposal activities. The following paragraphs describing the waste disposal history are from the Phase I report.

The majority of industrial operations at Bergstrom AFB have been in existence since the early 1950s. The initial construction of the installation began in 1942 and the base was in full operation by the end of 1943. Some industrial activities were conducted during the early years of operation. The major industrial operations include corrosion control shops, flightline maintenance shops, aerospace ground equipment (AGE) maintenance shops, nondestructive inspection (NDI) laboratories, photographic processing interpretation facilities (PPIF), and vehicle maintenance shops. These industrial operations generate varying quantities of waste oils, contaminated fuels, and spent solvents and cleaners.

The total quantity of waste oils, recovered fuels, and spent solvents and cleaners generated ranges from 50,000 to 75,000 gallons per year. This total quantity is believed to be representative for the period from the mid-1960s, when the base was transferred from the Strategic Air Command to the Tactical Air Command, to the present. Some aircraft maintenance activities were accelerated in 1976 with the transfer of the 924th Tactical Airlift Group to Bergstrom AFB.

Practices for past (based on information obtained from shop files and on the best recollection of interviewees) and present industrial waste disposal practices are as follows:

- 1943 to 1972: The majority of waste oils was burned during fire department training exercises. Waste engine oils, lubricating oils, hydraulic fluids, and transmission fluids were collected in 55-gallon drums and transported by shop personnel to the fire department training area (Site No. 23). The 55-gallon drums were stored at the training area until needed to ignite a practice burn during training exercises. Some waste oils were used for road oiling to control dust on unimproved roads (e.g., Site No. 14) from approximately 1955 to 1962. Waste oils generated by flightline maintenance shops were collected in a bowser. When the bowser was full, a spreader arm was attached and waste oils were sprayed over unimproved roads in the landfill area.

The majority of recovered fuels was also burned during fire department training exercises. Recovered fuels were collected in bowsers and transported to the fire department training area. The bowsers were emptied into the training pit area and the empty bowser was brought back to the shop.

The majority of spent industrial solvents and cleaners was burned during fire department training exercises or discharged to the sanitary sewer. Since no program of waste segregation existed, most spent solvents were commingled with waste oils and disposed of in the same manner as the waste oils, as previously described. Aircraft cleaning compounds and solvents used at the aircraft washrack (Facility No. 4540) were drained to an oil/water separation system which discharged to the storm sewer system. Some waste paints and paint thinners were disposed of in the base sanitary landfills in operation during this period.

- 1972 to Present: In 1972, three of the twelve underground 25,000-gallon storage tanks located at Facility No. 590 were converted to the storage of waste materials. Since 1972, these three tanks have stored spent non-halogenated solvents (Tank No. 7), waste oils (Tank No. 9), and recovered aviation fuels (Tank No. 11). The non-halogenated solvent storage tank receives all the various types of solvents generated by the base. Waste oils, recovered fuels, and spent solvents are collected in 55-gallon drums and transported by shop personnel to

Facility No. 590, where the materials are placed in the appropriate storage tank. The Defense Reutilization and Marketing Office (DRMO) accepts accountability for the waste materials, but not physical custody. DRMO assumes the responsibility for resale or contractor removal of the waste materials. In 1982, a program was initiated (currently in the process of being implemented) to designate waste accumulation points and waste accumulation point managers. Also in 1982, another storage tank at Facility No. 590 was converted to the storage of synthetic oils (Tank No. 5). The non-halogenated solvent storage tank is used for the storage of solvents, primarily PD-680. Other types of solvents are stored at the accumulation points until DRMO arranges for removal.

Aircraft cleaning compounds and solvents used at the aircraft washrack (Facility No. 4540) are discharged to the sanitary sewer system via an oil/water separator.

An inventory of the waste material delivered to the Facility No. 590 waste storage tanks over a 1-year period (April 1, 1982 to March 31, 1983) indicated the following quantities: 3,325 gal/yr of waste synthetic oils; 465 gal/yr of spent non-halogenated solvents; 7,675 gal/yr of waste oils; and 17,000 gal/yr of recovered aviation fuels.

1.5 Sampling and Analytical Program

The sampling program at Bergstrom AFB consisted of the collection of surface and subsurface sediments and groundwater. Surface sediments and selected shallow subsurface sediments were collected with a hand-operated auger. Deeper subsurface sediments were collected either with a split-spoon sampler or a Shelby tube during drilling activities. All soil samples were placed in individual glass jars and frozen. Groundwater samples were collected from temporary wells installed in boreholes and from alluvial monitoring wells using a Teflon bailer. The existing on-base well at the Golf Course was sampled with the electric pump dedicated to that well. All water samples were chilled to 4°C.

All samples were hand-carried to Radian Analytical Services for analysis. The general schedule of analyses is summarized on Table 1-1 with detailed descriptions provided in Section 3.0.

1.6 Investigation Personnel

The Bergstrom AFB IRP Phase II (Stage 1) investigation was conducted by several individuals from the Austin office of Radian Corporation. Thomas W. Grimshaw, Delivery Order Manager, was responsible for the contractual administration of the program. The overall technical program was directed by Rick A. Belan, Staff Geologist and Certified Professional Geological Scientist. Mr. Belan coordinated program activities, including participation with USAF personnel in the areas of contract and technical matters. Field activities were conducted by Mr. Belan; by Wayne Pearce, Senior Geologist and Certified Professional Geological Scientist; and by Peter A. Waterreus, Geologist. Mr. Pearce was the principal author of the report. Jenny B. Chapman, geologist, and Rick Belan were co-authors. Cartographic and technical illustrations were prepared by Jill P. Rossi. William M. Little provided senior technical staff review and editing. All of the above individuals were involved in the preparation of the report. Resumes for these individuals are provided in Appendix K.

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TABLE 1-1. ANALYTICAL SCHEDULE FOR AIR, SOIL AND WATER SAMPLES, BERGSTROM AFB, TEXAS

Parameter	Sites[1]						
	CSL*	8	9	13	17	23	Existing Well at Golf Course
Total Organic Carbon	W	W		W		W	W
Total Organic Halogen	W						W
Oil and Grease	W	W,S		S,W	S	S,W	W
Lead		W		S,W	S	S,W	
Cadmium, Chromium, Nickel		W		S,W	S	S,W	
Heavy Metals	W						W
Purgeable Halocarbons						W	
Purgeable Hydrocarbons		W	S,W	W		W	
Phenols	W						W
Pesticides	W						W
Herbicides	W						W
Dibrom	W						
PCBs	S						
Ambient Hydrocarbons			A				

[1] W = Water, S = Soil, A = Air.

* Combined Southeast Landfill Sites 3, 4, 5, 6, 7, and 14.

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2.0 ENVIRONMENTAL SETTING

This discussion of the Bergstrom AFB environmental setting is derived principally from the Installation Restoration Program Phase I Records Search Report (CH2M Hill, 1983). Information derived from that report is supplemented by the literature and the general findings of the Phase II study. The following sections describe the environmental setting of Bergstrom AFB. Basic features and history of the sites investigated in the Phase II study are also discussed here.

2.1 General Geographic Setting and Land Use

Bergstrom AFB is located 7 miles southeast of the center of the city of Austin, Travis County, Texas. The base is bordered on the east by State Highway 71 and on the west by U.S. Highway 183, both of which are main arteries leading into Austin (Figure 2-1). The base is situated on approximately 4,000 acres of land, of which 3,294 acres are Air Force owned, 691 acres are easement, and 65 acres are leased. The site map of Bergstrom AFB is shown in Figure 2-2.

The base is surrounded by used and unused croplands. Built-up areas are mainly to the northwest, in Austin. Some light commercial development exists just outside the base along the major traffic corridors.

2.2 Physiographic and Topographic Features

Bergstrom AFB is located in the Colorado River Terraces physiographic province. The other major physiographic provinces in the vicinity of the base include the Edwards Plateau, the Rolling Prairie, and the Blackland Prairie (see Figure 2-3). The physiographic provinces in this part of Texas are delineated on the basis of topographic expression.

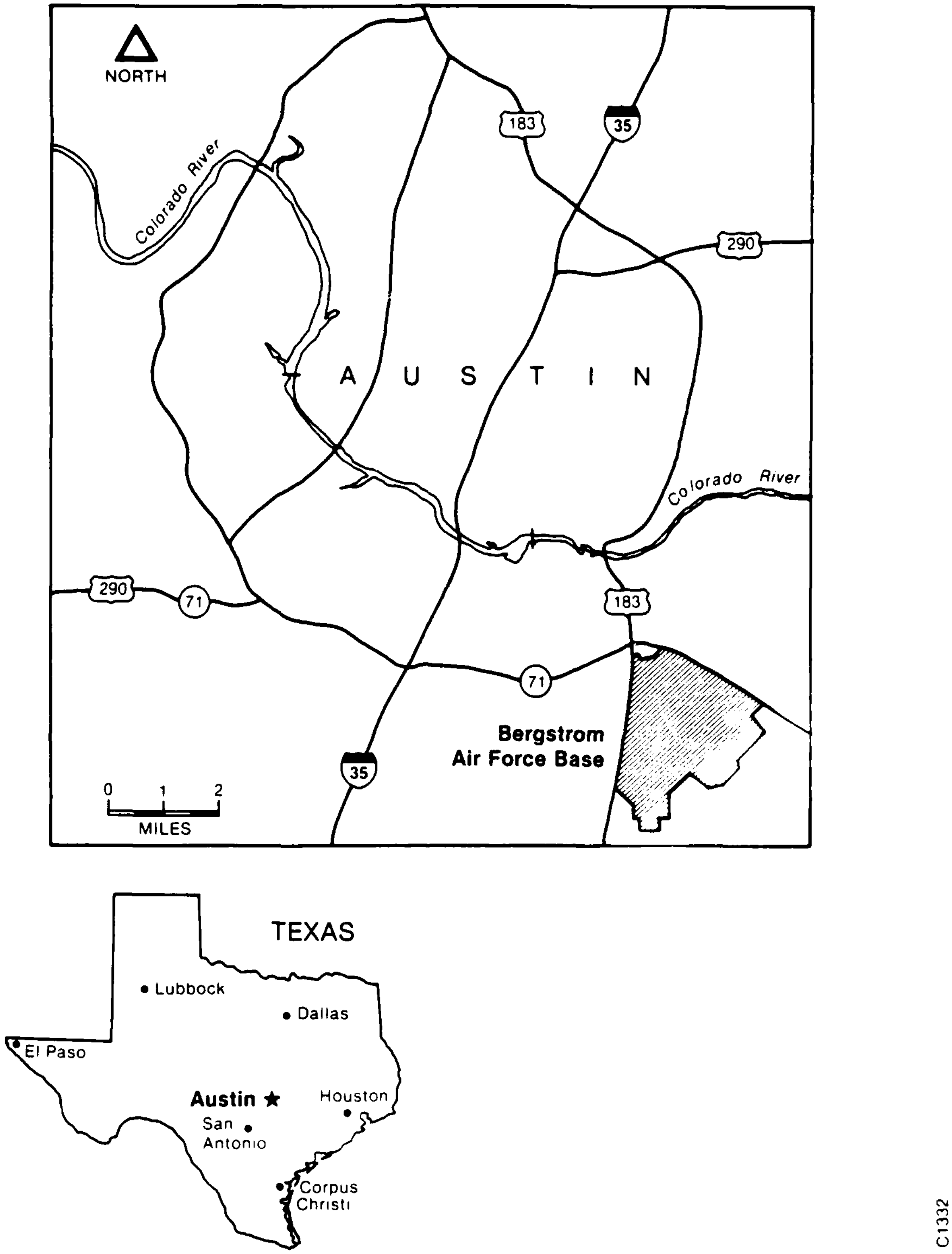

Figure 2-1. General Location of Bergstrom AFB, Texas

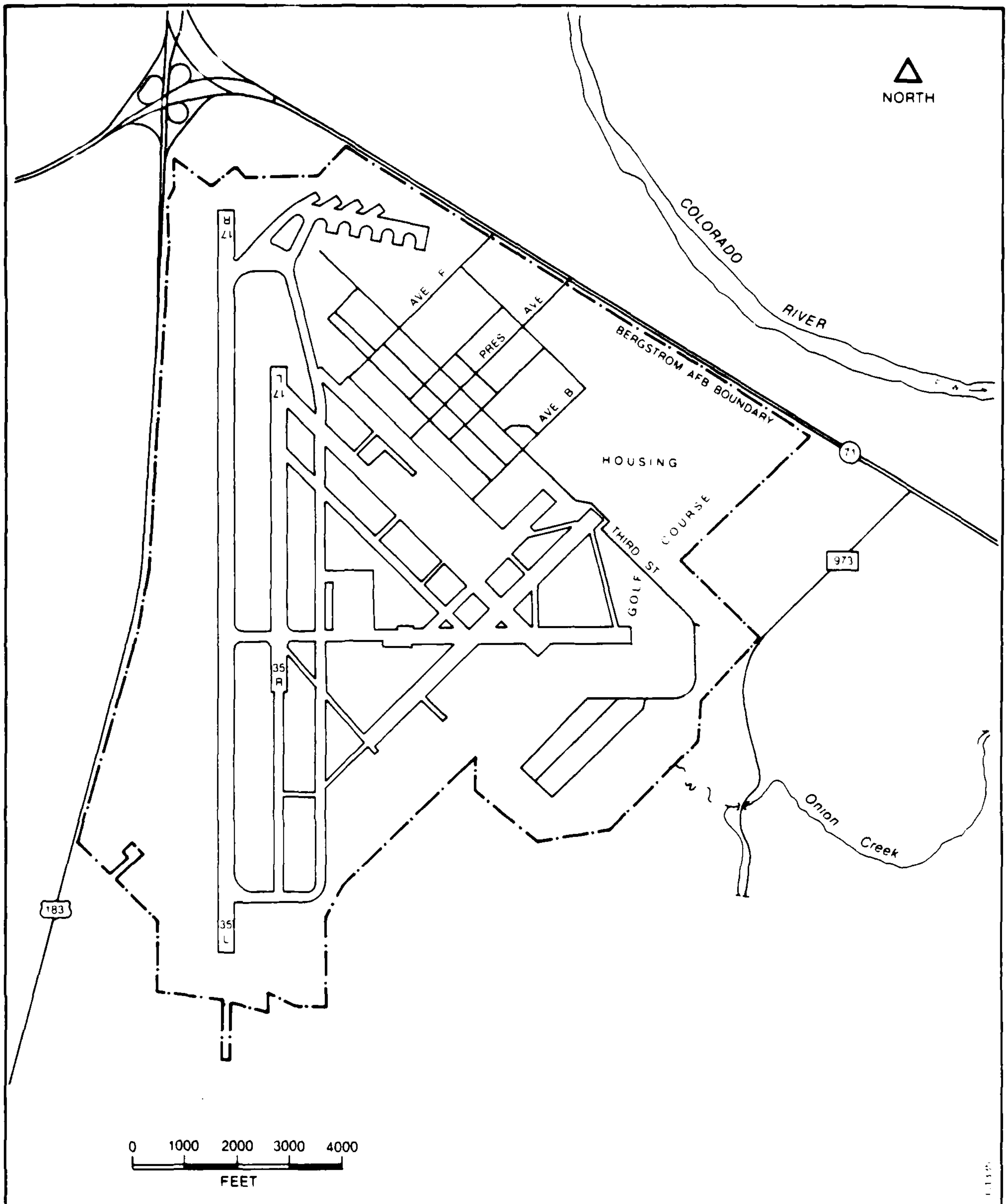

Figure 2-2. General Features of Bergstrom AFB, Texas

Source: Base records

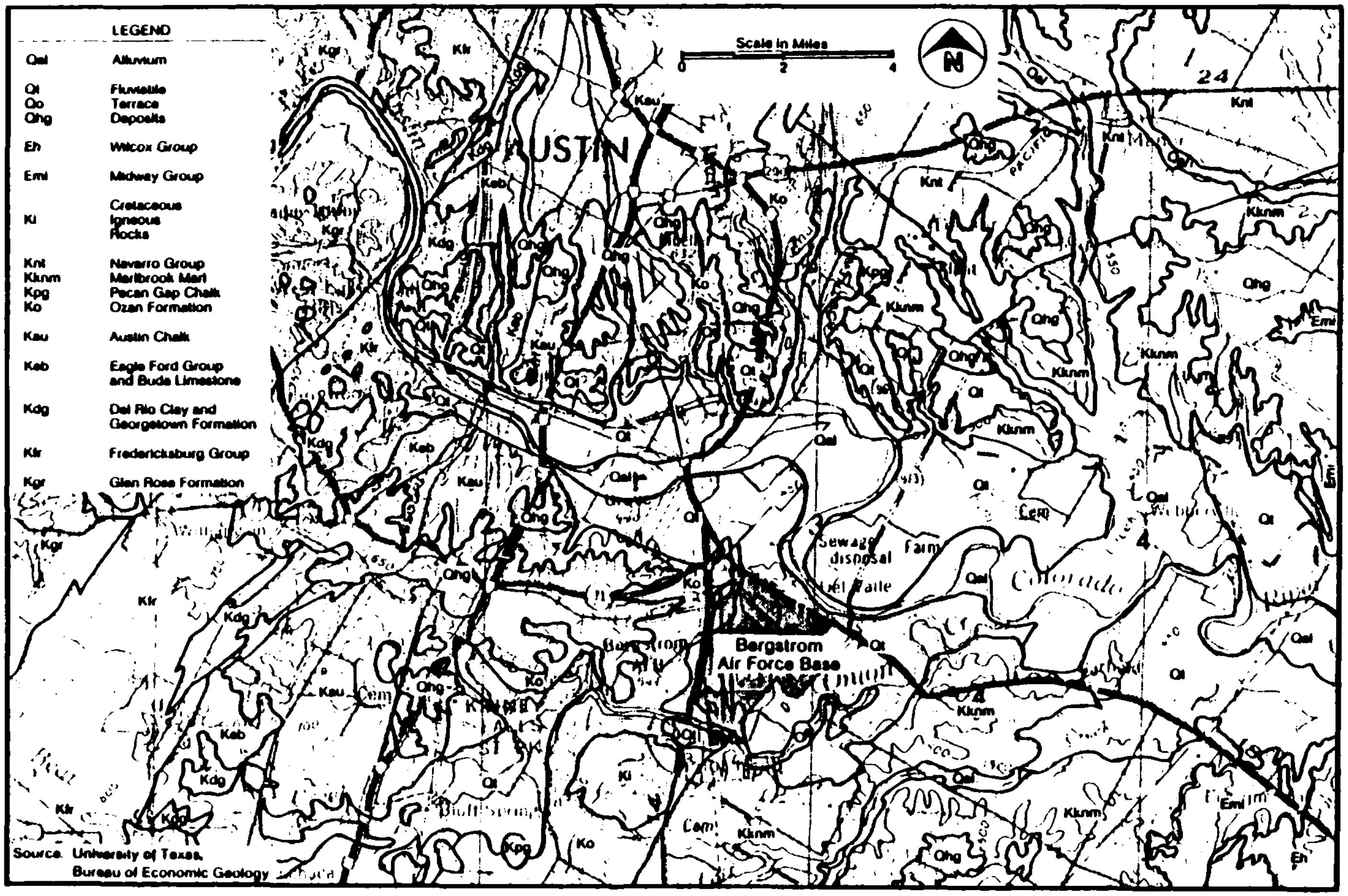

Figure 2-3. Physiographic Regions in the Vicinity of Bergstrom AFB, Texas

Topography at Bergstrom AFB is flat with little relief. Elevations range from 540 feet above mean sea level (msl) at the northwest corner to 420 feet above msl at the southeast corner.

The principal drainages for Bergstrom AFB are the Colorado River to the north and a tributary of the Colorado River, Onion Creek, to the south and southeast. Most of the surface drainage from the base is collected by a series of ditches and storm sewers that discharge to the Colorado River and Onion Creek. Figure 2-4 depicts the general surface drainage directions for Bergstrom AFB. The drainage characteristics of the sites evaluated in this investigation are discussed in Section 4.0.

2.3 Geologic and Hydrogeologic Conditions

2.3.1 Surficial Soils

Soils found at Bergstrom AFB are alluvial, generally consisting of brown to red-brown calcareous sandy loams, silty clay loams, and gravelly sands (see Figure 2-5). The U.S. Department of Agriculture, Soil Conservation Service (SCS) classified most of the soils on base as the Lewisville series. The Lewisville series consists of nearly level to gently sloping, well-drained silty clays. These soils occupy terraces along the major streams. Slopes are smooth: 2 percent or less. These soils develop under a grass cover. The soils are described as brown to red-brown calcareous and noncalcareous sandy to clay loams and gravelly sands. The soil groupings are provided in Figure 2-5.

2.3.2 Lithology

The surficial geology (Figure 2-6) or soils at Bergstrom AFB are underlain by the lower Colorado River Terrace deposits, which are composed of yellow to orange sand, silty clay, and gravel. Below the terrace deposits are about 700 feet of Taylor Group sediments. This unit consists of greenish-gray to brown calcareous montmorillonite and marly clay. The Taylor Group consists

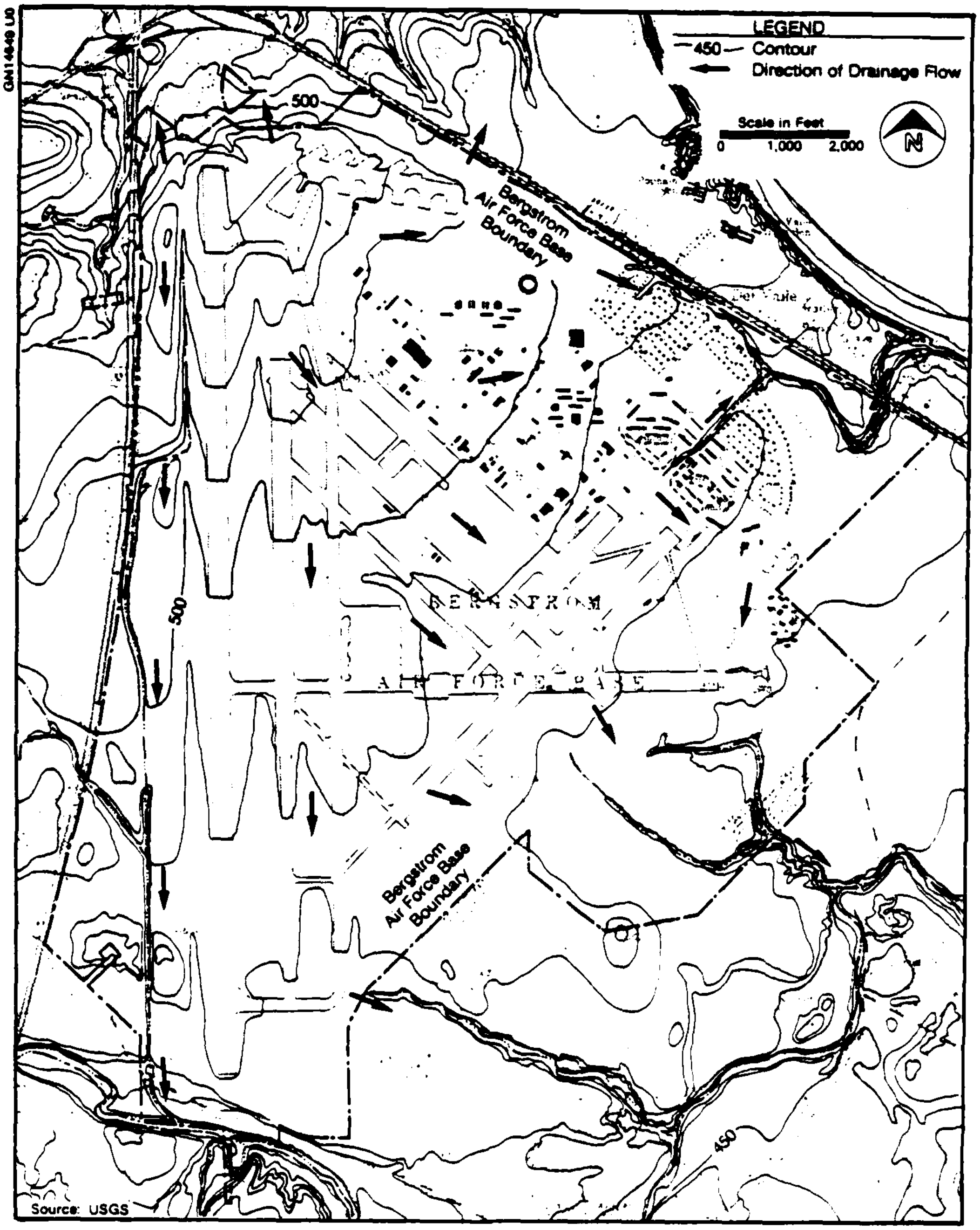

Figure 2-4. Surface Drainage of Bergstrom AFB, Texas

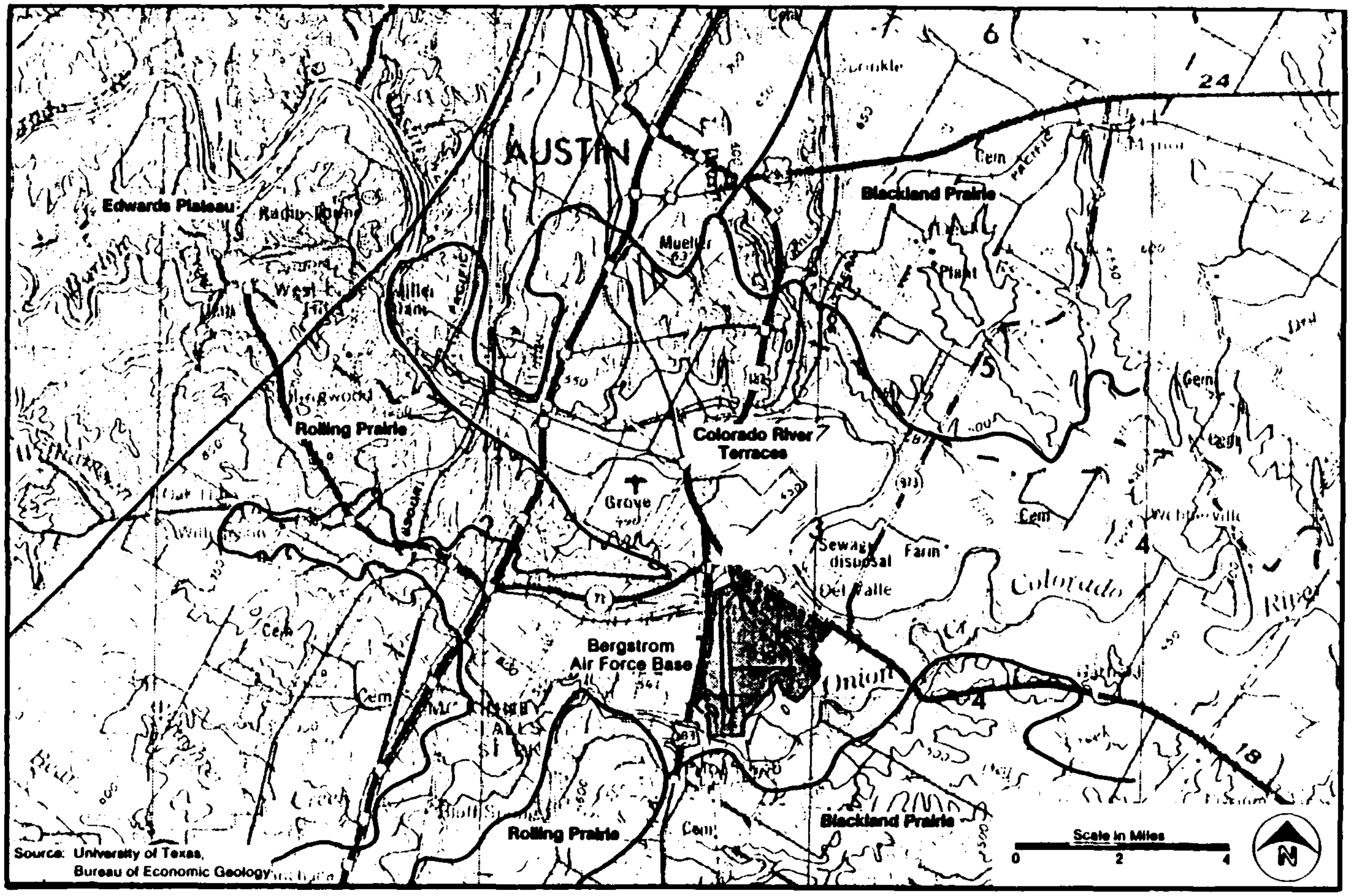

Figure 2-5. General Soil Types in the Vicinity of Bergstrom AFB, Texas.

