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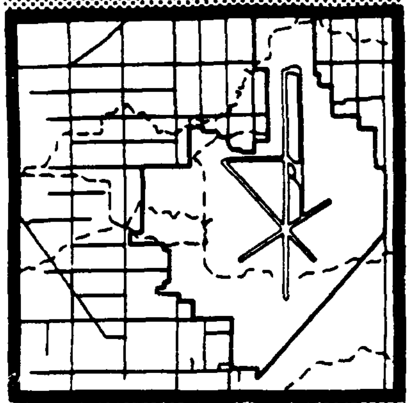
INSTALLATION RESTORATION PROGRAM
STAGE 3
McCLELLAN AIR FORCE BASE



PREPARED BY:
Radian Corporation
10395 Old Placerville Road
Sacramento, California 95827

FEBRUARY 1990

PRELIMINARY GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION (HYDROGEOLOGIC ASSESSMENT) SAMPLING & ANALYSIS PLAN

FINAL

PREPARED FOR:
HEADQUARTERS AFLC/DEV
WRIGHT-PATTERSON AFB, OHIO 45433

United States Air Force
Human Systems Division (AFSC)
Installation Restoration Program Office (HSD/YAQI)
Brooks Air Force Base, Texas 78235-5501

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Sacramento, CA 95827
(916)362-5332

INSTALLATION RESTORATION PROGRAM

STAGE 3

PRELIMINARY GROUNDWATER OPERABLE UNIT
REMEDIAL INVESTIGATION (HYDROGEOLOGIC ASSESSMENT)

SAMPLING AND ANALYSIS PLAN

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AF CONTRACT NO.: F33615-87-D-4023, DELIVERY ORDER NO. 0006
CONTRACTOR CONTRACT NO. 227-005, DELIVERY ORDER NO. 0006

HSD/YAQI
Mr. Gary Woodrum
TECHNICAL PROGRAM MANAGER (TPM)

HUMAN SYSTEMS DIVISION (AFSC)
IRP PROGRAM FOFICE (HSD/YAQI)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

STAGE 3 SHOULD BE CORRECT STAGE ON COVER
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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SACRAMENTO AIR LOGISTICS CENTER (AFLC)
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Preliminary Groundwater Operable Unit Remedial Investigation Sampling and Analysis Plan - Final Copy

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2. This document has been prepared for the United States Air Force for the purpose of aiding in the implementation of a final remedial action plan; and the ongoing nature of the Remedial Investigation/Feasibility Study, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this document, since subsequent facts may become known which may make this document premature or inaccurate. Acceptance of this document in performance of the contract under which it was prepared does not mean that the U.S. Air Force or the Department of Defense adopts the conclusions, recommendations, or other views expressed herein which are those of the contractor only and do not necessarily reflect the official position of either department. The attached Radian document has been reviewed as a matter involved in litigation and has been approved for release to the general public.

3. If you have any questions, contact Mr Bud Hoda, SM-ALC/EMR (916)643-1250.

MARIO E. IERARDI
Chief, Environmental Restoration Division
Directorate of Environmental Management

cc: SM-ALC/JA
SM-ALC/PA

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This report has been prepared for the United States Air Force by Radian Corporation for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). As the report relates to actual or possible releases of potentially hazardous substances, its releases prior to an Air Force final decision on remedial action is in the public interest. The limited objectives of this report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it was prepared does not mean that the U.S. Air Force or the Department of Defense adopts the conclusions, recommendations, or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

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PREFACE

Radian Corporation is the contractor for the RI/FS program at McClellan AFB, California. This work was performed for the Installation Restoration Program Office (HSD/YAQI) under AF Contract No. F33615-87-D-4023, Delivery Order 0006.

This report presents the sampling and analysis plan for a hydrogeologic assessment to be conducted at McClellan AFB. The sampling and analysis plan presents the rationale and methodology for gathering stratigraphic, hydrologic, and groundwater quality data at the base where such data are incomplete or unavailable.

Key Radian project personnel were:

Nelson Lund, P.E.--Contract Program Manager
Jack D. Gouge'--Delivery Order Manager
William Knight--Project Manager

Radian would like to acknowledge the cooperation of the McClellan AFB Office of Environmental Management. In particular, Radian acknowledges the assistance of Mr. Mario Ierardi, Mr. Bud Hoda and Mr. Gerry Robbins.

The work presented herein was accomplished between January 1988 and January 1990. Mr. Gary Woodrum, Installation Restoration Program Office (HSD/YAQI), was the Contracting Officer's Technical Representative.

Approved: ______ For
Nelson H. Lund, P.E.
Contract Program Manager

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The document presents the Sampling and Analysis Plan for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) to be conducted at McClellan AFB, California. The objectives of the Hydrogeologic Assessment are characterization of hydrogeologic conditions and further definition of the extent of groundwater contamination beneath McClellan AFB. The primary uses of the data from the assessment will be to determine which areas may require groundwater operable unit remedial investigations and to evaluate groundwater remedial alternatives in future work. The hydrogeologic investigation is intended to: identify geologic and hydrologic characteristics of hydrogeologic units; determine continuity of waterbearing zones and aquitards; more clearly define horizontal and vertical groundwater flow directions and gradients; and increase the number of sampling points for groundwater quality determination. Data obtained from the assessment will provide a framework within which potential groundwater operable units may be determined and more effectively evaluated in the future. The scope of work for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) includes: lithologic and geophysical logging of 19 pilot holes to depths of 360 feet; construction of as many as 51 monitoring wells in 19 well cluster locations; installation of 34 piezometric wells; sampling and analyses of all new monitoring wells; performance of 2 multiple-well and 40 single-well aquifer tests; and evaluation of the effects on local groundwater flow due to on-base water supply wells.

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1.0 INTRODUCTION

This document is a Sampling and Analysis Plan for a Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) to be conducted at McClellan Air Force Base (AFB), California. The scope of work, methods, and rationale for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) are presented. The Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) will be conducted as part of the Remedial Investigation/ Feasibility Study (RI/FS) currently underway at McClellan AFB and will provide the framework for future investigations and remediations of groundwater contamination at the base.

The objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) are characterization of hydrogeologic conditions and further definition of the extent of groundwater contamination beneath McClellan AFB. The primary uses of data from the hydrogeologic assessment will be to determine which areas may require groundwater operable unit remedial investigations and to evaluate groundwater remediation alternatives in future work. Of particular interest are those areas where little or no subsurface investigation has been completed to date or where the level of effort of past investigations is inadequate relative to what is known about past storage and disposal practices. The hydrogeologic investigation is intended to: identify geologic and hydrologic characteristics of hydrogeologic units; determine continuity of waterbearing zones and aquitards; more clearly define horizontal and vertical groundwater flow directions and gradients; and increase the number of sampling points for groundwater quality analyses. Attainment of the objectives will provide a hydrogeologic framework within which the hydrogeologic and water quality conditions of groundwater operable unit areas can be more effectively evaluated in the future and measures for groundwater remediation may be assessed from the larger perspective.

In the course of discussions and planning of hydrogeologic assessment for McClellan AFB between the United States Air Force and regulatory agencies, the objectives of the investigation have evolved, such that the targeting of areas as groundwater operable units has gained significant importance. In keeping with the adjustment in objectives, a preliminary division of McClellan AFB into geographic operable units has been proposed. Figure 1-1 illustrates the tentative operable unit areas which will be considered and further defined by the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). The geographic areas were selected and named using the following criteria:

- Geographic grouping of past waste disposal sites/locations and potential groundwater plume locations;

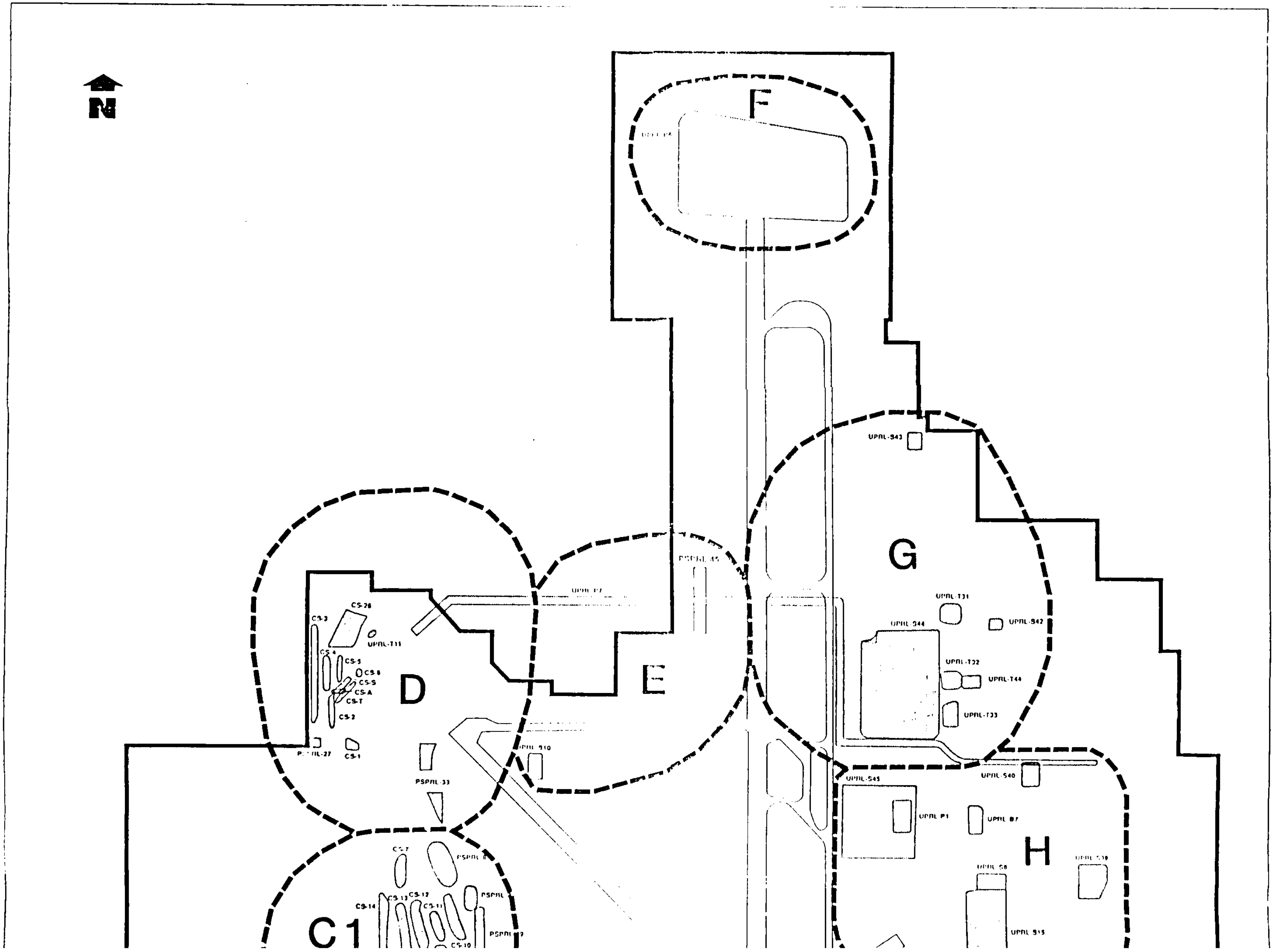
- Areas of the base where groundwater flow may have been significantly different from adjacent areas due to the present or historical impact of operation of on- and off-base supply wells;

- The size of the area in which there is an expectation for successful remediation of the groundwater pathway; and

- Maintaining, with some modifications, the historical nomenclature of known geographic areas of handling, use, treatment, and disposal of wastes.

Base Area A was divided into three sections. Section A1 has a potential for off-base migration to the southeast greater than A2. Section A3 was separated due to the impacts of Base Wells 13 and 18 and for possible combination with Area B. Size of the areas for successful remediation was also a consideration.

Base Area B was split because of the potential for combination of B2 with A3 and the higher likelihood of off-base migration from B1. Size for successful remediation was also a consideration.



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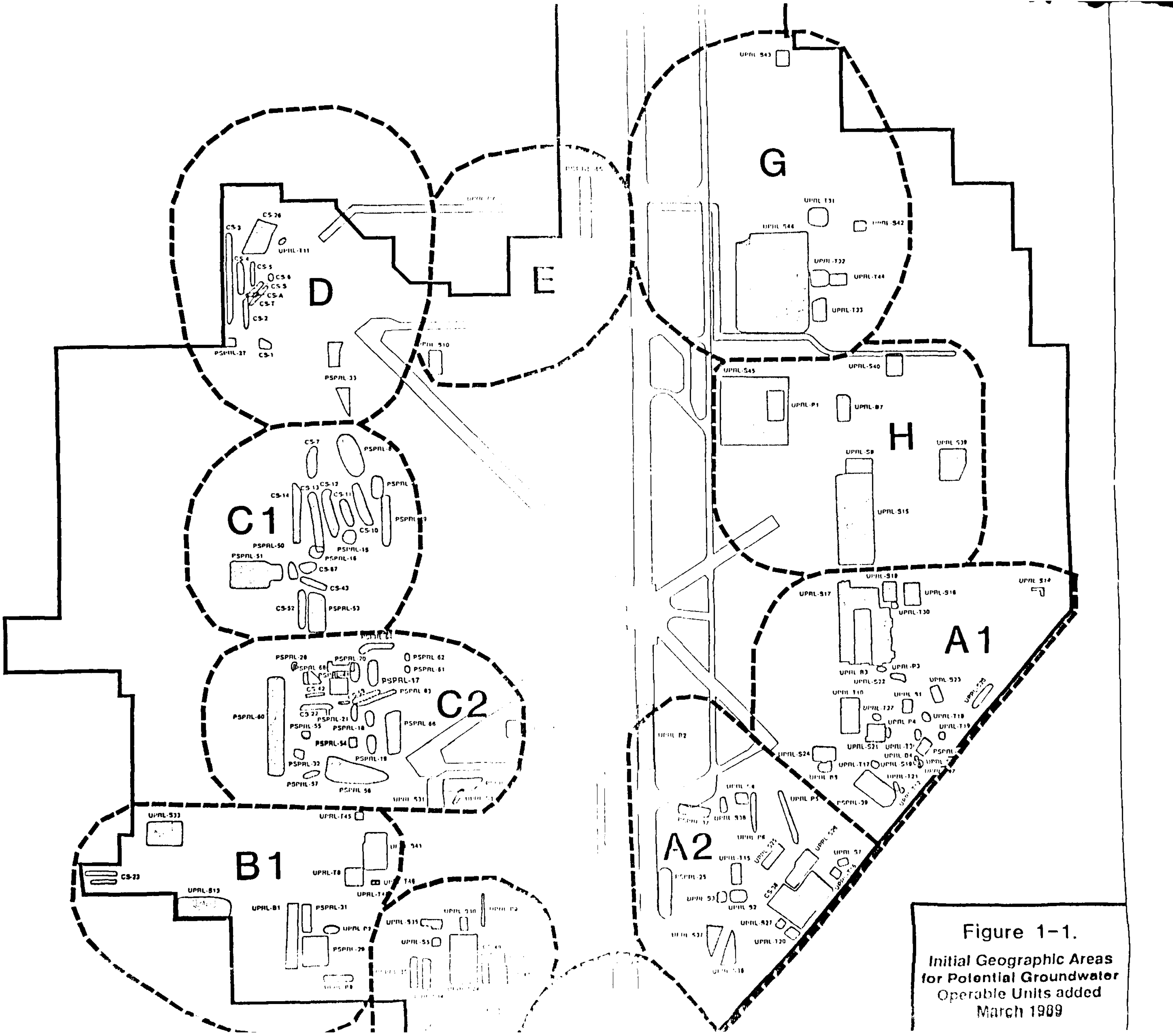

Figure 1–1.
Initial Geographic Areas for Potential Groundwater
Operable Units added
March 1989

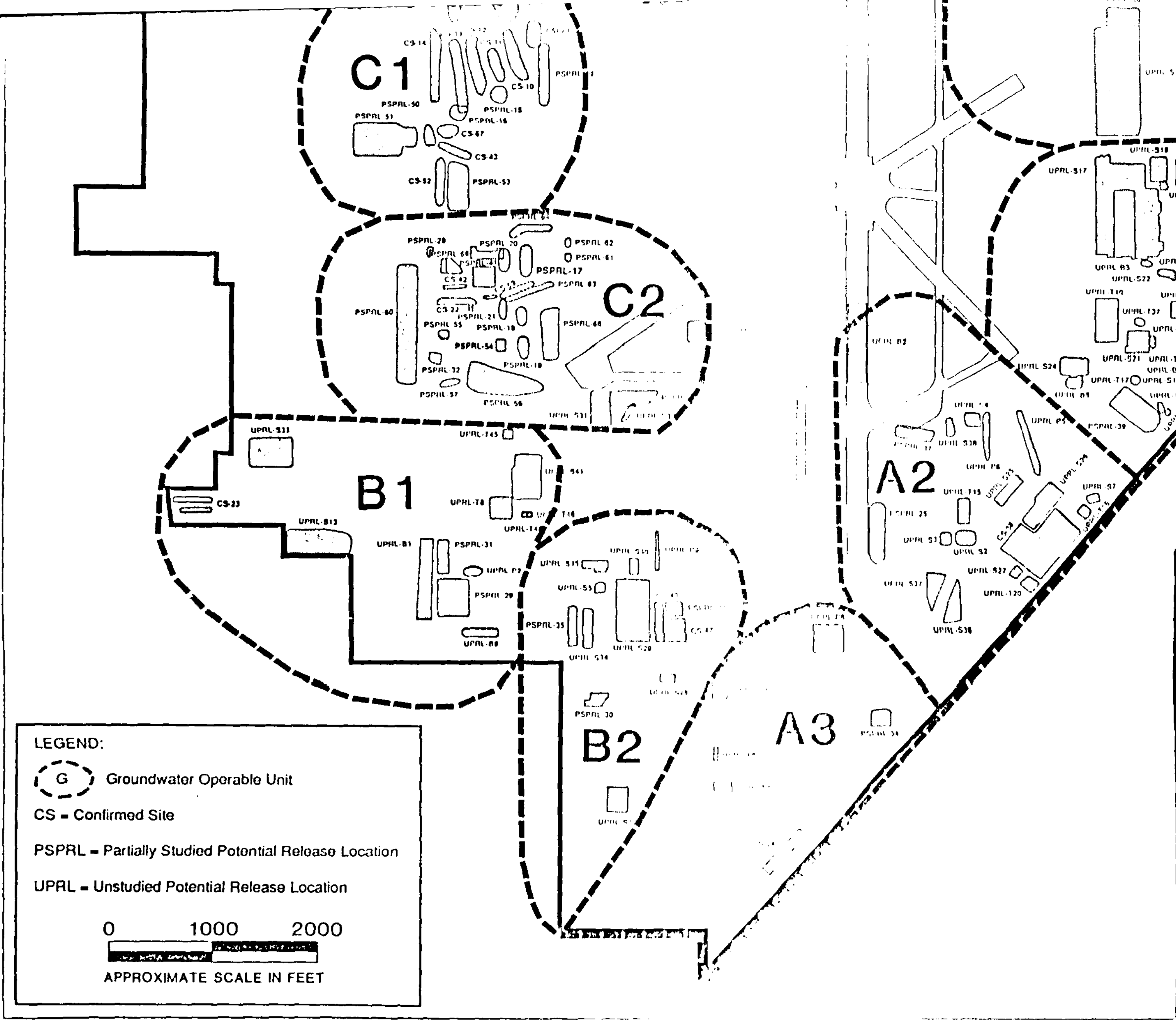

Figure 1-1.

Initial Geographic Areas for Potential Groundwater Operable Units added March 1989

Approximate Boundaries of Confirmed Sites and Potential Release Locations

DECEMBER 1988

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Area C was split into two sections because the locations naturally fall into two clusters and the possibility of separate areas of contamination exist. The Area D cap and extraction system is already under consideration by the agencies as an operable unit.

Based on the minimal groundwater flow direction data currently available in the northeast portion of the base, Areas F, G, and H all have the potential for different groundwater flow directions. At times, groundwater beneath Area G has shown some potential for seasonal off-base flow. In Area H and Area F, groundwater flow directions cannot be determined. Area E includes the few remaining sites/locations not easily connected to the others.

The following subsections present a summary of the AF's Installation Restoration Program (IRP) and its relation to the RI/FS process. The objectives of the RI/FS at McClellan AFB are also described. Section 2.0 summarizes historical storage and disposal operations at McClellan AFB and environmental investigations completed in the past to determine the magnitude and extent of subsurface contamination. Section 3.0 describes the environmental setting of McClellan AFB, including a summary of hydrogeologic conditions as they are currently understood. Section 4.0 presents the basis for implementation of RI/FS studies at the base. Section 4.6 addresses specifically the data requirements that dictate the scope of work for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). Section 5.0 describes the scope of work, and investigation and data evaluation methods, for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). Sections 6.0 and 7.0 present the technical report outline and schedule for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). Cited and uncited references that are applicable to the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) are presented in Section 8.0.

1.1 U.S. Air Force Installation Restoration Program

The U.S. Department of Defense (DOD) is conducting a nationwide program to evaluate waste disposal practices on DOD property. The purpose of the program is to control the migration of hazardous contaminants and to control hazards that may result from these waste disposal practices. The program is identified as the Installation Restoration Program (IRP) and consists of four phases: Phase I, Problem Identification/Records Search; Phase II, Problem Confirmation and Quantification; Phase III, Technology Base Development; and Phase IV, Remedial Actions in support of the program. The United States Air Force (AF) has initiated an IRP investigation at McClellan Air Force Base (AFB) near Sacramento, California. Phase I and Phase II Stages 2-1 through 2-5 have been completed. This document describes the elements of a Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) that will be completed by Radian Corporation as part of the RI/FS (equivalent to the IRP Phase II/IVA) at McClellan AFB. This Sampling and Analysis Plan has been completed under AF Contract No. F33615-87-D-4023, Delivery Order 06.

1.1.1 Program Origins

In 1976, the DOD developed the comprehensive IRP in response to the Resource Conservation and Recovery Act (RCRA) of 1976, and in anticipation of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (CERCLA is the legislation that authorizes the United States Environmental Protection Agency (U.S. EPA) "Superfund" program). The Department of Defense issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM), dated June 1980 (DEQPPM 80-6), that requires the identification of past hazardous waste disposal sites at DOD agency installations. The Air Force implemented the DEQPPM in December of 1980. The program was revised by DEQPPM 81-5, dated December 1981, which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 in January 1982.

Since the initiation of the IRP, experience has been gained in all phases of the program, and the approaches used in the IRP have evolved accordingly. Based on experience at Air Force bases nationwide, the Air Force has adopted an approach that streamlines and integrates the elements of the program.

1.1.2 Program Objectives

The long-range objectives of the McClellan AFB IRP are:

- Determination of the nature and extent of contamination and the potential health risks which result from contaminants found at former storage and disposal confirmed sites, potential release locations (PRLs), and in soil and groundwater at the base;
- Evaluation, screening, and selection of remedial measures appropriate for soils and groundwater;
- Submittal of selected remedial measures for public and regulatory agency comments;
- Acquisition of a Record of Decision followed by remedial design and implementation; and
- Attainment of post closure stature for past storage and disposal confirmed sites and PRLs at McClellan AFB.

Remedial measures selected will be consistent with the National Oil and Hazardous Substances Contingency Plan, also referred to as the National Contingency Plan (NCP) (40 CFR 300, November 20, 1985) for those sites that pose a threat to human health or welfare or the environment.

1.1.3 Program Organization

This subsection describes the organization of the current IRP. It is the intent of the Air Force that the IRP be equivalent to the NCP process in accordance with CERCLA procedures. Therefore, the NCP nomenclature is used throughout. Phases I, II/IVA, III, and IVB are briefly described below and presented in Table 1-1.

Phase I

The Phase I objectives are to identify and assess past disposal sites and PRLs. This assessment considers whether each site poses a hazard to human health or the environment as a result of direct contact, contamination migration, or contaminant persistence.

Phase II/IVA (RI/FS)

The integration of Phases II and IVA corresponds to the Remedial Investigation/Feasibility Study (RI/FS) program described in the NCP and in the Superfund Amendments and Reauthorization Act (SARA) of 1986. Data collection and subsequent site characterization are the main objectives of Phase II, which will be conducted concurrently with Phase IVA. Development, screening, and detailed analysis of remediation alternatives form the main portion of Phase IVA, which leads to selection of the recommended remedial action alternative.

Phase III

In Phase III, the research and technology required for objective assessment of environmental effects or remedial technologies are implemented.

Phase IVB

Phase IVB involves the construction and implementation of the remedial alternatives.

TABLE 1-1. COMPARISON OF REGULATORY WASTE REMEDIATION PROGRAMS

Objective	Agency / Program / Procedures	Department of Defense USAF: Installation Restoration Program[a]	U.S. EPA: Remedial Investigation/ Feasibility Study Process	California Department of Health Services: Decision Tree Process
Determine Nature and Extent of the Problem		Site Characterization Preliminary Assessment Records Search Site Visits Risk Assessment	Remedial Investigation Preliminary Assessment Site Inspections	Discovery Site Characterization
Development and Selection of Remedial Actions		Evaluation of Alternatives	Feasibility Study	Remedial Action Plan
Provide Public Comment Period for Review of Selected Remedial Alternative		Public Comment	Public Comment Public Hearing Public Workshop	Public Comment Public Hearing Public Workshop
Acceptance of Remedial Action		Record of Decision	Record of Decision	Remedial Action Plan
Develop Remedial Design		Remedial Design	Remedial Design	
Develop Remedial Construction		Implementation	Remedial Action	Implementation
Attain Post Closure		Operation and Maintenance	Operation and Maintenance	Implementation
Delist Sites		Delisting	Delisting	Certification

[a] Installation Restoration Program (IRP) terminology has been changed to Remedial Investigation/Feasibility Study (RI/FS) terminology.

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1.1.4 Program Documents

The AF IRP has been designed and is being conducted under guidance from the applicable documents presented in Table 1-2.

1.2 Current Study Objectives

This Sampling and Analysis Plan describes the field investigations, data evaluation, and reporting that are required for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). The objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) are characterization of the hydrogeologic conditions and further definition of the extent of groundwater contamination beneath McClellan AFB. The information will provide a framework for the interpretation of groundwater and contaminant migration on a basewide scale. Within the hydrogeologic framework, potential groundwater operable unit areas and groundwater remediation alternatives will be more readily identified and evaluated. To attain the objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment), the geologic and hydrologic characteristics of the alluvial deposits that have the greatest apparent influence on groundwater and contaminant migration will be identified. More specifically, the following elements will be assembled from the data obtained during the course of the investigation:

- Determination of the continuity of monitoring zones and aquitards that delineate waterbearing zones (for example, 100-, 150-, 200-, and 300-foot zones) in portions of the base where they have not been characterized;

- Better definition of horizontal and vertical hydraulic and gradients groundwater flow directions, including the effects of water supply pumping;

TABLE 1-2. LAWS, REGULATIONS, AND DOCUMENTS APPLICABLE TO THE IRP

Applicable Laws, Regulations, and Documents	Notes
• <u>Public Laws</u>	
PL 96-510	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980
United States Code 42 USC 9601 et seq.	CERCLA/SARA 1986
• <u>Regulations</u>	
Code of Federal Regulations	
40 CFR 136.3e, Table II	Required Containers, Preservation Techniques, and Holding Times
40 CFR 136, Appendix A	Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater
40 CFR 136, Appendix B	Definition and Procedure for the Determination of the Method Detection Limit
40 CFR 136, Appendix C	Inductively Coupled Plasma--Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes Method 200.7
40 CFR 300	National Contingency Plan (NCP)
Federal Register	
Vol. 51, No. 114, 13 June 1986	Toxicity Characteristics Leaching Procedure (TCLP)
• <u>Presidential Documents</u>	
Executive Orders	
EO 12088	Federal Compliance with Pollution Control Standards (13 October 1978)
EO 12580	Superfund Implementation (23 January 1987)

(Continued)

TABLE 1-2. (Continued)

Applicable Laws, Regulations, and Documents	Notes
• Environmental Protection Agency (EPA)	
EPA-330/9-51-002	MEIC Manual for Groundwater/Subsurface Investigations of Hazardous Waste Sites
	Superfund Exposure Assessment Manual (January 1986)
EPA-600/4-79-020	Methods for Chemical Analysis of Water and Wastes (1983)
SW-846	Test Methods for Evaluating Solid Waste, Third Edition (1986)
• American Public Health Association (APHA, AWWA, & WPCF)	
	Standard Methods for the Examination of Water and Wastes (16th Edition)
• American Society for Testing and Materials	
D-1452	Soil Investigation and Sampling by Auger Boring
D-1586	Penetrating Test and Split-Barrel Sampling of Soils
D-2487	Unified Soil Classification System
D-2488	Recommended Practices for Visual-Manual Description of Soils
Annual Book of ASTM Standards	Section 11, Water and Environmental Technology
• Handbooks	
Environmental Protection Agency	
EPA-540/G-85-002	Guidance on Remedial Investigations under CERCLA
EPA-540/G-85-003	Guidance on Feasibility Studies under CERCLA
Analytical Chemistry	
Vol. 55, Pages 2210-2218, 19 December 83	Principles of Environmental Analysis

- Evaluation of hydraulic conductivities and other hydraulic parameters for waterbearing zones and aquitards;

- Analysis of water quality samples from newly installed monitoring wells; and

- Better definition of groundwater operable units and to assist in determination of the need for expedited action, if any.

The information will be useful in developing a three-dimensional characterization of areas of the base where contaminants have been detected and where remedial measures will be considered. This characterization will provide a basis for determining migration behavior of contaminants and for evaluating measures to control migration and remediate contaminated groundwater.

Additional monitoring wells and hydrologic evaluation may be required in specific areas after completion of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). However, the basewide hydrogeologic framework will provide a base for more effective selection of future monitoring or extraction well locations and site-specific hydrogeologic assessments.

2.0 BACKGROUND

Section 2.0 presents a brief description of McClellan Air Force Base (AFB) and summarizes historical waste management practices. A summary of areas affected by soil and groundwater contamination, and investigations completed or ongoing to evaluate the contamination, is also presented.

2.1 Background of Base Activities

McClellan AFB was established in 1936 when Congress authorized the construction of a new air repair depot and supply base for the War Department (predecessor of the Department of Defense). Initially named the Sacramento Air Depot, the base was dedicated in 1939. Later it was renamed McClellan Field in honor of Major Hezekiah McClellan, a pioneer in the charting of Alaskan air routes.

Base operations increased dramatically during World War II. From an operation of a few thousand people, McClellan AFB grew to an industrial facility processing about 7,000 aircraft for action during the war years. In the early 1950s, McClellan AFB changed from a bomber depot to a jet fighter maintenance depot.

2.1.1 Description of Installation

McClellan AFB, an Air Force Logistics Command Center, is located approximately 7 miles northeast of downtown Sacramento, California, as shown on Figure 2-1. The base includes 2,598 acres within irregularly configured boundaries. The base property is bounded approximately by Elkhorn Boulevard to the north, Interstate 80 to the south, Watt Avenue to the east, and Raley Boulevard to the west. McClellan AFB currently employs approximately 22,000 personnel, including 7,000 military personnel and approximately 15,000 civilian employees.

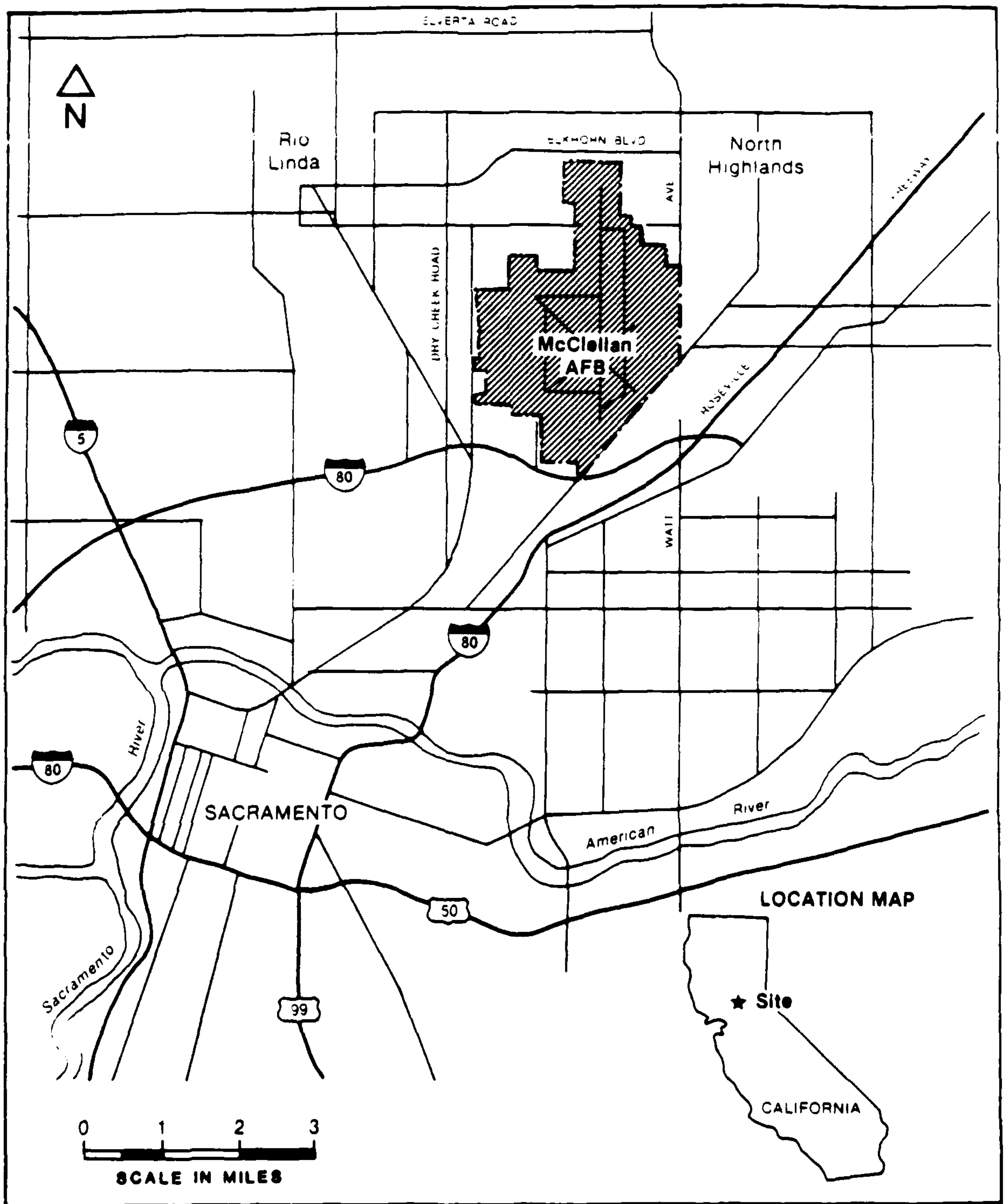

Figure 2-1. Location of McClellan Air Force Base, California.

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2.1.2 Past Waste Management Practices

The United States Air Force (AF), in fulfilling 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 the use of toxic and hazardous materials. Some hazardous materials that have been used at McClellan AFB include: industrial solvents and caustic cleaners, electroplating waste contaminated with heavy metals, oils contaminated with polychlorinated biphenyls (PCBs), contaminated jet fuels, low-level radioactive wastes, chemicals, and a variety of oils and lubricants.

Historically, most of these hazardous materials were buried as waste in pits along the western edge of the facility. That practice was phased out in the late 1970s. Today, these wastes are either placed in drums and transported to an approved Class I disposal site or discharged into the Industrial Wastewater Treatment Plant (IWTP). Sludge from the IWTP also is transported to an approved Class I disposal site.

In the past, McClellan AFB has used a variety of on-base disposal facilities, ranging from burial pits (used for disposal of refuse, demolition material, excess military equipment, chemicals, etc.), sludge/oil pits, and burn pits (used for disposal of refuse, oil, chemicals, etc.), to assorted miscellaneous disposal pits (used for disposal of sodium valves, etc.). Industrial waste sludge also was disposed of on base at the Class II-I site approved by the California Regional Water Quality Control Board. These practices have since been eliminated. The industrial waste sludge is now known to contain high concentrations of organic compounds including tetrachloroethene (PCE), trichloroethene (TCE), chloroform, and 1,1,2-trichloroethane, and 2,2,1-trifluoroethane. These organic compounds may have been disposed of in the sludge/oil pits.

2.1.3 Previous Investigations, Regulatory History, and Response Actions

The discovery of soil and groundwater contamination at McClellan AFB, and the subsequent implementation of the IRP, is summarized below.

2.1.3.1 Problem Discovery

Acknowledging that TCE had been used extensively at McClellan AFB prior to 1978, the McClellan AFB Environmental Protection Committee in August 1979 voluntarily created a special groundwater contamination committee to determine if groundwater quality problems existed in the McClellan AFB community. The committee's initial action was to analyze water from several water supply wells located near each corner of the base. In early November 1979, the base initiated a meeting with the California Central Valley Regional Water Quality Control Board, the City and County of Sacramento, and the California Department of Health Services to discuss initial findings. Representatives at this meeting agreed to analyze groundwater samples on and around the base to determine the magnitude of the problem. Monitoring of on- and off-base water supply wells throughout November 1979 resulted in the closure of three off-base wells and two on-base wells. Two of the off-base wells belonged to private homeowners; the third belonged to the City of Sacramento. Since that time, three additional base water supply wells have been taken off-line. To respond to the situation, McClellan AFB developed a five-part investigatory program that included: 1) protection of drinking water; 2) evaluation of past disposal practices; 3) initial identification of affected areas; 4) initial study of local geology and groundwater; and 5) initial source investigation, using monitoring wells and soil borings. Under this program, 15 monitoring wells were installed and sampled.

For purposes of discussion, the study area on and surrounding McClellan AFB was divided into 10 geographic on- and off-base areas as shown in Figure 2-2. The five geographic on-base areas are as follows:

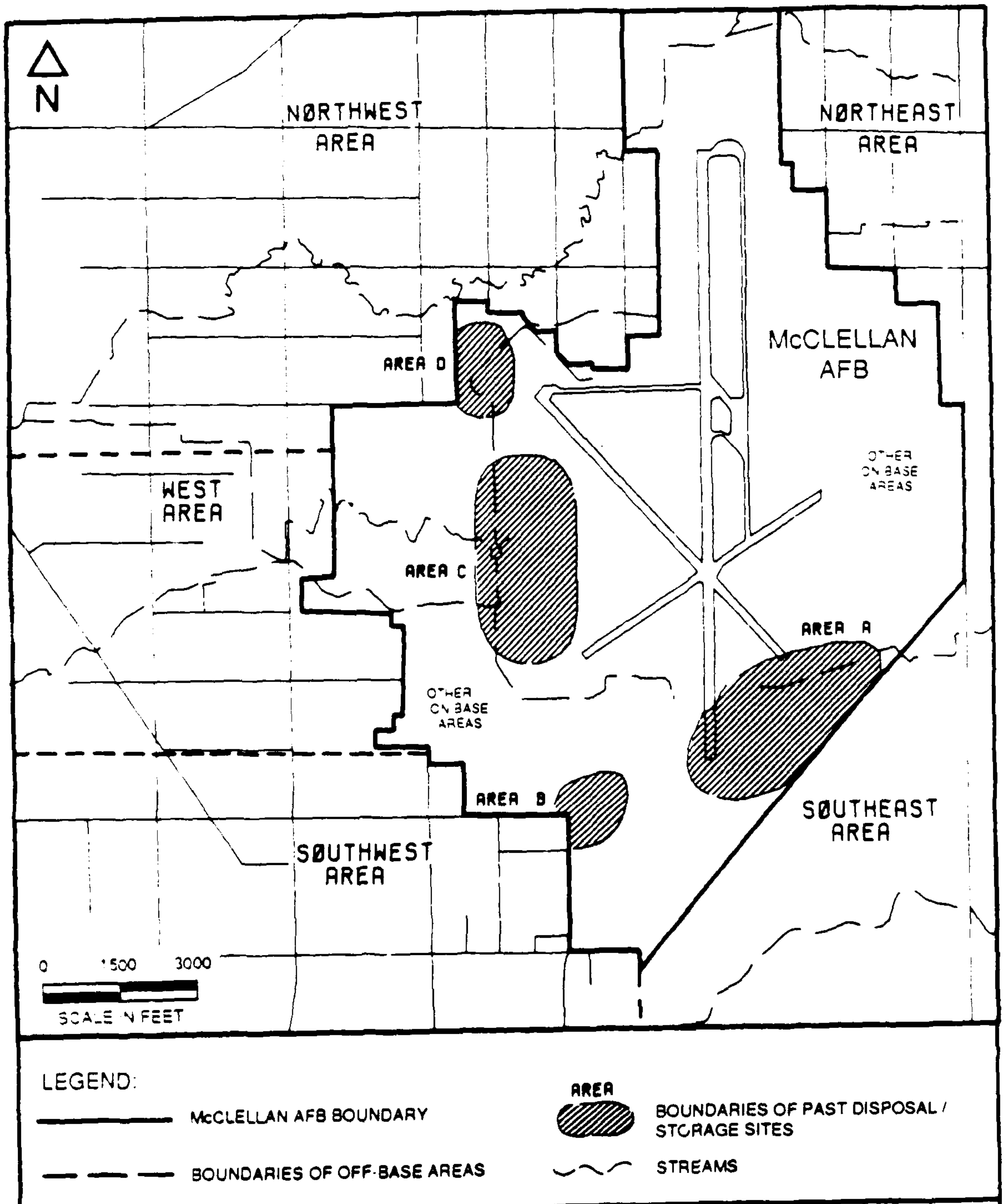

Figure 2-2. Location of On-Base Areas.

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- Area A and Adjacent On-Base Areas;
- Area B and Adjacent On-Base Areas;
- Area C and Adjacent On-Base Areas;
- Area D and Adjacent On-Base Areas; and
- Other On-Base Areas.

The five geographic off-base areas are as follows:

- Northeast Area;
- Northwest Area;
- West Area;
- Southwest Area; and
- Southeast Area.

Based on the results of the initial study, the Air Force determined that at least four areas of groundwater contamination required more detailed investigation. These four areas are Areas A, B, C, and D as shown on Figure 2-2. A brief description of these four areas follows.

<u>Area A</u>

Area A is located in the southeast portion of the base. Base water supply wells BW-1, BW-2, BW-8, and BW-12 are located within this area and were closed due to TCE contamination. Area A consists of 1 confirmed site and 51 potential release locations (PRLs) which, due to prior activities on base, were suspected to have contributed hazardous substances to the underlying soils and groundwater. Materials disposed included refuse and refuse ash, ethylene dichloride, cresylic acid, skimming pond sludges, and industrial wastewater sludge. Groundwater samples from monitoring wells in the vicinity of Area A have contained a variety of volatile organic compounds (VOCs), including: TCE, 1,1-dichloroethene (1,1-DCE), 1,2-dichlorethane (1,2-DCA), acetone, toluene, carbon tetrachloride, 1,1,1-trichloroethane (1,1,1-TCA), chloroform, dichloromethane, benzene, ethylbenzene, and chlorofluorocarbon. Analyses of soil samples have detected acetone, benzene, chloroform, ethylbenzene, TCA, total xylenes, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate.

Area B

Area B is in the southwest portion of the base. Low levels of TCE have been found in base well BW-18 which is located within Area D. A private well and a City of Sacramento well, CW-150, both located to the southwest of Area B, were closed due to TCE contamination. Area B has historically been an area of varied uses: storage buildings, a chemical laboratory, a woodshop and instrument repair facility, a paint facility, and a plating shop have been located within Area B. There are 2 confirmed sites and 22 PRLs in Area B. Materials handled at various locations within the area include TCE, chlorofluorocarbon, diethyl ether, low level radioactive wastewater, and waste chemicals generated during plating activities. The analytes detected in groundwater beneath Area B are 1,1-DCE, TCE, 1,2-dichloroethane (1,2-DCA), methyl ethyl ketone (MEK), carbon disulfide, dichlorobenzene, chloroform, and methylene chloride. Heavy metals that have been detected are barium, chromium, and lead.

Area C

Area C, in the western-central portion of the base, includes numerous past disposal sites. Solid waste, industrial waste sludges, waste solvents, oil, and chemicals were disposed of at these sites in the past. There are 12 confirmed sites and 31 PRLs in Area C.

Area D

Area D is in the northwest portion of the base. It includes the past sludge/oil disposal pit sites. Area D also is near the off-base area where a private well was closed due to TCE contamination. Analyses of groundwater samples from monitoring wells located in Area D indicate that compounds present in groundwater are similar to those present in the nearby sludge pits. The sludge pits are likely sources of the groundwater contamination in the area. There are 10 confirmed sites and 3 PRLs in Area D.

Other Areas

A number of storage and disposal sites have been identified in other areas throughout the base consisting of 2 confirmed sites and 16 PRLs. The majority of these sites have not been investigated to date. Potential and known wastes disposed at these sites are generally similar to wastes disposed in the other designated areas.

2.1.3.2 The IRP Program

In 1981, the Department of Defense (DOD) developed the Installation Restoration Program (IRP) to identify and evaluate suspected contamination problems resulting from past hazardous waste disposal practices. The IRP was developed as a four-phase program. Phase I consists of installation assessment (record searches) to identify the potential problem areas, base history, and environmental setting. Phase II/IVA corresponds to the Remedial Investigation/Feasibility Study (RI/FS) processes described in the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300, November 1985). Phase III identifies and develops remedial action technologies. Phase IVB includes the implementation of a recommended remedial action (operations). Major activities which have been performed at McClellan AFB as part of the IRP are described below.

In July 1981, CH2M Hill completed a Phase I records search to identify and prioritize past activities at McClellan AFB. The results of that study are contained in the report entitled, "Installation Restoration Program Records Search for McClellan Air Force Base, California" (CH2M Hill, 1981). The report also included information generated by the Air Force in a study entitled, "Investigating Groundwater Contamination as of 30 April 1981" (Brunner and Zipfel, 1981). The CH2M Hill Phase I report identified 46 potential hazardous waste storage and disposal sites and ranked them in order of priority.

The CH2M Hill Phase I report identified two main areas of concern: organic solvents found in the groundwater underlying the base, and PCBs contained in the soil in a small area at the northwest corner of the runway clear zone. The occurrence of PCBs was determined to be a result of previous landowner activity. The AF removed the soils containing PCBs and disposed of them at an approved site off base. The Phase I report recommended implementing an expanded monitoring program to determine the geographic extent of organic compounds in the groundwater. Later, CH2M Hill conducted a Phase II investigation of Area D.

In June 1983, Engineering-Science completed a Phase II study of the base. This study consisted of a groundwater monitoring well installation and sampling program to quantify the magnitude and extent of contamination on base. The results of the Phase II study are reported in "Final Report, Installation Restoration Program, Phase II - Confirmation, McClellan Air Force Base, California" (Engineering-Science, 1983). As part of the Phase II study, groundwater samples were collected from base water supply wells, existing monitoring wells, and monitoring wells installed during the field program. Specific compounds were targeted based on materials used and disposed of on base. Samples were analyzed for U.S. EPA priority pollutants, including: volatile organic compounds (VOCs), acid and base/neutral extractable organic compounds, pesticides, herbicides, PCBs, metals, and cyanide. Selected samples also were analyzed for cresylic acid and aliphatic material (oil and grease).

The results of the Phase II study indicated organic compounds and trace metals were present in shallow wells throughout the base. The study concluded that the shallow waterbearing zone (first waterbearing zone in the aquifer) was contaminated, particularly along the western border of the base. No apparent sources could be identified for the contaminants measured in some wells, suggesting that delineation of contaminant plumes from individual sites may be difficult. The levels of most contaminants in samples from the deeper waterbearing units were near or below the analytical limits of detection. Pesticides and herbicides were detected at very low concentrations.

Early in 1984, McClellan AFB contracted McLaren Environmental Engineering (McLaren) to conduct site characterization investigations at 56 sites within Areas A, B, C, and Other Areas on base. These investigations included waste, soil, and groundwater testing at 44 of the 46 sites identified in CH2M Hill's 1981 Phase I report. More than 700 soil borings were drilled; soil samples collected from the borings were analyzed. In addition, a total of 86 potential sites that had not yet been investigated were identified during these investigations.

Following federal and state agency review of the Engineering-Science Phase II report, the AF initiated the Phase III/IV study for Area D. That study, completed in February 1985, gathered additional data to define and quantify site characteristics, evaluate remedial response alternatives, and provide conceptual design for the selected remedial responses. In 1985 and 1986, McLaren conducted Phase III/IV studies in the areas of concern that were identified during the on-base Phase I and II studies. Results of the Phase III/IV studies, including the results of geologic, groundwater, and soil investigations by area, were documented in a series of reports and technical memoranda.

A series of six feasibility studies was conducted in 1985 and 1986 to evaluate source area control measures at specific locations of concern on base. McLaren and CH2M Hill participated in these studies. McLaren prepared a final Basewide Source Control Remedial Action Plan (RAP) in December 1986.

In a separate undertaking in May 1984, Radian Corporation prepared a presurvey report for conducting Phase II activities in the off-base areas around McClellan AFB and in certain on-base areas. The resulting staged investigations were conducted from 1984 through 1986. They included a wide range of activities related to the collection, management, and evaluation of hydrogeologic and analytic data.

In 1984, Radian Corporation began the Phase II Stage 2 study with a program of reconnaissance borings and an inventory of private wells in the area surrounding the base. In 1985, the installation and sampling of 47 on- and off-base monitoring wells, along with further characterization of the lateral and vertical extent of groundwater contamination, were completed.

Additional activities included an aquifer test in the southwest portion of the base, development of a sub-regional groundwater flow model, establishment of a computerized database, redevelopment of existing monitoring wells on base, and design of a permanent groundwater monitoring network. Nine soil vapor wells also were installed in the vicinity of Area D to detect vapors within the vadose (unsaturated) zone. Dedicated sampling systems (pumps) were installed in 99 on- and off-base monitoring wells included in the groundwater monitoring network.

The reconnaissance boring program started in 1984 was conducted to locate areas of groundwater contamination and to provide geological information. Data from the reconnaissance borings and results of groundwater sampling from private wells and existing monitoring wells guided placement of new monitoring wells on and off base. These wells were installed to determine the nature and the vertical and horizontal extent of contamination in the groundwater. Analysis of groundwater samples indicated the presence of contamination in several areas near the base boundary. One area was located north and northwest of Area D. A second area of groundwater contamination was located south of Area B, and a third was located in the vicinity of Santa Ana Street, west of Area C. In addition to monitoring well sampling, off-base residential wells were sampled to determine if groundwater supplies contained organic compounds or metals at concentrations above California Department of Health Services (DOHS) action levels. As households were supplied with municipal water in an interim remedial action program conducted by the AF between 1985 and 1987, residential well sampling was phased out. However, sampling of off-base monitoring wells continued.

Area D Interim Remedial Measures

In 1984, CH2M Hill completed site characterization work on Area D to determine the exact location of former disposal pits, the depth and lateral extent of contamination, and recommendations for a containment system. The study indicated the presence of contamination to a depth of approximately 150 feet and the lateral movement approximately 300 feet west of Area D. In conjunction with this effort, approximately 20,000 cubic yards of contaminated sludge and related soil were removed from one of the waste disposal sites (Pit No. 4) and transported to a Class I hazardous waste disposal site near Benicia, California. The pit was then back-filled with clean soil.

Following the evaluation of various alternatives, the McClellan AFB IRP Task Force (which included representatives of federal, state, and local regulatory agencies; the public; elected officials; and the Air Force) recommended a groundwater contamination containment system that included a cap over Area D and the installation of a groundwater extraction and treatment system. The cap, composed of layers of clay, compressed soil, a plastic liner, and natural vegetation, was designed to keep rainwater from percolating into the subsurface and further mobilizing contaminants. This umbrella effect will restrict future contaminant migration in the unsaturated zone beneath the pits. The cap was completed in 1986.

The groundwater extraction system was completed in 1986 and is composed of six extraction wells screened from 40 to 160 feet below ground surface. The extracted groundwater is piped to McClellan AFB's Groundwater Treatment Plant (GWTP), which was completed in 1987. The six wells currently discharge a total of approximately 100 gallons of water per minute. This creates a "cone of depression" that limits further migration of contaminated groundwater from the source.

The Groundwater Treatment Plant uses a variety of treatment methods, including activated carbon adsorption, air stripping, incineration, and biological treatment.

The Area C Interim Remedial Measures

In late August 1988, the Area C interim groundwater extraction system was put into operation. The following section briefly discusses the groundwater extraction system to provide background on the facility.

Concern about the effects of the Industrial Wastewater Treatment Plant (IWTP) and nearby disposal sites have prompted the Air Force to investigate the movement of groundwater contaminated with metals and organic compounds within and downgradient of Area C. The McClellan AFB IWTP is located in the southern portion of Area C; associated with the plant are the wastewater blending and aeration ponds. Located beneath and adjacent to the plant are several confirmed past disposal sites. Past disposal practices resulted in some of these constituents entering the subsurface and migrating downward to the groundwater. Contaminants have been detected in groundwater at various depths from 95 to approximately 220 feet below the ground surface (bgs). The Air Force has installed an interim groundwater extraction system to intercept and pump groundwater from beneath and downgradient of Area C. The water will be pumped to the Groundwater Treatment Plant via an above-ground pipeline where contaminants will be removed to meet permitted levels (EG&G Idaho, 1987).

The available subsurface information for the area south of Area C prior to 1988 was not sufficient to define and identify contaminant plumes downgradient from the IWTP. Information was needed to define the horizontal and vertical extent of the plumes, to locate wells to monitor migration of contaminants, to provide data to design an extraction system, to evaluate the effectiveness of the extraction system, and to determine hydraulic properties of the area south of Area C (EG&G Idaho, Inc., 1987).

To address the above, 1 extraction well and 11 monitoring wells were drilled and constructed by EG&G Idaho in the fall of 1987 within and immediately south of Area C. Two monitoring well sites included three wells, each in clusters. These wells were screened in shallow, middle, and deep aquifers as defined by EG&G Idaho (Figure 3-5). Another well site included two wells, one well screened in the middle aquifer and one well screened in the deep aquifer. Nine of the wells were completed with 10 feet of 0.020-inch (20 slot) stainless steel wire-wrap well screen. One well was completed with two 10-foot sections of well screen. One well (MW-136) was completed with 15 feet of 0.010-inch (10 slot) well screen. Monitoring well depths and construction materials for these wells are presented in the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) Report (EG&G Idaho, 1987). Three of the monitoring wells (MW-137, MW-140, and MW-141) were converted to extraction wells. Additional monitoring wells are needed to monitor groundwater quality and to evaluate the effectiveness of the extraction system; this need is addressed within this sampling and analysis plan.

Off-Base Well Sampling Program

In 1983, the McClellan AFB Groundwater Task Force established a quarterly sampling and anlaysis program that involved 240 private wells located primarily west and south of McClellan AFB. Initially, the California Regional Water Quality Control Board and the Sacramento County Health Department conducted this program. The largest number of wells sampled has been in the neighborhood immediately adjacent to Area D.

During the first phase of this program, 30 wells were sampled quarterly. Approximately two-thirds of the wells were sampled every quarter; the remainder of the wells sampled were selected on a quarter-to-quarter basis by the Task Force. The two-fold goal of this program was to protect public health and, secondly, to monitor any change in the magnitude and extent of groundwater contamination.

In June 1985, the Air Force contracted Radian Corporation to sample domestic wells. The total number of wells sampled each quarter had grown from approximately 30 in mid-1983 to more than 120 wells. Results from the first year's quarterly sampling program were used to evaluate the extent of off-base contamination and as a basis for providing bottled water to owners of contaminated wells.

In the spring of 1986, McClellan AFB announced an interim remediation plan to provide municipal drinking water hook-ups to approximately 550 residences that used private wells for drinking water supplies in the area west of the base. The area of the hook-ups (the remedial action area) is shown in Figure 2-3. The remedial action area contained all known areas of off-base groundwater contamination attributed to sources within McClellan AFB. The remediation plan called for continued monitoring of private wells in the remedial action area until municipal water hook-ups were in place, at which time private well sampling ceased. Hook-ups were completed in August 1987. Sampling of off-base monitoring wells continues on a regular basis as part of the Groundwater Sampling and Analysis Program.

2.2 Site-Specific Background Information

The Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) is a basewide investigation. Therefore, individual sites and PRLs on base will not be investigated. However, the findings will provide a framework in which future detailed investigations of specific sites may be better planned and implemented.

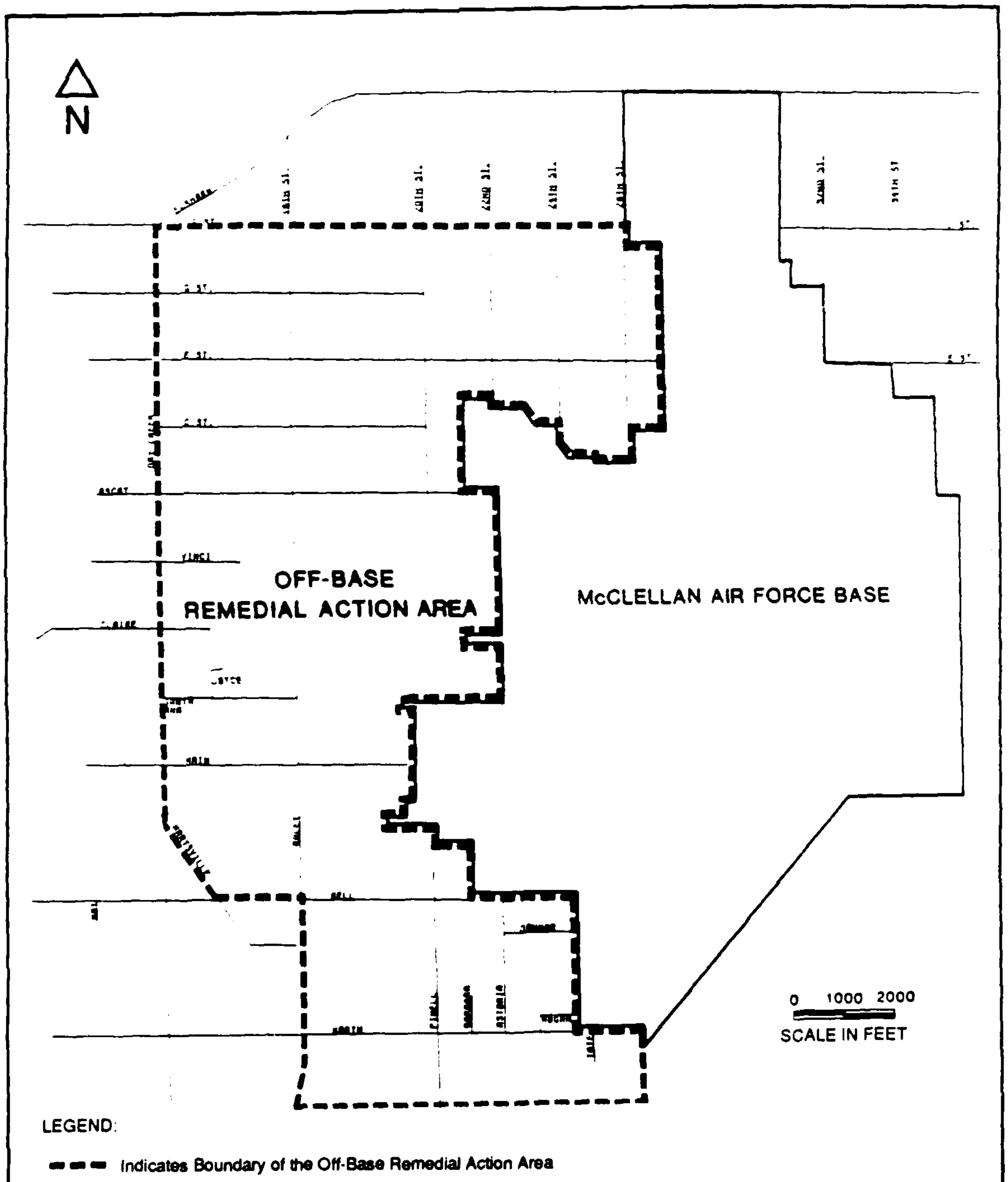

Figure 2-3. Off-Base Remedial Action Area (Inside Broken Lines). All Residents Within the Off-Base Remedial Action Area Have Been Supplied With Municipal Water Hook-Ups.

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3.0 ENVIRONMENTAL SETTING

The following subsections describe the environmental setting at McClellan Air Force Base (AFB). Section 3.1 presents the physical setting including physiography and topography. Section 3.2 addresses regional and local geologic conditions. Section 3.3 addresses surface water and ground-water hydrology.

3.1 Physical Setting

McClellan AFB is located in northern California, approximately seven miles northeast of downtown Sacramento (see Figure 3-1). The Sacramento area is characterized primarily by residential, recreational, agricultural, and industrial/commercial land use. The principal land uses in the immediate vicinity of McClellan AFB are light industrial, residential and agricultural.

3.1.1 Physiography

McClellan AFB is located in the Great Valley Geomorphic Province. This province extends from Red Bluff to Bakersfield, a distance of approximately 400 miles (California Department of Water Resources, 1974). The Great Valley Province includes of the Sacramento Valley to the north and the San Joaquin Valley to the south and averages 40 miles in width (California Department of Water Resources, 1974 and 1978). The Great Valley is bordered by the Sierra Nevada to the east and the Coast Range Mountains to the west, as shown on Figure 3-2. The Sacramento Valley extends about 150 miles from Red Bluff to the mouth of the Sacramento River at Suisun Bay.

McClellan AFB is located on the east side of the Sacramento Valley, on an alluvial plain known as the Victor Plain. The Victor Plain was created by deposition of sediments eroded from the Sierra Nevada. The Victor Plain slopes very gently to the west and is dissected by numerous westerly flowing streams draining the Sierra Nevada (California Department of Water Resources, 1978).

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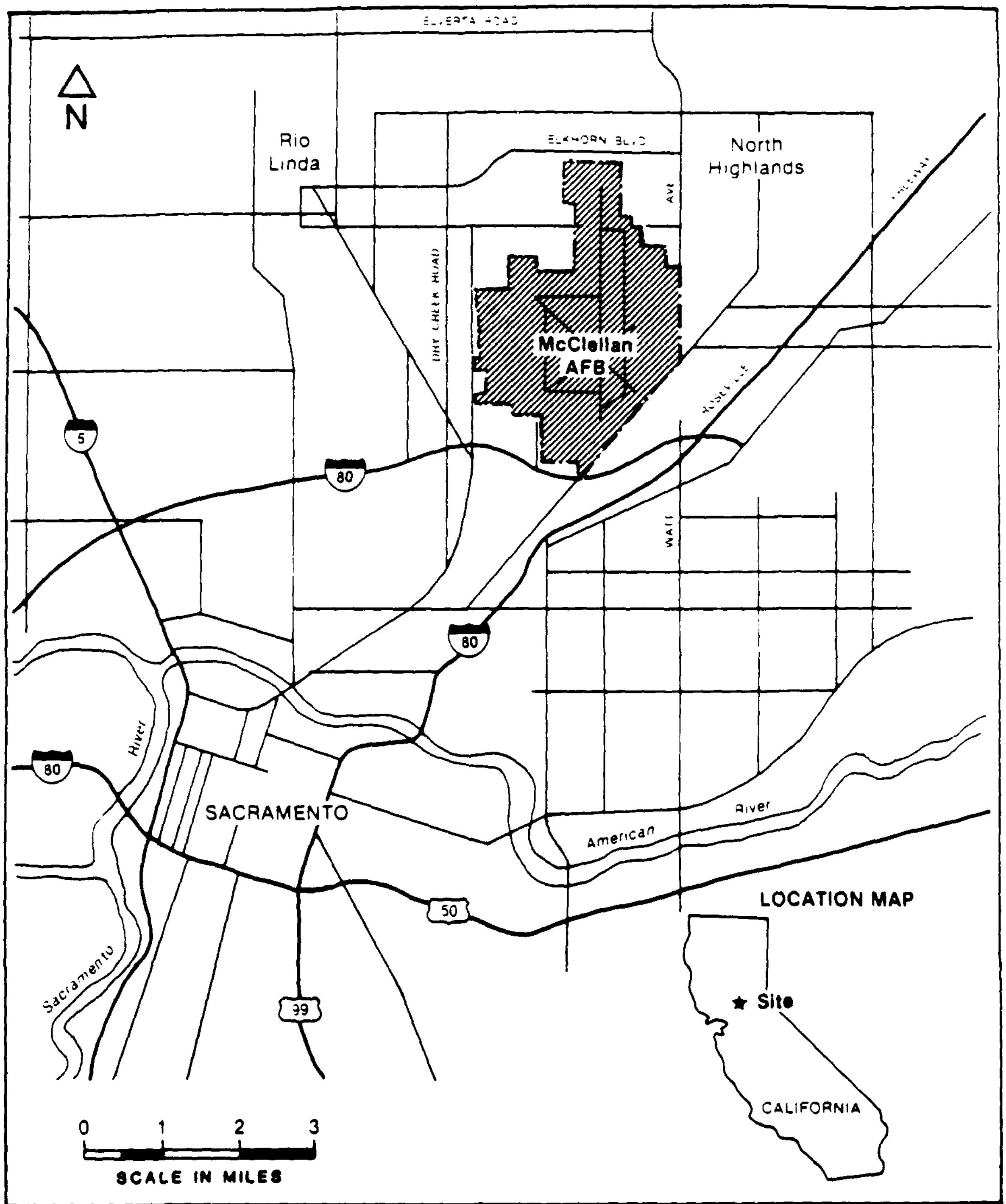

Figure 3-1. Location of McClellan Air Force Base, California.

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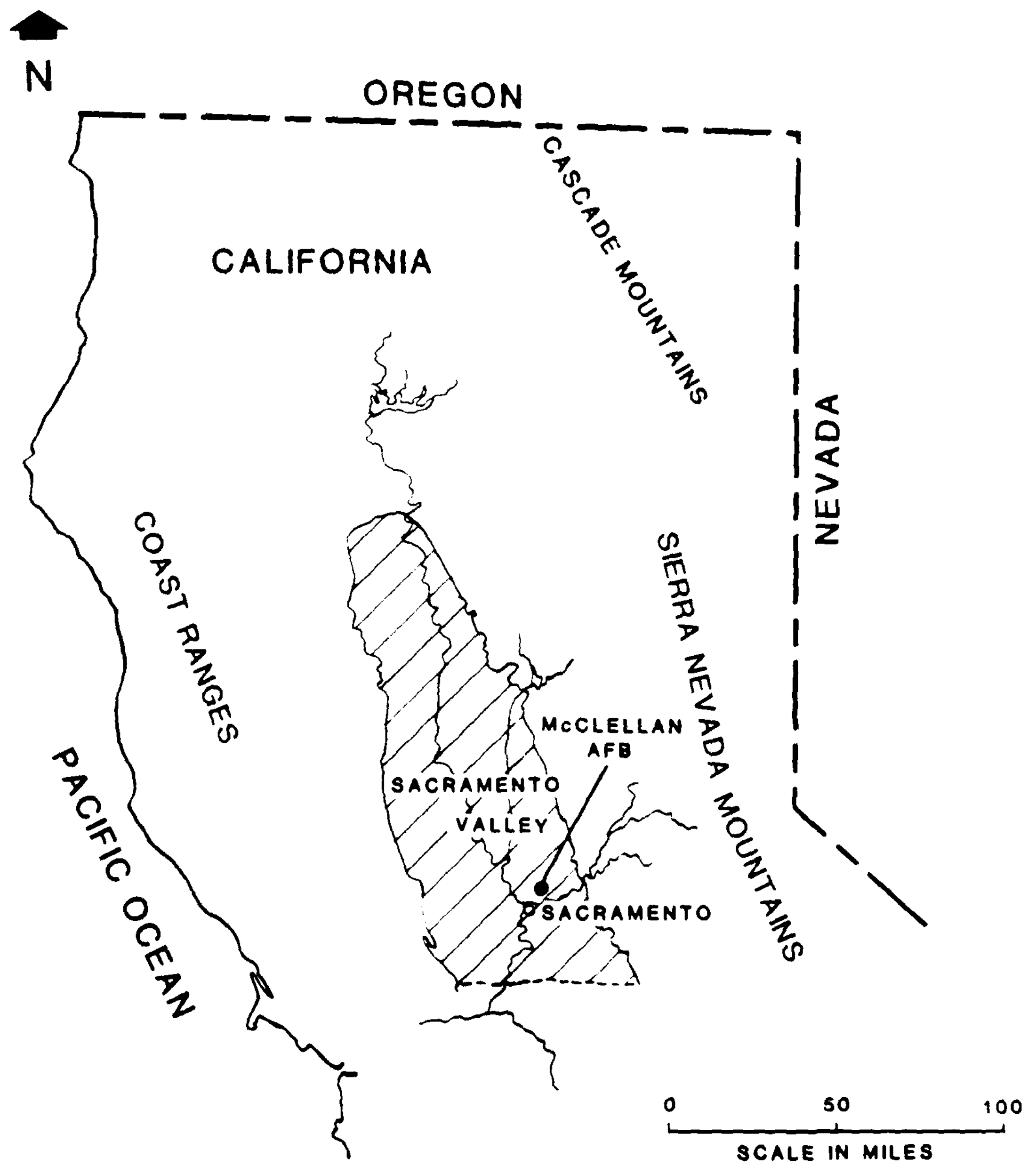


Figure 3-2. Regional Setting of McClellan Air Force Base, California.

3.1.2 Topography

McClellan AFB is located near the eastern edge of the Sacramento Valley, an area characterized by low topographic relief. The land surface at McClellan AFB slopes very gently to the west. Elevations range from 80 feet above mean sea level (msl) on the east side of the base to approximately 50 feet above msl on the west side. The major drainages in the vicinity of McClellan AFB are the Sacramento and American rivers. The source of the Sacramento River is Shasta Lake in Shasta County. The river receives runoff from numerous tributaries originating in the Coast Range, the Cascade Range, and the Sierra Nevada before reaching its junction with the American River near Sacramento. Major tributaries north of the Sacramento area are the Feather, Yuba, and Bear rivers. The American River originates in the Sierra Nevada east of the base. It consists of three forks, that flow westerly and converge east of Sacramento. The Sacramento River flows approximately 6 miles west of McClellan AFB. The American River is located approximately 4 miles south of the base. The location of McClellan AFB relative to the American and Sacramento rivers is shown in Figure 3-3.

3.2 Geology

The regional and local geologic settings of McClellan AFB are discussed in the following subsections.

3.2.1 Regional Geology

The Sacramento Valley is a large depositional basin, filled with thick sedimentary deposits. The sediments were transported from the Sierra Nevada to the east and the Coast Range Mountains to the west. The valley is a synclinal trough (basin) with a north-south axis. In some locations, the basin has been filled with as much as 15,000 feet of Tertiary alluvial sediments. Very little structural displacement of the sediments has occurred in the geologic history of this area. Folds in a north-south trend occurring along the Coast Range-Sacramento Valley boundary are present. On the eastern

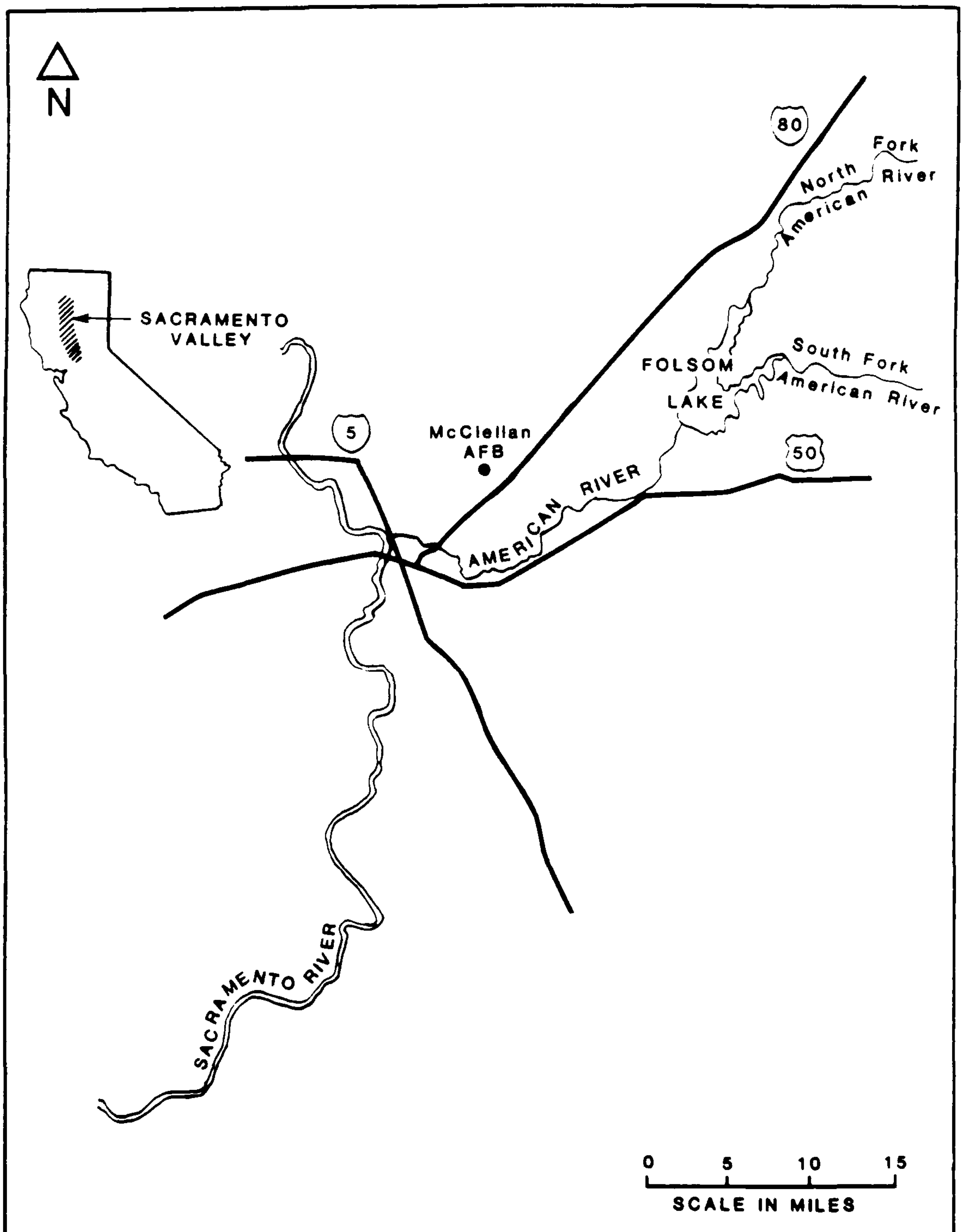


Figure 3-3. Drainage in the Sacramento Valley.

side of the Sacramento Valley, the basement rocks beneath the sedimentary deposits are contiguous with the rocks exposed in the Sierra Nevada.

The Sacramento Valley has a basement of Paleozoic and Mesozoic metamorphic and igneous bedrock which is overlain by Cretaceous and Eocene sandstone and shale of marine origin (California Department of Water Resources, 1978). These deposits are overlain by late Eocene and post-Eocene deposits consisting of sediments of nonmarine and volcanic origin transported and deposited by fluvial processes. Over 4,000 feet of sediments are estimated to have been deposited in the valley since the Eocene Epoch (about the last 60 million years). These sedimentary deposits are wedge-shaped, with the greatest sediment thickness located near the west side of the valley, as shown in Figure 3-4. The deposits have a regional dip that ranges from 300 feet per mile near the base of the Sierra Nevada to 5 feet per mile near the center of the Sacramento Valley (California Department of Water Resources, 1974). Table 3-1 summarizes the geologic formations found in Sacramento County and their waterbearing characteristics.

The Mehrten Formation of Miocene to Pliocene age represents the deepest fresh water aquifer in the Sacramento vicinity. The Mehrten Formation consists of volcanic detritus interbedded with tuff breccia and clays. The Mehrten Formation may reach thicknesses of about 1200 feet in the Sacramento Valley (California Department of Water Resources, 1974).

The younger sedimentary deposits that overlie the Mehrten Formation have been divided into four mappable units (Piper et al., 1939) which are from youngest to oldest: the Victor Formation, the Arroyo Seco Gravels, and the Laguna and Fair Oaks formations. Three of these units are present in the shallow subsurface at McClellan AFB. The Arroyo Seco Gravels have not been identified beneath the base.

The Victor, Laguna, and Fair Oaks formations were deposited in a complex fluvial environment. The postulated mechanism for deposition is a sinuous, meandering stream environment. These streams migrated across the

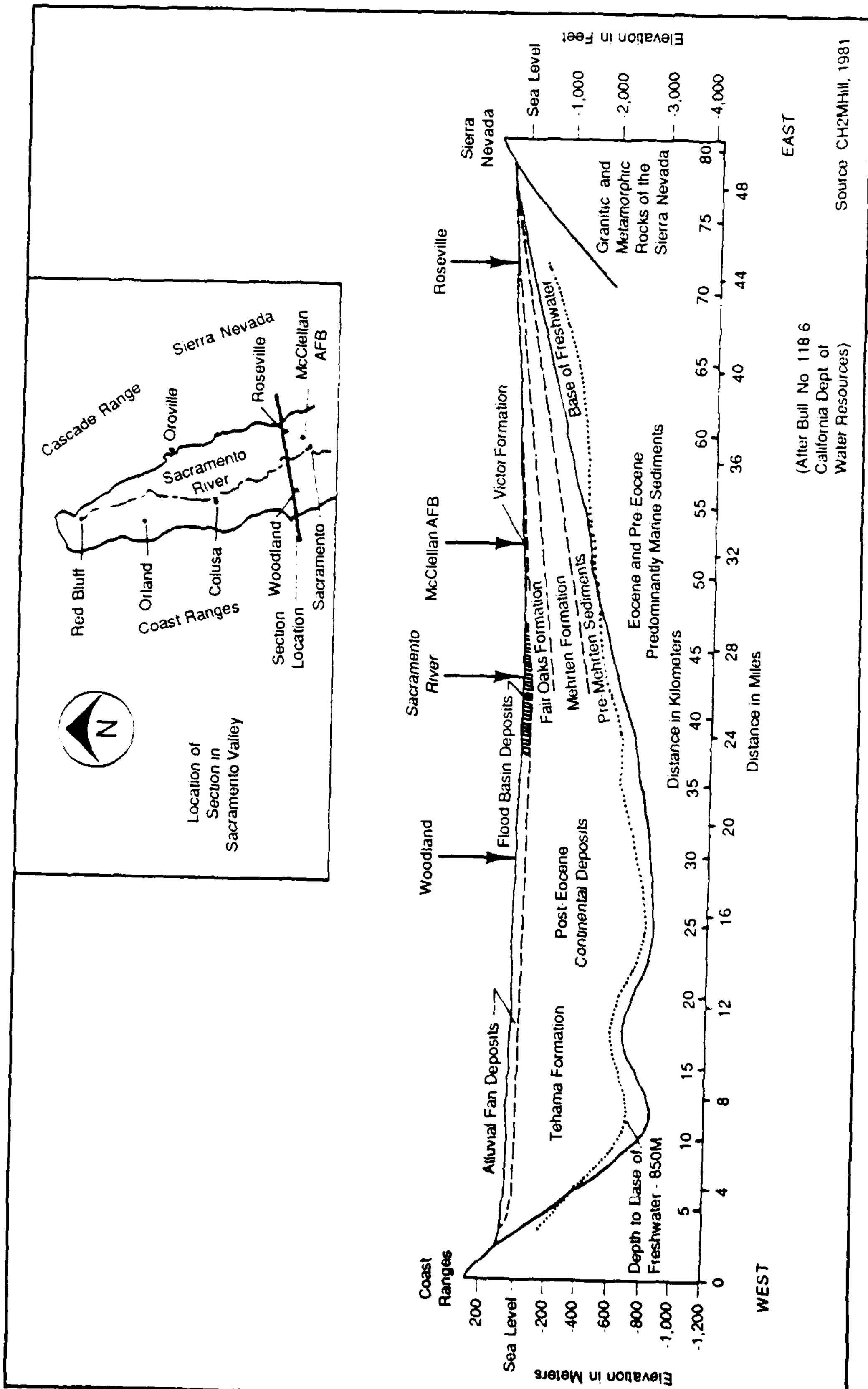


Figure 3-4. Sedimentary Deposits in the Sacramento Valley.

TABLE 3-1. GEOLOGIC FORMATIONS IN SACRAMENTO COUNTY

Era	Period	Epoch	Formation	Thickness (ft)	Physical Characteristics	Waterbearing Characteristics
Cenozoic	Quaternary	Holocene	Alluvium	0-100±	Unconsolidated gravel, sand, silt, and clay deposited along stream channels, on terraces and floodplains, and in basins.	Gravels and sands act as important recharge areas and yield large amounts of water to wells. Silts and clays are of low permeability and yield little water.
Cenozoic	Quarternary	Pleistocene	Victor Formation	0-100±	Unconsolidated sand, silt, and clay. Hardpan present. Sand and gravel along old stream courses.	Generally yields little water. Yields larger amounts of water if old stream channels tapped.
Cenozoic	Quarternary	Pleistocene	Arroyo Seco Gravel	20-50	Sand and gravel in iron-cemented clay matrix.	Of relatively low permeability and, thus, yield only small amounts of water to wells.
Cenozoic	Quarternary/ Tertiary	Pliocene to Pleistocene	Fair Oaks Formation	0-225±	Sand, silt, and clay. Hardpan present. Found principally north of American River. Cemented gravels south of the river.	Similar to the Victor Formation.
Cenozoic	Quarternary/ Tertiary	Pliocene to Pleistocene	Laguna Formation	125-200	Bedded silts, clays, and sands. Non-volcanic.	Sand beds yield moderate amounts of water to wells; clays yield little water.
Cenozoic	Tertiary	Pliocene	Mehrten Formation	200-1,200	Beds of black volcanic sands, brown clay and sand; zones of volcanic tuff-breccia (lava).	Volcanic sands yield large quantities of water to wells. Brown sands yield lesser amounts; clays yield little water. Tuff-breccias yield no water.

(Continued)

TABLE 3-1. (Continued)

Era	Period	Epoch	Formation	Thickness (ft)	Physical Characteristics	Waterbearing Characteristics
Cenozoic	Tertiary	Miocene	Valley Springs Formation	75-125	Beds of light collored sand and ash, beds of greenish-brown silty sand, few beds of gravel All of rhyolitic origin.	Of low overall permeability. Yields only small amounts of water to wells.
Cenozoic	Tertiary	Eocene	Ione Formation	100-400	Medium-grained quartz sandstone, thick beds of white to red clay, blue to gray clay with lignite.	Of low overall permeability. Yields only small amounts of fresh to brackish water to wells.
Mesozoic	Cretaceous		Chico Formation	200-15,000±	Brown marine fossiliferous sandstone and shale. Occurs principally in the subsurface.	Usually nonwaterbearing; contains salt water. Local areas may be flushed and now contain usable groundwater.
Pre-Tertiary			Basement Complex	?	Slate and sandstone of the Mariposa Formation. Greenstone, schist, and assorted metavolcanics of the Logtown Ridge Formation. Granodiorite and other intrusive rocks of the Sierra Nevada.	Essentially nonwaterbearing. Where sufficiently decomposed and/or fractured, may yield small quantities of water to wells.

SOURCE: CDWR, 1974.

area at right angles to the stream flow direction, depositing sandy materials within a meander belt and finer-grained sediments across a broad flood plain. The meandering streams alternately deposited, eroded, and redeposited sediment along ever-changing channel courses. As a result, distinct and continuous clay, silt, or sand horizons cannot typically be traced for long distances, either laterally or vertically. These horizons exist, rather, as interfingering lenses of material interbedded with other discontinuous lenticular deposits. Over distances as little as several tens of feet, these interbedded deposits vary dramatically in texture, porosity, and water transmitting capabilities.

Interbedded sands, silts, clays, and channel gravels of the Victor Formation are present at the ground surface in the vicinity at McClellan AFB. The beds of the Victor Formation are both laterally and vertically discontinuous due to the intricate structure of the fluvial system in which they were deposited. Results of investigations conducted in Areas A, B, C, and D at McClellan AFB indicate that individual stratigraphic units are not laterally extensive; however, geophysical well logs allow correlation of stratigraphic intervals with generally similar lithology. The thickness of the Victor Formation is estimated to be about 50 feet in the vicinity of McClellan AFB.

The Victor Formation is underlain by the Fair Oaks Formation. The sedimentary deposits of the Fair Oaks Formation consist primarily of poorly bedded sand, silt, and clay, with rare and widely dispersed gravel lenses. This formation is reported to be characterized by beds of volcanic tuff up to 1 foot thick that have been altered to white clay. The Fair Oaks Formation dips to the west at approximately 15 feet per mile and may attain thicknesses greater than 100 feet in the vicinity of McClellan AFB.

The Fair Oaks Formation interfingers with the contemporaneous Laguna Formation in the vicinity of McClellan AFB. The Laguna Formation is predominantly fine-grained, poorly bedded, and moderately compact. The formation is heterogeneous with irregular accumulations of silt, sand, clay, and lenticular gravel beds. The most common deposits are light-gray to yellow-brown clayey silt to silty fine-grained sand. Clean well-sorted sand occurs most commonly in relatively thin, laterally variable, beds. Gravel beds are scarce, poorly sorted, and of relatively low hydraulic conductivity. The sands have been eroded from granitic rock and contain abundant weathered feldspars, mica, and quartz grains. Mica particles are locally abundant and serve as a distinguishing characteristic for most of the formation. The formation is between 125 and 200 feet thick. The sediments of the Laguna and Fair Oaks formations are very similar in the vicinity of McClellan AFB. The presence of the white clay layers in the Fair Oaks Formation may be the primary characteristic distinguishing it from the Laguna Formation in this area. In the vicinity of the base, these two formations extend from a depth of about 75 feet to a depth of approximately 400 feet.

The Mehrten Formation underlies the Fair Oaks and Laguna formations. During the Pliocene era, material ejected from volcanic vents mantled the Sierra Nevada with fine-grained deposits. This material was subsequently eroded and transported to the west and deposited as black- to blue-colored sands, silts, gravels, and clays of the Mehrten Formation (California Department of Water Resources, 1978). The Mehrten Formation consists of an upper unit of gray to black sand interbedded with blue to brown clay, and a lower unit of hard, gray volcanic tuff-breccia. The top of the Mehrten Formation is present below McClellan AFB at a depth of about 400 feet.

Other continental sediments underlie the Mehrten Formation. Sandstones and claystones are underlain by deeper marine shales and sandstones, which rest ultimately on basement igneous or metamorphic rock found at depths of up to 15,000 feet.

3.2.2 Local Geology

The stratigraphy at McClellan AFB is complex and typical of heterogeneous fluvial deposits. Individual lithologic units undergo lateral and vertical facies changes over distances as little as several tens of feet. Lithologies in the fluvial deposits at McClellan AFB include sands, silts, clays, and rarely, gravels in upward-fining sequences that appear to repeat through the upper 220 feet of the subsurface deposits. The lithologies range from clean well-sorted sand, to clayey silty sand, to silty clay. Pure clay is very rare. Sand bodies grade laterally into silty and clayey sands. Clean, well-sorted sands may occupy paleochannels, and erosional contacts may be inferred where well-sorted sands occur horizontally adjacent to silt or clay. Sediments deposited outside of stream channels also grade laterally with variations in the proportions of silt and clay.

As part of the planning process for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment), hydrogeologic data available from past investigations at McClellan AFB were reviewed. This review focused on areas on base where data was present that were sufficient to meet the objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). A summary of the local geologic conditions at McClellan AFB based on the review of this information is presented below.

Subsurface investigations conducted in the past by various contractors have had multiple objectives. These objectives have typically included characterization of geology, groundwater hydrology, and occurrence and extent of soil and groundwater contamination. The objective of the geologic investigation aspects of past studies has been to identify and correlate stratigraphic units that are significant to the migration of contaminants in groundwater. Such correlation has been difficult due primarily to the lithologic heterogeneity and the wide spacing between boreholes.

However, much is known about the lithologies occurring from surface to depths of about 220 feet. The upper 100 feet (approximately) is unsaturated and is characterized by fine-grained material. Silty sand is typically the most permeable material present, and sandy silt, silt, and clayey silt are common at depths from surface to 100 feet. Below approximately 100 feet, permeable sands with minor amounts of interstitial silt or clay are the major lithologic units present. These sands vary in thickness from several inches to several tens of feet and are separated by silty sand, silt, and clayey silt. Where a more permeable sand unit is 10 to 20 or more feet thick, the possibility of correlating such a unit between boreholes increases.

Since 1980, 195 monitoring wells have been constructed at McClellan AFB. Contractors who installed these wells have attempted to categorize them based on the position of the screen intervals relative to correlatable stratigraphic units and/or elevation. Where stratigraphic correlation was not possible, previous investigations resulted in the grouping of wells on the basis of the elevation of their screen intervals. The grouping of wells on the basis of screen interval elevations was adopted due to the necessity of interpreting potentiometric and analytical data from borings whose areal spacing was too wide to correlate stratigraphic units. The grouping of wells by monitoring zone is a practical approach to data interpretation for zones which have similar hydrologic characteristics but noncorrelative lithologic characteristics. Although they are not based strictly on stratigraphy, the groupings have resulted in "working models" of hydrologic zones that have gained credibility through the comparison of monthly water-level measurements. Water levels measured in closely-spaced wells that are screened in different monitoring zones consistently show differences in hydraulic head between zones. The differences in head between the wells do not merely reflect variations in head with depth in the same zone but support the existence of separate potentiometric surfaces defined by data from a number of wells screened in the same elevation determined monitoring zone.

Since 1985, a system for identifying groundwater "monitoring zones" that does not depend on stratigraphic correlation has been used for all areas of the base. Monitoring zones were identified to more conveniently evaluate the distribution of groundwater contaminants with depth and produce potentiometric surface maps for three elevation intervals within the aquifer system. These zones were originally defined by United States Air Force Occupational and Environmental Health Laboratory (AFOEHL) in a 1985 Statement of Work issued to Radian (1986) for the Phase II, Stage 2-2, IRP investigation. The zone intervals as identified by AFOEHL were based on depth (below ground surface) intervals.

These three depth intervals were identified as follows:

- Shallow -- "unconfined aquifer" (90 - 100 feet);
- Middle -- "middle aquifer" (120 - 160 feet); and
- Deep -- "deep aquifer" (160 - 220 feet).

After completion of the Phase II, Stage 2-2, study, the definition of the zone intervals were modified on elevation instead of depth. These are the monitoring zones currently used in the Groundwater Sampling and Analysis Program and are identified as follows:

- Shallow -- above -55 feet msl (mean sea level);
- Middle -- -55 to -100 feet msl;
- Deep "A" -- -100 to -150 feet msl; and
- Deep "B" -- below -150 feet msl.

Four factors influenced the final definition of the four monitoring zones that are currently used in the Sampling and Analysis Program. These are:

- The aquifer system consists of multiple waterbearing zones that may be hydraulically interconnected.

- Surface topography varies across the base and the off-base study area. The topographic relief across the area is 20 to 30 feet. Therefore, definition of monitoring well zones by depth below ground surface could result in comparison of data from zones separated vertically by 20 to 30 feet.

- Across the McClellan AFB, the 195 monitoring wells constructed from 1980 to 1988 are screened over a fairly wide elevation range. Defining monitoring zones by elevation ranges allows a large number of wells to be grouped within zones that result in usable potentiometric surface maps.

- A system of monitoring zone designations applicable to the entirety of McClellan AFB was desirable for basewide interpretation.

The system of grouping monitoring wells into four elevation zones has been successful in terms of identifying vertical hydraulic and contaminant concentration gradients. However, it is recognized that these designations do not address the continuity of zones and are not based on hydraulic relationships.

In planning the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) for McClellan AFB geophysical and lithologic logs were used to target potential zones for monitoring wells:

- "Water Table" or "A" zone -- approximately -30 to -60 feet msl;
- "150-foot" or "B" zone -- approximately -90 to -130 feet msl;
- "200-foot" or "C" zone -- approximately -135 to -175 feet msl; and
- "300-foot" or "D" zone -- approximately -220 to -250 feet msl.

These zones are used in this plan to designate approximate depths for well construction. The "A", "B", "C", and "D" designations are used to designate the respective zones on Plate 5. Table 3-2 compares the previous monitoring zone designations with the ABGOURI geohydrologic zones.

