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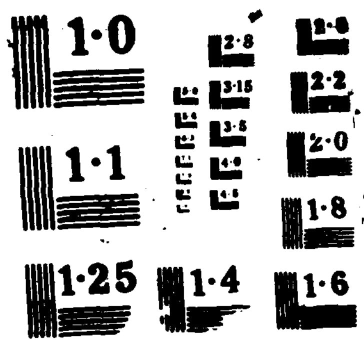
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INSTALLATION RESTORATION PROGRAM PHASE II - CONFIRMATION/QUANTIFICATION STAGE 1

VOLUME I

FOR

Mather Air Force Base
Sacramento, California

PREPARED BY:

Roy F. Weston, Inc.
West Chester, Pennsylvania 19380

JUNE, 1986

FINAL REPORT FOR PERIOD SEPTEMBER 1983 TO JUNE 1986

PREPARED FOR:

HEADQUARTERS AIR TRAINING COMMAND
COMMAND SURGEON'S OFFICE (HQATC/SGPB)
BIOENVIRONMENTAL ENGINEERING DIVISION
RANDOLPH AIR FORCE BASE, TEXAS

UNITED STATES AIR FORCE
OCCUPATIONAL & ENVIRONMENTAL HEALTH LABORATORY (USAF OEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION

STAGE 1

VOLUME 1

FINAL REPORT

FOR

Mather Air Force Base
Sacramento, California

USAF Air Training Command
Randolph Air Force Base, Texas

June, 1986

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USAF Contract No. F33615-80-D-4006, Delivery Order 0026
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Prepared for

UNITED STATES AIR FORCE
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A Problem Confirmation Study was performed at three sites on Mather AFB identified in the Phase I investigation as requiring further study (the ACW Area, the 7100 Area, the West Ditch) and the Northeast Perimeter. The field investigation was conducted from February 1984 to June 1985 and included installation of 11 monitor wells, collection of groundwater samples from the monitor wells and 15 base production wells, and collection of sediment samples from two locations on the West Ditch. Analytes included oil and grease, TOC, volatile organic compounds (VOA), as well as dimethylnitrosamine, phenols, pesticides and dissolved metals at some specific sites. Based on the hydrogeologic complexity of the physical setting and the findings of the sampling and analytical work, follow-on investigations have been recommended at all three sites.

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PREFACE

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (USAF OEHL) under Contract No. F33615-80-D-4006 to provide general engineering, hydrogeological and analytical services. These services were applied to a hydrogeologic investigation of former waste disposal sites and potential groundwater contamination at Mather Air Force Base in Sacramento, California.

This work was accomplished between February 1984 and June 1985. Lieutenant Colonel Edward S. Barnes, Technical Services Branch of the USAF OEHL was the principle point of contact during the project. The program was managed through the Roy F. Weston, Inc. (WESTON) home office in West Chester, Pennsylvania. Peter J. Marks was the program manager and Frederick Bopp III, Ph.D., P.G. was the project manager. In April 1985, Katherine A. Sheedy, P.G. became project manager. Alison L. Dunn was the technical team leader for the hydrogeologic portion of this project.

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WESTON

EXECUTIVE SUMMARY

ES.1 PROGRAM HISTORY AT MATHER AIR FORCE BASE

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (USAF OEHL) under Contract Number F33615-80-D-4006, to provide general engineering, hydrogeological, and analytical services. The Phase I Problem Identification/Records Search for Mather Air Force Base (MAFB) was accomplished by CH2M-Hill in March 1982, and their final report was dated June 1982. In response to the findings contained in the CH2M-Hill Phase I Final Report, the USAF OEHL requested that WESTON conduct a presurvey visit of MAFB. The results of the presurvey visit, including work scope and cost estimate, were submitted in a letter to USAF OEHL dated 19 May 1983.

Following modification of the work scope, Task Order 0026-02 (dated 30 March 1984) was issued, authorizing a Phase II, Stage 1, Problem Confirmation Study at three waste disposal sites and the northeast Base perimeter. At the request of the State of California, three rounds of groundwater sampling were included in the modified Task Order.

The first phase of field work, including drilling and installation of 11 monitor wells and a survey of well locations and elevations, was performed between 20 February and 10 April 1984. Groundwater elevations were measured at approximately two-week intervals from April to November 1984. Sampling was performed in six rounds on 3 to 9 May, 13 to 20 August, 27 September to 3 October, 13 to 20 November 1984, 29 May to 3 June 1985, and 26 and 27 June 1985. Three rounds of sampling from the monitor wells and a single round of sampling from the Base production wells were stipulated in the Task Order; WESTON scheduled three successive rounds for resampling in order to rectify quality assurance/quality control problems encountered in the first three rounds.

The following is a list of the sites evaluated during the Phase II, Stage 1 Confirmation Study:

- ACW (Air Command and Warning) disposal site.
- 7100 Area disposal site.
- West ditch (drainage ditch site No. 3).
- Northeast (NE) Base perimeter.

For the locations of these sites, see Figure ES-1.

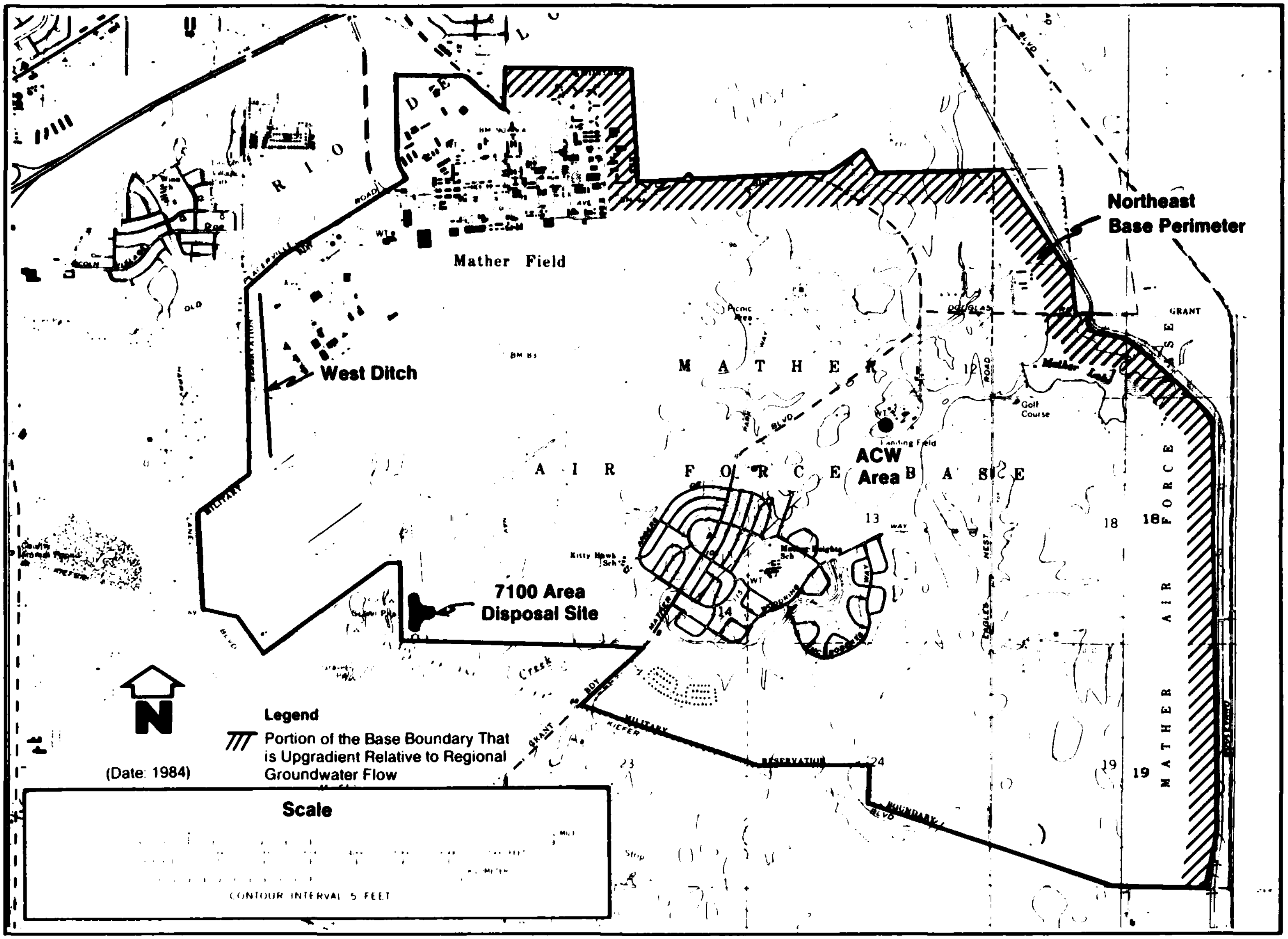

FIGURE ES-1 LOCATION OF PHASE II, STAGE I INVESTIGATION SITES AT MATHER AFB

ES.2 MAJOR FINDINGS

The following conclusions can be drawn concerning the hydrogeological and water quality conditions encountered during the Phase II, Stage 1 field investigation at Mather AFB. Conclusions are presented for each site following conclusions applicable to the Base as a whole.

ES.2.1 Hydrogeologic Conditions

- Subsurface sediments are very heterogeneous interbeds of sands, silts, clays, and gravels, lacking vertical or lateral continuity. This results in often complex groundwater conditions, such as perched water, locally confined conditions, and abrupt contrasts in hydraulic conductivity. These conditions can be expected to strongly influence the distribution, dispersion, and migration of any contaminants that may be present in the subsurface. Consequently, these phenomena cannot be analyzed by simple homogeneous aquifer models.

- The regional groundwater flow direction is to the southwest, and flow velocities are estimated to range from 0.01 to 0.1 foot/day, increasing with depth in the aquifer. Due to the complexity of the hydrogeological environment, many local anomalies occur in the overall regional flow pattern.

ES.2.2 Water Quality -- General

- Groundwater sampled from the northeast perimeter monitor wells contained only low levels of a few volatile organic compounds and was free of the pesticides and herbicides analyzed, as well as dimethylnitrosamine (DMN). This indicates little or no migration of contaminants onto MAFB from off-Base sources in the uppermost portion of the regional aquifer.

- The most common volatile organic compound found in consistently measurable concentrations (greater than 0.0001 mg/L) was trichloroethylene (TCE). The highest levels of TCE (up to 0.460 mg/L) were found in monitor wells downgradient of the ACW area. The next highest levels (up to 0.100 mg/L) were found in monitor wells downgradient of the 7100 Area. Only a trace concentration of TCE (0.00026 mg/L) was found in one sample from one well downgradient of the West Ditch. The only other VOA compounds confirmed to be present, at levels exceeding the state action level, were 1,1-dichloroethene and tetrachloroethene, found in wells downgradient from the 7100 Area.

The available data indicate that shallow groundwater at MAFB has been contaminated in the vicinity of the sites discussed below. Due to the heterogenous nature of the shallow materials, the potential pathways for contaminant migration will be controlled by the zones of highest hydraulic conductivity within the shallow sediments. The available data also indicate that deeper zones in the aquifer tapped by the remote Base production wells (GC-2 and the ACW well) have been affected by contaminants generated either on MAFB or at an off-site upgradient source. However, data for the deep aquifer zones are limited, and are therefore not conclusive, especially regarding quality of water entering the site from the upgradient direction.

ES.2.3 Base Production Wells

Data from the Base production wells do not indicate the presence of significant contamination, apart from the exceptions described below:

- The ACW well is a relatively shallow well (250 feet) that is no longer in use. This well contains 0.076 mg/L trichloroethylene, exceeding the California action level for this compound. 1,1,1-Trichloroethane was also confirmed in this well at a concentration of 0.0037 mg/L. The perforated intervals in this well are from 198 to 227 feet and from 234 to 244 feet below ground surface. The ACW well therefore intercepts groundwater immediately below that intercepted by the ACW area monitor wells (MAFB 1, 2, and 3). Comparison of water quality in the production well and the monitor wells indicate that the production well is being slightly affected by contamination generally occurring in more shallow aquifer zones in the ACW area.

- The golf course well GC-2 was found to contain 1,1,1-trichloroethane at levels between 0.0062 and 0.0095 mg/L. These levels do not exceed the California action level of 0.200 mg/L for that compound. Both golf course wells (GC-1 and GC-2) and the JTC well exhibited relatively high levels of TOC (in excess of 10 mg/L).

ES.2.4 ACW Area

- Concentrations of TCE in the three monitor wells in the ACW area exceeded the California action level for this parameter. The highest concentration, found in MAFB-1, was 90 times greater than the action level. In addition to having higher concentrations of TCE than the other two monitor wells, samples from the ACW monitor contained low levels of several other volatile organic contaminants that were not confirmed in both sampling rounds.

- The quality of the shallow groundwater in the ACW area has been affected by past operations in the area.

- Based on the concentration of TCE in the ACW production well it appears that water quality in the deeper aquifer zone has been slightly affected by past operations. The production well, however, appears to be upgradient of the probable contaminant source (the discharge pipe) and is also upgradient of the monitor wells. The absence of significant contaminant concentrations in the production well is not conclusive evidence that deeper aquifer zone(s) are not contaminated downgradient of the discharge pipe, particularly in the vicinity of MAFB-1.

- Based on the hydrogeological conditions and water quality in the shallow aquifer, there is a potential threat to the family housing production wells.

ES.2.5 7100 Area

- Concentrations in the groundwater samples from the monitor wells in the 7100 Area was found to exceed California action levels in at least one monitor well for 1,1-dichloroethene, trichloroethylene, and tetrachloroethene.

- Concentrations of TCE were higher in MAFB-8 than in the other two monitor wells. This is consistent with groundwater flow directions on the Base which indicate that MAFB-8 is the monitor well most directly downgradient from the 7100 Area landfill. The other two monitor wells would intercept flow from areas outside the landfill, as well as within the landfill, potentially resulting in dilution of contaminants by mixing with uncontaminated groundwater.

- The results of analyses for VOA, TOC, and specific conductance indicate that groundwater quality has been affected by the 7100 Area landfill.

- The monitor wells at the 7100 Area are adjacent to the downgradient Base boundary. Therefore, a strong potential exists for contaminant migration off-base from this source.

ES.2.6 West Ditch Area

- No Federal standard or state action level was exceeded in groundwater samples from the West Ditch area.

- A low concentration of TCE was found in a single sample from MAFB-10, below the California action level. The presence of TCE was not confirmed in other 1985 sampling rounds.

- Based on available data, shallow groundwater in the West Ditch area does not appear to have been significantly impacted.

- The West Ditch sediment samples were not found to contain any of the Priority Pollutant VOA Compounds above detection limits. On the basis of these data it is concluded that these sediments are not presently acting as a source of organic contaminants in groundwater.

- The heterogenous nature of the geologic materials at MAFB could result in contaminant migration in discrete zones in these materials. It is possible that the West Ditch area does contain contamination that is migrating off-base; however, the site-specific data do not support such a conclusion.

ES.2.7 Northeast Perimeter

- TCE was not found in the two northeast perimeter monitor wells. The only VOA compound confirmed was 1,1,1-trichloroethane, at a level well below the state action level in MAFB-6.

- Based on available data, shallow groundwater at the northeast (upgradient) perimeter of the Base has not been significantly affected by sources upgradient of the Base.

- Because of the hydrogeologic setting of the Base it is not possible to extend the above conclusion to the deeper portions of the aquifer. The quality of groundwater entering the Base in deeper aquifer zones cannot be determined on the basis of existing data.

ES.3 RECOMMENDATIONS

The findings of the Phase II Problem Confirmation Study at three waste disposal sites indicate the need for additional investigations at all four investigated sites.

ES.3.1 General Recommendations

The following general recommendations are made for routine groundwater monitoring on-Base and additional IRP investigations to be performed at Mather Air Force Base.

- A long-term sampling and monitoring program should be initiated at the Main Base and Family Housing production wells. The purpose of this program is to monitor the quality of the groundwater entering Mather AFB from the northeast (Main Base production wells) and the migration of contamination in the ACW Area (Family Housing wells).

- Due to the heterogeneity of hydrogeological conditions beneath the Base, and the need for better geological definition of the subsurface, it is recommended that future monitor wells be drilled by means of air hammer/casing drive techniques. Alternatively, borehole geophysics could be used in combination with mud rotary drilling techniques to better define subsurface geology and choose appropriate completion intervals.

ES.3.2 ACW Area - Recommendations

Upper aquifer contamination with TCE has been confirmed in the ACW area on the basis of sampling to date. The suspected source is a vertical pipe into which solvents were reportedly discharged directly to the soil. This indicates the existence of a localized area of highly contaminated soil somewhere in the ACW area.

The following recommendations are made to identify the source and the area of contaminated soil:

- Conduct additional intensive file search, review of building plans and aerial photography, and interviews of personnel to narrow the area of search.

- Conduct a combined ground penetrating radar (GPR) and magnetometer survey over a 25- or 50-foot grid to identify conductive or magnetic anomalies in the shallow subsurface. This effort should be supplemented in suspect areas with a fine grid survey in order to locate the pipe.

- Conduct a soil gas monitoring program designed to measure the concentration of TCE in the shallow subsurface beneath the site by sampling soil gas at several points in an array and executing in situ analyses for TCE. In this way, a contour map of TCE concentrations in soil can be generated within a short time frame which should enable the source area to be pinpointed.

- Following determination of the source area through combined geophysical and soil gas sampling means, the presence and extent of TCE in soil should be confirmed by collecting soil samples for laboratory analysis. Due to the presence of cobbles near the surface in the ACW area, it is anticipated that auger drilling to any significant depth would not be possible. For this reason, it is recommended that a backhoe excavation be conducted at the source site and soil samples collected directly from the bottom and sides of the excavation. It is anticipated that 8 to 10 soil samples would be collected for analysis.

- Based on the location of the source in the vadose zone, additional downgradient monitor well locations should be selected to further define the extent of groundwater contamination. It is recommended that up to three nests of three monitor wells (approximately 150, 200, and 400 feet deep) each be located downgradient of the source, with at least two on a line between the ACW area and the nearest family housing production well (FH-3).

- A single monitor well should be located upgradient of the source in the shallow aquifer.

The use of well nests will allow better definition of subsurface hydrogeological conditions, including isolation of permeable zones, identification of vertical hydraulic gradients, and evaluation of the potential for downward as well as lateral migration of contaminants. Sampling of these wells will yield a three-dimensional picture of the distribution of contamination downgradient of the site by providing sampling points in the horizontal and vertical dimensions.

ES.3.3 7100 Area - Recommendations

The following recommendations are made to provide some degree of source control and further define the magnitude and extent of groundwater contamination in the vicinity of the 7100 Area landfill:

- Remove or cover hardfill on the surface of the landfill and regrade in a mounded configuration. Compact the cap material, cover with topsoil, and plant with grass seed. These measures will serve to minimize infiltration of precipitation into the fill material.

- Install a single monitor well 30 feet into the aquifer directly between the Fire Department Training Area (FDTA) and the 7100 Area landfill. Sample this well concurrently with the downgradient monitor wells and compare the results to distinguish any contaminants contributed by the FDTA from those contributed by the landfill itself. In addition to previous analytical parameters, samples should be analyzed for sulfate, chloride, and boron, which are contaminants that are commonly associated with landfill leachate.

- Conduct an electromagnetic (EM) survey of ground surface off-base and downgradient from the landfill. The survey should be conducted at three separate spacings to provide vertical, as well as lateral definition for subsurface conductivity. It should be noted that, due to the depth of the water table (60 to 70 feet) and the complexity of the geologic terrain, the success of this method would not be guaranteed. Based on the difference in specific conductance between groundwater downgradient of the fill and background, however, it is anticipated that EM can be successfully used to track a plume of mineralized (i.e., conductive) groundwater emanating from the landfill area.

- Install three nests of two wells each to further define the lateral and vertical extent of contamination downgradient. Install one nest between the existing monitor wells MAFB-8 and MAFB-9 to better define migration pathways in shallow aquifer zones, and two nests off-Base in a downgradient direction, one on a line with the JTC production well.

ES.3.4 West Ditch - Recommendations

Although only relatively low concentrations of TCE have been detected in groundwater sampled from MAFB-10 and none has been detected in MAFB-11, groundwater sampled by the State of California in nearby residential wells, particularly in the Camellia Mather Mobile Home Park, has consistently exhibited levels of TCE slightly in excess of the State action level of 0.005 mg/L.

It is recommended, therefore, that additional monitor wells be drilled to further test for the presence of TCE in groundwater in the vicinity of the West Ditch. Specifically, it is recommended that another monitor well be drilled next to MAFB-10 and screened 50 to 60 feet deeper (depending on the lithology encountered). In addition, it is recommended that another pair of monitor wells at equivalent depths be drilled at a location approximately 200 feet north of MAFB-10. Based on the chemical results for groundwater sampled from MAFB-11, it is recommended that no further monitor wells be installed in a southerly direction from this site.

SECTION 1

INTRODUCTION

1.1 INSTALLATION RESTORATION PROGRAM

The purpose of the Installation Restoration Program (IRP) is to assess and control the potential migration of environmental contamination that may have resulted from past operations and disposal practices on DoD facilities. In response to the Resource Conservation and Recovery Act of 1976 (RCRA), and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA, or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June 1980 (DEQPPM 80-6), requiring identification of past hazardous waste disposal sites on DoD installations. The U.S. Air Force implemented DEQPPM 80-6 in December 1980. The program was revised by DEQPPM 81-5 (11 December 1981), which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 on 21 January 1982. The Installation Restoration Program has been developed as a four-phase program, as follows:

- Phase I - Problem Identification/Records Search
- Phase II - Problem Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Corrective Action

The Phase II, Stage 1, Problem Confirmation Study portion of the IRP effort at Mather Air Force Base was included in the effort described in this report. Definitions of the terms, nomenclature, acronyms, and units of measurement used in this report are contained in Appendix A.

1.2 PROGRAM HISTORY AT MATHER AIR FORCE BASE

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (USAF OEHL) under Contract Number F33615-80-D-4006, to provide general engineering, hydrogeological, and analytical services. The Phase I Problem Identification/Records Search for Mather Air Force Base (MAFB) was accomplished by CH2M-Hill in

March 1982, and their final report was dated June 1982. In response to the findings contained in the CH2M-Hill Phase I Final Report, the USAF OEHL requested that WESTON conduct a presurvey visit of MAFB. The purpose of this presurvey was to obtain sufficient information to develop a work scope and cost estimate for conducting a Phase II, Stage 1, Problem Confirmation Study at MAFB. The presurvey visit was conducted by two WESTON personnel in April 1983, and the results, including work scope and cost estimate, were submitted in a letter to USAF OEHL dated 19 May 1983.

Following modifications of the original work scope, Task Order 0026-02 (dated 30 March 1984) was issued, authorizing a Phase II, Stage 1, Problem Confirmation Study at three waste disposal sites and at the northeast Base perimeter. At the request of the State of California, three rounds of groundwater sampling on all monitor wells were included in the final Task Order. A copy of the formal Task Order is included in this report as Appendix B.

The first phase of field work, including drilling and installation of 11 monitor wells and a survey of well locations and elevations, was performed between 20 February and 10 April 1984. Groundwater elevations were measured at approximately two-week intervals from April to November 1984. Sampling was performed in three rounds on 3 to 9 May, 13 to 20 August, and 27 September to 16 October. In order to rectify QA/QC problems encountered in these sampling rounds, additional sampling was conducted on 13 to 20 November 1984, 29 May to 3 June 1985, and 26 to 27 June 1985.

1.3 BASE PROFILE

1.3.1 Mission and Organization

Mather Air Force Base is located on 5,798 acres, approximately 12 miles east of downtown Sacramento, California. The Base is situated approximately midway between San Francisco and Lake Tahoe, and is directly south of the community of Rancho Cordova. An index map showing the location of MAFB is presented in Figure 1-1.

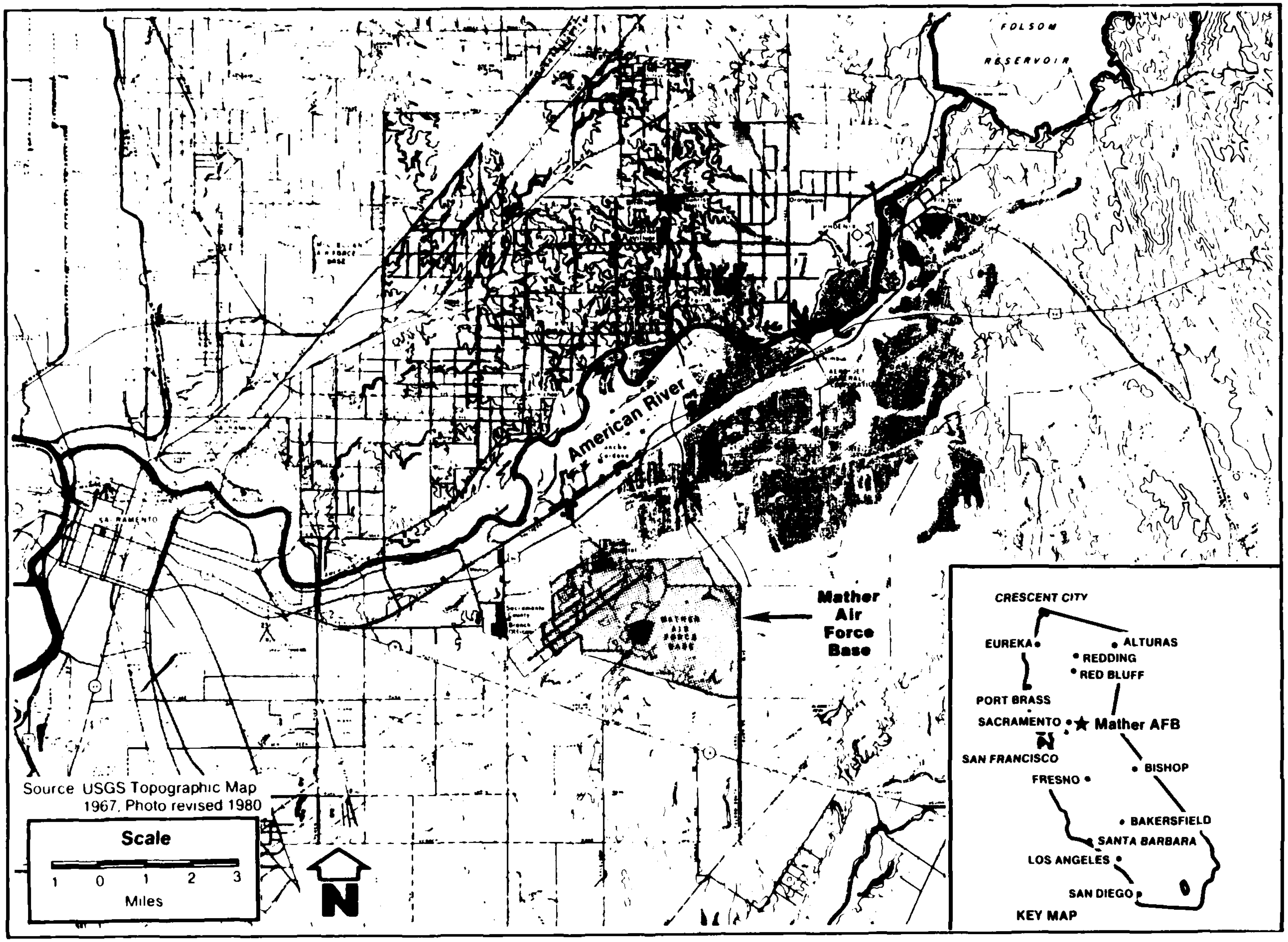

FIGURE 1-1 INDEX MAP FOR MATHER AFB

Construction of MAFB began in March 1918. After a few years as a flight training school, the Base was deactivated in June 1922. It was reactivated for a short period between March 1930 and November 1932, but was not involved in continuous military action again until World War II.. In 1941, it was reactivated and rebuilt as a school for pilot and navigator training. MAFB officially resumed its training mission in December 1945, becoming the first school for navigators and bombardiers.

In 1958, the Strategic Air Command (SAC) assigned the 4134th Strategic Wing to Mather as a tenant organization. In February 1963, the 320th Bombardment Wing was activated and replaced the 4134th Strategic Wing. In April 1973, the 323rd Flying Training Wing was activated and assumed the navigator training mission.

In July 1976, undergraduate navigator training for the U.S. Navy and U.S. Coast Guard, and support of the Marine Aerial Navigation School, was assumed by the 323rd Flying Training Wing, which became the only navigation training wing to provide undergraduate and advanced training to all services under the Department of Defense.

The 323rd Flying Training Wing of the Air Training Command (ATC) remains the current host unit at MAFB. The primary mission is to "qualify nonrated officers as navigators; and provide the navigator with the technical training, experience, guidance, and motivation required to operate the advanced navigation, bombing, missile, and electronic warfare systems used by the United States Armed Forces." There are 44 aircraft currently assigned to the training program. These include 31 T-37B aircraft and 13 T-43A aircraft. The total DoD work force on MAFB numbers 6,724, of whom 3,240 are military airmen, 1,641 are military officers, and 1,843 are civilians.

The major tenants at MAFB are the following:

- 320th Bombardment Wing (SAC)
- Detachment 7, 24th Weather Squadron
- 2034th Communications Squadron
- 3506th U. S. Air Force Recruiting Group
- Detachment 515, 3751st Field Training Squadron
- AFOSI Detachment 1904
- Detachment 3, 3314th Management Engineering Squadron
- Detachment 448, Area Audit Office
- U.S. Air Force Air Patrol Pacific Liaison Region
- Army Aviation Support Facility
- U.S. Air Force Judiciary Area Defense Counsel
- 940th Air Refueling Group
- Federal Aviation Administration
- Air Force Commissary Services

1.3.2 Past Disposal Sites

Past Air Force activities at MAFB in support of assigned missions have resulted in several waste disposal sites located on Base. A total of 23 disposal and spill sites on MAFB were identified in the Phase I Records Search by CH2M-Hill as being of potential concern.

Three of these sites were eliminated from further consideration based on the type of waste disposed. The remaining 20 sites were rated in accordance with the IRP Hazard Assessment Rating Methodology (HARM). The results of these ratings are summarized in Table 1-1. Based on these ratings and all other pertinent data, CH2M-Hill recommended that Phase II activities concentrate on the three sites with the highest ratings, sites Nos. 7, 12, and 15. The locations of all sites are shown in Figure 1-2.

From the Phase I report the three highest ranking sites were determined to need problem confirmation studies. In addition, the northeast Base perimeter was determined to require groundwater monitoring to establish background water quality conditions on the upgradient boundary of the installation. The following is a list of the sites evaluated during the Phase II, Stage 1, Problem Confirmation Study:

- ACW disposal site (site No. 12).
- 7100 Area disposal site (site No. 7)
- West Ditch (drainage ditch site No. 3) (site No. 15).
- Northeast (NE) Base perimeter.

The locations of these sites are shown in Figure 1-3.

The text that follows provides a brief history and description of each site.

1.3.2.1 History and Description of the ACW Disposal Site (Site No. 12)

This site is located in the Air Command and Warning (ACW) area of the Base, in the east-center of the Base between the alert apron and the family housing section. Figure 1-4 is a general site map for the ACW Area. Morrison Creek, an ephemeral stream, flows south of the site from northeast to southwest. A small pond (formed by damming the stream) occurs 400 feet to the southwest of the site.

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Table 1-1

Priority Ranking of Potential Contamination Sources
Mather Air Force Base

Site Rank	Phase I Site No.	Site Name	Date of Operation or Occurrence	Overall Total Score
1	12	ACW Disposal Site	1960 - 1966	85
2	7	7100 Area Disposal Site	1955 - present[1]	79
3	15	Drainage Ditch Site No. 3	1920's - present	78
4	13	Drainage Ditch Site No. 1	1920's - present	71
5	14	Drainage Ditch Site No. 2	1920's - present	66
6	17	Weapons Storage Area Septic Tank	1950's - 1978	60
7	4	NE Perimeter Landfill No. 2	1967 - 1971	52
8	11	Existing Fire Department Training Area	1958 - 1983	51
9	23	Sanitary Sewer System East of Eknes Street	1940's - present	51
10	8	Fire Dept. Training Area No. 1	1920's - 1945	49
11	10	Fire Dept. Training Area No. 3	1947 - 1958	48
12	3	NE Perimeter Landfill No.1	1950 - 1967	48
13	6	Firing Range Landfill Site	1972 - 1974	47
14	9	Fire Dept. Training Area #2	1945 - 1947	47
15	2	8150 Area Landfill	1942 - 1950	46
16	20	MOGAS Spill Site	1982	44
17	1	Runway Overrun Landfill	1920's - 1942	42
18	18	Old Burial Site	1940's	42
19	19	Fuel Tank Storage Burial Site	Prior to 1959	41
20	5	NE Perimeter Landfill No. 3	1971	[illegible]

[1]Since 1975 only inert materials have been disposed of at this site.

