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ROCKY MOUNTAIN ARSENAL
WATER QUANTITY / QUALITY SURVEY

INITIAL SCREENING PROGRAM REPORT
DRAFT FINAL
VOLUME I
OCTOBER 1986
CONTRACT NUMBER DAAK11-84-D-0016
TASK NUMBER 4

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
HARDING LAWSON ASSOCIATES RESOURCE CONSULTANTS, INC.

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ROCKY MOUNTAIN ARSENAL

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LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Water Quantity/Quality Survey

**Initial Screening Program Report
Draft Final
Volume I**

October, 1986

**Contract Number DAAK11-84-D-0016
Task Number 4**

FILE COPY

**Rocky Mountain Arsenal
Information Center
Commerce City, Colorado**

PREPARED BY

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

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PREPARED FOR

**U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL**

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LIST OF ACRONYMS AND ABBREVIATIONS
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AMC	U.S. Army Material Command
AR	Army Regulation
CCL ₄	Chloroform
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CDH	Colorado Department of Health
CFI	Colorado Fuel and Iron Corporation
cfs	cubic feet/second
CLC ₆ H ₅	Chlorobenzene
cm	centimeters
DBCP	Dibromochloropropane
DCA	Dichloroethane
DCE	Dichloroethylene
DCPD	Dicyclopentadiene
DDT	Dichlorodiphenyltrichloroethane
DDE	Dichlorodiphenyltrichloroethylene
DIMP	Diisopropylmethylphosphonate
DMDS	Dimethyl disulfide
DMMP	Dimethylmethylphosphonate
EPA	Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
ft	feet
gpm	gallons/minute
ha	hectares
HCCPD	Hexachlorocyclopentadiene

LIST OF ACRONYMS AND ABBREVIATIONS
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HLA	Harding Lawson Associates, Inc.
Hyman	Julius Hyman and Company
ISP	Initial Screening Program
km	kilometers
m	meters
mi	miles
MIBK	Methyl isobutyl ketone
mg/l	milligrams/liter
µg/l	micrograms/liter
MRI	Midwest Research Institute
PCPMS	p-Chlorophenylmethyisulfide
PCPMSO	p-Chlorophenylmethyisulfoxide
PCPMSO ₂	p-Chlorophenylmethyisulfone
ppb	parts per billion
PMO-RMA	Program Manager's Office-Rocky Mountain Arsenal
QA	Quality Assurance
QC	Quality Control
RCI	Resource Consultants, Inc.
RIC	Rocky Mountain Arsenal Resource Information Center
RMA	Rocky Mountain Arsenal --
Shell	Shell Chemical Company
SCC	Shell Chemical Company

LIST OF ACRONYMS AND ABBREVIATIONS
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sq mi	square mile
TCA	Trichloroethane
TCE	Trichloroethylene
TCDHD	Tri-County District Health Department
USAEHA	U.S. Army Environmental Hygiene Agency
USAMBRDL	U.S. Army Medical and Bioengineering Research and Development Laboratory
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
WES	U.S. Army Waterways Experiment Station
WW II	World War II

1.0 INTRODUCTION

1.1 OBJECTIVES

1.1.1 TASK OBJECTIVES

As part of the investigation of environmental conditions at the Rocky Mountain Arsenal (RMA), the necessity to establish a litigation quality data base for surface and ground water quantity and quality has been recognized. Task 4 addresses this need by providing the technical support necessary to develop a hydrologic assessment for RMA.

Under this task a one-year ground water and surface water surveillance program is being performed across RMA to achieve the following objectives:

- o Satisfy compliance-oriented regulatory requirements under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Resource Conservation and Recovery Act (RCRA), and the intent of the Cease and Desist Order;
- o Confirm the existence and chemical nature of known contamination and monitor any changes in the lateral and vertical extent of contaminant migration; and
- o Develop a core data base for use in litigation and Remedial Investigation/Feasibility Study analyses for RMA.

The initial effort performed under Task 4 was a comprehensive investigation of ground and surface water quantity and quality. This activity has been termed the Initial Screening Program (ISP) and was conducted over the period of October 1985 through February 1986. The program was designed to provide the hydrologic data necessary to select wells to form the core monitoring network for a long term ground and surface water program at RMA which would satisfy the above task requirements.

1.1.2 REPORT OBJECTIVES

This report presents the results of the Initial Screening Program (ISP) ground and surface water sampling program and provides recommendations

for continued monitoring. Specifically, this report addresses the following objectives:

- o Compile and present Initial Screening Program data;
- o Compare Initial Screening Program results to historical RMA data base; and
- o Develop a plan for continued monitoring.

1.2 SCOPE-OF-WORK

1.2.1 SCOPE-OF-TASK

The purpose of the Task 4 Water Quality/Quantity Survey is to execute a one-year ground water and surface water surveillance program capable of satisfying the various regulatory requirements, developing a litigation-quality data base, and verifying the extent and nature of known contamination. In order to achieve these objectives, five distinct technical elements are being performed. These are as follows:

- o Review historical data;
- o Develop a comprehensive monitoring program;
- o Execute the monitoring program utilizing litigation quality sampling and analysis procedures;
- o Assess data quarterly for possible adjustments in the monitoring program; and
- o Evaluate the accumulated data at the end of the one-year program in order to determine changes in contaminant concentrations within plumes and at sources.

1.2.2 SCOPE-OF-REPORT

In fulfillment of the stated Task 4 and Screening Program objectives, the scope of this report has been limited to discussion of the sampling and analytical program, presentation of resulting data, and recommendation of wells to be sampled for continued monitoring. Specific technical elements of this report include:

- o Tabulation and summary of ISP data;
- o Graphical presentation of ISP data;
- o Comparison of the ISP data to historical data;
- o Formulation of Third Quarter Sampling Program; and
- o Development of recommendations for a future sampling scheme.

A detailed geochemical and hydrogeologic interpretation of the Task 4 data is beyond the scope and objectives of this report. However, an integrated interpretive effort in which soil quality and water quality data will be merged to allow a comprehensive interpretation of how site hydrogeology and geochemical conditions affect rates and magnitude of contaminant transport will be performed under a subsequent RMA task.

1.3 BACKGROUND

1.3.1 RMA CHRONOLOGY OF EVENTS

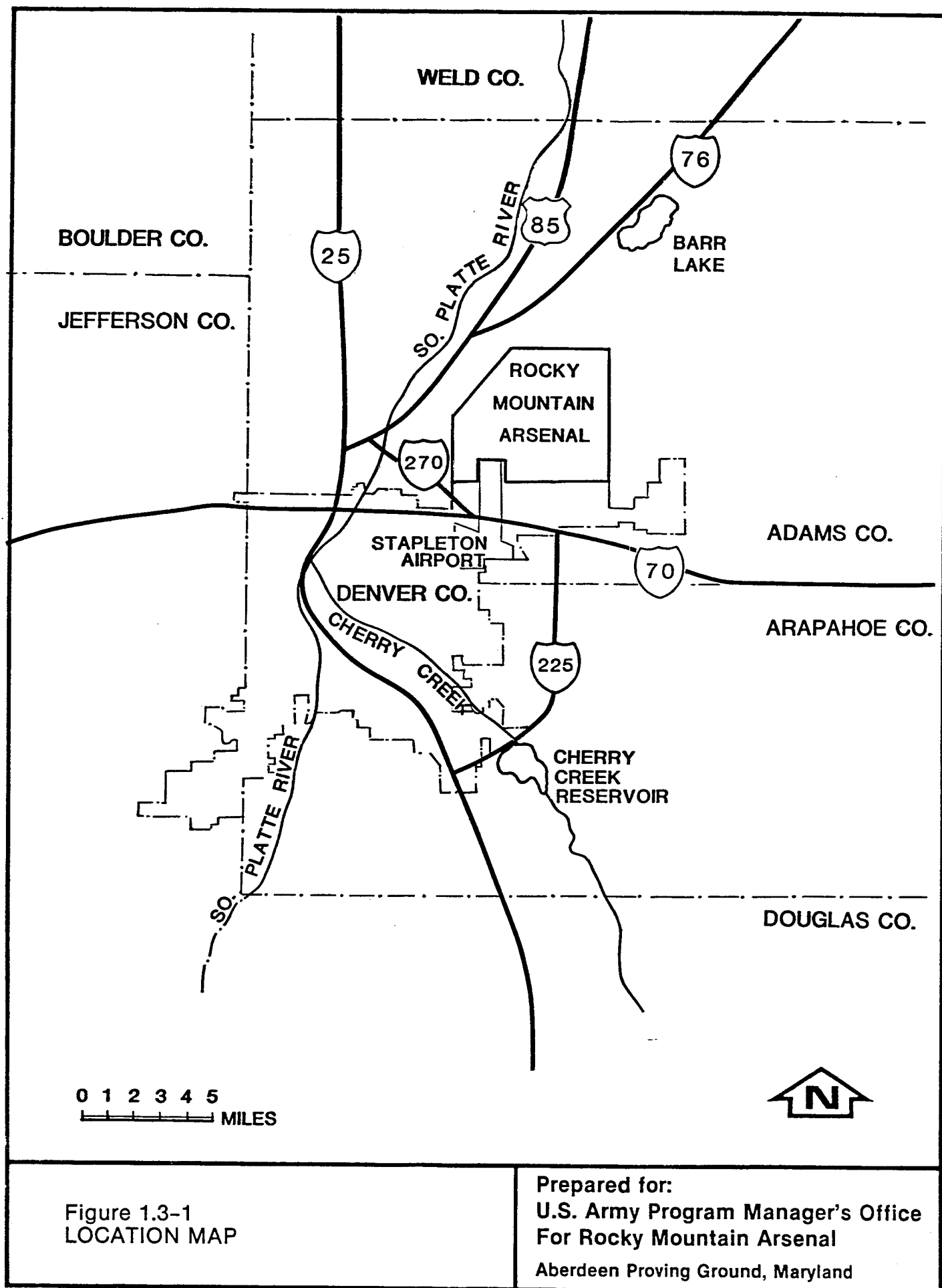
The Rocky Mountain Arsenal occupies over 27 square miles (sq mi) in Adams County, Colorado, and is located approximately 9 miles (mi) northeast of downtown Denver (Figure 1.3-1). RMA was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical ordnance demilitarization. Industrial chemicals were manufactured at RMA from 1947 to 1982.

The property occupied by RMA was purchased by the government in 1942. Throughout World War II (WWII), RMA manufactured and assembled chemical intermediate and toxic end-item products and incendiary munitions.

During the period 1945 to 1950, RMA distilled stocks of LeVinson mustard, demilitarized several million rounds of mustard-filled shells, and test-fired 10.7 centimeter (cm) mortar rounds filled with smoke and high explosives. Also, many different types of obsolete WWII ordnance were destroyed by detonation or burning.

In 1947, certain portions of RMA were leased to the Colorado Fuel and Iron Corporation (CF&I) for chemical manufacturing. CF&I manufactured chlorinated benzenes. Julius Hyman and Company (Hyman) assumed the CF&I lease in 1950 and Hyman produced several pesticides. Shell Chemical Company (Shell) later assumed the pesticide and herbicide manufacturing operations.

In the early 1950's, RMA was selected as the site for construction of a facility to produce chemical agents. The facility was completed in 1953, with manufacturing operations continuing until 1957. The munitions



filling operations continued until late 1969. Since 1970, RMA has been involved primarily with the disposal and distruction of chemical warfare material.

Discharge of industrial waste effluents to unlined evaporation basins and burial of solid wastes at various locations were past disposal practices at RMA. In addition, unintentional spills of raw materials, process intermediates, and end products have occurred within the manufacturing complexes at RMA. Many of the compounds are mobile in surface and ground waters.

In 1954 and 1955, farmers to the northwest of RMA reported severe crop losses due to use of well water for irrigation. In 1974, diisopropylmethylphosphonate (DIMP), which is a manufacturing by-product of GB nerve agent, and dicyclopentadiene (DCPD), a chemical used in insecticide production, were detected in offpost surface water. Since 1978, dibromochloropropane (DBCP), a nematocide produced onsite by Shell and shipped from RMA by rail from 1970 to 1975, has been observed in offpost ground water.

In response to the detection of offsite contaminant migration, the State of Colorado issued a Cease and Desist Order in 1975 which required RMA to initiate a regional hydrologic surveillance program. The program required the quarterly collection and analysis of over 100 onpost/offpost surface and ground water samples. In addition, various other programs have been implemented and are utilized for monitoring and surveillance of surface and ground water in order to satisfy other operational and regulatory requirements at RMA.

1.3.2 GEOLOGY

RMA is located within the geologic province of the Denver Basin, a structural depression resulting from tectonic adjustments which occurred intermittently throughout time. The study area lies on a bedrock surface formed by the late Cretaceous-early Tertiary Denver Formation. Quaternary alluvial and eolian deposits crop out at the surface, overlying the Denver Formation (Figure 1.3-2). Regional dip is to the southeast.

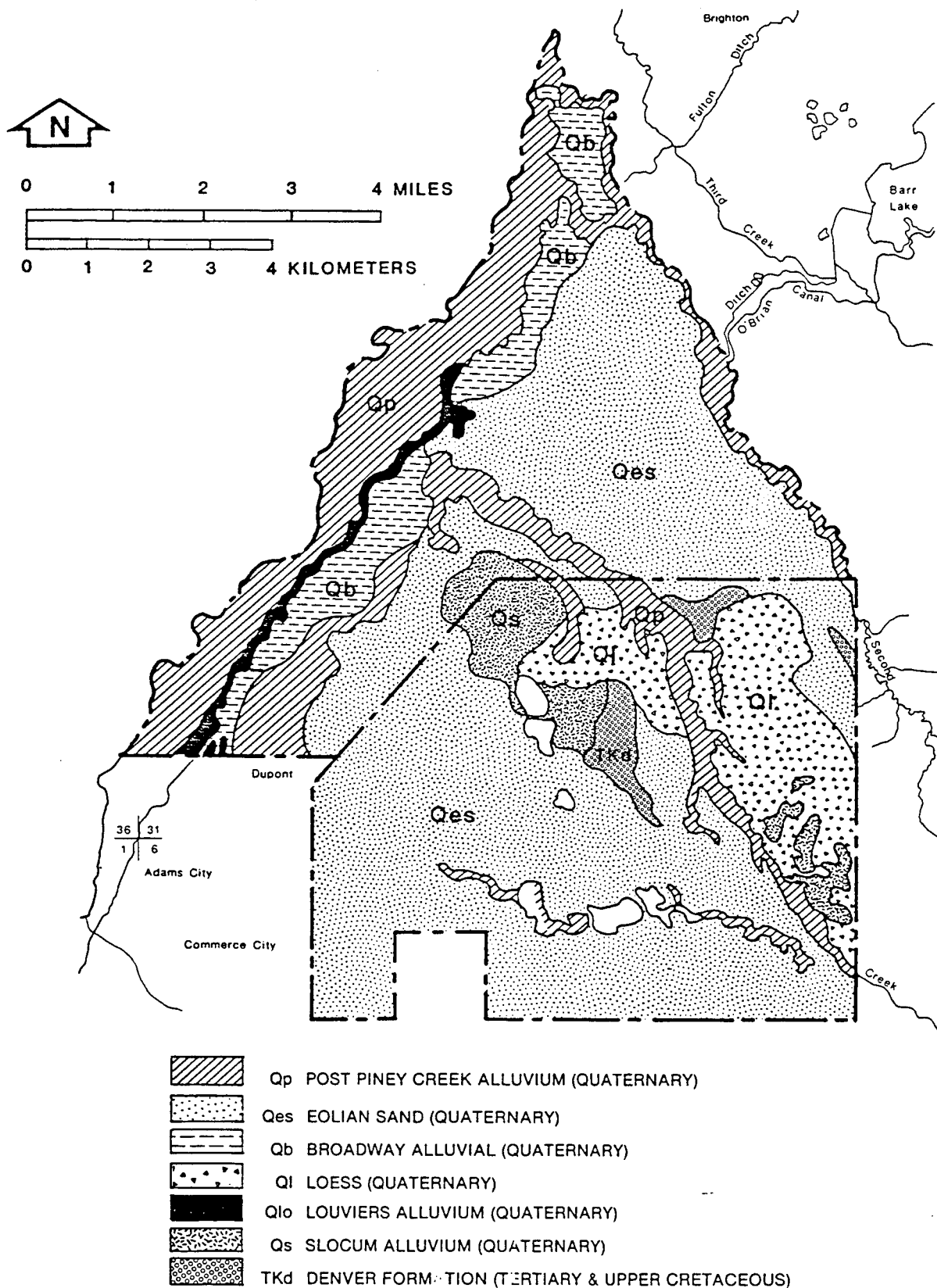


Figure 1.3-2
GEOLOGIC MAP OF RMA AREA

SOURCE: USGS, 1981

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

1.3.3 GEOHYDROLOGY

Ground water resources at RMA are classified as part of the Denver ground water basin. The four major bedrock aquifers are the Laramie-Fox Hills, the Arapahoe, the Denver, and the Dawson. Surficial deposits as well as crystalline rocks of the Front Range locally yield sufficient quantities of water to be considered aquifers. The strata of primary concern at RMA are the Denver Formation and the unconsolidated Quaternary alluvial and eolian surficial deposits. Aquifers within these units comprise the ground water regime in the study area.

1.3.3.1 Denver Formation

The Denver Formation unconformably overlies the Arapahoe Formation and consists of 250 to 400 feet (ft) of olive, bluish gray, green gray, and brown clay-shale, and siltstone interbedded with poorly sorted, weakly lithified tan to brown, fine to medium grained, sandstone and conglomerate. Lignite beds and carbonaceous shales are common, as are volcanic fragments and tuffaceous materials. The clay-shale is largely bentonitic. Water-bearing zones in the formation are restricted to sandstone lithologies that are lenticular. The lenses are irregularly distributed within thick clay-shale sequences and are sinuous in nature. They are discontinuous to semi-continuous.

1.3.3.2 Surficial Deposits (Alluvium)

Sediments present at the land surface consist of unconsolidated alluvial and eolian deposits of Quaternary age. The material is composed primarily of alluvial fill, dune sand, and glacial outwash which contain cobbles, boulders, and beds of volcanic ash as well as sands, gravels, silts, and clays. Combined thickness of the surficial materials ranges from 30 to 130 ft. The thicker deposits represent filling of paleochannels cut in the surface of the Denver Formation. A structure contour map constructed on the top of the bedrock surface delineates these paleochannel depressions (Figure 1.3-3). Paleochannels are likely to serve as the major alluvial ground water transport pathways in the study area. The entire sequence of surficial materials should be considered capable of bearing water.

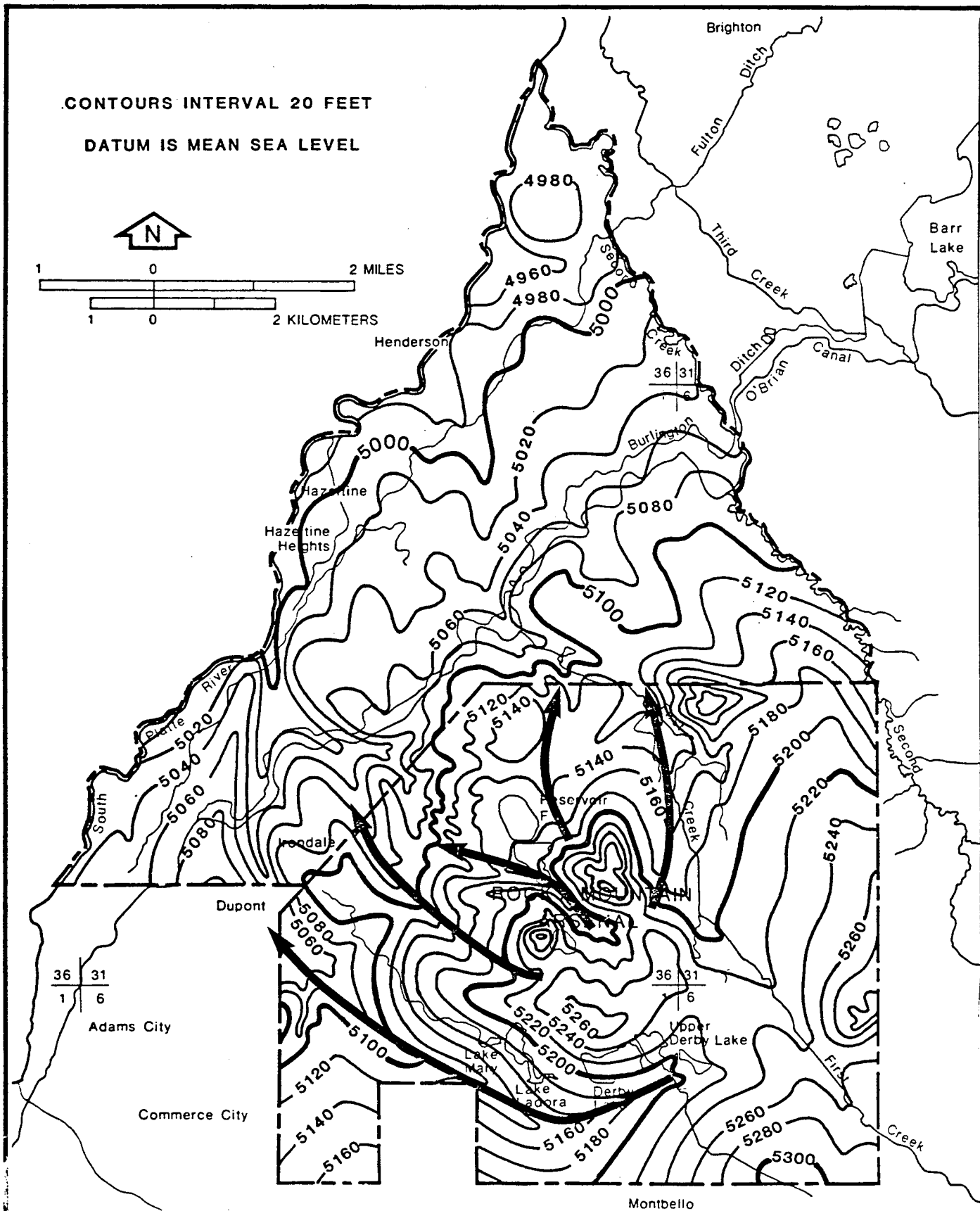


Figure 1.3-3
ELEVATIONS OF BEDROCK
SURFACE AND LOCATIONS OF
MAJOR PALEOCHANNELS

SOURCE: USGS, 1975

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

1.3.4 CONTAMINANTS

The problem of contaminated ground water at RMA has been recognized since the mid-1950's when the use of ground water for irrigation resulted in crop damage. Since then, numerous investigations have determined widespread contamination by a variety of organic and inorganic parameters. It has been well established that contamination is directly related to the past activities of the Army, Shell, and other industrial operators within the RMA boundaries. Investigations have been conducted to identify the sources and extent of contamination, the types of contaminants present, the mechanisms of contaminant migration within RMA, and changes in the nature and extent of contamination over time.

The number and types of contaminants analyzed for and detected in RMA ground water have changed somewhat over time due to several factors including environmental concern, analytical methods, RMA activities, and contaminant fate and migration. Essentially, the key contaminants are those associated with the production and demilitarization of munitions by the Army, the production of pesticides by Shell, and other industrial operations.

The first investigations of ground water contamination were conducted in the mid-1950's in response to claims of crop loss by farmers utilizing large quantities of ground water from the alluvial aquifer for irrigation purposes. The primary contaminants identified were chloride, fluoride, and unspecified herbicidal chemicals (Fairbanks and Kolmer, 1976).

In 1974, DIMP and DCPD were identified in surface water moving offpost (Fairbanks and Kolmer, 1976). In response, a regional hydrologic surveillance program (360° Monitoring Program) was initiated and DIMP, DCPD, and a number of other major contaminants were identified in RMA ground waters. Other major contaminants identified on an Arsenal-wide basis include DBCP, aldrin, dieldrin, endrin, isodrin, dithiane, oxathiane, PCPMS, PCPMSO, and PCPMSO₂ (Table 1.3-1).

Chloride originated from various brine solutions utilized in industrial processes and from cooling water discharges. DBCP, DCPD, PCPMS, PCPMSO, PCPMSO₂, aldrin, dieldrin, endrin, and isodrin are all related to Shell pesticide manufacture. DIMP, fluoride, dithiane, and oxathiane are all associated with Army agent manufacture, munitions filling, or demilitarization of munitions.

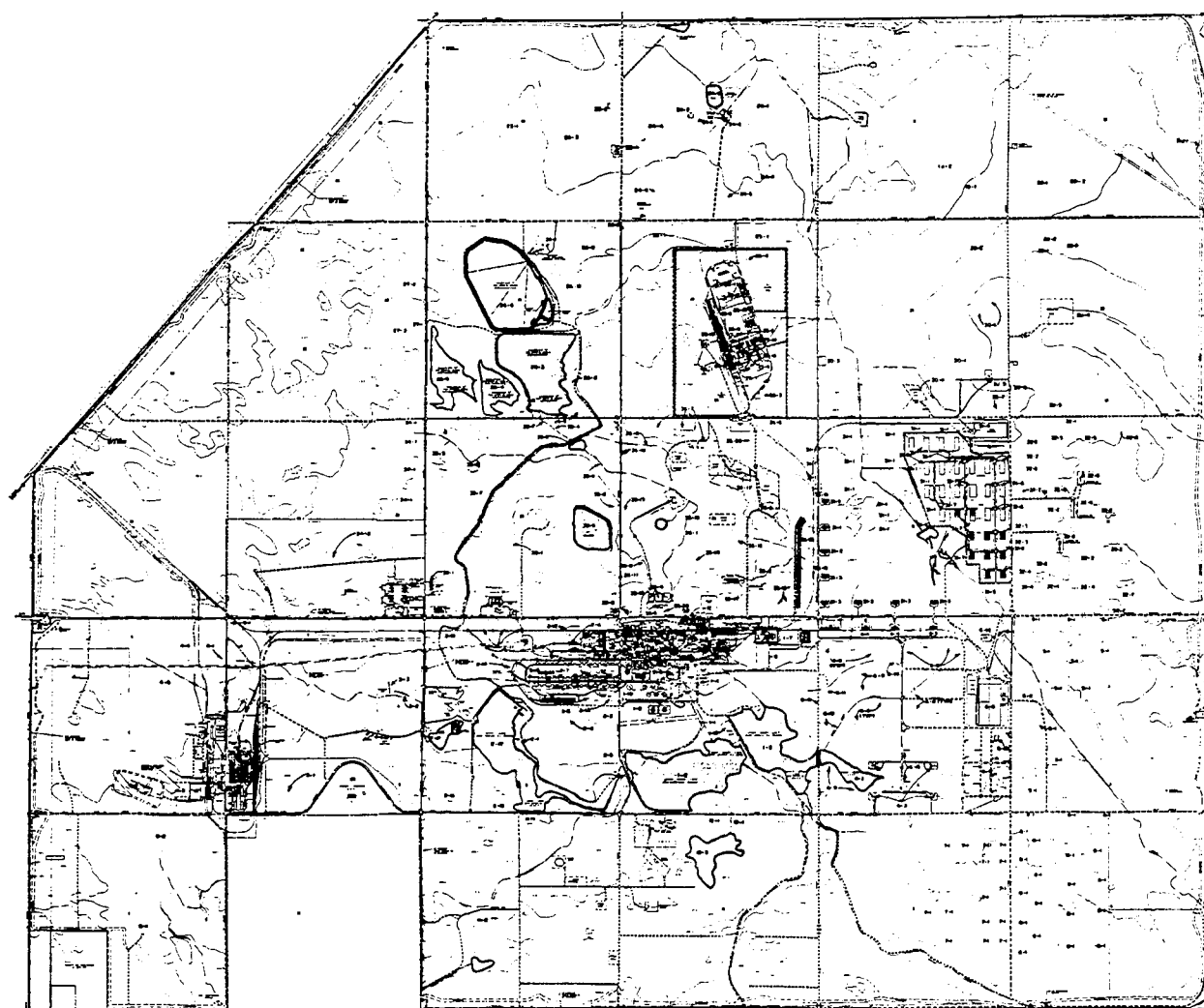
Recent investigations have also identified a number of volatile organic compounds distributed widely in the RMA ground water. These include toluene, xylene, benzene, chlorobenzenes, chloroform, methylene chloride, carbon tetrachloride, dichloroethylene, trichloroethylene, and tetrachloroethylene (Spaine, et al., 1984). These were first detected in 1982.

The contaminants currently considered to be of major significance are chloride, DIMP, dithiane, oxathiane, aldrin, dieldrin, endrin, DCPD, DBCP, TCE, PCPMS, PCPMSO, PCPMSO₂, and a series of volatile organic compounds. The relative significance of these contaminants is based on their widespread occurrence, their potential origin in RMA industrial operations, the concentration of contaminant, and their environmental fate and impact.

1.3.5 CONTAMINANT SOURCES

Major contaminant sources have been identified through previous hydrogeologic investigations, chemical analyses of soil and ground water samples, and reviews of historical activities at RMA. The locations of these primary contaminant sources are depicted in Figure 1.3-4. Detailed descriptions of site activities and contaminants present are presented in the Task 4 Technical Plan.

South Plants--The South Plants Area (1-13 and 2-18, Figure 1.3-4) was part of the original RMA manufacturing complex. These facilities were used by the Army for production and storage of chemical-filled munitions, incendiary munitions, and intermediate products. Shell also used the facility for pesticide manufacture.



ROCKY MOUNTAIN ARSENAL

EXPLANATION

-  Primary Migration Source
-  Potential Migration Source
-  Balance of Areas Investigated

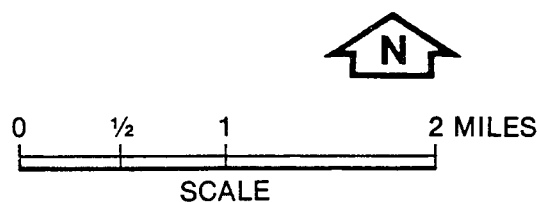


Figure 1.3-4
AREAS INVESTIGATED AS
MIGRATION SOURCES ON RMA

Prepared for:
U.S. Army Toxic and Hazardous
Materials Agency
Aberdeen Proving Ground, Maryland

Basin A--Basin A (36-1, Figure 1.3-4) was the original disposal site for most wastewater generated from military and lessee activities at RMA between 1942 and 1956. This source is an unlined, natural topographic depression which occupied approximately 25 acres during periods of maximum use.

Basins B, C, D, and E--Basins B through E (35-3, 26-3, 26-4, 26-5, respectively, Figure 1.3-4) are unlined modified topographic depressions utilized to contain overflow from Basin A between 1943 and 1956. Basin C was again used in 1957 to contain liquids from Basin F during repair of the Basin F liner.

Basin F--Basin F (26-6, Figure 1.3-4) is an asphalt-lined basin created by construction of a retention dike around a natural depression. This basin was constructed in 1955 in response to complaints from local farmers concerning ground water contamination. Basin F began to receive liquid waste streams in 1956, and was the disposal site for most liquid and some solid chemical wastes and production wastewater at RMA between 1956 and 1978.

Lower Lakes--The Lower Lakes area (1-2, 2-17, Figure 1.3-4) includes four interconnected man-made lakes and one smaller pond. Three of the four primary lakes (Upper and Lower Derby Lakes, and Lake Ladora) are part of a large process cooling water system for industrial operations at RMA. The Rod and Gun Club Pond was formed in a natural topographic depression by high water overflow from Lower Derby Lake.

Rail Classification Yard--DBCP was manufactured by Shell and shipped by rail from RMA. Contamination resulted from a suspected DBCP spill approximately in the middle of the yard (3-4, Figure 1.3-4). Smaller spills may also have occurred.

Sanitary Sewer System--The Sanitary Sewer System consists of a network of drainlines, connectors, laterals, trunklines, lift stations, and manholes which transmit wastewater generated throughout RMA to the Sewage Treatment Plant in Section 24. Unaccountable increases and decreases in

flow over different sections of the system indicate interaction between the sewer system, and surface water and/or ground water (Black and Veatch Consulting Engineers, 1979).

Industrial Waste System--The Industrial Waste System, also referred to as the contaminated waste lines or contaminated sewers, consisted of sewer lines which carried Army and Lessee waste to Basins A and F. Since 1982, large portions of the Industrial Waste System have been excavated and disposed in Basin F. There are documented instances of leakage into and out of these lines.

Table 1.3-1. Compounds Detected in RMA Ground Water (Historic)

Acetone
Arsenic
Atrazine
Aldrin
Benzene
Bladex
Bicyclo (2,2,1) Hepta-2,5-diene
Chloride
Carbon Tetrachloride
Chloroform
Chlorate
Chlorobenzene
Dichlorobenzenes
Dichloroethylene
Hexachlorocyclopentadiene
p-Chlorophenylmethylsulfide
p-Chlorophenylmethylsulfoxide
p-Chlorophenylmethylsulfone
Copper
Dibromochloropropane
Dicyclopentadiene
Dieldrin
Diisopropylmethylphosphonate
1,4-Dithiane
Endrin
Fluoride
Dimethyl Disulfide
Iron
Isodrin
Methyl isobutyl ketone
Malathion
Manganese
Methylene Chloride
1,4-Oxathiane
2-(o-chlorophenyl) 2-(p-chlorophenyl)-1,1,1-Trichloroethane
Phosphate
2,2-Bis (para-chlorophenyl)-1,1-Dichloroethene
2,2-Bis (para-chlorophenyl)-1,1,1-Trichloroethane
Tetrachloroethylene
Toluene
Trichloroethylene
Xylenes

Source: USATHAMA RMA Database, 1985.

2.0 INITIAL SCREENING PROGRAM

The purpose of this section of the report is to summarize the results of the ISP and to describe modifications or alterations to the Task 4 program resulting from this activity.

2.1 GROUND WATER MONITORING PROGRAM

The Initial Screening Program ground water monitoring network consisted of 357 wells designated for chemical sampling and 863 wells selected for measurement of static water levels.

2.1.1 DESIGN

The procedure used in developing the network is illustrated in Figure 2.1-1. The initial evaluation was performed with respect to well construction and resulted in wells being designated as acceptable, potentially acceptable, questionable, or unacceptable. Wells of acceptable and potentially acceptable construction were further evaluated with respect to sampling history and well location. Wells that are currently or were formerly sampled under an existing RMA Program were also evaluated. All wells of acceptable and potentially acceptable construction were plotted in relation to ground water flow direction, aquifer configuration, major sources of contamination, and contaminant plumes. Based on sampling history, areal relationships, and vertical distribution, wells were selected for inclusion into the program. Wells of acceptable or potentially acceptable construction were deleted from the program if another acceptable or potentially acceptable well in the proximity was expected to yield similar or repetitive information. Preference was given, when possible, to wells with detailed sampling histories and wells currently in the 360° Program or Basin F Monitoring Programs.

