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FINAL REPORT INSTALLATION RESTORATION PROGRAM

PHASE II — CONFIRMATION

EDWARDS AFB, CALIFORNIA

AD A137397

PREPARED FOR

U S AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY
BROOKS AFB, TEXAS

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The United States Air Force, ~~due to its primary~~ mission, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. The Department of Defense (DOD) has issued Defense Environmental Quality Program Policy Memorandum 81-5 which requires the identification and evaluation of past hazardous material disposal sites on DOD property, the control of migration of hazardous contaminants, and the control of hazards to health or welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP will serve as a basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. Phase II involves a comprehensive preliminary environmental and/or ecological survey to define and quantify the presence or absence of contamination that may adversely affect public health or the environment. This report describes the work performed during Phase II of the IRP at Edwards Air Force Base, California, including development of recommendations for follow-on actions and future monitorin

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INSTALLATION RESTORATION PROGRAM
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EDWARDS AFB, CALIFORNIA

PREPARED FOR

US AIR FORCE
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HEALTH LABORATORY
BROOKS AFB, TEXAS

September 1982

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The United States Air Force, due to its primary mission, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. Federal, state, and local governments have developed strict regulations to require that disposers identify the locations and contents of disposal sites and take action to eliminate the hazards in an environmentally responsible manner. The Department of Defense (DOD) has issued Defense Environmental Quality Program Policy Memorandum 81-5 which requires the identification and evaluation of past hazardous material disposal sites on DOD property, the control of migration of hazardous contaminants, and the control of hazards to health or welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP will serve as a basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

The Installation Restoration Program has been developed as a four-phased program. These phases are:

- ° Phase I - Installation Assessment
- ° Phase II - Confirmation
- ° Phase III - Technology Base Development
- ° Phase IV - Operations

Phase I, completed at Edwards Air Force Base in April 1981, includes the identification and prioritization of past disposal sites that may pose a hazard to public health or the environment as a result of contaminant migration. Phase II involves a comprehensive preliminary environmental and/or ecological survey to define and quantify the presence or absence of contamination that may adversely affect public health or the environment. During Phase III, a sound data base will be developed upon which to prepare a comprehensive contaminant control plan. This contaminant control plan and remedial measures will be implemented in Phase IV.

This report describes the work performed during Phase II of the IRP at Edwards Air Force Base, California, including development of recommendations for follow-on actions and future monitoring.

The Phase I study completed in 1981 assessed the potential for groundwater contamination on Edwards AFB. Twelve active and inactive waste disposal sites were identified and evaluated in the Phase I report according to degree of severity for contamination potential. Based on the Phase I evaluation, eight of the twelve sites were subsequently investigated in Phase II. These sites included abandoned drum storage areas and drum trenches (Sites 1A, 1B, and 1D); acid pits (Site 1C); an abandoned toxic waste disposal site (Site 2); an abandoned sanitary landfill (Site 3); underground waste POL storage tanks (Site 5); and an industrial waste pond for flight line wash water runoff (Site 8). After completion of the Phase I report, two additional sites were identified for consideration during Phase II. These included Site 10, where a jet fuel pipeline leak occurred in the late 1960's, and Site 11 where a fuel hydrant leak occurred in the mid 1970's. The locations of all sites investigated during Phase II are illustrated on Figure E.1.

Prior to development of the field program an extensive review of existing information on geologic conditions and aquifer systems was conducted. The main water supply aquifers in the vicinity of Edwards AFB are located at depths of 200 feet to 500 feet. Groundwater flow direction in these aquifers is largely dominated by local pumping, creating groundwater troughs south of the Main Base and near the North Base. The water supply aquifer systems carry water south-southwesterly near the Main Base and north-northwest near the North Base.

For each of the ten Phase II sites a field program was developed to determine the magnitude and extent of potential environmental contamination. The overall program included completion of eight soil borings, installation of ten groundwater monitoring wells, collection of surface soil samples, and sampling of pond water and bottom sediments. For each

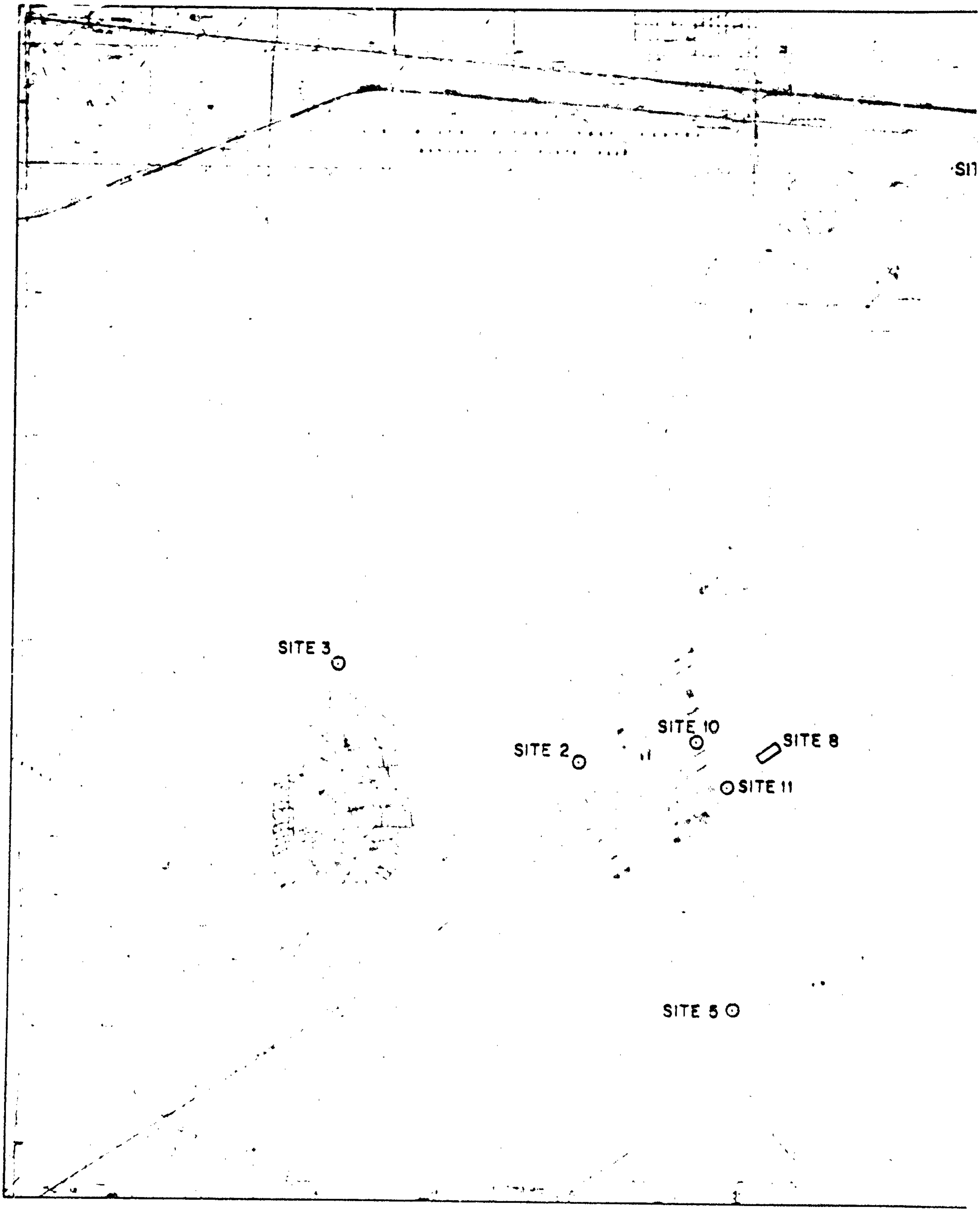
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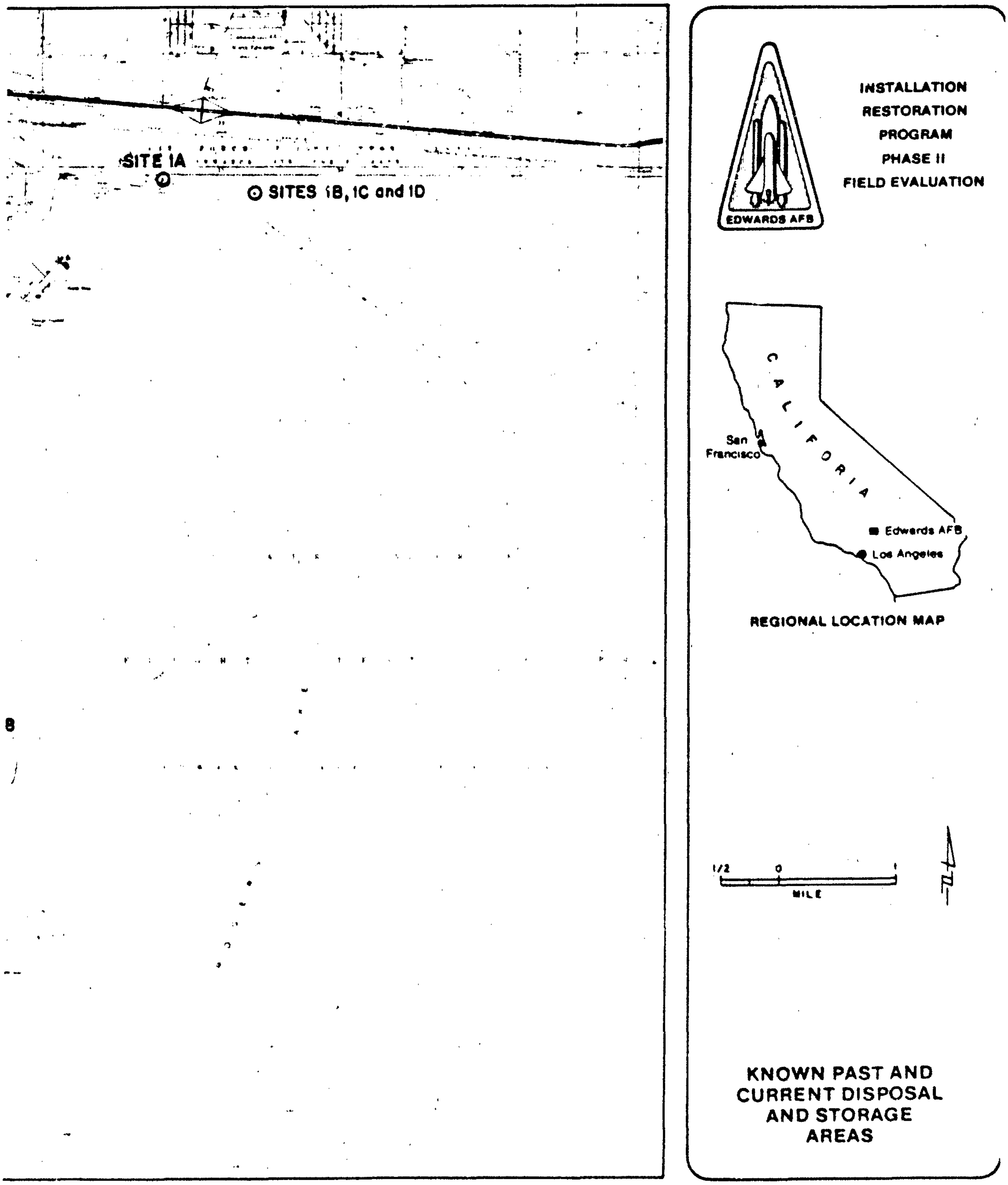
FIGURE E.1



INSTALLATION RESTORATION PROGRAM PHASE II FIELD EVALUATION

REGIONAL LOCATION MAP

KNOWN PAST AND CURRENT DISPOSAL AND STORAGE AREAS

1 2

soil boring, soil samples were obtained for laboratory analyses and soil classification. Following soil sampling, the soil borings were abandoned through grouting. During drilling of the monitoring wells, soil samples were obtained for soil classification purposes. Following development of the monitoring wells, groundwater samples were taken for laboratory analyses. Any holes that did not encounter water were abandoned and grouted.

Laboratory analyses of soil samples taken from borings at Sites 1A, 1B, 1C, and 1D indicate that most of the chemical constituents suspected at each site were not present in detectable amounts. Generally, the analytical results from each of these sites except 1C show the presence of volatile substances (chloroform and trichlorofluoromethane) within the soil column; small quantities of other constituents were detected at various sites and depths. Nitrates in high concentrations were found throughout the entire soil column sampled at Site 1C. At Sites 1A, 1B, 1C, and 1D, soil samples from the greatest depths (55 feet to 61 feet) showed chemical constituents present in detectable concentrations, but the levels of soil contamination identified at these sites would be unlikely to constitute an immediate health hazard. Groundwater was not encountered in any of the soil borings.

At Site 2, chromium and tetraethyllead were detected throughout the soil column. Contamination of the groundwater from leachates originating at Site 2 is considered unlikely. Soil samples from Site 3 contained constituents, particularly pesticides, with concentrations higher than normally would be expected. The concentration levels in the soil samples were all lower than the established California threshold limit concentrations. The potential for environmental health hazards from this site is considered minimal, primarily due to the absence of a permanent water table under the area. Groundwater samples from Phase II monitoring wells installed around Site 5 indicated no contaminants present in any of the samples; this could be a result of shallow groundwater flow in a direction different from the expected regional flow regime.

Analytic results of the water and sediment samples collected from Site 8 indicate the presence of metals. However, groundwater contamination from this site is considered unlikely due to the low permeabilities of the underlying deposits and the probable impermeability of the bottom sediment. In the soil borings at Site 10, fuel was found to be present within the soil column. Near Site 11, fuel was identified in the groundwater at one monitoring well, while no fuel was identified in the other well. The likelihood of groundwater contamination from the fuel spill at this site is considered to be low.

Recommended follow-on actions and future monitoring for each site are summarized in Table E.1.

TABLE E.1

RECOMMENDED ACTIONS AND MONITORING
EDWARDS AFB, CALIFORNIA

Site	Recommended Action and Monitoring	Rationale
1A, 1B, 1D1, 1D2	° Remove all waste containers from sites and dispose at permitted location.	° Prevent further soil contamination
	° Monitor downgradient wells semiannually for organic constituents.	° Identify potential migration of contaminants within the groundwater
	° Install one downgradient monitoring well and sample soils at the soil/water interface. Also sample groundwater for gaseous constituents.	° Define vertical extent of soil contamination
	° Complete 10-foot deep soil borings at compass points around the sites and sample for gaseous constituents.	° Define lateral extent of soil contamination
1C	° Construct impermeable mound across the nitric acid pits.	° Prevent mobilization of nitrates
	° Institute land use restrictions.	° Prevent construction and excavation at future dates
	° Monitor downgradient wells.	° Identify potential migration of contaminants within the groundwater
2	° Locate and remove buried waste containers (if present) and dispose at permitted location.	° Prevent potential leaching of contaminants into groundwater
	° Install two lysimeters downgradient from the site. If flow exists, collect water samples and analyze for metals and suspected contaminants.	° Determine existence of seasonal groundwater flow; if flow exists, laboratory analysis of water samples will identify potential contaminant migration

TABLE E.1 (Continued)

Site	Recommended Action and Monitoring	Rationale
2 (Cont'd)	° Install monitoring well if contaminants are detected in seasonal flow; sample annually for metals and suspected contaminants.	° Monitor potential migration of contaminants into groundwater
	° Construct an impermeable mound across the site.	° Prevent mobilization of contaminants by surface runoff
	° Institute land use restrictions.	° Prevent construction and excavation at future dates
3	° Install a lysimeter downgradient from the site; if seasonal groundwater flow exists, sample for metals and organics.	° Determine existence of seasonal groundwater flow; if flow exists, water sample analysis will identify potential contaminant migration
	° If contaminants are identified, install downgradient monitoring well.	° Monitor potential migration of contaminants into groundwater
5	° Locate existing wells 9N/9W-18C1 and 9N/9W-6L1; take groundwater samples and water level measurements if possible, and analyze for fuel and oil.	° Establish boundaries for the lateral extent of potential fuel migration
	° If the wells 18C1 and 6L1 can be located, they should be abandoned by grouting.	° Eliminate possibility of potential contamination migration through the well into deeper aquifers
	° Redevelop existing well 9N/9W-6E1 and sample for fuel.	° Verify fuel contamination in well 6E1
	° Install 3 monitoring wells downgradient of site; sample for fuel. If no fuel is detected in the soil or groundwater, the new wells should be monitored semiannually; if fuel is detected, install 3 to 6 additional wells.	° Identify lateral extent of potential fuel migration
	° Monitor underground storage tanks regularly.	° Determine the potential for future leakage.

TABLE E.1 (Continued)

Site	Recommended Action and Monitoring	Rationale
8	° Install one groundwater monitoring well immediately downgradient from the site; sample groundwater for metals and organic solvents. ° If the groundwater shows no contamination, sample installed monitoring well annually. ° If groundwater samples show contamination, the pond water could be treated *in situ*. Sample monitoring well semiannually.	° Determine leakage from pond into the groundwater ° Monitor potential future leakage from pond into groundwater ° Reduce the potential for groundwater contamination; sampling of groundwater monitoring well will allow for determination of water treatment effectiveness
10	° Install vapor detection pipes around the perimeter of suspected contaminated area. ° Institute land use restrictions.	° Identify lateral extent of contaminated area and monitor evaporation of fuel over time ° Prevent future excavation and construction in the area while fuel is still present in the soil
11	° Install one monitoring well immediately downgradient from the hydrant. Sample well water semiannually for fuels (the entire casing of the well should be perforated and the well sampled semiannually for gas vapors).	° Determine if fuel is present on top of the groundwater

CHAPTER 1

INTRODUCTION

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INTRODUCTION

BACKGROUND

The United States Air Force, due to its primary mission, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. Federal, state, and local governments have developed strict regulations to require that disposers identify the locations and contents of disposal sites and take action to eliminate the hazards in an environmentally responsible manner. The Department of Defense (DOD) has issued Defense Environmental Quality Program Policy Memorandum 81-5 which requires the identification and evaluation of past hazardous material disposal sites on DOD property, the control of migration of hazardous contaminants, and the control of hazards to health or welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP will serve as a basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

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This report describes the work performed during the Phase II program, including development of preliminary recommendations for follow-on actions and identification of requirements for additional information necessary prior to the institution of any mitigation measures.

PREVIOUS WORK

The Phase I study completed in 1981 assessed the potential for groundwater contamination on Edwards AFB, California (Envirodyne Engineers, Inc., 1981). The study provided a general description of the existing climatological, geological, and hydrological regimes at the Base and in its immediate vicinity.

Twelve active and inactive waste disposal sites were identified and evaluated in the report on the basis of site characteristics, potential for contamination, waste characteristics, and waste management practices. The evaluation consisted of assigning to each site numerical values weighted on a subjective scale according to degree of severity for contamination potential. Based on this evaluation, four of the twelve sites were subsequently dropped from further consideration; no Phase II actions are required for these sites at this time.

The final evaluation scores are presented in Table 1.1 for those sites investigated during the Confirmation phase (see Figure 1.1 for site locations). The table indicates that the sites determined as having the highest potential for contamination were Site 1A, Site 1C, Site 1D, Site 2, and Site 5. It should be kept in mind, however, that this rating, as well as the Overall Score Rating, was based on limited available information, particularly regarding the depth to groundwater in the area and the permeability of the underlying soils.

TABLE 1.1

SUMMARY OF PHASE I RATING SCORES FOR SITES CONSIDERED IN PHASE II

Site[a]	Overall Score[b]	Site Characteristics[b]	Potential for Contamination[b]	Waste Characteristics[b]	Waste Management Practices[b]
Site 1: North Lake Bed disposal and storage site					
West subsite: 1A	65	65	81	59	55
Drum storage: 1B	57	65	37	69	52
Acid pits: 1C	68	65	74	64	74
Drum trenches: 1D	78	77	85	69	85
Site 2 : Main Base toxic waste disposal site	83	46	78	100	100
Site 3: Abandoned Main Base sanitary landfill site	71	54	53	88	83
Site 5: South Base waste POL storage and disposal site	67	67	81	58	64
Site 8: Industrial waste pond	48	33	59	49	48

Source: Envirodyne Engineers, Inc., 1981

[a] Two additional sites were added to this list during Phase II.

[b] Scores are shown as a percentage of a 100 percent maximum.

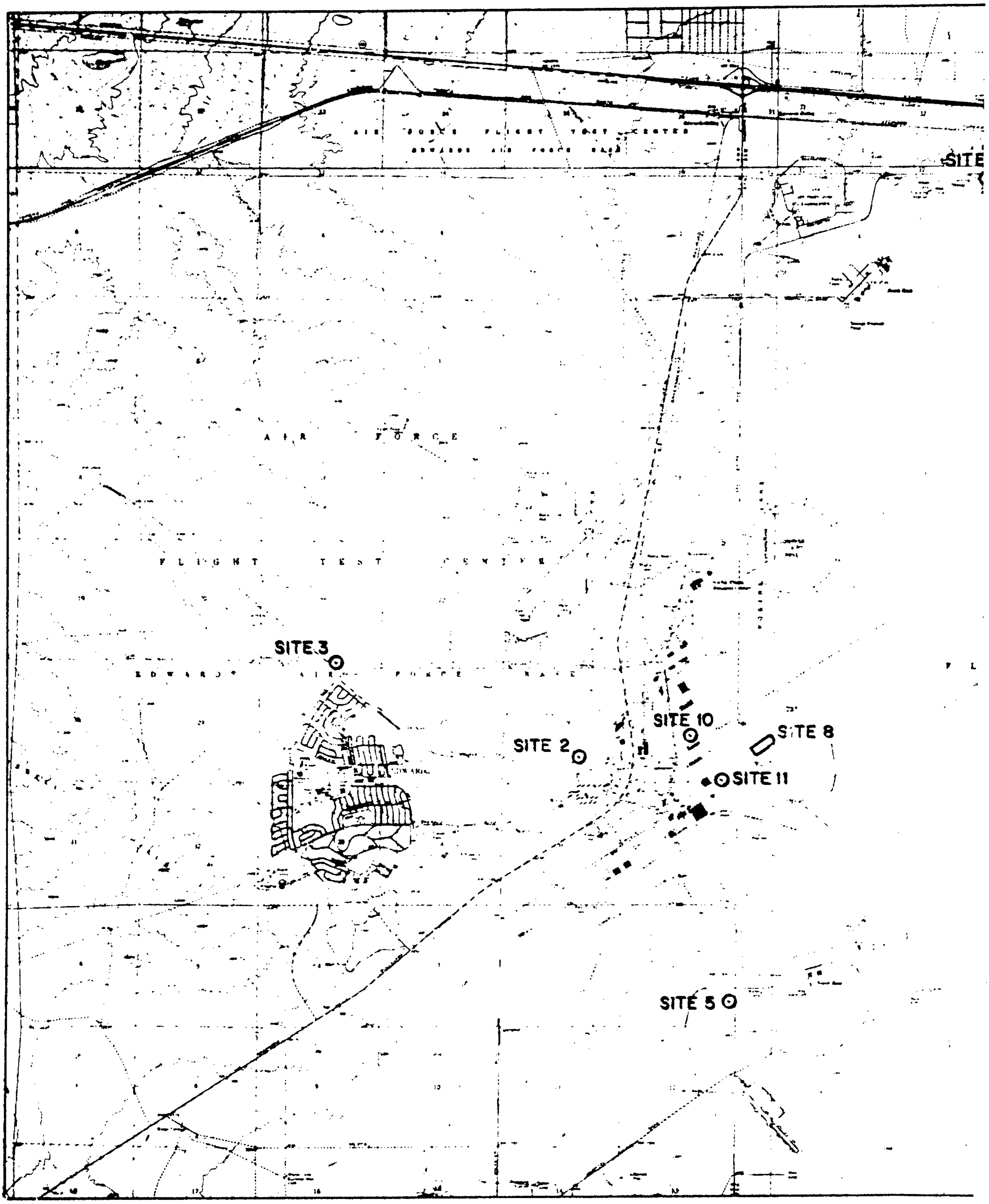
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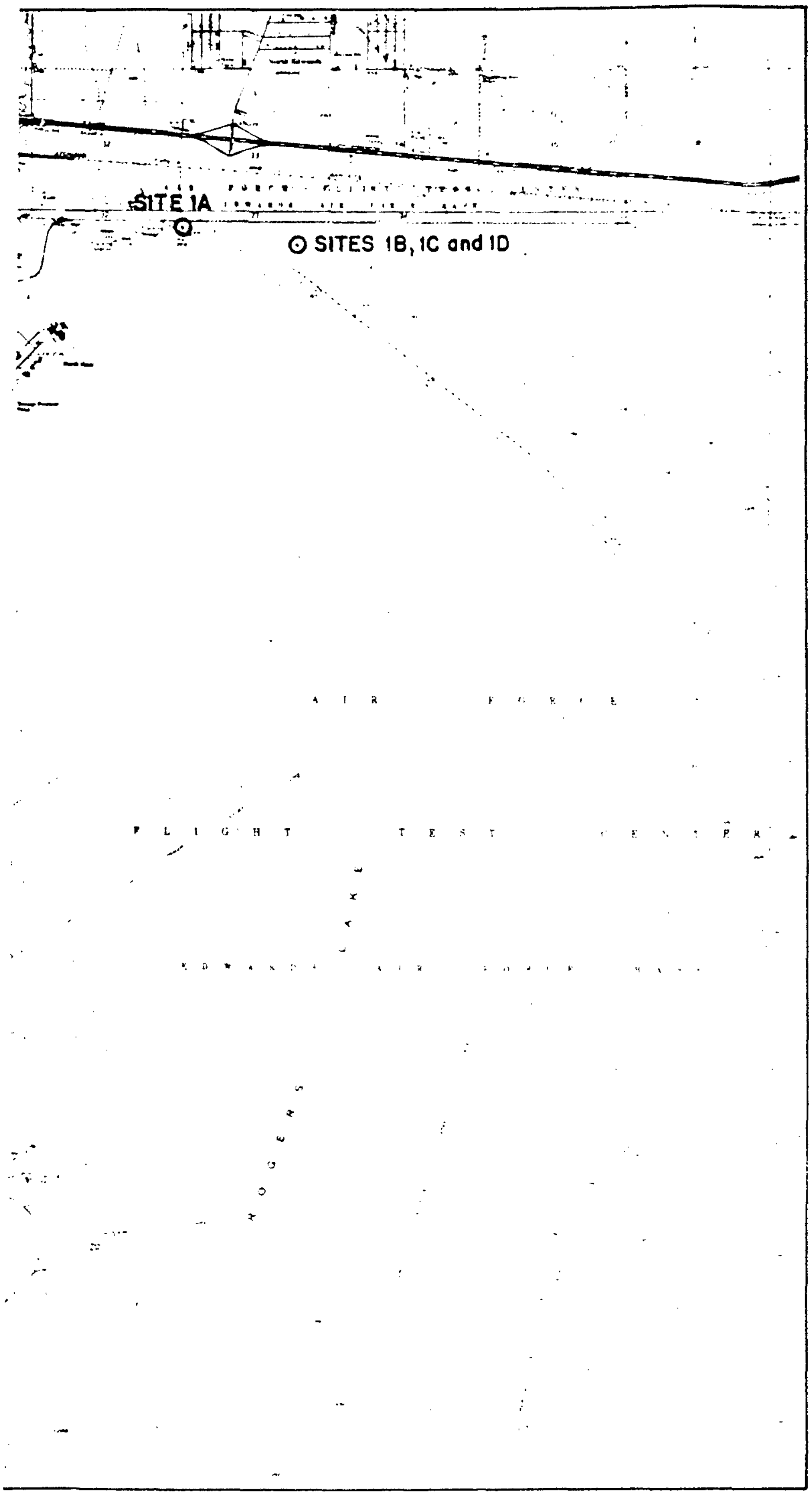
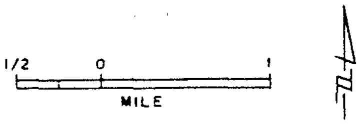
FIGURE 1.1



INSTALLATION RESTORATION PROGRAM PHASE II FIELD EVALUATION

EDWARDS AFB

REGIONAL LOCATION MAP



KNOWN PAST AND CURRENT DISPOSAL AND STORAGE AREAS

On the basis of the information contained in the Phase I Report, the pertinent geological and hydrological information for each site have been summarized in Table 1.2. As can be seen, data on the depth to groundwater are sparse, at best, and the thickness and characteristics of the subsurface material are unknown. Chapter 3 of this Phase II report, Field Program, elaborates on the site-specific geohydrological regimes, based on available well logs and data published by various federal, state, and local agencies as well as other published data on the Antelope Valley.

SCOPE OF WORK

On the basis of the Phase I Assessment of the Potential for Groundwater Contamination performed in April 1981, the Installation Restoration Program, Phase II Confirmation has been conducted. The purposes of this program have been to:

- Determine the extent and magnitude of environmental contamination resulting from previous waste disposal practices at Edwards AFB, California
- Recommend measures to alleviate impacts for identified contaminated areas
- Develop environmental monitoring programs to document environmental conditions resulting from past waste disposal activities at Edwards AFB

To accomplish these tasks the ES work program included the installation of monitoring wells and completion of soil borings for collection of water and soil samples as well as the collection of surface soil samples. This report presents the results of the project, including development and implementation of the field program, the sampling procedures utilized to obtain data, data analysis, conclusions, and recommendations for future actions. A copy of the ES Scope of Work has been included as Appendix A to this report.

TABLE 1.2

STORAGE AND DISPOSAL SITE CHARACTERISTICS
EDWARDS AIR FORCE BASE, CALIFORNIA

Site	Activity	Waste Characteristics	General Subsurface Material	Depth to Groundwater	Distance to Closest Active Production Well (feet)
1A	Drum storage (13 barrels) ABANDONED 1978	Motor oil, drycleaning solvent, lube oil, miscellaneous solvents	Lakeshore deposits (sand)		1,300
1B	Drum storage (116 barrels)	Aniline	Playa deposits		
1C	Acid pits, open trenches(4)	Fuming red and white nitric acids, burnt waste fuels	Sand dune underlain by playa deposits		4,000
1D	Drum trenches (2) (hundreds of barrels) ABANDONED	Aniline, furfuryl alcohol, engine cleaner, ethyl alcohol	Playa deposits		4,000
2	Toxic waste disposal ABANDONED 1960's	Cyanide, chromate, nitric acid, tetra-ethyllead, hydrogen peroxide, fuels	Loose sand	No aquifer (closest aquifer 3,500 feet away)	
3	Main Base sanitary landfill ABANDONED 1970's	Possibly hazardous wastes and banned pesticides	Sandy (younger fan deposits)	No aquifer, ground sloping toward arroyo draining into Rogers Dry Lake	
5	South Base waste POL storage and disposal site, underground tanks and 70 barrels	Water-contaminated fuels and oils, synthetic ester oil, jet fuel, hydraulic fluid	Young alluvium	85 feet	4,000
8	Industrial waste pond ACTIVE	Runway runoff and washdown, fuel spills, hangar drainage	Lake shore deposits (thin)	Underlain by ground-water mound	

Reference: Envirodyne Engineers, Inc., 1981

CHAPTER 2

ENVIRONMENTAL SETTING

CHAPTER 2

ENVIRONMENTAL SETTING

GENERAL GEOLOGIC REGIME

Antelope Valley and the area surrounding Rogers Dry Lake have been the subject of geohydrological investigations since as early as 1911, when Harry R. Johnson authored "Water Resources of Antelope Valley" in U.S. Geological Survey (U.S.G.S.) Water-Supply Paper 278 (Johnson, 1911). Around the turn of the century it was discovered that the valley contained large quantities of groundwater that, when extracted through wells, could be used for irrigation, transforming the valley into productive agricultural land.

Hundreds of wells have been installed to tap valuable water resources, which in the early days were thought to be practically inexhaustible. Some people, however, recognized the fact that even though "water keeps spouting out from wells developed in areas of artesian groundwater conditions," the resource was indeed limited. In the 1911 report, Mr. Johnson cautioned that "even though the groundwater appears to be inexhaustible, it is indeed finite," and the continued unmanaged use of the resource could lower the level of the water table and eventually dry out the groundwater reservoir.

The same view was presented in the later U.S.G.S. Water-Supply Paper 578 (Thompson, 1929). That paper advocated conservation of the water supply if maximum use is to be obtained. However, during the past 70 years extraction of groundwater has continued at a rapid pace with resulting declines in water tables and decreases in the areal extent of artesian conditions. The results, at least on the surface, have been to transform the nonirrigated lands from a semiarid grassland to a desert-like environment.

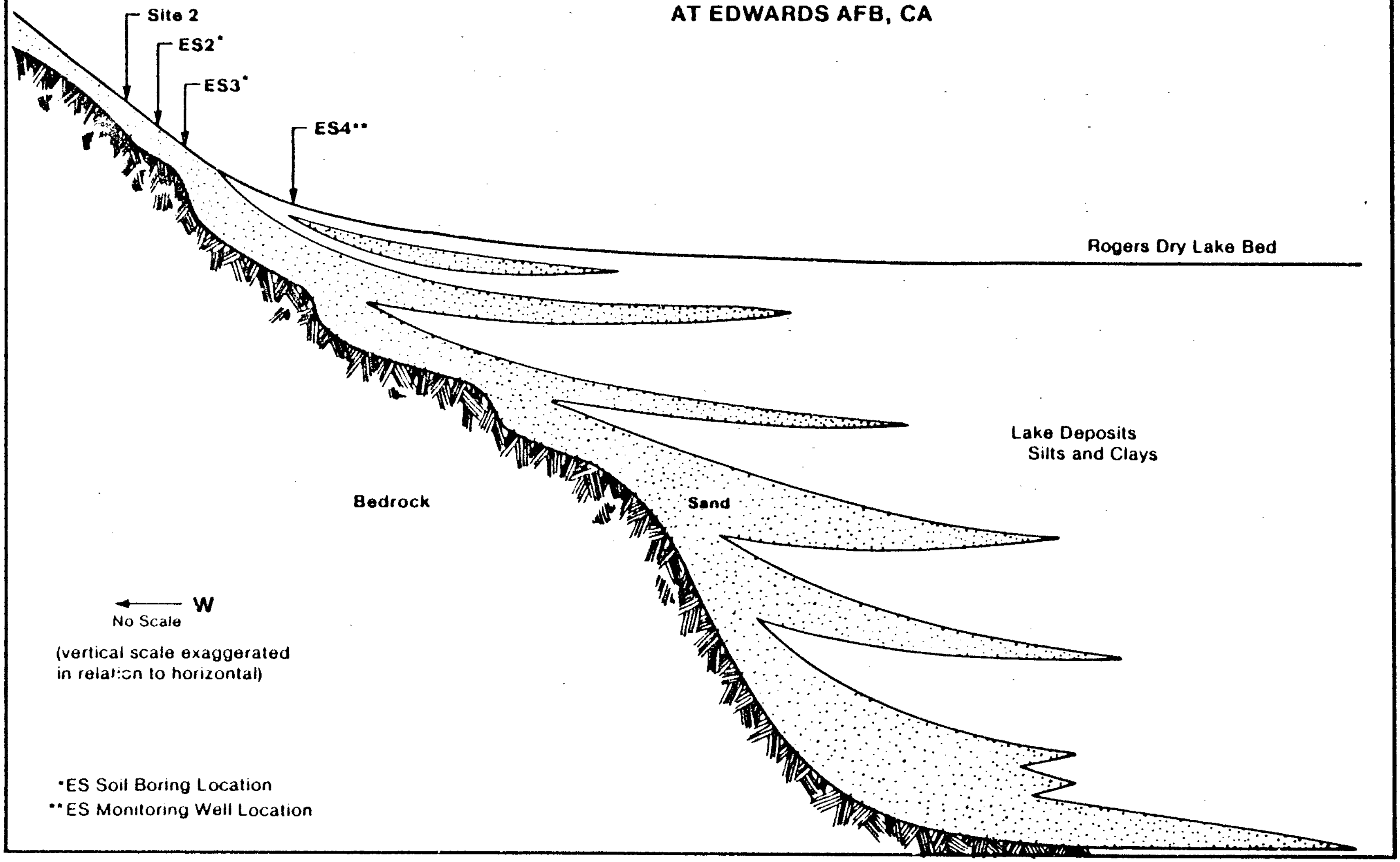
The overdrafting of the groundwater within Antelope Valley and specifically around Rogers Dry Lake near the aquifer boundaries has created unique hydrological conditions, with fluctuating water levels and continuously changing regimes of confinement, semiconfinement, and nonconfinement of the groundwater.

Groundwater in the major part of Antelope Valley, including the southern part of Rogers Dry Lake, occurs under confined conditions, even though in some cases the confinement is no longer effective to produce artesian flow due to overdraft. Along the "shores" of Rogers Dry Lake and north of the lake bed, groundwater occurs mainly under unconfined conditions.

The location and extent of water-bearing material is mainly dependent on the geologic history of an area. Antelope Valley is a triangular closed basin bordered by the active Garlock Fault to the north-northwest and the active San Andreas Fault to the south. Movement along these two faults, emplacement of granitic rocks, and regional uplift created the closed basin that exists today. During and following the uplift of the mountains, erosional processes were intensified. Precipitation resulted in runoff; the greater the surface gradient, the higher the velocities of the runoff, and therefore the higher the erosion potential. Eroded material from the mountains surrounding Antelope Valley was brought to the basin floor, including the Rogers Dry Lake area, by local streams. During times of heavy precipitation the eroded material consisted of mixed gravel and sand; the gravel and sand layers that are encountered today in the subsurface material have a relatively high porosity and excellent water-bearing capabilities. These layers constitute the main aquifers. Overlying and interfingering the sand and gravel are silt and clay lenses and layers which were deposited during times of little precipitation within the ancient lake that once covered the major part of Antelope Valley. These finer-grained materials have low porosity (45 to 50 percent) and permeability (0.0001 to 0.1 gallons/day/square foot). In many places, the clay and silt act as confining layers, preventing water within the lower-lying sand and gravel layers from rising to its potentiometric level. Figure 2.1 depicts a conceptual drawing of the transition zone between lake deposits and bedrock/ alluvium material; as

FIGURE 2.1

CONCEPTUAL SCHEMATIC DRAWING OF TRANSITION ZONE BETWEEN BEDROCK, ALLUVIUM, AND LAKE DEPOSITS AT EDWARDS AFB, CA



illustrated, recharge to the shallower water-bearing sands could occur through the "daylighting" layers (U.S.G.S., 1980).

GENERAL HYDROLOGIC REGIME

Water within the groundwater basin is derived from several sources. Some water is connate water, i.e., water trapped within the sediments from the time of deposition. Other water is provided through recharge into the water-bearing materials along the basin boundaries where sand and gravel layers "daylight"; still another source is from percolation through the valley floor. Figure 2.2 shows the surface geology at Edwards Air Force Base and in the vicinity of Rogers Dry Lake; as can be seen, the lake is bordered by a variety of sand, gravel, and silt deposits consisting of younger alluvium (yielding water to wells when saturated), younger fan deposits (primarily located above the water table, yielding little water to wells), lakeshore deposits (above the water table), old windblown sand, and dune sand (yielding water locally to wells from perched water tables).

Groundwater recharge from the valley floor (Rogers Dry Lake) is quite limited. The lake bed surface consists of playa deposits, silt, and clay which have low permeabilities, retarding downward migration of water. Water ponding on the lake surface during the rainy season primarily evaporates; limited seepage may occur through cracks developed during the summer, but the contribution of rainwater to the aquifer system should be limited.

Groundwater flow and direction in the main water-producing aquifers near Edwards AFB are largely dominated by pumping wells, resulting in changes in the regional gradient from north to south. Figure 2.3 shows the groundwater table contours as of 1979 (U.S.G.S., 1980). A groundwater trough was located immediately south of the Main Base as a result of groundwater pumping; the groundwater table elevation at that time was estimated to be about 2,200 feet above mean sea level, or 100 to 120 feet below the ground surface. Groundwater in the vicinity of the trough is moving toward this depression from the north, south, and west; to the east is the boundary of the valley aquifer systems. It should be noted, however, that these groundwater contours are based on water level

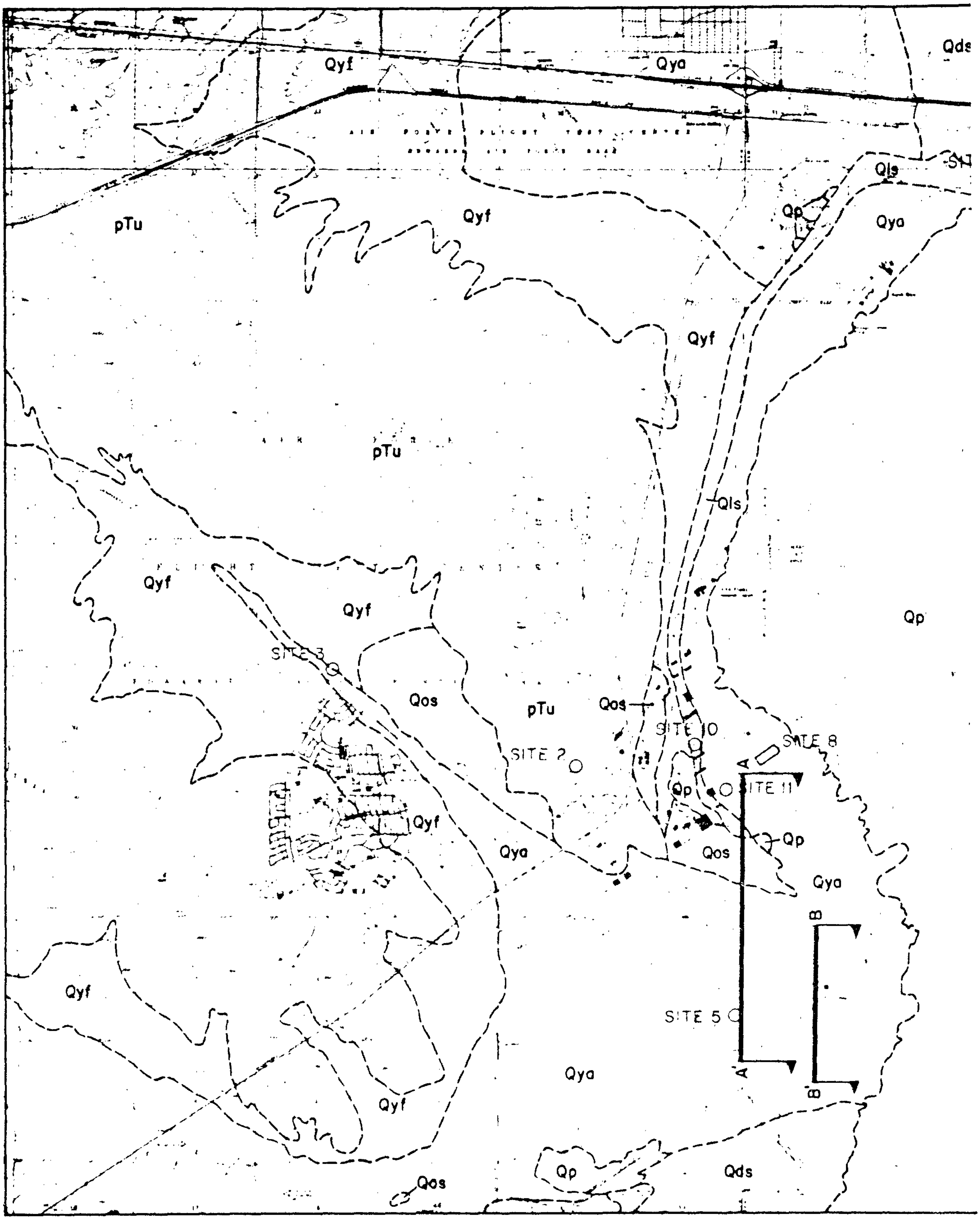

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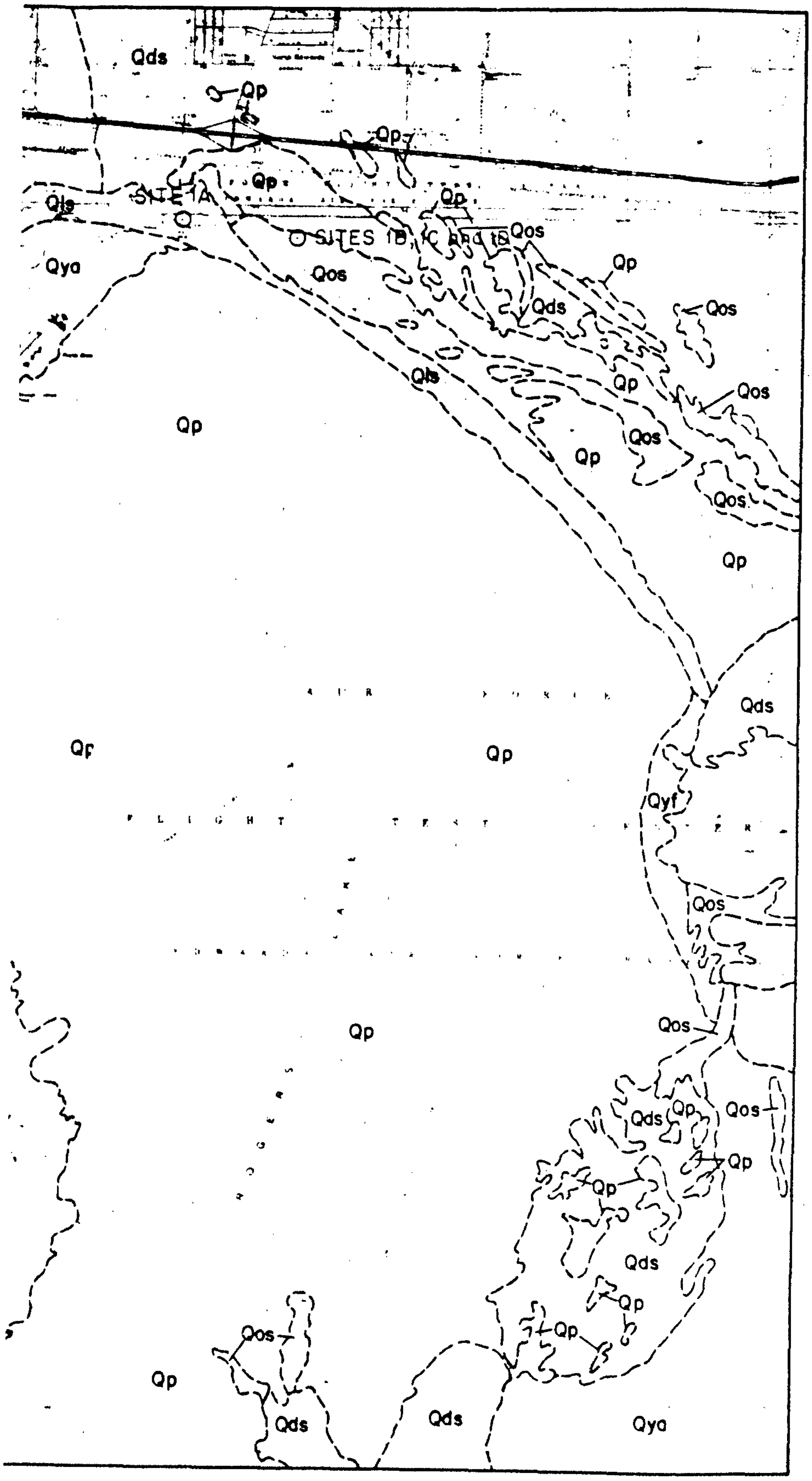
FIGURE 2.2



INSTALLATION
RESTORATION
PROGRAM
PHASE II
FIELD EVALUATION

EDWARDS AFB

LEGEND

Qyo	Younger Alluvium
Qyf	Younger Fan Deposits
Qp	Playa Deposits
Qds	Dune Sand
Qos	Old Windblown Sand
Qls	Lakeshore Deposits
pTu	Bedrock
A' A	Location of Geologic Cross-Section

Source: U.S. Geol. Survey Bulletin
No. 91-6, 1962.

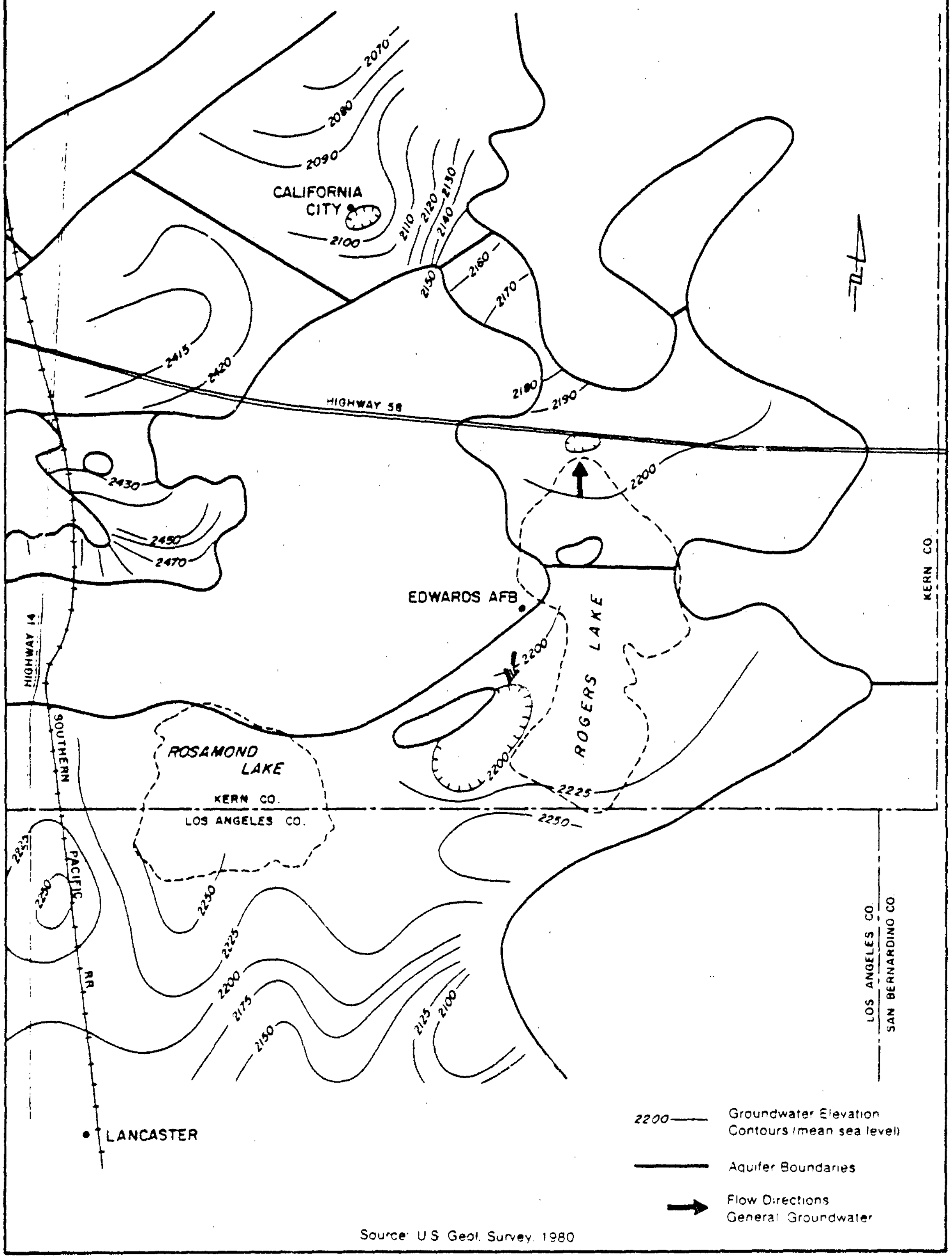
1/2 0 1
MILE

GEOLOGY IN THE VICINITY OF EDWARDS AIR FORCE BASE

7

FIGURE 2.3

GROUNDWATER TABLE CONTOURS OF AQUIFERS 200 TO 500-FOOT DEPTH BELOW GROUND SURFACE



Source: U.S. Geol. Survey, 1980

measurements from wells penetrating to depths of 200 feet to 500 feet, and are therefore not indicative of shallow groundwater conditions (Moyle, 1982).

Along the northern shores of Rogers Dry Lake by the North Base, the groundwater movement is in a south-to-north direction; a trough exists immediately around this part of the Base due to local groundwater extraction. A groundwater barrier exists just north of the Main Base across the dry lake bed, consisting of a zone of material with low permeability; this barrier is possibly the extension of the Muroc Fault trending in a northwest-southeast direction. The elevation of the groundwater in the North Base area was about 2,190 feet in 1979. Groundwater level contours for this area are included on Figure 2.3.