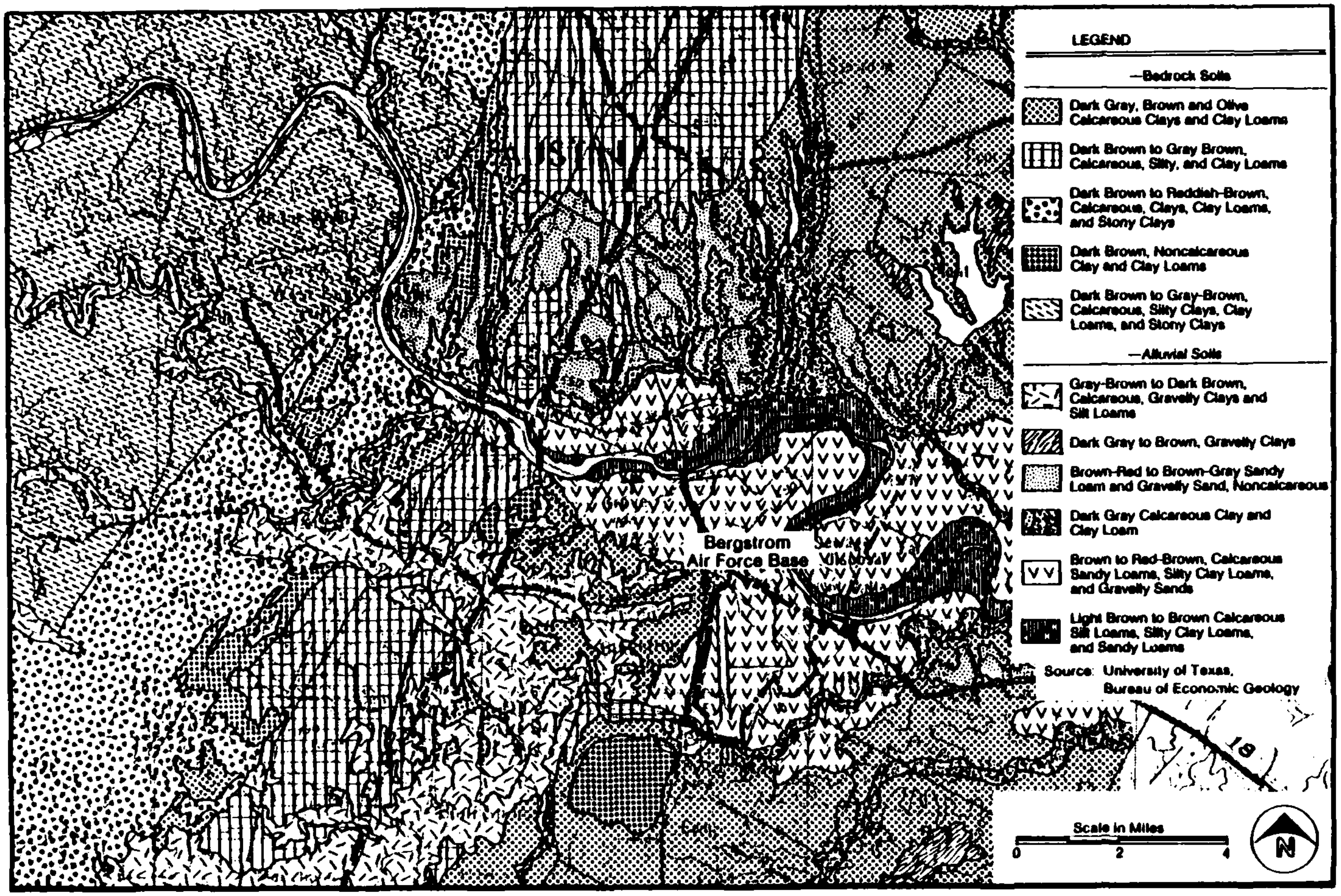

Figure 2-6. Surficial Geology in the Vicinity of Bergstrom AFB, Texas.

of three formations identified from shallowest to deepest as the Bergstrom, the Pecan Gap, and the Sprinkle. Underlying the Taylor Group are the Buda Formation, which consists of approximately 35 feet of glauconitic limestone, and the Del Rio Formation, which consists of 25 to 35 feet of clay.

Below the Del Rio Formation is the Georgetown Formation, consisting of limestone approximately 40 to 60 feet thick. The Georgetown Formation overlies the Edwards Formation. The Edwards is a regionally important aquifer, consisting of approximately 300 feet of limestone, dolomitic limestone, and chert nodules.

Approximately 20 feet of Comanche Peak limestone separate the Edwards Formation from the underlying Walnut Formation, which also consists primarily of limestone.

Below the Walnut Formation, another regional aquifer occurs within the Glen Rose Formation (approximately 1,000 feet thick), which consists of limestone, dolomite, and marl.

Below the Glen Rose, unconsolidated sands form the base of the Cretaceous-age (70 to 135 million years ago) formations in the vicinity of Bergstrom AFB. Table 2-1 lists the geologic formations discussed above, and Figure 2-7 illustrates a general geologic cross section drawn in a northwest-southeast direction.

2.3.3 Structure

Bergstrom AFB is located east of the Balcones Fault Zone and associated features (Figure 2-7). The Balcones Fault Zone trends northeast to southwest in the vicinity of Austin. This fault zone, which consists of a series of normal faults, influences most of the geologic structures in the study area. Additionally, it is hydrologically significant because it has

TABLE 2-1. GENERAL DESCRIPTIONS OF GEOLOGIC UNTIS BELOW BERGSTROM AFB, TEXAS

System	Group	Formation	Approximate Maximum Thickness (Feet)	Composition
Quaternary	--	Alluvium	20	Unconsolidated gravel, sand, silt, and clay deposits of the Colorado River and tributary streams.
		Lower Colorado River Terrace Deposits	60	Yellow- to red-brown, unconsolidated gravel, sand, silt, and clay; gravel more abundant near base.
		Tributary	20	Light gray to tan, mostly unconsolidated, calcareous gravel, sand, silt, and clay.
Tertiary	Midway	Kincaid	150	Dark gray to brown-gray, sandy, micaceous, and glauconitic clays with large concretions.
Cretaceous	Navarro	Kemp	350	Brown to dark gray, silty montmorillonitic clay; prominent calcareous and quartz siltstone layers; calcareous concretions occur at irregular intervals.
		Corsicana	120	Dark gray to blue-gray, calcareous, montmorillonitic clay; sandy phosphatic zone near base.
		Bergstrom	350	Green-gray to brown-gray, unctuous, calcareous, montmorillonitic clay; calcareous content increases toward base.
	Taylor	Pe_an Gap	75	Brown to dark grey, highly calcareous montmorillonitic clay and marl.
		Sprinkle	300	Green-gray, calcareous, montmorillonitic clay; calcium carbonate content increases toward base.
Cretaceous	Austin	Pilot Knob Basalt	--	Black to dark green-gray, hard, fine-grained basalt.
		Pilot Knob Tuff	--	Green-brown to tan, nontronitic, altered tuft, lenticular.
		McKown	50	Light gray to white, coarse-grained, porous, shell-fragment limestone.
		Pflugerville	40	Light gray, chalky, and clayey limestone with hard limestone beds at top and base.
		Burditt	15	Light gray, marly chalk containing 10 to 20 percent montmorillonitic clay.
		Dessau	75	Light gray, slightly clayey chalk and soft limestone bounded by an upper hard fossiliferous limestone and basal hard limestone.
		Jonah	25	Light gray, medium- to thin-bedded, hard fossiliferous limestone.
		Vinson	80	Gray to white, thin- to thick-bedded massive chalk.
		Atco	125	Gray to white, thin- to thick-bedded, massive to slightly nodular, fine-grained limestone, marly limestone, and chalk.
	--	Eagle Ford	56	Dark gray, calcareous montmorillonitic clay; mid portion consists of thin interbeds of sandy and flaggy limestone, chalk, clay, and bentonite.

continued

TABLE 2-1. (Continued)

System	Group	Formation	Approximate Maximu Thickness (Feet)	Composition
	Washita	Buda	35	Gray to tan, hard, fine-grained, glauconitic, shell-fragment limestone; lower part slightly nodular weathering.
		Del Rio	—	Dark gray to olive-brown, pyritic, gypsiferous, calcareous clay containing abundant Exogyra arietina.
Cretaceous		Georgetown	60	Gray to tan, interbedded, nodular-weathering, hard, fine-grained limestone, marly limestone, and marl containing abundant fossil shells.
	Fredericksburg	Edwards	300	Gray to brown, hard, dense, thick- to thin-bedded, fine-grained limestone with soft dolomitic limestone zone near middle, lower zones contain soft, nodular-weathering marly limestone, chert nodules, and porous dolomitic limestone.
	--	Walnut	180	Gray to tan, fine-grained, nodular limestone, marly limestone, and marl.
	--	Walnut	180	Gray to tan, soft marl and nodular limestone with abundant fossils.
				Gray to tan, hard, fine- to medium-grained, thin- to thick-bedded fossiliferous limestone.
				Gray to tan, thin- to thick-bedded, fine- to medium-grained, hard limestone.
				Gray to tan, hard, fine to medium-grained, thin- to thick-bedded limestone; shell fragments common.
	Trinity	Glen Rose	1,000	Gray to tan, hard and soft, fine to medium grained limestone, dolomite and marl.

Source: University of Texas, Bureau of Economic Geology, 1976.

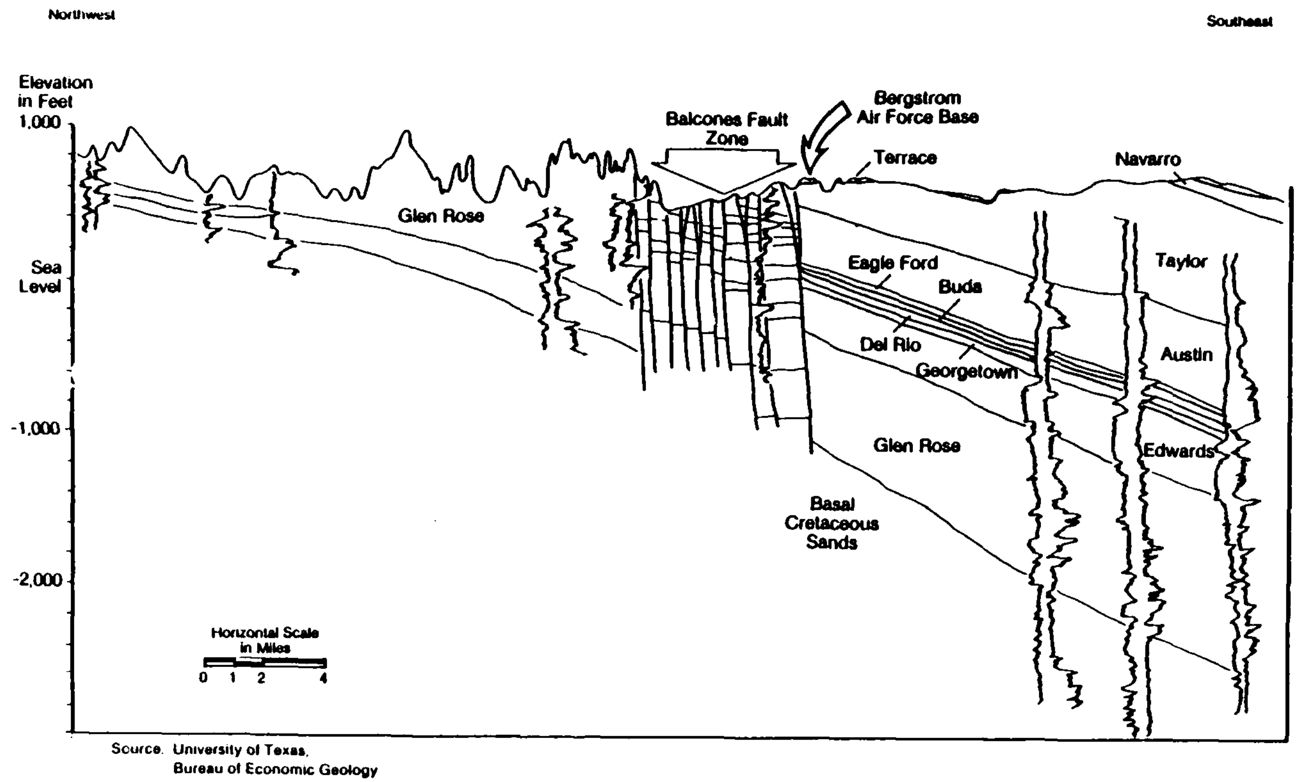

Figure 2-7. Regional Cross Section Vicinity of Bergstrom AFB, Texas.

enabled the development of secondary porosity in some units that generally are relatively impermeable.

The formations underlying Bergstrom AFB dip to the southeast at about 100 feet per mile. Units on the upthrown side of the Balcones Fault Zone dip at about 20 feet per mile toward the southeast. Near the fault zone the dips are about 50 feet per mile to the east. Dips vary greatly in direction and magnitude within the fault zone.

2.3.4 Groundwater

2.3.4.1 Shallow Groundwater

Shallow groundwater occurs in the sand and gravel deposits of the Colorado River terrace deposits. One 6-inch well, at the base golf course, reportedly was completed in this geologic unit and develops a small amount (approximately 25 gpm) of water. This well discharges to the pond on the golf course. Water quality is reportedly poor, although no analytical data were available prior to the Phase II study. This very limited resource is also developed off base for agricultural use, again in very small quantities.

The shallow aquifer of the Colorado River Terrace Deposits are the only potential receiving zone for contaminant migration. The water table at the base occurs at approximately 20-40 feet below land surface (bls), and recharge to this zone is by direct infiltration from the surface through soils and along stream channels. Rates of vertical movement would be low to moderate given the clay-silt soil at the surface. Horizontal movement over any distance would be slow since the deposits associated with river deposition tend to be lenticular, pinching out laterally.

The shallow groundwater system is recharged directly by precipitation, by irrigation, and by hydraulic connection with surface water bodies. Discharge from the unit is most likely to occur along the Colorado River and

Onion Creek, as well as along their tributaries, where the streams breach the alluvial system (depending on the stage of the creek). Downward migration of shallow groundwater is probably minimal because of the extensive thickness of clay-dominated strata (Taylor Group clays) immediately below the alluvium. However, inactive or improperly cemented wells in the area of the base may provide a path by which contaminants in the shallow unit could migrate to deeper strata. Little or no pumping of the shallow groundwater unit is expected to occur in the area of the base because of the limited extent and thickness of the groundwater.

Data developed through Phase II (Stage 1) monitoring well installation efforts support the literature and previous studies with respect to the nature of the shallow water-bearing unit at the base. Findings from this investigation demonstrate that the perched unit varies somewhat in composition and geometry throughout the installation. In addition, the coarse water-bearing sediments found throughout most of the base were not encountered in several localities. Descriptions of the nature of the shallow water-bearing unit for the various areas investigated in this study are discussed in Section 4.0.

2.3.4.2 Deep Groundwater

The primary regional aquifer that underlies Bergstrom AFB is the Edwards Aquifer and associated limestones. Because of the great depth (over 1500 feet) of the Edwards Aquifer and the abundance of intervening low permeability units, any potential contamination of the Edwards Aquifer from the shallow groundwaters just discussed is unlikely. A brief discussion of the Edwards Aquifer is provided below.

The Edwards Aquifer occurs under artesian conditions, and flow is generally to the southeast. At Bergstrom AFB, thick overlying strata consisting of clay and marl isolate the permeable strata from the surface.

The Edwards Aquifer, consisting of limestone, dolomitic limestone, and chert nodules, occurs at an elevation of 1,000 feet below mean sea level (msl), which is 1,500 feet below land surface (bls). The aquifer is characterized by solution channels interconnected over wide areas. Figure 2-8 illustrates the configuration of the top of the Edwards Aquifer in the vicinity of the base with structural contours. Also shown in this figure is the Balcones Fault Zone. It can be seen that the top of the Edwards Aquifer occurs at approximately 500 feet below msl northwest of the fault and 1,000 feet below msl southeast of the fault.

The Balcones Fault Zone represents the approximate boundary between good and poor quality water. Groundwater is not developed from the Edwards Aquifer immediately southeast of the fault zone, east of Bergstrom AFB, because the water is too high in total dissolved solids for most uses. Northwest of the fault, the Edwards Aquifer contains fresh water which is used extensively as a potable water supply.

Water is confined in the Edwards Aquifer by the overlying Del Rio Clay and by the underlying Glen Rose Formation. The Edwards Aquifer is recharged principally by direct infiltration of surface water and by precipitation in the area of the aquifer outcrop located to the northwest of the base. Flow in the Edwards Aquifer under the area of the base is generally to the south and southeast.

Because the Edwards is a limestone aquifer that is highly permeable because of faulting, jointing, fracturing, and solutioning, it is highly susceptible to contamination in the recharge zone. Bergstrom AFB is located away from (i.e., southeast and downslope of) the main outcrop, or recharge area, of the Edwards Aquifer. Because the Edwards is at a significant depth below Bergstrom AFB with confining layers located between the on-base perched water-bearing unit and the deeper Edwards, contamination of this aquifer from base operations is unlikely. The confining layers consist of low permeability

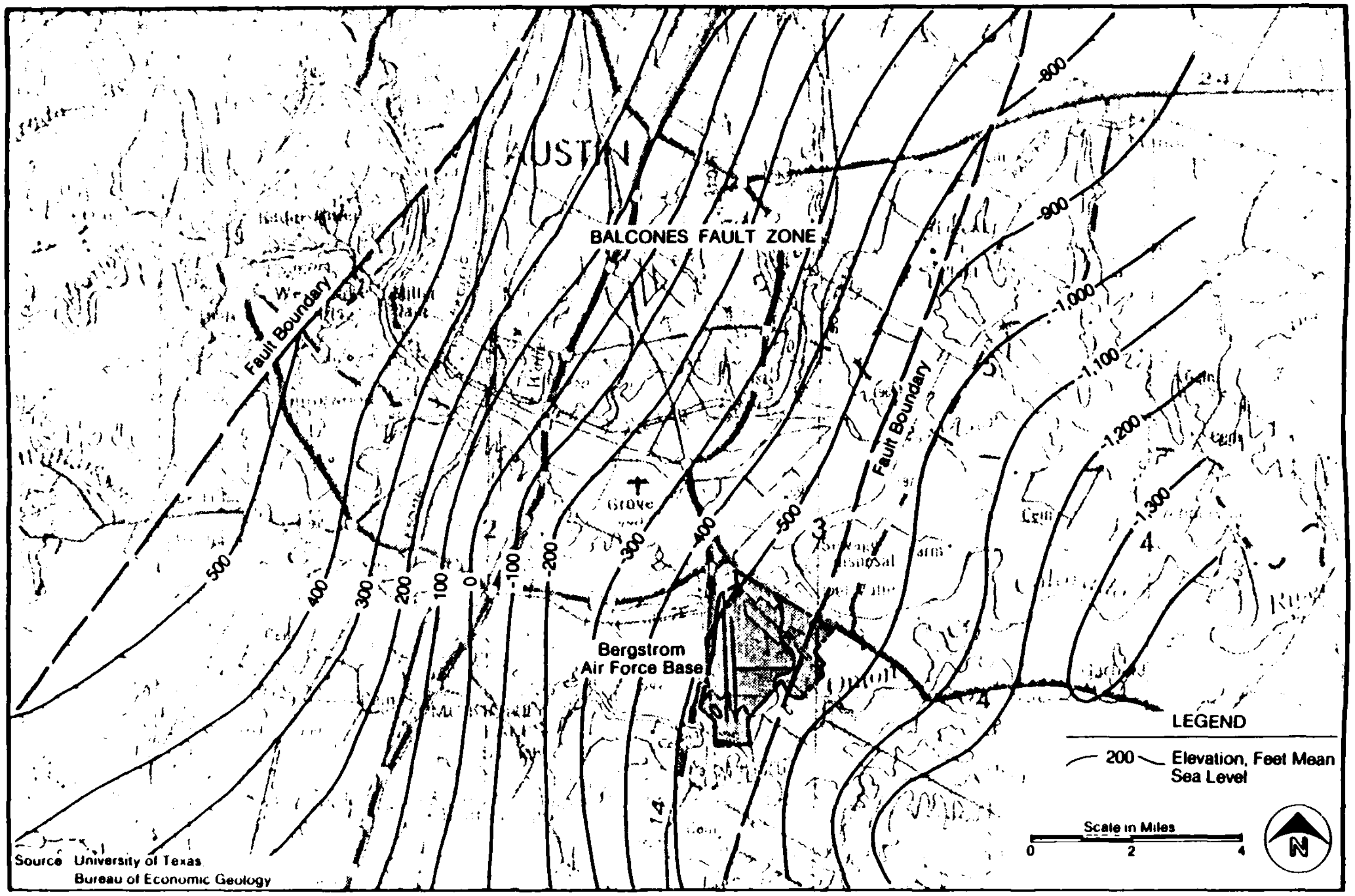

Figure 2-8. Top of the Edwards Aquifer, Austin Area, Texas.

formations, such as clays, that do not easily transmit water downward towards the Edwards Aquifer.

2.4 Site Descriptions

Phase I studies for the Bergstrom AFB Installation Restoration Program were completed by CH2M Hill in July 1983. The purpose of the Phase I study was to conduct a records search for the identification of past waste management activities that may have caused groundwater contamination and the migration of contaminants off-base.

Twenty-four individual sites at Bergstrom AFB were identified by the Phase I report as containing potentially hazardous waste. The potential environmental consequences of each site were evaluated with a rating or scoring system, the Air Force Hazard Assessment Rating Methodology (HARM). This system takes into account such factors as the site environmental setting, the nature and volume of the wastes present, past waste management practices and the potential for contaminant migration. Of the 24 sites identified, 10 sites (four individual sites and one combined site composed of six closely-spaced sites) and one base well were selected for Phase II (Stage 1) studies. One site was added by OEHL when evidence suggested an underground pipeline leak. All of the present study sites are shown in Figure 1-1. Brief summaries of the various areas are provided from the Phase I report.

2.4.1 Site 17. South Fork Drainage Ditch

Site 17, located at the south end of the base, is a drainage ditch that begins near Facility No. 4602, runs between Landfill Nos. 6 and 7, and extends beyond the base boundary. The ditch is the open portion of a storm drainage system that drains Apron A, the fuel hydrant area of Apron B, and some of the major industrial shop areas. This ditch has provided major drainage since construction of the base in 1942.

Because of the nature of the areas being drained, fuels and oils are probably the major contaminants that have entered this drainage ditch. Prior to the installation of an oil/water separator near the head of the ditch in 1981, waste materials could have (1) flowed through the ditch and off the base property, (2) soaked into the ground along the route of the ditch, or (3) evaporated. It is probable that a combination of all three occurred. Installation of the oil/water separator in 1981 effected the removal of fuel and oil layers, preventing their escape from base property, and reducing the potential area of contamination to the on-base section of ditch ending at the oil/water separator.

Bioenvironmental Engineering personnel routinely collect and analyze water samples from Onion Creek. To date, the data indicate that no significant levels of contaminants exist in Onion Creek downstream of the South Fork Drainage Ditch.

2.4.2 Site 13. MOGAS Spill at Motor Pool Area

Site 13, located at a Motor Pool area between vehicle fueling stands 1803 and 1804, is the site of repeated MOGAS spills occurring from 1974 to 1978. The spills were periodic and occurred during filling of two underground MOGAS storage tanks. Over the 4-year period from 1974 to 1978, the total spillage was estimated to be 1,600 to 3,200 gallons. Each time a tank was filled, fuel would be lost through a connection. All spills soaked into the gravel-covered ground. No attempts to recover spills were reported. The spills ceased in 1978 when a proper connection was established between the fill lines and filler pipes.