Upon completion of the above activities, areas were identified which did not contain wells of acceptable or potentially acceptable construction. Such locations included areas downgradient of known contaminant sources within known contaminant plumes, areas within primary ground water flow paths, and areas thought to be uncontaminated. Because of the

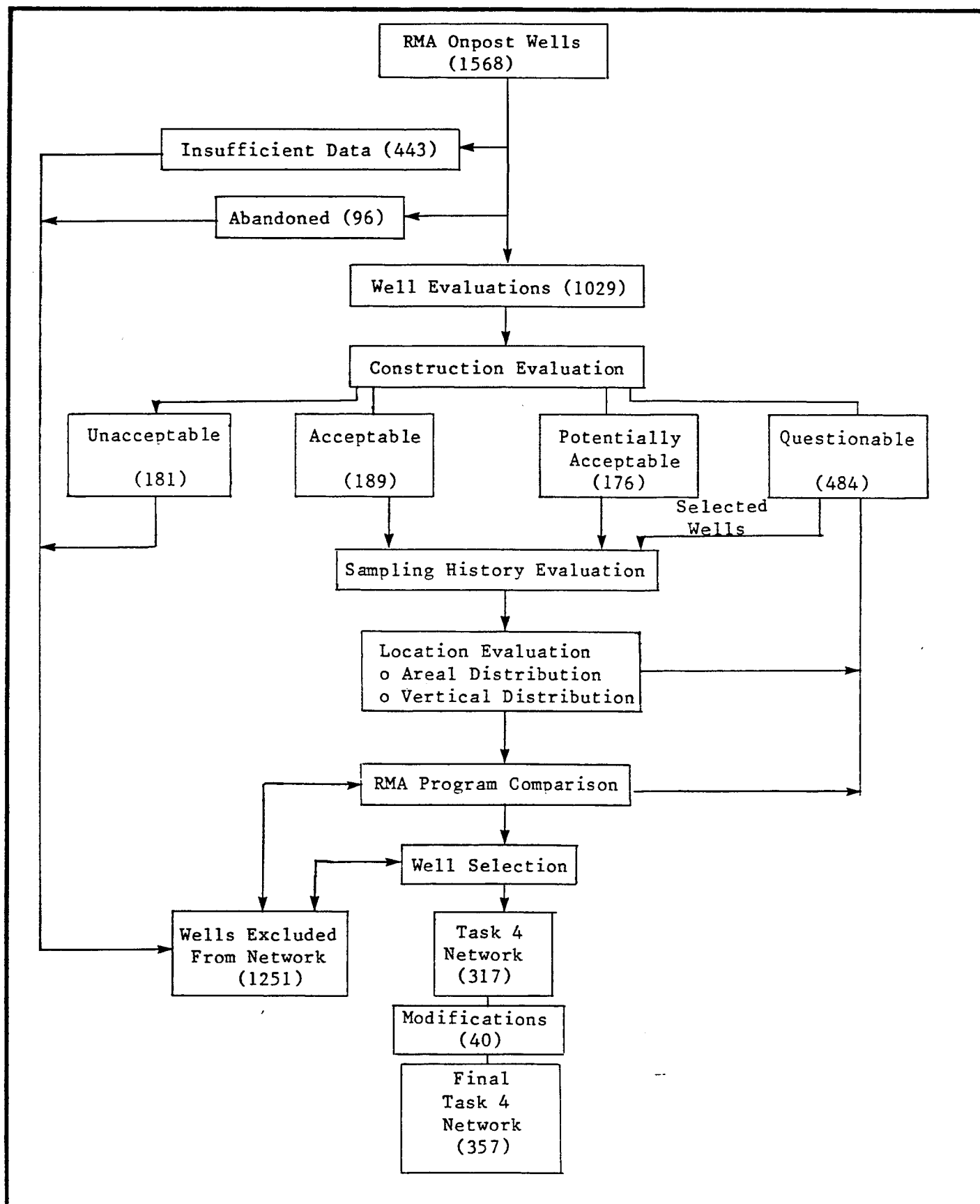


Figure 2.1-1
WELL SELECTION AND EVALUATION
PROCESS

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

unavailability of wells in the acceptable or potentially acceptable categories, ground water wells to be monitored in these locations were selected from the "questionable" category. Sampling histories were then evaluated. Again, preference was given to wells with detailed sampling records and wells currently in RMA programs. Additionally, wells of "questionable" construction which occurred in clusters with wells of acceptable construction were utilized to fully evaluate the vertical distribution of contaminants. A final screening was performed to assure that an adequate number of wells in appropriate locations was selected, and that the total number of wells in each section was balanced with respect to project objectives and source priority.

At the request of the PMO-RMA, several modifications were made to the design of the ground water monitoring network. Some of these modifications were made prior to the initiation of sampling activities, while other modifications were initiated during ISP ground water sampling. Program changes included alterations of the ground water wells to be monitored and modification of the list of target analytes for water samples. Specifically, program changes included:

- o The "One-Time Only" sampling of 31 additional monitoring wells primarily in the western portions of RMA;
- o The designation of 148 monitoring wells for which samples would be analyzed for a suite of trace metals;
- o The inclusion of three newly installed monitoring wells in the vicinity of the U.S. Post Office Facilities located off the southwest corner of RMA; and
- o The sampling of both existing and proposed monitoring wells in the vicinity of Basin F.

2.1.1.1 One-Time Only Wells

A total of 31 wells were added to the program to provide further definition of potential volatile organic contamination in ground water along the western boundary of RMA. These wells were sampled using the same sampling procedures outlined for network wells, but samples were analyzed for purgeable organic parameters and DBCP only.

The "One-Time Only" wells were selected by examining all wells located in Sections 3, 4, 9, and 33. The first step in selecting the one-time only wells for inclusion into the network was to examine all wells in these sections for which construction data are available. The distribution of wells currently in the network was then complemented by the addition of these other wells. Areas of excessive coverage and of inadequate coverage were identified. Selected wells were eliminated from the "One-Time Only" network in areas of excessive coverage to provide for an approximately equivalent distribution of ground water monitoring locations. For areas where inadequate coverage was identified, wells with no construction records were included in the network. This activity resulted in the addition of 31 new monitoring wells to the program.

2.1.1.2 Monitoring Wells for Metals Analyses

Under the original Task 4 Technical Plan metals were not identified as target analytes. As a result of discussions with the MOA parties, it was later decided to include metals at part of the analytical scheme. This decision was reached following initiation of sampling activities and consequently only a limited number of wells were available for metals analysis. Of these remaining wells, a network of wells designated for metals analyses was developed based on the following priorities:

- o Wells in which metal contaminants had previously been detected;
- o Wells with previous data on metals concentrations;
- o Wells required to provide adequate areal distribution throughout each saturated horizon; and
- o Wells in a cluster configuration with other wells selected for metals analyses.

The final network is summarized in Table 2.1-1. Of the total 148 wells to be sampled for metals analysis, only 128 could be sampled. The analytical parameters include 13 selected inorganic parameters (calcium, magnesium, sodium, potassium, cadmium, copper, chromium, lead, zinc, arsenic, mercury, nitrate-nitrite, and sulfate).

Table 2.1-1. Final Ground Water Monitoring for Metals Analyses

Section	Total Wells	Well Numbers
1	12	8, 12, 17, 20, 21, 22, 23, 27, 28, 29, 30, 31, 33
2	8	8, 9, 10, 17, 20, 21, 30, 31
3	7	1, 2, 3, 5, 6, 7, 8
4	4	7, 10, 11, 12
5	0	NONE
6	0	NONE
7	0	NONE
8	3	3, 4, 5
9	2	2, 4
11	0	NONE
12	3	2, 3, 4
19	3	14, 15, 16
22	4	22, 29, 30, 60
23	10	39, 49, 142, 166, 182, 183, 184, 191, 192, 193
24	4	1, 158, 159, 170
25	9	18, 19, 20, 22, 23, 24, 38, 39, 40
26	17	11, 412, 70, 71, 72, 83, 84, 85, 86, 127, 128, 129, 132, 133, 145, 146, 147
27	7	53, 56, 58, 59, 60, 61, 76
28	3	23, 25, 26
29	0	NONE
30	0	NONE
31	0	NONE
32	3	1, 2, 3
33	9	22, 25, 26, 27, 30, 31, 32, 33, 63
34	6	2, 3, 4, 5, 6, 7
35	17	12, 13, 16, 17, 34, 38, 52, 54, 58, 59, 60, 62, 65, 66, 67, 68, 69
36	16	1, 65, 76, 82, 83, 84, 90, 91, 109, 110, 112, 113, 114, 137, 138, 141
TOTAL	148	

Source: HLA, 1986

2.1.1.3 Basin F Monitoring Wells

Twelve ground water monitoring wells were included in the 1984-1985 Monitoring System for the Basin F facility. Upon evaluation of construction details for these wells, it was determined that six of the twelve Basin F wells had unacceptable construction. Therefore, these six poorly constructed wells were deleted from the original Task 4 ground water monitoring network. The original Task 4 Technical Plan proposed that these six unacceptable wells be replaced by nine additional ground water monitoring wells of adequate construction.

The revised Basin F monitoring program was proposed to the Colorado Department of Health (CDH). At this time, the deletion of the six monitoring wells of unacceptable construction and replacement of wells of more acceptable construction was deemed to be premature by CDH and EPA. Therefore, the six wells that had previously been deleted from the monitoring network were added back into the program and sampled. This sampling activity was performed from March 18, 1986 through March 20, 1986. Following issuance of this report, a modified ground water monitoring network for Basin F will be formulated and proposed to CDH and the EPA for approval.

2.1.1.4 U.S. Post Office Monitoring Wells

Three new ground water monitoring wells were installed in the vicinity of the U.S. Post Office Building located to the southwest of RMA at the southern end of Section 9. These wells were constructed and developed during the ISP and were sampled near the end of the ISP. The post office wells were installed at the request of EPA and sampled to assess the potential of upgradient, offsite contributions of volatile organic compounds, specifically TCE.

2.1.2 GROUND WATER MONITORING PROCEDURES

Static water levels were measured with Soil Test Model DR-760A water level indicators. Total depths were measured with bottom-weighted, nylon-coated steel measuring tapes. Measured values were reported to the tenth of a foot. All pertinent information obtained during the water level measurement phase was recorded on water level measurement forms and kept

in a bound field notebook. The following information was recorded for each well sampled:

- o Well number;
- o Casing diameter;
- o Date and time (24-hour system);
- o HNU readings (background and in well casing);
- o Casing stickup;
- o Depth to water from top of casing;
- o Total depth;
- o Measuring device;
- o Sampler's initials;
- o Casing volume; and
- o Pertinent comments (e.g., condition of well).

Ground water sampling methodology and techniques adhere to USATHAMA Geotechnical Requirements with respect to decontamination, collection, preservation, shipment and chain-of-custody requirements. Further discussion of these aspects of sample collection is provided in the Task 4 Technical Plan (ESE, 1986).

The following is a summary of the sampling procedures employed during ISP:

- o Sampling crews receive labeled sample kits from Field Team Coordinator;
- o Record well number, date, pertinent information (e.g., weather and well conditions), station elevation, casing diameter, screened interval, and field equipment identification (manufacturer and I.D. number);
- o Measure and record well stickup, depth to water, total well depth, HNU readings, and calculate well casing volume;
- o Lower submersible pump to a few feet below the maximum drawdown or to the bottom of the well. If well is constricted above water level and pump will not pass, lower bailer to a few feet below water level. Record depth to pump or bailer;
- o Pump or bail five well casing volumes out of well. Measure and record time, pH, conductivity, and temperature after each well

volume. Measure and record HNU readings by obtaining frequent background, well head and discharge water values. If well is located within a known contamination plume or if HNU readings are obtained above background levels, discharge water will be collected in barrels. Otherwise water may be discharged on the ground at least 50 feet from the wellhead;

- o Measure and record pumping rate, total pumping time, and total volume purged;
- o Remove pump after purging is completed or if well is dewatered;
- o Sample immediately. If well is dewatered, the field team will recheck the well in approximately one hour. If at least 2 gallons can be obtained, the well is sampled. If the well has not recovered to this volume, which is necessary to fill the sample bottles, the field crew will return every several hours until a maximum of 29 hours has passed. If the well has not produced 2 gallons, it is not sampled. Sample using bottom filling stainless steel bailer. Measure pH, conductivity, and temperature of water sample obtained from bailer being used for sampling. Record time and measured values on sampling sheet, in field notebook, and on sample labels;
- o Decant portion of water into sample bottles; cap bottles, agitate bottles and discard water. Fill rinsed sample bottles directly from bailer. Record sample depth;
- o Place bottles in ice chest;
- o Complete chain-of-custody forms;
- o Sign and date well sampling form; and
- o Seal cooler and ship samples.

All pertinent data obtained during ground water sampling has been recorded on Field Sampling Data sheets and kept in a bound field notebook. The information recorded for each well sampled includes:

- o Well number;
- o Date and time (24-hour system);
- o Pertinent observations (e.g., weather, well condition);
- o Station elevation;
- o Well stickup;

- o Static water level and well depth;
- o Casing diameter;
- o Number of gallons per casing volume;
- o Screened interval;
- o HNU readings;
- o Pump depth, measured pumping rates, total pumping time and total volume of water removed;
- o Characteristics of the water (color, odor, etc.);
- o Measurements of pH, temperature, and conductivity;
- o Identification of field equipment;
- o Sampling description (number of bottles, sample fractions, sample depth);
- o Field notebook number; and
- o Signature of samplers and field team coordinator.

Records have been kept of all wells visited, including those found to be dry or constricted such that sampling was impossible. Dry wells include those wells with the water level below the bottom of the screened interval.

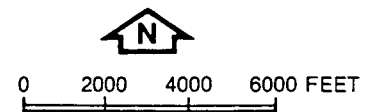
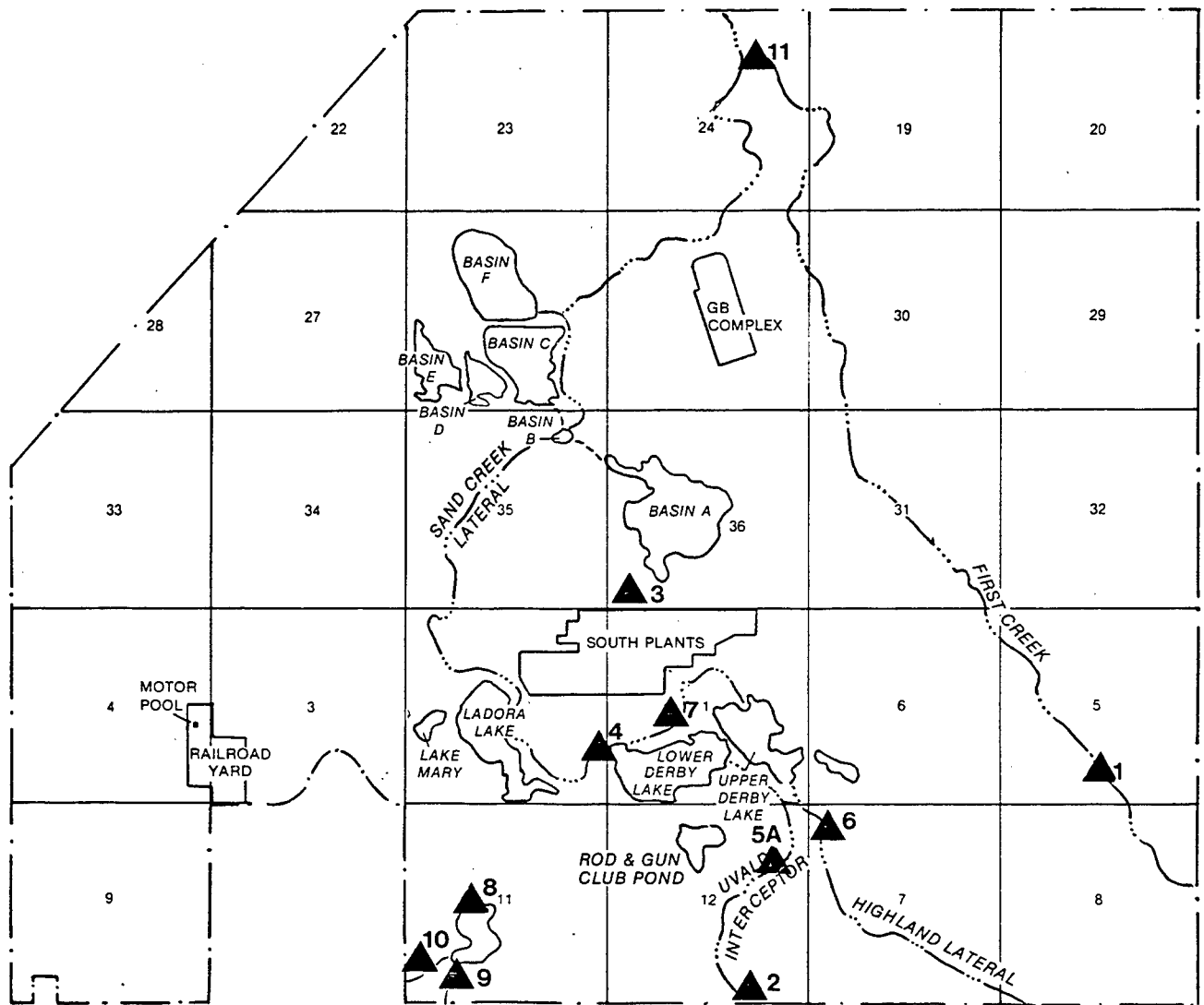
2.2 SURFACE WATER MONITORING PROGRAM

The surface water program at RMA is designed to monitor the surface water entering, leaving, and stored on RMA grounds. Data were collected, reduced, and compiled to determine both the surface water mass balance and surface water quality present at RMA.

2.2.1 SURFACE WATER MONITORING NETWORK

Currently there are 11 active sites on RMA (Figure 2.2-1) where streamflows and lake levels are measured on a continuous basis. These sites are as follows (numbers in parentheses refer to Station Numbers):

- (1) South First Creek
- (2) South Uvalda Interceptor;
- (3) Basin A Inflow;
- (4) Ladora Weir;
- (5) North Uvalda Interceptor;
- (6) Highline Lateral;



▲ STREAM FLOW MONITORING STATION

- 1 First Creek (entering RMA)
- 2 South Uvalde Interceptor
- 3 Basin A Inflow
- 4 Ladora Weir
- 5A North Uvalde Interceptor (relocated)
- 6 Highline Lateral
- 7 South Plants Ditch
- 8 Havana Detention Pond
- 9 Peoria Ditch
- 10 Havana Interceptor
- 11 North First Creek

Figure 2.2-1
SURFACE WATER MONITORING STATIONS

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

- (7) South Plants Ditch;
- (8) Havana Detention Pond;
- (9) Peoria Interceptor Ditch;
- (10) Havana Interceptor; and
- (11) North First Creek.

The gaging stations are equipped with devices that record the stage of the stream or depth of flow. Through the utilization of rating curves or hydraulic computations, these data are converted to rates of flow, i.e., cubic feet per second (cfs) or gallons per minute (gpm).

The gaging stations at North and South First Creek, North and South Uvalda, and Peoria Interceptor use small weirs placed in the channels. These weirs do not take into account the total channel cross section, so actual measurements of flow rates were performed. Measurements were made during the past year in order to produce verifiable rating curves. The rating curves were checked using a HEC-2 procedure. At the Havana station a uniform concrete channel exists and has been rated to verify flow conditions.

Gaging stations at the Highline Lateral, Basin A Inflow, Ladora Weir, South Plants Ditch, and the offpost First Creek site all have channel devices that do not require measurements at various stages to prepare rating curves. Common forms of weirs and flumes have been selected for which stage-discharge formulas have been experimentally derived and accepted.

A continuous recording gaging station is established at Havana Pond to measure pond level. A survey of this pond was conducted so that stage-volume and stage-area curves could be prepared. Although similar gaging stations are not installed on the Lower Lakes (Upper and Lower Derby, Ladora, and Mary), staff gages exist and are read weekly.

Two precipitation gages have been installed at RMA. These are used in conjunction with precipitation measurements obtained at National Weather Service stations at Stapleton International Airport and at Brighton,

Colorado, to determine the precipitation input to the RMA surface water. The gages are of the tipping bucket variety and are attached by cable to event recorders.

2.2.2 SURFACE WATER MONITORING PROCEDURES

Samples for chemical analysis were planned at 30 surface water locations across RMA (Figure 2.2-2). Data from surface water sampling were recorded on water sampling forms similar to those utilized in ground water sampling. These data include an accurate description of the point sample, the date, the sample number, parameter measurements (pH, temperature, and specific conductivity), sample bottles and the sampler's name. The samples were collected either directly in the sample container or in the bailer from which the water is decanted into the sample bottles.

2.3 ANALYTICAL METHODS

The objectives of the chemical analysis program are to provide the PMO-RMA with reliable, statistically supportable, and legally defensible chemical data regarding type and level of contamination in surface water and ground water at RMA. This work element consists of a quantitative screening program integrated with surface and ground water sampling efforts during the ISP.

The original Task 4 Technical Plan proposed an initial schedule of 24 chemical analytes for all ground water and surface water samples. This proposed list was modified in several stages and upon completion of ISP sampling consisted of 50 analytes. These target analytes included seven organochlorine pesticides, six organosulfur compounds, five purgeable aromatics, twelve purgeable halocarbons, DCPD, MIBK, DIMP, DMMP, DCPD, and 15 inorganic parameters. All analytical methods performed during the ISP were quantitatively certified to obtain the lower detection limits and higher accuracy associated with quantitative methods. No semi-quantitative (e.g., GC/MS) methods were performed. Table 2.3-1 contains the list of all final analytes, sample holding times, a reference to the specific methods utilized for each parameter, and method detection limits.

Table 2.3-1. Chemical Analysis - Task 4 Screening Program (Page 1 of 3)

Analysis/Analytes	Hold Time	Level of Certification	Reference Methods	RMA Method	Analytical Method	Method Reporting Limit (µg/l)
<u>Organochlorine Pesticides</u>						
Aldrin	Extract as quickly as possible. (No more than 7 days). Analyze within 40 days of extraction.	Quantitative	EPA 608	S8	CAP-GC/EOD	<0.07
Endrin						<0.05
Dieldrin						<0.06
Isodrin						<0.06
Hexachlorocyclopentadiene						<0.07
p,p'-DDE						<0.05
p,p'-DDT	<0.07					
<u>Volatile Organohalogenes</u>						
Chlorobenzene	14 days	Quantitative	EPA 601	Y8	PACK-GC/Hall	<0.58
Chloroform	14 days					
Carbon Tetrachloride	14 days					<1.40
trans-1,2-Dichloroethylene	14 days					<2.40
Trichloroethylene (TCE)	14 days					<1.20
Tetrachloroethylene	14 days					<1.10
1,1 Dichloroethylene	14 days					<1.10
1,1 Dichloroethane	14 days					<1.20
1,2 Dichloroethane	14 days					<0.61
1,1,1 Trichloroethane	14 days					<1.70
1,1,2 Trichloroethane	14 days					<1.00
Methylene Chloride	14 days					<5.00
<u>Organosulfur Compounds</u>						
P-Chlorophenylmethylsulfone (PCMSO ₂)	Extract as quickly as possible. (No more than 7 days.) Analyze within 40 days of extraction.	Quantitative	U8	PACK-GC/FPD-S		4.70
P-Chlorophenylmethylsulfoxide (PCMSO)						1.30
P-Chlorophenylmethylsulfide (PCMS)						4.20
1,4-Dithiane						1.10
1,4-Oxathiane						2.00
Dimethyldisulfide (DMS)						1.80

Table 2.3-1. Chemical Analysis - Task 4 Screening Program (Page 2 of 3)

Analysis/Analytes	Hold Time	Level of Certification	Reference Methods	RVA Method	Analytical Method	Method Reporting Limit (µg/l)
<u>Volatile Aromatics</u>						
Toluene	14 days	Quantitative	EPA 602	W8	PACK-GC/PID	<1.21
Benzene	14 days					<1.34
Xylene (m-)	14 days					<1.35
Ethylbenzene	14 days					<1.00
Xylene (o,p)						<2.47
<u>DCPD/MIBK</u>						
Dicyclopentadiene	Extract as quickly as possible. (No more than 7 days). Analyze extract within 40 days of extraction.	Quantitative	EPA 608	R8	CAP-GA/FTD	<9.31
Methylisobutyl Ketone						<13.00
<u>DIMP/DMP</u>						
Diisopropylmethylphosphonate	Analyze within 47 days of sampling	Qualitative	EPA 622	T8	PACK-GC/FPD-P	<10.00
Dimethylmethylphosphonate						<15.20
<u>DBCP</u>						
Dibromochloropropane	14 days	Quantitative		Q8	CAP-GC/ECD	<0.13

Table 2.3-1. Chemical Analysis - Task 4 Screening Program (Page 3 of 3)

Analysis/Analytes	Hold Time	Level of Certification	Reference Methods	RMA Method	Analytical Method	Method Reporting Limit (µg/l)
<u>Metals</u>						
Mercury	28 days	Quantitative	EPA 245	L8	Cold Vapor	<0.20
Arsenic	6 months		EPA 206	A8	AA-Hydride Furnace	<3.90
Potassium	6 months		EPA 258	AA8	AA-Flame	<1260
<u>ICP</u>						
Calcium	6 months	Quantitative	EPA 200.7	B8	Inductively Coupled Plasma	<500
Magnesium	6 months					<500
Sodium	6 months					<763
Cadmium	6 months					<5.2
Chromium	6 months					<6.0
Copper	6 months					<7.9
Lead	6 months					<18.5
Zinc	6 months					<20.1
<u>Inorganics</u>						
Chloride	28 days	Quantitative	EPA 300	X8	Ion Chromatograph	<4,800
Fluoride	28 days				Ion Chromatograph	<1,200
Sulfate	28 days				Auto Analyzer	<10,000
Nitrate =Nitrite	28 days				Ion Chromatograph	<10

Source: ESE, 1985.

The final list of target analytes was generated upon review of historical information concerning disposal practices, review of historical water quality data, and comments by the U.S. EPA, Shell, and CDH.

2.4 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance (QA) for Task 4 was consistent with the Field/Laboratory QA Plan developed for Task 1 activities. The plan was project specific and describes procedures for controlling and monitoring sampling and analysis activities as required under Task 4. As designed, the Field/Laboratory QA Plan ensured the production of valid and properly formatted data concerning the precision, accuracy, and sensitivity of each method used for USATHAMA sampling and analysis efforts. The plan is based on USATHAMA April, 1982 QA program requirements as modified by U.S. Army AMCCOM Procurement Directorate and ESE as well as certified analytical methods submitted to and approved by USATHAMA. The plan is presented in Appendix B of the Task 1 Technical Plan. Specific RMA QA/QC requirements are detailed in Section 5.0 of the same document.

Field Quality Control (QC) procedures for the ISP were consistent with EPA and USATHAMA approved methodologies. A summary of these procedures for all trip blanks, rinseate blanks, field blanks, and duplicates are summarized in Table 2.4-1.

2.5 ISP FIELD EFFORTS

Field work for Task 4 commenced on September 17, 1985, with field crews locating ground water monitoring wells designated for water level measurements and sampling. During this activity organic vapor concentrations at the wellhead were measured and well conditions documented. All wells were staked and labeled such that wells were identified for either water level measurements or water level measurements and ground water sampling. Following these activities water levels were measured and selected wells sampled.

2.5.1 WATER LEVEL MEASUREMENT

Following initial well reconnaissance, water level measurements were obtained. A total of 863 wells were selected for water level

Table 2.4-1. Field QA/QC Procedures

QA Sample Type	Analytical Method*	Required Frequency	Preparation
Volatile Trip Blank	W8, Y8	1 paint can with 3 volatile septum vials per week, each week samples for GC analysis are collected.	Transport filled blank volatile septum vials to field, open paint can and return to laboratory with samples.
Rinseate Blank	S8, U8, T8, W8, Y8, X8, K8, R8, Q8	1 suite per week, each samples are submitted	Decontaminate bailer used to collect samples. Pour deionized water into cleaned bailer, then transfer to sample bottles. Perform while onsite. Not applicable if dedicated bailer is used.
Field Blank	S8, U8, T8, W8, Y8, X8, K8, Q8, R8	1 suite per week, each week samples are submitted	Pour organic free deionized water directly into sample bottles. Perform while onsite.
Duplicates	S8, U8, T8, W8, Y8, X8, K8, R8, Q8	1 suite per week, each week samples are submitted	Collect 2 suites of sample bottles while onsite.

*See Table 2.3-1 for parameters analyzed using method name.

measurements. Of these 863 wells, 28 wells could not be located. Of the 835 wells located, three were found to be totally obstructed and water levels could not be obtained for these wells. Thirty-six wells were found to be dry. Of these 36 dry wells, several were later found to have been obstructed at depth with sampling ropes dedicated to the well. These wells were cleared, but water levels were not obtained in time for ISP water level measurements. Additional wells were cleared of obstructions when total depths from well logs did not correspond with field measurements.

Initial water level measurements were obtained from the 863 wells between October 7, 1985 and November 18, 1985. The 28 wells which could not be located are listed in Table 2.5-1.

A second quarter of water level measurements were obtained between March 7, 1986 and March 19, 1986. Data collected for water level measurement activities during both first and second quarter efforts can be found in Appendix A. The plotting and contouring of water level data for both first and second quarters are discussed in Section 3 of this report.

2.5.2 GROUND WATER SAMPLING

Ground water sampling followed the measurement of water levels. Ground water sampling was initiated on October 15, 1985 and generally completed by January 31, 1986. However, nine additional samples, six RCRA wells, and three resamples were collected between February 1 and 7, 1986. Sampling procedures are described in the Final Task 4 Technical Plan. No modifications were made to these procedures.

Of the 357 total wells which were designated for sampling, water samples were obtained from 320 of these wells. Of the 37 wells which were not sampled, 17 were found to be dry or contain water only beneath the screened interval, 15 wells were either constructed or obstructed such that small diameter bailers could not be lowered to the static water level, and five monitoring wells had been previously destroyed. The list of wells which could not be sampled is presented in Table 2.5-2. In addition, one well not originally included in the program of 357 was sampled by mistake resulting in collection of a total of 321 samples for analysis.

Table 2.5-1. Monitoring Wells Which Could Not Be Located for First Quarter
Water Level Measurements

<u>Well Number</u>	<u>Well Number</u>	<u>Well Number</u>
01009	23117	26045
01018	23130	26087
01510	23139	26119
02002	23342	26132
04006	24165	26133
04035	24176	26143
11001	26007	26144
22013	26008	27073
23005	26013	28001
		35047

Table 2.5-2. Wells That Could Not Be Sampled During Screening Program

Dry Wells (17)

02017	23039	26145
07003	23049	30003
19014	26065	33028
22025	26070	33062
22029	26076	36091
22049		36116

Wells Previously Destroyed (5)

01026	24188	35035
24170	26132	

Wells Obstructed or Constricted (15)

02013	27059	33031
02021	27060	34004
04012	27061	35055
25018	28029	35060
26146	33029	35072

Source: HLA, 1986

For many of the 321 monitoring wells that were sampled, the pump used for purging could not be lowered to the required depth. These wells were purged of the required 5 casing volumes by bailing. Many of the monitoring wells which contained small casing volumes of water were also bailed to increase sampling efficiency. Although five casing volumes of water were to be purged prior to sampling, some monitoring wells were purged dry prior to obtaining this volume of water. Table 2.5-3 contains well-specific information on the calculated casing volume, volume of water purged from the well by either pumping or bailing, the total volume of water removed, and if bailed, the reason for bailing. Reasons for bailing were coded as low volume (LV), constricted (C), or equipment not operable (E). As stated in the Task 4 Technical Plan, if the well was dewatered during purging, the initial recharge water was collected for sampling.

As described in Section 2.3, several alterations were made in the list of target analytes for monitoring wells. Samples from a total of 128 monitoring wells were analyzed for the complete suite of organic and inorganic analytes. A total of 31 monitoring wells in the Western Tier were sampled for purgeable halocarbons, purgeable aromatics, and DBCP only. Remaining wells were analyzed for the complete suite of organic analytes. A total of 21 monitoring wells were resampled, primarily to collect samples for metals analysis. Table 2.5-4 contains a tabulation of the analytical methods performed on Task 4 water samples by well. This table summarizes the analytical data developed during ISP sampling which is presented in Appendix B of this report.

2.5.3 SURFACE WATER SAMPLING

Field work for surface water monitoring activities was initiated July 15, 1985. Initial efforts were directed to the repair and rehabilitation of existing monitoring and recording structures and devices. Actual stage and flow monitoring commenced October 1, 1985. Lake levels were recorded weekly while stream stage was measured on a continuous basis except for the period December 15, 1985, through March 15, 1986, when low flows dictated weekly stream monitoring. Surface water quality sampling was performed between December 1985 and January 1986.