Source: CH2M-Hill (1982) and USAF OEHL records.

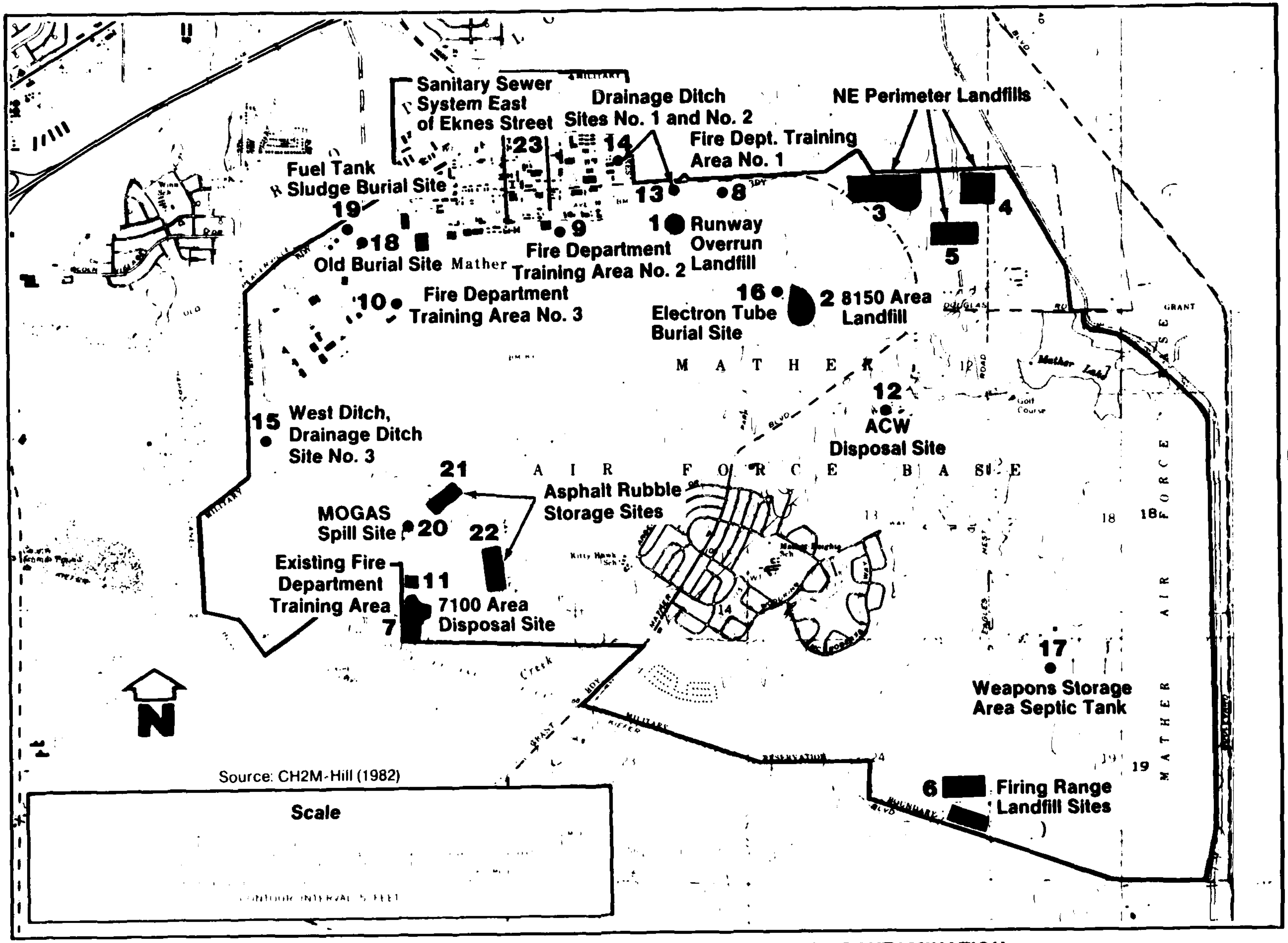


FIGURE 1-2 LOCATION OF POTENTIAL SOURCES OF CONTAMINATION IDENTIFIED IN PHASE I

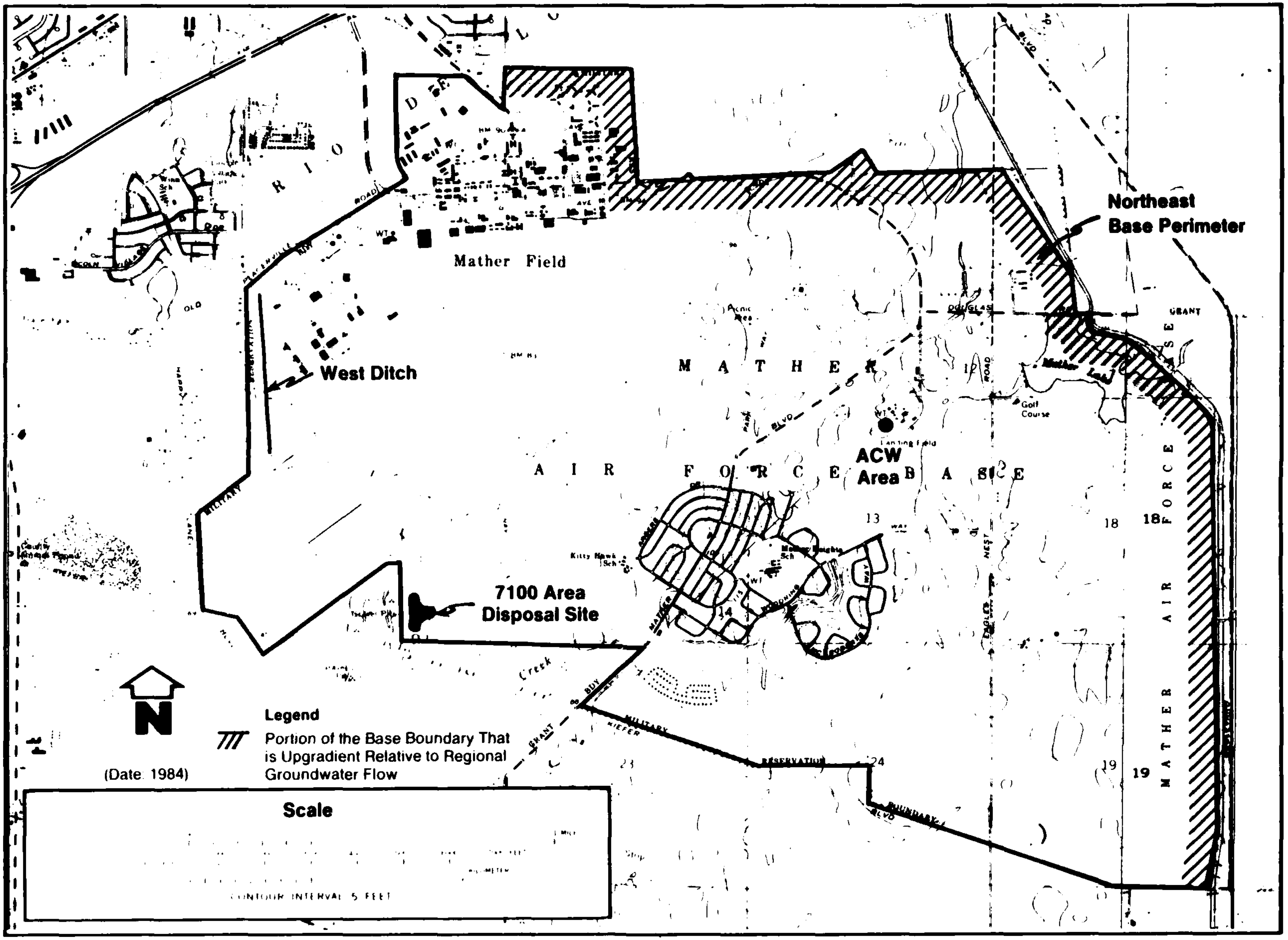


FIGURE 1-3 LOCATION OF PHASE II, STAGE I INVESTIGATION SITES AT MATHER AFB

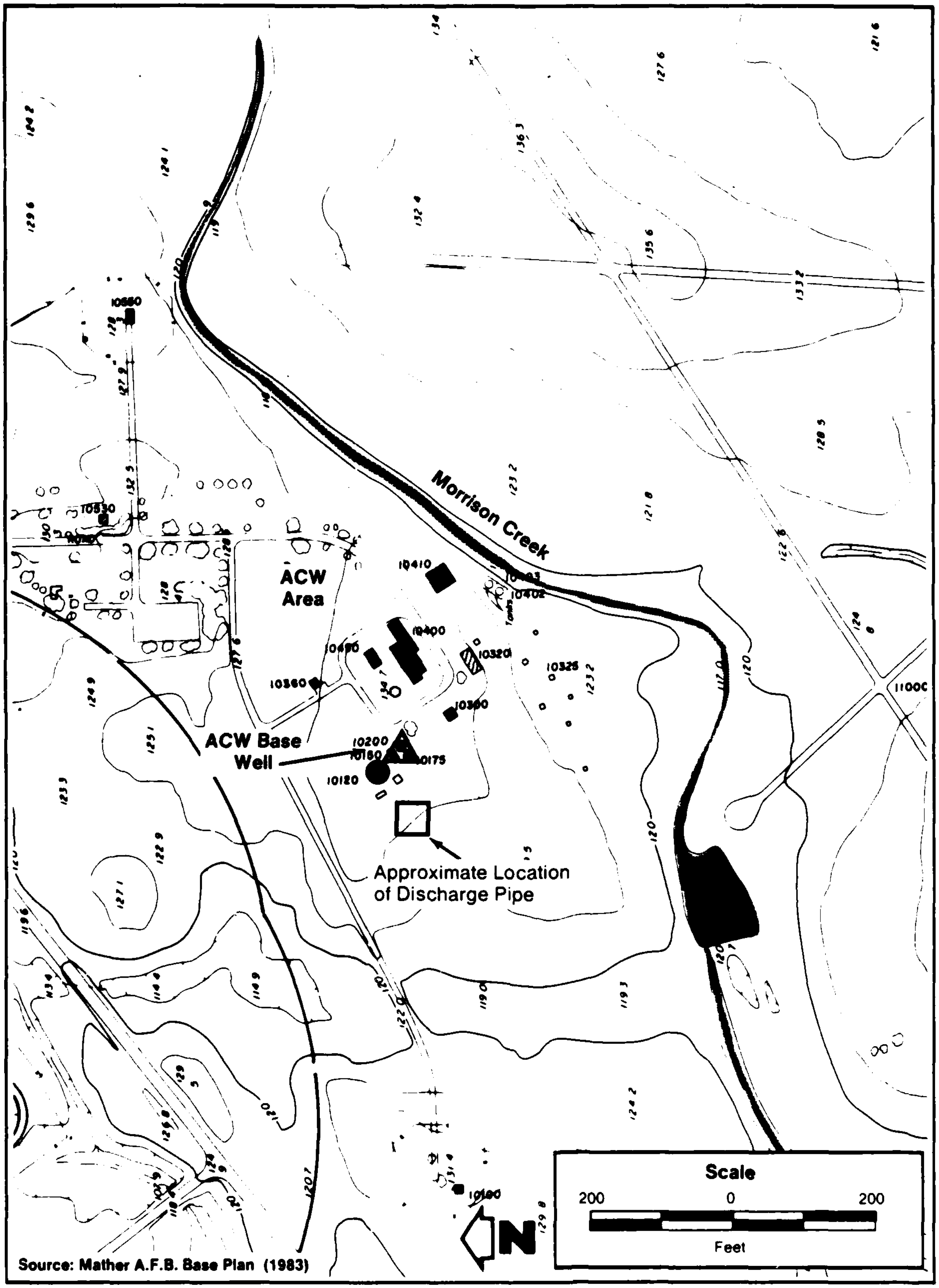


FIGURE 1-4 GENERAL SITE MAP FOR THE ACW DISPOSAL SITE

The site was constructed in the late 1950's as part of the Air Defense Command early warning system. The 668th ACW Squadron, which operated the site jointly with the Federal Aviation Administration (FAA), left MAFB in 1966. The site is currently occupied by the FAA and SAC Security Police Headquarters. It was reportedly common practice from 1960 (and possibly prior to 1960) until 1966 for personnel at the ACW radar site to dispose of waste solvents and oils into a waste disposal pipe located approximately 100 feet southwest of the ACW well. One interviewee recalled disposing of waste trichloroethylene (TCE), used for cleaning air intake filters and transformers, and transformer oil that may have contained polychlorinated biphenyl (PCB) compounds. Other wastes reportedly disposed of included waste engine oils, carbon tetrachloride, and antifreeze. CH2M-Hill estimated that approximately 1,350 gallons of TCE and 1,225 gallons of waste transformer oil were disposed of in the pipe between 1958 and 1966.

The pipe was described as about 10 inches in diameter with a removable cap. The Base Bioenvironmental Engineering (BEE) staff collected soil samples in November 1979 to determine the exact location of the past disposal site and the extent of soil contamination. A backhoe was used to excavate an area approximately 30 feet long and 15 feet wide. Excavation depths ranged from 4 feet at the edges to a maximum of 6 feet at the center of the site. Seven soil samples were collected at 3- to 6-foot depths and analyzed for TCE and PCB's. However, the results were negative, and the exact location of the pipe was not found.

1.3.2.2 History and Description of the 7100 Area Disposal Site

The 7100 Area disposal site is located in the southwestern section of the Base, south of the now abandoned sewage treatment plant (STP). Figure 1-5 is a general site map for the 7100 Area disposal site, which is bounded immediately to the north by the current Fire Department Training Area (site No. 11 in the Phase I report), to the east by the STP oxidation ponds, to the south and west by the Base boundary. A borrow pit, located off-base to the west, was excavated to approximately 40 feet below grade.

The 7100 Area landfill was also originally a borrow pit, excavated in 1953 for construction of the SAC area. The pit, originally about 40 feet deep, has been used since 1953 for waste disposal, and has been completely filled with refuse.

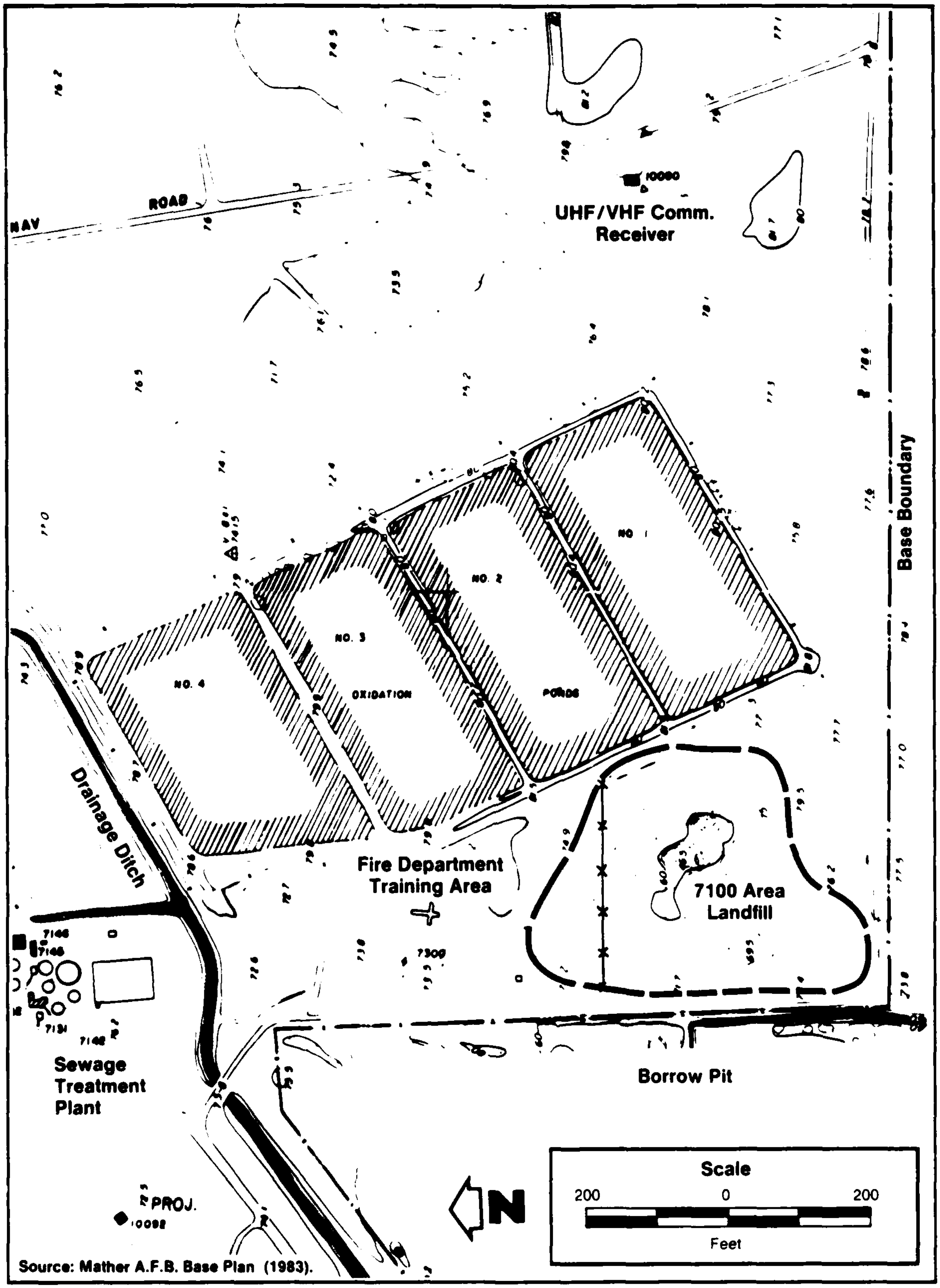


FIGURE 1-5 GENERAL SITE MAP FOR THE 7100 AREA DISPOSAL SITE

This site was also known as the "nonburn dump" and the "construction rubble disposal site." It is currently used for disposal of inert construction rubble, but was reportedly used in the past for all types of wastes, except household garbage which was sent to the Base sanitary landfills for disposal. From 1953 until about 1966 the landfill was a major disposal site for POL wastes. Bowsers (500-gallon capacity) containing POL wastes from the industrial shop areas were routinely transported to this site for disposal. TCE was in common use at MAFB during most of this time, and may have been commingled with the waste oils disposed of at this site. The practice was curtailed in 1966 when an oily seepage was observed leaching into the adjacent borrow pit. Other wastes reportedly disposed of included empty drums, sludge from the plating shop dip tanks (approximately 80 gallons per year until 1975), absorbent sand used in cleaning up oil and solvent spills, paint chips, waste paints and thinners, and one known incident of disposal of transformer oil that may have contained PCB's.

1.3.2.3 History and Description of the West Ditch (Drainage Ditch Site No. 3)

The West Ditch flows from north to south along the western Base perimeter between Perimeter Road and the Base boundary. It is located adjacent to and directly west of the SAC area of the Base. It is an unlined open drainage ditch that receives storm drainage from the entire Main Base area, including the ATC and SAC shop areas. Figure 1-6 is a general site map of the West Ditch area.

After installation of an oil skimmer in 1967, it was reported that waste oils and solvents were dumped directly into the skimmer, thereby overloading the skimmer and causing the waste oils and solvents to overflow into the ditch. A past waste inventory indicated that about 30 drums of TCE were on hand in the SAC area. It is possible that some of this TCE was included in the wastes that overflowed into the ditch. One of the interviewees indicated that, prior to the installation of the skimmer, an underground tank was located at this site for POL waste disposal and that this area was commonly referred to as the waste oil disposal site. This tank was evidently removed when the skimmer was installed.

This site may also have been subject to spills and dumping of POL waste on the ground and in the ditch. Many of the floor drains in the shop areas were also connected to the storm sewer system, and waste oils and solvents from inside the shops (spills and cleaning) may have entered the West Ditch.

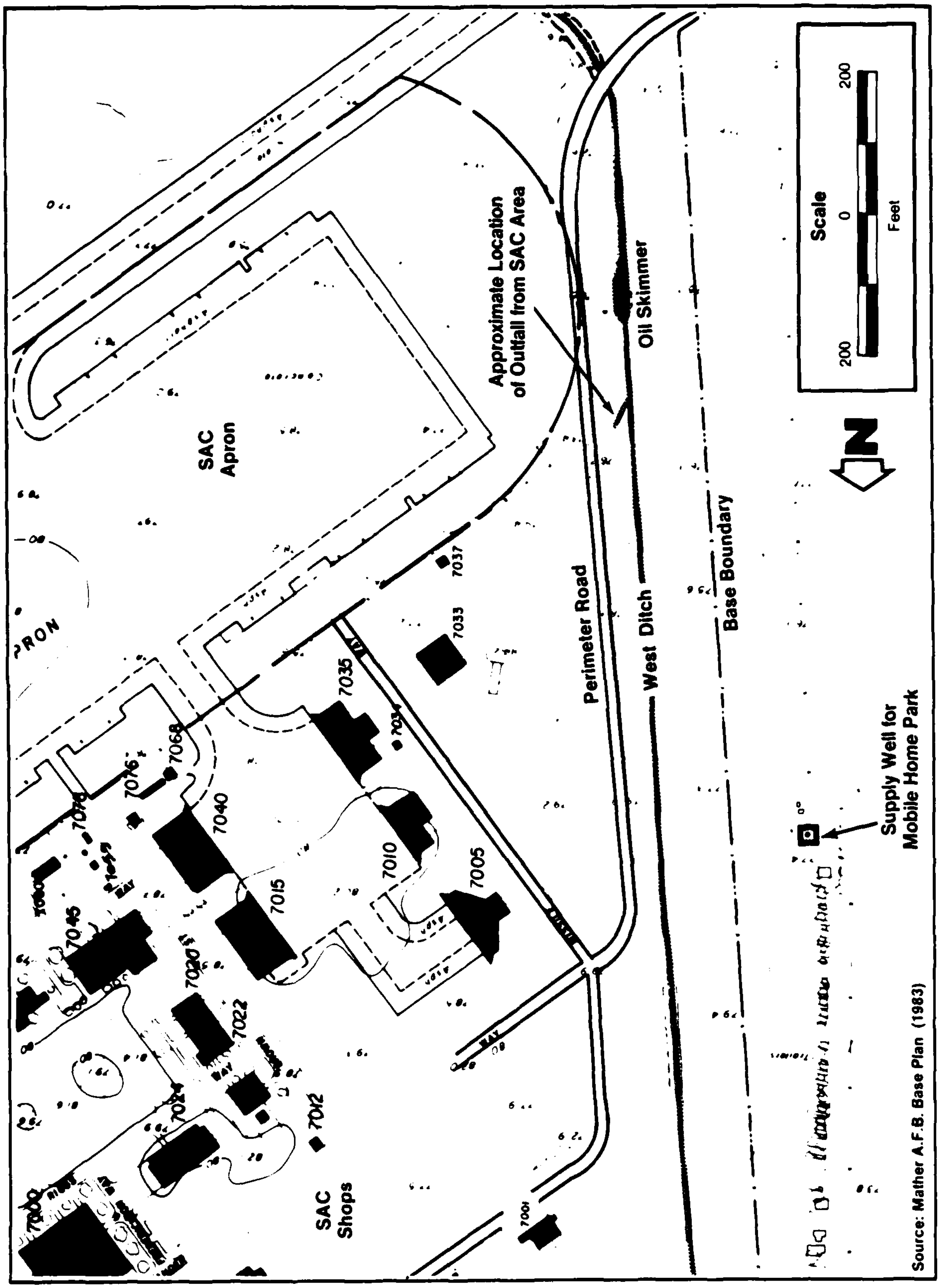


FIGURE 1-6 GENERAL SITE MAP FOR THE WEST DITCH

1.3.2.4 History and Description of the Northeast Base Perimeter

The northeast Base perimeter is the area of MAFB that is upgradient relative to the natural regional groundwater flow direction. Contamination carried in groundwater to MAFB from adjacent properties would most likely enter the Base from this direction. Two major industrial properties, now both owned by Aerojet-General Corporation, are located northeast and east of MAFB. The two properties combined occupy thousands of acres and have been used for the manufacture and testing of rocket propellants and associated industrial activities. According to the Phase I report (CH2M-Hill, 1982, page V-1), a portion of the Aerojet property, approximately 5 miles upgradient from MAFB, "is known to have serious groundwater contamination." The Aerojet-General site is a high priority site on the California Superfund list and is being evaluated and remediated by the responsible party in cooperation with the California Department of Health Services (DOHS). For this reason, the Phase I report recommended the installation of monitor wells on the northeastern and eastern perimeters to "serve as indicators of upgradient background water quality" and "to indicate if groundwater contamination is migrating onto the Base from off-base industrial areas" (CH2M-Hill, 1982, p. VI-5).

1.4 CONTAMINATION PROFILE

According to the Phase I report, industrial operations at MAFB have been associated primarily with routine aircraft maintenance. Primary chemicals of concern are waste oils and fuels, solvents and cleaners, and minor amounts of paint and plating wastes. Most of the industrial operations have been in existence since 1941, and the quantities of waste generated during prior periods of Base activation (1918 to 1922 and 1930 to 1932) are considered comparatively small. Expanded industrial activities related to the SAC mission resulted in increased waste generation rates after 1958. However, the quantities of wastes generated at MAFB are relatively small compared to those produced at Bases with major aircraft maintenance, overhaul, and other industrial missions. Standard procedures for industrial waste disposal in the past have included landfilling, fire department training, and contractor salvage.

Based on the Phase I report, the key chemical parameters of potential concern at MAFB are: volatile organic compounds (VOA), oils and greases, phenols, cyanide, and selected metals (chromium, lead, cadmium, nickel, and silver). In addition, certain pesticides and herbicides (DDT, chlordane, and 2,4-D) and dimethyl nitrosamine (DMN), a rocket fuel by-product, are suspected of being in the groundwater upgradient of MAFB. Total organic carbon (TOC) is a general indicator parameter for potential organic contamination, and was included as a screening parameter. The Task Order required that three rounds of groundwater samples be collected from the 11 new monitor wells and one round of groundwater samples be collected from 15 existing Base production wells in the continuing effort to assess whether or not past disposal operations had adversely affected the environment and the Base drinking water supply. In addition, two ditch sediment samples were to be collected upstream and downstream from the West Ditch oil skimmer. The parameters to be analyzed at each site are listed in Table 1-2. Details of the sampling and other field work accomplished by WESTON at MAFB are provided in Section 3 of this report.

1.5 PROJECT TEAM

The Phase II, Stage 1, Problem Confirmation Study at MAFB was conducted by staff personnel of Roy F. Weston, Inc. and was managed through WESTON's home office in West Chester, Pennsylvania.

1.5.1 WESTON Personnel

The following personnel served lead functions in this project:

Peter J. Marks, Program Manager: Corporate Vice President, Master of Science (M.S.) in Environmental Science, 20 years experience in laboratory analysis and applied environmental science.

Frederick Bopp, III, Ph.D., P.G., Project Manager: Manager of the Geosciences Department, Doctor of Philosophy (Ph.D.) in Geology and Geochemistry, Registered Professional Geologist (P.G.), over 8 years experience in hydrogeology and applied geological sciences.

Table 1-2

Analytical Protocol for Problem Confirmation Study -- Mather Air Force Base

SITE	POTENTIAL CONTAMINANTS	MEDIUM	ANALYTES
1. ACW Disposal Site	Waste solvents, engine and transformer oils.	Groundwater	TOC, oil and grease VOA, PCB
2. 7100 Area Disposal Site	Waste fuel, oils, solvents, plating sludge	Groundwater	TOC, oil & grease VOA, Phenol, Cyanide Cr, Pb, Cd, Ni, Ag
3. West Ditch	Industrial chemicals, waste fuel, oils, solvents	Groundwater	TOC, oil & grease VOA, Phenol, Cyanide Cr, Pb, Cd, Ni, Ag
		Sediment	Oil and grease, VOA Phenol, cyanide, TOC, Cr, Pb, Cd, Ni, Ag
4. NE Perimeter	Solvents, metals, pesticides and herbicides rocket fuel by-products	Groundwater	TOC, oil and grease VOA, Cr, Pb, Cd, Ni, Ag, DMN, DDT, chlordane, 2,4-D
5. Base Production Wells			
•Main Base	Industrial Chemicals, Waste solvents oil and fuels	Groundwater	TOC, oil and grease VOA, Cr, Pb, Cd, Ni, Ag, DMN, DDT, chlordane, 2,4-D
•Family Housing	Waste solvents, oil and fuel	Groundwater	TOC, oil & grease, VOA
•Golf Course	Waste solvents, oil and fuels	Groundwater	TOC, oil & grease, VOA
•K-9	Waste solvents, oil and fuels	Groundwater	TOC, oil and grease VOA
•ACW	Waste solvents, engine and transformer oil	Groundwater	TOC, oil and grease VOA, PCB
•JTC	Waste solvents, oils and fuels, plating waste	Groundwater	TOC, oil and grease VOA, phenol, cyanide, Cr, Pb, Cd, Ni, Ag

Katherine A. Sheedy, P.G., Project Manager: M.S. in Geology, 10 years experience in geology and hydrogeologic investigations.

Alison L. Dunn, P.G., Project Geologist: M.S. in Hydrogeology, Registered Professional Geologist (P.G.), over three years experience in hydrogeological site evaluation.

Walter M. Leis, P.G., Geotechnical Quality Assurance Officer: Corporate Vice President, M.S. in Geological Sciences, Registered Professional Geologist (P.G.), over 10 years experience in hydrogeology and applied geological science.

James S. Smith, Ph.D., Project Chemist: Manager of Laboratory Services, Ph.D. in Analytical Chemistry, over 10 years experience in laboratory analysis.

Professional profiles of these key personnel, as well as other project personnel, are contained in Appendix C.

1.5.2 Subcontractors

Soil borings, drilling, and well installation for this project were performed by the Stang Drilling and Exploration Company, Inc. of Rancho Cordova, California.

1.6 FACTORS OF CONCERN

There are several factors that impact the potential for migration of contaminants beyond the installation boundary, and which the reader should be aware of in reviewing the following sections:

- Soils underlying the installation and surrounding area include a low permeability layer, or hardpan, occurring just below the surface. This layer forms a barrier to downward migration of contaminants in areas where it has not been breached by excavation or gold dredging. The three disposal sites identified for Phase II investigation (the ACW disposal site, the 7100 Area disposal site, and West Ditch area) are sites where this layer has probably been breached.

- The principal regional direction of groundwater flow in the alluvial aquifer underlying the installation is from northeast to southwest. Contaminants discharged to groundwater northeast of the installation may eventually migrate beneath Mather AFB, and contaminants discharged within the installation boundaries may migrate to areas southwest of Mather AFB. Although the average rate of movement of groundwater is relatively slow, strong differentials in the rates of movement exist between relatively high-permeability buried stream channel sediments and the relatively lower permeability of the alluvial deposits that surround them.

- The solvent trichloroethylene (TCE) has been detected in several wells in the Sacramento area, and there is strong public concern over its presence in local groundwater. The Base production wells have been sampled for TCE since mid-1979. Although several wells have occasionally exhibited detectable levels of TCE, the ACW well is the only well to have consistently exhibited detectable TCE concentrations.

SECTION 2

ENVIRONMENTAL SETTING

Sources of information on the environmental setting of Mather Air Force Base include the climatic records of the U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture Soil Conservation Service (SCS) Soil Survey for Sacramento County, and the following publications on regional geology and hydrogeology: California Department of Water Resources (CDWR, 1964, 1974, and 1978), Rapp (1975), and Wagner and others (1982). These sources and additional information from interviews were summarized in the IRP Phase I Report for MAFB (CH2M-Hill, 1982).

2.1 GEOGRAPHY

Mather Air Force Base is located in the Sacramento Valley on the eastern edge of the Great Valley Physiographic Province, approximately 7 miles west of the boundary with the Sierra Nevada Province. The Great Valley of Central California is a north-south trending, flat-bottomed valley, approximately 400 miles long and an average of 40 miles wide, running from Red Bluff in the north to Bakersfield in the south. The Sacramento Valley comprises the northern section of the Great Valley, is 150 miles long, and is bounded on the west by the North Coastal Ranges. The valley floor in the vicinity of MAFB slopes gently to the southwest toward the Sacramento-San Joaquin River delta region that links drainage from the Great Valley with the San Francisco Bay. Immediately east of the installation, rolling foothills provide transitional topography between the valley and the Sierra Nevada Mountains, which rise abruptly to altitudes of 6,000 to 9,000 feet approximately 50 miles east of Sacramento. Relief on the installation ranges from a high of about 160 feet above MSL on the east-northeast corner of the Base to a low of 70 feet MSL on the southwest end of the runway.

