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FINAL REPORT INSTALLATION RESTORATION PROGRAM

PHASE II — CONFIRMATION McCLELLAN AFB, CALIFORNIA

VOLUME I

PREPARED FOR

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

JUNE 1983

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Letter on file

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FINAL REPORT

INSTALLATION RESTORATION PROGRAM

PHASE II - CONFIRMATION

McCLELLAN AFB, CALIFORNIA

VOLUME I

Prepared for

US AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY
BROOKS AFB, TEXAS

June 1983

Prepared by

Engineering-Science
125 West Huntington Drive

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22 June 1983

ES File 9793

Mr. Emile Baladi
USAF OEHL/EC
Brooks AFB, Texas 78235

Subject: Final Report, Contract F33615-80-D-4001,
Call Order Number 20

Dear Mr. Baladi:

Enclosed is the Engineering-Science, Inc. (ES) Final Report entitled "Installation Restoration Program, Phase II - Confirmation, McClellan AFB, California". The large amount of information and data generated during the project necessitated division of the report into two volumes. The first volume contains the report narration and the first few appendices; the second volume contains the remaining report appendices.

The report narration presents introductory background information on the Installation Restoration Program, a description of the environmental setting at McClellan AFB, an explanation of the field program, a discussion of field and analytical results, and an examination of possible alternative measures.

Engineering-Science has been pleased to be able to provide services to the Air Force. Please do not hesitate to contact us with any questions.

Sincerely,

James L. Mang

James L. Mang
Project Manager

Gordon S. Magnuson

Gordon S. Magnuson
Division Vice President

JLM/GSM/elj

Enclosures

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

INTRODUCTION

The United States Air Force, due to its primary mission to militarily defend the United States through the operation and maintenance of aircraft, has long been engaged in a wide variety of operations that require handling toxic and hazardous materials. Federal, state, and local governments have developed strict regulations that require disposers of these materials to identify the locations and contents of waste disposal sites and to implement action to eliminate any hazards to the public health or the environment. 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 the public health and welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP serves 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 McClellan Air Force Base in July 1981, includes the identification and prioritization of past disposal sites that could pose a hazard to public health or the environment as a result of contaminant migration. Phase II consists of a comprehensive preliminary

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environmental survey to define and quantify the presence or absence of contamination that may adversely affect public health or the environment. During Phase III, a data base will be developed upon which to prepare a comprehensive contaminant control plan. This contaminant control plan will be implemented in Phase IV.

This report describes the work performed during the Phase II program at McClellan AFB, California, including development of recommendations for follow-on actions and future monitoring.

The Phase I study was a records search assessing the potential for groundwater quality problems on McClellan AFB (CH2M Hill, 1981). The Phase I report included information generated by the Air Force in a study entitled "Investigating Ground Water Contamination as of 30 April 1981" (Brunner and Zipfel, 1981). The records search program resulted in the identification of two main areas of concern. These were (1) organic solvents found to be present in groundwater and (2) polychlorinated biphenyls (PCB's) contained in soil in a small area located at the northwest corner of the runway clear zone as a result of previous land owner activities. The soils containing PCB's were removed by the Air Force and transported to an approved PCB site. The Phase I report recommended the implementation of an expanded monitoring program in Phase II to determine the extent of organic constituents in groundwater. The results of that program are discussed in this report.

Forty-six active and inactive waste disposal and storage sites were identified in the Phase I report. Using the Air Force's Hazard Assessment Rating Methodology (HARM System), the sites were evaluated on the basis of site characteristics, potential for contamination, waste characteristics, and waste management practices. Most of the sites were envisioned as forming four discrete site clusters across the Base. The estimated locations of these sites and site clusters are illustrated on Figure E.1. In some instances the exact site location is unknown.

FIELD PROGRAM

Prior to the development of the field program an extensive review of existing information on geologic conditions and aquifer systems was conducted. Based on that information and specific recommendations from

FIG E. 1

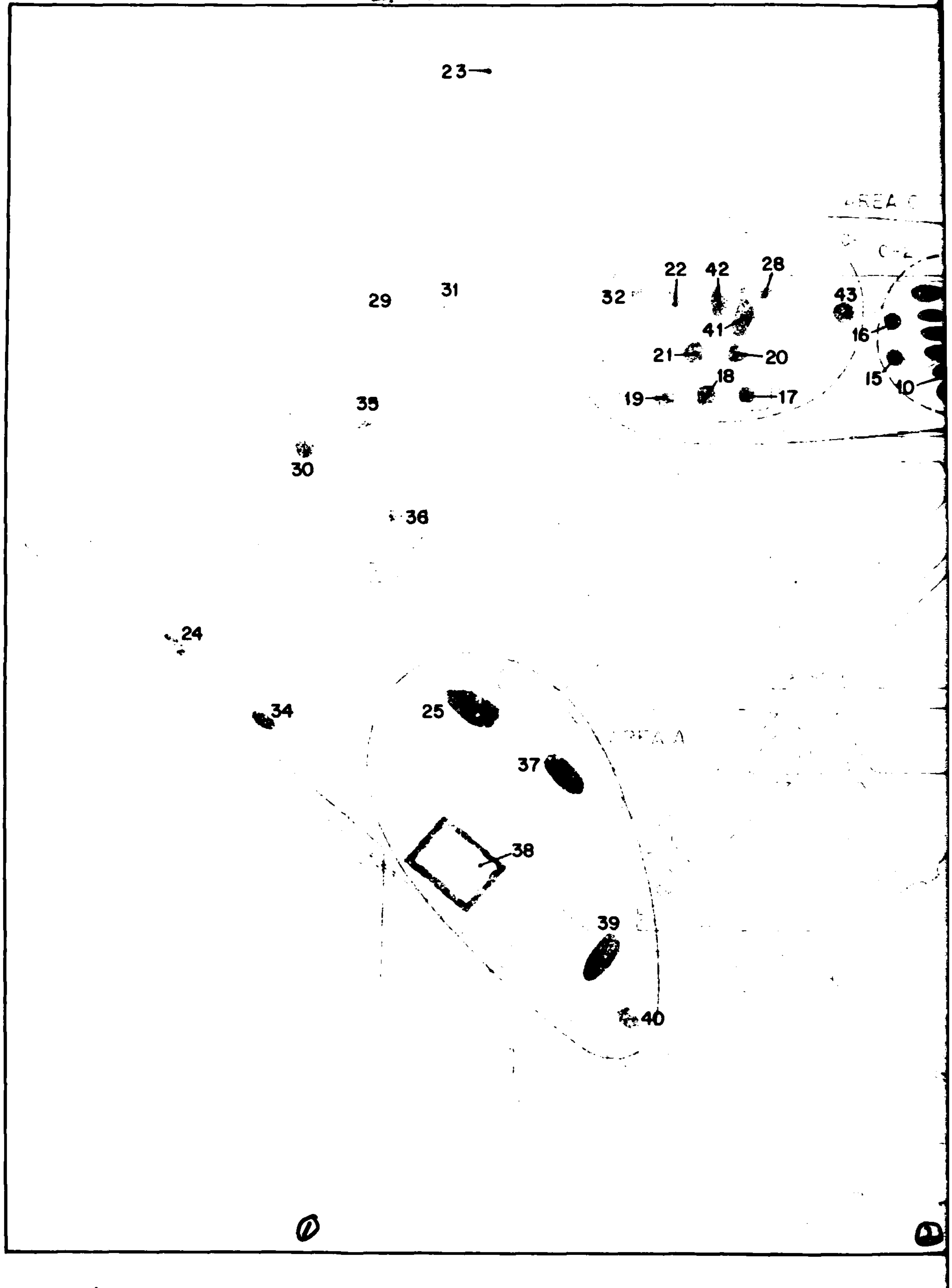

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FIG E.1

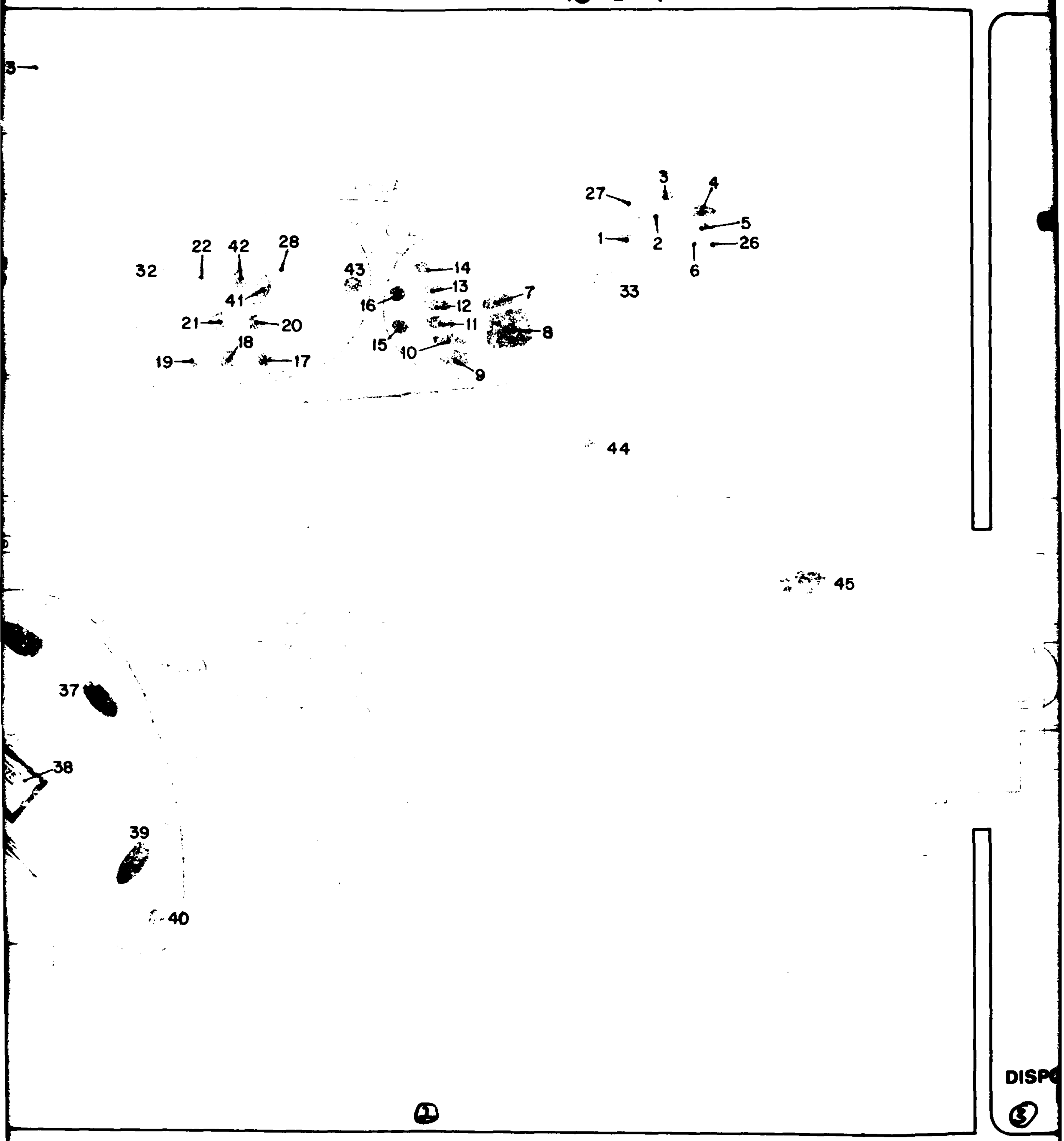

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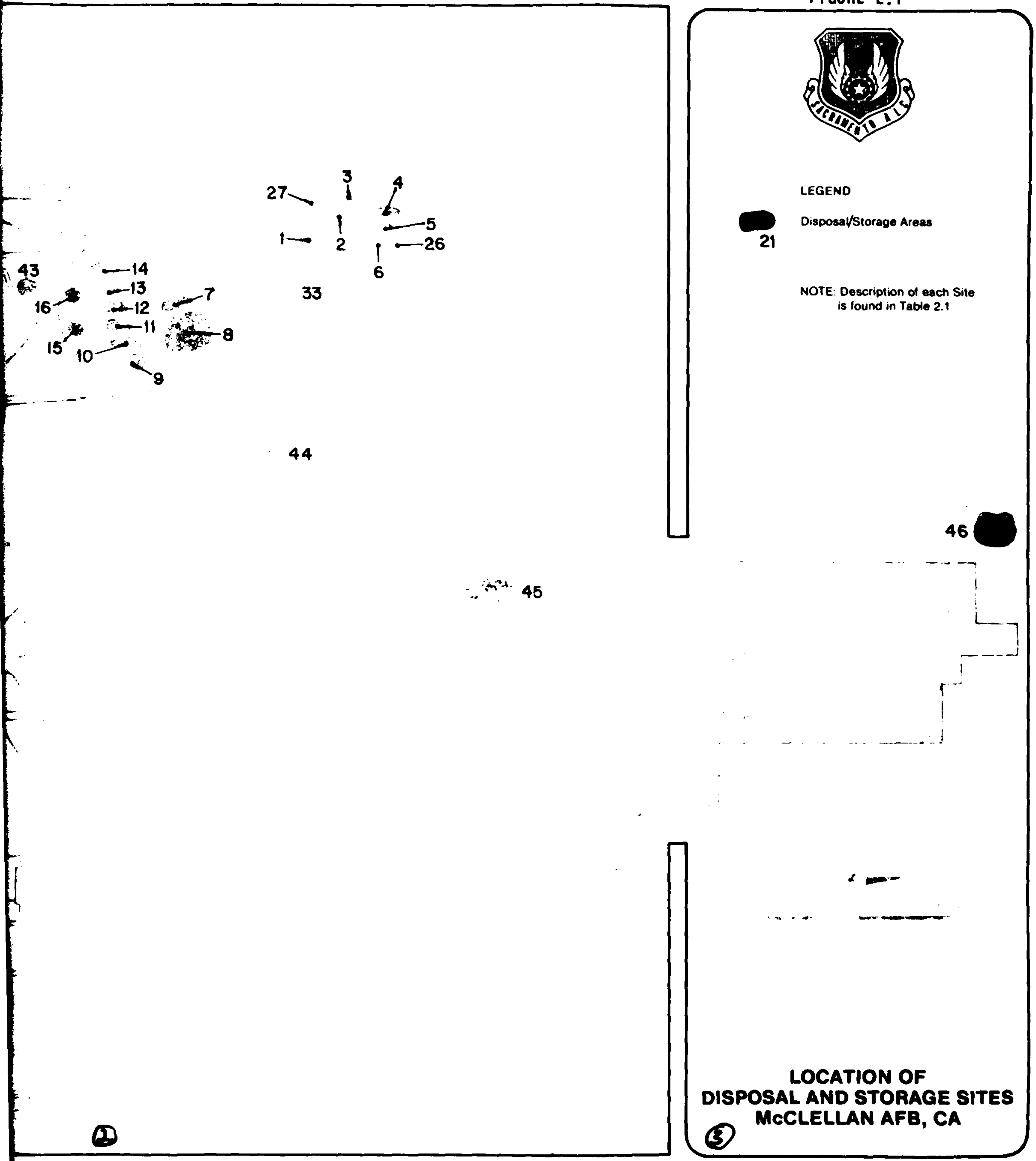
FIG E.1

FIGURE E.1



LEGEND

● 21 Disposal/Storage Areas

NOTE: Description of each Site is found in Table 2.1

LOCATION OF DISPOSAL AND STORAGE SITES McCLELLAN AFB, CA

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the Phase I report, a field program was developed that included installing monitoring wells, analyzing groundwater samples, conducting aquifer tests, investigating an industrial waste line, and locating an abandoned Base water supply well.

The drilling program at McClellan AFB was implemented in two successive stages. A total of 48 monitoring wells were installed during this two-phased program. The location and depth of Stage I monitoring wells were determined on the basis of existing hydrogeological information for the Base (primarily well logs from previously installed monitoring and water supply wells) and location of past disposal and storage areas on the Base. The Stage II drilling program was designed on the basis of analytical results obtained for the Stage I groundwater samples. Pump and slug tests were conducted to evaluate the transmissibility of water-bearing sands and lateral and vertical continuity between each sands zone. One pump test and three slug tests were performed. Seven wells were tested for specific conductance and temperature in the field. Readings were taken in wells to determine whether stratification was evident within a well and whether detectable differences could be noted between the shallow and deeper aquifers.

Part of the Stage I field program included establishing the location of Base production well 7. This was necessary since it was thought that well 7 could be a conduit for water to travel from near the surface down to lower production aquifers. Abandonment of the well in past years left no clue on the surface as to its location. A search of Base utility records showed the approximate location to be near the west side of Building 475 in an underground well house. The buried well building was located with a magnetic flux indicator (Schonstedt GA-52 Magnetic Locator), and the site was excavated for evaluation of the well head. The well head, located in the building basement, was found to be encased with concrete and fitted with a non-watertight fabricated steel cap; the gravel pack was sealed by a 24-inch outer casing. A watertight cap was installed on the 24-inch casing, in addition to a supplemental lockable steel cap. The well was found to be obstructed at an 80-foot depth, even after attempted clean-out of the well by rotary-wash drilling. Evidence from Base personnel interviews indicates the well casing probably was grouted in the late 1960's or early 1970's. Because a substantial amount of excess water from fill material drained into the well during excavation, sampling of BW7 for priority pollutants was not accomplished.

An investigation of the industrial waste collection system in the vicinity of Building 251 was performed in January 1982. The purpose of this investigation was to determine if the industrial waste line was a possible source of constituents that necessitated closure of two Base production wells in the immediate vicinity. The investigation included three soil borings beneath the line.

FINDINGS

Results of the field program demonstrated that the Base is underlain by a shallow sands zone at depths ranging from approximately 80 to 100 feet below ground surface. This zone varies in thickness from 1 foot to 17 feet and may be discontinuous in places. Permeabilities range from 0.8 to 4.2 gpd per square foot, and transmissibilities range from 4.7 to 21 gpd per foot. The groundwater in this zone moves in a south-southwesterly direction and is influenced locally primarily by off-base production wells. Based on physical characteristics, it appears that groundwater in this zone would move off Base no more than 1,000 feet in 40 years. However, localized pumping may accelerate this rate. Deeper aquifers exist, disconnected from the shallow sands and separated by at least 20 feet of predominately fine-grained material.

Since off-base wells may have been constructed with gravel packs and perforations in the shallow sands zone, constituents in groundwater (that could be the result of past McClellan AFB waste disposal practices) could migrate downward into lower aquifers causing water quality problems with off-base water supply wells. Sufficient time has passed since the disposal of waste material on McClellan property for constituents in the first sands beneath the Base to cause problems in public and private water supply wells.

Groundwater samples from all wells on the Base were analyzed for selected organic and inorganic constituents. The shallow aquifer (first sands zone) shows the presence of constituents particularly along the

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western border of the Base where former disposal sites existed. However, the data also show organic compounds and trace metals in shallow wells throughout the Base; often, these wells were not located near a known disposal area. The occurrence of these constituents in wells with no apparent known source indicates that the delineation of plumes from individual site locations may not be possible.

Numerous factors contribute to the fact that identification of constituent plumes in groundwater from individual sites on Base may be impossible. These factors include potentially unknown sites and varying groundwater table elevations, as well as the operation of disposal sites at different times. In addition, in many cases groundwater has flowed beneath several sites, picking up constituents from one or more areas. It is possible that chemical constituents may be identified in downgradient areas off the Base. The interface between areas containing detectable constituents and those areas which do not could be considered the leading edge of a plume. Phase II of the IRP did not provide for any off-base activity, so plume movement outside the boundaries of the Base was only estimated.

The deeper aquifer (second sands zone) shows constituents near or below limits of detection, except pesticides and herbicides. A deep well located downgradient of the sludge pit area in the northwest corner of the Base clearly shows an absence of constituents, even though it is situated in an area exhibiting "worst case" conditions.

Selected analyses of wells showed negative results in most cases. PCB analyses of all monitoring wells installed on the Base during Stages I and II resulted in non-detectable concentrations. However, aroclor (a polychlorinated biphenyl) was present above detection limits in one Base production well in a single sampling event. Low concentrations of cyanide were detected in six monitoring wells on the Base, including one well installed at the upgradient Base boundary. A seventh well contained an elevated cyanide concentration. Cresylic acid was detected in a shallow well placed between the suspected source (Building 475) and Base production well 7 (abandoned). Two wells (shallow and deep) placed downgradient from production well 7 did not contain cresylic acid. Aliphatic material (grease and oil) appeared at elevated concentrations in

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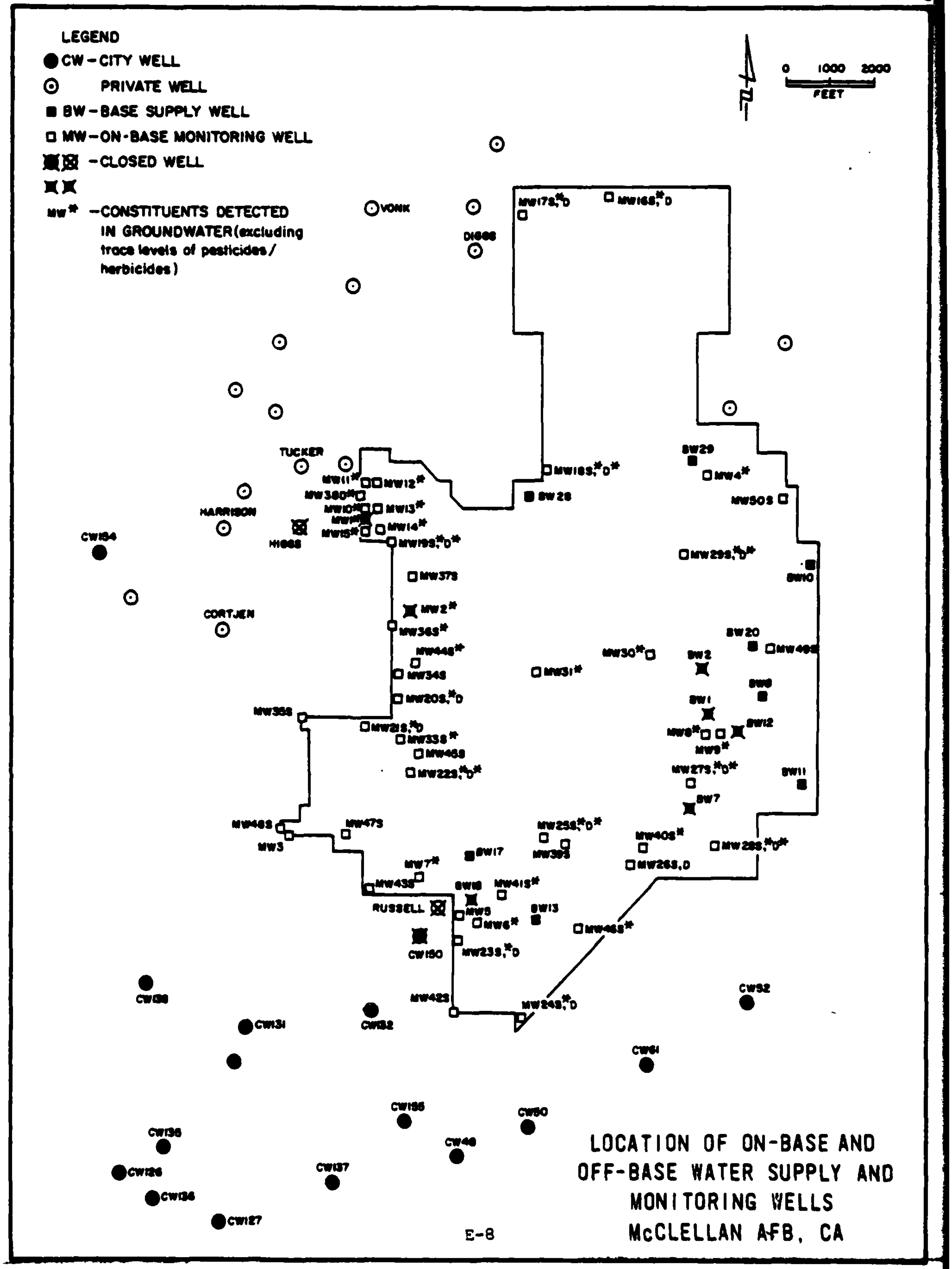
one well along the western edge of the Base. This material has not reached the second aquifer but has migrated in a southerly direction.

The presence of herbicides and pesticides in all of the shallow wells and most of the deeper wells is universal across the Base. Concentrations vary from one well location to another, and from one sampling to the next within the same well. The actual appearance of a particular compound is not consistent. One sampling often shows a compound that is not detected during a subsequent sampling. The source of these herbicides and pesticides in the groundwater may be partially from Base application and/or disposal. However, monitoring wells placed upgradient at the extreme north end of the Base show the presence of herbicides and pesticides in the shallow and deep aquifers. The source of groundwater for both wells is off Base from the north. Herbicides and pesticides are therefore being contributed to on-base groundwater from off-base sources. Historical records do show that two off-base production wells north of the Base contain 2,4,5-TP (Silvex). The occurrence of these herbicides and pesticides appears to be ubiquitous.

Figure E.2 depicts the location of all monitoring wells on the Base, and denotes those wells where *measurable concentrations* of most constituents were identified. A general range of constituent concentrations found in all on-base shallow wells is compiled in Table E.1. These data reflect results only for constituents identified at measurable levels in at least one well. Analytical reports which present comprehensive results for all constituent analyses performed are contained in the appendices. Constituent values lower than the detection limits were not used to calculate the range of concentration except for those constituents found at detectable levels in only one or two shallow groundwater samples. For these constituents, it was not possible to tabulate low and/or median concentrations representing measurable quantities. In these instances, trace level data and "not detected" results were used to establish the range of concentration. The source areas in which the high concentrations were found are noted in the table. Table E.2 provides a range of the most common volatile organic constituent concentrations from different source areas.



LOCATION OF ON-BASE AND
OFF-BASE WATER SUPPLY AND
MONITORING WELLS
McCLELLAN AFB, CA

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TABLE E.1

RANGE OF CONSTITUENT CONCENTRATIONS DETECTED IN BASE MONITORING WELLS AND STAGE I AND II SHALLOW WELLS

Constituent[a]	Unit of Measurement	Minimum Detection Level	Source Area[b]	Concentration High	Concentration Low	Concentration Median
Volatiles						
benzene	ppb	10.0	D	680	10	45
carbon tetrachloride	ppb	1.0	A	25	ND[c]	<10
chloroform	ppb	1.0	D	120	5	20
1,1-dichloroethane	ppb	1.0	D	250	19	110
1,2-dichloroethane	ppb	1.0	D	17	ND	ND
1,1-dichloroethylene	ppb	1.0	D	63,000	5	2,500
1,2-trans-dichloroethylene	ppb	1.0	D	200	6	80
ethylbenzene	ppb	1.0	C-1	220	ND	<10
methylene chloride	ppb	1.0	D	5,000	1,000	3,000
tetrachloroethylene	ppb	1.0	D	70	5	10
toluene	ppb	1.0	C-1	440	5	50
1,1,1-trichloroethane	ppb	1.0	D	12,000	55	2,300
trichloroethylene	ppb	1.0	D	14,100	0.54	61
trichlorofluoromethane	ppb	1.0	D	7	ND	ND
vinyl chloride	ppb	1.0	D	50	20	25
Acid Compounds						
2,4-dimethylphenol	ppb	1.0	D	94	ND	19
pentachlorophenol	ppb	1.0	DBB	260	6	15
phenol	ppb	10.0	D	400	<10	<10
Base/Neutral Compounds						
anthracene	ppb	1.0	C-1	220	ND	<10
bis(2-ethylhexyl)phthalate	ppb	1.0	C	230	8	20
1,2-dichlorobenzene	ppb	1.0	D	100	21	32
1,3-dichlorobenzene	ppb	1.0	D	28	<10	8
1,4-dichlorobenzene	ppb	1.0	D	40	10	12
di-n-butyl phthalate	ppb	1.0	C-1	9	ND	<10
fluorene	ppb	1.0	C-1	90	ND	ND
naphthalene	ppb	1.0	C-1	90	<10	25
1,2,4-trichlorobenzene	ppb	1.0	D	12	4	8
Pesticides/Herbicides						
Aldrin	ppb	0.003	D	6.97	0.041	0.503
alpha-BHC	ppb	0.002	A	0.08	0.018	0.032
beta-BHC	ppb	0.004	UBB	0.142	0.007	0.048
delta-BHC	ppb	0.004	C-1	0.83	0.025	0.066
gamma-BHC (lindane)	ppb	0.002	UBB	2.76	0.005	0.038
2,4-D	ppb	0.001	C-2	0.56	0.003	0.063
2,4,5-T	ppb	0.001	C-1	0.087	0.002	0.005
2,4,5-TP (Silvex)	ppb	0.002	D	0.36	0.004	0.051
dieldrin	ppb	0.006	D	0.20	<0.006	<0.006

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TABLE E.1 (Continued)

Constituent[a]	Unit of Measurement	Minimum Detection Level	Source Area[b]	Concentration High	Concentration Low	Concentration Median
endosulfan sulfate	ppb	0.03	C	0.011	<0.03	<0.03
heptachlor	ppb	0.002	DBB	0.88	0.013	0.056
heptachlor epoxide	ppb	0.004	DBB	0.17	0.007	0.027
Metals						
antimony	mg/l	0.005	D	0.06	0.006	0.008
arsenic	mg/l	0.05	D	0.66	0.24	0.30
cadmium	mg/l	0.01	UIA	0.08	0.01	0.014
chromium	mg/l	0.05	D	4.17	0.07	0.12
copper	mg/l	0.05	D	1.18	0.12	0.33
lead	mg/l	0.01	A	0.98	0.01	0.023
mercury	mg/l	0.0005	UBB	0.0027	0.0005	0.0012
nickel	mg/l	0.05	UIA	2.13	0.05	0.08
selenium	mg/l	0.01	D	0.355	0.01	0.049
zinc	mg/l	0.02	DBB	11.4	0.02	0.07
Selected Analyses						
cresylic acid (Cresol)	µg/l	5	A	26	<5	ø[d]
cyanide	mg/l	0.02	UIA	0.95	0.02	0.03

a List of constituents excludes those which were not detected in any shallow groundwater sample. A total of 77 constituents were tested and not found above detection limits. Comprehensive results for all analyses performed are contained in Appendices K, L, and M.

b Area in which high concentration was detected:
A - Area A
C - Area C
C-1 - Subarea C-1
C-2 - Subarea C-2
D - Area D
DBB - Downgradient Base Boundary
UBB - Upgradient Base Boundary
UIA - Upgradient Base Industrial Area

c ND - Not detected

d ø - Analyses were performed for only two shallow groundwater samples.

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TABLE E.2

RANGE OF VOLATILE ORGANIC CONSTITUENT CONCENTRATIONS IN SHALLOW GROUNDWATER FROM DIFFERENT SOURCE AREAS

Source Area	Disposal Sites Upgradient From Affected Wells Containing Volatile Organics	Range of Concentrations of Most Common Volatile Constituents in Groundwater
AREA A	25,37,38,34,40	trichloroethylene: ND-50 ppb
AREA B	30,36	1,1-dichloroethylene: ND-5 ppb 1,2-trans-dichloroethylene: ND-10 ppb trichloroethylene: ND-118 ppb
SUBAREA C-1	41,42,43	ethylbenzene: ND-220 ppb toluene: ND-440 ppb trichloroethylene: ND-2,000 ppb
SUBAREA C-2	7,8,9,10,11,12, 13,14,15,16	1,1-dichloroethylene: ND-30 ppb tetrachloroethylene: ND-5 ppb trichloroethylene: ND-10 ppb
AREA D	1,2,3,4,5,6,26,27	1,1-dichloroethylene: 500-63,000 ppb 1,1,1-trichloroethane: ND-12,000 ppb trichloroethylene: 160-14,100 ppb

ND - not detected

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Analytical results of groundwater samples from the deeper water-bearing materials indicate the deeper zone is "cleaner" than the shallow aquifer, with constituents mostly near or below limits of detection except for pesticides and herbicides. In general, the deeper sands appear to contain no EPA priority pollutants; the absence of constituents is consistent at most well locations.

All three soil borings beneath the industrial waste line contained trace metals, specifically arsenic and selenium, at both the 15-foot and 20-foot depths.

CONCLUSIONS

Past waste disposal practices at McClellan AFB have resulted in the creation of three types of problems. These are (1) affected materials (disposed waste and soils), (2) on-base water supply, and (3) off-base water supply. The groundwater affected by past disposal activities appears to be limited primarily to the shallow sands zone. That zone, which varies in thickness from 1 foot to 17 feet, is a very poor producer of water. Based on estimated groundwater velocities, constituents in the shallow sands have probably migrated outside Base boundaries up to a distance of 1,000 feet. However, this rate of movement may be accelerated by local pumping. Private and public water supply wells located off the Base are most likely gravel packed to depths exceeding 50 feet below the ground surface, with perforations possibly at greater depths. The deeper water-bearing sands are probably continuous off Base where they are tapped by private and public wells for water supply.

RECOMMENDATIONS

Recommended follow-on actions and future monitoring for each problem area are summarized in Table E.3.

TABLE E.3

RECOMMENDED ACTIONS AND MONITORING
McCLELLAN AFB, CALIFORNIA

Problem	Recommended Action and Monitoring	Rationale	Implementation Priority[a]
Affected Materials	• Ensure that Sites 8 and 40 are closed to meet RCRA requirements	• Prevent precipitation moisture from contacting affected materials/Meet PCRA requirements	2
	• Close Site 4 to meet RCRA requirements to include placing 4 feet of soil/cement mixture within the pit, and subsequently cap the site to prevent surface infiltration	• Absorb moisture on pit surface/ Prevent precipitation moisture from contacting affected materials	1
	• Inspect sites in Area A (25), Area B (30), Subarea C-1 (41, 42, 43), Subarea Subarea C-2 (7, 8, 9, 10, 11), and Area D (2, 3, 4, 5, 6, 26, 27) to evaluate status of surface conditions. Cover sites with impermeable cap designed to divert surface water from the site	• Prevent precipitation moisture from contacting affected materials	• Area D: 2 • Subarea C-1: 3 • Area B: 3 • Subarea C-2: 4 • Area A: 4
On-Base Water Supply	• Seal gravel pack on Base production wells 1, 8, 13, 18, 20, and 29 • Abandon BW2 and seal gravel pack • Seal gravel packs in MW1, 2, 3, and 4	• Prevent affected shallow groundwater from entering Base water supply system	2
	• Rehabilitate industrial waste line in front of Building 251	• Minimize amount of exfiltration from pipeline to the first sands zone	2
	• Remove manhole 33A and associated lines	• Prevent accumulation of sludge and eliminate potential contamination	2
	• Conduct investigation on remaining Base industrial waste line	• Identify potential areas of exfiltration into the first sands zone	3
	• Sample monitoring wells annually and Base production wells monthly[b]	• Monitor wells to determine effectiveness of corrective measure	1
Off-Base Water Supply	• Inform local governmental agencies of the need to set up regulations that require a 120-foot sanitary seal for new wells installed in the area	• Prevent new wells from providing migration route between water-bearing zones	1

TABLE E.3 (Continued)

Problem	Recommended Action and Monitoring	Rationale	Implementation Priority[a]
	• Inform local agencies of the need to seal gravel packs to a depth of 120 feet on private and public wells along affected Base boundaries	• Prevent shallow groundwater entering water supply wells	1
	• Inform local agencies of the need to monitor public and private wells semiannually within a 5,000-foot radius of affected Base boundaries[b]	• Provide early detection of downgradient migration of affected shallow groundwater	1
	• Investigate feasibility of constructing interception system along affected Base boundaries	• Develop system to prevent off-base migration of affected groundwater	3

a Priorities are ranked with 1 being highest and 4 the lowest.

b Well samples should be analyzed for: volatile compound (TCE); acid compound (pentachlorophenol); base/neutral compound (1,2-dichlorobenzene).

SECTION 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

BACKGROUND

The United States Air Force, due to its primary mission to militarily defend the United States through the operation and maintenance of aircraft, has long been engaged in a wide variety of operations that require handling toxic and hazardous materials. Federal, state, and local governments have developed strict regulations that require disposers of these materials to identify the locations and contents of waste disposal sites and to implement actions to eliminate any hazards to the public health or the environment. 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 the public health and welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP serves 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

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Phase I, completed at McClellan Air Force Base in July 1981, includes the identification and prioritization of past disposal sites that could pose a hazard to public health or the environment as a result of contaminant migration. Phase II consists of a comprehensive preliminary environmental 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 the Phase II program at McClellan AFB. During Phase III, a data base will be developed upon which to prepare a comprehensive contaminant control plan. This contaminant control plan will be implemented in Phase IV.

PREVIOUS WORK

In August 1979, the McClellan Environmental Protection Committee voluntarily created a special groundwater contamination committee to determine if aquifer water quality problems existed in the McClellan community. This action was prompted because of a problem with trichloroethylene (TCE), unrelated to McClellan AFB, in groundwater in the Rancho Cordova area, another community in the Sacramento region. The initial action of the committee was to analyze water from several wells located near each corner of the Base. In early November 1979, McClellan initiated a meeting with the California Central Valley Regional Water Quality Control Board, the City and County of Sacramento, and the State Department of Health Services to discuss initial Base findings. Representatives at this meeting agreed to analyze groundwater samples on and around McClellan AFB to determine the magnitude of the problem. Monitoring of on and off-base production wells throughout November 1979 resulted in the closure of three off-base wells and two McClellan wells. Two of the off-base wells belonged to private homeowners; the third belonged to the City of Sacramento. Since that time, two additional Base production wells have been taken off-line. To respond to the situation, McClellan AFB developed a five-part investigatory program. Included were: (1) drinking water protection; (2) evaluation of past disposal practices; (3) initial identification of affected areas; (4) initial local geology and groundwater study; and (5) initial source exploration, monitoring wells, and soil borings. Under this program, fifteen monitoring wells were installed and sampled.

Phase I - Installation Assessment of the Installation Restoration Program was conducted at McClellan AFB during 1981. The Phase I study was a records search assessing the potential for groundwater quality problems on McClellan AFB, California (CH2M Hill, 1981). It provided a general description of the existing climatological, geological, and hydrological regimes at the Base and in the immediate vicinity. The Phase I report included information generated by the Air Force in a study entitled "Investigating Ground Water Contamination aS of 30 April 1981" (Brunner and Zipfel, 1981).

Forty-six active and inactive waste disposal and storage sites were identified and evaluated in the Phase I report on the basis of site characteristics, potential for contamination, waste characteristics, and waste management practices. The records search program resulted in the identification of two main areas of concern. These were (1) organic solvents found to be present in groundwater and (2) polychlorinated biphenyls (PCB's) contained in soil in a small area located at the northwest corner of the runway clear zone as a result of previous land owner activities. The soils containing PCB's were removed by the Air Force and transported to an approved PCB site. The Phase I report recommended the implementation of an expanded monitoring program to determine the extent of organic constituents in groundwater.

SCOPE OF WORK

On the basis of the Phase I Assessment of the Potential for Groundwater Contamination performed in 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 groundwater contamination resulting from previous waste disposal practices at McClellan AFB, California
- Recommend measures to mitigate impacts for identified contaminated areas

- Develop environmental monitoring programs to document environmental conditions resulting from past waste disposal activities at McClellan AFB.

To accomplish these tasks, the ES work program included the installation of monitoring wells for collection of groundwater samples as well as the performance of hydrogeological field tests. A copy of the ES Scope of Work has been included as Appendix A to this report. Appendix B contains biographies of key ES individuals who contributed to the project.

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.

Apart from this introductory section, the main report body contains five chapters. Following are brief descriptions of each chapter.

Environmental Setting - overview of regional and local hydrogeology including aquifer systems and geology as well as a description of past disposal and storage sites

Field Program - discussion of field activities and procedures entailing Stage I and Stage II drilling programs, aquifer pumping and slug tests, establishing the location of Base Well 7, and the industrial waste line survey

Results of Field Program - interpretation of hydrogeological and groundwater quality data as well as ancillary field activities

Evaluation of Alternative Measures - discussion of alternative measures for mitigation of perceived environmental problems

Recommendations - discussion of systems that have been selected as appropriate mitigation measures

The appendices that follow these chapters contain the data that were generated and detail the procedures and equipment used during the project.

SECTION 2

ENVIRONMENTAL SETTING

CHAPTER 2

ENVIRONMENTAL SETTING

An understanding of the environmental setting at McClellan AFB was necessary to plan and execute the field program. This chapter contains a summary of the pertinent information extracted from past studies and from data sources identified by the project team. Included are discussions on (1) physical geography; (2) regional hydrogeology; (3) general hydrogeology of McClellan AFB; (4) disposal and storage areas identified in Phase I; (5) previous investigations; and (6) off-base wells. Major emphasis has been placed on the hydrogeological discussions since those areas had the greatest impact on development of the field program and subsequent interpretation of results.

PHYSICAL GEOGRAPHY

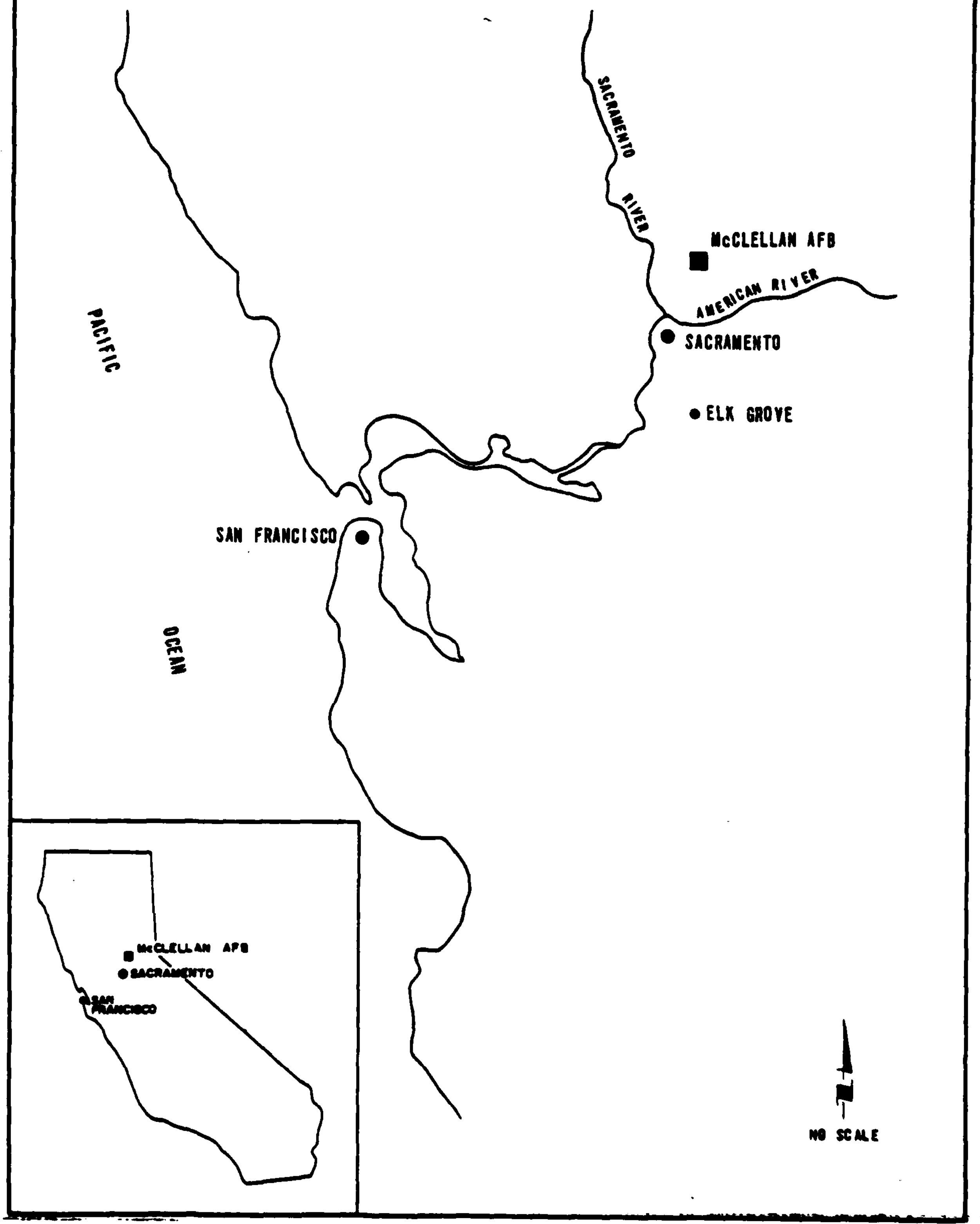
The general physical environment at McClellan AFB has been described in the Phase I report (CH2M Hill, 1981). The climatic conditions are characterized as Mediterranean-subtropical, with hot, dry summers and cool, moist winters, and an average annual rainfall of about 19 inches, most of which falls from November through May. The mean annual evapotranspiration rate for the Sacramento area is approximately 45 inches. The net precipitation for the area is approximately -26 inches per year (the difference between mean annual precipitation and mean annual evapotranspiration).

McClellan AFB encompasses 2,598 acres approximately 8 miles northeast of Sacramento, California. It has been in operation since 1936 and currently employs approximately 3,200 military personnel and 12,500 civilian employees. A regional location map is included as Figure 2.1.

1-31

FIGURE 2.1

REGIONAL LOCATION MAP
McCLELLAN AFB, CALIFORNIA



1-32

The Base is located within the Sacramento River drainage basin, about 8 miles east of the river. It is locally drained mainly by Magpie Creek flowing westward through the Base to the Natomas East Main Drainage Canal and eventually to the Sacramento River. The creek follows the topographical relief from about 75 feet above mean sea level (msl) on the east, to about 55 feet above msl on the west. Near the city of Sacramento, the Sacramento and American Rivers join prior to flowing through the San Francisco Bay delta for eventual discharge into the Pacific Ocean.

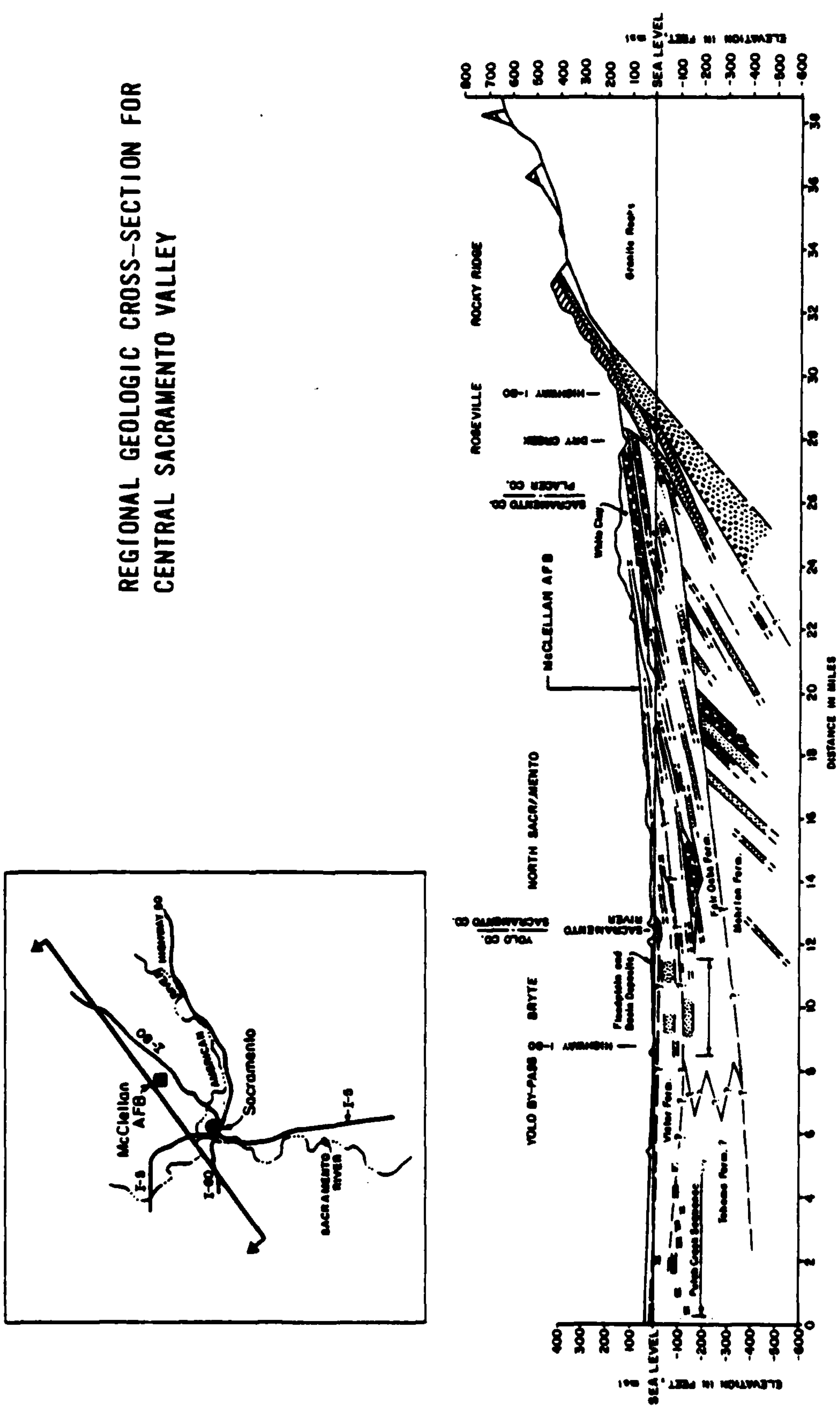
REGIONAL HYDROGEOLOGY

McClellan AFB is situated within the Sacramento Valley, a deep sedimentary trough that has received sediments from the Sierra Nevadas transported downhill by numerous tributaries to the meandering Sacramento River. Since post-Eocene time (about the last 60 million years), up to 4,000 feet of nonmarine sediments and volcanic detritus have been deposited in the valley. As indicated in the geologic cross-section on Figure 2.2, the deposited sediments resemble a wedge, relatively thin by the Sierras in the east and with maximum thickness near the Coast Ranges to the west. The sedimentary wedge slopes gently to the west, ranging from 300 feet per mile to as little as 5 feet per mile in the Sacramento County area (California Department of Water Resources, 1974).

In northern Sacramento County the surface sediments are part of the Victor Formation, underlain by the Fair Oaks Formation. The Victor Formation underlies the Victor Plain, a broad alluvial plain extending from south of Sacramento to the northern county boundary. From the east this formation dips below the American River and surfaces near the Sacramento River as a low ridge with a maximum elevation of 26 feet. The top surface of the formation slopes about 5 feet per mile and the base slopes at about 11 feet per mile in an east-west direction, indicating a gradual wedging to the west. The sediments within the Victor Formation consist of interbedded granitic sand, silt, and clay with occasional lenses of metamorphic channel gravels. The sediments are heterogeneous and laterally and vertically discontinuous, indicative of a past fluviatile environment. A great variability in grain size within this unit

1-33

REGIONAL GEOLOGIC CROSS-SECTION FOR CENTRAL SACRAMENTO VALLEY



SOURCE: CALIFORNIA DEPT. OF WATER RESOURCES, 1978

1-34

is the result of former intricately braided channels. Hardpan is usually encountered in the upper parts of the stratigraphic column. The formation has an overall moderate permeability, generally yielding little water unless old stream channels are penetrated.

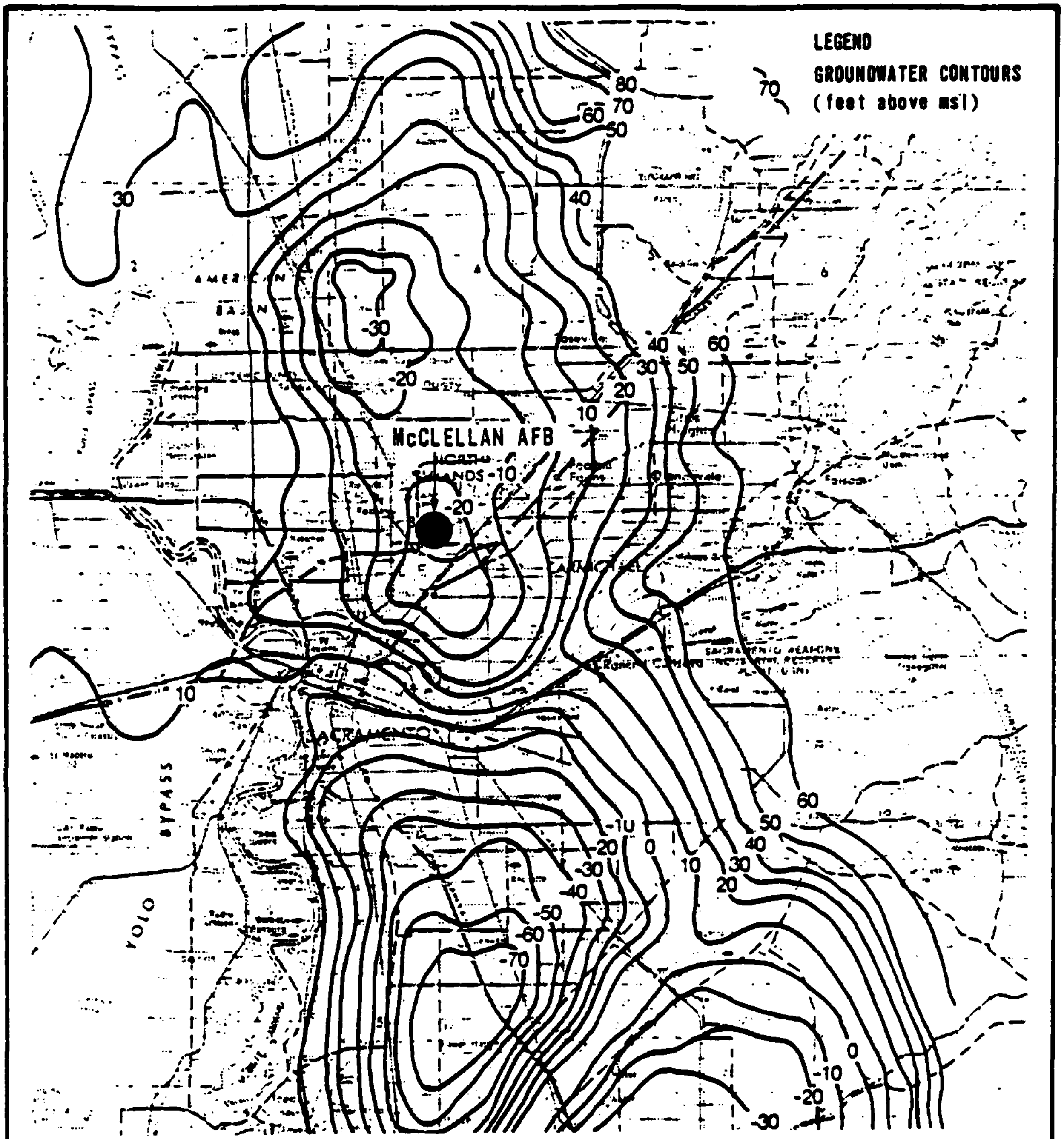
The Fair Oaks Formation underlies the Victor Formation near McClellan AFB. This formation slopes westward at about 15 feet per mile, and may reach thicknesses of over 100 feet. These sediments also consist of poorly bedded silts, clays, and sands, with occasional lenses of gravel. The formation is characterized by the presence of white clay beds (white volcanic tuff) up to one foot thick. The Fair Oaks Formation, like the Victor Formation, yields little water to wells except when wells penetrate old channel deposits; in those instances, the yields may be up to 3,500 gallons per minute (gpm) with drawdowns in the order of 30 feet (i.e., specific capacities of about 120 gpm per foot of drawdown) (California Department of Water Resources, 1974).

Groundwater within the Sacramento Valley basin occurs as a result of in-stream percolation into underlying permeable materials, through direct infiltration of precipitation, or through percolation of irrigation water. The recharge areas for that part of the basin underlain by hardpan (e.g., McClellan AFB) are along the eastern basin margins; hardpan severely restricts downward movement of water, except in places where fractures exist.

Groundwater discharge occurs almost exclusively by pumping. Since the turn of the century, extensive groundwater pumping for irrigation, industrial, domestic, and municipal usage has dramatically altered the groundwater flow directions and gradients within the basin. Water is pumped primarily from the Fair Oaks and Mehrten Formations in the area around Sacramento. Figure 2.3 shows a water level contour map for 1980 in the Sacramento area, based on water level measurements in selected water supply wells throughout the Sacramento Valley (California Department of Water Resources, 1980). Since the wells used may not all have been constructed to the same depth, the water levels measured may not be representative of site-specific conditions. In addition, the measurements may represent primarily water levels resulting from confined water; shallow unconfined aquifers may exhibit different water levels

1-36

FIGURE 2.3



NOTE: These contours reflect groundwater movement in the deeper water-production zone, and are not necessarily representative of the shallow water-bearing zone.

GENERAL REGIONAL
GROUNDWATER CONTOURS IN
THE SACRAMENTO VALLEY
SPRING 1980

SOURCE: ARDELL, 1980 (California Dept. of Water Resources)

1-3

and be less influenced by regional flow regimes. As indicated on Figure 2.3, McClellan AFB is located at the northern end of a pumping trough. Groundwater within the water-bearing formations tapped by most wells would be flowing south toward Sacramento, unless other local pumping troughs influence the groundwater flow direction.

GENERAL HYDROGEOLOGY OF McCLELLAN AFB

The general description of the hydrogeological environment of McClellan AFB provided in this section is based on published literature and information obtained from Base production wells and Base monitoring wells installed during 1980. A more detailed description of the hydrogeology is presented in Chapter 4, which discusses the results of the Phase II field program.

McClellan AFB is underlain by sediments from the Victor Formation (California Department of Water Resources, 1978). The thickness of these sediments varies, but they could be up to 50 feet thick beneath the Base. Underlying the Victor Formation is the Fair Oaks Formation, more than 300 feet thick. The diagnostic white clays that characterize this formation were noticed during monitoring well installation on the western side of the Base at depths ranging from 70 to 75 feet. Sediments from the Mehrten Formation underlie the Fair Oaks Formation to great depths.

Downgradient of the Base to the south, the top of the Victor Formation surfaces near the Sacramento River. The base of the formation dips beneath the river where it is eventually overlain by alluvial deposits. The Victor Formation is a wedge-shaped plain thickening from east to west, with an increase in fine-grained material in that direction (California Department of Water Resources, 1978).

Base water supply wells are completed within the Fair Oaks and Mehrten Formations at about 150 to 400 feet below the ground surface. Well logs from the installation of Base production wells are contained in Appendix C; these logs indicate great variety in subsurface conditions at each well location. Layers of sand, silt, and clay appear to

1-3

be alternating in no specific sequences or consistent thicknesses, indicating the possible discontinuous and lenticular nature of the sediments.

Geologic logs from monitoring wells installed by the Base in 1980 and subsequent water level readings in those wells have indicated water-bearing sands at an approximate 100-foot depth (about 20 feet below mean sea level). During Phase II monitoring well installation, water was also generally encountered in that depth range. Well logs for Base monitoring wells are contained in Appendix D; water level data for these wells are included in Appendix I.

A shallow water-bearing stratum at McClellan AFB consisting generally of a fine sand layer ranges in thickness from a few feet up to 17 feet. These sands contain water throughout the year, but the water levels are influenced by cyclical variations due to seasonal changes at the time of recharge. The sands are immediately underlain by either clays or silts that may be partially saturated. The shallow sands contain water under unconfined conditions.

Deeper water-bearing materials are separated from the shallow sands by extensive thicknesses (up to 60 feet) of silts and clays that act as confining layers; thus, the water encountered at greater depths is confined. The water supply wells on the Base tap these deeper sands for water.

An old now-buried stream channel, a former branch of the North Fork of the American River, appears to cross the eastern part of the Base trending in a northeast to southwest direction (California Department of Water Resources, 1974). This former channel is about 20 feet wide and located at depths over 100 feet; it contains considerable amounts of gravel and occasional boulders, and is a productive zone for groundwater. These channel deposits are probably located below the shallow water-bearing sands. Zones of higher permeability than surrounding material could act as conduits for constituent migration, serving as "channels" with water traveling at higher velocities in a downgradient direction.

The regional groundwater flow direction is to the south-southwest toward a pumping trough south of Sacramento. South and west of McClellan AFB are numerous active private and public water supply wells that influence the immediate subregional groundwater flow. Limited data indicate that these wells are completed at depths ranging from 125 feet to 210 feet, thus reaching into deeper water-bearing sands. The shallow water-bearing sands seem to be less influenced by the regional gradient dominated by surrounding pumping practices, and appear to have water flowing in a more southwesterly direction than the regional flow.

The recharge areas for the water-bearing sands underlying McClellan AFB are east of the Base in the Sierra Foothills. Recharge for the shallow sands is located closer to the Base than the recharge areas for the deeper water-bearing sands. Discharge from the groundwater basin would normally occur to the west into the Sacramento River. However, due to the creation of the pumping trough south of Sacramento, all groundwater underlying McClellan AFB either will discharge to wells near Sacramento or will increase groundwater storage in this vicinity.

DISPOSAL AND STORAGE SITES IDENTIFIED IN PHASE I

Forty-six waste disposal and storage sites were identified and evaluated in the Phase I report (CH2M Hill, 1981). The estimated locations of these sites are illustrated on Figure 2.4. Table 2.1 delineates each site, along with information obtained from historical records and personnel interviews regarding site usage, period in use, materials handled, and estimated site size. It should be noted that not all these sites contain materials designated as hazardous.

The Phase I evaluation of these sites was based upon site characteristics, potential for contamination, waste characteristics, and waste management practices. The evaluation was performed using a site rating model developed in June 1981, and consisted of assigning to each site numerical values weighted on a subjective scale according to degree of severity for contamination potential. Based upon these numerical evaluations, the sites were assigned either a high, medium, or low priority ranking. Table 2.2 contains a delineation of the sites broken

FIG 2.4

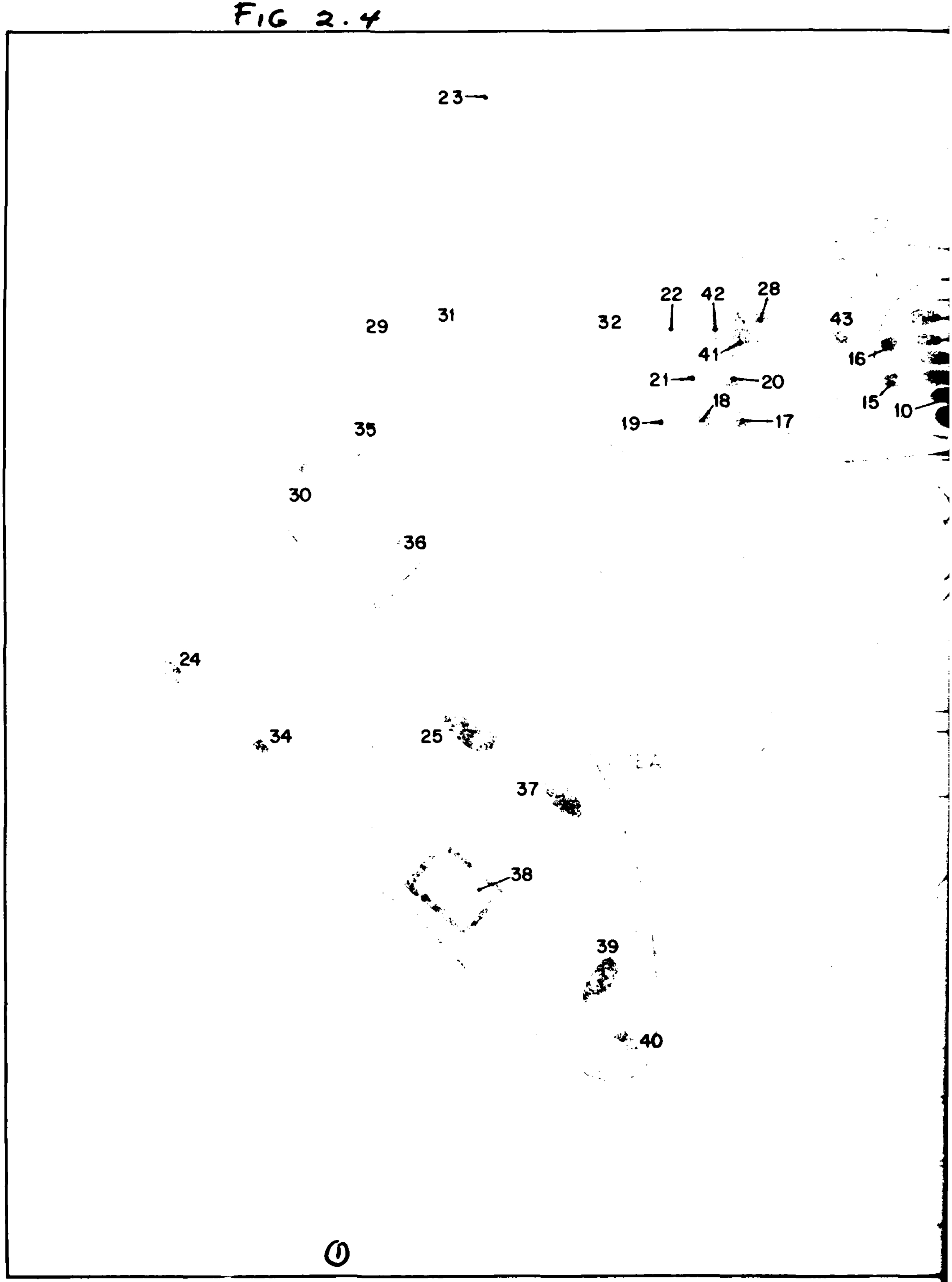

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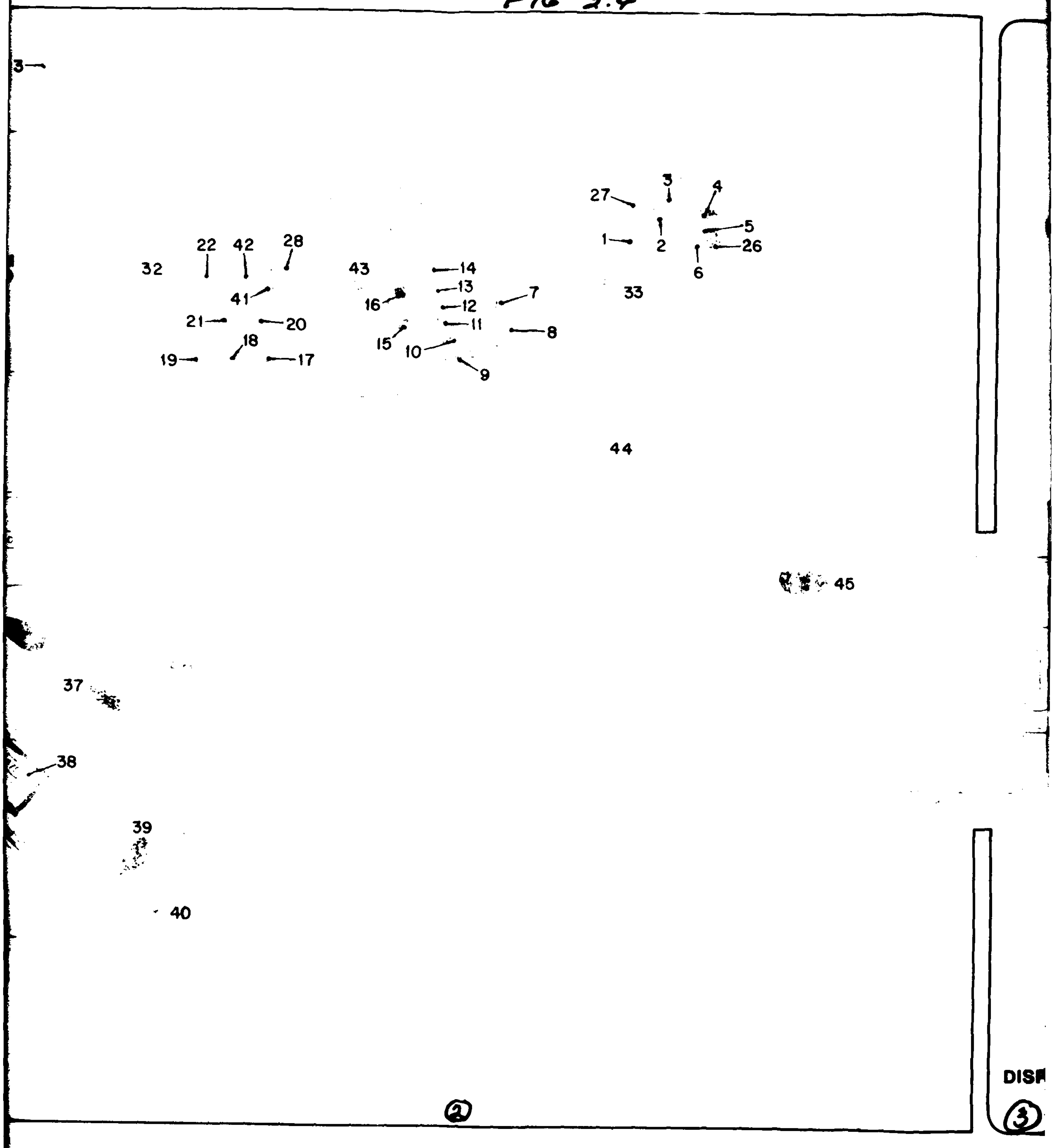
FIG 2.4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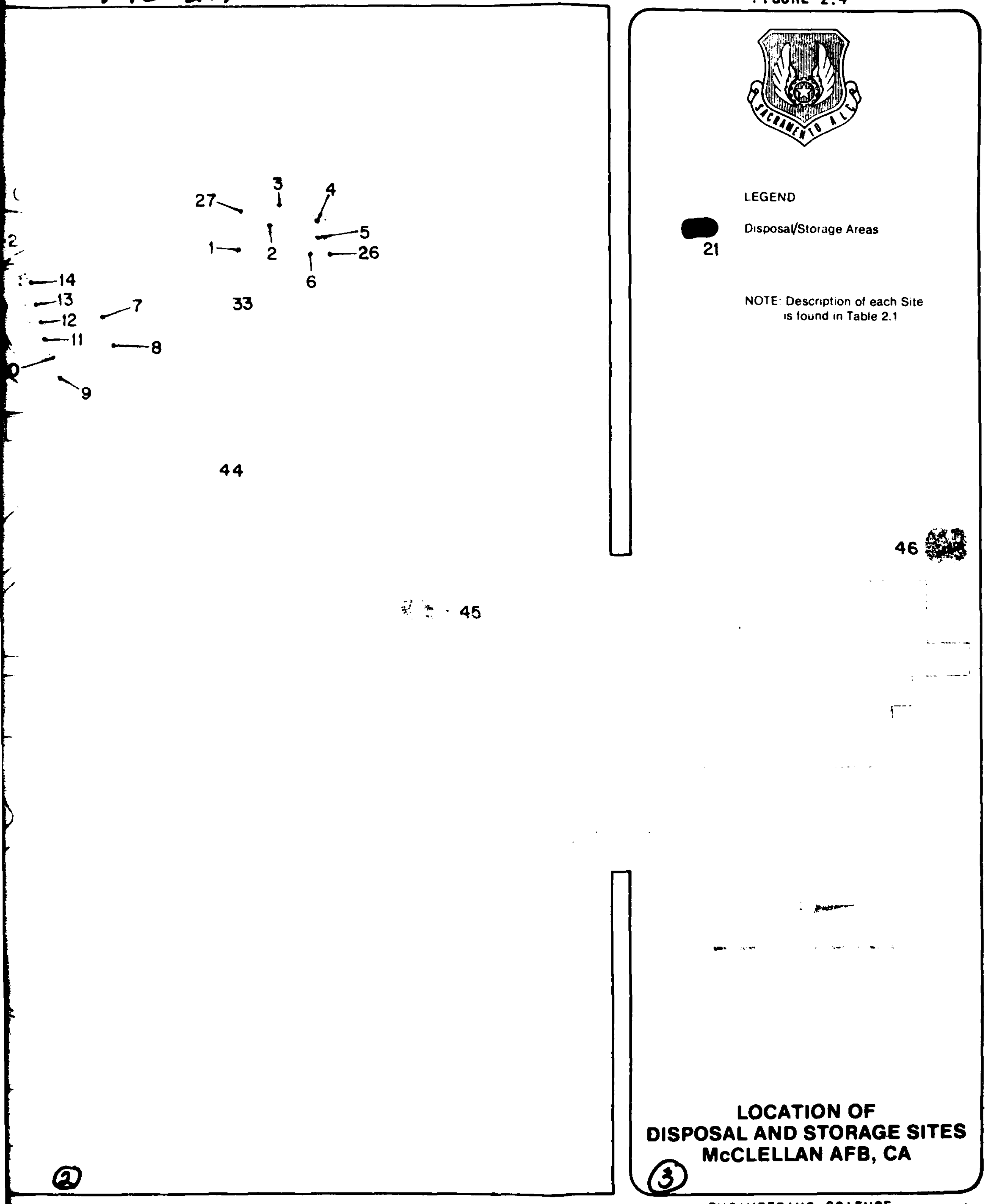
F/G 2.4

FIGURE 2.4



LEGEND

● Disposal/Storage Areas

NOTE: Description of each Site is found in Table 2.1

LOCATION OF DISPOSAL AND STORAGE SITES McCLELLAN AFB, CA

TABLE 2.1

DISPOSAL AND STORAGE SITES IDENTIFIED IN PHASE I
McCLELLAN AFB, CALIFORNIA

Site[a]	Prior Use	Dates in Use	Probable Materials Handled	Estimated Site Size
1	Burning/burial pit	1959 - 1962	Refuse/solid waste	310 ft x 190 ft
2	Sludge/oil pit Refuse burning/burial	1962 - 1979	Refuse/solid waste Undewatered industrial sludge Oil Waste solvents TCE-contaminated wastes	300-400 ft x 50 ft x 30 ft deep
3	Sludge/burning/ burial pit	1962 - 1965	Undewatered industrial sludge Oil	300-400 ft x 50 ft x 30 ft deep
4	Sludge/oil pit	1967 - 1981	Undewatered industrial sludge Oil TCE-contaminated wastes	300-400 ft x 50 ft x 30 ft deep
5	Sludge/oil pit	1972 - 1978	Undewatered industrial sludge Oil Waste solvents TCE-contaminated wastes	300-400 ft x 50 ft x 30 ft deep
6	Oil burn pit	1972 - 1978	Oil Fuel Solvents	125 ft x 125 ft
7	Sludge/oil pit	1966 - 1977	Undewatered industrial sludge Oil TCE-contaminated wastes	300-400 ft x 50 ft x 30 ft deep
8	Sludge/burial pit	1974 - 1981	Dewatered industrial sludge Demolition debris Creek debris Paint chips and residues Sanitary sewage sludge (grit) TCE-contaminated wastes	400 ft x 40 ft x 30 ft deep

TABLE 2.1 (Continued)

Site[a]	Prior Use	Dates in Use	Probable Materials Handled	Estimated Site Size
9	Burial pit	Pre-1949 - 1953	Ash and partially burned residue from Sites 22 and 31 Dewatered industrial wastewater treatment plant sludge Plating bath solutions and sludges (including lead, tin, antimony, and possibly cadmium plating wastes) Degreasing solvents and sludges Paint residues Fuels (probably including leaded) and oils PCB liquids, solids, transformers, and electrical components Miscellaneous laboratory chemicals Cyanide wastes (drummed) Low-level radioactive wastes (possibly) Herbicide/pesticide containers	100-400 ft x 50 ft x 30 ft deep
10	Burial pit	1953 - 1955	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
11	Burial pit[b]	1955 - 1957	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
12	Burial pit[b]	1967 - 1969	Same as Site 9[c]	100-400 ft x 50 ft x 30 ft deep
13	Burial pit[b]	1969 - 1971	Same as Site 9[c]	100-400 ft x 50 ft x 30 ft deep
14	Burial pit	1971 - 1974	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
15	Sodium valve trench	1940 - 1950	Sodium valves from aircraft engines	15-20 ft x 2 ft x 6-9 ft deep
16	Sodium valve trench	1940 - 1950	Sodium valves from aircraft engines	15-20 ft x 2 ft x 6-9 ft deep
17	Burial pit	1957 - 1959	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
18	Burial pit	1957 - 1959	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
19	Burial pit	1957 - 1959	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
20	Sludge/oil pit	1956 - 1957	Industrial wastewater treatment plant sludge Oil	250 ft x 190 ft
21	Sludge/oil pit	1956 - 1957	Industrial wastewater treatment plant sludge Oil	250 ft x 220 ft
22	Burning pit/ teepee burner/ burial pit	1946 - 1968	Refuse, ash and residue Oily wastes Waste solvents (including TCE in significant amounts Waste chemicals	100 ft x 400 ft x 50 ft
23	Burial pit	1966 - 1969[d]	No information available	125 ft x 280 ft
24	Burning/burial pit	1964 - 1969	Demolition debris Scrap material (lumber and paper)	310 ft x 160 ft

TABLE 2.1 (Continued)

Site[a]	Prior Use	Dates in Use	Probable Materials Handled	Estimated Site Size
25	Burial pit	1940's and early 1950's	No information available	625 ft x 250 ft
26	Sludge pit	Early 1960's	Undewatered industrial sludge	300-400 ft x 50 ft x 30 ft deep
27	Sodium valve trench	Late 1940's and early 1950's	Sodium valves from aircraft engines	15-20 ft x 2 ft x 6-9 ft deep
28	Creek debris sludge pit	Pre-1972	Creek debris/sediments Industrial waste spills and discharges (probably)	160 ft x 250 ft
29	Civil Engineering reclamation yard, transformer storage area, and scrap material burner	1950's and 1960's	Drums Transformers (some with PCB's)	160 ft x 250 ft
	Generator burial pit	1974	Aircraft generators (~50 - 60)	
30	Surface disposal site	Late 1950's - present	TCE Freon Diethyl ether Low-level radioactive wash water	220 ft x 220 ft
31	Refuse incinerator/ ash burial	1963 - 1968	Refuse/solid waste Ash	160 ft x 250 ft
32	Radioactive/hazardous waste storage	Pre-1963 - 1975	Low-level radioactive waste containers	160 ft x 160 ft
33	Industrial sludge landfarm	1972[e]	Industrial waste treatment sludge	350 ft x 250 ft
34	Waste solvent storage tanks	1950 - 1953	Waste solvents (2 underground tanks)	310 ft x 125 ft
35	Scrap metal burial pit	World War II[f]	Scrap strapping steel	220 ft x 160 ft
36	Open storage area	1958 - 1980	Plating shop chemicals	125 ft x 190 ft
37	Burial pit	Early 1950's[g]	Refuse	500 ft x 250 ft
38	Engine repair shop; carbon remover storage/burial/ sludge pits	1940's - mid 1960's	Carbon remover, including ethylene dichloride/cresylic acid/soap emulsion mixture and 50-50 mixture of cresylic acid/ orthodichlorobenzene (large quantities in above and below-ground tanks) Contaminated carbon removal sludges from skimming ponds	875 ft x 595 ft
39	Burning/burial pit	Pre-1941 - 1946	Refuse/ash All Base wastes	625 ft x 160 ft

1-45

TABLE 2.1 (Continued)

Site[a]	Prior Use	Dates in Use	Probable Materials Handled	Estimated Site Size
40	Industrial sludge drying beds (8, unlined)	1955 - 1972; 1980	Industrial wastewater treatment plant sludges in 4 beds (probably with significant concentrations of VOC's)	250 ft x 190 ft
41	Burial pit	Mid-1940's	Demolition debris (probably)	560 ft x 190 ft
42	Oil storage/burning/ burial pits (3 parallel burial pits and 2 burning pits)	Mid-1940's - 1960's	Oil Waste fuel Waste solvents Refuse	190 ft x 310 ft
43	Burial pit	Mid-1940's	Demolition debris (probably)	220 ft x 250 ft
44	Hazardous waste storage area	1975 - present	No information available	500 ft x 150 ft
45	Paint burial pit	1950's	Latex-based(?)paint (~ 200-300 55-gallon drums)	560 ft x 160 ft
46	Salvage yard operation (under previous owner)	Mid-1960's - 1978[h]	No information available (identified PCB surface contamination; possible burial pit)	500 ft x 375 ft

Sources: CH2M Hill, 1981 and Department of the Air Force, 1979

a Site locations are shown on Figure 2.4.

b Fire training is currently conducted in the vicinity of the site.

c Cyanide wastes were possibly removed from Site 12 or 13 during 1967-1971.

d Material was removed in 1970.

e Temporary (2 to 4 months).

f Material was removed in 1950.

g Material was removed in 1956.

h Material was removed in 1981.

TABLE 2.2

PHASE I PRIORITY LISTING OF McCLELLAN AFB DISPOSAL AND STORAGE SITES

Site No.	Site Description	Overall Score[a] 1981	HARM Score[b] 1982
	HIGH PRIORITY:	59 - 72	
Site 4	Sludge/oil pit	72	86
Site 2	Sludge/oil pit	71	86
Site 3	Sludge/burning/burial pit	71	86
Site 5	Sludge/oil pit	71	86
Site 6	Oil burn pit	71	86
Site 26	Sludge pit	71	86
Site 7	Sludge/oil pit	67	85
Site 8	Sludge/burial pit	66	85
Site 22	Burning pit/teepee burner/burial pit	66	81
Site 40	Industrial sludge drying beds	66	69
Site 17	Burial pit	65	71
Site 18	Burial pit	65	71
Site 19	Burial pit	65	71
Site 38	Engine repair shop	65	81
Site 20	Sludge/oil pit	64	81
Site 21	Sludge/oil pit	64	81
Site 9	Burial pit	63	75
Site 10	Burial pit	63	75
Site 11	Burial pit	63	75
Site 12	Burial pit	63	75
Site 13	Burial pit	63	75
Site 14	Burial pit	63	75
Site 1	Burning/burial pit	61	70
Site 46	Salvage yard operation	61	86
Site 39	Burning/burial pit	60	70
Site 42	Oil storage/burial/burning pits	59	75

1-47

TABLE 2.2 (Continued)

Site No.	Site Description	Overall Score[a] 1981	HARM Score[b] 1982
	MEDIUM PRIORITY:	**43 - 52**	
Site 33	Industrial sludge landfarm	52	72
Site 32	Radioactive/hazardous waste storage	51	N.R.[c]
Site 27	Sodium valve trench	50	N.R.
Site 28	Creek debris sludge pit	50	65
Site 30	Surface disposal site	50	67
Site 41	Burial pit	49	N.R.
Site 43	Burial pit	49	N.R.
Site 15	Sodium valve trench	44	N.R.
Site 16	Sodium valve trench	44	N.R.
	LOW PRIORITY:	**34 - 42**	
Site 29	Civil Engineering reclamation yard	42	N.R.
Site 45	Paint burial pit	42	41
Site 31	Refuse incinerator	41	N.R.
Site 34	Waste solvent storage tanks	38	N.R.
Site 24	Burning/burial pit	37	N.R.
Site 25	Burial pit	37	N.R.
Site 23	Burial pit	35	N.R.
Site 35	Scrap metal burial pit	34	N.R.
Site 37	Burial pit	34	N.R.

a CH2M Hill, 1981
b USAF Installation Restoration Program Hazard Assessment Rating Methodology, 1982
c N.R. - Not rated

down by these rankings. As indicated on this table, most of the sites were originally assigned to the high priority classification. In January 1982, a new site rating model was developed by the Air Force to more realistically evaluate the potential hazards posed by sites at Air Force installations. This new Hazard Assessment Rating Methodology (HARM System) was designed to improve the ranking of sites with regard to potential environmental contamination. The HARM scores for those sites which were reevaluated by the Air Force using this revised methodology are also presented on Table 2.2.

PREVIOUS INVESTIGATIONS

In August 1979, a Groundwater Contamination Committee was established by McClellan AFB to identify potential groundwater quality problems on the Base. As a result, on-base water supply wells were sampled for volatile organic compounds (VOC) and a number of groundwater monitoring wells were subsequently installed. The locations of the Base production wells and Base monitoring wells are shown on Figure 2.5.

Analysis of groundwater samples for volatile organic compounds over time showed that trichloroethylene (TCE) was the constituent most frequently identified. With this the case, TCE could be expected to serve as an indicator of the presence or absence of volatile organics in groundwater. Table 2.3 summarizes the chronology of the groundwater quality problems on the Base following initial identification of trichloroethylene (TCE) during an August 1979 sampling event. As represented on the table, chemical constituents were identified in BW1, BW2, BW12, BW13, and BW18 and MW1, MW2, MW3, and MW4. Table 2.4 presents analytical data for TCE for these wells prior to Phase II.

During installation of MW12, MW13, and MW14, solid material samples were obtained and analyzed for volatile organic compounds. The results of these analyses are depicted on Figure 2.6. In material from MW12 and MW13, most of the detected constituents were in the range of 100 to 400 μg/kg. MW14, which was installed through Site 2, showed high levels of 1,1,1-trichloroethane and trichloroethylene in samples from depths of twenty feet and forty feet.

Available well logs and well designs for Base production wells and Base monitoring wells are contained in Appendices C and D. Information for these wells regarding depths of casing, seals, gravel packs, and casing perforations is summarized in Table 2.5. These parameters are important for determination of the potential mode of transportation of constituents within the aquifer system underlying the Base.