As part of the planning process for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment), geologic data

TABLE 3-2. COMPARISON OF MONITORING AND PRELIMINARY GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION ZONE DESIGNATIONS

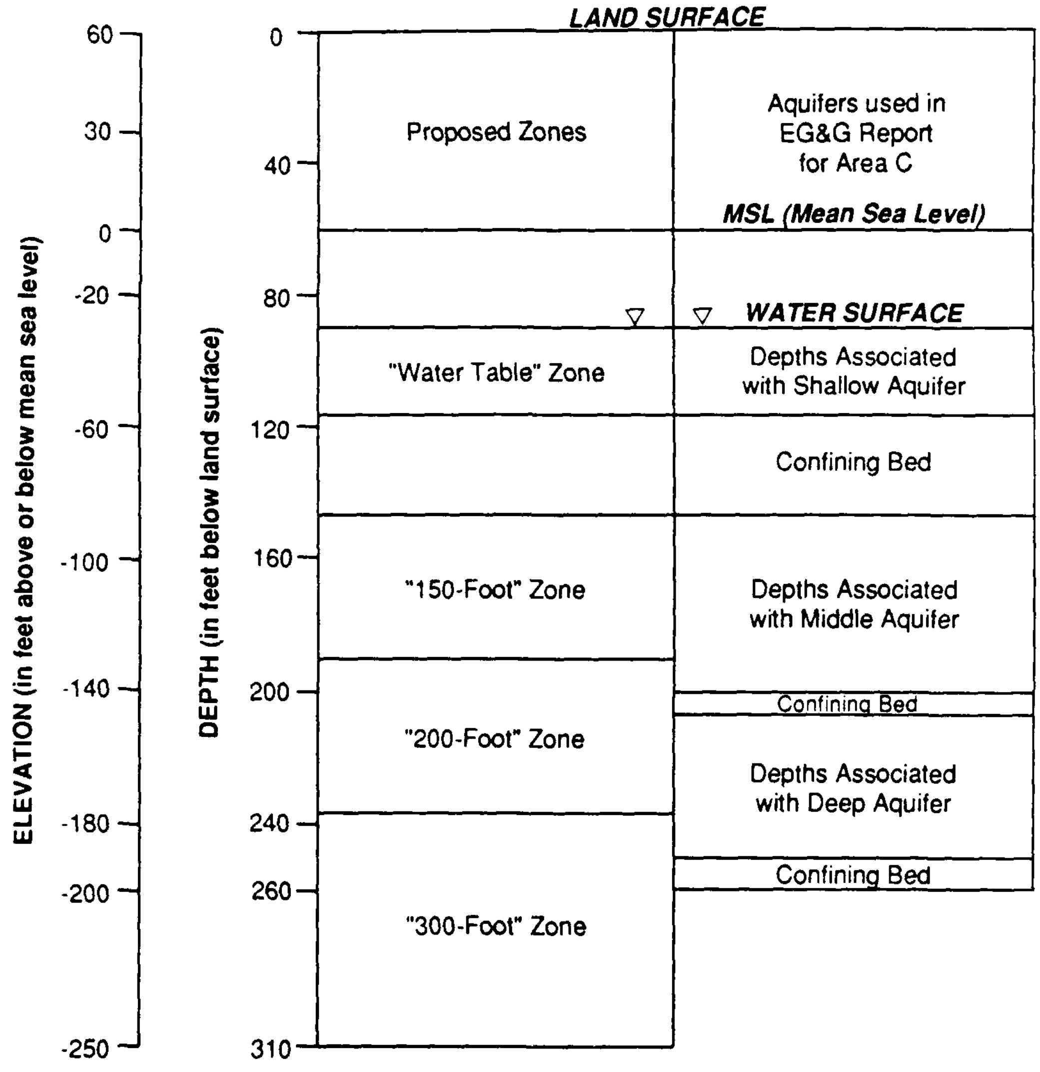
Groundwater Zone Designations		
Sampling and Analysis Program 1986-1988	Sampling and Analysis Program 1989	Preliminary Groundwater Operable Unit Remedial Investigation
Shallow Zone Above -55 feet msl	Shallow Zone Above -55 feet msl	"Water table or "A" zone Water table to -60 feet msl
Middle Zone -55 to -100 feet msl	Middle Zone -55 feet to 100 feet msl	"150 foot" or "B" zone -90 feet to -130 feet msl
Deep Zone Below -100 feet msl	Deep A Zone -100 to -150 feet msl	"200-foot" or "C" zone -135 to -175 feet msl
	Deep B Zone Below -150 feet msl	
		"300-foot" or "D" zone -220 to -250 feet msl

msl = mean sea level

available from all past IRP investigations was evaluated to determine if stratigraphic units could be identified and correlated over long distances. Available geologic data consists solely of lithologic and geophysical logs. Initially, emphasis was placed on evaluating lithologic logs and correlating the lithologies observed. Numerous cross sections and sand/silt ratio maps (net sand maps) were attempted for various depth or elevation intervals to identify major pathways through which groundwater and contaminants would migrate most readily.

Stratigraphic correlation over long distances (several thousand feet or more) is not possible using the existing lithologic data. The lack of lateral lithologic homogeneity is the major deterrent to stratigraphic correlation over long distances. The scarcity of boreholes with adequate lithologic descriptions in some areas, for example, the center of the base, precludes the possibility of correlation from east to west in any waterbearing zone. Lithologic correlation of units below 220 feet is impeded by the small number of lithologic logs available.

Geophysical borehole logs were evaluated to supplement lithologic logs in making stratigraphic correlations. Resistivity and spontaneous potential logs for 76 boreholes ranging up to 700 feet deep were evaluated. These logs included those for 11 monitoring wells recently installed in Area C by EG&G Idaho, Inc. (1987). Several of the EG&G Idaho monitoring wells are the deepest yet installed on or off base. Based on the new borehole geophysics data acquired from these new Area C wells, EG&G Idaho was able to correlate three distinct zones of relatively higher permeability beneath Area C between depths of approximately 90 and 250 feet. The zones are separated by lithologies of lower permeability although it is noteworthy that there are monitoring wells screened within these zones of lower permeability. Figure 3-5 presents a simplified comparison of the monitoring depths in Area C identified by EG&G Idaho with the zone designations proposed in this plan (EG&G Idaho, 1987). Other resistivity and spontaneous potential logs were evaluated by Radian geologists to determine if the three zones identified by EG&G Idaho in Area C appear to be laterally extensive.



Modified from: EG&G Idaho, 1987.

Figure 3-5. Simplified Comparison of Monitoring Zone Depths Used in Area C by EG&G Idaho, and Proposed Monitoring Well Depth Zones.

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The evaluation of all available on-base resistivity and spontaneous potential logs by Radian geologists indicate that the three stratigraphic zones identified by EG&G Idaho, Inc. do appear to extend laterally across the base. In addition, a deeper zone has been tentatively identified at a depth of approximately 300 feet. This deeper zone appears to be separated from the three zones present above a depth of 250 feet by a low permeability aquitard.

For purposes of planning the assessment, these four zones are identified by their approximate depths below ground surface. The zones are illustrated in cross section J-J' on Plate 1 and depict the vertical position of the zones as interpreted on the basis of borehole resistivity and spontaneous potential data. The four zones are described as follows:

- The "water table" zone--present at variable depth due to topographic and local geologic conditions, this zone occurs at a depth of approximately 90 to 120 feet (approximately -30 to -60 feet msl). The interval for the "water table" zone can be expected to change over a period of years as the regional water table continues to decline under sustained groundwater pumping.

- The "150-foot" zone--is characterized as a relatively permeable 20- to 40-foot-thick strata that appears to extend basewide. This zone occurs at approximately -90 to -130 feet msl.

- The "200-foot" zone--is characterized as a relatively permeable 10- to 30-foot-thick strata that appears to extend basewide. This zone occurs at approximately -135 to -175 feet msl.

- The "300-foot" zone--is characterized as a relatively permeable 30-foot-thick strata that appears to extend basewide. This zone occurs at approximately -220 to -250 feet msl.

The above-referenced four zones appear to be the most laterally extensive stratigrahic units of high permeability that can be identified from existing data. The findings of previous investigations at the base must be considered, however, when evaluating the significance of the four zones. The heterogeneous nature of the stratigraphy as evidenced by lithologic and geophysical logs for numerous boreholes indicate that these four zones are likely to include interbeds of less permeable strata such as silt and clay. Similarily, the less permeable sediments separating the zones are likely to include interbeds of permeable material such as clean sand. These zones, combined with other intervening permeable units that may not be as laterally extensive, are multiple waterbearing strata within a single groundwater flow system.

Evidence for one groundwater flow system with hydraulic communication between the upper three zones is found in the potentiometric and analytical data collected in the McClellan AFB Groundwater Sampling and Analysis Program (1986 to the present). Potentiometric data from the program indicate similar groundwater flow directions, horizontal gradients, and small vertical gradients in the first three zones. Analytical data indicate that contaminants have moved vertically from the shallow zone (approximately 90 feet below ground surface) to the middle and deep zones (approximately 245 feet below ground surface) in several areas of the base.

As shown in Plate 1, there is a 20- to 60-foot-thick low permeability unit that occurs at a depth of approximately 250 feet. This unit potentially underlies most or all of the base. Based on interpretation of the resistivity and spontaneous potential logs, this zone consists predominantly of clays and silts. In some locations, these clays and silts appear to be interbedded with fine-grained sand or sandy silts. Since this stratum appears to be generally finer-grained than overlying and underlying strata, it may represent a significant aquitard. An aquitard is a deposit or layer of low permeability that can store groundwater and also transmit water slowly from adjacent waterbearing zones.

Plate 1 suggests that the aquitard, depicted in the resistivity and spontaneous logs for BW-29, is 50 feet thick in the northeastern portion of the base. Logs from wells located to the southwest of BW-29 have a similar geophysical signature suggesting correlation from the northeast to the southwest portions of the base. South of BW-29 in the southeastern portion of the base, the aquitard appears to decrease in thickness from 50 to 20 feet and become increasingly interbedded with sandy strata.

3.3 Hydrology

Surface water and groundwater in the vicinity of McClellan AFB are discussed in the following subsections. Local use of the groundwater resource is also discussed.

3.3.1 Surface Water

Surface water in the Sacramento Valley originates in the Cascade and Sierra Nevada to the north and east, and from the east side of the Coast Range to the west. The Sacramento and American rivers are the major drainages in the vicinity of McClellan AFB. The drainage patterns of these rivers are described in Section 3.1.2.

Surface water drainage in the vicinity of the base occurs predominantly through Magpie, Second (Don Julio), Rio Linda (Robla), and Arcade creeks, as shown in Figure 3-6. Magpie Creek enters the base from the east and is joined by several small tributaries before leaving the base to the west. These on-base drainages have been modified by construction of a series of storm drains and channels across the base. Runoff from streets and runways is directed into the storm drainage system, and exits the base via Magpie Creek.

Dry Creek (not shown in Figure 3-6) is located approximately two miles northwest of the base. Arcade Creek is located just south of the base. Magpie, Dry, and Arcade creeks flow into the Natomas East Drainage Canal west of the base. The canal flows south and west until it discharges into the American River, just east of the confluence of the American and Sacramento rivers.

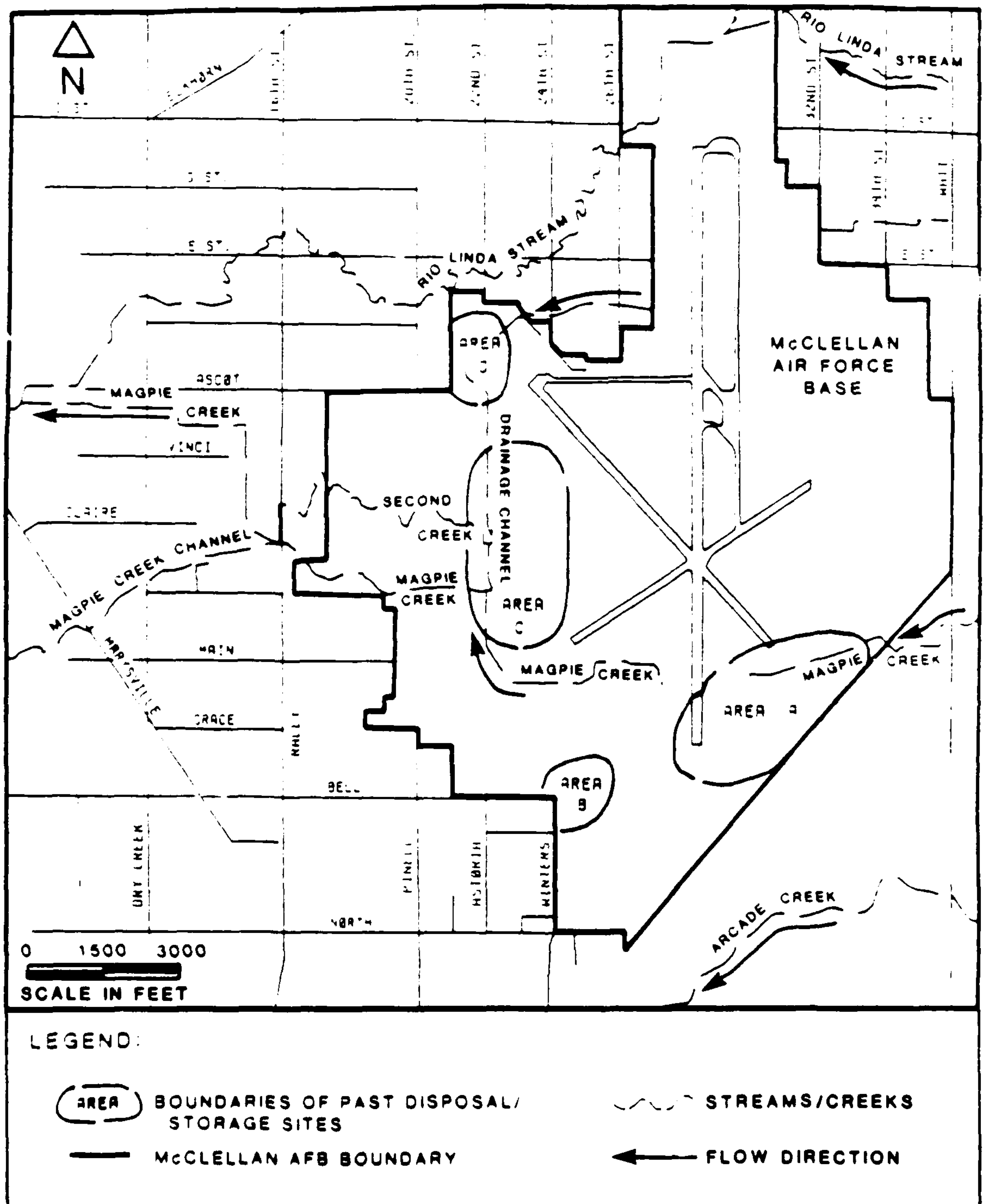

Figure 3-6. Surface Water Drainage In the Vicinity of McClellan AFB.

Water quality in the on-base creeks is generally good and is in compliance with NPDES (National Pollutant Discharge Elimination System) discharge criteria (CH2M Hill, 1981). Due to the dry climate of the region, several of the creeks (particularly Arcade Creek and Don Julio Creek) have periods of little or no flow. During extremely dry periods, the flow in Magpie Creek is almost totally comprised of irrigation return flow from upstream of McClellan AFB and discharge from the Groundwater Treatment Plant.

A study of Magpie Creek was conducted by the AF (1973). This study indicated that the quality of stream water improved from the time it enters the base to the time it exits the base, based on observations of the benthic macroinvertebrate community. In addition, during the study period, the measured concentrations of all constituents regulated by the California RWQCB (measured at the point where Magpie Creek exits the base) were within the RWQCB established limits. The City of Sacramento is currently conducting an Environmental Assessment of Magpie Creek.

3.3.2 Groundwater

Groundwater hydrology, aquifer characteristics, background water quality, and local groundwater use are discussed in the following subsections.

3.3.2.1 Groundwater Hydrology

The occurrence and movement of groundwater, and aquifer parameters are discussed below.

Regional Groundwater Hydrology

In the Sacramento region, groundwater occurs primarily in the Fair Oaks, Laguna, and Mehrten formations. The stratigraphic relationship among these units is shown in Table 3-1. Groundwater recharge in the eastern portion of the Sacramento Valley occurs as a result of infiltration from streams and rivers, rainfall and irrigation waters, and stream runoff from the foothills of the Sierra Nevada. The uppermost waterbearing zone in the Sacramento Valley is recharged by underflow and through percolation of water from the ground surface. Groundwater in the deeper waterbearing zones originates in recharge areas in the Sierra Nevada foothills east of McClellan AFB. Groundwater discharge in the Sacramento Valley occurs predominantly through pumping.

Where saturated, the Victor Formation has only moderate hydraulic conductivity and generally yields little water to wells unless stream channel deposits are penetrated. The Fair Oaks and Laguna formations have generally low to moderate hydraulic conductivity except where coarse-grained channel deposits are present. In these coarse-grained deposits, well yields may reach 3,500 gallons per minute (gpm) with drawdowns of approximately 30 feet, resulting in a specific capacity of about 120 gpm per foot (gpm/ft) of drawdown (California Department of Water Resources, 1974). The black sands of the Mehrten Formation generally demonstrate a specific capacity of approximately 45 gpm/ft. Specific capacities as high as 100 gpm/ft, however, have been noted in the Mehrten Formation (California Department of Water Resources, 1974). Specific capacity is the value of volume discharge per unit time from a pumped well divided by drawdown in the well measured at one time after pumping was started. There is no simple relationship between specific capacity and hydraulic conductivity because the characteristics of the well and the aquifer determine specific capacity. In general, waterbearing zones with greater hydraulic conductivity will have greater specific capacities.

During the early 1900s, groundwater in the vicinity of McClellan AFB moved from northeast to southwest (Figure 3-7) in response to the natural hydraulic gradient from areas of recharge in the northeast to areas of discharge in the southwest. Since the turn of the century, the extraction of groundwater for irrigation, industrial, municipal, and domestic use has dramatically altered groundwater levels and gradients in the Sacramento area. By 1960, pumping of groundwater had increased such that the rate of withdrawal began to exceed the rate of recharge, and groundwater levels began to decline. Under these conditions, local water table gradients changed in direction and

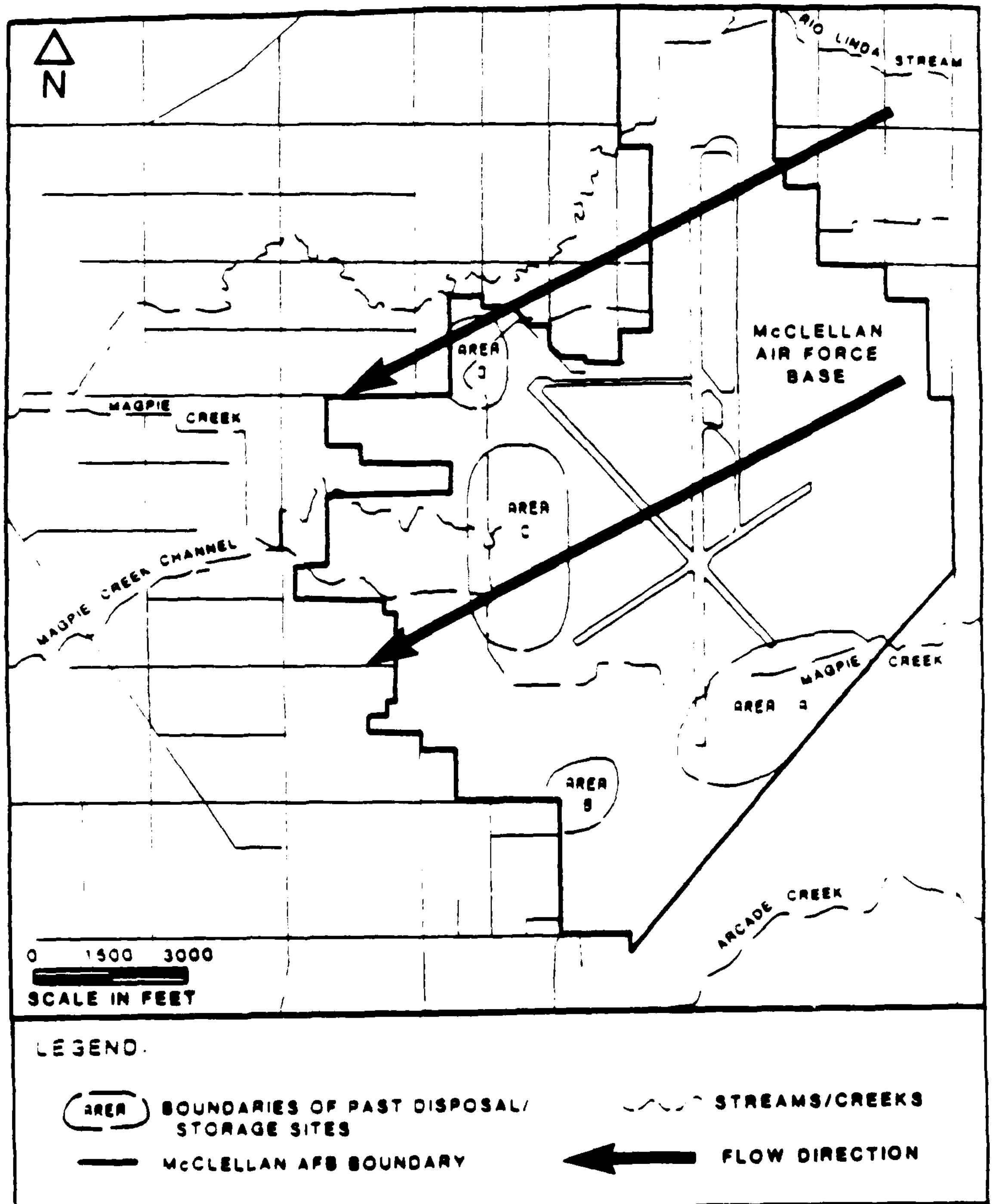

Figure 3-7. Estimated Groundwater Flow Directions for the Vicinity of McClellan AFB, 1912 (Adapted from Bloyd, 1978).

magnitude, and local groundwater depressions began to develop in areas of maximum withdrawal. At this time, a major regional pumping depression, approximately centered under McClellan AFB, is shown in Figure 3-8. This depression has resulted in a change in the area groundwater flow direction such that flow is now generally to the south, as shown in Figure 3-9.

Local Groundwater Hydrology

The aquifer beneath McClellan AFB is comprised of a succession of relatively permeable sandy deposits interbedded with relatively less permeable deposits of silt and silty clay. Most investigations of the hydrostratigraphy and groundwater hydrology at the base have been limited to the upper 220 feet. The water table occurs 80 to 110 feet below surface, and seasonal fluctuations of up to 5 feet on the surface are common. The waterbearing strata below a depth of approximately 120 feet are generally semi-confined and believed to be interconnected with the unconfined zone due to the heterogeneous nature of the local sedimentary deposits and the absence of a laterally extensive, very low permeability, confining zone. Lateral discontinuity and facies changes within the semi-confining layers allow for vertical groundwater movement between the various waterbearing zones.

In the vicinity of McClellan AFB, monitoring wells have been installed to measure groundwater levels and determine groundwater local flow patterns. Currently, there is a network of monitoring wells in which groundwater levels are measured quarterly as part of the Groundwater Sampling and Analysis Program. Each monitoring well has been grouped into one of the four monitoring zones as described in Section 3.3.1. The groundwater-level measurements are used to produce potentiometric surface maps for the monitoring zones except the deep "B" zone. The potentiometric surface maps for April 1988 (Plates 2 through 4) show local deviations from the regional flow pattern as well as graphically detailing those areas for which groundwater-level data is deficient. Deviations from the regional flow pattern are caused by the operation of extraction wells, on-base water supply wells, and off-base water supply wells.

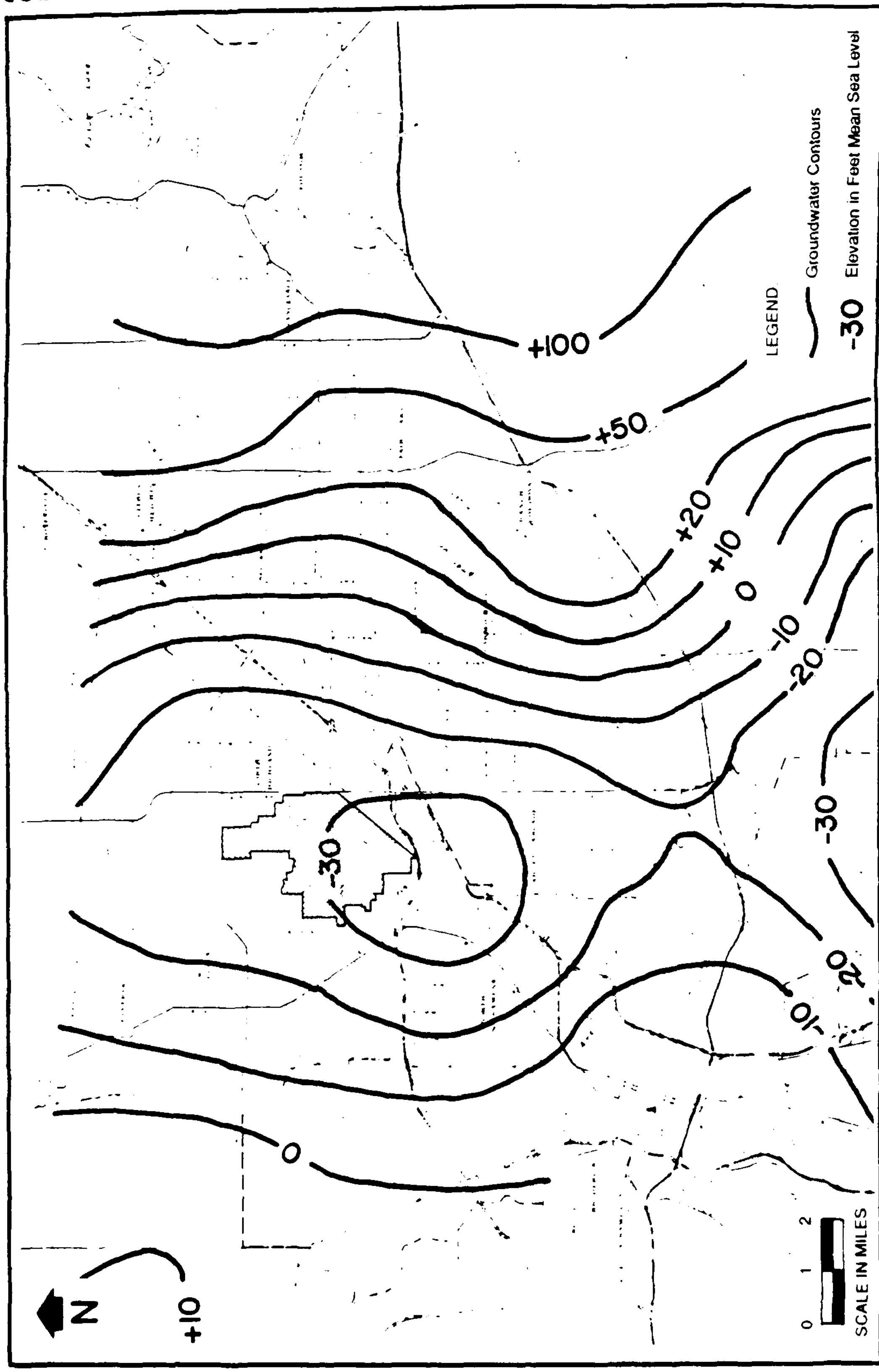

Figure 3-8. Groundwater Depression Beneath North Sacramento County Created by Supply Well Pumping, Spring 1988.

SOURCE Water Resources Division, Department of Public Works, County of Sacramento

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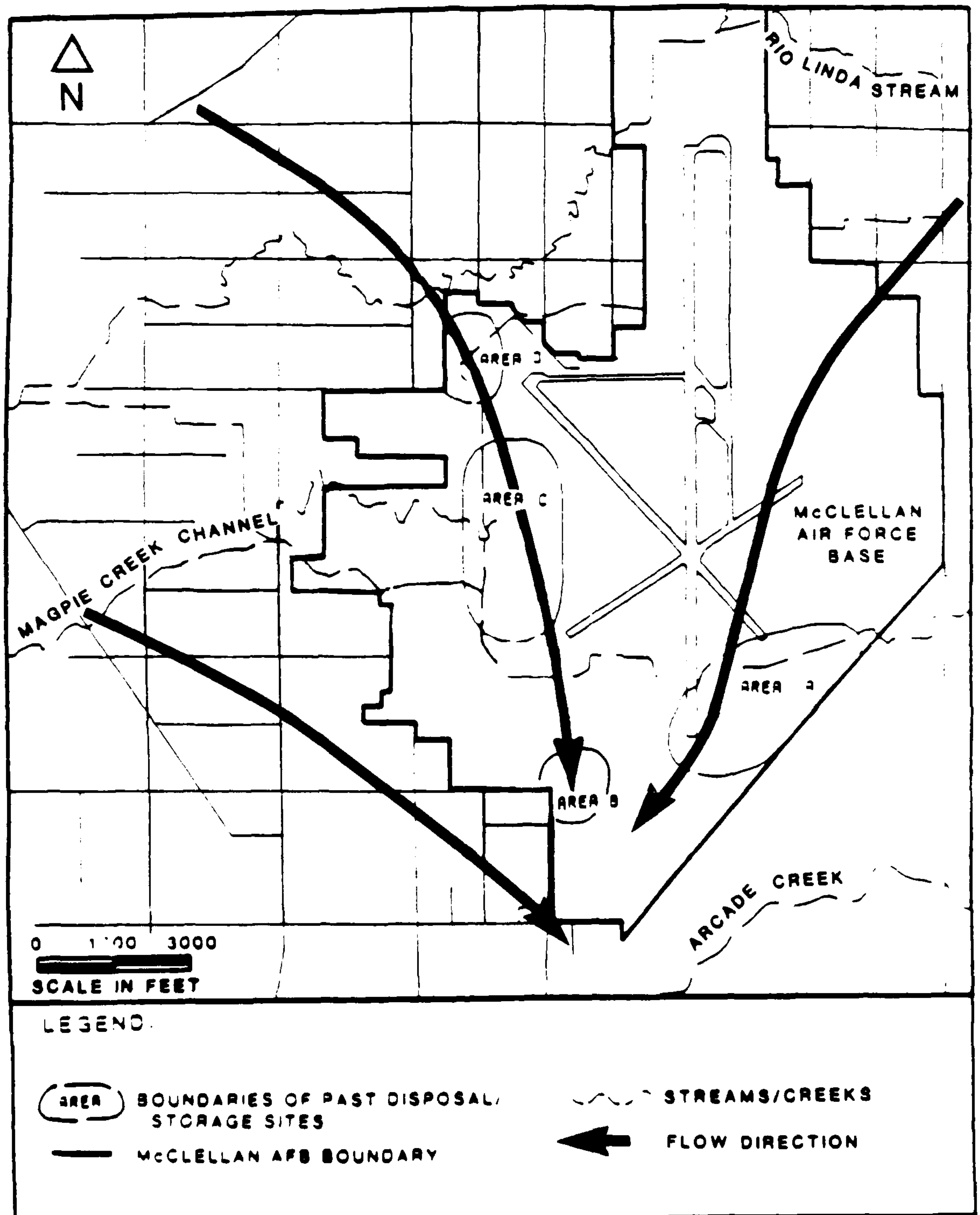

Figure 3-9. Estimated Groundwater Flow Directions for the Vicinity of McClellan AFB, 1985.

In Area A and Adjacent On-Base Areas (see Figure 2-2), and in the off-base Southeast Area, groundwater flow cannot be clearly defined from the three potentiometric surface maps. In the shallow and middle monitoring zones, groundwater flow appears to be toward the west-southwest. The effects of base wells BW-10 and BW-13 on the flow pattern cannot be distinguished because there are few monitoring wells near these active production wells. In the off-base Southeast Area the localized effects of off-base water supply wells are also not apparent due to the lack of monitoring wells.

In Area B and Adjacent On-Base Areas, and in the off-base Southwest Area, the potentiometric surface map for the middle monitoring zone indicates converging flow toward BW-18. Groundwater flow may also be influenced by pumping of off-base water supply wells as evidenced by a possible trough on the shallow and deep potentiometric surface maps. The areal extent of the influence of any of the water supply wells in this area cannot be determined from the limited data points (i.e., monitoring wells) in this area.

In Area C and the off-base West Area, groundwater flow in all three monitoring zones appears to be to the south-southwest. In the southern portion of Area C, there is better hydrologic control. However, there are fewer data points at the northern end of Area C. Horizontal gradients in this area are typical of those found in most areas of the base, but are expected to change once the extraction system in Area C is started.

In Area D and in the off-base Northwest Area, the effect of the Area D extraction system is readily apparent on all three potentiometric surface maps. The potentiometric surfaces indicate that groundwater in all three monitoring zones beneath Area D flows toward the six extraction wells. The direction of groundwater flow in the Northwest Area of the base is not obvious due to the lack of monitoring wells.

On the east side of the base, including the off-base Northeast Area, localized flow directions cannot be determined due to the lack of monitoring wells. The lack of data can be seen on all three potentiometric sur′ ıce maps and especially on the deep monitoring zone map. The hydrologic influence of base wells BW-10 and BW-29 is not evident on the potentiometric surface maps. Off-base water supply wells along Watt Avenue may also be affecting flow patterns in the east area of the base but this cannot be determined from the existing data.

At present, the annual mean water level is declining as a result of groundwater extraction for private, public, and industrial purposes. Throughout the region, the water levels have declined a total of 26 to 52 feet, depending on location, for the period of 1955 to 1985, or 0.9 to 1.7 feet per year (Radian, 1986b). Groundwater levels are expected to continue declining in future years due to use of the local groundwater resource.

Hydraulic Parameters of Waterbearing Zones

Several types of aquifer testing procedures have been used to determine the hydraulic properties of the aquifer system in the McClellan AFB study area. These tests have focused on the shallow, middle, and deep monitoring zones (as defined on page 3-14). Multiple and single well tests have been conducted in on- and off-base locations as shown in Figure 3-10. Multiple well tests in which one well is pumped and other wells are used to observe drawdown have been conducted in Areas C and D. Single well tests have been conducted in Area A and in various monitoring wells on and off base. A summary of the test results is presented in Table 3-3.

Radian conducted two large-scale aquifer tests at one site located between Area C and Area B. The two tests were completed using two different pumping wells and several observation wells (Radian, 1987). A well screened in the middle monitoring zone was pumped for 55 hours at 66 gpm. For the other test, a deep monitoring zone well was pumped for 71 hours at 73 gpm. The observed drawdown data was analyzed using the Walton (1962) type curve method for a semi-confined leaky aquifer and unsteady flow. The average transmissivity (T) values calculated using this analysis were 8,000 gpd/ft for the middle monitoring zone and 12,000 gpd/ft for the deep monitoring zone. The average hydraulic conductivity (K) values were 270 and 390 gpd/ft^2 for the

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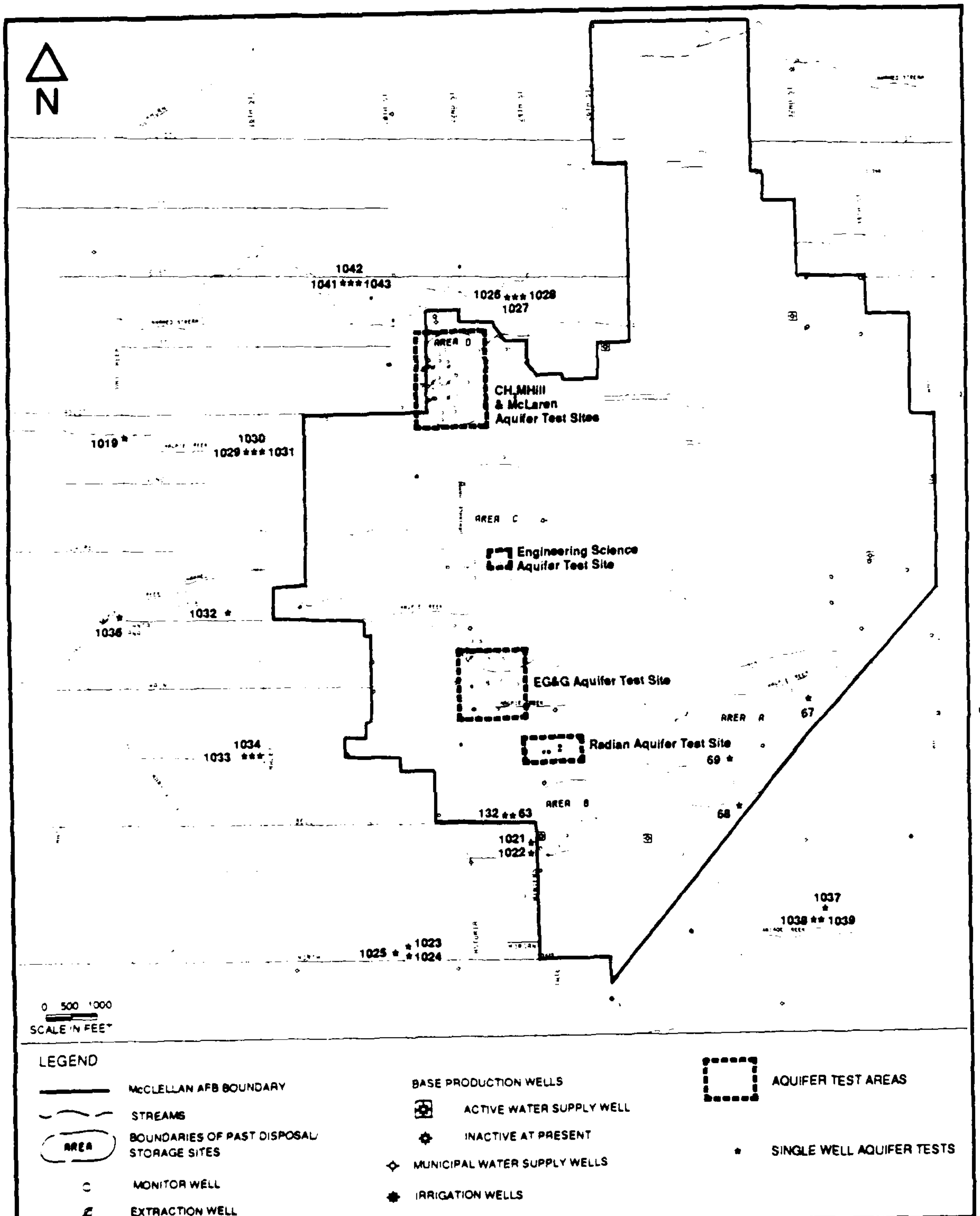

Figure 3-10. Locations of Previously Conducted Aquifer Tests.

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TABLE 3-3. SUMMARY OF AQUIFER TEST RESULTS REPORTED BY RADIAN AND OTHER CONTRACTORS

Contractor	Monitoring Zone	Transmissivity (gpd/ft) Range	Transmissivity (gpd/ft) Average	Hydraulic Conductivity (gpd/ft^2) Range	Hydraulic Conductivity (gpd/ft^2) Average	Storativity ($x10^{-4}$) Range	Storativity ($x10^{-4}$) Average
Radian (Area C)	Middle	7,700 - 8,600	8,000	260 - 290	270	1.3 - 6.2	3.0
	Deep	7,600 - 15,000	12,000	250 - 500	390	1.6 - 0.87	1.6
CH2M Hill (Area D)	Shallow	17,500 - 28,600	16,525	NR	NR (725)[b]	9.0 - 82.0	40[a]
	Middle	2,300 - 19,300	8,850	NR	NR (315)[b]	3.0 - 11.0	8.0
McLaren (Area D)	Shallow, Middle & Deep	6,851 - 19,110	12,000	NR	NR	5.0 - 91.0	30
Engineering-Science (Area C)	Shallow	21	21	4.2	4.2	NR	NR
McLaren (Area C)	Middle	1,200 - 1,900		97 - 120	109	ND	
EG&G Idaho, Inc. (Area C)	Middle	3,000 - 10,000	2,500	NR	NR (83)[b]	5.0	

[a] Specific yield not reported for unconfined condition in shallow monitor zone.
[b] Hydraulic conductivity estimated by Radian based on reported transmissivity value.

NR = Not reported.
ND = Not determined.

SOURCE: Engineering-Science, 1983. "Final Report, Installation Restoration Program, Phase II - Confirmation, McClellan AFB, California." Engineering-Science, Arcadia, California.

McLaren Environmental Engineering, January 1986a. "Area D Monitoring/Extraction System, Technical Report No. 2, Testing of Initial Extraction Well and System Confirmation by Computer Modeling," prepared by McLaren Environmental Engineering, Sacramento, California, for McClellan AFB, Sacramento, California, Contract No. F04699-85-C0020.

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middle and deep monitoring zones, respectively. The average storativity values (S) calculated were 3 x 10^{-4} and 1.6 x 10^{-4} for the middle and deep monitoring zones, respectively.

No water-level changes were observed in the shallow monitoring zone during either test, indicating that the shallow zone was not stressed by this pumping rate of the middle or deep monitoring zones. Water-level data in the middle and deep zones from both aquifer tests did indicate that the middle and deep zone are hydraulically connected. Both middle and deep monitoring zones showed the same daily water-level fluctuations during monitoring of "static" water levels before and after pump tests. The similarity of the water-level responses suggest that some degree of hydraulic connection may exist. The shallow zone did not show the same daily water-level fluctuations as measured in the middle and deep monitoring zones.

Engineering-Science attempted to quantify the hydraulic parameters of the shallow monitoring zone in Area C by pumping MW-44 and measuring drawdown in two adjacent observation wells. However, this test was partially unsuccessful in that no significant drawdown was observed in the observaton wells and transmissivity and hydraulic conductivity were calculated using only recovery data from MW-44 after pumping ceased (Engineering-Science, 1983).

McLaren Environmental Engineering conducted a 30-day pump test in Area D to provide information which could be used to finalize the design of the Area D extraction system. This test was designed to verify the performance of the proposed extraction system as projected by previous modeling. Extraction well EW-73, which is screened across multiple waterbearing zones, was pumped and drawdown was measured in a number of adjacent monitoring wells screened at discrete intervals in the shallow, middle, and deep monitoring zones. Drawdown data from shallow and middle monitoring zone wells were analyzed using Boulton's method (1963) to derive an average transmissivity value.

CH2M Hill conducted two aquifer tests in Area D to measure transmissivity and to determine the presence of barriers to groundwater flow between aquifers. Monitoring well MW-53, screened in the middle zone was pumped for 25 hours at 15 gpm. For the other aquifer test, monitoring well MW-56, screened in the shallow zone, was pumped for 9 hours at 15 gpm. Resultant drawdown data was analyzed by three different methods. These methods included the Cooper and Jacob (1946) straightline (semi-log) method, Theis modified recovery method and Hantush and Jacob (1955) curve-matching method. An "average" transmissivity value of 21,000 gpd/ft was determined from the results of all three analyses. This T value was used to determine an appropriate drawdown to be produced from the proposed extraction system. Based on pumping of EW-73 which is screened across multiple waterbearing zones and drawdown data from monitoring wells screened in discrete zones a transmissivity value for layer 2 was determined. The Cooper and Jacob (1946) straight line (semi-log) method is based on conditions of small radial distances between the pumped well and the monitoring well or a long pumping time. CH2M Hill reported an average transmissivity value of 21,000 gpd/ft.

EG&G Idaho, Inc. recently conducted pumping tests in all wells they installed in Area C in 1987. A submersible pump was installed in all wells and each well was pumped for eight hours. Pumping rates ranged from 1.3 gpm to 28 gpm. The specific capacity for each well was calculated and used to estimate transmissivity. A distance-drawdown analysis was used to calculate hydraulic parameters using drawdown data from wells not necessarily screened in the same waterbearing zone as the pumping well, even though EG&G Idaho recognized that the aquifer system is composed of multiple leaky waterbearing zones. However, they estimated a transmissivity value of 2,500 gpd/ft and a storativity value of 5×10^{-4} for the middle "aquifer" as defined in their investigation. Based on the thickness of this waterbearing unit, the hydraulic conductivity should be approximately 83 gpd/ft^2.

McLaren Environmental Engineering conducted two aquifer tests in Area A. However, drawdowns were only observed in the pumped wells (MW-71 and MW-69). Analysis of the drawdown data was made using the Papadopulos and Cooper Method (1967) that addresses the effect of well storage on drawdown.

Both MW-71 and MW-69 are screened in the middle monitoring zone. The transmissivity values calculated for MW-69 and from MW-71 are 1,900 gpd/ft and 1,200 gpd/ft, respectively. The corresponding hydraulic conductivity values for the waterbearing zones screened by monitoring wells MW-69 and MW-71 are 97 gpd/ft^2 and 120 gpd/ft^2, respectively.

Radian has also used drawdown data collected during development of single wells located in a number of areas to calculate transmissivity values. Drawdown was measured during development by pumping in 28 new monitoring wells installed in Phase II, Stages 2-4 and 2-5. Transmissivities were calculated as described by Walton (1962) using specific capacity data for each well. Transmissivity values for the 28 new wells range from 550 to greater than 30,000 gpd/ft with corresponding hydraulic conductivity values ranging from 41 to 1,100 gpd/ft^2. Mean hydraulic conductivities for the shallow, middle, and deep monitoring zones are 380, 380, and 500 gpd/ft^2, respectively.

Transmissivities were also calculated by Radian for 12 existing monitoring wells that were redeveloped in 1986, most of which were located in Area D. Pumping rates ranged from 0.9 to 15.0 gpm and all wells were pumped for 60 minutes. The Cooper-Popadapulos method was used to analyze the data. Calculated values for transmissivity for the 12 redeveloped monitoring wells ranged from 2,300 to 118,600 gpd/ft. The average transmissivity values calculated were 9,450 gpd/ft for the shallow zone, 19,160 gpd/ft for the middle monitoring zone, and 56,580 gpd/ft for the deep monitoring zone. For the six wells in which the thickness of the waterbearing zones was known, calculated hydraulic conductivity values range from 300 to 3,300 gpd/ft^2.

A wide range of transmissivity values have been determined by Radian and other contractors in different areas of the base. Table 3-3 presents the ranges of transmissivity values determined by Radian and other contractors. Because these aquifer tests and the methods used to analyze the data are so varied, comparisons between the data cannot be made. Conclusions as to what are "real" transmissivity values cannot be made because of the varied test methodology and the heterogeneity of the aquifer system. Most results do seem reasonable and are within an order of magnitude which indicates that the various methods are useful for estimating transmissivity of the McClellan AFB aquifer system.

Hydraulic Parameters of Aquitards

The aquifer system beneath McClellan AFB includes low permeability layers that act as aquitards. Most of the field investigations conducted to date have focused on characterizing the permeable strata, although aquifer tests by Radian, CH2M Hill, and McLaren have indicated hydraulic connection via the less permeable layers. Aquifer testing conducted by Radian and CH2M Hill also indirectly investigated vertical hydraulic conductivity of the aquitard.

Using the curve matching r/B solution of Hantush and Jacob (1955), Radian calculated an average vertical hydraulic conductivity of 0.68 gpd/ft^2 for the aquitards at the Radian aquifer test site based on data acquired while pumping a well screened in the middle monitoring zone. An average vertical hydraulic conductivity of 0.36 gpd/ft^2 was calculated from the data acquired while pumping a well screened in the deep zone. These are apparent vertical conductivities because this method cannot distinguish between leakage coming from below or above the pumped aquifer. The r/B method also assumes that storativity of the aquitard is negligible and that the total head in unpumped waterbearing zones is constant over time. Thus this method tends to overestimate the transmissivity of the pumped aquifer.

CH2M Hill calculated leakance which is the ratio of apparent vertical conductivity to the saturated thickness of the aquitard. The method used to calculate leakance was not discussed in the CH2M Hill report (CH2M Hill, 1987) but is presumably the r/B solution or a later solution developed by Hantush (beta solution). Both methods rely on type curve matching and drawdown observed in the pumped aquifer only. Leakage from above and below cannot be quantified by either method.

3.3.2.2 Groundwater Quality

This section discusses natural groundwater quality of McClellan AFB and also presents an overview of groundwater contamination problems in specific areas of the base and adjacent off-base areas.

Natural Groundwater Quality

Groundwater quality in the area of the base is naturally excellent for irrigation and domestic uses. The groundwater is characterized as a calcium-sodium bicarbonate type. In Sacramento County, the fresh groundwater zone ranges in thickness from several hundred feet near the eastern portion of the county, to an estimated 2,000 feet near the Sacramento River. The fresh water zone at McClellan AFB is approximately 1,385 feet thick (CH2M Hill, 1981).

Groundwater Contamination

Analyses of groundwater samples from the designated areas on base (Areas A, B, C, D, and "Other Areas") have indicated the presence of a variety of contaminants. Maximum levels of many compounds, especially chlorinated solvents, are near or above the California Department of Health Services (DHS) action levels or U.S. EPA Drinking Water Standards. Maximum concentrations of chlorinated solvents measured in Areas C and D have been generally higher than those measured in the other areas. Volatile organic compounds, especially chlorinated solvents, have been repeatedly measured in a large percentage of the on-base monitoring wells. Metals and base/neutral and acid extractable organic compounds have been measured frequently in certain on-base monitoring wells, but the areal distribution of these contaminants is less extensive than that for volatile organic compounds. Pesticides and herbicides have been detected in low concentrations in all of the on-base areas.

There are currently 126 monitoring wells sampled on a quarterly basis for various groundwater quality parameters. There are several wells that have been sampled in the past but are no longer sampled and for which a limited set of water quality data exists. The 126 wells currently being sampled are not uniformly distributed across the McClellan AFB study area, but are clustered primarily in and around Area D and the south end of Area C. Areas A and B, and Adjacent On-Base Areas, do include some monitoring wells but not enough to determine the horizontal and vertical extent of contamination.

Contaminants have been detected historically in water supply wells located on and off base. In 1979, water quality sampling of four base production wells detected trichloroethene (TCE) in base water supply well BW-18 located at the southern portion of the base in Area B, and trace concentrations of volatile organic compounds in BW-28 located northeast of Area D. In a subsequent monitoring program, TCE was found in BW-1, BW-2, and BW-12 north of Area A, and in BW-28 located northeast of Area D. Trichloroethene has been detected in samples from off-base residential wells located southwest of Area B and west of Area D. Other contaminants such as tetrachloroethane, 1,2-dichloroethene, 1,2-dichloroethene, and 1,1-dichloroethene have been detected at concentrations above state and federal standards.

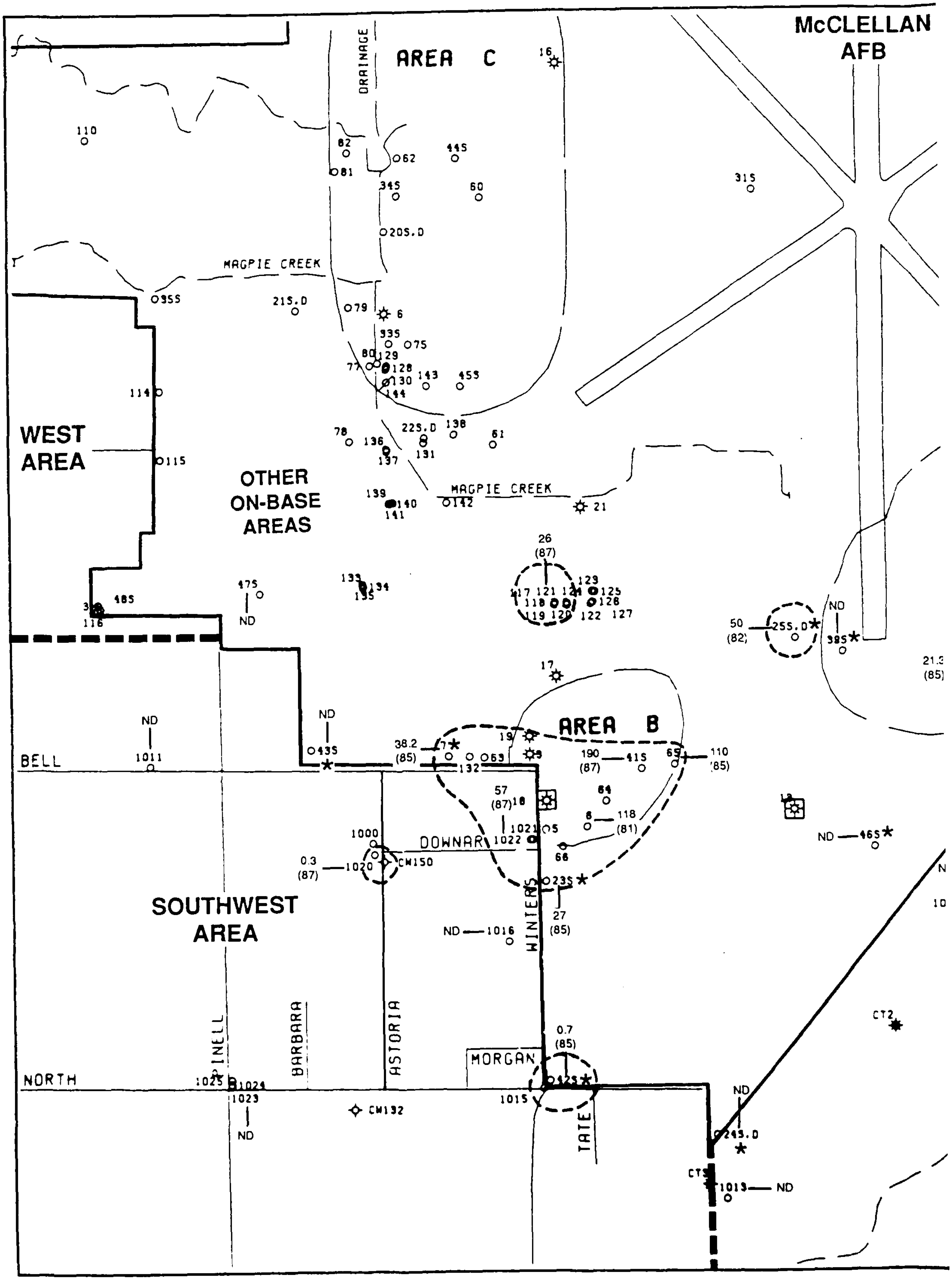
The subsections below present, by area, past water quality information. The focus of the discussions is on TCE because this compound has been most frequently and most consistently detected in on- and off-base wells. Tables and maps presenting the historic magnitude and extent of TCE in groundwater accompany these subsections. The tables also identify various other compounds detected over time in those wells.

<u>Area A and Adjacent On-Base Areas and the Southeast Area</u>--In Area A and Adjacent On-Base Areas, there are few monitoring wells in the existing sampling network. These include MW-27D, MW-67, MW-68, and MW-69. In the off-base Southeast Area there is one cluster of monitoring wells that includes three wells. One shallow zone monitoring well and one middie zone monitoring well are also located adjacent to the southeast boundary of the base.

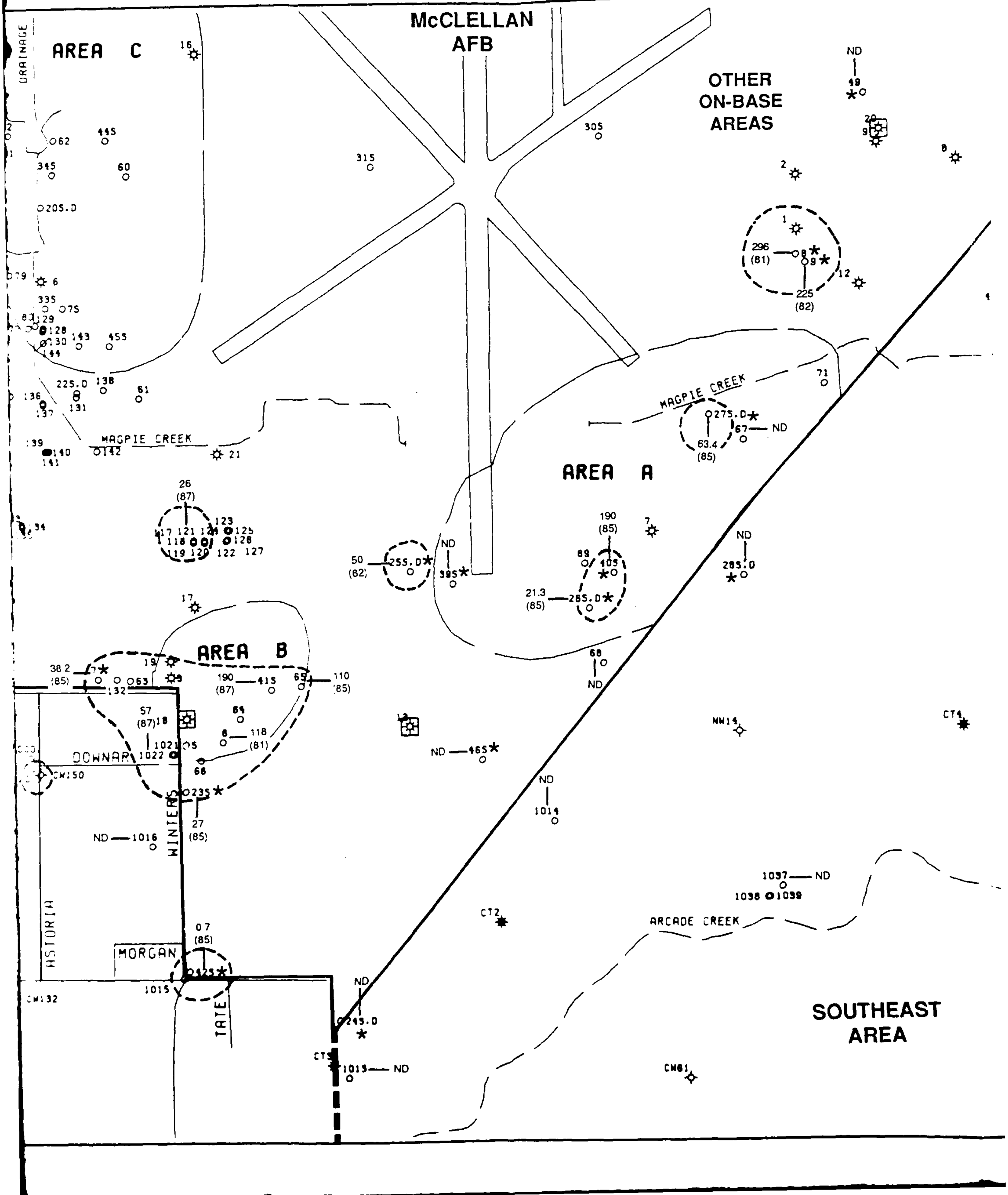
As shown in Figures 3-11 and 3-12, TCE has been detected in monitoring wells screened in the shallow and middle monitoring zone. (There are no monitoring wells screened in the deep zone in Area A.) Table A-1, presented in Appendix A, lists all monitoring wells in Area A and the Southeast Area and the compounds detected in those wells. Trichloroethene has been found in seven on-base shallow zone monitoring wells in Area A, four of which are now dry. The seven shallow monitoring zone wells are MW-8, MW-9, MW-25S, MW-25D, MW-26S, MW-27S, and MW-40S. Trichloroethene has not been detected in the off-base shallow zone monitoring wells MW-28S, MW-1014, and MW-1037. Of the seven middle zone monitoring wells, TCE has been detected in five including two off-base wells. The five middle monitoring zone wells include MW-26D, MW-27D, MW-69, MW-28D, and MW-1038. The one deep zone monitoring well present is MW-1039, located off base. No contaminants have been detected in MW-1039.

Area B and Adjacent On-Base Areas and the Southwest Area--In Area B and Adjacent On-Base Areas and the Southwest Area, the pumping of BW-18 influences local groundwater flow and the movement of contaminants. The extent of this influence on horizontal and vertical groundwater flow and contaminant migration has not been determined. Contaminants have been detected in BW-18; a wellhead water treatment unit consisting of carbon filters has been installed to treat water from this well.

The extent of historically detected TCE in each monitoring zone is shown in Figures 3-11, 3-12, and 3-13. Various levels of TCE have been detected in monitoring wells in Area B and in the Southwest Area. Table A-2, presented in Appendix A, lists all the monitoring wells in these areas and the concentrations of all halocarbons detected. Nine of the 16 shallow monitoring zone wells have contained TCE. The nine shallow monitoring zone wells include MW-6, MW-7, MW-23S, MW-41S, MW-42S, MW-65, MW-120, MW-1020, and MW-1021. One well is now dry (MW-42S); two wells (MW-1020 and MW-1021) are located in the off-base Southwest Area. There are eight middle monitoring zone wells and TCE has been detected in three of these wells (MW-121, MW-1000, and MW-1022). There are five deep monitoring zone wells. Trichloroethene has been detected in two of these deep monitoring zone wells (MW-63 and MW-132).



McCLELLAN AFB
AREA C
DRAINAGE
MAGPIE CREEK
WEST AREA
OTHER ON-BASE AREAS
AREA B
SOUTHWEST AREA
BELL
DOWNAR
WINTERS
NORTH
PINELL
BARBARA
ASTORIA
MORGAN
TATE
CW150
CW132
CT2
CT5



McCLELLAN AFB
AREA C
AREA A
AREA B
OTHER ON-BASE AREAS
SOUTHEAST AREA
DRAINAGE
MAGPIE CREEK
MAGPIE CREEK
ARCADE CREEK
DOWNAR
WINTERS
ASTORIA
MORGAN
TATE

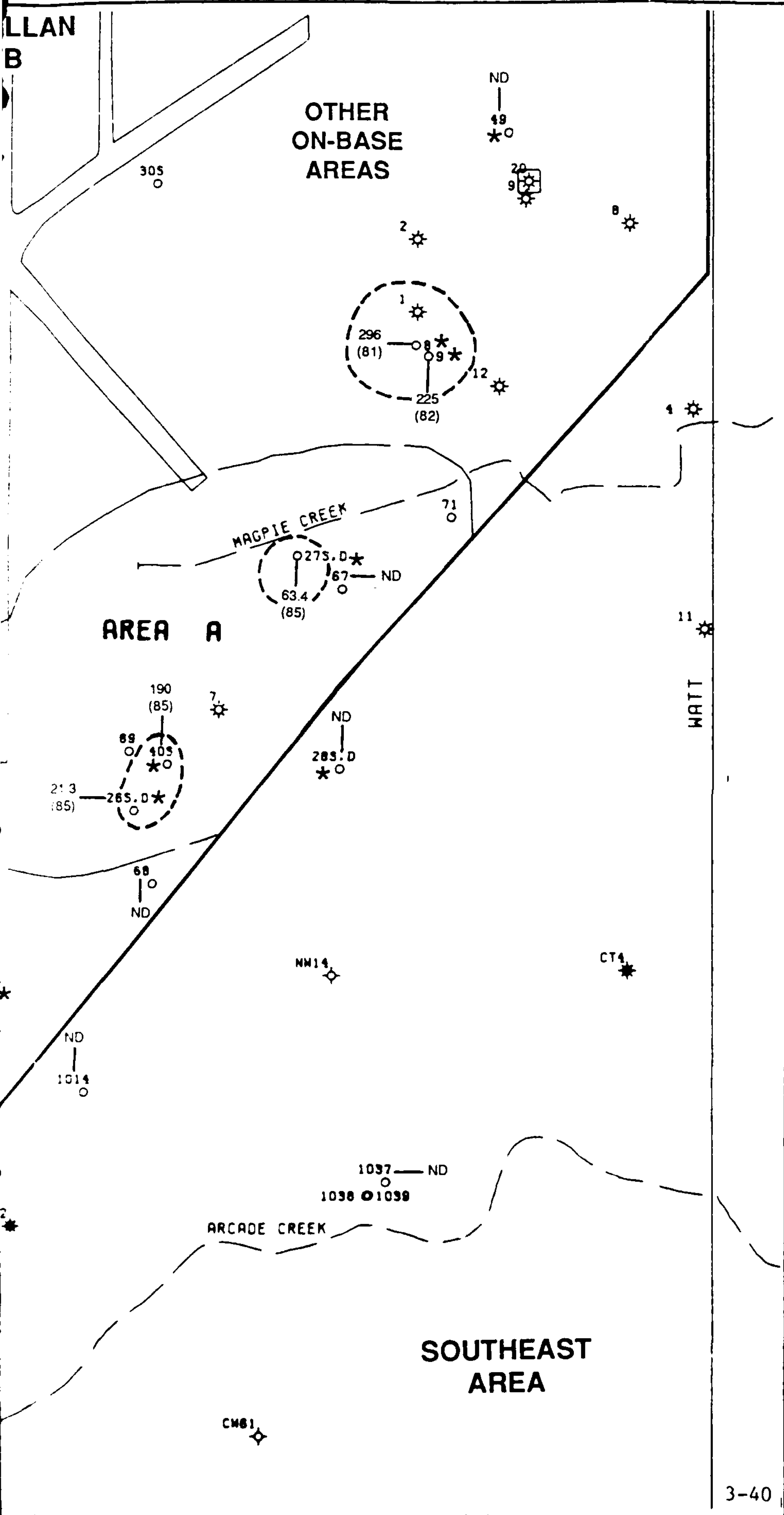


FIGURE 3-11.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN SHALLOW MONITORING ZONE OF AREAS A AND B AND ADJACENT OFF-BASE AREAS

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/ STORAGE SITES

MONITORING WELLS:

*	INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
110	MAXIMUM CONCENTRATION OF TCE (ug/L)
(85)	YEAR SAMPLED & ANALYZED
ND	TCE NOT DETECTED
	APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

CW	CITY OF SACRAMENTO
NW	NORTHRIDGE WATER DISTRICT
RW	RIO LINDA
AW	ARCADE WATER DISTRICT

IRRIGATION WELLS:

CT	CALTRANS

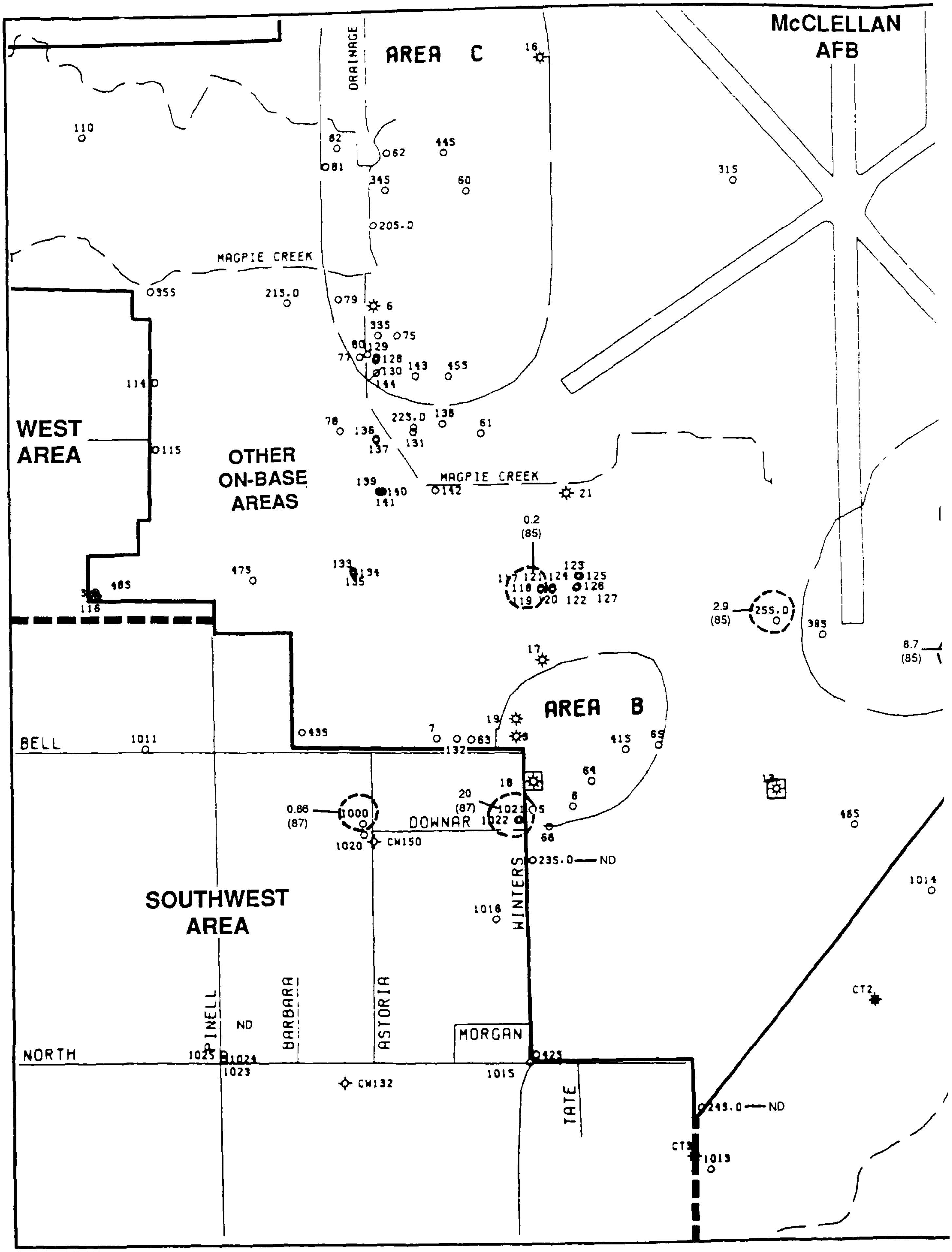
EXTRACTION WELLS

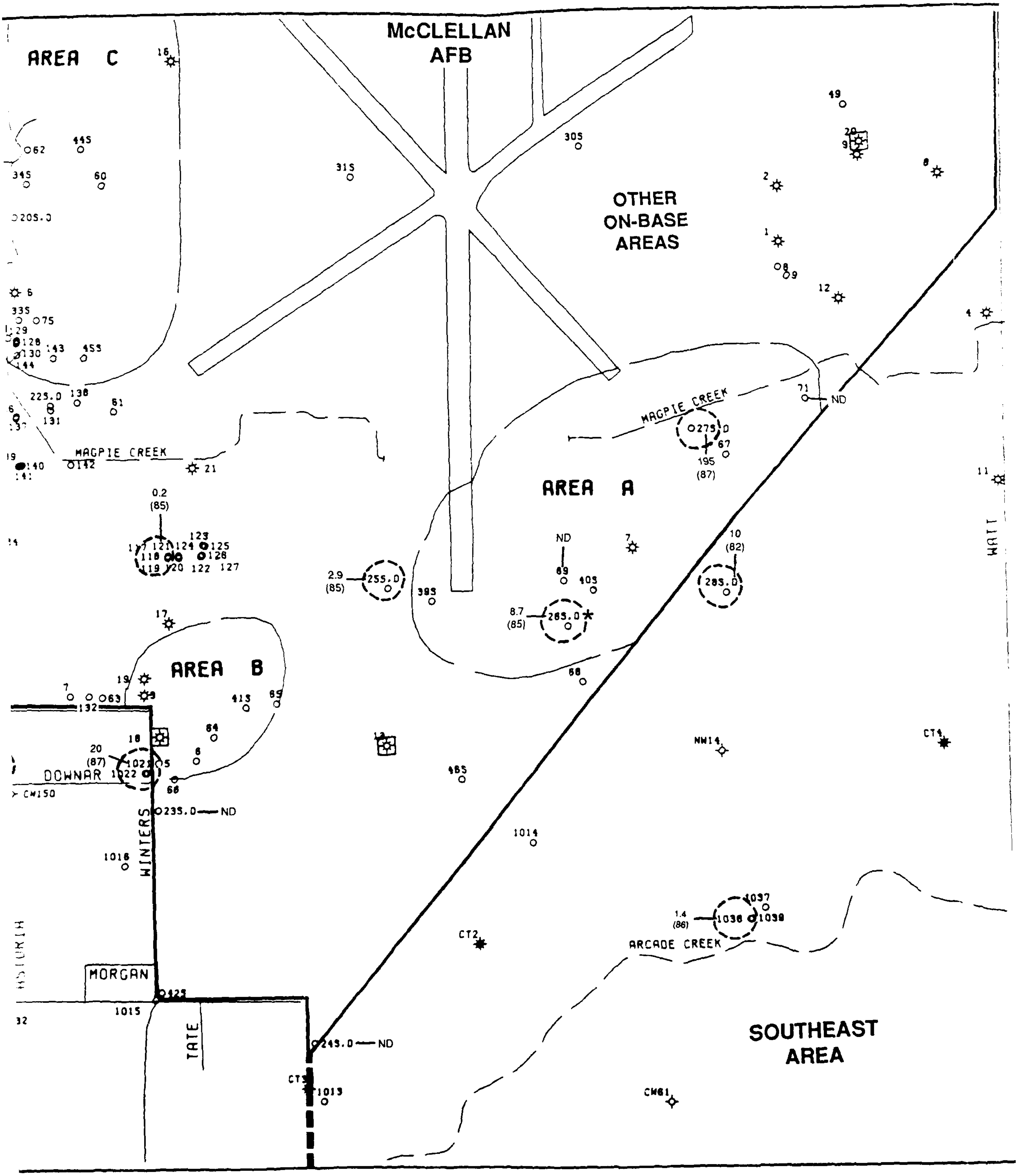
N

0 500 1000
SCALE IN FEET

GENERATED BY: DATE: 9-15-88
PEER REVIEW: DATE: 9-15-88
PROJECT REVIEW: DATE: 9-15-88

RADIAN CORPORATION


McCLELLAN AFB
AREA C
DRAINAGE
MAGPIE CREEK
WEST AREA
OTHER ON-BASE AREAS
AREA B
SOUTHWEST AREA
BELL
DOWNAR
WINTERS
NORTH
PINELL
BARBARA
ASTORIA
MORGAN
TATE
ND
0.2
(85)
2.9
(85)
8.7
(85)
0.86
(87)
20
(87)
CW150
CW132



McCLELLAN AFB
AREA C
OTHER ON-BASE AREAS
AREA A
AREA B
SOUTHEAST AREA
MAGPIE CREEK
ARCADE CREEK
DOWNAR
WINTERS
MORGAN
TATE
WATT

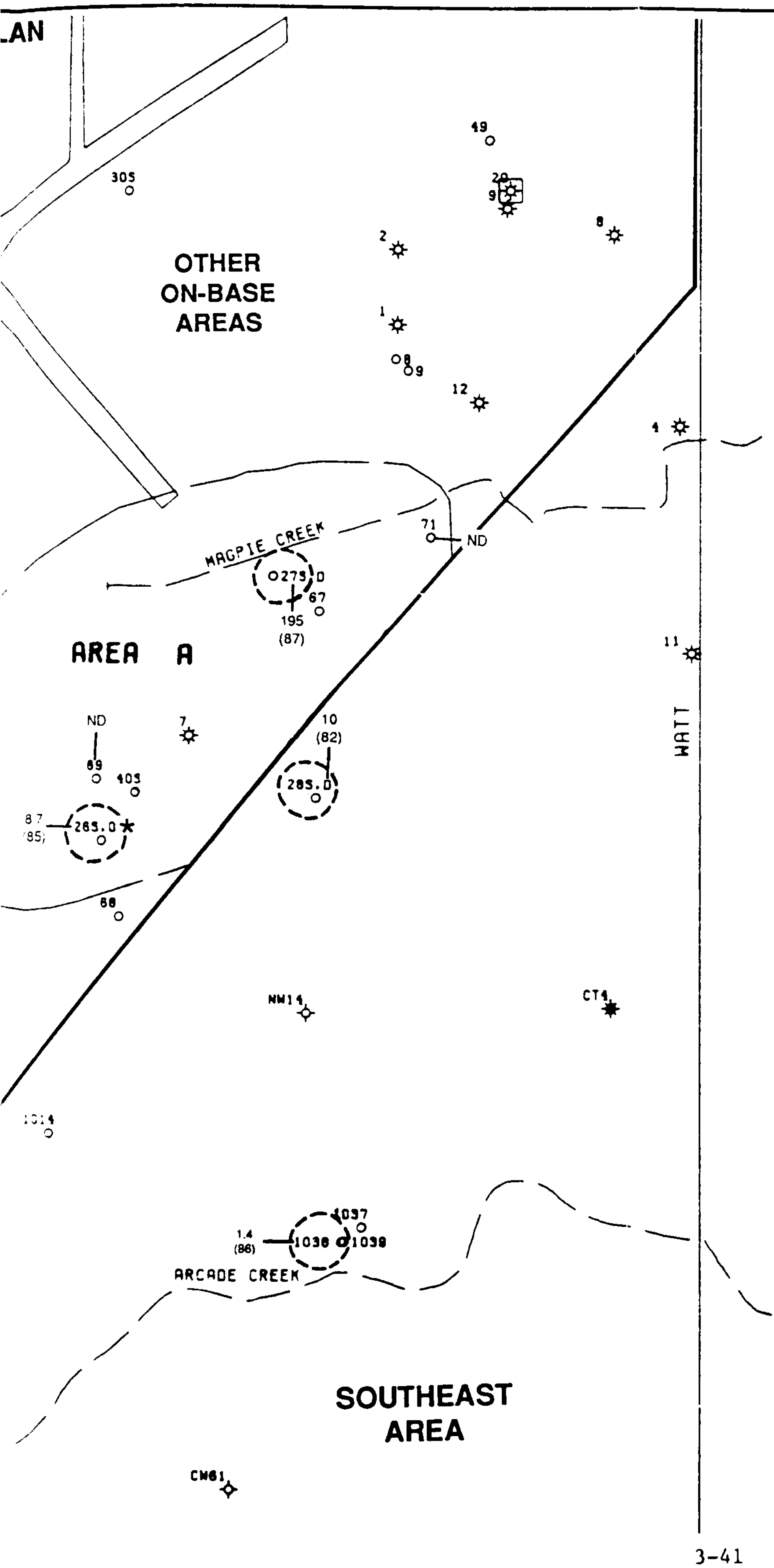


FIGURE 3-12.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN MIDDLE MONITORING ZONE OF AREAS A AND B AND ADJACENT OFF-BASE AREAS

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/ STORAGE SITES

MONITORING WELLS:

*	INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
110	MAXIMUM CONCENTRATION OF TCE (ug/L)
(85)	YEAR SAMPLED & ANALYZED
ND	TCE NOT DETECTED
— — —	APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

CW	CITY OF SACRAMENTO
NW	NORTHRIDGE WATER DISTRICT
RW	RIO LINDA
AW	ARCADE WATER DISTRICT

IRRIGATION WELLS:

CT	CALTRANS

EXTRACTION WELLS

N

0 500 1000
SCALE IN FEET

GENERATED BY: [signature] DATE: 9-15-88
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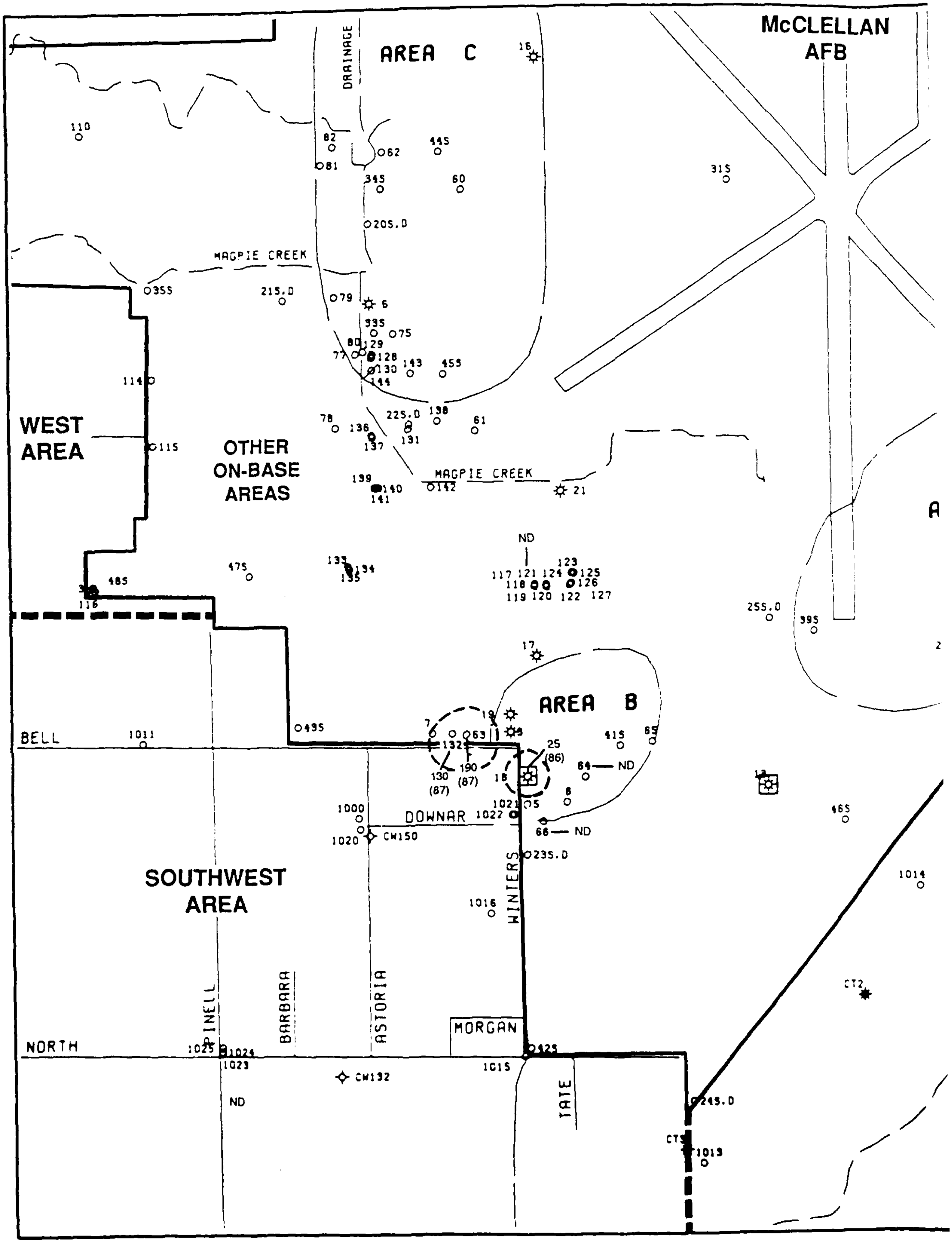
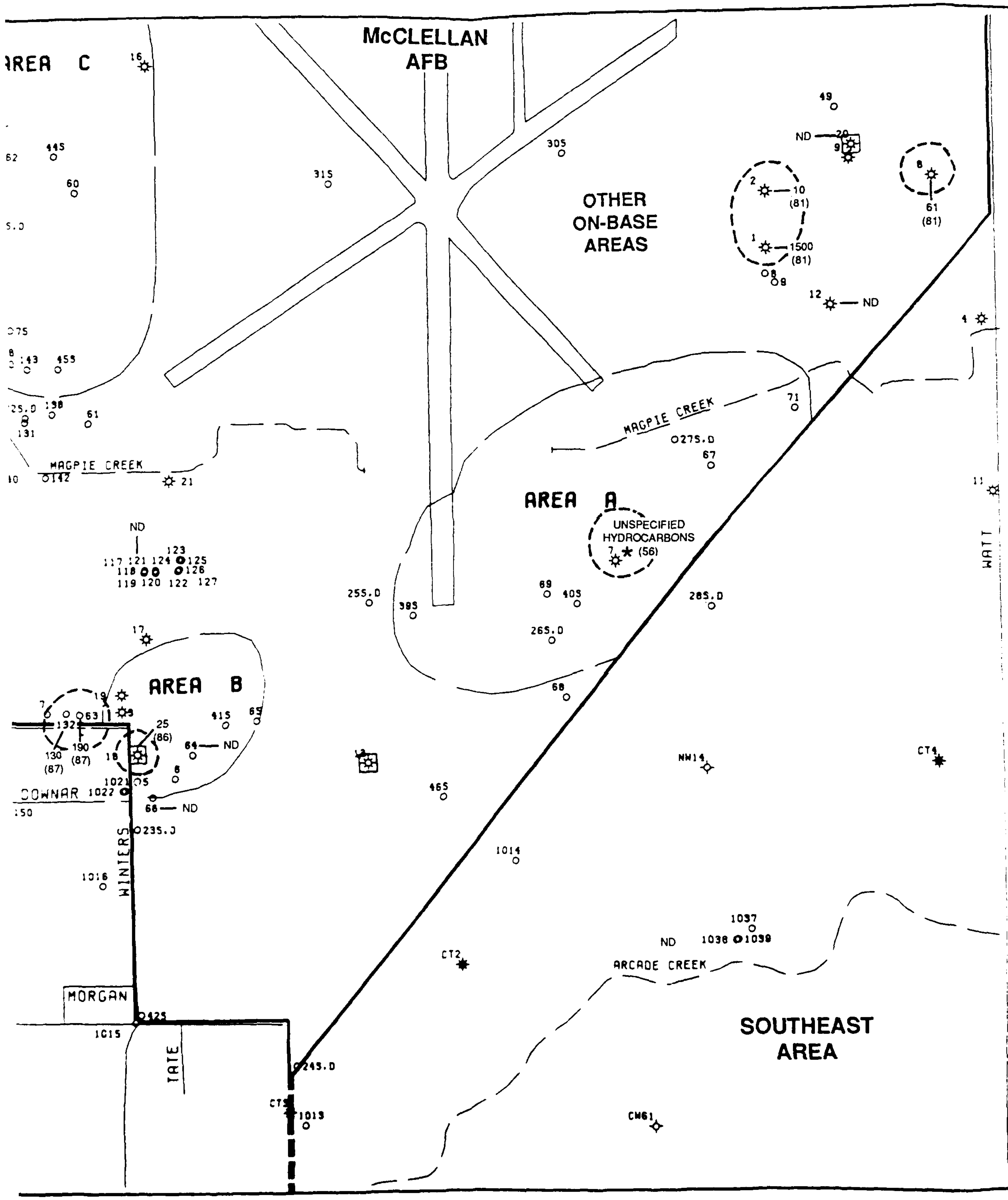
PROJECT REVIEW: Arthur Morell DATE: 9-15-88

RADIAN CORPORATION



McCLELLAN AFB
AREA C
DRAINAGE
MAGPIE CREEK
WEST AREA
OTHER ON-BASE AREAS
AREA B
SOUTHWEST AREA
BELL
DOWNAR
WINTERS
NORTH
PINELL
BARBARA
ASTORIA
MORGAN
TATE
ND


McCLELLAN
AFB
AREA C
OTHER
ON-BASE
AREAS
MAGPIE CREEK
AREA A
UNSPECIFIED
HYDROCARBONS
(56)
AREA B
DOWNAR
WINTERS
MORGAN
TATE
WATT
ARCADE CREEK
SOUTHEAST
AREA
ND
NW14
CT4
CT2
CT5
CW61

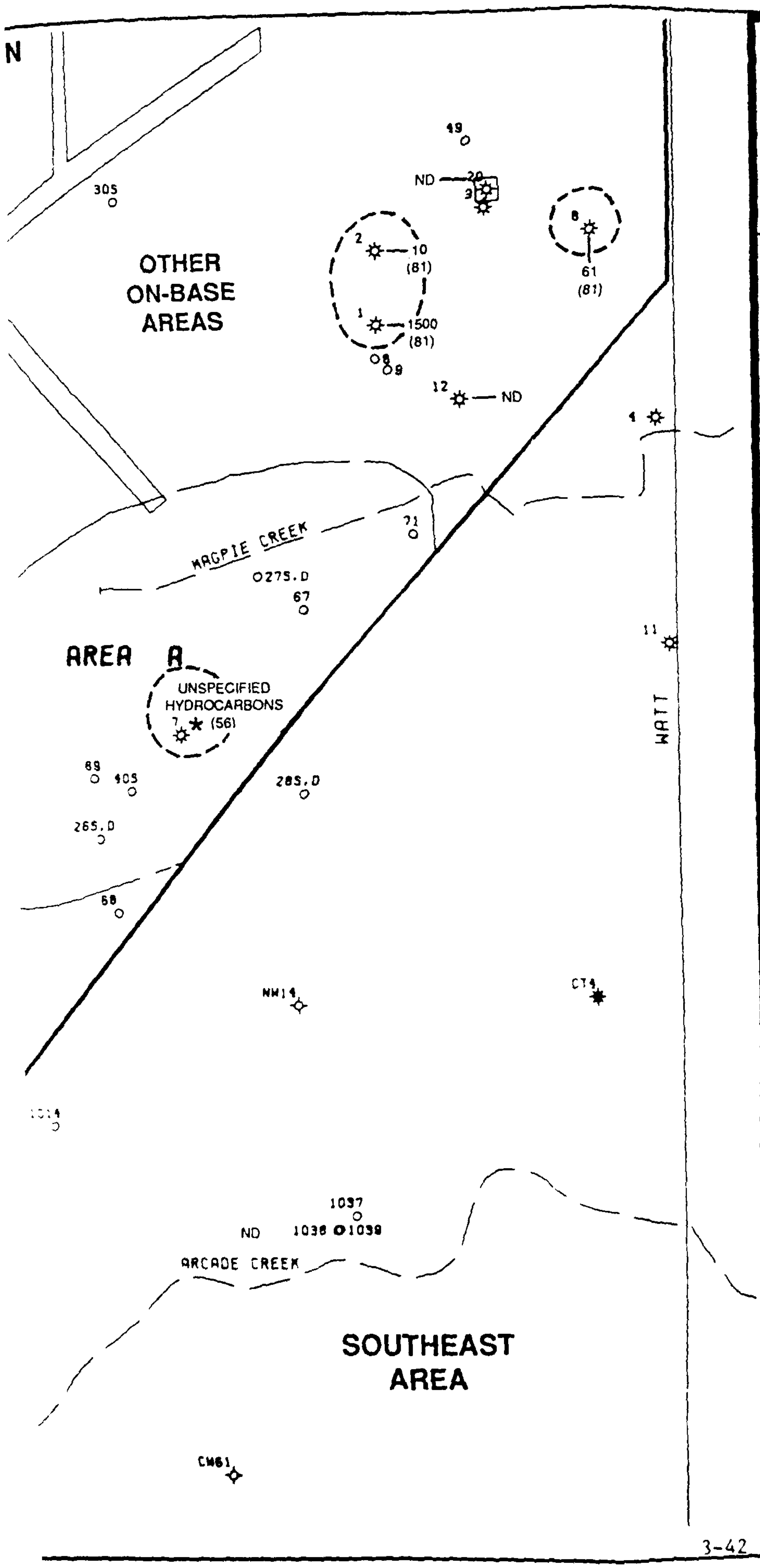


FIGURE 3-13.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN DEEP MONITORING ZONE OF AREAS A AND B AND ADJACENT ON-BASE AREAS, AND THE SOUTHEAST & SOUTHWEST AREAS

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/ STORAGE SITES

MONITORING WELLS:

- ★ INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
- 110 MAXIMUM CONCENTRATION OF TCE (ug/L)
- (85) YEAR SAMPLED & ANALYZED
- ND TCE NOT DETECTED
- APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

- CW CITY OF SACRAMENTO
- NW NORTHRIDGE WATER DISTRICT
- RW RIO LINDA
- AW ARCADE WATER DISTRICT

IRRIGATION WELLS:

- CT CALTRANS

EXTRACTION WELLS

N

0 500 1000
SCALE IN FEET

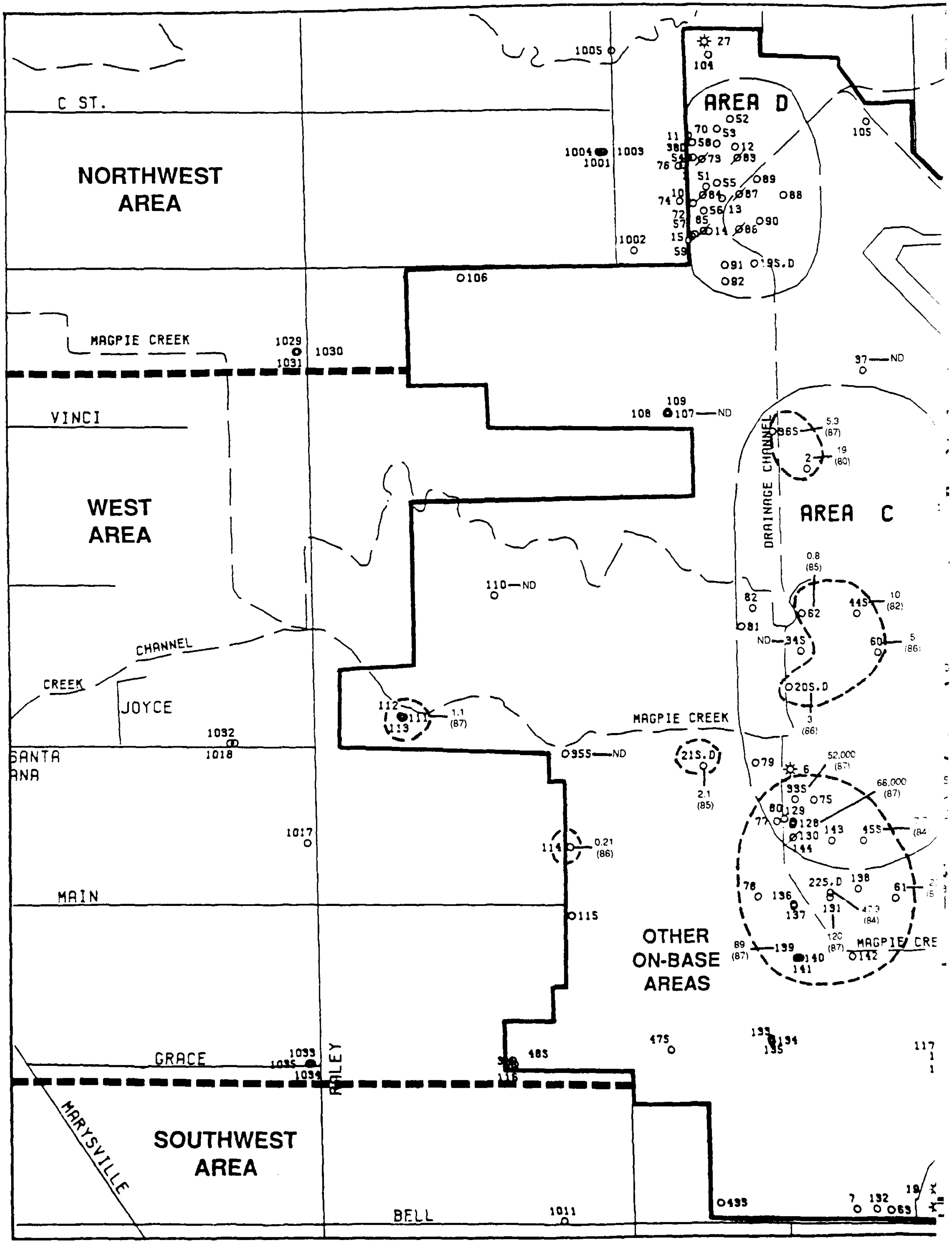
GENERATED BY: DATE: 9-15-88
PEER REVIEW: DATE: 9-15-88
PROJECT REVIEW: DATE: 9-15-88

RADIAN CORPORATION

Area C and Adjacent On-Base Areas and the West Area--As shown in Figures 3-14, 3-15, and 3-16, TCE has been detected in monitoring wells screened in the shallow, middle, and deep monitoring zones. Trichloroethene has been detected in 13 of 27 shallow monitoring zone wells, three of eight middle zone wells, and six of 13 deep zone wells. Currently, six of the shallow zone monitoring wells are dry. Table A-3, presented in Appendix A, lists the monitoring wells in Area C and the concentrations of compounds detected in these wells.