The climate in the Sacramento Valley is Mediterranean to subtropical, characterized by dry, hot summers and moist, cool winters (CH2M-Hill, 1982). The average annual temperature is approximately 60°F; monthly averages range between the mid-40's and the mid-70's. Daily temperatures vary by as much as 25° to 40°F in summer. The average annual precipitation is 17.9 inches, of which approximately 88 percent generally falls in the period from November through April, and over 50 percent in the months from December through February. The mean evapotranspiration for the area of MAFB is 45 inches/year, yielding an average annual net precipitation (actual precipitation minus potential evapotranspiration) of -27 inches.

Surface drainage in the East Sacramento-Rancho Cordova area is provided by the American River, a northeast to southwest flowing tributary of the north-south flowing Sacramento River. The confluence of these rivers is in downtown Sacramento, approximately 10 miles west of MAFB. Although the Base is located just 1 to 2 miles southeast of the channel of the American River (Figure 1-1), surface drainage is to the southwest, controlled by the flow of Morrison Creek. Morrison Creek is an ephemeral stream in its upper reaches that crosses the Base from northeast to southwest and joins the Sacramento River downstream from the confluence of the Sacramento River with the American River.

Natural drainage features at MAFB have been substantially altered by runway construction and installation of storm drains and perimeter ditches. Figure 2-1 is a surface drainage map of MAFB. Morrison Creek has been dammed in the northeast corner of the Base to form Mather Lake, a recreational lake that is fed by off-Base runoff through an aqueduct. The eastern boundary of the Base is bordered by the Folsom Canal, a concrete-lined channel that carries water from Nimbus Lake on the American River to the Rancho Seco power plant several miles to the south. During the summer, Mather Lake is fed by water from the Folsom Canal to maintain a relatively stable water level.

Native soils on the Base consist primarily of gravelly loams, including Bear Creek, Corning, Perkins, and Redding soils. The western edge of the Base is mantled with San Joaquin loam. The gravelly loams are similar in composition and structure, consisting of reddish-brown or brown gravelly loam grading downward to a dense gravelly clay layer between 3 and 5 feet below ground surface, according to CH2M-Hill (1982). The red clay soils that cover the southeast corner of the Base are characterized by a low-permeability or hardpan layer consisting of semi-consolidated gravelly and cobbly material found at 20 to 45 inches below ground surface. These soils are underlain by coarse gravel, and gravel and cobble sediments to depths exceeding 20 feet in most cases.

2.2 GEOLOGY

2.2.1 General

The Sacramento Valley is a deep structural trough bounded on the east and west by steep bedrock mountains and filled with Cretaceous, Tertiary, and Quaternary age sediments. The Sierra Nevada Mountains to the east consist of a tilted fault block of igneous and metamorphic crystalline rock, with a sharp escarpment to the east and a relatively gradual westward slope forming the eastern boundary of the valley.

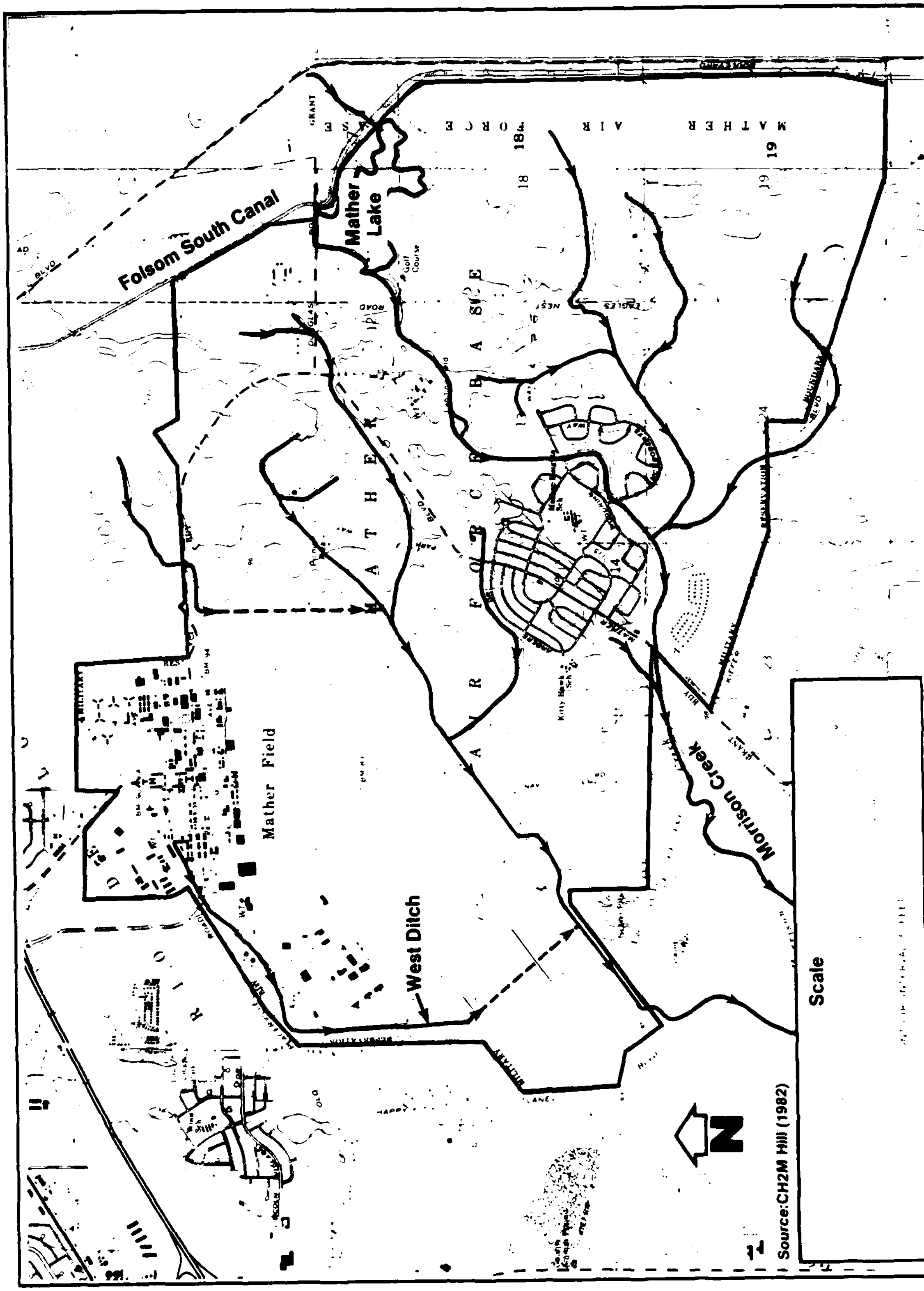


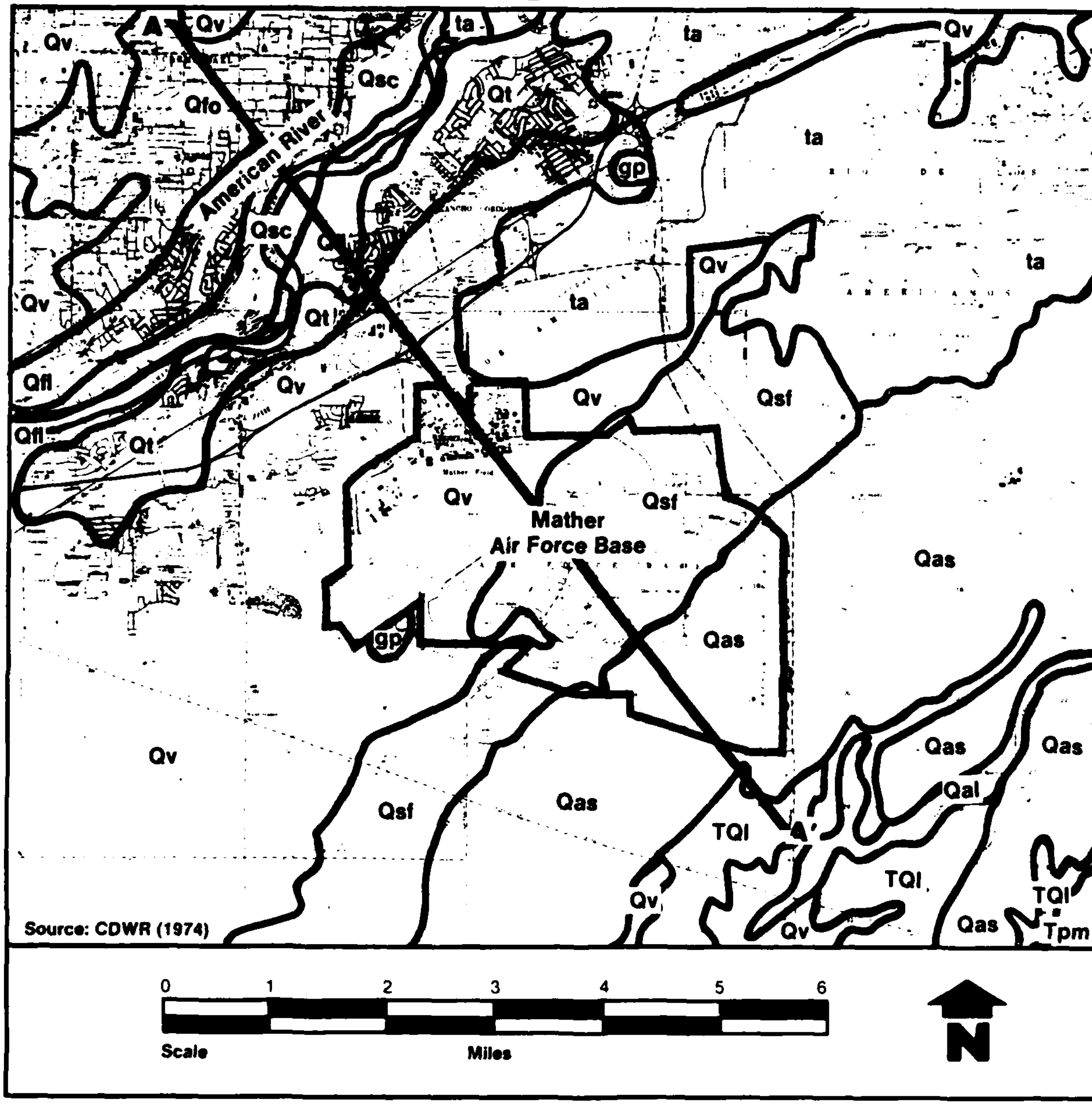
FIGURE 2-1 SURFACE DRAINAGE MAP OF MATHER AFB

The sedimentary deposits underlying the valley floor consist of older consolidated sedimentary rock formations and younger, unconsolidated Quaternary age sediments. These valley-fill deposits were formed first under marine and then under continental conditions, and were derived primarily from erosion of the Sierra Nevada Mountains as they rose to the east. The oldest Cretaceous and Tertiary age formations are exposed only in the foothills at the edges of the valley. The formations dip gently to the west-southwest toward the valley center. Progressively younger sediments are encountered at the surface westward from the foothills, including Older Quaternary age gravelly alluvium and younger age flood plain deposits of sand, silt, and clay adjacent to the American and Sacramento Rivers.

The surficial geology at MAFB is comprised entirely of Quaternary age alluvium (Figure 2-2). Two principal physiographic types are distinguished within the Base area: a dissected alluvial upland on the southeastern two-thirds of the Base, and a low alluvial plain on the northwestern third (including the runway and the Main Base areas). The dissected alluvial upland consists of a remnant alluvial plain, composed of the Pleistocene age South Fork and Arroyo Seco gravels, which were incised and terraced in a step-wise fashion by the lateral movement of the American River northwestward, and subsequently dissected into "mound and hollow" topography by the southwest-flowing branches of Morrison Creek. The low alluvial plain (commonly referred to as the Victor Plain), is a flat, featureless, bouldery depositional plain sloping 5 to 10 feet per mile to the southwest. Sediments in this plain consist of the Pleistocene age sands, silts, and clays of the Victor Formation, formed from the sedimentary debris that resulted from downcutting of the American River into the underlying Laguna Formation.

2.2.2 Stratigraphy

Geological formations in the Sacramento Valley range in age from pre-Cretaceous to Recent. Lithology and water-bearing properties of the major stratigraphic units are summarized in Table 2-1. Pre-Cretaceous age crystalline rocks form the basement complex, dipping about 3 to 4 degrees west-southwest beneath the valley. Overlying the basement rocks are Cretaceous age marine sediments, which are all considered as nonfreshwaterbearing due to the high salinity of the connate water in them. Freshwater-bearing formations underlying MAFB include primarily the Pliocene age Mehrten Formation, the Plio-Pleistocene age Laguna Formation, and the Pleistocene age Victor Formation. The total thickness of unsaturated and saturated freshwater-bearing permeable sediments underlying MAFB averages about 600 feet.



LEGEND

Age		Symbol	Formation Name
Quaternary	Holocene	gp	Gravel Pits
		ta	Gold-Dredge Tailings
		Qsc	Stream Channel Deposits
		Qfl	Flood Plain Deposits
		Qal	Valley Alluvium
	Pleistocene	Qv	Victor Formation
		Qsf	South Fork Gravels
		Qas	Arroyo Seco Gravels
		Qfo	Fair Oaks Formation
Tertiary	Pliocene	TQl	Laguna Formation
		Tpm	Mehrten Formation

A ——— A' Line of Geologic Cross-Section in Figure 2-3

FIGURE 2-2 GENERALIZED GEOLOGIC MAP OF MATHER AFB AND VICINITY

Table 2-1

Stratigraphic Units of the South Sacramento Valley

Geologic Unit Plate 2	Map Symbol	General Character Location and Thickness	Water-Bearing Properties
Alluvium	Qal	Consolidated sand and gravel with lesser amounts of silt and clay. Large gravelly deposits occur on streams draining the Sierra Nevada. Thickness up to 30 metres at Feather River near Marysville and 15 metres on tributaries to the Feather and Sacramento Rivers.	Highly permeable deposits on Yuba, Bear, American and Feather River. These areas provide recharge to their respective areas in the basin.
Flood Basin Deposits	Qfb	Unconsolidated beds of clay in Sutter, American, Yolo and lower Colusa Basins. Thickness up to 30 metres.	Poorly permeable deposits saturated to near the ground surface. Overlies more permeable material.
Alluvial Fan Deposits	Qaf	Heterogenous assemblage of clay, sand and gravel. Sand and gravel occur in buried channels deposited by migrating Putah and Cache Creeks. Deposits overlie Tehama Formation in thickness of up to 45 metres.	Moderately to highly permeable. Surface infiltration rates generally high in upper portion of fans. Well yields are high.
Victor Formation	Qv	Occupies the east side of the valley floor. Consists of sand, silt, and clay with a hardpan layer in the surface soil. Sand and gravel occurs in buried stream channel. Thickness approximately 30 metres.	Moderately permeable throughout and highly permeable where old stream channels are tapped. Generally yields little water except where old stream channels are present.
Pleistocene Gravels: Arroyo Seco Gravels, and South Fork gravels	Qg	Occur only in Sacramento County. Consists of well rounded pebbles and cobbles in a matrix of iron cemented sand and clay. Hardpan in surface soils.	Poorly permeable and yields only a small quantity of water to wells. Unimportant as a source of water.
Tertiary-Quaternary Continental Deposits: Laguna and Fair Oaks Formations	TQc	Principal area of surface exposure in Sacramento County and south Placer County. Laguna type sediments in north Sacramento County locally known as Fair Oaks Formation. Consists of compacted layers of silt, sand and clay with hardpan in surface soils. Overlain by Arroyo Seco gravels south of the American River. Thickness approximately 100 metres and possibly up to 300 metres along valley axis.	Sand layers yield moderate amounts of water to wells. Deep wells required for large yields. A locally important source of water for southeast Sacramento Valley.
Tertiary-Quaternary Continental Deposits: Tehama Formation	TQc	Occupies west side of valley and extends eastward beneath alluvial cover. Merges and interfingers with Laguna Formation. Sediments derived from the Coast Range are predominantly fine-grained. Thickness may be greater than 750 metres.	Principal water-bearing formation on the west side of the valley due to widespread distribution and thickness. Less permeable than overlying alluvium. Deep wells obtain moderate yields.
Pliocene Volcanic Rocks: Mehrten Formation	Pv	Similar to Tuscan Formation. Includes beds of black sand, brown clay and brown sand with layers of volcanic tuff breccia (mudflow deposits). Principal area of occurrence in eastern Sacramento and Placer Counties. Formation is largely overlain by younger sediments and only eastern edge is exposed. Thickness varies from 60 to 360 metres.	Volcanic sands yield large quantities of water to wells. Brown sands yield lesser amounts while clays and tuff breccias yield little water. An important source of water in southeast valley it provides large quantities of water to wells. Generally too deep in middle of valley to be tapped by most wells.
Miocene Volcanic Rocks: Valley Springs Formation	Mv	Occurs only in southeast valley. Consists of beds of volcanic sand and ash with little gravel. Thickness varies from 25 to 40 metres. Immediately underlies the Mehrten Formation.	Deposits are of low permeability and yield only small quantities of water to wells.

English equivalents: 1 metre (m) = 3.28 feet (ft)

Source: CDWR (1978)

The four formations of primary importance in this investigation are the following: the Mehrten Formation, the Laguna Formation, the Victor Formation, and the Pleistocene age gravels. The Laguna Formation beneath MAFB extends to a depth of about 200 to 300 feet below ground surface. It is underlain by the Mehrten Formation to a depth of from 450 to 700 feet. The Laguna is overlain on the east and southeast sides of the Base by approximately 50 feet of Pleistocene age gravels, and on the northwest side by from 40 to 75 feet of sands, silts, and clays of the Victor Formation. Brief lithologic descriptions of each of the formations follow:

- The Mehrten Formation of Pliocene age is composed of interbedded blue-to-brown clay and black volcanic sand, and includes beds of massive, dense, and hard tuff-breccia.

- The Laguna Formation is composed of nonvolcanic, tan to red-brown terrigenous sediments, and is a heterogeneous assemblage of beds of silt, clay, and sand, with lenticular gravels occurring as buried stream channels trending to the southwest. Sediments are unconsolidated, and their degree of compaction is variable. The degree of sorting is also highly variable, ranging from clean, well-sorted sands to poorly sorted, silty gravels (CDWR, 1974). The Fair Oaks Formation, cropping out north of the American River, is generally considered to be a stratigraphic equivalent of the top of the Laguna Formation.

- The Pleistocene age gravels, including the Arroyo Seco and South Fork gravels, occur as a relatively thin veneer capping the Laguna Formation. They consist of discontinuous beds and lenses of stream-deposited detritus, including well-rounded gravel, pebbles, and cobbles in a matrix of iron-cemented sandy clay.

- The Victor Formation is derived primarily from reworked sediments of the Laguna Formation, and is composed of interbedded sand, silt, and clay with lenses of stream-channel gravels. According to CDWR (1974, p. 38), "the lithology of the Victor Formation is heterogeneous and laterally and vertically discontinuous" and it "bears a striking similarity to that in the Laguna and Fair Oaks Formations, making it nearly impossible to differentiate the formations on the basis of well log data." Both formations are characterized by the presence of many intricately braided stream channels, resulting in extreme variability of grain size and lack of continuity from well to well.

A generalized geological cross-section through MAFB and vicinity is shown in Figure 2-3 (the line of cross-section is shown on Figure 2-2). This cross-section, which combines the Laguna and Fair Oaks Formations and the Pleistocene age gravels under the label "Plio-Pleistocene rock," illustrates schematically the extreme lithological variability to be expected in the upper 200 feet of the subsurface beneath MAFB.

2.3 HYDROGEOLOGY

2.3.1 Hydrogeological Units

Based primarily on stratigraphy as described in the preceding subsection, several distinct hydrogeological units can be distinguished in the subsurface beneath MAFB.

Although the exact depth to crystalline basement rock below MAFB is not known, it can be estimated to be greater than 6,000 feet. The overlying sedimentary rocks and unconsolidated alluvium can be divided into two major categories: nonfreshwater-bearing rocks and freshwater-bearing rocks. The nonfreshwater-bearing rocks include: Cretaceous age marine sandstones and shales that generally are saturated with saline water; the Eocene age Ione Formation, consisting of interbedded sandstone and clay and having a low overall permeability; and the Miocene age Valley Springs Formation, consisting of beds of sand and pumice ash, interlayered with silty sand and some gravel, and having a low overall permeability.

The depth of the base of freshwater in the subsurface is controlled in part by the depositional origin of the sediments (marine or continental) and in part by the depth to which freshwater recharged at ground surface is able to circulate. The base of the freshwater below MAFB occurs in the Valley Springs Formation at 1,100 to 1,400 feet below ground surface (CDWR, 1978). However, due to the relatively low productivity of the Valley Springs Formation, the base of the Mehrten Formation (varying from 450 feet below ground surface on the eastern boundary of the Base to 700 feet on the western Base boundary) (CDWR, 1974) is generally taken as the bottom of the usable freshwater-bearing stratigraphic section in this area of the Sacramento Valley.

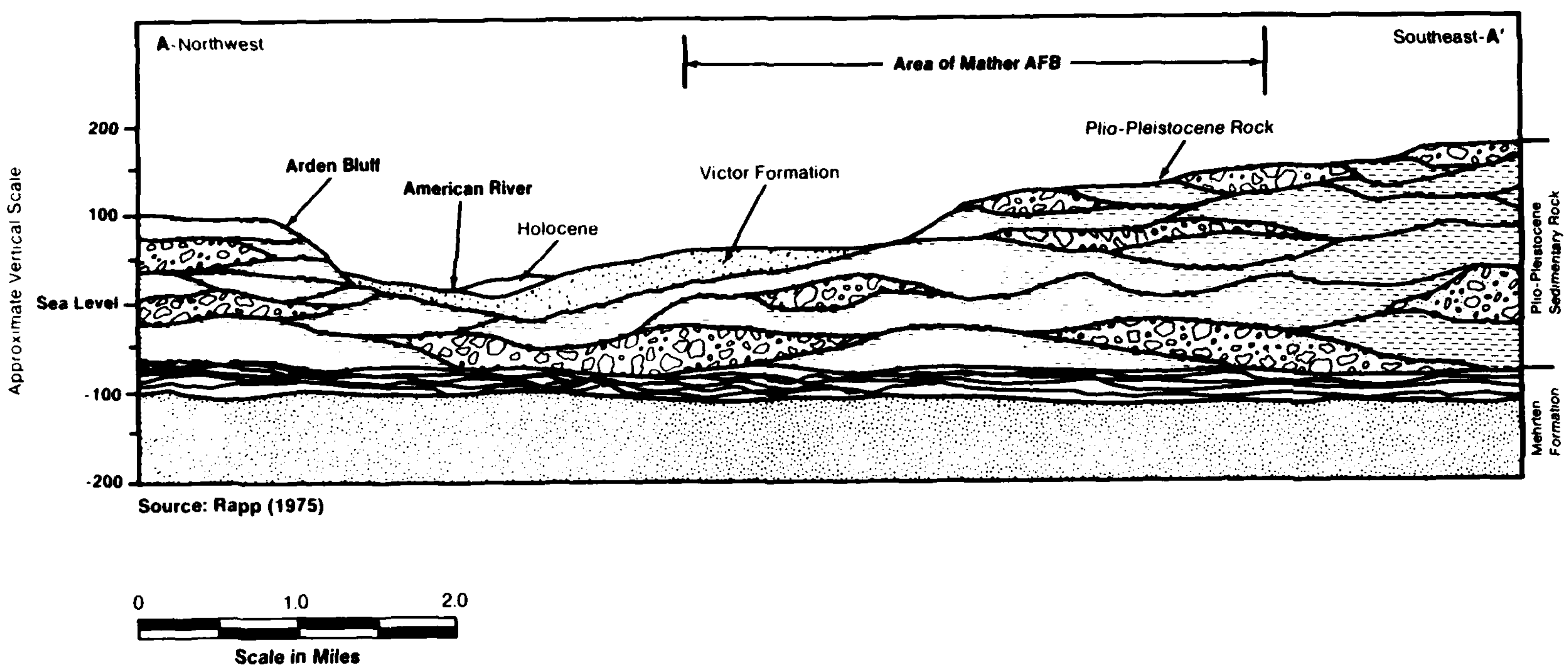


FIGURE 2-3 SCHEMATIC GEOLOGIC CROSS-SECTION THROUGH THE SHALLOW SUBSURFACE IN THE VICINITY OF MATHER AFB

For purposes of groundwater development, the freshwater-bearing section can be separated into two major subsections: the subjacent or lower series, including the Mehrten Formation and the freshwater-bearing portion of the Valley Springs Formation; and the superjacent or upper series, consisting of Plio-Pleistocene age sediments including the Laguna and Fair Oaks Formations, the Victor Formation, and the Pleistocene age gravels. The two sections are separated by a buried erosional surface of moderate to high relief (CDWR, 1974). The hydrogeological properties of these two sections are discussed separately in the following paragraphs.

- The Mehrten Formation, making up the usable portion of the subjacent section, is composed of two distinctly different rock types: sedimentary, relatively soft, well-sorted grey-to-black sands with interbeds of brown clay; and a hard, dense tuff-breccia composed of blocks of andesite in a highly cemented ash matrix. Whereas, the tuff-breccia has a very low permeability, the black sands are highly permeable and yield large volumes of water to wells. CDWR (1964) reported an average yield of 1,098 gpm for 18 wells perforated partially or wholly within the Mehrten Formation, an average specific capacity per foot (or yield per foot of drawdown per foot of perforated interval) of 14 gpm/foot/foot, and a specific capacity per foot of perforated interval in sand of 50 gpm/foot/foot.

- The Plio-Pleistocene age sediments making up the superjacent section are heterogeneous and horizontally and vertically discontinuous, grading from highly permeable, coarse, clean sand and gravel to compact, relatively low-permeability, poorly-sorted silty gravel. As a result, well yields are extremely unpredictable. CDWR (1964) reported an average yield of 898 gpm for 21 wells screened partially or wholly in the Laguna Formation, which makes up the saturated portion of the superjacent section beneath MAFB. In general, these wells produced from coarse sands and gravels at depths in excess of 250 feet. Average specific capacities per foot were 16 gpm/foot/foot for the whole perforated interval, and 93 gpm/foot/foot for the portions of the perforated intervals open to sand and gravel. The Victor Formation and the Pleistocene age gravels are generally not saturated. Both the Pleistocene age gravels and the upper section of the Victor Formation consist of predominantly coarse gravel- and cobble-size rounded particles in a silt-clay matrix.

A system of buried stream channels representing ancestral branches of the American River were identified by CDWR (1974) in the superjacent series and reported by CH2M-Hill in the Phase I report. Based on elevations reported for the tops and bottoms of these channels, where they occur beneath MAFB, they appear to lie above the present regional water table. Therefore, this particular buried channel system does not appear to represent a significant passageway for lateral migration of potential contaminants that may be present beneath the Base.

The soils associated with these formations are gravelly loams that typically include low-permeability clayey hardpan at approximately 3 feet below ground surface. As a result, infiltration rates at the surface are very low over the whole area of the Base. Recharge to the underlying saturated sediments occurs primarily in outcrop areas, at the fringes of the valley to the east, and along the channels of major rivers such as the American and the Sacramento.

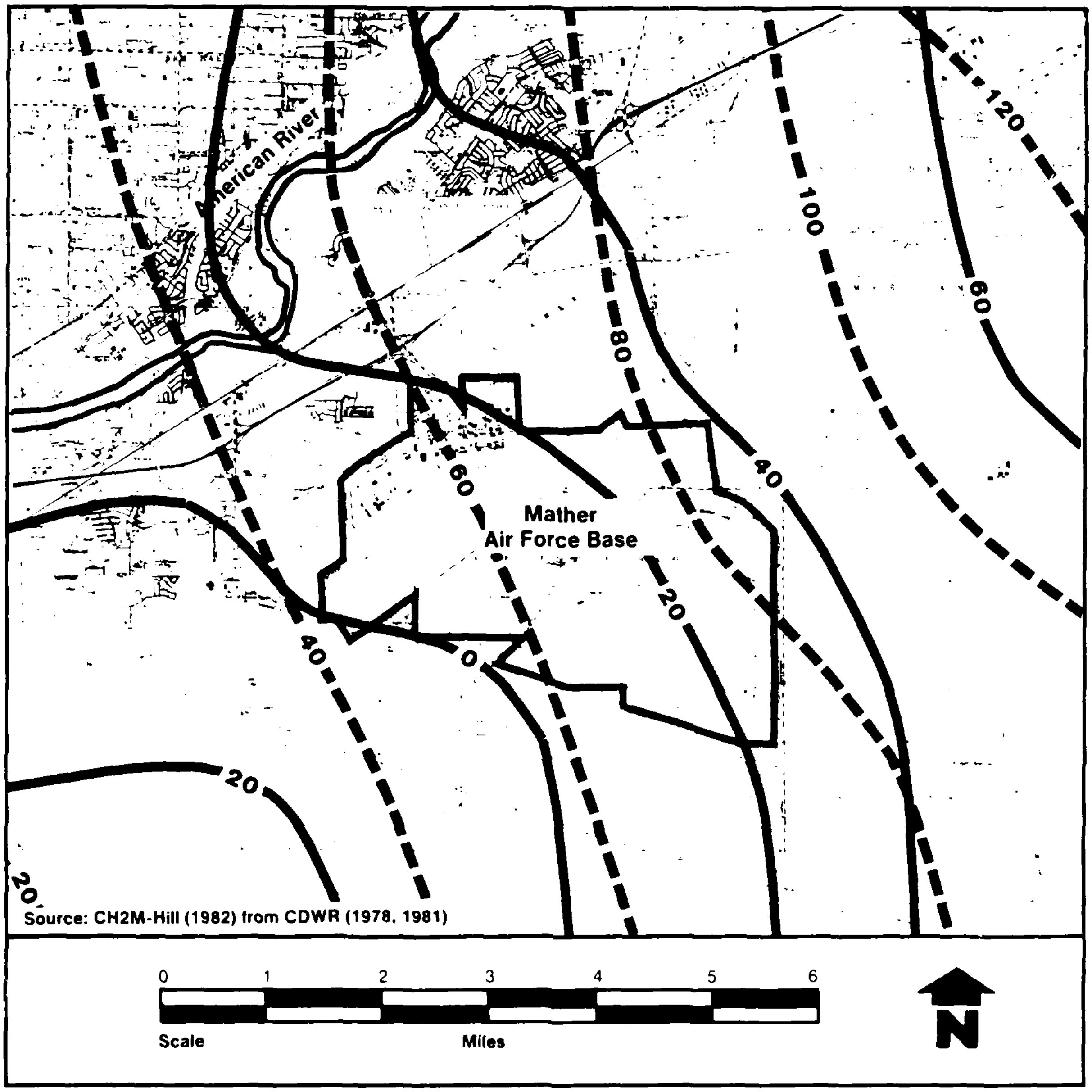
For regional groundwater modeling purposes, CDWR (1978) grouped all post-Eocene age sediments lying above the base of freshwater into a single valley aquifer. In the area of MAFB, municipal and other large water supply wells generally produce water from depths of 200 to 550 feet below ground surface, drawing from both the Mehrten and Laguna Formations. Domestic wells generally draw water from the Laguna at depths of 100 to 200 feet below ground surface. CDWR (1978) estimated the average hydraulic conductivity of sediments down to 300 feet below land surface at 20 feet/day, with the average transmissivity in the area of MAFB at 8,700 square feet/day. The valley aquifer as a whole was found to act as an unconfined aquifer, so that the aquifer storage coefficient is equal to the specific yield, or the volume of water in cubic feet yielded from gravity drainage per cubic foot of sediment drained. The average specific yield in the aquifer underlying MAFB was estimated at 0.07, typical of poorly-sorted, dense or partially-cemented clay and gravel or sandy clay (CDWR, 1978).

2.3.2 Regional Hydrogeology and Historic Trends

Mather Air Force Base is located on the eastern edge of the Sacramento Valley groundwater basin. The primary source of water to the basin is recharge occurring from direct precipitation and runoff in outcrop areas of the Laguna, Mehrten, and pre-Mehrten Formations in the foothills, and along the channels of major streams such as the American River that are lined with permeable alluvium. There is little or no recharge from direct precipitation over the valley floor due to the presence of hardpan soils that have developed on the Victor Formation and the Pleistocene age gravels, and that cause low infiltration rates over most of the ground surface. The natural direction of groundwater flow is from recharge areas at the edge of the valley toward the valley center, where natural groundwater discharge would occur into the Sacramento River.