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FIG 2.5

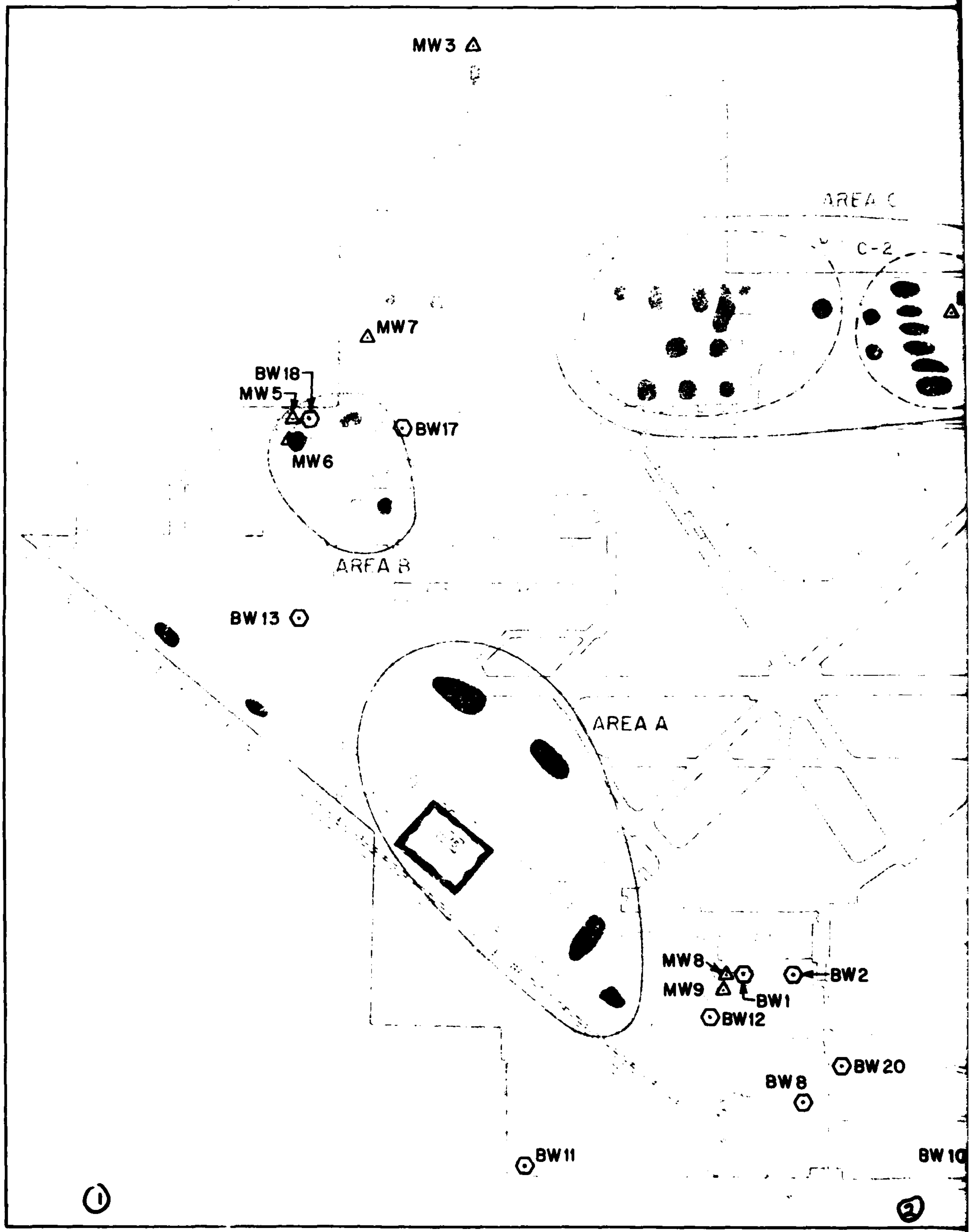
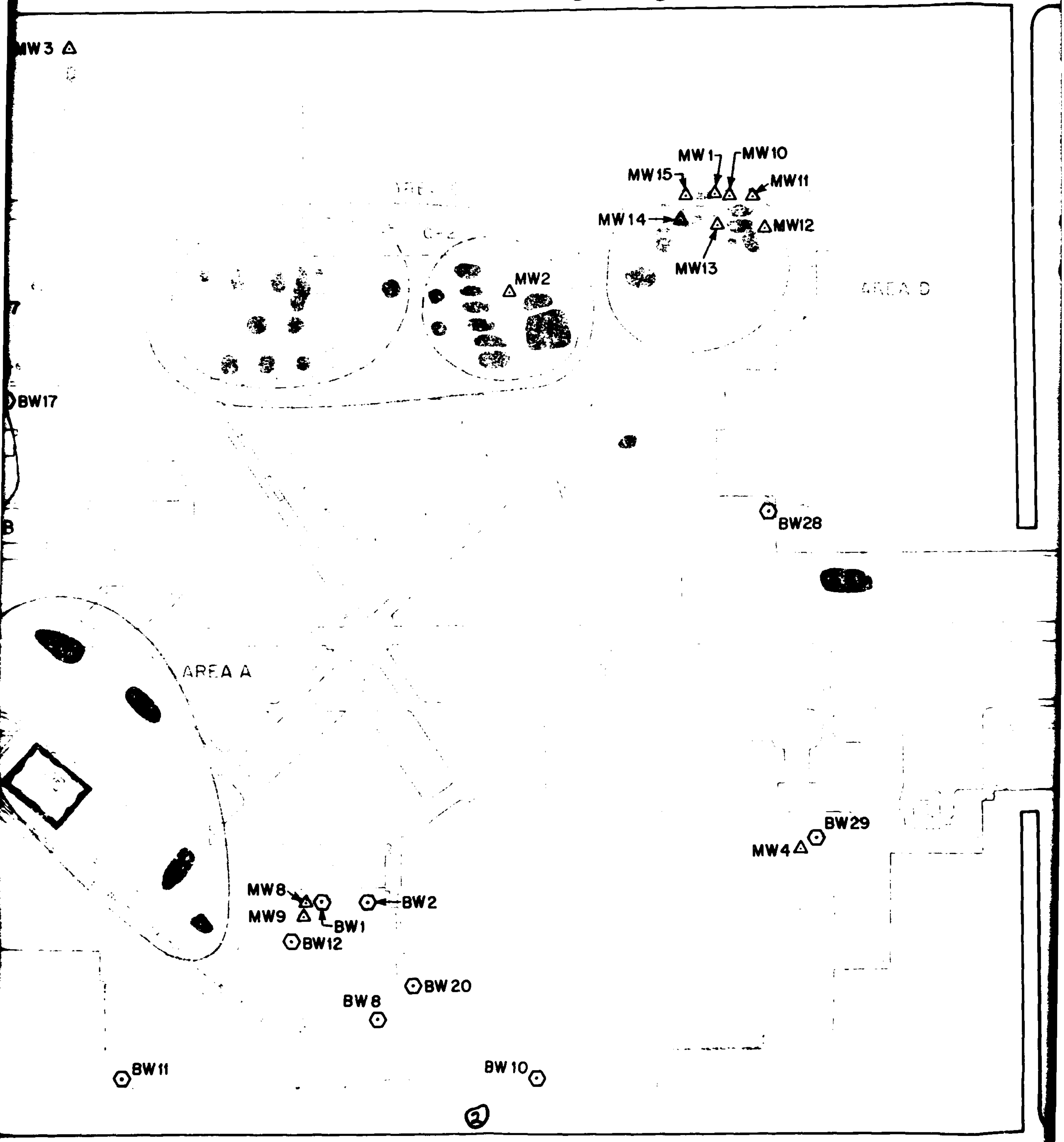

MW3
AREA C
C-2
MW7
BW18
MW5
BW17
MW6
AREA B
BW13
AREA A
MW8
MW9
BW2
BW1
BW12
BW20
BW8
BW11
BW10
①
②

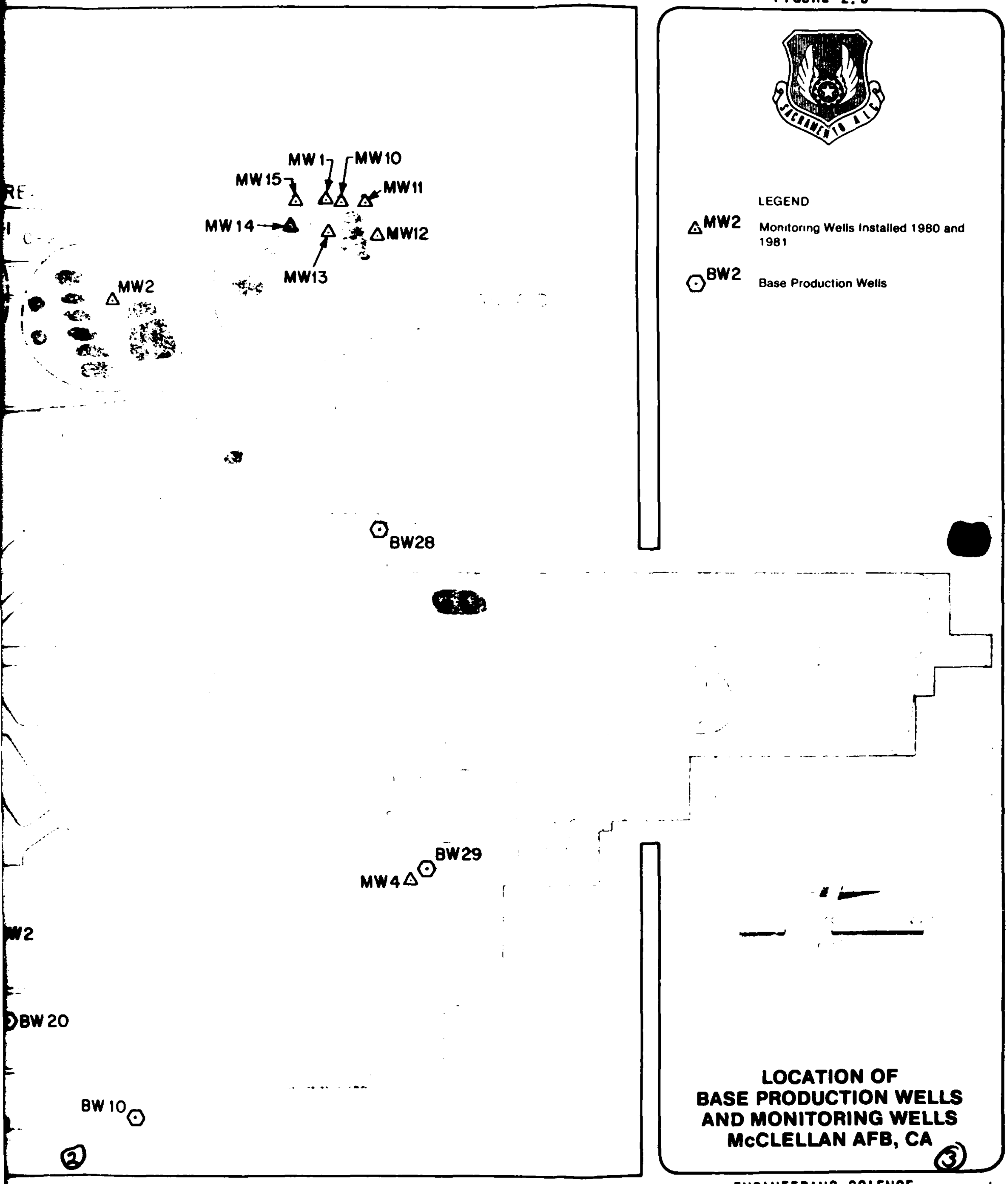
FIG 2.5



MW3
MW1
MW10
MW15
MW11
MW14
MW12
MW13
MW2
AREA D
AREA A
BW17
BW28
BW29
MW4
MW8
MW9
BW1
BW2
BW12
BW20
BW8
BW11
BW10
②

F16 2.5

FIGURE 2.5



②

LOCATION OF BASE PRODUCTION WELLS AND MONITORING WELLS McCLELLAN AFB, CA

③

TABLE 2.3

CHRONOLOGY OF EVENTS AT McCLELLAN AFB
PRIOR TO PHASE II

Date	Event	Result[a]
August 1979	• Initial sampling of BW10, BW11, BW18, and BW28	• BW10: no TCE detected • BW11: no TCE detected • BW18: TCE = 3.9/4.5 ppb (split sample) • BW28: trace of TCE found
November 1979	• Sampling of numerous on and off-base supply wells	• BW1 and BW2 taken off-line • Two private wells closed (Higgs and Russell) • One City of Sacramento well closed (Well 150)
January 1980	• BW1 sampled frequently; other Base wells sampled	• BW1 found to contain traces of TCE • BW1 placed back on-line • BW18: TCE = 12 ppb
March 1980	• BW1 sampled during eight hours of continuous pumping	• BW1: TCE values range from 1.3 to 716 ppb; carbon tetrachloride values range from 0.5 to 38 ppb • BW1 taken off-line
April 1980	• Sampling continued on Base wells • Construction begun on MW1, MW2, MW3, MW4	• BW12: TCE = 8 ppb
May 1980	• Open sludge pit sampled and analyzed for volatile organic compounds	• Material from open sludge pit found to contain: TCE = 29,600 ppb trichloroethane = 34,000 ppb dichloroethane = 49,600 ppb tetrachloroethylene = 23,200 ppb ethylbenzene = 27,200 ppb toluene = 335,000 ppb naphthalene = 46,800 ppb
June 1980	• Construction complete on MW1, MW2, MW3, and MW4 • Weekly sampling and analysis program begun on monitoring wells	• MW3: soil at 200-ft depth contained TCE = 100 μg/kg and dichloroethylene = 3.8 μg/kg • MW1 and MW2: TCE = <4.5 ppb
July 1980	• Sampling continued on Base wells	• BW1: TCE = 100 ppb dichloroethylene = 49 ppb dichloroethane = 13 ppb trichloroethane = 4.2 ppb • BW2: TCE = 2.9 ppb Freon = 99 ppb

TABLE 2.3 (Continued)

Date	Event	Result[a]
	• Sampling continued on monitoring wells	• MW1 and MW2 consistently show levels of TCE >4.5 ppb
August 1980	• Sampling continued on Base wells	• BW2: TCE = 110 ppb • BW12: TCE = 35 ppb • BW12 taken off-line • BW12: TCE = 8 ppb • BW18: TCE = 20 ppb
	• Sampling continued on monitoring wells	• MW1 and MW2 consistently show levels of TCE >4.5 ppb • MW3: TCE = 1.9 ppb (4 August only) • MW4: TCE = 2.2 ppb (4 August only) • Remaining open sludge pit closed to further use
	• Sampling performed at selected aquifer levels on MW1 and MW2	• MW1: dichlorobenzene = 126 ppb bis(2-ethylhexyl)phthalate = 10 ppb • MW2: bis(2-ethylhexyl)phthalate = 15 ppb
September to November 1980	• Additional monitoring wells installed (MW5-9)	• MW8: Soil at 100-ft depth contained TCE = 36 μg/kg
February/ March 1981	• Sampling continued on Base wells • MW1 plugged all the way to the surface • MW2 plugged from 249-ft to 60-ft depth below surface	• BW18: TCE = 9 ppb
May 1981	• Sampling continued on Base wells	• BW12: TCE = 27 ppb • BW18: TCE = 140 ppb
June 1981	• BW18 taken off-line	
July 1981	• Sampling continued on Base wells	• BW12: TCE = 54 ppb • BW18: TCE = 63 ppb
	• BW1 sampled at various levels	• BW1: TCE = 1,300-2,000 ppb at all perforation levels
	• IRP Phase I completed	
July/August 1981	• MW10-15 constructed (soil only)	• MW14: Soil at 20-ft, 40-ft, 50-ft, and 60-ft depths contained high levels of various solvent compounds
November 1981	• BW12 sampled at various levels	• BW12: TCE = 3.9-73 ppb throughout water column
December 1981	• IRP Phase II initiated	

---

[a] All constituents were measured in groundwater unless otherwise noted.

TABLE 2.4

DETECTED TCE CONCENTRATIONS IN BASE MONITORING WELLS PRIOR TO PHASE II[a]
(ppb)

Sampling Date 1980	MW1[b]	MW2[b]	MW3[c]	MW4[c]
11 June	-[d]	-	<0.5	-
12 June	1.8	-	-	-
18 June	1.1	0.2	<0.5	0.1
24 June	2.9	0.8	<0.5	<0.5
3 July	11.0	1.4	<0.5	<0.5
10 July	19.0	1.6	<0.5	<0.5
15 July	36.0	1.6	<0.5	<0.5
25 July	62.0	2.4	<0.5	1.4
30 July	110.0	2.9	<0.5	<0.5
31 July	61.0	2.6	<0.5	<0.5
1 August	68.0	2.3	<0.5	<0.5
4 August	2.1	2.1	1.9	2.2
5 August	71.0	4.7	0.2	<0.5
6 August	92.0	4.2	<0.5	<0.5
7 August	68.0	2.9	<0.5	<0.5
8 August	78.0	<0.5	<0.5	<0.5
11 August	70.0	3.4	<0.5	<0.5
12 August	90.0	2.8	<0.5	<0.5
13 August	100.0	3.0	<0.5	<0.5
14 August	88.0	3.3	<0.5	<0.5
15 August	28.0	2.8	<0.5	<0.5
21 August	78.0	4.6	<0.5	<0.5
25 August	-	1.6	<0.5	<0.5
27 August	-	8.8	-	-
28 August	32.0	-	-	-
7 October	-	-	<0.5	<0.5
28 October	-	-	<0.5	<0.5
6 November	-	-	<0.5	<0.5

Source: Brunner and Zipfel, 1981

a Pumping at approximately 200 feet plus.

b Volatile organic compounds (VOC) other than TCE were found during some analyses in monitoring wells 1 and 2; however, TCE was the predominate constituent.

c Monitoring wells 3 and 4 have been continually free of VOC contamination.

d (-) = not sampled

FIGURE 2.6

CONSTITUENTS IDENTIFIED IN SOIL SAMPLES COLLECTED DURING INSTALLATION OF MONITORING WELLS 12, 13, AND 14 (1980)

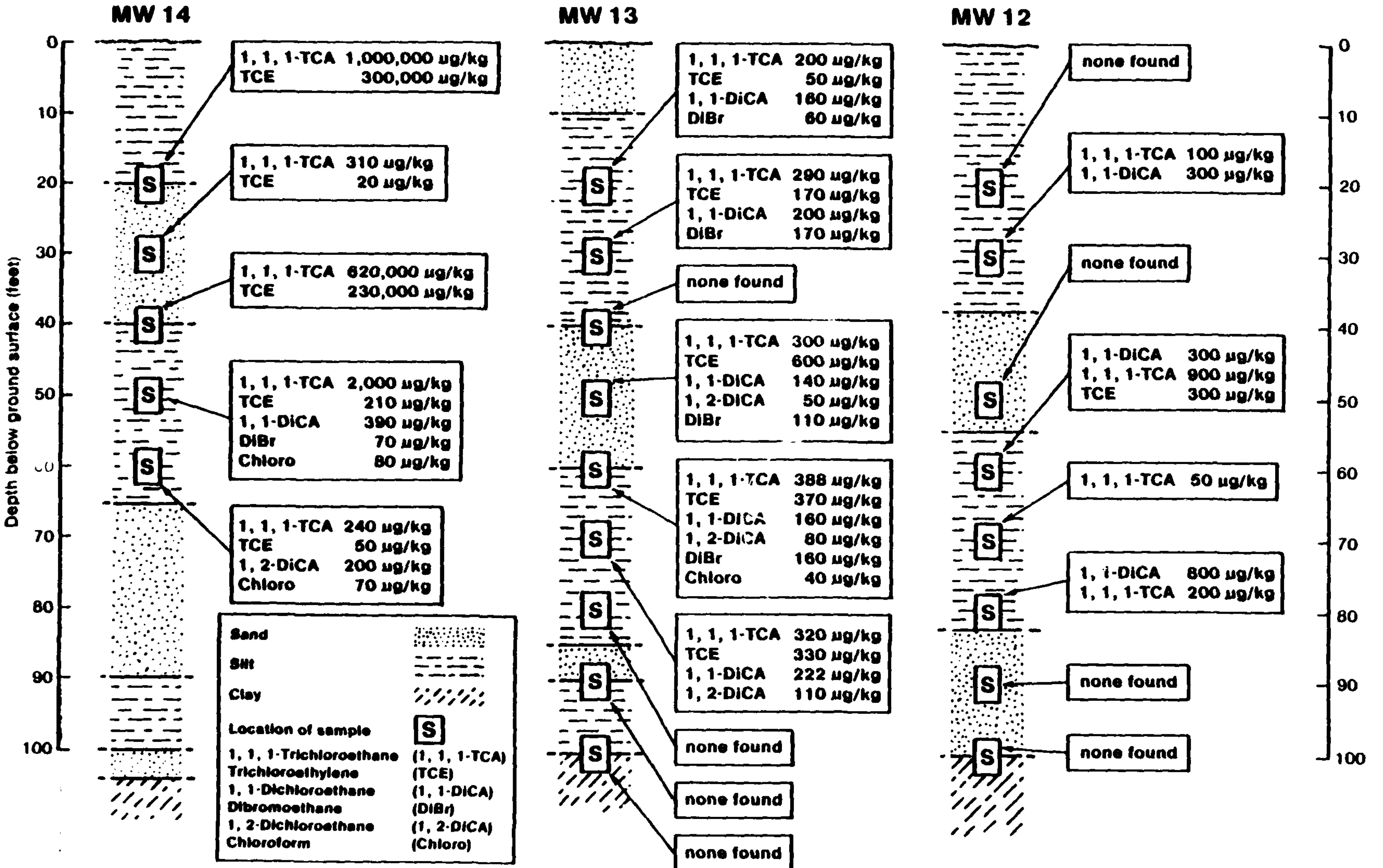


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TABLE 2.5

WELL DESIGN SPECIFICATIONS FOR WELLS IN WHICH CONTAMINATION WAS IDENTIFIED DURING INITIAL SAMPLING EVENTS FROM 1979 TO 1981
McCLELLAN AFB, CALIFORNIA

Well	Depth of Casing (feet)	Depth of Gravel Pack (feet)	Depth of First Perforations (feet)	Depth of Seal (feet)
BW1[a]	400	0-400	162	0-36
BW2	404	0-404	100	0-40
BW12[b]	390	0-390(?)	164	0-50
BW13[b]	391	0-391(?)	178	0-50
BW18	404	0-404	169	0-50
MW1[c]	249	75-249	75	0-75
MW2	249	75-249	75	0-75
MW3	205	70-205	70	0-70
MW4	249	85-249	85	0-85

a BW - Base production well
b No logs available
c MW - Base monitoring well

Generally, the first water-bearing sands beneath McClellan AFB are encountered at depths between 80 feet and 100 feet below the ground surface, with the next water-bearing material at depths reaching 160 feet. Table 2.5 indicates that the first perforations in the sampled Base production wells occur at depths ranging from 100 to 178 feet, and occur between depths of 70 and 85 feet in the four Base monitoring wells installed in April 1980 (MW1, MW2, MW3, and MW4). Gravel packs extend from the ground surface for the entire depths of the production wells, with grout seals around the perimeter of the gravel packs to a maximum depth of 50 feet. The sampled Base monitoring wells all reach depths exceeding 200 feet. Each monitoring well was gravel-packed from the water table (beginning at depths of 70 to 85 feet below the surface) to the bottom of the well, with grouting extending from the ground surface to the water table. The constituents identified in the groundwater could have migrated into the wells either through the perforated casing intervals or through the gravel packs. Since both the production wells and the monitoring wells have either perforations or gravel packs in the shallow groundwater zone, constituents identified could be present in the shallow zone only, the deeper zones only, or in all zones. The schematic drawing on Figure 2.7 illustrates potential modes of contaminant migration through a gravel-packed well that is perforated within several water-bearing strata, and where constituents are concentrated in a shallow aquifer. If migration has occurred through the casing perforations, the implication would be that the constituents are contained in the deeper aquifers being tapped by the wells; if the constituents are contained shallow aquifer, they may have traveled to the deeper-lying aquifers through the gravel pack surrounding the casing.

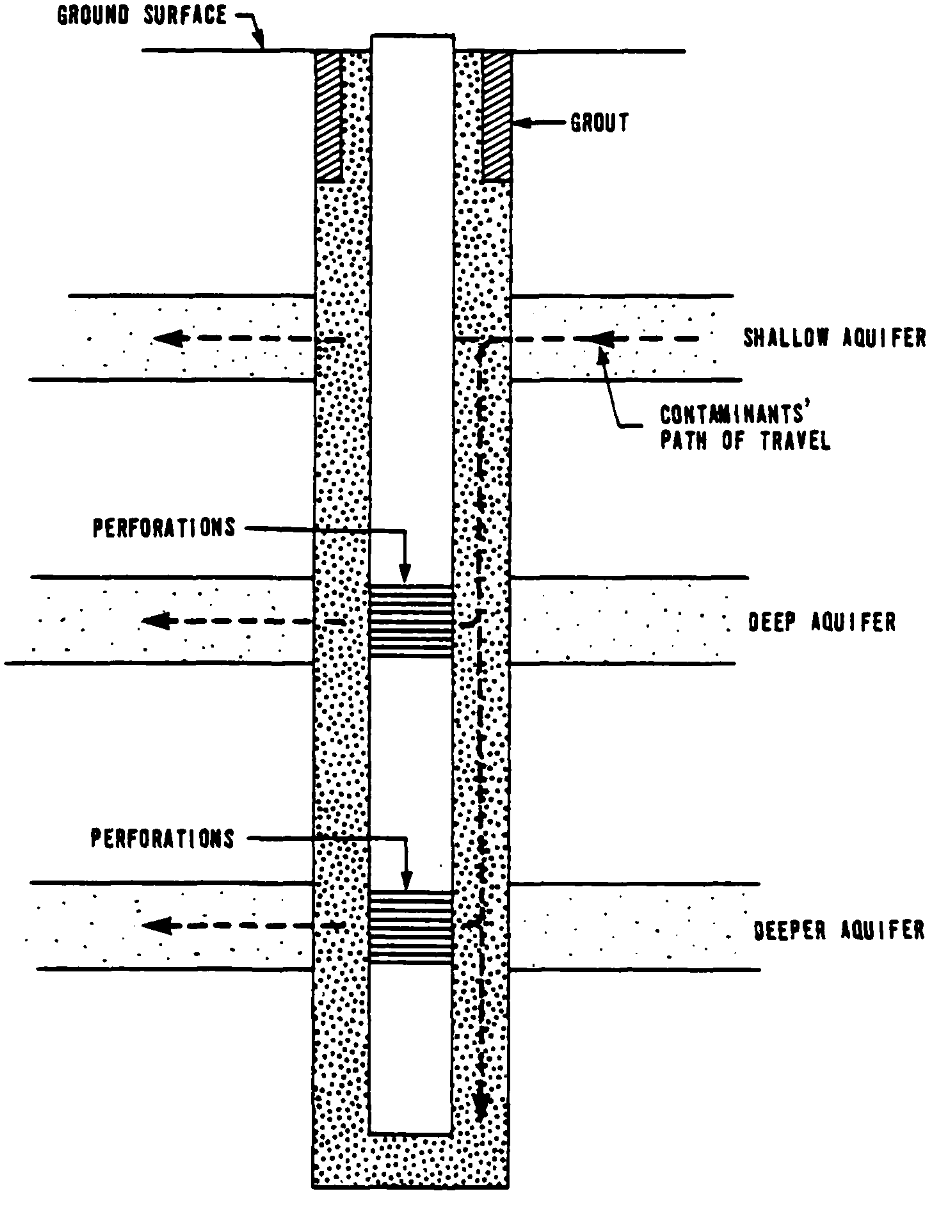
OFF-BASE WELLS

Off-base production wells located to the west and southwest of the Base have been sampled since 1979 as a result of trichloroethylene (TCE) being detected in groundwater samples from some Base wells. The locations of the surrounding off-base city and private wells are shown on Figure 2.8. Table 2.6 shows the sampling history for some of these wells and their associated constituent concentrations. During November 1979, groundwater analysis was performed for volatile organic compounds (VOC), leading to the subsequent closure of three off-base wells. Two of the wells were owned by private households (Higgs and Russell), and the third (CW150) belonged to the City of Sacramento. The depth of the Higgs well was 80 or 90 feet; the city well pumped from 144 to 372 feet. A new well constructed by Higgs has not been found to contain any volatile organic compounds. Several other off-base wells owned by the City of Sacramento have shown the presence of TCE, although information is limited. Chloroform, a trihalomethane, was found in several private wells west of the Base.

SUMMARY

The net precipitation for the Sacramento area is about -26 inches per year, based on an annual rainfall averaging 19 inches and a mean annual evapotranspiration rate of approximately 45 inches.

CONCEPTUAL SCHEMATIC OF POSSIBLE MODE OF MIGRATION OF CONTAMINANTS IN TYPICAL GRAVEL-PACKED BASE PRODUCTION WELL AT McCLELLAN AFB, CA



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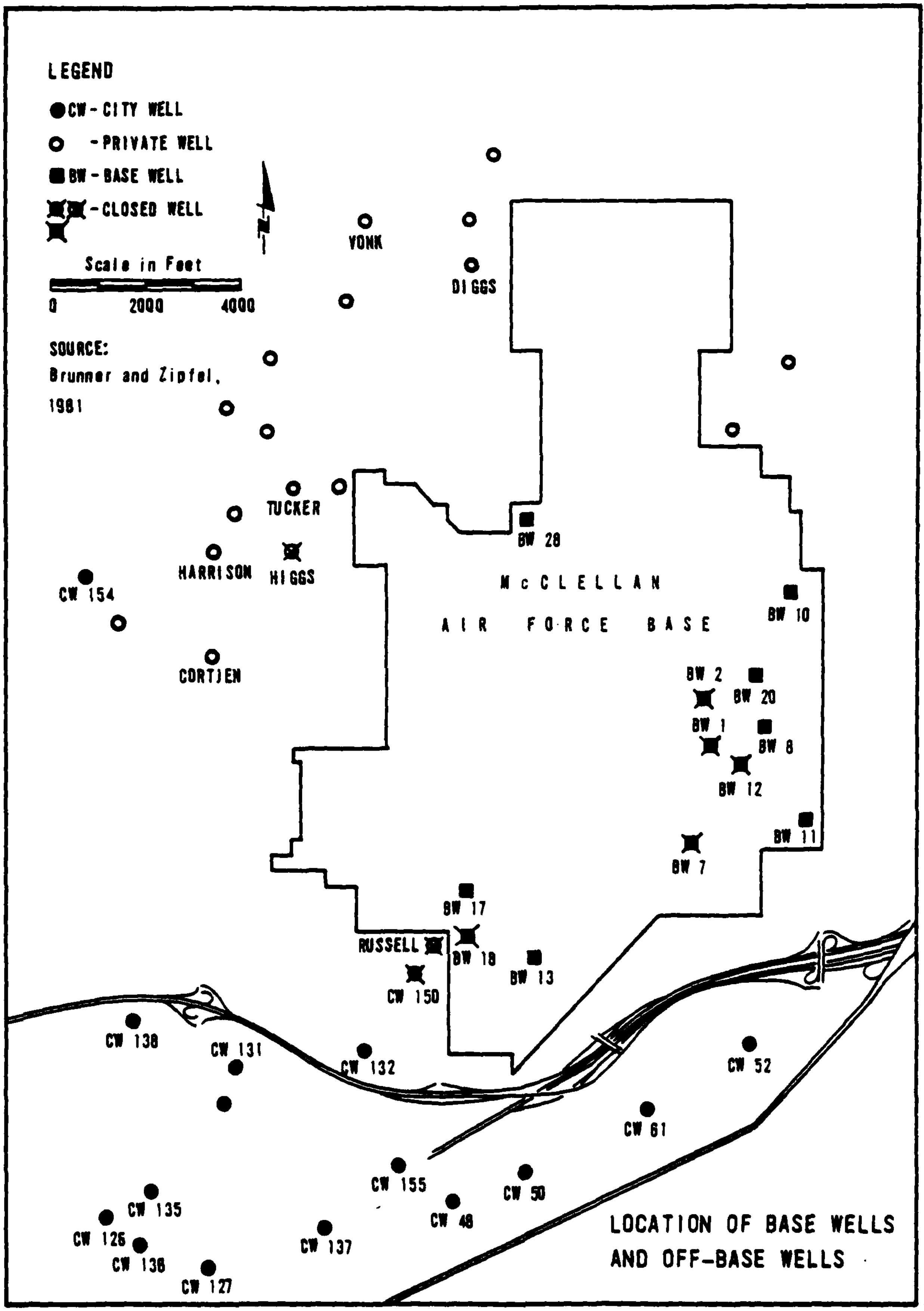

LOCATION OF BASE WELLS AND OFF-BASE WELLS

1-58

TABLE 2.6

VOLATILE ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES FROM OFF-BASE WELLS

(concentrations in ppb)

Well and Sampling Date	Compound						
	Trichloro-ethylene (TCE)	Chloro-form	1,1-di-chloroethylene	1,2-trans-dichloroethylene	1,2-di-chloroethylene	1,2-di-chloroethane	Tri-chloroethane
City Well 150							
(N. Barbara St.)							
13 Nov 1979	4.3	-	-	-	-	-	-
14 Nov 1979	5.8	-	-	2.3	-	-	-
21 Nov 1979	7.2	-	-	-	-	-	-
27 Feb 1980	5.1	-	-	-	-	-	-
3 Mar 1980	5.1	-	-	-	-	-	-
10 Mar 1980	6.1	-	-	-	-	-	-
17 Jul 1981	6.1	-	-	-	-	-	-
21 Jun 1982	<0.25	-	-	-	-	-	-
23 Jun 1982	0.30	-	-	-	-	-	-
24 Jun 1982	0.60	-	-	-	-	-	-
25 Jun 1982	2.3	-	-	-	-	-	-
29 Jun 1982	1.4	-	-	-	-	-	-
30 Jun 1982	1.7	-	-	-	-	-	-
1 Jul 1982	2.7	-	-	-	-	-	-
2 Jul 1982	1.7	-	-	-	-	-	-
3 Jul 1982	1.6	-	-	-	-	-	-
4 Jul 1982	0.9	-	-	-	-	-	-
5 Jul 1982	4.7	-	-	-	-	-	-
Higgs							
(5632 20th St)							
9 Nov 1979	48	ND	ND	ND	ND	ND	ND
19 Nov 1979	31	40	ND	ND	ND	ND	ND
29 Nov 1980	8.4	0.8	4.0	ND	4.0	85	4.0
New Well							
15 Jan 1980	ND	ND	ND	ND	ND	ND	ND
12 Sep 1980	ND	ND	ND	ND	ND	ND	ND
19 Jan 1981	ND	ND	ND	ND	ND	ND	ND
Russell							
(2248 Bell St)							
15 Nov 1979	13.3	3.2	ND	ND	ND	ND	ND
City Well 131							
(Jasmine and Ivy)							
15 Nov 1979	2.7	ND	-	-	-	-	-

TABLE 2.6 (Continued)

Well and Sampling Date	Compound						
	Trichloro-ethylene (TCE)	Chloro-form	1,1-di-chloroethylene	1,2-trans-dichloroethylene	1,2-di-chloroethylene	1,2-di-chloroethane	Tri-chloroethane
City Well 138 (4106 Fell St)							
13 Nov 1979	3.0	-	-	-	-	-	-
14 Nov 1979	<1.0	-	-	1.4	-	-	-
15 Nov 1979	3.6	-	-	1.4	-	-	-
City Well 116 (702 Plaza St)							
20 Nov 1979	1.2	-	-	-	-	-	-
Vonk (6645 22nd St)							
15 Nov 1979	ND	20	ND	ND	ND	ND	ND
29 Jan 1980	ND	ND	ND	ND	ND	ND	ND
Harrison (1820 C St)							
15 Nov 1979	ND	25.4	ND	ND	ND	ND	ND
27 Feb 1980	ND	ND	ND	ND	ND	ND	ND
19 Jan 1981	ND	ND	ND	ND	ND	ND	ND
Cortjen (1919 Ascot)							
19 Nov 1979	ND	46	ND	ND	ND	ND	ND
27 Feb 1980	ND	ND	ND	ND	ND	ND	ND
Tucker (5748 24th St)							
19 Nov 1979	ND	59.0	ND	ND	ND	ND	ND
Diggs (6500 24th St)							
15 Nov 1979	ND	25.2	ND	ND	ND	ND	ND
City Well 132							
18 March 1982	<0.05	-	-	-	-	-	-
City Well 154							
18 March 1982	<0.05	-	-	-	-	-	-
City Well 155							
18 March 1982	<0.05	-	-	-	-	-	-

ND = not detected
(-) = sample not analyzed for this compound

1-6

The Sacramento Valley consists of a sedimentary trough containing about 2,000 to 4,000 feet of material deposited in the form of a wedge thickening from east to west, with increasingly finer-grained materials deposited to the west. The sediments consist of poorly bedded silts, clays, and sands, with occasional lenses of gravel. Water is contained primarily in discontinuous stream channel deposits at depths of 150 to 400 feet. Groundwater discharge for the Sacramento basin occurs almost exclusively by pumping. There is no discharge to the ocean or other large surface water body.

Base water supply wells are completed within the Fair Oaks and Mehrten Formations about 150 to 400 feet below the surface. Logs from these wells and from Base monitoring wells indicate a great variety in subsurface conditions at each well location. Layers of sand, silt, and clay appear to be alternating in no specific sequences or consistent thicknesses, indicating the discontinuous and lenticular nature of the sediments. Beneath McClellan, shallow water-bearing sands occur at an approximate 100-foot depth; the flow direction in the shallow sands is toward the south-southwest, while the regional groundwater flow is toward the southwest.

Forty-six former waste disposal and storage sites were identified at McClellan during IRP Phase I. Most of the disposal sites were located in the northwestern corner of the Base and near the boundary of the Base west of the runway. A ranking of the sites based on site characteristics, potential for contamination, waste characteristics, and waste management practices assigned the majority of identified sites to the high priority classification. The sites were subsequently reevaluated by the Air Force using its improved Hazard Assessment Rating Methodology.

Analysis of soil samples from soil borings completed in the northwestern corner of the Base showed detectable levels of volatile organic compounds to depths of 80 feet. In November 1979 on-base and off-base production wells were sampled; volatile organics were found, and BW1 and BW2 were taken off-line. Three off-base wells were closed, including two private wells and one city well, at distances of 250 to 1,000 feet from the Base boundary. In August 1980, BW12 was taken off-line; BW18 was removed from production in June 1981. In April 1980 McClellan installed four monitoring wells at the northwest, southwest, and northeast corners of the Base. Samples from MW1 and MW2 in the northwest corner contained varying levels of TCE. In February and March 1981, MW1 and MW2 were plugged. In 1980 and 1981 an additional 11 monitoring wells were installed by McClellan AFB, primarily in the northwestern part of the Base at a depth of 105 feet.

SECTION 3

FIELD PROGRAM

CHAPTER 3

FIELD PROGRAM

An extensive field program was developed for McClellan AFB. Field activities included the installation of groundwater monitoring wells within different subsurface water-bearing zones. The purposes of monitoring well installation were to obtain site-specific hydrogeological data and to collect samples for analysis of chemical constituents contained in groundwater within the Base boundaries. Additional field work was performed to locate an abandoned Base water supply well (BW7) and to test the integrity of a segment of the industrial waste line adjacent to closed-down water supply wells.

This chapter describes the procedures and methodology used in field activities. Included are discussions on (1) the drilling program including Stage I and Stage II activities; (2) pump and slug tests; (3) sampling procedures; (4) locating Base production well 7; and (5) investigating the industrial waste line near Building 251.

DRILLING PROGRAM

The drilling program at McClellan AFB was implemented in two successive stages. A total of 48 monitoring wells were installed during this two-phased program. The Stage I wells were installed to identify the first and second water-bearing sands, to determine the direction of groundwater flow, and to identify potential groundwater contamination from past Base disposal practices. The location and depth of these Stage I monitoring wells were determined on the basis of existing hydrogeological information for the Base (primarily well logs from previously installed monitoring and water supply wells) and location of past disposal and storage areas on the Base. Some of the sites were "clustered" on the basis of their proximity to each other, and Stage I monitoring wells were then installed downgradient from specific site clusters, which were designated Area A, Area B, Area C, and Area D. The Stage II drilling program was designed based on the analytical results obtained for the Stage I groundwater samples. The Stage I program identified a shallow groundwater table containing volatile organic compounds and deeper aquifers containing primarily small amounts of pesticides and herbicides. The Stage II program was subsequently designed to further delineate the extent and source(s) of contamination within the shallow water-bearing zone. The locations of all Stage I and Stage II monitoring wells and designated site clusters are shown on Figure 3.1. Specific well completion designs and geologic logs for each well are included in Appendix D.

Stage I Drilling Program

A total of 30 wells were installed during the first stage of the Phase II field program. Fourteen multiple-completion wells, each comprising both a shallow (S) well and a deeper (D) well, were installed into the first and second water-bearing zones (MW16S,D through MW29S,D). Two single-completion wells penetrating only the shallow zone (MW30 and MW31) were installed in the center of the Base to assist in determination of groundwater flow direction. The designs of the single and multiple-completion wells are shown schematically on Figures 3.2 and 3.3.

The Stage I well locations were selected to determine:

- Depth to and thickness of the first water-bearing zone
- Depth to the second water-bearing zone
- Groundwater flow direction (MW30; MW31)
- Groundwater gradient
- Continuity between water-bearing zones at depth
- Background contaminant levels (MW28S,D)
- Vertical extent of possible groundwater contamination
- Constituent migration into the groundwater from
  - Area A (MW24S,D; MW25S,D; MW26S,D; MW27S,D)
  - Area B (MW23S,D)
  - Area C (MW20S,D; MW21S,D; MW22S,D)
  - Area D (MW19S,D)

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F IG 3.1

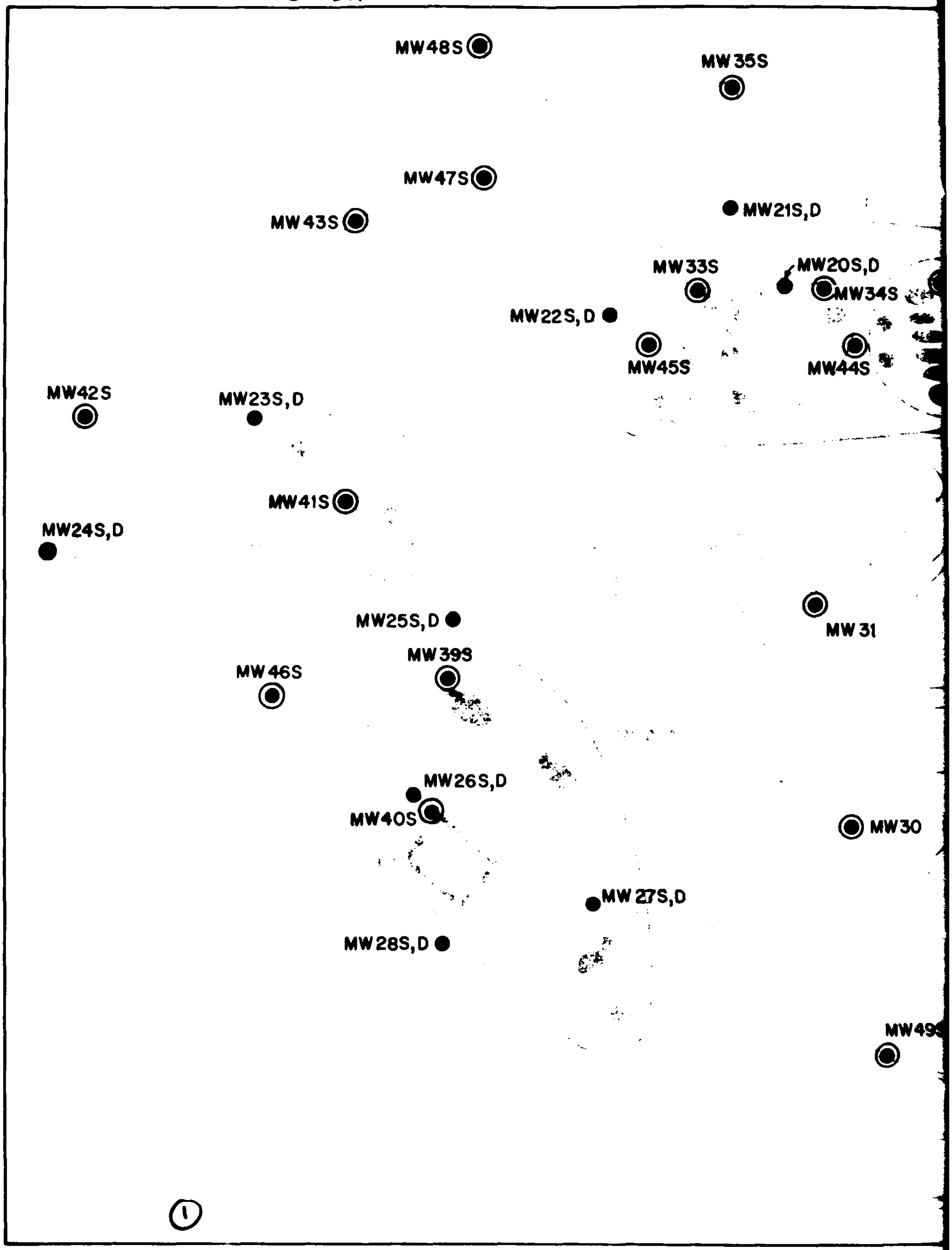
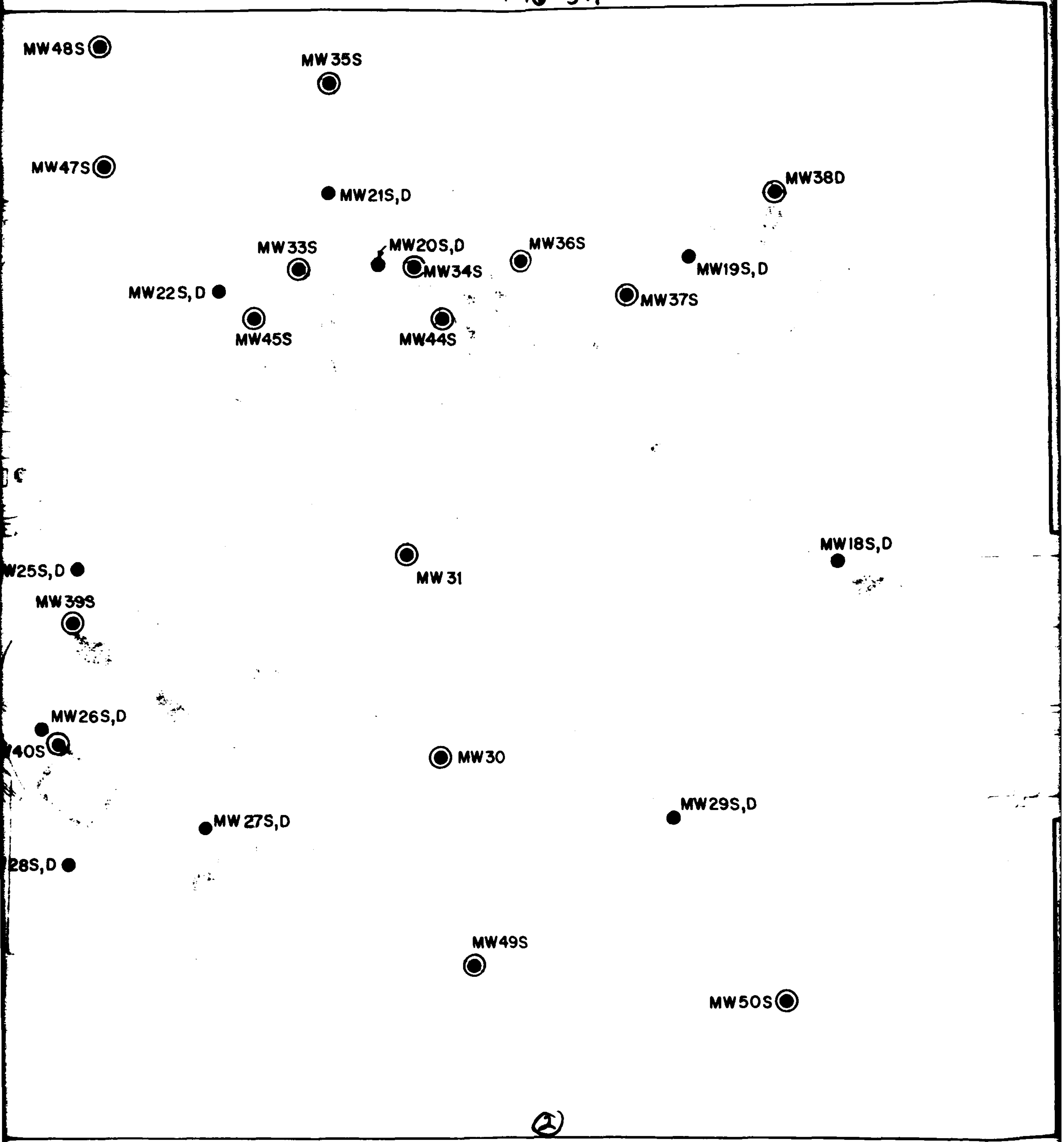

MW48S
MW35S
MW47S
MW21S,D
MW43S
MW33S
MW20S,D
MW34S
MW22S,D
MW45S
MW44S
MW42S
MW23S,D
MW41S
MW24S,D
MW31
MW25S,D
MW39S
MW46S
MW26S,D
MW40S
MW30
MW27S,D
MW28S,D
MW49
①

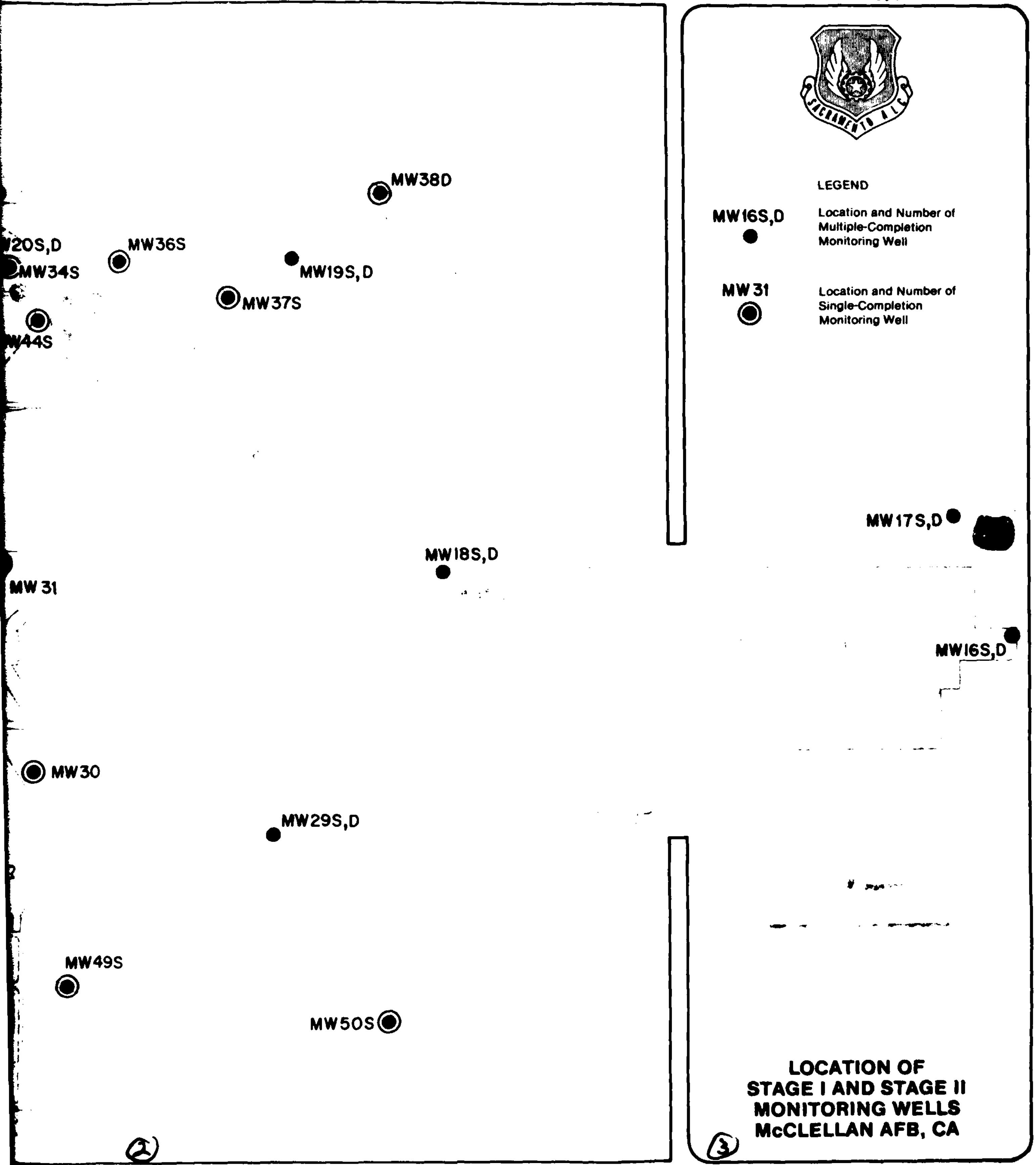
FIG 3.1


MW48S
MW35S
MW47S
MW21S,D
MW38D
MW33S
MW20S,D
MW36S
MW19S,D
MW34S
MW22S,D
MW37S
MW45S
MW44S
MW18S,D
W25S,D
MW31
MW39S
MW26S,D
40S
MW30
MW29S,D
MW27S,D
28S,D
MW49S
MW50S

②

FIG 3.1

FIGURE 3.1



**LOCATION OF
STAGE I AND STAGE II
MONITORING WELLS
McCLELLAN AFB, CA**

ENGINEERING-SCIENCE

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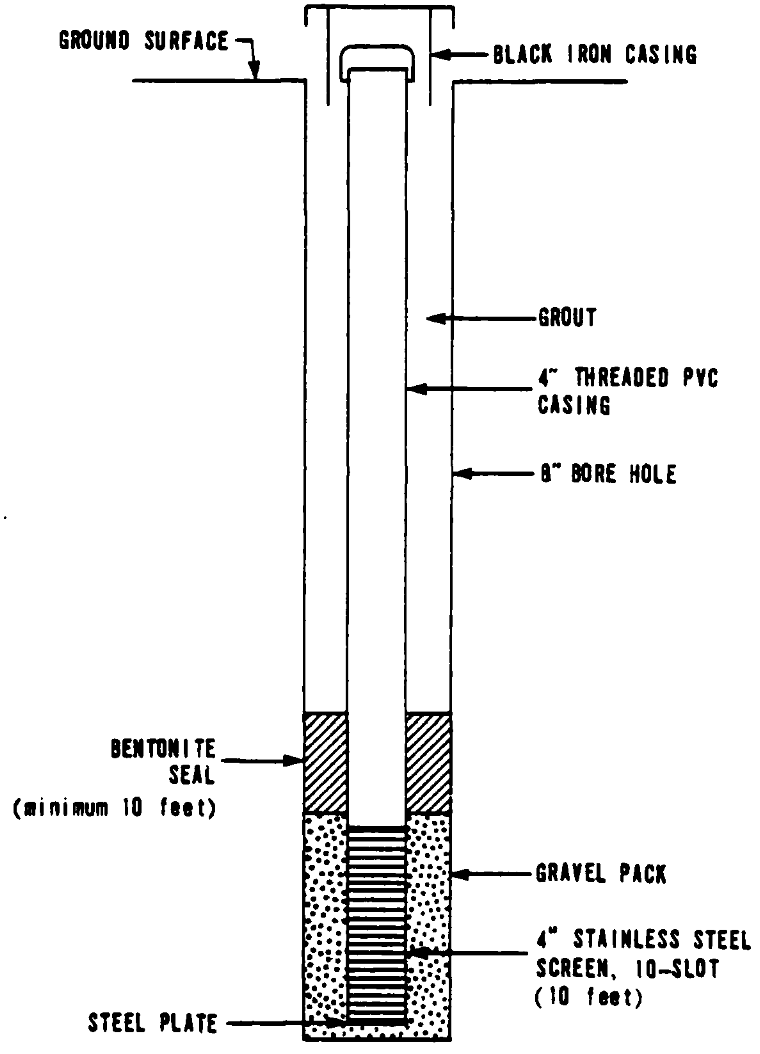
1 - 423

3-3

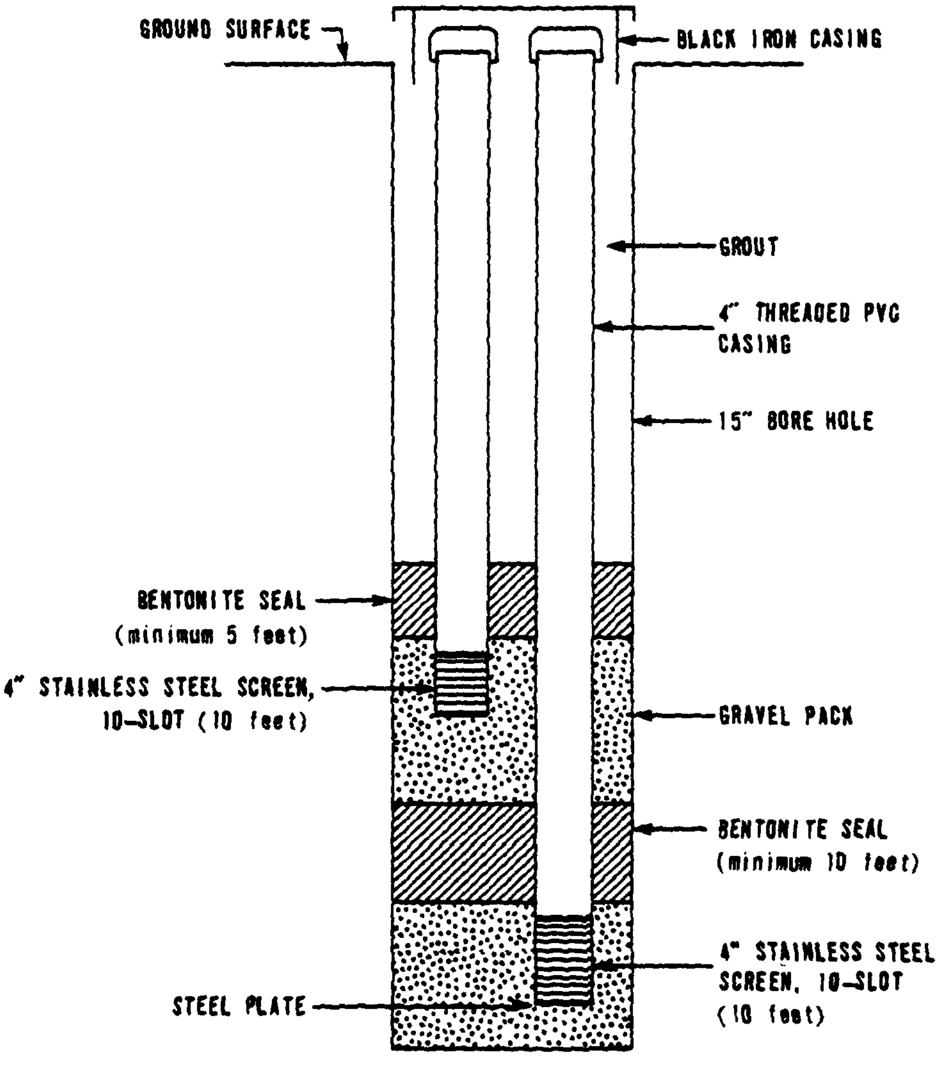
TYPICAL WELL DESIGN
SINGLE-COMPLETION MONITORING WELL
McCLELLAN AFB, CA



NOT TO SCALE

FIGURE 3.

TYPICAL WELL DESIGN
MULTIPLE-COMPLETION MONITORING WELL
McCLELLAN AFB, CA



NOT TO SCALE

- Sites 45 and 46 (MW18S,D; MW17S,D)

- Migration of groundwater contaminants onto the Base from off-base sources (MW16S,D)
- Migration of groundwater constituents off-base

The drilling methods employed consisted of hollow-stem augering and rotary wash. Drilling at each well was initiated with an 8-inch auger pilot hole for identification of the first water-bearing materials and for collection of undisturbed split-spoon soil samples for geological classification. Each auger hole was subsequently enlarged to 15 inches in diameter and extended in depth to the next water-bearing sands with a rotary-wash drill using fresh water with inorganic gel added as drilling fluid. The wells were installed and developed according to the specifications outlined in the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) Minimum Requirements for Well Drilling Operations. Stage I well installation was initiated in March 1982, but had to be interrupted due to unfavorable weather conditions; the remaining Stage I wells were installed in June 1982.

Stage II Drilling Program

Based on analytical and hydrogeological results obtained during the Stage I field program, a total of 18 monitoring wells, 17 shallow and one deep, were installed in Stage II. All Stage II wells (MW33 through MW50) were completed in the same manner as the single-completion Stage I wells (see Figure 3.2).

The well location network for Stage II was developed to identify more clearly specific groundwater contamination sources and source areas within site clusters that had shown downgradient groundwater contamination during Stage I. In addition, Stage II wells were installed along the southern and northern Base boundaries to ascertain aquifer characteristics along the downgradient boundary and to identify the magnitude of potential off-base constituent migration.

Although constituents were generally confined to the shallow water-bearing zone according to the Stage I results, two deeper wells were proposed for the Stage II program. Because Area D had shown the highest concentrations of priority pollutants in the shallow sands on the Base, a well was installed downgradient from Area D in the deeper sands (MW38D) to ascertain potential vertical migration of constituents as well as possible off-base migration of contaminated groundwater in the second water-bearing zone. A deep well (32D) was also proposed immediately upgradient from Stage I wells 20S,D. Monitoring well 20S had shown the presence of aliphatics (grease and oil); groundwater analysis also detected the presence of aliphatic material in MW20D. This material may have been carried into the deeper well during initial well construction. Prior to implementation of the Stage II drilling program, well 20D was pumped and resampled to determine if the initial presence of aliphatics in the groundwater could have been due to cross-contamination. Analytical results of the second sampling revealed no aliphatics present; therefore deep well 32D was not installed upgradient from MW20D for identification of a potential source area. However, shallow wells were installed upgradient and downgradient of MW20S to locate a source for the aliphatics observed in that well.

The Stage II wells were installed to identify:

- Off-base constituent migration and aquifer characteristics along Base boundaries (MW38D, 36S, 35S, 48S, 47S, 43S, 42S)
- Background constituent concentration in shallow water-bearing sands and groundwater flow direction (MW50S)
- Contamination sources in Area A
  Site 38: MW40S
  Site 25: MW39S
  Site 34: MW46S
- Contamination sources in Area B
  Site 36: MW41S
- Contamination sources in Area C
  Subarea C-1: MW34S, 44S, 45S, 33S
  Subarea C-2: MW36S, 37S
- Contamination from Area D
  Deeper sands: MW38D

The wells were installed using a rotary-wash drilling method. Pilot augering holes were not drilled in this stage since the Stage I

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drilling program provided general information as to the probable depth of water-bearing materials. Figure 3.4 shows photographs of the drilling operation during installation of monitoring well 38D in the northwestern part of the Base. The drilling fluid used was fresh water with no additives; the clays encountered at depth during drilling provided enough fluid viscosity to carry the bore cuttings to the ground surface. Wells were completed with locked iron casings above the ground. Four wooden posts were emplaced surrounding the wells in areas where the posts would not interfere with Base flight operations; in areas where conflicts existed, a concrete pad was installed around the iron casing. Figure 3.5 shows monitoring wells 27 and 25 at completion with posts and a concrete pad, respectively.

In addition to monitoring well installation during Stage II, two piezometers were completed adjacent to MW44S (see Figure 3.1); the piezometers were used for pump tests in conjunction with MW44S, as described in the following section.

PUMP AND SLUG TESTS

Pump and slug tests were conducted to evaluate the transmissibility of water-bearing sands and lateral and vertical continuity between each sands zone. One pump test (MW44S) and three slug tests (MW24S) were performed; the locations of these wells were indicated on Figure 3.1. Sample data sheets for recording field information are included in Appendix P. Field equipment used for these tests is listed in Appendix Q.

Pump Test

Based on pumping experience during earlier sampling events, well 44S was selected as the pumping well for the pump test. This well was capable of producing water continuously while being pumped at about 0.5 gpm; most other shallow wells ran dry when pumped and therefore would not sustain constant flow during a pump test. Two piezometers (44S-A and 44S-B) were installed at distances of 20 and 40 feet downgradient of the pumping well to monitor water level drawdown and recovery during pumping of MW44S.

FIGURE 3.4

DRILLING OPERATIONS
McCLELLAN AFB, CA

PHOTO A
Geologist collecting sample of cuttings contained in drilling fluid at MW38D for preparation of geologic log

PHOTO B
Rotary-wash drill rig and water tank at MW38D

Photos Courtesy of USAF

FIGURE 3.5

COMPLETED MONITORING WELLS
McCLELLAN AFB, CA

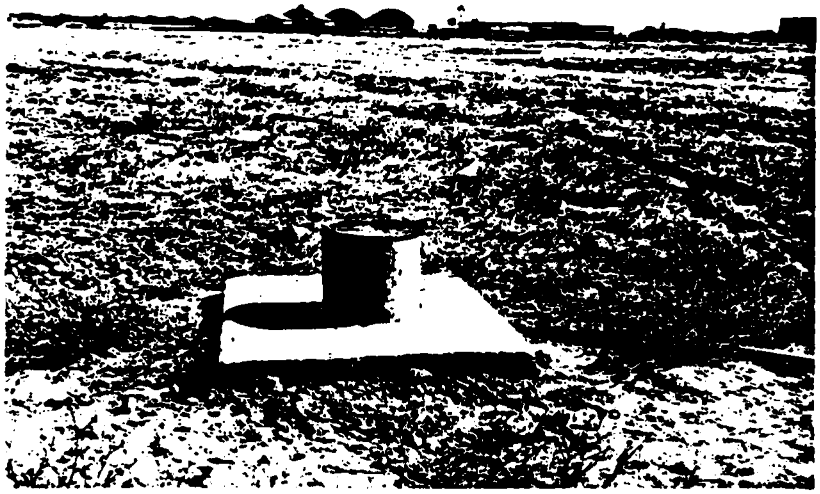

PHOTO A
Monitoring Well 25S,D with locked iron casing and concrete pad completed within clear zone

PHOTO B
Monitoring Well 27S,D with locked iron casing and wooden posts

Initial water levels were recorded for the pumping well and piezometers. The pump was then lowered into the pumping well (44S) and a second water level measurement was taken for this well; this water level was higher than the initial reading as a result of water displaced by the pump. At the specified time, the pump was activated and a series of water level readings were taken on the pumping well. Readings were obtained at 15-second intervals for the first two minutes, after which measurements were gradually reduced to once every 5 or 10 minutes, for a total pumping time of 220 minutes.

Simultaneously, flow rates were monitored for the pumping well. Flow rates were measured initially every 10 minutes until a constant rate was maintained, followed by readings every 30 minutes.

Water levels in the piezometers were monitored every 10 minutes during drawdown of the pumping well throughout the duration of the test. Final water level measurements were taken for the pumping well and piezometers just prior to stopping the pump.

When the pump was turned off, recovery measurements were taken on the pumping well. Readings were taken every 15 seconds during the first 2 minutes and then at increasingly longer intervals before reducing measurements to once every 5 or 10 minutes for the duration of the test. Water level measurements were taken until no further change in water level was detected. Water levels in piezometers were monitored once during recovery of the pumping well. No further readings were necessary because drawdown of both piezometers during pumping was minimal (less than 0.03 foot). At the end of the test, the pump was removed from the pumping well and one final water level reading was taken to determine the water level without pump displacement.

Slug Tests

Since only MW44S was productive enough for the performance of pump tests, a slug test was conducted on MW24S to obtain information on aquifer characteristics along the Base boundary. In the absence of pump tests, slug tests provide general order-of-magnitude data on permeabilities and transmissibilities of aquifers. Slug tests are often used when an aquifer shows low productivity and low permeability. A slug test

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consists of releasing a known volume of water into a well casing and measuring the rate at which the water level returns to its original position.

Three replicate tests were performed on the well, two the first day and one during the second day. Fifty gallons of water were released into the well during the first test and 100 gallons were used for each of the other two tests. Each test was performed by filling a 55-gallon drum with water, elevating it above the well, and releasing the water into the casing at a specified time. Initial water levels were measured prior to each test. Immediately after all water was released into the well, water level measurements began. Readings were taken at 15-second intervals during the first 10 minutes of each test, followed by subsequent measurements at increasingly longer intervals. Each replicate slug test was conducted for three hours before it was completed.

SAMPLING PROCEDURES

Field sampling of wells for groundwater required careful sampling techniques to avoid sample cross-contamination and still obtain a representative sample. The step-by-step sampling protocol is included in Appendix P, along with field data sheets and the method used for calculating well casing volume for monitoring well purging and sampling.

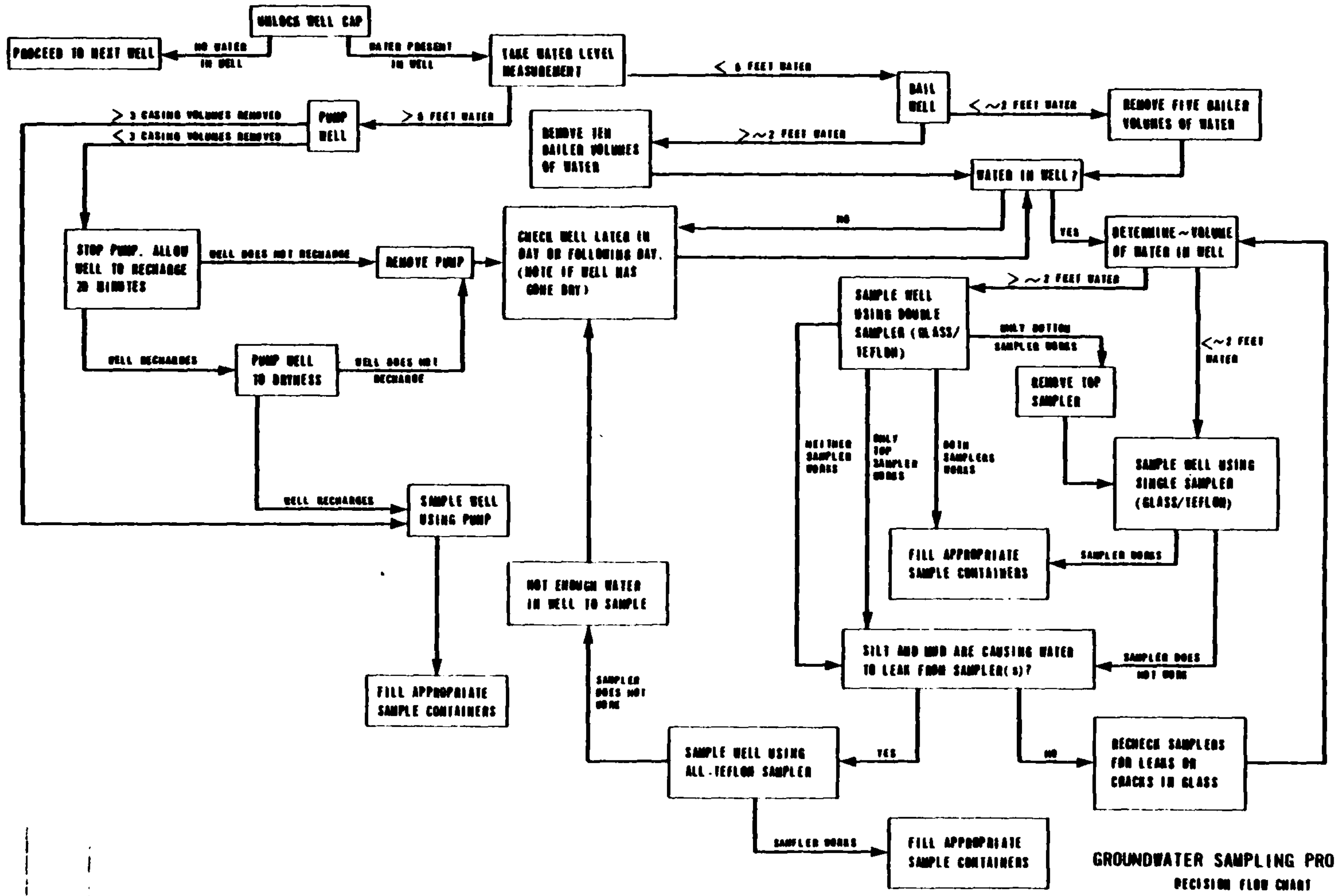
Numerous decisions are required in the field to determine the method of sampling. A decision flow chart providing alternatives and solutions for use during sampling is shown in Figure 3.6.

Pumping and Sampling

Prior to sampling a well, the static water level was measured using an electronic water level meter (M-scope) calibrated at 10-foot intervals. This device is pictured in Figure 3.7. A steel measuring tape was then used to record water levels to within 1/10 inch.

Pumping was the preferred method for sampling. Approximately three casing volumes of water were removed from a pumpable well prior to sampling from the Teflon tubing. This preliminary pumping served to purge the well of standing water in the casing, replacing it with groundwater from surrounding water-bearing sands. Pumping also flushed the previous

FIGURE 3.6



GROUNDWATER SAMPLING PROCEDURES
DECISION FLOW CHART

ENGINEERING-SCIENCE

FIELD AND SAMPLING EQUIPMENT

PHOTO A
Electronic water level meter (M-scope) used to measure static water level prior to sampling

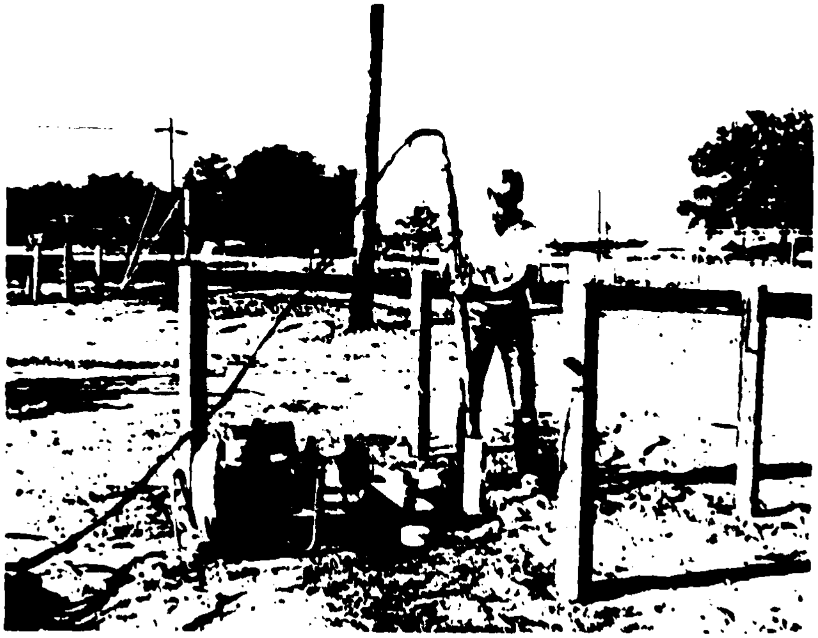


PHOTO B
Submersible well pump used for pumping and sampling wells

sampling water from the pump and outlet tube (see Figure 3.7). Sampling from the Teflon tube eliminated potential cross-contamination between samples and/or from the tube itself. During pumping, the wells frequently ran dry prior to removal of three casing volumes of water. Allowing the well to recharge at least once prior to sampling insured collection of a representative groundwater sample from the aquifer. If too little water remained in the well to sample with the pump, samplers constructed of glass and Teflon were used.

Bailing and Sampling

Wells were bailed prior to sampling whenever the pump was not used, promoting thorough well water mixing and some groundwater recharge. A minimum of one well casing volume was removed from each well prior to sampling. Groundwater samples were obtained using a single sampler or a pair of samplers tied together in series. This "double sampler" is shown in Figure 3.8. Samplers were constructed of glass and Teflon to prevent the introduction of contaminants from sampler components. Glass and Teflon also minimized adsorption of groundwater constituents to the surfaces of the sampler.

Wells containing significant amounts of sand or silt caused the sampler to leak when being extracted from the well. The Teflon ball at the base of the sampler would not "seat" properly due to the silt, allowing sample water to escape. For these wells, an all-Teflon sampler which filled from the top was used instead. However, use of this type of sampler required that at least one gallon of water be in the well in order for the sampler to be filled from its top. Another disadvantage was that the actual sample volumes collected with the Teflon sampler were small. Schematic drawings of the glass/Teflon and the all-Teflon samplers are included in Appendix Q.

A glass funnel facilitated the transfer of sample water from samplers to sample containers (see Figure 3.8). The glass funnel minimized surface adsorption of groundwater constituents that could otherwise occur with a plastic (polyethylene) funnel.

After sampling, the samplers, bailer, and funnel were thoroughly cleaned and washed. Deionized/distilled water was used for the first

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FIELD AND SAMPLING EQUIPMENT

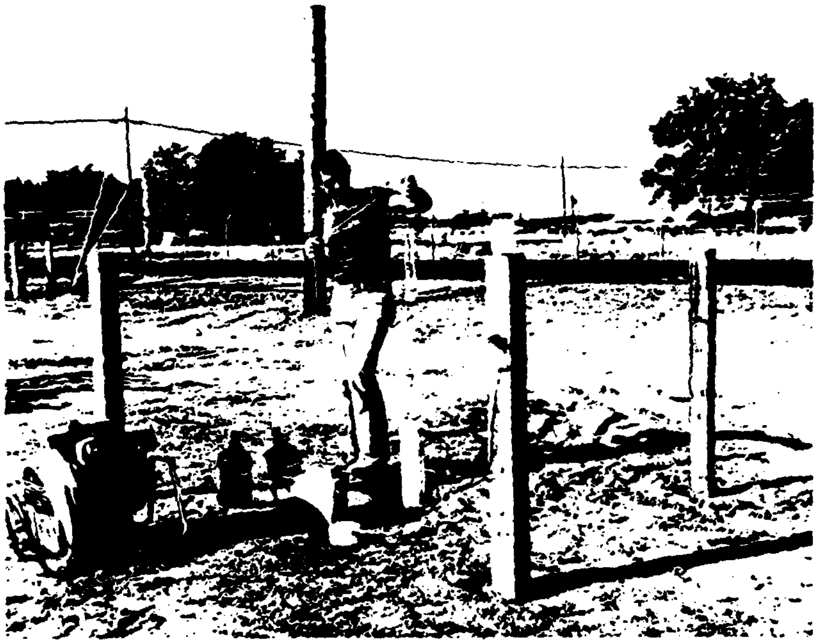

PHOTO A
Double sampler consisting of two glass and Teflon samplers linked in series

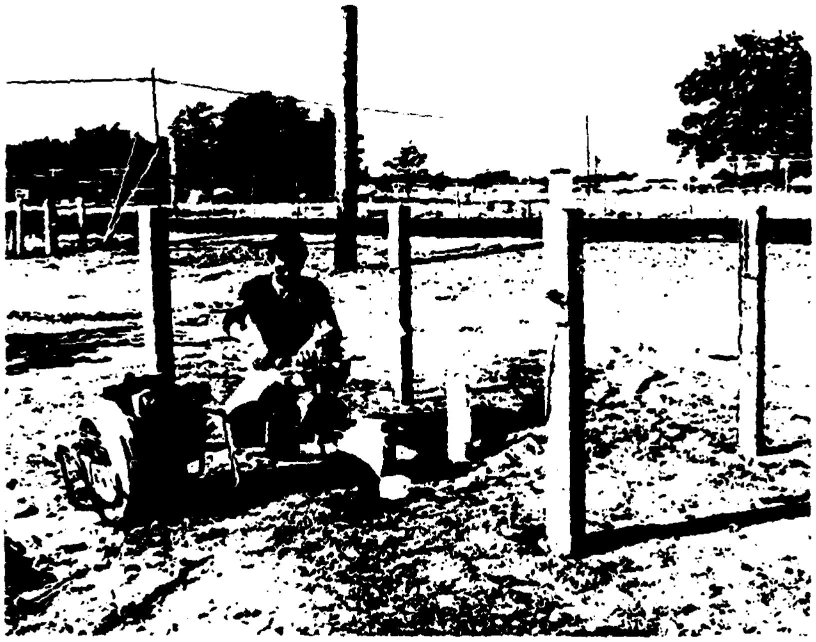

PHOTO B
Transfer of sample from glass and Teflon samplers to sample containers using glass funnel

rinse, followed by a reagent grade acetone rinse to remove any organic constituents adsorbed to the equipment surfaces. A final triple rinse with deionized/distilled water removed the acetone.

Sample Containers and Types of Samples

Several types of samples were obtained from each well, requiring individual treatment and preservation. Containers were specially prepared in the laboratory for given analyses prior to transport into the field. During sampling, all containers were filled completely with sample water and capped. Volatile organic analysis (VOA) bottles were filled directly from either the Teflon tube of the pump or samplers. After filling and capping, these bottles were inverted and checked for air bubbles. If any were present, a second sample was obtained. Samples for trace metals were obtained in glass containers and preserved with ultra-pure nitric acid. Samples for cyanide, collected in a 1-liter polyethylene bottle, were immediately preserved by the addition of sodium hydroxide. All samples were tightly capped, placed in a thermal chest containing ice, and transported to the laboratory for further pretreatment and analysis. Laboratories utilized during the study were California Analytical Laboratories of Sacramento, California, and the ES Laboratory at Berkeley.

SPECIFIC CONDUCTANCE/TEMPERATURE TESTING

Seven wells were tested in the field for specific conductance and temperature. These were Base monitoring wells MW4, MW6, and MW7, and Stage I monitoring wells MW19S, MW19D, MW26S, and MW26D. Specific conductance measurements indicate the presence and magnitude of dissolved ions (e.g., salts) within the groundwater. Groundwater that is moving at a slow rate through an aquifer assumes some of the chemical characteristics of the aquifer material; thus, water in a less permeable aquifer generally has a higher specific conductance than water in a more permeable aquifer. Readings for specific conductance (measured in μmho) and temperature were taken in each well at approximate 10-foot intervals to determine whether stratification was evident within each well and whether detectable differences could be noted between the shallow and deeper aquifers. Data for these wells are provided in Chapter 4, Results of Field Program.

LOCATING BASE PRODUCTION WELL 7

Part of the Stage I field program included establishing the location of Base production well 7, which was closed about 1956 due to reported contamination by cresylic acid. This was necessary since it was thought that well 7 could be a conduit for water to travel from near the surface down to lower production aquifers. Abandonment of the well in past years left no clue on the surface as to its location. A search of Base utility records showed the approximate location to be near the west side of Building 475 in an underground well house. The buried well building was located with a magnetic flux indicator (Schonstedt GA-52 Magnetic Locator), and the tops of walls at the four corners of the building were potholed by hand.

The inside of the building was excavated and the well head was located in the building basement. The well building was approximately 10 by 20 feet in size and 12 feet deep. The well casing was extended by a 12-inch steel casing to facilitate future site identification. The extension of the well is shown as photograph A on Figure 3.9.

The concrete-encased well head was found to have been fitted with a non-watertight, fabricated steel cap. During excavation, a substantial amount of excess water from the fill material drained into the well. A weighted line lowered into the well met refusal at a depth of 80 feet. One of the gravel feed pipes to the 12-inch casing was found to have been disturbed, while another opening was discovered about 2-1/2 feet from the top of the well head. This second opening was to the gravel pack, which was sealed by a 24-inch outer casing and concrete well head. Sampling for priority pollutants was not accomplished because of excavated material having entered the well. The disturbed feed pipe was welded closed.

Air Force records did not indicate actions taken, if any, for abandonment of BW7. The well could have been backfilled, grouted, or left unused. In order to obtain a representative water sample, a drilling program was developed to clean out the well. Prior to cleaning out the

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SITE RESTORATION AFTER LOCATION OF BASE PRODUCTION WELL 7

PHOTO A
Extension of well casing

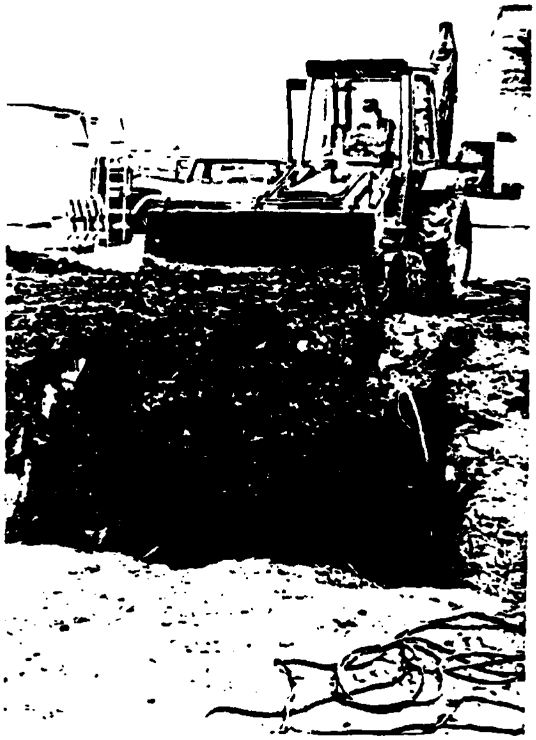


PHOTO B
Backfill of excavation by Air Force

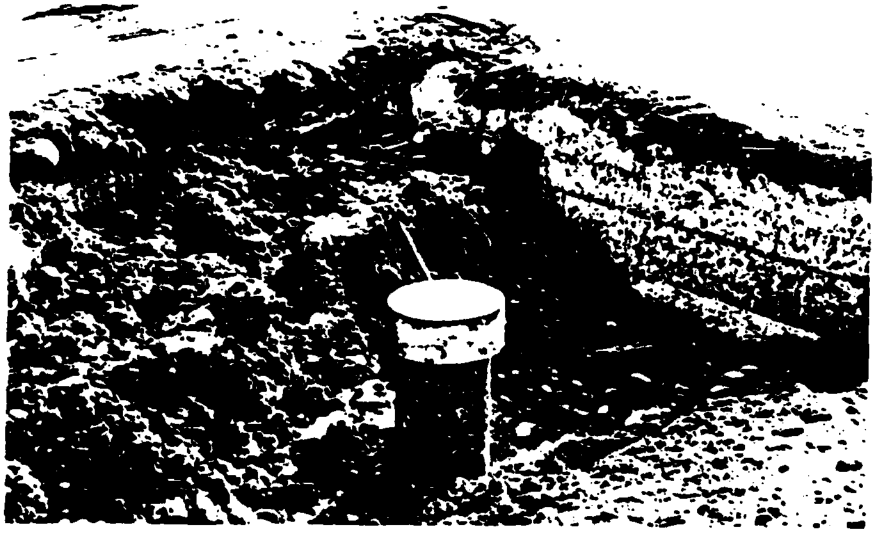


PHOTO C
Extended well head

Photos Courtesy of USAF

well, a 3-foot long, 12-inch diameter steel casing extension was welded onto the extension previously attached to the located well. The excavated area surrounding the well was backfilled by the Air Force to allow a drill rig to approach the casing for clean-out. This is shown as photograph B on Figure 3.9. A watertight cap was installed on the 24-inch casing and a supplemental lockable steel cap was fabricated and installed. The completed well head is shown as photograph C on Figure 3.9.

The well log from the time of installation (probably 1943) shows that the well consisted of a 12-inch steel casing with a double casing in the upper 50 feet. A diagram showing well construction of BW7 is presented on Figure 3.10. The annulus between the two casings is shown as being grouted, and the well was gravel packed for its entire depth of 398 feet. Perforations in the well casing begin at about 170 feet and extend to the bottom of the well.

Rotary-wash drilling was employed for clean-out of the well using an 8-inch drill bit and fresh water as a drilling fluid. During drilling, the well appeared clear to a depth of 60 feet from the ground surface. At this depth, hard material was encountered and the cuttings showed a mixture of coarse sand and small amounts of clay with some wood chips. At 80 feet, the drill bit met refusal; the 8-inch drill bit was changed to a 4-inch bit, but the drilling still encountered refusal. At this time, drilling was aborted; the refusal could have been caused by either a crooked casing or concrete having been poured into the well for closure.

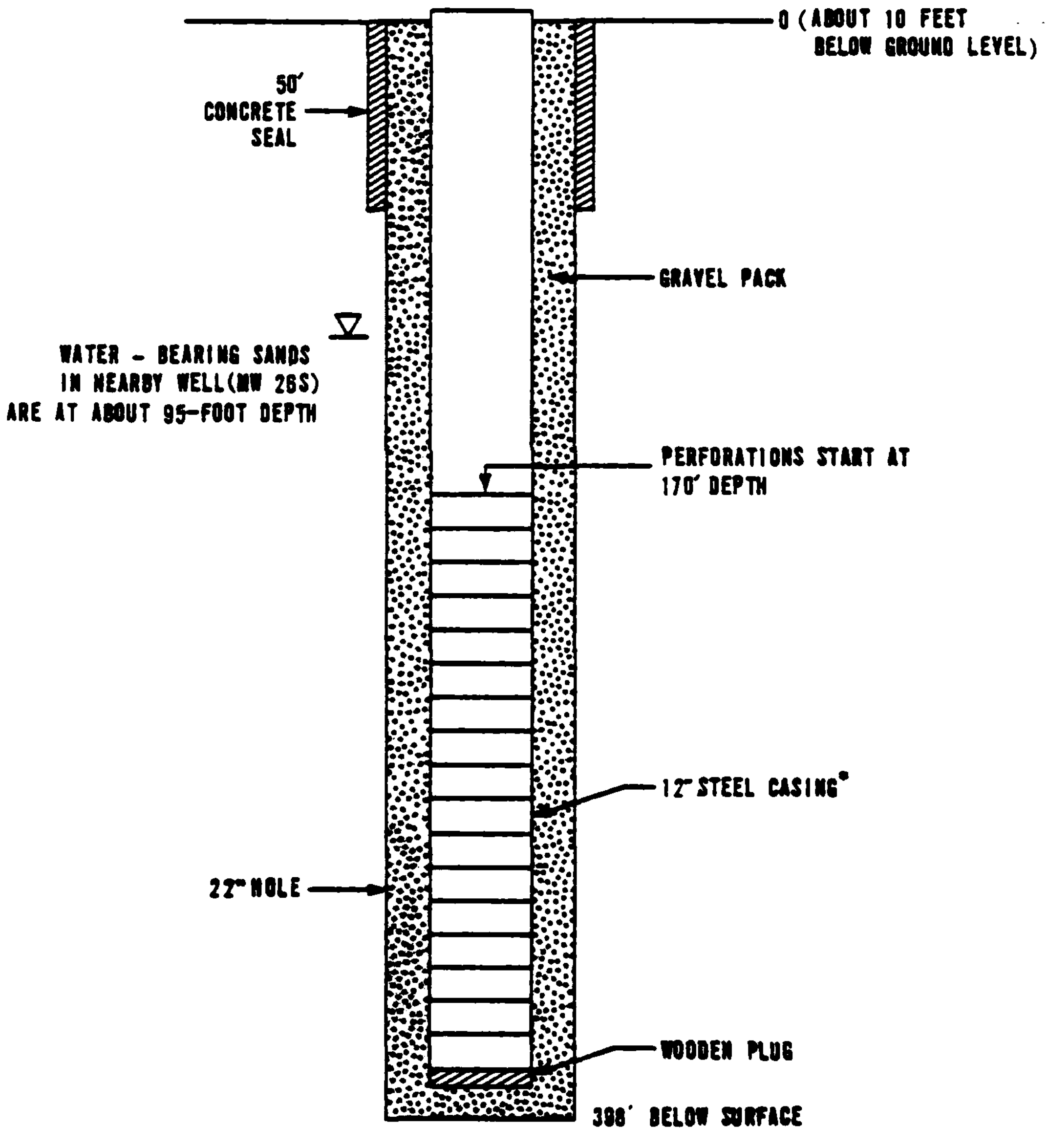
Subsequent interviews with Base personnel in the Water Department revealed that the well casing was possibly grouted in the late 1960's or early 1970's (Cunningham, 1982). This would seem probable in light of the refusal during drilling at a depth of 80 feet.