Table 2.5-3. Evacuation Data for Screening Program Sampling (Page 1 of 5)

Well Number	Casing Volume (gallon)	Pumped Volume (gallon)	Bailed Volume (gallon)	Reason for Bailing*	Casing Volumes Removed	Comments
01008	1.9	--	9.5	L.V.	5	--
01012	2.4	--	12.0	L.V.	5	--
01014	1.6	--	8.0	L.V.	5	50 ppm/breathing
01017	2.0	--	10.0	L.V.	5	--
01019	2.1	--	10.5	L.V.	5	--
01020	1.3	--	6.5	L.V.	5	--
01021	8.3	--	41.5	C	5	--
01022	16.8	--	84.0	C	5	--
01023	22.22	--	111.1	C	5	--
01024	7.7	--	38.5	C	5	--
01025	11.7	--	58.5	C	5	--
01027	1.3	--	6.5	L.V.	5	--
01028	9.9	4.0	20.8	C	2.5	Dewatered
01029	15.2	--	26.6	C	1.75	Dewatered
01030	1.5	--	7.5	L.V.	5	--
01031	8.3	41.5	--	--	5	--
01032	11.7	58.5	--	--	5	--
01033	1.9	--	9.5	L.V.	5	--
01034	12.7	12.7	--	--	1	Dewatered
01035	15.1	75.5	--	--	5	--
02008	10.1	--	50.5	C	5	--
02009	17.0	--	85.0	C	5	--
02010	20.0	--	101.0	C	5	--
02011	9.5	--	47.5	C	5	--
02012	16.8	--	84.0	C	5	--
02018	4.4	--	22.0	L.V.	5	--
02019	8.5	--	42.5	C	5	--
02020	3.8	--	19.0	L.V.	5	--
02022	11.4	--	57.0	C	5	--
02023	2.9	--	14.5	L.V.	5	--
02024	7.3	--	36.5	C	5	--
02025	13.2	--	66.0	C	5	--
02030	9.3	--	46.5	C	5	--
02031	13.2	--	66.0	C	5	--
02034	2.0	--	10.0	L.V.	5	--
02035	6.9	11.0	--	--	1.6	Dewatered
02036	14.3	--	71.5	C	5	--
02037	2.6	--	13.0	L.V.	5	--
02038	5.9	29.5	--	--	5	--
02039	10.4	52.0	--	--	5	--
03001	20.5	102.5	--	--	5	--
03002	5.2	--	26.0	C	5	--
03003	13.8	--	20.7	C	1.5	Dewatered
03004	19.0	--	19.0	C	1	Dewatered
03005	8.0	40.0	--	--	5	--
03006	16.0	--	20.8	C	1.3	Dewatered
03007	25.4	--	25.4	C	1	Dewatered
03008	2.6	--	13.0	L.V.	5	--
03009	2.48	--	2.48	L.V.	1	Dewatered
03010	3.9	--	19.5	L.V.	5	--
03523	6.0	30	--	--	5	--
04001	2.7	13.5	--	--	5	--
04004	5.4	27.0	--	--	5	--
04007	4.5	--	22.5	C	5	--
04008	7.9	--	39.5	C	5	--
04009	15.7	--	15.7	C	1	Dewatered
04010	3.5	--	17.5	L.V.	5	--
04011	12.2	--	14.6	C	1.2	Dewatered
04013	.65	--	3.25	L.V.	5	--
04014	2.14	--	10.7	L.V.	5	--
04015	4.2	--	21.0	L.V.	5	--
04016	5.4	27.0	--	--	5	--
04019	1.63	8.15	--	--	5	--
04020	3.25	16.25	--	--	5	--
04024	1.09	5.45	--	--	5	--
04025	2.6	13.0	--	--	5	--
04026	1.1	5.5	--	--	5	--
04027	2.0	10.0	--	--	5	--
04028	4.0	20.0	--	--	5	--
04029	5.75	28.75	--	--	5	--
04030	1.6	8.0	--	--	5	--
04031	3.26	--	16.3	L.V.	5	--
04032	5.0	25.0	--	--	5	--
04033	6.8	34.0	--	--	5	--

Table 2.5-3. Evacuation Data for Screening Program Sampling (Continued, Page 2 of 5)

Well Number	Casing Volume (gallon)	Pumped Volume (gallon)	Bailed Volume (gallon)	Reason for Bailing*	Casing Volumes Removed	Comments
04524	5.91	--	29.55	C	5	--
05001	10.0	50.0	--	--	5	--
05002	6.7	--	10.05	C	1.5	Dewatered
05003	9.01	--	9.91	C	1.1	Dewatered
06002	16.0	80.0	--	--	5	--
06003	1.4	--	7.0	L.V.	5	--
06004	8.5	--	9.35	C	1.1	Dewatered
06005	13.8	--	69.0	C	5	--
07001	13.4	20.1	--	--	1.5	Dewatered
07004	3.59	--	7.18	L.V.	2	Dewatered
07005	15.2	--	15.2	C	1	Dewatered
08002	8.7	43.5	--	--	5	--
08003	3.7	--	18.5	L.V.	5	--
08004	15.3	76.5	--	--	5	--
08005	27.4	--	137	C	5	--
09001	1.63	1.63	--	--	1	Dewatered, well in poor condition.
09002	2.8	14.0	--	--	5	--
09003	10.9	--	54.5	C	5	--
09004	21.0	--	63.0	C	3	3 Volumes removed in one day.
09005	35	175	--	--	5	--
09006	35	175	--	--	5	--
09007	18.5	92.5	--	--	5	--
11002	8.1	40.5	--	--	5	--
11003	10.8	--	54.0	C	5	--
11004	13.6	--	68.0	C	5	--
12002	4.5	--	22.5	L.V.	5	--
12003	9.8	49.0	--	--	5	--
12004	16.6	49.8	--	--	3	Dewatered
19015	6.7	--	33.5	C	5	--
19016	14.7	--	27.93	C	1.9	Dewatered
19017	5.1	--	25.5	C	5	--
19018	10	5.0	5.0	C	1	Dewatered
19019	15.4	24.64	--	--	1.6	Dewatered
22020	2.0	--	10.0	L.V.	5	--
22021	3.8	--	19.0	L.V.	5	--
22022	5.9	--	27.0	C	5	--
22023	8.6	--	43.0	C	5	--
22024	12.6	8	4.6	C	1	Dewatered
22027	4.6	--	9.2	L.V.	2	Dewatered
22028	9.9	--	49.5	C	5	--
22030	10.9	54.5	--	--	5	--
22031	15.7	78.5	--	--	5	--
22059	1.5	--	7.5	L.V.	5	--
22060	1.5	--	4.5	L.V.	3	Dewatered
23007	5.9	--	29.5	L.V.	5	--
23029	3.5	--	17.5	L.V.	5	--
23095	2.4	--	10.8	L.V.	5	--
23108	0.8	--	4.0	L.V.	5	--
23142	2.6	13.0	--	--	5	Pumped with well wizard
23166	0.7	--	0.7	L.V.	1	Dewatered
23176	24.2	121	--	--	5	--
23177	6.9	34.5	--	--	5	--
23178	2.6	--	13.0	L.V.	5	--
23179	1.5	--	7.5	L.V.	5	--
23180	5.2	--	7.8	L.V.	1.5	Dewatered
23181	9.9	--	19.8	C	2	Dewatered
23182	3.3	--	16.5	L.V.	5	--
23183	10.9	--	54.5	C	5	--
23184	19.5	--	14.5	C	1	Dewatered
23185	1.4	--	1.4	L.V.	1	Dewatered
23186	3.2	16.0	--	--	5	--
23187	12.4	--	62.0	C	5	--
23188	2.2	--	11.0	L.V.	5	--
23189	5.5	--	27.5	C	5	--
23190	11.9	6	29.7	C	3	Dewatered
23191	1.7	--	8.5	L.V.	5	--
23192	11.6	11.6	--	--	1	Dewatered
23193	19.1	15	11.74	C	1.4	Dewatered
24001	19.6	--	98	E	5	--
24150	30.8	--	154	E	5	--
24159	15.8	--	79.0	C	5	--
24178	11.1	--	55.5	E	5	--
24179	12.5	62.5	--	--	5	--

Table 2.5-3. Evacuation Data for Screening Program Sampling (Continued, page 3 of 5)

Well Number	Casing Volume (gallon)	Pumped Volume (gallon)	Bailed Volume (gallon)	Reason for Bailing*	Casing Volumes Removed	Comments
24184	14.4	--	72.0	E	5	--
24185	17.6	--	88.0	E	5	--
25008	1.5	--	7.5	L.V.	5	--
25009	7.6	--	38.0	C	5	--
25010	13.2	--	13.2	C	1	Dewatered
25011	6.1	--	30.5	C	5	--
25012	9.1	--	15.93	C	1.75	Dewatered
25013	14.2	--	24.85	C	1.75	Dewatered
25014	19.1	--	95.05	C	5	--
25015	1.3	--	6.5	L.V.	5	--
25016	4.2	--	4.2	C	1	Dewatered
25017	6.5	--	13.0	C	2	Dewatered
25019	10.2	8.0	2.2	C	1	Dewatered
25020	19.2	--	96	C	5	--
25022	1.4	--	1.4	L.V.	1	Dewatered
25023	3.5	--	17.5	L.V.	5	--
25024	7.0	--	35.0	C	5	--
25038	1.8	--	9.0	L.V.	5	--
25039	9.5	--	47.5	C	5	--
25040	12.6	--	31.5	C	2.5	Dewatered
26011	4.3	--	21.5	E	5	--
26015	1.1	--	5.5	L.V.	5	--
26017	1.1	--	5.5	L.V.	5	--
26020	1.0	--	2.4	L.V.	2	Dewatered
26041	1.1	--	1.1	L.V.	1	Dewatered, Recharge Req.23 hrs.
26066	4.2	--	21	L.V.	5	--
26067	10.9	54.5	--	--	5	--
26071	3.1	--	15.5	L.V.	5	--
26072	10.3	51.5	--	--	5	--
26073	1.6	--	8.0	L.V.	5	--
26074	2.0	--	6.0	L.V.	3	Dewatered
26075	8.5	42.5	--	--	5	--
26083	1.6	--	3.2	L.V.	2	Dewatered
26084	10.3	20.6	--	--	2	Dewatered
26085	1.2	--	6.0	L.V.	5	--
26086	8.4	42.0	--	--	5	--
26091	2.1	--	10.5	L.V.	5	--
26092	10.1	50.5	--	--	5	--
26093	2.0	6.0	--	--	3	Dewatered
26094	11.2	56.0	--	--	5	--
26127	6.1	--	30.5	C	5	--
26128	6.7	33.5	--	--	5	--
26129	10.9	54.5	--	--	5	--
26133	5.6	--	28.0	C	5	--
26140	4.5	--	22.5	C	5	--
26141	10.6	53.0	--	--	5	--
26142	13.5	25.65	--	--	1.9	Dewatered
26147	11.6	58.0	--	--	5	--
27003	14.4	--	72.0	E	5	--
27016	1.1	--	5.5	L.V.	5	--
27040	1.9	--	2.85	L.V.	1.5	Dewatered
27053	2.8	--	14.0	L.V.	5	--
27054	8.6	--	8.6	C	1	Dewatered
27055	13.5	13.5	--	--	1	Dewatered
27056	0.8	--	4.0	L.V.	5	--
27057	4.1	--	8.2	C	2	Dewatered
27058	10.5	--	10.5	C	1	Dewatered
27062	1.5	--	7.5	L.V.	5	--
27074	2.1	--	10.5	L.V.	5	--
27075	2.5	--	12.5	L.V.	5	--
27076	2.7	--	13.5	L.V.	5	--
27077	2.0	--	10.0	L.V.	5	--
27078	1.2	--	6.0	L.V.	5	--
28023	1.8	--	9.0	L.V.	5	--
28025	9.8	--	10.78	C	1.1	Dewatered
28026	14.2	--	28.4	C	2	Dewatered
28027	2.0	--	10.0	L.V.	5	--
28028	5.2	--	26.0	C	5	--
29002	2.0	--	10.0	L.V.	5	--
29003	6.9	--	34.5	C	5	--
30004	2.7	--	9.45	L.V.	3.5	Dewatered
30005	5.9	29.5	--	--	5	--
30009	2.4	--	12.0	L.V.	5	--
30010	12.4	62.0	--	--	5	--

Table 2.5-3. Evacuation Data for Screening Program Sampling (Continued, Page 4 of 5)

Well Number	Casing Volume (gallon)	Pumped Volume (gallon)	Bailed Volume (gallon)	Reason for Bailing*	Casing Volumes Removed	Comments
30011	19.7	98.5	--	--	5	--
31005	3.75	18.75	--	--	5	--
31006	6.2	31.0	--	--	5	--
31007	9.1	10.92	--	--	1.2	Dewatered
31008	17.4	--	87.0	C	5	--
32001	2.4	--	12.0	L.V.	5	--
32002	13.1	65.5	--	--	5	--
32003	21.5	--	107.5	C	5	--
33002	44.5	222.5	--	--	5	--
33015	5.3	26.5	--	--	5	--
33016	6.7	--	6.7	C	1	Dewatered
33017	4.6	--	23.0	C	5	--
33018	1.3	--	3.9	C	3	Dewatered
33019	3.0	--	15.0	L.V.	5	--
33020	5.0	--	25.0	C	5	--
33021	6.52	--	32.6	C	5	--
33022	8.1	--	40.5	C	5	--
33023	10.0	--	50.0	C	5	--
33024	11.3	--	56.5	C	5	--
33025	1.47	--	5.88	L.V.	4	Dewatered
33026	8.65	--	43.25	C	5	--
33027	12.1	60.5	--	--	5	--
33030	8.2	--	41.0	C	5	--
33032	22.9	--	22.0	C	1	Dewatered
33033	2.6	--	13.0	L.V.	5	--
33034	7.5	--	37.5	C	5	--
33035	11.4	--	15.96	C	1.4	Dewatered
33046	2.45	--	12.25	L.V.	5	--
33047	3.56	--	14.24	L.V.	4	Dewatered
33060	2.2	--	11.0	L.V.	5	--
33061	3.8	--	19.0	L.V.	5	--
33063	2.1	--	11.0	L.V.	5	--
33514	3.01	--	7.82	L.V.	2	Dewatered
34002	2.7	--	13.5	L.V.	5	--
34003	10.5	--	52.5	C	5	--
34005	1.47	--	7.35	L.V.	5	--
34006	3.26	--	16.3	L.V.	5	--
34007	11.0	16.5	--	--	1.5	Dewatered
34008	5.3	--	26.5	C	5	--
34009	9.7	19.4	--	--	2.0	Dewatered
34010	14.2	--	71.0	C	5	--
35005	7.8	--	39.0	L.V.	5	Bailed w/ 4" Diameter Bailer
35012	8.0	24.0	--	--	4	Dewatered
35013	2.9	--	14.5	L.V.	5	--
35016	3.8	--	19.0	L.V.	5	--
35017	11.6	23.2	--	--	2	Dewatered
35034	0.8	--	0.8	L.V.	1	Dewatered
35036	10.6	53.0	--	--	5	--
35037	2.0	--	10.0	L.V.	5	--
35038	6.4	32.0	--	--	5	--
35039	9.8	49.0	--	--	5	--
35052	2.0	--	10.0	L.V.	5	--
35053	7.3	--	10.22	C	1.4	Dewatered
35054	8.4	--	11.76	C	1.4	Dewatered
35056	12.7	63.5	--	--	5	--
35058	2.3	--	11.5	L.V.	5	--
35059	5.7	11.4	--	--	2	Dewatered
35061	2.8	--	14.0	L.V.	5	--
25062	7.8	--	11.7	C	1.5	Dewatered
25063	11.3	--	56.5	C	5	--
25065	2.9	--	14.5	L.V.	5	--
25066	7.0	--	35.0	C	5	--
25067	10.6	--	19.08	C	1.8	Dewatered
35068	20.0	100.0	--	--	5	--
35069	3.1	--	15.5	L.V.	5	--
35070	8.9	44.5	--	--	5	--
35071	10.4	52.0	--	--	5	--
36001	11.5	--	57.5	E	5	--
36048	2.2	--	2.2	L.V.	1	Dewatered, sampled by mistake.
36065	2.0	--	4.35	L.V.	1.5	Dewatered
36066	11.3	27.12	--	--	2.4	Dewatered
36069	2.3	--	11.5	L.V.	5	--
36075	1.0	--	5.0	L.V.	5	--
36076	1.5	--	7.5	L.V.	5	--

Table 2.5-3. Evacuation Data for Screening Program Sampling (Page 5 of 5)

Well Number	Casing Volume (gallon)	Pumped Volume (gallon)	Bailed Volume (gallon)	Reason for Bailing*	Casing Volumes Removed	Comments
36082	3.5	--	17.5	L.V.	5	--
36083	12.3	61.5	--	--	5	--
36084	1.1	--	5.5	L.V.	5	--
36090	1.4	--	7.0	L.V.	5	--
36109	1.6	--	8.0	L.V.	5	--
36110	12.2	--	61.0	C	5	--
36112	1.2	--	6.0	L.V.	5	--
36113	8.3	--	13.28	C	1.6	Dewatered
36114	15.9	--	79.5	C	5	--
36117	5.7	--	5.7	C	1	Dewatered
36118	7.8	9.36	--	--	1.2	Dewatered
36119	10.3	--	15.45	C	1.5	Dewatered
36121	3.8	--	19.0	L.V.	5	--
36122	8.5	--	44.0	C	5	--
36136	3.6	--	18.0	L.V.	5	--
36137	2.9	--	14.5	L.V.	5	--
36138	3.6	--	18.0	L.V.	5	--
36139	3.3	--	16.5	L.V.	5	--
36140	3.1	--	15.5	L.V.	5	--
36141	3.3	--	16.5	L.V.	5	--
36142	2.8	--	14.0	L.V.	5	--

*L.V. - Low Volume; C - Constricted; E -Equipment Not Operable

Table 2.5-4.

TASK 4 WATER QUALITY DATA INITIAL SCREENING EFFORT

SECTION	WELL#	SAMPLNO	AQUIFER	PEST	DCPD	DBCP	DHP/ DHMP	SULF	VGA	VOH	CL_F_S04	NO3	METALS
01	01008	560200	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	I
	01012	560201	A	Y	Y	Y	Y	Y	Y	Y	Y	N	I
	01014	560202	I	Y	Y	Y	N	Y	Y	Y	Y-	N	N
	01017	560203	A	Y	Y	Y	Y	Y	Y	Y	Y	N	I
	01019	560204	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	01020	560205	A	Y	Y	Y	N	Y	Y	Y	Y	N	I
	01021	560206	A	Y-	Y	Y	Y	Y	Y	Y	Y	Y	Y
	01022	560207	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	01023	560208	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	01024	560209	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	01025	560210	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	01027	560212	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	01028	560213	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	01029	560214	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	01030	560215	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	01031	560216	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	01032	560217	L	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	01033	560218	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	01034	560219	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	01035	560220	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
02	02008	560300	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	02009	560301	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	02010	560302	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
	02011	560303	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	N
	02012	560304	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02018	560310	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02019	560311	L	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	02020	560312	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	02022	560314	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02023	560315	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02024	560316	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02025	560317	L	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	02030	560321	I	Y-	Y	Y	Y	Y	Y	Y	Y	Y	Y
	02031	560322	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	02034	560323	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02035	560324	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02036	560325	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02037	560326	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02038	560327	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	02039	560328	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N

Table 2.5-4.

TABLE 4. WATER QUALITY DATA INITIAL SCREENING EFFORT

SECTION	WELL#	SAMPLING	AQUIFER	PEST	DCPD	DBCP	DIMP/ DMHP	SULF	VGA	VGH	CL_F_S04	NO3	METAL
03	03001	560400	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	03002	560401	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	N
	03003	560402	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	03004	560403	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	03005	560404	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	03006	560405	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	03007	560406	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	03008	560407	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	03009	560408	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	N
	03010	560409	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	N
	03523	560410	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04001	560506	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04004	560508	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04007	560500	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
04	04008	560501	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	04009	560502	L	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	04010	560503	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	N
	04011	560504	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	04013	560523	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	04014	560524	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	04015	560525	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	04016	560526	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	04019	560510	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04020	560511	A	N	N	Y	N	N	Y	Y	N	N	N
	04022	598705	A	N	Y-	Y	N	N	Y	Y	N	N	N
	04023	598706	A	N	Y-	Y	N	N	Y	Y	N	N	N
	04024	560512	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04025	560513	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04026	560514	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04027	560515	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04028	560516	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04029	560517	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04030	560518	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04031	560519	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04032	560520	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04033	560521	A	N	N	Y	N	N	Y-	Y-	N	N	N
	04524	560522	A	N	N	Y	N	N	Y-	Y-	N	N	N
05	05001	561702	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	05002	561700	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	05003	561701	L	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
06	06002	561803	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	06003	561800	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	06004	561801	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	06005	561802	L	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N

Table 2.5-4.

TASK 4 WATER QUALITY DATA INITIAL SCREENING EFFORT

SECTION	SITE#	SAMPLNO	AQUIFER	PEST	DCPD	DBCP	DIMP, DMHP	SULF	VOA	VOH	CL_F_S04	NO3	METALS
07	07001	561903	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	07004	561901	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	07005	561902	L	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
08	08002	562003	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	08003	562000	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	08004	562001	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	08005	562002	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
09	09001	562103	A	N	N	Y	N	N	Y-	Y-	N	N	N
	09002	562100	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	09003	562101	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	09004	562102	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	09005	598406	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	09006	598407	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	09007	598408	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
11	11002	562200	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	N
	11003	562201	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	N
	11004	562202	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
12	12002	562300	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	12003	562301	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	12004	562302	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
19	19015	562401	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	19016	562402	L	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	19017	562403	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	19018	562404	L	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	19019	562405	L	Y-	Y	Y	Y	Y	N	N	Y-	N	N
22	22020	562600	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	22021	562601	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	22022	562602	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	22023	562603	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	22024	562604	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	22027	562606	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	22028	562607	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	22030	562609	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	22031	562610	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	22059	562612	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	22060	562613	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 2.5-4.

TASK 4 WATER QUALITY DATA INITIAL SCREENING EFFORT

SECTION	WELL#	SAMPLNO	AQUIFER	PEST	DCPD	DBCP	DIMP, DMMP	SULF	VGA	VGH	CL_F_S04	NO3	METALS
23	23007	562700	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	23095	602900	A	Y	N	Y	Y	Y	Y	Y	Y	N	N
	23108	602901	A	Y	N	Y	Y-	Y	Y	Y	Y	N	N
	23142	562702	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	23166	562703	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23176	562719	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	23177	562704	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	23178	562720	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23179	562705	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23180	562706	I	N	Y	Y	Y	Y-	Y	Y	Y-	N	N
	23181	562707	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y-
	23182	562721	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y-
	23183	562722	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	23184	562723	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	23185	562708	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23186	562709	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23187	562710	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	23188	562711	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23189	562712	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23190	562713	L	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	23191	562714	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	23192	562715	L	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	23193	562716	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
24	24001	562800	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y-
	24150	562801	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	24158	562802	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y-
	24159	562803	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	24178	562805	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y-
	24179	562806	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	24184	562807	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	24185	562808	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	25008	562901	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	25009	562902	I	Y	Y	Y	Y	Y	Y	Y	Y	N	N
25	25010	562903	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	25011	562904	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	25012	562905	I	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	25013	562906	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	25014	562907	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	25015	562908	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	25016	562909	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	25017	562910	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	25019	562912	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	N
	25020	562913	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	25022	562914	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	25023	562915	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	25024	562916	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	25038	562917	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	25039	562918	I	N	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 2.5-4.

TAS. 4 WATER QUALITY DATA INITIAL SCREENING EFFORT

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SECTION	WELL#	SAMPLNO	AQUIFER	PEST	DCPD	DECP	DIMP/ DMMP	SULF	VOA	VOH	CL_F_S04	NO3	METALS
25	25040	562919	L	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
26	26011	563029	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	26015	602903	A	Y	N	Y	Y	Y	Y	Y	Y	N	N
	26017	602904	A	Y	N	Y	Y-	Y	Y	Y	Y	N	Y-
	26020	602905	A	Y	N	Y	Y	Y	Y	Y	Y	N	N
	26041	563030	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	26066	563001	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	26067	563002	L	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	26071	563032	A	Y-	Y	N	Y	Y	Y	Y	Y	Y	Y
	26072	563033	L	Y-	Y	N	Y	Y	Y	Y	Y	Y	Y
	26073	563003	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	26074	563004	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	26075	563005	I	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	26083	563009	A	Y-	Y	Y	Y	Y	Y	Y	Y	Y	Y
	26084	563010	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	26085	563011	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	26086	563012	L	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	26091	563013	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	26092	563014	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	26093	563015	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	26094	563016	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	26127	563017	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	26128	563018	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	26129	563019	I	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	26133	563021	A	Y-	Y	Y	Y	Y	Y	Y	Y	N	Y
	26140	563023	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	26141	563024	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	26142	563025	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	26147	563028	L	Y-	Y	Y	Y	Y	Y	Y	Y	Y	Y
27	27003	563115	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	27016	602902	A	Y	N	Y	Y-	Y	Y	Y	Y	N	Y
	27040	563116	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	Y
	27053	563100	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	27054	563101	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	27055	563102	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	27056	563103	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	27057	563104	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	27058	563105	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	27062	563109	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	27074	563110	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	27075	563111	A	Y-	Y	Y	Y	Y	Y	Y	Y-	N	N
	27076	563112	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	27077	563113	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	27078	563114	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N

Table 2.5-4.

TASK 4 WATER QUALITY DATA INITIAL SCREENING EFFORT

SECTION	WELL#	SAMPLNO	AQUIFER	PEST	DCPD	DBCP	DMHP/ SULF	VOA	VOH	CL_F_S04	NO3	NETALS
28	28023	563206	A	Y	Y	Y	Y	Y	Y	Y	Y	Y-
	28025	563201	I	Y	Y	Y	Y	Y	Y	Y	Y	Y
	28026	563202	L	Y	Y	Y	Y	Y	Y	Y	Y	Y
	28027	563203	A	Y	Y	Y	Y	Y	Y	Y-	N	N
	28028	563204	A	Y	Y	Y	Y	Y	Y	Y-	N	N
29	29002	563300	A	Y-	Y	Y	Y	Y	Y	Y-	N	N
	29003	563301	L	Y-	Y	Y	Y	Y	Y	Y-	N	N
30	30004	563401	A	Y-	Y	Y	Y	Y	Y	Y-	N	N
	30005	563402	I	Y-	Y	Y	Y	Y	Y	Y-	N	N
	30009	563403	A	Y-	Y	Y	Y	Y	Y	Y-	N	N
	30010	563404	I	Y-	Y	Y	Y	Y	Y	Y-	N	N
	30011	563405	L	Y-	Y	Y	Y	Y	Y	Y-	N	N
31	31005	563500	A	Y-	Y	Y	Y	Y	Y	Y-	N	N
	31006	563501	A	Y-	Y	Y	Y	Y	Y	Y-	N	N
	31007	563502	I	Y-	Y	Y	Y	Y	Y	Y-	N	N
	31008	563503	L	Y	Y	Y	Y	Y	Y	Y-	N	N
32	32001	563602	A	Y-	Y	Y	Y	Y	Y	Y-	N	N
	32002	563600	L	Y-	Y	Y	Y	Y	Y	Y-	N	N
	32003	563601	L	Y	Y	Y	Y	Y	Y	Y	Y	Y
33	33002	563720	A	Y-	Y	Y	Y	Y	Y	Y-	N	N
	33015	563721	A	N	N	Y	N	Y-	Y-	N	N	N
	33016	563722	A	N	N	Y	N	Y-	Y-	N	N	N
	33017	563723	A	N	N	Y	N	Y-	Y-	N	N	N
	33018	563724	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33019	563725	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33020	563726	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33021	563727	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33022	563728	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33023	563729	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33024	563730	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33025	563731	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33026	563700	I	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33027	563701	L	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33030	563704	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33032	599500	L	Y	Y	Y	Y	Y	Y	Y	N	N
	33033	563707	A	N	Y-	Y	N	Y	N	N	N	N
	33034	563708	I	N	Y-	Y	N	N	N	N	N	N
	33035	563709	I	N	Y-	Y	N	N	N	N	N	N
	33046	563732	A	N	N	Y	N	Y-	Y-	N	N	N
	33047	563733	A	N	N	Y	N	Y-	Y-	N	N	N
	33060	563710	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33061	563711	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33063	563713	A	Y-	Y-	Y	Y	Y-	Y-	Y-	N	N
	33514	563734	A	N	Y	Y	N	Y	Y	N	N	N

Table 2.5-4.

TASK 4 WATER QUALITY DATA INITIAL SCREENING EFFORT

SECTION	WELL #	SAMPLNO	AQUIFER	PEST	DCPD	DBCP	DIMP/ DHMP	SULF	VOA	VOH	CL_F_S04	NO3	METALS
34	34002	563800	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	34003	563801	I	Y-	Y-	Y	Y	Y-	N	N	Y-	N	Y-
	34005	563803	A	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	34006	563804	I	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	34007	563805	I	Y-	Y-	Y	Y	Y-	Y-	Y-	Y-	N	Y-
	34008	563806	A	N	Y-	Y	N	N	N	N	N	N	N
	34009	563807	I	N	Y-	Y	N	N	N	N	N	N	N
	34010	563808	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	35005	563927	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	35012	563928	I	Y	Y	Y	Y	Y-	Y	Y	Y	Y	Y
35	35013	563929	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35016	563930	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35017	563931	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35034	563900	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y-
	35036	563902	L	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	35037	563903	A	Y	Y	Y	N	Y	Y	Y	Y-	N	N
	35038	563904	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35039	563905	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	35052	563908	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y-
	35053	563909	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	35054	563910	I	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	35056	563912	L	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	35058	563913	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35059	563914	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35061	563916	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35062	563917	I	Y	Y	Y	N	Y	Y	Y	Y-	N	N
	35063	563918	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35065	563919	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35066	563920	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35067	563921	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35068	563922	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35069	563923	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	35070	563924	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	35071	563925	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
36	36001	564000	A	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
	36048	564029	A	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
	36065	564001	A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	36066	564002	I	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	36069	564003	A	Y	Y	Y	Y	Y	Y	Y	Y-	N	N
	36075	564004	A	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36076	564005	A	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36082	564006	A	Y-	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36083	564007	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36084	564008	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36090	564009	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36109	564011	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36110	564012	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36112	564013	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 2.5-4.

TASK 4 WATER QUALITY DATA INITIAL SCREENING EFFORT

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SECTION	WELL#	SAMPLNO	AQUIFER	PEST	DCPD	DBCP	DIMP/		SULF	VOA	VOH	CL_F_S04	NO3	METALS
36	36113	564014	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36114	564015	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36117	564017	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36118	599502	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36119	599501	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36121	564020	I	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36122	564021	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36136	564022	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36137	564023	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y-
	36138	564024	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36139	564025	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36140	564026	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	36141	564027	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	36142	564028	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N

PARAMETER ANALYSIS SUMMARY -- BY SECTION
 LEGEND: Y = ALL ANALYZED, Y- = SOME ANALYZED, N = NONE ANALYZED

PEST = Organochlorine Pesticides

SULF = Organosulfur Compounds

VOA = Volatile Aromatics

VOH = Volatile Organohalogenes

3.0 GROUND WATER MONITORING RESULTS

3.1 POTENTIOMETRIC DATA

Water level measurements were obtained from 835 wells onpost during September and October 1985 and again in March 1986. These data are summarized in Appendix A.

3.1.1 ALLUVIAL AQUIFER POTENTIOMETRIC DATA

Water level measurements obtained from 510 wells previously classified as alluvial (DP Associates, 1985) along with water levels obtained from wells completed in the uppermost portion of the Denver Formation bedrock were combined to form the alluvial water level data bases. The uppermost Denver wells that were included were only those wells for which the top of the well screen was located within 10 ft of the alluvial-bedrock interface. These wells were included in the alluvial aquifer based on the assumption that the upper 10 ft or less of the bedrock was probably not adequate to provide complete isolation. Thus it was inferred that the ground waters in these upper Denver wells were hydraulically connected with the overlying alluvial ground waters. For clarity, these upper Denver wells have been designated with different symbols on Plates 1 and 2.

Water table contour maps were developed for both the September/October 1985 (Plate 1) and the March 1986 (Plate 2) data sets. Both of these maps display very similar water table surfaces with a regional gradient of 40 ft per mile to northwest. Prominent localized features identified on both maps include the following:

- o A prominent ground water mound, approximately 10 ft high, beneath the South Plants Area;
- o A less prominent ground water ridge in the north central portion of Section 36;
- o A small ground water trough associated with Basin A-Neck;
- o A small ground water ridge along the west side of Basin F;
- o A small ground water trough to the west of this ridge;

- o A broad area of very low ground water gradient in the southern and central portions of Section 23; and
- o Regional deflections in the water table surface along First Creek and in the vicinity of the Lower Lakes.

Based on the great degree of similarity between these two maps, it does not appear that any significant seasonal fluctuations occurred in the alluvial aquifer between September/October 1985 and March 1986.

Comparison of these maps to equivalent maps developed by previous investigators indicate a strong similarity. May (1982) developed water level contour maps of the alluvial aquifer based on data obtained in the third quarters of 1980 and 1981. These maps display a regional gradient across the arsenal of approximately 40 ft per mile generally to the northwest similar to the 1985 (Plate 1) and 1986 (Plate 2) maps.

Many of the localized ground water features found on the more current maps are also apparent on the 1980 and 1981 maps. These include the ground water mound beneath the South Plants, the ground water ridge in the northern portion of Section 36, the small ground water trough associated with Basin A-Neck, the small ground water ridge and associated trough along the southwest side of Basin F, the broad low gradient area in Section 23, and the regional deflections in the water table surface along First Creek and in the vicinity of the Lower Lakes.

Finally, the ground water levels observed during 1980 and 1981 are extremely similar to the levels observed in 1985 and 1986. For example, the ground water levels beneath the South Plants, Basin A, and Basin F are generally 5250, 5230 and 5150 ft above mean sea level respectively on all four maps. Thus, there does not appear to have been any significant long-term changes in ground water elevations beneath RMA over this 5 year period.

3.1.2 INTERMEDIATE DENVER POTENTIOMETRIC DATA

Water level measurements obtained from 166 wells for which the top of screen was located between 10 and 50 ft below the alluvium-bedrock contact were classified as intermediate Denver wells. Water level data obtained from these wells during September 1985 and March 1986 were used to develop potentiometric maps of the upper portion of the bedrock aquifer (Plates 3 and 4).

Both of these maps display similar potentiometric surfaces with a regional gradient of approximately 40 ft per mile to the northwest. Prominent localized features identified on both maps include the following:

- o A prominent ground water mound beneath the South Plants area;
- o A prominent ground water ridge in the southwest corner of Section 25 and the southeast corner of Section 26;
- o A small ground water trough associated with Basin A-Neck;
- o A broad area of very low ground water gradient in Sections 23 and 24; and
- o Regional deflections in the water table surface along First Creek and in the vicinity of the Lower Lakes.

In general, there is a great degree of similarity between the two potentiometric surfaces and there does not appear to be any significant fluctuation in the potentiometric levels within the intermediate Denver aquifer between September/October 1985 and March 1986. The only exception is along the northwest boundary of RMA where the March 1986 potentiometric surface is approximately 10 ft lower than the September/October 1985 surface.

Comparison of the intermediate Denver potentiometric surface (Plates 3 and 4) to the alluvial water table maps (Plates 1 and 2) indicates that throughout most of RMA, the water levels for the two saturated horizons, alluvial and intermediate Denver, are generally quite close. However, along the western portion of the Arsenal, the alluvial water levels are generally 10 to as much as 30 ft higher than the potentiometric surface for the intermediate Denver aquifer.

3.1.3 LOWER DENVER POTENTIOMETRIC DATA

Water level measurements were obtained from 97 lower Denver wells; that is, wells with screens located at depths of 50 ft or more below the alluvial-bedrock interface. Potentiometric maps developed from this data are shown on Plates 5 and 6.

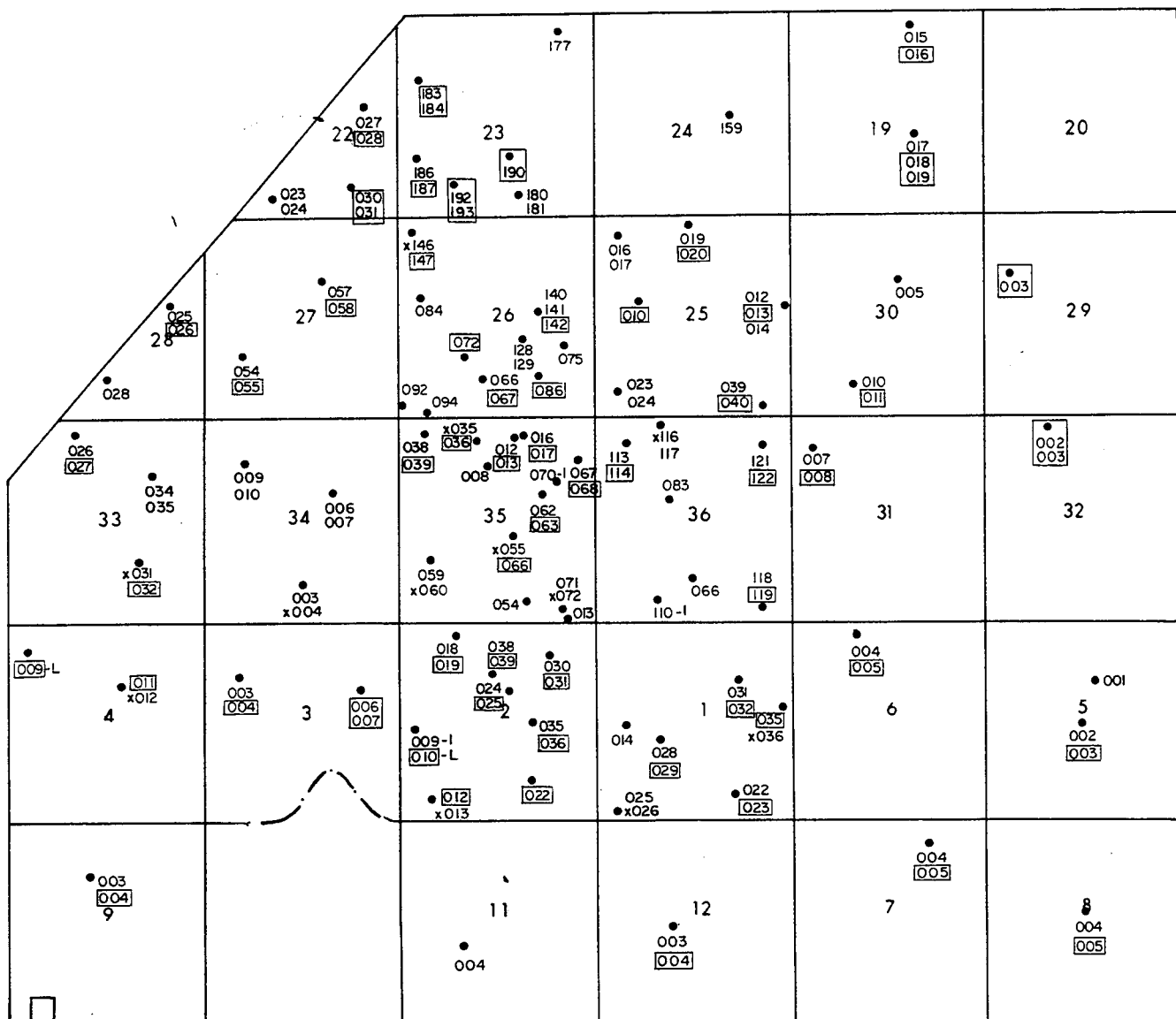
Both of these maps display very similar potentiometric surfaces with a regional gradient of approximately 35 ft per mile to the northwest. The only prominent localized feature identified on both maps was the ground water mound beneath the South Plants area. These two maps display very similar potentiometric surfaces suggesting that there were no significant seasonal fluctuations between September/October 1985 and March 1986.