The first extensive set of groundwater level data in the valley was compiled by the USGS from measurements made in 1912 and 1913. The map compiled from these data has been taken to represent natural, or "baseline," groundwater conditions. The 1912 groundwater level contours for the area in the immediate vicinity of MAFB have been reproduced in Figure 2-4. This map indicates that the historic and contemporary direction of groundwater flow beneath the Base would be from northeast to southwest.

Considerable development of groundwater resources has occurred over the south Sacramento Valley during this century, resulting in groundwater withdrawals in excess of recharge, and, consequently, in a general decline in groundwater levels throughout the valley. The decline began with initial development as early as 1850. It slowed during the Depression years and accelerated again after the mid-1940's, reaching an average rate of more than 1 foot per year. Groundwater levels in Sacramento County fell approximately 35 feet in the 30 years between 1940 and 1970 (CDWR, 1974). Significant groundwater withdrawals occur in a band along the east bank of the Sacramento River from Roseville south to Lodi, and a major agricultural pumping center has been established in the Elk Grove area, south-southwest of MAFB, which has significantly influenced groundwater levels beneath the Base. Comparison of 1980 groundwater contours to the 1912 contours in Figure 2-4 indicates that there has been a general decline in water levels of approximately 50 feet since 1912, and that the primary direction of groundwater flow has shifted somewhat from southwesterly to south-southwesterly. In addition, the shapes of the contours indicate that significant recharge now takes place through the channel of the American River, which has become a losing stream, feeding the underlying aquifer to the north and south of the river channel.



Legend

20 1912 Groundwater Level Contour

20 1980 Groundwater Level Contour

Elevations in Feet MSL

Contour Interval: 20 Feet

FIGURE 2-4 REGIONAL GROUNDWATER LEVELS, 1912 AND 1980

Well hydrographs reproduced in CDWR (1974, 1978) indicate that there is significant seasonal fluctuation in groundwater levels, generally ranging from a high in March or April to a low in September or October. This annual fluctuation is related to both natural variations in precipitation and recharge rates and seasonal variations in pumping rates for irrigation. Seasonal groundwater level fluctuations can be as high as 10 to 15 feet in agricultural areas, but are generally less, on the order of 3 to 5 feet, in urban or undeveloped areas, such as MAFB, where seasonal variation in groundwater withdrawal rates tends to be much less.

Groundwater occurs under confined, semi-confined, unconfined and perched conditions throughout the area (these terms are defined in Appendix A). According to CDWR (1974), confined conditions exist locally throughout Sacramento County, causing water levels to rise as much as 10 feet above the levels at which water was first encountered in wells after they are developed. An attempt to group water level data by formation, however, revealed that in most cases the potentiometric surfaces for the various formations coincide, indicating that there is little basis for distinguishing between formations hydraulically on a regional scale (CDWR, 1974). Therefore, the regional groundwater flow system can be treated as a single layer of water-bearing materials. Water level measurements made in wells screened over a significant portion of an aquifer generally represent a combination or average of unconfined, semi-confined, and confined conditions within a single well.

2.3.3 Base Supply and Other Area Wells

2.3.3.1 Base Supply Wells

Water for MAFB is supplied from a network of 14 water wells organized into five separate treatment and distribution systems. In addition, the old ACW well, occasionally used in the past as a back-up for fire protection, is now closed but can be operated for sampling purposes. Base well locations are shown in Figure 2-5, and available information on well specifications is summarized in Table 2-2. The principal drinking water supply systems are made up of the four Main Base wells and the six family housing wells.

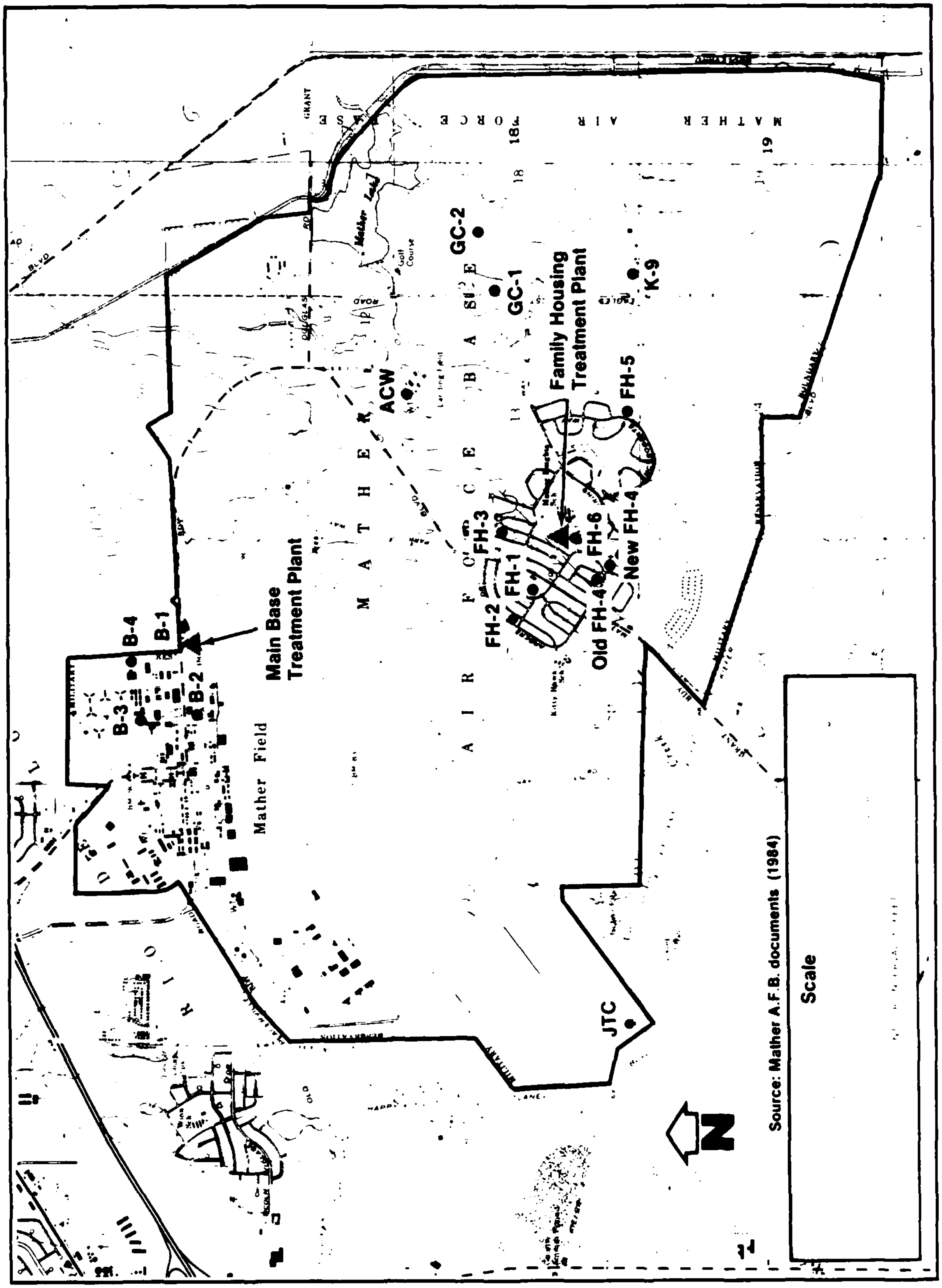


FIGURE 2-5 MATHER AFB SUPPLY WELL LOCATIONS

Table 2-2

Base Supply Well Specifications
Mather Air Force Base

Well Number	Date of Instal-lation	Build-ing No.	Casing Diam-eter (inches)	Total Depth (feet below ground surface)	Perforated Interval (feet below ground surface)	Original Capacity	Current Capacity (gpm)	Water Treatment
Main Base								
B-1	1941	3976	12	532	262-411 423-464 470-482 486-491 511-517	1,225	1,133	Chlorination
B-2	1941	3795	12	584	186-221 285-336 347-436 450-455 459-476	1,400	1,300	Chlorination
B-3	1943	2745	12	501	294-402 422-447 477-489	1,000	900	Chlorination
B-4	1957	2930	12	500	246-422 462-490	1,200	666	Chlorination
Family Housing								
FH-1	1951	14418	12	500	280-290 322-500	1,020	1,350	FE and Mn Removal, Chlorination Fluoridation
FH-2	1951	14147	12	500	205-209 370-386 478-485	825	1,350	" "
FH-3	1951	14488	12	400	348-368 374-396	1,100	1,350	" "
FH-4	1951	14987	12	400	330-342 348-374	572	Aban-doned	" "
FH-5	1961	17757	12	549	450-547	1,100	1,500	" "
FH-6	1977	16000	16	500	246-270 318-366 390-499	3,400	2,200	" "
Golf Course								
GC-1	1983	8867	12	562	302-522	2,400	1,000	None
GC-2	No data	8880	12	403	No data	No data	1,000	
Remote Wells								
ACW	1950	10151	10	250	198-227 234-244	450	Not Used	None
JTC	1961, deep-ened 1976	7098	12(0-83 ft) 6-5/8 (80-201 ft)	201	39-200	40	25	Chlorination
K-9	1957	18005	12	250	No data	50	25	Chlorination

Source: Mather AFB/BES files, CH2M-Hill (1983), and communication from Base personnel.

The golf course wells are used only for irrigation water supply. The Jet Engine Test Cell (JTC) well is used primarily for fire protection and wash water supply for jet engine testing. The K-9 well is used as a drinking water supply and for other uses, in a relatively remote area of the Base.

According to the IRP Phase I report, the average annual water demand at MAFB was 3.5 mgd in 1981-1982, compared with 2.5 mgd in 1961-1962 (CDWR, 1964). In 1983-1984, estimated average daily water demand at the Base ranged between a high of almost 9 mgd in summer to a low of about 2.5 mgd in winter.

2.3.3.2 Off-Base Wells

Figure 2-6, taken from CDWR (1964), shows the locations of wells in the vicinity of MAFB inventoried in the early 1960's for a report on Folsom-East Sacramento groundwater quality.

Much of the Rancho Cordova area along and to the north of Folsom Boulevard is served by private water companies drawing water from deep production wells in the area. The nearest public supply well field is located less than one-half mile north of the Base and currently belongs to Citizens Utility Service. The wellfield includes four wells with depths ranging from 364 to 525 feet.

Less densely-populated areas immediately to the west of the Base are served by relatively shallow domestic wells drilled into the upper Laguna Formation. Information provided by the State of California for this study indicates that domestic wells along Happy Lane, which parallels the western Base boundary and lies 1,500 to 2,000 feet from the West Ditch, generally range in total depth from 97 to 150 feet; one well has a total depth of 360 feet and another 600 feet.

2.3.4 Groundwater Quality

Groundwater from the fresh water column in the vicinity of MAFB was extensively analyzed for a set of inorganic parameters by CDWR (1964), and has been characterized as calcium-sodium bicarbonate and calcium-magnesium bicarbonate water. Calcium-sodium bicarbonate water is considered typical of shallow wells finished in Plio-Pleistocene age (Laguna and Victor Formations) sediments above the Mehrten Formation. Calcium-magnesium bicarbonate water is produced from wells screened in both the Laguna and the underlying Mehrten Formation. Based on mineral constituents, the quality of groundwater in the area was characterized by CDWR as excellent. Analyses of 203 well-water samples indicated that total dissolved solids (TDS) ranged from 173 to 405 ppm, averaging 178 ppm, and that total hardness ranged from 23 to 288 ppm, averaging 95 ppm.

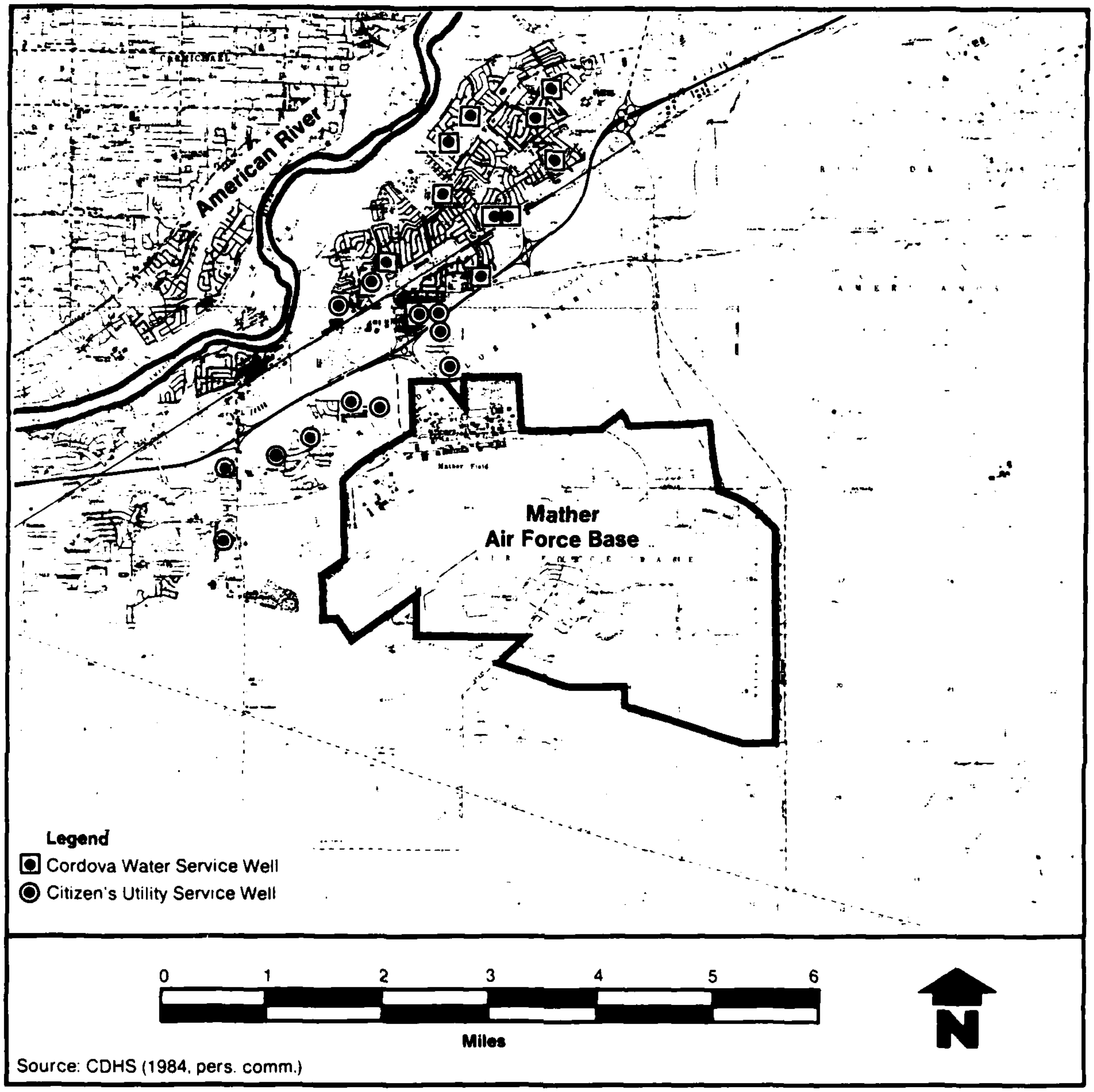


FIGURE 2-6 LOCATION OF PUBLIC SUPPLY WELLS IN THE VICINITY OF MATHER AFB

In the summer of 1983, MAFB analyzed all 10 Base supply wells currently used for drinking water purposes; samples were analyzed for Federal Drinking Water Standards (FDWS) constituents. Total dissolved solids ranged from 105 to 196 ppm, within the range found by CDWR (1964). The only parameters exceeding FDWS were iron, which exceeded 0.300 mg/L in Main Base well B-1 and in three of the family housing wells, and manganese, which exceeded 0.050 mg/L in the K-9 well and all of the family housing wells, ranging from 0.107 to 0.361 mg/L. A treatment system for iron and manganese removal is in place in the family housing system treatment plant, and both parameters are below FDWS in the finished water.

According to news media reports referenced by the IRP Phase I report (CH2M-Hill, 1982, p. IV-36), groundwater contaminated with trichloroethylene (TCE) was first found in August 1979 in the Sacramento area, in wells located northeast of MAFB. Mather Air Force Base first began testing its wells for TCE during the same month. Results of Base supply well sampling performed between 1979 and 1981 by the Bioenvironmental Engineering Services (BES) were summarized in the Phase I report. Most wells were sampled an average of 10 times during this period. TCE was never found above trace levels in any of the following wells: B-3, FH-1, FH-2, FH-3, FH-4, FH-5, GC-1, and GC-2. It was found only once or twice, at levels below 0.005 mg/L in four wells: B-4, FH-6, K-9, and JTC. In Main Base well B-2 TCE was found only two times in 14 sampling rounds with levels of 0.0139 mg/L and 0.0013 mg/L; in both cases duplicate sample results were below detection limits. The only Base supply well that consistently exhibited significant levels of TCE was the ACW well, in which TCE was found above detection limits 16 times in 19 sampling rounds, ranging from 0.0017 to 0.112 mg/L and averaging 0.0211 mg/L. Main Base well B-1 could not be analyzed because the pump was not operable during this period.

Domestic wells in the area immediately west of the Base have been sampled by the California Regional Water Quality Control Board, Central Valley Region (CRWQCB-CVR). These results indicate that there is a low level of groundwater contamination by volatile organic (solvent) compounds in the Happy Lane area immediately to the west of the Base. No source for this contamination has been confirmed by the CRWQCB-CVR. Data made available by the CRWQCB-CVR in a meeting in August 1984 can be found in Appendix M.

SECTION 3

FIELD PROGRAM

3.1 PROGRAM DEVELOPMENT

Task Order 0026 was originally issued on the basis of some of the recommendations contained in WESTON's Phase II pre-survey report, and was subsequently modified as reproduced in Appendix B (Task Order 0026-02). Three sites and the northeast perimeter were recommended for confirmation stage work in the Phase I report. All four sites were addressed in this Phase II, Stage 1, Problem Confirmation Study. The field program approved in the Task Order is summarized in Table 3-1.

The purpose of a Phase II, Stage 1, Problem Confirmation Study is primarily to confirm the presence or absence of contamination at a site, and, secondarily, to provide supplementary information on the potential for contaminant migration from a site. These purposes dictated the general approach used in developing the proposed field program, including the location and construction of monitor wells, and groundwater and sediment sampling. The following text discusses in more detail the rationale followed in program development.

3.1.1 Monitor Wells

Contamination discharged on or near ground surface would be expected to occur in the highest concentrations in the soils and in the shallowest groundwater underlying a site. At sites where the potential source of contaminant discharge was diffuse (e.g., the West Ditch), had been buried (e.g., the 7100 Area landfill), or could not be accurately located (e.g., the ACW Area discharge pipe), monitor wells were emplaced adjacent to and downgradient from the approximate source location to sample shallow groundwater for indicators of contamination. For the purposes of monitoring shallow groundwater only, the monitor wells at Mather AFB were to be drilled 20 feet into "first water," i.e., 20 feet beyond the point where saturated sediments were first encountered. Monitor wells were to average 120 feet in total depth, with the total well footage in 11 wells not to exceed 1,320 feet.

Table 3-1

Summary of Field Activity

SITE	ACTIVITY
1. ACW Disposal Site	•Install 3 downgradient monitor wells •Perform well and groundwater elevation survey •Sample each well three times for VOA, TOC, oil and grease, and PCB's
2. 7100 Area Disposal Site	•Install 3 downgradient monitor wells •Perform well and groundwater elevation survey •Sample each well three times for VOA, TOC, oil and grease, phenol, cyanide, Cr, Pb, Cd, Ni and Ag
3. West Ditch	•Install 2 downgradient monitor wells •Perform well and groundwater elevation survey •Sample each well three times for VOA, TOC, oil and grease, phenol, cyanide, Cr, Pb, Cd, Ni, and Ag •Collect two sediment samples, one upstream and one downstream from oil skimmer. Analyze for same parameters as groundwater
4. Northeast Base Perimeter	•Install 3 monitor wells •Perform well and groundwater elevation survey •Sample each well three times for VOA, TOC, oil and grease, dimethyl-nitrosamine (DMN), Cr, Pb, Cd, Ni, Ag, DDT, chlordane, and 2,4-D.
5. Base Supply Wells	•Sample each well one time for VOA, TOC and oil and grease and the following parameters at specific wells: ACW well....... PCB's B1, B2, B3, B4....Cr, Pb, Cd, Ni, Ag, DMN, DDT, chlordane, 2,4-D JTC Well..........Phenol, cyanide, Cr, Pb, Cd, Ni, Ag

Wells were to be constructed of 4-inch diameter welded black iron pipe and completed in the saturated zone with wire-wound 0.012-inch slot stainless steel well screen, and packed in Monterey sand or equivalent to a height of 2 to 5 feet above the top of the well screen to prevent entrainment of sediment into the well during pumping. The annular space was to be sealed with 2 feet of bentonite pellets and grouted with a 6:1 mixture (by dry weight) of Portland cement concrete mix and bentonite powder to prevent leakage down into the well annulus from the surface. Each well was to be secured with a locking cap. All wells were to be developed to ensure they were clear of sediment and foreign material introduced during drilling to the extent practicable.

Monitor wells were located in the presumed downgradient direction from the sites based on information available in the Phase I report. All wells were within the Mather AFB boundary. Upgradient wells were located immediately inside the northeast Base boundary in locations selected to monitor a representative section of the upper portion of the groundwater underflow entering Mather AFB from the northeast. A total of 11 wells were to be installed, including three at the ACW disposal site, three at the 7100 Area disposal site, two at the west ditch, and three on the northeast perimeter.

3.1.2 Elevation Surveys

To complete the hydrogeological investigation, WESTON proposed to survey the elevations of all the monitor well casings with respect to existing benchmarks, and to make a complete round of groundwater level measurements immediately upon completion of well installation. Additional rounds of groundwater level measurements were to be taken at approximately 2-week intervals thereafter. The intent of gathering these data were: to determine appropriate water level conditions at which to perform sampling; to confirm the presumed direction of migration for any contaminants found to be present; and, to measure the effect of seasonal fluctuations on the groundwater flow regime.

3.1.3 Groundwater Sampling

WESTON proposed sampling the 11 monitor wells in three rounds at different groundwater level conditions. All wells were to be purged of at least three well volumes immediately prior to sampling, using an electric submersible pump. Water samples were to be collected and preserved according to standard U.S. EPA groundwater sampling protocols for the analytes of interest.

In addition, at the request of Mather AFB, WESTON proposed sampling all 15 Base production wells in one round only for VOA, TOC, and oil and grease, and for additional specific parameters at a few of these production wells. Specific analytes for each zone are summarized in Table 3-1.

3.1.4 Sediment Sampling

In order to assess the presence or absence of contamination at this time in the West Ditch, WESTON proposed collecting two samples of bottom sediments from the ditch, one upstream and one downstream from the oil skimmer for comparison purposes. Sediments were to be analyzed for VOA, TOC, oils and greases, phenol, cyanide, and metals.

3.2 FIELD INVESTIGATION

A Phase II, Stage 1 field investigation was conducted to define the hydrological and geological setting at Mather AFB, and to determine the possible presence of hazardous environmental contaminants that may have resulted from past product storage and handling practices or waste disposal operations at the Base.

A total of 11 monitor wells were installed at three disposal sites and along the northeast perimeter of the Base. Top-of-casing elevations were surveyed and water levels were monitored regularly over a 6-month period. Groundwater samples were collected from the 11 monitor wells, from 14 Base production wells, and the ACW well. Sediment samples were collected both upstream and downstream from the West Ditch oil skimmer.

3.2.1 Schedule of Activities

The field investigation at Mather AFB began on 21 February 1984, and was completed on 27 June 1985. Drilling, construction and development of 11 monitor wells and casing elevation surveys were performed between 21 February and 10 April 1984. The monitoring program, including collection of water level measurements and water and ditch sediment samples was conducted between May 1984 and June 1985.

3.2.2 Drilling Program

The field program at MAFB included the drilling and construction of 11 monitor wells to an average depth of 120 feet below ground surface. All drilling was performed by the Stang Drilling and Exploration Company, Inc. of Rancho Cordova, California, under the direct on-site supervision of WESTON geologists. The drilling rig used was an Ingersoll-Rand TH60 rotary drill rig mounted on a 1978 International Paystar 5000 truck.

3.2.2.1 Drilling Method and Well Construction - General

All wells were drilled by mud rotary methods. In general, 1,000 to 1,500 gallons of fluid were used in each well mixed from drinking water from the Main Base system and 150 to 300 pounds of bentonite powder. Due to the use of drilling mud, accurate lithologic boundaries and the degree of saturation of the sedimentary materials penetrated could not be accurately evaluated. In general, the sediment encountered consisted primarily of poorly sorted mixtures of silty gravel and sandy silt and clay, with occasional gravel and cobbles and sand and gravel zones. Total well depths were chosen on the basis of lithology as well as regional groundwater level information available in the Phase I report. The saturated thickness penetrated was determined on the basis of the length of the water column in the well after it was developed. Perched water occurs at several levels in the subsurface, including very shallow zones, as evidenced by the overnight accumulation of ponded water in a few of the mud pits in the absence of any rainfall. Well logs of subsurface lithology were prepared, along with well construction summaries, by on-site WESTON geologists and are included in Appendix D.

An HNu portable photoionization detection unit was available at all times during the drilling operation, for use at the discretion of on-site geologists. The only well at which a significant odor (organic chemical, solvent, or possibly fuel) was noted during drilling was MAFB-7 in the 7100 Area. The HNu probe, when held near the drilling fluid discharging at the wellhead, registered atmospheric concentrations of volatile organics from 0 to 1.5 ppm at that site.

Monitor wells were installed in boreholes held open with drilling mud. All wells were constructed of 18 to 21 feet of 4 1/2-inch ID, 5-inch OD wire-wound stainless steel screen welded to 4-inch ID, 4 1/2-inch OD low-carbon steel riser pipe. The screen slot size was 0.012 inch in all wells, except MAFB-10 and MAFB-11, in which 0.007 inch-slot was used because 0.012 inch-slot screen was not available at the time of drilling.

In general, the holes were overdrilled by about 20 feet to allow for some collapse of formation materials and settling of cuttings during well construction. The well screen was lowered to the bottom of the open hole, and packed in clean No. 3 graded Monterey sand. The sand pack was brought to approximately 30 feet above the top of the screen to ensure that the entire saturated thickness of the formation penetrated would be in hydraulic connection with the well. The top of the sand pack was sealed with approximately 2 feet of bentonite pellets, and the remainder of the annulus was backfilled with a 6:1 mixture of sandy concrete/bentonite grout.

The riser pipe was cut approximately 3 feet above ground surface and fitted with a locking steel cap. A typical well construction diagram is shown in Figure 3-1. A summary of monitor well construction details is given in Table 3-2.

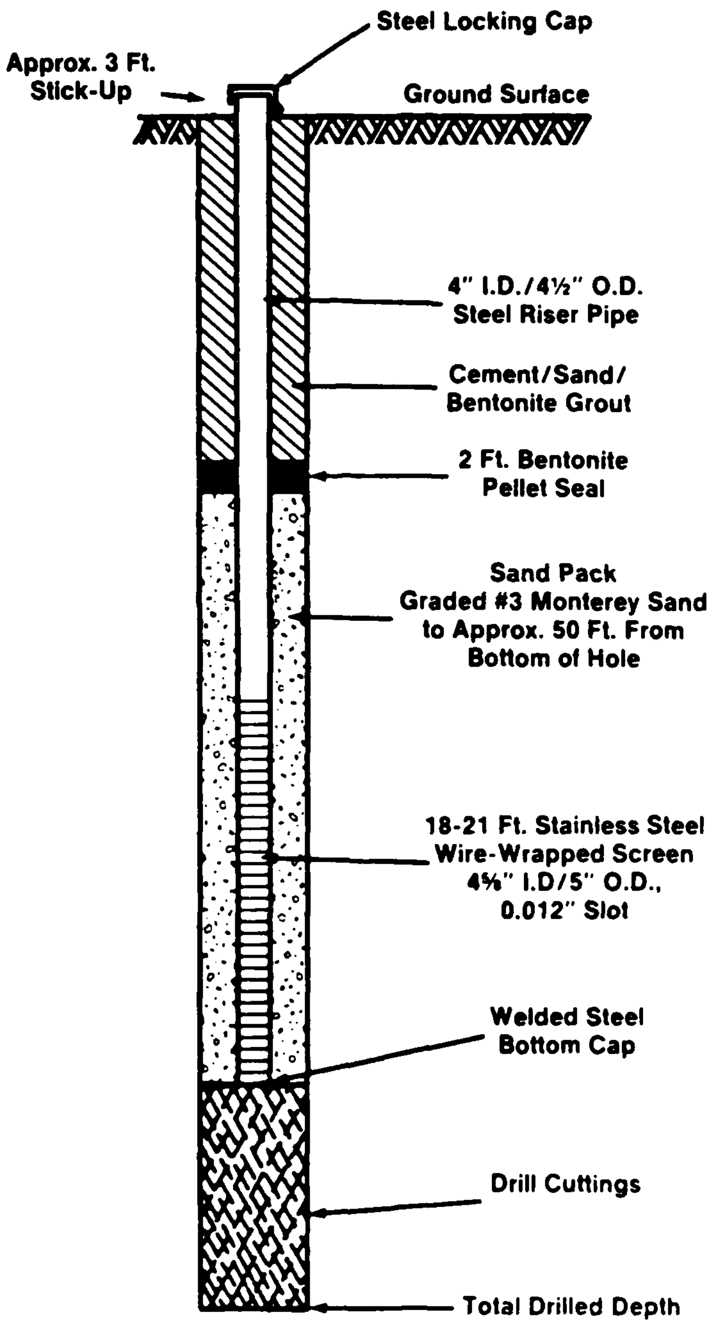
Following the completion of each well, drill cuttings in the mud pits were covered with backfill, the site was graded, and the general area was restored as closely as possible to predrilling conditions.

3.2.2.2 Site-Specific Well Locations and Well Construction Details

This subsection reviews the specific details of monitor well construction and location at each of the four field sites.

- ACW Area

  A total of three monitor wells, designated MAFB-1, -2, and -3, were drilled in downgradient locations from the presumed location of the abandoned discharge pipe, which was never found. The well locations are shown in Figure 3-2. All three wells were drilled to a completed depth of 120 feet below ground surface and sand-packed to a depth of 75 feet. They were screened with 18 feet of 0.012-inch slot screen. A construction summary diagram for these three monitor wells is shown in Figure 3-3.