Area D and Adjacent On-Base Areas and the Northwest Area--In Area D and Adjacent On-Base Areas, TCE has been detected in 14 of 23 shallow zone monitoring wells, 9 of 17 middle zone monitoring wells, and 2 of 11 deep zone monitoring wells. Based on analysis of all monitoring wells in the off-base Northwest Area, most of the contaminants appear to be confined to the shallow monitoring zone. As shown in Figure 3-17, TCE has been detected in 13 monitoring wells both on and off base. The on-base wells include MW-10, MW-11, MW-12, MW-14, MW-15, MW-91, and MW-92. The off-base wells include MW-1002, MW-1004. MW-1005. MW-1019, MW-1029, and MW-1041. Figures 3-18 and 3-19 present the extent of TCE detected in the middle and deep monitoring zones, respectively. Trichloroethene has been detected in middle zone wells MW-52, MW-53, MW-54, MW-55, MW-57, MW-70, MW-72, and MW-1042, and in deep zone wells MW-58 and MW-59. Table A-4, presented in Appendix A, lists all monitoring wells in Area D and the off-base Northwest Area, and the concentrations of compounds detected in these monitoring wells. Compounds other than TCE that have been detected above the DHS action levels include 1,1-dichloroethene, total-1,2-dichloroethene, 1,1-dichloroethane, and 1,2-dichloroethane.

Other On-Base Areas and the Northeast Area--Most of the known storage and disposal sites are located near the designated on-base Areas A, B, C, and D. In the northeast portion of the base, TCE has been detected in one location (MW-29S and MW-29D) as shown in Figure 3-20. No halocarbon compounds of interest have been detected in the other eight monitoring wells in the Other On-Base Areas and the off-base Northeast Areas shown in Table A-5, presented in Appendix A.



C ST.
NORTHWEST AREA
AREA D
MAGPIE CREEK
VINCI
WEST AREA
DRAINAGE CHANNEL
AREA C
CHANNEL
CREEK
JOYCE
SANTA ANA
MAGPIE CREEK
MAIN
OTHER ON-BASE AREAS
GRACE
RILEY
MARYSVILLE
SOUTHWEST AREA
BELL

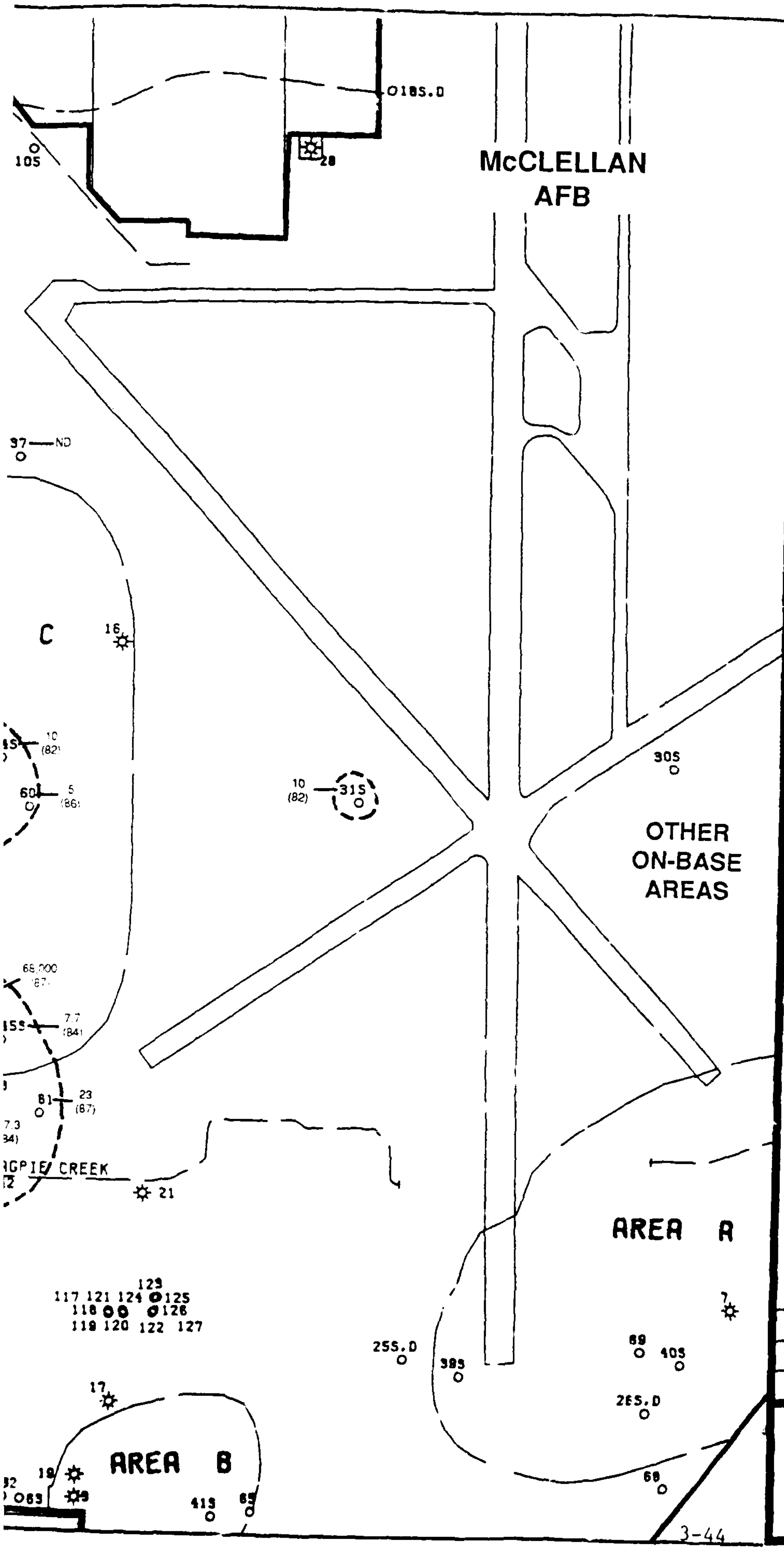


FIGURE 3-14.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN SHALLOW MONITORING ZONE OF AREA C & ADJACENT ON-BASE AREAS

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/STORAGE SITES

MONITORING WELLS:

- * INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
- 110 MAXIMUM CONCENTRATION OF TCE (ug/L)
- (85) YEAR SAMPLED & ANALYZED
- ND TCE NOT DETECTED
- APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

- CW CITY OF SACRAMENTO
- NW NORTHRIDGE WATER DISTRICT
- RW RIO LINDA
- AW ARCADE WATER DISTRICT

IRRIGATION WELLS:

- CT CALTRANS

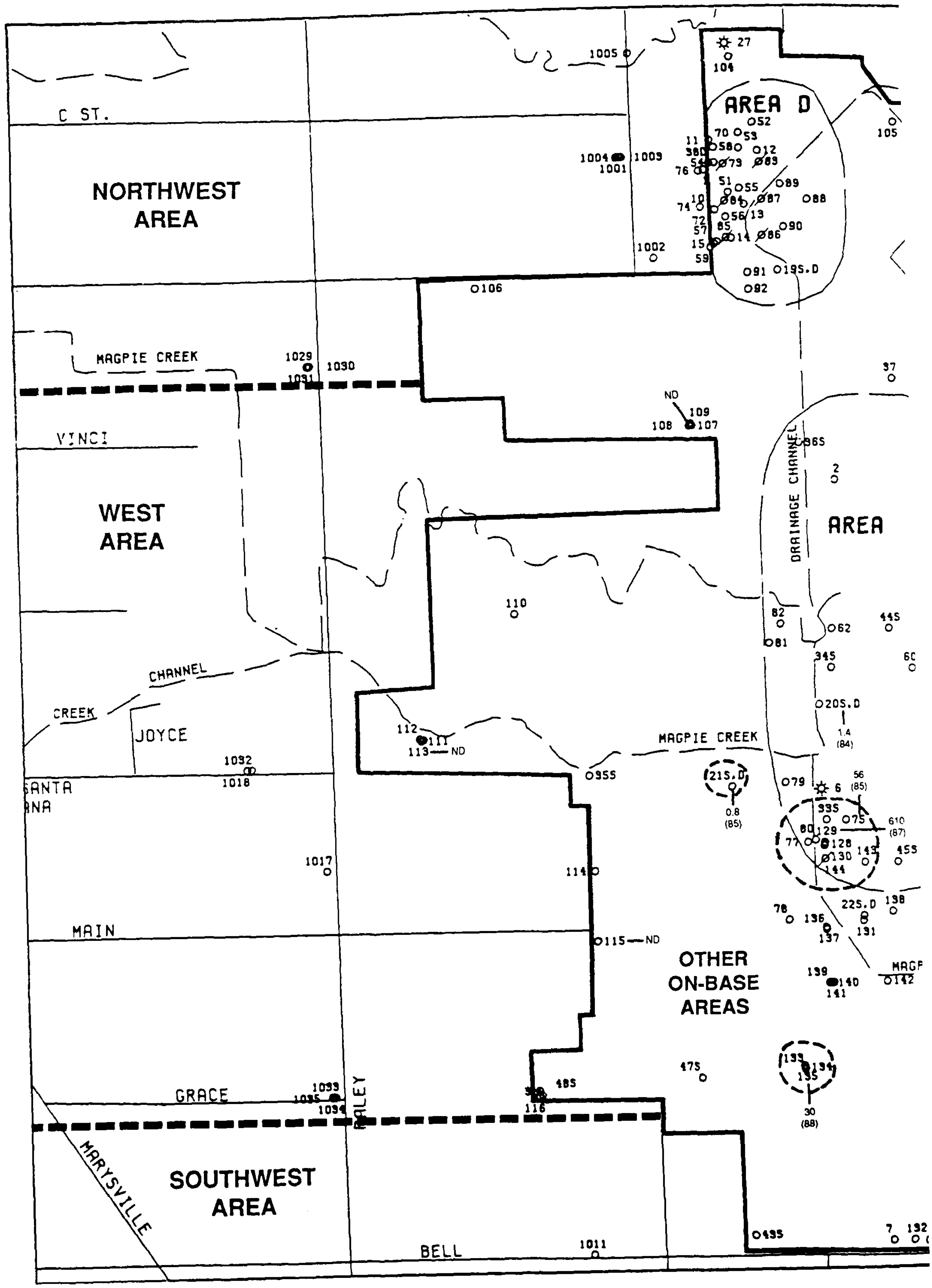
EXTRACTION WELLS

N

0 500 1000
SCALE IN FEET

GENERATED BY: [signature] DATE: 9-15-88
PEER REVIEW: [signature] DATE: 9-15-88
PROJECT REVIEW: [signature] DATE: 9-15-88

RADIAN CORPORATION


NORTHWEST AREA
WEST AREA
SOUTHWEST AREA
OTHER ON-BASE AREAS
AREA D
AREA
C ST.
MAGPIE CREEK
VINCI
CREEK CHANNEL
JOYCE
SANTA ANA
MAIN
GRACE
BELL
MARYSVILLE
PALEY
DRAINAGE CHANNEL
1005
1004
1001
1003
1002
106
1029
1030
1031
ND
109
108
107
110
112
111
113
1032
1018
1017
114
115
1033
1035
1034
116
485
475
1011
435
27
104
105
37
2
82
62
81
44S
345
60
20S.D
1.4
(84)
35S
21S.D
0.8
(85)
79
6
56
(85)
33S
75
61S
(87)
129
128
130
143
45S
144
77
80
78
136
137
22S.D
131
138
139
140
141
142
133
134
135
30
(88)
7
132
91
19S.D
92
52
70
53
58
12
83
73
89
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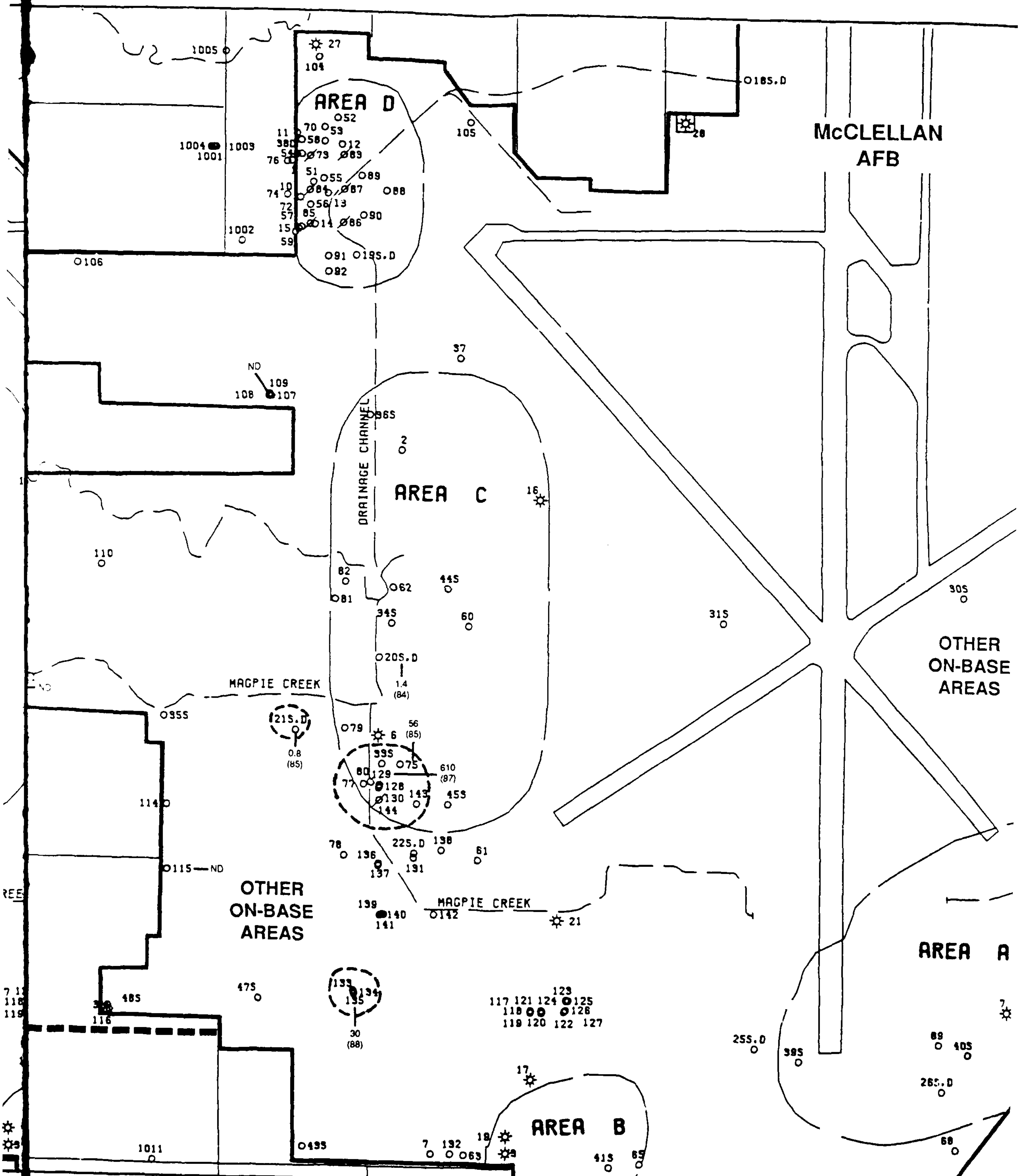

McCLELLAN
AFB
AREA D
AREA C
AREA B
AREA A
DRAINAGE CHANNEL
MAGPIE CREEK
MAGPIE CREEK
OTHER
ON-BASE
AREAS
OTHER
ON-BASE
AREAS

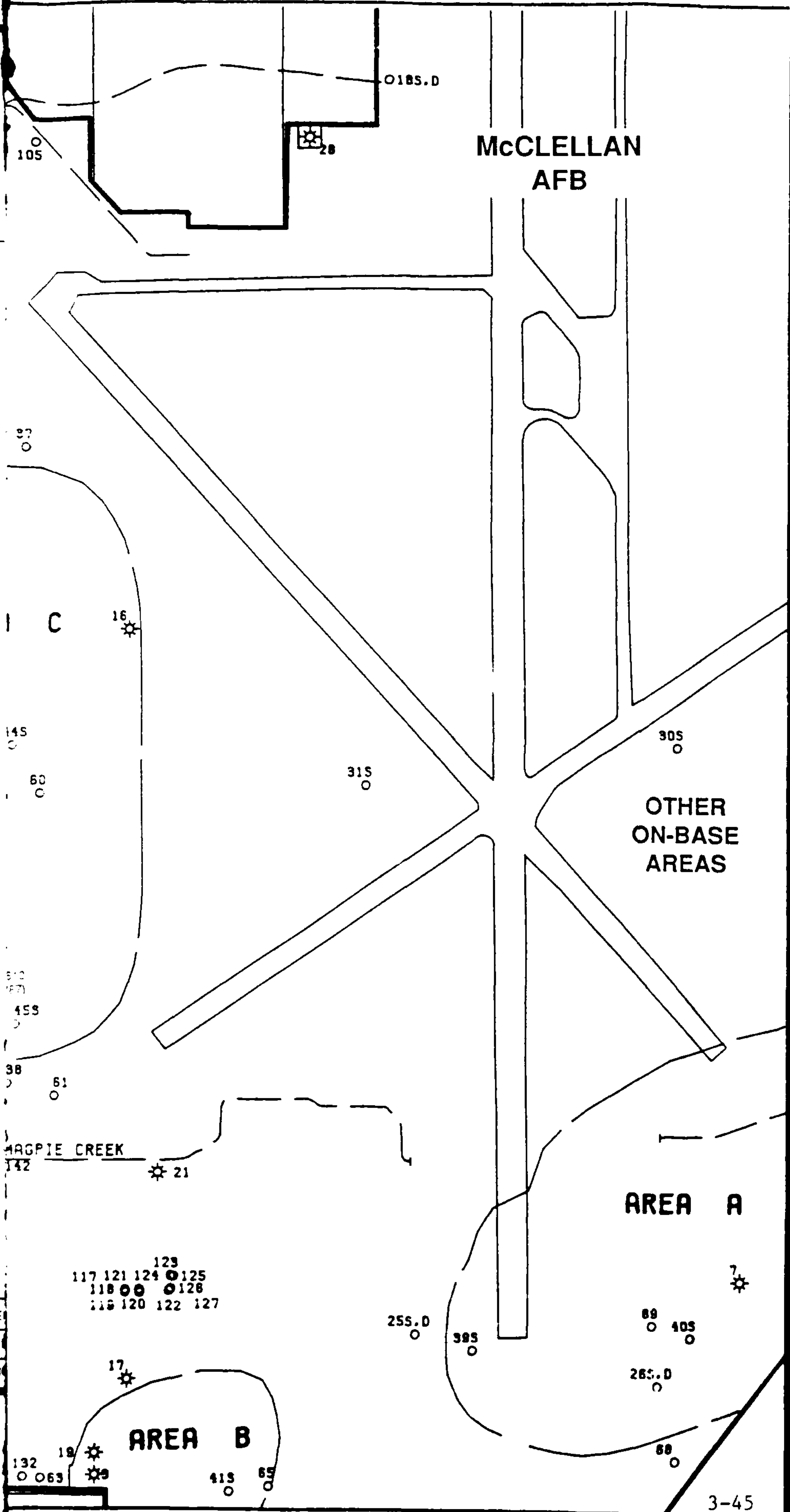


FIGURE 3-15.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN MIDDLE MONITORING ZONE OF AREA C & ADJACENT ON-BASE AREAS

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/STORAGE SITES

MONITORING WELLS:

*	INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
110	MAXIMUM CONCENTRATION OF TCE (ug/L)
(85)	YEAR SAMPLED & ANALYZED
ND	TCE NOT DETECTED
	APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

CW	CITY OF SACRAMENTO
NW	NORTHRIDGE WATER DISTRICT
RW	RIO LINDA
AW	ARCADE WATER DISTRICT

IRRIGATION WELLS:

CT	CALTRANS

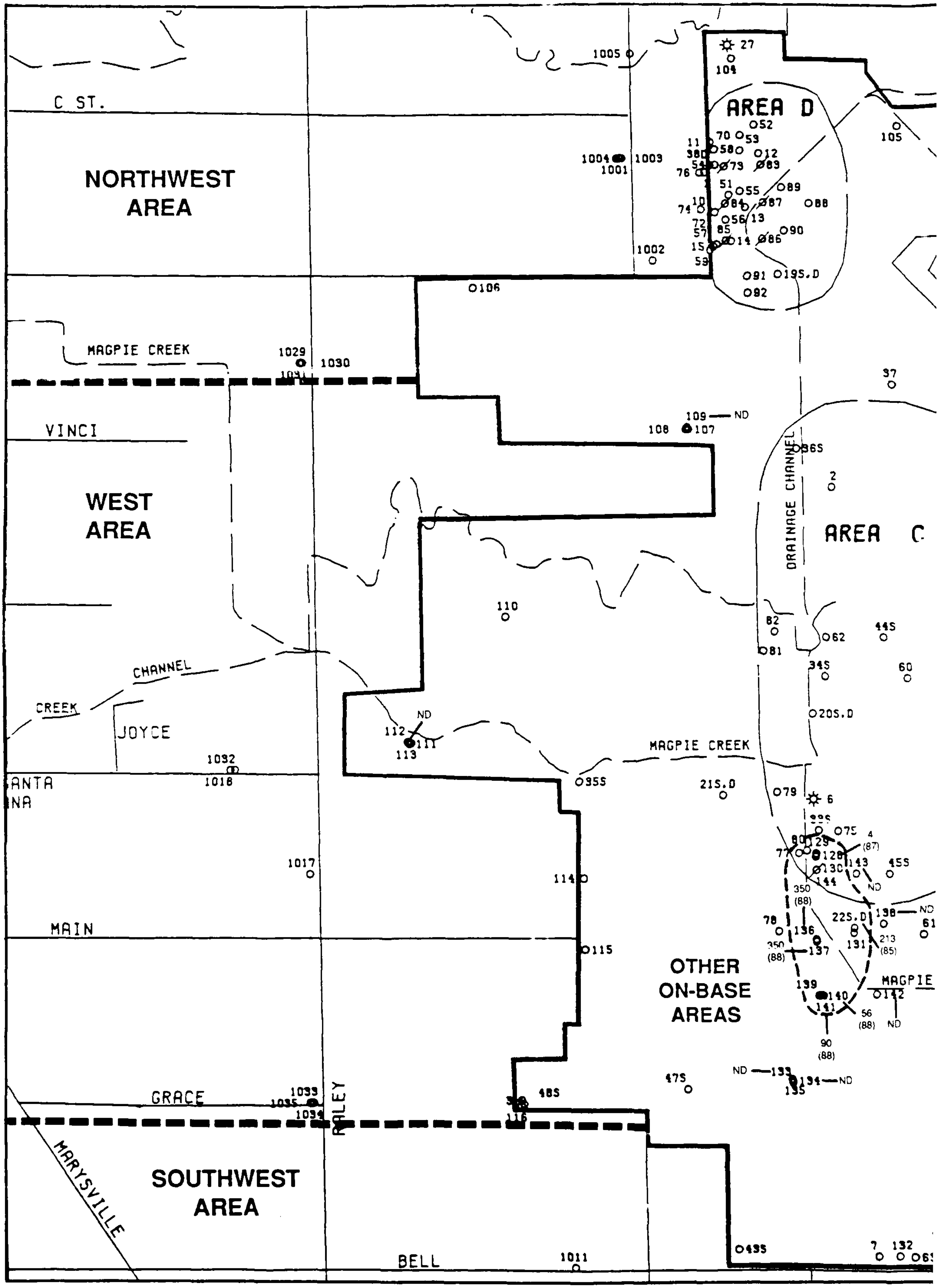
EXTRACTION WELLS

N

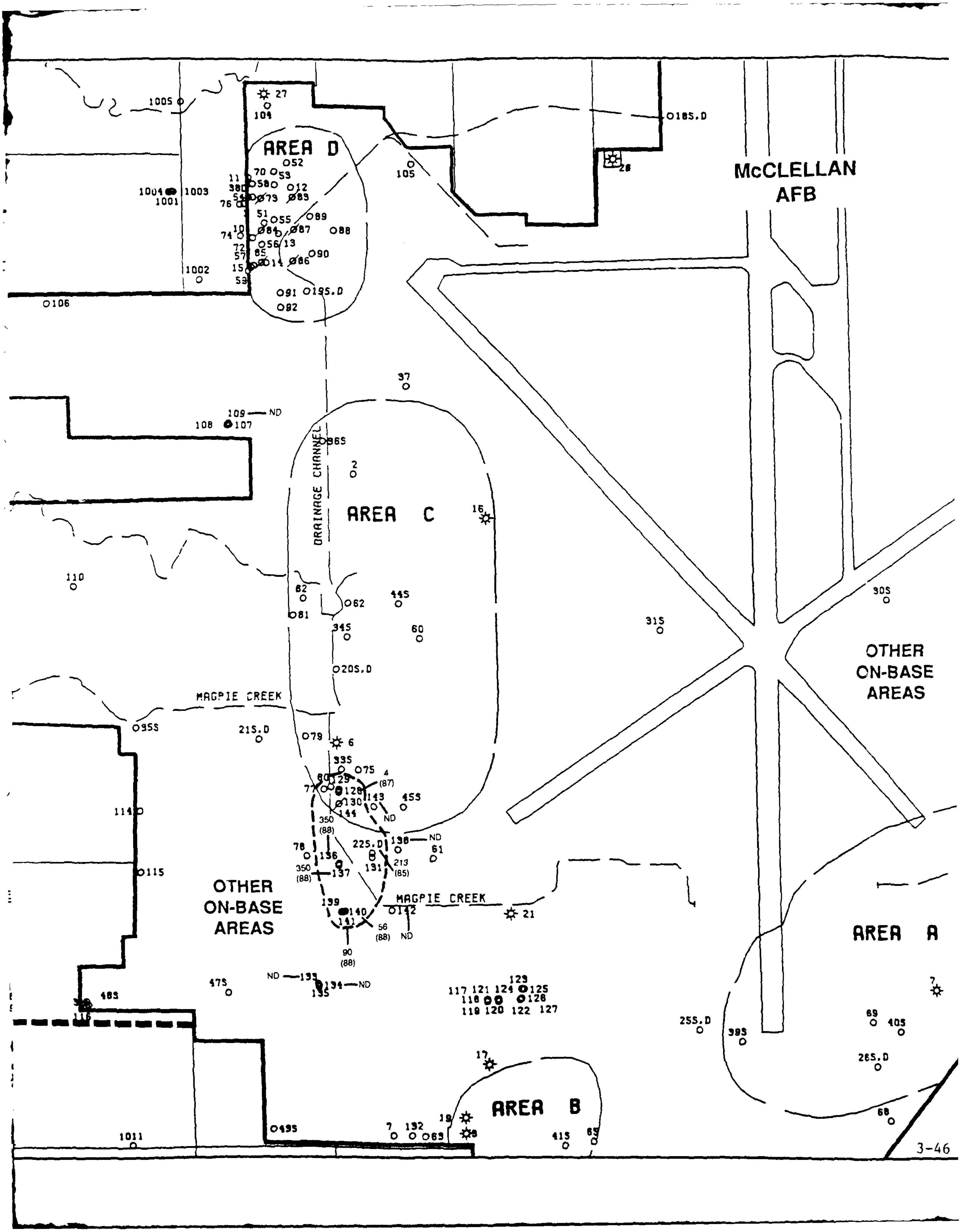
0 500 1000
SCALE IN FEET

GENERATED BY: DATE: 9-15-88
PEER REVIEW: DATE: 9-15-88
PROJECT REVIEW: DATE: 9-15-88

RADIAN CORPORATION



NORTHWEST AREA
WEST AREA
SOUTHWEST AREA
OTHER ON-BASE AREAS
AREA D
AREA C
C ST.
VINCI
JOYCE
MAIN
GRACE
BELL
MARYSVILLE
RALEY
MAGPIE CREEK
CREEK CHANNEL
DRAINAGE CHANNEL
ND



McCLELLAN AFB
AREA D
AREA C
AREA B
AREA A
OTHER ON-BASE AREAS
OTHER ON-BASE AREAS
DRAINAGE CHANNEL
MAGPIE CREEK
MAGPIE CREEK
27
104
1005
18S,D
28
105
52
70
53
11
38D
58
12
1004
1003
1001
54
73
83
76
51
89
55
10
74
84
87
88
56
13
72
57
85
90
15
14
86
1002
59
91
19S,D
106
92
37
109
ND
108
107
36S
2
16
110
82
62
44S
81
34S
60
31S
30S
20S,D
35S
21S,D
79
6
33S
75
4
(87)
80
29
77
128
143
45S
130
144
ND
350
(88)
225,D
138
ND
78
136
61
350
(88)
137
131
213
(85)
139
140
142
21
141
56
(88)
ND
90
(88)
114
115
ND
133
134
ND
135
47S
48S
116
117
121
124
129
125
118
126
119
120
122
127
25S,D
39S
69
40S
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65
49S
1011
68

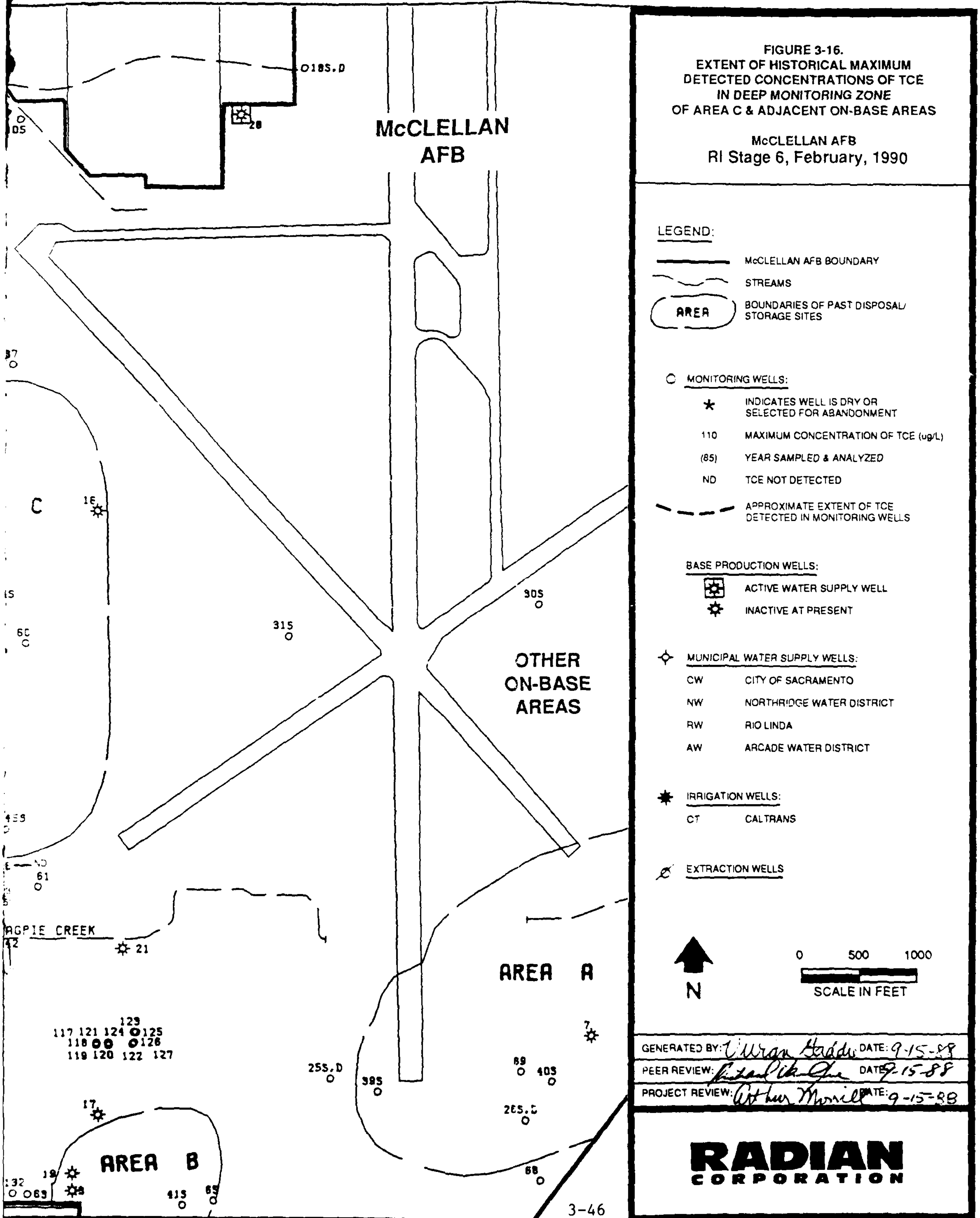
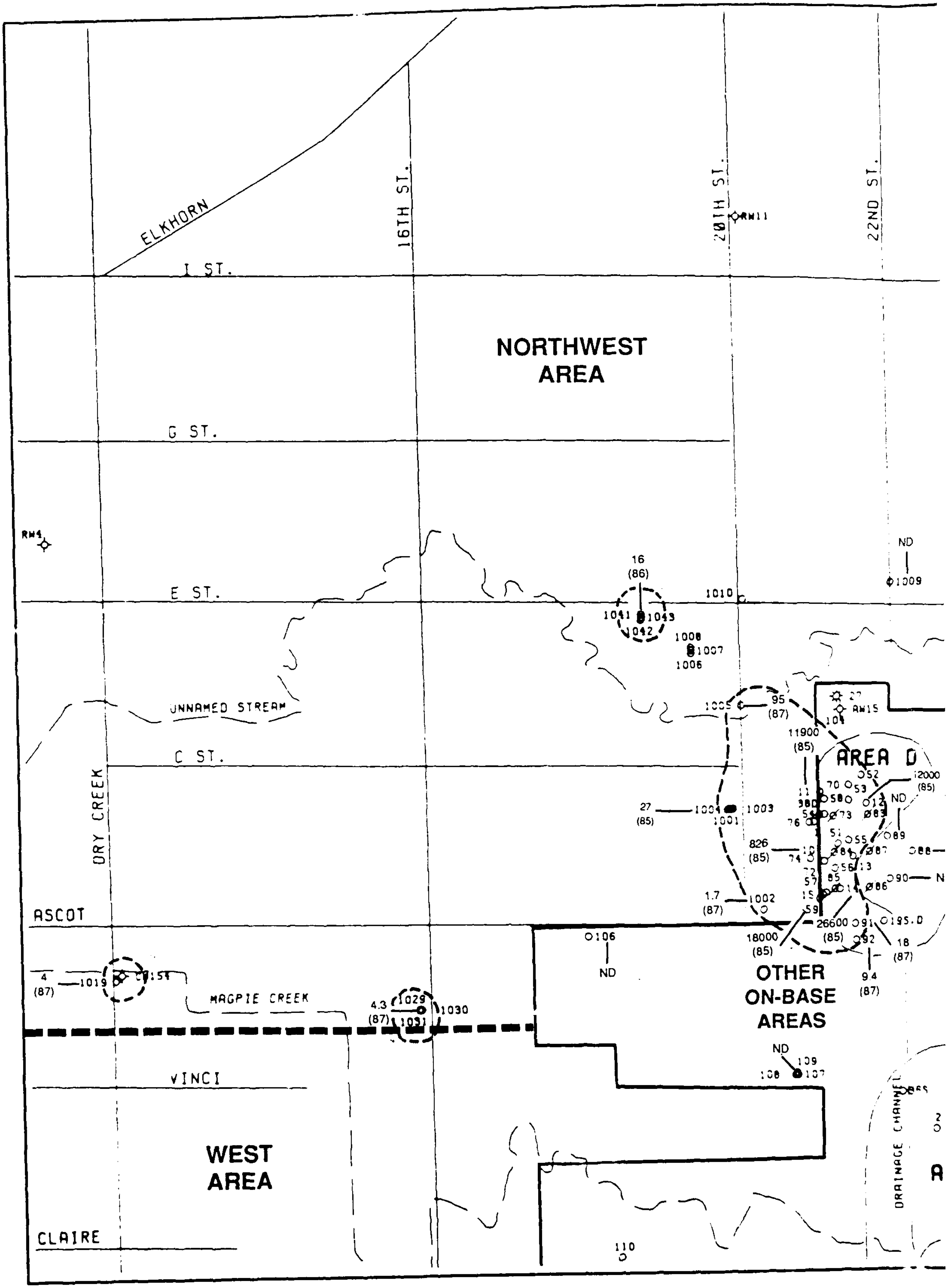
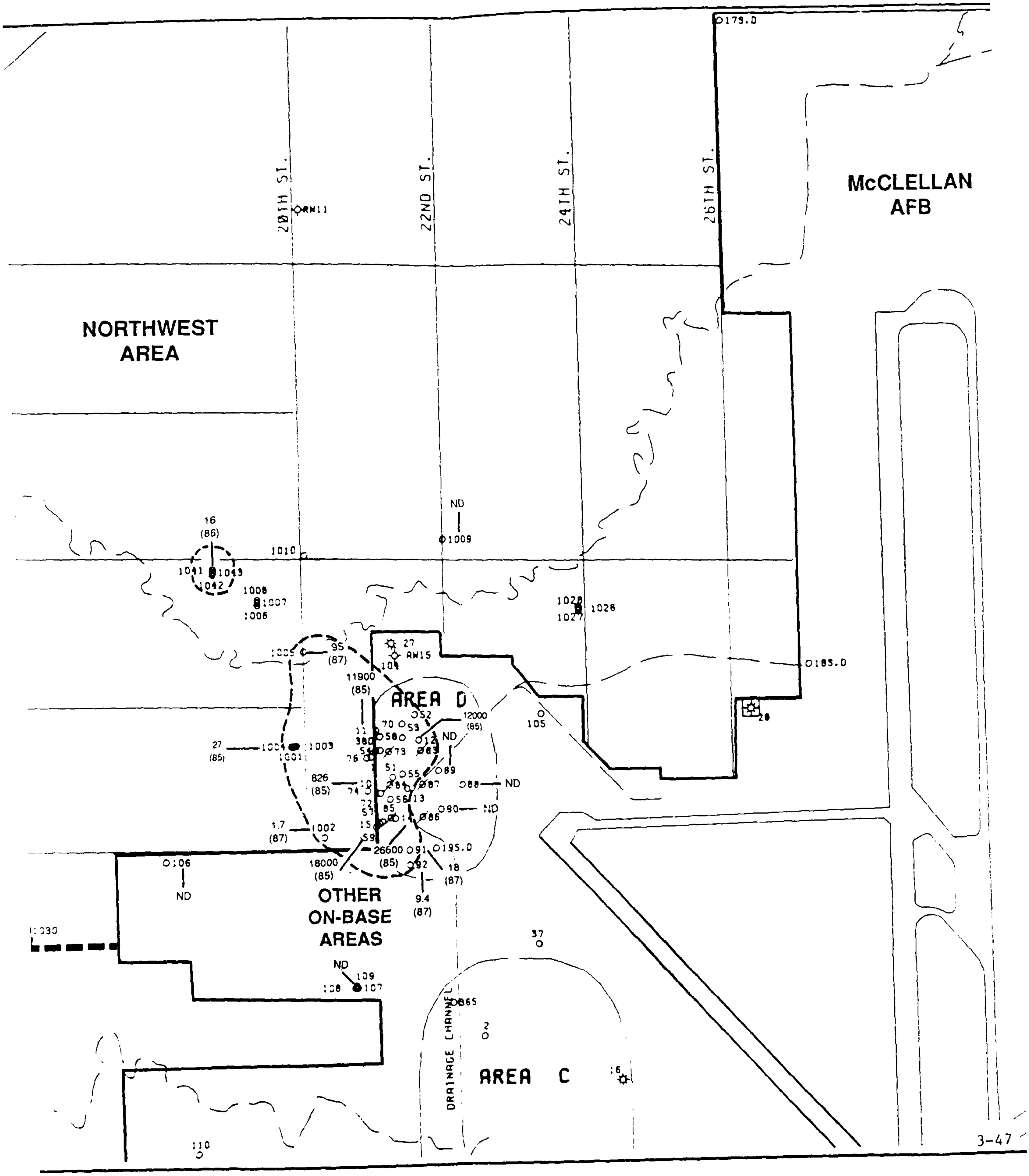


FIGURE 3-16.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN DEEP MONITORING ZONE OF AREA C & ADJACENT ON-BASE AREAS

McCLELLAN AFB
RI Stage 6, February, 1990



NORTHWEST AREA
WEST AREA
OTHER ON-BASE AREAS
AREA D
ELKHORN
I ST.
G ST.
E ST.
C ST.
16TH ST.
20TH ST.
22ND ST.
ASCOT
VINCI
CLAIRE
DRY CREEK
UNNAMED STREAM
MAGPIE CREEK
DRAINAGE CHANNEL
RW11
RW4
RW15
ND
1009
16
(86)
1041
1043
1042
1010
1008
1007
1006
1005
95
(87)
11900
(85)
12000
(85)
27
(85)
1004
1003
1001
826
(85)
1.7
(87)
1002
18000
(85)
26600
(85)
18
(87)
9.4
(87)
195.0
106
4
(87)
1019
4.3
(87)
1029
1031
1030
109
108
107
110


McCLELLAN AFB
NORTHWEST AREA
20TH ST.
22ND ST.
24TH ST.
26TH ST.
AREA D
AREA C
OTHER ON-BASE AREAS
DRAINAGE CHANNEL
ND
26600 (85)
18000 (85)
11900 (85)
12000 (85)

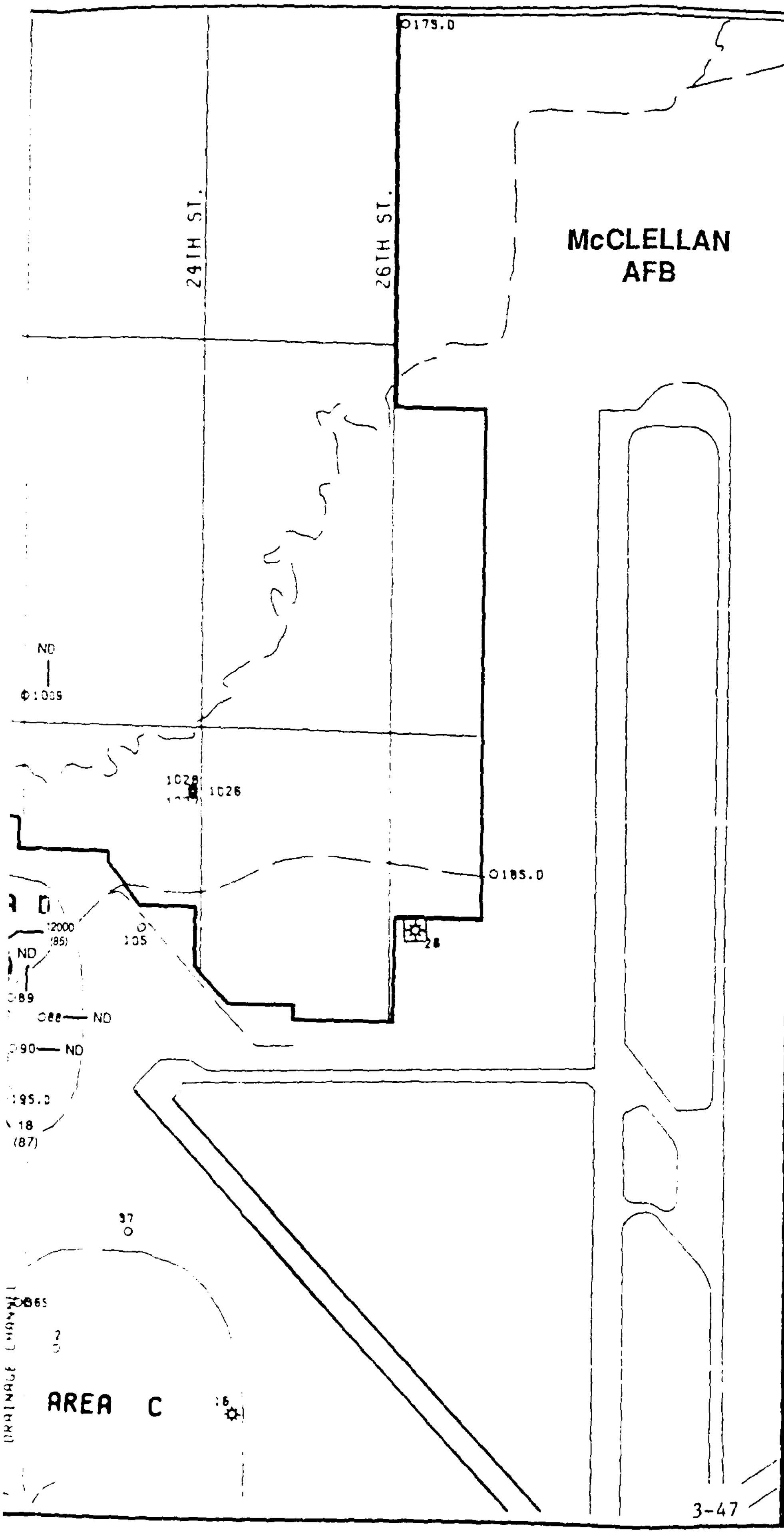


FIGURE 3-17.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN SHALLOW MONITORING ZONE OF AREA D & ADJACENT ON-BASE AREAS, AND THE NORTHWEST AREA

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/ STORAGE SITES

MONITORING WELLS:

- * INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
- 110 MAXIMUM CONCENTRATION OF TCE (μg/L)
- (85) YEAR SAMPLED & ANALYZED
- ND TCE NOT DETECTED
- APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

- CW CITY OF SACRAMENTO
- NW NORTHRIDGE WATER DISTRICT
- RW RIO LINDA
- AW ARCADE WATER DISTRICT

IRRIGATION WELLS:

- CT CALTRANS

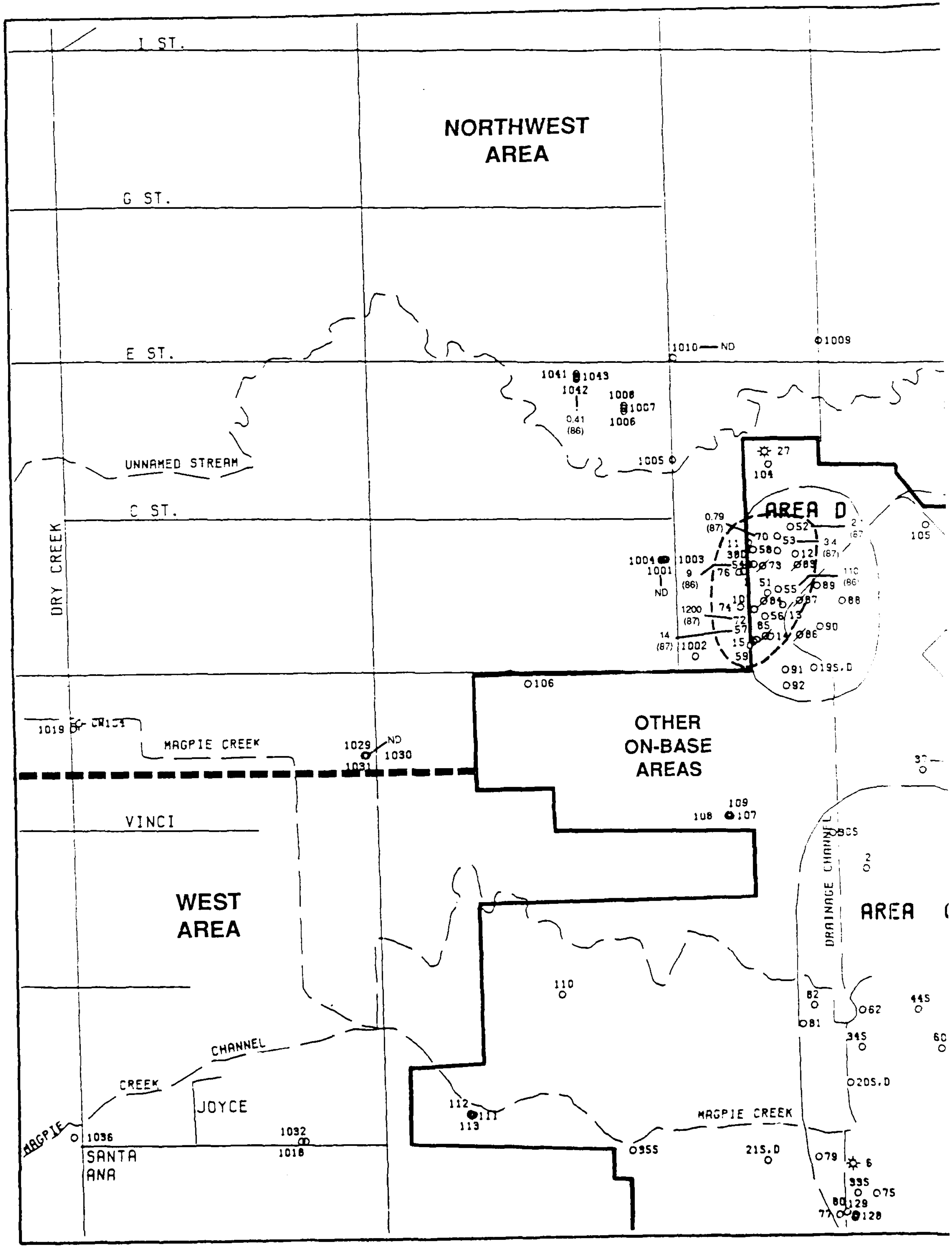
EXTRACTION WELLS

N

0 500 1000
SCALE IN FEET

GENERATED BY: [signature] DATE: 9-15-88
PEER REVIEW: [signature] DATE: 9-15-88
PROJECT REVIEW: [signature] DATE: 9-15-88

RADIAN CORPORATION



I ST.
NORTHWEST
AREA
G ST.
E ST.
UNNAMED STREAM
C ST.
DRY CREEK
AREA D
OTHER
ON-BASE
AREAS
MAGPIE CREEK
VINCI
WEST
AREA
DRAINAGE CHANNEL
AREA
CHANNEL
CREEK
MAGPIE
JOYCE
SANTA
ANA
MAGPIE CREEK
1010 — ND
1009
1041 1043
1042
0.41
(86)
1008
1007
1006
1005
27
104
0.79
(87)
1004
1003
1001
ND
9
(86)
1200
(87)
14
(87)
1002
106
1019
1029
ND
1030
1031
109
108
107
110
112
111
113
1036
1032
1018
105
955
215.D
79
6
335
075
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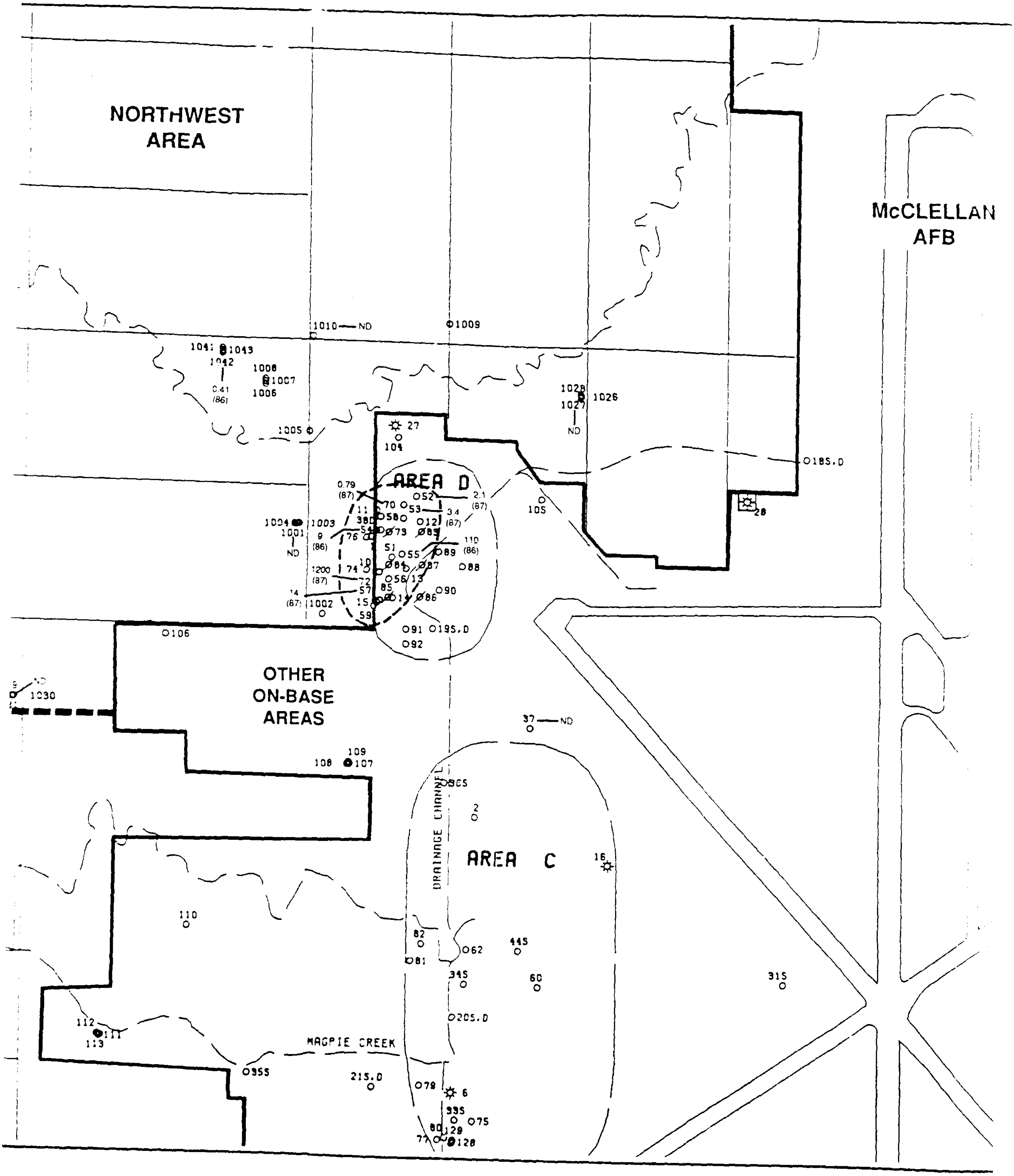
81
62
445
345
205.D


NORTHWEST AREA
McCLELLAN AFB
AREA D
OTHER ON-BASE AREAS
AREA C
DRAINAGE CHANNEL
MAGPIE CREEK
1010 — ND
1009
1041
1043
1042
1008
1007
1006
1005
1028
1026
1027
ND
27
104
18S,D
28
105
1004
1003
1001
ND
19S,D
106
37 — ND
109
108
107
30S
2
16
110
82
81
62
44S
34S
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75
80
129
77
128

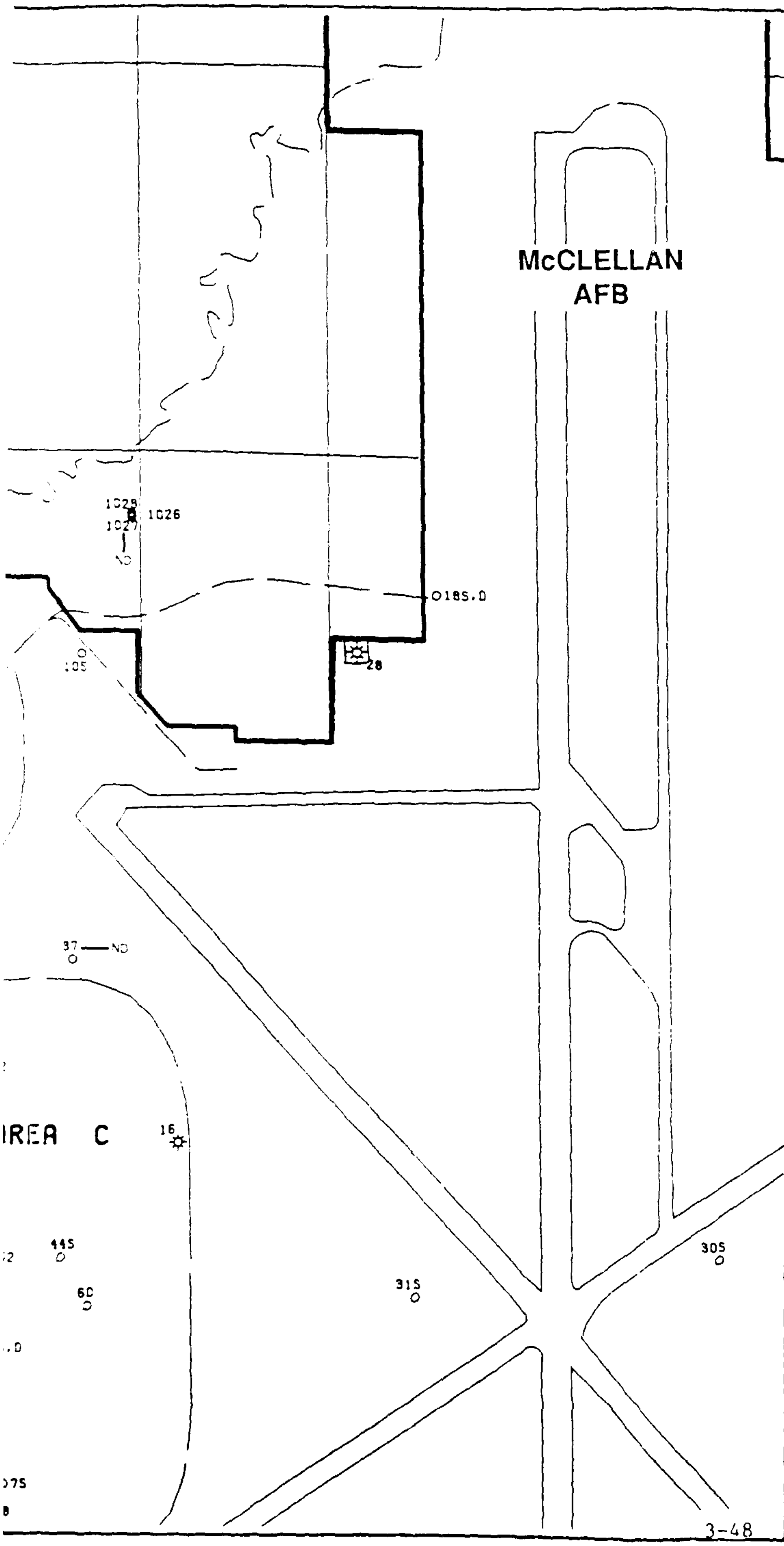


FIGURE 3-18.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN MIDDLE MONITORING ZONE OF AREA D & ADJACENT ON-BASE AREAS, AND THE NORTHWEST AREA

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/ STORAGE SITES

MONITORING WELLS:

- * INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
- 110 MAXIMUM CONCENTRATION OF TCE (ug/L)
- (85) YEAR SAMPLED & ANALYZED
- ND TCE NOT DETECTED
- APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

- CW CITY OF SACRAMENTO
- NW NORTHRIDGE WATER DISTRICT
- RW RIO LINDA
- AW ARCADE WATER DISTRICT

IRRIGATION WELLS:

- CT CALTRANS

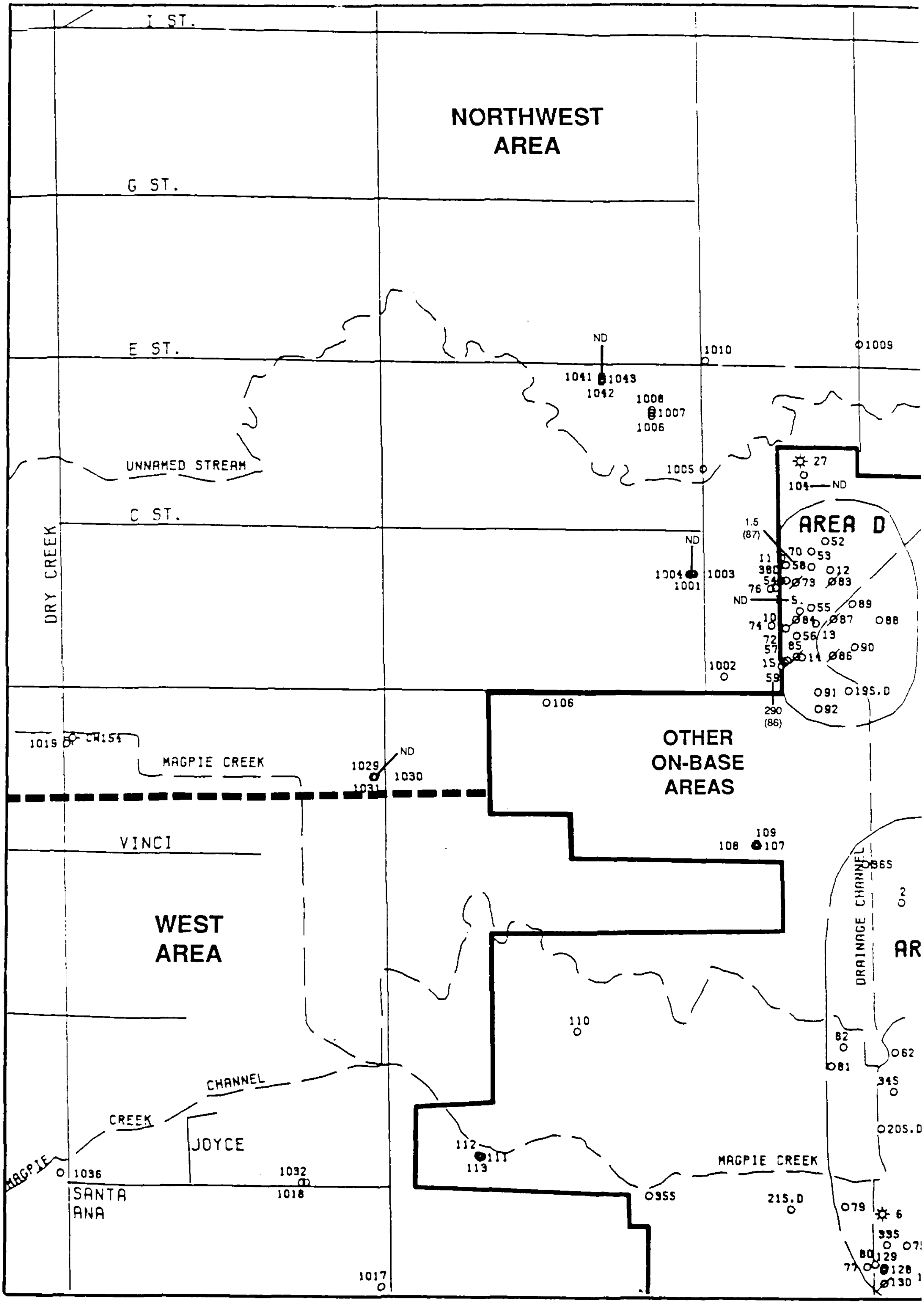
EXTRACTION WELLS

N

0 500 1000
SCALE IN FEET

GENERATED BY: William Haddix DATE: 9-15-88
PEER REVIEW: Arthur Morel DATE: 9-15-88
PROJECT REVIEW: [signature] DATE: 9-15-88

RADIAN CORPORATION



NORTHWEST AREA
I ST.
G ST.
E ST.
C ST.
DRY CREEK
UNNAMED STREAM
AREA D
OTHER ON-BASE AREAS
WEST AREA
MAGPIE CREEK
VINCI
MAGPIE CREEK CHANNEL
JOYCE
SANTA ANA
DRAINAGE CHANNEL
ND
1009
1010
1041
1043
1042
1008
1007
1006
1005
27
104
1.5 (87)
52
70
53
11
38D
58
12
54
73
83
76
1004
1003
1001
5
55
89
10
74
84
87
88
72
56
13
57
85
90
15
14
86
1002
59
91
19S,D
290 (86)
92
106
1019
CW154
1029
1030
1031
109
108
107
86S
2
110
82
62
81
34S
20S,D
112
111
113
1036
1032
1018
95S
21S,D
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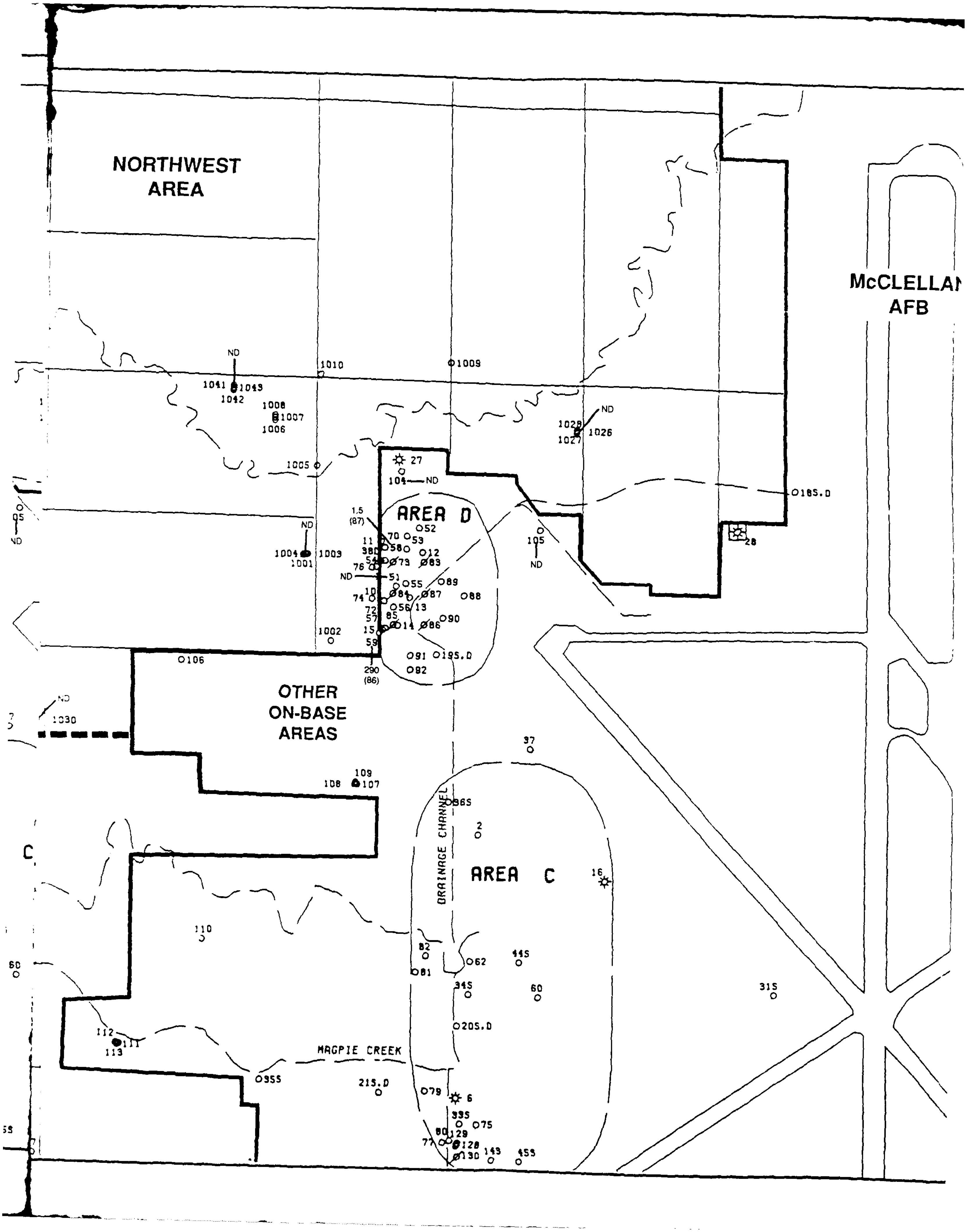
129
128
77
130
1017



NORTHWEST AREA
McCLELLAN AFB
AREA D
OTHER ON-BASE AREAS
AREA C
DRAINAGE CHANNEL
MAGPIE CREEK
ND
1041
1043
1042
1010
1009
1008
1007
1006
1005
1028
1027
1026
27
104
185.D
28
105
1004
1001
1003
1002
106
1030
109
108
107
195.D
290 (86)
37
86S
2
16
110
82
81
62
44S
34S
60
31S
20S.D
112
111
113
95S
21S.D
79
6
33S
75
80
129
77
128
130
14S
45S

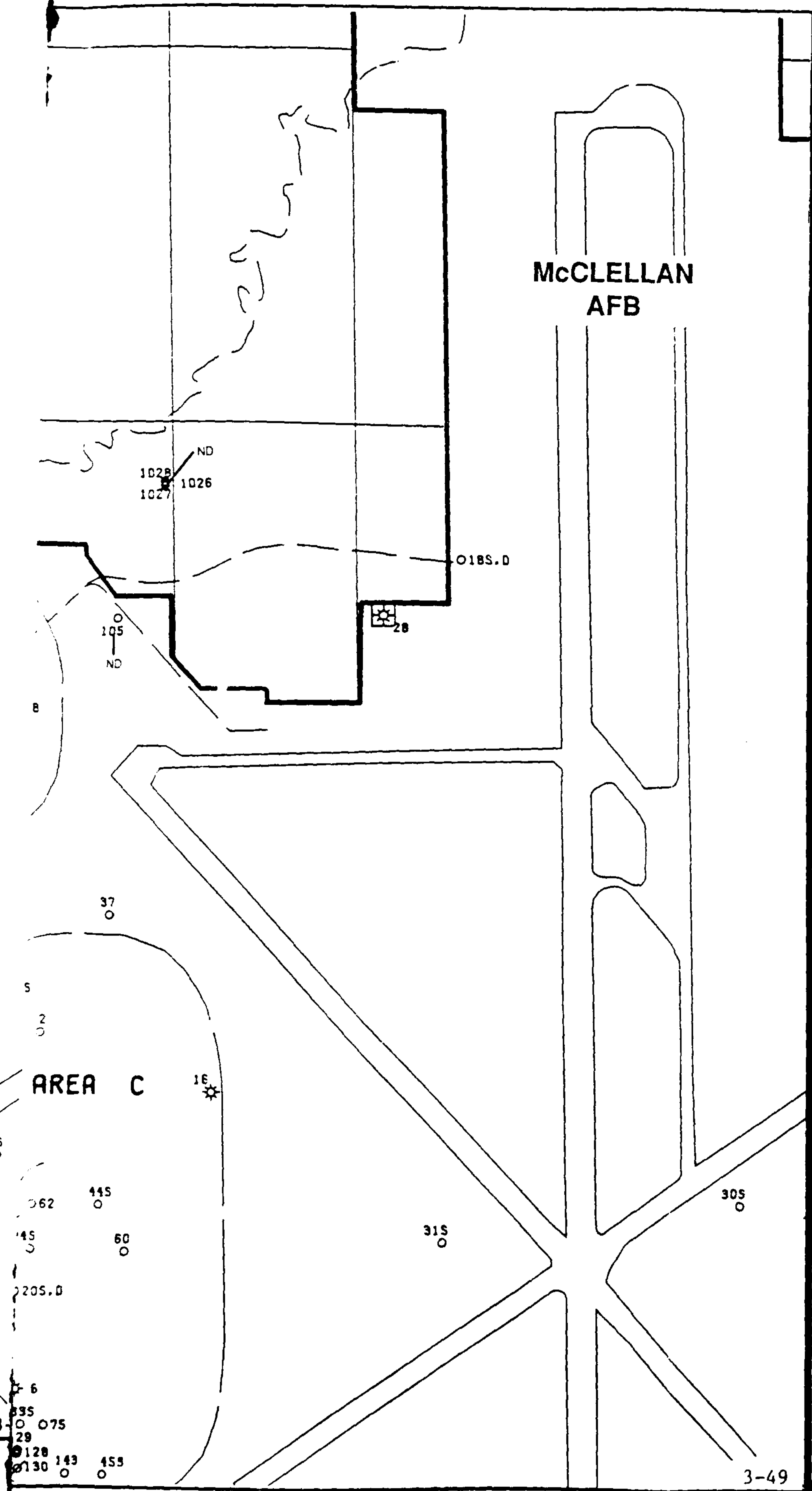


FIGURE 3-19.
EXTENT OF HISTORICAL MAXIMUM
DETECTED CONCENTRATIONS OF TCE
IN DEEP MONIOTIRNG ZONE
OF AREA D & ADJACENT ON-BASE AREAS,
AND THE NORTHWEST AREA

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/ STORAGE SITES

MONITORING WELLS:

- * INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
- 110 MAXIMUM CONCENTRATION OF TCE (ug/L)
- (85) YEAR SAMPLED & ANALYZED
- ND TCE NOT DETECTED
- APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:

- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:

- CW CITY OF SACRAMENTO
- NW NORTHRIDGE WATER DISTRICT
- RW RIO LINDA
- AW ARCADE WATER DISTRICT

IRRIGATION WELLS:

- CT CALTRANS

EXTRACTION WELLS

N

0 500 1000
SCALE IN FEET

GENERATED BY: Duran Griddle DATE: 9-15-88
PEER REVIEW: Arthur Ploni DATE: 9-15-88
PROJECT REVIEW: [signature] DATE: 9-15-88

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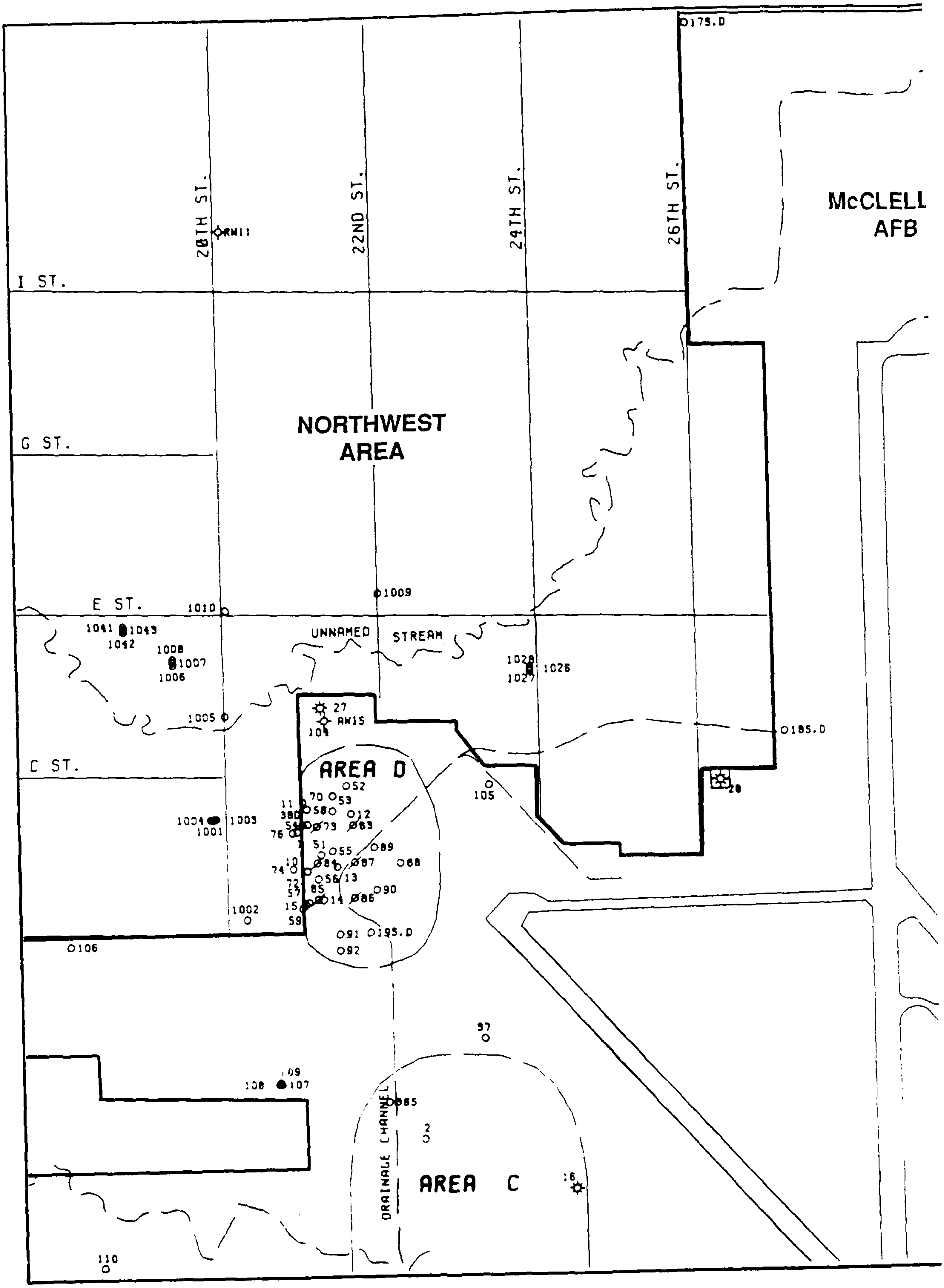
CORPORATION



McCLELL
AFB
NORTHWEST
AREA
20TH ST.
22ND ST.
24TH ST.
26TH ST.
I ST.
G ST.
E ST.
C ST.
UNNAMED STREAM
AREA D
AREA C
DRAINAGE CHANNEL
175.D
185.D
195.D
RW11
RW15
1009
1010
1041
1042
1043
1008
1007
1006
1005
1028
1027
1026
1004
1001
1003
1002
106
105
27
28
52
53
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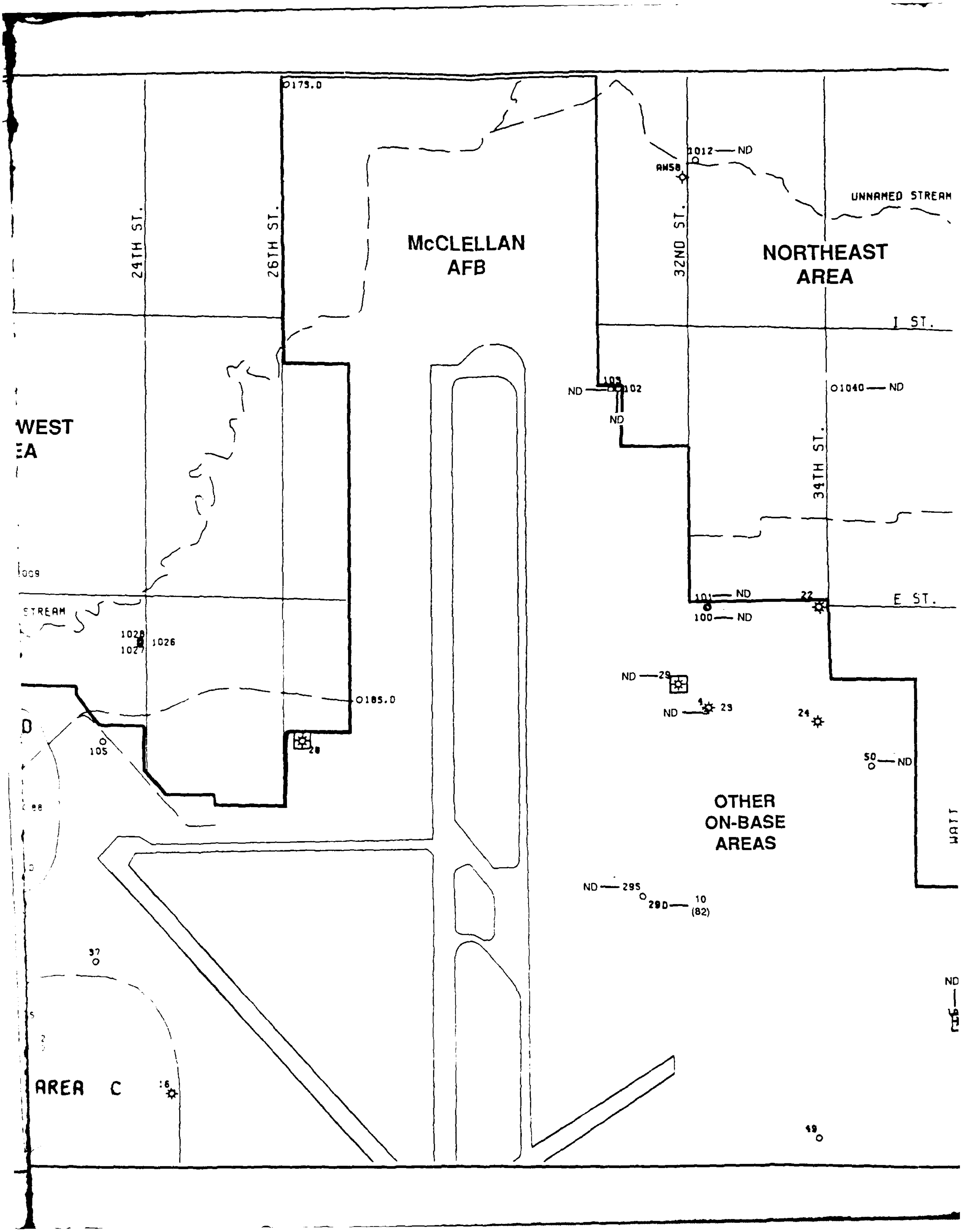
107
65
110


McCLELLAN AFB
NORTHEAST AREA
WEST AREA
OTHER ON-BASE AREAS
AREA C
24TH ST.
26TH ST.
32ND ST.
34TH ST.
I ST.
E ST.
UNNAMED STREAM
STREAM
WATT
173.D
1012 — ND
AW58
1040 — ND
ND — 103 102
ND
101 — ND
100 — ND
22
1028
1027
1026
185.D
ND — 29
ND — 23
24
50 — ND
28
105
ND — 295
290 — 10 (82)
37
16
49
ND

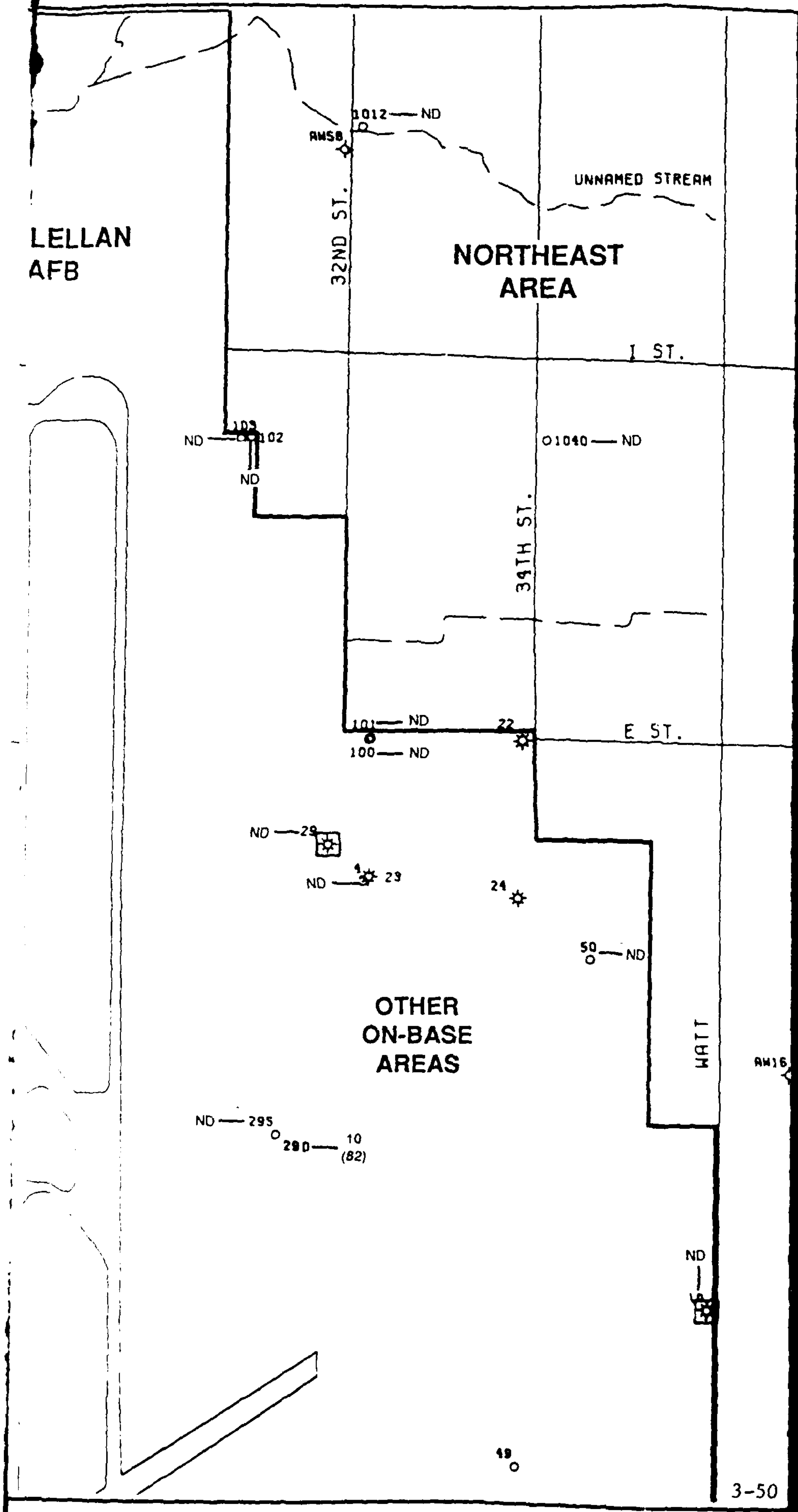


FIGURE 3-20.
EXTENT OF HISTORICAL MAXIMUM DETECTED CONCENTRATIONS OF TCE IN ALL MONITORING ZONES OF OTHER ON-BASE AREAS (NORTHEAST McCLELLAN AFB) & THE NORTHEAST AREA

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/STORAGE SITES

MONITORING WELLS:
- * INDICATES WELL IS DRY OR SELECTED FOR ABANDONMENT
- 110 MAXIMUM CONCENTRATION OF TCE (ug/L)
- (85) YEAR SAMPLED & ANALYZED
- ND TCE NOT DETECTED
- APPROXIMATE EXTENT OF TCE DETECTED IN MONITORING WELLS

BASE PRODUCTION WELLS:
- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS:
- CW CITY OF SACRAMENTO
- NW NORTHRIDGE WATER DISTRICT
- RW RIO LINDA
- AW ARCADE WATER DISTRICT

IRRIGATION WELLS:
- CT CALTRANS

EXTRACTION WELLS

N

0 500 1000
SCALE IN FEET

GENERATED BY: [signature] DATE: 9-15-88
PEER REVIEW: [signature] DATE: 9-15-88
PROJECT REVIEW: [signature] DATE: 9-15-88

RADIAN
CORPORATION

3.3.3 Water Use

The communities in the vicinity of McClellan AFB receive water from private and municipal wells. Most of the water for North Highlands is supplied by the Arcade Water District. The Rio Linda Water District and the Northridge Water District also supply water to the North Highlands community. North Sacramento receives water from the City of Sacramento Water Department. Many private wells are still in use in the area north of El Camino Boulevard in North Sacramento.

Rio Linda and Elverta receive water from the Rio Linda Water District and from private wells. In 1986, the Rio Linda Water District and the City of Sacramento Water Department began connecting Rio Linda, Elverta, and North Sacramento residences in a small area west of the base to the municipal water supplies. The residents in this area previously used private wells for their water needs. The hookup to municipal water supplies was a remedial action initiated by McClellan AFB, as discussed in Section 2.1.3.2.

3.4 Climatology

The climate of the Sacramento area is characterized by hot dry summers and cool moist winters. Average temperatures in the Sacramento Valley range from the mid-40s (degrees Fahrenheit) during the winter months, to the mid-70s during the summer. The average annual temperature is approximately 60°F. During the summer, maximum temperatures can exceed 100°F. During the winter, minimum temperatures rarely drop below 20°F. Temperatures may fluctuate up to 40°F per day, with the greatest fluctuations occurring during the summer months.

Approximately 17 inches of the 19.8-inch average annual precipitation in the Sacramento region fall between November and April. Over one-half of the total average rainfall occurs during the months of December, January, and February. The Sacramento area seldom receives snow. The mean annual evapotranspiration rate for the Sacramento area is about 45 inches per year.

The net precipitation for the area (mean annual precipitation minus the mean annual evapotranspiration) is approximately -25 inches per year.

3.5 Human Environment

A discussion of the human environment, including population, demographics, and land use, is not applicable to the work proposed for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment).

4.0 BASIS FOR PROGRAM APPROACH

Previous investigations conducted at McClellan Air Force Base (AFB) have begun to characterize the hydrogeologic conditions and the magnitude and extent of soil and groundwater contamination. Varying levels of characterization, dictated by anticipated contaminant levels, have been conducted in different on- and off-base areas. The results of these previous investigations at, and near, McClellan AFB are the basis for development of the remedial investigation/feasibility study (RI/FS) activities. A major element of the RI/FS process is to address data requirements that remain after the Phase I and Phase II efforts. Addressing these data requirements will further define the nature and extent of contamination at identified sites and will allow more detailed evaluation of potential impacts.

The objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) are to characterize hydrogeologic conditions and further define the extent of groundwater contamination. This information will be used in determining potential groundwater operable units. Of particular interest are those areas where little or no subsurface investigation has been completed to date or where the level of effort expended in the past has been inadequate relative to what is known about past waste storage and disposal practices. The Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) will provide a framework within which hydrogeologic conditions at specific sites can be more effectively evaluated, and groundwater remediation measures may be assessed from an operable unit area perspective.

This sampling and analysis plan presents the rationale and methodology for implementing the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) as part of the RI/FS process. The primary elements of the Hydrogeologic Assessment will include:

- Determining geographic areas that may require groundwater operable unit investigations;

- Drilling boreholes to depths of approximately 120 to 360 feet below ground surface to identify water bearing zones which are most appropriate for future monitoring of groundwater and contaminant migration;

- Aquifer testing to determine hydraulic parameters for both aquitards and saturated zones of higher permeability;

- Installing wells to monitor groundwater quality and potentiometric head in various zones of saturation; and

- Sampling and analysis (two rounds) of new monitoring wells for contaminant compounds.

4.1 Physiochemical Properties of Contaminants

The potential for release of a chemical compound from a site is related to its solubility, volatility, and mobility in underlying earth materials. The extent and magnitude of subsurface contamination in the vadose zones will not be addressed within the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). However, the extent and magnitude of contamination in groundwater will be addressed during the hydrogeologic assessment by two rounds of groundwater sampling and analysis. Based on the results of these two sampling rounds, recommendations will be made regarding which wells should be added to the groundwater monitoring network. Sampling would then continue under the Groundwater Sampling and Analysis Program.