Comparison of the lower Denver potentiometric maps (Plates 5 and 6) to the intermediate Denver potentiometric maps (Plates 3 and 4) indicate that in general the surfaces are similar with minor variations along the western and northwest boundary. In the South Plants area potentiometric surfaces are generally 10 ft lower in the Denver than in the Intermediate Denver.

3.2 WATER QUALITY DATA

A total of 321 ground water samples were collected and analyzed. Included in this total were 178 alluvial aquifer wells and 143 Denver aquifer wells. The locations of the 178 alluvial wells including designations for the 27 one-time-only wells, the 25 Upper Denver wells (wells screened within the upper 10 ft of the Denver Formation), and the 143 Intermediate and Lower Denver wells have been summarized on a base map and presented in Figure 3.2-1.

Quantitative analyses of all ground water samples were conducted by the ESE analytical laboratories in Denver, Colorado and Gainesville, Florida in accordance with USATHAMA and EPA approved methodologies. Analytical methods utilized on Task 4 Ground Water Samples were previously described



DENVER WELLS

- 006 INTERMEDIATE DENVER WELLS
- 010 LOWER DENVER WELLS
- x026 WELLS THAT COULD NOT BE SAMPLED

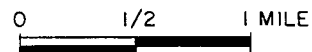
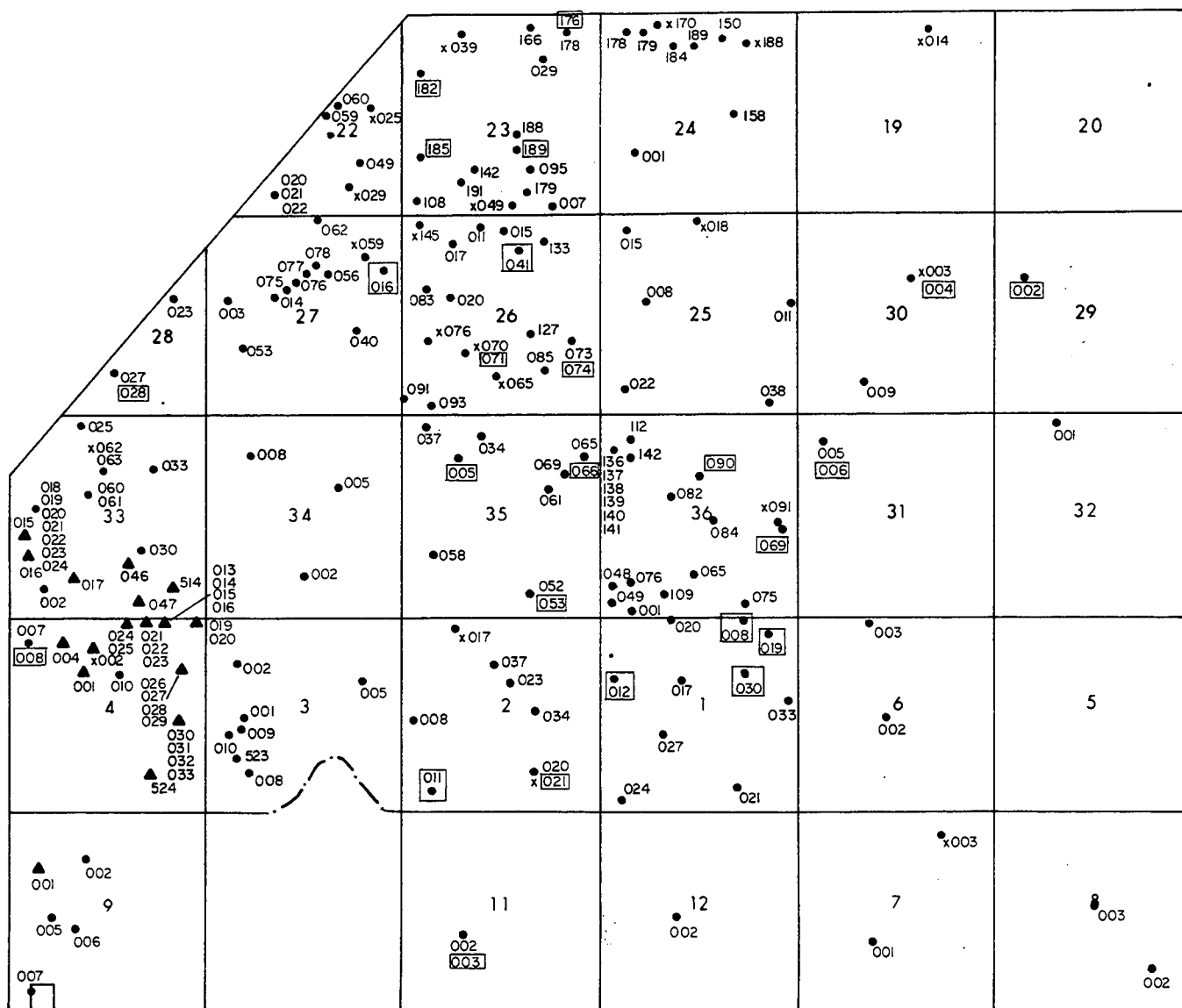


Figure 3.2-1
BASE MAP INITIAL SCREENING PROGRAM



ALLUVIAL WELLS

- 008 ALLUVIAL WELLS
- ▲ 004 ONE TIME ONLY WELLS (ALLUVIAL)
- ◻ 011 UPPER DENVER WELLS
(ie. Top of screen within 10feet below the Alluvial-Denver contact.)
- ✕ 017 WELLS THAT COULD NOT BE SAMPLED

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

and are presented in Table 2.3-1 of this report. The results of these chemical analyses can be found as Appendix B in this report. This appendix contains all "blank corrected" analytical data for the 321 ground water samples analyzed.

3.2.1 DATA PRESENTATION

This section of the report has been organized to present a discussion on the chemical distribution of frequently detected target analytes or groups of organic compounds at RMA. A separate subsection has been prepared for each analyte or group of analytes with respect to their distribution in the alluvial and Denver aquifers. Following these discussions a separate report subsection discusses the relationship of chemical distribution in the alluvium to observed chemical distribution in the Denver Formation. Finally, a comparison of the chemical distribution identified in this ISP is compared to the distributions of potential contaminants observed in the historical USATHAMA data base (1975 to 1984) and the 1984 Regional Groundwater Study prepared by the Department of Army Waterways Experiment Station (Spaine et al., 1984).

3.2.1.1 Historical Data Presentation

Data used to prepare the historical chemical distribution maps were obtained from the USATHAMA data base and are a cumulative representation of RMA, CDH, Tri-County Health (TCH), and SCC analytical programs submitted to and approved by USATHAMA between 1975 and 1984.

The analytical data were summarized by well in order to generate a manageable data base. A list of compounds analyzed for each well sampled was first compiled. For each compound, the period of record, number of determinations, number of detectable analyses, and range of reported concentrations were recorded. More rigorous statistical analyses of these data are beyond the scope of this task.

The resulting analytical data summaries were used to create maps of contaminant distribution in both the alluvial and Denver aquifers. Maximum contaminant concentrations for each well over their respective periods of record were plotted. In most cases, no readily

distinguishable concentration gradients were observed. As a result, the maps presented in this report have been simplified. Areas in which individual contaminants were detected in the alluvial and Denver aquifers over the period of record have been shaded. A significant limitation of these data is that they have not undergone rigorous quality control and quality assurance review. Both sampling and analytical techniques are largely undocumented. Other limitations of these data arise in the inconsistency of analytical parameter suites and sampling intervals.

Historical contaminant distribution has been compared to the results generated during the ISP. In addition, the historical analytical data for each well sampled during the Screening Program were qualitatively compared to the results of the present investigation. These comparisons have been used to validate the historical data base and to identify potential problems in the Task 4 sampling and analytical programs.

In addition to the USATHAMA data base, chemical data generated during the ISP were compared to contaminant distribution maps presented in the Department of the Army's (DOA) technical report (Spaine et al., 1984). This regional geochemical report was the result of a three year investigation conducted by the U.S. Army Engineer Waterways Experiment Station Environmental Laboratory. Analytical results from 66 well sampling locations produced during the quantitative phase of this study were used to generate a series of contaminant distribution maps. Maps in this report included a composite map of volatile organics (benzene, toluene, and chlorobenzene) and individual maps for dieldrin, endrin, DBCP, DIMP, DCPD, Cl, F, dithiane, oxathiane, and PCPMSO₂. Analytical data used to develop these maps were primarily generated from ground water samples collected from alluvial monitoring wells. However, data from the Denver Formation were included in areas where the alluvium is dry and ground water flows primarily through the Denver Formation. Exact locations of samples taken from Denver Formation wells were not indicated on the distribution maps. As a result, historical comparisons between the ISP data and data presented in the DOA report were only discussed with respect to the alluvial ground water chemistry.

3.2.1.2 ISP Data Presentation

For ease of interpretation and summarization of the ISP ground water chemistry, data reduction in the form of composite chemical distribution maps have been prepared. The composite maps represent combined or summed concentration values of identified chemical compounds which have similar chemical and physical properties. The maps representing the chemical distribution of identified target analytes were prepared by plotting the concentration for only those analytes identified above the laboratory detection limits. Isoconcentration lines were used to illustrate areas of elevated levels of target analytes detected in ground water at RMA. For the composite distribution maps, the lowest contour level was selected and set equal to the minimum detected concentration of any one of the single compounds detected within the chemical group represented. This contour level represents the maximum areal extent of the composite chemical distribution, but does not necessarily represent the maximum extent of any one single compound in ground water. Where possible NA symbols have been used to indicate wells for which individual compounds or groups of compounds were not analyzed during the ISP analytical program. In addition, values of detected compounds exceeding the upper limit of the analytical detection method were designated with a greater than symbol (>). Where this symbol appears on the composite chemical distribution maps, the reported numerical concentration values are equal to the summed concentration of the identified compounds in addition to the reported greater than values (e.g., 10 ppb + 20 ppb + >100 ppb = >130 ppb).

Data reduction results are presented for 25 chemical parameters on 5 composite distribution maps for each aquifer. Specific target analytes whose concentrations are contained in each composite map are listed in Table 3.2-1. As not all of the target analytes which were detected at RMA could be logically grouped with other compounds on a composite map, these compounds were examined on a compound specific basis; these data are presented on a series of six individual chemical distribution maps for each aquifer.

Table 3.2-1 Individual Organic Compounds Contained in Composite
Distribution Maps.

<u>Organochlorine Pesticides</u>	<u>Volatile Organohalogens</u>
Aldrin	Methylene Chloride
Isodrin	1,1-Dichloroethylene (1,1 DCE)
Diieldrin	1,1-Dichloroethane (1,1 DCA)
Endrin	trans 1,2-Dichloroethylene (T-1,2 DCE)
<u>Dithiane/Oxathiane</u>	Chloroform
Dithiane	1,2-Dichloroethane (1,2 DCA)
Oxathiane	1,1,1-Trichloroethane (1,1,1 TCA)
	Trichloroethylene (TCE)
<u>Organosulfur Compounds</u>	1,1,2-Trichloroethane (1,1,2 TCA)
p-Chlorophenylmethylsulfide (PCPMS)	Tetrachloroethylene (PCE)
p-Chlorophenylmethylsulfoxide (PCPMSO)	Chlorobenzene
p-Chlorophenylmethylsulfone (PCPMSO ₂)	Carbon Tetrachloride (CCl ₄)
<u>Volatile Aromatic Compounds</u>	
Benzene	
Xylene (o, m, p)	
Toluene	
Ethyl Benzene	

10/14/86

In addition to the composite chemical concentration maps for aqueous constituents, individual chemical distribution maps for the alluvial and Denver aquifers have been prepared for 29 target analytes. These analytes are summarized in Table 3.2-2. Included in this total of 29 sets of maps are four isomer composite maps reporting the combined concentrations for: 1) total dichloroethylenes (cis and trans isomers); 2) total dichloroethanes (1,1 and 1,2 isomers); 3) total trichloroethanes (1,1,1 and 1,1,2 isomers); and 4) total xylenes (m, o, and p isomers). These maps are presented in Appendix C to this report and show the separate alluvial and Denver concentrations of 29 target analytes (33 including isomer species) which may be represented within the chemical groups presented on the composite maps.

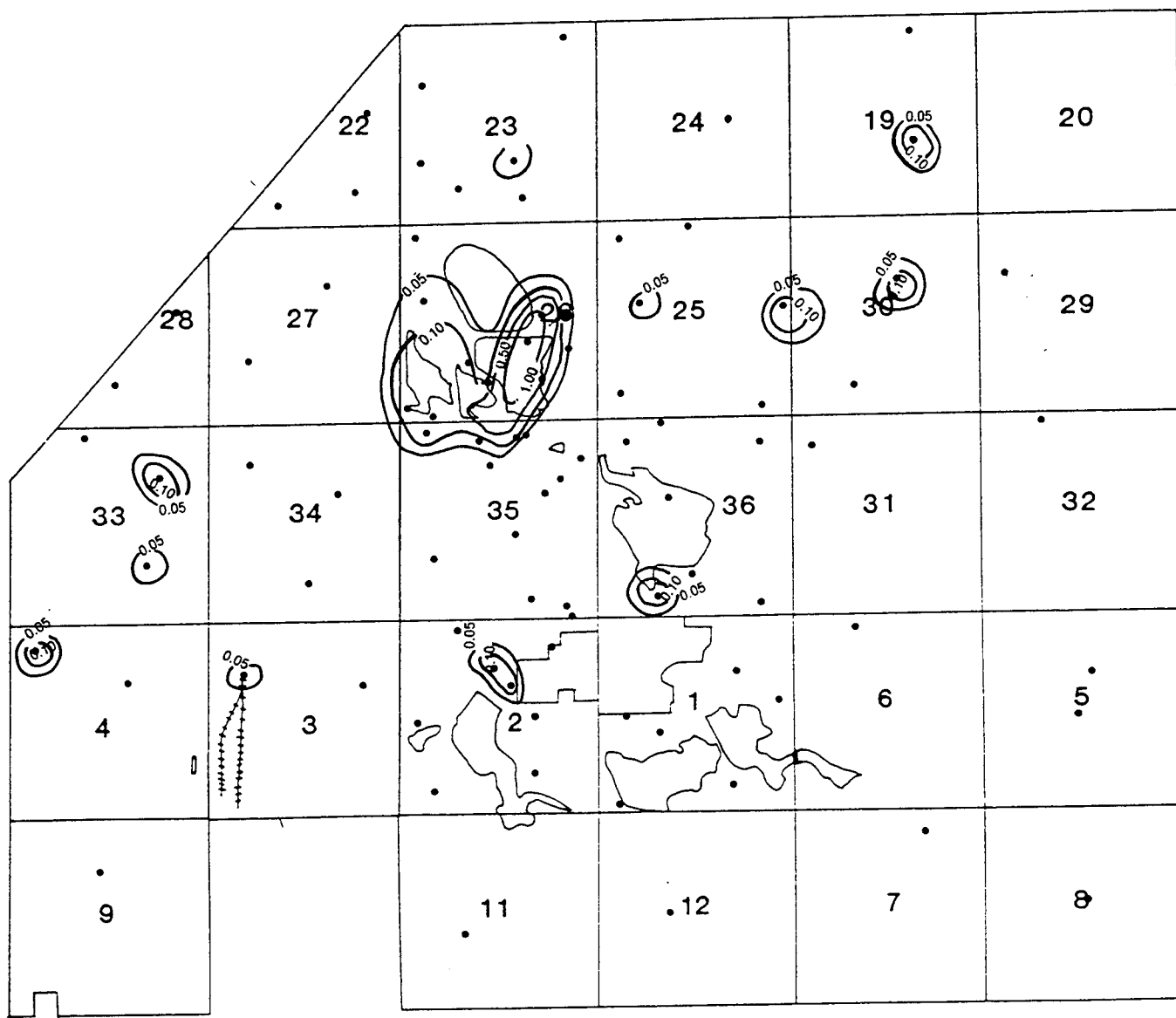
The eleven parameters not included for summarization in map form are SO_4 , NO_2 and NO_3 , Cu, Mg, Na, K, Cd (Total), Cr (Total), Cu (Total), Pb (Total), and Zn (Total). Historically, these eleven analytes have not been included in the overall evaluation of ground water chemistry at RMA. A review of the current chemical data base shows a minimal number of detections for these chemical species. As a result, these data will not be summarized in map form.

3.2.2 ORGANOCHLORINE PESTICIDES

Ground water samples collected during the ISP were subjected to chemical analysis for a group of seven organochlorine pesticides. These pesticides included aldrin, dieldrin, endrin, isodrin, HCCPD, DDE, and DDT. Four of these seven compounds (aldrin, dieldrin, endrin, isodrin) were frequently detected at measurable concentrations in RMA ground water. Therefore, only concentrations of these four compounds were utilized in preparation of the composite maps and associated discussions. One or more of these pesticides were detected in 93 of the 319 ground water wells sampled.

3.2.2.1 Alluvial Distribution

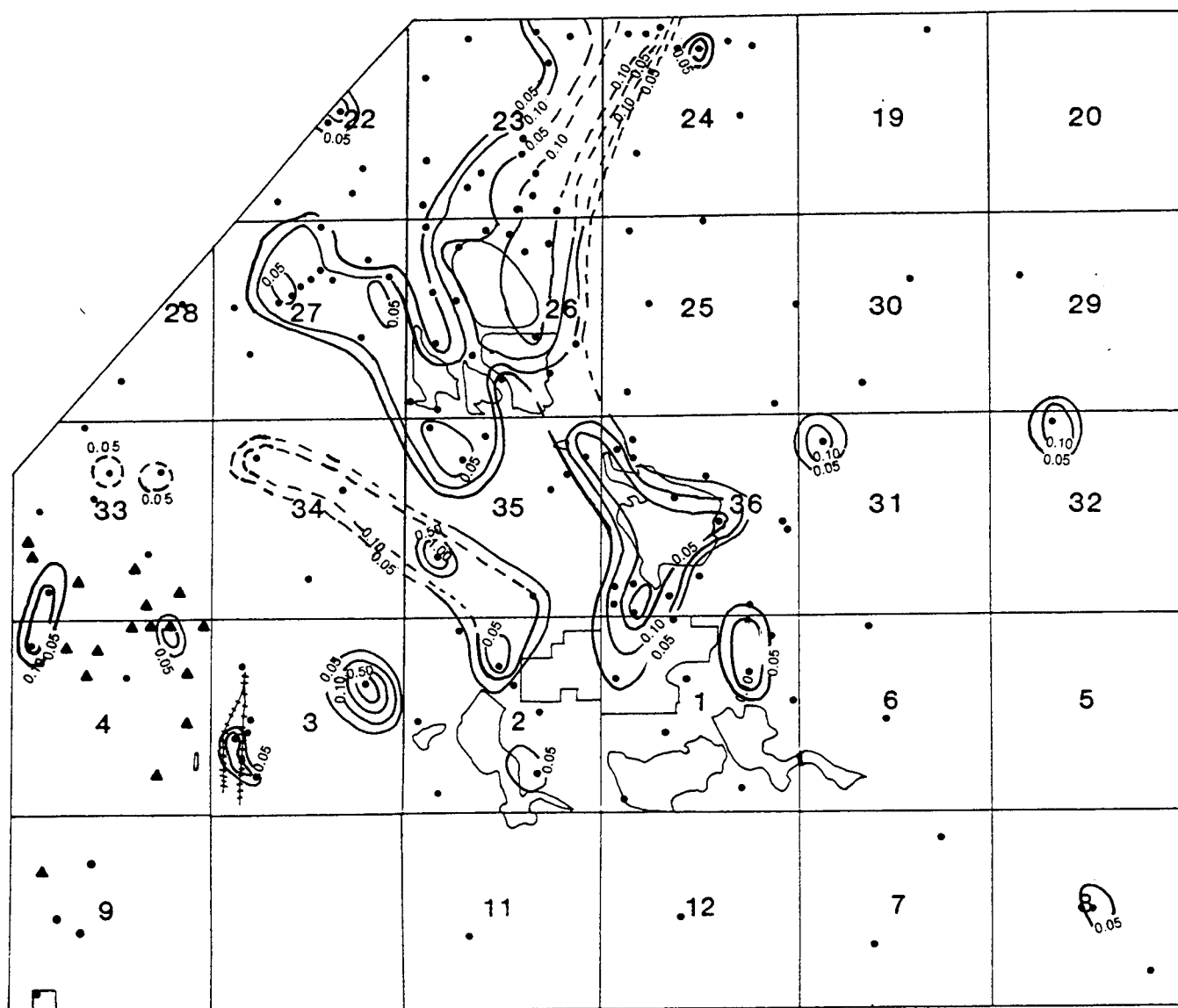
The distribution of organochlorine pesticides in alluvial ground water is presented in Figure 3.2-2. One or more of the organochlorine pesticides were detected in 66 of the 154 water samples analyzed from alluvial



DENVER WELLS

0 1/2 1 MILE

Figure 3.2-2
INITIAL SCREENING PROGRAM ORGANOCHLORINE PESTICIDES
DISTRIBUTION IN THE DENVER AND ALLUVIAL AQUIFERS



ALLUVIAL WELLS

Prepared for:
 U.S. Army Program Manager's Office
 For Rocky Mountain Arsenal
 Aberdeen Proving Ground, Maryland

Table 3.2-2. Twenty-nine Target Analytes Presented in Map Form in Appendix C

Compound/Element	
Aldrin	
Endrin	
Dieldrin	
Isodrin	
Hexachlorocyclopentadiene (HCCPD)	
2,2-Bis (Para-Chlorophenyl)-1,1-Dichloroethylene (p,p'DDE)	
2,2-Bis (Para-Chlorophenyl)-1,1,1-Trichloroethane (p,p'DDT)	
Methylisobutyl Ketone (MIBK)	
Dimethylmethyl Phosphonate (DMMP)	
P-Chlorophenylmethyl Sulfide (PCPMS)	
P-Chlorophenylmethyl Sulfoxide (PCPMSO)	
P-Chlorophenylmethyl Sulfone (PCPMSO ₂)	
Dimethyl Disulfide (DMDS)	
1,4 Dithiane	
1,4 Oxathiane	
Toluene	
Benzene	
m-Xylene	Combined with o,p-Xylene as Total Xylene on map
o,p-Xylene	Combined with m-Xylene as Total Xylene on map
Ethylbenzene	
Chlorobenzene	
Chloroform	
Carbon Tetrachloride	
Trans-1,2-Dichloroethylene	Combined on map as Total DCE
1,1 Dichloroethylene	Combined on map as Total DCE
Trichloroethylene	On map as TCE
Tetrachloroethylene	On map as PCE
Methylene Chloride	
1,1 Dichloroethane	Combined on map as Total DCA
1,2 Dichloroethane	Combined on map as Total DCA
1,1,1 Trichloroethane	Combined on map as Total TCA
1,1,2 Trichloroethane	Combined on map as Total TCA
Mercury (Hg)	

monitoring wells. Twenty-two samples were not analyzed for pesticides. Concentrations of total pesticides ranged from 0.06 µg/l in several wells to a concentration of 4.6 µg/l in well 26127.

The single pesticide most frequently detected in alluvial ground water was dieldrin. Aldrin, isodrin, and endrin were all detected in lesser but generally equal frequencies and similar concentrations. Individual detections of organochlorine pesticides in the alluvial aquifer are summarized below.

<u>Analyte</u>	<u>Number of Detections*</u>	<u>Range (µg/l)</u>
Aldrin	13	0.07->1.0
Isodrin	13	0.08->1.0
Dieldrin	47	0.06-3.0
Endrin	15	0.06-3.0

* A total of 176 alluvial wells were sampled, 154 samples analyzed.

Moderate concentrations of total pesticides were observed in the vicinity of Basin A and the region of the Basin A-Neck (Section 36). Moderate to high concentrations of total pesticides were also observed in the vicinity of Basin F (Section 26) and in the northwest corner of Section 35. The distribution of the organochlorine pesticides from these potential source areas is generally towards the north and northwest boundaries of RMA.

Significant concentrations of pesticides were also identified in the northeast corner of Section 3 and in the northern portion of Section 2. However, due to a lack of water quality information in adjacent areas it is difficult to predict plume continuity with other pesticide detections. Moderate concentrations of pesticides were observed in Sections 2, 35, 34, and 33 suggesting a pesticide plume may exist in this area, but due to a lack of water quality data the trend definition is uncertain. Numerous detections of pesticides in outlying portions of RMA such as Sections 31, 32, and 8 appear unrelated to documented source areas.

Upon examination of individual chemical distribution maps presented in Appendix C it is evident that dieldrin was the most frequently detected, most widely distributed, and occurred at the highest concentrations of the organochlorine pesticides. Dieldrin was detected in 47 of the 154 alluvial ground water samples analyzed. Concentrations ranged from 0.06 to 3.0 µg/l. Highest concentrations were observed in Basin A, Basin A-Neck, immediately downgradient of Basin F, and in the South Plants area. Dieldrin was also identified in ground water samples along the northwest and northern borders of RMA. Isolated detections of dieldrin were identified in Sections 3, 33, and 35. Endrin was identified in 15 of the 154 alluvial ground water samples analyzed. Concentrations ranged from 0.06 to 3.0 µg/l. Highest concentrations were observed immediately downgradient of Basin F and along the northern border of RMA. Endrin was also detected near the lime settling ponds area in isolated locations in Sections 1, 33, and 35.

Isodrin was detected in 13 of the 154 alluvial ground water samples analyzed. Concentrations ranged from 0.07 to >1.0 µg/l. Highest concentrations of isodrin were observed in the Basin F, Basin A, and Basin A-Neck areas. Isolated occurrences of isodrin were identified in Sections 23 and 27.

Aldrin was detected in 13 of the 154 alluvial ground water samples analyzed. Concentrations ranged from 0.07 to >1.0 µg/l. Highest concentrations of aldrin were identified in Basin A, immediately downgradient of Basin F, and in isolated occurrences along the western boundary of RMA. This compound was also identified in several isolated areas in Sections 3, 31, and 32.

HCCPD (5 detections), p,p'-DDT, and p,p'-DDE (2 detections each) were observed in a limited number of wells and their distribution was mainly confined to the Basin A area and perimeter areas of Basin F.

3.2.2.2 Denver Distribution

Organochlorine pesticides were detected in 27 of the 143 monitoring wells sampled in the Denver Aquifer. The chemical distribution of total organochlorine pesticides in this aquifer is presented as Figure 3.2-2. The summed concentrations of total pesticides ranged from 0.06 µg/l in several wells to 8.87 µg/l in well 26141. As was observed for the alluvial aquifer, the dominant organochlorine pesticide detected was dieldrin with less frequent detections of aldrin, isodrin, and endrin. A summary of the frequency of detections for the individual compounds and observed concentration ranges in ground water samples obtained from the Denver aquifer is presented below:

<u>Analyte</u>	<u>Number of Detections*</u>	<u>Range (µg/l)</u>
Aldrin	14	0.07 - 3.0
Isodrin	5	0.06 - 4.0
Dieldrin	20	0.06 - 8.87
Endrin	10	0.06 - 0.8

*Total Denver wells sampled and analyzed were 143.

The highest observed concentrations of organochlorine pesticides in the Denver aquifer occur in the vicinity of Basins C, D, E and F in Section 26. Other detections of pesticides in the Denver aquifer appear to be sporadic and essentially related to singular wells. These isolated detections occurred in Sections 2, 3, 4, 19, 23, 25, 30, 33, and 36. Some of these apparently isolated detections may be interrelated, but additional control wells are necessary to confirm such trends.

As was observed in the alluvial ground water chemical data, dieldrin was the most frequently detected, most widespread, and occurred at the highest concentration of organochlorine pesticides in Denver ground water. Dieldrin was detected in 20 of the 143 Denver samples analyzed and ranged in concentrations from 0.06 to 6.0 µg/l. Highest concentrations of the compound were observed both east and west of Basin F in Section 26 and in the vicinity of Basins B and C. Several isolated occurrences of dieldrin were identified in Sections 2, 4, 19, 25, and 36.

Endrin was detected in 10 of the 143 Denver ground water samples analyzed. Concentrations ranged from 0.06 to 0.8 µg/l. Highest concentrations were observed east of Basin F in Section 26. Several isolated occurrences of endrin were also identified throughout RMA, many of them at or slightly above the laboratory detection limit.

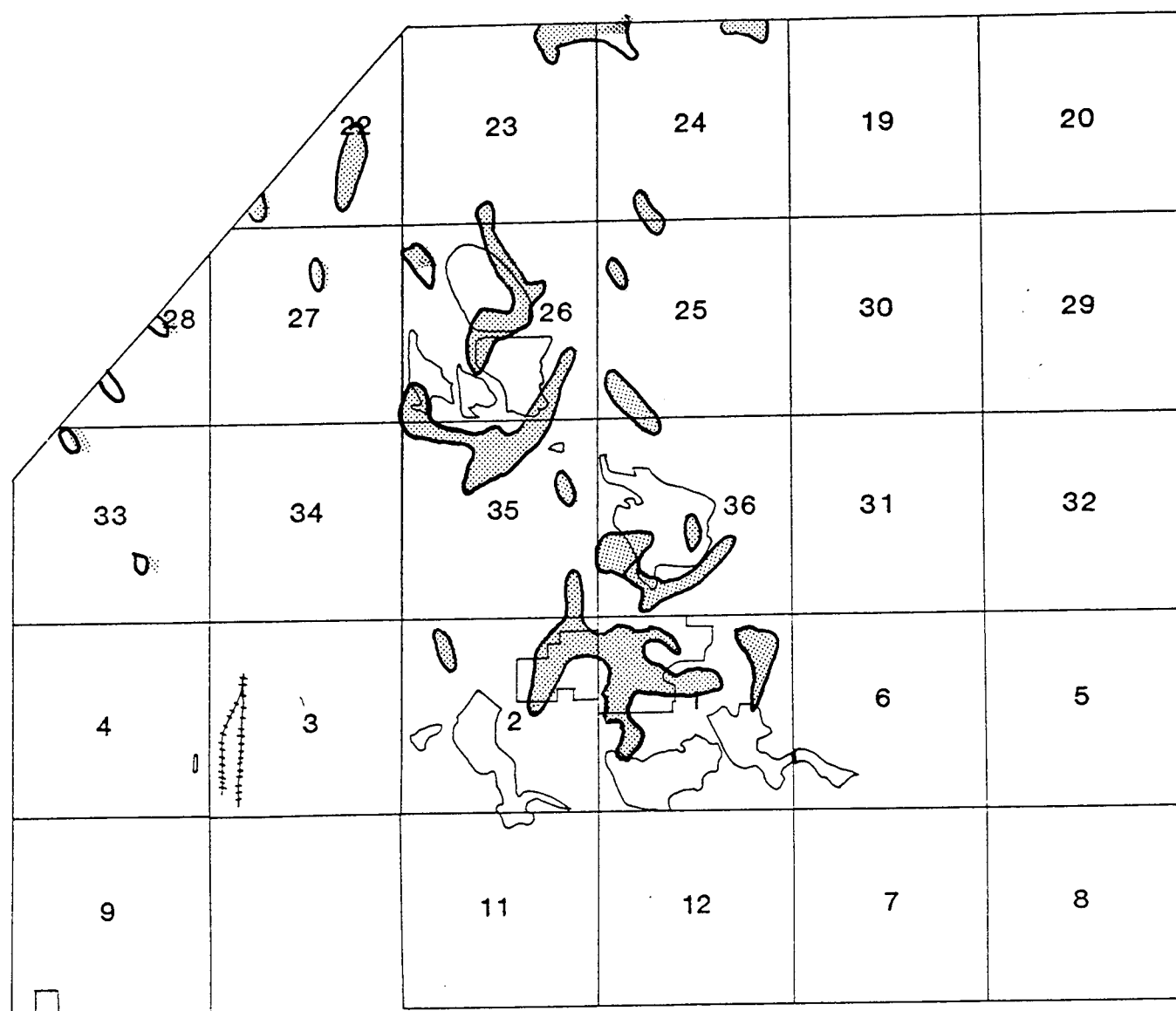
Isodrin was detected in 5 of the 143 Denver ground water samples analyzed. Concentrations ranged from 0.06 to 4.0 µg/l. Highest concentrations of isodrin were observed in the Basin F area and northwest of the Basin B area. An isolated occurrence of isodrin was detected in Section 33. Aldrin was identified in 14 of the 143 Denver ground water samples analyzed. Concentrations ranged from 0.07 to 3.0 µg/l. Highest concentrations were observed near Basins F and C and in the northwest corner of Section 35. Isolated occurrences were also identified in Sections 2, 25 and 31.

P,P'-DDT was identified in two ground water samples from Sections 4 and 9. Concentrations were 0.2 and 0.5 µg/l, respectively. P,P'-DDE and HCCPD were not identified in samples collected and analyzed from Denver ground water.

3.2.2.3 Comparison of Alluvial to Denver Water Quality

It is evident that organochlorine pesticides observed in the alluvial aquifer in the vicinity of Section 26 (Basin F) are also present in significant quantities in the Denver aquifer (Figure 3.2-2). The distribution of these compounds in the Denver appears to be confined to the immediate vicinity of Section 26 with the exception of numerous isolated detections in a number of RMA sections.

Many of the isolated detections of organochlorine pesticides in the Denver aquifer are related to observed detections in the alluvium and therefore may be actual trends. Specifically, simultaneous detections in both the alluvium and Denver aquifer occur in Sections 23, 33, 36, 2, and 4. However, approximately one-half of the isolated detections in the Denver aquifer are unrelated to alluvial detections and therefore are more suspect.



DENVER WELLS

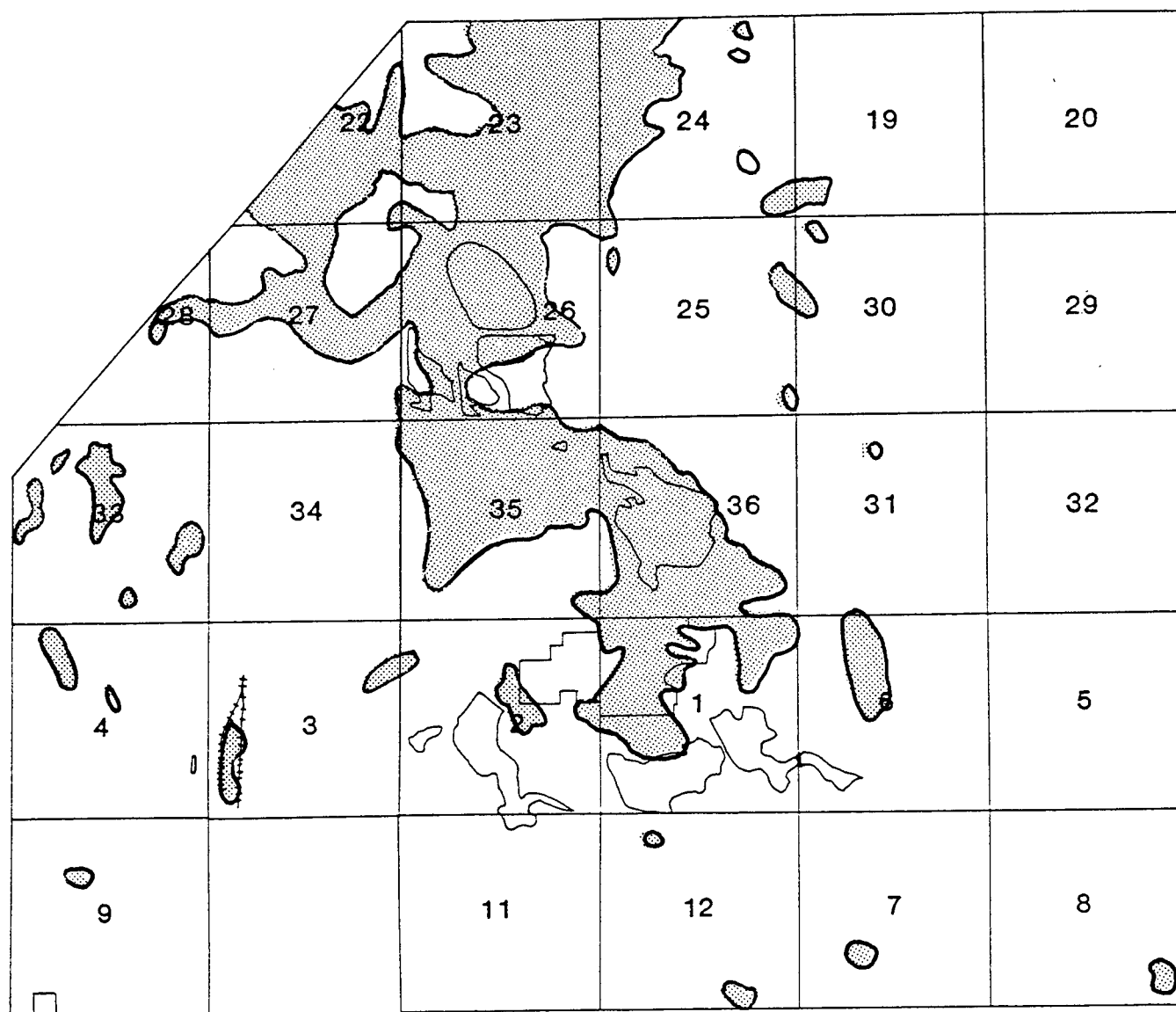
EXPLANATION



AREAS WHERE DETECTED

0 1/2 1 MILE

Figure 3.2-3
HISTORICAL ORGANOCHLORINE PESTICIDES DISTRIBUTION IN THE DENVER



ALLUVIAL WELLS

AND ALLUVIAL AQUIFERS

Prepared for:
 U.S. Army Program Manager's Office
 For Rocky Mountain Arsenal
 Aberdeen Proving Ground, Maryland

3.2.2.4 Comparison of ISP to Historical Water Quality Data

The historical composite distribution maps of the organochlorine pesticides (endrin, isodrin, aldrin, and dieldrin) in alluvial and Denver ground water have been prepared and are presented in Figure 3.2-3.

