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FINAL INSTALLATION RESTORATION STAGE 2 REMEDIAL INVESTIGATION FOR THE
EAST AREA NAS FORT WORTH TX
10/1/1991
RADIAN CORPORATION



**NAVAL AIR STATION
FORT WORTH JRB
CARSWELL FIELD
TEXAS**

**ADMINISTRATIVE RECORD
COVER SHEET**

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INSTALLATION RESTORATION PROGRAM (IRP)

STAGE 2

CARSWELL AFB, TEXAS

RADIAN CORPORATION
8501 MOPAC BOULEVARD
P. O. BOX 201088
AUSTIN, TEXAS 78720-1088

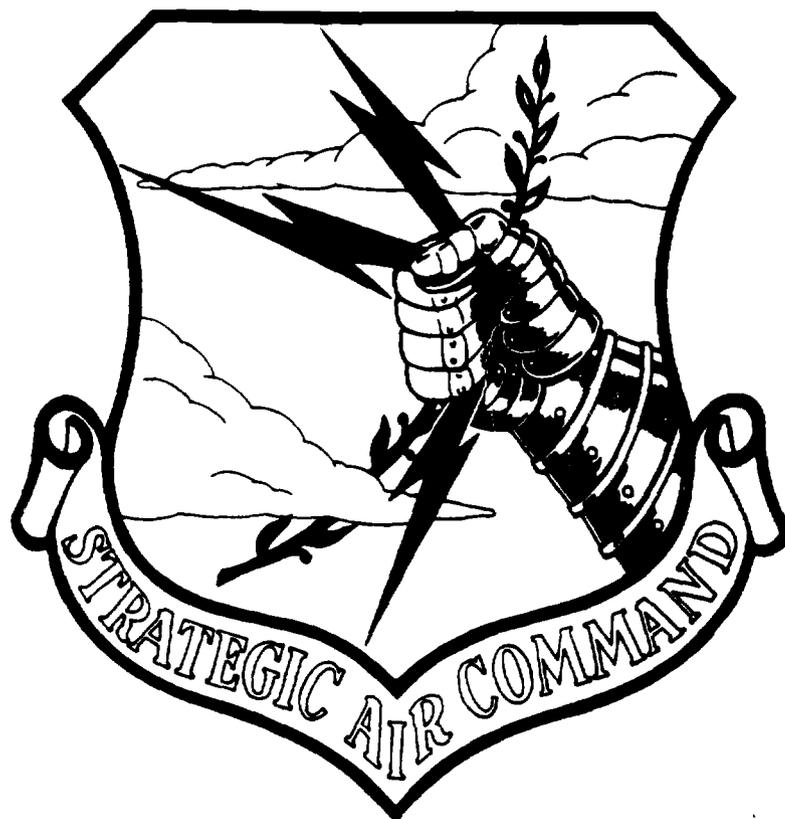
FINAL REPORT - OCTOBER 1991

REMEDIAL INVESTIGATION REPORT
FOR THE EAST AREA

PREPARED FOR

HEADQUARTERS STRATEGIC AIR COMMAND
(HQ SAC/DE)
OFFUTT AIR FORCE BASE, NEBRASKA 68113-5001

UNITED STATES AIR FORCE
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
ENVIRONMENTAL SERVICES OFFICE
ENVIRONMENTAL RESTORATION DIVISION (AFCEE/ESR)
BROOKS AIR FORCE BASE, TEXAS 78235-5000



100



8501 Mo-Pac Blvd.
P.O. Box 201088
Austin, TX 78720-1088
(512)454-4797

REMEDIAL INVESTIGATION
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CARSWELL AIR FORCE BASE, TEXAS

HEADQUARTERS, STRATEGIC AIR COMMAND
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PREPARED BY

RADIANT CORPORATION
P. O. BOX 201088
8501 MO-PAC BOULEVARD
AUSTIN, TEXAS 78720-1088

USAF CONTRACT NO. F33615-87-D-4023, DELIVERY ORDER NO. 0004, MODIFICATION 0005
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IRP TECHNICAL OPERATIONS BRANCH (AFCEE/ESR)
KARL RATZLAFF
TECHNICAL PROJECT MANAGER

UNITED STATES AIR FORCE
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
ENVIRONMENTAL SERVICES OFFICE
ENVIRONMENTAL RESTORATION DIVISION (AFCEE/ESR)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

11-03-91

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PREFACE

Radian Corporation is the contractor for the Installation Restoration Program (IRP) Phase II, Stage 2 investigation at Carswell AFB, Texas. The work was performed under USAF Contract No. F33615-87-D-4023, Delivery Order 0004, in two separate efforts; the first in 1987-88, and the second in 1990.

A hydrogeological investigation was conducted at several landfills, fire department training areas, and fuels handling areas to further assess and define the extent of contamination confirmed in the Stage 1 investigation at Carswell AFB. Soil gas surveys were conducted in 1988 at two locations to determine the extent of petroleum hydrocarbon vapors. Ground-water monitor wells were installed in alluvial materials to further define the limits of ground-water contamination. Soil samples were collected during drilling operations and with hand augers at selected sites and analyzed for a broad range of parameters in the initial Stage 2 effort. Water samples collected from the wells and several surface water bodies were analyzed for a wide spectrum of total metals, inorganic compounds, and organic compounds. Dissolved metals concentrations were analyzed only in the samples collected in 1990. A pumping test of the Upper Zone Aquifer was also performed in the Flightline Area in 1990. A baseline risk assessment, incorporating all analytical data, was performed, and remedial action alternatives were identified and evaluated for the Flightline Area and four sites in the East Area of the base (Sites LF01, SD13, ST14, and BSS) in the Feasibility Study.

Key Radian project personnel were:

Nelson H. Lund	IRP Contract Manager
William L. Boettner	IRP Program Manager
Lawrence N. French	Project Director/Delivery Order Manager (1987-88)
Debra L. Richmann	Project Director (1990)
Guy J. Childs	Supervising Geologist (1987-1988)
Stephen E. Fain	Supervising Geologist (1990)
Scott B. Blount	Supervising Geologist (1990)
Sandra A. Smith	Risk Assessment Task Leader
Kathleen A. Alsup	Remedial Alternatives Task Leader
Jeffery P. Young	Flightline Area FS Task Leader
Gary S. Shaw	East Area FS Task Leader
Gary L. Patton	Database Management and QA/QC Task Leader

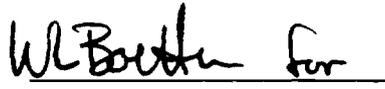
Greg A. Hamer
James H. Clary
James L. Machin
Leo M. Dielmann

Senior Technical Reviewers

Radian would like to acknowledge the cooperation of the Carswell AFB Civil Engineering Staff. In particular, Radian acknowledges the assistance of Mr. Frank Grey, Mr. Raj Sheth, and Sgt. Stanley Reinhartz.

The work reported herein was accomplished between December 1987 and July 1990. Mr. Karl W. Ratzlaff, IRP Technical Operations Branch, Human Services Division (AFSC) IRP Program Office (HSD/YAQ), was the Technical Project Manager.

Approved:



Nelson H. Lund, P.E.
Contract Manager

10/11/90

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EXECUTIVE SUMMARY

A Remedial Investigation (RI) was performed by Radian under the U.S. Air Force Installation Restoration Program (IRP) to characterize environmental contamination present in East Area IRP sites on Carswell AFB, Texas, the existence of which was documented in preceding IRP studies. The affected environmental media include soil, surface water, and ground water present in the surficial alluvial aquifer (Upper Zone). In contrast to Upper Zone ground-water contamination that occurs within the Carswell AFB Flightline Area, contamination in the East Area is considerably less extensive, and is of varying nature that can be directly correlated with discrete point sources (i.e., the subject IRP sites of this report). The RI was conducted in stages from 1988 to 1991. Radian also performed the earlier IRP Phase II Stage 1 investigation (1986); the IRP Phase I Records Search was performed by CH2M Hill (1984).

The most recent field and analytical effort was conducted in 1990 to provide additional information necessary to support a Feasibility Study (FS) of remedial alternatives applicable to the East Area sites. The 1990 effort was limited to further characterization of four of the East Area IRP sites:

- Site LF01 - Landfill 1;
- Site SD13 - Unnamed Stream and Abandoned Gasoline Station;
- Site ST14 - POL Tank Farm; and
- Site BSS - Base Service Station.

The locations of these, and other East Area IRP sites that are addressed in separate project reports and documents, are shown in Figure ES-1.

Two major tasks were performed to address existing data gaps. Monitor wells were installed at Sites SD13 and ST14 to provide new or additional information on the extent of Upper Zone ground-water contamination,

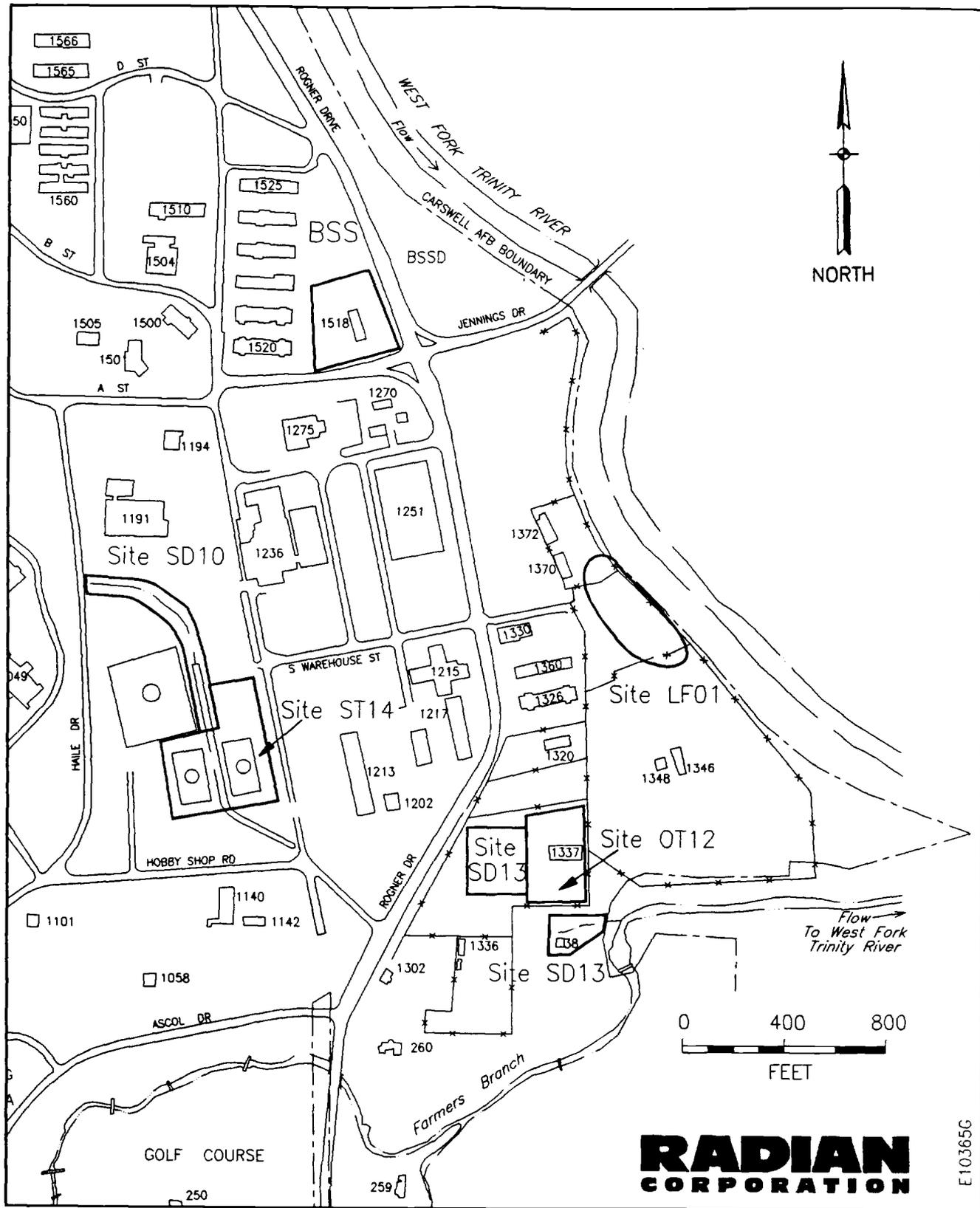


Figure ES-1. Location of East Area Sites, Carswell AFB, Texas

the potentiometric surface configuration and ground-water flow directions. One additional round of ground-water samples was collected from the newly installed and existing monitor wells, and four surface water samples were collected from Unnamed Stream at Site SD13. All samples were analyzed for waste-specific indicator chemicals for each site. Metals analyses were performed on both filtered and unfiltered samples.

The shallowest water-bearing zone, known as the Upper Zone Aquifer was the focus of the East Area IRP efforts. In the East Area, as well as across Carswell AFB and the adjoining area of Air Force (AF) Plant 4, the Upper Zone consists of unconsolidated Quaternary and Recent alluvial deposits (sand, gravel, silt, and clay) that contain ground water under unconfined conditions. The Upper Zone deposits in the East Area vary from approximately 7 to 20 feet thick, except immediately adjacent to the Trinity River where they are thicker. The Upper Zone is underlain by low permeability limestones and shales of the Cretaceous Goodland and Walnut Formations which form a basal aquiclude. Ground water in the Upper Zone Aquifer is encountered at depths ranging from approximately 6 to 13.5 feet below ground level (bgl) and ground-water flow in the East Area is generally toward the Trinity River. Based on six slug tests performed in East Area wells in 1988, calculated hydraulic conductivities of the Upper Zone range from approximately 10^{-5} to 10^{-2} cm/sec. A series of hydrogeologic cross-sections through the East Area was prepared from boring logs and synoptic water level measurements. They are included in Section 3 of this report to illustrate the local subsurface conditions.

The main surface water bodies located in the East Area are the West Fork of the Trinity River, Farmers Branch, and the Unnamed Stream at Site SD13. The Unnamed Stream emerges from an oil/water separator and flows into Farmers Branch, which in turn discharges to the Trinity River along the eastern boundary of Carswell AFB.

Ground-water samples from 21 wells were most recently collected by Radian for chemical analysis during April and May 1990. Four surface water samples were also collected. All East Area monitor wells are completed in the Upper Zone Aquifer. Since the wastes and known contaminants vary from site to site, not all samples were analyzed for the same suite of indicator chemicals.

Therefore, the analytical results are most conveniently discussed on a site-by-site basis. Both organic and inorganic constituents exceeding EPA Maximum Contaminant Levels (MCLs) for drinking water were detected in the East Area in past sampling efforts.

Generally, detected contaminant concentrations in ground-water and surface water samples collected in 1990 were lower than concentrations of the same analytes detected in previous IRP studies. This trend may be the result of normal variability or natural attenuation of these constituents in the ground-water and surface water systems; however, it should be noted that the weeks immediately preceding the Spring 1990 sampling event were characterized by abnormally high precipitation (and flooding). The resultant increase in infiltration and recharge may have had the effect of diluting contaminants, resulting in lower concentrations of detected constituents. It is recommended that remedial alternatives to be developed in the FS incorporate technologies (i.e., verification sampling, long-term monitoring) to resolve this uncertainty.

No definable volatile organic or metals contaminant plumes were identified in the Upper Zone ground water at Landfill 1 (Site LF01). Although several volatile organic compounds were detected in past sampling efforts, and in ground-water samples collected most recently in 1990, all concentrations have been below MCLs. Further, the occurrence of detectable concentrations of volatile organic compounds is sporadic, and therefore inconsistent with the existence of a coherent plume. No metals were detected in concentrations above MCLs in any ground-water or surface water samples collected in 1990. Therefore, the previously interpreted metals contamination is not supported by the most recent data.

IRP activities conducted at Site SD13 (Unnamed Stream and Abandoned Gasoline Station) in 1985 revealed high levels of organic compounds in ground water, probably originating from petroleum hydrocarbons. However, based on the 1990 volatile organic compounds analytical results, the abandoned gasoline station does not appear to be contributing appreciable organic contamination to the shallow ground-water system. No metals were detected above MCLs in the shallow ground water at Site SD13. Any contaminants in the

ground water would be expected to move hydraulically downgradient, eventually entering either the oil/water separator and the Unnamed Stream or Farmers Branch itself, where the initially low ground-water concentrations would be further diluted. Still more dilution of contaminants would result as Farmers Branch flows into the West Fork of the Trinity River less than one-half mile from Site SD13. Any VOCs entering Farmers Branch and the Trinity River would be subject to volatilization to the air.

No volatile organic compounds were detected above MCLs in the surface water samples from Site SD13. The results of the laboratory analysis for inorganic constituents suggest that metals in the Unnamed Stream are preferentially adsorbed to sediments rather than remaining dissolved in the surface water. Total arsenic and total lead were detected above MCLs in at least one surface water sample. Selenium in one sample was the only metal reported above the MCL in any dissolved metals analysis. This concentration was determined to be a reporting error and was actually below the detection limit. As evidenced by the lower dissolved and total concentrations of arsenic and lead in the downstream water samples, the metals apparently tend to accumulate in the stream bed sediments. Iron oxides, observed coating bottom sediments in the Unnamed Stream in the Phase II Stage 1 investigation, suggest that precipitation of metals is active. As long as the source of these metals persists, the metals will continue to accumulate in the sediments in the upper reaches of the stream.

Benzene, ethylbenzene, chlorobenzene, toluene, and total xylenes were detected in the ground water at Site ST14 (POL Tank Farm). Of these, ethylbenzene was the most common. However, benzene was the only volatile organic compound detected at a concentration which exceeded its MCL. Figure ES-2 depicts the probable extent of benzene contamination at Site ST14, interpreted from the 1990 analytical data and the distribution of soil gas determined in an earlier survey (Radian, 1989). Two separate accumulations of benzene are suggested. These plumes are roughly coincident with the two plumes interpreted earlier. Monitor well ST14-17M, located at the center of the benzene plume beneath the fuel loading facility, had the highest concentration of benzene, and the only concentration in excess of the MCL. Over

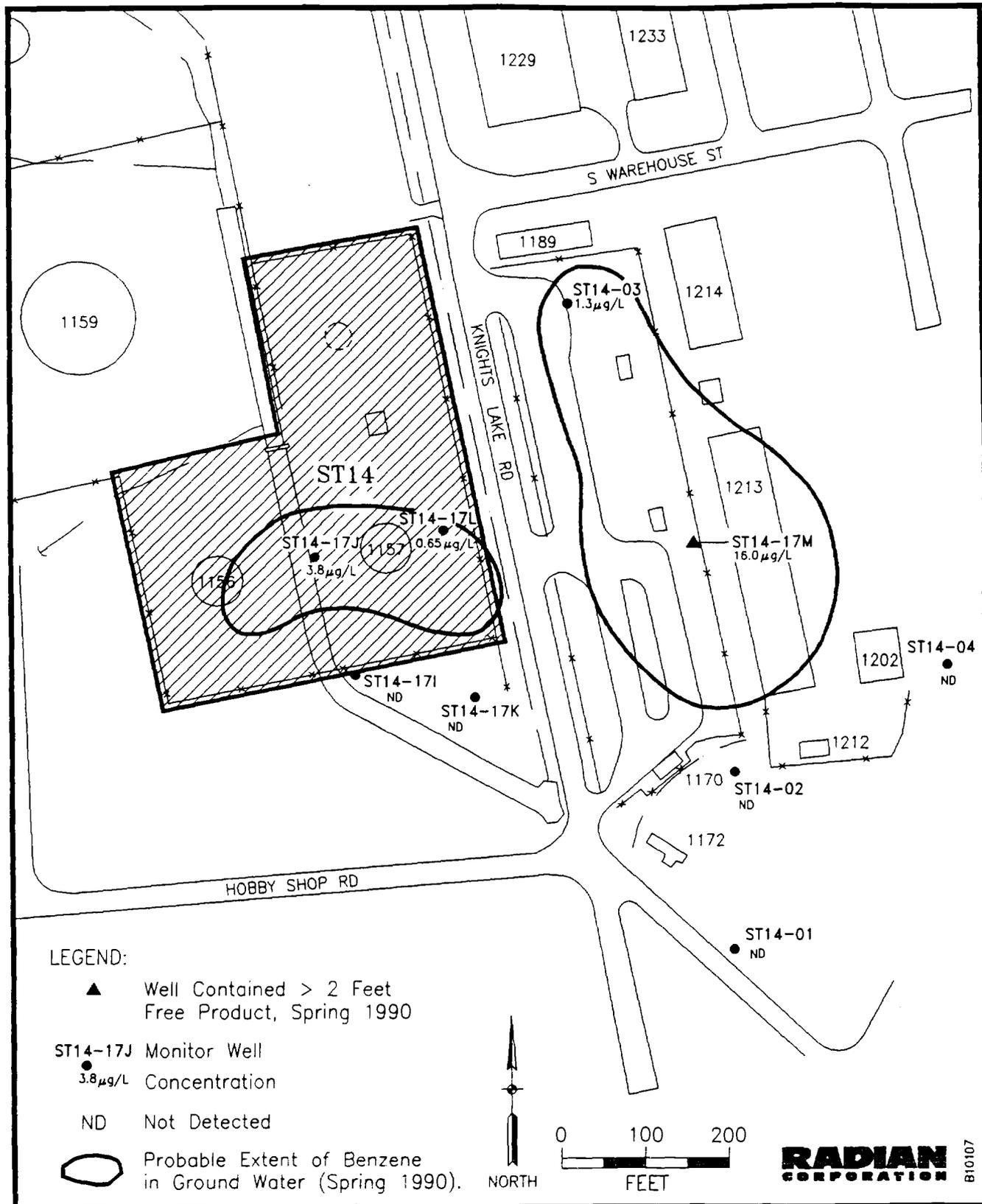


Figure ES-2. Probable Extent of Benzene Contamination (Spring 1990), Site ST14, Carswell AFB, Texas

2 feet of free product was encountered at ST14-17M during the 1990 sampling event. The highest concentrations of chlorobenzene, toluene, and total xylenes were also detected in this well.

Chromium was detected above its MCL in only one well at Site ST14, and this concentration was measured in the total metals analysis. Lead was detected above MCLs in three monitor well samples at ST14, but only one analysis was for dissolved metals. The single dissolved lead occurrence above the MCL does not suggest significant ground-water contamination.

Both volatile organic compounds and metals were detected at Site BSS (Base Service Station). In the previous Stage 2 investigation (Radian, 1989), volatile organic compounds were detected primarily in ground-water samples from monitor well BSS-B. In samples collected during the Spring 1990 sampling event, volatile organic compounds were detected only in this well. Because of the apparent localized nature of the volatile organic contamination, the underground storage tank adjacent to monitor well BSS-B is interpreted as the source of the observed contamination.

In the 1990 sampling event, cadmium was detected above the MCL in monitor well BSS-C in the total metals analysis. Cadmium was not detected in any other well, or in the filtered sample (dissolved metal fraction) from the same well. Therefore, ground-water contamination at the site is interpreted to be limited to volatile organic compounds.

Baseline risk assessments incorporating the 1990 analytical results were performed for the East Area sites included in the 1990 effort. Indicator chemicals, contaminant release, transport and fate mechanisms, and potential receptors and exposure pathways, specific to each of the East Area sites were identified and evaluated. All of the East Area sites were determined to pose no significant human health threat, based on evaluation of carcinogenic and noncarcinogenic (chronic) risks. In all cases, noncarcinogenic risks were too low to merit quantification. Environmental (terrestrial wildlife and aquatic organisms) risks were concluded to be minimal.

Using all available information generated in the IRP, the East Area sites were evaluated using the Defense Priority Model (DPM). The East Area sites (and the combined IRP sites in the Flightline Area) received the following scores and ranks:

<u>Rank</u>	<u>Site</u>	<u>Score</u>
1	Unnamed Stream (SD13)	20,760
2	Flightline Area (LF04, LF05, WP07, FT09)	19,381
3	Landfill 1 (LF01)	7,036
4	Base Service Station (BSS)	5,929
5	POL Tank Farm (ST14)	4,584

Based on a more detailed review of available data, Radian assigns a higher priority to the POL Tank Farm and the Base Service Station, respectively, than to Landfill 1. A Decision Document for Site BSS (Radian, 1990), describing on a preliminary basis the recommended remedial alternative, has already been prepared and provided to the Air Force.

Recommendations for addressing remaining data needs for design and implementation of remedial actions are provided in Section 7. It is anticipated that all of the required data can be obtained within the detailed design phase of the selected remedial actions, and no additional separate remedial investigation effort is proposed.

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this study was to supplement previously obtained information to describe in detail the environmental conditions in the East Area (Sites LF01, SD13, ST14, and BSS) of Carswell AFB, Texas. The knowledge of environmental conditions allows the evaluation of environmental impacts of past and/or ongoing releases of wastes or waste constituents from these sites so that remedial actions can be designed and implemented, if required.

Previous IRP studies documented environmental contamination associated with each of these East Area sites. Detectable concentrations of several organic and inorganic constituents were found in surface water samples and in soil and ground-water samples from the Upper Zone (referred to as the Upper Zone and the uppermost aquifer, consisting of unconsolidated alluvial deposits and fill, originally defined by Hargis and Montgomery, Inc., 1983). However, the extent of the existing contamination was not completely defined, and the additional Stage 2 activities reported in this document were recommended by Radian and authorized by HSD/YAQ under Modification 05, USAF Contract No. F33615-87-D-4023, Delivery Order No. 04.

In contrast to the Upper Zone ground-water contamination that underlies the IRP sites in the Carswell AFB Flightline Area, contamination in the East Area is considerably less extensive and can be directly correlated with discrete point sources (i.e., the subject IRP sites of this investigation). Additional IRP RI/FS Stage 2 field and analytical efforts were performed in the East Area between 5 March and 22 June 1990 to better define the nature and extent of contamination associated with Sites LF01, SD13, ST14, and BSS. This report summarizes the current understanding of the hydrogeologic setting and Upper Zone ground-water characteristics at these sites based on all data compiled to date.

Two major field tasks were performed to fill existing data gaps. Monitor wells were installed at Sites SD13 and ST14 to provide new or ad-

ditional information concerning the extent of Upper Zone ground-water contamination, the potentiometric surface configuration, and ground-water flow directions. One additional round of ground-water samples was collected from all newly installed and existing monitor wells, and four surface water samples were collected from the Unnamed Stream at Site SD13. Ground-water and surface water samples were analyzed for waste-specific indicators for each site. Metals analyses were performed on both filtered and unfiltered samples to determine the dissolved metals contribution to the total metals concentrations.

1.2 East Area Site Descriptions

Carswell AFB is located approximately six miles west of the center of Fort Worth in Tarrant County, Texas (Figure 1-1). This report focuses on four of the previously investigated IRP sites located in the East Area of the base (Figure 1-2).

The East Area includes six discrete sites that were identified as potential sources of contaminants in previous IRP studies (Figure 1-3). They are:

- Site LF01 (previously Site 1) - Landfill 1;
- Site SD10 (previously Site 13) - Flightline Drainage Ditch;
- Site OT12 (previously Site 15) - Entomology Dry Well;
- Site SD13 (previously Site 16) - Unnamed Stream and Abandoned Gasoline Station;
- Site ST14 (previously Site 17) - POL Tank Farm; and
- Site BSS - Base Service Station.

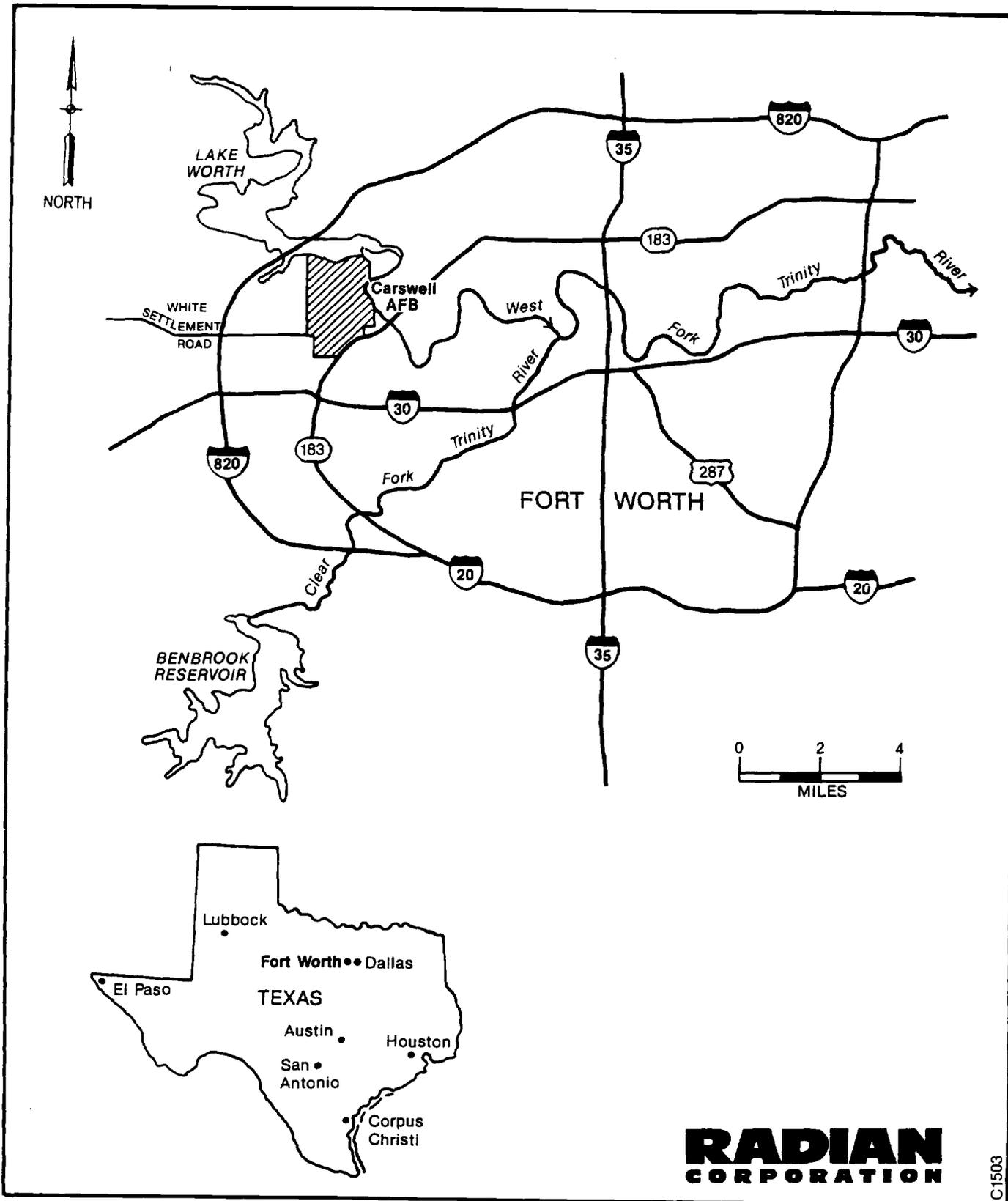


Figure 1-1. Regional Setting of Carswell AFB, Texas

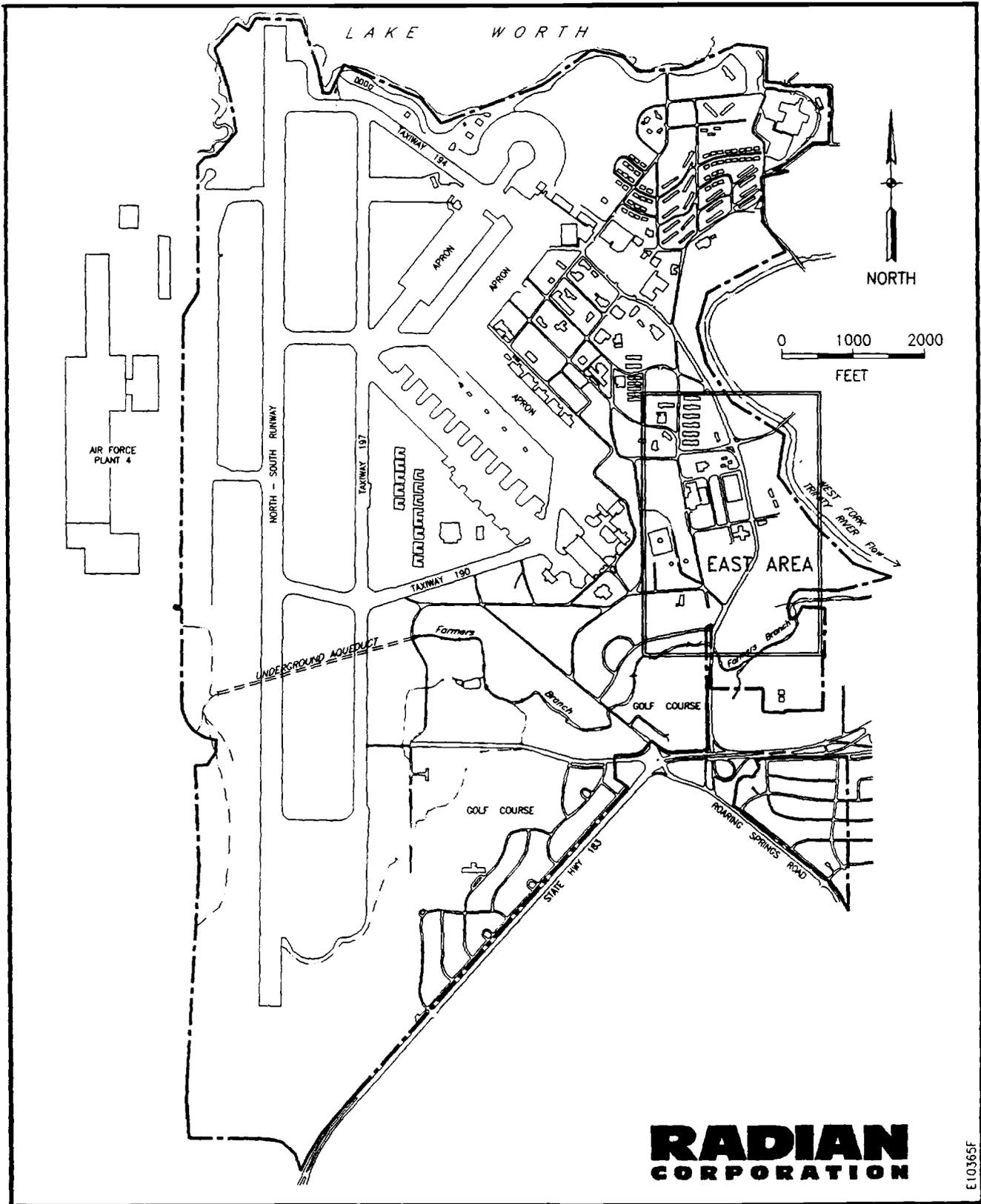


Figure 1-2. Location of the East Area, Carswell AFB, Texas

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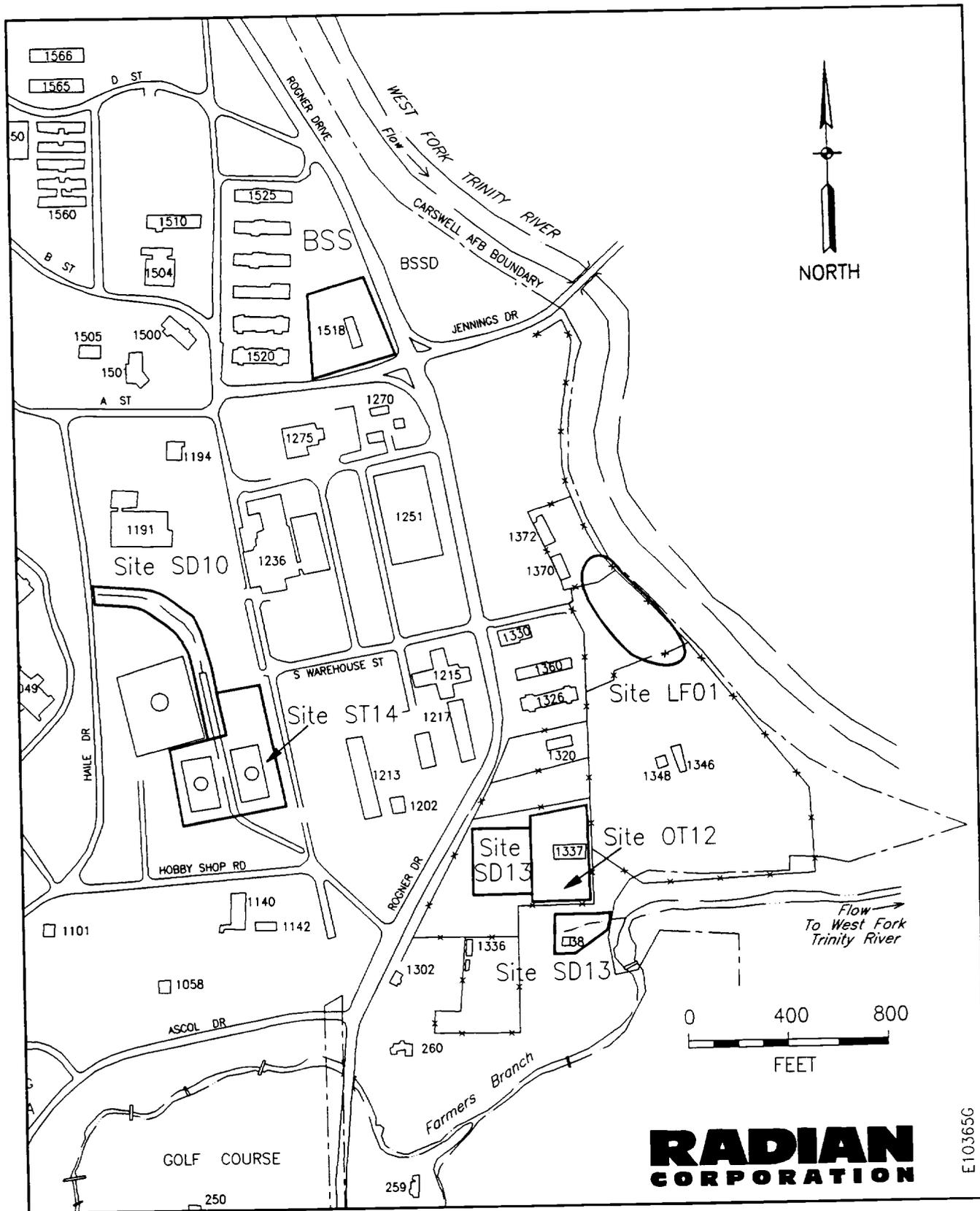


Figure 1-3. Location of East Area IRP Sites, Carswell AFB, Texas

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Data obtained in the earlier IRP investigations were sufficient to prepare a Decision Document identifying the recommended remedial action for Site SD10; and for Carswell AFB personnel to take over additional site characterization activities (soil sampling and analysis) prior to planned construction at Site OT12. Additional Stage 2 activities were undertaken at Sites LF01, SD13, ST14, and BSS only. In the following subsections, these sites are described in terms of their physical features and historical uses. The descriptions of these sites and the wastes reportedly disposed of or released from each are taken mainly from the Phase I Records Search (CH2M Hill, 1984).

1.2.1 Site LF01 - Landfill 1

Landfill 1 is, reportedly, the original base landfill and was operated during the 1940s. The site is located adjacent to the Trinity River levee at the current location of the Defense Reutilization and Marketing Office (DRMO) storage yard. Due to its age, no records were found concerning past waste disposal practices. However, analytical data obtained in the IRP studies suggest that solvent and metals-bearing wastes may have been among the landfilled wastes.

1.2.2 Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Site SD13 consists of two areas: a paved lot near an abandoned gasoline station located west of the former Entomology Dry Well (Site OT12), and the Unnamed Stream itself. The paved lot was investigated because past operation of the abandoned gasoline station might have resulted in petroleum products being released to the environment. The only remnant of the former gasoline station is a concrete island where the pumps were situated. Surface runoff from the paved lot is to the south and east. The Unnamed Stream is a small tributary of Farmers Branch that emerges from an underground oil/water separator (Facility 38). The stream and the separator are located south of the new communications building (No. 1337) and immediately south of the fenced civil engineering storage yard. The oil/water separator is connected to a french underdrain system which was reportedly built in 1965 to intercept hydrocarbon products leaking from the POL Tank Farm into sewer pipes. Unnamed

Stream is perennial, receiving flow from ground water entering the french drain and separator.

1.2.3 Site ST14 - POL Tank Farm

The POL Tank Farm is located along Knights Lake Road, near the Carswell AFB main gate. The site is occupied by two above ground fuel storage tanks. Three additional tanks were formerly located at this site, but have been dismantled. During the early 1960s, fuel was discovered in the ground at and downgradient of the site. A french drain system was installed in the downgradient area to collect the released fuel. The french drain discharged through the oil/water separator at Site SD13 (Section 1.2.2). At that time, the leaking underground pipes were reportedly located and replaced. No other fuel releases were reported after 1965, but the french drain system continues to collect petroleum wastes, and free floating product was present in one site monitor well during the 1990 IRP field effort.

1.2.4 Site BSS - Base Service Station

The Base Service Station is located on the northwest corner of Rogner Drive and Jennings Drive. Gasoline is stored in four 10,000-gallon, fiberglass reinforced plastic underground tanks located north of the pump islands. Surface drainage from Site BSS flows to culverts adjacent to Rogner Drive. The Base Service Station has been in operation for less than 20 years. It was constructed to replace the service station which was formerly located at Site SD13 (Section 1.2.2). The main contaminants identified with Site BSS are petroleum fuel and fuel derivatives. A Decision Document for remediation of this site was prepared (Radian, 1990), but collection and analysis of another round of ground-water samples from existing site monitor wells was authorized by the Air Force to supplement available data.

1.3 Summary of Previous East Area Investigations

Sites LF01, SD13, and ST14 were included in two separate IRP Phase II investigative efforts; the Stage 1 Preliminary Assessment (PA) and the

Stage 2 Site Inspection (SI). Site BSS, the Base Service Station, was not identified in the IRP Records Search as a potential contaminant source and was first investigated in the Stage 2 effort conducted by Radian in 1987-88 at the request of the Air Force. The existence of environmental contaminants associated with each of these sites was documented; however, additional information to define or verify the extent of contamination, and the nature and magnitude of contaminants at these sites was recommended. Radian performed the second episode of Stage 2 activities in March through June, 1990.

The East Area is located on land that gently slopes eastward to the West Fork of the Trinity River and southward to Farmers Branch. Surface elevations range from 595 feet above mean sea level (MSL) west of the POL Tank Farm (Site ST14) to 560 feet MSL on the flood plain above the Trinity River. No abrupt elevation changes occur within this area except close to the Trinity River and Farmers Branch.

In general, the geologic settings of the Flightline Area and the East Area are similar. The geology of the East Area consists of a thin veneer of alluvial material (Upper Zone) overlying the Goodland Limestone and Walnut Formation. The alluvium consists of clay, sand, and gravel. The Goodland and Walnut Formations contain fresh and weathered limestone, and shale. Together these units form a basal confining unit to the Upper Zone. No wells were drilled in the East Area that penetrated through the Goodland/Walnut Formations to the underlying Paluxy Formation.

The Upper Zone in the East Area generally consists of 5 to 15 feet of gray to black clay overlying 2 to 10 feet of fine-grained sand and up to 5 feet of gravel. The shallowest bedrock, the Goodland Formation, is usually encountered from 7 to 20 feet below ground level (bgl) in the East Area. In general, the depth to the Goodland decreases as the Trinity River is approached.

Upper Zone ground water in the East Area generally occurs at depths ranging from 7 to 23 feet bgl. Upper Zone ground-water flow is either east, toward the Trinity River, or south, toward Farmers Branch. The local direc-

tion of ground-water flow in the Upper Zone is apparently controlled by the elevation of the upper surface of the Goodland Limestone. This observation is consistent with the finding from the Flightline Area, where ground water in the Upper Zone also flows along the top of the Goodland Limestone. No information on the nature of the Paluxy Aquifer in the East Area is available because drilling activities in this area were confined to the Upper Zone.

The following paragraphs summarize, on a site-by-site basis, the major findings of activities previously performed throughout the IRP relative to the nature and extent of contamination at Sites LF01, SD13, ST14, and BSS. All field and analytical data from preceding investigations are contained in the Phase I Records Search (CH2M Hill, 1984), Phase II Stage 1 report (Radian, 1986), and Final Draft Phase II Stage 2 RI/FS report (Radian, 1989).

1.3.1 Site LF01 - Landfill 1

Landfill 1 is located on a gently sloping terrace immediately west of the West Fork of the Trinity River. Surface elevations range from approximately 567 feet above mean sea level (MSL) near the west boundary of the DRMO yard to 560 feet MSL on the levee above the river.

Prior to the current study, six Upper Zone monitor wells (four in Stage 1 and two in Stage 2) were installed at Site LF01 (Figure 1-4). Electromagnetic profiling and an earth resistivity survey (vertical electrical soundings) were also performed during Stage 1. The Upper Zone deposits encountered during drilling were somewhat different than those encountered elsewhere in the East Area. The material beneath Site LF01 consists entirely of fill, clay, and sandy clay. The sand and gravel layers penetrated in other East Area wells and borings are absent beneath the DRMO. The large amount of fill material (asphalt, concrete, tar, wood chips) encountered beneath the DRMO indicates that the area has been extensively modified by human activities.

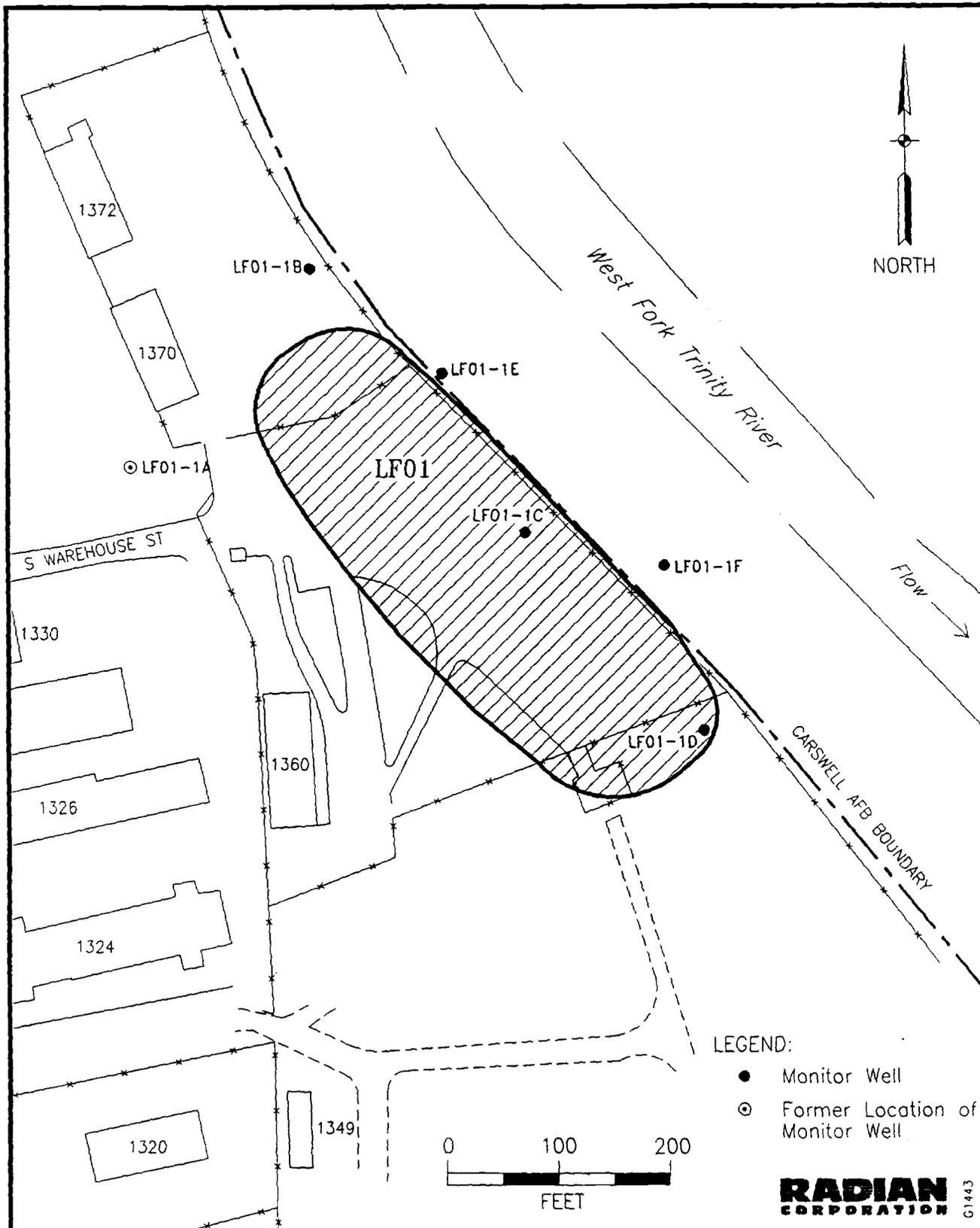


Figure 1-4. Location of Previously Installed Monitor Wells at Site LF01, Carswell AFB, Texas

The surface of the underlying Goodland Limestone dips relatively steeply to the east beneath the site, reflecting channel cutting and erosion of the limestone by the West Fork of the Trinity River. The land surface elevation does not dip eastward as steeply as the limestone; therefore, the thicknesses of alluvium in the easternmost wells (LF01-1E and LF01-1F) are greater than in other wells in the East Area.

The depth to Upper Zone ground water at Site LF01 ranges from about 5 feet at the upgradient location to about 20 feet bgl at the downgradient locations. The Upper Zone water table tends to reflect the surface of the Goodland Limestone because the ground water in the Upper Zone is confined below by the Goodland Formation. Ground-water flow beneath the site is eastward to northeastward, toward the West Fork of the Trinity River. An average seepage velocity of approximately 0.6 feet per day was calculated from slug test results of site wells.

Soil analytical results provided no evidence of waste material or contamination by waste constituents. Very low levels of volatile organic compounds (TCE, vinyl chloride) were detected in some ground-water samples. However, their sporadic occurrence and low concentrations did not suggest the existence of a defined ground-water contaminant plume.

Metals were detected in concentrations above their MCLs in some unfiltered ground-water samples. However, no dissolved metals analyses were performed prior to 1990. Total metals concentrations generally increased in downgradient wells, suggesting the former landfill was their source.

1.3.2 Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Site SD13 is located to the south and west of Site OT12. It is divided into two parts: the Unnamed Stream from the oil/water separator to Farmers Branch, and the paved lot in the vicinity of an abandoned gasoline station near Site OT12. The Stage 1 investigations near the Unnamed Stream consisted of the collection of soil samples from three hand-augered borings and of water samples from the oil/water separator and a point near the

confluence of the Unnamed Stream and Farmers Branch. Investigations in the paved lot included a geophysical survey and drilling of three soil borings from each of which grab samples of ground water were collected and analyzed. The Stage 2 investigation required collection of surface water samples from the Unnamed Stream at four locations (Figure 1-5) that were resampled in the 1990 study.

Site SD13 is underlain by clay, sand, and gravel of alluvial origin that rests on the southerly dipping surface of the Goodland Limestone. The sand and gravel beneath the site are apparently laterally continuous, providing a permeable pathway for the movement of Upper Zone ground water on top of the relatively impermeable limestone. Ground-water levels were estimated during drilling of the Stage 1 soil borings at depths ranging from about 7 to 10 feet bgl, corresponding to elevations of approximately 558 to 560 feet MSL. Based on these observations, ground-water flow is southward toward Farmers Branch.

Past total metals concentrations detected in the surface water samples from Site SD13 appeared to be related to discharge from the oil/water separator. Metals were detected in the water sample collected from the separator and in the soils downstream from the separator. However, the analytical results provided little evidence of significant metals contamination of surface water in Unnamed Stream. The adsorption of metals onto the sediments of the Unnamed Stream is apparently an effective mechanism for removing the metals from the stream water. The concentration distribution of total metals detected in the surface water was consistent with the tendency for metals to sorb onto sediments.

Surface water samples from Unnamed Stream contained benzene and toluene, apparently derived from waste fuels. Concentrations of these contaminants decreased with increasing distance downstream, probably due to volatilization. On this basis it was concluded that natural seepage, if any, entering the stream did not contribute significant contaminants and therefore the oil/water separator is the primary source of the surface water contamination.

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Grab samples of ground water collected in Stage 1 contained detectable concentrations of volatile aromatic compounds, probably derived from fuels. Given the conditions near the site, the contaminants were interpreted to be from one or both of the following sources: 1) a spill at the former gasoline station or leakage from buried tanks associated with the station; or 2) leakage from the POL Tank Farm.

1.3.3 Site ST14 - POL Tank Farm

The land surface at Site ST14 is relatively flat, ranging from about 580 to 572 feet MSL, west to east. Surface drainage is to the east-southeast, with some drainage into the concrete-lined portion of the Flight-line Drainage Ditch (Site SD10).

Prior to the current study, eight soil borings were drilled in and around the site in Stage 1. In Stage 2, five Upper Zone monitor wells were installed and a soil gas survey was performed (Figure 1-6).

Drilling on site indicated that the Upper Zone in the POL Tank Farm area typically consists of approximately 10 feet of gray to tan clay, underlain by five to 10 feet of sand and gravel. Limonite staining, pebbles and freshwater gastropod shells are common in the clay. The clay also frequently had a hydrocarbon odor during drilling. The sand is gray, tan to brown, or pink in color, and is generally fine-grained. Gravel ranges from pea size to pebbles over an inch in diameter.

The depth to the Goodland Limestone beneath the POL Tank Farm ranges from 16 to over 20 feet bgl. Where the elevation of the limestone is known, it forms a fairly uniform, gently southwesterly-dipping, surface at approximately 555 feet to 556 feet MSL.

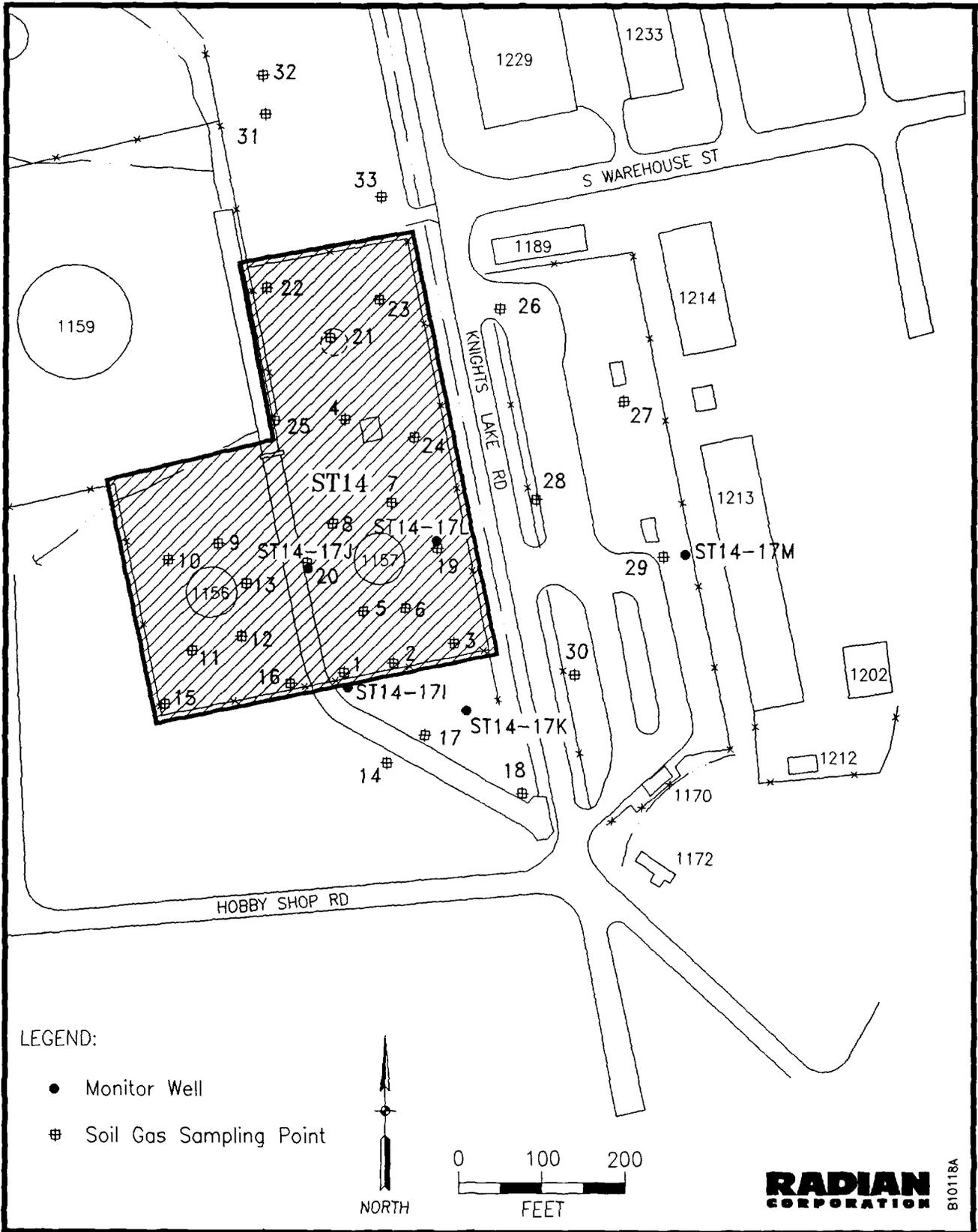


Figure 1-6. Location of Stage 2 Monitor Wells and Soil Gas Sampling Points, Site ST14 - POL Tank Farm, Carswell AFB, Texas

The depth to Upper Zone ground water at the site varies from approximately 9.5 feet to 16 feet bgl, with corresponding elevations of 560 to 571 feet MSL. The ground-water surface slopes to the southeast, toward Farmers Branch, and the average ground-water flow velocity, calculated from slug test results is approximately 0.2 feet per day. Ground water in the Upper Zone occurs under unconfined conditions.

The results of the soil gas survey conducted at the POL Tank Farm and the pipeline/truck loading area east of the tanks during Stage 2 indicated that two areas are underlain by hydrocarbon vapor plumes (Figure 1-7). The largest plume encompassed an area approximately 100 feet wide and 300 feet long underlying the vicinity of Tanks 1156 and 1157. A smaller plume was present beneath the pipeline/truck terminal area.

Soil analytical results indicated that petroleum hydrocarbons are the principal contaminant of concern. The distribution of hydrocarbon contamination in soil resembled the occurrence of ground-water contaminants. Drilling in the unsaturated portion of the Upper Zone deposits generally did not yield materials with visible contamination, suggesting localized sources of contamination and migration of contamination to the ground water.

Ground-water contaminants, principally volatile aromatic compounds associated with petroleum products, occurred in two areas at Site ST14 that partially correlated with the two soil vapor plumes. The extent of the easternmost ground-water plume was not well defined.

1.3.4 Site BSS - Base Service Station

The Base Service Station is located on a gently sloping terrace on the west side of the West Fork of the Trinity River. Elevations range from approximately 567 feet MSL near the Base Service Station to 560 feet MSL just east of the site. All previous work performed at Site BSS was accomplished during Stage 2 and consisted of a soil gas survey, installation of three Upper Zone monitor wells, and soil sampling from one soil boring.

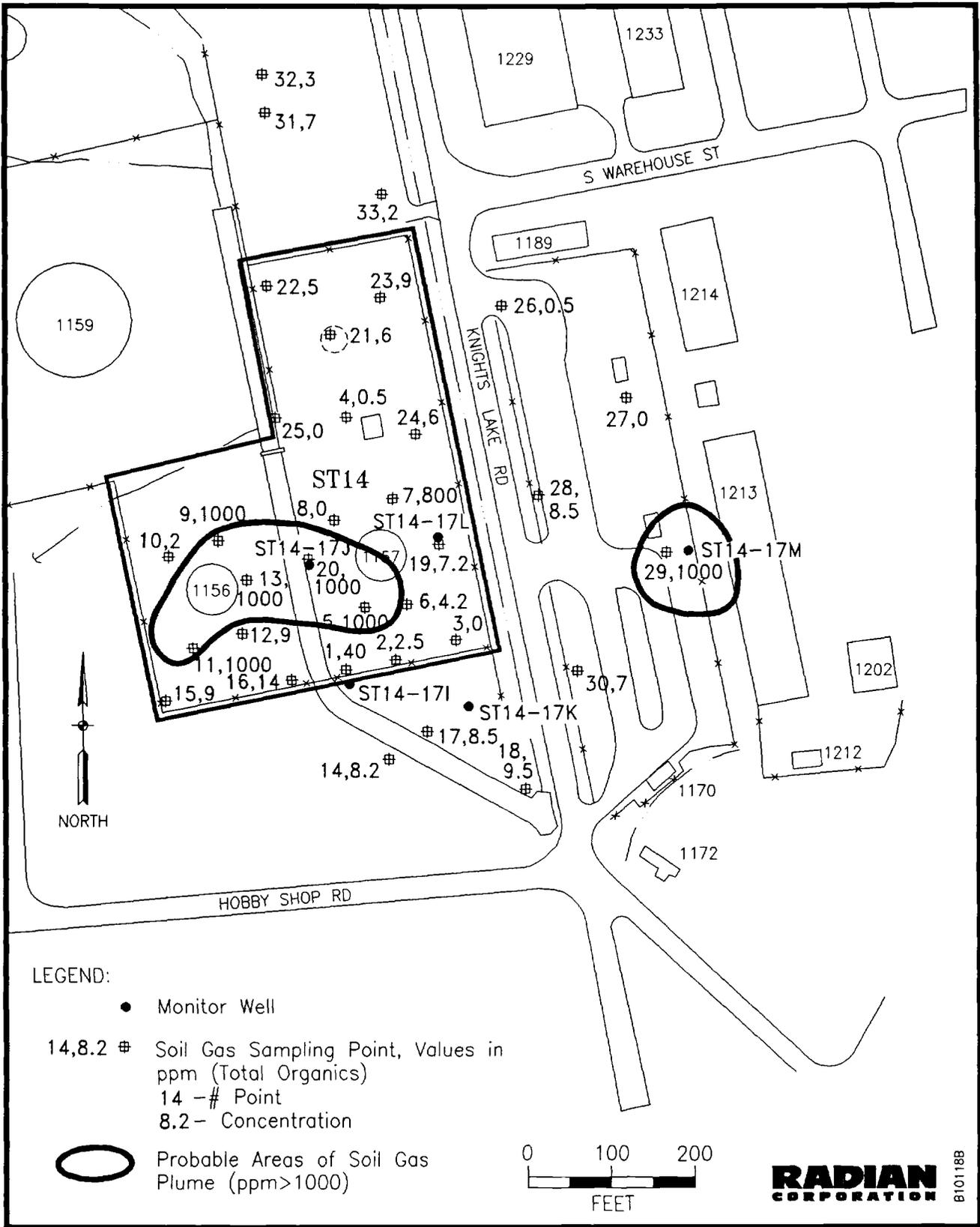


Figure 1-7. Probable Areas of Soil Gas Plumes (ppm > 1000) at Site ST14 (POL Tank Farm), Carswell AFB, Texas (December 1987)

The Upper Zone deposits encountered during drilling at the BSS site are characteristic of the East Area in general. Bedrock was encountered between depths of 6 to 12 feet bgl in all boreholes. The typical Upper Zone sequence consists of 3 to 9 feet of clay and silt, underlain by a thin layer of sand with minor gravel. Under the sand and gravel is the limestone of the Goodland Formation. The shallow depth of the Goodland is consistent with the overall geologic setting of the East Area. The surface of the Goodland Limestone dips to the east beneath the site, with the dip of the bedrock being slightly greater than the slope of the land surface.

The depth to water at the BSS site ranges from about 5 feet to just over 11 feet bgl. The water table in the Upper Zone slopes to the east. The ground-water gradient is fairly consistent with the slope of the underlying bedrock surface. Ground-water flow is toward the West Fork of the Trinity River.

Based on the results of the soil gas survey, two areas were underlain by hydrocarbon vapor plumes (Figure 1-8). The results showed that soil vapor plumes were present just north of the station, extending from the underground storage tanks to east of Rogner Drive, and also at the southern end of the station. The largest plume encompassed an area approximately 100 feet wide and 200 feet long. The smaller plume at the south end of the station was roughly 75 feet in diameter.

Contaminants detected in soils were petroleum hydrocarbons and a variety of volatile organic compounds. However, the extent of soil contamination appeared to be localized around boreholes BSS-A and BSS-B and no off-site soil contamination was detected.

Ground-water contaminants were principally volatile aromatic compounds associated with petroleum products and occurred mostly at well BSS-B, located in close proximity to the underground storage tanks.

Soil gas results and ground-water results correlated well for the northernmost vapor plume, but there was a poor correlation for the vapor plume that was centered on monitor well BSS-A. Although a soil gas plume was detected at BSS-A, concentrations of organic contaminants in ground water were low enough to be attributable to cross-contamination alone. Therefore, the extent of ground-water contamination appeared to be localized around monitor well BSS-B.

1.4 Report Organization

Following this Introduction, the field activities performed to characterize the East Area sites are presented in Section 2. The techniques and methodologies used to accomplish the field program for the comprehensive Phase II scope of work are described in detail. Section 3 presents a generalized description of the physical environmental setting of the East Area based on interpretation of data from the current investigation and from previous studies. As appropriate, notable site-specific features are also described. The nature and extent of surface water and ground-water contamination, determined from the most recent round of sampling and analysis (May-June 1990) are discussed by site in Section 4, and Section 5 addresses contaminant fate and transport. Section 6 outlines the risks to human health and the environment associated with exposure to the contaminants present in the East Area, and presents the Defense Priority Model (DPM) site ranking results. Section 7 summarizes the major findings of the RI and presents the conclusions regarding data limitations and recommendations for additional activities.

2.0 FIELD TECHNIQUES AND ANALYTICAL METHODS

Numerous field techniques and analytical methods were used to characterize environmental conditions in the East Area of Carswell AFB during the Phase II IRP effort. The following subsections describe the techniques for drilling and soil sampling (including analytical methods, holding times, and collection and preservation requirements), the methods for conducting geophysical surveys, the methods and specifications for well construction and development, the techniques for collecting water samples (including analytical methods, holding times, and collection and preservation requirements), the single well aquifer (slug) test method used to estimate aquifer properties, and surveying requirements.

2.1 Drilling and Soil Sampling

All drilling in the East Area of Carswell AFB was accomplished using the hollow-stem auger (HSA) method. The HSA drilling technique was selected based on the shallow anticipated depth of completion, and the expected geologic conditions. After each borehole was completed, the drilling rig, auger flights, and equipment were decontaminated with a high temperature, high pressure steam-sprayer using base potable water. Cuttings suspected of being contaminated on the basis of visual evidence and organic vapor analyzer (OVA) or photoionization detector (HNU) readings were placed in steel 55-gallon drums. Selected samples of cuttings were collected and submitted for analysis of EP Toxicity.

A Mobile Drill B-61 or a CME-75 hollow-stem auger drilling rig was used to perform shallow soil borings and installation of the Upper Zone monitor wells. The hollow-stem auger method allows for recovery of relatively undisturbed subsurface soil cores, determination of subsurface lithologies and structures, and accurate identification of the position of the water table. The boreholes were drilled dry; no drilling fluids or additives were used. Samples of soil were collected with either a split-spoon sampler, a thin-wall sampler (Shelby tube), or a CME 5-foot continuous core sampler.

The soil samples were described in terms of lithology, moisture content and any evidence of contamination. Lithologic logs of boreholes drilled during the most recent (1990) field activities are provided in Appendix A. Photographs of selected soil cores showing lithologic characteristics were also taken.

Selected samples were shipped on ice to Radian's laboratory for chemical analysis. Analytical parameters for soil samples are listed in Table 2-1. No soil samples were collected for chemical analysis in the Stage 2 effort performed in 1990.

2.2 Geophysical Surveys

Geophysical surveys were performed to define the vertical and lateral extent of waste-disposal activities, to provide a preliminary assessment of the subsurface conditions around the sites, and to investigate the potential existence of buried objects at several locations. All geophysical tasks at the East Area sites were performed during Phase II Stage 1.

All survey grids were laid out using a compass and measuring chain. Stations were marked with labelled pin flags or spray paint. The geophysical techniques employed in the East Area characterization efforts were earth resistivity (Site LF01), magnetic and magnetic gradient (Site SD13), and fixed frequency electromagnetic profiling (EMP) conductivity (Site LF01). The Earth Technology Corporation of Golden, Colorado performed the geophysical surveys. Following are brief descriptions of the various geophysical techniques used to characterize the East Area sites included in this report.