INDUSTRIAL WASTE LINE SURVEY NEAR BUILDING 251

An investigation of the industrial waste collection system in the vicinity of Building 251 was performed in January 1982. The purpose of this investigation was to determine if the industrial waste line was a possible source of constituents that necessitated closure of two Base

FIGURE 3.10

WELL CONSTRUCTION DIAGRAM
BASE PRODUCTION WELL 7
McCLELLAN AFB, CA



*THE ORIGINAL WELL LOG INDICATES DOUBLE CASING (?) 3-21

NOT TO SCALE

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production wells in the immediate vicinity. The system includes a 6-inch PVC force main between manhole 33 and the pump station at Building 243B, an abandoned 4-inch force main between manhole 33 and Building 243G, and 18-inch RCP gravity lines between manholes 32 and 33A and between manholes 32 and 33. Figure 3.11 shows the location of these facilities.

The integrity of these lines was evaluated through low-pressure air testing in accordance with ASTM C 828-78 and in conformance with CAL/OSHA safety orders and ES Industrial Sewer Entry Procedures. Individuals entering manholes wore complete life support systems. The photographs on Figure 3.12 show two people donning safety equipment and making final preparations just prior to manhole entry. Appendix R contains a listing of safety equipment and low-pressure air test equipment as well as the sewer entry procedures.

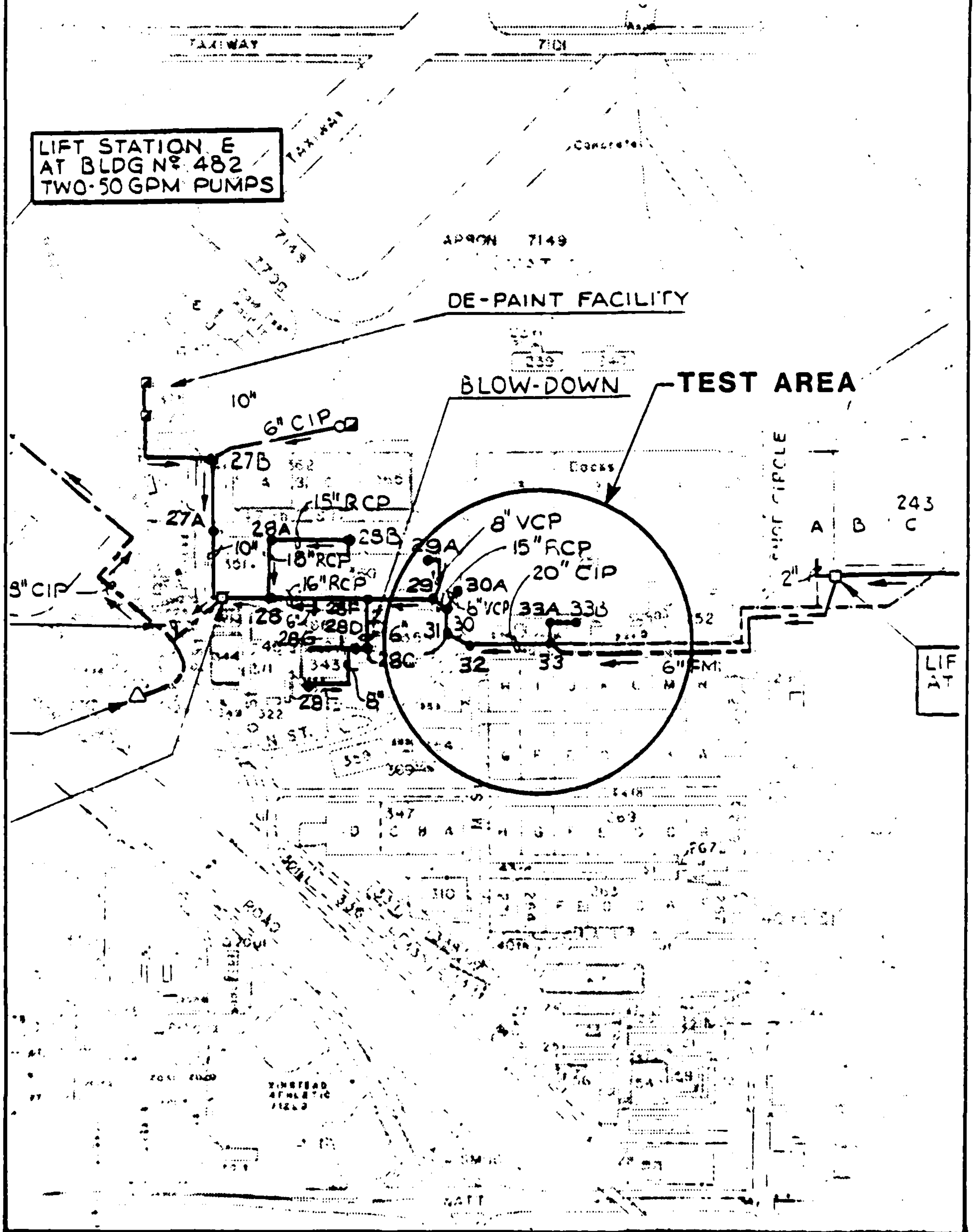
The 6-inch force main was plugged and a pressure of 4 psi (gage) was applied. This pressure held for an appropriate length of time, constituting a successful test. The pressure was subsequently boosted to 9 psi, which again held steady.

Testing of the 18-inch RCP gravity line was performed between the vapor traps at manhole 32 and manhole 33A. A maximum pressure of only 2 psi was obtained. Similarly, only 1 psi was attainable in the section between manholes 32 and 33.

In order to isolate areas of potentially high leakage in the 18-inch RCP gravity line, an attempt was made to test the line in overlapping 25-foot lengths. The first section tested held a maximum pressure of only 3 psi. Malfunction of one of the test plugs forced cancellation of further testing.

Visual inspection of the 18-inch RCP gravity line, at least 38 years old, showed it to be in reasonably good condition. However, the joints probably are the flush-bell-and-spigot-with-mortar type, which have a high potential for leakage compared to more modern rubber ring joints. The old joints could be a possible source of exfiltration throughout the 18-inch gravity sewer.

LOCATION OF INDUSTRIAL WASTE LINE
TEST AREA



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INDUSTRIAL WASTE LINE INSPECTION

PHOTO A
Donning life support system

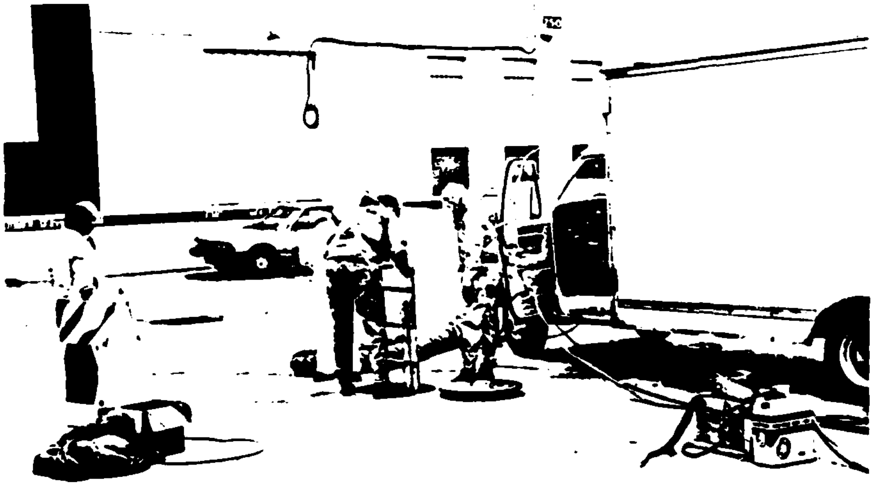


PHOTO B
Preparing for manhole entry

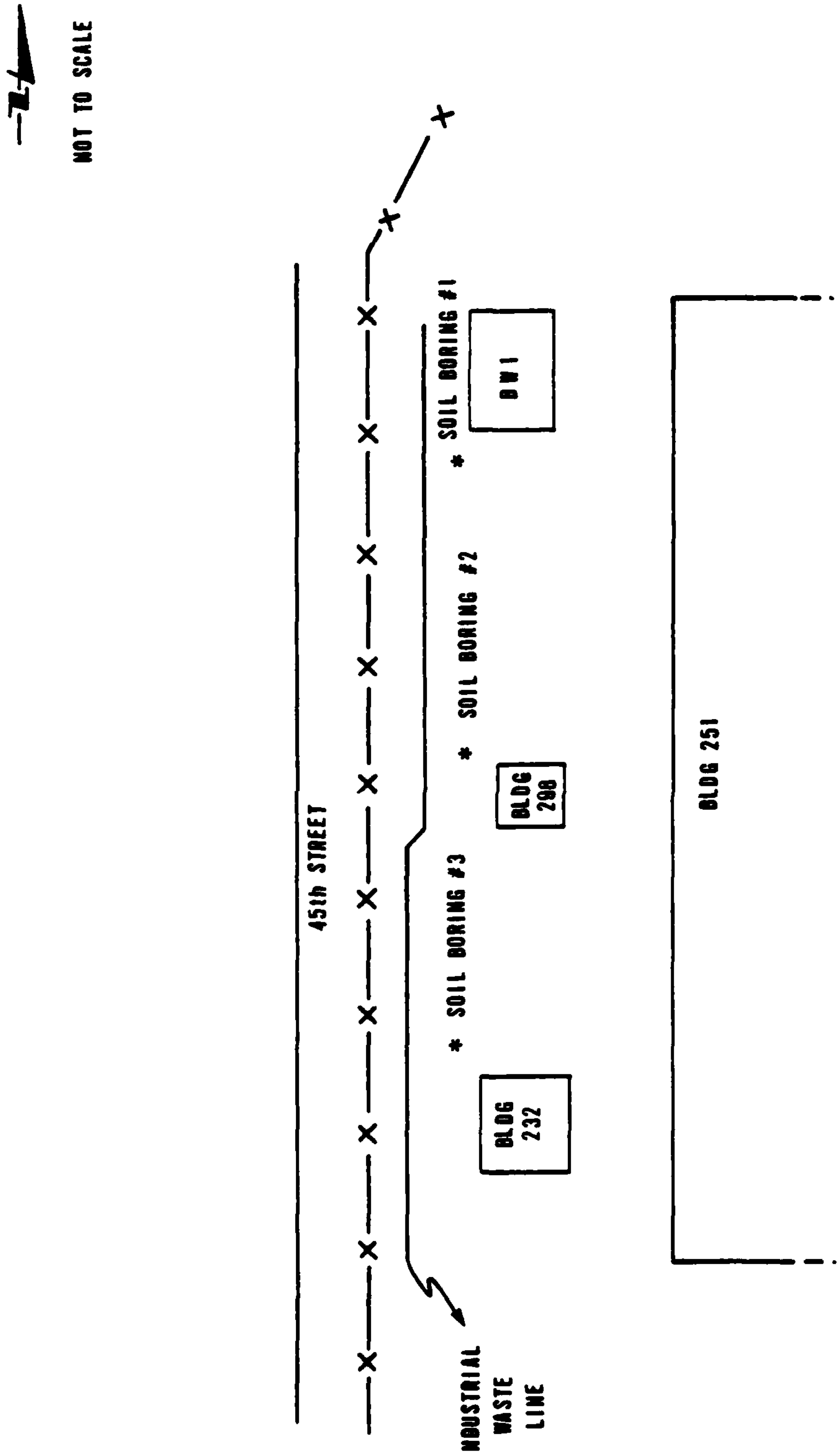
Photos Courtesy of USAF

A drilling program was developed to obtain soil samples along the industrial waste line alignment. Analyses of the samples for GC/MS organics and trace metals were performed to identify potential soil contamination from the waste line if exfiltration had occurred in the past. Soil borings were completed at three locations along the waste line as shown in Figure 3.13. Two of the borings were located along the 18-inch diameter gravity portion of the line, while the third was along the 6-inch diameter force main. The waste line slopes from north to south from a depth of 8 feet by BW2 to 10 feet by BW1.

The three soil borings were completed with an 8-inch hollow-stem auger at a 30-degree slant from the vertical. Slant drilling allowed soil sampling to be performed directly beneath the waste line. The holes were drilled to a depth of 20 feet, and samples were collected at depths of 15 feet and 20 feet with a 1-1/2-inch split-spoon sampler. Following each sampling event, the spoon was rinsed in acetone and deionized water. The samples were collected in solvent-washed glass bottles and VOA bottles, then refrigerated and transported to the laboratory for analysis.

While drilling soil boring 2, the soil from the auger smelled of fuel; this was not noticed at the other soil boring locations.

LOCATION OF SOIL BORINGS
ALONG INDUSTRIAL WASTE LINE
BY BUILDING 251
McCLELLAN AFB, CA



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SECTION 4

RESULTS OF FIELD PROGRAM

CHAPTER 4

RESULTS OF FIELD PROGRAM

During the field program, the effects of past waste management practices on groundwater were investigated. This chapter discusses and evaluates the results of those investigations. Included are sections on analytical data, the hydrogeologic regime, field testing, and problem descriptions. The section on analytical data presents the results from laboratory analyses of groundwater samples from Base production wells, Base monitoring wells, Stage I wells, and Stage II wells in addition to discussions of data related to potential source areas and selected sites monitored during the Phase II field program. Also included are discussions of the industrial waste line survey near Building 251, as well as laboratory results for soil samples collected beneath the waste line. The section pertaining to the hydrogeologic regime contains discussions on the status of deeper aquifers and shallow sands as well as results from pump and slug tests. The field testing section covers establishing the location of Base production well 7, and logging specific conductance and temperature. A summary of the information presented in this chapter is provided in the final section on problem definition.

ANALYTICAL DATA

Groundwater samples were obtained from Base production wells, Base monitoring wells, and monitoring wells installed during Stages I and II of the field program. Specific constituents for analysis were selected based on materials used and waste products generated and disposed at McClellan AFB. Analyses performed included EPA priority organic pollutants (volatile organic compounds, acid and base/neutral compounds, pesticides/ herbicides, and polychlorinated biphenyls), trace metals, and cyanide. Selected wells were also analyzed for cresylic acid and aliphatic material (grease and oil). Historical groundwater information and concurrent analytical results formed the rationale for these analyses. This section describes the analytical results obtained for all the wells on the Base, discusses analyses of soil samples collected near Building 251 beneath the industrial waste line, and summarizes the results of the waste line survey.

Records of sampling events for Base production wells, Base monitoring wells, and Stage I and II monitoring wells are contained in Appendices F, G, and H. Laboratory results for the constituents for which the groundwater and soil samples were analyzed are presented in Appendices J through N. Analytical procedures employed are described in Appendix S.

Base Production Wells

Analytical results for those organic compounds identified above detection limits in the groundwater samples from Base production wells are presented in Table 4.1. No other constituents tested were found in samples from any of the production wells.

The only wells that showed the presence of volatile priority pollutants during sampling in December 1981 were BW1 and BW2; these wells have since been closed. Though the two wells are located but a few hundred yards apart, the trichloroethylene (TCE) concentrations observed vary within two orders of magnitude (1,500 ppb and 10 ppb, respectively). Although no formal federal or state standard has been established for TCE in drinking water, the State of California Department of Health Services has utilized 5.0 ppb as an "action level". The concentrations of TCE detected in Base production wells during Stage I sampling events are presented on Figure 4.1.

Detectable concentrations of three other volatile organic compounds (VOC) were also found in samples from Base production wells 1 and 2. These compounds were chloroform (24 ppb), 1,2-trans-dichloroethylene (23 ppb), and 1,1-dichloroethylene (175 ppb). Chloroform is a natural by-product of chlorine disinfection, and is used as a solvent for oils, rubber, alkaloids, and resins. 1,1-Dichloroethylene is an intermediate

TABLE 4.1

BASE PRODUCTION WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in ppb)

Compound[a]	Well Number and Sampling Dates									
	BW1		BW2		BW8		BW11		BW12	
	12-21-81	1-11-82	12-21-81	1-11-82	12-21-81	1-11-82	12-21-81	1-11-82	12-21-81	1-11-82
Volatiles										
1,1,1-trichloroethane	ND	-	<10	-	ND	-	ND	-	ND	-
chloroform	24	-	ND	-	ND	-	ND	-	ND	-
1,1-dichloroethylene	ND	-	175	-	ND	-	ND	-	ND	-
1,2-trans-dichloroethylene	23	-	ND	-	ND	-	ND	-	ND	-
trichloroethylene	1,500	-	10	-	ND	-	ND	-	ND	-
Acid Compounds										
phenol	-	ND	-	ND	-	ND	-	ND	-	ND
Pesticides/Herbicides										
alpha-BHC	-	ND	-	0.12	-	0.26	-	ND	-	0.003
beta-BHC	-	ND	-	ND	-	ND	-	ND	-	ND
gamma-BHC (lindane)	-	ND	-	0.06	-	ND	-	0.08	-	ND
DDD	-	ND	-	ND	-	ND	-	0.07	-	ND
endosulfan I	-	ND	-	0.03	-	ND	-	0.09	-	ND
endosulfan sulfate	-	ND	-	0.17	-	ND	-	ND	-	ND
heptachlor	-	ND	-	0.05	-	ND	-	ND	-	ND
2,4-D	-	0.04	-	0.04	-	0.06	-	0.02	-	0.03
2,4,5-T	-	ND	-	0.18	-	0.01	-	0.004	-	0.05
Polychlorinated Biphenyls										
aroclor 1254	-	ND	-	ND	-	ND	-	ND	-	<0.08

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TABLE 4.1 (Continued)

Compound[a]	Well Number and Sampling Dates									
	BW13		BW17		BW18		BW28		BW29	
	12-21-81	1-11-82	12-21-81	1-11-82	12-21-81	1-11-82	12-21-81	1-11-82	12-21-81	1-11-82
Volatiles										
1,1,1-trichloroethane	ND	-	ND	-	ND	-	ND	-	ND	-
chloroform	ND	-	ND	-	ND	-	ND	-	ND	-
1,1-dichloroethylene	ND	-	ND	-	ND	-	ND	-	ND	-
1,2-trans-dichloroethylene	ND	-	ND	-	ND	-	ND	-	ND	-
trichloroethylene	ND	-	ND	-	ND	-	ND	-	ND	-
Acid Compounds										
phenol	-	<10	-	ND	-	ND	-	ND	-	ND
Pesticides/Herbicides										
alpha-BHC	-	0.004	-	ND	-	ND	-	ND	-	ND
beta-BHC	-	ND	-	ND	-	0.10	-	ND	-	ND
gamma-BHC (lindane)	-	ND	-	ND	-	ND	-	ND	-	ND
DDD	-	ND	-	ND	-	ND	-	ND	-	ND
endosulfan I	-	ND	-	0.27	-	ND	-	ND	-	ND
endosulfan sulfate	-	ND	-	ND	-	ND	-	ND	-	ND
heptachlor	-	ND	-	0.04	-	ND	-	ND	-	ND
2,4-D	-	0.006	-	ND	-	ND	-	0.008	-	0.01
2,4,5-T	-	0.006	-	ND	-	0.003	-	0.002	-	0.002
Polychlorinated Biphenyls										
aroclor 1254	-	<0.08	-	<0.08	-	<0.08	-	0.24	-	<0.08

ND = not detected (-) = sample was not analyzed for this compound

a See Appendix J for a complete list of analyses performed.

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FIG 4.1

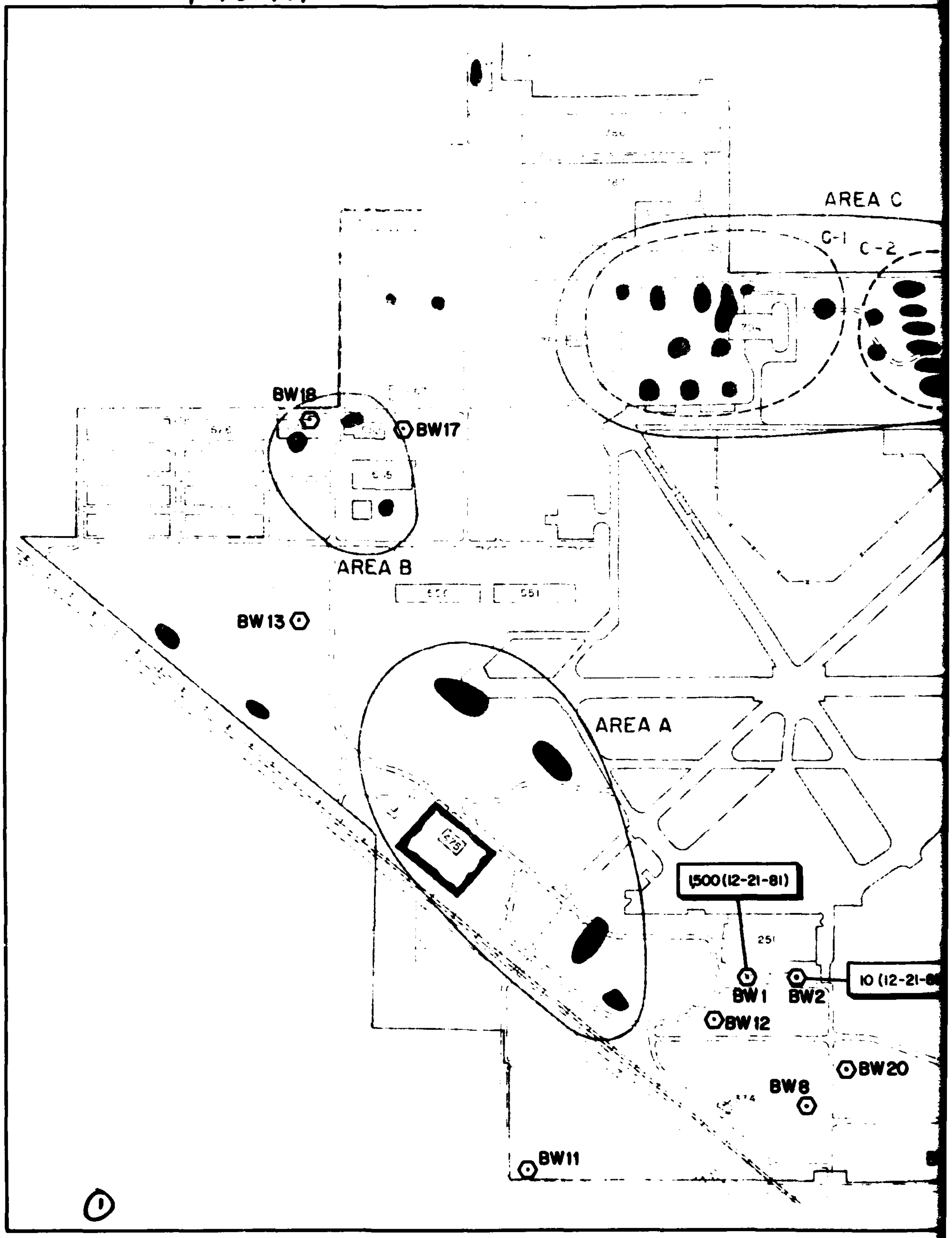
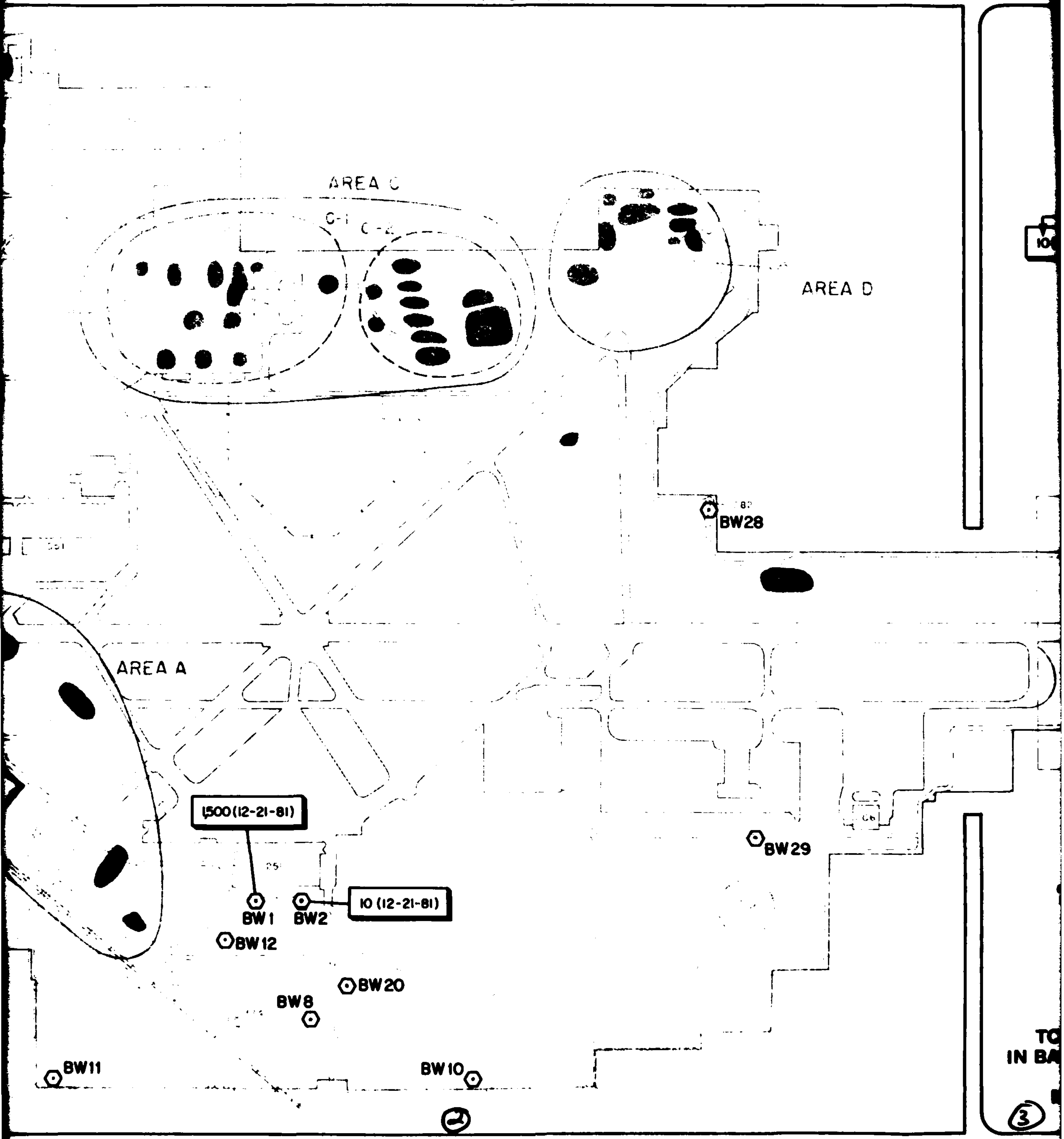

AREA C
C-1
C-2
BW18
BW17
AREA B
551
BW13
AREA A
675
1500 (12-21-81)
251
10 (12-21-8
BW1
BW2
BW12
BW20
BW8
BW11
①

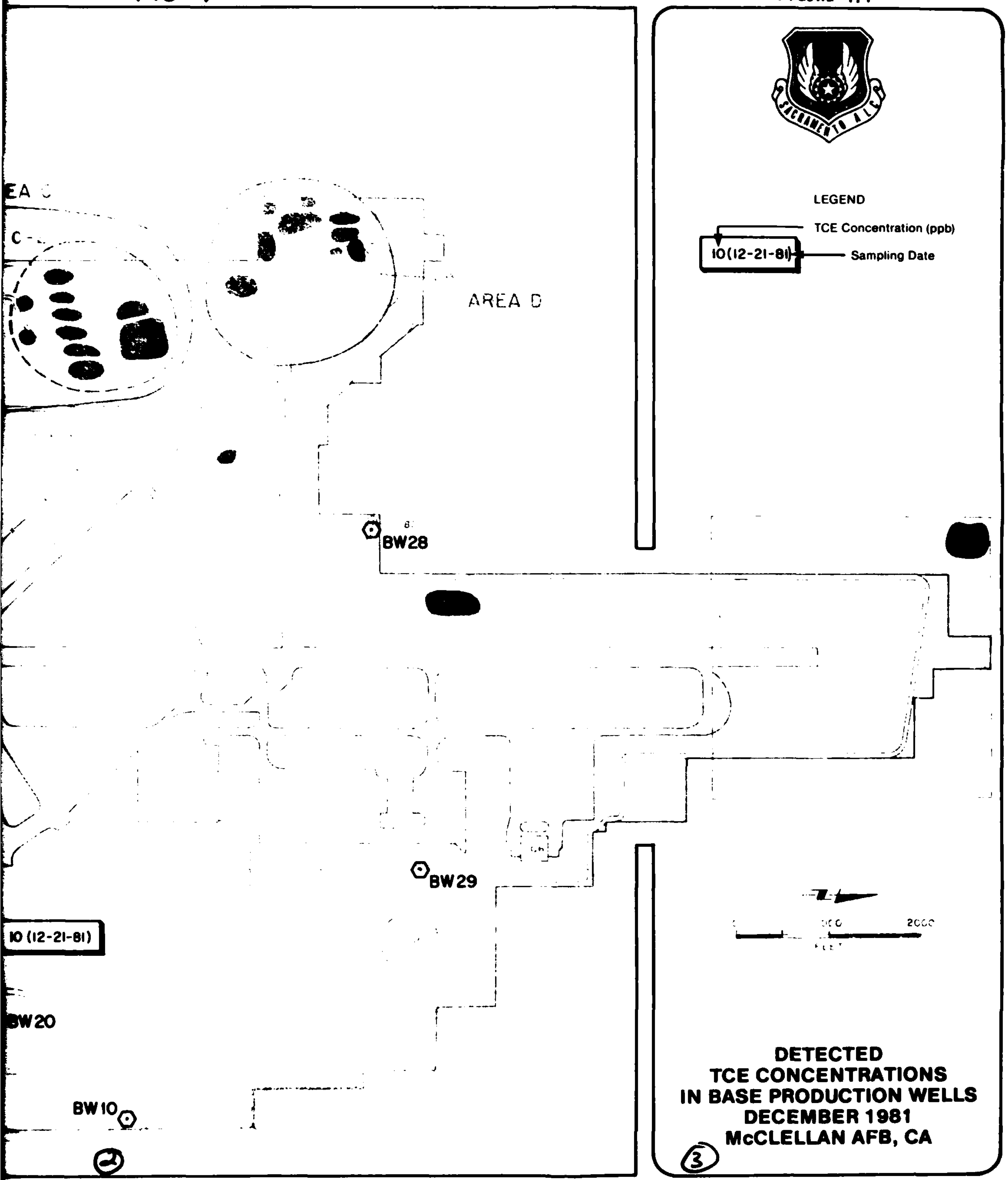
FIG 4.1



AREA C
C-1
C-2
AREA D
AREA A
BW28
BW29
1500 (12-21-81)
10 (12-21-81)
BW1
BW2
BW12
BW20
BW8
BW11
BW10
②
③
TO
IN BA

FIG 4.1

FIGURE 4.1



DETECTED
TCE CONCENTRATIONS
IN BASE PRODUCTION WELLS
DECEMBER 1981
McCLELLAN AFB, CA

ENGINEERING-SCIENCE

1-424

4-5

for vinylidene polymers. A concentration of 0.24 ppb was detected for aroclor (a polychlorinated biphenyl) in a groundwater sample collected in January 1982 from BW28.

Various concentrations of pesticides and herbicides were detected in all Base production wells. These compounds included 2,4-D and 2,4,5-T, the herbicides detected most frequently throughout the Base. The highest concentration of 2,4-D detected was 0.06 ppb at BW8. This value is three orders of magnitude lower than the California Drinking Water Standard of 100 ppb (California Administrative Code, Title 22). No current standard exists for 2,4,5-T. All the herbicides and pesticides found either are currently used or have been used extensively in the past for Sacramento Valley agriculture.

Trace metal analyses of the Base production wells showed concentrations of all the metals except zinc to be at or below limits of detection. These detection limits are equivalent to the California Drinking Water Standards for each metal except zinc, mercury, copper, and lead. The highest zinc concentration detected in any Base production well was 0.097 mg/l at BW11. California Secondary Drinking Water Standards reflect maximum zinc levels of 5.0 mg/l, more than 50 times greater than the concentration in BW11. Results of the trace metal analyses for all Base production wells are presented on Table 4.2.

Base-Installed Monitoring Wells

A complete EPA priority pollutant scan was performed for all Base monitoring wells. The organic compounds found above detection limits in these monitoring wells are identified in Table 4.3. Constituents which were not detected in any of the Base monitoring wells are not listed in the table.

Trichloroethylene was detected in groundwater samples from every Base monitoring well except MW4. Excluding MW10 through MW15, the TCE concentrations ranged between 0.54 ppb at MW3 to 296 ppb at MW8. The detected TCE concentrations in Base monitoring wells are shown on Figure 4.2. The base/neutral compound bis(2-ethylhexyl)phthalate was identified in all of the groundwater samples at a maximum concentration of 100 ppb; this compound is commonly used in vacuum pumps and vacuum chambers.

TABLE 4.2

BASE PRODUCTION WELLS
TRACE METALS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in mg/l)

Metal[a]	Well Number and Sampling Date										Ca DWS[b]
	BW1	BW2	BW8	BW11	BW12	BW13	BW17	BW18	BW28	BW29	
	1-11-82	1-11-82	1-11-82	1-11-82	1-11-82	1-11-82	1-11-82	1-11-82	1-11-82	1-11-82	(mg/l)
Antimony (Sb)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	N.S.[c]
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Chromium (Cr)	0.055	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.0
Lead (Pb)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Mercury (Hg)	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Nickel (Ni)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	N.S.[c]
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	0.028	0.02	<0.02	0.097	<0.02	<0.02	<0.02	<0.02	0.048	<0.02	5.0

a See Appendix J for a complete list of analyses performed.

b Ca DWS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.

c N.S. - No standard has been established for drinking water.

TABLE 4.3

BASE MONITORING WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in ppb)

Compound[a]	Well Number and Sampling Dates												
	MW3	MW4		MW6		MW7			MW8		MW9		
	12-22-81	3-31-82	4-28-82	12-22-81	3-30-82	12-22-81	3-17-82[b]	3-29-82	12-22-81	3-31-82	12-22-81	3-31-82[c]	4-28-82
Volatiles													
benzene	-	ND	-	-	ND	-	ND	ND	-	<10	-	ND	ND
carbon tetrachloride	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	25
chlorobenzene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
chloroform	-	ND	-	-	ND	-	ND	ND	-	<10	-	ND	20
1,1-dichloroethane	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
1,2-dichloroethane	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
1,1-dichloroethylene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
1,2-trans-dichloroethylene	-	ND	-	-	ND	-	20	26	-	<10	-	ND	ND
ethyl benzene	-	ND	-	-	ND	-	ND	ND	-	<10	-	ND	ND
methylene chloride	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
tetrachloroethylene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
toluene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
1,1,1-trichloroethane	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
trichloroethylene	0.54	ND	-	118	24	14.4	30	29	296	61	4.03	ND	225
trichlorofluoromethane	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
vinyl chloride	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
Acid Compounds													
2,4-dimethylphenol	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
phenol	-	ND	-	-	ND	-	ND	ND	-	<10	-	ND	ND
Base/Neutral Compounds													
bis(2-ethylhexyl)phthalate	-	15	-	-	16	-	12	13	-	100	-	21	ND
butyl benzyl phthalate	-	ND	-	-	ND	-	ND	ND	-	<10	-	ND	ND
1,2-dichlorobenzene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
1,3-dichlorobenzene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
1,4-dichlorobenzene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
naphthalene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
1,2,4-trichlorobenzene	-	ND	-	-	ND	-	ND	ND	-	ND	-	ND	ND
Pesticides/Herbicides													
Aldrin	-	-	ND	-	ND	-	0.26	1.03	-	ND	-	0.15	ND
alpha-BHC	-	-	ND	-	ND	-	ND	ND	-	ND	-	0.08	ND
gamma-BHC (lindane)	-	-	2.76	-	ND	-	ND	ND	-	0.005	-	0.12	0.16
heptachlor	-	-	ND	-	0.70	-	ND	0.88	-	0.04	-	ND	ND
heptachlor epoxide	-	-	ND	-	ND	-	ND	ND	-	ND	-	0.08	ND
2,4-D	-	-	0.377	-	0.02	-	ND	0.03	-	ND	-	ND	ND
2,4,5-T	-	-	ND	-	0.006	-	0.002	ND	-	0.008	-	0.003	0.007
2,4,5-TP (Silvex)	-	-	0.06	-	ND	-	ND	ND	-	ND	-	ND	ND

TABLE 4.3 (Continued)

Compound[a]	Well Number and Sampling Dates										
	MW10		MW11			MW12			MW13		
	12-22-81	3-30-82	12-22-81	3-30-82	8-18-82	12-22-81	4-29-82	8-18-82	12-22-81	3-30-82	8-18-82
Volatiles											
benzene	-	ND	-	<10	ND	-	ND	ND	-	ND	ND
carbon tetrachloride	-	ND	-	ND	ND	ND	ND	-	ND	ND	ND
chlorobenzene	-	ND	-	ND	ND	-	ND	ND	-	ND	ND
chloroform	-	ND	-	40	<10	-	ND	ND	-	ND	ND
1,1-dichloroethane	-	19	-	170	250	-	ND	ND	-	40	ND
1,2-dichloroethane	-	17	-	ND	ND	-	ND	ND	-	ND	ND
1,1-dichloroethylene	-	500	-	19,300	63,000	-	4,200	2,500	-	1,100	780
1,2-*trans*-dichloroethylene	-	15	-	180	200	-	ND	ND	-	80	6
ethyl benzene	-	ND	-	ND	ND	-	ND	ND	-	ND	ND
methylene chloride	-	ND	-	3,700	ND	-	ND	ND	-	1,000	ND
tetrachloroethylene	-	ND	-	10	ND	-	70	18	-	20	<10
toluene	-	ND	-	80	ND	-	10	ND	-	ND	ND
1,1,1-trichloroethane	-	ND	-	4,300	12,000	-	2,700	520	-	300	68
trichloroethylene	>313	140	10.4	2,100	5,000	3,730	930	160	8,920	1,470	230
trichlorofluoromethane	-	ND	-	ND	ND	-	ND	7	-	ND	ND
vinyl chloride	-	ND	-	20	ND	-	ND	ND	-	50	<10
Acid Compounds											
2,4-dimethylphenol	-	ND	-	ND	ND	-	ND	ND	-	ND	ND
phenol	-	ND	-	ND	ND	-	ND	ND	-	ND	ND
Base/Neutral Compounds											
bis(2-ethylhexyl)phthalate	-	13	-	14	ND	-	ND	ND	-	64	ND
butyl benzyl phthalate	-	ND	-	ND	ND	-	ND	ND	-	ND	ND
1,2-dichlorobenzene	-	21	-	<10	32	-	ND	ND	-	<10	ND
1,3-dichlorobenzene	-	ND	-	ND	<10	-	ND	ND	-	ND	ND
1,4-dichlorobenzene	-	ND	-	ND	10	-	ND	ND	-	ND	ND
naphthalene	-	ND	-	<10	25	-	ND	ND	-	ND	ND
1,2,4-trichlorobenzene	-	ND	-	ND	8	-	ND	12	-	ND	ND
Pesticides/Herbicides											
Aldrin	-	1.80	-	ND	-	-	ND	-	-	ND	-
alpha-BHC	-	ND	-	ND	-	-	ND	-	-	ND	-
gamma-BHC	-	ND	-	ND	-	-	ND	-	-	ND	-
heptachlor	-	ND	-	ND	-	-	ND	-	-	ND	-
heptachlor epoxide	-	ND	-	ND	-	-	ND	-	-	ND	-
2,4-D	-	ND	-	ND	-	-	ND	-	-	-	-
2,4,5-T	-	ND	-	ND	-	-	0.004	-	-	0.009	-
2,4,5-TP (Silvex)	-	ND	-	ND	-	-	ND	-	-	ND	-

TABLE 4.3 (Continued)

Compound[a]	Well Number and Sampling Dates					
	MW14			MW15		
	12-22-81	3-30-82	8-18-82	12-22-81	4-29-82	8-18-82
Volatiles						
benzene	-	<10	ND	-	680	10
carbon tetrachloride	-	ND	ND	-	ND	ND
chlorobenzene	-	<10	ND	-	ND	ND
chloroform	-	120	<10	-	20	40
1,1-dichloroethane	-	110	100	-	225	200
1,2-dichloroethane	-	ND	ND	-	ND	ND
1,1-dichloroethylene	-	4,600	17,000	-	5,980	9,600
1,2-trans-dichloroethylene	-	130	200	-	135	110
ethyl benzene	-	ND	ND	-	ND	ND
methylene chloride	-	3,000	ND	-	5,000	ND
tetrachloroethylene	-	ND	ND	-	ND	ND
toluene	-	50	ND	-	ND	ND
1,1,1-trichloroethane	-	8,700	2,300	-	2,200	2,500
trichloroethylene	14,100	5,800	11,000	1.79	2,800	3,000
trichlorofluoromethane	-	ND	ND	-	ND	ND
vinyl chloride	-	25	ND	-	ND	<10
Acid Compounds						
2,4-dimethylphenol	-	19	94	-	ND	ND
phenol	-	<10	400	-	ND	ND
Base/Neutral Compounds						
bis(2-ethylhexyl)phthalate	-	11	ND	-	ND	ND
butyl benzyl phthalate	-	ND	ND	-	ND	ND
1,2-dichlorobenzene	-	22	100	-	ND	50
1,3-dichlorobenzene	-	<10	28	-	ND	8
1,4-dichlorobenzene	-	<10	40	-	ND	12
naphthalene	-	ND	<10	-	ND	ND
1,2,4-trichlorobenzene	-	ND	6	-	ND	ND
Pesticides/Herbicides						
Aldrin	-	6.97	-	-	ND	-
alpha-BHC	-	ND	-	-	ND	-
gamma-BHC	-	ND	-	-	ND	-
heptachlor	-	ND	-	-	ND	-
heptachlor epoxide	-	ND	-	-	ND	-
2,4-D	-	-	-	-	0.02	-
2,4,5-T	-	0.005	-	-	ND	-
2,4,5-TP (Silvex)	-	ND	-	-	0.36	-

ND = not detected (-) = sample was not analyzed for this compound

a See Appendix K for a complete list of analyses performed.

b This well contained large quantities of silt; the well was sampled on 17 March 1982, and the sample analyzed. On 24 March 1982, this well as well as the existing monitoring wells were cleaned out for silt, and an additional sample was taken on 29 March 1982.

c When this well was sampled on 31 March 1982, the water level was measured at a depth of 9 feet below the ground surface. The well cap was missing, and rainwater had entered the well.

1-99

FIG - 4.2

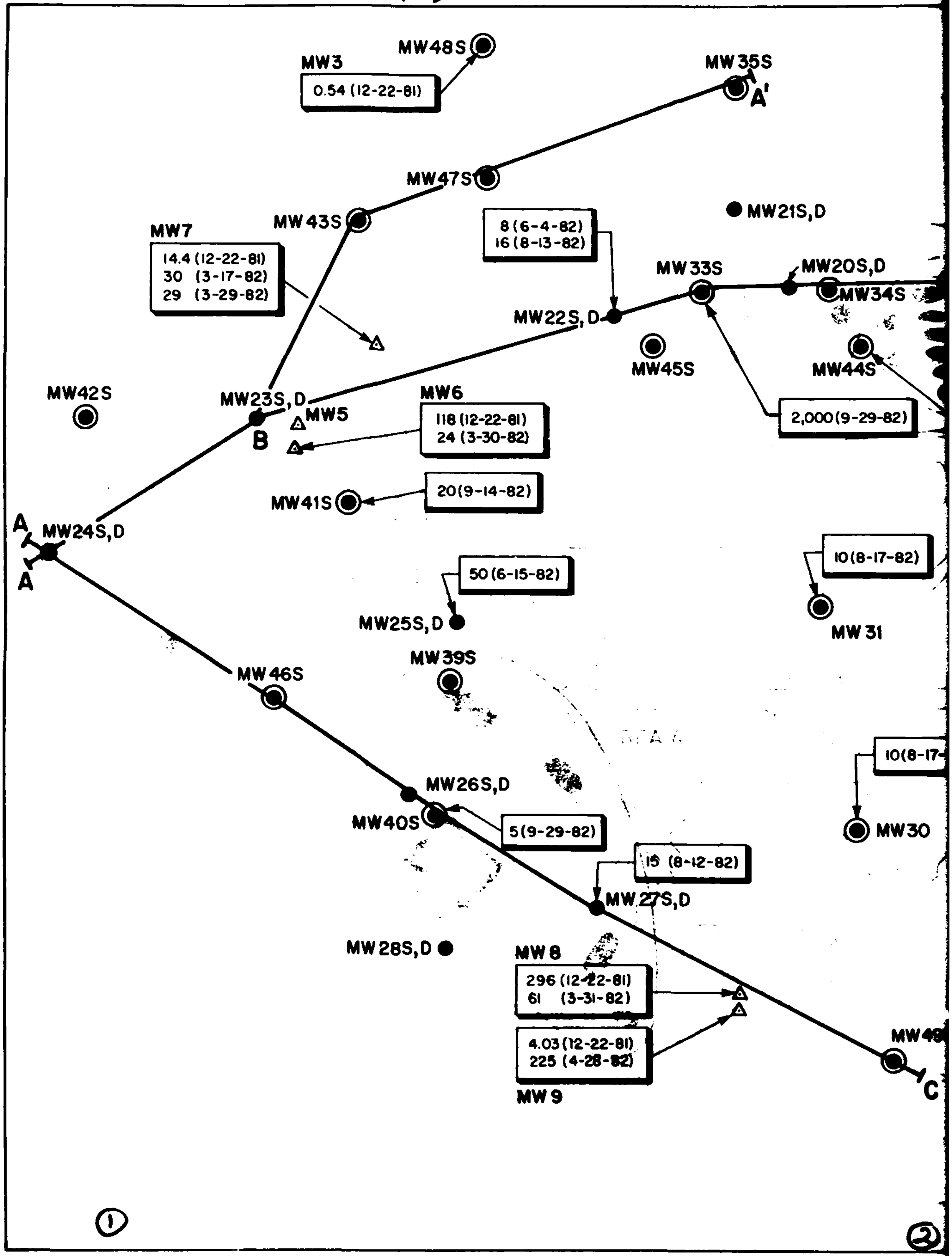
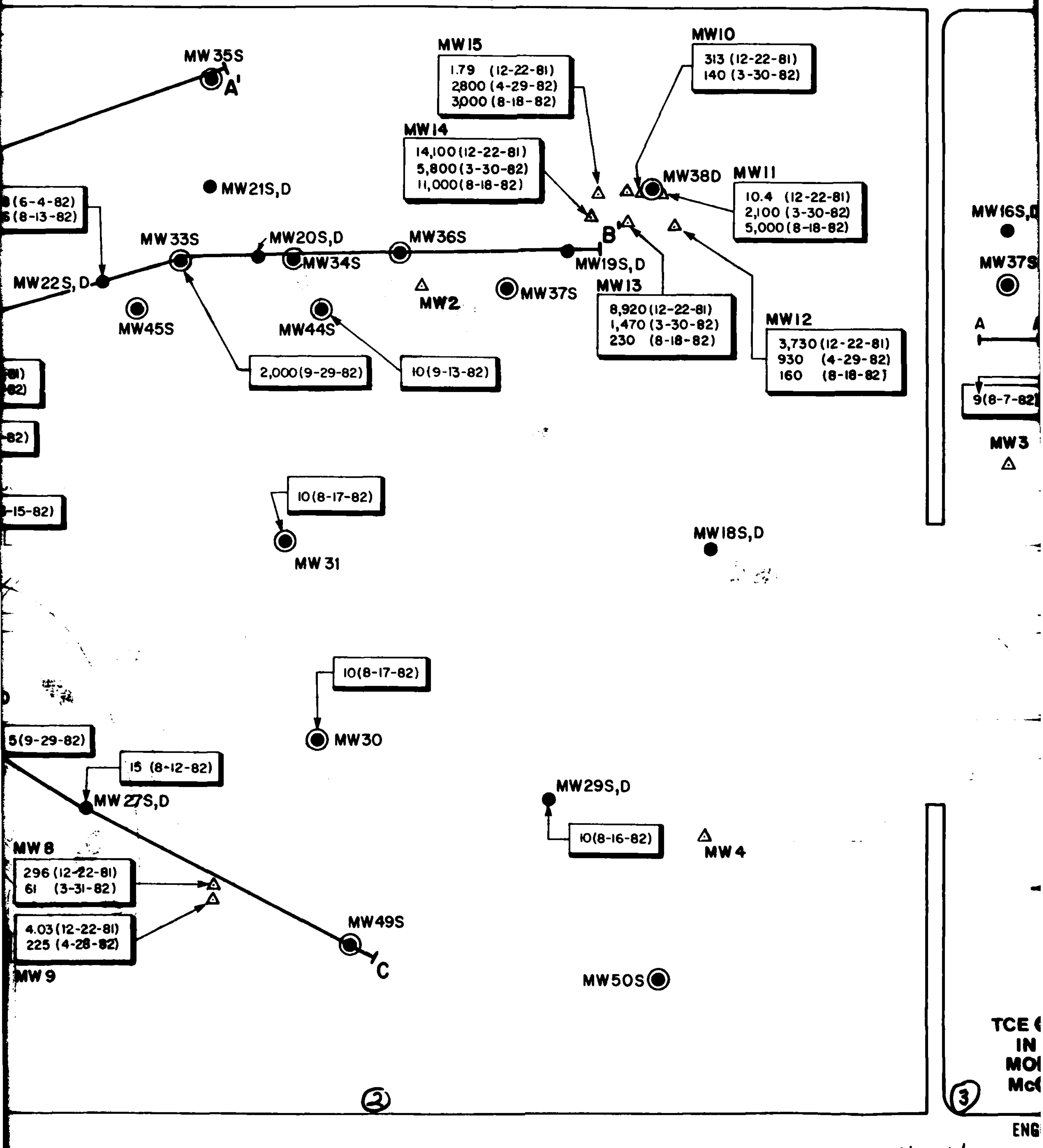
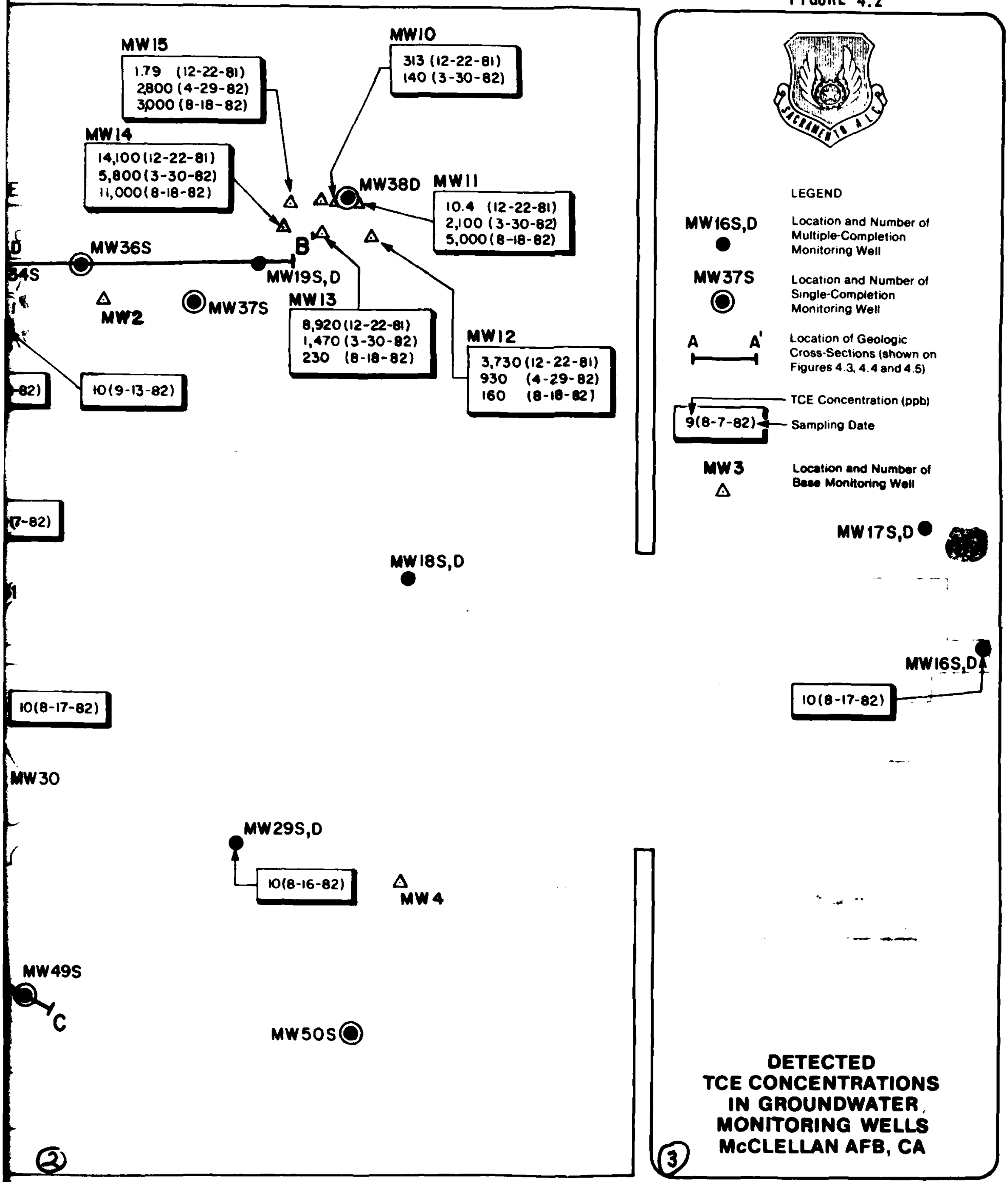

MW48S
MW3
0.54 (12-22-81)
MW35S
A'
MW47S
MW43S
MW21S,D
MW7
14.4 (12-22-81)
30 (3-17-82)
29 (3-29-82)
8 (6-4-82)
16 (8-13-82)
MW33S
MW20S,D
MW34S
MW22S, D
MW45S
MW44S
MW42S
MW23S, D
MW5
B
MW6
118 (12-22-81)
24 (3-30-82)
2,000 (9-29-82)
MW41S
20 (9-14-82)
A
MW24S,D
A
10 (8-17-82)
50 (6-15-82)
MW25S, D
MW31
MW46S
MW39S
10 (8-17-
MW26S,D
MW40S
5 (9-29-82)
MW30
15 (8-12-82)
MW27S,D
MW28S,D
MW8
296 (12-22-81)
61 (3-31-82)
4.03 (12-22-81)
225 (4-28-82)
MW9
MW49
C
①
②

FIG 4.2


MW35S
A'
MW15
1.79 (12-22-81)
2,800 (4-29-82)
3,000 (8-18-82)
MW10
313 (12-22-81)
140 (3-30-82)
MW14
14,100 (12-22-81)
5,800 (3-30-82)
11,000 (8-18-82)
MW38D
MW11
10.4 (12-22-81)
2,100 (3-30-82)
5,000 (8-18-82)
MW21S,D
(6-4-82)
(8-13-82)
MW33S
MW20S,D
MW36S
B'
MW34S
MW19S,D
MW22S,D
MW13
8,920 (12-22-81)
1,470 (3-30-82)
230 (8-18-82)
MW2
MW37S
MW45S
MW44S
MW12
3,730 (12-22-81)
930 (4-29-82)
160 (8-18-82)
2,000 (9-29-82)
10 (9-13-82)
MW16S,D
MW37S
A
9(8-7-82)
MW3
10 (8-17-82)
MW31
MW18S,D
10 (8-17-82)
MW30
5(9-29-82)
15 (8-12-82)
MW27S,D
MW29S,D
10(8-16-82)
MW4
MW8
296 (12-22-81)
61 (3-31-82)
4.03 (12-22-81)
225 (4-28-82)
MW9
MW49S
C
MW50S
②
③
TCE
IN
MO
Mc
ENG

F.G 4.2

FIGURE 4.2



DETECTED
TCE CONCENTRATIONS
IN GROUNDWATER
MONITORING WELLS
McCLELLAN AFB, CA

ENGINEERING-SCIENCE

4-11

1-425

A number of pesticides/herbicides were identified, the prevalent ones being 2,4-D and 2,4,5-T.

The wells in the sludge pit area (MW10 through MW15) all showed high concentrations of volatiles, particularly TCE, methylene chloride, 1,1-dichloroethylene, and 1,1,1-trichloroethane, which are common degreasing agents and/or associated impurities. Monitoring wells 11, 14, and 15 appear to contain the greatest numbers and concentrations of constituents. It should be noted that MW14 appears to have been installed directly within a former sludge/oil disposal site; this may be the reason for the high concentrations of groundwater constituents detected in this well.

Several trace metals were detected in the Base monitoring wells, particularly chromium, lead, mercury, nickel, and zinc. Data for metals identified above detection limits in these wells are contained in Table 4.4. Arsenic and silver were the only two metals not detected in any of the Base monitoring wells. Generally, except for zinc, mercury, copper, and lead, analytic limits of detection are equivalent to the established California Drinking Water Standards. (No state standards have been established for antimony or nickel in drinking water.) Any other values above detection limits therefore exceed drinking water standards. The wells containing most of the metals were MW4, MW8, and MW10, where antimony, cadmium, chromium, lead, mercury, nickel, selenium, and zinc were detected.

Stage I Monitoring Wells

Several shallow (S) Stage I monitoring wells revealed the presence of organic constituents. Analytical results for priority pollutants found above detection limits in the Stage I shallow wells are presented in Table 4.5. The detection of compounds was not consistent over successive samplings. Constituents present from the first sampling were often absent during the second sampling. Conversely, compounds initially absent were detected during the second sampling. Groundwater from MW20S, located along the western border of the Base, showed the greatest number of constituents present. Benzene (45 ppb), ethyl benzene (220 ppb), and toluene (440 ppb) were the volatiles identified above detection limits in MW20S; base/neutral compounds detected in water from that

TABLE 4.4

BASE MONITORING WELLS
TRACE METALS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in mg/l)

Metal[a]	Well Number and Sampling Dates													Ca DWS[d]
	MW4	MW6	MW7[b]		MW8	MW9[c]		MW10	MW11	MW12	MW13	MW14	MW15	
	4-28-82	3-30-82	3-17-82	3-29-82	3-31-82	3-31-82	4-28-82	3-30-82	3-30-82	3-30-82	3-30-82	3-30-82	3-30-82	(mg/l)
Antimony (Sb)	0.016	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	0.006	N.S.[e]
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	0.014	<0.01	<0.01	<0.01	0.013	<0.01	<0.01	0.012	<0.01	<0.01	0.01	<0.01	0.012	0.01
Chromium (Cr)	0.08	<0.05	0.21	0.09	0.90	<0.05	<0.05	0.12	0.07	<0.05	<0.05	0.09	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.0
Lead (Pb)	<0.01	0.109	0.081	0.023	0.98	0.29	<0.01	0.03	0.093	<0.01	0.022	0.057	<0.01	0.05
Mercury (Hg)	0.0007	0.0005	0.0005	0.0005	0.0006	0.0006	<0.0005	0.0010	0.0021	<0.0005	0.0010	0.0011	<0.0005	0.002
Nickel (Ni)	0.07	0.06	0.10	0.05	0.08	<0.05	<0.05	0.10	<0.05	<0.05	<0.05	0.05	0.07	N.S.[e]
Selenium (Se)	0.016	<0.01	<0.01	<0.01	0.027	<0.01	<0.01	<0.01	0.049	<0.01	<0.01	<0.01	<0.01	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	0.10	0.028	0.21	0.15	0.96	0.15	0.05	0.073	0.036	0.07	0.02	0.02	<0.05	5.0

[a] See Appendix K for a complete list of analyses performed.

[b] This well contained large quantities of silt; the well was sampled on 17 March 1982, and the sample analyzed. On 24 March 1982, this well as well as the existing monitoring wells were cleaned out for silt, and an additional sample was taken on 29 March 1982.

[c] When this well was sampled on 31 March 1982, the water level was measured at a depth of 9 feet below the ground surface. The well cap was missing, and rainwater had entered the well.

[d] Ca DWS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.

[e] N.S. - No standard has been established for drinking water.

TABLE 4.5

STAGE I SHALLOW WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in ppb)

Compounds[a]	Well Number and Sampling Dates											
	16S		17S		18S		19S		20S		21S	
	6-16-82	8-17-82	6-16-82	8-17-82	6-15-82	8-16-82	4-28-82	8-16-82	5-25-82	8-11-82	6-15-82	8-13-82
Volatiles												
benzene	ND	ND	ND	ND	ND	ND	ND	ND	45	ND	ND	ND
carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethylene	ND	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ethyl benzene	ND	ND	ND	ND	ND	ND	ND	ND	220	ND	ND	ND
methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tetrachloroethylene	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
toluene	ND	ND	ND	ND	ND	ND	ND	ND	440	5	ND	ND
1,2-trans-dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trichloroethylene	ND	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acid Compounds												
pentachlorophenol	ND	ND	ND	ND	ND	6	ND	7	ND	ND	ND	ND
Base/Neutral Compounds												
anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	220	ND	ND
benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	ND	ND	ND	22	ND	8	ND	20	ND	ND	230	ND
chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
di-n-butyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	90	ND	ND
naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	90	ND	ND
phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides/Herbicides												
Aldrin	0.503	ND	0.112	ND	0.052	ND	ND	ND	ND	ND	0.049	ND
alpha-BHC	ND	0.024	ND	ND	ND	0.032	ND	ND	ND	ND	ND	ND
beta-BHC	0.142	0.009	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.048
delta-BHC	ND	0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
gamma-BHC (lindane)	ND	0.020	ND	ND	ND	0.036	0.047	ND	ND	ND	ND	ND
dieldrin	ND	ND	ND	ND	ND	ND	0.20	ND	ND	ND	ND	ND
endosulfan sulfate	ND	<0.03	ND	ND	ND	ND	ND	ND	ND	ND	0.011	ND
heptachlor	ND	0.015	ND	ND	ND	ND	ND	0.056	ND	ND	ND	ND
heptachlor epoxide	ND	ND	ND	ND	ND	0.027	ND	ND	ND	ND	ND	0.007
2,4-D	0.058	ND	0.114	ND	0.138	ND	ND	ND	ND	0.13	0.122	ND
2,4,5-T	0.020	ND	0.031	ND	ND	ND	ND	ND	0.008	ND	0.087	ND
2,4,5-TP (Silvex)	0.094	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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TABLE 4.5 (Continued)

Compounds[a]	Well Number and Sampling Dates											
	22S		23S		24S		25S		26S		27S	
	6-4-82	8-13-82	4-28-82	8-13-82	4-28-82	8-12-82	6-15-82	8-12-82	6-16-82	8-11-82	6-16-82	8-12-82
Volatiles												
benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<10
chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<10
1,1-dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ethyl benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tetrachloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-trans-dichloroethylene	ND	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	<10
trichloroethylene	8	16	ND	ND	ND	ND	50	ND	ND	ND	ND	15
Acid Compounds												
pentachlorophenol	ND	15	ND	ND	ND	260	ND	ND	ND	ND	ND	120
Base/Neutral Compounds												
anthracene	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
chrysene	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
di-n-butyl phthalate	ND	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
fluoranthene	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenanthrene	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
pyrene	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
Pesticides/Herbicides												
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	0.165	ND	4.95	ND
alpha-BHC	ND	0.057	ND	ND	ND	ND	ND	ND	ND	0.035	ND	ND
beta-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.077	ND	ND
delta-BHC	0.83	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
gamma-BHC (lindane)	0.064	ND	ND	0.034	ND	ND	ND	ND	0.013	0.053	ND	ND
dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
heptachlor	ND	ND	ND	ND	ND	ND	0.32	ND	ND	ND	ND	ND
heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	0.095	ND	ND	ND
2,4-D	0.026	ND	ND	ND	ND	ND	ND	ND	0.003	ND	ND	ND
2,4,5-T	0.003	ND	ND	ND	ND	0.027	ND	ND	0.002	0.002	ND	0.002
2,4,5-TP (Silvex)	0.031	ND	ND	ND	ND	ND	ND	ND	0.004	ND	ND	ND

TABLE 4.5 (Continued)

Compounds[a]	Well Number and Sampling Dates							
	28S		29S		30S		31S	
	6-16-82	8-17-82	4-28-82	8-16-82	6-16-82	8-17-82	6-15-82	8-17-82
Volatiles								
benzene	ND	*	ND	ND	ND	ND	ND	ND
carbon tetrachloride	ND	*	ND	ND	ND	ND	ND	ND
chloroform	ND	*	ND	ND	ND	ND	ND	ND
1,1-dichloroethylene	ND	*	ND	ND	ND	<10	ND	<10
ethyl benzene	ND	*	ND	ND	ND	ND	ND	ND
methylene chloride	ND	*	ND	ND	1,500	ND	ND	ND
tetrachloroethylene	ND	*	ND	ND	ND	ND	ND	ND
toluene	ND	*	ND	ND	ND	ND	ND	ND
1,2-trans-dichloroethylene	ND	*	ND	ND	ND	ND	ND	ND
trichloroethylene	ND	*	ND	10	ND	10	ND	10
Acid Compounds								
pentachlorophenol	ND	*	ND	ND	ND	ND	ND	ND
Base/Neutral Compounds								
anthracene	ND	*	ND	ND	ND	ND	ND	ND
benzo(a)anthracene	ND	*	ND	ND	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	ND	*	ND	16	150	ND	ND	ND
chrysene	ND	*	ND	ND	ND	ND	ND	ND
di-n-butyl phthalate	ND	*	ND	ND	ND	ND	ND	ND
fluoranthene	ND	*	ND	ND	ND	ND	ND	ND
fluorene	ND	*	ND	ND	ND	ND	ND	ND
naphthalene	ND	*	ND	ND	ND	ND	ND	ND
phenanthrene	ND	*	ND	ND	ND	ND	ND	ND
pyrene	ND	*	ND	ND	ND	ND	ND	ND
Pesticides/Herbicides								
Aldrin	0.61	*	ND	ND	0.041	ND	2.53	ND
alpha-BHC	ND	*	ND	ND	ND	0.018	ND	0.024
beta-BHC	ND	*	ND	ND	0.007	ND	ND	ND
delta-BHC	ND	*	ND	ND	ND	ND	ND	ND
gamma-BHC (lindane)	ND	*	ND	1.54	ND	ND	ND	0.0085
dieldrin	ND	*	ND	ND	ND	ND	ND	ND
endosulfan sulfate	ND	*	ND	ND	ND	ND	ND	ND
heptachlor	ND	*	ND	ND	ND	ND	ND	ND
heptachlor epoxide	0.17	*	ND	ND	ND	ND	ND	0.011
2,4-D	0.014	*	ND	ND	0.063	ND	ND	ND
2,4,5-T	0.002	*	ND	ND	0.024	ND	ND	0.003
2,4,5-TP (Silvex)	ND	*	ND	ND	ND	ND	ND	ND

ND = not detected * = no sample taken (dry well)

a See Appendix L for a complete list of analyses performed.

well were anthracene (220 ppb), fluorene (190 ppb), and naphthalene (190 ppb).

Additional constituents detected in the Stage I shallow wells were primarily trichloroethylene, pentachlorophenol, and bis(2-ethylhexyl)-phthalate. TCE data for the Stage I shallow wells are depicted on Figure 4.2. Other constituents (volatiles and base/neutral compounds) are near limits of detection, except methylene chloride in well 30S (1,500 ppb). A number of pesticides and herbicides were identified in most wells, predominately 2,4-D and 2,4,5-T. Pesticide/herbicide results for Stage I shallow wells are shown in Table 4.5.

Trace metal data for the Stage I shallow wells are shown on Table 4.6. Two of the wells (MW19S and MW29S) contained all of the metals analyzed, except silver. Well 23S showed detectable levels of all metals except cadmium and silver. Wells 19S and 23S border the western boundary of the Base adjacent to waste disposal sites. However, MW29S is more centrally located on the Base, without an apparent source for metals. Several other shallow wells contained metals, primarily antimony and mercury. Most of the metals identified above analytical detection limits exceed allowable California drinking water standards.

Those compounds showing concentrations above detection limits for the Stage I deep wells are presented in Table 4.7. None of the Stage I deep wells contained organic constituents above detection limits, except for herbicides/pesticides and one base/neutral compound. Bis(2-ethylhexyl)phthalate appears in MW18D and MW29D at concentrations of 12 and 9 ppb, respectively. The identified herbicides/ pesticides were similar to those detected previously in Base wells, primarily 2,4-D and 2,4,5-T.

Trace metal data for the Stage I deep wells are given on Table 4.8. Trace metals in the Stage I deep wells were near or below limits of detection. Several wells contained minimal but detectable concentrations of cadmium and mercury, which exceed California drinking water standards established for these metals at 0.010 mg/l and 0.002 mg/l, respectively. Concentrations exceeding these standards were detected for cadmium in MW18D and MW27D, and for mercury in MW19D and MW28D. Well 22D contained an anomalous concentration of chromium (0.84 mg/l), while all other deep wells except MW25D showed less than detectable

TABLE 4.6

STAGE I SHALLOW WELLS
TRACE METALS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in mg/l)

Metal[a]	Well Number and Sampling Date								Ca DWS[b] (mg/l)
	16S 6-16-82	17S 6-16-82	18S 6-15-82	19S 4-28-82	20S 5-25-82	21S 6-15-82	22S 6-4-82	23S 4-28-82	
Antimony (Sb)	0.008	0.011	<0.005	0.06	0.026	<0.005	<0.005	0.025	N.S.[c]
Arsenic (As)	<0.05	<0.05	<0.05	0.66	0.24	<0.05	<0.05	0.30	0.05
Cadmium (Cd)	<0.01	<0.01	<0.01	0.045	0.02	<0.01	0.03	<0.01	0.01
Chromium (Cr)	<0.05	<0.05	<0.05	4.17	<0.05	<0.05	<0.05	1.04	0.05
Copper (Cu)	<0.05	<0.05	<0.05	1.18	<0.05	<0.05	<0.05	0.33	1.0
Lead (Pb)	<0.01	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	0.026	0.05
Mercury (Hg)	0.0027	0.0012	0.0016	0.0016	<0.0005	0.0014	<0.0005	0.0009	0.002
Nickel (Ni)	<0.05	<0.05	<0.05	1.33	<0.18	<0.05	<0.18	0.41	N.S.[c]
Selenium (Se)	<0.01	<0.01	<0.01	0.355	0.074	<0.01	<0.01	0.057	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	<0.02	<0.02	<0.02	1.75	<0.02	<0.02	<0.02	11.4	5.0

TABLE 4.6 (Continued)

Metal[a]	Well Number and Sampling Date								Ca DWS[b] (mg/l)
	24S	25S	26S	27S	28S	29S	30	31	
	4-28-82	6-15-82	6-16-82	6-16-82	6-16-82	4-28-82	6-16-82	6-15-82	
Antimony (Sb)	0.008	<0.005	<0.005	<0.005	<0.005	0.041	<0.005	<0.005	N.S.[c]
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	<0.05	0.55	<0.05	<0.05	0.05
Cadmium (Cd)	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	<0.01	<0.01	0.01
Chromium (Cr)	<0.05	<0.05	<0.05	<0.05	<0.05	0.24	<0.05	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	<0.05	<0.05	0.59	<0.05	<0.05	1.0
Lead (Pb)	<0.01	<0.01	<0.01	<0.01	<0.01	0.022	<0.01	<0.01	0.05
Mercury (Hg)	0.0016	<0.0005	<0.0005	0.0017	<0.0005	0.0021	0.0016	0.0017	0.002
Nickel (Ni)	<0.05	<0.05	<0.05	<0.05	<0.05	2.13	<0.05	<0.05	N.S.[c]
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	0.105	<0.01	<0.01	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	0.04	0.032	<0.02	<0.02	0.052	2.96	<0.02	<0.02	5.0

(-) = no sample (well dry)

a See Appendix L for a complete list of analyses performed.

b Ca DWS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.

c N.S. - No standard has been established for drinking water.

TABLE 4.7

STAGE I DEEP WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in ppb)

Compound[a]	Well Number and Sampling Dates													
	16D		17D		18D		19D		20D		21D		22D	
	6-16-82	8-17-82	6-15-82	8-17-82	6-15-82	8-16-82	4-28-82	8-16-82	4-28-82	8-11-82	6-15-82	8-13-82	4-28-82	8-13-82
Volatiles														
1,1-dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-trans-dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
trichloroethylene	ND	<10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acid Compounds														
phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Base/Neutral Compounds														
anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	12	ND	<10	ND	ND	ND	ND	ND	ND
1,2,4-trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	<10	ND	<10	ND	<10	ND	<10
Pesticides/Herbicides														
Aldrin	0.005	ND	ND	ND	0.01	ND	ND	ND	ND	ND	0.012	ND	ND	ND
alpha-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
beta-BHC	ND	ND	ND	ND	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
delta-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0039
gamma-BHC (lindane)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND	ND	ND	<0.006	ND	ND	ND	ND	ND	ND
endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.008	ND	ND	ND
endrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
heptachlor	0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
heptachlor epoxide	ND	ND	ND	ND	0.017	ND	ND	<0.004	ND	ND	ND	ND	ND	ND
2,4-D	0.082	ND	0.099	ND	0.122	ND	0.008	ND	ND	ND	0.175	ND	ND	ND
2,4,5-T	0.037	ND	0.032	ND	0.022	ND	ND	ND	ND	ND	0.044	<0.001	ND	ND
2,4,5-TP (Silvex)	0.080	ND	ND	ND	ND	ND	0.003	ND	ND	ND	0.42	ND	ND	ND

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TABLE 4.7 (Continued)

Compound[a]	Well Number and Sampling Dates													
	23D		24D		25D		26D		27D		28D		29D	
	4-28-82	8-13-82	4-28-82	8-12-82	6-15-82	8-12-82	4-28-82	8-11-82	4-28-82	8-12-82	6-16-82	8-17-82	4-28-82	8-16-82
Volatiles														
1,1-dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<10	ND	<10
1,2-trans-dichloroethylene	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trichloroethylene	ND	ND	ND	ND	ND	<10	ND	ND	ND	<10	ND	10	ND	10
Acid Compounds														
phenol	ND	ND	ND	ND	ND	ND	ND	<10	ND	ND	ND	ND	ND	ND
Base/Neutral Compounds														
anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9
1,2,4-trichlorobenzene	ND	<10	ND	<10	ND	<10	ND	<10	ND	<10	ND	ND	ND	ND
Pesticides/Herbicides														
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.145	ND	ND	ND
alpha-BHC	ND	0.0018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
beta-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.027	ND	ND	ND
delta-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
gamma-BHC (lindane)	ND	0.039	0.009	ND	ND	ND	ND	ND	0.12	ND	ND	ND	0.82	0.0825
DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.006	ND	ND
endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
endrin	ND	ND	ND	ND	ND	<0.009	ND	ND	ND	ND	ND	ND	ND	ND
heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.004	ND	ND
2,4-D	ND	ND	ND	ND	0.12	ND	ND	ND	0.04	ND	0.246	ND	ND	ND
2,4,5-T	ND	ND	0.60	0.005	0.025	0.004	0.004	0.038	ND	0.003	0.022	<0.001	ND	ND
2,4,5-TP (Silvex)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = not detected

a See Appendix L for a complete list of analyses performed.

TABLE 4.8

STAGE I DEEP WELLS
TRACE METALS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in mg/l)

Metal[a]	Well Number and Sampling Date								Ca DWS[b] (mg/l)
	16D 6-16-82	17D 6-15-82	18D 6-15-82	19D 4-28-82	20D 4-28-82	21D 6-15-82	22D 4-28-82	23D 4-28-82	
Antimony (Sb)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	N.S.[c]
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	0.05
Cadmium (Cd)	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Chromium (Cr)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.84	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.0
Lead (Pb)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Mercury (Hg)	<0.0005	0.0009	<0.0014	0.013	<0.0005	<0.0005	<0.0005	0.001	0.002
Nickel (Ni)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	N.S.[c]
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	<0.02	<0.02	<0.02	0.13	<0.05	<0.02	0.16	<0.05	5.0

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TABLE 4.8 (Continued)

Metal[a]	Well Number and Sampling Date						Ca DWS[b]
	24D	25D	26D	27D	28D	29D	
	4-28-82	6-15-82	4-28-82	4-28-82	6-16-82	4-28-82	(mg/l)
Antimony (Sb)	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	N.S.[c]
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	<0.01	<0.01	<0.01	0.023	<0.01	<0.01	0.01
Chromium (Cr)	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	0.13	<0.05	<0.05	1.0
Lead (Pb)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Mercury (Hg)	0.0008	<0.0005	-	<0.0005	0.0039	<0.0026	0.002
Nickel (Ni)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	N.S.[c]
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	0.14	0.024	0.05	0.32	0.14	0.07	5.0

(-) = sample not analyzed for this metal

a See Appendix L for a complete list of analyses performed.

b Ca DWS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.

c N.S. - No standard has been established for drinking water.

levels of chromium. The California drinking water standard for chromium is 0.05 mg/l. Zinc was present in over half the deep wells, although all concentrations were one order of magnitude lower than the zinc secondary drinking water standard of 5.0 mg/l.

Stage II Monitoring Wells

The groundwater samples from the Stage II monitoring wells were analyzed for all EPA priority organic pollutants. Analytical results for those organic compounds found above detection limits in Stage II wells are given in Table 4.9. Compounds listed are those present in one or more wells.

Four of the shallow (S) Stage II monitoring wells showed the presence of two base/neutral compounds. Bis(2-ethylhexyl)phthalate, a constituent commonly identified in the Stage I wells, was detected at concentrations of 68 ppb in MW33S and 54 ppb in MW36S, while wells 41S and 44S showed low levels of 1,2,4-trichlorobenzene (4 and 8 ppb respectively). These four wells (MW33S, MW36S, MW41S, and MW44S) also contained various volatile organic compounds, including trichloroethylene, chloroform, 1,2-trans-dichloroethylene, 1,1-dichloroethylene, and tetrachloroethylene. Two other shallow Stage II wells contained volatile compounds. Well 40S showed the presence of TCE at 5 ppb, and chloroform was detected at 5 ppb in MW46S. TCE data for all Stage II wells are presented on Figure 4.2. Most of the shallow Stage II wells contained herbicides and pesticides characteristically present in the Stage I wells.

One deep well, MW38D, was installed and sampled during the Stage II program. This well contained bis(2-ethylhexyl)phthalate (42 ppb) and numerous volatile compounds in addition to one pesticide (beta-BHC) above detection limits. Two compounds detected in MW38D which were not previously noted in the shallow wells were 1,1-dichloroethane (75 ppb) and 1,1,2-trichloroethane (5 ppb).

Trace metal data for Stage II monitoring wells are listed in Table 4.10. None of the Stage II shallow wells contained trace metals above limits of detection except for lead and zinc. Well 38D contained only zinc (0.09 mg/l) above detection limits. Zinc concentrations in all

TABLE 4.9

STAGE II WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in ppb)

Compound[a]	Well Number and Sampling Date								
	33S 9-29-82	34S 9-28-82	35S 9-14-82	36S 9-29-82	37S 9-28-82	39S[b] 9-14-82	40S 9-29-82	41S 9-14-82	42S 9-27-82
Volatiles									
chloroform	5	•	•	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	•	•	ND	ND	ND	ND	ND	ND
1,1-dichloroethylene	ND	•	•	ND	ND	ND	ND	5	ND
1,2-trans-dichloroethylene	30	•	•	ND	ND	ND	ND	10	ND
tetrachloroethylene	ND	•	•	5	ND	ND	ND	ND	ND
1,1,1-trichloroethane	ND	•		ND	ND	ND	ND	ND	ND
1,1,2-trichloroethane	ND	•	•	ND	ND	ND	ND	ND	ND
trichloroethylene	2,000	•	•	ND	ND	ND	5	20	ND
Base/Neutral Compounds									
bis(2-ethylhexyl)phthalate	68	•	•	54	ND	ND	ND	ND	ND
di-n-butyl phthalate	ND	•	•	ND	ND	ND	ND	ND	ND
1,2,4-trichlorobenzene	ND	•	•	ND	ND	ND	ND	4	ND
Pesticides/Herbicides									
Aldrin	<0.003	•	•	<0.003	<0.003	•	<0.003	<0.003	<0.003
alpha-BHC	<0.002	•	•	<0.002	<0.002	•	<0.002	<0.002	<0.002
beta-BHC	<0.004	•	•	<0.004	<0.004	•	<0.004	<0.004	<0.004
delta-BHC	0.066	•	•	0.052	0.121	•	0.048	<0.004	0.051
gamma-BHC (lindane)	<0.002	•	•	0.015	<0.002	•	<0.002	<0.002	<0.002
chlordane	<0.04	•	•	<0.04	<0.04	•	<0.04	<0.04	<0.04
DDD (TDE)	<0.012	•	•	<0.012	<0.012	•	<0.012	<0.012	<0.012
DDE	<0.006	•	•	<0.006	<0.006	•	<0.006	<0.006	<0.006
DDT	<0.016	•	•	<0.016	<0.016	•	<0.016	<0.016	<0.016
dieldrin	<0.006	•	•	<0.006	<0.006	•	<0.006	<0.006	<0.006
endosulfan I	<0.005	•	•	<0.005	<0.005	•	<0.005	<0.005	<0.005
endosulfan II	<0.01	•	•	<0.01	<0.01	•	<0.01	<0.01	<0.01
endosulfan sulfate	<0.03	•	•	<0.03	<0.03	•	<0.03	<0.03	<0.03
endrin	<0.009	•	•	<0.009	<0.009	•	<0.009	<0.009	<0.009
heptachlor	<0.002	•	•	<0.002	<0.002	•	<0.002	<0.002	<0.002
heptachlor epoxide	<0.004	•	•	0.01	<0.004	•	<0.004	<0.004	<0.004
methoxychlor	<0.02	•	•	<0.02	<0.02	•	<0.02	<0.02	<0.02
toxaphene	<0.40	•	•	<0.40	<0.40	•	<0.40	<0.40	<0.40
2,4-D	0.134	•	•	0.56	<0.001	•	<0.001	<0.001	<0.001
2,4,5-T	<0.001	•	•	<0.001	0.004	•	<0.001	<0.001	<0.001
2,4,5-TP (Silvex)	<0.002	•	•	<0.002	<0.002	•	<0.002	<0.002	0.031

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TABLE 4.9 (Continued)

Compound[a]	Well Number and Sampling Date								
	43S	44S	45S	46S	47S	48S	49S	50S	38D
	9-14-82	9-13-82	9-14-82	9-29-82	9-29-82	9-15-82	9-29-82	9-14-82	9-27-82
Volatiles									
chloroform	ND	ND	ND	5	ND	*	ND	*	ND
1,1-dichloroethane	ND	ND	ND	ND	ND	*	ND	*	75
1,1-dichloroethylene	ND	30	ND	ND	ND	*	ND	*	500
1,2-trans-dichloroethylene	ND	ND	ND	ND	ND	*	ND	*	80
tetrachloroethylene	ND	ND	ND	ND	ND	*	ND	*	ND
1,1,1-trichloroethane	ND	ND	ND	ND	ND	*	ND	*	55
1,1,2-trichloroethane	ND	ND	ND	ND	ND	*	ND	*	5
trichloroethylene	ND	10	ND	ND	ND	*	ND	*	30
Base/Neutral Compounds									
bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	*	ND	*	42
di-n-butyl phthalate	ND	<10	ND	ND	ND	*	ND	*	ND
1,2,4-trichlorobenzene	ND	8	ND	ND	ND	*	ND	*	ND
Pesticides/Herbicides									
Aldrin	<0.003	<0.003	<0.003	<0.003	<0.003	*	<0.003	*	<0.003
alpha-BHC	<0.002	<0.002	<0.002	<0.002	<0.002	*	<0.002	*	<0.002
beta-BHC	<0.004	<0.004	<0.004	<0.004	<0.004	*	<0.004	*	0.021
delta-BHC	<0.004	<0.004	0.121	<0.004	<0.004	*	<0.004	*	<0.004
gamma-BHC (lindane)	0.012	<0.002	0.038	0.016	0.041	*	<0.002	*	<0.002
chlordane	<0.04	<0.04	<0.04	<0.04	<0.04	*	<0.04	*	<0.04
DDD (TDE)	<0.012	<0.012	<0.012	<0.012	<0.012	*	<0.012	*	<0.012
DDE	<0.006	<0.006	<0.006	<0.006	<0.006	*	<0.006	*	<0.006
DDT	<0.016	<0.016	<0.016	<0.016	<0.016	*	<0.016	*	<0.016
dieldrin	<0.006	<0.006	<0.006	<0.006	<0.006	*	<0.006	*	<0.006
endosulfan I	<0.005	<0.005	<0.005	<0.005	<0.005	*	<0.005	*	<0.005
endosulfan II	<0.01	<0.01	<0.01	<0.01	<0.01	*	<0.01	*	<0.01
endosulfan sulfate	<0.03	<0.03	<0.03	<0.03	<0.03	*	<0.03	*	<0.03
endrin	<0.009	<0.009	<0.009	<0.009	<0.009	*	<0.009	*	<0.009
heptachlor	0.013	<0.002	<0.002	<0.002	<0.002	*	<0.002	*	<0.002
heptachlor epoxide	0.013	<0.004	<0.004	<0.004	<0.004	*	<0.004	*	<0.004
methoxychlor	<0.02	<0.02	<0.02	<0.02	<0.02	*	<0.02	*	<0.02
toxaphene	<0.40	<0.40	<0.40	<0.40	<0.40	*	<0.40	*	<0.40
2,4-D	<0.001	<0.001	<0.001	<0.001	<0.001	*	<0.001	*	<0.001
2,4,5-T	<0.001	<0.001	<0.001	<0.001	<0.001	*	<0.001	*	<0.001
2,4,5-TP (Silvex)	0.030	<0.002	0.051	<0.002	0.196	*	<0.002	*	<0.002

ND = not detected * = no sample taken (dry well) (-) = sample was not analyzed for this compound.

[a] See Appendix M for a complete list of analyses performed.