A comparison of the current alluvial ground water data with historical data confirms general pesticide plume trends identified in the historical data base. Both data sets show reported concentrations associated with known sources, particularly Basins A and F and the South Plants Area. The ISP chemical data reports an additional potential plume originating in Section 2. The plume appears to be moving in a northwesterly direction from the central area of Section 2 and continues through Sections 34 and 35. This plume is not confirmed in the historical data.

Several "single point anomalies" have been identified in the historical and current data sets. A comparison of these anomalies does not reveal any relationship.

Historical data presented in the DOA report show high concentrations of endrin and dieldrin west and northwest of the Basin A-Neck area. High concentrations were identified along the northwest boundary. Plumes of endrin and dieldrin are also evident immediately downgradient of Basin F and continuing toward the north boundary. General plume trends reported in the DOA report agree, within limitations, with the ISP pesticide distribution maps. However, pesticide concentrations were on average an order of magnitude greater than these values reported in the ISP data base. The DOA report suggests there was insufficient data to contour aldrin data; however, aldrin was present in the general vicinities where dieldrin and endrin were reported. Isodrin was not analyzed for in the DOA investigation.

A comparison of the current Denver ground water chemical data base with historical data confirms general plume trends for the organochlorine pesticides. Both data sets show reportable concentrations of these compounds associated with Basin F in Sections 23, 26, and 35. Discrepancies are apparent between the two data sets in Sections 1, 2, and 36 where historical data shows identifiable concentrations of the organochlorine pesticides.

Historical data also indicated concentrations of pesticides along the northern border of RMA in Sections 23 and 24. Concentrations of the pesticides in these sections have not been identified in the current chemical data base.

3.2.3 OXATHIANE AND DITHIANE

The compounds oxathiane and dithiane were detected in 35 of the total 319 ground water monitoring wells sampled during the ISP. As these compounds are similar in structure, physical properties, and origin, composite maps of the distribution for these two compounds were prepared for presentation purposes.

3.2.3.1 Alluvial Distribution

A composite map for the distribution of oxathiane and dithiane in the alluvial aquifer was prepared and is presented as Figure 3.2-4. One or both of these compounds were detected in 29 of the 153 alluvial ground water samples analyzed. Twenty-three samples were not analyzed for these compounds. Detectable concentrations ranged from 1.6 µg/l to 84 µg/l in well 35065. High concentrations were observed in the vicinity of Basin A, in the Basin A-Neck (Section 36) and in the immediate vicinity of Basin B (Section 35). High concentrations were also observed in the vicinity of Basin F and the distribution of oxathiane/dithiane extends northward towards the northern Boundary Control System. The overall plume trend is interrupted in the southeast corner of Section 26 where samples from several monitoring wells do not show detectable concentrations of these compounds.

Upon examination of the individual chemical distribution maps presented in Appendix C, it is evident that dithiane was more frequently detected, more widespread, and occurred at higher concentrations than oxathiane. Dithiane was detected in 29 of the 153 alluvial ground water samples analyzed. Concentration ranged from 1.6 to 84 µg/l. Highest concentrations of dithiane were observed in the Basin F area, immediately downgradient of Basin F, Basin A, and the South Plants area.

Oxathiane was identified in 23 of the 153 alluvial ground water samples analyzed. Concentrations ranged from 2.8 to >39 µg/l. Highest concentrations were observed in the Basin A area, immediately downgradient of Basin F, and the South Plants area.

3.2.3.2 Denver Distribution

Of the 143 monitoring wells sampled in the Denver aquifer, oxathiane and/or dithiane were detected in only six wells in concentrations ranging from 15 to 85 µg/l. The distribution of these detections is shown in Figure 3.2-4. Detectable concentrations of oxathiane/dithiane were confined to the northern portion of Section 35 and the southern portion of Section 26 in the vicinity of Basin C. No other detections were observed in the Denver aquifer.

As was observed in the alluvial ground water chemical data, dithiane was detected more frequently and at higher concentrations than oxathiane. Dithiane was detected in 6 of the 143 Denver ground water samples analyzed. Concentrations ranged from 15 to 85 µg/l. Highest concentrations were reported in the Basin C area and northwest of Basin B.

Oxathiane was detected in 3 of the 143 Denver ground water samples analyzed. Concentrations ranged from 9.3 to 32 µg/l. Observed concentrations were associated with Basins B and C in Sections 26 and 35, respectively.

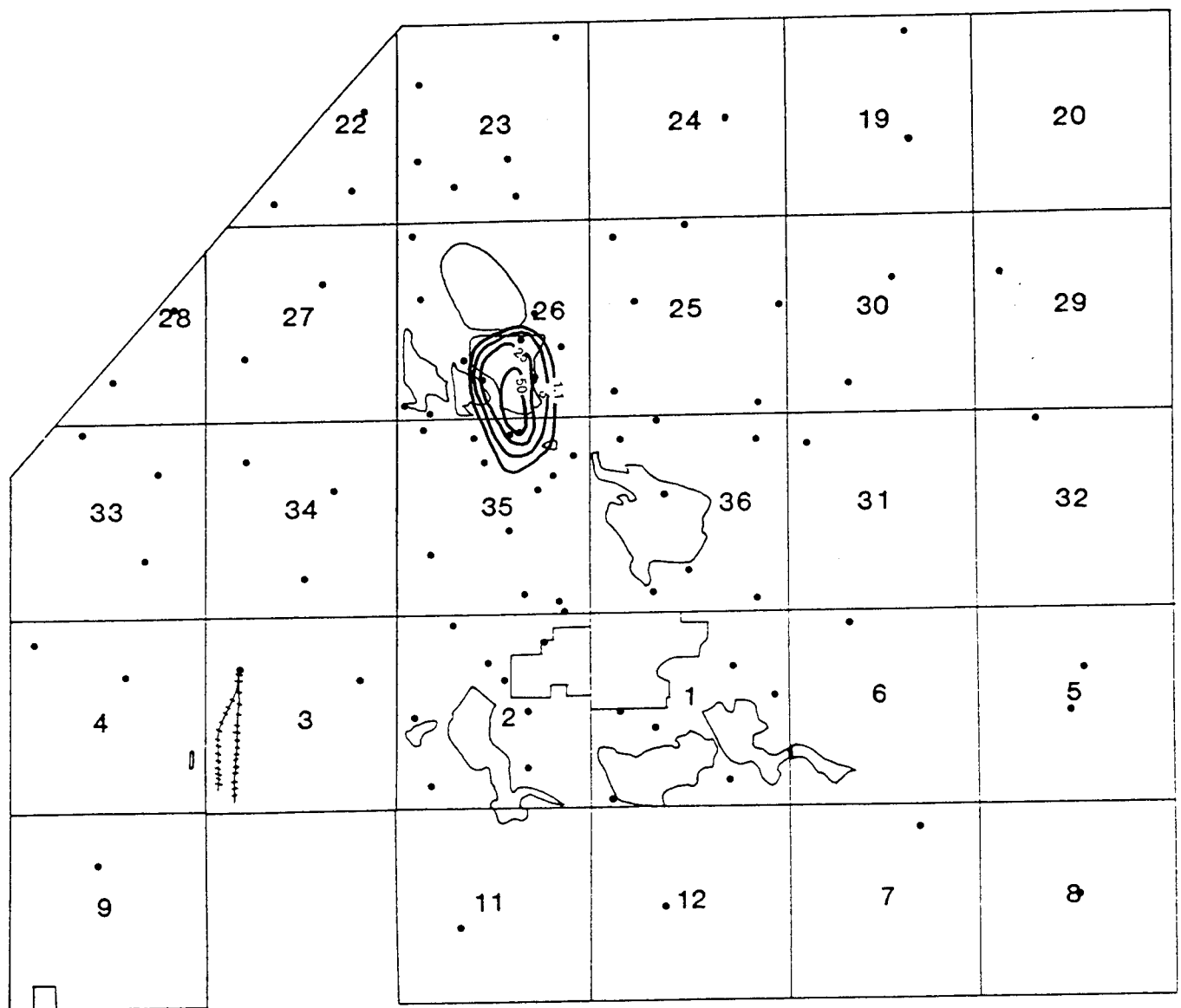
3.2.3.3 Comparison of Alluvial to Denver Water Quality

A comparison of the distribution of oxathiane/dithiane in the alluvial aquifer to concentrations observed in the Denver aquifer (Figure 3.2-4) shows that detectable concentrations in both aquifers appear related. Although detectable concentrations of oxathiane/dithiane were present in the vicinity of Basins A and F in alluvial ground water, no detections were present between these discrete occurrences. Detection of these compounds between the two plume areas in the Denver aquifer suggests that the plumes are hydrologically connected. These compounds were detected in the Denver aquifer at a concentration of 85 µg/l (well 35065) in the Basin A-Neck area and immediately downgradient at the same concentration in well 35016.

All detections of these compounds were confined to the basin area; no isolated occurrences were detected in any other section of RMA.

3.2.3.4 Comparison of ISP to Historical Water Quality Data

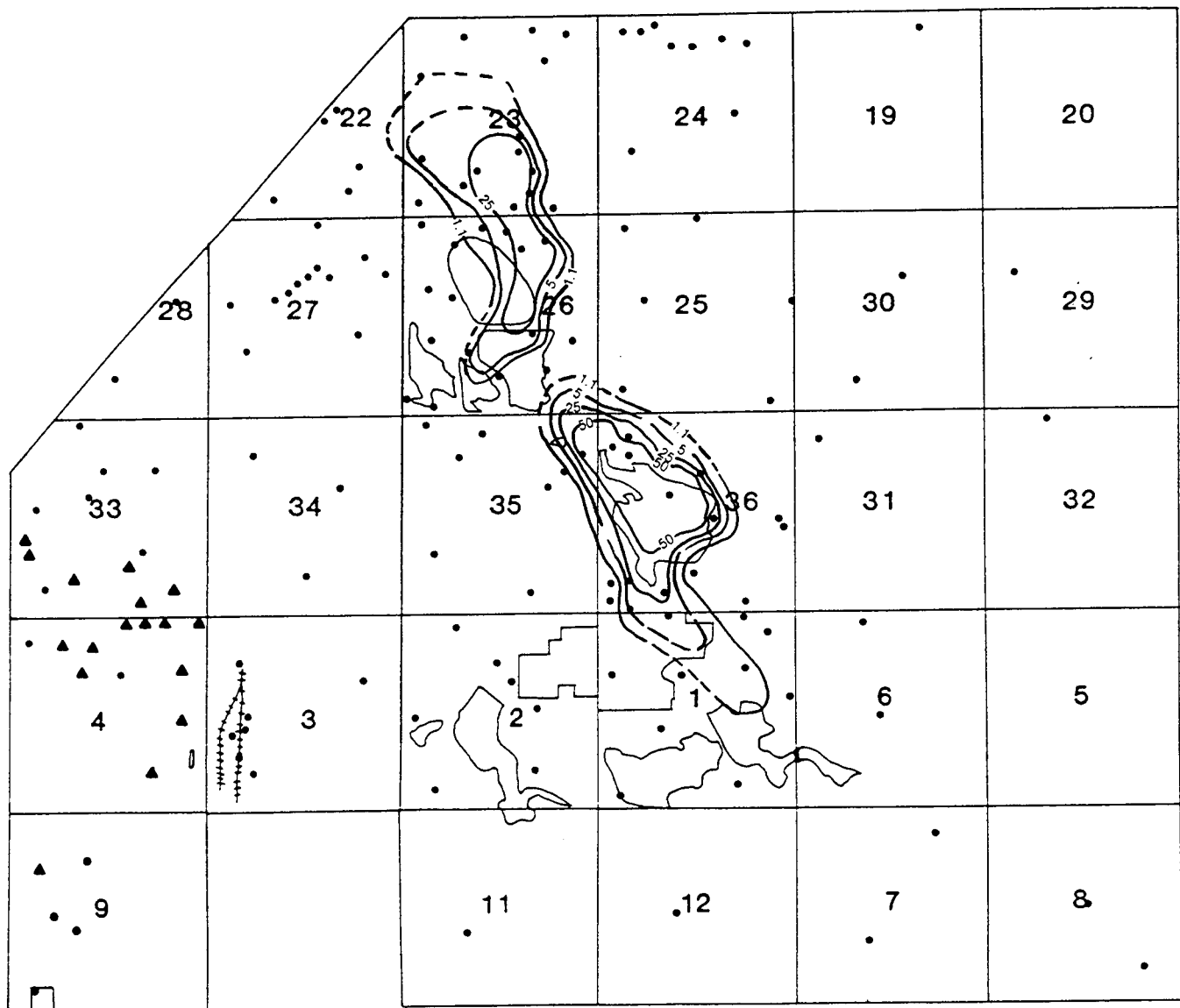
The historical composite distribution maps for dithiane and oxathiane identified in alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-5.



DENVER WELLS

0 1/2 1 MILE

Figure 3.2-4
INITIAL SCREENING PROGRAM DITHIANE - OXITHIANE DISTRIBUTION IN THE



ALLUVIAL WELLS

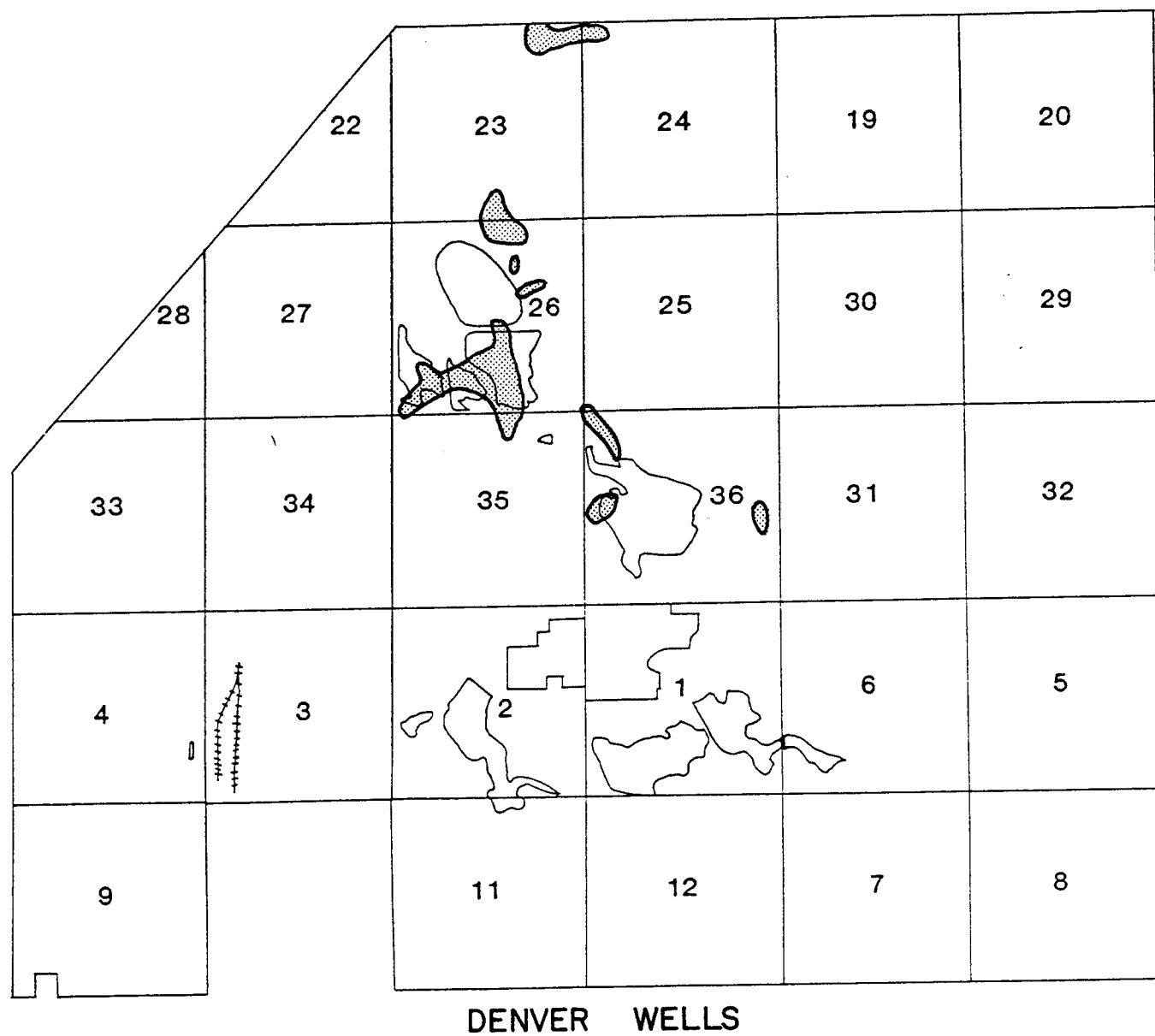
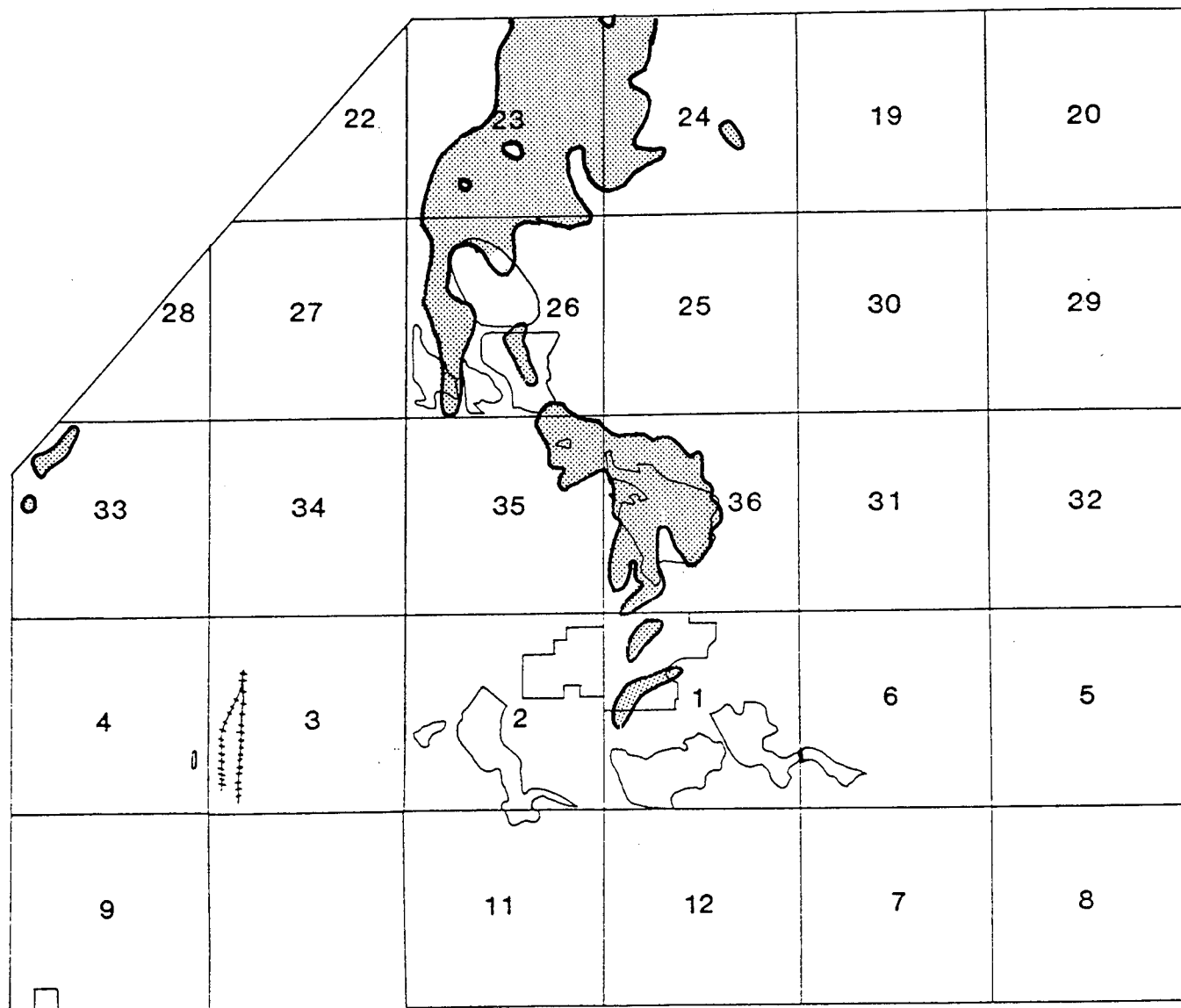


Figure 3.2-5
HISTORICAL DITHIANE - OXATHIANE DISTRIBUTION IN THE DENVER AND A



ALLUVIAL WELLS

ALLUVIAL AQUIFERS

Prepared for:
 U.S. Army Program Manager's Office
 For Rocky Mountain Arsenal
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A comparison of the current alluvial ground water distribution map confirms general plume trends identified in the historical plume maps for dithiane and oxathiane. Both data sets report concentrations associated with known sources, particularly Basins A and F and the South Plants area. Discrepancies in the chemical distribution of these compounds between the historical and current data bases are seen in Sections 23 and 24. Dithiane and oxathiane have been historically identified along the northern border of RMA in these sections. The current chemical data base shows no reportable concentrations in these areas.

Historical data presented in the DOA report show high concentrations of dithiane and oxathiane in the Basin A area, northwest of the Basin A-Neck area, and Basin C area. A plume was also reported immediately downgradient of Basin F and extending out to the north boundary. General plume trends reported in the DOA report appear to be coincident with data shown in the ISP dithiane/oxathiane distribution map. However, concentrations of dithiane and oxathiane reported in the DOA report were 1 to 2 orders of magnitude greater than those reported in the ISP data base.

A comparison of the ISP Denver ground water chemical data confirms general plume trends identified in the historical data base for dithiane and oxathiane. The data sets show reportable concentrations of these compounds associated with the Basins B, C, and F in Sections 26 and 35. Major discrepancies in detections of dithiane and oxathiane have been identified in the historical data in Section 26, northwest of Basin F, and along the northern boundary of RMA in Sections 23 and 24. Current chemical data does not confirm these detections.

3.2.4 ORGANOSULFUR COMPOUNDS

All ground water samples collected during the ISP were subjected to chemical analyses for several organosulfur compounds. The three compounds quantified by this method include PCPMS, PCPMSO, and PCPMSO₂ all of which are structurally related and have similar physical and chemical properties. To aid in the interpretation of the organosulfur analytical data, composite maps of chemical distributions were prepared for each aquifer (alluvial and Denver). One or more of the organosulfur compounds were detected in ground water in 42 of the total of 319 wells sampled under this program.

3.2.4.1 Alluvial Distribution

One or more of the organosulfur compounds were detected in 33 of the 152 alluvial ground water samples analyzed. Twenty-four samples were not analyzed for these compounds. Concentrations ranged from 6 µg/l to 812 µg/l. The distribution of these compounds in alluvial ground water is shown in Figure 3.2-6.

Highest concentrations of the organosulfur compounds were observed in the general vicinity of Basin A (Section 36) and Basin F (Section 26). The highest detectable concentration in the alluvial aquifer was measured for well 23095 directly north of Basin F.

The distribution of organosulfur compounds shows that moderate concentrations are also observed within the South Plants area in Section 1. The contoured concentration data shows an essentially continuous ground water plume passing from the South Plants area through Basin A, Basin A Neck, Basin C, and Basin F toward the north boundary. However, the lack of adequate ground water quality control in some areas has resulted in the dashing of contour lines in these areas where monitoring wells are greater than 0.5 mile apart.

Examination of the individual chemical distribution maps presented in Appendix C shows that PCPMSO₂ was detected more frequently and in higher concentrations than PCPMSO and PCPMS. PCPMSO₂ was detected in 33 of the 152 alluvial ground water samples analyzed. Concentrations ranged from 6 to 680 µg/l. Highest concentrations of PCPMSO₂ were observed in Basin F, immediately downgradient of Basin F, Basin A and Basin A-Neck, and the South Plants area. An isolated occurrence of this compound was identified in Section 2.

PCPMSO was identified in 20 of the 153 alluvial ground water samples analyzed. Concentrations ranged from 4.5 to 130 µg/l. Highest concentrations of PCPMSO were observed in Basin F, immediately downgradient of Basin F, Basin A and Basin A Neck, and the South Plants area.

PCPMS was detected in 22 of the 153 alluvial ground water samples analyzed. Concentrations ranged from 2.6 to 120 µg/l. Highest concentrations of PCPMS were observed on Basin F, immediately downgradient of Basin F, Basin A and A Neck, and the South Plants area.

3.2.4.2 Denver Distribution

Organosulfur compounds were detected in 9 of the 142 samples analyzed from wells in the Denver aquifer. Detectable concentrations ranged from 10 µg/l to 94 µg/l. The distribution of the organosulfur compounds in the Denver aquifer is shown in Figure 3.2-6. With the exception of a single isolated detection in the northern portion of Section 2, all detectable concentrations were found in the vicinity of Basin C and F in Section 26. The highest concentrations were observed immediately adjacent to Basin F.

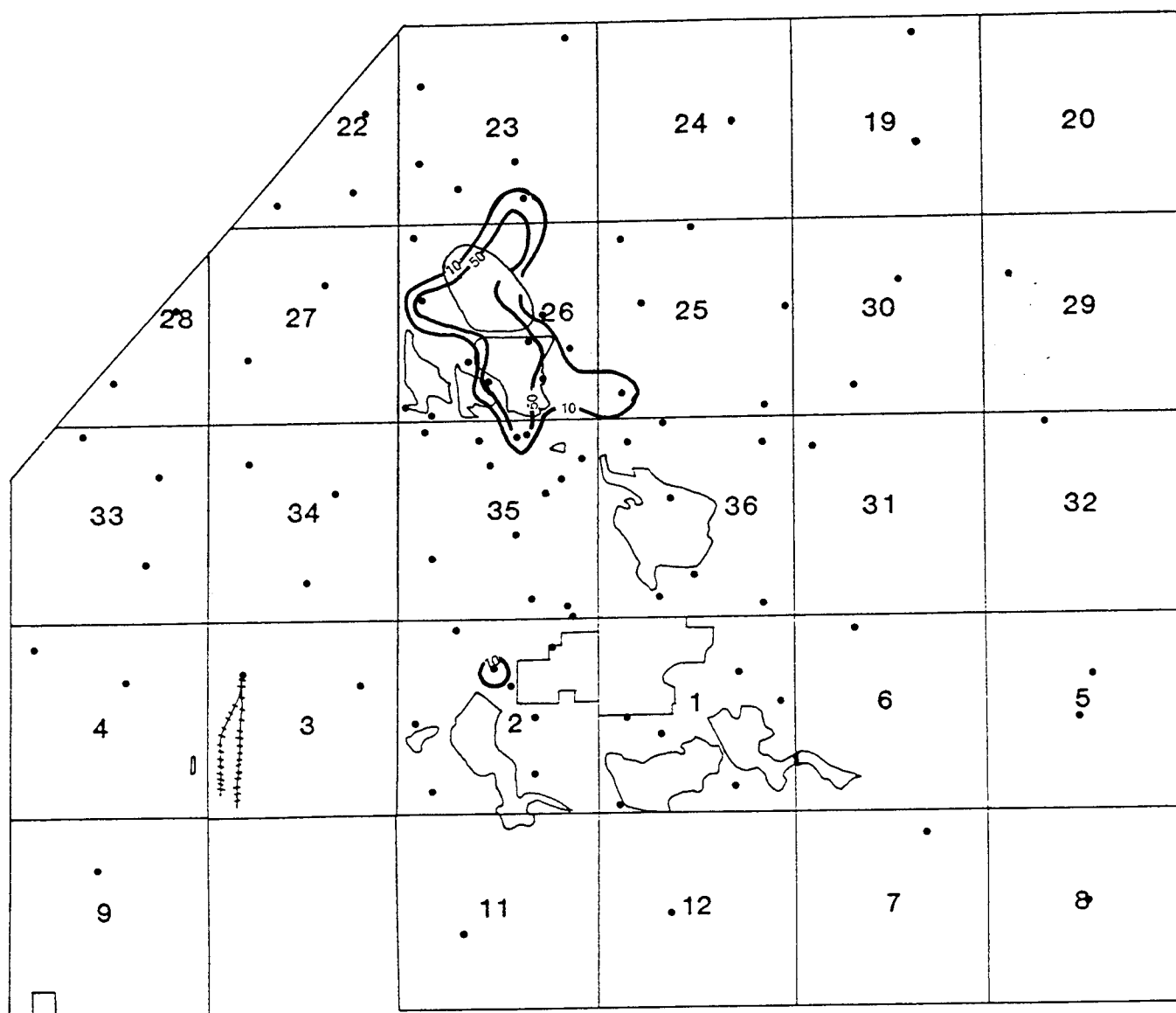
As was observed in the alluvial ground water chemical data base, PCPMSO₂ was observed more frequently and in higher concentrations than PCPMSO and PCPMS. PCPMSO₂ was detected in 7 of the 143 Denver ground water samples analyzed. Concentrations ranged from 7.5 to 66 µg/l. Highest concentrations were observed in Basin F, downgradient of Basin F, and Basin C.

PCPMSO was identified in 4 of the 143 Denver ground water samples analyzed. Concentrations ranged from 10 to 56 µg/l. Highest concentrations were observed in and west of Basin F.

PCPMS was identified in 6 of the 143 Denver ground water samples analyzed. Concentrations ranged from 5.3 to 31 µg/l. Highest concentrations of PCPMS were observed in the Basin C area and northwest of Basin B.

3.2.4.3 Comparison of Alluvial to Denver Water Quality

Examination of the distribution of organosulfur compounds in the alluvial and Denver aquifers (Figure 3.2-6) shows that although the presence of these compounds in the alluvium is relatively widespread, detectable concentrations in the Denver Formation are confined to the immediate vicinity of Basin F. The distribution of organosulfurs in the alluvium suggests a continuous plume from the primary source areas to the north boundary. Detectable concentrations of these compounds in the Denver are not present further north than central portions of Section 23 based on the limited number of Denver wells sampled.

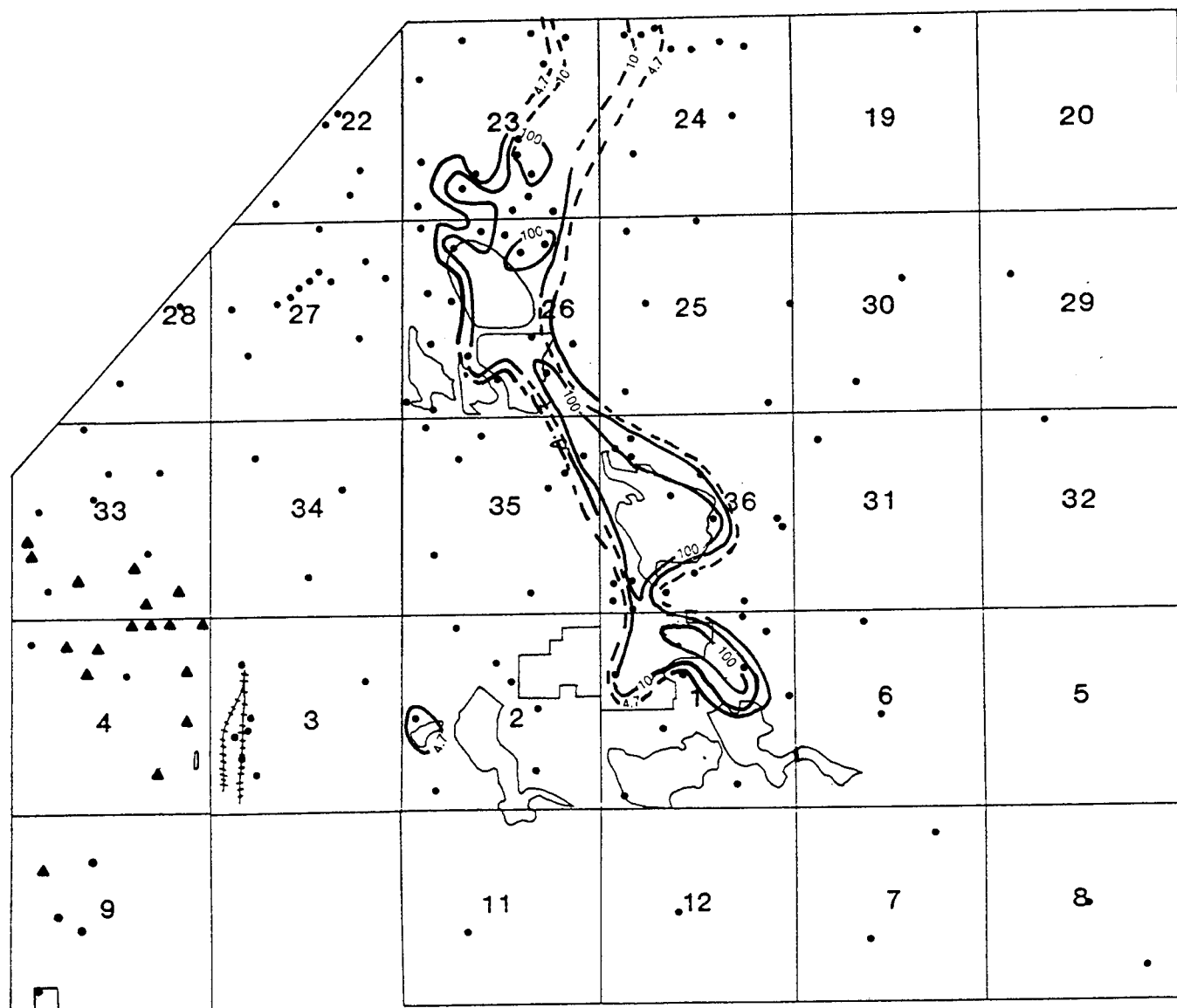


DENVER WELLS

0 1/2 1 MILE

Figure 3.2-6

INITIAL SCREENING PROGRAM PCPMS, PCPMSO, & PCPMSO2 DISTRIBUTION



ALLUVIAL WELLS

IN THE DENVER AND ALLUVIAL AQUIFERS

Prepared for:
 U.S. Army Program Manager's Office
 For Rocky Mountain Arsenal
 Aberdeen Proving Ground, Maryland

3.2.4.4 Comparison of ISP to Historical Water Quality Data

The historical composite distributions maps of the organosulfur compounds (PCPMS, PCPMSO, PCPMSO₂) identified in alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-7.