2.4.3 Site 23. Fire Training Area

Site 23 is located at the south end of the base adjacent to taxiway 9. This active training site is an unlined circular pit of approximately 120 feet in diameter surrounded by a dirt berm. Improvements made over the years include enlargement, regrading, and the installation of a new limestone base in 1982. Also, a drain and an oil/water separator were connected to the sanitary sewer in 1982 to collect and pretreat runoff. Prior to this time, runoff percolated into the ground within the pit area.

Most potential contaminants would have been consumed in the fires; however, some minor percolation of residual materials into the ground is assumed to have occurred, especially before 1972, when the practice of water presaturation of the ground was begun. It is not known what quantity of fuels, waste oils, and spent solvents have infiltrated into the ground.

2.4.4 Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

The Combined Southeast Landfill (Figure 1-1) consists of several individual disposal sites located on the southeast side of Bergstrom AFB in the area of the South Fork Drainage Ditch. This combined site consists of Landfill Nos. 3, 4, 5, 6, and 7. An old road oiling area (Site 14) is located between Landfill Nos. 3 and 4. All these landfills were considered a single site in Phase II (Stage 1) for monitoring program development, because of the proximity of the sites to each other and the similarity of wastes disposed of at each site. The site was determined to pose a potential threat for off-base contaminant migration. General features for each of the individual landfills that make up the site are given below.

Site 3. Landfill No. 3

Landfill No. 3 was operated from 1952 to 1957. This site is located on the east side of the base along the south side of Third Street, just southeast of the senior officers' Military Family Housing (Facility Nos. 4402 through 4428) and includes approximately 10 acres. This site is now a cleared field covered with grass; no evidence of recent use or unauthorized dumping exists. Landfill No. 3 received primarily domestic solid waste. Construction rubble was also disposed of at the site. Other materials that may have been disposed of include empty pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents from the industrial shop areas.

The mode of operation at Landfill No. 3 was to burn and bury wastes in trenches. Historical aerial photographs show evidence of at least two covered trenches at the site. An asphalt emulsion tank had been located at this landfill until 1975. No environmental problems were known to be associated with this tank, which was removed in 1975.

Site 4. Landfill No. 4

Landfill No. 4 was operated from 1957 to 1965. This site, approximately 10 acres in area, is located on the east side of the base, southeast of the senior officers' Military Family Housing and across Third Street from Landfill No. 3. The site as it now appears is a cleared field, covered with grass; no evidence of recent use or unauthorized dumping was found.

Landfill No. 4 received primarily domestic solid waste. Construction rubble was also probably buried at the site. Rinsed and punctured pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents are also suspected of having been buried at the site.

Normal operation at this landfill was to burn and bury wastes in 12-foot-deep trenches. The practice was to burn in one trench while covering the previously burned waste in the other trench. Historical aerial photographs show evidence of at least three covered trenches running the length of the site. Landfill No. 4 was the last landfill at which routine burning was practiced.

Site 5. Landfill No. 5

Landfill No. 5 was operated from 1965 to 1971. This landfill, approximately 12 acres in size, is located in the southeast corner of the base. It is bordered on the east and southeast by the base boundary and on the west and southwest by a deep drainage ditch that carries drainage off base. The site is bordered on the northwest by an access road.

Domestic solid waste and construction rubble were disposed of at this landfill. Rinsed and punctured pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents are also suspected of having been buried at the site.

The site as it now appears is an open field, partially covered by grass. Two asphalt storage tanks (approximately 6,000 gallons each) are located near the center of the site and are reported to have been installed here when the emulsion tank at Landfill No. 3 was removed.

Miscellaneous rubble including broken concrete, an old television set, and an empty 55-gallon drum were observed during the base visit. The site also serves as the storage point for three solid waste collection bins located on the west side of the site.

The method of operation at this landfill was similar to that at the landfills discussed previously, i.e., trenching; however, burning of refuse prior to burying was not practiced.

Site 6. Landfill No. 6

Landfill No. 6 was operated from 1971 to 1976. This landfill includes approximately 12 acres and is located in the southeast corner of the base between Landfills 5 and 7. The site is bordered on the southwest, south, and southeast by a deep drainage ditch (South Fork Drainage Ditch). A munitions storage area borders the site on the northwest side, while the northeast side borders the drainage ditch separating this landfill from Landfill No. 5.

The types of materials received at this landfill included domestic solid waste and construction rubble. Other materials suspected of having been disposed of at this site include rinsed and punctured pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils and solvents. In the early 1970's, seven 55-gallon drums of DDT were found abandoned at this landfill. One of the drums was corroded and had leaked its contents into the ground. It was not known whether or not the drum was full prior to leaking. The remaining six drums were given to the city of Austin.

The site is now an open field, scarred with roads and partially covered with grass. Solid waste materials are pushed up to the edge of the South Fork Drainage Ditch. The records search team observed construction debris (e.g., broken concrete) and several empty 5-gallon paint containers near the ditch. Four 55-gallon drums were also observed. One of the drums was marked PD-680 and had been leaking because of a loose bung cap. It appeared to be about 20 percent full, while the other three drums were empty. Whether the PD-680 drum had been full prior to leaking is not known. The physical appearance of the four drums indicated that they were probably placed there after the landfill was closed in 1976. These drums were subsequently removed by base personnel.

Landfill No. 6 consisted of open trenches for waste disposal. The trenches may have been as deep as 30 feet. No burning was practiced at this landfill.

Site 7. Landfill No. 7

Landfill No. 7 covers approximately 7 acres and was operated from 1976 to 1980. This landfill is located in the southeast corner of the base, south of Landfill No. 6. The southeast side of the site borders the base property line.

Materials received at this landfill include domestic solid waste and construction rubble. Other materials suspected of being present at the site include empty pesticide containers, paint cans, and incidental quantities of waste paints, thinners, strippers, oils, and solvents. One interviewee reported that approximately 5 years ago, a small quantity of antifreeze was poured into the landfill. More specific information was not available.

The landfill is now an open field with sparse grass coverage. Two open trenches are currently in use at the site for disposal of tree limbs and similar rubbish. One trench extends nearly the entire length of the southwest side of the site while the other runs a short distance along the southeast boundary. No evidence of hazardous wastes or vegetation stress was observed during the base visit.

Site 14. Road Oiling Area

Site No. 14, located at the southern area of Third Street, was the site of road oiling for dust control. The site extends for about one-half mile, covering the length of Third Street between Landfill Nos. 3 and 4 and a short road section next to the base boundary. Road oiling occurred from the mid-1950s to 1962. The source of the waste oils was the industrial shops located along the flightline areas. Oil was dispensed from a spreader bar on the back of a 150- to 500-gallon bowser. Reportedly, approximately two times per year up to 300 gallons of waste oil may have been spread onto the road. Over a period of approximately seven years, up to 4,200 gallons could have been spread over the unimproved road.

2.4.5 Site 8. JP-4 Spill/Overtopped Tank

Site 8, at the POL bulk storage area (Facility No. 513), was the site of a tank-filling accident in 1975 that resulted in the loss of 2,000 to 8,000 gallons of JP-4 fuel. The tank being filled was the larger of two vertical storage tanks located at the facility. The spill occurred when the floating top was allowed to exceed its maximum height, permitting JP-4 to escape and overflow the top of the tank. The lost fuel soaked into the gravel base of the POL storage area. No attempts to recover the spilled fuel were reported.

2.4.6 Site 9. JP-4 Suspected Underground Line Leak

Site 9 is a small area around a JP-4 low flow valve in the vicinity of Building 4544 (Bergstrom AFB flight tower) (Figure 1-1). In early 1984 an Air Force corrosion team conducted gas line testing at Bergstrom AFB. A pit approximately 6 1/2 feet deep was dug at Site No. 9 to inspect the 8-inch JP-4 line. Water with a sheen was noted at the bottom of the pit. It was suspected that there might be a pipeline leak from the JP-4 transmission system. Foundation borings near the area did not indicate the presence of free groundwater. A study was initiated under the IRP program to confirm and investigate a leak at the JP-4 pipeline.

3.0 FIELD PROGRAM

The field program included investigations at six sites at Bergstrom AFB. These sites as presented in the statement of work are:

- Site 17. South Fork Drainage Ditch
- Site 13. MOGAS Spill at Motor Pool
- Site 23. Fire Training Area
- Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill
- Site 8. JP-4 Spill/Overtopped Tank Area
- Site 9. JP-4 Suspected Underground Line Leak

3.1 Site 17. South Fork Drainage Ditch

In order to assess the impacts of potential contaminants being transported by water in the South Fork Drainage Ditch, a series of sediment samples were collected. Because the drainage ditch flows only intermittently, water samples were not collected. No precipitation or runoff had occurred for at least a week before sampling.

The sediment samples were collected using a hand auger with a 3-inch diameter bucket. Samples were taken from the deepest part of the stream channel, either through standing water or in the dry creek bottom, depending on conditions at each sampling point. Samples were collected beginning at the farthest downstream point of the drainage ditch (that was still on Bergstrom AFB property) and working upstream toward the outfall where the storm drainage system discharges to the ditch. These locations are shown in Figure 3-1. Table 3-1 describes the sample locations.

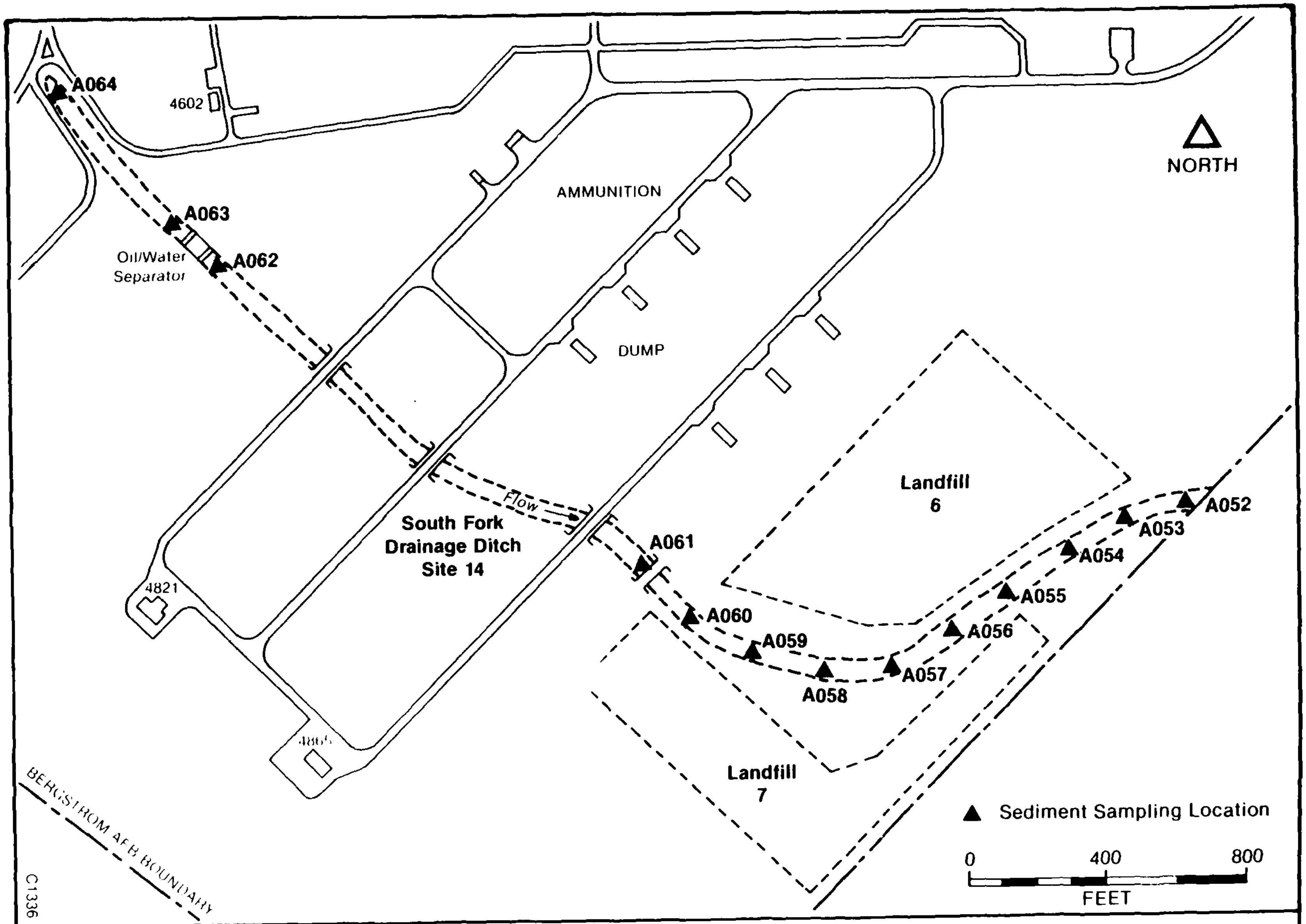

Figure 3-1. Sediment Sampling Points at Site 17, South Fork Drainage Ditch

TABLE 3-1. SAMPLE POINT DESCRIPTION FOR SITE 17, SOUTH FORK DRAINAGE DITCH

Sample Number	Description
A052	Sediment 0-1 ft. Located in shallow water (very low flow) 65 feet upstream of confluence of South Fork Drainage Ditch and drainage ditch to the east. Sampled approximately at base boundary.
A053	Sediment 0-1 ft. Located approximately 200 feet upstream of A052, near large concrete block. Sampled in stagnant water. NOTE: Small spring from Landfill 6 located 20 feet upstream.
A054	Sediment 0-1/2 ft. Located approximately 200 feet upstream of A053 in rocky streambed area.
A055	Sediment 0-1 ft. Located approximately 200 feet upstream of A054 in sandy, dry streambed, near two very large trees.
A056	Sediment 0-1 ft. Located approximately 200 feet upstream of A055. Sampled muck bottom through stagnant water.
A057	Sediment 0-1 ft. Located approximately 200 feet upstream of A055. Sampled muck bottom through stagnant water.
A058	Sediment 0-1/2 ft. Located apprximately 200 feet upstream of A057. Sample point 30 feet upstream of old metal drum.
A059	Sediment 0-1/2 ft. Located approximately 200 feet upstream of A058. Dry stream bottom with water just below surface. Oily sheen on water.
A060	Sediment 0-1/2 ft. Located approximately 200 feet upstream of A059. Dry stream bottom with water just below surface.
A061	Sediment 0-1/2 ft. Located upstream of small bridge, downstream of ammunition dump fence.
A062	Sediment 0-1/2 ft. Located 50 feet downstream of oil/water separator in dry stream bottom.
A063	Sediment 0-1/2 ft. Located 50 feet upstream of oil/water separator in dry stream bed.
A064	Sediment 0-1/2 ft. Located 50 feet downstream of outfall in muck stream bottom.

Each sediment sample was placed in a glass bottle with a Teflon -lined lid, transported to Radian laboratories, and frozen until analyses were conducted.

The following analyses were conducted on each sediment sample:

Analysis	EPA Method
Oil and Grease	413.1
(Extraction)	503.D (Standard Methods for the Examination
Copper (Cu)	200.7 of Water and Wastewater)
Chromium (Cr)	200.7
Nickel (Ni)	200.7
Lead (Pb)	239.2

3.2 Site 13. MOGAS Spill at Motor Pool

In order to assess the impacts of periodic fuel spills that occurred between 1974 and 1978 in the vicinity of the fuel tank loading area, one corehole was drilled close to the fuel tanks. Figure 3-2 shows the location of the corehole. The corehole was drilled using a hollow-stem auger. Soil samples were collected with a split-barrel sampler or Shelby-tube at 2-1/2 foot intervals from 0 to 20 feet below land surface (bls) and at 5-foot intervals from 25 feet bls to the water table. Each sample was described (logged) by a geologist, placed in a glass bottle with a Teflon-lined lid, transported to Radian laboratories, and frozen until analyzed. Figure 3-3 shows the generalized log for Corehole 1. The detailed log for Corehole 1 is given in Appendix D.

A total of 14 soil samples were collected from Corehole 1. Six soil samples were selected for analysis based upon lithology, depth, and visual observations. These analyses were:

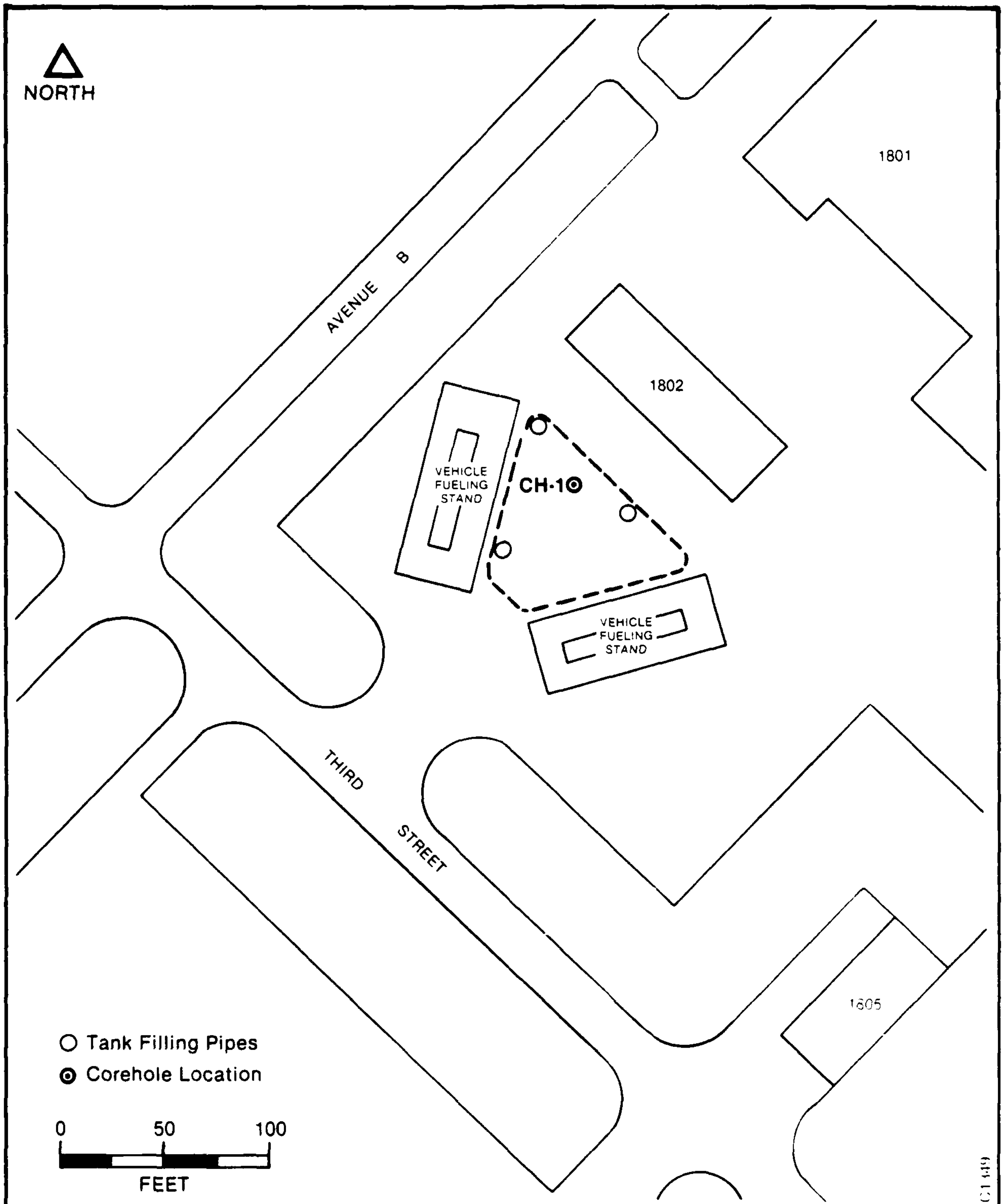

Figure 3-2. Location of Corehole 1 at Site 13, Motor Pool Area

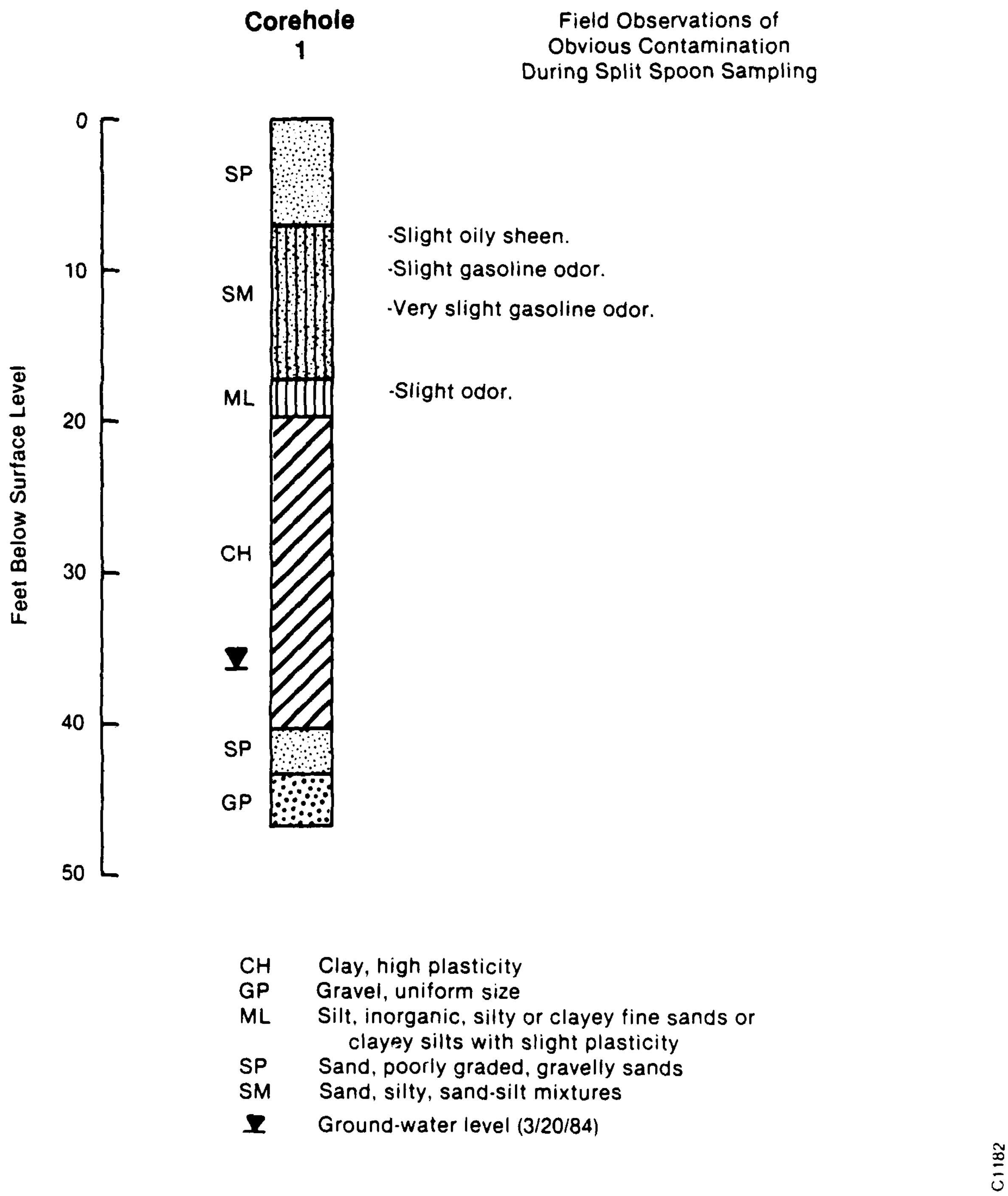

Figure 3-3. Generalized Geologic Log for Corehole 1 at Site 13, Motor Pool Area

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Analysis	EPA Method
Oil and Grease	413.1
(Extraction)	503.D (Standard Methods for the Examination
Cd, Cr, Ni	200.7 of Water and Wastewater)
Pb	239.2

The corehole was advanced 5 feet below the water table into the saturated zone. A temporary PVC casing (2-inch diameter) with hand-cut slots was emplaced through the auger. The auger flights were then extracted and a cover was placed over the corehole.

This temporary casing provided access for a water-level measurement and groundwater sampling. After allowing the groundwater level to stabilize overnight, the depth to groundwater was measured using a steel tape. The temporary well was then sampled using a Teflon bailer. After removing 3 to 5 wetted casing volumes of water, the water was sampled using the bailer. The sample was split and preserved for analysis as follows:

- o 500-mL glass jar, preserved with sulfuric acid to pH <2, refrigerated.

- o 500-mL plastic bottle, preserved with nitric acid to pH <2, refrigerated.

The water sample from Corehole 1 was analyzed for:

Analysis	EPA Method
Oil and Grease	413.1
Total Organic Carbon	415.1
Cd, Cr, Ni	200.7
Pb	239.2
Purgeable Hydrocarbons	602

After collecting the water sample, the temporary casing was pulled from the corehole and the hole was filled with grout up to the land surface.

3.3 Site 23. Fire Training Area

Two borings were drilled in the vicinity of the fire training area to assess the possible migration of contaminants from the fire pit area. The coreholes were drilled by the method described in Section 3.2. Hollowstem auger drilling was used with soil sampling every 2-1/2 feet from 0 to 20 feet bls, and every 5 feet from 25 feet bls to the water table. Soil samples were placed in glass bottles with Teflon-lined lids, transported to Radian laboratories, and frozen until analyzed. Figure 3-4 shows the locations of the two coreholes (Coreholes 3 and 4). Figures 3-5 and 3-6 show the generalized geologic logs for Coreholes 3 and 4, respectively. Detailed geologic logs are given in Appendix D.