[b] When sampled on 14 September 1982, MW39S ran dry before the pesticide/herbicide sample was collected. Sampling was again attempted on 27 September 1982, but the well was still dry.

TABLE 4.10

STAGE II WELLS
TRACE METALS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in mg/l)

	Well Number and Sampling Date										
Metal[a]	33S 9-29-82	34S 9-28-82	35S 9-14-82	36S 9-29-82	37S 9-28-82	39S 9-14-82	40S 9-29-82	41S 9-14-82	42S 9-27-82	43S 9-14-82	Ca DWS[b] (mg/l)
Antimony (Sb)	<0.01	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	N.S.[c]
Arsenic (As)	<0.05	-	-	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	<0.01	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	0.01
Chromium (Cr)	<0.05	-	-	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	0.05
Copper (Cu)	<0.05	-	-	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	1.0
Lead (Pb)	0.018	-	-	0.019	0.01	-	0.013	<0.02	<0.01	<0.02	0.05
Mercury (Hg)	<0.0005	-	-	<0.0005	<0.0005	-	<0.0005	<0.0005	<0.0005	<0.0005	0.002
Nickel (Ni)	<0.05	-	-	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	N.S.[c]
Selenium (Se)	<0.01	-	-	0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	0.01
Silver (Ag)	<0.05	-	-	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	<0.02	-	-	<0.02	<0.02	-	<0.02	<0.02	<0.04	<0.02	5.0

TABLE 4.10 (Continued)

Metal[a]	Well Number and Sampling Date								Ca DWS[b]
	44S	45S	46S	47S	48S	49S	50S	38D	
	9-13-82	9-14-82	9-29-82	9-29-82	9-15-82	9-29-82	9-14-82	9-27-82	(mg/l)
Antimony (Sb)	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	<0.01	N.S.[c]
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	-	<0.05	-	<0.05	0.05
Cadmium (Cd)	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	<0.01	0.01
Chromium (Cr)	<0.05	<0.05	<0.05	<0.05	-	<0.05	-	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	<0.05	-	<0.05	-	<0.05	1.0
Lead (Pb)	<0.02	<0.02	0.018	0.017	-	0.016	-	<0.01	0.05
Mercury (Hg)	<0.0005	<0.0005	<0.0005	<0.0005	-	<0.0005	-	<0.0005	0.002
Nickel (Ni)	<0.05	<0.05	<0.05	<0.05	-	<0.05	-	<0.05	N.S.[c]
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	<0.01	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	-	<0.05	-	<0.05	0.05
Zinc (Zn)	<0.02	<0.02	<0.02	<0.02	-	<0.02	-	0.09	5.0

(-) = no sample (well dry)

a See Appendix M for a complete list of analyses performed.

b Ca DWS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.

c N.S. - No standard has been established for drinking water.

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Stage II wells were lower than the California secondary drinking water standard of 5.0 mg/l.

Selected Analyses

In addition to EPA priority pollutant and trace metal analyses, selected analyses were performed on Stage I and Stage II monitoring well samples. These data are presented on Tables 4.11, 4.12 and 4.13. The rationale for conducting these analyses was based on historical Base usage and/or disposal. Analyses included: a cresylic acid (cresol), aliphatics (grease and oil), polychlorinated biphenyls (PCB's), and cyanide. The three wells tested for cresylic acid were MW26S, MW26D, and MW40S. Well 40S contained a detectable concentration of cresylic acid (26 μg/l), where wells 26S and 26D did not (<5 μg/l). Uses for cresol depend on its isomer, although generally it has been used for making synthetic resins. The meta isomer is used for fumigants and in photographic developers and explosives. The ortho isomer is used as a solvent. The occurrence of cresol in the groundwater is discussed in more detail later in this section with specific reference to monitoring wells 26S, 26D, and 40S, located downgradient from Site 38 in Area A.

Aliphatic material was determined to be present in wells 20S and 20D after observing a grease film layer 1/4 to 1/2-inch thick on the water surface during sampling of MW20S. Results showed MW20S to contain 915 mg/l of grease and oil, while MW20D contained 1.8 mg/l. A subsequent sampling of MW20D after extended pumping showed no detectable levels of aliphatic material. Because of the extremely elevated levels of grease and oil in the shallow aquifer, it is probable that material was transferred to the deeper zone during drilling, resulting in detectable concentrations during initial analyses. Possible sources of the aliphatic material in the well are addressed later in the discussion pertaining to Area C.

PCB analyses were performed on all Stage I and Stage II monitoring wells with water present. No PCB's were detected in the wells. A more detailed discussion of MW17S and MW17D, located downgradient of Site 46 from which PCB materials have been removed, is contained later in this section.

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TABLE 4.11

STAGE I SHALLOW WELLS
SELECTED CONSTITUENTS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA

Constituent	Unit of Measurement	Well Number and Sampling Date							
		16S 8-17-82	17S 8-17-82	18S 8-16-82	19S 8-16-82	20S 8-11-82	21S 8-13-82	22S 8-13-82	23S 8-13-82
Cresylic acid (Cresol)	µg/l	-	-	-	-	-	-	-	-
Cyanide (CN)	mg/l	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Polychlorinated biphenyls (PCB's)	ppb	ND	ND	ND	ND	ND	ND	ND	ND
Aliphatics (grease and oil)	mg/l	-	-	-	-	915	-	-	-
		24S 8-12-82	25S 8-12-82	26S 8-11-82	27S 8-12-82	28S 8-17-82	29S 8-16-82	30 8-17-82	31 8-17-82
Cresylic acid (Cresol)	µg/l	-	-	< 5	-	-	-	-	-
Cyanide (CN)	mg/l	< 0.02	0.15	0.02	< 0.02	*	0.95	< 0.02	< 0.02
Polychlorinated biphenyls (PCB's)	ppb	ND	ND	ND	ND	ND	ND	ND	ND
Aliphatics (grease and oil)	mg/l	-	-	-	-	-	-	-	-

ND = not detected
(-) = sample not analyzed for this constituent
* = no data (well dry)

TABLE 4.12

STAGE I DEEP WELLS
SELECTED CONSTITUENTS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA

Constituent	Unit of Measurement	Well Number and Sampling Date						
		16D 8-17-82	17D 8-17-82	18D 8-16-82	19D 8-16-82	20D 8-11-82	21D 8-13-82	22D 8-13-82
Cresylic acid (Cresol)	µg/l	-	-	-	-	-	-	-
Cyanide (CN)	mg/l	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.05	< 0.02
Polychlorinated biphenyls (PCB's)	ppb	ND	ND	ND	ND	ND	ND	ND
Aliphatics (grease and oil)	mg/l	-	-	-	-	1.8	-	-

		23D 8-13-82	24D 8-12-82	25D 8-12-82	26D 8-11-82	27D 8-12-82	28D 8-17-82	29D 8-16-82
Cresylic acid (Cresol)	µg/l	-	-	-	< 5	-	-	-
Cyanide (CN)	mg/l	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Polychlorinated biphenyls (PCB's)	ppb	ND	ND	ND	ND	ND	ND	ND
Aliphatics (grease and oil)	mg/l	-	-	-	-	-	-	--

ND = not detected
(-) = sample not analyzed for this constituent

TABLE 4.13

STAGE II WELLS
SELECTED CONSTITUENTS IDENTIFIED IN GROUNDWATER SAMPLES
McCLELLAN AFB, CALIFORNIA

Constituent	Unit of Measurement	Well Number and Sampling Date								
		33S 9-29-82	34S 9-28-82	35S 9-14-82	36S 9-29-82	37S 9-28-82	39S 9-14-82	40S 9-29-82	41S 9-14-82	42S 9-27-82
Cresylic acid (Cresol)	µg/l	-	-	-	-	-	-	26	-	-
Cyanide (CN)	mg/l	< 0.02	*	*	0.03	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Polychlorinated biphenyls (PCB's)	ppb	ND	*	*	ND	ND	*	ND	ND	ND
Aliphatics (grease and oil)	mg/l	5.7	*	-	-	-	-	-	-	-

Constituent	Unit of Measurement	43S 9-14-82	44S 9-13-82	45S 9-14-82	46S 9-29-82	47S 9-29-82	48S 9-15-82	49S 9-29-82	50S 9-14-82	38D 9-27-82
Cresylic acid (Cresol)	µg/l	-	-	-	-	-	-	-	-	-
Cyanide (CN)	mg/l	<0.02	< 0.02	< 0.02	0.02	< 0.02	*	< 0.02	*	< 0.02
Polychlorinated biphenyls (PCB's)	ppb	ND	ND	ND	ND	ND	*	ND	*	ND
Aliphatics (grease and oil)	mg/l	-	-	-	-	-	-	-	-	-

ND = not detected
(-) = sample not analyzed for this constituent
* = no data (well dry)

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Cyanide analyses were performed on all Stage I and Stage II monitoring wells that contained water. Cyanide use is widespread, particularly in electroplating baths and for fumigation. Concentrations of cyanide above limits of detection were found in seven wells including MW16S, MW25S, MW26S, MW29S, MW36S, MW46S, and MW21D. No specific past or present disposal site is located near MW29S, in which 0.95 mg/l of cyanide was detected. However, as mentioned earlier in this chapter, trace metal concentrations were notable in MW29S. An area previously used to dispose metals/ electroplating waste is therefore likely to be nearby.

While analyzing the groundwater samples from all wells, a number of non-priority pollutants were identified using GC/MS, but their concentrations were not quantified. A list of these compounds is included in Appendix M.

Monitored Source Areas

The locations of the 46 disposal and storage sites identified in Phase I of the Installation Restoration Program formed the basis for selection of Phase II monitoring well locations. Most of the sites were perceived as forming a number of discrete clusters or source areas throughout the Base. Stage I of the field program was designed to identify potential groundwater contamination from these individual sites and site clusters, and the Stage II program was implemented to further define source locations and single sources within a cluster that had shown evidence of affecting the groundwater.

Table 4.14 delineates the relationship between the sites or site clusters and monitoring wells installed by the Base and by ES during the Phase II field program. Listed on Table 4.15 are the constituents believed to have been stored and/or disposed at specific sites and site clusters, along with the constituents identified in monitoring wells located upgradient and downgradient from each source area. Table 4.16 identifies wells in each monitored site area that contain volatile organics, in conjunction with disposal sites upgradient from these affected wells. The range of concentrations of the most common volatile constituents in groundwater samples from affected wells in each area are presented in Table 4.17. Following are brief discussions of potential

TABLE 4.14

SOURCE AREAS/SITES AND CORRESPONDING MONITORING WELLS McCLELLAN AFB, CALIFORNIA

Source Areas/Sites	Upgradient Monitoring Wells	Downgradient Monitoring Wells
AREA A		
Sites 25,37,38,39,40	8; 9; 49S	25S,D; 26S,D; 27S,D; 28S,D; 39S; 40S
AREA B		
Sites 30,35,36	25S,D	6; 23S,D; 41S
AREA C		
Subarea C-1 Sites 17,18,19,20,21, 22,28,32,41, 42,43	37S	20S,D; 21S,D; 22S,D; 33S; 34S; 45S
Subarea C-2 Sites 7,8,9,10,11, 12,13,14,15,16	37S	36S; 44S; 2
AREA D		
Sites 1,2,3,4,5,6, 26,27,33	19S,D	38D; 1; 10; 11; 12; 13; 14; 15
Site 23		48S
Site 24		24S,D
Site 29		43S
Site 31		43S
Site 34		46S
Site 45		18S,D
Site 46		17S,D

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TABLE 4.15

CONSTITUENTS *IDENTIFIED IN MONITORING* WELLS ASSOCIATED WITH SOURCE AREAS/SITES

Source Area/ Site	Materials Reported Disposed/ Stored in Area	Constituents Identified in Associated Monitoring Wells	
		Downgradient	Upgradient
AREA A	refuse/ash ethylene dichloride cresylic acid soap emulsion orthodichlorobenzene skimming pond sludges industrial wastewater sludges unknown materials	Volatile compounds: TCE Acid compounds: pentachlorophenol Pesticides/herbicides: Aldrin alpha-BHC beta-BHC gamma-BHC (lindane) *heptachlor* heptachlor epoxide 2,4-D 2,4,5-T 2,4,5-TP (Silvex) Trace metals: antimony cadmium chromium copper mercury zinc Other constituents: cyanide cresylic acid	Volatile compounds: carbon tetrachloride chloroform TCE Base/neutral compounds: bis(2-ethylhexyl)phthalate Pesticides/herbicides: Aldrin alpha-BHC beta-BHC gamma-BHC (lindane) heptachlor heptachlor epoxide 2,4-D 2,4,5-T Trace metals: antimony cadmium chromium copper lead mercury nickel selenium zinc
AREA B	TCE Freon diethyl ether low-level radioactive washwater scrap steel plating chemicals	Volatile compounds TCE 1,1-dichloroethylene Base/neutral compounds: bis(2-ethylhexyl)phthalate 1,2,4-trichlorobenzene Pesticides/Herbicides: alpha-BHC gamma-BHC (lindane) heptachlor 2,4-D 2,4,5-T	Volatile compounds: TCE Pesticides/herbicides: endrin heptachlor 2,4-D 2,4,5-T Trace metals: chromium zinc Other constituents: cyanide

TABLE 4.15 (Continued)

Source Area/ Site	Materials Reported Disposed/ Stored in Area	Constituents Identified in Associated Monitoring Wells Downgradient	 Upgradient
		Trace metals: antimony arsenic chromium copper lead mercury nickel selenium zinc	
AREA C			
Subarea C-1	refuse,ash, and residue industrial wastewater sludge metal plating wastes TCE/waste solvents paint wastes fuels and oils PCB wastes waste chemicals cyanide wastes low-level radioactive wastes herbicide/pesticide containers creek debris industrial waste spills demolition debris	Volatile compounds: benzene chloroform ethylbenzene toluene 1,2-trans-dichloroethylene TCE Acid compounds: pentachlorophenol Base/neutral compounds: anthracene bis(2-ethylhexyl)-phthalate di-n-butyl phthalate fluorene naphthalene Pesticides/herbicides: Aldrin alpha-BHC beta-BHC delta-BHC gamma-BHC (lindane) endosulfan I endosulfan sulfate heptachlor epoxide 2,4-D 2,4,5-T 2,4,5-TP (Silvex) Trace metals: antimony arsenic cadmium chromium lead mercury selenium zinc	Pesticides/herbicides: delta-BHC 2,4,5-T Trace metals: lead

TABLE 4.15 (Continued)

Source Area/ Site	Materials Reported Disposed/ Stored in Area	Constituents Identified in Associated Monitoring Wells	
		Downgradient	Upgradient
		Other constituents: cyanide grease and oil	
Subarea C-2	industrial sludges fuels and oils TCE/waste solvents demolition debris creek debris paint wastes sewage sludge ash and residue metal plating wastes PCB wastes waste chemicals cyanide wastes low-level radioactive wastes herbicide/pesticide containers sodium valves	Volatile compounds: tetrachloroethylene 1,1-dichloroethylene TCE Base/neutral compounds: bis(2-ethylhexyl)- phthalate 1,2,4-trichlorobenzene Trace metals: lead selenium Other constituents: cyanide Pesticides/herbicides: delta-BHC gamma-BHC (lindane) heptachlor epoxide 2,4-D	Pesticides/herbicides: delta-BHC 2,4,5-T Trace metals: lead
AREA D	refuse/solid waste industrial sludges fuels and oils TCE/waste solvents sodium valves	Volatile compounds: benzene chloroform 1,1-dichloroethane 1,2-dichloroethane 1,1-dichloroethylene 1,2-trans-dichloro- ethylene methylene chloride tetrachloroethylene toluene 1,1,1-trichloroethane 1,1,2-trichloroethane TCE trichlorofluoromethane vinyl chloride Acid compounds: 2,4-dimethylphenol phenol Base/neutral compounds: bis(2-ethylhexyl)- phthalate 1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene 1,2,4-trichlorobenzene	Acid compounds: pentachlorophenol Base/neutral compounds: bis(2-ethylhexyl)- phthalate Pesticides/herbicides: dieldrin gamma-BHC (lindane) heptachlor 2,4-D 2,4,5-TP (Silvex) Trace metals: antimony arsenic cadmium chromium copper lead mercury nickel selenium zinc

TABLE 4.15 (Continued)

Source Area/ Site	Materials Reported Disposed/ Stored in Area	Constituents Identified in Associated Monitoring Wells	
		Downgradient	Upgradient
		Pesticides/herbicides: Aldrin beta-BHC 2,4,5-T 2,4,5-TP (Silvex) Trace metals: antimony cadmium chromium lead mercury nickel selenium zinc	
Site 23	no information available	no data	
Site 24	demolition debris lumber and paper scrap	Acid compounds: pentachlorophenol Pesticides/herbicides: 2,4,5-T gamma-BHC (lindane) Trace metals: antimony mercury zinc	
Site 29	scrap material drums transformers (PCB's) generators	Pesticides/herbicides: gamma-BHC (lindane) heptachlor heptachlor epoxide 2,4,5-TP (Silvex)	
Site 31	refuse/solid waste ash	Pesticides/herbicides: gamma-BHC (lindane) heptachlor heptachlor epoxide 2,4,5-TP (Silvex)	
Site 34	waste solvents	Volatile compounds: chloroform Pesticides/herbicides: gamma-BHC (lindane) Trace metals: lead Other constituents: cyanide	

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TABLE 4.15 (Continued)

Source Area/ Site	Materials Reported Disposed/ Stored in Area	Constituents Identified in Associated Monitoring Wells	
		Downgradient	Upgradient
Site 45	waste paint (latex-based ?) in drums	Acid compounds: pentachlorophenol Base/neutral compounds: bis(2-ethylhexyl)phthalate Pesticides/herbicides: Aldrin alpha-BHC beta-BHC gamma-BHC (lindane) heptachlor epoxide 2,4-D 2,4,5-T Trace metals: cadmium mercury	
Site 46	no information available (identified PCB surface contamination)	Trace metals: antimony mercury Pesticides/herbicides: Aldrin 2,4-D 2,4,5-T Base/neutral compounds: bis(2-ethylhexyl)phthalate	

TABLE 4.16

IDENTIFICATION OF DISPOSAL SITES UPGRADIENT FROM AFFECTED WELLS CONTAINING VOLATILE ORGANIC CONSTITUENTS

Monitored Area/Site	Monitoring Wells		Monitoring Wells Containing Volatile Organics		Disposal Sites Upgradient from Affected Wells	Has Area Contributed to Groundwater Degradation?
	Upgradient	Downgradient	Upgradient	Downgradient		
Area A						Yes
25, 37, 38, 39, 40	8		8		(General TCE-use area)	
	9		9			
	49S	25S,D		25S,D	25, 37	
		26S,D				
		27S,D		27S	39, 40	
		28S,D				
		39S				
		40S		40S	38	
Area B						Yes
30, 35, 36	25S,D					
		6		6	30	
		23S,D				
		41S		41S	36	
Area C						
Subarea C-1						Yes
17, 18, 19, 20, 21,	37S					
22, 28, 32, 41, 42,		20S,D		20S	43	
43		21S,D		21S	(Subarea C-1)	
		22S,D		22S	(Subarea C-1)	
		33S		33S	41, 42	
		34S				
		45S				
Subarea C-2						Yes
7, 8, 9, 10, 11,	37S					
12, 13, 14, 15, 16		36S				
		44S		44S	9, 10, 11	
		2		2	7, 8	

TABLE 4.16 (Continued)

Monitored Area/Site	Monitoring Wells Upgradient	Monitoring Wells Downgradient	Monitoring Wells Containing Volatile Organics Upgradient	Monitoring Wells Containing Volatile Organics Downgradient	Disposal Sites Upgradient from Affected Wells	Has Area Contributed to Groundwater Degradation?
Area D						Yes
1, 2, 3, 4, 5, 6, 26, 27, 33	19S,D					
		38D		38D	4, 5, 6, 26	
		1		1	2, 3	
		10		10	4, 5, 6, 26	
		11		11	4, 5, 6, 26	
		12		12	26	
		13		13	5, 6	
		14		14	2	
		15		15	1, 27	
Site 24		24S,D				No
Site 29		43S				No
Site 31		43S				No
Site 34		46S				No
Site 45		18S,D				No
Site 46		17S,D				No
Upgradient Base Boundary						No
		16S,D				
		31				
		50S				
		4				
Downgradient Base Boundary						Yes
		20S,D		20S	(Subarea C-1)	
		23S				
		24S,D				
		28S,D				
		34S				
		35S				
		36S				
		38D				
		42S				
		43S				
		47S				
		48S				
		10		10	(Area D)	
		11		11	(Area D)	
		15		15	(Area D)	

TABLE 4.17

RANGE OF VOLATILE ORGANIC CONSTITUENT CONCENTRATIONS IN GROUNDWATER FROM DIFFERENT SOURCE AREAS

Source Area	Disposal Sites Upgradient From Affected Wells Containing Volatile Organics	Range of Concentrations of Most Common Volatile Constituents in Groundwater
AREA A	25,37,38,34,40	trichloroethylene: ND-50 ppb
AREA B	30,36	1,1-dichloroethylene: ND-5 ppb 1,2-trans-dichloroethylene: ND-10 ppb trichloroethylene: ND-118 ppb
SUBAREA C-1	41,42,43	ethylbenzene: ND-220 ppb toluene: ND-440 ppb trichloroethylene: ND-2,000 ppb
SUBAREA C-2	7,8,9,10,11,12, 13,14,15,16	1,1-dichloroethylene: ND-30 ppb tetrachloroethylene: ND-5 ppb trichloroethylene: ND-10 ppb
AREA D	1,2,3,4,5,6,26,27	1,1-dichloroethylene: 500-63,000 ppb 1,1,1-trichloroethane: ND-12,000 ppb trichloroethylene: 160-14,100 ppb

ND - not detected

source areas and other selected locations on the Base which were monitored during the Phase II field program.

Area A

The constituents identified in the monitoring wells downgradient from Area A correspond to the materials that were disposed in the sites in that area, except for the pesticides and herbicides; however, the wells upgradient from Area A contain constituents for which no apparent source area or areas exist. The sources may be industrial areas at the northern part of the Base. In Area A, Sites 25, 37, 38, 39, and 40 were identified as being upgradient from monitoring wells containing volatile organics. When groundwater samples from wells in Area A were analyzed for TCE, results ranged from "none detected" (ND) to 50 ppb.

Base production well 7, which was previously abandoned due to the reported presence of cresylic acid, is located downgradient from Building 475 (Site 38). From 1942 until the late 1950's, this site operated as an aircraft reciprocating engine repair shop and solvent recovery area for cresylic acid and dichlorobenzene. Monitoring wells 26S and 26D were installed 1,000 feet downgradient from BW7 and were tested for cresylic acid. Analyses showed concentrations to be lower than detection limits. Based on these results, cresylic acid did not appear to be migrating in the groundwater beyond the production well. Monitoring well 40S was then installed approximately 250 feet downgradient from the production well. Cresylic acid was found to be present in MW40S at a concentration of 26 μg/l, indicating that past activities at Building 475 could be the source.

Monitoring well 39S is located upgradient from monitoring wells 25S and 25D, and downgradient from disposal site 25 (burial pit). TCE was identified in MW25S and could have originated from Site 25. However, no volatile compounds were detected in MW39S, indicating that the source of TCE in MW25S probably is not currently burial site 25. Monitoring well 27S contained measurable levels of TCE and pentachlorophenol indicating that Site 39 may have caused groundwater problems.

<u>Area B</u>

In Area B Sites 10 and 36 were identified as being upgradient from monitoring wells containing volatile organics. Concentrations in this monitoring area ranged from ND to 5 ppb for 1,1-dichloroethylene; ND to 10 ppb for 1,2-trans-dichloroethylene; and ND to 118 ppb for trichloroethylene. Monitoring well 41S was installed downgradient from MW25S and MW25D, both of which showed the presence of TCE. Well 41S was to aid in establishing the extent of TCE migration. Analysis of the well showed volatile compounds present, including TCE. However, the source may have been disposal site 36, which was used for the open storage of plating shop chemicals from 1958 to 1980. Monitoring well 27S (located downgradient from Area B at the Base boundary) contained 15 ppb of TCE and 120 ppb of pentachlorophenol.

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Area C

Subarea C-1. In Subarea C-1 Sites 17, 18, 19, 20, 21, 22, 28, 32, 41, 42, and 43 were identified as being upgradient from monitoring wells containing volatile organic constituents. Concentrations of these volatile compounds ranged from ND to 220 ppb for ethyl benzene; ND to 440 ppb for toluene; and ND to 2,000 ppb for trichloroethylene.

A burial pit designated Site 43 is located near monitoring wells 20S and 20D. The pit collected demolition debris and probably received spills and discharges of oily wastes in the 1940's. Analysis of MW20S groundwater samples showed the presence of volatile and base/neutral constituents, several trace metals, and a high concentration (915 mg/l) of aliphatics (grease and oil). Installation of MW34S during Stage II was to have more clearly defined the source of aliphatic material found in MW20S. However, the well was dry during sampling (dry season months) and data are not available. Monitoring of MW34S during the wet season will more clearly identify the source. Well 33S was installed downgradient from MW20S to identify potential migration of aliphatic material. Results do show the presence of grease and oil in MW33S (5.7 mg/l). The aliphatic material appears to be moving southward through the groundwater.

Monitoring well 45S was located downgradient from Site 21 (sludge/oil pit) to ascertain potential point source areas for constituent movement to groundwater. However, no constituents were found in the well.

Subarea C-2. In Subarea C-2 Sites 7, 8, 9, 10, 11, and 16 were identified as being upgradient from monitoring wells containing volatile organic constituents. Concentrations of these volatile compounds ranged from ND to 30 ppb for 1,1-dichloroethylene; ND to 5 ppb for tetrachloroethylene; and ND to 10 ppb for trichloroethylene.

Monitoring well 36S is located along the western Base boundary immediately northwest of the burial pits designated as Sites 9 through 14. The well was completed into the shallow aquifer to determine off-base flow of constituents in the groundwater. Constituents do not appear to be leaving the Base in this area; analysis of the well shows it to be virtually "clean".

Monitoring well 44S was located downgradient from Site 15 (sodium valve trench). Well 44S does identify potential point sources for shallow groundwater constituents, although concentrations appear minimal. The only constituents present were 1,2,4-trichlorobenzene (8 ppb), trichloroethylene (10 ppb), and 1,1-dichloroethylene (30 ppb) which were probably not contributed by Site 15.

Area D

In Area D sites 1, 2, 3, 4, 5, 6, 26, and 27 were identified as being upgradient from monitoring wells containing volatile organic compounds. Concentrations for selected volatile compounds ranged from 500 to 63,000 ppb for 1,1-dichloroethylene; ND to 12,000 ppb for 1,1,1-trichloroethane; and 160 to 14,100 ppb for trichloroethylene.

Monitoring well 37S is located immediately downgradient from disposal site 33. This site was used for temporary (2 to 4 months) landfarming of industrial waste treatment sludge during 1972. Although MW37S was located near a possible source of material, constituents were not detected in the well.

Monitoring well 38D at the western boundary of the Base was completed in the second sands. The surrounding area contains several monitoring wells installed by the Base in 1980. All of the Base monitoring wells have shown high concentrations of organic constituents at each sampling period during the past two years. Sources of these constituents are located in disposal sites clustered to the east of MW38D (Sites 4, 5, 6, and 26). Each of these waste disposal sites contains various buried materials including industrial sludge and oil, fuel, and solvents. Analyses of MW38D reveal the presence of particularly volatile constituents. However, because of the extremely elevated concentrations of these constituents found in the shallow sands, it is presumed that these were transferred to the deeper aquifer during drilling of MW38D.

Analysis of samples from monitoring wells 10 through 15 revealed consistently high levels of TCE and other volatile organics. Monitoring wells 10, 11, and 15 were located in proximity to the downgradient Base boundary in this area.

Site 24

Located downgradient at a distance from Site 24, monitoring wells 24S and 24D did not reveal the presence of significant levels of constituents.

Site 29/Site 31

Monitoring well 43S (located downgradient at a distance from both Site 29 and Site 31) did not contain volatile organics or trace metals. This indicates that these sites probably are not causing groundwater quality problems.

Site 34

Monitoring well 46S was placed immediately adjacent to past disposal site 34 (underground waste solvent storage tanks). The tanks do not appear to be point sources for movement of constituents to groundwater. Analytical results show only chloroform (5 ppb), lead (0.018 mg/l), and cyanide (0.02 mg/l) detected.

Site 45

Monitoring wells 18S and 18D were located downgradient from Site 45, a paint burial pit which was operated in the 1950's. Analytical data for these two wells show that they are practically "clean". Excluding the herbicides and pesticides, detectable compounds in MW18S included: pentachlorophenol (6 ppb), bis(2-ethylhexyl)phthalate (8 pbb), and mercury (0.0016 mg/l). Well 18D contained only bis(2-ethylhexyl)phthalate (12 ppb) and cadmium (0.09 mg/l). Constituents from this site do not appear to be migrating into groundwater.

Site 46

Disposal site 46 is the location of an old salvage yard operation where PCB contamination had been identified in surface soil in a small area adjacent to the runway clear zone. Salvage operations were conducted by a previous owner from the mid-1960's through 1978. The site is located at the northwestern corner of the Base, with groundwater flow toward the southwest. The soils containing PCB's were removed by the Air Force in a program approved by the state DOHS and the Central Valley RWQCB and transported to a permitted PCB site. Site 46 comprised about

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2.6 acres and at some points was excavated to a depth of two feet. Material was removed that had PCB concentrations greater than 50 ppm. The excavation was started in July 1981 and was completed in September 1981. The material was transported to the Grandview Site B disposal facility (ID Number IDD07314654) in Grandview, Idaho.

Wells 17S and 17D were located directly downgradient from the disposal site to determine the extent of PCB migration, if any. PCB's were absent from all monitoring wells on the Base, including MW17S and MW17D.

Upgradient Base Boundary

The location of monitoring wells 16S and 16D was selected to determine the quality of the groundwater entering McClellan AFB. The shallow well, MW16S, showed the presence of pesticides and herbicides, but no volatile, acid, or base/neutral compounds were detected in this well. Cyanide was detected in the shallow well at 0.02 mg/l. In subsequent sampling of MW16S, 1,1-dichloroethylene and TCE were each identified at concentrations of 10 parts per billion. This shallow well was resampled on 8 October 1982, and no constituents were identified other than pesticides and herbicides. Other background wells were also relatively "clean".

Downgradient Base Boundary

Monitoring well 42S was located at the southern Base border to identify potential constituent migration from the Base. Analytical results showed no constituents detected, except zinc at 0.04 mg/l.

Monitoring well 43S was installed along the southwestern border of the Base to identify potential off-base movement of constituents in the shallow aquifer. Monitoring well 7, located just south of MW43S, has shown TCE concentrations in the past. However, analysis of MW43S detected no constituents.

Monitoring well 47S was located near the southwestern Base boundary to identify potential migration of groundwater constituents off Base. Lead was the only constituent present in the groundwater, showing a concentration of 0.017 mg/l.

Monitoring well 20S located at the middle of the western Base boundary in Subarea C-1 contained measurable levels of trace metals as well as 45 ppb of benzene, 220 ppb of ethyl benzene, and 440 ppb of toluene at one sampling.

Monitoring wells 10, 11, and 15 were located at the northwestern Base boundary downgradient from Area D. Appreciable levels of volatile organics were measured in groundwater samples from these wells. For example, 1,1-dichloroethylene was measured at 19,300 ppb and 63,000 ppb in two successive samplings at well 11.

Industrial Waste Line Survey and Soil Sampling Near Building 251

During investigation of the industrial waste line near Building 251, the 6-inch PVC force main passed the air test at 4 psi and 9 psi. The force main is therefore assumed to be in acceptable condition. All industrial gravity sewers tested failed the air test, indicating a high potential for exfiltration of waste. The industrial gravity sewer is in excess of 38 years old. It is likely that the joints are flush-bell-and-spigot-with-mortar joints and that the majority of these joints may leak. The abandoned 4-inch force main, which discharged to the manhole 33 outlet, should at least be plugged at the manhole 33 outlet and should perhaps be removed entirely.

In 1944 manhole 33A was replaced with a vapor trap structure by the US Army Corps of Engineers. The abandoned manhole 33A and inlet and outlet lines were left in place and available plans indicate that they were plugged. This manhole is now partially filled with sludge. The manhole and lines should be removed and disposed. The replacement vapor trap structure traps sludge and should be periodically flushed.

In 1944 a manhole in the vicinity of manhole 30 was also replaced by a vapor trap structure. In 1954 the vapor trap structure [illegible] by-passed by manholes 92, 30, and 30A. From the Corps of Engineers plan of 1954, it appears that there are two 15-inch drains from Building 251 and an 18-inch storm drain overflow still connected to the abandoned vapor trap structure and that all the outlets were plugged.

No volatile, acid, or base/neutral compounds were identified above detection limits in any of the soil samples obtained during drilling under the industrial waste line near Building 251. A number of pesticides and herbicides were present in all the samples. Table 4.18 presents the results for organic analyses of soil samples collected at this site.

Trace metals were detected in all of the soil samples obtained beneath the industrial waste line. These data are presented in Table 4.19. Generally, metals showed highest concentration levels in the first soil boring at a 15-foot depth, where arsenic was detected at 137.5 mg/kg and selenium at 23.7 mg/kg.

HYDROGEOLOGIC REGIME

The hydrogeological investigations conducted during the field program resulted in the identification of three different conditions under which water occurs: (1) as perched water within shallow, discontinuous, and localized water-bearing material at depths ranging from 30 to 50 feet; (2) under unconfined conditions within shallow water-bearing sands ranging in depths from about 80 to 100 feet; and (3) within deeper water-bearing material at over 120-foot depths, consisting of numerous aquifers with water under confined conditions.

Perched Water

The perched water is of a localized nature, with no continuity off the Base. There are no monitoring wells installed in these perched zones and therefore no data on the quality of that water. Since the areal extents of the perched zones are limited, migration of that water is not considered likely. The analytical results of groundwater samples from the deeper water-bearing materials indicate a range of concentrations of chemical constituents that is below established standards. As a consequence, the main focus of the hydrogeological investigations has been to establish the characteristics of the water-bearing materials found at a depth of about 80 to 100 feet. It is within this stratum that the highest concentrations of chemical constituents were found throughout the Base.

TABLE 4.18

BUILDING 251 SOIL BORINGS BENEATH INDUSTRIAL WASTE LINE
ORGANIC COMPOUNDS IDENTIFIED IN SOIL SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in µg/kg)

Compound[a]	Boring Number/Depth and Sampling Date					
	#1/15 feet 6-04-82	#1/20 feet 6-04-82	#2/15 feet 6-04-82	#2/20 feet 6-04-82	#3/15 feet 6-07-82	#3/20 feet 6-07-82
Base/Neutral Compounds						
naphthalene	ND	ND	ND	<10	ND	ND
Pesticides/Herbicides						
Aldrin	ND	ND	1.44	1.60	1.47	ND
gamma-BHC (lindane)	1.40	0.57	1.01	0.70	1.72	1.76
DDE	ND	ND	ND	ND	0.69	ND
dieldrin	ND	2.11	ND	2.10	ND	ND
endosulfan I	2.46	2.51	2.38	0.56	ND	ND
heptachlor	1.41	0.59	1.45	1.70	2.35	2.29
2,4-D	1.40	3.02	0.45	4.14	2.06	2.09
2,4,5-T	2.63	0.81	0.067	1.10	1.87	1.18
2,4,5-TP (Silvex)	0.98	ND	0.224	3.53	4.80	ND

ND = not detected

[a] See Appendix N for a complete list of analyses performed.

TABLE 4.19

BUILDING 251 SOIL BORINGS BENEATH INDUSTRIAL WASTE LINE
TRACE METALS IDENTIFIED IN SOIL SAMPLES
McCLELLAN AFB, CALIFORNIA
(concentrations in mg/kg)

Metal[a]	Boring Number/Depth and Sampling Date					
	#1/15 feet 6-4-82	#1/20 feet 6-4-82	#2/15 feet 6-4-82	#2/20 feet 6-4-82	#3/15 feet 6-7-82	#3/20 feet 6-7-82
Antimony (Sb)	23.1	1.75	3.12	3.37	5.87	4.55
Arsenic (As)	137.5	57.0	82.5	52.5	80.0	52.5
Cadmium (Cd)	1.27	2.07	1.32	1.0	0.82	1.04
Chromium (Cr)	124.0	75.0	94.0	85.0	85.0	80.5
Copper (Cu)	28.0	91.0	107.0	26.0	26.0	22.0
Lead (Pb)	11.1	11.1	93.7	13.6	12.4	14.9
Mercury (Hg)	< 0.1	0.21	< 0.1	< 0.1	< 0.1	< 0.1
Nickel (Ni)	48.5	20.5	32.2	28.5	27.5	27.2
Selenium (Se)	23.7	7.5	17.2	11.1	13.5	10.5
Silver (Ag)	1.5	0.35	0.92	0.8	1.2	0.86
Zinc (Zn)	68.2	54.0	57.2	54.5	53.0	48.9

[a] See Appendix N for a complete list of analyses performed.

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Deeper Aquifers

The deeper water-bearing materials found at depths ranging from 120 feet to 160 feet consist of silty sands that are of medium grain size. Some traces of gravel were found in borings for wells along the eastern side of the Base. The sands appear in at least three distinct levels on the Base at depths of 120 feet, 140 feet, and 160 feet. These three different zones may not be interconnected. The thickness of the sands may vary and there may be additional lenses at greater depths. Water within all the deeper sands are under confined conditions with heads averaging 40 feet (i.e., the water levels in the wells are at an average of about 40 feet above the top of the water-bearing sands). Nowhere were the heads of the confined deeper aquifers observed to be above the shallow groundwater levels. Examination of water level data from the wells penetrating the deeper sands shows a general trend of groundwater flow from north to south. Drawdowns in water levels in the deeper wells range from one to over four feet over a four-month period. The variance in drawdowns could be a result of lenticular and discontinuous sands and/or potential interferences from nearby on-line production wells.

During sampling of the Stage I multiple-completion wells, the deeper wells were pumped to evacuate about five casing volumes of water; during pumping, the water levels within the adjacent shallow wells were monitored to determine potential hydraulic continuity between the deep and shallow water-bearing sands. For the selected wells that were observed, no continuity between the shallow and deep sands was noted. At a constant pumping rate of about 1 gpm during sampling events, none of the deep wells ran dry and only a minimal drawdown (less than one foot) was observed after pumping ceased; one exception was well 19D, which showed about a 7-foot drawdown after three well casing volumes had been removed. The general lack of drawdown in the wells after pumping indicates that the deeper sands are good producers of water. This is further substantiated by the fact that production wells on the Base draw about 1,100 gpm from the deeper-lying aquifers, including the second water-bearing zone, with a maximum drawdown of 25 feet.

Shallow Sands

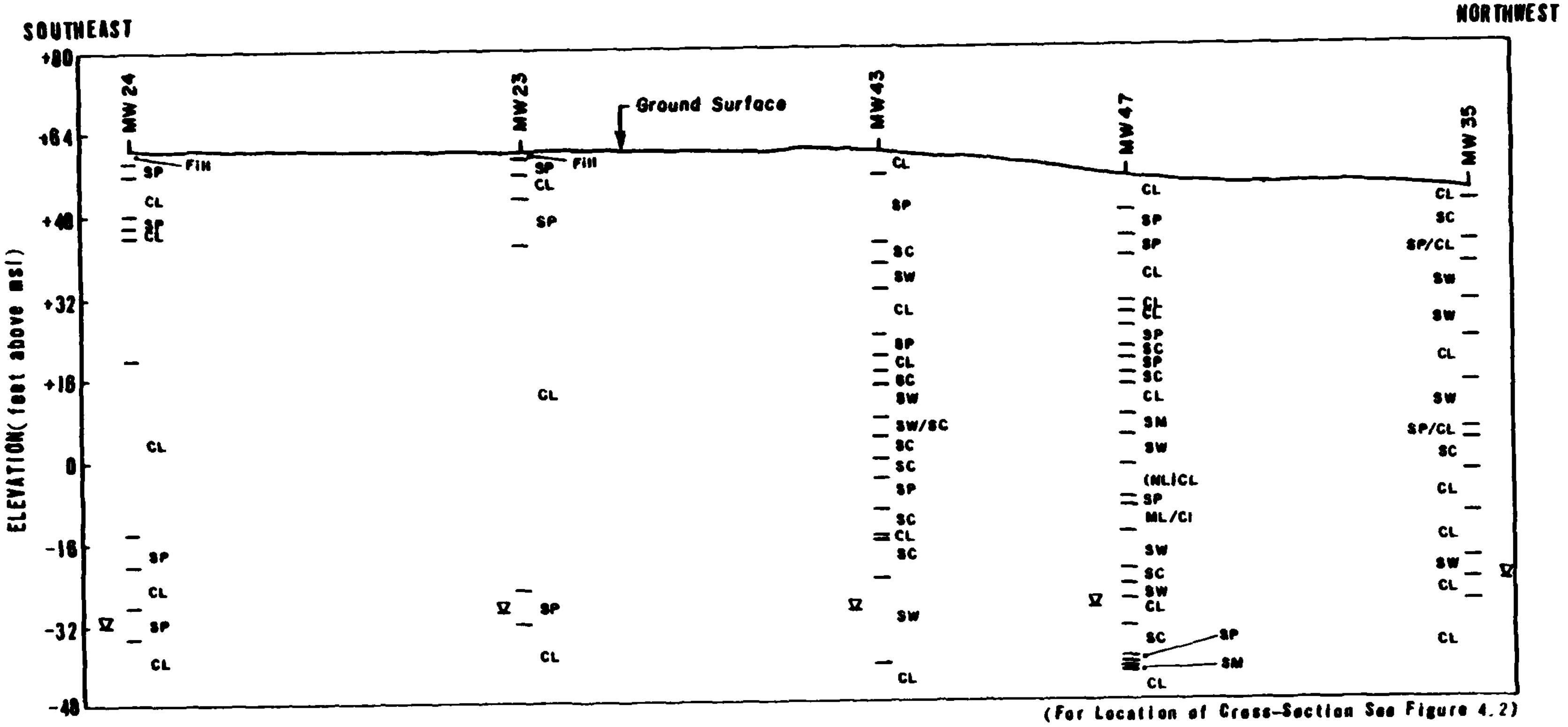
During the entire field program, a total of 32 shallow wells were installed. Throughout the Base, a shallow groundwater table was generally encountered at depths ranging from approximately 80 feet to 100 feet below ground surface, or about 20 feet to 33 feet below mean sea level (water levels were measured in September 1982). The water is contained within fine-grained sands of variable thickness. The water-bearing sands may be discontinuous or have variable permeabilities under the Base. Well logs are presented schematically on Figures 4.3, 4.4, and 4.5 for three cross-sectional areas on the Base; these figures show the intricate interbedded nature of the sediments identified during the field program. The well logs show the sediments above and immediately below the shallow aquifer. A determination of the continuity of the shallow sands is not possible; however, it should be noted that since shallow groundwater is present throughout the Base, it can be assumed that the sands are interconnected, but may vary laterally in permeability.

The thickness of the shallow water-bearing sands varies at different monitoring well locations. In the northern part of the Base, the sands were found to be as little as one foot thick, with a general increase in thickness to the south-southwest. In the southern part of the Base by MW43S, the sands reach thicknesses up to 17 feet. The average thickness of the sands is about 6 feet.

A generalized fence diagram is shown on Figure 4.6. On this diagram, the sediments underlying the Base have been divided into two types of materials: fine-grained (clays and silts) and coarse-grained (sands, silty sands, and clayey sands). This figure was prepared on the basis of data contained in the geologic logs shown in Appendix E. The lateral and vertical extents of the materials and their continuity in the areas between the monitoring well locations are unknown but have been presented diagrammatically to provide an overview of the subsurface conditions; the diagram should not be construed to represent actual subsurface conditions, but should be viewed simply as a graphic presentation of the collected data.

FIGURE 4.3

GEOLOGIC CROSS-SECTION A-B-A′



(For Location of Cross-Section See Figure 4.2)

LEGEND

SW-WELL-GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES

SP-POORLY GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES

SM-SILTY SANDS, SAND-SILT MIXTURES

⊽ GROUNDWATER LEVEL (SEPTEMBER 1982)

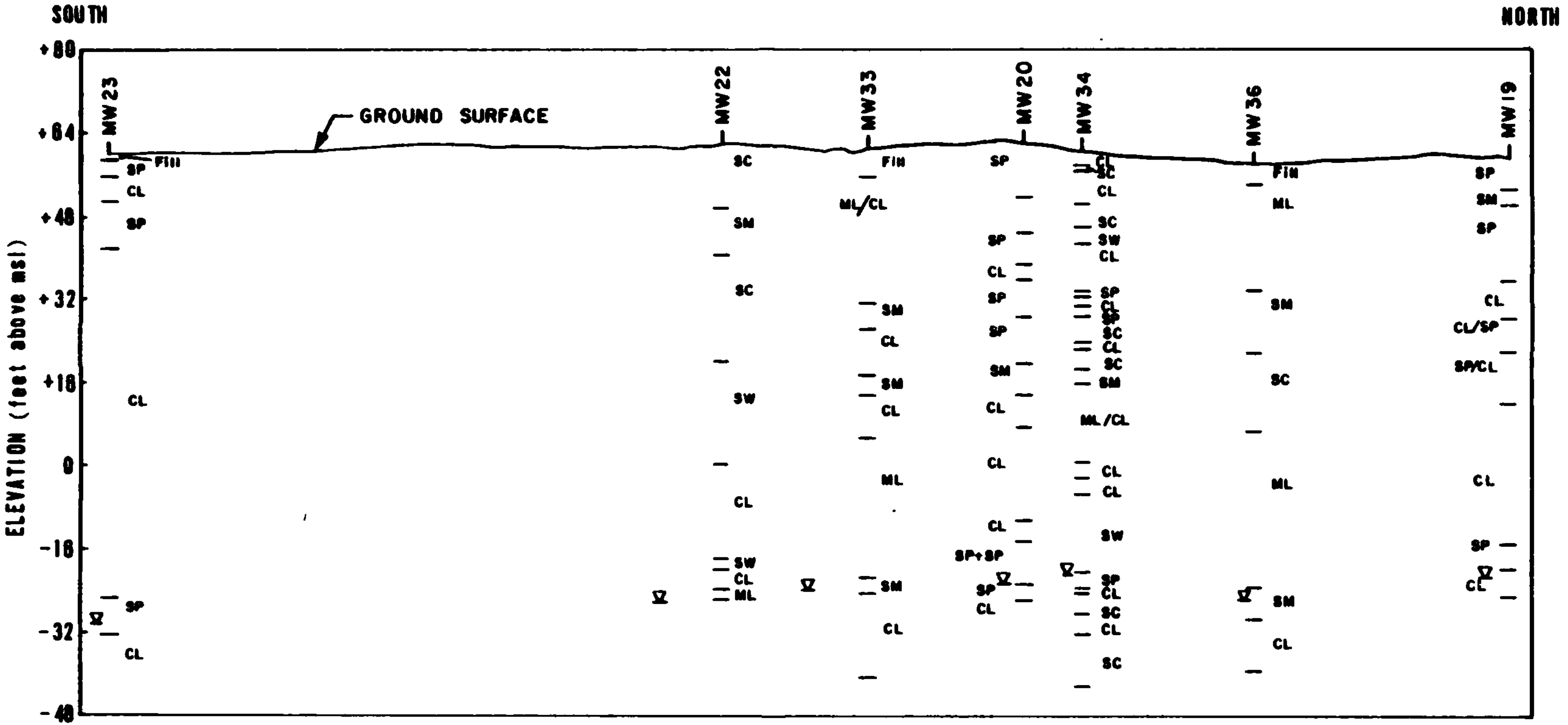
SC - CLAYEY SANDS, SAND-CLAY MIXTURES

ML - INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS

CL - INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS

SCALE
VERTICAL: 1"= 16'
HORIZONTAL: 1"= 500'

GEOLOGIC CROSS-SECTION B-B′



(For Location of Cross-Section See Figure 4.2)

LEGEND

SW–WELL-GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES

SP–POORLY GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES

SM–SILTY SANDS, SAND-SILT MIXTURES

∇ GROUNDWATER LEVEL (SEPTEMBER 1982)

SC–CLAYEY SANDS, SAND-CLAY MIXTURES

ML–INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS

CL–INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS

SCALE
VERTICAL: 1″=16′
HORIZONTAL: 1″=500′

FIGURE 4.4

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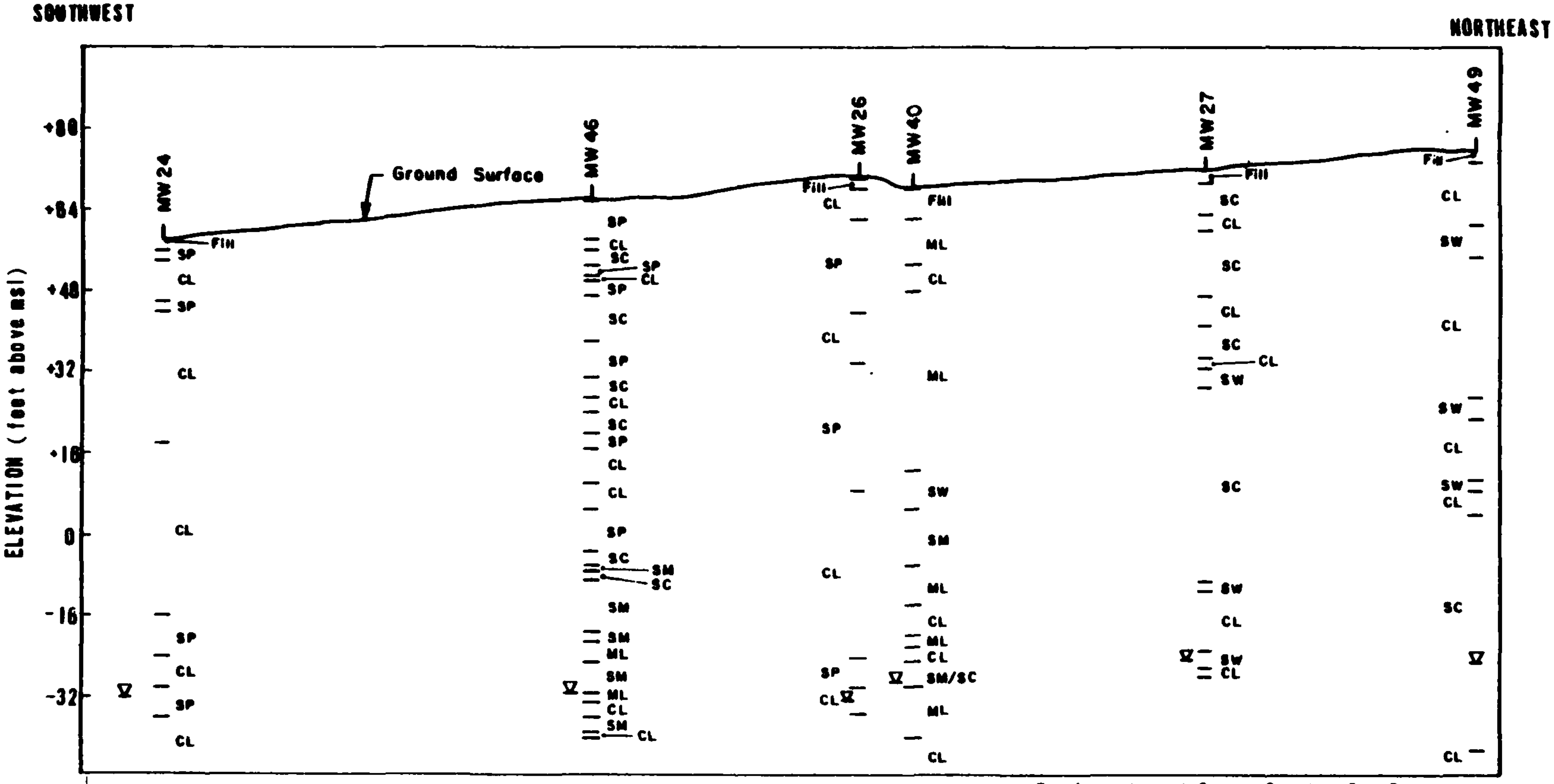
FIGURE 4.5

GEOLOGIC CROSS-SECTION A-C



(For Location of Cross-Section See Figure 4.2)

LEGEND

SW-WELL-GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES

SP-POORLY GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES

SM-SILTY SANDS, SAND-SILT MIXTURES

∇ GROUNDWATER LEVEL (SEPTEMBER 1982)

SC-CLAYEY SANDS, SAND-CLAY MIXTURES

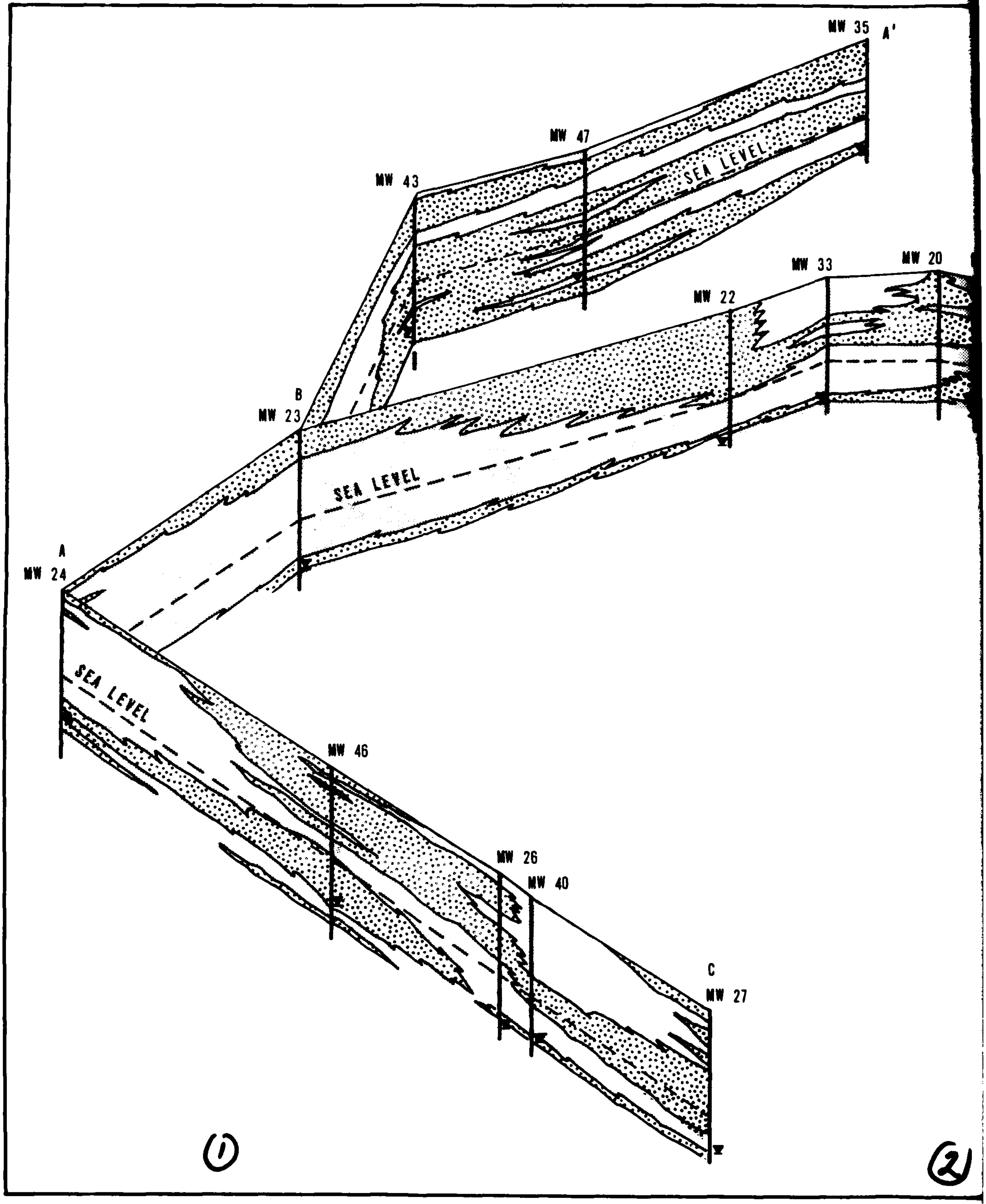
ML-INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS

CL-INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS

SCALE

VERTICAL: 1"=16'
HORIZONTAL: 1"=500'

1-144


MW 35
A'
MW 47
SEA LEVEL
MW 43
MW 33
MW 20
MW 22
B
MW 23
SEA LEVEL
A
MW 24
SEA LEVEL
MW 46
MW 26
MW 40
C
MW 27
①
②

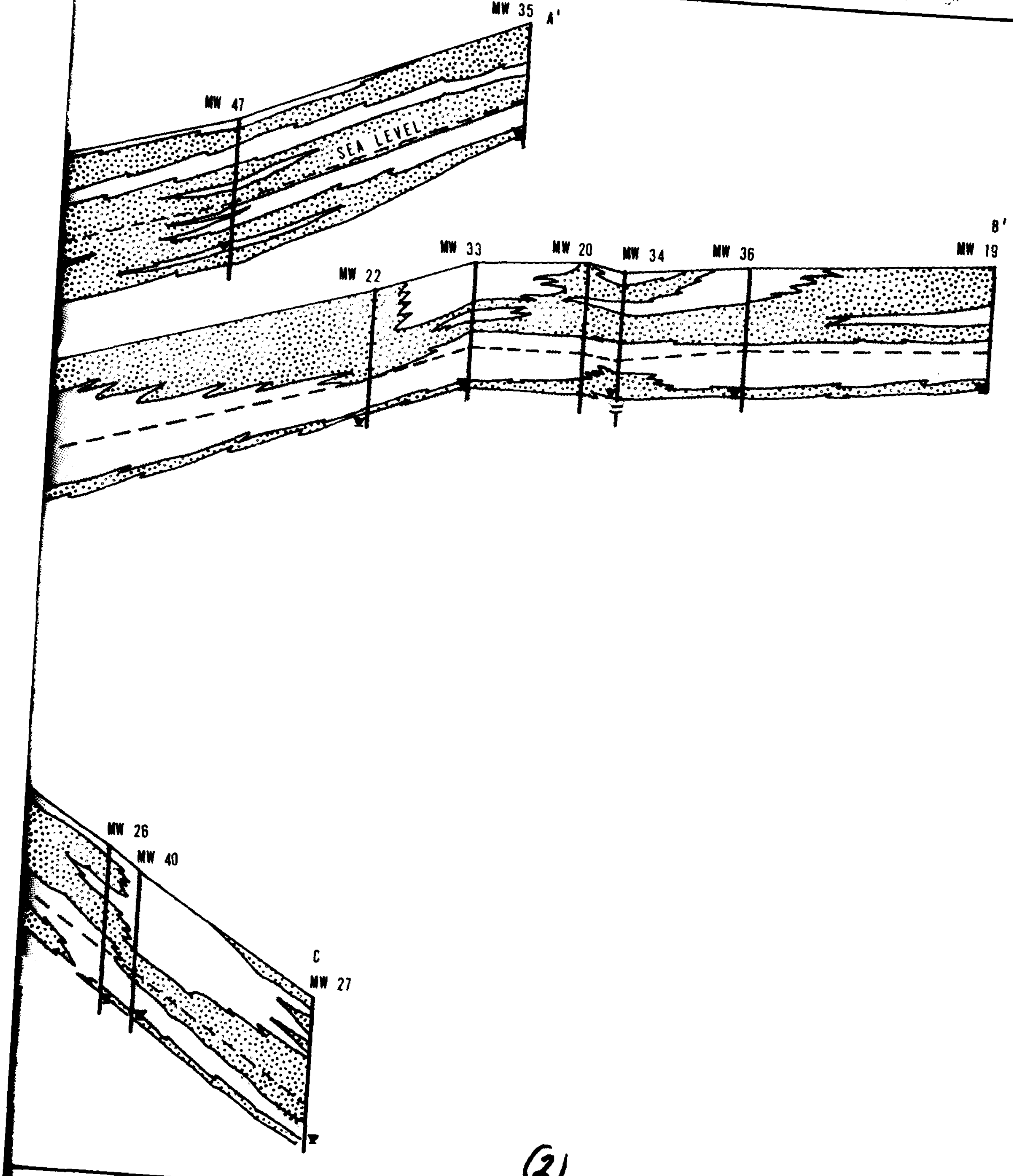


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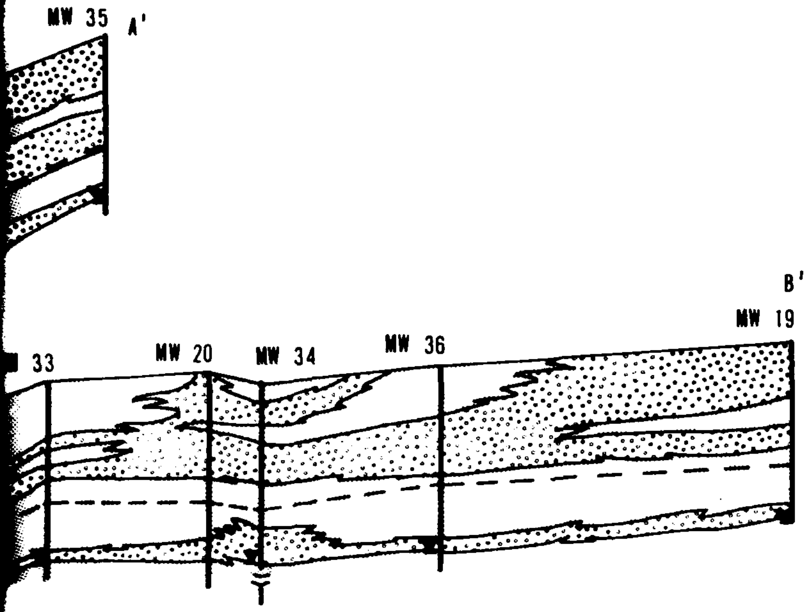
FIGURE 4.6



SACRAMENTO A L C

(FOR LOCATION OF CROSS-SECTIONS SEE FIGURE 4.2)

HORIZONTAL SCALE 1" = 1000'

VERTICAL SCALE 1" = 80'

▨ COARSE-GRAINED MATERIAL (SANDS)

☐ FINE-GRAINED MATERIAL (SILTS AND CLAYS)

▼ GROUNDWATER LEVEL

NOTE:
This diagram was prepared based on the geologic logs presented in Appendix D. The indicated types of sediments are general and contain numerous interfingering lenses of finer and coarser-grained material. Lenses of less than 5 feet in thickness are not included on this diagram.

GENERALIZED GEOLOGIC FENCE DIAGRAM
McCLELLAN AFB, CALIFORNIA

②

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The shallow water-bearing sands are overlain by coarse and fine-grained material. The finer-grained materials (clays and silts) reach considerable thicknesses in places. These sediments generally have very low permeabilities inhibitive to vertical movement of water; hardpan encountered in numerous monitoring well locations likewise restricts vertical transmission of water. Therefore, the groundwater recharge to the shallow sands is probably not occurring directly from precipitation on the Base, but rather from an area upgradient where the sediments surface. The general dip of sediments from the Victor and Fair Oaks Formations is from east to west with a minimum slope of 5 feet per mile (California Department of Water Resources, 1974). Thus, the maximum distance to a recharge area for the shallow water-bearing sands would be about 14 miles east of the Base (assuming an average depth of the sands as 80 feet below the ground surface). Precipitation falling in the recharge area would enter the sands and flow downgradient through the aquifer system. The shallow water-bearing sands are present along the southern Base boundary and continue off Base downgradient toward the City of Sacramento. The exact lateral and vertical extents of the shallow zone are not known, but the Victor and Fair Oaks Formations both extend southward beneath Sacramento. Water within any of the water-bearing sands would travel toward the groundwater trough near the city of Sacramento unless extracted by pumping.

The pump tests performed at MW44S failed to cause responses in the nearby piezometers. However, recovery measurements taken during pumping of well 44S were used to estimate the permeability and transmissibility of the shallow sands in that location. Data from these tests are contained in Appendix O. Transmissibility near MW44S was determined using Jacob's modification to the Theis equation:

$$T = \frac{264Q}{\Delta h'}$$

where T = transmissibility (gal/day/ft)
Q = discharge from pump (gal/min)
$\Delta h'$ = change in residual drawdown (ft/log cycle of time)

Transmissibility in the shallow zone near MW44S was estimated to be 21 gal/day/ft, based on a pump discharge rate of 0.82 gal/min and a 10-ft change in residual drawdown.

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Permeability (K) is obtained from the relationship between transmissibility (T) and aquifer thickness (b), where K = T/b. The permeability for the MW44S area is thus estimated to be 4.2 gal/day/ft^2, assuming an aquifer thickness of 5 feet. Based on water level measurements taken in September 1982, the groundwater levels on the Base range from 20 feet to 33 feet below sea level in a northeast-southwest direction; this represents a gradient of 3.7 feet per mile. The estimated velocity of the groundwater in the shallow sands in the MW44S area thus would be about 8 feet per year (velocity equals the permeability multiplied by the groundwater gradient). This velocity estimate is localized and does not account for the influence of area pumping or changing aquifer characteristics. Local pumping, especially by adjacent off-base water supply wells, could increase the gradient of the groundwater and therefore increase its velocity in that particular area.

Slug test data, also presented in Appendix O, were analyzed according to the methods described in Lohman (1972):

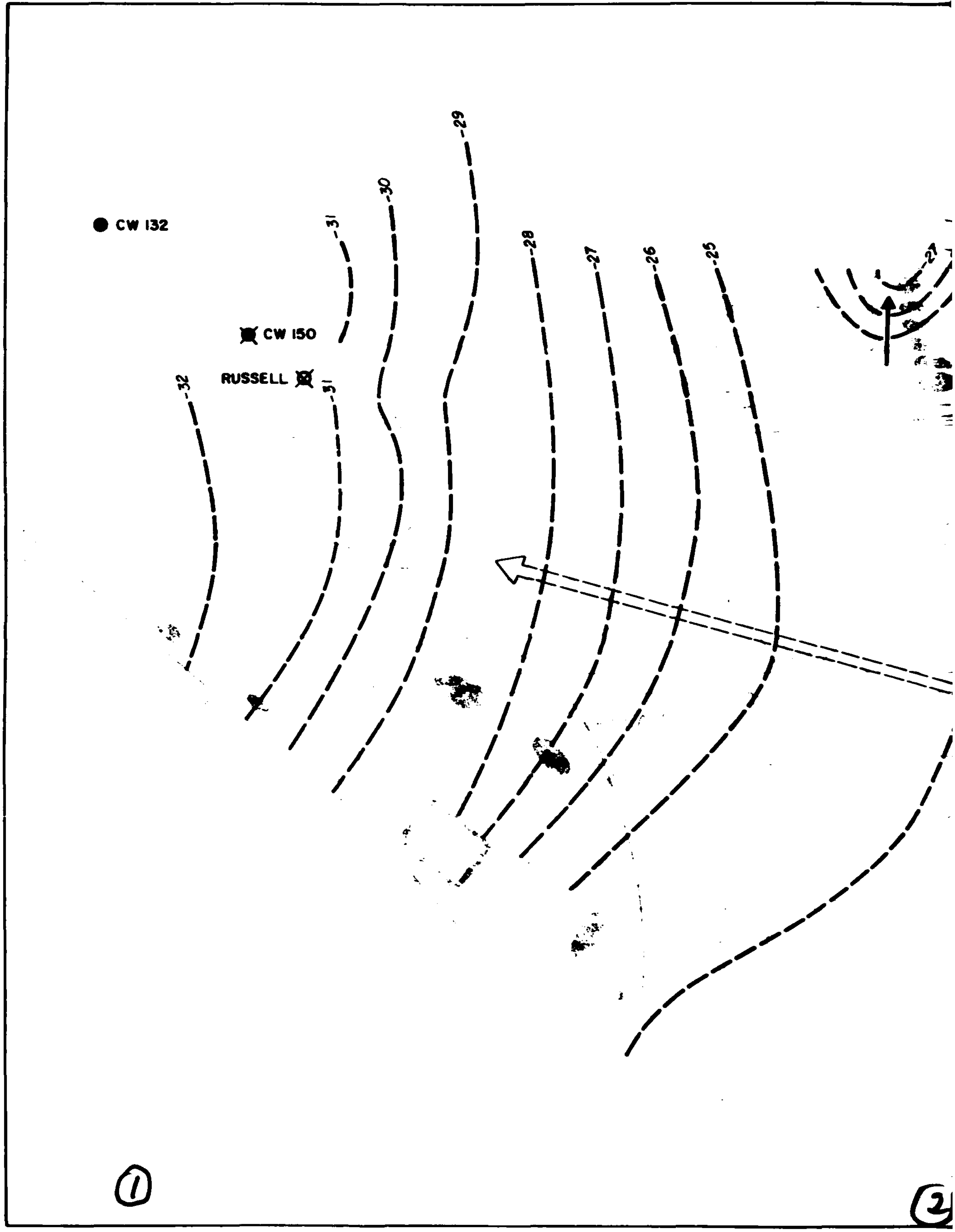
$$T = \frac{1.0\, r_c^2}{t}$$

where T = transmissibility
r_c = radius of well casing
t = time (determined from a match plot)

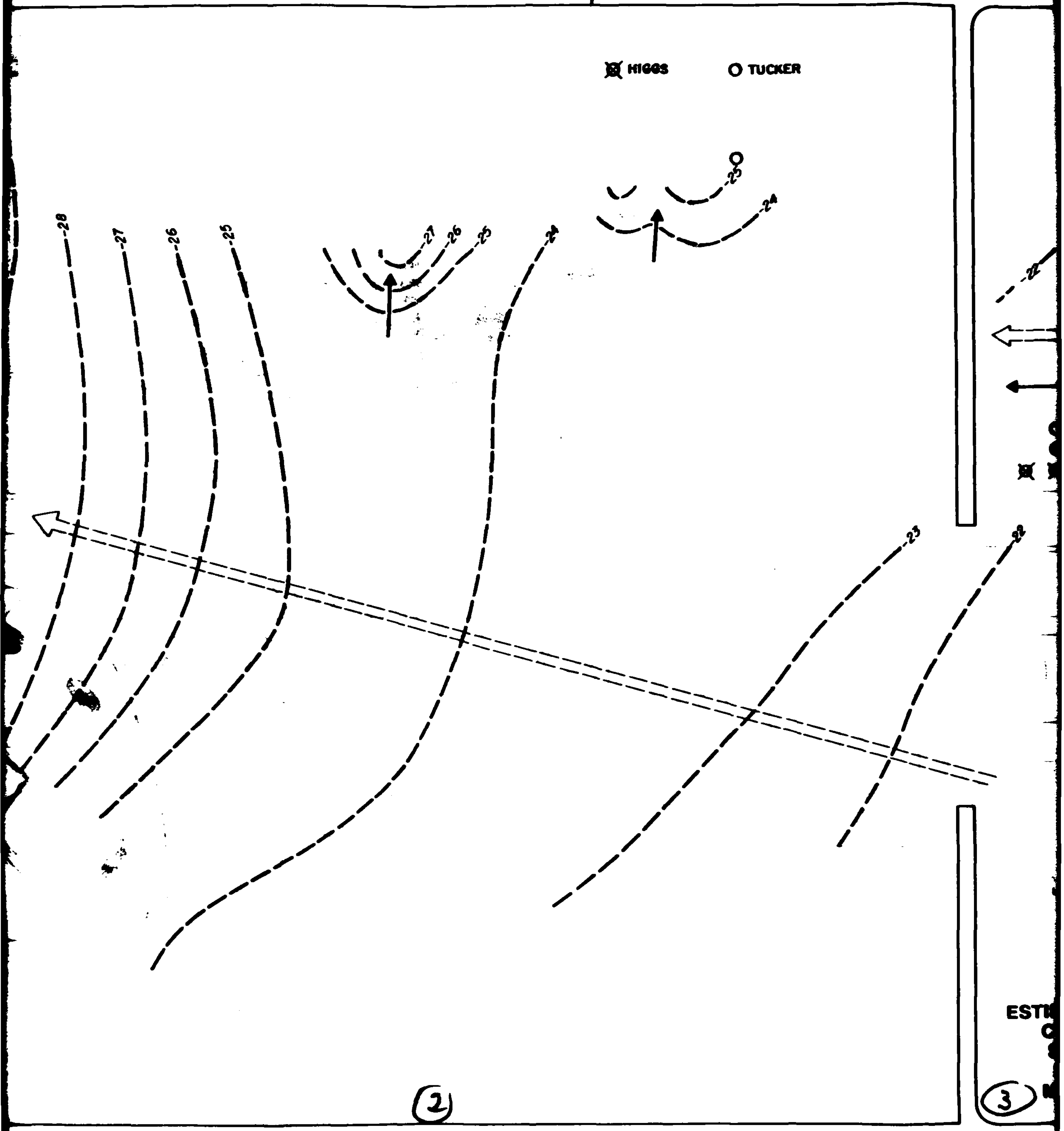
The slug tests performed on MW24S showed an average transmissibility of about 5 gal/day/ft and a permeability of 0.8 gal/day/ft^2. This is considerably less than the permeability estimated from the pump test at MW44S. Generally, good aquifers have permeabilities ranging from 10^6 to 10^2 gal/day/ft^2 while poor aquifers range from 10 to 10^{-2} gal/day/ft^2, with impervious materials having permeabilities below 10^{-3} gal/day/ft^2.

Groundwater level data obtained in September 1982 for all ES and Base monitoring wells were used for the development of a generalized groundwater contour map for the Base which is shown on Figure 4.7; these contours assume a continuous shallow aquifer underlying the Base. The general groundwater movement is toward the south-southwest. Pumping of off-base wells along the western Base boundary appears to influence the local groundwater in that area, causing it to flow to the west. Based on the water level measurements taken at the monitoring wells, pumping of Base production wells does not appear to influence the shallow

4.7

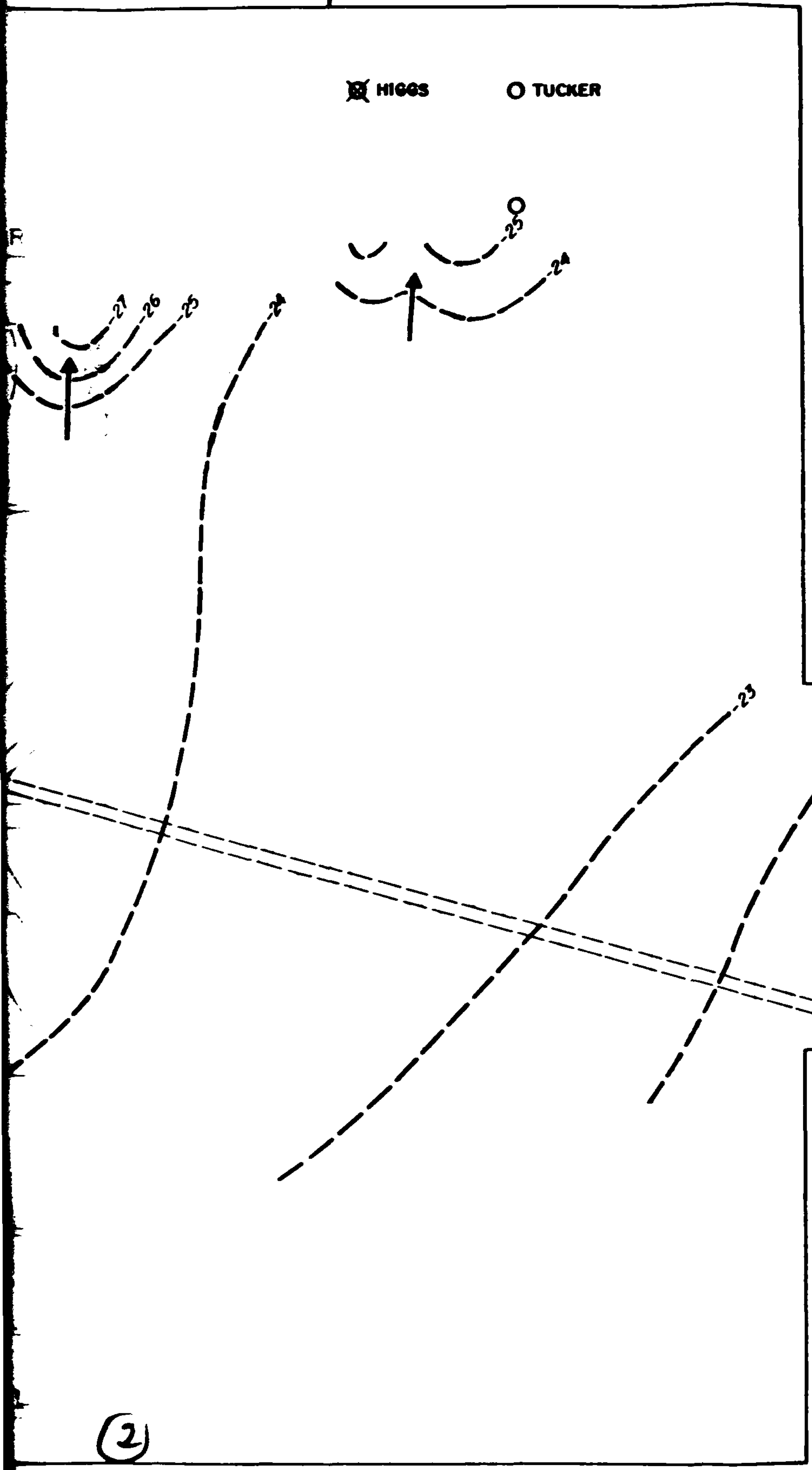


4.7



4.7

FIGURE 4.7



LEGEND

-22	Groundwater Levels in Feet below msl (Dashed where inferred)
⇐	General Direction of Groundwater Movement
←	Groundwater Movement Influenced by Local Pumping Wells
○	Off-base private well
●	Off-base city well (Sacramento)
☒ ☒	Closed well

ESTIMATED GROUNDWATER CONTOURS FOR THE SHALLOW AQUIFER SEPTEMBER 1982 ③ McCLELLAN AFB, CA

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groundwater contours in the southern part of the Base. This is probably due to the well design of these production wells. Base production well 17 is a cable-tool well, with perforations below the shallow aquifer, and no gravel pack; Base production well 13 may be constructed similarly since it was installed at approximately the same time as BW17.

The two aquifer tests conducted in the middle of the Base (MW44S) and along the southern boundary (MW24S) showed variability in the thickness and permeability of the shallow aquifer. These tests confirm field observations during well installation and sampling events regarding changing characteristics of the shallow water-bearing zone. The rate of movement of water through the shallow sands may therefore vary considerably. Water supply wells located off Base to the southwest and to the west have shown contamination by TCE. To the southwest, ranging from the Base boundary to as far as 3,000 feet from the Base, several private and public water supply wells have been shut down at various intervals since 1980 in response to changing concentrations of TCE in the well water. Immediately inside the southern Base boundary lies the cluster of sites designated as Area B, where materials such as TCE, Freon, diethyl ether, scrap metal, and plating chemicals were probably disposed and stored. The sites in Area B were active from as early as World War II to as late as 1980, or about 40 years.

Along the western boundary, TCE contamination has been detected in wells within 1,000 feet of the Base. Area D is located along the Base boundary closest to the off-site wells that have shown contamination. From the late 1940's to 1981, sites within Area D are reported to have handled TCE-contaminated wastes, waste solvents, undewatered industrial sludge, fuels and oils, and sodium valves from aircraft engines. From water level measurements taken in monitoring wells in Area D, the groundwater in this area seems to be moving to the west, probably in response to localized off-base pumping, and the local gradient is about 6 times greater than the subregional gradient at the Base.

It is possible that localized steeper shallow groundwater gradients as well as the unknown thickness and characteristics of the shallow aquifer off Base could increase the groundwater velocity as much as three times. With a decrease in aquifer thickness to about 1 foot and steepening of the gradient to about 2 percent, the velocity of the water in the shallow sands zone would be about 25 feet per year, assuming the porosity remains the same. In places on the Base, the shallow sands have been about 1 foot thick, and a 2 percent gradient is reasonable near producing groundwater wells.

Disposal practices along the Base boundaries over the past 40 years therefore could have resulted in migration of shallow groundwater contaminants off Base at a rate of 25 feet per year. However, some of the off-base contaminated wells are located at distances greater than 1,000 feet from the Base boundaries. The data collected on the Base during the Phase II Installation Restoration Program do not allow a determination of whether private or public wells located at distances greater than 1,000 feet off Base have been contaminated by past Base disposal practices. It should be noted that the areas southwest and west of the Base contain numerous light industries of types that traditionally have used the kinds of solvents that have been found in the off-base wells.

FIELD TESTING

This section presents results from certain field testing activities which included establishing the location of Base well 7 and logging specific conductance and temperature for selected monitoring wells.

Locating Base Well 7

The foundation of the well house surrounding BW7 was located using a magnetic flux indicator. The inside of the building was excavated and the well head was located in the building basement. A weighted line lowered into the well met refusal at a depth of 80 feet. Rotary-wash drilling was employed for cleaning out the well. After the well was cleared to 60 feet, the drill encountered a coarse mixture of sand and clay. Both 8-inch and 4-inch drill bits met refusal at 80 feet. The well log for this well shows that it was gravel packed for its entire length of 80 feet.

Specific Conductance and Temperature Logging

Results showing specific conductance and temperature readings taken in the field are presented in Table 4.20. Three Base monitoring wells

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(MW4, MW6, and MW7) and four Stage I monitoring wells (MW19S, MW19D, MW26S, and MW26D) were tested. Temperature readings were constant (20 to 21°C) for all of the wells, both shallow and deep. Specific conductance varied irregularly with well depth. However, the fluctuation within each well was minimal (<7 percent) relative to the mean difference between wells. A noticeable difference in specific conductance occurs between shallow and deep wells at the same locations (i.e., MW19S in relation to MW19D, and MW26S in relation MW26D). Mean conductance values for wells 19S and 26S, respectively, are 403 μmho and 527 μmho, where the deep wells (MW19D and MW26D) show respective conductance readings of 240 μmho and 211 μmho. Clearly, two separate aquifers have been identified, with the shallow zone exhibiting more total dissolved solids than the deeper zone. This finding is consistent with analytical data. The deeper groundwater aquifer is "cleaner" than the shallow one. As indicated by specific conductance, the concentration of inorganic constituents (salts) present in the shallow wells is about twice the concentration in the deeper wells.

PROBLEM DEFINITION

Plume Identification

Groundwater samples from all wells on the Base were analyzed for selected organic and inorganic constituents. The shallow wells (completed into the first sands) show the presence of constituents particularly along the western border of the Base, where former disposal sites existed. However, the data also show organic compounds and trace metals in shallow wells throughout the Base; often, these wells were not located near a known disposal area (i.e., MW29S, MW30, and MW31). Chemical constituents entering a groundwater system from a specific single source often migrate as a plume with semi-defined boundaries. The highest constituent concentrations within the plume tend to exist near the source area, with concentrations decreasing downgradient as dilution takes place.

TABLE 4.20

SPECIFIC CONDUCTANCE AND TEMPERATURE IN SELECTED MONITORING WELLS

Well No.	Testing Date	Depth (feet)	Temperature (°C)	Specific Conductance (µ mho)	Mean Conductance (µ mho)
MW4	9/24/82	110	21	320	
		110[a]	21	358	358 ± 27
		125	21	382	
		Bottom of well	21	372	
MW6	9/23/82	∿90	20.5	285	
		100	20.5	265	266 ± 13
		110	20.5	260	
		Bottom of well	20	255	
MW7	9/24/82	95	20	243	
		105	20	239	240 ± 2
		120[b]	20	239	
MW19S	9/24/82	85	20	395	
		85[a]	20	410	
		100	20	399	403 ± 6
		120	20	405	
		Bottom of well	20	405	
MW19D	9/24/82	85	20	242	
		100	20	238	
		120	20	238	240 ± 2
		140	20	240	
		Bottom of well	20	241	
MW26S	9/24/82	100	21	540	
		115	21	530	527 ± 15
		Bottom of well	21	510	
MW26D	9/24/82	100	21	209	
		120	21	212	211 ± 2
		140	21	213	
		160[b]	21	210	

[a] Duplicate test

[b] Bottom of well

Attempts to delineate plumes of constituents migrating from individual disposal sites at McClellan AFB have been complicated by the detection of constituents at unaccountable concentrations and locations across the Base. Figures 4.1 and 4.2 depict the varying concentrations of TCE detected in monitoring wells on successive sampling dates. These data indicate an attenuation of concentrations occurring in no definite pattern in relation to time or area. The occurrence of constituents in wells with no apparent source indicates that accurate delineation of plumes from individual site locations may not be possible.

Since there appear to be multiple sources for the constituents identified, and the source materials were emplaced at different times, migration would be likely to occur at unpredictable time intervals. In addition, groundwater levels in the upper sands zone vary seasonally, so constituents from some sites may have been solubilized from soil in a fluctuating sequence. Another factor that inhibits tracing groundwater constituents back to a specific source is that, in many cases, groundwater has flowed beneath several sites, picking up constituents from one or more areas. Also, past waste management practices may have resulted in the deposit of materials in areas not identified during Phase I of the IRP.

It is possible that chemical constituents may be identified in downgradient areas off the Base. The interface between areas containing detectable constituents and those areas which do not could delineate the leading edge of a plume. Phase II of the IRP did not provide for any off-base activity so off-base plume movement was only estimated.

Effects on Base Water Supply Wells

Since most Base production wells were constructed in such a way that gravel packs or casing perforations exist in the first sands zone, a potential problem exists with the on-base water supply wells. Constituents in the water in the first sands could migrate through the well gravel packs causing potential quality problems in the Base water supply.

The deeper aquifers show constituents to be near or below limits of detection, except pesticides and herbicides. Deep well MW19D, located

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in the sludge pit area, clearly shows an absence of constituents, even though it is situated in an area exhibiting "worst case" conditions. Well 38D, located west of the sludge pit, contained low levels of constituents. This well was located immediately adjacent to and downgradient from Area D, which has shown the highest level of groundwater contamination. During well installation, the shallow groundwater was encountered, and would be expected to mix during drilling with deeper-lying water in the second sands; there is thus the probability of cross-contamination. Additional samplings of MW38D would provide data on the actual water quality in the second sands. In general, the deeper sands appear to contain no EPA priority organic pollutants; the absence of constituents is consistent at all well locations on the Base. Consecutive samplings of these deeper wells (MW16D through MW29D and MW38D) should further reinforce this finding.

Selected analyses of wells showed negative results in most cases. PCB analyses of groundwater samples from all wells installed on the Base during Stages I and II resulted in non-detectable concentrations. Cyanide was found in seven wells on the Base, mostly at or near detection limits except for MW29S. Cyanide was also detected in MW16S located at the extreme northern (upgradient) Base boundary. Cresylic acid was detected in a shallow well placed between the suspected source (Building 475) and Base production well 7 (abandoned). Two wells (shallow and deep) placed further downgradient from production well 7 did not contain cresylic acid. Aliphatic material (grease and oil) appeared at elevated concentrations in one well (MW20S) along the western edge of the Base. This material has not reached the second aquifer but has migrated in a southerly direction. Detectable concentrations of grease and oil were found in a shallow well (MW33S) located due south of MW20S.

The presence of herbicides and pesticides in all of the shallow wells and most of the deeper wells is universal across the Base. Concentrations vary from one well location to another, and from one sampling to the next within the same well. The actual appearance of a particular compound does not follow a consistent pattern, with one sampling often showing a compound that is not detected during a subsequent sampling event. The evidence indicates that, to some degree,

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herbicides and pesticides are being contributed to on-base groundwater from off-base sources. The source of these constituents in the groundwater also may be partially from Base application and/or disposal. However, monitoring wells 16 and 17, both at the extreme northern (upgradient) end of the Base, show the presence of herbicides and pesticides in the shallow and deeper aquifers. The source of groundwater for both wells is off-base from the north. Historical records do show that two off-base production wells north of the Base contain 2,4,5-TP (Silvex). The occurrence of these herbicides and pesticides appears to be ubiquitous.