A comparison with the current alluvial ground water distribution map confirms general plume trends identified in the historical maps. The data sets report concentrations associated with known sources, particularly Basins A and F and the South Plants area.

Of the three organosulfur compounds, only PCPMSO₂ was analyzed in the Spaine et al. (1984) report. The contaminant plume map of this compound shows high concentrations associated with Basins A, C, and F. High concentrations are also shown immediately downgradient of Basin F and extend up to the north boundary. General plume trends shown in the Spaine et al. (1984) report are consistent with those reported in the ISP data base. However, concentrations of PCPMSO₂ were reported as high as 3000 µg/l, almost an order of magnitude greater than concentration levels reported in the ISP distribution maps.

A comparison of the ISP Denver ground water chemical data confirms general plume trends identified in the historical data base maps for the organosulfur compounds. Both data sets report concentrations associated with Basin F. Concentrations of the organosulfur compounds are reported in the historical data along the north boundary of RMA (Sections 23 and 24), Basin A (Section 36), and the South Plants area (Section 1). These detections were not identified in the current data base.

3.2.5 PURGEABLE AROMATICS

All ground waters collected during the ISP were subjected to chemical analyses for an array of purgeable aromatic compounds. These analytical methods included quantification for benzene, toluene, o- and p-xylene, m-xylene, and

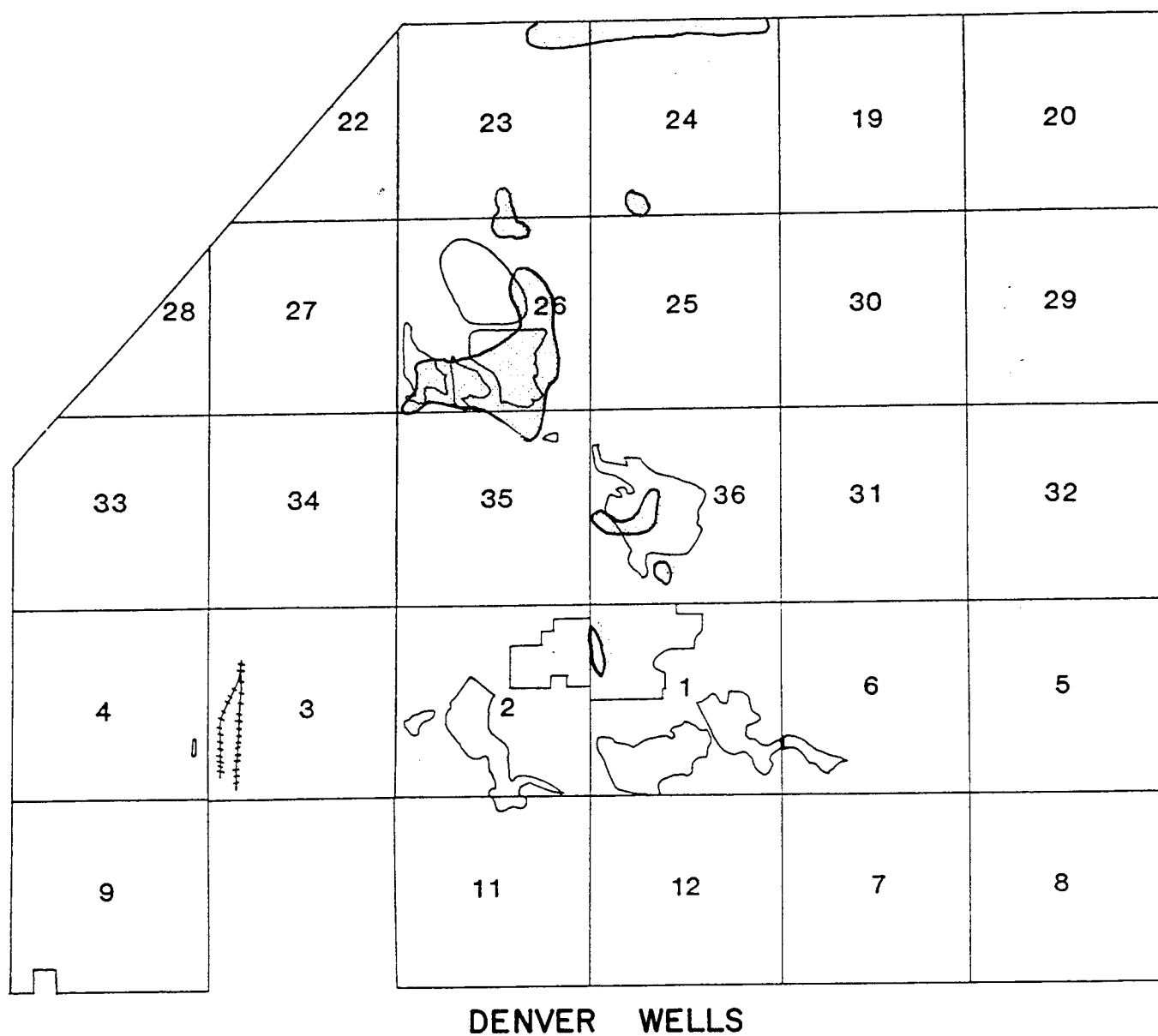
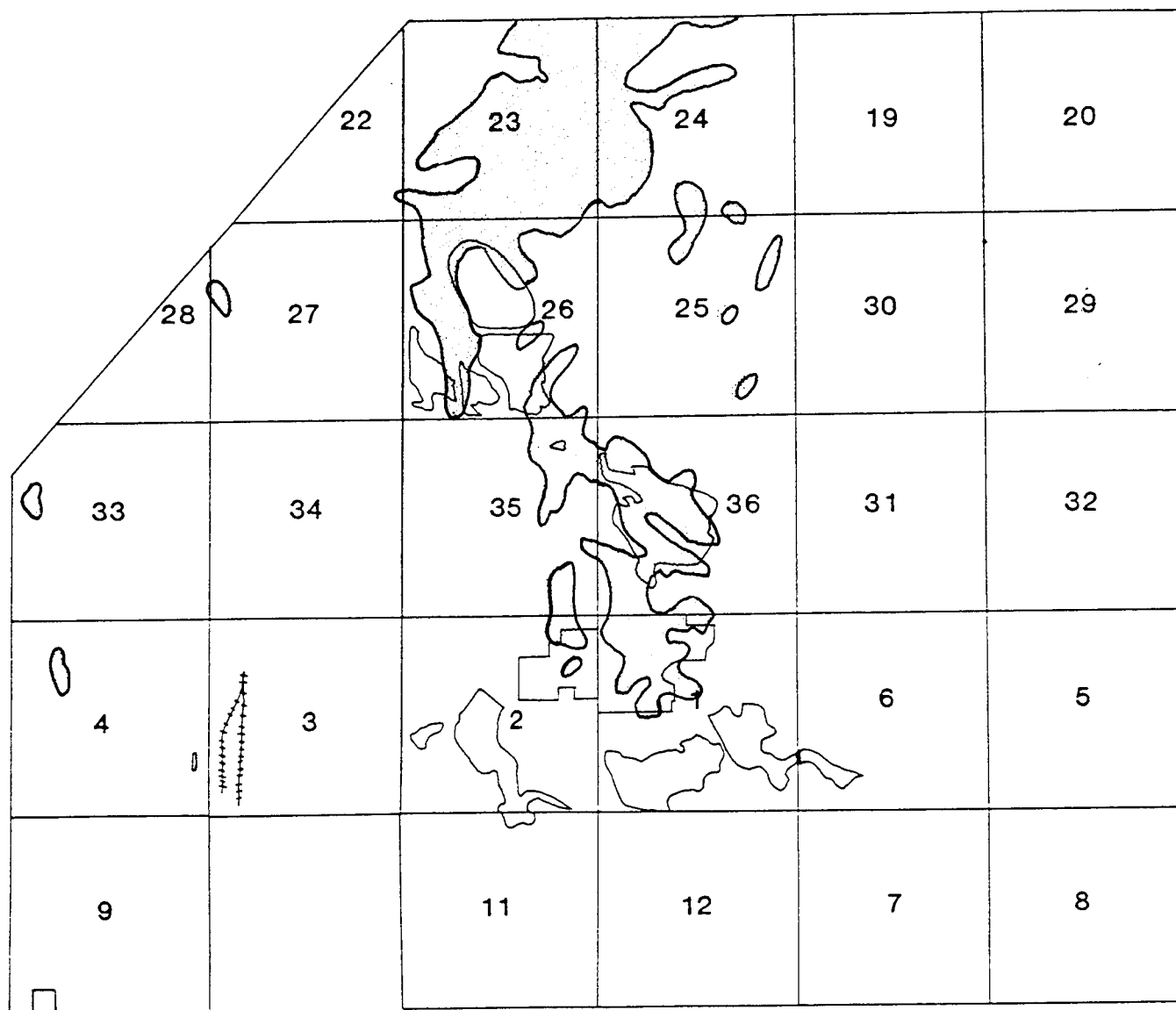


Figure 3.2-7
HISTORICAL PCPMS, PCPMSO, & PCPMSO₂ DISTRIBUTION IN THE DENVER AREA



ALLUVIAL WELLS

ND ALLUVIAL AQUIFERS

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

ethylbenzene. Three separate isomers existed for xylene and were designated ortho (o), meta (m), and para (p). Combined concentrations were listed for o-xylene and p-xylene isomers, while the m-xylene isomer was reported as a discrete concentration in the analytical data base (Appendix B). For purposes of data presentation the concentrations of all purgeable aromatics (including the xylene isomers) were added and chemical distribution maps were constructed for each aquifer. Purgeable aromatic compounds were detected in 56 of the 319 samples analyzed.

3.2.5.1 Alluvial Distribution

The distribution of purgeable aromatics in the alluvial aquifer is presented in Figure 3.2-8. One or more of the purgeable aromatic compounds were detected in 25 of the 176 alluvial monitoring wells sampled. Concentrations of total purgeable aromatics ranged from approximately 2.0 µg/l to a high of 34,400 µg/l at well 36001.

The frequency of detection for the purgeable aromatics is tabulated below.

<u>Analyte</u>	<u>Number of Detections*</u>	<u>Range (µg/l)</u>
Benzene	20	1.35-29,100
Toluene	9	1.78-1250
Total Xylenes	10	1.80-3750
Ethyl Benzene	3	3-560

*A total of 176 alluvial ground water samples were analyzed.

Figure 3.2-8 shows elevated levels of total purgeable aromatics in the immediate vicinity of the Lime Settling Pits, Basin A in Section 36, and immediately downgradient of Basin F in Sections 26 and 23. Isolated occurrences of aromatics are seen in Sections 1, 3, 4, and 33. The frequency of these isolated occurrences in Sections 4 and 33 may be related, but additional water quality control points are necessary to define such a trend if it is present.

Examination of the chemical distribution maps presented in Appendix C indicates that among the purgeable aromatic compounds, benzene was detected more frequently, on a more widespread basis, and in higher concentrations in alluvial ground water than any of the other aromatics. Benzene was identified in 20 of the 176 samples analyzed. Concentrations ranged from 1.35 to 29,100 $\mu\text{g/l}$. Highest concentrations of benzene were observed near the Lime Settling Pits, Basin A, immediately downgradient of Basin F, and in and downgradient of the Motor Pool area. Several isolated single point aromatics were also identified in Sections 1, 28, 33, 35 and 36.

Total xylenes were detected in 10 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 1.8 to 3750 $\mu\text{g/l}$. Highest concentrations were observed in the Lime Settling Pits, Basin A, and directly downgradient of Basin F. Isolated occurrences of xylenes were observed in Sections 3 and 4.

Toluene was observed in 9 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 1.78 to 1250 $\mu\text{g/l}$. Highest concentrations of toluene were observed near the Lime Settling Pits and directly downgradient of Basin F. Occurrences of toluene were also identified in Sections 3 and 33.

Ethylbenzene was identified in 3 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 3 to 560 $\mu\text{g/l}$. The highest concentrations were observed in the Lime Settling Pits and downgradient of Basin F.

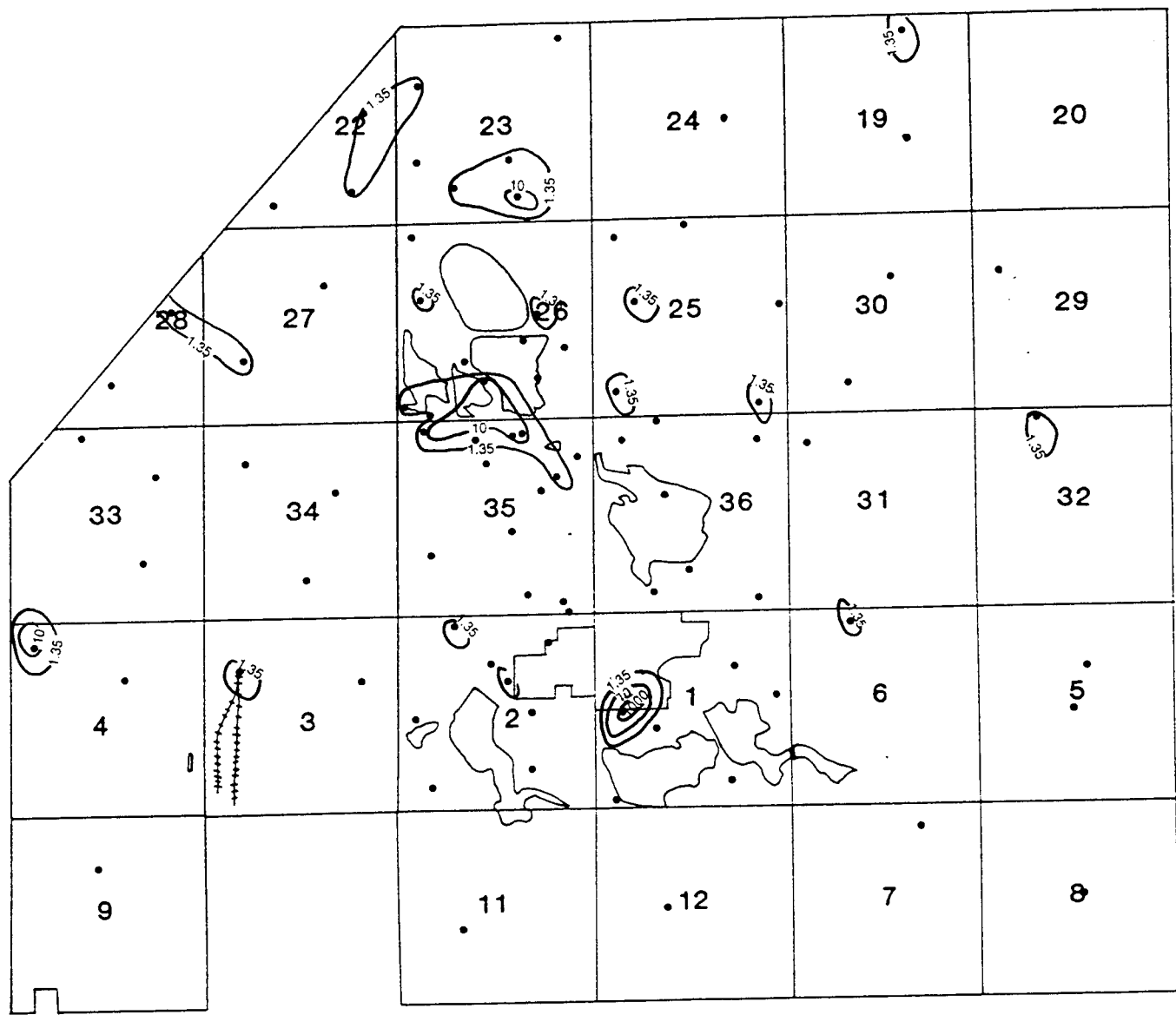
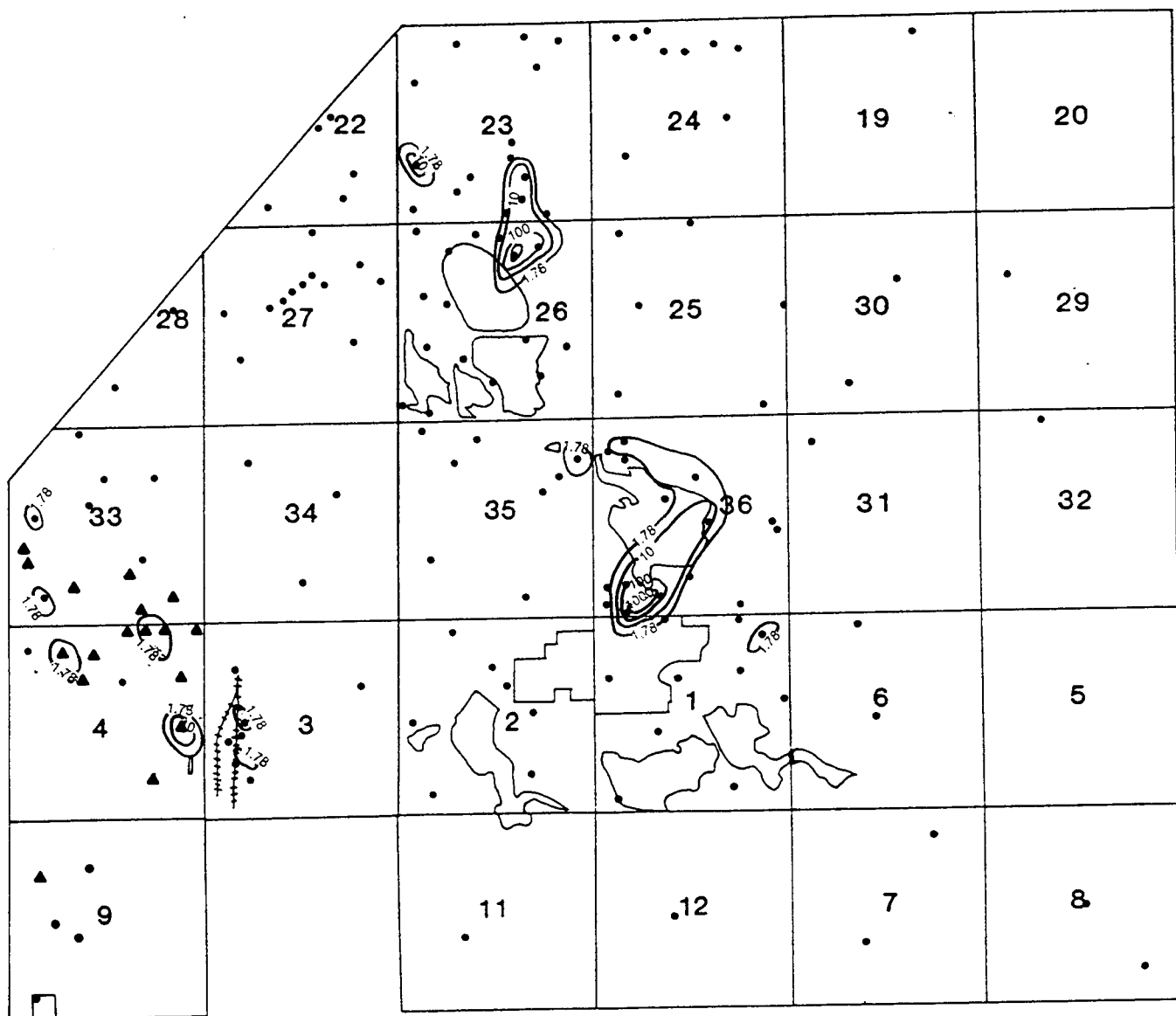


Figure 3.2-8
INITIAL SCREENING PROGRAM VOLATILE AROMATICS DISTRIBUTION IN THE



ALLUVIAL WELLS

3.2.5.2 Denver Distribution

The distribution of purgeable aromatics in the Denver aquifer is shown in Figure 3.2-8. Concentrations ranged from 1.25 µg/l to 151,000 µg/l.

Purgeable aromatics were detected in 31 of the 143 Denver monitoring wells, with benzene detected in 28 of those 31 wells. The number of detections for individual purgeable aromatics and associated concentration ranges are found below.

<u>Analyte</u>	<u>Number of Detections</u>	<u>Range (µg/l)</u>
Benzene	28	1.35-151,000
Toluene	4	1.25-719
Total Xylenes	3	7.81-2190
Ethyl Benzene	3	4-28

The distribution of purgeable aromatics in the Denver aquifer was sporadic. High concentrations were detected in the South Plants area (Section 1) while moderate concentrations were detected south of Basin F in Sections 26 and 35. Singular occurrences of these volatiles were present in Sections 2, 3, 4, 25, and 26. Many of these isolated occurrences may be interrelated, but such a hypothesis must be confirmed by the addition of more data points between wells which are currently separated by large distances.

As was observed in the alluvial ground water chemical data base, benzene was detected more frequently, on a more widespread basis, and in higher concentrations than the other purgeable aromatic compounds. Benzene was identified in 28 of the 143 Denver ground water samples analyzed. Concentrations ranged from 1.35 to 151,000 µg/l. Highest concentrations of benzene were observed in the South Plants area, Basins B and C, and immediately downgradient of Basin F. Isolated plumes of benzene were also identified along the northwest boundary of RMA in Section 22 and north of Basin F in Section 25. Isolated detections of benzene were identified in Sections 3, 6, 9, 19, 27, and 32.

Total xylene was identified in three Denver ground water samples ranging in concentrations from 7.81 to 2186 µg/l. The highest concentration was observed in the South Plants area of Section 1. Isolated occurrences were identified in Sections 4 and 23.

Toluene was identified in four Denver ground water samples. The four isolated occurrences of this compound ranged in concentration from 1.25 to 719 µg/l. The highest concentration was identified in the South Plants area of Section 1.

Ethylbenzene was identified in 3 of the 143 Denver ground water samples analyzed. Concentrations ranged from 4 to 28 µg/l. The highest concentration was reported in the South Plants area. Isolated occurrences were identified in Sections 4. and 23.

3.2.5.3 Comparison of Alluvial to Denver Water Quality

Although purgeable aromatics were detected in the alluvium in Section 36 (Basin A), no detections were observed in the Denver formation in this section (Figure 3.2-8); however, immediately downgradient of the Basin A-Neck, purgeable aromatics were present primarily in the Denver aquifer. The presence of purgeable aromatics in the Denver aquifer occurred throughout the northern portion of Section 35 and southern Section 26, although no detections occurred in the alluvium at this location.

Immediately north of Basin F purgeable aromatics were observed in both the alluvium and Denver with higher concentrations occurring in the alluvium. Other relatively isolated occurrences of purgeable aromatics in outlying sections were not obviously correlated between alluvial and Denver aquifers.

3.2.5.4 Comparison of ISP to Historical Water Quality Data

Chemical data presented in Spaine et al. (1984) indicate that high concentrations of benzene, toluene, and chlorobenzene were associated only with the South Plants area. These compounds were also identified in lesser concentrations "in the southwest corner of the Arsenal". The distribution of these compounds as shown in the report was confined areally over RMA when compared to the ISP data. This is probably a function of the high method detection levels for volatile organic compounds established by the Army Analytical Program.

3.2.6 PURGEABLE HALOCARBONS

Ground water samples collected from all 319 monitoring wells during the ISP were analyzed for a suite of chlorinated volatile organic compounds. These chlorinated organics include carbon tetrachloride, chloroform, trichloroethylene, dichloroethylenes (cis and trans), tetrachloroethylene, trichloroethanes (1,1,1 and 1,1,2), dichloroethanes (1,1 and 1,2), chlorobenzene, and methylene chloride. As the analytical method utilized quantifies 12 purgeable halocarbons and these compounds are generally similar in chemical structures and physical properties, composite chemical concentration maps were prepared for each aquifer. Concentration distribution maps for each individually identified purgeable halocarbon can be found in Appendix C.

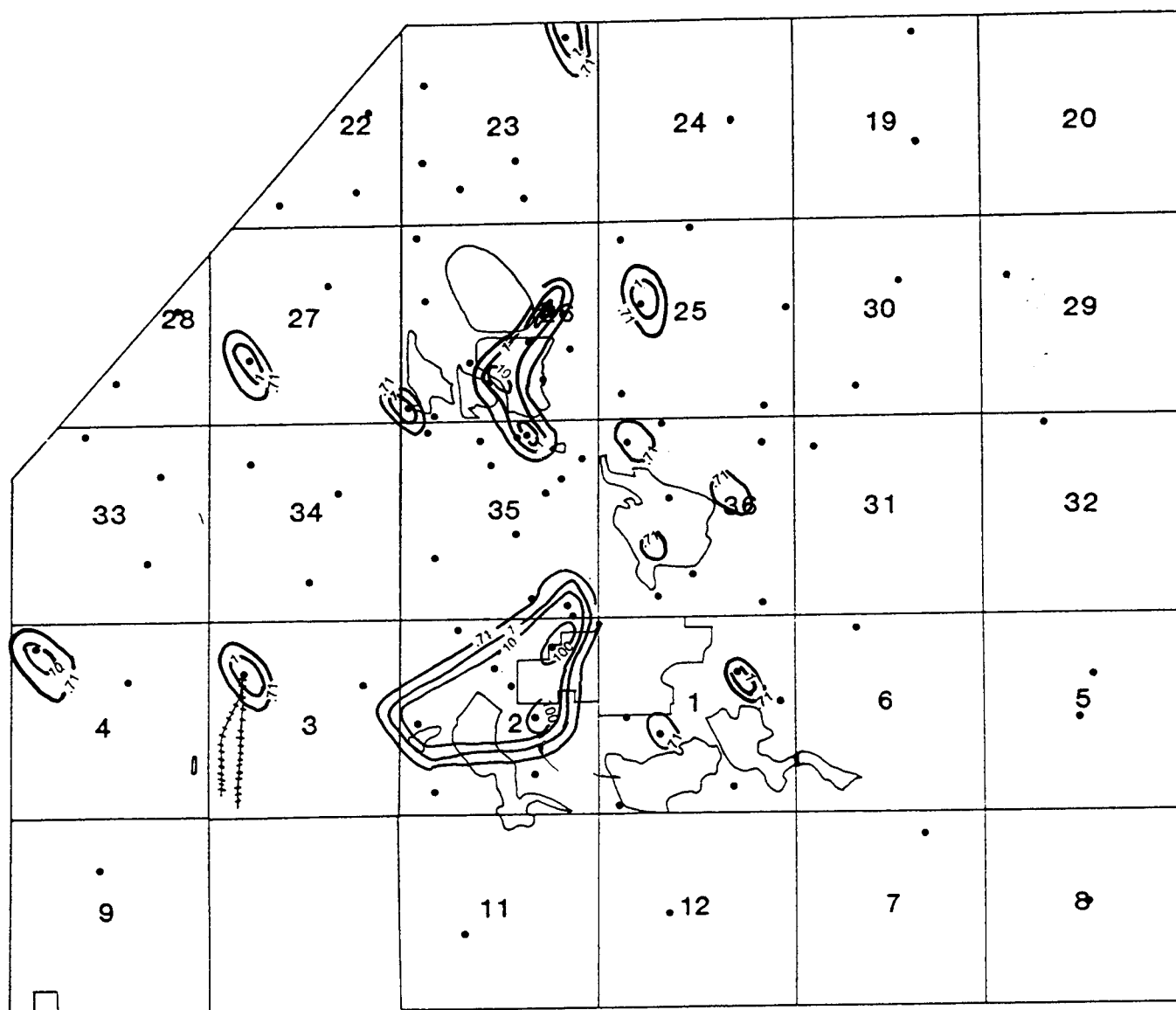
3.2.6.1 Alluvial Distribution

Figure 3.2-9 shows the distribution of total purgeable halocarbons in the alluvial aquifer. Of the 176 monitoring wells sampled one or more purgeable halocarbons were detected in 83 wells. Concentrations of total purgeable halocarbons ranged from less than 1 µg/l to values in excess of 211,000 µg/l.

The primary components of the purgeable halocarbons identified in ground water are chloroform, trichloroethylene, and tetrachloroethylene. The frequency of detections for the purgeable halocarbons and the observed concentration ranges for each compound are tabulated below.

<u>Analyte</u>	<u>Number of Detections*</u>	<u>Range (µg/l)</u>
Total Dichloroethylenes (cis and trans)	11	1.4-127
Total Dichloroethanes (1,1 and 1,2)	23	0.87-7,200
Total Trichloroethanes (1,1,2 and 1,1,1)	4	2.6-200
Trichloroethylene	40	1.2-4,400
Tetrachloroethylene	24	1.3-350
Chlorobenzene	11	1.7-44,000
Chloroform	48	1.8-211,000
Methylene Chloride	6	17-7300
Carbon Tetrachloride	6	2.63-499

*A total of 176 Alluvial wells were sampled.



DENVER WELLS

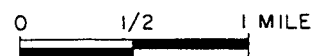
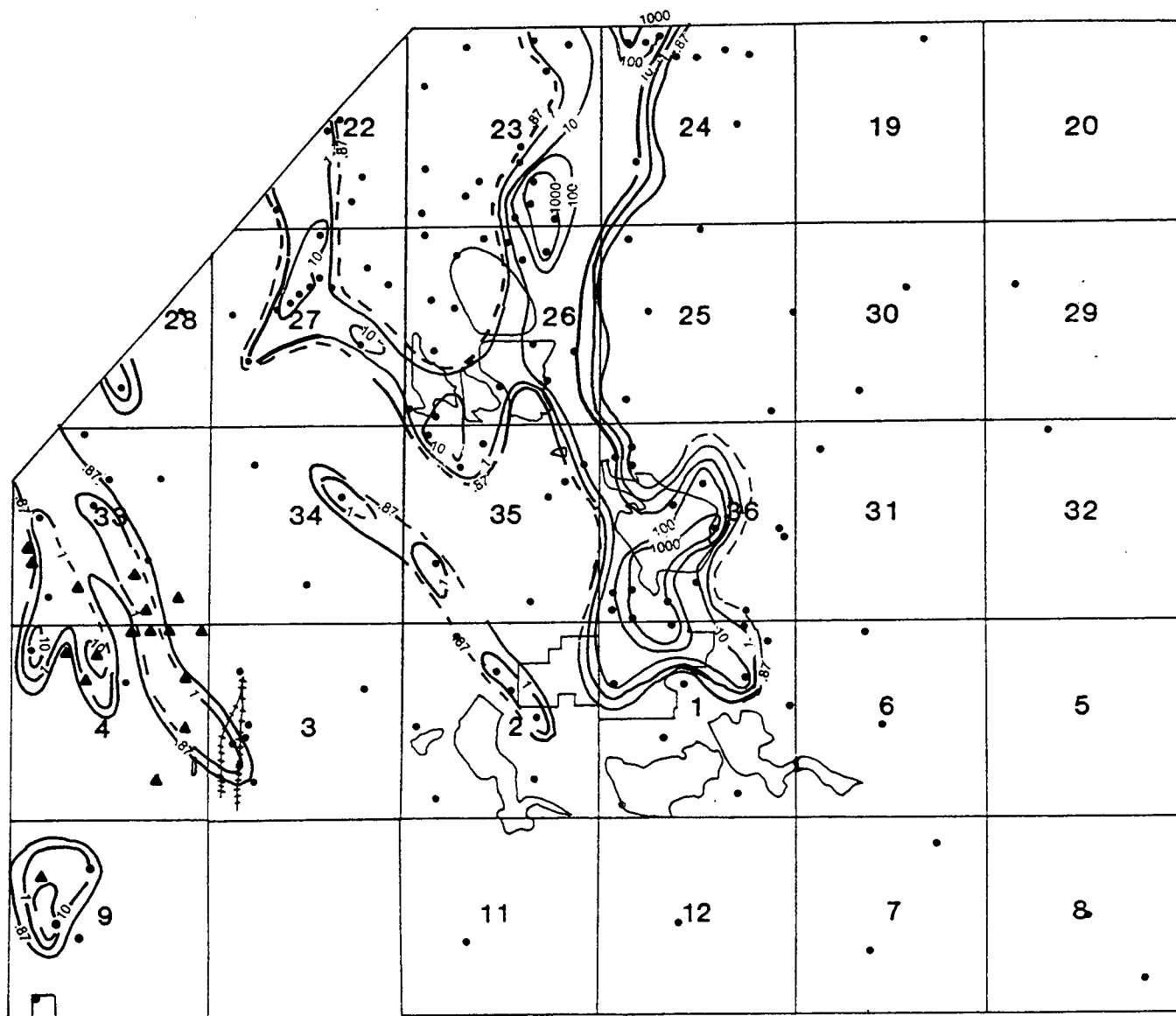


Figure 3.2-9
INITIAL SCREENING PROGRAM VOLATILE ORGANOHALOGENS DISTRIBUTION



ALLUVIAL WELLS

IN THE DENVER AND ALLUVIAL AQUIFERS

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Figure 3.2-9 shows that highest concentrations of total purgeable halocarbons were observed in the vicinity of the South Plants area, Basin A, immediately downgradient of Basin F, and in Sections 4 and 33. Although data points between the Basin A-Neck and Section 26 are of insufficient density, an examination of Figure 3.2-9 suggests that the distribution of purgeable halocarbons is continuous from Basin A and the South Plants area, through the Basin A-Neck and Basin B, through the general area of Basin F, and on to the northern boundary. A secondary distribution trend is observed from Section 26 towards the northwest boundary.

The possibility of a continuous distribution of purgeable halocarbons through Section 2, the southern portion of Section 35, and Section 34 appears to exist, but additional control wells are necessary for confirmation.

The distribution of purgeable halocarbons in Sections 4 and 33 is apparent at concentrations that are significantly lower than those observed in the Basins and South Plants areas. It should be noted that the western boundary of the outer concentration contour reaches the western boundary of RMA. Because offpost water quality data have not been integrated into this presentation, contoured concentrations along this boundary are uncertain.

Examination of the individual chemical distribution maps presented in Appendix C shows that among the purgeable halocarbons, chloroform was detected more frequently, on a more widespread basis, and in higher concentrations in alluvial ground water at RMA. Chloroform was detected in 48 of 176 samples analyzed and concentrations ranged from 1.8 to 211,000 $\mu\text{g}/\text{l}$. The highest concentrations of this compound were observed in the vicinity of Basin A, the South Plants area, and immediately downgradient of Basin F. Other occurrences of chloroform were observed in the western and eastern halves of Sections 35 and 34, respectively. Chloroform was also identified along the northwest boundary in Sections 27 and 28. Isolated occurrences of chloroform were also observed in Sections 2, 3, and 4.

Trichloroethylene (TCE) was identified in 40 of the 176 alluvial wells sampled and analyzed. Concentrations ranged from 1.2 to 4400 µg/l. The highest concentrations of this halocarbon in alluvial ground waters were identified in the South Plants area, Basin A, and the Motor Pool area. Detectable concentrations of TCE were observed immediately downgradient of Basin F, and west of Basin F in Section 27. A plume was also observed extending from the Motor Pool area in a northwesterly direction through Sections 4 and 33 toward the western boundary of RMA. Isolated occurrences of TCE were detected in Sections 2 and 9.

Tetrachloroethylene (PCE) was observed in 24 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 1.3 to 350 µg/l. Highest concentrations of this halocarbon were observed immediately downgradient of Basin F, in Basin A, and in the South Plants area. Detectable concentrations of tetrachloroethylene were also identified along the western border of RMA in Sections 4, 9, and 33.

Total dichloroethanes (isomers 1,1 and 1,2) were observed in 23 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 0.87 to 7,200 µg/l. Highest concentrations of these compounds were observed in Basin A, the South Plants area, and immediately downgradient of Basin F. Detectable concentrations of total dichloroethanes were also identified in Section 27, west of the Basin F area.

Total dichloroethylenes (cis and trans isomers) were identified in 11 of 176 alluvial ground water samples analyzed. Concentrations ranged from 1.4 to 127 µg/l. Highest concentrations of these compounds were observed in Basin A and the South Plants areas. Isolated occurrences were also reported in Sections 4, 9, and 23.