(Date: 1984)

FIGURE 3-1 TYPICAL MONITOR WELL CONSTRUCTION

Table 3-2

Summary of Well Construction Details

Well Number	Approx. Ground Surface Elevation (feet MSL)	Top of Casing Elevation (feet)	Screened Interval Below *Ground Surface* (feet)	Elevation Top of *Screened* Interval	Sandpacked Interval Below Ground Surface (feet)	Predominant Lithology In Screened Interval
ACW Area						
1	129.1	131.39	102-120	105.48	75-120	CLAY and SILT, SILT and coarse gravel
2	127.8	130.87	102-120	105.67	75-120	Fine SAND, SILT and CLAY, some gravel
3	125.4	128.12	102-120	105.58	75-120	Fine-medium SAND, some silt and clay
Northeast Perimeter						
4	170.5	173.41	135.5-153.5	138.40	103-153.5	CLAY, little fine sand and gravel
5	132.2	135.17	110.5-128.5	109.92	85-128.5	CLAY and SILT, little sand and gravel
6	95.9	98.41	81.5-99.5	84.46	50.5-99.5	GRAVEL, some silt and clay
7100 Area						
7	70.8	73.35	92-110	94.83	65-110	Medium GRAVEL, some fine-medium sand
8	72.0	74.70	89-107	91.84	60-107	Fine-medium SAND, some clay
9	75.0	78.00	92-110	95.76	66-110	SILT and fine SAND, some gravel
West Ditch						
10	78.2	81.14	84-105	86.92	50-105	SILT, CLAY and fine SAND
11	77.4	80.40	84-105	87.33	50-105	SILT and fine SAND, little gravel

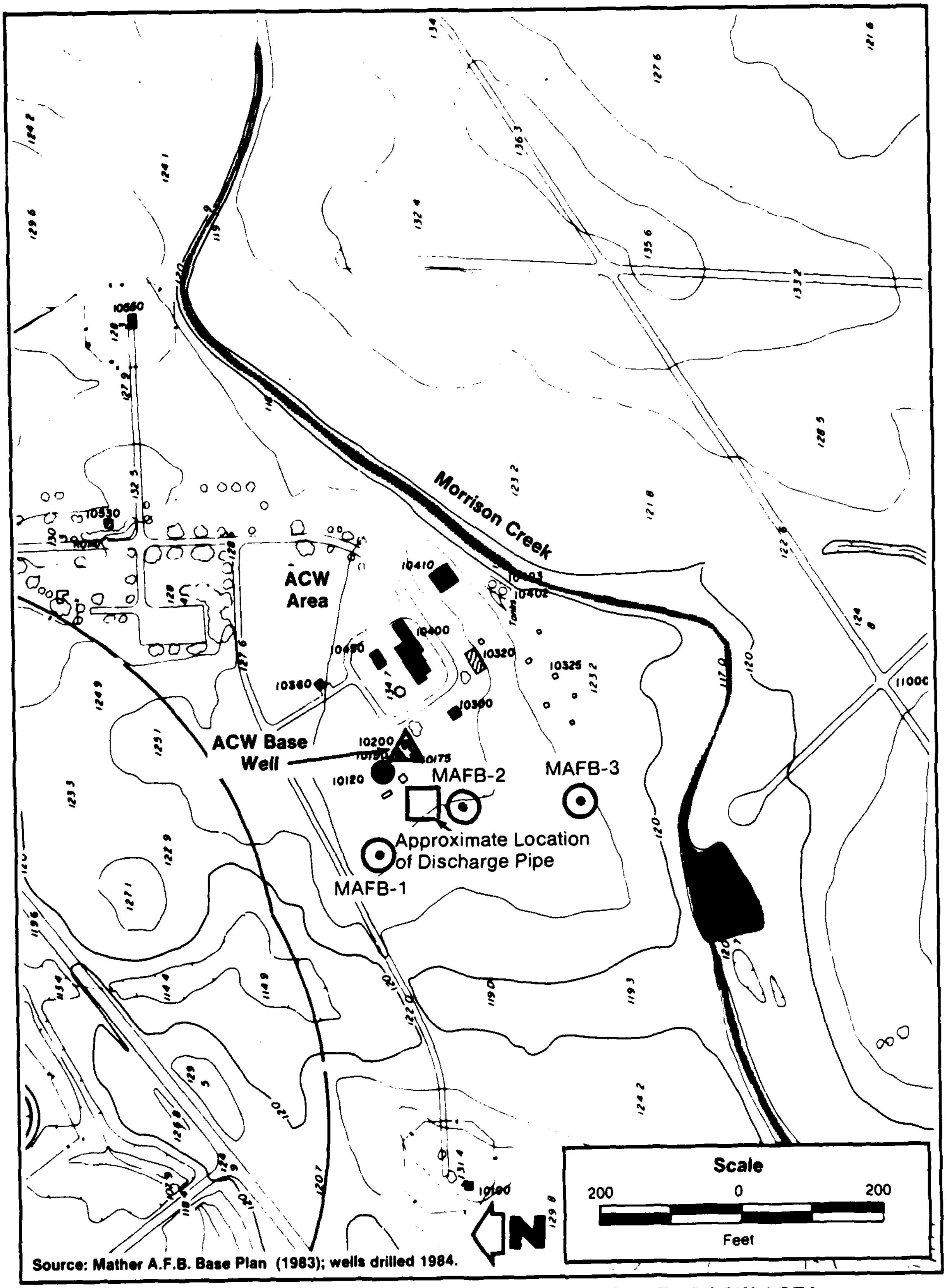


FIGURE 3-2 MONITOR WELL LOCATIONS IN THE ACW AREA

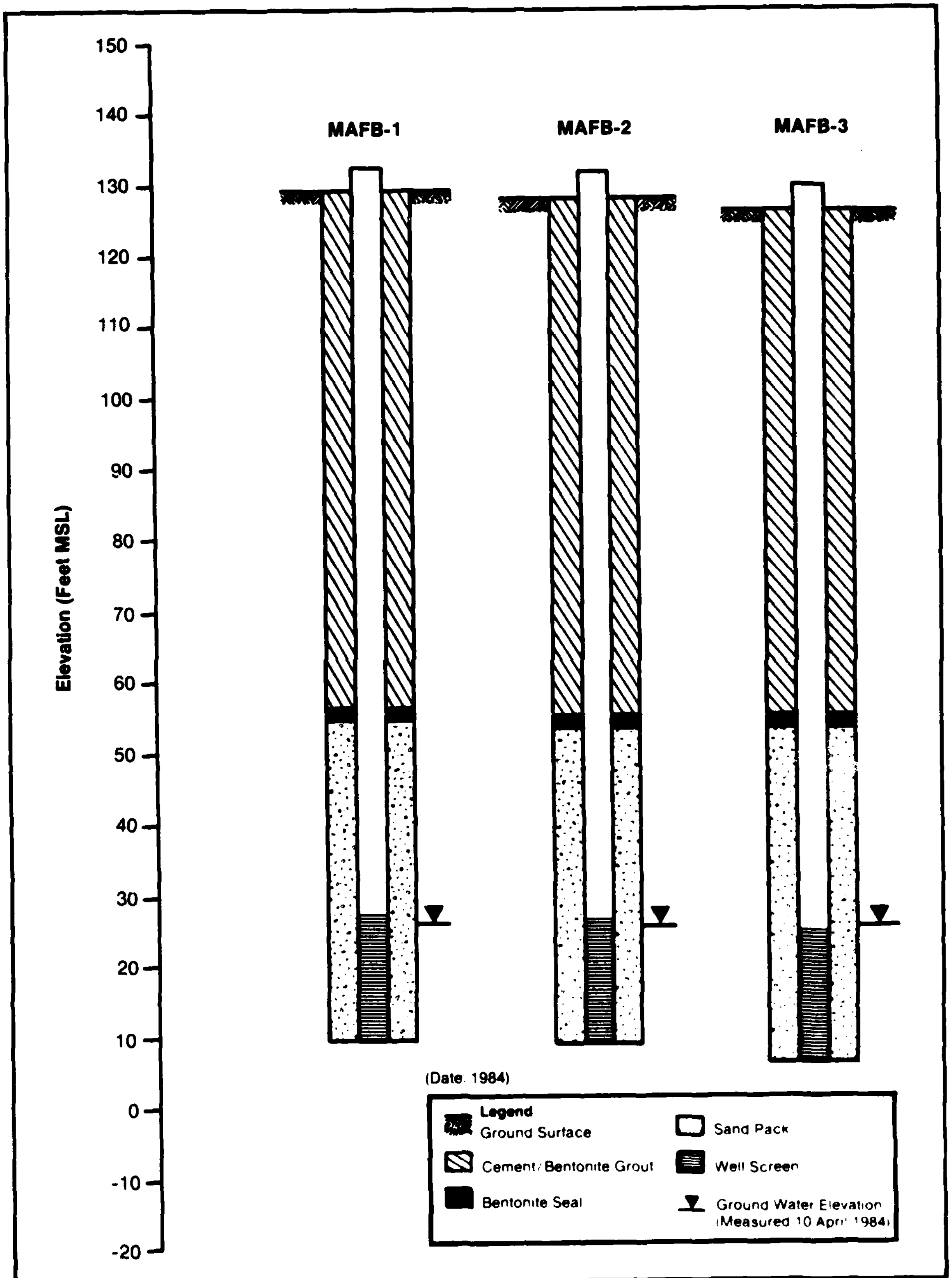


FIGURE 3-3 WELL CONSTRUCTION SUMMARY, ACW AREA

- 7100 Area

A total of three monitor wells, designated MAFB-7, -8, and -9, were drilled in presumed downgradient locations from the 7100 Area disposal site, as shown in Figure 3-4. Well locations were within the Base boundary, which on the west side of the site follows the edge of a deep gravel pit excavated from 40 to 50 feet below ground surface. There is a pond at the bottom of this pit. The pond is reported to be a seasonal feature.

The three wells were drilled to depths of 107 to 110 feet, and sand-packed to depths of 60 to 65 feet. They were screened with 18 feet of 0.012-inch slot screen. A monitor well construction diagram is shown in Figure 3-5.

- West Ditch

A total of two monitor wells, designated MAFB-10 and -11, were drilled between the West Ditch and the western Base boundary at locations shown in Figure 3-6. Final locations were chosen with the cooperation of a representative of the California Regional Water Quality Control Board. The nearest drinking water supply well outside the Base is located in the Camellia Mather Mobile Home Park just beyond the boundary. Additional domestic wells are located along Happy Lane from 1,500 to 2,000 feet to the west, and range in total depth from 97 to 150 feet, with two wells deeper than 360 feet in total depth.

The two monitor wells were drilled to a total depth of 105 feet, and were sand-packed to a depth of 50 feet. They were screened with 21 feet of 0.007-inch slot screen made up of two welded sections each. A monitor well construction diagram is shown in Figure 3-7.

- Northeast Perimeter

A total of three monitor wells, designated MAFB-4, -5, and -6, were drilled along the northeast perimeter. Figure 3-8 is a map of Mather AFB showing the locations of all 11 monitor wells, including these three wells.

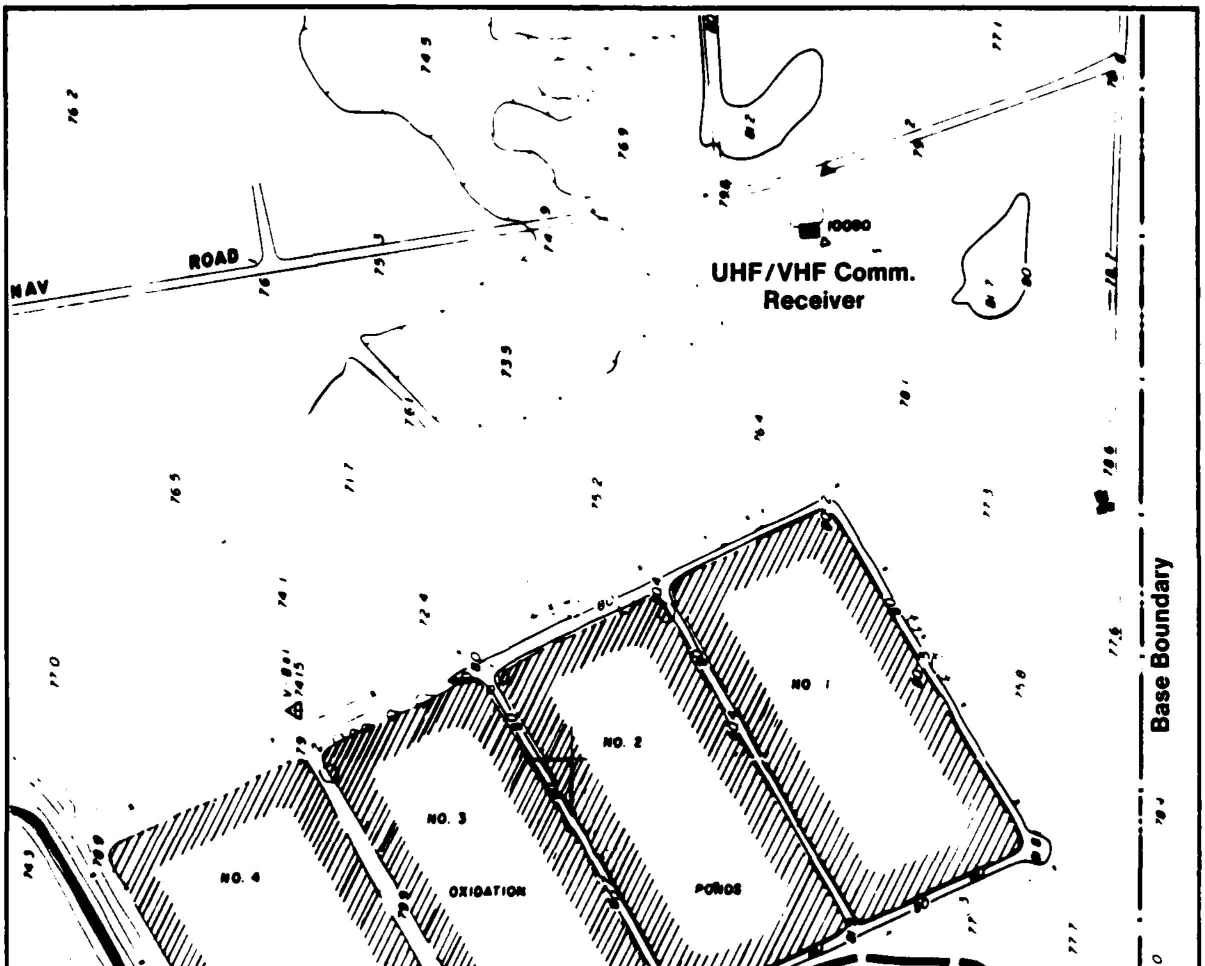


FIGURE 3-4 MONITOR WELL LOCATIONS IN THE 7100 AREA

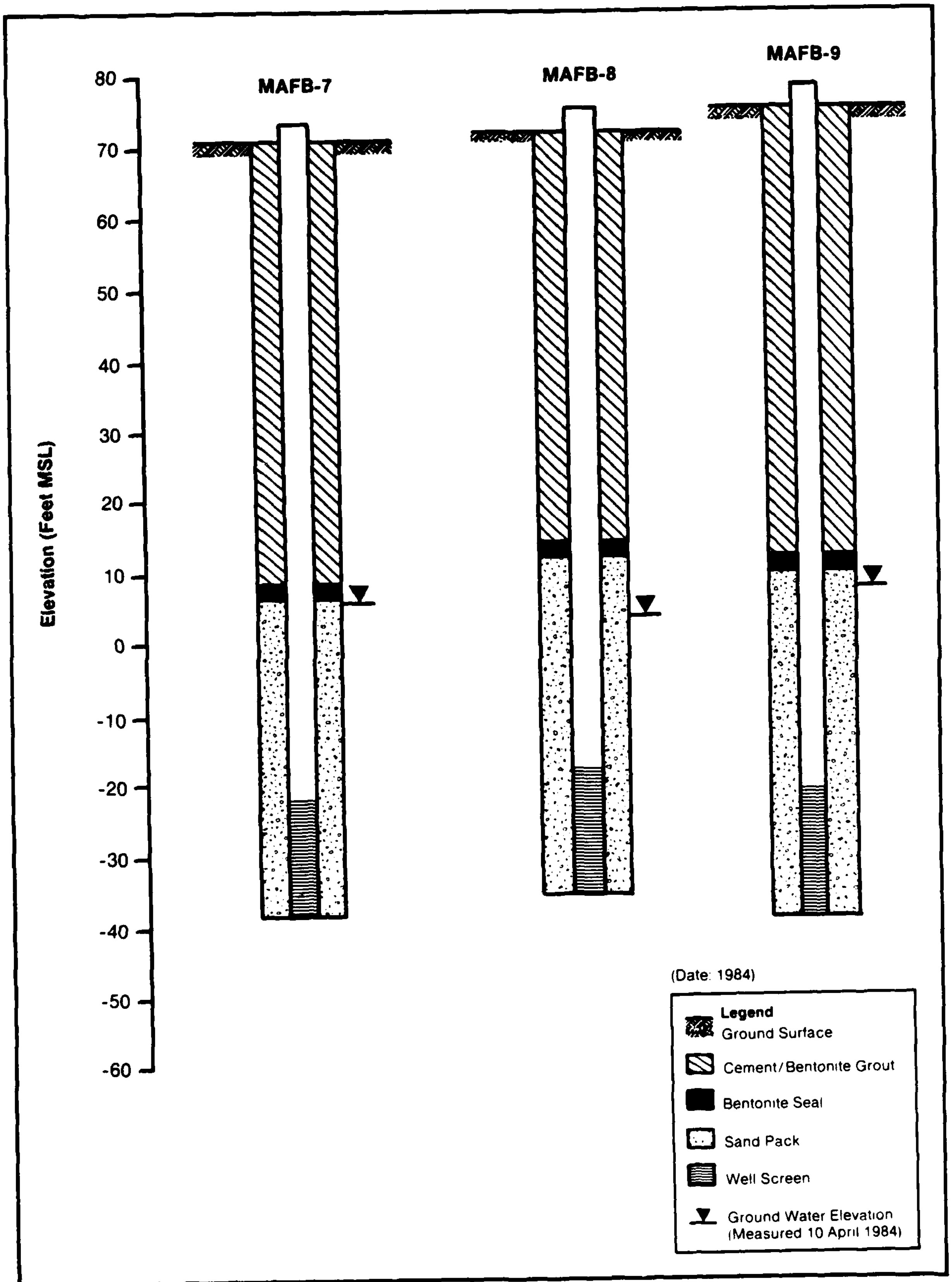


FIGURE 3-5 WELL CONSTRUCTION SUMMARY, 7100 AREA

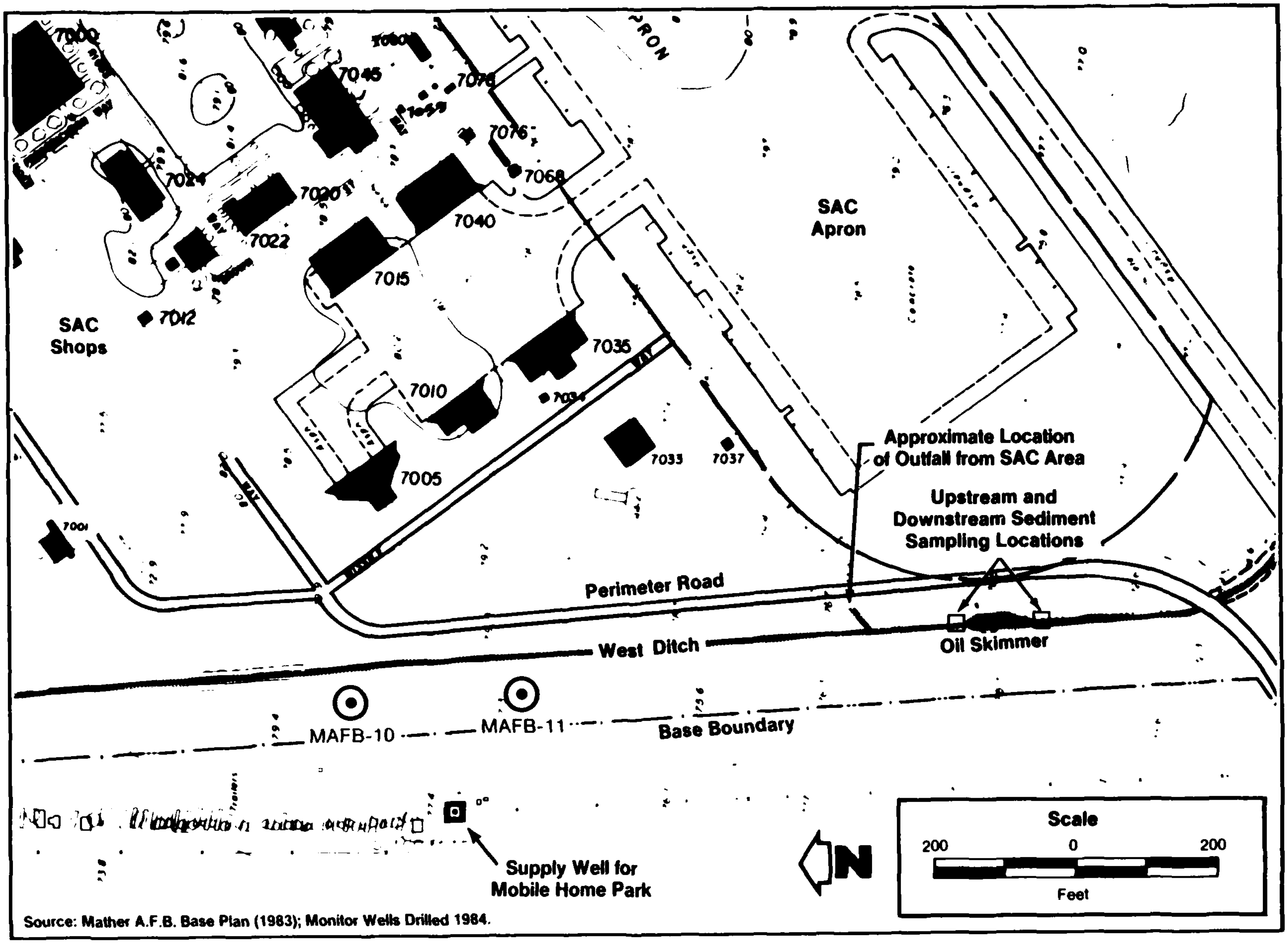


FIGURE 3-6 MONITOR WELL AND SEDIMENT SAMPLING LOCATIONS AT THE WEST DITCH

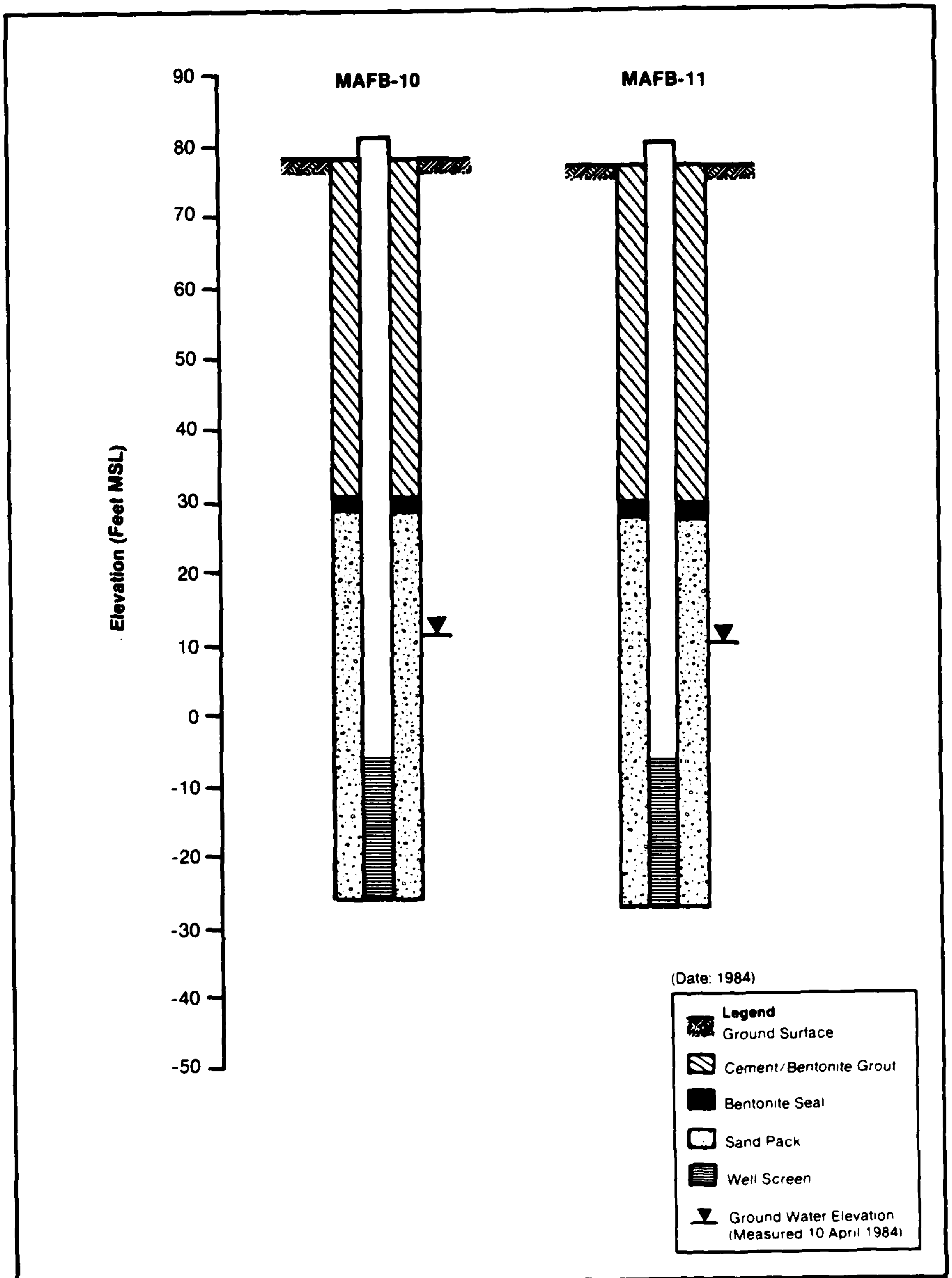


FIGURE 3-7 WELL CONSTRUCTION SUMMARY, WEST DITCH

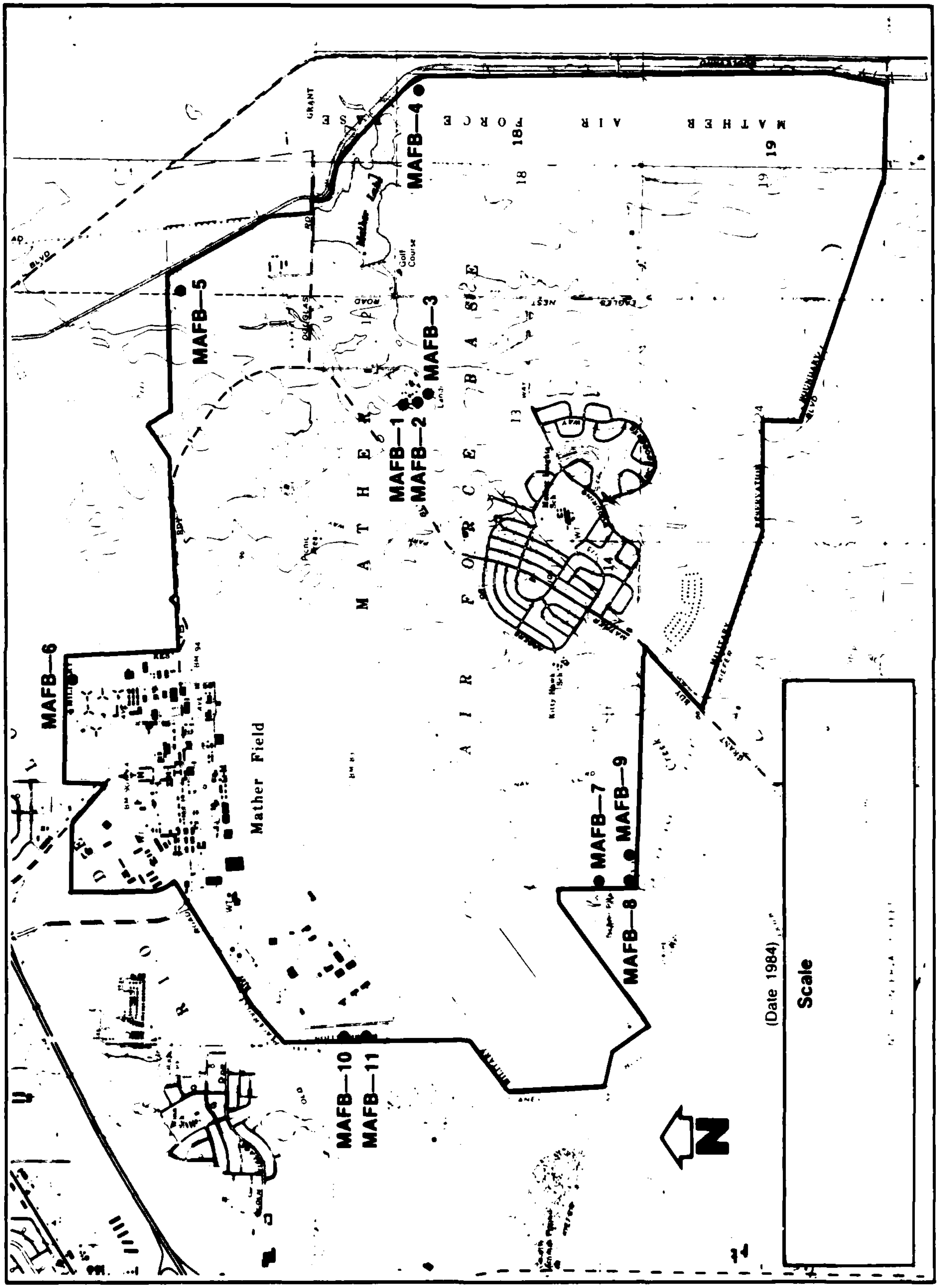


FIGURE 3-8 MONITOR WELL LOCATIONS, MATHER AFB

Total completed depths in the three wells varied based on the topography of the sites. Total depths are 153.5, 128.5, and 99.5 feet for MAFB-4, MAFB-5, and MAFB-6, respectively. They are sand-packed to depths of 103, 85, and 50.5 feet, respectively. A well construction summary diagram is shown in Figure 3-9.

3.2.2.3 Well Development and Aquifer Testing

All monitor wells were developed first by surging and bailing to loosen the mud pack deposited on the face of the formation during drilling, then by pumping with an electric submersible pump for periods of 1 to 3 hours. In addition, MAFB-11 had to be developed by using trisodium phosphate to break down the mud and later jetting with compressed air before pumping with the submersible pump. Although most wells could not sustain pump yield when first pumped, their capacity developed over time. Final well yields ranged from a low of 2.5 gpm in MAFB-11 to more than 30 gpm in MAFB-6. All wells were pumped until discharged water was observed to be running clear at the maximum sustained yields of the wells.

In order to evaluate the range of hydraulic conductivities to be expected in the materials penetrated by the monitor wells, recovery rates were measured in eight of the wells when the pump was turned off at the end of the well development period. The eight wells tested do not include either of the wells exhibiting the highest and lowest yields (MAFB-6 and MAFB-11, respectively) because useful data could not be collected from these wells. The data were analyzed using the standard method of analysis as described by Kruseman and De Ridder (1979), which incorporates the assumptions of the classic Theis aquifer test drawdown analysis. This analysis yields a value of transmissivity, defined as the rate of flow through a unit aquifer thickness under a hydraulic gradient of one, for the aquifer in the vicinity of the well. The data and analyses are shown graphically in Appendix E, and the results have been summarized in Table 3-3. Hydraulic conductivity, which represents the ability of a porous material to transmit water, and is equivalent to the term "permeability" used in soil science, is calculated by dividing the value of transmissivity derived from the aquifer test analysis for a well by the saturated thickness of the aquifer in the vicinity of the well. The saturated thickness was taken to be equal to the depth of penetration of the well into the saturated sediments, or the height of the water column above the bottom of the well, based on the assumption that, in highly stratified sediments, flow to a partially penetrating well can be considered fully horizontal.

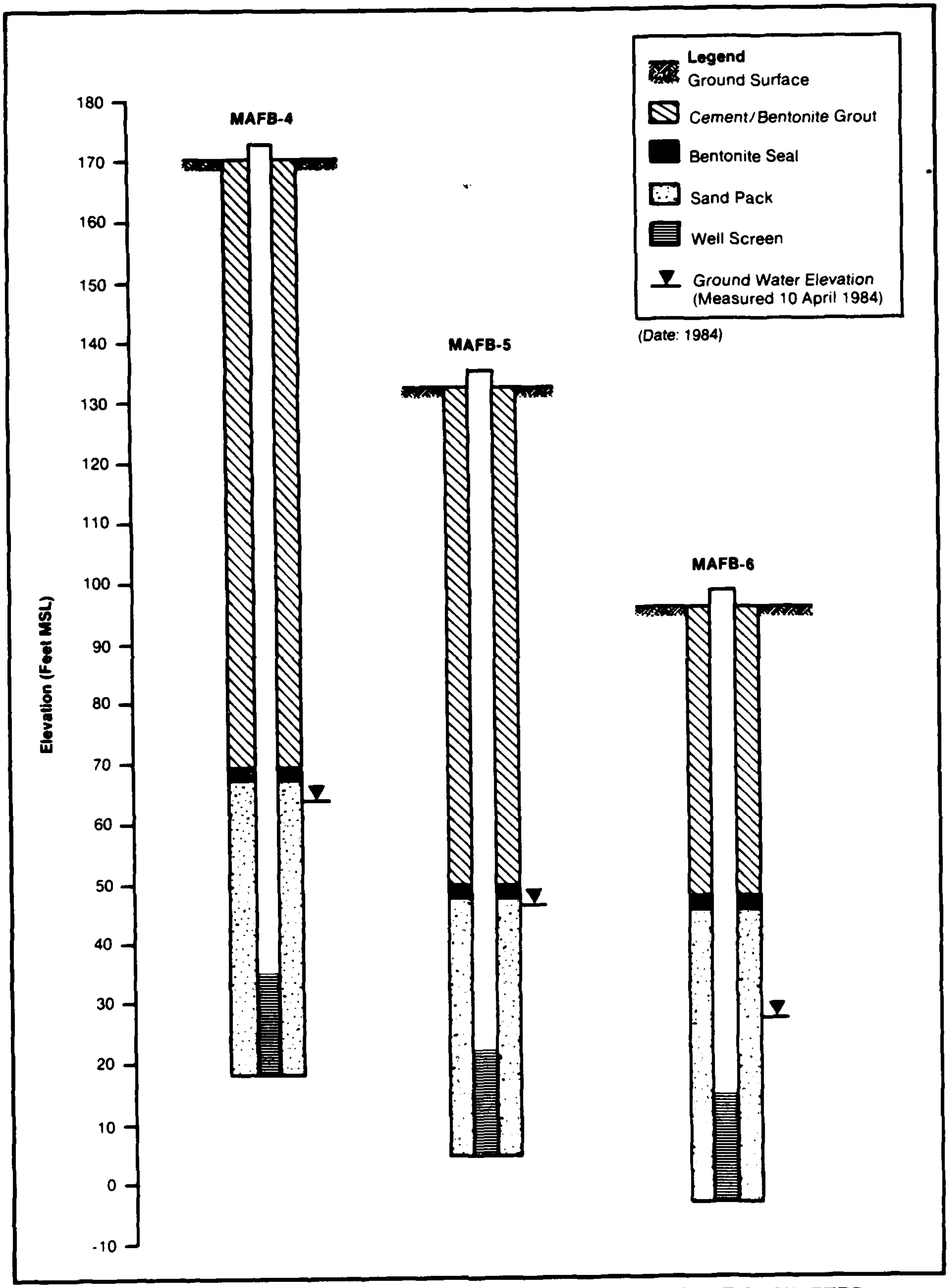


FIGURE 3-9 WELL CONSTRUCTION SUMMARY, NORTHEAST PERIMETER

Table 3-3

Summary of Recovery Test Results

Well No.	Pumping Rate (gpm)	Transmissivity ($ft.^2$/day)	Saturated Thickness (feet)	Hydraulic Conductivity (ft./day)
ACW Area				
2	5	34	17	2.0
3	7.3	40	19	2.1
N.E. Perimeter				
4	12	47	46	1.0
5	6	10	44	0.2
7100 Area				
7	12	18	44	0.4
8	25	79	39	2.0
9 (1)	10	41	41	1.0
9 (1)	15	15	41	0.4
West Ditch				
10	20	36	38	1.0

(1) MAFB-9 was tested twice, at two different pumping rates.