CHAPTER 3

FIELD PROGRAM

CHAPTER 3

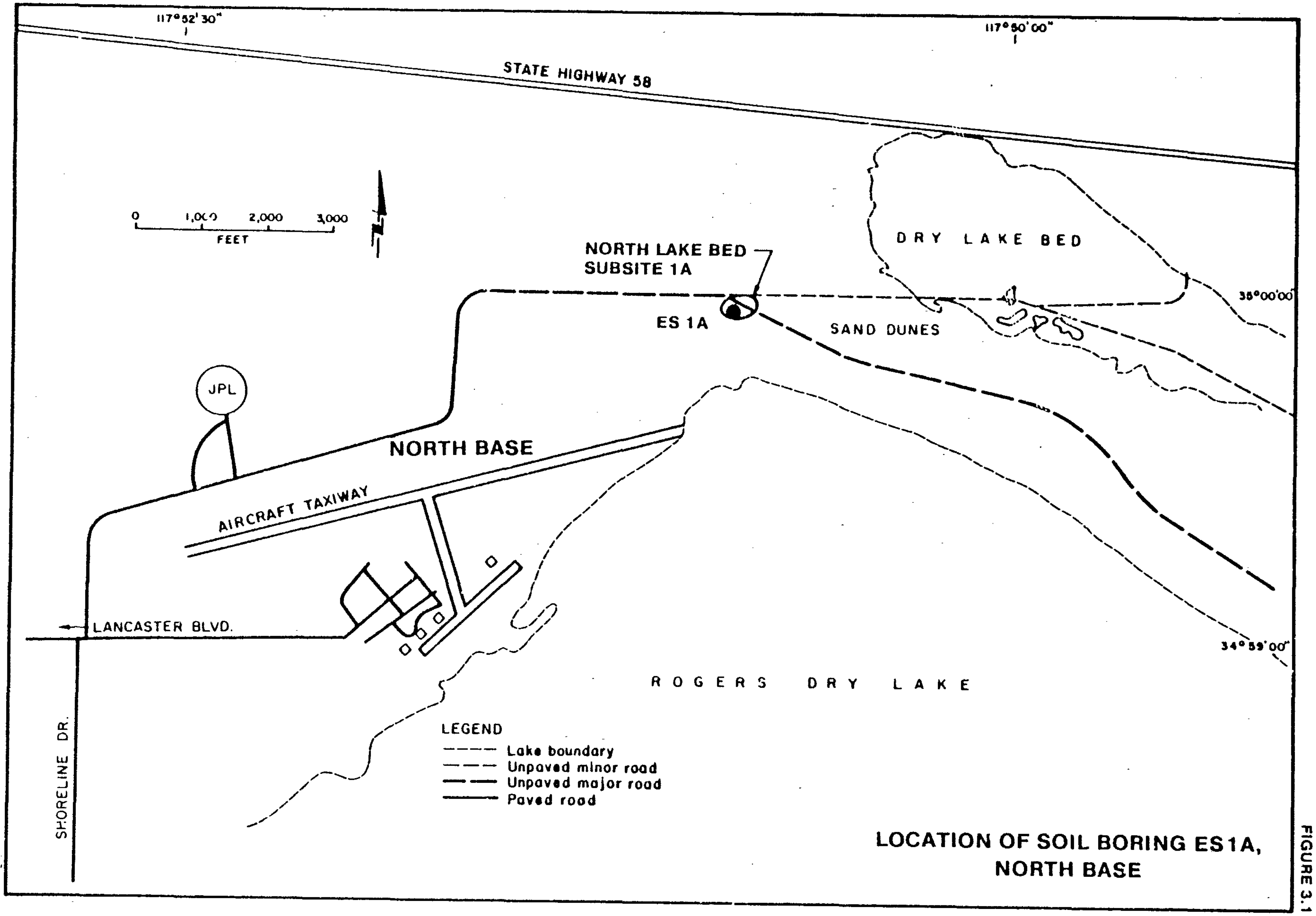
FIELD PROGRAM

DEVELOPMENT OF FIELD PROGRAM

The potential for contamination of the groundwater resources at Edwards AFB exists in three distinct areas along the shores of Rogers Dry Lake. At the North Base, contamination could have occurred as a result of past waste disposal practices at Sites 1A, 1B, 1C, and 1D (see Figures 3.1 and 3.2). At the Main Base, contamination of the groundwater could have occurred from past and current disposal practices at Sites 2, 8, and 3 (see Figure 1.1). In addition, the groundwater may have received unknown amounts of jet fuel from a jet fuel pipeline leak that occurred in the late 1960's at a location designated as Site 10. An estimated 250,000 gallons of jet fuel leaked from the pipeline just below the ground surface. Possibly 100,000 gallons of fuel may have been recovered immediately following the spill. Remaining were an approximate 150,000 gallons of jet fuel, possibly available for seepage downgradient into the groundwater. A hydrant at the end of the fuel pipeline leaked about 5,000 gallons of jet fuel onto the ground in the mid 1970's. This location was designated Site 11. At the South Base, a leaking underground fuel storage tank at Site 5 may have caused fuel to migrate into the groundwater and downgradient from the site.

To determine monitoring well and soil sampling locations, ES reviewed the existing data on geology, aquifer systems, and past and current disposal practices for the area. This included review of work performed during Phase I, contained in the 1981 report by Envirodyne Engineers, Inc., contact with the U.S. Geological Survey, and literature search for pertinent publications. The U.S.G.S. maintains a program for annual water level measurements in the vicinity of Rogers Dry Lake for

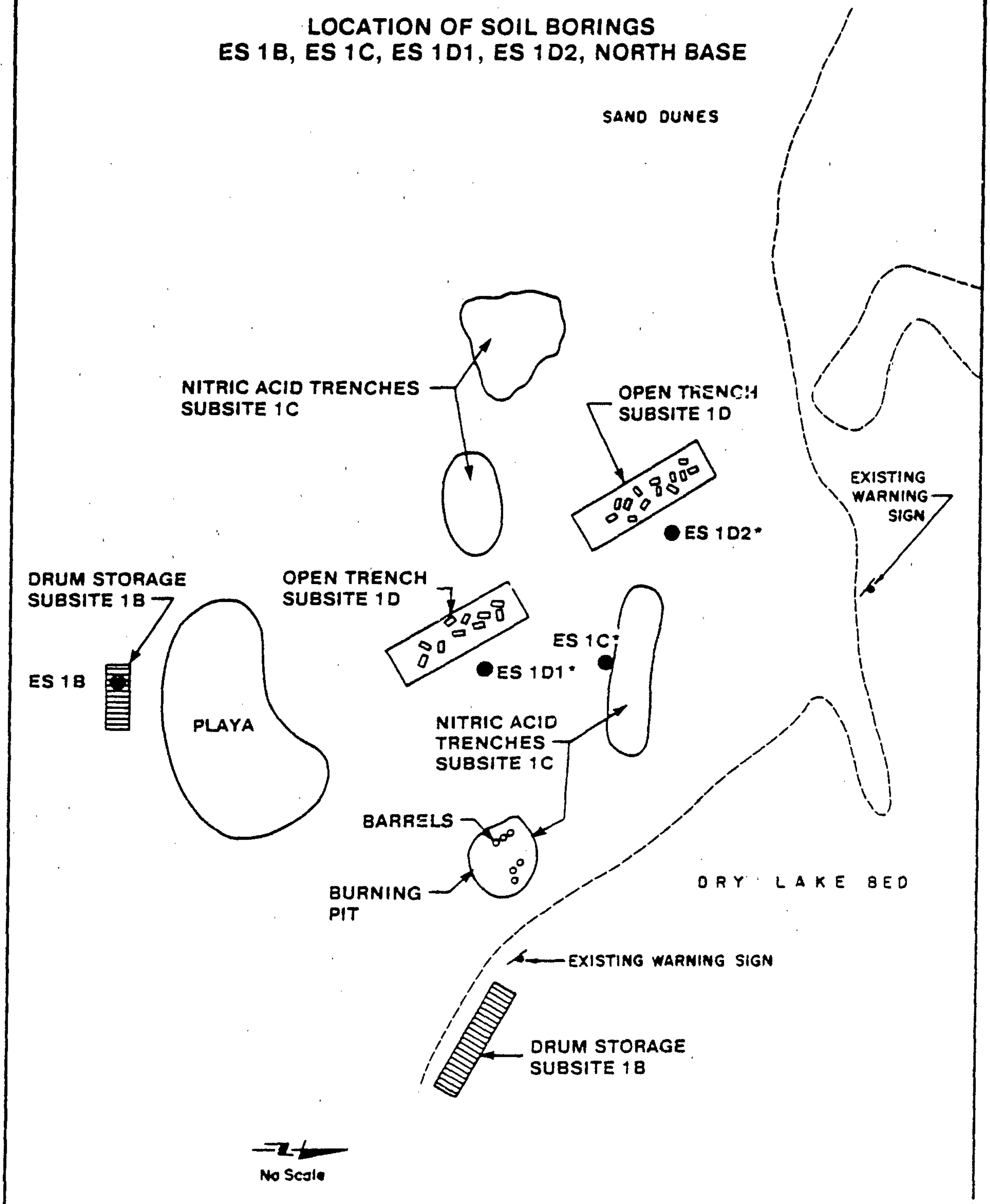
FIGURE 3.1



LOCATION OF SOIL BORING ES1A, NORTH BASE

FIGURE 3.2

LOCATION OF SOIL BORINGS
ES 1B, ES 1C, ES 1D1, ES 1D2, NORTH BASE



*Slant-drilled

the preparation of groundwater level elevations throughout Antelope Valley over time.

The following discussion describes the local geohydrological regimes of the North Base and Main and South Bases, respectively, based on available data. A description of the numbering system for wells discussed in this chapter is contained in Appendix B. Available well logs in the vicinity of disposal sites are included in Appendix C.

North Base

Geohydrology

Sites 1A, 1B, 1C, and 1D are located along the northern shore of Rogers Dry Lake. Site 1A, an abandoned drum storage area, is located within the geologic unit, Lakeshore Deposits. These deposits are characterized by gravel and sand and some silt and clay (U.S.G.S., 1962). The ground elevation is approximately 2,306 feet above mean sea level. Two active water supply wells, 10N/9W-4D1 and 10N/9W-4D2 (North Base Well 4), completed in 1957 and 1958, respectively, are located less than one-quarter mile east of the site and one well, 11N/9W-32Q1 (North Base Well 3), is less than one-quarter mile northwest of the 1A site. Well logs for these three wells are included in Appendix C.

The 10N/9W-4D1 and 4D2 wells were drilled to a depth of 500 feet (see Table 3.1). Well 4D1 has perforations in the casing from 144 to 195 feet and from 200 to 433 feet. Well 4D2 has perforations from 150 to 500 feet. The perforations are usually indicative of the location of water-bearing materials as perceived during the drilling of the wells.

Well 11N/9W-32Q1 was drilled to a depth of 450 feet in 1957 with perforations from 234 to 450 feet. The well was reperforated at a later date to a shallower depth, but there are no records showing the new intervals. Inspection of the two logs, which are from wells located within a few hundred feet of each other, illustrates the difficulty involved in establishing the nature of subsurface conditions from previously prepared drilling logs. The logs indicate two entirely different geological environments.

TABLE 3.1

NORTH BASE WATER WELLS DATA

Well Number	Base Well Number	Well Depth (feet)	Depth of Perforations (feet)	Water Levels	
				Depth (feet)	Date of Measurement
10N/9W-4D1	No data	500	144-195	117.3	1981
			200-433	95.02	1957
10N/9W-4D2	4[a]	500	150-500[b]	No data	No data
11N/9W-32Q1	3	450	234-450	125.8	1981
10N/9W-5B1	5	No data	No data	98.5	1981

a Abandoned

b This well was later reperforated to an unknown shallower depth.

Log 10N/9W-4D1 shows that granite (decomposed) was encountered at a 410-foot depth, while no granite was reported in well 4D2. It is unlikely that granite would be encountered at the 4D1 location, especially considering that sand, gravel, and clay were identified below the "granite." If granite were present at relatively shallow depths, it would constitute bedrock and would be massive with no underlying water-bearing sediments. The logs do indicate, however, that the area around Site 1A is underlain by a sequence of lakeshore-related sediments of gravel, sand, silt, and clays, and that good water-bearing sands were probably present at a depth of about 100 feet in 1957 to 1958.

In March 1957, the static water level in 4D1 was measured by U.S.G.S. at a depth of 95.02 feet. By April 1981, the static water level had declined to a depth of 117.63 feet. It should be kept in mind that the perforations in the well casing commence at a depth of 144 feet; thus, if the well logs correctly describe subsurface conditions, the static water level reported by U.S.G.S. could indicate a water level influenced by possibly confined conditions in the deeper-lying water-bearing sands and gravel. It is unknown whether the sands at 142 to 156 feet still contain water. If this stratum is no longer producing, the next major sands would supposedly be located below an additional 60 feet of clay.

The well log from well 10N/9W-4D2, located only a few hundred feet northeast of well 4D1, shows an entirely different geologic substructure with clays at a depth of 40 to 53 feet underlain by hundreds of feet of sands. At this well, however, perforations are at the 150 to 500-foot depth. Inspection of well log 11N/9W-32Q1 presents yet another picture of the subsurface conditions near Sites 1A, 1B, 1C, and 1D that is substantially different from that presented in the logs for 10N/9W-4D1 and 4D2. The subsurface condition near well 32Q1 is recorded to consist of sand from the ground surface to a depth of about 200 feet, underlain by clays of various thicknesses.

The discussion above illustrates that the available information on the geohydrological subsurface condition at the North Base is tenuous, at best, with little information on the conditions under which water occurs and the sedimentary sequences underlying the area. However, it appears that water-producing strata are present at about a 100-foot depth and could extend as far down as 500 feet. The well designs of the North Base wells are unknown; they could be gravel-packed the entire length or grouted at the top and gravel-packed further down. Gravel packs around a well provide a conduit for water and contaminants to potentially reach the water table and contaminate water supplies.

Existing production wells at the North Base consist of North Base Wells (NBW) 3 and NBW5. Due to poor drinking water quality, NBW1, NBW2, and NBW4 have been sealed off but apparently not abandoned through grouting. Water levels available for the North Base wells are shown on Table 3.1. The data collected yearly by U.S.G.S. on well water levels throughout the Base (U.S.G.S., 1980) indicate that in 1979 a groundwater trough existed immediately north of Sites 1A, 1B, 1C, and 1D, with the groundwater levels reported at elevation 2,190 feet above mean sea level (see Figure 2.3).

Field Program

The concern at the North Base centers around the potential for soil contamination through leakage and/or leaching from the drum sites at 1A, 1B, and 1D and the three nitric pits that constitute Site 1C. To evaluate this possibility, five soil borings were installed which penetrated 50 feet under the center of the disposal areas. The holes were drilled at a 30-degree angle from the vertical along the edge of the disposal areas to reach directly under the center of the sites. The drilling method selected for the North Base soil borings was hollow stem auger, with sampling conducted at five different depths with a driven split-spoon sampler. Following soil sampling, the soil borings were abandoned through grouting. The locations of the soil borings are shown on Figures 3.1 and 3.2.

Main Base and South Base

Geohydrology

The Main Base is located along the west shore of Rogers Dry Lake at the terminus of a large deposit of alluvium extending southwesterly toward Rosamond Dry Lake. It is within this alluvium that most of the water wells at the Main Base are located. The alluvium (younger) extends northward from the South Base to the Main Base and pinches out north of the Main Base to a width of about one-quarter mile toward the North Base. The alluvium consists of gravel, sand, silt, and clay beneath the alluvial plains. This alluvium is largely above the water table, but where saturated, the alluvium yields water to wells. Bordering the alluvium to the west is a narrow band of lakeshore deposits northward from the Main Base. These deposits consist of gravel and sand and some silts and clays, and are located above the water table. Further westward are younger fan deposits, made up of poorly sorted gravel, sand, silt, and mudflow debris that is locally derived. These deposits are largely above the water table and yield little water to wells immediately west of the Main Base. The gently sloping hill where Site 2 is located consists of basement rock of granitic origin (quartz monzonite). The material is deeply weathered locally resulting in soil mantle development. The granite-type rocks are fractured and yield some water from cracks and fissures (see Figure 2.2 for delineation of geologic units).

Perhaps as many as 200 wells have been completed in the past in the Main Base and South Base areas to provide drinking and irrigation water for the now abandoned town of Muroc. Most of these wells have been sealed off or abandoned as new water supply wells were installed in other areas. Well logs exist for a limited number of the old wells;

inspection of the logs allows a general interpretation of the areal and vertical relationship of the geologic subsurface conditions in the South Base area. Pertinent existing logs for wells near the Base disposal sites are included in Appendix B. Figures 3.3 and 3.4 show schematic geologic cross-sections based on old well logs, as well as on the logs prepared during the recent installation of monitoring wells. The sections show the subsurface geology in a north-south direction from the Main Base to the South Base. The granite hills northwest of the Main Base continue southward overlain by about 70 feet of lake shore and alluvial deposits. A sudden drop occurs south of the South Base, where the granite bedrock is found at a depth of more than 240 feet. The sediments overlying the granitic basement rock consist of variable thicknesses of lenticular, interfingering clay, silt, and sand.

In order to define the hydrological regime, geological logs as well as historical water level data are necessary. Within the Main Base and South Base areas, this information was available for only two wells. One well, 9N/9W-6E1, is located on the South Base, and another well, 9N/10W-12R1 (Main Base Well 6), is south of Old Hospital Road (see Figure 3.5 for location). The geological logs for both wells are part of the cross-section A-A', presented in Figure 3.3. The original well log for 9N/10W-12R1 is presented in Figure 3.6. This figure shows a total drilling depth of 252 feet, with apparent water-bearing sands at 169 to 178 feet and at 223 to 248 feet. Perforations in the well casing were located at these intervals. Sands at shallower depths did not appear to show water at the time of well installation in 1944. In 1951 the depth of the well was recorded as 186.6 feet, a difference of 65.6 feet from the original depth; this could be due to siltation of the well. There are no data on the water level immediately following well completion, but in 1948 the water level was recorded at 11.1 feet below ground surface. At this depth, the well log shows that the subsurface material consists of clay (non-water-bearing) extending to a depth of 131 feet; thus the water in the well must have risen from the water-bearing sands at 169 feet to its recorded depth. This would indicate that the water was under confined conditions at the time of installation and that the more than 100 feet of clay acted as a confining layer.

CROSS-SECTION A-A'
MAIN BASE AND SOUTH BASE
EDWARDS AIR FORCE BASE, CA
(for location, see Figure 2.2)

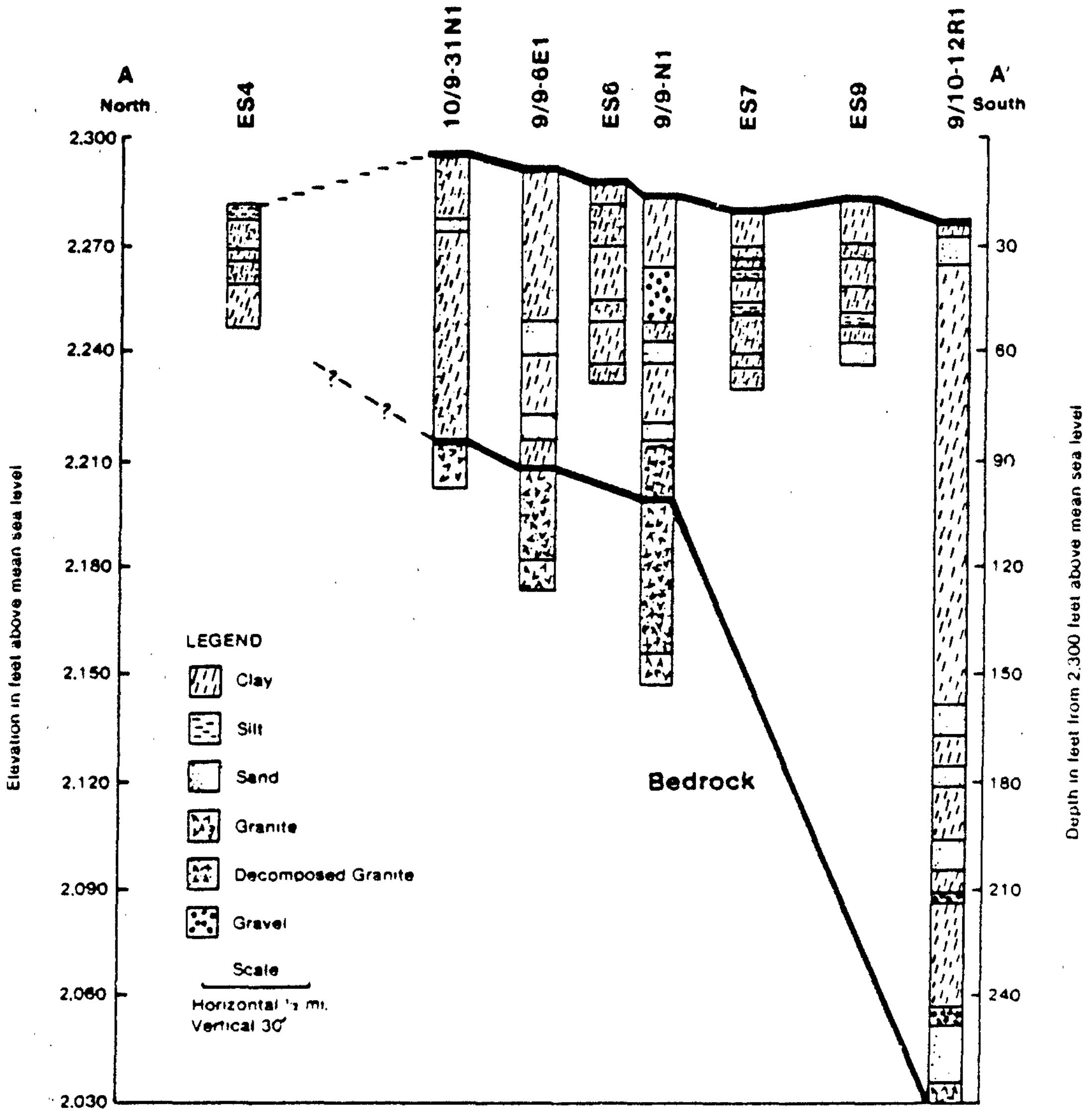
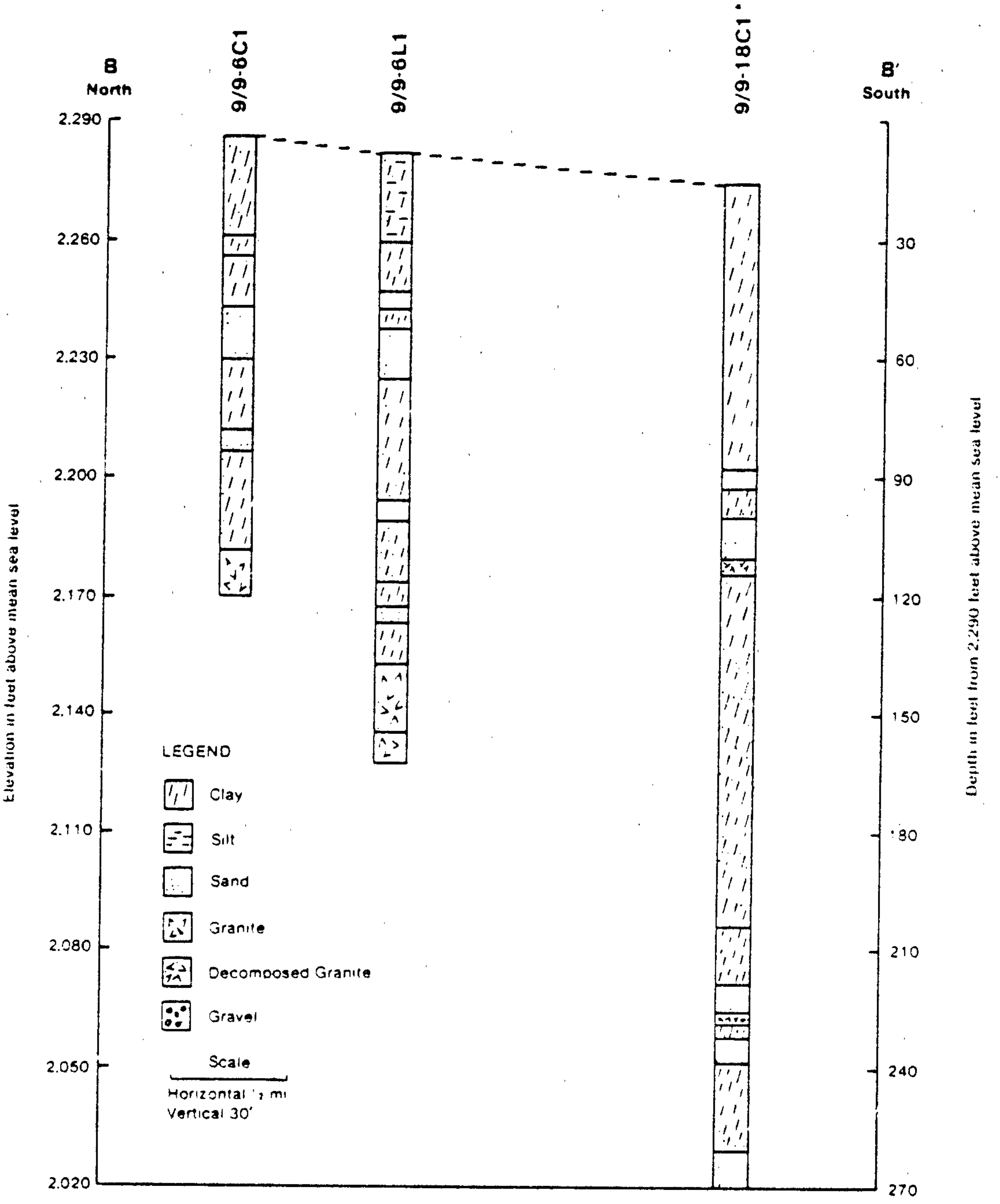


FIGURE 3.4

CROSS-SECTION B-B'
MAIN BASE AND SOUTH BASE
EDWARDS AIR FORCE BASE, CA
(for location, see Figure 2.2)



* When this well was drilled in 1944 water was encountered at 75 feet but rose to 10 feet indicating confined conditions at that time

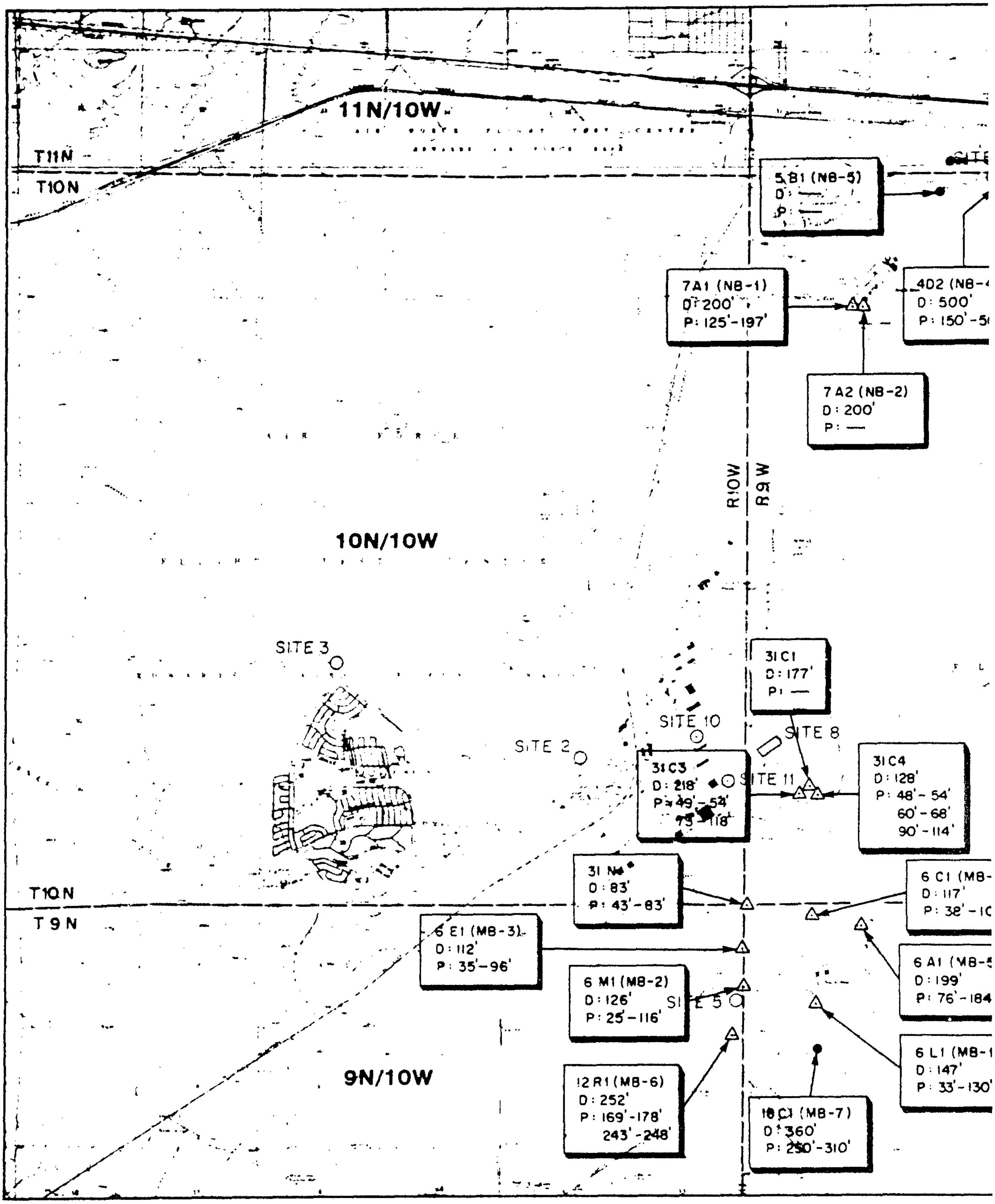
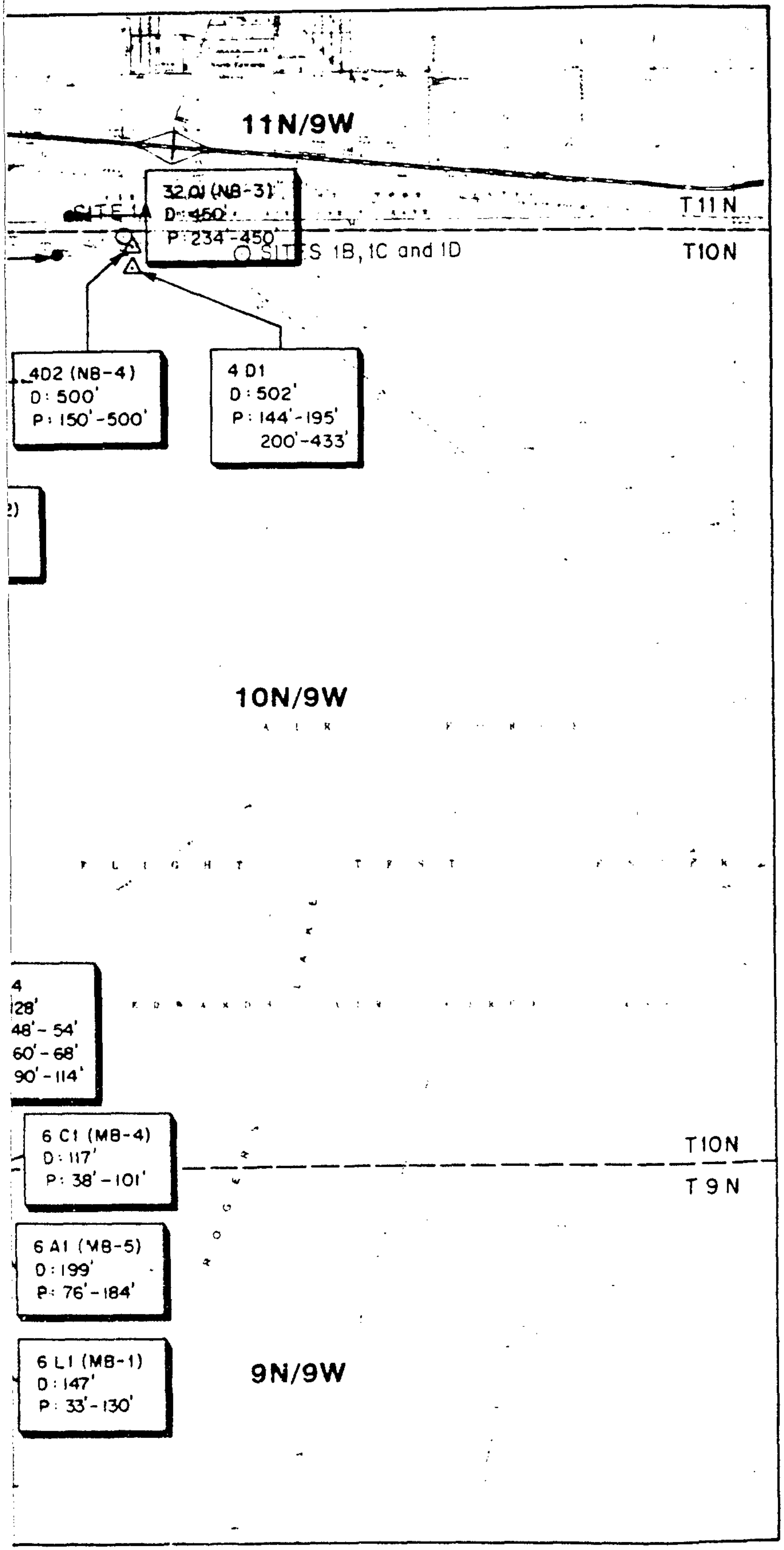

11N/10W
T11N
T10N
5B1 (NB-5)
D: —
P: —
7A1 (NB-1)
D: 200'
P: 125'-197'
402 (NB-
D: 500'
P: 150'-5
7A2 (NB-2)
D: 200'
P: —
R10W
R9W
10N/10W
SITE 3
31C1
D: 177'
P: —
SITE 10
SITE 8
SITE 2
31C3
D: 218'
P: 49'-54'
73'-118'
SITE 11
31C4
D: 128'
P: 48'-54'
60'-68'
90'-114'
31 N4
D: 83'
P: 43'-83'
6 C1 (MB-
D: 117'
P: 38'-1
T10N
T9N
6 E1 (MB-3)
D: 112'
P: 35'-96'
6 A1 (MB-
D: 199'
P: 76'-184
6 M1 (MB-2)
D: 126'
P: 25'-116'
SITE 5
6 L1 (MB-
D: 147'
P: 33'-130'
9N/10W
12 R1 (MB-6)
D: 252'
P: 169'-178'
243'-248'
18 C1 (MB-7)
D: 360'
P: 250'-310'

FIGURE 3.5



EDWARDS AFB

INSTALLATION RESTORATION PROGRAM PHASE II FIELD EVALUATION

LEGEND

● Active Production Wells

△ Abandoned Wells

USGS Number

Base Well Number

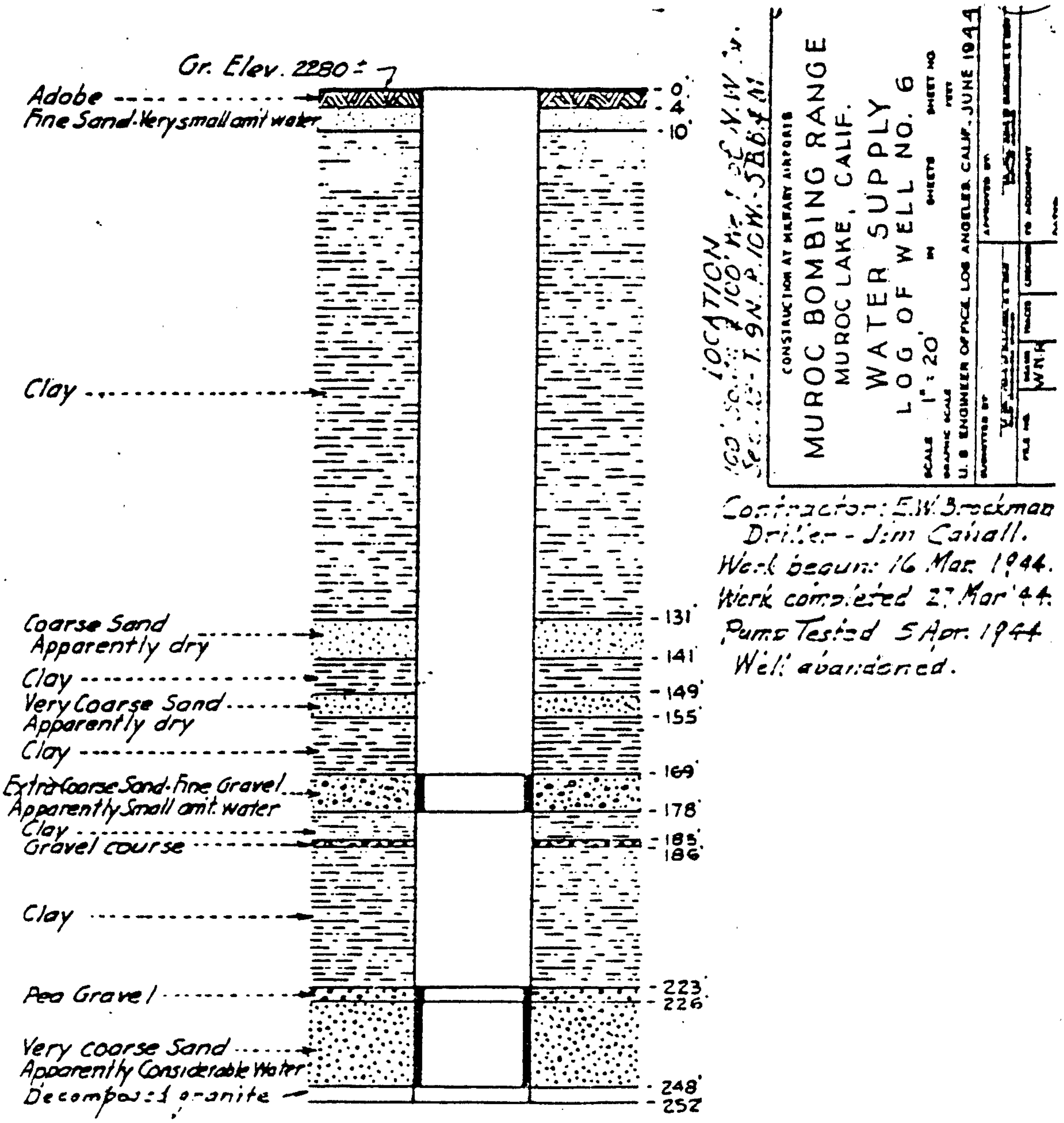
12 R1 (MB-6)
D: 252' ← Depth of Well
P: 169'-178' ← Perforated Intervals in Casing

(See Appendix B for standard California well numbering system)

1/2 0 1
MILE

LOCATION OF BASE WELLS WITH WELL LOGS AVAILABLE

ORIGINAL WELL LOG FROM SOUTH BASE
WELL 9N/10W-12 R1



Contractor: E.W. Brockman
Driller - Jim Cahall.
Work begun: 16 Mar. 1944.
Work completed 27 Mar '44.
Pump Tested 5 Apr. 1944
Well abandoned.

The water levels in the 9N/10W-12R1 well from 1948 to 1981 have been presented graphically on Figure 3.7. The data show a steadily declining water level from 11.1 feet in 1948 to 89.65 feet in 1981. Although monthly readings were discontinued in 1966, monthly records from the 1960's show an annual seasonal variation in the water levels of about 7 feet, and an overall yearly decline of about 3 feet. This indicates that following the yearly low water level of August and September, the water level never recovered to its previous shallower depth. The 1981 water level reading of 89.65 feet appears to indicate that the water in the well is still under confined conditions since the first perforations are at a depth of 169 feet, and the massive clay layer reaches down to a depth of 131 feet.

South Base Well 9N/9W-6E1 was drilled in 1942 to a depth of about 107 feet into bedrock. In 1951, the depth of the well was recorded as 103.7 feet, or 3.3 feet shallower than when completed in 1942; this could be due to siltation of the well. The original well log presented on Figure 3.8 indicates that sands should be located at various intervals below 37 feet. The log does not indicate which of these sands were water bearing at the time of installation. The perforations extend from 35 feet to 96 feet, with the static water level recorded as 36 feet on the original well log. Available data do not indicate whether the water was confined or unconfined; however, when a pump test was performed in 1942, 67 feet of drawdown resulted while pumping 254 gallons per minute, which could be indicative of nonconfining conditions.

Water level data for 9N/9W-6E1 are available from 1942 to date. The water levels show a continuous downward trend from the initial 36 feet to 51.17 feet in April 1981, a total drop of 15.17 feet in 39 years, or less than 0.5 foot per year. Seasonal water levels generally appear to vary less than 0.25 foot.

The wells described above are indicative of the geohydrologic environment existing along the shores of Rogers Dry Lake. The Main Base and South Base are located in a hydrological transition zone where the groundwater can be under confined and/or nonconfined conditions. In this transition zone, the thickness of sediments overlying bedrock vary dramatically over short distances; the thicknesses of water-bearing

FIGURE 3.7

WATER LEVEL DATA FROM 1948 TO 1981
WELLS 9N/9W-6E1 and 9N/10W-12R1
EDWARDS AFB, CA

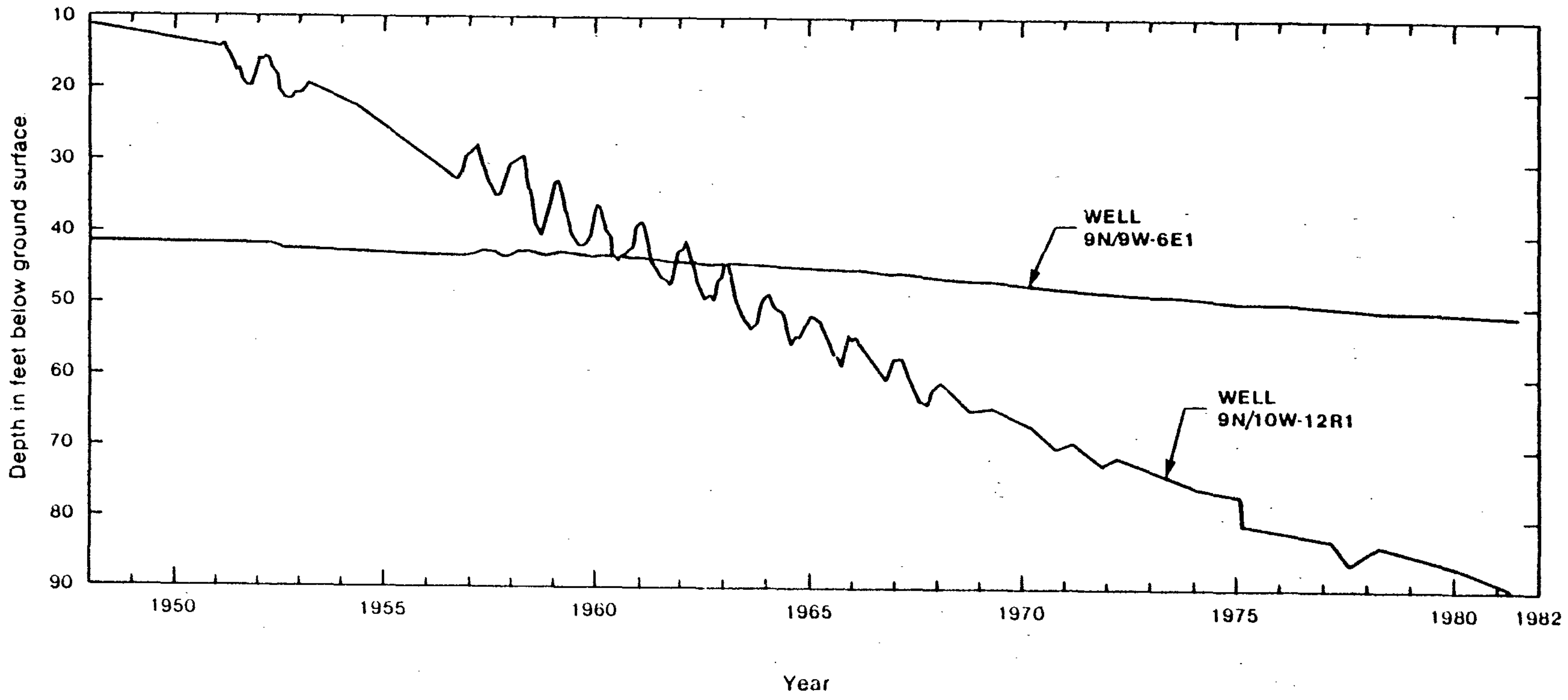
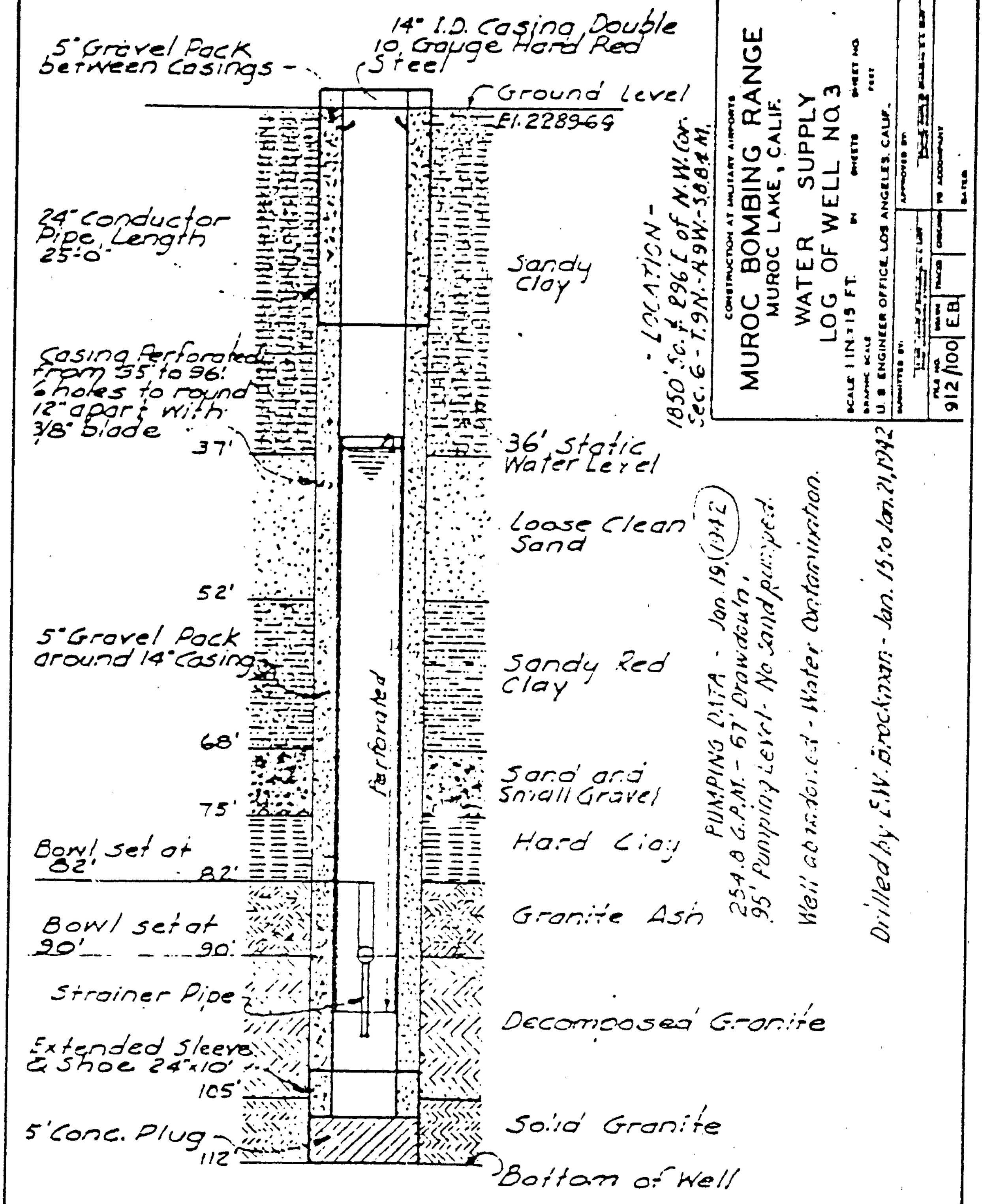


FIGURE 3.8

ORIGINAL WELL LOG FROM SOUTH BASE
WELL 9N/9W-6E1



sands and gravels are lenticular and interfingering with clays and silts, and perched water conditions are distinct possibilities. Here, different groundwater zones experience different seasonal variations, and the decline in the water table over time depends on the aquifer location and characteristics.

Field Program

The investigation of groundwater contamination in the Main and South Base areas focused on the three source areas described below:

- Site 5: Underground waste POL storage tank leak

  Three monitoring wells were installed downgradient and one well upgradient from the site to identify potential waste POL migration into the groundwater.

- Site 10: Jet fuel pipeline break

  Two soil borings were installed immediately adjacent to the break to identify the extent of fuel seepage topographically downgradient from the site.

- Site 11: Fuel hydrant spill

  Three groundwater monitoring wells were installed downgradient from the hydrant spill, one immediately southeast of the site and two wells less than one-half mile southward.

Also included in the field program were a soil boring downhill from the Main Base toxic waste disposal site (Site 2), collection of two surface soil samples downhill from the abandoned sanitary landfill (Site 3), and sampling of water and bottom sediments from the industrial waste pond (Site 8).

The selected drilling method for the monitoring wells and soil borings was hollow-stem auger, with the possible addition of rotary wash depending on the nature of subsurface material. To identify whether suspected problems exist, the focus of the field program at the Main Base and South Base was to penetrate to the first water-bearing material and install the monitoring wells at those depths. At the North Base, the focus was to determine the presence of potential soil contamination beneath each past disposal site. During drilling, soil samples were obtained for soil classification purposes and water samples were taken for laboratory analyses. Any holes that did not encounter water were abandoned and grouted.

IMPLEMENTATION OF FIELD PROGRAM

North Base

The field program for the North Base was designed to identify potential contamination of soils underlying each disposal site. The locations of soil borings were shown on Figure 3.1 and 3.2. Table 3.2 delineates the drilling method employed at each site, the depth and size of each boring, and the date of completion.

TABLE 3.2

DRILLING METHODS
NORTH BASE

Site	Drilling Method	Soil Boring Depth (feet)	Size of Soil Boring (inches)	Completion Date
1A	Rotary wash	51.5	4	26 Feb 1982
1B	Rotary wash	51.5	4	25 Feb 1982
1C	Hollow-stem auger	56.5	8	19 Feb 1982
1D1	Hollow-stem auger	61.5	8	24 Feb 1982
1D2	Hollow-stem auger	60.5	8	25 Feb 1982

All soil borings at the North Base were proposed to be completed by hollow-stem augering. However, due to the nature of the subsurface materials (in certain cases clay lenses were present), refusals were encountered with the auger drilling. As a result, soil borings at Sites 1A and 1B were completed with rotary wash. At Site 1B, water was used as drilling fluid for the rotary wash, and at Site 1A, bentonite (Red Devil Gel) was added at a depth of 18 feet to prevent cave-in and to limit loss of circulation water into a large deposit of non-water-bearing gravels. No organic additives were added to the drilling fluid.

All soil borings were grouted to prevent vertical migration of contaminants following completion of sampling. The photographs presented on Figures 3.9 and 3.10 depict typical drilling methods employed at the North Base.

For each soil boring, soil samples were obtained with a driven split-spoon sampler (1.5-inch diameter) at five different depth intervals. Samples from three depths were analyzed for contaminants, while remaining samples were retained for potential future analyses. In addition, soil grab samples were obtained from 20-foot intervals for soil classification purposes. Table 3.3 indicates the depths at which samples were obtained, the types of samples collected at each depth, the samples that were retained by the Base, and those that were analyzed for contaminants.

Main Base and South Base

The groundwater monitoring wells were installed by a combination of hollow-stem auger and rotary wash depending on the subsurface material. A total of ten wells were envisioned with the possibility of some wells not yielding water due to the geohydrological transition zone underlying the Base. The aim of the drilling program was to complete the wells within the first water-bearing zone encountered, whether perched, confined, or unconfined, and install screened casing at the water-table level to intercept hydrocarbons that may float on top of the water.

Figure 3.11 shows the locations of soil borings and monitoring wells installed at the Main Base and South Base. Table 3.4 lists the known Base disposal sites and the soil borings and monitoring wells associated with each site, as well as the methods of drilling, depths and sizes of holes, and date of completion. Hollow-stem augers were used initially for each hole, and at depths where drilling refusal was encountered, the drilling method was switched to rotary wash if possible; when necessary, bentonite was added to the hole.