4.2 Pathways and Receptors

The primary pathways for human exposure to contaminants that are present at McClellan AFB include inhalation, ingestion, and dermal contact. The media that may carry the contaminants include air, surface water, groundwater, and soil. A detailed description of the pathways and receptors was presented in the Draft Preliminary Pathways Assessment Sampling and Analysis Plan (Radian, September 1988) prepared as part of the McClellan AFB RI/FS.

4.3 Environmental/Health Effects

The Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) will not address environmental and health effects.

4.4 Preliminary Technologies

The Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) will not address preliminary technologies. Site and operable unit assessments will be conducted within the Identification and Screening of Remedial Technologies task of the McClellan AFV RI/FS.

4.5 Applicable or Relevant and Appropriate Requirements (ARARs)

The Superfund Amendments and Reauthorization Act (SARA) has resulted in significant changes to the RI/FS process. The provisions that have the greatest impact are those pertaining to cleanup objectives. Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by SARA, requires that remedial actions comply with the requirements or standards provided under federal and state environmental laws. The requirements that must be complied with are those that are applicable or relevant and appropriate (i.e., ARARs) to the contaminants at a site, the circumstances of their release, or the type of remedial action selected (United States Environmental Protection Agency [U.S. EPA], 1987a). Selection of ARARs will not be addressed during the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) but will be conducted within the task designed for Identification of ARARs and Cleanup Goals as part of the McClellan AFB RI/FS process.

4.6 Data Requirements

The following subsections identify data that are required to fulfill the objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). The availability or absence of specific types of geologic, hydrologic, and groundwater quality information also is discussed, as required to demonstrate the need for additional data. The references identified in Section 8.0 of this Sampling and Analysis Plan provide more detailed presentations of existing information. In addition to the data from previous investigations and the data to be obtained in the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment), subsurface characteristics which may have an impact on contaminant migration (for example, vadose zone permeability and contaminant parameters) will be obtained in site characterization tasks.

4.6.1 Geologic Data

Existing geologic and geophysical data have been extensively reviewed in an effort to gain a comprehensive understanding of the hydrogeological regime at McClellan AFB. In many cases, the existing data have furthered current understanding of the subsurface conditions; however, the current database is inadequate for assessing hydrogeologic conditions in some areas of the base. Data required to adequately assess the local hydrogeology can be obtained from strategically located boreholes drilled to the necessary depths and logged with accurate geological and geophysical techniques. The need for aquifer parameter data to better understand the groundwater hydrology is discussed in Section 4.6.2.

The following subsections summarize Radian Corporation's review of the existing geologic data, interpretations based on these data, and deficiencies in the current database. Additional geologic data required to meet the objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) also are discussed.

4.6.1.1 Existing Geologic Data

Existing geologic and geophysical data are available in the numerous geological and geophysical logs presented in reports by various contractors who have performed subsurface investigations at McClellan AFB. Section 8.0 lists the contractor reports. Table 4-1 summarizes the sources and types of available subsurface data.

In an effort to understand the hydrostratigraphy on a basewide scale, Radian constructed geological cross sections and net-sand maps using existing geologic logs. Most of the wells used in these evaluations are located in a north-south orientation in the western half of the base. Borehole geophysical logs also were reviewed, as available. Net-sand maps were constructed by plotting ratios of permeable (sandy and gravelly strata) and impermeable (silts and clays) lithologies on a map and attempting to discern any vertical or areal patterns. The lithologic ratios were determined from the available boring logs. The vertical intervals chosen for comparison and evaluation were the three monitoring zone intervals (shallow, middle, and deep) currently in use, as described in Section 3.2. Lithologic cross sections and net-sand maps derived from existing lithologic logs do not add significantly to the understanding of hydrogeology beneath some areas of the base, and they were not adequate for indicating any major, laterally extensive waterbearing zones that would represent favorable strata for proposed monitoring well screen intervals. Evaluation of geophysical logs available for boreholes drilled on base revealed that resistivity and spontaneous potential logs are more amenable than available lithologic logs in interpreting geologic correlations over the distances between monitoring wells.

The distribution of borehole data is biased toward those areas where historic waste storage and disposal sites are located. Most waste storage and disposal activity occurred in a north-south orientation in the western portion of the base, west of the flight line in Area B, Area C, and Area D. On the east, central, and north portions of the base, the density of boreholes is significantly lower. Whereas the resulting monitoring wells are adequate for

TABLE 4-1. SUMMARY OF SOURCES AND TYPES OF GEOLOGICAL AND GEOPHYSICAL DATA, McCLELLAN AFB, 1988

Contractor	Time Work Conducted	Area Work Conducted	Well Numbers	Type of Geological/Geophysical Data Available
MONITORING WELLS EXTRACTION WELLS RECONNAISSANCE BORINGS				
McClellan AFB (Drilling conducted by All-Terrain Exploration Drilling)	1980	B, C, D	MW-1 to MW-4	4 Geological Logs
Kleinfelder	1980-1981	A, B, D, Others	MW-6 to MW-15	10 Geological Logs
Engineering-Science	1982-1983	A, B, C, D, Others	MW-16S/D to MW-50	35 Geological Logs
CH2M Hill	1984	Area D	MW-51 to MW-58	7 Geological Logs 7 Geophysical Logs a) resistivity b) spontaneous potential (SP)
McLaren Environmental Engineering	1985-1986	A, B, C, D, Others	MWs and EWs 59 to 92	34 Geological Logs 34 Geophysical Logs a) resistivity b) SP c) Caliper
Radian Corporation	1984-1986	On Base: A, B, C, D, Others	MW-100 to MW-132	33 Geological Logs 14 Geophysical Logs a) natural gamma ray
		Off Base: All Areas	Reconnaissance Borings 1 to 29	29 Geological Logs
			MW-1000 to MW-1043	27 Geological Logs 13 Geophysical Logs a) natural gamma ray
EG&G Idaho, Inc.	1987	C	MW-133 to MW-143	Geological Logs (not yet available) 6 Geophysical Logs a) resistivity b) SP c) natural gamma ray
BASE PRODUCTION WELLS				
McClellan AFB	1942-1981 (Some wells were on site when base was established in 1936.)	A,B,C,D, Others	BW-1 to BW-29	7 Geological Logs 2 Geophysical Logs a) resistivity b) SP
				TOTALS: 186 Geological Logs 76 Geophysical Logs

a general characterization of Areas B, C, and D, the distribution of wells is inadequate to assess hydrogeologic conditions basewide.

It is evident from the review of existing borehole lithologic logs that the work conducted in previous investigations was not directed toward the assessment of hydrogeologic conditions from a basewide perspective. Investigations were conducted to assess local stratigraphy, hydrology, and the presence of contaminants near Potential Release Locations (PRLs). Due to the emphasis in previous investigations, it is understandable that the locally-focused data are not generally applicable to basewide hydrogeologic characterization. However, a significant body of data has been compiled in the preparation of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) Sampling and Analysis Plan.

In preparation for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment), the most applicable geologic, geophysical, and hydrologic data have been gathered. The most graphic lithologic descriptions from strategically-placed boreholes have been utilized and compared with geophysical and hydrologic data. Borehole geophysical logging has been employed in several previous investigations and in the construction of base wells BW-18 and BW-29. Geophysical logs represent physical responses which result from the interaction of borehole fluids, groundwater, and the properties of granular media. They are not dependent on the subjective or conflicting visual descriptions which may be reported on lithologic logs. For subsurface conditions at McClellan AFB, resistivity and spontaneous potential logs significantly add to the capability for correlation of stratigraphic intervals where lithologic logs were not continuous or incomplete. It is unfortunate that more of the deeper boreholes were not logged with high quality resistivity and spontaneous potential techniques. Some previous boreholes were logged with inadequate quality assurance or with techniques which are not appropriate for the physical characteristics of the lithologies at McClellan AFB.

To supplement the existing lithologic and geophysical data, borings drilled in future hydrogeologic investigations will be completed with continuous, graphic lithologic logs and high quality resistivity, spontaneous potential gamma ray, and caliper logs. Five of the pilot holes to be drilled in the Preliminary Groundwater Operable Unit Investigation will be cored continuously. Cores will be logged and stored for reference. Logging methods are described in Sections 5.2.1.4 and 5.2.1.5.2.

4.6.1.2 Required Geologic Data

The scope of work for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) has been designed to complement existing data by drilling and logging new boreholes and installing monitoring wells in areas where hydrogeologic data are absent or lacking. The hydrogeologic data obtained in the remedial ivnestigation will be used to better define potential operable units, although that use of the data is not specifically described in the table. Specific borehole and monitoring well locations and depths, including the rationale for their placement, are presented in Table 4-2 located on page 4-34. Monitoring well clusters 10, 12, 13, 16, and 25 that were constructed in the Area B Groundwater Operable Unit Remedial Investigation (Radian, 1989) are not described in Table 4-2. Locations of the pilot holes and monitoring well clusters to be installed during the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) or completed in the Area B Groundwater Operable Unit Remedial Investigation are presented on Plate 5.

Well clusters are listed in Table 4-2 in the numerical sequence in which they are shown in Plate 5. The sequence does not reflect the order in which monitoring wells or pilot borings will be drilled or constructed. Clusters numbered 10, 11, 12, 13, 16, and 25 in Plate 5 have already been constructed. At each cluster, the pilot hole will be drilled and geophysically and lithologically logged first to assess local hydrogeologic conditions. Five of the pilot holes will be continuously cored to allow comparison of lithologic and geophysical characteristics. After the pilot hole is grouted or completed as a monitoring well, the deepest planned well in the cluster will be drilled and constructed. If the deepest planned well is a "200-foot" zone well, it will be constructed, developed, sampled, and analyzed for volatile halocarbons. While the sample is being analyzed on a short turnaround basis, the next shallowest well planned for the cluster will be drilled and constructed. When analytical results for the "200-foot" zone well are available, a decision will be made regarding the need for a "300-foot" zone well in the cluster. If the "200-foot" zone well sample had detectable halocarbons confirmed by second column analysis, one of the optional "300-foot" zone monitoring wells will be constructed in the cluster. If the "200-foot" zone well sampled has no detectable halocarbons, no "300-foot" zone well will be constructed except at Cluster 17. Materials will be available for construction of optional "300-foot" zone wells in as many as seven clusters. After construction of the "200-foot" zone or "300-foot" zone monitoring wells, the shallower wells in any cluster will be constructed.

The cores and geophysical logs from pilot holes and cuttings from the drilling of monitoring well boreholes will provide the geologic data considered necessary to assess the local hydrogeologic conditions. These data are:

- Strategic areal distribution of boreholes. In general, these locations are:

  1) Eastern portion of the base,
  2) Southern portion of the base (between Areas A and B),
  3) Central north-south portion of the base,
  4) Northwest portion of the base between Areas C and D,
  5) Northwest of Area D, off-base,
  6) Southwest of Area B, off-base,
  7) Southeast of Area A, off-base, and
  8) North of Area A, east of Area D.

- Deeper boreholes to characterize hydrogeology and/or determine the presence of contaminants at depth in selected areas. Wells drilled to, and screened in, the "300-foot" and "200-foot" zones will help characterize the nature and extent of these zones in addition to the "250-foot" aquitard in areas where contaminant migration to greater depth is most likely to have occurred. Wells will not be constructed in the "300-foot" zone unless contaminants have been detected in the "200-foot" zone in the cluster or in an upgradient cluster. Cluster 17 includes the only definite "300-foot" zone well.

- Consistent use of high quality spontaneous potential and resistivity surveys. Specifically, resistivity surveys in the short-normal (16-inch) and long-normal (64-inch) configurations will be employed during the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). Spontaneous potential, resistivity, gamma ray, caliper, and declination geophysical surveys will be conducted in 19 pilot holes; one in each monitoring well cluster.

- Geological logs based on the Wentworth Scale and Unified Soil Classification System will be produced during the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment).

As many as 51 monitoring wells may be installed, either singly or in well clusters, in 19 specific locations during the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). Of these 51 wells, 14 are "water table" zone wells, 12 are "150-foot" zone wells, 17 are "200-foot" zone wells, and 8 are in the "300-foot" zone. However, 7 of the "300-foot" zone wells are optional and will be constructed only if analyses of samples from the "200-foot" zone well indicate contaminants are present. Mud rotary pilot holes will be drilled at each cluster site prior to installation of monitoring wells. Thirty-four piezometers will be installed in Areas B and C.

Eleven geologic cross sections, A-A' through I-I', and one fence diagram, present the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) well locations and depths. Figure 4-1 presents the locations of all the proposed monitoring wells relative to the fence diagram and other cross sections. Table 4-3 indicates the specific monitoring wells and well cluster locations that are presented on the cross sections. The cross sections and fence diagram are shown in Figures 4-2 through 4-10 and Plate 6. These illustrations were constructed on the basis of interpretation of existing borehole geophysical logs. The nine cross sections present 51 monitoring well locations and depths in 21 clusters, 4 of which were constructed in the Area B Groundwater Operable Unit Remedial Investigation. Proposed clusters 18 and 26, are not presented on a cross section because existing hydrogeologic data are not sufficient to construct a cross section.

In the eastern portion of the base, proposed well depths have been projected from known geologic reference points to areas where geologic control is lacking. The target monitoring well screen intervals (the "water table," "150-foot," "200-foot," and "300-foot" zones) are identified in Section 3.2 and on the enclosed cross sections and fence diagram.

The exact depth to the water table and the thickness of the "water table" zone vary across the base due to local topography and geologic and because of uncertainty in identifying the base of the zone from available data. The lower limit of the "water table" zone is not indicated on the cross sections. Approximate groundwater levels based on recent potentiometric surface maps are shown on the sections to indicate the upper boundary of the "water table" zone. Wells proposed to monitor the water table zone will be constructed with screen intervals placed to monitor the most permeable strata and the upper water surface.

The methods and procedures that will be used to obtain the required geological data are discussed in Section 5.0.

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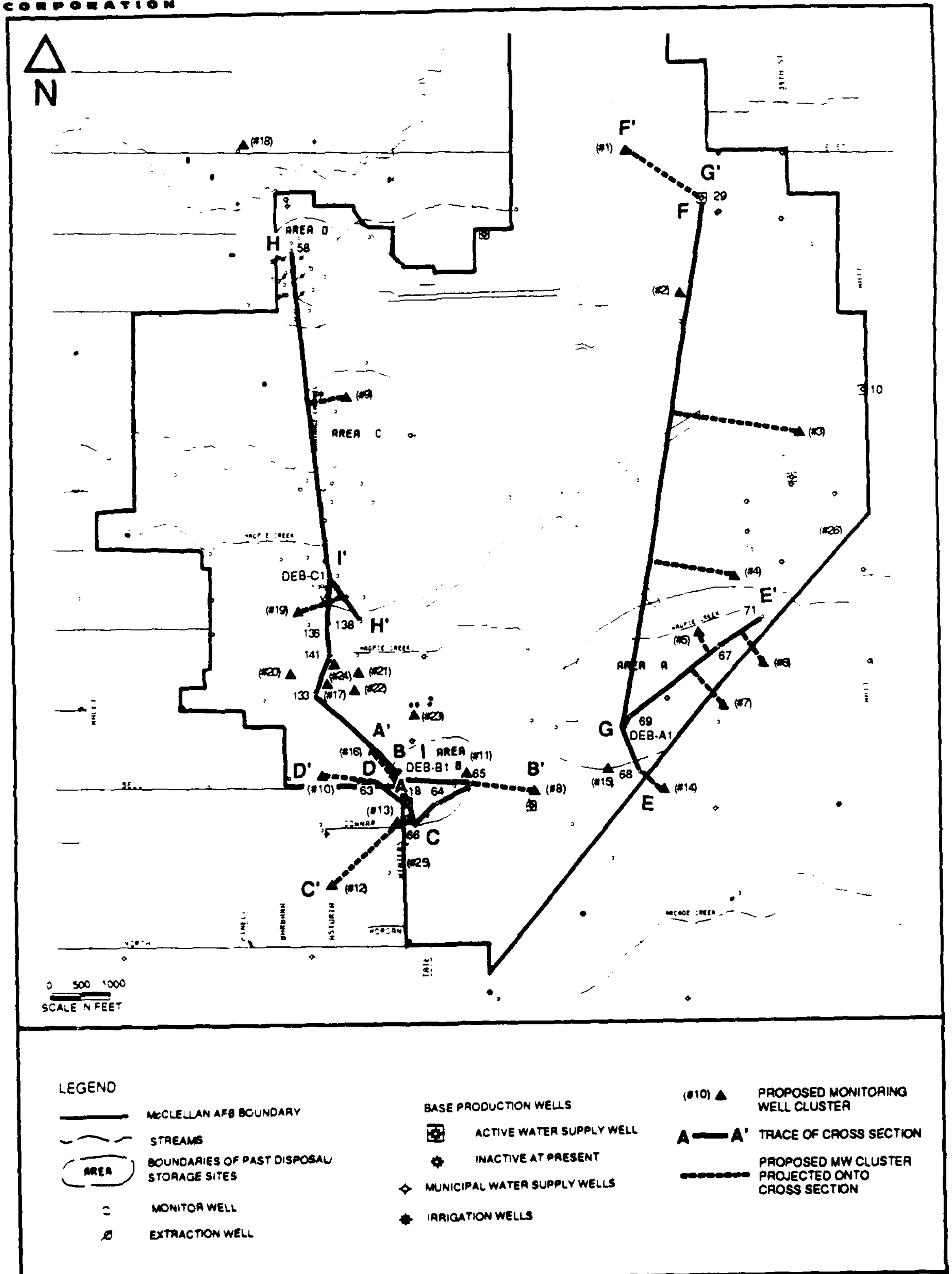
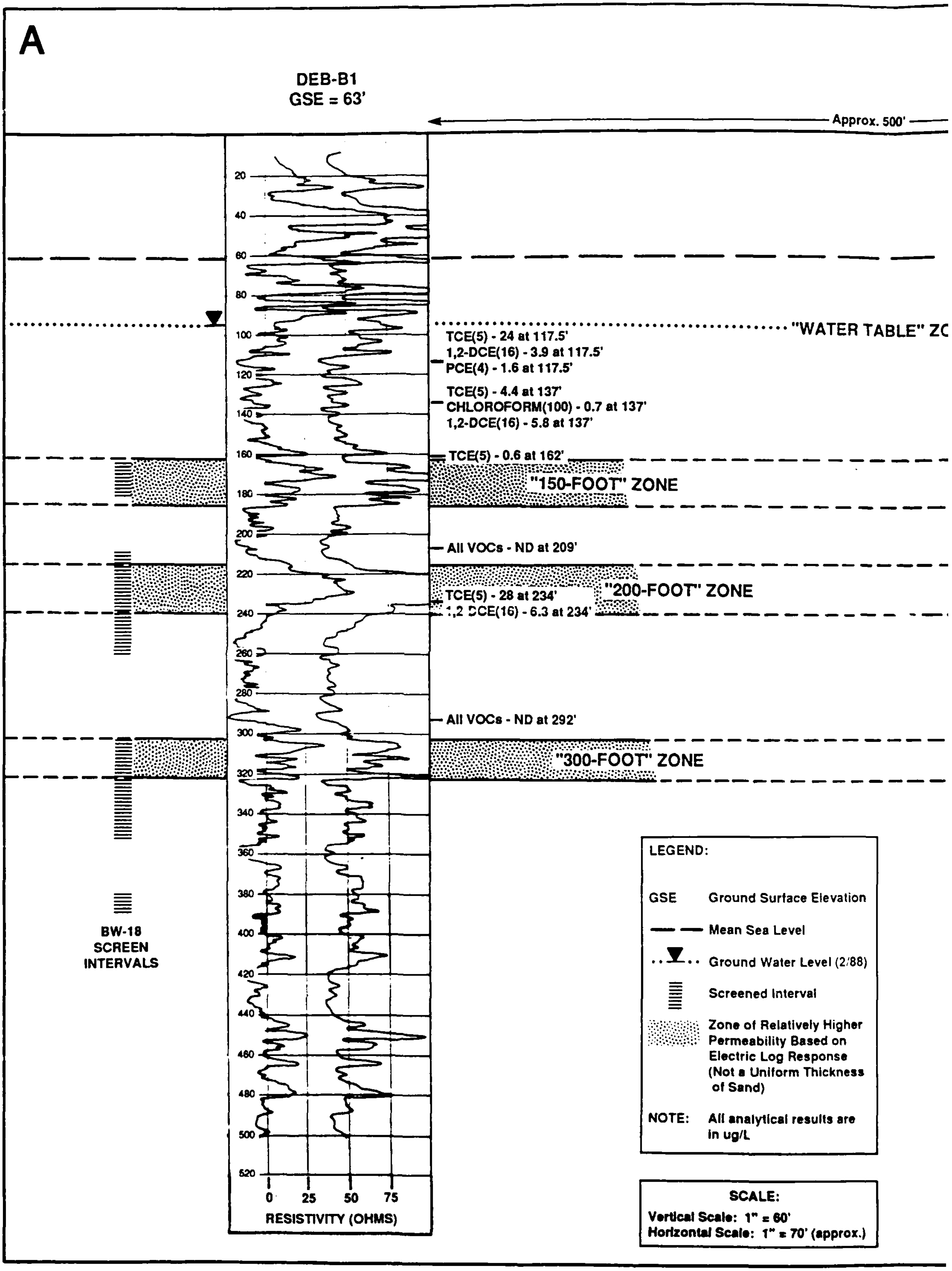


Figure 4-1. Locations of Proposed Monitoring Wells and Locations of Geologic Cross Sections and Fence Diagrams.

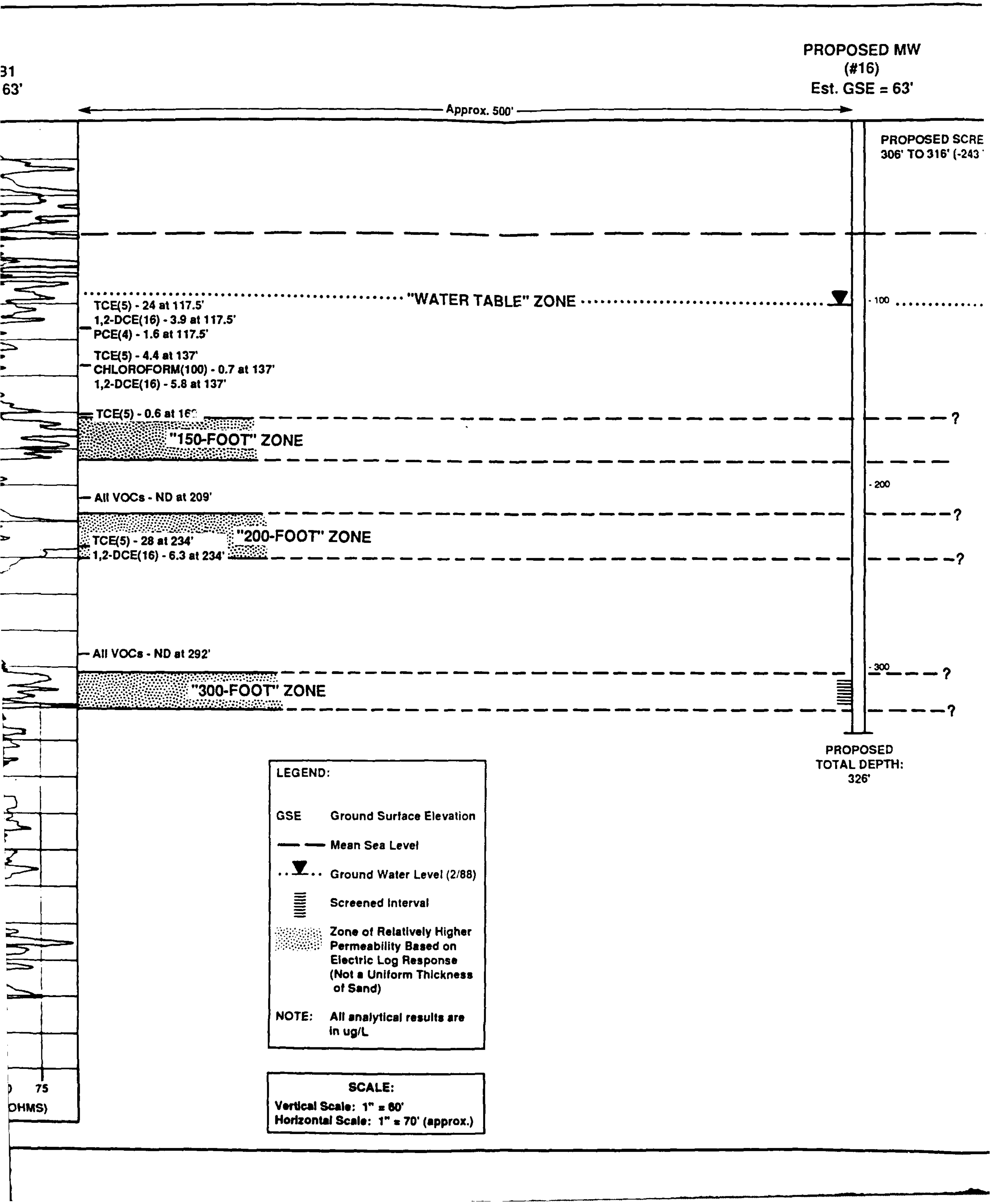
0588-040-02

TABLE 4-3. CROSS SECTIONS ILLUSTRATING PROPOSED MONITORING WELL LOCATIONS

Cross Section	Proposed Monitoring Well and Well Clusters
A-A'	Well Number 16 (1 well)
B-B'	Cluster Numbers 18 (4 wells), 11 (2 wells)
C-C'	Cluster Number 12 (3 wells), Well Number 13 (1 well)
D-D'	Cluster Number 10 (3 wells)
E-E'	Cluster Numbers 5 (2 wells), 6 (3 wells), 7 (3 wells), 14 (3 wells), 15 (2 wells)
F-F'	Cluster Number 1 (3 wells)
G-G'	Cluster Numbers 2 (1 well), 3 (3 wells), 4 (4 wells)
H-H'	Cluster Number 9 (4 wells)
I-I'	Cluster Numbers 19 (2 wells), 20 (3 wells), 21 (3 wells) Well Number 22 (1 well)
K-K'	Cluster Number 23 (4 piezometers)
L-L'	Cluster Numbers 17 (1 well), 24 (5 piezometers)



A
DEB-B1
GSE = 63'
Approx. 500'
"WATER TABLE" ZO
TCE(5) - 24 at 117.5'
1,2-DCE(16) - 3.9 at 117.5'
PCE(4) - 1.6 at 117.5'
TCE(5) - 4.4 at 137'
CHLOROFORM(100) - 0.7 at 137'
1,2-DCE(16) - 5.8 at 137'
TCE(5) - 0.6 at 162'
"150-FOOT" ZONE
All VOCs - ND at 209'
TCE(5) - 28 at 234'
1,2 DCE(16) - 6.3 at 234'
"200-FOOT" ZONE
All VOCs - ND at 292'
"300-FOOT" ZONE
BW-18
SCREEN
INTERVALS
0 25 50 75
RESISTIVITY (OHMS)
LEGEND:
GSE Ground Surface Elevation
Mean Sea Level
Ground Water Level (2/88)
Screened Interval
Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
NOTE: All analytical results are in ug/L
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 70' (approx.)


31
63'
PROPOSED MW
(#16)
Est. GSE = 63'
Approx. 500'
PROPOSED SCRE
306' TO 316' (-243
"WATER TABLE" ZONE
100
TCE(5) - 24 at 117.5'
1,2-DCE(16) - 3.9 at 117.5'
PCE(4) - 1.6 at 117.5'
TCE(5) - 4.4 at 137'
CHLOROFORM(100) - 0.7 at 137'
1,2-DCE(16) - 5.8 at 137'
TCE(5) - 0.6 at 16
"150-FOOT" ZONE
200
All VOCs - ND at 209'
"200-FOOT" ZONE
TCE(5) - 28 at 234'
1,2-DCE(16) - 6.3 at 234'
All VOCs - ND at 292'
300
"300-FOOT" ZONE
?
PROPOSED
TOTAL DEPTH:
326'
75
OHMS)
LEGEND:
GSE Ground Surface Elevation
Mean Sea Level
Ground Water Level (2/88)
Screened Interval
Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
NOTE: All analytical results are in ug/L
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 70' (approx.)

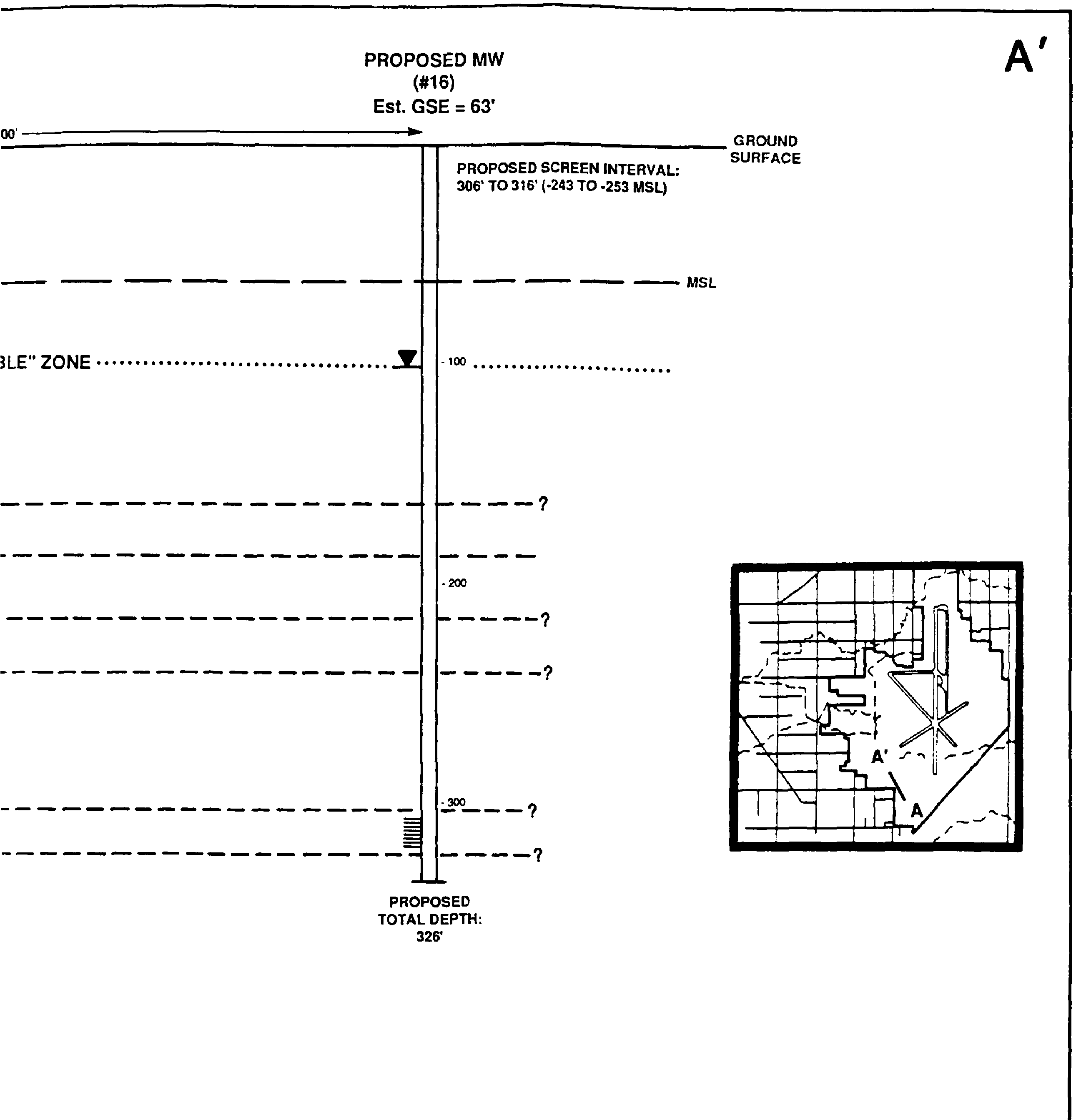
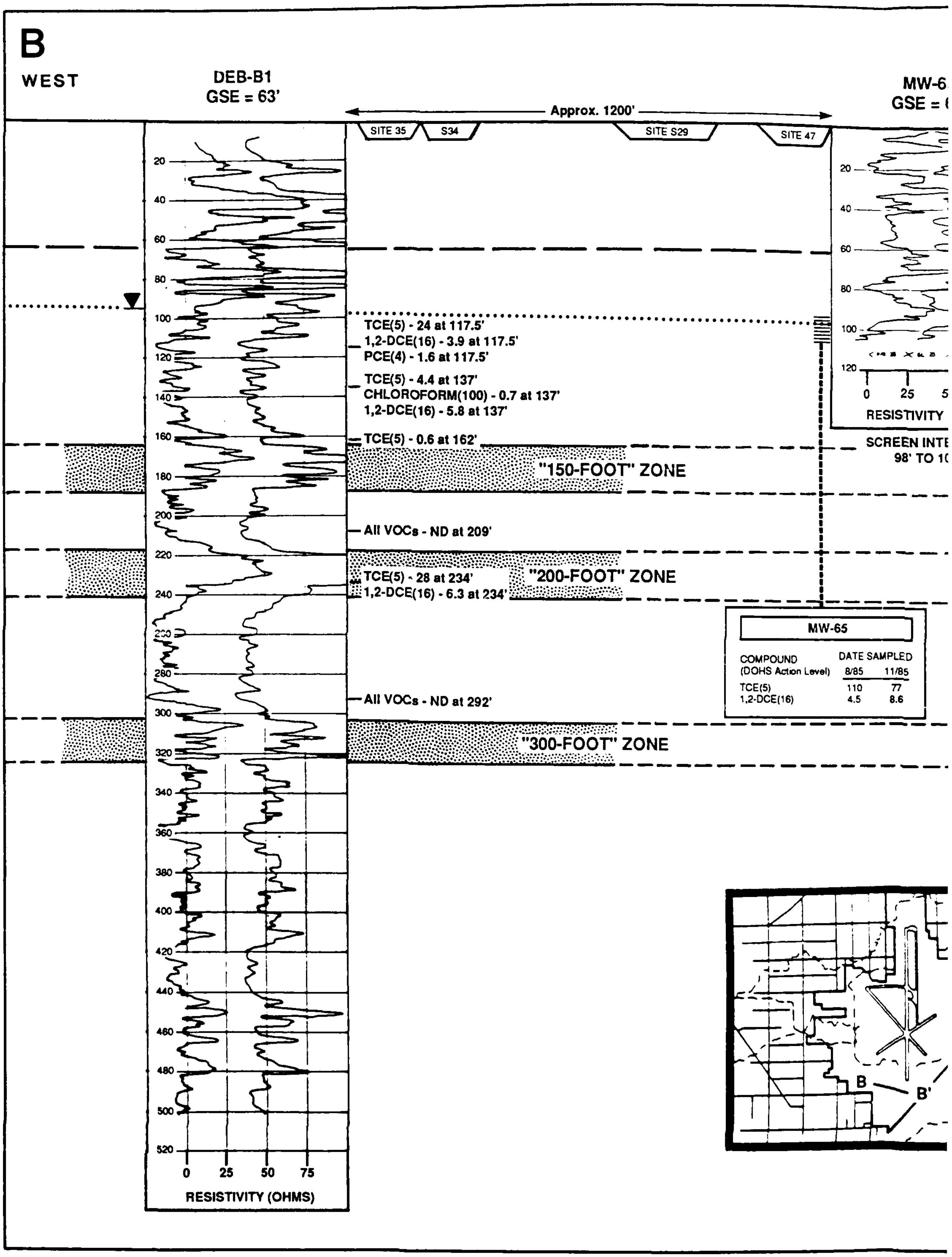
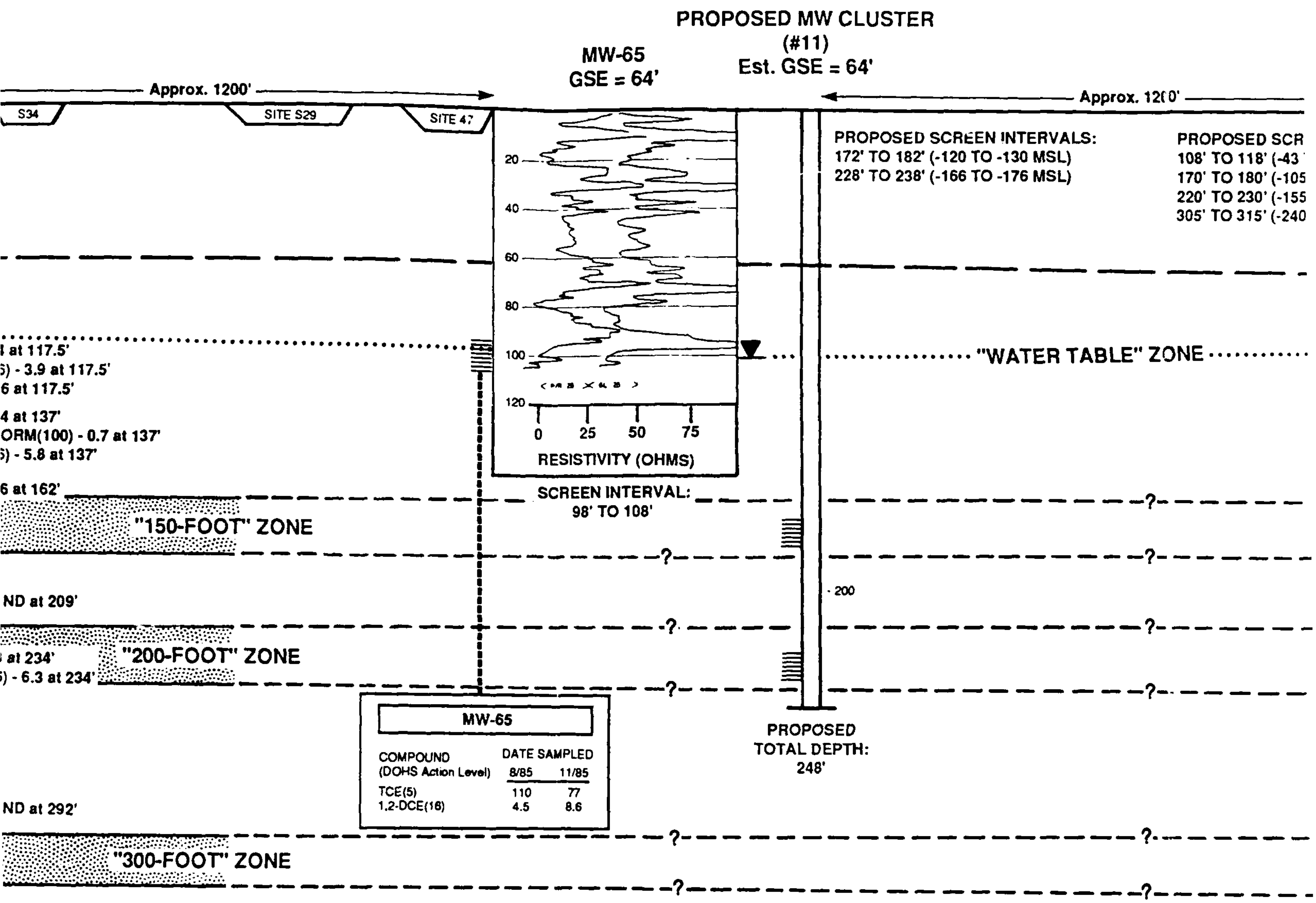


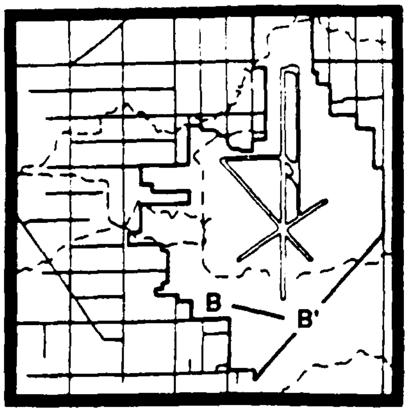
FIGURE 4-2.
GEOLOGIC CROSS SECTION
(A - A')

McCLELLAN AFB
RI Stage 6, February, 1990

RADIAN CORPORATION


B
WEST
DEB-B1
GSE = 63'
MW-6
GSE =
Approx. 1200'
SITE 35
S34
SITE S29
SITE 47
TCE(5) - 24 at 117.5'
1,2-DCE(16) - 3.9 at 117.5'
PCE(4) - 1.6 at 117.5'
TCE(5) - 4.4 at 137'
CHLOROFORM(100) - 0.7 at 137'
1,2-DCE(16) - 5.8 at 137'
TCE(5) - 0.6 at 162'
"150-FOOT" ZONE
All VOCs - ND at 209'
TCE(5) - 28 at 234'
1,2-DCE(16) - 6.3 at 234'
"200-FOOT" ZONE
All VOCs - ND at 292'
"300-FOOT" ZONE
RESISTIVITY (OHMS)
RESISTIVITY
SCREEN INTE
98' TO 1
MW-65
COMPOUND
(DOHS Action Level)
DATE SAMPLED
8/85
11/85
TCE(5) 110 77
1,2-DCE(16) 4.5 8.6
B
B'

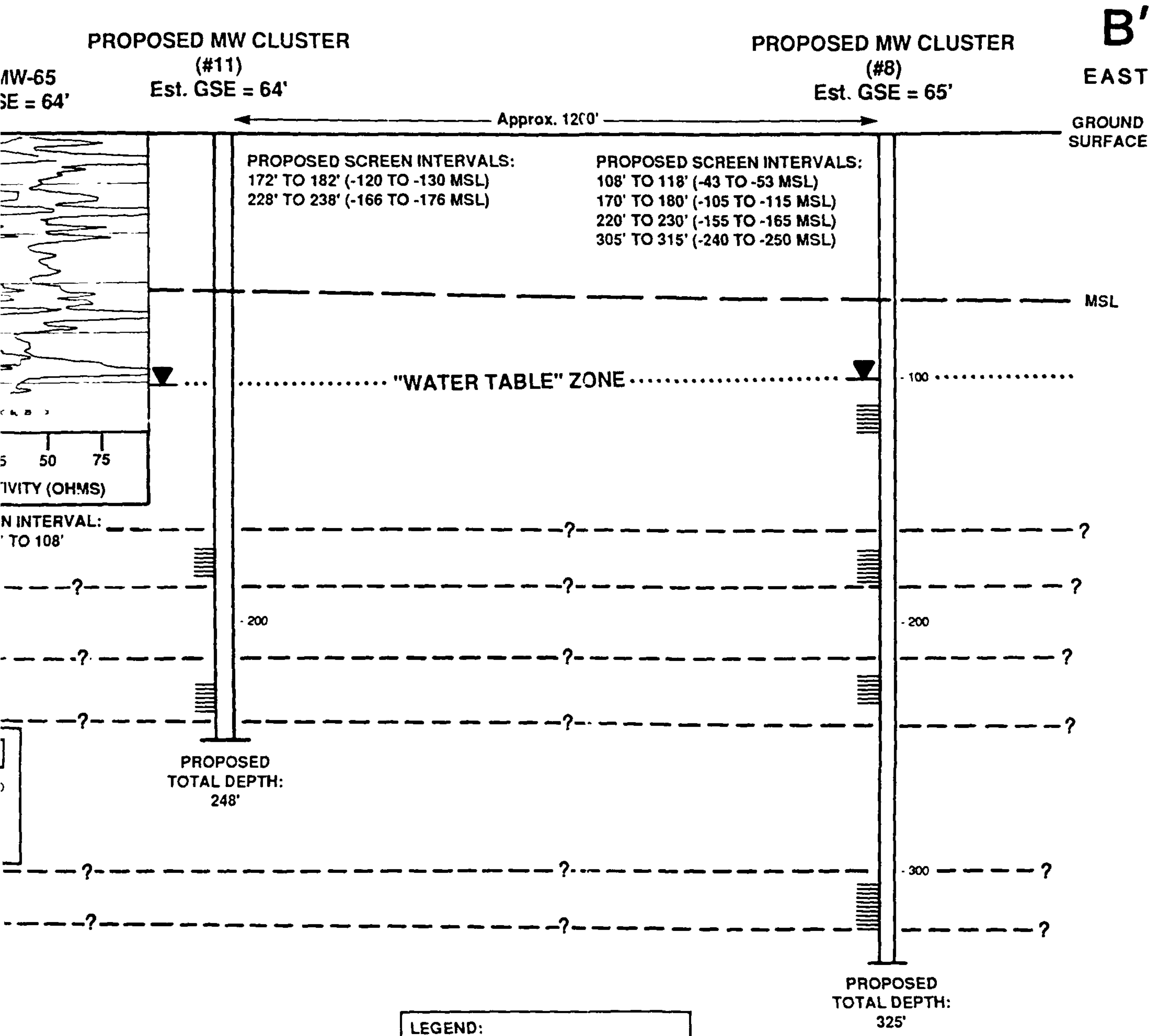




LEGEND:

GSE	Ground Surface Elevation
— —	Mean Sea Level
..▼..	Ground Water Level (2/88)
≣	Screened Interval
(stippled)	Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
NOTE:	All analytical results are in ug/L

SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 200' (approx.)



LEGEND:

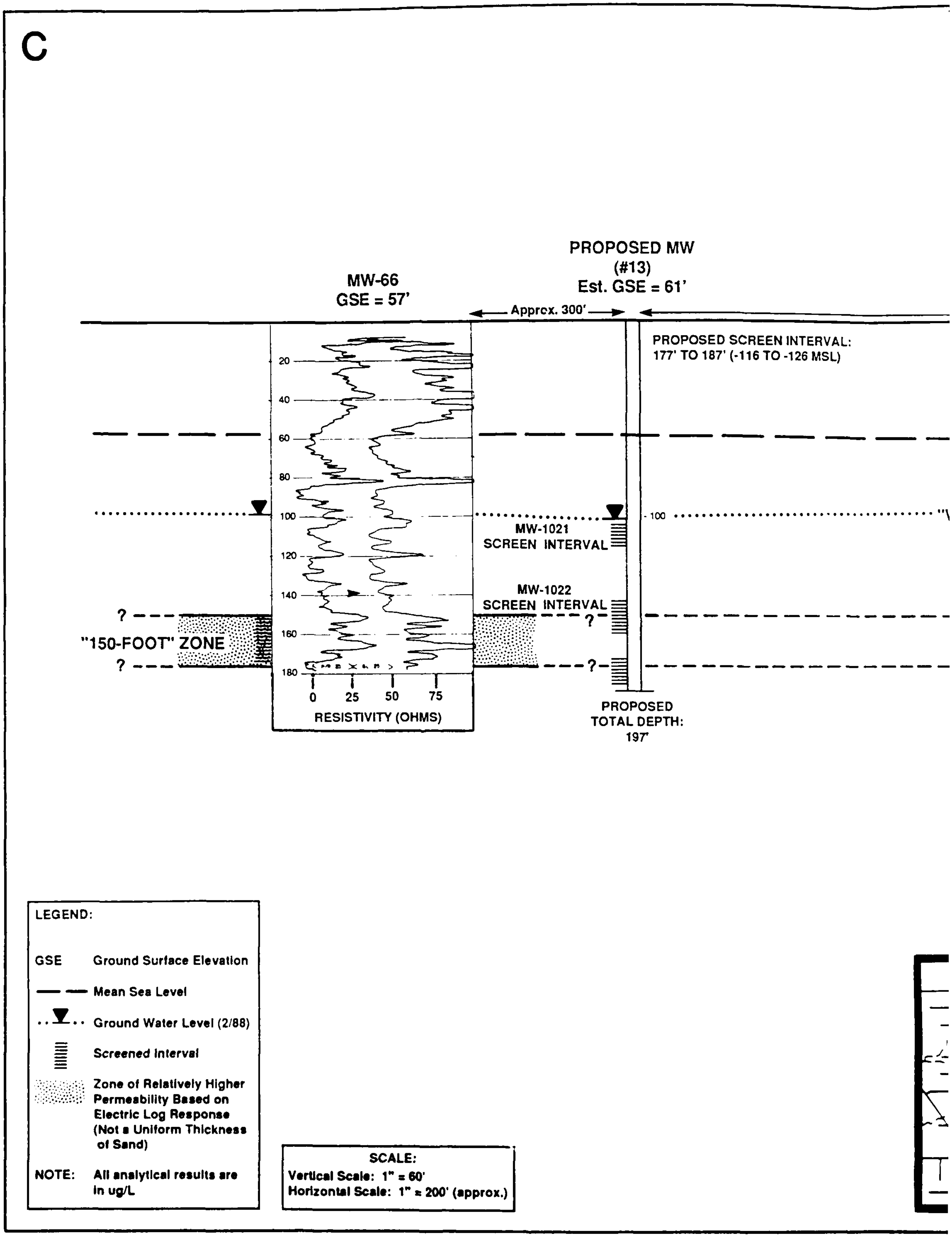
GSE	Ground Surface Elevation
— —	Mean Sea Level
..▼..	Ground Water Level (2/88)
≡	Screened Interval
(stippled)	Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
NOTE:	All analytical results are in ug/L

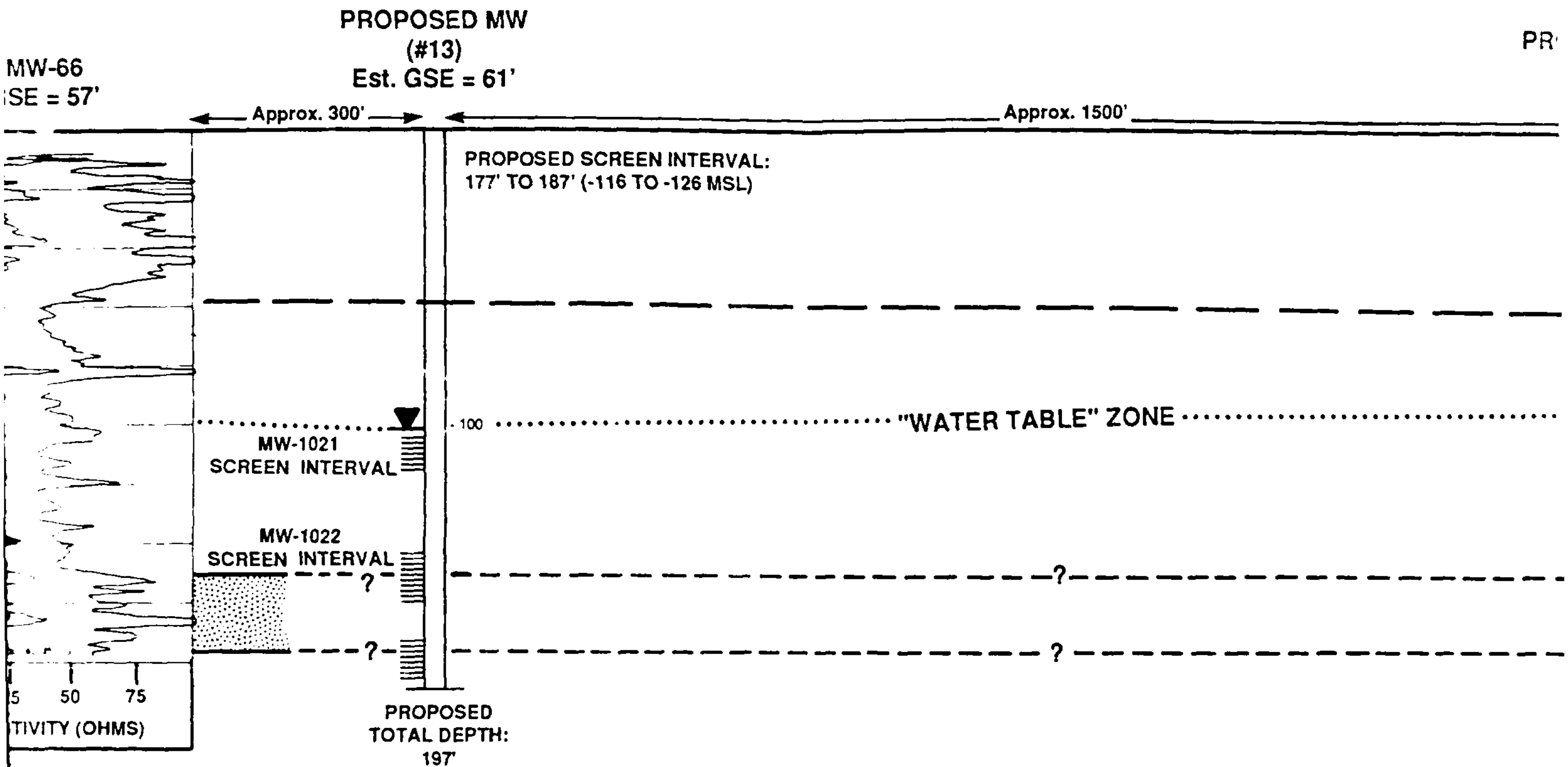
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 200' (approx.)

FIGURE 4-3.
GEOLOGIC CROSS SECTION
(B - B')

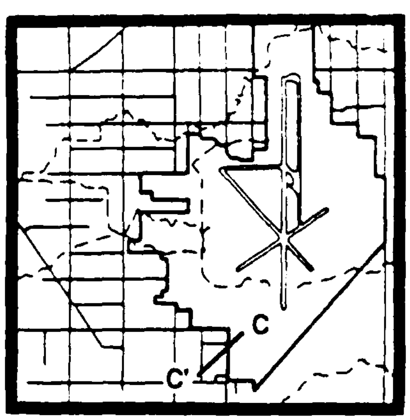
McCLELLAN AFB
RI Stage 6, February, 1990

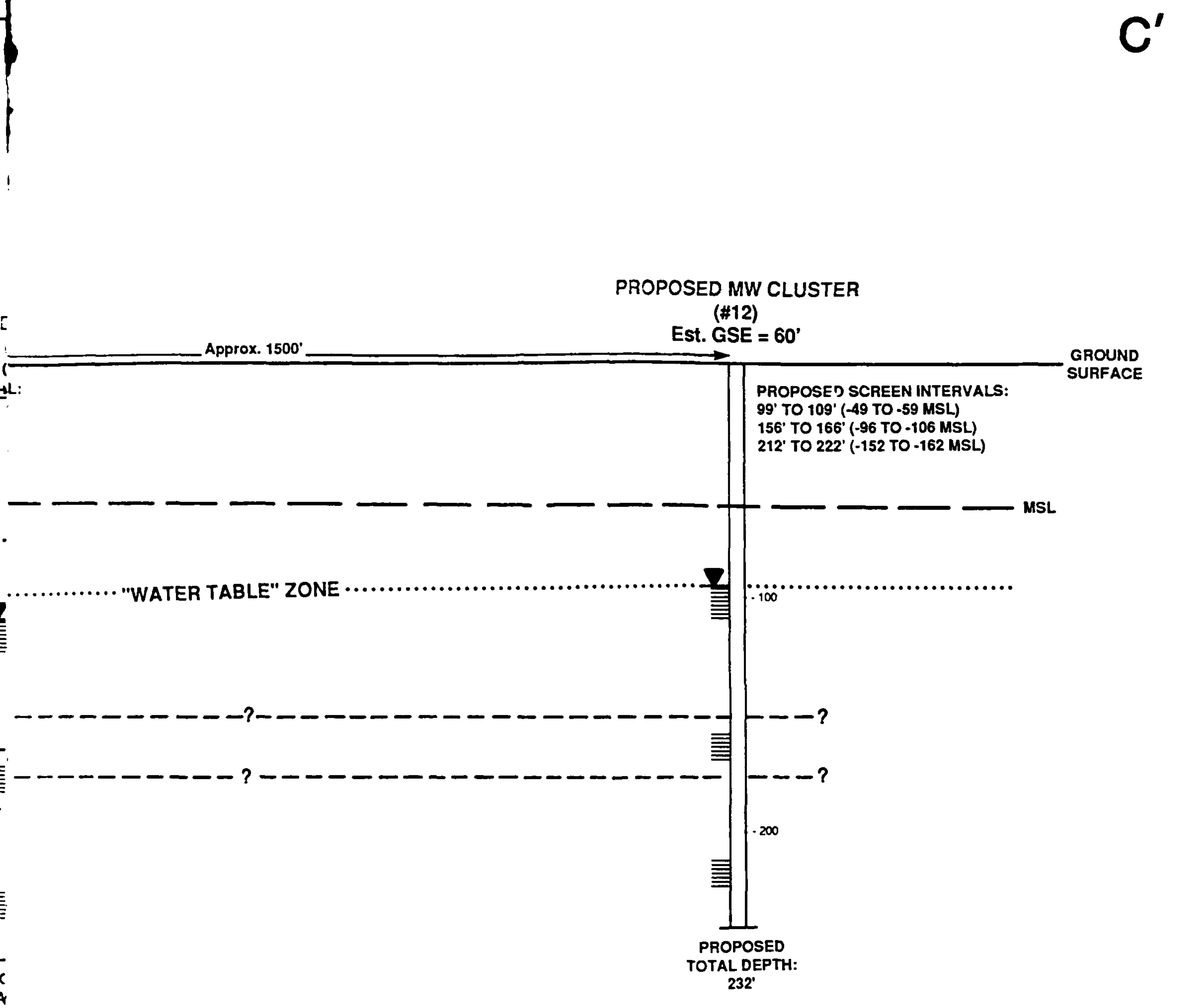
RADIAN CORPORATION


C
MW-66
GSE = 57'
PROPOSED MW
(#13)
Est. GSE = 61'
Approx. 300'
PROPOSED SCREEN INTERVAL:
177' TO 187' (-116 TO -126 MSL)
20
40
60
80
100
120
140
160
180
0
25
50
75
RESISTIVITY (OHMS)
MW-1021
SCREEN INTERVAL
MW-1022
SCREEN INTERVAL
?
"150-FOOT" ZONE
PROPOSED
TOTAL DEPTH:
197'
LEGEND:
GSE Ground Surface Elevation
Mean Sea Level
Ground Water Level (2/88)
Screened Interval
Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
NOTE: All analytical results are in ug/L
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 200' (approx.)



SCALE:
e: 1" = 60'
cale: 1" = 200' (approx.)





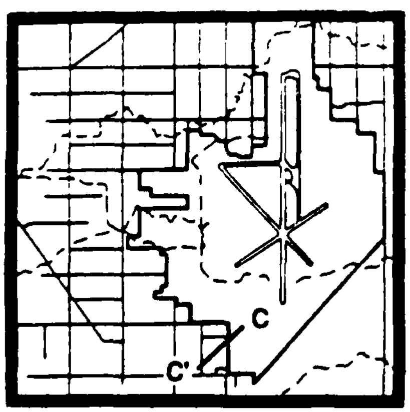
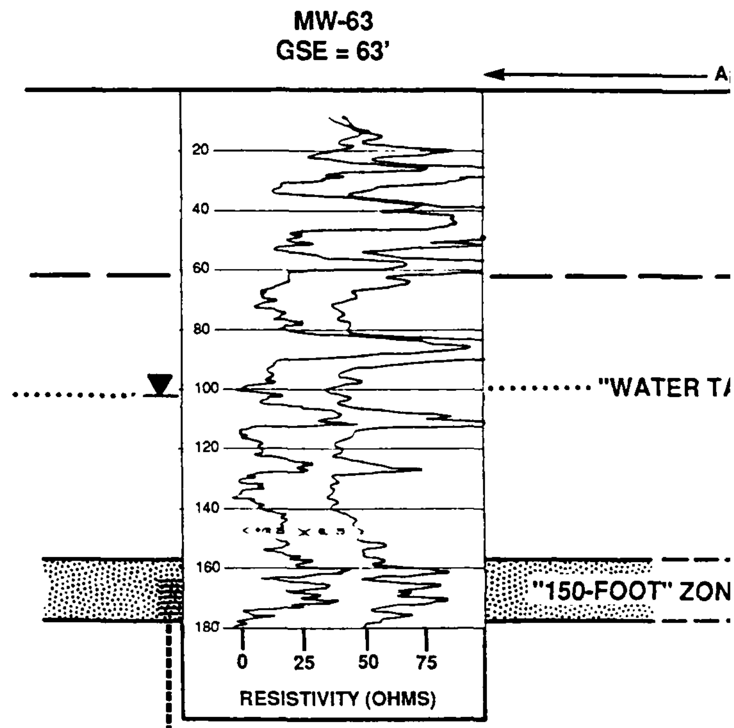


FIGURE 4-4.
GEOLOGIC CROSS SECTION
(C - C')

McCLELLAN AFB
RI Stage 6, February, 1990

RADIAN CORPORATION

D



MW-63					
COMPOUND (DOHS Action Level)	DATE SAMPLED				
	8/85	9/85	8/87	10/87	2/88
TCE(5)	60	65	190	52	69
1,2-DCE(16)	29	26	ND	52	43
METHYLENE CHLORIDE(40)	ND	ND	ND	ND	3.2
1,2-DCA(1)	ND	ND	ND	ND	.78
1,1-DCE(6)	ND	ND	ND	ND	.76

LEGEND:

GSE — Ground Surface Elevation

— — Mean Sea Level

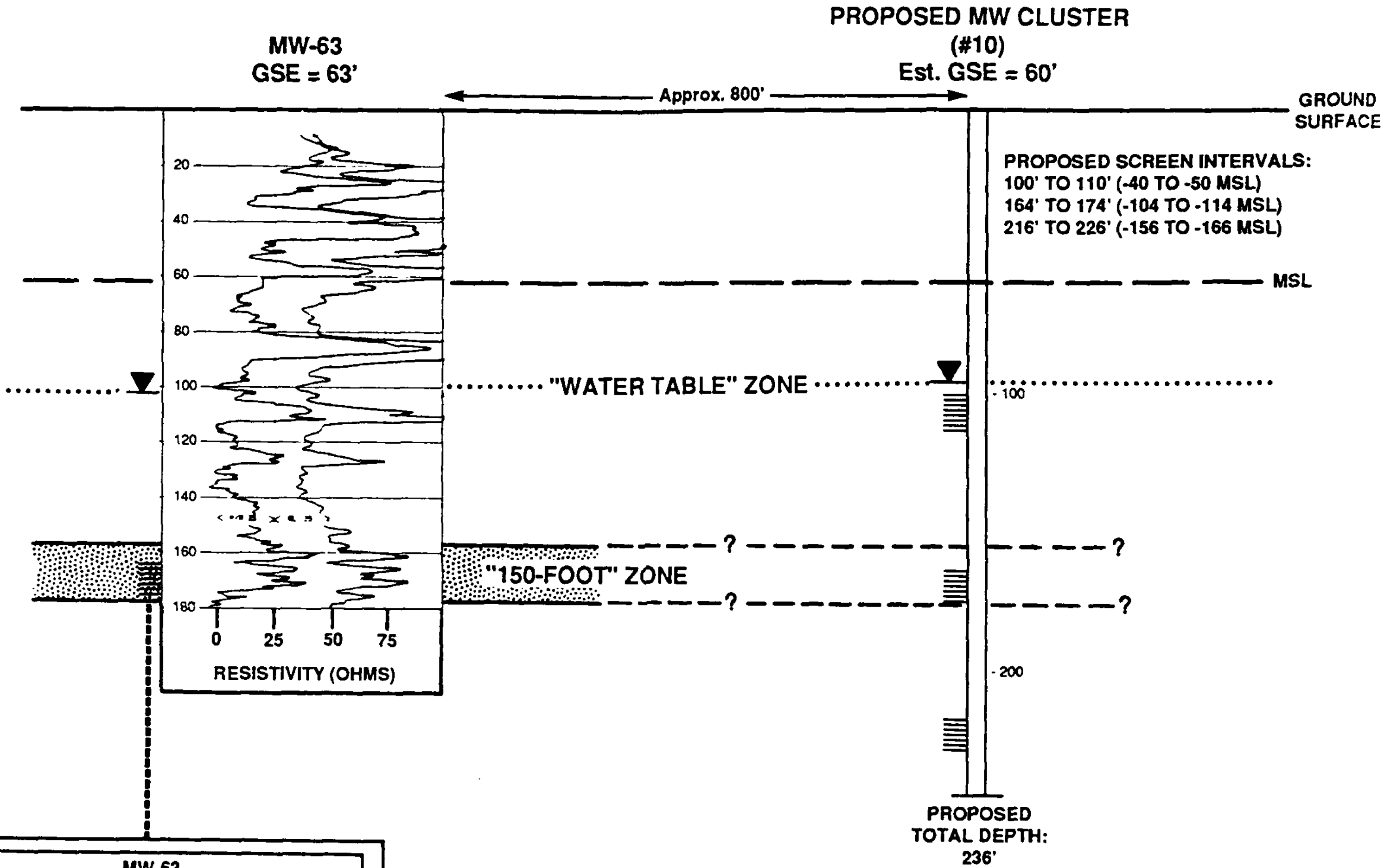
..▼.. Ground Water Level (2/88)

Screened Interval

Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)

NOTE: All analytical results are in ug/L

SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 200' (approx.)



MW-63

COMPOUND (DOHS Action Level)	DATE SAMPLED 8/85	9/85	8/87	10/87	2/88
TCE(5)	60	65	190	52	69
1,2-DCE(16)	29	26	ND	52	43
METHYLENE CHLORIDE(40)	ND	ND	ND	ND	3.2
1,2-DCA(1)	ND	ND	ND	ND	.78
1,1-DCE(6)	ND	ND	ND	ND	.76

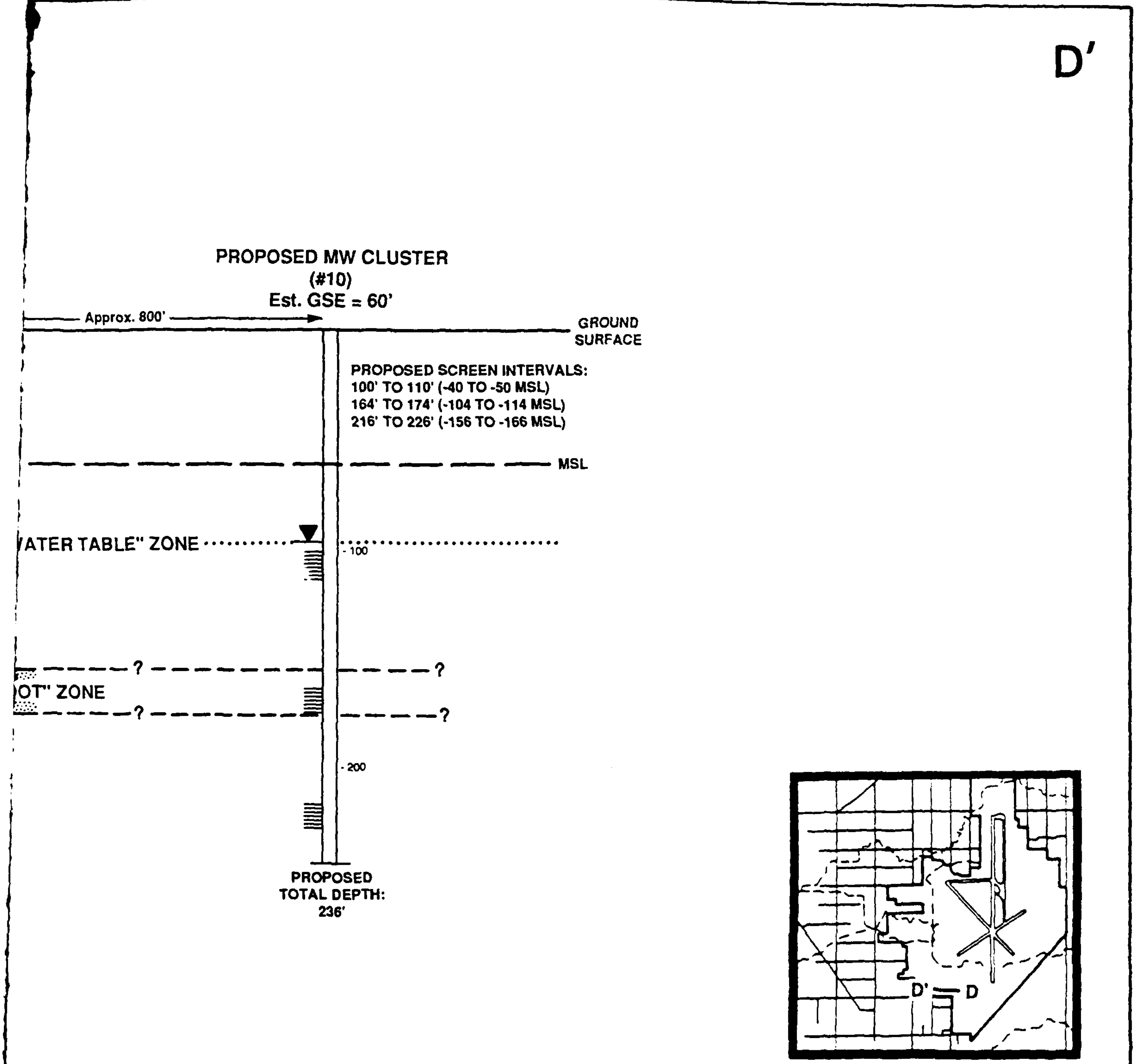
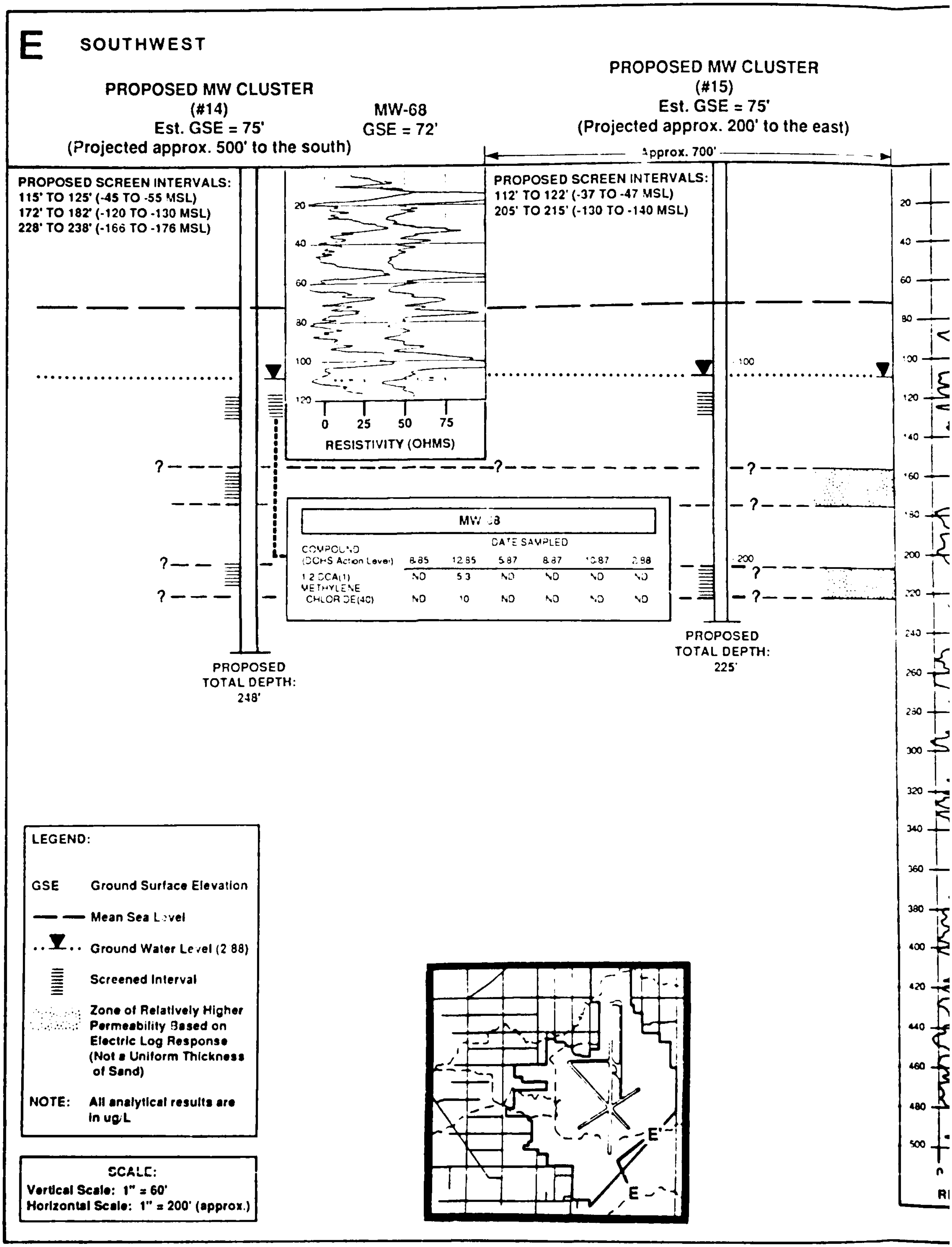


FIGURE 4-5.
GEOLOGIC CROSS SECTION
(D - D')

McCLELLAN AFB
RI Stage 6, February, 1990

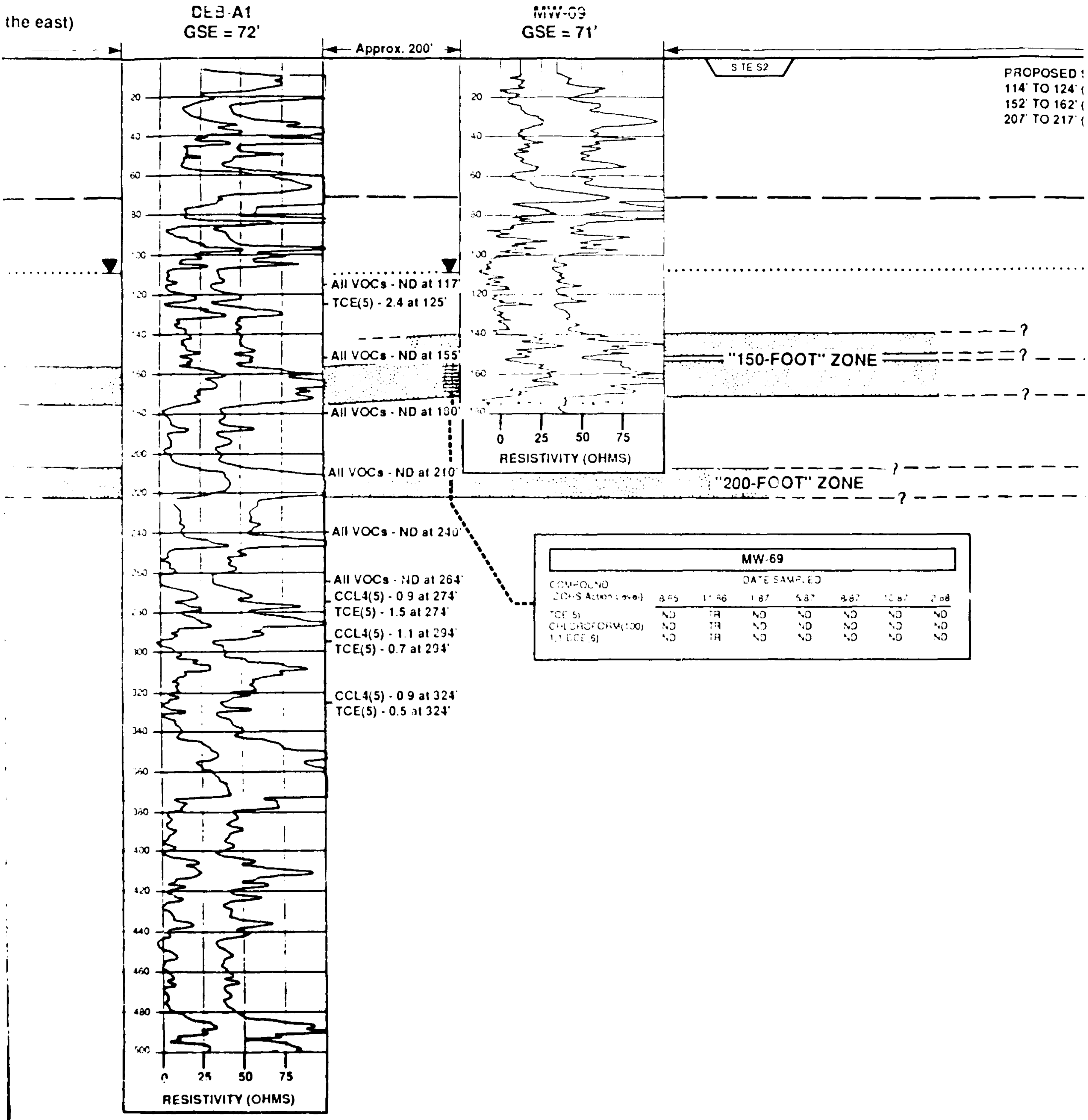
RADIAN
CORPORATION



MW 68

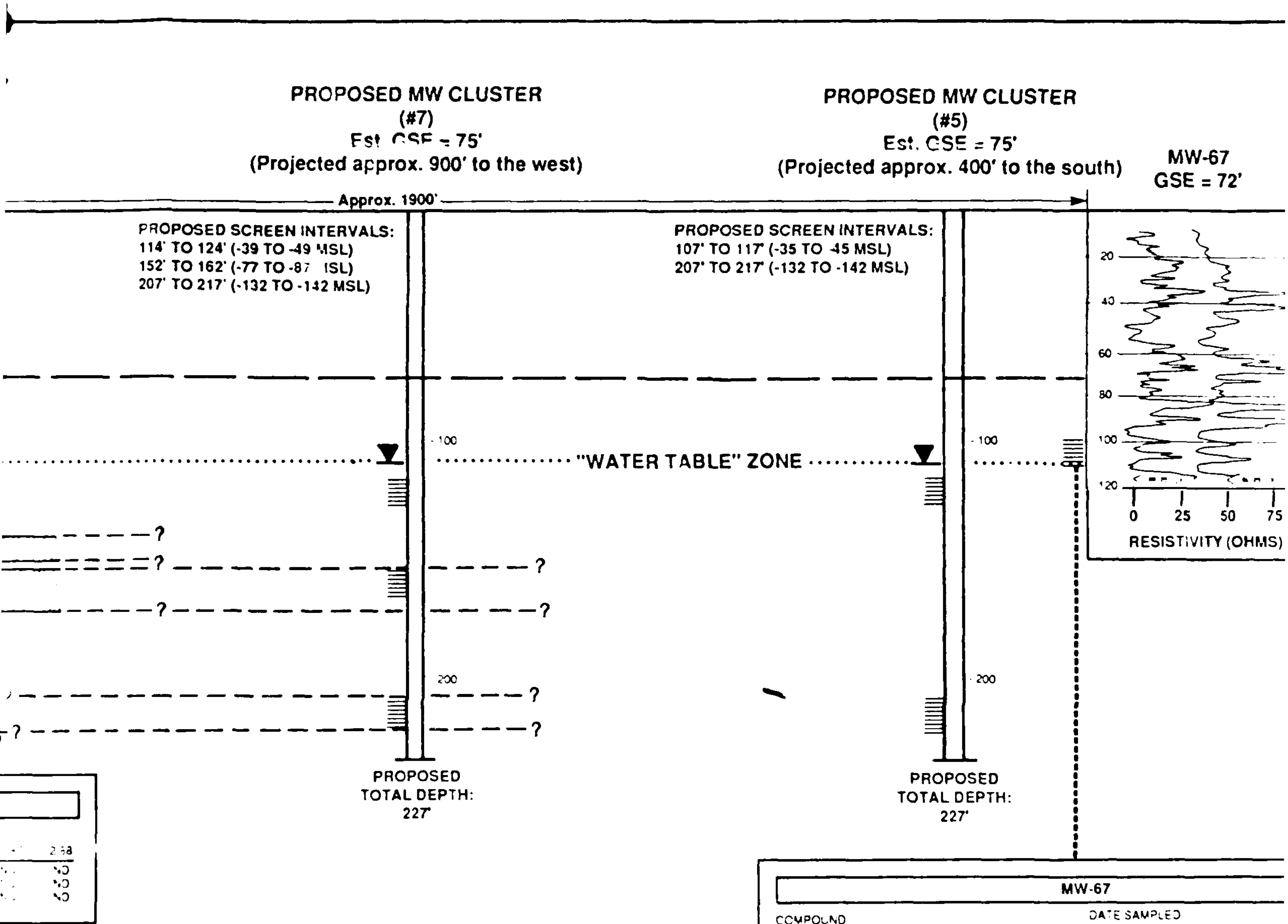
COMPOUND (DOHS Action Level)	DATE SAMPLED 8.85	12.85	5.87	8.87	10.87	2.88
1,2 DCA (1)	ND	5.3	ND	ND	ND	ND
METHYLENE CHLORIDE (40)	ND	10	ND	ND	ND	ND

STER



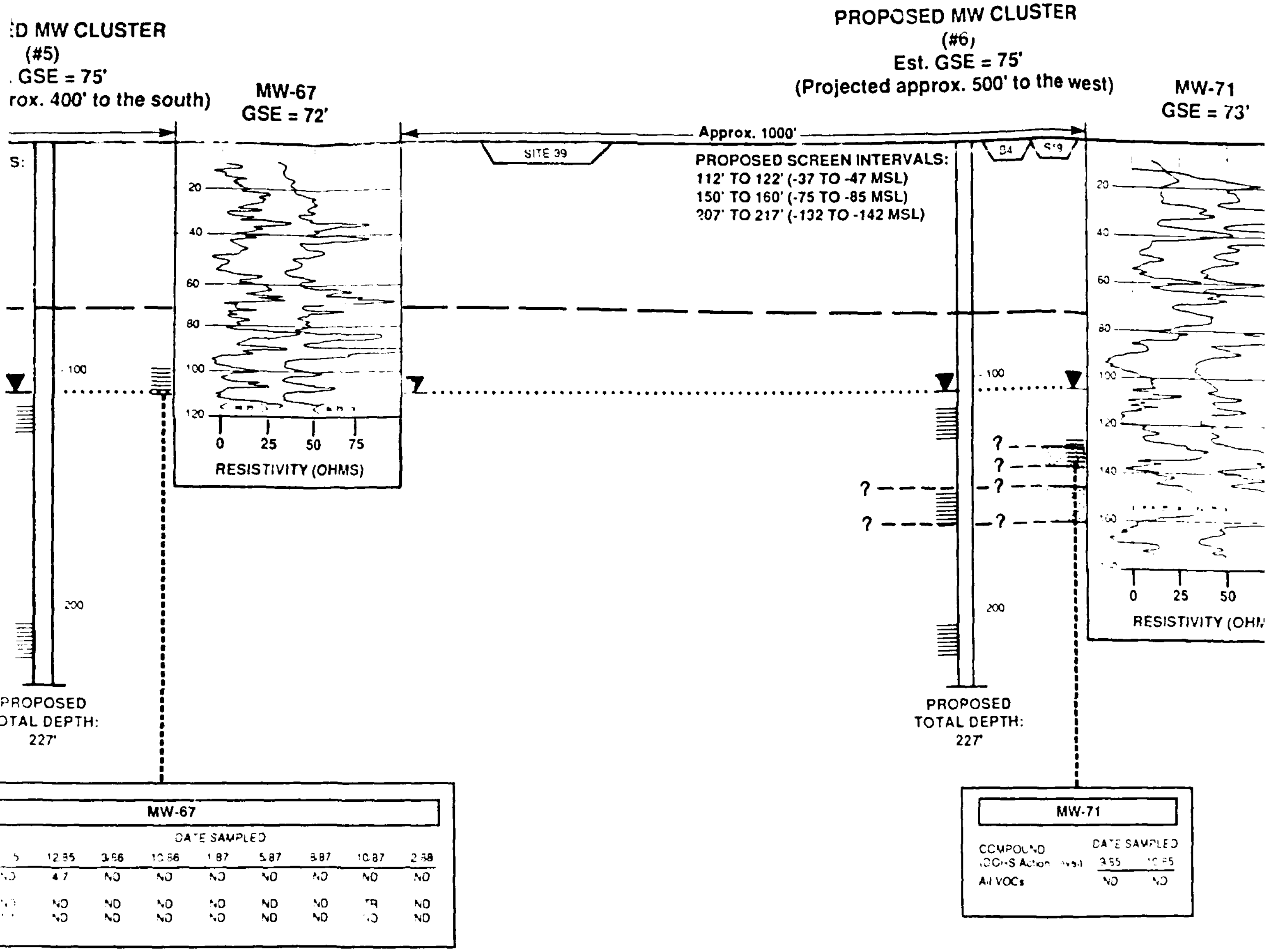
MW-69

COMPOUND (DOHS Action Level)	DATE SAMPLED						
	8 85	11 86	1 87	5 87	8 87	10 87	2 88
TCE(5)	ND	TR	ND	ND	ND	ND	ND
CHLOROFORM(100)	ND	TR	ND	ND	ND	ND	ND
1,1 DCE(5)	ND	TR	ND	ND	ND	ND	ND



MW-67

COMPOUND (DOHS Action Level)	DATE SAMPLED						
	[illegible] 85	12.85	3.86	10.86	1.87	5.87	8.87
1,2 DCA(1)	ND	4.7	ND	ND	ND	ND	ND
METHYLENE CHLORIDE(40)	ND	ND	ND	ND	ND	ND	ND
1,1,1-TCA(200)	1.1	ND	ND	ND	ND	ND	ND



:D MW CLUSTER
(#5)
. GSE = 75'
rox. 400' to the south)
MW-67
GSE = 72'
S:
RESISTIVITY (OHMS)
Approx. 1000'
SITE 39
PROPOSED MW CLUSTER
(#6)
Est. GSE = 75'
(Projected approx. 500' to the west)
PROPOSED SCREEN INTERVALS:
112' TO 122' (-37 TO -47 MSL)
150' TO 160' (-75 TO -85 MSL)
207' TO 217' (-132 TO -142 MSL)
MW-71
GSE = 73'
RESISTIVITY (OHM
PROPOSED
OTAL DEPTH:
227'
PROPOSED
TOTAL DEPTH:
227'
MW-67
DATE SAMPLED
12.85 3.86 10.86 1.87 5.87 8.87 10.87 2.88
4.7 ND ND ND ND ND ND ND
ND ND ND ND ND ND TR ND
ND ND ND ND ND ND ND ND
MW-71
COMPOUND
DATE SAMPLED
3.85 10.85
All VOCs ND ND

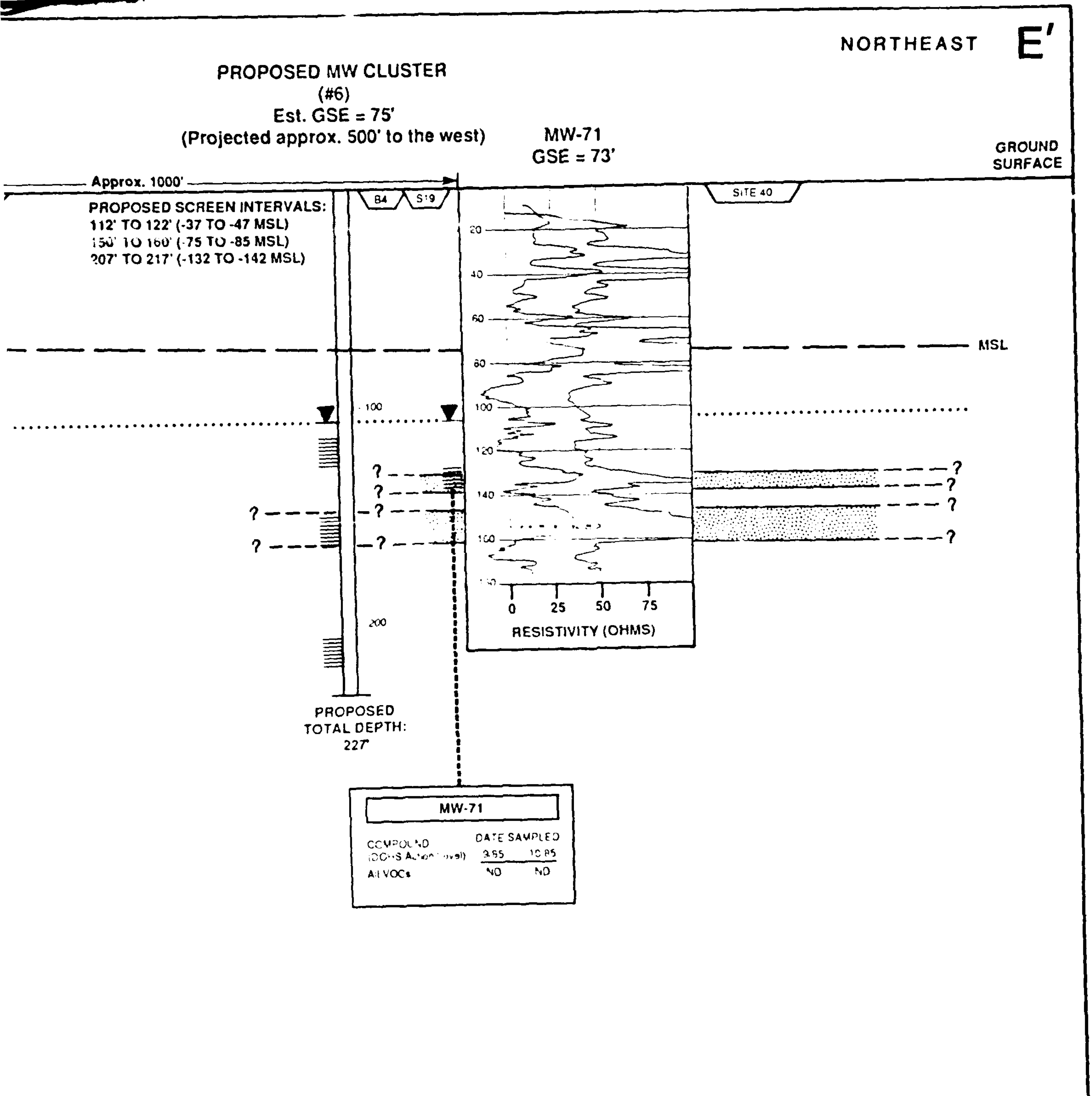


FIGURE 4-6.
GEOLOGIC CROSS SECTION
(E - E')

McCLELLAN AFB
RI Stage 6, February, 1990

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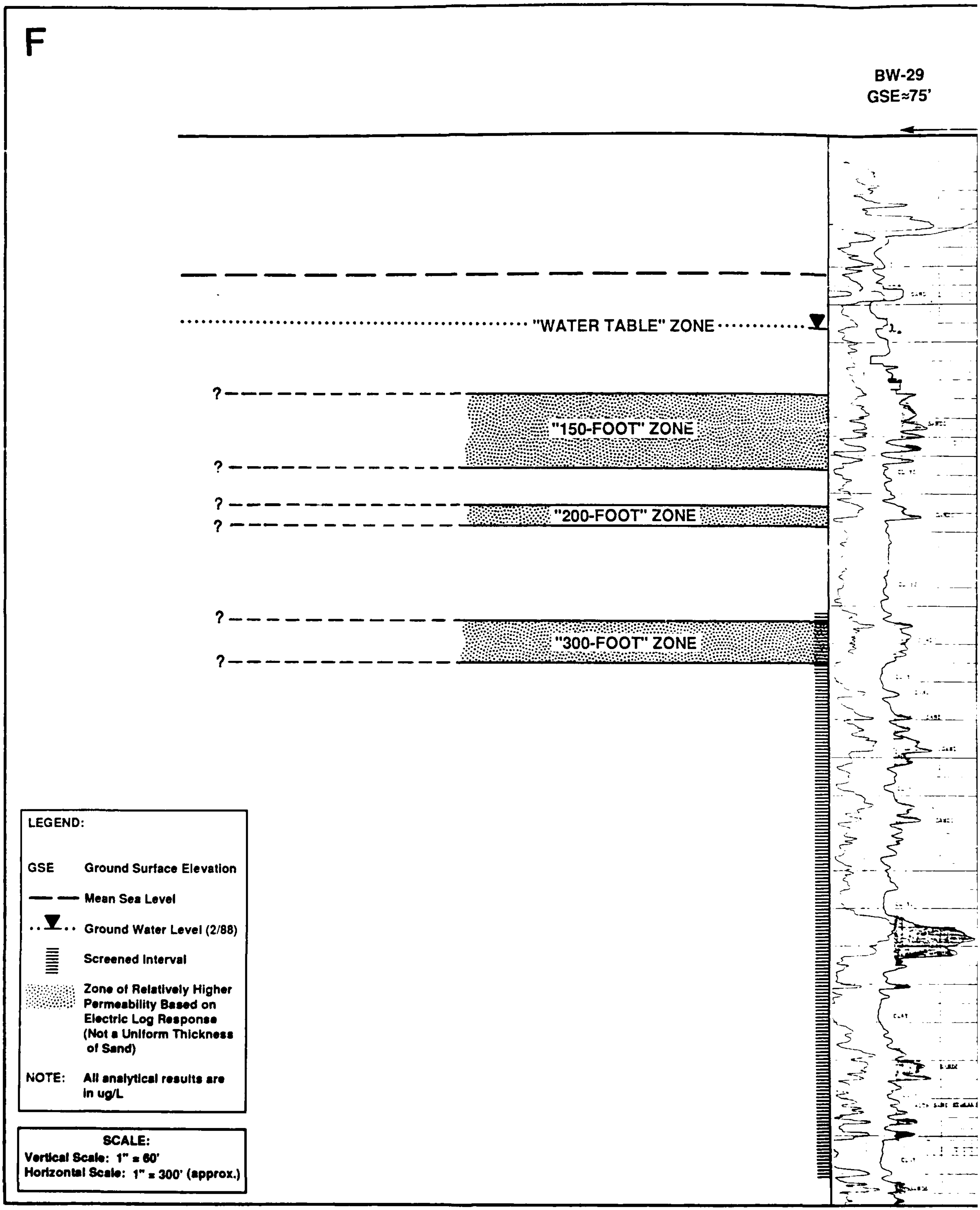
F
BW-29
GSE≈75'
"WATER TABLE" ZONE
?
"150-FOOT" ZONE
?
?
"200-FOOT" ZONE
?
?
"300-FOOT" ZONE
?
LEGEND:
GSE Ground Surface Elevation
Mean Sea Level
Ground Water Level (2/88)
Screened Interval
Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
NOTE: All analytical results are in ug/L
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 300' (approx.)