A general range of constituent concentrations detected in all on-base shallow wells is compiled in Table 4.21. These data reflect results only for constituents present at measurable levels in at least one groundwater sample. Analytical reports which present comprehensive results for all constituent analyses performed are contained in the appendices. Values lower than the detection limits were not used to calculate the range of concentration except for those constituents found above detection limits in only one or two shallow groundwater samples. For these constituents, it was not possible to tabulate low and/or median concentrations representing measurable quantities. In these instances, trace level data and "not detected" results were used to establish the range of concentration. The source areas in which the high concentrations were found are noted in the table.

All three soil borings beneath the industrial waste line contained trace metals at both the 15 and 20-foot depths, including high levels of arsenic and selenium.

Effects on Off-Base Water Supply

The physical characteristics of the shallow sands zone are summarized on Table 4.22. The Base is underlain by a shallow aquifer of thicknesses varying from 1 foot to 17 feet; the aquifer may be discontinuous in places. Permeabilities range from 0.8 gpd/ft^2 to 4.2 gpd/-ft^2, and transmissibilities range from 4.7 to 21 gpd per foot. The groundwater in this zone moves in a south-southwesterly direction but is influenced locally primarily by off-base production wells. Based on physical characteristics, it appears that groundwater velocity is about

TABLE 4.21

RANGE OF CONSTITUENT CONCENTRATIONS DETECTED IN BASE MONITORING WELLS AND STAGE I AND II SHALLOW WELLS

Constituent[a]	Unit of Measurement	Minimum Detection Level	Source Area[b]	Concentration High	Concentration Low	Concentration Median
Volatiles						
benzene	ppb	10.0	D	680	10	45
carbon tetrachloride	ppb	1.0	A	25	ND[c]	<10
chloroform	ppb	1.0	D	120	5	20
1,1-dichloroethane	ppb	1.0	D	250	19	110
1,2-dichloroethane	ppb	1.0	D	17	ND	ND
1,1-dichloroethylene	ppb	1.0	D	63,000	5	2,500
1,2-trans-dichloroethylene	ppb	1.0	D	200	6	80
ethylbenzene	ppb	1.0	C-1	220	ND	<10
methylene chloride	ppb	1.0	D	5,000	1,000	3,000
tetrachloroethylene	ppb	1.0	D	70	5	18
toluene	ppb	1.0	C-1	440	5	50
1,1,1-trichloroethane	ppb	1.0	D	12,000	55	2,300
trichloroethylene	ppb	1.0	D	14,100	0.54	61
trichlorofluoromethane	ppb	1.0	D	7	ND	ND
vinyl chloride	ppb	1.0	D	50	20	25
Acid Compounds						
2,4-dimethylphenol	ppb	1.0	D	94	ND	19
pentachlorophenol	ppb	1.0	DBB	260	6	15
phenol	ppb	10.0	D	400	<10	<10
Base/Neutral Compounds						
anthracene	ppb	1.0	C-1	220	ND	<10
bis(2-ethylhexyl)phthalate	ppb	1.0	C	230	8	20
1,2-dichlorobenzene	ppb	1.0	D	100	21	32
1,3-dichlorobenzene	ppb	1.0	D	28	<10	8
1,4-dichlorobenzene	ppb	1.0	D	40	10	12
di-n-butyl phthalate	ppb	1.0	C-1	9	ND	<10
fluorene	ppb	1.0	C-1	90	ND	ND
naphthalene	ppb	1.0	C-1	90	<10	25
1,2,4-trichlorobenzene	ppb	1.0	D	12	4	8
Pesticides/Herbicides						
Aldrin	ppb	0.003	D	6.97	0.041	0.503
alpha-BHC	ppb	0.002	A	0.08	0.018	0.032
beta-BHC	ppb	0.004	UBB	0.142	0.007	0.048
delta-BHC	ppb	0.004	C-1	0.83	0.025	0.066
gamma-BHC (lindane)	ppb	0.002	UBB	2.76	0.005	0.038
2,4-D	ppb	0.001	C-2	0.56	0.003	0.063
2,4,5-T	ppb	0.001	C-1	0.087	0.002	0.005
2,4,5-TP (Silvex)	ppb	0.002	D	0.36	0.004	0.051
dieldrin	ppb	0.006	D	0.20	<0.006	<0.006

TABLE 4.21 (Continued)

Constituent[a]	Unit of Measurement	Minimum Detection Level	Source Area[b]	Concentration High	Concentration Low	Concentration Median
endosulfan sulfate	ppb	0.03	C	0.011	<0.03	<0.03
heptachlor	ppb	0.002	DBB	0.88	0.013	0.056
heptachlor epoxide	ppb	0.004	DBB	0.17	0.007	0.027
Metals						
antimony	mg/l	0.005	D	0.06	0.006	0.008
arsenic	mg/l	0.05	D	0.66	0.24	0.30
cadmium	mg/l	0.01	UIA	0.08	0.01	0.014
chromium	mg/l	0.05	D	4.17	0.07	0.12
copper	mg/l	0.05	D	1.18	0.12	0.33
lead	mg/l	0.01	A	0.98	0.01	0.023
mercury	mg/l	0.0005	UBB	0.0027	0.0005	0.0012
nickel	mg/l	0.05	UIA	2.13	0.05	0.08
selenium	mg/l	0.01	D	0.355	0.01	0.049
zinc	mg/l	0.02	DBB	11.4	0.02	0.07
Selected Analyses						
cresylic acid (Cresol)	μg/l	5	A	26	<5	Ø[d]
cyanide	mg/l	0.02	UIA	0.95	0.02	0.03

a List of constituents excludes those which were not detected in any shallow groundwater sample. A total of 77 constituents were tested and not found above detection limits. Comprehensive results for all analyses performed are contained in Appendices K, L, and M.

b Area in which high concentration was detected:
A - Area A
C - Area C
C-1 - Subarea C-1
C-2 - Subarea C-2
D - Area D
DBB - Downgradient Base Boundary
UBB - Upgradient Base Boundary
UIA - Upgradient Base Industrial Area

c ND - Not detected

d Ø - Analyses were performed for only two shallow groundwater samples.

TABLE 4.22

PHYSICAL CHARACTERISTICS OF THE SHALLOW SANDS ZONE

Parameter	Value
Thickness	1 foot - 17 feet
Transmissibility	4.7 gpd/ft - 21 gpd/ft
Permeability	0.8 gpd/ft^2 - 4.2 gpd/ft^2
Velocity of groundwater	8 ft/year - 25 ft/year[a]

[a] The higher value reflects groundwater velocity influenced by local pumping and varying thicknesses.

8 feet per year, with the possibility of velocities of 25 ft/year in cases where the gradient is influenced by local pumping and changing aquifer characteristics; higher velocities would be possible if the aquifer material were dramatically different from what has been observed, i.e., old stream channel deposits with high permeability. Deeper aquifers exist, disconnected from the shallow aquifer and separated by at least 20 feet of predominately fine-grained material.

Since off-base wells may have been constructed with gravel packs and perforations in the shallow sands zone, constituents in groundwater (that could be the result of past McClellan AFB waste disposal practices) could migrate downward into lower aquifers causing quality problems with off-base water supply wells. Sufficient time has passed since the disposal of waste material on McClellan property for constituents in the first sands beneath the Base to cause problems in public and private water supply wells.

Source Areas

Based upon analytical data from groundwater monitoring wells, the correlation between wells and associated disposal sites and clusters was examined. Perceived correlations are summarized on Table 4.23. Very little definite information exists as to contents of these sites. As can be seen from the table, twenty-one sites could have direct effects on groundwater. The other twenty-five sites were not identified as causing groundwater degradation but remain as potential sources of

TABLE 4.23

SUMMARY OF DISPOSAL/STORAGE SITES AND CURRENT PERCEIVED STATUS

Has the Site Affected Groundwater?	Site Designation
Yes[a]	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 25, 26, 27, 30, 36, 37, 38, 40, 41, 42, 43
Not identified[b]	1, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 28, 29, 31, 32, 33, 34, 35, 39, 44, 45

[a] Site was located upgradient from affected wells.

[b] No evidence exists to document that the site is causing groundwater quality problems; however, future monitoring may change results.

groundwater quality problems. There are two types of material that can be causing potential problems. These are the disposed material and underlying site soils. Where constituents have migrated from disposed material into groundwater, the underlying site soils may have been contaminated. Both of these affected materials may pose groundwater quality problems through continued discharge.

Summary

Past waste disposal practices at McClellan AFB have resulted in three main areas of concern under the IRP. These are (1) affected materials (waste and soils), (2) on-base water supply, and (3) off-base water supply. The groundwater affected by past disposal activities appears to be primarily limited to the shallow sands zone. Based on estimated groundwater velocities and aquifer characteristics, constituents in groundwater on the Base have migrated outside Base boundaries, causing contamination of off-base private and public wells within a radius of 1,000 feet. Further off-base field work would be required to determine if migration of constituents could have occurred at greater distances from the Base. The limitations on how far the groundwater may travel are related to the fact that the Sacramento region is a closed basin due to overdrafting of the groundwater resources. A groundwater trough exists around the City of Sacramento (see Figure 2.3); groundwater thus would flow toward this trough from the aquifers being tapped for water supply. It is unknown if the shallow groundwater encountered at McClellan AFB would follow the regional groundwater movement trend. If it did not move toward the groundwater trough, it would continue moving downgradient within the Victor Formation which surfaces along the Sacramento River.

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SECTION 5

EVALUATION OF ALTERNATIVE MEASURES

CHAPTER 5

EVALUATION OF ALTERNATIVE MEASURES

In general, environmental concerns identified during field programs and past investigations at McClellan AFB focus on affected material, on-base water supply, and off-base water supply. A discussion of potentially applicable measures to address these concerns is presented in this chapter. The first part of the discussion provides a general overview of the alternatives that could be applicable to the situation at McClellan AFB. The second part of this chapter discusses the application of the alternatives to the three major problems.

OVERVIEW OF ALTERNATIVES

Alternative Measures for Affected Materials

Excavation

The most direct approach to eliminating affected materials involves excavation. The removed material can be hauled to an existing secure site off Base and the excavation can be refilled and/or regraded. When the quantities of excavated materials are relatively small, haul and replacement can be feasible. If large quantities of material must be managed or secure disposal sites are not conveniently located, then on-site treatment and replacement of excavated material can be a viable alternative. Another alternative would be to develop a secure landfill on Base. Management techniques for affected materials are discussed in the following paragraphs.

Management of Excavated Materials

Off-Base Landfill. Excavated material can be disposed at existing landfills. If the material to be removed is considered to be hazardous waste then disposal at a Class I or Class II-1 site may be necessary.

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The two closest facilities of this type, owned by IT, are located at Benecia (Class I) and Montezuma Hills (Class II-1), about 80 and 50 miles away from McClellan AFB, respectively. Transport of large volumes of material to these facilities will require a major hauling operation at high costs over a long period of time.

In addition, there is a shortage of hazardous waste landfill capacity in California. Deposition of large volumes of soil material in these sites will reduce their capacity to handle waste loadings from current operations. Later in this chapter in the discussion entitled "On-Base Affected Materials", the volume of disposed material and affected soils is estimated to be 70,790,000 cubic feet or 2,622,000 cubic yards. This volume is more than half the available secure landfill capacity in northern California, which has been estimated to be approximately four million cubic yards.

Since several sites may contain soil materials with constituent levels that could necessitate removal to depths reaching groundwater, excavation may pose a significant problem. Removal of materials to depths reaching 80 or 100 feet may be extremely difficult to accomplish. At best, removal of material to these depths will be extremely expensive even if technically feasible.

On-Base Landfill. The design and construction of a secure hazardous waste site on Base would be an alternative to off-site transport of material or treatment and replacement of material. The landfill would have to meet RCRA standards and would require permits from several state agencies. Included would be a hazardous waste facility permit from the state health services department and waste discharge requirements from the regional water quality control board. After construction of an approved facility, affected material removed during excavation would be placed there for permanent disposal.

One advantage of this alternative is that it may be possible during permitting to arrange to dispose of McClellan's operational hazardous waste at such a site.

Heat Treatment. Chemical constituents that are mostly organics, particularly readily volatile organics like solvents, may be converted to gases by application of heat. A possible way to accomplish this would be by placing excavated materials in a rotary-kiln type dryer that would heat the solid material to a temperature that is needed to remove the volatiles. The resultant gases could be ignited to destroy the organics, using supplemental fuels.

If the affected materials vaporize at low temperature, and if these affected materials constitute a relatively small fraction of the total material mass, thin layers of material may be applied on ground surfaces to utilize solar heat to volatilize the constituents. This process results in hydrocarbon emissions to the atmosphere which may require air pollution control measures. The major limitation of heat treatment is that it is only effective for organic constituents.

Extraction with Solvents. Constituents may also be removed by leaching affected materials with suitable solubilizing or chelating agents. Leaching may be accomplished by mixing an appropriate solvent with the material mass and draining the resulting solution from the mixture either by gravity or by the use of vacuum-type filters. The spent solvent could then be recovered using distillation or exchange processes. Recovered solvent may be returned to the solid material for additional passes until the desired level of constituent removal is achieved. Depending on the type of solvent used, it may be necessary before replacement to cleanse the remaining solvent in the affected material with water. Because of water solubility, certain alcohols may be suitable as a solvent for removing many organic substances. Trace metals may be removed from affected materials with the use of strong chelating agents such as EDTA. The final choice of solvent and removal system would depend largely on the specific natures of the particular materials to be treated. This type of operation has not yet been done on a large scale.

Microbial Decomposition. It may be possible to use microorganisms to treat affected materials. Organisms are often used to metabolize constituents for treatment of dilute solutions of liquid industrial wastes. Oil refinery wastes are commonly treated by landfarming in which the wastes are plowed into soil surfaces where aerobic conditions and viable cultures of organisms are maintained. Microbes suited to this environment then metabolize the organic constituents into innocuous constituents. Microbial degradation may be enhanced by addition of moisture, trace materials, and/or a nutrient source. Such systems are used in the ridge-and-furrow composting of wastewater sludges.

The major limitation of microbial decomposition is that it is only effective for organic constituents.

Fixation. Fixation can be used to immobilize constituents by altering the physical state of the affected materials. This is usually accomplished by the addition of chemical agents to affected materials to produce a final product resembling weak concrete. A number of commercial fixation processes are currently available. Fixation technology is most often used to solidify liquid wastes so that, when water contacts the affected material, constituents are not mobilized.

Fixants typically used are cement, lime, fly ash, and other solidifying materials. It is sometimes necessary to add soil in addition to the fixatives to make the weak concrete. These processes are particularly effective when the constituents are inorganic in nature, such as plating wastes. However, commercial processes are available for organic materials.

Although unproven technology, materials containing organic constituents could possibly be fixed by addition of a small amount of asphaltic material. Both hot asphalts and emulsified asphalts might serve this purpose.

Site Closure

Closure of disposal sites, land treatment facilities, and storage areas (when no longer used) to meet Resource Conservation and Recovery Act (RCRA) requirements may be a desired alternative. In most cases proper closure will be in a manner to comply with Section 267.10 of RCRA for facilities in operation after 1976. For each individual site the exact closure requirements and procedures will reflect the type of site, the nature and amount of waste, location and topography, and geological and soil profiles as well as other considerations that must be evaluated. Under certain conditions closure may include the implementation of a groundwater monitoring program.

In Situ Management of Affected Materials

Several of the treatment methods that were discussed for excavated materials could be used on an in situ basis by leaving the material in the ground and altering its chemical or physical properties. These methods include heat treatment (air stripping), solvent extraction, microbial degradation, and fixation. In situ treatment requires bringing the treating or fixing agent into contact with the material in the voids of its physical structure. This contact is ordinarily brought about by either pressure injection or gravity percolation of the treating agent. If solvents are introduced to "cleanse" in-place materials then the resulting solution may have to be removed from the ground and treated.

Percolation. Percolation is the process through which fluid materials are introduced into solid material by gravity flow. A percolation pond could be constructed on the surface to introduce solvents or fixation materials into the underlying soils through a series of wells.

Injection. Solvents or fixants can be introduced using injection techniques through wells. Injection has been used to isolate waters or problem wastes to deep aquifers where the intervening materials will not permit percolation by gravity. In practical applications the aquifers are generally very permeable and the injection head is usually only the depth of the well.

It is possible to increase the pressure on an injection well to increase the flow into the well. However, there are physical limits on the amount of pressure that can be applied. Since soil density is typically about twice that of water, a cavity will be formed and upheaval may occur at the surface if the pressure head is increased to more than twice the depth to the point of injection. The ability to inject fluids into soil is highly dependent on soil permeability.

Gas Injection. It may be possible to inject ambient air, heated air, or other gases into unsaturated soils and materials. The gas would return to the surface carrying with it volatile organic materials.

Where the constituents are volatile organics this may be a viable solution.

If air pollution associated with the materials flowing out of the ground presents a problem, it may be necessary to operate the system in reverse, using vacuum pumps to draw air into the wells. The contaminated air could then be treated, probably with activated carbon or other cleansing units.

Gas scrubbing of constituents from solid material is untried and untested technology. Should such a system be contemplated considerable predesign research and testing will be required. The major drawback of this system is that it is only effective on organic constituents.

Capping. One method of material management is to leave the material in place and cover affected surface areas with an impermeable seal. The material used for the seal could be clay, cement, asphalt, or other material of that nature. Caps are constructed to be sloped in such a manner so that rainfall is diverted away from the site and is not permitted to recharge through affected material. In this way the site is sealed from intrusion of surface water.

Alternative Measures for Affected Groundwater

Where a contaminated groundwater pool exists the options are to (1) remove the affected water, or (2) isolate the affected water and its constituents to prevent continued migration to unaffected areas.

Removal of Affected Water

The removal of constituents from groundwater is dependent on the ability to pump or drain the aquifer. It might be possible to drain the aquifer by installing an artificial drain perpendicular to the aquifer. This could be accomplished by excavating past the aquifer and then installing gravel and a pipe in the trench. The pipe would terminate in a sump or sumps which could be pumped intermittently. The depth below surface for which this method is effective is limited to current trenching techniques.

Another method of removal of affected water is by installation of a series of withdrawal wells. The wells are installed and perforated at depths that will provide for removal of affected water zones. The distance between wells is based on local hydrogeological conditions. Good producing water zones are necessary for this system to be effective.

Alternately, it may be possible to excavate several deep holes to the groundwater level and install a Ranney collector system. In this system a machine could be lowered into the holes and perforated pipe could then be jacked horizontally to provide the required drainage. This technology is used to jack pipes under highways and other structures for drainage and for tapping water sources below surface water bodies; it is expected that such jacking could force a drainage pipe up to 500 feet into an aquifer.

Isolation of Affected Groundwater

It may be possible to contain affected groundwater under a site or group of sites by surrounding the groundwater with slurry walls, generally constructed of clayey material. Coupled with capping the surface to prevent infiltration, this technique could effectively isolate problem areas. Depending upon the depth to groundwater, extensive excavation could be required to install the slurry walls. The placement of slurry walls hydraulically by injection is possible in certain situations, depending upon soil permeabilities. The use of slurry walls is not recommended for isolation of sites containing plating wastes or other low/high pH waste material as caustic materials tend to destroy the integrity of clay barriers.

The affected waters might also be effectively isolated by injection of water through wells located around a site or an area to create a "mounding" effect. This system requires that the soil material be highly permeable so that an effective mound can be created.

Treatment of Affected Groundwater

When the water removed from an aquifer contains constituents that negate its direct discharge to receiving water bodies, some type of treatment may be necessary. If only volatile organics are present in small quantities, the treatment might consist only of spraying the water

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into the air while watering the landscape to permit the organics to volatilize. Activated carbon treatment along with coagulation/flocculation (for trace metal removal) in small package units might be used to treat the affected water. Air stripping may be used in tandem with activated carbon for organic removal. The removal of organics by air stripping tends to extend the operational life of carbon. A drawback of air stripping is the air pollution problem that could be created.

Alternative Measures for Industrial Waste Line Remediation

To minimize the amount of water that is transferred from the surface to the first sands zone, the leaking industrial waste line can be rehabilitated or replaced. The technologies involved in these endeavors are those that are routine and common practices. Included in these alternatives are: (1) repair the line in place by pressure grouting; (2) locate leaks and replace sections by excavation; (3) thread plastic pipe sleeve through the existing line; and (4) install a new line next to the existing problem line.

Pressure Grouting

In this procedure, the leaks are located by means of video camera inspection or by localized air testing procedures. Once located, the defective sections of the line can be repaired by pressure grouting from the inside with a chemical sealant. The sealant is solidified by a catalyst after being forced into the leak.

Excavation

In this procedure, after the leaks have been located, the trench is re-excavated and the leaking sections or joints are replaced. This is accomplished by using a plain-end type of coupling to secure the new pipe lengths to the adjacent sections that are still in place.

Pipe Sleeving

In this procedure, a suitable type of plastic pipe is threaded into the existing pipe to provide a secure conduit for transporting the liquid. The existing pipe provides the structural capability and the interior threaded sleeve provides the hydraulic integrity.

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Installation of New Line

When the existing line is determined to have numerous leaks or is badly deteriorated, it may be the most cost-effective solution to abandon the line and construct a new line to provide reliable capability.

ON-BASE AFFECTED MATERIALS

Problem Definition

The assumption throughout Phases I and II of the IRP has been that past Base disposal practices could be affecting groundwater quality. Materials that could affect the groundwater as a result of disposal practices include materials disposed, as well as the soil column underlying the disposal/storage sites to the depth of the shallow groundwater. The soil column may have been affected by the downward migration of constituents from the disposal area as was graphically illustrated on Figure 2.6. The affected materials could constitute a continued source of potential groundwater quality problems.

Affected Sites

Forty-six disposal/storage sites have been identified on the Base. During the Phase II field program, monitoring wells were installed downgradient from some of the past disposal sites. On the basis of the presence or absence of constituents identified in those wells, the 46 sites have been evaluated according to their identified contribution to groundwater problems. These site evaluations were presented on Table 4.23.

For each of the 21 sites identified as affecting groundwater quality, the estimated volume of disposed material as well as the estimated volume of the affected soil column from ground surface to the shallow groundwater are presented in Table 5.1. Similar information is presented in Table 5.2 for those sites not identified to be affecting groundwater quality. The sites that have been assumed to affect the shallow groundwater comprise over 14 million cubic feet of disposed material, and the affected soil column would constitute over 56 million cubic feet of material. It should be noted that these volumes are only gross estimations; actual volumes may vary significantly. The estimated

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TABLE 5.1

ESTIMATED VOLUME OF AFFECTED MATERIALS AT SITES AFFECTING GROUNDWATER QUALITY McCLELLAN AFB, CALIFORNIA

Area	Disposal/Storage Site Affecting Groundwater Quality	Estimated Volume of Disposed Material (1,000's cu ft)	Estimated Volume of Affected Soils (1,000's cu ft)
A			
	25	3,000	12,500
	37	*	10,000
	38	**	**
	40	240	3,800
	Area A Total	3,240	17,300
B			
	30	97	4,000
	36	***	***
	Area B Total	97	4,000
C-1			
	41	2,000	9,000
	42	1,200	5,000
	43	1,100	4,400
	Subarea C-1 Total	4,300	18,400
C-2			
	7	600	1,600
	8	500	1,300
	9	600	1,600
	10	600	1,600
	11	600	1,600
	Subarea C-2 Total	2,900	7,700
D	2	600	1,600
	3	600	1,600
	4	600	1,600
	5	600	1,600
	6	500	1,300
	26	600	1,600
	27	0.4	3
	Area D Total	3,500.4	9,303
	BASE TOTAL	14,037.4	56,703

* Material removed (see Table 2.1).

** Site is Building 475.

*** Site is storage area.

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TABLE 5.2

ESTIMATED VOLUME OF AFFECTED MATERIALS AT SITES NOT IDENTIFIED TO BE AFFECTING GROUNDWATER QUALITY McCLELLAN AFB, CALIFORNIA

Area	Disposal/Storage Site Not Identified to be Affecting Groundwater Quality	Estimated Volume of Disposed Material (1,000's cu ft)	Estimated Volume of Affected Soils (1,000's cu ft)
A			
	39	3,000	8,000
	Area A Total	3,000	8,000
B			
	35	*	3,000
	Area B Total	0	3,000
C-1	17	600	1,600
	18	600	1,600
	19	600	1,600
	20	1,500	3,800
	21	1,700	4,400
	22	2,000	3,200
	28	4,000	3,200
	32	51	2,000
	Subarea C-1 Total	11,051	21,400
C-2	12	600	1,600
	13	600	1,600
	14	600	1,600
	15	0.4	3
	16	0.4	3
	Subarea C-2 Total	1,800.8	4,806
D	1	2,000	5,000
	33	400	7,000
	Area D total	2,400	12,000
Isolated Sites			
	24	1,500	4,000
	29	80	3,200
	31	400	3,200
	34	80	3,100
	45	450	7,200
	46	**	**
	Isolated Sites Total	2,510	20,700
	BASE TOTAL	20,761.8	69,906

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* Material removed (see Table 2.1).

** Affected material has been excavated and transported to approved site.

volume of affected soils reflects the amount of material that is present beneath each site down to the water table. Actual excavation would entail removal of significantly more material. Excavation to the depths that might be necessary would require removal of significant amounts of soil from sidewalls.

Alternative Corrective Measures

To eliminate potential sources of groundwater contamination, a number of alternative options are available. Table 5.3 lists these alternatives along with equipment requirements, identified short and long-term impacts, and the advantages and disadvantages associated with each alternative measure. That generic summary delineates options available for affected material management. The alternatives that entail in situ treatment do not appear practical for the particular geologic regime underlying McClellan AFB.

For injection of a fixant into either the soils above the shallow groundwater or into the aquifer material itself, the limiting conditions would be the permeability of these materials and the corresponding pressure that would need to be applied to inject the fixant. Based on the permeability determined from field test results, injection wells would need to be placed at such close distances to each other as to make this system impractical (i.e., about one foot apart). Further discussion is contained in Appendix T.

Since the geology of the area effectively limits the treatment of affected materials in place, alternatives that can be considered include excavation to remove the material from the ground as well as capping the sites to isolate them from surface water intrusion. Table 5.4 identifies the alternative technologies potentially applicable to each site. Since no samples were taken of site materials in this project the application of the different management techniques is based upon background information summarized in Table 2.1.

It should be kept in mind that removal of affected soils would have no effect upon the shallow groundwater which currently contains identified chemical constituents. This shallow groundwater would continue to move downgradient and off the Base.

TABLE 5.3

ALTERNATIVE CORRECTIVE MEASURES FOR AFFECTED MATERIALS
McCLELLAN AFB, CALIFORNIA

Measure	Description	Major Required Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Excavation/ Off-Base Landfill	Excavate affected sites to shallow groundwater. Acquire fill material to replace removed soils. Transport material to approved off-site hazardous waste landfill.	. Excavation equipment . Hauling trucks . Fill material	None	. Generation of truck trips from Base to landfill over years . Local noise and air pollution problems caused by truck traffic . Air pollution problems caused by excavation . Disruption to localized areas from excavation	Elimination of hazardous waste landfills in area	Removal of constituent source material	. Extensive excavation . Reduce lifetime of approved hazardous waste landfills in area . Existing contaminated shallow groundwater would remain
Excavation/ On-Base Landfill	Design and develop secure hazardous waste landfill on Base. Obtain permits from state and local agencies. Excavate affected sites to shallow groundwater. Acquire fill material to replace removed soils. Transport material to on-base hazardous waste landfill.	. On-base landfill . Excavation equipment . Conveyor/hauling system . Fill material	Inspection and monitoring of landfill	. Air pollution problems caused by excavation . Disruption to localized areas from excavation	Consolidation of material into one secure site area	. Removal of constituent source material . No material sent to area hazardous waste landfills	. Extensive excavation . Excavated material is still on Base . Existing contaminated shallow groundwater would remain

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TABLE 5.3 (Continued)

Measure	Description	Major Required Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Excavation/Heat Treatment	Excavate affected sites. Heat the material in rotary kiln to remove volatiles and replace material (additional fill may be necessary).	. Excavation equipment . Conveyor system . Rotary kiln equipment	None	. Disruption to localized areas from excavation . Air pollution problems caused by excavation	Metals would remain available within the soil for potential migration into groundwater	Organics would be removed from material	. Extensive excavation . Only organics are removed; metals remain in material . Affected shallow groundwater would remain
Excavation/ Extraction with Solvents	Excavate material and place within concrete-lined containment areas; if material contains organics, leaching with ethyl alcohol is possible. Removal of metals could be by strong chelating agent (EDTA). Determine operational requirements for solvents by field testing.	. Excavation equipment . Conveyor system . Leaching fluids . Leachate collection and treatment system	None	. Disruption to localized areas from excavation and leaching operation . Air pollution problems caused by excavation	Removal of contaminant sources to groundwater	Removal of contaminants from material	. Extensive excavation . Residual leaching water requires treatment . Affected groundwater would remain . Not a proven technology

TABLE 5.3 (Continued)

Measure	Description	Major Required Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Excavation/ Microbial Decomposition	Excavate affected sites. Place material on concrete-lined containment areas. Mix microorganisms that were developed for specific wastes with this material. Additional fill may be necessary.	. Excavation equipment . Conveyor system . Strain of microorganisms developed for specific waste requirements . Contact areas	None	. Disruption to localized areas from excavation . Air pollution problems caused by excavation	Metals would remain in material	Organics would be removed from material	. Extensive excavation . Remaining shallow groundwater available for flow off Base . Metals would remain in material . Not a proven technology
Excavation/ Fixation	Excavate affected sites. Treat the excavated material and replace material in site.	. Excavation equipment . Conveyor system . Fixation material and equipment	None	. Disruption to localized areas from excavation . Air pollution problems caused by excavation	Elimination of source material for shallow groundwater contamination	Waste and soil materials are made inert, thereby eliminating shallow groundwater contamination sources	. Extensive excavation . Remaining shallow groundwater available for flow off Base
Capping	Inspect site area to determine if cap is required. If necessary determine the appropriate material to be used. Grade area to drain water from site. Install cap.	. Paving/grading equipment . Asphalt, concrete, clay, etc.	Inspection of cap integrity	Distruption to localized areas from grading operations	Prevention of surface water from contacting waste material	. Prevent additional leachate from being generated by surface water . Isolate sites from surface environment . Standard technology	. Material remains in place . Remaining shallow groundwater available for flow off Base

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TABLE 5.3 (Continued)

Measure	Description	Major Required Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
In Situ Heat Treatment	Install air injection wells into affected soil material. Inject hot air into well and apply pressure to remove volatiles.	. Injection wells . Air blowers . Heat generators . Carbon adsorption unit for air treatment	None	Disruption to localized Base areas	Removal of volatile organic constituents	Removal of volatile organic constituents	. Removal of volatile constituents only . Affected groundwater would remain . Permeability of affected soils too low for injection . Potential air quality impairment . Not a proven technology
In Situ Extraction with Solvents	Inject leaching fluid into affected materials. Install wells downgradient from site to remove seepage from leaching process. Treat leachate with air stripping, carbon adsorption, coagulation/flocculation depending on solvent used.	. Injection equipment . Leaching fluids . Evacuation wells . Treatment units . Injection wells	None	Disruption to localized Base areas	Leachate removal from potentially affected shallow groundwater	Removal of soil contaminants from soil column	. Permeability of soils too low for injection of any leaching fluid . Affected groundwater would remain . Leachates could enter shallow groundwater . Removal of leachates in the groundwater would be inhibitive due to low permeability of sands . Evacuation wells may not remove all impacted water . Not a proven technology

TABLE 5.3 (Continued)

Measure	Description	Major Required Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
In Situ Microbial Decomposition	Inject organic digesting microbes into affected materials.	. Injection equipment . Microbes adapted to specific waste/soil materials . Injection wells	None	Disruption to localized Base areas	Inorganic constituents remain in the soil column	Removal of organic contaminants	. Permeability of soils too low for injection of microbes . Affected shallow groundwater would remain . Inorganic constituents would remain in soil column . Not a proven technology
In Situ Fixation	Inject fixant into affected materials to immobilize contaminants.	. Injection equipment . Fixants selected for particular materials . Injection Wells	None	Disruption to localized Base areas	Immobilization of soil contaminants	Isolation of contaminants from environment	. Permeability of soils too low for injection of any fixant . Affected shallow groundwater would remain . Difficult to assess effectiveness . Not a proven technology
In Situ Gas Injection (Air Stripping)	Install air injection wells into affected material. Pressurize air to "strip" volatile organics or use reverse system by applying vacuum process.	. Injection wells . Air blowers/ vacuum systems . Carbon adsorption unit for air stripping treatment	None	Disruption to localized Base areas	Highly volatile organics would be removed	Removal of highly volatile organics	. Non-volatile and low-volatility constituents would remain in soil . Affected groundwater would remain . Permeability of affected soils too low for injection . Potential air quality impairment . Not a proven technology

TABLE 5.4

ALTERNATIVE CORRECTIVE MEASURES AND ASSOCIATED SITES CONTAINING AFFECTED MATERIALS
McCLELLAN AFB, CALIFORNIA

			Alternative Corrective Measures							
Area	Site Containing Affected Material	Has Source Affected Groundwater[a]	Excavation/ Off-Base Landfill	Excavation/ On-Base Landfill	Excavation/ Heat Treatment	Excavation/ Extraction With Solvents	Excavation/ Microbial Decomposition	Excavation/ Fixation	RCRA Site Closure	Capping
A										
	25	Partially covered by south end of runway overrun								
	37	Material removed in 1956 (see Table 2.1)								
	38	Site is Building 475								
	39	POL tank farm built over site								
	40	Yes	X	X		X			X	
B										
	30	Yes	X	X	X	X	X	X		X
	35	Material removed in 1950 (see Table 2.1)								
	36	Open storage area (See Table 2.1)								
C										
Subarea C-1										
	17	Not Identified								
	18	Not Identified								
	19	Not Identified								
	20	Not Identified								
	21	Not Identified								
	22	Not Identified								
	28	Not Identified								
	32	Not Identified								
	41	Yes	X	X		X		X		X
	42	Yes	X	X	X	X	X	X		X
	43	Yes	X	X		X		X		X
Subarea C-2										
	7	Yes	X	X		X		X		X
	8	Yes	X	X		X		X	X	X
	9	Yes	X	X		X		X		X
	10	Yes	X	X		X		X		X
	11	Yes	X	X		X		X		X
	12	Not Identified								
	13	Not Identified								
	14	Not Identified								
	15	Not Identified								
	16	Not Identified								

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TABLE 5.4 (Continued)

Area	Site Containing Affected Material	Has Source Affected Groundwater[a]	Alternative Corrective Measures							
			Excavation/ Off-Base Landfill	Excavation/ On-Base Landfill	Excavation/ Heat Treatment	Excavation/ Extraction With Solvents	Excavation/ Microbial Decomposition	Excavation/ Fixation	RCRA Site Closure	Capping
D										
	1	Not Identified								
	2	Yes	X	X		X		X		X
	3	Yes	X	X		X		X		X
	4	Yes	X	X		X		X	X	X
	5	Yes	X	X		X		X		X
	6	Yes	X	X	X	X	X	X		X
	26	Yes	X	X		X		X		X
	27	Yes	X	X		X		X		X
	33	Not Identified								
Isolated Sites										
	23	Material removed in 1970 (see Table 2.1)								
	24	Not Identified								
	29	Not Identified								
	31	Not Identified								
	34	Not Identified								
	45	Not Identified								
	46	Material removed in 1981 (see Table 2.1)								

a Based on Table 4.23.

X Technology has potential application based on site contents delineated on Table 2.1.

ON-BASE WATER SUPPLY

Problem Definition

Prevention of contamination of the Base water supply wells is of prime importance to the environmental health of Base personnel. Since the shallow aquifer contains the highest concentrations of chemical constituents within the aquifer systems underlying the Base, the objective for securing the Base water supply will be to prevent shallow aquifer water from entering deeper water-bearing sands.

Chemical constituents may enter the deeper water supply aquifers through the gravel pack of existing water supply wells or deeper monitoring wells. The following sections outline a methodology that should preserve the existing water supply wells while preventing introduction of shallow aquifer constituents into the deeper aquifer systems.

Affected Wells

Any well that has been constructed with continuous gravel pack from the shallow aquifer (occurring at depths less than 80 feet) to the deeper aquifers, and/or perforations within the shallow sands zone, constitutes a potential conduit for chemical constituent migration. Any monitoring well that has been completed with gravel packs at depths greater than 105 feet likewise constitutes a potential conduit. It should be noted that some production wells were constructed in the 1930's and 1940's when the most common drilling method used a cable-tool drill rig. Cable-tool wells do not contain gravel packs, and therefore would not allow constituent migration into deeper aquifers unless perforations were present within the shallow aquifer zone. Table 5.5 lists the known physical characteristics of all Base production and monitoring wells that could be considered as possible constituent conduits.

Well logs available for certain Base production wells indicate that they are all gravel packed except for BW17; this well does not have a gravel pack, and was therefore probably constructed by the cable-tool method. Four monitoring wells constructed in 1980 were gravel packed from the shallow aquifer to depths exceeding 200 feet.

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TABLE 5.5

WELL CONSTRUCTION PARAMETERS FOR AFFECTED BASE PRODUCTION AND BASE MONITORING WELLS McCLELLAN AFB, CALIFORNIA

Well Number	Year of Construction	Drilling Method	Depth of Casing (feet)	Gravel Pack Interval (feet)	First Perforation Interval (feet)	Casing Diameter (inches)	Casing Material
Production Wells							
1[a]	1937	Unknown	400	0-400	162-177	12	steel
2[a]	1937	Unknown	298	0-298	100-112	12	steel
7[a]	1943	Unknown	398	0-398	170	12	steel
8	1943	Unknown	625	0-625	None	10	steel
10[b]	1945	Unknown	400	0-400	170-392	14/10	steel
11[b]	1945	Unknown	400	0-400	154-346	14/10	steel
12[a,h]	1943	Unknown	390	0-390 (?)	164-390	14	steel
13[b]	1945	Unknown	391	0-391 (?)	178-300	14/12	steel
17	1943	Cable tool	353	none	216-224	14	steel
18[a]	1954	Unknown	400	0-400	169-185	14	steel
20	1954	Unknown	600	0-600	178-190	14	steel
28	1968	Unknown	247	0-247	None	8	steel
29	1980	Air	499	0-499	Unknown	12	steel
Monitoring Wells							
1	1980	Auger	249	75-249	75	4	PVC
2	1980	Auger	249	75-249	75	4	PVC
3	1980	Auger	205	70-205	70	4	PVC
4	1980	Auger	249	85-205	85	4	PVC

a Well closed down

b No logs available

Available Alternative Corrective Measures

To ensure that the water quality of the water supply wells is not impaired by the introduction of shallow aquifer water into the system, the gravel pack conduits must be eliminated. Even if the wells were abandoned and removed from production, the gravel packs could still act as conduits in the future.

The gravel packs should be sealed by grouting to prevent downward migration of constituents from the shallow aquifer. In a typical well, this could be accomplished from inside the well casing or from outside the well. Since all the Base production wells are located within housing structures, there would not be enough space to accommodate the equipment needed to seal the gravel packs from inside the well casing. Therefore, sealing the gravel packs would have to be accomplished from outside the well housing.

Monitoring wells 1 and 2 are 249 feet deep and gravel packed from 75 feet downward; they were both abandoned shortly after installation. MW1 was grouted within the entire casing, but the gravel pack was not grouted. In MW2, the casing was grouted from 120 to 249 feet, with perforations starting at a 75-foot depth. MW3 and MW4 have not been grouted; they reach depths of 205 feet and 249 feet, respectively.

The gravel pack around the Base production wells can be sealed by using a slant rotary-wash drilling method. Slant holes could be drilled at compass points around the well down to the estimated depth of the shallow aquifer (a minimum of 75 feet). When the gravel pack is reached, it could be pressure grouted. The grout should be injected from a 75-foot depth to an estimated depth of 120 feet. In BW2 the perforations in the casing begin at a depth of 100 feet, or in the vicinity of the shallow aquifer. Therefore, if the gravel pack were to be pressure grouted in this interval, the grout would probably enter the well casing. This would result in total abandonment of BW2, unless the well housing were removed to allow space for drilling equipment to operate adjacent to the well. The remaining production wells to be sealed include Base wells 7 (abandoned, but the gravel pack not sealed), 8, 10, 11, 12, 13, 18, 20, 28, and 29, assuming that they are all gravel packed. Since there are no well logs available for Base production

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wells 10, 11, 12, and 13, it is unknown if they were gravel packed or completed with cable-tool methods. To ascertain the drilling method used, a video camera can be lowered into the well, and an experienced drilling contractor can determine the drilling method by examining the type of perforations in the well casing. This would determine the need for gravel-pack sealing of Base production wells 10, 11, 12, and 13.

Sealing of the deep monitoring wells 1, 2, 3, and 4 can be accomplished by pressure grouting directly in the well casings. The grout would flow through the perforations in the well casing to the desired elevation. These monitoring wells could be pressure grouted to depths of 100 feet to ensure discontinuity between the shallow and deeper aquifers.

Regular monitoring of the water quality in the production wells would determine the effectiveness of well-sealing over time.

OFF-BASE WATER SUPPLY WELLS

Problem Definition

The direction of shallow groundwater movement is to the south-southwest except where locally influenced by off-base pumping near the western Base boundary. Three wells downgradient from the Base have been closed as a result of contamination; those wells are within approximately 1,000 feet of the Base boundary. Other private and public wells are located farther downgradient, but have not shown excessive concentrations of chemical constituents. It therefore may be inferred that the average distance of shallow groundwater travel away from the Base boundary in the past 40 years has been about 1,000 feet, with local variations due to off-base pumping.

Migration of constituents into existing off-base wells could have occurred through well gravel packs or perforations within the shallow aquifer. However, the well construction of these wells is unknown.

Affected Wells

If the behavior of the shallow groundwater were to follow the same pattern as is presently observed, it would move farther downgradient away from the Base boundaries. Within a 5,000-foot radius south and west of the Base, 14 public wells are known to be located to the south and 13 to the west. The area west of the Base is without public water service. Most homes in the area rely on individual private wells for domestic water supply. Thirteen wells were tested by Sacramento County in 1979 through 1980. One well was found contaminated and was closed. The City of Sacramento provides public water service south of the Base. Future monitoring of the off-base wells could determine potential direction and rate of contaminant migration. Table 4.21 presented the range of constituent concentrations that have been identified in the shallow groundwater, and therefore could be available for migration off Base.

Alternative Corrective Measures

Protection of off-base water supplies from migration of constituents contained in the shallow groundwater aquifer could be accomplished by a variety of measures. The measures could be categorized as either (1) interception of shallow groundwater flow prior to its moving across the Base boundaries or (2) protection of each individual downgradient off-base well from shallow groundwater flowing uninhibited off Base. Table 5.6 summarizes available corrective measures for either protecting each off-base well or intercepting and treating the shallow groundwater around affected areas or at Base boundaries.

Corrective measures applied directly to affected off-base wells would entail sealing the gravel packs of these wells at the depth of the shallow aquifer, or abandoning the affected wells and properly reinstalling new wells. It should be noted that the shallow aquifer is a very poor producer of water, and sealing the gravel pack through the shallow aquifer would not affect the quantity of water available. In addition, the Air Force could advise agencies regulating well installations (e.g., County Public Health Department) that new wells should be constructed with perforations or gravel packs below a minimum depth of 120 feet. This alternative measure would protect the public health downgradient from the Base but would not result in removal of affected groundwater from the downgradient hydrologic regime.

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TABLE 5.6

ALTERNATIVE CORRECTIVE MEASURES FOR OFF-BASE WELLS
McCLELLAN AFB, CALIFORNIA

Alternative Measure	Description	Major Required Equipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Seal gravel packs	Seal gravel packs in off-base wells to a depth of 100 feet. In wells with perforations in the upper sands zone, either use packers in casing, pressure grout through perforations, or abandon well by pressure grouting entire well.	. Drill rigs . Pressure grouting equipment	None	None	Protection of deeper aquifers	. Protection of downgradient private and public wells within areas anticipated to be impacted over the next 80 years . Protection of public health . Reuse of closed wells	None
Regulate installation of future off-base wells	Coordinate well installation guidelines with local regulatory agencies to avoid gravel packs and perforations to depths of 120 feet.	None	Well installation inspection program	None	Protection of local water supply systems from shallow aquifer constituents	Protection of public health	None

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TABLE 5.6 (Continued)

Alternative Measure	Description	Major Required Equipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Install upgradient slurry trench at affected Base boundaries	Divert shallow groundwater flow around the Base. This would prevent recharge to shallow aquifer on the Base leading to eventual drying out of shallow sands.	. Earth-moving equipment for excavation of trench and emplacement . Slurry materials	None	None	Elimination of shallow groundwater under Base	Diversion of shallow groundwater currently flowing under affected Base sites and off Base	. Drying out of shallow aquifer, which acts as interceptor for constituents moving vertically, could permit constituents to migrate vertically to water supply aquifers . Water currently in shallow aquifer on the Base would be available for downgradient migration to the off-base wells (maximum distance would be about 19,000 feet, or possibly 1,000 years of groundwater travel)
Install downgradient slurry walls at affected Base boundaries	Prevent shallow groundwater from leaving the Base. Groundwater behind slurry wall would be pumped out, treated, and made available for other uses. Pumps would be spaced at very close intervals.	. Earth-moving equipment for trench excavation . Slurry materials . Pumps to evacuate groundwater behind slurry wall . Treatment facilities for evacuated groundwater . Reinjection or distribution systems for treated water	. Evacuation pump maintenance . Treatment facility maintenance . Distribution system maintenance	. Prevents additional shallow groundwater from leaving Base . Off-base abandoned wells would remain abandoned	No affected groundwater would flow off Base	Discontinuation of shallow groundwater flow off Base	. Extensive excavation . High maintenance of evacuation pumps . High potential for failure of pumps due to low yield of shallow sands

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TABLE 5.6 (Continued)

Alternative Measure	Description	Major Required Equipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Install slurry walls around affected sites	Isolate affected sites from shallow groundwater flow regime by surrounding each affected site by a slurry wall.	. Earth-moving equipment for trench excavations . Slurry materials	None	Prevents further contribution of chemical constituents to shallow groundwater from affected sites	. Elimination of constituent contribution from affected sites to shallow groundwater . Improvement of off-base water quality in shallow aquifer	Eliminate contact between affected areas and shallow groundwater	. Extensive excavation activities . Difficult to install down to groundwater . Not recommended for containment of caustic wastes
Install upgradient evacuation wells at affected Base boundaries	Surround affected Base boundaries with pumping wells to prevent recharge to shallow sands underlying Base. Evacuated water would be discharged for overland flow (less than 1 gpm).	. Well installation equipment . Evacuation pump . Overland-flow distribution system	Evacuation pump maintenance	None	Elimination of shallow groundwater under Base	Elimination of shallow groundwater flowing under the Base	. High maintenance and therefore potential for failure . Shallow sands have low permeabilities, so pumping would be discontinuous and the wells would need to be spaced at extremely close intervals around Base boundaries . Water currently within shallow groundwater would remain available for off-base flow for possibly 1,000 years
Install evacuation wells downgradient from affected areas	Intercept shallow groundwater flows downgradient from each affected site with pumps spaced at extremely close intervals. Treat evacuated water and discharge overland.	. Well installation equipment . Evacuation pumps . Treatment facilities for evacuated groundwater . Overland-flow distribution system	Maintenance of evacuation pumps, treatment system, distribution system	Prevents any more shallow groundwater from migration off Base	Elimination of constituents entering off-base shallow groundwater	Eliminates off-base flow of shallow groundwater	. High maintenance of pumping system . Wells would be required at extremely close intervals . Cost to treat evacuated groundwater

TABLE 5.6 (Continued)

Alternative Measure	Description	Major Required Equipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Inject water to create groundwater mound around affected Base boundaries	Create a groundwater mound acting as a barrier for off-base shallow groundwater movement. Upgradient evacuation wells would pump ponded water out of system for treatment and disposal.	. Injection wells . Evacuation wells upgradient from injection wells . Water treatment system . Water distribution system	Maintenance of evacuation and injection pumps and water distribution system	Prevents constituents currently in shallow groundwater from moving off Base	No off-base flow of shallow groundwater	Prevents further off-base migration of constituents in shallow groundwater	. High maintenance . Injection wells needed at close intervals . Evacuation wells needed at extremely close intervals
Inject water to create groundwater mound around affected areas	Place injection wells around each affected area. Install evacuation wells inside mound area for removal and treatment of contaminated water and distribution of treated water.	. Injection wells at close invervals . Evacuation wells . Water treatment system . Water distribution system	Maintenance of evacuation and injection pumps, water treatment and water distribution system	Prevents further contribution of constituents to shallow groundwater from affected sites	Constituents currently in shallow groundwater would be moving off Base	Prevents further contribution of constituents from affected sites to shallow groundwater	. Shallow groundwater outside mounds still available for off-base migration . Installation of injection and evacuation wells at extremely close intervals . High pump maintenance program
Install French drain along affected Base boundaries	Excavate trench beyond shallow aquifer and emplace rock fill. Cover drain and install well points to evacuate water. Treat water and discharge for other uses.	. Excavation equipment . Rock material for drain pumps . Treatment facilities . Water distribution system	. Pump maintenance . Treatment system maintenance	Interception of shallow groundwater flowing off-base	Elimination of potential constituent sources for off-base wells in shallow groundwater	Prevents off-base flow of shallow groundwater into private and public wells	. Extensive excavation of trench to a depth of 100 feet . Pump maintenance . Cost of treating evacuated water

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TABLE 5.6 (Continued)

Alternative Measure	Description	Major Required Equipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Install sumps and dewatering pipes along affected downgradient Base boundaries	Excavate localized shafts to shallow groundwater and drive dewatering pipes laterally along the base of the shallow aquifer. Install pumps within shafts to remove draining shallow groundwater. Treat and distribute water.	. Excavation equipment . Dewatering pipes . Pumps . Treatment facilities	Maintenance of dewatering pumps and water treatment system	Interception of shallow groundwater flowing off Base	Elimination of potential constituent sources for off-base wells in shallow groundwater	Prevents off-base flow of shallow groundwater into private and public wells	. Extensive excavation, but only in localized areas . Pump maintenance

Removal of affected shallow groundwater could be accomplished along the Base boundaries by installation of downgradient slurry trenches or groundwater evacuation pumps, by creation of groundwater mounds, or by construction of French drains or sumps at the depth of the shallow sands. Any of the above structural alternatives could be applied to specific disposal sites or areas as listed in Table 5.4. It should be noted that if structural methods were employed on a site-specific basis, the existing affected groundwater would remain available for off-base migration. In addition, if corrective measures were applied along the Base boundaries, affected groundwater already off Base would continue to move downgradient, potentially affecting other wells in the future. Since the groundwater movement is extremely slow except when accelerated by local pumping, these effects will probably not occur for many years.

At McClellan AFB, affected groundwater is contained in an aquifer an average of six feet thick which possibly extends the length of the Base. The permeability of this aquifer probably averages close to 2.5 gpd/ft^2. The aquifer is flowing at a gradient approximating 0.01 percent. The flow of the aquifer is therefore approximately one gallon per foot of cross-section per day. Based on pump test results, a well in this aquifer would be capable of pumping no more than 150 gallons per day. To pump out the aquifer would therefore theoretically require one well for every 150 feet of cross-section. However, the cone of depression for each well would extend only a few feet from the well point because of the low permeability of the shallow sands. Therefore, in order for the cones of depression to interfere with each other, the well points probably would have to be placed closer than one foot on center. Such a system is probably infeasible under these conditions. This means that alternatives which entail pumping water from the first sands zone or injecting material into the ground will not work at McClellan AFB. Further discussion on this limitation is contained in Appendix T.

SECTION 6

RECOMMENDATIONS

CHAPTER 6

RECOMMENDATIONS

The following recommendations for preventive or corrective measures will accomplish the protection of public health on and off the Base, as well as mitigation of environmental impacts that have occurred or may occur off Base as a result of past disposal and storage practices at McClellan AFB. The recommendations are divided into three categories addressing the impacts of affected materials, on-base water supply, and off-base water supply. These recommendations are summarized on Table 6.1. Included with the recommendations is a recommended priority for implementation.

AFFECTED MATERIALS

Chapter 5 discussed the estimated volume of affected disposed material as well as the total volume of affected material reaching to the shallow groundwater. The extensive volumes which would require disposal or treatment following excavation would cause this approach to be prohibitively costly. Table 4.23 delineated the sites that may have affected groundwater quality. Excavating solely the disposed material in these sites would amount to over an estimated one million tons of material to be hauled and disposed. Removal of the affected materials would not mitigate the existing shallow groundwater quality problems.

It is therefore recommended that Sites 4, 8, and 40 be closed to meet RCRA requirements. This will entail development of a closure and post-closure plan that must be approved by the California Department of Health Services. Disposal site 4, the currently open sludge pit, should be abandoned by placing 4 feet of soil/cement mixture into the pit to absorb available moisture. The site should then be graded and capped with impermeable material to prevent infiltration of surface moisture.

TABLE 6.1

RECOMMENDED ACTIONS AND MONITORING
McCLELLAN AFB, CALIFORNIA

Problem	Recommended Action and Monitoring	Rationale	Implementation Priority[a]
Affected Materials	• Ensure that Sites 8 and 40 are closed to meet RCRA requirements	• Prevent precipitation moisture from contacting affected materials/Meet RCRA requirements	2
	• Close Site 4 to meet RCRA requirements to include placing 4 feet of soil/cement mixture within the pit, and subsequently cap the site to prevent surface infiltration	• Absorb moisture on pit surface/ Prevent precipitation moisture from contacting affected materials	1
	• Inspect sites in Area A (25), Area B (30), Subarea C-1 (41, 42, 43) Subarea C-2 (7, 8, 9, 10, 11), and Area D (2, 3, 4, 5, 6, 26, 27) to evaluate status of surface conditions. Cover sites with impermeable cap designed to divert surface water from the site	• Prevent precipitation moisture from contacting affected materials	• Area D: 2 • Subarea C-1: 3 • Area B: 3 • Subarea C-2: 4 • Area A: 4
On-Base Water Supply	• Seal gravel pack on Base production wells 1, 8, 13, 18, 20, and 29 • Abandon BW2 and seal gravel pack • Seal gravel packs in MW1, 2, 3, and 4	• Prevent affected shallow groundwater from entering Base water supply system	2
	• Rehabilitate industrial waste line in front of Building 251	• Minimize amount of exfiltration from pipeline to the first sands zone	2
	• Remove manhole 33A and associated lines	• Prevent accumulation of sludge and eliminate potential contamination	2
	• Conduct investigation on remaining Base industrial waste line	• Identify potential areas of exfiltration into the first sands zone	3
	• Sample monitoring wells annually and Base production wells monthly[b]	• Monitor wells to determine effectiveness of corrective measure	1
Off-Base Water Supply	• Inform local governmental agencies of the need to set up regulations that require a 120-foot sanitary seal for new wells installed in the area	• Prevent new wells from providing migration route between water-bearing zones	1

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TABLE 6.1 (Continued)

Problem	Recommended Action and Monitoring	Rationale	Implementation Priority[a]
	• Inform local agencies of the need to seal gravel packs to a depth of 120 feet on private and public wells along affected Base boundaries	• Prevent shallow groundwater entering water supply wells	1
	• Inform local agencies of the need to monitor public and private wells semiannually within a 5,000-foot radius of affected Base boundaries[b]	• Provide early detection of downgradient migration of affected shallow groundwater	1
	• Investigate feasibility of constructing interception system along affected Base boundaries	• Develop system to prevent off-base migration of affected groundwater	3

a Priorities are ranked as 1 being highest and 4 the lowest.

b Well samples should be analyzed for: volatile compound (TCE); acid compound (pentachlorophenol); base/neutral compound (1,2-dichlorobenzene).

No further action is recommended for Site 46, from which soils containing PCB's have been removed by the Air Force and transported to an approved PCB site.

To prevent precipitation moisture from contacting affected materials it is recommended that sites found to impact groundwater quality be capped with an impermeable barrier. The barrier may be constructed of asphalt, concrete, clay, or other suitable material depending on the individual site location in relation to Base activities. Each site should be inspected to determine if a cap is necessary. This inspection may include physical and chemical analysis of surface materials. Affected sites and corresponding areas are delineated on Table 6.1. Because of the level of constituents in the groundwater beneath Area D it is recommended that sites in this area be given top priority.

ON-BASE WATER SUPPLY

To protect the on-base water supply it is recommended that Base production wells known to have gravel-packed casings be sealed by slant drilling at depths from 75 feet to 120 feet. This would include Base wells 1, 7, 8, 18, 20, and 29. For Base wells 10, 11, 12, and 13, for which no well logs exist, video cameras should be lowered into the wells to ascertain whether they were constructed by cable-tool methods. If they were constructed by cable tool, there would be no gravel packs, and the wells would require no further corrective measures. If the wells did have gravel packs, sealing would be required by slant drilling. Base well 2, with perforations starting at 100 feet, is located in an inaccessible well house. The well house should be removed and the well abandoned by pressure grouting the gravel pack through existing perforations.

Base monitoring wells 1, 2, 3, and 4 should be abandoned by sealing the gravel pack. This can be accomplished by pressure grouting directly into the well casings; the grout would flow through the perforations and move into the gravel packs.

Although the industrial waste line near Building 251 was found to have potential exfiltration problems, the constituents in water from nearby closed production wells were not the same as those found in the soil beneath the line. However, the industrial waste line could be a constant source of water for recharge into the first sands zone. In addition, trace metals were found in soils beneath the industrial waste line which could leach into the water-bearing zone. To eliminate this possibility other portions of the industrial waste line should be examined across the Base. The line in front of Building 251 should be surveyed and inspected for structural integrity, then repaired or replaced depending on the results of the survey. Abandoned manhole 33A and the inlet and outlet lines should be removed.

After sealing Base supply wells and Base monitoring wells, monitoring should be implemented on a regular basis and should continue indefinitely until such time as deemed no longer necessary. As noted on Table 6.2, Base supply wells should be monitored monthly and all monitoring wells should be monitored annually. Constituents to be analyzed should include a tracer from the following groups: volatile compounds (TCE), acid compounds (pentachlorophenol), and base/neutral compounds (1,2-dichlorobenzene).

TABLE 6.2

MONITORING PROGRAM FOR ON-BASE AND OFF-BASE WELLS
McCLELLAN AFB, CALIFORNIA

Wells to be Monitored	Monitoring Frequency[a]
Base Production Wells	Monthly
Monitoring Wells	
Base monitoring wells	Annually
Stages I and II wells	Annually
Off-Base Wells	
City Wells (150,132,131,137,127,136,126,138, 135,155,50,48,61, and 52)	Semiannually
Private Wells 13 wells west of Base within 5,000-foot radius	Semiannually

[a] All wells should be analyzed for:
1. Volatile compound (TCE)
2. Acid compound (pentachlorophenol)
3. Base/neutral compound (1,2-dichlorobenzene)

OFF-BASE WATER SUPPLY

It is recommended that efforts to protect off-base water supply be initiated immediately by informing local agencies of the need to seal affected well gravel packs to a depth of 120 feet. In addition, contacts should be initiated with the local regulatory agencies to ensure that new wells being installed downgradient from the Base boundaries are grouted to a minimum depth of 120 feet.

Because of the geological formation of the first water-bearing sands beneath McClellan AFB, pumping removal of affected water or injection of grout curtains or slurry walls is not practical. The installation of a French drain by conventional trenching and shoring techniques is also not feasible because of the depth to groundwater. To prevent future migration of affected shallow groundwater off Base it is suggested that investigations be initiated to determine the feasibility of construction of an interception drain system along affected Base boundaries.

If such a system is determined to be feasible, individual drain units could be installed at about 1,000-foot intervals along affected Base boundaries. Evacuated water then could be pumped to the existing industrial wastewater system or to a small package treatment unit. Based on flow calculations the treatment system would have to be large enough to handle between 15 and 20 gallons/minute from the entire downgradient Base boundary. Treatment would probably consist of air stripping, carbon adsorption, and possibly coagulation/flocculation. The exact nature of the treatment system would be determined by performing pilot tests on groundwater samples.

It is recommended that the development of an interception pipe be initiated as a Phase III action under IRP. Since this is an unproven technology it is recommended that a scaled-down field demonstration be conducted to evaluate feasibility. If feasibility is proven then installation of such a system downgradient from Area D is recommended. That installation would include intensive monitoring to determine full-scale system effectiveness. If proved effective the system would then be installed downgradient from other areas in the following priority: Subarea C-1, Area B, Subarea C-2, and Area A.

APPENDIX A

SCOPE OF WORK

INSTALLATION RESTORATION PROGRAM
PHASE II FIELD EVALUATION
McCLELLAN AFB, CALIFORNIA

I. DESCRIPTION OF PROPOSED 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 McClellan 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 McClellan AFB.

The presurvey task (Order 18) report incorporated background and description of the sites for this task. To accomplish this survey effort, the following steps will be taken.

A. Review all available background data to develop a comprehensive working knowledge of past and present base operations as they relate to use and disposal of potentially hazardous materials. Included in this review will be the Phase I IRP survey report for McClellan AFB prepared by CH_2M Hill, Inc. of Gainesville FL, and the Final Report for Investigating Groundwater Contamination as of 30 April 1981, for McClellan AFB by Bruner and Zipfel of the Air Force.

B. Visit McClellan AFB and obtain samples, from the twelve (12) existing monitoring wells. A total of twelve (12) samples should be collected from these wells and analyzed for TCE content and organic priority pollutants using GC/Ms.

C. Samples will be collected from ten (10) production wells located at McClellan AFB. Four (4) wells are known to be contaminated. Samples will be collected from each of these four (4) wells; six (6) other production wells will also be selected for sampling. A total of ten (10) samples will be analyzed for organic priority pollutants utilizing GC/MS and for TCE content.

D. All of the foregoing data will be reduced and a drilling program will be developed to produce further data required to characterize the problem.

E. Upon Air Force review of the preliminary analysis and recommended well drilling program, the well drilling phase will be implemented. A total of thirty (30) monitoring wells will be installed in two (2) stages. In this effort, fifteen (15) wells will be installed in Stage I. Samples will be collected from each of these wells and analyzed for organic and heavy metal priority pollutants utilizing GC/MS and AA. Based upon these results and other information gained in Stage I, Stage II will be implemented. In this stage, fifteen (15) additional monitoring wells will be located and installed. Samples will be collected from each of these fifteen (15) wells and analyzed for organic and heavy metal priority pollutants utilizing GC/MS and AA.

1-200

F. All of the information developed in Stage I will be integrated with that of Stage II and an interim draft report will be developed. Recommendations will be made and further drilling needs will be identified.

G. The total magnitude and extent of contamination found in Stages I and II must be identified. To accomplish this task, a total of twenty-three (23) additional monitoring wells will be installed. Samples will be collected from each of these twenty-three (23) monitoring wells. An additional thirty (30) samples will be collected from monitoring wells previously installed at McClellan AFB. The following numbers and types of analyses shall be performed on appropriate samples: 23 heavy metals; 53 GC/MS organic scans; and 53 cyanide tests.

H. Production Well Number 7 at McClellan AFB was closed because of cresylic acid contamination many years ago. The exact location of this well is not known. The contractor will review CE records of buried water distribution facilities in order to localize the search area. The contractor will locate Well Number 7, excavating as required. A steel casing will be installed to bring the wellhead to ground surface. An attempt will be made to clean out and sample the well. If the well cannot be sampled, one of the monitoring wells from Task G above will be installed in this area. Four ground water samples will be obtained from wells in this area and analyzed for cresylic acid.

I. Contamination of the ground water by aliphatic hydrocarbons is suspected in the area around Bldg 704. Four ground water samples will be obtained from monitoring wells in this area and analyzed for aliphatics.

J. A pump test will be conducted on Well Number 28 to determine general aquifer characteristics. Two (2) piezometers will be installed at predetermined locations. Water-level measurements will be taken during pumping to determine aquifer characteristics.

K. A total of four (4) water samples shall be obtained from wells 17 and 18 near the old PCB site. These samples shall be analyzed for PCBs.

L. The integrity of the industrial waste collection system in the vicinity of Building 251 will be evaluated. The line will be temporarily plugged and flooded. The static water level will be monitored to determine if exfiltration from the industrial waste line is occurring.

M. Install three (3) ten-foot deep auger holes at selected locations along the industrial waste collection line in the vicinity of Building 251. Six (6) samples will be examined to determine if industrial waste contamination is occurring by performing GC/MS scans and heavy metal analyses.

N. Monitor ambient air quality for total hydrocarbon at each site described above during drilling operations.

O. All wells installed by the contractor shall be in accordance with USATHAMA well installation guidelines. A copy of these guidelines has been provided to the contractor. Additionally, the bottom ten feet of well casing will be made of 316 stainless steel.

P. Data collected in this task must be reviewed and assessed to include the following major items:

1. preparation of stratigraphic cross-sections,

2. preparation of graphical displays of principal data parameters,

3. preparation of piezometric surface maps for the shallow aquifer,

4. preparation of a flow net map for the shallow aquifer.

Q. Preliminary concept engineering analysis for remedial actions will be accomplished and conceptual remedial action plans prepared for each contaminated area discovered during this investigation.

R. Prepare a final report which will document all survey activities conducted at McClellan AFB. This report will include applicable raw data, all maps and computations and all remedial action plans prepared pursuant to this project. The magnitude and extent of environmental contamination will be delineated. Recommendations for actions necessary to mitigate adverse environmental effects of existing contamination problems must be included. Potential ways of restoring the environment to as near a normal level as is practical will also be included. Future environmental monitoring programs necessary to document environmental conditions at McClellan AFB must also be included.

S. McClellan AFB personnel will survey all monitoring wells described above. The wells will be surveyed to tolerances of ± 3-feet horizontally and ± 0.1 foot vertically.

T. Meet with representatives of HQ AFLC/DE/SG, McClellan AFB/SG/DE, AFMSC, and the USAF OEHL four times during this project to review progress of investigations, and resolve problems which may be encountered. Two meetings will be held in Sacramento CA and two will be held at the Engineering Science Office in Arcadia CA.

II. SITE LOCATION AND DATES

McClellan AFB, California
Bldg 334, Bioenvironmental Engineering

28 Sep 1981

III. BASE SUPPORT. McClellan AFB will provide adequate office and field laboratory space.

IV. GOVERNMENT-FURNISHED PROPERTY: None.

V. GOVERNMENT TECHNICAL POINTS OF CONTACT:

1. Dr Dee Ann Sanders
USAF OEHL/ECW
Brooks AFB TX 78235
(512) 536-3305

2. Lt Col Milo Myers
USAF Clinic McClellan/SGB
McClellan AFB CA 95652
(916) 643-3672

3. Mr Paul Bruner
2852 Civil Engineers/DEEX
McClellan AFB CA 95652
(916) 643-3336

APPENDIX B

KEY PROJECT PERSONNEL

APPENDIX B

KEY PROJECT PERSONNEL

D. R. Anderson
F. R. Bowerman
R. E. Brogden
S. L. Deering
J. T. DeZellar
L. E. Doane
J. Ehmann, Ph.D.
F. C. Healy
T. H. Luiten
G. S. Magnuson
J. L. Mang
T. K. Martella
Y. Nordhav
J. L. Rubin

Biographical Data

DONALD R. ANDERSON

Sanitary Engineer

PII Redacted

[redacted]

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 water quality master plans for Lake Tahoe and Napa Valley, California, and the San Francisco Bay-Delta.
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 technical direction of projects involving preliminary water quality studies and master planning, water resources development, solid waste management/resource recovery, and wastewater collection, treatment and disposal. Project activities include development of a master plan for wastewater management for the Greater Seoul, Korea, area. Served as Project Manager for conceptual design of an industrial waste management program for zero discharge for IBM at Tucson, Arizona.

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. Cracup 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

PII Redacted

[redacted]

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, 1962)
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)
Smithsonian Institution (Consultant)

Frank R. Bowerman (Continued)

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. Conducts national and regional hazardous waste management seminars and supervises design of remedial hazardous waste control measures for industrial facilities. Served as project manager on development of a comprehensive solid waste management system for Orange County, California, and a study of the feasibility of co-disposal of municipal sludge and refuse for the Orange County Sanitation Districts. Served as technical director of hazardous waste investigations/groundwater monitoring studies and at two California Air Force bases as part of the U.S. Air Force's Installation Restoration Program - Phase II. Other recent projects include: investigation of soil and groundwater contamination at a semiconductor firm which included representation at government agency meetings for institution of an ameliorative program; investigation of trace metal distribution in soil to determine the extent of contamination which resulted from past handling practices at Drew Manufacturing Company in Berkeley, California; and development of soil and groundwater contamination cleanup programs at a semiconductor firm which involved sensitive negotiations with state and local agencies on acceptable ameliorative measures.

Frank R. Bowerman (Continued)

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.

"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.

Frank R. Bowerman (Continued)

"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).

"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).

"Surface Impoundment of Hazardous Waste," presented at Hazardous Waste Disposal Seminar, Hazardous Materials Control Research Institute, Baltimore, Maryland, August 1981.

"Hazardous Wastes in Orange County, California," presented to Environmental and Engineering Council, Orange County Chamber of Commerce, Santa Ana, California, September 1982.

Biographical Data

ROBERT E. BROGDEN

Hydrogeologist

PII Redacted

[redacted]

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 and surface water resources of Pierce

Robert E. Brogden (Continued)

	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 Reservation and the geology and hydrology of the Arapahoe aquifer.

Robert E. Brogden (Continued)

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. In charge of groundwater development projects, surface water investigations, and water rights studies. 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. Involved in soil and groundwater contamination studies at two semiconductor firms in California including examination of past waste disposal practices, establishment of a monitoring well and soil boring program to determine the extent of contamination, and development of an ameliorative program. Also participated in groundwater monitoring and soil sampling and analysis for development of remedial action and environmental restoration plans at several U.S. Air Force Bases.

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

Robert E. Brogden (Continued)

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 groundwater flow, and extent of groundwater contamination.

PII Redacted

Biographical Data

STEPHEN L. DEERING

Sanitary Engineer

[redacted]

Education

B.S. in Civil Engineering (Sanitary/Environmental Engineering), 1972, Tufts University, Medford, Massachusetts

M.S. in Sanitary Engineering, 1977, University of California, Berkeley

Professional Affiliations

Registered Professional Engineer (California No. C 26514)
American Society of Civil Engineers
American Water Works Association
Water Pollution Control Federation

Honorary Affiliations

Chi Epsilon

Experience Record

1970-1971	Haley & Aldrich, Inc., Cambridge, Massachusetts. Soils Lab Technician and Engineering Assistant. Performed shear, Atterberg limits, and consolidation tests.
1971	Herman G. Protze, Inc., Newton Highlands, Massachusetts. Concrete Inspector. Responsible for slump tests, preparation of cylinders, form and rebar examination, and safety requirements for large construction projects in Boston, Massachusetts.
1972	Lower Cape Foundation Company, Eastham, Massachusetts. Foreman of concrete construction crew and responsible for excavation, setting, and placing concrete house foundation footings.
1973-Date	Engineering-Science. Project Engineer. Involved with all phases of planning, report preparation, design, and specification, bid estimation, and construction supervision on water supply and wastewater disposal projects as well as inspection of sewer lines using

Stephen L. Deering (Continued)

air and water pressure techniques. Conducted extensive sewage collection system plan checking for subdivision development for a municipal sewer district and for design of sewerage collection and pumping systems. Involved in Greater Kathmandu, Nepal, Water Supply and Sewerage Project for spring and well domestic water source development and water treatment plants rehabilitation; designed 80 km of water and sewer pipe and coordinated aerial survey, soils testing, raw water and sewage pump stations design, and two sewage treatment plant designs. Assisted with the Clean Water Grant (PL 92-500, Section 201) project report and environmental impact report in San Diego County, California, which called for a sewer district planning study, a flow metering study, and design of a sewage package pumping station, force main, and a four-compartment, 20-acre percolation pond. Completed final review and coordination of plans and specifications for five sewage pump stations, 6.3 miles of gravity sewer and force mains, and a sewage treatment plant expansion for a sewerage consolidation project at Monterey Peninsula, California.

Senior Project Engineer. Shared responsibility for design of a 2.7 mgd Maryland City two-stage pure oxygen activated sludge sewage treatment facility including flow equalization, nitrification, solids contact phosphorus removal, mixed media filtration, ozone disinfection, gravity sludge thickening, anaerobic sludge digestion, and sludge filter pressing. Responsible for design of an 18-mile treated sewage effluent land outfall and plan checking sewage collection system designs for subdivision developments for the Fallbrook Sanitary District in San Diego County, California. Also responsible for application of safety and OSHA procedures required for maintenance of complete life support system as part of hazardous waste cleanup program at a U.S. Air Force base. Prepared process evaluation and design of solids handling and raw sewage equalization facilities for the Rancho Santa Fe pollution control plant expansion.

Involved in the World Bank funded Colombo, Sri Lanka, Sewerage Project including design of rehabilitation for 11 existing pump stations, 161 km of new force mains and sewers, 14 new pump stations, and two new 1,500-mm diameter ocean outfalls. Participated in retrofitting design of three raw sewage pump stations of 60, 80, and 100 mgd capacities for the Greater Bombay sewerage project in India.

Stephen L. Deering (Continued)

Project Manager (1979-Date). Developed a flood control plan for the City of San Marcos including preliminary channel design for capacity up to 7,400 cfs. Managed a water main relocation project for a section of new Interstate Highway 15 for Rainbow Municipal Water District. Supervised a water treatment and distribution system study investigating potable water quality, fire system adequacy and safety, and industrial water quality criteria at the U.S. Naval Ship Research and Development Facility. Responsible for contract administration for a sewage treatment facility expansion in San Diego County, California.

Biographical Data

JEFFREY T. DeZELLAR

Civil Engineer

PII Redacted [redacted]

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. Investigated potential groundwater and soil contamination associated with past hazardous waste disposal for a semiconductor firm and the U.S. Air Force.

Conducted engineering studies for a comprehensive solid waste management program for Orange County, California. Performed analysis and evaluation of the present landfill and transfer station system, the need for additional or improved facilities and equipment, present and projected waste quantities and composition, materials recovery, landfill gas recovery, waste-to-energy system, hazardous waste management, financial and institutional arrangements, and present and projected solid waste management costs. Performed engineering analysis of available solid waste quantities and traffic considerations for a co-disposal project for the Orange County Sanitation Districts.

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

PII Redacted

[redacted]

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 regional 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 Edwards and McClellan Air Force Bases in California, 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

PII Redacted

[redacted]

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 the U.S. Air Force at Edwards and McClellan AFB's in California. Also assisted with NPDES permit application and the monitoring of pollutants discharged under existing permits.

Biographical Data

FRANK C. HEALY

Groundwater Geologist

PII Redacted

[redacted]

Education

B.A. in Geography, 1974, University of Denver, Colorado
B.S. in Geology, 1980, Metropolitan State College, Denver, Colorado

Professional Affiliations

Association of Engineering Geologists Associate Member)
National Water Well Association, Technical Division

Experience Record

1974	U.S. Geological Survey, Environmental Geology Division, Lakewood, Colorado. Geologic Technician. Assisted in the compilation of geologic and land use maps of Jefferson County, Colorado, and Cape Girardeau, Missouri.
1977-1979	F. M. Fox & Associates, Inc., Wheat Ridge, Colorado. Geologist. Conducted engineering geology studies, groundwater investigations, water quality monitoring, and field investigations including geologic mapping, site evaluations, and test hole drilling, coring, and sampling. Prepared designs and operation plans for sanitary landfill and fly ash disposal sites. Performed investigation and prepared designs for sewage disposal system along the Colorado Front Range.
1979-1980	Colorado Geological Survey. Ground Water Investigations Section, Denver, Colorado. Geologist. Responsible for conduct of several geologic investigations concerning geothermal energy potential and groundwater quality in Colorado. Served as Project Chief for statewide groundwater quality mapping project and geothermal commercialization program.
1980-Date	Engineering-Science. Groundwater Geologist. Involved in a variety of hydrogeologic studies for municipal, Industrial, and agricultural clients. Serves as Project Hydrologist for groundwater development

Frank C. Healy (Continued)

studies and water resource and water rights investigations. Involved in pump tests, well design and inspection, hydrologic baseline studies, and report preparation.

Biographical Data

THEODORE H. LUITEN

Construction Engineer/Estimator

PII Redacted

[redacted]

Education

A.S. in Engineering Drafting, 1969, Citrus Community College, Azusa, California

B.S. in Engineering Technology, 1976, California State Polytechnic University, Pomona

Professional Affiliations

Engineer-in-Training (California No. 38427)
American Society of Professional Estimators

Experience Record

1968-1972	Conrac Corporation, Duarte, California. Draftsman. Prepared mechanical and electrical drawings.
1972	Envirogenics Company, El Monte, California. Designer. Constructed and tested prototype reverse osmosis water systems.
1973	Kennedy Engineers, Inc., San Francisco, California. Draftsman. Prepared civil, electrical, piping, and structural drawings for sewage treatment plants.
1973-1976	Conrac Corporation, Duarte, California. Design Draftsman. Responsible for design and layout of electromechanical devices and printed wiring boards.
1976-1978	The Ralph M. Parsons Company, Pasadena, California. Cost Engineer. Responsible for cost control and fund allocation forecasting on a portion of the ARAMCO project.
1978	P. H. Luiten & Associates, Arcadia, California. Construction Manager. Involved in engineering and construction of light industrial buildings and similar structures.
1978-Date	Engineering-Science. Construction Engineer/Estimator. Responsible for preparation of construction cost estimates and contract administration during construction for a variety of projects including

Theodore H. Luiten (Continued)

water, wastewater, and industrial waste treatment plants, sewage collection systems including inspection of sewer lines using air and water pressure techniques, and other environmental control facilities. Prepared preliminary cost estimate for San Luis Obispo Water Reclamation Plant.

Prepared definitive cost estimate for small hydroelectric plant in Alaska. Also prepared performance requirements and developed cost estimate for small hydroelectric installation at wastewater reclamation facility proposed for San Luis Obispo.

Biographical Data

GORDON S. MAGNUSON

Civil Engineer

PII Redacted

[redacted]

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.

Division 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).

"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

PII Redacted [redacted]

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 problems with emphasis upon water and soil chemistry. Responsible

James L. Mang (Continued)

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 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 U.S. Air Force bases including groundwater monitoring, soil sampling and analysis, industrial wasteline investigation, and development of remedial action and environmental restoration plans. Managed soil and groundwater contamination studies at two semiconductor firms in California involving groundwater monitoring and soil sampling to determine the extent of contamination, and developed ameliorative programs to meet strict government agency regulations. 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 ineluding 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. 2D02, 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

TOM K. MARTELLA

Hydrogeologist

PII Redacted [redacted]

Education

B.S. in Geology, 1975, Fort Lewis College
Domestic Water Supply Planning, Water Well Technology, Hydrogeology, and Pump Service, Installation, and Selection, 1976, Fort Lewis College

Professional Affiliations

American Water Resource Association
National Water Well Association

Experience Record

1973	Amoco Minerals Corporation, Alaska. Assistant Field Geologist. Supervised geochemical and geophysical survey data collection on mineral exploration program for molybdenum and copper mine sites.
1974	U.S. Forest Service. Geologic Field Technician. Participated in project to locate and evaluate sites for potential gravel pit development for Forest Service road construction. Performed soil compaction tests, moisture content evaluations, and surveying duties.
1975 and 1977-1978	Rio Blanco Oil Shale Company. Geologic Drafter/ Illustrator. Prepared various graphic materials for Rio Blanco oil shale project reports and presentations. Prepared site and process illustrations for magazines and brochures. Assisted in cross-section preparation, lithology, and preliminary mine construction calculations.
1978-1980	Wright Water Engineers. Project Geologist (1978-1979). Responsible for data analysis and interpretation, preparation and review of reports, and training of field personnel on Rio Blanco oil shale project.

Tom K. Martella (Continued)

Hydrogeologist (1979-1980). Served as project engineer on various water supply projects. Responsible for well pump installation and selection, drilling supervision, controlled well pump tests to evaluate aquifers, and evaluation of field data. Participated in geophysical investigations, well design, groundwater quality and resource development studies, and hydrogeologic studies. Also prepared contract documents and well specifications. Major clients included Cyprus Mine Corporation and Utah International of Wyoming.

1980-1981 Camp, Dresser & McKee, Inc. Hydrogeologist. Served as drilling supervisor and field coordinator for large Mobil synfuels project in Montana. Responsible for piezometer installation and construction, aquifer testing and analysis, instruction and supervision of technical personnel, supervision of materials acquisition, and contracting of third-party services.

1981-Date Engineering-Science. Hydrogeologist. Responsible for supervision of drilling, well pump installation, and piezometer installation and construction on a number of hydrogeologic and groundwater quality investigations. Projects include piezometer installation and drilling supervision for Sunedco in Utah.

Biographical Data

YANE NORDHAV

Hydrogeologist

PII Redacted [redacted]

Education

B.A. in Political Science, 1974, University of Copenhagen
B.A. in Geology, 1976, University of California, Berkeley
M.Sc. candidate in Geology, 1983, California State University, Hayward

Professional Affiliations

Association of Engineering Geologists
Association of Environmental Professionals
Association of Women Geoscientists

Experience Record

1977-1980 Environmental Impact Planning Corporation, San Francisco, California. Geologist/Project Manager. Conducted geologic and hydrologic studies to evaluate adverse impacts of residential, commercial, and industrial developments. Responsible for evaluating effects on groundwater quality and quantity of converting 750 acres of prime agricultural land to residential use in Fresno County. Developed a water balance for the basin for existing and future conditions and estimated water quality impacts of installing septic tank systems in areas with a high water table and well-developed hardpan.

Supervised study of quantity and quality of available sand and gravel resources in Sacramento County, including an estimate of the cost-effectiveness of extraction versus importation. Conducted hydrogeologic investigation focusing on groundwater occurrence and movement, fault activity, and nature of soil material to determine suitable disposal sites for sludge generated in the San Francisco Bay area. Served as project manager for numerous environmental studies focusing on hazards from slope instability, settlement, subsidence, erosion, and flooding in California, Wyoming, and Nevada.

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Yane Nordhav (Continued)

1981-Date Engineering-Science. Hydrogeologist/Project Manager. Responsible for hydrologic and geologic investigations supporting hazardous waste investigations and water resource development and groundwater management programs in a variety of geologic and hydrologic regimes. Activities include development of drilling programs, supervision of well installation, geophysical logging, and groundwater sampling for trace metals and organic analysis. Developed and supervised drilling programs to investigate potential groundwater contamination at Edwards AFB and McClellan AFB as part of the U.S. Air Force's Installation Restoration Program - Phase II. Directed installation and sampling of groundwater monitoring wells and completion of soil borings downgradient from suspected contamination sources to determine the extent of area contamination resulting from past waste management practices of semiconductor firms. Involved in a study of past material handling practices at Drew Manufacturing Company to determine surface and subsurface distribution of trace metals and the extent of soil contamination.

Served as project manager on field investigations and preparation of environmental impact reports concerning increased discharge of wastewater treatment plant effluent to the Santa Ynez River in Santa Barbara County, development of an area subject to severe flooding in Richmond, California, and proposed gold mining operations in Napa County. Also involved in major research and field demonstration project investigating the feasibility of irrigating food crops with treated wastewater. Duties include preparing reports on studies of aerosol generation and pathogen dispersion as well as interpreting water quality and physical/chemical soils data.

Biographical Data

JEFFREY L. RUBIN

Soil Chemist

PII Redacted

[redacted]

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. Determined the physical properties of farm animal manures using traditional soil testing techniques.

Department of Soils and Plant Nutrition. Laboratory Assistant II (1974-1975). Investigated the utilization of nitrogenous organic residues from agricultural wastes for energy and use of the 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.

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

Jeffrey L. Rubin (Continued)

	Agronomy and Range Science Department. <u>Soil Scientist/Intern</u> (1975). Surveyed and mapped the soils within the irrigated pasture fields of the University of California Sierra Foothill Range Field Station. The survey was used to prepare a comprehensive plan for the development, management, and experimental use of irrigated fields.
	Department of Land, Air, and Water Resources: Soils Division. <u>Graduate Research Assistant</u> (1975-1979). Conducted research on the transfer of trace metals in the food chain and their potential hazard to the public.
	Department of Engineering. <u>Laboratory Consultant</u> (1978). Responsible for performing chemical analyses on soil test samples to determine sulfate-sulfur content.
	Department of Land, Air, and Water Resources: Soils Division. <u>Staff Research Associate</u> (1979). Served as project manager for salinity study of the San Joaquin Delta. Responsible for laboratory analyses of organic soils as well as data management.
1974-1975	Department of the Interior, Bureau of Reclamation, Division of Water and Land Operations (Recreation and Wildlife Resources Branch), Sacramento, California. <u>Resource Specialist/Intern</u>. Compiled environmental data on outdoor recreation areas in California for a total management study of the Central Valley.
1978	Sacramento Area Consultants, Sacramento, California. <u>Field Consultant</u>. Responsible for conducting a soil survey emphasizing 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. <u>Graduate Student Assistant</u>. Responsible for coordination and reproduction of base maps, analysis of survey questionnaires, soil problem studies, and preparation of a report assessing statewide soil problems.
1979-Date	Engineering-Science. <u>Soil Chemist</u>. 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

Jeffrey L. Rubin (Continued)

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. Directed laboratory studies examining the mobility of trace metals under various environmental conditions as part of a soil contamination investigation performed for a precious metals stripping facility. Developed an innovative soil sampling device to allow undisturbed extraction of potentially hazardous materials, particularly volatile hydrocarbons. Supervised field studies and laboratory analyses of contaminated soils and groundwater for semiconductor firms. 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).

1-2f7

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.