Chlorobenzene was detected in 11 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 1.7 to 44,000 µg/l. Highest concentrations of this compound were observed in Basin A, the South Plants area, and north of Basin F.

Methylene chloride was detected in 6 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 17 to 7300 µg/l. Highest concentrations of this compound were identified directly downgradient of Basin F and in the Lime Settling Pits area.

Carbon tetrachloride was identified in 6 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 2.63 to 499 µg/l. Highest concentrations were observed in isolated occurrences in the Basin A area, the South Plants area, and east and northeast of Basin F.

Total trichloroethane (1,1,1 and 1,1,2 isomers) were identified in 4 of the 176 alluvial ground water samples analyzed. Concentrations ranged from 2.6 to 200 µg/l. The compounds were identified in ground water associated with the Lime Settling Pits and in an isolated occurrence along the northwest boundary in Section 28.

3.2.6.2 Denver Distribution

Figure 3.2-9 presents the distribution of total purgeable halocarbons in the Denver aquifer. Of the 143 wells sampled in this formation, 22 contained detectable concentrations of one or more of the halocarbons. Concentrations ranged from 0.7 µg/l to a high of 430 µg/l. The most frequently encountered halocarbon in the Denver aquifer was chloroform. A summary of the frequency of detections and ranges of detectable concentrations for individual purgeable halocarbons follows.

<u>Analyte</u>	<u>Number of Detections*</u>	<u>Range (µg/l)</u>
Total Dichloroethylenes (cis and trans)	1	5.3
Total Dichloroethanes (1,1 and 1,2)	5	2.7-18
Total Trichloroethanes (1,1,1 and 1,1,2)	3	1.1-2.5
Trichloroethylene	8	1.6-11
Tetrachloroethylene	4	2.7-5.4
Chlorobenzene	5	0.7-50
Chloroform	9	2.5-430
Methylene Chloride	5	6-21
Carbon Tetrachloride	3	4.8-41

*Total of 143 samples were analyzed.

Figure 3.2-9 shows that numerous detections of purgeable halocarbons at low concentrations occurred in all central sections of RMA. Many of these measurements appear to be isolated detections. As indicated by the dashed contour lines on the chemical distribution map, many of these isolated occurrences may be interrelated. However, lack of ground water quality data in intermediate locations prevents confirmation of these trends.

As was observed in the alluvial ground water data base, chloroform was identified more frequently, on a more widespread basis, and in higher concentrations than the other purgeable halocarbon compounds. Chloroform was detected in 9 of the 143 Denver ground water samples analyzed. Concentrations ranged from 2.49 to 430 $\mu\text{g}/\text{l}$. Highest concentrations of chloroform were observed in Section 2, west of the South Plants area, and in isolated occurrences east and west of Basin F in Section 26.

Trichloroethylene was observed in 8 of the 143 Denver ground water samples analyzed. Concentrations ranged from 1.6 to 11 $\mu\text{g}/\text{l}$. Highest concentrations were observed in Sections 2 and 35 just west of the South Plants area and in the Basin C area. An isolated occurrence of trichloroethylene was identified in Section 27.

Total dichloroethane (1,1 and 1,2 isomers) was identified in 5 of the 143 Denver ground water samples analyzed. Concentrations ranged from 2.7 to 18 $\mu\text{g}/\text{l}$. The highest concentrations of these compounds were observed in Section 2. Isolated occurrences were also identified in Sections 4, 35, and 36.

Tetrachloroethylene was identified in 4 of the 143 Denver ground water samples analyzed. Concentrations ranged from 2.7 to 5.4 $\mu\text{g}/\text{l}$. The highest concentrations were observed in the Basin C area and in Section 2 west of the South Plants area.

Dichloroethylenes were identified in 1 of the 143 Denver ground water samples analyzed at a concentration of 5.2 $\mu\text{g}/\text{l}$. This single occurrence was identified in the southeast corner of Section 36.

Chlorobenzene was identified in 5 of the 143 Denver ground water samples analyzed. Concentrations ranged from 0.7 to 50 µg/l. Highest concentrations were observed in Basin C and northwest of Basin B. An isolated detection of chlorobenzene was observed in Section 1.

Methylene chloride was observed in 5 of the 143 Denver ground water samples analyzed. Concentrations ranged from 6 to 21 µg/l. All occurrences of methylene chloride were isolated and located in Sections 1, 2, 4, 25, and 27. Carbon tetrachloride was observed in 3 of the 143 Denver ground water samples analyzed. Concentrations ranged from 4.8 to 41 µg/l. The three samples which contained this compound were located in Sections 1 and 35, just west of the South Plants area and the Lime Settling Pits.

Total trichloroethanes (1,1,1 and 1,1,2 isomers) were identified in 3 of the 143 Denver ground water samples analyzed. Concentrations ranged from 1.1 to 2.5 µg/l. The three isolated occurrences were located in Sections 2, 4, and 23.

3.2.6.3 Comparison of Alluvial to Denver Water Quality

A comparison of chemical distribution maps for purgeable halocarbons in alluvial and Denver aquifers (Figure 3.2-9) shows that many of the isolated occurrences of these compounds in the Denver are related to alluvial concentrations. Specifically, isolated detections in the Denver aquifer in Sections 1 and 36 are related to significant alluvial concentrations in these areas. Purgeable halocarbons identified in Denver ground water in Section 26 are also related to high alluvial ground water concentrations in this section. Halocarbons were also detected in the alluvial and Denver ground waters along the north boundary of RMA in Section 23.

There were no confirmed detections of purgeable halocarbons in either the alluvial or Denver aquifers of Sections 4 and 33; however, there are an insufficient number of adequately placed monitoring wells in this vicinity.

3.2.6.4 Comparison of ISP to Historical Water Quality Data

Historical data presented in the Spaine et al. (1984) report states that "some of the ethylenes were identified in the southwest corner of the Arsenal". Distribution maps and concentration data were not tabulated in the report.

3.2.7 DBCP

Dibromochloropropane (DBCP) was detected in 31 of the 319 monitoring wells sampled during the ISP. Concentrations of DBCP have been plotted on separate alluvial and Denver aquifer maps to examine the distribution in the ground water system.

3.2.7.1 Alluvial Distribution

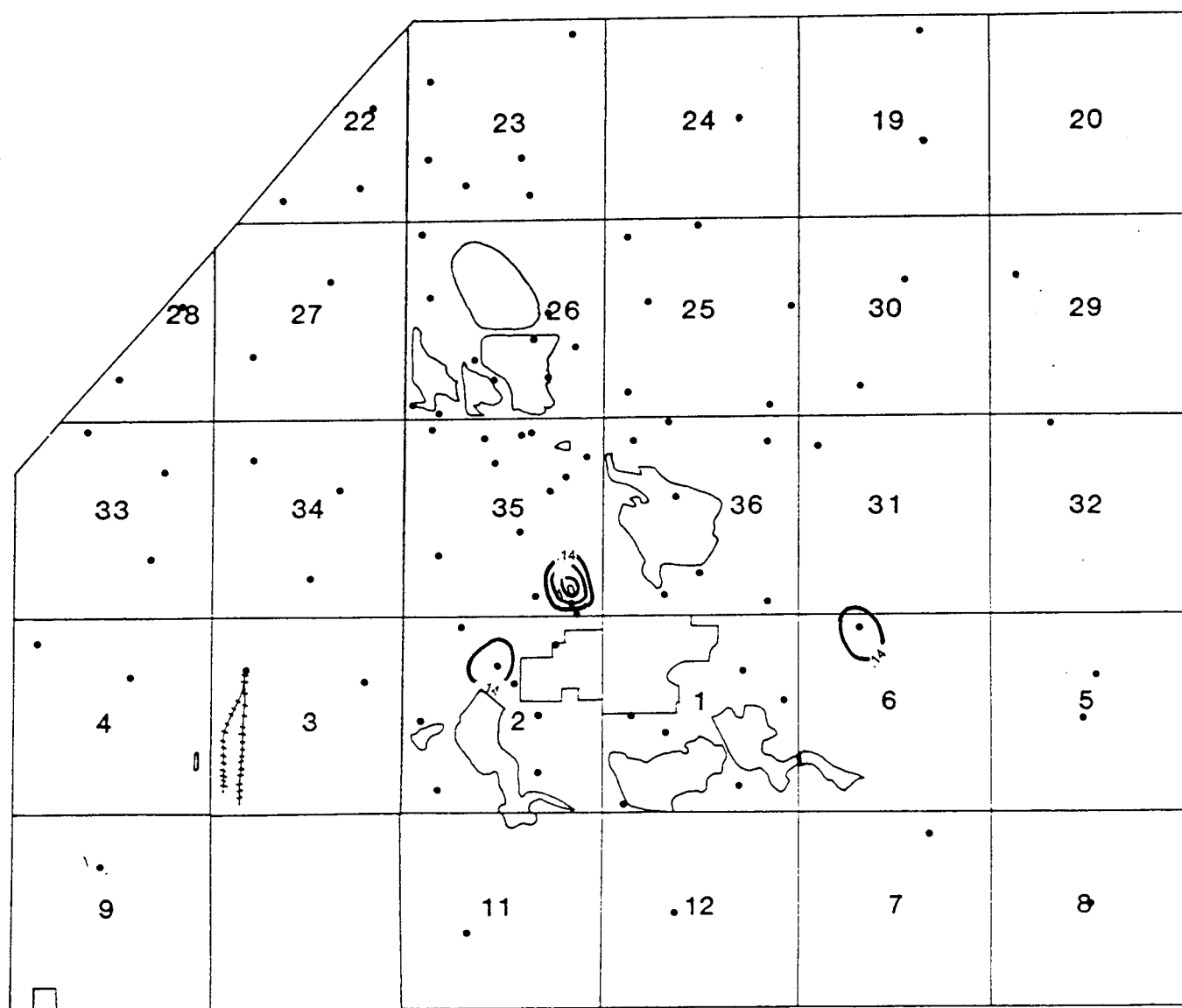
The concentration of DBCP in the alluvial aquifer ranged from 0.14 µg/l (several wells) to 310 µg/l in well 36001. The distribution of DBCP in the alluvial aquifer is presented in Figure 3.2-10. Measureable concentrations of DBCP in ground water were located in the South Plants area, the southern portion of Basin A (Sections 1 and 36), and in the general area of the previously identified Irondale DBCP plume in Sections 4 and 33. Moderate concentrations of DBCP were also detected north of Basin F in Sections 23 and 26. As shown on Figure 3.2-10, detectable concentrations of DBCP in Section 24 and along the north boundary may be related to high concentrations detected north of Basin F. However, additional data points are necessary to confirm this trend.

3.2.7.2 Denver Distribution

The distribution of DBCP in the Denver aquifer is shown in Figure 3.2-10. Only two of the 143 wells sampled in this aquifer contained detectable concentrations of DBCP. The concentrations of DBCP found in Sections 2 and 6 were 0.14 and 0.75 µg/l, respectively.

3.2.7.3 Comparison of Alluvial to Denver Water Quality

The primary locations of DBCP plumes in the alluvial aquifer do not appear to have associated detections of DBCP in the Denver aquifer. Isolated occurrences of DBCP in the Denver aquifer were generally in the vicinity of the South Plants area but do not appear to be hydrologically related to the Sections 1 and 36 alluvial plume.

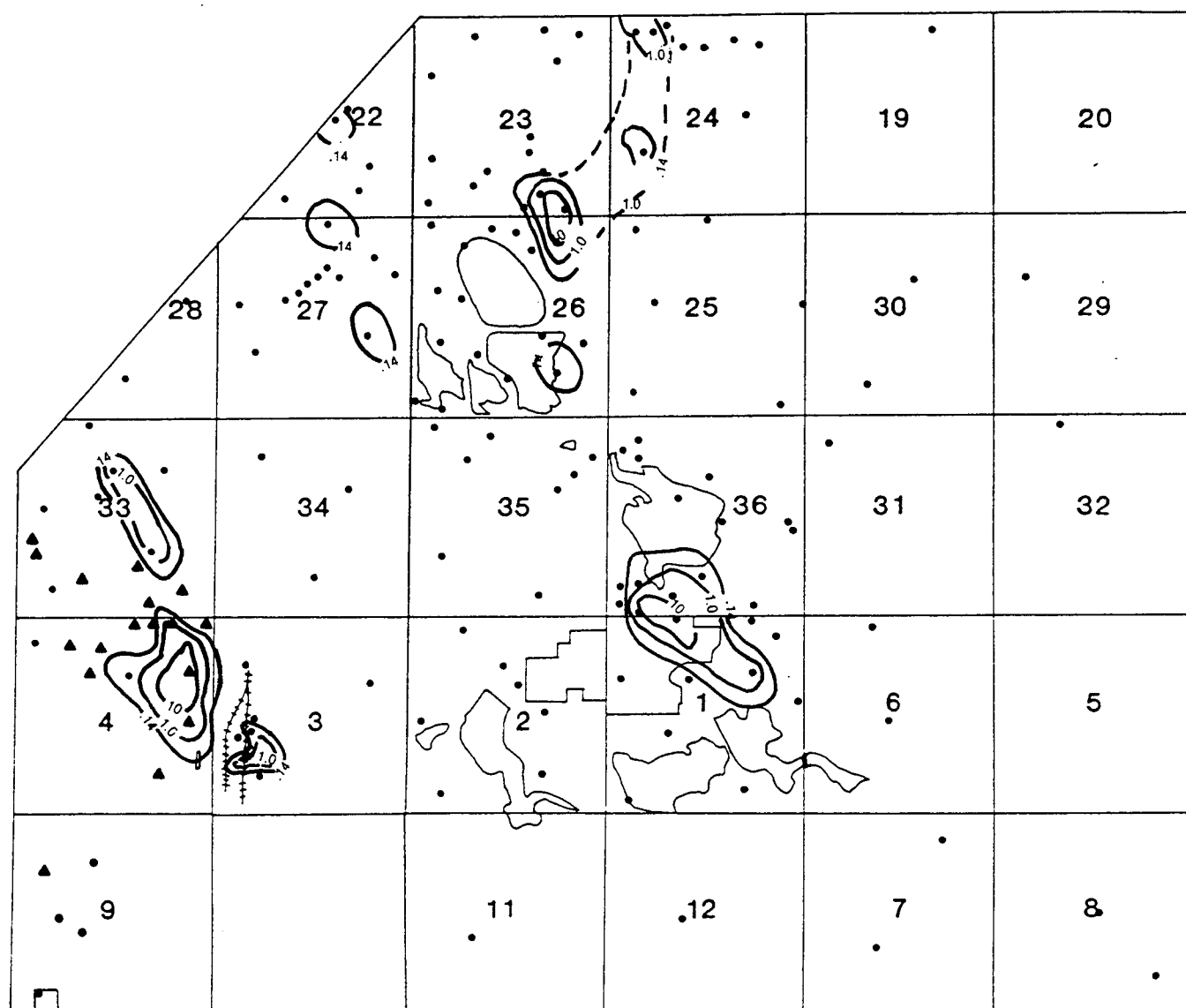


DENVER WELLS

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Figure 3.2-10

INITIAL SCREENING PROGRAM DBCP DISTRIBUTION IN THE DENVER AND AL



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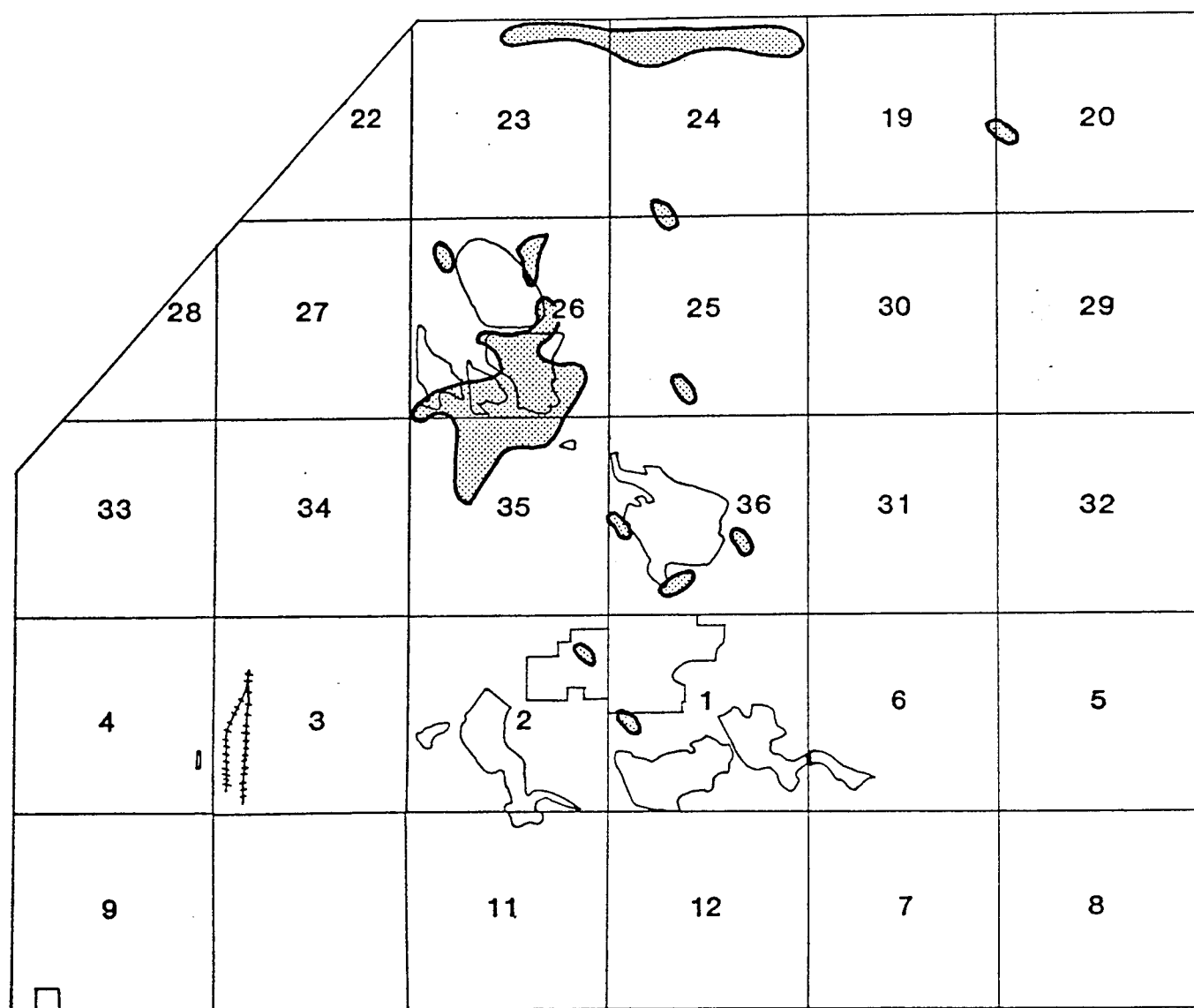
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For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

3.2.7.4 Comparison of ISP to Historical Water Quality Data

The historical distribution maps of DBCP identified in alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-11. A comparison of the ISP alluvial ground water distribution map partially confirms general plume trends indicated in the historical distribution maps for DBCP. Both data sets report concentrations immediately downgradient of Basin F (Section 23), in Basin A, (Section 36) and the South Plants area (Section 1) and the Rail Classification Yard (Section 3). The historical data base reports a general widespread distribution in Sections 2, 22, 23, 24, and 25. These data are not confirmed in the current ISP chemical data base.

Historical data presented in Spaine et al. (1984) report high concentrations of DBCP associated with the South Plants area. A major plume which appears to originate in the Basin A-Neck area, proceeds in a northwesterly direction through Section 35, turns north in Section 27, and crosses the northwest boundary in Section 22. A separate plume, immediately downgradient of Basin F, extends to the north boundary of RMA. The report also indicates the presence of the plume extending outward to the northwest from the Rail Classification Yard. A comparison of the report data and ISP data confirm general plume trends. However, the areal distribution of DBCP reported in the ISP data base is more extensive in the South Plants area and the Rail Classification Yard. Concentration values of DBCP reported in the ISP data base are generally 10 times higher than values reported by Spaine et al. (1984) in similar areas of RMA.

A comparison of the ISP Denver ground water chemical data with the historical data shows significant discrepancies in the distribution of DBCP. Major plumes were identified in the historical data in Sections 26 and 35 of the Basin F area and along the northern boundary of RMA in Sections 23 and 24. These plumes are not identified in the current chemical data base. Additionally, single point anomalies are identified in Sections 1, 2, 19, and 20 of the historical data base. These anomalies are not confirmed in the ISP chemical data base.



DENVER WELLS

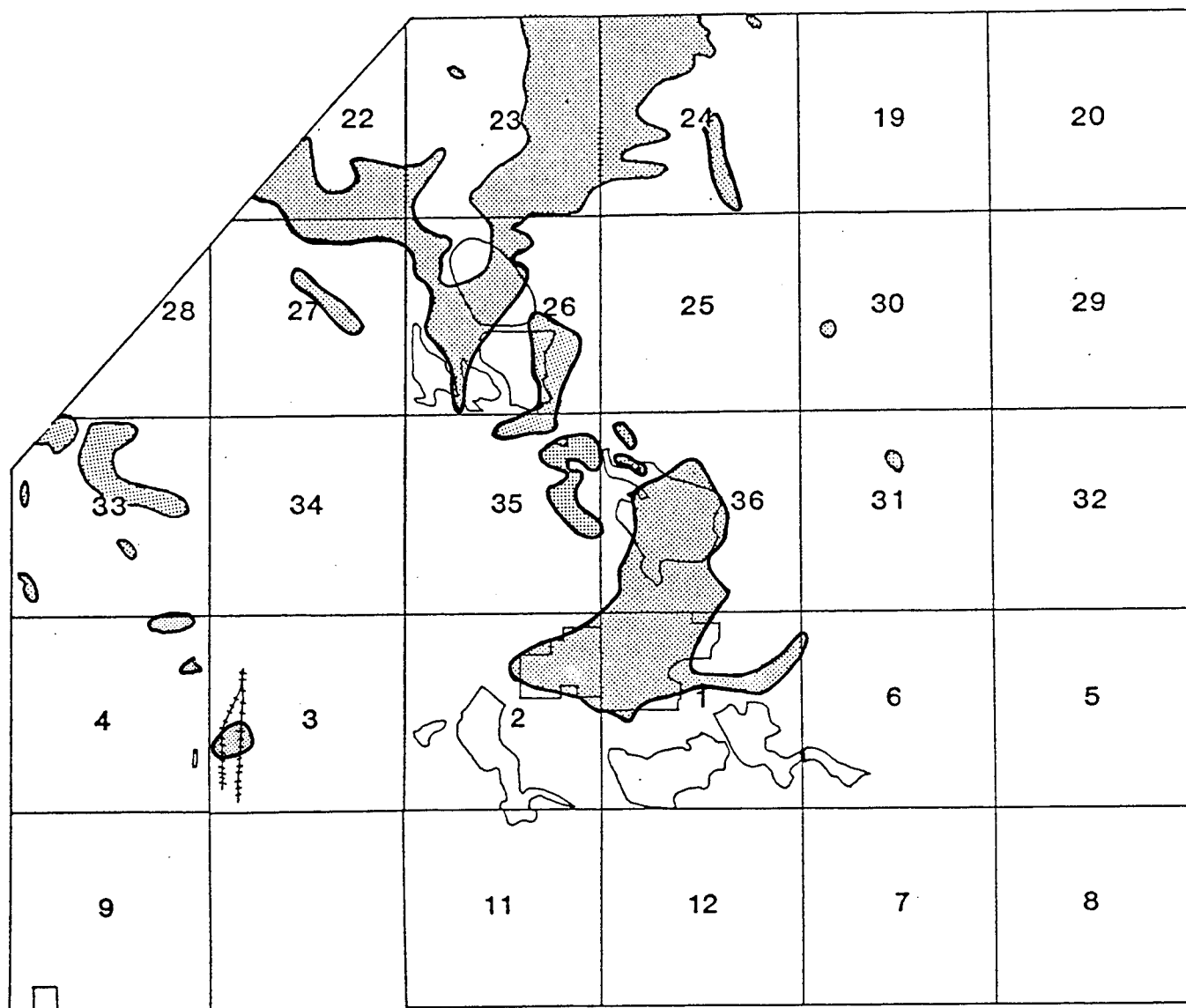
EXPLANATION



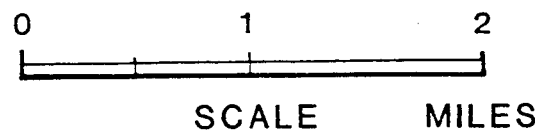
AREAS WHERE DETECTED

Figure 3.2-11

HISTORICAL DBCP DISTRIBUTION IN THE DENVER AND ALLUVIAL AQUIFERS



ALLUVIAL WELLS



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 For Rocky Mountain Arsenal
 Aberdeen Proving Ground, Maryland

3.2.8 DCPD

Dicyclopentadiene was detected in 11 of 319 ground water samples analyzed during the ISP. Twenty samples were not analyzed for this compound. Concentrations of DCPD have been plotted on separate maps for the alluvial and Denver aquifers.

3.2.8.1 Alluvial Distribution

The distribution of DCPD in the alluvial aquifer is presented in Figure 3.2-12. The compound was detected in 8 of the 156 alluvial ground water samples and ranged in concentration from 10.3 to 571 µg/l. The highest concentration of 571 µg/l was observed in well 26133. Single detections of DCPD in the alluvial aquifer were found in Sections 3, 22, 24, 34, 35, and 36. The only spatially related ground water wells reporting detections of DCPD occurred in Sections 26 and 23 immediately north of Basin F.

3.2.8.2 Denver Distribution

Two detections of DCPD were observed in the Denver aquifer wells sampled during the ISP. Concentrations were 16.7 µg/l in well 23187 and 1510 µg/l in monitoring well 01014 from Sections 1 and 23, respectively.

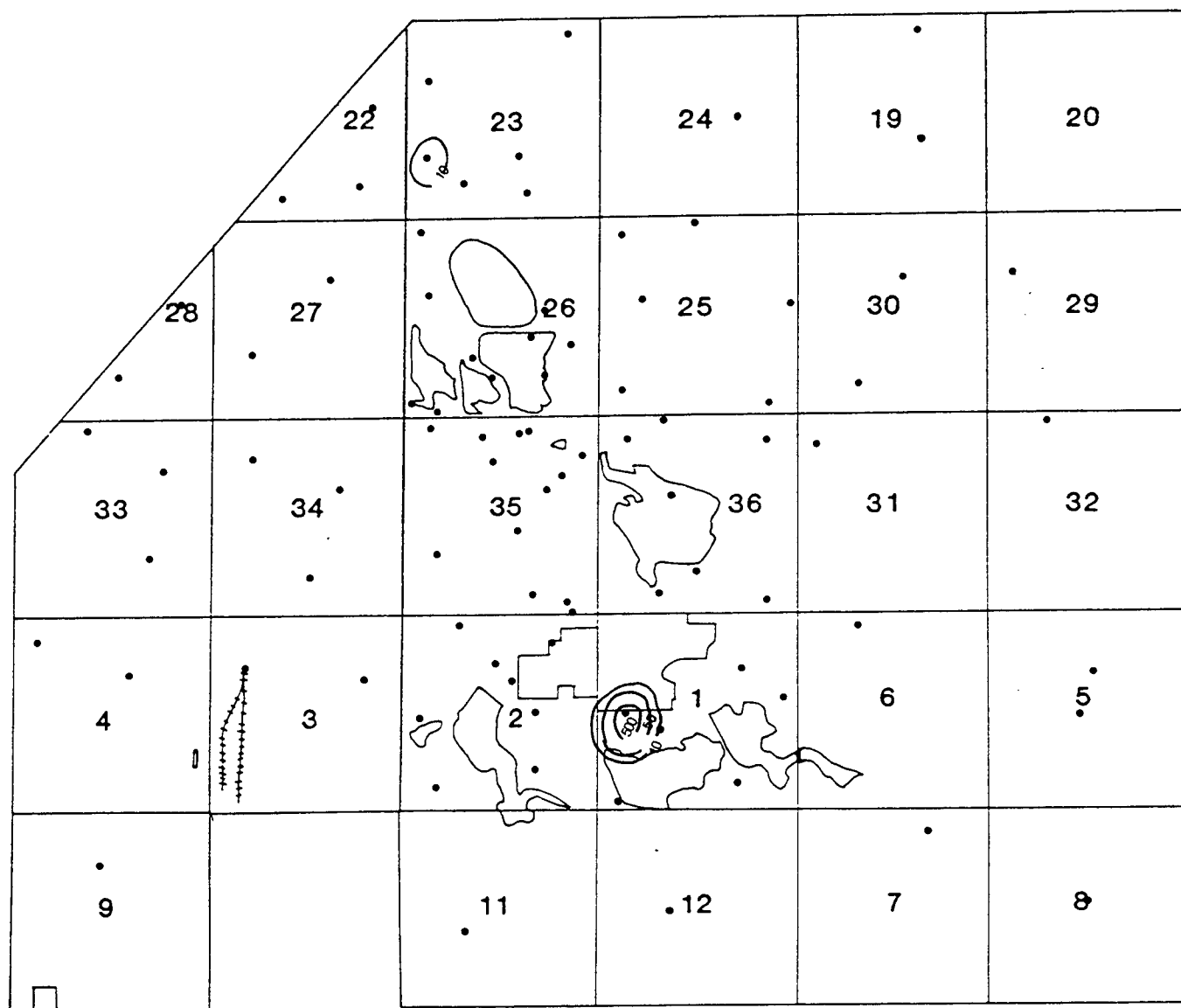
3.2.8.3 Comparison of Alluvial to Denver Water Quality

The detections of DCPD in the alluvial aquifer do not have corresponding detections of this compound in the Denver aquifer.

3.2.8.4 Comparison of ISP to Historical Water Quality Data

The historical distribution maps identifying DCPD in alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-13.

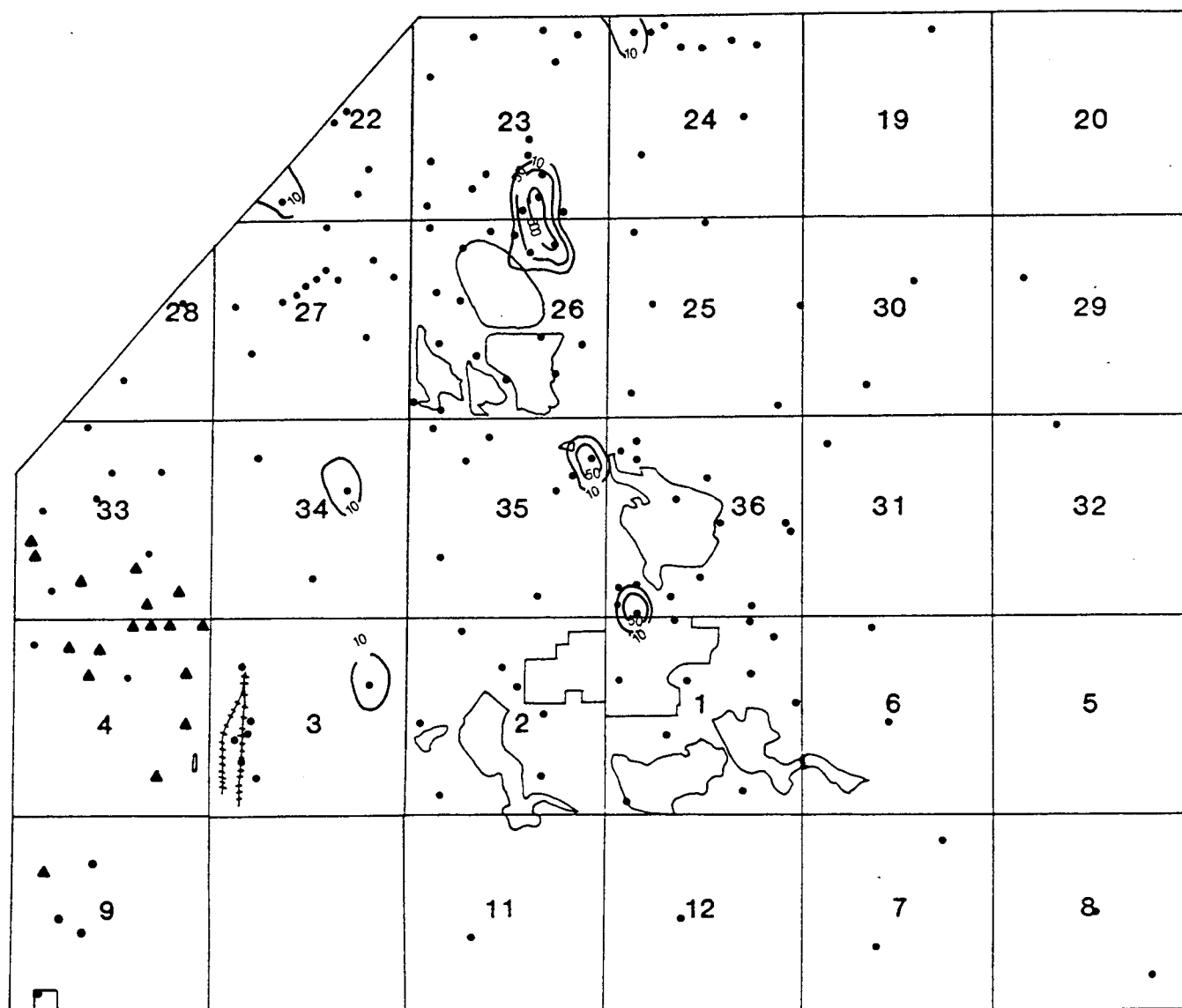
A comparison of the current ground water distribution map with the historical data shows significant discrepancies in the distribution of DCPD. Major plumes reaching the northern border of RMA in Sections 23 and 24 have been identified in ground water as indicated on the historical maps. Widespread distribution of the compound was also reported in Sections 1, 35, and 36. These plumes have not been identified in the current chemical data base. Isolated areas of reported DCPD concentrations in the historical data were reported in Sections 22, 27, 28, and 33. Again, these anomalies are not confirmed in the current chemical data base.