The results summarized in Table 3-3 indicate that in general the hydraulic conductivity of the sediments penetrated (presumably all in the Laguna Formation) ranges between 0.2 and 2.1 feet/day, although this range does not include extreme values. The value reported for a well represents a bulk value for the thickness of saturated sediments penetrated, and is an average for the different types of sediments encountered. The range reported is typical of values reported for fine-grained (silt-size) and poorly-sorted mixed unconsolidated sediments (Todd, 1980; Davis and DeWiest, 1965).

3.2.3 Groundwater Level Monitoring

Upon well completion, the top of the casing in each monitor well was permanently marked, and the elevation of this mark was surveyed relative to the National Geodetic Vertical Datum (NGVD). All surveying was performed by WESTON personnel using an engineer's level, and elevations were tied to benchmarks with known elevations referenced to NGVD. Elevations were surveyed to the nearest 0.01 foot with a computed error of ±0.02 foot.

A complete round of water level measurements in the monitor wells was taken on 10 April 1984, at the end of the drilling and development program. Groundwater levels in the monitor wells were measured 12 more times between April and November 1984, at approximately two-week intervals. Water levels were also measured on 30 May 1985 and 26 and 27 June 1985 prior to sampling. The depth-to-water data are summarized in Table 3-4, which also lists the surveyed elevations of the tops of well casings.

The purpose of groundwater level monitoring at Mather AFB was to determine appropriate sampling intervals, so that groundwater sampling could be performed as close as possible to high-level, mid-level, and low-level regional groundwater conditions.

3.2.4 Groundwater Sampling

As described in Subsection 3.1.3, the 11 monitor wells at Mather AFB were to be sampled three times each, for the parameters listed by site in Tables 1-2 and 3-1. In addition, the 15 Base production wells were to be sampled once for the parameters listed in Table 3-1. Contract analytical requirements are summarized in Table 3-5 and in Appendix B (Table 2).

TABLE 3-4

Summary of Monitor Well Water Levels, April 1984 - June 1985

Site	Well No.	Top of Casing Elevation (feet MSL)	Water Elevation (feet MSL) 1984													1985	
			10 Apr	1 May	15 May	30 May	13 June	29 June	18 July	1 Aug	13 Aug	29 Aug	14 Sept	24 Sept	13-19 Nov	30 May	27 June
AC&W Area	1	131.79	25.13	25.31	24.42	23.93	23.90	22.79	22.04	21.89	21.69	20.98	20.84	20.79	21.79	21.71	20.42
	2	130.87	24.70	26.4	24.14	23.6	23.33	22.47	21.70	21.47	21.15	20.57	20.57	20.35	21.17	21.40	20.27
	3	128.12	23.97	24.17	23.38	22.9	20.65	21.78	21.07	20.76	20.35	19.97	19.89	19.73	20.0	20.94	19.68
Northeast Perimeter																	
	4	173.41	63.51	64.00	63.79	63.87	63.87	63.89	63.78	63.91	63.87	63.69	63.77	63.89	64.01	64.05	64.94
	5	135.17	45.61	45.43	45.91	45.79	45.62	43.97	44.63	44.70	45.02	45.57	45.74	45.94	42.27	45.99	44.77
	6	98.41	30.16	30.37	30.04	29.94	29.41	28.92	28.41	28.04	27.86	27.35	27.52	27.14	25.91	27.14	26.30
[illegible] Area																	
	7	73.35	5.45	5.02	3.55	1.61	1.32	0.31	-0.85	1.10	-1.18	-1.65	-1.49	-1.50	1.85	0.80	-1.48
	8	71.70	2.89	1.78	0.52	-1.46	-1.95	-3.36	-4.30	-5.02	-5.40	-5.67	-5.48	-5.70	-18.21	-2.79	-4.61
	9	78.00	7.00	12.76	13.48	12.76	12.46	11.46	10.75	9.38	10.14	10.19	9.98	10.00	12.00	12.35	9.79
West Gate																	
	10	81.14	10.69	10.73	10.21	9.75	9.64	9.24	8.81	8.64	8.46	8.18	7.52	7.84	7.74	6.43	6.82
	11	80.10	9.49	9.82	9.40	9.24	8.80	9.10	8.35	8.35	8.40	7.93	7.00	7.70	7.40	7.03	6.61

[1] [illegible] considered to be an error.

Table 3-5

Summary of Contract Analytical Requirements

		Monitor Wells				Base Wells						QA		
	Sampled Medium	ACW (MAFB-1,2,3)	7100 (MAFB-7,8,9)	West Ditch (MAFB-10,11)	Perim-eter (MAFB-4,5,6)	Main Base (B1, 2,3,4)	Family Housing (FH-1,2 3,4,5,6)	Golf Course (GC-1,2)	K9	ACW	JTC	Field Blanks	Dupli-cates	Total Samples
VOA	Water	9	9	6	9	4	6	2	1	1	1	5	5	58
TOX	Water	9	9	6	9	4	6	2	1	1	1	5	5	58
Oil and Grease (IR)	Water	9	9	6	9	4	6	2	1	1	1	5	5	58
PCB's	Water	9	---	---	---	---	---	---	---	1	---	2	---	12
Phenol	Water	---	9	6	---	---	---	---	---	---	1	1	2	19
Cyanide	Water	---	9	6	---	---	---	---	---	---	1	---	2	18
Metals(1)	Water	---	9	6	9	4	---	---	---	---	1	3	3	35
DMN(2)	Water	---	---	---	9	4	---	---	---	---	---	1	2	16
Pesticides(3) and Herbi-cides	Water	---	---	---	9	4	---	---	---	---	---	1	2	16
VOA	Sediment	---	---	2	---	---	---	---	---	---	---	---	1	3
Oil and Grease (IR)	Sediment	---	---	2	---	---	---	---	---	---	---	---	1	3
Phenol	Sediment	---	---	2	---	---	---	---	---	---	---	---	1	3
Cyanide	Sediment	---	---	2	---	---	---	---	---	---	---	---	1	3
Metals(1)	Sediment	---	---	2	---	---	---	---	---	---	---	---	1	3
TOC	Sediment	---	---	2	---	---	---	---	---	---	---	---	1	3

(1)Metals - Cr, Pb, Cd, Ni, Ag
(2)DMN = Dimethylnitrosamine
(3)Pesticides - DDT, Chlordane, 2,4-D

In order to accomplish groundwater sampling efficiently and to ensure adequate field quality control, specific procedures were developed for groundwater sampling at Mather AFB and are described in Appendix F, the Field Sampling and QA/QC Plan. These procedures address well purging, sample collection and preservation, and collection of quality control samples. Base production wells were purged (when possible, given physical constraints in the distribution system) using the existing pump, and samples were collected from taps in the discharge line before the water passed through any form of treatment system. The monitor wells were sampled by purging them with a portable submersible pump equipped with a Teflon discharge line, and the sample was collected directly from the discharge line. The pump and line were fully decontaminated by rinsing and flushing with Base drinking water and deionized water between wells. Field procedures included filtering of the portion of the sample to be analyzed for metals before preservation with nitric acid, and measurement of field pH and specific conductance in the sample. A summary of field-tested water quality parameters is given in Table 3-6.

Groundwater sampling was performed initially in 1984 on 3 to 9 May (Round 84-1), 13 to 20 August (Round 84-2), 27 September to 16 October (Round 84-3), and 13 to 20 November (Round 84-4). However, field and laboratory problems developed which left portions of the analytical data generated from the 1984 sampling rounds without adequate QA/QC support. For this reason, two more rounds of sampling were performed in 1985, on 29 May to 3 June (Round 85-1) and 26 to 27 June (Round 85-2).

A review of the 1984 data showed incomplete and inconsistent sample sets after the data without adequate QA/QC support were deleted from the data set. The 1985 data, which include two full rounds of samples from the monitor wells and one round of samples from 14 production wells, present a more complete picture of groundwater quality conditions at Mather AFB. Furthermore, the 1985 data do not alter in any way the preliminary conclusions that had been based on the 1984 data. In the interest of accuracy and clarity, therefore, only the 1985 analytical data are presented and discussed in this report. However, the analytical results for the samples collected in 1984 are presented in Appendix N.

[illegible] sample log sheets documenting sample collection are in- [illegible] in Appendix G, and sample chain-of-custody records are [illegible] in Appendix H. Standard laboratory analysis protocols are [illegible] in Appendix I.

Table 3-6

Summary of Field Tested Water Quality Parameters

Site	Well No.	pH Round 84-1	pH Round 84-2	pH Round 84-3	pH Round 84-4	pH Round 85-1	pH Round 85-2	Specific Conductance (umhos/cm) Round 84-1	Round 84-2	Round 84-3	Round 84-4	Round 85-1	Round 85-2
ACW Area	MAFB-1	7.2	8.1	8.2	8.3	7.5	7.3	120	150	163	148	139	282
	MAFB-2	7.2	7.2	7.1	8.3	7.3/7.3	6.8	155	150	200	114	134/128	316
	MAFB-3	7.4	8.1	8.6	9.0	7.6	7.6/7.6	150	130	152	129	120	317/288
Northeast Perimeter	MAFB-4	6.7	7.1	7.2	7.5	6.6	6.9	130	140	130	155	205	163
	MAFB-5	6.6	7.2	7.9	7.5	7.1/7.1	7.1	200	110	120	105	109/112	132
	MAFB-6	6.8	7.1	7.0	7.6	7.2	6.9/6.9	175	240	245	251	253	242/238
7100 Area	MAFB-7	6.5	6.9	7.0	6.9	6.7	6.7	1,000	1,070	1,005	966	914	1,005
	MAFB-8	6.5	6.9	7.0	6.8	6.6/6.6	6.9	750	1,070	1,074	1,020	986/987	1,093
	MAFB-9	6.4	6.8	7.0	6.7	6.6	6.7/6.7	700	1,090	1,100	860	1,012	1,093/1,097
West Ditch	MAFB-10	7.9	7.3	7.5	7.2	7.4	7.6/7.5	150	243	272	302	207	280/283
	MAFB-11	8.7	7.3	7.5	7.1	7.0/7.5	7.5	175	190	202	259	168/217	216
Base Wells	B-1	6.9	7.0			7.7		105	122			106	
	B-2	6.9	7.4			7.8		95	114			111	
	B-3	7.0	7.6			7.9		85	115			105	
	B-4	N.O.	7.9			7.6/7.7		N.O.	119			106/107	
	FH-1	6.9	7.0			7.3		120	147			168	
	FH-2	6.9	7.0			7.3		115	129			113	
	FH-3	7.3	7.0			7.2/7.3		200	208			210/212	
	FH-4	7.0	N.O.			N.O.		120	N.O.			N.O.	
	FH-5	7.0	[illegible]			N.O.	7.4	155	178			N.O.	
	FH-6	7.1	7.1			7.5		135	142			129	
	GC-1	7.1	7.1			7.4		150	166			145	
	GC-2	6.4	7.3			7.5/7.8		175	169			146/141	
	A-9	6.9	7.2			7.5		150	220			151	
	ACW	7.7	6.9			N.O.	7.0	100	156			N.O.	294
	JTC	6.9	7.0	7.1		7.5		155	190	160		145	

N.O. - Pump not operable
/ - Denotes results for field duplicates

3.2.5 Sediment Sampling

Sediment from the bottom of the West Ditch was collected approximately 50 feet upstream and downstream from the oil skimmer. Samples were initially collected in 1984, and another round of sediment samples was taken on 30 May 1985 (Round 85-1) to rectify QA/QC problems encountered in the 1984 sampling. The 1985 samples were analyzed for VOA's, TOC, oil and grease, phenols, cyanide, and metals. A duplicate soil sample was collected from the upstream sampling point. All sediment samples were collected using a clean, stainless steel spatula, and transferred into glass containers as described in Appendix F.

SECTION 4

RESULTS

4.1 INTERPRETIVE GEOLOGY

A generalized description of the shallow subsurface below Mather AFB can be derived from the boring logs for the 11 monitor wells (Appendix D) installed in Stage 1. Total drilled depths in the monitor wells ranged from 118 to 166 feet. The wells penetrated the Plio-Pleistocene age sediments described in Section 2, including the Pleistocene age gravels (found only in MAFB-4), and the Laguna and Victor Formations, which were indistinguishable in drill cuttings.

The shallow stratigraphy beneath Mather AFB can be divided into the following generalized layers: topsoil, sometimes including a dense silt hardpan, to a depth of approximately 6 feet; cobbles and gravel generally in a dense clay or silt matrix, to a depth of 40 to 50 feet; and interbeds of silt, sandy silt, and sand, with occasional layers of clay and gravel, to a depth of 120 feet. The water table generally occurs below the cobble and gravel layer in mixed deposits exhibiting little vertical or lateral continuity. Along the northeast perimeter, the lower saturated section is generally coarser-grained than in other areas of the Base. Distinct sandy gravel or gravel and cobble zones were noted in all three of the northeast perimeter monitor well borings near the base of the drilled section. These zones were 8 feet thick in MAFB-4, 30 feet thick in MAFB-5, and almost 40 feet thick in MAFB-6. During developing and testing, MAFB-6 exhibited the highest yield and the highest specific capacity of the 11 monitoring wells, indicating that it was completed in the most permeable materials.

4.2 GROUNDWATER CONDITIONS

4.2.1 General

The sediments penetrated by the monitor wells can be considered to represent the upper section of a highly heterogeneous aquifer that is generally unconfined, but in which confined conditions and perched groundwater occur locally. Due to the limited number of monitor wells drilled for this investigation, their depth, and the drilling method, the impact of perched groundwater on the presence and migration of contaminants could not be fully assessed.

Based on background references cited in Section 2, the following bulk average values can be considered typical for the regional aquifer, consisting of the combined Laguna and Mehrten formations: transmissivity in the range of 8,700 square feet/day, hydraulic conductivity in the range of 20 feet/day, and a storativity (equal to the specific yield in an unconfined aquifer) of 0.07. However, as indicated by the monitor well logs and recovery test results reported in Section 3, sediments in the upper section of the aquifer are relatively fine-grained, poorly-sorted, heterogeneous, and exhibit permeabilities that are generally lower than the bulk average for the full saturated thickness. In general, predominant grain sizes in the top 50 feet of the saturated section range from sand and some gravel along the northeast perimeter to silt and silty sand in the 7100 Area on the southwest corner of the Base. Hydraulic conductivities measured in the recovery tests were in the range of 0.2 to 2.1 feet/day, except for MAFB-6, in which the recovery was too rapid to be accurately measured.

Due to the absence of monitor well coverage upgradient of suspected contaminant sources, and the lack of lateral continuity in the sediments, site-specific hydrogeological analyses were not found to be useful for this study. Instead, anomalies in water level hydrographs and water table maps have been used to distinguish specific site characteristics in the following general discussions of water level trends and groundwater flow direction at MAFB.

4.2.2 Water Level Trends

Figure 4-1 includes a set of hydrographs for the 11 monitor wells, constructed from water level measurements made between April and November 1984 and on 30 May and 26 June 1985. In general, groundwater levels were highest in late April, then declined from May through August, levelling off in late August and September.

Comparison of water level data from May and June 1984 and May and June 1985 indicates that the pattern of early summer decline occurs in both years, substantiating that this is a seasonal trend. In addition, comparison of these water levels shows that an overall decline in water levels (ranging from less than one foot to two feet) occurred between June 1984 and June 1985. This decline is in conformance with the regional decline in water levels of approximately one foot per year that has been described in Subsection 2.3.2. The regional decline shown for 1984-1985 may be greater than normal since 1983-1984 was a wet year relative to 1984-1985.

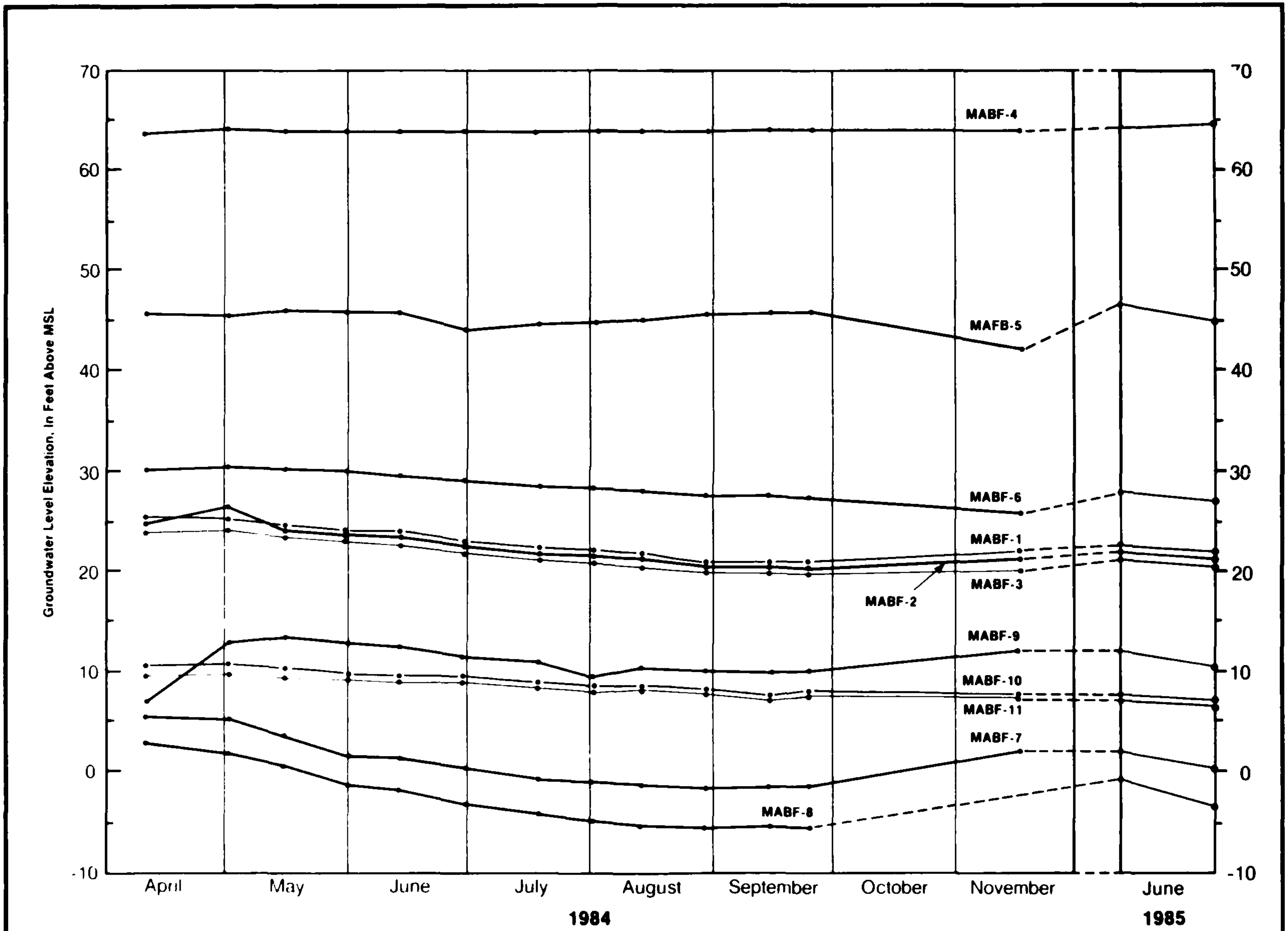


FIGURE 4-1 MONITOR WELL HYDROGRAPHS, APRIL-NOVEMBER 1984, MAY-JUNE 1985

The hydrographs shown in Figure 4-1 suggest that groundwater levels are highest during the winter months (December through March or April) in conformance with regional trends described in Subsection 2.3.2. This trend is only suggested however by the data for November 1984 and May 1985; in the absence of water level readings for the winter months, the trend cannot be confirmed.

With the exception of MAFB-4, all of the monitor wells exhibit these trends to some extent. Variations among the wells can be attributed to the influence of local pumping and to the variable permeability and discontinuous nature of the water-bearing materials.

MAFB-7, MAFB-8 and MAFB-9 most clearly exhibit the water-level trends expected from the regional data. Expression of these trends is more subdued on the hydrographs for MAFB-1, -2, and -3 and MAFB 10 and 11. These trends suggest that local pumping has a significant effect on water levels in these wells. MAFB-1, -2, and -3 are proximate to the Family Housing wells, while MAFB 10 and 11 are proximate to off-base domestic wells.

MAFB-4 is the only monitor well that is apparently unaffected by seasonal fluctuation in water levels. The stability of the water level in this well is most likely due to the well's proximity to Mather Lake and suggests that groundwater at MAFB-4 is in hydraulic connection with Mather Lake and the lake level locally controls groundwater levels.

Groundwater levels decrease from MAFB-4, on the northeast perimeter, to MAFB-7 and MAFB-8 in the 7100 Area on the southwest corner. MAFB-9, however, exhibited an anomalously high water level throughout most of the year, although the water level measured in that well on 10 April, shortly after well development, was only 1.5 feet higher than the level in MAFB-8 on the same date. The water level in MAFB-9 rose 6 feet between 10 April and 1 May, and remained from 10 to 15 feet higher than the other two monitor wells in the 7100 Area which followed a parallel seasonal trend. This appears to indicate the existence of perched groundwater conditions at MAFB-9, or locally confined conditions in MAFB-7 and MAFB-8, although neither can be definitively documented on the basis of the mud rotary well logs. The presence of perched water may be indicated, however, by the existence of a seasonal pond approximately 40 feet below grade, in the bottom of the borrow pit immediately to the west of the 7100 Area landfill.

In summary, water levels in the shallow aquifer at MAFB are affected by seasonal fluctuations and, in addition, by local hydrologic and geologic conditions.

4.2.3 Groundwater Flow Direction

Figure 4-2 represents generalized groundwater level contours for Mather AFB on 1 May and 24 September 1984 based on water level data obtained at 10 monitor wells. MAFB-9 was excluded due to the anomalous water levels measured in this well, as described in the previous subsection.

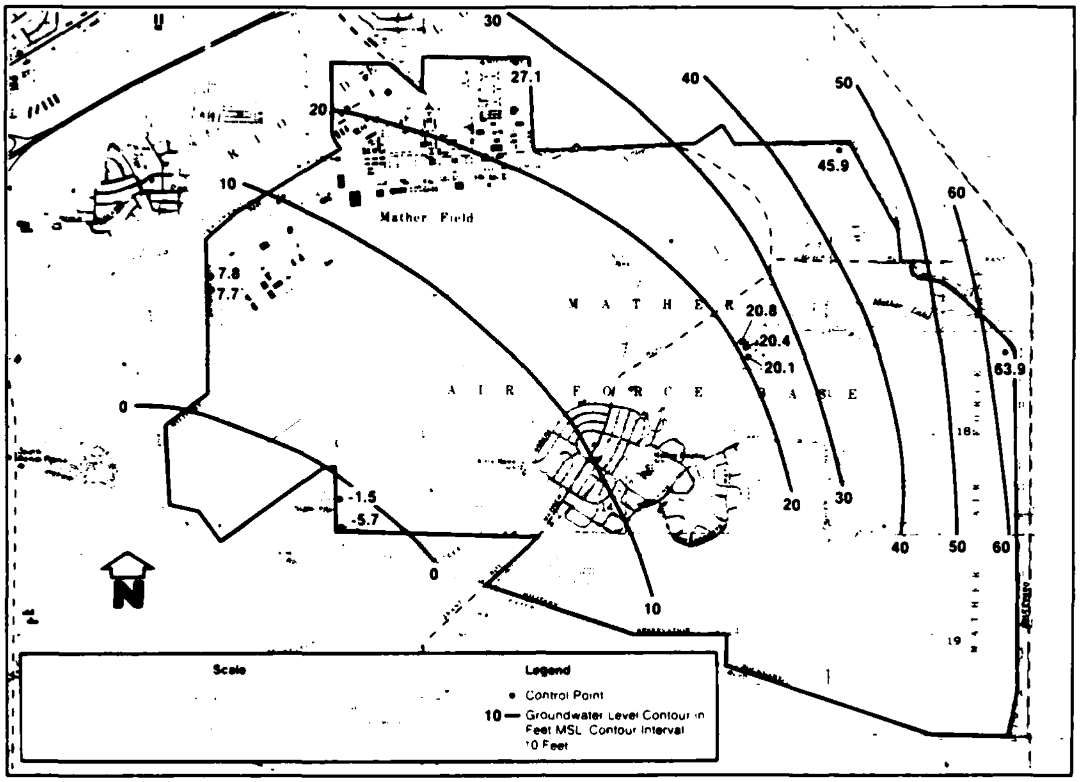
The water level map indicates that the direction of the hydraulic gradient measured in the shallow subsurface generally parallels the regional gradient illustrated in Figure 2-4, resulting in a southwesterly direction of groundwater flow beneath the Base. Only a generalized approximation of the hydraulic gradient can be obtained from the limited data points available for the Base. However, the magnitude of the hydraulic gradient exhibited in Figure 4-2 appears to be somewhat steeper in the northeast sector of the Base. This steeper gradient results from the relatively high water levels measured in MAFB-4 and MAFB-5 along the northeast perimeter. As mentioned in the previous section, hydrographs for MAFB-4 were anomalously stable, lacking the seasonal fluctuation exhibited by the other monitor wells. This evidence indicates that a portion of the northeast perimeter area may be influenced by a relatively constant source of groundwater recharge in the vicinity of the two wells. Such a source could be represented by leakage from Mather Lake, the Folsom Canal, or a combination of the two. Communications with personnel from the U.S. Bureau of Reclamation Office in Sacramento, however, indicate that there are no major breaches in the cement lining of the canal along this section, and seepage losses are estimated to be minimal. In addition, there may be off-site sources of recharge to the northeast that could not be documented for this report.

Although there was a general decline in groundwater levels, no significant differences in water table configuration were noted between 1 May and 24 September.

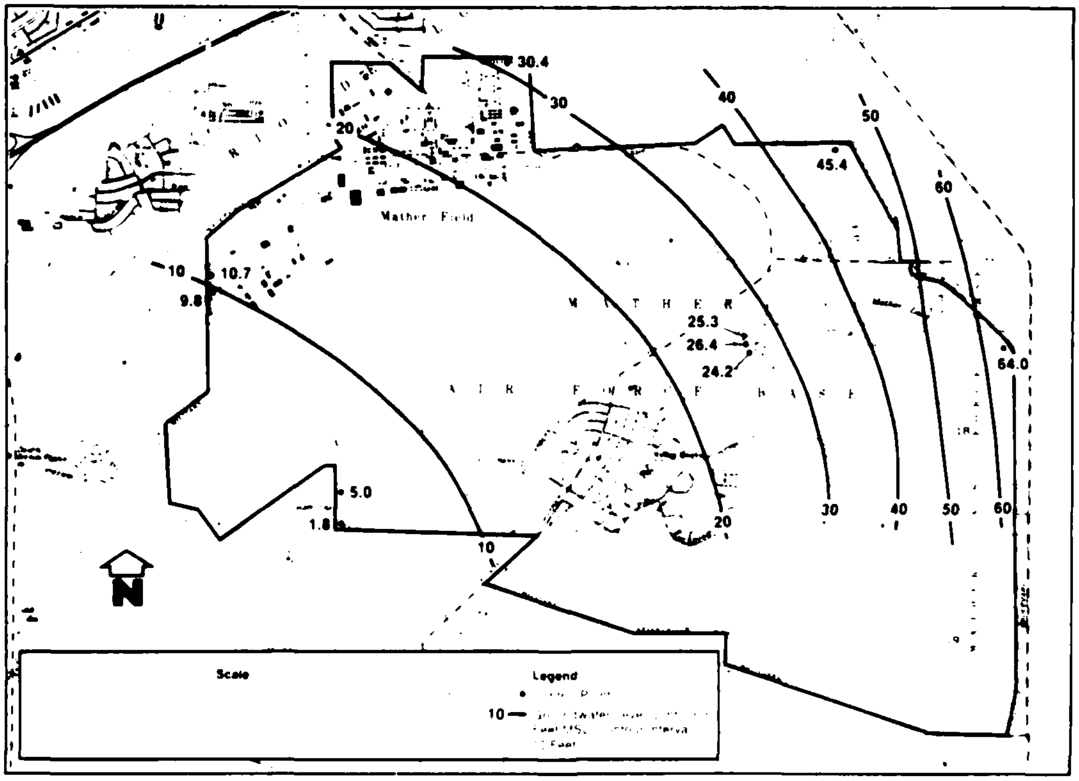
The average hydraulic gradient over most of the Base (excluding the northeast perimeter), calculated from Figure 4-2, is 0.002. Groundwater seepage velocity in the upper portion of the regional aquifer beneath Mather AFB can be calculated using a value for hydraulic conductivity, K, of 1.0 foot/day, based on the range of values calculated from the recovery tests, and an estimated effective bulk porosity, n, of 0.2 in the formula:

$$v_s = Ki/n$$

Where K = Hydraulic conductivity, in feet/day.
i = Hydraulic gradient, dimensionless.
n = Porosity, dimensionless.
v_s = Groundwater seepage flow velocity.



a) GROUNDWATER LEVEL MAP, 1 MAY 1984



b) GROUNDWATER LEVEL MAP, 24 SEPTEMBER 1984

FIGURE 4-2 GROUNDWATER LEVEL CONTOUR MAP, MAY AND SEPTEMBER 1984

From this formula, average seepage flow velocity in the upper aquifer is calculated to be on the order of 0.01 foot/day. This analysis applies to the upper aquifer zone, which has a lower permeability than the aquifer as a whole. A representative seepage velocity for the entire saturated thickness of the regional aquifer, calculated using a larger average hydraulic conductivity of 10 feet/day, is estimated at 0.1 foot/day.

4.3 RESULTS OF CHEMICAL FIELD TESTS AND LABORATORY ANALYSES

This subsection reviews chemical data, including those data obtained from field measurements and from laboratory analyses of environmental samples collected at Mather AFB between May and June 1985. As described in Subsections 3.2.4 and 3.2.5, sampling for the Phase II, Stage 1 investigation at Mather AFB was initially performed in four rounds between May and November 1984. Due to field and laboratory QA problems, however, the resulting body of data was found to be incomplete and inconsistent. Therefore, two more rounds of sampling were performed on 29 May to 3 June 1985 (Round 85-1) and 26 to 27 June (Round 85-2). Only the data from the two 1985 rounds are reported and discussed in this report. The preliminary conclusions which had been drawn from the 1984 data are not altered by considering only the 1985 data. Analyses results for 1984 and 1985 are available in the appendices.