Each monitoring well was completed with a 10-foot, 4-inch, 10-slot stainless steel screen at the bottom, threaded to 4-inch Schedule 40 PVC casing for the remaining part of the well. The well was gravel-packed with #3 kiln-dried Monterey sand around the screens, and overlain by a

TABLE 3.3

NORTH BASE SAMPLES

Site	Depth of Sample (feet)	Number and Type of Samples	Disposition of Samples
Site 1A	3	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	5	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	10	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	20	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	20	1 soil classification grab sample	Retained by Edwards AFB
	40	1 soil classification grab sample	Retained by Edwards AFB
	50	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	50	1 soil classification grab sample	Retained by Edwards AFB
Site 1B	3	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	5	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	10	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	10	1 soil classification grab sample	Retained by Edwards AFB
	20	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	40	1 soil classification grab sample	Retained by Edwards AFB
	50	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	50	1 soil classification grab sample	Retained by Edwards AFB
Site 1C	3	1 one-liter polyethylene bottle	Analyzed for contaminants
	10	1 one-liter polyethylene bottle	Retained by Edwards AFB
	20	1 soil classification grab sample	Retained by Edwards AFB
	25	1 one-liter polyethylene bottle	Analyzed for contaminants
	25	1 glass vial sample by split-spoon sampler	Retained by Edwards AFB
	25	1 soil classification grab sample	Retained by Edwards AFB
	40	1 soil classification grab sample	Retained by Edwards AFB
	40	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	55	2 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	55	1 soil classification grab sample	Retained by Edwards AFB
	55	1 one-liter polyethylene bottle	Analyzed for contaminants
1D	3	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	20	1 soil classification grab sample	Retained by Edwards AFB
	30	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	40	1 soil classification grab sample	Retained by Edwards AFB
	50	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	55	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	60	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
1D2	3	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	20	1 soil classification grab sample	Retained by Edwards AFB
	30	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	30	1 soil classification grab sample	Retained by Edwards AFB
	40	1 soil classification grab sample	Retained by Edwards AFB
	50	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	55	3 glass vial samples by split-spoon sampler	Retained by Edwards AFB
	60	3 glass vial samples by split-spoon sampler	Analyzed for contaminants
	60	1 soil classification grab sample	Retained by Edwards AFB

FIGURE 3.9

DRILLING METHODS
NORTH BASE SITES 1A AND 1B

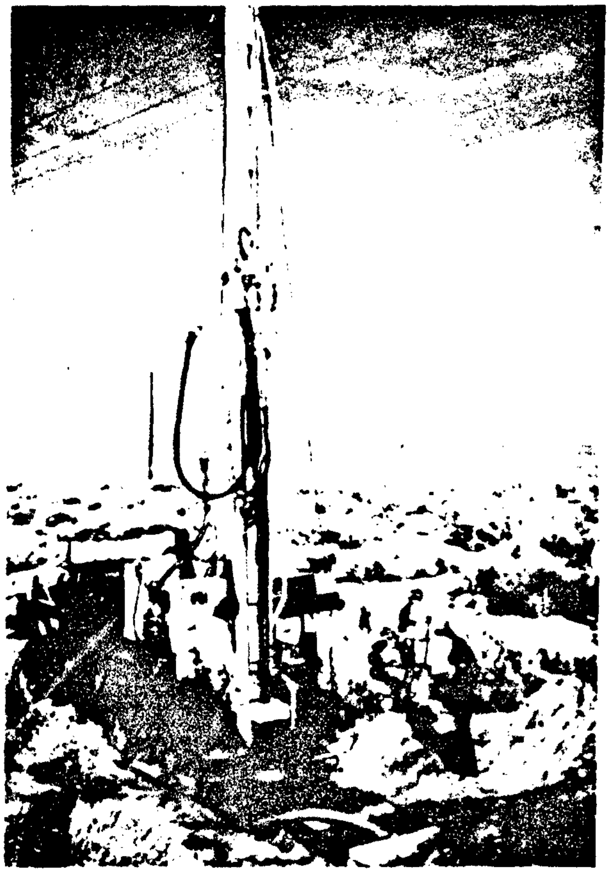


PHOTO A
Rotary-wash drilling at Site 1A

PHOTO B
Rotary-wash drilling at Site 1B

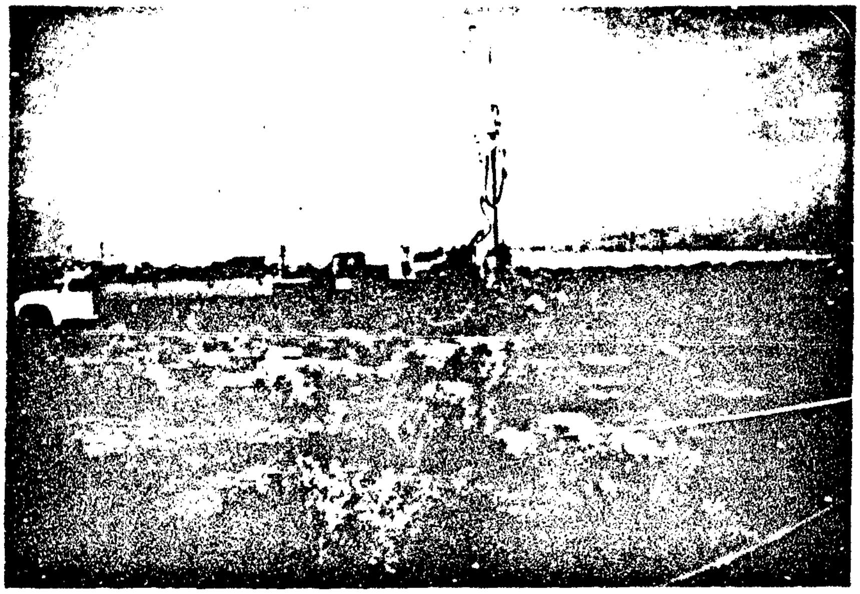


FIGURE 3.10

DRILLING METHODS
NORTH BASE SITES 1C AND 1D1

PHOTO A
Slant-drilling with hollow-stem auger at Site 1C.

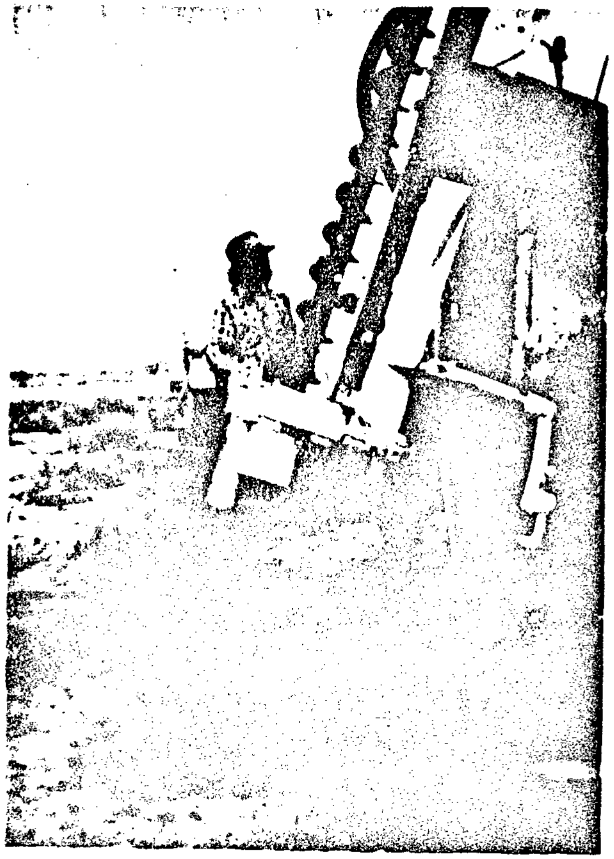
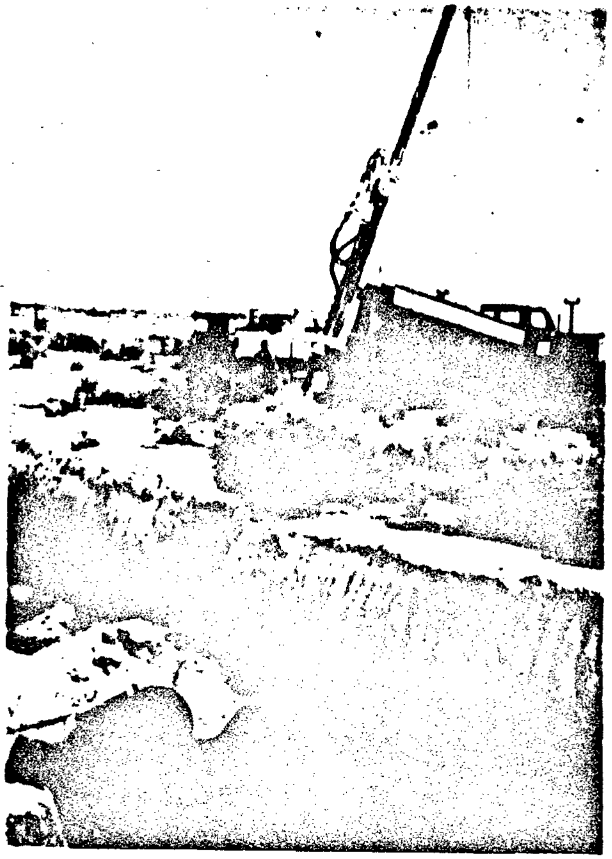


PHOTO B
Slant-drilling with hollow-stem auger at Site 1D1.



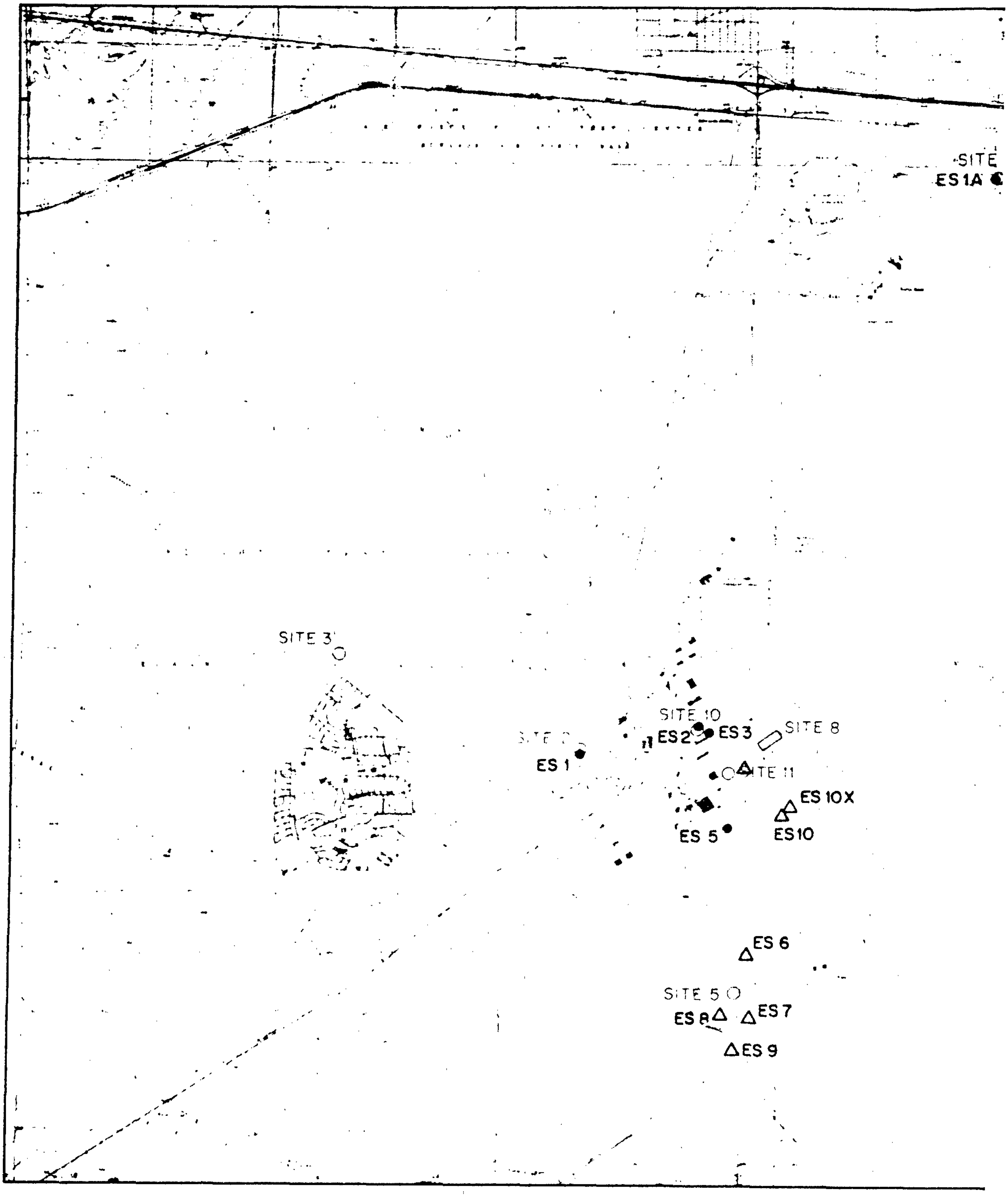
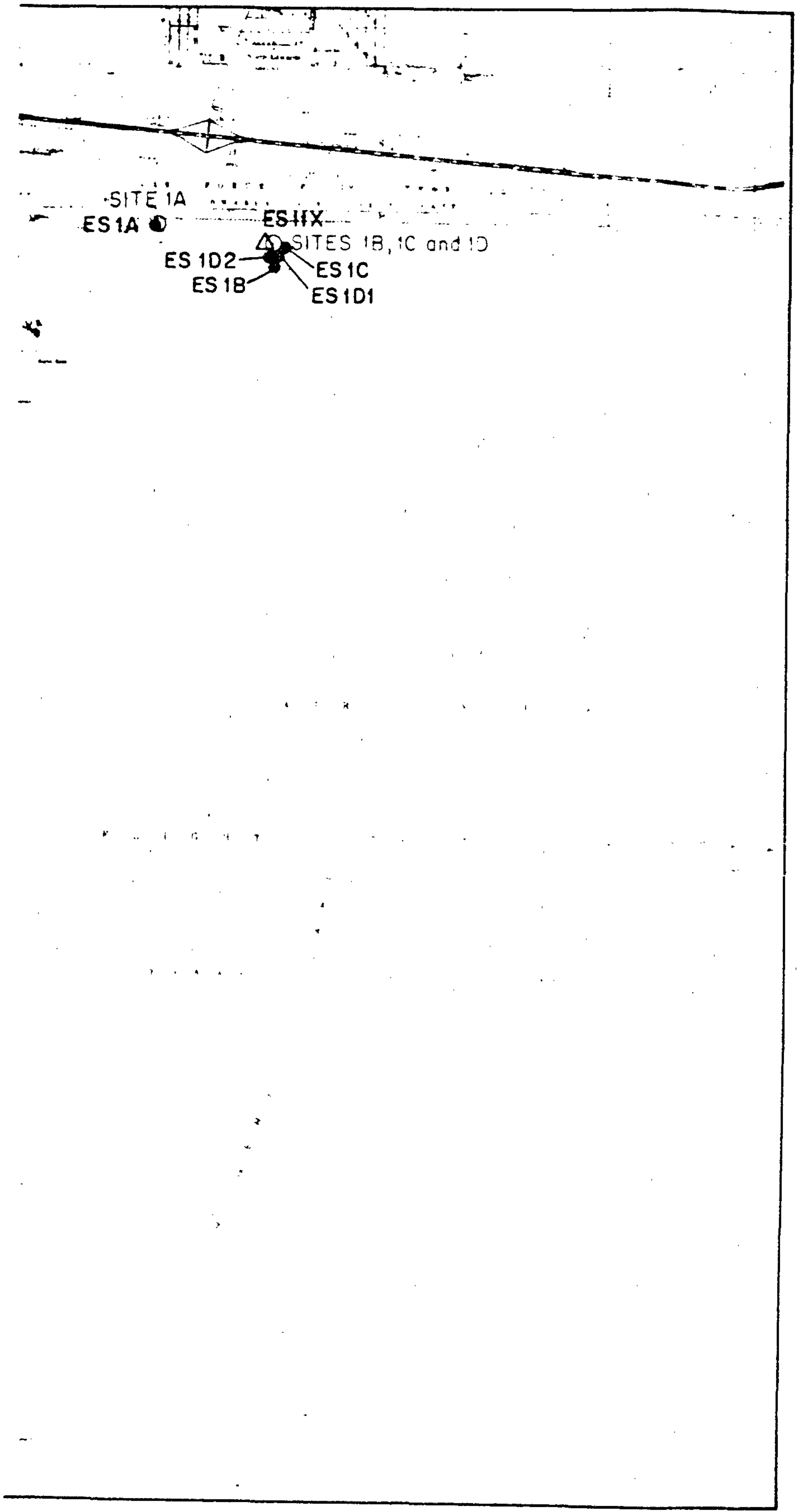

SITE
ES 1A
SITE 3
SITE 10
ES 2
ES 3
SITE 8
SITE 2
ES 1
SITE 11
ES 10X
ES 10
ES 5
ES 6
SITE 5
ES 8
ES 7
ES 9

FIGURE 3.11

INSTALLATION RESTORATION PROGRAM PHASE II FIELD EVALUATION

EDWARDS AFB



LEGEND

- ● Soil Borings
- △ Monitoring Wells

LOCATION OF SOIL BORINGS AND MONITORING WELLS INSTALLED SPRING 1982

1 2

TABLE 3.4

DRILLING METHODS
MAIN BASE AND SOUTH BASE

Location	Drilling Method	Drilling Depth (feet)	Size of Hole (inches)	Size of Casing (inches)	Completion Date
Site 2	Hollow-stem auger	21	8	NA[a]	27 Feb 1982
Site 3	Surface soil grab samples	NA	NA	NA	5 Apr 1982
Site 5					
ES 6	Hollow-stem auger Rotary	0 - 52 52 - 55	8	4	2 Mar 1982
ES 7	Hollow-stem auger Rotary	0 - 40 40 - 50	8	4	4 Mar 1982
ES 8	Hollow-steam auger Rotary	0 - 42 42 - 47	8	4	4 Mar 1982
ES 9	Hollow-stem auger Rotary	0 - 36	8	4	5 Mar 1982
Site 10					
ES 2	Hollow-stem auger	21	8	NA	26 Feb 1982
ES 3	Hollow-stem auger	11	8	NA	26 Feb 1982
Site 11					
ES 4	Hollow-stem auger	33	8	4	5 Mar 1982
ES 5		42	refusal at 42 feet	NA	27 Feb 1982
ES 10	Hollow-stem auger Rotary	0 - 40 40 - 88	8	4	1 Mar 1982
ES 10X	Rotary	55	8	4	7 Apr 1982

a NA - Not applicable

bentonite pellet seal above. The entire well was grouted from the top of the bentonite seal to the ground surface and a black iron casing was installed over the PVC casing aboveground. Development of the wells was accomplished with a 3-inch submersible pump pumping and surging the well until the discharged water was clear, an average of one hour. Water had to be added to some wells to facilitate development and prevent the pump from running dry and/or becoming silted up by the fine-grained material within the well. Figures 3.12, 3.13, and 3.14 show typical drilling methods and well development methods used for installation of the monitoring wells. Appendix D contains the well completion logs for each monitoring well installed. Soil grab samples were collected for soil classification purposes at 3-foot intervals during drilling of the monitoring wells. Following development of the wells, groundwater samples were retrieved for laboratory analyses.

Samples from Site 8, the industrial waste pond, were collected from a small rubber raft launched from the shores of the pond. Two water samples and four bottom sediment samples were collected at the locations shown on Figure 3.15. It should be noted that Site 8 is not a traditional industrial waste pond, but serves as a collection basin for runoff from the flight line.

SAMPLING PROCEDURES AND SAMPLE PRESERVATION

Based on speculations concerning the types of materials that may have been disposed or spilled at the sites identified on the Base (refer to Figure 1.1), a specific sampling program was developed for each site. The various types of contaminants suspected as being contained in materials disposed or spilled on the Base fall into the categories of acids, alcohols, heavy metals, pesticides, oils and fuels, and purgeable halocarbons. Figure 3.16 summarizes the analytical methods and sampling equipment generally used for determination of contamination in soil and water samples. Table 3.5 delineates the constituents suspected to have been disposed at each site. This list has been based on interviews with personnel associated with the Base for over 20 years and on the labels and signs posted by the sites. Table 3.5 also includes the type of sample containers used for sampling and the preparation of each sample container.

Soil boring samples were collected by a split-spoon sampler. The "spoon" consists of a 1.5-foot long metal cylinder that can be split into two halves. The photographs in Figure 3.17 show the sampler after it had been opened, exposing the sample retrieved. The sampler was driven through the hollow stem of the auger and then into the bottom of the drilled hole to obtain an undisturbed sample. The photograph in

FIGURE 3.12

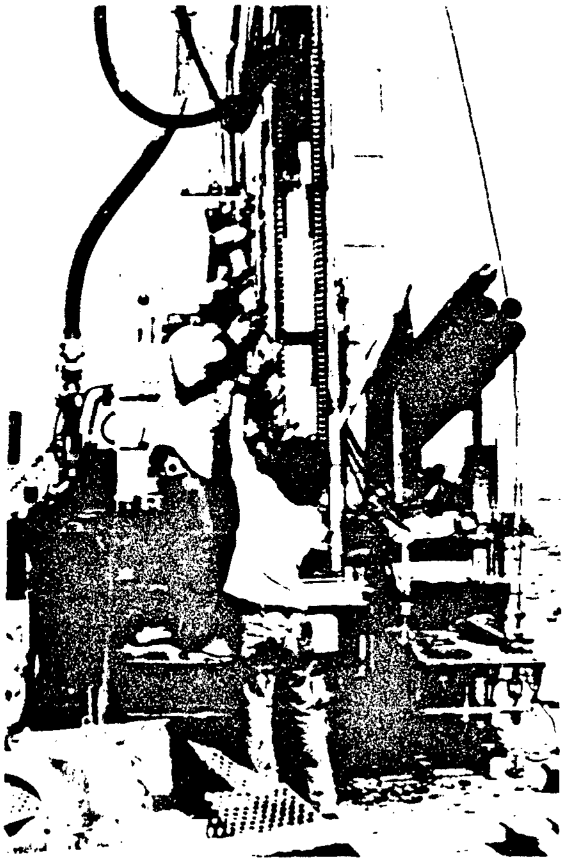


PHOTO A
Adding hollow-stem augers at the start of drilling at Main Base.

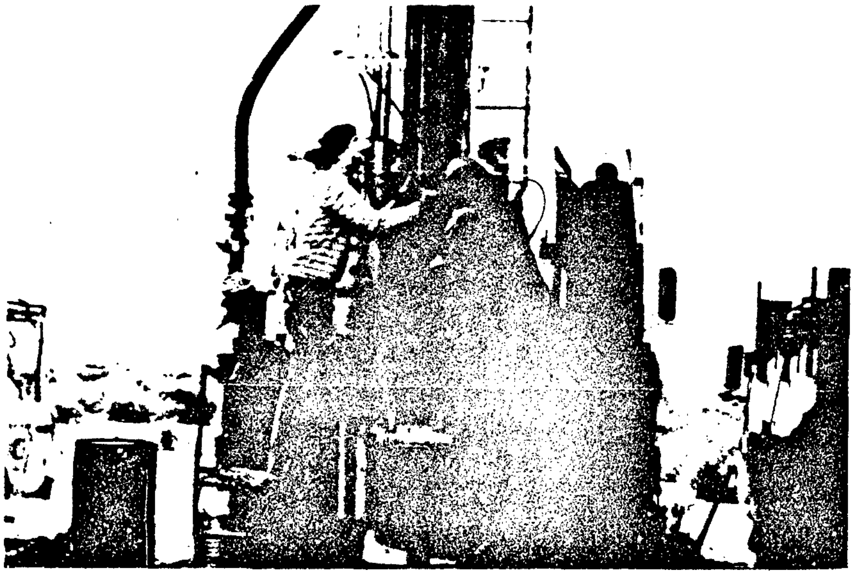


PHOTO B
Adding pipes for rotary at Main Base.

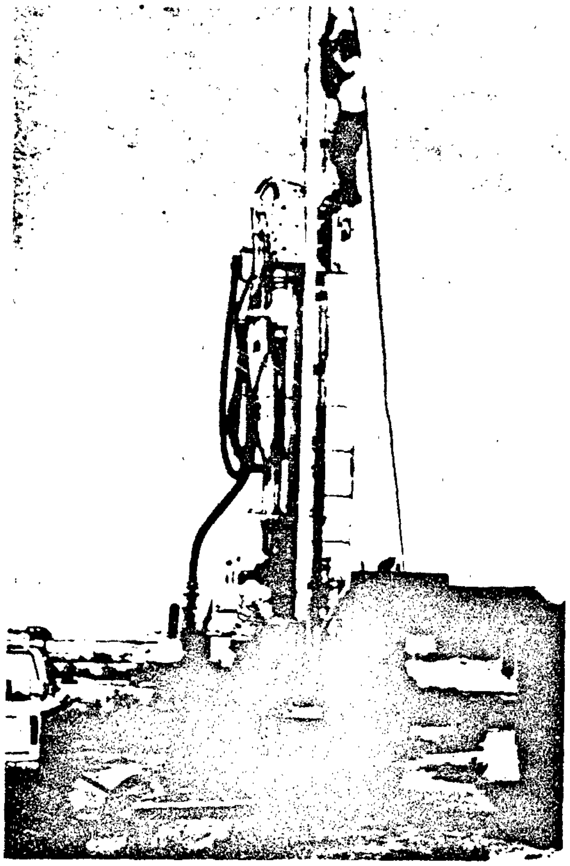


PHOTO C
Installation of stainless steel screen and PVC casing at Main Base.

PHOTO D
Pouring sand into hole for gravel pack around the screen.

FIGURE 3.14

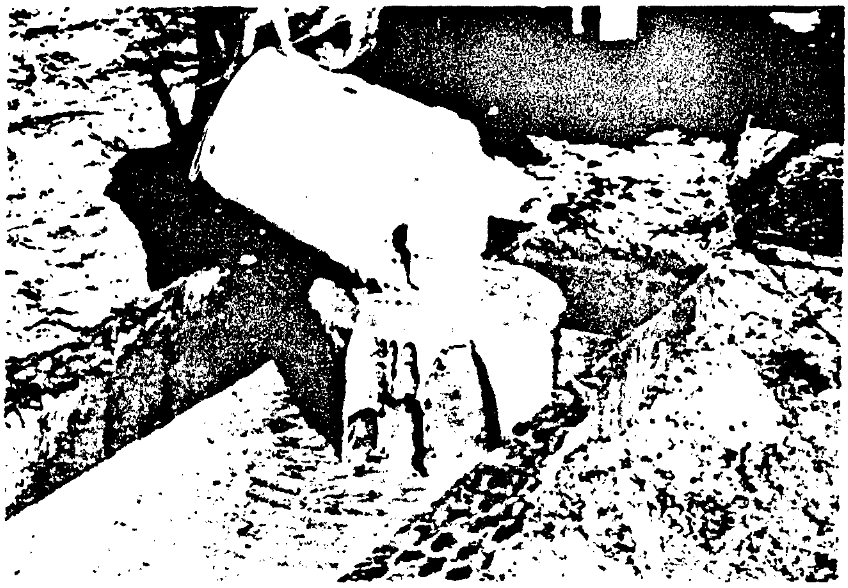


PHOTO E
Pouring bentonite pellets into hole for seal above gravel pack at Main Base.

PHOTO F
Lowering submersible pump into well for development at Main Base.

FIGURE 3.15

SCHEMATIC DRAWING OF SITE 8, INDUSTRIAL WASTE POND, WITH SAMPLING LOCATIONS

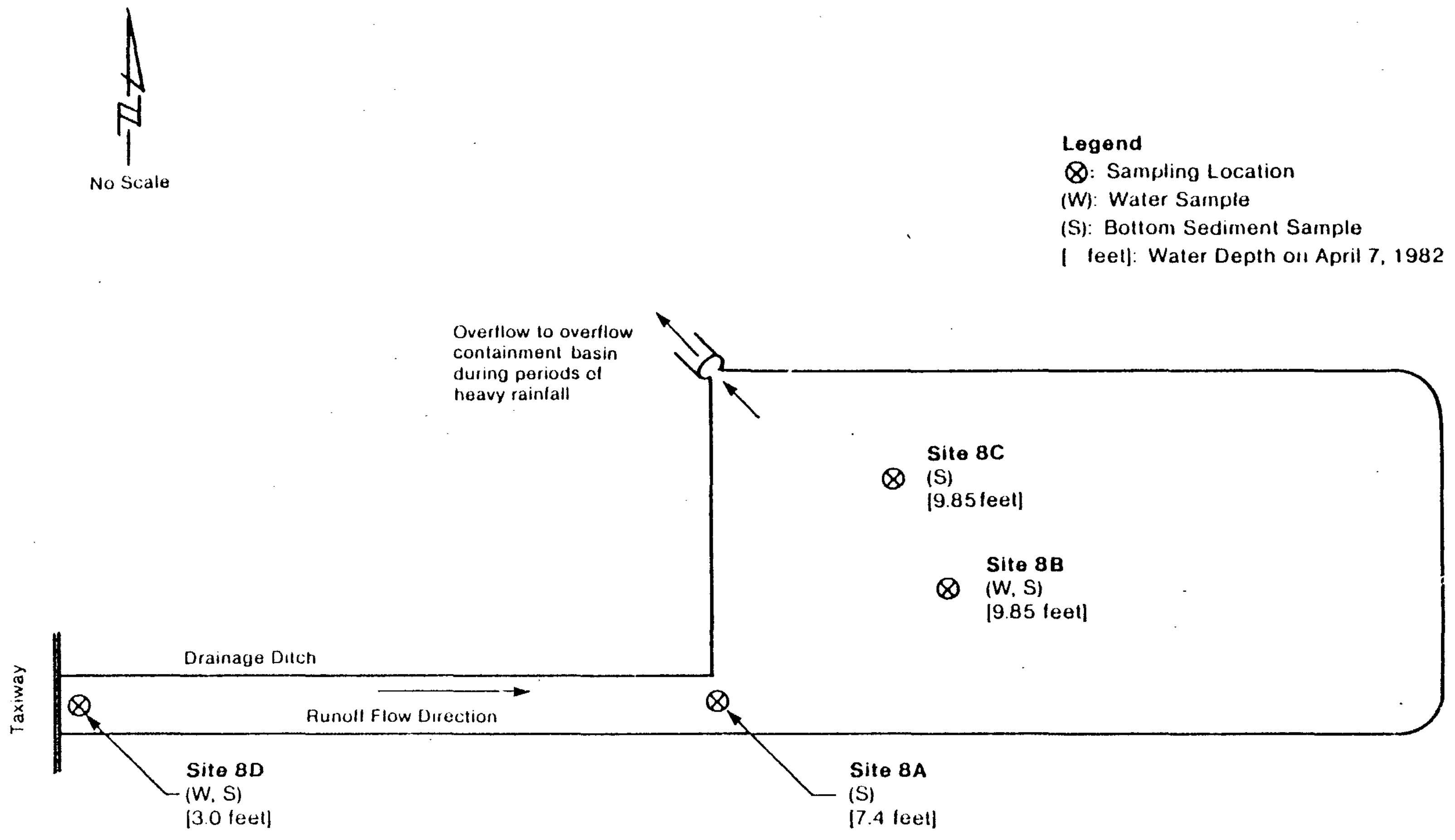
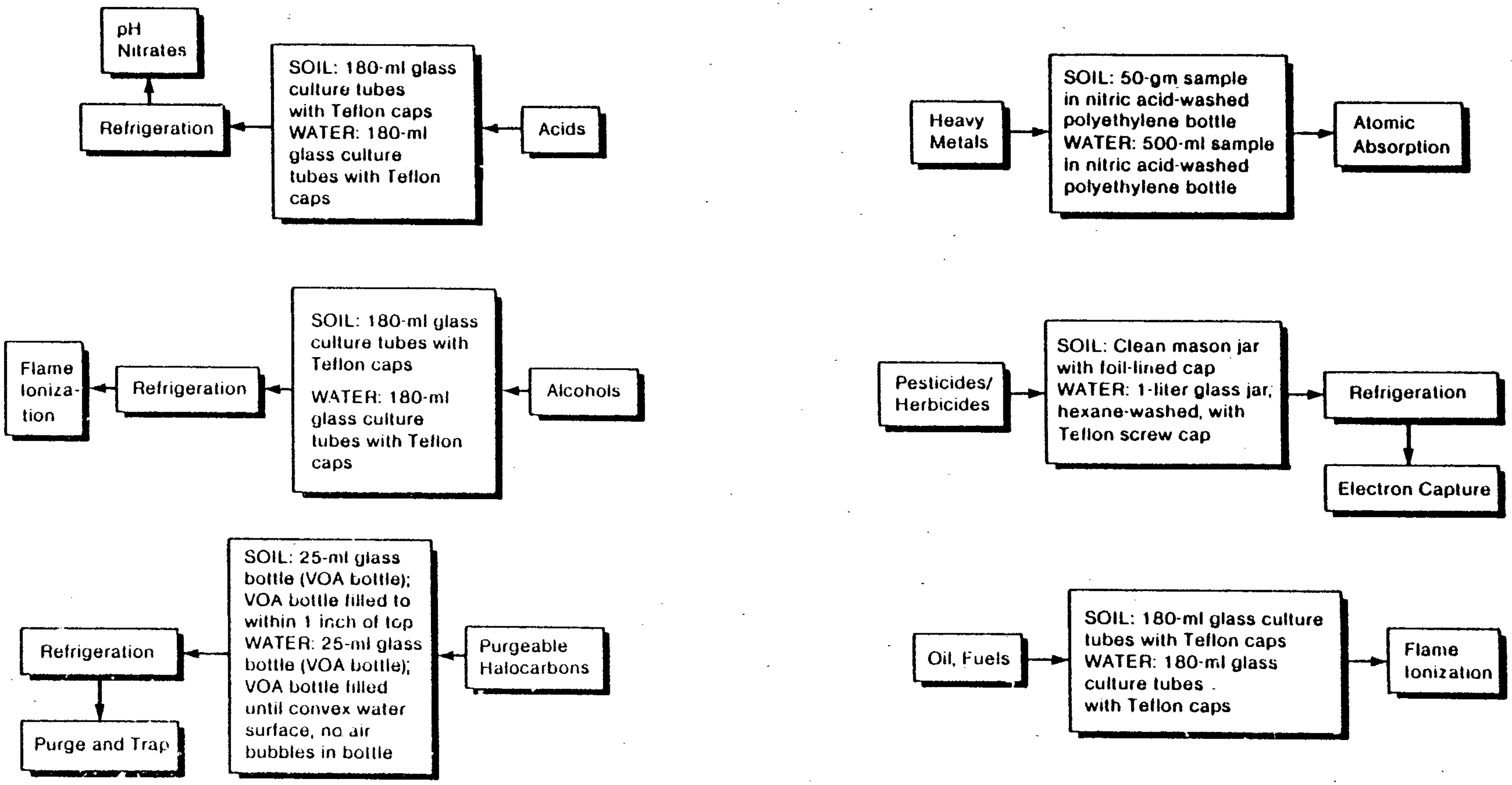


FIGURE 3.16

ANALYTICAL METHODS AND SAMPLING EQUIPMENT USED FOR SOIL AND WATER SAMPLES FROM EDWARDS AFB



COLLECTION OF SPLIT-SPOON SAMPLES
NORTH BASE SITES 1A AND 1C

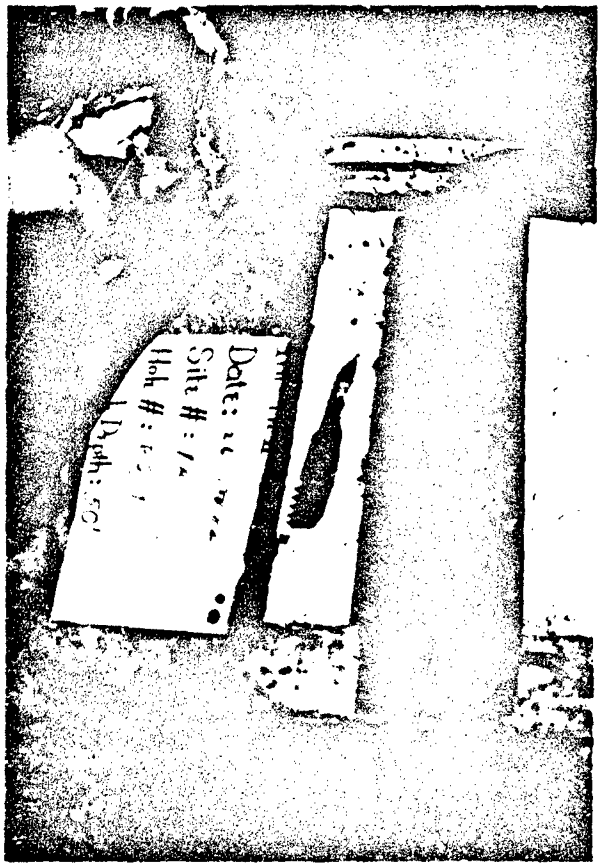


PHOTO A
Open split-spoon containing sample obtained from Site 1A at a 50-foot depth.

PHOTO B
Split-spoon sample being collected for acid and pH analysis from Site 1C.

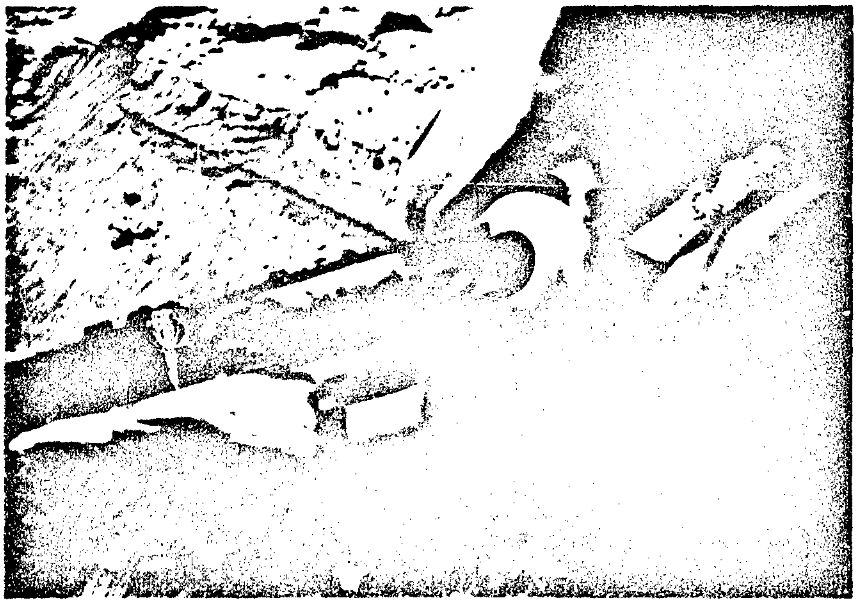


TABLE 3.5

POTENTIAL CONTAMINANTS AND CONTAINERS USED FOR SAMPLING

Site	Potential Contaminant	Sample Containers[a]	Type of Material Sampled
1A	Fuel, oils Solvents	VOA bottles [b]	Soil
1B	Aniline Fuel, oils PCB's	VOA bottles	Soil
1C	Nitric acids (low pH)	1-liter polyethylene bottles	Soil
1D1	Aniline Furfuryl and ethyl alcohol Engine cleaner (trichloroethylene) Fuel	VOA bottles	Soil
1D2	Aniline Furfuryl and ethyl alcohol Engine cleaner (trichloroethylene) Fuel Acids	VOA bottles	Soil
2	Acids Tetraethyllead Fuel	VOA bottles	Soil
	Heavy metals	1-liter polyethylene bottles	
3	Pesticides	1-liter glass jar with foil-lined screw cap	Soil
	Heavy metals	1-liter polyethylene bottle	
5	Fuel, oils	VOA bottles	Water
8	Fuel	1-liter nitric-acid washed glass bottle with foil-lined screw cap	Soil and water
	Heavy metals	1-liter nitric-acid washed polyethylene bottle	

TABLE 3.5 (Continued)

Site	Potential Contaminant	Sample Containers[a]	Type of Material Sampled
10	Fuel Heavy metals	VOA bottles	Water
11	Fuel Heavy metals	VOA bottles	Water

[a] New containers were used for collection of all samples.
[b] 25-ml glass vial with Teflon screw cap.

Figure 3.17A shows a sample from Site 1A at a depth of 50 feet; the boring was completed with rotary wash. Since rotary-wash drilling uses water as a circulation fluid, part of the sample in the spoon was wet; all samples collected for laboratory analysis were taken from the dry, undisturbed part of the split-spoon sample. Figure 3.17B shows collection of a sample at Site 1C from the split-spoon. Following each sampling event, the split-spoon was rinsed with methanol and deionized water. All samples were immediately refrigerated and shipped either by air or bus to the laboratory for analysis.

Groundwater samples were collected after each well had been developed. A 500-ml plastic bailer was lowered to the water table, the bailer retrieved, and the sample poured into a glass culture tube after visual inspection for evidence of oil. All samples were refrigerated and shipped by air or bus to the laboratory.

Surface grab samples from Site 3, the abandoned sanitary landfill, were obtained by digging a hole 0.5-foot deep. The collected samples were refrigerated and air-freighted to the laboratory.

Water and sediment grab samples were obtained from Site 8. After retrieving each sample, the sampler was rinsed with nitric acid and deionized water. All samples were refrigerated and air-freighted to the laboratory.

CHAPTER 4

RESULTS OF FIELD PROGRAM

CHAPTER 4

RESULTS OF FIELD PROGRAM

The Phase II field program at Edwards AFB has focused on investigation of the environmental effects of past and current disposal practices upon the subsurface soils and shallow groundwater at various North Base, Main Base, and South Base locations.

NORTH BASE

A total of five soil borings were completed under Sites 1A, 1B, 1C, 1D1, and 1D2, as shown on Figures 3.1 and 3.2. Soil samples from three different depths in each boring were analyzed in the laboratory for potential contamination. The analytical results from each sample are contained in Appendix F. The appendix lists all analyses performed on each soil sample. As the data indicate, most of the chemical constituents suspected at each site were not present in detectable amounts. The constituents for which positive results were obtained are listed on Figures 4.1 through 4.5. These figures also show the site-specific subsurface environment as logged during drilling of each soil boring as well as air quality observations.

The subsurface conditions at each site show gradational variations. Generally, the soils of the North Base are all coarse-grained, consisting of gravels and sands with lenses of clays and silts. Sites 1D1, 1D2, and 1C show larger amounts of fine-grained material, such as clays and silts, whereas Sites 1A and 1B are underlain by more sandy and gravelly sediments with little clay except in thin lenses or within sand and gravel mixtures.

Generally, the results from each site except 1C show the pervasive presence of volatile substances (chloroform and trichlorofluoromethane) at nearly every sample depth, even though small quantities of other constituents were detected at various sites and depths. Inspection of Figures 4.1 through 4.5 also indicates that soil contamination is not limited to areas immediately underlying the disposal sites (1D1 and 1D2), but is present in the surficial soils at least 25 feet away from the actual disposal area. At all North Base sites, soil samples from the greatest depths (55 feet to 61 feet) showed chemical constituents present in detectable concentrations. Groundwater was not encountered in any of the soil borings.

Identification of the potential extent and magnitude of contamination requires an understanding of the transporting mechanisms of the constituents detected during laboratory analyses. There are a number of ways that the pervasive trichlorofluoromethane and chloroform may be transported. These migration mechanisms include:

- unsaturated liquid flow
- percolating water
- molecular diffusion

If the constituents had been transported through the soil column by unsaturated flow, they should be present as a "film" within the soil voids. The void spaces in a clean sandy soil represent approximately 40 percent of the total volume. In general, coarse-grained materials contain larger void volumes than finer-grained materials. If it is assumed that the North Base is underlain by sandy material (worst-case situation) and it is assumed that the density of the chemical constituents is 1.3 g/ml, the concentrations of the pervasive organic constituents at the North Base would be expected to be approximately 2,600 mg/kg. Since the concentration levels identified are about 100 times smaller, unsaturated liquid flow is an unlikely migration mechanism.

Transport of chemical constituents by percolating water would require that precipitation penetrate to a depth of at least 60 feet below ground surface, an unlikely situation at Edwards AFB where the mean annual rainfall is about 4 inches with a maximum of 11 inches. The maximum mean monthly rainfall occurs in February with about 0.5 inch in one day (Envirodyne Engineers, Inc., 1981). In arid climates, evaporation usually occurs from the upper 3 feet of bare soils at a rate of 0.2 inch per day (Dunne and Leopold, 1978). Due to site topography and the low permeability of the surface deposits, precipitation falling near the North Base disposal areas tends to flow rapidly toward the dry lake beds where it ponds (Envirodyne Engineers, Inc., 1981). Evaporation, topography, and low soil permeability account for the assumption that percolating water would not be the transporting mechanism for identified chemical constituents in the North Base soil borings.

In order for constituents to be transported by molecular diffusion, vaporized molecules must be present. The formation of vapor is largely dependent on the boiling point of a substance. Table 4.1 lists the boiling points as well as the densities of the organic constituents found at the North Base.

TABLE 4.1

PHYSICAL PROPERTIES OF CONTAMINANTS
OBSERVED AT NORTH BASE

Constituent	Boiling Point °C	Boiling Point °F	Density (g/cm^3)
Chloroform	62	143.6	1.498
Trichlorofluoromethane (Freon-11)	24	75.2	1.484
Methylene chloride	40	104	1.326
1,1-Dichloroethane (ethylidene chloride)	58	136.4	1.174
1,1,2,2-Tetrachloroethane (acetylene tetrachloride)	147	296.6	1.600
Trichloroethylene (TCE)	87	214	1.456
Carbon tetrachloride	77	170.6	1.597
Dichlorodifluoromethane (Freon-12)	-30	-22	1.486

Sources: The Merck Index, 1976
Sax, 1979

Table 4.1 reveals that trichlorofluoromethane has a boiling point of 24°C. This is within the normal range of temperatures to be expected in the desert soils. If relatively large quantities of liquids containing this organic compound were disposed or spilled in the North Base area, a zone within the soil column would be created where the vapor from the methane would displace the air present within the voids. This would create a concentration gradient producing diffusion. The diffusion would take place in accordance with Fick's law which states that the rate of diffusion of matter across a plane is proportional to the concentration gradient of the diffusing substance.

$$\frac{C}{t} = D\left[\frac{{}^2C}{x^2} + \frac{{}^2C}{y^2} + \frac{{}^2C}{z^2}\right]$$

where:

C = concentration (or partial pressure) of the diffusing substance
t = time
x,y,z = directional coordinate system
D = diffusivity

If vapor were occupying all the air in the soil void spaces, the resulting concentration would approximate 1,250 mg/kg. The concentration levels identified at the North Base (see Figures 4.1 through 4.5) suggest that the trichlorofluoromethane exists in the gaseous state and the partial pressure of the substance in the pores is on the order of 0.015 atmosphere (atm).

Chloroform is also very volatile; at the soil temperatures encountered at the North Base, the partial pressure of chloroform is approximately 0.3 atm. Based on concentrations identified, it appears that chloroform may have been disposed in relatively large quantities. The transport mechanism here is probably also molecular diffusion. Since chloroform has a high density, it could exist at higher concentrations near the groundwater interface.

Since the sampling program was not specifically developed to detect gases, the difference in detected concentration levels could be due to sampling methods, as some volatiles may escape during sample retrieval. Detected concentration levels have qualitative value only; no conclusions can be drawn concerning concentration gradients in groundwater from these data. The only firm conclusion is that the constituents are present at least at the levels detected.

In the past, many solvents were disposed to the pits on the North Base. The use of poor techniques while unloading barrels from trucks probably could have resulted in ground spills near the pit areas. In this case, solvents would very likely be detected near the surface. At Site 1B, 1,1,2,2-tetrachloroethane was found at a 3-foot depth. At Sites 1D1 and 1D2, methylene chloride and 1,1-dichloroethane were detected at depths of 5 feet; 1,1-dichloroethane was also identified at a 50-foot depth at Site 1D2. These compounds were not found at any other locations. The apparent conclusion is that either these substances were not disposed in quantity or they evaporated to the atmosphere before dispersing in the soil. The minimal concentrations detected suggest that no potential contamination problems exist for these materials. At Site 1D2, trichloroethylene was detected at 5 feet and 60 feet, while carbon tetrachloride and dichlorodifluoromethane were found at 60 feet. The reason for the appearance of these substances is unclear, but since these concentrations are low and their presence was so limited, these materials are not believed to constitute a potential problem.

Fuel oil was identified within the soil column at Site 1A in samples from depths of 8 and 15 feet. The sample taken from a depth of 55 feet did not show the presence of fuel. During drilling operations, however, the smell of oil was noticed in the soil to a depth of 35 feet. At Site 1B, the smell of oil was present in the soil at various depth intervals to a maximum depth of 46 feet. Possible sources of the fuel oil detected at Site 1A and the oil smell at Site 1B could be hydraulic fluids or lube oils disposed at these sites in the past. Since fuel oil was not detected at the bottom of the soil borings, the potential for future contamination problems is minimal.

Nitrates were identified throughout the entire soil column sampled at Site 1C. Nitrates may be present at greater depths. During disposal of the nitric acid, a large but unknown volume of liquid was poured into the pit; this liquid initially could have mobilized nitrates in a downward direction. Since there is no continuous supply of water for groundwater recharge, nitrates may migrate downward in "slugs"; some may have entered the groundwater causing higher than normal nitrate concentrations. Assuming an average level of 15,000 mg/kg of nitrates in the soil, each cubic foot of soil would contain 2 pounds of nitrates.

While sampling and drilling in the field at Site 1C, it was noted that acid-stained soil was present to the bottom of the soil boring. As a result, an additional monitoring well was completed downgradient (to the north) to ascertain the potential for groundwater nitrate contamination. The well was drilled to a total depth of 57 feet on 9 March 1982. Sands and gravel were encountered at a depth of 54 feet, while groundwater was present at 53 feet. One groundwater sample was obtained; during shipment to the laboratory, the sample container was broken, and the sample lost. When subsequently inspected in April, the well was dry. This indicates that the groundwater encountered initially may have been a perched water table. To avoid the possibility of drilling into seasonal water tables, a future field program should be planned for late summer or fall.

MAIN BASE AND SOUTH BASE

Site 2

Near Site 2, the Main Base toxic waste disposal site, soil samples were taken downslope from the site inside the fenced area at a distance of 85 feet north of the south fence. Figure 4.6 displays a generalized geologic log based on the soil boring. The surficial soil cover is less than 5 feet thick, consisting of fine sand. Underlying the thin soil, decomposed granitic bedrock was found to a depth of 21 feet, at which point hard bedrock was encountered. The results of the laboratory analyses of soil samples from various depths are indicated on Figure 4.6 for the compounds present in amounts above the detection limits.