A total of 11 soil samples were collected from each corehole. Of these samples, six were selected from each corehole for chemical analysis. These were selected based upon lithology, depth, and visual observations. Each of the 12 samples was analyzed for:

Analysis	EPA Method
Oil and Grease	413.1
(Extraction)	503.D (Standard Methods for the Examination
Cd, Cr, Ni	200.7 of Water and Wastewater)
Pb	239.2

Following the installation and stabilization of the temporary casings (as described in Section 3.2), one water sample was collected from each well after bailing 3 to 5 wetted casing volumes. Samples were preserved as described in Section 3.2 and analyzed for:

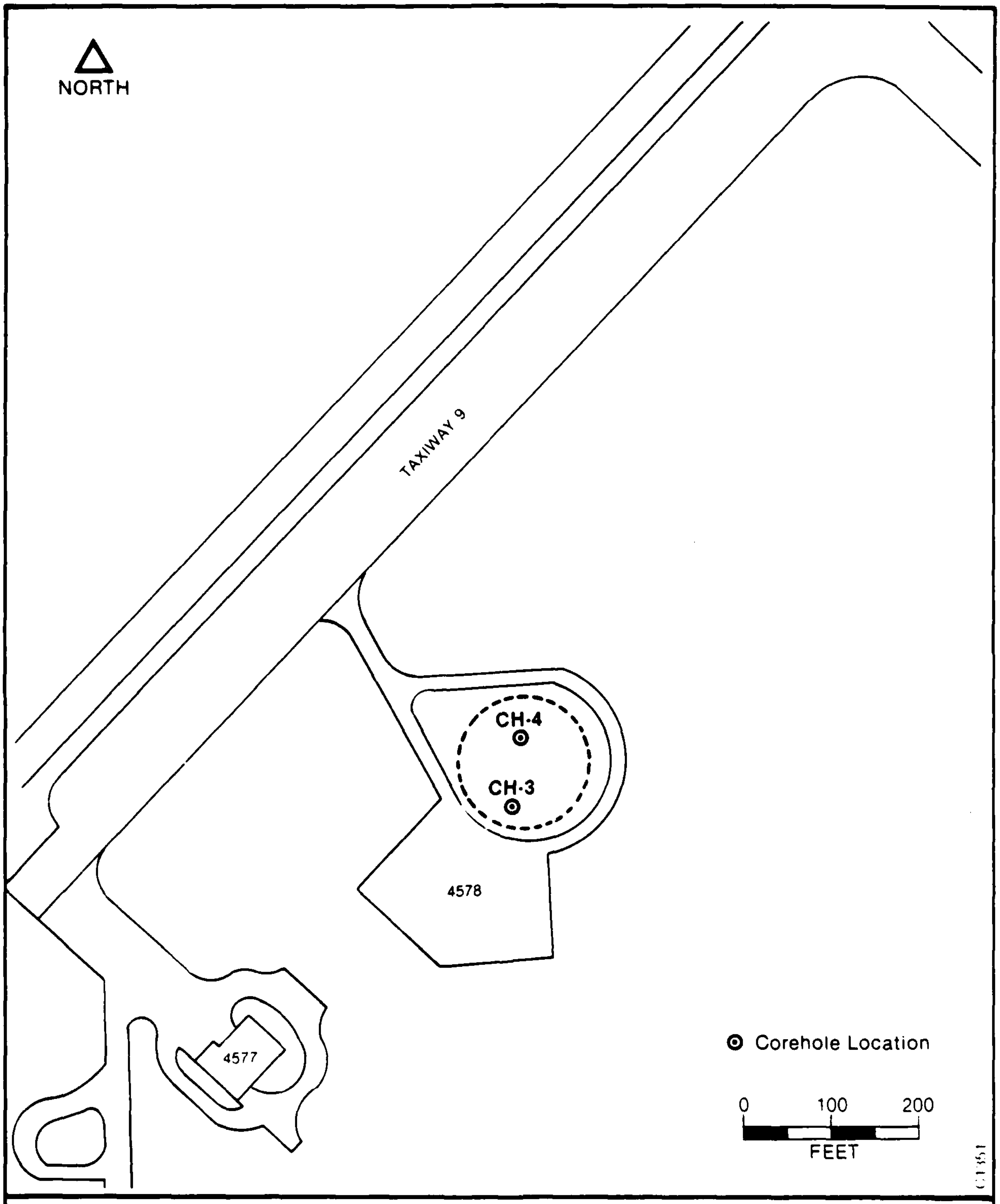

Figure 3-4. Corehole Locations at Site 23,
Fire Training Area

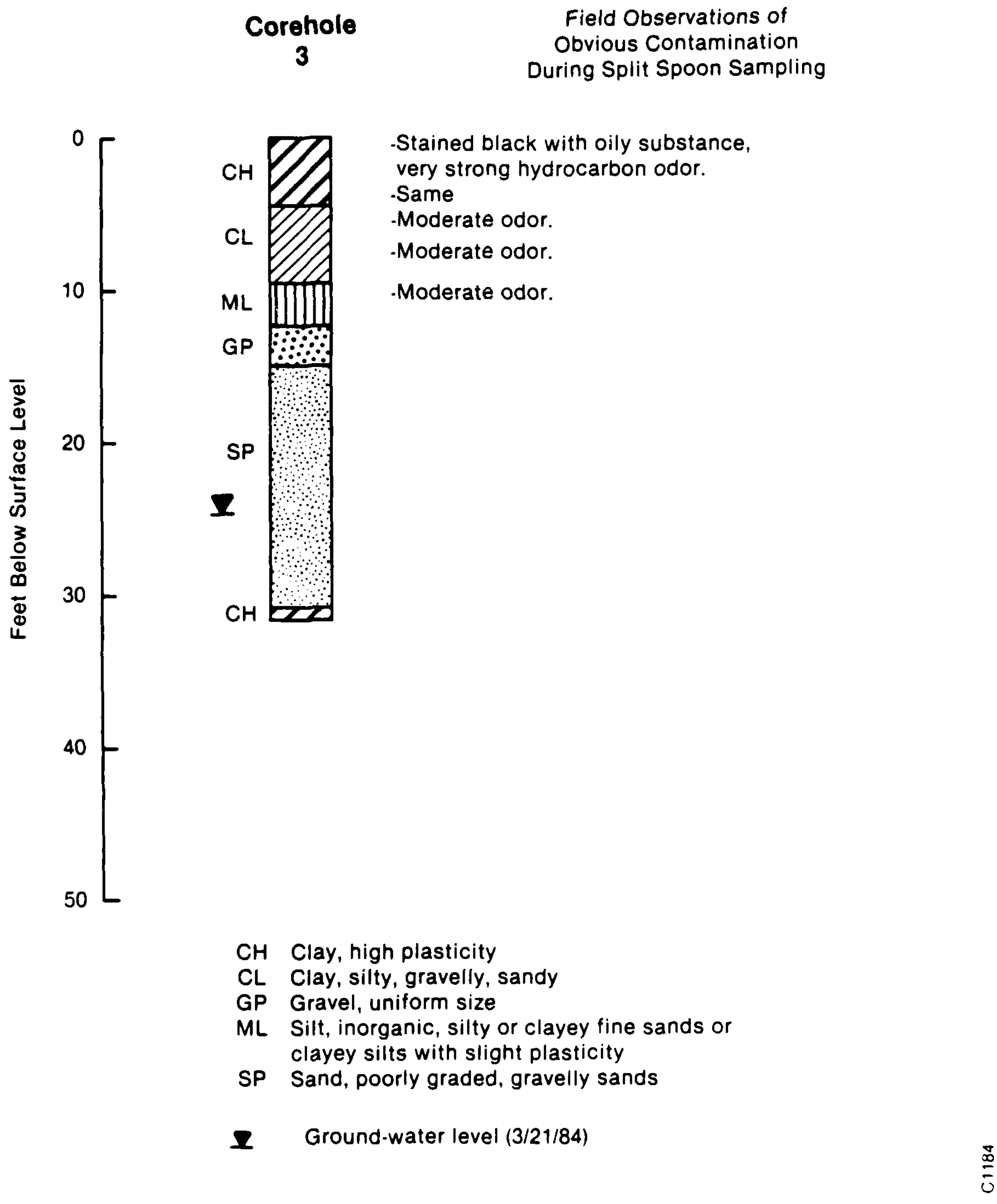

Figure 3-5. Generalized Geologic Log for Corehole 3 at Site 23, Fire Training Area

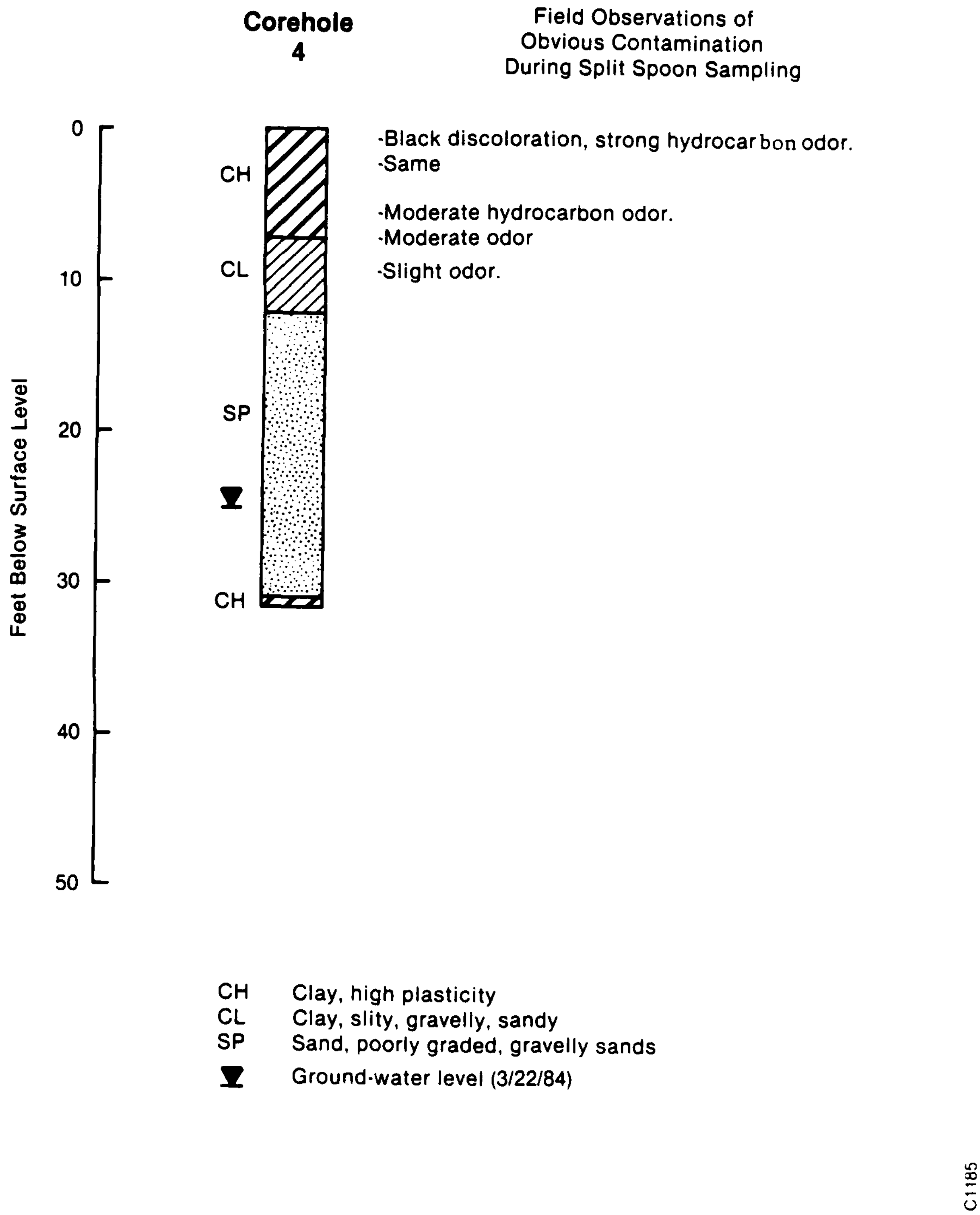

Figure 3-6. Generalized Geologic Log for Corehole 4 at Site 23, Fire Training Area

Analysis	EPA Method
Oil and Grease	413.1
(Extraction)	503.D (Standard Methods for the
Cd, Cr, Ni	200.7 Examination of Water and
Pb	239.2 Wastewater)
Total Organic Carbon	415.1
Purgeable Halocarbons	601
Purgeable Hydrocarbons	602

Both coreholes were grouted to the land surface following removal of the temporary casings.

In addition to the Radian-collected samples, base personnel collected eight soil samples from the Fire Training Area down to a depth of about 6 inches. The soil coring locations are shown in Figure 3-7. The samples were collected in response to EPA Region VI comments to the Phase I report concerning the possibility that transformer oils containing PCBs may have been burned at the site. The soil samples were analyzed for PCBs by Air Force laboratories and the results are provided in Table 3-2.

3.4 Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

Included in the discussion of the Combined Southeast Landfill area are three work elements. These are:

- The installation, sampling, and analysis of monitoring wells near landfill boundaries,

- The sampling and analysis of the existing golf course well (included in this section for the purpose of comparison with monitoring well data), and

- The sampling and analysis of soils in the road oiling area.

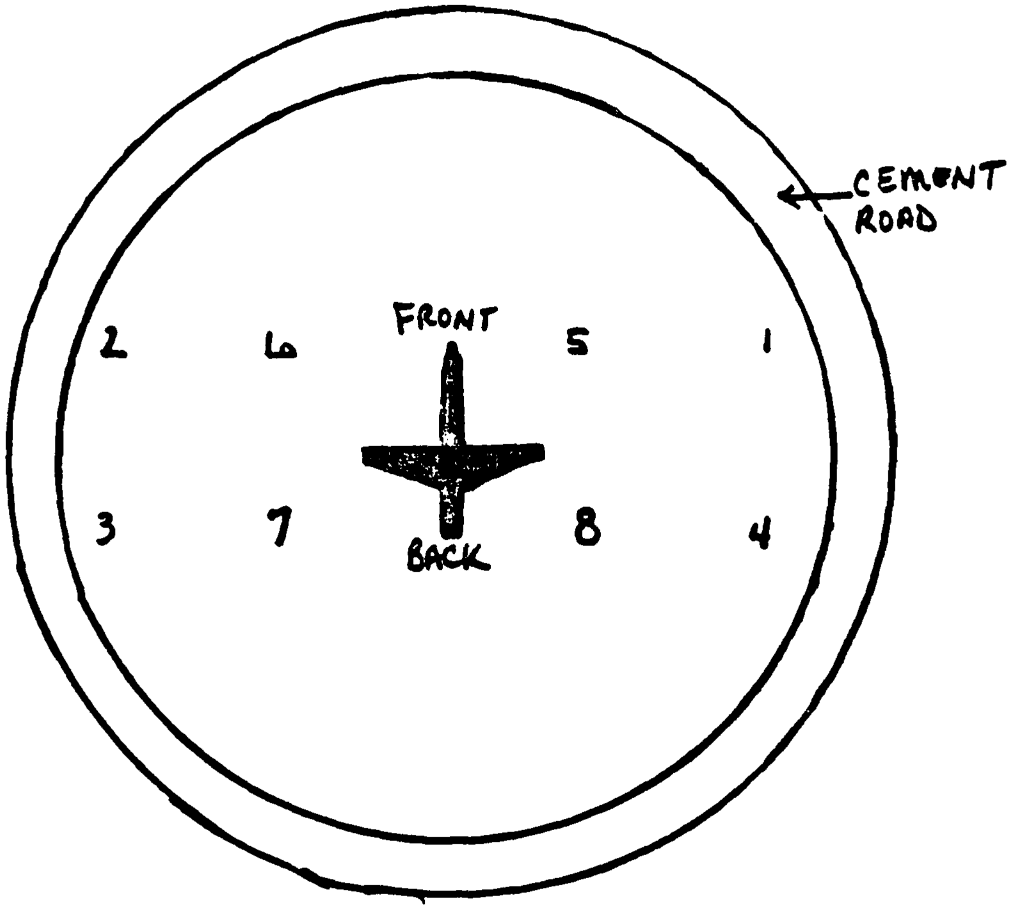

Figure 3-7. Soil Sampling Locations by the Base at Site 23, Fire Training Area

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TABLE 3-2. ANALYTICAL RESULTS OF SOIL SAMPLES FROM SITE 23, FIRE TRAINING AREA

Soil Sample Numbers OEHL #	Base #	Polychlorinated Biphenyls (PCBs)[1] mg/kg[2]
58801	GS840341	Trace
58802	GS840342	Trace
58803	GS840343	Trace
58804	GS840344	ND
58805	GS840345	ND
58806	GS840346	ND
58807	GS840347	ND
58808	GS840348	ND

[1]Analyses provided by USAFOEHL/SR, Brooks AFB, Texas.

[2]ND denotes none detected. Less than the detection limit of 0.5 mg/kg. Trace denotes present but less than the quantitative limit of 1.0 mg/kg.

3.4.1 Monitoring Wells

A total of 6 monitoring wells were installed in the Combined Southeast Landfill area as shown in Figure 3-8. Also shown in Figure 3-8 are the locations of Coreholes 5 and 6 which did not encounter significant groundwater and were not completed as monitoring wells.

The monitoring wells were drilled using the hollow-stem auger method. Soil samples were collected at 5-foot intervals using either a split-barrel or Shelby-tube sampler. Wells were drilled to approximately 15 feet below the water table. The wells were completed with a 10-foot long, 4-inch diameter, wire-wound, stainless steel screen and 4-inch diameter PVC casing (using threaded joints and no solvent glues). The top of the screen was set at approximately the level of the water table. Clean sand was backfilled around the screen, and a bentonite-pellet seal was emplaced on top of the sand. The remainder of the annular space was then cemented up to the land surface with Portland Type I neat cement (no aggregate). A protective steel pipe with locking cap was installed over the PVC casing, a concrete pad was completed, and three protective posts were emplaced around the wellhead. Detailed geologic logs for the monitoring wells and the completion sketches for each well are provided in Appendix D.

Following installation each well was developed by pumping using a 1/3-horsepower submersible pump. Details of the development are given in Appendix E.

The top of each monitoring well casing was surveyed to determine the elevation. This served as the reference point for water level measurements taken prior to each well sampling.

After allowing the wells to stabilize for a period of approximately one week, water levels were measured and the wells were purged and sampled. (During the stabilization period no precipitation or rainfall infiltration occurred). This was accomplished using either an air-driven bladder pump or a

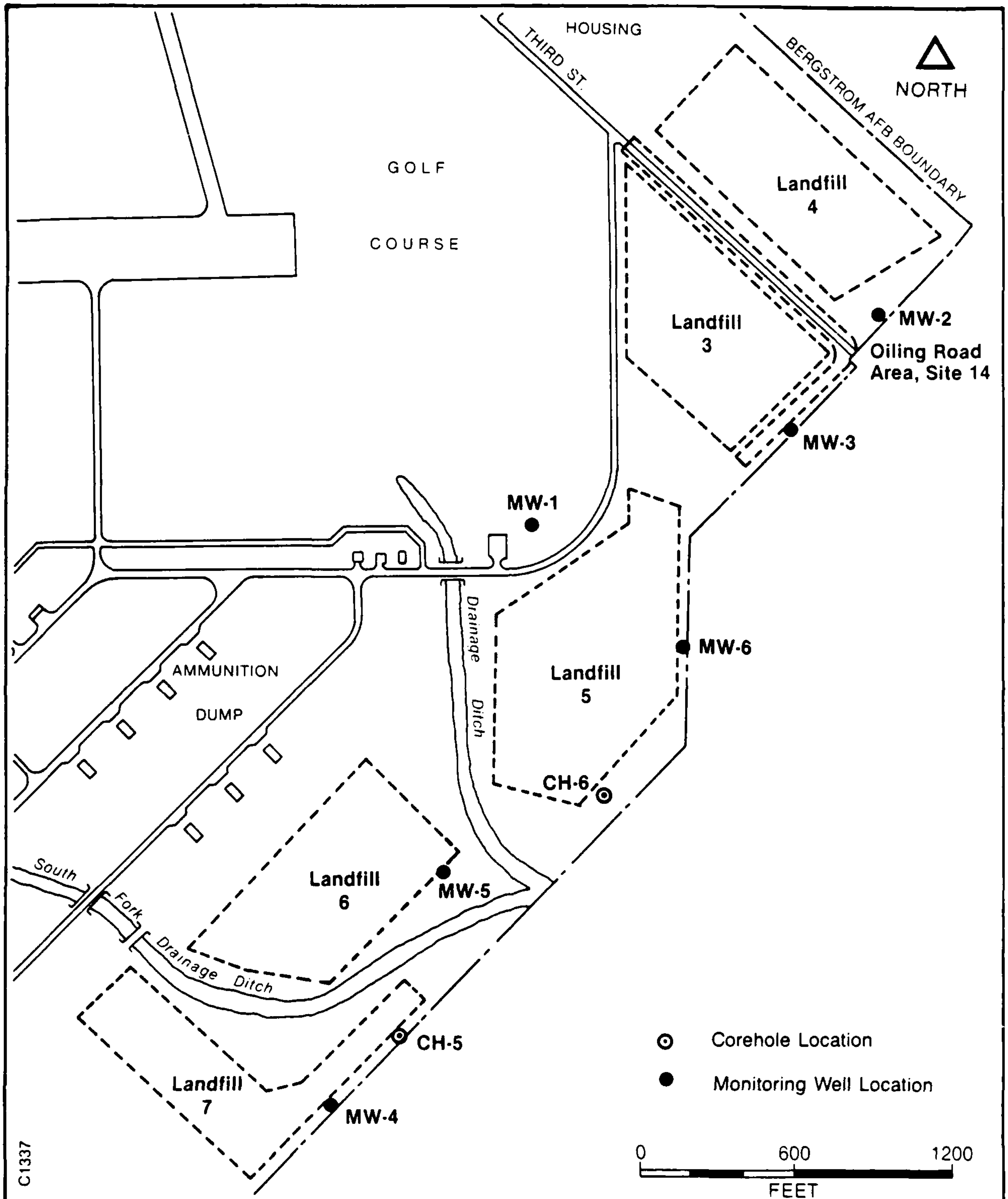

Figure 3-8. Locations of Monitoring Wells and Coreholes in the Vicinity of Sites 3, 4, 5, 6, 7, and 14, Combined Southeast Landfill

Teflon bailer. The sampling effort was repeated one month after the initial round of sampling.

Each water sample was split and preserved for analysis as follows:

- o 1-liter glass bottle, preserved with sulfuric acid to pH <2.

- o Two 1-liter glass bottles, no field preservative.

- o 500-mL plastic bottle, preserved with nitric acid to pH <2.

- o 1-quart wide-mouth glass jar, no field preservative.

All sample fractions were refrigerated while awaiting analysis. The following analyses were conducted:

Analysis	EPA Method
Oil and Grease	413.1
Total Organic Carbon	415.1
Total Organic Halogens	450.1
Phenolics	420.1
Ba, Cd, Cr, Ag	200.7
Pesticides, DDT isomers, PCBs	608
2,4-D; 2,4,5-TP (Silvex)	509B (Standard Methods for the Examination of Water and Wastewater)
Dibrom	608 (special scan)

3.4.2 Existing Golf Course Well Sampling

Only one on-base well is currently active. This well, located in the northeast corner of the base, produces 25 to 30 gallons per minute. This water is pumped directly to small ponds on the golf course. During the first round of monitoring well sampling in the Southeast Landfill area, the golf course well pump was inoperative and the well could not be sampled. The pump was repaired and the golf course well was sampled during the second round of monitoring well sampling.

The groundwater sample from the golf course well was split, preserved, and analyzed in the same manner as the monitoring well samples in Section 3.4.1 above. No precipitation or rainfall infiltration had occurred for at least a week before sampling.

3.4.3 Road Oiling Area

During a seven-year period in the 1950s and 1960s, waste oils were spread over the section of road shown in Figure 3-9. To determine if the waste oils contained PCBs, three soil samples were collected from the road area. The sampling locations were:

Sample Number	Description
A071	Soil - Sample was taken at a depth of approximately 1/2 foot, 80 feet southeast of the yield sign at the intersection of Third Street and the road that veers to the south, and 18 inches southwest of the pavement. Thin, black layering was visible in the sample hole.
A072	Soil - Sample was taken at approximately 275 feet southeast of the yield sign, 1 foot east of the pavement, and at a depth of approximately 3 inches. Black material was encountered.
A073	Soil - Sample was taken at approximately 660 feet southeast of the yield sign, 1 foot east of the pavement, and at a depth of approximately 1/2 foot. Dark brown clayey soil but no black material was encountered.

All samples were placed in glass jars with Teflon-lined lids, transported to Radian laboratories, and frozen until analyzed.