2.2.1 Electrical Resistivity

Earth resistivity was measured by direct current Schlumberger soundings (vertical electrical soundings - VES) at Site LF01 (Landfill 1). The Bison Model 2350 Earth Resistivity meter was utilized for the VES measurements. Current electrode separations used were (in meters): 1, 2, 3, 4, 6,

TABLE 2-1. SUMMARY OF RI/FS PHASE II SOIL SAMPLING AND ANALYSIS REQUIREMENTS, CARSWELL AFB, TEXAS

Reference Method	Parameter	Method Detection Limit	Method Type ¹	Container Type, No. and Volume	Preservation and Storage Requirements	Sample Extraction Procedures	Maximum Holding Time (Preparation) ²	Maximum Holding Time (Analysis)
EPA 6010	Metals	0.2 - 90 µg/g	ICP	250 mL glass bottle	Refrigerated at 4°C	Acid digestion (3050R)	N/S	6 months
EPA 7060	As	0.5 µg/g	Furnace AA	250 mL glass bottle	Refrigerated at 4°C	Acid digestion (3050R)	N/S	6 months
EPA 7740	Se	0.5 µg/g	Furnace AA	250 mL glass bottle	Refrigerated at 4°C	Acid digestion (3050R)/N/S	N/A	6 months
EPA 7471	Hg	0.5 µg/g	Cold Vapor AA	250 mL glass bottle	Refrigerated at 4°C	Acid digestion (3050R)	N/A	28 days
EPA 7420	Pb	0.5 mg/g	AA (furnace)	250 mL glass bottle	Refrigerated at 4°C	Acid digestion (3050R)	N/S	6 months
EPA 413.2	Oil and Grease	10 µg/g	IR	250 mL glass bottle	Refrigerated at 4°C	Freon extraction by sonication (2550)	N/S	28 days
EPA 418.1	Petroleum Hydrocarbons	50 µg/g	IR	250 mL glass bottle	Refrigerated at 4°C	Sonication extraction (3550) with freon	N/S	28 days
EPA 8240	Volatile Organic Compounds	0.1 µg/g	GC/MS	250 mL glass bottle	Refrigerated at 4°C	Purge and trap (5030)	14 days	14 days
EPA 8270	Semi-Volatile Organic Compounds	1 µg/g	GC/MS	250 mL stainless steel sleeve or 250 mL glass bottle	Refrigerated at 4°C	Sonication (3550)	14 days	40 days
EPA 8150	Chlorinated Phenoxy Herbicides	0.1 - 160 µg/g	GC/ECD	250 mL glass bottle	Refrigerated at 4°C	Extraction, hydrolysis, GC	7 days	40 days
EPA 8080	Organochloride Pesticides and FCB's	0.01 - 0.2 µg/g	GC/ECD	250 mL glass bottle	Refrigerated at 4°C	Sonication extraction (3550)	7 days	40 days

Notes: 1. ICP = Inductively Coupled Plasma Emission Spectroscopy

AA = Atomic Absorption

IR = Infrared Spectroscopy

GC/PID = Gas Chromatograph/Photoionization Detector

GC/HSD = Gas Chromatograph/Halide Specific Detector

2. N/A = Not Applicable

N/S = Not Specified

SM = Standard Method

(Continued)

TABLE 2-1. (Continued)

Reference Method	Parameter	Method Detection Limit	Method Type ¹	Container Type, No. and Volume	Preservation and Storage Requirements	Sample Extraction Procedures	Maximum Holding Time (Preparation) ²	Maximum Holding Time (Analysis)
40 CFR 261.21 (EPA 1310)	EP Toxicity	0.002-0.5 mg/L	AA, ICP	250 mL glass bottle	Refrigerated at 4°C	Extraction	N/S	28 days
EPA 8140	Organophosphorus Pesticides	0.5 - 5 µg/g	GC	250 mL glass bottle	Refrigerated at 4°C	Sonication, extraction (2550) with freon	7 days	40 days
ASTM D2216	Soil Moisture							

Notes: 1. ICP = Inductively Coupled Plasma Emission Spectroscopy

AA = Atomic Absorption

IR = Infrared Spectroscopy

GC/FID = Gas Chromatograph/Photoionization Detector

GC/HSD = Gas Chromatograph/Halide Specific Detector

2. N/A = Not Applicable

N/S = Not Specified

SM = Standard Method

10, 14, 20, 30, 40, and 50 (1 meter equals 3.28 feet). The sounding data were processed using the ABEM VES iteration process to obtain a best fit curve and were plotted logarithmically as resistivity in ohm-meters versus half the current electrode separation in meters. The plot also includes the layered earth model giving the best match. At most VES sites, orthogonal electrode arrays were used to test for distortions of the data due to lateral inhomogeneities in the ground.

2.2.2 Electromagnetic Surveys

An electromagnetic profiling (EMP) survey was conducted at Site LF01 (Landfill 1) using two devices: the Geonics EM31 and the Geonics EM34-3 ground conductivity sensors. Both ground conductivity sensors are designed for rapidly obtaining data over large areas. The meters employ magnetic dipoles or magnetic induction loops for transmission and reception of low frequency electromagnetic waves. The effective depth of investigation of the EM31 is six meters; the depth of investigation provided by the EM34-3 depends on the coil separation and orientation, applied frequency, and to some extent, the conductivity profile of the subsurface. The techniques and conditions at Carswell AFB resulted in an effective investigation depth of 15 meters (50 feet) with the EM34-3. The resulting data were reported in units of millimhos/meter.

2.2.3 Magnetometer Surveys

The magnetometer survey at Site SD13 was accomplished using an EDA PPM500 proton magnetometer. The magnetometer survey was performed because the overburden at Carswell has a low magnetic susceptibility and buried metallic objects would create a noticeable magnetic anomaly. Readings of the total field and magnetic gradient were taken at each location. The units for these readings are gammas and gammas per one-half meter (1.64 feet), respectively. The magnetometer survey of Site SD13 was performed to determine the locations of buried tanks reportedly existing at the site in the vicinity of the former base service station.

2.3 Monitor Well Construction and Development

During the Phase II activities in the East Area, a total of 22 Upper Zone monitor wells were installed. The construction specifications and well development procedures are described in the following sections.

2.3.1 Monitor Well Construction

Upper Zone monitor wells were installed either immediately after completion of the drilling operations or after the borehole produced enough water to warrant a well. Construction specifications for the Upper Zone monitor wells are presented in Table 2-2. Well completion summaries for East Area monitor wells completed in the most recent (1990) investigation are provided in Appendix B. Construction methods were generally consistent with the specifications provided in the SOW. Any changes necessitated by unanticipated field conditions were made with the knowledge and approval of the HSD/YAQ Technical Program Manager. Decisions regarding the setting of the screen and casing, length of screen, amount of sand pack and bentonite were made in the field by the Radian Supervising Geologist based on the static water level and saturated thickness of Upper Zone sediments. Monitor wells were installed using the following procedures:

1. Prior to installation, the casing and screen sections were thoroughly washed using a high temperature, high-pressure steam sprayer, with base potable water.
2. Screen and casing sections were assembled, then lowered carefully into the borehole. As the string of screen and casing was lowered, additional sections of casing were added until the bottom of the screen reached the bottom of the borehole. The top of the casing was capped to prevent any completion materials (sand, bentonite pellets, and grout) from entering the casing during well construction activities.

TABLE 2-2. UPPER ZONE MONITOR WELL CONSTRUCTION SPECIFICATIONS,
EAST AREA, CARSWELL AFB, TEXAS

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-
1. Casing: Two-inch diameter, threaded and flush jointed, Schedule 40 PVC.
 2. Screen: Two-inch diameter, threaded and flush-jointed factory-slotted, Schedule 40 PVC, 0.020 inch slot. Normal screen length is 10 feet.
 3. Sand/gravel pack: Washed and bagged, rounded sand/gravel with grain size compatible with screen slot and formation (Coarse, No. 8-20). A sand pack was placed from the bottom of the borehole to two to five feet above the top of the well screen. Sand was placed at a controlled rate to avoid bridging within the auger.
 4. Bentonite seal: Two feet (minimum) of pelletized bentonite placed above the sand pack.
 5. Grout: Type II Portland cement grout poured into the annular space from the top of the bentonite seal to land surface. A grout mixture consisting of approximately four pounds of bentonite to 94 pounds of cement was used. The grout was allowed to set for at least 24 hours before any well development activities.
 6. Surface completion: PVC casing cut off to provide a 2- to 3-foot stickup with a solid cap placed on the casing. A 4- to 6-inch square steel well protector, four to five feet in length, was placed over the exposed PVC casing, and seated in cement and surrounded by a concrete pad. A locking cap is incorporated in the well cover. Steel guard posts were installed as described in (8) below. The steel well protector and steel guard posts were painted for corrosion control and visibility.
 7. Alternate flush completion: PVC casing cut off two to three inches below land surface, with a cast-iron valve box cemented in place. To prevent any surface water infiltration, the valve box is slightly elevated above land surface and the surrounding concrete is sloped away from the well. The lid to the valve box is secured with allen bolts. Most wells located on the heavy traffic areas of the Carswell AFB golf course were completed flush with the land surface.
 8. Guard pipes or posts: Three 3-inch diameter steel posts, six feet in length, with a minimum of two feet below ground, installed radially four feet from the wellhead (not emplaced for flush surface completion).
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3. Clean silica sand (Coarse, No. 8-20) was poured carefully inside the annular space as the augers were slowly withdrawn from the borehole. The sand pack was regularly measured by the supervising geologist until the level of the sand was at least 2 feet above the top of the screen. Bentonite pellets were placed above the sand to form a 2-foot thick seal (minimum). If necessary, water bailed from the borehole was poured down the annular space to hydrate the bentonite.
4. Neat cement grout containing approximately four percent bentonite was either emplaced through the augers as they were withdrawn, or slowly poured down the borehole, if the formation was sufficiently consolidated to remain open.
5. After completion of grouting, the casing was cut two to three feet above land surface and a protective 4- to 6-inch diameter steel casing protector with a lockable lid was cemented into place and surrounded by a concrete pad. Three steel guard posts were then placed around the well. If above-ground stickups were of concern in an area, the well was completed flush with the land surface. For flush completions, the lid to the valve box was secured with allen bolts.

After all wells were completed, well locations and elevations were professionally surveyed. Table 2-3 presents the elevations of the ground surface, the wellhead, and the screened interval of the Upper Zone monitor wells in the East Area.

2.3.2 Well Development

After allowing the cement grout to set-up for a minimum of 24 hours, monitor wells were developed by either bailing using a bottom-entry bailer or pumping with a Triloc[®] hand pump (1.7-inch diameter).

TABLE 2-3. SPECIFICATIONS FOR EAST AREA UPPER ZONE MONITOR WELLS, CARSWELL AFB, TEXAS

Monitor Well Number	Previous Monitor Well Number	Measuring Point ¹ Elevation (feet MSL)	Ground Level Elevation (feet MSL)	Screened Interval (feet BLS)	Screen Elevations (feet MSL)	Total Depth (feet BLS)
LF01-1A	1A	570.42	566.62	2.75-7.75	563.87-558.87	7.75
LF01-1B	1B	560.24	560.69	9-19	551.69-541.69	19.07
LF01-1C	1C	560.03	560.46	23-33	537.46-527.46	33.06
LF01-1D	1D	564.06	560.46	13-23	547.46-437.46	23.26
LF01-1E	1E	562.25	559.40	16.75-27.5	542.65-531.9	29.6
LF01-1F	1F	562.26	559.50	17.25-28	542.25-531.9	30.0
SD13-01	NA	573.24	570.30	7.12-14.32	563.18-555.98	14.50
SD13-02	NA	573.39	570.64	9.50-13.50	561.14-557.14	14.20
SD13-03	NA	571.54	568.60	7.08-13.85	561.52-554.75	14.00
SD13-04	NA	569.24	566.81	5.80-9.80	561.01-557.01	10.50
ST14-17I	17I	578.19	575.20	4-16.5	571.2-558.7	17.5
ST14-17J	17J	578.19	577.00	8.45-19.2	568.55-552.8	20.2
ST14-17K	17K	575.34	573.80	7.7-17.7	566.1-556.1	18.7
ST14-17L	17L	577.27	574.40	8.45-19.2	565.95-555.2	20.2
ST14-17M	17M	574.28	572.60	4.9-14.9	567.7-557.7	15.9
ST14-01	NA	575.89	573.20	8.45-18.20	564.75-555.00	18.40
ST14-02	NA	575.64	572.70	7.05-16.80	565.65-555.90	17.10
ST14-03	NA	576.72	574.83	7.85-17.60	566.98-557.23	17.90
ST14-04	NA	575.74	572.90	6.45-16.20	566.45-556.70	16.50
BSS-A	NA	566.38	566.9	5-10	561.9-556.9	11.0
BSS-B	NA	569.73	567.1	3.8-8.8	563.3-558.3	9.8
BSS-C	NA	559.57	560.0	6-11	554.0-549.0	12.0

Notes: ¹ Measured from top of casing.
 MSL = Mean Sea Level
 BLS = Below Land Surface

Water levels in some of the monitor wells recovered slowly and the wells were bailed dry several times. Other wells produced sufficient water and were developed in a single effort, without a recovery period. Development was considered complete when the water in the well was free of sediment to the greatest extent possible. The pH, temperature, and conductivity of the development discharge water were measured and recorded at frequent intervals. The ground water removed from the wells was placed in steel 55-gallon drums, sealed and appropriately labeled, based on field observations. Well development logs for the monitor wells installed in the East Area in 1990 are provided in Appendix C.

2.4 Water Sampling

Both ground-water and surface water samples were collected from the East Area. The following subsections describe the sampling techniques and methodologies for the various water samples collected during IRP Phase II investigations. Ground-Water and Surface Water Quality Sampling Records for the most recent (1990) round of Stage 2 sampling, including measurements of pH, conductivity, and temperature; and information such as volumes of water purged prior to sampling are provided in Appendix D.

2.4.1 Surface Water Sampling

Surface water grab samples were collected directly in clean sample containers to minimize sample handling (and possible cross-contamination). The samples were collected approximately six inches below the water surface, or half-way between the water surface and the bed of the stream if the stream was not six inches deep. During the 1990 field activities, surface water samples were collected from the East Area at four previously sampled locations on Unnamed Stream (Site SD13). Additionally, estimates of flow volume were made at each surface water sample location at the time of sample collection.

Specific conductance, pH and temperature were measured on an aliquot of each sample. Specific conductance and pH were measured with a DSPH-1 meter and the temperature was taken with a mercury thermometer.

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Alkalinity measurements were made in the field using a Hach Alkalinity Test Kit (Model AL-DT) and digital titrator. Prior to obtaining the field measurements, the pH meter was calibrated with pH 4, 7, and 10 standard solutions and the conductivity meter was calibrated using either a 1413 or a 1504 umhos/cm KCl conductivity standard solution.

2.4.2 Ground-Water Sampling

Prior to sample collection, water levels were measured in each of the monitor wells with an Olympic Actat water level meter, and were recorded in a field notebook or on appropriate IRPIMS data collection forms. Measurements were taken from the surveyed mark point at the top of the casing, and read to the nearest 0.01-foot. Between measurements, the probe and associated electrical line were washed with laboratory grade detergent, rinsed with potable water, and then rinsed with deionized water to reduce the possibility of cross-contamination.

Before samples were collected, a minimum of three well volumes of water were bailed from the well using a bottom-entry Teflon™ bailer attached to a nylon monofilament line. This procedure ensured that representative formation water was collected. Purged water was placed in 55-gallon drums for final disposal pending the outcome of chemical analyses (provided to the Base Environmental Coordinator). Between wells, all equipment used for bailing operations was cleaned with laboratory grade detergent (Alconox), rinsed with potable water, ASTM Type II Reagent Water (or approved equivalent), pesticide-grade methanol, and finally pesticide-grade hexane. The equipment was allowed to air dry completely before reuse. The nylon line was replaced between wells.

Specific conductance, pH, temperature, and alkalinity were determined as described for surface water. On a few occasions, field measurements could not be made due to instrument malfunction.

After each well was purged of the required volume of water, ground-water samples were collected using a Teflon™ bailer. After collection,

samples were placed into pre-labeled sample bottles and preserved according to the requirements listed in Table 2-4. Ground-water samples for dissolved metals were filtered in the field. Samples were placed in ice chests with ice and were shipped for overnight delivery to Radian's laboratories in Sacramento, California, or Austin, Texas; or were hand delivered to the laboratory in Austin. To ensure that sample integrity was maintained during shipping and handling, custody seals were affixed to each ice chest and chain-of-custody forms were completed and transmitted with the samples to each laboratory.

2.5 Aquifer Testing

Single-well in situ permeability aquifer tests (i.e., slug tests) were performed on selected wells to determine the hydraulic properties of the Upper Zone Aquifer in the East Area. Following is a discussion of the slug test method.

2.5.1 Slug Tests

Slug tests were performed in six monitor wells (LF01-1D, LF01-1F, ST14-17J, ST14-17K, ST14-17L, and ST14-17M) in the East Area, and results were used to calculate the hydraulic conductivity of the Upper Zone Aquifer. The wells selected for slug testing represent a range of hydrogeologic conditions.

The slug test evaluates the response of water levels in a well when a "slug" (known volume) of water is instantaneously removed or added. Typically, the response of the water level in a moderately permeable formation, such as the Upper Zone at Carswell AFB, is quite rapid. By determining the behavior of the water level in the well in response to the stress of the slug, the hydraulic conductivity of the aquifer material directly adjacent to the well screen can be calculated. To perform these calculations, the geometry of the well, aquifer boundary conditions, and initial water level must be known. The hydraulic conductivities were calculated using the method developed by Bouwer and Rice (1976).

TABLE 2-4. SUMMARY OF EAST AREA WATER SAMPLING AND ANALYSIS REQUIREMENTS, CARSWELL AFB, TEXAS

Reference Method	Parameter	Method Detection Limit	Method Type ¹	Container Type, No. and Volume	Preservation and Storage Requirements	Sample Extraction Procedures	Maximum Holding Time (Preparation) ²	Maximum Holding Time (Analysis)
SM403	Alkalinity-Carbonate, Bicarbonate & Hydroxide (Field Test)	10 mg/L	Titration	(1) 1-Liter Polyethylene or Borosilicate glass bottle	Refrigerated at 4°C	None	N/S	Analyze immediately
EPA 120.1	Specific Conductance (Field Test)	N/S	Wheatstone Bridge-type conductivity meter	None	None	None	N/A	Analyze immediately
EPA 150.1	pH (Field Test)	N/S	Electrometric pH meter	None	None	None	N/A	Analyze immediately
EPA 170.1	Temperature (Field Test)	N/A	Thermometric	(1) 500 mL plastic bottle	None	None	N/A	Analyze immediately
EPA 200.7	Metals	0.002-0.9 mg/L	ICP	(1) 500 mL polyethylene bottle	pH<2 w/HNO ₃	HNO ₃ /HCl digestion	N/S	6 months
EPA 206.3	As	4 µg/L	AA (furnace)	(1) 500 mL	pH<2 w/HNO ₃	HNO ₃ digestion	N/S	6 months
EPA 270.3	Se	2 µg/L	AA (furnace)	Polyethylene	pH<2 w/HNO ₃	HNO ₃ digestion	N/S	6 months
EPA 245.1	Hg	0.2 µg/L	AA (vapor)	(1) 500 mL polyethylene bottle	pH<2 w/HNO ₃	KMnO ₄ , HNO ₃ , H ₂ SO ₄ digestion	N/S N/S	6 months 28 days
EPA 239.2	Pb	0.005 µg/L	AA (furnace)	(1) 500 mL Polyethylene	4°C, pH < 2 w/HNO ₃	HNO ₃ digestion	N/S	6 months
EPA 413.2	Oil and Grease	0.2 µg/L	IR	(1) 1000 mL glass bottle	pH<2 w/HCl refrigerated at 4°C	Freon extraction	N/S	28 days
EPA 418.1	Petroleum Hydrocarbons	1 mg/L	IR	(1) 1-L glass bottle	4°C, pH<2 w/HCl	Freon extraction	N/S	28 days
EPA 160.1	Total Dissolved Solids	10 mg/L	Gravimetric	(1) 1000 mL plastic bottle	Refrigerated at 4°C	N/A	None	14 days

Notes: 1. ICP = Inductively Coupled Plasma Emission Spectroscopy
AA = Atomic Absorption
IR = Infrared Spectroscopy
GC/FID = Gas Chromatograph/Photoionization Detector
GC/HSD = Gas Chromatograph/Halide Specific Detector
2. N/A = Not Applicable
N/S = Not Specified
SM = Standard Method

(Continued)

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TABLE 2-4. (Continued)

Reference Method	Parameter	Method Detection Limit	Method Type ¹	Container Type, No. and Volume	Preservation and Storage Requirements	Sample Extraction Procedures	Maximum Holding Time (Preparation) ²	Maximum Holding Time (Analysis)
EPA 8020	Purgeable Aromatics	0.2-0.4 µg/L	GC/PID	(3) 40 mL VOA vial w/Teflon septa	pH<2, w/1:1 HCl, refrigerated at 4°C	Nitrogen purge	N/S	14 days
EPA 601	Purgeable Halocarbons	0.02-5 µg/L	GC/HSD	(3) 40 mL VOA vial w/Teflon septa	Refrigerated at 4°C	Nitrogen purge	N/S	14 days
EPA 325.3	Chloride	1 mg/L	Titration	(1) 1-L Polyethylene	Refrigerated at 4°C	None	N/S	28 days
EPA 240.2	Fluoride	0.1 mg/L	Ion Selective Electrode	(1) 1-L Polyethylene	Refrigerated at 4°C	None	N/S	28 days
EPA 353.1	Nitrate	0.02 mg/L	Colorimetry	(1) 500 mL Polyethylene	4°C, pH<2 w/H ₂ SO ₄	None	N/S	14 days
EPA 375.4	Sulfate	1 mg/L	Turbidimetry	(1) 1-L Polyethylene	Refrigerated at 4°C	None	N/S	28 days
EPA 365.1	O-Phosphate	0.02 mg/L	Colorimetry	(1) 500 mL Polyethylene	4°C, pH<2 w/H ₂ SO ₄	None	N/S	28 days
EPA 604	Phenols	0.5 - 80 µg/L	GC	(2) 1-L glass bottle	Refrigerated at 4°C	Methylene chloride extraction	7 days	40 days
EPA 625	Priority Pollutants	50 µg/L	GC/MS	(2) 1000 mL glass; TFE-lined cap	Refrigerated at 4°C	Continuous extraction with methylene chloride	7 days	40 days
EPA 608	Organochloride Pesticides	0.05 - 1 µg/L	GC	(2) 1-L glass bottle	4°C pH 5 to 9	Methylene chloride extraction	7 days	40 days
SM508b	Chlorinated Phenoxy Acid Herbicides	0.01 µg/L	GC	1-L glass bottles w/TFE lined caps	4°C	Hydrolyze, esterify	7days	40 days

Notes: 1. ICP = Inductively Coupled Plasma Emission Spectroscopy

AA = Atomic Absorption

IR = Infrared Spectroscopy

GC/PID = Gas Chromatograph/Photoionization Detector

GC/HSD = Gas Chromatograph/Halide Specific Detector

2. N/A = Not Applicable

N/S = Not Specified

SM = Standard Method

The first step of the slug test was to measure the static water level in the well. Next, a known volume of water was removed by bailing and segregated for use as the slug. After the desired volume of water was removed from the well, a pressure transducer and attached cable were lowered into the well and suspended at a point just above the bottom of the well screen. The pressure transducer was connected to an In-Situ, Inc. Hermit 1000B automatic data logger, capable of measuring and recording pressure changes on a logarithmic frequency, beginning every 0.2 seconds in the first few seconds of the test. Before introducing the slug, the water level in the well was allowed to return to static conditions. Then, as the slug was rapidly poured in the well, the data recorder was activated to measure the response of the water level. At least two slug tests were performed on each well tested to determine the reproducibility of the results.

2.6 Surveying

Land surveying activities were conducted by Brittain & Crawford, Inc., Registered Land Surveyors, of Fort Worth, Texas. These activities consisted of measurements of the horizontal location of wells, boreholes, hand-auger holes, and surface water sampling locations in terms of State Plane Coordinates; and of measurements of reference point elevations to an accuracy of ± 0.01 foot. The survey was conducted to an accuracy needed for a second order survey. All of the data were provided as values posted on a map, and in tabular form (Appendix E).

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3.0 PHYSICAL CHARACTERISTICS OF THE EAST AREA

This section describes the physical characteristics of the East Area with respect to local surface features, surface water bodies, geology, and ground-water occurrence. The primary basis of this characterization is interpretation of field and laboratory data obtained from the Installation Restoration Program (IRP) at Carswell AFB, Texas. Radian maintains a database containing all environmental data from the East Area developed during the Phase II Stage 2 field program at Carswell AFB. The data are managed using the U.S. Air Force required Installation Restoration Program Information Management System (IRPIMS) format.

Topography and Surface Features

The East Area is located on land that gently slopes eastward to the West Fork of the Trinity River and southward to Farmers Branch. Elevations range from 595 feet MSL west of the POL Tank Farm (Site ST14) to 560 feet MSL on the flood plain above the Trinity River and Farmers Branch. Figure 3-1 shows the location of the various surface features associated with the East Area, including the location of the four sites where additional field activities were conducted in 1990.

The Soils Conservation Service (SCS) has identified three soil associations in the East Area of Carswell AFB (USDA, 1981). The clayey soils of the Sanger-Purves-Slidell association occur in the western portion of the East Area at Site ST14. Approaching the Trinity River, the Bastsil-Silawa loamy soils are prevalent in the nearly level to sloping stream terrace sections found at Sites SD13 and the Base Service Station (Site BSS), while the Frio-Trinity association of clayey soil occurs in the nearly level flood plain environment in the easternmost portion of Site LF01. The permeability of the surficial soils ranges from $<4.2 \times 10^{-5}$ to 3×10^{-3} cm/sec.

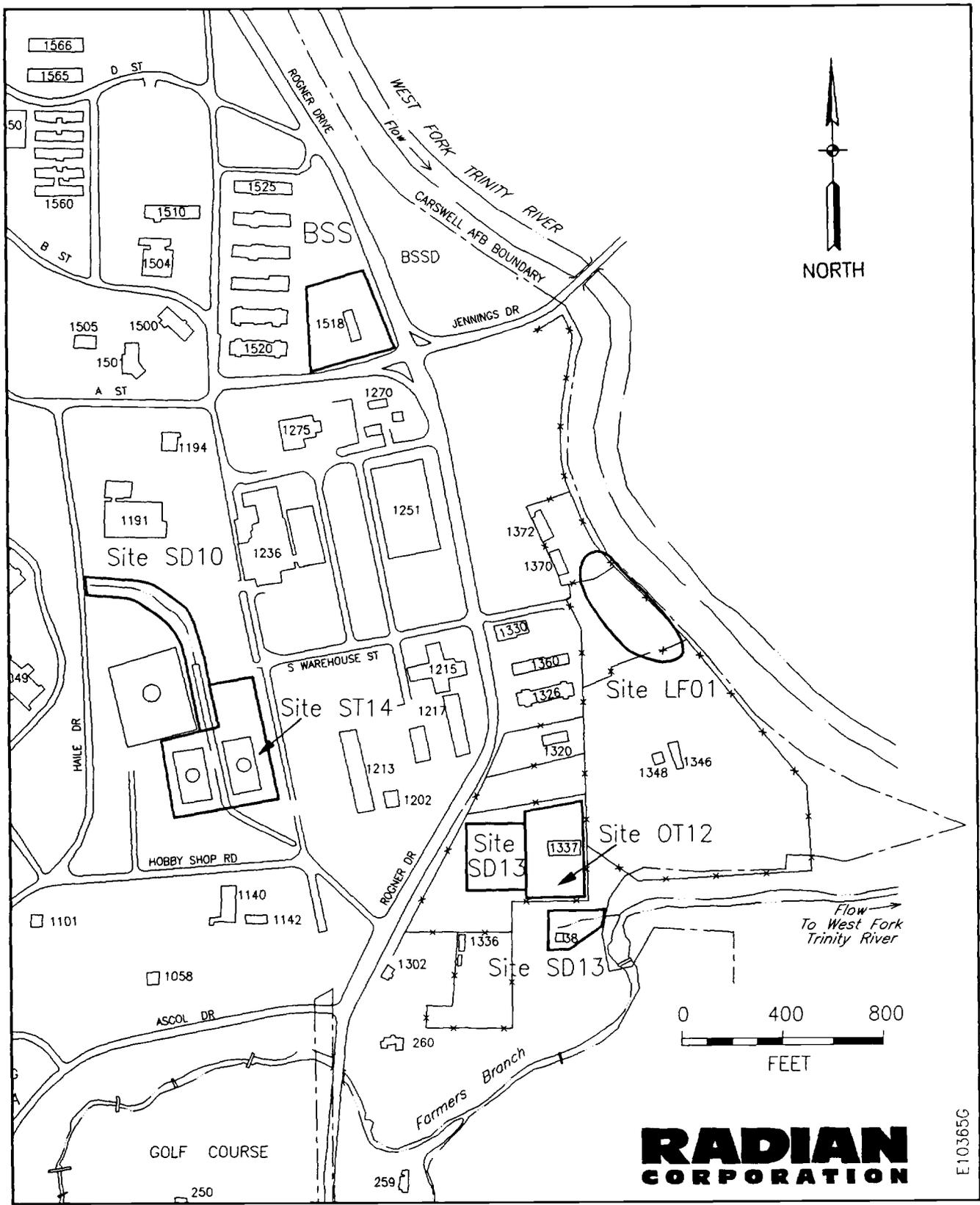


Figure 3-1. Prominent Surface Features in East Area, Carswell AFB, Texas

Surface Water

The main surface water bodies in the East Area are the West Fork of the Trinity River, Farmers Branch, and the Unnamed Stream at Site SD13 (Figure 3-1). Surface drainage at Sites LF01 and BSS is toward the Trinity River, with drainage at Sites ST14 and SD13 being mainly toward Farmers Branch.

Water in the Unnamed Stream emerges from an oil/water separator. Water enters the separator from a french drain which was installed to aid the removal of fuels from the ground at the POL Tank Farm (Site ST14) and/or at the abandoned gasoline station at Site SD13. Whatever the source, the Unnamed Stream is a perennial stream feeding into Farmers Branch.

Four locations on the Unnamed Stream were sampled during the 1990 field activities. Orange-colored foam and a rusty film were noted on the surface of the water at the time of sampling. Discharge from the Unnamed Stream to Farmers Branch occurs through a 1-foot diameter concrete pipe. The discharge rate of the stream to Farmers Branch was estimated at 0.2 cubic feet per second (cfs) during the May 1990 water sampling.

Estimates of flow in Farmers Branch were made in April 1990 and averaged 6.0 cfs. However, observed flow in Farmers Branch has been extremely variable, with Spring 1990 flow estimates ranging from <5 to >100 cfs, the highest flows being observed after a period of heavy rains. Farmers Branch flows over limestone bedrock at Carswell AFB. Synoptic water-level measurements in monitor wells and in Farmers Branch at a staff gauge located upstream of the East Area suggest the stream is receiving ground-water inflow from the adjacent alluvial terrace deposits.

Geology

The major elements of the shallow geologic setting at the East Area are illustrated in a series of cross-sections. Figure 3-2 shows the cross-section locations. Generally, the geology of the East Area (Figures 3-3 through 3-6) consists of a thin veneer of alluvial material (Upper Zone)

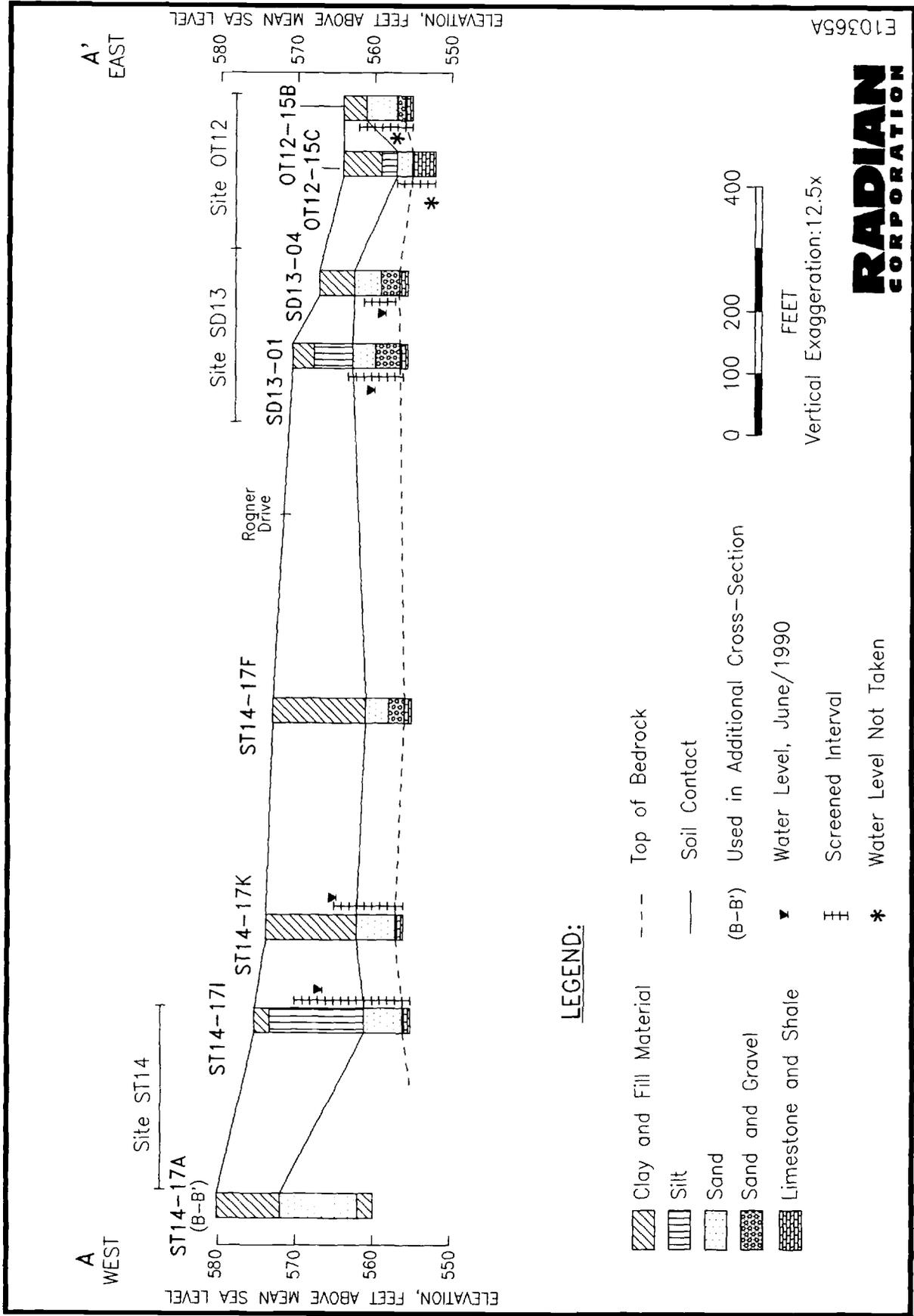


Figure 3-3. Cross-Section A-A'

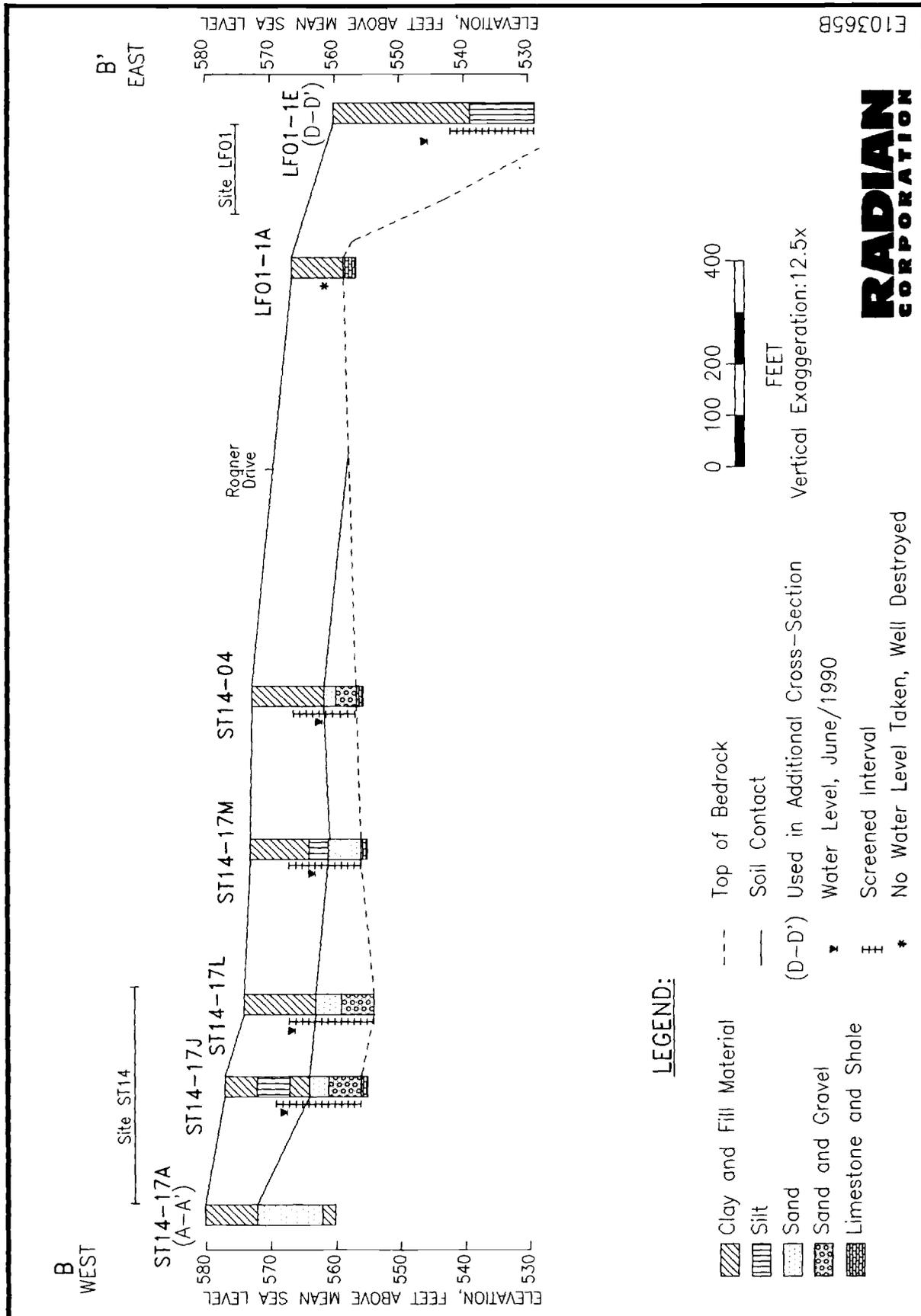


Figure 3-4. Cross-Section B-B'

LF01-1E

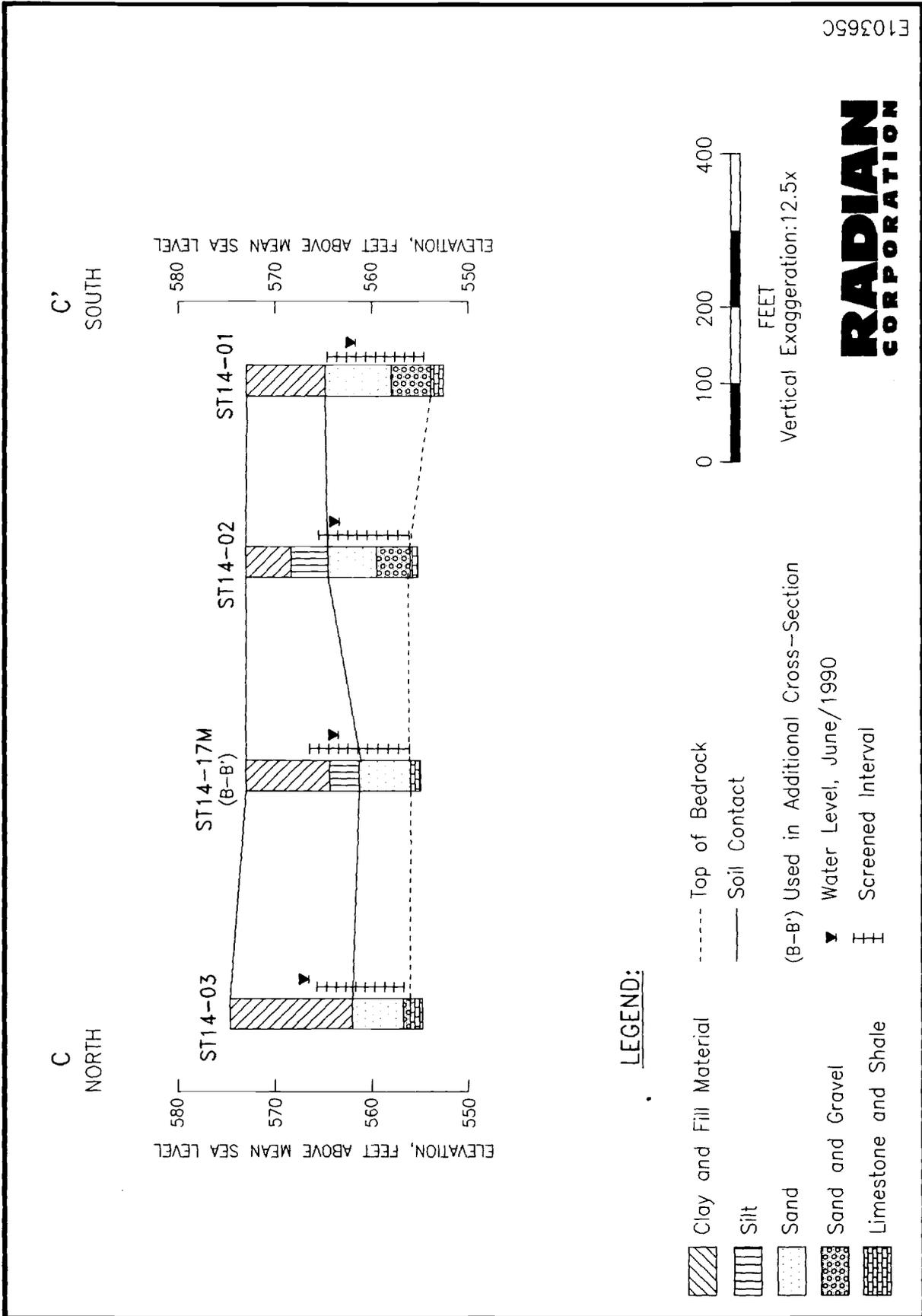


Figure 3-5. Cross-Section C-C'

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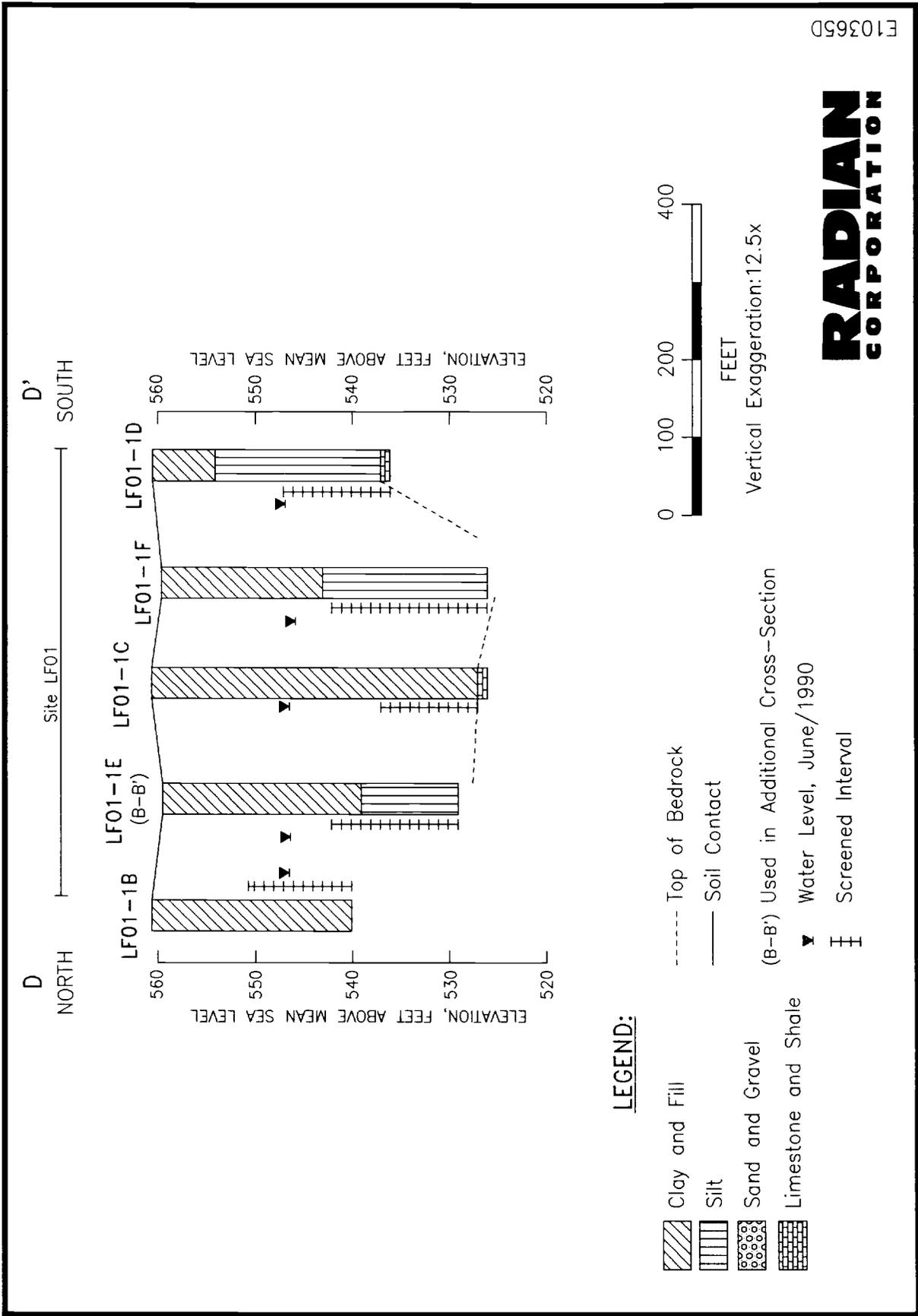


Figure 3-6. Cross-Section D-D'

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overlying the Goodland Limestone. The alluvium consists of clay, sand, and gravel. The Goodland Limestone contains fresh and weathered limestone, and shale. No monitor wells were drilled in the East Area that penetrated through the Goodland/Walnut Formations into the Paluxy Formation.

The Upper Zone in the East Area generally consists of 5 to 15 feet of gray to black clay and clayey silt overlying 2 to 10 feet of fine-grained sand and up to 5 feet of gravel. The clay is often sandy and occasionally contains pebbles, freshwater gastropod shells, and gravel stringers. Limonite stains occur in some clay beds. Two types of sand occur in the alluvium and are distinguished on the basis of their color. One sand is tan and the other is light gray or green, with the gray/green sand typically overlying the tan sand. Both sands are predominantly fine-grained, though medium-grained sand is a common subsidiary constituent. The gravel ranges from 1/8-inch to over 1-inch in diameter. Sand is a common accessory in gravel layers, and clay is sometimes present.

The continuity of the permeable sand and gravel beds across the East Area is shown on the geologic cross-sections (Figures 3-3 through 3-6). The east-west dip oriented section A-A' (Figure 3-3) shows that an approximately 5-foot thick sand/gravel layer reaches from the POL Tank Farm to close to Farmers Branch. The other dip oriented section, B-B' (Figure 3-4), shows the sand/ gravel layer pinching out before it reaches the West Fork of the Trinity River. The strike oriented section C-C' (Figure 3-5), also shows a continuous sand/gravel layer in the subsurface east of the POL Tank Farm. At Site LF01 the strike-oriented section D-D' (Figure 3-6) does not contain any sand and gravel layers near the Trinity River.

The Goodland Formation in the East Area is usually encountered between 7 and 20 feet, though it is deeper in some wells. In general, the depth to the Goodland decreases as the Trinity River is approached (Figures 3-3 and 3-4). The exception to this trend occurs immediately adjacent to the Trinity River, where the depths to the Goodland exceed 20 feet. The Goodland in the East Area occurs as gray, hard limestone and as blue-gray, mottled

shale. A contour map of the elevation of the base of the Upper Zone is shown in Figure 3-7. Most of the East Area occurs on a fairly level limestone surface. However, the Goodland Formation is found at increasing depths within 400 feet of the Trinity River, as evidenced at Site LF01 (Figure 3-6, Cross-Section D-D'). In the southern part of the East Area, the top of the limestone surface occurs at increasing depths in a southward direction, at a more gentle slope, toward Farmers Branch. The observed slopes on the top of the Goodland Formation are probably due to erosion of the Goodland by the respective streams.

Hydrogeology

Ground water was observed in the Upper Zone of the East Area during drilling of soil borings and monitor wells. A synoptic water level survey was conducted at Sites LF01, ST14, SD13, and BSS on June 18, 1990. The depth to ground water in the East Area ranged from 6 to 13.5 feet bgl. The elevation of water in each well is shown in Table 3-1.

A potentiometric surface map for the Upper Zone of the East Area is presented in Figure 3-8. The ground-water surface contour lines reveal decreasing hydraulic heads from west to east, indicating ground-water flow toward the Trinity River. The direction of ground-water flow in the Upper Zone is apparently controlled principally by the elevation of the upper surface of the Goodland Limestone.

No information on the nature of the Paluxy Aquifer in the East Area is available because drilling activities in this area were confined to the Upper Zone.

Hydraulic Conductivity of Upper Zone Deposits

The ability of the Upper Zone alluvial deposits to transmit ground water was evaluated based on the results of the single-well aquifer tests

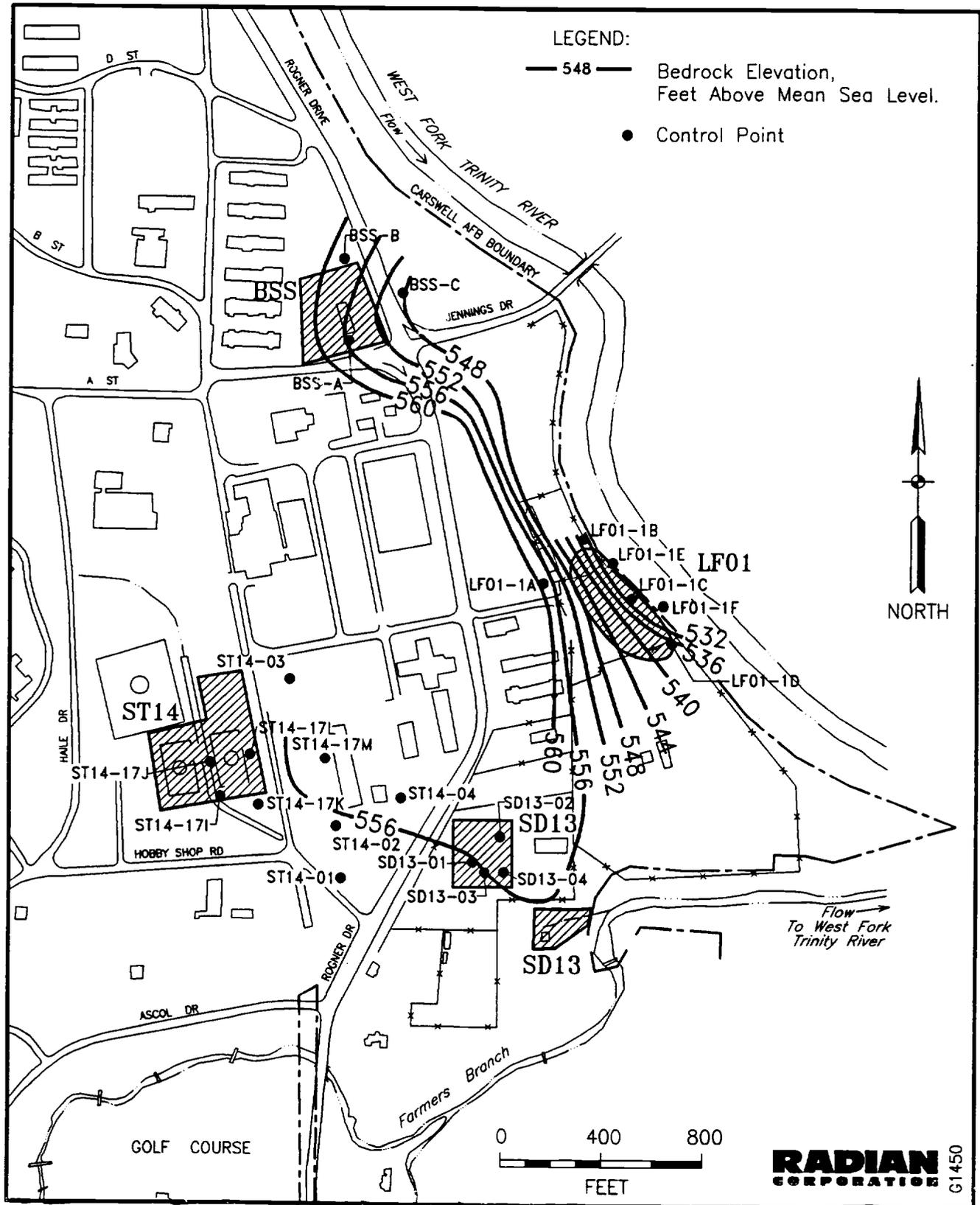


Figure 3-7. Contour Map of the Top of Bedrock, East Area, Carswell AFB, Texas

TABLE 3-1. RESULTS OF EAST AREA UPPER ZONE SYNOPTIC WATER LEVEL SURVEY
 CONDUCTED ON JUNE 18, 1990

Location ID	Time	Measuring Point Elevation (Ft, MSL)	Depth to Water (Ft)	Water Level Elevation (Ft, MSL)
ST14-17I	1054	578.19	11.41	566.78
ST14-17J	1035	579.79	11.81	567.98
ST14-17K	1057	575.34	10.38	564.96
ST14-17L	1041	577.27	11.17	566.10
ST14-17M	1047	574.28	10.90	563.38
ST14-01	1101	575.89	14.18	561.71
ST14-02	1104	575.64	12.47	563.17
ST14-03	1045	576.72	9.99	566.73
ST14-04	1107	575.74	12.93	562.81
SD13-01	1115	573.24	13.19	560.05
SD13-02	1118	573.39	15.38	558.01
SD13-03	1120	571.54	12.11	559.43
SD13-04	1123	569.24	10.31	558.93
BSS-A	1136	566.38	5.47	560.91
BSS-B	1142	569.73	9.81	559.92
BSS-C	1145	559.57	7.58	551.99
LF01-1B	1204	560.25	12.38	547.87
LF01-1C	1159	560.00	13.14	546.86
LF01-1D	1210	563.93	16.84	547.09
LF01-1E	1219	562.25	15.69	546.56
LF01-1F	1222	562.26	16.25	546.01

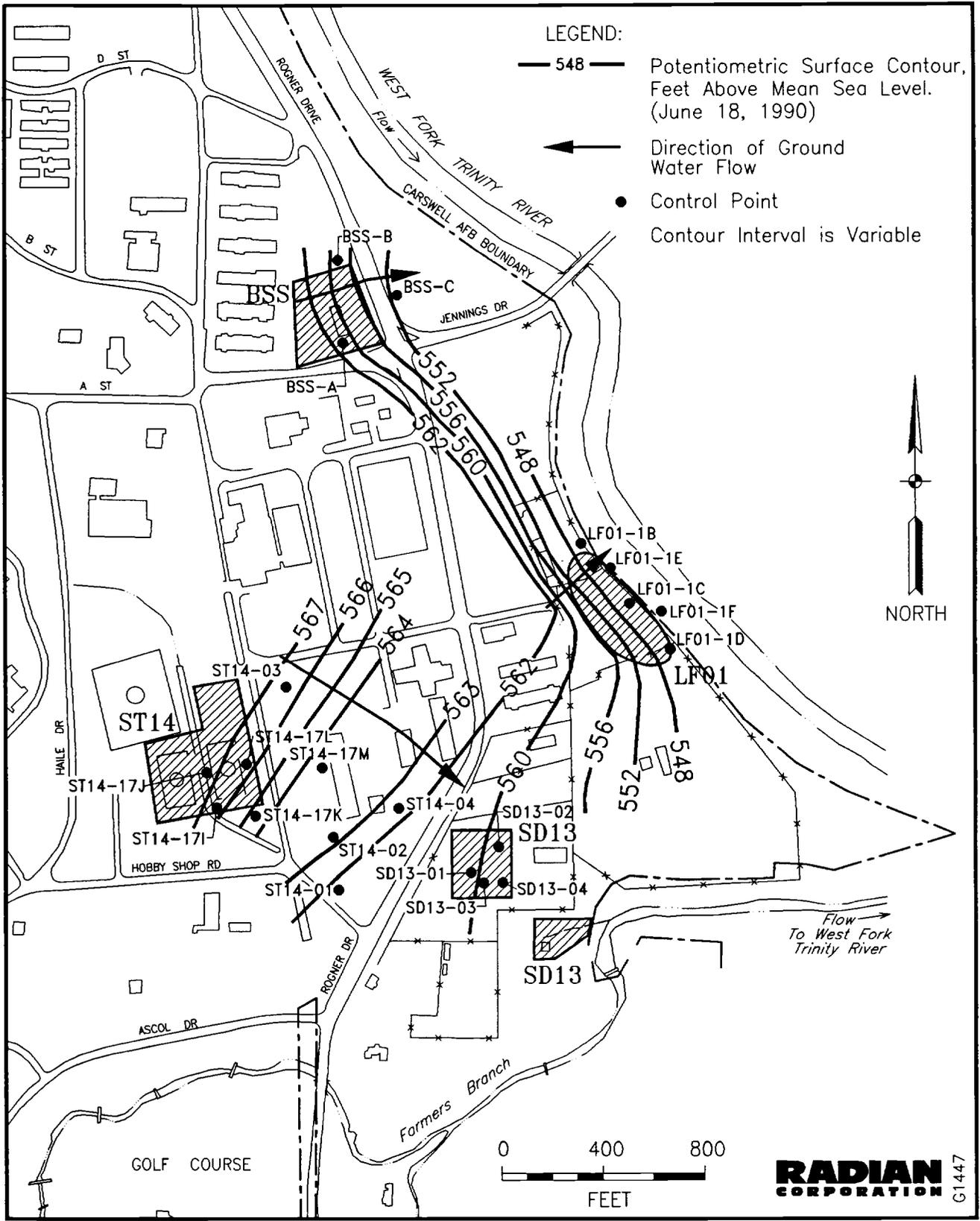


Figure 3-8. Potentiometric Surface Map of the Upper Zone, East Area, Carswell AFB, Texas

TABLE 3-2. SUMMARY OF UPPER ZONE HYDRAULIC CONDUCTIVITY VALUES,
EAST AREA, CARSWELL AFB, TEXAS (APRIL 1988)

Location	Hydraulic Conductivity (cm/sec)
LF01-1D	1.0×10^{-5}
LF01-1F	1.4×10^{-3}
ST14-17J	6.1×10^{-4}
ST14-17K	5.4×10^{-4}
ST14-17L	1.2×10^{-2}
ST14-17M	2.5×10^{-4}

14-17M
 14-17L
 14-17K
 14-17J
 14-17F
 14-17D

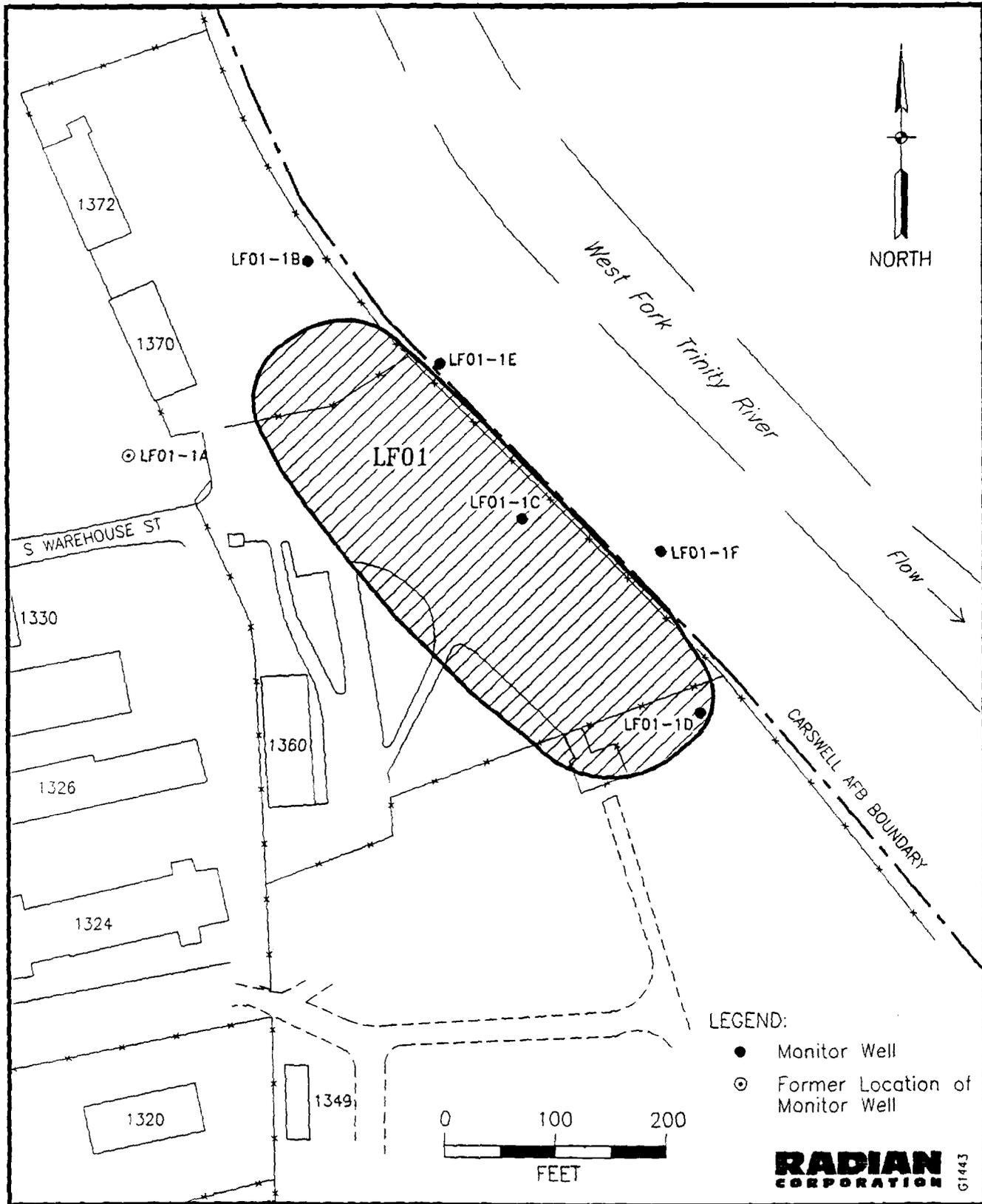


Figure 3-9. Location of Monitor Wells at Site LF01, Carswell AFB, Texas

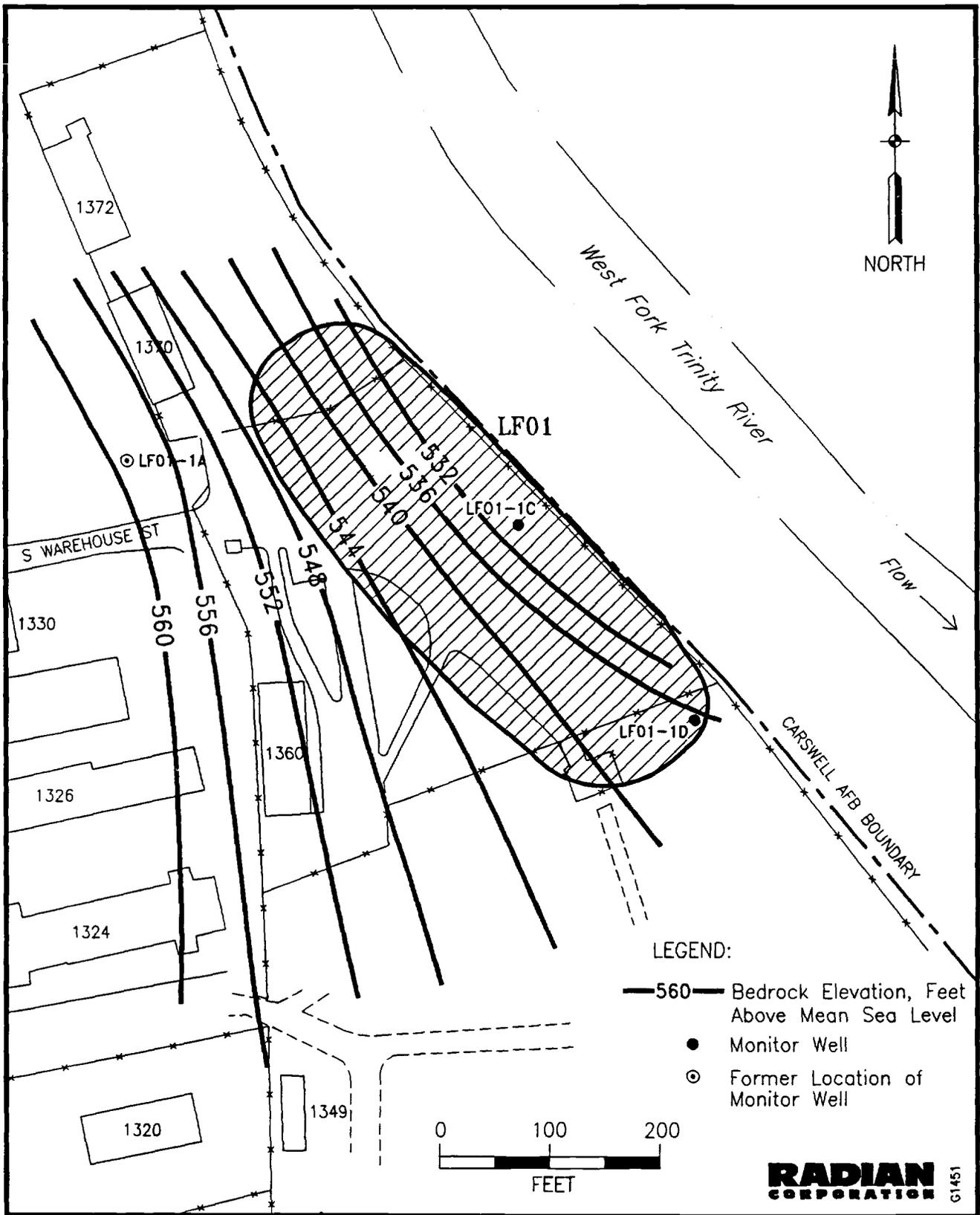


Figure 3-10. Contour Map of the Top of Bedrock, Site LF01 (Landfill 1), Carswell AFB, Texas

to the water-level survey, no measurement of the upgradient water level at the site could be made. Although the June 1990 water levels are approximately 6 to 7 feet higher than those observed in February to March 1988, the configuration of the water table is probably similar to that determined in 1988 (Figure 3-11). The closely spaced contours on the water table in the Landfill 1 area resemble the contour pattern on the surface of the Goodland Limestone. This similarity in limestone and water table surfaces is expected because the water in the Upper Zone flows along the top of the Goodland. Ground-water flow beneath Site LF01 is eastward to northeastward, to the West Fork of the Trinity River.

Based on the hydraulic conductivity values calculated from slug test results at Landfill 1, and the hydraulic gradient of approximately 0.09 (from Figure 3-11), the calculated average ground-water flow velocity at Landfill 1 is approximately 0.6 feet per day. This velocity represents an average seepage velocity, as opposed to a particle velocity that would be considered in contaminant transport evaluations. This estimate is derived from a simplification of Darcy's Law:

$$\bar{v} = \frac{k i}{\phi}$$

where: \bar{v} = average ground-water flow velocity,
k = hydraulic conductivity of Upper Zone deposits,
(average 7×10^{-4} cm/sec or 2 feet/day)
i = hydraulic gradient (0.09) in the Upper Zone; and
 ϕ = estimated porosity of Upper Zone deposits
(assume 0.30)

3.2 Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Site SD13 is located generally east of the POL Tank Farm and south of Landfill 1 (see Figure 3-1). It is divided into two parts: the Unnamed Stream from the oil/water separator to Farmers Branch, and the paved lot in

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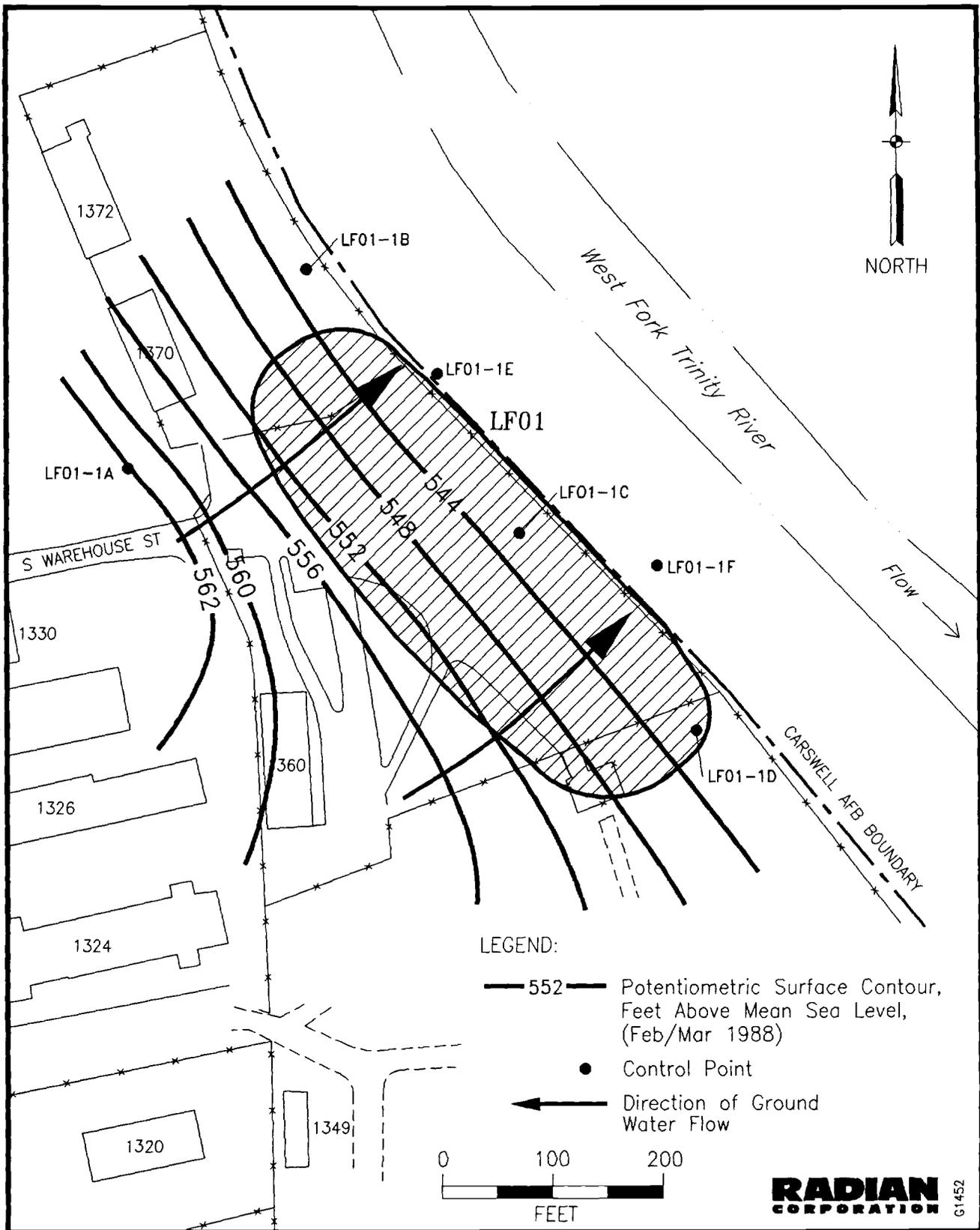


Figure 3-11. Potentiometric Surface Map of the Upper Zone, Site LF01 (Landfill 1), Carswell AFB, Texas

the vicinity of an abandoned gasoline service station. The investigation at Site SD13 performed in 1990 consisted of the collection of water samples from the Unnamed Stream at four locations and the installation and subsequent water sampling of four Upper Zone monitor wells (Figure 3-12).