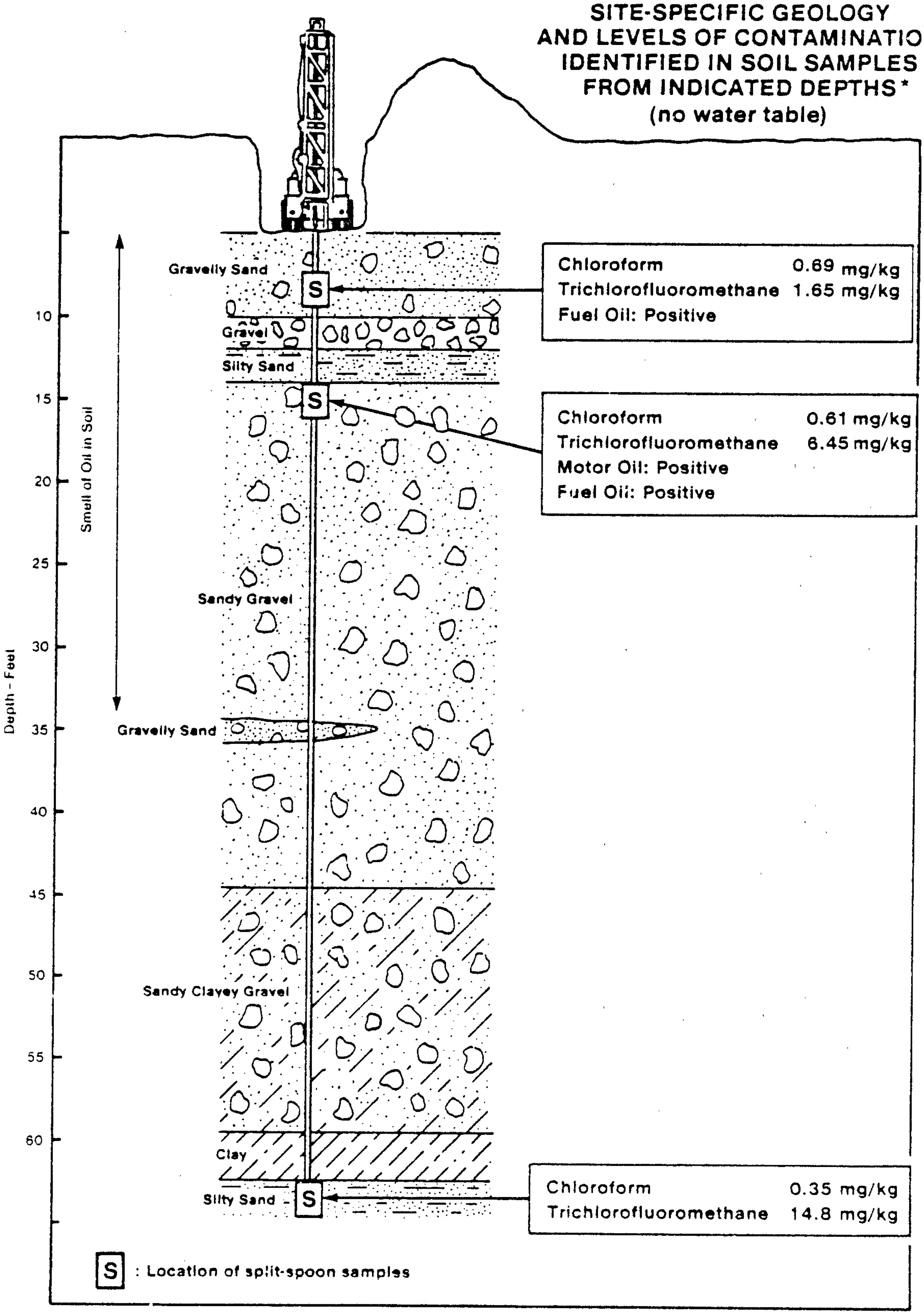
Chromium (total) and tetraethyllead were detected throughout the soil column; both of these materials have been identified as having been disposed at Site 2 (Envirodyne Engineers, Inc., 1981). Since the chromium was detected from the surface soil to the bedrock it is unlikely that the transporting medium would have been seasonal rainwater flowing at the bedrock surface within the decomposed granitic material. If chromium had been carried by the seasonal rainwater, concentrations within the topsoil would probably have been considerably less than those observed at depth. It is likely that chromium-containing water used by

FIGURE 4.1

SITE 1A (ES 1A)

SITE-SPECIFIC GEOLOGY AND LEVELS OF CONTAMINATION IDENTIFIED IN SOIL SAMPLES FROM INDICATED DEPTHS*

(no water table)



Chloroform	0.69 mg/kg
Trichlorofluoromethane	1.65 mg/kg
Fuel Oil: Positive	

Chloroform	0.61 mg/kg
Trichlorofluoromethane	6.45 mg/kg
Motor Oil: Positive	
Fuel Oil: Positive	

Chloroform	0.35 mg/kg
Trichlorofluoromethane	14.8 mg/kg

S : Location of split-spoon samples

* For discussion of analytical results, refer to page 4-5.

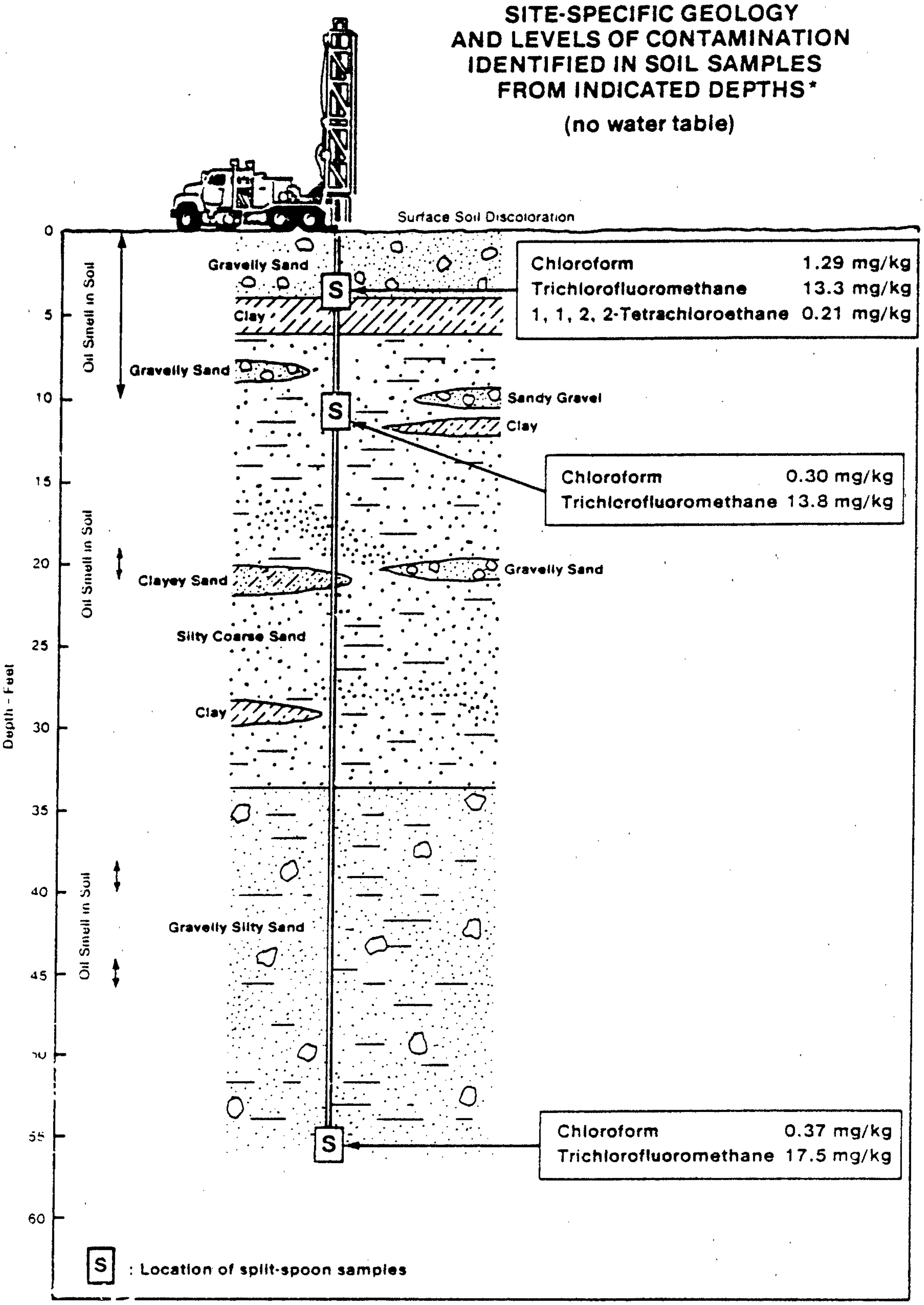
ENGINEERING-SCIENCE

FIGURE 4.2

SITE 1B (ES 1B)

SITE-SPECIFIC GEOLOGY AND LEVELS OF CONTAMINATION IDENTIFIED IN SOIL SAMPLES FROM INDICATED DEPTHS*

(no water table)



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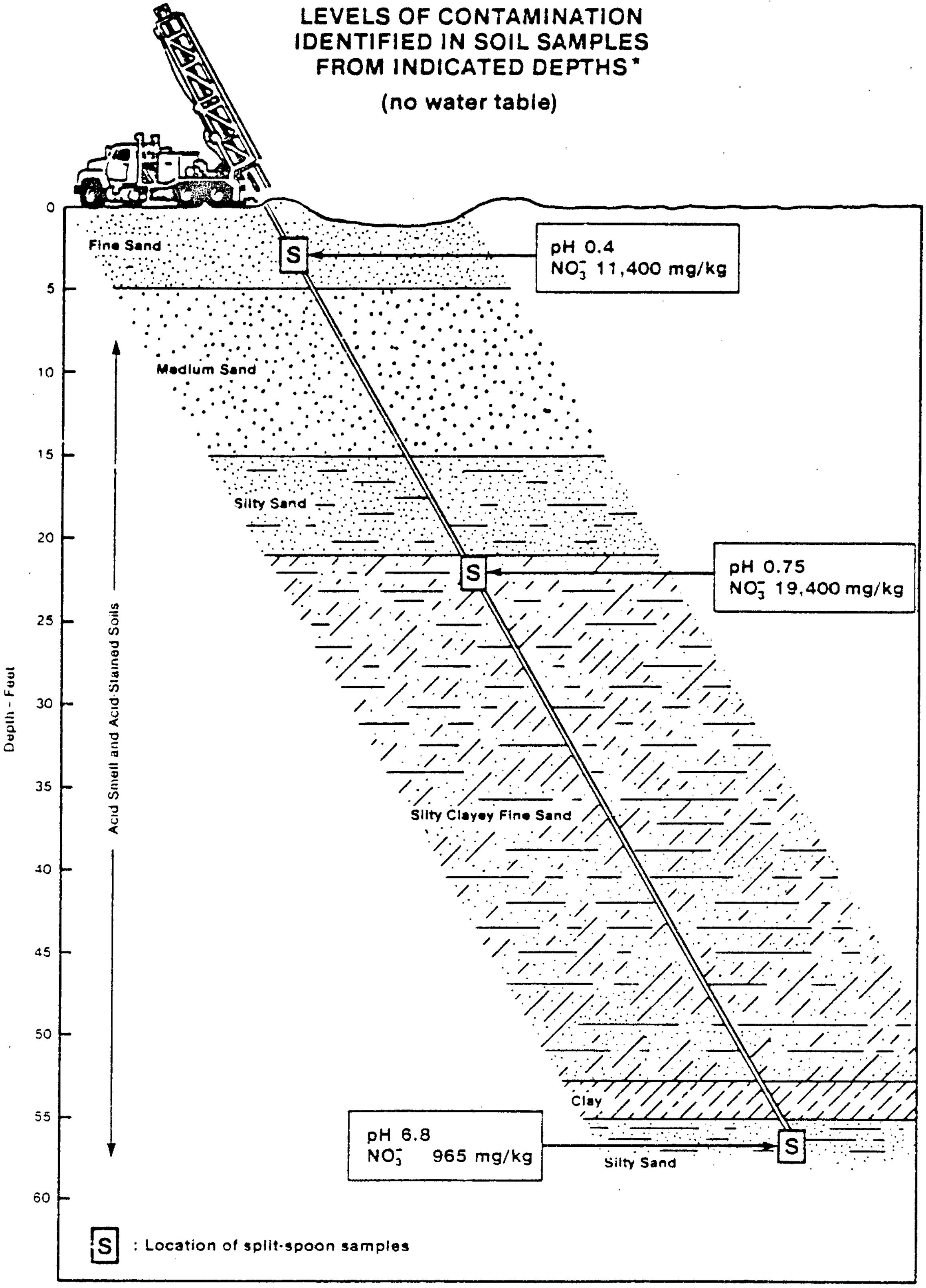
* For discussion of analytical results, refer to page 4-5.

FIGURE 4.3

SITE 1C (ES 1C)

SITE-SPECIFIC GEOLOGY AND LEVELS OF CONTAMINATION IDENTIFIED IN SOIL SAMPLES FROM INDICATED DEPTHS*

(no water table)



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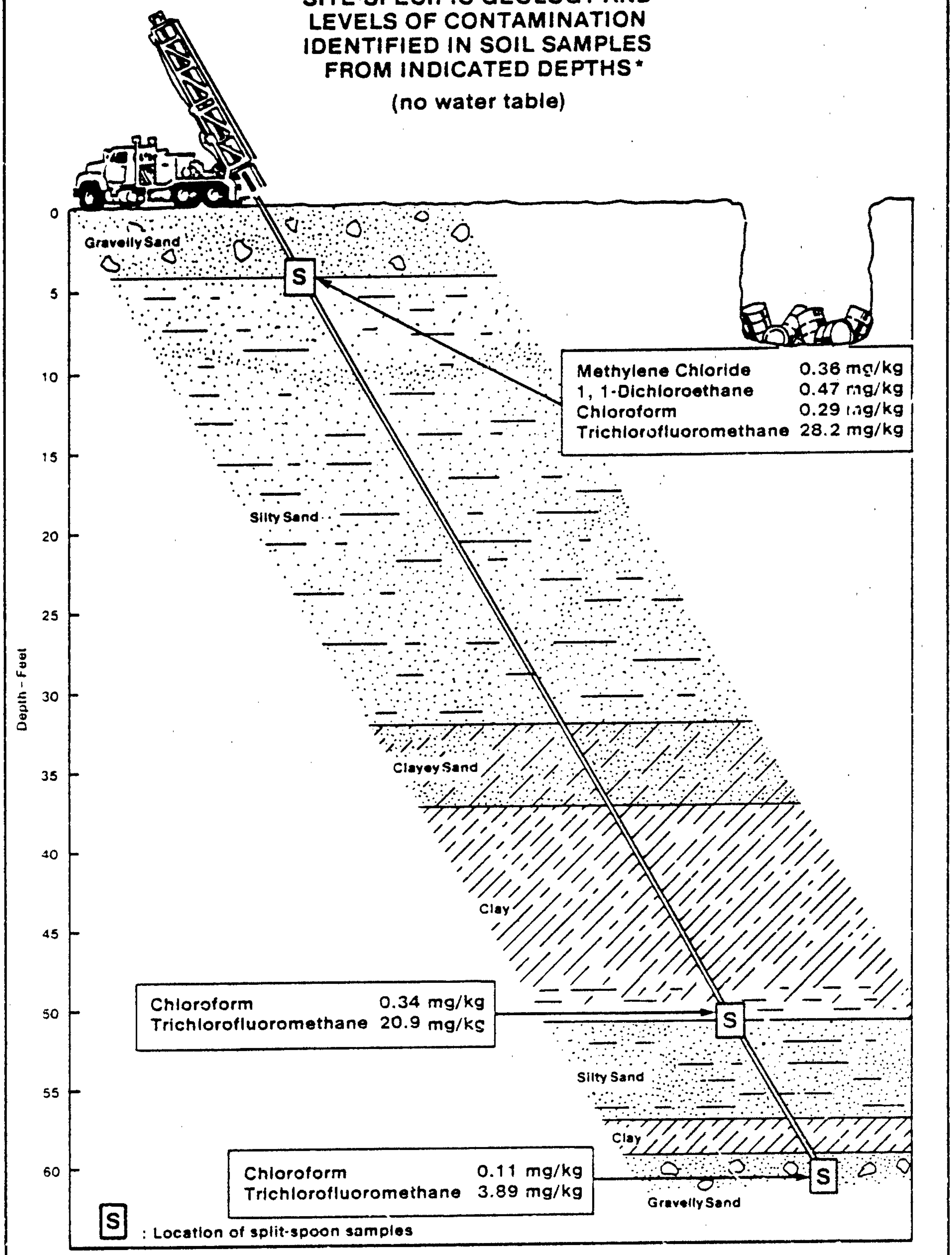
* For discussion of analytical results, refer to page 4-5.

FIGURE 4.4

SITE 1D1 (ES 1D1)

SITE-SPECIFIC GEOLOGY AND LEVELS OF CONTAMINATION IDENTIFIED IN SOIL SAMPLES FROM INDICATED DEPTHS*

(no water table)

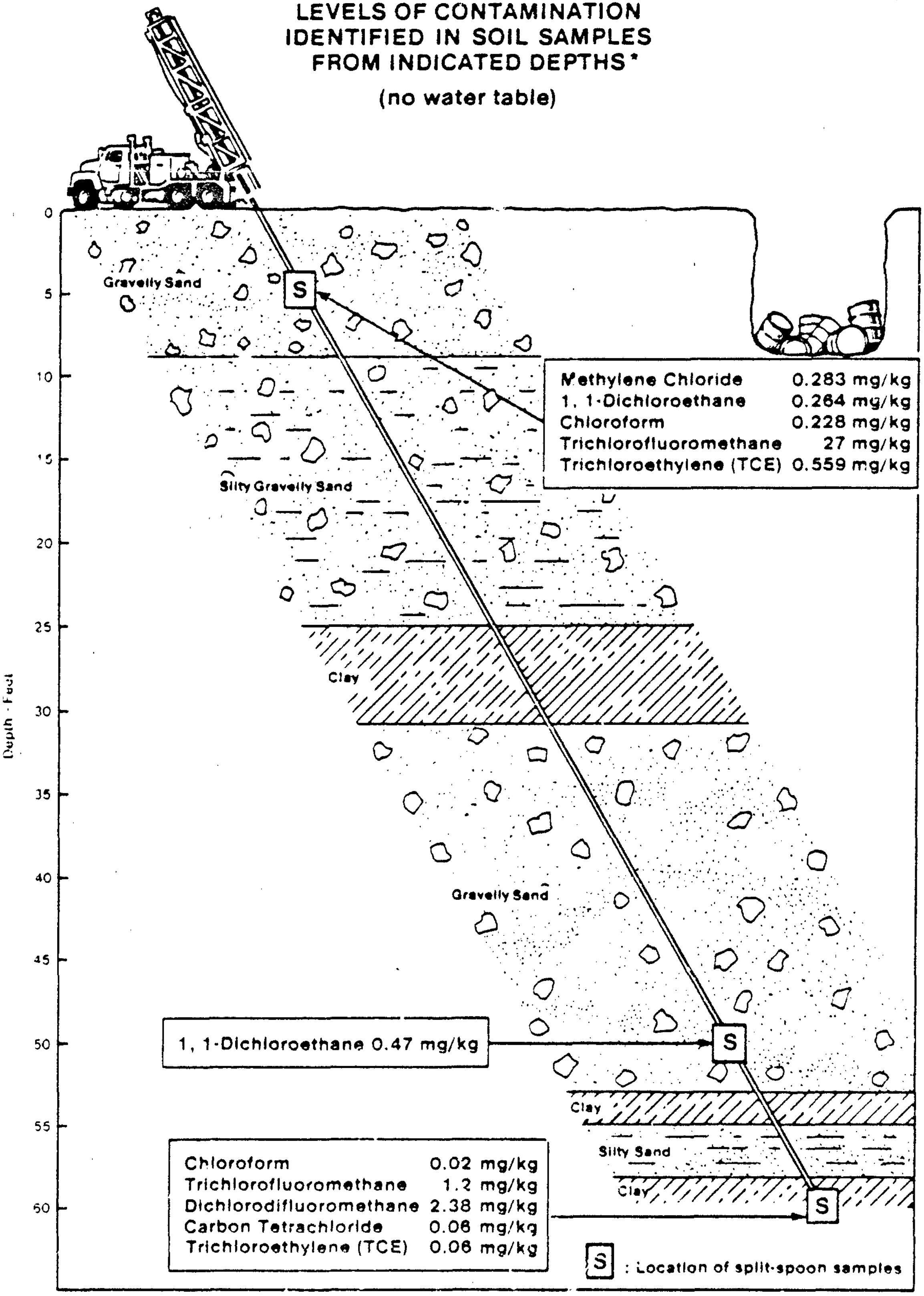


* For discussion of analytical results, refer to page 4-5.

SITE 1D2 (ES 1D2)

SITE-SPECIFIC GEOLOGY AND LEVELS OF CONTAMINATION IDENTIFIED IN SOIL SAMPLES FROM INDICATED DEPTHS*

(no water table)



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* For discussion of analytical results, refer to page 4-5

the Air Force was dumped directly on the ground either at the soil bor- location or immediately upslope. Assuming an average concentration of 80 mg/kg of chromium in the soil column, the original concentration of chromium-containing water may have been approximately 800 mg/l. The distance from the site to the groundwater aquifer system is less than two miles; for the chromium-water to move downgradient toward the aquifers along the bedrock surface, over one million liters of this material would be required. It is unlikely that such a large quantity of waste would have been disposed, and it is therefore unlikely that it would reach the groundwater. Tetraethyllead was probably carried downslope through the permeable topsoil and weathered granitic bedrock by liquid fuel which later evaporated. The areal extent of soil contamination has not been determined.

Site 3

Two surface soil grab samples were collected downslope from the abandoned sanitary landfill. The sample locations are shown on Figure 4.7. The analytical results of the samples for constituents above the detection limits are included on this figure.

There are no data available on the concentrations of chemical constituents and metals in the soil under non-contaminated conditions. However, even without these data, some of the analytical results from soil samples at Site 3 appear higher than would normally be expected. Table 4.2 lists the threshold limit concentrations of metals and organic compounds for determination of hazardous material; the table also lists toxicity data. The concentration levels in the soil samples are all lower than the threshold limits. The contaminants were most likely carried downslope by surface runoff.

Site 5

To detect potential groundwater contamination from the underground storage tanks at Site 5 (see Figure 1.1), three monitoring wells were installed south of the site and one monitoring well was installed north of Site 5. The location of the monitoring wells had been determined based on local topography, geology, available logs, and U.S.G.S. water level data. The monitoring wells were therefore located immediately

TABLE 4.2

COMPARISON OF WET WEIGHT CHEMICAL CONCENTRATIONS IN THE SOIL SAMPLES AT SITES 3A AND 3B WITH TOXICITY DATA FOR HAZARDOUS WASTE CLASSIFICATIONS

Substance	Concentration[a] (mg/kg) Site 3A	Concentration[a] (mg/kg) Site 3B	Total Threshold Limit Concentration[b] (mg/kg)	Oral Dose Producing Toxicity[c] (mg)	Fatal Dose by Ingestion[c] (mg)
Antimony	12.09	18.75	1,000	100	100-200
Arsenic	< 0.03[d]	0.68	50	5-50	120
Cadmium	1.14	0.75	10	3	
Chlordane	0.02	< 0.01[d]	3		
Chromium (total)	50.82	46.29	300	200	5,000
Coppe	7.91	8.33	150	50-250	10,000
DDT, DDE, DDD (TDE)	0.03	< 0.01[d]	1		
Heptachlor epoxide	< 0.01[d]	< 0.01[d]	3		
Lead	19.23	26.67	50		500
Lindane	< 0.01[d]	< 0.01[d]	4		
Mercury	0.31	< 0.21[d]	2		20-1,000
Nickel	11.27	11.40	200		
Selenium	0.74	0.60	10	5	
Silver	1.56	0.46	50	60	2,000
2, 4 - D	< 0.01[d]	< 0.01[d]	100		
2, 4, 5 - T	< 0.01[d]	< 0.01[d]	10		
Zinc	47.80	44.58	200		10,000

a Wet weight chemical concentrations in the soil samples at Sites 3A and 3B were converted from the analytical dry weight concentrations based on moisture contents of 9 percent and 4 percent respectively.

b Concentrations exceeding Total Threshold Limit Concentrations would qualify soils as hazardous. See Table III, "California Assessment Manual for Hazardous Wastes," prepared by California Department of Health Services Hazardous Materials Management Section, August 1979.

c Based on Table 151, "Health Effects Associated With Wastewater Treatment and Disposal Systems, State-of-the-Art Review, Volume I," EPA-600/1-79-016a, April 1979.

d Below detection limit

south of Site 5 and the old well 9N/9W-6E1. The groundwater samples from wells ES6, ES7, ES8, and ES9 were analyzed for the presence of fuels and oils; the analyses indicated no contaminants present in any of the samples. Figures 4.8 and 4.9 depict the site-specific subsurface conditions at each well location as well as analytical results. In addition to sampling the newly installed monitoring wells, 9N/9W-6E1 was sampled. This well showed fuel contamination; the thickness of hydrocarbons on the water was estimated to be 1 to 2 inches during field sampling.

Following development of all the monitoring wells, water level measurements were taken and each well site was surveyed by the Base for determination of ground level elevation. Using these data, groundwater table contours were developed for the shallow groundwater table at the Main Base and South Base (Figure 4.10). When comparing regional groundwater elevation contours from Figure 2.3 with the shallow groundwater table on Figure 4.10, significant differences are noticeable. The shallow groundwater table is present at elevations ranging from 2,239 feet to 2,250 feet above mean sea level (msl), whereas the water table in Figure 2.3 shows an elevation of 2,225 feet above msl. In the vicinity of Site 5, the shallow groundwater table exhibits a steep gradient to the east, whereas the regional flow in Figure 2.3 is to the south-southeast toward the groundwater trough south of the South Base. Therefore, if leakage from underground tanks at Site 5 reached the shallow groundwater table, migration would most likely be eastward toward Rogers Dry Lake. This could explain the analytical results obtained for the groundwater samples south of Site 5. Monitoring well ES6 was installed to identify potential migration of fuel from 9N/9W-6E1. However, based on the newly developed shallow groundwater table contours, migration would occur toward the southeast rather than to the south. If fuel were migrating downgradient from 9N/9W-6E1 it would migrate southeasterly according to the local shallow groundwater gradient and thus would not be expected to be present in ES6.

Site 8

The analytic results of the water and sediment samples collected from the industrial waste pond have been presented on a schematic fence diagram in Figure 4.11. Potential migration of identified constituents into the underlying soil column and groundwater has not been determined, but the analytical results show that metals are present in higher concentrations in the sediments than in the water. Metals are probably contained within the sediments as insoluble sulfides. They would not be likely to migrate into the ground, but rather would remain within the fine sediments which naturally form at the bottom. Bottom sediments are probably less permeable than the natural soils.

Examination of the shallow groundwater table contours on Figure 4.10 shows a groundwater gradient that indicates a possible mound under Site 8. This could mean that some seepage from the pond into the groundwater has taken place.

Site 10

No groundwater was encountered during drilling, so no monitoring wells were installed downgradient from the jet fuel pipeline break. The site-specific subsurface conditions for soil borings ES2 and ES3 are shown on Figure 4.12. This figure indicates the depth to decomposed bedrock and the depths at which jet fuel was identified in the field. As can be seen, jet fuel was present within the decomposed granitic material from 12 to 21 feet at ES2 and from 8 to 9 feet at ES3. It appears that ES2 is located within a depression containing a thicker cover of decomposed bedrock than exists at ES3. The fuel spill may have been contained within this depression rather than migrating downslope. Field capacity indicates the amount of liquid held by capillary forces within the soil. If it is assumed that a maximum of 200,000 gallons of fuel spilled to the ground, that the field capacity of the soil is 10 percent by volume for oil, and that the average thickness of decomposed granite is 5 feet, the fuel spill could cover an area of 200 square feet. If the fuel were immobile, it would slowly vaporize within the soil and evaporate into the atmosphere.

Site 11

At the Main Base, two monitoring wells were installed downgradient from the fuel hydrant spill. Both ES4 and ES10 are located in the downgradient direction of the shallow groundwater table (see Figure 4.10).

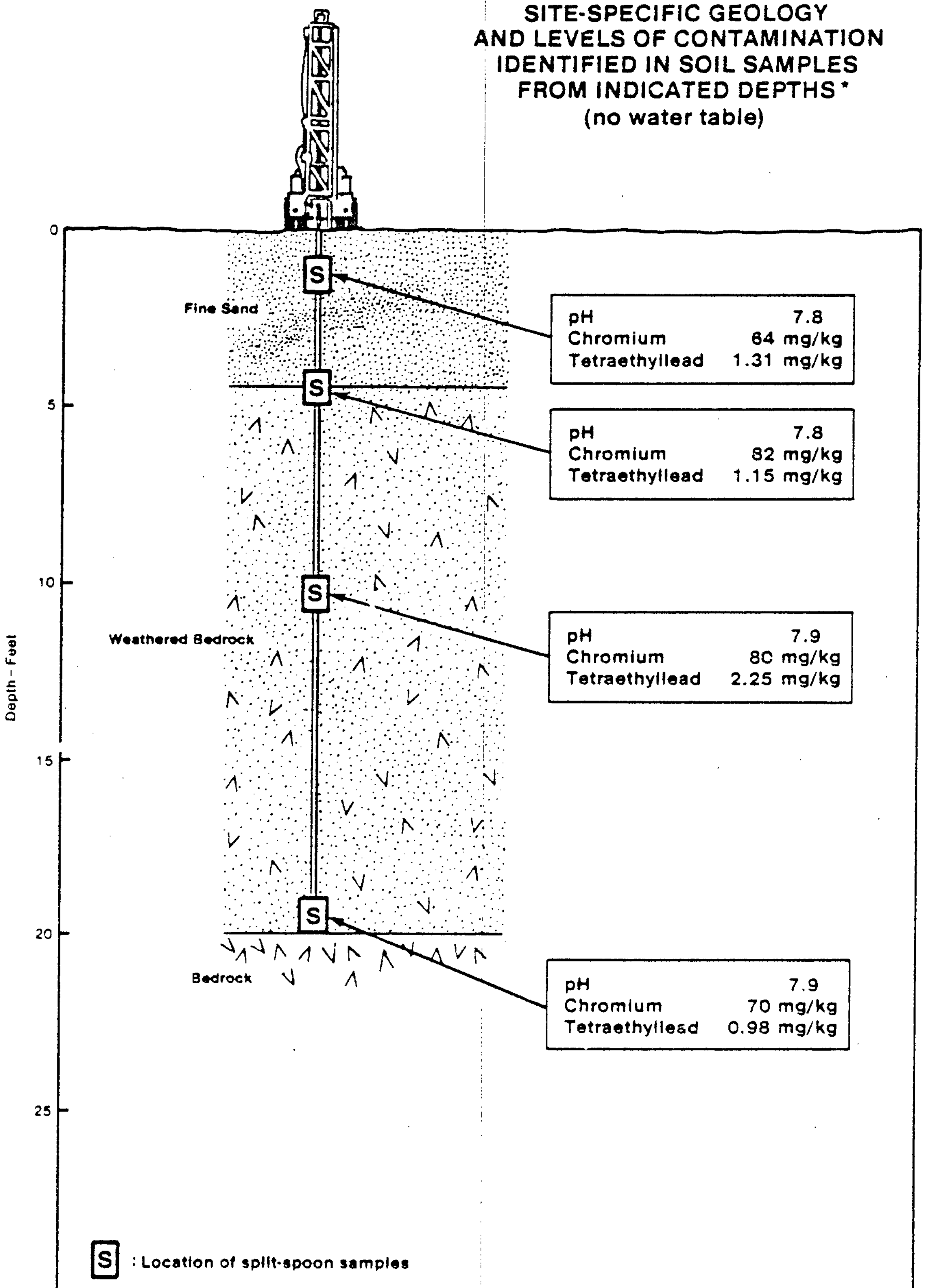
Fuel was identified in the groundwater sample from ES4 (see Figure 4.13); no fuel was identified in ES10. During sampling of ES4, no fuel was visible in the glass vial, yet laboratory analysis showed the presence of hydrocarbons. It is possible that the fuel spilled at the fuel hydrant migrated downward in a liquid phase. During migration, however, the liquid fuel would be preceeded by vapor entering the intergranular void spaces. Thus, the fuel identified in the groundwater sample from ES4 could have been vapor from an advancing liquid fuel plume. If 5,000 gallons of fuel were migrating toward groundwater located at a 40-foot depth through soil with a 10 percent field capacity for liquid hydrocarbons, an area of 40 square feet could be contaminated. Vapors from fuel could have greater lateral and vertical extents. Analyses were performed for trace metals but the concentration levels were found to be below threshold limits and thus probably do not pose a significant problem.

FIGURE 4.6

SITE 2 (ES-1)

SITE-SPECIFIC GEOLOGY AND LEVELS OF CONTAMINATION IDENTIFIED IN SOIL SAMPLES FROM INDICATED DEPTHS *

(no water table)



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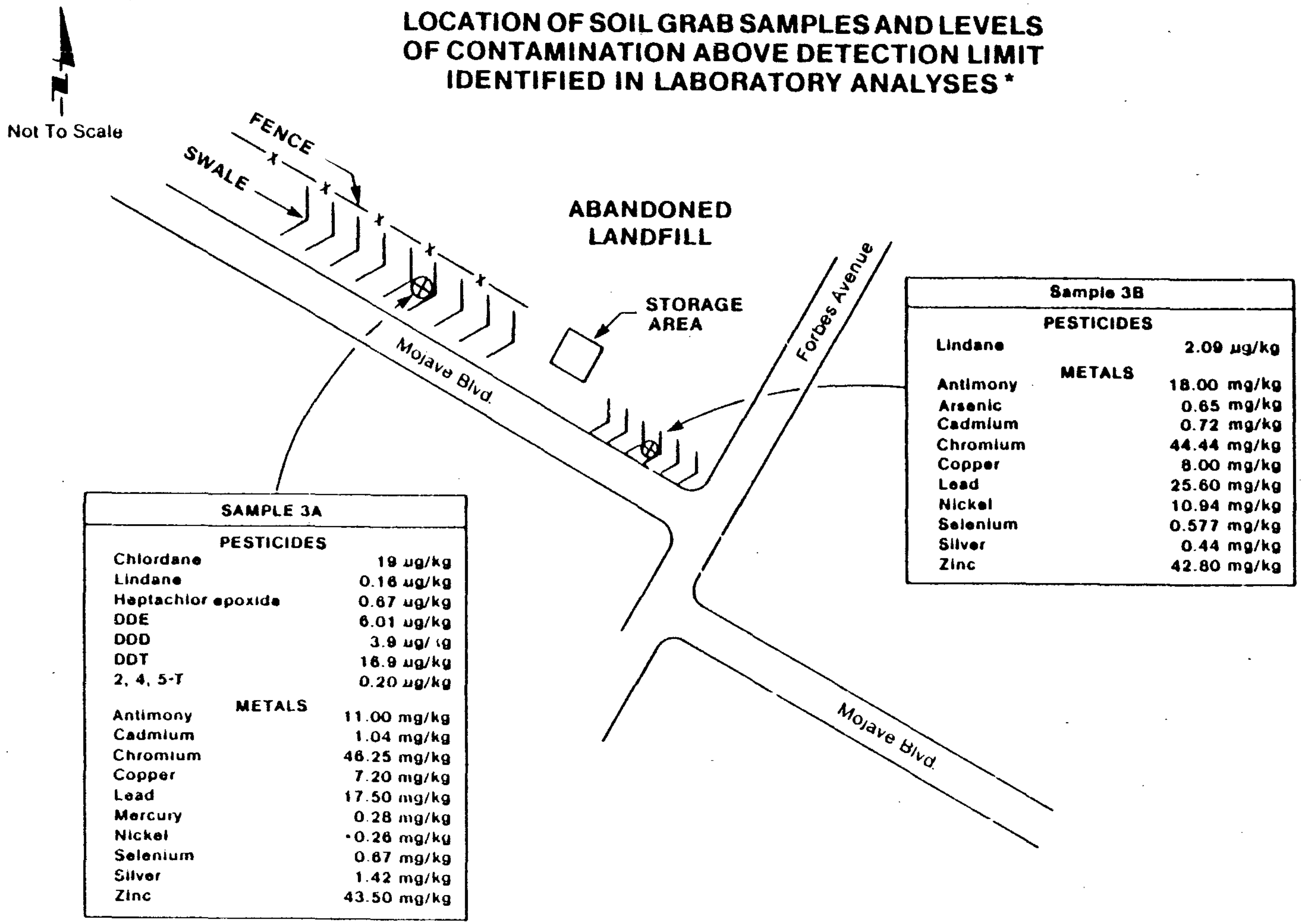
* For discussion of analytical results, refer to page 4-6.

SITE 3

LOCATION OF SOIL GRAB SAMPLES AND LEVELS OF CONTAMINATION ABOVE DETECTION LIMIT IDENTIFIED IN LABORATORY ANALYSES *



SAMPLE 3A	
PESTICIDES	
Chlordane	19 µg/kg
Lindane	0.16 µg/kg
Heptachlor epoxide	0.67 µg/kg
DDE	6.01 µg/kg
DDD	3.9 µg/kg
DDT	16.9 µg/kg
2, 4, 5-T	0.20 µg/kg
METALS	
Antimony	11.00 mg/kg
Cadmium	1.04 mg/kg
Chromium	46.25 mg/kg
Copper	7.20 mg/kg
Lead	17.50 mg/kg
Mercury	0.28 mg/kg
Nickel	0.26 mg/kg
Selenium	0.67 mg/kg
Silver	1.42 mg/kg
Zinc	43.50 mg/kg

Sample 3B	
PESTICIDES	
Lindane	2.09 µg/kg
METALS	
Antimony	18.00 mg/kg
Arsenic	0.65 mg/kg
Cadmium	0.72 mg/kg
Chromium	44.44 mg/kg
Copper	8.00 mg/kg
Lead	25.60 mg/kg
Nickel	10.94 mg/kg
Selenium	0.577 mg/kg
Silver	0.44 mg/kg
Zinc	42.80 mg/kg

* For discussion of analytical results refer to page 4-12

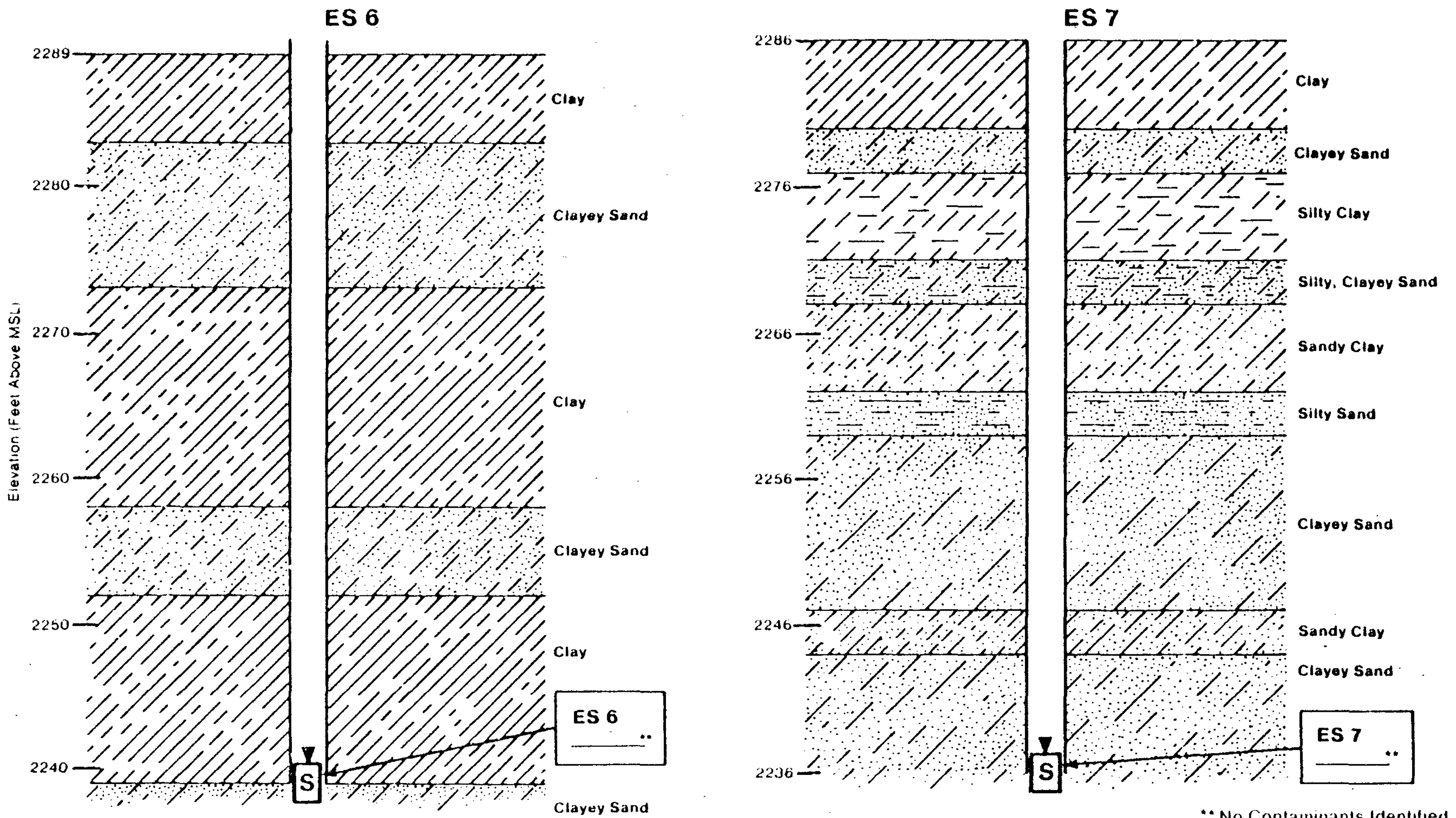
FIGURE 4.8

SITE 5

SITE-SPECIFIC GEOLOGY AND LABORATORY RESULTS OF IDENTIFIED CONTAMINANTS IN SAMPLED GROUNDWATER*

▼ Water Level 8 March 1982

S Groundwater Sample



* For discussion of analytical results, refer to page 4-14

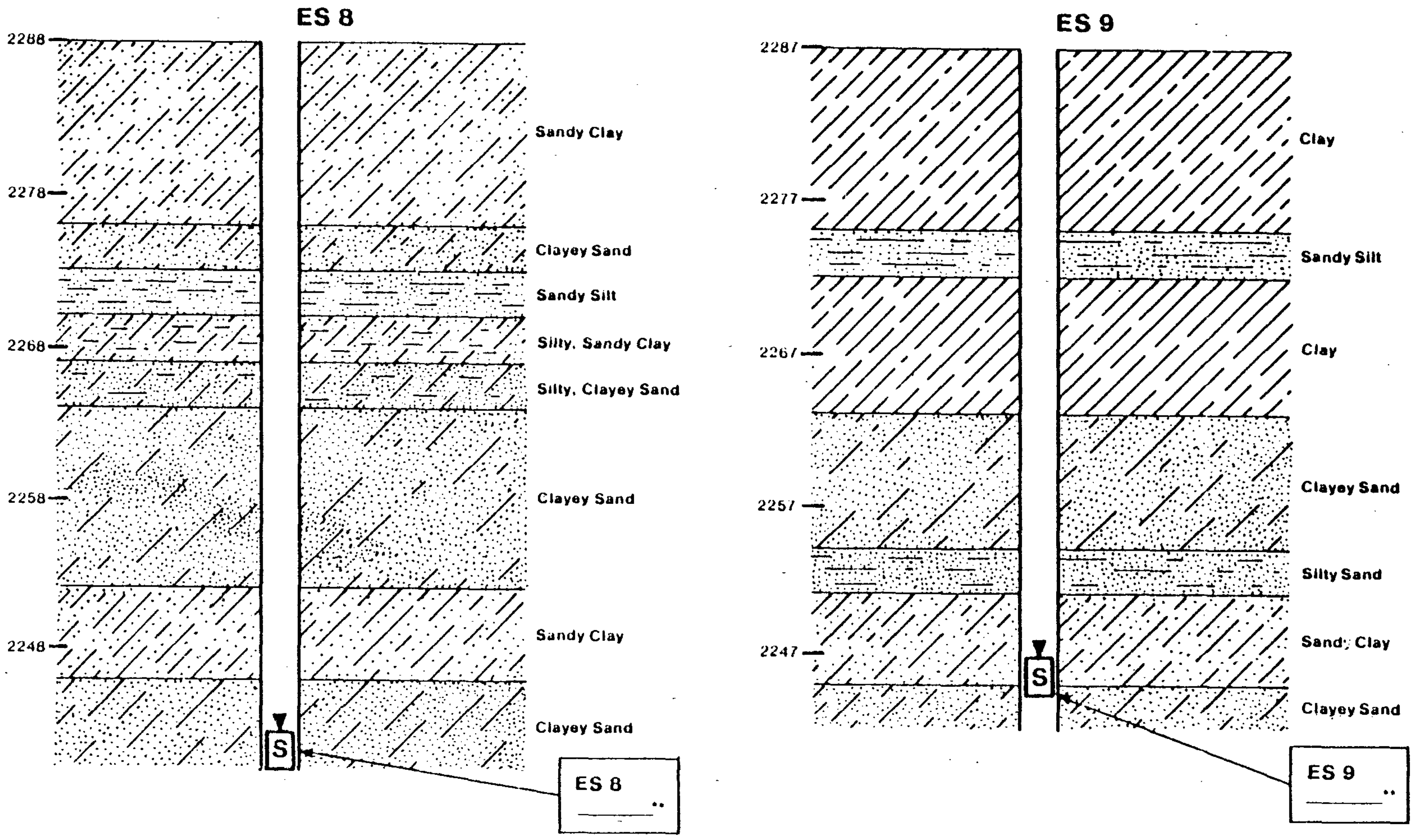
** No Contaminants Identified

SITE 5

SITE-SPECIFIC GEOLOGY AND LABORATORY RESULTS OF IDENTIFIED CONTAMINANTS IN SAMPLED GROUNDWATER*

▼ Water Level 8 March 1982

S Groundwater Sample



* For discussion of analytical results refer to page 4-14

**No Contaminants Identified

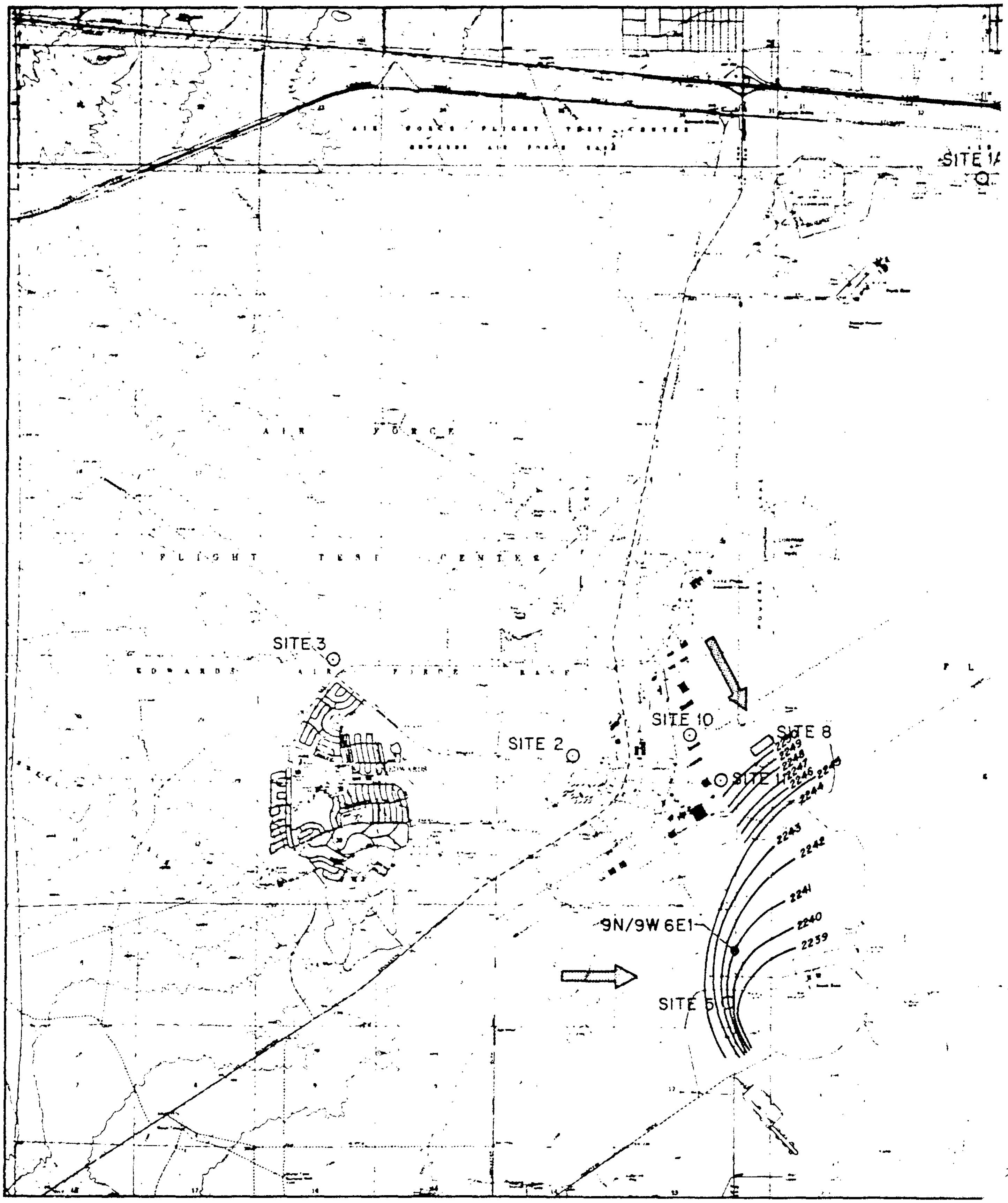
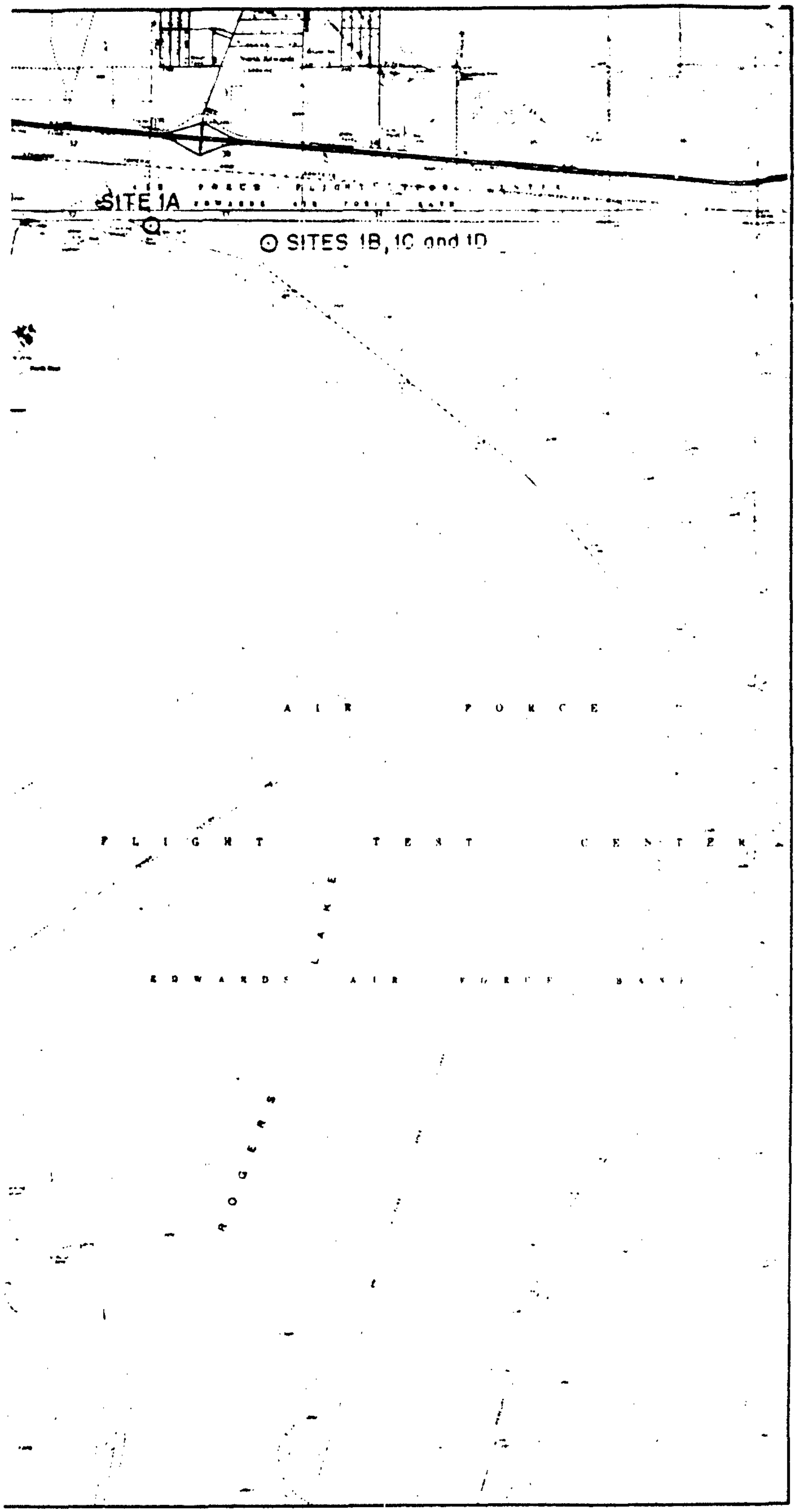

AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE
SITE 1
AIR FORCE
FLIGHT TEST CENTER
SITE 3
EDWARDS AIR FORCE BASE
SITE 10
SITE 2
SITE 8
SITE 11
2249
2248
2247
2246
2245
2244
2243
2242
2241
2240
2239
9N/9W 6E1
SITE 5