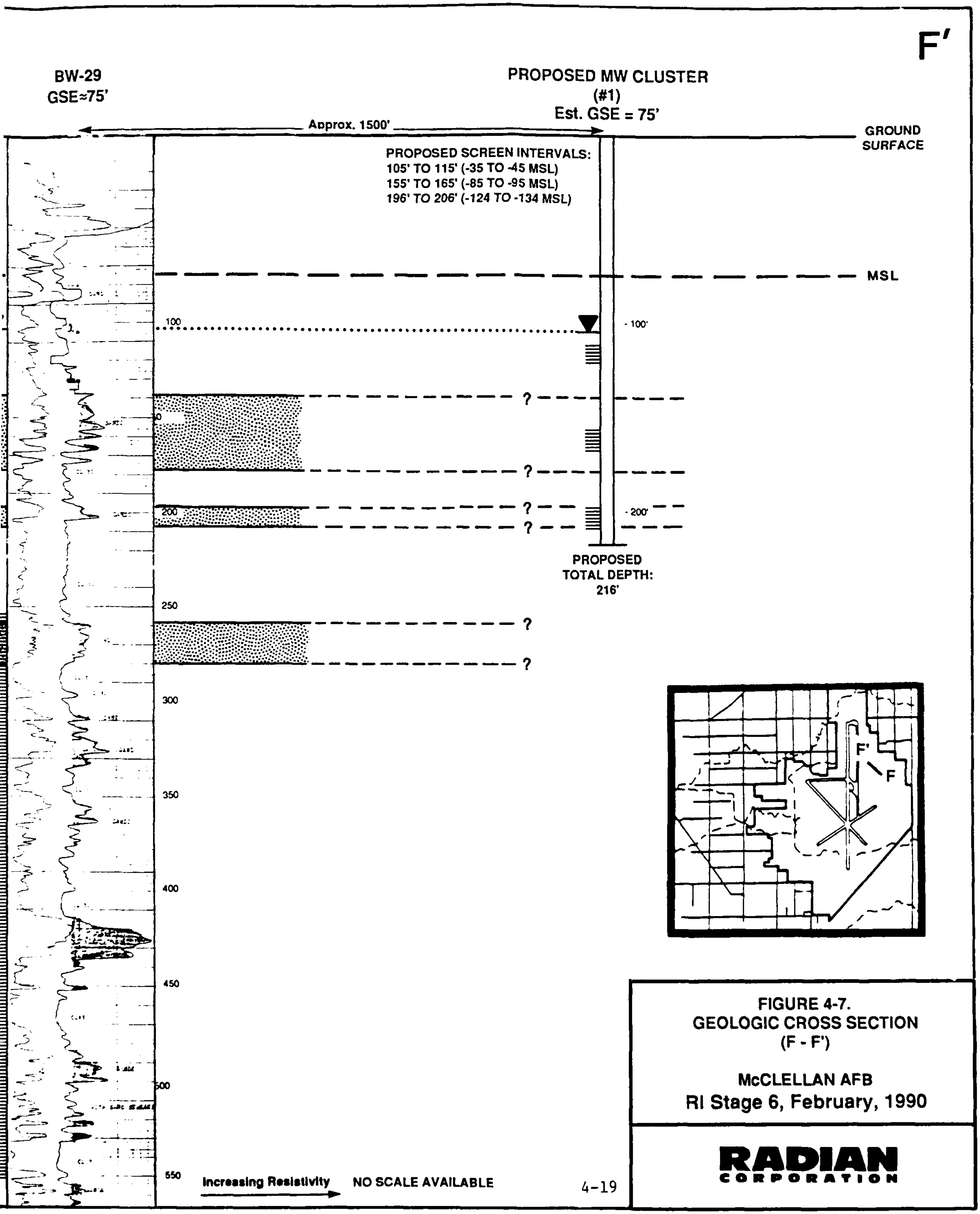

FIGURE 4-7.
GEOLOGIC CROSS SECTION
(F - F')

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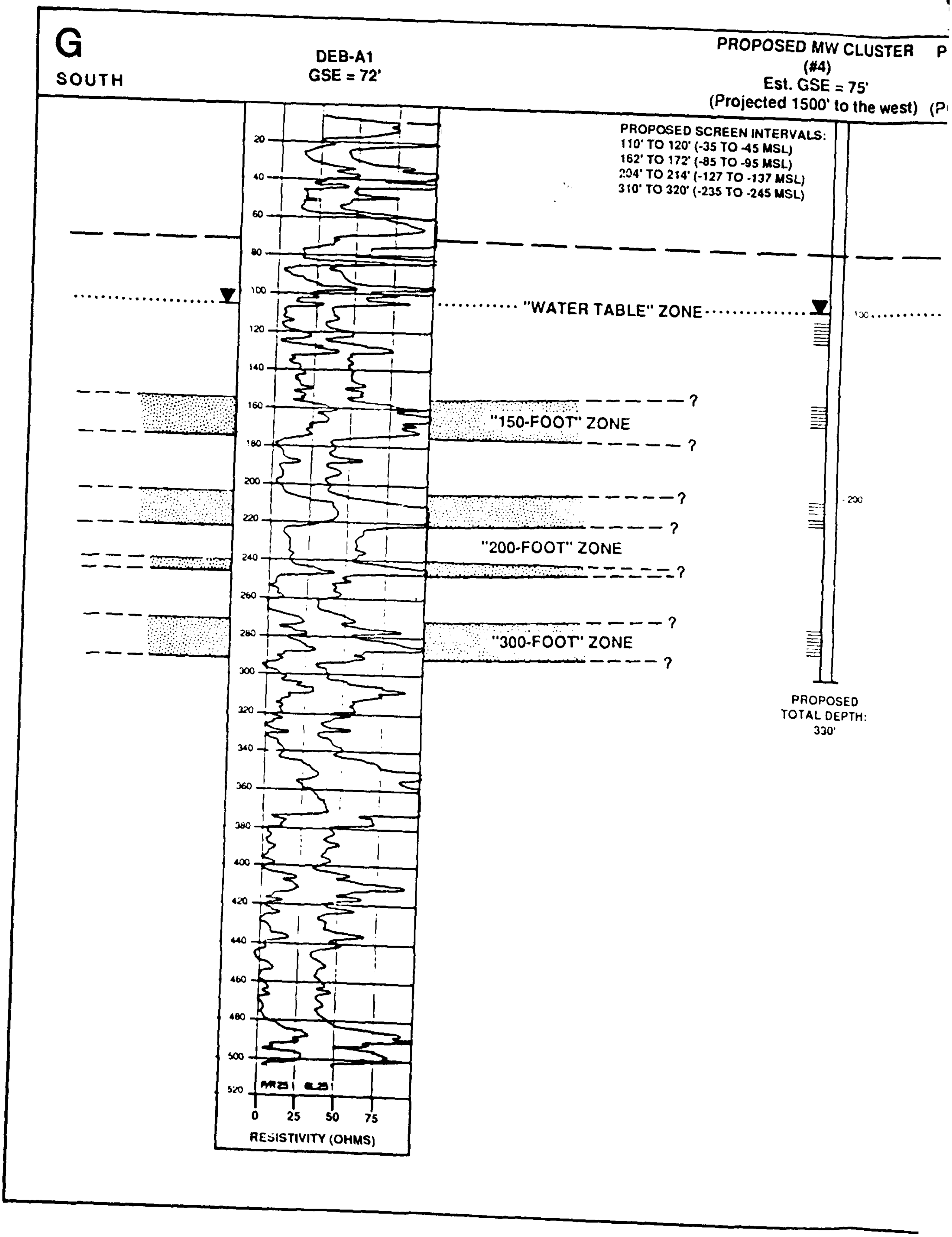
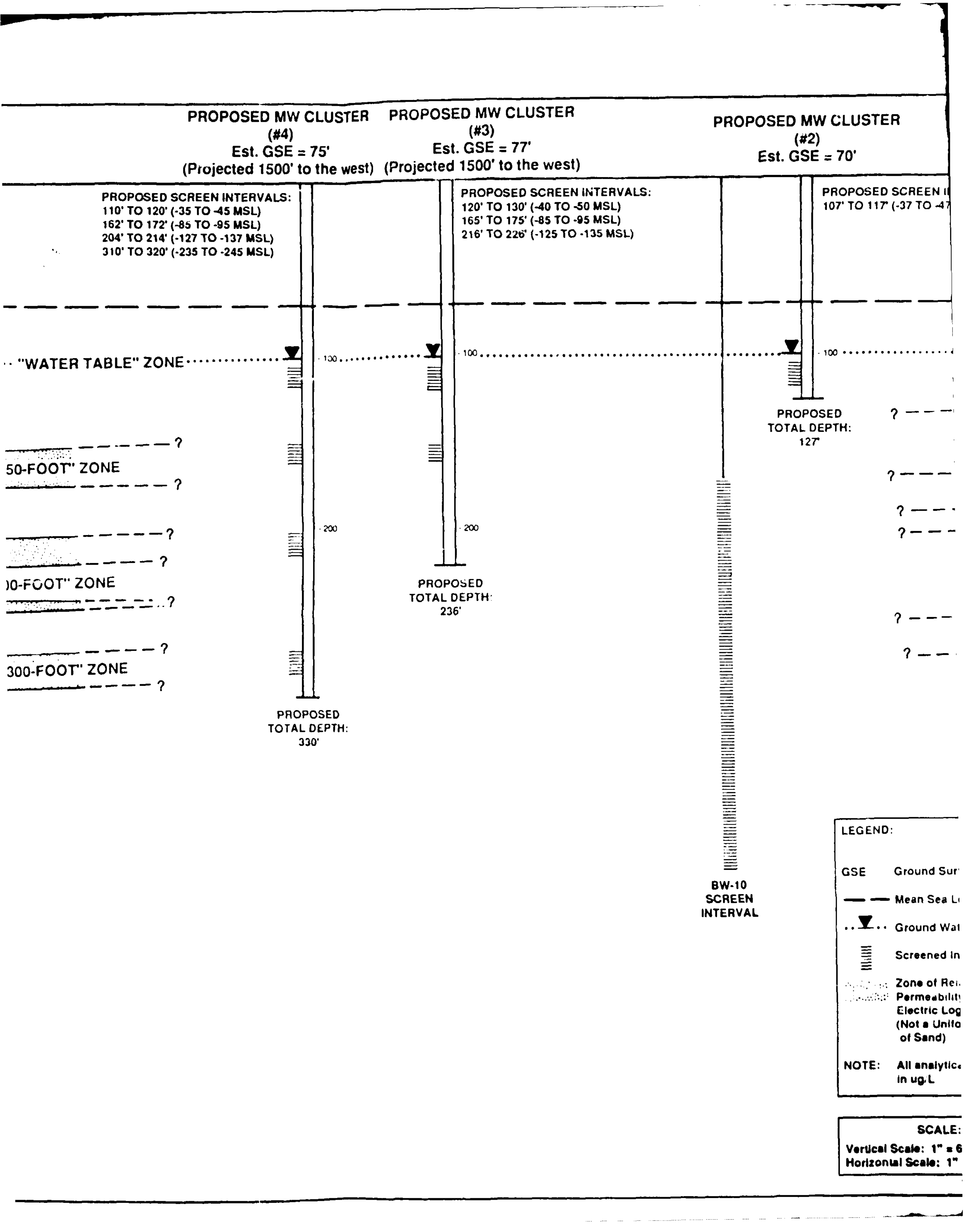
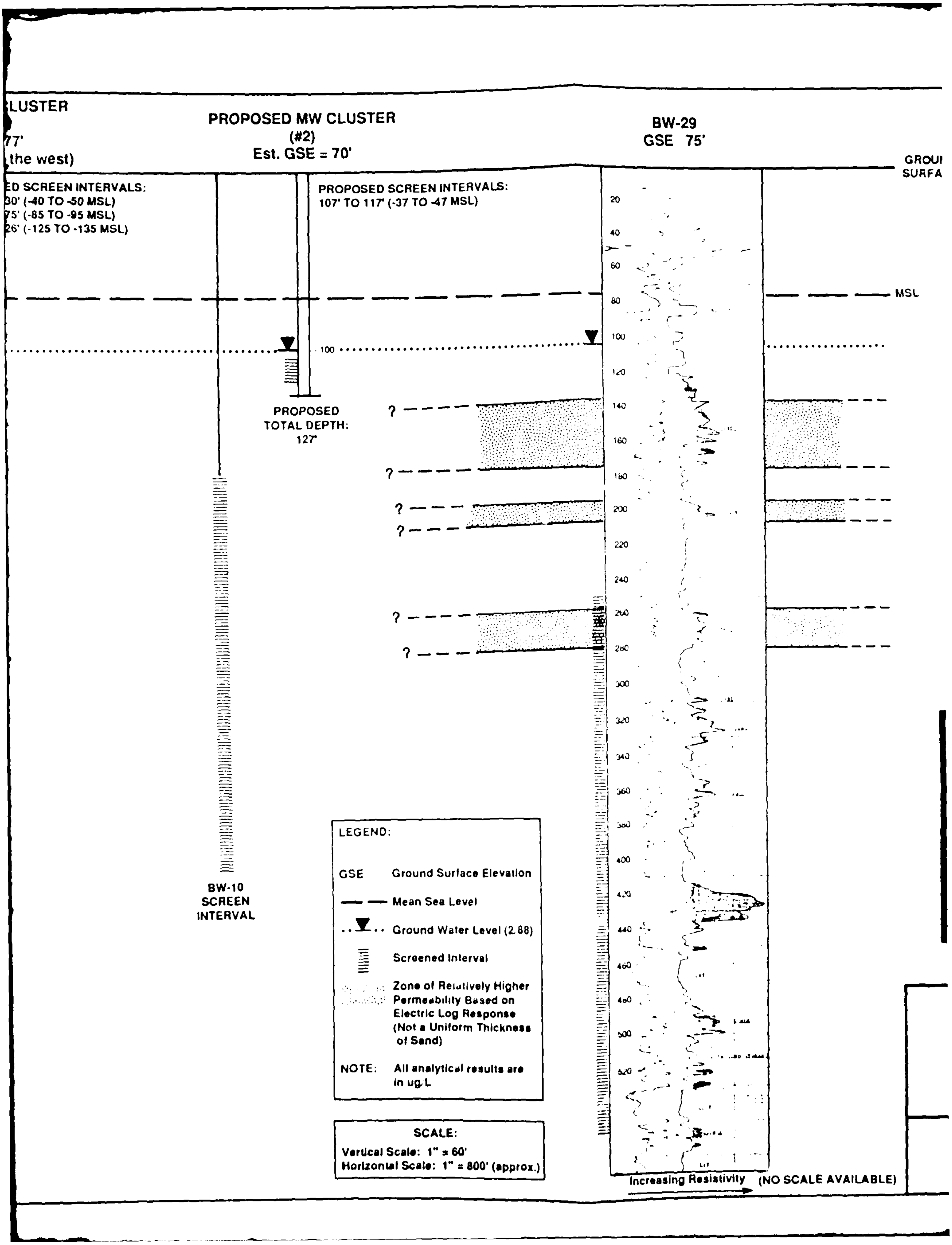


G
SOUTH
DEB-A1
GSE = 72'
PROPOSED MW CLUSTER
(#4)
Est. GSE = 75'
(Projected 1500' to the west)
PROPOSED SCREEN INTERVALS:
110' TO 120' (-35 TO -45 MSL)
162' TO 172' (-85 TO -95 MSL)
204' TO 214' (-127 TO -137 MSL)
310' TO 320' (-235 TO -245 MSL)
"WATER TABLE" ZONE
"150-FOOT" ZONE
"200-FOOT" ZONE
"300-FOOT" ZONE
PROPOSED
TOTAL DEPTH:
330'
RESISTIVITY (OHMS)

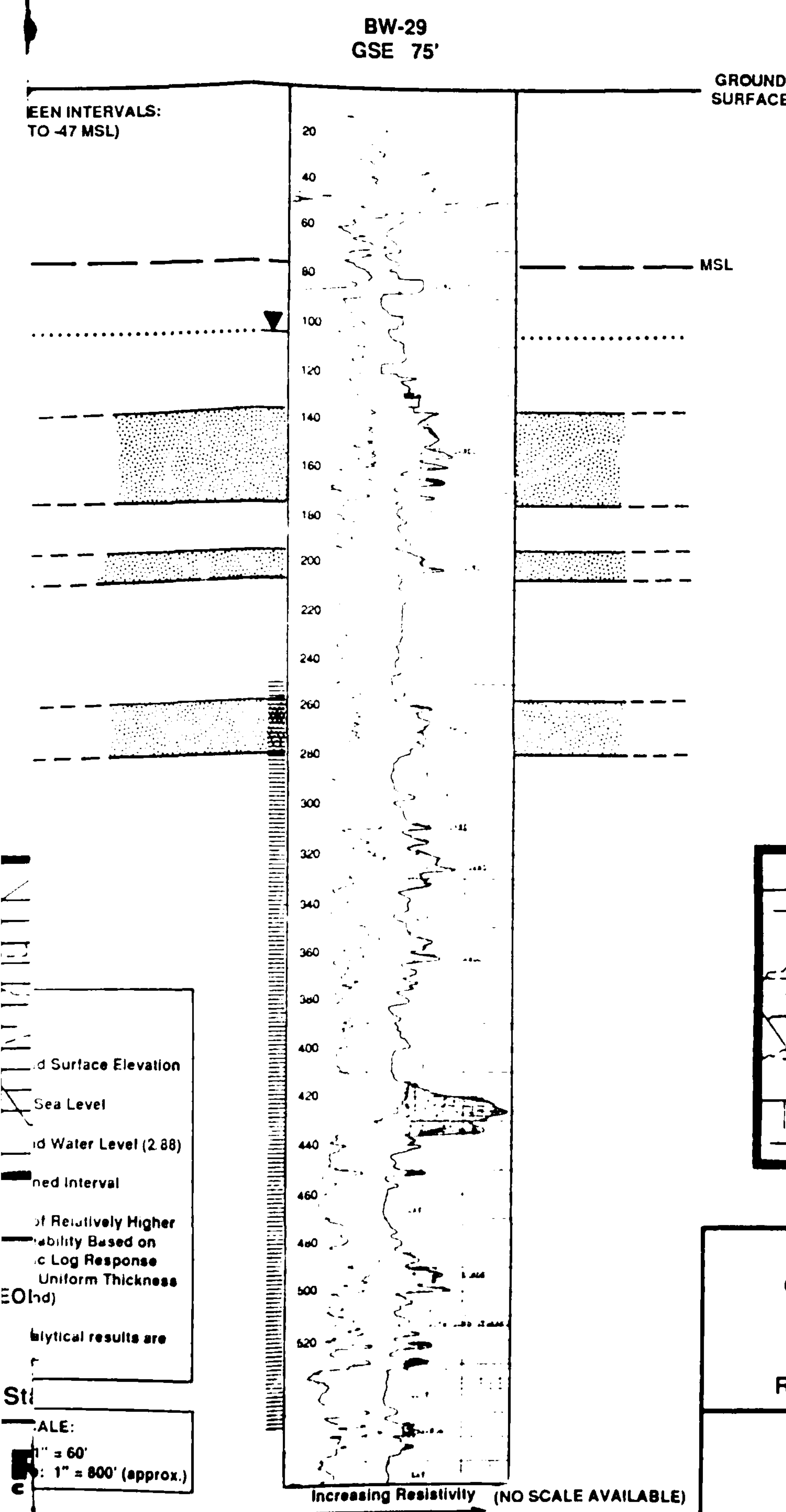


PROPOSED MW CLUSTER
(#4)
Est. GSE = 75'
(Projected 1500' to the west)
PROPOSED MW CLUSTER
(#3)
Est. GSE = 77'
(Projected 1500' to the west)
PROPOSED MW CLUSTER
(#2)
Est. GSE = 70'
PROPOSED SCREEN INTERVALS:
110' TO 120' (-35 TO -45 MSL)
162' TO 172' (-85 TO -95 MSL)
204' TO 214' (-127 TO -137 MSL)
310' TO 320' (-235 TO -245 MSL)
PROPOSED SCREEN INTERVALS:
120' TO 130' (-40 TO -50 MSL)
165' TO 175' (-85 TO -95 MSL)
216' TO 226' (-125 TO -135 MSL)
PROPOSED SCREEN I
107' TO 117' (-37 TO -47
"WATER TABLE" ZONE
100
200
50-FOOT" ZONE
)0-FOOT" ZONE
300-FOOT" ZONE
PROPOSED TOTAL DEPTH: 127'
PROPOSED TOTAL DEPTH: 236'
PROPOSED TOTAL DEPTH: 330'
BW-10 SCREEN INTERVAL
LEGEND:
GSE Ground Sur
Mean Sea L
Ground Wat
Screened In
Zone of Re
Permeability
Electric Log
(Not a Unifo
of Sand)
NOTE: All analytic
in ug/L
SCALE:
Vertical Scale: 1" = 6
Horizontal Scale: 1"



LUSTER
77'
the west)
ED SCREEN INTERVALS:
30' (-40 TO -50 MSL)
75' (-85 TO -95 MSL)
26' (-125 TO -135 MSL)
PROPOSED MW CLUSTER
(#2)
Est. GSE = 70'
PROPOSED SCREEN INTERVALS:
107' TO 117' (-37 TO -47 MSL)
PROPOSED
TOTAL DEPTH:
127'
BW-10
SCREEN
INTERVAL
BW-29
GSE 75'
GROU
SURFA
MSL
100
LEGEND:
GSE Ground Surface Elevation
Mean Sea Level
Ground Water Level (2.88)
Screened Interval
Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
NOTE: All analytical results are in ug/L
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 800' (approx.)
Increasing Resistivity
(NO SCALE AVAILABLE)

G′
NORTH



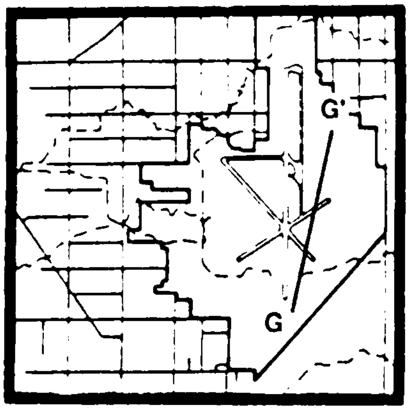


FIGURE 4-8.
GEOLOGIC CROSS SECTION
(G - G')

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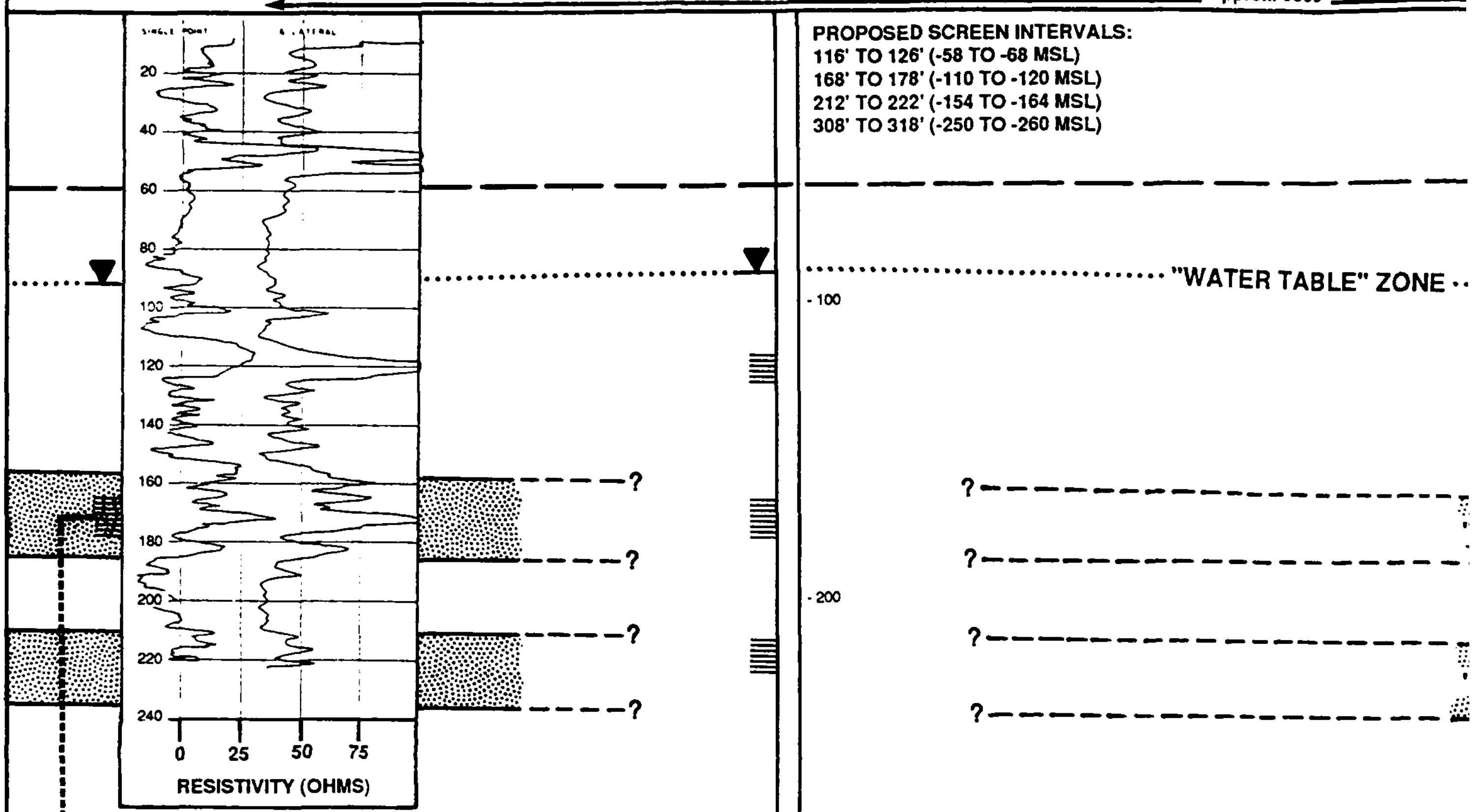
H

NORTH

MW-58
GSE ≈ 60'

PROPOSED MW CLUSTER
(#9)
Est. GSE = 58'
(Projected 800' to the west)

Approx. 5500'



MW-58						
COMPOUND (DOHS Action Level)	DATE SAMPLED 11/86	1/87	4/87	8/87	10/87	2/88
TCE(5)	TR	1.5	1.5	ND	ND	ND
1,1-DCE(6)	1.7	3.3	ND	ND	ND	TR
1,1-DCA(20)	2.0	0.32	ND	ND	ND	ND
1,1,1-TCA(200)	TR	2.4	2.3	ND	ND	TR
VINYL CHLORIDE(2)	1.3	ND	ND	ND	ND	ND

LEGEND:

GSE — Ground Surface Elevation

— — Mean Sea Level

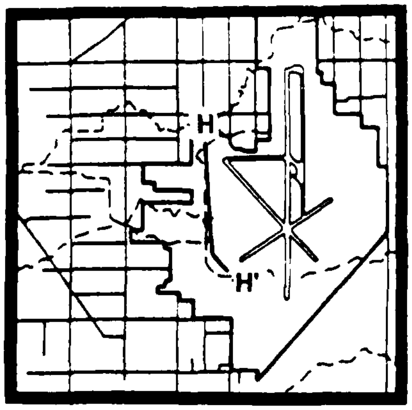
..▼.. Ground Water Level (2/88)

Screened Interval

Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)

NOTE: All analytical results are in ug/L

SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: 1" = 800' (approx.)



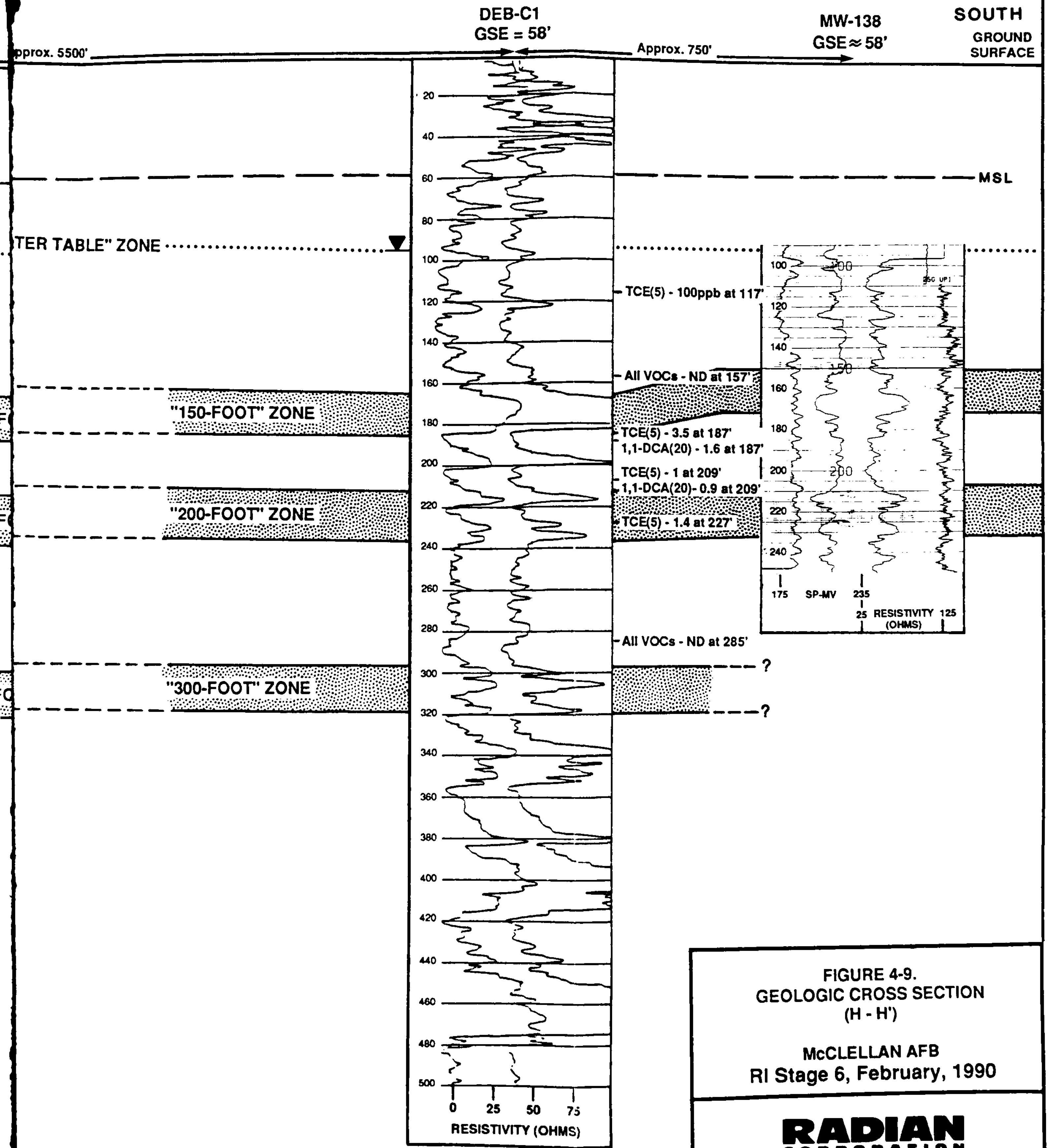


FIGURE 4-9.
GEOLOGIC CROSS SECTION
(H - H')

McCLELLAN AFB
RI Stage 6, February, 1990

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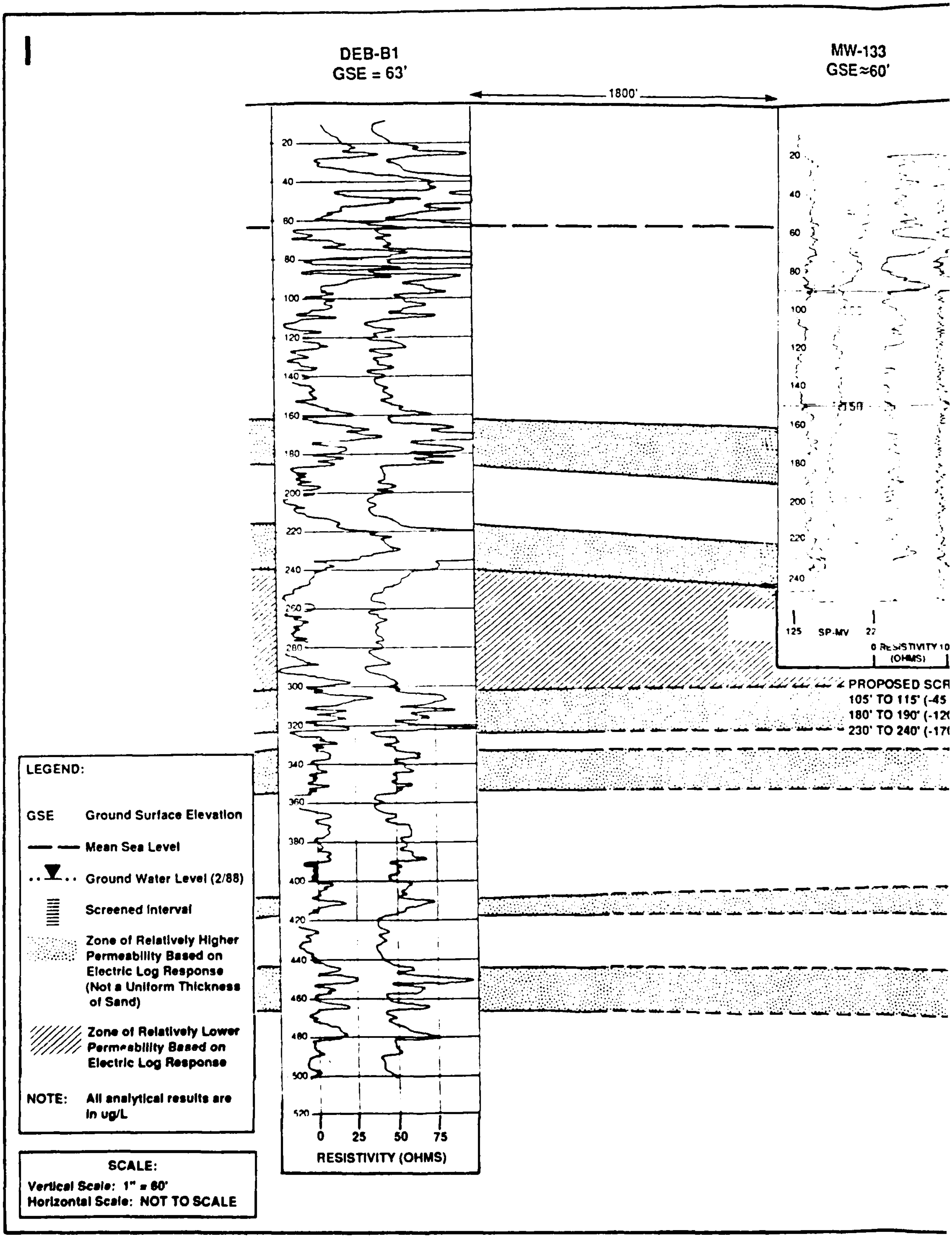
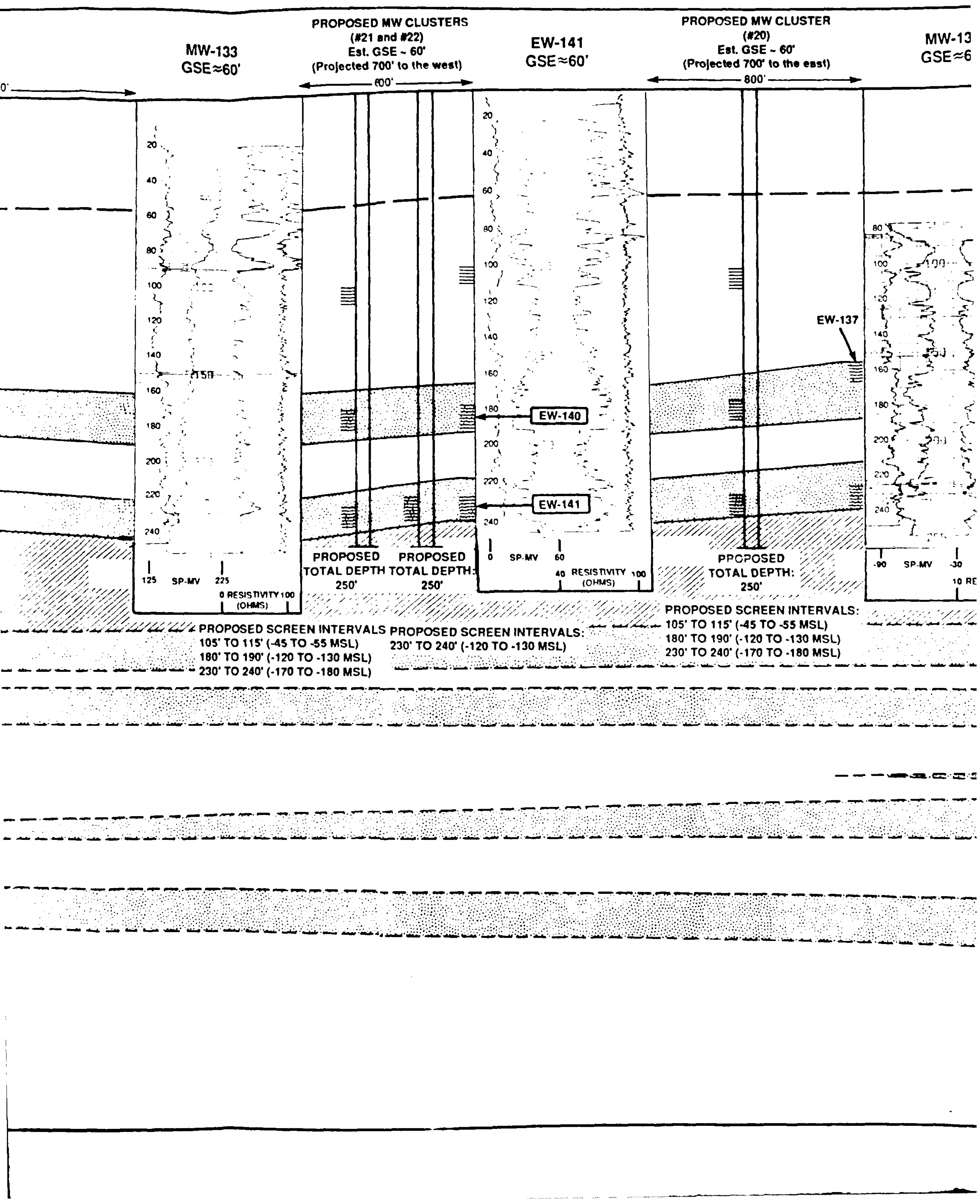
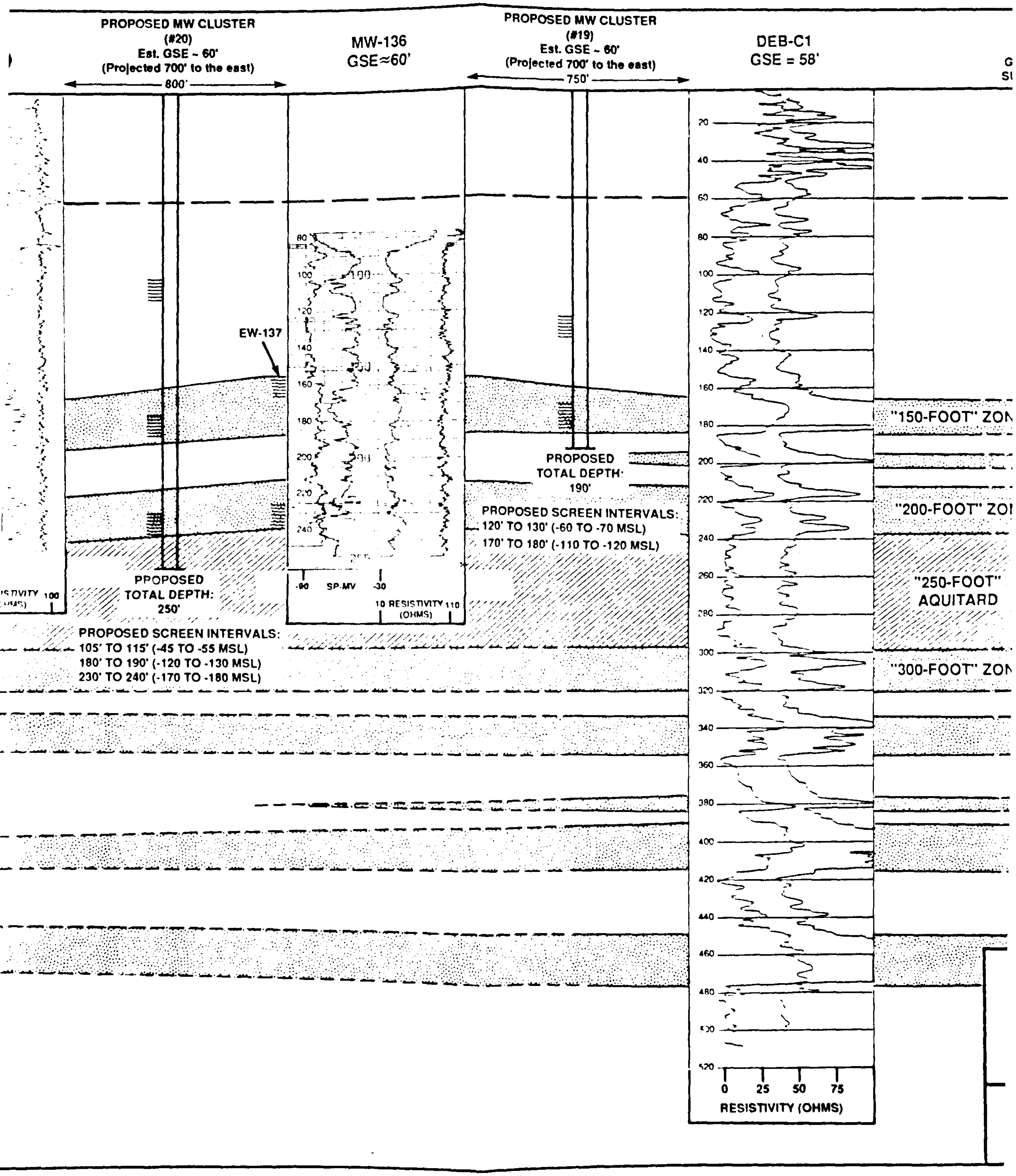

DEB-B1
GSE = 63'
MW-133
GSE≈60'
1800'
RESISTIVITY (OHMS)
0 25 50 75
SP-MV
RESISTIVITY
(OHMS)
PROPOSED SCR
105' TO 115' (-45
180' TO 190' (-12
230' TO 240' (-17
LEGEND:
GSE Ground Surface Elevation
Mean Sea Level
Ground Water Level (2/88)
Screened Interval
Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
Zone of Relatively Lower Permeability Based on Electric Log Response
NOTE: All analytical results are in ug/L
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: NOT TO SCALE



MW-133
GSE≈60'
PROPOSED MW CLUSTERS
(#21 and #22)
Est. GSE ~ 60'
(Projected 700' to the west)
600'
EW-141
GSE≈60'
PROPOSED MW CLUSTER
(#20)
Est. GSE ~ 60'
(Projected 700' to the east)
800'
MW-13
GSE≈6
EW-137
EW-140
EW-141
125 SP-MV 225
0 RESISTIVITY 100 (OHMS)
0 SP-MV 60
40 RESISTIVITY 100 (OHMS)
-90 SP-MV -30
10 RE
PROPOSED TOTAL DEPTH 250'
PROPOSED TOTAL DEPTH: 250'
PROPOSED TOTAL DEPTH: 250'
PROPOSED SCREEN INTERVALS
105' TO 115' (-45 TO -55 MSL)
180' TO 190' (-120 TO -130 MSL)
230' TO 240' (-170 TO -180 MSL)
PROPOSED SCREEN INTERVALS:
230' TO 240' (-120 TO -130 MSL)
PROPOSED SCREEN INTERVALS:
105' TO 115' (-45 TO -55 MSL)
180' TO 190' (-120 TO -130 MSL)
230' TO 240' (-170 TO -180 MSL)



PROPOSED MW CLUSTER
(#20)
Est. GSE ~ 60'
(Projected 700' to the east)
800'
MW-136
GSE≈60'
PROPOSED MW CLUSTER
(#19)
Est. GSE ~ 60'
(Projected 700' to the east)
750'
DEB-C1
GSE = 58'
EW-137
PROPOSED TOTAL DEPTH: 250'
PROPOSED SCREEN INTERVALS:
105' TO 115' (-45 TO -55 MSL)
180' TO 190' (-120 TO -130 MSL)
230' TO 240' (-170 TO -180 MSL)
PROPOSED TOTAL DEPTH: 190'
PROPOSED SCREEN INTERVALS:
120' TO 130' (-60 TO -70 MSL)
170' TO 180' (-110 TO -120 MSL)
SP-MV
-90
-30
10 RESISTIVITY 110 (OHMS)
0 25 50 75
RESISTIVITY (OHMS)
"150-FOOT" ZON
"200-FOOT" ZON
"250-FOOT" AQUITARD
"300-FOOT" ZON

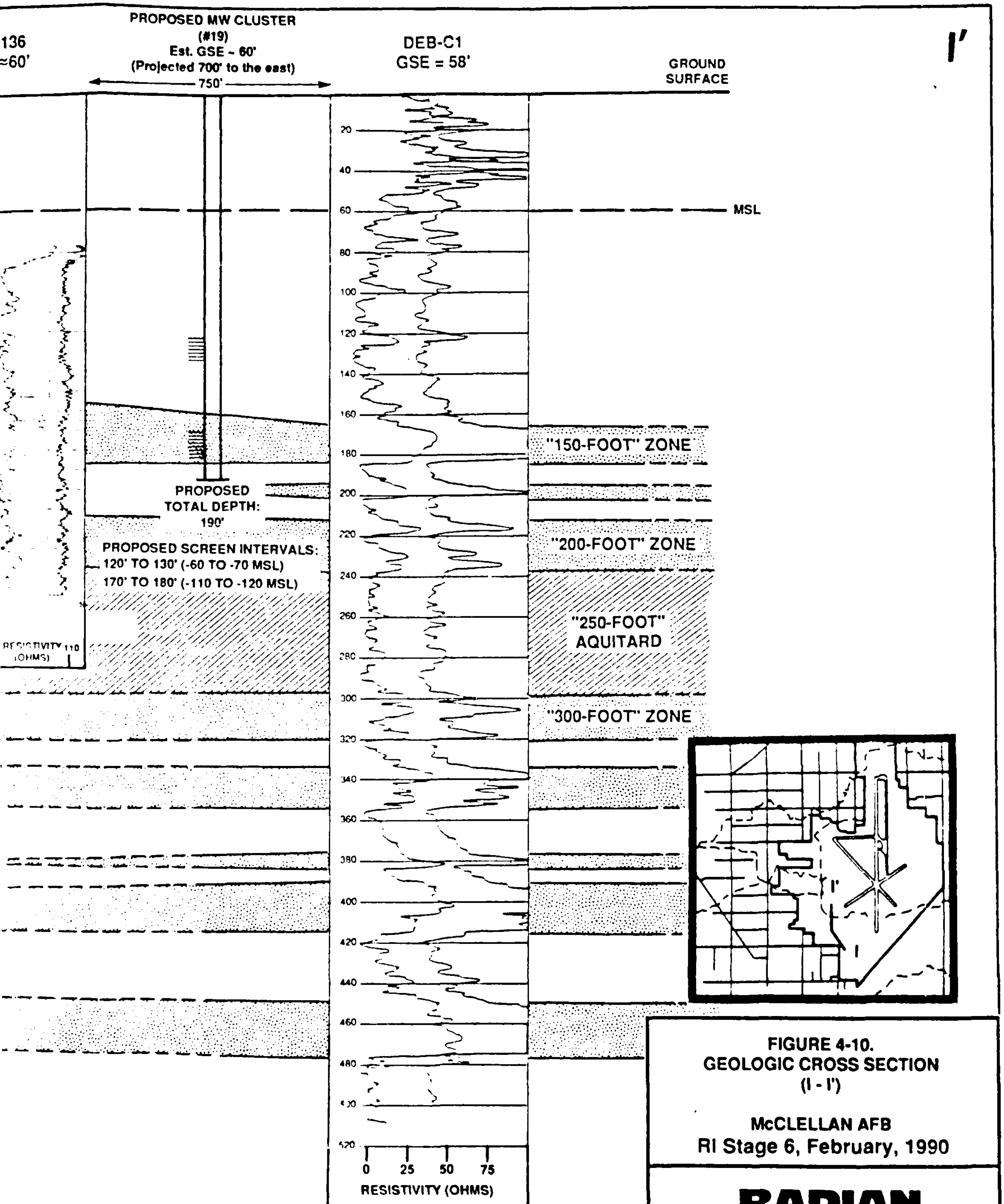


FIGURE 4-10.
GEOLOGIC CROSS SECTION
(I - I')

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RI Stage 6, February, 1990

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4.6.2 Groundwater Hydrology Data

This section identifies additional hydrologic parameters that are needed to more fully assess the movement of groundwater and the potential extent of groundwater contamination. The existing database and additional data required to satisfy the objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) are presented.

In order to assess the extent and magnitude of groundwater contamination and determine potential groundwater operable unit areas at McClellan AFB, the hydraulic properties of the subsurface media require characterization. Parameters such as hydraulic conductivity and aquifer storage coefficients are needed to understand groundwater movement. Determination of vertical hydraulic conductivity of aquitards is required to characterize vertical movement of groundwater and to begin characterizing vertical contaminant movements. In addition, an adequate network of wells for measuring groundwater levels is necessary to develop potentiometric surface maps. Groundwater levels are used to determine flow directions and gradients in all areas of the base. The location, duration, and magnitude of groundwater withdrawals influencing groundwater movement are also needed to evaluate potential contaminant migration.

Available groundwater hydrology data have been reviewed to determine the additional information required to meet the objectives of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment). Available data include potentiometric surface maps for the three monitoring zones and results of single- and multiple-well aquifer tests conducted by various IRP contractors. Based on a review of the existing information, the groundwater hydrology data requirements include:

- Hydraulic parameters, thickness, and extent for aquitards, in particular, the 250- to 300-foot aquitard zone;

- Additional hydraulic parameters for the more permeable water bearing zones, especially in the east and southeast portions of the base;

- Additional wells to be used for static groundwater-level measurements to determine groundwater flow directions and hydraulic gradients across the base and for the collection of groundwater quality data; and

- Data for on-base water supply wells to qualitatively assess their influence on local groundwater flow directions and gradients.

4.6.2.1 Existing Groundwater Hydrology Data

The aquifer system at McClellan AFB is composed of waterbearing zones of variable thickness and lateral extent interlayered with zones of less permeable silts and clays. The hydraulic properties of the waterbearing zones have been determined at various wells located on the west side of the base, primarily in Areas C and D. Smaller scale single-well pumping tests have been conducted at various on- and off-base locations. The locations of historic single- and multiple-well aquifer tests are shown in Figure 3-10. A summary of past aquifer testing is presented in Section 3.3.2. The hydraulic conductivity and storativity data developed from these tests have been for permeable zones located primarily at elevations above -180 feet msl (zones located within the upper 250 feet of the sediments). Recent discovery of contamination in Area C by EG&G, Idaho (1987) at depths of up to 245 feet, and concern about the influence of on- and off-base water supply wells on contaminant migration present a need to acquire hydrologic data from greater depths.

A network of monitoring wells located on and off base has been established for water-level measurements that are used to determine groundwater flow patterns. In portions of the study area, however, additional wells are needed to provide data where none is currently available and to assess more complicated flow patterns resulting from pumping of on-base water supply and extraction wells (see Plates 2, 3, and 4). Near Area A and in the off-base Southeast Area, there are few data points from which total hydraulic head can be determined. The eastern side of the base also lacks wells for groundwater-level measurements, especially near BW-10 where groundwater pumpage is probably affecting local flow patterns.

Previous field testing of the aquifer system has not been conducted for all portions of the base where contaminants have been detected or are likely to be present. In Area A and adjacent areas on and off base, the hydraulic properties of the aquifer system have not been adequately characterized.

Field testing of the aquifer system has determined hydraulic properties of the more permeable zones. The hydraulic properties of the less permeable confining zones have only been indirectly determined from aquifer testing. Vertical hydraulic conductivity and storage coefficients of the aquitards have not been determined, although clusters of wells have been installed to monitor vertical gradients between waterbearing zones.

4.6.2.2 Required Groundwater Hydrology Data

The above subsection has summarized the existing hydrologic database and identified deficiencies in terms of lack of data. This subsection identifies the additional information required to more fully characterize the hydrologic parameters of the aquifer system.

The hydraulic properties have not been characterized for all areas near or downgradient of known waste storage and disposal sites. Additional testing of the permeable zones is required in Area A and Adjacent On-Base Areas to the northeast and southwest, as well as in the adjacent off-base Southeast Area located south of Area A. The specific wells to be used in characterizing Area A are identified in Section 5.2.1.6.

The hydraulic properties of the less permeable zones that separate the waterbearing zones have never been quantified through the use of field tests designed for this purpose. The storage coefficient and the vertical conductivity of the confining layers need to be determined in order to evaluate the downward movement of groundwater and also contaminants. Field testing of the confining layers and laboratory determination of storativity and hydraulic conductivity are necessary to provide an initial database of the aquitard properties. Specific details of the field and laboratory methods are described in Section 5.2.1.6. Field testing of the aquifer system will be used to determine "in situ" parameters for certain zones. Analyses of the field test data requires laboratory measurements of specific storage from compression tests. In addition, laboratory measurements of hydraulic conductivity from permeameter tests of samples collected from boreholes will be used for comparison with field-derived values. Field and laboratory methods are explained in Section 5.2.1.6.1.

Potentiometric surface maps are generated from quarterly groundwater-level measurements for the shallow, middle, and deep "A" monitoring zones. Monitoring wells for groundwater-level measurements are required in several portions of the study area and in additional waterbearing zones where none currently exist. In general, additional water-level data are needed in the off-base Southeast and Southwest areas, in Area A, and in the eastern portion of the base.

The effects of active on-base water supply wells are evident on many of the potentiometric surface maps presented in the past. The operating schedule of the water supply wells and water-level measurements from nearby monitoring wells are required to develop information on the hydrologic effects of on-base water supply wells. The specific tasks to evaluate the effects of on-base water supply wells are discussed in Section 5.2.1.6.3. Of particular interest are horizontal and vertical hydraulic gradients near these production wells and the rate at which these gradients change as the water supply wells are turned on and off. Methods to be used to determine these affects are explained in Section 5.2.1.6.3.

Based on the general data requirements summarized above, the following hydrologic work will be conducted during the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment):

- Single-Well Aquifer Tests--A maximum of 40 single-well tests will be conducted at the locations shown on Figure 4-11. The wells designated for single well tests were selected to provide parameters for locations and waterbearing zones where these data are not available. The data will be evaluated to determine transmissivity and hydraulic conductivity of the water-bearing units in which the wells are screened. The single well pumping tests will be conducted in wells located on and off base. Single-well tests are needed to define aquifer parameters affecting flow.

- Multiple-Well Aquifer Tests--Two multiple-well aquifer tests will be conducted at the aquifer test well field installed during Phase II, Stage 2-3, of the IRP, and in Area C. Groundwater levels in observation wells screened in different aquitards will be used to quantify the vertical hydraulic conductivity of these fine-grained sediments.

- Installation of Monitoring Wells--All of the monitoring wells to be installed as described in Table 4-2 will be used to measure groundwater levels. The use of new and existing wells for this purpose will allow preparation of potentiometric surface maps from which groundwater flow conditions across the base can be interpreted.

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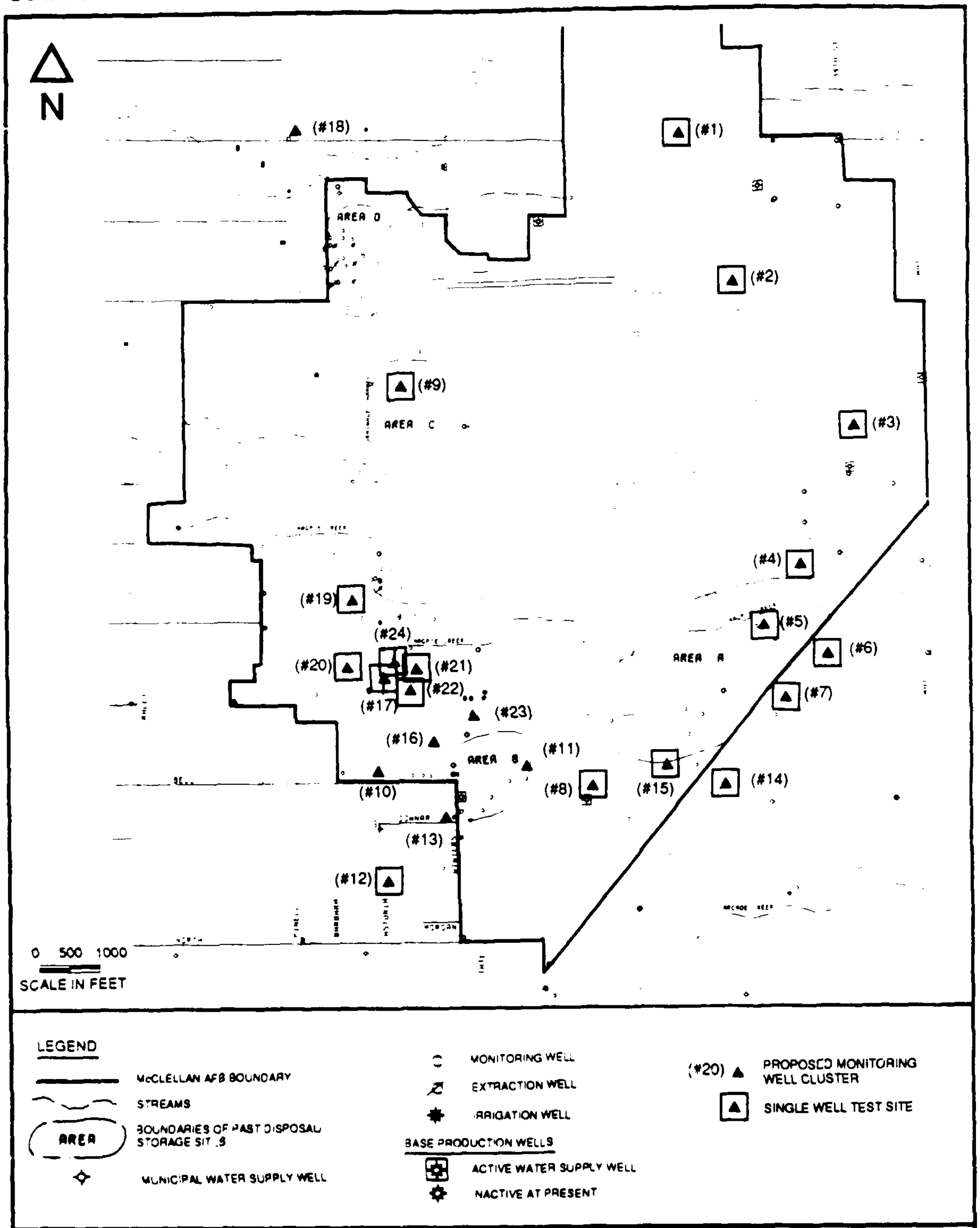

Figure 4-11. Locations of Proposed Single-Well Aquifer Tests.

0588-040-21

- Monitoring Groundwater Levels Near On-Base Water Supply Wells--Automated hydrologic data loggers will be installed in four on-base water supply wells and nearby monitoring wells. This will allow determination of pumping schedules and specific capacity of the water supply wells, and how the use of these wells affects local groundwater flow directions and hydraulic gradients.

4.6.3 Groundwater Quality Data

A principal objective of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) is to development a hydrogeologic framework of conditions beneath McClellan AFB. In attaining this objective, data obtained and wells constructed will have a direct impact on the characterization of groundwater contamination and evaluation of groundwater remediation alternatives.

Interpretation of lithologic and geophysical data from boreholes will help to define the continuity and characteristics of waterbearing zones in which contaminated groundwater is most likely to migrate. The data will also be used to identify confining beds or aquitards which may slow or impede the vertical migration of contaminants in the saturated zone. Hydrologic measurements obtained in field and laboratory testing of aquifer and aquitard materials will be used to determine hydraulic gradients and hydraulic conductivities that may also affect contaminant migration.

After well construction and hydrologic testing, the new monitoring wells will provide as many as 51 new sampling points for the determination of water quality. The wells will provide 14 sampling locations in the shallow or "water table" zone, 12 locations in the "150-foot" zone, 17 locations in the "200-foot" zone, and as many as 8 locations in the "300-foot" zone. Monitoring wells completed in the "300-foot" zone at clusters 16 and 17 are the first wells to be screened in that zone for the purpose of determining the maximum vertical extent of groundwater contamination. The two "300-foot" zone wells have been sited in locations where contaminant migration to that depth is most likely to be detected because contaminants have been detected in the "200-foot" zone upgradient from the wells in Area C (EG&G Idaho, 1987). Monitoring well completions in the water table, "150-foot" zone, and "200-foot" zone were selected to further define water quality in each of the zones.

Groundwater samples from each new monitoring well will be taken for analysis in two separate sampling events. The first sampling will occur shortly after development of each well. All wells completed in the "200-foot" zone will be sampled for volatile organic compounds on a "short" turnaround-time schedule. If contaminants are detected in that zone, a "300-foot" zone well will be constructed and sampled in a maximum of 7 clusters. The second sampling of each new well will occur approximately one month after the first sampling event. Each groundwater sample will be analyzed for volatile and semivolatile organic compounds, and metal ions. A number of new monitoring wells will also be analyzed for base/neutral and acid extractable compounds if they are constructed in areas where these compounds were previously detected. If there are conflicting analytical results between the first and second sampling rounds, additional sampling will be recommended to resolve inconsistencies. Quality assurance/quality control procedures to be used in sampling and analysis of the wells are explained in the Draft Quality Assurance Project Plan for McClellan AFB (Radian, October 1988). The number of samples and analytical methods for these wells is presented on Table 5-3.

Section 4.6.3.1 summarizes the groundwater quality data that currently are available. Section 4.6.3.2 identifies those areas where additional wells to monitor groundwater quality are considered necessary at this time.

4.6.3.1 Existing Groundwater Quality Data

Water quality data have been collected for monitoring wells at McClellan AFB since 1981. However, as discussed in Section 3.3.2.2, a network of monitoring wells has developed over time as new monitoring wells have been installed. Other monitoring wells have gone dry and are no longer available for sampling. The monitoring network has evolved over time, and installation of monitoring wells has occurred in areas of specific concern. The groundwater monitoring network does not include wells in all on- and off-base areas where contamination may be present. The extent of contamination detected historically in monitoring wells is presented in Section 3.3.2.2 to provide a basis by which the requirements for additional water quality data can be evaluated.

In Area A and Adjacent On-Base Areas, nine of the 15 shallow zone monitoring wells can no longer be used for sampling purposes because the wells are dry or the wells do not provide reliable hydrologic data. Only five monitoring wells are screened in the middle monitoring zone in Area A and Adjacent On-Base Areas.

In Area B and the Southwest Area, pumping of water supply well BW-18 influences local groundwater flow, as evidenced on the potentiometric surface maps (Plates 2, 3, and 4). BW-18 is screened at intervals below 170 feet. The extent of the pumping influence and the effect on contaminant movement are not evident from the existing water quality database.

In Area D and Adjacent On-Base Areas, groundwater contaminants have been detected consistently in 10 shallow zone monitoring wells. Three off-base wells screened in the shallow monitoring zone also have shown the presence of contaminants. The groundwater extraction system composed of six extraction wells in Area D is performing as designed (see Plates 2, 3, and 4) such that groundwater is flowing toward Area D preventing off-base migration of groundwater contaminants.

In Other On-Base Areas and in the Northeast Area, groundwater quality as determined from analyses of existing monitoring wells is generally good. Other On-Base Areas include on-base areas in the north, east, and central portions of the base.

4.6.3.2 Required Groundwater Quality Data

Implementation of the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) Sampling and Analysis Plan will result in installation of monitoring wells sited to confirm the presence or absence of groundwater contamination in selected locations and in four waterbearing zones. As discussed in Sections 3.3.2.2 and 4.6.3.1, the groundwater quality database is not complete for specific areas where there are few or no wells and contamination is known or is suspected to have migrated.

In Area A, an area where wastes may have been released in the past, few monitoring wells are available for sampling. In the adjacent off-base Southeast Area, there are only two wells along the base boundary to monitor any off-base groundwater movement. Monitoring wells are needed in Area A and Adjacent On-Base Areas and in the off-base Southeast Area to determine the extent of groundwater contamination. Monitoring wells screened at various depths are required so that the vertical extent of any groundwater contamination may be determined. The new monitoring wells at well sites 3, 4, 5, 6, 7, 14, 15, and 26 (see Section 4.6.1) will help to monitor groundwater quality vertically and horizontally.

In Area B and Adjacent On-Base Areas and in the off-base Southwest Area, the horizontal and vertical extent of contamination has not been fully determined. The effect of water supply well BW-18 on horizontal movement of contaminants within Area B will be better defined by new monitoring well clusters. Shallow and deep wells at the new cluster sites 10, 11, 12, 13, and 25 will help to assess the horizontal and vertical extent of groundwater contamination. The new wells at cluster sites 16, 17, and 21 will serve, in part, to determine groundwater quality at several depths in the area upgradient from the McClellan AFB boundary.

In the off-base Northwest Area near Area D, a monitoring well in the shallow monitoring zone is needed to assess the horizontal movement of contaminants. The new shallow zone monitoring well at cluster site 18 will assist in determining the presence or the absence of groundwater contaminant plume(s) in the Northwest Area. In the east-central portion of the base, few wells are available to determine groundwater quality changes that may be influenced by the pumping of BW-10. The proposed wells at clusters 3 and 26 will provide water quality data for groundwater that may be migrating from Area A towards BW-10.

TABLE 4-2. PROPOSED MONITORING WELL LOCATIONS AND RATIONALE

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
NOTE: Locations are listed numerically, not in preferred drilling order.			
CLUSTER NUMBER 1			
1 - "Water Table"	North-central portion of base, 750' east of main north-south runway, 1600' west of cluster 100/101, 1900' northeast of MW-18D.	Screen Elevation: -45' msl; Total Depth: 115' bgs	1) Lack of subsurface data in the central one-third of the base (occupied by the north-south runway and taxiways). 2) Characterize local hydrogeology. 3) Determine groundwater flow directions in north-east area of base. 4) Determine water quality in this part of base.
1 - "150-foot"	As above.	Screen Elevation: -95' msl; Total Depth: 165' bgs	As above.
1 - "200-foot"	As above.	Screen Elevation: -134' msl; Total Depth: 206' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
1 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
1 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	*Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot hole will be drilled and logged before any cluster wells are drilled or constructed.*

msl = mean sea level.
bgs = below ground surface.

(Continued)

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TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
<u>CLUSTER NUMBER 2</u>			
2 - "Water Table"	Northeast portion of base, adjacent to "middle" monitoring zone well MW-29D (MW-29D has a screen elevation of -78.40 msl and a total depth of 147.0 bgs); 400 feet east of Building 870.	Screen Elevation: -47' msl; Total Depth: 117' bgs	1) Lack of subsurface data in the central one-third of the base (occupied by the north-south runway and taxiways). 2) Characterize local hydrogeology. 3) Determine groundwater flow directions in north-east area of base. 4) Determine water quality in this part of base. 5) Replace water table monitoring well. (MW-29S is dry.)
2 - Pilot Hole	As above.	Total Depth: 330' bgs; (Elevation -260' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot hole will be drilled and logged before any cluster wells are drilled or constructed.
<u>CLUSTER NUMBER 3</u>			
3 - "Water Table"	East-central portion of base; approximately 500 feet southwest of BW-10, approximately 300 feet northeast of MW-49.	Screen Elevation: -50' msl; Total Depth: 130' bgs	1) Characterize local hydrogeology. 2) To define groundwater flow directions and hydraulic gradients, especially with regard to the effects of BW-10. 3) Monitor groundwater quality.
3 - "150-foot"	As above.	Screen Elevation: -95' msl; Total Depth: 175' bgs	As above.

msl = mean sea level.
bgs = below ground surface.

(Continued)

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TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 3 (Continued)			
3 - "200-foot"	As above.	Screen Elevation: -135' msl; Total Depth: 226' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
3 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
3 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 4			
4 - "Water Table"	North of Area A immediately east of Building 362.	Screen Elevation: -45' msl; Total Depth: 120' bgs	1) Characterize local hydrogeology. 2) Provide data for potentiometric surface maps and hydraulic gradients. 3) Characterize groundwater quality in an area surrounded by numerous potential release locations (PRLs). This cluster is located between two areas of known groundwater contamination detected in BWs 1 and 2 to the north and MW-27D to the south.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 4 (Continued)			
4 - "150-foot"	As above.	Screen Elevation: -95' msl; Total Depth: 172' bgs	As above.
4 - "200-foot"	As above.	Screen Elevation: -137' msl; Total Depth: 214' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
4 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
4 - Pilot Hole	As above.	Total Depth: 330' bgs; (Elevation -255' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 5			
5 - "Water Table"	Southeast portion of base, in Area A, adjacent to "middle" monitoring zone well	Screen Elevation: -45' msl; Total Depth: 217' bgs	1) Area A has no clustered wells. 2) MW-27D southwest of cluster 5 location is a "middle" monitoring zone well with compounds consistently above action levels.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 5 (Continued)			
5 - "Water Table" (Continued)	MW-27D (MW-27D has a screen elevation of -75.78′ msl and a total depth of 148′ bgs).		3) MW-27S, originally a "shallow" zone well, is now dry. 4) Installing a new "water table" ("shallow zone") well will assist in delineating vertical distribution of contaminants along with a proposed "200-foot" well (see below). 5) Characterize local hydrogeology. 6) Provide data for potentiometric surface maps and hydraulic gradients.
5 - "200-foot"	As above.	Screen Elevation: -142′ msl; Total Depth: 217′ bgs	As above and Area A has no "deep" monitoring zone wells. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
5 - "300-foot"	As above.	Screen Elevation: approx. -240′ msl; Total Depth: 350′ bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
5 - Pilot Hole	As above.	Total Depth: 360′ bgs; (Elevation -250′ msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 6			
6 - "Water Table"	South of base, adjacent to Area A, approximately 400' from base boundary; approximately 1000' southeast of MW-67.	Screen Elevation: -47' msl; Total Depth: 122' bgs	1) Provide "sentry" cluster to monitor groundwater in the off-base vicinity of Area A. 2) Characterize local hydrogeology. 3) Provide data for potentiometric surface maps and hydraulic gradients. 4) Monitor groundwater quality at the periphery of the base.
6 - "150-foot"	As above.	Screen Elevation: -90' msl; Total Depth: 165' bgs	As above. NOTE: DOHS recommended a 150-foot deep well in this approximate location.
6 - "200 foot"	As above.	Screen Elevation: -140' msl; Total Depth: 215' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
6 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
6 - Pilot Hole	As above.	Total Depth: 360' bgs; (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 7			
7 - "150-foot"	Southeast portion of study area, approximately 500' south of base boundary, adjacent to existing "middle" monitoring zone well MW-28D (MW-28D has a screen elevation of -57' msl and a total depth of 130' bgs).	Screen Elevation: -87' msl; Total Depth: 162' bgs	1) Provide a "sentry" cluster to monitor potential off-base migration. 2) Characterize local hydrogeology. 3) Provide data for potentiometric surface maps and hydraulic gradients. 4) Monitor groundwater quality at the periphery of the base.
7 - "200-foot"	As above.	Screen Elevation: -142' msl; Total Depth: 217' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
7 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
7 - Pilot Hole	As above.	Total Depth: 360' bgs; (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
<u>CLUSTER NUMBER 8</u>			
8 - "Water Table"	Southern portion of base, approximately 200 feet northeast of BW-13, approximately 2400 feet east of BW-18.	Screen Elevation: -53' msl; Total Depth: 118' bgs	1) There are no monitoring wells near BW-13. A cluster in this location can more accurately detect contaminants moving near BW-13 which caused the well to be restricted to emergency use only. 2) Monitor migration and vertical distribution of contaminants, especially carbon tetrachloride. 3) A cluster in this location will place monitoring wells between Area A (upgradient of BW-13) and BW-13. 4) A "300-foot" zone pilot hole in this location will provide data on local hydrogeology and will allow possible stratigraphic correlation with other proposed "300-foot" zone pilot holes located to the north, east, and west of this location. 5) Verify the nature and extent of the "250-foot" aquitard in this vicinity and determine if contamination has occurred beneath it.
8 - "150-foot"	As above.	Screen Elevation: -115' msl; Total Depth: 185' bgs	As above.
8 - "200-foot"	As above.	Screen Elevation: -165' msl; Total Depth: 230' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 8 (Continued)			
8 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: approx. 350' bgs	As above. Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
8 - Pilot Hole	As above.	Total Depth: 330' bgs; (Elevation -260' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 9			
9 - "Water Table"	Northwest portion of base, south of Area D, northern portion of Area C, 1500' northeast of cluster 107/108/109, southeast of Area D cap.	Screen Elevation: -68' msl; Total Depth: 126' bgs	1) There is a distance of approximately 2000' between the southern part of Area D and northern part of Area C for which there is no data regarding local hydrogeclogy. 2) Assist in possible hydrostratigraphic correlation between these two relatively well-characterized areas. 3) Provide data for potentiometric surface maps and hydraulic gradients. 4) Provide an additional sampling point to monitor the effectiveness of the Area D and Area C extraction systems. 5) There are currently no monitoring wells (except for "shallow" zone monitoring well MW-36S) in this portion of the base. This cluster will monitor groundwater quality in this area.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 9 (Continued)			
9 - "150-foot"	As above.	Screen Elevation: -120 msl; Total Depth: 178' bgs	As above.
9 "200-foot"	As above.	Screen Elevation: -164' msl; Total Depth: 222' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
9 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
9 - Pilot Hole	As above.	Total Depth: 330' bgs; (Elevation -272' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 11			
11 - "Water Table"	Southern portion of base, in Area B, approximately 500' east of BW-18, approximately 200 feet southwest of MW-41S.	Screen Elevation: -64.07' msl; Total Depth: 126.5' bgs	1) Characterize local hydrogeology. 2) Provide data for potentiometric surface maps and hydraulic gradients. 3) Monitor groundwater quality upgradient from BW-18. 4) There are currently no "150-foot" or "200-foot" zone wells in this area. NOTE: This well was constructed during the Area B Groundwater Operable Unit Remedial Investigation, May, 1989.

msl = mean sea level.
bgs = below ground surface.

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 11 (Continued)			
11 - "200-foot"	As above.	Screen Elevation: -205.98' msl; Total Depth: 267.50' bgs	As above. This well was completed in May, 1989. Well was sampled and analyzed immediately after development. The absence of detectable volatile organic compounds indicated no immediate need for optional "300-foot" zone well in the cluster.
11 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in an upgradient "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
11 - Pilot Hole	As above.	Total Depth: 430' bgs (Elevation -367.44' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot hole was drilled and logged in May, 1989.
CLUSTER NUMBER 14			
14 - "Water Table"	Southeast portion of study area, approximately 300' south of base boundary, approximately 500' south of MW-68.	Screen Elevation: -55' msl; Total Depth: 125' bgs	1) Provide a "sentry" cluster to monitor potential off-base contaminant migration at the periphery of the base. 2) Characterize local hydrogeology. 3) Provide data for potentiometric surface maps and hydraulic gradients. 4) Monitor groundwater quality.
14 - "150-foot"	As above.	Screen Elevation: -130' msl; Total Depth: 182' bgs	As above.

msl = mean sea level.
bgs = below ground surface.

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(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 14 (Continued)			
14 - "200-foot"	As above.	Screen Elevation: -176' msl; Total Depth: 238' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
14 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
14 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 15			
15 - "Water Table"	Southern portion of base, in Area A, adjacent to existing "middle" zone well MW-26D (MW-26D has a screen elevation of -80' msl and a total depth of 150' bgs), approximately 400' southeast of MW-40S.	Screen Elevation: -47' msl; Total Depth: 122' bgs	1) Characterize local hydrogeology. 2) Provide data for potentiometric surface maps and hydraulic gradients. 3) Monitor groundwater quality in an area of known groundwater contamination. MW-26S and MW-40S have had a history of detecting significant contamination. These wells are now dry and should be replaced. Contaminants have also been detected in MW-26D. A recent inspection by the Air Force has determined that the base Wastewater Transfer Line had been leaking in this area.

msl = mean sea level.
bgs = below ground surface.

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TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 14 (Continued)			
15 - "200-foot"	As above.	Screen Elevation: -140' msl; Total Depth: 215' bgs	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
15 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
15 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
WELL NUMBER 17			
17 - "300-foot"	Southwest portion of base, south of Area C, north of Area B, adjacent to existing well cluster 139/140/141.	Screen Elevation: -245' msl; Total Depth: 315' bgs	1) Monitor groundwater quality from beneath the "250-foot" aquitard in the area between Areas B and C. 2) To determine if contaminants detected in MW-141 have migrated to the "300-foot" zone in Area C. 3) Characterize local hydrogeology. This well will be drilled using mud rotary to allow logging of the borehole before well construction.

msl = mean sea level.
bgs = below ground surface.

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TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
<u>WELL NUMBER 18</u>			
18 - "Water Table"	Approximately 1000' northwest of base, adjacent to existing "middle" zone monitoring well MW-1010, approximately 1300' southwest and 900' northeast of existing "shallow" monitoring zone wells MW-1019 and MW-1041, respectively.	Screen Elevation: -47' msl; Total Depth: 122' bgs	1) In this portion of the study area, contamination in the shallow monitoring zone is detected at relatively greater concentrations and more extensive areal extent when compared to the "middle" and "deep" monitoring zones. 2) Provide data for potentiometric surface maps and hydraulic gradients. 3) Assist in evaluating the performance of the Area D extraction system. 4) Allow groundwater quality monitoring in what is currently a spatial gap in the monitoring network in this area.
18 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
<u>CLUSTER NUMBER 19</u>			
19 - "Water Table"	Area C, approximately 750' southwest of EW-144, approximately 750' northwest of cluster MW-136/137.	Screen Elevation: -70' msl; Total Depth: 130' bgs	Monitoring well Cluster Number 19 is intended to provide data to evaluate the Area C interim extraction system; specifically, it will help define the capture zone of the system and track trends of contaminant concentrations. Currently there is a lack of monitoring wells to the west of the extraction wells. The "150-foot" zone well in Cluster Number 19 would monitor the interval of -60 to -70 msl which is the upper interval screened by EW-144. The lower screened interval is 106 to -126 msl, and is discussed below.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 19 (Continued)			
19 - "150-foot"	As above.	Screen Elevation: -120' msl; Total Depth: 180' bgs	The "200-foot" zone well would monitor the interval of -110' to -120' msl which is within the lower screen interval (-106' to -126 msl) of EW-144 and the screen interval (-103.76' to -113.76 msl) of EW-137. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
19 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
19 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 20			
20 - "Water Table"	Area C, Approximately 500' west of MW-140/141, adjacent to Building 783.	Screen Elevation: -55' msl; Total Depth: 115' bgs	Well Cluster Number 20 is intended to provide data for evaluating the the Area C interim extraction system (see above). This "water table" well would also help delineate the southwestern edge of the groundwater contaminant plume in the shallow, "water table" zone which is now migrating south.

msl = mean sea level.
bgs = below ground surface.

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TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 20 (Continued)			
20 - "150-foot"	As above.	Screen Elevation: -130' msl; Total Depth: 190' bgs	As above, including monitoring the screen interval of EW-140 (-123.42 to -133.42' msl).
20 - "200-foot"	As abcve.	Screen Elevation: -180' msl; Total Depth: 240' bgs	As above, including monitoring the screen interval of EW-141 (-173.45' to -183.45' msl). Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
20 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
20 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 21			
21 - "Water Table"	Area C, approximately 700' southeast of MW-133/134/135 and 1000' northwest of MW-63.	Screen Elevation: -55' msl; Total Depth: 115' bgs	Monitoring well Cluster Number 21 is intended to provide data to evaluate of the Area C interim extraction system. This "water table" well may also help delineate the southeast edge of the groundwater contaminant plume in the shallow "water table" zone which is now migrating south.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 21 (Continued)			
21 - "200-foot"	As above.	Screen Elevation: -130' msl; Total Depth: 190' bgs	Evaluate Area C interim extraction system (see above) including delineating the southeast edge of the groundwater contaminant plume in the "200-foot" zone and monitoring the screen interval of EW-140 (-123.42' to -133.42' msl).
21 - "200-foot"	As above.	Screen Elevation: -180' msl; Total Depth: 240' bgs	Evaluate Area C interim extraction system (see above) including delineating the southeast edge of the groundwater contaminant plume in the deeper portions of Area C. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
21 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
21 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation: -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
WELL NUMBER 22			
22 - "200-foot"	Area C, adjacent to existing MW-142 (MW-142 has a screen elevation of -122.54' msl, and a total depth of 180' bgs); approximately 500' east of EW-140/141.	Screen Elevation: -180' msl; Total Depth: 240' bgs	This well, in conjunction with existing well MW-142, is intended to provide data to evaluate of the Area C extraction system (see Cluster Number 19). Specifically, this well will monitor the screened interval of EW-141 (-173.45' to -183.45' msl). Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
22 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
22 - Pilot Hole	As above.	Total Depth: 360' bgs (Elevation -250' msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.
CLUSTER NUMBER 23			
23 - PZ-1	Phase II Aquifer Test Site (Area B) approximately 50' from PW-126.	Screen Elevation: -45' msl; Total Depth: 105' bgs	Water-level observation wells for multiple-well aquifer test that will be conducted to determine vertical hydraulic conductivity of less permeable zone above the middle monitoring zone.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 23 (Continued)			
23 - PZ-2	As above.	Screen Elevation: -65' msl; Total Depth: 125' bgs	As above.
23 - PZ-3	As above.	Screen Elevation: 100' msl; Total Depth: 160' bgs	As above.
23 - PZ-4	As above.	Screen Elevation: -130' msl; Total Depth: 190' bgs	As above.
CLUSTER NUMBER 24			
24 - PZ-5	Area C, approximately 50 feet from MW-141.	Screen Elevation: -215' msl; Total Depth: 275' bgs	Water-level observation wells for multiple-well aquifer test that will be conducted to determine vertical conductivity of less permeable "250-foot" aquitard.
24 - PZ-6	As above.	Screen Elevation: -185' msl; Total Depth: 245' bgs	As above.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 24 (Continued)			
24 - PZ-7	As above.	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
24 - PZ-8	As above.	Screen Elevation: -130' msl; Total Depth: 190' bgs	As above.
24 - PZ-9	As above.	Screen Elevation: -90' msl; Total Depth: 150' bgs	As above.
24 - PZ-10	As above.	Screen Elevation: -210' msl; Total Depth: 270' bgs	As above.
24 - PZ-11	Area C; adjacent to MW-138.	Screen Elevation: -45' msl; Total Depth: 100' bgs	Monitor water levels to evaluate the Area C extraction system.
24 - PZ-12	As above.	Screen Elevation: -90' msl; Total Depth: 145' bgs	As above.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 24 (Continued)			
24 - PZ-13	Area C; adjacent to MW-142.	Screen Elevation: -45′ msl; Total Depth: 145′ bgs	As above.
24 - PZ-14	Area C; approximately 250 feet east of EW-140/EW-141.	Screen Elevation: -45′ msl; Total Depth: 100′ bgs	As above.
24 - PZ-15	As above.	Screen Elevation: -90′ msl; Total Depth: 145′ bgs	As above.
24 - PZ-16	As above.	Screen Elevation: -150′ msl; Total Depth: 210′ bgs	As above.
24 - PZ-17	Area C; approximately 400 feet southwest of EW-140/EW-141.	Screen Elevation: -45′ msl; Total Depth: 100′ bgs	As above.
24 - PZ-18	As above.	Screen Elevation: -90′ msl; Total Depth: 145′ bgs	As above.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 24 (Continued)			
24 - PZ-19	As above.	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
24 - PZ-20	Area C; approximately 300 feet west of EW-140/EW-141.	Screen Elevation: -45' msl; Total Depth: 100' bgs	As above.
24 - PZ-21	As above.	Screen Elevation: -135' msl; Total Depth: 195' bgs	As above.
24 - PZ-22	As above.	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
24 - PZ-23	Area C; approximate- feet west of EW-144.	Screen Elevation: -45' msl; Total Depth: 100' bgs	As above.
24 - PZ-24	As above.	Screen Elevation: -90' msl; Total Depth: 145' bgs	As above.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 24 (Continued)			
24 - PZ-25	As above.	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
24 - PZ-26	Area C; approximately 400 feet west of EW-144.	Screen Elevation: -45' msl; Total Depth: 100' bgs	As above.
24 - PZ-27	As above.	Screen Elevation: -90' msl; Total Depth: 150' bgs	As above.
24 - PZ-28	As above.	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
24 - PZ-29	Area C; approximately 300 feet west of EW-137.	Screen Elevation: -45' msl; Total Depth: 100' bgs	As above.
24 - PZ-30	As above.	Screen Elevation: -90' msl; Total Depth: 145' bgs	As above.

msl = mean sea level.
bgs = below ground surface.

(Continued)

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TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
<u>CLUSTER NUMBER 24</u> (Continued)			
24 - PZ-31	As above.	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
24 - PZ-32	Area C, approximately 300 feet north of EW-144.	Screen Elevation: -90' msl; Total Depth: 145' bgs	As above.
24 - PZ-33	As above.	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
24 - PZ-34	Area C, adjacent to MW-131 and MW-22D	Screen Elevation: -150' msl; Total Depth: 210' bgs	As above.
<u>CLUSTER NUMBER 26</u>			
26 - "Water Table"	Approximately 1400' southeast of BW-20 along the southeast boundary of the base.	Screen Elevation: -50 msl; Total Depth: 130 bgs	1) Provide data to define groundwater flow directions. 2) Monitor water quality in the southeastern corner of the base. 3) Characterize local hydrogeology.

msl = mean sea level.
bgs = below ground surface.

(Continued)

TABLE 4-2. (Continued)

Monitoring Well Designation and Zone Monitored	Location	Recommended Screen Elevation (Bottom of Screen); Total Depth	Rationale for Well Locations and Depths
CLUSTER NUMBER 26 (Continued)			
26 - "150-foot"	As above.	Screen Elevation: -95 msl; Total Depth: 175 bgs	As above.
26 - "200-foot"	As above.	Total Depth: -135 bgs (Elevation -240' msl)	As above. Well to be sampled and analyzed immediately after development to determine need for optional "300-foot" zone well in the cluster.
26 - "300-foot"	As above.	Screen Elevation: approx. -240' msl; Total Depth: 350' bgs	Optional emplacement if contamination is detected in "200-foot" zone well and seven other optional "300-foot" zone wells have not been constructed.
26 - Pilot Hole	As above.	Total Depth: 360 bgs; (Elevation: -240 msl)	Characterize local hydrogeology using new geophysical logs in conjunction with existing logs and determine screen elevations for cluster wells. Pilot holes will be drilled and logged before any cluster wells are drilled or constructed.

msl = mean sea level.
bgs = below ground surface.

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5.0 SCOPE OF WORK

As part of the Remedial Investigation/Feasibility Study (RI/FS) process at McClellan AFB a Preliminary Groundwater Operable Unit Remedial Investigation (RI) (Hydrogeologic Assessment) will be conducted. The purpose of this work is to provide a hydrogeologic framework from which the extent and magnitude of groundwater contamination and the need for remediation can be evaluated when supplemented by more local data. The field data collected during the Hydrogeologic Assessment will be evaluated and compared to hydrogeologic data acquired during past phases of the Installation Restoration Program (IRP). The data will be used to determine potential groundwater operable units areas. The hydrogeologic data needs, as presented in Section 4.6, will be fulfilled as a result of this work.

The McClellan AFB Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) will result in:

- Better definition of the subsurface distribution of permeable sediments which may represent preferred migration paths for contaminants;
- Determination of the extent and integrity of confining zones which could impede downward migration of contaminants;
- Quantification of aquifer parameters, including vertical hydraulic conductivity values for aquitards;
- Determination of the impact of on-base water supply wells on hydraulic gradients and groundwater flow directions both horizontally and vertically;
- Installation of groundwater monitoring wells from which samples can be taken and analyzed to further delineate water quality;

- A more complete understanding of the extent of groundwater contamination and the physical characteristics which will affect remediation alternatives; and

- Based on the understanding of the extent of contamination and physical characteristics, define any areas which may require groundwater operable unit investigations.

The scope of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) has been designed to meet these general data requirements. The scope of work will include: the drilling and logging of exploratory boreholes; the installation of wells to monitor groundwater quality and hydraulic head; single- and multiple-well aquifer tests; and groundwater sampling, analysis, and evaluation of analytical data.

The remainder of this section describes the field and data evaluation activities that will be conducted during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). The McClellan AFB RI/FS Quality Assurance Project Plan (QAPP) (Radian, October 1988) describes the methodologies and protocols to be followed during the field work that will be conducted during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). The QAPP is referenced where appropriate in the following sections. However, field procedures developed specifically for the Hydrogeologic Assessment are described in detail.

5.1 Organization of Effort

The RI/FS effort being conducted at McClellan AFB has been designed to identify and remediate any hazardous contaminants that may have migrated to the environment. This section describes how this sampling and analysis plan fits within the RI/FS effort.

5.1.1 Operable Units

For the purposes of the RI/FS being conducted at McClellan AFB, individual potential waste storage and disposal locations may be grouped in potential operable units pending further study. Investigation and evaluation will be conducted on a location-specific basis as part of the Preliminary Pathways Assessment to further define operable units. The Preliminary Groundwater Operable Unit RI Hydrogeologic Assessment) will not address conditions at individual waste storage and disposal locations, but will attempt to determine potential groundwater operable unit areas by strategically locating monitoring wells and collecting hydrogeologic and water quality data from the wells.

5.1.2 Combined Site Investigations

Site investigations that would be conducted concurrently with the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) have not been scheduled. The Groundwater Contaminant Source Investigation Sampling and Analysis Plan, formerly called the Groundwater Pathways Assessment Work Plan, is currently in preparation.

5.2 General Discussion of Integrated IRP Tasks

Section 5.2 presents the tasks to be completed during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) and the techniques and/or methodologies that will be used. In general, the tasks may be grouped into field and data evaluation tasks. Sections 5.2.1 and 5.2.2 describe how the field activities and data evaluation will be conducted, respectively.

5.2.1 Field-Related Tasks

The technical scope of work and methodologies to be used during the field work required for the Preliminary Groundwater Operable Unit RI (Hydro geologic Assessment) are presented in the following subsections. Field work will include drilling, borehole lithologic logging, geophysical surveys, monitoring well construction, well location and elevation surveying, and conducting single- and multiple-well aquifer tests. Field activities are summaried in Table 5-1.

5.2.1.1 Soil Gas Surveys

Soil gas surveys will not be required during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.1.2 Geophysical Surveys

Ground surface geophysical surveys will not be required during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.1.3 Subsurface Soil Surveys

Subsurface soil surveys will not be required during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.1.4 Borehole Geophysical Surveys

Geophysical surveys will be conducted in selected boreholes drilled during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). Borehole geophysical survey techniques are used to assist in the determination of subsurface geologic conditions such as thickness, lithology, and relative permeability of stratigraphic units. Borehole geophysical logs may also be valuable in determining the presence and relative natural quality of groundwater. All geophysical measurements will be collected digitally to allow scale adjustments to be made prior to hard copy reproduction. Geophysical logs will be used extensively in conjunction with borehole lithology logs to refine geologic descriptions.