Water in the Unnamed Stream emerges from an oil/water separator. Water enters the separator from a french drain which was installed to aid in the removal of fuels from the ground that were released from either the POL Tank Farm (Site ST14) or the abandoned gasoline station. The Unnamed Stream is a perennial stream feeding into Farmers Branch.

3.2.1 Site Description

Topography

The abandoned service station area at Site SD13 is fairly flat; however, there is an approximately 15- to 20-foot difference in elevation between the former service station and the Unnamed Stream. The four monitor wells (SD13-01 through SD13-04) installed at the site are on the upper terrace deposits, while the Unnamed Stream is located on the lower floodplain of Farmers Branch.

Geology

Four ground-water monitor wells were installed at Site SD13 during March 1990 (Figure 3-12). A coarsening downwards sequence was observed in each of the well borings, with surficial clays coarsening to sands and gravels with depth. A 2- to 5-foot layer of gravel was encountered in all four borings, with the gravel resting directly on the weathered limestone surface of the Goodland Formation.

The depth to the Goodland Formation at Site SD13 was between 10 and 15 feet bgl, and the top of the bedrock surface varied by less than 2 feet across the abandoned service station area, showing a slight slope to the

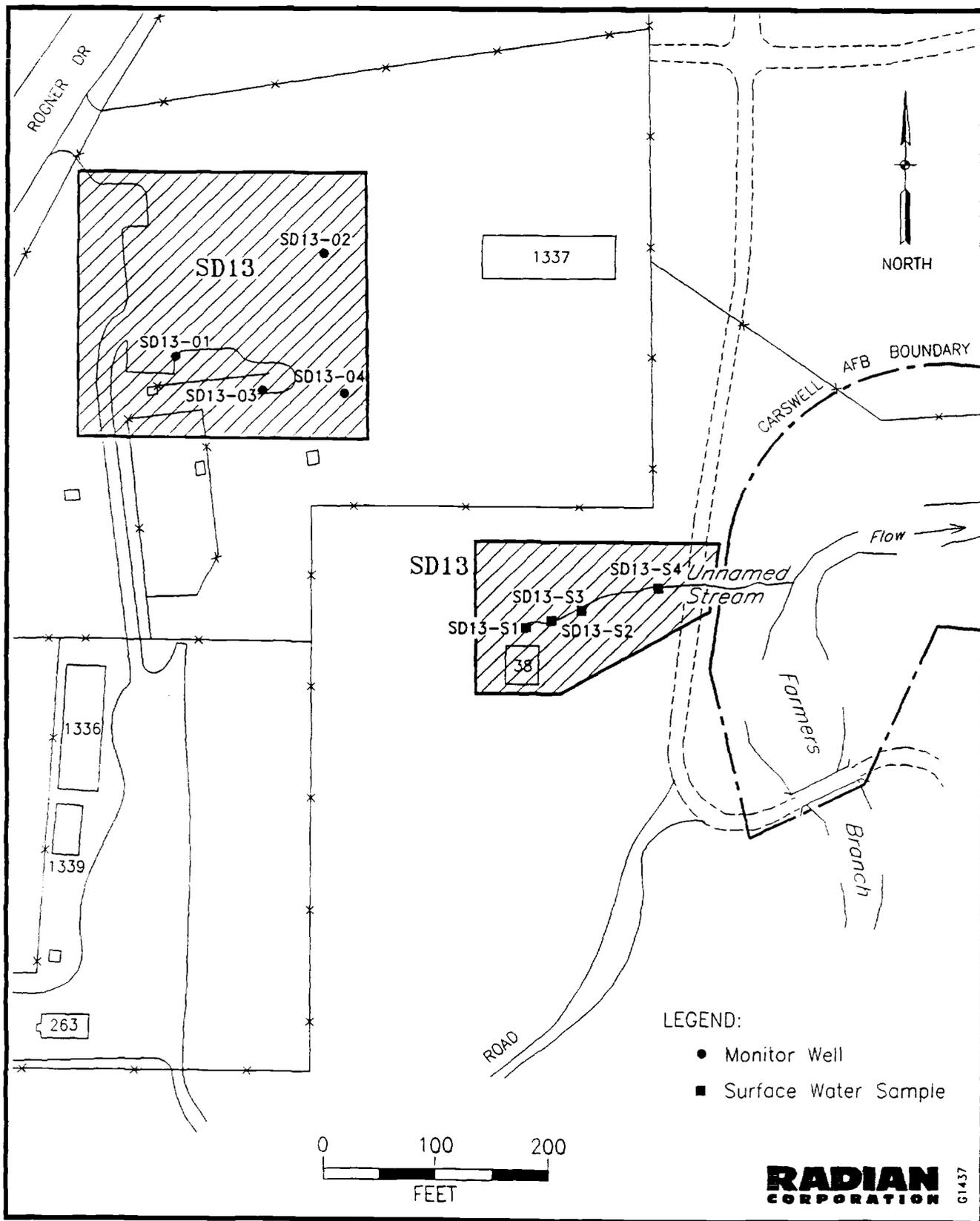


Figure 3-12. Location of Monitor Wells and Surface Water Samples, Site SD13, Carswell AFB, Texas

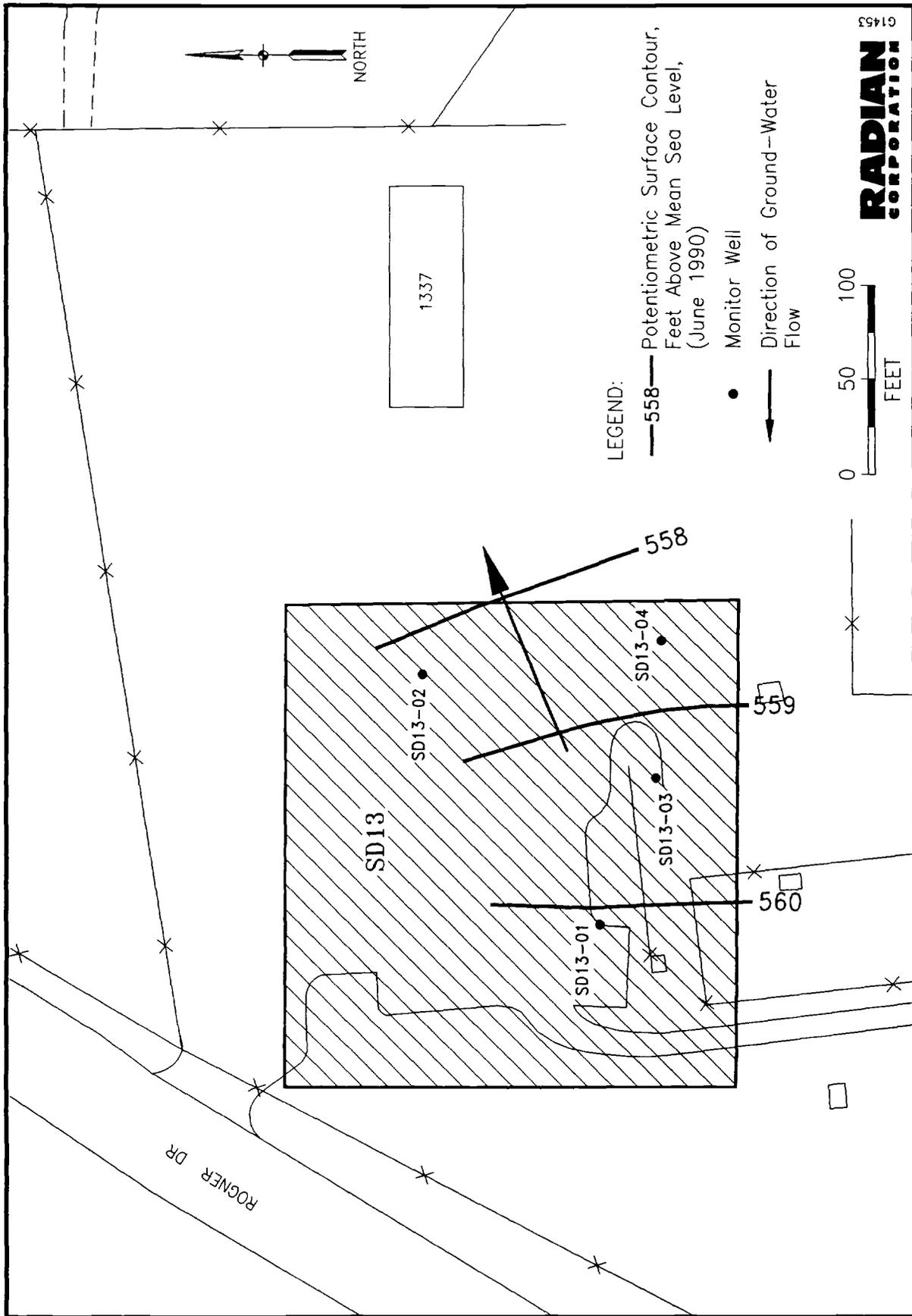


Figure 3-13. Upper Zone Potentiometric Surface, Site SD13, Carswell AFB, Texas (June 1990)

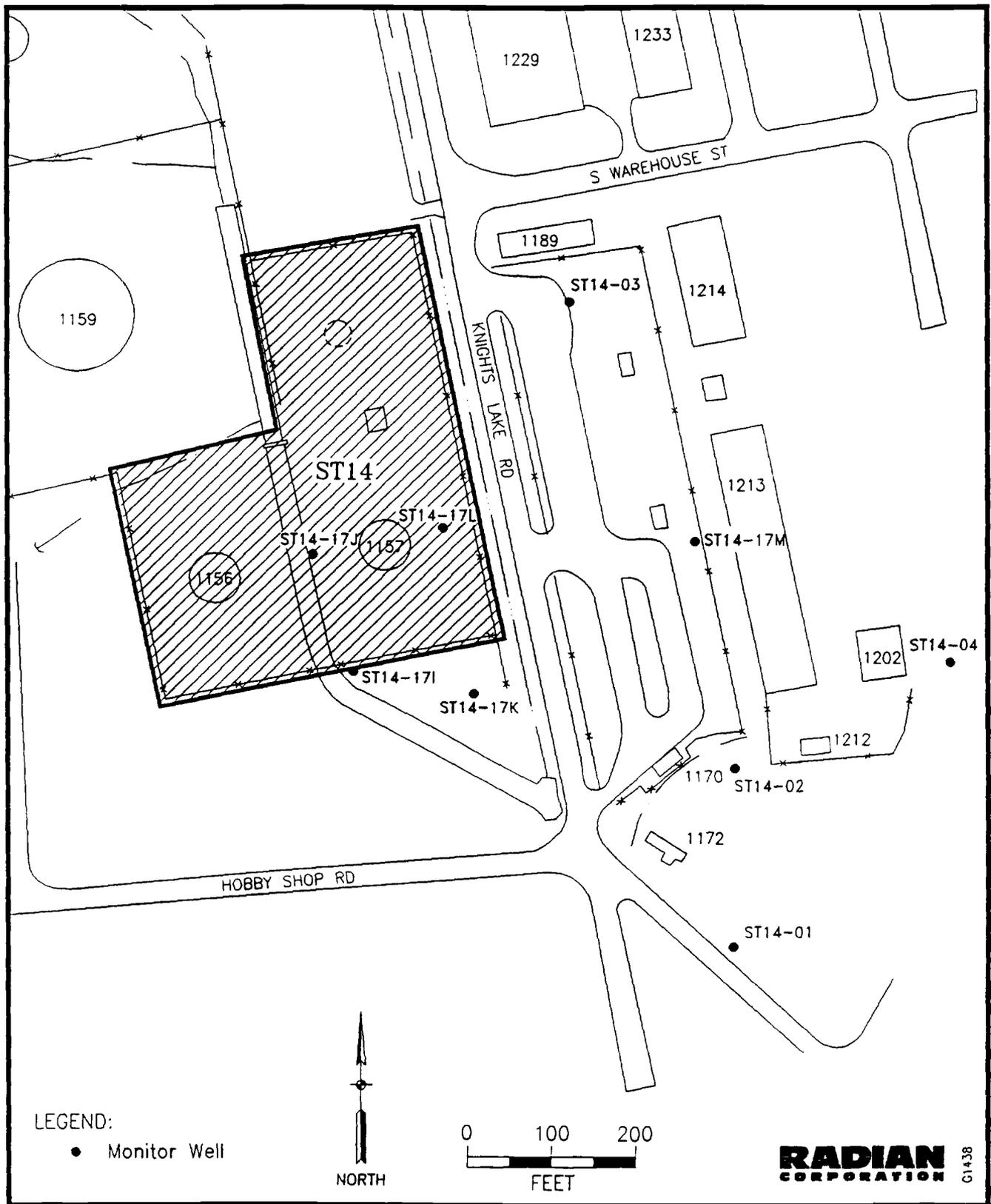


Figure 3-14. Location of Monitor Wells at Site ST14, Carswell AFB, Texas

Surface drainage is to the east-southeast, with some drainage into the concrete-lined portion of the Flightline Drainage Ditch (Site SD10).

Geology

The Upper Zone in the POL Tank Farm area typically consists of approximately 10 feet of gray to tan clay, underlain by another 5 to 10 feet of sand and gravel. Gravel content increases with depth and usually rests directly on the underlying bedrock (Goodland Formation) surface. The clay often has minor limonite staining and contains pebbles and freshwater gas-tropod shells. The sand is grayish-green or tan to brown in color, and is generally fine-grained. Gravel ranges from pea size to pebbles over an inch in diameter.

The depth to the Goodland Limestone beneath the POL Tank Farm area ranges from 16 to over 20 feet bgl. The boreholes drilled for the four most recently installed monitor wells (ST14-01 through ST14-04) all encountered the Goodland Limestone at 16 to 18 feet bgl.

Hydrogeology

During the June 1990 synoptic water-level survey, the depth to water at Site ST14 varied from approximately 8 to 16 feet bgl, with corresponding water-level elevations ranging from 561 to 567 feet MSL. A potentiometric surface map is presented in Figure 3-15. The water surface slopes primarily to the southeast across Site ST14, toward Farmers Branch. Although the ground-water equipotential lines do not have equidistant spacings across the site, the average hydraulic gradient for the site is approximately 0.007 feet/foot.

Based on the hydraulic conductivity values calculated from slug test results at the POL Tank Farm, an estimated porosity of Upper Zone sediments of 20 percent, and the hydraulic gradient of approximately 0.007 feet/foot, the average ground-water flow velocity at the POL Tank Farm is calculated at

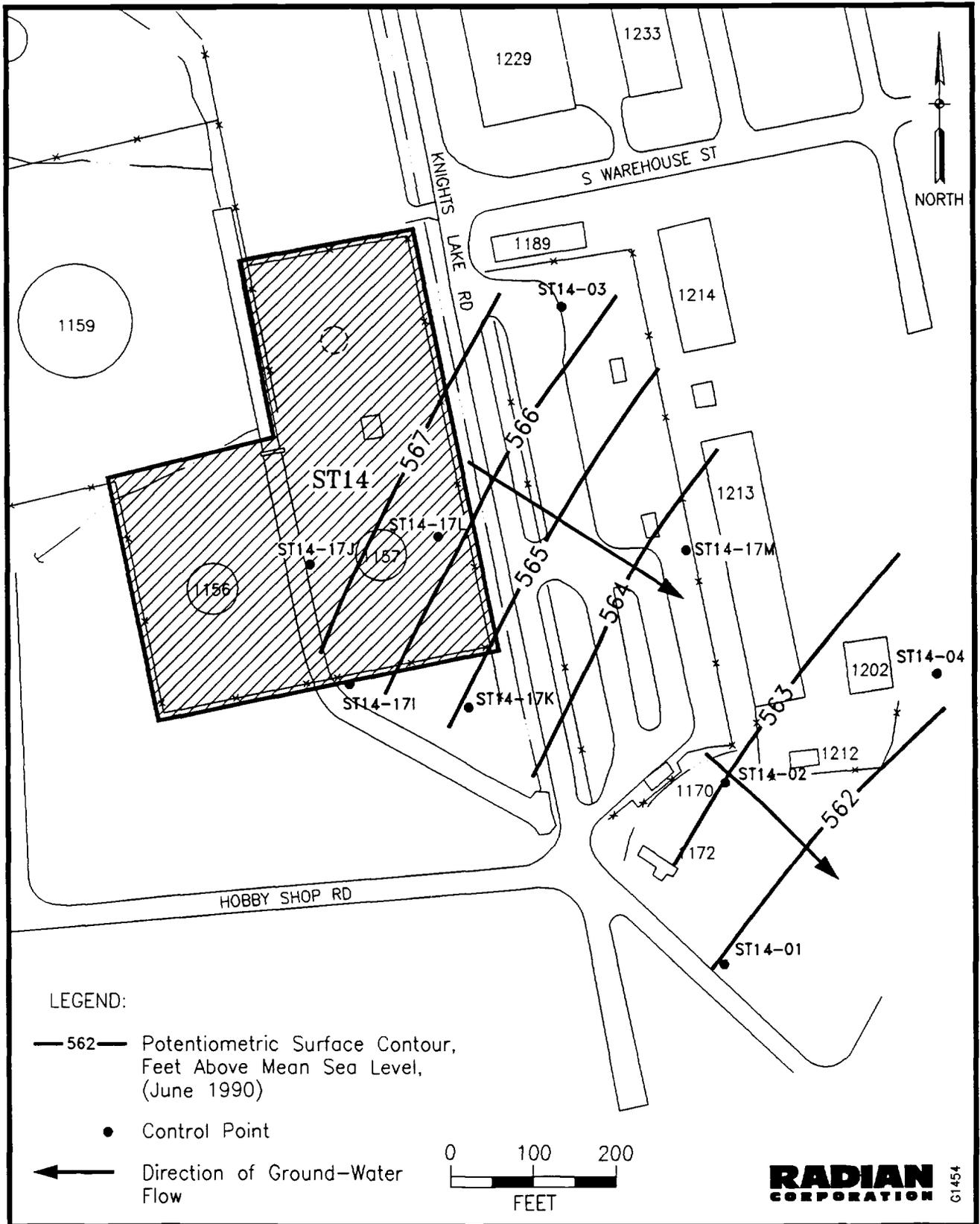


Figure 3-15. Potentiometric Surface Contour Map of Site ST14, Carswell AFB, Texas

approximately 0.3 feet per day. This velocity represents an average seepage velocity.

3.3.2 Soil Gas Investigation

The results of a soil gas survey conducted in December 1987 at the POL Tank Farm and the pipeline/truck loading area east of the tanks indicated that some areas were underlain by hydrocarbon vapor plumes. Figure 3-16 illustrates the soil gas concentrations and those areas believed to be underlain by vapor plumes. Using the 1,000 ppm total organic compound concentration as a criterion for delineating contamination, the results show that two soil vapor plumes exist at Site ST14. The largest plume encompasses an area approximately 100 feet wide and 300 feet long underlying the areas in the vicinity of Tanks 1156 and 1157. A smaller plume exists at the pipeline/truck terminal area, centered on soil gas probe 29. This smaller plume is located around monitor well ST14-17M, where viscous, black hydrocarbon product was observed on the ground-water surface during the June 1990 sampling event, and dissolved hydrocarbon constituents were detected in the water.

3.4 Site BSS - Base Service Station

The BSS (Base Service Station) site is located on the northeast corner of the intersection of Jennings Drive and Rogner Drive, on the eastern edge of the base. Previous work performed at the BSS site consisted of a soil gas survey, installation of three Upper Zone monitor wells, and soil sampling from one soil boring. The recent field work (June 1990) included ground-water sampling of the three monitor wells. The three monitor wells encountered limestone between 10 and 12 feet below the surface and the soil boring within 6 feet. Monitor well BSS-B was completed above ground, and wells BSS-A and BSS-C were completed flush to the ground surface. The locations of the Upper Zone monitor wells installed at the BSS site are shown in Figure 3-17, as well as the location of two cross-sections constructed through the site.

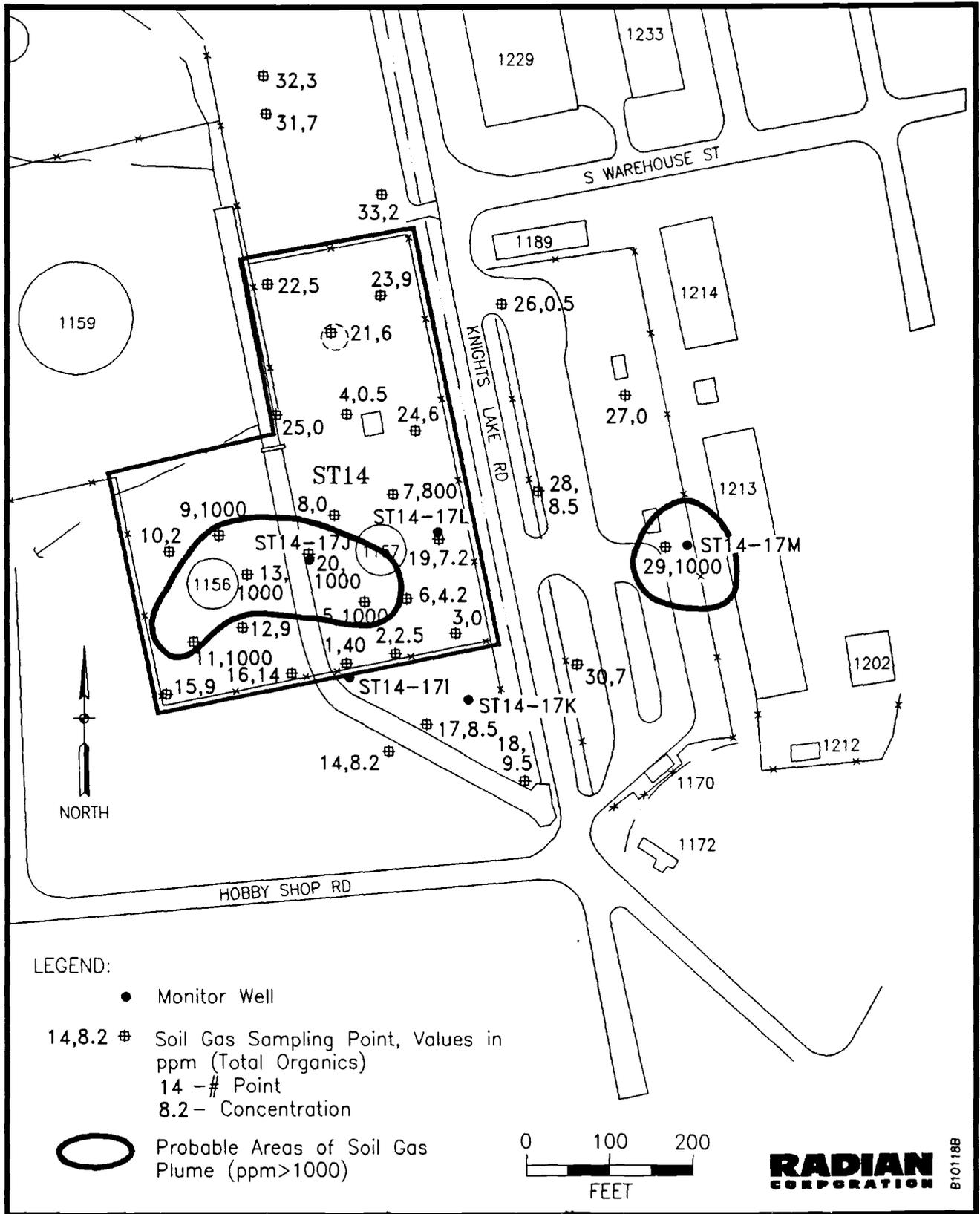


Figure 3-16. Probable Areas of Soil Gas Plumes (ppm > 1000) at Site ST14 (POL Tank Farm), Carswell AFB, Texas (December 1987)

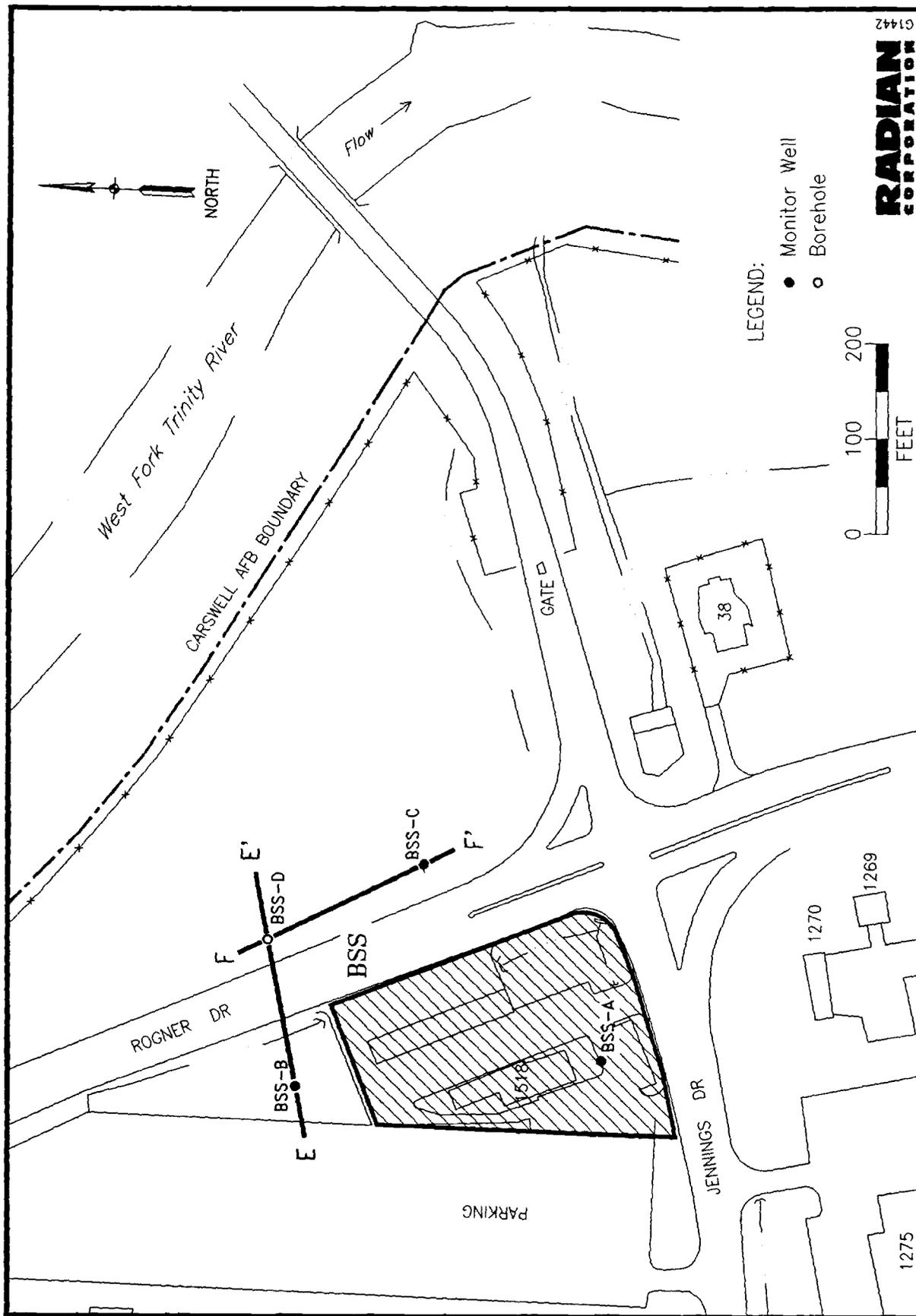


Figure 3-17. Location of Monitor Wells and Borehole at the BSS Site, Carswell AFB, Texas

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3.4.1 Site Description

Topography

The BSS site is located on a gently sloping terrace on the west side of the West Fork of the Trinity River. Elevations range from approximately 567 feet near the Base Service Station (Bldg. 1518) to 560 feet at monitor well BSS-C.

Geology

The Upper Zone deposits encountered during drilling at the BSS site are characteristic of the East Area in general. Cross-sections E-E' and F-F' (Figure 3-18) illustrate geologic features at the site. Because bedrock was encountered within 12 feet of the surface in all boreholes drilled at the BSS site, the sequences encountered are generally thin. There are typically 3 to 9 feet of clay and silt, underlain by a thin stratum of sand with minor gravel. Under the sand and gravel is the limestone of the Goodland Formation, which was encountered in all boreholes. The shallow depth of the Goodland is consistent with the overall geologic setting of the East Area. Based on observations from drilling at Site LF01, the depth to the Goodland probably increases abruptly toward the Trinity River. The surface of the Goodland Limestone dips to the east beneath the BSS site (Figure 3-7), with the dip of the bedrock being slightly greater than the slope of the land surface.

Hydrogeology

The depth to water at Site BSS ranged from about 6 feet to just over 8 feet bgl during the June 1990 synoptic water-level survey. The water table is contoured in Figure 3-8, sloping to the east. The water table gradient is fairly consistent with the slope of the underlying bedrock surface. The hydraulic gradient observed at this site indicates ground-water movement toward the West Fork of the Trinity River.

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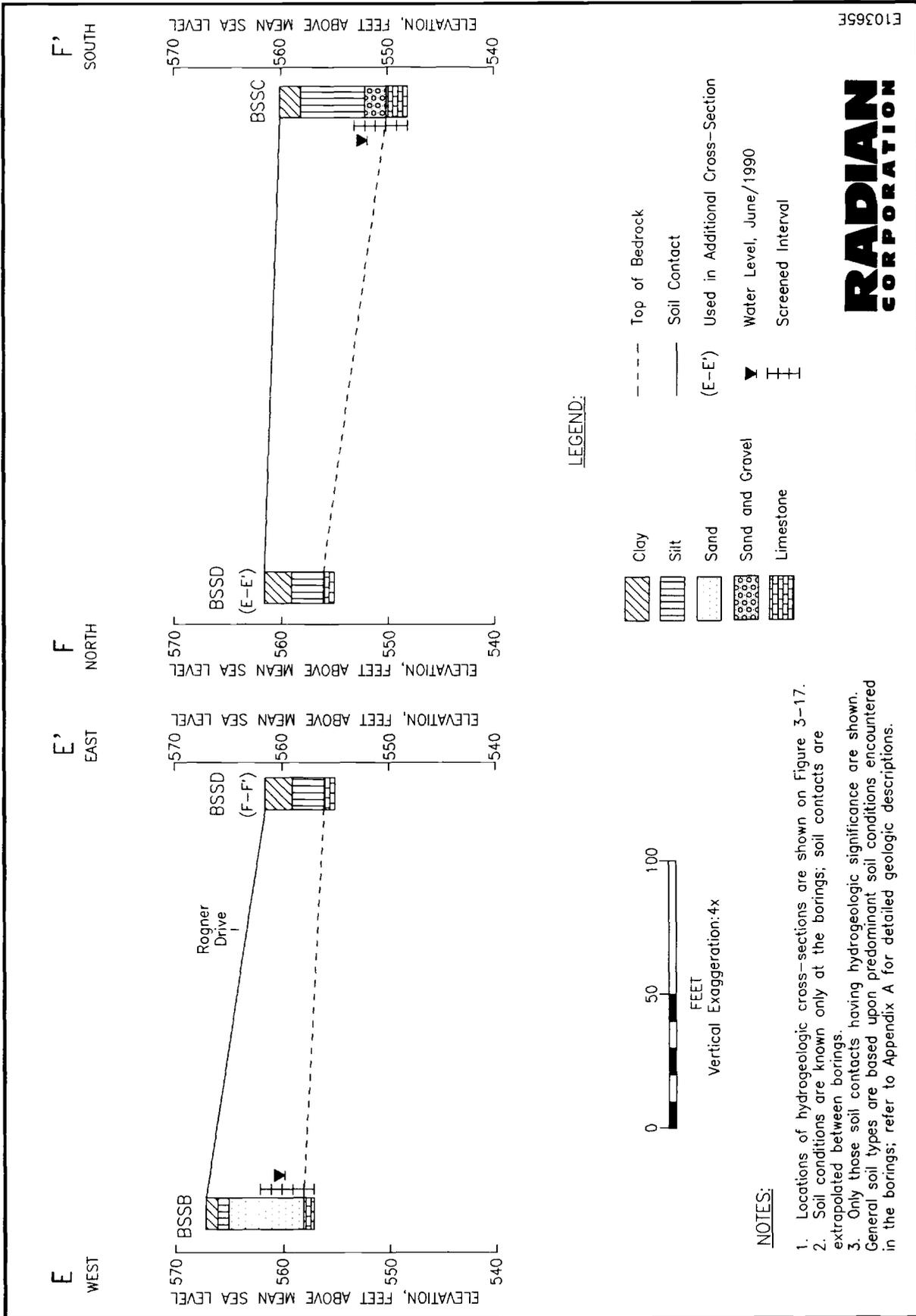
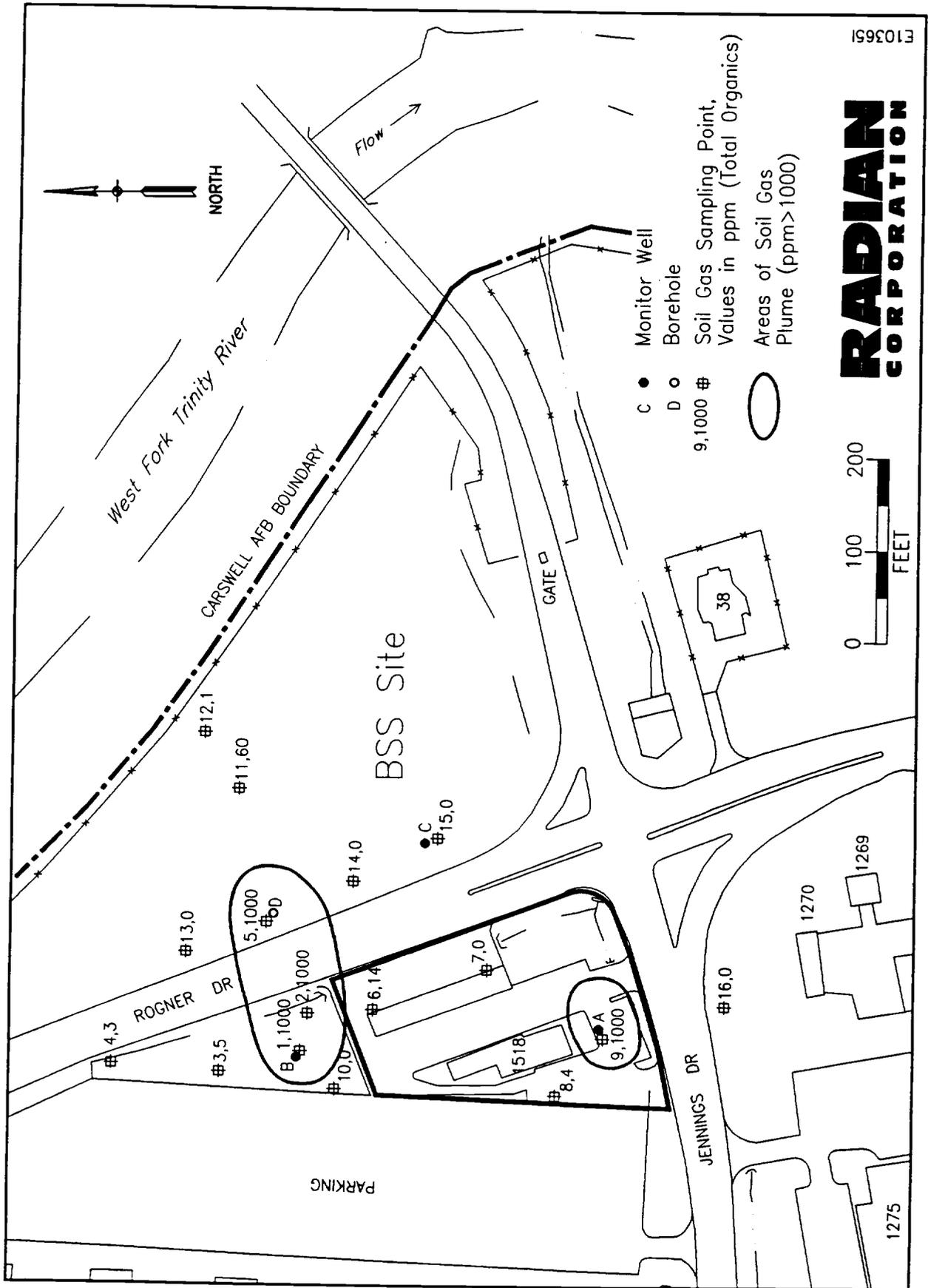


Figure 3-18. Hydrogeologic Cross-Sections E-E' and F-F' at BSS Site, Carswell AFB, Texas

3.4.2 Soil Gas Investigation

The results of the December 1987 soil gas survey conducted at the Base Service Station indicate that two areas are underlain by hydrocarbon vapor plumes. Figure 3-19 shows the soil gas probe results and the two areas interpreted as delineating the vapor plumes. The gas chromatograph used for the soil gas investigation had a maximum quantifiable organic vapor concentration of 1000 ppm. Since several probe locations had concentrations exceeding 1000 ppm, this concentration was used as the criterion for total organic compound plume delineation. The results of the investigation indicate soil vapor plumes located just north of the station extending from the underground storage tanks to east of Rogner Drive and also at the southern end of the station. The largest plume was estimated to encompass an area approximately 100 feet wide and 200 feet long. The smaller plume at the south end of the station was roughly 75 feet in diameter.

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Figure 3-19. Probable Areas of Soil Gas Plumes, BSS Site, Carswell AFB, Texas

4.0 NATURE AND EXTENT OF CONTAMINATION

The Carswell AFB IRP Phase II Stage 1 report (Radian, 1986) identified organic and metals contamination at several sites in the East Area. Additional work was performed during Stage 2 (1987-88) to define the vertical and lateral extent of contaminants in the East Area, and in addition, to investigate other sites with the potential for subsurface contamination (e.g., Site BSS - Base Service Station).

The primary objective of the activities performed by Radian in 1990 was to further characterize the nature and extent of various contaminants in the Upper Zone ground water beneath the East Area. Specifically, the goal was to better define the upgradient and/or downgradient margins of ground-water contaminant plumes, and to collect additional data necessary to support a Feasibility Study (FS) for the East Area sites.

Four sites had additional work performed in 1990: Site LF01 (Landfill 1), Site SD13 (Unnamed Stream and Abandoned Gasoline Station), Site ST14 (POL Tank Farm), and Site BSS (Base Service Station). This discussion of the nature and extent of contamination is limited to these sites, as no new data were collected on other East Area sites since completion of the Final Draft IRP Phase II Stage 2 RI/FS report (Radian, 1989).

Samples collected during the 1990 field program were analyzed for various volatile organic compounds and metals species. Metals analyses were performed on both filtered and unfiltered samples to evaluate concentrations of both total and dissolved metals. In previous investigations, only the total metal analyses were performed, which do not yield results that are representative of the dissolved concentrations of metals in water. Evaluation of ground-water and surface water impacts based solely on total metals concentrations can lead to an erroneous conclusion of metals contamination if the data are not supported by dissolved metals results. This is because metals ions can be leached from suspended sediments present in unfiltered samples when the samples are acidified (preserved). There is no means to determine the magnitude of the metals contribution from this mechanism to the

total metals concentration except by performing a dissolved metals analysis on a corresponding filtered sample. This issue is discussed by site in Section 4.3. Following is a summary of the quality assurance/quality control (QA/QC) results for the most recent (1990) Carswell AFB ground-water sampling effort.

4.1 Quality Assurance/Quality Control

A primary data set, consisting of analytical results for organic and inorganic compounds in ground and surface water, was collected to characterize ground and surface waters at Carswell AFB and to determine if these waters were contaminated. A quality assurance/quality control (QA/QC) program was incorporated in the data collection effort to control and assess the uncertainty of measurement results.

The uncertainty in the measurement of a chemical concentration in an environmental sample may be broadly divided into components that may be controlled by a laboratory and components that may not be controlled by a laboratory. For example, error due to the analytical method (method error) may be controlled by analyzing the appropriate quality control (QC) samples and using the results as feedback for corrective actions. Error due to the nature of the sample media (matrix effects) may not be controlled, so QC samples are analyzed to assess total uncertainty and provide uncertainty estimates to be used during the interpretation of natural sample results. Therefore, the collection and analysis of quality control samples during the Carswell AFB program served two objectives: (1) to evaluate and control the laboratory component of measurement error; and (2) to evaluate error related to sample variability and matrix effects and ultimately assess total measurement uncertainty.

The approach used to accomplish these objectives is described in Section 4.1.1, along with a general summary and conclusion of the results of the quality control sample analyses. A discussion of the QC results, in regards to the analytical system, is presented in Section 4.1.2. A discussion of the QC results, in regards to total measurement error due to the environmental matrix is presented in Section 4.1.3. A discussion of sample collec-

tion documentation, including chain-of-custody, sample hold times, and use of standard forms is presented in Section 4.1.4. Detailed QC results are presented in Appendix H of the Flightline Remedial Investigation (RI) report.

4.1.1 QA/QC Approach and Summary

The goals of the QA/QC program were to ensure control over the measurement process in the laboratory and to collect data to assess total measurement error (i.e., non-controllable error due to matrix effects or sample collection). The quality of the measurement program was also enhanced through the use of standard analytical methods, standardized data collection forms, chain-of-custody procedures, and standard sample hold times. The reference analytical methods used on this project are identified in Table 4-1. Quality control requirements described in the reference methods and the approved Carswell AFB Quality Assurance Project Plan (QAPP) were followed for all analyses.

QC samples used to control and/or assess measurement error included blanks, spikes, and replicates. A glossary of QC sample types is presented in Table 4-2. Analysis of these QC samples provided information related to contamination (false-positives), bias, and variability, respectively. The approach to using these QC samples to control laboratory performance and assess total measurement error is described in the following sections.

Approach and Summary of Laboratory Matrix QC Efforts

The QA effort to control and assess analytical error consisted of QC samples, analyzed along with natural samples, and a prescribed set of corrective actions to implement when error exceeded data quality objectives. Thus, a feedback mechanism was used which enabled the lab to continuously monitor bias and imprecision in a laboratory matrix. Types of QC samples with acceptance criteria and limits, as well as the prescribed corrective actions, were presented in Table 1.10-1 of the approved QAPP. The QC samples used to

4-3

TABLE 4-1. STANDARD METHODS USED FOR CHEMICAL ANALYSES

IRP Test Name	Radian Code	IRP Code
Purgeable Halocarbons	601EW001	E601
Arsenic	ASGSWA00	SW7060
Chloride (Titrimetric, Mercuric Nitrate)	CLTEWN00	E325.3
Fluoride, Potentiometric, ION Selective Electrode	F_SEWA00	E340.2
Total Recoverable Petroleum Hydrocarbons	HCTEWN00	E418.1
Mercury (cold vapor, manual)	HGC_WN00	E245.1
Inductively Coupled PLASMA (ICP) Metals Screen	ICPSWN00	SW6010
Nitrate ION	N03EWA00	E353.2
Orthophosphate	OPOEWN00	E365.2
Lead (Furnace)	PBGSWA00	SW7421
Selenium	SEGSWA00	SW7740
Sulfate by Nephelometry	SFN_WN00	SW9038
Filterable Residue (Also known as Total Dissolved Solids)	TDSEWN00	E160.1
Nitrate ION	N03EWN00	E353.2
Purgeable Aromatics	602EW001	E602

control precision and accuracy in the laboratory matrix included continuing calibration control samples, laboratory quality control check (QCCS) samples, and for metals by SW6010 (ICAP), ICP interference check samples. Data quality objectives for laboratory-controllable parameters during this program were presented in Table 1.4-1 in the approved QAPP, in terms of precision and accuracy, and are reproduced in this document as Table 4-3.

In summary, the analytical system was in control for all analyses. Quality control check samples (QCCS) or continuing calibration check samples were always used as a final analysis if there was a concern about system control.

Laboratory blanks indicate a potential for false-positive results due to laboratory contamination. Maximum concentrations found in lab. blanks are presented below with specific analytes:

- EPA 601 - Tetrachloroethene 0.17 µg/L;
Trichloroethene 1.3 µg/L;
- EPA 325.3 - Chloride 1.5 mg/L;
- SW6010 - Aluminum 0.53 mg/L;
Beryllium 0.0023 mg/L;
Copper 0.053 mg/L;
Nickel 0.021 mg/L;
Silver 0.051 mg/L;
Strontium 0.0047 mg/L;
Vanadium 0.025 mg/L;
Zinc 0.044 mg/L;
- EPA 365.2 Orthophosphate 0.012 mg/L; and,
- SW7421 Lead 0.0099 mg/L.

A more detailed discussion of laboratory matrix QC samples is provided in Section 4.1.2.

TABLE 4-3. PRECISION AND ACCURACY OBJECTIVES FOR THE LABORATORY MATRIX

Parameter	Method	Precision ^a	Accuracy ^b
Total Petroleum Hydrocarbons	EPA 418.1-IR	Not specified	Not specified
Metals Screen (23 metals)	SW846 6010-ICP (modified)	20%	±15%
Arsenic	SW846 7060 Furnace AA	20%	±15%
Lead	SW846 7421 Furnace AA	20%	±15%
Mercury	SW846 7471 Cold Vapor AA	20%	±20%
Selenium	SW846 7740 Furnace AA	20%	±15%
Volatile Halocarbons	EPA 601	50%	±30% to 110% ^c
Volatile Aromatics	EPA 602	50%	±4% to 65% ^c
Chloride	EPA 325.3	15%	±15%
Sulfate	SW846 9038	15%	±10%
Fluoride	EPA 340.2	10%	±10%
Total Dissolved Solids	EPA 160.1	20%	±15%

^a Coefficient of variation (relative standard deviation) for replicate determinations (exclusive of sampling variability).

^b Total error for a single measurement, including both systematic error (bias) and random error (variability due to imprecision), expressed as a percentage of the measured value.

^c Range of relative error for species of interest, based on EPA method validation testing. See method for further explanation.

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Approach and Summary of Environmental Matrix QC Efforts

Total measurement error includes components of error associated with matrix effects (recovery), lack of homogeneity in the matrix (variability), and sample collection (variability and contamination). Total error may be expressed in terms of bias, measured by matrix and surrogate spike results; imprecision, measured by matrix spike duplicate and field duplicate results; and contamination, measured by field blanks such as ambient condition and equipment rinse blanks. Imprecision may be expressed in terms of the pooled coefficient of variation (CV) for matrix spike duplicate and field duplicate results. Matrix spike duplicate results allow for estimates of imprecision at an established concentration level above the detection limit, whereas concentrations of target analytes in field duplicate samples may vary widely or even be not detectable.

In summary, field blanks indicated a potential for false-positive results due to field contamination. Generally, field blanks contained very low concentrations for common organic and inorganic compounds. Natural sample results near laboratory and field blank concentrations may be considered false-positive results. Estimates of imprecision and bias are presented in Section 4.1.3.

Approach and Summary of Sample Collection QC Efforts

The QA effort to control and/or evaluate sample collection error consisted of using standard sample collection methods, standard sample holding times until analysis, standard forms to document sample collection and chain-of-custody, along with trip blanks to quantitate bias (i.e., contamination) due to sample handling, shipment or storage. The standard forms used at Carswell AFB originated with the Air Force IRP program and may be found in the data collection handbook. Chain-of-custody forms are presented as Figure 1.6-2 in Section 1.6.1 of the QAPP.

A feed-back mechanism to control sample collection error was not possible for the Carswell project because field teams finished sample collec-

tion before sample analysis was complete. While there were some inconsistencies in hold times for trip blanks and signatures on chains-of-custody, no sample results were invalidated. A discussion of the completeness of sample collection QC efforts is presented in Section 4.1.4.

4.1.2 Laboratory Matrix QC Sample Results

Bias and imprecision in results is most controllable for the analytical system because QC samples may be analyzed along with natural matrix samples and a batch reanalyzed if QC samples indicate the system is out of control. As discussed in Section 4.1.1, and the QAPP, data quality objectives, Table 4-3, are for QC samples using reagent water as the matrix. Results for samples in natural matrices would not be expected to be as unbiased nor precise. If imprecision or bias exceed these data quality objectives, then the analytical system is out of control and must be corrected, and affected samples reanalyzed. Bias due to laboratory contamination is not included in Table 4-3. Generally, any systematic contamination for laboratory sources is not allowed. However, the presence of some common lab contaminants is allowed and corrective action is taken only when concentrations reach a significant level as directed in the QAPP.

Instrument calibrations were performed according to laboratory standard operating procedures (SOPs) which reference the standard methods specified in the QAPP. One problem occurred with the calibration curve for a gas chromatograph (GC) used for 601 analyses. This problem was documented in the ITIR and the solution and a discussion are represented here.

As pointed out in the ITIR, this problem does not invalidate any sample results for samples analyzed by Method 601 and does not make this project incomplete. The calibration curve for Method 601 analyses on instrument "B" was not within specifications. The fifth, and highest, calibration point (30 ppb) was inaccurate and thus caused results to be biased high. To solve this problem, data generated on instrument "B" for 601 analyses was recalculated using a four point calibration curve, dropping the 30 ppb calibration point, with the new highest point of 15 ppb. New reports were

issued and affected results flagged. Second column confirmation need be only qualitative for Carswell AFB analyses, so these results (i.e., Instrument B data) will be used solely for second column confirmation. Results for instrument "5" were considered the "primary" result and site evaluations will be based on this quantitation.

QC sample results for organic methods are used internally by the laboratory to determine if the analytical system remains in control. These results are not reported. Since these results are used as a feedback mechanism on system control and not to evaluate total bias or imprecision after reporting, it is the laboratory's responsibility to maintain system control. For this discussion it is assumed all samples were analyzed by Method 601 and Method 602 when the system was in control.

4.1.2.1 Laboratory Matrix Blanks

A list of analytes detected in laboratory matrix blanks is presented in Table 4-4 with a count of the number of times detected and maximum concentrations. Generally, there is little concern for false-positive results due to laboratory contamination. However, for the analytes listed in Table 4-4, it is possible for sporadic false-positive results. Corrective actions outlined in the QAPP were followed regarding laboratory contamination. Therefore, no sample results were invalidated due to laboratory contamination. Summary and detailed results for all blanks are presented in Table 1 and Table 2 of Appendix H of the Flightline RI, respectively.

4.1.2.2 Laboratory Matrix Spikes

Continuing calibration and quality control check samples (QCCS) check samples were used to determine if the analytical system was in control for methods by AA, ICAP, or cold-vapor graphite furnace AA; fluoride, chloride, total hydrocarbons, orthophosphate, and total dissolved solids. Results of these samples are presented in Table 4-5. Detailed results are presented in Table 3 of Appendix H of the Flightline RI. A comparison of Table 4-5 to data quality objectives (DQOs) from Table 4-3, indicates the analytical system

TABLE 4-4. SUMMARY OF LAB BLANK RESULTS, CARSWELL AFB, TEXAS

Method	Type	Parameter	Total Number of Blanks	Total Number Above Detection Limit	Concentration Range		Maximum Detection Limit
					Minimum Units	Maximum Units	
Halocarbons by EPA 601	Reagent Blank	Tetrachloroethene	39	1	0.170	0.17	0.100 µg/L
		Trichloroethene	39	1	1.300	1.3	0.200 µg/L
Chloride, by titration	Method Blank	Chloride	16	8	1.400	1.5	1.000 mg/L
	Preparation	Chloride	5	2	1.440	1.5	1.000 mg/L
ICP 25 Element Scan	Calibration	Beryllium	38	1	0.0023	0.0023	0.0020 mg/L
		Nickel	38	1	0.021	0.021	0.020 mg/L
		Silver	38	3	0.011	0.051	0.010 mg/L
		Strontium	38	2	0.0041	0.0047	0.0030 mg/L
	Method Blank	Aluminum	17	1	0.530	0.53	0.200 mg/L
	Copper	17	2	0.023	0.053	0.020 mg/L	
	Zinc	17	6	0.025	0.044	0.020 mg/L	
Preparation		Aluminum	6	1	0.530	0.53	0.200 mg/L
		Silver	6	1	0.014	0.014	0.010 mg/L
		Vanadium	6	1	0.025	0.025	0.020 mg/L
	Method Blank	Orthophosphate	13	1	0.012	0.012	0.010 mg/L
Lead by SW7421	Initial Calibration Blank	Lead	11	4	0.0030	0.0092	0.0030 mg/L
	Method Blank	Lead	17	4	0.0040	0.0042	0.0030 mg/L
Preparation	Lead	9	5	0.0040	0.0099	0.0030 mg/L	

TABLE 4-5. SUMMARY OF QUALITY CONTROL CHECK SAMPLE (QCCS) RESULTS,
CARSWELL AFB, TEXAS

Parameter	Number of Samples	Mean % Recovery	Precision CV (%)	Accuracy Mean Relative Error ($\pm\%$)
ARSENIC BY SW7060				
Continuing Calibration Control Sample				
Arsenic	53	95.9	4.5	5.0
Laboratory Control Sample (QCCS)				
Arsenic	2	90.3	5.8	9.7
CHLORIDE, BY TITRATION				
Continuing Calibration Control Sample				
Chloride	15	97.5	1.2	2.5
FLUORIDE BY EPA 340.2]				
Continuing Calibration Control Sample				
Fluoride	17	96.4	3.6	4.2
HYDROCARBONS, TOTAL E418.1				
Continuing Calibration Control Sample				
Hydrocarbons	4	93.6	3.8	6.4
MERCURY BY COLD VAPOR				
Continuing Calibration Control Sample				
Mercury	50	96.7	13.6	5.4
ICP 25 ELEMENT SCAN				
Continuing Calibration Control Sample				
Aluminum	41	101.3	2.6	2.3
Antimony	38	101.3	2.9	2.3
Arsenic	40	103.1	2.8	3.6
Barium	39	99.8	3.2	2.6
Beryllium	43	100.9	4.1	3.8
Boron	38	99.8	3.9	3.2
Cadmium	40	103.7	4.3	5.4
Calcium	38	104.3	2.2	4.3
Chromium	41	100.8	2.7	2.2
Cobalt	36	102.2	2.8	3.1
Copper	40	102.7	3.8	4.1
Iron	40	98.8	2.1	1.9
Lead	39	104.0	4.0	5.1
Magnesium	39	100.5	2.5	2.0
Manganese	41	103.6	3.1	4.3
Molybdenum	35	99.0	3.2	2.9
Nickel	39	102.9	2.9	3.5
Potassium	42	100.7	2.5	2.2
Selenium	41	103.1	2.3	3.3
Silicon	42	101.5	3.5	3.1
Silver	36	101.4	4.3	3.9
Sodium	40	101.8	12.3	4.0
Strontium	44	100.2	2.7	2.3
Thallium	41	100.4	2.9	2.4
Vanadium	41	102.5	3.1	3.7
Zinc	38	103.9	2.4	4.0
ICP Interference Check Sample				
Aluminum	17	92.7	6.0	7.7
Barium	26	103.8	2.3	3.8
Beryllium	27	104.4	2.4	4.5
Cadmium	28	102.9	2.2	3.1
Calcium	17	82.6	15.7	17.6
Chromium	28	104.6	2.7	5.0
Cobalt	28	107.3	3.4	7.7
Copper	28	105.0	4.1	5.9
Iron	17	77.0	24.6	24.3
Lead	30	104.5	4.6	5.6
Magnesium	17	88.1	10.0	12.2
Manganese	27	102.7	4.9	4.7

(Continued)

TABLE 4-5 (Continued)

Parameter	Number of Samples	Mean % Recovery	Precision CV (%)	Accuracy Mean Relative Error (+%)
Nickel	28	102.2	3.9	3.8
Silver	30	101.7	4.4	4.1
Vanadium	30	99.6	6.2	4.3
Zinc	28	106.2	3.4	6.7
Initial Calibration Control Sample				
Aluminum	2	100.4	1.3	.9
Barium	2	101.0	.3	1.0
Beryllium	2	101.3	.3	1.3
Cadmium	2	97.2	.8	2.8
Calcium	2	101.8	.1	1.8
Chromium	2	100.6	.2	.6
Cobalt	2	99.2	.6	.8
Copper	2	92.9	.2	7.1
Iron	1	104.3		4.3
Lead	2	101.2	2.6	1.9
Magnesium	1	101.5		1.5
Manganese	2	85.5	.5	14.5
Nickel	2	100.1	2.4	1.7
Silver	2	92.2	.2	7.8
Vanadium	2	90.9	.2	9.1
Zinc	2	97.7	.2	2.3
Laboratory Control Sample (QCCS)				
Aluminum	2	96.9	.5	3.1
Antimony	2	94.5	3.7	5.5
Arsenic	2	117.0	.0	17.0
Barium	2	99.0	.0	1.0
Beryllium	2	100.3	1.0	.7
Boron	2	99.0	1.4	1.0
Cadmium	2	97.4	.9	2.6
Calcium	2	100.0	1.4	1.0
Chromium	2	98.3	.4	1.8
Cobalt	2	97.9	.1	2.1
Copper	2	97.8	.4	2.3
Iron	2	96.3	1.9	3.7
Lead	2	98.8	1.1	1.2
Magnesium	2	96.6	1.6	3.4
Manganese	2	97.4	.6	2.6
Molybdenum	2	97.4	.7	2.6
Nickel	2	98.4	.9	1.7
Potassium	2	95.5	3.1	4.5
Selenium	2	101.5	.7	1.5
Silicon	2	92.9	5.3	7.1
Silver	2	92.0	4.7	8.0
Sodium	2	94.6	.6	5.4
Strontium	2	98.9	.2	1.2
Thallium	2	96.8	1.8	3.3
Vanadium	2	95.9	.2	4.1
Zinc	2	99.1	1.3	.9
NITRATE BY E353.2				
Continuing Calibration Control Sample				
Nitrate	20	99.7	4.4	3.6
ORTHOPOSPHATE				
Continuing Calibration Control Sample				
Orthophosphate	22	99.0	3.3	2.5
LEAD BY SW7421				
Continuing Calibration Control Sample				
Lead	56	103.2	4.3	4.6
Laboratory Control Sample (QCCS)				
Lead	2	108.3	2.2	8.3

(Continued)

TABLE 4-5 (Continued)

Parameter	Number of Samples	Mean % Recovery	Precision CV (%)	Accuracy Mean Relative Error (+%)
SELENIUM BY SW7740				
Continuing Calibration Control Sample Selenium	46	97.6	5.6	5.1
Laboratory Control Sample (QCCS) Selenium	1	90.0		10.0
SULFATE				
Continuing Calibration Control Sample Sulfate	13	98.6	2.4	2.2
TOTAL DISSOLVED SOLIDS				
Laboratory Control Sample (QCCS) Total Dissolved Solids	6	100.6	3.5	2.5

TABLE 4-6. SUMMARY OF SPIKE RESULTS, CARSWELL AFB, TEXAS

SUMMARY OF SPIKE RESULTS FOR MATRIX = Laboratory Water

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Arsenic by SW7060 Method (Blank) Spike	18	83.0	4.57908	12	0	85.0 - 115.0
Arsenic						
Chloride, by titration Method (Blank) Spike	1	106.0		0	1	
Chloride						
Hydrocarbons, total E418.1 Method (Blank) Spike	1	104.0		0	0	80.0 - 120.0
Hydrocarbons						
ICP 25 element scan Method (Blank) Spike						
Aluminum	14	95.5	3.52355	1	0	90.0 - 110.0
Antimony	14	73.0	3.18113	14	0	90.0 - 110.0
Arsenic	14	85.1	5.12106	12	0	90.0 - 110.0
Barium	14	98.7	2.76891	0	0	90.0 - 110.0
Beryllium	14	100.7	2.79432	0	0	90.0 - 110.0
Boron	14	45.8	13.65921	14	0	90.0 - 110.0
Cadmium	14	96.6	2.62954	0	0	90.0 - 110.0
Calcium	14	92.5	9.49572	4	1	90.0 - 110.0
Chromium	14	97.6	2.49302	0	0	90.0 - 110.0
Cobalt	14	97.4	2.45916	0	0	90.0 - 110.0
Copper	14	96.5	2.70276	0	0	90.0 - 110.0
Iron	14	95.9	3.42736	1	0	90.0 - 110.0
Lead	14	93.8	3.64649	1	0	90.0 - 110.0
Magnesium	14	87.2	3.72134	13	0	90.0 - 110.0
Manganese	14	97.1	2.35759	0	0	90.0 - 110.0
Molybdenum	14	92.8	2.64073	3	0	90.0 - 110.0
Nickel	14	97.3	2.68349	0	0	90.0 - 110.0
Potassium	14	34.8	4.05501	14	0	90.0 - 110.0
Selenium	14	70.7	2.88177	14	0	90.0 - 110.0
Silicon	14	79.2	8.03564	13	0	90.0 - 110.0
Silver	14	94.0	5.35741	2	0	90.0 - 110.0
Sodium	14	85.7	4.35145	13	0	90.0 - 110.0
Strontium	14	99.2	2.67113	0	0	90.0 - 110.0
Thallium	14	89.3	4.70496	9	0	90.0 - 110.0
Vanadium	14	94.9	3.11534	0	0	90.0 - 110.0
Zinc	14	96.2	5.45483	1	0	90.0 - 110.0
Orthophosphate Method (Blank) Spike	5	78.0	40.80044	0	5	
Orthophosphate						

(Continued)

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TABLE 4-6. (CONTINUED)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below		Acceptance Limits	Acceptance Criteria
				Acceptance Limits	Acceptance Limits		
Lead by SW7421 Method (Blank) Spike Lead	17	94.5	6.15363	1	0		85.0 - 115.0
Selenium by SW7740 Method (Blank) Spike Selenium	9	89.3	8.25321	3	0		85.0 - 115.0

TABLE 4-7. SUMMARY OF SURROGATE SPIKE RESULTS, CARSWELL AFB, TEXAS
 SUMMARY OF SPIKE RESULTS FOR MATRIX = Laboratory Water

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Halocarbons by EPA 601						
Matrix Spike						
1-Bromo-4-fluorobenzene	12	130.7	9.71721	0	2	40.0 - 140.0
Surrogate Spike						
1-Bromo-4-fluorobenzene	67	124.8	10.32149	0	4	40.0 - 140.0
Aromatics by EPA 602						
Matrix Spike						
1-Bromo-4-fluorobenzene	4	99.5	5.97216	0	0	40.0 - 140.0
Surrogate Spike						
1-Bromo-4-fluorobenzene	28	96.5	16.07271	0	0	40.0 - 140.0

Laboratory Matrix Replicates

Analytical duplicates (i.e., duplicate analysis of the same prepared sample at the instrument) were used to determine if the imprecision associated with the analytical system was in control relative to precision objectives. Results of analytical duplicates indicated slightly greater variability, as estimated by coefficient of variation (CV), than expected for the following analytes:

- Nickel (SW6010) - 24%;
- Lead (SW7421) - 47%;
- Selenium (SW7740) - 51%;
- Orthophosphate (E365.2) - 28%.

Results of analytical duplicates are summarized in Table 5 of Appendix H of the Flightline RI.

4.1.3 Environmental Matrix QC Sample Results

Measurement bias and imprecision are confounded with environmental variability in natural matrix samples. Since environmental variability (eg. non-uniform distribution of pollution, variation in natural background concentrations over space and time, etc) will not be adequately characterized, measurement error and bias may be quantified but not controlled. Also, generally sample analyses are performed after field teams have finished at the site, so timely re-sampling is not an option. Therefore, the following results are used to qualify interpretations, not to validate procedures or sample results. Acceptance criteria as specified in Table 1.10-1 of the QAPP are used throughout this discussion as an indication that bias and imprecision are normal or abnormal based on historical analyses. Generally, the QAPP specified corrective action for results outside acceptance criteria is to flag data and assume matrix interference. Five types of QC samples were used on the Carswell project to quantify measurement bias and imprecision that is confounded with environmental variability. These five QC sample types are:

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- Matrix spikes (quantify bias);
- Surrogate spikes (quantify bias);
- Matrix spike duplicates (quantify imprecision);
- Predigestion duplicates (quantify imprecision due to matrix, preparation and analytical effects); and
- Field duplicates (quantify imprecision due to sampling, matrix, preparation and analytical effects).

False-positive results due to wind-blown contamination or cross-contamination from using non-dedicated sampling equipment are possible during any sampling effort. Field blanks are used to identify and estimate the quantity of contamination that may be associated with sampling efforts. Ambient condition and equipment blanks were used during the Carswell groundwater program.

Contamination, bias and imprecision are discussed in following sections by QC sample type. Results that exceeded expectations base on historical laboratory bias and imprecision estimates are discussed for appropriate methods.

Field Blanks

A synopsis of the results for compounds detected in field blanks and the maximum concentration detected are presented in Table 4-8. All results for field blanks are summarized and presented in detail in Table 1 and Table 2 of Appendix H of the Flightline RI, respectively.

Spikes

Analytical, matrix and surrogate spikes were used to evaluate bias on the Carswell project. Analytical spikes are added after preparation,

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TABLE 4-8. SUMMARY OF FIELD BLANK RESULTS, CARSWELL AFB, TEXAS

Method	Type	Parameter	Total Number of Blanks	Total Number Above Detection Limit	Concentration Range		Maximum Detection Limit	
					Minimum Units	Maximum Units		
Halocarbons by EPA 601	Ambient Conditions Blank	1,2-Dichloroethane	4	4	0.790 - 1.2	0.100 µg/L		
		Methylene chloride	4	2	0.540 - 0.67	0.400 µg/L		
		Tetrachloroethene	4	1	0.160 - 0.16	0.100 µg/L		
		Trichloroethene	4	4	0.500 - 1.0	0.200 µg/L		
		Trichlorofluoromethane	4	3	0.260 - 0.42	0.200 µg/L		
		Vinyl chloride	4	3	0.290 - 1.6	0.200 µg/L		
Equipment Blank	Equipment Blank	Methylene chloride	4	2	0.490 - 0.64	0.400 µg/L		
		Trichloroethene	4	4	0.410 - 0.58	0.200 µg/L		
		Trichlorofluoromethane	4	1	0.330 - 0.33	0.200 µg/L		
		Vinyl chloride	3	1	0.710 - 0.71	0.200 µg/L		
Trip Blank	Trip Blank	Methylene chloride	12	2	2.000 - 6.7	4.000 µg/L		
		Trichloroethene	12	1	0.260 - 0.26	2.000 µg/L		
		Vinyl chloride	12	1	0.610 - 0.61	2.000 µg/L		
Aromatics by EPA 602	Trip Blank	Chlorobenzene	4	1	0.280 - 0.28	0.200 µg/L		
		Toluene	4	1	0.490 - 0.49	0.200 µg/L		
		Xylenes (total)	4	1	0.630 - 0.63	0.200 µg/L		
ICP 25 element scan	Equipment Blank	Barium	14	7	0.025 - 0.12	0.011 µg/L		
		Beryllium	14	1	0.0030 - 0.0030	0.0022 µg/L		
		Calcium	14	1	1.000 - 1.0	1.100 µg/L		
		Iron	14	2	0.046 - 0.047	0.044 µg/L		
		Lead	14	2	0.055 - 0.057	0.055 µg/L		
		Silicon	14	1	1.200 - 1.2	1.100 µg/L		
		Silver	14	1	0.010 - 0.010	0.011 µg/L		
		Sodium	14	3	1.100 - 1.8	1.100 µg/L		
		Strontium	14	7	0.0039 - 0.0068	0.0033 µg/L		
		Zinc	14	6	0.022 - 0.065	0.022 µg/L		
		Nitrate	7	3	0.020 - 0.50	0.020 mg/L		
		Lead by SW7421	Equipment Blank	Lead	14	8	0.0034 - 0.013	0.0060 mg/L
		Sulfate	Equipment Blank	Sulfate	7	1	1.400 - 1.4	1.000 mg/L
		Total dissolved solids	Equipment Blank	Total dissolved solids	7	1	2600.0 - 2600.0	9.000 mg/L

immediately before analysis, so only bias and imprecision due to the matrix, or analyst's error, is quantified. Matrix spikes are added to the sample before preparation and provide information about total matrix effects. Bias and imprecision estimates from matrix spikes include method preparation error. Analytical spike results should complement results of matrix spike studies regarding error due to the natural matrix. Surrogate spikes are known concentrations of compounds not expected to be found naturally in samples, added to samples. Surrogate recoveries indicate potential bias in recovery for classes of compounds. The corrective action for results outside acceptance criteria for all types of spike results is to recheck calculations and if an error is not found, assume a matrix effect.