APPENDIX C

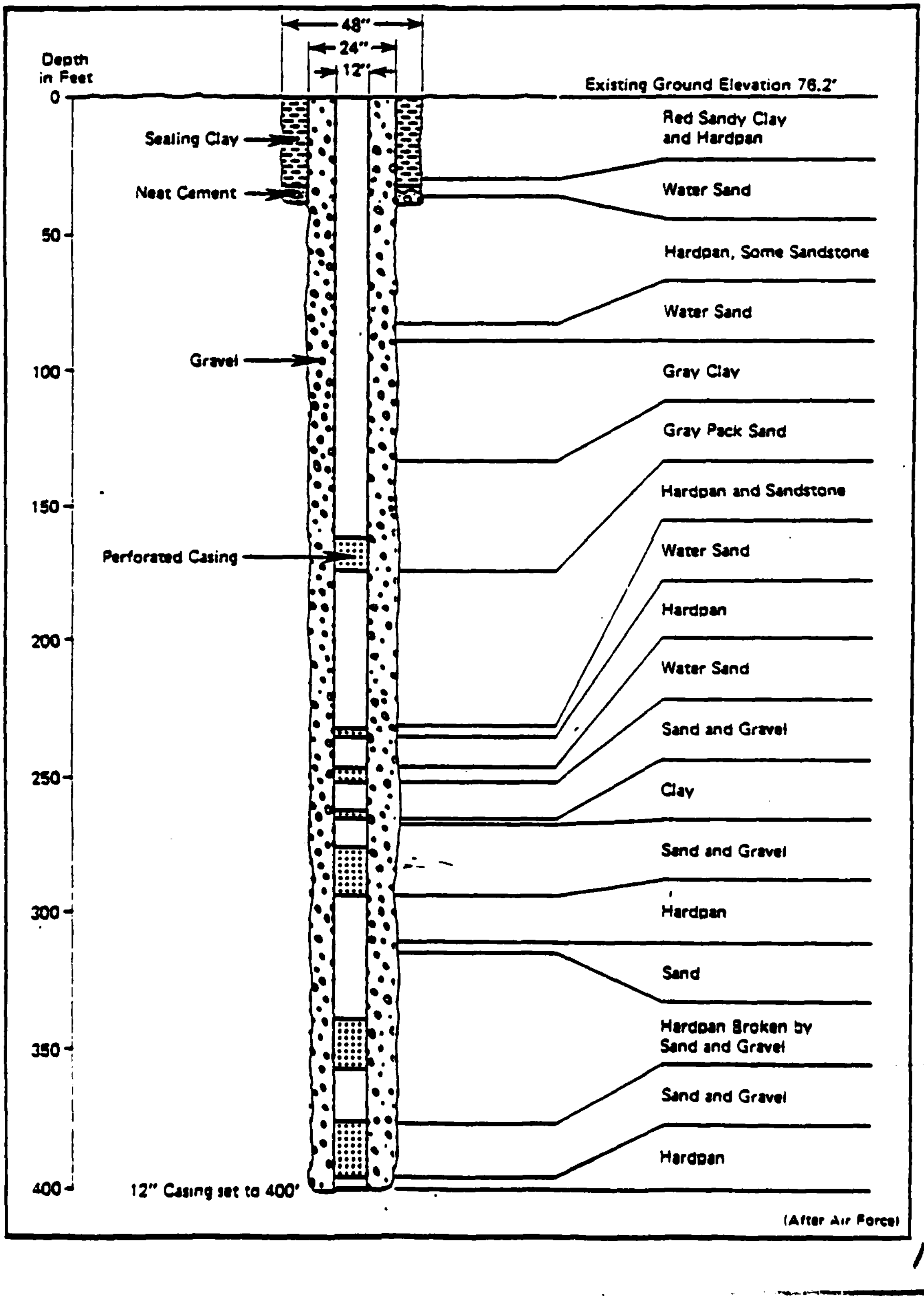
WELL DESIGNS AND WELL LOGS
BASE PRODUCTION WELLS

1-250

WELL CHARACTERISTICS FOR BASE PRODUCTION WELLS
McClellan AFB, California

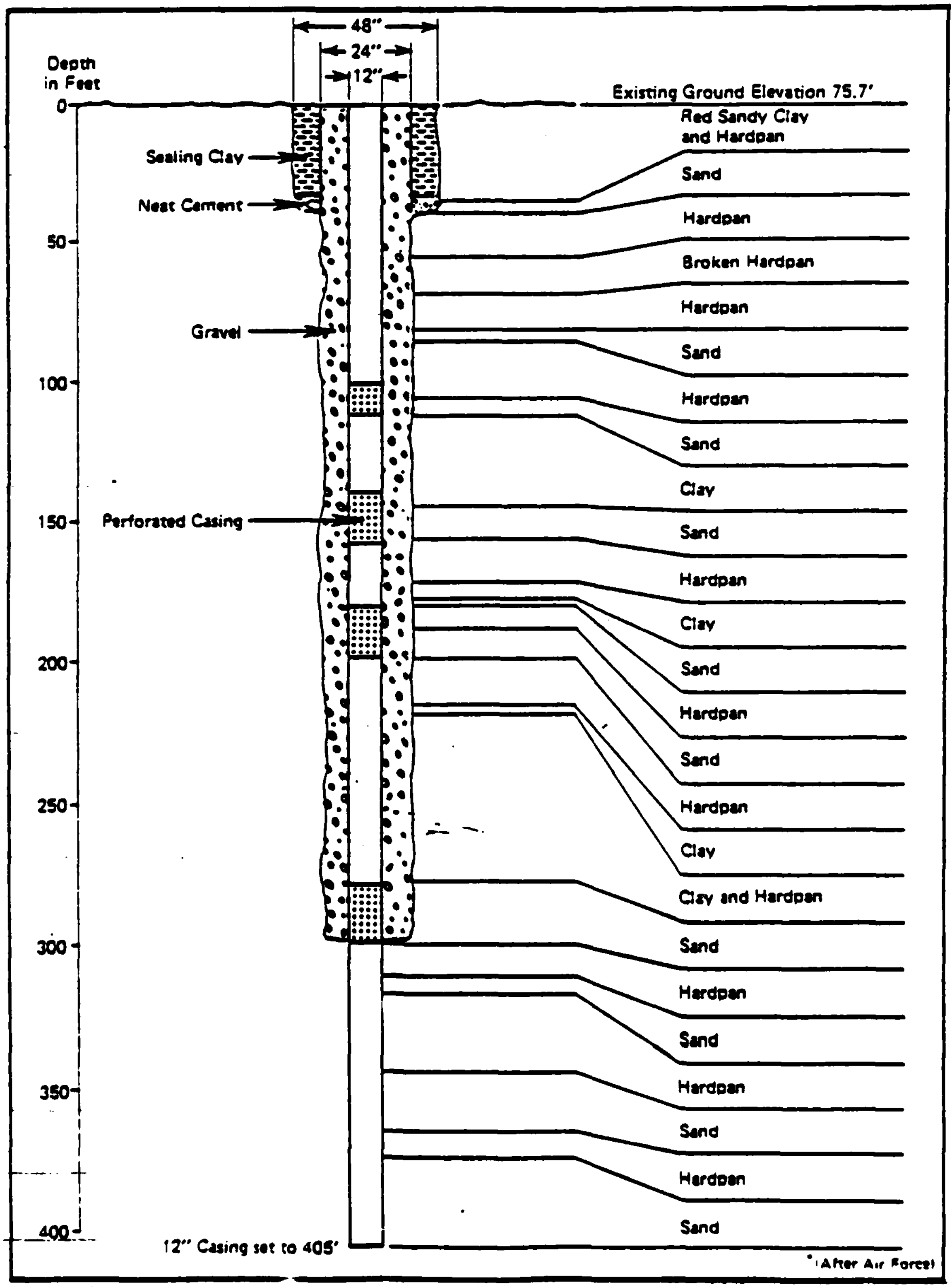
Base Well	Casing Depth (feet)	Perforation Locations (feet)	Depth of Gravel Pack (feet)	Grout Seal (feet)	Casing Diameter (inches)
1	400	162 - 174 232 - 252 247 - 252 266 - 268 274 - 292 340 - 354 376 - 396	0 - 400	0 - 36	12
2	298	100 - 112 141 - 158 180 - 197 282 - 296	0 - 298	0 - 40	12
7	398	170 - 398	0 - 398	0 - 50	12
8	625	None	0 - 625	0 - 50	12
10	400	170 - 392	0 - 400	0 - 50	14/10
11	400	154 - 346	0 - 400	0 - 50	14/10
12	390	164 - 390	0 - 390	0 - 50	14
13	391	178 - 300	0 - 391	0 - 50	14/12
17	353	216 - 224 286 - 294 302 - 312	0 - 353	0 - 50	14
18	400	169 - 185 210 - 260 304 - 349 378 - 387	0 - 400	0 - 50	14
20	600	178 - 190 234 - 274 338 - 374 494 - 506 564 - 598	0 - 600	0 - 50	14
28	247	None			8
29	604		0 - 604	0 - 50	

BASE PRODUCTION WELL BW 1



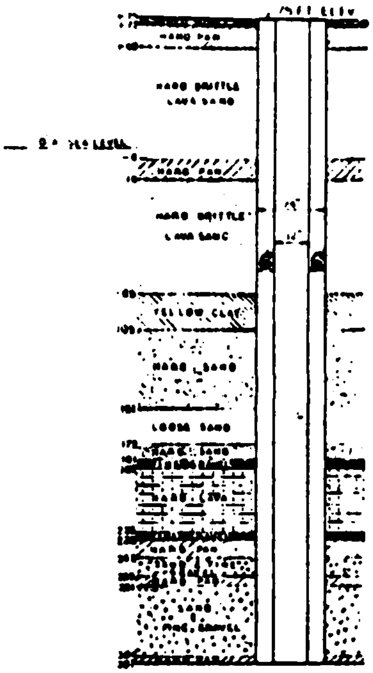
(After Air Force)

BASE PRODUCTION WELL BW2



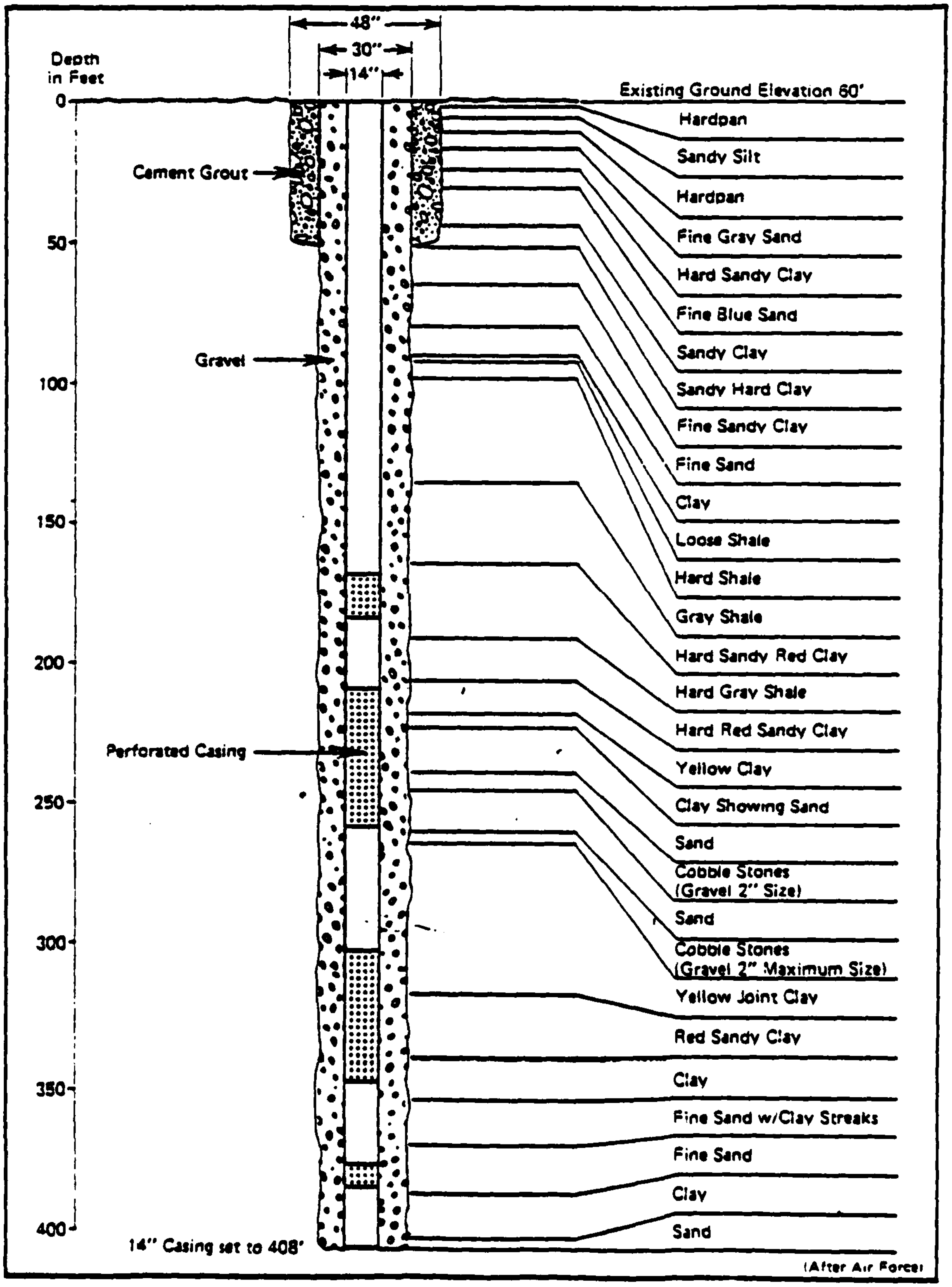
(After Air Force)

BASE PRODUCTION WELL BW 8



12" CASING

BASE PRODUCTION WELL BW 18



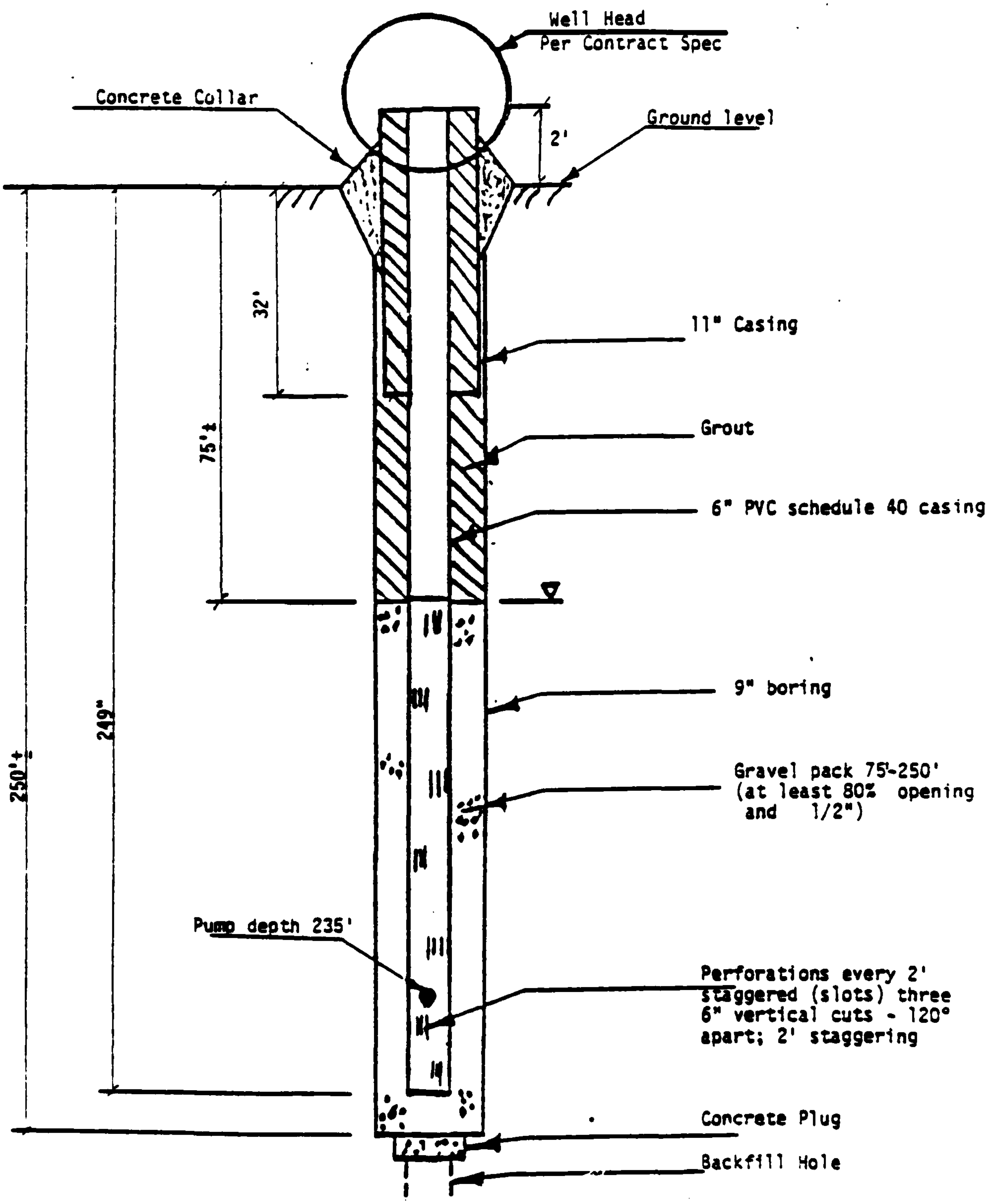
(After Air Force)

APPENDIX D

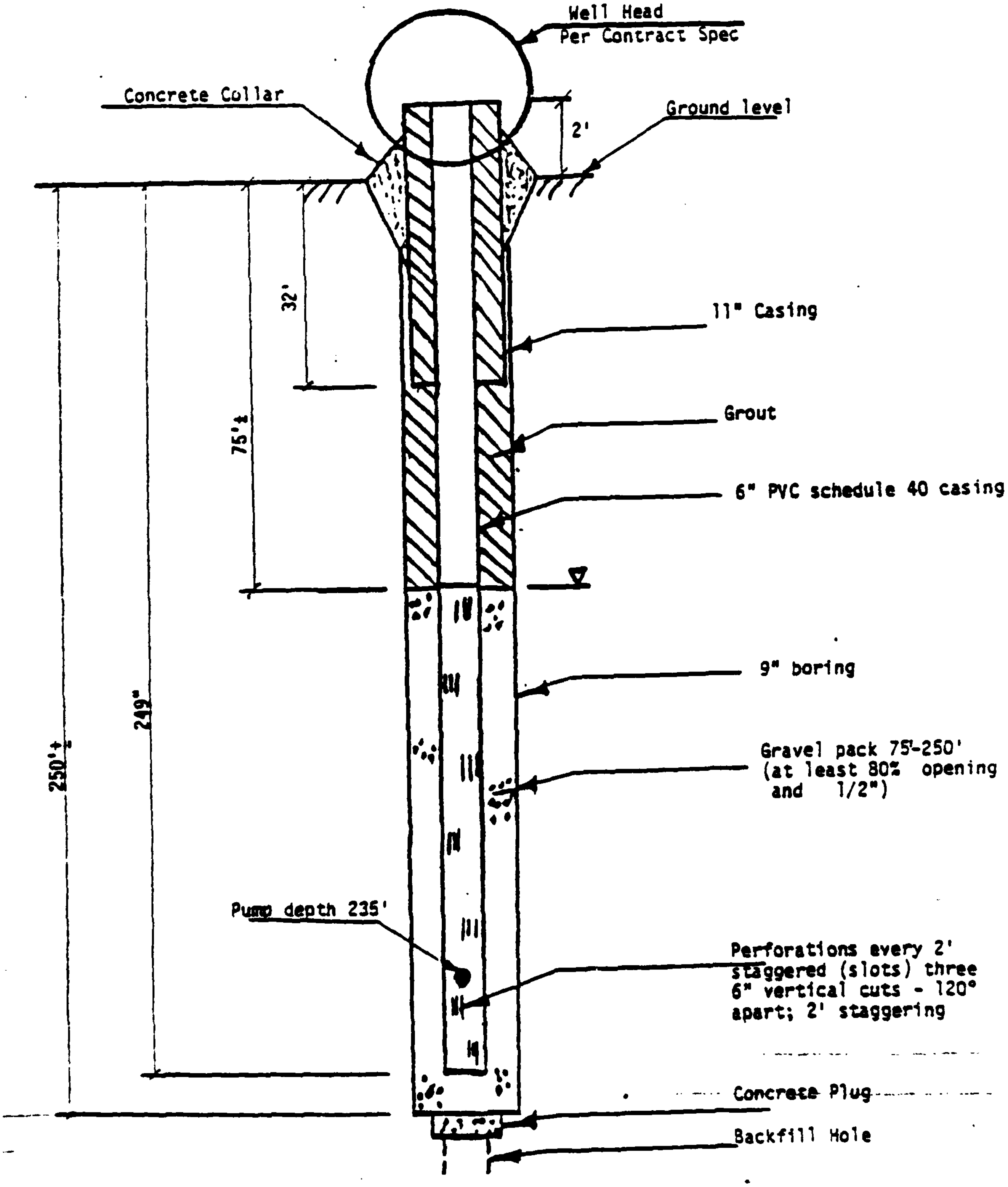
WELL DESIGNS AND WELL LOGS
BASE MONITORING WELLS

WELL DESIGNS
BASE MONITORING WELLS

BASE MONITORING WELL MW 1



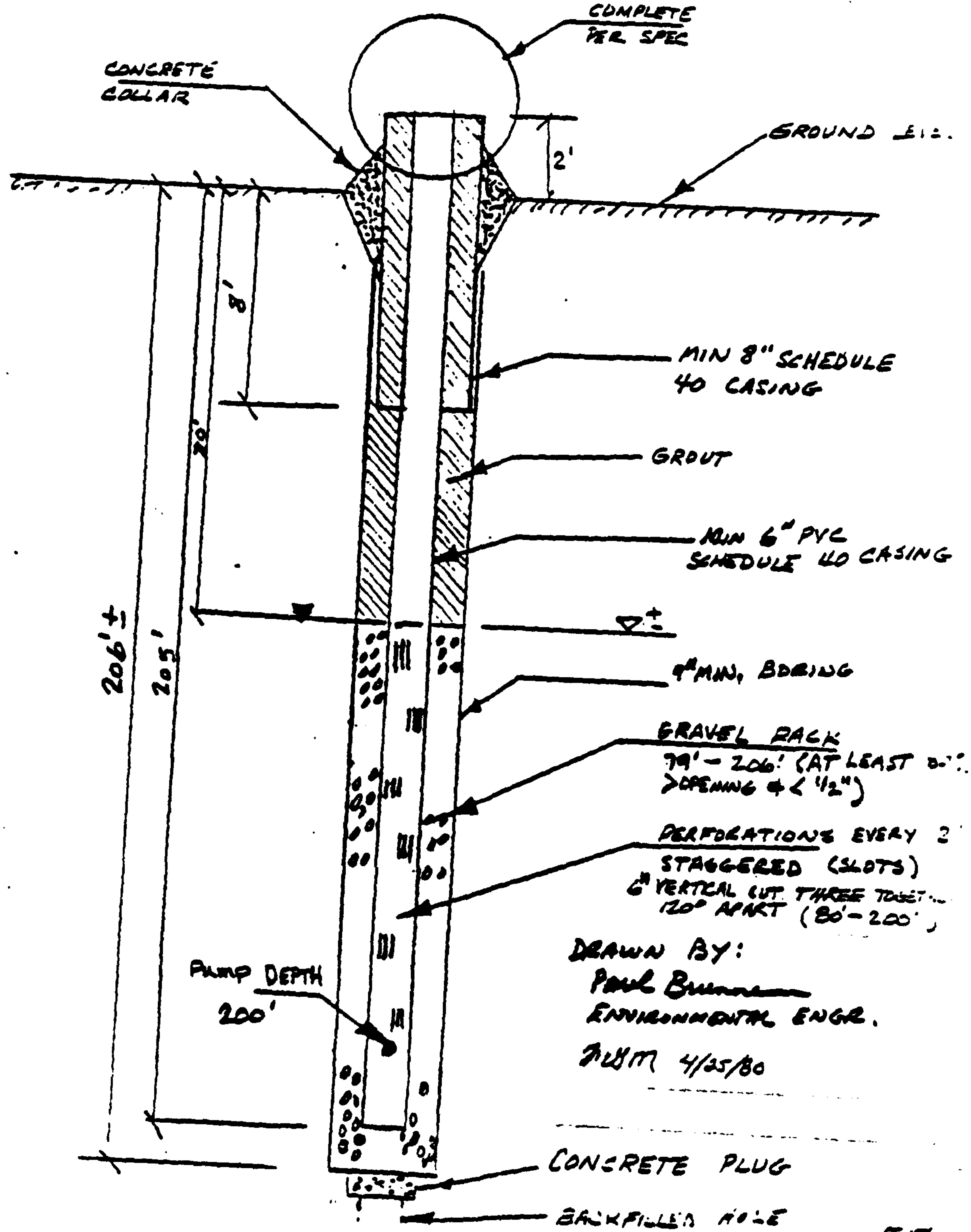
BASE MONITORING WELL MW 2



BASE MONITORING WELL MW3

LOCATION OF WELL PERFORATIONS
CONTRACT No. F04699-80-C0205

WELL No: 3
DATE: 25 APRIL 80
No SCALE



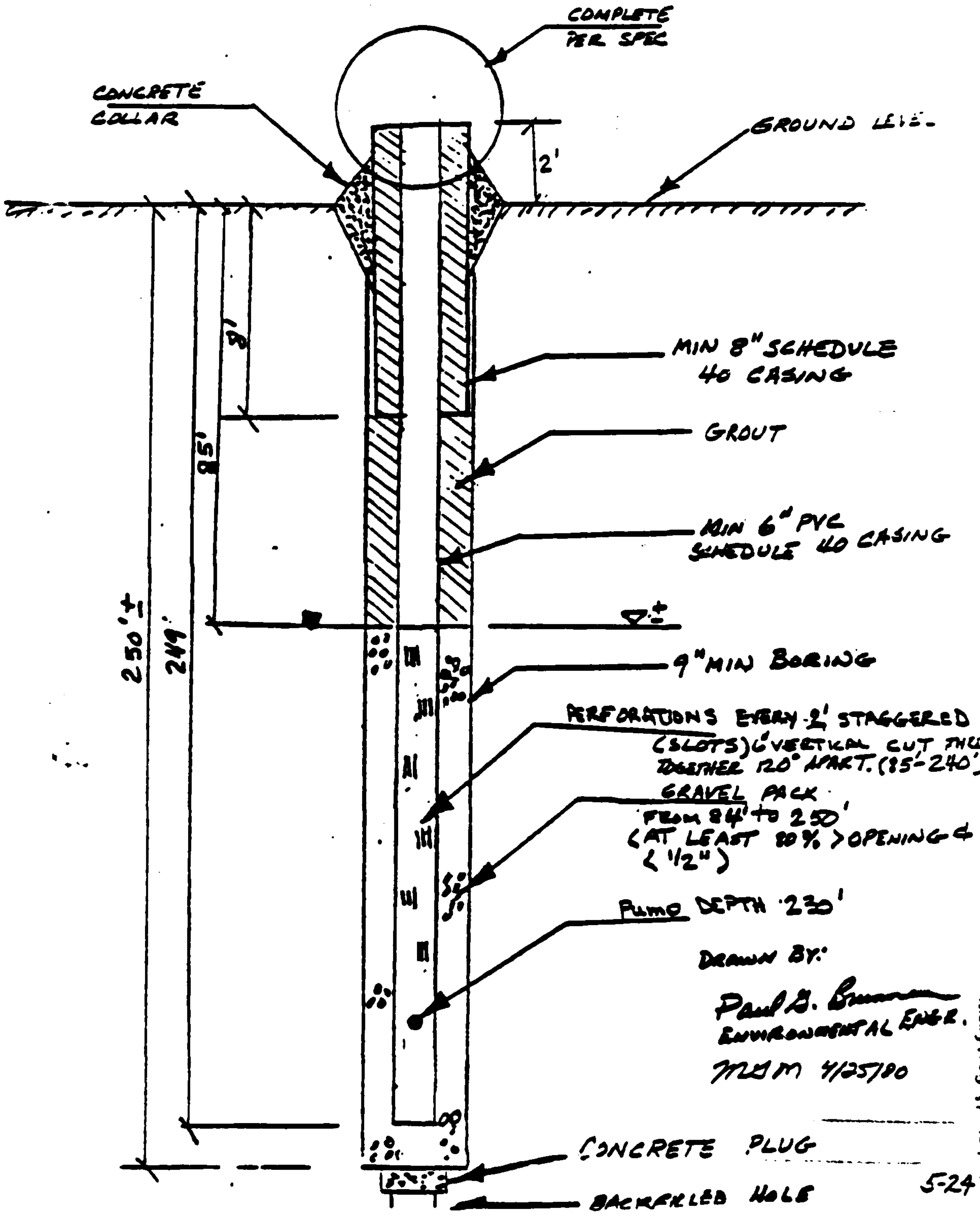
DRAWN BY:
Paul Brunner
ENVIRONMENTAL ENGR.

RWM 4/25/80

BASE MONITORING WELL MW4

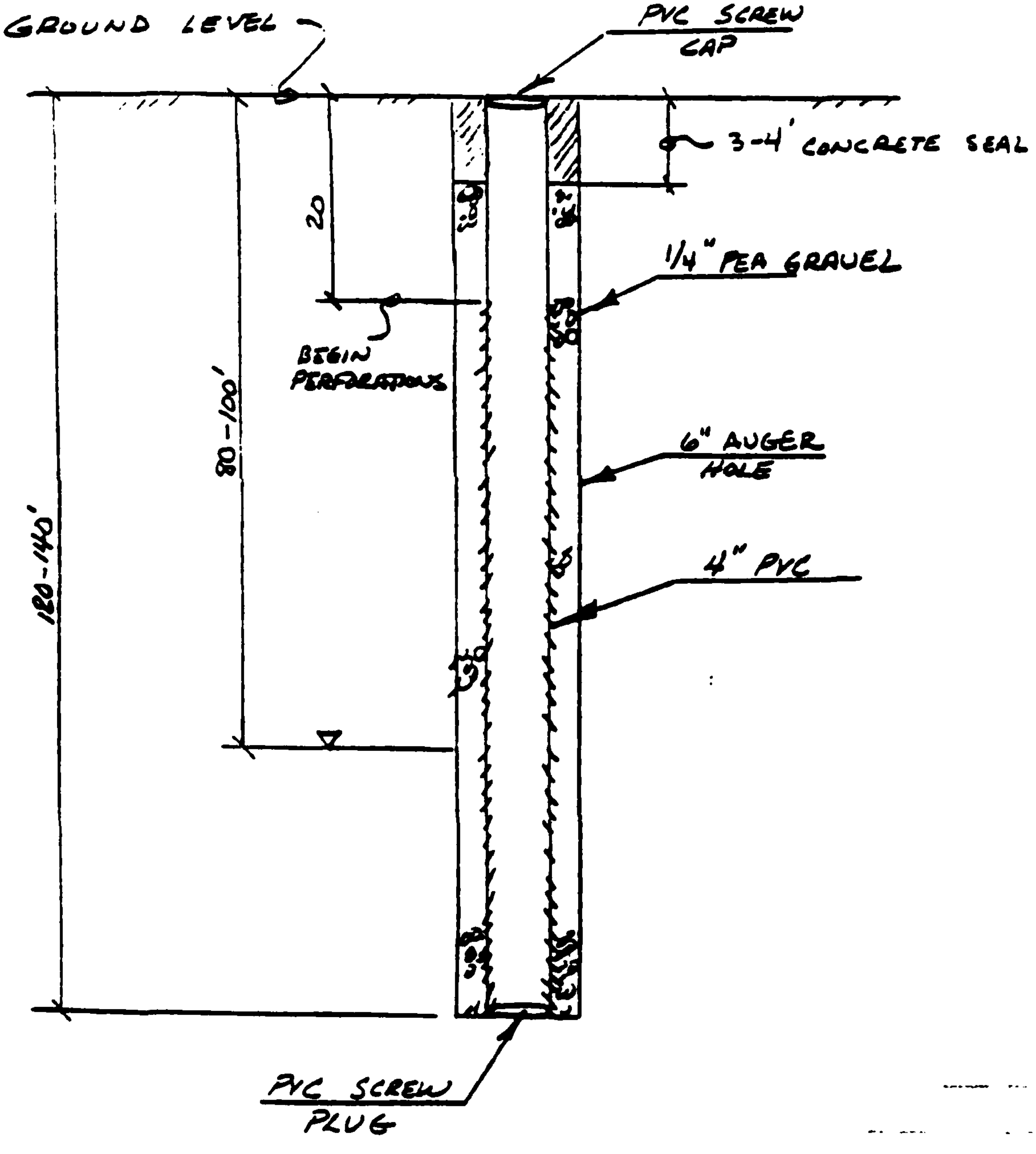
WELL No: 4
DATE: 25 APRIL 80
No SCALE

LOCATION OF WELL PERFORATIONS
CONTRACT No. F0 46 99-80-C0285



DRAWN BY:
Paul G. B
ENVIRONMENTAL ENGR.
MGM 4/25/80

BASE MONITORING WELLS MW 5, 6, 7, 8, 9



WELL LOGS
BASE MONITORING WELLS

BASE MONITORING WELL MW1

MOC

Drilling log for boreing #1 Contract #F04699 80 C0205
April 29, 1980 (Copy 5-7-80)

On Monday April 21, hauled approx. 5000 gallons water and mixed 12 sacks mud to get a seal on mud pit. Mixed mud (6 sacks) started drilling about 2pm. (steel, bolders plastic, switches) so changed to solid augers and at 23 feet soil changed to black contaminated sand of some sort. Took a grab sample and notified office at 3pm. Persons notified—Mr. Clark, E.B. Friar, and Paul Brunner.

Wed. April 23
Set caseing to 32 feet (Contaminated sand to 24 feet). Hole crooked because of all the steel in the hole, mixed 6 sacks mud.

Thur April 24
Caseing leaking had to drill alongside caseing and grout, mixed another [illegible] sacks mud.

Footage	Type of soil	Samples taken at intervals
0 to 32	see above	23'
32 to 40	silty sand with trace of clay	40'
40 to 45	silty sand	
45 to 60	silty sand	60'
60 to 70	silty sand	70'
70 to 80	dence silt	80'
80 to 90	dence silt partly cemented in layers	90'
90 to 100	Dence silt partly cemented in layers	100'
100 to 108	Clay	
108 to 116	sand ✓	110'
1[illegible] to 130	clay	120', 130'
1[illegible] to 168	sand ✓	150
168 to 175	silt	175'
175 to 200	clay silt	200'
2[illegible] to 209	sand ✓	
209 to 212	silty clay	
212 to 220	dence	
220 to 258	sand ✓	258'
[illegible] to 263	silty clay	
263 to 270	silty sand	
270 to 281	silty clay	
281 to 287	silty sand	
287 to 292	sand	
292 to 298	clay sand	
298 to 320	silty clay	300'
320 to 348	silty sand	
348 to 364	clay sand	
364 to 370	clay	
370 to 389	sandy silt	
389 to 400		400'

BASE MONITORING WELL MW2

ALL TERRAIN Exploration Drilling
2789 Liberty Lane
Roseville, California 95678

Drilling Log for boreing #2 Contract #F04699 80 C0205
April 18, 1980

Footage	type of soil	Samples taken at Intervals
0 to 10	fill	
10 to 20'	garbage	
20 to 40'	silty sand with clay	40'
40 to 60'	silty sand with trace of gravel	50'
60 to 75'	sand with trace of gravel	75'
75 to 89'	dense silty sand	
89 to 117'	clay	
117 to 125'	dence clay	100'
125 to 141'	dence clay	
141 to 149'	clean sand--lost approx. 1000 gallons mud in formation	
149 to 150	clay sand	150
150 to 175	clean silty sand	175'
175 to 184'	Silty clay	
184 to 198'	dence clay	
198 to 200'	sand	200'
200 to 223'	clay silt	
223 to 250'	clay silt	250'
250 to 260'	sandy silt	
260 to 270'	clay sand	
270 to 300'	clay sand	300'
300 to 310'	silty sand	
310 to 329'	cemented sand with layers of cemented clay silt.	
329 to 347'	clay	
347 to 361'	silty sand	
361 to 400'	silty sand with some cemention	400'

*11 inch steel caseing set to 30'.

Copy 5-2-80

BASE MONITORING WELL MW3

DRILLING [illegible] 3 [illegible] 80 [illegible], SMA-129-5
April 14, [illegible]

Footage	Type of soil	Samples taken at Intervals
0 to 4'	fill gravel, black top cement in silty sand	
4 to 20'	silty sand with layers of cemented silt and clay	20'
20 to 40'	Silty sand with alternating layers of cemented silt and clay	
40 to 50'	silty send	50'
50 to 90'	clay sand	75'
90 to 105'	sand	100'
105 to 145'	silt	125'
145 to 160	sand	150'
160 to 190	sand (lost mud-no return 7 sacks mud)	175'
190 to 198'	silt	
198 to 204'	gray sand	200'
204 to 208'	clay silt	
208 to 235'	sand with cemented layers	
235 to 251'	cemented silty clay	
251 to 254'	sand with cemented layers	250'
254 to 261'	dence silty clay	
261 to 300'	dence silty clay	300'
300 to 304'	sandy clay	
304 to 320'	silty clay	
320 to 330'	dence sand	
330 to 373'	dence silty clay with some layers of sand cemented	
373 to 400'	cemented silty clay with some sand	400'

1-266

BASE MONITORING WELL MW4

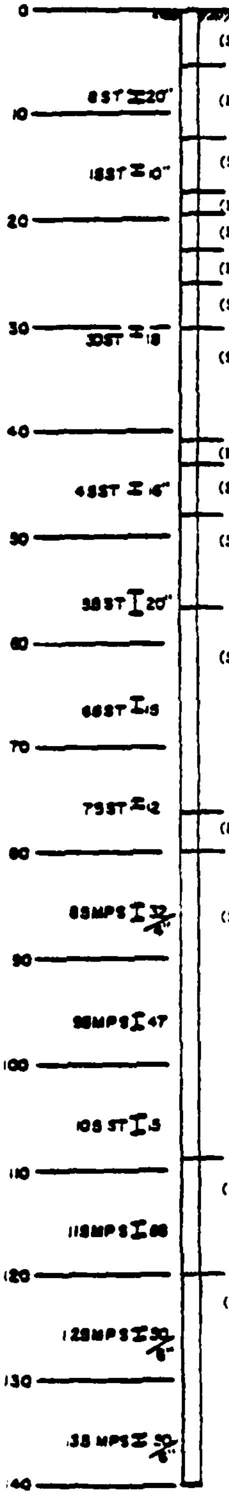
ALL TERRAIN Exploration Drilling
2789 Liberty Lane
Roseville, California 95678

DRILLING LOG FOR BOREING #4 CONTRACT F04699 80 C0205
April 3, 1980

Footage	Type of soil	Samples taken at intervals
0 to 45'	sand	20'
45 to 55'	clean sand	50'
55 to 60'	trace of light gravel	
60 to 95'	dense clay sand	75'
95 to 120'	clay silt	100'
120 to 142'	silty clay with trace of gravel	125'
142' to 148'	sand	
148 to 151'	silty clay	150'
151 to 168'	silty sand	
168 to 178'	sandy silt	175'
178 to 180'	lightly cemented	
80 to 201 '	sand	200'
201 to 209'	clay silt with trace of gravel	
209 to 220'	sand	
220 to 225'	dense sandy silt	
225 to 230'	silty sand	
230 to 248'	sand	
248 to 282'	silt	250'
282 to 288'	silty clay	
288 to 293'	dense hard clay almost rock	
293 to 360'	dense silty clay	300'
360 to 400'	dense silty sand with trace of clay	
400'	bottom of boreing	400'

BASE MONITORING WELL MW 5

Begin drilling 9-18-80



(SM) sand: fine to medium grain, silty, partially cemented, light brown, hard

(ML) silt: partially cemented, light-gray, hard

(SM) sand: fine grain, silty, gray, dense

(ML) silt: gray, hard

(ML) silt: fine grain sandy, gray

(ML) silt: cemented, gray with some fine black specks

(SW) sand: fine to medium grain, brown

(SM) sand: fine to medium grain, silty, gray & brown

(ML) silt: fine grain sandy, cemented, gray

(SW) sand: fine to medium grain, brown

(SW) sand: fine to medium grain, trace silt, brown

grades very silty

(SW) sand: fine to medium grain, clean, brown

grades silty

(ML) silt: fine grain sandy, cemented, hard, gray

(SM) sand: fine to medium grain, silty, hard, gray, brown

hard drilling

(ML) silt: partially cemented, hard, tan with rust streaks

(ML) silt: clayey, trace fine grain sand, partially cemented, hard, tan

grades less clayey

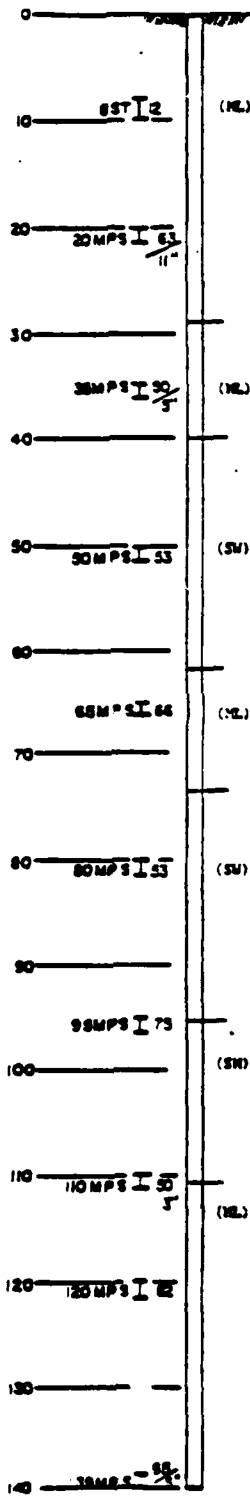
Boring Terminated at 140' 9-19-80
Groundwater encountered at 93'
PVC Pipe installed.

J H KLEINFELDER & ASSOCIATES
DRAWN BY: [illegible] DATE: [illegible]
CHECKED BY: [illegible] DATE: [illegible]

SOILS INVESTIGATION
McCLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
BORING LOG
PROJECT NO. [illegible] PLATE NO.

BASE MONITORING WELL MW 6

Begin drilling 9-23-80



(ML) silt: fine grain sandy, clayey, stiff, gray-brown

grades less clay & becomes green-brown
partially cemented

(ML) silt: very fine grain sandy, partially cemented, gray-brown with rust streaks

(SW) sand: fine to medium grain, dense, tan with black streaks

(ML) silt: very fine grain sandy, hard, red-brown

(SW) sand: fine to medium grain, some silt, dense, brown-tan

(SM) sand: fine grain, silty, hard, partially cemented, brown-tan

(ML) silt: clayey, very fine grain sandy, hard, gray-tan

hard drilling below 125'

Boring terminated at 140' 9-24-80
Groundwater encountered at 95'.
No caving noted. PVC Pipe installed.

J H KLEINFELDER & ASSOCIATES
DRAWN BY JTP DATE SEPT 1980
CHECKED BY DJP DATE SEPT 1980

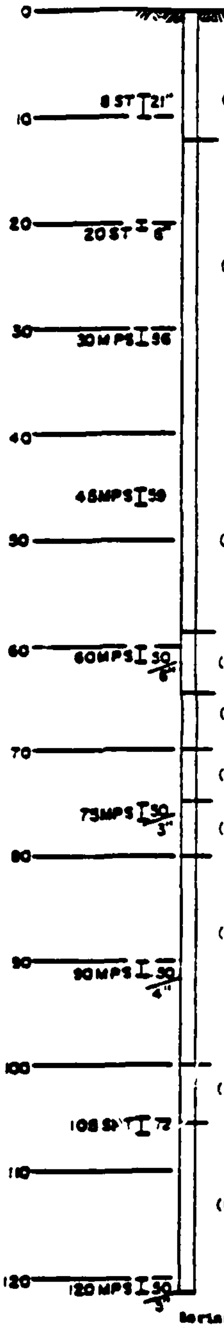
McCLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
BORING LOG
PROJECT NO A-1017-1
PLATE NO

8-6

1-269

BASE MONITORING WELL MW 7

Begin drilling 9-25-80



(SC) sand: fine to medium grain, some clay, red-brown with gray streaks, medium dense

(ML) silt: clayey, trace of fine grained sand, gray-brown with rust-streaks, hard

(SM) sand: fine to medium grain, silty, gray-tan with black & rust streaks, medium dense

grades less silt

(ML) silt: very fine grain sandy, red-brown with black streaks, hard

(CL) clay: silty, partially cemented, gray-brown, hard

(ML) silt: clayey, moist, red-brown, hard ~

(SM) sand: fine to medium grain, silty, tan, dense

(CL) clay: silty, some fine grain sand lenses, gray, hard

(SM) sand: fine grain, some silty and clay, brown, very dense

(CL) clay: silty, some fine grain sand lenses 1/4" thick, tan, hard

Boring terminated at 121.5' 9-26-80
Groundwater encountered at 45'
No caving noted.
PVC Pipe installed.

J. H. KLEINFELDER & ASSOCIATES

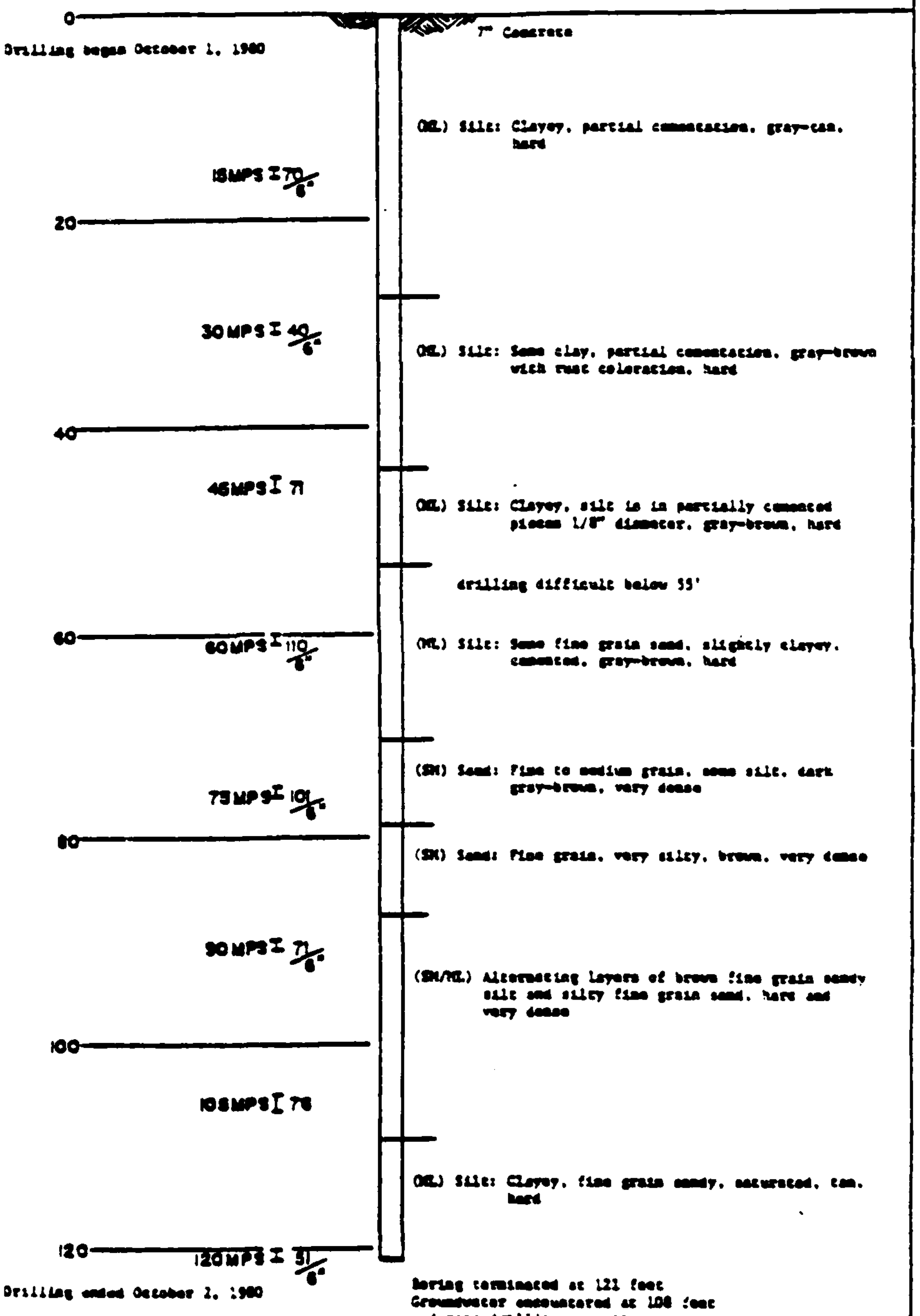
DRAWN BY JTP DATE SEPT 1980
CHECKED BY RJP DATE SEPT 1980

SOIL INVESTIGATION
McCLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
BORING LOG
PROJECT NO A-4977-1 PLATE NO

2-2

1-270

BASE MONITORING WELL MW8



Drilling began October 1, 1980

7" Concrete

(ML) Silt: Clayey, partial cementation, gray-tan, hard

(ML) Silt: Some clay, partial cementation, gray-brown with rust coloration, hard

(ML) Silt: Clayey, silt is in partially cemented pieces 1/8" diameter, gray-brown, hard

drilling difficult below 55'

(ML) Silt: Some fine grain sand, slightly clayey, cemented, gray-brown, hard

(SM) Sand: Fine to medium grain, some silt, dark gray-brown, very dense

(SM) Sand: Fine grain, very silty, brown, very dense

(SM/ML) Alternating layers of brown fine grain sandy silt and silty fine grain sand, hard and very dense

(ML) Silt: Clayey, fine grain sandy, saturated, tan, hard

Drilling ended October 2, 1980

Boring terminated at 121 feet
Groundwater encountered at 108 feet
during drilling operations
No caving noted
4" PVC Pipe Installed

J H KLEINFELDER & ASSOCIATES

DRAWN BY	JTP	DATE	OCT 1980
CHECKED BY	RWO	DATE:	OCT 1980

SOILS INVESTIGATION

McCLELLAN AIR FORCE BASE

SACRAMENTO CALIFORNIA

BORING LOG

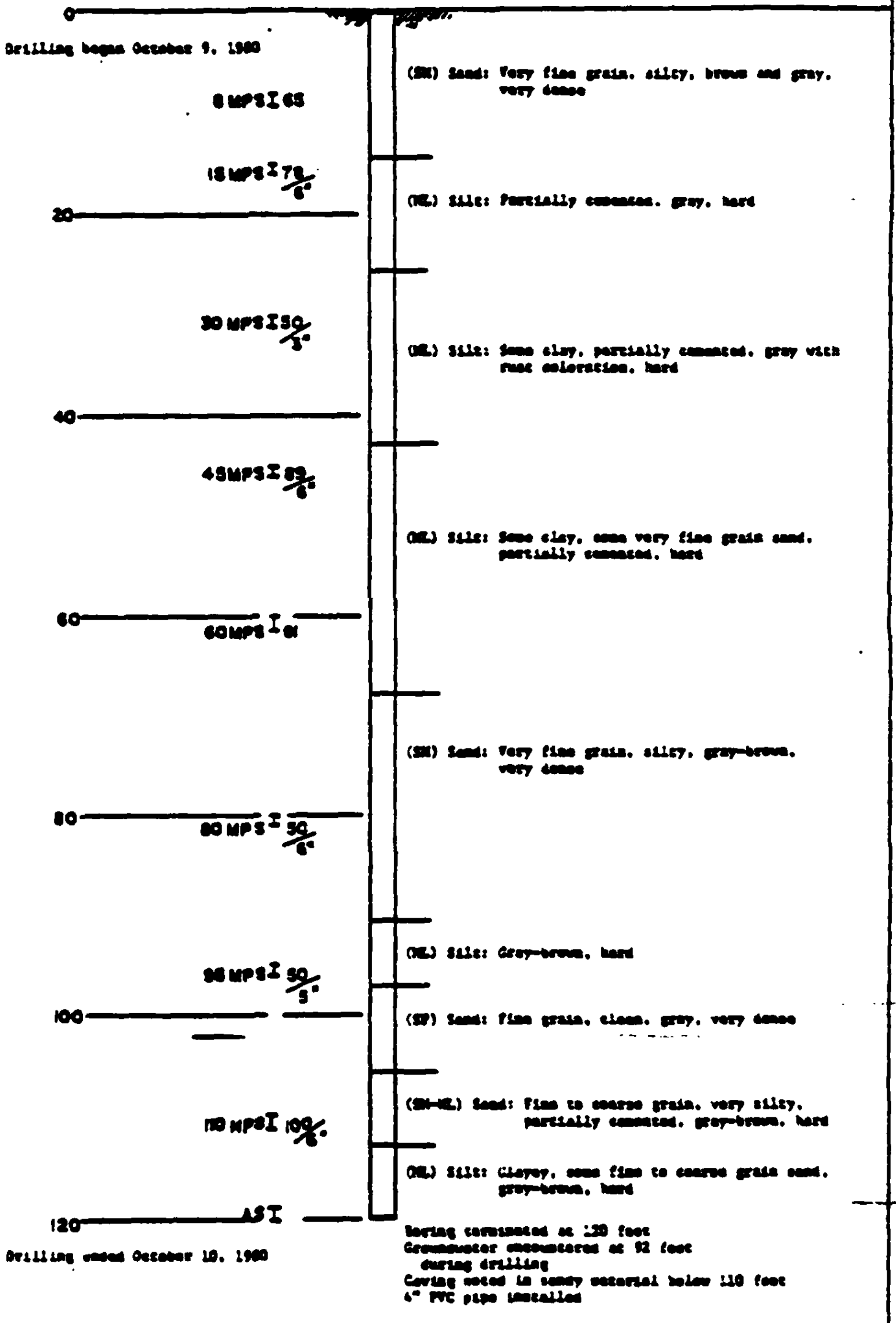
PROJECT NO A-1037-1

PLATE NO

2-9

1-271

BASE MONITORING WELL MW9



Drilling began October 9, 1980

(SM) Sand: Very fine grain, silty, brown and gray, very dense

(ML) Silt: Partially cemented, gray, hard

(ML) Silt: Some clay, partially cemented, gray with rust coloration, hard

(ML) Silt: Some clay, some very fine grain sand, partially cemented, hard

(SM) Sand: Very fine grain, silty, gray-brown, very dense

(ML) Silt: Grey-brown, hard

(SP) Sand: fine grain, clean, grey, very dense

(SM-ML) Sand: Fine to coarse grain, very silty, partially cemented, grey-brown, hard

(ML) Silt: Clayey, some fine to coarse grain sand, grey-brown, hard

Drilling ended October 10, 1980

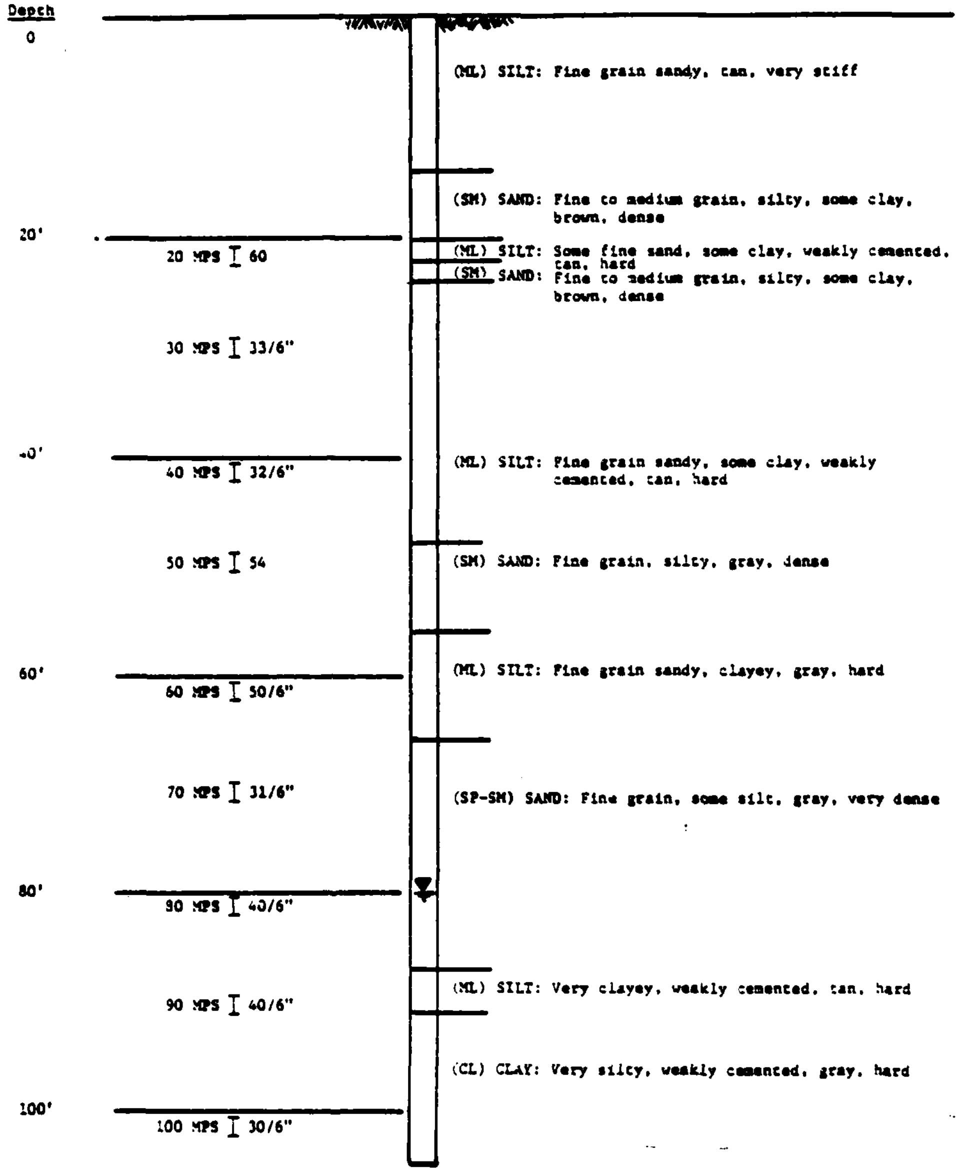
Boring terminated at 120 feet
Groundwater encountered at 92 feet
during drilling
Caving noted in sandy material below 110 feet
4" PVC pipe installed

J. H. KLEINFELDER & ASSOCIATES

DRAWN BY JIP DATE OCT 1980
CHECKED BY RWO DATE OCT 1980

SOIL INVESTIGATION
McCLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
BORING LOG
PROJECT NO A-1037-1
PLATE NO

BASE MONITORING WELL MW 10



(ML) SILT: Fine grain sandy, tan, very stiff

(SM) SAND: Fine to medium grain, silty, some clay, brown, dense

(ML) SILT: Some fine sand, some clay, weakly cemented, tan, hard

(SM) SAND: Fine to medium grain, silty, some clay, brown, dense

(ML) SILT: Fine grain sandy, some clay, weakly cemented, tan, hard

(SM) SAND: Fine grain, silty, gray, dense

(ML) SILT: Fine grain sandy, clayey, gray, hard

(SP-SM) SAND: Fine grain, some silt, gray, very dense

(ML) SILT: Very clayey, weakly cemented, tan, hard

(CL) CLAY: Very silty, weakly cemented, gray, hard

Boring terminated at 105', 7-27-81.
Groundwater initially encountered at 80' during drilling 7-27-81. Groundwater measured at 76' on 7-28-81.
107 feet of 4" Schedule 40 pvc pipe installed on 7-28-81.

Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

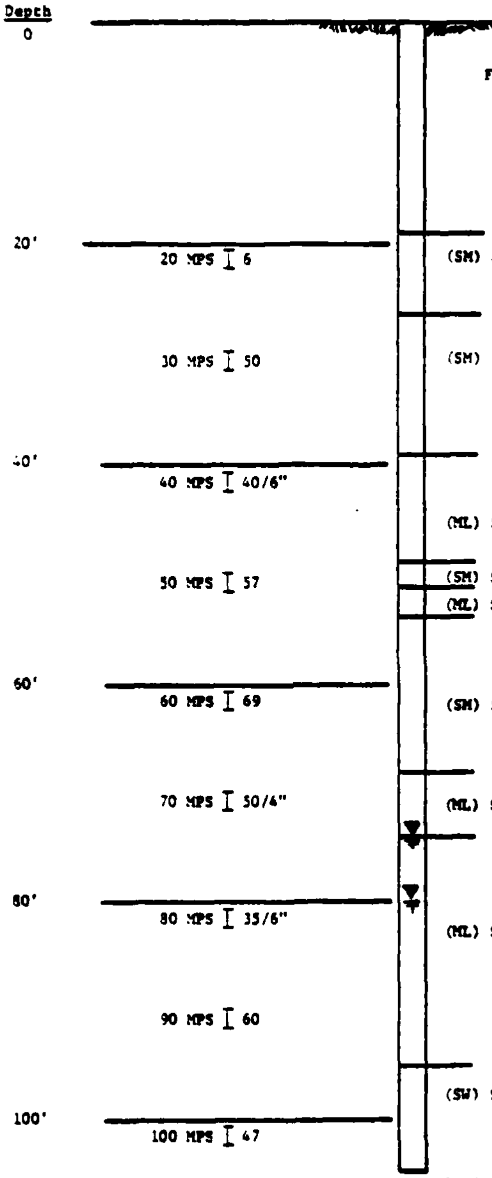
SUPPLIES/SERVICES - SUMMARY

Item Number	Quantity
0001AA	50 feet
0001AB	55 feet
0001AE	3
0001AF	6
0001AI	107 feet
0001AJ	105 feet

J. H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS — ENGINEERING GEOLOGISTS
DRAWN BY: MAC DATE July 1981
CHECKED BY RJP DATE July 1981

BORING LOG
MC CLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
PROJECT NO A-1957-2 PLATE NO.

BASE MONITORING WELL MW 11



FILL: Matrix composed of clay, silt and sand with pieces of pipe, metal, paper and glass, no apparent evidence of chemical odor

(SM) SAND: Fine to medium grain, silty, black, loose

(SM) SAND: Fine grain, some silt, tan, dense

(ML) SILT: Some clay, weakly cemented, light tan, hard

(SM) SAND: Fine grain, some silt, light brown, dense

(ML) SILT: Some clay, weakly cemented, tan, hard

(SM) SAND: Fine grain, silty, brown

(ML) SILT: Some fine grain sand, some clay, weakly cemented, gray and brown, hard

(ML) SILT: Some fine grain sand, some clay, tan, hard

(SW) SAND: Fine to medium grain, relatively clean, gray-brown, medium dense

Boring terminated at 105', 7-24-81.
Groundwater initially encountered at 79' during drilling 7-24-81. Groundwater measured 10 minutes after initial encounter and level rose to 74'.
107 feet of 4" Schedule 40 pvc pipe installed on 7-24-81.

Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

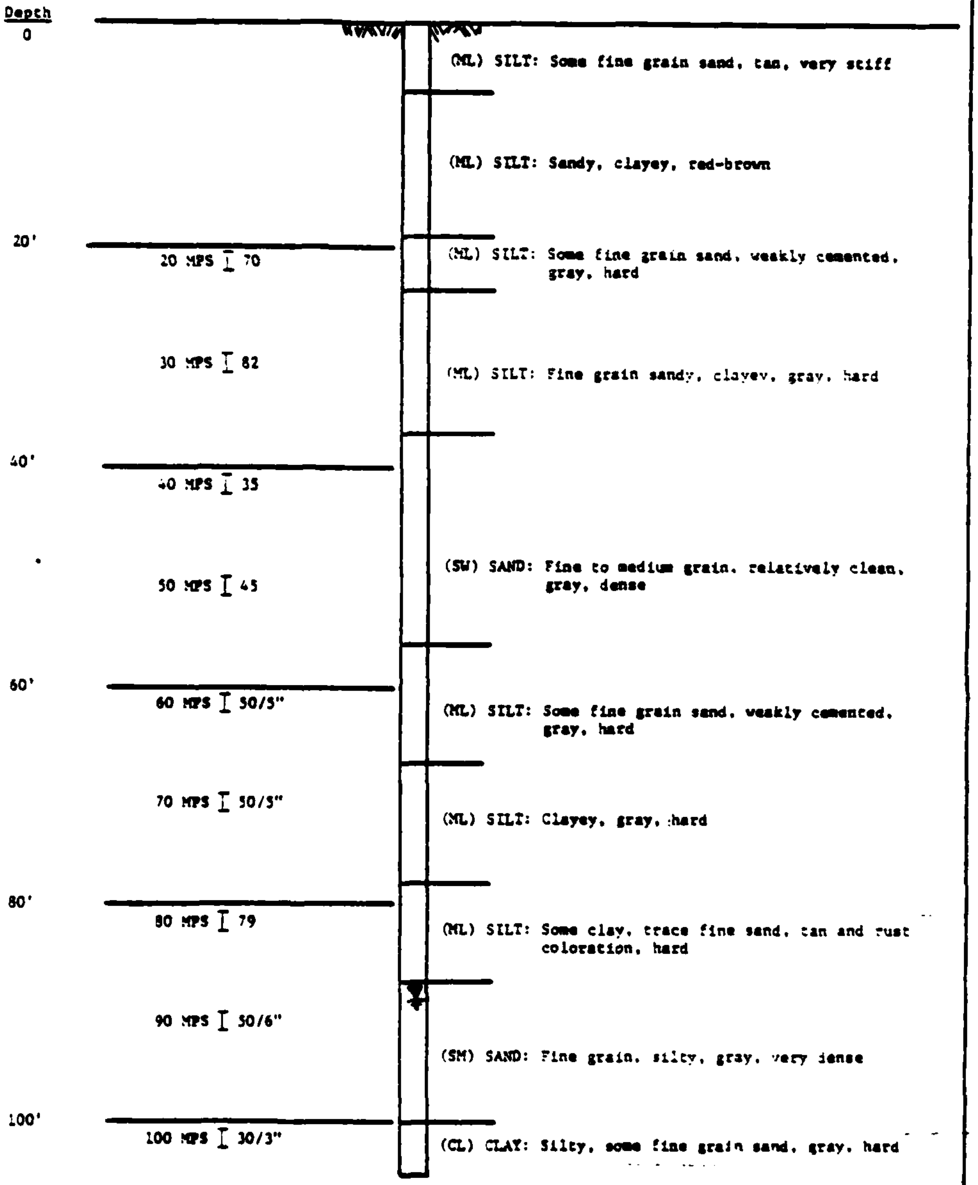
SUPPLIES/SERVICES - SUMMARY

Item Number	Quantity
0001AA	50 feet
0001AB	55 feet
0001AE	3
0001AF	6
0001AI	107 feet
0001AJ	105 feet

J. H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS · ENGINEERING LABORATORIES
DRAWN BY: MMC DATE July 1981
CHECKED BY: RJP DATE: July 1981

BORING LOG
MC CLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
PROJECT NO A-1957-2
PLATE No

BASE MONITORING WELL MW 12



(ML) SILT: Some fine grain sand, tan, very stiff

(ML) SILT: Sandy, clayey, red-brown

(ML) SILT: Some fine grain sand, weakly cemented, gray, hard

(ML) SILT: Fine grain sandy, clayey, gray, hard

(SW) SAND: Fine to medium grain, relatively clean, gray, dense

(ML) SILT: Some fine grain sand, weakly cemented, gray, hard

(ML) SILT: Clayey, gray, hard

(ML) SILT: Some clay, trace fine sand, tan and rust coloration, hard

(SM) SAND: Fine grain, silty, gray, very dense

(CL) CLAY: Silty, some fine grain sand, gray, hard

Boring terminated at 105'.
Groundwater initially encountered at 87' during drilling 7-22-81.
107 feet of 4" Schedule 40 pvc pipe installed on 7-23-81.

Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SUPPLIES/SERVICES - SUMMARY

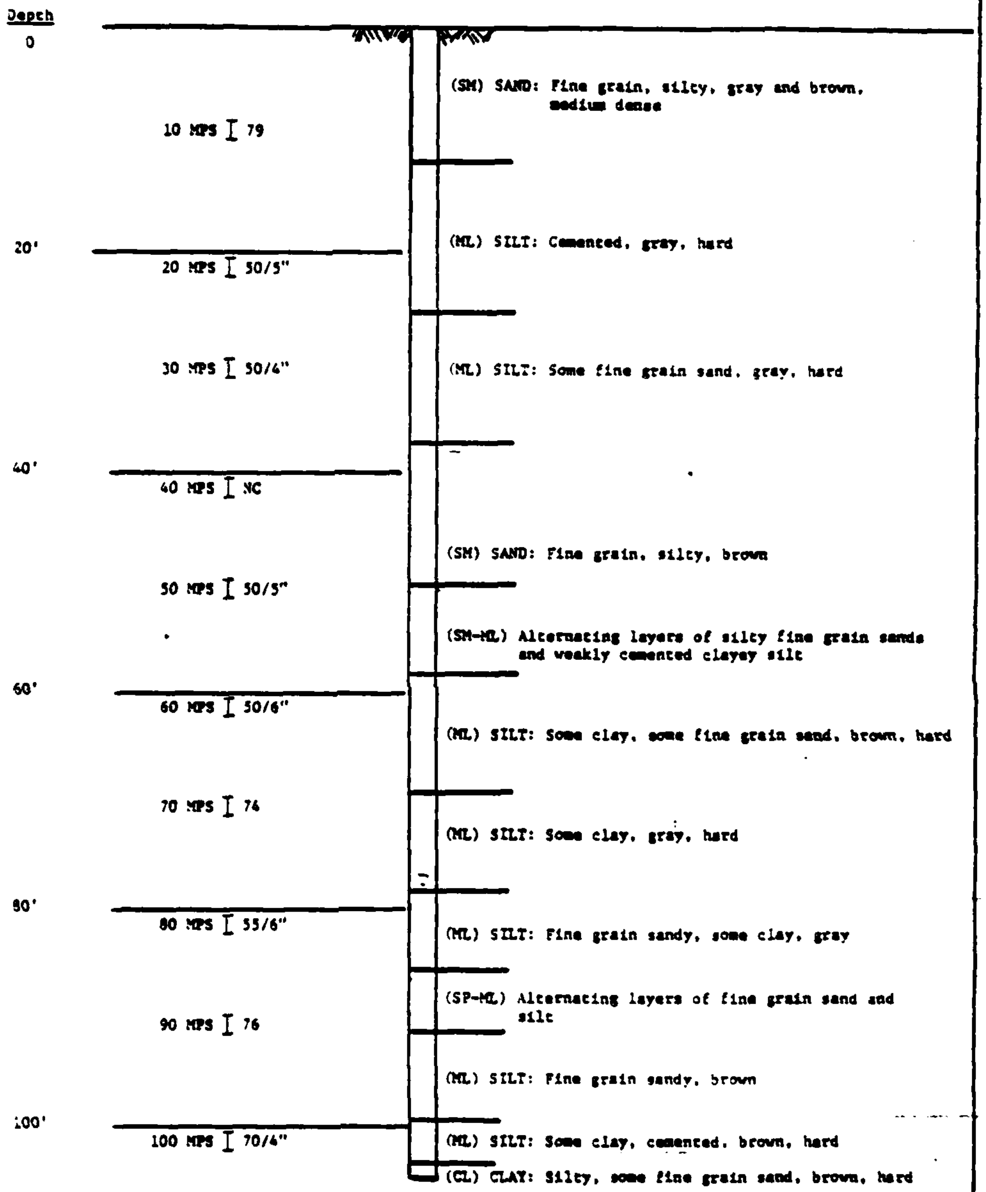
Item Number	Quantity
0001AA	50 feet
0001AB	55 feet
0001AE	3
0001AF	6
0001AI	107 feet
0001AJ	105 feet

J. H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS · ENGINEERING LABORATORIES

DRAWN BY: MWC DATE July 1981
CHECKED BY: RJP DATE July 1981

BORING LOG
MC CLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
PROJECT NO. A-1957-2
PLATE NO.

BASE MONITORING WELL MW 13



(SM) SAND: Fine grain, silty, gray and brown, medium dense

(ML) SILT: Cemented, gray, hard

(ML) SILT: Some fine grain sand, gray, hard

(SM) SAND: Fine grain, silty, brown

(SM-ML) Alternating layers of silty fine grain sands and weakly cemented clayey silt

(ML) SILT: Some clay, some fine grain sand, brown, hard

(ML) SILT: Some clay, gray, hard

(ML) SILT: Fine grain sandy, some clay, gray

(SP-ML) Alternating layers of fine grain sand and silt

(ML) SILT: Fine grain sandy, brown

(ML) SILT: Some clay, cemented, brown, hard

(CL) CLAY: Silty, some fine grain sand, brown, hard

Boring terminated at 105', 7-15-81
Groundwater initially encountered at 78' during drilling 7-15-81. Groundwater measured at 78' 3" one hour after completion of drilling.
107 feet of 4" Schedule 40 pvc pipe installed on 7-15-81.

Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SUPPLIES/SERVICES - SUMMARY

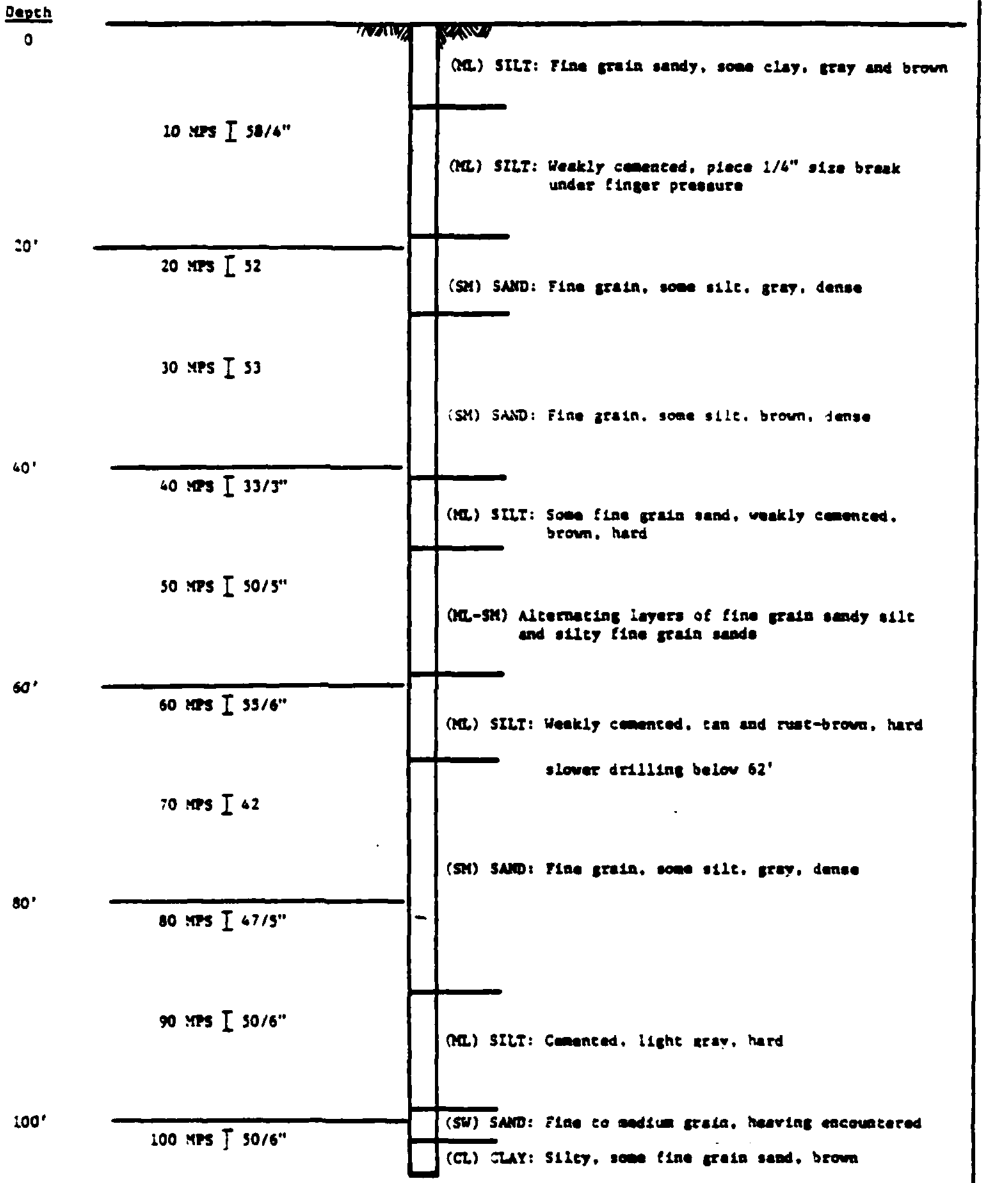
Item Number	Quantity
0001AA	50 feet
0001AB	55 feet
0001AE	4
0001AF	6
0001AI	107 feet
0001AJ	105 feet

J. H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS - ENGINEERING GEOLOGISTS

DRAWN BY: MNG DATE: July 1981
CHECKED BY: RJP DATE: July 1981

BORING LOG
MC CLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
PROJECT NO. A-1557-2
PLATE NO.

BASE MONITORING WELL MW14



(ML) SILT: Fine grain sandy, some clay, gray and brown

(ML) SILT: Weakly cemented, piece 1/4" size break under finger pressure

(SM) SAND: Fine grain, some silt, gray, dense

(SM) SAND: Fine grain, some silt, brown, dense

(ML) SILT: Some fine grain sand, weakly cemented, brown, hard

(ML-SM) Alternating layers of fine grain sandy silt and silty fine grain sands

(ML) SILT: Weakly cemented, tan and rust-brown, hard

slower drilling below 62'

(SM) SAND: Fine grain, some silt, gray, dense

(ML) SILT: Cemented, light gray, hard

(SW) SAND: Fine to medium grain, heaving encountered

(CL) CLAY: Silty, some fine grain sand, brown

Boring terminated at 105', 7-14-81.
Groundwater measured at 82' one hour after completion of drilling.
107 feet of 4" Schedule 40 pvc pipe installed on 7-14-81.

Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SUPPLIES/SERVICES - SUMMARY

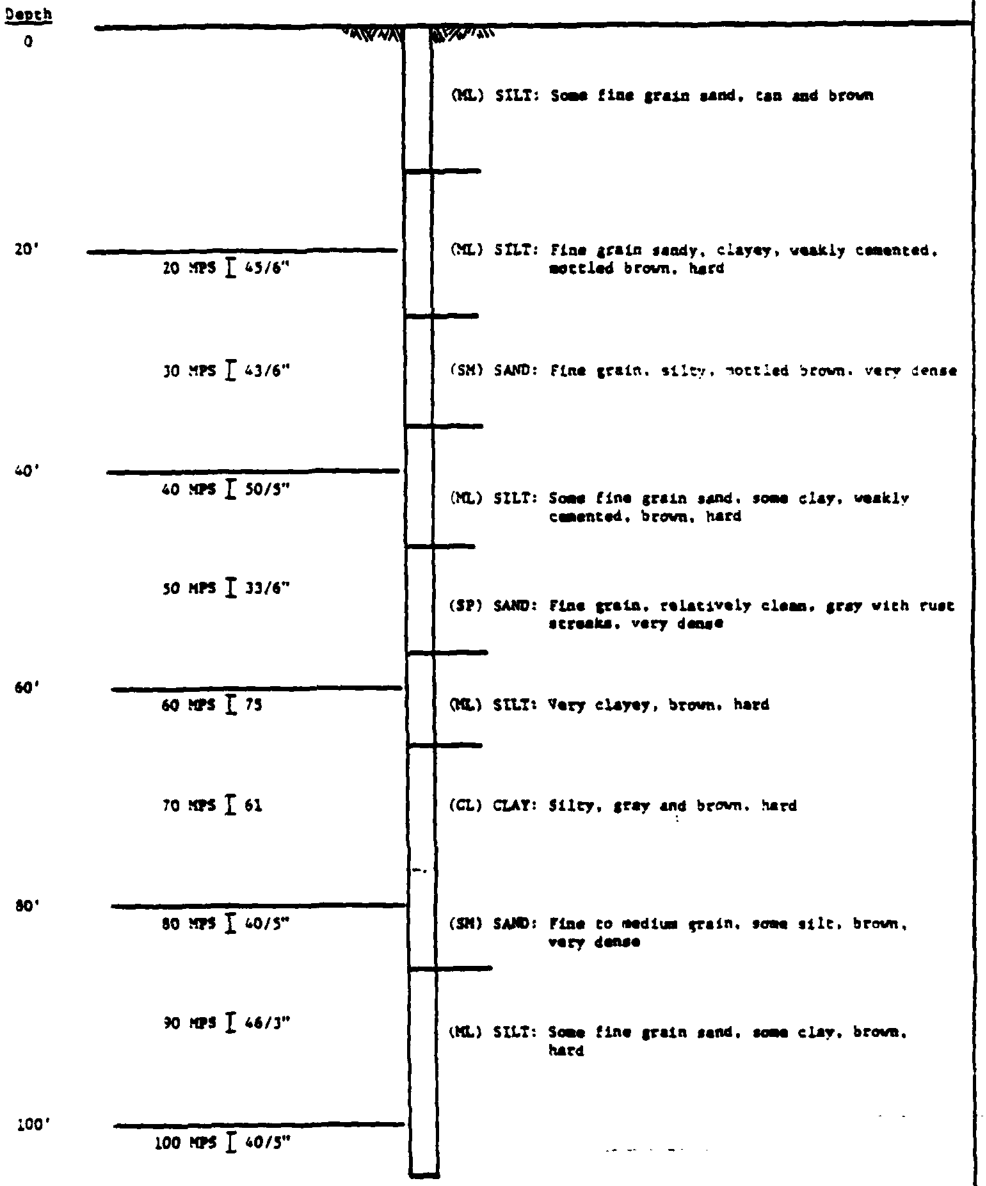
Item Number	Quantity
0001AA	50 feet
0001AB	55 feet
0001AE	4
0001AF	6
0001AI	107 feet
0001AJ	105 feet

J. H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS · ENGINEERING LABORATORIES

DRAWN BY MHG DATE July 1981
CHECKED BY RJP DATE: July 1981

BORING LOG
MC CLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
PROJECT NO. A-1957-2
PLATE NO.

BASE MONITORING WELL MW15



(ML) SILT: Some fine grain sand, tan and brown

(ML) SILT: Fine grain sandy, clayey, weakly cemented, mottled brown, hard

(SM) SAND: Fine grain, silty, mottled brown, very dense

(ML) SILT: Some fine grain sand, some clay, weakly cemented, brown, hard

(SP) SAND: Fine grain, relatively clean, gray with rust streaks, very dense

(ML) SILT: Very clayey, brown, hard

(CL) CLAY: Silty, gray and brown, hard

(SM) SAND: Fine to medium grain, some silt, brown, very dense

(ML) SILT: Some fine grain sand, some clay, brown, hard

Boring terminated at 105', 7-28-81
Groundwater initially encountered at 78' during drilling 7-28-81.
107 feet of 4" Schedule 40 pvc pipe installed on 7-28-81.

Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SUPPLIES/SERVICES - SUMMARY

Item Number	Quantity
0001AA	50 feet
0001AB	55 feet
0001AE	3
0001AF	6
0001AI	107 feet
0001AJ	105 feet

J. H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS   ENGINEERING LABORATORIES
DRAWN BY: HMG DATE July 1981
CHECKED BY: KJP DATE July 1981

BORING LOG
MC CLELLAN AIR FORCE BASE
SACRAMENTO CALIFORNIA
PROJECT NO A-1957-2
PLATE NO.