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TABLE 5-1. PRELIMINARY GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION (HYDROGEOLOGIC ASSESSMENT) FIELD ACTIVITIES

Activity	Quantity	Locations	Comments
Monitoring Wells	51	Areas A, B, C, Other On-Base Areas, and off base	Borehole depths grouped as follows: 14 less than 150 ft bgs 12 at 150 to 200 ft bgs 17 at 200 to 250 ft bgs 8 deeper than 250 ft bgs (7 of these are optional wells)
Piezometers	34	Areas B and C	Borehole depths grouped as follows: 9 less than 150 ft bgs 13 at 150 to 200 ft bgs 12 deeper than 210 ft bgs
Pilot Holes (Exploratory Borings)	18	Areas A, B, C, and Other On-Base Areas	Mud rotary pilot holes drilled to approximately 430 feet
Borehole Geophysical Surveys	19	Areas A, B, C, Other On-Base Areas, and off base	Geophysical logging to include resistivity, spontaneous potential, gamma ray, deviation, and caliper logs
Aquifer Tests			
-- Single-well tests	40	Areas A, B, D, Other On-Base Areas, and off base	
-- Multiple-well tests	2	Area B and C	Additional testing at Radian (Stage 2-3) aquifer test site and Area C to determine vertical hydraulic conductivity of aquitards
Hydrologic monitoring of of On-Base Production Wells	4	Base Wells 10, 13, 18, and 29	Monitoring of on-base production wells and nearby observation wells with hydrologic data acquisition system to determine the effects the production wells have on groundwater flow directions and gradients (horizontal and vertical)

bgs = Below ground surface.

Electrical resistivity, spontaneous potential, gamma ray, caliper, and declination surveys are the borehole geophysical methods that will be used during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). The resistivity logs will consist of the point, short-normal (16-inch), and long-normal (64-inch) configurations. Geophysical logging will be completed in the pilot hole or deepest borehole in all monitoring well clusters (see Section 5.2.1.5). A total of 19 boreholes will be logged. Geophysical logging will be conducted by a qualified subcontractor. A Radian geologist or engineer will supervise and observe all logging activities to assure the quality of the data. Cell cables, probes, and other equipment will be thoroughly steam-cleaned prior to being lowered into a borehole.

The geophysical log data will be evaluated prior to monitoring well construction to optimize the well design. The geophysical logs will be used to determine the most appropriate depth intervals for placement of the screen, sand pack, and grout seal.

The principles and general procedures associated with resistivity and spontaneous potential surveys are presented in the QAPP.

5.2.1.5 Monitoring Wells and Pilot Holes

Based on the review and evaluation of existing geologic and hydrogeologic data, a total of 51 monitoring wells and 18 pilot holes are proposed to further characterize the hydrogeologic conditions at McClellan AFB. Fourteen monitoring wells will be installed in the "water table" zone, 12 in the "150-foot" zone, 17 in the "200-foot" zone, and as many as 8 in the "300-foot" zone. One well, at cluster 17, will definitely be completed in the "300-foot" zone, but 7 "300-foot" zone wells are considered optional. Most of the wells will be installed in clusters. Each cluster will include one to as many as four wells. Several wells will be installed to augment existing well clusters. Wells in clusters will be drilled 10 to 20 feet apart, site conditions permitting. One "water table" zone well and one "300-foot" zone well will be installed as single wells. The 18 pilot holes will be drilled to depths of approximately 430 feet below ground surface for the purpose of having geophysical logs run within them

5.2.1.5.1 Well Location Rationale

Monitoring well locations and screen intervals have been selected on the basis of data requirements, as defined in Section 4.6. A need for hydrogeologic data has been identified in the southern and eastern portions of the base and in one location in the northwestern portion of the base between Areas C and D. Plate 5 shows all proposed monitoring well locations. Plate 6 and Figures 4-1 through 4-9 illustrate in cross section the anticipated screen intervals as determined from the geophysical logs of existing wells. Well locations and rationale, total depths, and anticipated screen intervals are summarized in Table 4-2. The additional monitoring wells are needed to acquire hydrogeologic and/or water quality data. The rationale for new monitoring wells may be categorized as follows:

- Characterization of hydrogeology;
- Providing data for potentiometric surface maps;
- Providing data for determining hydraulic gradient and groundwater flow directions;
- Evaluation of effects of on-base water supply wells;
- Determination of lateral and vertical extent of groundwater contamination; and
- Determination of potential groundwater operable unit areas.

5.2.1.5.2 Methodology

Brief discussions on site selection, drilling, recordkeeping, and well installation, completion, and development procedures are presented below. A more detailed presentation of these field methods is found in the McClellan AFB RI/FS Draft QAPP (Radian, October 1988).

Site Selection

The selection of specific field locations for monitoring wells will be a cooperative effort between Radian Corporation and the AF monitoring well locations will be selected such that they conform as closely as possible to those presented in Table 4-2 and Plate 5. The actual field locations selected will be subject to drill rig access, presence or absence of underground utilities, future access considerations, and acquisition of permits (on-base wells) and easements (off-base wells). The U.S. Army Corps of Engineers will be involved in obtaining easements for off-base wells. The need to better characterize known or suspected waste storage and disposal sites also will be taken into consideration when selecting the actual well locations in the field.

Drilling Preparation

Prior to beginning drilling activities at any site, the Radian field coordinator will:

- Determine that the necessary permits and clearances have been granted;
- Position the drill rig to prevent damaging utilities;
- Cover the ground surface to protect the immediate area from potentially contaminated drill cuttings;

- Verify that drilling equipment entering the borehole is steam-cleaned; and

- Ensure that health and safety precautions identified in the Health and Safety Plan will be taken.

Drilling Methods

Well drilling methods used during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) will depend on the objectives of each boring. A summary of drilling methods is presented in Table 5-2.

The approach to monitoring well drilling will be staged; initially, mud rotary rigs will drill a pilot hole at each cluster location followed by construction of monitoring wells using air rotary casing drive and mud rotary methods. These methods are discussed below.

Nineteen pilot holes (exploratory borings) will be drilled by the mud rotary method. These pilot holes will provide the ability to run resistivity, spontaneous potential (SP), gamma ray, and caliper logs. The resulting geophysical logs will augment the existing geophysical logs. Evaluation of the entire suite of geophysical logs will allow for increased understanding of the hydrogeology, including determining the nature and extent of the "250-foot" aquitard, and allow any necessary adjustments to the areal locations and screened elevations of the proposed wells. The direct mud rotary method employs a rotating bit and a fluid (mud) which is pumped through the drill pipe, out the bit, and up the annular space carrying cuttings in suspension to the surface. The mud in the annular space provides the fluid medium necessary for electric logging.

One of the objectives of these pilot holes is to characterize the nature and extent of the "250-foot" aquitard. It is anticipated that it will require two days to drill the 300-plus-foot-deep boreholes. Therefore, a strategy has been developed to minimize the opportunity for downward migration of contaminants. On the first day, the drilling will proceed to approximately

TABLE 5-2. SUMMARY OF DRILLING METHODS[a]

Proposed Well Type and Groundwater Zone	Number of Wells	Drilling Method	Proposed Borehole Depth (ft bgs)	Approximate Well Depth (ft bgs)
Monitoring Wells				
"Water Table"	14	ARCD[c]	130	130
"150-foot"	12	ARCD	190	190
"200-foot"	17	ARCD	240	240
"300-foot"	1	ARCD/MR[d]	350	350
Pilot "430-foot"[b]	19	MR[e]	430	NA[f]
Optional "300-foot"	7	ARCD/MR	350	350
Piezometers				
"Water Table"	9	ARCD	130	130
"150-foot"	10	ARCD	190	190
"200-foot"	9	ARCD	240	240
"300-foot"	1	ARCD	350	350
"130-foot aquitard"	1	ARCD	150	150
"175-foot aquitard"	2	ARCD	200	200
"250-foot aquitard"	2	ARCD	300	300
		19 MR 76 ARCD 8 ARCD/MR	8,970 ft MR 16,910 ft ARCD	17,710 ft

TOTALS: 103 Borings

18 Pilot Holes

34 Piezometers

51 Monitoring Wells
- 14 "Water Table"
- 12 "150-foot"
- 17 "200-foot"
- 1 "300-foot"
- 7 Optional "300-foot"

[a] This table does not include wells drilled for the Area B Groundwater Operable Unit Remedial Investigation.

[b] Scheduled for geophysical logging.

[c] ARCD = Air rotary casing drive.

[d] ARCD/MR = Air rotary casing drive to 250 feet and mud rotary drilling to total depth.

[e] MR = Mud rotary.

[f] NA = Not applicable.

250 feet below ground surface or immediately above the "250-foot" aquitard. The filter cake left on the walls of the borehole and the mud, with a density greater than water, in the borehole will diminish the potential for vertical migration of contaminants from shallower zones to deeper zones in the two-day period. On the second day, the remaining 180 feet will be drilled through and beneath the aquitard. When total depth of the pilot holes has been reached, geophysical logs will be run in the borehole. Existing resistivity logs from the base water supply wells and deep exploration borings will assist in determining target total depth before drilling. Upon completion of the geophysical logging, the borehole will be abandoned by filling with grout using the positive displacement (tremie) technique. The tremie pipe will initially be placed 2 to 7 feet above the bottom of the borehole but will be gradually withdrawn as grout fills the borehole. The intention of the two-day drilling strategy is to preclude cross contaminating strata beneath the "250-aquitard" with any contaminants encountered in the shallower strata. By limiting to one day or less exposure of the aquitard and saturated strata below it to mud that may have come into contact with contaminated shallower groundwater, it is believed that the chance for detectable cross-contamination will be essentially eliminated. To decrease the chance for cross-contamination, a thick bentonite drilling mud with a Marsh funnel time less than 55 seconds will be used in drilling the boreholes to create a filter cake on the borehole walls which will reduce the potential for the mixing of contaminated groundwater with borehole fluids. The locations of the proposed pilot holes are shown on Plate 5.

For any mud rotary borings in which a monitoring well will be constructed, the well will be thoroughly surged during and after construction to remove filter cake in the zone to be screened. Temporary conductor casing will be emplaced through any shallow contaminated groundwater zone prior to drilling for well construction below 240 feet.

The geophysical logs from the pilot holes will be scrutinized as they are obtained; following evaluation of new and existing geophysical logs, most monitoring wells will be drilled using air rotary casing-drive drilling rigs.

The air rotary casing-drive method offers the advantage of relatively rapid drilling without the need to dispose of potentially contaminated drilling mud and the need for swabbing to remove filter cake mud in the zone to be screened. The drive casing provides a temporary barrier to the entry of contaminated groundwater from shallow zones that could penetrate to deeper zones in the borehole. However, caution must be observed in the use of the method to prevent: "air lock" in fine-grained deposits; the entry of lubricating oil mist to the deposits in an inadequately filtered air stream; the loss of drive casing due to breakage during retrieval; and potenital contamination of deeper zones if the drill bit is advanced too far beyond the casing in shallow contaminated zones.

The air rotary casing-drive drilling method consists of a rotating drilling bit placed within a non-rotating drive casing. As the drive casing is driven into the ground, the drill bit will advance no more than one foot ahead of the casing. Pressurized air is forced downward through the drilling rods and bit. The air returns to the ground surface upward through the annulus between the drive casing and the smaller rotating drill rod bringing with it, continuously, the materials cut by the drill bit and any groundwater. The cuttings are discharged into a cyclonic separator that separates the air from the formation cuttings to facilitate sampling and drill cuttings containment. Groundwater produced during drilling will be collected by a vacuum truck. An illustration of the drilling method is shown in Figure 5-1.

The drive casing is a heavy wall flush-jointed threaded pipe. The approximately 10-inch outside diameter (o.d.) system allows for the installation of up to a 4-inch well to depths of 600 feet. The casing is driven by a pneumatic drill through a drive hammer which is rated at 6,200 foot-pounds. The inner drill rod is a 4-1/2-inch o.d. heavy wall flush-jointed pipe capable of passing 3,000 c.f.m. of air at high pressures.

Filtered air is supplied by an on-board air compressor. If the use of water (clean) is required to assist in the recovery of the cuttings, it will be injected into the airstream by means of a water injection pump which can meter the discharge amount. All power for the compressor, pumps, and hydraulic components is supplied by the engine of the truck or carrier.

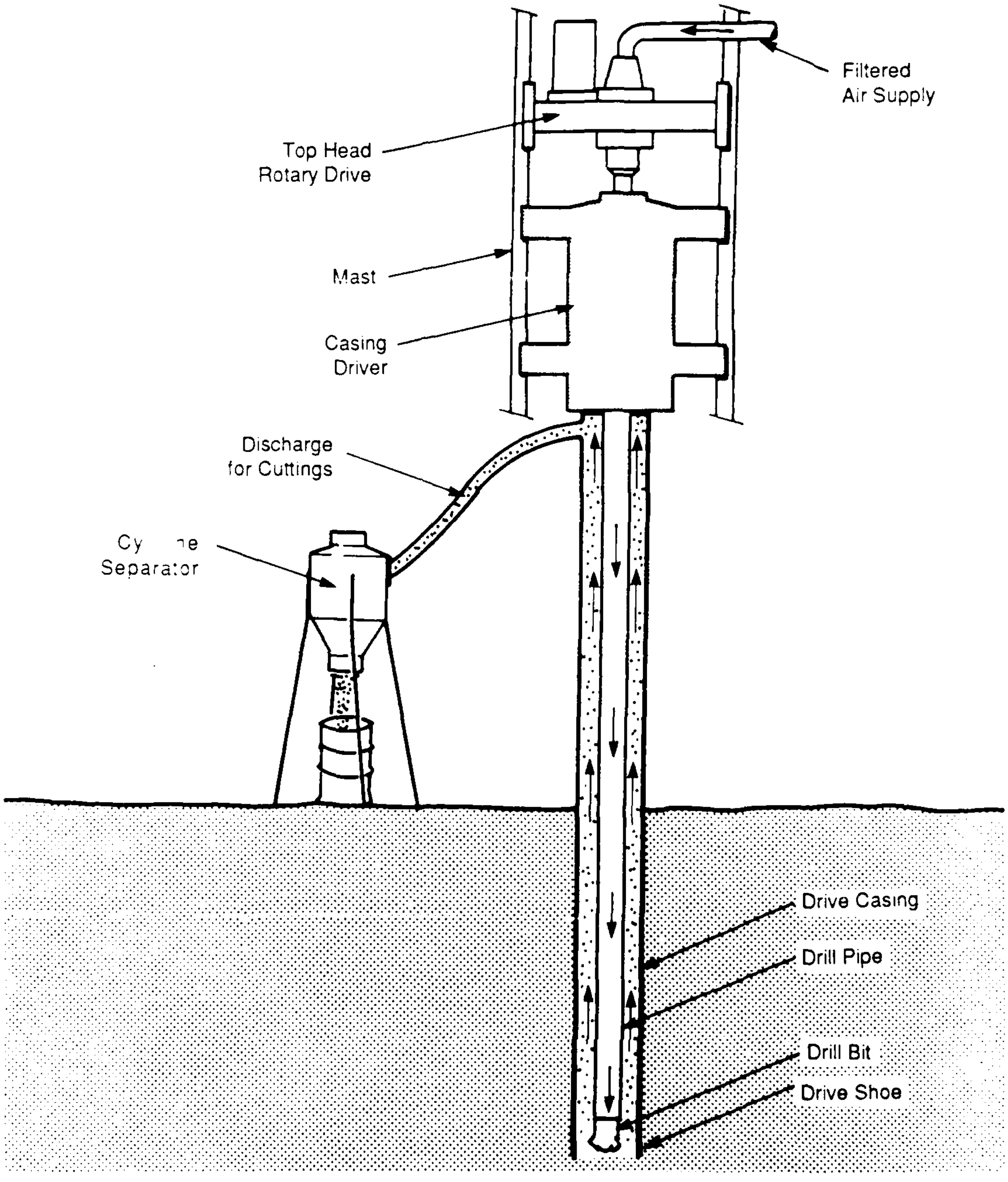

Figure 5-1. Diagrammatic Illustration of Air Rotary Casing Hammer Drilling Method.

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Upon completion of the drilling, the rotating drill rod and bit are extracted from the center of the drive casing. Permanent well completion materials are then installed down the center of the casing. Withdrawal of the drive casing is accomplished in stages by a hydraulic casing extractor system as filter pack sand, bentonite seal, and grout are emplaced in the annulus. This puller system consists of a structure housing two hydraulic cylinders and a tapered slip arrangement which grips the outside of the drive casing. As each section is pulled back out of the ground, handling of the casing is accomplished by means of a hydraulically operated cable lift arrangement.

Monitoring well borehole diameters will be approximately 10 inches. Monitoring wells less than 130 feet in depth ("water table" wells) will be constructed with 4-inch-diameter casing and screen. Monitoring wells greater than 130 feet in depth (the "150-foot," 200-foot," and "300-foot" zone wells) will also be constructed with 4-inch-diameter casing and screen. Four-inch casing will allow the installation of Teflon® and stainless steel submersible well purge pumps that may be dedicated to the monitoring wells. Thirty-four 2-inch-diameter piezometer wells will be drilled and constructed in both permeable and fine-grained zones at depths ranging from 100 to 250 feet below ground surface. Borehole diameters for the piezometers will be six inches.

Cuttings and Groundwater Disposal

A licensed hazardous waste transportation company under subcontract to Radian will transport and dispose of all borehole cuttings, drilling fluids, and groundwater removed from the boreholes and completed monitoring wells. During the drilling operations, the solid cuttings will be monitored for organic vapors, contained in steel, plastic-lined 20-cubic-yard capacity roll-off bins. Bentonite drilling fluids will be contained in large tanks on site. Groundwater produced during the drilling will be collected by vacuum truck and discharged to the Industrial Wastewater Treatment Plant at McClellan AFB; groundwater disposal will be coordinated with and approved by the management of the IWTP.

Drilling cuttings will be monitored for organic vapors in the field by Radian personnel. Cuttings from off all boreholes will be preliminarily characterized for disposal purposes by monitoring for organic vapors with a photoionization detector or organic vapor analyzer, and, if need be, species-specific Drager® detector tubes.

Any material, nonhazardous or otherwise, being transported off McClellan AFB will be handled according to procedures stipulated by the McClellan AFB Office of Environmental Management. Any hazardous material transported off McClellan AFB will be sent to an approved Class I waste disposal site and be accompanied by a required California Department of Health Services (DHS) Uniform Hazardous Waste Manifest. McClellan AFB is the generator of these materials and will be responsible for attending to any Hazardous Waste Manifests.

A detailed transportation and disposal plan will be developed as part of the implementation of this sampling and analysis plan. The plan will include the numbers and types of analyses to be conducted to profile drill cuttings and drilling muds prior to disposal.

Recordkeeping

Radian's supervising rig geologist will be responsible for all recordkeeping associated with the drilling. The supervising rig geologist will be under the direct supervision of a California Registered Geologist or licensed Civil Engineer. Examples of forms to be used Table 5-3 during drilling projects are illustrated in Figures 5-2 through 5-8. The following forms will be completed:

- Log of drilling operations;
- Well Completion Log;
- Time and Materials Log;
- Daily Field Report;
- Well Development Log;
- Photoionization Detector Screening Data Sheet;

TABLE 5-3. SUMMARY OF NUMBER AND TYPE OF CHEMICAL ANALYSES FOR PRELIMINARY GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION (HYDROGEOLOGIC ASSESSMENT)

Description	Analytical Method	Number of Analyses	Trip Blanks[a]	Ambient Conditions (Field) Blanks[a]	Equipment Blanks[a]	Duplicates	Second Column Confirm	Total Analyses
WATER ANALYSES								
Halocarbons (short turnaround time)	SW-8010[b]	25	0	2	3	3	13	46
Halocarbons (normal turnaround time)	SW-8010[b]	119	32	32	32	14	60	287
Aromatic Compounds	SW-8020	136	32	32	32	16	0	246
ICP Screen (23 Metals Less B, Si)								
Total Recoverable	SW-3005/SW-6010	136	0	8	32	16	0	192
Dissolved	SW-3005/SW-6010	136	0	0	32	16	0	184
Arsenic								
Total Recoverable	SW-7060	102	0	0	32	12	0	146
Dissolved	SW-7060	102	0	0	32	12	0	146
Mercury								
Total Recoverable	SW-7470	102	0	0	32	12	0	146
Dissolved	SW-7470	102	0	0	32	12	0	146
Selenium								
Total Recoverable	SW-7740	102	0	0	32	12	0	146
Dissolved	SW-7740	102	0	0	32	12	0	146
Lead								
Total Recoverable	SW-3020	102	0	0	32	12	0	146
	SW-7421	102	0	0	32	12	0	146

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TABLE 5-3. (Continued)

Description	Analytical Method	Number of Analyses	Trip Blanks[a]	Ambient Conditions (Field) Blanks[a]	Equipment Blanks[a]	Duplicates	Se. Column Confirm	Total Analyses
WATER ANALYSES (Continued)								
Cyanide, Total[c]	SW-9010	30	0	0	10	3		138
Volatile Organic Compounds	SW-8240	28	6	6	3	3	0	49
Semivolatile Organic Compounds	SW-8270	52	10	10	6	6	0	100

[a] Based on 32 days of sampling--32 batches of samples.
[b] The SW-8010 analyses proposed include the "short list" of volatile organic compounds.
[c] Sampling and analysis for cyanide is limited to 15 wells in Area C and Area D.

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RADIAN CORPORATION

Log of Drilling Operations

Sheet ________ of ________

Boring or Well No. ____________________

Location ____________________

Log Recorded By ____________________

Boring Diameter ____________________

Drill Type ____________ Bit Type ____________

Project ____________________

Beginning ____________________ and ending ____________________ of drilling operation

Boring Depth ____________________ (ft.)

Drill Operator ____________________

Depth (ft.)	Sampling Interval	ID No. of Sample Taken	Type of Sample Taken	Lithology	Remarks

Figure 5-2. Log of Drilling Operations.

0888-040-16

WELL COMPLETION LOG
McClellan AFB
RI/FS

Well Number ______________________ Log Recorded by ______________

Location ______________________ Completion Date ______________

Drilling Method ____

Borehole Depth ______________________ Borehole Diameter ______________

Borehole Declination ____

Materials:

Casing Diameter/Type ____

Screen Diameter/Type/Slot Size ______________________________________

Sand/Gravel Type ______________________ Volume ______________

Bentonite Seal Type ______________________ Volume ______________

Grout Mixture ______________________ Volume ______________

Intervals:

Screen Interval ____

Casing Interval ____

Sand/Gravel Pack Interval ______________________________________

Bentonite Seal ____

Grout Interval ____

Type of Surface Completion ______________________________________

NOTES: ____

____

____

Figure 5-3. Well Completion Log.

0888-040-23

RADIAN
CORPORATION

TIME AND MATERIALS LOG

McClellan AFB

RI/FS

Well No. ______________________ Completion Date ______________

Total Depth Drilled ______________ Screen Interval ______________

Supervising Rig Geologist ______________________________________

DRILLING TIME:

Mobilization ______________________

Rig Setup ______________________

Drilling ______________________

Standby ______________________

Rig Decon ______________________

Other ______________________

Subtotal Drilling ______________

WELL COMPLETION TIME:

Sand Pack ______________________

Bentonite Seal ______________________

Grout ______________________

Wellhead ______________________

Site Cleanup ______________________

Other ______________________

Subtotal Completion ______________

TOTAL __________

NOTES: ____

Figure 5-4. Time and Materials Log.

RADIAN CORPORATION

DAILY FIELD REPORT

McClellan AFB

RI/FS

Date ______________________ Reported By ______________________________________

S M T W T F S

Summary of Events and Observations:

____
____
____
____
____
____
____
____
____
____

Summary of Subcontractor Activities:

____
____
____
____
____
____
____
____

Figure 5-5. Daily Field Report.

RADIAN CORPORATION

WELL DEVELOPMENT LOG

McClellan AFB

Well No. ______________________ Reported by ______________________

Screen Type/Interval ______________________

Screen Diameter/Slot Size ______________________

Static Water Level Prior to Development ______________________

Development Started ______________________ Ended ______________________

Quantity of Water Discharged During Development ______________________

Equipment/Tools Used ______________________

Pump Type ______________________

Pump Capacity ______________________

Depth-to-Pump Intake ______________________

Time	Development Method	Observations and Remarks

Figure 5-6. Well Development Log

RADIAN
CORPORATION

PHOTOIONIZATION DETECTOR

SCREENING DATA SHEET

Area ______________________________

Date ______________ Time ______________

Screener's Initials ______________ Instrument I.D. ______________

SPECIFIC LOCATION	SCREENING VALUE (ppmv)
1. Ambient (average background)	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	

COMMENTS: ______________________________

Figure 5-7. Photoionization Detector Screening Data Sheet.

RADIAN
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DIRECT READING INDICATOR TUBES

FIELD DATA

Date ______________________________

Client/Location ____

____

Sample Location	Time	Tube Type/Mfg.	Concentration	Comment

Figure 5-8. Direct Reading Indicator Tubes Field Data.

- Direct Reading Indicator Tubes Field Data Sheet: and
- Geophysical log forms prepared by logging company.

In addition to completing these forms, the supervising rig geologist will be responsible for keeping a daily log of events and observations in a personal field notebook.

Well Installation and Completion

The termination depth and screened interval for a monitoring well will be determined by the supervising rig geologist in consultation with AFOEHL/TS and McClellan AFB EM engineers. The geophysical logs from the deepest borehole in any cluster of monitoring wells, in combination with the lithologic log for the well being drilled, will be used to determine the most favorable screen interval. Pilot holes drilled with mud rotary will be completed approximately 10 feet deeper (overdrilled) than the deepest anticipated screen interval to accommodate positioning of borehole geophysical sondes. Pilot holes will be grouted (abandoned) after geophysical logging. Although it is not anticipated, if a monitoring well is to be drilled by mud rotary and geophysically logged, it will not be overdrilled.

All groundwater monitoring wells will be constructed in a similar manner, regardless of the drilling method used. A schematic diagram showing well construction details is presented in Figure 5-9. A summary of well-specific construction materials is presented in Table 5-4. The materials used will include stainless steel screen, flush joint threaded polyvinyl chloride (PVC), low carbon steel and stainless steel casing, stainless steel casing centralizers, sand pack, and cement-bentonite seals. The stainless steel casing will be used for that portion of the monitoring well that lies below the water table. Polyvinyl chloride casing will be used in the vadose zone in wells less than 190 feet deep. Low carbon steel casing will be used in the vadose zone in wells greater than 190 feet deep. All screen and casing will

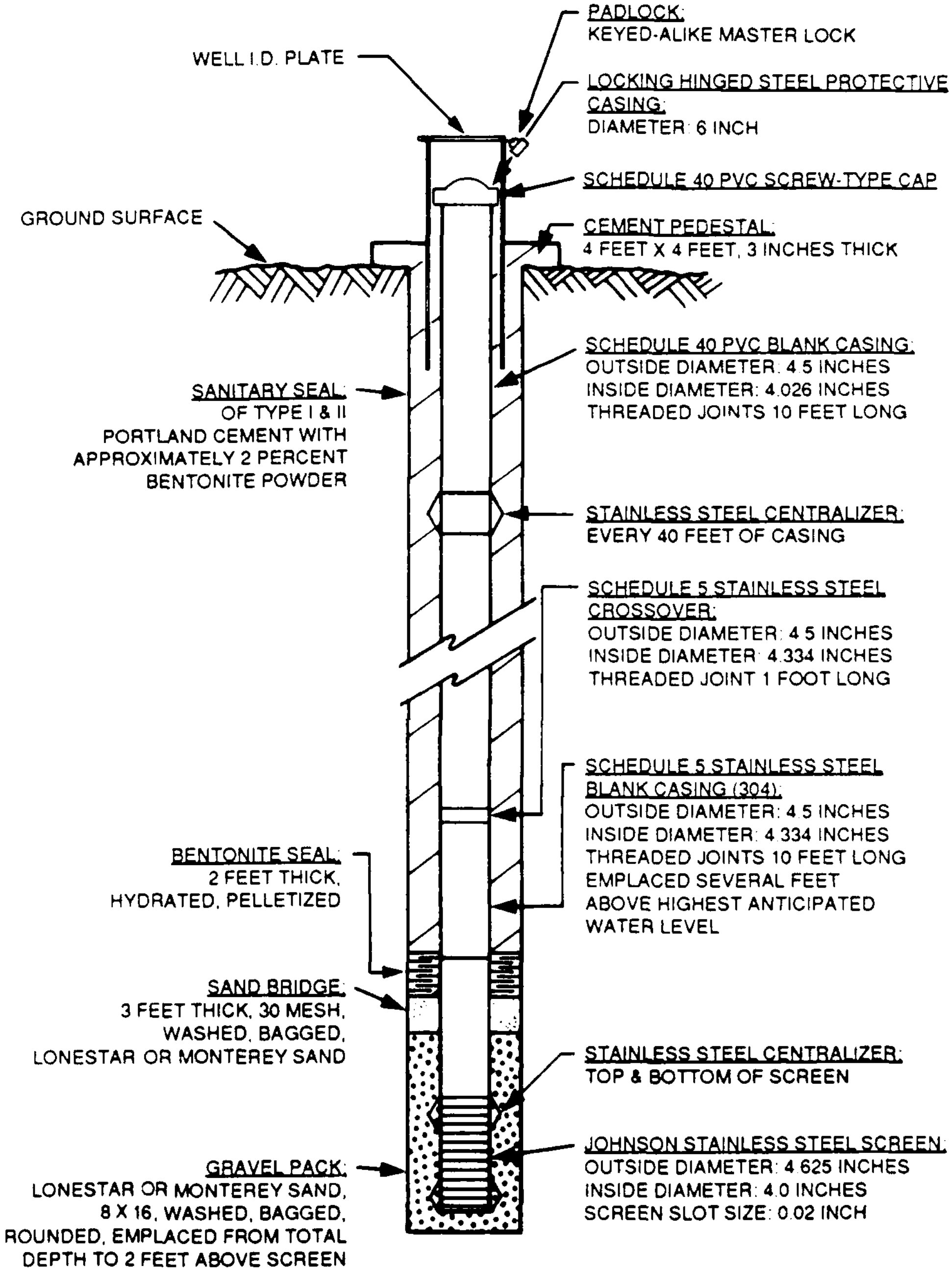

Figure 5-9. Schematic Well Construction Diagram for Groundwater Monitoring Wells Completed Above 250 Feet Below Ground Surface.

0688-040-15

TABLE 5-4. SUMMARY OF WELL-SPECIFIC CONSTRUCTION MATERIALS

Proposed Monitoring Well*	Length Stainless Steel Screen (linear ft)	Approximate Length Schedule 40 PVC Casing (linear ft)	Approximate Length Low Carbon Steel Casing (linear ft)	Approximate Length Stainless Steel Casing (linear ft)	Casing Centralizers	Steel Security Casing	Utility Boxes
Monitoring Wells							
14 "Water Table"	140 (10 ft each)	1,400 (100 ft each)	--	280 (20 ft each)	70 (5 each)	14	6
12 "150-foot"	120 (10 ft each)	1,200 (100 ft each)	--	960 (80 ft each)	84 (7 each)	12	5
17 "200-foot"	170 (10 ft each)	--	1700 (100 ft each)	2210 (130 ft each)	136 (8 each)	17	6
1 "300-foot"	10 (10 ft each)	--	100 (100 ft each)	240 (240 ft each)	11 (11 each)	1	1
Piezometers							
9 "Water Table"	18 (2 ft each)	1170 (130 ft each)	--	--	27 (3 each)	8	1
10 "150-foot"	20 (2 ft each)	1900 (190 ft each)	--	--	50 (5 each)	10	1
9 "200-foot"	18 (2 ft each)	2160 (240 ft each)	--	--	54 (6 each)	9	--
1 "300-foot"	2 (2 ft each)	350 (350 ft each)	--	--	9 (9 each)	1	--
1 "130-foot aquitard"	2 (2 ft each)	150 (150 ft each)	--	--	4 (4 each)	1	1
2 "175-foot aquitard"	4 (2 ft each)	400 (200 ft each)	--	--	20 (5 each)	1	1
2 "250-foot aquitard"	4 (2 ft each)	600 (300 ft each)	--	--	16 (8 each)	2	--
Optional Wells							
7 "300-foot"	70 (10 ft each)	--	700 (100 ft each)	1680 (240 ft each)	77 (11 each)	7	3
TOTAL QUANTITY	578 ft	9,330 ft	2,500 ft	5,370 ft	558	83	25

* Table does not include any wells drilled for the Area B Groundwater Operable Unit Remedial Investigation.

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either be received clean in factory packaging or be pre-cleaned on site by steam cleaning. Well construction procedure and materials are discussed below:

- Screen--Type 304 stainless steel, wire-wrapped, 10-foot lengths, 4-inch inside diameter, 0.01 or 0.020-inch slot size.

- Casing--Schedule 5, Type 304 stainless steel, flush-threaded, 10-foot lengths, 4-inch inside diameter. Stainless steel casing will be used between the screen and the highest anticipated groundwater level.

- PVC Casing--Each well drilled and constructed at depths less than or equal to approximately 190 feet shall be completed with 4-inch inside diameter, Schedule 40, flush-threaded joint, polyvinyl chloride (PVC) water well casing from the top of the stainless steel casing to the ground surface.

- Casing--Each well drilled and constructed at depths below approximately 190 feet shall be completed with 4-inch inside diameter, flush-threaded joint mild steel water well casing from the top of the stainless steel casing to the ground surface.

- Casing Centralizers--Stainless steel centralizers shall be installed at the top and bottom of each well screen and at 40-foot intervals on all well casing.

- Sand Pack--Monterey sand, 8x16 mesh (2.36 mm to 1.40 mm or 0.09 to 0.05 inches in diameter-U.S. Standard System, Driscoll, 1986) or equivalent and Lonestar 1C 16x40 (1.168 mm to 0.417 mm or 0.046 to 0.164 inches) or equivalent.

- Sand Bridge--Monterey sand, 30 mesh (0.58 mm or 0.023 inches in diameter-U.S. Standard System, Driscoll, 1986).

- Bentonite seal--at least two feet of pure API cement grade pelletized, non-beneficiated sodium bentonite.

- Sanitary Seal-Neat mixture of Type I Portland cement with approximately 2 to 3 percent (by dry weight) powdered bentonite and approximately 7 to 9 gallons of water per 94-pound sack of cement.

- Steel Security Casing-Six-inch diameter by 5-foot-long steel casing with locking lid.

- Cast Iron Utility Box--Will be used to protect wellhead for "flush" completions only.

The preferred slot width of 0.02 inches for wire-wrapped well screen was selected on the basis of 1984 Stage 2-1 sieve analysis and the satisfactory performance record of McClellan AFB monitoring wells with screens of that slot width. Sieve analyses were performed on samples from 29 reconnaissance borings completed on and adjacent to McClellan AFB in 1984. Analyses of the grain size distribution in those samples indicated that a slot of 0.02 inches would pass 10 percent or less of the grains in a 8 x 16 filter pack placed around the screen. The monitoring wells with 0.02-inch slotted screens, which have been periodically purged and sampled, discharge water at adequate pumping rates without producing measurable amounts of sand or silt.

Although a sieve analysis of grain size distribution to determine screen slot size and filter pack is desirable in construction of a groundwater production well, it is not practical or cost effective to conduct sieve analyses during drilling to optimize the design of a monitoring well. Screen slot sizes of 0.01 or 0.02 inches will be available and adequate for the purpose of providing a sediment-free, representative groundwater sample for monitoring.

Prior to placement of the screen and casing, the borehole depth will be verified with a weighted surveyors tape. The screen and casing will then be placed through the drive casing of the air rotary casing drive drill rig. Declination of the screen and casing will be measured to ensure that it is no more than 3° from vertical. Any well exceeding 3° in deviation from vertical will be considered unacceptable and will be redrilled. Stainless steel casing centralizers will be placed at the top and bottom of the well screen and at least every 40 feet of well casing. Stainless steel casing will be used to the highest anticipated water table elevation. The highest anticipated water-level elevation is estimated for each monitoring well from: 1) the depth of the first saturated stratum encountered during drilling; 2) the observed decrease in the regional water table elevation of approximately 1 to 2 feet per year; and 3) seasonal fluctuations in static water levels of approximately 1 to 2 feet from March (highest measured annual levels) to October (lowest measured annual levels). PVC casing will be used above the stainless steel casing. All screen and casing will be flush-joint threaded. Once enough sand has been placed to support the screen and casing, the well will be checked for proper alignment by passing a length of PVC pipe (measuring 3.75 inches x 10 feet) through the casing to the bottom of the well. The sand pack will then be placed around the screen through a tremie pipe to a height of at least 3 feet above the top of the screen. The drive casing will slowly be pulled up and recovered as the sand pack is installed. After installation of the sand pack, a surveyor's tape shall be used to measure the top of the filter pack. Materials will then be added through the tremie pipe to construct the sand bridge, bentonite seal, and grout sanitary seal. The grout sanitary seal will be pumped through a tremie pipe placed into the annulus between the well casing and drive casing. Prehydrated powdered bentonite will be added to the cement during mixing to provide a smooth, consistent blend. The drive casing and tremie pipe will gradually be pulled up and recovered as the level of grout rises in the borehole. No more than 20 percent of the length of drive casing or tremie pipe will be pulled at one time.

Borehole diameters will range from 6 to 10 inches depending on the drilling method and well construction specifications. All wells will be constructed with 4-inch-diameter screen and casing in a 10-inch-diameter borehole. All piezometer wells, regardless of depth, will be constructed of 2-inch diameter well casing and screen. Pilot holes will be drilled with 6-inch diameter boreholes.

The wellheads for monitoring wells will be completed above ground or as flush completions as shown in Figures 5-10 and 5-11, respectively. Monitoring wells completed above ground will have a 6-inch-diameter locking steel security casing installed around the PVC monitoring well stickup. The steel security casing will be set in a 4-foot-square concrete pedestal. Three 3-inch-diameter steel security posts will be positioned around those wells where such protection is considered necessary. Steel security casings and security posts will be painted and capped.

The PVC casing for all flush completed wells will be set several inches below grade. Each wellhead will be enclosed within a cast iron utility box equipped with a threaded lid. The valve boxes will be set slightly above the surrounding ground surface so that surface water flows away from the wellhead. Flush completed wells will be fitted with a water tight cap.

Well identification plates will be secured on the lid of the steel security casing. All wells will be secured with identically keyed padlocks. Keys will be provided to McClellan AFB EM.

Monitoring Well Development

All groundwater monitoring wells will be developed to remove any fine-grained sediment and drilling fluid from the screen and sand pack. Prior to development of each well, total well depth and depth to static water level will be measured. Development will consist of bailing, surging, and pumping with an electric submersible pump.

Each well will be bailed with a 10-foot-long, 3-inch minimum diameter, steel bailer to remove drilling mud (if used) and formation material from the well. The bailers will be closed at the top and fitted with a dart-valve at the bottom that when "tripped" or pushed will allow water and sediment up

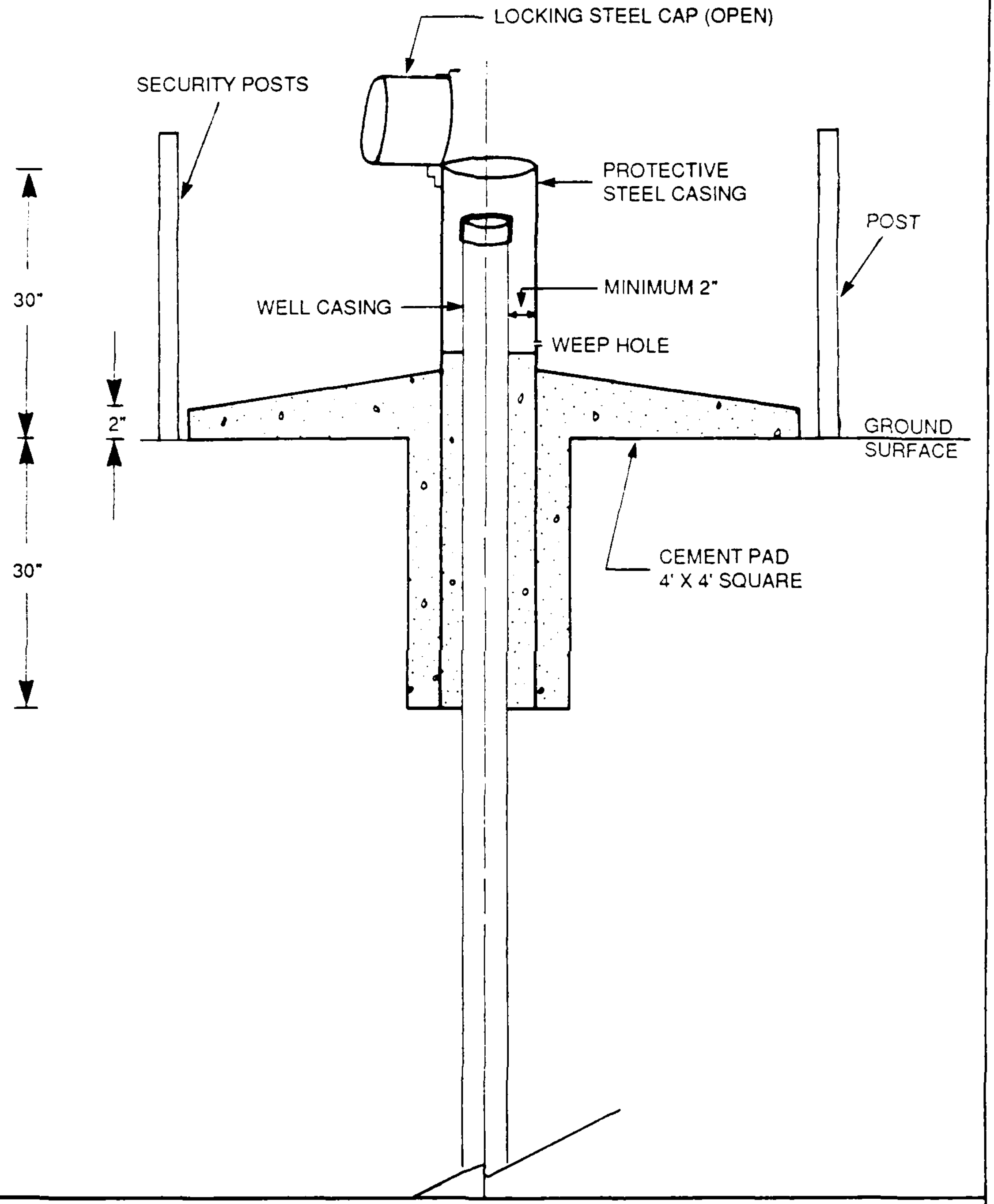

Figure 5-10. Schematic Well Construction Diagram of Above Ground Groundwater Monitoring Well Completion.

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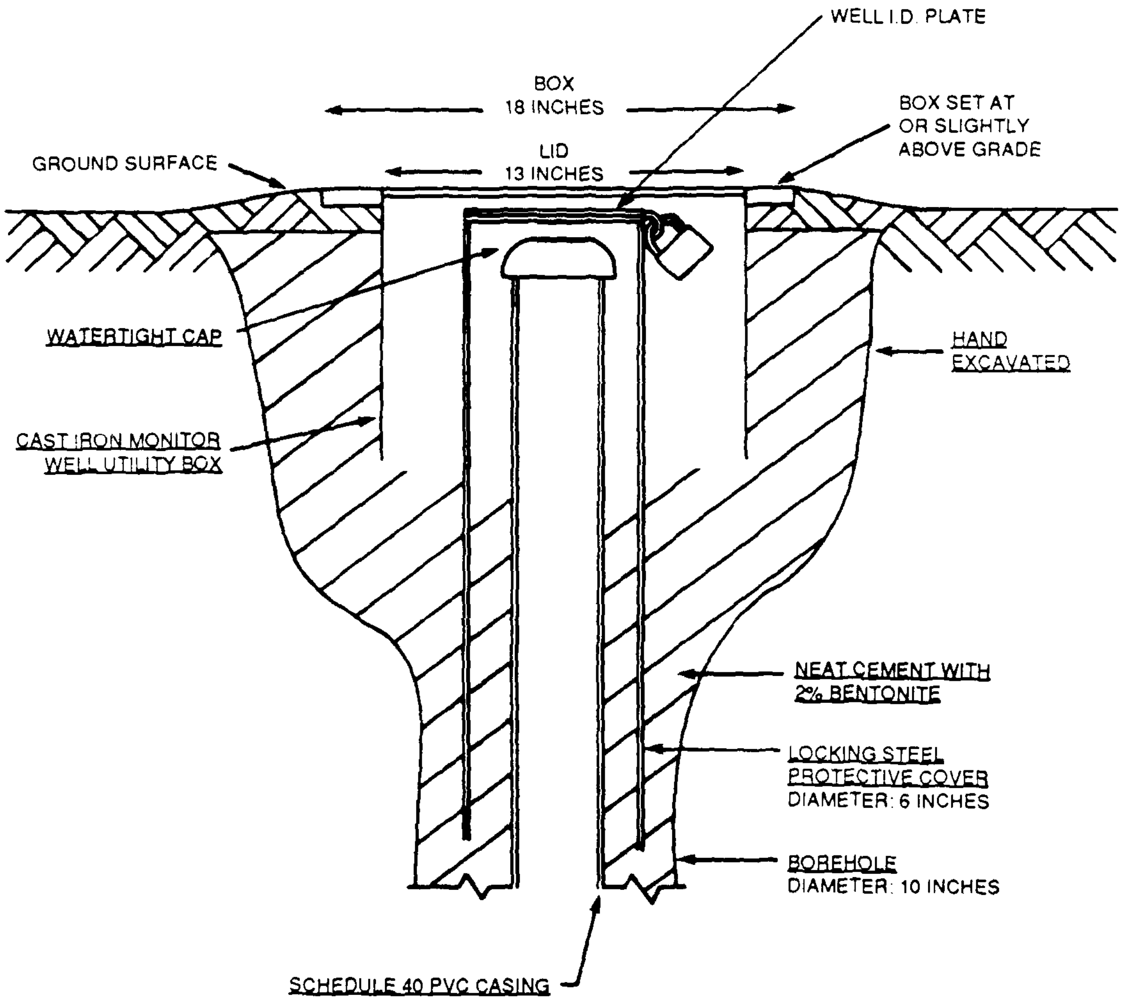

Figure 5-11. Schematic Diagram of Flush Groundwater Monitoring Well Completion.

0588-040-14

into the bailer. This will allow the collected material to be discharged from the bailer when it is removed from the well. The well will then be surged with a vented surge block to induce flow across the screen openings and bring fine-grained material into the well. The material brought into the well will be removed by bailing. The bailing and surging process will be repeated until little or no fine-grained material is produced, as determined by the Radian geologist.

After bailing and surging is complete, development of each well will be concluded by pumping with an electric submersible pump. The pump used will be capable of discharging at least 20 gallons per minute (gpm) at 100 feet of lift. The well will be pumped initially at a low discharge rate (e.g., 5 gpm). The pumping rate will be periodically increased, not moving to a higher rate until the discharge is relatively free of turbidity. The final pumping rate will be about 20 gpm unless limited by the specific capacity of the well and pump submergence. During pumping, groundwater will be analyzed for temperature, specific conductivity, and pH; pumping will continue until these measurements stabilize. Selected wells may be equipped with dedicated purge and sampling pumps. The wells selected and the types of dedicated pumps will be determined following initial sampling analyses.

Surveying

The top north side of the PVC well casing will be permanently notched to indicate a reference point (at the bottom of the notch) from which all future water level measurements will be made. At the completion of drilling operations, a licensed land surveyor will determine the vertical (elevation) and horizontal position of the reference point. The accuracy for vertical and horizontal survey control will be ±0.01 and ±1.0 feet, respectively.

5.2.1.6 Aquifer Tests

Aquifer testing will be conducted as part of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) to determine the hydraulic properties of both permeable zones and aquitards. The effects that on-base water supply wells have on the local groundwater flow patterns also will be evaluated. The hydraulic properties of the aquifer system have been characterized during past investigations at various locations in the study area, and generally only in two monitoring zones. The effects of on-base water supply wells have only been inferred from potentiometric surface maps.

The following subsections discuss a multiple-well aquifer test, 40 single-well aquifer tests, and long-term water-level monitoring of production and nearby monitoring wells.

5.2.1.6.1 Multiple-Well Aquifer Tests

The purpose of the two multiple-well aquifer tests planned for the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) is to directly characterize the vertical hyraulic conductivity of the clayey silty aquitards that separate waterbearing zones. Several multiple-well aquifer tests have been completed on base to determine the hydraulic properties of the more permeable waterbearing zones. However, no data have been collected for the finer-grained, less permeable aquitards that separate these zones. The vertical hydraulic conductivity data will be used with field-determined vertical gradients to evaluate groundwater movement vertically. The vertical hydraulic conductivity data may also help to evaluate the effects that the aquitards have on the migration of contaminants in groundwater.

One of the two aquifer tests will involve pumping a middle zone monitoring well, PW-126, at the Phase II, Stage 2-3, aquifer test site (Radian, 1987). Water levels will be measured in observation wells screened in the shallow, middle, and deep monitoring zones and in the aquitards above and below the middle monitoring zones.

The other multiple-well aquifer test will be conducted south of Area C. The "200-foot" aquifer will be pumped and water levels measured in the "150-foot" aquifer, the "200-foot" aquifer, the "300-foot" aquifer, the

"250-foot" aquitard, and the aquitard between the "150-foot" and "200-foot" aquifers.

Vertical hydraulic conductivity will be determined from the test data through the use of the ratio method (Neuman and Witherspoon, 1972). Monitoring zone definitions for the Phase II aquifer test site are the same used during the previous aquifer test (Radian, 1987), as existing observation wells will be used. Monitoring zone definitions for the Area C test will follow the proposed zones described in Section 3.2.2 because screen intervals of the piezometers and of some existing monitoring wells were installed by EG&G Idaho based on borehole geophysical logs.

Field Methods

Before the aquifer tests can be conducted, new observation wells must be installed and core samples of the aquitard material collected for consolidated testing, falling head parameter tests, and grain size analysis.

During the Phase II, Stage 2-3, aquifer test, observation wells were installed in the shallow, middle, and deep monitoring zones at a distance of approximately 85 feet from PW-126. Figure 5-12 presents the location of the observation wells at the Radian Phase II, Stage 2-3 aquifer test site. One additional observation well will be required at this location in the aquitard underlying the middle monitoring zone, as shown in Figure 5-13 (cross section K-K'). The piezometer will be installed at an approximate elevation of -130 feet msl.

An additional cluster of observation wells will be installed at a distance of approximately 40 feet from PW-126. These piezometers will be installed in the shallow and middle monitoring zones and in the aquitard between these two zones. As shown in Figure 5-13, the piezometers will be installed at approximately -45 feet msl, -65 feet msl, and -100 feet msl. Table 5-5 summarizes the proposed piezometer specifications at both aquifer test sites.

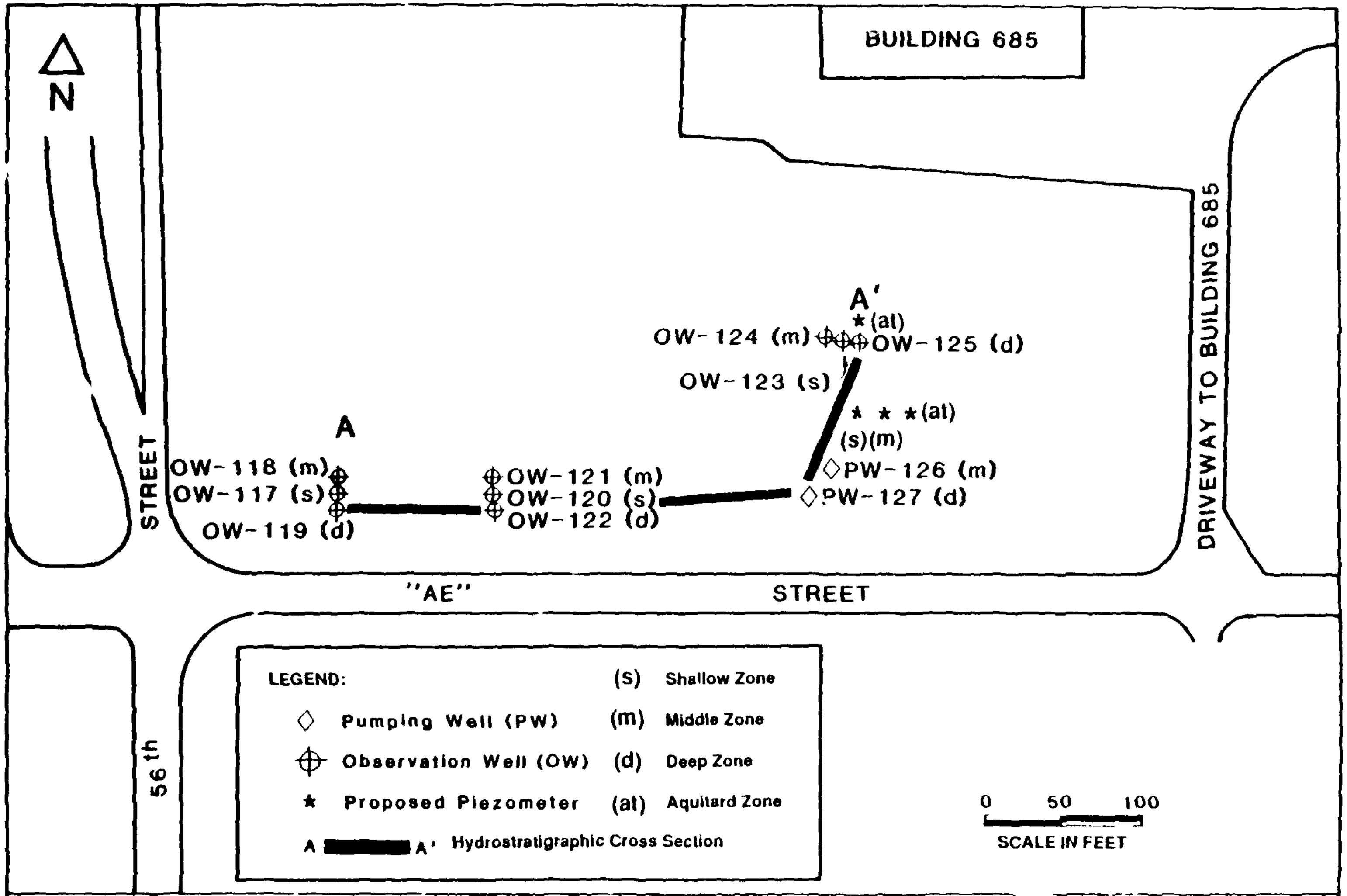

Figure 5-12. Location of Proposed Piezometers at the 1986 R 'ian Aquifer Test Site for Vertical Hydraulic Conductivity Test.

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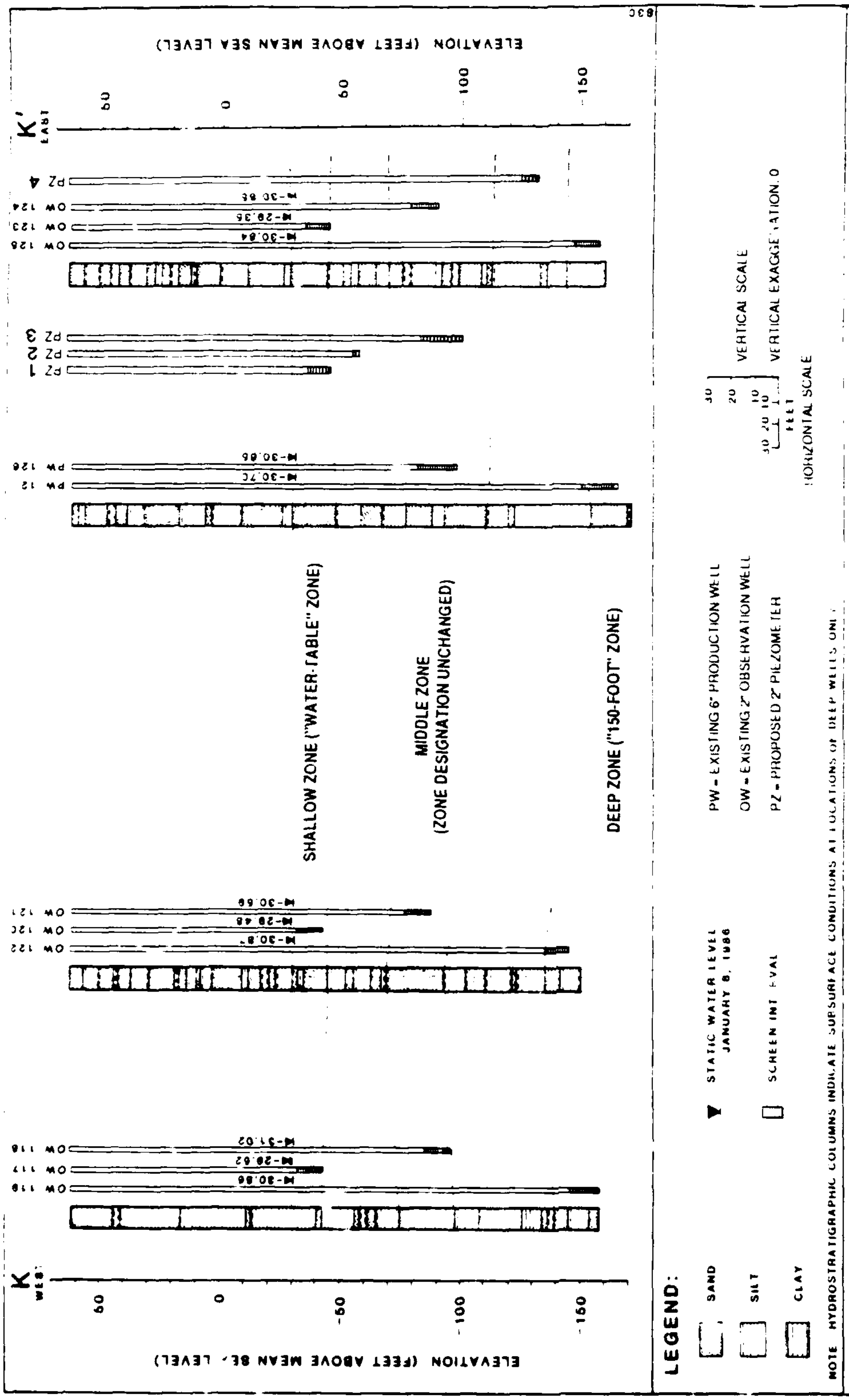


Figure 5-13. Hydrogeologic Cross Section (K-K') of the 1986 Radian Aquifer Test Site and Proposed Depths of Piezometers for Vertical Hydraulic Conductivity Test.

0588-040-04

TABLE 5-5. PROPOSED PIEZOMETERS TO BE INSTALLED FOR MULTIPLE-WELL AQUIFER TESTS AND AREA C WATER-LEVEL MEASUREMENTS

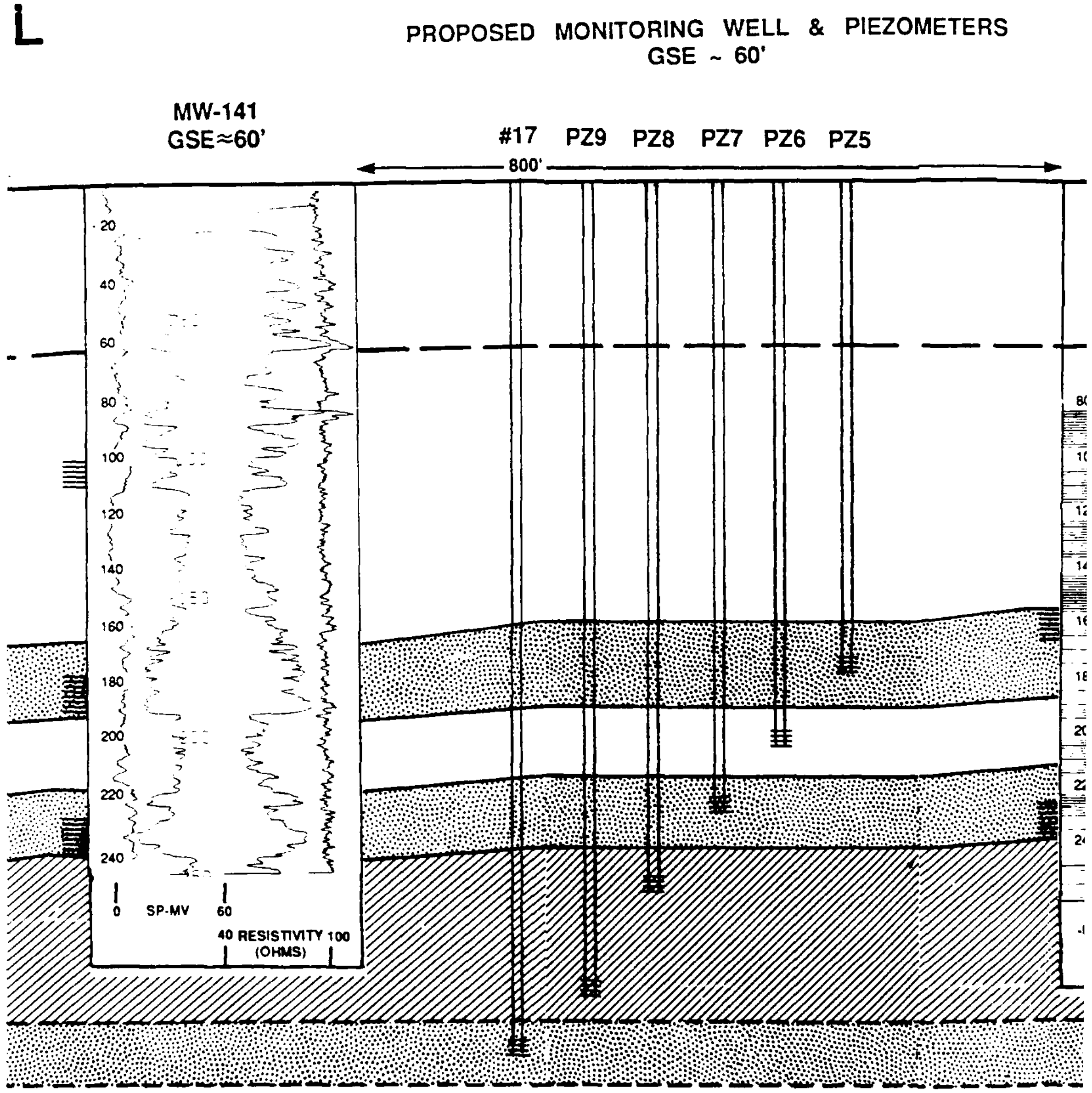
Proposed Piezometer	Estimated Depth (ft msl)	Screen Length (ft)	Zone to be Monitored
PHASE II TEST SITE			
PZ-1	-45	2	Shallow monitoring zone.
PZ-2	-65	2	Aquitard between shallow and middle monitoring zones.
PZ-3	-100	2	Middle monitoring zone.
PZ-4	-130	2	Aquitard between middle and deep monitoring zones.
AREA C			
PZ-5	-90	2	"150-foot" zone.
PZ-6	-130	2	Aquitard between "150-foot" and "200-foot" zones.
PZ-7	-150	2	"200-foot" zone.
PZ-8	-185	2	"250-foot" aquitard.
PZ-9	-215	2	"300-foot" zone.
Number of Other Piezometers in Area C			
8	-50	2	Water table
7	-90	2	150-foot zone.
8	-150	2	200-foot zone.

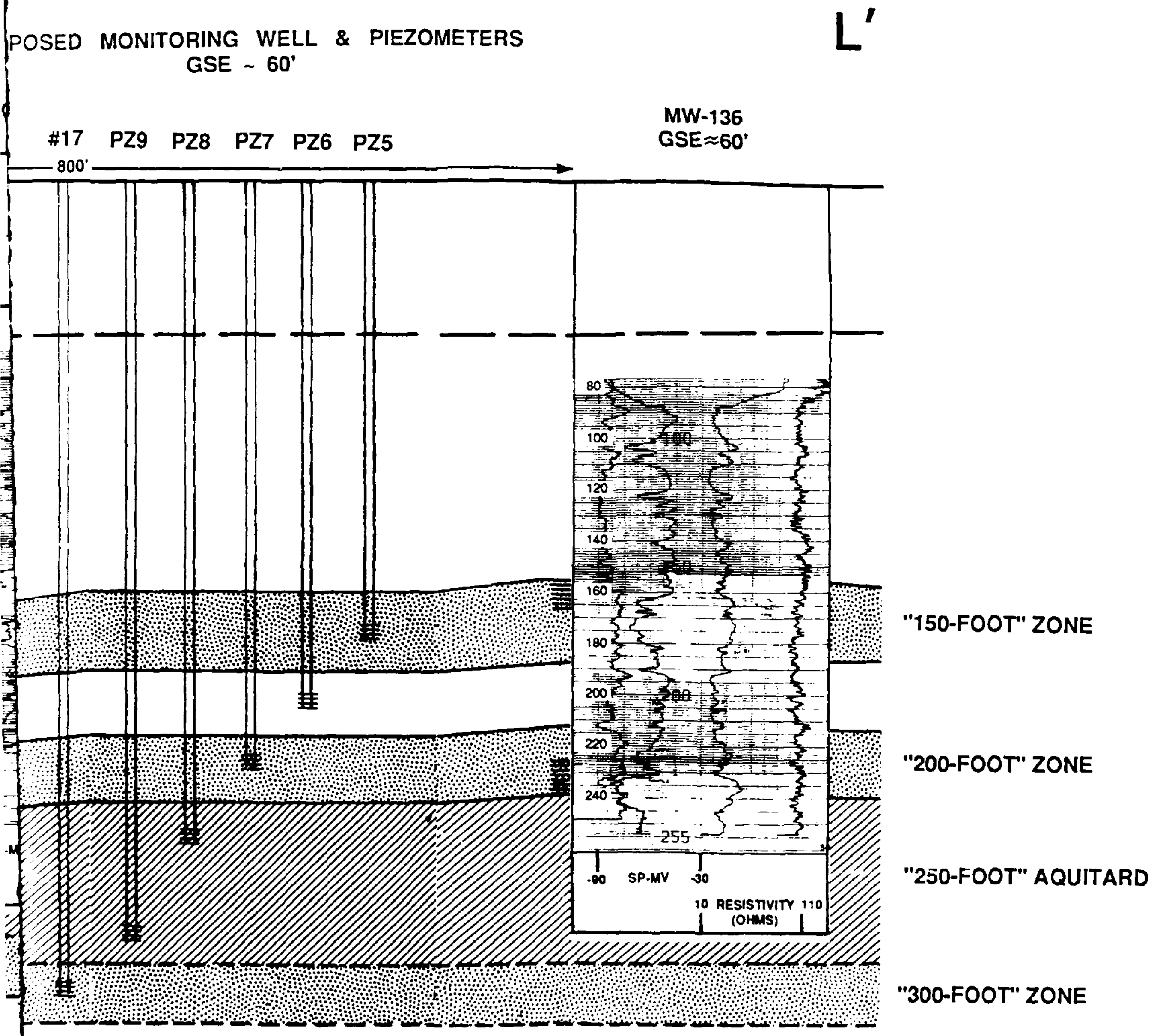
The second aquifer test will be conducted immediately south of Area C. The proposed new monitoring well cluster 17 will be used to monitor water level changes in the "300-foot" zone. A cluster of five piezometers will be installed approximately 25 feet from an existing monitoring well near MW-141. These piezometers will be installed in the "250-foot" aquitard, in the aquitard between the "150-foot" and "200-foot" zones, in the "200-foot" zone, and in the "150 foot" zone (Figure 5-14). As shown in Table 5-5, the piezometers will be installed at approximately -215 feet msl, -185 feet msl, -150 feet msl, -130 feet msl, and -90 feet msl.

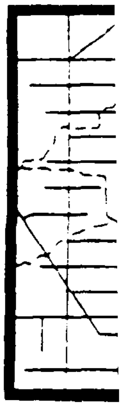
Drilling of the new observation wells (piezometers) will be accomplished with the air rotary casing drive drill rig, as described in Section 5.2.1.5.2. The borehole diameter will be a minimum of 6 inches to allow installation of the 2-inch (inside diameter) observation wells. Two-inch Schedule 40 PVC casing with a 2-foot long stainless steel mill-slotted screen will be used for the observation well. The screen slot size will be 0.020 inches. Construction of the observation wells will follow the monitoring well construction methods described in Section 5.2.1.5.2. After installation, the observation wells will be developed to remove any fine-grained particles from the screen. Development will include bailing and surging.

The piezometers will be installed using an air rotary casing drive drilling method. During drilling, core samples of the aquitards underlying and overlying the middle monitoring zone will be collected with a Christensen core barrel. Five-foot long samples will be collected and split for laboratory analysis. Five core samples will be collected from the zone of finer material using a wire-line and down-hole hammer drive sampler. Two cores will be collected from the 1986 Phase II test site located southeast of Area C; three similar cores will be collected from Area C.

The core samples will be used for laboratory determination of the coefficients of compressibility, permeability, and grain size distribution (Table 5-6). The compression characteristics of 27 soil samples (12 from the Phase II test site and 15 from the Area C test site) will be determined using


L
PROPOSED MONITORING WELL & PIEZOMETERS
GSE ~ 60'
MW-141
GSE≈60'
#17 PZ9 PZ8 PZ7 PZ6 PZ5
800'
20
40
60
80
100
120
140
160
180
200
220
240
0 SP-MV 60
40 RESISTIVITY 100
(OHMS)





LEGEND:

GSE G

M

S

Z
P
E

Z
P
E

PZ P
(F

SP S

MV M

Vertical S
Horizont

HYDROGEOLO
SHOWIN
APPR
PIEZOME

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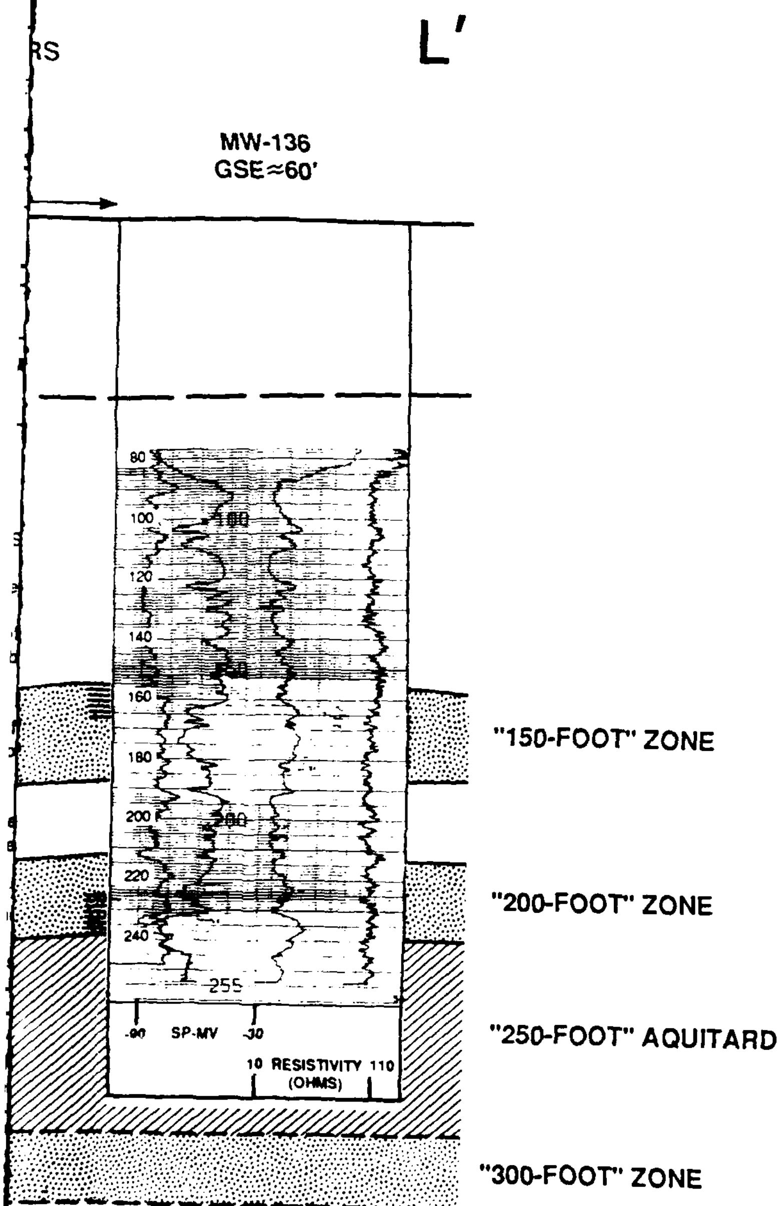

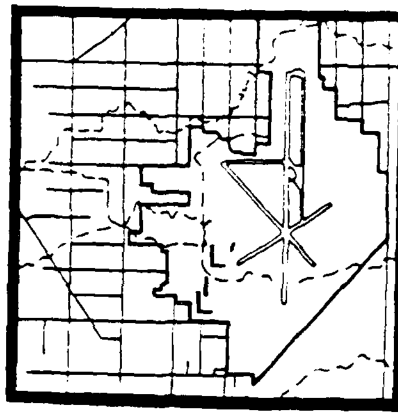

LEGEND:

- GSE — Ground Surface Elevation
- Mean Sea Level
- Screened Interval
- Zone of Relatively Higher Permeability Based on Electric Log Response
- Zone of Relatively Lower Permeability Based on Electric Log Response
- PZ — Piezometer (Piezometers will have 2-foot screens)
- SP — Spontaneous Potential
- MV — Millivolts

SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: NOT TO SCALE

FIGURE 5-14.
HYDROGEOLOGIC CROSS SECTION (L - L') SHOWING PROPOSED DEPTHS & APPROXIMATE LOCATION OF PIEZOMETERS (PZ) FOR AREA C AQUIFER TEST

McCLELLAN AFB
RI Stage 6, February, 1990

RADIAN CORPORATION

TABLE 5-6. SUMMARY OF NUMBER AND TYPES OF PHYSICAL PROPERTIES TESTS

ASTM Designation	Test Method	# Samples
D 2434-68	Permeability of Granular Soil	15
D 2435-80	One-Dimensional Consolidation Properties of Soil	27
D 422-68	Grain-Size Distribution	27
D 2216-80	Moisture Content	27
D 854-83	Specific Gravity of Soils	27

standard consolidation testing procedures (Lambe, 1951). Consolidation test results (coefficient of compressibility, a_v) are used to calculate specific storage (S's) of the aquitard material from the relationship $S's = (a_v X_w)/(1+e)$ where X_w is the specific weight of water and e is the void ratio. Permeameter tests on a maximum of 15 samples will also be conducted to determine vertical hydraulic conductivity values for comparison with the field-derived values. Twenty samples from the aquitards will also be collected for bulk density and grain size distribution.

Water levels will be measured during both aquifer tests with transducers wired to a programmed data logger. Water levels will be monitored in the pumped well and the observation wells. The transducers will be installed and water levels monitored hourly for one week prior to the pumping step of the aquifer test. Water level measurements will be taken every 15 minutes for at least 72 hours prior to the start of the test. Transducers will be laboratory calibrated before installation in wells. Barometric data will also be acquired for the same time period. Daily changes in water levels will identify effects of barometric pressure changes and outside pumping influences.

Procedure

Procedures for the field portion of the aquifer tests include the following:

- The test period will be planned and coordinated with base water supply personnel to avoid interference of base well pumping with scheduled aquifer tests.

- Water levels in all observation wells and piezometers will be monitored every 15 minutes for a minimum of 72 hours prior to the test to quantify any antecedent trends that may exist.

- For each test, an existing monitoring well will be pumped at about 60 to 70 gpm. The optimum pumping rate of 60 to 70 gpm was determined from prior aquifer testing in this area; no step drawdown test is required. The duration of the pumping will be dictated by the time required to obtain measurable head responses in the unpumped aquifers. The anticipated minimum pumping time will be five hours. The analysis of the aquifer test results will utilize early time data. Water-level recovery data will not be taken during the test because the method does not require the data.

- Water levels will be monitored in existing wells and in newly installed observation wells. Water levels will be measured with transducers and the information recorded using a data logger during pumping and during recovery. Observation wells will be sounded at least hourly with water level probes as a check on the transducer-generated data.

- Water from the pumped well will be collected in vacuum trucks and discharged to the Groundwater Treatment Plant or to the Industrial Wastewater Line (IWL) upon approval of McClellan AFB personnel.

Method of Analysis

The water levels in the middle monitoring zone and the confining layers will be analyzed using the ratio method developed by Neuman and Witherspoon (1972). This method of analysis will be used to calculate vertical hydraulic conductivity of the aquitards above and below the middle monitoring zone. Results of the laboratory consolidation tests will be used to determine storage coefficient of the aquitards which is needed for the calculation of the vertical hydraulic conductivity of the aquitard. Neuman and Witherspoon's ratio method is presented in more detail in Section 5.2.2.2.

5.2.1.6.2 Single-Well Tests

Pump testing of single wells will be conducted at 40 locations in order to develop ranges and average values for transmissivity and hydraulic conductivity in areas, and in monitoring zones, for which these data are sparse or unavailable. The primary advantage of single-well tests over multiple-well tests is their low cost. Many single-well tests can be conducted relatively inexpensively. Single-well tests will be conducted on wells installed during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) and on selected existing monitoring wells. The new wells to be tested will include most of the new Hydrogeologic Assessment wells to be installed on the east side of the base, and in and around Area A. Single-well tests will also be conducted on wells in the off-base Southeast Area. Existing wells to be tested includes MW-27D, MW-71, MW-68, MW-49, and MW-1014. As shown in Figure 4-11, a total of 40 wells will be tested, including 12 wells screened in unconfined conditions in the "water table" zone, 12 wells screened in the "150-foot" zone, 12 wells screened in the "200-foot" zone, and 4 existing wells screened above the "150-foot" zone.

Procedure

After the new monitoring wells have been installed and developed, the wells will be pumped at a constant rate and drawdown versus time will be recorded. At monitoring well clusters, water levels in adjacent wells screened at different intervals will also be monitored to evaluate the hydraulic connection between waterbearing zones. Transducers and a data logger will be used to measure and record water levels. Lithologic samples taken during drilling of the wells to be tested will be submitted for grain size analysis. With this data, it can be determined if a relationship exists between grain size distribution and hydraulic conductivity.

For each single-well test, the wells will be pumped with an electric submersible pump for at least four hours at an approximate rate of 5 to 15 gpm. This pumping rate range is based on the specific capacity observed when existing wells have been developed by pumping. After the pump is turned off in the wells, water-level recovery will be monitored until the levels return to their prepumping elevation. The pumped water will be collected in portable tanks and disposed at the Groundwater Treatment Plant. The drilling contractor will be responsible for installation of the submersible pumps. Between each test, the submersible pump will be thoroughly cleaned according to the procedures outlined in the Draft QAPP (Radian, October 1988).

Method of Analysis

The Papadopulos and Cooper (1967) method will be used to analyze the single-well pump test data. This method accounts for well storage and is appropriate because single-well tests will be conducted for two to four hours at relatively low pumping rates. The general procedure of Papadopulos-Cooper's method, as outlined in Kruseman and DeRidder (1983), involves plotting observed drawdown data versus time and curve matching with type curves. The method is described in more detail in Section 5.2.2.2.

Hydraulic continuity between waterbearing zones will be qualitatively evaluated from water levels measured during pump tests. If a decrease in water levels is detectable in wells screened in zones above or below the zone pumped during the test, hydraulic continuity between zones will be indicated.

5.2.1.6.3 Effects of Water Supply Wells

Pumping of water supply wells located on and off base has been recognized as a primary influence on local groundwater flow directions and hydraulic gradients. However, the effects have not been described. The purpose of this activity is to measure daily water levels in monitoring wells near on-base water supply wells and compare hydrographs to pumping schedules. The overall objective is to qualitatively assess the effects of water supply pumping on groundwater flow patterns. Pumping schedules, discharge rates, local response will be monitored and evaluated in order to assess the potential effects of pumping on the distribution of groundwater contaminants and on potential remedial alternatives. As a result of this activity, hydrographs of monitoring and water supply wells will be produced, pumping schedules will be summarized, and the effect of pumping water supply wells will be qualitatively assessed.

Method

The initial step to evaluate the effects of groundwater pumpage on flow directions will be the collection of well construction data, historical pumping schedules, and analytical data for on- and off-base water supply wells. Figure 5-15 shows the locations of active on-base water supply wells and off-base water supply wells.

Water levels will be monitored initially in on-base water supply wells BW-10, BW-13, BW-18, and BW-29, and in nearby monitoring wells MW-41, MW-49, MW-63, MW-132, MW-1021, and MW-1022. Water levels will also be monitored in all of the new wells at well sites 3, 11, 13, and 16 as shown on Plate 5. Pumping schedules for those same days will be obtained and compared with water-level changes. Water-level data from the wells will be collected for at least two months after all new Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) wells have been installed.

Water levels in the water supply wells and monitoring wells will be monitored with individual transducers and data loggers on a time schedule appropriate to the rate at which the water-levels change. Water-level data will be used to construct hydrographs of water levels. The hydrographs will be composited such that the hydraulic response of each water supply well and adjacent monitoring wells will be illustrated together.

The water-level data collected from water supply and monitoring wells will be used to help define horizontal and vertical gradients in response to groundwater pumpage. Horizontal and vertical gradients at different times during and after pumping will be determined. In addition, both horizontal and vertical gradients at various distances from the water supply well will be determined. Other horizontal flow responses that will be investigated include the radius of influence of the water supply wells and directional differences in the zone of influence. This information, in addition to vertical hydraulic conductivity measured by the multiple-well aquifer test, will be used to estimate vertical flow rates near pumping wells.

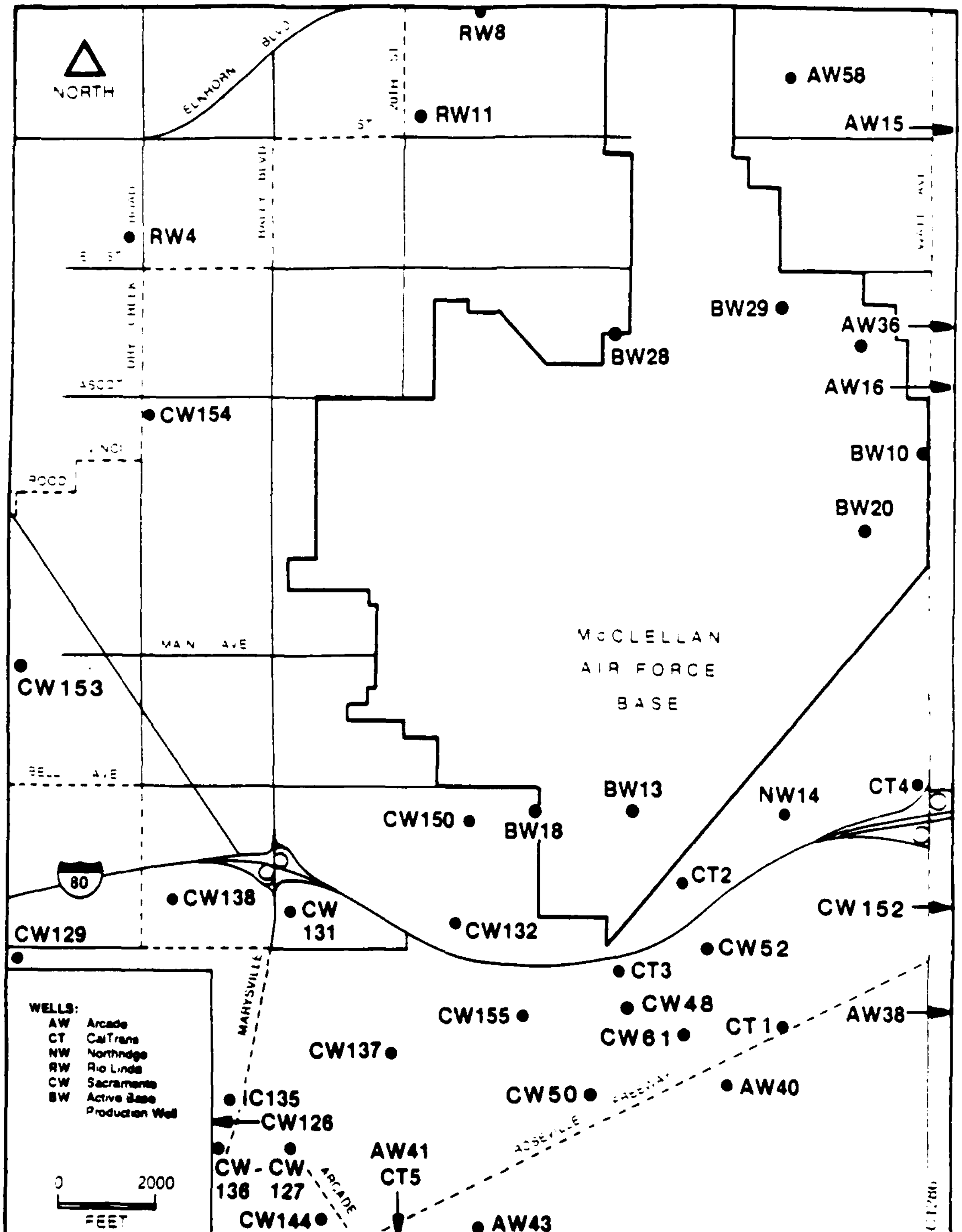

Figure 5-15. Locations of Municipal Wells On and In the Vicinity of McClellan AFB.

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5.2.1.7 Groundwater Samples

One objective of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) is to install monitoring wells that can be used to determine the magnitude and extent of groundwater contamination. Groundwater from all new wells installed during the assessment and the Area B Groundwater Operable Unit Remedial Investigation will be sampled and analyzed twice. Each well will be sampled once immediately after well development. Approximately one month after all new monitoring wells are sampled one time, a second round of sampling will be started. The new wells will be sampled for volatile organic chemicals, metals, and aromatic hydrocarbons to establish a preliminary baseline for water quality. Approximately 20 percent of the new monitoring wells will also be analyzed for semivolatile organic compounds by U.S. EPA Method 8270. A summary of the number of analyses and analytical methods is presented on Table 5-3. Sampling, analysis, and QA/QC procedures to be used during the sampling events are described in the Draft Quality Assurance Project Plan (QAPP) for McClellan AFB (Radian, October 1988). In addition, water levels of all new wells installed during the Hydrogeologic Assesment will be measured in a scheduled monthly sounding with pre-existing wells. Water levels will be measured in all wells in one area in one day or less, but not all monitoring wells on McClellan AFB will be measured in one day. The sounding data will be used in the production of potentiometric maps for each monitored waterbearing zone.

5.2.1.8 Trenching

Trenching will not be required during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.1.9 Drum Sampling

Drum sampling will not be required during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

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5.2.2 Evaluation-Related Tasks

Data management and analytical techniques that will be used to evaluate the data collected during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) are discussed below.

5.2.2.1 Data Management

The field investigation will generate large amounts of data including groundwater quality samples. In addition, large amounts of relevant environmental data have already been collected. Radian is therefore designing and constructing a database system to provide for efficient storage and handling of the data. This system will be used to convert the raw field data and analytical data into usable form for reporting. In addition, the database will conform to the AFOEHL Installation Restoration Program Information Management System (IRPIMS) and McClellan AFB requirements.

The database will be designed to support the following activities:

- Archive and analyze data collected during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment); and

- Produce subsets of data to form summary reports and data files.

Data evaluation and reporting procedures are described in the "Draft McClellan Air Force Base Quality Assurance Project Plan (QAPP)," (Radian, October 1988).

A variety of data other than groundwater data will be gathered during the program and will require proper management. These data include:

- Geologic logs, geology will be described using the Unified Soil Classification and Wentworth systems;

- Geophysical logs;

- Monitoring well construction details including:

  - Borehole diameter and depth,
  - Well diameter and depth,
  - Construction materials,
  - Screened interval,
  - Sand pack, sand bridge, bentonite seal, and grout intervals,
  - Wellhead and casing protective apparatus,
  - Casing centralizer depths, and
  - Surface and casing elevations;

- Well development data; and

- Time versus drawdown data collected during aquifer testing and evaluation of production well effects.

All data described above will be recorded in the field on designated forms. Forms that will be used include:

- Log of Drilling Operations;
- Well Completion Log;
- Well Development Log;
- Time and Materials Log;
- Daily Field Report;
- Photoionization Detector Screening Data Sheet; and
- Direct Reading Indicator Tubes Field Data Sheet.

Examples of these forms are presented in Figures 5-2 through 5-8. The computerized database management system will be used to provide efficient storage and handling of the physical data collected during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.2.2 Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment)

Data obtained during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) field effort will be used to develop a framework of hydrogeologic conditions beneath and adjacent to McClellan AFB. This framework will provide:

- A basis for determining the velocity, depth, and general areal extent of groundwater contaminant migration;
- Estimates of aquifer and aquitard parameters necessary for the development of groundwater models; and
- An understanding of hydrogeology necessary prior to determination of groundwater operable units and design of groundwater remedial actions.

5.2.2.2.1 Evaluation of Geologic Data

Geologic data obtained from the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) field investigation will enhance the basewide correlation of zones of relatively low and high permeability and the characterization of geologic conditions below a depth of 250 feet. Geologic data will consist of lithologic descriptions (geological logs) and geophysical logs which will be used to assess the subsurface geologic conditions at the base.

The migration of contaminants in groundwater at the base depends on the groundwater pathways and on the magnitude and orientation of the groundwater gradient. Groundwater pathways and potential contaminant pathways at the base are the widespread sandy deposits. Contrasting permeabilities within the sands result from the heterogeneous distribution of grain size and texture. Permeability barriers may form where the sands thin or grade laterally into less permeable materials. Vertical pathways for migration may be developed where sands from later depositional episodes occur stratigraphically above those from older episodes, and where low permeability strata pinch out or have been breached by erosion.

Of significant interest in the basewide characterization of geologic conditions is the identification of sand deposits that may represent paleochannels. Under saturated conditions, the sands in paleochannels may act as high permeability conduits for migration of groundwater and contaminants. The relatively low permeability deposits adjacent to paleochannel sands would retard horizontal or vertical movement of groundwater. Therefore, individual paleochannels or concentrations of paleochannels in any hydrostratigraphic unit beneath the base would provide preferred migration paths for groundwater flow and contaminant migration.

Geology

Radian will continually evaluate geological and geophysical data as they are obtained during the implementation of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) to increase the effectiveness of the ongoing field activities. Following the completion of the field activities, Radian will compile and evaluate all new data and integrate new data with data acquired previously. The approach to the acquisition and evaluation of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) data is discussed below.

The acquisition and evaluation of data is time-dependent and will occur in a staged fashion. Mud rotary drilling will occur initially; air rotary casing drive drilling will follow.

Mud rotary drilling rigs will be used at 19 proposed well clusters to drill 18 pilot holes and drill and construct one monitoring well. The mud rotary drilling method will allow geophysical surveys to be conducted at 19 different locations. Five borings will be continuously cored. The method by which the monitoring wells are drilled as presented in Table 5-2.

The geophysical and lithologic core and cuttings logs obtained during the drilling of wells by both the mud-rotary and air rotary casing drive methods will be compared to lithologic and geophysical logs for existing wells. Geologic logs based on classification of lithologic samples will augment the geophysical logs to provide a more complete understanding of the hydrologic regime at McClellan AFB.

5.2.2.2.2 Evaluation of Hydrologic Data

A variety of hydrologic data will be collected during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). These include static water-level data, aquifer test data, and groundwater-level data from on-base production wells and nearby monitoring wells. The following subsections discuss the methods to be used to analyze the data collected during the field-related tasks.

Potentiometric Surface Maps

A total of 51 new monitoring wells may be installed during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). Static water levels will be measured in these new wells and in the existing wells included in the McClellan AFB Groundwater Monitoring Network within a two day period. Measurements of all monitoring wells in any area will be completed within 8 hours to provide uniformity in water-level conditions. Potentiometric surface maps will be prepared for individual zones identified from the evaluation of pre-existing data and interpretation based on new lithologic and geophysical logs. Groundwater flow directions and horizontal and vertical hydraulic gradients will be determined from the hydraulic head data.