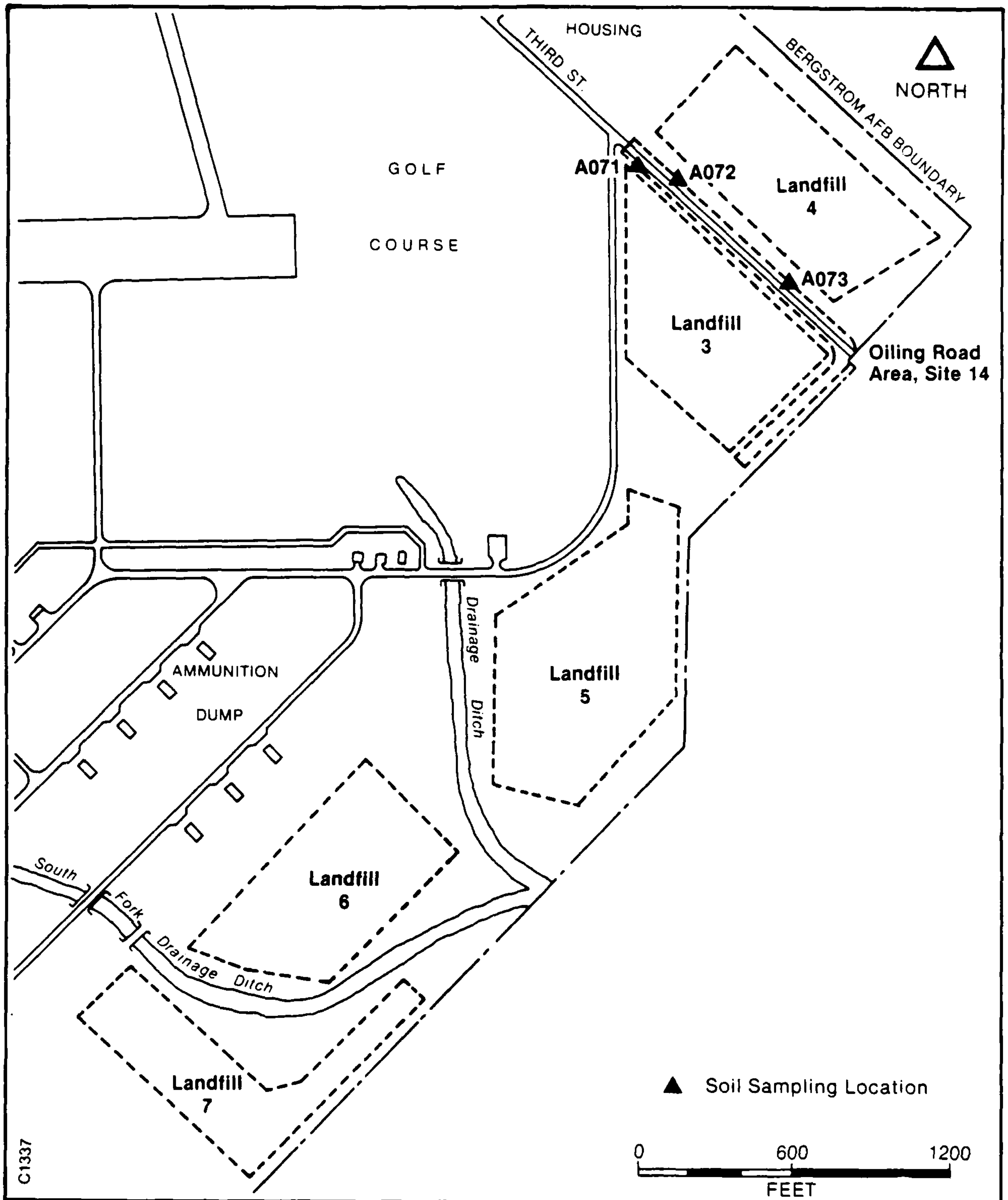

Figure 3-9. Locations of Soil Sampling Points on Site 14, Road Oiling Area

Samples were extracted by Soxhlet extraction (EPA 3540) and analyzed by EPA Method 8080 for PCBs.

3.5 Site 8. JP-4 Spill/Overtopped Tank Area

In 1975, an estimated 2,000 to 8,000 gallons of JP-4 fuel was spilled in the area surrounding Tank 513 because of overfilling. To assess potential impacts of this spill, one corehole was drilled within the bermed area surrounding the tank, as shown in Figure 3-10.

The corehole was drilled using the hollow-stem auger method described in Section 3.2. Soil samples were taken at 2 1/2-foot intervals from 0 to 20 feet bls with one additional sample taken at 25 feet bls. Samples were placed in glass jars with Teflon-lined lids, transported to Radian laboratories, and frozen until analyzed. The soil samples were analyzed for oil and grease content by EPA 413.2 (infrared method). A generalized geologic log is shown in Figure 3-11. Detailed geologic logs are presented in Appendix D.

A temporary casing was placed in the corehole, as described in Section 3.2, and one water sample was extracted after bailing. The water sample was preserved as follows:

- 1-liter glass jar, preserved with sulfuric acid to pH <2.
- 500-mL plastic bottle, preserved with nitric acid to pH <2.
- Two 40-mL VOA vials, no field preservative.

The water sample was transported on ice to the Radian laboratory, and refrigerated until analyzed. The water sample was analyzed as follows:

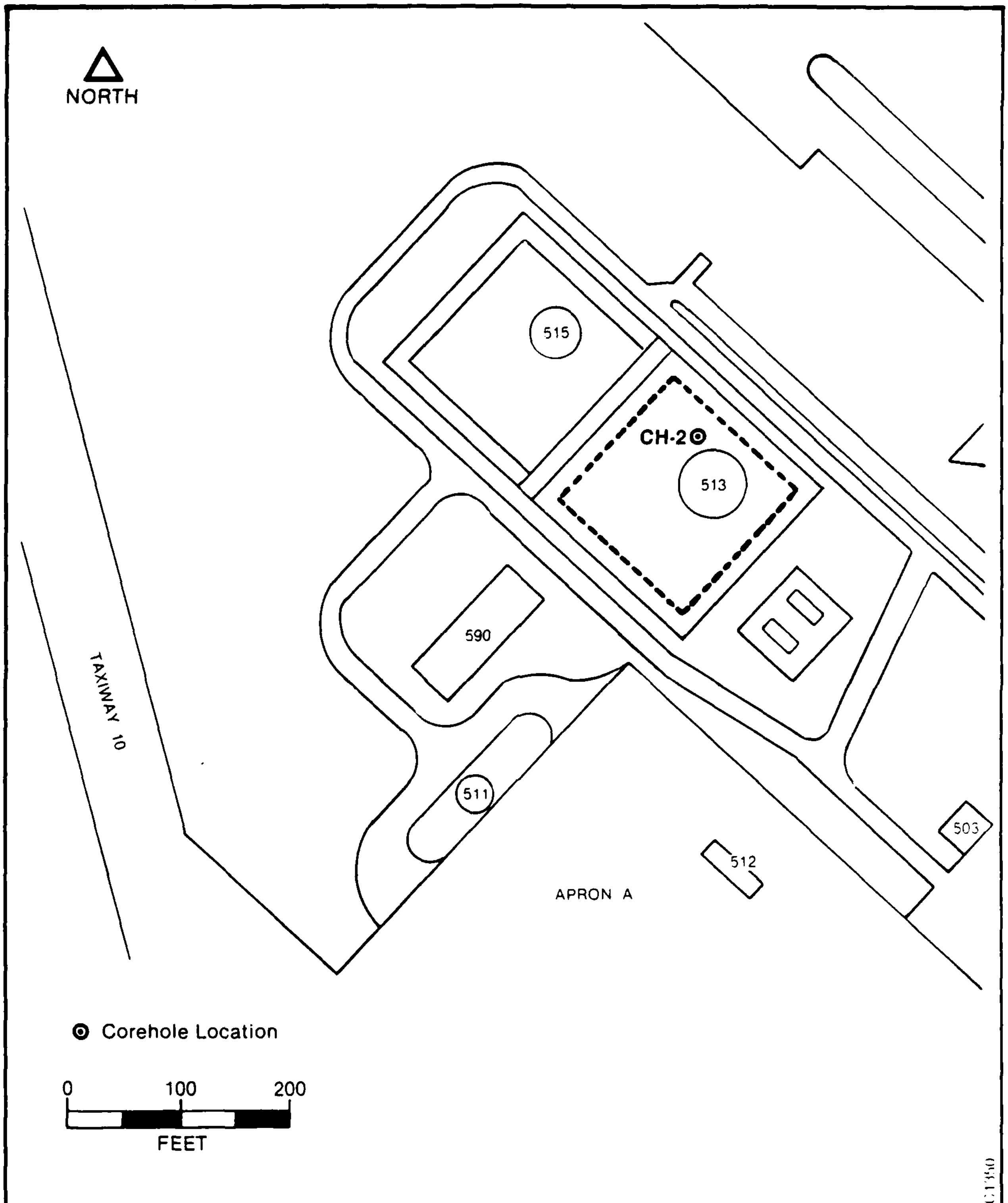

Figure 3-10. Corehole Location at Site 8, JP-4 Spill/Overtopped Tank

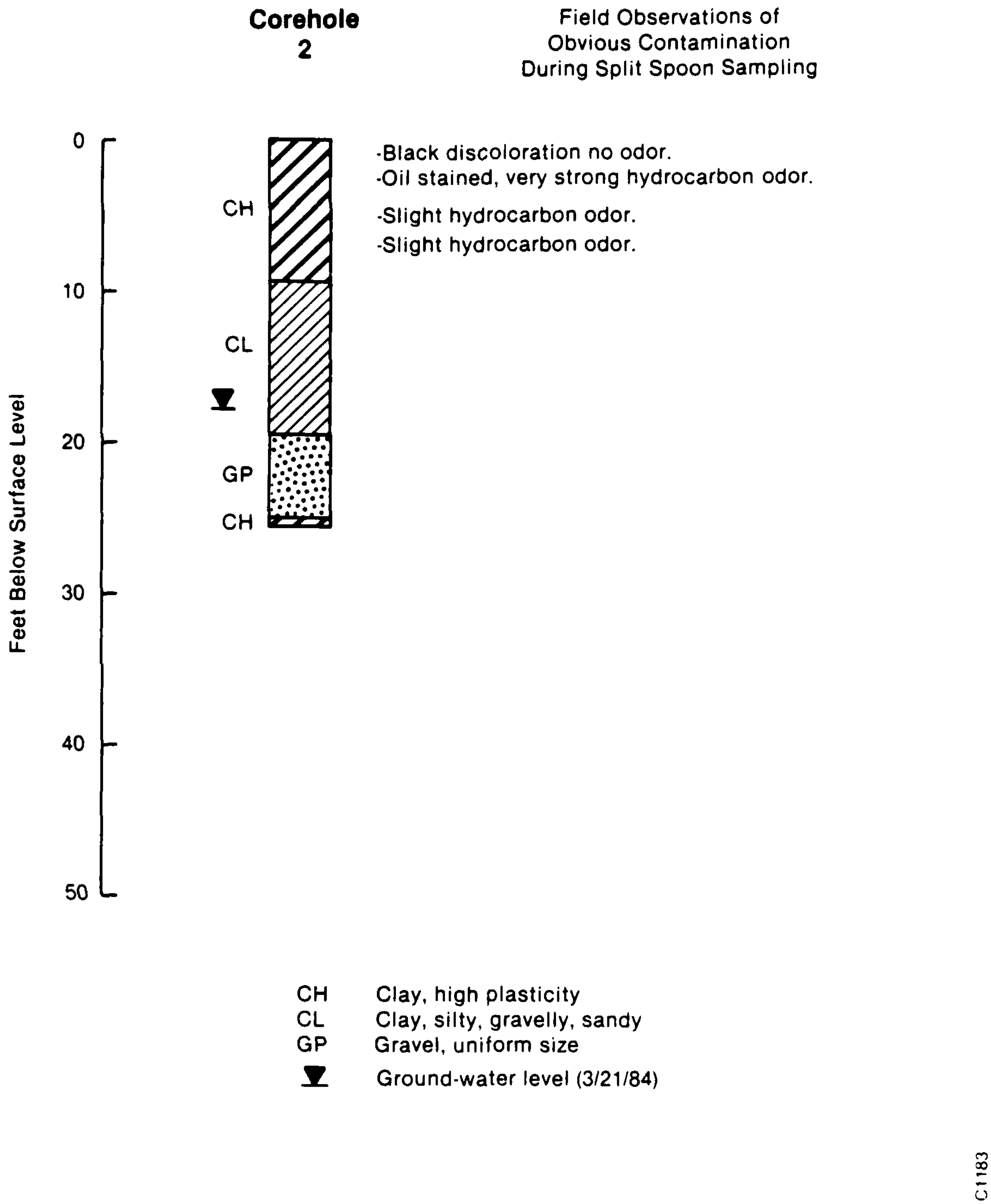

Figure 3-11. Generalized Geologic Log of Corehole 2 at Site 8, JP-4 Spill/Overtopped Tank Area

Analysis	EPA Method
Oil and Grease	413.1
Total Organic Carbon	415.1
Cd, Cr, Ni	200.7
Pb	239.2
Purgeable Hydrocarbons	602

The temporary casing was removed and the corehole was grouted up to the land surface.

3.6 Site 9. JP-4 Suspected Underground Line Leak

Based upon the results of an Air Force corrosion team's inspection of the JP-4 pipeline in 1984, it was determined that the pipeline might be leaking. In order to determine if the fuel line was leaking, the following was accomplished: a data review, acoustic emissions (AE) testing, coring and installation of four monitoring wells, and ambient air sampling.

A data review was done to determine if the Air Force had conducted a line pressure test, to collect data on the nearby utility lines and vaults where fluid or vapor migration could occur, and to review fueling and extraction procedures at the JP-4 fuel low-point drain box. The results of the data review and base personnel interviews permitted tailoring the field investigation to provide the optimum data results.

Acoustic emission (AE) testing was conducted around the JP-4 pipeline. A total of seven locations along the pipeline were selected for excavation, as shown in Figure 3-12. Prior to excavation, the locations were screened, using a pipe locator, by the Radian on-site geologist in coordination with Base personnel from the Liquid Fuels Division. Base personnel assisted in the excavation to ensure that the buried pipeline was properly located and safely exposed. A Radian geologist supervising the activities examined and described the soil being excavated and noted the presence of

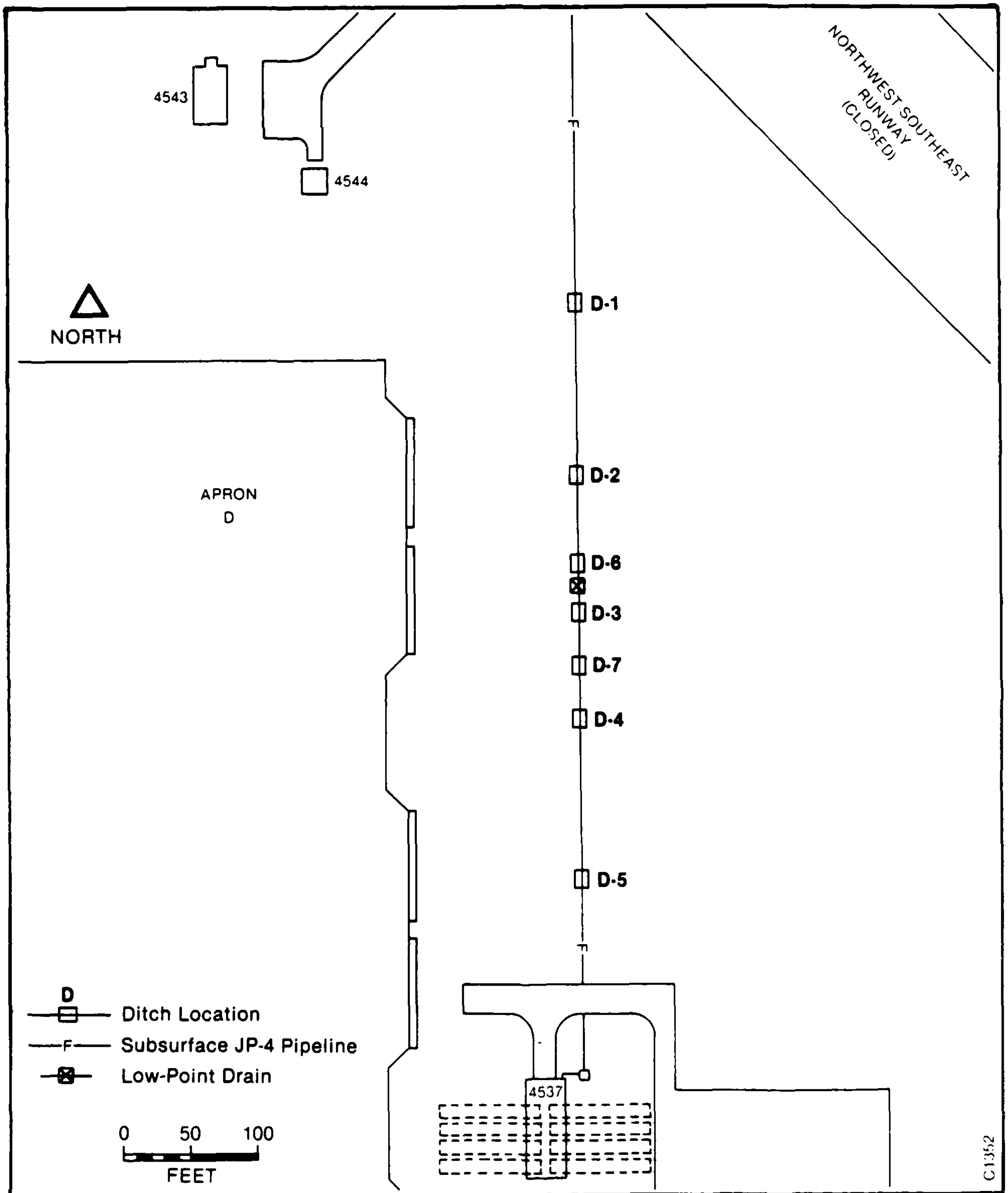

Figure 3-12. Location of JP-4 Pipeline Excavations at Site 9, JP-4 Suspected Underground Line Leak

any hydrocarbons. Once the pipeline had been exposed, a small section of it (approximately a 1/2-foot square) was cleaned of paint and corrosion, and the AE sensors were attached for conducting the pipeline testing.

In AE testing, sensors are used to pick up high-frequency noise that can result from small leaks in a pipeline or connections. In principle, the louder the noise signal, the closer the leak source is to the sensor. To ensure that a leak can be detected, it is best to pressurize a pipeline above normal working pressures.

To conduct the acoustic emissions testing, the pipeline was pressurized several times at pressures ranging from about 121 to 152 psi (pounds per square inch). Line pressurization was conducted by base personnel from the Liquid Fuels Division.

Coreholes

Four coreholes were drilled using a hollow-stem auger to detect the migration, if any, of fuel out of or along the pipeline trench and into other utility pipelines. Additionally, the deepest corehole, CH-7, was used to determine the presence of any aquifers below the pipeline system. The corehole locations were selected to provide data near the storm drain and sanitary sewer located near the pipeline. The corehole locations are shown in Figure 3-13. The coring rationale is provided in Table 3-3. A total of 25 soil and formation samples were obtained for examination and selected for chemical analysis. Table 3-4 provides a summary of the sampling schedule. Each soil sample selected was analyzed for purgeable hydrocarbons using EPA Method 8020.

Monitoring Wells

Three 2-inch monitoring wells were completed in the area of the suspected leak. The locations of the wells are depicted in Figure 3-13. One of

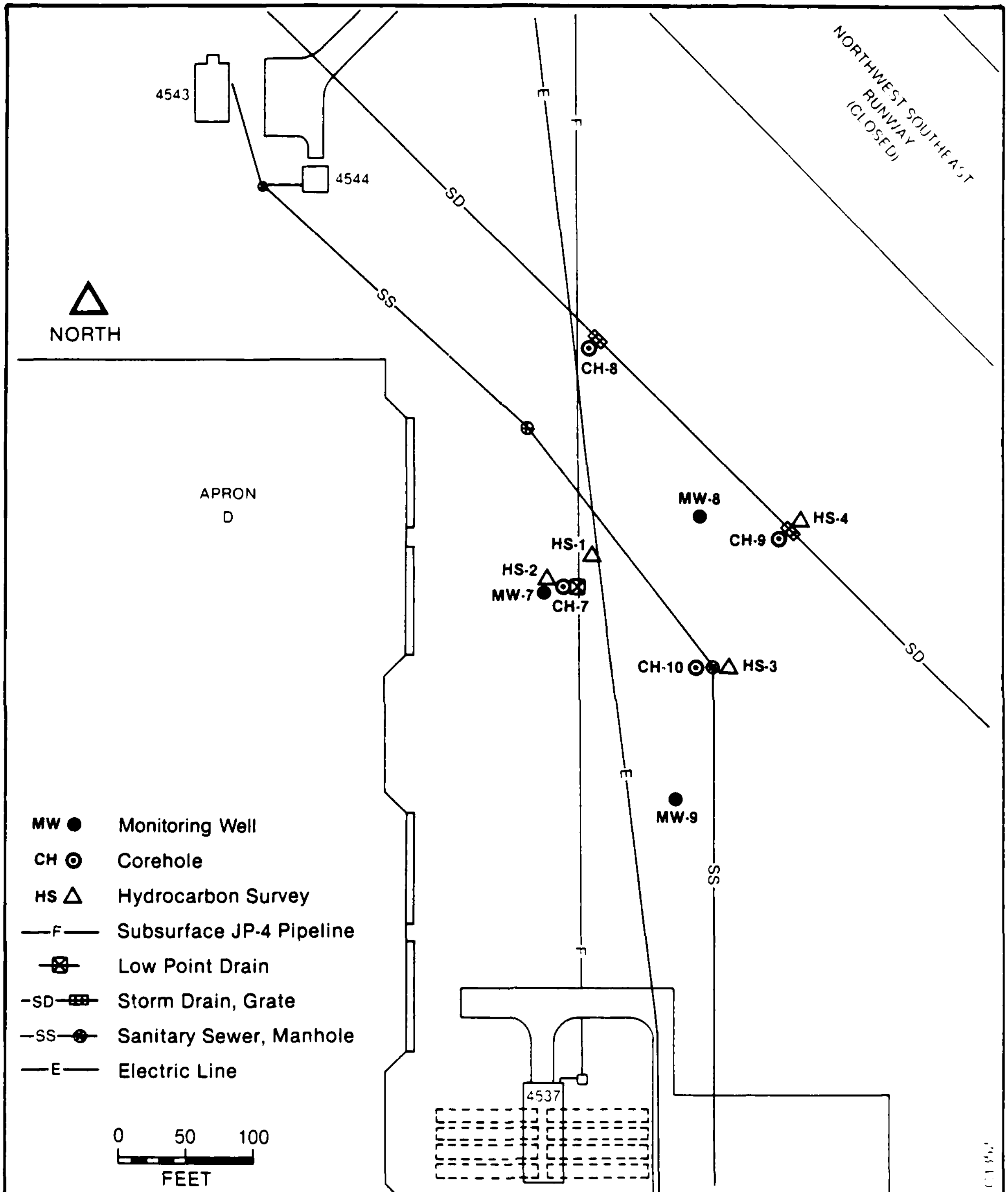

Figure 3-13. Locations of Coreholes, Monitoring Wells and Air Sampling Points, Vicinity JP-4 Pipeline, Site 9, Suspected Underground Line Leak

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TABLE 3-3. SITE 9. JP-4 SUSPECTED UNDERGROUND LINE LEAK-COREHOLE AND HYDROCARBON SURVEY RATIONALE FOR LOCATIONS

Location	Activity	Rationale
CH-7	Corehole to 35 ft.	Confirm lateral and/or vertical fuel migration from the bedding sand and emplace a monitoring well if ground or water vapors are encountered.
CH-8,9, & 10	Corehole to 10 ft.	Confirm lateral fuel migration along JP-4 pipeline intersecting with other underground utilities.
MW-7,8, & 9	Monitoring wells drilled ranging from 30 to 45 ft.	Detect the presence of fuel migration to the water table.*
HS-1,2,3 & 4	Hydrocarbon Survey of Utilities.	Detect the presence of fuel vapors migrating along and into underground utilities.

*Monitoring Well M-7 located in CH-7.

TABLE 3-4. SITE 9, JP-4 SUSPECTED UNDERGROUND LINE LEAK-COREHOLE SAMPLING DEPTHS AND SAMPLES FOR CHEMICAL ANALYSES

Corehole Depth of Sampling (Feet)[1]	CH-7	CH-8	CH-9	CH-10
0	X*	X	X	X
2.5	X*	X	X	X
5	X*	X*	X*	X*
7.5	X*	X*	X*	X*
10	X*	X*	X*	X*
15	X*			
20	X*			
25	X*			
30	X*			
35	X*			

[1] Samples selected for chemical analysis denoted with an asterisk.

the monitoring wells was installed in Corehole CH-7. The rationale for the monitoring well locations is provided in Table 3-3. Groundwater from Monitoring wells MW-8 and 9 was sampled and chemical analysis was performed for purgeable hydrocarbons by EPA Method 602. No groundwater was encountered in Monitoring Well MW-7, but fuel vapors were sampled as described below.

Air Sampling

An air sample was collected from each of three utility access points and from Monitoring Well MW-7 using an evacuated air canister and stainless steel tubing. The sampling locations are shown in Figure 3-13, and the location rationale is given in Table 3-3. The air samples were analyzed for ambient hydrocarbons.

Surveying

After completion of the monitoring wells, the top of each casing and selected ground control points were surveyed for elevations. The elevations were determined to the nearest 0.01 foot.

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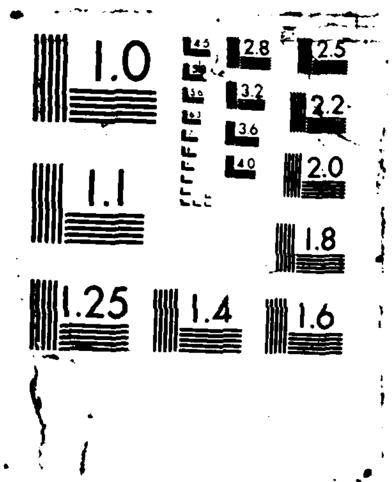
1.0
2.8
2.5
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2.2
3.6
4.0
2.0
1.1
1.8
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1.4
1.6

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4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

In this section, hydrogeologic observations and chemical analyses are discussed on a site-by-site basis. Analytical chemistry data are discussed within the context of available regulatory standards and criteria. After an introductory section dealing with available standards and criteria, the discussion of results and significance of findings for each site are addressed in separate sections.

4.1 Regulatory and Human Health Criteria and Standards

In order to determine possible water quality impacts on the groundwater, the organic and inorganic compounds detected in the groundwater samples were compared to various criteria. These criteria were drawn from federal and state drinking water regulations, standards, and guidelines. Table 4-1 shows parameters detected at Bergstrom AFB, along with the corresponding primary or secondary drinking water standard. These standards provide a stringent comparison for human health considerations.

Table 4-2 lists the maximum contaminant levels, EPA toxicity values, and human health criteria that are available for most of the organic chemicals detected. Although these criteria do not have the force of standards, they do provide a valid means of assessing properties of chemicals of concern. Several of the compounds are proven or suspected animal carcinogens for which zero consumption is recommended for the protection of human health. Many are also regulated as hazardous waste under RCRA regulations (40 CFR Parts 262 and 263). For each site, parameters detected are evaluated in comparison with these standards and criteria.

The use of human health criteria and standards for comparison of groundwater contamination at Bergstrom AFB provides stringent evaluations of observed concentrations. Since the shallowest zones of the aquifer at the base are not used as potable water supply sources, and as long as the

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TABLE 4-1. REGULATORY STANDARDS OR CRITERIA FOR GROUNDWATER ANALYSES

Parameter[1]	Federal Standard (mg/L)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP (Silvex)	0.01

[1] Regulatory reference: Environmental Protection Agency National Interim Primary Drinking Water Regulations, Revised, 14 November 1985.