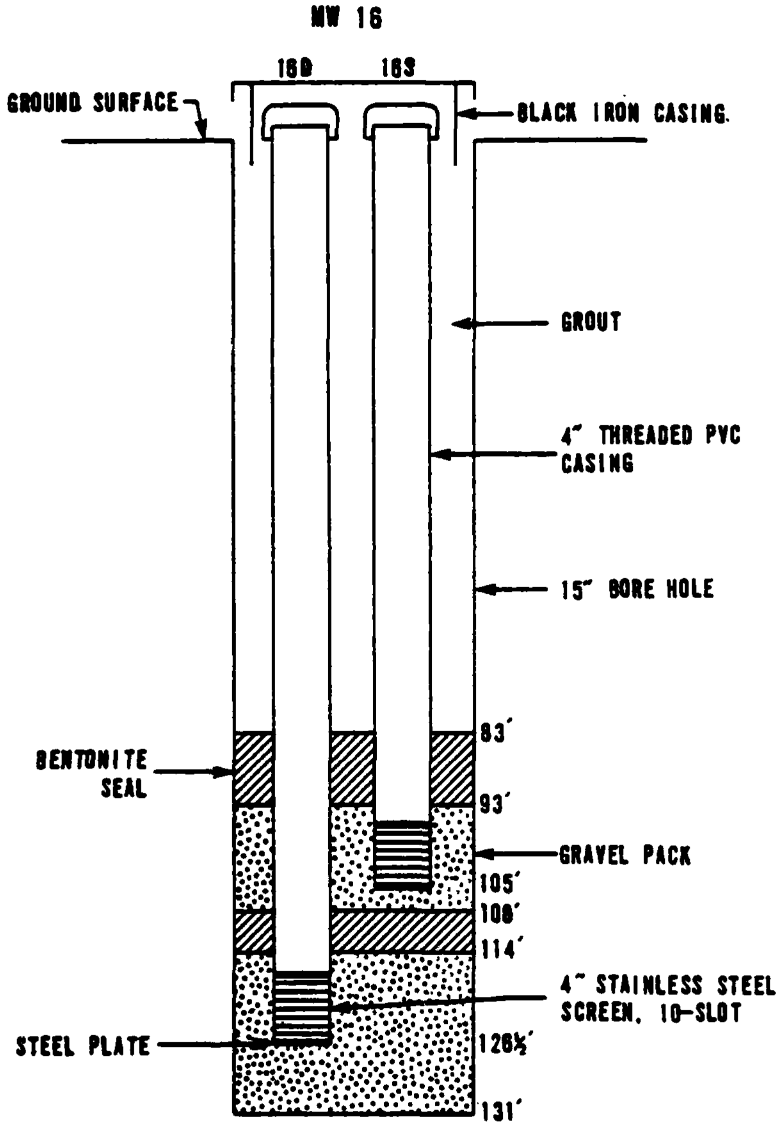
1-278

APPENDIX E

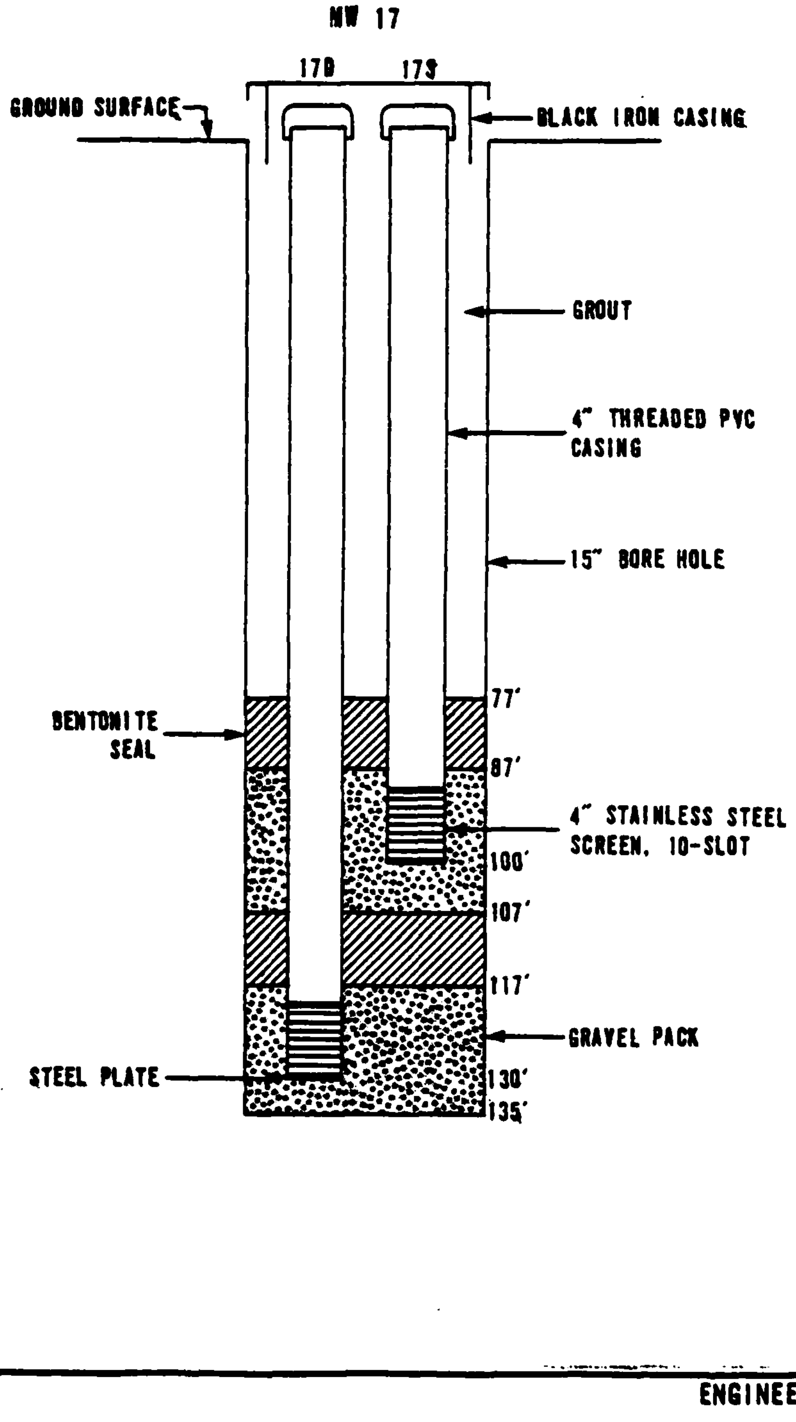
WELL DESIGNS AND WELL LOGS
STAGE I AND STAGE II MONITORING WELLS

WELL DESIGNS
STAGE I MONITORING WELLS

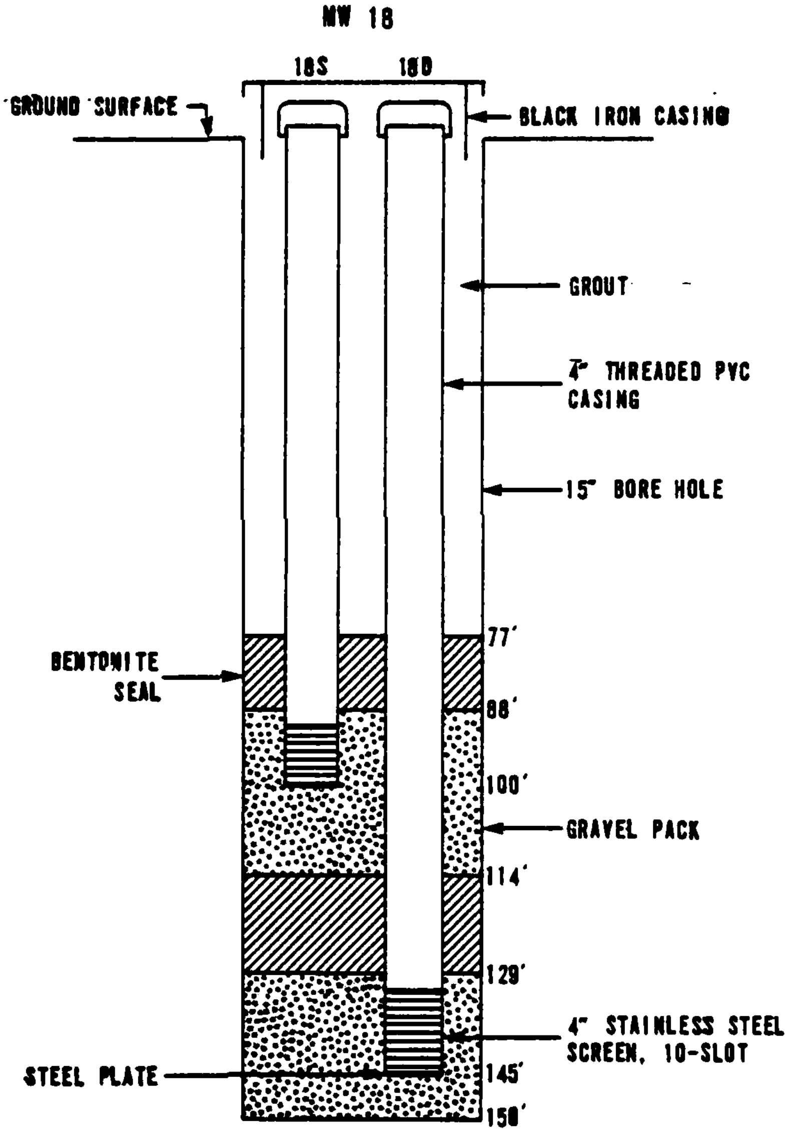
WELL DESIGN


MW 16
16D
16S
GROUND SURFACE
BLACK IRON CASING.
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
83'
93'
GRAVEL PACK
105'
108'
114'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
126½'
131'

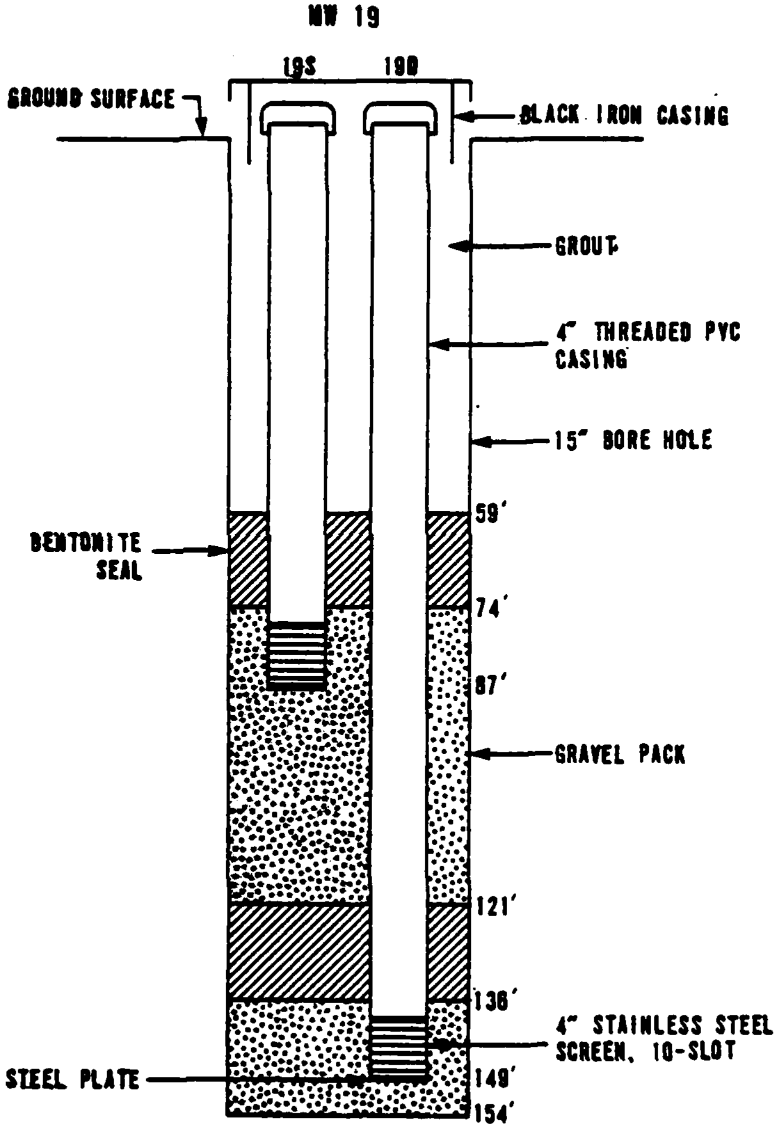
WELL DESIGN


MW 17
17D
17S
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
77'
87'
4" STAINLESS STEEL SCREEN, 10-SLOT
100'
107'
117'
GRAVEL PACK
STEEL PLATE
130'
135'

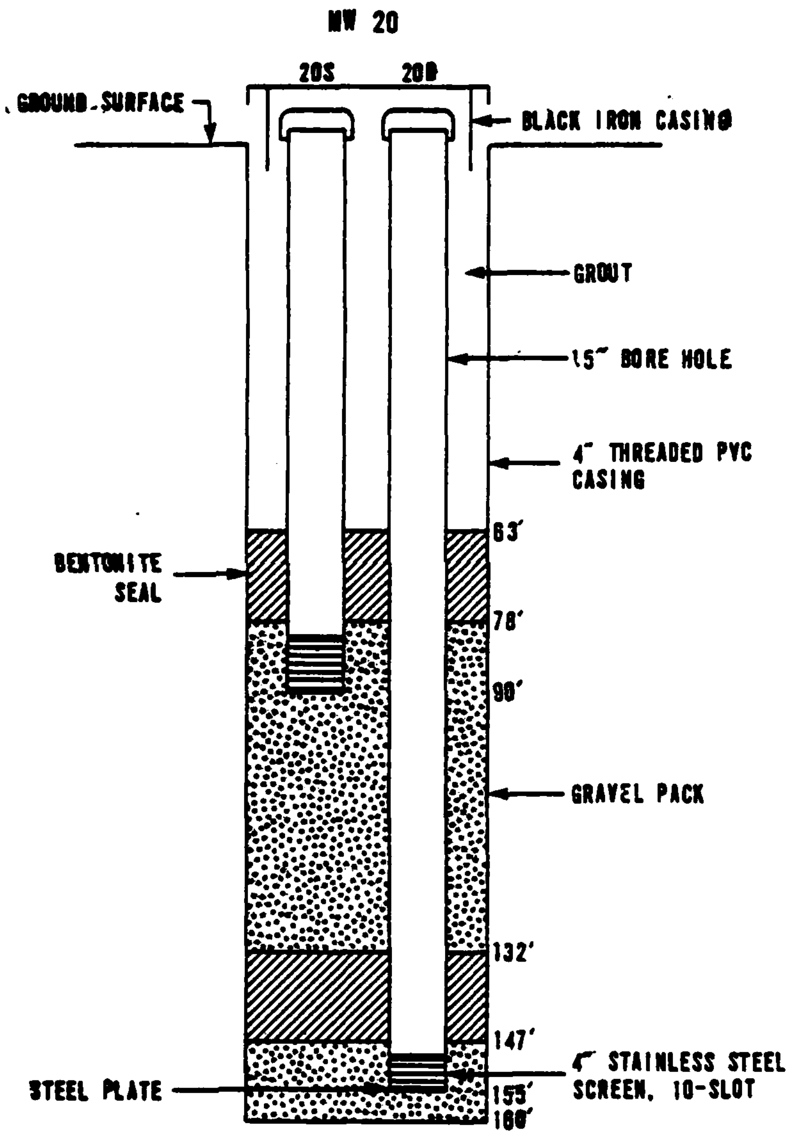
WELL DESIGN


MW 18
18S
18D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
77'
88'
100'
GRAVEL PACK
114'
129'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
145'
150'

WELL DESIGN

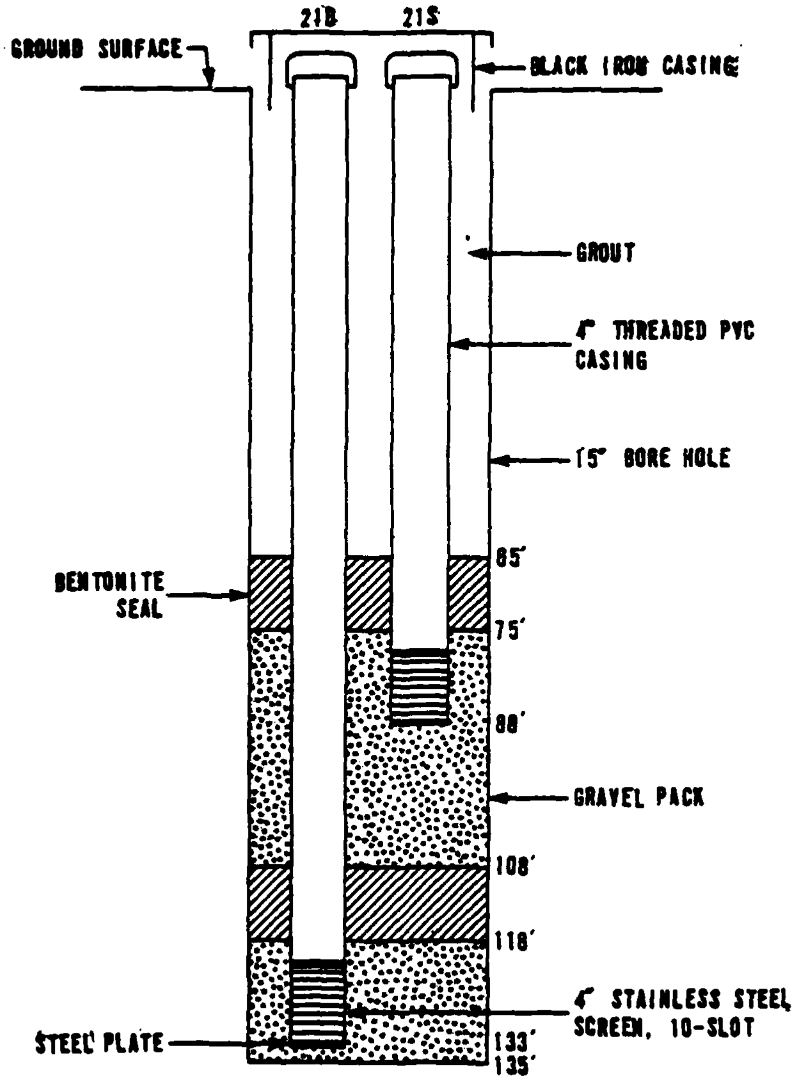

MW 19
19S
19D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
59'
BENTONITE SEAL
74'
87'
GRAVEL PACK
121'
136'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
149'
154'

WELL DESIGN

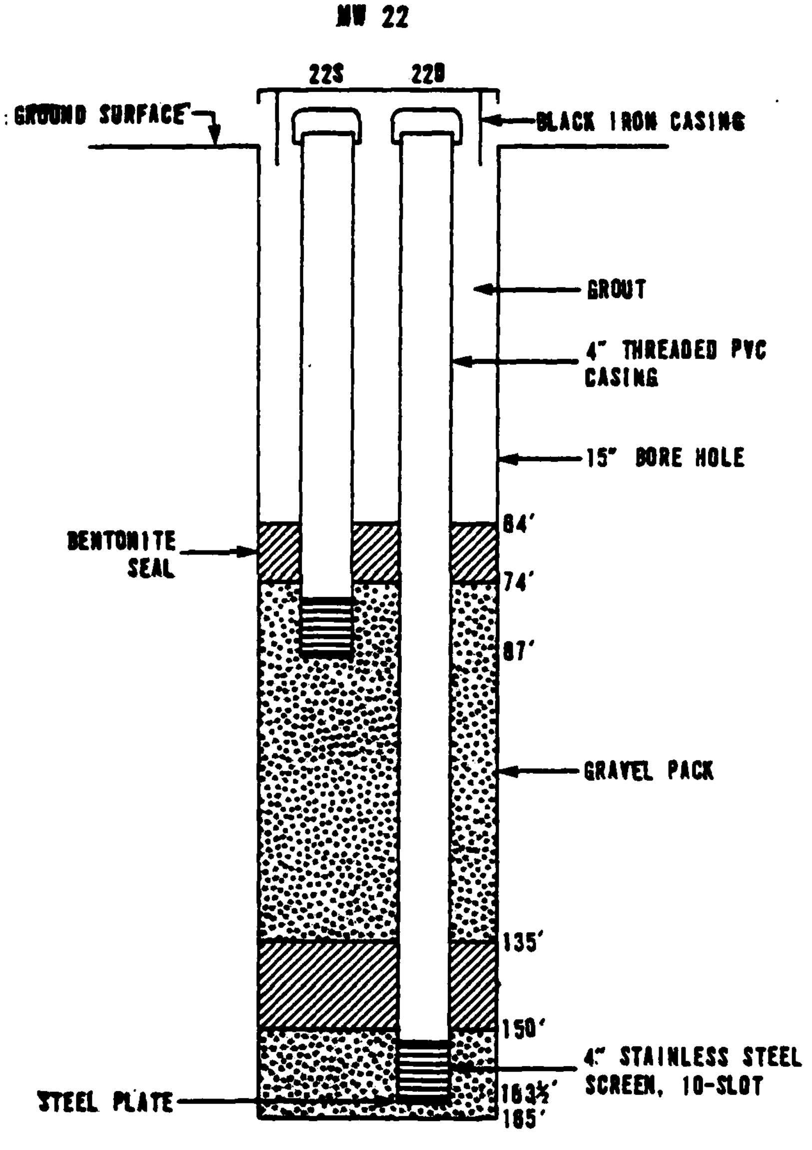

MW 20
20S
20D
GROUND SURFACE
BLACK IRON CASING
GROUT
15" BORE HOLE
4" THREADED PVC CASING
63'
BENTONITE SEAL
78'
90'
GRAVEL PACK
132'
147'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
155'
160'

WELL DESIGN

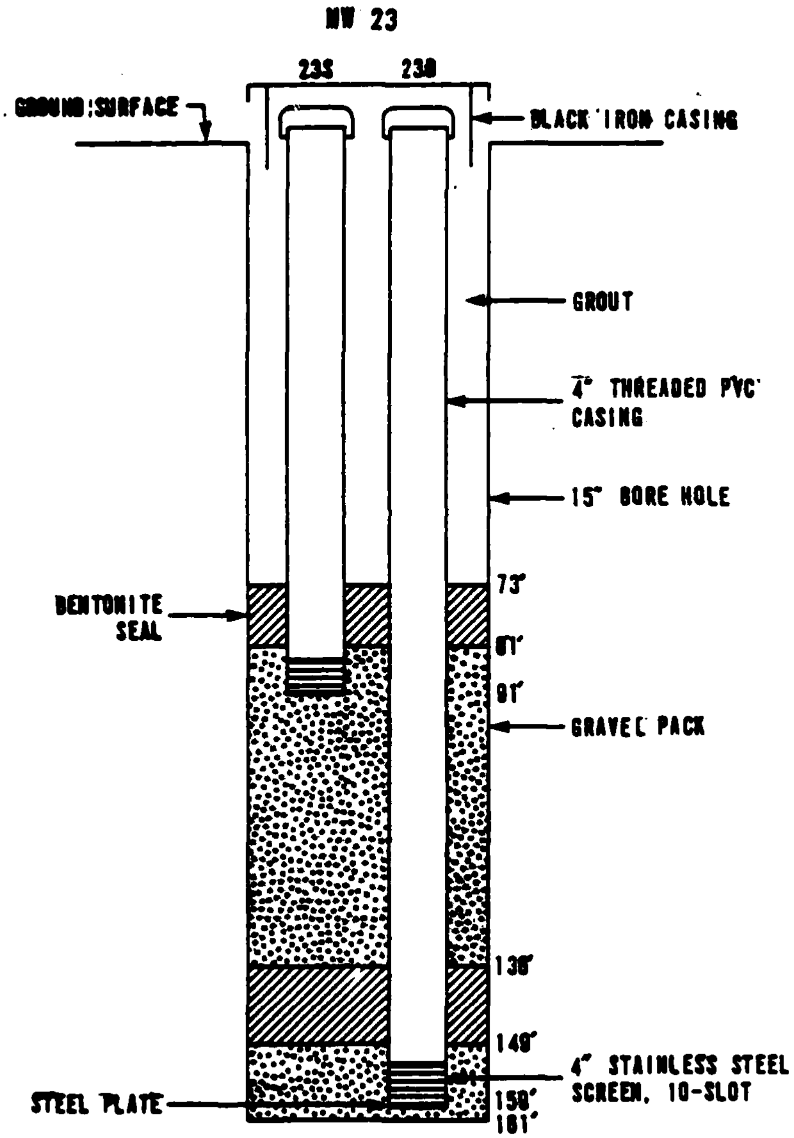
MW 21



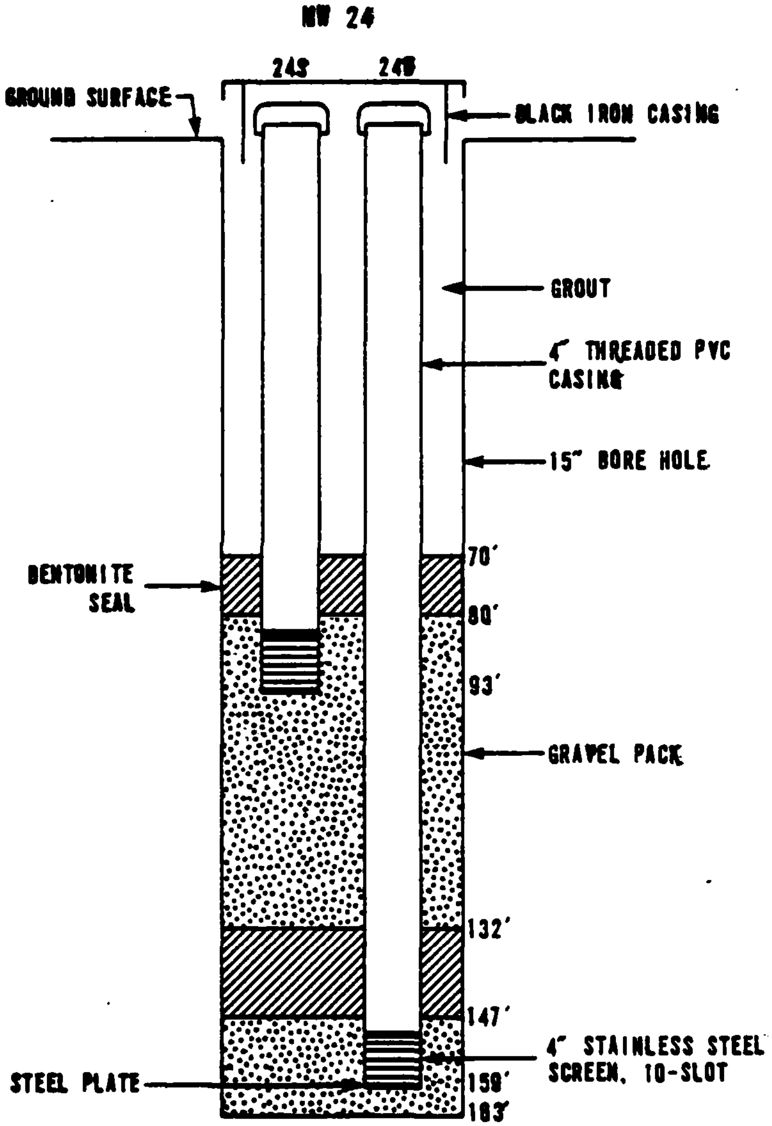
WELL DESIGN


MW 22
22S
22D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
64'
74'
87'
GRAVEL PACK
135'
150'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
163½'
165'

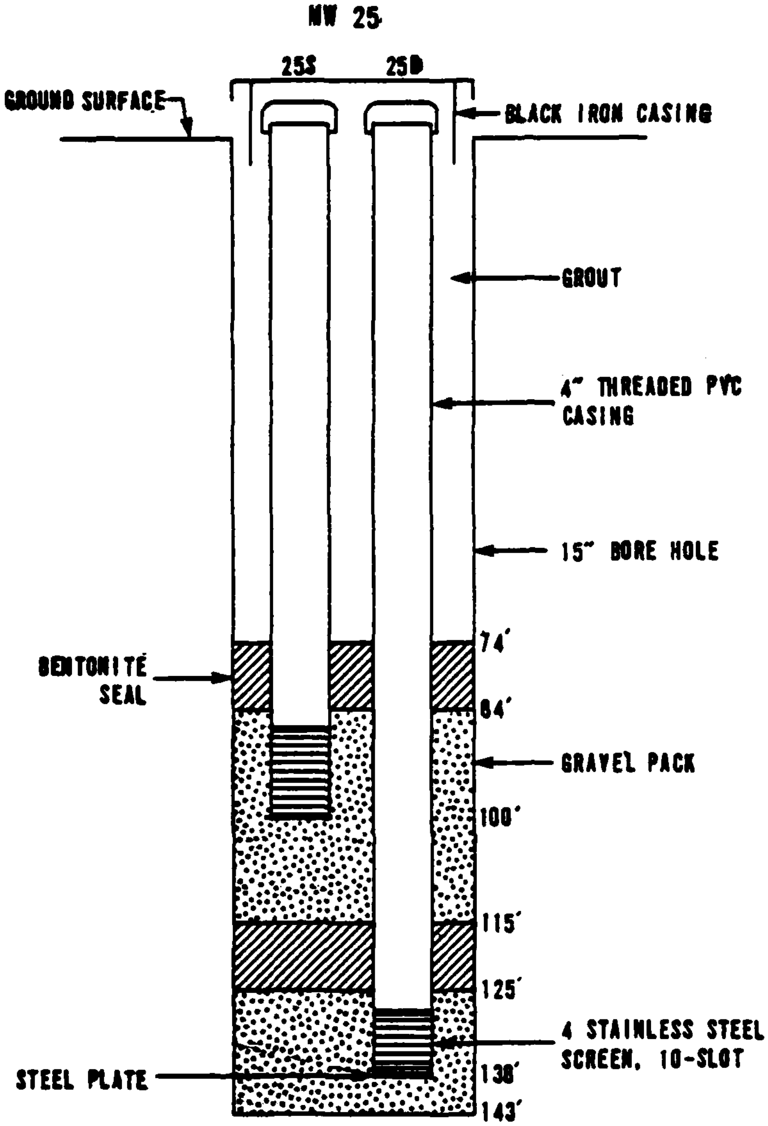
WELL DESIGN


MW 23
23S
23D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
73'
BENTONITE SEAL
81'
91'
GRAVEL PACK
138'
149'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
158'
161'

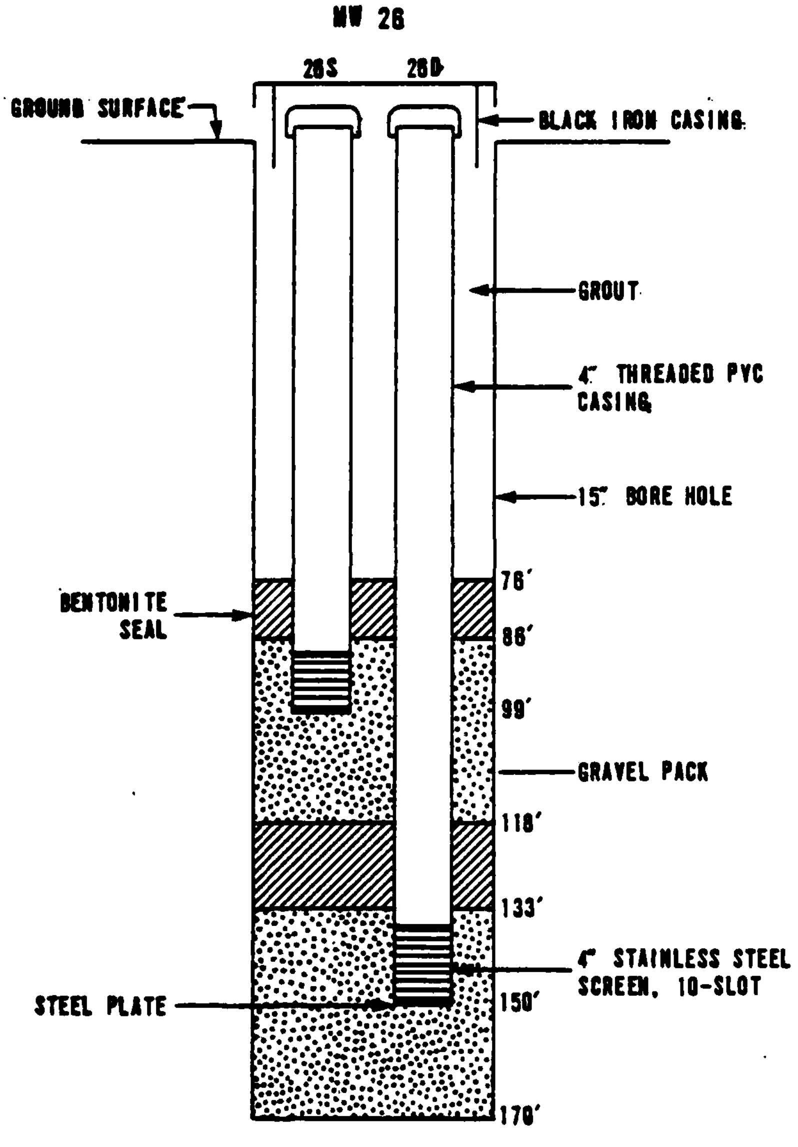
WELL DESIGN


MW 24
24S
24D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
70'
80'
93'
GRAVEL PACK
132'
147'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
158'
163'

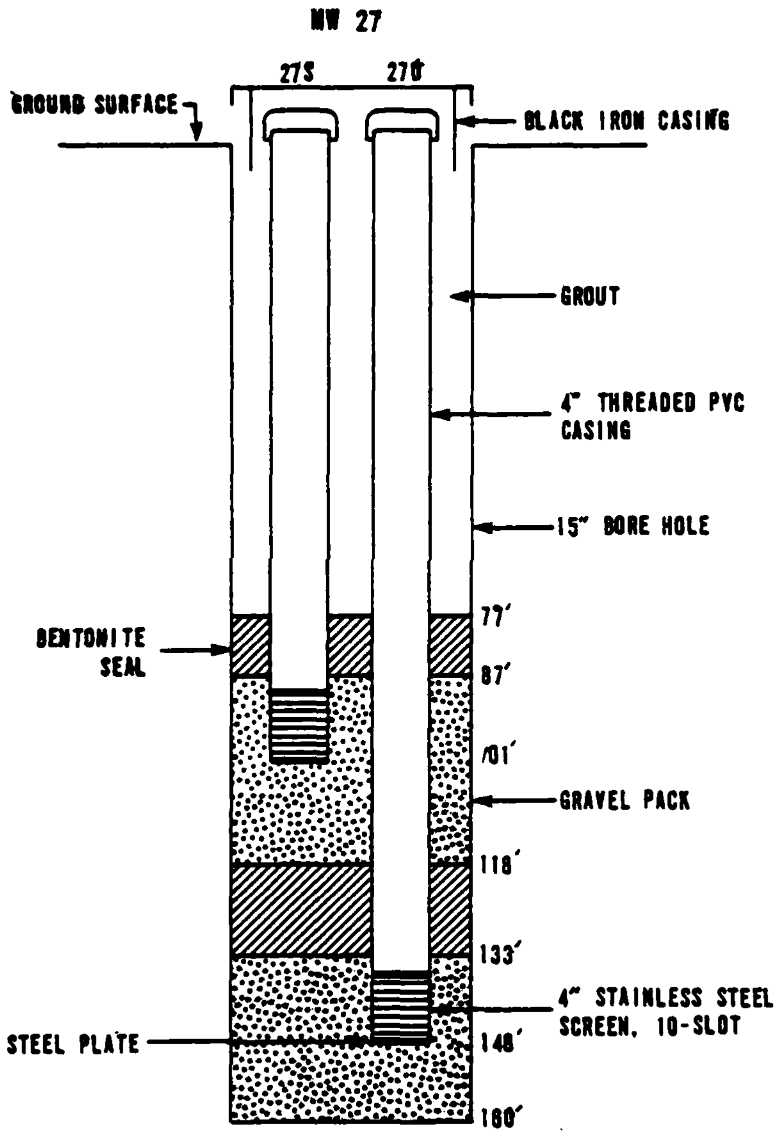
WELL DESIGN


MW 25
25S
25D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
74'
84'
GRAVEL PACK
100'
115'
125'
4 STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
138'
143'

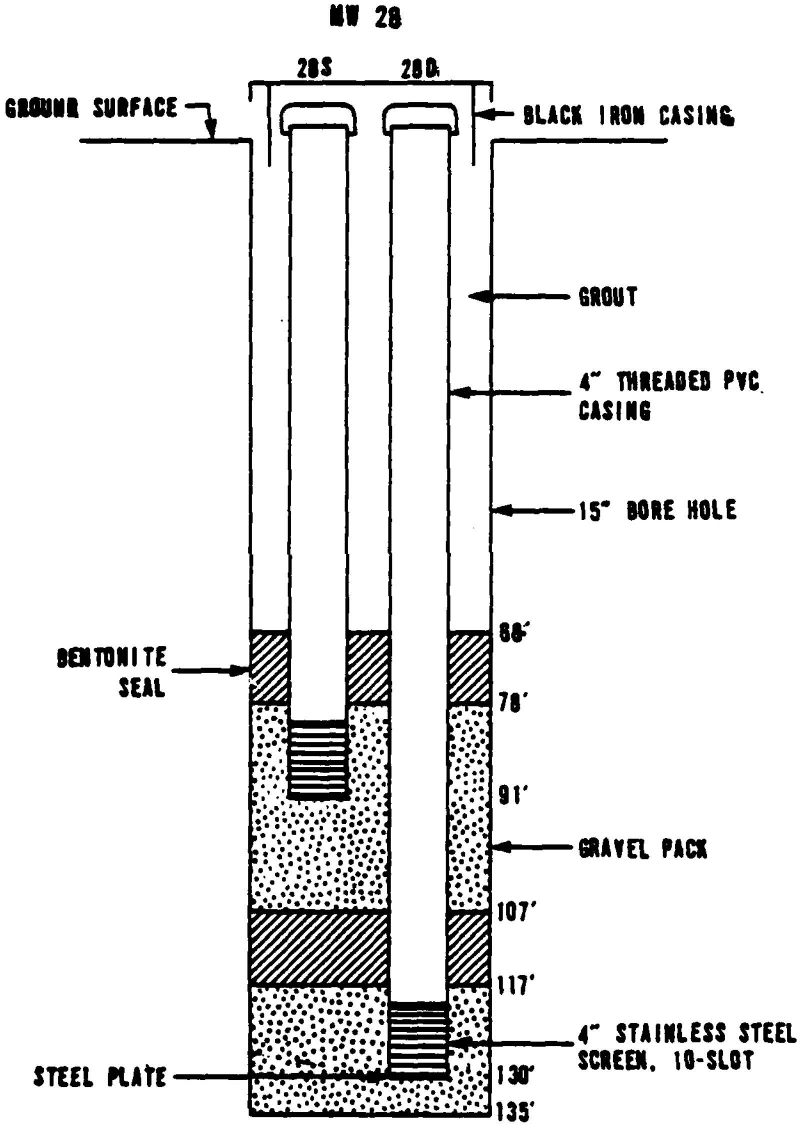
WELL DESIGN


MW 26
26S
26D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
76'
BENTONITE SEAL
86'
99'
GRAVEL PACK
118'
133'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
150'
170'

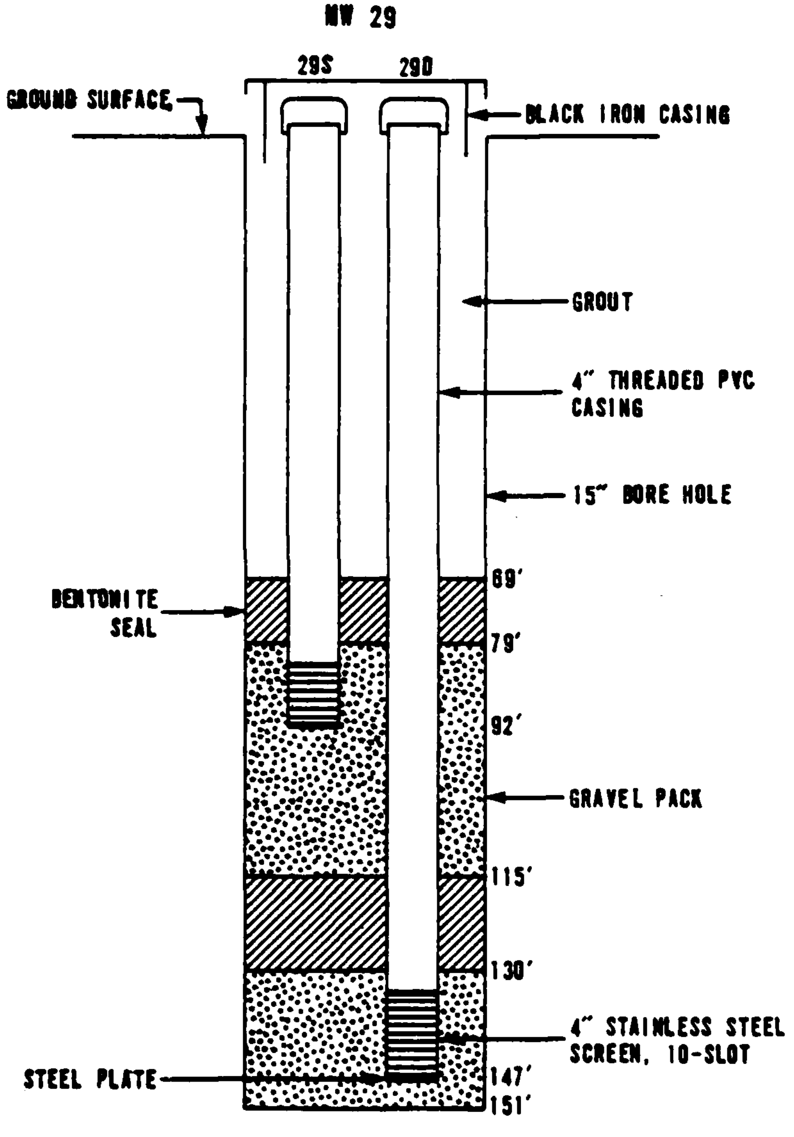
WELL DESIGN


MW 27
27S
27D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
77'
87'
101'
GRAVEL PACK
118'
133'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
148'
160'

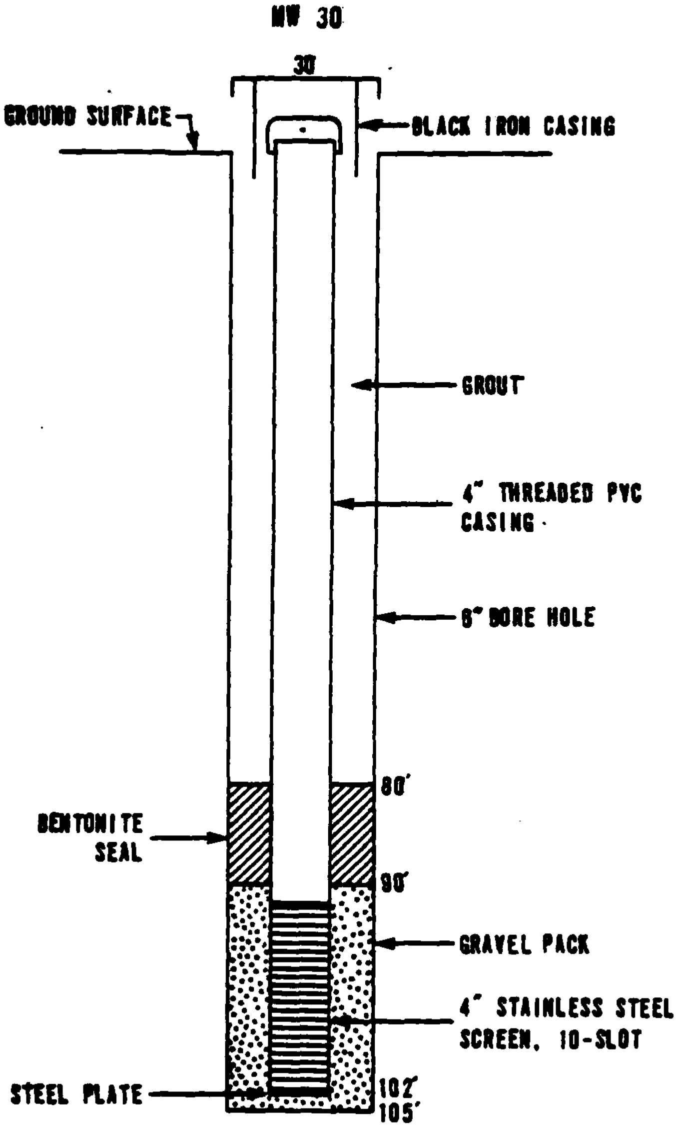
WELL DESIGN


MW 28
28S
28D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
68'
78'
91'
GRAVEL PACK
107'
117'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
130'
135'

WELL DESIGN

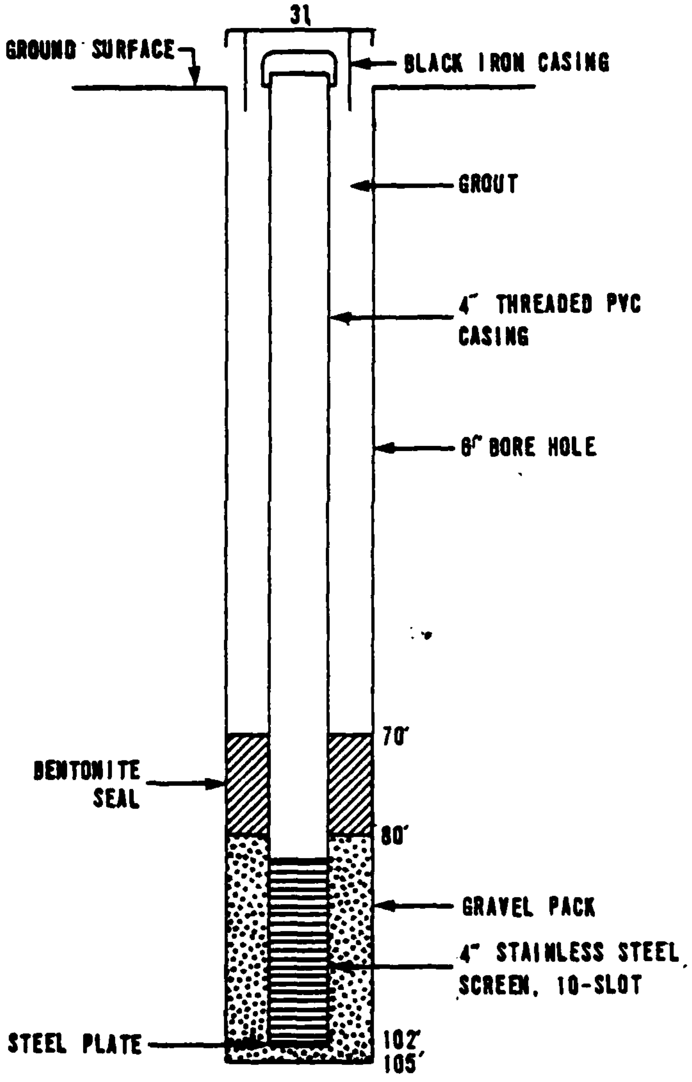

MW 29
29S
29D
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
15" BORE HOLE
BENTONITE SEAL
69'
79'
92'
GRAVEL PACK
115'
130'
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
147'
151'

WELL DESIGN


MW 30
30
GROUND SURFACE
BLACK IRON CASING
GROUT
4" THREADED PVC CASING
8" BORE HOLE
80'
BENTONITE SEAL
90'
GRAVEL PACK
4" STAINLESS STEEL SCREEN, 10-SLOT
STEEL PLATE
102'
105'

WELL DESIGN

MW 31



WELL LOGS
STAGE I MONITORING WELLS

ES DRILLING LOG

Well No.: ES 16

Date: MARCH 10,1983

Location: McClellan AFB, NORTH GATE

Altitude (Datum):

Method: Hollow-stem Auger

Size of hole: 8"

Size of casing: none, pilot hole

Driller: Stong Drilling and Exploration . Rancho Cordova, CA

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0		Clayey sand, SC, 35% fines, brown, moist, plastic	SC	
2				
4		Medium sand, SW, [illegible] tan, moist, loose	SW	
6				
8				
10				
12				
14			- - - - -	cemented [illegible]
16				
18				
20	▽		- - -	little clay, 35% clay, [illegible]
22				coarse sand stiff
24				
26				
28				
30			- - - - -	
32				
34				
36		Clayey sand, SC, 35% clay, light brown, moist, dense	SC	
38		Medium sand, SW, reddish [illegible], dense, moist	SW	clay streaks
40	▽			
42				
44				
46		Clayey sand, 20% clay,	- - - -	cemented, [illegible], streaks
48		reddish brown, dense, moist	SC	
50				
52				
54				
56				30% clay
58		Sandy clay, CL, 10% sand, light brown, plastic, moist	CL	cemented
60			- - - -	

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ES DRILLING LOG

Well No.: ES 16

Date: March 10, 1982

Location: McClellan AFB

Altitude (Datum):

Method: Hollow-stem auger

Size of hole: 8"

Size of casing: none pilot hole

Driller: Stang Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
			CL	
62				
64				20% medium sand
66				
68				
70				5% medium sand
72				
74				
76				
78				
80	S			
82				5% coarse sand
84			- - - - -	cemented
86				
82				
90				
92				
94				10% medium sand
96				
98			sand?	
100	S		- - - ∇	wet auger tip
102			sand	sand 1', auger going fast
104			CL	
106				
108				
110				
112				
114	S		∇	— auger tip wet
116		silty sand, yellowish	SM/SC	
118		clayey		dry
120			hole com	pleted at 120

ES

DRILLING LOG

Well No.: [illegible]

Date: [illegible]

Location: McClellan

Altitude (Datum): [illegible]

Method: Rotary Wash

Size of hole: 15"

Size of casing: [illegible]

Driller: [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
			SM/SC	
130				
			T.D. 130	

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1-300

ES

DRILLING LOG

Well No.: 17

Date: May 26 1982

Location: McClellan AFB, CA

Altitude (Datum): 73.3 msl

Method: Rotary Wash

Size of hole: 15"

Size of casing 2 × 4"

Driller: Stang Drilling & Exploration [illegible] [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		gn bn, clayey si [illegible] sand	SC	
		SC		
10		bn silt, getting clayey ML	ML	
12		bn clay, increasing si [illegible] CL	CL	
			SW	
		[illegible] med. sand, clean, pyritic, SW		
		[illegible] (5%), clayey [illegible] ML	[illegible]	
20		getting siltier		
		black med sand py- ritic, SW	SW	
		[illegible] (20%) [illegible]	CL	
		[illegible]		
30				
40				
50				
[illegible]				

ES

DRILLING LOG

Well No.: 17
Date: [illegible]

Location:
Altitude (Datum):
Method:
Size of hole:
Size of casing:
Driller:

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		Brn [illegible] clay ML	ML	
70				
[illegible]				
		green [illegible] CL	CL	
		silt [illegible]		
		[illegible] med. [illegible] sand [illegible] SW	SW	
			CL	
		cla[illegible]		
		[illegible]		

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ES

DRILLING LOG

Well No.: [illegible]

Date: [illegible]

Location:

Altitude (Datum):

Method:

Size of hole:

Size of casing

Driller:

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		[illegible] sand	[illegible]	
20		[illegible]		
		[illegible]		
30				
			TD. 35	
40				

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ES DRILLING LOG

Well No.: MW 18
Date: 3-16-82

Location: McClelland
Altitude (Datum):

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

Driller: Stamp
–

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0	4:00 PM	Topsoil		
2		CL, very silty, bn, ms m.		
10				
18		SP, clayey, bn-dk bn ms-dk m		←
20				20 FT. Auger-Sample
23		CL, silty, bn, some olive bn, iron		
		staining, ms-s, sm-mm,		
		occ. int. bedded sand, (SP,		bn, grey,
30				
40				40 FT. split spoon
				43-67-72/6 inches
				
				+0 full
				CL, silty, bn [illegible]
50				SP, bn [illegible]
				md. mm
		55ft.		4:50 PM - stop - lightning
				Resume 7:15 AM 3-17-82

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ES

DRILLING LOG

Well No.: MW 18

Date: 3-17-82

Location: McClelland

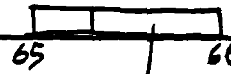
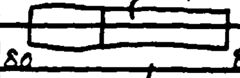
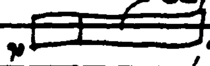
Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8"

Size of casing: —

Driller: STANG

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				Some wet cuttings 55-60 may be
				perched water or from rain
		65 FT split spoon		
				CL, silty, bn, MS-S, MM M
70				29-55-70/6 inches
				CL, v. silty, dk bn, iron stain MS-S, M, vn
80				
				17-25-9/6 inches
?-88		SP (contact unknown)		CL, silty, dk bn, s, vs, MM
90 ? →		CL (as in drive)		
94		← CL, hard drilling		22-48-54/6 inches
95	8:35AM	T.D 95 ft		
		Water 89' 9:00	AM - 3-	17-82

F-305

ES DRILLING LOG

Well No.: 18

Date: [illegible]

Location: [illegible]

Altitude (Datum): [illegible]

Method: Rotary wash

Size of hole: 15"

Size of casing [illegible]

Driller: [illegible] Drilling [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
95		grn brown [illegible], sandy clay, CL	CL	
		[illegible]	M	[illegible]
[illegible]				
[illegible]				
[illegible]				[illegible]
[illegible]				
130				
		increasing sand [illegible]		
		Red [illegible] sand	SM	
[illegible]				
1[illegible]0			7 L 'S'	

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ES

DRILLING LOG

Well No.: MW 19

Date: 3-11-82

Location: McClellan AFB **Altitude (Datum):**

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

Driller: Stang Drilling

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0	8:40AM	SP, brown-red bn, loose, sli. moist		
7		SM, lt bn-bn, md, sm-mm		
10				
12		SP, red. gr., sli clayey, lt. bn-bn, md, sm-mm		
20				auger sample - 20 ft.
25		CL, silty, sli sdy, bn, ms-s, sm-mm		
30				
32		CL-SP interbedded, bn, ms, mm		
38		SP, f-g & CL, silty, bn, rd bn. md, mm, iron staining		split spoon - 40 ft.
40				
48		CL, silty, bn-rd bn, s-vs, mm.		
50				
60				

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ES DRILLING LOG

Well No.: MW 19

Date: 3-11-82

Location: McClelland AFB

Altitude (Datum):

Method: Hollow Auger

Size of hole: 8"

Size of casing

Driller: Stang Drilling

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				60 ft - split spoon
70				
≈75		SP, med gr. dk bn, grey,		
		blk part., m'd, wet.		77.5' - wat. level after drilling
80				split spoon - 80 ft
		CL, dk bn, olive gn, silty		
		s-vs, moist-very moist		
85	10:34AM	T.D.		

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DRILLING LOG

Well No.: 1

Date: [illegible]

Location: McClellan

Altitude (Datum): [illegible]

Method: Rotary Wash

Size of hole: 5"

Size of casing: [illegible]

Driller: Sierra Drilling & Exploration [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		bn [illegible] clay	CL	
95				
105				
108		b'ish clay [illegible]	-	[illegible]
115			- -	[illegible]
125				
[illegible]				
		[illegible] clay [illegible]	[illegible]	
[illegible]			T.D. 150'	

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ES

DRILLING LOG

Well No.: MW 20

Date: 3-11-82

Location: McClelland

Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8"

Size of casing: —

Driller: STANG

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0, 1		Toposoil		
		SP, clayey, med gr +		
		f. gr., bn-red, l-md,		
		mm		
10				
17		SP, med gr., some dk.		
20		particles, lt bn. sli. ay		20 ft- auger sample
		l-md, mm		
23		CL, silty, blk organics		
		bn-grn, ms-s, sm		
26		SP, med gr -CL silty		
30		interbedds. rd bn-bn,		
		mm		
33		SP, f. to med gr, bn, md,	MM.	
		+ CL, silty, iron staining,		
		bn, vs, sm interbeds		
40				40 ft.- split spoon
42		SM, silty, bn, d, sm		
48				
50		CL, silty, f. gr sdy, bn, s,		
		mm		
54		CL, silty, rd bn, lt bn grey, ms, sm-mm		
60				split spoon - 60 ft

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1-3/7

ES

DRILLING LOG

Well No.: MW 20

Date: 3-11-82

Location: McClelland

Altitude (Datum):

Method: Hollow Auger

Size of hole: 8"

Size of casing

Driller: STANG

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				
70				
72		CL, sli silty, rd bn, ms-s, mm		
76		SP-CL, bn-gy bn, ironstained + SP, fig, bn-gy bn		
80		interbd's, md-d, mm		split spoon - 80ft.
? -84		SP, med gr, bn-gray bn, md, wet.		WATER approx 85 ft.
87		CL, gy to olive bn, sli silty, h, mm		
90		90' T.D.		

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ES

DRILLING LOG

Well No.: 20

Date: [illegible]

Location: McClellan

Altitude (Datum): 60.[illegible]

Method: Rotary [illegible]

Size of hole: 15"

Size of casing: [illegible]

Driller: [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
90'		[illegible] hard		[illegible]
		clay		
[illegible]				
130				
		sand, md. 5%		
		[illegible] sand [illegible]	[illegible]	
150				
		[illegible] sand [illegible]	[illegible]	
			T.D. [illegible]	
170				

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ES DRILLING LOG

Well No.: MW 21

Date: 3-11&12-82

Location: McClelland AFB **Altitude (Datum):**

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

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0 1	2:50PM	Topsoil, dk bn		
4		CL, silty, dk bn, ms, mm	CL	
		CL, silty bn-rd bn, ms mm		
7		CL, sli silty, sli sdy,		
		grn bn, vs, sm		
10				
				auger sample - 20 ft.
20				
25		SP, v silty, bn, md, wt	SP	3:30 PM stop at 25 ft.
26		CL, v. sdy, bn, ms, mm	CL	1 ft thick perched water 25'-26
28		SP, f.gr. bn, md, mm	SP	
30				
38		CL, silty, ML, bn, ms, sm	CL	
40				
42		ML, clayey, f.gr sdy,	ML	
		iron staining, md, sm-mm		45 ft - split spoon sample
50		SP-CL interbeds		
59		CL, v silty, rd bn vs, mm	CL	
60				60 ft - split spoon

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ES

DRILLING LOG

Well No.: MW 21

Date: 3-11-12-82

Location: McClelland AFB **Altitude (Datum):**

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

Driller: Stane

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				
70				
≈73		SP, f.g., wet	SP - ?	
78				
80		CL, sli silty, bn-gry br,	CL	
		vs, vm, iron staining		80 ft - split spoon
85		T.D.		

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ES

DRILLING LOG

Well No.: [illegible]

Date: [illegible]

Location: [illegible]

Altitude (Datum): [illegible]

Method: [illegible]

Size of hole: [illegible]

Size of casing: [illegible]

Driller: [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
55'		[illegible]	[illegible]	
		[illegible]		
[illegible]				
		[illegible] 15%		
120		brownish silt		
25				
		[illegible] sand [illegible]	SM	
		[illegible] hard	[illegible]	
			T.D. 135'	
[illegible]5				

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YN

ES DRILLING LOG

Well No.: ES22

Date: 3/13/82

Location: McClellan AFB, Sacramento

Altitude (Datum):

Method: Hollow-stem auger

Size of hole: 8"

Size of casing: None Pilot hole

Driller: Slava Drilling & Exploration

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2	10:00	clayey sand, CL, 10% fines, reddish brown moist, plastic fines	SC	some cementation
4				
6				iron stains, cemented clay
8				
10				dark tan
12				
14		medium silty sand, SM, 10% fines, tan, loose, moist	SM	
16				
18				
20				cemented clay layer
22			SC	
24		clayey sand, CL, 10% fines, reddish brown, moist, plastic fines, hard		cementation w/ [illegible] iron stains
26				
28				brown, iron cemented
30				
32				
34				
36				
38				
40	10:30			cemented clay layers
42		medium sand, SW, >5% fines, [illegible] loose	SW	[illegible]
44				
46				
48				
50				
52				
54				
56				
58				
60	11:00			

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ES

DRILLING LOG

Well No.: ES 22

Date: 3/13/82

Location: McClellan AFB, Sacramento **Altitude (Datum):**

Method: Hollow-stem auger **Size of hole:** 8" **Size of casing:** none pilot hole

Driller. Stang Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
62		lean clay CL, brown, low plasticity.	CL	iron stains
64				
66				
68				
70				
72				
74				
76				
78				
80		clean medium sand SW, bn	SW	rust bands - moist
82		clay CL, brown, hard	CL	
84			▽	wet auger
86	12:00	clayey silt, ML, brown, low plasticity, hard	ML	
88			Hole completed 85'.	
90				
92				
94				
96				
98				
100				

ES

DRILLING LOG

Well No.: 22

Date: [illegible]

Location: [illegible]

Altitude (Datum): [illegible]

Method: Rotary wash

Size of hole: 5"

Size of casing: 2"

Driller: [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
[illegible]		clayey silt, gn	[illegible]	
		green sandy clay [illegible]	[illegible]	
105				
		[illegible]		
[illegible]				
[illegible]				
[illegible]		tn clayey sand	[illegible] T.D. 135	

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ES

DRILLING LOG

Well No.: MW23

Date: 3-12-82

Location: McClelland

Altitude (Datum):

Method: Hollow Auger

Size of hole: 8"

Size of casing:

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0				
1	9:40AM	- Fill, gravel, etc.		
		SP, clayey, rd bn, nd, mm		
4		CL, sdy, rd bn, ms, mm,		
		iron staining		
9		SP, sli clayey, bn, nd, sm		
10				
18				
		CL, sli sdy, bn to dk bn, ms,		
20		sm-mm, iron staining,		20 ft- auger sample
30				
40				40 ft - split spoon
50				
60				60 ft - split spoon

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ES DRILLING LOG

Well No.: MW23

Date: 3-12-82

Location: McClelland

Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8"

Size of casing: —

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				
70				
80				80ft split spoon
≈85		SP, clayeu (sli) br, f.gr. md-d, wet		
90				
92				90 ft split spoon
		CL, vs-s, hard ϕ (no auger sample)		
95	1:00PM	T.D. 95 ft.		

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ES

DRILLING LOG

Well No.: 23

Date: [illegible] 23 [illegible]

Location: McClellan

Altitude (Datum): 58.[illegible]

Method: [illegible]

Size of hole: 5"

Size of casing: [illegible]

Driller: [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
5'		[illegible] clay		
[illegible]				
[illegible]				
		[illegible] sand	SC	
[illegible]			T.D. [illegible]	

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ES

DRILLING LOG

Well No.: MW24

Date: 3-12-82

Location: McClelland

Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8"

Size of casing: —

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0	1:13PM	Fill, gravel, scrapings		
2		SP, silty, clayey bn, sl, mm-m		
4		CL, silty, dk bn, s, M		
10		→SP, clayey + CL, silty		
12		rd bn-bn, md, m		
14		CL, silty bn, gn bn,		
		s, M and rd bn-iron		
		staining		
20				20ft auger sample
30				
38				
40		CL, silty rd bn iron		40 ft split spoon
		stained to olive bn,		
		bn, s-vs, MM		
50				
60				60 ft split spoon

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ES

DRILLING LOG

Well No.: MW24

Date: 3-12-82

Location: McClelland

Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8''

Size of casing: —

Driller: Stang Drilling

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				
70				
≈74		SP, f.gr., silty, bn		
80		CL, sity, olive greybn, s, sm		80 ft split spoon
≈88		SP, vf.g, bn to greybn, md,	WET.	
90				90 ft split spoon
94		CL, silty, s-vs -mm		
95	3:30PM	T.D. 95'		

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ES

DRILLING LOG

Well No.: [illegible]

Date: [illegible] 24, [illegible]

Location: [illegible] ov

Altitude (Datum): 58 [illegible]

Method: R[illegible] Wash

Size of hole: 15"

Size of casing: [illegible]

Driller: [illegible] Drilling & Exploration

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
95		gn. olive bn. clay	CL	
125				
		[illegible] sand		
		bn. silty sandy clay		
145				
		gr. clayey sand, fine	SC	
165				

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ES

DRILLING LOG

Well No.: ES 25

Date: 3/15/82

Location: McClellan AFB, Sacramento

Altitude (Datum):

Method: Hollow-stem auger, Mobile B-53

Size of hole: 8"

Size of casing: none pilot hole

Driller: Stang Drilling & Exploration. Rancho Cordova, CA

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2	10:00	Sandy clay, 20% sand, CL, reddish bn, [illegible]	CL	
4				
6		well graded medium sand, SW, light bn, < 5% clay fines, moist, non-plastic	SW	
8				
10				
12				
14				
16				cemented clay w/ iron stains
18				fine sand
20	☐	clayey sand, SC, 25% fines, light bn, dense	SC	iron-stained cementation
22				
24		well graded medium sand, SW, reddish bn, loose, non-plastic	SW	
26				
28		clayey sand, SC, 20% clay, orbwn	SC	
30			SW	perched water
32				
34		well graded medium sand, SW, reddish bn, loose, non-plastic	SW	iron-stained bands
36				
38				
40	☐			pump
42				
44				
46				
48				
50				
52		clayey sand, SC, 20% sand, [illegible]	SC	perched water, wet
54				
56				
58				
60	☐	sandy silt, 10% sand, light bn, hard, non-plastic	ML	

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ES

DRILLING LOG

Well No.: ES25

Date: 3/15/82

Location: McClellan AFB, Sacramento, CA

Altitude (Datum):

Method: Hollow-stem auger, Mobile B-53

Size of hole: 8"

Size of casing: none pilot hole

Driller:

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
			(ML)	
62				
64				
66				
68				
70				
72				
74				
76				
78				
80				
82	12:07			
84				
86				
88				
90				
92				
94				
? 96				
98		SP, top of sand lens unknown		Water ≈ 98 ft
				(87' after drilling)
100				
101		CL, sdy, silty, s-vs.M		≈ M" scope
		olive br-bn		102' hard'g
105	12:45PM	T.D. 105'		
		(1:30 PM wait for trans)		

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ES

DRILLING LOG

Well No.: 25

Date: [illegible]

Location: McClellan

Altitude (Datum): [illegible]

Method: Rotary Wash

Size of hole:

Size of casing -

Driller:

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
115		Greenish brn, silty clay	-	
125				
		[illegible]	SM	
			T.D. 143'	
[illegible]5				

ES DRILLING LOG

Well No.: MW 26

Date: 3-17^{18}-82

Location: McClelland

Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8"

Size of casing: —

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0	1:20 PM	Artificial Fill, gravel, asphalt, etc		
2		CL, silty, bn, ms, MM		
8		SP, f.gr., sli clayey, bn, md, mm		
10		some med gr. lenses.		
20				20 FT. AUGER SAMPLE
26		CL, v. sdy, silty, bn-occ iron staining, MS-S, MM		
30				
36		SP, f.gr., bn-grey bn, md, SM		
40				40 FT SPLIT SPOON 12-18-23/6" SP, f.gr., bn-grey bn, md, SM
50				

ES

DRILLING LOG

Well No.: MW 26

Date: 3-17-82 &18

Location: McClelland

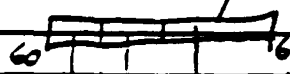
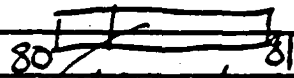
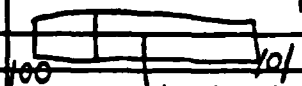
Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8''

Size of casing: —

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60 61		CL, silty, MS, SM-MM		60 FT SPLIT SPOON 18 · 22-26 /6 inches  slough CL, silty, MS, SM-MM SP, fi gr, bn, md, SM
70				
80				80 FT SPLIT SPOON  39-62-74/6 inches CL, sli silty, bn, s-vs, MM
90				
94	?	SP, wet		STOP AT 3:00 PM - at 90' - RAIN START 8:40 - 3-18-82 water at ≈98 during drilling
100		CL, bn-olive bn, sli silty, vs, mn-m		 CL, olive bn, sli silty, vs, mn-m
105'	9:20AM	TD		

Water - 91' at 10:00AM after pulling auger

DRILLING LOG

Well No.: 26

Date: [illegible] 2[illegible]

Location: McClellan

Altitude (Datum): [illegible]

Method: Rotary Wash

Size of hole: 15"

Size of casing: [illegible]

Driller: Stauc. Drilling & Exploration [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
[illegible]'		CL, [illegible] clay	CL	
25				
		[illegible] sand		
145				
		[illegible] sand, br	SC	
		on clay		
1[illegible]5				
			T.D. 170'	
185				

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(1)

ES

DRILLING LOG

Well No.: ES 27

Date: 3/13/82

Location: McClellan AFB, Sacramento

Altitude (Datum):

Method: Hollow-stem auger

Size of hole: 8"

Size of casing: none pilot hole

Driller: Stang Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2	12:55	Fill, concrete blocks	Fill	
4		clayey sand SC 20% fines reddish brown, moist, low plasticity	SC	
6				
8				
10		gravelly clay CL light bn -20% gravel and coarse sand	CL	
12				
14		clayey sand SC 20% fines reddish bn, moist, low plasticity	SC	
16			- - - -	iron-stain, clay cemented
18				
20	▽			30% fines
22				
24				
26		sandy clay CL brown moist low plasticity, 20% fine sand	CL - - -	cemented iron stains
28				
30				
32		clayey sand 15% fines reddish bn, moist, low plasticity	SC	
34				
36				
38		sandy clay CL 40% sand bn, moist, low plasticity	CL	pyrite
40	▽	well graded medium sand, SW, reddish brown loose	SW	
42				iron stains
44		clayey sand SC 15% fines reddish bn, moist, low plasticity	SC	
46			- - - -	iron stains, cemented
48				
50				
52				
54			- - - -	cemented.
56				
58			- - - -	cemented
60	1:55 ▽			

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ES

DRILLING LOG

Well No.: ES 27

Date: 3/15/82

Location: McClellan AFB, Sacramento **Altitude (Datum):**

Method: Hollow-stem auger, Mobile B-53 **Size of hole:** 8" **Size of casing:** none pilot hole

Driller: Stang Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
	7		▽	perched water
62				
64				auger dry
66				
68				
70				
72				
74				
76				
78	[illegible]			
80		well-graded medium	SW	
82		sand, SW, light brownish		cemented
84		gray	CL	
86		sandy clay, CL, greenish		
88				
90				
92				
94	8	well-graded medium sand,	SW ▽	wet auger, [illegible] 95'
96		SW, brownish black, loose, wet		
98	9:30		CL	
100			hole cave- [illegible] at 100'	

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DRILLING LOG

Well No.: 27

Date: [illegible]

Location: [illegible]

Altitude (Datum): 71.8 msl

Method: Rotary Wash

Size of hole: 15"

Size of casing: [illegible]

Driller: S[illegible] Drilling & Exploration Co.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		greenish red silty clay	CL	
110				
120				
		clayey sand, brn, greenish	SC	
130				
		greenish-red clayey silt	ML	
140				
			T.D. 160'	
150				

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ES

DRILLING LOG

Well No.: MW 28

Date: 3-18-82

Location: McClelland

Altitude (Datum):

Method: Hollow Auger

Size of hole: 8"

Size of casing:

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0	10:20	Topsoil		
2		CL, v. silty, bn, some iron staining, s, sM		
10				
12		CL, sdy, bn, iron stained, s, sM - MM		
17				
20		SP, sli clayey, bn - rd bn, d, sM		20 FT AUGER SAMPLE SP, f.gr, sli clayey, bn- rd bn, d, sM
30				
38				
40		CL, bn - silty, s, mm iron staining, occ. organics.		40 FT. SPLIT SPOON  12 - 21 - 34 / 6 inches CL, bn - silty, s, mm
48				
50		SP, f.gr, bn, sli silty, occ cl interbedding, md, mm.		

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ES DRILLING LOG

Well No.: MW 28

Date: 3-18-82

Location: McClelland

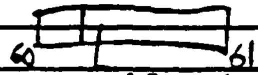
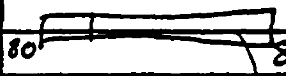
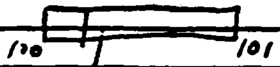
Altitude (Datum):

Method: Hollow Auger

Size of hole: 8"

Size of casing:

Driller: Stang

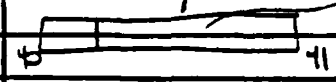
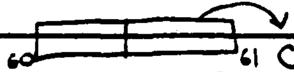
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				16-26-31/6"
				60 FT SPLIT SPOON
				
70				SP, f, gr, bn some iron staining, md-d, sm
80				80 FT SPLIT SPOON
?		SP, saturated = top unknown		
88				33-26-20/6"
90		CL, bn-olive bn, vs, m, sl silty		CL, sdy, bn, s, m
100	11:50AM	T.D. 100 ft		100 FT. SPLIT SPOON
				
				CL, bn-olive bn, vs, m
				tip of sampler wet
				15-26-39/6"

ES

DRILLING LOG

Well No.: MW 29
Date: 3-16-82

Location: McClelland
Altitude (Datum):
Method: Hollow Auger
Size of hole: 8"
Size of casing:
Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0 1	11:50AM	Artificial fill, gravel, etc.		
3		SP, gravel, dk bn, l-md, organics, moist,		
		CL, silty, occ. iron staining, bn, MS, SM		
10				
16		SP, sli clayey, bn, md, SM-MM		12:[illegible] RA[illegible]
19 20		CL, sli silty, sli sdy, bn-dk bn		MS, MM, occ. iron staining,
				20 FT Auger sample.
25		SP, sli clayey, mostly clean, bn, md,		SM-MM, like above sand layer.
30				
37		CL, v silty, bn-dk bn, some (dk-bn)	S-VS, MM	iron staining ←
40				
				40 FT. - split spoon
		occ. sdy interbeds,		23-45-66/6 inches
				
				
				61 CL, silty, [illegible] sdy, bn, md-dk, MM
60				60 FT split spoon -
				47/6" and 100/4"

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ES

DRILLING LOG

Well No.: 28

Date: June 3, 1982

Location: McClellan

Altitude (Datum): 72.6 msl

Method: Rotary Wash

Size of hole: 15"

Size of casing: 2 x 4"

Driller: Sierra Drilling & Exploration Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
100		greenish brn silty clay	CL	
		coarse brn sand pyritic	SP	
120				
130			T.D. 130	
140				

ES

DRILLING LOG

Well No.: MW 29

Date: 3-16-82

Location: McClelland

Altitude (Datum): —

Method: Hollow Auger

Size of hole: 8"

Size of casing: /

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				
70				
				driller didn't know where sand in 80' sample was encountered.
80				21-33-43/6"
		tip of sampler at 80' wet		80 81 SP, f, ar, bn, sli damp, md-d, mm
90				23/50/5'6" 90 91 CL, sli silty, dk gr green, s-vs
95	2:26	T.D 95		sampler wet at 90'±
		water after ϕ-84' 7:45AM 3-17-82		

ES

DRILLING LOG

Well No.: 29

Date: March 26 '92

Location: McClellan

Altitude (Datum): 62.5 msl

Method: Rotary Wash

Size of hole: 15"

Size of casing: 2"

Driller: Stava Drilling & Exploration Rancho [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
95		Olive gray and reddish silty clay	CL	
105				
125				
		bn silty gravel	GM	
			SM	
		silty sand, pyritic		
145				
151				
			T.D 151'	
155				

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ES DRILLING LOG

Well No.: MW 30

Date: 3-17-82

Location: McClelland

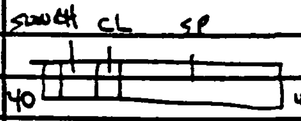
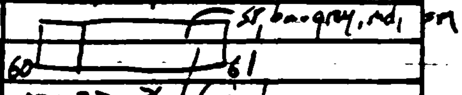
Altitude (Datum): 73.0 msL

Method: Hollow Auger

Size of hole: 8"

Size of casing:

Driller. Stang Drilling

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
1	10:00AM	— Topsoil, fill, asphalt		
		CL, v sdy, rd bn, s, wet to m		
4		CL, silty, sdy, bn, iron staining,		ms, MM
9		SP, v.f.gr., lt bn-bn, md, sm (sli clayey)		
10				
12		CL, v. silty, bn, ms, sm		
20				
				20 FT auger sample
24				CL, silty, iron staining, bn, ms, silty
		ML, clayey, bn, md, mm		
28		SP, v.f.gr. lt bn-bn, md, sm		
30		occ CL, sdy, interbd?		
				
40				40 FT. SPLIT SPOON
				16-31-40 16"
				SP, f.gr. lt bn-bn, md-sm
46		bn, iron staining		and CL, silty, sdy, ms-sm mm
		CL, v. silty, s-vs, sn-vm	(poss. perched water)	iron staining in CL + SP.
50				
54				
		SP, bn-grey, md-d, sn-MM		60 FT SPLIT SPOON
				
60				12-22-26/6 inches

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ES

DRILLING LOG

Well No.: MW 30

Date: 3-17-82

Location: McClelland

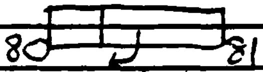
Altitude (Datum):

Method: Hollow Auger

Size of hole: 8"

Size of casing:

Driller: Stang

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				
		occ CL interbeds		
70				
78		CL, very silty, bn, VS, MM		80 FT. SPLIT SPOON
80				
82		SP, bn, d, M to wet		
				CL, v. silty, bn, VS, MM
				15-30-38/6 inches
89		CL, bn-olive bn, VS, M		tip at 90' wet
90				
		T.D 100 ft.		
100	12:15	Water level after drilling		- caved to 93 ft.
				100 FT sample from auger
				CL, sl silty, olive bn, VS/M

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ES

DRILLING LOG

Well No.: 30

Date: May 27, 1982

Location: McClellan

Altitude (Datum):

Method: Rotary Wash

Size of hole: 6"

Size of casing 4"

Driller: Sierra Drilling & Exploration, Rancho [illegible]

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		Redrilled auger		
		hole to install		
		PVC		

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DRILLING LOG

Well No.: 31

Date: Nov 28, 1982

Location: McClellan

Altitude (Datum): 65.8 MSL

Method: Rotary Wash

Size of hole: 6"

Size of casing: 4"

Driller: Stang Drilling & Exploration, Rancho Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		bn. silty clayey sand	SM/SC	
20				
40				
		bn silty sand, pyritic	SM	
		bn. green clayey silt	ML	
		bn. black sand pyritic	SW	
[illegible]				
[illegible]				
		bn. grey clayey silt	ML	
		black, bn. sand, pyritic	SW	
		bn. greenish silty clay	CL	
[illegible]				
[illegible]				

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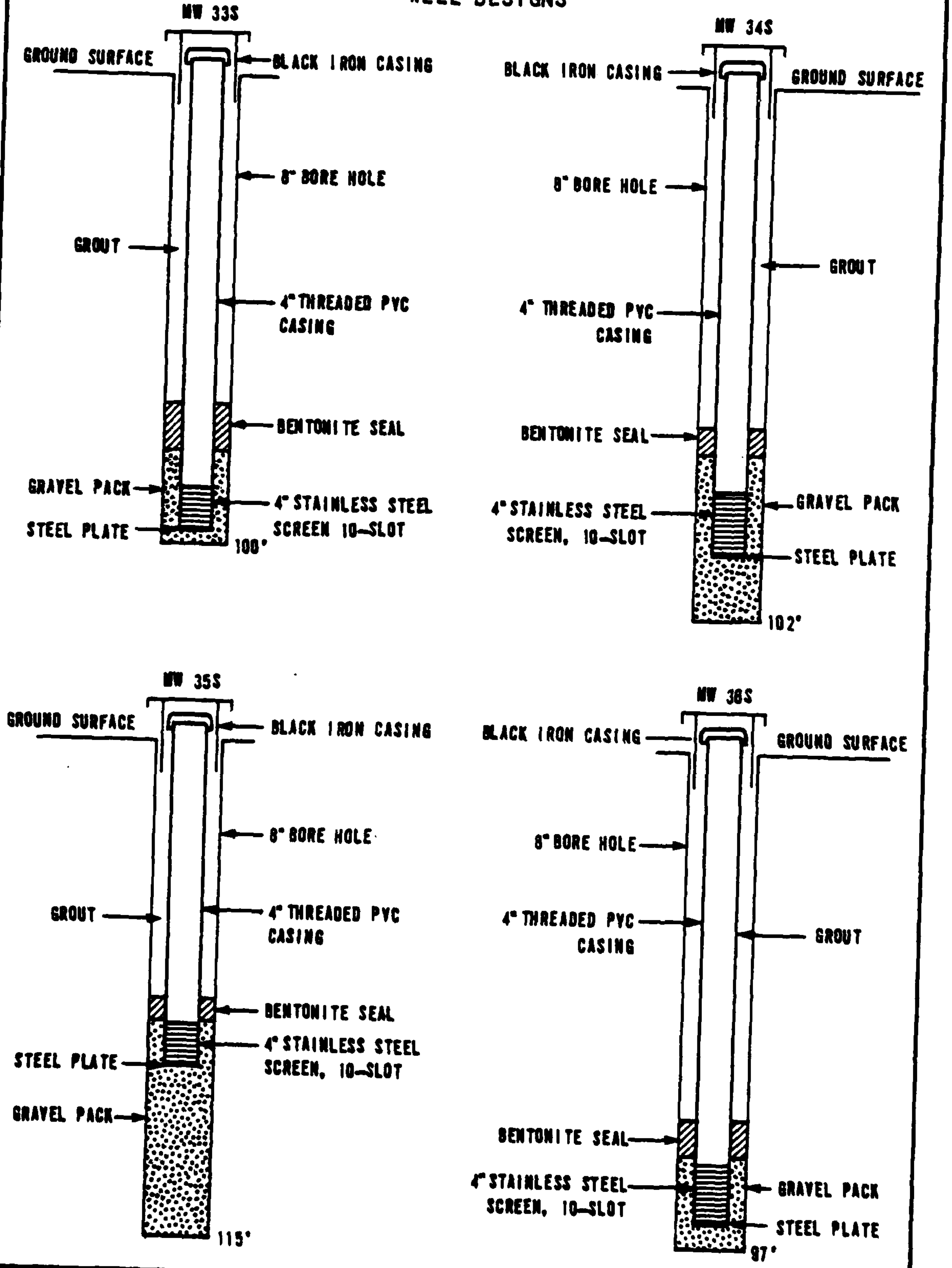
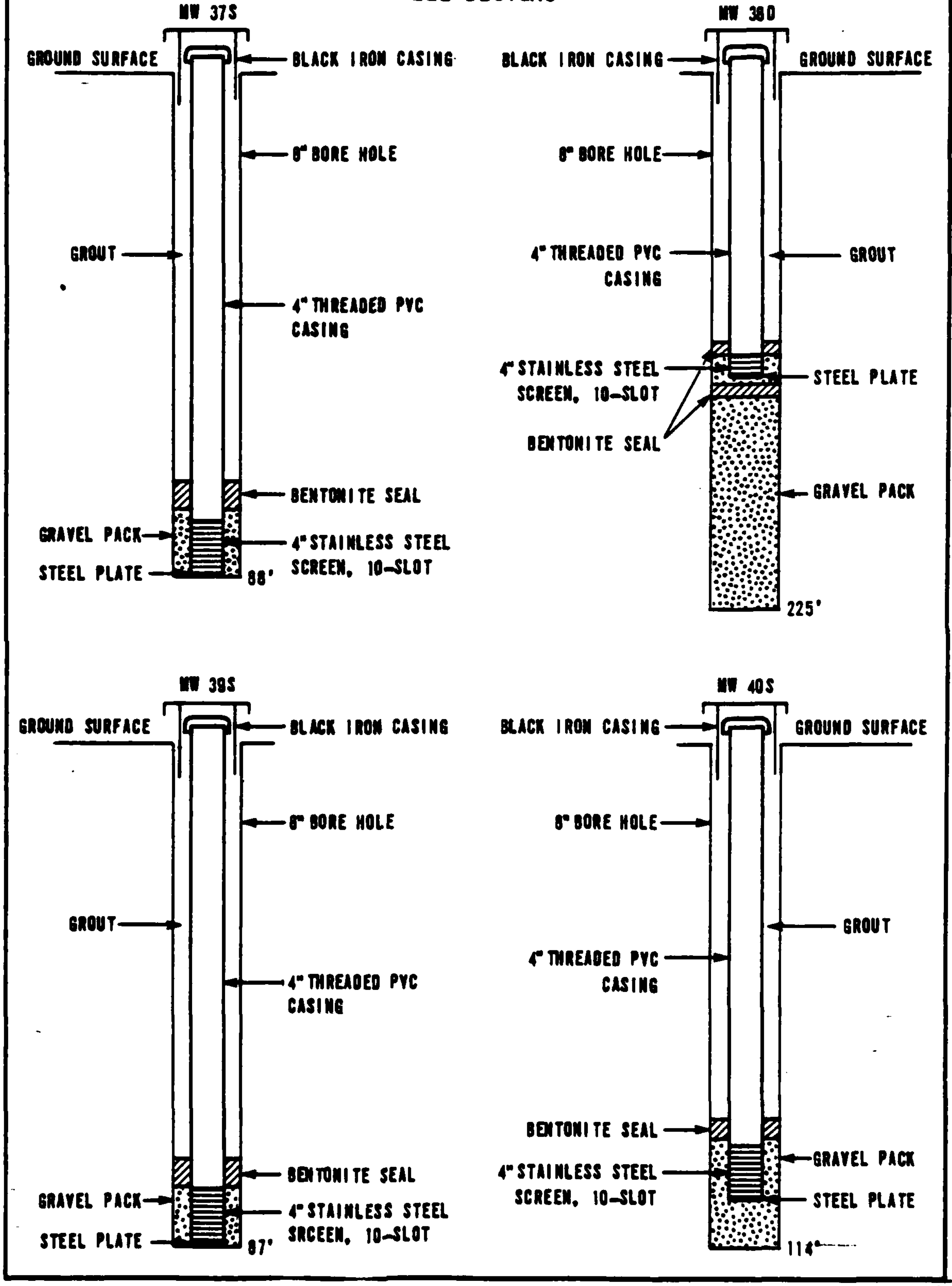
WELL DESIGNS

STAGE II MONITORING WELLS

WELL DESIGNS

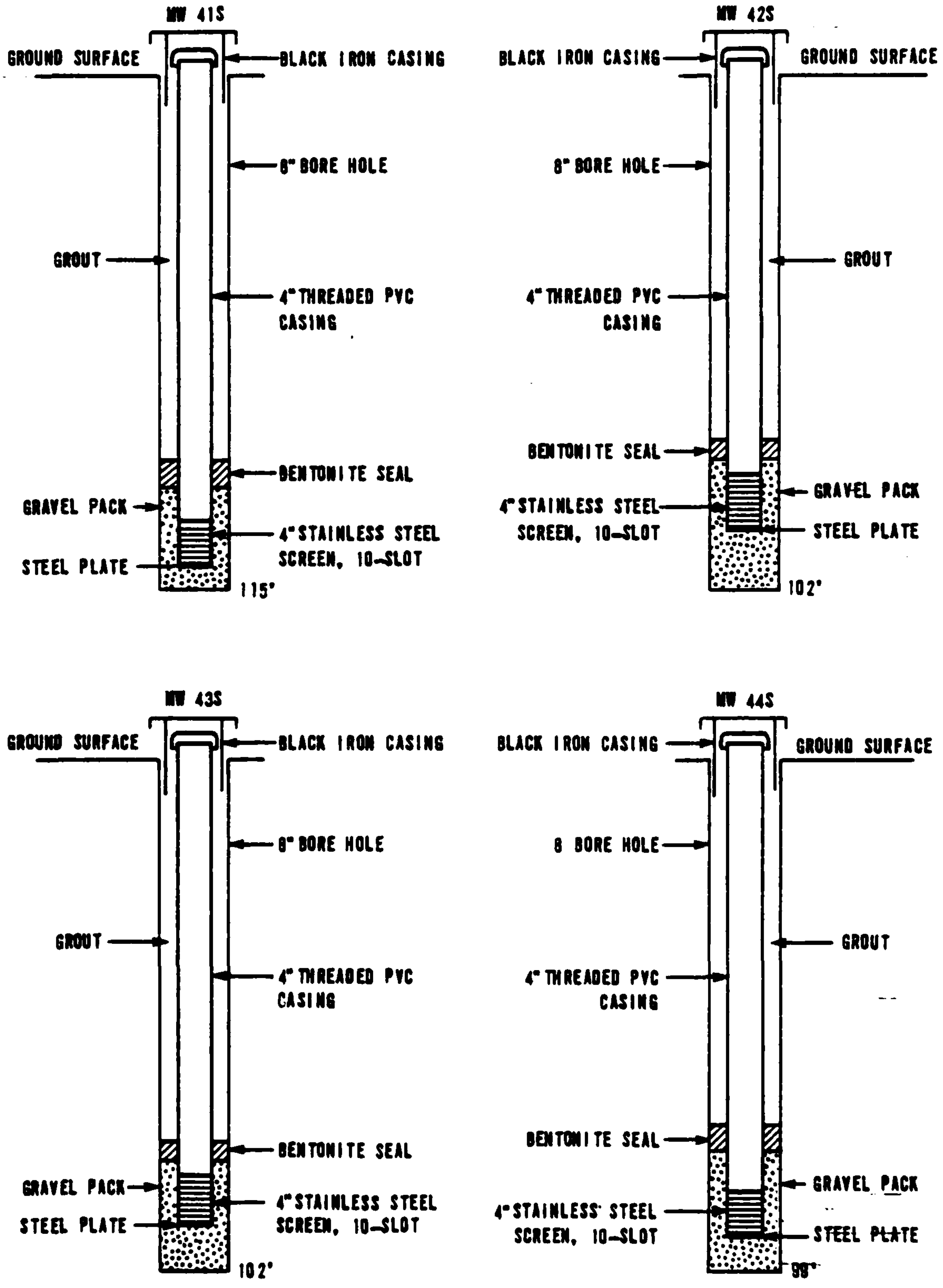


WELL DESIGNS

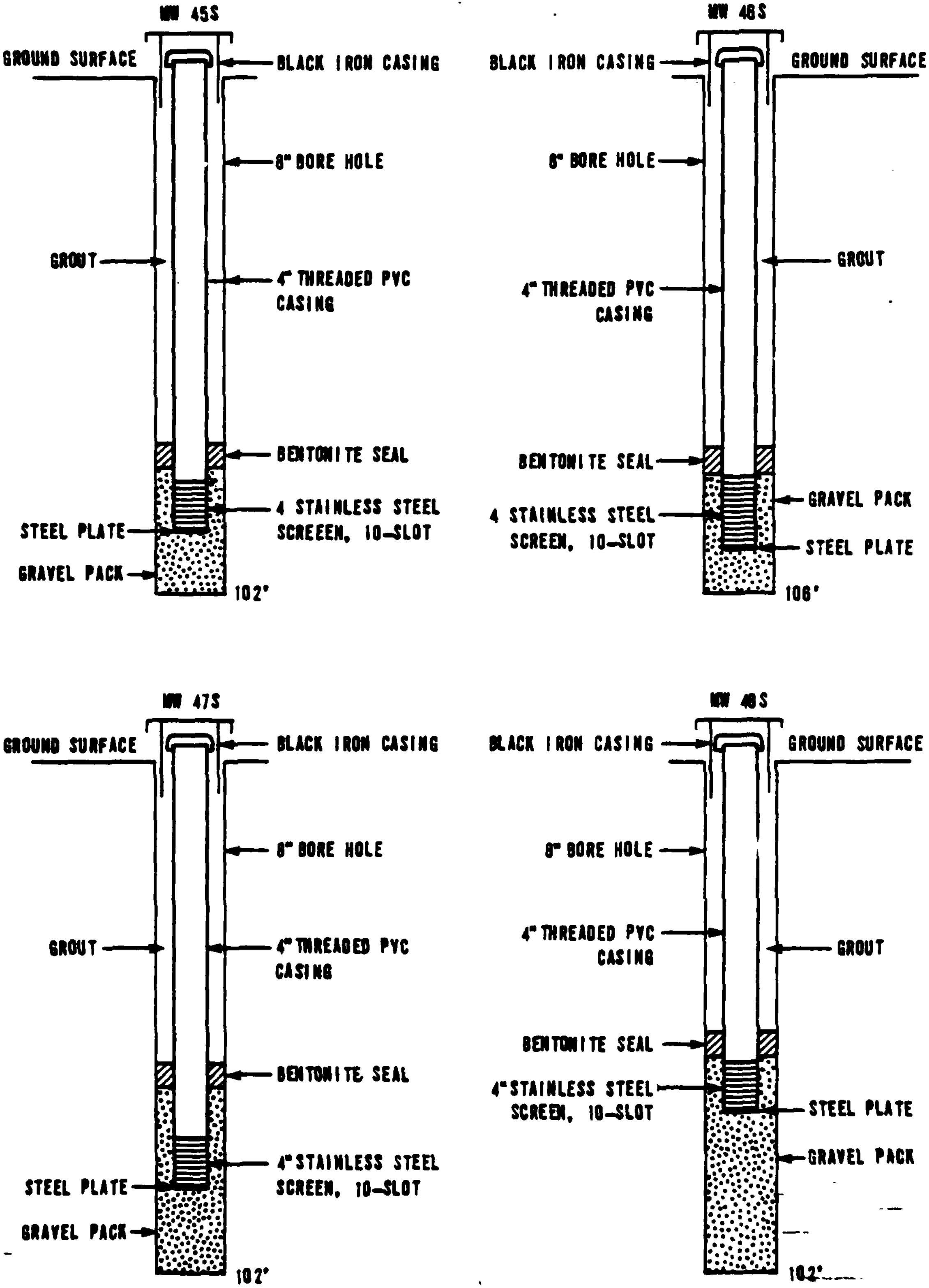


1-346

WELL DESIGNS



WELL DESIGNS

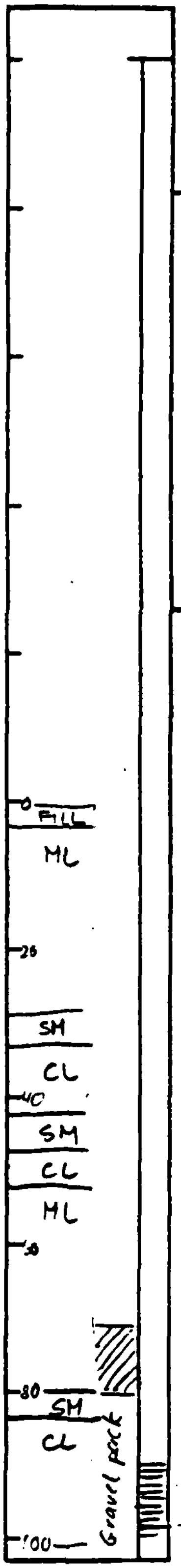


WELL LOGS
STAGE II MONITORING WELLS

LOCATION McClellan AFB, CA

PERSONNEL Yane Bordhav, ES

PROJECT McClellan IRP, Phase II



WELL 335

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

ELEVATION: GROUND LEVEL 58.28'

TOP OF CASING

DRILLING SUMMARY:

TOTAL DEPTH 100'

BOREHOLE DIAMETER 8"

DRILLER Water Development Corp. Woodland, CA

RIG Rotary - Drilltech D40K

BIT(S) Wing

DRILLING FLUID Natural

SURFACE CASING

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

	87	C
87	97	S

CASING: C1 4" PVC, SCH 40, threaded

C2

C3

C4

SCREEN: S1 4" Stainless steel, 10 slot

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL Monterey Sand #3 97' - 80'

CEMENT Grout 70' - gr. level

OTHER Bentonite seal 80'-70'

CONSTRUCTION TIME LOG:

TASK	START		FINISH	
	DATE	TIME	DATE	TIME
DRILLING:	9/17	16^{45}	9/17	17^{50}
GEOPHYS. LOGGING:				
CASING:	9/17	18^{20}		20^{00}
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:	9/21		9/21	
OTHER:				

WELL DEVELOPMENT

COMMENTS:

ES

DRILLING LOG

Well No.: 333

Date: Sept 17, 1980

Location: McClellan AFB, CA **Altitude (Datum):**

Method: Rotary wash - using bit **Size of hole:** 8" **Size of casing:** 4"

Driller: Water Development Corporation Woodland CA

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		Fill	Fill	
3				
		Clayey sandy (fine,	ML	
		5%) silt, rd		
15		Clayey (5%) silt		
		brn		
				iron stains
30		Silty fine sand, rd	SM	
		Silty (10%) sandy	CL	
		(5%) clay, brn		
45		Fine sand, red	SM	micaceous
		Sandy clay, red-brn	CL	
		Silt, lt brn	ML	micaceous
60				
				streaks of white clay
75				
		Sand, medium-fine	SM	micaceous
		black-white		
		Clay, greenish-brn	CL	
11				

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ES

DRILLING LOG

Well No.: 335 (continued)

Date:

Location:

Altitude (Datum):

Method:

Size of hole:

Size of casing

Driller.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
			CL	
			TD. 100'	
105				

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WELL 345

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS: McCLELLAN AFB

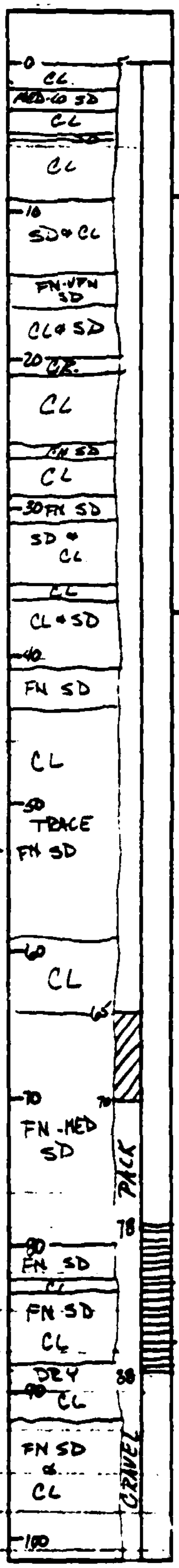
ELEVATION: GROUND LEVEL 58.17

TOP OF CASING 1.1

LOCATION SACRAMENTO, CAL.