Aquifer Tests

Single- and multiple-well aquifer tests will be conducted as part of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). The aquifer tests will be conducted as described in Section 5.2.1.6. The multiple-well tests will be conducted at the Phase II, Stage 2-3, aquifer test site and in Area C to determine vertical conductivity of the fine-grained layers above and below the middle monitoring zone and the fine-grained layer at approximately 250 feet bgs. There will be 40 single-well tests conducted primarily using monitoring wells to be installed as part of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). Many of the single-well tests will be conducted in the east and southeast areas of the base where little or no such data are available. These 40 single-well tests will be used to characterize the hydraulic properties of the more permeable zones around these wells.

Multiple-Well Aquifer Test--The aquifer system beneath McClellan AFB, as observed in previous aquifer tests, is composed of multiple zones of saturation that are "leaky." Analysis of previous aquifer tests conducted at McClellan AFB have used the "r/B solution" by Hantush and Jacob (1946) that relies on drawdown as measured in the pumped aquifer and that assumes that the quantity of water released from storage in the aquitards is negligible. This analytical method can be used under certain conditions to account for leakage from either an overlying or underlying waterbearing zone, but not from both (i.e., the zone being pumped is bounded on one side by an impervious layer). Therefore, the r/B method cannot be used to quantify hydraulic conductivity of aquitards when leakage occurs from both above and below the pumped aquifer.

The method to be used for the multiple-well aquifer test is the "ratio method" developed by Neuman and Witherspoon (1972), which requires measurement of head changes in the aquifers and the aquitards to determine hydraulic diffusivity (a') of the aquitards above and below the pumped aquifer. The hydraulic diffusivity is equal to the hdyraulic conductivity divided by specific storage (K/S_s). The ratio method is applicable to multiple aquifer systems and to aquifers that may be confined or unconfined. The ratio method relies on early time data, as determined by in-field measurements of water levels in the unpumped aquifers and adjacent confining zones.

The analytical procedure for the ratio method requires calculating the ratio of the drawdown in the aquitard (s') to the drawdown in the pumped aquifer (s) at a specific time (t). A dimensionless time factor (t_D) is calculated from the equation:

$$t_D = Tt/Sr^2$$

where:

T = Transmissivity,

t = Time,

S = Storativity, and

r = Radial distance from the observation well to the pumping well.

These values are used in conjunction with a series of established curves to determine another dimensionless time factor (t_D'). The hydraulic diffusivity, a', of the aquitard is calculated from the equation:

$$a' = (z^2/t)t_D'$$

where:

z = Distance from the middle of the observation well screen to the aquifer-aquitard interface,

S_s' = Specific storage coefficient of the aquitard, and

t_D' = Dimensionless time factor.

The vertical hydraulic conductivity is then calculated from the relationship $a' = K'/S's$. The specific storage is determined from laboratory consolidation tests. A more reliable but much more technically complicated method, borehole extensometers, can also be used to determine S's directly in the field. However, the laboratory consolidation test is an acceptable method of determining specific storage (Neuman and Witherspoon, 1972).

Single-Well Tests--Single-well tests in which monitoring wells will be pumped while drawdown and elapsed time are recorded will be conducted in 40 monitoring wells. Data from these pumping tests will be analyzed using the Papadopulos-Cooper (1967) method (see Kruseman and Ridder, 1983). This method is useful for conditions in which well storage cannot be neglected.

The Papadopulos-Cooper method involves plotting drawdown data versus time on double logarithmic scales and matching data with type curves. Values obtained from the type curve are then used to calculate transmissivity. Transmissivity values determined from single-well tests represent only a limited portion of the aquifer material. Therefore, many single-well tests will be conducted to characterize the range of transmissivity values in an area. Single-well tests are advantageous in areas where large-scale multiple-well aquifer tests cannot be conducted due to a lack of observation wells. Data can be collected in a short time and provide estimates of aquifer characteristics.

Hydraulic conductivity will be determined from the calculated transmissivity value by the equation:

$$K = T/b$$

where:

K = Hydraulic conductivity,
T = Transmissivity, and
b = Thickness of the waterbearing zone being pumped.

Hydraulic Effects of Water Supply Wells--The effect of pumping schedules and rates of four on-base water supply wells will be evaluated using pumping schedules and rates of the water supply wells, and water-level data from the pumped well and nearby monitoring wells. The purpose of this evaluation is to determine how pumping of these wells affects gradients and groundwater flow directions. More specifically this evaluation will examine the zone of influence around each water supply, the magnitude of the induced vertical and horizontal gradients, and the rate at which gradients change when pump are turned on and off. This information will be used to qualitatively assess the effects of water supply pumping on groundwater flow and, thus, potential contaminant movement.

As described in Section 5.2.1.6, each water supply well and selected nearby monitoring wells will be equipped with transducers connected to an automated data logger. Water levels in the wells will be monitored over a 72-hour period, and the data stored in the data logger memory. The frequency at which water levels are monitored will be determined after an initial review of pumping schedules.

Time versus water-level data (hydrographs) will be qualitatively evaluated to determine the hydrologic effects of the production wells. Data from each water supply well and the surrounding monitoring wells will be plotted on the same graph, to illustrate the magnitude and lag of hydraulic response in the monitored zone as the water supply well goes on and off line. These data cannot be used to determine aquifer parameters because each production well is screened over several monitoring zones and hydraulic response is monitored in one specific zone. Thus, the discharge component necessary to calculate transmissivity for each individual waterbearing unit cannot be determined because of the extensive screen interval of the pumped well.

5.2.2.3 Demographic Survey

A demographic survey will not be conducted during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.2.4 Evaluation and Screening of Data

All physical data collected during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) will be subjected to a quality assurance evaluation. Data will be screened for completeness, accuracy, precision, and comparability, to the extent possible, and the methods used to collect the data will be evaluated to determine their conformance to the QAPP requirements. The Supervising Hydrogeologist will screen and evaluate all data. Data will be evaluated as the field program progresses so that there will be maximum opportunity to correct any deficiencies that may become evident. Groundwater analytical data collected during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) will undergo data reduction, validation, and reporting as specified by quality assurance procedures in the McClellan AFB Draft QAPP (Radian, October 1988).

5.2.2.5 Endangerment Assessment

An endangerment assessment will not be conducted during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.2.6 Map and Cross Section Preparation

Maps will be presented as part of the report that will be prepared at the conclusion of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment). In general, the following types of maps will be prepared to more clearly present the results of the Hydrogeologic Assessment:

- McClellan AFB features and boundaries;
- Locations for all monitoring wells and aquifer tests conducted;
- Potentiometric surface maps for various waterbearing zones; and
- Cross sections will be constructed to present hydrogeologic interpretations based on all available lithologic and geophysical data. Contaminant concentrations will be included where appropriate on cross sections.

Other methods of data presentation will be considered during the preparation of the Preliminary Groundwater Operable Unit RI (Hydrogeologic

Assessment) Report. For example, contaminant concentration isopleth maps, fence diagrams, isopachous maps, and two-dimensional representation of three-dimensional relationships will be prepared for the report if data are sufficient for interpretation and presentation.

5.2.2.7 Treatability Studies

Treatability studies will not be conducted during the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

5.2.2.8 IRP Reports

As part of the data evaluation process for the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment), consideration will be given to all hydrogeologic information presented in existing IRP reports. The primary objectives of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) are to characterize hydrogeologic conditions and groundwater contamination, especially in those areas where little or no work has been conducted. As such, the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) activities will utilize existing data to supplement current knowledge about conditions across the study area.

The following IRP contractors have published reports that will be available for use during the evaluation and interpretation of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) data:

- Radian Corporation;
- EG&G Idaho, Inc.;
- McLaren Environmental Engineering;
- Engineering-Science, Inc.;
- CH2M Hill;
- Luhdorf and Scalmanini; and
- Papadopulos & Associates.

5.3 Site-Specific Discussion

Individual waste sites will not be investigated as part of the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment).

6.0 REPORTING REQUIREMENTS

After completion of the field activities for this sampling and analysis plan, a report will be written to compile and summarize data and to present conclusions based on the interpretation of those data.

6.1 Remedial Investigation/Feasibility Study (RI/FS) Reports

A technical report describing all findings from the Preliminary Groundwater Operable Unit RI (Hydrogeologic Assessment) will be prepared. Information on hydrogeologic conditions and contaminant distribution produced in the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) will be used in feasibility studies. A proposed outline for the technical report is presented in Table 6-1.

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TABLE 6-1. PROPOSED OUTLINE FOR THE HYDROGEOLOGIC ASSESSMENT REPORT

Report Cover

Title Page

Disclaimer

Report Documentation Page (DD Form 1473)

Preface

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3.0 FIELD INVESTIGATION PROGRAM

4.0 RESULTS AND SIGNIFICANCE OF FINDINGS

5.0 ALTERNATIVE REMEDIAL MEASURES

6.0 RECOMMENDATIONS

BIBLIOGRAPHY (including list of scientific references and personal communications)

APPENDICES:

A. Glossary of Definitions, Nomenclature, and Units of Measurement

B. Copy of the Task Descriptions/Statement of Work (SOW)

C. Raw Field Data

D. Chain-of-Custody Forms

E. Analytical data for groundwater samples and soil cuttings including internal quality control data such as lab blanks, spikes, and lab duplicates

F. Any correspondence with federal, state, and/or local governmental agencies

G. Data from related or previous IRP investigations

H. Biographies of Key Personnel

7.0 SCHEDULE

A preliminary schedule for the Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) to be conducted at McClellan Air Force Base (AFB) is presented in Figure 7-1. A final schedule and chart showing significant milestones will be prepared upon final approval of the sampling and analysis plan by the United States Air Force (AF) and regulatory agencies.

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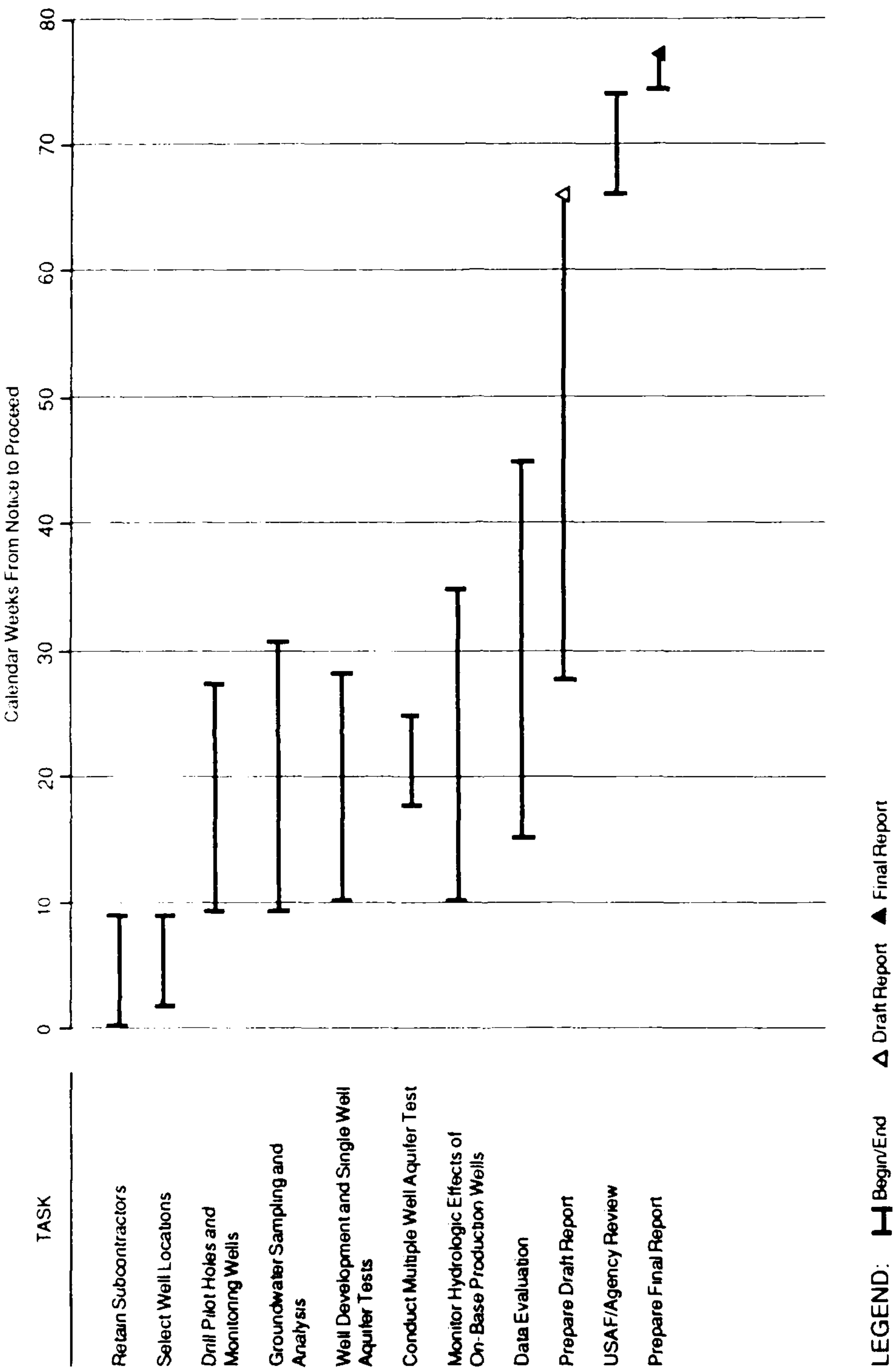

Figure 7-1. Preliminary Schedule for the Preliminary Groundwater Operable Unit Remedial Investigation Report.

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APPENDIX A

Summary of Purgeable Halocarbon Concentrations
Detected in Monitoring Wells From 1980 to 1988, McClellan AFB

TABLE A-1. SUMMARY OF PURGEABLE HALOCARBON CONCENTRATIONS DETECTED IN MONITORING WELLS LOCATED IN AREA A AND ADJACENT ON-BASE AREAS AND THE SOUTHEAST AREA FROM 1981 TO 1988, McCLELLAN AFB

		Compounds (ug/L)								
		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
Wells	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
SHALLOW MONITORING ZONE										
On-Base Monitoring Wells										
MW-8										
12/81		296								
03/82		61								
				<10						
MW-9										
12/81*		4.03								
03/82										
04/82		225	25	20						
09/84				11.5	1.8					
06/85		134		40	0.9		0.4	0.2		
MW-25S										
06/82*		50								
08/82*										
09/84										
05/85		2.4								
(This well is now dry)										

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051088/JKS

RADIAN CORPORATION

TABLE A-1. (Continued)

Monitoring Wells		Compounds (ug/L)								
		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
SHALLOW MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-25D										
06/82*										
08/82		<10		<10						
09/84*										
06/85		2.9							2.6	
MW-26S										
06/82*										
08/82*										
09/84		14		1.1						36
06/85		21.3		3.7		6.5				
(This well is now dry)										
MW-27S										
04/82*										
06/82*										
08/82		15	<10	<10	<10					
09/84		81.2		6.9						
06/85		63.4		18.9						
(This well is now dry)										

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051088/JKS

TABLE A-1. (Continued)

Monitoring Wells		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
		Compounds (ug/L)								
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
SHALLOW MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-39S										
09/82*										
(This well is now dry)										
MW-40S										
09/82		5								
09/84		64.8		10						
06/85		190		13.5						
(This well is now dry)										
MW-46S										
09/82				5						
(This well is now dry)										
MW-49S										
09/82*										

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051088/JKS

TABLE A-1. (Continued)

Monitoring Wells		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
		Compounds (ug/L)								
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
SHALLOW MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-67										
08/85						1.1				
12/85								4.7		
03/86*										
10/86*										
01/87*										
05/87*										
08/87*										
10/87						TR				TR
02/88*										
MW-68										
08/85*										
12/85								5.3		10
05/87*										
08/87*										
10/87*										
02/88*										

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051088/JKS

RADIAN CORPORATION

TABLE A-1. (Continued)

Monitoring Wells		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
		Compounds (ug/L)								
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
Wells	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
SHALLOW MONITORING ZONE (Continued)										
Off-Base Monitoring Wells										
MW-28S										
06/82*										
(This well is now dry.)										
MW-1014										
11/85*										
03/86*										
10/86										TR
01/87*										
04/87*										
08/87*										
10/87*										
02/88										
MW-1037										
10/86										
01/87										
05/87										
08/87										
10/87										

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051088/JKS

TABLE A-1. (Continued)

Monitoring Wells		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
		Compounds (ug/L)								
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
MIDDLE MONITORING ZONE										
On-Base Monitoring Wells										
MW-26D										
04/82*										
08/82*										
09/84*										
06/85		8.7		2.5		2.6	3.8			
(This well is now dry)										
MW-27D										
04/82*										
08/82		<10								
10/84		0.7								58.8
05/85		4.6								
05/87		195	27	15						
08/87		76	14	8.9						
10/87		40	9.6	8.8	26			TR		TR
02/88		55	7.1	11.0	23			0.41		
MW-69										
08/85										
11/86		TR		TR			TR			
01/87										
05/87										
08/87										TR
10/87*										
02/88*										

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

RADIAN CORPORATION

TABLE A-1. (Continued)

Monitoring Wells		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
		Compounds (ug/L)								
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
MIDDLE MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-71										
09/85*										
10/85*										
Off-Base Monitoring Wells										
MW-28D										
06/82*										
08/82		10					<10			
09/84*										
06/85		8.9				2.5	6.5			
05/87*										
08/87*										
10/87*										
02/88*										
MW-103B										
11/86		1.4							TR	
01/87*										
04/87*										
08/87*										
10/87*										
02/88*										

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

040688/JKS
TASK 6/AM

TABLE A-1. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
Wells	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
DEEP MONITORING ZONE										
Off-Base Monitoring Wells										
MW-1039										
11/86*										
01/87*										
04/87*										
08/87*										
10/87*										
02/88*										

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

040688/JKS
TASK 6/AM

TABLE A-2. SUMMARY OF PURGEABLE HALOCARBON CONCENTRATIONS DETECTED IN MONITORING WELLS LOCATED IN AREA B AND ADJACENT ON-BASE AREAS AND THE SOUTHEAST AREA FROM 1981 TO 1988, McCLELLAN AFB

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
SHALLOW MONITORING ZONE											
On-Base Monitoring Wells											
MW-6											
12/81		118									
03/82		24									
10/84		27									
06/85		86.2								35	
MW-7											
12/81		14.4									
03/82		30			26						
09/84		20		8.2		8.4					
05/85		38.2		5.5							
MW-23S											
04/82*											
08/82*											
06/85		2.7									
(This well is now dry.)											

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

032488/JKS
TASK 6/AM

RADIAN CORPORATION

TABLE A-2. (Continued)

Monitoring Wells		Compounds (ug/L)									
		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
Wells	U.S. EPA PMCL:	,5	5	100	NE	NE	7	5	NE	NE	0
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-24S											
04/82*											
08/82*											
06/85*											
(This well is now dry.)											
MW-41S											
09/82		20			10		5				
06/85		23.2			2.3						3.3
03/86		20		1.4							0.6
11/86		44	0.25								
01/87		37		1.0							
04/87		91	0.71	1.8				TR			
08/87		130		1.0							
10/87		110		1.4	17			2.1		2.9	3.2
01/88		190		1.8	18						6.2
MW-42S											
09/82*											
06/85		0.7									
(This well is now dry.)											

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells	Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
SHALLOW MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-43S										
09/82*										
05/85*										
(This well is now dry.)										
MW-47S										
09/82*										
06/85*										
(This well is now dry.)										
MW 65										
08/85	110			4.5						
11/85	77			8.6						
MW-120										
04/86	24		1.2				0.2			
10/86	20		1.9							
01/87	19.3		0.9							
04/87	25		0.77							
08/87	26		0.68							
10/87	9.3		0.5	18						
02/88	10		0.35	10			TR			

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
SHALLOW MONITORING ZONE (Continued)											
Off-Base Monitoring Wells											
MW-1011											
11/85*											
03/86										7.9	
10/86										11	
01/87*											
04/87*											
08/87*											
10/87						TR					
MW-1013											
11/85*											
3/86*											
10/86										230	
01/87*											
04/87*											
08/87*											
10/87*											
02/88*											

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
SHALLOW MONITORING ZONE (Continued)											
Off-Base Monitoring Wells (Continued)											
MW-1016											
*											
11/85*											
03/86											
10/86*				TR							
01/87											
05/87*				0.33							
08/87										TR	
10/87*										TR	
02/88											
MW-1020											
*											
11/85*											
03/86											
10/86*					TR						TR
01/87											
04/87		C.3									
08/87*										TR	
10/87*											
02/88											

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
SHALLOW MONITORING ZONE (Continued)											
Off-Base Monitoring Wells (Continued)											
MW-1021											
11/86		57		TR							2.8
01/87		32								14	
04/87		57								TR	5.6
08/87		46									2.7
10/87		17		TR	1.3						3.3
02/88		11		TR							1.3
MW-1023											
11/86*											
01/87*											
04/87*											
08/87*											
10/87*											
02/88*											
MIDDLE MONITORING ZONE											
On-Base Monitoring Wells											
MW-23D											
04/82*											
08/82*											

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

RADIAN CORPORATION

TABLE A-2. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
Wells	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
MIDDLE MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-23D (Continued)											
09/84*											
06/85										2.5	
03/86										TR	
10/86*											
01/87*											
05/87*											
08/87*											
10/87*											
02/88*											
MW-24D											
04/82*											
08/82*											
06/85*											
03/86*											
09/86*											
01/87*											
05/87*											
08/87*											
10/87*											

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
MIDDLE MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-121											
02/86		0.2									
10/86*											
01/87*											
04/87*											
08/87*											
10/87*											
02/88*											
Off-Base Monitoring Wells											
MW-1000											
12/85*											
03/86*											
10/86		TR			TR						TR
01/87*											
04/87		TR									
08/87		0.86								1.5	
10/87*											
MW-1015											
12/85*											
03/86*											
10/86										17	TR

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
MIDDLE MONITORING ZONE (Continued)											
Off-Base Monitoring Wells (Continued)											
MW-1015 (Continued)											
01/87*											
05/87*											
08/87*											
10/87*											
01/88*											
MW-1022											
11/86		13		0.49							0.54
01/87				0.21							0.57
04/87		20								TR	1.0
08/87		21									0.77
10/87		9.4		TR	4					TR	0.94
02/88		4.8		TR	2					TR	0.36
MW-1024											
11/86*											
01/87*											
04/87										TR	
08/87*											
10/87*											

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
DEEP MONITORING ZONE											
On-Base Monitoring Wells											
MW-63											
08/85		60			29						
09/85		65			26						
04/86		40						0.4			
11/86		24		0.15			TR		0.15		
01/87		41									
05/87		210									
08/87		190									
10/87		52			52						
02/88		69			43		0.76	0.78		3.2	
MW-66											
08/85										12	
11/85*											
MW-122											
02/86*											
11/86*											
01/87*											
05/87*											
08/87*											
10/87*											

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

HGAWP/051188/JKS

TABLE A-2. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0
DEEP MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-132											
11/86		90		0.51			0.33	0.7			
01/87		62			17						
05/87		110			17						
07/87		110			23						
10/87		130			29		TR				
02/88		77		0.9	33		0.48	0.9			
Off-Base Monitoring Wells											
MW-1025											
11/86*											
01/87*											
04/87*											
08/87*											
10/87*											

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

HGAWP/051188/JKS

RADIAN CORPORATION

TABLE A-3. SUMMARY OF PURGEABLE HALOCARBON CONCENTRATIONS DETECTED IN MONITORING WELLS LOCATED IN AREA C FROM 1980 TO 1988, McCLELLAN AFB

Monitoring Wells		Compounds (ug/L)									
		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE											
On-Base Monitoring Wells											
MW-2											
09/80		19					7.8	12			
MW-20S											
04/82*											
05/82*											
06/82*											
08/82*											
09/84						1.2	0.3				
06/85		2.3				3.2					
05/86		3.0					4.7				
10/86						.91	.35			0.4	
MW-21S											
06/82*											
08/82*											
09/84*											
06/85		2.1									
03/86		0.2		0.1					2.2		

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells	TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
	Compounds (ug/L)									
DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-21S (Continued)										
09/86	0.99		0.19						0.12	
01/87*										
05/87*										
08/87	1.9									
10/87	0.4		0.13							
01/88	0.[illegible]		0.16							
MW-22S										
06/82	8									
08/82	16									
09/84	47.3									
05/86	68									
MW-31S										
06/82*										
08/82	10									
06/85*										
03/86			0.1							
10/86			0.12							

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

HGAWP/090888/JKS

RADIAN CORPORATION

TABLE A-3. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-31S (Continued)											
01/87*											
04/87*											
08/87*											
10/87*											
01/88*											
MW-33S											
09/82		2,000		5							
09/84		17,500									
06/85		22,600									
05/86		29,000		45				52			
10/86		25,000		42			2.6	62			2.9
01/87		27,000		45		0.27	4.6	79	1.2	9.8	15
04/87		25,000	0.41			0.49			4.0	8.7	11
07/87		52,000				280					
09/87		20,000	22	42		45	3.5	140	4.6	6.9	5.1
10/87		35,000									
01/88		22,000									

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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RADIAN CORPORATION

TABLE A-3. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-34S											
No samples collected--dry well.											
MW-35S											
No samples collected--dry well.											
MW-36S											
09/82*											
09/84		1.0									
06/85		2.9									
03/86		1.8							12		
09/86		2.2							860	0.15	0.6
01/87*											
04/87		3.7		.42						0.3	
07/87		5.3							2.2		
10/87		1.8		0.20						0.35	
01/88		1.9					0.24				
MW-37											
09/82*											

* = No purgeable halocarbons of interest detected during sampling.

TR = Trace.

Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-44S											
09/82		10					30				
09/84		1.2				1.0					
03/86*											
09/86							.55				
01/87*											
05/87*											
08/87							8.5				
10/87		0.44					3.3				
01/88		0.63					3.3				
MW-45S											
09/82*											
09/84		7.7		1.7			15.5				
06/85		4.1									
MW-60											
05/85*											
09/85		2.3									
05/86		5.0									

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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RADIAN CORPORATION

TABLE A-3. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-60 (Continued)											
10/86*											
01/87*											
04/87*											
08/87*											
10/87*											
01/88*											
MW-61											
06/85*											
09/85*											
10/85		2.6									
03/86		3.1									
12/86		7.4									
01/87		22		0.16							
05/87		23									
08/87		14									
10/87		5.3									
01/88		4.3									

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells		Compounds (ug/L)									
		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-62											
08/85		0.8									
MW-77											
No information available.											
MW-78											
No information available.											
MW-79											
No information available.											
MW-80											
No information available.											
MW-81											
No information available.											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-82											
No information available.											
MW-107											
11/85*											
04/86*											
09/86*											
01/87*											
04/87									0.54		
07/87*											
10/87*											
01/88*											
MW-110											
11/85*									15		
03/86*											
09/86*											
01/87*											
04/87									2.1		
07/87											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

HGAWP/090888/JKS

TABLE A-3. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-110 (Continued)											
10/87*											
01/88*											
MW-111											
11/85*		0.3									
04/86		0.2									
09/86		0.3									
01/87*											
04/87		1.1									
07/87									1.0		
10/87		0.39									
01/88		0.9					0.7	0.12			
MW-114											
11/85*											
02/86*											
10/86		0.21		0.10					13		
01/87*											
04/87*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-114 (Continued)											
08/87*											
10/87									1.3		
01/88*											
MW-128											
12/86		41,000		48			5.7	41			
01/87		28,200									
04/87		55,000		58				63	5.1	23	
08/87		68,000									
09/87		36,000		57			5.5	75	1.1		1.2
10/87		27,000									
01/88		19,000									
MW-131											
11/86		27		0.17							
01/87		19									
04/87		30				0.24					
08/87		120									

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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RADIAN CORPORATION

TABLE A-3. (Continued)

Monitoring Wells	TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
	Compounds (ug/L)									
DOHS Action Levels:	5	5	10	16	200	6	1	40	4	1
U.S. EPA PMCL:	5	5	10	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-131 (Continued)										
10/87	55									
01/88	32		0.30				0.31			
MW-139										
02/88	89		1.1			1.0	1.8			
MIDDLE MONITORING ZONE										
On-Base Monitoring Wells										
MW-20D										
04/82*										
08/82*										
09/84	1.4									
06/85*										
05/86*										
10/86*										
01/87*										
05/87*										
07/87*										

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
MIDDLE MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-20D (Continued)											
10/87*											
01/88*											
MW-21D											
06/82*											
08/82*											
09/84*											
06/85		0.8									
03/86*											
09/86*											
01/87*											
05/87*											
08/87*											
10/87*											
01/88*											
MW-75											
10/85		56									

* = No purgeable halocarbons of interest detected during sampling.

TR = Trace.

Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

		Compounds (ug/L)									
		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
MIDDLE MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-108											
12/85*											
04/86*											
09/86*											
01/87*											
04/87									0.82		
10/87*											
01/88*											
MW-113											
11/86*											
01/87*											
04/87*											
07/87*											
10/87*											
01/88*											
MW-115											
12/85									680		
03/86*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

HGAWP/090888/JKS

TABLE A-3. (Continued)

	Compounds (ug/L)									
	TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
Monitoring Wells — DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
MIDDLE MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-115 (Continued)										
10/86*										
01/87*										
04/87*										
07/87*										
10/87*										
01/88*										
MW-129										
12/86	130									
01/87	10									
04/87	48									
08/87	610									
10/87	45									
01/88	11									
MW-135										
02/88	30		0.96				0.74			

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

HGAWP/090888/JKS

TABLE A-3. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
DEEP MONITORING ZONE											
On-Base Monitoring Zone											
MW-22D											
04/82*											
08/82*											
09/84		2.4				1.8	4.5				
06/85		213				133	297		15.7	13.5	
05/86		15									
10/86*											
01/87*											
05/87*											
08/87*											
10/87*											
01/88*											
MW-109											
11/86*											
01/87*											
04/87*											
07/87									1.3		
10/87*											
01/88*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(continued)

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TABLE A-3. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
DEEP MONITORING ZONE (Continued)											
On-Base Monitoring Zone (Continued)											
MW-112											
12/85									260		
04/86*									12		
09/86*											
01/87*											
04/87											
07/87*									1.4		
10/87*											
01/88											
MW-130											
11/86		2.6				0.97	3.2				
01/87		1.9				0.80	4.0				
04/87		3.2		0.43		1.3	6.1				
07/87		4.0				1.2	8.6		1.1		
10/87		1.2		0.28		0.93	2.5				
01/88		2.0		0.29		0.61	2.9				
MW-133											
02/88*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
DEEP MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-134											
02/88*											
MW-136											
03/88		350									
MW-137											
02/88		350									
MW-138											
03/88*											
MW-140											
02/88		56									
MW-141											
02/88		90					1.2				

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-3. (Continued)

Monitoring Wells		Compounds (ug/L)									
		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
Monitoring	DOMS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2

DEEP MONITORING ZONE (Continued)

On-Base Monitoring Wells (Continued)

MW-142

02/88*

MW-143

02/88*

EW-144

No information available.

* = No purgeable halocarbons of interest detected during sampling.

TR = Trace.

Und. = Undetermined.

RADIAN CORPORATION

TABLE A-4. SUMMARY OF VOLATILE ORGANIC COMPOUND CONCENTRATIONS DETECTED IN MONITORING WELLS LOCATED IN AREA D AND ADJACENT ON-BASE AREAS AND THE NORTHWEST AREA FROM 1981 TO 1988, McCLELLAN AFB

Monitoring Wells		Compounds (ug/L)										
		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE	Vinyl Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4	1
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0	2
SHALLOW MONITORING ZONE												
On-Base Monitoring Wells												
MW-10												
12/81		>313										
03/82		140			15		500	17	19			
06/85		826				327	1,500	94.7	118	55.3	64.9	
10/87		910			780		1,100	330	330			810
MW-11												
12/81		10.4										
03/82		2,100		40	180	4,300	19,300		170	3,700	10	20
08/82		5,000		<10	200	12,000	63,000		250			
06/85		11,900				18,100	64,300		3,560	3,140	2,480	
10/87		8,000				10,000	46,000			1,700		
MW-12												
12/81		3,730										
04/82		930					4,200				70	
08/82		160				2,700	2,500				18	
06/85		12,000				520	25,500				1,260	
10/87		4,700				3,200	11,000					

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)										
	DOHS Action Levels:	.5	5	100	16	200	6	1	20	40	4	1
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0	2
SHALLOW MONITORING ZONE (Continued)												
On-Base Monitoring Wells (Continued)												
MW-14												
12/81		14,100										
03/82		5,800		120	130	8,700	4,600		110	3,000		25
08/82		11,000		<10	200	3,400	17,000		100			
06/85		26,600		2,320		22,800	22,600	2,790		11,400		
08/87		350				350	260					
MW-15												
12/81		1.79										
04/82		2,800		20	135	2,200	5,980		225	5,000		
08/82		3,000		40	110	2,500	9,600		200			<10
06/85		18,000				4,100	18,500		1,780	1,790		
10/87		1,000			9.8	180	1,500		15			
MW-88												
01/87*							1.1					
05/87*												
08/87*												
10/87*												
02/88												

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)										
	DOHS Action Levels:	.5	5	100	16	200	6	1	20	40	4	1
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0	2
SHALLOW MONITORING ZONE (Continued)												
On-Base Monitoring Wells (Continued)												
MW-89												
01/87*												
05/87*												
08/87*												
10/87*												
02/88*												
MW-90												
01/87*												
05/87*												
08/87							1.6					
10/87							0.52					
02/88*												
MW-91												
01/87		9.9					14					
04/87		13					14					
07/87		18					8.1					
10/87		8.4					3.3					
02/88*												

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)										
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4	1
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0	2
SHALLOW MONITORING ZONE (Continued)												
On-Base Monitoring Wells (Continued)												
MW-92												
01/87		6.2										
04/87		7.9			TR							
07/87		9.4										
10/87		3.8			0.84							
02/88*												
MW-106												
11/85*												
03/86*												
09/86*												
01/87*												
04/87*												
07/87*												
10/87*												
02/88*												
MW-107												
11/85*												
04/86*												
09/86*												
01/87*												

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)										
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4	1
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0	2
SHALLOW MONITORING ZONE (Continued)												
On-Base Monitoring Wells (Continued)												
MW-107 (Continued)												
04/87*												
07/87										tr		
10/87*												
Off-Base Monitoring Wells												
MW-1002												
11/85		TR					2.4					
04/86		0.9		0.2			1.0					
09/86		1.7		0.33			3.3			TR		
02/87*												
05/87		1.2										
08/87						TR	1.8					
10/87		TR		TR			0.98			TR		
02/88		TR		TR			0.96					
MW-1004												
12/85		14				TR	120		11	TR		
03/86		15		0.2	4.0	3.2	59	0.7	7.3			
09/86		26				1.5	100	1.9	9.2			
01/87		18				1.7	62		8.1	2.3		

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

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(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)										
	DOHS Action Levels:	.5	5	100	16	200	6	1	20	40	4	1
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0	2
SHALLOW MONITORING ZONE (Continued)												
Off-Base Monitoring Wells (Continued)												
MW-1004 (Continued)												
05/87		27					160		8.8	TR		
08/87		24					150		6.3			
10/87		7.2		TR	1.9	1.1	41	TR	2.6			
02/88		3.6			0.54	TR	23	0.4	1.6			
MW-1005												
12/85		100		TR	43	16	160	5	41			
03/86		62		0.2		5.6	99	9.8	15		0.1	
09/86		80		2.8			110	14	26	72	0.32	
01/87		59		0.56		2.6	102	5.7	12	4.4	0.21	
04/87		95				4.3	160	7.9	27	0.42	0.37	
07/87		86				2.3	280		24			
10/87		22			14		79	5.1	7.5	42		
02/88		14			5.1		58	2.2	5.2			
MW-1009												
12/85*												
03/86*												
10/86*												
02/87*												
04/87										TR		

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

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(Continued)

TABLE A-4. (Continued)

Monitoring Wells	TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride	PCE	Vinyl Chloride
	Compounds (ug/L)										
DOHS Action Levels:	5	5	100	16	200	6	1	20	40	4	1
U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE	0	2
SHALLOW MONITORING ZONE (Continued)											
Off-Base Monitoring Wells (Continued)											
MW-1009 (Continued)											
07/87*											
10/87									TR		
02/88*											
MW-1019											
12/85	0.5		0.5						13		
04/86	2.0		0.1	0.1	0.2			0.4	TR		
09/86	1.6		0.58	0.34				0.81	510		
01/87	1.3		0.17					0.59			
04/87	3.7		TR					2.1			
08/87	4.0				0.68			4.0			
10/87	1.5		TR	0.78	TR			1.4			
02/88	1.7		TR	0.53		TR		1.5	TR	0.61	
MW-1029											
11/86	1.2			1.6		TR		6.8			
01/87	0.85							5.3			
04/87	3.0							6.4			
08/87	4.3							6.3	TR		
10/87	1.8		0.71	2.7				2.2			
02/87	1.21		TR	1.8				2.5			

NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
SHALLOW MONITORING ZONE (Continued)											
Off-Base Monitoring Wells (Continued)											
MW-1041											
11/86*		16									
01/87*											
05/87											
10/87*									TR		
02/88											
MIDDLE MONITORING ZONE											
On-Base Monitoring Wells											
MW-52											
11/86*											
01/87*		2.1							0.53		
05/87*											
07/87*											
10/87*											
01/88											
MW-53											
11/86*											
01/87*											
05/87*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
MIDDLE MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-53 (Continued)											
07/87							2.1		1.9		
10/87		3.4				2.9	13			0.27	
01/88		2.7				1.5	11			0.16	
MW-54											
11/86		9.0		1.8		19	430	39		4.1	1,200
01/87		3.9					171	14			1,224
04/87							52				190
08/87							11	0.23			17
10/87		1.8				0.58	22	1.2			40
01/88		1.4					8.5	0.17			5.0
MW-55											
11/86		110				15	210	2.9	320	13	0.34
01/87		70		0.57		41	160	2.9		46	0.34
04/87		51				69	310	0.93		47	
08/87		37				71	130				
10/87		7.0				34	24	0.95		25	
01/88		11				10	33	1.1		6.8	

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
MIDDLE MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-57											
11/86		2.5					2.3				
01/87		14				0.88	13				
04/87*											
07/87							1.6		1.9		
10/87		0.58					1.2				
01/88		2.3					3.6				
MW-70											
01/87*											
05/87*											
08/87		0.79									
10/87							0.27				
01/88							0.25				
MW-72											
05/87		410				5.9	550	28			41
08/87		1,200				43	1,900	140			
10/87		580		3.2		23	520	120			
01/88		870				49	930	140			

* = No purgeable halocarbons of interest detected during sampling.

TR = Trace.

Und. = Undetermined.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/l)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
MIDDLE MONITORING ZONE *(Continued)*											
Off-Base Monitoring Wells											
MW-74											
No data available.											
MW-76											
No data available.											
MW-1003											
12/85*											
03/86			0.2								
10/86							0.16		16		
01/87*											
05/87*											
08/87*											
10/87*											
01/88*											
MW-1010											
04/86									12		
10/86*											
01/87*											
05/87*											
07/87*											
10/87									0.4		
01/88*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
MIDDLE MONITORING ZONE (Continued)											
Off-Base Monitoring Wells (Continued)											
MW-1027											
11/86*											
01/87*											
04/87									1.0		
08/87*											
10/87*											
01/88*											
MW-1030											
11/86*											
01/87*											
04/87*											
08/87*											
10/87*											
01/88*											
MW-1042											
11/86		0.41									
01/87*											
05/87*											
08/87*											
10/87*											
01/88*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		ICE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DONS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
DEEP MONITORING ZONE											
On-Base Monitoring Wells											
MW-51											
11/86*									7.4		
01/87*											
04/87*											
08/87											
10/87*									1.5		
01/88											
MW-58											
11/86		0.62				0.36	1.7				1.3
01/87		1.5				2.4	3.3				
04/87*		1.5				2.3					
08/87*											
10/87											
01/88						0.25	0.27				
MW-59											
04/86		12				1.1	11				
11/86		290		0.85		19	270		520	0.1	
01/87		108				8.1	99				
04/87		40				3.3	50				
08/87		13				1.0	19		0.87		
10/87		6.2					15				
01/88		2.3				0.21	3.1				

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.
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(Continued)

TABLE A-4. (Continued)

Monitoring Wells		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
		Compounds (ug/L)									
	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
DEEP MONITORING ZONE (Continued)											
On-Base Monitoring Wells (Continued)											
MW-104											
12/85*											
03/86*									870		
10/86*											
01/87*											
05/87*											
07/87*											
10/87*											
01/88											
MW-105											
12/85									220		
03/86*									420		
10/86*											
01/87*											
04/87*											
08/87											
10/87*							0.31				
01/88											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-4. (Continued)

		Compounds (ug/L)									
		TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
Monitoring	DONS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
DEEP MONITORING ZONE (Continued)											
Off-Base Monitoring Wells											
MW-1001											
12/85									310		
04/86									18		
10/86*											
01/87*											
05/87									0.69		
08/87*											
10/87*											
01/88*											
MW-1028											
08/87									0.40		
10/87									0.45		
01/88*											
MW-1031											
11/86*											
01/87*											
04/87*											
08/87*											
10/87*											
01/88*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

(Continued)

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TABLE A-4. (Continued)

Monitoring Wells		Compounds (ug/L) TCE	Carbon Tetra-chloride	Chloro-form	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	Methylene Chloride	PCE	Vinyl Chloride
Monitoring	DOHS Action Levels:	5	5	100	16	200	6	1	40	4	1
Wells	U.S. EPA PMCL:	5	5	100	Und.	Und.	7	5	Und.	0	2
DEEP MONITORING ZONE (Continued)											
Off-Base Monitoring Wells (Continued)											
MW-1043											
11/86*											
01/87*											
05/87*											
08/87*											
10/87*											
01/88*											

* = No purgeable halocarbons of interest detected during sampling.
TR = Trace.
Und. = Undetermined.

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TABLE A-5. SUMMARY OF VOLATILE ORGANIC COMPOUND CONCENTRATIONS DETECTED IN MONITORING WELLS LOCATED IN OTHER AREAS (NORTHEAST McCLELLAN AFB) AND THE NORTHEAST AREA FROM 1981 TO 1988, McCLELLAN AFB

Monitoring Wells		Compounds (ug/L)								
		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
SHALLOW MONITORING ZONE										
On-Base Monitoring Wells										
MW-4										
03/82*										
(This well has been selected to be destroyed [abandoned] because the screen length exceeds 20 feet.)										
MW-29S										
04/82*										
08/82		10								
MW-50S										
No sample taken -- dry well										
MW-10I										
11/85*										
03/86*										
09/86*										
01/87*										
04/87*										
08/87*										
10/87*										
02/88										TR

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

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(Continued)

TABLE A-5. (Continued)

Monitoring Wells		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
		Compounds (ug/L)								
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
SHALLOW MONITORING ZONE (Continued)										
On-Base Monitoring Wells (Continued)										
MW-102										
11/85*										
03/86*										
09/86*										TR
01/87*										
04/87										
08/87*										
10/87*										TR
02/88										
Off-Base Monitoring Wells										
MW-1012										
11/85*										
03/86*										
09/86*						0.2				
01/87*										
05/87*										
07/87										
10/87*										
02/88						TR				

NE = Not established.
* No purgeable halocarbons of interest detected from samples collected on this date.

(Continued)

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TABLE A-5. (Continued)

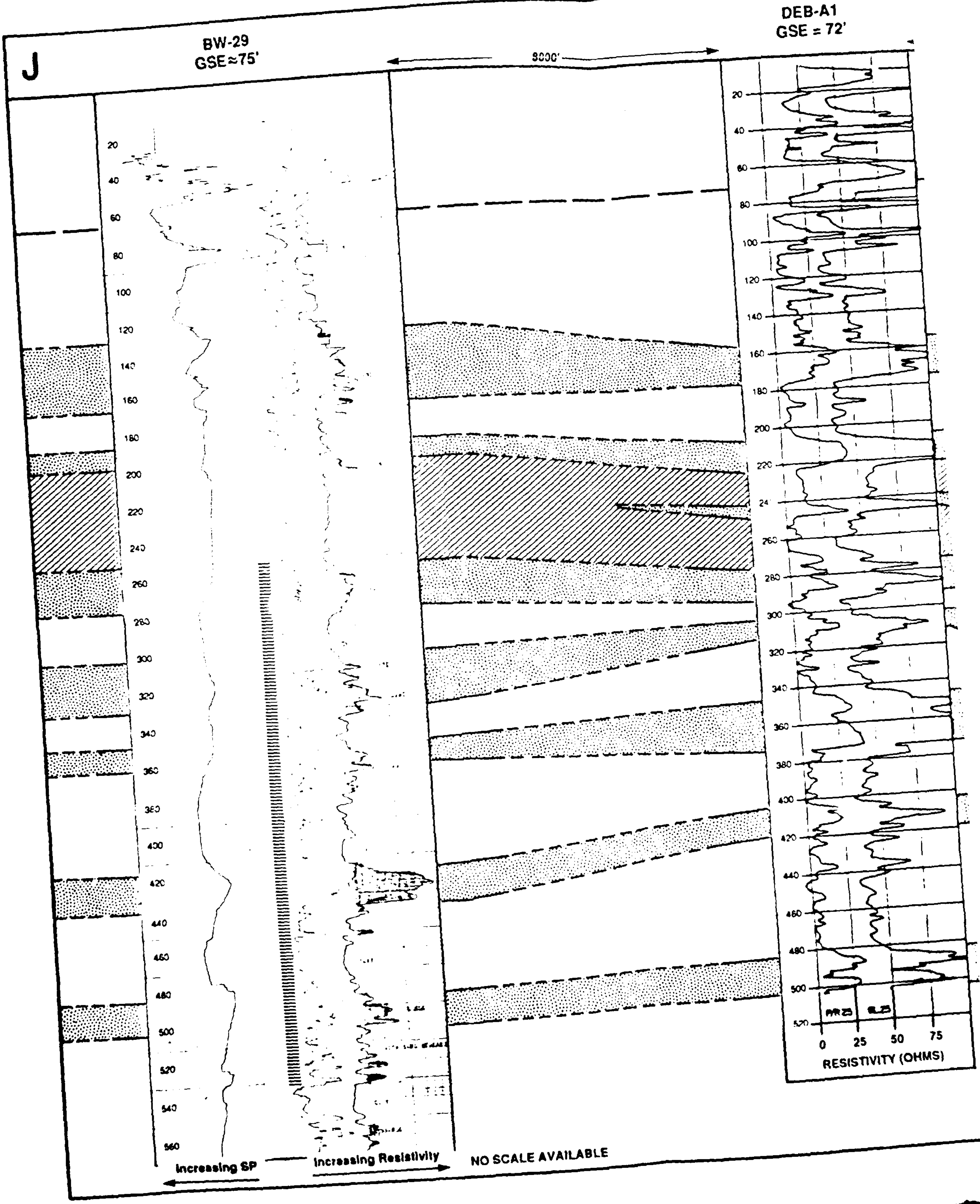
Monitoring Wells		TCE	Carbon Tetrachloride	Chloroform	1,2-DCE	1,1,1-TCA	1,1-DCE	1,2-DCA	1,1-DCA	Methylene Chloride
		Compounds (ug/L)								
	DOHS Action Levels:	5	5	100	16	200	6	1	20	40
	U.S. EPA PMCL:	5	5	100	NE	NE	7	5	NE	NE
MIDDLE MONITORING ZONE										
On-Base Monitoring Wells										
MW-29D										
04/82*										
08/82		10					<10			
06/85*										
04/86										270
10/86*										
01/87*										
04/87*										
08/87*										
10/87*										
02/88*										
MW-10D										
12/85*										
02/86*										
09/86*										
01/87*										
04/87*										
08/87*										
10/87*										
02/88*										

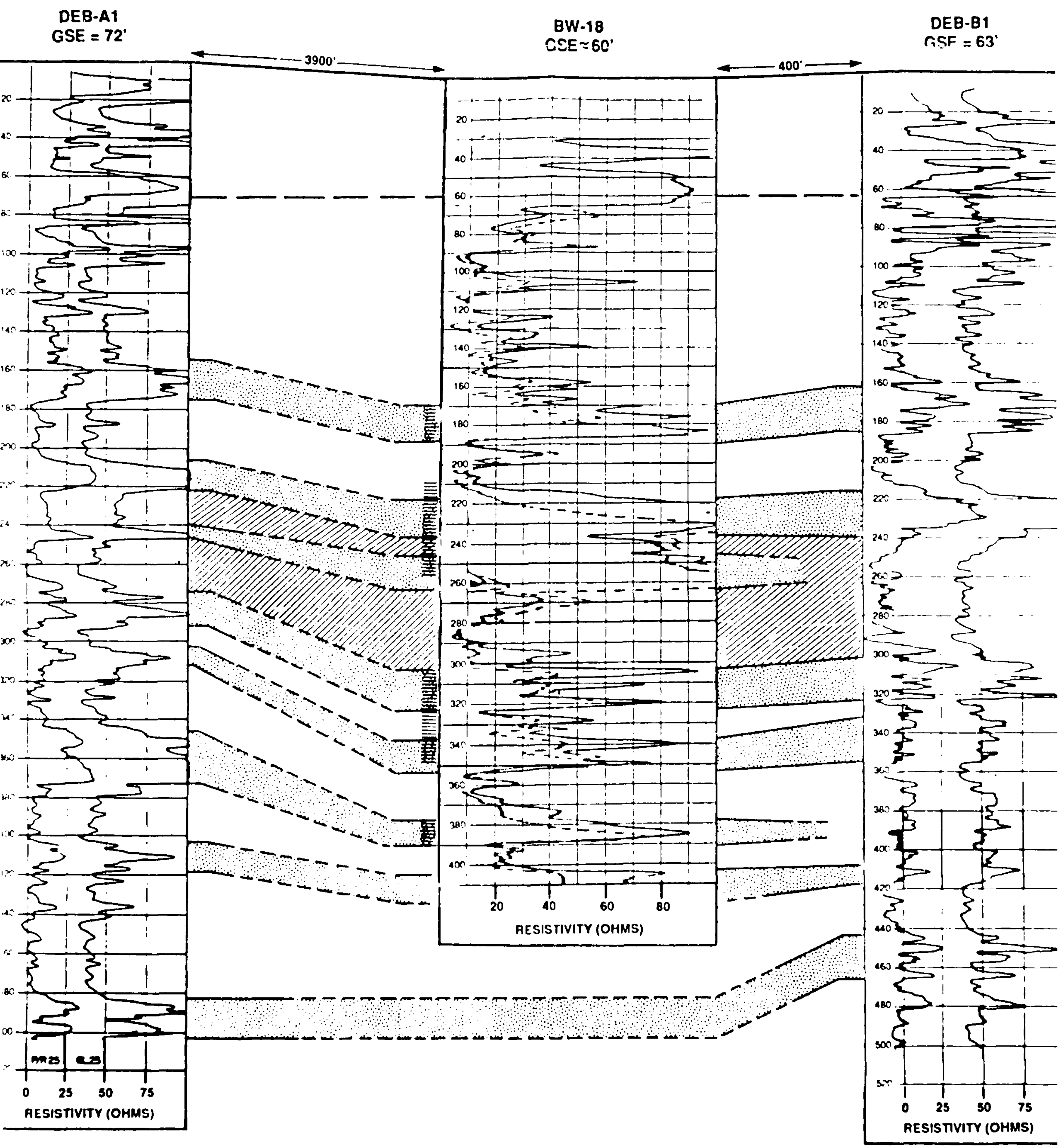
NE = Not established.

* No purgeable halocarbons of interest detected from samples collected on this date.

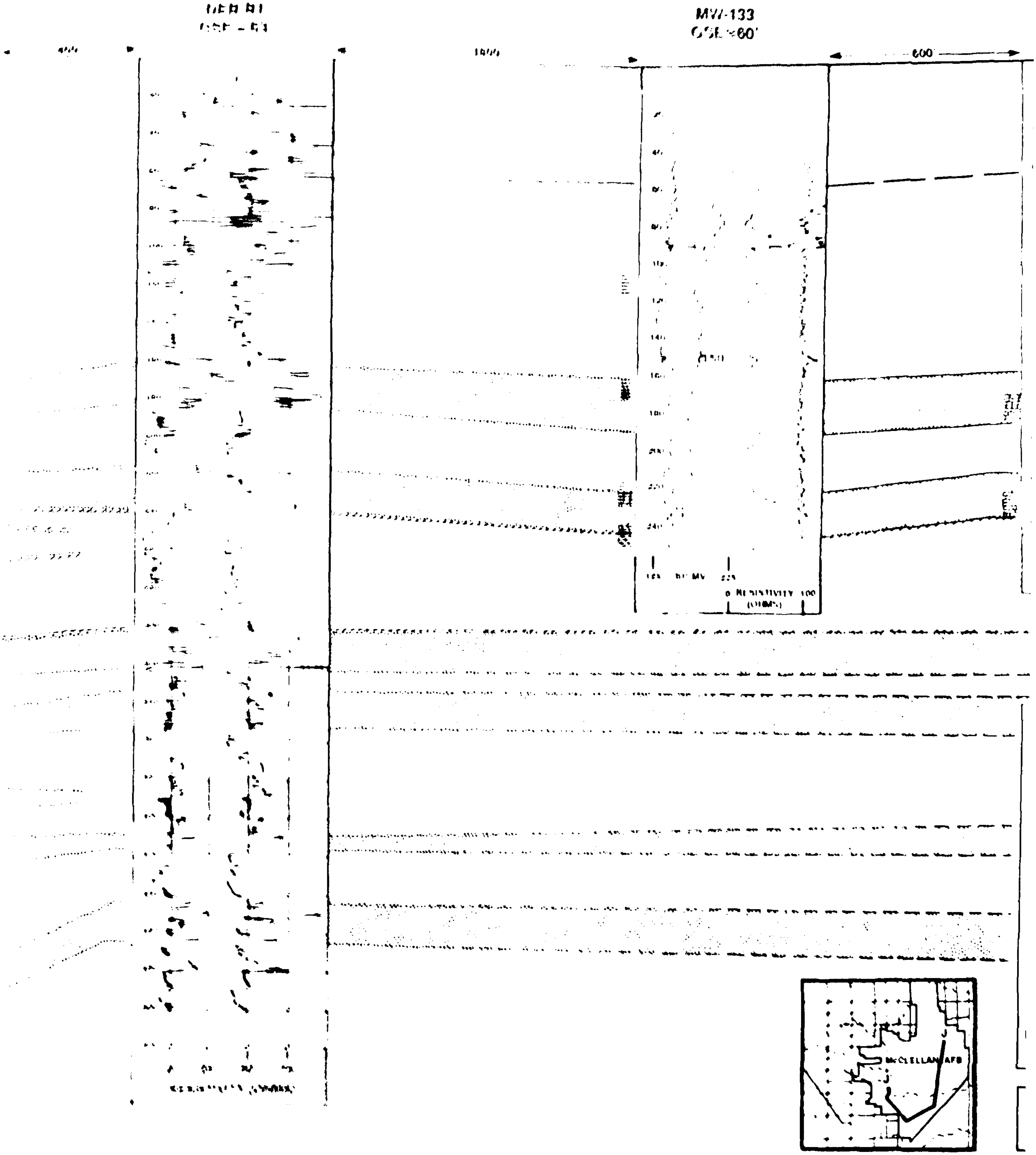
(Continued)

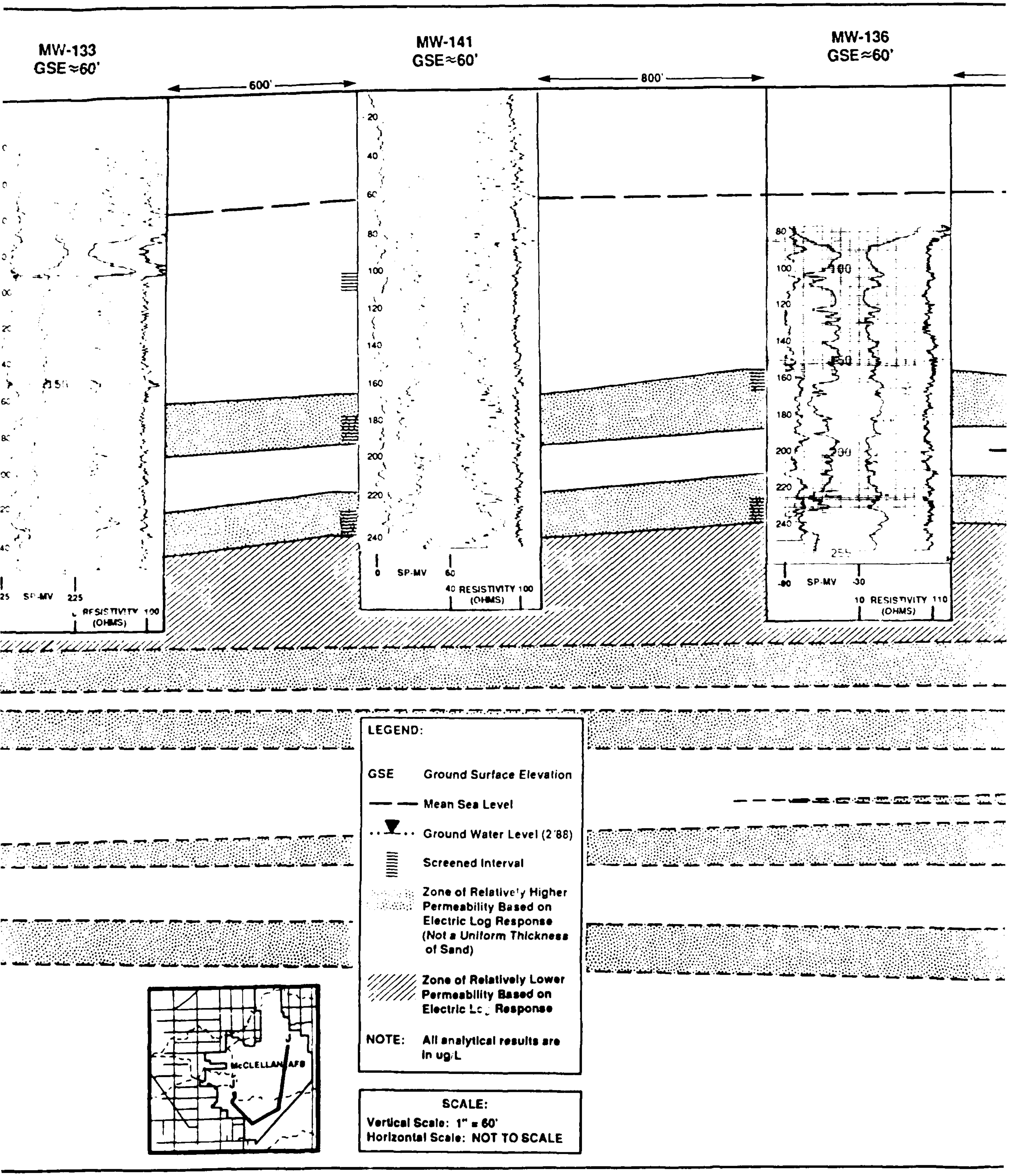
NGAMP/051088/JKS


J
BW-29
GSE≈75'
8000'
DEB-A1
GSE = 72'
Increasing SP
Increasing Resistivity
NO SCALE AVAILABLE
RESISTIVITY (OHMS)
0 25 50 75



DEB-A1
GSE = 72'
BW-18
GSE ≈ 60'
DEB-B1
GSE = 63'
3900'
400'
RESISTIVITY (OHMS)
RESISTIVITY (OHMS)
RESISTIVITY (OHMS)


MW-133
GSE=60'
600
RESISTIVITY
(OHMS)
McCLELLAN AFB



MW-133
GSE≈60'
MW-141
GSE≈60'
MW-136
GSE≈60'
600'
800'
SP-MV
225
RESISTIVITY 100
(OHMS)
0
SP-MV
60
40 RESISTIVITY 100
(OHMS)
-80
SP-MV
-30
10 RESISTIVITY 110
(OHMS)
McCLELLAN AFB
LEGEND:
GSE Ground Surface Elevation
Mean Sea Level
Ground Water Level (2'88)
Screened Interval
Zone of Relatively Higher Permeability Based on Electric Log Response (Not a Uniform Thickness of Sand)
Zone of Relatively Lower Permeability Based on Electric Log Response
NOTE: All analytical results are in ug/L
SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: NOT TO SCALE

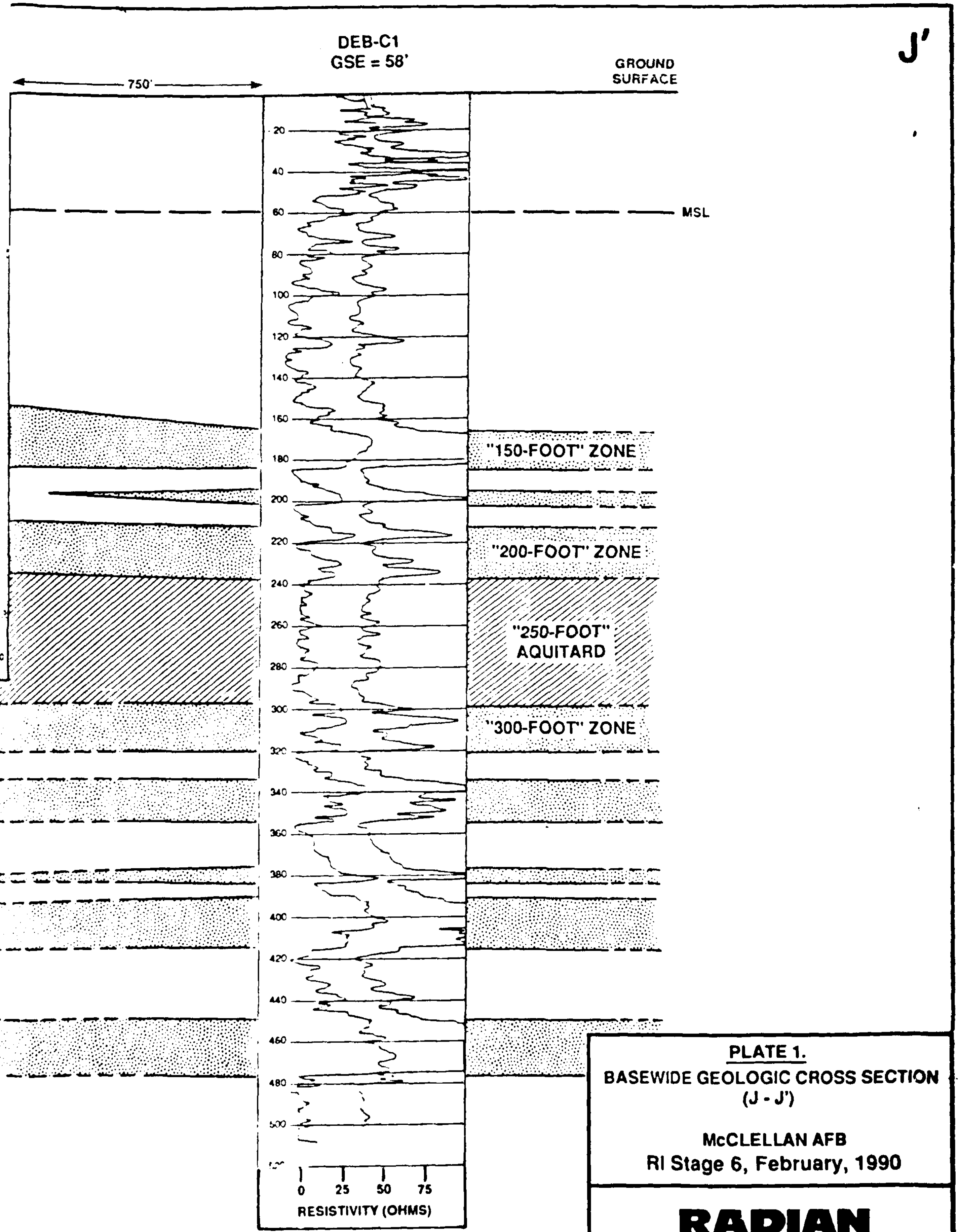


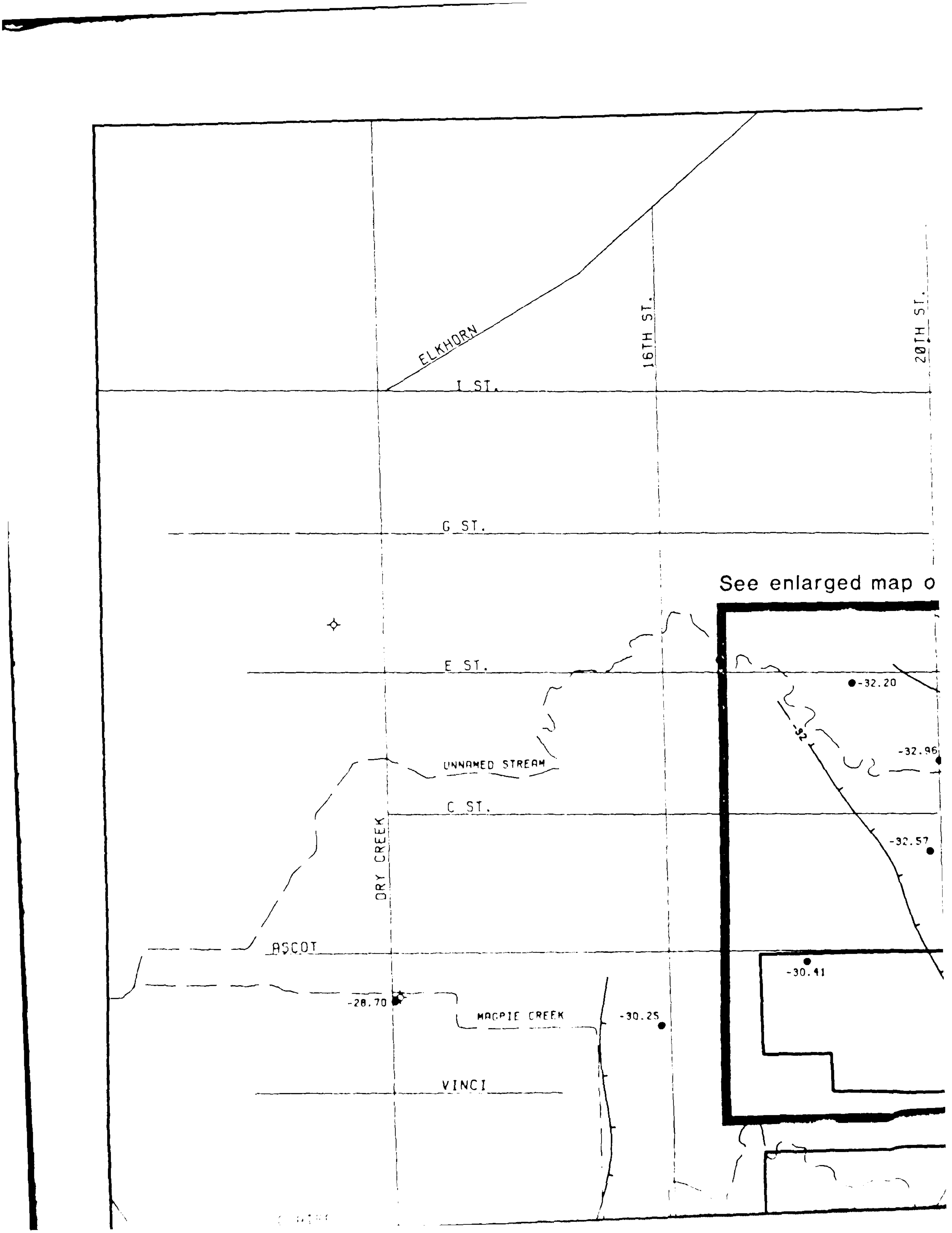
PLATE 1.

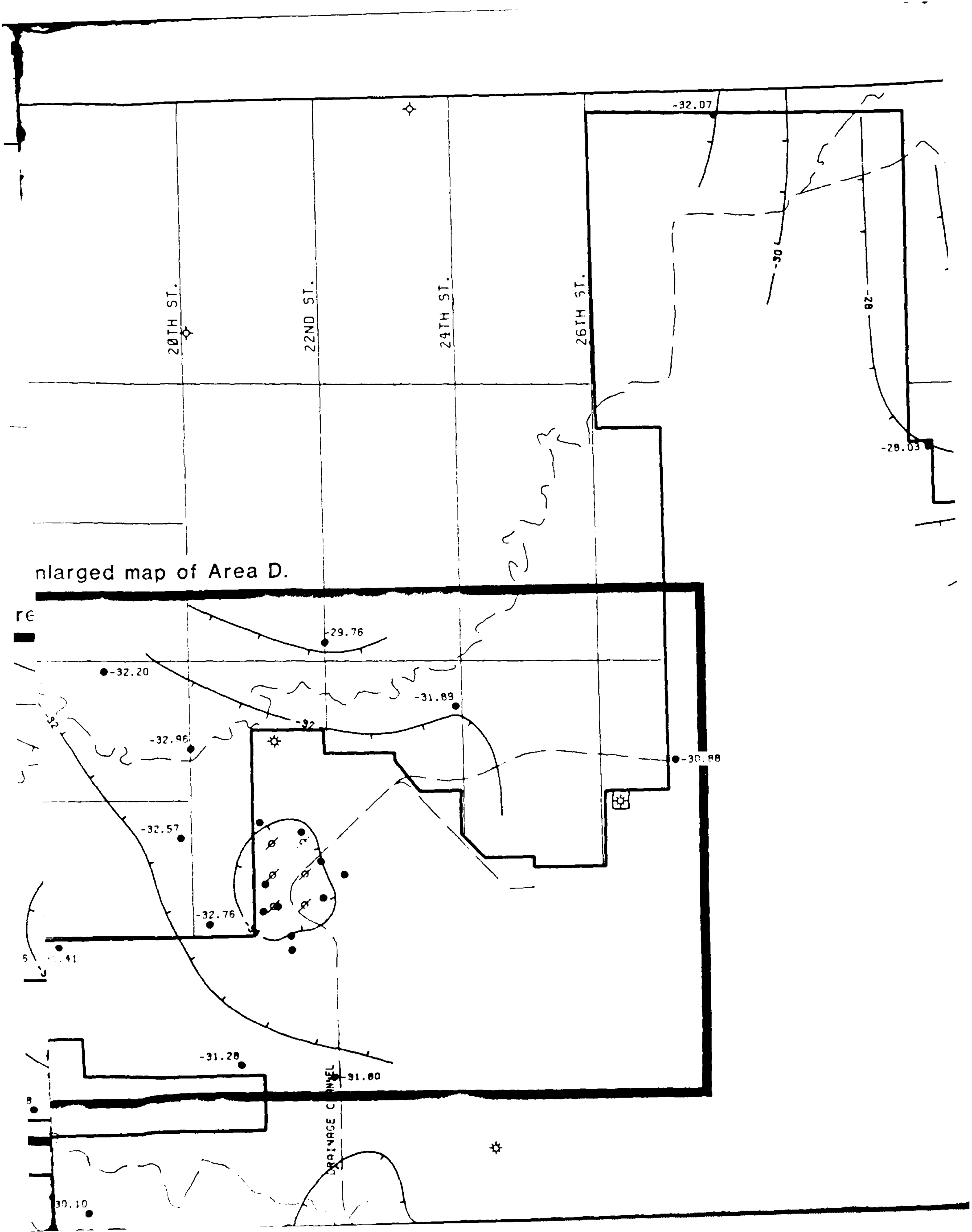
BASEWIDE GEOLOGIC CROSS SECTION (J - J')

McCLELLAN AFB

RI Stage 6, February, 1990

RADIAN CORPORATION


ELKHORN
16TH ST.
20TH ST.
I ST.
G ST.
See enlarged map o
E ST.
-32.20
-32
-32.96
UNNAMED STREAM
C ST.
DRY CREEK
-32.57
ASCOT
-30.41
-28.70
MAGPIE CREEK
-30.25
VINCI


20TH ST.
22ND ST.
24TH ST.
26TH ST.
-32.07
-30
-28
-28.03
nlarged map of Area D.
-29.76
-32.20
-31.89
-32
-32.96
-30.88
-32.57
-32.76
-31.28
-31.80
DRAINAGE CHANNEL
30.10

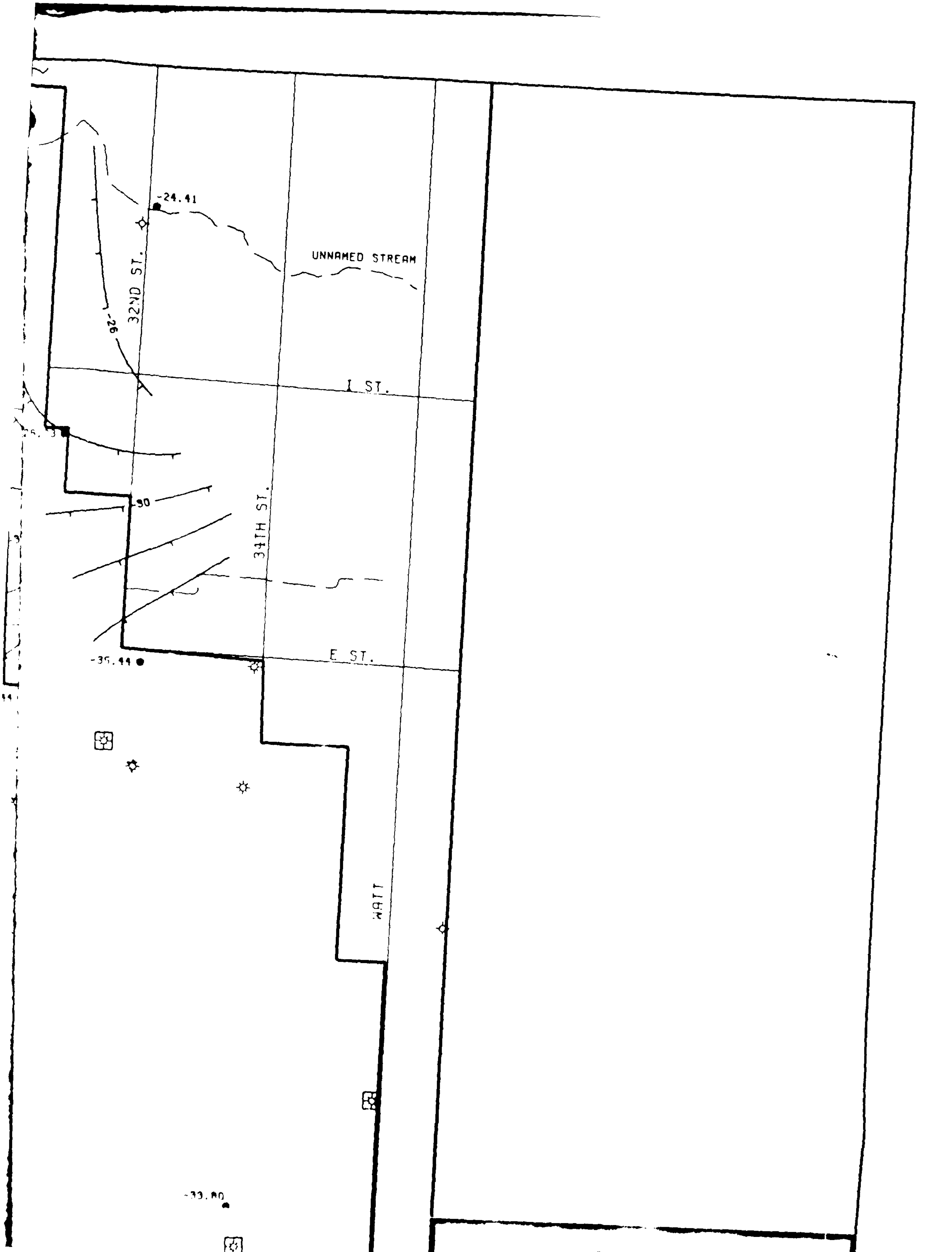
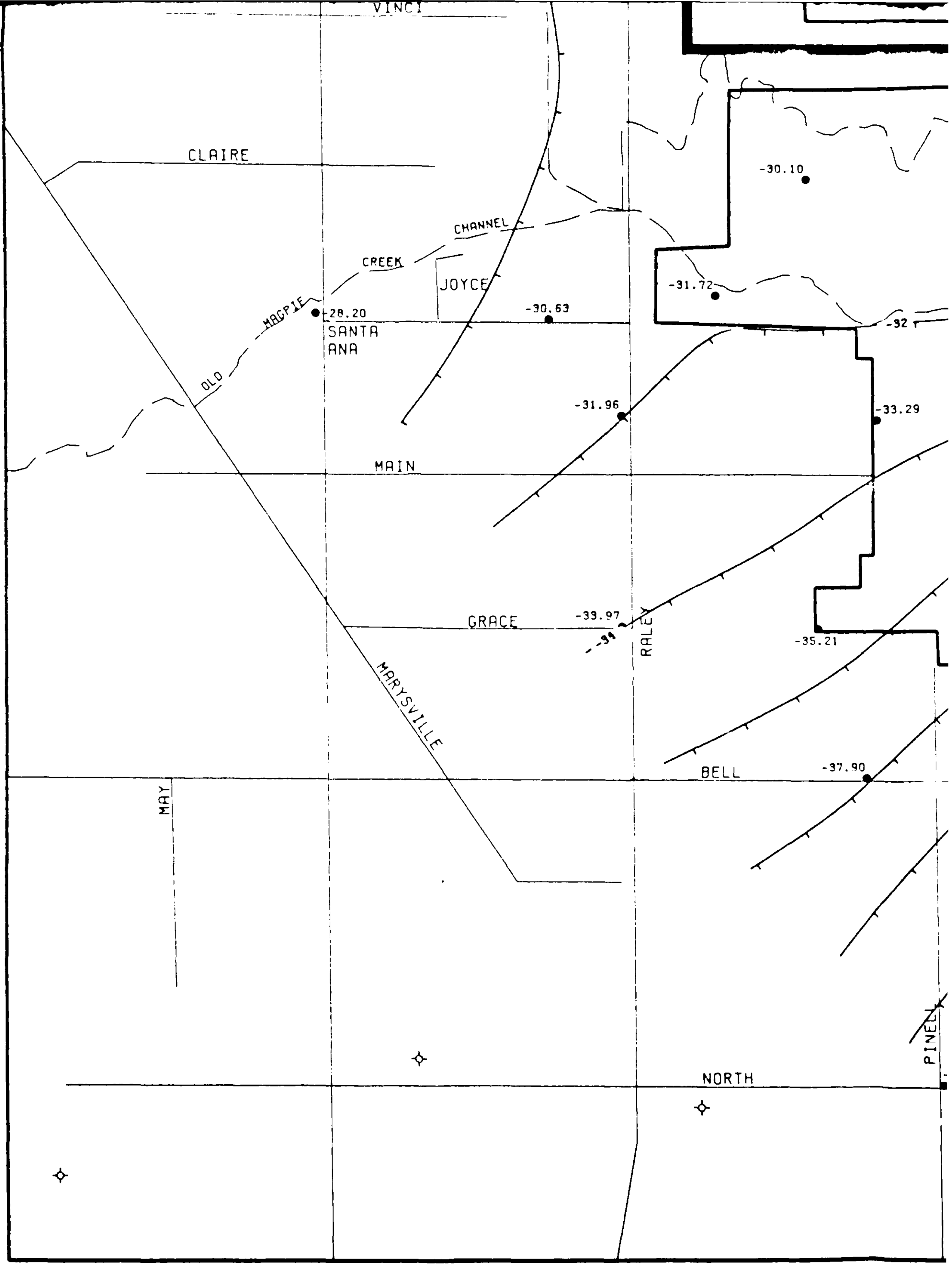
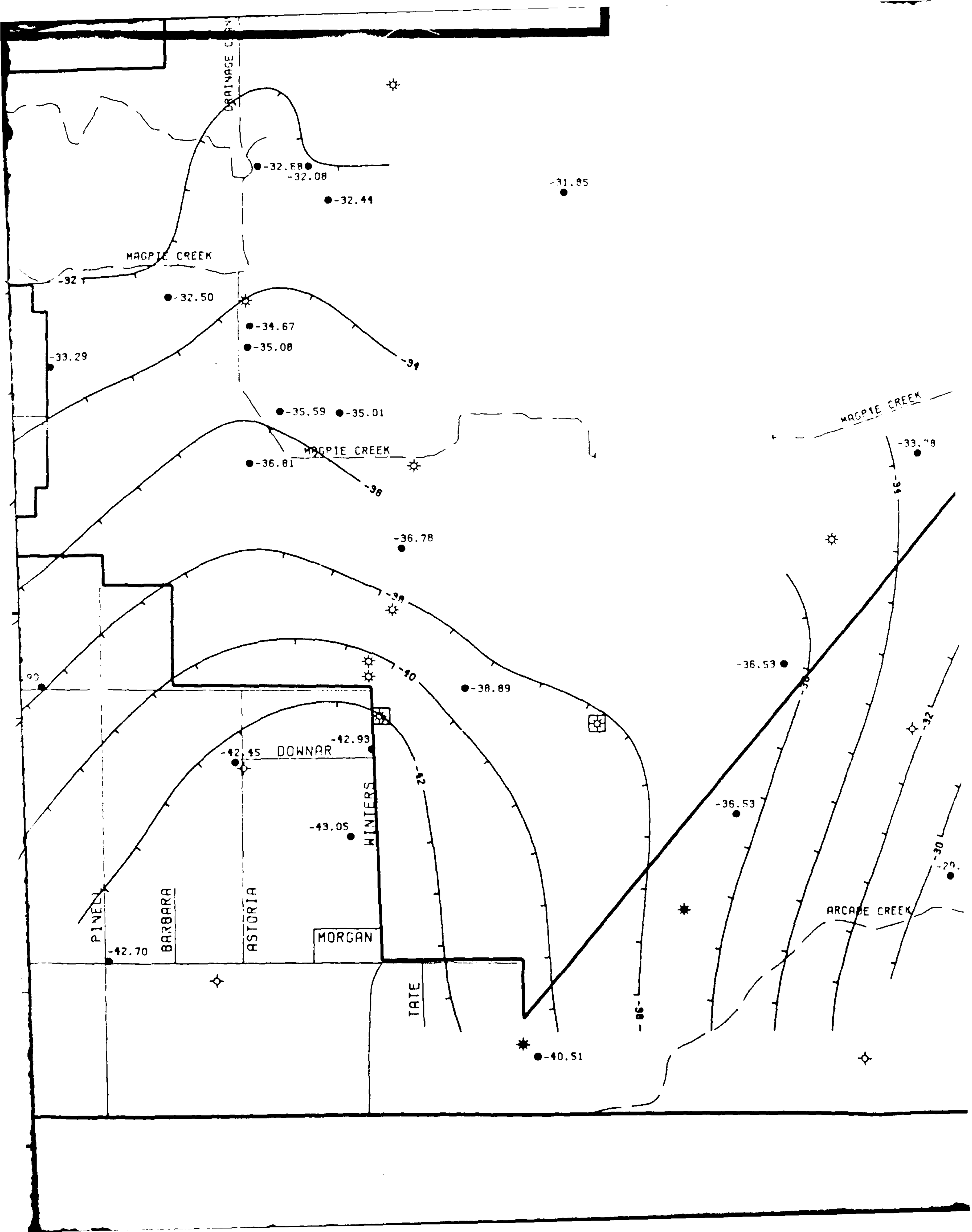


PLATE 2



VINCI
CLAIRE
CHANNEL
CREEK
MAGPIE
OLD
JOYCE
-28.20
SANTA
ANA
-30.63
-30.10
-31.72
-32
-31.96
-33.29
MAIN
GRACE
-33.97
-34
RALEY
-35.21
MARYSVILLE
BELL
-37.90
MAY
PINELL
NORTH



MAGPIE CREEK
-32
-32.68
-32.08
-32.44
-31.85
-32.50
-34.67
-35.08
-33.29
-34
-35.59
-35.01
MAGPIE CREEK
-36.81
-36
-36.78
-38
-40
-38.89
-36.53
-42.93
-42.45
DOWNAR
-42
-43.05
WINTERS
-36.53
-30
-32
BARBARA
ASTORIA
MORGAN
-42.70
TATE
-38
ARCADE CREEK
-40.51

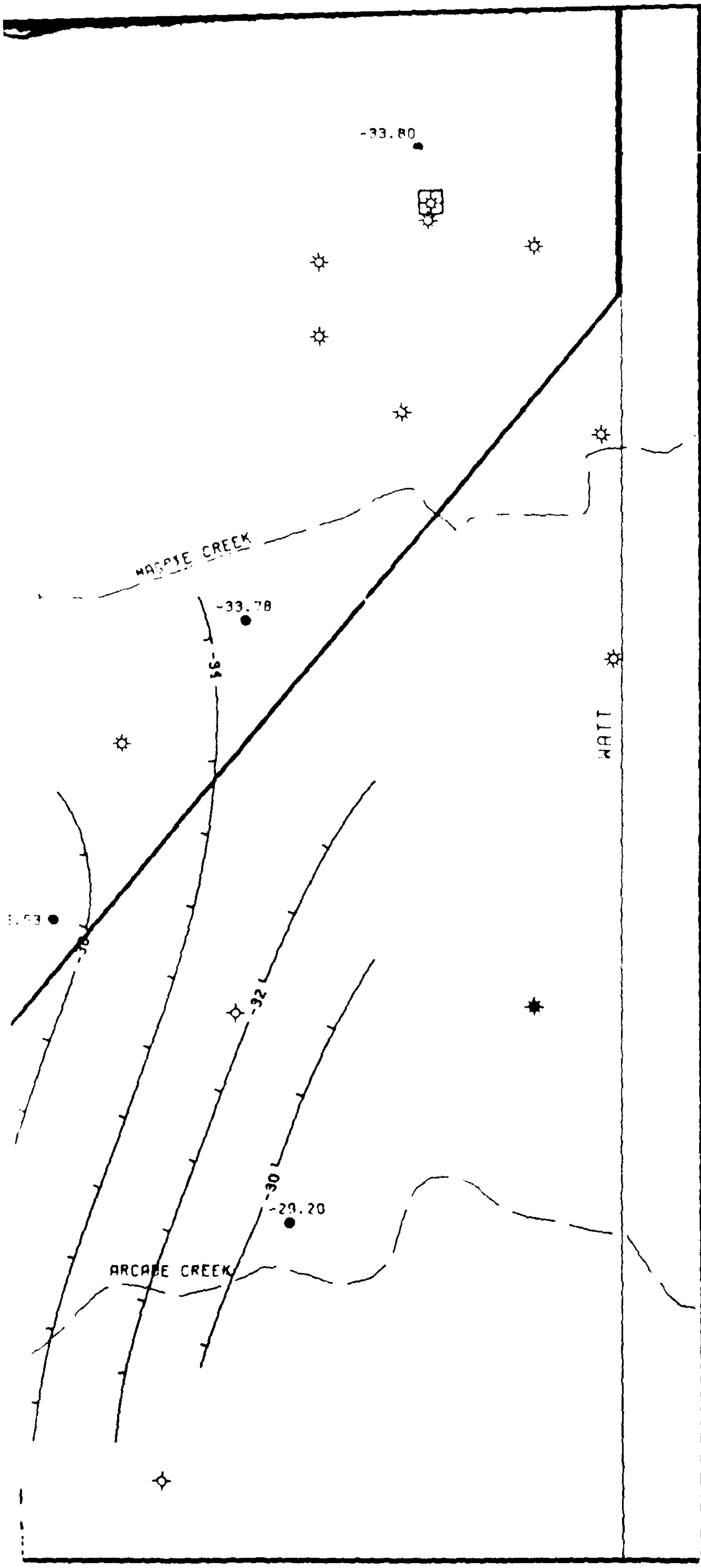


PLATE 2.

SHALLOW MONITORING ZONE POTENTIOMETRIC SURFACE MAP FOR DATA COLLECTED SEPT. 29 - 30, 1988

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

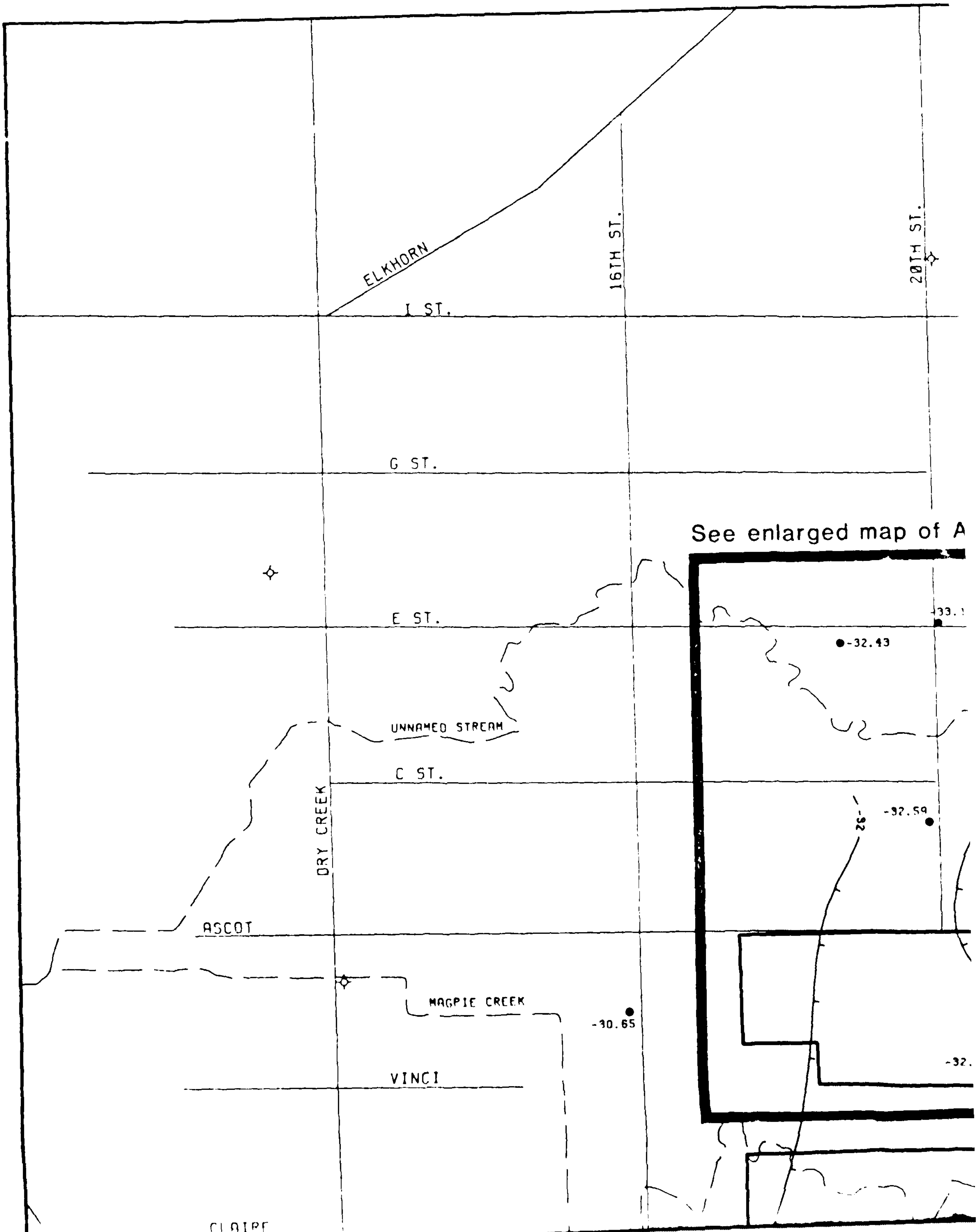
- McCLELLAN AFB BOUNDARY
- STREAMS
- 30 POTENTIOMETRIC CONTOUR LINE AND ELEVATION (FT MSL)
- SHALLOW ZONE MONITORING WELL
- INACTIVE BASE PRODUCTION WELL
- ACTIVE BASE PRODUCTION WELL
- CITY WELL
- CALTRANS WELL
- EXTRACTION WELL

N

0 500 1000
SCALE IN FEET

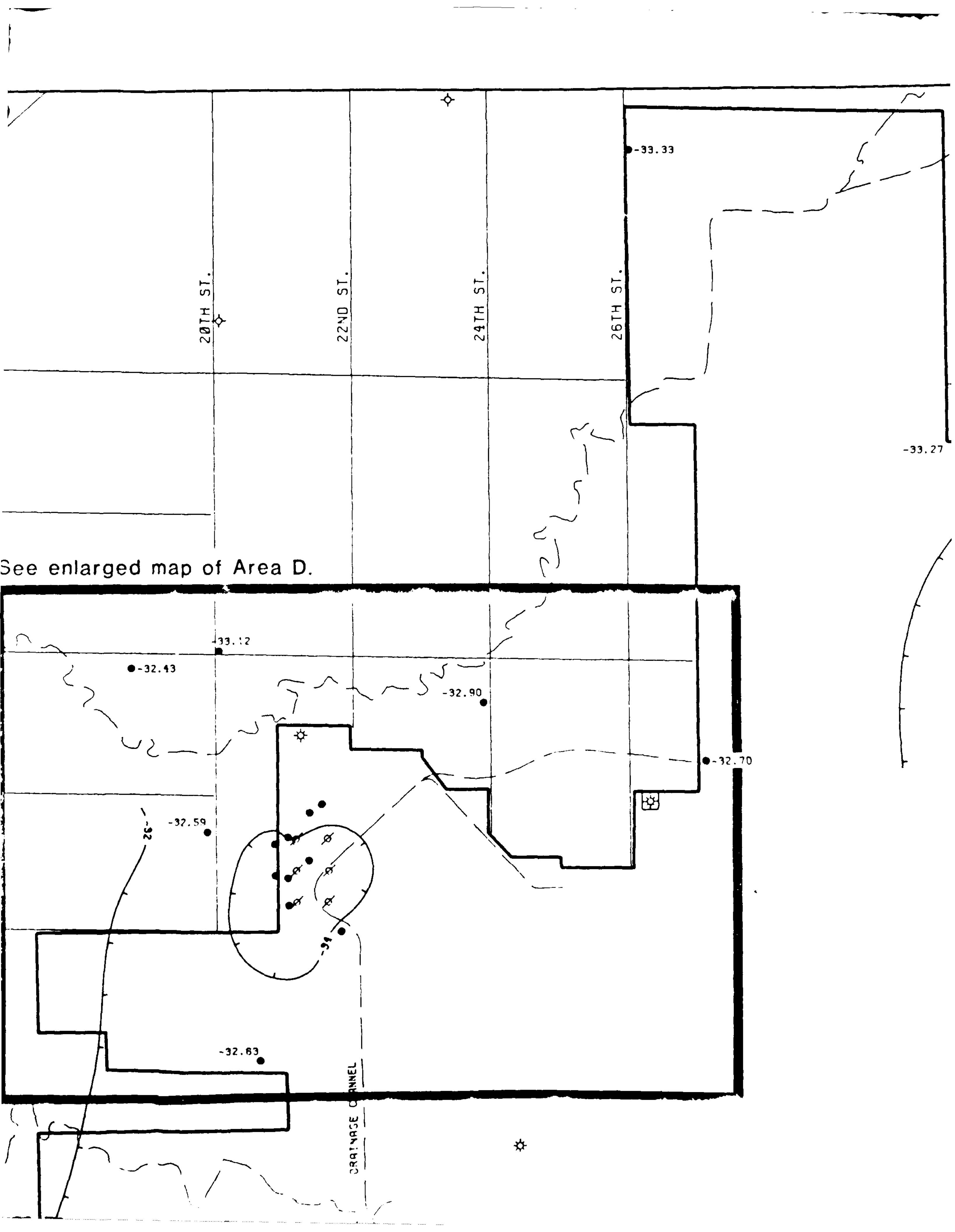
GENERATED BY [signature]	DATE 10-19-88
PEER REVIEW Thomas F. [signature]	DATE 10-19-88
PROJECT REVIEW Deena A Stanley	DATE 10/19/88

RADIAN CORPORATION



ELKHORN
I ST.
16TH ST.
20TH ST.
G ST.
See enlarged map of A
E ST.
-33.
-32.43
UNNAMED STREAM
C ST.
-32.59
-32
DRY CREEK
ASCOT
MAGPIE CREEK
-30.65
VINCI
-32.