FIGURE 4.10



EDWARDS AFB

INSTALLATION RESTORATION PROGRAM PHASE II FIELD EVALUATION

LEGEND

Groundwater Flow Direction

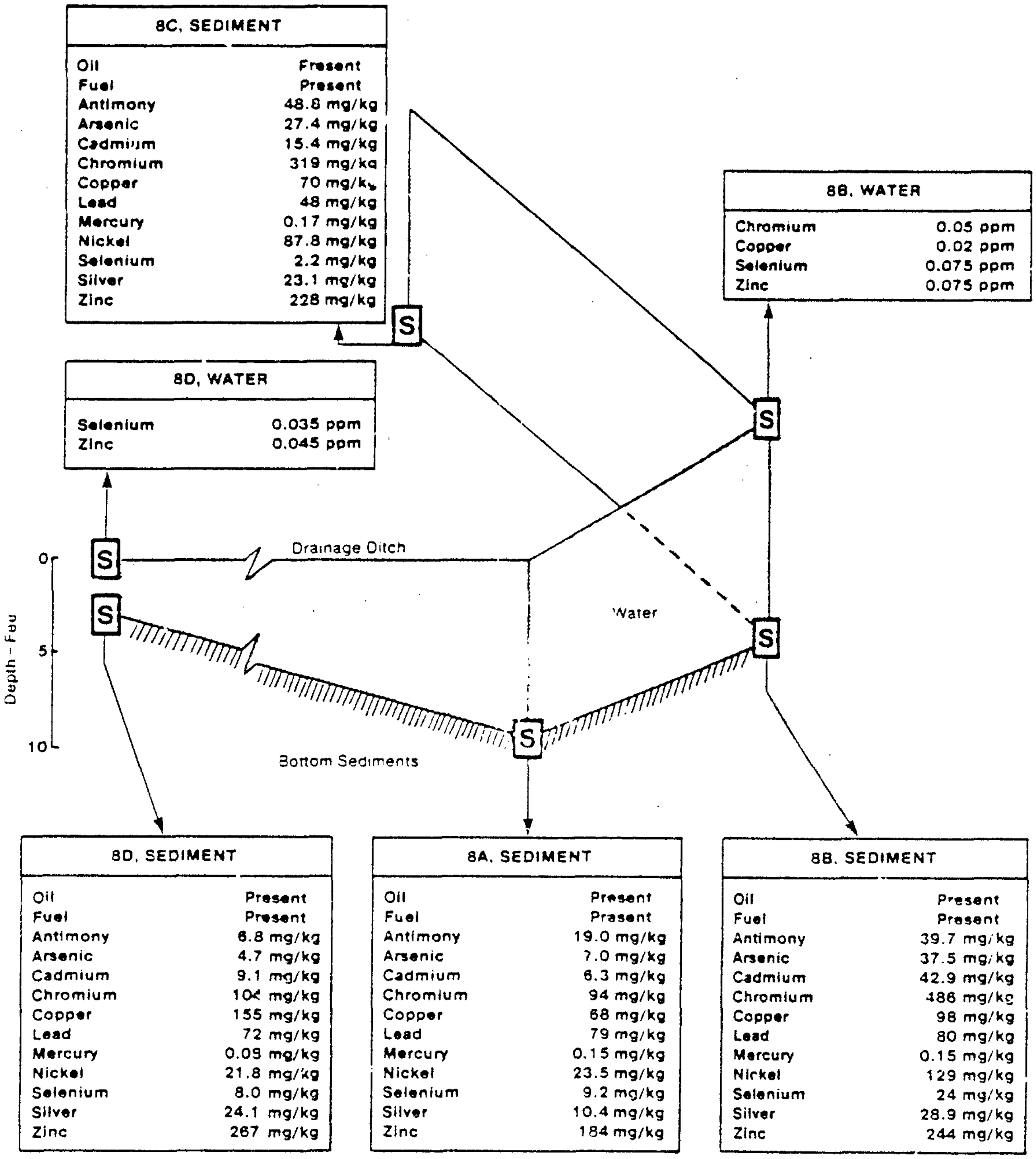
—2250— Groundwater Table Elevation (Mean Sea Level)

1/2 0 1
MILE

GROUNDWATER TABLE CONTOURS FOR THE SHALLOW GROUNDWATER TABLE AT MAIN BASE AND SOUTH BASE (8 MARCH 1982)

FIGURE 4.11

SCHEMATIC FENCE DIAGRAM OF SAMPLING LOCATIONS AT SITE 8, INCLUDING LEVELS OF CONTAMINATION ABOVE DETECTION LIMIT IDENTIFIED IN SEDIMENT AND WATER SAMPLES*



8C, SEDIMENT	
Oil	Present
Fuel	Present
Antimony	48.8 mg/kg
Arsenic	27.4 mg/kg
Cadmium	15.4 mg/kg
Chromium	319 mg/kg
Copper	70 mg/kg
Lead	48 mg/kg
Mercury	0.17 mg/kg
Nickel	87.8 mg/kg
Selenium	2.2 mg/kg
Silver	23.1 mg/kg
Zinc	228 mg/kg

8B, WATER	
Chromium	0.05 ppm
Copper	0.02 ppm
Selenium	0.075 ppm
Zinc	0.075 ppm

8D, WATER	
Selenium	0.035 ppm
Zinc	0.045 ppm

8D, SEDIMENT	
Oil	Present
Fuel	Present
Antimony	6.8 mg/kg
Arsenic	4.7 mg/kg
Cadmium	9.1 mg/kg
Chromium	104 mg/kg
Copper	155 mg/kg
Lead	72 mg/kg
Mercury	0.09 mg/kg
Nickel	21.8 mg/kg
Selenium	8.0 mg/kg
Silver	24.1 mg/kg
Zinc	267 mg/kg

8A, SEDIMENT	
Oil	Present
Fuel	Present
Antimony	19.0 mg/kg
Arsenic	7.0 mg/kg
Cadmium	6.3 mg/kg
Chromium	94 mg/kg
Copper	68 mg/kg
Lead	79 mg/kg
Mercury	0.15 mg/kg
Nickel	23.5 mg/kg
Selenium	9.2 mg/kg
Silver	10.4 mg/kg
Zinc	184 mg/kg

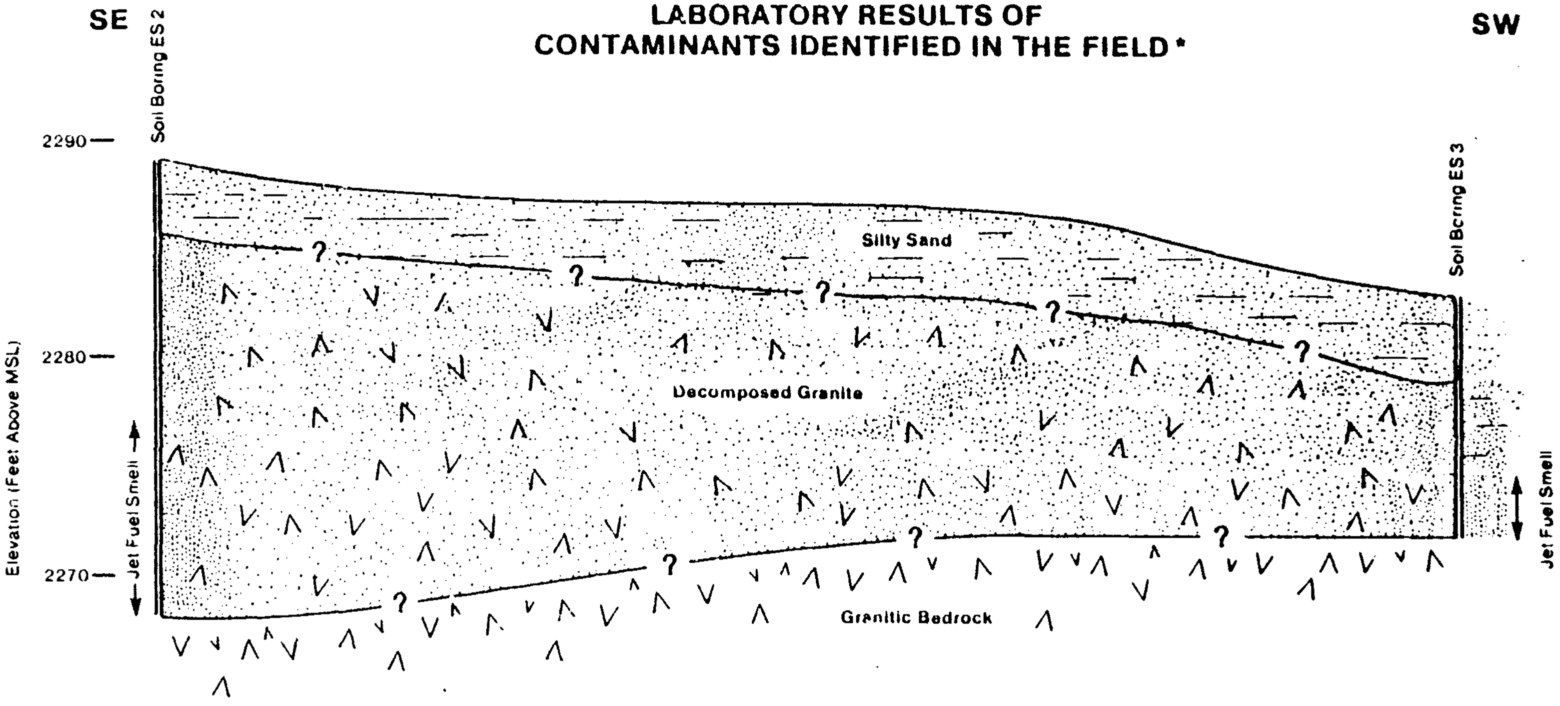
8B, SEDIMENT	
Oil	Present
Fuel	Present
Antimony	39.7 mg/kg
Arsenic	37.5 mg/kg
Cadmium	42.9 mg/kg
Chromium	486 mg/kg
Copper	98 mg/kg
Lead	80 mg/kg
Mercury	0.15 mg/kg
Nickel	129 mg/kg
Selenium	24 mg/kg
Silver	28.9 mg/kg
Zinc	244 mg/kg

Scale
Horizontal: None
Vertical: 1" = 5'

* For discussion of analytical results, refer to page 4-15.

SITE 10

SITE-SPECIFIC GEOLOGY AND LABORATORY RESULTS OF CONTAMINANTS IDENTIFIED IN THE FIELD*



Scale
Horizontal: 1¼"=100'
Vertical: 1¼"=10'

* For discussion of analytical results, refer to page 4-15.

FIGURE 4.12

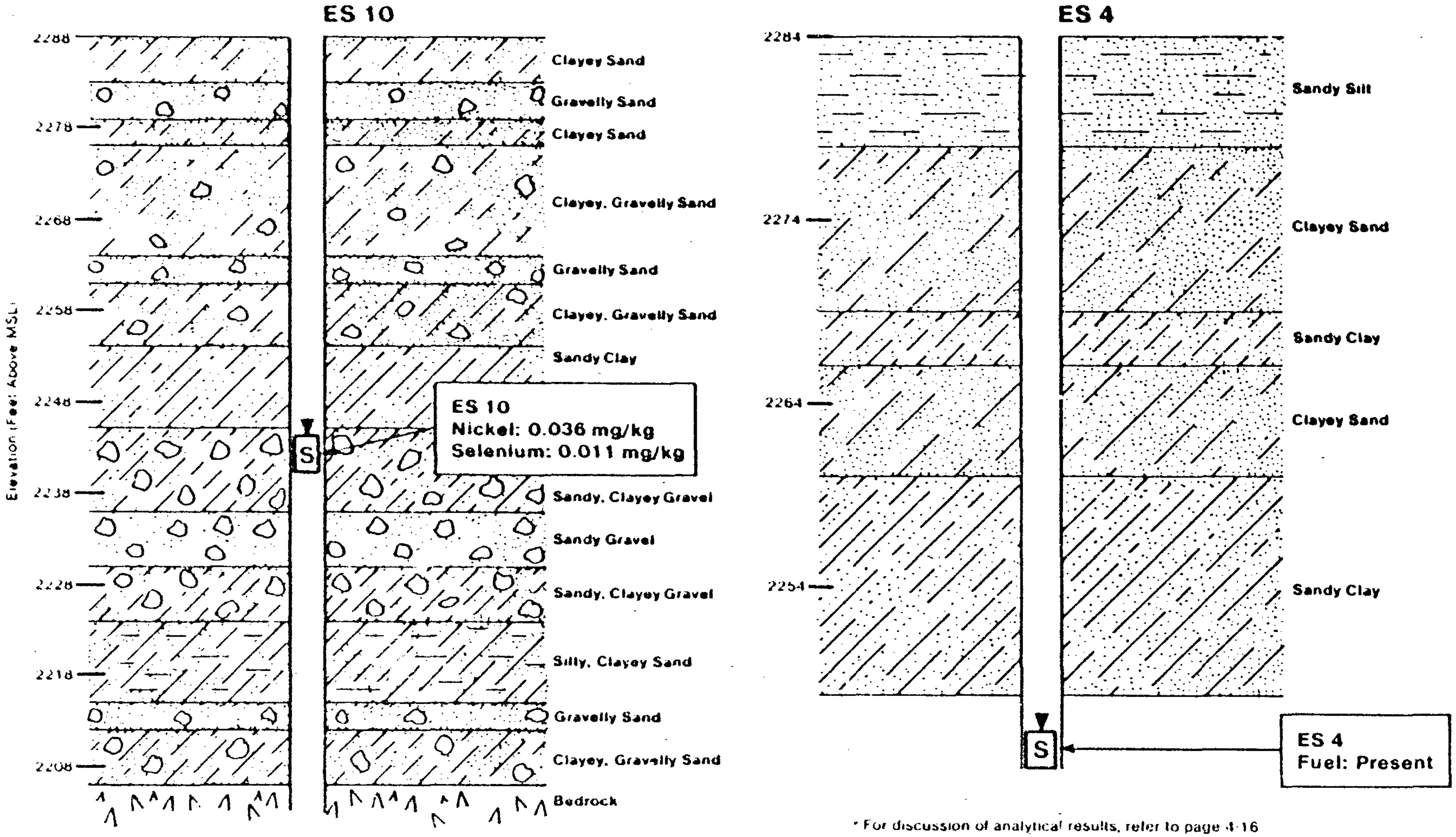
FIGURE 4.13

SITE 11

SITE-SPECIFIC GEOLOGY AND LABORATORY RESULTS OF IDENTIFIED CONTAMINANTS IN SAMPLED GROUNDWATER *

▼ Water Level 8 March 1982

S Groundwater Sample



ES 10
Nickel: 0.036 mg/kg
Selenium: 0.011 mg/kg

ES 4
Fuel: Present

* For discussion of analytical results, refer to page 4-16

CHAPTER 5

ALTERNATIVE MEASURES

CHAPTER 5

ALTERNATIVE MEASURES

In general, environmental concerns identified during the field program at Edwards AFB consist of soil contamination, shallow groundwater contamination, and the potential for future contamination. A discussion of potentially applicable measures to address these concerns, including the perceived advantages and disadvantages, is presented in this chapter. Specific applications at each of the sites and subsites on the Base are then discussed.

OVERVIEW OF ALTERNATIVES

Excavation

The most direct approach to solving the problem of soil contamination is to excavate the affected materials. The excavated materials must be then either hauled to a secure site for disposal or treated to render them nonhazardous before returning them to the excavated site.

When the quantities of hazardous materials are small, removal and transport to a secure site can be the optimal solution. However, as the quantity of materials increases, the costs of excavation, transportation, and disposal render such options clearly infeasible.

Leaching of Contaminated Soils

Contaminated soils may be cleansed *in situ* by permitting water to percolate through and carry the contaminants to the groundwater below. At the same time, wells could be installed to pump this percolating water to the ground surface where it could be treated to remove the contaminants before it is repercolated for reuse in further cleansing the soils. This mitigation measure has the inherent disadvantage of providing a direct means of groundwater contamination even though part of the system includes water removal and cleanup. The percolation and pumping operations are widely known although this technique has had very little similar application in the United States.

Waters pumped out of the ground could be treated using available technologies for the removal of organics.

Where waters are contaminated with high concentrations of nitrates, the only developed technique for their removal is biological denitrification using an organic substrate. In this process, nitrates are converted to nitrogen gas and the substrate is consumed. There has been considerable experience with this method in municipal wastewater treatment. However, this application is quite specialized and pilot denitrification tests using leachate from the pits would be advisable before proceeding with full-scale operations should such an option be elected.

Leaching with water has the advantages of being a monitorable system. When the leachate is no longer contaminated the site can be considered cleansed and the operation halted.

Air Sweeping of Contaminated Soils

It may be possible to remove vapors in soil by air sweeping. Air sweeping as discussed here is an entirely new process. As far as is known it has never been discussed or utilized prior to this report. Therefore, no prior experience exists on which to base designs.

In general, the idea is to drill wells down to a level just short of the groundwater. These wells would be cased and perforated only at the bottom. At the ground surface blowers would be attached to force the flow of air either into or out of the well perforations. The blower would produce a pressure difference and air would flow through the soil carrying the entrapped vapors with it. The well system could be designed using potential flow mapping to determine the areal effectiveness of any given well and the required spacing and flow of the total well system.

The system could be designed to operate under positive pressure where the vapors would be forced out of the soil to be dispersed and lost to the atmosphere. Should it be determined that the escaping material had unacceptable air quality impacts, then the system could be designed as a suction system forcing air into the ground and exhausting it through the well into an activated carbon system for cleansing prior to discharge back to the atmosphere.

Since the system is a new concept considerable pilot testing would be advisable before going to full-scale operation. However, if accepted by various state agencies, this potentially could be a relatively inexpensive and simple way to resolve many of the problems at the North Base.

Immobilization of Contaminants

Various techniques can be used to prevent migration of the contaminants. Where contaminants can be mobilized by water, one method is to construct a barrier over the entire site using very impermeable soils. Other types of impermeable barriers could also be used. This would prevent water ponding and surface percolation. As long as no underground flow passed into the contaminated soils the contaminants would remain immobilized and should not present an environmental problem. If this alternative is implemented, it is essential that good records be kept so no future construction could ever remove the mound and/or introduce percolating waters.

Where underground flow through the site is possible, it may be desirable to construct slurry walls or gel barriers to divert the flow. In some cases it may be possible to immobilize contaminants using a combination of slurry walls, gel encasements, and surface control. The potential effectiveness and cost of immobilization should be carefully evaluated to determine the best future course of action at this site. If the hazards and costs of excavation are great this may be the only other viable option.

Oil and Fuel Removal

At those sites where oil or fuel is found floating on the groundwater the only viable cleanup method is to remove these materials. This is accomplished by a double pumping system.

In this system a casing is placed into the groundwater with perforations in the casing extending from above the groundwater to a point well below the groundwater surface. A submersible pump is placed in the bottom of the well which draws surrounding groundwater into the well through the perforations below the groundwater surface, while the oil or fuel remains floating on top of the water outside the well. This pumping lowers the groundwater level as water drawn into the well is pumped to the ground surface to be percolated or reinjected later at a distant point. A second small skimming pump is floated on the water surface in the well. This pump skims oil and fuel off the lowered surface of the groundwater as it flows into the well. Oil or fuel collected in this manner is pumped into aboveground tanks. Under certain circumstances, recovery and reuse of these materials are feasible.

There is experience with this system and contractors are available who will provide this service.

Natural Diffusion

Where soils are contaminated with organic vapors, the problem will eventually be solved by natural diffusion processes. When proper engineering analysis and monitoring are provided, this may represent a viable alternative solution. The vapors will ultimately be carried to the soil surface where they will be released to the atmosphere. However, these natural processes may require a great deal of time, and as long as the vapors remain in the soil they represent a potential source of groundwater contamination.

In order to estimate the time required for these processes, more geological contamination data must be collected and computer simulation of the diffusional process must be conducted. These three-dimensional simulations are very large and require a great deal of computer time to achieve reliable results.

SITE-SPECIFIC ALTERNATIVES

North Base

To reduce potential for future contamination, it would appear advisable for the Air Force to commence removal and disposal of all known buried waste containers on the North Base as soon as possible. Contractors are available who specialize in this type of work.

Prior to initiating cleanup of identified soil contamination, the existing North Base wells should be sampled and analyzed for nitrates, chloroform, and trichlorofluoromethane. In addition, private off-base wells located downgradient should be sampled if possible to ascertain the extent of potential nitrate and organics contamination.

Sites 1A, 1B, 1D1, and 1D2

The primary contaminants identified in the soil at these sites are chloroform and trichlorofluoromethane (Freon-11). Although these constituents have not been found in the groundwater, they are soluble in water to 7,840 mg per liter and 1,100 mg per liter, respectively. Migration of volatile solvents in the gaseous phase into the groundwater is a concern, but the potential environmental and health hazards associated with the identified levels of soil contamination do not appear to be significant. If contaminants have entered the groundwater they would migrate downgradient. Sampling of nearby downgradient wells for chloroform and Freon-11 would establish whether contamination had migrated to those locations, and thus establish preliminary contamination boundaries.

The lateral extent of contamination from organic compounds in the gaseous state can be estimated by the use of a mathematical model. The upper circumference of contamination could be identified in the field by completing a number of shallow soil borings about 10 feet deep radiating from the disposal site. The drilling program should be carried out in conjunction with a field monitoring program. By using a portable chromatograph, each hole can be sampled in the field for volatile organics; the presence or absence of volatiles would determine the extent of the required program.

In order to establish the nature of contamination an exploratory well should be drilled to the groundwater north of the sites. The purpose of this well would be to sample the soils immediately above the water table. To identify the soil/water interface, in-place soil samples should be taken at 1-foot intervals beginning 85 feet below the surface. The sample taken at the soil/water interface should be analyzed to ascertain whether chloroform or Freon-11 is present. Samplers should consist of closed containers (e.g., Shelby tubes) to minimize escape of contaminants during sampling. The following options for remedial actions are available:

- Alternative 1: In situ removal by leaching

  In situ removal of contaminants could be accomplished by establishing a constant water supply for percolation into the ground. Installation of a well would bring the percolating water and contaminants to the surface for treatment. The contaminants could possibly be removed by activated carbon treatment. Following treatment the water would be returned to the percolation pond.

- Alternative 2: Pressure air sweeping

  The organic compounds present in the soil could possibly be removed by blowing compressed air through the soil column, bringing the contaminants to the surface by advective mass transfer.

- Alternative 3: Vacuum air sweeping

  An alternative to injecting pressurized air into the ground would be the installation of wells with perforated casings that would be evacuated to create suction; the low pressure within the well would cause migration of air and volatilized organics within the soil into the well. By drawing the contaminants out of the soil profile at defined points, random release of organics to the atmosphere would be prevented. Periodic monitoring of the air from each well would provide information on the removal effectiveness.

- Alternative 4: Immobilization of contaminants

  Even though the organic compounds present within the soil column are most likely in the gaseous state and migrating by molecular diffusion, percolating water could cause downward transport of contaminants which could potentially enter the groundwater. An impermeable cover consisting of playa deposits would effectively prevent water from entering the contaminated soil column. This option would be particularly feasible if the nitric acid pits at Site 1C were to be overlain by an impermeable cover. If the sites were covered, effective future land use restrictions should be implemented to prevent excavation and construction in these areas.

- Alternative 5: Monitoring

  This option would mean that the contamination identified at the sites would remain in place. However, since the migration probably occurs by molecular diffusion, it is likely that, given enough time, the vaporized organics would escape to the atmosphere, and also potentially enter the groundwater. If no remedial action is taken, monitoring at existing wells in the vicinity would be of utmost importance. If the organics enter the water supply system, remedial actions would be required by either closing a well, treating the water, or preventing further migration of the organics.

Site 1C

At Site 1C, high nitrate levels were identified in the soil column. The nitrates may or may not be immobilized within the soils. In the event that nitrates have entered the groundwater, remedial actions would be limited since existing technology does not provide for nitrate removal from water. However, several options are available to mitigate the adverse effects of nitrate migration.

- Alternative 1: Excavation of contaminated soil

  The first option entails excavation of the entire contaminated soil column. There are four nitric acid disposal areas at the North Base, with a total surface area of 20,000 square feet. The soil boring ES1C revealed nitrate contamination within the soil to the maximum drilled depth of 55 feet, and it is probable that contamination would be present at greater depths, possibly extending to the groundwater (approximately 100 feet). If contaminated soil were assumed to be present to a depth of 100 feet under each nitric acid pit, a minimum of about two million cubic feet of soil would need to be removed. The soil then would have to be hauled to a permitted hazardous waste disposal site, and the excavated area then would be restored as necessary.

- Alternative 2: In situ removal by leaching

  In situ removal of contaminants could be accomplished by leaching them out of the soil with water. The system would consist of a surface percolation pond that would provide a continuous source of water for downward movement; a well or wells would be installed to pump the contaminated water back to the surface. The water would then be subjected to treatment to remove the nitrates. Removal could be accomplished biologically.

- Alternative 3: Immobilization of contaminants

  Nitrates are easily mobilized by percolating water. Immobilization of nitrates could be accomplished by preventing any water from percolating into the nitrate-contaminated soils. The construction of a mound composed of fine-grained material with very low permeability (e.g., playa deposits) would inhibit water percolation. The cover would be placed as a mound draining away from the site. Implementation of this mitigatory action would necessitate effective land use restrictions to ensure that no future excavation or construction takes place in the area.

- Alternative 4: Monitoring

  The major mobilization of the nitrates probably occurred at the time of disposal when large amounts of liquid were poured into the pits. Recharge to the groundwater from rainfall is probably minimal; therefore the existing nitrate contamination may not be very mobile. One option would therefore be no remedial action at the present time. If no action were taken, existing wells downgradient from the site, both on and off base, should be sampled on a semiannual basis for nitrates. Measures to assure no future construction or disposal of water at this site will be necessary as a minimum.

Main Base and South Base

Site 2

The soil samples collected downslope from the site indicated contamination from chromium and tetraethyllead. The areal extent of contamination is unknown, but it could extend further downslope. To eliminate the possibility of future contamination by leaking containers either on the surface or buried, all waste containers should be removed. While no evidence exists that waste containers have been buried at this site, metal detectors or ground-penetrating radar should be used to confirm the absence of buried containers. If buried containers do exist, they should be removed and transported to a permitted hazardous waste disposal site.

The levels of soil contamination identified do not appear to be excessive or to pose significant environmental hazards or public health risks. The major concern regarding this site is the potential for contaminant migration toward the aquifer system along the shores of Rogers Dry Lake.

Two lysimeters should be installed immediately downgradient from the site near the bedrock/soil interface to assess the potential for subsurface flow. If a seasonal water table exists, the lysimeters should be used to withdraw samples which should be analyzed for suspected contamination. If a seasonal water table is identified and contaminants are detected, a monitoring well could be installed in the aquifer closest to the site, less than 2 miles away. This would allow for early detection of contamination prior to infiltration of the water supply.

The possible options for remedial actions are described below.

° Alternative 1: Excavation of contaminated soil

Removal of contaminated soil in the burial area could require excavation of large quantities of material. Based on the assumption that the entire 20 feet of topsoil and weathered bedrock were to be removed, 300,000 cubic feet would be involved. Removing the soil from Site 2 may not eliminate all contaminated soil, but would remove the source for potential future contaminant migration. Since it is unknown exactly what has been disposed at the site, contaminants may continue to migrate.

- Alternative 2: Immobilization of contaminants

  If the soils were not excavated and removed, immobilization of the contaminants remaining at the site could be accomplished by installation of well points through which gels would be injected forming an impermeable barrier around the entire site to the depth of the bedrock. In conjunction with creating an impermeable subsurface barrier, an impermeable surface cover would be necessary to prevent site runoff from carrying contaminants downslope. The impermeable material surrounding the site would entomb the contaminants present within the soils. If this option were implemented effective land use restrictions would be needed to ensure no future construction or excavation activities could take place in this area.

- Alternative 3: Monitoring

  Assuming that the contaminants identified in the soils have not reached the groundwater near the dry lake shore, it is probable that contaminants migrating by seasonal runoff within the soil have been deposited in the soil profile downslope from the site and will not reach the groundwater. In that case, the impacts of no remedial action at Site 2 would be potential increases in soil contamination downslope. If no remedial action were taken, land use restrictions should be applied to the area of potential soil contamination downslope and groundwater monitoring should be implemented.

Site 3

The abandoned sanitary landfill covers an area of about 150 acres (Envirodyne Engineers, Inc., 1981). Neither the depth of the landfill nor the depth to bedrock is known. Migration of contaminants contained in the disposed material could occur either by surface runoff or by leaching vertically down to the bedrock where a seasonal water table would transport contaminants downslope.

Although metals and organic constituents were detected in the surface soil grab samples collected downslope from the site, the concentration levels identified were all lower than the threshold limit concentrations used by the State of California for determination of hazardous materials.

On the basis of the local geology and the levels of contamination found downslope from the landfill, Site 3 does not appear to pose immediate environmental and health hazards. The only concern would be the potential for seasonal groundwater movement carrying leachates toward the aquifer system along the shores of Rogers Dry Lake.

Excavation of the entire sanitary landfill is clearly infeasible. Should exploration reveal remedial actions are necessary the following options are possible.

- Alternative 1: Surface runoff containment

  Prior to implementation of this alternative, the areal and vertical extent of the disposal area should be identified and the depth to bedrock should be ascertained. Control of surface runoff then could be achieved either by covering the landfill with an impermeable material (e.g., clays), or by constructing drainage ditches upslope and downslope to intercept and retain the runoff from the site. Along Mojave Boulevard downslope from the landfill, swales currently intercept surface runoff. One of the grab samples (3A) collected during the field program was from this area; laboratory results indicated higher levels of contamination in this sample than in 3B, collected from the edge of the swale further downslope.

- Alternative 2: Construction of groundwater barrier

  Construction of an upslope groundwater barrier would prevent seasonal groundwater from flowing under the landfill and thereby potentially carrying leached contaminants downslope. The areal and vertical extent of the landfill should be identified and the depth to bedrock should be determined. The dimensions of the barrier would depend on the depth to bedrock and the lateral extent of the landfill. The barrier could be constructed either by a slurry trench or gel injection through well points.

- Alternative 3: Monitoring

  To investigate the presence of a seasonal water table, a lysimeter could be installed downgradient from the site. If seasonal groundwater flow exists, a sample could be obtained and analyzed for metals and organic constituents. If contaminants are identified, a downgradient monitoring well could be installed to monitor potential migration of contaminants into the groundwater.

Site 5

The potential for fuel contamination of the Base water supply (deeper aquifer) from past tank leakage is probably remote. The shallow groundwater gradient near Site 5 is toward the east. The shallow groundwater table appears to be unconfined, whereas deeper aquifers are confined. Since fuel is immiscible with water and floats on top of water, it could not migrate downward into the deeper confined aquifers.

To minimize any potential shallow groundwater contamination from Site 5, the following recommendations are made.

- Locate abandoned wells 9N/9W-18C1 (MB-7) and 9N/9W-6L1 (MB-1), situated downgradient of Site 5. If the wells can be located, if the top cover can be removed, and if the wells have not been grouted (abandoned), a water sample should be taken if possible and analyzed for fuels and oils. After the wells are sampled, or if the wells are not in a condition to be sampled, they should be grouted for proper abandonment. This is particularly important for well 9N/9W-18C1 since it is 360 feet deep and gravel-packed the entire length. If contaminants have migrated downgradient from Site 5, the gravel pack around this well constitutes an ideal conduit through which contaminants may travel to the aquifer used for the Base water supply. Well 9N/9W-6L1 is 147 feet deep with perforations from 33 feet to 130 feet (see Figure 3.5 for location). This well would also provide a conduit for migrating contaminants.

- Three monitoring wells should be installed east of Site 5. The first well should be immediately adjacent to the site, the second should be approximately 50 feet east of the Site 5 boundary, and the third should be located about 500 feet from the site boundary. For the well closest to the site, soil samples should be retrieved at 20-foot depth intervals for laboratory analysis for fuel and oils. A water sample from the shallow aquifer should be retained.
- If no fuel is detected in the soil or groundwater, the new wells should be monitored on a semiannual basis. If the soil or groundwater in newly installed monitoring wells contains fuel, additional wells should be installed in phases to delineate the areal extent of contamination. A rapid laboratory turnaround time would be desirable for analyses of groundwater samples so that determination of well location and installation of additional monitoring wells can be accomplished in the field on the basis of laboratory results. This would minimize lengthy delays in implementation of mitigatory measures and would reduce drilling costs.
- The remaining underground storage tanks should be monitored regularly to detect potential leakage.
- The source of fuel within the old well 9N/9W-6E1 has not been identified. However, the odor of fuel was noted in the water from 1978 to the present time by U.S.G.S., which conducts yearly water level measurements in selected wells on the Base. For the years 1974 to 1981 these measurements were obtained by the same person (Downing, 1981); the logs show that jet fuel was smelled in the well water from 1978 to 1981. A water sample was obtained from the well by the Air Force in March 1982 and analyzed for fuel; the analysis was positive. The source of the fuel is assumed to be upgradient from the well unless the fuel is present due to random vandalism. Prior to initiating a monitoring program, well 6E1 should be redeveloped and sampled. If fuel is identified in the sample from well 6E1, one monitoring well should be installed immediately upgradient (northwest) of the

Base well, with two additional wells downgradient at 50 feet and 500 feet southeast of the well. If these wells should show hydrocarbon contamination in considerable amounts, additional monitoring wells may be necessary to identify the extent of the plume.

Figure 5.1 summarizes the options available to mitigate potential adverse environmental impacts resulting from fuel contamination. These alternatives are discussed below.

- Alternative 1: Fuel recovery

  This alternative involves the installation of a filter-scavenger system in a 26-inch well. A floating separator collection unit allows hydrocarbons to enter through a filter for transport to the surface. A submersible pump creates a cone of depression that allows hydrocarbons and groundwater to flow into the well, while a probe adjusts the water level in the well to the appropriate level for fuel recovery. The water discharged from the well would need to be disposed or reinjected into the ground. To evaluate the effectiveness of contaminant removal the monitoring wells installed downgradient should be sampled on a monthly basis until recovery is complete, after which annual monitoring would be recommended.

- Alternative 2: No remedial action

  Depending on the severity of potential groundwater contamination, hydrocarbons may not pose an environmental hazard. If this is the case, the fuel may be left in place to migrate further downgradient, and eventually vaporize and evaporate into the atmosphere. If no remedial actions are implemented the wells installed downgradient from the site should be monitored semiannually.

Site 8

Laboratory analyses of the industrial waste pond water and sediment samples indicate high concentrations of metals within the bottom sediments. Organic solvents may be present originating from aircraft cleaning operations. Since the shallow groundwater table contours shown on

FIGURE 5.1

ALTERNATIVE ACTIONS AND MONITORING AT SITE 5

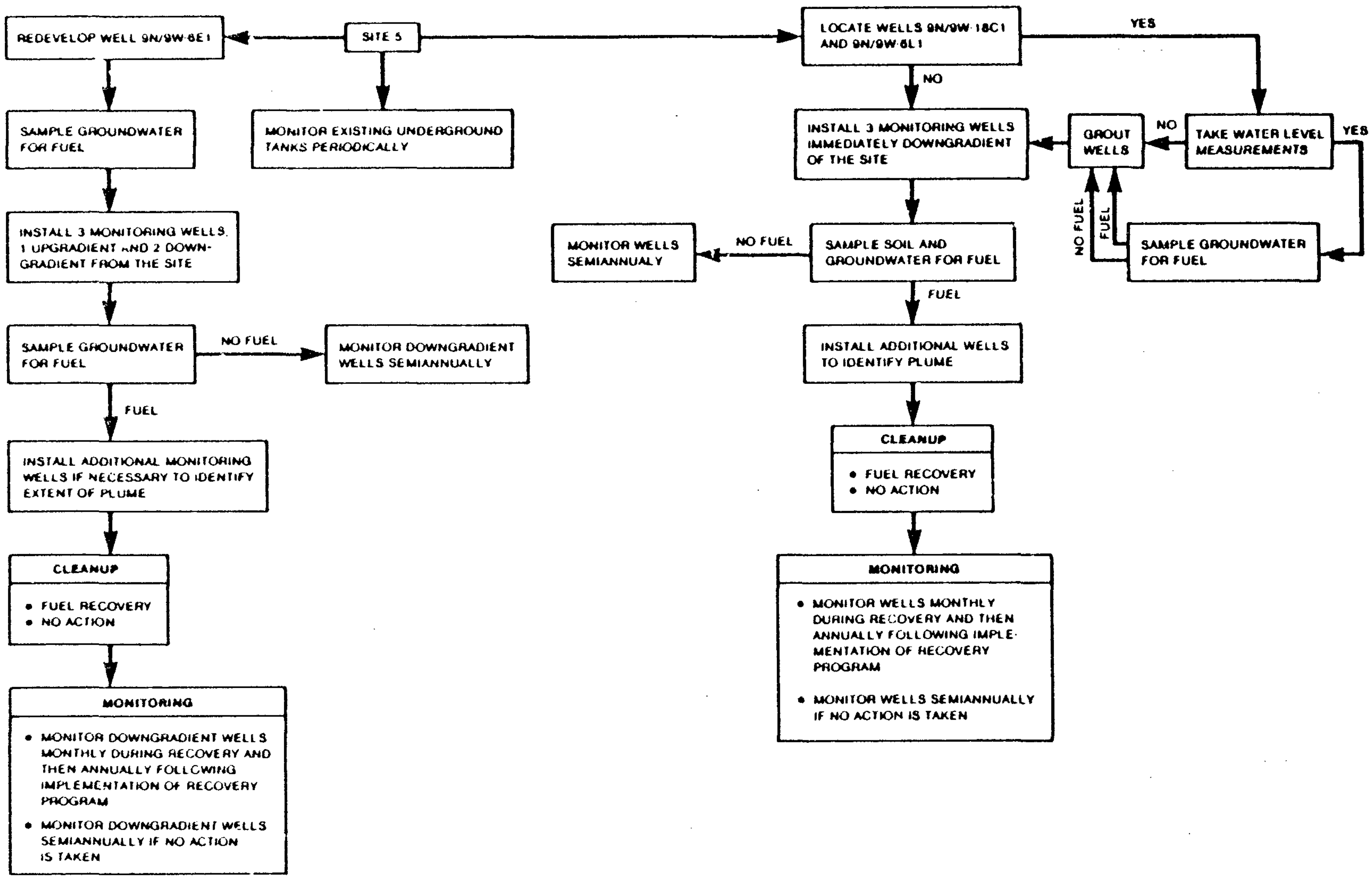


Figure 4.10 indicate an increase in gradient adjacent to the pond, seepage from the pond may have occurred. Considering the physical characteristics of the playa deposits underlying Site 8, however, the potential for groundwater contamination from pond seepage appears low. The bottom sediments within the sand itself are probably quite impermeable providing an effective barrier for contaminant migration. There is no information on groundwater quality near the site.

To determine potential groundwater contamination, a monitoring well should be installed immediately downgradient of the pond in the shallow groundwater, and a water sample retrieved and analyzed for metals and organic solvents. An undisturbed soil sample should be obtained for permeability testing.

Should the results of the groundwater monitoring analyses show contamination, several options are available. These options are discussed below.

- Alternative 1: Treatment of pond water

  If the analyses of the groundwater indicate contamination, periodic in situ treatment of the pond water to remove metals and solvents could be accomplished by precipitation of the metals, possibly with the addition of a coagulant, and air stripping of the solvents.

- Alternative 2: Installation of pond lining

  If the pond is determined to be contributing to groundwater contamination, lining the pond with an impermeable material would prevent percolation of contaminants into the shallow groundwater. A lining material consisting of either bentonite clay or a vinyl chloride could be installed after the water has been evacuated from the pond. Evacuation could easily be accomplished by pumping the water into the overflow ponds northeast of the main pond. Prior to lining the pond the bottom sediments should be removed and disposed at an appropriate disposal facility. The overflow ponds should also be lined with impermeable material to prevent migration of contaminants.

- Alternative 3: Monitoring

  No remedial actions would be necessary if laboratory analyses indicate no evidence of groundwater contamination. However, monitoring and annual sampling of the well for soluble contaminants should be conducted.

Site 10

Soil contamination from fuel was identified in soil borings ES2 and ES3. The areal extent of fuel within the decomposed granitic material downgradient from ES3 is not known. Soil boring ES3 appears to be located on a bedrock "knob" that may have detained downslope migration of hydrocarbons. There is no permanent water table in the area.

The jet fuel was identified at depths of 8 feet and 11 feet; at the time of the fuel spill, the entire soil column could have been saturated and over the succeeding years, approximately 10 feet of hydrocarbons could have vaporized and evaporated into the atmosphere. There is little reason to assume that the fuel has been extensively mobile since there is no permanent water table in the area. Therefore, the potential for groundwater contamination is considered remote.

To define the extent of soil contamination from fuel, vapor detection pipes should be installed to determine the perimeter of the suspected contaminated area. Following identification of the extent of soil contamination from Site 10, a number of options are available to eliminate or minimize the contamination.

- Alternative 1: In situ removal (fluid injection)

  If the fuel is confined within a topographical depression preventing it from migrating downslope, injection of water could "lift" the hydrocarbons to the top of the water. Fuel recovery by an oil recovery filter installed within a recovery well would then be possible.

- Alternative 2: In situ removal (air sweeping)

  The fuel could be eliminated by air sweeping. The system would pull air through the soil causing the hydrocarbons to vaporize.

Installation of a vent system would remove the vapors for dispersal into the atmosphere. This option would be particularly applicable if the contaminated soils were confined within a relatively small area such as a topographical depression.

- Alternative 3: Monitoring

  If the fuel-contaminated soil is confined by topography, the possibility of migration would be limited. The hydrocarbons would then vaporize and evaporate into the atmosphere over time. If no remedial actions are taken to remove the contamination, land use restrictions should be implemented to limit future construction in the area. In addition, vapor detection pipes should be installed to determine the perimeter of the suspected contaminated area.

Site 11

The areal extent of soils contaminated by liquid hydrocarbons is likely to be small, possibly about 40 square feet. The vapors from the hydrocarbons could have a greater lateral extent since the groundwater in ES4, located about 400 feet from the hydrants, showed presence of fuel. However, fuel within the shallow unconfined groundwater is unlikely to migrate downward into confined water supply aquifers. Therefore, potential environmental health risks from this fuel spill are considered insignificant. To define the extent of the spill it is recommended that one monitoring well be installed downgradient from the hydrant for sampling of groundwater and soils. The possible remedial measures are discussed below.

- Alternative 1: Air sweeping

  It is not known whether the groundwater has been contaminated. It is known only that the fuel identified in ES4 was probably in the gaseous phase, since there was no visual evidence of fuel in the sample. Air sweeping would draw air through the soil, vaporizing the hydrocarbons for dispersal into the atmosphere.

- <u>Alternative 2: Monitoring</u>

If no groundwater contamination were identified, the hydrocarbons may be held within the soil where they would vaporize over time. If no remedial actions were implemented, a groundwater monitoring well should be installed upgradient of ES4 to semiannually monitor hydrocarbon concentrations over time. Perforating the entire casing of the well would allow volatiles from the soil to enter the well.

CHAPTER 6

RECOMMENDATIONS

CHAPTER 6

RECOMMENDATIONS

The recommendations which have been developed for each site are summarized on Table 6.1.

NORTH BASE

Prior to initiating mitigation measures for identified soil contamination, the existing North Base wells should be sampled and analyzed for nitrates, chloroform, and trichlorofluoromethane. In addition, procedures should be initiated to allow for sampling of private off-base wells located downgradient from North Base disposal sites to ascertain the extent of potential nitrate and organics contamination.

Sites 1A, 1B, 1D1, and 1D2

The levels of soil contamination identified at these sites hardly would constitute an immediate health hazard. However, to prevent potential environmental contamination in the future, all remaining waste containers should be removed from the sites and transported to a permitted hazardous waste disposal location. Periodic sampling of downgradient wells for chloroform and trichlorofluoromethane should be performed to establish whether contaminants have migrated to those locations.

Except for drum removal, no remedial action is recommended for Sites 1A, 1B, 1D1, and 1D2 at this time. However, semiannual monitoring for nitrates and organics at existing downgradient wells in the vicinity will be of utmost importance. In order to establish the vertical distribution of contamination a monitoring well should be completed to the groundwater downgradient of the sites. If the organics enter the water supply system, remedial actions would be required either through closure of the well(s), treatment of the water, or immobilization of the organic constituents.

TABLE 6.1

RECOMMENDED ACTIONS AND MONITORING
EDWARDS AFB, CALIFORNIA

Site	Recommended Action and Monitoring	Rationale
1A, 1B, 1D1, 1D2	° Remove all waste containers from sites and dispose at permitted location. ° Monitor downgradient wells semiannually for organic constituents. ° Install one downgradient monitoring well and sample soils at the soil/water interface. Also sample groundwater for gaseous constituents. ° Complete 10-foot deep soil borings at compass points around the sites and sample for gaseous constituents.	° Prevent further soil contamination ° Identify potential migration of contaminants within the groundwater ° Define vertical extent of soil contamination ° Define lateral extent of soil contamination
1C	° Construct impermeable mound across the nitric acid pits. ° Institute land use restrictions. ° Monitor downgradient wells.	° Prevent mobilization of nitrates ° Prevent construction and excavation at future dates ° Identify potential migration of contaminants within the groundwater
2	° Locate and remove buried waste containers (if present) and dispose at permitted location. ° Install two lysimeters downgradient from the site. If flow exists, collect water samples and analyze for metals and suspected contaminants.	° Prevent potential leaching of contaminants into groundwater ° Determine existence of seasonal groundwater flow; if flow ex-exists, laboratory analysis of water samples will identify potential contaminant migration

TABLE 6.1 (Continued)

Site	Recommended Action and Monitoring	Rationale
2 (Cont'd)	° Install monitoring well if contaminants are detected in seasonal flow; sample annually for metals and suspected contaminants.	° Monitor potential migration of contaminants into groundwater
	° Construct an impermeable mound across the site.	° Prevent mobilization of contaminants by surface runoff
	° Institute land use restrictions.	° Prevent construction and excavation at future dates
3	° Install a lysimeter downgradient from the site; if seasonal groundwater flow exists, sample for metals and organics.	° Determine existence of seasonal groundwater flow; if flow exists, water sample analysis will identify potential contaminant migration
	° If contaminants are identified, install downgradient monitoring well.	° Monitor potential migration of contaminants into groundwater
5	° Locate existing wells 9N/9W-18C1 and 9N/9W-6L1; take groundwater samples and water level measurements if possible, and analyze for fuel and oil.	° Establish boundaries for the lateral extent of potential fuel migration
	° If the wells 18C1 and 6L1 can be located, they should be abandoned by grouting.	° Eliminate possibility of potential contamination migration through the well into deeper aquifers
	° Redevelop existing well 9N/9W-6E1 and sample for fuel.	° Verify fuel contamination in well 6E1
	° Install 3 monitoring wells downgradient of site; sample for fuel. If no fuel is detected in the soil or groundwater, the new wells should be monitored semiannually; if fuel is detected, install 3 to 6 additional wells.	° Identify lateral extent of potential fuel migration
	° Monitor underground storage tanks regularly.	° Determine the potential for future leakage.

TABLE 6.1 (Continued)

Site	Recommended Action and Monitoring	Rationale
8	° Install one groundwater monitoring well immediately downgradient from the site; sample groundwater for metals and organic solvents. ° If the groundwater shows no contamination, sample installed monitoring well annually. ° If groundwater samples show contamination, the pond water could be treated *in situ*. Sample monitoring well semiannually.	° Determine leakage from pond into the groundwater ° Monitor potential future leakage from pond into groundwater ° Reduce the potential for groundwater contamination; sampling of groundwater monitoring well will allow for determination of water treatment effectiveness
10	° Install vapor detection pipes around the perimeter of suspected contaminated area. ° Institute land use restrictions.	° Identify lateral extent of contaminated area and monitor evaporation of fuel over time ° Prevent future excavation and construction in the area while fuel is still present in the soil
11	° Install one monitoring well immediately downgradient from the hydrant. Sample well water semiannually for fuels (the entire casing of the well should be perforated and the well sampled semiannually for gas vapors).	° Determine if fuel is present on top of the groundwater

Should a problem be defined, in order to implement measures to clean up the contaminated soils at the North Base, it will be necessary to perform a predesign reconnaisssance to determine the lateral extent of contaminant migration in the area. It is therefore recommended that a series of shallow soil borings be completed to a depth of 10 feet, with one soil sample collected from the bottom of each hole with a Shelby tube to be analyzed for chloroform and trichlorofluoromethane. The borings should be distributed at compass points around the sites; the number of borings will be decided in the field, but would be a minimum of ten.

The soils immediately above the water table should be sampled to ascertain whether chloroform or trichlorofluoromethane is present. Samplers should consist of closed containers to minimize escape of volatile contaminants during sampling.

Site 1C

The risk of contamination of drinking water supplies from this site is considered low. However, to mitigate identified soil contamination it is recommended that the nitrates be immobilized by preventing any water from percolating into the contaminated soils. A mound composed of fine-grained material with very low permeability (e.g., playa deposits) should be emplaced across the nitric acid pits to inhibit water percolation. The cover should be placed as a mound draining away from the site. Implementation of this mitigatory action will necessitate effective land use restrictions to ensure that no future excavation or construction takes place in the area. In addition, downgradient wells should be sampled on a semiannual basis for nitrates.

MAIN BASE AND SOUTH BASE

Site 2

Imminent contamination of the Base water supply from leachates originating at Site 2 is considered unlikely. However, steps should be taken to eliminate any potential sources. To this end, metal detectors should be used to locate any buried containers. If located, the buried containers should be transported to a permitted hazardous waste disposal site. This would eliminate the possibility of any soil contamination from leaking containers.

Two lysimeters should be installed immediately downgradient from the site near the bedrock/soil interface to assess the potential for subsurface flow. The lysimeters should be used to sample for suspected contaminants. A monitoring well could be installed downgradient from the site, near the aquifer boundary less than 2 miles away, if a seasonal water table is identified with the lysimeters and contaminants are detected. Monitoring should be conducted annually for metals and organic constituents. This will allow for early detection of potential contamination prior to its entering the water supply.

If the lysimeter samples indicate the presence of subsurface flow, in situ contaminants at the site should be immobilized by construction of an impermeable surface cover. This would prevent site runoff from carrying contaminants downslope. On-base playa deposits would provide an adequate impermeable cover. In conjunction with installation of the impermeable cover, effective land use restrictions will be required to ensure that no future construction or excavation activities can take place in this area.

Site 3

The potential for environmental health hazards from this site is considered minimal, primarily due to the absence of a permanent water table under the area. To investigate the presence of a seasonal water table, a lysimeter should be installed downgradient from the site and used to sample for metals and organic constituents. If these substances are detected, a monitoring well should be installed for annual sampling. No other remedial actions are recommended at this time.

Site 5

The potential for contamination of the Base water supply from Site 5 is considered unlikely. However, the contamination of the shallow aquifer will require more investigation. To trace the path of tank leakage in the shallow aquifer, the following recommendations are made.

- Locate abandoned wells 9N/9W-18C1 (MB-7) and 9N/9W-6L1 (MB-1), downgradient from Site 5. If the wells can be located and are in a condition that will allow sampling of the groundwater, a sample should be obtained and analyzed for fuels and oils. Water level measurements should be taken if possible. After the wells are sampled, or if the wells are not in a condition to be sampled, they should be properly abandoned by grouting of the well casings.

- Three monitoring wells should be installed downgradient, east of Site 5. The first well should be immediately adjacent to the site, the second should be approximately 50 feet east of the Site 5 boundary, and the third should be located about 500 feet from the site boundary. For the well closest to the site, soil samples should be retrieved at 20-foot depth intervals for laboratory analysis for fuel and oils. Water samples should be obtained from the shallow (first) aquifer (probably less than 100 feet deep).

- If no fuel is detected in the soil or groundwater, the new wells should be monitored semiannually. If the soil or groundwater in newly installed monitoring wells contains fuel, three to six additional wells should be installed in phases to delineate the areal extent of contamination. Ideally, determination of well locations and installation of additional monitoring wells should be accomplished in the field on the basis of laboratory results from previously installed monitoring wells.

- The remaining underground storage tanks should be monitored regularly to determine the potential for future leakage.