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TABLE 4-2. GUIDELINES FOR ORGANIC COMPOUNDS DETECTED IN GROUNDWATER

Compound	Proposed or Recommended Standard (ug/L unless noted)
Benzene	5[1]
Ethylbenzene	680[2]
trans-1,2-Dichloroethene	70[2]
Phenols	3.5 mg/L[3]
Polychlorinated Biphenyls (PCBs)	0 (0.00079)[3]
Trichloroethene	5[1]

[1] Proposed MCLs (Maximum Contaminant Level); Federal Register 46904, 13 November 1985.

[2] Proposed RMCL (Recommended Maximum Contaminant Level); Federal Register 47022, 13 November 1985.

[3] EPA has recommended human health effects criteria of zero (0) for carcinogens, but notes that this level may currently be infeasible. The Agency provides criteria for achieving various levels of protection on an interim basis. The levels which may result in a 10^{-5} incremental increase of cancer risk over a lifetime are presented in parentheses in ppb unless noted. These levels would permit one case of cancer per 100,000 people exposed (Federal Register, 28 November 1980).

contaminants remain in the shallow aquifer, the contaminants have neither human health nor environmental consequences. As these contaminants exit from the shallow groundwater system, they may encounter potential receptors. Where subsurface waters come to the land surface, either as seeps or as groundwater outflow to streams, there exists the potential for human contact and exposure. If alternative (less stringent) limits were established specifically for Bergstrom AFB, a formal risk assessment would be required. Since the formal assessment of environmental and human health risks associated with the occurrence of contaminants is beyond the scope of this program, the use of human health standards and criteria is both reasonable and prudent.

4.2 Results and Significance of Findings of Phase II (Stage 1) Investigation

This section presents the results of geologic, hydrologic, and chemical data obtained during the Phase II (Stage 1) investigation. The discussions are organized by site with the significance of findings discussed immediately after each site section.

4.2.1 Site 17. South Fork Drainage Ditch

As discussed in Section 3.1, 13 sediment samples were collected along the length of the South Fork Drainage Ditch, from the outfall to the base boundary. These samples (A052-A064) were analyzed for oil and grease, chromium (total), copper, nickel, and lead. Table 4-3 shows the results of the analyses listed in order from the outfall to the base boundary. The sampling locations and landfill area are shown in Figure 3-1.

The analysis of sediments in the South Fork Drainage Ditch indicates the presence of metals as well as oil and grease. Sample A064, taken near the outfall, shows the highest levels of lead and chromium. Drainage from the flight line is probably the source of the contaminants. Samples farther

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TABLE 4-3. ANALYTICAL RESULTS FOR SEDIMENT SAMPLES FROM SITE 17, SOUTH FORK DRAINAGE DITCH

Sample Number	Parameters: Oil & Grease (O & Gr) (ug/g)	Chromium (Cr) (ug/g)	Copper (Cu) (ug/g)	Nickel (Ni) (ug/g)	Lead (Pb) (ug/g)	Location (see Figure 3-1)
A064	950	79	41	8.7	250	50 feet below outfall
A063	<1,000	18	240	17	21	above o/w separator
A062	<1,000	13	8.2	9.8	9.3	below o/w separator
A061	13,800	10	11.9	7.4	15	above landfill area
A060	<900	4.16	3.46	2.54	11	
A059	1,990	0.74	1.9	1.5	4.5	Through Landfill Area (A059–A053)
A058	1,810	7.2	4.1	5.9	7.8	
A057	<900	6.7	4.4	6.3	11	
A056	1,990	7.6	5.8	5.3	7.5	
A055	170	21	5.4	16	10	
A054	1,910	11.7	10	8.0	9.6	
A053	880	11.0	6.7	9.8	10	
A052	4,700	3.9	4.2	5.0	5.8	Base Boundary

downstream display generally lower concentrations of these metals, although the decrease does not correlate directly with distance.

Sample A063, collected upstream of the oil/water separator, shows the highest levels of copper and nickel. These metals are also found at lower concentrations in downstream samples; however, no concentration pattern is apparent. Concentrations of oil and grease are generally higher through the landfill area. This does not, by itself, indicate that the landfills are contributing to the contaminant load in the ditch. The variability in the concentrations of metals, as well as that of oil and grease, is probably caused by variabilities at sampling points such as:

- o Sediment type (gravel, sand, mud);
- o Flow characteristics during flow periods;
- o Ponding or drying during non-flow periods; and
- o Incoming sediment loads during storm events.

Because the ditch is dry most of the time, the analyses were conducted on the ditch sediments. Therefore, the analyses represent the non-soluble species that have settled to the bottom becoming incorporated into the sediments. Ongoing base monitoring of the water in the ditch will define the concentrations of soluble species. The greatest opportunity for contaminant transport is probably the physical movement of contaminated sediment, in suspension, during periods when flow is great enough for physical movement to occur, such as following a heavy thunderstorm. No flood stage records were available to determine the extent of sediment movement in the ditch after rainfall events.

Significance of Findings

Analysis of sediment samples from the South Fork Drainage Ditch indicates the presence of metals and organic compounds in the ditch sediments. The impact of organic compounds cannot be quantified, however, because only oil and grease content was determined. This analysis is conducted following a Freon (fluorocarbon) extraction and therefore, the only organic species identified in the oil and grease analysis are those that are soluble in the Freon. Those species that are insoluble are not detected in the analysis. Slightly soluble or partly soluble organic compounds are only partially recovered using the Freon extraction.

Impacts from metals are of most concern in sediments near the outfall. Elevated concentrations of lead (250 ug/g), chromium (79 ug/g), and copper (240 ug/g) occur between the outfall and the oil/water separator. Maximum concentrations downstream of the oil/water separator are:

- Chromium (Cr) - 13 ug/g;
- Copper (Cu) - 11.9 ug/g;
- Nickel (Ni) - 16 ug/g; and
- Lead (Pb) - 15 ug/g.

These concentrations are considered to be higher than those expected as natural background. However, no actual "background" stream sediment sample was collected as part of this program.

Water in the South Fork Drainage Ditch has been sampled by base personnel upstream of the oil/water separator. The drainage ditch eventually discharges to Onion Creek. Concentrations of chromium and lead have been below detection limits (<0.05 mg/L) and averaged 0.025 mg/L for copper. At Onion Creek, the same analyses showed none detected or <0.05 mg/L for Cr and Pb and an average of 0.0214 mg/L for Cu.

This information indicates that metals existing in the ditch sediments are essentially insoluble in water and are not causing an impact on water quality in Onion Creek. There is, however, a slight potential for impact due to physical movement of sediments in suspension during flow events.

This impact potential cannot be quantified at this time because no low flow records or flood stage records were available.

4.2.2 Site 13. MOGAS Spill at Motor Pool

A total of 14 soil samples were collected in Corehole 1 at the Motor Pool area. Six of these samples were selected to be analyzed for oil and grease, cadmium, chromium, nickel, and lead. Table 4-4 presents the results of these analyses.

The most obvious trend shown in the analytical results is that the sample at 7.5 to 9 feet below land surface (bls) displays the highest concentrations of all four metal species. The sample immediately above (5 to 6.5 feet bls) displays the lowest concentrations of chromium, nickel, and lead. This distribution suggests that the metal contaminants probably did not result from vertical migration of surface spills at Corehole 1. The source may be from nearby surface spills or tank leaks that have resulted in some horizontal migration of contaminants in the 7.5- to 16.5-foot-deep zone. This is supported by the drilling log, which reveals the existence of relatively permeable silty sands from 7.5 to 16.5 feet bls underlain by less permeable silts and clays. In addition, gasoline odors were noted in the silty sands but not in the underlying clays.

The groundwater sample collected from the sand and gravel zone (screened interval 38 to 43 feet bls) was analyzed for oil and grease, cadmium, chromium, nickel, lead, total organic carbon, and purgeable hydrocarbons. The results are given in Table 4-5. The sampling locations as previously discussed are in Figure 3-2.

The groundwater analysis indicates that some contaminants have reached the shallow saturated zone. Table 4-6 compares the analyses of the groundwater at the Motor Pool with the analyses of groundwater from the background well (Monitoring Well 1) at the golf course (Figure 3-8).

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TABLE 4-4. ANALYTICAL RESULTS FOR SOIL SAMPLES FROM COREHOLE 1, SITE 13, MOGAS SPILL AT MOTOR POOL

Sample Number	Depth (ft)	Parameter O & G (ug/g)	Cd (ug/g)	Cr (ug/g)	Ni (ug/g)	Pb (ug/g)
A001	0-1.5	400	<0.083	10	6.2	5.8
A003	5-6.5	300	<0.080	3.9	1.7	2.5
A004	7.5-9.0	300	0.67	21	12	14
A007	15-16.5	300	0.62	12	9.1	5.8
A012	35-36.5	300	<0.086	18	9.8	7.4
A014	45-46.5	280	<0.062	7.9	4.8	9.4

TABLE 4-5. ANALYTICAL RESULTS FOR GROUNDWATER SAMPLE FROM COREHOLE 1, SITE 13, MOGAS SPILL AT MOTOR POOL

Parameter	Sample A036
Oil and Grease (mg/L)	38
Cd (mg/L)	0.004
Cr (mg/L)	0.065
Ni (mg/L)	0.26
Pb (mg/L)	1.5
TOC (mg/L)	38
Benzene (ug/L)*	1040
Ethylbenzene (ug/L)*	303

* Only species detected in EPA 602 analysis.

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TABLE 4-6. COMPARISON OF GROUNDWATER QUALITY OF COREHOLE 1 WITH MONITORING WELL 1 AT SITE 13, MOGAS SPILL AT MOTOR POOL

Parameter	Corehole 1	Monitoring Well 1	
		Round 1	Round 2
Oil and Grease (mg/L)	38	8	2
Cd (mg/L)	0.004	<0.002	<0.002
Cr (mg/L)	0.065	0.017	<0.001
Ni (mg/L)	0.26	NA	NA
Pb (mg/L)	1.5	<0.002	<0.002
TOC (mg/L)	38	<1	5
Benzene (ug/L)	1040	NA	NA
Ethylbenzene (ug/L)	303	NA	NA

NA - Not analyzed.

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Significance of Findings

Results of the chemical analysis from Corehole 1 in the Motor Pool area indicate that soil and groundwater impacts have occurred. The soils do not show high concentrations of oil and grease but, as noted in Section 4.2.1, this analysis does not detect all hydrocarbon species, only those soluble in Freon.

Metal concentrations in the soils were higher in the 7.5- to 9-foot zone. No background soil samples were available for chemical analysis to determine the relative impact of the Motor Pool activities on the subsurface.

The groundwater at Corehole 1 received an impact primarily from lead and organic compounds. Although cadmium was detected at levels slightly above those seen in the background Monitoring Well 1, the concentration of 0.004 mg/L is below the primary drinking water standard (0.010 mg/L). Chromium was detected at 0.065 mg/L, which is slightly above the primary drinking water standard (0.05 mg/L). Groundwater is not used at the base for drinking water. Therefore, the low level of chromium does not appear to be an immediate health hazard or a significant environmental impact. Because the chromium value is close to five times the detection limit or 0.01 mg/L, there is a degree of analytical uncertainty that can further reduce any level of concern. Groundwater use outside of the base is unknown. Investigation of off-base groundwater use would require a water well inventory to determine any off-base receptors; such an investigation was not part of this Stage 1 program.

Lead was detected at 1.5 mg/L, which is 30 times the primary drinking water standard. As noted above, the groundwater is not a source of drinking water at the base and no immediate health hazard exists.

The organic compounds benzene and ethylbenzene were both detected in groundwater from the site. The level of benzene detected (1040 ug/L) is far above the criteria of 5 ug/L, though ethylbenzene is within guideline concentrations. Although the groundwater is not a local drinking water supply, the permeable beds that were detected between 7.5 and 16.5 feet bls during coring at the site indicate that there is the possibility of movement of these contaminants.

4.2.3 Site 23. Fire Training Area

Two coreholes were drilled in the Fire Training Area to determine the impacts of potential contaminants used in fire training exercises. In each corehole (Nos. 3 and 4), 11 soil samples were collected and described. Six of the soil samples from each corehole were analyzed for oil and grease, cadmium, chromium, nickel, and lead. Table 4-7 presents the results of the soil analyses for both coreholes, and the corehole locations are shown in Figure 3-4.

The results of the soil analysis show that contaminants exist in the soil. A pattern of highest concentrations at the surface and decreasing concentrations with depth is demonstrated, especially in Corehole 4. Corehole 4 also shows higher levels of contaminants than Corehole 3. Corehole 4 was located nearer the center of the Fire Training Area than Corehole 3 and therefore received more contaminants.

A groundwater sample was obtained from each corehole, and the results of the analyses are given in Table 4-8. Although metals are present in the soils, very low concentrations were detected in the groundwater. Organic compounds are present in the groundwater. Because the species detected are only slightly soluble in water, it is expected that organic compounds exist in the soil column above the groundwater.

Both trichloroethene (trichloroethylene) and trans-1,2-dichloroethene (1,2-dichloroethylene) are common solvents, which were probably placed in the area for fire training although trichloroethylene is nonflammable.

TABLE 4-7. ANALYTICAL RESULTS FOR SOIL SAMPLES FROM COREHOLES 3 AND 4, SITE 23, FIRE TRAINING AREA

Sample	Depth (ft)	O & G (ug/g)	Cd (ug/g)	Cr (ug/g)	Ni (ug/g)	Pb (ug/g)
COREHOLE 3						
A025	0-.15	300	<0.64	19	4.8	9.3
A026	2.5-4	600	<0.080	8.2	4.8	9.7
A028	7.5-9	600	<0.019	15	9.2	7.0
A030	12.5-14	800	<0.076	9.4	7.2	2.66
A032	17.5-19	800	<0.86	9.4	7.0	2.8
A034	25-26.5	800	<0.070	5.3	5.3	3.6
COREHOLE 4						
A037	0-1.5	2100	0.87	27	17	35
A038	2.5-4	800	0.85	25	18	9.1
A040	7.5-9	500	<0.077	12	8.1	6.7
A042	12.5-14	400	<0.093	7.9	8.1	4.5
A044	17.5-19	500	<0.077	8.3	7.1	3.4
A046	25-26.5	400	<0.055	6.2	7.6	3.0

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TABLE 4-8. ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES FROM COREHOLES 3 AND 4, SITE 23, FIRE TRAINING AREA

Parameter	Corehole 3	Corehole 4
Oil and Grease (mg/L)	43	6
Cd (mg/L)	<0.002	<0.002
Cr (mg/L)	0.002	<0.001
Ni (mg/L)	0.076	0.006
Pb (mg/L)	0.090	0.030
TOC (mg/L)	40	2
Benzene (ug/L)*	196	8
Ethylbenzene (ug/L)*	440	ND
Trichlorofluoromethane (ug/L)[1]	2.3	2.4
Trans-1,2-Dichloroethene** (ug/L)	42.6	15.8
Trichloroethylene (ug/L)**	0.8	ND

ND - Not Detected.
* Only species detected in EPA 602 analysis.
** Only species detected in EPA 601 analysis.
[1] Trichlorofluoromethane was deleted from toxic pollutants list 1981 (46 FR 2266).

Trichlorofluoromethane is a nonflammable solvent (and refrigerant) that is used in some fire extinguishing equipment.

Base Soil Sampling at Fire Training Area

In response to EPA comments to the Phase I report (CH2M Hill, 1983), base personnel collected eight soil samples from the Fire Training Area. These samples were collected from about six inches underground at the training pit. The samples were then forwarded to OEHL laboratories for PCB chemical analyses. The results of chemical analyses provided are shown in Table 4-9.

Significance of Findings

Soil and groundwater samples from Coreholes 3 and 4 in the Fire Training Area indicate the presence of oil and grease as well as metals in the soils and groundwater.

Oil and grease were detected in concentrations as high as 2100 ug/g in the surface soil sample in Corehole 4. The oil and grease analysis detected only those organic species soluble in Freon; therefore, total organic loading may be higher.

For the soil samples taken by the base for PCB analysis, only a trace was detected in three of the eight samples, and that concentration was below the quantitative limit of 1.0 ug/g. In the remaining samples, no PCBs were detected. These findings are well below the regulatory limit of 50 ug/g set in the Toxic Substances Control Act.

Metal species, especially lead, chromium, and nickel, are present in the surface soils. These concentrations decrease with depth, probably because of adsorption in the soils. Metal concentrations in the groundwater are relatively low, which may indicate that the metals in the soil are essentially

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TABLE 4-9. ANALYTICAL RESULTS OF SOIL SAMLES FROM SITE 23, FIRE TRAINING AREA

Soil Sample Numbers		Polychlorinated Biphenyls (PCBs)[1] (ug/g)
OEHL #	Base #	
58801	GS840341	Trace
58802	GS840342	Trace
58803	GS840343	Trace
58804	GS840344	ND[2]
58805	GS840345	ND[2]
58806	GS840346	ND[2]
58807	GS840347	ND[2]
58808	GS840348	ND[2]

[1] Analyses provided by USAFOEHL/SA, Brooks AFB, Texas.
[2] ND denotes none detected. Less than the detection limit of 0.5 ug/g. Trace denotes present but less than the quantitative limit of 1.0 ug/g.

non-leachable. However, the lead content of water from Corehole 3 of 0.090 mg/L exceeds the primary drinking water standard of 0.05 mg/L (Table 4-1).

Organic compounds detected in the groundwater include benzene, ethylbenzene (attributable to fuels dumped on the site for fire training purposes), trans-1,2-dichloroethene, trichloroethylene (solvents that were probably dumped on-site for fire training purposes even though these solvents are nonflammable), and trichlorofluoromethane (probably dumped as a solvent or as a component of the fire extinguishing materials). Benzene is present in quantities (196 and 8 ug/L) exceeding criteria (Table 4-2). Groundwater is not used at the base for drinking water. Therefore, the levels of benzene are not an immediate health hazard, nor do they cause a significant environmental impact at the base.

4.2.4 Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

Six monitoring wells were installed in the Combined Southeast Landfill area. In addition, two borings drilled did not encounter groundwater and were not completed as monitoring wells. The locations of the monitoring wells (MW), borings, and geologic cross sections (Figure 4-2 and 4-3) are shown in Figure 4-1.

Geologically, the landfill areas consist of lenses of clays, sands, and gravels overlying a bluish clay. The bluish clay appears to be laterally continuous over the entire area; this correlates to the Taylor Formation. Groundwater exists in the sands and gravels and, to a minor degree, in clay lenses above the blue clay. The deep ditches of the South Fork Drainage Ditch (and of the unnamed ditch that flows between Landfills 5 and 6) appear to intersect the shallow water table, altering flow locally. Both ditches bottom in clay, which probably allows groundwater to slowly discharge to these surface water bodies. This is confirmed by seeps observed along the banks of the South Fork Drainage Ditch.

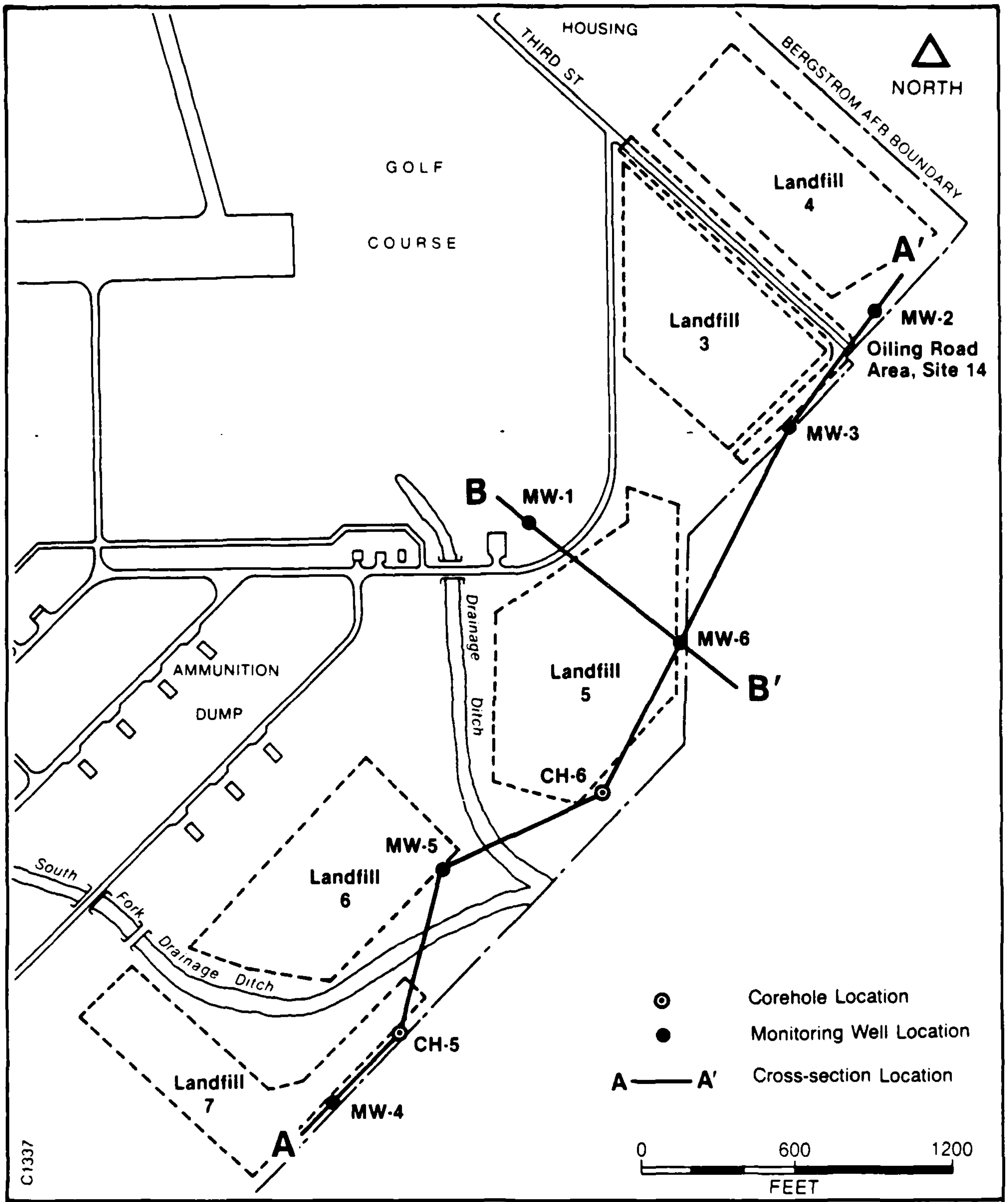

Figure 4-1. Location of Monitoring Wells, Coreholes, and Cross-Sections, Sites 3, 4, 5, 6, 7, and 14, Combined Southeast Landfill

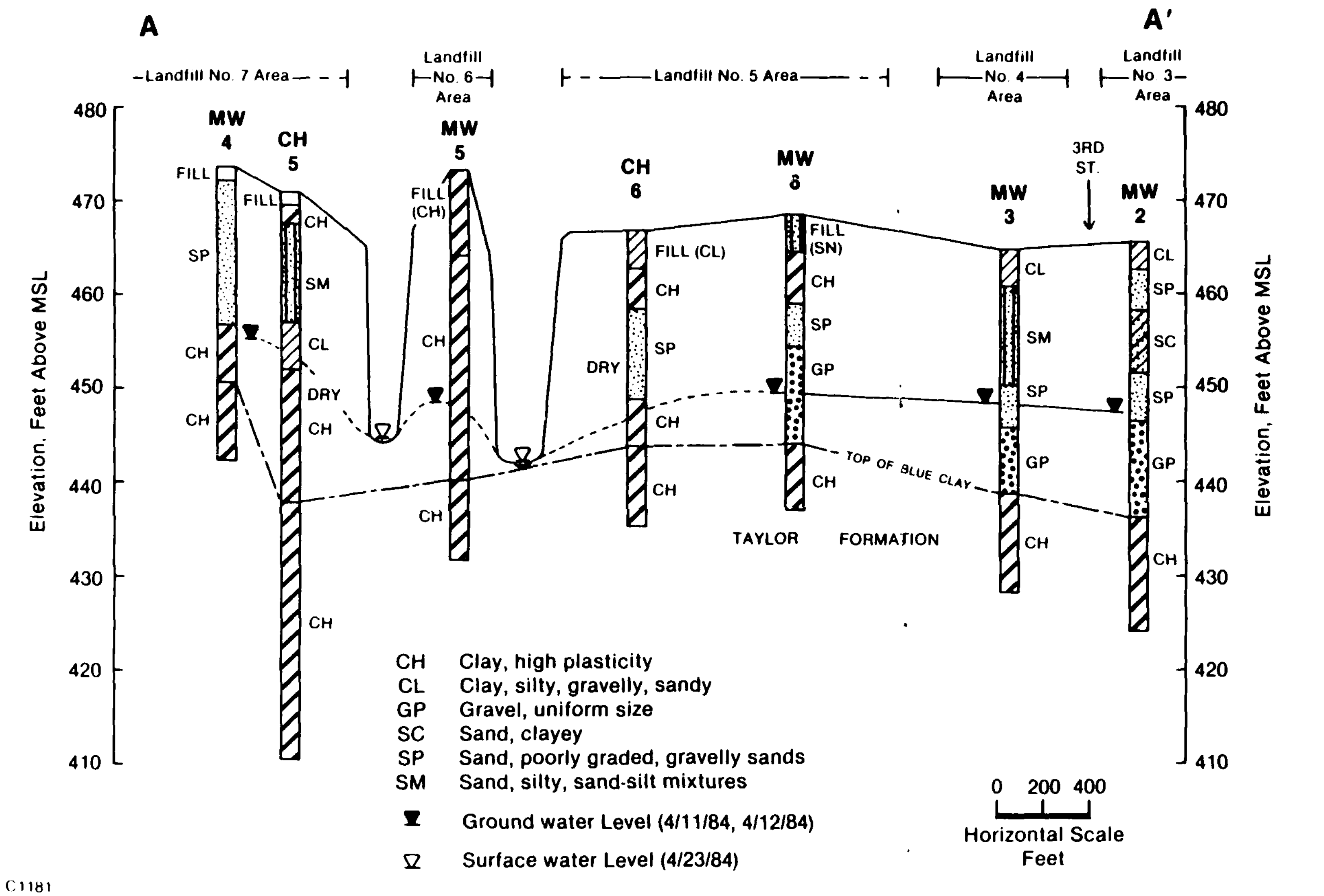

Figure 4-2. Cross-Section A-A' - Sites 3, 4, 5, 6, 7, and 14, Combined Southeast Landfill