See enlarged map of Area D.



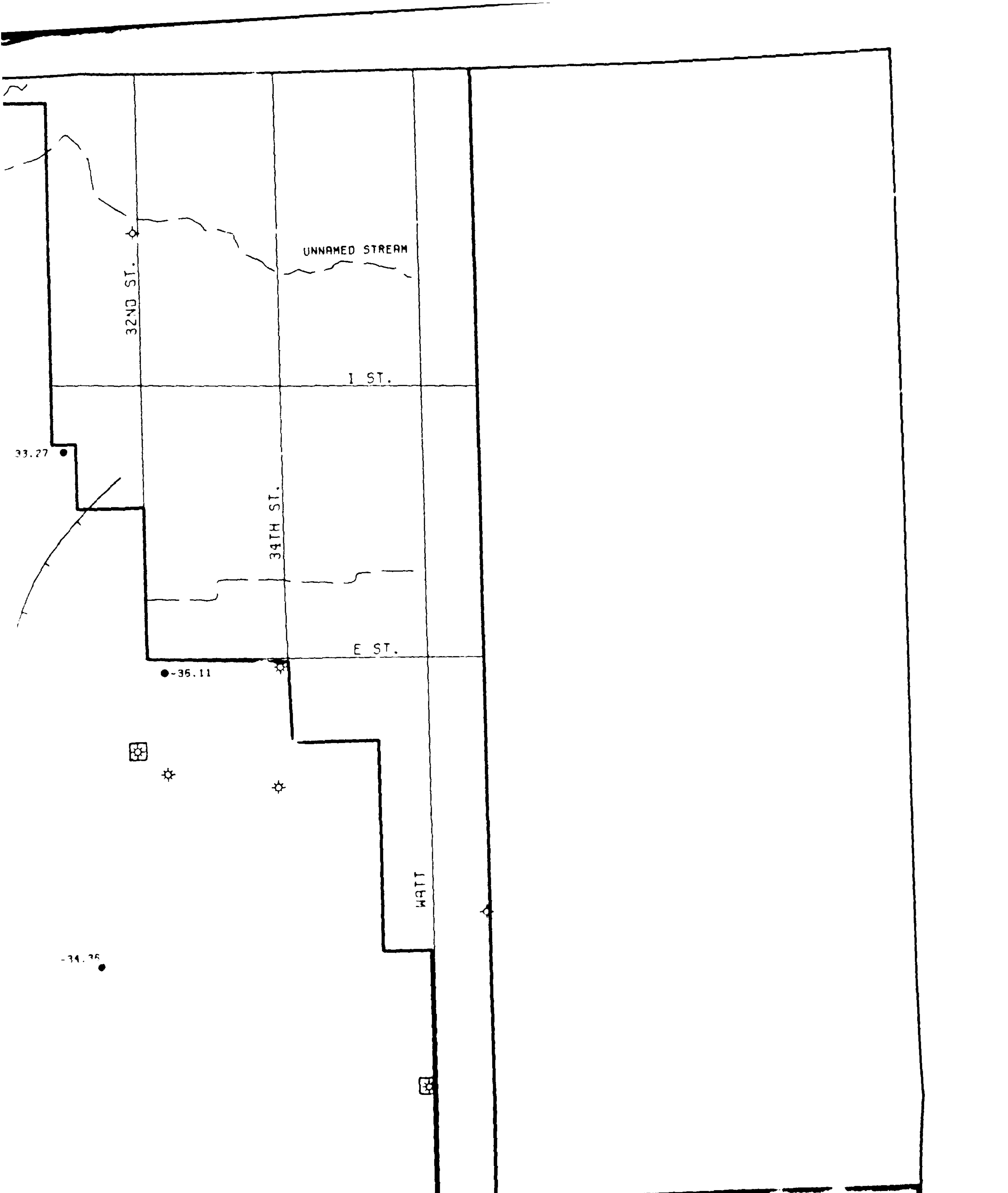
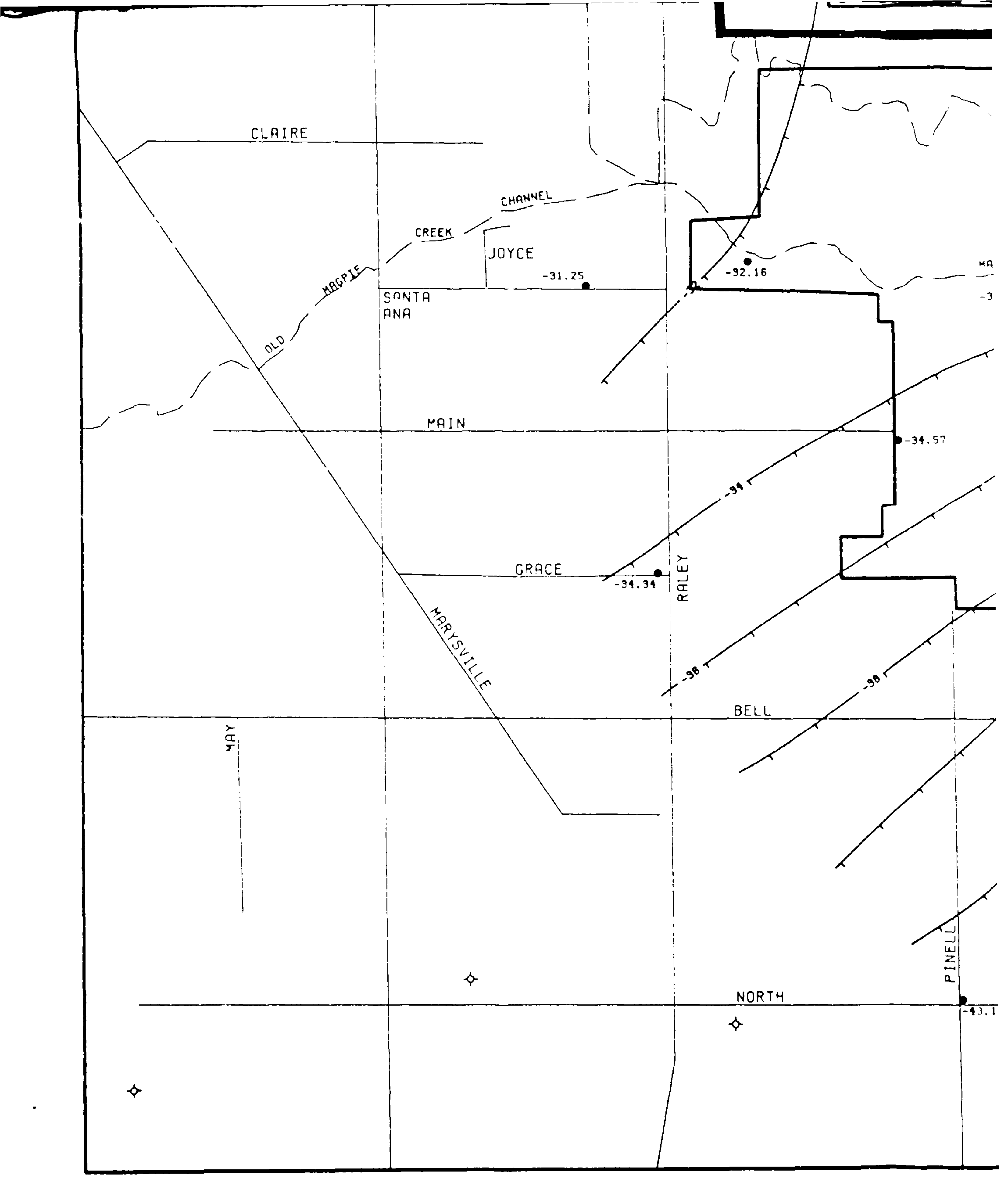
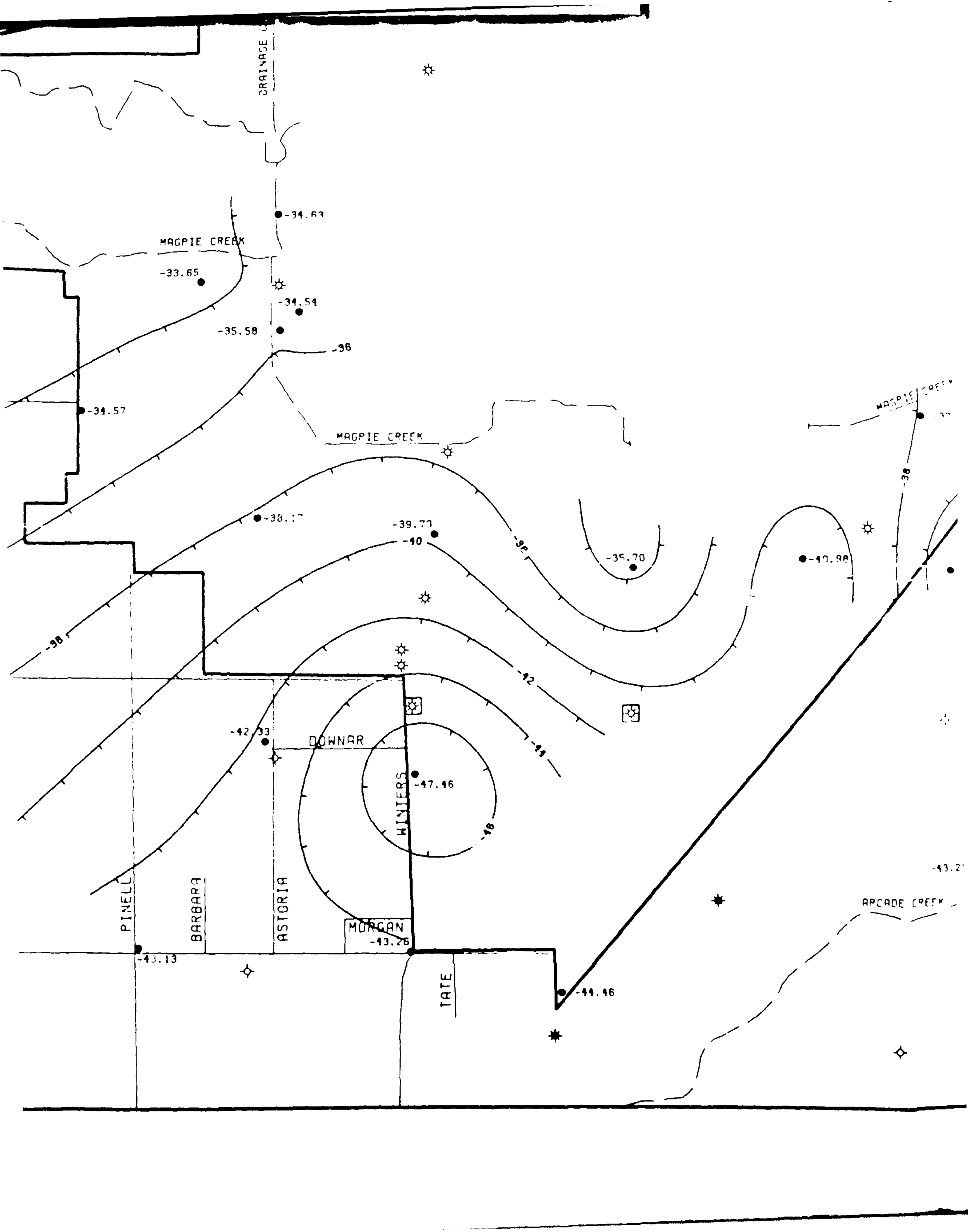


PLATE 3.



CLAIRE
CHANNEL
CREEK
OLD MAGPIE
JOYCE
SANTA ANA
-31.25
-32.16
MAIN
-34.57
-34
GRACE
-34.34
RALEY
MARYSVILLE
-38
-38
BELL
MAY
PINELL
NORTH
-43.1


DRAINAGE
-34.63
MAGPIE CREEK
-33.65
-34.54
-35.58
-34.57
MAGPIE CREEK
-39.73
-40
-35.70
-42
-44
-42.33
DOWNAR
-47.46
WINTERS
-48
PINELL
BARBARA
ASTORIA
MORGAN
-43.26
-43.13
TATE
-44.46
ARCADE CREEK

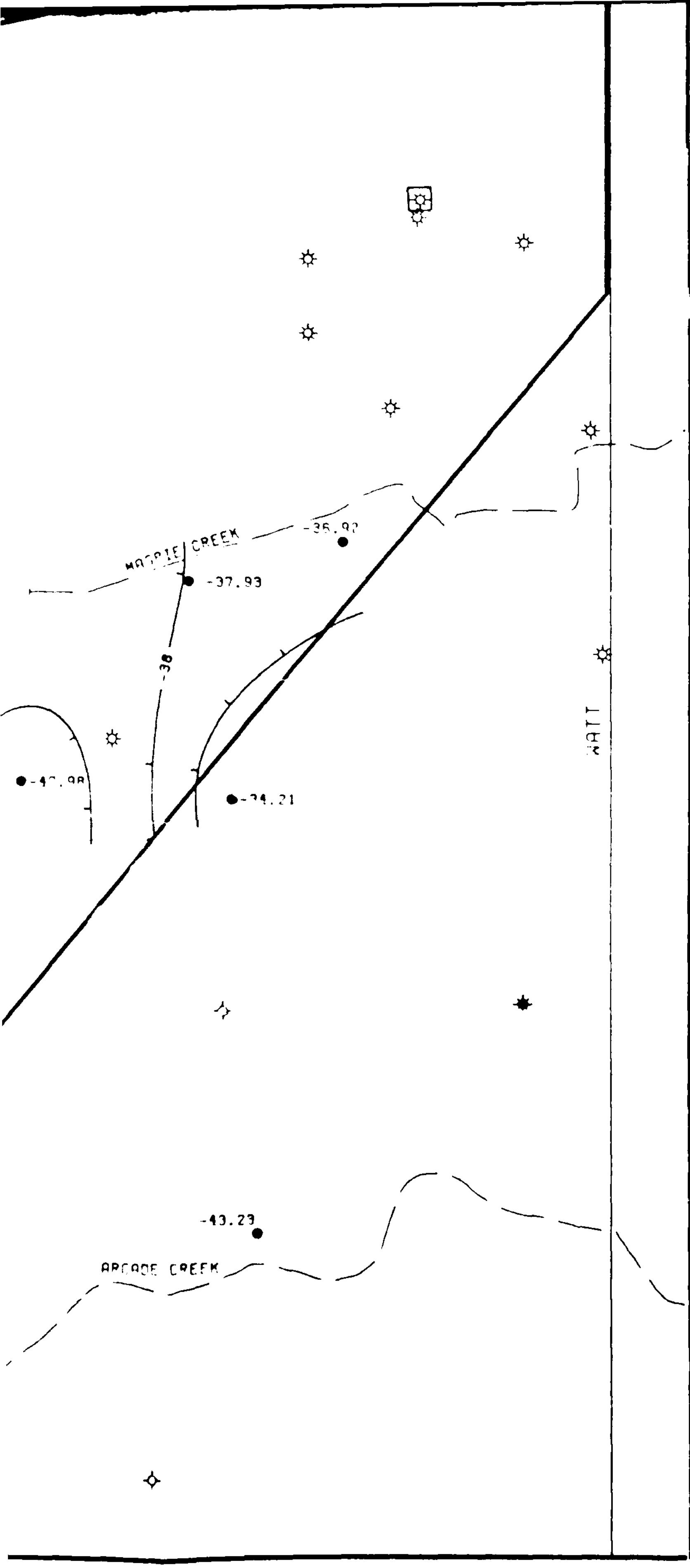


PLATE 3.

MIDDLE MONITORING ZONE POTENTIOMETRIC SURFACE MAP FOR DATA COLLECTED SEPT. 29 - 30, 1988

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND

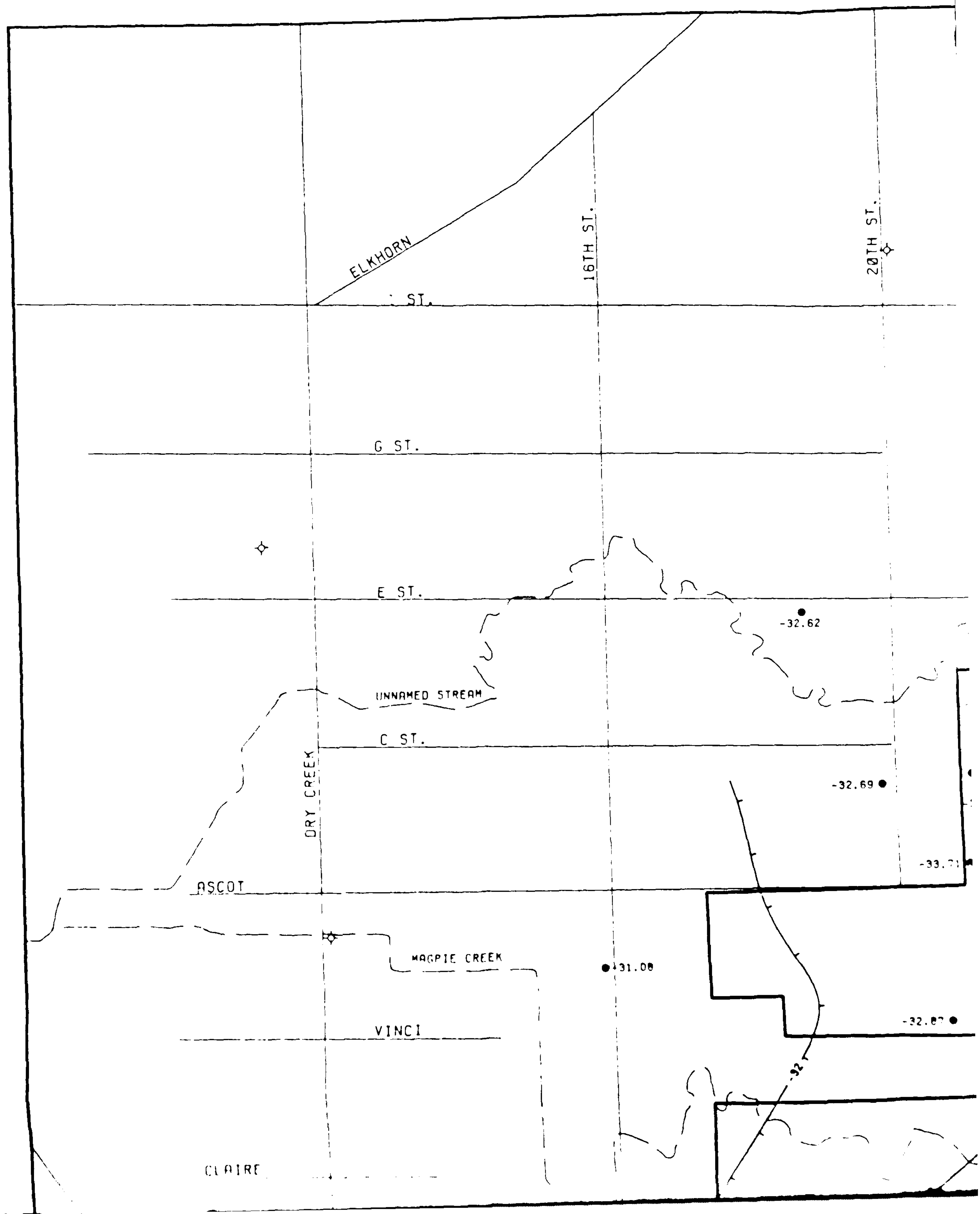
- McCLELLAN AFB BOUNDARY
- STREAMS
- 30 — POTENTIOMETRIC CONTOUR LINE AND ELEVATION (FT MSL)
- MIDDLE ZONE MONITORING WELL
- INACTIVE BASE PRODUCTION WELL
- ACTIVE BASE PRODUCTION WELL
- CITY WELL
- CALTRANS WELL
- EXTRACTION WELL

N

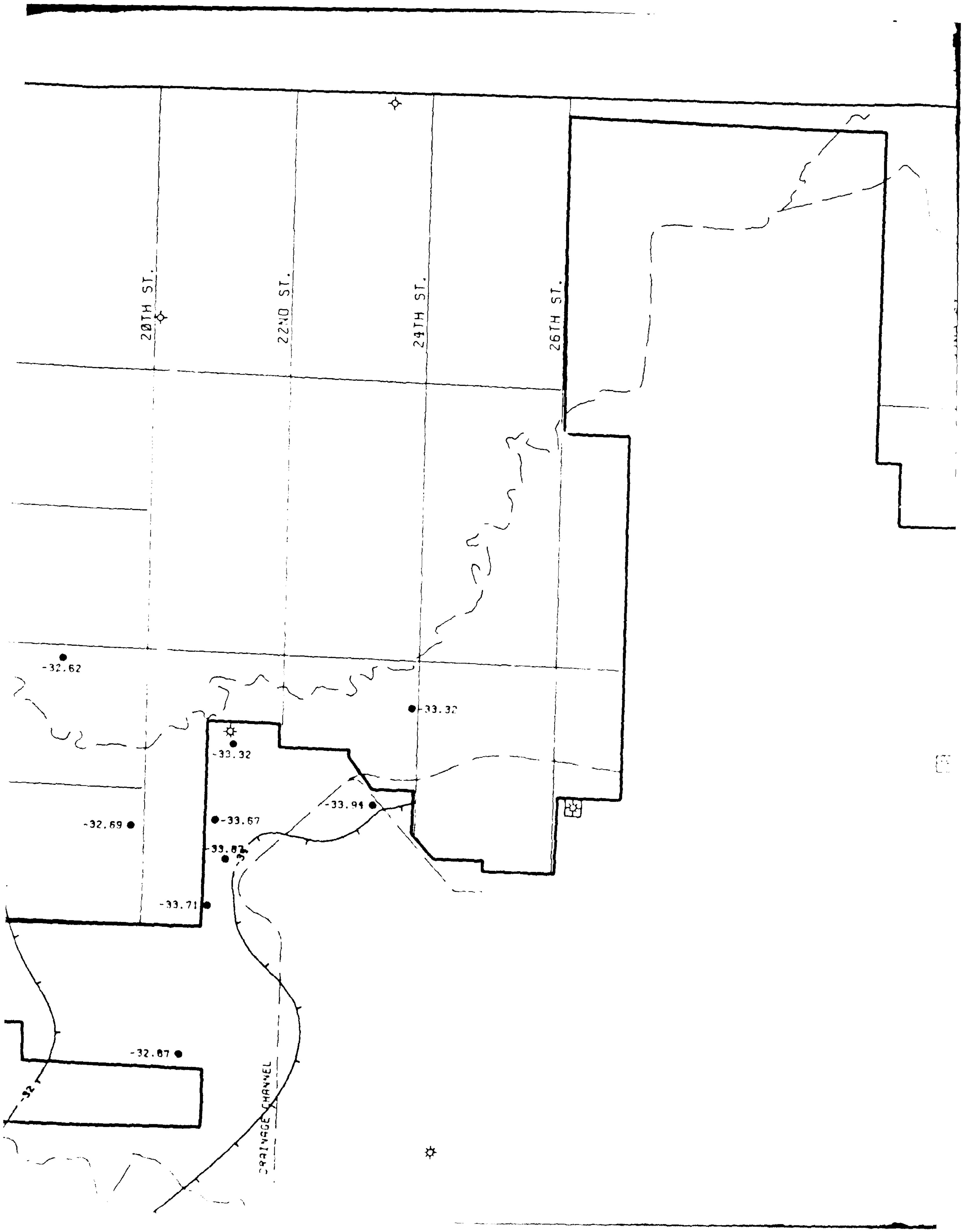
0 500 1000
SCALE IN FEET

GENERATED BY Duran M. Stoddard DATE 10-19-88
PEER REVIEW Thomas F. Liebzeit DATE 10-19-88
PROJECT REVIEW Deena A. Stanley DATE 10/19/88

RADIAN CORPORATION



ELKHORN
16TH ST.
20TH ST.
ST.
G ST.
E ST.
-32.62
UNNAMED STREAM
C ST.
DRY CREEK
-32.69
ASCOT
MAGPIE CREEK
31.08
VINCI
32
CLAIRE



20TH ST.
22ND ST.
24TH ST.
26TH ST.
-32.62
-33.32
-33.32
-33.94
-33.67
-32.69
-33.82
-33.71
-32.87
DRAINAGE CHANNEL

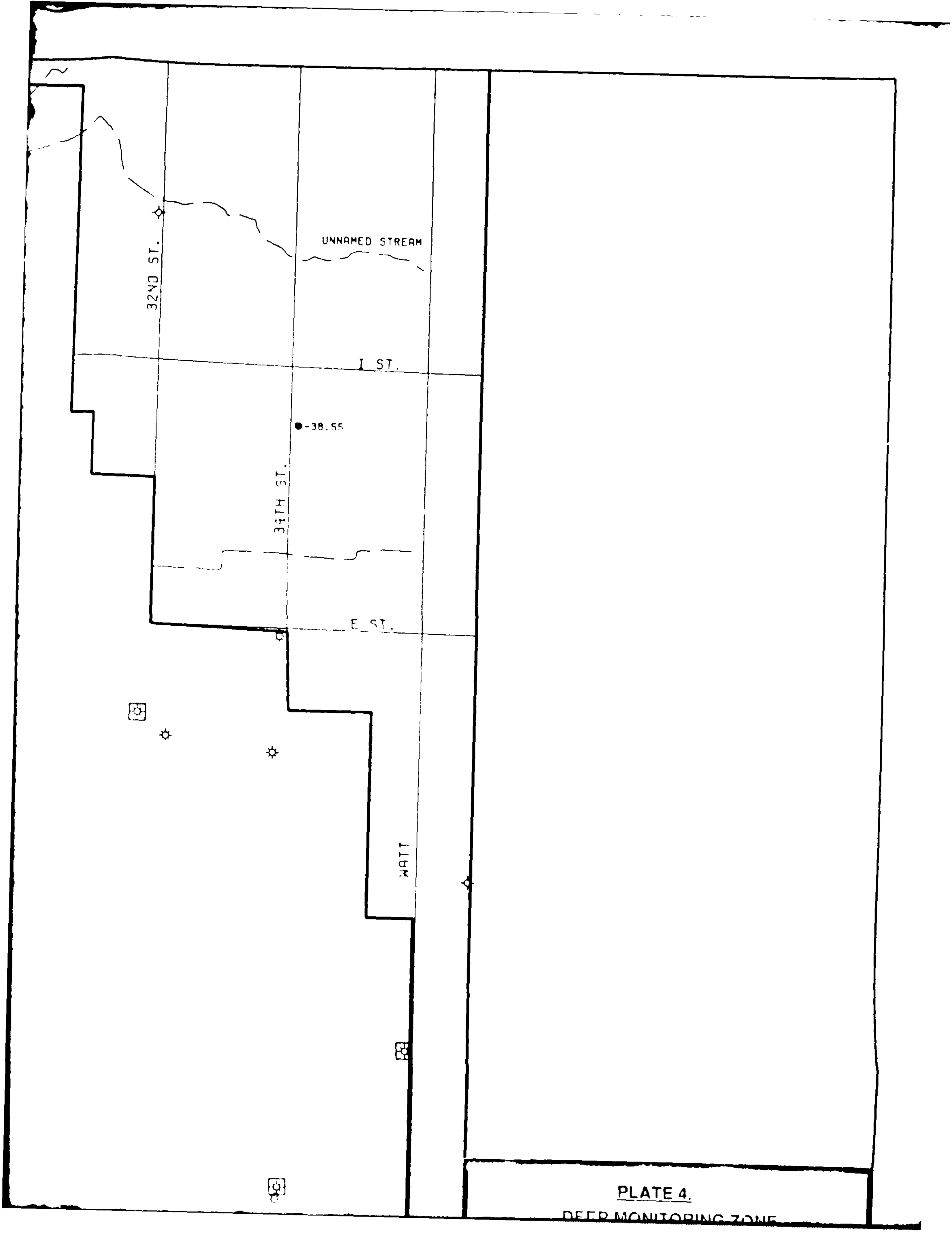
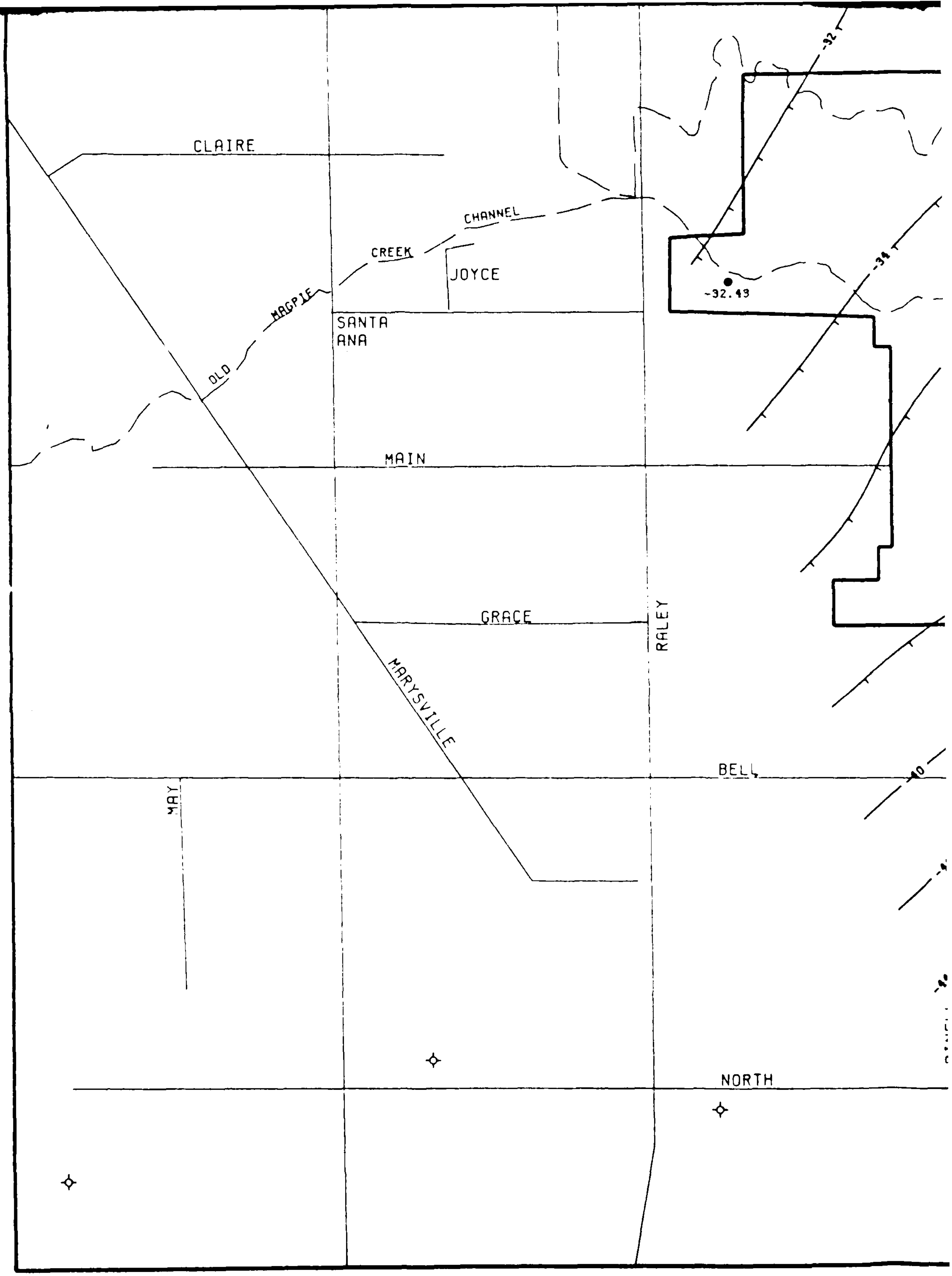
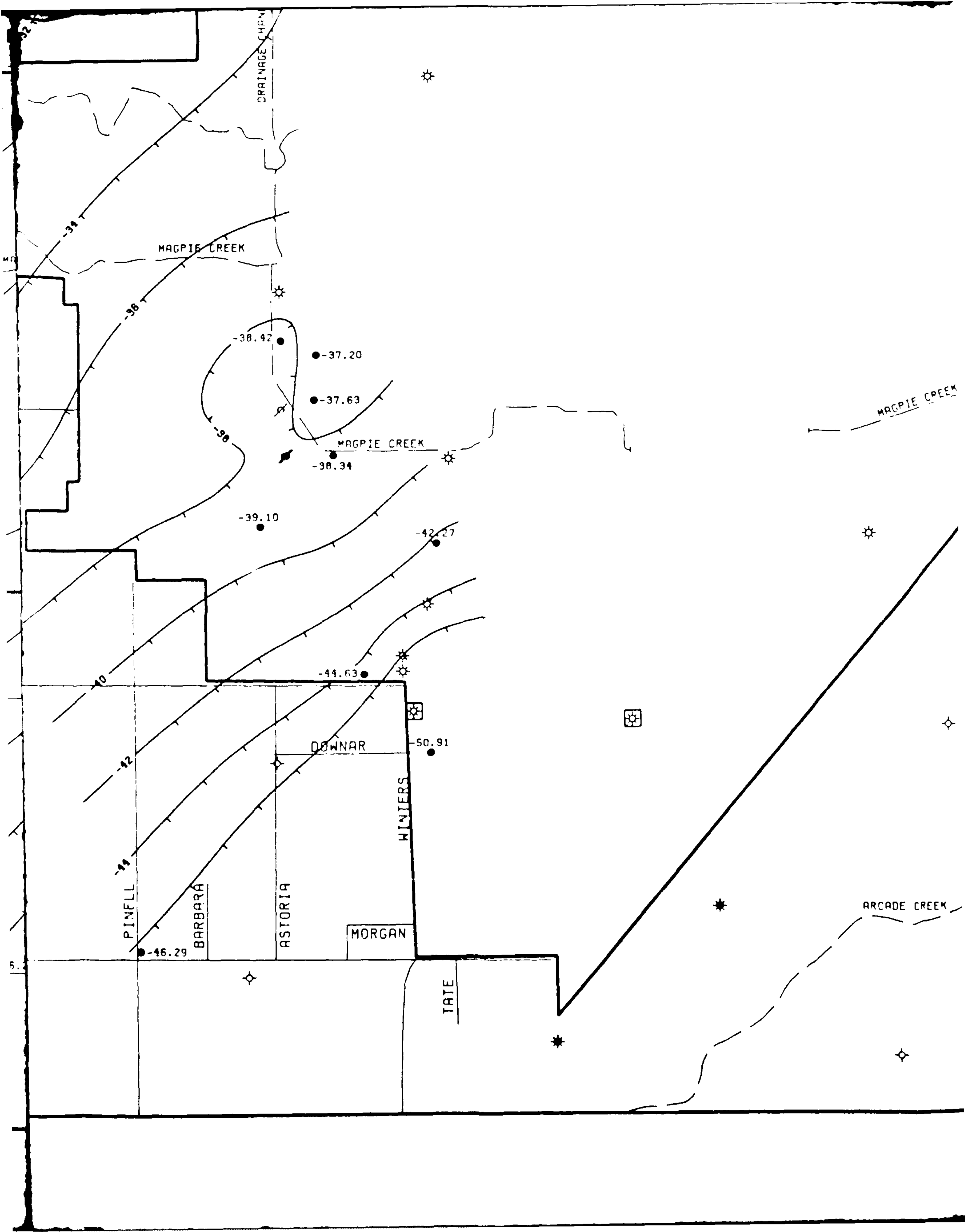


PLATE 4.

DEER MONITORING ZONE


CLAIRE
OLD MAGPIE CREEK CHANNEL
JOYCE
SANTA ANA
-32.49
-32
-34
MAIN
GRACE
RALEY
MARYSVILLE
BELL
-40
MAY
NORTH



DRAINAGE CHAN
MAGPIE CREEK
-34
-38
-38.42
-37.20
-37.63
-38
MAGPIE CREEK
-38.34
-39.10
-42.27
-40
-44.63
-42
DOWNAR
-50.91
WINTERS
-44
PINELL
BARBARA
ASTORIA
MORGAN
-46.29
TATE
MAGPIE CREEK
ARCADE CREEK

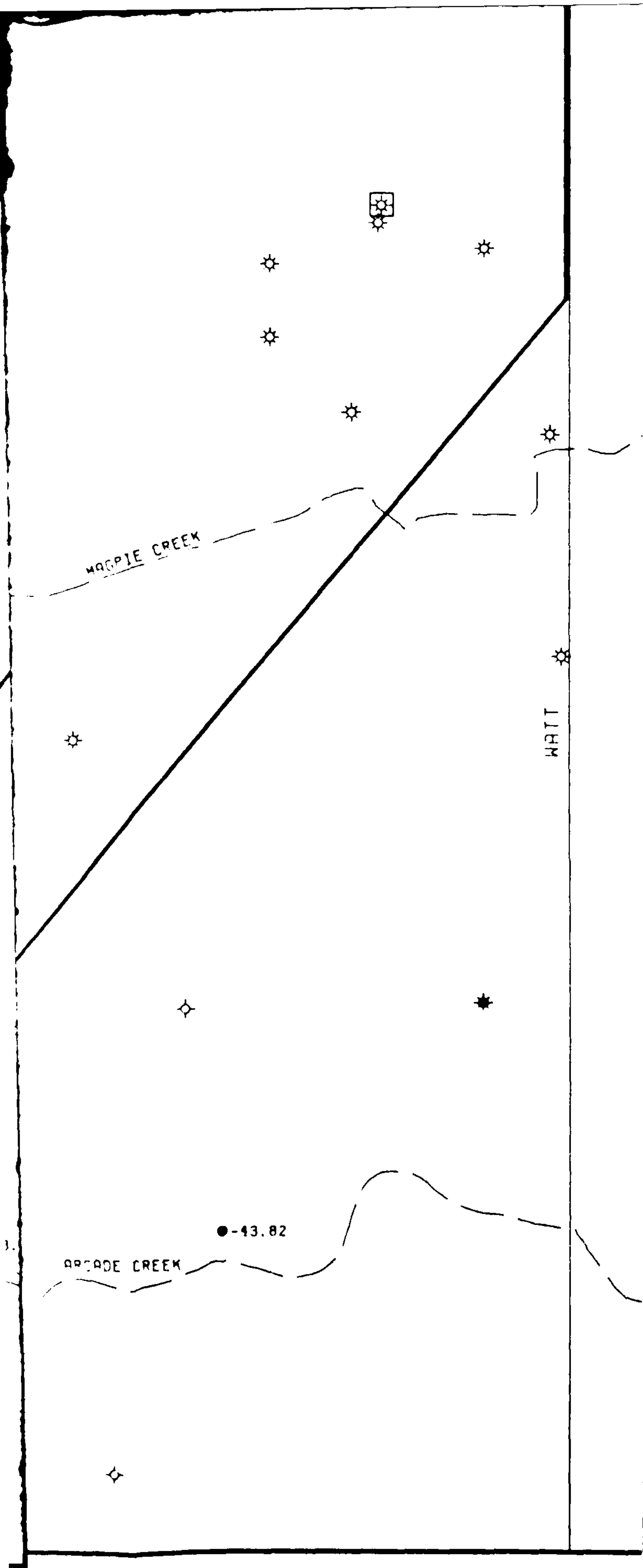


PLATE 4.

DEEP MONITORING ZONE
POTENTIOMETRIC SURFACE MAP
FOR DATA COLLECTED SEPT. 29 - 30, 1988

McCLELLAN AFB
RI Stage 6, February, 1990

LEGEND:

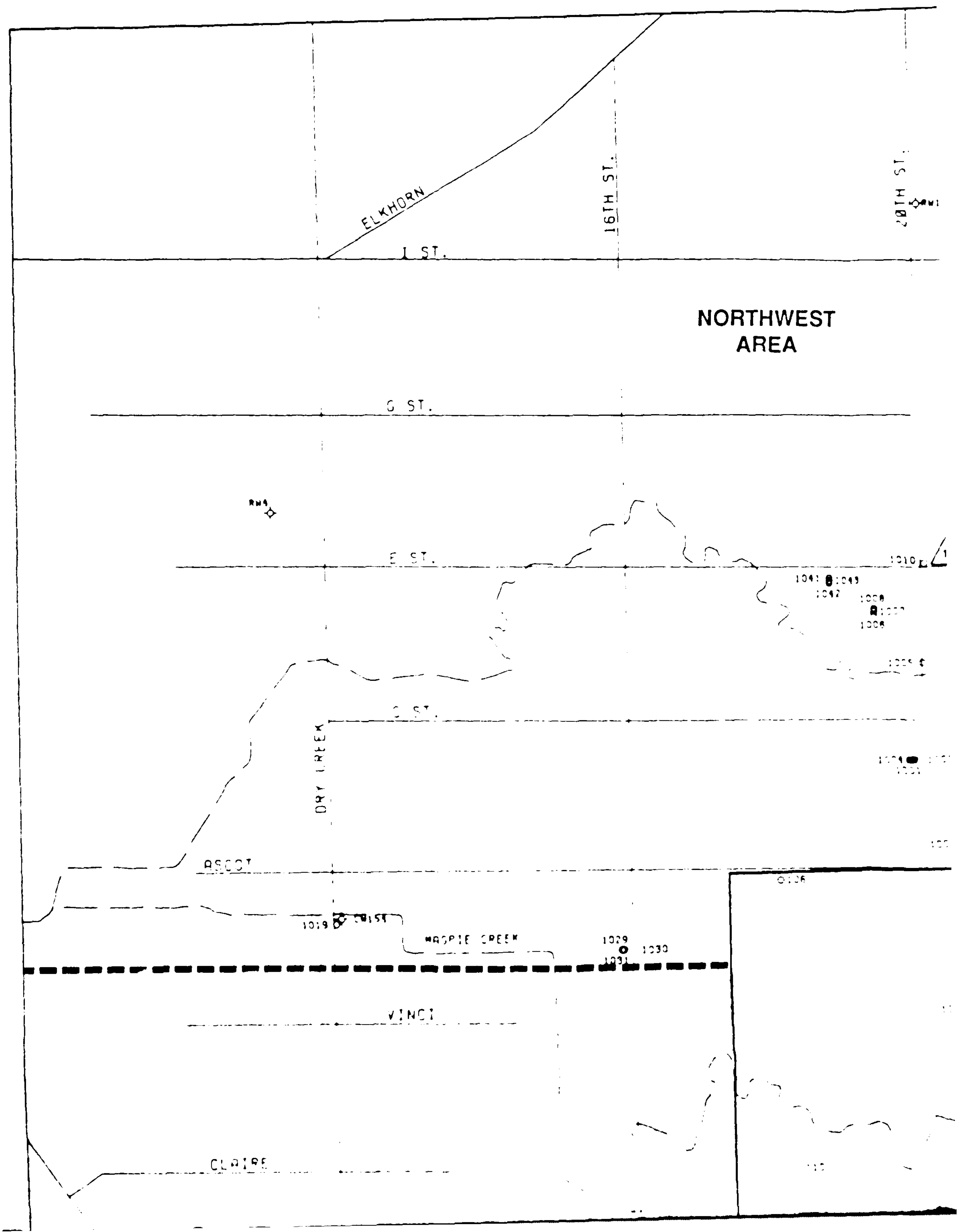
- McCLELLAN AFB BOUNDARY
- STREAMS
- 30 POTENTIOMETRIC CONTOUR LINE AND ELEVATION (FT MSL)
- DEEP ZONE MONITORING WELL
- INACTIVE BASE PRODUCTION WELL
- ACTIVE BASE PRODUCTION WELL
- CITY WELL
- CALTRANS WELL
- EXTRACTION WELL

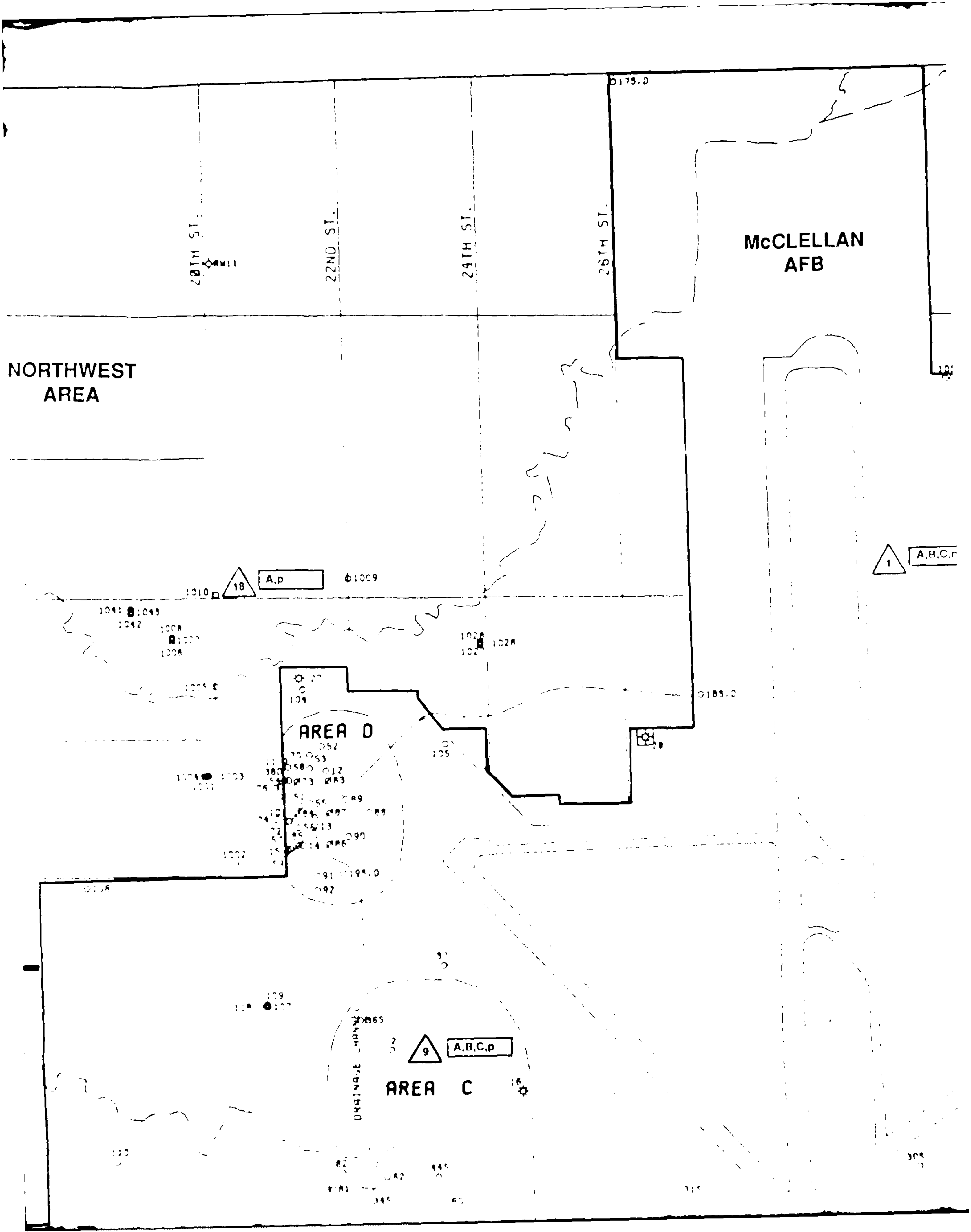
N

0 500 1000
SCALE IN FEET

GENERATED BY	[illegible]	DATE	10-19-88
PEER REVIEW	Thomas F. [illegible]	DATE	10-19-88
PROJECT REVIEW	Deena [illegible]	DATE	10/19/88

RADIAN CORPORATION


NORTHWEST AREA
ELKHORN
16TH ST.
20TH ST.
I ST.
G ST.
E ST.
DRY CREEK
ASCOT
MAGPIE CREEK
VINCI
CLAIRE
RW4
RW1
1010
1041
1042
1043
1008
1006
1019
1029
1030
1031



NORTHWEST AREA
McCLELLAN AFB
20TH ST.
22ND ST.
24TH ST.
26TH ST.
AREA D
AREA C
DRAINAGE CHANNEL
A,p
18
A,B,C,p
9
1
1009
1010
1028

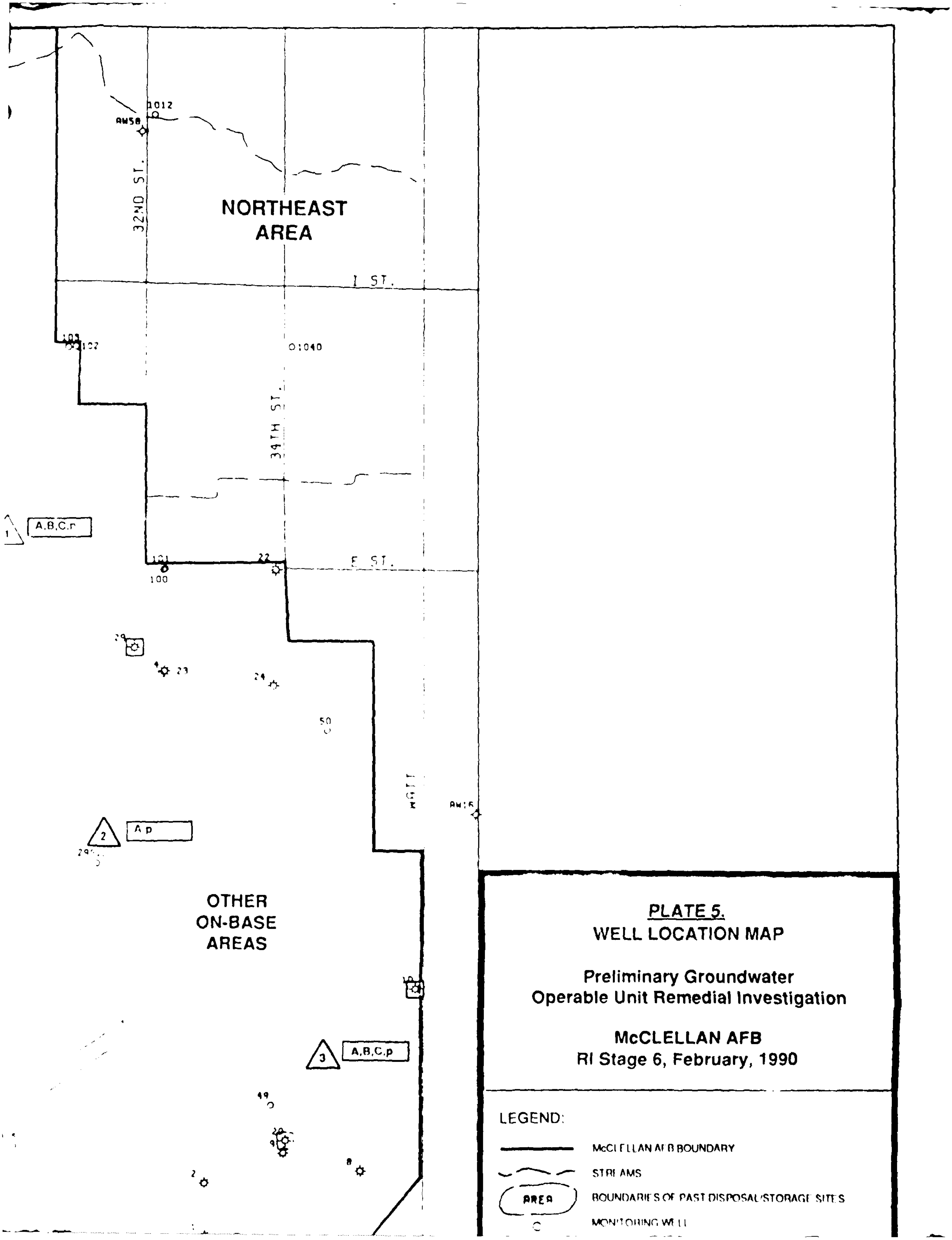
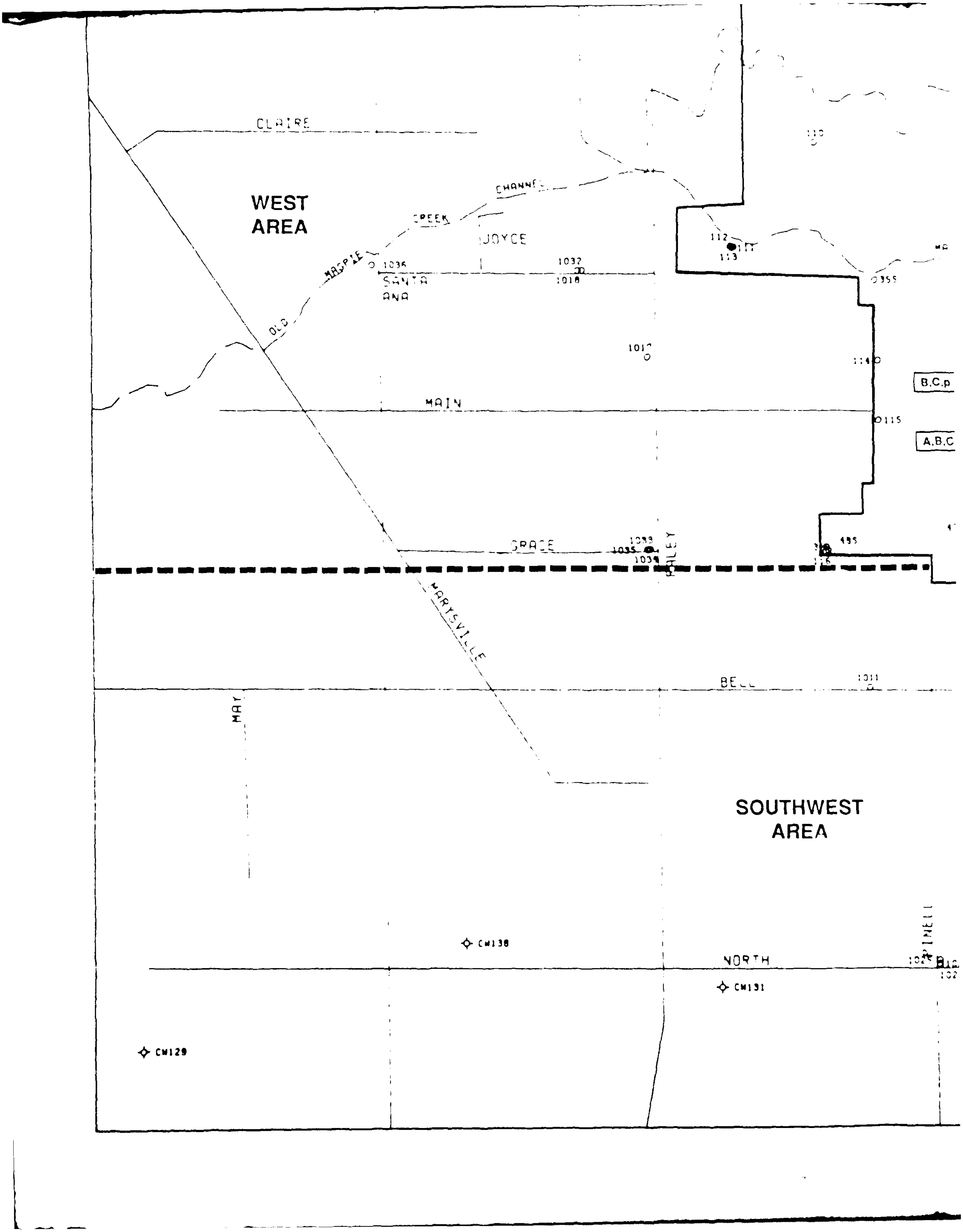


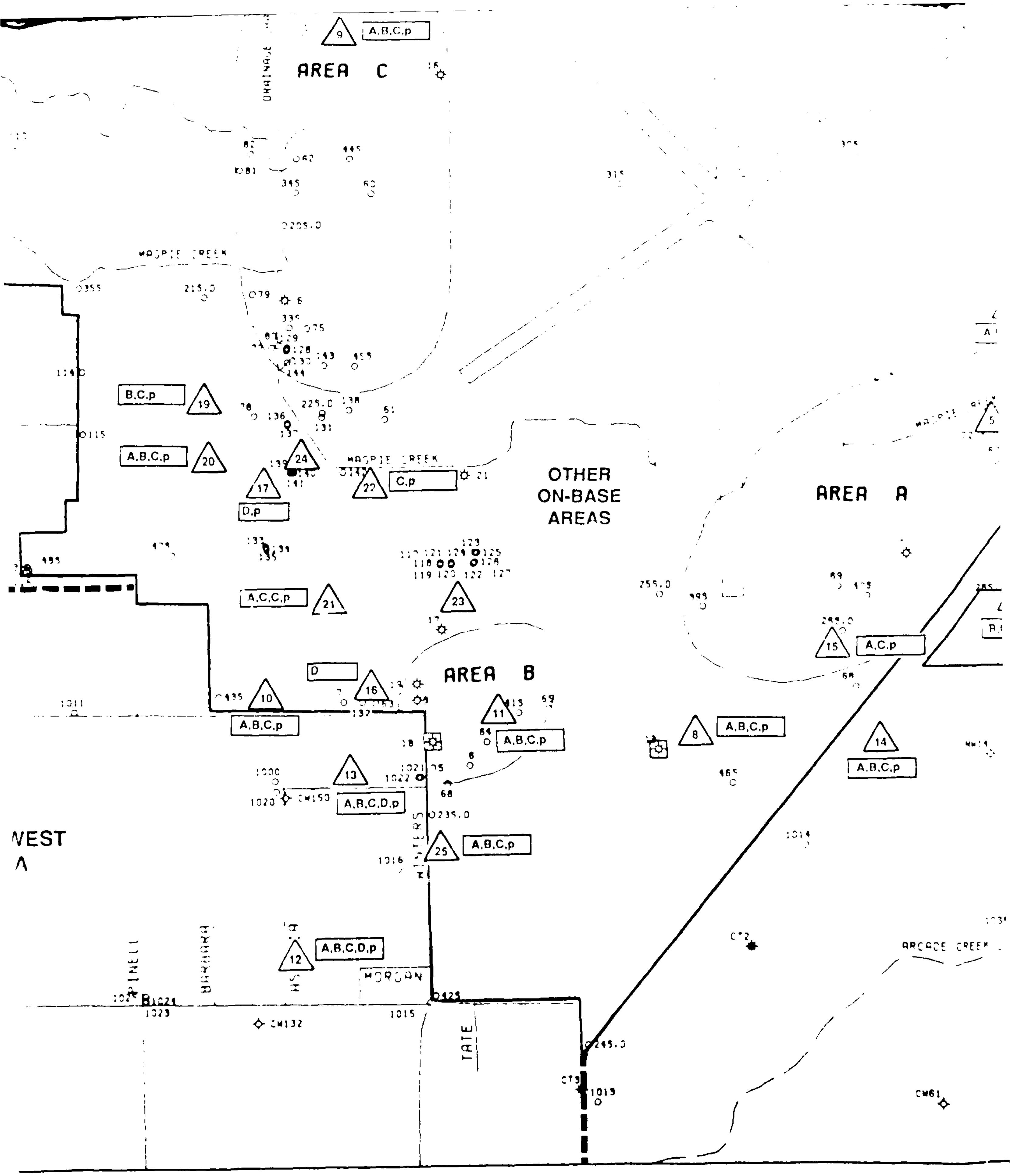
PLATE 5.
WELL LOCATION MAP

Preliminary Groundwater Operable Unit Remedial Investigation

McCLELLAN AFB
RI Stage 6, February, 1990

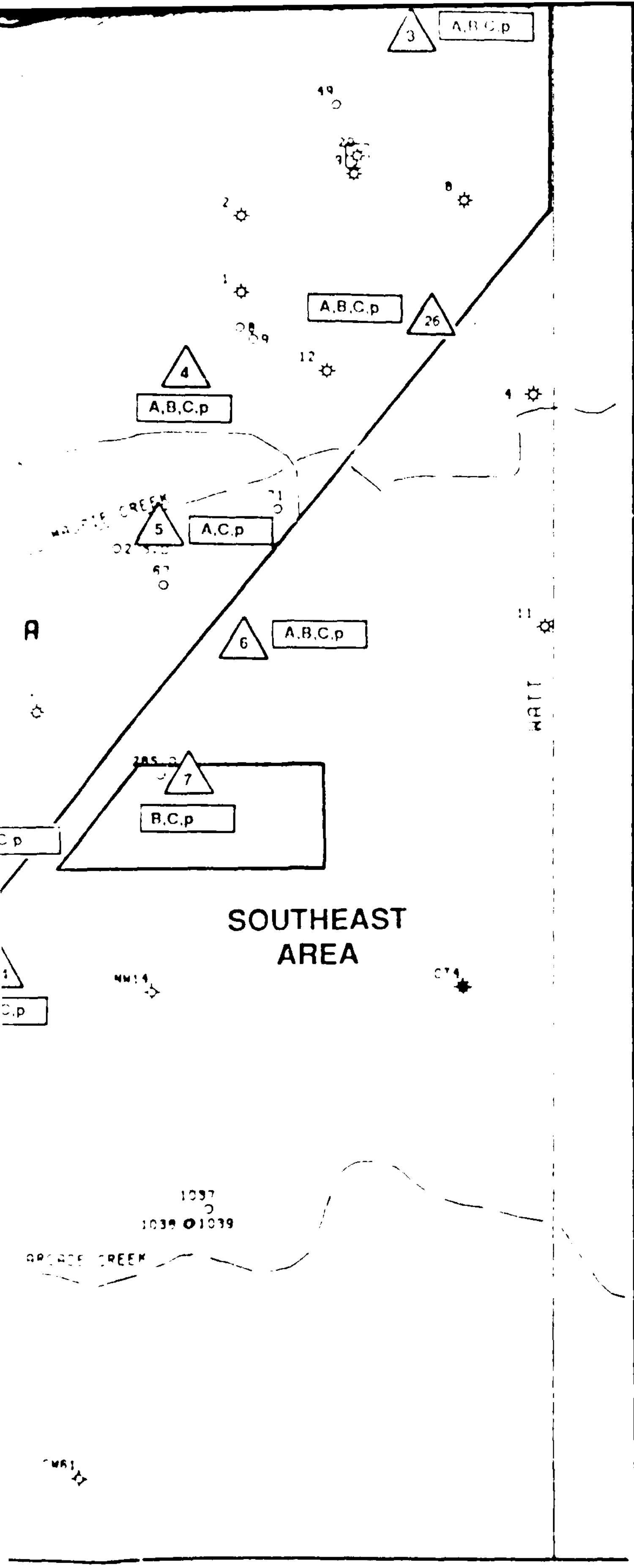


WEST AREA
SOUTHWEST AREA
CLAIRE
CHANNEL
CREEK
MAGPIE
OLD
JOYCE
SANTA ANA
MAIN
GRACE
PALEY
MARYSVILLE
BELL
MAY
NORTH
1036
1032
1018
112
113
355
114
115
B.C.p
A.B.C
1038
1035
1034
455
1011
CM130
CM131
CM129



AREA C
A,B,C,p
DRAINAGE
MAGPIE CREEK
B,C,p
A,B,C,p
D,p
C,p
OTHER
ON-BASE
AREAS
AREA A
A,C,C,p
D
AREA B
A,C,p
A,B,C,p
A,B,C,p
A,B,C,p
A,B,C,p
A,B,C,D,p
A,B,C,p
WINTERS
A,B,C,D,p
MORGAN
TATE
ARCADE CREEK

McCLELLAN AFB
RI Stage 6, February, 1990



LEGEND:

- McCLELLAN AFB BOUNDARY
- STREAMS
- AREA — BOUNDARIES OF PAST DISPOSAL/STORAGE SITES
- MONITORING WELL
- EXTRACTION WELL
- 1 – 26 — PROPOSED PILOT HOLES & MONITORING WELL CLUSTERS
- A — "WATER TABLE" ZONE
- B — "150 FOOT" ZONE
- C — "200 FOOT" ZONE
- D — "300 FOOT" ZONE
- p — PILOT HOLE to 350 FEET & GEOPHYSICALLY LOGGED
- 23 — PIEZOMETERS
  105 FOOT DEEP, 125 FOOT DEEP, 160 FOOT DEEP, 190 FOOT DEEP
- 24 — PIEZOMETERS
  INCLUDES 30 PIEZOMETERS IN AREA C LOCATED NEAR THE EXTRACTION WELLS

BASE PRODUCTION WELLS
- ACTIVE WATER SUPPLY WELL
- INACTIVE AT PRESENT

MUNICIPAL WATER SUPPLY WELLS
- CW — CITY OF SACRAMENTO
- NW — NORTHRIDGE WATER DISTRICT
- RW — RIO LINDA WATER DISTRICT
- AW — ARCADE WATER DISTRICT

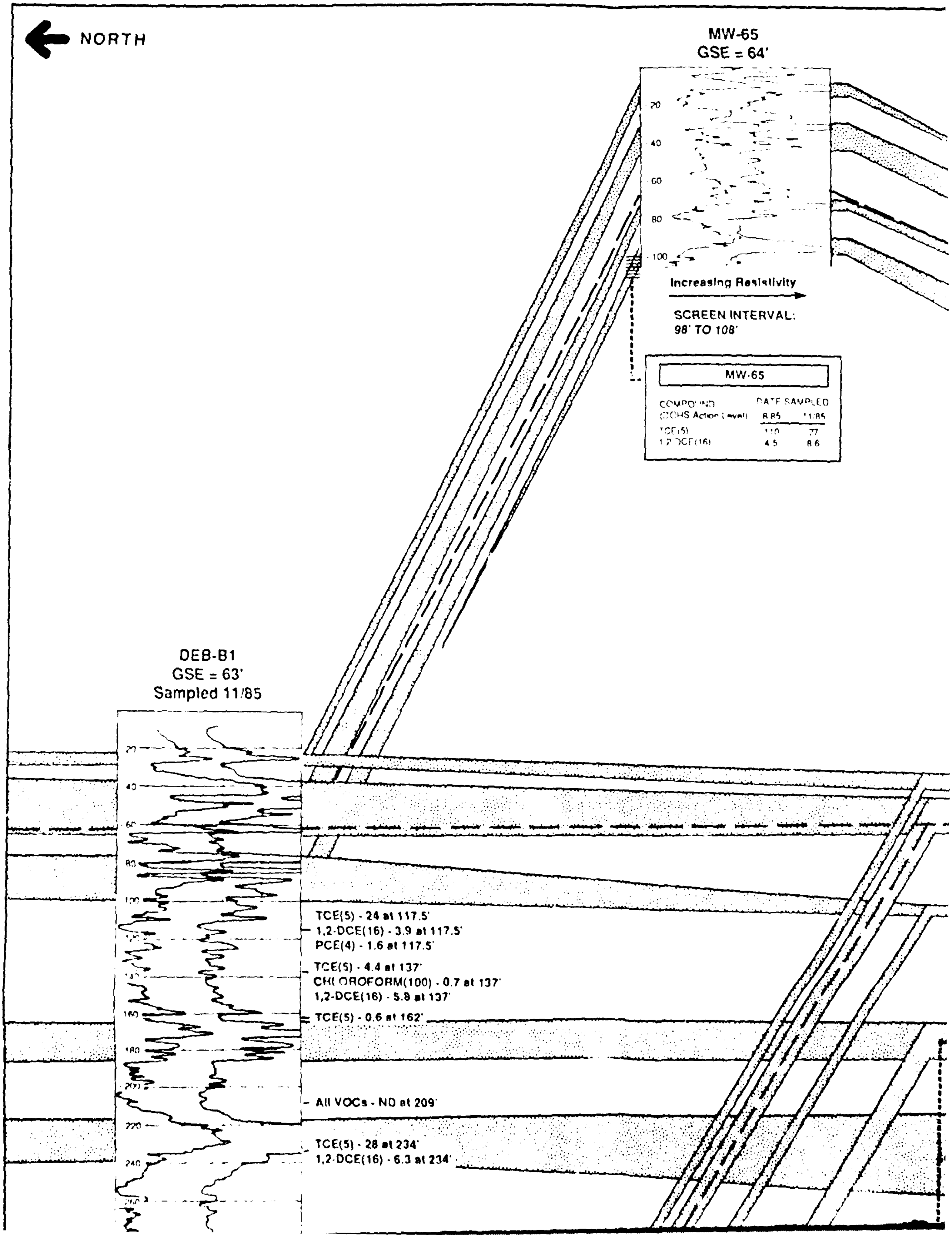
IRRIGATION WELLS
- CT — CALTRANS

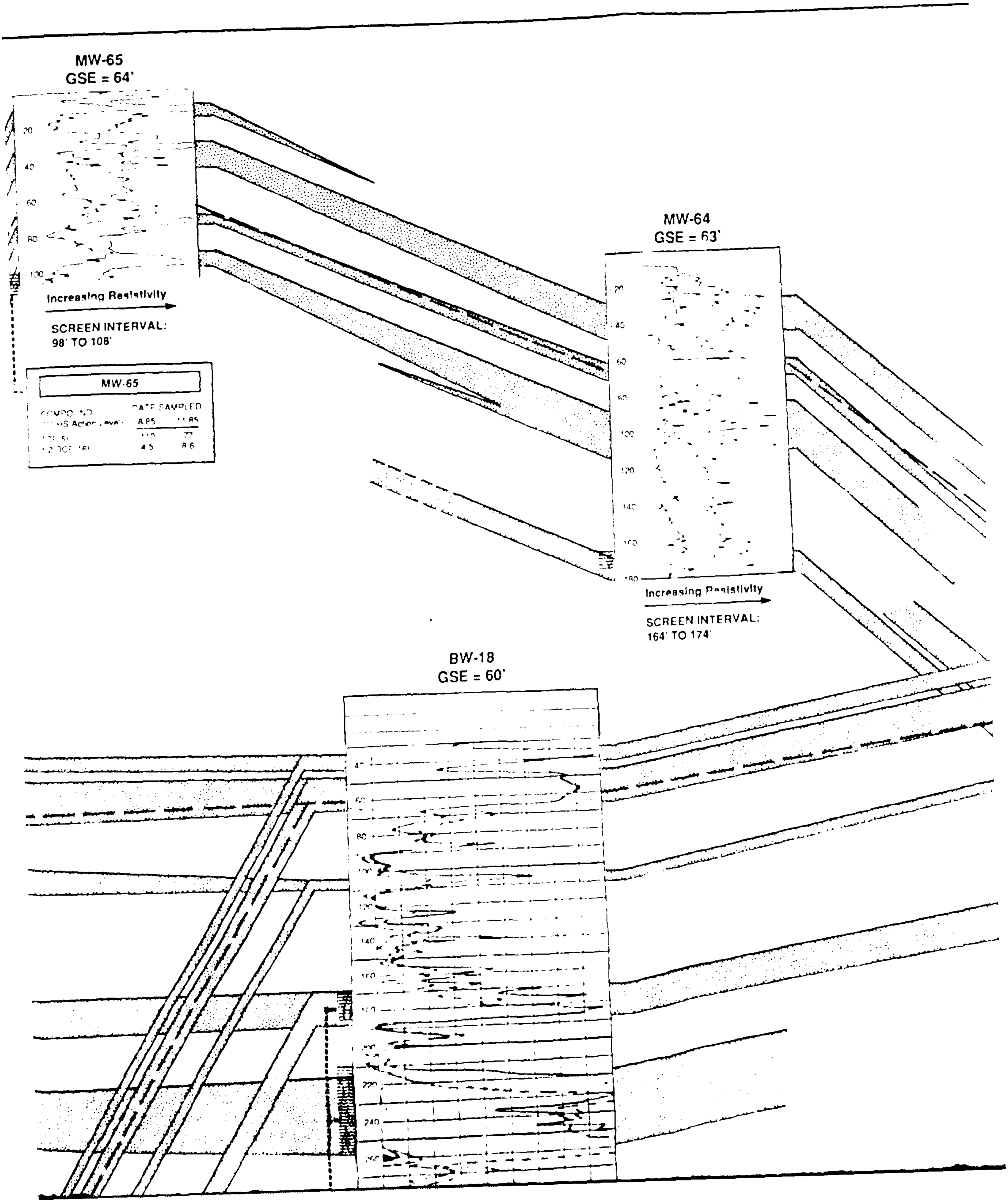
N

0 500 1000
SCALE IN FEET

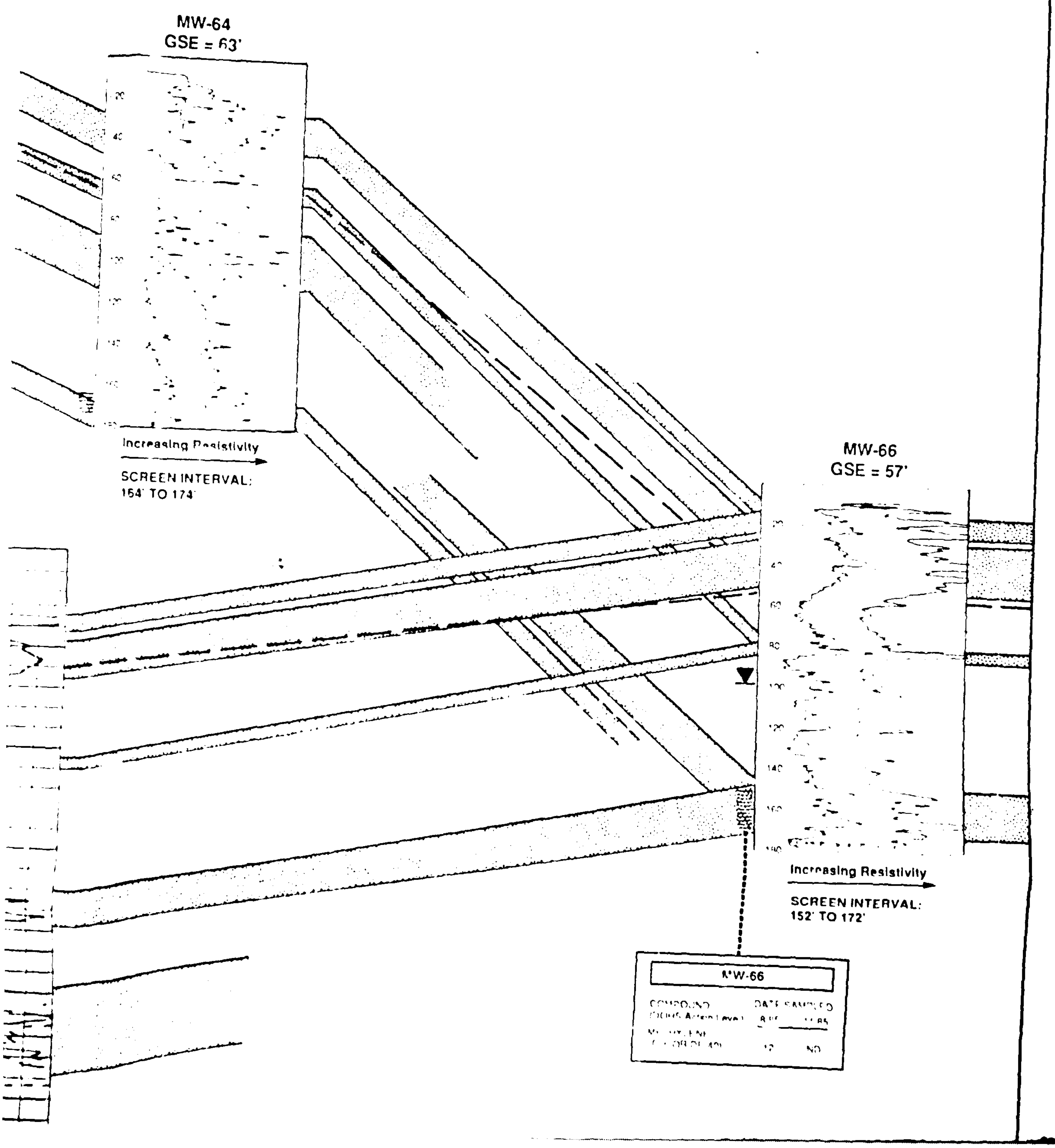
GENERATED BY Duran M. Gaddie DATE 8-25-89
PEER REVIEW Joann Stanley DATE 8-25-89
PROJECT REVIEW Thomas F. Ciebzb DATE 8-25-89

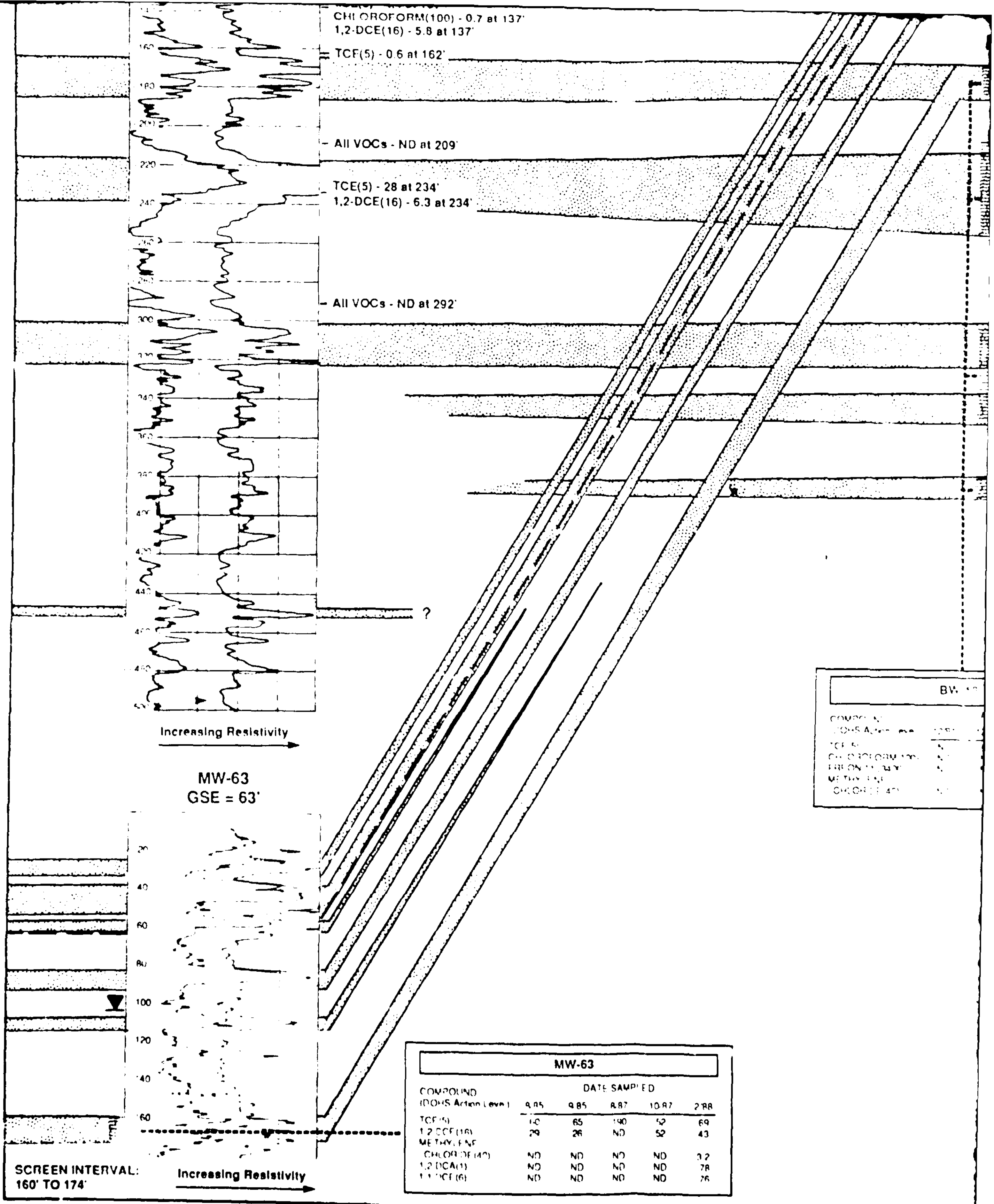
RADIAN CORPORATION


NORTH
MW-65
GSE = 64'
20
40
60
80
100
Increasing Resistivity
SCREEN INTERVAL:
98' TO 108'
MW-65
COMPOUND
DATE SAMPLED
(DOHS Action Level)
8/85
11/85
TCE(5)
110
77
1,2-DCE(16)
4.5
8.6
DEB-B1
GSE = 63'
Sampled 11/85
20
40
60
80
100
160
180
220
240
TCE(5) - 24 at 117.5'
1,2-DCE(16) - 3.9 at 117.5'
PCE(4) - 1.6 at 117.5'
TCE(5) - 4.4 at 137'
CHLOROFORM(100) - 0.7 at 137'
1,2-DCE(16) - 5.8 at 137'
TCE(5) - 0.6 at 162'
All VOCs - ND at 209'
TCE(5) - 28 at 234'
1,2-DCE(16) - 6.3 at 234'



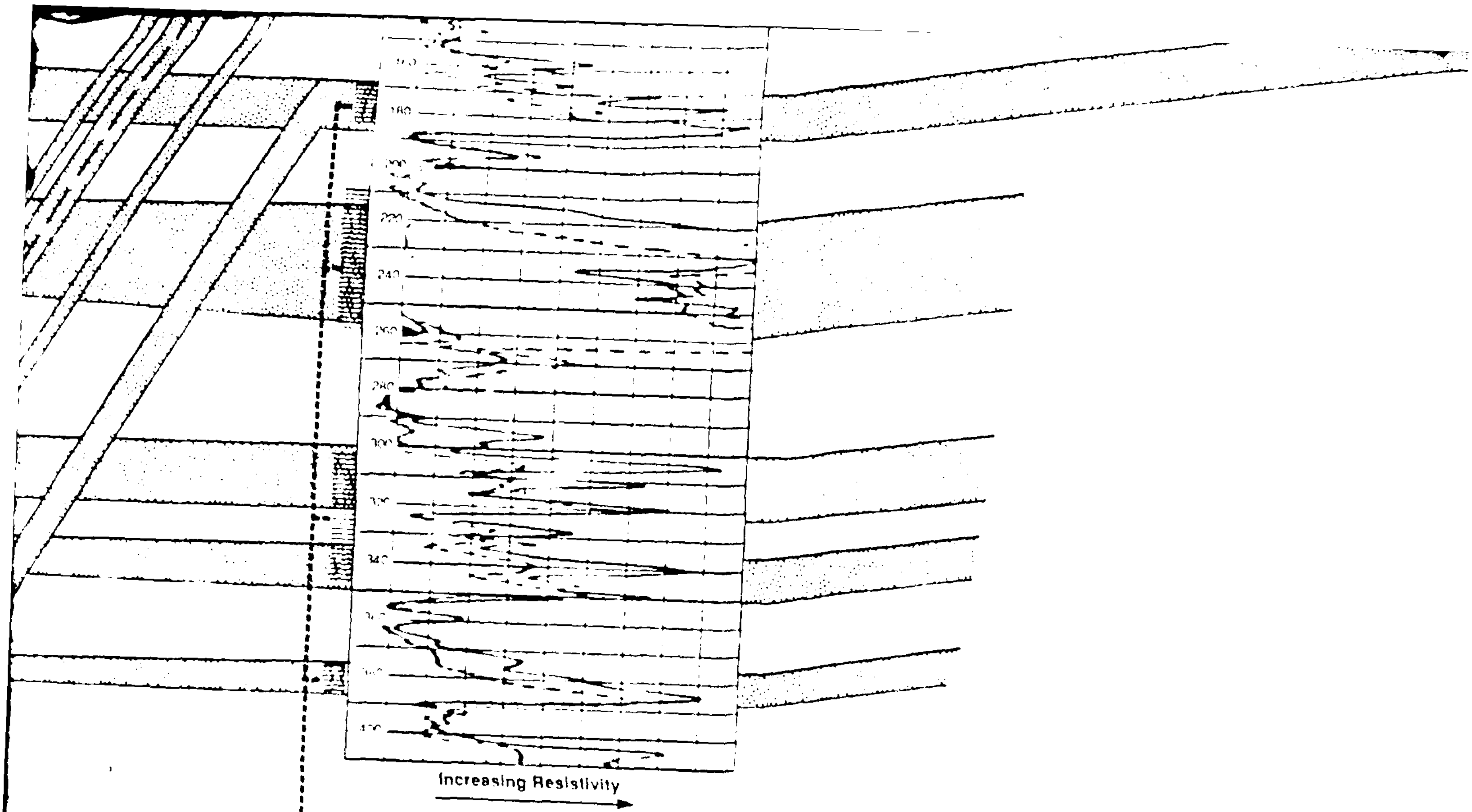
MW-65
GSE = 64'
Increasing Resistivity
SCREEN INTERVAL:
98' TO 108'
MW-65
DATE SAMPLED
8.85
11.85
4.5
8.6
MW-64
GSE = 63'
Increasing Resistivity
SCREEN INTERVAL:
164' TO 174'
BW-18
GSE = 60'


MW-64
GSE = 63'
Increasing Resistivity
SCREEN INTERVAL:
154' TO 174'
MW-66
GSE = 57'
Increasing Resistivity
SCREEN INTERVAL:
152' TO 172'
MW-66
COMPOUND
DATE SAMPLED
ND



MW-63

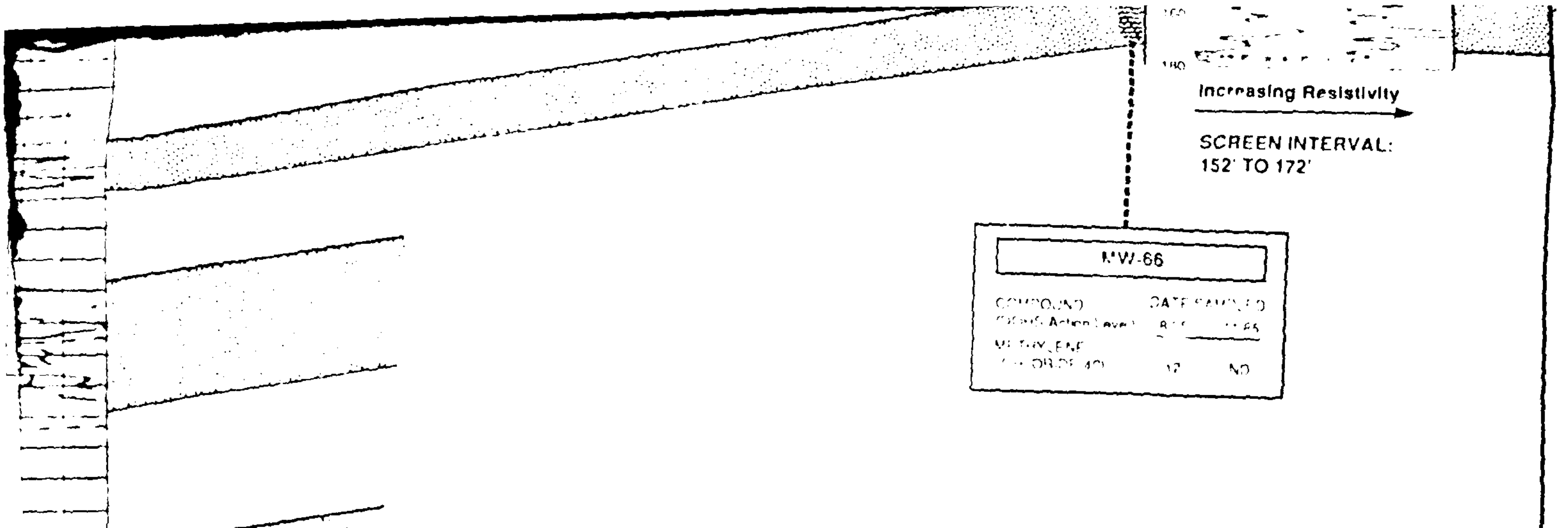
COMPOUND (DOHS Action Level)	DATE SAMPLED 9/85	9/85	8/87	10/87	2/88
TCE(5)	[illegible]	65	190	52	69
1,2-DCE(16)	29	26	ND	52	43
METHYLENE CHLORIDE(40)	ND	ND	ND	ND	3.2
1,2-DCA(1)	ND	ND	ND	ND	78
1,1-DCE(6)	ND	ND	ND	ND	76

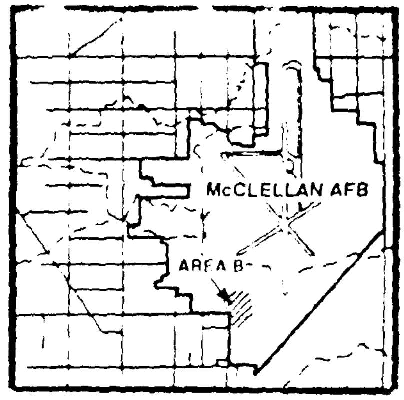


SCREEN INTERVALS:
169' TO 185'
210' TO 260'
304' TO 319'
378' TO 387'

BW-18				
[illegible]	[illegible]			
[illegible]	[illegible]	12-85	3-86	12-86
[illegible]	N	5.6	ND	[illegible]
CHLOROFORM [illegible]	N	ND	ND	[illegible]
FREON [illegible]	ND	ND	ND	[illegible]
METHY[illegible]				49
[illegible] CHLOR[illegible]	N[illegible]	ND	4.0	ND

Monitoring zones depicted in the cross section represent zones of higher permeabilities relative to zones above or below. Monitoring zones may not be sands, and intervening strata may not be silts and clays over their entire thicknesses.





LEGEND:

GSE Ground Surface Elevation

Mean Sea Level

Ground Water Level (2/88)

Screened Interval

Zone of Relatively Higher Permeability Based on Electric Log Response

NOTE: All analytical results are in ug/L

SCALE:
Vertical Scale: 1" = 60'
Horizontal Scale: NOT TO SCALE

PLATE 6.

GEOLOGIC FENCE DIAGRAM, AREA B, BASED ON RESISTIVITY SURVEYS

McCLELLAN AFB
RI Stage 6, February, 1990

RADIAN CORPORATION