PERSONNEL TLM (BISHOP ASSOC.)

PROJECT McCLELLAN AFB



DRILLING SUMMARY:

TOTAL DEPTH 102'

BOREHOLE DIAMETER 8½"

DRILLER WTR. DEVEL. CORP.

RIG MUD ROTARY

BIT(S) TRI-CONE

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	8/30	11:15	8/31	9:10
GEOPHYS. LOGGING:				
CASING:	8/31	9:30	-	10 30
FILTER PLACEMENT:	8/31	10:30		10.50
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

-	78	C
78	- 88	S

CASING: C1

C2

C3

C4

SCREEN: S1

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3"

CEMENT

OTHER

WELL DEVELOPMENT

COMMENTS:

8/30 - 11:25 - MUD PUMP DOWN

REPAIRED 12:15. 12:35 PUMP [illegible]

DOWN. REPAIRED 1:50. [illegible]

@ 20' [illegible] DOWN [illegible] 2:20. FINISHED

DRILLING UNIT (25') CONTROLS REPAIRED @

4:50. DRILLED TO 50' BY [illegible].

8/31 - SDS BETWEEN 65-88. CHECKED W.L.

IN 345 = 78.0' WILL COMPLETE 345 TO 88'.

W.L. IN MW 30 = 84.75'

9/2 08:45 W.L. = 80.7 - 1.1 = 79.6

1-353

Field Engr/Tech TKM Sheet 1 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/30/82

Ground Elev. ______ Hole No. 34S Dia. 8½S T.D. ______

Final Hole No ______

Water Table At Drilling:

Water: Depth 1st Encountered ______ Dry ☐ Won't ☐ Might ☐ Should ☐ Will

Water-After 0 ______

Caved-After 0 ______

Water Table After Drilling

Water At Depth ______

Date ______ By ______

Dry At Depth ______

☐ Couldn't Find ☐ Covered

☐ ______

Plot	Depth	Class	Field Soil Description	Stiff Den	Moist	Color	Calc
	0-2	CL	RED CLAY			RD	
	2-3	SC	MED-COARSE SD + CL (2½ Cobble)				
	3-5	CL.	RED CLAY			RD	
	5-5.5	SP	FN SD			RD	
	5.5-9	CL.	TN CL HD	HD	DRY	TN	
	9-14	SC	SD + TN CL			TN	
	14-17	SW	VFN- FN SD				
	17-20'	CL.	GR. CL & some FN SD				
	20'-21	G	ANGULAR GRAVEL				

Comments: SAMPLE @ 20': CRUSHED ANGULAR ROCK WITH CLAY. PIECE OF RUBBER GROMET FOUND IN SAMPLE. SITE IS PROBABLY UNLISTED DISPOSAL SITE.

Depth	Samples - Spoon				Standard Penetration		Laboratory Sample Description	[illegible]
	Calif.	Std.	Shelby	Auger	Field	Final		
20'								

Form 1-102

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Field Engr/Tech TKM Sheet 2 of 3

Project McCLELLAN Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/30/82

Ground Elev. ______ Hole No. 34S Dia. 8½ T.D. ______

Final Hole No ______

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry ☐ Won't	Water At Depth ______
Water-After ∅ ______ ☐ Might	Date ______ By ______
Caved-After ∅ ______ ☐ Should ☐ Will	Dry At Depth ______
	☐ Couldn't Find ☐ Covered ☐

Plot	Depth	Class	Field Soil Description	Stiff Den	Moist	Color	Calc
	21-26	CL.	HD RED DRY CLAY	HD	DRY	RD	
	26-27	SP	FN SD - MICACEOUS				
	27-29	CL.	GR CLAY DRY		DRY	GR	
	29-31	SP	FN SD MICACEOUS				
	31-33	SC	SD & GR. CLAY				
	33-36	SC	FN SD & CLAY				
	36-37	CL.	RED CLAY				
	37-41	SC	GREY CLAY & SD (SD LENSE 39.5-40) NO SAMPLE 40'				
	41-44	SM	VFN SILTY SD				

Depth	Samples - Spoon				Standard Penetration		Comments:	
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	Sample Sealed

Form 1-102

Field Engr/Tech TKM Sheet 3 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 3/30

Ground Elev. ______ Hole No. 345 Dia. 8½ T.D. ______

Final Hole No ______

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry ☐ Won't Water-After 0 ______ ☐ Might Caved-After 0 ______ ☐ Should ☐ Will	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐ ______

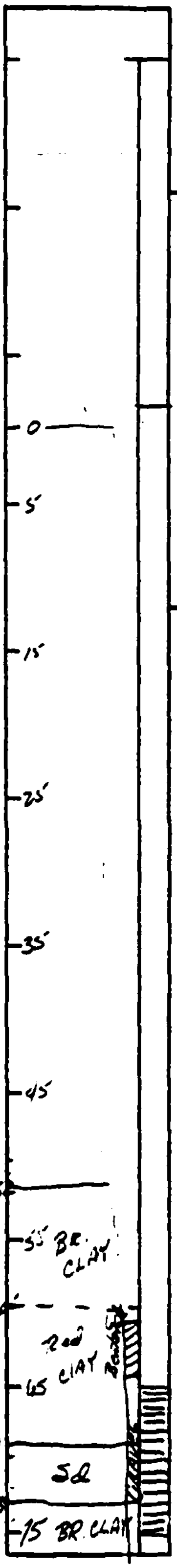
Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	49-59	CL	RED CLAY w/ TRACE FN SD			RD	
	59-62	CL	TN CL			TN	
	62-65	CL	RED CL.		DRY	RD	
	65-80	SW	FN-MED SD.				
	80-83	SP	FN SD				
	83-84	CL	GR CL				
	84-88	SC	FN SD, CL				
	88-92	CL	DRY GREY CL				
	92-1[illegible]	SC	FN SD, CL				

Depth	Samples - Spoon				Standard Penetration		Comments:	
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	Unified Symbol

Form 1-102

7.0.5

LOCATION ____
PERSONNEL ____
PROJECT ____



WELL 35 S

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS: ____

ELEVATION: GROUND LEVEL 51.5
TOP OF CASING 1.65

DRILLING SUMMARY:

TOTAL DEPTH 175'
BOREHOLE DIAMETER 8½
DRILLER Water Devel. Corp.
RIG ____
BIT(S) ____
DRILLING FLUID Natural Mud
SURFACE CASING n/a

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	8/26	9:30	8/26	11:15
GEOPHYS. LOGGING:				
CASING:	8/26	1:20		1:40
		~~[illegible]~~		~~[illegible]~~
FILTER PLACEMENT:		1:40		1:55
CEMENTING:				
DEVELOPMENT:		2:00		2:20
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG ____

CASING STRING(S): C=CASING S=SCREEN

0 - 65	C	
65 - 75	S	

CASING: C1 +1.65 - 65 - 4" PVC
C2 [illegible]
C3 ____
C4 ____

SCREEN: S1 65-75 .010 SLOT STAINLESS STEEL
S2 ____
S3 ____
S4 ____

CENTRALIZERS ____

FILTER MATERIAL .030 - @ 64.5'

CEMENT ____

OTHER ____

WELL DEVELOPMENT

Clean fresh wtr.

COMMENTS:

W.L. - 8/27 08.17 - 76.05 - 1.65 = [illegible]
6/10 of wtr. in well.

Field Engr/Tech TKM Sheet 1 of 2

Project McClellan Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/26/82

Ground Elev. ________ Hole No. 35 S Dia. 8½ T.D. 115

Final Hole No ________

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry ☐ Won't Water-After ∅ ______ ☐ Might Caved-After ∅ ______ ☐ Should ☐ Will	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	0-1	CL	CUT			BR.	
	1-7	SC	Sandy Clay - occ gr.			BR.	
	7-12	SP & CL	whitish S.S. clay stringers, coarse sand			GR.	
	12-19	SW	Fine-Med Sand - Micaceous			GR.	
	19-26	SW	Med-Coarse Sand salt-pepper				
	26-35	CL	Clay			BR.	
	35-44	SW	Med-Coarse Sand			BR.	
	44-46	SP WITH CL	Sd w/ Clay stringers			BR.	
	46-52	SC	Sdy Clay			BR.	

Depth	Samples - Spoon: Calif.	Std.	Shelby	Auger	Standard Penetration: Field	Final	Comments: / Laboratory Sample Description	Sample Number

Form 1-102

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Field Engr/Tech TKM Sheet 2 of 2

Project McClellan Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/26/87

Ground Elev. ________ Hole No. 35 S Dia. 8½ T.D. 115

Final Hole No ________

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry ☐ Won't	Water At Depth ______
Water-After ______ ☐ Might	Date ______ By ______
Caved-After ______ ☐ Should ☐ Will	Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Stiff Den	Moist	Color	Calc
	52-60	CL	Br Clay, lenses Black SD.			BR	
	60-69	CL	Red Clay w/ Br. Clay			RD.	
	69-73	SW	Fine-Med Sd			BL.	
	73-77	CL	Br. Clay			BR	
	77-115	CL	Grey Clay (Balls) - Plastic at 66' DRY-72'	stiff	DRY	GR.	
			TD - 115'				

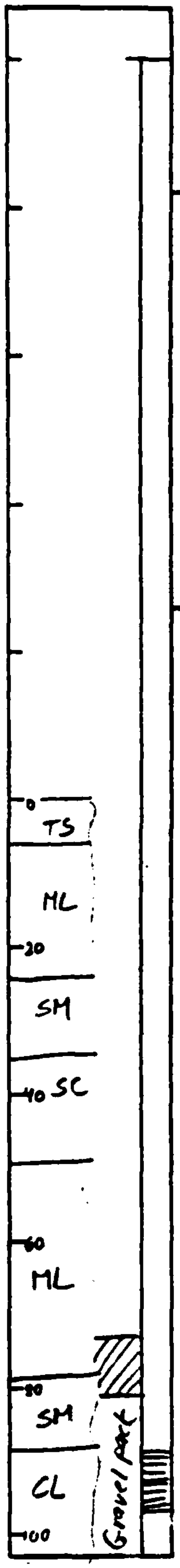
Depth	Samples - Spoon: Calif.	Samples - Spoon: Std.	Samples - Spoon: Shelby	Samples - Spoon: Auger	Standard Penetration: Field	Standard Penetration: Final	Comments: / Laboratory Sample Description	Symbol Correction

Form 1-102

LOCATION McClellan AFB, CA

PERSONNEL YADE MOEDHAV, E.S.

PROJECT McClellan IRP Phase II



WELL 36S

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

ELEVATION: GROUND LEVEL 56.14

TOP OF CASING

DRILLING SUMMARY:

TOTAL DEPTH 97'

BOREHOLE DIAMETER 8"

DRILLER Water Development Corp. Woodland CA, Scott

RIG Rotary - Drilltech D40K

BIT(S) Wing

DRILLING FLUID Natural mud

SURFACE CASING

WELL DESIGN:

BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

	-	82	C
82	-	92	S

CASING: C1 4" PVC, SCH 40,

C2 threaded

C3

C4

SCREEN: S1 4" stainless steel, 10slt

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL Monterey sand #3 92'-79'

CEMENT Grout, 72' - Gr. level

OTHER Bentonite seal 79'-72'

CONSTRUCTION TIME LOG:

TASK	START		FINISH	
	DATE	TIME	DATE	TIME
DRILLING:	9/17	11:50	9/17	13:00
GEOPHYS. LOGGING:				
CASING:	9/17	13:30	9/17	15:50
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DEVELOPMENT

COMMENTS:

ES **DRILLING LOG**

Well No.: 36S

Date: Sept 17, 1982

Location: McClellan AFB, CA Altitude (Datum):

Method: Rotary wash - wing bit Size of hole: 8" Size of casing 4"

Driller: Water Development Corp. Woodland, CA

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
3		Fill	Fill	
		red silt	ML	
15				
		Reddish bn silty sand	SM	fuel smell
30				
		sandy (fine) silty clay; rd, micaceous	SC	fuel smell
45				
		Sandy (fine) rd.bn silt (no mica)	ML	still little fuel smell, may be residual
60		clay streaks		
75				streaks of white clay
		Clean black/white sand, micaceous	SM	
90		Green clay	CL T.D. 97'	

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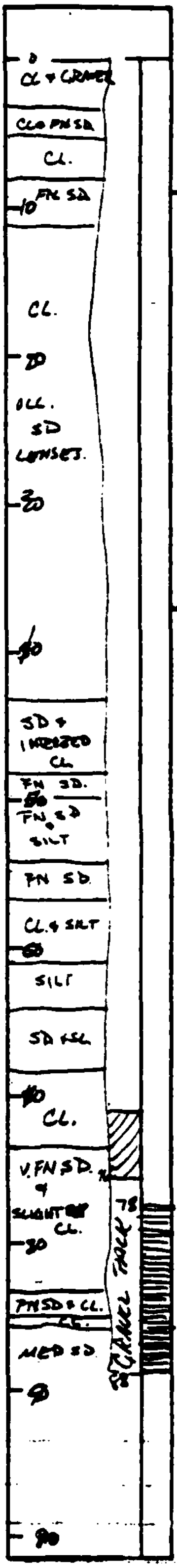
LOCATION SACRAMENTO CAL.
PERSONNEL JKM (BISHOP ASSOC.)
PROJECT McCLELLAN AFB



WELL 375

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS: ______

ELEVATION: GROUND LEVEL 60.04
TOP OF CASING ______

DRILLING SUMMARY:

TOTAL DEPTH 88'
BOREHOLE DIAMETER 8½"
DRILLER WDR DEVEL CORP
RIG ROTARY
BIT(S) ROLLER
DRILLING FLUID NAT. MUD
SURFACE CASING N/A

WELL DESIGN:

BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

-	78	C	
78	-	88	S

CASING: C1 4" PVC
C2
C3
C4

SCREEN: S1 4" JOHNSON STAINLESS
S2 10 SLOT.
S3
S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "S"

CEMENT

OTHER

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	9/8	3:00	9/8	6:30
GEOPHYS. LOGGING:				
CASING:	9/13	4:00	-	
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DEVELOPMENT

COMMENTS:

RIG DOWN 9/9 - MUD PUMP ROT. RETURN TO COMPLETE HOLE 9/13 AFTER REBUILDING PUMP.

ES

DRILLING LOG

Well No.: 375

Date: 9/8

Location: McClellan

Altitude (Datum): 60.07

Method: ROTARY

Size of hole: 8½

Size of casing: 4"

Driller: WTR. DEVEL. CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0-		RED CL & GRAVEL	GC	
3		RED CL & FN SD	CL	
5		GREY CL		
8		FN SP MICACEOUS	SP	
0 11'		GREY CL w/ SD LENSES		
		GREEN CL @ 13'		
		GREY CL @ 15'		
		FN SD LENSE @ 18', 21', 31'		
20		SAMPLE @ 20' (GREY CL & GRAVEL)		
30				
		RED + GREY CL @ 37'-40'		
40				
43		CLAY INTERBEDDED SD,		
48		V FN SD, SLIGHT MICACEOUS		
50'		FN SD, RED SILT		
54'		FN SD, V. SLIGHT MICA		
57		GREY SILT		

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ES DRILLING LOG

Well No.: 37S

Date: 9/8

Location:

Altitude (Datum):

Method: ROTARY

Size of hole: 8½"

Size of casing: 4" PVC

Driller: WTR. DEVEL. CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
61		RED CL		
64		SD & SILT.		
68		CL. DRY		
70				
74 9/9 W.L.		VFN SD + SLIGHT CL		
80				
83		FN SD & CL		
9/8 – 85		— GREY CLAY		9/13 - DRILLER TRIED TO
86		MED-SD.		CHECK W.L. IN HOLE. EST.
TD 88 90				W.L. @ 70'. HOLE TAKING
				WTR. RAPIDLY, OPEN TO
				88', SINCE W.L. ON 9/9
				75' will COMPLETE TO
				88'. DRILL RIG TO MOVE
				TO 36S, SET CASING W/
				SEAL.

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WELL 33D

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

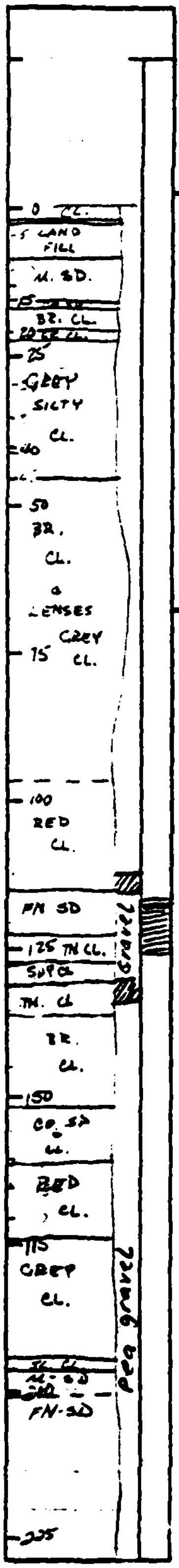
ELEVATION: GROUND LEVEL 55.07

TOP OF CASING

LOCATION SACRAMENTO, CAL.

PERSONNEL TKM (BISHOP ASSOC)

PROJECT McCLELLAN AFB



DRILLING SUMMARY:

TOTAL DEPTH 225'

BOREHOLE DIAMETER 8 1/2"

DRILLER WTP DEVEL. CORP

RIG ROTARY

BIT(S) ROLLER TO 145' - WING TD.

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

WELL DESIGN:

BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

CASING: C1

C2

C3

C4

SCREEN: S1

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3"

CEMENT

OTHER

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:				
	9/14	10:00	9/15	5:00
GEOPHYS. LOGGING:				
CASING:				
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DEVELOPMENT

COMMENTS:

BAILER REMOVED FROM 575,
BROKEN - MUD PIT LEAKING
BADLY, SWITCH TO SHAKER

1-365

ES

DRILLING LOG

Well No.: 38D

Date: 9/14

Location: SAC., CAL. M. CLELLAN AFB

Altitude (Datum):

Method: ROTARY

Size of hole: 8½"

Size of casing 4"

Driller. WTR. DEVEL. CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		CLAY	CL	3:30 - RIG OVER HEATED -
2 3		MED-CO. SD & GRAVEL	Fill	DOWN ½ HOUR.
		LAND FILL - BURNT WOOD,		10:30 - DRILLER FORGOT SAMPLE
		GLASS, PORCELAINE ETC.		TUBE - DOWN 1 HR.
8		MED SD - VERY		12:15 - MUD PUMP NOT
10		MICACEOUS	SW	WORKING AFTER PUMPING
				WOOD CHIPS.
15		CO. SD & GRAVEL	SW/GM	1:28 - DRILL STEM PULLED
16		BR. CL. - MOIST. (HD DRILL)	CL	FROM SAMPLE COLLECTION.
18		DRY BR. CL. (EASY DRILL)		RIG DOWN 1HR 25 MIN.
20		GR. FN SILTY SD	SP	PROBABLY CAUSE OF DELAY.
22		CO. SD		
23		GR SILTY CL. W/ VFN SD	CL	
		INTERBEDDED "PLASTIC" CL.		
		VERY SLOW DRILLING		
30				
		COLOR CHANGES TO		
		BR @ 30'		
40				
45				
		BR. CL.		
50				
		MICACEOUS @ 53'		
		DRILLING VERY SLOW @ 54'		
		CHANGES TO GREY @ 54'		
		BACK TO ~~[illegible]~~ @ 60'		
60				

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ES DRILLING LOG

Well No.: 38D

Date: 9/4

Location: SACRAMENTO, CAL. McCLELLAN AFB Altitude (Datum):

Method: ROTARY Size of hole: 8½ Size of casing 4"

Driller: WTR. DEVEL. CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60		BR., SLIGHTLY	SC	SD IS SO FINE GRAINED, STAYS
		MICACEOUS, V FN SILTY		SUSPENDED IN CIRC. WTR.
		SD & CL.		
		VERY SLOW DRILLING		
70				
		79' CLAY LENSE	CL	4:45 - MUD PUMP TAKEN
80				IN TOO MUCH WOOD CHIPS
				AND PIECES OF RUBBER FROM
		INCREASE CL. CONTENT		DISPOSAL ZONE. COULDN'T
		@ 90'.		REGAIN PRIME. DOWN 1HR
				15 MIN. END
9/15 90		BETTER CIRC. VELOCITY.		
		DRILLING RELATIVELY FASTER	?	
95		"BLUE" FLAKE "MINERAL"	SM ? SW	
		(ALTERED MICA)		
		DRILLING SLOWED @ 95'		
100		REDDISH BR. "PLASTIC" CL. IN CUTTINGS		
110				
112				
114		FN SD LESS CLAYEY	SM	
120				
122		122'		

ES

DRILLING LOG

Well No.: 38D

Date: 9/15/82

Location: SAC. CAL. McCLELLAN AFB **Altitude (Datum):**

Method: ROTARY **Size of hole:** 8 1/2 **Size of casing:** 4"

Driller: WTR. DEVEL. CORP

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
127		TAN CL.	CL	
127		SDY CL.		
130				
131		TAN CL. (SLOW DRILLING)		CHANGED TO WING BIT @ 145'
135		HARD DRY RD. CL.		ROLLER WAS CLOGGED W/ CLAY
[illegible]2				THAT 2 JETS MAY HAVE BEEN
				PLUGGED AND ROLLERS WOULDN'T
				TURN.
150				
152		[illegible]	SC	
1[illegible]				
162		DRY RED CL	CL	
170				
174				
175		GREY CL.		
180				

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ES

DRILLING LOG

Well No.: 38D

Date: 9/15/82

Location: SAC. CAL. McCLELLAN AFB

Altitude (Datum):

Method: ROTARY

Size of hole: 8 1/2

Size of casing: --

Driller. WTR. DRLG. CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
180				
		GREY CL.		
190				
192		SILTY GREY CL		
195			SM	
		MED SD, SILT.		
200				
201		CLAY LENSE @ 204	CL	
204		FN. SILTY SD.		
210				
				216' -RIG DOWN MUD PIT
216'			T.D216'	LEAKING

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WELL 395

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

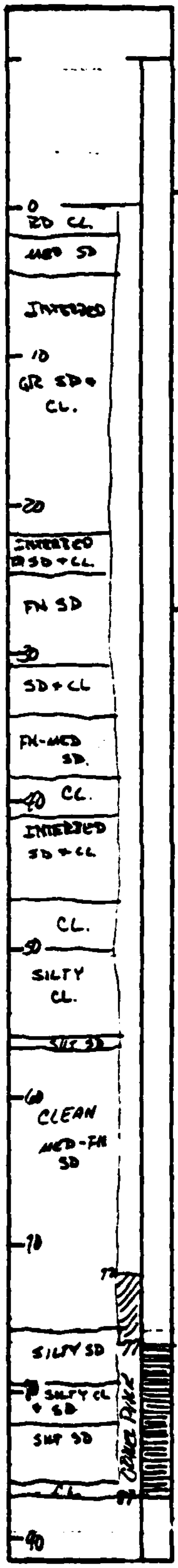
ELEVATION: GROUND LEVEL 67.96

TOP OF CASING

PROJECT McClellan AFB

LOCATION

PERSONNEL



DRILLING SUMMARY:

TOTAL DEPTH 87'

BOREHOLE DIAMETER 8½"

DRILLER WTR. DEVEL CORP

RIG ROTARY

BIT(S) ROLLER

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	9/2	11:00	9/2	1:00
GEOPHYS. LOGGING:				
CASING:	9/2	1:30	-	2:00
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:	9/3			
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

+1.1 - 76

72 - 87

CASING: C1 4" PVC

C2

C3

C4

SCREEN: S1 4" STAINLESS, 10 SLOT

S2 76-86

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3"

CEMENT

OTHER

WELL DEVELOPMENT

COMMENTS:

COMPLETE FROM 76" to 86", SAME "GUMMY" CLAY IN 465 @ 86" IN 395. ALSO A.F. NEEDED US TO MOVE TO CALIBRATE FLIGHT LINE INSTRU.

MW25 13.33 9/2 : 96.2 - 1.2 = 95'

W.L. 9:35 9/3: 76.95 - 1.1 = 75.85 (BEFORE PUMPING)

Field Engr/Tech JKM Sheet 1 of 2

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/2

Ground Elev. ________ Hole No. 395 Dia. 8½ T.D. 87'

Final Hole No ________

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry ☐ Won't	Water At Depth ______
Water-After ⌀ ______ ☐ Might	Date ______ By ______
Caved-After ⌀ ______ ☐ Should	Dry At Depth ______
☐ Will	☐ Couldn't Find ☐ Covered
	☐

Plot	Depth	Class	FIELD SOIL DESCRIPTION	Stiff Den	Moist	Color	Calc
	0-2	CL.	RED CLAY				
	2-4	SP	MED SD				
	4-23	SC	DRY GR. CL. INTERBEDDED "PYRITIC" FN SD.				
	23-25	SC	DRY RED CL INTERBEDDED FN SD				
	25-31	SP	FN SD (CLAY LENSE @ 28-285)				
	31-35	SC	FNSD/ DRY RED CLAY				
	35-38	SW	FN-MED SD BLACK "PYRITIC"				
	38-41	CL.	GREY CL.				
	41-47	SC	GREY CL INTERBEDDED FN SD "PYRITIC"				

Comments:

Depth	Samples - Spoon				Standard Penetration		Laboratory Sample Description	
	Calif.	Std.	Shelby	Auger	Field	Final		

Form 1-102

Field Engr/Tech T[illegible] Sheet 2 of

Project MCCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/2

Ground Elev. Hole No. 395 Dia. 8½" T.D. 87'

Final Hole No

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry: ☐ Won't ☐ Might ☐ Should ☐ Will Water-After ______ Caved-After ______	Water Table After Drilling: Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	47-50	CL.	GREY CLAY				
	50-56	ML.	DRY SILTY CLAY				
	56-57	SM	SILTY RED SD				
	57-76	SW	CLEAN MED-FN SD (NOT [illegible])				
	76-79	SM	SILTY SD				
	79-82	SM	SILTY CL. SD				
	82-86	SM	SILTY FN SD, SL. "PYRITIC"				
	86-87'	ML.	GR. SILTY CLAY ("GUMMIE") (SAME AS 46S) SLOW DRILLING "PLASTIC"			GR	
			TD 87'				

Comments:

Depth	Samples - Spoon				Standard Penetration		Laboratory Sample Description	[illegible]
	Calif.	Std.	Shelby	Auger	Field	Final		

Form 1-102

WELL 40S

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

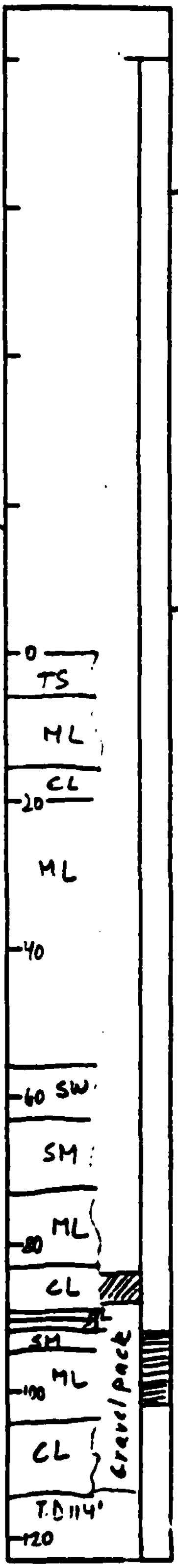
ELEVATION: GROUND LEVEL 67.76'

TOP OF CASING

PROJECT McClellan

LOCATION Sacramento

PERSONNEL YN, ES



DRILLING SUMMARY:

TOTAL DEPTH 114'

BOREHOLE DIAMETER 8"

DRILLER Wtr. Development Corp. Woodland, CA

RIG Rotary Drilltech D40K

BIT(S) Wing

DRILLING FLUID Nat. mud

SURFACE CASING

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	9/18	10:20	9/18	11:15
GEOPHYS. LOGGING:				
CASING:	9/18			
FILTER PLACEMENT:	9/18			
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

0 - 93 C

93 - 103 S

CASING: C1 4" PVC, SCH 40

C2 threaded

C3

C4

SCREEN: S1 4" stainl. steel

S2 threaded, 10 slots

S3

S4

CENTRALIZERS

FILTER MATERIAL Monterey sand #3

CEMENT Grout

OTHER Bentonite seal

WELL DEVELOPMENT

COMMENTS:

ES DRILLING LOG

Well No.: 40S

Date: 18 Sept, 1982

Location: McClellan

Altitude (Datum): 67.76' msl

Method: Rotary

Size of hole: 8"

Size of casing: 4"

Driller: Water Development Corp.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
	10:20		T.S.	
		Bn silt	ML	
		claystreaks		micaceous
15		Silty clay, bn	CL	
		Rd silt, (5% clay)	ML	
30				
		sandy (micaceous) 5%		
		rd-bn clayey silt (10% clay)		mica
45				
60		clean fn-md sand bn-rd	SW	mica
		Silty md sand bn-rd, some clay streaks	SM	
75		Grey silt clay streaks	ML	mica
		Grey clay	CL	
90		green silt	ML	

ES DRILLING LOG

Well No.: 40S (continued)

Date:

Location:

Altitude (Datum): 67.76 MSL

Method:

Size of hole:

Size of casing

Driller.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
93		sandy clay	CL	
96		silty clayey sand	SM/SC	
99			ML	
102		Clayey silt, grey		
105				
		silty clay greenish-grey	CL	
			T.D. 114'	
120				

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WELL 4/5

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

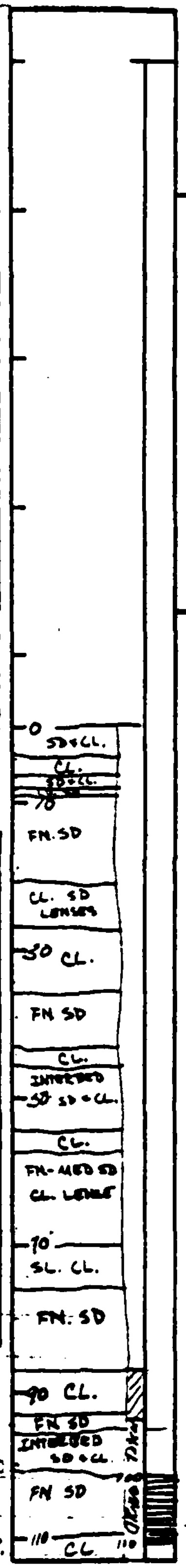
ELEVATION: GROUND LEVEL 63.74

TOP OF CASING +1.15

LOCATION SACRAMENTO, CAL.

PERSONNEL JKM (BISHOP ASSOC.)

PROJECT McClellan AFB



DRILLING SUMMARY:

TOTAL DEPTH 115'

BOREHOLE DIAMETER 8½"

DRILLER WTR. DEVEL CORP.

RIG ROTARY

BIT(S) ROLLER

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	9/2	4:10	9/2	4:45
	9/3	8:15	9/3	9:15
GEOPHYS. LOGGING:				
CASING:	9/3	10:15		
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:	9/3			
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

+1.15 – 100	C
100 – 110	S

CASING: C1 4" PVC

C2

C3

C4

SCREEN: S1 4" STAINLESS 10 SLOT 10'

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3" - 92-115'

CEMENT BENTONITE 92-87'

OTHER

WELL DEVELOPMENT

COMMENTS:

W.L. 9/9/82 09:51 = 96.4 - 1.15 = 95.25

1-376

Field Engr/Tech TKU Sheet 1 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/2

Ground Elev. ________ Hole No. 4/5 Dia. 8½ T.D. 15'

Final Hole No ________

Water Table At Drilling:

Water: Depth 1st Encountered ________ Dry: ☐ Won't ☐ Might ☐ Should ☐ Will

Water-After ________

START 9/2 4:00 Caved-After ________

Water Table After Drilling

Water At Depth ________

Date ________ By ________

Dry At Depth ________

☐ ☐ Couldn't Find ☐ Covered

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	0-4	CL.	RED CL SD				
	4-6	CL.	RED CL				
	6-8	SC	RD CL+SD (CL LENSES)				
	8-9	SP	CO. SD				
	9-21	SP	FN SD - MED @ 18' (PYRITIC)				
	21-27	CL	GREY CL. SD LENSES.				
	27-36	CL	DRY CLAY				
	36-43	SP	FN SD "PYRITIC"				
	43-47	CL.	DRY GR. CL.				

Comments:

Depth	Samples - Spoon				Standard Penetration		Laboratory Sample Description	Sample
	Calif.	Std.	Shelby	Auger	Field	Final		
								-

Form 1-102

Field Engr/Tech TKM Sheet 2 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/2

Ground Elev. ____ Hole No. 415 Dia. 8½" T.D. 115'

Final Hole No ____

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ____ Dry ☐ Won't Water-After ∅ ____ ☐ Might Caved-After ∅ ____ ☐ Should ☐ Will	Water At Depth ____ Date ____ By ____ Dry At Depth ____ ☐ Couldn't Find ☐ Covered ☐ ____

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	47-53	SC	INTERBED FN SD, & CL. (PYRITIC)				
	53-59	CL.	GREY CL. to 55, RED CL 55-59		M.		
	59-70'	SW	FN-MED SD, CL LENSES SL. MICACEOUS				
	70'-76'	CL.	SILTY GREY CLAY DRY		DRY		
	76'-87'	SP	FN SD SL. MICACEOUS				
	87'93	CL.	GREY CL w/ REDDISH BR. CL.				
	93'95	SP	FN SD				
	95'-100'	SC	INTERBED FN SD & CL.				
	100-110'	SP	FN SD MICACEOUS "PYRITIC"				

Depth	Samples - Spoon				Standard Penetration		Comments:	
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	[illegible]

Form 1-102

Field Engr/Tech TKM Sheet 3 of 3.

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐ Date 9/3

Ground Elev. ________ Hole No. 41S Dia 8½ T.D. 115'

Final Hole No ________

Water Table At Drilling:

Water: Depth 1st Encountered ______ Dry ☐ Won't ☐ Might ☐ Should ☐ Will

Water - After ⌀ ______

Caved - After ⌀ ______

Water Table After Drilling

Water At Depth ______

Date ______ By ______

Dry At Depth ______

☐ Couldn't Find ☐ Covered

☐ ______

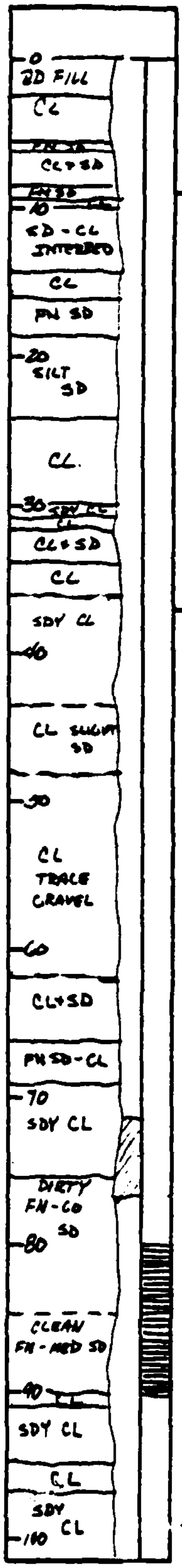
Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	110'-115'	CL.	GREY CL.				
			TD - 115' 9:12				

Depth	Samples - Spoon: Calif.	Samples - Spoon: Std.	Samples - Spoon: Shelby	Samples - Spoon: Auger	Standard Penetration: Field	Standard Penetration: Final	Comments: / Laboratory Sample Description	[illegible]

Form 1-102

1-379

LOCATION SACRAMENTO, CAL
PERSONNEL TKM (BISHOP ASSOC.)
PROJECT McCLELLAN AFB



WELL 425

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:
ELEVATION: GROUND LEVEL 56.58
TOP OF CASING 1.2

DRILLING SUMMARY:

TOTAL DEPTH 102'
BOREHOLE DIAMETER 8½"
DRILLER WTR. DEVEL. CORP.
RIG ROTARY
BIT(S) ROLLER
DRILLING FLUID NAT. MUD
SURFACE CASING N/A

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:				
	8/31	2:30	9/1	11:00
GEOPHYS. LOGGING:				
CASING:				
	9/1	11:20	-	1:00
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:	9/1			
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG
CASING STRING(S): C=CASING S=SCREEN
+1.2 - 80' C
80' - 90' S

CASING: C1 ~~[illegible]~~ 4" PVC.
C2
C3
C4
SCREEN: S1 10 SLOT JOHNSON
S2 STAINLESS
S3
S4
CENTRALIZERS
FILTER MATERIAL MONTEREY "3"
CEMENT
OTHER

WELL DEVELOPMENT

COMMENTS:

W.L. IN MW23 = 90.47'
W.L. 08:35-9/2/82 = 87.2 -1.2 = 86.0

Field Engr/Tech TKM Sheet 1 of 3

Project McCLELLEN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/31

Ground Elev. ______ Hole No. 42S Dia. 8½" T.D. 102'

Final Hole No ______

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry ☐ Won't ☐ Might ☐ Should ☐ Will Water-After ∅ ______ Caved-After ∅ ______	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	0-5	CL	DRY GR CLAY (0-3' ASPHALT & FILL)				
	5-6	SP	VFN SD				
	6-8	SC	CLAY AND SD				
	8-9	SP	FN SD				
	9-10	CL	GREY CL				
	10-14	SC	CLAY & SD INTERBEDDED				
	14-16	CL	GREY CLAY				
	16-18	SP	FN SD				
	18-24	SP	SILTY SD				

Comments:

Depth	Samples - Spoon				Standard Penetration		Laboratory Sample Description	[illegible]
	Calif.	Std.	Shelby	Auger	Field	Final		

Form 1-102

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Field Engr/Tech TKU Sheet 2 of 3

Project McCLELLAN Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/1

Ground Elev. ____ Hole No. 425 Dia. 8 1/2 T.D. 102'

Final Hole No ____

Water Table At Drilling: Water: Depth 1st Encountered ____ Dry ☐ Won't Water - After ____ ☐ Might Caved - After ____ ☐ Should ☐ Will	Water Table After Drilling Water At Depth ____ Date ____ By ____ Dry At Depth ____ ☐ Couldn't Find ☐ Covered ☐ ____

Plot	Depth	Class	Field Soil Description	Std. Pen	Moist	Color	Calc
	24-30	CL	BR. CLAY				
	30-31	CL	SANDY CL				
	31-32	CL	HD ZEDDISH-BR CL				
	32-34	SC	ZD-BR CL & SD, TRACE GRAVEL				
	34-37	CL	BR "GUMMIE" CLAY				
	37-44	CL	SANDY CLAY, "GUMMIE @ 39'" VERY SLOW DRILLING				
	44-48	CL	BR CLAY, SLIGHT SD . DRIER THAN ABOVE				
	48-62	CL	BR. "GUMMIE" CLAY, TRACE GRAVEL - SD				
	62-67	CL	BR. CLAY FN BLACK SD				

Depth	Samples - Spoon				Standard Penetration		Comments:	
	Calif.	Sed.	Shelby	Auger	Field	Final	Laboratory Sample Description	

Field Engr/Tech TKM Sheet 3 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 91

Ground Elev. ______ Hole No. 475 Dia. 8½ T.D. 102

Final Hole No ______

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry ☐ Won't ☐ Might ☐ Should ☐ Will Water-After ø ______ Caved-After ø ______	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	67-69	SP	FN SD SLIGHT CLAY				
	69-76	CL	SANDY BR CL - DRIER @ 70'	-		BR	
	76-85	SW	FN-CO SD @ 80-85' DIRTY				
	85-90	SW	CLEAN FN-MED SD				
	90-91	CL	DRY GREY CLAY		DRY	GR	
	91-95	CL	SANDY GREY CLAY			GR	
	95-97	CL	GREY CLAY			GR	
	97-102	CL	SANDY GREY CLAY			GR	

Depth	Samples - Spoon				Standard Penetration		Comments:
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description

Form 1-102

1-383

WELL 435

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

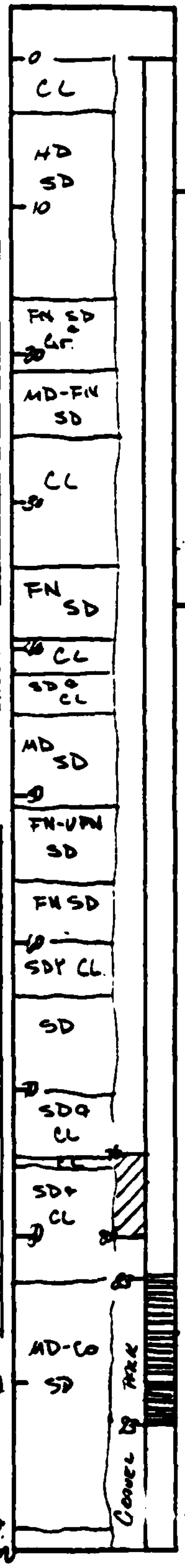
ELEVATION: GROUND LEVEL 57.01

TOP OF CASING

LOCATION SAC. CAL.

PERSONNEL TKM (BISHOP)

PROJECT McCLELLAN AFB



DRILLING SUMMARY:

TOTAL DEPTH 102'

BOREHOLE DIAMETER 8½"

DRILLER WATER DEVEL. CORP

RIG

BIT(S)

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

WELL DESIGN:

BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

-	83	C
83 -	93	S

CASING: C1

C2

C3

C4

SCREEN: S1

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3"

CEMENT 100 lbs. BENTONITE IN GRAVEL PACK

OTHER

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	8/27	10:15	–	11:42
GEOPHYS. LOGGING:				
CASING:	8/27	11:45	-	12:40
FILTER PLACEMENT:		12:40		1:00
CEMENTING:				
DEVELOPMENT:				
OTHER:	8/27			

WELL DEVELOPMENT

FRESH WTR.

COMMENTS:

TAKING WTR. RAPIDLY DURING PACK PLACEMENT - PERM. MATERIAL

W.L. 8/30 - 88.57 - 1.1 = 87.47'

1-384

Field Engr/Tech TKM Sheet 1 of 2

Project McCLELLAN Job No. ☐☐☐☐–☐☐☐☐☐ Date 8/27

Ground Elev. ____ Hole No. 435 Dia. 8½ T.D. ____

Final Hole No ____

Water Table At Drilling:

Water: Depth 1st Encountered ____ Dry ☐ Won't

Water-After ____ ☐ Might

Caved-After ____ ☐ Should

☐ Will

Water Table After Drilling

Water At Depth ____

Date ____ By ____

Dry At Depth ____

☐ Couldn't Find ☐ Covered

☐ ____

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	0-4	CL	BR.. CLAY			BR.	
	4-17	SP	GN. HARD SAND - MICACEOUS			GN.	
	17-21	SG	Fine UNCONSOLIDATED SD., OCC. GR.			GR.	
	21-26	SW	FN-MED SD. SALT-PEPPER.				
	26-35	CL	HARD CLAY			TN	
	35-39	SP	FN SD MICA				
	39-42	CL	CLAY			TN	
	42-45	SC	CLAY INTERBED FN. SD.				
	45-51	SW	FN-MED SALT-PEPPER SD				

Depth	Samples – Spoon				Standard Penetration		Comments:	
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	[illegible]

Form 1-102

1-385

Field Engr/Tech TKK Sheet 2 of 2

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/27

Ground Elev. ________ Hole No. 435 Dia. 8 1/2 T.D. 102

Final Hole No ________

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry ☐ Won't Water-After ϕ ______ ☐ Might Caved-After ϕ ______ ☐ Should ☐ Will	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find: ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Stiff/Pen	Moist	Color	Calc
	51-56	SW	FN-VFN SD, CLAY LENSES				
	56-60	SC	FN BLACK SD CLAY LENSES			BL.	
	60-64	SC	SDY CLAY			LT BR.	
	64-70	SP	FN SD			BR.	
	70-75	SC	SD & CLAY Interbedded			BR & RD	
	75-76	CL	CLAY				
	76-83	SC	FN SD & CLAY				
	83-100	SW	MED- COARSE SD, SMALL BL. GRAVEL				
	100-	CL	CLAY TD - 102'				

Depth	Samples - Spoon				Standard Penetration		Comments:	
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	

Form 1-102

1-356

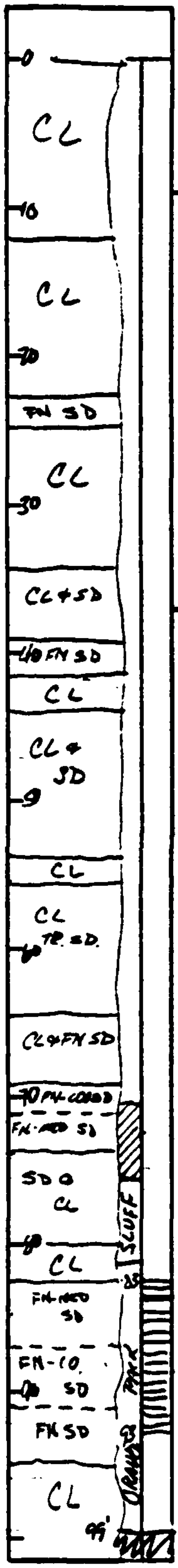
WELL 445

WELL CONSTRUCTION SUMMARY

LOCATION SACRAMENTO, CAL

PERSONNEL TCH (TUHOP ASSOC)

PROJECT MCCLELLAN



LOCATION or COORDS:

ELEVATION: GROUND LEVEL 53.76

TOP OF CASING 1.0' ABOVE G.L.

DRILLING SUMMARY:

TOTAL DEPTH 99'

BOREHOLE DIAMETER 8½"

DRILLER WATE. DEVEL. CORP.

RIG

BIT(S)

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	8/28	9:30	-	11:30
GEOPHYS. LOGGING:				
CASING:	8/28	11:30		1.00
FILTER PLACEMENT:	8/28	1:00		1:25
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

 - 83 C
85 - 93 S

CASING: C1 4" PVC

C2

C3

C4

SCREEN: S1 4", 10 SLOT JOHNSON

S2 STAINLESS.

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY #3

CEMENT 100 lbs BENTONITE ON GRAVEL PACK

OTHER

WELL DEVELOPMENT

COMMENTS:

5 BAGS MONTEREY IN WELL - LEVEL PROBABLY TO 82 - DURING PLACEMENT, CAVING OCCURED TO 76'. SAND LAYER AT 69-74' MAYBE SATURATED WHICH CAUSED CAVING.

W.L. 8/30 = 77.75 - 1.0 = 76.75

Field Engr/Tech TKM Sheet 1 of 3

Project McCLELLAN Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/88

Ground Elev. ________ Hole No. 44S Dia. 8½ T.D. 99'

Final Hole No ________

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry Water-After ______ Caved-After ______ ☐ Won't ☐ Might ☐ Should ☐ Will	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find: ☐ Covered ☐

Plot	Depth	Class	FIELD SOIL DESCRIPTION	Stiff/Den	Moist	Color	Calc
	0-12	CL	BR. CLAY - EASY DRILLING			BR.	
	12-23	CL	BR CLAY - w/ FINE SD			BR.	
	23-25	SP	FN SD - NO SAMPLE (NOT MUCH WTR TAKEN WHILE ADD JOINT)			BR	
	25-35	CL	BR - HD DRY CLAY			BR.	
	35-39	SC	BR CLAY & SD (INTERBEDDED)			BR	
	39-42	SP	FN - SD (MICACEOUS)			BR	
	42-44	CL	DRY CLAY			BR	
	44-54	SC	RED CLAY w/ SD (INTERBEDDED) INCRESED SD @ 46' (SAME WTR TAKEN, ADD JOINT)			RD	
	54-57	SC	BR. CLAY w/SD			BR	

Depth	Samples - Spoon				Standard Penetration		Comments:
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description

Form 1-102

Field Engr/Tech 1KU Sheet 2 of 3

Project McCLELLAN Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/28

Ground Elev.______ Hole No. 445 Dia. 8½ T.D. 99

Final Hole No ______

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry ☐ Won't	Water At Depth ______
Water-After ☐ Might	Date ______ By ______
Caved-After ☐ Should	Dry At Depth ______
☐ Will	☐ Couldn't Find ☐ Covered ☐

Plot	Depth	Class	Field Soil Description	Stiff Pen	Moist	Color	Calc
	57-65	CL	DRY TAN CLAY TRACE SD			TN	
	65-69	SC	INTERBEDDED BR CLAY + FN SD			Be	
	69-71	SP	FN-[illegible] SD				
	71-72	SW	FN-COARSE SD				
	71-74	SW	FN-MED SD				
	74-80	SC	SD + DRY CL INTERBEDDED (LITTLE WTR TAKEN)			TN	
	80-83	CL	TN CLAY				
	83-87	SW	FN-MED SD				
	87-91	SW	FN-CO. SD (ENVO, OBSIR, GREEN)				

Depth	Samples - Spoon				Standard Penetration		Comments:	
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	Sample

Form 1-102

Field Engr/Tech TKM Sheet 3 of 3

Project McCLELLEN Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/28

Ground Elev. ______ Hole No. 44S Dia. 7 7/8 T.D. 99'

Final Hole No ______

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry ☐ Won't ☐ Might ☐ Should ☐ Will Water-After ⌀ ______ Caved-After ⌀ ______	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	91-94	SP	FN. SD.				
	94-95	SC	FN SD TRACE TN CLAY			TN	
	95-99	CL	GREY "PLASTIC" CLAY HARD DRILLING			GR	

Depth	Samples - Spoon: Calif.	Std.	Shelby	Auger	Standard Penetration: Field	Final	Comments: / Laboratory Sample Description	Sample Number

Form I-102

1-390

WELL 455

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

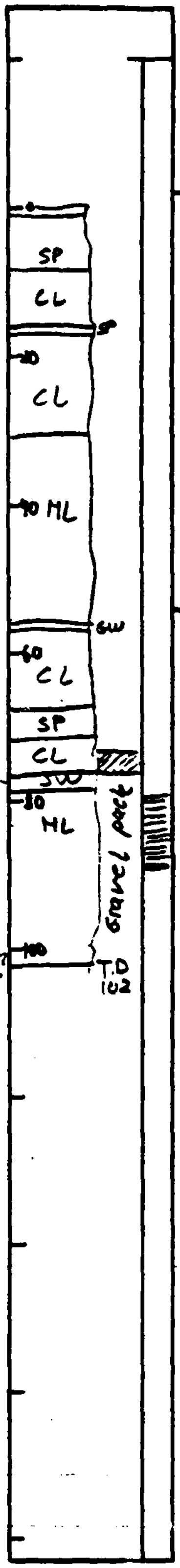
ELEVATION: GROUND LEVEL 60.64

TOP OF CASING

LOCATION

PERSONNEL

PROJECT McClellan



DRILLING SUMMARY:

TOTAL DEPTH 102

BOREHOLE DIAMETER 8.5"

DRILLER Scott-Water Dev Corp

RIG Drittech D40K

BIT(S)

DRILLING FLUID natural mud clear water

SURFACE CASING

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

0 - 80 C

80 - 90 S

CASING: C1 10' - 4" dia

C2 10 slot Johnson

C3 stainless steel

C4

SCREEN: S1

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL Monterey "3"

CEMENT

OTHER Bentonite

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	8-24	8-25-	82	
GEOPHYS. LOGGING:				
CASING:	8-25-82			
FILTER PLACEMENT:	8-25-82			
CEMENTING:				
DEVELOPMENT:	8-25-82			
OTHER:				

WELL DEVELOPMENT

flush with clear water

COMMENTS:

8/86 - 08.58

WL 87.75 - 1.55 = 86.20'

Field Engr/Tech FH Sheet 1 of 2

Project McClellan Job No. ☐☐☐☐-☐☐☐☐☐ Date 8/25/92

Ground Elev. ________ Hole No. 45S Dia. 8½ T.D. ________

Final Hole No ________

Water Table At Drilling: Water: Depth 1st Encountered ________ Dry ☐ Won't Water- After ∅ ________ ☐ Might Caved- After ∅ ________ ☐ Should ☐ Will	Water Table After Drilling Water At Depth ________ Date ________ By ________ Dry At Depth ________ ☐ Couldn't Find ☐ Covered ☐ ________

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	0	TS			sm	dk bn	
	1	CL	"Hardpan"	VS	dry	bn	
	2	SP	med gr	sd	–	bn	
	7	CL	+ ML, interbedded	d	rd -gn	bn slt bn clay	
	16	SP	med gr, occ. gravel.	sd		bn	
	17.5	CL	sli silty, ML interbedded after 28 ft.	VS		bn- gn bn	
	32	ML	clayey, easier drilling	ss		gn bn	
	57	GW	no sample - crunchy drilling				
	58	CL	silty - slow drilling	VS		bn- rd bn gn bn	

Depth	Samples - Spoon: Calif.	Std.	Shelby	Auger	Standard Penetration: Field	Final	Comments: / Laboratory Sample Description	Stiff/Dense

Form 1-102

Field Engr/Tech FH Sheet 2 of 2

Project McClelland Job No. ☐☐☐☐-☐☐☐☐☐ Date 8-25-82

Ground Elev ________ Hole No. 455 Dia. 8 1/2 T.D. 102

Final Hole No ________

Water Table At Drilling: Water: Depth 1st Encountered ______ Dry ☐ Won't ☐ Might ☐ Should ☐ Will Water-After ϕ ______ Caved-After ϕ ______	Water Table After Drilling Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find: ☐ Covered ☐

Plot	Depth	Class	Field Soil Description	Stiff Den	Moist	Color	Calc
	68	SP	med f., peppered.	L		bn	
	72	CL	silty	S-VS		gy bn	
	77	SW	no sample - drilled like sand				
	79	ML	silt. drills like sand, with sandy interbeds			bn	
			T.D. 102' at 11:00AM				

Comments:

Depth	Samples - Spoon: Calif.	Std.	Shelby	Auger	Standard Penetration: Field	Final	Laboratory Sample Description	Sample Class

WELL 46S

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

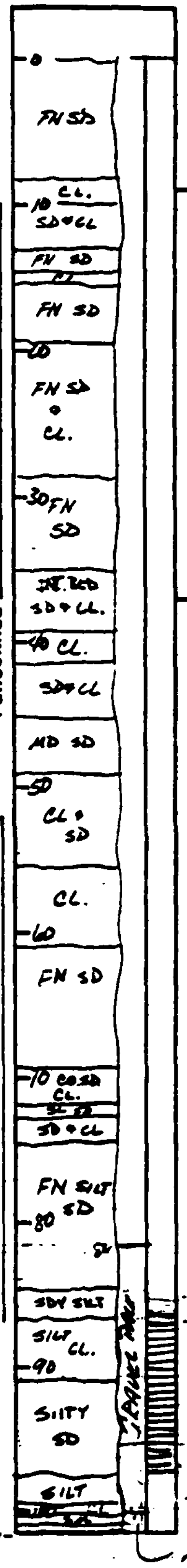
ELEVATION: GROUND LEVEL 1.5.67

TOP OF CASING

PROJECT McCLELLAN AFB

LOCATION SACRAMENTO, CAL.

PERSONNEL



MAYBE 3' OF SLUFF ON BOTTOM

DRILLING SUMMARY:

TOTAL DEPTH 106'

BOREHOLE DIAMETER 8½"

DRILLER WTR. DEVEL. CORP.

RIG ROTARY

BIT(S) ROLLER

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:	9/1	3:05	9/1	4:50
GEOPHYS. LOGGING:				
CASING:	9/1	5:00	-	6:45
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:	9/3			
OTHER:				

WELL DESIGN:

BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

+1 - 87 C

87 - 97 S

CASING: C1 4" PVC

C2

C3

C4

SCREEN: S1 4" 10 SLOT JOHNSON

S2 STAINLESS STEEL

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3"
6 BAGS (FILL TO 85')

CEMENT

OTHER

WELL DEVELOPMENT

COMMENTS:

SCREEN 87-97'; MW-24, 25, 26 ALL COMPLETED IN SILTY SAND. W.L.'s 87'=24, 95'=25, 96'=26, PROJECTING CONTOURS WOULD GIVE 46S a W.L. of 92'; THERE'S A SAND LAYER 91-97'. PAST INFO WOULD INDICATE COMPLETION HERE.

W.L. 9:25 9/3: 95-1.3 = 93.7' (BEFORE PUMPING)

/

Field Engr/Tech TKM Sheet 1 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/1/8

Ground Elev. ________ Hole No. 46S Dia. 8½ T.D. 106

Final Hole No ________

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry ☐ Won't	Water At Depth ______
Water-After ______ ☐ Might	Date ______ By ______
Caved-After ______ ☐ Should	Dry At Depth ______
☐ Will	☐ Couldn't Find ☐ Covered
	☐ ______

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	0-8	SP	~~?~~FN SD				
	8-10	CL	RED CLAY			RD	
	10-13	SC	MED-FN SD & CLAY				
	13-15	SP	FN SD				
	15-16	CL	GREY CLAY			GR	
	16-19	SP	FN SD				
	19-28	SC	FN SD & CLAY (COARSER @ 21')				
	28-35	SP	FN-SD Very MICACEOUS (Pyritic)				
	35-59	SC	TN CLAY INTERBEDDED FN SD			TN	

Depth	Samples - Spoon				Standard Penetration		Comments:	
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	
								-

Form 1-102

Field Engr/Tech KU Sheet 2 of 3

Project ______ Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/1

Ground Elev. ______ Hole No. 465 Dia. ______ T.D. 106

Final Hole No ______

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry ☐ Won't	Water At Depth ______
Water-After 0 ______ ☐ Might	Date ______ By ______
Caved-After 0 ______ ☐ Should	Dry At Depth ______
☐ Will	☐ Couldn't Find ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Stiff Pen	Moist	Color	Calc
	39-42	CL	GREY CLAY			GR	
	42-46	SC	RED CLAY & MED-FN SD			RD	
	46-49	SP	MED SD @ 48' FN SD				
	49-56	CL	RED CLAY & SAND			RD	
	56-61	CL	TN-RD CLAY OCC. SAND INCREASE SD @ 60'			TN + RD	
	61-69	SP	FN SD COARSER @ 67'.				
	65-72	SC	COARSER SD + CLAY				
	72-73	SM	SILTY SD				
	73-75	SC	FN SD & CLAY				

Depth	Samples - Spoon: Calif.	Std.	Shelby	Auger	Standard Penetration: Field	Final	Comments: Laboratory Sample Description	Sample Consol

Field Engr/Tech TRM Sheet 3 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/1

Ground Elev. ______ Hole No. 46S Dia. 8½ T.D. 106

Final Hole No ______

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry: ☐ Won't ☐ Might ☐ Should ☐ Will	Water At Depth ______
Water - After 0 ______	Date ______ By ______
Caved - After 0 ______	Dry At Depth ______
	☐ Couldn't Find ☐ Covered
	☐ ______

Plot	Depth	Class	Field Soil Description	[illegible] Den	Moist	Color	Calc
	75-85	SM	FN SD (NOT MICACEOUS) & SILT				
			82-84 - CLAY LENSES.				
	85-87	SM	SDY SILT				
	87-91	MH	SILT & CLAY				
	91-93	SM	~~S~~ SILTY, FN. SAND				
	93-99	ML	SILT				
	99-102	CL	Gr. CLAY			GR	
	102-105	SM	SILTY SAND				
	105-106	CL	"GUMMIE" GREY CL.			GR	
			SLOW DRILLING				

Depth	Samples - Spoon				Standard Penetration		Comments:
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description

Form 1-102

WELL 475

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

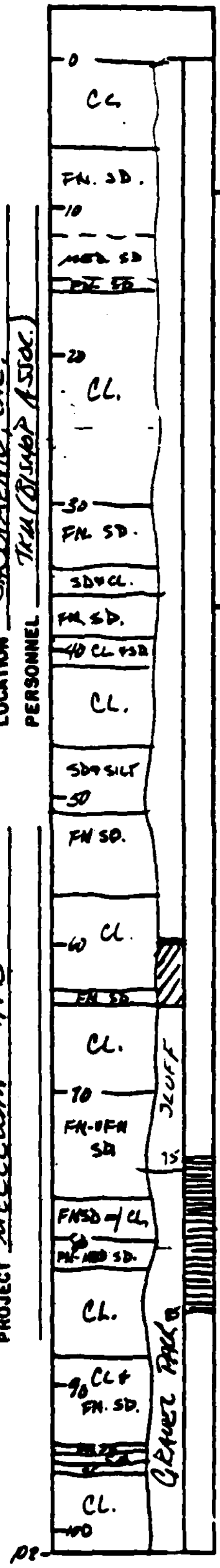
ELEVATION: GROUND LEVEL 55.29

TOP OF CASING

LOCATION SACRAMENTO, CAL.

PERSONNEL TKM (BISHOP ASSOC.)

PROJECT McCLELLAN AFB



DRILLING SUMMARY:

TOTAL DEPTH 102'

BOREHOLE DIAMETER 8½"

DRILLER WTR. DEVEL. CORP.

RIG ROTARY

BIT(S) ROLLER

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

	-	75	C		-	
75	-	85	S		-	

CASING: C1 4" PVC

C2

C3

C4

SCREEN: S1 4" JOHNSON STAINLESS

S2 10 SLOT

S3

S4

CENTRALIZERS N/A

FILTER MATERIAL MONTEREY "3"

CEMENT

OTHER

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:				
	9/8	8:00	-	11:00
GEOPHYS. LOGGING:				
CASING:				
	9/8	11:45	-	1:00
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DEVELOPMENT

COMMENTS:

AFTER PLACING LAST SAND BAG IN HOLE CAVED IN TO 64'.

ES DRILLING LOG

Well No.: 475

Date: 9/8

Location:

Altitude (Datum):

Method: ROTARY

Size of hole: 8 ⅞"

Size of casing: 4" PVC

Driller: WTR DEVEL CORP

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
0				
		RED CL	CL.	
6 7		FN SD / CL. LENSE @	SP	
		7'		
10				
⑫		MED SD	–	
			SP	
15 16		FN SD	SP	
		GREY CL. - DRY		
		CL.ST		
20			CL.	
		21' - CL w/ VFN SD.		
25				
27		RED CL.		
		GREY CL. @ 29' = GREEN CL.ST.		
30		FN-SD	SP	
34		FN SD INTERBED GR CL.	SC	
36		FN SD	SP	
39 40		TAN CL. W/ FNSD	SC	
41		TAN & GREEN CL.	CL.	
47				
		VFN SD + SILT ("LENSE" CL.)	SM	
50				
51		FN-MED SD. LENSE @ 50'		
		FN-MED SD - MICACEOUS	SW	
57		GREY CL. & RED CL.	CL.	
60'				

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2/2

ES DRILLING LOG

Well No.: 475

Date: 9/8

Location:

Altitude (Datum):

Method: ROTARY

Size of hole: 8½

Size of casing 4" PVC

Driller: W+R. DELEZ. CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60		GREY, CL. & RED w/FNSD	CL.	
65		FN MICACEOUS SD	SP	
65½		RED CL TRACE BLACK SD @ 68'	CL.	
70		FN-VFN SD	SW	
77				
		FN SD & RED CL.	SC	
80		FN-MED SD (MED-10 @ 81'	SW	
83		GREY CL	CL.	
88		GREY CL. & FN SD	SC	
90				
94		FN SD	SP	
95				
96		FN SD & SILT	SW	
97		SD & CL	SC	
		GREY CL.	CL.	
102				

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1-400

WELL 485

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS: ______

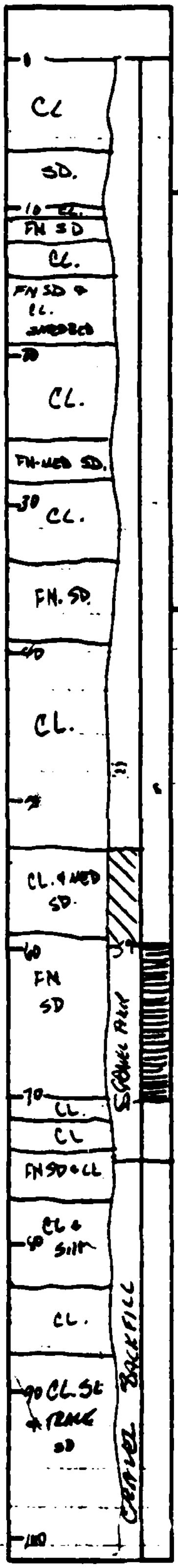
ELEVATION: GROUND LEVEL 54.23

TOP OF CASING ______

LOCATION SACRAMENTO CAL

PERSONNEL TEAM (BISHOP ASSOC

PROJECT McCLELLAN AFB



TD102.

DRILLING SUMMARY:

TOTAL DEPTH 102'

BOREHOLE DIAMETER 8½"

DRILLER WM. DEVEL CORP.

RIG ROTARY

BIT(S) ROLLER

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

–	60	C
60 –	70	S

CASING: C1 4" PVC

C2

C3

C4

SCREEN: S1 4" STAINLESS JOHNSON 10

S2 SLOT

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3"

CEMENT

OTHER

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:				
	9/7	10:00	-	12:20
GEOPHYS. LOGGING:				
CASING:				
	9/7	1:45	-	
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DEVELOPMENT

COMMENTS:

W.L. 9/9 10:00 = 70.15 - .5 = 69.65

DRY?

1-401

Field Engr/Tech TKM Sheet 1 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/7

Ground Elev. ______ Hole No. 48S Dia. 8½ T.D. 102

Final Hole No ______

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry ☐ Won't Water-After ⌀ ______ ☐ Might Caved-After ⌀ ______ ☐ Should ☐ Will	Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐

Plot	Depth	Class	Field Soil Description	Stiff/Den	Moist	Color	Calc
	06	CL	CLAY				
	6-10	SP	FN SD				
	10-11	CL	CLAY				
	11-13	SP	CLEAN FN, SD				
	13-15	CL	DRY CL				
	19 15-20	SC	FN SD & CL INTERBEDDED				
	19 20-26	CL	GREY CLAY, SLOW DRILL				
	26-28	SW	MED-FN SD, CLEAN				
	28-34	CL	GREY & RED CLAY, DRY GREEN CL. STONE @ 9'				

Comments:

Depth	Samples - Spoon				Standard Penetration		Laboratory Sample Description	
	Calif.	Std.	Shelby	Auger	Field	Final		

Form 1-102

1-402

Field Engr/Tech 1KU Sheet 2 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐-☐☐☐☐☐ Date 9/7

Ground Elev.______ Hole No. 48S Dia. 8½ T.D. 102

Final Hole No______

Water Table At Drilling: Water: Depth 1st Encountered______ Dry ☐ Won't Water-After ⌀ ______ ☐ Might Caved-After ⌀ ______ ☐ Should ☐ Will	Water Table After Drilling Water At Depth______ Date______ By______ Dry At Depth______ ☐ Couldn't Find ☐ Covered ☐

Plot	Depth	Class	Field Soil Description	Stiff Pen	Moist	Color	Cal
	34-39	SP	FN-SD				
	39-54	CL.	DRY GR CL. (INTERMIXE GR+RD CLST. @ 41') TRACE SD+GR @ 46'-46'				
	54-59	SC	RD CL & BLACK SD "PYRITIC"				
	59-70'	SP	FN SD HEAVILY "PYRITIC"				
	70'-72'	CL.	RDWH BR CLAY				
	72'-74'	CL.	GREY CL.				
	74'-77'	SC	FN SD +CL				
	77'-83'	CL.	GREY CL & SILT - VERY SLOW DRILL				
	83-88	CL.	DRK GREY CL.				

Comments:

Depth	Samples - Spoon				Standard Penetration		Laboratory Sample Description	[illegible]
	Calif.	Std.	Shelby	Auger	Field	Final		

Form 1-102

Field Engr/Tech TKM Sheet 3 of 3

Project McCLELLAN AFB Job No. ☐☐☐☐–☐☐☐☐☐ Date 9/7

Ground Elev. ______ Hole No. 485 Dia. 8 1/2 T.D. 102'

Final Hole No ______

Water Table At Drilling:	Water Table After Drilling
Water: Depth 1st Encountered ______ Dry: ☐ Won't Water-After ⌀ ______ ☐ Might Caved-After ⌀ ______ ☐ Should ☐ Will	Water At Depth ______ Date ______ By ______ Dry At Depth ______ ☐ Couldn't Find ☐ Covered ☐ ______

Plot	Depth	Class	Field Soil Description	Split Den	Moist	Color	Calc
	88-102	CL.	CL, SILT, TRACE SD.				

Depth	Samples - Spoon				Standard Penetration		Comments:
	Calif.	Std.	Shelby	Auger	Field	Final	Laboratory Sample Description	[illegible]

Form 1-102

1-404

WELL 495

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

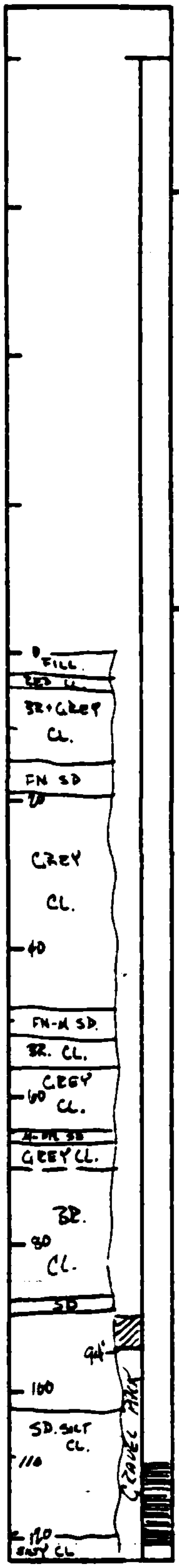
ELEVATION: GROUND LEVEL 74.90

TOP OF CASING

LOCATION SACRAMENTO, CAL.

PERSONNEL TKM (BISHOP ASSOC.)

PROJECT MCCLELLAN AFB



DRILLING SUMMARY:

TOTAL DEPTH 126'

BOREHOLE DIAMETER 8½"

DRILLER WTR. DEVEL. CORP

RIG ROTARY

BIT(S) ROLLER TO 10', WING T.D.

DRILLING FLUID NAT. MUD

SURFACE CASING N/A

WELL DESIGN:

BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG ___

CASING STRING(S): C=CASING S=SCREEN

– 110 C

110 – 120 S

CASING: C1 4" PVC

C2

C3

C4

SCREEN: S1 4" STAINLESS 10 SLOT

S2

S3

S4

CENTRALIZERS

FILTER MATERIAL MONTEREY "3" TD TO 94'

CEMENT

OTHER

CONSTRUCTION TIME LOG:

TASK	START		FINISH	
	DATE	TIME	DATE	TIME
DRILLING:				
	9/16	8:00	-	10:30
GEOPHYS. LOGGING:				
CASING:				
FILTER PLACEMENT:				
CEMENTING:				
DEVELOPMENT:				
OTHER:				

WELL DEVELOPMENT

COMMENTS:

DRILLING LOG

Well No.: 495

Date: 9/16/82

Location: McCLELLAN AFB

Altitude (Datum):

Method: ROTARY

Size of hole: 8½

Size of casing: 4"

Driller: W.R. DEVEL CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
	2	ROAD FILL	FILL	
2		RED ~~FEL~~ CL.	CL	
4		BR-GREY CL. STONE		
		w/GRAVEL @ 6'		
10				
14		FN. SD - MICACEOUS	SW	
		(SILVER & BLUE)		
19				
20		GREY CL. - DRY	CL	
		SD LENSE @23' - MICACEOUS		
		(GOLD COLOR)		
30				
40				
48'		FN-MED SD w/SLIGHTLY MICACEOUS	SW	
50				
52'		DRY BR. CL.	CL	
[illegible]		[illegible]		
[illegible]		[illegible]		
[illegible]				

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ES

DRILLING LOG

Well No.: C95

Date: 9/16/82

Location: McCLELLAN AFB

Altitude (Datum):

Method: ROTARY

Size of hole: 8½

Size of casing: [illegible]

Driller: JTR PEREZ. CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
50		GREY CL		
64		FN-MED SD.	SW	
66		GREY CL.	CL	
70				
71'		BR. CL. W/FN SD V. SLIGHTLY MICACEOUS.	SC	
80				
90		SD LENSE 89'	SW	
100				
103		FN SD. & CL. V.LITTLE MICA SILTY		
110'				
113'		→ DRILLING SLOWED.		
115'				
119'				
120'		SILTY [illegible] CL W/ SD	CL	

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ES **DRILLING LOG**

Well No.: 475

Date: 9/16

Location: McCLELLAN AFB

Altitude (Datum):

Method: ROTARY

Size of hole: 8 1/2

Size of casing: 4"

Driller: WTR DEVEL CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
120				
		DRY BR. SILTY CL		
		w/ TRACE SD.		
125				
		TD-126'		

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Field Engr/Tech FH Sheet 1 of 1

Project McClellan Job No. ☐☐☐☐-☐☐☐☐☐ Date 8.30,23, 24, 82

Ground Elev. ________ Hole No. 50S Dia. 8.5" T.D. 127'

Final Hole No ________ 50S-Redrill-84.5'

Water Table At Drilling:

Water: Depth 1st Encountered ________ Dry ☐ Won't ☐ Might ☐ Should ☐ Will

Water-After ϕ ________

Caved-After ϕ ________

Water Table After Drilling

Water At Depth ________

Date ________ By ________

Dry At Depth ________

☐ Couldn't Find ☐ Covered

Plot	Depth	Class	Field Soil Description	Stiff Den	Moist	Color	Calc
	0	TS					
	1	CL	some m gr sand, slow ϕ	S- VS	M	bn, rd bn, gr. bn	
	39	SW	f to m. gr. cly. interbeds, fast ϕ some pyritic sand	sl d- d		bn, [illegible]	[illegible]
	65	CL	silty	VS		bn - grn bn	
	72	SP	f. gr. with clay interbeds, occ 1/4 - 3/8 dia black round gravel	d		bn grn	
	82	CL	silty to v. silty	VS		grn bn	
			T.D. 50S Redrill 84.5 ft.				

Comments:

Depth	Samples – Spoon: Calif.	Std.	Shelby	Auger	Standard Penetration: Field	Final	Laboratory Sample Description	[illegible]

WELL 50S

WELL CONSTRUCTION SUMMARY

LOCATION or COORDS:

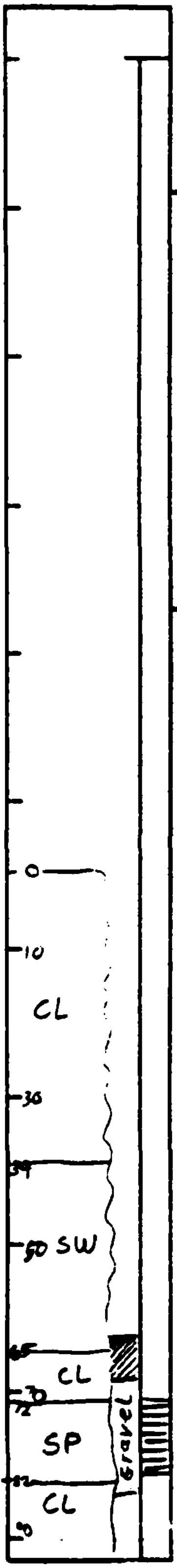
ELEVATION: GROUND LEVEL 82.82

TOP OF CASING

PROJECT McClellan

LOCATION 50S

PERSONNEL FH



DRILLING SUMMARY:

TOTAL DEPTH 84.5'

BOREHOLE DIAMETER 8.5"

DRILLER Water Dev Corp - Scott & Scott

RIG DrilTech D40

BIT(S) Tri Cone

DRILLING FLUID mud

SURFACE CASING

WELL DESIGN:

BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG

CASING STRING(S): C=CASING S=SCREEN

0 - 72 C
72 - 82 S

CASING: C1
C2
C3
C4

SCREEN: S1 Johnson 4" 10slot
S2 stainless
S3
S4

CENTRALIZERS

FILTER MATERIAL Monterey "3"
68 - 84.5' — 4 bags

CEMENT

OTHER bentonite - 2 - 5gal buckets - 62-68'

CONSTRUCTION TIME LOG:

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING:		8-23&	24-82	
GEOPHYS. LOGGING:				
CASING:		8-24		
FILTER PLACEMENT:		8-24		
CEMENTING:				
DEVELOPMENT:		8-24		
OTHER:				

WELL DEVELOPMENT

pumped & surged with clear water 1 Hour

COMMENTS:

APPENDIX F

SAMPLING EVENTS
BASE PRODUCTION WELLS

1-411

SAMPLING EVENTS FOR BASE PRODUCTION WELLS
McClellan AFB, California

Base Supply Well	Date	Sampling Procedure	Sample
1	12/21/81	Pump ran for 10 minutes. Water was initially very silty.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
2	12/21/81	Pump ran for 10 minutes. Water was initially silty.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
8	12/21/81	Water ran for 10 minutes. Well on-line.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
11	12/21/81	Pump ran for 10 minutes.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
12	12/21/81	Pump ran for 10 minutes. Water was very silty.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)

1-412

SAMPLING EVENTS FOR BASE PRODUCTION WELLS
(Continued)

Base Supply Well	Date	Sampling Procedure	Sample
13	12/21/81	Water ran for 10 minutes. Well on-line.	2 VOA bottles
	1/11/82	Water ran for 10 minutes. Well on-line.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
17	12/21/81	Water ran for 10 minutes. Well on-line.	2 VOA bottles
	1/11/82	Water ran for 10 minutes. Well on-line.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
18	12/21/81	Pump ran for 10 minutes.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
28	12/21/81	Pump ran for 10 minutes.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)
29	12/21/81	Water ran for 10 minutes. Well on-line	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals)

APPENDIX G

SAMPLING EVENTS
BASE MONITORING WELLS

SAMPLING EVENTS
FOR BASE MONITORING WELLS
McCLELLAN AFB, CALIFORNIA

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
3	12/21/81	(Closed well cap with pump installed in well)	Generator was connected to in-place pump; water flowed immediately at high rate. Two samples were taken after 10 minutes.	2 VOA bottles
4	12/21/81	-----	Generator was connected to submerged, in-place pumps with extension cord. After 10 minutes of pumping, no water appeared. Well was probably dry, possibly due to new base supply well (BW29) adjacent to MW4.	None
	1/11/82	101	In-place pump had been removed. One sample was taken with bailer after 1-1/2 gallons of well water were removed.	1 VOA bottle
	3/31/82	100	Bailed 1-1/2 gallons of well water and used bailer for sampling.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
6	12/22/81	90	The pump was too big for the well casing. The 250-ml bailer was used to bail ten times its volume of water before sampling.	1 VOA bottle 1 rinsewater sample
	3/31/82	85	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle

SAMPLING EVENTS FOR BASE MONITORING WELLS
(Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
7	12/22/81	95	The 250-ml bailer was used to bail ten times its volume of water before sampling.	1 VOA bottle 1 rinsewater sample
	3/29/82	98.5	Pumped for 40 minutes. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
8	12/22/81	100	Bailed 2 gallons of well water. Bailer defective. Almost no water in well.	None
	3/31/82	99	Bailed 1-1/2 gallons of well water prior to sampling with bailer. Very little water in well (approximately 2 feet).	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals)
9	12/22/81	95	Bailed 1-1/2 gallons prior to sampling. Sampled with the bailer.	1 VOA bottle
	3/31/82	7.7	The well cap was missing. Rainwater had entered the well. Well sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
	4/28/82	93.3	Pump ran for 20 minutes. Samples were taken from Teflon tubing.	1 gallon bottle (GC/MS) 1 gallon bottle (pest/herb/metals) 1 VOA bottle

SAMPLING EVENTS FOR BASE MONITORING WELLS
(Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
10	12/22/81	79	Bailed 1 gallon of well water. Sample taken with bailer.	1 VOA bottle 1 rinsewater sample
	1/11/82	79	MW10 was resampled for TCE.	1 VOA bottle
	3/30/82	78.5	Bailed 1-1/2 gallons of well water prior to sampling. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
11	12/22/81	81	Bailed 1 gallon of well water. Sampled with bailer.	1 VOA bottle 1 rinsewater sample
	3/30/82	76.2	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
	8/18/82	78	Pump ran continuously for 27 minutes at >2.5 gpm. Sampled with pump. Three casing volumes were removed prior to sampling.	1 gallon bottle (GC/MS) 2 VOA bottles

SAMPLING EVENTS FOR BASE MONITORING WELLS
(Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
12	12/22/82	82	The 250-ml bailer was used to bail ten times its volume of water.	1 VOA bottle 1 rinsewater sample
	4/29/82	82	Pump ran for 30 minutes. Samples were taken from Teflon tubing.	1 gallon bottle (GC/MS) 1 gallon bottle (pest/herb/metals) 1 VOA bottle
	8/18/82	84.1	Continuous pumping for 20 minutes at >2.2 gpm. Sampled with pump. Three casing volumes were removed before sampling.	1 gallon bottle (GC/MS) 2 VOA bottles
13	12/22/81	92	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 VOA bottle 1 rinsewater sample
	3/30/82	81	Bailed 1 gallon of well water. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
	8/18/82	82.6	Continuous pumping for 20 minute sat >2.2 gpm. Sampled with pump. Three casing volumes were removed before sampling.	1 gallon bottle (GC/MS) 2 VOA bottles

SAMPLING EVENTS FOR BASE MONITORING WELLS
(Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
14	12/22/81	85	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 VOA bottle 1 rinsewater sample
	3/30/82	81.5	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
	8/18/82	82.6	Well was pumped continuously for 20 minutes at >2.2 gpm. Sampled with pump. Three casing volumes were removed prior to sampling.	1 gallon bottle (GC/MS) 2 VOA bottles 1 quart polyethylene bottle (cyanide)
15	12/22/81	82.5	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 VOA bottle 1 rinsewater sample
	4/29/82	Excessive silt	Very little water in the well. Samples taken with plastic bailer.	1 gallon bottle (GC/MS) 1 gallon bottle (pest/herb/metals) 1 VOA bottle
	8/18/82	81	Well pumped dry after 10 minutes of pumping at 2.5 gpm. One casing volume was removed before sampling. Samples were collected using double sampler technique. Water level was 99 feet prior to sampling.	1 gallon bottle (GC/MS) 2 VOA bottles

AD-A137364

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE LOGISTICS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433

REPLY TO ATTN OF: SGPB

26 October 1983

SUBJECT: Final Report, Phase II Installation Restoration Program, McClellan AFB, CA

TO: See Distribution List

The attached errata sheets for the subject report are forwarded for your information and action. Please forward copies of the errata sheets to all recipients of the subject report.

FOR THE COMMANDER

Harry C Russell
HARRY C. RUSSELL, Colonel, USAF, BSC
Command Bioenvironmental Engineer
Office of the Surgeon

1 Atch
Errata Sheets

AFLC - Lifeline of the Aerospace Team

McClellan AFB Installation
Restoration Program Phase II Final Report

Errata

Page	Paragraph/Line	Change
E-6	First full/7	Change sentence to read, "Chemical constituents have been detected in downgradient areas off the base."
2-4	Fig. 2.2/Reference	Reference should read "DWR, 1974".
2-26	Fig. 2.8	Base well 29 was mistakenly left out of Figure 2.8. The location of the well can be found on Figure E.2, page E-8.
4-43	Second full/7	Add sentence to end of paragraph, "Monitoring well 27S contained 15 ppb of TCE and 120 ppb of pentachlorophenol."
4-43	Last/10-12	Delete entire sentence.
4-45	3/1-5	Delete entire paragraph as written. Change to read, "Monitoring well 37S was installed to determine if contamination was migrating from site 33. However, the groundwater gradient in the area of MW 37S is flat (see Figure 4.7, page 4-60), and MW 37S cannot be assumed to be downgradient of site 33."
4-49	Last/5-7	Delete sentence, "The analytical results... below established standards."
4-58	1/11-14	Change sentence to read, "The recharge area for the shallow water-bearing sands appears to be from two to ten miles upslope (east) of the base."
4-59	1/9	Change to read "...would be less than one foot per year...."
4-71	Top/1	Change to read "...trough exists north of the City of Sacramento...."

5-1	Last/3	Change to read "...disposal at Class I or Class II-1 site will be necessary."
5-7	Last/3	Change to read "...treatment will be necessary."
5-30	2/4-5	Change to read "The aquifer is flowing at a gradient approximating 0.07 percent."