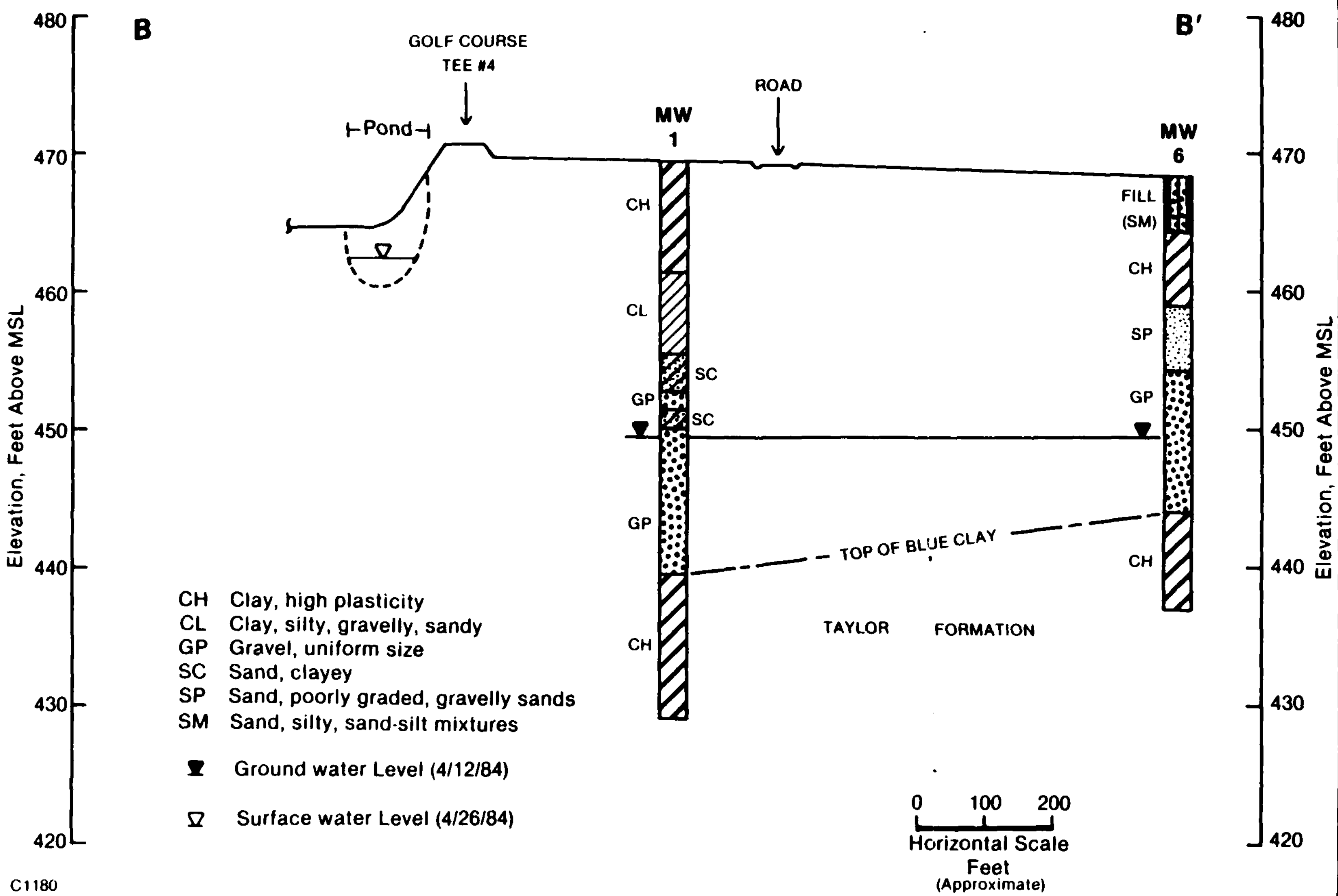

Figure 4-3. Cross-Section B-B' - Sites 3, 4, 5, 6, 7, and 14, Combined Southeast Landfill

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The six monitoring wells installed in the landfill areas (see Section 3.4) were sampled twice (one month between samples). Weather conditions were dry during sampling and for at least a week before the field activities. The samples were analyzed for oil and grease, total organic carbon (TOC), total organic halogens (TOX), heavy metals, pesticides (including DDT, PCB, and dibrom), and herbicides.

Table 4-10 shows the analytical results from the first sampling round. Table 4-11 shows the analytical results from the second sampling round, which includes a sample collected from the golf course well.

As can be seen in Tables 4-10 and 4-11, no pesticides or herbicides were detected in any of the samples. Extraction holding times were exceeded for pesticides and herbicides for the second sampling round. Resampling was done on 4 September 1985, and the results were negative as in the previous samplings. Although some metal species were detected, all concentrations were low. Concentrations of oil and grease, TOC, TOX, and phenolics were also low and within ranges that are considered background, such as at Monitoring Well 1.

Water level measurements in each monitoring well are given in Table 4-12. Using data from wells 1, 2, 3, and 6, the direction of groundwater flow is approximately northeast (N 45° E). Data from Monitoring Wells 4 and 5 are not included in the analysis because the deep ditches (near MW-5) alter shallow groundwater flow patterns. Groundwater at Monitoring Wells 4 and 5 represent groundwater systems that are separate from the main landfill area (i.e., Landfill Nos. 3, 4, and 5). The groundwater flow directions at these two locations cannot be determined with only one control point, but some component of flow would be toward the drainage ditches. Figure 4-4 illustrates the direction of groundwater flow in the area estimated using Round 2 data. As seen in Table 4-12, water levels had dropped very similarly in wells 1, 2, 3, and 6 at the time of the second measurements. Therefore, the Round 1 data would show a similar flow direction.

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TABLE 4-10. ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES FROM MONITORING WELLS IN SITES 3, 4, 5, 6, 7, AND 14, COMBINED SOUTHEAST LANDFILL, FIRST SAMPLING ROUND (11 April 1984)

Parameter	MW-1 A065	MW-2 A066	MW-3 A067	MW-4 A070	MW-5 A069	MR-6 A068
O & G (mg/L)	8	11	7	9	8	8
TOC (mg/L)	<1	<1	<1	<1	<1	<1
TOX (mg/L)	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Phenolics (mg/L)	0.048	0.023	0.065	0.023	0.005	0.088
As (mg/L)	<0.003	<0.003	<0.003	<0.002	<0.002	<0.002
Ba (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cd (mg/L)	<0.002	<0.008	0.009	0.034	0.008	<0.002
Cr (mg/L)	0.017	0.004	0.014	0.063	<0.001	<0.001
Pb (mg/L)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Hg (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Se (mg/L)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Ag (mg/L)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Pesticides* (ug/L)	ND	ND	ND	ND	ND	ND
Herbicides** (ug/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

ND - Not detected.
* All pesticide species by EPA 608 (including DDT, PCB, Dibrom).
** 2,4-D and 2,4,5-TP (Silvex).

TABLE 4-11. ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES FROM MONITORING WELLS AT SITES 3, 4, 5, 6, 7, AND 14, COMBINED SOUTHEAST LANDFILL, SECOND SAMPLING ROUND (10 May 1984)

Parameter	MW-1 A074	MW-2 A076	MW-3 A077	MW-4 A079	MW-5 A080	MR-6 A078	Golf Course Well A075
O & G (mg/L)	2	<0.01	<1	<1	<1	<1	<1
TOC (mg/L)	5	7	7	11	22	8	11
TOX (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenolics (mg/L)	0.018	0.009	0.014	0.022	0.046	0.027	0.010
As (mg/L)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Ba (mg/L)	<0.061	<0.070	<0.072	<0.011	<0.083	<0.012	0.048
Cd (mg/L)	<0.002	<0.002	0.002	0.002	0.002	<0.002	<0.002
Cr (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb (mg/L)	<0.002	<0.004	0.003	0.006	0.006	0.002	<0.002
Hg (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Se (mg/L)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Ag (mg/L)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Pesticides*+ (ug/L)	ND	ND	ND	ND	ND	ND	ND
Herbicides**+ (ug/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01

ND - Not detected.
* All pesticide species by EPA 608 (including DDT, PCB, Dibrom).
** 2,4-D and 2,4,5-TP (Silvex).
\+ Holding time exceeded for pesticides and herbicides; wells resampled 4 Sept.1985 and results were negative.

TABLE 4-12. WATER LEVEL ELEVATIONS IN MONITORING WELLS AT SITES 3, 4, 5, 6, 7, AND 14, COMBINED SOUTHEAST LANDFILL

Well	M.P. Elev.[1] (ft. above MSL)	Round 1[2] (ft. above MSL)	Round 2[3] (ft. above MSL)	Change[4] (ft.)
MW-1	472.41	449.40	449.15	-0.25
MW-2	468.60	447.51	447.24	-0.27
MW-3	467.79	448.31	448.05	-0.26
MW-4	476.58	455.25	455.22	-0.03
MW-5	476.06	448.64	448.28	-0.36
MW-6	471.26	449.34	449.10	-0.24

[1] Measuring Point - top of PVC casing.
[2] Round 1 measurements - 11-12 April 1984
[3] Round 2 measurements - 10 May 1984
[4] Change in water level between rounds.
"-" denotes water level decline.

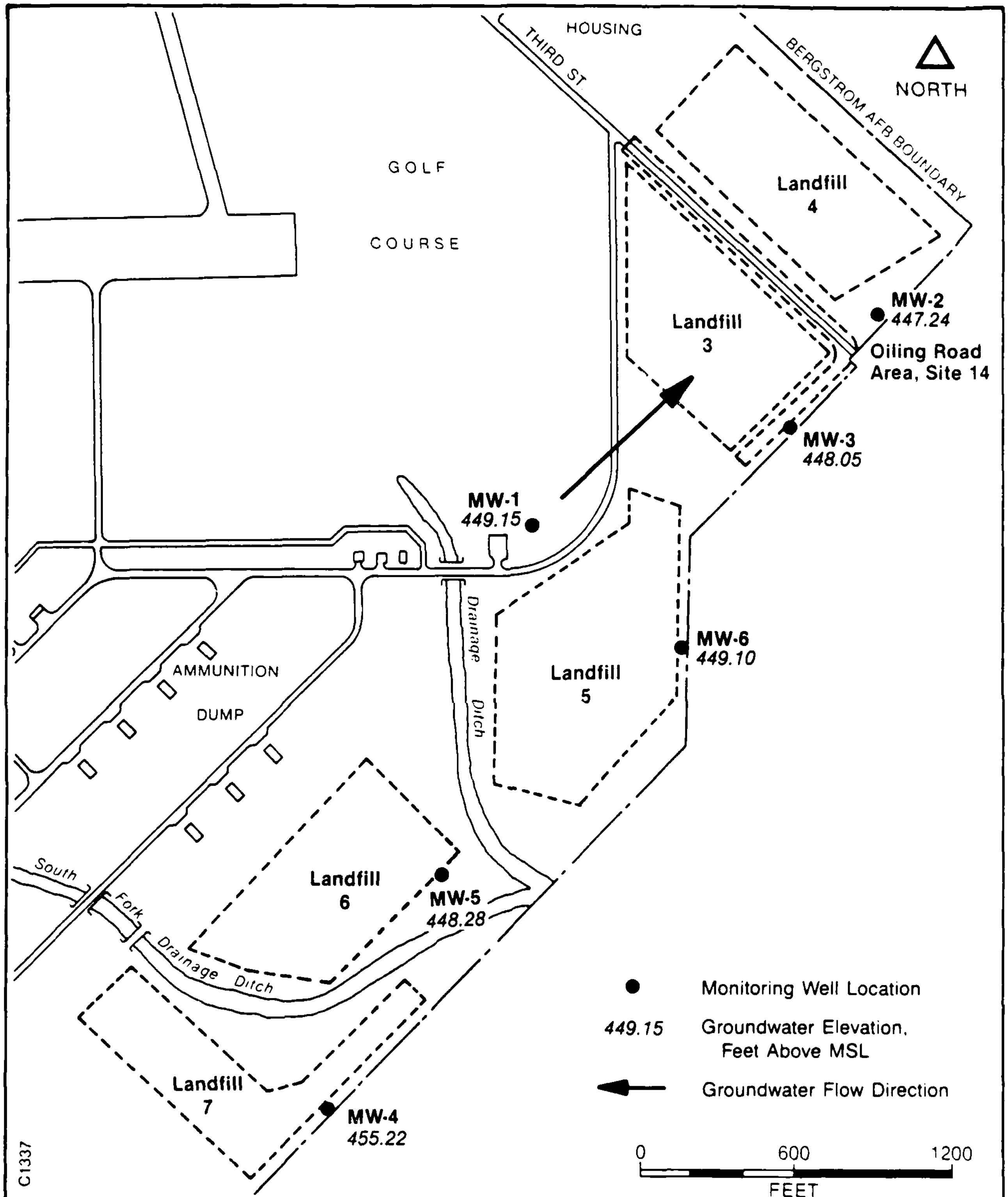

Figure 4-4. Estimated Direction of Groundwater Flow Using Round 2 Data (May 1984), Sites 3, 4, 5, 6, 7, and 14, Combined Southeast Landfill

As part of the investigation of the Combined Southeast Landfill area, three soil samples were taken in the road oiling area. The samples were analyzed for PCB content. No PCBs were detected. Although sampling at three points does not absolutely confirm the absence of PCBs from the entire site, there is no reason to suspect that PCBs would be present in some areas but not in the areas sampled, because of the consistent method of conducting the road oiling; that is, the three samples are representative of the site.

Significance of Findings

The significance of results from the monitoring wells in the Combined Southeast Landfill area must be considered with respect to the representativeness of sampling points. The original estimation of the groundwater flow direction was east and southeast, toward Onion Creek. Based on the results of water level measurements in Monitoring Wells (MW) 1, 2, 3, and 6, the flow direction is to the northeast. Therefore, the following conclusions can be made:

- MW-1 is in an acceptable position to serve as a background monitoring well.

- MW-2 and MW-3 are not optimally positioned to monitor landfills 3 and 4. These wells are downgradient of Landfill 5 and should detect contaminants migrating from that site if they exist and if time has allowed transport over that distance. Further, MW-2 could detect contamination from Landfill 3 while both MW-2 and MW-3 could detect contaminants if the sources were adjacent to them at the landfill.

- MW-4 is not optimally positioned to monitor Landfill 7 (Figure 4-1), although it probably would intercept the edge of a contaminant plume from the north-south section, if such a plume existed. MW-4 may actually represent an upgradient condition if shallow groundwater discharges to the South Fork Drainage Ditch.

- MW-5 is not directly downgradient of Landfill 6, but the local gradient is probably altered in the area because of the deep drainage ditches. MW-5 is probably positioned adequately to monitor contaminants, if any, from Landfill 6.

- MW-6 is positioned downgradient of Landfill 5. If contaminants exist, it is probable that they would be detected in MW-6.

Chemical analysis of the groundwater obtained from Monitoring Wells 1 through 6 indicates that no identifiable contaminants exist at the sampling points. While some of the monitoring wells may not be optimally positioned, the data collected indicate that no evidence of contamination was detected in any well.

4.2.5 Site 8. JP-4 Spill/Overtopped Tank Area

One corehole was drilled within the bermed area of Tank 513, and 10 soil samples were collected between the land surface and 26.5 feet bls. Six of the samples were analyzed for oil and grease. The results are shown in Table 4-13; the sampling locations are depicted in Figure 3-10.

The oil and grease analysis suggests that hydrocarbons have migrated vertically, as shown by the general increase in oil and grease with depth. During drilling operations a strong hydrocarbon odor was noted in the upper five feet, and slight odors were noted from 5 to 10 feet. The strong odor in the shallow soils may be due to the rising of the volatile components from the hydrocarbon contamination noted deeper in the soil column.

The groundwater sample obtained from Corehole 2 was analyzed for oil and grease, cadmium, chromium, nickel, lead, total organic carbon, and

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TABLE 4-13. ANALYTICAL RESULTS FOR SOIL SAMPLES FROM COREHOLE 2, SITE 8, JP-4 SPILL/OVERTOPPED TANK AREA

Sample	Depth (ft)	O & G (ug/g)
A015	0-1.5	280
A016	2.5-4	300
A017	5-6.5	500
A019	10-11.5	400
A021	15-16.5	600
A023	20-20.9	600

TABLE 4-14. ANALYTICAL RESULTS FOR GROUNDWATER SAMPLE FROM COREHOLE 2, SITE 8, JP-4 SPILL/OVERTOPPED TANK AREA

Parameter	Concentration
O & G (mg/L)	<1
Cd (mg/L)	<0.002
Cr (mg/L)	<0.001
Ni (mg/L)	<0.003
Pb (mg/L)	0.190
TOC (mg/L)	4
Purgeable Hydrocarbons*	ND

ND - not detected.
* Includes all species in EPA Method 602.

purgeable hydrocarbons. The results are given in Table 4-14. The only contaminant present in amounts in excess of federal drinking water standards (Table 4-1) is lead.

Significance of Findings

Soil analysis from the JP-4 Spill/Overtopped Tank Area confirms the presence of organic contamination. The pattern of oil and grease concentrations in the soil suggests that the fuel is migrating vertically downward. Despite the high levels of oil and grease in the soil of the area, an elevated lead content is the only detected impact on the groundwater. The detected lead concentration, 0.190 mg/L, exceeds the federal primary drinking water standard of 0.05 mg/L; however, the water is not part of a base drinking water supply. The relatively disturbed nature of the water sample, caused by taking it from a boring and not from a permanently installed monitoring well, might have allowed some of the purgeable compounds detected by the EPA Method 602 analysis to volatilize to the atmosphere before sampling. On the other hand, the thick clays encountered down to about 20 feet bls may slow the vertical movements of fuels spilled, such that greater amounts of contaminants may not have reached the groundwater.

4.2.6 Site 9. JP-4 Suspected Underground Line Leak

The field investigation revealed that the pipeline bedding sand would provide the primary flow path for any leaking fuel. Migration vertically or laterally from the old trench was not observed during the acoustic emission (AE) testing field activities. Migration of fuel through the clay would appear to be a minor pathway compared with movement through the more permeable bedding sands parallel to the pipeline.

Taking into account probable contaminant pathways, seven ditches, four coreholes, three monitoring wells, and four air samples were located around the low-point drain area as described in Section 3.6. These locations are shown in Figures 3-11 and 3-12. Two purposes of using these locations were first to verify a pipeline leak and second to confirm the existence of groundwater that JP-4 fuel from the pipeline could contaminate. A third purpose was to determine if hazardous vapors might be migrating along the pipeline to underground utility structures (e.g., pipelines and vaults). The following provides a summary of the findings of the various investigation techniques.

A total of 7 ditches were excavated to examine the pipe and to conduct AE testing. The locations of the ditches are shown in Figure 3-11. The following items provide a summary of the excavation findings:

- The pipeline and bedding sand were trenched into a hard clay;
- Water, fuel, and fuel vapors were found in the bedding sand around the pipeline closest to the low-point drain;
- No obvious migration through the wall of the pipeline trench was noted;
- A leak of up to 0.13 gallons per minute was confirmed at the old valve and flanges at the low-point drain box; the leak appeared to occur during periods of excessive line pressures; and
- Liquid Fuels System maintenance personnel tightened the flanges and emplaced a new ball valve on-line with the old valve, thus eliminating the leak.

Four coreholes were drilled around the fuel line. Their locations are shown in Figure 3-12. A total of 21 soil samples from the coreholes were obtained for chemical analysis. Logs of the coreholes are provided in Appendix D. The formation encountered was principally clay, confirming the observations from the pipeline excavation. The soil samples were analyzed using EPA Method 8020 as a reconnaissance indicator of JP-4 contamination. No compounds in the soils were detected at the detection limit of 150 ug/kg, as shown in Table 4-15.

Three monitoring wells were emplaced. The locations are shown in Figure 3-12. The first one emplaced was Monitoring Well (MW) 7 into Corehole (CH) 7. No groundwater was encountered in Monitoring Well 7, but strong hydrocarbon vapors from the borehole and the completed monitoring well were confirmed with Draeger tubes during the field activities. The well was completed to provide a fuel vapor monitoring point, allowing hydrocarbons to be sampled for chemical analysis. Monitoring Wells 8 and 9 were completed in shallow water-bearing sands. Monitoring well construction logs are provided in Appendix D.

Vapors from volatile contaminants often travel some distance ahead of the actual liquid or solid contaminant source. For this reason, a hydrocarbon survey (HS) was conducted where an ambient air sample was obtained from each of four locations as shown in Figure 3-12. These were an electrical utility vault (HS-1), Monitoring Well 7 (HS-2), a sanitary sewer (HS-3), and a storm drain (HS-4). The air samples collected were analyzed for ambient hydrocarbon vapors using a GC (gas chromatograph) with a multiple detector, an analytical method accepted by EPA for determining VOCs (volatile organic compounds). The results of the ambient hydrocarbon analyses are shown in Table 4-16.

Significance of Findings

The investigation of the JP-4 fuel pipeline at Site 9 was designed to confirm the presence of a pipeline leak and to detect fuel migration in the subsurface. Acoustic emission testing indicated that a leak existed at the low-point drain box and specifically at the old drain valve.

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TABLE 4-15. ORGANIC COMPUNDS DETECTED IN SOIL SAMPLES USING TEST METHOD 8020 SITE 9, JP-4 SUSPECTED UNDERGROUND LINE LEAK

Sample Location And (Depth in Ft.)		Sample Number		Parameter ug/Kg
C-1(MW-7)	(0.0)	A084		No Compounds Detected In Any Of The Samples*
	(2.5)	A085		
	(5.0)	A086		
	(7.5)	A087		
	(10.0)	A088		
	(15.0)	A089		
	(20.0)	A090		
	(20.0)	A090	QC	
	(25.0)	A091		
	(30.0)	A092		
	(35.5)	A093		
C-2	(5.0)	A081		
	(7.5)	A082		
	(10.0)	A083		
C-3	(5.0)	A094		
	(7.5)	A095		
	(10.0)	A096		
C-4	(5.0)	A097		
	(7.5)	A098		
	(10.0)	A099		
	(10.0)	A100	QC	

* No compounds detected at detection limit of 150 ug/kg.

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TABLE 4-16. JP-4 CONSTITUENTS DETECTED IN AIR SAMPLES COLLECTED IN THE VICINITY OF LOW-POINT DRAIN AT SITE 9, JP-4 SUSPECTED UNDERGROUND LINE LEAK

Parameter[1]	Hydrocarbon Survey Point and Results (ug/m^3)[1,2] HS-1 (Electrical Vault)	HS-2 (MW-7)	HS-3 (Sanitary Sewer)	HS-4 (Storm Drain)
N-Pentane	7	52,600	5	4
3-Methylpentane	8	499,000		7
N-Hexane		310,000		3
Methylcyclopentane		258,000		
3-Methylhexane		369,000		
N-Heptane		209,000		1
Methylcyclohexane		120,000		
3-Methylheptane		282,000		
N-Octane		106,800		
N-Nonane		18,300		
N-Decane		6,690		98
N-Undecane		1,350		
Benzene[3]		6,070		
Toluene		12,400		
Ethylbenzene[3]		26,600		
O-Xylene		7,710		
1,2,4-Trimethylbenzene		3,350		10

[1] Parameters selected from typical components detected in JP-4 fuel.
[2] Results rounded to nearest whole numbers. Values at HS-2 rounded to three significant digits.
[3] EPA Method 602 compounds.

Excavations along the pipeline revealed the presence of fuel and fuel vapors in the bedding sands around the pipeline in the vicinity of the low-point drain box. However, no obvious migration of fuel through the wall of the pipeline trench or further ditches was noted.

Four coreholes were drilled to determine if fuel was migrating along the bedding sands of the pipeline trench and into the utility pipelines. Three of the coreholes showed that no hydrocarbons were present using on-site testing equipment and laboratory chemical analyses using EPA Method 8020. The fourth corehole, CH-7, just west of the low-point drain box, was completed as Monitor Well 7 in response to the high concentration of hydrocarbon vapors emanating from it. Chemical analysis of the soil from CH-7/MW-7 location showed that no hydrocarbon compounds were present. This indicates that the liquid phase of the fuel has possible not yet reached this location, although the vapor phase has. The exact depth of the vapor source cannot be determined because of the nature of the completion method; however, it is highly probable that the source does not extend below the weathered top portion of the Taylor formation. This very hard, thick sequence of shale, ranging from 30 to 42 feet below the surface, can provide a barrier to vertical migration.