Methods used in sample collection and preparation were described in Subsection 3.2. Additional details on field sampling and laboratory analytical methods are provided in Appendices F and I. The laboratory analytical reports are provided in Appendix K.

4.3.1 Groundwater Results

A total of 11 monitor wells were installed in four areas of Mather AFB and screened in a shallow section of the regional aquifer. All of the monitor wells were sampled twice in 1985, in May-June (Round 85-1) and in June (Round 85-2). In addition, all accessible Base production wells were sampled once in 1985. Twelve of the production wells were sampled in May-June; the ACW well and well FH-5 could not be accessed at that time, and were sampled in June (Round 85-2). Well FH-4, which was redrilled in 1984, was still under construction and could not be accessed during either round.

Groundwater quality data generated from the 1985 sampling rounds are discussed in the following subsections. Laboratory analytical data in Appendix K have been summarized in data tables for each site. Field measurements of pH and specific conductance have previously been summarized in Table 3-6. A general discussion of data interpretation precedes the site-by-site discussions. Data from the 1984 rounds are available in Appendix N.

4.3.1.1 General

Samples for volatile organic analytes (VOA) were collected from all groundwater monitoring points and analyzed by EPA Methods 601 and 602. Method detection limits and reported laboratory detection limits are summarized in Table 4-1. In general, although compound concentrations are reported at levels below one part per billion (0.001 mg/L), the accuracy of the analysis is significantly less at these lower concentrations. Furthermore, VOA samples are susceptible to both loss of some compounds and cross-contamination with others in the process of collection, storage, transport, and analysis. For this reason, field and laboratory quality control procedures are established to help distinguish compounds at low concentrations which may be artifacts from compounds which are actually present in the medium sampled. In the treatment of VOA analytical results, compounds detected in laboratory blanks have been subtracted from the sample results up to the concentrations detected in the blanks.

Results of VOA analyses performed on field blanks are summarized in Table 4-2. No VOA compounds were detected above detection limits in the two field blanks from the May-June 1985 round, and only one compound was found in the field blanks from the June 1985 round: benzene at a concentration of 0.00028 mg/L. Therefore, concentrations of benzene up to 0.00028 mg/L reported in samples collected in June 1985 can be considered artifacts and are so identified on the appropriate data tables.

Laboratory blanks for VOA were also analyzed as part of the laboratory Quality Control process. In conjunction with analysis of the samples collected during the May-June round, four blanks were analyzed for EPA Method 601 and three blanks were analyzed for Method 602. All of the Method 601 blanks showed detectable levels of methylene chloride (0.00020 to 0.00038 mg/L). Methylene chloride is commonly used in laboratories and therefore its occurrence was not unexpected. One of the blanks contained chloroform at 0.00017 mg/L, which is slightly above the detection limit. In two of the three Method 602 blanks toluene was identified at concentrations slightly above the detection limit. Concentrations found were 0.00021 and 0.00023 mg/L.

For samples analyzed from the June sampling round one laboratory blank was analyzed for EPA Method 601 and one laboratory blank was analyzed for EPA Method 602. The Method 601 blank contained methylene chloride (0.00032 mg/L) and 1,1,1-trichloroethane (0.00017 mg/L). The Method 602 blank contained 0.00023 mg/L of toluene.

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Table 4-1

List of Volatile Organic Halogenated and Aromatic Compounds Determined by EPA Methods 601 and 602, with Method Detection Limits

Compound	Method Detection Limits in Water (1) (mg/L)	Laboratory Detection Limits in Water (mg/L)	Laboratory Detection Limits in Sediment (mg/kg)
Chloromethane	0.00008	0.0010	0.0001
Bromomethane	0.00118	0.0012	0.0012
Dichlorodifluoromethane	0.00181	0.0018	0.0018
Vinyl chloride	0.00018	0.0002	0.0002
Chloroethane	0.00052	0.0005	0.0005
Methylene chloride	0.00025	0.0002	0.0002
Trichlorofluoromethane	--	0.0010	0.0100
1,1-Dichloroethene	0.00013	0.0002	0.0002
1,1-Dichloroethane	0.00007	0.0001	0.0001
Trans-1,2-Dichloroethene	0.00010	0.0001	0.0001
Chloroform	0.00005	0.0001	0.0001
1,2-Dichloroethane	0.00003	0.00002	0.00002
1,1,1-Trichloroethane	0.00003	0.0001	0.0001
Carbon tetrachloride	0.00012	0.0001	0.0001
Bromodichloromethane	0.00010	0.0001	0.0001
1,2-Dichloropropane	0.00004	0.0001	0.0001
Cis-1,3-Dichloropropene	0.00034	0.0003	0.0003
Trichloroethylene	0.00012	0.0001	0.0001
Dibromochloromethane	0.00009	0.0001	0.0001
1,1,2-Trichloroethane	0.00002	0.00005	0.00005
Trans-1,3-Dichloropropene	0.0002	0.0002	0.0002
2-Chloroethylvinylether	0.00013	0.0002	0.0002
Bromoform	0.00020	0.0002	0.0002
1,1,2,2-Tetrachloroethane	0.00003	0.00005	0.00005
Tetrachloroethene	0.00003	0.00005	0.00005
Chlorobenzene	0.00025	0.0003	0.0003
1,3-Dichlorobenzene	0.00032	0.0003	0.0003
1,2-Dichlorobenzene	0.00015	0.0002	0.0002
1,4-Dichlorobenzene	0.00024	0.0002	0.0002
Benzene	0.0002	0.0002	0.0002
Toluene	0.0002	0.0002	0.0002
Ethylbenzene	0.0002	0.0002	0.0002

(1) - Source: Federal Register, 40 CFR 49, 209 (26 October 1984)
-- - Not determined

Table 4-2

Summary of Analyses Results for Field Blanks - VOA Compounds

Compound (mg/L)	Laboratory Detection Limits in Water (mg/L)	Field Blank 1 May-June 85	Field Blank 2 May-June 85	Field Blank 1 June 85
Chloromethane	0.0010	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND
Methylene chloride	0.0002	ND	ND	ND
Trichlorofluoromethane	0.0010	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND
1,1-Dichloroethane	0.0001	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND
Chloroform	0.0001	ND	ND	ND
1,2-Dichloroethane	0.00002	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	ND	ND
Carbon tetrachloride	0.0001	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	ND
Dibromochloromethane	0.0001	ND	ND	ND
1,1,2-Trichloroethane	0.00005	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND
Bromoform	0.0002	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND
Benzene	0.0002	ND	ND	0.00028
Toluene	0.0002	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	ND

ND - Below detection limit

No other constituents were identified in any of the blanks. The results of analyses of blank samples are found in Appendix K. All VOA data reported in the tables in this section and in Appendix K have been blank corrected.

Field duplicates were collected for 25 percent of the VOA samples collected in 1985, and have been reported in data summary tables in the following subsections. Field duplicates, along with duplicate rounds of sampling, are used to confirm the presence of VOA compounds in groundwater. For the purposes of this discussion, a compound will be considered "confirmed" in a monitoring well if it is detected in at least two samples from that well.

Additional parameters sampled at Mather AFB in the Phase II, Stage 1 investigation included total organic carbon (TOC), oil and grease, phenols, cyanide, dimethylnitrosamine (DMN), pesticides and herbicides (DDT, chlordane, and 2,4-D), PCB's, and metals (cadmium, chromium, lead, nickel, and silver). Detection limits for these parameters are summarized in Table 4-3. Detection limits for chromium and nickel were lowered between the two 1985 sampling rounds due to improvements in laboratory technique. Field blanks were collected and analyzed for all parameters at least once, and the results are summarized in Table 4-4.

The only metal detected in the field blanks was nickel, at a concentration of 0.05 mg/L. TOC was detected up to 0.6 mg/L in May-June field blanks, oil and grease up to 0.72 mg/L in May-June field blanks, and phenols up to 0.009 in the June field blank. Cyanide, DMN, pesticides, herbicides, and PCB's were below detection limits in the field blanks.

Non-VOA parameters detected at or below field blank concentrations are annotated as such on the data summary tables.

Field measurements of pH and specific conductance have been summarized in Table 3-6, which includes data from both 1984 and 1985. A review of these data indicates that the background range for pH in groundwater at Mather AFB is 6.5 to 8.0 and the background range for specific conductance is 80 to 320 umhos cm. Values in these ranges were encountered in all of the production wells, the monitor wells along the northeast (upgradient) perimeter, and the West Ditch monitor wells.

4.3.1.2 Groundwater Quality in Base Production Wells

Fourteen Base production wells were sampled in 1985. The [illegible] of completion for these wells have been previously [illegible] in Table 2-2. Analytical results are summarized in [illegible] (VOA data) and 4-6 (non-VOA data). Field measurements [illegible] specific conductance (Table 3-6) fell with the back[illegible] in all production wells (with the exception of [illegible] ment).

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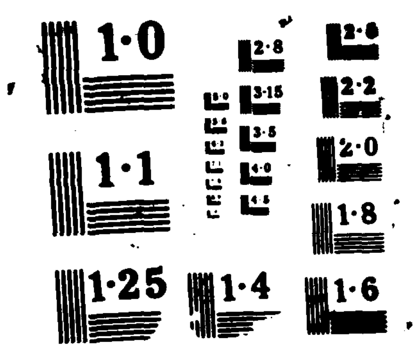
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Table 4-3

Laboratory Detection Limits
by Parameter and Date of Analysis
Non-VOA Parameters in Water

Analyte	Laboratory Dection Limits (mg/L) May-June 85	June 85
TOC	0.5	0.5
Oil and grease	0.10	0.10
Phenols	0.005	0.005
Cyanide	0.01	0.01
DMN	0.001	0.001
DDT	0.00002	0.00002
Chlordane	0.00002	0.00002
2,4-D	0.00006	0.00006
Cadmium	0.0025	0.0025
Chromium	0.050	0.010
Lead	0.010	0.010
Nickel	0.100	0.040
Silver	0.0025	0.0025
PCB's	(1)	(1)

(1) - Varies by arochlor; see laboratory reports in Appendix K

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Table 4-4

Summary of Water Analyses for Field Blanks - Non-VOA Parameters

Analyte (mg/L)	FB-1 May-June 85	FB-2 May-June 85	FB-3 May-June 85	FB-1 June 85
TOC	0.6	0.6	--	0.5
Oil and grease	0.72	0.20	--	0.24
Phenols	--	0.006	--	0.009
Cyanide	--	ND	--	ND
DMN	--	--	--	ND
PCB's	ND	--	--	ND
Chromium	--	ND	ND	ND
Lead	--	ND	ND	ND
Cadmium	--	ND	ND	ND
Nickel	--	ND	ND	0.051
Silver	--	ND	ND	ND
DDT	--	--	--	ND
Chlordane	--	--	--	ND
2,4-D	--	--	--	ND

-- - Analysis not performed
ND - Below detection limit (see Table 4-3)

Table 4-5

Summary of Groundwater Analyses Results for VOA Compounds
Base Production Wells

Compound (mg/L)	Laboratory Detection Limits in Water (mg/L)	Main Base Wells						Family Housing Wells				
		B-1 May-June 85	B-2 May-June 85	B-3 May-June 85	B-4 May-June 85	B-40 (1) May-June 85	FH-1 May-June 85	FH-2 May-June 85	FH-3 May-June 85	FH-30 (2) May-June 85	FH-5 June 85	FH-6 May-June 85
Chloromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.00002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	0.0002	0.002	0.00084	ND	0.0019	0.0011	0.00074	0.00094	0.00069	0.00094	0.00060	0.00074
Ethylbenzene	0.0002	ND	ND	0.00035	ND	ND	ND	ND	ND	ND	ND	ND

ND Below detection limit

(1) - Duplicate of B-4
(2) - Duplicate of FH-3

Table 4-5
(continued)

Compound (mg/L)	Laboratory Detection Limits in Water (mg/L)	Golf Course Wells: GC-1 May-June 85	Golf Course Wells: GC-2 May-June 85	Golf Course Wells: GC-2 (3) May-June 85	Remote Wells: ACW June 85	Remote Wells: ACW-1 (4) June 85	Remote Wells: K-9 May-June 85	Remote Wells: JTC May-June 85
Chloromethane	0.0010	ND	ND	ND	ND	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND	ND	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	0.0002	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.0010	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.0001	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND	ND	ND	ND	ND
Chloroform	0.0001	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	*0.00002*	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	0.0062	0.0095	0.0037	0.0037	ND	ND
Carbon tetrachloride	0.0001	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	ND	0.067	0.076	ND	ND
Dibromochloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND	ND	ND	ND	ND
Bromoform	0.0002	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	ND	ND	ND	0.00048	ND	ND
Toluene	0.0002	0.00031	ND	0.00084	0.00030	ND	0.00066	0.0012
Ethylbenzene	0.0002	ND	ND	ND	ND	ND	ND	0.00067

ND - Below detection limit.

(3) - Duplicate of GC-2
(4) - Duplicate of ACW

Table 4-6

Summary of Groundwater Analyses Results for Non-VOA Parameters
Base Production Wells

Analyte (mg/L)	Main Base Wells				Family Housing Wells				
	B-1	B-2	B-3	B-4	FH-1	FH-2	FH-3	FH-5	FH-6
	May-June 85	May-June 85	May-June 85	May-June 85	May-June 85	May-June 85	May-June 85	June 85	May-June 85
TOC	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND	ND
Oil and grease	ND	0.10*	0.13*	ND/0.13*	0.21*	0.12*	0.19*/0.22*	0.20*	0.31*
DMN	ND	ND	ND	ND/ND	--	--	--	--	--
Pesticides/herbicides (1)	ND	ND	ND	ND/ND	--	--	--	--	--
Metals (2)	ND	ND	ND	ND/ND	--	--	--	--	--
PCB's	--	--	--	--	--	--	--	--	--
Phenols	--	--	--	--	--	--	--	--	--
Cyanide	--	--	--	--	--	--	--	--	--

(1) - Pesticides and herbicides include DDT, chlordane, and 2,4-D
(2) - Metals include Cr, Pb, Cd, Ni, and Ag
-- - Analysis not requested
ND - Below detection limit (see Table 4-3)
* - Below concentration detected in field blank (see Table 4-4)
/ - Denotes results from field duplicates

Table 4-6
(continued)

Analyte (mg/L)	Golf Course Wells GC-1 May-June 85	Golf Course Wells GC-2 May-June 85	Remote Wells ACW June 85	Remote Wells K-9 May-June 85	Remote Wells JTC May-June 85
TOC	16.1	17.8/17.8	ND/ND	ND	13.0
Oil and grease	0.63*	0.22/0.22*	0.27/0.28*	ND	ND
DMN	--	--	--	--	--
Pesticides/ herbicides (1)	--	--	--	--	--
Metals (2)	--	--	--	--	ND
PCB's	--	--	ND/ND	--	--
Phenols	--	--	--	--	0.006*/ND
Cyanide	--	--	--	--	ND/ND

(1) - Pesticides and herbicides include DDT, chlordane, and 2,4-D
(2) - Metals include Cr, Pb, Cd, Ni, and Ag
-- - Analysis not requested
ND - Below detection limit (see Table 4-3)
* - Below concentration detected in field blank (see Table 4-4)
/ - Denotes results from field duplicates

In the Main Base and Family Housing wells, the only VOA compounds detected were toluene (in seven out of eight wells up to a concentration of 0.002 mg/L) and ethylbenzene in B-3 at a concentration of 0.00035 mg/L. Toluene is a laboratory solvent and, as part of laboratory quality control, the reported data have been adjusted to account for any toluene that may have been a laboratory artifact. Toluene was found in a large proportion of the samples collected in May-June 1985, was not reported in either of the field blanks in that round (Table 4-2), and therefore cannot be considered a sampling or laboratory artifact. A second round of samples would be required to confirm the presence of low concentrations of toluene in the production wells. The concentrations reported in Table 4-5 are well below the California action level for toluene, 0.100 mg/L. There is currently no action level for ethylbenzene.

Toluene was also reported in most of the remote production wells, but was not confirmed in duplicates from either GC-2 or the ACW well. Benzene was detected in the ACW well, but not confirmed in the duplicate. 1,1,1-trichloroethane was confirmed in GC-2 (0.0062 and 0.0095 mg/L) and the ACW well (0.0037 mg/L). Trichloroethylene (TCE) was confirmed in the ACW well at concentrations of 0.067 and 0.076 mg/L.

Of the non-VOA parameters in Base production wells, the following parameters either were not found above the detection limits or were found in concentrations below those found in field blanks in the wells in which they were sampled: oil and grease, DMN, metals, pesticides/herbicides and PCB's, phenols, and cyanide. TOC was below detection limits in the Main Base, Family Housing, and ACW well, but was found at concentrations exceeding 10 mg/L in wells GC-1 (16.1 mg/L), GC-2 (17.8 mg/L), and JTC (13.0 mg/L).

4.3.1.3 ACW Area - Shallow Groundwater Quality

Three downgradient wells (MAFB-1, MAFB-2, and MAFB-3) were sampled in the ACW Area. All three are screened from 102 to 120 feet below ground surface and sandpacked to a depth of 75 feet below ground surface. Values of pH and specific conductance in all three wells (Table 3-6) were within background, although levels of specific conductance appeared to be higher in June 1985 (Round 85-2) than in earlier rounds. Analytical data are summarized in Tables 4-7 (VOA data) and 4-8 (non-VOA data).

Table 4-7

Summary of Groundwater Analyses Results for VOA Compounds ACW Area

Compound (mg/L)	Laboratory Detection Limits in Water (mg/L)	MAFB-1 May-June 85	MAFB-1 June 85	MAFB-2 May-June 85	MAFB-2 June 85	MAFB-20 (1) May-June 85	MAFB-3 May-June 85	MAFB-3 June 85	MAFB-30 (2) June 85
Chloromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	0.00043	ND	ND	ND	ND	ND	ND
Chloroform	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.00002	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	0.0045	ND	ND	ND	ND	0.0025	ND
Carbon tetrachloride	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	0.0077	0.460	0.013	0.036	0.0051	0.033	0.027	0.120
Dibromochloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	0.00021*	ND	0.00021*	ND	ND	0.00022*	0.00040
Toluene	0.0002	0.0020	0.00044	0.00074	ND	0.00084	0.00094	ND	ND
Ethylbenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND

* - below concentration detected in field blank (see Table 4-2)

(1) - Duplicate of MAFB-2
(2) - Duplicate of MAFB-3

Table 4-8

Summary of Groundwater Analyses Results for Non-VOA Parameters
ACW Area

Analyte (mg/L)	MAFB-1		MAFB-2		MAFB-3	
	May-June 85	June 85	May-June 85	June 85	May-June 85	June 85
TOC	ND	ND	2.4/ND	0.7	ND	1.0/0.6
Oil and grease	0.74	0.76	0.52*/0.52*	0.29	0.26*	0.19*/0.21*
PCB's	ND	ND	ND/ND	ND	ND	ND/ND

ND - Below detection limit (see Table 4-3)
* - Below concentration detected in field duplicate (see Table 4-4)
/ - Denotes results from field duplicates

The only VOA compound confirmed in all three wells at the site was TCE, which was found in all samples (including duplicates) from both rounds, at levels ranging from 0.0051 to 0.460 mg/L. Benzene was detected in all samples collected in June, but at levels below the concentration in the field blank, and is, therefore, considered a sampling artifact at this site. Toluene was found in two samples each from MAFB-1 and MAFB-2, at levels well below the state action level of 0.100 mg/L. Other compounds which were detected at the ACW Area, but not confirmed in two samples, were trans-1,2-dichloroethene and 1,1,1-trichloroethane (at levels well below the state action level of 0.200 mg/L).

The only non-VOA parameters sampled at the ACW Area were TOC, oil and grease, and PCB's. TOC was not detected at MAFB-1, and was found in samples from MAFB-2 and MAFB-3 at levels between nondetected and 2.4 mg/L. Oil and grease were found in all three wells; except for the samples from MAFB-1, concentrations were at or below those found in field blanks. No PCB's were detected in any of the ACW Area monitor wells.

4.3.1.4 7100 Area - Shallow Groundwater Quality

Three monitor wells (MAFB-7, MAFB-8, and MAFB-9) in a presumed downgradient direction from the 7100 Area landfill were sampled. All three wells were screened between depths of approximately 90 and 110 feet, and sandpacked to depths between 60 and 65 feet. Based on water level data, MAFB-9 is suspected of being sandpacked into a perched groundwater zone. However, no significant differences in water quality were found between MAFB-9 and the other two monitor wells for this site.

Specific conductance levels in all three wells (Table 3-6) were significantly higher than background levels (as defined in Subsection 4.3.1.1), ranging from 700 to 1,100 umhos/cm. This indicates contamination by dissolved solids in groundwater downgradient from the 7100 Area. The pH in all three wells was within the range of background values for the area. Analytical results have been summarized in Table 4-9 (VOA data) and Table 4-10 (non-VOA data).

Table 4-9

Summary of Groundwater Analyses Results for VOA Compounds
7100 Area

Compound (mg/L)	Laboratory Detection Limits in Water (mg/L)	MAFB-7		MAFB-8		MAFB-80 (1)	MAFB-9		MAFB-90 (2)
		May-June 85	June 85	May-June 85	June 85	May-June 85	May-June 85	June 85	June 85
Chloromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND	0.0014	ND	ND	0.00064	0.00064
1,1-Dichloroethane	0.0001	ND	ND	ND	0.0016	ND	ND	0.00034	0.00031
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND	0.0020	ND	ND	0.00015	0.00014
Chloroform	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.00002	ND	ND	ND	0.00016	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	0.00015	ND	0.00071	ND	ND	0.00089	0.0037
Carbon tetrachloride	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	0.00079	0.087	0.100	0.034	0.0048	0.0054	0.0055
Dibromochloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	0.020	0.0054	0.013	0.0013	0.00095	0.00098
Chlorobenzene	0.0003	ND	ND	0.0017	0.0030	0.0017	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	0.00055
1,2-Dichlorobenzene	0.0002	ND	ND	0.0012	0.0010	0.0012	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	0.00054	0.00032	ND	0.00061	ND	ND	0.0027
Benzene	0.0002	ND	ND	ND	0.00099	ND	ND	0.00045	0.00032
Toluene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND

ND - Below detection limit
* - Below concentration detected in field blank (see Table 4-2)

(1) - Duplicate of MAFB-8
(2) - Duplicate of MAFB-9

Table 4-10

Summary of Groundwater Analyses Results for Non-VOA Parameters
7100 Area

Analyte (mg/L)	MAFB-7		MAFB-8		MAFB-9	
	May-June 85	June 85	May-June 85	June 85	May-June 85	June 85
TOC	9.0	10.2	4.4/4.5	4.6	5.7	5.6/5.7
Oil and grease	0.44*	0.57	0.52*/0.56*	0.68	0.55*	0.67/0.57
Phenols	0.006*/ND	ND/0.007*	0.007/ND	ND/0.007*	ND/0.008	ND/0.006*
Cyanide	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND
Cadmium	ND	ND	ND/ND	ND	ND	ND/ND
Chromium	ND	ND	0.06/ND	ND	ND	ND/ND
Lead	ND	0.032	ND/ND	ND	ND	ND/ND
Nickel	ND	ND	0.15/ND	ND	ND	0.055/0.054
Silver	ND	ND	ND/ND	ND	ND	ND/ND

ND - Below detection limit (see Table 4-3)
* - At or below concentration detected in field blank (see Table 4-4)
/ - Denotes results from field duplicates

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The VOA results for the 7100 Area indicate that a variety of VOA compounds are found in groundwater downgradient from the site. The compound found most consistently at the site is TCE, which was confirmed in all samples from MAFB-8 (0.034 to 0.100 mg/L) and MAFB-9 (0.0048 to 0.0055 mg/L). TCE was found in only one sample from MAFB-7 at a relatively low level (0.00079 mg/L). MAFB-7 generally appears to have less VOA contaminants than the other two wells; no VOA compounds were detected in the May 1985 sample from MAFB-7. In addition to TCE, the following compounds were confirmed in either MAFB-8 or MAFB-9:

Compound	Concentration	Location
1,1-Dichloroethene	0.00064 mg/L	in MAFB-9
1,1-Dichloroethane	0.00031 to 0.00034 mg/L	in MAFB-9
Trans-1,2-Dichloroethene	0.00014 to 0.00015 mg/L	in MAFB-9
1,1,1-Trichloroethane	0.00089 to 0.0037 mg/L	in MAFB-9
Tetrachloroethene	0.0054 to 0.020 mg/L	in MAFB-8
	0.00095 to 0.0013 mg/L	in MAFB-9
Chlorobenzene	0.0017 to 0.0030 mg/L	in MAFB-8
1,2-Dichlorobenzene	0.0010 to 0.0012 mg/L	in MAFB-8
1,4-Dichlorobenzene	0.00032 to 0.00061 mg/L	in MAFB-8
Benzene	0.00032 to 0.00045 mg/L	in MAFB-9

Although benzene was found in MAFB-8 at a level (0.00099 mg/L) exceeding the state action level of 0.0007 mg/L, it was not detected in two other samples from the same well, and is considered not confirmed. Benzene was confirmed in two duplicates from MAFB-9 collected in June. A field blank from the same round, however, exhibited benzene at a concentration of 0.00028 mg/L.

Non-VOA parameters sampled in the 7100 Area included TOC, oil and grease, phenols, cyanide, and metals. TOC values ranged from 4.4 to 10.2 mg/L. Values of oil and grease and phenols were below or close to levels in field blanks. Cyanide, cadmium, and silver were not detected in any samples. Chromium and lead were found in occasional samples, but they were not confirmed in duplicates or in second-round samples. Nickel was confirmed in two duplicates from MAFB-9, but a field duplicate collected in the same round exhibited a nickel level of 0.051 mg/L.

4.3.1.5 West Ditch Area - Shallow Groundwater Quality

Two monitor wells (MAFB-10 and MAFB-11) were sampled in an area downgradient from the West Ditch, between the ditch and the Base boundary. Both wells were screened between depths of approximately 85 and 105 feet, and sandpacked to a depth of 50 feet. Both specific conductance and pH (Table 3-6) were found to be within background ranges in both wells.

Analytical results have been summarized in Tables 4-11 (VOA data) and 4-12 (non-VOA data).

There are no VOA compounds which were found consistently in the West Ditch monitor wells. Benzene, at the levels detected, is considered a sampling artifact because it occurred at concentrations lower than in the field blank. Four other VOA compounds were detected at concentrations less than 0.002 mg/L (including trichloroethylene at a concentration of 0.00026 in MAFB-10), but none were confirmed in duplicates or second sampling rounds.

Non-VOA parameters sampled in the West Ditch Area were TOC, oil and grease, phenols, cyanide, and metals. TOC ranged from non-detected to 0.7 mg/L, oil and grease from 0.17 to 0.33 mg/L, and phenols from non-detected to 0.013 mg/L; none of these appear to be occurring at levels significantly above background. No metals were detected except for nickel in a single sample. The concentration of nickel was below that found in the field blank from the same round.

4.3.1.6 Northeast Perimeter - Shallow Groundwater Quality

Three monitor wells (MAFB-4, MAFB-5, and MAFB-6) were drilled along the northeast perimeter, the upgradient boundary of Mather AFB. They were completed at depths of 154, 129, and 100 feet, respectively, screened along the bottom 20 feet, and sandpacked along the bottom 45 to 50 feet (see Figure 3-9). Values of pH and specific conductance (Table 3-6) were within background levels. Analytical data have been summarized in Table 4-13 (VOA data) and Table 4-14 (non-VOA data).

Two VOA compounds were confirmed in the duplicate samples in the Northeast Perimeter wells. These include 1,1,1-trichloroethane found at concentrations of 0.0014 and 0.0017 mg/L in MAFB-6, and toluene at concentrations of 0.00069 and 0.00084 mg/L in MAFB-5. Benzene values reported can be considered sampling artifacts. Tetrachloroethene and ethylbenzene were also detected, but were not confirmed in duplicate samples or in second sampling rounds.

Table 4-11

Summary of Groundwater Analyses Results for VOA Compounds
West Ditch Area

Compound (mg/L)	Laboratory Detection Limits in Water (mg/L)	MAFB-10 May-June 85	MAFB-10 June 85	MAFB-100 (1) June 85	MAFB-11 May-June 85	MAFB-11 June 85	MAFB-110 (2) May-June 85
Chloromethane	0.0010	ND	ND	ND	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND	ND	ND	ND
Methylene chloride	0.0002	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.0010	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.0001	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND	ND	ND	ND
Chloroform	0.0001	ND	ND	ND	ND	0.00032	ND
1,2-Dichloroethane	0.00002	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	ND	ND	ND	0.00052	ND
Carbon tetrachloride	0.0001	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	0.00026	ND	ND	ND
Dibromochloromethane	0.0001	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.[illegible]	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND	ND	ND	ND
Bromoform	0.0002	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	ND	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	ND	0.0019	ND
Benzene	0.0002	ND	0.00025*	0.00025*	ND	0.00032	ND
Toluene	0.0002	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	ND	ND	ND	ND
Number of unidentified peaks							

ND - Below detection limit
* - Below concentration detected in field blank (see Table 4-3)
[1]Duplicate of MAFB-10
[2]Duplicate of MAFB-11

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Table 4-12

Summary of Groundwater Analyses Results for Non-VOA Compounds
West Ditch Area

Analyte (mg/L)	MAFB-10		MAFB-11	
	May-June 85	June 85	May-June 85	June 85
TOC	ND	0.6/ND	0.7/0.7	0.6
Oil and grease	0.26*	0.33/0.30	0.17*/0.17*	0.33
Phenols	0.013/0.005*	0.007*/ND	0.006*/0.005*	ND/ND
Cyanide	ND/ND	ND/ND	ND/ND	ND/ND
Cadmium	ND	ND/ND	ND/ND	ND
Chromium	ND	ND/ND	ND/ND	ND
Lead	ND	ND/ND	ND/ND	ND
Nickel	ND	0.041*/ND	ND/ND	ND
Silver	ND	ND/ND	ND/ND	ND

ND - Below detection limit (see Table 4-3)
* - At or below concentration detected in field blank (see Table 4-4)
/ - Denotes results from field duplicates

Table 4-13

Summmary of Groundwater Analyses Results for VOA Compounds
Northeast Perimeter

Compound (mg/L)	Laboratory Detection Limits in Water (mg/L)	MAFB-4 May-June 85	MAFB-4 June 85	MAFB-5 May-June 85	MAFB-5 June 85	MAFB-50 (1) May-June 85	MAFB-6 May-June 85	MAFB-6 June 85	MAFB-60 (2) June 85
Chloromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.0010	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.00002	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	ND	ND	0.0016	ND	ND	0.0014	0.0017
Carbon tetrachloride	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	0.0001	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	ND	0.00013	ND	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	0.0002	ND	0.00057	ND	0.00027*	ND	ND	ND	ND
Toluene	0.0002	0.0012	ND	0.00069	ND	0.00084	ND	ND	0.00031
Ethylbenzene	0.0002	0.00035	ND	ND	ND	ND	ND	ND	ND

ND - Below detection limit (See Table 4-1)
* - At or below concentration detected in field blank (see Table 4-3)
[1]Duplicate of MAFB-5
[2]Duplicate of MAFB-6

Table 4-14

Summary of Groundwater Analyses Results for Non-VOA Compounds
Northeast Perimeter

Analyte (mg/L)	MAFB-4		MAFB-5		MAFB-6	
	May-June 85	June 85	May-June 85	June 85	May-June 85	June 85
TOC	ND	0.8	ND/ND	0.5	ND	ND/ND
Oil and grease	0.34*	0.38	0.38*/0.52*	0.14*	0.27*	0.29/0.31
DMN	ND	ND	ND/ND	ND	ND	ND/ND
DDT	ND	ND	ND/ND	ND	ND	ND/ND
Chlordane	ND	ND	ND/ND	ND	ND	ND/ND
2,4-D	ND	ND	ND/ND	ND	ND	ND/ND
Cadmium	ND	ND	ND/ND	ND	ND	ND/ND
Chromium	ND	ND	ND/ND	ND	ND	ND/ND
Lead	ND	ND	ND/ND	ND	ND	ND/ND
Nickel	ND	0.062	ND/ND	0.051*	ND	0.058/0.061
Silver	ND	ND	ND/ND	ND	ND	ND/ND

ND - Not detected above detection limit (see Table 4-3)
/ - Denotes results from field duplicates
* - At or below concentration detected in field blank (see Table 4-4)

The non-VOA analysis conducted on samples from the wells along the Northeast Perimeter were TOC, oil and grease, cadmium, chromium, lead, nickel, and silver. In the June sampling round, TOC occurred at low levels in MAFB-4 and MAFB-5. TOC was not above the detection limit in the other samples. Oil and grease were found in all samples. However, only in the June sampling for MAFB-6 were the concentrations above those found in field blanks.