Detailed spike results are presented in Table 4 (detailed results) of Appendix H of the Flightline RI. Results of these QC samples are discussed below for both ground-water and surface water matrices.

4.1.3.1 Ground-Water Matrix

Generally, spike recoveries were within expected limits. Matrix spike and surrogate spike recoveries are presented in Table 4-9 and Table 4-10, respectively. Exceptions are discussed below by spike type and method.

Arsenic by SW846 Method 7060 -- Matrix spike recoveries for arsenic indicate little overall bias but imprecision. Three recoveries were below acceptance criteria limits and one recovery above criteria limits. Mean recovery (standard deviation) for 20 matrix spiked samples was 91% (32%). Analytical spike recoveries for arsenic were also biased. Seven out of 144 analytical spike recoveries were less than the 75% acceptance criteria.

Lead by SW846 Method 7421 -- Matrix spike recoveries for lead by SW7421 indicate little bias but fair imprecision. Two sample recoveries out of 20 samples were below the lower acceptance criteria limit of 75% and six recoveries out of 20 were above upper limits of 125%. Mean (standard deviation) recovery was 107% (32%). Analytical spike recoveries also indicated

TABLE 4-9. SUMMARY OF SPIKE RESULTS, CARSWELL AFB, TEXAS

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Halocarbons by EPA 601						
Matrix Spike	4	64.8	29.76995	0	0	28.0 - 167.0
1,1-Dichloroethene	4	106.3	13.50000	0	0	38.0 - 150.0
Chlorobenzene	4	83.8	7.41058	0	0	35.0 - 146.0
Trichloroethene						
Aromatics						
Matrix Spike	4	97.0	9.38083	0	0	39.0 - 150.0
Benzene	4	105.3	11.23610	0	0	55.0 - 135.0
Chlorobenzene	4	105.0	21.36976	0	0	46.0 - 148.0
Toluene						
Arsenic by SM7060						
Analytical Spike	144	93.6	12.16579	7	0	75.0 - 125.0
Arsenic						
Matrix Spike	20	91.3	32.06059	3	1	75.0 - 125.0
Arsenic						
Chloride, by titration						
Matrix Spike	14	102.3	6.16522	0	0	80.0 - 120.0
Chloride						
Fluoride by EPA 340.2						
Matrix Spike	22	101.6	3.74439	0	0	85.0 - 115.0
Fluoride						
Hydrocarbons, total E418.1						
Matrix Spike	4	88.8	5.05800	0	0	80.0 - 120.0
Hydrocarbons						
Mercury by cold vapor						
Analytical Spike	144	94.0	10.82663	2	0	75.0 - 125.0
Mercury						

(Continued)

TABLE 4-9. (Continued)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Matrix Spike Mercury	20	98.1	6.32018	0	0	75.0 - 125.0
ICP 25 element scan						
Analytical Spike Aluminum	144	91.4	5.38505	1	0	75.0 - 125.0
Antimony	144	85.9	5.55358	0	0	75.0 - 125.0
Arsenic	144	102.2	4.63232	0	0	75.0 - 125.0
Barium	144	88.8	8.00610	1	0	75.0 - 125.0
Beryllium	144	89.8	4.22653	0	0	75.0 - 125.0
Boron	144	104.6	13.25564	0	0	75.0 - 125.0
Cadmium	144	86.7	3.74249	0	0	75.0 - 125.0
Calcium	144	93.2	5.83919	0	0	75.0 - 125.0
Chromium	144	86.6	3.96527	0	0	75.0 - 125.0
Cobalt	144	85.9	3.78757	0	0	75.0 - 125.0
Copper	144	88.6	4.14678	0	0	75.0 - 125.0
Iron	144	86.5	3.65457	0	0	75.0 - 125.0
Lead	144	83.6	4.66458	0	0	75.0 - 125.0
Magnesium	144	90.1	3.46163	0	0	75.0 - 125.0
Manganese	144	85.1	4.38962	0	0	75.0 - 125.0
Molybdenum	144	86.5	3.90081	0	0	75.0 - 125.0
Nickel	144	85.9	3.95909	0	0	75.0 - 125.0
Potassium	144	90.4	4.20580	0	0	75.0 - 125.0
Selenium	144	90.5	5.96257	0	0	75.0 - 125.0

(Continued)

TABLE 4-9. (Continued)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Silicon	144	94.7	9.04646	0	0	75.0 - 125.0
Silver	144	86.5	4.62265	0	0	75.0 - 125.0
Sodium	144	92.4	4.30209	0	0	75.0 - 125.0
Strontium	144	88.9	4.40489	0	0	75.0 - 125.0
Thallium	144	85.0	5.38642	0	0	75.0 - 125.0
Vanadium	144	87.5	3.46611	0	0	75.0 - 125.0
Zinc	144	87.4	3.96414	0	0	75.0 - 125.0
Matrix Spike						
Aluminum	20	114.3	46.19079	0	3	75.0 - 125.0
Antimony	20	86.3	5.31235	0	0	75.0 - 125.0
Arsenic	20	107.1	9.02569	0	1	75.0 - 125.0
Barium	20	92.7	5.23425	0	0	75.0 - 125.0
Beryllium	20	93.5	5.92475	0	0	75.0 - 125.0
Boron	20	107.7	15.05114	0	2	75.0 - 125.0
Cadmium	20	90.3	4.74480	0	0	75.0 - 125.0
Calcium	20	77.4	48.30634	7	2	75.0 - 125.0
Chromium	20	90.7	5.15318	0	0	75.0 - 125.0
Cobalt	20	89.8	5.43478	0	0	75.0 - 125.0
Copper	20	92.1	5.56209	0	0	75.0 - 125.0
Iron	20	93.3	13.79121	1	1	75.0 - 125.0
Lead	20	89.0	6.47261	0	0	75.0 - 125.0
Magnesium	20	92.9	7.86665	0	0	75.0 - 125.0

(Continued)

TABLE 4-9. (Continued)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Manganese	20	90.1	5.67984	0	0	75.0 - 125.0
Molybdenum	20	90.7	4.73814	0	0	75.0 - 125.0
Nickel	20	90.3	5.86582	0	0	75.0 - 125.0
Potassium	20	106.2	29.28732	0	2	75.0 - 125.0
Selenium	20	92.4	6.36003	0	0	75.0 - 125.0
Silicon	20	177.4	170.12419	0	8	75.0 - 125.0
Silver	20	90.6	4.78374	0	0	75.0 - 125.0
Sodium	20	90.5	19.02761	4	1	75.0 - 125.0
Strontium	20	91.4	5.37318	0	0	75.0 - 125.0
Thallium	20	87.9	5.54313	0	0	75.0 - 125.0
Vanadium	20	90.4	4.17102	0	0	75.0 - 125.0
Zinc	20	92.3	9.06178	0	0	75.0 - 125.0
Nitrate by E353.2						
Matrix Spike Nitrate	21	97.5	20.05586	3	4	80.0 - 120.0
Orthophosphate						
Matrix Spike Orthophosphate	12	99.8	5.33493	0	0	80.0 - 120.0
Lead by SW7421						
Analytical Spike Lead	144	111.6	18.02823	1	26	75.0 - 125.0
Matrix Spike Lead	20	106.8	31.83077	2	6	75.0 - 125.0

(Continued)

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TABLE 4-9. (Continued)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Selenium by SW7740						
Analytical Spike Selenium	144	82.9	20.32919	34	0	75.0 - 125.0
Matrix Spike Selenium Sulfate	20	74.1	29.35710	5	0	75.0 - 125.0
Matrix Spike Sulfate	9	101.1	12.37053	0	0	80.0 - 120.0

TABLE 4-10. SUMMARY OF SURROGATE SPIKE RESULTS, CARSWELL AFB, TEXAS

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Halocarbons by EPA 601						
Surrogate Spike 1-Bromo-4-fluorobenzene	87	120.1	14.25544	0	6	40.0 - 140.0
Aromatics by EPA 602						
Surrogate Spike 1-Bromo-4-fluorobenzene	33	95.3	31.53735	3	2	40.0 - 140.0

bias and imprecision. Twenty-six of 144 analytical spikes were greater than the analytical spike acceptance criteria of 125%. QCCS and/or continuing calibration check samples were analyzed after the out-of-control spikes to prove the system was in control. Recoveries were within limits for these QC samples, so the laboratory assumed matrix effects influenced recovery and no samples were reanalyzed.

Selenium by SW846 Method 7740 -- Analytical spikes for selenium indicated bias and imprecision. Thirty-four of 144 analytical spikes had recoveries less than the lower acceptance criteria of 75%. Analysis of QCCS and/or continuing calibration check samples indicated the system was in control and so matrix effects were assumed to cause recoveries less than the minimum acceptance limit.

Metals by SW846 Method 6010 (ICAP) -- Matrix spike recoveries for several metals by SW6010 indicated some bias and imprecision. Silicon recoveries were most heavily biased and imprecise (mean (standard deviation) = 177% (170%)) with eight of 20 recoveries greater than the acceptance limit of 125%. Calcium spike recoveries indicate calcium recoveries are biased low and are imprecise.

Nitrate by EPA Method 353.2 -- Matrix spike recoveries for nitrate by E353.2 indicate little bias but slightly greater imprecision than expected. Mean (std. dev.) recovery was 98% (22%). Three of 21 recoveries were below the lower acceptance criteria of 80% and four recoveries were greater than the upper acceptance criteria of 120%.

Halocarbons by EPA 601 -- Surrogate spike results for samples analyzed for halocarbons by EPA 601 indicate bias towards high recovery for 1-bromo-4-fluorobenzene. Mean recovery was 120% with six of 87 sample recoveries were greater than the acceptance criteria limit of 140%.

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4.1.3.2 Surface Water Matrix

Generally, spike recoveries were within expected limits. Matrix and surrogate spike recoveries are presented in Table 4-11 and Table 4-12, respectively. Exceptions are discussed below by spike type and method.

Aromatics by EPA 602 -- Ten samples were spiked with the surrogate 1-bromo-4-fluorobenzene. Recoveries indicate a bias towards low recovery and high imprecision. Five recoveries were below acceptance criteria limits of 40%. Mean (standard deviation) percent recovery was 70% (52%).

Lead by SW846 Method 7421 -- Analytical spike recoveries for lead indicated bias and imprecision. Fourteen out of 24 samples had recoveries greater than the upper acceptance criteria of 125%. Analysis of QCCS and/or continuing calibration check samples indicated the system was in control and so no samples were reanalyzed.

Selenium by SW846 Method 7740 -- Analytical spike recoveries for selenium indicated bias and imprecision. Ten out of 24 samples had recoveries less than the lower acceptance criteria of 75%.

Field QC Water Matrix

Spike recoveries were within expected limits. Matrix and surrogate spike recoveries are presented in Table 4-13 and Table 4-14, respectively.

Field and Matrix Duplicates

Variability can be assessed against several components of a sampling effort. For Carswell, sampling and analytical variability are the primary components of total variability. Since samples were collected over a short time period, temporal variability is assumed to be negligible. Also,

9
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TABLE 4-11. SUMMARY OF SPIKE RESULTS, CARSWELL AFB, TEXAS

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
ARSENIC BY SW7060						
Analytical Spike						
Arsenic	24	88.9	6.40864	0	0	75.0 - 125.0
MERCURY BY COLD VAPOR						
Analytical Spike						
Mercury	24	98.1	6.59326	0	0	75.0 - 125.0
ICP 25 ELEMENT SCAN						
Analytical Spike						
Aluminum	24	87.6	2.99153	0	0	75.0 - 125.0
Antimony	24	81.4	5.57882	0	0	75.0 - 125.0
Arsenic	24	100.8	2.84344	0	0	75.0 - 125.0
Barium	24	86.3	1.77544	0	0	75.0 - 125.0
Beryllium	24	87.2	1.80980	0	0	75.0 - 125.0
Boron	24	97.7	6.31538	0	0	75.0 - 125.0
Cadmium	24	84.7	1.98865	0	0	75.0 - 125.0
Calcium	24	90.6	4.12750	0	0	75.0 - 125.0
Chromium	24	85.2	3.33188	0	0	75.0 - 125.0
Cobalt	24	84.5	1.53167	0	0	75.0 - 125.0
Copper	24	84.9	2.55235	0	0	75.0 - 125.0
Iron	24	83.9	2.32036	0	0	75.0 - 125.0
Lead	24	82.4	3.22917	0	0	75.0 - 125.0
Magnesium	24	86.7	2.95865	0	0	75.0 - 125.0

(Continued)

4-11-60

TABLE 4-11. (Continued)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Manganese	24	83.3	1.73623	0	0	75.0 - 125.0
Molybdenum	24	85.5	1.44463	0	0	75.0 - 125.0
Nickel	24	85.0	3.56894	0	0	75.0 - 125.0
Potassium	24	86.0	3.34247	0	0	75.0 - 125.0
Selenium	24	86.9	2.87291	0	0	75.0 - 125.0
Silicon	24	98.8	3.90837	0	0	75.0 - 125.0
Silver	24	81.5	4.42326	0	0	75.0 - 125.0
Sodium	24	99.5	9.38073	0	0	75.0 - 125.0
Strontium	24	85.3	1.89393	0	0	75.0 - 125.0
Thallium	24	83.8	4.56812	0	0	75.0 - 125.0
Vanadium	24	85.7	2.88141	0	0	75.0 - 125.0
Zinc	24	86.5	2.58760	0	0	75.0 - 125.0
LEAD BY SW7431						
Analytical Spike						
Lead	24	121.1	20.10908	0	14	75.0 - 125.0
SELENIUM BY SW7740						
Analytical Spike						
Selenium	24	80.6	12.82632	10	0	75.0 - 125.0

TABLE 4-12. SUMMARY OF SURROGATE SPIKE RESULTS, CARSWELL AFB, TEXAS

Parameter	Number of Samples	Mean X Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
HALOCARBONS BY EPA 601						
Surrogate Spike						
1-Bromo-4-fluorobenzene	16	114.4	13.69656	0	0	40.0 - 140.0
AROMATICS BY EPA 602						
Surrogate Spike						
1-Bromo-4-fluorobenzene	10	70.0	52.01282	5	0	40.0 - 140.0

TABLE 4-13. SUMMARY OF SPIKE RESULTS, CARSWELL AFB, TEXAS
 SUMMARY OF SPIKE RESULTS FOR MATRIX = Water (Field/Trip QC)

Parameter	Number of Samples	Mean X Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
HALOCARBONS BY EPA 601						
Matrix Spike						
1,1-Dichloroethene	8	82.8	6.69221	0	0	28.0 - 167.0
Chlorobenzene	8	109.4	9.73855	0	0	38.0 - 150.0
Trichloroethene	8	114.6	37.97344	0	2	35.0 - 146.0
ARSENIC BY SW7060						
Analytical Spike						
Arsenic	14	90.9	8.33403	0	0	75.0 - 125.0
FLUORIDE BY EPA 340.2						
Matrix Spike						
Fluoride	2	97.7	1.07137	0	0	85.0 - 115.0
MERCURY BY COLD VAPOR						
Analytical Spike						
Mercury	14	95.4	6.69796	0	0	75.0 - 125.0
ICP 25 ELEMENT SCAN						
Analytical Spike						
Aluminum	14	91.4	2.49945	0	0	75.0 - 125.0
Antimony	14	84.5	3.56802	0	0	75.0 - 125.0
Arsenic	14	102.4	1.74154	0	0	75.0 - 125.0
Barium	14	88.7	1.68379	0	0	75.0 - 125.0

(Continued)

TABLE 4-13. (Continued)

Parameter	Number of Samples	Mean \bar{X} Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
Beryllium	14	89.6	1.86495	0	0	75.0 - 125.0
Boron	14	101.6	12.53676	0	0	75.0 - 125.0
Cadmium	14	86.6	1.90575	0	0	75.0 - 125.0
Calcium	14	94.8	4.11710	0	0	75.0 - 125.0
Chromium	14	86.8	1.84718	0	0	75.0 - 125.0
Cobalt	14	86.5	1.74312	0	0	75.0 - 125.0
Copper	14	87.4	1.69680	0	0	75.0 - 125.0
Iron	14	88.4	1.60357	0	0	75.0 - 125.0
Lead	14	82.9	2.47626	0	0	75.0 - 125.0
Magnesium	14	90.8	2.22498	0	0	75.0 - 125.0
Manganese	14	86.5	1.55662	0	0	75.0 - 125.0
Molybdenum	14	85.8	2.19014	0	0	75.0 - 125.0
Nickel	14	87.0	1.56893	0	0	75.0 - 125.0
Potassium	14	88.9	1.85904	0	0	75.0 - 125.0
Selenium	14	89.7	2.84006	0	0	75.0 - 125.0
Silicon	14	93.6	8.27149	0	0	75.0 - 125.0
Silver	14	86.9	2.64471	0	0	75.0 - 125.0
Sodium	14	92.0	5.33494	0	0	75.0 - 125.0
Strontium	14	88.4	1.73680	0	0	75.0 - 125.0
Thallium	14	84.9	4.12976	0	0	75.0 - 125.0
Vanadium	14	87.4	2.27746	0	0	75.0 - 125.0
Zinc	14	87.9	2.10703	0	0	75.0 - 125.0

(Continued)

TABLE 4-13. (Continued)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
NITRATE BY E353.2						
Matrix Spike						
Nitrate	1	85.0		0	0	80.0 - 120.0
LEAD BY SW7421						
Analytical Spike						
Lead	14	111.1	9.49060	0	1	75.0 - 125.0
SELENIUM BY SW7740						
Analytical Spike						
Selenium	14	87.9	30.57013	2	0	75.0 - 125.0

TABLE 4-14. SUMMARY OF SURROGATE SPIKE RESULTS, CARSWELL AFB, TEXAS

SUMMARY OF SURROGATE SPIKE RESULTS FOR MATRIX = Water (Field/Trip QC)

Parameter	Number of Samples	Mean % Recovery	Standard Deviation	Number Below Acceptance Limits	Number Above Acceptance Limits	(Matrix) Acceptance Criteria
HALOCARBONS BY EPA 601						
Surrogate Spike						
1-Bromo-4-fluorobenzene	16	121.4	14.26826	0	1	40.0 - 140.0
AROMATICS BY EPA 602						
Surrogate Spike						
1-Bromo-4-fluorobenzene	3	91.7	3.05505	0	0	40.0 - 140.0

the water systems are assumed to be fairly homogeneous at each location throughout the base, so spatial variability for any duplicate pair is assumed to be negligible. Using these assumptions, total variability is the variability due to the sample effort and analytical effort combined and as such indicate total measurement imprecision. Standard deviations and CVs for field duplicates and matrix spike duplicates are pooled to estimate total variability as a pooled standard deviation (pooled std. dev.) or pooled coefficient of variation (pooled CV).

Variability due to the analytical method can be estimated using predigestion duplicates. Although variability for these duplicates would include natural matrix effects as well as method preparation and analysis effects, comparison of predigestion duplicate results to field duplicate results and matrix spike duplicate results can provide information about the analytical system.

Total variability is discussed below for each method by matrix.

Ground Water

Generally, total variability for ground water was as expected. Little information was available from field duplicates since many analytes were not detected in samples. Also as expected, variability estimates indicate greater relative variability when concentrations are near detection limits and lesser relative variability when concentrations are significantly greater than detection limits. Methods or analytes with large variability are discussed below. Summarized results are presented in Table 5 of Appendix H of the Flightline RI.

Arsenic by SW7060 -- Sixteen pairs of matrix spike duplicates were analyzed for arsenic by Method SW7060. Variability was approximately 26% with four matrix spike results outside acceptance criteria. Results outside criteria suggest that although the average variability (pooled CV) was reasonable, results may sporadically be more imprecise than expected.

Two predigestion duplicate pairs were analyzed by SW7060 for arsenic. Mean recoveries ranged from "not detected" to 0.033 mg/L. Variability (expressed as CV%) was 33%.

Mercury by E245.1 -- Twelve field duplicate pairs were analyzed for mercury by Method E245.1. While variability was fairly high, pooled CV = 60%, it was not unreasonable because concentrations were very near detection limits. Results ranged from "not detected" to 0.0044 mg/L, concentrations at which relative variability is very great as compared to absolute variability.

Sixteen matrix spike duplicate pairs were analyzed for mercury by E245.1. Mean recoveries ranged from 87.5% to 105%. Variability was approximately 5%.

Lead by SW7421 -- Twelve field duplicates were analyzed for lead by Method SW7421. Mean concentrations ranged from both samples "not detected" to 0.81 mg/L. Variability (CV%) was 45%. Since these results are near the detection limit it is not unexpected for relative variability to be higher than expected.

Sixteen matrix spike duplicate pairs were analyzed for lead by Method SW7421. Mean percent recoveries were widely variable ranging from 23% to 132% with a pooled CV of 32%.

Two predigestion duplicate pairs were analyzed by SW7421 for lead. Mean recoveries ranged from 0.012 mg/L to 0.079 mg/L. Variability (expressed as CV%) was 89%.

Apparently, matrix affects contribute to variability but affect measurement imprecision less than overall variability.

Selenium by SW7740 -- Sixteen matrix spike duplicate pairs were analyzed for selenium by Method SW7740. Mean recoveries ranged from 39% to 96% with a pooled CV of 52%. At least one matrix spike recovery was less than

acceptance criteria, thus increasing variability. Imprecision is assumed to be solely due to matrix effects.

Hydrocarbons by E418.1 -- Four field duplicate pairs were analyzed by Method E418.1 for hydrocarbons. Variability was greater than expected at 42%. However, mean concentrations ranged from "not detected" to only 8.5 mg/L. This relative variability may be due to concentration variability near the detection limit.

Two matrix spike duplicate pairs were analyzed for hydrocarbons by Method E418.1. Mean recoveries ranged from 88% to 90% with 7% variability.

Nitrate by E353.2 -- Three field duplicates were analyzed for nitrate by Method E353.2. Total variability was 41% for means ranging from 0.095 mg/L to 0.740 mg/L.

Surface Water

Where data was available, total variability for surface water was as expected. Little information was available from field duplicates since many analytes were not detected in samples. Matrix spike duplicates were not requested for surface water samples. Variability estimates indicate greater relative variability when concentrations are near detection limits and lesser relative variability when concentrations are significantly greater than detection limits. Methods or analytes with large variability are discussed below. Summarized results are presented in Table 5 of Appendix H of the Flightline RI.

Lead by SW7421 -- Two field duplicate pairs were analyzed for lead by Method SW7421 in surface water. Concentrations were very near detection limits and as expected relative variability was high (CV = 42%).

Metals by SW6010 (ICAP) -- Two field duplicate pairs were analyzed for metals by SW6010. Total variability could not be estimated for several analytes because of "not detected" results for all samples. Of the analytes

that were detected, variability (expressed as CV%) ranged from 1% for strontium to 132% for chromium. As expected variability was greatest for analytes with concentrations near the detection limit.

Nitrate by E353.2 -- One field duplicate pair was analyzed by Method E353.2 for nitrate in surface water. Variability was 116%.

4.1.4 Sample Collection Quality Control

The QA effort for sample collection was successful and data capture complete. No samples were invalidated. Standard forms, methods, chain-of-custody and hold times were generally followed as specified. However, some chains-of-custody were not signed by the laboratory recipient.

4.1.4.1 Standard Forms

Standard forms taken from the Air Force IRP program were used to log sample collection. Standard, bound, log books (used to log field data associated with samples) and chain-of-custody forms (used to document custody of samples from time of collection to reporting analytical results) were used as specified in the QAPP. A discussion of the completeness of the sampling follows. Sample log forms were used to record sample inventory data (eg. location data, sample type, matrix, etc.). This data was entered into the project database and the forms archived by the project geologist. Chain-of-custody forms were filled out at the time samples were shipped from the field to the lab and specified analyses to be performed on each sample, the relinquishing field team member, and the recipient for the laboratory. Some chain-of-custody forms were not signed upon receipt at the lab. Sample numbers and associated analyses are presented in Table 4-15.

While lack of a signature by a laboratory representative breaks the physical chain-of-custody it may be assumed samples were handled appropriately and results are valid estimates for chemical concentrations on each sample. This assumption of valid custody is possible due to laboratory practices which

TABLE 4-15. SAMPLES WITH UNSIGNED LABORATORY RECIPIENT
CHAIN-OF-CUSTODY

Sample ID	Analysis Required
154	Chloride, Fluoride, TDS, NO ₃ , OPO ₄ , Metals
157	154 + MS
160	154 + MSD
163	Dissolved Metals, MS, MSD
168	Chloride, Fluoride, Sulfate, TDS
169	Nitrate, Orthophosphate
170	Total Metals
171	Dissolved Metals
174	Chloride, Fluoride, Sulfate, TDS
175	Chloride, Fluoride, Sulfate, TDS
176	Nitrate, Orthophosphate
177	Nitrate, Orthophosphate
178	Total Metals
179	Total Metals + Analytical Duplicate
180	Dissolved Metals
181	Dissolved Metals + Analytical Duplicate
354	Chloride, Fluoride, Sulfate, TDS
355	Nitrate, Orthophosphate
356	Total Metals
357	Dissolved Metals
358	Hydrocarbons
361	Chloride, Fluoride, Sulfate, TDS
362	Nitrate, Orthophosphate
363	Total Metals
364	Dissolved Metals
365	Hydrocarbons
367	Chloride, Fluoride, Sulfate, TDS
368	Nitrate, Orthophosphate
369	Total Metals
370	Dissolved Metals
371	Hydrocarbons
374	Chloride, Fluoride, Sulfate, TDS

TABLE 4-15

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include a picture of the samples as received and sample tracking in the laboratory database. The laboratory database provides a valid means of recording sample custody up through reporting of results and sample disposal.

Three samples were not analyzed as directed. These were samples 392, 393, and 354. These samples were collected again during field efforts.

Standard Methods

Standard methods were used for sample collection. Standard methods used for chemical analysis were presented in Table 4-1.

Hold Times

Use of method-specified, standard, sample holding times controls variability caused by samples being analyzed after constituents have partially decomposed. Data regarding hold times (e.g., log data, date analyzed, specified maximum hold time and actual day until analysis) are provided in Table 6 in Appendix H of the Flightline RI. Sample 017 was analyzed by Method 601 one day over the hold time of 14 days. Trip blanks 050, 081, 093, 114, and 359, to be analyzed by Method 602, were analyzed between three and seven days over the seven day hold time. This problem does not invalidate results of these trip blanks. As noted in the ITIR, trip blanks to be analyzed by Method 602 were not acid preserved. Because they were not acid preserved the hold times were seven days instead of 14 days as for the acid preserved field samples to be analyzed by Method 602. Trip blanks are used to identify contamination during shipping or during storage in the laboratory. Samples to be analyzed for purgeable aromatics by Method 602 are preserved to prevent biological degradation of the analytes of interest during storage (i.e., beyond the normal seven day holding time). Biological activity will depend on a number of factors, such as natural biological populations, concentration of compounds, mix of compounds, etc. Therefore, the extent to which the integrity of a given sample may be compromised by not analyzing within the seven day hold time for an unpreserved sample may vary. Historically, trip blanks for Method 602 analyses were not preserved so that the trip blank could be

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analyzed for Method 601 (where the sample is not acid preserved) or Method 602 as needed for a project. Since the preparation procedure for trip blanks renders the water practically sterile, it is generally assumed that bacterial populations will not expand to natural levels within 14 days and thus biological activity is minimal. Therefore, the results of these trip blanks are considered usable and provide information about potential shipping and handling contamination. However, it is recognized that as a worst-case situation the Method 602 results of these trip blanks may be falsely low (i.e., a false-negative result) due to biological degradation. And, as such, low-level concentrations in natural samples shipped with these trip blanks may in fact be due to shipping contamination. Natural samples possibly affected are:

- TB 050: 044, 051, 063, 069, 070,
- TB 093: 087, 094, 100,
- TB 114: 108, 115, 121, 127, 128, 129, 140.

No results are invalidated due to hold time violation.

Concentrations of compounds in natural matrix samples should be considered suspect as a false-positive if less than the maximum concentrations depicted in Table 4-9.

4.2 East Area Chemical Analytical Results

Ground-water samples from 21 wells were collected for laboratory analysis during April and May 1990. Four surface water samples were also collected. All East Area wells are completed in the Upper Zone aquifer. Figure 4-1 depicts the locations of all of the wells and surface water locations sampled in the East Area. Each sample was submitted to Radian's laboratory for the analysis of required volatile organic and inorganic constituents. Both organic and inorganic constituents in concentrations exceeding EPA primary drinking water standards (Maximum Contaminant Levels, or MCLs) were detected in the East Area in past sampling efforts. Table 4-16

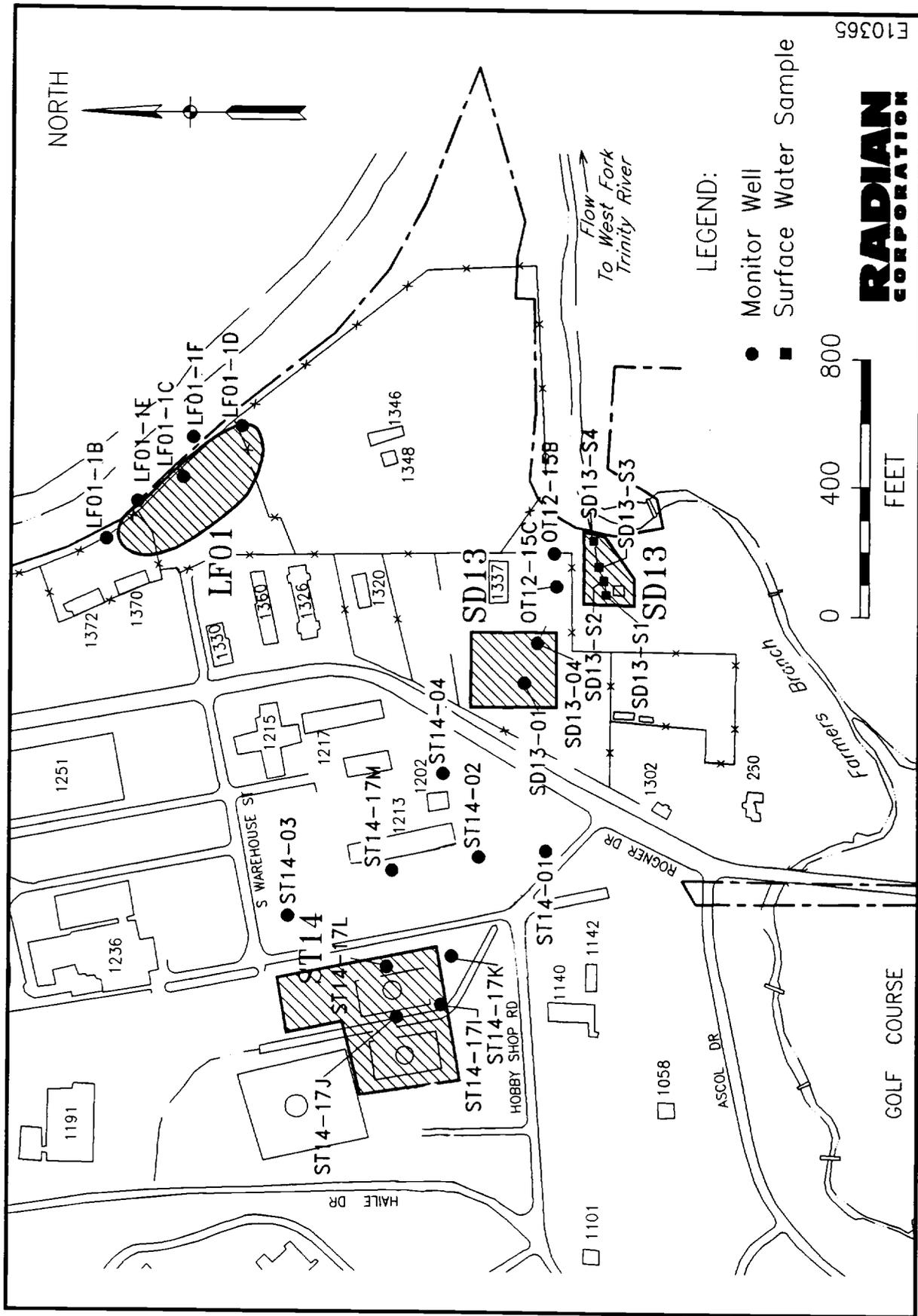


Figure 4-1. Site Map with Environmental Sampling Locations, East Area, Carswell AFB, Texas

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TABLE 4-16. SUMMARY OF MCLs RELEVANT TO THE EAST AREA STUDY (1990),
CARSWELL AFB, TEXAS

Analyte	Maximum Contaminant Level (MCL)*	
	Final, Currently in Effect	Final as of 1/30/91; Effective Date - 7/30/92
<u>Inorganics (mg/L)</u>		
Arsenic	0.05	
Barium	1.0	2.0
Cadmium	0.01	0.005
Chromium	0.05	0.1
Fluoride	4.0	4.0
Lead	0.05	
Mercury	0.002	0.002
Nitrate	10.0	10.0
Selenium	0.01	0.05
Silver	0.05	
<u>Organics (µg/L)</u>		
1,2-Dichlorobenzene		600
1,2-Dichloroethane	5.0	
1,2-Dichloropropane		5.0
1,1,1-Trichloroethane	200.0	
1,1-Dichloroethene	7.0	
1,2-Dichloroethane	5.0	
1,4-Dichlorobenzene	75.0	
cis-1,2-Dichloroethene		70
trans-1,2-Dichloroethene		100
Carbon Tetrachloride	5.0	
Ethylbenzene		700
Tetrachloroethene		5.0
Toluene		1,000
Trichloroethene	5.0	
Vinyl Chloride	2.0	
Xylenes (total)		10,000

*References:

40 CFR 141.11.

Federal Register, Vol. 52, No. 130, July 8, 1987.

Federal Register, Vol. 56, No. 20, January 30, 1991.

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lists the MCLs for those compounds for which analyses were performed in the East Area.

Since the wastes and known contaminants vary from site to site, not all samples were analyzed for the same suite of chemical constituents. Therefore, the chemical analytical results of each site are most conveniently discussed individually in the following subsections. An Informal Technical Information Report (ITIR) with analytical summary tables, QA/QC data, sample cross-reference tables and chain-of-custody forms for the recent ground-water investigation at the East Area was provided to the U. S. Air Force HSD IRP Program Office in September 1990.

4.2.1 Site LF01 - Landfill 1

Review of Available Data

Six Upper Zone monitor wells have been installed at the site (Figure 4-2). Recently, monitor well LF01-1A was destroyed during construction activities. In previous IRP investigations the principal ground-water contaminants identified at Site LF01 were total metals, and to a lesser extent, volatile organic compounds. In Stage 1, both total metals and volatile organic compounds were identified at the site at concentrations below MCLs. All volatile organic compounds identified were near instrument detection limit concentrations. Some soil samples, screened for oil and grease, contained concentrations up to 50 milligrams per kilogram (mg/kg, or parts per million).

All metals analyses performed in previous site investigations were for total metals. In the Stage 2 investigation, several metals were detected as total concentrations exceeding their MCLs in both rounds of sampling. Selenium, arsenic, barium, cadmium, chromium, and lead were each detected above their MCL in one or more samples. All of the metals identified were detected in monitor wells LF01-1E and LF01-1F. Only chromium and cadmium were detected in other wells.

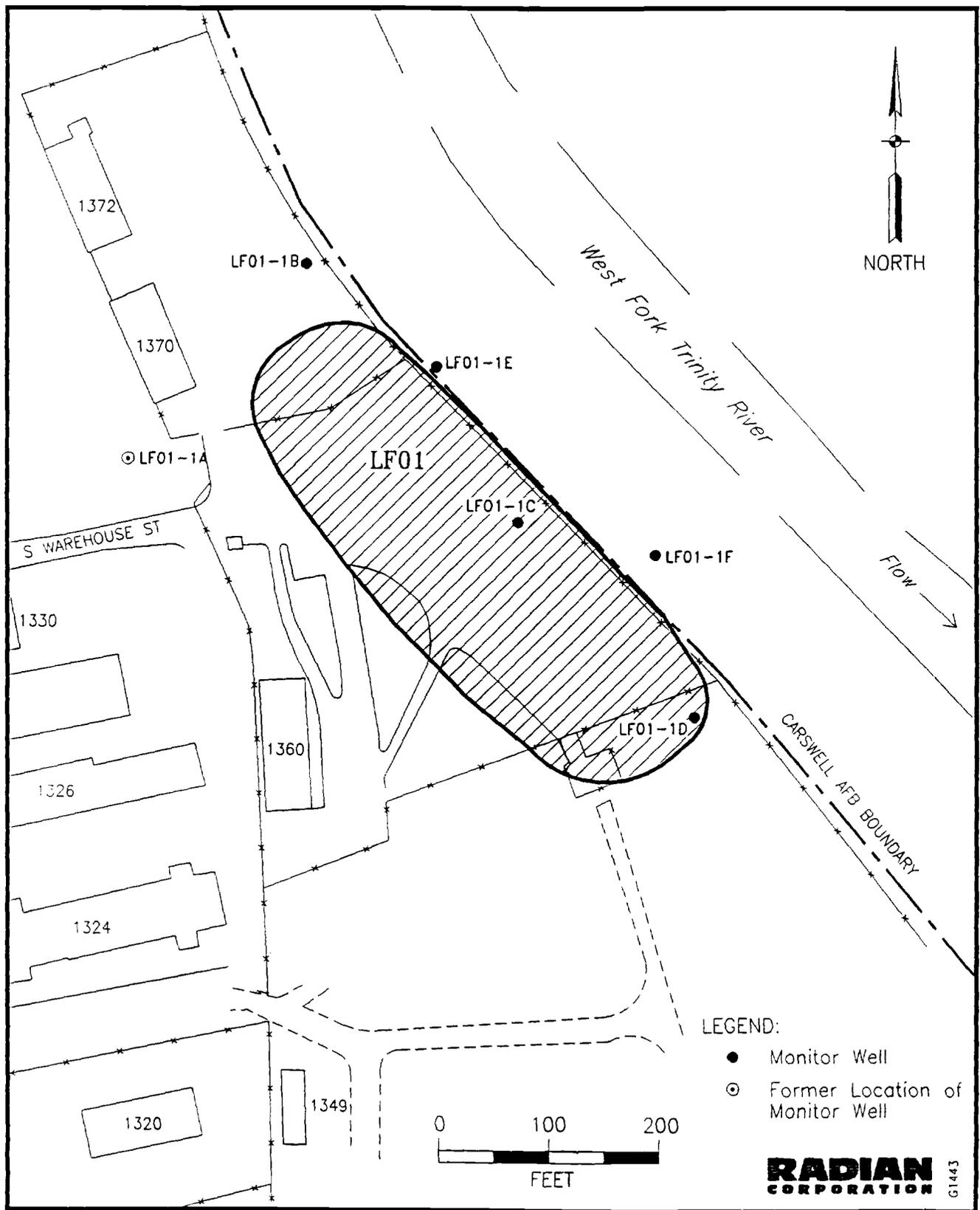


Figure 4-2. Location of Wells Sampled at Site LF01, Carswell AFB, Texas

Environmental & Engineering

Based on these data, no discrete metals contaminant plumes were identified due to the limited number of wells and the varying distribution of metals detected. However, because the metals identified in Stage 2 were generally found in higher concentrations in the downgradient wells (LF01-1E and LF01-1F) relative to background concentrations, the source of the metals was suspected to be Landfill 1.

Volatile organic compounds were detected in both rounds of ground-water samples collected during Stage 2. Trichloroethene (TCE) and vinyl chloride were detected in several wells at levels below their MCLs. No definable volatile organics contaminant plume was identified beneath Site LF01, as the distribution of detected compounds was sporadic, and the detected concentrations were very low. In the first round of sampling (February 1988), oil and grease was detected in concentrations below 1 mg/L, but was below the detection limit in all second round ground-water samples (April 1988). As a result, oil and grease contamination was not considered significant.

East Area Study - 1990 Results

Table 4-17 lists the volatile organic and inorganic constituents for which analyses were performed during the Spring 1990 sampling round at Site LF01. Table 4-18 presents a list of all volatile organic compounds whose presence was confirmed by second column analysis, along with the concentrations detected and the detection limits. A summary of the inorganic analytical results for all wells sampled at Site LF01 is presented in Table 4-19.

Results of Volatile Organic Compounds Analyses--Vinyl chloride, cis-1,2-dichloroethene, and chlorobenzene were detected in ground-water samples from Site LF01 (Table 4-18). Of these, only vinyl chloride was detected in more than one well and at a concentration above 1 $\mu\text{g}/\text{L}$. The detection limits for these compounds ranged from 0.20 to 0.25 $\mu\text{g}/\text{L}$. Consequently, in each case where one of these compounds was detected, the concentration of the compound was at or below five times its detection limit. At such levels, the concentrations are considered approximate.

TABLE 4-17. LIST OF VOLATILE ORGANIC AND INORGANIC PARAMETERS ANALYZED IN GROUND WATER, SITE LF01, CARSWELL AFB, TEXAS

Organic Parameters	Inorganic Parameters	
	Metals	Non-Metals
1,1,1-Trichloroethane	Aluminum	Chloride
1,1,2,2-Tetrachloroethane	Antimony	Fluoride
1,1,2-Trichloroethane	Arsenic	Nitrate as N
1,1-Dichloroethane	Barium	Orthophosphate
1,1-Dichloroethene	Beryllium	Sulfate
1,2-Dichlorobenzene	Boron	Total Dissolved Solids
1,2-Dichloroethane	Cadmium	
1,2-Dichloropropane	Calcium	
1,3-Dichlorobenzene	Chromium	
1,4-Dichlorobenzene	Cobalt	
2-Chloroethylvinyl ether	Copper	
Bromodichloromethane	Iron	
Bromoform	Lead	
Bromomethane	Magnesium	
Carbon tetrachloride	Manganese	
Chlorobenzene	Mercury	
Chloroethane	Molybdenum	
Chloroform	Nickel	
Chloromethane	Potassium	
Dibromochloromethane	Selenium	
Methylene chloride	Silicon	
Tetrachloroethene	Silver	
Trichloroethene	Sodium	
Trichlorofluoromethane	Strontium	
Vinyl chloride	Thallium	
cis-1,2-Dichloroethene	Vanadium	
cis-1,3-Dichloropropene	Zinc	
trans-1,2-Dichloroethene		
trans-1,3-Dichloropropene		

TABLE 4-18. SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN UPPER ZONE GROUND WATER,¹ SPRING 1990, SITE LF01, CARSWELL AFB, TEXAS

Well No.	Analyte	Concentration ² ($\mu\text{g/L}$)	Detection Limit ($\mu\text{g/L}$)
LF01-1C	Chlorobenzene	0.36	0.25
LF01-1C	Vinyl Chloride	0.58	0.20
LF01-1C	cis-1,2-Dichloroethene	0.27	0.20
LF01-1F	Vinyl Chloride	1.1	0.20
LF01-1F	cis-1,2-Dichloroethene	0.47	0.20

Notes:

¹All other analyzed organic compounds (Table 4-2) were non-detectable.

²Confirmed result by second column analysis.

TABLE 4-19. SUMMARY OF INORGANIC ANALYTES IN UPPER ZONE GROUND WATER (mg/L), SPRING 1990, SITE LF01, CARSWELL AFB, TEXAS

Analytical Parameter	EPA Primary MCLs (mg/L)	Range of Detection Limits	Range of Concentrations of Constituents Detected	Total Number of Samples		
				Analyses for Constituent (No. of Locations)	With Constituent Detected (No. of Locations)	Exceeding EPA MCL (No. of Locations)
Metals						
Aluminum		0.220	0.29-34.0	10 (5)	5 (5)	0
Antimony		0.110	ND	10 (5)	0	0
Arsenic	0.05	0.0040-0.330	0.0068-0.022	20 (5)	4 (3)	0
Barium	1.0	0.0110	0.043-0.33	10 (5)	10 (5)	0
Beryllium		0.00220	ND	10 (5)	0	0
Boron		0.660	0.94-1.2	10 (5)	2 (1)	0
Cadmium	0.01	0.00550	ND	10 (5)	0	0
Calcium		1.1	140.0-280.0	10 (5)	10 (5)	0
Chromium	0.05	0.0110	0.011-0.037	10 (5)	3 (3)	0
Cobalt		0.0110	0.015	10 (5)	1 (1)	0
Copper		0.0220	0.038	10 (5)	1 (1)	0
Iron		0.0440	0.055-37.0	10 (5)	9 (5)	0
Lead	0.05	0.0030-0.0550	0.0033-0.022	20 (5)	9 (5)	0
Magnesium		1.1	7.0-13.0	10 (5)	4 (2)	0
Manganese		0.0110	0.093-1.3	10 (5)	4 (2)	0
Mercury	0.002	0.00020	ND	10 (5)	0	0
Molybdenum		0.0550	ND	10 (5)	0	0
Nickel		0.0220	ND	10 (5)	0	0
Potassium		3.3	3.5-5.7	10 (5)	4 (3)	0
Selenium	0.010	0.0050-0.330	ND	20 (5)	0	0
Silicon		1.1	7.0-41.0	10 (5)	10 (5)	0
Silver	0.05	0.0110	ND	10 (5)	0	0
Sodium		1.1	21.0-31.0	10 (5)	10 (5)	0
Strontium		0.00330	0.41-1.3	10 (5)	10 (5)	0
Thallium		0.110	ND	10 (5)	0	0
Vanadium		0.0220	0.025-0.066	10 (5)	3 (3)	0
Zinc		0.0220	0.038-0.076	10 (5)	8 (5)	0
Non-Metals						
Chloride		1.0	13.0-48.0	10 (5)	4 (4)	0
Fluoride		0.10	0.26-0.60	10 (5)	5 (5)	0
Nitrate as N	4.0	0.040	0.12-0.40	10 (5)	4 (4)	0
Orthophosphate		0.0100	ND	10 (5)	0	0
Sulfate		1.0-2.0	6.5-370.0	10 (5)	5 (5)	0
Total Dissolved Solids		9.0	650.0-1100.0	10 (5)	5 (5)	0

ND = Not detected

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The highest concentration of vinyl chloride detected in the Spring, 1990 sampling event was 1.1 $\mu\text{g/L}$ in monitor well LF01-1F. Monitor well LF01-1C, the only other well in which vinyl chloride was detected, had a concentration of 0.58 $\mu\text{g/L}$. Vinyl chloride was also detected in monitor well LF01-1C following the April 1988 sampling event at a concentration of less than 1 $\mu\text{g/L}$. The significance of the volatile organic compounds identified at LF01 is discussed in Section 4.3.1.

Results of Metals Analyses--No metals were detected above their respective MCLs in the 1990 sampling event. However, all species but selenium were present in detectable concentrations. The potential for metals contamination at Site LF01 is discussed in Section 4.3.1.

4.2.2 Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Review of Available Data

In the Phase II Stage 1 investigation of Site SD13, several surface water samples and grab ground-water samples from three soil borings were analyzed. The results of these analyses indicated the presence of metals, oil and grease, and volatile organic compounds. The Stage 2 investigation focused on surface water only. Analytical results from Stage 2 suggested low level metals and volatile organic compounds contamination in the surface water. Oil and grease was also detected at low levels in all samples. It was observed in Stage 2 that contaminant concentrations decreased in a downstream direction, suggesting material entering the upstream oil/water separator through the french drain system as the principal contributor. The approximate locations of the french drain and the oil water separator with respect to Site SD13 are depicted in Figure 4-3.

Benzene and toluene were the most widespread volatile organic compounds detected in the surface water samples analyzed during Stage 2, with benzene detected in all samples collected in the first round of sampling. The

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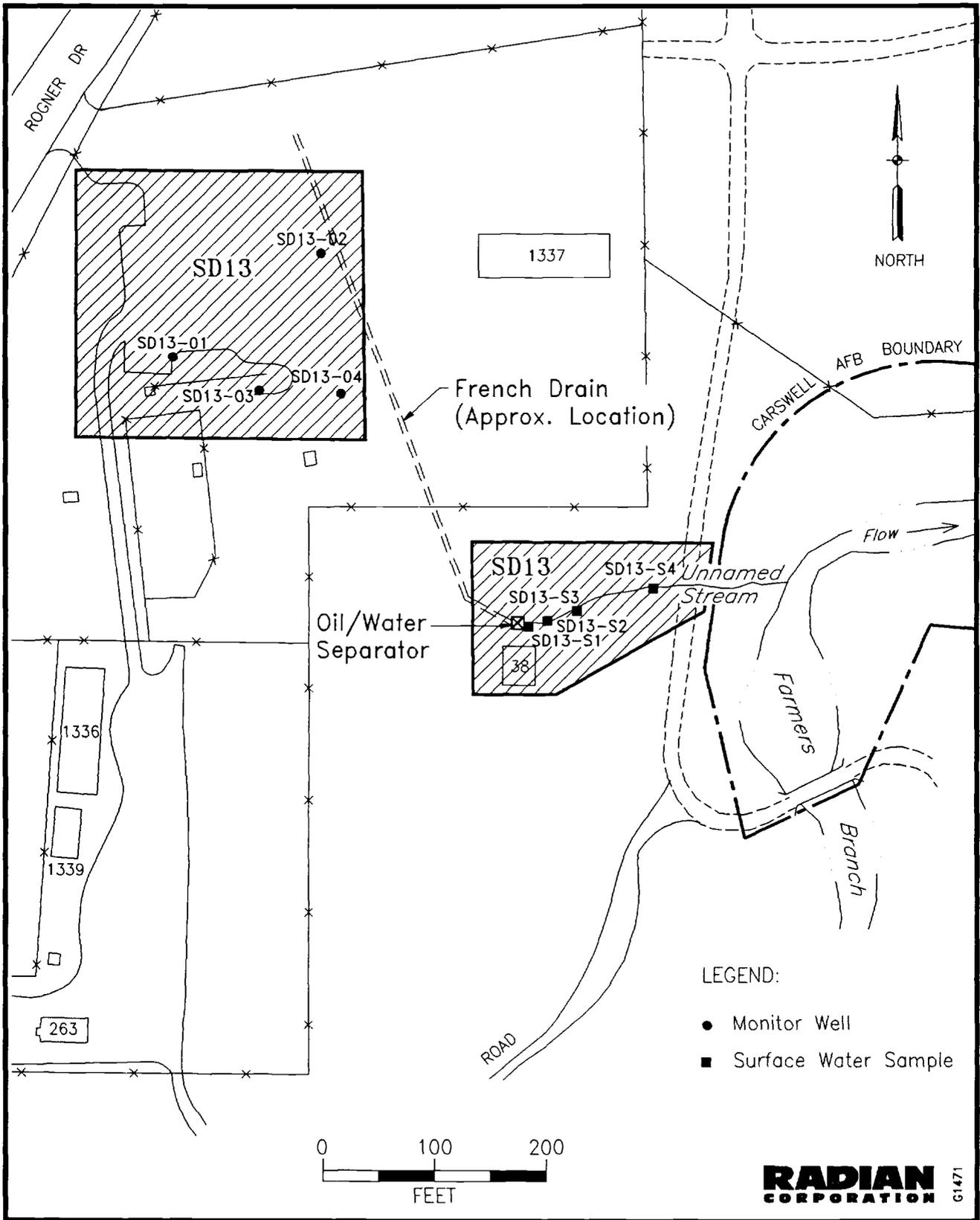


Figure 4-3. Location of Newly Installed Wells and Surface Water Sampling Locations and Approximate Locations of French Drain and Oil/Water Separator, Site SD13, Carswell AFB, Texas

highest concentration of benzene detected was 120 $\mu\text{g/L}$. Toluene was present at concentrations up to 19 $\mu\text{g/L}$. No benzene was detected in the second round of sampling during Stage 2.

East Area Study - 1990 Results

During this investigation, four monitoring wells were installed and sampled, and four surface water samples were collected for analysis. The locations of the wells and the surface water sampling points are shown on Figure 4-3. Based on previous analytical results, ground-water and surface water samples from Site SD13 were analyzed for the volatile aromatic compounds and inorganic constituents listed in Table 4-20. Tables 4-21 and 4-22 present summaries of the volatile organic compounds detected in ground-water and surface water samples, respectively. Tables 4-23 and 4-24 summarize inorganic analytical results for Site SD13 ground-water and surface water samples, respectively.

Results of Volatile Organic Compounds Analyses--Volatile organic compounds were detected in three wells and in all surface water samples collected during the 1990 sampling event, but none of the concentrations exceeded MCLs. Benzene was detected in only one well, SD13-01, at the sample detection limit concentration of 2.0 $\mu\text{g/L}$. Consequently it should be treated as an approximate value. Benzene was also detected in three of the four surface water samples, but all concentrations were less than five times the detection limit. The highest level of benzene detected in the surface water samples was 0.31 $\mu\text{g/L}$.

Toluene was detected in two ground-water samples and in one surface water sample. The maximum concentration of toluene occurred in monitor well SD13-03 (59.0 $\mu\text{g/L}$). Other volatile organic compounds detected in ground-water or surface water samples included chlorobenzene, 1,3-dichlorobenzene, xylenes (total), 1,4-dichlorobenzene and ethylbenzene. The extent of the volatile organic compounds present in ground water at Site SD13 is addressed in Section 4.3.2.

TABLE 4-20. LIST OF VOLATILE ORGANIC AND INORGANIC PARAMETERS ANALYZED IN
GROUND WATER AND SURFACE WATER, SITE SD13, CARSWELL AFB, TEXAS

Organic Parameters	Inorganic Parameters	
	Metals	Non-Metals
1,2-Dichlorobenzene	Aluminum	Chloride
1,3-Dichlorobenzene	Antimony	Fluoride
1,4-Dichlorobenzene	Arsenic	Nitrate as N
Benzene	Barium	Orthophosphate
Chlorobenzene	Beryllium	Sulfate
Ethylbenzene	Boron	Total Dissolved
Toluene	Cadmium	Solids
Xylenes (Total)	Calcium	
	Chromium	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Magnesium	
	Manganese	
	Mercury	
	Molybdenum	
	Nickel	
	Potassium	
	Selenium	
	Silicon	
	Silver	
	Sodium	
	Strontium	
	Thallium	
	Vanadium	
	Zinc	

TABLE 4-21. SUMMARY OF VOLATILE ORGANIC COMPOUND CONCENTRATIONS ($\mu\text{g/L}$) IN UPPER ZONE GROUND WATER, SPRING 1990, SITE SD13, CARSWELL AFB, TEXAS

Well No.	1,2-Dichloro- benzene	1,3-Dichloro- benzene	1,4-Dichloro- benzene	Benzene	Chlorobenzene	Ethylbenzene	Toluene	Xylenes (Total)
SD13-01	ND	ND	ND	2.0	ND	ND	12.0	ND
SD13-02	ND	ND	ND	ND	ND	ND	ND	ND
SD13-03	ND	ND	ND	ND	ND	ND	59.0	ND
SD13-04	ND	ND	ND	ND	3.6	ND	ND	ND

ND = Not detected

TABLE 4-22. SUMMARY OF VOLATILE ORGANIC COMPOUND CONCENTRATIONS ($\mu\text{g/L}$) IN SURFACE WATER, SPRING 1990, SITE SD13, CARSWELL AFB, TEXAS

Well No.	1,2-Dichloro- benzene	1,3-Dichloro- benzene	1,4-Dichloro- benzene	Benzene	Chlorobenzene	Ethylbenzene	Toluene	Xylenes (Total)
SD13-S1	ND	1.2	ND	0.26	0.65	ND	ND	0.53
SD13-S2	ND	1.0	1.7	ND	2.8	0.97	0.59	ND
SD13-S3	ND	ND	ND	0.31	2.6	ND	ND	0.37
SD13-S4	ND	ND	ND	0.23	1.2	ND	ND	ND

ND = Not detected

TABLE 4-23. SUMMARY OF INORGANIC ANALYTES IN UPPER ZONE GROUND WATER (mg/L), SPRING 1990, SITE SD13, CARSWELL AFB, TEXAS

Analytical Parameter	EPA Primary MCLs (mg/L)	Range of Detection of Limits	Range of Concentrations of Constituents Detected	Total Number of Samples		
				Analyses for Constituent (No. of Locations)	With Constituent Detected (No. of Locations)	Exceeding EPA MCL (No. of Locations)
Metals						
Aluminum		0.20	2.5-12.0	8 (4)	4 (4)	0
Antimony		0.30	ND	8 (4)	0	0
Arsenic	0.05	0.0040-0.30	0.004-0.042	16 (4)	7 (4)	0
Barium	1.0	0.010	0.21-0.63	8 (4)	8 (4)	0
Beryllium		0.0020	ND	8 (4)	0	0
Boron		0.60	0.65-1.1	8 (4)	6 (3)	0
Cadmium	0.01	0.0050	ND	8 (4)	0	0
Calcium		1.0	120.0-270.0	8 (4)	8 (4)	0
Chromium	0.05	0.010	0.010-0.024	8 (4)	3 (3)	0
Cobalt		0.010	0.011-0.017	8 (4)	3 (3)	0
Copper		0.020	0.022-0.023	8 (4)	2 (2)	0
Iron		0.040	1.1-4.0	8 (4)	8 (4)	0
Lead	0.05	0.0030-0.030	0.020-0.031	16 (4)	5 (5)	0
Magnesium		1.0	4.8-9.5	8 (4)	8 (4)	0
Manganese		0.010	0.079-0.46	8 (4)	8 (4)	0
Mercury	0.002	0.00020	ND	8 (4)	0	0
Molybdenum		0.050	ND	8 (4)	0	0
Nickel		0.020	0.031-0.041	8 (4)	3 (3)	0
Potassium		3.0	3.6	8 (4)	1 (1)	0
Selenium	0.010	0.050	ND	16 (4)	0	0
Silicon		1.0	7.7-36.0	8 (4)	8 (4)	0
Silver		0.010	0.010-0.012	8 (4)	4 (3)	0
Sodium	0.05	1.0	25.0-29.0	8 (4)	8 (4)	0
Strontium		0.0030	0.23-0.56	8 (4)	8 (4)	0
Thallium		0.10	ND	8 (4)	0	0
Vanadium		0.020	0.038-0.058	8 (4)	3 (3)	0
Zinc		0.020	0.028-0.13	8 (4)	8 (4)	0
Non-Metals						
Chloride		1.0	24.0-26.0	8 (4)	4 (4)	0
Fluoride		0.10	0.20-0.29	8 (4)	4 (4)	0
Nitrate as N	4.0	0.020	0.11-0.14	8 (4)	4 (4)	0
Orthophosphate		0.010	ND	8 (4)	0	0
Sulfate		1.0	2.1-13.0	8 (4)	3 (3)	0
Total Dissolved Solids		9.0	390.0-460.0	8 (4)	4 (4)	0

ND = Not detected

TABLE 4-24. SUMMARY OF INORGANIC ANALYTES IN SURFACE WATER (mg/L), SPRING 1990,
SITE SD13, CARSWELL AFB, TEXAS

Analytical Parameter	EPA Primary MCLs (mg/L)	Range of Detection Limits	Range of Concentrations of Constituents Detected	Total Number of Samples		
				Analyses for Constituent (No. of Locations)	With Constituent Detected (No. of Locations)	Exceeding EPA MCL (No. of Locations)
Metals						
Aluminum		0.22	ND	8 (4)	0	0
Antimony		0.11	ND	8 (4)	0	0
Arsenic	0.05	0.0040-0.0080	0.037-0.086	16 (4)	8 (4)	2 (2)
Barium	1.0	0.011	0.24-0.29	8 (4)	8 (4)	0
Beryllium		0.0022	ND	8 (4)	0	0
Boron		0.66	ND	8 (4)	0	0
Cadmium	0.01	0.0055	ND	8 (4)	0	0
Calcium		1.1	110-130	8 (4)	8 (4)	0
Chromium	0.05	0.011	ND	8 (4)	0	0
Cobalt		0.011	0.011	8 (4)	2 (2)	0
Copper		0.022	0	8 (4)	0	0
Iron		0.044	7.6-26.0	8 (4)	8 (4)	0
Lead	0.05	0.0030-0.055	0.0035-0.066	16 (4)	4 (4)	1 (1)
Magnesium		1.1	5.5-6.4	8 (4)	0	0
Manganese		0.011	0.18-0.21	8 (4)	8 (4)	0
Mercury	0.002	0.00020	ND	8 (4)	0	0
Molybdenum		0.055	ND	8 (4)	0	0
Nickel		0.022	ND	8 (4)	0	0
Potassium		3.3	ND	8 (4)	0	0
Selenium	0.010	0.0050-0.33	30.0	16 (4)	1 (1)	1 (1)
Silicon		1.1	ND	8 (4)	0	0
Silver	0.05	0.011	ND	8 (4)	0	0
Sodium		1.1	ND	8 (4)	0	0
Strontium		0.0033	ND	8 (4)	0	0
Thallium		0.11	ND	8 (4)	0	0
Vanadium		0.022	ND	8 (4)	0	0
Zinc		0.022	ND	8 (4)	0	0
Non-Metals						
Chloride		1.0	23.0-26.0	8 (4)	4 (4)	0
Fluoride		0.10	0.28-0.29	8 (4)	4 (4)	0
Nitrate as N	4.0	0.040-0.10	0.33-0.56	8 (4)	4 (4)	0
Orthophosphate		0.010	0.022-0.024	8 (4)	2 (2)	0
Sulfate		5.0	16.0	8 (4)	1 (1)	0
Total Dissolved Solids		9.0	260-470	8 (4)	3 (3)	0

ND = Not detected

Results of Metals Analyses--No metals were detected in either the unfiltered or the filtered ground-water samples in excess of MCLs (Table 4-21). Metals were detected in all of the surface water samples collected. However, only two surface water samples contained metals in excess of MCLs (SD13-S1 and SD13-S2). The highest metals concentrations were detected in SD13-S1, the farthest upstream sample (Figure 4-3). In this sample, total selenium was detected at 30 mg/L, and total arsenic was detected at 0.086 mg/L. In sample SD13-S2, total arsenic was detected at 0.052 mg/L and total lead was detected at 0.066 mg/L. Both of these concentrations in SD13-S2 occurred in the unfiltered sample and are slightly above their respective MCLs. Arsenic, barium and lead were detected in each of the SD13 surface water samples (Table 4-22).

Of the three metals species which exceeded their MCLs, only selenium was detected above the MCL in the dissolved metals analysis. This concentration was subsequently determined to be a reporting error and the actual dissolved selenium concentration was below detection. The extent and significance of metals in the surface water at Site S13 is discussed in Section 4.3.2.

4.2.3 Site ST14 - POL Tank Farm

Review of Available Data

Grab water samples collected from soil borings at Site ST14 were screened for Total Organic Carbon (TOC), oil and grease, and Total Organic Halogens (TOX) in the Stage 1 investigation. All parameters were above detection limits in one or more samples. In Stage 2, monitor wells were installed and a soil gas survey was performed. A hydrocarbon odor was noticeable during drilling. Analytical results indicated the presence of metals and volatile aromatic compounds at the site. One of the principal contaminants identified at the site was benzene, which was detected in a ground-water sample from one well at a concentration of 11,000 µg/L. In addition, arsenic, lead, barium, cadmium and chromium were all identified in the total metals analyses at concentrations exceeding MCLs.

East Area Study - 1990 Results

Four new ground-water monitoring wells were installed in 1990. The new and existing wells were sampled for the volatile aromatic compounds and inorganic parameters listed in Table 4-25. Figure 4-4 depicts the location of all of the sampled wells. Table 4-26 presents a summary of the volatile organic compounds analytical results, and Table 4-27 summarizes the inorganic analytical results for Site ST14.

Results of Volatile Organic Compounds Analyses--Several volatile aromatic compounds were detected at Site ST14. These included ethylbenzene, benzene, chlorobenzene and total xylenes. Ethylbenzene was the most common, being detected in six of the nine wells sampled, and having a maximum concentration of 35 $\mu\text{g/L}$ in monitor well ST14-04. The next highest concentration detected was less than 5 $\mu\text{g/L}$. The final MCL for ethylbenzene was promulgated on 30 January 1991 and is 700 $\mu\text{g/L}$ (Table 4-16); however, it will not be effective until July 1992.

Benzene was detected in four of the nine wells sampled at Site ST14. The MCL for benzene was exceeded in one well, ST14-17M. A concentration of 11,000 $\mu\text{g/L}$ benzene was detected in this well during the first round of sampling during the Stage 2 investigation; however, no benzene was detected in the second round sample from this well. Other wells in which benzene was detected during the 1990 sampling event include ST14-17J (3.8 $\mu\text{g/L}$), ST14-03 (1.3 $\mu\text{g/L}$), ST14-17L (0.65 $\mu\text{g/L}$), and ST14-17K (0.50 $\mu\text{g/L}$). The interpreted distribution of benzene and other volatile organic compounds detected in the ground water below Site ST14 is discussed in Section 4.3.3.

Total xylenes and chlorobenzene were also detected at Site ST14. Xylenes were detected in three wells, ST14-03, ST14-04 and ST14-17M. Xylenes were also detected in the duplicate sample collected at monitor well ST14-17J. The highest concentration of total xylenes was 300 $\mu\text{g/L}$ in ST14-17M. As in the case of ethylbenzene, the final MCL for total xylenes (10,000 $\mu\text{g/L}$) was

TABLE 4-25. LIST OF VOLATILE ORGANIC AND INORGANIC PARAMETERS ANALYZED IN GROUND WATER, SITE ST14, CARSWELL AFB, TEXAS

Organic Parameters	Inorganic Parameters	
	Metals	Non-Metals
1,2-Dichlorobenzene	Aluminum	Chloride
1,3-Dichlorobenzene	Antimony	Fluoride
1,4-Dichlorobenzene	Arsenic	Nitrate as N
Benzene	Barium	Orthophosphate
Chlorobenzene	Beryllium	Sulfate
Ethylbenzene	Boron	Total Dissolved
Toluene	Cadmium	Solids
Xylenes (Total)	Calcium	
	Chromium	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Magnesium	
	Manganese	
	Mercury	
	Molybdenum	
	Nickel	
	Potassium	
	Selenium	
	Silicon	
	Silver	
	Sodium	
	Strontium	
	Thallium	
	Vanadium	
	Zinc	

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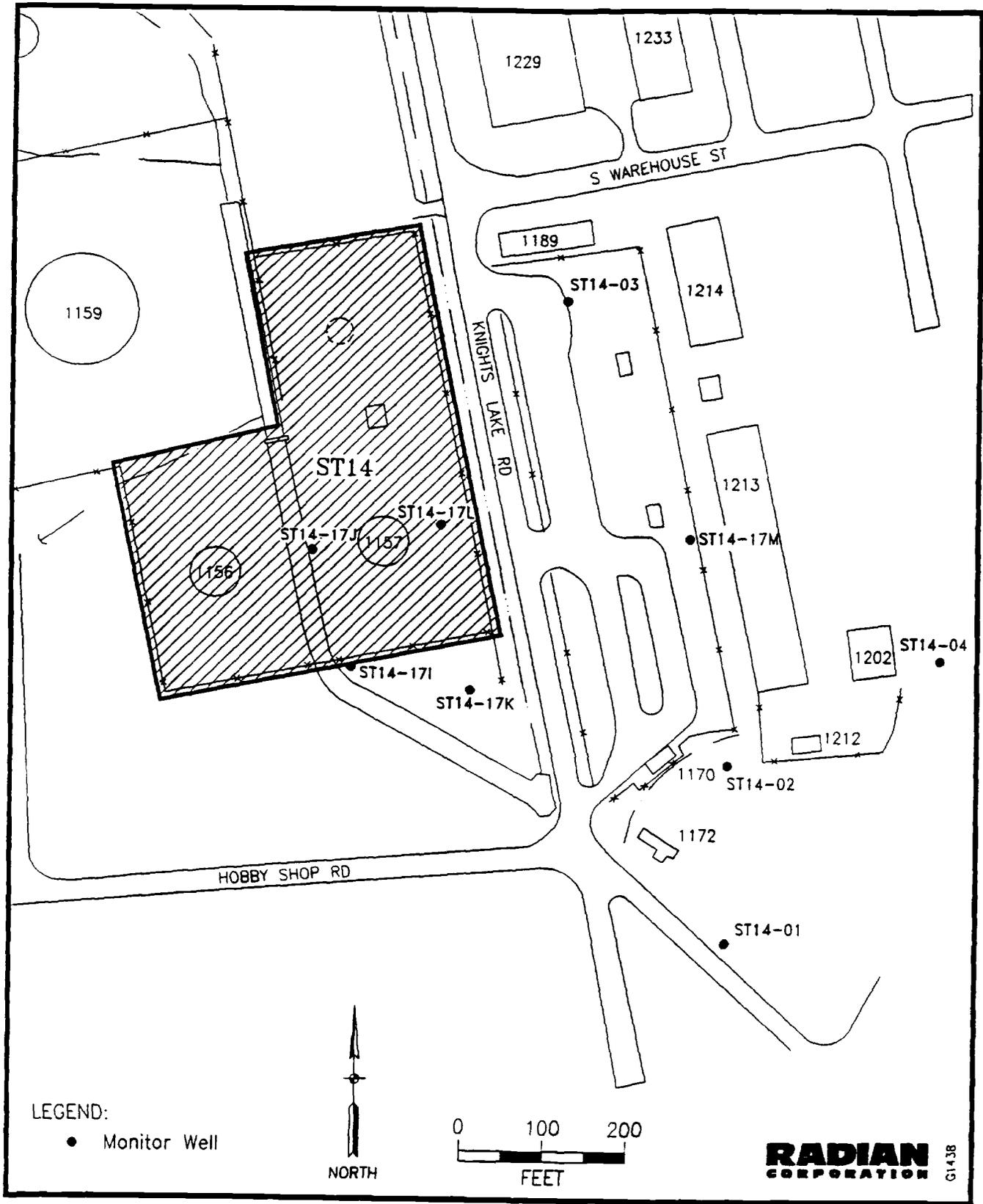


Figure 4-4. Location of Wells Sampled at Site ST14, Carswell AFB, Texas

TABLE 4-26. SUMMARY OF VOLATILE ORGANIC COMPOUND CONCENTRATIONS ($\mu\text{g/L}$) IN UPPER ZONE GROUND WATER, SPRING 1990, SITE ST14, CARSWELL AFB, TEXAS

Well No.	1,2-Dichloro- benzene	1,3-Dichloro- benzene	1,4-Dichloro- benzene	Benzene	Chlorobenzene	Ethylbenzene	Toluene	Xylenes (Total)
ST14-01	ND	ND	ND	ND	ND	0.68	ND	ND
ST14-02	ND	ND	ND	ND	ND	4.3	ND	ND
ST14-03	ND	ND	ND	1.3	ND	0.57	ND	0.39
ST14-04	ND	ND	ND	ND	ND	35.0	ND	36.0
ST14-17I	ND	ND	ND	ND	ND	0.73	ND	ND
ST14-17J	ND	ND	ND	3.8	ND	1.3	3.7	ND
ST14-17K	ND	ND	ND	0.50	ND	ND	2.4	ND
ST14-17L	ND	ND	ND	0.65	0.45	ND	ND	ND
ST14-17M	ND	ND	ND	16.0 [#]	38.0	ND	22.0	300

[#] Exceeds EPA MCL for this compound.