- The source of fuel in the old well 9N/9W-6E1 has not been identified but is assumed to be upgradient from the well unless the fuel is present due to random vandalism. Prior to initiating a monitoring program, well 6E1 should be redeveloped and sampled. If fuel is identified in the sample from well 6E1, one monitoring well should be installed immediately upgradient (northwest) of the Base well, with two additional wells downgradient at 50 feet and 500 feet southeast of the well. If these wells should show hydrocarbon contamination in considerable amounts, additional monitoring wells may be necessary to identify the extent of the plume. Depending on the amount of hydrocarbons in the groundwater, the implementation of fuel recovery may be desirable. If it is determined that hydrocarbons do not pose an environmental hazard, the fuel may be left in place to migrate further downgradient, and eventually vaporize and evaporate into the atmosphere. In this case, the wells installed downgradient from the site should be monitored semiannually.

Site 8

It is considered unlikely that this site would cause groundwater contamination due to the low permeabilities of the playa deposits and the probable impermeability of the bottom sediment. A monitoring well installed immediately downgradient of this site in the shallow groundwater and sampled for metals and organic solvents would allow for determination of groundwater contamination. An undisturbed soil sample should be obtained for permeability testing.

No remedial actions would be necessary if laboratory analyses indicate no evidence of groundwater contamination. However, monitoring and annual sampling of the well for soluble contaminants should be conducted.

The need for further action should be evaluated pending the results of the laboratory analyses of the groundwater sample. If groundwater contamination is evident, monitoring and semiannual sampling should be conducted. If mitigatory action is required, the most appropriate measure would be periodic in situ treatment of the pond water.

Site 10

The potential for contaminant migration in this area is considered remote given there is no permanent water table. However, to define the areal extent of soil contamination from fuel, vapor detection pipes should be installed to determine the perimeter of the suspected contaminated area. If the fuel-contaminated soil is confined by topography, the potential for migration and subsequent groundwater contamination would be limited. Therefore, no further actions would be recommended at this time. The hydrocarbons would then vaporize and evaporate into the atmosphere over time. No remedial actions will require implementation of land use restrictions to prevent any future construction in the area.

Site 11

Although it is improbable that the Base water supply would be imperiled by the fuel spill at this site, it is recommended that the extent of the spill be defined. One monitoring well should be installed downgradient from the hydrant for sampling of groundwater and soils.

If no groundwater contamination is identified in the monitoring well, no remedial actions will be needed since the hydrocarbons, held within the soil, would vaporize over time. The groundwater monitoring well installed should be sampled semiannually for fuels. The monitoring well should be perforated the entire length of the casing to allow volatiles in the soil to enter the well. The well should be monitored for hydrocarbon vapors semiannually with a gas probe.

APPENDIX A

SCOPE OF WORK

APPENDIX A

SCOPE OF WORK

INSTALLATION RESTORATION PROGRAM
PHASE II FIELD EVALUATION
EDWARDS AFB, CALIFORNIA

I. DESCRIPTION OF TASK:

The purpose of this task is to determine the magnitude and extent of environmental contamination which has resulted from previous waste disposal practices at Edwards AFB, California; to make recommendations for actions necessary to mitigate adverse environmental effects of existing contamination problems; to suggest potential ways of restoring the environment to as near a normal level as is practical; and to suggest a future environmental monitoring program to document environmental conditions at Edwards AFB.

The presurvey task (order 2) report incorporated background and description of the sites for this task. To accomplish this survey effort, the following steps will be taken:

A. Install one test hole downstream of the main toxic waste disposal area, Site 2. Perform analyses for toxic contaminants on two soil-moisture samples.

B. Install four groundwater monitoring wells, one well upgradient and three wells downgradient of the waste POL storage area, Site 5. Perform analyses for organic contaminants on eight water samples.

C. Monitor ambient air quality for total hydrocarbon at the sites described below after wells are installed.

D. Install test holes to remove subsurface soils for analysis as follows:

1. one hole slant-drilled at Site 1A,

2. one hole slant-drilled at the subsite south of the playa at Site 1B,

3. two slant holes (1 per subsite) at Site 1D, and

4. one slant hole under each underground tank at Site 5, determined in paragraph I.C. to be leaking.

Three soil samples from each hole will be analyzed for organic contaminants.

E. Install one test hole in the center of the main nitric acid pit at Site 1C. Remove five samples and analyze for nitrates.

F. Collect two surface soil samples downslope of the abandoned sanitary landfill, Site 3. Analyze for organic contaminants and heavy metals.

G. Collect one liquid sample and four sediment samples from the industrial waste pond, Site 8. Analyze for toxic organic contaminants.

H. Install five monitoring wells in the vicinity of Site 8. The wells shall be installed to define the plume originating from the pipeline break between Buildings 1635 and 1810, and pipeline leak at Building 1724. Analyze two samples from each well (10 samples total) for organic contaminants.

I. Close all abandoned test wells and test holes from the above tasks in accordance with regulations of the California Water Quality Control Board.

J. A final report (Item VI below) will be prepared delineating the magnitude and extent of environmental contamination, to include recommendations required for cleanup or to mitigate the adverse effects of previous waste disposal practices. Recommendations for future environmental monitoring must also be included.

II. SITE LOCATION AND DATE:

Edwards AFB CA
Building 3925
21 September 1981

III. BASE SUPPORT: NONE

IV. GOVERNMENT FURNISHED PROPERTY: NONE

V. GOVERNMENT TECHNICAL POINTS OF CONTACT

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APPENDIX B

WELL NUMBERING SYSTEM

APPENDIX B

WELL-NUMBERING SYSTEM

The well-numbering system used in the Edwards Air Force Base area conforms to that used in virtually all ground-water investigations made by the Geological Survey in California since 1940. The system has been adopted by the California Department of Water Resources and by the California Water Pollution Control Board for use throughout the state.

Wells are assigned numbers according to their location in the rectangular system for the subdivision of public land. For example, in the number 8/11-35J2 the part of the number preceding the slash indicates the township (T. 8 N.), the part between the slash and the hyphen indicates the range (R. 11 W.), the number between the hyphen and the letter indicates the section (sec. 35), and the letter indicates the 40-acre subdivision of the section as shown in the accompanying diagram.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Within the 40-acre tract, the wells are numbered serially as indicated by the final digit. Thus, well 8/11-35J2 is the second well to be listed in the NE¼SE¼ sec. 35, T. 8 N., R. 11 W. (San Bernardino base and meridian).

Source: U. S. Geological Survey, 1962

APPENDIX C

U.S. GEOLOGICAL SURVEY WELL LOGS

WELLS IN THE VICINITY OF DISPOSAL AND STORAGE AREAS
EDWARDS AIR FORCE BASE, CALIFORNIA
MAIN AND SOUTH BASES

	Logs Available	Water Levels Available	Elevations Available	Water Quality Data	Comments
9N9W6A1	X		X		Main Base Well 5
6C1	X		X		Main Base Well 4
6E1	X	X	X		Jet Fuel Smell,USGS
6L1	X		X	X	Main Base Well 1
6M1	X		X		Main Base Well 2
7N1					
18C1	X		X	X	Main Base Well 7
9N10W13A1					
12R1	X	X	X	X	Main Base Well 6
12R2					
24C1	X	X	X	X	Base Production Well Main Base 9A
24E1			X	X	Main Base Well 11
24F1	X		X	X	Main Base Well 6A
24F2					
24G1	X		X	X	Main Base Well 8
24G2					
24N1			X		
24XX		X			Main Base Well 12
10N9W30P1					
30Q1					
30Q2					
30Q3					
31A1					
31A2					
31A3					
31A4					
31B1					
31C1	X		X		
31C3	X		X		
31C4	X		X		
31C5					
10N9W31H1					
31H2					
31J1					
31J2					
31M1					
31N1	X		X		
31N2					
31N3					

WELLS IN THE VICINITY OF DISPOSAL AND STORAGE AREAS

EDWARDS AIR FORCE BASE, CALIFORNIA

MAIN AND SOUTH BASES (Continued)

	Logs Available	Water Levels Available	Elevations Available	Water Quality Data	Comments
10N10W25R1					
25R3					
<u>WELLS, NORTH BASE</u>					
10N9W4D1	X	X	X		
4D2	X				North Base Well 4
7A1	X	X	X	X	North Base Well 1
7A2	X		X		North Base Well 2
5B1		X			North Base Well 5
11N9W32Q1	X	X			North Base Well 3

9/9 6A1

9/9-6A1 (EAFB, well 5). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,274.7 feet. Perforated: 76-184 feet. Gravel pack well.

Material	Thickness (feet)	Depth (feet)
Top soil and silt	17	17
Sand, fine	5	22
Clay, soft	7	29
Clay, soft sandy, moist	38	67
Clay, hard	9	76
Sand, coarse; water bearing	6	82
Clay, soft, sandy; water bearing	22	104
Clay, hard sandy; water bearing	28	132
Sand, coarse and gravel; water bearing	12	144
Clay, sandy, soft; water bearing	13	157
Gravel, river, six inch; water bearing	42	199

9/9-6C1 (EAFB well 4). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,287.5 feet. Perforated: 38-101 feet. Gravel pack well.

Clay, sandy	25	25
Clay, semifine	4	29
Clay loam	13	42
Sand, coarse; water bearing	15	57
Clay, sandy; water bearing	19	76
Sand, coarse; water bearing	6	82
Clay	26	108
Bedrock	9	117

9/9-6E1 (EAFB well 3). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,290.25 feet. Perforated: 35-96 feet. Gravel pack well.

Clay, sandy	37	37
Sand, loose, clean	15	52
Clay, red, sandy	16	68
Sand and gravel, small	7	75
Clay, hard	7	82
Granite ash	8	90
Granite, decomposed	15	105
Granite	7	112

9/9 6C1

9/9-6A1 (EAFB, well 5). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,274.7 feet. Perforated: 76-184 feet. Gravel pack well.

Material	Thickness (feet)	Depth (feet)
Top soil and silt	17	17
Sand, fine	5	22
Clay, soft	7	29
Clay, soft sandy, moist	38	67
Clay, hard	9	76
Sand, coarse; water bearing	6	82
Clay, soft, sandy; water bearing	22	104
Clay, hard sandy; water bearing	28	132
Sand, coarse and gravel; water bearing	12	144
Clay, sandy, soft; water bearing	13	157
Gravel, river, six inch; water bearing	42	199

9/9-6C1 (EAFB well 4). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,287.5 feet. Perforated: 38-101 feet. Gravel pack well.

Clay, sandy	25	25
Clay, semifine	4	29
Clay loam	13	42
Sand, coarse; water bearing	15	57
Clay, sandy; water bearing	19	76
Sand, coarse; water bearing	6	82
Clay	26	108
Bedrock	9	117

9/9-6E1 (EAFB well 3). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,290.25 feet. Perforated: 35-96 feet. Gravel pack well.

Clay, sandy	37	37
Sand, loose, clean	15	52
Clay, red, sandy	16	68
Sand and gravel, small	7	75
Clay, hard	7	82
Granite ash	8	90
Granite, decomposed	15	105
Granite	7	112

9/9 6E1

9/9-6A1 (EAFB, well 5). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,274.7 feet. Perforated: 76-184 feet. Gravel pack well.

Material	Thickness (feet)	Depth (feet)
Top soil and silt	17	17
Sand, fine	5	22
Clay, soft	7	29
Clay, soft sandy, moist	38	67
Clay, hard	9	76
Sand, coarse; water bearing	6	82
Clay, soft, sandy; water bearing	22	104
Clay, hard sandy; water bearing	28	132
Sand, coarse and gravel; water bearing	12	144
Clay, sandy, soft; water bearing	13	157
Gravel, river, six inch; water bearing	42	199

9/9-6C1 (EAFB well 4). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,287.5 feet. Perforated: 38-101 feet. Gravel pack well.

Clay, sandy	25	25
Clay, semifine	4	29
Clay loam	13	42
Sand, coarse; water bearing	15	57
Clay, sandy; water bearing	19	76
Sand, coarse; water bearing	6	82
Clay	26	108
Bedrock	9	117

9/9-6E1 (EAFB well 3). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,290.25 feet. Perforated: 35-96 feet. Gravel pack well.

Clay, sandy	37	37
Sand, loose, clean	15	52
Clay, red, sandy	16	68
Sand and gravel, small	7	75
Clay, hard	7	82
Granite ash	8	90
Granite, decomposed	15	105
Granite	7	112

9/9 6L1

9/9-6L1 (EAFB well 1). Drilled by Delbert Bomar. 14-inch casing. Altitude 2,282.26 feet. Perforated: 33-130 feet.

Material	Thickness (feet)	Depth (feet)
Top soil	22	22
Clay, brown, hard	13	35
Sand	5	40
Clay	4	44
Sand	14	58
Sand, cemented, and clay	32	90
Sand	6	96
Clay, sandy	14	110
Clay	6	116
Sand	3	119
Clay	9	128
Broken rock	3	131
Granite, decomposed	15	146
Live granite	1	147

9/9-6M1 (EAFB well 2). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,286.79 feet. Perforated: 25-116 feet. Gravel pack well.

Clay, hard and sand	20	20
Gravel, small and sand	15	35
Clay, hard, sandy	5	40
Sand and gravel, small	6	46
Clay, hard	15	61
Sand and gravel	7	68
Clay, soft and sand	18	86
Granite, broken	15	101
Granite ash	6	107
Granite, decomposed	13	120
Granite	6	126

9/9-18C1 (EAFB well 7). Drilled by E. W. Brockman. 14- and 10-inch casing. Altitude 2,279.86 feet. Perforated: 250-310 feet.

Clay, sandy	75	75
Sand, coarse; water bearing, water raised to 10 foot level	2	77
Sand, dirty	3	80
Sand and clay, cemented	7	87
Sand, coarse, dirty	8	95

9/9 6M1

9/9-6L1 (EAFB well 1). Drilled by Delbert Bomar. 14-inch casing. Altitude 2,282.26 feet. Perforated: 33-130 feet.

Material	Thickness (feet)	Depth (feet)
Top soil	22	22
Clay, brown, hard	13	35
Sand	5	40
Clay	4	44
Sand	14	58
Sand, cemented, and clay	32	90
Sand	6	96
Clay, sandy	14	110
Clay	6	116
Sand	3	119
Clay	9	128
Broken rock	3	131
Granite, decomposed	15	146
Live granite	1	147

9/9-6M1 (EAFB well 2). Drilled by E. W. Brockman. 14-inch casing. Altitude 2,286.79 feet. Perforated: 25-116 feet. Gravel pack well.

Clay, hard and sand	20	20
Gravel, small and sand	15	35
Clay, hard, sandy	5	40
Sand and gravel, small	6	46
Clay, hard	15	61
Sand and gravel	7	68
Clay, soft and sand	18	86
Granite, broken	15	101
Granite ash	6	107
Granite, decomposed	13	120
Granite	6	126

9/9-18C1 (EAFB well 7). Drilled by E. W. Brockman. 14- and 10-inch casing. Altitude 2,279.86 feet. Perforated: 250-310 feet.

Clay, sandy	75	75
Sand, coarse; water bearing, water raised to 10 foot level	2	77
Sand, dirty	3	80
Sand and clay, cemented	7	87
Sand, coarse, dirty	8	95

9/9 18C1

9/9-18C1. U.S. Air Force, Edwards Air Force Base Main Base well 7. Drilled by E. W. Brockman. 14- and 10-inch casing. Altitude 2,280.3 ft. Perforated: 250-310 ft. (From top to bottom [illegible] [illegible])

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay, sandy ----------	75	75	Clay -----------------	13	207
Sand, coarse; water-bearing, water raised to 10-ft level ------	2	77	Sand, coarse ---------	6	213
Sand, dirty -----------	3	80	Rock ledge -----------	4	217
Sand and clay, cemented	7	87	Clay -----------------	4	221
Sand, coarse, dirty ---	3	95	Sand, dirty ----------	7	228
Granite, decomposed ---	4	99	Clay, sandy ----------	20	248
Sand and clay ---------	93	192	Sand, dirty ----------	67	315
Sand and gravel, pea-size ----------------	2	194	Sand, coarse, dirty---	13	328
			Clay, sandy ----------	32	360

9/9-27E2. U.S. Air Force. Drilled for the Arrow Rock Co. by Frank Rottman in June 1957. Rotary well, 8-inch casing, perforated 100 to 200 ft. Altitude about 2,280 ft.

Surface sand ---------	20	20	Sand, coarse, and clay ----------------	20	160
Sand and clay --------	20	40	Sand, coarse ----------	20	180
Sand, coarse, and clay	60	100	Sand, fine ------------	20	200
Sand and clay --------	40	140			

9/10-12R1. U.S. Air Force, Edwards Air Force Base Main Base well 6. Drilled by E. W. Brockman. 16-inch casing. Altitude 2,280.0 ft.

Adobe ---------------	4	4	Sand, very coarse, and fine gravel ---------	9	178
Sand, fine; very small amount water ------	6	10	Clay -----------------	7	185
Clay ----------------	121	131	Gravel, coarse --------	1	186
Sand, coarse, apparently dry ----	10	141	Clay -----------------	37	223
Clay ----------------	8	149	Gravel, pea-size ------	3	226
Sand, very coarse, apparently dry ----	6	155	Sand, very coarse; apparently considerable water --------------	22	248
Clay ----------------	14	169	Granite, decomposed ---	4	252

9/10-14C1. U.S. Air Force, Edwards Air Force Base Old Hospital Well. Drilled by Delbert Bomar. 12-inch casing. Altitude 2,207.3 ft. Perforated: 40-52, 72-82 ft.

Topsoil and clay ---	40	40	Clay, hard ------------	14	84
Gravel, sandy ------	9	49	Granite, decomposed,soft	24	108
Clay, sandy ---------	21	70	Granite, hard ---------	5.8	113.8

9/9-18C1.—Continued

Material	Thickness (feet)	Depth (feet)
Granite, decomposed	4	99
Sand and clay	93	192
Sand and gravel, pea sized	2	194
Clay	13	207
Sand coarse	6	213
Rock ledge	4	217
Clay	4	221
Sand, dirty	7	228
Clay, sandy	20	248
Sand, dirty	67	315
Sand, coarse, dirty	13	328
Clay, sandy	32	360

9/10-12R1 (EAFB well 6). Drilled by E. W. Brockman. 16-inch casing. Altitude about 2,280 feet. Perforated: 169-178, and 223-248 feet.

Adobe	4	4
Sand, fine; very small amount water	6	10
Clay	121	131
Sand, coarse; apparently dry	10	141
Clay	8	149
Sand, very coarse, apparently dry	6	155
Clay	14	169
Sand, extra coarse, fine gravel	9	178
Clay	7	185
Gravel, coarse	1	186
Clay	37	223
Pea gravel	3	226
Sand, very coarse; apparently considerable water	22	248
Granite, decomposed	4	252

9/10 24C1

9/10-16P1. U.S. Air Force, formerly W. H. Graham. Drilled by R & C Drilling Co. 14-inch casing. Altitude about 2,322 ft.

	Thickness (feet)	Depth (feet)
Soil	16	16
Sand and gravel	5	21
Sand, coarse	15	36
Clay, sandy	3	39
Sand and gravel	13	52
Clay, sandy	7	59
Sand, coarse	6	65
Sand and streaks of clay	21	86
Gravel, coarse	13	99
Sand and gravel; streaks of clay	30	129
Boulders	2	131
Sand and gravel; streaks of clay	11	142
Clay	3	145
Sand, coarse; streaks of clay	16	161
Gravel, coarse; small boulders	32	193
Sand, hard	10	203
Sand, medium hard, and streaks of loose gravel	31	234
Sand, hard	20	254
Sand, medium hard	8	262
Sand, hard	14	276
Sand, medium hard	5	281
Sand, medium hard; streaks of clay	6	287
Sand, hard	141	428
Sand and streaks of clay	4	432
Sand, hard; streaks of clay	30	462
Sand, medium hard; streaks of clay	6	468
Sand, hard; streaks of clay	41	509
Sand, loose, and streaks of clay	11	520
Sand, hard	12	532

9/10-24C1. U.S. Air Force, Edwards Air Force Base Main Base well 9. Drilled by J. Beylik. 14-inch casing. Altitude about 2,285 ft. Perforated: 156-733 ft.

Topsoil	10	10
Sand, fine, and clay	35	45
Clay, sandy	45	90
Gravel, coarse, and clay	65	155
Gravel, smaller; boulders; small amount of clay	55	210
Gravel, medium coarse; little clay	70	280
Sand, fine; little clay and small boulders (hard)	30	310
Gravel, medium coarse; small boulders, little clay	50	360
Sand, fine; some clay and small boulders (hard)	10	370
Gravel, medium coarse; some clay	28	398
Sand, sharp, fine; clay, medium hard	64	462
Clay, cemented at 462 ft; boulders, hard	8	470
Gravel, coarse; clay; hard boulders	15	485
Gravel, coarse; clay (smooth drilling at 485 ft)	50	535
Clay, soft, sandy	25	560
Clay, hard, sandy, and boulders	30	590
Gravel, medium coarse, and clay	30	620
Clay, soft, sandy, and small boulders	70	690
Clay, fine, sandy, small boulders (hard)	37	727
Clay, hard	23	750

733

9/10 24F1

9/10-24C1 (EAFB well 9). Drilled by J. Beylic. 14-inch casing.
Altitude about 2,285 feet. Perforated: 156-733 feet

Material	Thickness (feet)	Depth (feet)
Top soil	10	10
Fine sand and clay	35	45
Sandy clay	45	90
Coarse gravel and clay	65	155
Smaller gravel and boulders. Very little clay	55	210
Medium coarse gravel. Little clay	70	280
Fine sand and little clay-small boulders (hard)	30	310
Medium coarse gravel and small boulders-little clay	50	360
Fine sand and little clay and small boulders (hard)	10	370
Medium coarse gravel and little clay	28	398
Sharp sand and clay-medium hard (fine)	64	462
(Pick up some cemented clay at 462)		
Hard boulders	8	470
Coarse gravel; clay; hard boulders	15	485
Coarse gravel; clay-(smooth drilling at 485)	50	535
Soft sandy clay	25	560
Hard sandy clay and boulders	30	590
Medium coarse gravel and clay	30	620
Soft sandy clay and small boulders	70	690
Fine sandy clay; small boulders (hard)	37	727
Hard clay	23	750

9/10-24F1 (EAFB well 6A). Drilled by Brockman. 12-inch casing.
Altitude 2,281.21 feet. Perforated: 70-400 feet.

Top soil	16	16
Sand	8	24
Clay	70	94
Gravel	4	98
Clay	56	154
Sand	9	163
Clay	48	211
Gravel, fine	4	215
Clay, very hard	6	221
Gravel, fine	2	223
Clay, very hard	7	230
Gravel, fine	2	232
Clay, very hard	8	240
Gravel, fine	4	244
Clay, hard	65	309
Sand, coarse; apparently considerable water	23	332
Clay	57	389
Sand, coarse; apparently considerable water	21	410
Clay	20	430

9/10 24G1

9/10-24G1 (EAFB well 8). Drilled by J. Seylic. 14-inch casing. Altitude about 2,278 feet. (Materials classified by the U. S. Geological Survey)

Material	Thickness (feet)	Depth (feet)
Soil, sandy, loose; light brown	2	2
Clay, silty; some sand, very fine; fairly hard, buff	8	10
Sand, very fine to medium, light-gray; and clay; sand coarse near base, well sorted	32	42
Sand, medium to coarse, hard, light-brown; some clay from 70 to 76 feet	34	76
Sand, medium to very coarse, silty, buff; some gravel, very fine; coarser zones at 76 and 83 feet	24	100
Sand, very coarse, well sorted, light-brown; and some very fine sand, mostly dark minerals	8	108
Sand, very coarse, well sorted, brown; and small amounts of clay, usually buff with occasional dark brown zones; medium to very coarse from 140 to 143 feet, medium to coarse from 143 to 208 feet, becoming finer at base	35	143
Sand, medium to coarse, silty, buff	65	208
Sand, very coarse, silty, buff	6	214
Sand, very coarse, silty, hard, high in biotite mica; and gravel	11	225
Clay, sandy, mostly medium to coarse; light brown	6	231
Sand, medium to coarse, hard, silty, buff; and some small gravel from 231 to 233 feet and 237 to 240 feet	9	240
Sand, fine to medium, buff	11	251
Sand, coarse, silty, hard, buff; in light brown clay matrix	19	270
Sand, coarse, brown, hard, high in unweathered dark minerals; some clay at 285 feet	20	290
Sand, medium to coarse, silty, buff; very coarse 340 to 343 feet	53	343
Clay, hard, compact, light brown; sand, fine to medium	7	350
Sand, very coarse, angular, hard; and some fine gravel in clay matrix	6	356
Sand, fine to medium, fairly soft, brown; some gravel and clay	4	360
Gravel, silty, hard; and sand, medium to coarse	5	365
Sand, coarse, well sorted, buff gravel streaks at 403 feet and 422 feet, some clay from 440 to 442 feet	77	442

9/10 24G1

9/10-24G1. — Continued.

Material	Thickness (feet)	Depth (feet)
Sand, fine to medium, poorly sorted, hard; 454 to 455 hard compact sandy clay	15	457
Sand, medium to coarse, softer, buff; clay increasing at base	71	528
Clay, light brown, soft; sand medium to coarse	17	545
Sand, very coarse, buff; and gravel; very little clay; medium to coarse from 630 to 640 feet	95	640
Sand, fine to medium, hard poorly sorted, buff; some clay, light brown	26	666
Sand, medium to coarse, some clay, poorly sorted, buff	39	705
Sand, medium, some brown clay	4	709
Clay, light brown, hard; and sand, medium to coarse	7	716
Sand, medium to coarse, very little clay	14	730
Clay, light brown; and sand fine to medium; clay increasing with depth	20	750

10/9-7A1 (EAFB, North Base, well 1). Drilled by J. B. Henderson. 10-inch casing. Altitude about 2,276 feet. Perforated: 125-197 feet.

Blow sand and top soil	3	3
Clay, yellow, with sand, fine. This thin strain of sand and clay showed a small am't of surface water ~~[illegible]~~ with alkali	80	83
Clay, yellow, with some small gravel	30	113
Clay, yellow, with some fine sand	9	122
Clay, yellow, with small gravel, very tight	2	124
Clay, yellow	5	129
Gravel, loose, with some clay. This is the best showing of water so far. Water standing at 75-foot level	6	135
Clay, yellow	5	140
Clay, yellow, and gravel, small	2	142
Clay, yellow, and gravel, small	10	152
Clay, yellow, and sand	3	155
Clay, gray, with some fine sand; some water	16	171
Clay, gray, with coarse sand	13	184
Gravel, clean	2	186
Clay, gray, and sand, coarse	6	192
"Rock-sparr"	1	193
Rock, gravel, and clay, light brown	7	200

10/9 31C1

10/9-7A2 (EAFB, North Base, well 2). Drilled by J. B. Henderson. 10-inch casing. Altitude 2,276.89 feet.

Material	Thickness (feet)	Depth (feet)
(No data)	5	5
Clay, fine, and decomposed granite	5	10
Sand, clay, and some decomposed granite	70	80
Clay and gravel, sandy	30	110
Clay, sandy, and some decomposed granite	30	140
Gravel and rock	25	165
Clay, sandy, and decomposed granite	20	185
Sand, gravel, and rock; some clay	15	200

10/9-31C1 (EAFB Federal housing project, well 3). 10-inch casing. Altitude about 2,280 feet.

Clay, sandy, hard	45	45
Granite, decomposed	9	54
Sand, fine, loose; water bearing	1	55
Sandstone	2	57
Granite, decomposed; water bearing	6	63
Clay, sandy	5	68
Granite, decomposed, quartz decomposed	12	80
Sand, fine	2	82
Granite, decomposed, loose; water bearing	8	90
Granite, decomposed, hard	30	120
Granite, friable; main water bearing member	42	162
Granite, decomposed, hard	3	165
Granite, hard	12	177

10/10-35F1 (EAFB Toxic Gas Yard Well). 12-inch casing. Altitude 2,321.50 feet. Perforated 35-82 feet.

Top soil	4	4
Sand	11	15
Sandy clay	10	25
Cemented sand and clay	47	72
Granite sand and gravel	18	90
Granite ash	8	98
Granite	2	100
Granite ash	2	102
Hard granite	12	114

10/9 31C3

10/9-31A1. Drilled by Charles Grant. 8-inch casing. Altitude about 2,275 feet.

Material	Thickness (feet)	Depth (feet)
Feldspar sand	12	12
Whitesand	38	50
Limeclay	8	58

10/9-31C3 (Formerly ATSF Railroad, well 3). Drilled by W. C. Rielly. 12.5- and 10-inch casing. Altitude about 2,280 feet. Perforated: 49-54, 73-118 feet.

Soil, top	7	7
Sand, hard cemented	43	50
Sand, coarse	5	55
Clay	8	63
Sand, hard	4	67
Clay	7	74
Sand, water	7	81
Clay	13	94
Sand, water	11	105
Gravel, water	14	119
Granite, decomposed	56	175
Granite, blue	43	218

10/9-31C4 (Formerly ATSF Railroad, well 6). Drilled by Roscoe Moss Co. 16-inch casing. Altitude about 2,280 feet. Perforated: 48-54, 60-68, 90-114 feet.

Clay, sandy	54	54
Granite, decomposed	2	56
Clay, sandy	4	60
Sand, fine	3	63
Clay	2	65
Granite, decomposed	2	67
Sand	1	68
Granite, decomposed	1	69
Clay, sandy	44	113
Granite, friable	12	125
Granite, solid grey	3	128

10/9 31C4

10/9-31A1. Drilled by Charles Grant. 8-inch casing. Altitude about 2,275 feet.

Material	Thickness (feet)	Depth (feet)
Feldspar sand	12	12
Whitesand	38	50
Limeclay	8	58

10/9-31C3 (Formerly ATSF Railroad, well 3). Drilled by W. C. Rielly. 12.5- and 10-inch casing. Altitude about 2,280 feet. Perforated: 49-54, 73-118 feet.

Soil, top	7	7
Sand, hard cemented	43	50
Sand, coarse	5	55
Clay	8	63
Sand, hard	4	67
Clay	7	74
Sand, water	7	81
Clay	13	94
Sand, water	11	105
Gravel, water	14	119
Granite, decomposed	56	175
Granite, blue	43	218

10/9-31C4 (Formerly ATSF Railroad, well 6). Drilled by Roscoe Moss Co. 16-inch casing. Altitude about 2,280 feet. Perforated: 48-54, 60-68, 90-114 feet.

Clay, sandy	54	54
Granite, decomposed	2	56
Clay, sandy	4	60
Sand, fine	3	63
Clay	2	65
Granite, decomposed	2	67
Sand	1	68
Granite, decomposed	1	69
Clay, sandy	44	113
Granite, friable	12	125
Granite, solid grey	3	128

10/9 31N1

/9-31N1. Drilled by Pengilley Bros. 6-inch casing. Altitude about 2,294 feet. Perforated: 43-83 feet.

Material	Thickness (feet)	Depth (feet)
Sand, clay	18	18
Sand, water	2	20
Sand, clay-caved	62	82
Hard rock	1	83

/11-18C1 (Formerly Reed). 12-inch casing. Altitude about 2,510 feet.

ndy loam and clay streaks	108	108
ravel, clay and sand mixture	8	116
Fine water sand	4	120

/11-18P1 (Formerly Brown). 14-inch casing. Altitude about 2,505 feet.

ndy	20	20
iff clay	36	56
nd	22	78

/11-19R2 (Formerly Wheeler). Destroyed well. Altitude about 2,545 feet.

lternate clay and sand	76	76
attered granite	14	90
fter granite	16	106

/11-30D1. 14-inch casing. Altitude about 2,550 feet.

il, gravelly	60	60
anite, rotten	34	94

/11-30L1. Drilled by Pengilley Bros. Destroyed well. Altitude about 2,615 feet.

anite	118	118

10/9 4D1

10/8-32R1. U.S. Air Force. Drilled by Clyde. Uncased test hole. Altitude about 2,450 ft.

	Thickness (feet)	Depth (feet)
Surface soil and sand	62	62
Granite, red	27	89
Clay, blue, with streaks of coarse sand	25	114
Granite, blue	34	148

10/9-4D1. U.S. Air Force, Edwards Air Force Base test well 4. Drilled by Barber-Bridge Drilling Corp., in February 1957. Altitude about 2,280 ft. 12-inch casing 0 to 500 ft. Perforated: 144-195 ft and 200-433 ft.

Quartz sand	34	34
Clay, silty, and coarse sand	108	142
Gravel and very fine sand, poorly sorted	14	156
Clay, silt, and sand; with gravel, very hard; no water	33	189
Gravel, sand, and silt, very dirty	2	191
Clay, hard, sandy, light-brown to red, very tight, forms balls; sand, fine to very coarse with intermixed fine gravel	27	218
Sand and silt with some fine gravel, dirty	10	228
Clay and sand, silty, some gravel to pebble size, clastics, very adhesive, forms compact balls	87	315
Granite and quartz	87	402
Granite, decomposed	8	410
Gravel, fine	8	418
Sand, cemented	10	428
Silt, fine, tight	5	433
Sand, cemented	4	437
Clay, hard, sandy, yellow	27	464
Clay, hard, sandy	33	497
Clay, hard, blue	5	502

10/9-4D2. U.S. Air Force. Drilled by Evans Bros. in August 1958. 14-inch casing. Altitude 2,306.9 ft. Perforated: 150-500 ft. Materials classified by Corps of Engineers, U.S. Army.

Sand, light-brown, fine- to coarse-grained	40	40
Clay, streaks of fine sand	13	53
Sand, fine- to coarse-grained	122	175
Sand, fine- to coarse-grained, slightly cemented	10	185
Sand, fine- to coarse-grained	25	210
Sand, fine- to coarse-grained, occasional streaks of clay	5	215
Sand, fine- to coarse-grained	19	234
Sand and clay, slightly gravelly at 255 ft	61	295
Sand and occasional streaks of clay	30	325

10/9 4D2

10/8-32R1. U.S. Air Force. Drilled by Clyde. Uncased test hole. Altitude about 2,450 ft.

	Thickness (feet)	Depth (feet)
Surface soil and sand	62	62
Granite, red	27	89
Clay, blue, with streaks of coarse sand	25	114
Granite, blue	34	148

10/9-4D1. U.S. Air Force, Edwards Air Force Base test well 4. Drilled by Barber-Bridge Drilling Corp., in February 1957. Altitude about 2,280 ft. 12-inch casing 0 to 500 ft. Perforated: 144-195 ft and 200-433 ft.

Quartz sand	34	34
Clay, silty, and coarse sand	108	142
Gravel and very fine sand, poorly sorted	14	156
Clay, silt, and sand; with gravel, very hard; no water	33	189
Gravel, sand, and silt, very dirty	2	191
Clay, hard, sandy, light-brown to red, very tight, forms balls; sand, fine to very coarse with intermixed fine gravel	27	218
Sand and silt with some fine gravel, dirty	10	228
Clay and sand, silty, some gravel to pebble size, clastics, very adhesive, forms compact balls	87	315
Granite and quartz	87	402
Granite, decomposed	8	410
Gravel, fine	8	418
Sand, cemented	10	428
Silt, fine, tight	5	433
Sand, cemented	4	437
Clay, hard, sandy, yellow	27	464
Clay, hard, sandy	33	497
Clay, hard, blue	5	502

10/9-4D2. U.S. Air Force. Drilled by Evans Bros. in August 1958. 14-inch casing. Altitude 2,306.9 ft. Perforated: 150-500 ft. Materials classified by Corps of Engineers, U.S. Army.

Sand, light-brown, fine- to coarse-grained	40	40
Clay, streaks of fine sand	13	53
Sand, fine- to coarse-grained	122	175
Sand, fine- to coarse-grained, slightly cemented	10	185
Sand, fine- to coarse-grained	25	210
Sand, fine- to coarse-grained, occasional streaks of clay	5	215
Sand, fine- to coarse-grained	19	234
Sand and clay, slightly gravelly at 255 ft	61	295
Sand and occasional streaks of clay	30	325

10/9 4D2

10/9-4D2.--Continued

	Thickness (feet)	Depth (feet)
Sand, clayey	60	385
Clay, sandy	10	395
Sand and streaks of clay, well-cemented at 426 ft, 452 ft, and 470 ft	95	490
Sand, cemented	10	500

10/9-7A1. U.S. Air Force, Edwards Air Force Base North Base well 1. Drilled by J. B. Henderson. 10-inch casing. Altitude 2,276.0 ft. Perforated: 125-197 ft.

Sand, windblown, and topsoil	3	3
Clay, yellow, and sand, fine. This thin bed of sand and clay contained a small amount of alkali surface water	80	83
Clay, yellow, and some small gravel	30	113
Clay, yellow, and some fine sand	9	122
Clay, yellow, and fine gravel, very tight	2	124
Clay, yellow	5	129
Gravel, loose, and some clay. This is the best showing of water so far. Water standing at the 75-ft level	6	135
Clay, yellow	5	140
Clay, yellow, and gravel, fine	12	152
Clay, yellow, and sand	3	155
Clay, gray, and some fine sand; some water	16	171
Clay, gray, and coarse sand	13	184
Gravel, clean	2	186
Clay, gray, and sand, coarse	6	192
"Rock-spar"	1	193
Rock, gravel, and clay, light-brown	7	200

10/9-7A2. U.S. Air Force, Edwards Air Force Base North Base well 2. Drilled by J. B. Henderson. 10-inch casing. Altitude 2,276.9 ft.

No entry	5	5
Clay, fine, and decomposed granite	5	10
Sand, clay, and some decomposed granite	70	80
Clay and gravel, sandy	30	110
Clay, sandy; and some decomposed granite	30	140
Gravel and rock	25	165
Clay, sandy; and decomposed granite	20	185
Sand, gravel, and rock; some clay	15	200

10/9 7A1

9/10-24G1. — Continued.

Material	Thickness (feet)	Depth (feet)
Sand, fine to medium, poorly sorted, hard; 454 to 455 hard compact sandy clay	15	457
Sand, medium to coarse, softer, buff; clay increasing at base	71	528
Clay, light brown, soft; sand medium to coarse	17	545
Sand, very coarse, buff; and gravel; very little clay; medium to coarse from 630 to 640 feet	95	640
Sand, fine to medium, hard poorly sorted, buff; some clay, light brown	26	666
Sand, medium to coarse, some clay, poorly sorted, buff	39	705
Sand, medium, some brown clay	4	709
Clay, light brown, hard; and sand, medium to coarse	7	716
Sand, medium to coarse, very little clay	14	730
Clay, light brown; and sand fine to medium; clay increasing with depth	20	750

10/9-7A1 (EAFB, North Base, well 1). Drilled by J. B. Henderson. 10-inch casing. Altitude about 2,276 feet. Perforated: 125-197 feet.

Blow sand and top soil	3	3
Clay, yellow, with sand, fine. This thin strain of sand and clay showed a small am't of surface water ~~strong~~ with alkali	80	83
Clay, yellow, with some small gravel	30	113
Clay, yellow, with some fine sand	9	122
Clay, yellow, with small gravel, very tight	2	124
Clay, yellow	5	129
Gravel, loose, with some clay. This is the best showing of water so far. Water standing at 75-foot level	6	135
Clay, yellow	5	140
Clay, yellow, and gravel, small	2	142
Clay, yellow, and gravel, small	10	152
Clay, yellow, and sand	3	155
Clay, gray, with some fine sand; some water	16	171
Clay, gray, with coarse sand	13	184
Gravel, clean	2	186
Clay, gray, and sand, coarse	6	192
"Rock-sparr"	1	193
Rock, gravel, and clay, light brown	7	200

10/9 7A2

10/9-7A2 (EAFB, North Base, well 2). Drilled by J. B. Henderson. 10-inch casing. Altitude 2,276.89 feet.

Material	Thickness (feet)	Depth (feet)
(No data)	5	5
Clay, fine, and decomposed granite	5	10
Sand, clay, and some decomposed granite	70	80
Clay and gravel, sandy	30	110
Clay, sandy, and some decomposed granite	30	140
Gravel and rock	25	165
Clay, sandy, and decomposed granite	20	185
Sand, gravel, and rock; some clay	15	200

10/9-31C1 (EAFB Federal Housing project, well 3). 10-inch casing. Altitude about 2,280 feet.

Clay, sandy, hard	45	45
Granite, decomposed	9	54
Sand, fine, loose; water bearing	1	55
Sandstone	2	57
Granite, decomposed; water bearing	6	63
Clay, sandy	5	68
Granite, decomposed, quartz decomposed	12	80
Sand, fine	2	82
Granite, decomposed, loose; water bearing	8	90
Granite, decomposed, hard	30	120
Granite, friable; main water bearing member	42	162
Granite, decomposed, hard	3	165
Granite, hard	12	177

10/10-35F1 (EAFB Toxic Gas Yard Well). 12-inch casing. Altitude 2,321.50 feet. Perforated, 35-82 feet.

Top soil	4	4
Sand	11	15
Sandy clay	10	25
Cemented sand and clay	47	72
Granite sand and gravel	18	90
Granite ash	8	98
Granite	2	100
Granite ash	2	102
Hard granite	12	114

11/9 32Q1

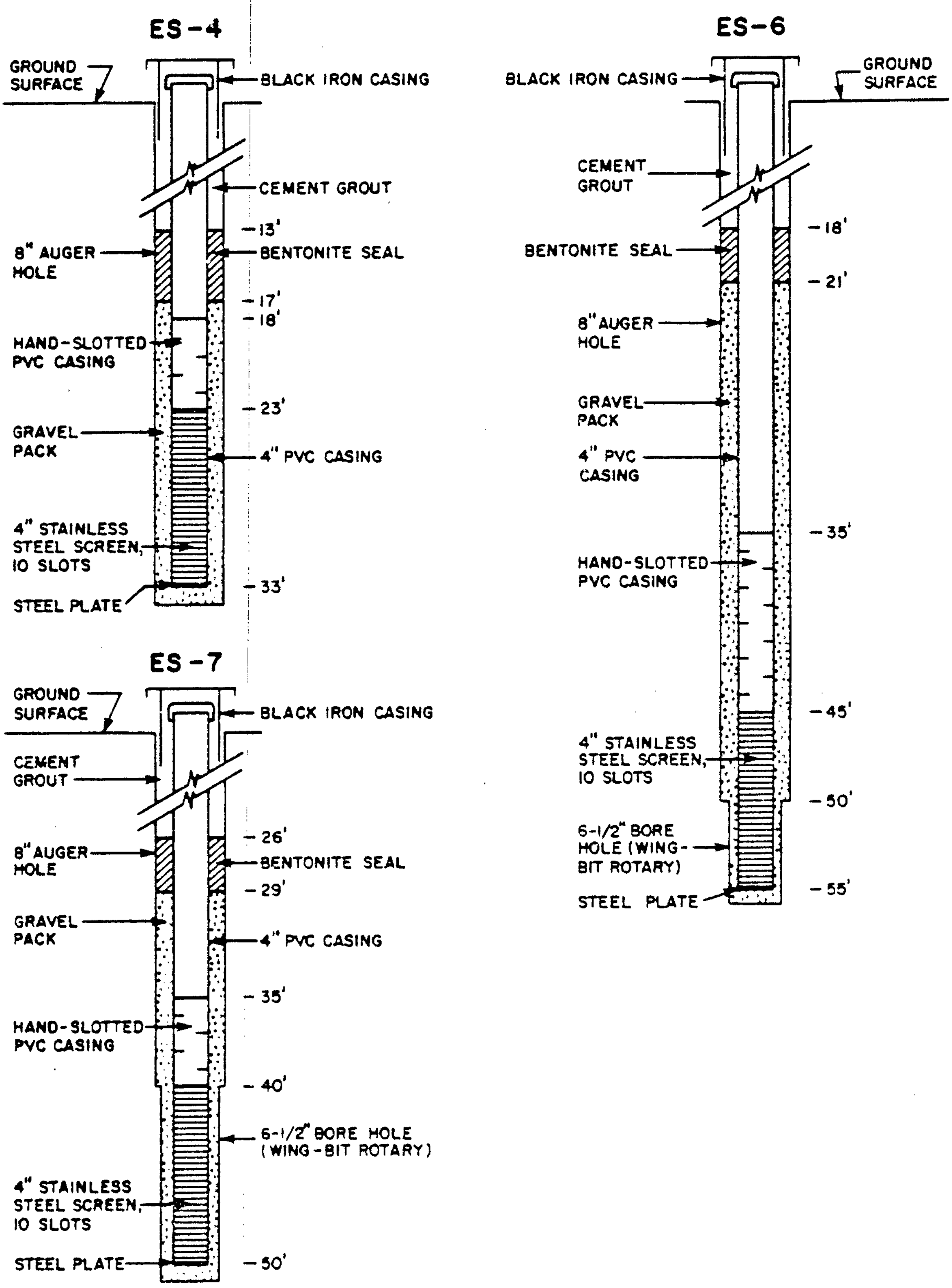
11/9-32Q1. U.S. Air Force, Edwards Air Force Base North Base well 3. Drilled for the Linde Co. by Evans Bros. in September 1957. Rotary well, 16-inch casing, perforated 234 to 450 ft. Casing was reperforated after the well was first tested. The perforated interval was at shallower depth but the exact interval is unknown. Altitude 2,302.5 ft. Materials classified by driller.

	Thickness (feet)	Depth (feet)
Surface sand	22	22
Sand and streaks of clay	98	120
Sand	85	205
Boulders with some clay	35	240
Clay and gravel	10	250
Clay	10	260
Coarse sand with streaks of sandy clay	25	285
Sandy clay	20	305
Clay with streaks of sand	45	350
Clay with thin streaks of sand	100	450

APPENDIX D

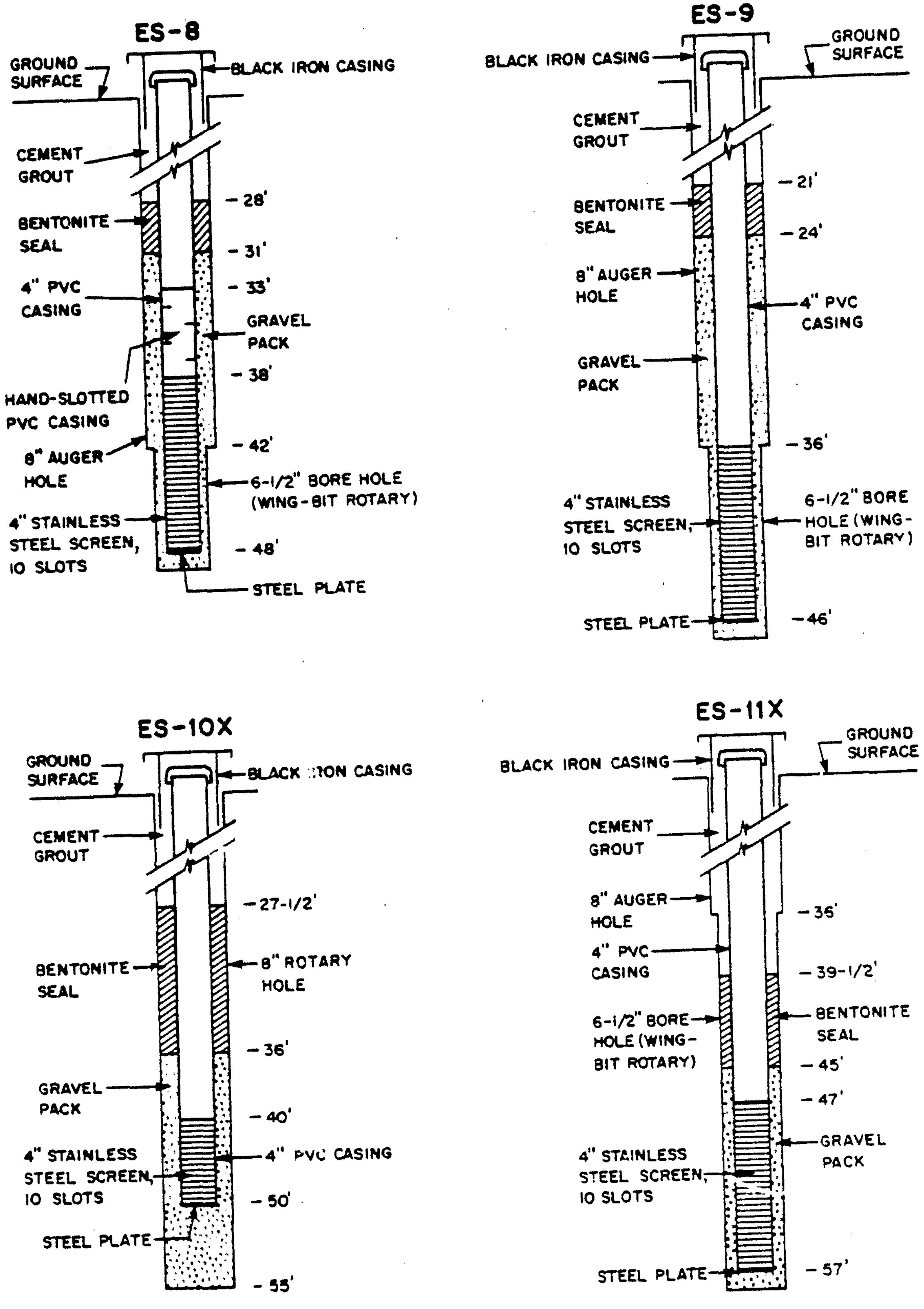
WELL COMPLETION LOGS,
MARCH 1982

WELL DESIGN



ES-4
GROUND SURFACE
BLACK IRON CASING
CEMENT GROUT
-13'
8" AUGER HOLE
BENTONITE SEAL
-17'
-18'
HAND-SLOTTED PVC CASING
-23'
GRAVEL PACK
4" PVC CASING
4" STAINLESS STEEL SCREEN, 10 SLOTS
STEEL PLATE
-33'
ES-7
GROUND SURFACE
BLACK IRON CASING
CEMENT GROUT
-26'
8" AUGER HOLE
BENTONITE SEAL
-29'
GRAVEL PACK
4" PVC CASING
-35'
HAND-SLOTTED PVC CASING
-40'
6-1/2" BORE HOLE (WING-BIT ROTARY)
4" STAINLESS STEEL SCREEN, 10 SLOTS
STEEL PLATE
-50'
ES-6
BLACK IRON CASING
GROUND SURFACE
CEMENT GROUT
-18'
BENTONITE SEAL
-21'
8" AUGER HOLE
GRAVEL PACK
4" PVC CASING
-35'
HAND-SLOTTED PVC CASING
-45'
4" STAINLESS STEEL SCREEN, 10 SLOTS
-50'
6-1/2" BORE HOLE (WING-BIT ROTARY)
STEEL PLATE
-55'

WELL DESIGN



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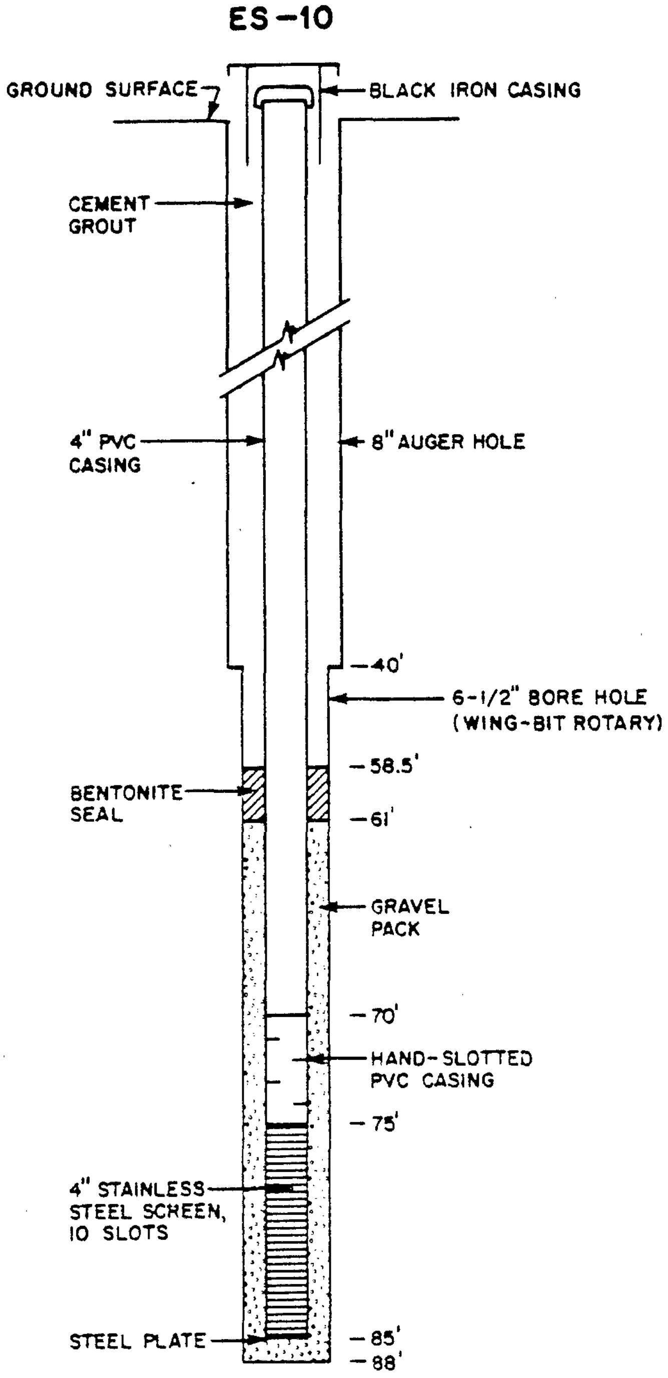
WELL DESIGN


ES-10
GROUND SURFACE
BLACK IRON CASING
CEMENT GROUT
4" PVC CASING
8" AUGER HOLE
40'
6-1/2" BORE HOLE (WING-BIT ROTARY)
58.5'
BENTONITE SEAL
61'
GRAVEL PACK
70'
HAND-SLOTTED PVC CASING
75'
4" STAINLESS STEEL SCREEN, 10 SLOTS
STEEL PLATE
85'
88'

APPENDIX E

GEOLOGIC DRILLING LOGS, MARCH 1982

ES

DRILLING LOG

Well No.: ES-1

Date: 5/27/82

Location: Main Base Dump Site

Altitude (Datum):

Method: Auger.