Groundwater was found in the sands and/or gravels that overlay the Taylor Formation at Monitoring Wells 8 and 9. Monitoring Well 7 was drilled completely through clay to a depth of 35 feet and was dry. The composition and shape of the deposits at monitoring wells 8 and 9 indicate the existence of an old river channel. This channel is a potential pathway for the migration of fuel. The direction of groundwater flow cannot be accurately determined with only two groundwater elevation points; however, based on existing data (Figure 4-5), the flow should move in a general direction from MW-9 towards MW-8 or a southerly to northerly direction. Normally, three groundwater level elevations are needed to accurately define a flow direction. Although only two control points were available (i.e., MW-8 and 9) the third point (M-7) had dry conditions well below (i.e., approximately 15 feet) the water levels at MW-8 and 9. The water level at MW-9 was higher than at MW-8,

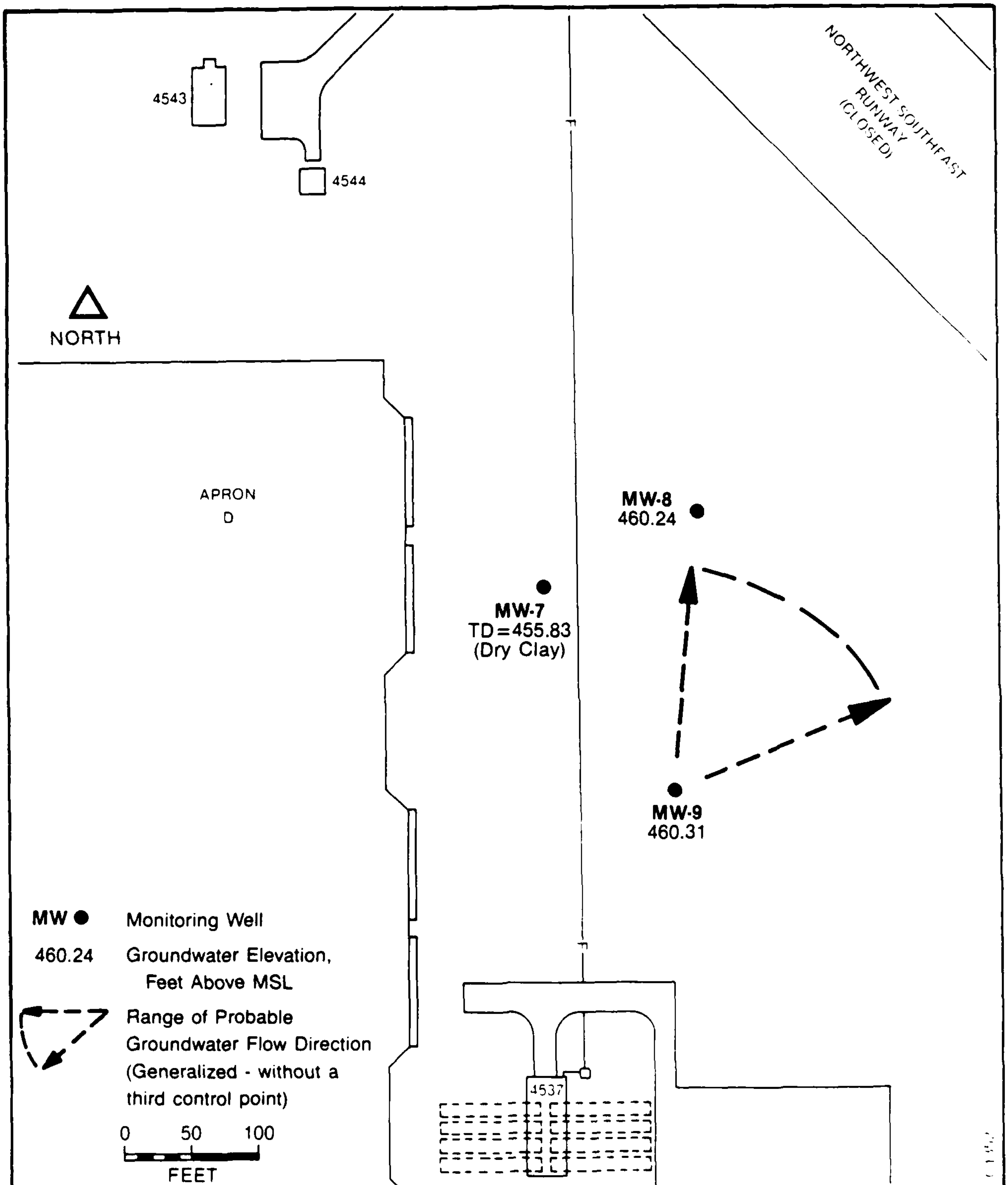

Figure 4-5. Estimated Direction of Groundwater Flow Using February 1985 Data, Vicinity of JP-4 Pipeline at Site 9, JP-4 Suspected Underground Line Leak

which indicates a groundwater gradient towards MW-8. But without a third control point with a water level, the flow direction can only be generalized as shown in Figure 4-5. Chemical analysis performed on groundwater samples from these monitoring wells showed (MW-8 and MW-9) no compounds detected using EPA Method 602. Precipitation occurred prior to groundwater sampling, and water filled the utility vault next to the low-point drain.

Air samples were taken at the following four locations: an electrical utility vault (HS-1), Monitoring Well 7 (HS-2), a sanitary sewer (HS-3), and a storm drain (HS-4). These samples were taken to detect the presence of fuel vapors and are summarized (from data in Table 4-16) in Figure 4-6. Of the four locations, only two showed concentrations of compounds typical of JP-4 fuel. Sample HS-2, taken from location MW-7, has a large number of these compounds; whereas sample HS-4, taken from a storm drain, shows only a few components. It is probable that the vapors in the storm drain originated from compounds introduced from the flightline rather than directly from the pipeline. Additionally, the low hydrocarbon value at HS-1 may have been affected by local precipitation that filled the electrical vault with water within several feet of the ground surface. This may have flushed any hydrocarbons that were present at HS-1.

The investigation indicates that a periodic leak in the JP-4 pipeline did exist, but the contamination caused by the leak is fairly well contained in the small area around the low-point drain box.

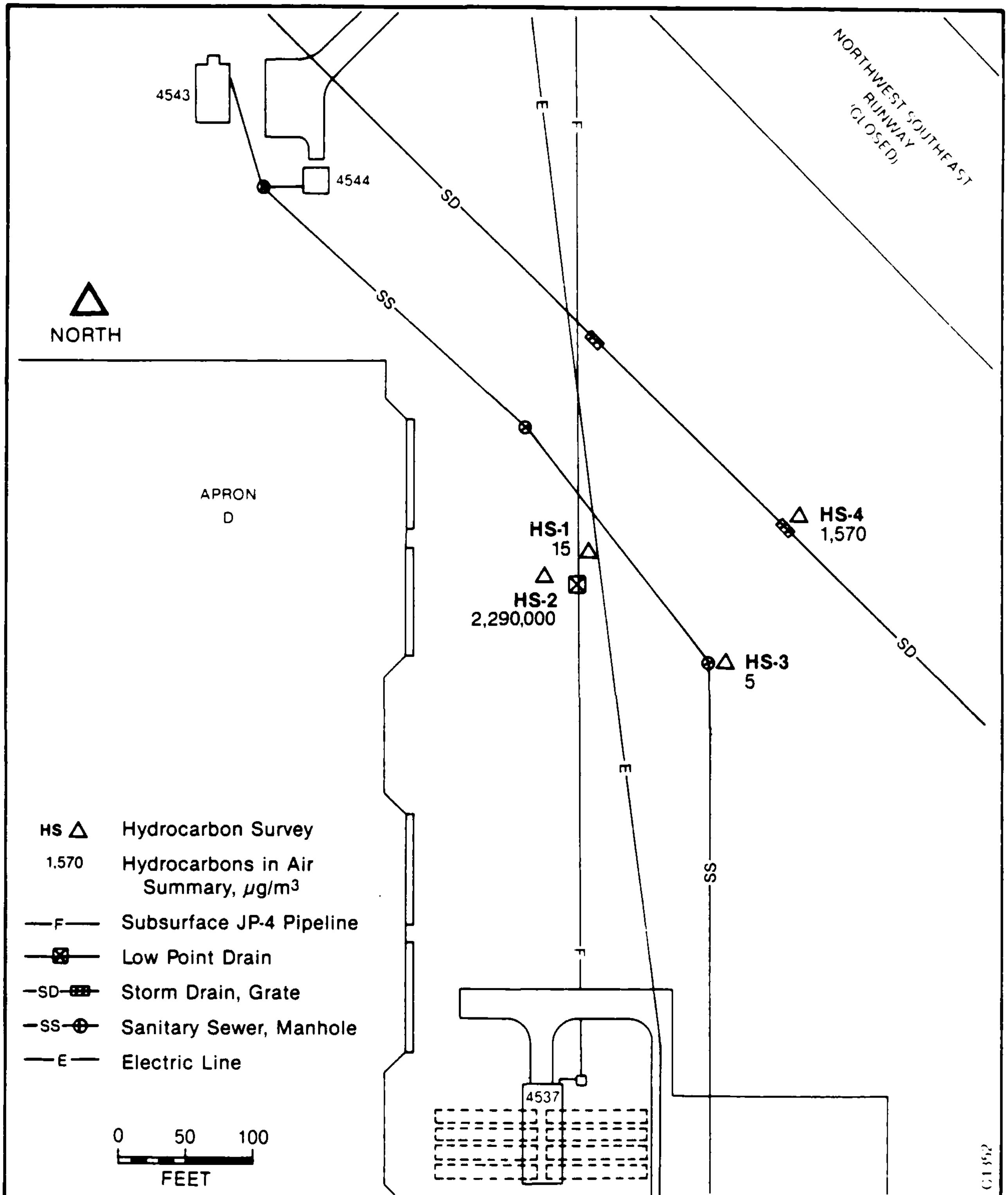

Figure 4-6. Summary of Hydrocarbons at Air Sampling Points, Vicinity JP-4 Pipeline at Site 9, JP-4 Suspected Underground Line Leak

5.0 ALTERNATIVE MEASURES

This section presents a discussion of the alternative measures that may be applied to the sites that were investigated as part of the Phase II Stage 1 work at Bergstrom AFB. The general alternative measures presented in this section are based on the hydrogeologic and analytical findings discussed in Section 4.0. Based upon the general alternative measures discussed in this section, specific recommendations are provided in Section 6.0.

The following paragraphs describe the major options for dealing with each site. There are two classes of options (excluding clean-up or other remedial actions) that are available at each site. These options are: (1) no further action, appropriate in the case in which available evidence does not suggest the potential for environmental impairment; and (2) further monitoring, appropriate for sites where possible problems have been indicated but not fully identified.

5.1 Site 17. South Fork Drainage Ditch

The investigation of the South Fork Drainage Ditch consisted of the collection and chemical analysis of soil from various points along the ditch. The investigation revealed that the soil in the ditch is contaminated with metals and organic compounds. Air Force personnel have sampled and analyzed water in the South Fork Drainage Ditch and have not detected any metal concentrations in excess of Federal Primary Drinking Water Standards. Therefore, the metals existing in the ditch are apparently adsorbed onto the sediments and will only be transported with sediments in suspension during high-flow periods. The available alternative measures at Site 17 are:

- Assume that the metals and organic compounds found in the soil of the South Fork Drainage Ditch pose no threat to the water quality in Onion Creek (to which the ditch discharges) and cease action at the site.

- o Investigate the water quality in the South Fork Drainage Ditch in more detail. Specifically, the organic species load could be evaluated with EPA 601 and 602. In conjunction with the water analysis, more detailed soil analyses should also be performed to identify what species constitute the organic compounds detected by the oil and grease analysis. Water samples can be collected at three locations during a runoff event while soil samples would be collected at seven locations during a dry period.

Radian recommends the latter option, that of investigating the water and soil quality further. The confirmed presence of organic compounds in the soil of the ditch presents the possibility of water contamination by organic compounds. Although Air Force sampling and analysis have confirmed that the concentrations of heavy metals in the water are within drinking water standards, the organic content has not been determined in sufficient detail. In addition, identifying the compounds present in the soil will enable informed decisions to be made as to whether the contaminated soil should be removed from the site or left in place.

5.2 Site 13. MOGAS Spill at Motor Pool

The investigation of the MOGAS spill included the drilling of one corehole, the collection of soil samples during drilling, and the collection of a water sample from the hole before it was grouted to the surface. The investigation revealed heavy metal and organic contamination in both the soil and groundwater at the site. The alternative measures available are:

- o Assume that the metals and organic compounds found at the MOGAS Spill Site pose no threat to the environment of the site, and cease action at the site.

- o Assume that the groundwater contamination detected could eventually enter a water supply; in response, therefore, institute additional drilling and sampling to determine flow directions and potential discharge points and to assess the areal extent of contamination.

Radian recommends the second option, that of instituting additional drilling and sampling of three monitoring wells. The same analytical parameters used in this study should be used. Alhough the shallow groundwater is not a local drinking water source, the permeable beds noted during Phase II (Stage 1) drilling indicate that there is the possibility of contaminant movement. The high level of benzene measured in the groundwater warrants continued investigation at the site.

5.3 Site 23. Fire Training Area

The investigation at the Fire Training Area included the drilling of two coreholes and the collection of soil and water samples. The chemical analysis of the soil and water samples revealed heavy metal and organic contamination. The available alternative measures are:

- o Assume that the metals and organic compounds detected in the soil and water at Site 23 pose no threat to the environment, and cease action at the site.

- o Assume that the contamination detected could eventually enter a water supply and institute additional drilling and sampling of three monitoring wells to determine flow directions and potential discharge points. This would also make it possible to assess the areal extent of contamination.

Radian recommends the second option, that of conducting additional investigations. The low levels of contaminants detected in the groundwater, the close proximity of the site to the base boundary (about 1,000 feet), and the age of the site are all factors that warrant continued investigation. Additionally, the source of the contamination should be eliminated to reduce the possibility of future contamination. An impermeable fire training area is suggested to prevent future contaminant migration.

5.4 Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

The investigation of the Combined Southeast Landfill area included the installation of six monitoring wells and two borings followed by two rounds of groundwater sampling for chemical analysis. No contaminants were detected in concentrations greater than background levels. The available alternative measures are:

- Assume that no contaminant problem exists at the landfills and cease further action at the site.

- Install additional monitoring wells and continue water sample collection and chemical analysis.

Radian recommends the second option, that of installing additional wells and continuing the sampling effort. Using data obtained from the wells installed during the Phase II Stage 1 project, it has been determined that not all of the existing wells are placed in the optimal positions to intersect contaminant migration. Installation of additional wells can resolve doubts about sample location with respect to the landfills. Continued monitoring of water quality is warranted considering the proximity of the site to the base boundary. Radian does not recommend any further investigation of the Road Oiling Area (Site 14). The negative results from Stage 1 chemical analysis indicate no apparent PCB soil contamination.

5.5 Site 8. JP-4 Spill/Overtopped Tank Area

The investigation at the JP-4 Spill/Overtopped Tank Area consisted of the drilling of one corehole and the collection and chemical analysis of soil and water samples. The investigation revealed organic contamination (i.e., oil and grease) in the soil and an elevated lead content in the water. Available alternative measures are:

- o Assume that the observed contamination will have no adverse effect on the environment and cease action at the site.

- o Assume that the disturbed nature of the water sample (i.e., caused by taking it from a borehole, not a well) accounts for the absence of organic compounds in the analytical results, and that the presence of oil and grease detected in the soil suggests the possibility for organic compounds in the groundwater. Additionally, the presence of lead in the groundwater grab samples should be verified. Possible actions include installing a monitoring well, sampling the water, and analyzing for organic and inorganic compounds to determine what effect the spill has had on groundwater quality.

Radian recommends the second option, that of installing a monitoring well at the site. The negative results of the groundwater analysis indicate that significant amounts of organic compounds are not present in the groundwater below the site. The absence of organic compounds as noted above may be due to the disturbed method of sampling. Additionally, the site is about 3,500 feet from the base boundary, reducing the chances of affecting neighboring areas, but off-base shallow groundwater uses are unknown. Even if the sample was disturbed by collection in a borehole, some evidence of organics in the TOC (total organic carbon) analysis would still be expected. The elevated level of lead in the groundwater would not normally be expected as a component of JP-4 and may reflect natural conditions. It may be appropriate for the base to consider installing an impervious ground cover within the tank area to reduce the infiltration potential at the site.

5.6 Site 9. JP-4 Suspected Underground Line Leak

The investigation of the JP-4 Pipeline leak consisted of digging seven ditches along the pipeline for AE testing, installing three monitoring wells, and collecting four air samples taken around the low-point drain area. The results of the study indicated that a leak existed at the low-point drain valve, that JP-4 fuel-contaminated soils exist along the pipeline at the low point drain, that no fuel vapors were present in nearby utility lines, and that strong fuel vapors were present at a dry monitoring well next to the low-point drain. The available alternative measures at Site 9 are:

- Assume that the JP-4 fuel detected along the pipeline poses no environmental threat and cease further actions at the site.

- Assume that the fuel contamination detected could enter the nearby groundwater and eventually reach a water supply; in response, therefore, institute additional drilling and sampling.

- Assume that the fuel slug has not yet reached the goundwater and monitor the groundwater for evidence of fuel contamination with time.

Radian recommends the third option, that of monitoring the site to ensure that the fuel contamination has not yet reached the groundwater.

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6.0 RECOMMENDATIONS

This section contains the Phase II (Stage 1) IRP recommendations for further actions at Bergstrom AFB. In accordance with Air Force criteria, each site has been assigned to one of the following categories:

Category I - Sites where no further action is required

Category II - Sites requiring additional monitoring or work to assess the extent of current or future contamination

Category III - Sites that require and are ready for remedial action

The site classifications are based on Radian's assessment of the impact of each site on the local environment and the likelihood of contaminants entering drinking water supplies and/or having an impact on the health of plant and/or animal communities.

All six sites have been assigned to Category II, sites requiring additional monitoring. These sites are considered to need more monitoring because of the relative ease with which potential contaminants could move off-base. No sites were assigned to Categories I or III.

The following sections present the recommendations and basis for further action required for the sites at Bergstrom AFB. The sites are grouped by category.

6.1 Category I Sites

Category I sites are defined as sites where no further action is required. Every site investigated had evidence of some soil and/or ground-water contamination. The hydrogeologic data, and particularly the chemical data, for the study sites was not sufficient to define the physical environment required for the design and implementation of remedial actions, or no further activities. Each site was investigated and evaluated according to the Delivery Order specifications for this IRP Stage 1 activity; however, data gaps exist with respect to an adequate characterization. No sites were assigned to Category I.

6.2 Category II Sites

Category II sites are defined as sites requiring additional monitoring work or work to quantify or further assess the extent of contamination. The sites listed as Category II are: the South Fork Drainage Ditch (Site 17), the MOGAS Spill at Motor Pool (Site 13), the Fire Training Area (Site 23), the Combined Southeast Landfill (Sites, 3, 4, 5, 6, 7, and 14), the JP-4 Spill/ Overtopped Tank Area (Site 8), and the JP-4 Suspected Underground Line Leak (Site 9).

6.2.1 Site 17. South Fork Drainage Ditch

Sediment samples taken in the South Fork Drainage Ditch indicate that there has been some impact to the sediments. Heavy metals, especially chromium, copper, and lead, were detected in elevated levels near the outfall to the ditch. Monitoring of the water in the ditch, which has been conducted by Air Force personnel, has not detected significant concentrations of metals, indicating that the metal contaminants are probably insoluble.

It is recommended that surface water monitoring in the South Fork Drainage Ditch be continued with emphasis on peak discharge periods. Water should be sampled at four points in the ditch during two peak flow periods including:

- o Discharge from the drainage pipe before it enters the ditch;

- o Ditch water upstream and downstream of the oil/water separator; and

- o Ditch water downstream of the base.

The water samples should be analyzed for organic compounds (i.e., EPA 601 and 602) as well as metals and oil and grease, the analytes used in the Phase II (Stage 1) study.

During a dry period, two sediment samples should be collected from as many as seven locations in the ditch. Additionally, a background soil sample should be collected from an undisturbed area of the base for comparisons with previous analytical data. Chemical analyses should be for the water analytes noted above.

Aside from this continued monitoring, it is recommended that the Air Force continue to work toward reducing contaminant input to the ditch from the flightline area. Improved maintenance will serve to reduce the loading of both dissolved and suspended contaminants. In addition, the Air Force should remove the refuse that has been dumped into the drainage ditch in the vicinity of Landfills 5, 6, and 7, and implement stricter controls to prevent future dumping. Included in the refuse dumped into the ditch, adjacent to Landfill 5, are several old 55-gallon drums with unknown contents. Caution should be used during removal of these drums.

6.2.2 Site 13. MOGAS Spill at Motor Pool

Analysis of soil samples taken in the boring at the Motor Pool area confirmed that chromium, nickel, and lead are present in some samples, especially at a depth of 7.5 to 9 feet below land surface. The presence of metals at that depth and the much lower concentration of metals in the 5-foot to 6.5-foot sample may indicate that leaking tanks elsewhere in the vicinity, as opposed to surface spills, may have been the source of the contaminants.

No background soil samples were available for chemical analysis on this project; therefore, up to three soil samples should be collected from one corehole drilled at an undisturbed area of the base. The chemical analyses should be the same as those performed for the Phase II (Stage 1) study.

The presence of an organic compound (benzene) and metals (lead and nickel) indicates that groundwater impact has occurred. However, because groundwater is not utilized locally except to fill golf course ponds, there is no immediate health threat to base personnel. The extent of the impacts has not been fully defined. It is recommended that three monitoring wells be installed about the site to define the groundwater impacts, flow directions, and groundwater chemistry. Two rounds of groundwater sampling should be conducted for chemical analysis for the parameters used in the Phase II (Stage 1) study. This will also aid in determining the possibility of off-base migration.

An additional recommendation regarding the Motor Pool area is that the Air Force continue to work toward eliminating future fuel releases. These steps may include (if not already conducted):

- Accurate and frequent fuel inventory;
- Tank inspection;
- Installation of leak detectors;
- Tank replacement as necessary; and
- Monitoring for hydrocarbon gases in the unsaturated sand/silt between 7 and 17 feet below land surface. This monitoring is for the detection of tank leaks. It is more timely than groundwater monitoring because of the time required for fluid to percolate through the clay bed to the groundwater.

6.2.3 Site 23. Fire Training Area

Analysis of soil samples from two borings drilled in the fire training area indicates that an impact on the soils by heavy metals has occurred. Chromium, nickel, lead, and (to a lesser degree) cadmium were found in near-surface samples and generally decreased in concentration with depth. Groundwater samples extracted from each boring did not contain high concentrations of metals but did contain several organic compounds. The groundwater is not utilized on the base and no health threat to base personnel is known. But because of the age of the site, impacts could extend well beyond the site. For this reason, installation of three monitoring wells and two rounds of groundwater sampling should be done. The analyses to be performed should be as conducted under the Phase II (Stage 1) program. Also, a water well inventory should be conducted within one-half mile of the base boundary across from this site to determine any groundwater users.

No background soil samples were available for this project. Therefore the analytical results from background soil samples described in Section 6.2.2 above should be used for comparisons at the Fire Training Area.

It is also recommended that the contaminant source be eliminated to reduce future impact to the groundwater. This could be accomplished by building an impermeable fire training area for future exercises. Should the present fire training are be abandoned, it is recommended that several feet of soil be removed and replaced with compacted clayey soil. This will allow natural revegetation and reduce the infiltration of rain water into the site, thereby limiting the vertical movement of contaminants contained in the soils.

6.2.4 Sites 3, 4, 5, 6, 7, and 14. Combined Southeast Landfill

Groundwater samples collected from monitoring wells in the Combined Southeast Landfill area did not contain any contaminants at significant levels. This was confirmed by a second round of sampling conducted one month after the initial sampling. Because of the large size of the disposal areas and the proximity of the disposal areas to the installation boundary, it is recommended that groundwater monitoring be continued. The recommended monitoring program is:

- Install two additional monitoring wells to serve as downgradient monitoring points. These could be located in the areas north of Landfill No. 4 and/or north of Landfill No. 5.

- Record the water level elevations and conduct two rounds of sampling for each well.

- Analyze all samples taken, including field replicates and blanks, for a similar suite of analytes as were completed in this delivery order. (The analyte list may be altered with time).

- Conduct an off-base water well inventory within one-half mile of the boundary adjacent to the site to identify groundwater users.

In addition, inspection of Landfills 5, 6, and 7 for bank erosion along the South Fork and other drainage ditches should be done during the sampling. Wastes have, in some locations, been buried close to the edge of the ditches. Peak runoff events will probably cause some erosion of the banks and may expose wastes.

Part of the Combined Southeast Landfill area, the road oiling area (Site 14), was sampled and analyzed for polychlorinated biphenyls (PCBs). No PCBs were detected and therefore no further action is recommended.

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6.2.5 Site 8. JP-4 Spill/Overtopped Tank Area

One boring was drilled within the bermed area of Tank 513. Soil samples taken in the boring indicated that the oil and grease content was slightly greater at depth than near the ground surface. However, the groundwater sample extracted from the boring did not contain significant hydrocarbon contaminants. A possible reason for the lack of hydrocarbons may be that a disturbed sample was obtained from a borehole, or that no measurable hydrocarbons have reached the groundwater. The higher content in oil and grease with depth increases the likelihood that hydrocarbons should have reached the groundwater. Downward migration would be inhibited by the clays encountered there. Based upon the present data, the site appears to have had minimal impact on the subsurface, but additional data would be needed to fully assess the spill impact. Therefore, it is recommended that further action be taken. The recommended monitoring program is:

- Install four boreholes around the site for obtaining soil samples to determine if the spill is near the surface or has migrated at depth and to plan the installation of a monitoring well.

- Install one monitoring well for obtaining soil and groundwater samples to confirm the presence of lead and/or organics in the subsurface.

- Analyze soil and water samples for the same parameters as the present delivery order.

No background soil samples were available for this project. Therefore, the analytical results from background soil samples described in Section 6.2.2 above should be used for comparisons at the JP-4 Spill/Overtopped Tank Area (Site 8).

Additionally, it is recommended that the Air Force consider installing an impervious ground cover within the tank area. This will prevent infiltration of future spills, allow recovery of future spills, and limit the amount of rainfall percolating through the site.

6.2.6 Site 9. JP-4 Suspected Underground Line Leak

A single round of groundwater samples was collected at the site for chemical analysis as a reconnaissance tool. No contaminants were detected by EPA Method 602. Because of the intermittent leaks that occurred at the site, it is recommended that additional groundwater monitoring be initiated. The recommended monitoring program is:

- Conduct two rounds of groundwater sampling for hydrocarbon analyses using a GC (gas chromatograph) equipped with multiple detectors. This will permit direct comparisons with fuel vapor analytical results from Monitoring Well 7.

- If contamination is confirmed in the groundwater, install a third well to define groundwater flow direction.

- Obtain an air sample from the electrical vault next to the low-point drain during dry conditions for hydrocarbon analysis. The vault was filled with snowmelt when the air was previously sampled. The water may have displaced any fuel and/or vapors. Also, fuel management personnel have noted JP-4 fuel in utility vaults in other areas of the Base.

Additionally, the base should ensure that fuel line pressures are maintained at proper operational levels. Excessive pressuring of the JP-4 pipeline during packing caused temporary leaking at the low-point drain in the old valve. This was corrected during this investigation. The leak at the low-point drain was stopped when base personnel put a new ball valve in line with the old fuel line valve. The base should consider similar ball valve installations or other appropriate remedies to reduce leakage out of other valves along the fuel lines. From a safety standpoint, other utility vaults near JP-4 lines should be checked for evidence of similar valve leaks.

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