ND = Compound not present in detectable quantity.

TABLE 4-27. SUMMARY OF INORGANIC ANALYTES IN UPPER ZONE GROUND WATER (mg/L), SPRING 1990, SITE ST14, CARSWELL AFB, TEXAS

Analytical Parameter	EPA Primary MCLs (mg/L)	Range of Detection Limits	Range of Concentrations of Constituents Detected	Total Number of Samples		
				Analyses for Constituent (No. of Locations)	With Constituent Detected (No. of Locations)	Exceeding EPA MCL (No. of Locations)
Metals						
Aluminum		0.20	0.71-36.0	18 (9)	10 (9)	0
Antimony		0.100	ND	18 (9)	0	0
Arsenic	0.05	0.0040-0.0080	0.0059-0.039	36 (9)	13 (8)	0
Barium	1.0	0.010	0.092-0.58	18 (9)	18 (9)	0
Beryllium		0.0020	0.002-0.007	18 (9)	4 (3)	0
Boron		0.600	0.63-3.8	18 (9)	6 (5)	0
Cadmium	0.01	0.0050	0.007	18 (9)	1 (1)	0
Calcium		1.0	120.0-550.0	18 (9)	18 (9)	0
Chromium	0.05	0.010	0.011-0.066	18 (9)	8 (8)	1 (1)
Cobalt		0.010	0.011-0.029	18 (9)	6 (6)	0
Copper		0.020	0.02-0.07	18 (9)	4 (4)	0
Iron		0.040	0.12-72.0	18 (9)	18 (9)	0
Lead	0.05	0.0030-0.050	0.0042-0.69	36 (9)	15 (9)	3 (3)
Magnesium		1.0	4.5-14.0	18 (9)	18 (9)	0
Manganese		0.010	0.016-0.73	18 (9)	18 (9)	0
Mercury	0.002	0.00020	ND	18 (9)	0	0
Molybdenum		0.050	ND	18 (9)	0	0
Nickel		0.020	0.026-0.072	18 (9)	5 (5)	0
Potassium		3.0	3.6-7.3	18 (9)	7 (7)	0
Selenium	0.010	0.050	ND	36 (9)	0	0
Silicon		2.0	7.4-75.0	18 (9)	17 (9)	0
Silver	0.05	0.010	0.013-0.036	18 (9)	3 (3)	0
Sodium		1.0	17.0-32.0	18 (9)	18 (9)	0
Strontium		0.0030	0.20-0.71	18 (9)	18 (9)	0
Thallium		0.10	ND	18 (9)	0	0
Vanadium		0.020	0.033-0.17	18 (9)	8 (8)	0
Zinc	5.0	0.020	0.023-0.12	18 (9)	16 (8)	0
Non-Metals						
Chloride		1.0	20.0-35.0	18 (9)	9 (9)	0
Fluoride	4.0	0.10	0.21-0.3	18 (9)	9 (9)	0
Nitrate as N		0.020	0.11-1.1	18 (9)	9 (9)	0
Orthophosphate		0.010	ND	18 (9)	0	0
Sulfate		1.0	2.1-37.0	18 (9)	9 (9)	0
Total Dissolved Solids		9.0	410.0-1200.0	18 (9)	9 (9)	0

ND = Not detected

0104-04

recently promulgated and is not currently in effect (Table 4-16). Chlorobenzene was detected in only two monitor wells, at a maximum concentration of 38.0 $\mu\text{g/L}$ (ST14-17M). The highest concentrations of benzene, chlorobenzene and total xylenes were all found at monitor well ST14-17M. Over 2 feet of free product was also present in this well during the 1990 sampling event.

Results of Metals Analyses--Numerous metal species were detected in the ground water at Site ST14. However, only two metals were detected above their MCLs. Lead exceeded the MCL in three wells, at a maximum concentration of 0.69 mg/L (total lead). Total chromium exceeded its MCL in one well, with a concentration of 0.066 mg/L. The MCL for both lead and chromium is 0.05 mg/L. Both total lead (AA analysis) and total chromium were detected above their MCLs in monitor well ST14-04. However, total lead by ICPEs analysis on the same sample was below detection.

Monitor wells ST14-17M and ST14-02 were the other wells in which lead was detected above the MCL. Dissolved lead was reported slightly above its MCL in the AA analysis of the filtered sample collected from monitor well ST14-02. However, the corresponding reported total concentration was below the MCL; and both of the ICPEs results (total and dissolved) were below the detection limit of 0.05 mg/L. Only one other sample collected from any East Area site (SD13-S1) had any dissolved metal concentration over the MCL. The occurrence of lead at Site ST14 is discussed in Section 4.3.3 of this report.

4.2.4 Site BSS - Base Service Station

Review of Available Data

Metals and volatile aromatic compounds were identified as contaminants of concern during previous investigations at Site BSS. Total concentrations of lead and chromium were detected in unfiltered samples from each of the three wells at the site at levels above their MCLs. Total arsenic also exceeded its MCL. Figure 4-5 shows the Site BSS monitor well locations.

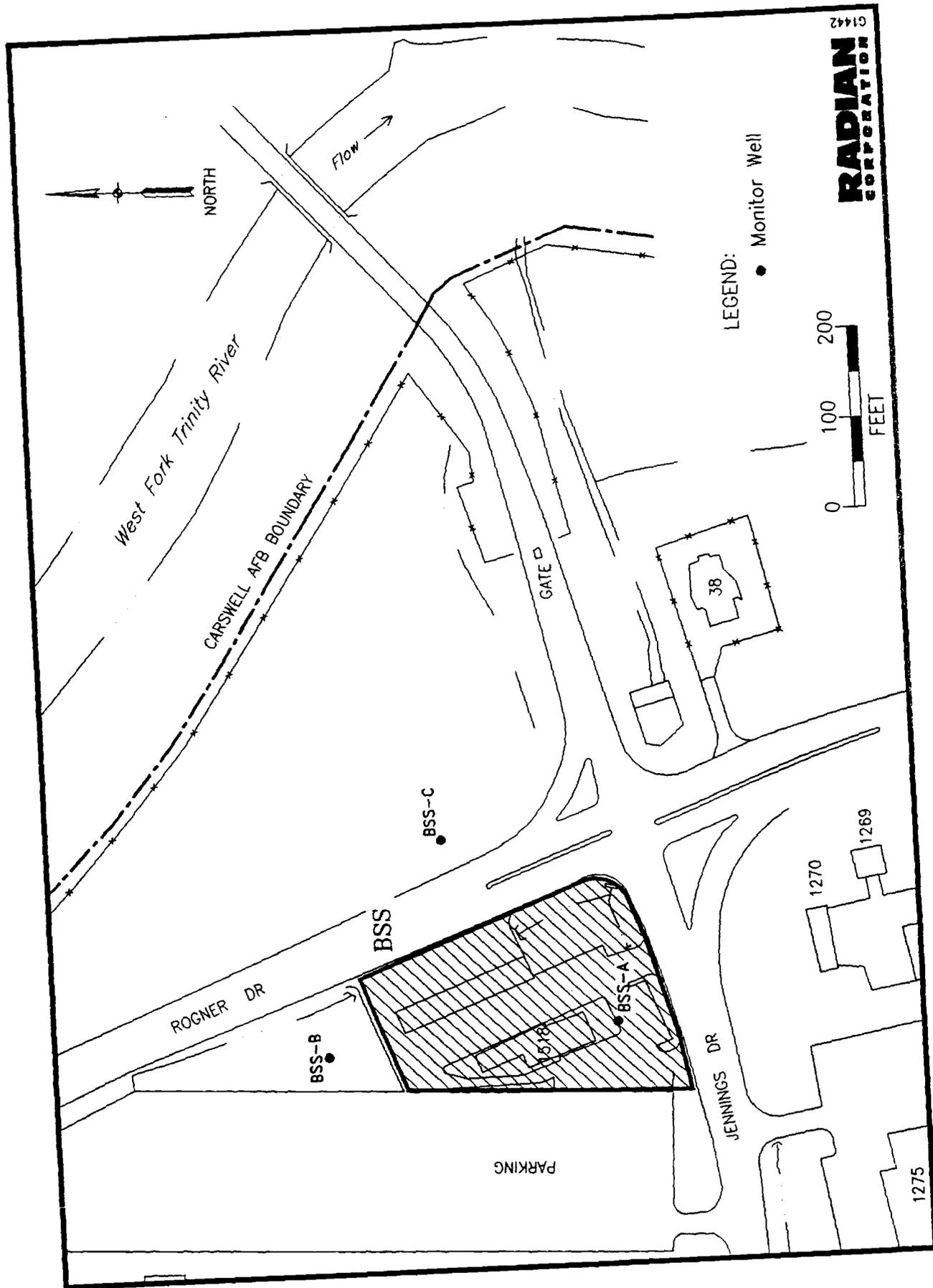


Figure 4-5. Location of Monitor Wells at Site BSS, Carswell AFB, Texas

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Benzene, ethylbenzene, toluene and xylenes were all detected at Site BSS. Benzene, ethylbenzene and toluene were detected in monitor well BSS-B in excess of their respective MCLs in both rounds of Stage 2 sampling. Benzene was detected at 4,400 $\mu\text{g}/\text{L}$ in the first round. Lower levels of all three compounds (below MCLs) were also detected in the other two BSS wells.

East Area Study - 1990 Results

Results of Volatile Organic Compounds Analyses--Site BSS was sampled for the same suite of volatile aromatic compounds as Sites SD13 and ST14. Table 4-28 lists the organic and inorganic parameters for which analyses were performed. No volatile organic compounds were detected in either BSS-A or BSS-C. The data appear to confirm the findings of Stage 2, that volatile organic contamination at Site BSS is very localized, and is centered around monitor well BSS-B. Table 4-29 summarizes the analytical results for volatile organic compound at Site BSS.

Benzene, toluene and total xylenes were detected in the ground-water sample collected from monitor well BSS-B, and each of these compounds was detected above its MCL. Benzene was detected at 3,200 $\mu\text{g}/\text{L}$ (similar to the concentration detected in Stage 2). Toluene and total xylenes were detected at 16,000 and 15,000 $\mu\text{g}/\text{L}$, respectively. Final MCLs for toluene and total xylenes are not as yet in effect.

Results of Metals Analyses--Numerous metals species were identified in the ground water from Site BSS wells (Table 4-30). Arsenic, barium, lead and zinc were detected in all wells.

Total concentrations of lead, chromium and arsenic were detected above their MCLs in unfiltered samples collected during Stage 2, however, these nor any other metals were detected above their MCLs in any of the filtered samples collected during the 1990 sampling event. Only one unfiltered sample (BSS-C) contained total cadmium in excess of its MCL, with a concentration of 0.011 $\mu\text{g}/\text{L}$. No dissolved cadmium was detected in the corresponding filtered sample. The significance of these results with respect to

TABLE 4-28. LIST OF VOLATILE ORGANIC AND INORGANIC PARAMETERS ANALYZED
 IN GROUND WATER, BASE SERVICE STATION (SITE BSS),
 CARSWELL AFB, TEXAS

Organic Parameters	Inorganic Parameters	
	Metals	Non-Metals
1,2-Dichlorobenzene	Aluminum	Chloride
1,3-Dichlorobenzene	Antimony	Fluoride
1,4-Dichlorobenzene	Arsenic	Nitrate as N
Benzene	Barium	Orthophosphate
Chlorobenzene	Beryllium	Sulfate
Ethylbenzene	Boron	Total Dissolved
Toluene	Cadmium	Solids
Xylenes (Total)	Calcium	
	Chromium	
	Cobalt	
	Copper	
	Iron	
	Lead	
	Magnesium	
	Manganese	
	Mercury	
	Molybdenum	
	Nickel	
	Potassium	
	Selenium	
	Silicon	
	Silver	
	Sodium	
	Strontium	
	Thallium	
	Vanadium	
	Zinc	

TABLE 4-29. SUMMARY OF VOLATILE ORGANIC COMPOUND CONCENTRATIONS ($\mu\text{g/L}$) IN UPPER ZONE GROUND WATER, SPRING 1990, BASE SERVICE STATION (SITE BSS), CARSWELL AFB, TEXAS

Well No.	1,2-Dichloro- benzene	1,3-Dichloro- benzene	1,4-Dichloro- benzene	Benzene	Chlorobenzene	Ethylbenzene	Toluene	Xylenes (Total)
BSS-A	ND	ND	ND	ND	ND	ND	ND	ND
BSS-B	ND	ND	ND	3,200	ND	ND	16,000	15,000
BSS-C	ND	ND	ND	ND	ND	ND	ND	ND

ND = Compound not present in detectable quantity.

TABLE 4-30. SUMMARY OF INORGANIC ANALYTES IN UPPER ZONE GROUND WATER (mg/L), SPRING 1990, BASE SERVICE STATION (SITE BSS), CARSWELL AFB, TEXAS

Analytical Parameter	EPA Primary MCLs (mg/L)	Range of Detection Limits	Range of Concentrations of Constituents Detected	Total Number of Samples		
				Analyses for Constituent (No. of Locations)	With Constituent Detected (No. of Locations)	Exceeding EPA MCL (No. of Locations)
Metals						
Aluminum		0.220	0.88-8.3	6 (3)	3 (3)	0
Antimony		0.110	ND	6 (3)	0	0
Arsenic	0.05	0.0040-0.330	0.017-0.032	12 (3)	5 (3)	0
Barium	1.0	0.0110	0.15-0.31	6 (3)	6 (3)	0
Beryllium		0.00220	0.0059	6 (3)	1 (1)	0
Boron		0.660	ND	6 (3)	0	0
Cadmium	0.01	0.00550	0.011	6 (3)	1 (1)	0
Calcium		1.1	130.0-200.0	6 (3)	1 (1)	1 (1)
Chromium	0.05	0.0110	0.015	6 (3)	6 (3)	0
Cobalt		0.0110	0.015-0.018	6 (3)	1 (1)	0
Copper		0.0220	ND	6 (3)	2 (2)	0
Iron		0.0440	4.4-35.0	6 (3)	0	0
Lead	0.05	0.0030-0.0550	0.0047-0.042	12 (3)	6 (3)	0
Magnesium		1.1	7.6-13.0	6 (3)	5 (3)	0
Manganese		0.0110	0.36-1.2	6 (3)	6 (2)	0
Mercury	0.002	0.00020	ND	6 (3)	6 (3)	0
Molybdenum		0.0550	ND	6 (3)	0	0
Nickel		0.0220	ND	6 (3)	0	0
Potassium		3.3	ND	6 (3)	0	0
Selenium	0.010	0.0050-0.330	ND	6 (3)	0	0
Silicon		1.1	ND	12 (3)	0	0
Silver		0.0110	7.7-22.0	6 (3)	0	0
Sodium	0.05	1.1	0.014-0.021	6 (3)	6 (3)	0
Strontium		0.0030	51.0-72.0	6 (3)	3 (2)	0
Thallium		0.11	0.49-0.96	6 (3)	5 (3)	0
Vanadium		0.0220	ND	6 (3)	6 (3)	0
Zinc		0.0220	0.044	6 (3)	0	0
			0.025-31.0	6 (3)	1 (1)	0
				6 (3)	6 (3)	0
Non-Metals						
Chloride		1.0	54.0-69.0	6 (3)	3 (3)	0
Fluoride	4.0	0.10	0.34-0.68	6 (3)	3 (3)	0
Nitrate as N		0.020-0.040	0.3-1.4	6 (3)	3 (3)	0
Orthophosphate		0.010	ND	6 (3)	0	0
Sulfate		5-10	38-64	6 (3)	3 (3)	0
Total Dissolved Solids		9	590.0-720.0	6 (3)	3 (3)	0

ND = Not detected

4-10-1990

Two surface water analyses showed that arsenic and lead exceeded their respective MCLs, with arsenic exceeding the MCL in both samples. All results above MCLs reflect total concentrations. A reported dissolved selenium concentration above the MCL in one surface water sample is erroneous and should have been reported as "ND."

4-14-00

4.3.3 Site ST14 - POL Tank Farm

Benzene, ethylbenzene, chlorobenzene, toluene and total xylenes were detected in the ground water at Site ST14. Of these, ethylbenzene was the most common. Benzene was the only volatile organic compound detected at a concentration which exceeded its MCL.

During Stage 2, a contaminant plume map was prepared for total volatile organic compounds at Site ST14 based on a soil gas investigation conducted in the area. The contamination underlying Site ST14 and vicinity appeared to be divided into two regions; the first associated with Tanks 1156 and 1157, and the second associated with the adjacent fuel loading facility. Ground-water contaminant occurrence and concentrations of volatile organic compounds corroborated the existence and the areal distribution of the plume interpreted from the soil gas survey. Figure 4-6 depicts the volatile organic plume map prepared for Stage 2.

Figure 4-7 depicts the probable extent of benzene contamination at Site ST14, based on the most recent analytical data and the distribution of soil gas determined in the Stage 2 survey. As in Stage 2, two separate accumulations of benzene are suggested. These plumes are roughly coincident with the two plumes interpreted during Stage 2. Monitor well ST14-17M, located at the center of the benzene plume beneath the fuel loading facility, had the highest concentration of benzene (16.0 $\mu\text{g}/\text{L}$), and the only detected concentration in excess of the MCL. Over two feet of free product was

encountered in ST14-17M during the 1990 sampling event. The highest concentrations of chlorobenzene, toluene and total xylenes were also detected in this well.

Figure 4-6 suggests that the maximum downgradient limit of the benzene plume associated with the fuel loading facility may occur north of monitor wells ST14-02 or ST14-04 where no benzene was detected. However, due to the distance between these two wells and the uncertainty with regard to the site-specific direction of ground-water flow, this interpretation is not conclusive. The benzene plume associated with Tanks 1156 and 1157 is adequately defined, as no benzene was detected in downgradient monitor wells ST14-17I or ST14-17K. The well in which the maximum concentration of ethylbenzene was detected (35 $\mu\text{g/L}$) was ST14-04, the farthest downgradient well at the site. No ethylbenzene was detected at monitor well ST14-17M.

Chromium was detected above its MCL in only one well at Site ST14, and this concentration was measured in the total metals analysis. Lead was detected above MCLs in three monitor well samples at ST14, but only one was in the dissolved metals analysis and it is considered suspect (see discussion in Section 4.2.3).

As previously discussed, total metals concentrations are not completely representative of actual water quality. Therefore, a single dissolved lead concentration above the MCL would not necessarily indicate ground-water contamination, even if it were not suspect. However, if the most recently obtained analytical results are abnormally low due to high precipitation, there is a low probability that a plume could exist. In this scenario, the maximum downgradient extent of the postulated lead contamination at Site ST14 might be delineated by adjacent Site SD13, where no monitor well samples contained lead in excess of the MCL.

4.3.4 Site BSS - Base Service Station

Both volatile organic compounds and metals were identified at Site BSS. In the Stage 2 investigation, the volatile organic compounds were

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detected primarily in monitor well BSS-B. In samples collected during the Spring 1990 sampling event, volatile organic compounds were detected only in monitor well BSS-B. Because of the localized nature of the volatile organic contamination detected previously and in the 1990 study, the underground storage tank adjacent to monitor well BSS-B is considered the most likely source of the observed contamination.

Cadmium was detected above the MCL at 0.011 $\mu\text{g}/\text{L}$ in monitor well BSS-C in the total metals analysis. Cadmium was not detected in any adjacent well, or in the filtered sample (dissolved metal fraction) from the same well. Therefore, no ground-water contamination by cadmium at the site, barring significant dilution effects due to high precipitation during the 1990 sampling event, is interpreted.

5.0 CONTAMINANT FATE AND TRANSPORT

The purpose of this section is to discuss the migration and persistence of contaminants in ground water and surface water of the East Area at Carswell AFB. The contaminants discussed in this section are limited to those volatile organic compounds and metals detected in concentrations exceeding MCL values. Both total and dissolved metals concentrations were considered, even though the possibility of significant metals contamination at any of the sites is very remote, based on the 1990 analytical results.

Ground-water sampling and analysis conducted in the East Area identified two areas of volatile organic contamination in Upper Zone ground water. Lead and chromium were detected above the MCL in one or more ground-water samples from the POL Tank Farm, but all but one lead analysis were for total concentrations. Similarly, one sample from Site BSS had a total cadmium concentration above the MCL. Total lead and total arsenic were also detected above their MCLs in surface water samples from Unnamed Stream. Overall concentrations of both volatile organic and inorganic constituents in ground-water and surface water samples were generally lower than concentrations for the same analytes in previous IRP studies. This trend may be the result of natural attenuation, however, it should be noted that the weeks immediately preceding the Spring 1990 sampling event were characterized by abnormally high precipitation (and flooding). The resultant increase in infiltration and recharge may have had the effect of diluting contaminants, resulting in lower concentrations for detected constituents.

The following paragraphs summarize the persistence and migration of the analytes detected above MCLs in the East Area. The fate of these constituents is discussed below (Section 5.1). The primary pathways of migration (transport) are discussed on a site by site basis in Section 5.2.

5.1 Fate of Main Constituents in the East Area

Benzene and lead were the principal ground-water constituents occurring in excess of MCLs in the East Area sites. Total concentrations of

arsenic and lead were also identified above MCLs in the surface water at Site SD13. In general these constituents exhibit the following characteristics relative to fate in ground-water and/or surface water systems:

- Benzene has a very high solubility in water, and is relatively inactive chemically. Volatilization is the principal means of removal of benzene from ground water, followed by slow biodegradation.
- Lead may be removed from the ground water up to 100 percent by the formation of organic complexes and other compounds with a high affinity to adsorb onto soil grains and/or a low solubility coefficient. As such, lead will tend to accumulate in near source soils. Lead in surface water may also be removed through bioaccumulation.
- Arsenic has an extremely high chemical activity, and cycles through the surface water system by sorption and desorption from soil grains and the formation of various compounds and complexes. Due to this high activity, little arsenic is removed from the surface water by these processes. Arsenic may be removed from surface water by bioaccumulation.

5.2 Contaminant Transport Pathways

Following is a site-by-site discussion of the various contaminants found in the East Area and the transport mechanisms through the ground-water and surface water systems.

5.2.1 Site LF01 - Landfill 1

Recent ground-water sampling results show very low levels (below MCLs) of vinyl chloride and cis-1,2-dichloroethene (1,2-DCE) in wells LF01-1C and LF01-1F. Ground-water sampling in 1988 also showed very low levels of trichloroethene (TCE) and vinyl chloride.

Since there is no historical record indicating usage of cis-1,2-dichloroethene or vinyl chloride at Carswell AFB, the small quantities of these compounds in ground water are likely the result of the chemical and biological breakdown of TCE, which was detected in the 1988 study.

Although several metals were detected in the ground water at concentrations exceeding MCLs during the 1988 investigation, their occurrences were sporadic and no plume could be defined (Radian, 1989). There were no metals (dissolved or total) detected above MCLs in the 1990 sampling.

Conclusions

The low levels of volatile organic compounds in the Upper Zone ground water would be expected to move downgradient to the east, toward the Trinity River (Figure 3-11). Shallow ground-water flow near the Trinity River will probably be discharged at the surface as broadly diffuse seepage that is consumed by evapotranspiration. There is no visual evidence of seepage at the land surface between Site LF01 and the river. Shallow ground-water flow will not be downward to deeper aquifers or laterally beyond the Trinity River. Any contaminants which reach the river via ground-water migration are subject to dilution and movement with the surface flow downstream. Any VOCs present in surface water will be subject to volatilization to the air. Since the detected concentrations of volatile organic compounds are already (in most cases) at levels less than five times their detection limits, it is unlikely that these compounds would be detectable following their introduction into the Trinity River. No metals (dissolved or total) were detected above MCLs at the site.

5.2.2 Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Shallow Ground Water--Laboratory analyses of ground-water samples from the four monitor wells did not reveal volatile organic compounds exceeding MCLs. Toluene (12.0 $\mu\text{g/L}$) was found at monitor well SD13-01 but no toluene was detected in monitor wells immediately hydraulically downgradient (SD13-03 and -04). No MCL was exceeded by any metal in any of the shallow ground-water samples collected in Spring 1990 at Site SD13.

1044-500

Unnamed Stream--Very low levels of several volatile aromatic compounds were detected in the June 1990 sampling of the Unnamed Stream. The highest detected concentration of benzene was 0.31 $\mu\text{g/L}$, which is slightly above the detection limit (0.20 $\mu\text{g/L}$). Concentrations of aromatic compounds detected in the 1990 sampling do not decrease significantly with distance downstream. In contrast to these low levels, sampling and analyses of the Unnamed Stream in 1988 revealed benzene concentrations ranging from 39 to 120 $\mu\text{g/L}$. Concentrations of dissolved lead and arsenic did not exceed MCLs in the upper reach of the Unnamed Stream; however, concentrations of the total species were above MCLs at the same locations.

Conclusions

Shallow Ground Water--Investigative activities conducted in 1985 revealed high levels of organic compounds in the ground water underlying the paved lot, probably originating from petroleum hydrocarbons. However, based on the 1990 volatile organic compound analytical results, the abandoned gasoline station does not appear to be contributing appreciable organic contamination to the shallow ground-water system. Any contaminants in the ground water would be expected to move hydraulically downgradient, eventually entering either the oil/water separator and Unnamed Stream or Farmers Branch itself where the initially low concentrations would be further diluted. Still more dilution of contaminants would result as Farmers Branch flows into the West Fork of the Trinity River less than one-half mile from Site SD13. Any VOCs entering Farmers Branch and the Trinity River would be subject to volatilization to the air. No metals were detected above MCLs in the shallow ground water at Site SD13.

Unnamed Stream--No volatile organic compounds were detected above MCLs in the Unnamed Stream. The results of the laboratory analysis for inorganic constituents suggest that metals in the Unnamed Stream are preferentially adsorbed to sediments rather than occurring primarily dissolved in the surface water. This mode of transport (i.e., adsorbed to sediment) would result in slower migration of contaminants downstream than for the dissolved phase, and would be slower than the actual surface water flow rate. As

evidenced by the lower dissolved and total concentrations of arsenic and lead in the downstream water samples, the metals apparently tend to accumulate in the stream bed sediments. The presence of iron oxides, initially identified coating sediments in the Unnamed Stream in the Phase II Stage 1 investigation, suggests that precipitation of metals is active in the stream sediments. The removal of metals such as lead and arsenic is enhanced by this process, as these metals commonly co-precipitate with or are adsorbed onto hydrous iron oxide compounds. Both lead and arsenic are generally nonvolatile and will tend to remain adsorbed to the stream bed sediments in the Unnamed Stream. As long as there is a source of these metals, the metals will continue to accumulate in the sediments in the upper reach of the stream.

5.2.3 Site ST14 - POL Tank Farm

The RI/FS Phase II Stage 2 investigation (Radian, 1989) of the POL Tank Farm site encountered aromatic hydrocarbons (associated with petroleum products) in both the soil and shallow ground water. The hydrocarbons occurred near tanks 1156 and 1157 in the tank farm and near monitor well ST14-17M in the fuel loading area.

Benzene, the only organic compound detected at a concentration exceeding its MCL, occurred in one ground-water sample (from well ST14-17M) at a concentration of 16 $\mu\text{g/L}$. Other organic compounds detected at multiple locations in the ground-water samples from Site ST14 were ethylbenzene and xylenes, although in concentrations lower than MCLs. Also, over two feet of viscous, black hydrocarbon waste was observed floating on the ground-water surface in monitor well ST14-17M. It was the only well sampled at Carswell AFB that contained an observable free-phase lens. The probable extent of benzene in the ground water at Site ST14 is shown in Figure 5-1.

Lead was the only inorganic compound detected in ground water above the MCL during the June 1990 sampling event. Total lead was detected in concentrations up to 0.69 mg/L in the unfiltered sample from monitor well

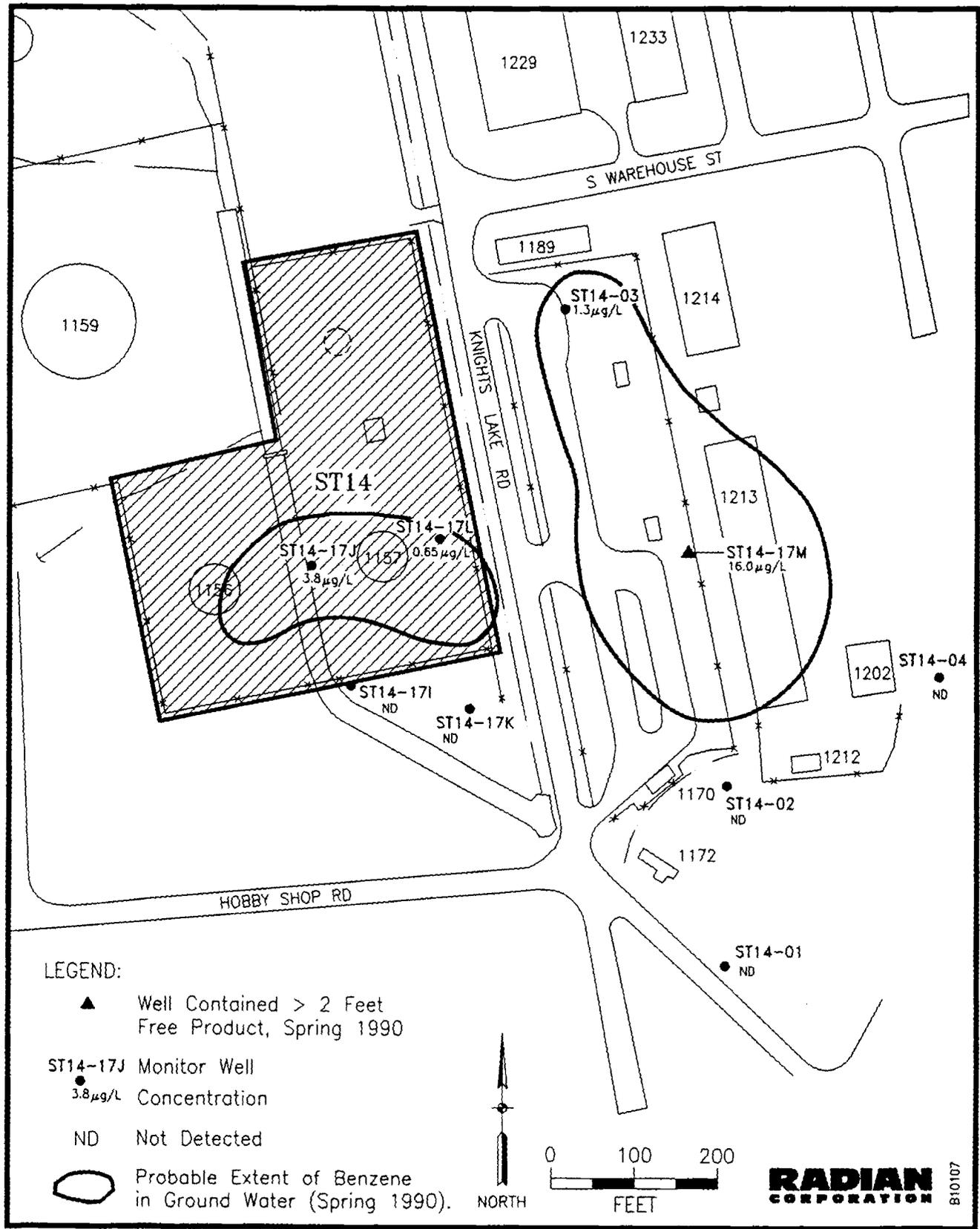


Figure 5-1. Map of Site ST14 With Probable Extent of Benzene in Ground Water (Spring 1990)

5.2.4 Site BSS - Base Service Station

The recent (1990) investigation at the Base Service Station was limited to ground-water sampling of the three existing monitor wells. The RI/FS Stage 2 investigation (Radian, 1989) resulted in the detection of volatile organic compounds at monitor well BSS-B, which is located near an underground fuel storage tank. The recent ground-water sampling (May, 1990) confirmed earlier findings as ground water in monitor well BSS-B again had elevated levels of volatile organic compounds. Benzene (3,200 $\mu\text{g/L}$), toluene (16,000 $\mu\text{g/L}$), and total xylenes (15,000 $\mu\text{g/L}$) were found in monitor well BSS-B. These compounds were not detected in the other two wells sampled at the BSS site.

Cadmium was detected in an unfiltered sample from one well, BSS-C, at a level above its MCL, (0.011 mg/L). No cadmium was detected in the filtered sample (dissolved species) from this well. In addition, no other metals were found above their MCLs in samples from wells at the site.

Conclusions

Migration of volatile organic compounds in the shallow ground water would be toward the Trinity River, as suggested by the potentiometric surface map of the site (Figure 3-8). However, the permeable water-bearing sands observed at BSS-B are not present in the lithologic log of BSS-D (Figure 3-18), located downgradient, or east, of Site BSS. Therefore, ground-water flow velocities are probably less east of monitor well BSS-B. Nonetheless, contaminants could still potentially migrate toward the Trinity River in the lower permeability materials.

The principal fate of the volatile organic compounds detected in the ground water at well BSS-B would be volatilization to the atmosphere. This could occur as the ground water moves toward the Trinity River or upon entering the river. Insufficient downgradient well control precludes determination of the maximum contaminant extent. Metals contamination is not of concern at the Base Service Station since no cadmium was detected in the

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6.0 BASELINE RISK ASSESSMENT

Selection of Indicator Chemicals

Sampling and analysis of soil and water from the East Area IRP sites has resulted in a large number of chemical substances being detected. Conducting a baseline risk assessment that included every detected chemical would be unnecessarily time consuming. The baseline risk assessment for the East Area sites is therefore based on selected indicator chemicals that pose the greatest potential risks, a methodology endorsed by the U.S. EPA for evaluation of the health impacts of waste sites (U.S. EPA, 1986). At the time this study was done, current EPA guidance on Superfund risk assessments (U.S. EPA, 1989) was not available. All data generated in the 1988 program are summarized and discussed in the IRP Stage 2 RI/FS Final Draft Report (Radian, 1989) and are provided in data tables in the IRP Stage 2 ITIR (Radian, 1988). The data from the 1990 study are presented in the ITIR (Radian, (1990d) and corresponding data quality discussions are presented in Section 4.1 of this report.

Indicator chemicals for each site were selected from approximately 80 chemicals known to be present in the East Area, according to procedures documented in Health Evaluation Manual (U.S. EPA, 1986). The selection process, based on both 1988 and 1990 analytical results of soil, ground water, and/or surface water samples from each site, resulted in the generation of lists of site-specific indicator chemicals. The indicator chemical selection process is explained in detail in the IRP Stage 2 RI/FS Final Draft Report (Radian, 1989).

Some of the indicator chemicals, particularly those detected at very low concentrations, may be the result of matrix interferences or sample cross-contamination. No analysis for semivolatile compounds was performed in 1990 and the low levels of bis(2-ethylhexyl)phthalate, the only semivolatile organic indicator parameter detected previously in the East Area, are suspected as being artifacts of sampling or laboratory contamination. As already discussed, dissolved metals concentrations in ground water and surface

water samples, determined only in the 1990 effort, were, with only minor exceptions, below MCLs and do not suggest a metals contamination problem. Nevertheless, all of the identified indicator chemicals were included in the risk assessment process to ensure a conservative (stringent-case) evaluation of possible health risks.

Source and Release Characterization

Possible mechanisms of contaminant release applicable to one or more of the East Area IRP sites include: 1) volatilization to the air, 2) fugitive dust generation, 3) leachate to ground water, 4) surface runoff, 5) direct release to surface water, and 6) contaminated ground-water discharge to surface water. These mechanisms are evaluated on a site-specific basis in the following sections, which summarize the baseline risk assessment for each of the East Area sites.

6.1 Site LF01 - Landfill 1

Evaluation of all Stage 2 analytical results shows the following indicator chemicals were detected in at least one soil and/or ground-water sample from Site LF01:

<u>Metals</u>	<u>Semivolatile Organic Compounds</u>	<u>Volatile Organic Compounds (VOCs)</u>
Antimony	Bis(2-ethylhexyl)-	Methylene chloride
Arsenic	phthalate	Toluene
Barium		Trichloroethene
Beryllium		Vinyl chloride
Cadmium		
Chromium		
Lead		
Nickel		
Selenium		
Silver		

6.1.1 Source and Release Characterization

Contaminant release mechanisms potentially applicable to Landfill 1 are discussed below.

Volatilization to the Air--VOCs present in the soil are subject to volatilization to the air by virtue of high vapor pressures. Semivolatile organic compounds generally have low vapor pressures and are not subject to volatilization. Most metals are nonvolatile as well. Indicator chemicals detected at the site which can volatilize include methylene chloride, toluene, trichloroethene, and vinyl chloride.

Estimated emission rates based conservatively on maximum concentrations detected in the soil or ground water at the site are:

<u>Indicator Chemical</u>	<u>Emission Rate (grams/second)</u>
Methylene chloride	7.38×10^{-8}
Toluene	5.64×10^{-8}
Trichloroethene	4.62×10^{-9}
Vinyl chloride	2.12×10^{-7}

The methodology used to estimate emission rates is described in the IRP Stage 2 RI/FS Final Draft Report (Radian, 1989).

Fugitive Dust Generation--Contaminants must be present in exposed surface soil to be subject to fugitive dust generation. Because Landfill 1 is paved over with impervious material, contaminants present in the soil at this site are not subject to significant fugitive dust generation.

Leachate to Ground Water--Indicator chemicals detected in the ground water near Landfill 1 include: antimony, arsenic, barium, beryllium, cadmium, chromium, lead, nickel, selenium, silver, bis(2-ethylhexyl)phthalate, toluene, trichloroethene, and vinyl chloride.

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- Evaluation of both a receptor grid and discrete receptor points; and
- Simultaneous evaluation of multiple source impacts and individual source impacts.

The ISCLT model accepts a summarized statistical array of meteorological conditions based on data for a year or more. Model output consists of one average concentration for each source and/or source group at each input receptor.

The model was run using urban mode 3 as recommended by EPA for developed areas. Wind profile exponents, vertical potential temperature gradients, and the plume rise equation all affect source plume rise and were set to the EPA-recommended default values. The choice of these options had little or no effect on model results since all sites were modeled with no significant plume rise. A complete description of the modeling methodology is discussed in the IRP Stage 2 RI/FS Final Draft Report (Radian, 1989).

To model the dispersion of contaminants in the air from Landfill 1 to selected receptor locations requires the use of simplifying assumptions to simulate the atmospheric environment. In reality, dispersion of contaminants in the ambient air involves numerous complex processes that are not always addressed by available models. Some simplifying assumptions may lead to either overestimates or underestimates of exposures. Generally, the ISCLT model, and the modeling methodology used in the assessment, incorporate conservative assumptions that will result in overestimates of exposure. For example, model inputs included emission rates calculated using the highest measured concentration regardless of depth or whether the sample was aqueous or soil. Maximum ground-level concentrations estimated by the ISCLT model were assumed to be inhaled continuously, 24 hours per day, for 70 years, at the receptor locations. The successive use of conservative assumptions is likely to produce estimated exposures that are higher than the reasonable maximum exposure that is likely to occur.

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Ground-Water Migration--At Landfill 1, as at all East Area sites, available water level and geologic data indicate that ground water in the Upper Zone flows to the east, toward the Trinity River. The subsurface conditions at the East Area are similar to those in the Flightline Area; ground water remains in the Upper Zone above the bedrock and flows to the nearest surface water drainage. As ground-water flow nears the Trinity River, discharge will be either into the river, or as broadly diffuse seepage that is consumed by evapotranspiration, perhaps without evidence of direct flow at the land surface. Ground-water flow will not be toward deeper aquifers (vertical) or beyond the Trinity River or Farmers Branch (ground-water divides). Thus, migration of contaminants from Landfill 1 to any domestic or agricultural use wells in the area is precluded by the natural hydrogeologic conditions in the East Area.

Transport in Surface Water--Since VOCs remain in a gaseous state and do not deposit on the ground, surface water in the area is not subject to contamination via emissions to the air from Landfill 1. However, VOCs present in surface water may volatilize to the air. Any contaminants which reach the West Fork of the Trinity River by ground-water discharge would be diluted and would move with the surface flow downstream. The West Fork of the Trinity River is downstream of Lake Worth, which is the source of drinking water for Fort Worth and Carswell AFB. The path of surface water drainage therefore precludes the potential transport of contaminants from Landfill 1 to Lake Worth.

Uptake by Plants and Animals--Food crops, including commercial agricultural crops and backyard gardens, could accumulate contaminants originating at Landfill 1 through root uptake of any contaminants present in the water used for irrigation. Migration of ground water to a surface water source used for irrigation is the only significant pathway for contaminants to move from Landfill 1 to plants. However, farming operations in the area generally rely on natural precipitation or irrigation of crops with ground water (South, J., 1988), which removes this potential pathway to human exposure. Since emissions to the air from Landfill 1 are limited to VOCs, which remain in a gaseous state in ambient air, they will not deposit on

above-ground plant surfaces or on the soil or surface water so as to be available for root uptake.

Terrestrial organisms, including farm animals and wildlife, are subject to accumulation of contaminants originating at Landfill 1 by: 1) inhalation of ambient air, and 2) ingestion of surface water contaminated by ground-water discharge. As discussed above, farm operations in the area do not use surface water to irrigate crops. Therefore, farm animals are not subject to ingestion of plants potentially contaminated by surface water used for irrigation.

Aquatic organisms, including fish, are subject to accumulation of contaminants originating at Landfill 1 by uptake from surface water contaminated via ground-water discharge/surface water transport. Contaminants can bioaccumulate in the food chain of both terrestrial and aquatic organisms.

6.1.3 Exposure Pathways

Figure 6-1 depicts potential pathways for contaminants to move from Landfill 1 to human exposure points. These same pathways apply to Sites ST14 and BSS. Pathways which are not complete have been crossed out. Remaining pathways include:

1. Volatilization to the air/air dispersion/inhalation of ambient air;
2. Volatilization to the air/air dispersion/inhalation by animals/ingestion of meat and dairy products;
3. Leaching to ground water/ground-water migration to surface water (fishable source)/uptake by fish and other aquatic organisms/ingestion of aquatic organisms;

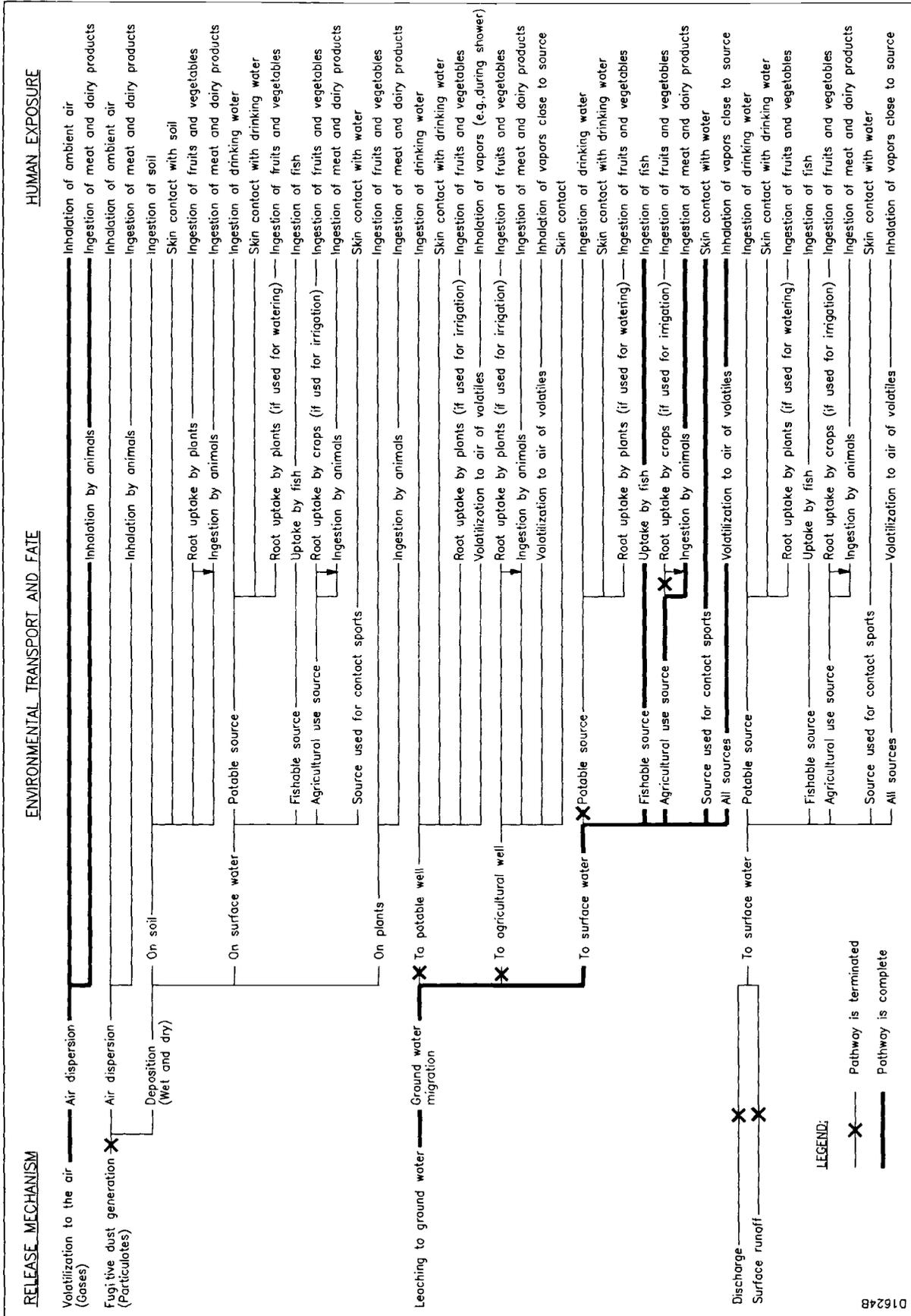


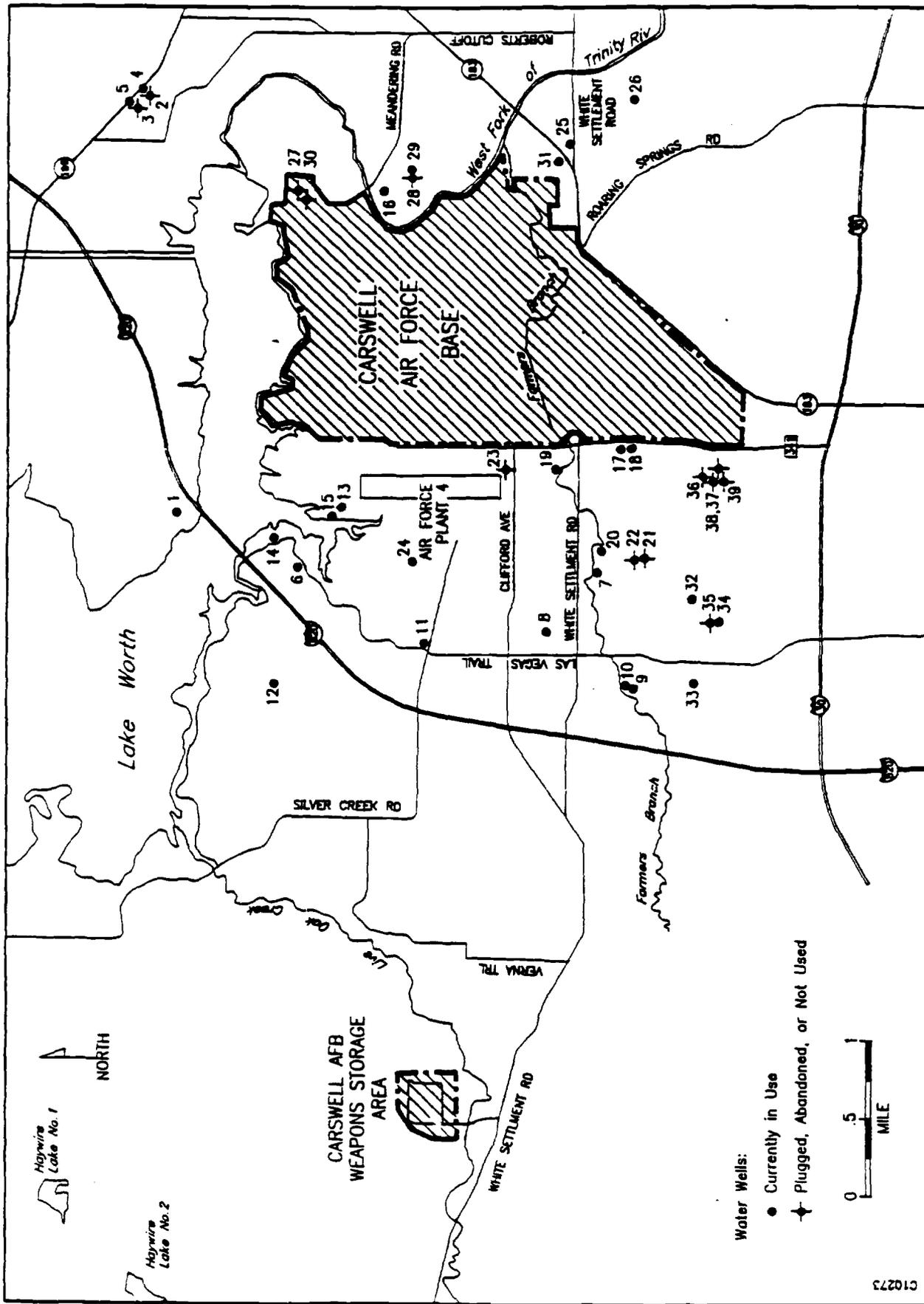
Figure 6-1. Potential Pathways to Human Exposure from Landfill 1, the POL Tank Farm, and the Base Service Station

4. Leaching to ground water/ground-water migration to surface water (agricultural use source)/ingestion by animals/ingestion of meat and dairy products;
5. Leaching to ground water/ground-water migration to surface water (source used for contact sports)/skin contact with water; and
6. Leaching to ground water/ground-water migration to surface water/volatilization of volatiles/inhalation of vapors close to source.

A major potential exposure pathway, ground-water ingestion, is not applicable to Upper Zone ground water in the East Area. The ground-water discharges to on-base surface water bodies or directly (Farmers Branch, Unnamed Stream) to the West Fork of the Trinity River downstream of Lake Worth. Lake Worth is the source of drinking water for Fort Worth and Carswell AFB. In addition, ground water present in the Upper Zone, in general, is not hydraulically connected to the underlying aquifers (CH2M Hill, 1984). For the most part, it is not economical to develop ground water from the alluvium because of the water's limited distribution and susceptibility to surface pollution. The community of River Oaks, immediately east of Carswell AFB, at one time had supply wells that developed water from the alluvial deposits at a location near the USAF Hospital. However, the wells were abandoned when Carswell AFB purchased the property. An inventory of water wells located within one mile of the Carswell AFB boundary was conducted (Radian, 1989). Figure 6-2 shows the locations of the existing and abandoned wells identified from Texas Water Commission records. Thirty-nine wells were identified, but none were completed in the Upper Zone aquifer.

6.1.4 Identification of Receptors

Based on available exposure pathways, potential human receptors for exposure to contaminants originating from Landfill 1 include: 1) persons



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Figure 6-2. Location of Water Wells Within 1 Mile of Carswell AFB, Texas

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residing and/or working in nearby areas, particularly downwind of the site; 2) persons ingesting meat and dairy products from animals exposed to contaminants in the ambient air or contaminated surface water; 3) persons ingesting fish or other aquatic organisms exposed to contaminated surface water; and 4) persons swimming or participating in other contact sports in contaminated water. Landfill 1 and the other East Area sites are located farther away from the primary southeast base housing areas than are the Flightline Area sites. However, they are closer to base office buildings and occupied work areas, and to off-base residential areas to the east side of the West Fork of the Trinity River and bordering on State Highway 183.

Potential wildlife receptors include: 1) terrestrial organisms with habitats close to Landfill 1 that inhale ambient air and ingest surface water, particularly from the West Fork of the Trinity River; and 2) aquatic organisms in the West Fork of the Trinity River.

6.1.5 Quantification of Exposures

Inhalation Exposure--Inhalation of ambient air is the most direct exposure pathway for contaminants to move from Landfill 1 to human receptors. Table 6-1 presents the on-site maximum and off-site maximum predicted annual ambient air concentrations resulting from estimated Landfill 1 emissions, and predicted concentrations at several discrete locations: the site of the proposed base day care center (which is central to the largest on-base residential area), the Fort Worth National Fish Hatchery, and the closest dairy and beef operations. The table also lists Texas Air Control Board (TACB) health Effects Screening Levels (ESLs) which the agency uses to evaluate the impacts of air contaminants. TACB screening levels are based on occupational exposure limits (American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), Occupational Health and Safety Administration (OSHA) standards, or National Institute for Occupational Safety and Health (NIOSH) recommendations), odor nuisance potential, vegetation effects, or corrosion effects. Generally, the annual ESL corresponds to 0.1% of the lowest occupational exposure limit.

TABLE 6-1. PREDICTED ANNUAL AVERAGE AMBIENT AIR CONCENTRATIONS RESULTING FROM ESTIMATED LANDFILL 1 EMISSIONS

Contaminant	Predicted Annual Average Ambient Air Concentration (ug/m ³)							TACB Annual Effects Screening Level (ug/m ³)
	On-Site Maximum	Off-Site Maximum	Day Care	Fish Hatchery	Dairy Operation	Beef Operation		
Methylene chloride	1.2x10 ⁻⁶	3.7x10 ⁻⁶	5.0x10 ⁻⁹	2.3x10 ⁻⁸	<10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	26
Toluene	9.0x10 ⁻⁷	2.8x10 ⁻⁶	4.0x10 ⁻⁹	1.8x10 ⁻⁸	<10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	375
Trichloro-ethene	7.4x10 ⁻⁸	2.3x10 ⁻⁷	>10 ⁻⁹	1.0x10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	135
Vinyl chloride	3.3x10 ⁻⁶	1.1x10 ⁻⁵	1.7x10 ⁻⁸	6.6x10 ⁻⁸	<10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	10

The maximum predicted annual average concentrations resulting from estimated Landfill 1 emissions for methylene chloride, toluene, trichloroethene, and vinyl chloride are lower than the conservative TACB Effects Screening Levels by 7, 8, 9, and 7 orders of magnitude, respectively. Note that maximum concentrations occur off-base due to the location of the site at the east base perimeter and the prevailing wind direction.

Ingestion Exposure--Potential ingestion exposures include ingestion of meat and dairy products from animals exposed to contaminants in the ambient air or contaminated surface water and fish exposed to contaminated surface water.

Landfill 1 contributes very low concentrations of VOCs to the ambient air. At the sites of the nearest dairy and beef operations, concentrations are predicted to be less than 1/1,000,000,000 $\mu\text{g}/\text{m}^3$ (see Table 6-1). Although cows, like humans, will absorb inhaled VOCs, these compounds do not tend to accumulate in milk or fatty tissues which humans might consume. Likewise, livestock consumption of surface water containing contaminants originating from Landfill 1 is theoretically possible, if livestock consumes water from the West Fork of the Trinity River. However, any exposure is expected to be minimal due to the distance from Carswell AFB to the nearest dairy and beef operations. Consumption of locally produced beef and dairy products therefore does not represent a significant pathway of human exposure to contaminants originating from Landfill 1.

The most significant fishable resource in the vicinity of Carswell AFB is Lake Worth. The Fort Worth National Fish Hatchery is located at the western end of the lake. Since there is no available pathway for contaminants to move from Landfill 1 to Lake Worth, there is no potential for human exposure to contaminants originating at Landfill 1 by ingestion of fish caught in the lake. There is some potential for fish in the West Fork of the Trinity River to accumulate contaminants from Landfill 1 due to its location at the base perimeter adjacent to the river, and the expected discharge of groundwater into the river. Contaminant contributions to the river from Landfill 1 via contaminated ground-water discharge could be significant if ground-water

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concentrations are high. However, any contaminants would be immediately diluted and dispersed downstream. Also, based on ground-water analytical results from monitor wells located immediately downgradient of the site, contaminant levels are generally low. As the actual ground-water contribution to the West Fork of the Trinity River is unknown, concentrations of contaminants in the river which originate from Landfill 1 were not estimated.

Dermal Exposure--The potential for skin contact with contaminants originating from Landfill 1 is limited to exposures while swimming in (or otherwise in contact with) contaminated surface water. Lake Worth is the most highly utilized surface water body for swimming and other water contact sports in the area. Again, since there is no available pathway for contaminants to move from Landfill 1 to Lake Worth, there is no potential for human exposure to contaminants originating from Landfill 1 by skin contact with lake water. As discussed above, contaminant contributions to the West Fork of the Trinity River from Landfill 1 probably do occur; therefore, skin contact with river water close to the site is a possible exposure pathway. However, because the river is not widely used for swimming and water contact sports, the exposure potential from this pathway was not quantified.

6.1.6 Threat to Human Health

Noncarcinogenic Risks

Table 6-2 shows estimates of average daily inhalation exposure (in mg/kg body weight/day) at the location of the on-site and off-site maximum predicted annual average concentration, and at the proposed on-site day care facility, and compares these values with inhalation Reference Doses (RFDs) for chronic (long-term) exposure. An inhalation RFD is an estimate of the dose of a chemical that can be inhaled daily for a lifetime without producing adverse noncarcinogenic health effects. The derivation of RFDs (formerly Acceptable Daily Intakes--ADIs) used in this assessment is discussed in the IRP Stage 2 RI/FS Final Draft Report (Radian, 1989).

Average daily inhalation exposures for methylene chloride, toluene, trichloroethene, and vinyl chloride are lower than pollutant-specific RFDs in all cases by more than six orders of magnitude. The total hazard index is significantly less than one at all locations, indicating that the threat of noncarcinogenic health effects of inhalation exposure to contaminants originating from this site is not significant.

Carcinogenic Risks

Inhalation Risk--Of the four contaminants released to the air from Landfill 1, methylene chloride, trichloroethene, and vinyl chloride are potential carcinogens. Cancer potency estimates developed by EPA were used in conjunction with total daily contaminant doses to develop estimates of incremental individual cancer risk:

$$\text{individual cancer risk} = \text{total daily dose} \times \text{cancer potency}$$
$$(\text{mg/kg/day}) \quad (\text{mg/kg/day})^{-1}$$

Incremental individual cancer risk is the increased probability of developing cancer in one's lifetime.

Table 6-3 provides estimates of individual cancer risk for the maximum on-site and maximum off-site exposed individual, and for an individual inhaling ambient concentrations in the immediate vicinity of the proposed day care facility continuously for a lifetime. These risks, the highest of which is 9 in 10 billion, can be dismissed as inconsequential.

Ingestion Risk--The potential for ingestion exposure to contaminants originating from Landfill 1 is limited to ingestion of fish from the West Fork of the Trinity River. The risk of ingestion exposure by this pathway was not quantified because residents are more likely to fish in Lake Worth than in the river, and ground-water contributions to the river from Landfill 1 are not known, although they are expected to be low.

TABLE 6-3. ESTIMATED INCREMENTAL INDIVIDUAL CANCER RISK ASSOCIATED WITH INHALATION OF POTENTIAL CARCINOGENS ORIGINATING FROM LANDFILL 1

Contaminant	Individual Cancer Risk ^b			
	Inhalation Slope Factor ^a (mg/kg/day) ⁻¹	On-Site Maximum Exposed Individual	Off-Site Maximum Exposed Individual	Individual Exposed at Day Care Facility
Methylene chloride	1.4x10 ⁻²	4.7x10 ⁻¹²	1.5x10 ⁻¹¹	2.1x10 ⁻¹⁴
Trichloroethene	1.7x10 ⁻²	3.6x10 ⁻¹³	1.1x10 ⁻¹²	1.6x10 ⁻¹⁵
Vinyl chloride	2.9x10 ⁻¹	2.8x10 ⁻¹⁰	9.0x10 ⁻¹⁰	1.2x10 ⁻¹²
TOTAL 70 year risk		2.9x10 ⁻¹⁰	9.2x10 ⁻¹⁰	1.2x10 ⁻¹²

^aSee the IRP Stage 2 RI/FS Report (Radian, 1989) for discussion and documentation. Some values have been revised by EPA and revised values have been used. The source for the listed values in the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Fourth Quarter FY 1990 (EPA, 1990). The values for benzene, chloroform, 1,2-dichloroethane, and methylene chloride are listed on the EPA Integrated Risk Information System (IRIS). The values for tetrachloroethene and vinyl chloride were derived from unit risk values listed in HEAST, assuming a 70 kg person inhales 20 m³/day. The value for trichloroethene is listed in HEAST but was removed from IRIS pending further review.

^bRisk calculation assumes inhalation for 24 hours/day for a 70 year lifetime of predicted annual average ambient concentrations by an individual with an average body weight of 70 kg and with an average inhalation rate of 20 m³/day.

Dermal Risk--The potential for dermal exposure to contaminants originating from Landfill 1 is remote. Unless an individual immersed frequently in the West Fork of the Trinity River for long periods of time, skin contact exposure can be considered insignificant. The risk of dermal exposure was therefore not quantified.

6.1.7 Threat to Wildlife

Contaminants originating from Landfill 1 pose some risk to terrestrial wildlife that use the West Fork of the Trinity River as a source of drinking water, as well as to aquatic organisms in the river. The potential contribution of Landfill 1 to contaminant concentrations in the river was not estimated because neither the ground-water inflow to the river nor existing contaminant concentrations in the river are known. However, site ground-water contaminant concentrations are generally low, suggesting the contribution is small.

6.2 Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Evaluation of all Stage 2 analytical results indicates the following indicator chemicals were detected in at least one surface water and/or ground-water sample from Site SD13:

<u>Metals</u>	<u>Semivolatile Organic Compounds</u>	<u>Volatile Organic Compounds (VOCs)</u>
Antimony	None	Benzene
Arsenic		Tetrachloroethene
Barium		Toluene
Beryllium		
Cadmium		
Chromium		
Lead		
Nickel		
Selenium		
Silver		

6.2.1 Source and Release Characterization

Contaminant release mechanisms potentially applicable to Site SD13 are discussed below.

Volatilization to the Air--VOCs present in the surface water or soil are subject to volatilization to the air by virtue of high vapor pressures. Indicator chemicals detected in the surface water which can volatilize include benzene, tetrachloroethene, and toluene.

Estimated emission rates based conservatively on maximum concentrations detected in the surface water from the Unnamed Stream are:

<u>Indicator Chemical</u>	<u>Emission Rate (grams/second)</u>
Benzene	3.79×10^{-5}
Tetrachloroethene	3.79×10^{-7}
Toluene	1.86×10^{-5}

Fugitive Dust Generation--Contaminants must be present in exposed surface soil to be subject to fugitive dust generation. Because the area in the vicinity of the former gas station associated with this site is a paved lot, this potential contaminant release mechanism is not applicable.

Leachate to Ground Water--Indicator chemicals detected in ground water at Site SD13 include: benzene, toluene, and all the indicator chemical metals.

Surface Runoff--Contaminants in surface soil must be exposed to be subject to significant surface runoff during precipitation. As previously mentioned, the area of potential soil contamination is paved and therefore not subject to release of contaminants to runoff.

Discharge to Surface Water--The Unnamed Stream discharges directly to Farmers Branch less than 1/2 mile from its intersection with the West Fork of the Trinity River.

6.2.2 Transport and Fate of Contaminants

The Unnamed Stream and abandoned gasoline station at Site SD13 potentially release VOCs to the air via volatilization; and VOCs and metals to the surface water and ground water via direct and indirect discharge, and leachate generation, respectively. Potentially significant contaminant transport and fate mechanisms in the air, ground water, and surface water include: 1) air dispersion, 2) ground-water migration, 3) transport in surface water, and 4) subsequent uptake by plants and animals. The transport and fate of contaminants from Site SD13 follows the same pathways as described for Landfill 1 in Section 6.1.2. Refer to that section for details on transport and fate.

6.2.3 Exposure Pathways

Figure 6-3 depicts potential pathways for contaminants to move from Site SD13 to human exposure points. Pathways which are not complete have been crossed out. The remaining pathways are the same as those identified for Landfill 1 (Section 6.1.3), plus:

1. Discharge to surface water/transport to fishable source/uptake by fish and other aquatic organisms/ingestion of aquatic organisms;
2. Discharge to surface water/transport to agricultural use source/ingestion by animals/ingestion of meat and dairy products; and
3. Discharge to surface water/transport to source used for contact sports/skin contact with water.

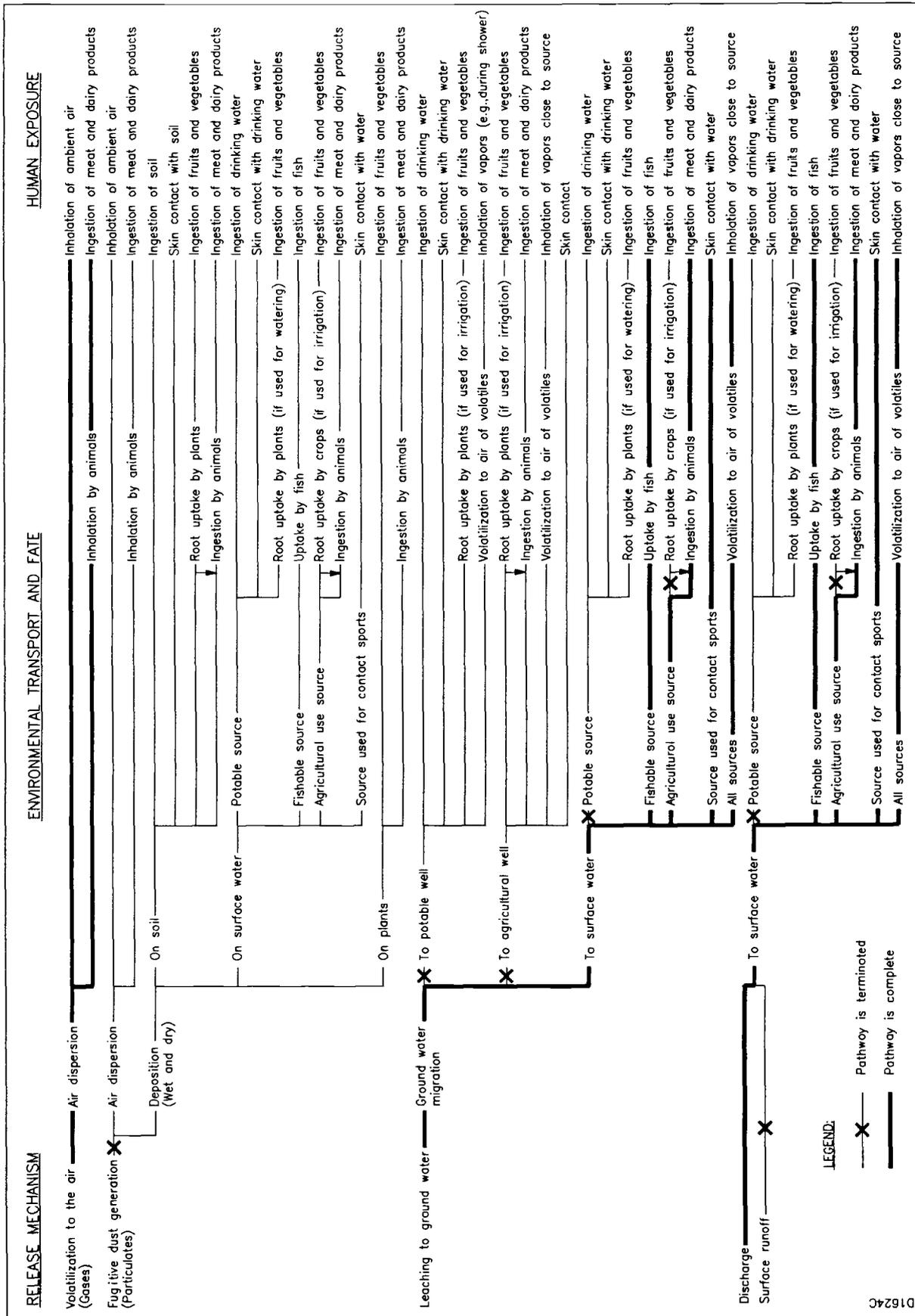


Figure 6-3. Potential Pathways to Human Exposure from Site SD13

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6.2.4 Identification of Receptors

The potential human and wildlife receptors of contaminants released from Site SD13 are the same as those identified for Landfill 1 (see discussion in Section 6.1.4).