Size of hole: 8"

Size of casing

Driller: Sterling

Start 13:15

End - 19:50

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1				
2		Split Spoon Sample Fn Sd, Trace gravel, Trace Clay 96%, 2%, 2% L Be	SP	8/6" = Blow count
3				
4				
5		Weathered Bedrock - Al Granite. Tan.	Bedrock	Glass Vials filled from Spoon, Plastic Bottle from Grab - Not enough sample in Spoon. 20/3" - Blow count.
6				
7				
8		Weathered Bedrock, Tan	"	
9				
10				
11		Weathered Bedrock L. Brown.	"	Sample damp.
12				
13				
14		Weathered Bedrock L. Brown.	"	damp
15				
16				
17				
18		Weathered Bedrock [illegible] Be.	"	damp
19				
20		Weathered Bedrock D. Be. - Granite	"	Damper
21	TD.			

S = split spoon sample

≤ soil grab sample

ES DRILLING LOG

Well No.: ES 1A

Date: Feb 25, '22

Location: EAFB, North Base, 1A

Altitude (Datum):

Method: Rotary

Size of hole: 4"

Size of casing: none

Driller: Stone Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		Gravelly sand, SW, 40% gravel, dark brwn, loose, non-plastic	SW	smell of oil
2				
4	S	coarse well-graded sand, SW		smell of oil
	S	5% fines, tan, loose, non-plastic		
6		well-sorted gravel, GW 25%	GW	
		coarse sand, grey-brown, loose		
8		silty sand, SM, 10% fines, reddish	SM	hint of oil smell
		brown, loose, non-plastic		
10	S	sandy gravel, (GW), coarse sand	GW	
		25%, lgt brwn, streaks of clay, grading to less gravel at 11' loose		
12				
14				oil smell
16				
18				loss of water in tub, smell of oil bentonite mud added to hole
				smell of oil
20	S S			
22		gravelly sand SW, 20% gravel	SW	smell of oil
		light brown, loose		
24				
26				smell of oil
28				
30				
32				
		Poorly graded sandy, clayey gravel, clay 10%, sand 20% light brown, loose	GC	
34				
36				
38				
40	S			
42				
44				
46				
		sandy clay, CL, sand 10%, brown, moist, plastic	CL	
48				
50	S S			
		Silty coarse sand SM, 10% fines reddish brown, loose non-plastic	SM hole completed at 57 ½ ft	

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SS = split spoon sample

S : soil grab sample

ES DRILLING LOG

Well No.: ES 1B

Date: Feb 25, 1982

Location: EAFB, North Base, Site 1B

Altitude (Datum):

Method: Rotary (no mud, only water)

Size of hole: 6"

Size of casing: none

Driller: Stang Drilling & Exploration. Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2		Gravelly sand, SW, light brown, non-plastic, loose, 50% gravel	SW	oil smell
4	S			
6	S	Sandy clay, CL, brown, 15% coarse sand, plastic	CL	oil smell
8		Silty coarse sand, SM, 10% fines, reddish brown, loose	SM SW	oil smell
10	S		SW CL	oil smell, lenses of coarse sand
12				
14				
16				
18				
20	S SS		SW SC	hint of oil smell
22				SM white
24				
26				
28				
30			CL	
32				
34				
36		Gravelly, silty sand, 15% gravel, 10% silt, brown loose	SW	
38				little clay
40	SS			oil smell
42				
44				
46		gravelly, silty sand, 30% gravel, 25% silt, brown, non-	SM	very little clay, oil smell
48		plastic, loose		
50	S			
			hole completed 57 1/2'	
60				

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ES

DRILLING LOG

Well No.: ES 1C

Date: Feb 2, [illegible]

Location: NORTH BASE 1C **Altitude (Datum):**

Method: Hollow stem auger **Size of hole:** 2" **Size of casing:** NONE

Driller: Sierra Drilling and Exploration, Rancho Cordova

[S] - sample for [illegible] and [illegible] for nitrates

[ ] - sample for soil classification

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2	11:40	Fine sand, SW, well sorted, lt grey, non-plastic, loose, dry	SW	[illegible] gravel-size [illegible]
4	[S]			
6		Medium sand, SP, Fine sand 25%, light grey, [illegible]	SP	
8		moist		
10	[S]			light brown
12				[illegible] moist, gravel-size white [illegible]
14				[illegible]
16		silty sand, SM, 55% fines,	SH	
18		brown low plasticity		
20	[illegible]			
22		silty clayey fine sand HL,	HL	Acid smell, white gravel-size accretions, that [illegible] to touch
24		dark brown, semi-plastic, loose moist		
26	[S]			white
28				
3[illegible]				
32				[illegible] gravel [illegible]
34				light brown
36				
38				
4[illegible]	[S] [illegible]	Silt HL, white, non-plastic, dense		
42				light brown
44				
46				
48				
5[illegible]				
[illegible]				Acid smell [illegible]
[illegible]		[illegible] CL, light brown, plastic, stiff, moist	CL	[illegible] drilling [illegible]
[illegible]	[S] [S]		SM	acid stains on SM
[illegible]	12:30	silty sand, SM, 30% fines, [illegible] non-plastic, loose	hole completed at 53½'	
[illegible]		dry		
[illegible]				

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ES DRILLING LOG

Well No.: ES 1D1

Date: Feb. 19, 1982

Location: North base, 1D1

Altitude (Datum):

Method: Hollow stem auger, slant 30°

Size of hole: 8"

Size of casing: none

Driller: Stana Drilling & Exploration, Rancho Cordova

I = split-spoon sample

[S] = [illegible] 3x1 sample

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
	1:00 p.m	Gravelly sand, SW, 10% fines, brown, non plastic, loose, moist	SW	
2	[S]			
4		Silty sand, SM, 10% medium sand, brown, non-plastic loose, moist	SM	
6				
8				
10				
12		SM, light tan slightly moist		
14				cuttings contain white nodules [illegible]
16				
18		SM, light brown slightly moist		
20	[SS]			
22				
24				
26		SM tan, slightly moist		
28				
30	[S]			
32		Clayey sand, SC, 5% medium sand, brown plastic, dense, moist	SC	
34				smoke coming out of hole
36		Clay, CL, dark brown, moist, stiff		
38			CL	
40	[SS]		- _ - - =	cemented hard drilling
42				
44				
46				
48		[illegible] clay, CL, [illegible] brown, low plasticity, moist		auger stuck in hole no more water added to hole [illegible] white [illegible]
50	I			10 gallons of water added
52		Poorly graded silty sand, SM, silt 40%, light brown, non-plastic, loose, moist	SM	
54				
56	[S]			silt decreasing to 5%
58		Sandy clay, brown	C-	
60	I II	Gravelly sand, well graded, 10% fines, brown, loose	SW	Hole completed at 61½'

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S = split spoon sample

[illegible] sample

ES

DRILLING LOG

Well No.: ES 1D2,

Date: Feb. 24, 1982

Location: North Base, Site 1D

Altitude (Datum):

Method: Hollow-Stem Auger

Size of hole: 2"

Size of casing: none

Driller: Stang Drilling & Exploration, Rancho Cordova, CA

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2		gravelly sand, SW, 10% fines, 20% gravel, lgt brown, non-plastic, loose, dry	SW	
4	S			20% gravel, brown
6				
8				white nodules
10		silty gravelly sand, 20% fines, 10% gravel, reddish brown, nonplastic, loose moist	SM	
12				(some clay streaks)
14				
16				
18				clay streaks
20	SS			increasing gravel: 25%
22				
24				
26		gravelly clay, CL, brown, plastic, stiff, gravel 10%, very wet	CL	
28				
30	S			10 gals of water added to hole
32		gravelly sand, SM, 20% fines, 25% gravel, reddish brown, non-plastic, loose, moist	SM	
34				
36				
38				
40	SS			clay streaks
42				
44				
46				
48				
50	S			increasing [illegible]
52				[illegible]
54		sandy clay, CL, brown, plastic	CL	rust and oil(?) discoloration
56	S	loose silty sand, light brown, silt 40%, moist	SM	white nodules
58				
60	S SS		CL	CL like at 53' [illegible]
		End of hole at 60½'	SM	SM like at 55'

5 gal added

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ES DRILLING LOG

Well No.: ES2, Site 10

Date: 2/26/82

Location: Jet fuel line, Bldg 1810, Site 10 **Altitude (Datum):**

Method: Hollow stem auger **Size of hole:** 8" **Size of casing**

Driller: Staug Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1		Silty sand, SH, 30% fines, reddish brown, loose, moist	SH	clay streaks
2				
3				
4		Decomposed granite with clay streaks; light grey	Decomp granite	
5				
6				
7				
8				
9				
10				
11				
12				Jet fuel smell
13				— " —
14				— " —
15				— " —
16				— " —
17				— " —
18				— " —
19				— " —
20				— " —
21				— " —
22		Granite bedrock	Hole completed	
23				
24				
25				
26				
27				
28				
29				
30				

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ES

DRILLING LOG

Well No.: ES 3

Date: 2/26/82

Location: Site 10, By Bldg 1810

Altitude (Datum):

Method: Hollow-stem auger

Size of hole: 8"

Size of casing: none

Driller: Staug Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1		silty sand, SM, 30% fines, reddish brown, loose, moist	SM	
2				
3				
4				
5		Decomposed granite, dark grey-brown, loose moist		contains pyrite
6				
7				
8				jet fuel smell faint
9		granite becoming greyer		—"— faint
10				no more fuel smell
11				
12		Bedrock	Hole completed	
13				
14				
15				

ES

DRILLING LOG

Well No.: ES-4

Date: 3/5/82

Location: Main Base, Site 8, 10, 11

Altitude (Datum): 2283.8'

Method: Auger

Size of hole: 8"

Size of casing:

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1				
2				
③		Silt, Med-fine Sand 80% 20% L Brown	SM	Dry No fuel
4				
5				
⑥		Med-fine Sand, Clay, Silt 60% 30% 10% Brown	SC	Damp no fuel
7				
8				
⑨		Course-fine Sand, Clay, Grav → 85% 10% 5% Brown	SC	wet no fuel
10				
11				
⑫		Course-fine Sand. Clay 90% 10% D. Brown	SC	wet No fuel - decrease coarseness
13				
14				
⑮		Clay, fine Sand 80% 20% D Br.	CL	Damp No fuel
16				
17				
⑱		~~Coarse~~ fine Sand, Clay 60% 40% Reddish Br.	SC	moist No fuel
19				
20				
㉑		Course-fine Sand. Clay 60% 40% Reddish Br.	SC	moist No fuel
22				
23				
㉔		D. BR. "Plastic" Clay, fine Sd 90% 10%	CL	Damp No fuel
25				
26				
㉗		D. Brown "Plastic" Clay, Med-fine Sd. 70% 30%	CL	Damp No fuel
28				
29				
㉚		D Brown Clay "Plastic" Med-fine Sand 80% 20%	CL	moist No fuel

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ES

DRILLING LOG

Well No.: ES-4

Date: 3/5/82

Location: Main Base Site, 8, 10, 11

Altitude (Datum):

Method: Auger

Size of hole:

Size of casing:

Driller:

1.5
37.95
34.05
1.50

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
31				
32				
㉝		D Brown Clay "Plastic" Fine Sand	CL	Moist No fuel - Clay in Balls
34		80% - 20%		
35				Damp
㊱		D Brown Clay "Plastic" "Fine Sd	CL	
37		70% , 50%		
38				no cuttings return in sample
㊴				some wet cuttings on auger
40				
41				
㊷			T.D. 36'	
43				
44				
㊺				

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ES

DRILLING LOG

Well No.: ES-5

Date: 5/27/82

Location: Main Base **Altitude (Datum):**

Method: Auger **Size of hole:** 8" **Size of casing:** None

Driller: S[illegible] 08:15

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
				Sample every 3'
1				
2		Gravel		
③		Decomposed Granite, subangular <?% sand.	GP	No Fuel Smell, sample [illegible] damp.
4		Tan.		
5				
⑥		Fine Sand, Decomposed Granite 60% 40%	SW	No Fuel smell, sample dry
7		Tan		
8				
⑨		Very Fine Sd, Decomposed Granite 95% / Sm. Amt. Clay 5%	SW	No Fuel smell, Damp.
10		Tan		
11				
⑫		SAA, Very Fine Sd, Decomp. Granite 93% 7%	SW	Increased Dampness, No Fuel
13		L. Br.		
14				
⑮		med. Gr		
16		Sandy, Gravel, Sm. Clay 87% 10% 3%	SW	Damp some [illegible], No Fuel
17		Reddish Br.		
⑱				
19		Sandy Gravel, Clay 80% 15% 5%	SW	[illegible] plastic [illegible]
20		D. Reddish Br.		
㉑				
22		Coarse-Med Sandy Gravel, Clay 80% 10% 10%	SW	Moist [illegible], plastic, No Fuel subangular
23		Reddish Br		
㉔				
25		Coarse-Med Sandy, Gravel, Clay 70%, 20% 10%	SW	Damp, No Fuel Sub Angular
26		Br.		
㉗				
28		Coarse-Med Sand, Small Gravel 70%, 20% 10%	GP	Damp, No Fuel Sub-Angular
29				
㉚		Coarse-Med Sand Fine-Sm Gravel,	GP	Damp, No Fuel
		65%, 20% 15%		

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ES

DRILLING LOG

Well No.: ES-5

Date: 2/27/92

Location: Main Base

Altitude (Datum):

Method: Auger

Size of hole: 8"

Size of casing: None

Driller: Stang

End Drilling 10:40

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		C		
31'				
32				
		G		
Damp ㉝		Coarse-Med sand, Coarse-Med Gravel	SW	Increase size in Gravel
34		Clay.		Damp, No Fuel.
		65%, 20% 15%		2" Gravel lense, Clay lense
35'		Br.		
Damp ㊱		Coarse-Med Sand, Coarse-Med Gravel	SW	material size SAA Damp No Fuel
37		Clay		
		65%, 20%, 15% Br.		
38				
Lower damp ㊴		Med-Fine Sand, small Gravel, Clay	SW	Clay in balls, less sand. Moisture
40		30%, 10%, 10% Br.		in sample - boiling (compacted)
41'				
㊷		Boulder		
Sample at 42'		Fine Sd, Clay, Trace gravel	SC	Damp, No Fuel
		80%, 20%		
		Br.		

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ES

DRILLING LOG

Well No.: ES-6
Date: 3/2/82

Location: South Base
Altitude (Datum): 2289.2'

Method: Auger
Size of hole: 8"
Size of casing

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1				
2				
③		Clay, Coarse Sand, Gravel 90% 5% 5% Tan	CL	Dry
4				
5				
⑥		Coarse-Fine Sand, Clay, Gravel 60% 30% 10% L. Brown.	SC	Dry
7				
8				
⑨		Med-Fine Sand, Clay, Gravel 55% 40% 5% Brown.	SC	DRY
10				
11				
⑫		Med-Fine Sand, Clay, Gravel 50% 45%, 5% L. Brown	SC	Decrease Coarse Material Dry
13				
14				
⑮		Coarse-Fine Sand, Clay, Gravel 50% 45% 5% Brown.	SC	Dry, Increase coarse material TO. Clay. White [illegible]
16				
17				[illegible]
⑮		Clay, Silt, Fine Sand, TR. Gravel 60%, 30% 10% L. Brown	CL	[illegible] [illegible]
9				
20				
㉑		Clay, Silt, Med-Fine Sand. 60% 20% 20% Brown	CL	Dry, Clay Caking
22				
23				
㉔		Clay Gravel, Med-Fine Sand 85% 10% 5% Reddish Brown	CL	Dry, Clay caking compacted
25				
26				
㉗		Clay, Silt, [illegible] Sand, 80% 15% 5% Reddish Brown	CL	Dry, Clay cutting [illegible] [illegible] Hard drilling
28				
29		Clay Med-Fine Sand Gravel	CL	Reddish Brown [illegible]
㉚		70% 25% 5%		

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ES

DRILLING LOG

Well No.: ES-6

Date: 3/2/82

Location: South Base

Altitude (Datum):

Method: Auger

Size of hole: 8"

Size of casing

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
31				
32				
33		Coarse-Fine Sand, Clay 60% 40%	SC	Dry - Drilling Easy Reddish Br
34				
35'				
36		Coarse-Fine Sand, Clay 70% 30%	SC	Dry Reddish Brown
37				
38				
39		Clay, Med-Fine Sand 60% 40%	CL	Dry Drilling Easy Reddish Br.
40				
41				
42		Clay, Coarse-Fine sand, Gravel 60% 55% 5%	CL	Dry - Increase in coarseness Reddish Br
43				
44		C		
45		Clay, Coarse-Fine Sand 70% 30%	CL	Dry - Drilling Easy Reddish Brown Clay lense (Compacted in place)
46				
47				
48		Clay, Coarse-Fine Sand 60% 40%	CL	Dry - Increase in Moisture Content Reddish Brown, sticking to Auger)
49				50' End of Auger
-50				
51				52' Rotary
52		Med Fine Sand, Clay 65% 35% L. Brown	SC	Taking wtr.
53				
54				
55		Med-Fine Sand, Clay 80% 20% Reddish Brown	SC	Taking wtr.

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DRILLING LOG

Well No.: ES-7

Date: [illegible]

Location: South Base Site 5

Altitude (Datum): 2286.1

Method: Auger

Size of hole: 8"

Size of casing: 2"

Driller: Steve

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1				
2				
3		Brown Clay, Trace Sand 100%	CL	Dry
4				
5				
6		Clay, Silt, ~~Coarse~~-Fine Sand. 70%, 25% 5% Tan-Green	CL	Dry
7				
8				
9		Med-Fine Sand, Clay, Silt 60% 30% 10% Green	SC	Dry
10				
11				
12		Clay, Silt 70% 30% Brown	CL	Dry
13				
14				
15		Coarse-Fine Sand, Silt, Clay. 65% 20% 15% L. Brown.	SM	Dry
16				
17				
18		Clay, Coarse-Fine Sand 80% 20% Brown.	CL	Dry Beds of White Clay (Coarse) " of Brown Clay.
19				
20				
21		Clay, Sand 90% 10% D. Brown	CL	Damp - Plastic Clay.
22				
23				
24		Fine Sand, Silt, Clay. 80% 15% 5% L. Brown.	SM	DRY.
25				
26				
27		Med.-Fine Sand, Clay Silt 80% 15%, 5% Reddish Brown.	SC	Damp - Increase in Moisture + Coarseness
28				
29				
30		Med-Fine Sand Clay 70% 30% D. Brown	SC	Damp Drilling Easy

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ES DRILLING LOG

Well No.: ES-7

Date: 3/3/82 - 3/4/82

Location: S. Base Site 5

Altitude (Datum): 2286.1

Method: Auger

Size of hole: 8

Size of casing

Driller: [illegible] Start 13:30 3/3/82 finished 09:30 3/4/82

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
31				
32				
33		Med-Fine Sand, Clay 75% 25% Brown	SC	Damp Clay Balls-Lenses Drilling Easy
34				
35				
36		Med-Fine Sand, Clay 80% 20% Reddish Brown	SC	Damp Drilling Easy
37				
38				
39		Clay, Coarse-Fine Sand -Damp 60% 40% Reddish Brown	CL	Clay layer (Dry) [illegible] content
40				
41				
3/4/82 42		Med-Fine Sand, Clay 60% 40% L Brown.	SC	Rotary sample - taking wtr.
43				
44				
45		Coarse-Med Sand, Clay 70% 30% L Brown.	SC	Rotary sample taking wtr.
46				
47				
48		Coarse-Med Sand, Clay 75% 25% L. Br.	SC	Increase in coarseness Taking wtr
49				
50		Coarse-Med Sand, Clay 80% 20%	SC	Taking wtr
			[illegible] silt	
			T.D. 50'	

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ES DRILLING LOG

Well No.: ES-8

Date: 3/4/82

Location: S. Base. 5. to 5

Altitude (Datum): 2288.4

Method: Auger

Size of hole:

Size of casing

Driller: Stang Start 10:10 End:

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1				
2				
③		Clay, Med-Fine Sand 90% 10% Brown.	CL	Dry
4				
5				
⑥		Clay, Silt, Coarse-Fine Sand 70% 20% 10% Tan	CL	Dry
7				
8				
⑨		Clay, Coarse-Med Sand, Gravel 60% 30% 10% Brown.	CL	Dry Layer of Clayey Sand.
10				
11				
⑫		Coarse-Fine Sand, Clay, Gravel 70% 20% 10% L. Br.	SC	Dry-Damp White Clay w/ Coarse Sd Lense (Small amt.)
13				
14				
⑮		Silt, Coarse-Fine Sd. Clay. 60% 30% 10% Tan	SM	Dry Layer Silty Sand
16				
17				
⑱		Clay, Silt, Med-Fine Sand 60% 20% 20% Reddish Br.	CL	Dry-Damp Balls of Clay-Med Fine Sd (lense)
19				
20				
㉑		Fine Sand, Silt, Clay 50% 30% 20% L. Reddish Br.	SM	Dry
22				
23				
㉔		Med-Fine Sand, Clay 60% 40% Reddish Br.	SC	Dry-Damp White Clay Balls (large) Small amt Br. Clay (lense)
25				
26				
㉗		Med-Fine Sand, Clay, Coarse Gravel. 40% 40%	SC	Increase coarse material Damp
28				
29				
㉚		Coarse-Fine Sand, Clay 70% 30% Red. Br.	SC	Damp.

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ES

DRILLING LOG

Well No.: ES-8

Date: 3/4/82

Location: S. Base S. to S

Altitude (Datum):

Method: Auger

Size of hole:

Size of casing:

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
31				
32				
③③		Coarse-Fine Sand, Clay 75% 25% Red. Br.	SC	Damp
34				
35				
③⑥		DRY Red Clay, mixed w/ coarse-fine Sand - Damp 70% Clay - 30% Sand	CL	Damp - DRY
37				
38				
③⑨		White Red Clay - Dry, 10% Sand 90%	CL	DRY
40				
41				
④②		Coarse-Med Sand, Clay 70% 30%	SC	Damp Drilling Hard (wtr. Zone)
43				
44				
④⑤		Coarse-fine Sand, Clay 70% 30%	SC	Rotary Sample. Taking wtr.
46				
47				
④⑧		Coarse-fine Sand, Clay 80% 20%	SC	Taking wtr. Increase [illegible]

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ES DRILLING LOG

Well No.: ES-9

Date: 3/4/82

Location: S. Base Site 5

Altitude (Datum): 2287.1

Method: Auger

Size of hole:

Size of casing:

Driller:

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1				
2				
③				
4		Br. Clay, Coarse Sand 90% 10%	CL	Dry
5				
⑥				
7		Green Clay, Silt, Fine Sand 75% 20% 5%	CL	DRY
8				
⑨				
10		Green Clay, Med-Fine Sand 90% 10%	CL	DAMP Balls "plastic" green Clay
11				
⑫				
13		Silt, Fine Sand, Clay 50% 40% 10% L. Brown.	ML	DRY
14				
⑮				
16		Dry Brown Clay 100%	CL	DRY In Balls.
17				
⑱				
19		white Brown Clay, Coarse Sand 90% 10%	CL	DRY White Clay in sample
20				
㉑				
22		Red Clay, Med-Fine Sand 60% 40%	CL	DAMP
23				
㉔				
25		Red Coarse Fine Sand, Clay, Gravel 80% 15% 5%	SC	DAMP
26				26' Red Coarse-Fine Sand, Clay - Very Damp
㉗				
28		Red Coarse-Fine Sand, Clay 80% 20%	SC	V. Damp Increase in coarseness
29				
㉚		Red Med-fine Sand, Clay, trace Gravel 80% 20%	SC	Moist Red Clay Balls in Sample (layer)

ES

DRILLING LOG

Well No.: ES-9

Date: 3/4/82

Location: S. Base Site 5

Altitude (Datum):

Method: Auger

Size of hole:

Size of casing

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
31				
32				
33		Red Fine Sand, Silt, Clay 60% 30% 10%	SM	Damp.
34				
35				
36		Red "Plastic" Clay, Fine Sand Streaks of White Clay	CL	Damp - Plastic Switch to Rotary
37		Clay, Sand 90% 10%		
38				
39		Red Clay, Med-Fine Sand 70% 30%	CL	Rotary Sample
40				
41				
42		Coarse-Fine Sand, Clay 70% 30%	SC	taking Wtr.
43		Reddish Brown.		
44				
45		Coarse-fine Sand, Clay 70% 30%	SC	Taking Wtr. Decreasing coarseness

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ES

DRILLING LOG

Well No.: ES-10

Date: 2/27/82

Location: Main Base - Flight Line

Altitude (Datum): 2288.2

Method: Auger

Size of hole: 8"

Size of casing: 4"

Driller: [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1	014:15			
2				
③		Fn. Sand, Clay, Dry 70% 30% L. Br.	SC	Dry
4				
5				
⑥		Crse-Fn. Sand, Gravel, Clay Sub-angular. 85%, 10%, 5% Tan	SW	Dry
7				
8				
⑨		Fine Sand, Clay, Trace Gravel 90%, 10%, L. Brown	SM	Dry
10				
11				
⑫		Fine Sand, Clay, Gravel 85%, 10%, 5% L. Brown	SC	Dry
13				
14				
⑮		Coarse-Fine Sand, Clay, Gravel 83% 10% 7% Brown	SC	Dry [illegible]
16				
17				
⑱		Coarse-Fine Sand, Clay, Gravel 80% 10% 10% Brown	SC	Damp. Some caving [illegible]
19				
20				
㉑		Med-Fine Sand, Trace Gravel, Clay 90%, 10% Tan	SC	Less Damp, some caving (compaction) Decrease - Coarse material
22				
23				
㉔		Coarse-Fine Sand, Gravel, Clay 80%, 15%, 5% Tan	GC	Damp. - No caving Increase - coarse material
25				
26				
㉗		Coarse-Med Sand, Clay, Gravel Brown 70%, 20%, 10%	SC	Damp - Clay-Plastic Increase - coarse material & clay
28				
29				
㉚		Gravel, Clay, coarse sand 1" 70% 20% 10% Brown	GC	Increase coarse material drill Damp, [illegible]

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ES

DRILLING LOG

Well No.: ES-10

Date: 2/27/82

Location: Main Base Flight Line

Altitude (Datum):

Method: Auger to 40ft.

Size of hole: 8"

Size of casing:

Driller: Strong

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
31		1' Gravel lense -32-33'		
32				
33		Clay, med. Fine Sand, Trace Gravel 60% 40% Brown	CL	Damp, Plastic
34				
35'				
36		Clay, Fine Sand, Trace Gravel 80% 20%	CL	Damp. Plastic
37				Switched to Rotary 39', Auger Binding up
38				
39		Clay, Fine Sand 65% 35%	ML	Less Damp, not Plastic
40				
41				
42				43' taken from Rotary
3/1/83 — 43		Sand, Gravel, Clay 50% 30% 20%	GC	Damp
44				
45				
46		Sand, Gravel, Clay 40% 40% 20%	GC	Damp
47				
48				
49		Gravel, Sand, Clay 60% 30% 10%	GC	Increase material size Damp
50'				
51'				
52		Gravel, Sand, Clay 70% 25% 5%	GP	Increase, Material size Damp
53				
54				
55		Gravel, Sand 70% 30%	GP	Increase material size Damp
56				
57				
58		Gravel, Sand, Clay 55% 30% 15%	GC	Damp
59				
60				

DRILLING LOG

Well No.: ES-10

Date: 3/1/82

Location: Main Base

Altitude (Datum):

Method: Rotary

Size of hole: 6"

Size of casing:

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
61 62 63		Gravel, Sand, Clay 55% 30% 15% Reddish Br.	GP	DRILLER ADDING WATER TO PIT Reduced material size
64 65 66		Coarse-Fine Sand, Silt, Clay. Trace Gravel 70%, 15%, 15% Reddish Br.	SC	Reduce material size Adding wtr.
67 68 69		Med-Fine Sand, Silt, Clay 80% 10% 10% Reddish Br.	SM	Reduced material size wtr. stabilized in Pit.
70 7 72		Med-Fine Sand, Silt Clay 85% 10% 5% Reddish Br.	SM	No wtr.
73 74 75		Med-Fine Sand, Small Gravel, Clay 65%, 30%, 5% Reddish Br.	SP	No wtr.
76 77 78		Coarse-Fine Sand, Clay, Trace Gravel 70% 25% 5% Reddish Br.	SC	No wtr.
79 80 81		Coarse-Fine Sand, Clay, Gravel 65% 20% 15% White Clay, Reddish Br. Trace of Granite	SC	Decomposed Granite No wtr.
82 83 84		Tan Decomposed Granite	Bedrock	
85 86 87		Decomposite Granite	"	
88		Hard Granite		

* May be wtr. bearing (67–80)

ES

DRILLING LOG

Well No.: ES-11x

Date: 3/6/82

Location: North Base, Disposal Site

Altitude (Datum): 2286.9

Method: Auger

Size of hole: 8"

Size of casing: 4"

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1				
2				
③		Clay, Silt, Fine Sand 75% 20% 5% Tan-L. Brown	CL	DRY
4				
5				
⑥		L. Br. Clay, Fine Sand 90% 10%	CL	Dry
7				
8				
⑨		Br. Clay, Silt, Fine Sand 75% 20% 5%	CL	Dry
10				
11				
⑫		Br. Clay, Silt, Fine Sand 75% 20% 5%	CL	Some Clay Balls Dry Trace White Clay
13				
14				
⑮		Red Clay, Fine Sand 95% 5%	CL	DRY
16				
17				
⑱		Br. Clay, Fine Sand 95% 5%	CL	some moisture - basically Dry
19				
20				
㉑		Reddish Br. Clay, Trace Fn. Sd. 95% 5%	CL	increase in moisture.
22				
23				
㉔		Red Clay, silt 95% 5%	CL	increase in moisture
25				
26				
㉗		L. Br. Clay, Fine Sand, Gravel 85% 10% 5%	CL	Decrease in moisture
28				
29				
㉚		Red Clay, Med-Fine Sand 95% 5%		Increase moisture

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ES

DRILLING LOG

Well No.: ES-11X

Date: 3/6/82

Location: North Base

Altitude (Datum):

Method: Auger / Rotary

Size of hole: 8"

Size of casing: 4"

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
31				
32				
33		Br. Clay, Med-Fine Sd 90% 10%	CL	Semi-Damp.
34				
35				
36		Br-Red Clay, Med Sd, Gravel 85% 10% 5%	CL	Clay in Balls. Compact & DRY - Damp - Rotary hole dry auger caved up.
37				
38				
39		Br. Clay 100%	CL	DRY - DAMP
40				
41				
42		Br. Clay, Med-Fine Sand 80% 20%	CL	
43				
44				
45		Br. Clay, Med-Fine Sand 70% 30%	CL	
46				
47				
48		Br. Clay, Med-Fine Sand 85% 15%	CL	
49				
50				
51		Br. Clay, Med Fine Sand 70% 30%	CL	
52				
53				
54		Med-Fine Sand, Br Clay 80% 20%	SC	Taking WTR.
55				
56				
57		Coarse-Med Sand, Clay 90% 10%	SC	Taking WTR.

APPENDIX F

ANALYTICAL DATA

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Page 1 of 13

Date Received 2 March 1982

Date Reported 21 April 1982

Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base Attention:

Address

Lab No. Site 1C Soil	820286	820287	820283
Source of Sample	S-ES1C-55'	S-ES1c-3 ft	S-ES1C-25 ft
Date Collected:			
Time Collected:			

Analyses	Units	ANALYTICAL RESULTS		
pH		6.8	0.4	0.75
NO_3^-	ppm	965*	11400*	19400
NO_3^-	%	.0965	1.14	1.94

COMMENTS: As-is basis (some soils wet, others dry)

*Average of quality assurance duplicates

Laboratory Manager

ES ENGINEERING-SCIENCE

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Page 2 of 13

Date Received 2 March 1982

Date Reported 21 April 1982

Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base

Attention:

Address

Lab No. Site 1A, 1B Soil	820257	820251	820250	820266
Source of Sample	S-1A-3 ft	S-1A-10 ft	S-1A-50 ft	S-1b-3 ft
Date Collected:				
Time Collected:				

Analyses	Units	ANALYTICAL RESULTS			
Ethanol	%	-	-	-	-
Furfuryl Alcohol	ppm	-	-	-	-
Motor oil	±	negative	positive	negative	-
Fuel oil	±	positive	positive	negative	-
Aniline (free)	%	-	-	-	<0.027*
Methylene chloride	ppm	<0.01*	<0.01*	<0.01*	<0.01*
1,1-dichloroethane	ppm	<0.004*	<0.004*	<0.004*	<0.004*
Chloroform	ppm	0.69	0.61	0.35	1.29
Trichlorofluoro-methane	ppm	1.65	6.45	14.8	13.3
dichlorodifluoro-methane	ppm	<0.03*	<0.03*	<0.03*	<0.03*
1,1,2,2-tetrachloro-ethane	ppm	<0.006*	<0.006*	<0.006*	0.21
Carbon tetrachloride	ppm	<0.007*	<0.007*	<0.007*	<0.007*
Trichloroethylene	ppm	<0.005*	<0.005*	<0.005*	<0.005*
PCB's (as Arochlor 1254)	ppm	-	-	-	<0.05*

COMMENTS: As-is basis (some soils wet, others dry)

*Below detection limit

- Analysis not requested

Laboratory Manager

ENGINEERING-SCIENCE

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Date Received 2 March 1982
Date Reported 21 April 1982
Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base Attention:

Address

Lab No.	Site 1B, 1D Soil	820264	820265	820272	820279
Source of Sample		S-1B-10 ft	S-1B-50 ft	S-1D1-3 ft	S-1D1-50 ft
Date Collected:					
Time Collected:					

Analyses	Units	ANALYTICAL RESULTS			
Ethanol	%	-	-	<0.3*	<0.3*
Furfuryl alcohol	ppm	-	-	<13.0*	<13.0*
Motor oil	±	-	-	-	negative
Fuel oil	±	-	-	-	negative
Aniline (free)	%	<0.027*	<0.027*	<0.027*	<0.027*
Methylene chloride	ppm	<0.01*	<0.01*	0.36	<0.01*
1,1-dichloroethane	ppm	<0.004*	<0.004*	0.47	<0.004*
Chloroform	ppm	0.30	0.37	0.29	0.34
Trichlorofluoromethane	ppm	13.8	17.5	28.2	20.9
dichlorodifluoromethane	ppm	<0.03*	<0.03*	<0.03*	<0.03*
1,1,2,2-Tetrachloroethane	ppm	<0.006*	<0.006*	<0.006*	<0.006*
Carbon tetrachloride	ppm	<0.007*	<0.007*	<0.007*	<0.006*
Trichloroethylene	ppm	<0.005*	<0.005*	<0.005*	<0.005*
PCB's	ppm	<0.05*	<0.05 *	-	-

COMMENTS: As-is basis (some soils wet, others dry)
* Below detection limit
\- Analysis not requested

Laboratory Manager

ENGINEERING-SCIENCE

RESEARCH AND DEVELOPMENT LABORATORY
600 BANCROFT WAY • BERKELEY, CALIFORNIA 94710 • 415/548-7970

Date Received 2 March 1982

LABORATORY ANALYSIS REPORT

Date Reported 21 April 1982
Ref: 09789.00

For Edwards Air Force Base Attention:

Address

Lab No. Site 1D1, 1D2 Soil	820273	820285	820280	820277
Source of Sample	S-1D1-60 ft	S-1D2-3 ft	S-1D2-50 ft	S-1D2-60 ft
Date Collected:				
Time Collected:				

Analyses	Units	ANALYTICAL RESULTS			
Ethanol	%	<0.3 *	<0.3 *	<0.3 *	<0.3 *
Furfuryl alcohol	ppm	<13.0*	<13.0*	<13.0*	<13.0*
Motor oil	±	negative	-	negative	negative
Fuel oil	±	negative	-	negative	negative
Aniline (free)	%	<0.027*	<0.027*	<0.027*	<0.027*
methylene chloride	ppm	<0.01*	0.283	<0.01*	<0.01*
1,1-dichloroethane	ppm	<0.004*	0.264	0.47	<0.004*
Chloroform	ppm	0.11	0.228	<0.006*	0.02
Trichlorofluoromethane	ppm	3.89	27.0	<0.01*	1.20
Dichlorodifluoromethane	ppm	<0.03*	<0.03*	<0.03*	2.38
1,1,2,2-Tetrachloroethane	ppm	<0.006*	<0.006*	<0.006*	<0.006*
Carbon Tetrachloride	ppm	<0.007*	<0.007*	<0.007*	0.06
Trichloroethylene	ppm	<0.005*	0.559	<0.005*	0.06

COMMENTS:

* Below detection limit

\- Analysis not requested

Laboratory Manager

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600 BANCROFT WAY • BERKELEY, CALIFORNIA 94710 • 415/548-7970

Date Received 2 March 1982
Date Reported 21 April 1982
Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base Attention:

Address

Lab No.	Site 1D2 Soil	820322	820329	830335
Source of Sample		S-1D2-3 ft.	S-1D2-50 ft.	S-1D2-60 ft.
Date Collected:				
Time Collected:				

Analyses	Units	ANALYTICAL RESULTS			
pH	ppm	7.3	7.2	7.1	
NO_3^-	ppm	<10.0*	<10.0*	<10.0*	

COMMENTS: * Below detection limit

Laboratory Manager

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600 BANCROFT WAY • BERKELEY, CALIFORNIA 94710 • 415/548-7970

Date Received 10 March 1982
Date Reported 21 April 1982
Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base
Attention:
Address

Lab No.	Site 2 Soils	820317	820318	820308	820316
Source of Sample		S-2- 2 ft	S-2- 5 ft	S-2- 11 ft	S-2- 20 ft
Date Collected:					
Time Collected:					

Analyses	Units	ANALYTICAL RESULTS			
CN -	mg/kg	<.68*	<.68*	<0.68*	<0.68*
NO_3^-	ppm	<3 *	<3 *	<3 *	<3 *
pH		7.8	7.8	7.9	7.9
Cr	ppm	64 **	82 **	80	70
Tetraethyllead	ppm	1.31	1.15**	2.25	0.98
Fuels	±	negative	negative	negative	negative

COMMENTS: * Below detection limit
** Average of quality assurance duplicates

Laboratory Manager

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Date Received

Date Reported 21 April 1982

Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base
Attention:

Address

Lab No.	820505	820506		
Source of Sample Site 3 Soils	S-3A	S-3B		
Date Collected:				
Time Collected:				

Analyses	Units	ANALYTICAL RESULTS			
Sb	ppm	11.00	18.00		
As	ppm	<0.03**	0.65		
Cd	ppm	1.04*	0.72*		
Cr	ppm	46.25*	44.44*		
Cu	ppm	7.20	8.00		
Pb	ppm	17.50*	25.60*		
Hg	ppm	0.28	<0.20**		
Ni	ppm	10.26*	10.94*		
Se	ppm	.67*	.577*		
Ag	ppm	1.42	.44*		
Zn	ppm	43.50	42.80*		

COMMENTS: *Average of quality assurance duplicates
**Below detection limit

Laboratory Manager

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Date Received

LABORATORY ANALYSIS REPORT

Date Reported 21 April 1982

Ref: 09789.00

For Edwards Air Force Base Attention:

Address

Lab No.	Site 3 Soils	820505	820506		
Source of Sample		S-3A	S-3B		
Date Collected:					
Time Collected:					

Analyses	Units	ANALYTICAL RESULTS			
Chlordane	ppb	19.00	<0.04*		
Lindane	ppb	0.16	2.09		
Heptachlor epoxide	ppb	0.67	<0.04*		
DDE	ppb	6.01	<0.006*		
DDD	ppb	3.90	<0.012*		
DDT	ppb	16.90	<0.016*		
2,4 -D	ppb	<0.001*	<0.001*		
2,4,5-T	ppb	0.20	<0.001*		

COMMENTS: * Below detection limit

Laboratory Manager

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Date Received

Date Reported 21 April 1982

Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base

Attention:

Address

Lab No.	Site 5 Water Samples	820351	820325	820353	820360
Source of Sample		W-6E1	W-ES6	W-ES7	W-ES8
Date Collected:					
Time Collected:					

Analyses	Units	ANALYTICAL RESULTS			
fuels	±	positive	negative	negative	negative
oils	±	negative	negative	negative	negative

COMMENTS:

THESE RESULTS WERE OBTAINED BY FOLLOWING ACCEPTED LABORATORY PROCEDURES.
THE LIABILITY OF THE CORPORATION SHALL NOT EXCEED THE AMOUNT PAID FOR THIS REPORT.

Laboratory Manager

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LABORATORY ANALYSIS REPORT

Date Received

Date Reported 21 April 1982

Ref: 09879.00

For Edwards Air Force Base

Attention:

Address

Lab No. 820357

Source of Sample Site 5 Water W-ES9

Date Collected:

Time Collected:

Analyses	Units	ANALYTICAL RESULTS			
fuels	±	negative			
oils	±	negative			

COMMENTS:

THESE RESULTS WERE OBTAINED BY FOLLOWING ACCEPTED LABORATORY PROCEDURES.
THE LIABILITY OF THE CORPORATION SHALL NOT EXCEED THE AMOUNT PAID FOR THIS REPORT.

Laboratory Manager

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Date Received

Date Reported 21 April 1982
Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base
Attention:
Address

Lab No.	Site 8 Sediment & water samples	820503	820504	820507	820508
Source of Sample		W-8B	W-8D	Sed - 8A	Sed - 8B
Date Collected:					
Time Collected:					

Analyses	Units	ANALYTICAL RESULTS			
Sb	ppm **	<0.1***	<0.1***	19.0	39.7
As	ppm	insufficient sample	<0.03***	7.0	37.5
Cd	ppm	<0.015***	<0.015***	6.3	42.9
Cr	ppm	0.05*	<0.05* ***	94.0	486.0
Cu	ppm	0.02	<0.01***	68.0	98.0
Pb	ppm	<0.01***	<0.01***	79.0	80
Hg	ppm	<0.001***	<0.001***	.15	.15
Ni	ppm	<0.10***	<0.10***	23.5	129
Se	ppm	0.075	0.035*	9.2	24.0
Ag	ppm	<0.01***	<0.01***	10.4	28.9
Zn	ppm	0.075	0.045	184.0	244.0
fuels	±	absent	absent	present	present
oils	±	absent	absent	present	present
% solids	%			23.3	13.5

COMMENTS: *Average of quality assurance duplicates
** Dry weight basis
*** Below detection limit

Laboratory Manager

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Date Received

Date Reported 21 April 1982

Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base Attention:

Address

Lab No.	820509	820510		
Source of Sample	Sed - 8C	Sed - 8D		
Date Collected:				
Time Collected:				

Analyses	Units	ANALYTICAL RESULTS			
fuels	±	present	present		
oils	±	present	present		
Sb	ppm	48.8	6.8		
As	ppm	27.4	4.7*		
Cd	ppm	15.4	9.1		
Cr	ppm	319.0	104.0		
Cu	ppm	70.0	155.0		
Pb	ppm	48.0	72.0		
Hg	ppm	.17	.08		
Ni	ppm	87.8	21.8		
Se	ppm	2.2	8.0		
Ag	ppm	23.1	24.1		
Zn	ppm	228.0	267.0		
% solids	%	13.1	74.0		

COMMENTS: * Average of quality assurance duplicates

THESE RESULTS WERE OBTAINED BY FOLLOWING ACCEPTED LABORATORY PROCEDURES.
THE LIABILITY OF THE CORPORATION SHALL NOT EXCEED THE AMOUNT PAID FOR THIS REPORT.

Laboratory Manager

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Date Received

Date Reported 21 April 1982

Ref: 09789.00

LABORATORY ANALYSIS REPORT

For Edwards Air Force Base Attention:

Address

Lab No.	Site 11 Water	820348	820349		
Source of Sample		W-ES4	W-ES10		
Date Collected:					
Time Collected:					

Analyses	Units	ANALYTICAL RESULTS			
Sb	ppm	<0.1 *	<0.1 *		
As	ppm	insufficient sample	insufficient sample		
Cd	ppm	<.01*	<.01*		
Cr	ppm	<.05*	<.05*		
Cu	ppm	<.05*	<.05*		
Pb	ppm	<.01*	<.01*		
Hg	ppm	insufficient sample	insufficient sample		
Ni	ppm	<.01*	.036		
Se	ppm	<.01*	.011		
Ag	ppm	<.01*	<.01*		
Zn	ppm	<.02*	<.02*		
fuels	±	present	negative		
oils	±	negative	negative		

COMMENTS: * Below detection limit

THESE RESULTS WERE OBTAINED BY FOLLOWING ACCEPTED LABORATORY PROCEDURES
THE LIABILITY OF THE CORPORATION SHALL NOT EXCEED THE AMOUNT PAID FOR THIS REPORT

Laboratory Manager

APPENDIX G

ANALYTICAL PROCEDURES

APPENDIX G

ANALYTICAL PROCEDURES

I. ORGANICS

Aniline

Soil samples were extracted with methanol on a mechanical shaker for 2 hours and analyzed by flame ionization gas chromatography. Reference aniline was purchased from Mallinckrodt Chemical Company.

Dry Cleaning Solvents

Volatile solvents in soil were measured using a modified purge and trap apparatus according to EPA procedures described in Interim Methods for Measurements of Organic Priority Pollutants in Sludges.

Engine Cleaner/Trichloroethylene (TCE)

Soil samples were analyzed for TCE using a modified purge and trap apparatus described in Interim Methods for Measurements of Organic Priority Pollutants in Sludges, EPA, 1979. Each sealed vial was weighed and then heated to 60°C. The system cap was penetrated with 2 needles; one needle sampled the head space while helium flowed through the second needle inserted into the bottom of the sediment. The sampling needle was attached to a Tenax sorbent trap which collects the volatile compounds. The trap was then desorbed onto the gas chromatography column and the standard volatile program run.

Water samples were analyzed for TCE using the standard purge and trap system described in Federal Register, Method 601, Purgeable Halocarbons.

Ethyl Alcohol

Soil samples were extracted with methanol on a mechanical shaker for 2 hours and analyzed against their reference material using thermoconductivity gas chromatography.

Fuels/Oils

Both water and soil samples were extracted with carbon disulfide on a mechanical shaker for 2 hours and analyzed by flame ionization gas chromatography for any contaminating fingerprint. All samples were compared to fingerprints from standard reference kerosene, jet fuel, avgas, and diesel oil.

Furfuryl Alcohol

Soil samples were extracted with carbon disulfide on a mechanical shaker for 2 hours. The samples were then analyzed by flame ionization gas chromatography, against reference furfuryl alcohol purchased from the Aldrich Chemical Company.

Motor Oil/Lube Oil

Soil samples were extracted with carbon disulfide on a mechanical shaker for 2 hours. Each sample was then examined by flame ionization gas chromatography and any resulting fingerprint indicating contamination was then compared to a fingerprint of commercially available motor and lube oil.

PCB's and Organochlorine Pesticides in Soil

PCB's and organochlorine pesticides were determined using the Soxhlet extraction procedure, followed by electron capture gas chromatography, as described in *Chemistry Laboratory Manual for Bottom Sediments and Elutriate Testing*, EPA 905/4-79-014, page 108-115. A sample of soil was dried and extracted for 6 hours by Soxhlet extraction, using a mixture of 1:1 acetone-hexane. The extract was concentrated, then partitioned through florisil for the elimination of interferences and the separation of various mixtures. Quantitative determination was performed by electron capture gas chromatography. The extract was treated with mercury to eliminate sulfur contamination common to soil and sediment samples.

II. INORGANICS

Cyanide

Total cyanides were determined in soils spectrophotometrically according to the procedure in *Chemistry Laboratory Manual for Bottom Sediments and Elutriate Testing*, EPA 905/4-79-014, page 25.

Metals (to include Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn)

Soil Metals

Soil samples were processed through dry ash procedure as described in *Atomic Absorption Newsletter*, Vol. 17 (4), page 70, where each sample was ignited at 550°, the residue digested in 3N HCl, filtered, diluted to volume, and analyzed by flame.

Water Metals

Previously acidified water samples were digested with 5 ml of concentrated HCl. After cooling, the volume was adjusted and samples analyzed according to procedure described in Methods for Chemical Analysis of Water and Wastes, EPA 600, 4-79-020.

Nitrate

Soil nitrate analyses were carried out according to the procedure in California Soil Testing Procedures.

pH

All pH measurements were performed on an Orien 601A equipped with a combination glass electrode. The pH meter was standardized periodically under conditions of temperature and concentration which were as close as possible to those of the sample, using various standard pH buffer solutions (pH 4, 7, and 10) as described in California Soil Testing Procedures, Method 5:30.

Tetraethyllead

Analysis of soils for tetraethyllead was carried out according to procedure described in Atomic Absorption Newsletter, Vol. 17 (2), page 78. A 5-gram soil sample was placed in a flask with 5 ml of concentrated nitric acid, shaken for 24 hours, diluted to 25 ml, and read.

APPENDIX H

REFERENCES

APPENDIX H

REFERENCES

Baker, James, Personal Communication, Edwards Air Force Base, California, 1981.

California Department of Health Services, California Assessment Manual for Hazardous Wastes, 1979.

Downing, Dan, U.S. Geological Survey, Annual Water Leval Measurement Logs, Laguna Niguel, California, 1981.

Dunne, T. and Leopold, L., Water in Environmental Planning, San Francisco, California, 1978.

Envirodyne Engineers, Inc., Assessment of the Potential for Groundwater Contamination, Edwards Air Force Base Waste Disposal Site Evaluations, Contract Number F08647 80 G0002, prepared for the U.S. Department of Defense, U.S. Air Force, 30 April 1981.

Federal Register, Vol. 40, p. 28850, 9 July 1975.

Johnson, H. R., Water Resources of Antelope Valley: U.S. Geological Survey Water-Supply Paper 278, 1911.

Merck & Co., Inc., The Merck Index, Ninth Edition, 1976.

National Academy of Sciences, Drinking Water and Health, Washington, D.C., 1977.

Sax, N. Irving, Dangerous Properties of Industrial Materials, Fifth Edition, 1979.

Thompson, D. G., The Mojave Desert Region, California, A Geographic, Geologic and Hydrologic Reconnaissance, U.S. Geological Survey Water-Supply Paper 578, 1929.

U.S. Environmental Protection Agency, Health Effects Associated with Wastewater Treatment and Disposal Systems, State-of-the-Art Review, Vol. I, EPA-600/1-79-016a, 1979.

U.S. Geological Survey, Data on Wells in the Edwards Air Force Base Area, California, Bulletin No. 91-6, June 1962.

U.S. Geological Survey Map, Antelope Valley-East Kern Water Agency Area, California, showing groundwater subunits and areas, location of wells, and water level contours for Spring 1979, 1980.

APPENDIX I

GLOSSARY

APPENDIX I

GLOSSARY

Alluvium. The detrital materials eroded, transported, and deposited by streams.

Aquifer. Underground water-bearing material usually consisting of sands or gravel.

Artesian well. A well in which the water rises above the water-bearing bed.

BW. Base well

Confined aquifer. An aquifer that contains water under pressure. When punctured by a well, the water rises to a level above the aquifer.

Daylight. A subsurface geological formation which slopes towards the ground surface. At the intersection with the topography, the formation daylights.

DOD. Department of Defense

ES. Engineering-Science

Fan deposit. Gently sloping, fan-shaped geological formation.

Freon-11. Trichlorofluoromethane.