The only metal detected was nickel. Nickel was also detected in the field blank in the same sampling round and is not confirmed to be present at this site. The other four metals (chromium, lead, cadmium, and silver) were not found above the detection limits in any of the wells.

Samples were also analyzed for DMN, DDT, chlordane, and 2,4-D. These parameters were not detected in either round in any of the three wells.

4.3.1.7 Significance of Groundwater Results

The Federal standards applicable to the water quality parameters analyzed in this investigation are summarized in Table 4-15. There are currently no mandatory Federal standards for VOA compounds. The 0.05 mg/L standard for chromium was exceeded in MAFB-8, where a concentration of 0.06 mg/L was obtained. However, in a duplicate sample from this well, chromium was not detected. MAFB-8 is located in the 7100 Area. In addition, a few values of pH were measured outside the range prescribed in the Federal Standard. These anomalous results were generally not duplicated in other rounds of sampling.

TOC is a generalized screening parameter for organic contaminants. Background levels of TOC in groundwater are usually below 1.0 mg/L, although it is not unusual for TOC in shallow water table aquifers to range above 10 mg/L. Values of TOC found in the northeast perimeter monitor wells, ranging from <0.5 to 0.8 mg/L, can be considered background for the shallow aquifer zone monitored at Mather AFB. The only sites at which these levels were exceeded were the 7100 Area, where TOC concentrations in the three downgradient monitor wells ranged from 4.4 to 10.2 mg/L, and the ACW Area, where TOC concentrations in some samples ranged up to 2.4 mg/L. In addition, TOC concentrations exceeding 0.8 mg/L were measured in three Base production wells: GC-1 (16.1 mg/L), GC-2 (17.8 mg/L), and JTC (13.0 mg/L).

Table 4-15

Comparison of Groundwater Results with Applicable Federal Standards, Guidelines, and Criteria

Parameter	Water Quality Standard	Reference	Monitor Wells at or Exceeding Standard
Field pH	6.5-8.5	(2)	MAFB-9*, MAFB-11*, GC-2*
Metals (mg/L)			
Lead	0.05	(1)	None
Chromium	0.05	(1)	MAFB-8*
Cadmium	0.01	(1)	None
Silver	0.05	(1)	None
2,4-D (mg/L)	0.1	(1)	None

(1) - Federal Primary Drinking Water Standard
(2) - Federal Secondary Drinking Water Standard

* - Exceeded in one sample only; not confirmed in field duplicate or in second sampling round

The California Regional Water Quality Control Board (CRWQCB) has adopted the Federal primary and secondary drinking water standards as listed in Appendix L. In addition, the California Department of Health Services has promulgated action levels for 43 organic and inorganic compounds. The action levels, which are based primarily on health effects, have been adopted by the CRWQCB in an interim guidance document for hazardous substance site cleanup dated 15 March 1985. They are enforceable standards for drinking water. A complete list of action levels, including 14 volatile organic compounds analyzed for in this investigation and listed in Table 4-16, is provided in Appendix L. Base production wells and monitor wells in which these action levels were exceeded are also listed in Table 4-16. They include wells from the ACW Area, and the 7100 Area. The action level for TCE was exceeded in the ACW area. Action levels for the following parameters were exceeded in the 7100 Area: 1,1-dichloroethene, TCE, tetrachloroethene, and benzene (unconfirmed). Although the action level for TCE was not exceeded in the West Ditch area monitor wells, it has been exceeded in residential wells immediately beyond the Base boundary (Appendix M).

4.3.2 West Ditch Sediment Results

Ditch sediments were sampled at locations upstream and downstream from the West Ditch oil skimmer, as described in Subsection 3.2. Sediments were sampled in May 1985 and analyzed for VOA's, oil and grease, phenols, cyanide, and metals (chromium, lead, cadmium, nickel, and silver). A field duplicate of the upstream sample was collected and analyzed. Results for these parameters are summarized in Tables 4-17 and 4-18. Complete laboratory reports are provided in Appendix K.

The only U.S. EPA priority pollutant volatile organic compound found in samples either upgradient or downgradient from the oil skimmer was 1,4-dichlorobenzene. It was detected in the upstream sample and duplicate at concentrations of 0.0011 and 0.0019 mg/L. No other VOA compounds were detected in the sediment samples.

Results for non-VOA parameters are summarized in Table 4-18. Concentrations of oil and grease were found to be significantly higher in upstream than in downstream samples, presumably due to the effect of the oil skimmer on ditch quality. When these results are compared with the VOA data (Table 4-17), they indicate that oils which have accumulated in sediments upstream from the oil skimmer are largely made up of nonvolatile fractions.

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Table 4-16

Comparison of Groundwater VOA Results with Applicable California Action Levels

VOA Compound	CDHS Action Level (mg/L)	MAFB Wells at or Exceeding Action Level
Methylene chloride	0.040	None
1,1-Dichloroethene	LOQ (0.0001-0.0004)	MAFB-8*, MAFB-9
1,2-Dichloroethane	0.0010	None
1,1,1-Trichloroethane	0.200	None
Carbon Tetrachloride	0.0050	None
1,2-Dichloropropane	0.010	None
Trichloroethylene	0.0050	ACW, MAFB-1, MAFB-2 MAFB-3, MAFB-8, MAFB-9,
Vinyl Chloride	0.002	None
Tetrachloroethene	0.004	MAFB-8
1,2-Dichlorobenzene 1,3-Dichlorobenzene 1,4-Dichlorobenzene	0.130 (1)	None
Benzene	0.00070	MAFB-8*
Toluene	0.100	None

LOQ - Limit of quantitation

(1) - Action level is for a single isomer or sum of three
* - Detected in one sample only, not confirmed

Table 4-17

Summary of Analyses Results for U.S. EPA Priority
Pollutant VOA Compounds
West Ditch Sediments Upstream and Downstream
from Oil Skimmer

Compound (mg/kg)	Laboratory Detection Limits in Sediment	May 1985 Up-stream	Upstream Field Duplicate	Down-stream
Chloromethane	0.0001	ND	ND	ND
Bromomethane	0.0012	ND	ND	ND
Dichlorodifluoromethane	0.0018	ND	ND	ND
Vinyl chloride	0.0002	ND	ND	ND
Chloroethane	0.0005	ND	ND	ND
Methylene chloride	0.0102	ND	ND	ND
Trichlorofluoromethane	0.0000	ND	ND	ND
1,1-Dichloroethene	0.0002	ND	ND	ND
1,1-Dichloroethane	0.0001	ND	ND	ND
Trans-1,2-Dichloroethene	0.0001	ND	ND	ND
Chloroform	0.0001	ND	ND	ND
1,2-Dichloroethane	0.00002	ND	ND	ND
1,1,1-Trichloroethane	0.0001	ND	ND	ND
Carbon tetrachloride	0.0001	ND	ND	ND
Bromodichloromethane	0.0001	ND	ND	ND
1,2-Dichloropropane	0.0001	ND	ND	ND
Cis-1,3-Dichloropropene	0.0003	ND	ND	ND
Trichloroethylene	0.0001	ND	ND	ND
Dibromochloromethane	0.0001	ND	ND	ND
1,1,2-Trichloroethane	0.00005	ND	ND	ND
Trans-1,3-Dichloropropene	0.0002	ND	ND	ND
2-Chloroethylvinylether	0.0002	ND	ND	ND
Bromoform	0.0002	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.00005	ND	ND	ND
Tetrachloroethene	0.00005	ND	ND	ND
Chlorobenzene	0.0003	ND	ND	ND
1,3-Dichlorobenzene	0.0003	ND	ND	ND
1,2-Dichlorobenzene	0.0002	ND	ND	ND
1,4-Dichlorobenzene	0.0002	0.0011	0.0019	ND
Benzene	0.0002	ND	ND	ND
Toluene	0.0002	ND	ND	ND
Ethylbenzene	0.0002	ND	ND	ND

ND - Below detection limit

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Table 4-18

Summary of Analyses Results, West Ditch Sediments Upstream and Downstream from Oil Skimmer

Analyte (mg/kg)	Detection Limit in Sediments	Upstream May-June 85	Downstream May-June 85
Oil and grease	8.0	3,840/2,140	302
Phenol	0.123	0.395/0.357	0.234
Cyanide	0.13	ND/ND	ND
Chromium	2.0	53.8/101	35.0
Lead	5.05 US (1) 5.04 USD (1) 12.6 DS (1)	14.4/13.1	44.3
Cadmium	0.5	4.20/4.03	4.65
Nickel	2.52	26.0/22.7	26.2
Silver	0.625	0.730/0.580	0.220

ND - Below detection limit
/ - Denotes results from field duplicates

(1) - Samples had to be diluted to read concentrations in calibrated range of instrument. Therefore, detection limits were raised
US - Upsteam
USD - Upstream Duplicate
DS - Downstream

Phenols are slightly higher in upstream than in downstream sediments, but this difference is not considered significant. Cyanide was not detected in any of the samples.

All five of the metals analyzed were detected in all sediment samples collected from the West Ditch. Based on background ranges given in Aubert and Pinta (1977), sample concentrations of cadmium, chromium, lead, nickel, and silver were within the range typical of natural soils.

4.4 CONCLUSIONS

The following conclusions can be drawn from the preceding discussion of hydrogeological and chemical conditions encountered during the Phase II, Stage 1 field investigation at Mather AFB: Conclusions are presented for each site following conclusions applicable to the Base as a whole.

4.4.1 Hydrogeologic Conditions

- Subsurface sediments are very heterogeneous interbeds of sands, silts, clays, and gravels, lacking vertical or lateral continuity. This results in often complex groundwater conditions, such as perched water, locally confined conditions, and abrupt contrasts in hydraulic conductivity. These conditions can be expected to strongly influence the distribution, dispersion, and migration of any contaminants that may be present in the subsurface. Consequently, these phenomena cannot be analyzed by simple homogeneous aquifer models.

- The regional groundwater flow direction is to the southwest, and flow velocities are estimated to range from 0.01 to 0.1 foot/day, increasing with depth in the aquifer. Due to the complexity of the hydrogeological environment, many local anomalies occur in the overall regional flow pattern.

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4.4.2 Water Quality -- General

- Groundwater sampled from the northeast perimeter monitor wells contained only low levels of a few volatile organic compounds and was free of the pesticides and herbicides analyzed, as well as dimethylnitrosamine (DMN). This indicates little or no migration of contaminants onto MAFB from off-Base sources in the uppermost portion of the regional aquifer.

- The most common volatile organic compound found in consistently measurable concentrations (greater than 0.0001 mg/L) was trichloroethylene (TCE). The highest levels of TCE (up to 0.460 mg/L) were found in monitor wells downgradient of the ACW area. The next highest levels (up to 0.100 mg/L) were found in monitor wells downgradient of the 7100 Area. Only a trace concentration of TCE (0.00026 mg/L) was found in one sample from one well downgradient of the West Ditch. The only other VOA compounds confirmed to be present, at concentrations exceeding the state action level, were 1,1-dichloroethene and tetrachloroethene, found in wells downgradient from the 7100 Area.

The available data indicate that shallow groundwater at MAFB has been contaminated at least in the vicinity of the sites as discussed below. Due to the heterogenous nature of the shallow materials, the potential pathways for contaminant migration will be controlled by the zones of highest hydraulic conductivity within the shallow sediments. The available data also indicate that deeper zones in the aquifer tapped by the remote Base production wells (GC-2 and the ACW well) have been affected by contaminants generated either on MAFB or at an off-site upgradient source. Contaminant concentrations and occurrences in the deeper zones are less than in the shallow zones. Data for the deep aquifer zones are limited, however, and are therefore not conclusive, especially regarding quality of water entering the site from the upgradient direction.

4.4.3 Site-Specific Conclusions

Base Production Wells

Data from the Base production wells do not indicate the presence of significant contamination, apart from the exceptions described below:

- The ACW well is a relatively shallow well (250 feet) that is no longer in use. This well contains up to 0.076 mg/L trichloroethylene, exceeding the California action level for this compound. 1,1,1-trichloroethane was also confirmed in this well at a concentration of 0.0037 mg/L. Benzene was detected at a level of 0.00048 mg/L, but was not detected in a duplicate from the same round. The perforated intervals in this well are from 198 to 227 feet and from 234 to 244 feet below ground surface. The ACW well therefore intercepts groundwater below that intercepted by the ACW area monitor wells (MAFB 1, 2, and 3). Comparison of water quality in the production well and the monitor wells indicates that the production well is being slightly affected by contamination generally occurring in more shallow aquifer zones in the ACW area.

- The golf course well GC-2 was found to contain 1,1,1-trichloroethane at levels between 0.0062 and 0.0095 mg/L. These levels do not exceed the California action level of 0.200 mg/L for that compound. Both golf course wells (GC-1 and GC-2) and the JTC well exhibited elevated levels of TOC (in excess of 10 mg/L).

<u>ACW Area</u>

- Concentrations of TCE in the three monitor wells in the ACW area exceeded the California action level for this parameter. The highest concentration, found in MAFB-1, was 90 times greater than the action level. Low levels of several other volatile organic contaminants were detected but not confirmed in the ACW monitor wells.

- Shallow groundwater quality in the ACW area has been affected by past operations in the area.

- Based on the concentration of TCE in the ACW production well it appears that water quality in the deeper aquifer zone has been slightly affected by past operations. The production well, however, appears to be upgradient of the probable contaminant source (the discharge pipe) and is also upgradient of the monitor wells. The absence of significant contaminant concentration in the production well is not conclusive evidence that deeper aquifer zone(s) are not contaminated downgradient of the discharge pipe, particularly in the vicinity of MAFB-1.

- Due to the location of the ACW area, 3,500 feet directly upgradient of the nearest family housing production well (FH-3); the levels of contaminants in the shallow groundwater; and the potential for vertical and lateral migration, there exists a potential threat to the family housing production wells.

<u>7100 Area</u>

- Groundwater from the monitor wells in the 7100 Area was found to exceed California action levels in at least one monitor well for 1,1-dichloroethene, trichloroethylene, and tetrachloroethene. Benzene was detected in one sample above the action level, but was nondetected in two other samples from the same well.

- Concentrations of TCE were higher in MAFB-8 than in the other two monitor wells. This is consistent with groundwater flow directions on the Base which indicate that MAFB-8 is the monitor well most directly downgradient from the 7100 Area landfill. The other two monitor wells would intercept flow from areas outside the landfill, as well as within the landfill, potentially resulting in dilution of contaminants by mixing with uncontaminated groundwater.

- The results of analyses for VOA, TOC, specific conductance, and pH indicate that groundwater quality has been affected by the 7100 Area landfill.

- The monitor wells at the 7100 Area are adjacent to the downgradient Base boundary. Therefore, the potential exists for contaminant migration off-base from this source.

<u>West Ditch Area</u>

- No Federal standard or state action level was exceeded in groundwater samples from the West Ditch area.

- A low concentration of TCE was found in a single sample from MAFB-10, below the California action level. The presence of TCE was not confirmed in the two 1985 sampling rounds.

- Based on available data, shallow groundwater in the West Ditch area does not appear to have been significantly impacted.

- The West Ditch sediment samples were not found to contain any of the Priority Pollutant VOA Compounds above detection limits, except for 1,4-dichlorobenzene at concentrations of less than 0.002 mg/kg in the upstream sediments. On the basis of these data it is concluded that these sediments are not presently acting as a significant source of organic contaminants in groundwater.

- The heterogenous nature of the geologic materials at MAFB could result in contaminant migration in discrete zones in these materials. It is possible that the West Ditch area does contain contamination that is migrating off-base, but was not detected by the monitor wells. The site-specific data do not support such a conclusion.

Northeast Perimeter

- TCE was not found in the three northeast perimeter monitor wells. The only VOA compound confirmed was 1,1,1-trichloroethane, at a level well below the state action level in MAFB-6.

- Based on available data, shallow groundwater at the northeast (upgradient) perimeter of the Base has not been significantly affected by sources upgradient of the Base.

- Because of the hydrogeologic setting of the Base it is not possible to extend the above conclusion to the deeper portions of the aquifer. The quality of groundwater entering the Base in deeper aquifer zones cannot be determined on the basis of existing data.

SECTION 5

ALTERNATIVES

5.1 GENERAL

The results of this investigation and the data available to date, presented in Section 4, confirm that the shallow water table aquifer has been contaminated at two of the sites investigated. Some questions remain concerning the potential presence of contamination in the West Ditch area. A general description of the available alternative actions is presented in this section. Specific recommendations resulting from the analysis of alternatives are described in Section 6.

There are three categories of alternatives that are available for implementation; these are:

- Eliminate site from further consideration -- For this type of alternative to be selected it is necessary that the data be sufficiently conclusive to confirm that the site is not an active or potentially active source of contaminants and to confirm that there is no significant residual contamination in the hydrogeologic system associated with past releases from the site.

  None of the data collected at the three sites investigated at MAFB can be considered sufficiently conclusive to eliminate the site(s) from further consideration.

- Remedial action -- Remedial action alternatives are considered for a site when the data are sufficient to determine that a site is a contaminant source and the data are sufficient to support development of short-term or long-term remedial actions.

  A short-term remedial action is a remedial action of relatively limited scope which is taken within a short time frame to reduce or eliminate ongoing contaminant generation at a site. A long-term remedial alternative is a relatively large-scale remedial action designed to both eliminate contaminant generation at a site and remediate those areas of the environment (soil, surface water, groundwater, air resources, vegetation) affected by the contamination. A long-term remedial action generally includes a combination of remedial technologies developed from a feasibility study which considers, in detail, evaluation of such criteria as environmental and public health impact, technical feasibility, cost-effectiveness, and regulatory requirements. As described in more detail below, the only site that falls into this category is the 7100 Area landfill.

- Further investigation -- Additional investigation alternatives are considered when the data base must be expanded in order to either remove a site from further consideration or implement remedial actions. The 7100 Area, the ACW Area, and the West Ditch area are considered to fall in this category.

The following subsections present a general discussion of remedial action alternatives and investigation alternatives, followed by site-specific discussions of potentially applicable alternatives.

5.2 REMEDIAL ALTERNATIVES

Three types of remedial alternatives are normally considered: source control actions, contaminant clean-up action, and migration control actions.

Source control actions are those which result in limiting further release of contaminants from the source. Some source control alternatives may be amendable to short-term implementation. They do not preclude further investigation of the site to expand the data base available for design of long-term remedial action. Source control alternatives are summarized in Table 5-1.

Clean-up and migration control alternatives are implemented when the extent of contamination and migration pathways have been fully defined. They are long-term actions and are generally preceded by comprehensive site feasibility studies unless there is an immediate threat. These alternatives are also summarized in Table 5-1.

Table 5-1

Summary of Alternatives

Alternatives	Applicable Site(s)	Rationale
1. Eliminate from further consideration.	None	Site(s) data do not provide negative confirmation.
2. Remedial action:		
a. Source control:	7100 Area	Data indicate that site is generating leachate that is entering the hydrogeologic system.
• Capping • Regrading • Waste fixation • Waste isolation		
b. Cleanup/migration control:	None	Data are not sufficiently detailed to determine the need and/or design for such actions.
• Groundwater removal and treatment		
• Waste removal and treatment		
• Gradient control		
3. Further investigation:	ACW, 7100, and West Ditch Areas	To confirm previous results.
a. Additional monitoring at existing points		

Table 5-1
(continued)

Alternatives	Applicable Site(s)	Rationale
b. Expansion of monitoring network:		
• Drill additional wells	ACW, 7100, West Ditch Areas	Additional data are needed.
• Collect additional soil samples	ACW Area	Determine extent of contamination and identify sources.
• Soil gas sampling	ACW Area	Define extent and magnitude of TCE contamination.
• Nondestructive geophysical methods	ACW and 7100 Areas	Useful for source location and plume monitoring when identified contaminants are nonconductive.

5.3 INVESTIGATION ALTERNATIVES

Table 5-1 summarizes the major classes of investigation alternatives. Geophysical methods (i.e., ground penetrating radar, resistivity, electromagnetic conductivity) may be useful at MAFB for detection or mapping of contaminant plumes. Although the contaminants that have been identified to date at MAFB have been primarily organic constituents, the state-of-the-art in geophysical methods is such that these methods are being used experimentally for organic (i.e., nonconductive) contaminants. They may be particularly successful at sites where relatively conductive (inorganic) constituents are associated with the organics. The methods have been proven effective in locating conductive contaminants and buried structures, and use for that purpose would be applicable at MAFB.

The use of soil borings and well drilling and groundwater sampling is applicable at MAFB. The hydrogeologic system at MAFB is a complex heterogeneous one that is characterized by multiple aquifers and zones of laterally variable permeability. This setting results in the potential for complex migration pathways that are best defined by subsurface investigation.

5.4 *SITE-SPECIFIC ALTERNATIVES*

5.4.1 ACW Area

There has been an identifiable impact on the shallow groundwater zone due to known TCE contamination of the ACW site. Although a "dry well" was known to exist, its exact location is not known. Further review of Base records and plans may be helpful in identifying its location. A followup investigation of two subsurface zones is appropriate. The unsaturated soil zone (vadose zone) above the water table could contain solvents that are continuing to affect groundwater quality. This zone can be investigated by a soil gas monitoring program designed to define the magnitude and extent of TCE in soil through the use of portable organic analyzers to measure volatile organic vapor concentrations. The second zone of concern is the deeper groundwater zone. If contaminants found in the shallow wells are moving vertically into deeper aquifer zones, they may, at some point, reach the water production zones tapped by Base wells. Therefore, clusters of monitor wells screened at different levels are necessary to identify vertical gradients of flow and monitor deeper groundwater zones for contaminant migration.

5.4.2 7100 Area

There has been an impact on the shallow groundwater at the 7100 Area site from several volatile organic compounds. For this reason, both short-term remedial actions and further investigations designed to expand the data base should be considered for this site. Short-term remedial actions should include source control measures designed to limit infiltration through the fill material and resultant leachate generation. At present, the landfill surface is covered with demolition debris, giving it a highly irregular topography and serving as a trap for precipitation. Removal or covering of the landfill, regrading of the surface to a mounded configuration, and planting with low-maintenance vegetation would serve to enhance runoff and evapotranspiration of precipitation and significantly reduce infiltration into the buried fill.

Two lines of investigation are potentially useful in additional site studies designed to further define the nature and extent of contamination generated from the site. The first is to identify and separate the effects of the principal sources of contamination, which are potentially the nearby landfill and the fire training area. This could be accomplished by locating monitor wells in areas near each potential source and by using an analytical protocol that would identify contaminants in groundwater samples that may distinguish a landfill leachate plume from one expected from a fire training area. For instance, high sulfates, chloride, or boron could be contributed by a landfill, thus distinguishing between the landfill and fire training area as a contaminant source. The second line of investigation is to determine the possible migration of contaminants along vertical paths toward deeper portions of the aquifer. Multi-level screened wells, as discussed in Subsection 5.4.1, would be appropriate downgradient of the 7100 Area, as well as the ACW area.

There is a strong potential for off-site migration of contaminants from the 7100 Area. Based on the elevated specific conductance measured in groundwater, the plume may have a component of conductive constituents (i.e., inorganic salts); this would be consistent with the expected character of landfill leachate. In this case, nondestructive geophysical methods would be useful for plume identification across the Base boundary downgradient of the 7100 Area. The limitations associated with such use are that the composition of leachate would have to be determined via sampling, and migration in the deeper portions of the aquifer may be masked by contaminants in the shallow portion of the aquifer and it would be necessary to install monitor wells to fill these data gaps. Geophysical methods are used to determine the approximate geometry of the plume so that monitor well locations can be selected that will provide the most useful data. This will reduce the number of off-base monitor wells that will be required, since geophysical methods rather than drilling, are used for initial data collection.

5.4.3 West Ditch Area

Although TCE was detected in only one well at a very low concentration, there remains a high level of concern about this area based on measured levels of TCE in off-base wells in areas immediately adjacent to the west perimeter. A reasonable strategy would be to install a deeper monitor well paired with the existing monitor well in which the low level of TCE was detected, and to install another pair of wells to the north. These wells would provide a means for confirming the absence or presence of contamination in the vertical direction.

SECTION 6

RECOMMENDATIONS

The findings of the Phase II Problem Confirmation Study indicate the need for additional investigation at all four investigated sites. This section reviews both general and site-specific recommendations for followup action.

6.1 GENERAL RECOMMENDATIONS

The following general recommendations are made for routine groundwater monitoring on-Base and additional IRP investigations to be performed at Mather Air Force Base.

- A long-term sampling and monitoring program should be initiated at the Main Base and Family Housing production wells. The purpose of this program is to monitor the quality of the groundwater entering Mather AFB from the northeast (Main Base production wells) and the migration of contamination in the ACW Area (Family Housing wells).

- Due to the heterogeneity of hydrogeological conditions beneath the Base, and the need for better geological definition of the subsurface, it is recommended that future monitor wells be drilled by means of air hammer/casing drive techniques. Alternatively, borehole geophysics could be used in combination with mud rotary drilling techniques to better define subsurface geology and choose appropriate completion intervals.

6.2 SITE-SPECIFIC RECOMMENDATIONS

In addition to the general recommendations, the following recommendations are made for followup actions on a site-specific basis at the ACW area, the 7100 Area, the West Ditch, and the northeast perimeter.

6.2.1 ACW Area - Recommendations

Upper aquifer contamination with TCE has been confirmed in the ACW area on the basis of sampling to date. The suspected source is a vertical pipe into which solvents were reportedly discharged directly to the soil. This indicates the existence of a localized area of highly contaminated soil somewhere in the ACW area.

The following recommendations are made to identify the source and the area of contaminated soil:

- Conduct additional intensive file search, review of building plans and aerial photography, and interviews of personnel to narrow the area of search.

- Conduct a combined GPR and magnetometer survey over a 25- or 50-foot grid to identify conductive or magnetic anomalies in the shallow subsurface. This effort should be supplemented in suspect areas with a fine grid survey in order to locate the pipe.

- Conduct a soil gas monitoring program designed to measure the concentration of TCE in the shallow subsurface beneath the site by sampling soil gas at several points in an array and executing in situ analyses for TCE. In this way, a contour map of TCE concentrations in soil can be generated within a short time frame which should enable the source area to be pinpointed.

  More specifically, the soil gas monitoring program would be conducted by setting up a grid over the suspected source area, to consist of 36 (6 x 6) points with 100-foot spacing. A shallow (2 to 3 foot) relatively small diameter (2 to 3 inch) hole would be made with a hand auger at each point and carefully plugged at the surface. After installation of the shallow borings, an appropriately sized gas pump fitted with Teflon tubing would be used to draw a gas sample from each hole. The sample would be immediately injected into a portable gas chromatograph (GC) unit calibrated for TCE and able to meet a detection limit of 1 ppb or better, so that accurate determinations of relatively low concentrations of TCE in soil gas could be made. After completion of the first "sweep" of soil gas sampling, a fine grid could be set up in the area of highest concentration and the process repeated for 20 to 30 more points in a smaller area to further narrow the area of investigation.

- Following determination of the source area through combined geophysical and soil gas sampling means, the presence and extent of TCE in soil should be confirmed by collecting soil samples for laboratory analysis. Due to the presence of cobble near the surface in the ACW area, it is anticipated that auger drilling to any significant depth would not be possible. For this reason, it is recommended that a backhoe excavation be conducted at the source site and soil samples collected directly from the bottom and sides of the excavation. It is anticipated that 8 to 10 soil samples would be collected for analysis.

Based on the location of the source in the vadose zone, additional downgradient monitor well locations should be selected to further define the vertical and horizontal extent of groundwater contamination. It is recommended that up to three nests of three monitor wells each be located downgradient of the source, with at least two on a line between the ACW area and the nearest family housing production well (FH-3). The use of well nests will allow better definition of subsurface hydrogeological conditions, including isolation of permeable zones, identification of vertical hydraulic gradients, and evaluation of the potential for downward as well as lateral migration of contaminants. Sampling of these wells will yield a three-dimensional picture of the distribution of contamination downgradient of the site by providing sampling points in the horizontal and vertical dimensions.

The recommended approximate depths for the wells in each cluster are 150, 200, and 400 feet. However, because the specific depths of water-producing zones are not known in this area, the following procedure is recommended:

- Drill the deepest (400 foot) well in a cluster first.

- Based on the lithologic log obtained if air hammer/casing drive drilling methods are used, or based on a borehole geophysical log of the well, identify the exact location of the shallower water-producing zones.

- Select completion zones for the two shallower wells.

- Install the remaining two wells in the cluster.

The target depth of 400 feet for the deeper well has been selected based on the completion depth of production well FH-3, since the protection of this well is of immediate concern.

In addition, a single monitor well should be located upgradient in the shallow aquifer.

6.2.2 7100 Area - Recommendations

The following recommendations are made to provide some degree of source control and further define the magnitude and extent of groundwater contamination in the vicinity of the 7100 Area landfill:

- Remove or cover hardfill on the surface of the landfill and regrade in a mounded configuration. Compact the cap material, cover with topsoil, and plant with grass seed. These measures will serve to minimize infiltration of precipitation into the fill material.

- Install a single monitor well 30 feet into the aquifer directly between the Fire Department Training Area (FDTA) and the 7100 Area landfill. Sample this well concurrently with the downgradient monitor wells and compare the results to distinguish any contaminants contributed by the FDTA from those contributed by the landfill itself. In addition to previous analytical parameters, samples should be analyzed for sulfate, chloride, and boron.

- Conduct an electromagnetic (EM) survey of ground surface off-base and downgradient from the landfill. The survey should be conducted at three separate spacings to provide vertical, as well as lateral definition for subsurface conductivity. It should be noted that, due to the depth of the water table (60 to 70 feet) and the complexity of the geologic terrain, the success of this method would not be guaranteed. Based on the difference in specific conductance between groundwater downgradient of the fill and background, however, it is anticipated that EM can be successfully used to track a plume of mineralized (i.e., conductive) groundwater emanating from the landfill area.

- Install three nests of two wells each to further define the lateral and vertical extent of contamination downgradient. Install one nest between the existing monitor wells MAFB-8 and MAFB-9 to better define migration pathways in shallow aquifer zones, and two nests off-Base in a downgradient direction, one on a line with the JTC production well.

6.2.3 West Ditch - Recommendations

Although only relatively low concentrations of TCE have been detected in groundwater sampled from MAFB-10 and none has been detected in MAFB-11, groundwater sampled by the State of California in nearby residential wells, particularly in the Camellia Mather Mobile Home Park, has consistently exhibited levels of TCE slightly in excess of the State action level of 0.005 mg/L.

It is recommended, therefore, that additional monitor wells be drilled to further test for the presence of TCE in groundwater in the vicinity of the West Ditch. Specifically, it is recommended that another monitor well be drilled next to MAFB-10 and screened 50 to 60 feet deeper (depending on the lithology encountered). In addition, it is recommended that another pair of monitor wells at equivalent depths be drilled at a location approximately 200 feet north of MAFB-10. Based on the chemical results for groundwater sampled from MAFB-11, it is recommended that no further monitor wells be installed in a southerly direction from this site.

6.2.4 Northeast Perimeter - Recommendations

Although no significant contamination was found in the northeast perimeter monitor wells, or in any of the Base production wells except the ACW well, the possibility still exists that contaminated groundwater from upgradient sources may be moving toward MAFB. This contamination may not yet have reached the upgradient area of the Base, or may be moving toward the Base production wells through deeper portions of the aquifer not sampled by monitor wells MAFB-4, MAFB-5, and MAFB-6. For this reason, it is recommended that the current monitoring network be upgraded to include monitor points in deeper zones of the aquifer. This could be accomplished by adding one deep monitor well to be paired with MAFB-5, drilled to 450 feet, and screened across 60 feet (exact screen location to be determined from borehole geophysics). This monitor well pair, in conjunction with MAFB-4, MAFB-6, and Base production wells GC-1 and GC-2, would provide sufficient monitor points to enable protection of the Family Housing Area wellfield through early detection of contaminants. Unfortunately, the Base production wellfield is too close to the upgradient boundary to be adequately protected by on-base upgradient monitor wells; it is recommended, therefore, that the Main Base production wells be monitored routinely, along with the golf course wells and/or upgradient monitor wells for early detection of contaminants moving into the Base area from upgradient sources. The recommended sampling frequency would be quarterly, and would be incorporated into existing Base groundwater sampling programs. The recommended analytical protocol for these wells would include the analysis for VOA by Method 601 with second column confirmation or another method with equivalent sensitivity. It is recommended that dimethylnitrosamine (DMN) be included in the protocol for a well only when the CDHS action level for any of the volatiles is exceeded in that well.

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