6.2.5 Quantification of Exposures

Inhalation Exposure--Except for skin contact with the stream water, inhalation of ambient air is the most direct exposure pathway for contaminants to move from Site SD13 to human receptors. Table 6-4 presents the on-site maximum and off-site maximum predicted annual ambient air concentrations resulting from estimated emissions, and predicted concentrations at the site of the proposed base day care center, the Fort Worth National Fish Hatchery, and the closest dairy and beef operations. The table also lists the TACB ESLs.

The maximum predicted annual average concentrations resulting from estimated site emissions for benzene, tetrachloroethene, and toluene are lower than the conservative TACB Effects Screening Levels by 3, 6, and 6 orders of magnitude, respectively.

Ingestion Exposure--Potential ingestion exposures include ingestion of meat and dairy products from animals exposed to contaminants in the ambient air or contaminated surface water and fish exposed to contaminated surface water. For the same reasons discussed in Section 6.1.4 for Landfill 1, exposure by these pathways is likely to be minimal and was not quantified.

Dermal Exposure--The potential for skin contact with contaminants originating from Site SD13 is limited to exposures while swimming in (or otherwise in contact with) contaminated surface water. Again, for reasons discussed in Section 6.1.4 for Landfill 1, exposure by this pathway is also likely to be minimal and was not quantified.

TABLE 6-4. PREDICTED ANNUAL AVERAGE AMBIENT AIR CONCENTRATIONS RESULTING FROM ESTIMATED EMISSIONS FROM SITE SD13

Contaminant	Predicted Annual Average Ambient Air Concentration (ug/m ³)							TACB Annual Effects Screening Level (ug/m ³)
	On-Site Maximum	Off-Site Maximum	Day Care	Fish Hatchery	Dairy Operation	Beef Operation		
Benzene	1.6x10 ⁻³	1.8x10 ⁻⁴	3.4x10 ⁻⁶	9.3x10 ⁻⁶	2.3x10 ⁻⁷	1.2x10 ⁻⁷		3
Tetrachloroethene	1.6x10 ⁻⁵	1.8x10 ⁻⁶	3.4x10 ⁻⁸	9.3x10 ⁻⁸	2.0x10 ⁻⁹	1.0x10 ⁻⁹		33.5
Toluene	8.1x10 ⁻⁴	8.9x10 ⁻⁵	1.9x10 ⁻⁶	4.5x10 ⁻⁶	1.1x10 ⁻⁷	6.1x10 ⁻⁸		375

TABLE 6-5. ESTIMATED ANNUAL AVERAGE DAILY INHALATION EXPOSURES FOR CONTAMINANTS ORIGINATING FROM SITE SD13 COMPARED WITH POLLUTANT-SPECIFIC REFERENCE DOSES

Contaminant	Inhalation Reference Dose ^a (mg/kg/day)	On-Site Maximum			Off-Site Maximum			Day Care
		Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d	Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d	Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d	
Benzene	3.2×10^{-1b}	4.66×10^{-7}	1.46×10^{-6}	5.20×10^{-8}	1.63×10^{-7}	9.82×10^{-10}	3.07×10^{-9}	
Tetrachloroethene	1.0×10^{-2}	4.66×10^{-9}	4.66×10^{-7}	5.20×10^{-10}	5.20×10^{-8}	9.82×10^{-12}	9.82×10^{-10}	
Toluene	5.7×10^{-1}	2.28×10^{-7}	4.00×10^{-7}	2.56×10^{-8}	4.49×10^{-8}	4.82×10^{-10}	8.46×10^{-10}	
TOTAL HAZARD INDEX			2.33×10^{-6}		2.60×10^{-7}		4.90×10^{-9}	

^aEstimate of the dose of a chemical that can be inhaled daily for a lifetime without producing adverse noncarcinogenic health effects. The source for the listed values in the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Fourth Quarter FY 1990 (EPA, 1990), unless otherwise noted. If an inhalation RfD was not available, the oral RfD was used. If an inhalation reference concentration (RfC) was listed in mg/m³ and not an RfD, the RfC was converted to an RfD assuming a 70 kg person inhales 20 m³/day. The HEAST values used are listed on the EPA Integrated Risk Information System (IRIS) or IRIS input is pending.

^bDerived for this assessment (See Radian, 1989).

^cInhalation exposure assumes inhalation for 24 hours/day of predicted annual average ambient concentrations by an individual with an average body weight of 70 kg and with an average inhalation rate of 20 m³/day.

^dInhalation Exposure/Inhalation Reference Dose.

TABLE 6-6. ESTIMATED INCREMENTAL INDIVIDUAL CANCER RISK ASSOCIATED WITH INHALATION OF POTENTIAL CARCINOGENS ORIGINATING FROM SITE SD13

Contaminant	Inhalation		Individual Cancer Risk ^b	
	Slope Factor ^a (mg/kg/day) ⁻¹	On-Site Maximum Exposed Individual	Off-Site Maximum Exposed Individual	Individual Exposed at Day Care Facility
Benzene	2.9x10 ⁻²	1.4x10 ⁻⁸	1.5x10 ⁻⁹	2.8x10 ⁻¹¹
Tetrachloroethene	1.8x10 ⁻³	8.4x10 ⁻¹²	9.4x10 ⁻¹³	1.8x10 ⁻¹⁴
TOTAL 70 year risk		1.4x10 ⁻⁸	1.5x10 ⁻⁹	2.8x10 ⁻¹¹

^aSee the IRP Stage 2 RI/FS Report (Radian, 1989) for discussion and documentation. Some values have been revised by EPA and revised values have been used. The source for the listed values in the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Fourth Quarter FY 1990 (EPA, 1990). The values for benzene, chloroform, 1,2-dichloroethane, and methylene chloride are listed on the EPA Integrated Risk Information System (IRIS). The values for tetrachloroethene and vinyl chloride were derived from unit risk values listed in HEAST, assuming a 70 kg person inhales 20 m³/day. The value for trichloroethene is listed in HEAST but was removed from IRIS pending further review.

^bRisk calculation assumes inhalation for 24 hours/day for a 70 year lifetime of predicted annual average ambient concentrations by an individual with an average body weight of 70 kg and with an average inhalation rate of 20 m³/day.

point where the Unnamed Stream flows into the creek, skin contact exposure can be considered insignificant. The risk of dermal exposure was therefore not quantified.

6.2.7 Threat to Wildlife

Contaminants originating at Site SD13, as discussed previously for Landfill 1, pose some risk to terrestrial wildlife that use Farmers Branch or the stream itself as a source of drinking water, as well as aquatic organisms in Farmers Branch. Sampling and analysis results provide some measure of the contribution of the Unnamed Stream to contaminant concentrations in Farmers Branch.

6.3 Site ST14 - POL Tank Farm

Evaluation of all Stage 2 analytical results shows the following indicator chemicals were detected in at least one soil and/or ground-water sample at the site:

<u>Metals</u>	<u>Semivolatile Organic Compounds</u>	<u>Volatile Organic Compounds (VOCs)</u>
Antimony	Bis(2-ethylhexyl)-	Benzene
Arsenic	phthalate	Methylene chloride
Barium		Toluene
Beryllium		Trichloroethene
Cadmium		Vinyl chloride
Chromium		
Lead		
Nickel		
Selenium		
Silver		

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6.3.1 Source and Release Characterization

Contaminant release mechanisms potentially applicable to the POL Tank Farm are discussed below.

Volatilization to the Air--VOCs present in the soil are subject to volatilization to the air due to their high vapor pressures. Indicator chemicals detected at the site which can volatilize include benzene, methylene chloride, toluene, trichloroethene, and vinyl chloride.

Estimated emission rates based conservatively on maximum concentrations detected in the soil or ground water at the site are:

<u>Indicator Chemical</u>	<u>Emission Rate (grams/second)</u>
Benzene	1.19×10^{-3}
Methylene chloride	5.31×10^{-6}
Toluene	4.41×10^{-6}
Trichloroethene	2.07×10^{-8}
Vinyl chloride	9.04×10^{-7}

Fugitive Dust Generation--The ground surface in the POL Tank Farm is either covered with gravel and rock, or vegetated. Therefore, any contaminants present in the soil at this site are not subject to significant fugitive dust generation.

Leachate to Ground Water--Indicator chemicals detected in the Upper Zone ground water at Site ST14 include: antimony, arsenic, barium, beryllium, cadmium, chromium, lead, nickel, selenium, silver, bis(2-ethylhexyl)phthalate, benzene, toluene, trichloroethene, and vinyl chloride.

Surface Runoff--Because the ground surface in the POL Tank Farm is either covered with gravel and rocks, or vegetated, and is flat, any contaminants present in the soil at this site are not subject to significant surface runoff.

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Discharge to Surface Water--There is no direct discharge of contaminants from this site to surface water. It is possible that contaminants could be introduced indirectly to Farmers Branch through discharge of Upper Zone ground water.

6.3.2 Transport and Fate of Contaminants

The POL Tank Farm potentially releases VOCs to the air via volatilization, and VOCs, bis(2-ethylhexyl)phthalate, and metals to the ground water via leachate generation. Potentially significant contaminant transport and fate mechanisms in the air, ground water and surface water include: 1) air dispersion, 2) ground-water migration, 3) ground-water discharge to and transport in surface water, and 4) subsequent uptake by plants and animals. The transport and fate of contaminants from the POL Tank Farm follows the same pathways as described for Landfill 1 in Section 6.1, except that Upper Zone ground water might discharge into the downstream portion of Farmers Branch before it reaches the West Fork of the Trinity River. Refer to Section 6.1.2 for details on transport and fate.

6.3.3 Exposure Pathways

Figure 6-1 in Section 6.1.3 indicates the potential pathways for contaminants to move from Landfill 1 to human exposure points. These same pathways apply to the POL Tank Farm.

6.3.4 Identification of Receptors

The potential human and wildlife receptors of contaminants released from the POL Tank Farm are the same as those identified for Landfill 1 (see discussion in Section 6.1.4).

6.3.5 Quantification of Exposures

Inhalation Exposure--Inhalation of ambient air is the most direct exposure pathway for contaminants to move from the POL Tank Farm to human

receptors. Table 6-7 presents the on-site maximum and off-site maximum predicted annual ambient air concentrations resulting from estimated POL Tank Farm emissions, and predicted concentrations at the proposed base day care center, the Fort Worth National Fish Hatchery, and the closest dairy and beef operations. The table also lists TACB ESLs.

The maximum predicted annual average concentrations resulting from estimated POL Tank Farm emissions for benzene, methylene chloride, toluene, trichloroethene, and vinyl chloride are lower than the conservative TACB ESLs by orders of magnitude ranging from 3 to 9.

Ingestion Exposure--Potential ingestion exposures include ingestion of meat and dairy products from animals exposed to contaminants in the ambient air or contaminated surface water and fish exposed to contaminated surface water. For the same reasons discussed in Section 6.1.4 for Landfill 1, any exposure by these pathways is likely to be minimal and was not quantified.

Dermal Exposure--The potential for skin contact with contaminants originating from the POL Tank Farm is limited to exposures while swimming in (or otherwise in contact with) contaminated surface water. Again, for reasons discussed in Section 6.1.4 for Landfill 1, any exposure by this pathway is also likely to be minimal and was not quantified.

6.3.6 Threat to Human Health

Noncarcinogenic Risks

Table 6-8 shows estimates of average daily inhalation exposure (in mg/kg body weight/day) at the location of the on-site and off-site maximum predicted annual average concentration, and at the proposed on-site day care facility, and compares these values with RFDs for chronic exposure.

TABLE 6-7. PREDICTED ANNUAL AVERAGE AMBIENT AIR CONCENTRATIONS RESULTING FROM ESTIMATED POL TANK FARM EMISSIONS

Contaminant	Predicted Annual Average Ambient Air Concentration (ug/m ³)							TACB Annual Effects Screening Level (ug/m ³)
	On-Site Maximum	Off-Site Maximum	Day Care	Fish Hatchery	Dairy Operation	Beef Operation		
Benzene	7.0x10 ⁻³	1.3x10 ⁻³	1.1x10 ⁻⁴	2.0x10 ⁻⁴	7.5x10 ⁻⁶	3.8x10 ⁻⁶		3
Methylene chloride	3.1x10 ⁻⁵	5.9x10 ⁻⁶	5.0x10 ⁻⁷	9.0x10 ⁻⁷	3.3x10 ⁻⁸	1.7x10 ⁻⁸		26
Toluene	2.6x10 ⁻⁵	4.9x10 ⁻⁶	4.2x10 ⁻⁷	7.5x10 ⁻⁷	2.8x10 ⁻⁸	1.4x10 ⁻⁸		375
Trichloroethene	1.2x10 ⁻⁷	2.3x10 ⁻⁸	2.0x10 ⁻⁹	3.0x10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹		135
Vinyl chloride	5.3x10 ⁻⁶	1.0x10 ⁻⁶	8.6x10 ⁻⁸	1.5x10 ⁻⁷	6.0x10 ⁻⁹	3.0x10 ⁻⁹		10

TABLE 6-8. ESTIMATED ANNUAL AVERAGE DAILY INHALATION EXPOSURES FOR CONTAMINANTS ORIGINATING FROM THE POL TANK FARM COMPARED WITH POLLUTANT-SPECIFIC REFERENCE DOSES

Contaminant	Inhalation Reference Dose ^a (mg/kg/day)	On-Site Maximum		Off-Site Maximum		Day Care	
		Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d	Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d	Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d
Benzene	3.2x10 ^{-1b}	1.97x10 ⁻⁶	6.16x10 ⁻⁶	3.74x10 ⁻⁷	1.17x10 ⁻⁶	3.23x10 ⁻⁸	1.01x10 ⁻⁷
Methylene chloride	8.6x10 ⁻¹	8.80x10 ⁻⁹	1.02x10 ⁻⁸	1.67x10 ⁻⁹	1.94x10 ⁻⁹	1.44x10 ⁻¹⁰	1.67x10 ⁻¹⁰
Toluene	5.7x10 ⁻¹	7.31x10 ⁻⁹	1.28x10 ⁻⁸	1.39x10 ⁻⁹	2.44x10 ⁻⁹	1.20x10 ⁻¹⁰	2.11x10 ⁻¹⁰
Trichloroethene	2.46x10 ^{-2b}	3.43x10 ⁻¹¹	1.39x10 ⁻⁹	6.51x10 ⁻¹²	2.65x10 ⁻¹⁰	5.62x10 ⁻¹³	2.28x10 ⁻¹¹
Vinyl chloride	1.3x10 ^{-3b}	1.50x10 ⁻⁹	1.15x10 ⁻⁷	2.84x10 ⁻¹⁰	2.18x10 ⁻⁷	2.45x10 ⁻¹¹	1.88x10 ⁻⁸
TOTAL HAZARD INDEX			6.30x10 ⁻⁶		1.43x10 ⁻⁶		1.20x10 ⁻⁷

^aEstimate of the dose of a chemical that can be inhaled daily for a lifetime without producing adverse noncarcinogenic health effects. The source for the listed values in the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Fourth Quarter FY 1990 (EPA, 1990), unless otherwise noted. If an inhalation RfD was not available, the oral RfD was used. If an inhalation reference concentration (RFC) was listed in mg/m³ and not an RfD, the RfD was converted to an RfD assuming a 70 kg person inhales 20 m³/day. The HEAST values used are listed on the EPA Integrated Risk Information System (IRIS) or IRIS input is pending.

^bDerived for this assessment.

^cInhalation exposure assumes inhalation for 24 hours/day of predicted annual average ambient concentrations by an individual with an average body weight of 70 kg and with an average inhalation rate of 20 m³/day.

^dInhalation Exposure/Inhalation Reference Dose.

TABLE 6-9. ESTIMATED INCREMENTAL INDIVIDUAL CANCER RISK ASSOCIATED WITH INHALATION OF POTENTIAL CARCINOGENS ORIGINATING FROM THE POL TANK FARM

Contaminant	Individual Cancer Risk ^b			
	Inhalation Slope Factor ^a (mg/kg/day) ⁻¹	On-Site Maximum Exposed Individual	Off-Site Maximum Exposed Individual	Individual Exposed at Day Care Facility
Benzene	2.9x10 ⁻²	5.7x10 ⁻⁸	1.1x10 ⁻⁸	9.4x10 ⁻¹⁰
Methylene chloride	1.4x10 ⁻²	1.2x10 ⁻¹⁰	2.3x10 ⁻¹¹	2.0x10 ⁻¹²
Trichloroethene	1.7x10 ⁻²	5.8x10 ⁻¹³	1.1x10 ⁻¹³	9.6x10 ⁻¹⁵
Vinyl chloride	2.9x10 ⁻¹	4.4x10 ⁻¹⁰	8.2x10 ⁻¹¹	7.1x10 ⁻¹²
TOTAL 70 year risk		5.7x10 ⁻⁸	1.1x10 ⁻⁸	9.4x10 ⁻¹⁰

^aSee the IRP Stage 2 RI/FS Report (Radian, 1989) for discussion and documentation. Some values have been revised by EPA and revised values have been used. The source for the listed values in the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Fourth Quarter FY 1990 (EPA, 1990). The values for benzene, chloroform, 1,2-dichloroethane, and methylene chloride are listed on the EPA Integrated Risk Information System (IRIS). The values for tetrachloroethene and vinyl chloride were derived from unit risk values listed in HEAST, assuming a 70 kg person inhales 20 m³/day. The value for trichloroethene is listed in HEAST but was removed from IRIS pending further review.

^bRisk calculation assumes inhalation for 24 hours/day for a 70 year lifetime of predicted annual average ambient concentrations by an individual with an average body weight of 70 kg and with an average inhalation rate of 20 m³/day.

6.4 Site BSS - Base Service Station

Evaluation of all Stage 2 analytical results indicates the following indicator chemicals were detected in at least one soil or ground-water sample at the site:

<u>Metals</u>	<u>Semivolatile Organic Compounds</u>	<u>Volatile Organic Compounds (VOCs)</u>
Antimony	Bis(2-ethylhexyl)-	Benzene
Arsenic	phthalate	1,2-Dichloroethane
Barium		Tetrachloroethene
Beryllium		Toluene
Cadmium		Trichloroethene
Chromium		
Lead		
Nickel		
Selenium		
Silver		

6.4.1 Source and Release Characterization

Contaminant release mechanisms potentially applicable to Site BSS are discussed below.

Volatilization to the Air--Indicator chemicals detected at the site which can volatilize include benzene, 1,2-dichloroethane, tetrachloroethene, toluene, and trichloroethene.

Estimated emission rates based conservatively on maximum concentrations detected in the soil or ground water at the site are:

<u>Indicator Chemical</u>	<u>Emission Rate (grams/second)</u>
Benzene	2.33×10^{-5}
1,2-Dichloroethane	2.16×10^{-8}
Tetrachloroethene	8.08×10^{-10}
Toluene	1.17×10^{-4}
Trichloroethene	2.56×10^{-9}

Fugitive Dust Generation--The Base Service Station area is either paved or covered with vegetation; therefore any contaminants present in the soil are not subject to significant fugitive dust generation.

Leachate to Ground Water--Indicator chemicals detected in the ground water near the Base Service Station include: antimony, arsenic, barium, beryllium, cadmium, chromium, lead, nickel, selenium, silver, benzene, 1,2-dichloroethane, tetrachloroethene, toluene, and trichloroethene.

Surface Runoff--As noted above, the Base Service Station area is covered with concrete/asphalt or with vegetation, and is flat. Therefore, any contaminants present in the soil at this site are not subject to significant surface runoff.

Discharge to Surface Water--There is no direct discharge of contaminants from this site to surface water.

6.4.2 Transport and Fate of Contaminants

The Base Service Station potentially releases VOCs to the air via volatilization, and VOCs, bis(2-ethylhexyl)phthalate, and metals to the ground water via leachate generation. Potentially significant contaminant transport and fate mechanisms in the air and ground water include: 1) air dispersion, 2) ground-water migration, 3) ground-water discharge to and transport in surface water, and 4) subsequent uptake by plants and animals. The transport and fate of contaminants from the Base Service Station follows the same

pathways as described for Landfill 1 in Section 6.1.2. Refer to this section for details on transport and fate.

6.4.3 Exposure Pathways

Figure 6-1 in Section 6.1.3 depicts potential pathways for contaminants to move from Landfill 1 to human exposure points. These same pathways apply to the Base Service Station.

6.4.4 Identification of Receptors

The potential human and wildlife receptors of contaminants released from the Base Service Station site are the same as those identified for Landfill 1 (see discussion in Section 6.1.4).

6.4.5 Quantification of Exposures

Inhalation Exposure--As is the case for all other East Area sites, inhalation of ambient air is the most direct exposure pathway for contaminants to move from the Base Service Station to human receptors. Table 6-10 presents the on-site maximum and off-site maximum predicted annual ambient air concentrations resulting from estimated Base Service Station emissions, and predicted concentrations at the proposed base day care center, the Fort Worth National Fish Hatchery, and the closest dairy and beef operations. The table also lists TACB ESLs.

The maximum predicted annual average concentrations resulting from estimated Base Service Station emissions for benzene, 1,2-dichloroethane, tetrachloroethene, toluene, and trichloroethene are lower than the conservative TACB ESLs by orders of magnitude ranging from 4 to 10.

Ingestion Exposure--Potential ingestion exposures include ingestion of meat and dairy products from animals exposed to contaminants in the ambient air or contaminated surface water, and fish exposed to contaminated surface

TABLE 6-10. PREDICTED ANNUAL AVERAGE AMBIENT AIR CONCENTRATIONS RESULTING FROM ESTIMATED POL TANK FARM EMISSIONS

Contaminant	Predicted Annual Average Ambient Air Concentration (ug/m ³)							TACB Annual Effects Screening Level (ug/m ³)
	On-Site Maximum	Off-Site Maximum	Day Care	Fish Hatchery	Dairy Operation	Beef Operation		
Benzene	2.3x10 ⁻⁴	1.8x10 ⁻⁴	1.9x10 ⁻⁶	5.3x10 ⁻⁶	1.4x10 ⁻⁷	6.9x10 ⁻⁸	3	
1,2-Dichloroethane	2.1x10 ⁻⁷	1.6x10 ⁻⁷	2.0x10 ⁻⁹	5.0x10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	4	
Tetrachloroethene	8.0x10 ⁻⁹	6.0x10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	33.5	
Toluene	1.1x10 ⁻³	8.9x10 ⁻⁴	9.3x10 ⁻⁶	2.6x10 ⁻⁵	6.3x10 ⁻⁷	3.5x10 ⁻⁷	375	
Trichloroethene	2.5x10 ⁻⁸	1.9x10 ⁻⁸	<10 ⁻⁹	1.0x10 ⁻⁹	<10 ⁻⁹	<10 ⁻⁹	135	

water. For the same reasons discussed in Section 6.1.4 for Landfill 1, any exposure by these pathways is likely to be minimal and was not quantified.

Dermal Exposure--The potential for skin contact with contaminants originating from the Base Service Station is limited to exposures while swimming in (or otherwise in contact with) contaminated surface water. Again, for reasons discussed in Section 6.1.4 for Landfill 1, any exposure by this pathway is also likely to be minimal and was not quantified.

6.4.6 Threat to Human Health

Noncarcinogenic Risks

Table 6-11 shows estimates of average daily inhalation exposure (in mg/kg body weight/day) at the location of the on-site and off-site maximum predicted annual average concentration, and at the proposed on-site day care facility, and compares these values with RFDs for chronic exposure.

Average daily inhalation exposures for benzene, 1,2-dichloroethane, tetrachloroethene, toluene, and trichloroethene are lower than pollutant-specific RFDs in all cases by more than five orders of magnitude.

Carcinogenic Risks

Inhalation Risk--Of the five contaminants that may be emitted to the air from the Base Service Station, benzene, 1,2-dichloroethane, tetrachloroethene, and trichloroethene are potential carcinogens. Table 6-12 provides estimates of incremental individual cancer risk for the maximum on-site and maximum off-site exposed individual, and for an individual inhaling ambient concentrations in the immediate vicinity of the proposed day care facility continuously for a lifetime. These risks, the highest of which is 1.9 in 1 billion, can be dismissed as inconsequential.

TABLE 6-11. ESTIMATED ANNUAL AVERAGE DAILY INHALATION EXPOSURES FOR CONTAMINANTS ORIGINATING FROM THE BASE SERVICE STATION COMPARED WITH POLLUTANT-SPECIFIC REFERENCE DOSES

Contaminant	Inhalation Reference Dose ^a (mg/kg/day)	On-Site Maximum			Off-Site Maximum			Day Care
		Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d	Inhalation Exposure ^c (mg/kg/day)	Inhalation Exposure ^c (mg/kg/day)	Hazard Index ^d	Inhalation Exposure ^c (mg/kg/day)		Hazard Index^{d}
Benzene	3.2x10 ^{-1b}	6.52x10 ⁻⁸	2.04x10 ⁻⁷	4.99x10 ⁻⁸	1.56x10 ⁻⁷	5.31x10 ⁻¹⁰	1.66x10 ⁻⁹	
1,2-Dichloroethane	2.7x10 ^{-3b}	6.05x10 ⁻¹¹	2.24x10 ⁻⁸	4.63x10 ⁻¹¹	1.71x10 ⁻⁸	4.92x10 ⁻¹³	1.82x10 ⁻¹⁰	
Tetrachloroethene	1.0x10 ⁻²	2.26x10 ⁻¹²	2.26x10 ⁻¹⁰	1.73x10 ⁻¹²	1.73x10 ⁻¹⁰	1.84x10 ⁻¹⁴	1.84x10 ⁻¹²	
Toluene	5.7x10 ⁻¹	3.28x10 ⁻⁷	5.75x10 ⁻⁷	2.52x10 ⁻⁷	4.42x10 ⁻⁷	2.68x10 ⁻⁹	4.70x10 ⁻⁹	
Trichloroethene	2.46x10 ^{-2b}	7.17x10 ⁻¹²	2.91x10 ⁻¹⁰	5.49x10 ⁻¹²	2.23x10 ⁻¹⁰	5.84x10 ⁻¹⁴	2.37x10 ⁻¹²	
TOTAL HAZARD INDEX			8.02x10 ⁻⁷		6.15x10 ⁻⁷		6.55x10 ⁻⁹	

^aEstimate of the dose of a chemical that can be inhaled daily for a lifetime without producing adverse noncarcinogenic health effects. The source for the listed values in the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Fourth Quarter FY 1990 (EPA, 1990), unless otherwise noted. If an inhalation RfD was not available, the oral RfD was used. If an inhalation reference concentration (RfC) was listed in mg/m³ and not an RfD, the RfC was converted to an RfD assuming a 70 kg person inhales 20 m³/day. The HEAST values used are listed on the EPA Integrated Risk Information System (IRIS) or IRIS input is pending.

^bDerived for this assessment (see Radian, 1989).

^cInhalation exposure assumes inhalation for 24 hours/day of predicted annual average ambient concentrations by an individual with an average body weight of 70 kg and with an average inhalation rate of 20 m³/day.

^dInhalation Exposure/Inhalation Reference Dose.

Ingestion Risk--The potential for ingestion exposure to contaminants originating from the Base Service Station is remote and likely to be, at most, minimal. The risk of ingestion exposure was therefore not quantified.

Dermal Risk--The potential for dermal exposure to contaminants originating from the Base Service Station is also remote. Unless an individual immersed himself frequently and for prolonged periods of time in the West Fork of the Trinity River near the base, skin contact exposure can be considered insignificant. The risk of dermal exposure was therefore not quantified.

6.4.7 Threat to Wildlife

Contaminants originating from the Base Service Station pose a similar low level of risk to terrestrial wildlife that use the West Fork of the Trinity River as a source of drinking water, and to aquatic organisms in the river, as described for Landfill 1 (Section 6.1.7).

6.5 Defense Priority Model Evaluation

Radian used the Defense Priority Model (DPM) (Oak Ridge National Laboratory, 1987) to evaluate the four East Area IRP Sites LF01, SD13, ST14, and BSS; and the Flightline Area at Carswell AFB. DPM uses site-specific data to prioritize sites according to the severity of contamination. For the DPM, geologic and hydrologic data are used to indicate ground-water travel times and chemical analyses are compared to toxicological benchmarks to indicate risk to the local human population and natural environment.

Using information obtained during Stage 2 of the IRP at Carswell AFB, the DPM indicated the following ranking for the sites investigated (numbers in parentheses are the results of the DPM scoring and indicate relative rankings):

TABLE 6-12. ESTIMATED INCREMENTAL INDIVIDUAL CANCER RISK ASSOCIATED WITH INHALATION OF POTENTIAL CARCINOGENS ORIGINATING FROM THE BASE SERVICE STATION

Contaminant	Individual Cancer Risk ^b			
	Inhalation Slope Factor ^a (mg/kg/day) ⁻¹	On-Site Maximum Exposed Individual	Off-Site Maximum Exposed Individual	Individual Exposed at Day Care Facility
Benzene	2.9x10 ⁻²	1.9x10 ⁻⁹	1.4x10 ⁻⁹	1.5x10 ⁻¹¹
1,2-Dichloroethane	9.1x10 ⁻²	5.5x10 ⁻¹²	4.2x10 ⁻¹²	4.5x10 ⁻¹⁴
Tetrachloroethene	1.8x10 ⁻³	4.1x10 ⁻¹⁵	3.1x10 ⁻¹⁵	3.3x10 ⁻¹⁷
Trichloroethene	1.7x10 ⁻²	1.2x10 ⁻¹³	9.3x10 ⁻¹⁴	9.9x10 ⁻¹⁶
TOTAL 70 year risk		1.9x10 ⁻⁹	1.4x10 ⁻⁹	1.5x10 ⁻¹¹

^aSee the IRP Stage 2 RI/FS Report (Radian, 1989) for discussion and documentation. Some values have been revised by EPA and revised values have been used. The source for the listed values in the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Fourth Quarter FY 1990 (EPA, 1990). The values for benzene, chloroform, 1,2-dichloroethane, and methylene chloride are listed on the EPA Integrated Risk Information System (IRIS). The values for tetrachloroethene and vinyl chloride were derived from unit risk values listed in HEAST, assuming a 70 kg person inhales 20 m³/day. The value for trichloroethene is listed in HEAST but was removed from IRIS pending further review.

^bRisk calculation assumes inhalation for 24 hours/day for a 70 year lifetime of predicted annual average ambient concentrations by an individual with an average body weight of 70 kg and with an average inhalation rate of 20 m³/day.

1. Unnamed Stream and Abandoned Gasoline Station (20,760);
2. Flightline Area (19,381);
3. Landfill 1 (7,036);
4. Base Service Station (5,929); and
5. POL Tank Farm (4,584).

Radian has conducted extensive, detailed investigations of these sites and has produced a ranking of these sites which differs somewhat from the DPM ranking. The alternate ranking, which is based on the results of the Radian investigations is as follows:

1. Flightline Area;
2. Unnamed Stream and Abandoned Gasoline Station/POL Tank Farm;
3. Base Service Station; and
4. Landfill 1.

This discrepancy is probably because the DPM is designed as an unbiased tool for comparison and, therefore, has a simple, rigid format that does not take into account all factors which might be relevant to the ranking of a particular site. Indeed, the Introduction to the User's Manual for the DPM indicates the possibility of false high scores using the DPM. The justification for the high priority ranking for the Flightline Area is provided in the Flightline Area Draft RI report (Radian, 1991). The justification for the revised ranking with respect to the East Area sites is explained below. The DPM evaluation worksheets for each site are provided in Appendix F.

Priority Evaluation for East Area Sites

The most significant difference between Radian's ranking and the DPM ranking is the position of Landfill 1. In the DPM model, Landfill 1 received a relatively high ranking based on the site's proximity to the Trinity River and the lack of an effective barrier system. Based on the most recent analytical data, however, only very low levels of indicator chemicals were identified at the site, with no detected concentrations of any volatile

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organic compound or metal above the MCL. For this reason, Radian assigns a higher priority to the other East Area sites.

The Unnamed Stream and Abandoned Gasoline Station (Site SD13) ranked high in the DPM model and in the ranking by Radian because the site represents a direct migration pathway to the West Fork of the Trinity River. It is anticipated that this site will be treated in conjunction with the POL Tank Farm in the FS for the East Area, since the POL Tank Farm, where groundwater contamination is documented, is directly upgradient of Unnamed Stream, and is directly or indirectly contributing contaminants to Site SD13. The nature of the contaminant source, the overall areal extent of contamination, and the potential for the contamination to reach the river make this combined site of the highest priority in the East Area.

The Base Service Station is given a relatively low priority in both the DPM evaluation and in Radian's evaluation based on several factors. While maximum detected concentrations of benzene and toluene were relatively high, these compounds were only detected in one well, suggesting the areal extent of the contamination is limited. The nature of the contaminant source is known (i.e., gasoline UST). In addition, the occurrence of ground water at the site is limited and is not continuous, reducing the potential for migration of contaminants at the site to the West Fork of the Trinity River.

7.0 SUMMARY AND CONCLUSIONS

This section summarizes the environmental contaminants detected in the East Area sites, with special emphasis on the extent of contaminant migration, the mechanisms/pathways by which the contaminants are transported, and the level of risk the contaminants pose to the human health and the environment. Also identified are existing data gaps, possible ways to address additional data requirements, and the objectives of any remedial actions conducted in the East Area.

7.1 Summary of Contamination and Associated Risks

The following subsections present an overview of the main contaminants in the East Area and the quantified risks associated with exposure to those contaminants.

7.1.1 Nature and Extent of Contamination

Ground-water and surface water sampling and analysis conducted in the East Area in 1990 identified two areas of volatile organic contamination in Upper Zone ground water, at the POL Tank Farm and the Base Service Station. Evidence of inorganic contamination in Upper Zone ground water and Unnamed Stream was limited to a few occurrences of chromium, lead, and arsenic above MCLs, mainly in the total metals analyses. Overall concentrations of both volatile organic and inorganic constituents in ground-water and surface water samples were generally lower than concentrations for the same analytes in previous IRP studies. This trend may be the result of natural attenuation of these constituents in the ground-water or surface water systems, however, it should be noted that the weeks immediately preceding the Spring 1990 sampling event were characterized by abnormally high precipitation (and flooding). The resultant increase in infiltration and recharge may have had the effect of diluting contaminants, resulting in lower concentrations of detected constituents.

11/11/89

Following is a summary of the current understanding of the nature and extent of contamination at the four sites where additional investigative activities were performed in 1990: Site LF01 (Landfill 1), Site SD13 (Unnamed Stream and the Abandoned Gasoline Station), Site ST14 (POL Tank Farm), and Site BSS (Base Service Station). There were no additional data collected at Site OT12 (Entomology Dry Well) or Site SD10 (Flightline Drainage Ditch), and the Phase II Stage 2 Remedial Investigation report (Radian, 1989) contains the current interpretation of the nature and extent of contamination at these sites.

Site LF01 - Landfill 1

Recent (1990) ground-water sampling of the five monitor wells at Site LF01 provided no basis for inferring the existence of a ground-water contaminant plume, organic or inorganic, at this site. A previously interpreted metals contaminant problem at the site was not supported by the most recent ground-water analyses.

Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Although volatile organic compounds (VOCs) were detected in both ground water and surface water at Site SD13, no MCLs were exceeded and there was no pattern observed to the VOC detections. Therefore, there is no evidence of a volatile organic compound contaminant problem at the site.

The most recent (1990) inorganic analytical results, from ground water of the four recently installed monitor wells, do not suggest metals contamination of the Upper Zone ground water at the site. No metals were detected above MCLs.

Concerning metals concentrations in the Unnamed Stream, the same metals species found in excess of MCLs in the surface water samples appear to be adsorbed to stream sediments. Two surface water samples that contained total concentrations of three metals above MCLs had corresponding dissolved metals concentrations below the MCLs. One dissolved selenium concentration

above the MCL was determined to be a laboratory reporting error and the actual concentration was below detection.

Site ST14 - POL Tank Farm

Several volatile organic compounds were detected in ground-water samples from monitor wells at Site ST14. Benzene was the only VOC detected in the most recent ground-water sampling at a concentration which exceeded its MCL.

Based on the 1988 soil gas and ground-water sampling and the 1990 ground-water sampling at the site, the contamination underlying Site ST14 and vicinity appears to be divided into two regions; the first associated with Tanks 1156 and 1157, and the second associated with the adjacent fuel loading facility.

Figure 7-1 depicts the probable extent of benzene contamination at Site ST14, based on the most recent analytical data and the distribution of soil gas determined in the Stage 2 soil gas survey. Monitor well ST14-17M, located at the center of the interpreted benzene plume beneath the fuel loading facility, contained the only detected concentration of benzene above the respective MCL in the nine wells sampled in the 1990 investigation. Over two feet of immiscible material was encountered in this well in the 1990 sampling event. Monitor well ST14-17M also had the highest concentrations of chlorobenzene, toluene, and total xylenes detected at the site in the most recent sampling. The extent of the benzene plume in the Upper Zone ground water is delineated on Figure 7-1, and is within the confines of the existing monitor well network at the site.

Chromium was detected above its MCL in only one well at the site, and this concentration was measured in the total metals analysis. Lead was detected above MCLs in three monitor well samples at ST14, only one of which (from ST14-02) was for the dissolved metals analysis and is considered suspect.

07/14/00

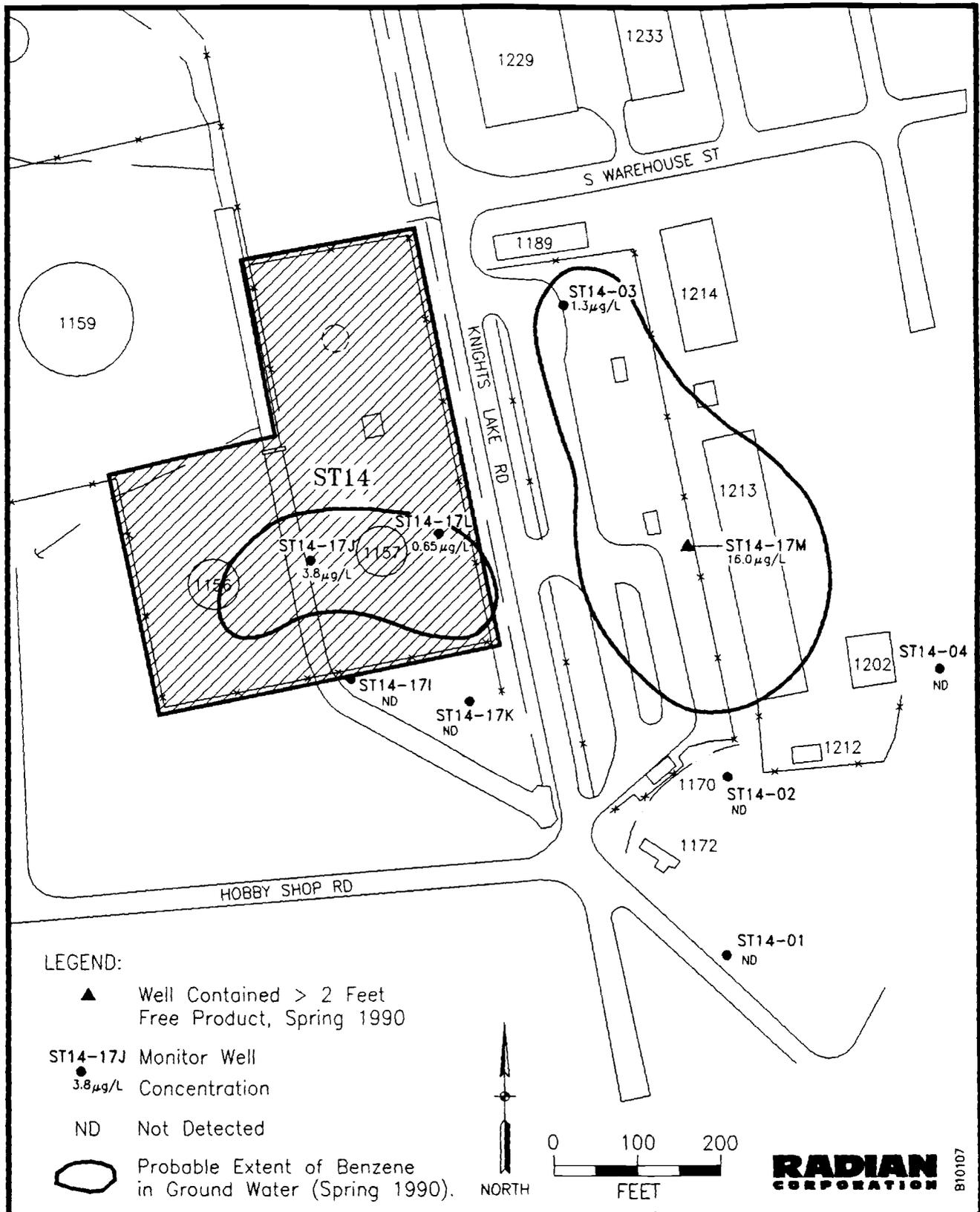


Figure 7-1. Probable Extent of Benzene Contamination (Spring, 1990), Site ST14, Carswell AFB, Texas

Site BSS - Base Service Station

Information gathered to date on Site BSS suggests a contaminant problem associated with the underground storage tank adjacent to monitor well BSS-B.

In the 1990 sampling investigation, of the three wells sampled at the site, only well BSS-B contained detectable levels of volatile organic compounds. Benzene, toluene, and total xylenes were all detected in the ground water at this location above their MCLs. The downgradient extent of the VOC contamination detected in monitor well BSS-B is not defined with the current monitor well network, however, results of the soil gas analyses performed at the site in 1987 suggested a plume size of approximately 100 feet wide by 200 feet long.

Cadmium was detected above the MCL of well BSS-C in the total metals analysis but was not detected in the dissolved metals analysis. No other metals concentrations exceeded MCLs.

7.1.2 Fate and Transport

Site LF01 - Landfill 1

The low levels of volatile organic contaminants in the Upper Zone ground water at Site LF01 are expected to move downgradient to the east, toward the Trinity River (Figure 3-11). Shallow ground-water flow near the Trinity River will probably be discharged at the surface as broadly diffuse seepage that is consumed by evapotranspiration. There is no visual evidence of seepage at the land surface between Site LF01 and the river. Shallow ground-water flow will not be downward to deeper aquifers or laterally beyond the Trinity River. Any contaminants which reach the river via ground-water migration are subject to dilution and movement with the surface flow downstream. Any VOCs present in surface water will be subject to volatilization to the air. Since the detected concentrations of volatile organic compounds are already (in most cases) at levels less than five times their detection

limits, it is unlikely that these compounds would be detectable following their introduction into the Trinity River. No metals (dissolved or total) were detected above MCLs at the site.

Site SD13 - Unnamed Stream and Abandoned Gasoline Station

Shallow Ground Water--Investigative activities conducted in 1985 revealed high levels of organic compounds in ground water, probably originating from petroleum hydrocarbons. However, based on the 1990 volatile organic compound analytical results, the abandoned gasoline station does not appear to be contributing appreciable organic contamination to the shallow ground-water system. Any contaminants in the ground water would be expected to move hydraulically downgradient, eventually entering either the oil/water separator and the Unnamed Stream or Farmers Branch itself where the initially low concentrations would be further diluted. Still more dilution of contaminants would result as Farmers Branch flows into the West fork of the Trinity River less than one-half mile from Site SD13. Any VOCs entering Farmers Branch and the Trinity River would be subject to volatilization to the air. No metals were detected above MCLs in the shallow ground water at Site SD13.

Unnamed Stream--No volatile organic compounds were detected above MCLs in the Unnamed Stream. The results of the laboratory analysis for inorganic constituents suggest that metals in the Unnamed Stream are preferentially adsorbed to sediments rather than occurring primarily dissolved in the surface water. This mode of transport (i.e., adsorbed to sediment) would result in slower migration of contaminants downstream than for the dissolved phase, and would be slower than the actual surface-water flow rate. As evidenced by the lower dissolved and total concentrations of arsenic and lead in the downstream water samples, the metals apparently tend to accumulate in the stream bed sediments. The presence of iron oxides, initially identified coating sediments in the Unnamed Stream in the Phase II Stage 1 investigation, suggests that precipitation of metals is active in the stream sediments. The removal of metals such as lead and arsenic is enhanced by this process, as these metals commonly co-precipitate with or are adsorbed onto hydrous iron

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The principal fate of the volatile organic compounds detected in the ground water at well BSS-B would be volatilization to the atmosphere. This could occur as the ground water moves toward the Trinity River and upon entering the river. Insufficient downgradient well control precludes determination of the maximum contaminant extent.

Metals contamination is not of concern at the Base Service Station since no cadmium was detected in the filtered sample in monitor well BSS-C and no other metals were found above their MCLs in samples from wells at this site.

7.1.3 Risk Assessment

Using both the 1988 and 1990 analytical results from the various media sampled in the East Area sites, indicator chemicals for each site were selected according to procedures documented in the U.S. EPA Health Evaluation Manual (1986). Although several of the indicator chemicals selected, particularly the semi-volatile and metals compounds, are not believed to represent an actual contaminant problem at the site, they were included in the risk assessment process to ensure a conservative (stringent-case) evaluation of possible health risks.

Possible mechanisms of contaminant release applicable to one or more of the East Area IRP sites include: 1) volatilization to the air, 2) fugitive dust generation, 3) leachate to ground water, 4) surface runoff, 5) direct release to surface water, and 6) contaminated ground-water discharge to surface water.

Following is a site-by-site summary of the possible risks to human health and the environment posed by the chemicals found in the various media at the East Area sites.

Site LF01 - Landfill 1

Landfill 1 potentially releases VOCs to the air via volatilization; and VOCs, bis(2-ethylhexyl)phthalate, and metals to the ground water through leachate generation. Potentially significant contaminant transport and fate mechanisms from LF01 in the air and ground water include: 1) air dispersion, 2) ground-water migration, 3) ground-water discharge to and transport in surface water, and 4) subsequent uptake by plants and animals.

Results of an evaluation to determine possible human exposure routes from the four previously mentioned waste release mechanisms show six potential pathways exist (Figure 6-1). All six of the pathways initially involve contaminants volatilizing to the air or leaching to the ground water. Based on the potential pathways identified, potential human and wildlife receptors for exposure to contaminants migrating from LF01 were identified.

Attempts at quantifying three types of exposures - inhalation, ingestion, and dermal contact were made in the LF01 risk assessment. Both on-site and off-site maximum predicted annual air concentrations of VOC emissions originating from LF01 were compared to the Texas Air Control Board (TACB) health Effects Screening Levels (ESLs), which the agency uses to evaluate the impacts of air contaminants. The maximum predicted annual average concentrations resulting from Landfill 1 VOC emissions were a minimum of seven orders of magnitude lower than the conservative TACB ESLs. Potential ingestion exposures, including meat and dairy products and fish exposed to contaminants, were evaluated and found to not represent a significant pathway for human exposure to contaminants originating from the site. Dermal exposure to contaminants in the West Fork of the Trinity River is possible, however, because the river is not widely used for swimming and water contact sports this potential exposure pathway was not quantified.

The threat to human health posed by the site was evaluated in terms of noncarcinogenic and carcinogenic risks. The total hazard index was found to be significantly less than the level of concern, indicating the threat of noncarcinogenic health effects of inhalation exposure to contaminants origin-

ating from the site is not significant. The individual cancer risk for the maximum on-site and off-site exposed individual, the highest of which is 9 in 10 billion, can be dismissed as inconsequential. The potential for ingestion exposure to contaminants originating from Site LF01 is limited to ingestion of fish from the West Fork of the Trinity River. The risk of ingestion exposure by this pathway was not quantified because most local fishing takes place in lake Worth and the ground-water contributions to the river from Site LF01 are both not known and probably low. The potential for dermal exposure to contaminants originating from Landfill 1 is remote and therefore was not quantified.

Because the site ground-water contaminant concentrations are generally low and the ground-water inflow to the Trinity River is not known, the risk to terrestrial wildlife that use the river as a source of drinking water and to aquatic organisms in the river is suspected to be minimal.

Site SD13 - Unnamed Stream and Abandoned Gasoline Station

The Unnamed Stream and Abandoned Gasoline Station potentially release VOCs to the air via volatilization; and VOCs and metals to the surface water and ground water via direct and indirect discharge, and leachate generation, respectively. Potentially significant contaminant transport and fate mechanisms in the air, ground water, and surface water include: 1) air dispersion, 2) ground-water migration, 3) transport in surface water, and 4) subsequent uptake by plants and animals.

Potential pathways for contaminants to move from Site SD13 to human exposure points are the same as Site LF01 plus three additional pathways associated with an initial discharge to surface water (Figure 6-2). The potential human and wildlife receptors of contaminants released from Site SD13 were identified and are the same as those for Site LF01.

Quantification attempts of inhalation, ingestion, and dermal exposures to contaminants originating from the site were made. The maximum predicted annual average concentrations resulting from site indicator chemical

VOC emissions are at least three orders of magnitude lower than the TACB ESLs. Following the same reasoning presented relating to Landfill 1, ingestion and dermal exposure pathways are considered to be minimal and were not quantified.

With inhalation the remaining exposure pathway of significance, the threat to human health by inhalation of VOCs emitting from Site SD13 was evaluated in terms of noncarcinogenic and carcinogenic risks. Noncarcinogenic risks were compared to a hazard index and found to be insignificant. Carcinogenic risks associated with inhalation of ambient concentrations of VOCs emitted from the site, the highest of which is 1.4 in 100 million, can be dismissed as inconsequential.

Site ST14 - POL Tank Farm

The POL Tank Farm potentially releases VOCs to the air via volatilization, and VOCs, bis(2-ethylhexyl)phthalate, and metals to the ground water via leachate generation. Potentially significant contaminant transport and fate mechanisms in the air, ground water and surface water include: 1) air dispersion, 2) ground-water migration, 3) ground-water discharge to and transport in surface water, and 4) subsequent uptake by plants and animals. The transport and fate of contaminants from the POL Tank Farm follows the same pathways as described for Landfill 1 except that Upper Zone ground water might discharge into the downstream portion of Farmers Branch before it reaches the West Fork of the Trinity River.

Figure 6-1 in Section 6.1.3 indicates the potential pathways for contaminants to move from Landfill 1 to human exposure points. These same pathways apply to the POL Tank Farm. The potential human and wildlife receptors of contaminants released from the POL Tank Farm are the same as those identified for Landfill 1.

Quantification of the exposure to inhalation of ambient air concentrations of VOCs originating from Site ST14 was accomplished and the predicted annual average concentrations resulting from the site were found to be lower than the conservative TACB ESLs by a minimum of three orders to

magnitude. Exposure by ingestion and dermal pathways is likely to be minimal and was not quantified.

The threat to human health, both noncarcinogenic and carcinogenic, was evaluated in terms of risks. Noncarcinogenic health effects of inhalation exposure to contaminants originating from Site ST14 was found to be insignificant. Carcinogenic risks associated with an individual inhaling ambient concentrations of VOCs originating from the site, the highest of which was determined to be 5.7 in 100 million, can be dismissed as inconsequential. Ingestion and dermal noncarcinogenic and carcinogenic risks are likely to be minimal and were therefore not quantified.

The threat to wildlife from exposure to contaminants originating from the POL Tank Farm site is a similar low level of risk as described for Landfill 1.

Site BSS - Base Service Station

The Base Service Station potentially releases VOCs to the air via volatilization, and VOCs, bis(2-ethylhexyl)phthalate, and metals to the ground water via leachate generation. Potentially significant contaminant transport and fate mechanisms in the air and ground water include: 1) air dispersion, 2) ground-water migration, 3) ground-water discharge to and transport in surface water, and 4) subsequent uptake by plants and animals. The transport and fate of contaminants from the Base Service Station follows the same pathways as described for Landfill 1.

Figure 6-1 in Section 6.1.3 depicts potential pathways for contaminants to move from Landfill 1 to human exposure points. These same pathways apply to the Base Service Station. The potential human and wildlife receptors of contaminants released from the Base Service Station site are the same as those identified for Landfill 1. As is the case for all other East Area sites, inhalation of ambient air is the most direct exposure pathway for contaminants to move from the Base Service Station to human receptors.

concentration variations possibly related to this are not expected to differ significantly from previously observed concentration variations between sampling events. Activities to confirm this interpretation, especially with regard to lead concentrations in ground water at the POL Tank Farm, should be included in pilot scale testing of selected treatment technologies, if required. Similarly, final delineation of the extent of contaminated soils and ground water at combined Sites SD13/ST14 and Site BSS should be accomplished within the context of the detailed remedial alternatives (i.e., verification sampling, long-term monitoring) to be developed in the East Area FS.

7.2.2 Recommended Remedial Action Objectives

Results of studies conducted in the East Area have shown varying degrees of contamination in the ground water, surface water, and soils. Based on the existing environmental conditions, the recommended objectives of any remedial actions are to:

- 1) Reduce or eliminate potential impacts to human health and the environment;
- 2) Reduce or eliminate the potential for future contaminant migration in the ground water or surface water; and
- 3) Reduce, eliminate, or immobilize contaminants in residual wastes or near-surface soil (Upper Zone deposits).

To identify and evaluate remedial alternatives, potentially contaminated environmental media were identified based on previous East Area investigative results. These media include contaminated soil, Upper Zone ground water, and surface water. Specific remedial action objectives identified for each of the media are presented in Table 7-1. Remedial action objectives were developed for each media based upon the following standards or criteria:

- 70-year cancer risk potential;
- National interim primary drinking water standards maximum contaminant levels (MCLs) for organics (40 CFR 141.12 and 141.61) and inorganics (40 CFR 141.11 and 141.62); and
- Final MCLs for organics and inorganics (Federal Register, Vol. 56, No. 20, 30 January 1991).

Table 7-1 does not list all contaminants that have regulatory criteria or standards. Instead the table lists those contaminants that were identified as indicator chemicals in the baseline risk assessment for the East Area. As previously explained, metals are included as indicator chemicals, primarily on the basis of total concentrations detected. The dissolved metals concentrations detected in the 1990 sampling event do not suggest significant metals contamination.

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TABLE 7-1. REMEDIAL ACTION OBJECTIVES FOR EAST AREA IRP SITES, CARSWELL AFB, TEXAS

Environmental Media	Remedial Action Objectives
WASTE AND CONTAMINATED SOIL	<p>FOR HUMAN HEALTH: Prevent ingestion or direct contact with soil or waste at sites which contributes to greater than or equal to 10^{-6} excess cancer risk (or a potential risk characterized as greater than negligible) from the following carcinogens: TCE, benzene, bis(2-ethylhexyl)phthalate, arsenic, cadmium, and methylene chloride.</p> <p>Reduce inhalation of potential carcinogens [TCE, 1,2-DCE, tetrachloroethylene, vinyl chloride, methylene chloride, benzene, chloroform, and bis(2-ethylhexyl)phthalate] at locations which contribute to excess inhalation cancer risk levels of greater than or equal to 10^{-6} so that risk levels are lower than 10^{-6}.</p> <p>FOR ENVIRONMENTAL PROTECTION: Prevent migration of contaminants from soil that would result in ground-water contamination in excess of the following concentrations for each specific contaminant:</p>
	<u>Inorganics</u>
	<p>Arsenic 0.05 mg/L Barium 1.0 (2.0) mg/L Cadmium 0.01 (0.005) mg/L Chromium 0.05 (0.1) mg/L Lead 0.05 mg/L Selenium 0.01 (0.05) mg/L Silver 0.05 mg/L</p>
	<u>Organics</u>
	<p>TCE 5 ug/L Vinyl Chloride 2 ug/L Benzene 5 ug/L cis-1,2-DCE (100 ug/L) trans-1,2-DCE (70) ug/L Tetrachloroethene 8 ug/L Toluene 2,000 ug/L</p>

(Continued)

TABLE 7-1. (Continued)

Environmental Media	Remedial Action Objectives															
GROUND WATER	<p>FOR HUMAN HEALTH: Prevent ingestion of ground water that contributes to an excess cancer risk of greater than or equal to 10^{-6}.</p> <p>FOR ENVIRONMENTAL PROTECTION: Remove contaminants from the ground water to levels below the following concentrations:</p>															
	<table border="0"> <thead> <tr> <th style="text-align: center;"><u>Inorganics</u></th> <th style="text-align: center;"><u>Organics</u></th> </tr> </thead> <tbody> <tr> <td>Arsenic</td> <td>Vinyl Chloride</td> </tr> <tr> <td>Barium</td> <td>Benzene</td> </tr> <tr> <td>Cadmium</td> <td>cis-1,2-DCE</td> </tr> <tr> <td>Chromium</td> <td>trans-1,2-DCE</td> </tr> <tr> <td>Lead</td> <td>TCE</td> </tr> <tr> <td>Selenium</td> <td>Tetrachloroethene</td> </tr> <tr> <td>Silver</td> <td>Toluene</td> </tr> </tbody> </table>	<u>Inorganics</u>	<u>Organics</u>	Arsenic	Vinyl Chloride	Barium	Benzene	Cadmium	cis-1,2-DCE	Chromium	trans-1,2-DCE	Lead	TCE	Selenium	Tetrachloroethene	Silver
<u>Inorganics</u>	<u>Organics</u>															
Arsenic	Vinyl Chloride															
Barium	Benzene															
Cadmium	cis-1,2-DCE															
Chromium	trans-1,2-DCE															
Lead	TCE															
Selenium	Tetrachloroethene															
Silver	Toluene															
SURFACE WATER	<p>FOR HUMAN HEALTH: Prevent ingestion of or skin contact with surface water that contributes to an excess cancer risk of greater than or equal to 10^{-6}. Prevent ingestion of fish from surface water that contributes to an excess cancer risk of greater than or equal to 10^{-6}.</p> <p>FOR ENVIRONMENTAL PROTECTION: Prevent future discharge of contaminated ground water to surface water. If treated ground-water effluent is discharged to Farmers Branch, it must meet the environmental protection criteria for ground water (above).</p>															

() = Final MCL as of 30 January 1991, not effective until 30 July 1992.

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GLOSSARY OF DEFINITIONS, NOMENCLATURE, AND UNITS

AA	atomic absorption
AFB	Air Force Base
Alluvium	stream-deposited sediment; predominantly clay, silt, sand, and gravel
Aquifer	geologic unit capable of storing and transmitting significant quantities of ground water
Aquitard	geologic unit impervious to ground water which acts to contain ground water within an adjacent unit
ARAR	Applicable or Relevant and Appropriate Requirement
Artesian	term applied to ground water confined under hydrostatic pressure, water level in well rises above the top of the aquifer
BGL	below ground level
BLS	below land surface
Confined Aquifer	aquifer confined between two aquitards
DOD	U.S. Department of Defense
ECD	electron capture detector
EICP	Extracted Ion Current Profile
EPA	U.S. Environmental Protection Agency
Evapotranspiration	loss of water from the soil both by evaporation and by transpiration to growing plants
Extraction	method for mobilizing contaminant species from a solid matrix prior to analysis
FDTA	Fire Department Training Area
FS	feasibility study
GC	gas chromatography

GLOSSARY OF DEFINITIONS, NOMENCLATURE, AND UNITS (Cont.)

GC/HSD	gas chromatography/halide specific detector
GC/MS	gas chromatography/mass spectroscopy
GFAA	graphite furnace atomic absorption spectroscopy
gpd	gallons per day
gpm	gallons per minute
Hydraulic Conductivity	a coefficient of proportionality describing the rate at which water can move through a permeable medium
IRP	Installation Restoration Program
MCL	Maximum Contaminant Level
MS	mass spectroscopy
MSL	mean sea level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NCP	National Contingency Plan
OEHL	Occupational and Environmental Health Laboratory
OVA	organic vapor analyzer
O&G	oil and grease
PCB	polychlorinated biphenyl
PID	photoionization detector
Piezometric/Potentiometric Surface	an imaginary surface representing the static head of ground water defined by the level to which water will rise in a well
ppb	parts per billion
ppm	parts per million
QAPP	Quality Assurance Program Plan

GLOSSARY OF DEFINITIONS, NOMENCLATURE, AND UNITS (Cont.)

QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/Feasibility Study
SOW	Statement of Work
Spike	a known amount of a compound added to a sample and analyzed to determine the accuracy of analysis
SW-846	EPA test methods for evaluating solid wastes, physical and chemical methods
TCE	trichloroethene
TDS	Total dissolved solids
TOC	Total organic carbon
TOX	Total organic halides
TPM	Technical Program Manager
Transmissivity	the rate at which water is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient
Unconfined Aquifer	also referred to as "water-table aquifer," an aquifer in which the water table forms the upper boundary
USAF	United States Air Force
USAFOEHL	United States Air Force Occupational and Environmental Health Laboratory
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VOC	volatile organic compound
Water Table	the elevation of the ground-water surface in an unconfined aquifer

GLOSSARY OF DEFINITIONS, NOMENCLATURE, AND UNITS (Cont.)

<u>Multiplication Factor</u>	<u>Prefix</u>	<u>Symbol</u>
1,000,000,000,000,000,000=10 ¹⁸	exa-	E
1,000,000,000,000,000=10 ¹⁵	peta-	P
1,000,000,000,000,000=10 ¹²	tera-	T
1,000,000,000,000=10 ⁹	giga-	G
1,000,000,000=10 ⁶	mega-	M
1,000,000=10 ³	kilo-	k
100=10 ²	hecto-	h
10=10 ¹	deka-	da
0.1=10 ⁻¹	deci-	d
0.01=10 ⁻²	centi-	c
0.001=10 ⁻³	milli-	a
0.000 001=10 ⁻⁶	micro-	u
0.000 000 001=10 ⁻⁹	nano-	n
0.000 000 000 001=10 ⁻¹²	pico-	p
0.000 000 000 000 001=10 ⁻¹⁵	femto-	f
0.000 000 000 000 000 001=10 ⁻¹⁸	atto-	a

ppm(parts per million) = mg/kg, ug/g, ng/mg, pg/ug, mg/L, ug/mL, ng/uL
 ppb (parts per billion) = ug/kg, ng/g, pg/mg, ug/L, ng/mL, pg/uL
 ppt (parts per trillion) = ng/kg, pg/g, fg/mg, ng/L, pg/mL, fg/uL

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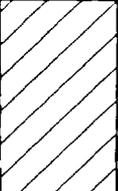
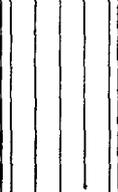
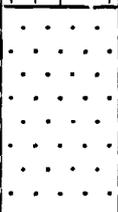
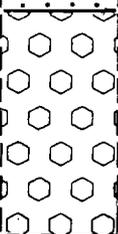
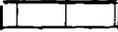
APPENDIX A

Lithologic Logs

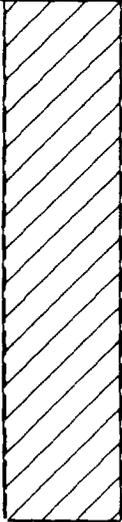
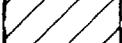
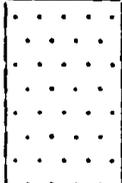
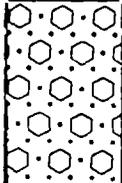
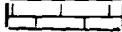
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Radian (1986) and Radian (1989)]

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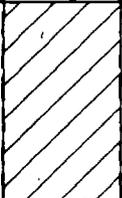
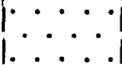
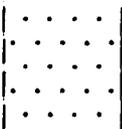
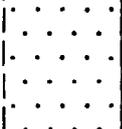
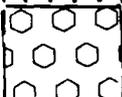
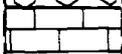
DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 14.6 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: SD13-01		10. NO. OF SAMPLES TAKEN: 6	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 558.64 ft MSL (3/26/90)	
6. COORDINATES OF HOLE: X: 2024842.22 Y: 399964.37		12. DATE HOLE ESTABLISHED: 3/26/90	
		13. SURFACE ELEVATION: 570.30 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 573.24 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/CLLR	Clay: Dark brown, slightly silty, organic, stiff, roots and decaying wood, damp.	Topsoil first 0.5 ft. Caliche zone (0.2 ft.) at 0.5 ft. BLS. Full sample recoveries unless noted.
3			U/SILT	Silt: Light brown, slightly clayey, cohesive, 1 - 2% granule size calcareous nodules, oxidation stained mottling, damp.	
4			U/SILT	Silt: As above, getting sandy (fine grained), not as cohesive.	1.5 ft. recovery. Slight diesel odor.
7.2			U/SAND	Sand: Greenish/gray, slightly clayey, slightly cohesive, fine to medium grained, quartzose, damp; At 9.0 ft. going to tan, loose, gravelly.	Gradational change; 1.2 ft. recovery; Strong diesel odor.
11			U/GRVL	Gravel: Varicolored, 5 - 10% sand, shells, saturated; Most gravels are quartz-chert, 2 - 10 mm, subangular to subrounded.	W.L. measured at 10.7 ft. BLS. Measured after well completion at 9.9 ft. BLS; 3.2 ft. sample recovery.
14.5		50	U/MARL	Limestone: Whitish - gray, weathered, indurated, fissile.	Drove 1.5 in. S.S. 1 in. = 50 Blows. T.D. = 14.6 ft.

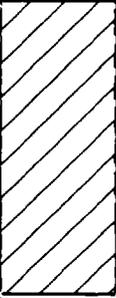
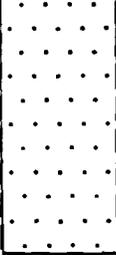
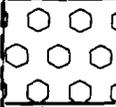
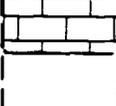
DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 14.2 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: SD13-02		10. NO. OF SAMPLES TAKEN: 7	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 559.19 ft MSL (3/26/90)	
6. COORDINATES OF HOLE: X: 2024974.41 Y: 400058.53		12. DATE HOLE ESTABLISHED: 3/27/90	
		13. SURFACE ELEVATION: 570.64 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 573.39 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/CLLR	Clay: Orange, brown, and green, silty, sandy, 1 - 3% limestone gravels, firm, cohesive, damp.	Full samplers unless noted; 1.3 ft. recovery; Looks like fill.
2			U/CLLR	Clay: As above, mottled and layered with varying colors and grain sizes, very disturbed looking.	1.6 ft. recovery.
4			U/CLLR	Clay: As above.	Looks like fill.
6			U/CLLR	Clay: As above, matrix supported gravels, still has disturbed appearance.	
8			U/SDLR	Sand: Orange/tan, 5 - 10% small gravel, loose, varying grain sizes but mostly medium grained, gravels mainly 5-10 mm but some to 20 mm, damp.	1.0 ft. recovery.
11			U/SDGR	Sand and Gravel: As above but increasing percentage of gravel, wet at 13.5 ft. Largest gravels are limestone and occur between 13.5 ft. and 14.0 ft.	2.8 ft. recovery; W.L. measured at 13.4 ft. BLS.
14			U/LMSN	Limestone: Gray, hard, oxidation stained on partings.	T.D. = 14.2 ft.

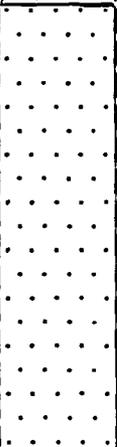
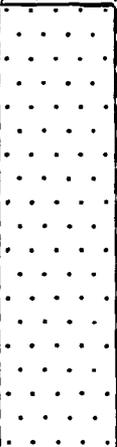
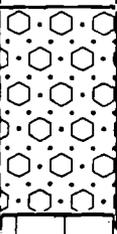
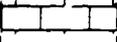
DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 14.1 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: SD13-03		10. NO. OF SAMPLES TAKEN: 9	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 557.44 ft MSL (3/26/90)	
6. COORDINATES OF HOLE:		12. DATE HOLE ESTABLISHED: 3/26/90	
X: 2024919.81 Y: 399934.09		13. SURFACE ELEVATION: 568.60 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 571.54 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/CLLR	Clay: Dark brown, silty, firm, damp, organic, roots.	Full recoveries unless noted; 1.3 ft. recovery.
2			U/CLLR	Clay: As above, becoming orange/brown.	
3			U/SILT	Silt: Orange/brown, clayey, cohesive, small roots, damp, 2 - 5 mm calcareous nodules.	1.7 ft. recovery; Gradational change.
4			U/SILT	Silt: As above, increasing coarseness (fine sand).	
6.8			U/SAND	Sand: Green/gray, very fine - medium grained, slightly clayey and cohesive, damp, quartzose, subrounded.	1.1 ft. recovery.
8			U/SAND	Sand: As above, less clay; 0.4 ft. sand and gravel seam at 9.0 ft., wet at approximately 9.0 ft. Gravels 2 - 5 mm (small). Sand is slightly cohesive.	W.L. measured 9.1 ft. BLS after well completion; Strong diesel odor.
10			U/SAND	Sand: As above, less clay, fine to coarse grained.	3.0 ft. recovery.
12			U/GRVL	Gravel: Varicolored, 20% sand, 2 - 40 mm, larger gravels limestone and angular, smaller quartz and subrounded.	Strong diesel odor.
13.5		50	U/LMSN	Limestone: Dark gray, indurated.	Sampler (CME) refusal at 14.0 ft. Drove 1 1/2 in. S.S.; 50 Blows = 0.1 ft. T.D. = 14.1 ft.