Gel barrier. An injection of, for example, silica gel into the ground to divert groundwater movement.

IRP. Installation Restoration Program

kg. Kilogram

Lenticular. Having the shape of a lentil or double convex lense.

Lysimeter. An instrument for measuring the water percolating through soils and determining the materials dissolved by the water.

MB. Main base well

mg. Milligram

MSL. Mean sea level

MW. Monitoring well

PCB. Polychlorinated biphenyl

Playa deposit. A low essentially flat part of a basin or other undrained area in an arid region where fine grain material is deposited.

Semiconfined aquifer. An aquifer that alternates between being confined or unconfined depending upon conditions, such as pumping and seasonal fluctuations.

Slurry walls. Walls comprised of a free-flowing pumpable suspension of fine solid material in liquid installed underground to inhibit groundwater movement.

Swale. A sloping topographical depression that drains a small area.

TCE. Trichloroethylene

Threshold limit concentration. The concentration of a compound above which the compound is considered as hazardous.

u/kg. Microgram per kilogram

Unconfined aquifer. An aquifer containing water under hydrostatic pressure. When punctured by a well, the water will not rise above the initial level.

U.S.G.S. United States Geological Survey

VOA bottle. A 25-ml glass vial with a Teflon screw cap.

Volatile. Compounds that vaporize readily at a relatively low temperature.

APPENDIX J

BIOGRAPHIES OF KEY PERSONNEL

Biographical Data

DONALD R. ANDERSON

Sanitary Engineer

Personal Information

Date of Birth: 18 June 1930

Education

B.S. in Civil Engineering, 1958, University of Miami, Florida
M.S. in Civil Engineering, 1960, Purdue University, Indiana
Radiation Physics, 1962, University of Oklahoma
Mathematical Modeling of Biological Systems, 1972, Utah State University

Professional Affiliations

Registered Civil Engineer (Arizona No. 8654)
Registered Professional Engineer (California)
American Academy of Environmental Engineers (Diplomate)
American Society for Engineering Education
American Society of Civil Engineers (Chairman, Environmental Engineering Group, Los Angeles Section, 1978)
Association of Environmental Engineering Professors
Citizens Advisory Committee - 208 Planning, Southern California Association of Governments
Environmental Management Institute, University of California
Los Angeles Regional Forum on Solid Waste Management (Vice Chairman, 1981-1982)
United States Environmental Protection Agency Extramural Reviewer-Solid Waste Management Projects
Water Pollution Control Federation (Secretary/Treasurer and WPCF Bulletin Editor, California, 1963-1966)

Experience Record

1951-1953	United States Air Force Security Service. Russian Linguist.
1953-1958	General Building Contractor, Miami, Florida. Engaged in construction of residential, commercial, and industrial facilities.
1958-1960	Purdue University. Instructor in Civil Engineering. Responsible for teaching graphics and surveying.
1960-1965	Loyola Marymount University. Assistant Professor of Civil Engineering. Academic responsibilities included teaching sanitary engineering and soil mechanics.

Donald R. Anderson (Continued)

1965-1968	Engineering-Science. Manager, Research and Development Office. Projects included a master plan for solid waste management for Fresno, California; investigation of movement of gases from sanitary landfills; and a master plan for refuse management for Newport Beach, California.
1968-1969	Ohio Northern University. Associate Professor of Civil Engineering. Responsible for teaching environmental engineering and hydraulics.
1970-Date	Loyola Marymount University. Professor of Civil Engineering and Environmental Science. Serves as Program Director for graduate studies in environmental engineering.
1972-1973	Environmental Dynamics, Inc. Project Technical Director. Projects included mathematical modeling of water quality in the Tahoe-Truckee-Carson Rivers system of California-Nevada and the Jordan River-Utah Lake system near Salt Lake City, Utah.
1974-1978	Toups Corporation, Division of Planning Research Corporation. Project Technical Director. Responsible for operation of the Yuma Desalting Test Facility for the U.S. Bureau of Reclamation; nonpoint runoff studies for Tucson, Arizona, and Orange County, California; studies of the impact of abandoned mines on water quality in the United States for EPA; and studies of the impact of the Oregon Bottle Bill on collection and disposal of solid wastes.
1978-Date	Engineering-Science. Project Technical Advisor. Responsible for preliminary studies and facilities design for solid waste collection, transfer, and disposal; resource recovery; and the management of landfill-generated gas. Also provided technical guidance on hazardous waste management studies for various industrial clients, state governments, and federal agencies.

Publications

"Gas Generation and Movement in Landfills," Proceedings: National Industrial Solid Waste Management Conference, Houston, Texas, March 1970 (Coauthor J. P. Callinan).

"Steady-State Water Quality Modeling in Streams," Journal Environmental Engineering Division, American Society of Civil Engineers, April 1975 (Coauthors J. Dracup and R. Willis).

Donald R. Anderson (Continued)

"Water Quality Modeling in Deep Reservoirs," Journal Water Pollution Control Federation, January 1976 (Coauthors J. Dracup and T. Fogarty).

"Transient Water Quality Modeling in Streams," Water Resources Bulletin, American Water Resources Association, February 1976 (Coauthors J. Dracup and R. Willis).

"An Integrated Pretreatment System for Reverse Osmosis," Proceedings: International Desalination and Environmental Association, Tokyo, Japan, December 1977.

"Application of Aerobic Composting in the Disposal of Liquid Palm Oil Wastes," Proceedings: Asia Aquatech, Singapore, Malaysia, March 1980 (Coauthors R. White and C. Ponniah).

"Surface Impoundment of Hazardous Wastes," Proceedings: Conference on Hazardous Materials Control of the Hazardous Materials Control Institute, Baltimore, Maryland, August 1981 (Coauthors F. Bowerman and J. Mang).

Patents

Magnesium Substitution Process for Removal of Calcium in Brines: U.S. Patent No. 4,036,749

Biological Denitrification of Nitrate-containing Waters Using Cellulose as the Organic Energy Source: U.S. Patent No. 4,039,048

Biographical Data

FRANK R. BOWERMAN

Civil and Sanitary Engineer

Personal Information

Date of Birth: 9 July 1922

Education

B.S. in Engineering, 1947, California Institute of Technology
M.S. in Civil Engineering, 1948, California Institute of Technology

Professional Affiliations

Registered Professional Engineer (California No. 8112)
American Academy of Environmental Engineers (Diplomate; President, 1973)
American Public Works Association (National Director-at-Large, 1974-1977; President, Institute for Solid Wastes, 1966)
American Society of Civil Engineers (Fellow; Vice President, Los Angeles Section, 1975)
California Water Pollution Control Association
Water Pollution Control Federation (National Director-at-Large, 1965-1968)

Honorary Affiliations

Charles Walter Nichols Award (American Public Works Association, 1965)
Government Refuse Collection and Disposal Association
Rudolph Hering Medal (American Society of Civil Engineers, 1961)
Chi Epsilon
Sigma Xi
Tau Beta Pi

Special Appointments

California Governor's Council on Earthquakes
California State Solid Waste Management Board (1973-1975)
Pollution Committee, National Research Council/National Academy of Sciences Summer Research Center at Woods Hole, Massachusetts (1965)
President's Office of Science and Technology (Consultant)
Refuse Disposal Practices Committee, American Society of Civil Engineers
Science Advisory Board, U.S. Environmental Protection Agency (Environmental Consultant)
Sewerage and Sewage Treatment Committee, American Society of Civil Engineers (Chairman, 1952-1955)

Frank R. Bowerman (Continued)

Smithsonian Institution (Consultant)
Solid Waste Advisory Committee, California State Department of Public Health
Solid Waste Management Committee, National Academy of Engineering
United Nations Development Program (Consultant)
United States Information Agency (Consultant)
U.S. Public Health Service (Consultant)
Waste Disposal Committee, Air Pollution Control Association (Chairman, 1955-1960)

Experience Record

1948-1966 Los Angeles County Sanitation Districts. Sanitary Engineer (1948-1958) and Assistant Chief Engineer (1958-1966). Developed and implemented a regional transfer station and sanitary landfill and hazardous waste management program to serve four million persons. Coauthored bulletin on municipal incineration as sanitary engineering consultant to the University of California.

Supervised a comprehensive investigation and report on the collection and disposal of refuse in the county sanitation districts as well as a report on planned refuse disposal. Represented the districts for preparation of a joint report with the Los Angeles County Flood Control District concerning the potential reclamation of sewage wasting to the ocean in Los Angeles County. Also participated in the study of sewerage, air and water pollution control, and solid waste collection and disposal throughout the United States.

1966-1968 Aerojet-General Corporation. Assistant to the Vice President - Development. Served as Program Manager for a solid waste management system study at Fresno, a typical urban/agricultural complex, for the California State Public Health Department under a matching fund grant from the U.S. Public Health Service, Department of Health, Education and Welfare. Directed a system study of solid waste management for the Kansas City Metropolitan Regional Planning Commission, funded under a matching grant from the U.S. Public Health Service, Bureau of Solid Waste Management, Department of Health, Education and Welfare.

1969-1970 Engineering-Science. Vice President. Responsible for projects involving the design, construction, and operation of solid waste management systems for cities and industries.

Frank R. Bowerman (Continued)

1970-1975	University of Southern California. Chairman, Department of Civil Engineering (1970-1973). Professor and Director of Environmental Engineering Programs (1970-1975). In responsible charge of the implementation of graduate degree programs in environmental engineering, as well as research and development projects and community-related educational activities.
1975-1978	CDM, Inc., Environmental Engineers. President. Directed operations of California-based subsidiary of Camp Dresser & McKee, Inc. Projects involved water supply, wastewater collection and treatment, drainage and flood control, solid waste management, and related areas of environmental engineering.
1978-Date	Engineering-Science. Senior Vice President. Responsible for management and conduct of environmental engineering projects involving such specialties as sewerage, marine waste disposal, solid and hazardous waste management, and water supply. Activities include facility planning, design, construction, and system operation assistance. Serves as Director of hazardous waste management programs companywide. Directly responsible for conducting national and regional hazardous waste management seminars. Supervises design of remedial hazardous waste control measures for industrial facilities.

Publications

"Factors Influencing and Limiting the Location of Sewer Ocean Outfalls," Proceedings of Institute of Coastal Engineering. University of California, October 1950.

"Refuse Disposal Program for 27 Cities and County Area," Western City, December 1950.

"Past and Present Municipal Incinerators in the United States," American City, March 1952.

"Can Waste Heat from Refuse Incinerators be Employed Economically?" Civil Engineering, May 1952.

"Problems in Municipal Refuse," Virginia Municipal Review, May 1953.

Frank R. Bowerman (Continued)

"Integrating Reclamation and Disposal of Wastewater," Journal American Water Works Association, Vol. 45, No. 5, May 1953.

"Engineering Waste Disposal to Prevent Air Pollution," Proceedings of Conference on Incineration, Rubbish Disposal, and Air Pollution, Report No. 3, January 1955.

"The Membrane Filter: Advantages and Disadvantages," Water and Sewage Works, No. 103, January 1956.

"Refuse Collection and Disposal in the West," Western City, Part I, May 1958 and Part II, June 1958.

"Economic Aspects of Engineering Control - Land Disposal and Incineration," Proceedings of National Conference on Air Pollution, Washington, D.C., 18-20 November 1958.

"Diffusers for Disposal of Sewage in Sea Water," Transactions of American Society of Civil Engineers, Vol. 126, Part III, 1961 (Rudolf Hering Medal, 1961, American Society of Civil Engineers).

"Municipal Refuse Transfer Stations," American Public Works Association Yearbook, 1962.

"Los Angeles County Activities in Refuse Disposal," Proceedings of National Conference on Solid Waste Management, 4-5 April 1966.

"Changing Concepts in Pollution Control Hardware," American Engineer, January 1968.

"Comprehensive Planning: The Systems Design Approach, Part II of the Fresno Story," Proceedings of Institute for Solid Wastes, American Public Works Association, 1968.

"Land Pollution Abatement," Investment Dealers Digest, Section II, 27 May 1969.

"Solid Waste Disposal," Chemical Engineering Deskbook, 27 April 1970.

"A Decision Theory Approach to Solid Waste Management System Selection," American Public Works Association Yearbook, 1971.

"Environmental Impact of Storm Drainage on a Semi-enclosed Coastal Water," Proceedings of Eighth Marine Technology Society Conference, 1972, pp. 763-770, (Coauthors K. Y. Chen and M. Petridis).

"Mechanisms of Leachate Formation in Sanitary Landfills," Recycling and Disposal of Solid Wastes (Ann Arbor Science Publishers, 1974), pp. 349-367 (Coauthor K. Y. Chen).

Frank R. Bowerman (Continued)

"Pyrolysis as a Means of Sewage Sludge Disposal," Journal Environmental Engineering Division, American Society of Civil Engineers, 1978 (Coauthors N. E. Folks, R. A. Lockwood, B. Eichenberger, and K. Y. Chen).

Papers and Presentations

"Microbial Decomposition of Oil and Clay Wastes in the Soil," presented at 45th Annual Conference, Water Pollution Control Federation, Cleveland, Ohio, September 1973 (Coauthors B. Loran., Y. Tsai, and K. Y. Chen).

Biographical Data

ROBERT E. BROGDEN

Hydrogeologist

Personal Information

Date of Birth: 8 November 1944

Education

B.S. in Geology, 1968, University of Nebraska
M.S. in Civil Engineering, 1972, University of Nebraska
Fortran IV Computer Programming, Groundwater - Surface Water Relationships, Modeling of Groundwater Flow, and Surface Geophysics, 1975-1976, U.S. Geological Survey

Professional Affiliations

National Water Well Association

Experience Record

1965-1968 U.S. Geological Survey, Water Resources Division. Aide (part-time). Duties included geologic logging of samples collected during test hole drilling programs, stream gaging to determine groundwater gains and losses, inventorying irrigation and industrial wells in select parts of the state, collection of water samples for regional groundwater studies, and drafting of maps, figures, and graphs for report publication.

1965-1969 University of Nebraska, Conservation and Survey Division. Aide (part-time) (1965-1968). Duties included geologic logging of samples collected during test hole drilling programs, stream gaging to determine groundwater gains and losses, inventorying irrigation and industrial wells in select parts of the state, collection of water samples for regional groundwater studies, and drafting of maps, figures, and graphs for report publication.

Hydrogeologist (1968-1969). Responsible for collection and interpretation of hydrologic and geologic data and preparation of reports describing the occurrence of surface water and groundwater supplies throughout the state in connection with the county groundwater program. Participated in joint study with U.S. Geological Survey to identify groundwater

Robert E. Brogden (Continued)

and surface water resources of Pierce County, Nebraska, and the Elkhorn River basin. Authored report describing the availability and chemical characteristics of groundwater and surface water in Pierce County. Participated in program to identify aquifer subcrops using surface geophysics and other techniques.

1969-1971 United States Army.

1972 South Dakota Geological Survey. Research Geologist. Involved in county groundwater program. Duties included mapping surficial Pleistocene deposits and identifying aquifers. Responsible for interpretation of geologic and hydrologic data as well as for supervision of drilling operations, electric logging, and other field investigations in the Missouri Coteau near Pierre, South Dakota. Initiated study to identify the occurrence and characteristics of the Codel sandstone, a principal water supply source in parts of the state.

1972-1975 Leonard Rice Consulting Water Engineers, Inc. Groundwater Geologist and Senior Hydrologist. Engaged in groundwater and surface water development projects including analysis of quantity and quality capabilities of individual aquifers. Supervised test hole drilling programs, aquifer tests, water rights investigations, and report preparation. Served as Project Manager for preliminary groundwater and surface water report describing the availability of water for energy-related development of Battlement Mesa. Developed runoff and snowpack correlations to estimate the surface water yields of ungaged basins in west slope Colorado and presented testimony in water and district courts for groundwater conflicts.

1975-1976 U.S. Geological Survey, Water Resources Division. Project Hydrologist. Supervised investigations related to the occurrence, availability, and chemical characteristics of groundwater in coal-rich areas of Colorado. Participated in high plains groundwater studies and served as project chief on a Denver geologic basin study describing the availability of groundwater in the Arapahoe aquifer. Involved with the Bureau of Land Management's Energy Minerals Rehabilitation Inventory and Analysis to determine baseline conditions in parts of the state that were projected to be intensely mined. Developed reports on the water supply of the Southern Ute Indian

Robert E. Brogden (Continued)

Reservation and the geology and hydrology of the Arapahoe aquifer.

1976-1980 Leonard Rice Consulting Water Engineers, Inc. Groundwater Geologist and Executive Vice President. Supervised studies involving test hole drilling, observation well installation, surface water and groundwater monitoring programs, and determination of regional and site-specific aquifer characteristics. Served as Project Manager on deep well construction projects for wells as deep as 2,300 ft. Described water rights and surface water and groundwater relationships for a large Colorado ranch. Developed technique by which natural groundwater contribution to consumptive use of crops could be quantified.

Directed hydrologic studies in western Colorado for numerous coal mine operations. Promoted development of natural geologic deposits as operating groundwater reservoirs. Conducted investigations in New Mexico, Utah, Colorado, and Wyoming to quantify groundwater stored in naturally occurring reservoirs. Provided expert testimony in district and water courts for groundwater conflicts.

1980-Date Engineering-Science. Hydrogeologist/Project Manager. In charge of groundwater development projects, surface water investigations, and water rights studies.

Hydrogeologist. Involved in test hole drilling, well design and completion, analysis of aquifer quantity and quality capabilities, and presentation of expert testimony in water courts. Performed compliance review of mine plans for the Office of Surface Mining. Other projects include quantification of impacts of Federal Reserve filing on Wind River Reservation in Wyoming as well as impacts of minimum stream flow filings on proposed and existing surface water and groundwater rights and developments.

Project Manager. Responsible for hydrologic studies for several coal mine operations in Colorado and neighboring states, including Colowyo Coal Company, Texasgulf Inc., Trinidad Coal Company, Empire Energy Company, and A. T. Massey, Inc. Supervised design and construction inspection of high capacity wells completed to depths as great as 2,500 ft with surface flows of 3,000 gpm. Managed study for Newmont Mining Services (a Magma Copper Subsidiary) to identify leakage from tailing ponds, direction of

Robert E. Brogden (Continued)

groundwater flow, and extent of groundwater contamination.

Biographical Data

ERNEST V. CLEMENTS III

Environmental Engineer

Personal Information

Date of Birth: 3 February 1949

Education

B.S. in Aeronautical and Astronautical Engineering, 1971, University of Illinois
M.S. in Environmental Engineering, 1972, University of Illinois

Professional Affiliations

Registered Professional Engineer (California No. C-34482)
American Society of Civil Engineers
California Water Pollution Control Association
Water Pollution Control Federation

Honorary Affiliations

James Scholar (University of Illinois)
Phi Kappa Phi
Sigma Tau
Tau Beta Pi

Experience Record

1972-1981 SCS Engineers, Long Beach, California. Project Engineer (1972-1975). Responsible for all field and literature research, technological evaluations, and detailed cost analyses of a variety of solid waste collection system options for cities in Washington, Arizona, and California. Conducted studies of office wastepaper source separation and recycling programs for the U.S. Environmental Protection Agency. Contributed to study of solid waste handling and disposal practices at a large U.S. Air Force base. Project involved the design and cost-benefit analysis of a complete system for storage, collection, transport, and disposal of all wastes generated on the base. Participated in nationwide EPA study of source separation and collection of recyclable solid waste which entailed analysis of residential and commercial solid waste management costs.

Participated in worldwide state-of-the-art field and literature survey of water reclamation and reuse operations for EPA. Responsible for development of

Ernest V. Clements III (Continued)

computer program for design of cost-effective cascade water reuse systems for the U.S. Air Force. Supervised field sampling, computer program application, and initial design of full-scale wastewater treatment and irrigation reuse system at Peterson AFB. Involved in development of conceptual and final engineering design of cascade water reuse system for McClellan AFB involving tertiary treatment, pumping, distribution, and reuse. Participated in field investigations, established sampling programs, and prepared extensive treatment performance and cost information for EPA effluent guidelines study of the fruit and vegetable industry.

Project Manager (1975-1981). Responsible for planning and supervising solid waste management and resource recovery projects. Evaluated the feasibility of areawide solid waste management and resource recovery for Yuma, Arizona. Prepared master plans for solid waste management for American Indian reservations in California and Arizona, which involved development of plans for landfills and small transfer stations. Headed team of engineers in evaluating transfer station and sanitary landfill operations for Sacramento County, California. Directed study for Albuquerque, New Mexico, to determine new rates for residential and commercial refuse collection. Supervised implementation of two pilot programs for Seattle, Washington, to evaluate the technical and economic feasibility of source separation and recyclable materials collection.

Responsible for development of model to assess potential for wastewater reclamation/reuse at over 400 U.S. Army and Navy bases. Prepared a state guidance manual for rural wastewater management in California including all types of on-site treatment units and procedures, alternative collection methods, and central treatment facilities. Updated and expanded Manual of Septic Tank Practices for EPA. Served as Deputy Project Manager for design of domestic wastewater treatment and reuse facilities for an IBM manufacturing complex near Tucson, Arizona.

1981-Date Engineering-Science. Environmental Engineer/Project Manager. Responsible for study and design projects involving solid waste collection and disposal, resource recovery, municipal and industrial wastewater treatment, water reclamation/reuse, and hazardous waste management.

Ernest V. Clements III (Continued)

Served as Deputy Project Manager on a study for Orange County, California, to develop a countywide solid waste management system for the next 20 years, which involved evaluation of refuse transfer and landfill disposal, resource recovery alternatives, hazardous waste management, private versus public ownership and operation, institution of gate fees, and financial options.

Managed feasibility evaluation of energy recovery from solid waste for the Los Angeles Unified School District, and developed recommendations for implementation of small 5 to 10-TPD waste-to-energy systems for steam production at selected schools. Also involved in projects to assess hazardous waste management practices involving implementation of groundwater monitoring programs and development of hazardous waste cleanup plans.

Publications

"A Survey of Practices and Regulations for Reuse of Water by Groundwater Recharge," Journal American Water Works Association, March 1978 (Coauthors C. J. Schmidt and S. P. Shelton).

"Sewer Surcharges: How To Ease the Spiraling Cost of Wastewater Discharge," Canner/Packer, July 1975.

"Wastewater Characterization for the Specialty Food Industry," Proceedings of the 29th Industrial Waste Conference, Purdue University, 1974 (Coauthors C. J. Schmidt and J. Farquhar).

"Municipal Wastewater Reuse in the U.S.," Journal Water Pollution Control Federation, Vol. 47, No. 9, September 1975 (Coauthors C. J. Schmidt and I. Kugelman).

Biographical Data

JEFFREY T. DeZELLAR

Civil Engineer

Personal Information

Date of Birth: 27 April 1950

Education

B.A. in Mathematics and Sociology, 1972, University of Minnesota
B.S. in Zoology, 1974, University of Minnesota
M.S. in Civil Engineering, 1978, University of Minnesota
Urban Planning, 1979-1980, University of California, Los Angeles

Experience Record

1974-1977 Minnesota Pollution Control Agency, Division of Water Quality, Roseville, Minnesota. Environmental Planner. Responsible for development of water quality management basin plans pursuant to Federal Water Pollution Control Act Amendments of 1972. Other duties included review of environmental impact documents for municipal wastewater treatment facilities, administration of the Construction Grants Program, and assessment of the potential for on-site sewage treatment for small communities.

1978-1979 Los Angeles County Sanitation Districts, Whittier, California. Project Engineer. Responsible for preparation of environmental impact report for a proposed wastewater treatment plant expansion in the Saugus-Newhall-Valencia area. Served as Project Manager for a study to develop mitigation or corrective measures for structural deterioration and hydraulic overloading in the districts' main sewer system.

1979-1980 The Conservation Foundation, Washington, D.C. Research Assistant. Performed engineering study of nonstructural and ecologically sound methods of runoff reduction and flood control. Identified management practices which promote natural percolation and storage of storm water.

1980-1981 U.S. Army Corps of Engineers, Los Angeles District, California. Project Manager. Supervised biological investigations related to flood control projects in Rancho Mirage and the Whitewater River. Also responsible for management of multipurpose flood control

Jeffrey T. DeZellar (Continued)

project for Goleta, California, emphasizing increased water supply, sediment control, and environmental enhancement of Goleta Slough. Developed preliminary restoration plans for Goleta Slough, initiated sediment sampling program for seven Goleta streams, and developed alternative flood control and water supply plans. Developed and conducted extensive public and agency involvement program.

1981-Date	Engineering-Science. Civil Engineer. Responsible for conducting engineering studies and assessments for hazardous waste disposal, including groundwater well installation and monitoring, evaluation of alternative waste handling systems, investigation of the fate and effect of hazardous materials, assessment of water and air quality impacts, and facility siting. Participated in development of cleanup programs for existing sites and control strategies for new facilities.

Publications

"Effects of Water Conservation on Sanitary Sewers and Wastewater Treatment Plants," Journal Water Pollution Control Federation, Vol. 52, No. 1, January 1980, pp. 76-88 (Coauthor W.J. Maier).

"Benefits from Water Conservation Depend on Comprehensive Planning," Water Resources Bulletin, Vol. 17, No. 4, August 1981, pp. 672-677 (Coauthors W.J. Maier and R.M. Miller).

Biographical Data

LENDA E. DOANE

Environmental Scientist

Personal Information

Date of Birth: 5 November 1948

Education

B.S. in Biology/English, 1972, Pan American University, Edinburg, Texas

Water Quality Management Workshop, 1973, Texas Water Quality Board, Houston, Texas

M.Ed. in Secondary Science Education, 1976, University of Houston, Texas

Professional Affiliations

Certified Environmental Study Area Leader (National Park Service, 1973)

Experience Record

1972-1979	La Porte Independent School District, La Porte High School, La Porte, Texas. Science Instructor. Developed and implemented classroom, field, and laboratory curricula in the physical sciences, general biology, field ecology, vertebrate zoology, marine biology, and environmental science/human ecology. Sponsored student chapter of Earth Awareness Foundation, organized annual environmental symposium, and led field studies in various areas along the Texas Gulf Coast and in central Texas.
1980-1981	George C. Page Museum, Los Angeles, California. Museum Aide. Involved in preparation, restoration, identification, and cataloging of fossil specimens excavated from La Brea Pits and stored in the Hancock Collection. Performed microscopic examination of matrix for sorting and identification of microfossils.
1980-Date	Engineering-Science. Environmental Scientist. Participates in projects involving solid and hazardous waste management, air and water pollution control, and other environmental and engineering programs. Prepared RCRA contingency plan and personnel training program for W.R. Grace and Company synfuels plant in Kentucky. Evaluated sites for spent shale disposal

Lenda E. Doane (Continued)

for TOSCO and selected site based on various ecological criteria and archaeological significance. Conducted hazardous material spill notification and response investigation, evaluated Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as well as other federal, state, and local hazardous waste control legislation, and edited reference handbook for hazardous waste management under RCRA. Participated in resource recovery/transfer system study for the Fresno-Clovis metropolitan area including assessment of environmental impacts and technological and economic evaluation of alternate transfer and recovery operations.

Responsible for data collection and analysis, identification of current and future hazardous waste generation patterns and disposal practices, regulatory analysis, and report preparation on a major waste management study for Orange County, California. Participated in project involving waste identification, site selection, and conceptual design of solid and hazardous waste disposal facilities for a proposed TOSCO oil shale processing program. Also involved in data collection and report preparation for hazardous waste studies at government installations, Northrop Aircraft hazardous materials identification, development of Texaco groundwater monitoring plan, coastal water quality baseline study for a major South American petrochemical manufacturer, landfill methane gas migration and control system evaluation, and ecological study/wetlands evaluation of a hazardous waste disposal site for Shell Oil Company.

Papers and Presentations

"Symbiotic Relationships of Zooxanthellae and Certain Marine Invertebrates," presented at Seventh Annual Biology Seminar, Pan American University, Edinburg, Texas, October 1971.

"History of Medicine in Ancient Cultures," presented at Multicultural Education Symposium, University of Houston, Houston, Texas, November 1975.

"Cultural Assimilation and Ethnic Identity: Melting Pot or Salad Bowl?" presented at Multicultural Education Symposium, University of Houston, Houston, Texas, November 1975.

"Population Trends and Related Environmental Considerations," presented at Science Curriculum Development Seminar, University of Houston, Houston, Texas, April 1976.

Lenda E. Doane (Continued)

"Spill Response: Who to Notify?" presented at Industrial Waste Conference, California Water Pollution Control Association, Los Angeles, California, February 1982 (Coauthors J.L. Mang and F.R. Bowerman).

Biographical Data

JANISE EHMANN, Ph.D.

Chemist

Personal Information

Date of Birth: 4 June 1942

Education

B.S. in General Science, 1965, University of Toledo, Ohio
M.S. in Reproductive Physiology, 1971, University of Toledo, Ohio
Ph.D. in Analytical Chemistry, 1976, Michigan State University, East Lansing
Electron Optics, Transmission Electron Microscopy (TEM), and Scanning Electron Microscopy (SEM), 1976-1977, Michigan State University, Lansing

Professional Affiliations

American Chemical Society
American Association for the Advancement of Science

Experience Record

1977-1978 Foster Farms, Livingston, California. Supervisor, Chemistry-Nutrition Laboratory. Responsible for operation of nutrient analysis facility for major food processing company. Developed and conducted technical and operational training workshops for laboratory personnel. Also conducted independent research on protein quality.

1978-1979 California Water Labs, Modesto, California. Supervisor, Organic Residue Division. Responsible for development and operation of the trace organics division of a company providing comprehensive water quality analyses for government and industry. Established sampling, sample preparation, and analytical procedures and trained laboratory staff.

1979-1981 Agri-Chem Analytical, Modesto, California. Owner. Responsible for administration and management of a consulting laboratory specializing in analysis of soils, water, and chemicals for the agriculture/agricultural chemical industries.

1979-1981 Valley Fresh Foods, Inc., Turlock, California. Laboratory Manager. Responsible for the design and operation of a nutrient chemistry laboratory, as well

Janise Ehmann, Ph.D. (Continued)

as for the training of all laboratory personnel. Conducted a feasibility study of the treatment, by-product recovery, and land disposal of industrial wastewater effluent for a new processing plant for the Department of Ecology, Olympia, Washington. Carried out a comprehensive in-plant waste generation and reduction study including analysis of daily water consumption and development of a water conservation program. Established light microscopy procedures for examination of certain feed ingredients.

1981 Environmental Research Group, Emeryville, California. Technical Director. Responsible for the efficient operation of an environmental testing facility engaged in providing research and development services to a wide variety of clients. Activities included the design and implementation of cost-effective research projects, training and supervision of laboratory personnel, and upgrading analytical capabilities of organic analysis division.

1982-Date Engineering-Science. Manager, Laboratory Services. Responsible for supervising sample collection, preparation, preservation, and analysis for projects involving municipal and industrial water and wastewater treatment, water quality and soils studies, and hazardous waste contamination. Supervises quality assurance program maintained in determination of organic and inorganic analyses. Responsible for all special analytical determinations including gas chromatography and atomic absorption. Prepares designs and contract specifications for waste treatment laboratories.

Supervised analyses of soil and groundwater samples for various organic and inorganic hazardous constituents for a major semiconductor firm and for federal installations. Also assisted with NPDES permit application and the monitoring of pollutants discharged under existing permits.

Biographical Data

GORDON S. MAGNUSON

Civil Engineer

Personal Information

Date of Birth: 30 April 1922

Professional Affiliations

B.S. in Civil Engineering, 1942, Stanford University, Palo Alto, California

M.S. in Civil Engineering, 1956, University of Southern California, Los Angeles

Professional Affiliations

Registered Professional Engineer (Arizona No. 4188 and California No. 7673)
American Academy of Environmental Engineers (Diplomate)
American Public Works Association
American Society of Civil Engineers (Fellow)
American Water Works Association
Arizona Water and Pollution Control Association
California Water Pollution Control Association (President, 1970)
City and County Engineers Association
Nevada Water and Pollution Control Association
Structural Engineers Association of Southern California
Water Pollution Control Federation (Director, 1973-1976)

Honorary Affiliations

Chi Epsilon

Experience Record

1943-1946	U.S. Navy, Civil Engineer Corps. Lieutenant. Served as representative of Bureau of Yards and Docks on several advance base floating dry docks in South and Central Pacific. Responsible for insuring proper operation and maintenance of the vessel.
1946-1948	Chicago Bridge and Iron Company, Torrance, California. Construction Engineer. Supervised erection of steel structures and welded and riveted tanks for California refineries. Responsible for ensuring construction conformance to plans and specifications, making field design revisions, and maintaining liaison with clients' engineering departments.

Gordon S. Magnuson (Continued)

1948-1951	Los Angeles County Road Department, Bridge Division. Structural Engineering Supervisor. Directed the activities of structural engineers group in the design of rigid frame reinforced concrete and steel bridges crossing rivers in Los Angeles County. Participated in determining bridge locations and alignments. Maintained liaison with flood control officials and other government agencies and utilities affected by the bridge structure.
1951-1954	Ralph M. Parsons Company, Los Angeles, California. Structural Engineering Supervisor and Project Engineer. Supervised structural engineering design of large complex installations on projects for the Atomic Energy Commission, U.S. Army, U.S. Navy, and U.S. Air Force. Served as Project Engineer for static test tower at Redstone arsenal and atomic energy facilities at Los Alamos, New Mexico.
1954-1955	Davidson Brick Company, Los Angeles, California. Provided consultation to architects and structural engineers for the design of reinforced brick masonry with particular emphasis on seismic considerations. Completely revised and updated a manual for design of reinforced brick masonry structures which is still used as a basic design reference by structural engineers in southern California.
1955-1967	Interpace Corporation, Clay Pipe Division, Los Angeles, California. Senior Applications and Special Process Engineer. Provided technical assistance to consulting engineers and municipal and district engineers in design of sanitary sewerage systems. Responsible for selection and development of all pipe products.
1967-1969	National Clay Pipe Institute, Los Angeles, California. Vice President and General Manager of Western Region. Provided technical advice and information on pipe specifications and assistance to consulting and municipal engineers for design of sanitary sewerage systems. Provided major input and editing of Clay Pipe Engineering Manual used as a basic reference in sewer design. Participated in writing ASCE-WPCF manual of practice for design of sanitary sewers and storm drains and in developing various technical publications on sewer design.
1969-1974	Pacific Clay Products, Los Angeles, California. Vice President. Responsible for technical liaison, engineering coordination, distribution, and product

Gordon S. Magnuson (Continued)

development for all products manufactured by Pacific Clay. Served as a Director of the National Clay Pipe Institute and represented the company on numerous technical and professional committees.

1974-Date Engineering-Science. Senior Technical Director (1974). Responsible for the development of project design criteria, supervision of projects, and technical monitoring and review. Provided technical consultation and coordination for the design of sewer interceptors and outfall lines and installation of pipelines requiring special structural considerations. Also provided special consultation regarding sulfide generation in sewer lines and application of mitigating measures.

Vice President and Regional Manager (1975-1980). Responsible for development of project design criteria, special consultation, technical review and coordination, and project administration and liaison.

Senior Vice President (1980-Date). Responsible for directing the firm's civil and environmental engineering activities in the western U.S.

Publications

"How to Select a Consulting Engineer to Perform Gas Control Engineering Services," Workbook of the EPA/DOE Intergovernmental Methane Task Force, Denver, Colorado, March 1979 (Coauthor M. E. Nosanov).

Papers and Presentations

"Sewage Treatment Plant Design," Symposium Panel Moderator, California Water Pollution Control Association Annual Conference, 1969.

"The Hydraulic Properties of Tees Versus Wyes for Sewer Lateral Connections," presented at Arizona Water and Pollution Control Association Annual Conference, 1970.

"Site Investigation, Selection, Design and EIR for an Industrial Process Residue Facility Meeting the Requirements of a Class II-1 Disposal Facility," presented at California Water Pollution Control Association Southern Region Industrial Waste Conference Workshop, Los Angeles, California, January 1980 (Coauthor M. E. Nosanov).

Gordon S. Magnuson (Continued)

"Methane from Combined Gas Control Venting and Recovery Systems," presented at Landfill Methane Utilization Symposium, Argonne National Laboratories, Asilomar, California, March 1980 (Coauthor M. E. Nosanov).

Biographical Data

JAMES L. MANG

Environmental Engineer

Personal Information

Date of Birth: 12 October 1950

Education

B.S. in Mechanical Engineering, 1973, University of Cincinnati, Ohio

M.S. in Environmental Engineering, 1974, University of Southern California, Los Angeles

Professional Affiliations

American Society of Civil Engineers
Water Pollution Control Federation

Experience Record

1968-1973	The Timken Company, Canton, Ohio. Engineer Trainee. Responsibilities included drafting, product design, machine and machine tool design, quality control, and time study at a roller bearing factory and a steel mill. Also involved in labor relations, setting labor rate incentives, and facilities management. Developed a mathematical model for solid waste collection for Covington, Kentucky, and served as project manager for the design and testing of a waste incinerator.
1973-1974	University of Southern California Environmental Engineering Laboratory, Los Angeles, California. Research Assistant. Responsible for the operation of analytical equipment including gas chromatograph, atomic absorption units, and spectrophotometer. Designed and executed experiments to assess the environmental effects of disposal of dredged material in water and developed new techniques for measuring water quality parameters in sediment.
1974-1977	SCS Engineers, Long Beach, California. Staff Engineer (1974-1975), Project Engineer (1975), and Project Manager (1975-1977). Responsible for managing financial and personnel resources for a wide variety of environmental engineering projects including field, laboratory, and literature studies concerned with water pollution and land disposal

James L. Mang (Continued)

problems with emphasis upon water and soil chemistry. Responsible for marketing, proposal preparation, and client development and liaison.

Managed several extensive studies on land disposal of dredged material for the U.S. Army Corps of Engineers Waterways Experiment Station. Projects included development and implementation of a field monitoring and sampling program for the physical and chemical characterization of dredged material sediments involving determination of the quality of interstitial water and leachates associated with active and inactive disposal areas. Conducted laboratory investigation of leachate composition and analysis of treatment techniques for application to leachates generated from disposal of different dredged materials to landfills and other types of land disposal sites. Performed literature review of state-of-the-art technology, environmental impacts, and economics associated with inland disposal of contaminated dredged material.

Other activities included groundwater well installation and sampling, design of landfill gas control systems, analysis of surface water and groundwater quality data, state-of-the-art review of health effects associated with wastewater and sludge disposal systems, and assessment of health effects associated with direct reuse of municipal wastewater. Prepared a study on the control of birds attracted to a sanitary landfill as a hazard to aircraft. Participated in the development of several areawide solid waste management plans, a nationwide project on groundwater impacts of municipal sludge disposal in landfills, and a national study of leachate from municipal sanitary landfills.

1977-1979 Calscience Research, Huntington Beach, California. Vice President. Responsible for federal government overhead negotiations, contract negotiations, marketing, and management of water pollution and land disposal projects including field and literature studies. Responsible for proposal preparation and client development and liaison. Projects included studies on the enhancement of biological treatment and sludge digestion of municipal wastewaters; environmental and public health effects of land disposal of wastes from coal utilization; treatment of industrial wastes from electroplating; leachates from sanitary landfills; and sanitary

James L. Mang (Continued)

landfill disposal of sludges. Also prepared synthesis of laboratory and field investigations for the U.S. Army Corps of Engineers Waterways Experiment Station to evaluate potential water quality impacts associated with effluents and leachates generated during confined land disposal in active and inactive sites.

1979-Date Engineering-Science. Environmental Engineer/Project Manager (1979-Date). Responsible for direction of projects involving solid and hazardous waste management. Supervised hazardous waste cleanup programs at government installations including groundwater monitoring, soil sampling and analysis, industrial wasteline investigation, and development of remedial action and environmental restoration plans. Conducted resource recovery/transfer station system conceptual design study involving site selection and technical, environmental, and economic evaluation of alternatives for the Fresno-Clovis Metropolitan Solid Waste Commission. Also responsible for developing preliminary design of waste-to-energy system for Los Angeles Unified School District including evaluation of solid waste collection, transportation, and disposal operations, feasibility assessment of energy and materials recovery, and development of solid waste management plan.

Developed an ameliorative program for a municipal landfill which was polluting groundwater above one of only five sole source aquifers in the United States as well as a remedial action program for an industrial land disposal site operated by an aluminum producer above another of the nation's sole source aquifers. Devised hazardous waste management training program for aircraft manufacturing plant supervisors and developed legislative guidelines for hazardous waste facility siting for a major oil refiner. Identified hazardous wastes generated by a leading steel-producing company. Reviewed design of hazardous waste facilities for coal-to-ethanol-to-gasoline plant for major chemical company. Performed hazardous waste identification and evaluated storage, transfer, handling, and disposal operations for an aircraft manufacturing facility. Developed RCRA compliance monitoring program for semiconductor firm including waste analysis plan, facility inspection plan, contingency plan, training program, and employee testing manual.

James L. Mang (Continued)

Performed comprehensive technological and economic analysis and evaluation of EPA hazardous waste regulations including landfilling, landfarming, and surface impoundments for the Chemical Manufacturers Association. Responsible for conceptual design of hazardous and nonhazardous waste disposal facilities for oil shale processing for TOSCO including waste characterization, site selection, and development of operational plan for RCRA compliance. Supervised spill and chemical solvent tank cleanup including soil sampling and analysis, groundwater monitoring, aquifer testing, and cleanup and disposal operations for a major semiconductor firm under review of numerous federal and state agencies. Developed groundwater monitoring program for Texaco and conducted ecological/wetlands evaluation of a hazardous waste disposal site for Shell Oil Company. Also responsible for development of management plans for hazardous and nonsewerable liquid wastes generated within Orange County, California.

Editor and Lecturer (1980-Date). Responsible for developing and editing a reference handbook for hazardous waste management for industrial facilities. Serves as lecturer at public and industrial seminars on hazardous waste, with responsibility for lecturing on meeting RCRA requirements; design of hazardous waste treatment, storage, and disposal facilities; characterization of waste materials; and industrial facilities management.

1980-Date California State University at Long Beach, California. Instructor (concurrent position). Responsible for aiding in development of hazardous waste occupational and engineering training course sponsored by the U.S. Environmental Protection Agency. Teaches course segments addressing the design and operation of hazardous waste landfills, land cultivation sites, and underground injection facilities; sampling, analysis, and characterization of waste material; and industrial facilities management under RCRA.

Publications

"The Potential for Adverse Health Effects Associated with the Application of Wastewaters and/or Sludges to Agricultural Lands," Land As A Waste Management Alternative (Ann Arbor, Michigan: Ann Arbor Press, 1977) (Coauthors D. Weaver, W. Galke, and G. Love).

James L. Mang (Continued)

A Study of Leachate from Dredged Material in Upland Areas and/or in Productive Use, U.S. Army Corps of Engineers Waterways Experiment Station Report No. 7D02, February 1978 (Coauthors J.C.S. Lu, R.J. Lofy, and R.P. Stearns).

Physical and Chemical Characterization of Dredged Material Sediments and Leachates in Confined Land Disposal Areas, U.S. Army Corps of Engineers Waterways Experiment Station Report No. 2D05, May 1978 (Coauthors K.Y. Chen, K.Y. Yu, and R.D. Morrison).

Synthesis Report--Confined Disposal Area Effluent and Leachate Control, U.S. Army Corps of Engineers, Chief of Engineers Office, June 1978 (Coauthors K.Y. Chen and B.A. Eichenberger).

Evaluation of Potential Water Quality Impacts from Coal Utilization Solid Waste Disposal under the National Energy Plan, Energy and Environmental Systems Division, Argonne National Laboratory, July 1978 (Coauthors K.Y. Chen, B.A. Eichenberger, and J.C.S. Lu).

Reference Handbook for Hazardous Waste Management, First Ed. (Berkeley, California: Engineering and Science Research Foundation, March 1980) (Editor-in-Chief and Coauthor).

Reference Handbook for Hazardous Waste Management, Second Ed. (Berkeley, California: Engineering and Science Research Foundation, July 1980) (Editor-in-Chief and Coauthor).

"Surface Impoundment of Hazardous Wastes," Proceedings: Conference on Hazardous Materials Control of the Hazardous Materials Control Institute, Baltimore, Maryland, August 1981 (Coauthors F.R. Bowerman and D.R. Anderson).

Papers and Presentations

"Control of Groundwater Contamination from Sanitary Landfills: a State-of-the-Art Review," presented to the Eighth Annual National Groundwater Conference, Las Vegas, Nevada, September 1976 (Coauthors R.P. Stearns and D.E. Weaver).

"Monitoring of Confined Dredged Material Disposal Sites," presented to the Ninth Annual National Groundwater Conference, Boston, Massachusetts, September 1977 (Coauthor R.D. Morrison).

"Analysis of RCRA, Phase II," presented at Seminar on Reviewing RCRA Part A Permits and Phase II Hazardous Waste Plans, Engineering and Science Research Foundation, 5-6 November 1980.

"Conducting Technical Audits and Developing Hard Data to Meet RCRA Regulations," presented at Seminar on Reviewing RCRA Part A Permits and Phase II Hazardous Waste Plans, Engineering and Science Research Foundation, 5-6 November 1980.

James L. Mang (Continued)

"Plant Management Guidelines Under RCRA," presented at Western Metal and Tool Conference, American Society for Metals/Society of Manufacturing Engineers, Los Angeles, California, 23-26 March 1981 (Coauthor W.R. Kirkpatrick).

"Meeting Near-term RCRA Regulations," presented at Western Metal and Tool Conference and Exposition, American Society for Metals Society of Manufacturing Engineers, Los Angeles, California, 23-26 March 1981.

"How to Satisfy RCRA's Training Requirements," presented at National Hazardous Waste Conference, Engineering and Science Research Foundation, Chicago, Illinois, 7-8 April 1981; and at Hazardous Waste Management Workshop for Semiconductor Firms, Semiconductor Industry Association Engineering and Science Research Foundation, Santa Clara, California, 5 June 1981.

"Hazardous Waste Training Programs," presented at National Hazardous Waste Conference, Engineering and Science Research Foundation, Chicago, Illinois, 7-8 April 1981.

"Contingency Plans and Emergency Procedures," presented at Hazardous Waste Management Workshop for Semiconductor Firms, Semiconductor Industry Association/Engineering and Science Research Foundation, Santa Clara, California, 5 June 1981.

"Superfund Update (CERCLA of 1980)," presented to Los Angeles Regional Forum on Solid Waste Management, Long Beach, California, September 1981 (Coauthor P. Rogers).

"Types of Wastes and Disposal Systems," presented at Symposium on Hazardous Waste Management: Protection of Water Resources, Louisiana State University, Baton Rouge, Louisiana, 16-18 November 1981 (Coauthors D.R. Anderson and F.R. Bowerman).

"Spill Response: Who to Notify?" presented at Industrial Waste Conference, California Water Pollution Control Association, Los Angeles, California, February 1982 (Coauthors F.R. Bowerman and L.E. Doane).

"Cleaning Up Hazardous Waste Sites," presented at Thirteenth Annual Western Regional Solid Waste Symposium, Governmental Refuse Collection and Disposal Association, Buena Park, California, 28-30 April 1982.

Biographical Data

JEFFREY L. RUBIN

Soil Chemist

Personal Information

Date of Birth: 28 June 1952

Education

B.S. in Soil and Water Science (honors), 1974, University of California, Davis
M.S. in Soil Science, 1980, University of California, Davis

Professional Affiliations

Certified Professional Soil Specialist, American Registry of Certified Professionals in Agronomy, Crops, and Soils (ARCPACS)
American Society of Agronomy
Council for Agricultural Science and Technology
Professional Soil Scientists Association of California
Soil Conservation Society of America
Soil Science Society of America

Experience Record

1972-1979 University of California, Davis, California. Department of Soils and Plant Nutrition. Laboratory Helper (1972-1973) and Laboratory Assistant I (1973-1974). Assisted in research projects involving soils and plant nutrition. Conducted mechanical soil analyses using traditional soil testing techniques to determine the physical properties of farm animal manures.

Department of Soils and Plant Nutrition. Laboratory Assistant II (1974-1975). Investigated the utilization of nitrogenous organic residues from agricultural wastes for energy and remaining ash for crop fertilizer. Conducted closed system field study on the fate of applied fertilizer nitrogen. Research also included manure decomposition rate studies, effects of animal manure on soil crusting, greenhouse studies demonstrating plant response to manure ashes, and studies to determine plant-available phosphorus in ashed crop residue.

Jeffrey L. Rubin (Continued)

Academic Advising and Counseling. Resource Science Advisor (1973-1974). Advised students on academic program alternatives and future employment prospects.

Agronomy and Range Science Department. Soil Scientist/Intern (1975). Surveyed and mapped the soils within the irrigated pasture fields of the University of California Sierra Foothill Range Field Station to aid in forming a comprehensive plan for the development, management, and experimental use of irrigated fields.

Department of Land, Air, and Water Resources: Soils Division. Graduate Research Assistant (1975-1979). Conducted research on the transfer of trace metals in the food chain and their potential hazard to the public under a university grant.

Department of Engineering, Laboratory Consultant (1978). Responsible for performing chemical analyses on soil test samples to determine sulfate-sulfur content.

Department of Land, Air, and Water Resources: Soils Division. Staff Research Associate (1979). Served as project manager for salinity study of the San Joaquin Delta, including laboratory and data management for analyses performed on the organic soils.

1974-1975	Department of the Interior, Bureau of Reclamation, Division of Water and Land Operations (Recreation and Wildlife Resources Branch), Sacramento, California. Resource Specialist/Intern. Conducted research, compiled environmental data on urban and non-urban parks and beaches and shores, and organized baseline data for total management study of the Central Valley.
1978	Sacramento Area Consultants, Sacramento, California. Field Consultant. Responsible for conducting soil surveys with emphasis on soil susceptibility to permeability. Performed site evaluations for the Sacramento Regional County Sanitation District's proposed sludge application and management plan.
1979	California State Department of Conservation, Sacramento, California. Graduate Student Assistant. Responsible for coordination and reproduction of base maps, analysis of survey questionnaires,

Jeffrey L. Rubin (Continued)

special soil problem studies, and preparation of a report assessing statewide soil problems.

1979-Date Engineering-Science. Soil Chemist. Responsible for managing laboratory personnel, coordinating field sampling and laboratory analyses, and performing soil and tissue tests on projects utilizing wastewater for irrigation of agricultural land. Developed entire field sampling programs for water and soils which included arranging for drilling subcontractors, establishing technical procedures, developing precautionary measures for sampling such as prevention of sample cross-contamination, and developing criteria for the well drilling and sampling activities. Project manager for all laboratory work for the Monterey Wastewater Reclamation Study for Agriculture, with responsibility for data management, statistical evaluation, and quality assurance for laboratory analyses performed by involved personnel.

Coordinated the development and performance of laboratory and field sampling procedures for soil and water assessments of hazardous wastes and conducted extraction tests utilizing EPA and California Department of Health Services methods of extraction and analysis. Other major projects involved groundwater monitoring and analysis for priority pollutants; sampling and analysis for metals, PCBs, TCE, fluoride, and organic solvents, consisting of phenol, sulfonic acid, aromatic solvents, and chlorinated benzene; and field monitoring and analysis for dye tracing studies which simulate point source pollutant discharge. Served as liaison between clients and the California Department of Health Services in dealing with possible priority pollutants by coordinating field sampling programs and requirements with the state and participating in mutual on-site sampling efforts and splitting of samples. Promoted the firm's involvement with the hydrological aspects, sampling, and analysis of hazardous wastes for those projects requiring recommendations for further sampling and for groundwater monitoring.

Publications

"Physical Properties of Farm Animal Manures," California Agricultural Experiment Station Bulletin, No. 867, University of California - Division of Agricultural Sciences, November 1974 (Coauthors A.A.R. Hafez, J. Azevedo, and P. R. Stout).

Jeffrey L. Rubin (Continued)

An Interpretive Survey of Some Irrigated Pasture Soils of the Lower Foothills of the Sierra Nevada Mountains of Northern California (University of California, Davis: Department of Agronomy and Range Science, Water Resources Center, 1975) (Coauthor C. A. Raguse).

"Phosphorus Fertilizer as a By-product of Energy Production from Agricultural Wastes," Journal of Environmental Quality, 1977 (Coauthors R. Siegel, A. Hafez, and P.R. Stout).

California Soils: An Assessment (State of California: Department of Conservation, Soil Resources Protection Unit - Resources Agency, 1979) (Coauthors B. Brown, E. Craddock, B. T. Beutenmuller, T. Irving, S. Anderson, D. Stanley, and P. Vonich).

Papers and Presentations

"Comparative Chemical Effects of Organic Versus Inorganic Metal Salts Incorporated into Soil," M.S. Thesis, University of California, Davis, California, 1980.