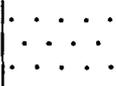
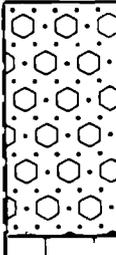
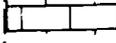
DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 10.6 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: SD13-04		10. NO. OF SAMPLES TAKEN: 6	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 558.64 ft MSL (3/26/90)	
6. COORDINATES OF HOLE: X: 2024992.02 Y: 399931.97		12. DATE HOLE ESTABLISHED: 3/26/90	
		13. SURFACE ELEVATION: 566.81 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 569.24 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/CLLR	Clay: Dark brown, stiff, organic, damp; At 1.5 ft. going to a green silty clay with calcareous mottling.	Full recoveries unless noted otherwise; Limestone fill first 0.3 ft.
2			U/CLLR	Clay: As above, getting sandy (very fine to fine grained).	1.2 ft. recovery.
4.5			U/SDMD	Sand: Orange/tan, loose, medium grained, quartzose, damp.	0.8 ft. recovery.
6			U/SAND	Sand: Green/gray, slightly clayey and slightly cohesive. At 7.5 ft. becoming coarse grained, loose, wet, 5% granule size gravel.	W.L. measured at 7.45 ft. BLS after well completion.
8.5			U/GRVL	Gravel: Varicolored, 20% sand, slightly clayey, gravels to 50 mm, larger sizes are limestone clasts, saturated.	Strong diesel odor 8.5 - 9.5 ft.
10.2			U/LMSN	Limestone: Dark gray, fissile, indurated, no fossils.	Drove S.S. sampler; 50 blows = 1 3/4 in.; T.D. = 10.6 ft.

DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 18.8 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: ST14-01		10. NO. OF SAMPLES TAKEN: 8	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 557.09 ft MSL (3/26/90)	
6. COORDINATES OF HOLE: X: 2024309.32 Y: 399886.09		12. DATE HOLE ESTABLISHED: 3/27/90	
		13. SURFACE ELEVATION: 573.20 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 575.89 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/CLLR	Clay: Dark brown, slightly silty, stiff, organic, damp.	Full samplers unless noted.
2			U/CLLR	Clay: As above, very stiff.	
4			U/CLLR	Clay: As above, turning gray/green at 5.0 ft.	
6			U/CLLR	Clay: Gray/green, silty, 5% calcareous material, firm to stiff, damp, oxidation staining.	
8			U/SAND	Sand: Greenish/gray, slightly clayey, 3 - 9 ft., slightly cohesive, fine grained, damp; at 9.0 ft. going to tan, fine to medium grained, loose, quartzose, damp.	1.0 ft. recovery.
10			U/SDMD	Sand: Tan, medium grained (mainly), loose, >95% quartz, 1-5% small gravel, saturated.	1.5 ft. recovery; W.L. measured at 11.1 ft. BLS through augers.
15			U/SDGR	Sand and Gravel: As above, increasing gravel content with depth to 60% at 17.5 ft.	
18.2			U/LMSN	Marl: Gray, fissile, indurated.	T.D. = 18.8 ft.

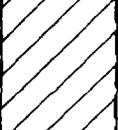
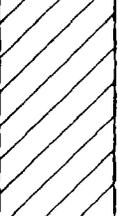
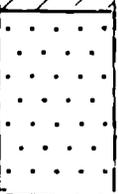
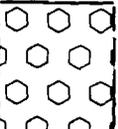
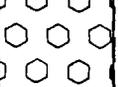
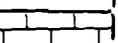
DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 17.5 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: ST14-02		10. NO. OF SAMPLES TAKEN: 8	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 558.14 ft MSL (3/27/90)	
6. COORDINATES OF HOLE: X: 2024311.81 Y: 400102.44		12. DATE HOLE ESTABLISHED: 3/27/90	
		13. SURFACE ELEVATION: 572.70 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 575.64 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/CLLR	Clay: Dark brown, silty, stiff, organic, damp; going to light brown at 3.0 ft.	Full recoveries unless noted.
2			U/CLLR	Clay: As above, carbonaceous nodules (5%, 1 - 3 mm), siltier.	Appears to be in-situ.
4.8			U/SILT	Silt: Green with oxidation stained mottling, very fine grained sand, slightly clayey, cohesive, 1 - 3% calcareous nodules.	Gradational change.
6			U/SILT	Silt: As above, sandier, roots.	
8.5			U/SAND	Sand: Greenish/gray, fine to medium grained, clayey, slightly cohesive, wet at 9.0 ft.	Strong diesel odor.
10			U/SAND	Sand: Greenish/gray, coarsening with depth, quartzose, loose, minor gravel (<10%) 12.5 - 13.5 ft.	W.L. measured at 9.4 ft. BLS through augers; 3.0 ft. recovery.
13.5			U/SDGR	Sand and Gravel: Varicolored, 40% gravel (to 20 mm), saturated; gravels mainly quartz - chert, subround, sand quartzose; increasing gravel to 60% at 16 ft. BLS.	
17.1			U/LMSN	Limestone: Gray, hard, oxidation staining.	T.D. = 17.5 ft.

DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 18.3 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: ST14-03		10. NO. OF SAMPLES TAKEN: 12	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 558.42 ft MSL (3/28/90)	
6. COORDINATES OF HOLE: X: 2024116.09 Y: 400672.37		12. DATE HOLE ESTABLISHED: 3/28/90	
		13. SURFACE ELEVATION: 574.83 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 576.72 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/LMSN	Limestone: Limestone base material; fill material.	Drilled first 0.5 ft.
0.5			U/CLLR	Clay: Dark brown, stiff, brick fragments, broken glass, damp.	
2			U/CLLR	Clay: As above, at 3.0 ft. sharp change to light brown, stiff, silty clay, with calcareous nodules.	Full samplers unless noted.
4			U/CLLR	Clay: Light brown, silty, firm, shell fragments, moist.	
6			U/CLLR	Clay: As above, soft, very moist.	
8			U/CLLR	Clay: Green/gray, silty, calcareous nodules, oxidation staining, firm, damp.	Green foamy liquid observed on sample.
11			U/SDCL	Sand: Green/gray with oxidation stained mottling, very clayey, fine to medium grained, slightly cohesive, wet.	0.5 ft. recovery.
12			U/SDCL	Sand: Clayey, as above.	1.2 ft. recovery.
14			U/SAND	Sand: As above, light gray, not as clayey.	W.L. measured down augers at 15.4 ft. BLS.
16			U/SAND	Sand: Light gray, fine to medium grained, subround, homogeneous, wet.	
17.5			U/SDGR	Sand and Gravel: 50/50, rust colored, limestone gravels to 30 mm, smaller gravel mainly chert.	Sampler (CME) refusal at 18.2 ft.
18.2		50	U/LMSN	Limestone: Gray, hard.	Drove S.S; 50 blows = 0.1 ft.; T.D. = 18.3 ft.

DRILLING LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB, TX	SHEET 1 OF 1 SHEETS
1. PROJECT: CARSWELL AFB, IRP PHASE II STAGE 2		7. TOTAL DEPTH OF HOLE: 17.0 ft BGL	
2. LOCATION: East Area		8. DATUM FOR ELEVATION SHOWN: sea level	
3. DRILLING AGENCY: Environmental Drillers, Inc.		9. MANUFACTURER'S DESIGNATION OF DRILL: Mobile Drill B-61	
4. HOLE NO.: ST14-04		10. NO. OF SAMPLES TAKEN: 10	
5. NAME OF GEOLOGIST: S. E. Fain		11. ELEVATION GROUND WATER: 558.74 ft MSL (3/28/90)	
6. COORDINATES OF HOLE: X: 2024566.48 Y: 400231.53		12. DATE HOLE ESTABLISHED: 3/29/90	
		13. SURFACE ELEVATION: 572.90 ft MSL	
		14. BACKGROUND:	
		15. MEASURING POINT ELEVATION: 575.74 ft MSL	

Depth (Ft.)	Graphic Log	Blow Count	Soil Class/Code	Visual Description	Remarks
0			U/SAND	Sand: Sandy loam for first 0.5 ft.	Full sample recoveries unless noted.
0.5			U/CLLR	Clay: Dark brown, slightly silty, stiff, carbonaceous spotting, roots, damp.	
2			U/CLLR	Clay: As above, going to orange/brown at 3.8 ft., siltier.	
4			U/CLLR	Clay: Orange/brown, stiff, calcareous material, damp.	
6			U/CLLR	Clay: As above, oxidation staining, calcareous nodules to 15 mm.	
8			U/CLLR	Clay: Gray/green, very silty, very fine grained sand, calcareous nodules, damp.	Strong fuel odor.
10.2			U/SAND	Sand: Gray/green, clayey, fine grained, wet, carbonaceous staining, cohesive; Going to medium and coarse grained at 11.7 ft.	Gradational change; W.L. measured in well at 9.6 ft. BLS.
13			U/GRVL	Gravel: Varicolored, slightly sandy, saturated, bimodal; smaller gravel (5 - 20 mm) mainly subrounded chert, larger gravels (20 - 50 mm) limestone.	Strong fuel odor.
15			U/GRVL	Gravel: As above, sand is approximately 25%.	
16.5			U/LMSN	Limestone: Gray, hard, fissile, oxidation staining on partings.	T.D. = 17.0 ft.

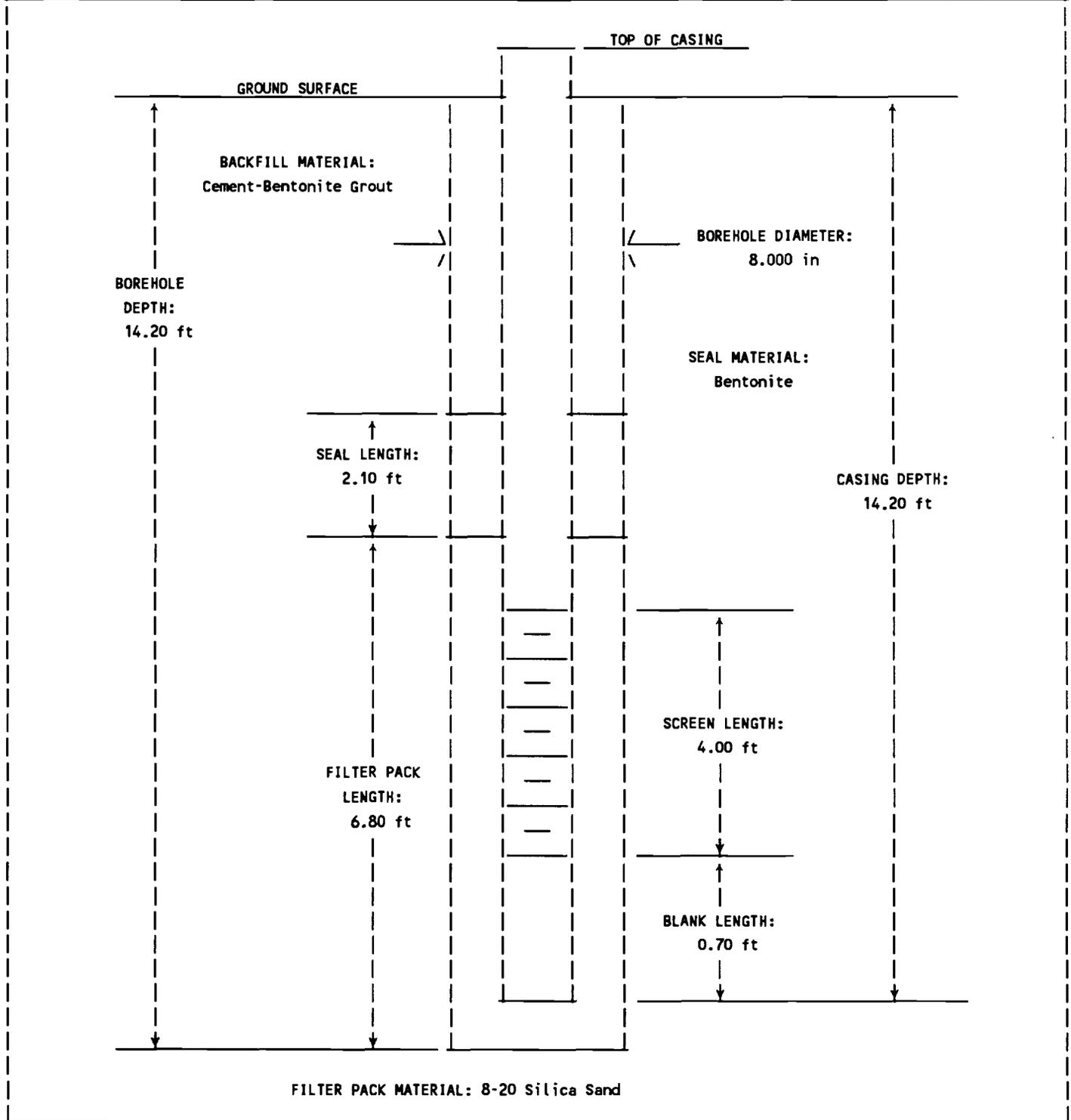
APPENDIX B
Well Completion Summaries

APPENDIX B

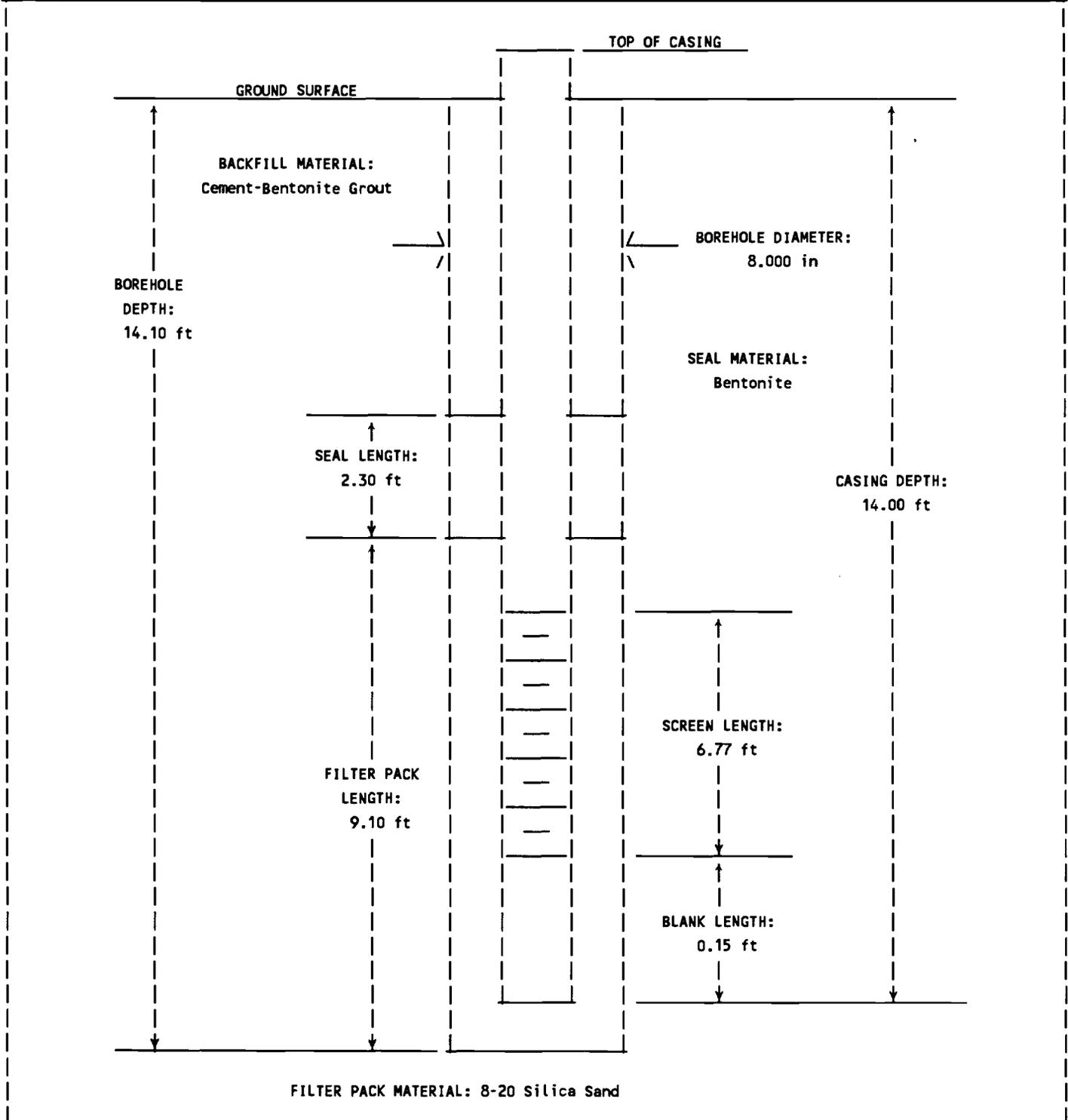
Well Completion Summaries

[Previous Well Completion Summaries may be found in
Radian (1986) and Radian (1989)]

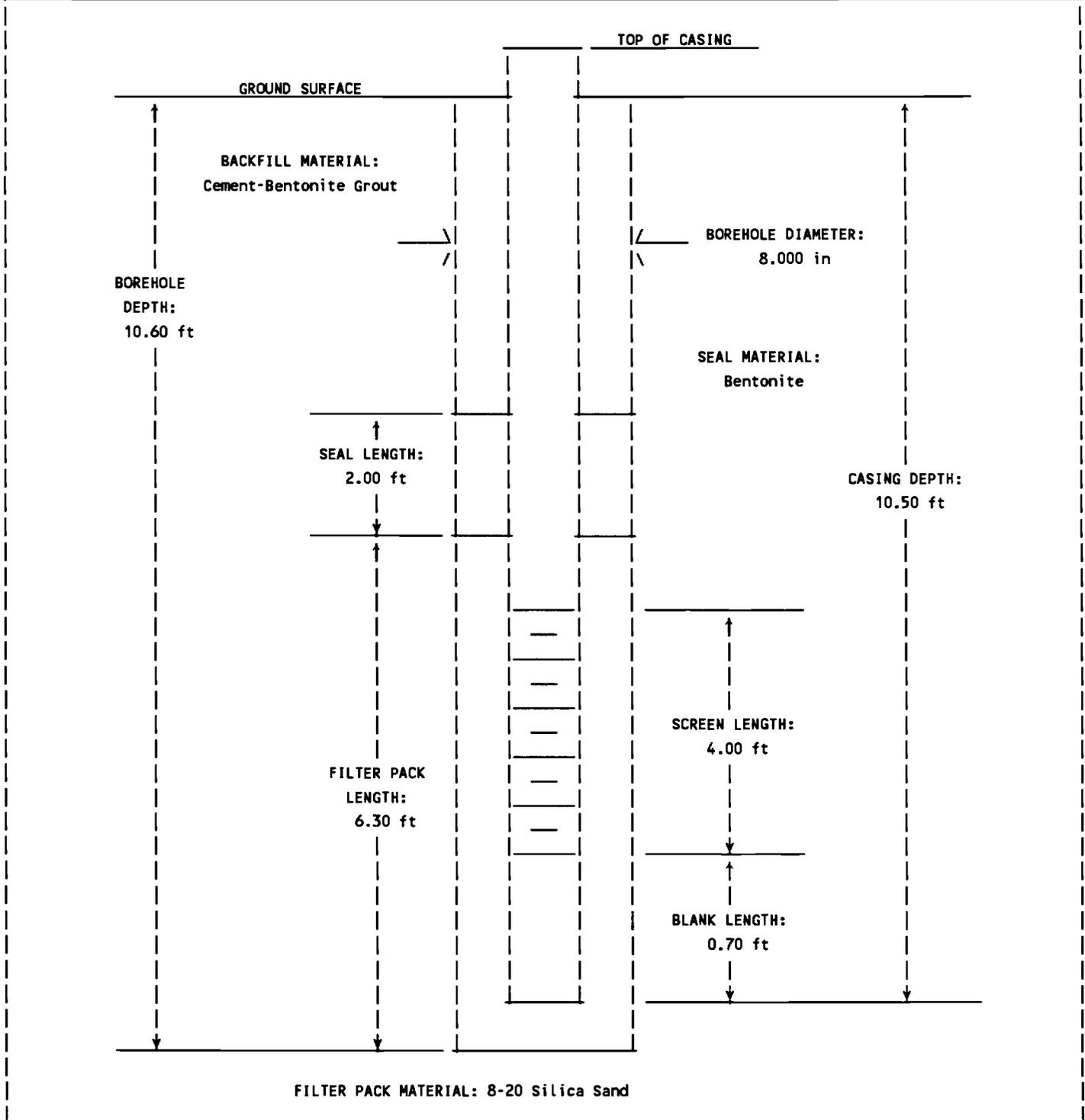
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1. PROJECT: IRP PHASE II STAGE 2, CARSWELL AFB		9. INSTALLATION DATE: 3/27/90
		10. WELL COMPLETION METHOD: GRAVEL PACK W/SCREEN
2. LOCATION: site SD13		11. ZONE OF COMPLETION: Aquifer
3. INSTALLING CO.: Radian Corporation		12. SEAL END DEPTH: 7.40 ft
4. WELL NO.: SD13-02		13. MEAS. POINT ELEV.: 573.39 ft MSL
5. WELL OWNER: U.S. AIR FORCE		14. CASING DIAMETER: 2.00 in
6. WELL TYPE CLASS: MONITORING WELL		15. CASING MATERIAL: Schedule 40 PVC
7. FORMATION OF COMPLETION:		16. SCREEN BEGIN. DEPTH: 9.50 ft
8. LOCATION TYPE: WL		17. SCREEN SLOT SIZE: 0.02 in
18. REMARKS: 1-5'x2" Screen, 1-10'x2" Riser, 1-2.5'x2" Riser, 1-0.2' Bottom Trap, 1-Locking Cap, 1-5'x0.5' Steel Protective Cover		



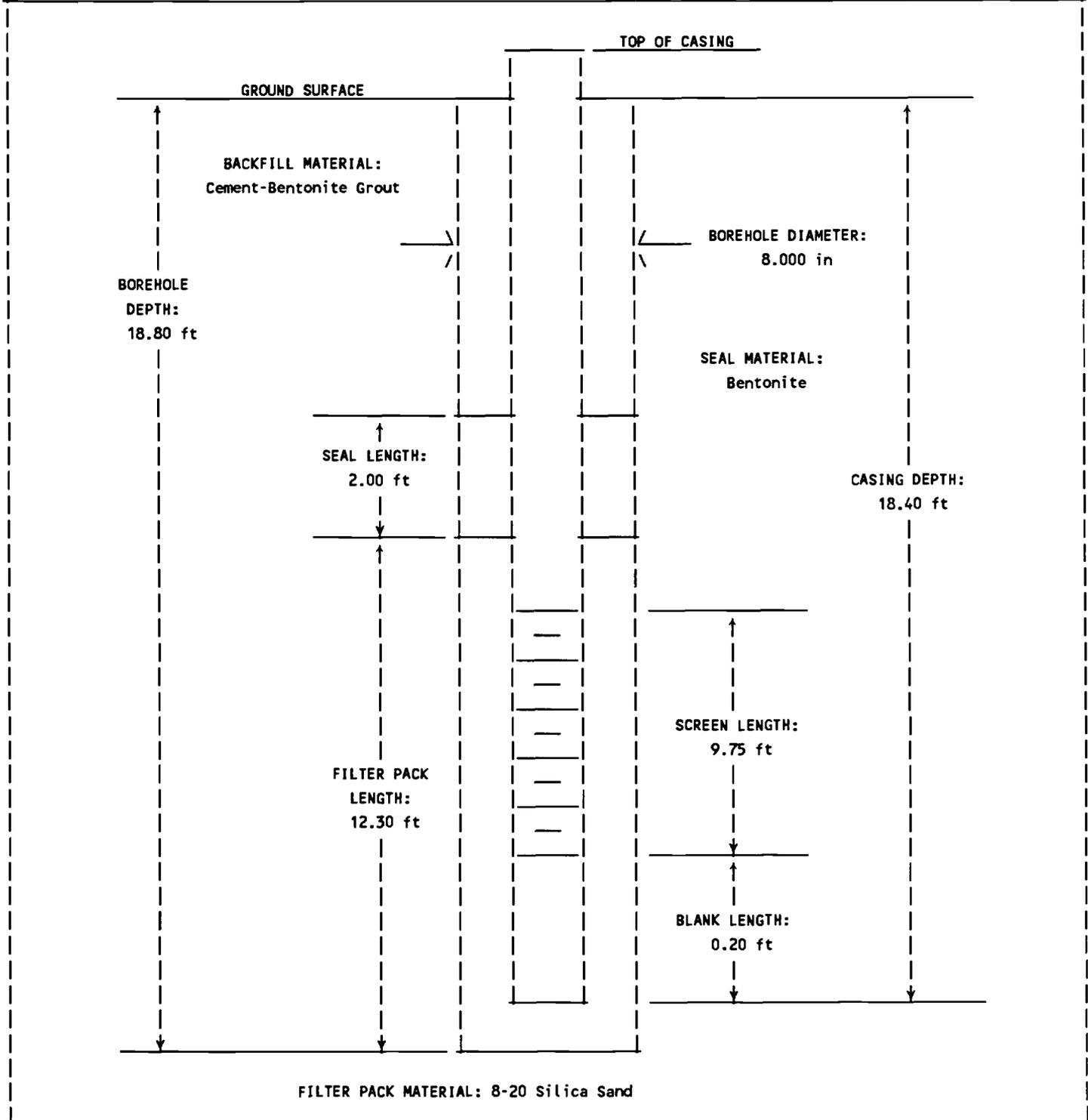
WELL COMPLETION LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB
1. PROJECT: IRP PHASE II STAGE 2, CARSWELL AFB		9. INSTALLATION DATE: 3/26/90
		10. WELL COMPLETION METHOD: GRAVEL PACK W/SCREEN
2. LOCATION: Site SD13		11. ZONE OF COMPLETION: Aquifer
3. INSTALLING CO.: Radian Corporation		12. SEAL END DEPTH: 5.00 ft
4. WELL NO.: SD13-03		13. MEAS. POINT ELEV.: 571.54 ft MSL
5. WELL OWNER: U.S. AIR FORCE		14. CASING DIAMETER: 2.00 in
6. WELL TYPE CLASS: MONITORING WELL		15. CASING MATERIAL: Schedule 40 PVC
7. FORMATION OF COMPLETION:		16. SCREEN BEGIN. DEPTH: 7.08 ft
8. LOCATION TYPE: WL		17. SCREEN SLOT SIZE: 0.02 in
18. REMARKS: 1-5'x2" Screen (cut), 1-10'x2" Riser, 1 Bottom Cap, 1-Locking 2" Cap, 1-5'x0.5' Steel Protective Cover		



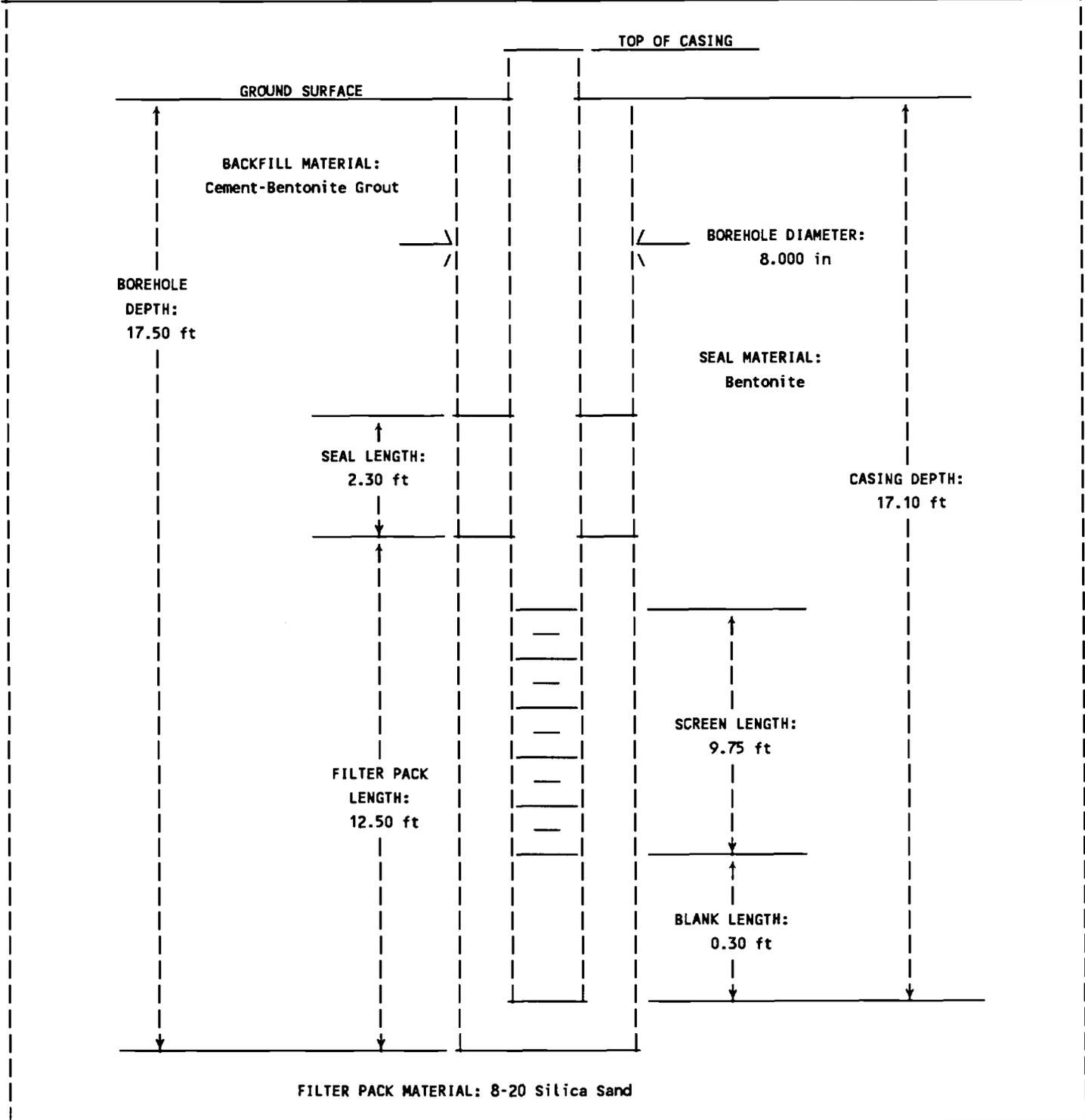
WELL COMPLETION LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB
1. PROJECT: IRP PHASE II STAGE 2, CARSWELL AFB		9. INSTALLATION DATE: 3/26/90
		10. WELL COMPLETION METHOD: GRAVEL PACK W/SCREEN
2. LOCATION: Site SD13		11. ZONE OF COMPLETION: Aquifer
3. INSTALLING CO.: Radian Corporation		12. SEAL END DEPTH: 4.30 ft
4. WELL NO.: SD13-04		13. MEAS. POINT ELEV.: 569.24 ft MSL
5. WELL OWNER: U.S. AIR FORCE		14. CASING DIAMETER: 2.00 in
6. WELL TYPE CLASS: MONITORING WELL		15. CASING MATERIAL: Schedule 40 PVC
7. FORMATION OF COMPLETION:		16. SCREEN BEGIN. DEPTH: 5.80 ft
8. LOCATION TYPE: WL		17. SCREEN SLOT SIZE: 0.02 in
18. REMARKS: 1-0.2' Bottom Trap, 1-5'x2" Screen, 1-10'x2" Riser (cut), 1-Locking Cap, 1-5'x0.5' Steel Protective Cover		



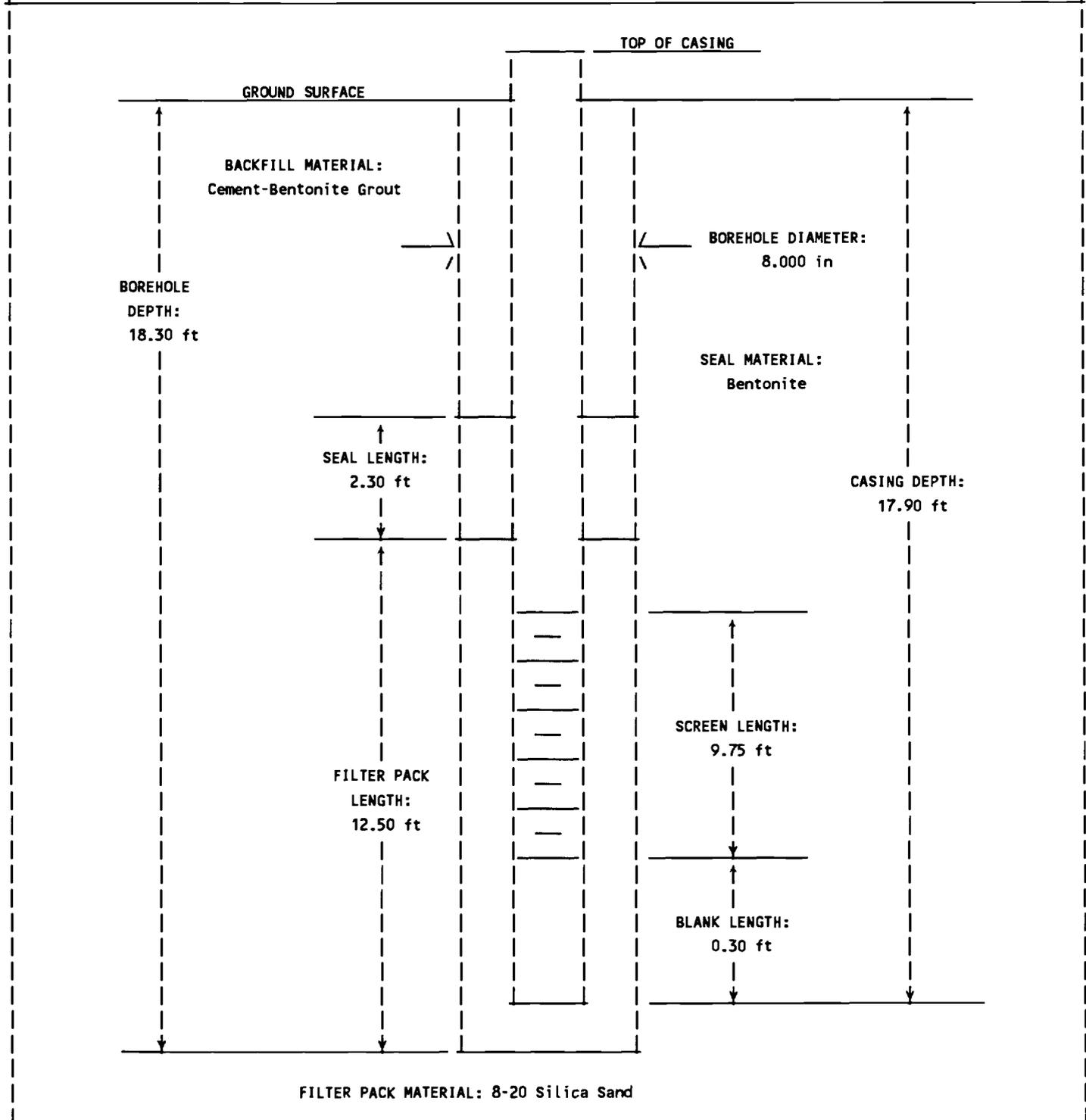
WELL COMPLETION LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB
1. PROJECT: IRP PHASE II STAGE 2, CARSWELL AFB		9. INSTALLATION DATE: 3/27/90
		10. WELL COMPLETION METHOD: GRAVEL PACK W/SCREEN
2. LOCATION: Site ST14		11. ZONE OF COMPLETION: Aquifer
3. INSTALLING CO.: Radian Corporation		12. SEAL END DEPTH: 6.50 ft
4. WELL NO.: ST14-01		13. MEAS. POINT ELEV.: 575.89 ft MSL
5. WELL OWNER: U.S. AIR FORCE		14. CASING DIAMETER: 2.00 in
6. WELL TYPE CLASS: MONITORING WELL		15. CASING MATERIAL: Schedule 40 PVC
7. FORMATION OF COMPLETION:		16. SCREEN BEGIN. DEPTH: 8.45 ft
8. LOCATION TYPE: WL		17. SCREEN SLOT SIZE: 0.02 in
18. REMARKS: 1-10'x2" Screen, 1-10'x2" Riser, 1-Locking Cap, 1-Bottom Cap, 1-5'x0.5' Locking Steel Cover		



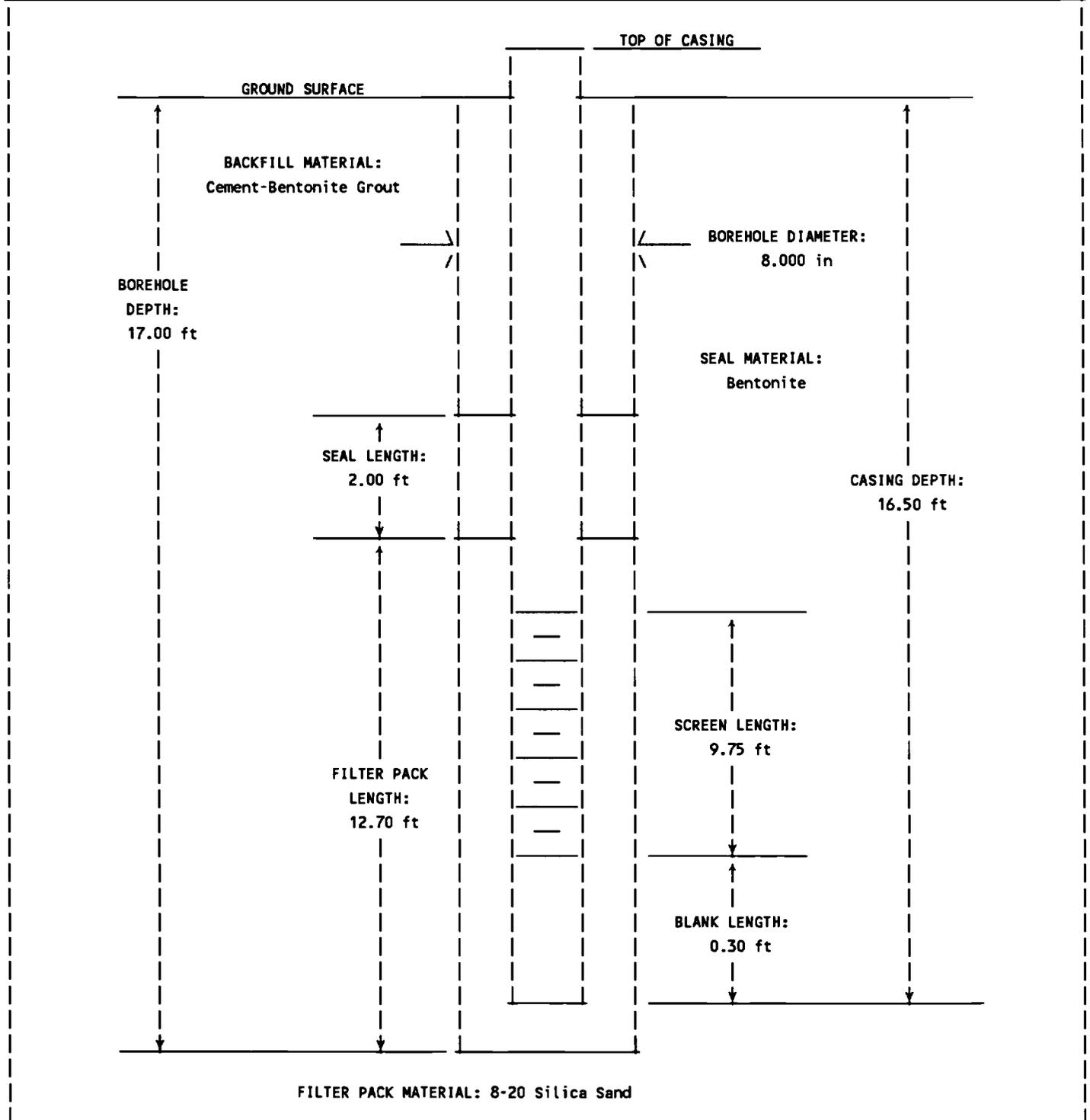
WELL COMPLETION LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB
1. PROJECT: IRP PHASE II STAGE 2, CARSWELL AFB		9. INSTALLATION DATE: 3/27/90
2. LOCATION: Site ST14		10. WELL COMPLETION METHOD: GRAVEL PACK W/SCREEN
3. INSTALLING CO.: Radian Corporation		11. ZONE OF COMPLETION: Aquifer
4. WELL NO.: ST14-02		12. SEAL END DEPTH: 5.00 ft
5. WELL OWNER: U.S. AIR FORCE		13. MEAS. POINT ELEV.: 575.64 ft MSL
6. WELL TYPE CLASS: MONITORING WELL		14. CASING DIAMETER: 2.00 in
7. FORMATION OF COMPLETION:		15. CASING MATERIAL: Schedule 40 PVC
8. LOCATION TYPE: WL		16. SCREEN BEGIN. DEPTH: 7.05 ft
		17. SCREEN SLOT SIZE: 0.02 in
18. REMARKS: 1-10' Screen, 1-10' Riser, 1-0.2' Bottom Trap		



WELL COMPLETION LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB
1. PROJECT: IRP PHASE II STAGE 2, CARSWELL AFB		9. INSTALLATION DATE: 3/28/90
		10. WELL COMPLETION METHOD: GRAVEL PACK W/SCREEN
2. LOCATION: Site ST14		11. ZONE OF COMPLETION: Aquifer
3. INSTALLING CO.: Radian Corporation		12. SEAL END DEPTH: 5.80 ft
4. WELL NO.: ST14-03		13. MEAS. POINT ELEV.: 576.72 ft MSL
5. WELL OWNER: U.S. AIR FORCE		14. CASING DIAMETER: 2.00 in
6. WELL TYPE CLASS: MONITORING WELL		15. CASING MATERIAL: Schedule 40 PVC
7. FORMATION OF COMPLETION:		16. SCREEN BEGIN. DEPTH: 7.85 ft
8. LOCATION TYPE: WL		17. SCREEN SLOT SIZE: 0.02 in
18. REMARKS: 1-10'x2" Screen, 1-10'x2" Riser, 1-Locking Cap, 1-0.2' Bottom Trap, 1-2.5'x2" Riser (cut)		



WELL COMPLETION LOG	RADIAN CORPORATION	INSTALLATION: CARSWELL AFB
1. PROJECT: IRP PHASE II STAGE 2, CARSWELL AFB		9. INSTALLATION DATE: 3/29/90
		10. WELL COMPLETION METHOD: GRAVEL PACK W/SCREEN
2. LOCATION: Site ST14		11. ZONE OF COMPLETION: Aquifer
3. INSTALLING CO.: Radian Corporation		12. SEAL END DEPTH: 4.30 ft
4. WELL NO.: ST14-04		13. MEAS. POINT ELEV.: 575.74 ft MSL
5. WELL OWNER: U.S. AIR FORCE		14. CASING DIAMETER: 2.00 in
6. WELL TYPE CLASS: MONITORING WELL		15. CASING MATERIAL: Schedule 40 PVC
7. FORMATION OF COMPLETION:		16. SCREEN BEGIN. DEPTH: 6.45 ft
8. LOCATION TYPE: WL		17. SCREEN SLOT SIZE: 0.02 in
18. REMARKS: 1-10'x2" Screen, 1-10'x2" Riser, 1-0.2' Bottom Trap, 1-5'x0.5' Steel Protective Cover, 1-Locking Cap (2")		



SECRET

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WELL DEVELOPMENT DATA - CARSWELL AFB

Location ID	Log Date	Cumulative Gallons	Cumulative Bore Volumes	Specific Conductance		Temp_F	Comments	Method
				(micromhos/cm)	pH			
SD13-01	7/4/90	4.00		780	9.22	64.40	Fuel odor	Bailmaster 36" Teflon Fluoroware Bailer
		12.00		720	6.84	66.38	Fuel odor	
		16.00		3480	6.62	66.20	Mild fuel odor	
		20.00		740	6.52	66.20	Mild fuel odor	
		27.00		740	6.67	66.02	Mild fuel odor	
		32.00	4.47	720	6.75	65.66	Mild fuel odor	
SD13-02	6/4/90	1.00		720	6.57	61.16		Brainard Killman 1 1/2" Hand Pump
		6.00		720	7.76	62.42		
		8.50		710	7.38	63.50	Slow recharge stop pumping : 15:20 - 15:25	
		9.50		720	6.86	65.12		
		12.00		710	9.18	66.20	Slow pumping checked pH w/ standard = 7.02 w/7.00	
		15.00		710	7.02	66.38	Stop pumping 15:48 - 15:55	
		15.50	9.57	720	7.03	66.20	Checked pH - checked 10.10 @ 10.00 std. 1400 @ 14 Responded quickly research	
SD13-03	7/4/90	2.00		4030	4.89	66.56	Fuel odor	Bailmaster 36" Teflon Fluoroware Bailer
		10.00		780	6.63	64.40	Fuel odor	
		13.00		780	6.58	64.76	Fuel odor	

Environmental Sciences

WELL DEVELOPMENT DATA - CARSWELL AFB

Location ID	Log Date	Cumulative Gallons	Cumulative Bore Volumes	Specific			Comments	Method
				Conductance (micromhos/cm)	pH	Temp_F		
		15.00		770	6.61	64.76	Fuel odor	
		17.00		770	6.68	64.40	Fuel odor	
		23.00		760	7.29	64.40	Fuel odor	
		30.00	4.95	760	6.70	64.40	Fuel odor	
SD13-04	6/4/90	3.00		810	6.87	63.50	Strong fuel odor	Brainard Killman 1 1/2" Hand Pump
		3.50		730	7.48	64.40	Slow recovery	
		6.50		750	8.03	64.40	Switch to bailer	
		10.00		720	7.17	64.04	Still strong fuel odor	
		14.00		730	7.25	63.50	Still strong fuel odor	
		16.00		750	4.98	63.50	pH not accurate; batt low replacement	
		18.00		750	5.12	63.50	pH not accurate but water clearing	
		23.00	3.69	740	63.50		pH not accurate but water clearing;Purged 5 vols. pH began to stabilize before meter failure-well is developed	
ST14-01	7/4/90	2.00		720	6.84	67.10		Bailmaster 36" Teflon Fluoroware Bailer
		6.00		700	6.69	66.20		
		13.00		710	6.83	65.84		
		20.00		30	6.91	66.74		

WELL DEVELOPMENT DATA - CARSMELL AFB

Location ID	Log Date	Cumulative Gallons	Cumulative Bore Volumes	Specific			Temp_F	Comments	Method
				Conductance	pH	(micromhos/cm)			
		23.00		700	6.93	66.56			
		30.00		700	6.86	66.92			
		37.00		710	6.91	66.74			
		42.00	5.73	700	6.94	66.74			
ST14-02	7/4/90	2.00		780	6.76	66.38			Bailmaster 36" Teflon Fluoroware Bailer
		8.00		740	6.84	65.84			
		15.00		720	6.87	66.56			
		20.00		710	6.85	66.74		Mild fuel odor	
		28.00		710	6.88	66.56		Mild fuel odor	
		36.00		710	6.92	66.92		Mild fuel odor	
		50.00	4.22	710	6.88	66.74		Mild fuel odor	
ST14-03	7/4/90	2.00		820	6.86	67.10		Heavy strong fuel odor	Bailmaster 36" Teflon Fluoroware Bailer
		12.00		750	6.79	67.10		Heavy strong fuel odor	
		18.00		760	6.81	67.10		Heavy strong fuel odor	
		26.00		770	6.80	66.92		Heavy strong fuel odor	
		35.00	3.96	750	6.83	67.28		Heavy strong fuel odor	
ST14-04	7/4/90	3.00		800	6.85	66.20		Strong fuel odor	Bailmaster 36" Teflon Fluoroware

WELL DEVELOPMENT DATA - CARSWELL AFB

Location ID	Log Date	Cumulative Gallons	Cumulative Bore Volumes	Specific Conductance (micromhos/cm)	pH	Temp_F	Comments	Method
		8.00		720	6.99	66.92	Strong fuel odor	Bailer
		14.00		670	7.02	66.92	Strong fuel odor	
		22.00		670	7.02	67.10	Strong fuel odor	
		29.00		700	6.99	66.92	Strong fuel odor	
		34.00		670	6.99	66.74	Strong fuel odor	
		40.00		760	6.84	66.74	Weak fuel odor	
		48.00		710	6.94	66.74	Weak fuel odor	
		52.00	3.27	730	6.94	66.74	Weak fuel odor	

APPENDIX D

Water Quality Sampling Records

[Data from Previous Studies may be found in
Radian (1986) and Radian (1989)]

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GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID C5WL LOG DATE 5-10-90 LOG TIME 1030
 LOCATION ID LFO1-1B LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 7.20 BTC

INITIAL GROUNDWATER DEPTH (FT) 7.20 BTC T.D. = 17.9 BTC (SOUNDLED)
 SAMPLING PERIOD: START 1103 COMPLETE 1111 6.47 gal = 3 water casing volu
 SAMPLING METHOD B LOGGER CODE RADN
 LAB CODE RADN DATE SENT 5-10-90
 PRESERVATION METHOD 4°C, HNO₃ - METALS
 COMMENTS ONLY FILTERED ALKALINITY PERFORMED, LOW ON ACID VIALS

FINAL PARAMETER MEASUREMENTS:

					DETECTIO: LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.62</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>833</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts	<u>-</u>		<u>-</u>
TEMPERATURE	TEMP	°C			<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			

FILTERED ALK = 422 µg/l

TIME	TOTAL VOLUME WITHDRAWN		pH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	Bore Volume(s)				
<u>1048</u>	<u>0.0</u>	<u>0.0</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>START PUMPING</u>
<u>1050</u>	<u>1.0</u>		<u>6.45</u>	<u>640</u>	<u>18.5°F</u>	<u>SLIGHTLY CLOUDY</u>
<u>1052</u>	<u>2.5</u>		<u>6.59</u>	<u>720</u>	<u>68.0°F</u>	<u>BAILING DOWN RAPIDLY</u>
<u>1054</u>	<u>4.0</u>		<u>6.62</u>	<u>727</u>	<u>68.3°F</u>	<u>LT. TAN, MOD. TURBID</u>
<u>1057</u>	<u>6.0</u>		<u>6.62</u>	<u>821</u>	<u>68.7°F</u>	<u>ALMOST GOING DRY</u>
<u>1058</u>	<u>7.0</u>		<u>6.62</u>	<u>833</u>	<u>69.0°F</u>	<u>LT. TAN SLIGHTLY TURBID</u>

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 5-10-90 LOG TIME 1135
 LOCATION ID JF01-10 LOT CONTROL NO. _____
 SAMPLE TYPE NAD SAMPLE ID _____ SAMPLE DEPTH (FT.) 8.56 BTC

INITIAL GROUNDWATER DEPTH (FT) 8.56 BTC T.D. = 35.82' BTC (SOUNDING)
12.89 gal = 3' water casing
 SAMPLING PERIOD: START 1215 COMPLETE 1228
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 5-10-90
 PRESERVATION METHOD 4°C H₂O - METALS
 COMMENTS FIRST PH AND CONDUCTIVITY VALUES SHOW EVIDENCE OF POSSIBLE SURFACE WATER EFFECTS

FINAL PARAMETER MEASUREMENTS:

					DETECTIC LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.80</u>	<u>6.80</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>797</u>	<u>797</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	<u>-</u>	<u>-</u>	<u>-</u>
TEMPERATURE	TEMP	°C	<u>-</u>	<u>-</u>	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	<u>-</u>	<u>-</u>	<u>-</u>

UNFILTERED = 343 mg/L FILTERED = 315 mg/L DAPS = 339/317

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1152	0.0	0.0	-	-	-	START PUMPING
1155	2.0		7.25	141	72.0°F	SLIGHTLY CLOUDY
1201	5.0		6.82	642	71.2°F	"
1207	7.5		6.79	772	71.8°F	"
1211	10.0		6.82	795	71.8°F	"
1213	12.0		6.80	797	71.8°F	"
1214	13.0		-	-	-	END PURGE

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 5-10-90 (SEP) LOG TIME 1400
 LOCATION ID LF01-1D LOT CONTROL NO. _____
 SAMPLE TYPE N # EB SAMPLE ID _____ SAMPLE DEPTH (FT.) 12.22 BIC
 INITIAL GROUNDWATER DEPTH (FT.) 12.22 BIC *T.D. = 24.02 BIC (SOUNDING)*
 SAMPLING PERIOD: START 1434 COMPLETE _____ *8.06 gal = 3 netted containers*
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 5-10-90
 PRESERVATION METHOD 4°C HNO₃ - METALS
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.61</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>1343</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts	<u>—</u>		<u>—</u>
TEMPERATURE	TEMP	°C			<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			

Phen Alk = 0.0
 Total Alk unfiltered - not taken
 Filtered Total Alk = 383

TIME	TOTAL VOLUME WITHDRAWN		pH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1410	0.0	0.0	-	-	-	START PUMPING
1414	2.0		6.48	1316 (SEP)	67.5°F	CLEAR
1420	4.0		6.49	1337	67.7°F	CLEAR
1424	6.0		6.52	1345	67.8°F	"
1429	8.0		6.64	1347	67.5°F	"
1431	9.0		6.61	1343	67.3°F	"
						EQUIPMENT BLANK
			5.90	2.0	72.5°F	
						ALKALINITY = 0.0

SAMPLES TYPES: (WSACODE)

D - DUPLICATE FB - FIELD BLANK
 R - REPLICATE TB - TRIP BLANK
 S - SPIKE LB - LAB BLANK
 K - KNOWN N - NORMAL

SAMPLE METHODS: (WSMCODE)

G - GRAB SP - SUBMERSIBLE PUMP
 B - BAILER AL - AIR-LIFT SAMPLER
 PP - PERISTALTIC PUMP BP - BLADDER PUMP
 SL - SUCTION LIFT PUMP

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 5-10-90 LOG TIME 1640
 LOCATION ID LF01-1E LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 11.16 BTC

 INITIAL GROUNDWATER DEPTH (FT) 11.16 BTC *TD = 32.15 BTC (SOUND)*
10.70 gal to purge
 SAMPLING PERIOD: START 1658 COMPLETE 1718
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 5-10-90
 PRESERVATION METHOD 4°C; HNO₃-METALS
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

					DETECTIC LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.78</u>	<u>0.01</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>840</u>	<u>1</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	_____	_____	_____
TEMPERATURE	TEMP	°C	_____	_____	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	_____	_____	_____

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1642	0.0	0.0	-	-	-	START PUMPING
1645	2.0		6.73	849	67.8°F	CLEAR
1649	4.0		6.75	838	67.5°F	(LT. BROWN) SLIGHTLY TURB
1652	6.0		6.80	838	67.2°F	"
1654	8.0		6.80	835	67.8°F	"
1656	10.0		6.78	840	67.8°F	"
1657	11.0		-	-	-	END PURGE

SAMPLES TYPES: (WSACODE)

D - DUPLICATE FB - FIELD BLANK
 R - REPLICATE TB - TRIP BLANK
 S - SPIKE LB - LAB BLANK
 K - KNOWN N - NORMAL

SAMPLE METHODS: (WSMCODE)

G - GRAB SP - SUBMERSIBLE PUMP
 B - BAILER AL - AIR-LIFT SAMPLER
 PP - PERISTALTIC PUMP BP - BLADDER PUMP
 SL - SUCTION LIFT PUMP

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID 05WL LOG DATE 5-10-90 LOG TIME 1550
 LOCATION ID LF01-1F LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 11.38 BTC
 INITIAL GROUNDWATER DEPTH (FT) 11.38 BTC T.D. = 32.58' BTC (SOUND)
 SAMPLING PERIOD: START 1617 COMPLETE 1626
 SAMPLING METHOD B LOGGER CODE RA02
 LAB CODE RA02 DATE SENT 5-10-90
 PRESERVATION METHOD 4°C; HNO₃ - METALS
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.82</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>903</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts			
TEMPERATURE	TEMP	°C			<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			

PHEN = 0 ALK FILTERED ALK = 358 MG/L

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1558	0.0	0.0	-	-	-	START PUMPING
1603	2.5		6.66	906	69.7°F	ORANGE/BROWN, MOD. TURBID
1608	5.0		6.78	920	70.0°F	"
1612	7.5		6.80	911	69.9°F	"
1614	8.5		6.82	907	69.5°F	"
1616	10.0		6.82	903	69.5°F	"
1617	11.0		-	-	-	END PURGE

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID C50/L LOG DATE 4/19/90 LOG TIME 0800
 LOCATION ID SD13-01 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 12.70 BTC
 INITIAL GROUNDWATER DEPTH (FT) 12.70 BTC $TD = 17.32 - 12.7 = 4.62 \times 0.17 = 0.786$
 $2.37g = 3 \text{ wetted casings}$
 SAMPLING PERIOD: START 0844 COMPLETE 0905
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/19/90
 PRESERVATION METHOD 4°C; ALL FOR PETROLEUM HYDROCARBONS; HNU₃ FOR METALS
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.84</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>780</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts			
TEMPERATURE	TEMP	°C			<u>12.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			

PHENOLPHTHALEIN ALK = 0
 TOTAL UNFILTERED = 1126 mg/L
 FILTERED TOTAL ALK. = 363 mg/L

TIME	TOTAL VOLUME WITHDRAWN		pH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	Net Volume Bore Volume				
0826	0.0	0.0	-	-	-	START PUMPING
0831	1.0	1.27	6.70	0780	65°F	ORANGE/BROWN TURBID SLIGHT SWEET
0834	2.0	2.53	6.80	0770	65.5°F	"
0837	2.5	3.16	6.81	0770	65.5°F	"
0842	4.0	5.06	6.84	0780	65.5°F	"

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4/18/90 LOG TIME 1350
 LOCATION ID SD13-02 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 15.35 (BTC)

 INITIAL GROUNDWATER DEPTH (FT) 15.35 BTC $TD = 16.5 \text{ BTC}$ $16.5 - 15.35 = 1.15$
 $1.15 \times 0.17 = 0.2$
 $0.2 \times 3 = 0.6$
 SAMPLING PERIOD: START 1410 COMPLETE 1434
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/18/90
 PRESERVATION METHOD 4°C; HNO₃ (PH < 2) IN METALS, HCL IN PET. HYD.
 COMMENTS _____

Fi W.L. = 15.35' BTC AFTER SAMPLING

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.34</u>		<u>12.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>720</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts			
TEMPERATURE	TEMP	°C			<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			

DENDRIPATHALEIN ALK = 0
TOTAL ALK (UNFILTERED) = 340 mg/L *FILTERED = 340 mg/L*

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1353	0.0	0.0	-	-	-	START PUMPING
1357	0.25	1.25	6.40	790	68°F	SLIGHTLY CLOUDY
1400	0.40	2.00	6.40	720	68°F	"
1404	0.50	2.50	6.30	710	68°F	"
1406	0.60	3.00	6.34	720	68.5°F	"
1409	1.0	5.00				

SAMPLES TYPES: (WSACODE)

D - DUPLICATE FB - FIELD BLANK
 R - REPLICATE TB - TRIP BLANK
 S - SPIKE LB - LAB BLANK
 K - KNOWN N - NORMAL

SAMPLE METHODS: (WSMCODE)

G - GRAB SP - SUBMERSIBLE PUMP
 B - BAILER AL - AIR-LIFT SAMPLER
 PP - PERISTALTIC PUMP BP - BLADDER PUMP
 SL - SUCTION LIFT PUMP

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL 5D13- LOG DATE 4/19/90 LOG TIME 1015
 LOCATION ID 5D13-03 LOT CONTROL NO. _____
 SAMPLE TYPE N&D SAMPLE ID _____ SAMPLE DEPTH (FT.) 11.73 BTC

INITIAL GROUNDWATER DEPTH (FT) 11.73 BTC *TD=16.34; 16.34-11.73=4.61
2.35g = 3' water casing volumes*
 SAMPLING PERIOD: START 1032 COMPLETE _____
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/19/90
 PRESERVATION METHOD 4°C; HNO₃ FOR METALS; HELD IN PETROLEUM H.C.
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

**DETECTION
LIMIT**

POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.75</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>840</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	_____	_____
TEMPERATURE	TEMP	°C	_____	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	_____	_____

*PHEN. ALK. = 0
 TOTAL UNFILTERED ALK = 870 µg/l FILTERED TOTAL ALK = 405 µg/l*

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP (°C)	COMMENTS
	(GALS)	<i>Netted</i> Bore Volume				
1017	0.0	0.0	-	-	-	START PUMPING
1020	0.5	0.64	6.68	820	65°F	BROWN M.D. TURBID, SLIGHT SHEEN
1022	1.5	1.92	6.72	850	65°F	"
1025	2.5	3.21	6.73	840	65°F	"
1030	4.0	5.13	6.75	840	65°F	"

SAMPLES TYPES: (WSACODE)

- D - DUPLICATE FB - FIELD BLANK
- R - REPLICATE TB - TRIP BLANK
- S - SPIKE LB - LAB BLANK
- K - KNOWN N - NORMAL

SAMPLE METHODS: (WSMCODE)

- G - GRAB
- B - BAILER
- PP - PERISTALTIC PUMP
- SL - SUCTION LIFT PUMP
- SP - SUBMERSIBLE PUMP
- AL - AIR-LIFT SAMPLER
- BP - BLADDER PUMP

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4/19/90 LOG TIME 1330
 LOCATION ID SD13-04 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 10.07

INITIAL GROUNDWATER DEPTH (FT) 10.07 BTC 15.5' TD 3.43' OF H₂O
 SAMPLING PERIOD: START 1443 COMPLETE 1440 0.5' of volume 1.75' of 1/3 wetted volume
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/19/90
 PRESERVATION METHOD 4°C; HNO₃-METALS; HCL - PETROLEUM HYDROCARBONS
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

DETECTION LIMIT

POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.78</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>822</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	—	—
TEMPERATURE	TEMP	°C	—	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	—	—

PHEN ALK = 0
 UNFILTRATED TOTAL ALK = 439 mg/l FILTERED TOTAL ALK = 400 mg/l

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1345	0.0	0.0	-	-	-	START PUMPING
1350	1.0	1.72	6.75	820	65°F	LT. BROWN, MOD. TURBID, SLIGHT SALTY
1355	1.5	2.59	6.82	834	65°F	"
1359	2.0	3.45	6.77	830	65.5°F	"
1402	3.0	5.17	6.78	822	65.5°F	"

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

SURFACE WATER QUALITY SAMPLING RECORD

INSTALLATION ID CSWL LOG DATE 5-9-90 LOG TIME 0850
 LOCATION ID SD3-52 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 0.3' BWS
 SAMPLING PERIOD: START 0903 COMPLETE 0914
 SAMPLING METHOD G LOGGER CODE RAON
 LAB CODE RAON DATE SENT 5-9-90
 PRESERVATION METHOD 4°C; HCL-602 & PET. HCL; HNO₃-METALS
 COMMENTS Rusty film on water

PARAMETER MEASUREMENTS:			DETECTION LIMIT
POTENTIAL OF HYDROGEN	Temp = 69.0°F		
	pH S.U.	6.88	0.01
SPECIFIC CONDUCTANCE	SC μmhos/cm	729	1
REDOX POTENTIAL	Eh mvolts	—	—
TEMPERATURE	TEMP °C		0.1
ALKALINITY (CaCO ₃)	ALK mg/l		
phen alk = 0.0 Total Alk = 418 Filtered = 369			

INSTALLATION ID CSWL LOG DATE 5-9-90 LOG TIME 0920
 LOCATION ID SD3-~~52~~53(SEP) LOT CONTROL NO. _____
 SAMPLE TYPE N ~~(SEP)~~ SAMPLE ID _____ SAMPLE DEPTH (FT.) 0.5 BWS
 SAMPLING PERIOD: START 0927 COMPLETE 0939
 SAMPLING METHOD G LOGGER CODE RAON
 LAB CODE RAON DATE SENT 5-9-90
 PRESERVATION METHOD 4°C; HCL-602 & PET. HCL; HNO₃-METALS
 COMMENTS WATER FAIRLY CLEAR

PARAMETER MEASUREMENTS:			DETECTION LIMIT
POTENTIAL OF HYDROGEN	Temp 69.0°F		
	pH S.U.	6.99	0.01
SPECIFIC CONDUCTANCE	SC μmhos/cm	723	1
REDOX POTENTIAL	Eh mvolts	—	—
TEMPERATURE	TEMP °C		0.1
ALKALINITY (CaCO ₃)	ALK mg/l		
phen Alk = 0.0 Total Alk = 379 Filtered Alk = 371			

- | | | | |
|--------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLE TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

SURFACE WATER QUALITY SAMPLING RECORD

INSTALLATION ID CSWL LOG DATE 5-9-90 LOG TIME 0945
 LOCATION ID SD13-54 LOT CONTROL NO. _____
 SAMPLE TYPE N&602D SAMPLE ID _____ SAMPLE DEPTH (FT.) 0.5 BWS

SAMPLING PERIOD: START 0955 COMPLETE 1007
 SAMPLING METHOD G LOGGER CODE RAON
 LAB CODE RAON DATE SENT 5-9-90

PRESERVATION METHOD 4°C; HCL-602 & PKT. HCL; HNO₃-METALS

COMMENTS RUSTY FILM AND ORANGE FORM IN WATER
ESTIMATED DISCHARGE OF UNNAMED STREAM TO FARMERS BRANCH = 0.2 cfs
(Outflow from pipe = 1' width x 0.1' depth x 2 ft/sec)
ALSO SMALL FLOW COMING IN FROM ADJACENT SOURCE IMMEDIATELY UPSTREAM

PARAMETER MEASUREMENTS:	Temp	69.5 °F		DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>7.09</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>720</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	_____	_____
TEMPERATURE	TEMP	°C	_____	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	_____	_____

Pinn Alk = 0.0
 Total Alk = 263 Filtered = 243 (SMALL TRIBUTARY FLOW) ≈ 0.05 cfs

INSTALLATION ID _____ LOG DATE _____ LOG TIME _____
 LOCATION ID _____ LOT CONTROL NO. _____
 SAMPLE TYPE _____ SAMPLE ID _____ SAMPLE DEPTH (FT.) _____

SAMPLING PERIOD: START _____ COMPLETE _____
 SAMPLING METHOD _____ LOGGER CODE _____
 LAB CODE _____ DATE SENT _____
 PRESERVATION METHOD _____
 COMMENTS _____

PARAMETER MEASUREMENTS:				DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	_____	_____
SPECIFIC CONDUCTANCE	SC	µmhos/cm	_____	_____
REDOX POTENTIAL	Eh	mvolts	_____	_____
TEMPERATURE	TEMP	°C	_____	_____
ALKALINITY (CaCO ₃)	ALK	mg/l	_____	_____

- | | | | |
|-------------------------|------------------|---------------------------|-----------------------|
| SAMPLE TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSNL LOG DATE 4/20/90 LOG TIME 0820
 LOCATION ID ST14-01 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 13.55 BTC
 INITIAL GROUNDWATER DEPTH (FT.) 13.55 (BTC) TD=13.55 BTC (SOUNDING) 4.45' D.17 = 0.04' * 3 = 2.529' ^{3 unit} _{cosin}
 SAMPLING PERIOD: START 0854 COMPLETE _____
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/20/90
 PRESERVATION METHOD 4°C; HW₂ - METALS; HCL - PETROLEUM HYDROCARBON
 COMMENTS SAMPLE FOR NO₃ & OPD₄ NEXT WEEK

FINAL PARAMETER MEASUREMENTS:

POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.91</u>	DETECTION LIMIT	<u>12.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>746</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts	<u>—</u>		
TEMPERATURE	TEMP	°C	<u>—</u>		<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	<u>—</u>		

PHEN. ALK = 0.0 mg/L
 TOTAL UNFILTERED ALK = 642 mg/L FILTERED TOTAL ALK = 353 mg/L

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	Bore Volume				
0843	0.0	0.0	-	-	-	START PUMPING
0845	0.5	0.60	6.83	751	66°F	ORANGE/BROWN, VERY TURBID
0847	1.5	1.79	6.86	757	66°F	"
0848	2.5	2.98	6.89	755	66°F	"
0850	4.0	4.76	6.91	746	66°F	LIGHT BROWN, SLIGHTLY TO MODERATELY TURBID

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4/20/90 LOG TIME 1040
 LOCATION ID ST14-02 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 11.84 BTC

 INITIAL GROUNDWATER DEPTH (FT) 11.84 BTC $TD = 19.46 - 11.84 = 7.62$
 $D.P. = 1.3$
 $1.3 \times 5 = 3.99$ to purge
 SAMPLING PERIOD: START 1100 COMPLETE 1155
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/20/90 (DRIVE TO AUSTIN)
 PRESERVATION METHOD 4°C; HCL - PETROLEUM HYDROCARBONS; HNO₃ - METALS (602'S SENT TO SAC)
 COMMENTS WILL SAMPLE FOR NDS AND OPUL NEXT WEEK

FINAL PARAMETER MEASUREMENTS:				DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.93</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>3710</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	—	—
TEMPERATURE	TEMP	°C	—	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	—	—

PHEN. ALK. = 0
 TOTAL UNFILTERED = 850 mg/L TOTAL FILTERED ALK = 340 mg/L

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP (°C)	COMMENTS
	(GALS)	Bore Volumes				
1050	0.0	0.0	-	-	-	START PUMPING
1052	0.5	0.38	6.87	3720	67°F	ORANGE/BROWN, MUD. TURBID
1054	2.0	1.54	6.90	3720	68°F	"
1056	3.5	2.69	6.91	3700	67°F	" , STRONG FUEL ODOR
1058	4.5	3.46	6.93	3710	67°F	"

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4/23/90 LOG TIME 1300
 LOCATION ID ST14-03 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 872 BTC

INITIAL GROUNDWATER DEPTH (FT) 8.72 BTC $70 = 120 - 18 - 6.72 = 9.28 - 0.17 = 1.59$
 $1.58 \cdot 3 = 4.739 / 3 \approx 1.58$
 SAMPLING PERIOD: START 1404 COMPLETE 1430
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/23/90
 PRESERVATION METHOD 4°C: HNO₃ - METALS; HCL - CO₂ & PET. H.C.
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

						DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.		<u>6.94</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm		<u>888</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts		—		
TEMPERATURE	TEMP	°C				<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l				

PHEN. ALK = 0
 TOTAL UNFILTERED ALK. = 512 mg/L TOTAL FILTERED ALK. = 382 mg/L

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1350	0.0	0.0	-	-	-	START PUMPING
1356	1.0		6.92	888	70°F	BROWN MUD - HIGH TURBIDITY
1358	2.0		6.93	922	68.5°F	BROWN MODERATELY TURBID
1400	3.0		6.90	930	68°F	"
1402	5.0		6.94	888	68°F	LIGHT BROWN, SLIGHTLY TURBID

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4/19/90 LOG TIME 1540
 LOCATION ID ST14-04 LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 12.32 BTC

 INITIAL GROUNDWATER DEPTH (FT) 12.32 BTC $70 = 19.4$ $19.4 - 12.32 = 7.08$
 $7.08 \times 0.17 = 1.2035 \approx 3.6g = 3 \text{ wetted casing}$
 SAMPLING PERIOD: START 1625 COMPLETE 1715
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/19/90
 PRESERVATION METHOD 4°C; HNO₃ - METALS; HCL - PETROLEUM HYDROCARBONS
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

						DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.		<u>6.79</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm		<u>792</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts		<u>—</u>		
TEMPERATURE	TEMP	°C				<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l				

PHENOL PATRALEIN ALK = 0
UNFILTERED TOTAL ALK. = 713 mg/l *FILTERED TOTAL ALK. = 366 mg/l*

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	Bore Volume				
1549	0.0	0.0	-	-	-	START PUMPING
1551	1.0	0.83	6.74	775	66°F	ALMOST CLEAR, SLIGHT SHADE
1554	1.5	1.25	6.80	800	67°F	BROWN-MUD. TO HIGH TURBIDITY
1557	2.5	2.08	6.81	788	67°F	" RAINBOW SHADE
1600	3.5	2.92	6.81	783	67.5°F	"
1604	5.0	4.17	6.79	792	67.5°F	"

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID C5WL LOG DATE 4/24/90 LOG TIME 0745
 LOCATION ID ST14-17E LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 10.06 BTC
 INITIAL GROUNDWATER DEPTH (FT) 10.06 BTC TD = 9.65' BTC (SOUNDING)
17.65 - 10.65 = 9.99' O.P. = 1.63' 3 = 4
4.899 = 3 wetted casings
 SAMPLING PERIOD: START 0833 COMPLETE 0852
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/24/90
 PRESERVATION METHOD 4°C; HNO₃ - METALS; HCL - LOZ & PET. H.C.
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.94</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>828</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts	-		
TEMPERATURE	TEMP	°C			<u>19.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			

PHEN. ALK = 0

TOTAL UNFILTERED ALK = 425 µg/L

TOTAL FILTERED ALK = 370 µg/L

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
<u>0817</u>	<u>0.0</u>	<u>0.0</u>	-	-	-	START PUMPING
<u>0821</u>	<u>0.5</u>		<u>6.83</u>	<u>804</u>	<u>64.5°F</u>	<u>LT. BROWN SLIGHTLY TURBID</u>
<u>0824</u>	<u>1.5</u>		<u>6.86</u>	<u>845</u>	<u>65°F</u>	<u>"</u>
<u>0826</u>	<u>3.0</u>		<u>6.91</u>	<u>822</u>	<u>65°F</u>	<u>LT. BROWN/GRAY, SLIGHTLY TURBID</u>
<u>0828</u>	<u>4.0</u>		<u>6.92</u>	<u>820</u>	<u>65°F</u>	<u>"</u>
<u>0830</u>	<u>5.0</u>		<u>6.94</u>	<u>828</u>	<u>65°F</u>	<u>"</u>

SAMPLES TYPES: (WSACODE)

D - DUPLICATE FB - FIELD BLANK
 R - REPLICATE TB - TRIP BLANK
 S - SPIKE LB - LAB BLANK
 K - KNOWN N - NORMAL

SAMPLE METHODS: (WSM CODE)

G - GRAB SP - SUBMERSIBLE PUMP
 B - BAILER AL - AIR-LIFT SAMPLER
 PP - PERISTALTIC PUMP BP - BLADDER PUMP
 SL - SUCTION LIFT PUMP

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4-24-90 LOG TIME 1240
 LOCATION ID 5T14-17J LOT CONTROL NO. _____
 SAMPLE TYPE N & D & EB SAMPLE ID _____ SAMPLE DEPTH (FT.) 10.65 BTC

INITIAL GROUNDWATER DEPTH (FT.) 10.65 BTC T.D. = 21.4 BTC (SAMPLED)
10.75 - 0.17 = 1.03 - 3 = 5.48g. to pump
 SAMPLING PERIOD: START 1309 COMPLETE 1410
 SAMPLING METHOD B LOGGER CODE 11A0N
 LAB CODE RAON DATE SENT 4-24-90
 PRESERVATION METHOD 4°C; HCL-602 & PET. H.C.; HNO₃-METALS
 COMMENTS TOOK NORMAL SAMPLE, DUPLICATE AND EQUIPMENT BLANK AT THIS LOCATION

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.74</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>800</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts	<u>—</u>		
TEMPERATURE	TEMP	°C			<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			
PHEN. ALK. = 0		EA ALKALINITY = 0			
TOTAL UNFILTERED ALK. = 348 mg/L		TOTAL FILTERED ALK. = 329 mg/L, 332 mg/L duplicate			

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	Bore Volumes				
1257	0.0	0.0	-	-	-	START PUMPING
1259	1.0		6.65	860	65.5°F	ALMOST CLEAR
1301	2.0		6.74	795	66°F	" VERY SLIGHTLY CLOUDY
1303	3.5		6.77	793	66°F	"
1305	5.0		6.75	807	66°F	"
1307	6.0		6.74	800	66°F	ALMOST CLEAR

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4/24/90 LOG TIME 0925
 LOCATION ID ST14-17K LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 9.22 BTC

INITIAL GROUNDWATER DEPTH (FT) 9.22 BTC T.D. = 13.34 BTC (SOUNDING) 3200
9.12 - 0.17 = 1.55; 1.55 - 3 = 4.65g/1000
 SAMPLING PERIOD: START 0940 COMPLETE 1000
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/24/90
 PRESERVATION METHOD 7°C; HNO₃ - METALS; HCL - PET. H.C. & 602
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:				DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.98</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>797</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	_____	_____
TEMPERATURE	TEMP	°C	_____	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	_____	_____

PHEN. ALK = 0
 TOTAL UNFILTERED ALK = 697 mg/L FILTERED ALK (TOTAL) = 314 mg/L

TIME	TOTAL VOLUME WITHDRAWN		pH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volumes)				
0930	0.0	0.0	-	-	-	START PUMPING
0932	0.5		6.92	797	66°F	LT. ORANGE/BROWN, SLIGHTLY TURBID
0934	2.0		6.97	796	66°F	" MOD. TURBID
0936	3.5		6.97	793	66°F	"
0938	5.0		6.98	797	66°F	"

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 4/24/90 LOG TIME 1035
 LOCATION ID ST14-17L LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 9.98 BTC

INITIAL GROUNDWATER DEPTH (FT.) 7.98' BTC *TD = 21.2' BTC*
1.99 gal. netted cos. of volume
5.72913"
 SAMPLING PERIOD: START 1053 COMPLETE 1110
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 4/24/90
 PRESERVATION METHOD 4°C. HNO₃ - METALS; HCL - 602 & PET. H.C.
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

**DETECTION
LIMIT**

POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.81</u>	<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>856</u>	<u>1</u>
REDOX POTENTIAL	Eh	mvolts	—	—
TEMPERATURE	TEMP	°C	—	<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	—	—

PHEN. ALK. = 0
 TOTAL UNFILTERED ALK = 504 mg/L TOTAL FILTERED ALK = 387 mg/L

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	Bore Volume				
1041	0.0	0.0	-	-	-	START PUMPING
1043	1.0		6.62	866	65.5°F	SLIGHTLY TURBID, ORANGE GELATINOUS MATERIAL
1045	2.5		6.76	868	66°F	" LESS GELATINOUS MAT.
1047	4.0		6.80	857	66°F	" < 1% ORANGE MAT.
1049	5.0		6.83	838	66°F	ORANGE, SLIGHTLY TURBID
1051	6.5		6.81	856	66°F	"

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID OSWL LOG DATE 10/23/90 LOG TIME 1530
 LOCATION ID 5TH-17M LOT CONTROL NO. _____
 SAMPLE TYPE N & EB SAMPLE ID _____ SAMPLE DEPTH (FT.) 10.1 BTC

 INITIAL GROUNDWATER DEPTH (FT) 10.10 BTC $15.45 \text{ (1.0 BTC)} - 10.1 = 5.35 = 0.1$
 $0.91 \cdot 3 = 2.73 \text{g (3' depth)}$
 SAMPLING PERIOD: START 1605 COMPLETE 1715 N EB
 SAMPLING METHOD B LOGGER CODE 100N
 LAB CODE 100N DATE SENT 4/23/90
 PRESERVATION METHOD 400. ANO³-METALS HEL-602 & PER. HYDROCARBONS
 COMMENTS 1.12' OF HYDROCARBON FREE PHASE IN FIRST BAILED

FINAL PARAMETER MEASUREMENTS:

						DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.		<u>6.87</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm		<u>850</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts				
TEMPERATURE	TEMP	°C				<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l				

PHEN. ALK = _____
 TOTAL UNFILTERED ALK = 521 mg/L TOTAL FILTERED ALK = 385

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
1542	0.0	0.0	-	-	-	START PUMPING
1547	1.0		6.85	687	71° F	Brown Hydrocarbon Layer
1551	2.5		6.87	858	70° F	" SILTY, SANDY
1554	3.5		6.92	849	69.5° F	" SLIGHTLY TURBID
1558	4.0		6.87	850	69.5° F	SLIGHTLY TURBID, OILY FILM
EQUIPMENT BLANK						
1730			6.80	0.00	83° F	CLEAR

SAMPLES TYPES: (WSACODE)

- D - DUPLICATE FB - FIELD BLANK
- R - REPLICATE TB - TRIP BLANK
- S - SPIKE LB - LAB BLANK
- K - KNOWN N - NORMAL

SAMPLE METHODS: (WSMCODE)

- G - GRAB SP - SUBMERSIBLE PUMP
- B - BAILER AL - AIR-LIFT SAMPLER
- PP - PERISTALTIC PUMP BP - BLADDER PUMP
- SL - SUCTION LIFT PUMP

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID USWL LOG DATE 5-14-90 LOG TIME 0750
 LOCATION ID BSS-A LOT CONTROL NO. _____
 SAMPLE TYPE N + EA SAMPLE ID _____ SAMPLE DEPTH (FT.) 4.98 BTC
 INITIAL GROUNDWATER DEPTH (FT) 4.98 BTC I.D. = 10.3" BTC (30.206g)
3.71991 = 3' NETTED CASING
 SAMPLING PERIOD: START 0840 COMPLETE 0855
 SAMPLING METHOD B LOGGER CODE RA01
 LAB CODE RA01 DATE SENT 5-10-90
 PRESERVATION METHOD 4.00 4.50 - PH; HCL - 607; HCL - METALS
 COMMENTS USING 0.16 ACID FOR ALKALINITY - 10X MULTIPLIER

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.75</u>		<u>N.D.</u>
SPECIFIC CONDUCTANCE	SC	μ mhos/cm	<u>1017</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts	<u>—</u>		<u>—</u>
TEMPERATURE	TEMP	°C	<u>—</u>		<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	<u>—</u>		

PHEN. ALK = 0

TOTAL UNFILTERED ALK = 4125 μ g/L

TOTAL FILTERED ALK = 4300

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (μ mhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
0830	0.0	0.0	-	-	-	START PUMPING
0832	1.0		6.55	1040	70.0°F	SLIGHTLY CLOUDY BLACK FLAKE
0834	2.0		6.73	999	70.1°F	"
0836	3.0		6.74	1009	70.1°F	"
0838	4.0		6.75	1017	70.1°F	"
						EQUIPMENT BREAK
0840			5.88	500	72.0°F	CLEAR
						ENTERED
						ALKALINITY = 62 μ g/L *
						= 19 μ g/L after scrubbing
						100ml oxidant
						cylinder

SAMPLES TYPES: (WSACODE)

D - DUPLICATE FB - FIELD BLANK
 R - REPLICATE TB - TRIP BLANK
 S - SPIKE LB - LAB BLANK
 K - KNOWN N - NORMAL

SAMPLE METHODS: (WSMCODE)

G - GRAB SP - SUBMERSIBLE PUMP
 B - BAULER AL - AIR-LIFT SAMPLER
 PP - PERISTALTIC PUMP BP - BLADDER PUMP
 SL - SUCTION LIFT PUMP

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID USWL LOG DATE 5-9-90 LOG TIME 1400

LOCATION ID (B55-B) LOT CONTROL NO. _____

SAMPLE TYPE N MS MSD SAMPLE ID _____ SAMPLE DEPTH (FT.) 2.60 BTC
 - - - # AC

INITIAL GROUNDWATER DEPTH (FT) 2.60 BTC T.D. = 12.92" BTC (SOUND)
 2.2 gal = 3 worked casing

SAMPLING PERIOD: START 1515 COMPLETE 1548

SAMPLING METHOD B LOGGER CODE RAON

LAB CODE RAON DATE SENT 5-9-90

PRESERVATION METHOD 4°C, HCL - 60%, H₂SO₄ - PH; H₂O₂ - METALS

COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

						DETECTIC LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.		<u>6.88</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm		<u>1140</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts		<u>---</u>		<u>---</u>
TEMPERATURE	TEMP	°C				<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l				<u>---</u>

Phen Alk = 0.0
 Total Alk = 321 Filtered 297

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volumes)				
1426	0.0	0.0	-	-	-	START PUMPING
1428	0.5		6.88	1185	70.2°F	CLEAR - BLACK FLAKES
1431	1.5		6.80	1136	69.0°F	SLIGHTLY TURBID, BLACK FLAKES
1434	2.5		6.87	1148	69.5°F	"
1436	3.0		6.88	1140	69.5°F	"

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NCRMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 5-9-90 LOG TIME 1625
 LOCATION ID (BSS-C) LOT CONTROL NO. _____
 SAMPLE TYPE N&D SAMPLE ID _____ SAMPLE DEPTH (FT.) 3.90 BTC

 INITIAL GROUNDWATER DEPTH (FT) 3.90 BTC T.D. = 12.03' BTC (SOUNDING)
 SAMPLING PERIOD: START 1650 COMPLETE 1710 4.14991 = 3 WETTED CASING MINUTES
 SAMPLING METHOD B LOGGER CODE RAON
 LAB CODE RAON DATE SENT 5-9-90
 PRESERVATION METHOD 4°C, HNO₃-METALS, HCL-602, H₂SO₄-PETROLEUM HC
 COMMENTS _____

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>6.83</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>896</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts	<u>-</u>		<u>-</u>
TEMPERATURE	TEMP	°C			<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l			

Phen Alk 0.0
 Total Alk 241 µg/L TOTAL FILTERED = 229 µg/L DUP = 236 µg/L / 229 µg/L

TIME	TOTAL VOLUME WITHDRAWN		PH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
<u>1645</u>	<u>0.0</u>	<u>0.0</u>	<u>-</u>	<u>-</u>	<u>-</u>	START PUMPING
<u>1648</u>	<u>1.0</u>		<u>6.82</u>	<u>921</u>	<u>66.0°F</u>	<u>ORANGE TINT, SLIGHTLY TURBID</u>
<u>1650</u>	<u>2.0</u>		<u>6.80</u>	<u>894</u>	<u>66.7°F</u>	<u>"</u>
<u>1653</u>	<u>3.0</u>		<u>6.80</u>	<u>895</u>	<u>66.8°F</u>	<u>"</u>
<u>1655</u>	<u>4.5</u>		<u>6.83</u>	<u>896</u>	<u>66.7°F</u>	<u>"</u>

- | | | | |
|---------------------------------|------------------|----------------------------------|-----------------------|
| SAMPLES TYPES: (WSACODE) | | SAMPLE METHODS: (WSMCODE) | |
| D - DUPLICATE | FB - FIELD BLANK | G - GRAB | SP - SUBMERSIBLE PUMP |
| R - REPLICATE | TB - TRIP BLANK | B - BAILER | AL - AIR-LIFT SAMPLER |
| S - SPIKE | LB - LAB BLANK | PP - PERISTALTIC PUMP | BP - BLADDER PUMP |
| K - KNOWN | N - NORMAL | SL - SUCTION LIFT PUMP | |

GROUND WATER QUALITY SAMPLING RECORD

PAGE 1

INSTALLATION ID CSWL LOG DATE 9-13-90 LOG TIME 1245
 LOCATION ID BSS:C LOT CONTROL NO. _____
 SAMPLE TYPE N SAMPLE ID _____ SAMPLE DEPTH (FT.) 11.26

INITIAL GROUNDWATER DEPTH (FT) 11.26' BTC TD = 12.02 BTC (Sounded)
 SAMPLING PERIOD: START 1317 COMPLETE _____
 SAMPLING METHOD B LOGGER CODE RADN
 LAB CODE RADN DATE SENT 9-13-90
 PRESERVATION METHOD HCL + 4%
 COMMENTS Bailer hitting impediment 0.3' above 'bottom' of well

FINAL PARAMETER MEASUREMENTS:

					DETECTION LIMIT
POTENTIAL OF HYDROGEN	pH	S.U.	<u>7.29</u>		<u>0.01</u>
SPECIFIC CONDUCTANCE	SC	µmhos/cm	<u>0780</u>		<u>1</u>
REDOX POTENTIAL	Eh	mvolts			
TEMPERATURE	TEMP	°C	<u>83°F</u>		<u>0.1</u>
ALKALINITY (CaCO ₃)	ALK	mg/l	<u>-</u>		

TIME	TOTAL VOLUME WITHDRAWN		pH	SC (µmhos/cm)	TEMP. (°C)	COMMENTS
	(GALS)	(Bore Volume)				
	0.0	0.0	-	-	-	START PUMPING
1323	0.1	0.75	7.39	0690	83°F	CLOUDY, FULL 1' IRON' COL. SILT
1341	0.3	2.25	7.75	0760	83°F	CLEARING, 2 ND PULL TURBID
1346	0.4	3.00	7.29	0780	83°F	CLEAR TAN, 3 RD PULL TURBID

SAMPLES TYPES: (WSACODE)

D - DUPLICATE FB - FIELD BLANK
 R - REPLICATE TB - TRIP BLANK
 S - SPIKE LB - LAB BLANK
 K - KNOWN N - NORMAL

SAMPLE METHODS: (WSMCODE)

G - GRAB SP - SUBMERSIBLE PUMP
 B - BAILER AL - AIR-LIFT SAMPLER
 PP - PERISTALTIC PUMP BP - BLADDER PUMP
 SL - SUCTION LIFT PUMP

APPENDIX E
Survey Data

11/24/2010

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7

**HYDROGEOLOGIC INVESTIGATION
CARSWELL AIR FORCE BASE
FORT WORTH, TEXAS**

**Texas State Plane Coordinate and Elevation
of
Test Wells,
Soil Gas Probes and
Sampling Points**

April 8, 1988

EXISTING WELL SITES

NUMBER	NORTH "Y"	EAST "X"	ELEVATION OF TOP OF P.V.C.	ELEVATION OF NATURAL GROUND AT WELL
BSS A(45)	402,068.84192	2,024,357.78905	566.38	566.9
BSS B(34)	402,390.17981	2,024,331.93158	569.73	567.1
BSS C(36)	402,254.07567	2,024,565.70484	559.57	560.0
BSS D(38)	402,418.08908	2,024,487.37097	561.45	
P1 (111)	397,712.30601	2,019,695.14307	*628.58	625.5
P2 (96)	397,542.85438	2,020,627.90845	*618.78	615.5
1A (131)	401,089.90010	2,025,128.18992	570.27	566.5
1B (132)	401,268.84868	2,025,291.18966	560.25	560.49 (ASP)
1C (134)	401,032.46237	2,025,482.01757	560.00	560.31 (ASP)
1D (137)	400,852.84768	2,025,642.78693	563.93	560.5
1E (135)	401,173.20809	2,025,407.53205	562.25	559.4
1F (136)	401,002.55061	2,025,607.46316	562.26	559.5
3A (121)	398,360.53325	2,017,786.72397		633.47
3B (118)	398,345.88397	2,018,291.94176		633.84
3C (117)	397,831.27206	2,018,292.28878		635.39
3D (120)	398,698.98292	2,017,477.40425	625.25	621.6
3E (119)	398,358.43081	2,019,005.28691		622.87
4A (129)	396,920.99434	2,020,042.19064	625.76	624.6
4B (130)	396,940.34767	2,020,463.63663	619.90	618.4
4C (98)	397,217.02642	2,020,785.31555	613.04	610.9
4D (97)	397,446.17694	2,020,610.98175	615.35	613.1
4E (95)	397,651.12948	2,020,607.56231	618.54	617.5
4F (93)	397,680.42416	2,020,255.75892	625.36	622.8
4G (100)	397,836.73039	2,020,857.61303	620.02	619.1
4H (99)	397,541.43725	2,020,916.84913	613.43	610.5
5A (109)	398,061.75689	2,019,781.72497	623.18	619.4
5B (90)	398,520.35788	2,020,283.72459	600.45	597.4
5C (104)	398,339.27594	2,020,196.97152	608.68	606.8
5D (103)	398,362.32313	2,019,960.19729	611.71	608.5
5E (110)	397,802.46440	2,019,748.19597	626.89	623.9
5F (94)	397,904.64236	2,020,535.56245	618.95	619.4
5G (88)	398,174.57747	2,020,894.69337	615.39	612.0
5H (89)	398,351.69445	2,020,546.91832	610.62	608.4
10A (108)	397,913.30549	2,020,009.97063	626.70	624.2
10B (92)	397,899.01251	2,020,243.06886	624.46	621.1
10C (91)	398,197.02603	2,020,267.33493	617.24	615.4
10D (107)	397,857.53638	2,020,078.59020		623.33
10E (106)	397,896.37914	2,020,147.65721		622.52
10F (105)	397,946.08160	2,020,196.19956		621.47
11A (101)	398,941.02097	2,020,086.99390	608.22	604.8
11B (102)	398,653.41765	2,020,136.88570	608.14	603.8
12A (124)	397,175.89292	2,019,636.22169	635.66	632.0
12B (113)	397,333.41742	2,019,895.65480	627.55	625.6
12C (115)	397,213.82758	2,019,968.84527	628.05	625.5
12D (112)	397,511.40056	2,019,943.01512	627.45	624.8
12E (114)	397,324.25035	2,020,019.35440	627.48	624.5
12G (127)	397,111.16499	2,019,819.73011		629.22
12H (126)	397,175.34773	2,019,813.89486		629.06
12I (125)	397,231.20475	2,019,814.97473		269.15
12J (128)	397,175.26975	2,019,858.53625		628.66
12K (116)	397,222.63773	2,019,904.66442		626.74

	NORTH "X"	EAST "Y"	ELEVATION OF TOP P.V.C. PIPE	ELEVATION OF NATURAL GROUND AT WELL
15A (149)	400,123.22038	2,025,232.61342	570.24	570.7
15B (148)	399,906.57343	2,025,252.78758	567.12	564.2
15C (144)	399,884.41824	2,025,168.58849	566.89	564.3
17I (75)	400,225.13342	2,023,849.67063	578.19	575.2
17J (56)	400,362.97881	2,023,809.58530	579.79	577.0
17K (72)	400,193.17235	2,024,001.90555	575.34	573.8
17L (61)	400,394.21647	2,023,966.04349	577.27	574.4
17M (65)	400,380.91204	2,024,264.07312	574.28	572.6

*NOTE: WELLS P1 & P2 - THE ELEVATIONS SHOWN ARE THE TOP OF THE OPERATOR NUT.

HYDROGEOLOGIC INVESTIGATION
CARSWELL AIR FORCE BASE
FORT WORTH, TEXAS

Texas State Plane Coordinate and Elevation
of
Test Wells,
Soil Gas Probes and
Sampling Points

July 10, 1990

SITE ST14

<u>NUMBER</u>	<u>TYPE</u>	<u>NORTH "Y"</u>	<u>EAST "X"</u>	<u>ELEVATION TOP OF PVC</u>	<u>ELEVATION NATURAL GROUND AT WELL/BORE</u>
ST14-01	WELL	399,886.0854	2,024,309.3181	575.89	573.2
ST14-02	WELL	400,102.4353	2,024,311.8094	575.64	572.7
ST14-03	WELL	400,672.3650	2,024,116.0939	576.72	574.83 ASP
ST14-04	WELL	400,231.5326	2,024,566.4807	575.74	572.9

SITE SD13

<u>NUMBER</u>	<u>TYPE</u>	<u>NORTH "Y"</u>	<u>EAST "X"</u>	<u>ELEVATION TOP OF PVC</u>	<u>ELEVATION NATURAL GROUND AT WELL/BORE</u>
SD13-01	WELL	399,964.3693	2,024,842.2218	573.24	570.3
SD13-02	WELL	400,058.5313	2,024,974.4094	573.39	570.64 ASP
SD13-03	WELL	399,934.0917	2,024,919.8140	571.54	568.6
SD13-04	WELL	399,931.9664	2,024,992.0174	569.24	566.81 ASP

SURFACE WATER SAMPLES

<u>NUMBER</u>	<u>NORTH "Y"</u>	<u>EAST "X"</u>	<u>WATER ELEVATION</u>
SD13-S1	399,722.7878	2,025,153.1150	551.64
SD13-S2	399,729.5605	2,025,176.1395	551.14
SD13-S3	399,747.0566	2,025,235.6200	549.72
SD13-S4	399,757.2157	2,025,270.1565	548.95

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Approved for Release by NSA on 05-08-2014 pursuant to E.O. 13526

APPENDIX F
Defense Priority Model Worksheets

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Site identification: Site SD13 - Unnamed Stream and Abandoned Gasoline Station

SURFACE WATER PATHWAYS

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max.</u> <u>score</u>
<u>Observed releases</u>				
1. Have contaminants been detected in surface water? If yes, assign score of 100 and proceed to item 10. If no, assign score of 0 and proceed to item 2.	0 100	1	<u>100</u>	100
<u>Pathway characteristics</u>				
2. Distance to nearest surface water	0 1 2 3	4	_____	12
3. Net precipitation	0 1 2 3	1	_____	3
4. Surface erosion potential	0 1 2 3	4	_____	12
5. Rainfall intensity	0 1 2 3	4	_____	12
6. Surface permeability	0 1 2 3	3	_____	9
7. Sum of items 2 through 6			_____	48
8. Normalized score (multiply item 7 x 100/48)			_____	
9. Flooding potential	0 1 2 3	8	_____	24
10. Adjusted pathways score If item 1 is 100, enter 100. If item 1 is 0, enter sum of items 8 and 9. If sum exceeds 100, enter 100.			<u>100</u>	
11. Waste containment effectiveness factor (Table 2)			<u>1.0</u>	
12. Final score for surface water pathways (multiply item 10 x item 11)			<u>100</u>	

COMMENTS ON SURFACE WATER PATHWAYS

Known discharges from oil/water separator. No containment/treatment.

GROUNDWATER PATHWAYS

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max. score</u>
<u>Observed releases</u>				
13. Have contaminants been detected in groundwater? If yes, assign score of 100 and proceed to item 20. If no, assign score of 0 and proceed to item 14.	0 100	1	<u>100</u>	100
<u>Pathway characteristics</u>				
14. Depth to seasonal high groundwater from base of waste or contaminated zone	0 1 2 3	9	_____	27
15. Permeability of the unsaturated zone	0 1 2 3	5	_____	15
16. Infiltration potential	0 1 2 3	5	_____	15
17. Sum of items 14 through 16			_____	57
18. Normalized score (multiply item 17 x 100/57)			_____	
19. Potential for discrete features in the unsaturated zone to "short-circuit" the pathway to the water table	0 1 2 3	5	_____	15
20. Adjusted pathways score. If item 13 is 100, enter 100. If item 13 is 0, enter sum of items 18 and 19. If sum exceeds 100, enter 100.			_____	
21. Waste containment effectiveness factor (Table 5)			<u>1.0</u>	
22. Final score for groundwater pathways (multiply item 20 x item 21)			<u>100</u>	

COMMENTS ON GROUNDWATER PATHWAYS

Known contamination in ground water. No containment/treatment.

10/14/00

Site identification: SD13 - Unnamed Stream and Abandoned Gasoline Station

CONTAMINANT HAZARD -- SURFACE WATER

If contaminants have been detected in surface water (score of 100 in item 1), complete items 23 through 28. If contaminants have not been detected (score of 0 in item 1), complete items 29 through 32. Attach Hazard Worksheet or list of contaminants, as appropriate.

	<u>Score</u> (circle one)	<u>Result</u>	<u>Logarithm</u> (base 10)
23. Sum of human health hazard quotients (from column 10 of Hazard Worksheet)		<u>7.4x10⁶</u>	<u>6.9</u>
24. Human health hazard score	0 1 2 4 6		
25. Normalized human health hazard score (multiply item 24 x 100/6)		<u>100</u>	
26. Sum of ecological hazard quotients (enter the larger of the sums of column 11 or 12 of Hazard Worksheet)		<u>67.8</u>	<u>1.8</u>
27. Ecological hazard score	0 1 2 3 4 5 6		
28. Normalized ecological hazard score (multiply item 27 x 100/6)		<u>66.7</u>	

29. Maximum human health hazard index	0 1 2 3 4 5 6 7 8 9	Contaminant: _____	
30. Normalized human health hazard score (multiply item 29 x 100/9)		_____	
31. Maximum ecological hazard index	0 1 2 4 6	Contaminant: _____	
32. Normalized ecological hazard score (multiply item 31 x 100/6)		_____	

CONTAMINANT HAZARD -- GROUNDWATER

If contaminants have been detected in groundwater (score of 100 in item 13), complete items 33 through 38. If contaminants have not been detected (score of 0 in item 13), complete items 39 through 42. Attach Hazard Worksheet or list of contaminants, as appropriate.

33. Sum of human health hazard quotients (from column 10 of Hazard Worksheet)		<u>4.7x10⁷</u>	<u>7.7</u>
34. Human health hazard score	0 1 2 4 6		
35. Normalized human health hazard score (multiply item 34 x 100/6)		<u>100</u>	
36. Sum of ecological hazard quotients (enter the larger of the sums of column 11 or 12 of Hazard Worksheet)		<u>113.4</u>	<u>2.1</u>
37. Ecological hazard score	0 1 2 3 4 5 6		
38. Normalized ecological hazard score (multiply item 37 x 100/6)		<u>83.3</u>	

39. Maximum human health hazard index	0 1 2 3 4 5 6 7 8 9	Contaminant: _____	
40. Normalized human health hazard score (multiply item 39 x 100/9)		_____	
41. Maximum ecological hazard index	0 1 2 4 6	Contaminant: _____	
42. Normalized ecological hazard score (multiply item 41 x 100/6)		_____	

Site identification: Site SD13 - Unnamed Stream and Abandoned Gasoline Station

HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max.</u> <u>score</u>
43. Population that obtains drinking water from potentially affected surface water body(ies) within 3 miles (4.8 km) downstream	0 1 2 ③	3	<u>9</u>	9
44. Water use of nearest surface water body(ies)	0 1 2 ③	3	<u>9</u>	9
45. Population within 1000 ft (305 m) of the site	0 1 2 ③	1	<u>3</u>	3
46. Distance to the nearest installation boundary	0 1 2 ③	1	<u>3</u>	3
47. Land use and/or zoning within 1 mile (1.6 km) of the site	0 1 2 ③	1	<u>3</u>	3
48. Sum of items 43 through 47			<u>27</u>	27
49. Final score for human health receptors on surface water pathways (multiply item 48 x 100/27)			<u>100</u>	

ECOLOGICAL RECEPTORS -- SURFACE WATER PATHWAYS

50. Importance/sensitivity of biota/habitats in potentially affected surface water bodies nearest the site	0 1 ② 3	5	<u>10</u>	15
51. Presence of "critical environments" within 1 mile (1.6 km) of the site	① 3	1	<u>0</u>	3
52. Sum of items 50 and 51			<u>10</u>	18
53. Final score for ecological receptors on surface water pathways (multiply item 52 x 100/18)			<u>55.6</u>	

COMMENTS ON SURFACE WATER RECEPTORS

Site identification: Site SD13 - Unnamed Stream and Abandoned Gasoline Station

HUMAN HEALTH RECEPTORS -- GROUNDWATER PATHWAY

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
54. Estimated mean groundwater travel time from current waste location to nearest downgradient water supply well(s)	0 1 2 3	9	<u>0</u>	27
55. Estimated mean groundwater travel time from current waste location to any downgradient surface water body that supplies water for domestic use or for food chain agriculture	0 1 2 3	5	<u>15</u>	15
56. Groundwater use of the uppermost aquifer	0 1 2 3	4	<u>8</u>	12
57. Population potentially at risk from groundwater contamination	0 6 9 12 18 24 27 36	1	<u>27</u>	36
58. Population within 1000 ft (305 m) of the site	0 1 2 3	1	<u>3</u>	3
59. Distance to the nearest installation boundary	0 1 2 3	1	<u>3</u>	3
60. Sum of items 54 through 59			<u>56</u>	96
61. Final score for human health receptors on groundwater pathways (multiply item 60 x 100/96)			<u>58.3</u>	

ECOLOGICAL RECEPTORS -- GROUNDWATER PATHWAYS

62. Estimated mean groundwater travel time from current waste location to any downgradient habitat or natural area	0 1 2 3	3	<u>9</u>	9
63. Importance/sensitivity of downgradient biota/habitats that are confirmed or suspected groundwater discharge points	0 1 2 3	3	<u>6</u>	9
64. Presence of "critical environments" within 1 mile (1.6 km) of the site	0 3	1	<u>0</u>	3
65. Sum of items 62 through 64			<u>15</u>	21
66. Final score for ecological receptors on groundwater pathways (multiply item 65 x 100/21)			<u>71.4</u>	

COMMENTS ON GROUNDWATER RECEPTORS (attach additional pages if needed)

54. Ground-water flow towards Farmers Branch nearest well is on opposite side, thus no flow towards well.

Site identification: Site SD13 - Unnamed Stream and Abandoned Gasoline Station

SCORING SUMMARY SHEET

	<u>Pathways score</u>		<u>Contaminant hazard score</u>		<u>Receptors score</u>		<u>Overall score</u>
67. Surface water/human health scores	(<u>100</u>)	x	<u>100</u>	x	<u>100</u>	) /10,000 =	<u>100.0</u>
	item 12		item 25/30		item 49		
68. Surface water/ecological scores	(<u>100</u>)	x	<u>66.7</u>	x	<u>55.6</u>	) /10,000 =	<u>37.1</u>
	item 12		item 28/32		item 53		
69. Groundwater/human health scores	(<u>100</u>)	x	<u>100</u>	x	<u>58.3</u>	) /10,000 =	<u>58.3</u>
	item 22		item 35/40		item 61		
70. Groundwater/ecological scores	(<u>100</u>)	x	<u>83.3</u>	x	<u>71.4</u>	) /10,000 =	<u>59.5</u>
	item 22		item 38/42		item 66		

OVERALL SITE SCORE:

$$71. \quad \left(\frac{100}{\text{item 67}} \right)^2 \times 5 + \left(\frac{37.1}{\text{item 68}} \right)^2 + \left(\frac{58.3}{\text{item 69}} \right)^2 \times 5 + \left(\frac{59.5}{\text{item 70}} \right)^2 = \underline{71,911.1}$$

$$72. \quad \text{Overall site score} = \frac{71,911.1}{\text{item 71}} \cdot 3.464 = \underline{20,759.6}$$

Site identification: Site ST14 - POL Tank Farm

SURFACE WATER PATHWAYS

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max.</u> <u>score</u>
<u>Observed releases</u>				
1. Have contaminants been detected in surface water? If yes, assign score of 100 and proceed to item 10. If no, assign score of 0 and proceed to item 2.	0 100	1	<u>0</u>	100
<u>Pathway characteristics</u>				
2. Distance to nearest surface water	0 1 <u>2</u> 3	4	<u>8</u>	12
3. Net precipitation	<u>0</u> 1 2 3	1	<u>0</u>	3
4. Surface erosion potential	0 <u>1</u> 2 3	4	<u>4</u>	12
5. Rainfall intensity	0 1 2 <u>3</u>	4	<u>12</u>	12
6. Surface permeability	0 1 <u>2</u> 3	3	<u>6</u>	9
7. Sum of items 2 through 6			<u>30</u>	48
8. Normalized score (multiply item 7 x 100/48)			<u>62.5</u>	
9. Flooding potential	<u>0</u> 1 2 3	8	<u>0</u>	24
10. Adjusted pathways score If item 1 is 100, enter 100. If item 1 is 0, enter sum of items 8 and 9. If sum exceeds 100, enter 100.			<u>62.5</u>	
11. Waste containment effectiveness factor (Table 2)			<u>0.1</u>	
12. Final score for surface water pathways (multiply item 10 x item 11)			<u>6.3</u>	

COMMENTS ON SURFACE WATER PATHWAYS

11. Tanks are in excellent condition.

Site identification: Site ST14 - POL Tank Farm

GROUNDWATER PATHWAYS

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max. score</u>
<u>Observed releases</u>				
13. Have contaminants been detected in groundwater? If yes, assign score of 100 and proceed to item 20. If no, assign score of 0 and proceed to item 14.	0 100	1	<u>100</u>	100
<u>Pathway characteristics</u>				
14. Depth to seasonal high groundwater from base of waste or contaminated zone	0 1 2 3	9	_____	27
15. Permeability of the unsaturated zone	0 1 2 3	5	_____	15
16. Infiltration potential	0 1 2 3	5	_____	15
17. Sum of items 14 through 16			_____	57
18. Normalized score (multiply item 17 x 100/57)			_____	
19. Potential for discrete features in the unsaturated zone to "short-circuit" the pathway to the water table	0 1 2 3	5	_____	15
20. Adjusted pathways score. If item 13 is 100, enter 100. If item 13 is 0, enter sum of items 18 and 19. If sum exceeds 100, enter 100.			<u>100</u>	
21. Waste containment effectiveness factor (Table 5)			<u>1.0</u>	
22. Final score for groundwater pathways (multiply item 20 x item 21)			<u>100</u>	

COMMENTS ON GROUNDWATER PATHWAYS

13. Ground water contamination detected.

Site identification: Site SD14 - POL Tank Farm

CONTAMINANT HAZARD -- SURFACE WATER

If contaminants have been detected in surface water (score of 100 in item 1), complete items 23 through 28. If contaminants have not been detected (score of 0 in item 1), complete items 29 through 32. Attach Hazard Worksheet or list of contaminants, as appropriate.

	Score (circle one)	Result	Logarithm (base 10)
23. Sum of human health hazard quotients (from column 10 of Hazard Worksheet)		_____	_____
24. Human health hazard score	0 1 2 4 6		
25. Normalized human health hazard score (multiply item 24 x 100/6)		_____	
26. Sum of ecological hazard quotients (enter the larger of the sums of column 11 or 12 of Hazard Worksheet)		_____	_____
27. Ecological hazard score	0 1 2 3 4 5 6		
28. Normalized ecological hazard score (multiply item 27 x 100/6)		_____	

29. Maximum human health hazard index	0 1 2 3 ④ 5 6 7 8 9	Contaminant: <u>manganese</u>	
30. Normalized human health hazard score (multiply item 29 x 100/9)		<u>44.4</u>	
31. Maximum ecological hazard index	0 1 2 ④ 6	Contaminant: <u>lead</u>	
32. Normalized ecological hazard score (multiply item 31 x 100/6)		<u>66.7</u>	

CONTAMINANT HAZARD -- GROUNDWATER

If contaminants have been detected in groundwater (score of 100 in item 13), complete items 33 through 38. If contaminants have not been detected (score of 0 in item 13), complete items 39 through 42. Attach Hazard Worksheet or list of contaminants, as appropriate.

33. Sum of human health hazard quotients (from column 10 of Hazard Worksheet)		<u>1.7x10⁷</u>	<u>7.2</u>
34. Human health hazard score	0 1 2 4 ⑤		
35. Normalized human health hazard score (multiply item 34 x 100/6)		<u>100</u>	
36. Sum of ecological hazard quotients (enter the larger of the sums of column 11 or 12 of Hazard Worksheet)		<u>86.7</u>	<u>1.9</u>
37. Ecological hazard score	0 1 2 3 ④ 5 6		
38. Normalized ecological hazard score (multiply item 37 x 100/6)		<u>66.7</u>	

39. Maximum human health hazard index	0 1 2 3 4 5 6 7 8 9	Contaminant: _____	
40. Normalized human health hazard score (multiply item 39 x 100/9)		_____	
41. Maximum ecological hazard index	0 1 2 4 6	Contaminant: _____	
42. Normalized ecological hazard score (multiply item 41 x 100/6)		_____	

01/11/00

Site identification: Site SD14 - POL Tank Farm

HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
43. Population that obtains drinking water from potentially affected surface water body(ies) within 3 miles (4.8 km) downstream	0 1 2 <u>3</u>	3	<u>9</u>	9
44. Water use of nearest surface water body(ies)	0 1 2 <u>3</u>	3	<u>9</u>	9
45. Population within 1000 ft (305 m) of the site	0 1 2 <u>3</u>	1	<u>3</u>	3
46. Distance to the nearest installation boundary	0 1 <u>2</u> 3	1	<u>2</u>	3
47. Land use and/or zoning within 1 mile (1.6 km) of the site	0 1 2 <u>3</u>	1	<u>3</u>	3
48. Sum of items 43 through 47			<u>26</u>	27
49. Final score for human health receptors on surface water pathways (multiply item 48 x 100/27)			<u>96.3</u>	

ECOLOGICAL RECEPTORS -- SURFACE WATER PATHWAYS

50. Importance/sensitivity of biota/habitats in potentially affected surface water bodies nearest the site	0 1 <u>2</u> 3	5	<u>10</u>	15
51. Presence of "critical environments" within 1 mile (1.6 km) of the site	<u>0</u> 3	1	<u>0</u>	3
52. Sum of items 50 and 51			<u>10</u>	18
53. Final score for ecological receptors on surface water pathways (multiply item 52 x 100/18)			<u>55.6</u>	

COMMENTS ON SURFACE WATER RECEPTORS

Site identification: Site SD14 - POL Tank Farm

HUMAN HEALTH RECEPTORS -- GROUNDWATER PATHWAY

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max. score</u>
54. Estimated mean groundwater travel time from current waste location to nearest downgradient water supply well(s)	0 1 2 3	9	<u>0</u>	27
55. Estimated mean groundwater travel time from current waste location to any downgradient surface water body that supplies water for domestic use or for food chain agriculture	0 1 2 3	5	<u>10</u>	15
56. Groundwater use of the uppermost aquifer	0 1 2 3	4	<u>8</u>	12
57. Population potentially at risk from groundwater contamination	0 6 9 12 18 24 27 36	1	<u>27</u>	36
58. Population within 1000 ft (305 m) of the site	0 1 2 3	1	<u>3</u>	3
59. Distance to the nearest installation boundary	0 1 2 3	1	<u>2</u>	3
60. Sum of items 54 through 59			<u>50</u>	96
61. Final score for human health receptors on groundwater pathways (multiply item 60 x 100/96)			<u>52.1</u>	

ECOLOGICAL RECEPTORS -- GROUNDWATER PATHWAYS

62. Estimated mean groundwater travel time from current waste location to any downgradient habitat or natural area	0 1 2 3	3	<u>9</u>	9
63. Importance/sensitivity of downgradient biota/habitats that are confirmed or suspected groundwater discharge points	0 1 2 3	3	<u>6</u>	9
64. Presence of "critical environments" within 1 mile (1.6 km) of the site	0 3	1	<u>0</u>	3
65. Sum of items 62 through 64			<u>15</u>	21
66. Final score for ecological receptors on groundwater pathways (multiply item 65 x 100/21)			<u>71.4</u>	

COMMENTS ON GROUNDWATER RECEPTORS (attach additional pages if needed)

55. Ground water flow is 0.2 ft/day. 1,000 ft to surface water 13.9 years.

Site identification: Site SD14 - POL Tank Farm

SCORING SUMMARY SHEET

	<u>Pathways score</u>		<u>Contaminant hazard score</u>		<u>Receptors score</u>		<u>Overall score</u>
67. Surface water/human health scores	(<u>6.3</u>)	x	<u>44.4</u>	x	<u>96.3</u>	) /10,000 =	<u>2.7</u>
	item 12		item 25/30		item 49		
68. Surface water/ecological scores	(<u>6.3</u>)	x	<u>66.7</u>	x	<u>55.6</u>	) /10,000 =	<u>2.34</u>
	item 12		item 28/32		item 53		
69. Groundwater/human health scores	(<u>100</u>)	x	<u>100</u>	x	<u>52.1</u>	) /10,000 =	<u>52.1</u>
	item 22		item 35/40		item 61		
70. Groundwater/ecological scores	(<u>100</u>)	x	<u>66.7</u>	x	<u>71.4</u>	) /10,000 =	<u>47.6</u>
	item 22		item 38/42		item 66		

OVERALL SITE SCORE:

$$71. \quad \left(\frac{2.7}{\text{item 67}} \right)^2 \times 5 + \left(\frac{2.34}{\text{item 68}} \right)^2 + \left(\frac{52.1}{\text{item 69}} \right)^2 \times 5 + \left(\frac{47.6}{\text{item 70}} \right)^2 = \underline{15,879.76}$$

$$72. \quad \text{Overall site score} = \frac{15,879.76}{\text{item 71} \times 3.464} = \underline{4,584.2}$$

Site identification: Site BSS - Base Service Station

SURFACE WATER PATHWAYS

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
<u>Observed releases</u>				
1. Have contaminants been detected in surface water? If yes, assign score of 100 and proceed to item 10. If no, assign score of 0 and proceed to item 2.	0 100	1	<u>0</u>	100
<u>Pathway characteristics</u>				
2. Distance to nearest surface water	0 1 2 <u>3</u>	4	<u>12</u>	12
3. Net precipitation	<u>0</u> 1 2 3	1	<u>0</u>	3
4. Surface erosion potential	0 <u>1</u> 2 3	4	<u>4</u>	12
5. Rainfall intensity	0 1 2 <u>3</u>	4	<u>12</u>	12
6. Surface permeability	0 1 <u>2</u> 3	3	<u>6</u>	9
7. Sum of items 2 through 6			<u>34</u>	48
8. Normalized score (multiply item 7 x 100/48)			<u>70.8</u>	
9. Flooding potential	<u>0</u> 1 2 3	8	<u>0</u>	24
10. Adjusted pathways score If item 1 is 100, enter 100. If item 1 is 0, enter sum of items 8 and 9. If sum exceeds 100, enter 100.			<u>70.8</u>	
11. Waste containment effectiveness factor (Table 2)			<u>0.5</u>	
12. Final score for surface water pathways (multiply item 10 x item 11)			<u>35.4</u>	

COMMENTS ON SURFACE WATER PATHWAYS

11. Tanks and piping in good condition. No obvious spills. Drainage is not separated or treated and feeds directly to city sewer.

Site identification: Site BSS - Base Service Station

GROUNDWATER PATHWAYS

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max.</u> <u>score</u>
<u>Observed releases</u>				
13. Have contaminants been detected in groundwater? If yes, assign score of 100 and proceed to item 20. If no, assign score of 0 and proceed to item 14.	0 100	1	<u>100</u>	100
<u>Pathway characteristics</u>				
14. Depth to seasonal high groundwater from base of waste or contaminated zone	0 1 2 3	9	<u> </u>	27
15. Permeability of the unsaturated zone	0 1 2 3	5	<u> </u>	15
16. Infiltration potential	0 1 2 3	5	<u> </u>	15
17. Sum of items 14 through 16			<u> </u>	57
18. Normalized score (multiply item 17 x 100/57)			<u> </u>	
19. Potential for discrete features in the unsaturated zone to "short-circuit" the pathway to the water table	0 1 2 3	5	<u> </u>	15
20. Adjusted pathways score. If item 13 is 100, enter 100. If item 13 is 0, enter sum of items 18 and 19. If sum exceeds 100, enter 100.			<u> </u>	
21. Waste containment effectiveness factor (Table 5)			<u>1.0</u>	
22. Final score for groundwater pathways (multiply item 20 x item 21)			<u>100</u>	

COMMENTS ON GROUNDWATER PATHWAYS

Known ground water contamination

Site identification: Site BSS - Base Service Station

HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max.</u> <u>score</u>
43. Population that obtains drinking water from potentially affected surface water body(ies) within 3 miles (4.8 km) downstream	0 1 2 <u>3</u>	3	<u>9</u>	9
44. Water use of nearest surface water body(ies)	0 1 2 <u>3</u>	3	<u>9</u>	9
45. Population within 1000 ft (305 m) of the site	0 1 2 <u>3</u>	1	<u>3</u>	3
46. Distance to the nearest installation boundary	0 1 2 <u>3</u>	1	<u>3</u>	3
47. Land use and/or zoning within 1 mile (1.6 km) of the site	0 1 2 <u>3</u>	1	<u>3</u>	3
48. Sum of items 43 through 47			<u>27</u>	27
49. Final score for human health receptors on surface water pathways (multiply item 48 x 100/27)		<u>100</u>		

ECOLOGICAL RECEPTORS -- SURFACE WATER PATHWAYS

50. Importance/sensitivity of biota/habitats in potentially affected surface water bodies nearest the site	0 1 <u>2</u> 3	5	<u>10</u>	15
51. Presence of "critical environments" within 1 mile (1.6 km) of the site	<u>0</u> 3	1	<u>0</u>	3
52. Sum of items 50 and 51			<u>10</u>	18
53. Final score for ecological receptors on surface water pathways (multiply item 52 x 100/18)			<u>55.6</u>	

COMMENTS ON SURFACE WATER RECEPTORS

Site identification: Site BSS - Base Service Station

HUMAN HEALTH RECEPTORS -- GROUNDWATER PATHWAY

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
54. Estimated mean groundwater travel time from current waste location to nearest downgradient water supply well(s)	0 1 2 3	9	<u>0</u>	27
55. Estimated mean groundwater travel time from current waste location to any downgradient surface water body that supplies water for domestic use or for food chain agriculture	0 1 2 3	5	<u>15</u>	15
56. Groundwater use of the uppermost aquifer	0 1 2 3	4	<u>8</u>	12
57. Population potentially at risk from groundwater contamination	0 6 9 12 18 24 27 36	1	<u>27</u>	36
58. Population within 1000 ft (305 m) of the site	0 1 2 3	1	<u>3</u>	3
59. Distance to the nearest installation boundary	0 1 2 3	1	<u>3</u>	3
60. Sum of items 54 through 59			<u>56</u>	96
61. Final score for human health receptors on groundwater pathways (multiply item 60 x 100/96)			<u>58.3</u>	

ECOLOGICAL RECEPTORS -- GROUNDWATER PATHWAYS

62. Estimated mean groundwater travel time from current waste location to any downgradient habitat or natural area	0 1 2 3	3	<u>9</u>	9
63. Importance/sensitivity of downgradient biota/habitats that are confirmed or suspected groundwater discharge points	0 1 2 3	3	<u>6</u>	9
64. Presence of "critical environments" within 1 mile (1.6 km) of the site	0 3	1	<u>0</u>	3
65. Sum of items 62 through 64			<u>15</u>	21
66. Final score for ecological receptors on groundwater pathways (multiply item 65 x 100/21)			<u>71.4</u>	

COMMENTS ON GROUNDWATER RECEPTORS (attach additional pages if needed)

54. Ground water flow to Trinity River. No downgradient wells.

Site identification: Site BSS - Base Service Station

SCORING SUMMARY SHEET

	<u>Pathways score</u>		<u>Contaminant hazard score</u>		<u>Receptors score</u>		<u>Overall score</u>
67. Surface water/human health scores	(<u>35.4</u>)	x	<u>44.4</u>	x	<u>100</u>	) /10,000 =	<u>15.7</u>
	item 12		item 25/30		item 49		
68. Surface water/ecological scores	(<u>35.4</u>)	x	<u>33.3</u>	x	<u>55.6</u>	) /10,000 =	<u>6.6</u>
	item 12		item 28/32		item 53		
69. Groundwater/human health scores	(<u>100</u>)	x	<u>100</u>	x	<u>58.3</u>	) /10,000 =	<u>58.3</u>
	item 22		item 35/40		item 61		
70. Groundwater/ecological scores	(<u>100</u>)	x	<u>66.7</u>	x	<u>71.4</u>	) /10,000 =	<u>47.6</u>
	item 22		item 38/42		item 66		

OVERALL SITE SCORE:

$$71. \quad \left(\frac{15.7}{\text{item 67}} \right)^2 \times 5 + \left(\frac{6.6}{\text{item 68}} \right)^2 + \left(\frac{58.3}{\text{item 69}} \right)^2 \times 5 + \left(\frac{47.6}{\text{item 70}} \right)^2 = \underline{20,536.2}$$

$$72. \quad \text{Overall site score} = \frac{20,536.2}{\text{item 71}} \times 3.464 = \underline{5,928.5}$$

Site identification: Site LF01 - Landfill 1

SURFACE WATER PATHWAYS

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max.</u> <u>score</u>	
<u>Observed releases</u>					
1. Have contaminants been detected in surface water? If yes, assign score of 100 and proceed to item 10. If no, assign score of 0 and proceed to item 2.	0	100	1	0	100
<u>Pathway characteristics</u>					
2. Distance to nearest surface water	0 1 2 3		4	12	12
3. Net precipitation	0 1 2 3		1	0	3
4. Surface erosion potential	0 1 2 3		4	4	12
5. Rainfall intensity	0 1 2 3		4	12	12
6. Surface permeability	0 1 2 3		3	6	9
7. Sum of items 2 through 6				34	48
8. Normalized score (multiply item 7 x 100/48)				70.8	
9. Flooding potential	0 1 2 3		8	0	24
10. Adjusted pathways score If item 1 is 100, enter 100. If item 1 is 0, enter sum of items 8 and 9. If sum exceeds 100, enter 100.				70.8	
11. Waste containment effectiveness factor (Table 2)				0.1	
12. Final score for surface water pathways (multiply item 10 x item 11)				70.8	

COMMENTS ON SURFACE WATER PATHWAYS

2. 300 ft to Trinity River.
3. Mean precipitation = 31.9 inches. Lake evaporation = 57 inches.
4. From HARM FORM.
5. 3.5 inches.
6. 3×10^{-4} to $< 4.2 \times 10^{-5}$
9. From HARM FORM.

GROUNDWATER PATHWAYS

	<u>Score</u> (circle one)	<u>Multiplier</u>	<u>Product</u> (score x mult.)	<u>Max. score</u>
<u>Observed releases</u>				
13. Have contaminants been detected in groundwater? If yes, assign score of 100 and proceed to item 20. If no, assign score of 0 and proceed to item 14.	0 <u>00</u>	1	<u>100</u>	100
<u>Pathway characteristics</u>				
14. Depth to seasonal high groundwater from base of waste or contaminated zone	0 1 2 3	9	_____	27
15. Permeability of the unsaturated zone	0 1 2 3	5	_____	15
16. Infiltration potential	0 1 2 3	5	_____	15
17. Sum of items 14 through 16			_____	57
18. Normalized score (multiply item 17 x 100/57)			_____	
19. Potential for discrete features in the unsaturated zone to "short-circuit" the pathway to the water table	0 1 2 3	5	_____	15
20. Adjusted pathways score. If item 13 is 100, enter 100. If item 13 is 0, enter sum of items 18 and 19. If sum exceeds 100, enter 100.			<u>100</u>	
21. Waste containment effectiveness factor (Table 5)			<u>1.0</u>	
22. Final score for groundwater pathways (multiply item 20 x item 21)			<u>100</u>	

COMMENTS ON GROUNDWATER PATHWAYS

Known ground water contamination.

Site identification: Site LF01 - Landfill 1

CONTAMINANT HAZARD -- SURFACE WATER

If contaminants have been detected in surface water (score of 100 in item 1), complete items 23 through 28. If contaminants have not been detected (score of 0 in item 1), complete items 29 through 32. Attach Hazard Worksheet or list of contaminants, as appropriate.

	<u>Score</u> (circle one)	<u>Result</u>	<u>Logarithm</u> (base 10)
23. Sum of human health hazard quotients (from column 10 of Hazard Worksheet)		_____	_____
24. Human health hazard score	0 1 2 4 6		
25. Normalized human health hazard score (multiply item 24 x 100/6)		_____	
26. Sum of ecological hazard quotients (enter the larger of the sums of column 11 or 12 of Hazard Worksheet)		_____	_____
27. Ecological hazard score	0 1 2 3 4 5 6		
28. Normalized ecological hazard score (multiply item 27 x 100/6)		_____	

29. Maximum human health hazard index	0 1 2 3 4 5 6 7 8 9	Contaminant: <u>manganese</u>	
30. Normalized human health hazard score (multiply item 29 x 100/9)		<u>44.4</u>	
31. Maximum ecological hazard index	0 1 2 4 6	Contaminant: <u>manganese</u>	
32. Normalized ecological hazard score (multiply item 31 x 100/6)		<u>33.3</u>	

CONTAMINANT HAZARD -- GROUNDWATER

If contaminants have been detected in groundwater (score of 100 in item 13), complete items 33 through 38. If contaminants have not been detected (score of 0 in item 13), complete items 39 through 42. Attach Hazard Worksheet or list of contaminants, as appropriate.

33. Sum of human health hazard quotients (from column 10 of Hazard Worksheet)		<u>2.78x10⁸</u>	<u>8.4</u>
34. Human health hazard score	0 1 2 4 6		
35. Normalized human health hazard score (multiply item 34 x 100/6)		<u>100</u>	
36. Sum of ecological hazard quotients (enter the larger of the sums of column 11 or 12 of Hazard Worksheet)		<u>102.5</u>	<u>2</u>
37. Ecological hazard score	0 1 2 3 4 5 6		
38. Normalized ecological hazard score (multiply item 37 x 100/6)		<u>66.7</u>	

39. Maximum human health hazard index	0 1 2 3 4 5 6 7 8 9	Contaminant: _____	
40. Normalized human health hazard score (multiply item 39 x 100/9)		_____	
41. Maximum ecological hazard index	0 1 2 4 6	Contaminant: _____	
42. Normalized ecological hazard score (multiply item 41 x 100/6)		_____	

29 & 31. Ground water contaminants were used. Only confirmed information on contaminants.

Site identification: Site LF01 - Landfill 1

HUMAN HEALTH RECEPTORS -- SURFACE WATER PATHWAY

	Score (circle one)	Multiplier	Product (score x mult.)	Max. <u>score</u>
43. Population that obtains drinking water from potentially affected surface water body(ies) within 3 miles (4.8 km) downstream	0 1 2 <u>3</u>	3	<u>9</u>	9
44. Water use of nearest surface water body(ies)	0 1 2 <u>3</u>	3	<u>9</u>	9
45. Population within 1000 ft (305 m) of the site	0 1 2 <u>3</u>	1	<u>3</u>	3
46. Distance to the nearest installation boundary	0 1 2 <u>3</u>	1	<u>3</u>	3
47. Land use and/or zoning within 1 mile (1.6 km) of the site	0 1 2 <u>3</u>	1	<u>3</u>	3
48. Sum of items 43 through 47			<u>27</u>	27
49. Final score for human health receptors on surface water pathways (multiply item 48 x 100/27)			<u>100</u>	

ECOLOGICAL RECEPTORS -- SURFACE WATER PATHWAYS

50. Importance/sensitivity of biota/habitats in potentially affected surface water bodies nearest the site	0 1 <u>2</u> 3	5	<u>10</u>	15
51. Presence of "critical environments" within 1 mile (1.6 km) of the site	<u>0</u> 3	1	<u>0</u>	3
52. Sum of items 50 and 51			<u>10</u>	18
53. Final score for ecological receptors on surface water pathways (multiply item 52 x 100/18)			<u>55.6</u>	

COMMENTS ON SURFACE WATER RECEPTORS

Information from HARM FORM

50. Trinity River, Lake Worth, and Fort Worth Fish Hatchery.

Site identification: Site LF01 - Landfill 1

HUMAN HEALTH RECEPTORS -- GROUNDWATER PATHWAY

	Score (circle one)	Multiplier	Product (score x mult.)	Max. score
54. Estimated mean groundwater travel time from current waste location to nearest downgradient water supply well(s)	0 1 2 3	9	<u>0</u>	27
55. Estimated mean groundwater travel time from current waste location to any downgradient surface water body that supplies water for domestic use or for food chain agriculture	0 1 2 3	5	<u>15</u>	15
56. Groundwater use of the uppermost aquifer	0 1 2 3	4	<u>8</u>	12
57. Population potentially at risk from groundwater contamination	0 6 9 12 24 ¹⁸ 27 36	1	<u>27</u>	36
58. Population within 1000 ft (305 m) of the site	0 1 2 3	1	<u>3</u>	3
59. Distance to the nearest installation boundary	0 1 2 3	1	<u>3</u>	3
60. Sum of items 54 through 59			<u>56</u>	96
61. Final score for human health receptors on groundwater pathways (multiply item 60 x 100/96)			<u>58.3</u>	

ECOLOGICAL RECEPTORS -- GROUNDWATER PATHWAYS

62. Estimated mean groundwater travel time from current waste location to any downgradient habitat or natural area	0 1 2 3	3	<u>9</u>	9
63. Importance/sensitivity of downgradient biota/habitats that are confirmed or suspected groundwater discharge points	0 1 2 3	3	<u>6</u>	9
64. Presence of "critical environments" within 1 mile (1.6 km) of the site	0 3	1	<u>0</u>	3
65. Sum of items 62 through 64			<u>15</u>	21
66. Final score for ecological receptors on groundwater pathways (multiply item 65 x 100/21)			<u>71.4</u>	

COMMENTS ON GROUNDWATER RECEPTORS (attach additional pages if needed)

54. Ground water flow calculated at 2 ft/day. 0.5 mile to nearest well, which is a municipal supply well on the other side of the Trinity River, where gradient is towards Base, thus no flow towards well.

Site identification: Site LF01 - Landfill 1

SCORING SUMMARY SHEET

	<u>Pathways score</u>	<u>Contaminant hazard score</u>	<u>Receptors score</u>	<u>Overall score</u>
67. Surface water/human health scores	($\frac{70.8}{\text{item 12}}$ x	$\frac{44.4}{\text{item 25/30}}$ x	$\frac{100}{\text{item 49}}$) /10,000 =	<u>31.4</u>
68. Surface water/ecological scores	($\frac{70.8}{\text{item 12}}$ x	$\frac{33.3}{\text{item 28/32}}$ x	$\frac{55.6}{\text{item 53}}$) /10,000 =	<u>13.1</u>
69. Groundwater/human health scores	($\frac{100}{\text{item 22}}$ x	$\frac{100}{\text{item 35/40}}$ x	$\frac{58.3}{\text{item 61}}$) /10,000 =	<u>58.3</u>
70. Groundwater/ecological scores	($\frac{100}{\text{item 22}}$ x	$\frac{66.7}{\text{item 38/42}}$ x	$\frac{71.4}{\text{item 66}}$) /10,000 =	<u>47.6</u>

OVERALL SITE SCORE:

$$71. \quad \frac{(31.4)^2}{\text{item 67}} \times 5 + \frac{(13.1)^2}{\text{item 68}} + \frac{(58.3)^2}{\text{item 69}} \times 5 + \frac{(47.6)^2}{\text{item 70}} = \underline{24,372.7}$$

$$72. \quad \text{Overall site score} = \frac{24,372.7}{\text{item 71} \times 3.464} = \underline{7,036.0}$$

UNNAMED STREAM--GROUND WATER

CONT. NAME	CONC. (UG/L)	HEALTH BMARK	AQUATIC BMARK	TERRE BMARK	BIOACC BMARK	WINTAKE (UG/DAY)	F INTAKE (UG/DAY)	TOTAL INTAKE	HEALTH H QUOTIENT	AQ HAZ QUOTIENT	TERRE HAZ QUOTIENT
BENZENE	2	30	5300	0	32	4	0.416	1.664	0.055466666	0.00037735	0
CHLOROBENZENE	3.6	2600	15900	0	450	7.2	10.53	75.816	0.02916	0.00022641	0
TOLUENE	59	24	17500	0	83	118	31.8305	3755.999	156.4999583	0.00337142	0
IRON	44000	150	400	5000	100	88000	28600	2.52E+09	16778666.66	110	8.8
MANGANESE	1200	0.25	350	200	400	2400	3120	7488000	29952000	3.42857142	6
TOTALS									46730823.25	113.432546	14.8

UNNAMED STREAM--SURFACE WATER

CONT. NAME	CONC. (UG/L)	HEALTH BMARK	AQUATIC BMARK	TERRE BMARK	BIOACC BMARK	W INTAKE (UG/DAY)	F INTAKE (UG/DAY)	TOTAL INTAKE	HEALTH QUOTIENT	AQ HAZ QUOTIENT	TERRE HAZ QUOTIENT
1,3-DICHLOROBEN	1.2	460	2850	0	740	2.4	5.772	13.8528	0.030114782	0.00042105	0
1,4-DICHLOROBEN	1.7	460	1120	0	690	3.4	7.6245	25.9233	0.056355	0.00151785	0
CHLOROBENZENE	2.8	2600	15900	0	450	5.6	8.19	45.864	0.01764	0.00017610	0
BENZENE	0.31	30	5300	0	32	0.62	0.06448	0.039977	0.001332586	0.00005849	0
XYLENES	0.53	15	13500	0	190	1.06	0.65455	0.693823	0.046254866	0.00003925	0
ETHYLBENZENE	0.97	2200	32000	0	290	1.94	1.82845	3.547193	0.001612360	0.00003031	0
ARSENIC	86	0.04	360	100	280	172	156.52	26921.44	673036	0.23888888	0.86
LEAD	66	100	34	5000	300	132	128.7	16988.4	169.884	1.94117647	0.0132
IRON	26000	150	400	5000	100	52000	16900	8.8E+08	5858666.666	65	5.2
MANGANESE	210	0.25	350	200	400	420	546	229320	917280	0.6	1.05
TOTALS									7449152.704	67.7823084	7.1232

BASE SERVICE STATION--GROUND WATER

CONT. NAME	CONC. (UG/L)	HEALTH BMARK	AQUATIC BMARK	TERRE BMARK	BIOACC BMARK	W INTAKE (UG/DAY)	F INTAKE (UG/DAY)	TOTAL INTAKE	HEALTH H QUOTIENT	AQ HAZ QUOTIENT	TERRE HAZ QUOTIENT
BENZENE	3200	30	5300	0	32	6400	665.6	4259840	141994.6666	0.60377358	0
TOLUENE	16000	24	17500	0	83	32000	8632	2.8E+08	11509333.33	0.91428571	0
XYLENES	15000	15	13500	0	190	30000	18525	5.6E+08	37050000	1.11111111	0
CADMIUM	11	20	0.66	10	50	22	3.575	78.65	3.9325	16.66666666	1.1
IRON	9600	150	400	5000	100	19200	6240	1.2E+08	798720	24	1.92
MANGANESE	5600	0.25	350	200	400	11200	14560	1.6E+08	652288000	16	28
TOTALS									701788051.9	59.2958370	31.02

FLIGHT LINE AREA--SURFACE WATER

CONT. NAME	CONC. (UG/L)	HEALTH BMARK	AQUATIC BMARK	TERRE BMARK	BIOACC BMARK	W INTAKE (UG/DAY)	F INTAKE (UG/DAY)	TOTAL INTAKE	HEALTH H QUOTIENT	AQ HAZ QUOTIENT	TERRE HAZ QUOTIENT
TRICHLOROETHEN	10000	42	45000	0	17	20000	1105	22100000	526190.4761	0.222222222	0
VINYL CHLORIDE	10000	1000	381000	0	7.2	20000	468	93600000	9360	0.02624671	0
CIS-1,2-DCE	10000	2.6	135000	2.0E+08	7.2	20000	468	93600000	3600000	0.07407407	0.00005
IRON	2600	150	400	5000	100	5200	1690	8788000	58586.66666	6.5	0.52
MANGANESE	1100	0.25	350	200	400	2200	2860	6292000	25168000	3.14285714	5.5
TOTALS									29362137.14	9.96540015	6.02005

FLIGHT LINE AREA -- GROUND WATER

CONT. NAME	CONC. (UG/L)	HEALTH BMARK	AQUATIC BMARK	TERRE BMARK	BIOACC BMARK	W INTAKE (UG/DAY)	F INTAKE (UG/DAY)	TOTAL INTAKE	HEALTH H QUOTIENT	AQ HAZ QUOTIENT	TERRE HAZ QUOTIENT		
TETRACHLOROETH	30000	4	5280	0	44	60000	8580	5.1E+08	128700000	5.68181818	0		
TRICHLOROETHEN	4400000	42	45000	0	17	8800000	486200	4.28E+12	1.0187E+11	97.7777777	0		
VINYL CHLORIDE	170000	1000	381000	0	7.2	340000	7956	2.71E+09	2705040	0.44619422	0		
CIS-1,2-DCE	730000	2.6	135000	2.0E+08	7.2	1460000	34164	4.99E+10	19184400000	5.40740740	0		
ARSENIC	53	0.04	360	100	280	106	96.46	10224.76	255619	0.14722222	0.53		
CHROMIUM	200	0.016	16	100	200	400	260	104000	6500000	12.5	2		
IRON	61000	150	400	5000	100	122000	39650	4.84E+09	32248666.66	152.5	12.2		
LEAD	90	100	34	5000	300	180	175.5	31590	315.9	2.64705882	0.018		
MANGANESE	5000	0.25	350	200	400	10000	13000	1.3E+08	52000000	14.2857142	25		
MERCURY	6.2	0.4	2.4	0	63000	12.4	2538.9	31482.36	78705.9	2.58333333	0		
TOTALS											1.2175E+11	293.976526	39.748

FINAL PAGE

ADMINISTRATIVE RECORD

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