DENVER WELLS

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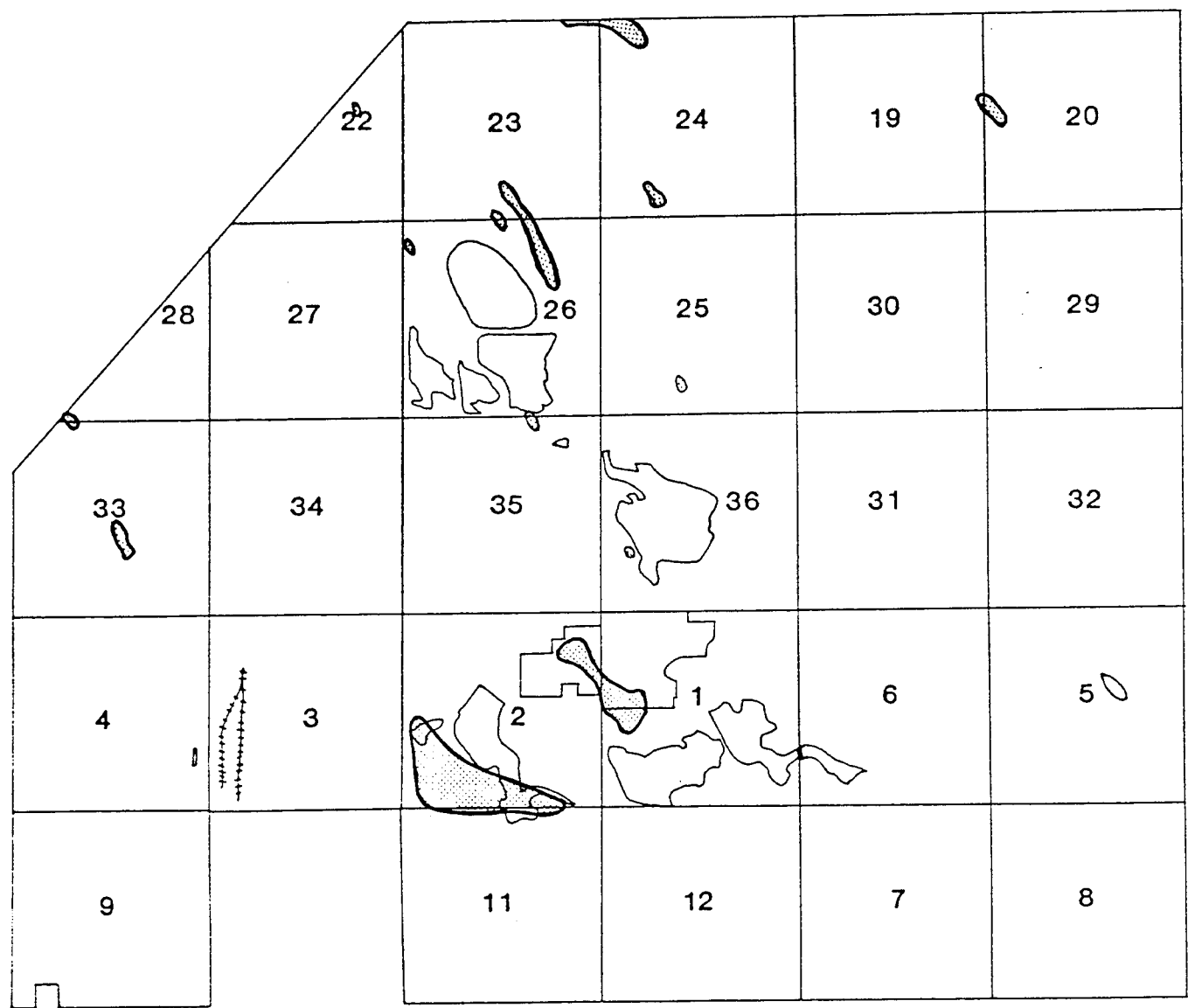
Figure 3.2-12
INITIAL SCREENING PROGRAM DCPD DISTRIBUTION IN THE DENVER AND A



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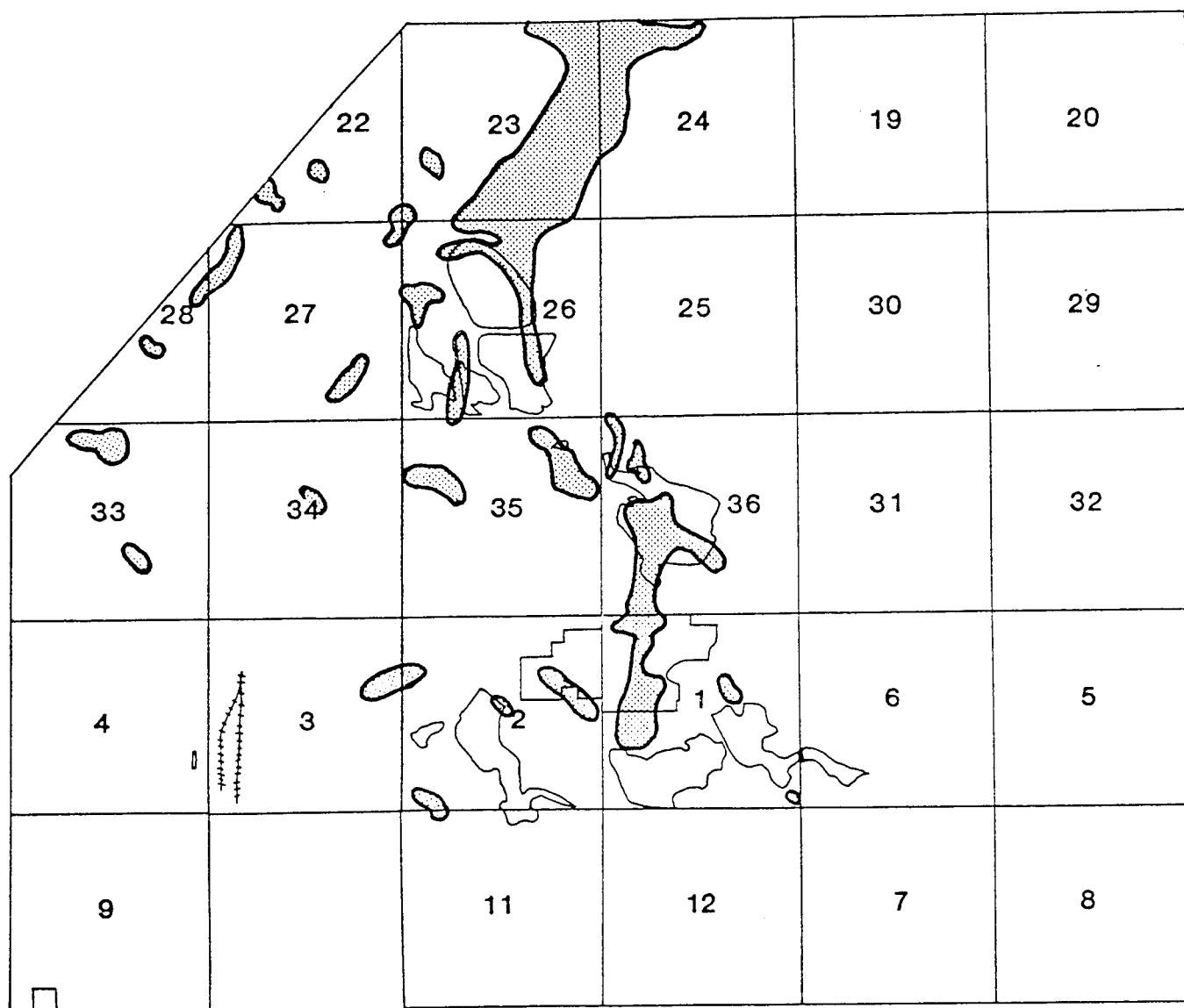
EXPLANATION



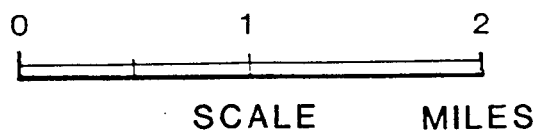
AREAS WHERE DETECTED

Figure 3.2-13

HISTORICAL DCPD DISTRIBUTION IN THE DENVER AND ALLUVIAL AQUIFERS



ALLUVIAL WELLS



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Historical data presented in Spaine et al. (1984) report that high concentrations of DCPD were associated with the South Plants area, Basin A, and the Basin A-Neck area. A plume was also identified immediately downgradient of Basin F extending to the north boundary of RMA. A comparison of the chemical data shows that DCPD was more widely distributed and concentrations significantly higher in ground water samples analyzed during the 1984 investigation.

A comparison of the current Denver ground water chemical data with historical data shows major discrepancies in the distribution of DCPD. Major plumes are identified in the historical data in Sections 1, 2, 23, 24, and 26. These plumes are not identified in the current Denver data base. Isolated anomalies have also been identified in Sections 19, 20, 28, and 33. These anomalies are not identified in the current chemical data base.

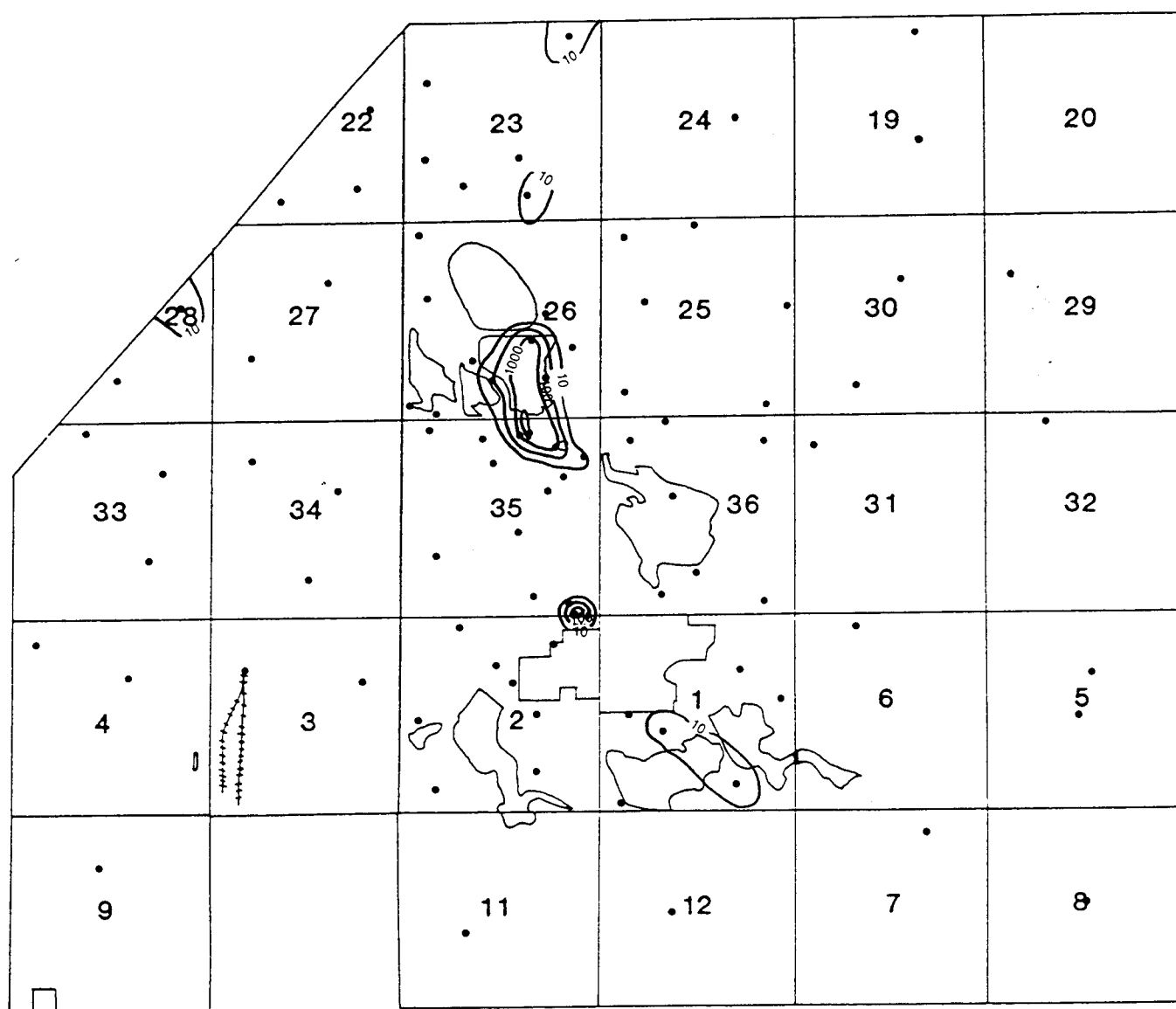
3.2.9 DIMP

Of the 319 ground water samples collected during the ISP, 50 contained detectable concentrations of DIMP. These concentrations ranged from 12 to 14,000 µg/l. The concentrations of DIMP have been plotted on separate alluvial and Denver aquifer maps to examine the distribution in the ground water system.

3.2.9.1 Alluvial Distribution

Measureable concentrations of DIMP were found in ground water in 40 of the 151 alluvial ground water samples analyzed. Twenty-five samples were not analyzed for DIMP. Concentrations in the alluvium ranged from 12 to 14,000 µg/l. The highest concentration was observed in well 36084. Figure 3.2-14 presents the distribution of DIMP in the alluvial aquifer. Significant concentrations are present in the vicinity of Basins A, B, C, and F. Lower concentrations were observed north of Basin F towards the north and northwest. The lack of monitoring well data in the northern portion of Section 23 does not allow for a high degree of confidence in concentration contours presented in Figure 3.2-14.

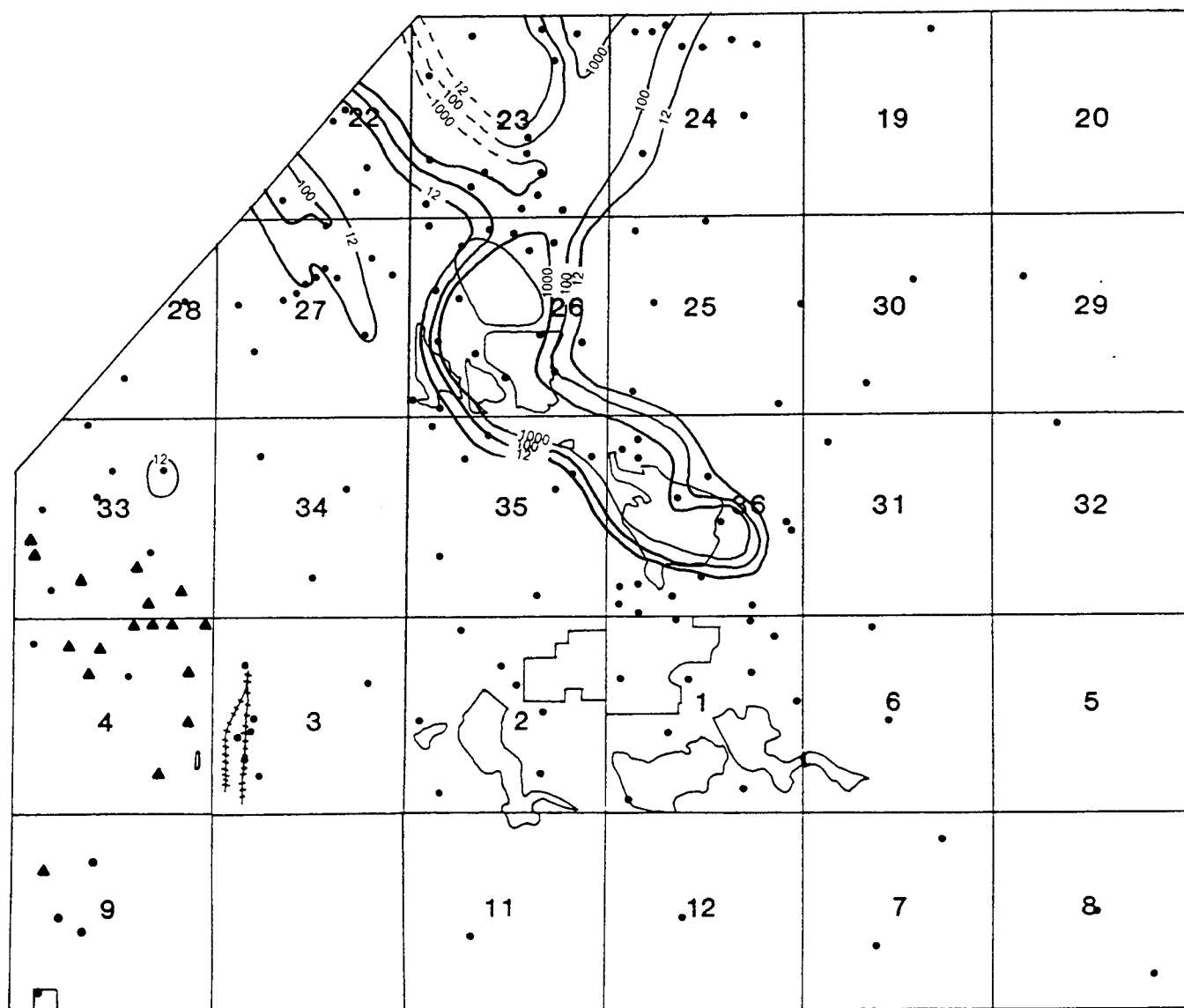
Measureable concentrations of DIMP were also observed along the northwest boundary within Sections 27 and 22.



DENVER WELLS

0 1/2 1 MILE

Figure 3.2-14
INITIAL SCREENING PROGRAM DIMP DISTRIBUTION IN THE DENVER AND AL



ALLUVIAL WELLS

ALLUVIAL AQUIFERS

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3.2.9.2 Denver Distribution

DIMP was identified in 10 of the 142 Denver ground water samples analyzed. Concentrations ranged from 76 µg/l to 11,000 µg/l. The distribution of DIMP in the Denver aquifer is plotted in Figure 3.2-14. Highest concentrations were observed at well 35012. Several isolated occurrences of DIMP were found in Sections 1, 23, and 28. Several related detections of DIMP in the Denver were observed in the vicinity of Basins B, C, and F. However, no detections of DIMP in the Denver were observed in the northern portion of Section 26.

3.2.9.3 Comparison of Alluvial to Denver Water Quality

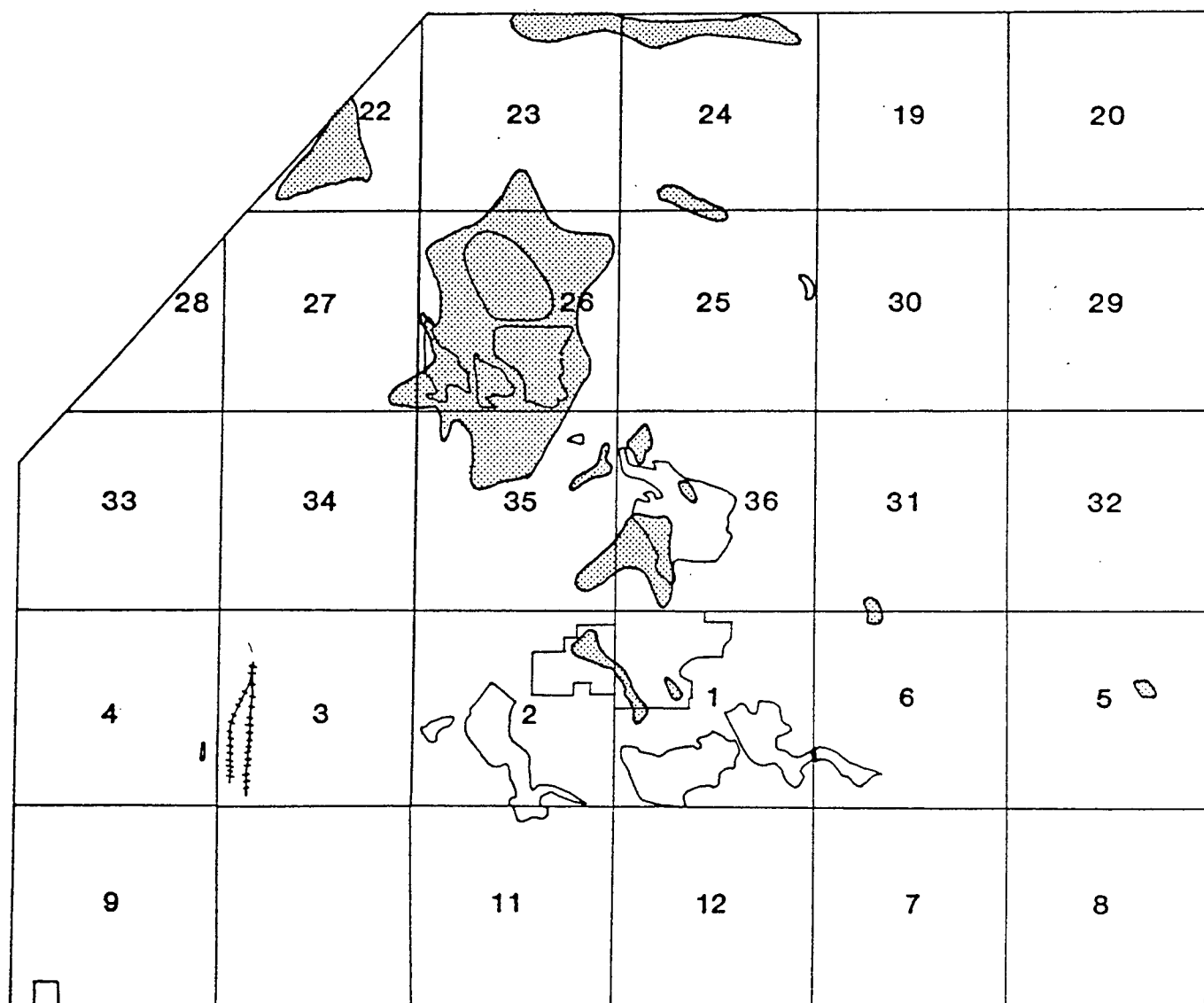
The primary area of DIMP in alluvial ground water occurs from Basin A through Basins B, C, and F with significant distributions occurring toward the north and northwest boundaries of RMA. An associated occurrence of DIMP is present in the Denver in the vicinity of Basins B, C, and F. No measureable concentrations were detected immediately north of Basin F.

Isolated detections of DIMP in the Denver aquifer within Sections 1, 28, and the southern portion of Section 35 do not have corresponding occurrences in the alluvial aquifer.

3.2.9.4 Comparison of ISP to Historical Water Quality Data

Historical chemical distribution maps identifying DIMP in the alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-15.

A comparison of the ISP ground water distribution map of DIMP in the alluvial aquifer confirms the general plume trends identified in the historical chemical data base. The two data sets identify the presence of DIMP associated with known sources, particularly Basins A and F. Coincident plumes are also shown along the northern boundary of RMA in Sections 22, 23, and 24. Some discrepancies between the current and historical data sets are identified in Sections 1 and 2 (South Plants area) where the historical data reports identifiable concentrations of DIMP. ISP chemical data does not coincide with these reported concentrations. Small anomalies of DIMP in alluvial ground waters have been identified in Sections 3, 25, 30 and 33 of the historical data base. This is inconsistent with the current chemical data.



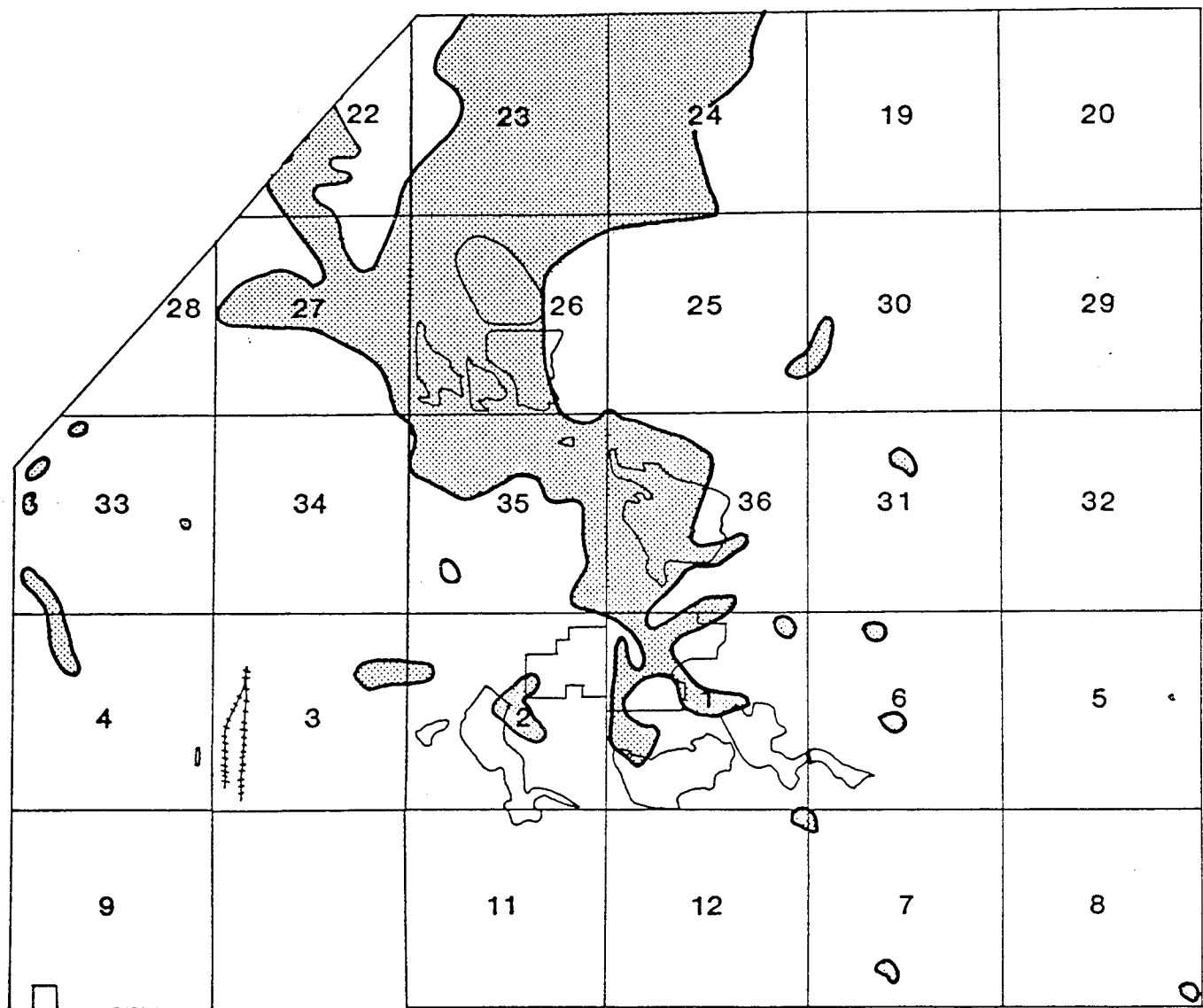
DENVER WELLS

EXPLANATION



AREAS WHERE DETECTED

Figure 3.2-15
HISTORICAL DIMP DISTRIBUTION IN THE DENVER AND ALLUVIAL AQUIFERS



ALLUVIAL WELLS

0 1 2
SCALE MILES

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Historical data in Spaine et al. (1984) show that high concentrations of DIMP originate in Basin A and extend northwest through the Basin A-Neck to Basin C. High concentrations were also identified around and immediately downgradient of Basin F. These plumes extended northeast and northwest towards the northern boundaries of RMA. A plume was also identified north of the GB plant. General plume trends for both data sets are in agreement; however, the areal distribution of DIMP is more extensive as shown in the report. The concentration range of DIMP in alluvial ground water was also in general agreement when the ISP and historical data sets were compared.

A comparison of the current Denver ground water chemical data with the historical Denver data confirms concentrations of DIMP in ground water in Section 35 south of Basin F. The historical data identify a widespread distribution of DIMP in Sections 23 and 24 (north boundary) and in Section 22 along the northwest boundary of RMA. Occurrences of DIMP have also been identified in Section 30. These historically identified alluvial plumes are not confirmed in the ISP chemical data base.

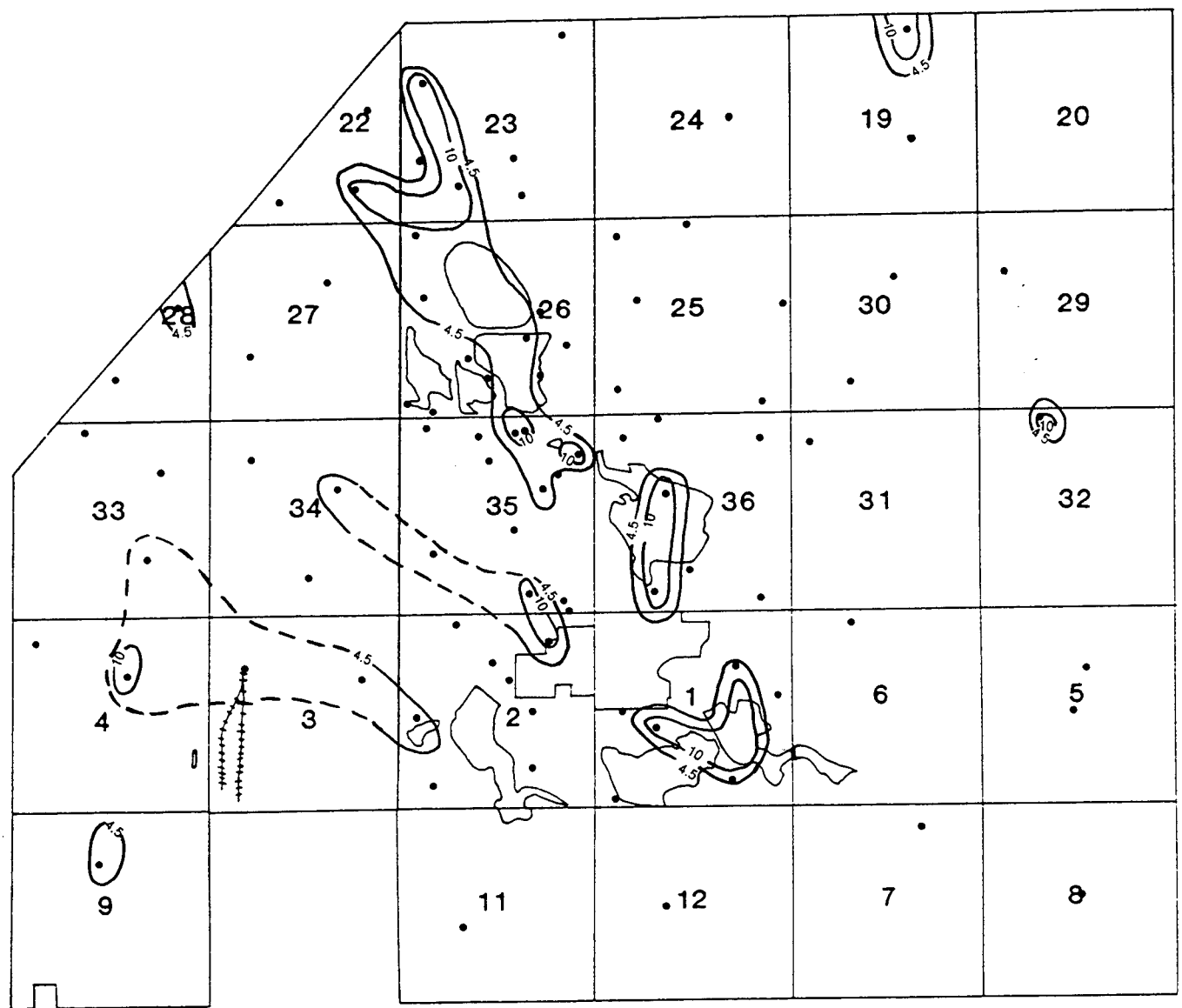
3.2.10 ARSENIC

A total of 128 ground water samples were analyzed for arsenic with measureable concentrations found in 78 samples. Concentrations ranged from values of 4 µg/l to of 270 µg/l. The highest concentration was reported in well 36076. The distribution of arsenic in the alluvial and Denver aquifers have been plotted on separate maps and will be discussed in the following subsections.

3.2.10.1 Alluvial Distribution

Arsenic was identified in 38 of the 65 alluvial ground water samples analyzed. Concentrations ranged from 4.3 µg/l (well 03008) to 270 µg/l (well 36076). Highest concentrations were reported in Section 36 and in the Basin A-Neck.

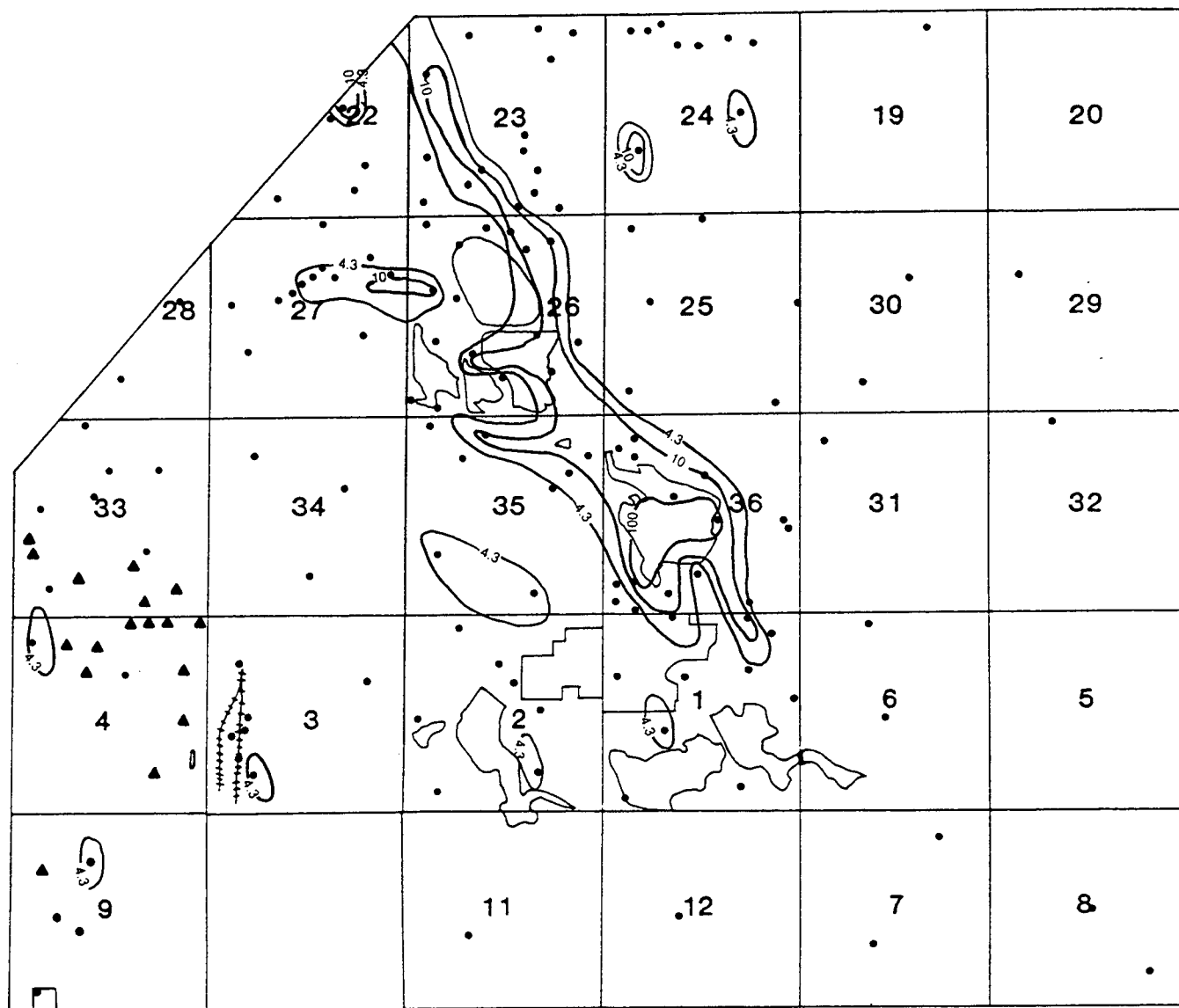
The distribution of arsenic in the alluvial aquifer is shown in Figure 3.2-16. The general vicinity of Basin A shows the highest levels of arsenic while decreasing concentrations occurred through the Basin F area towards the northern boundary of RMA. The continuity of arsenic identified in Section 23 and extending toward the northern boundary is uncertain due to the lack of water quality control in the immediate vicinity of the boundary at this location.



DENVER WELLS

0 1/2 1 MILE

Figure 3.2-16
INITIAL SCREENING PROGRAM ARSENIC DISTRIBUTION IN THE DENVER AN



ALLUVIAL WELLS

D ALLUVIAL AQUIFERS

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Apparent isolated occurrences of arsenic were identified in Sections 1, 2, 3, 4, 9, 22, 24, and 32. These detections were generally at concentrations less than 10 µg/l.

3.2.10.2 Denver Distribution

Arsenic was identified in 40 Denver ground water samples analyzed. Concentrations ranged from 4.5 µg/l (well 26128) to 35 µg/l (well 35012). Highest concentrations were identified in Sections 35 and 36, west of the Basin A-Neck area and in the South Plants area of Section 1. Arsenic was also identified in ground water in several wells located in Sections 2, 3, 4, and 33.

Figure 3.2-16 shows the distribution of arsenic in the Denver aquifer. Due to the limited number of Denver aquifer wells analyzed for arsenic in the ISP, it is uncertain whether the detections observed in Figure 3.2-16 are related in the form of contaminants plumes. Therefore dashed contour lines have been presented in the figure to represent the most probable but unconfirmed distribution of arsenic in ground water. Of note are occurrences of arsenic in Denver ground water in Sections 1, 3, 4, 9, 19, 23, 26, 34, 35, and 36.

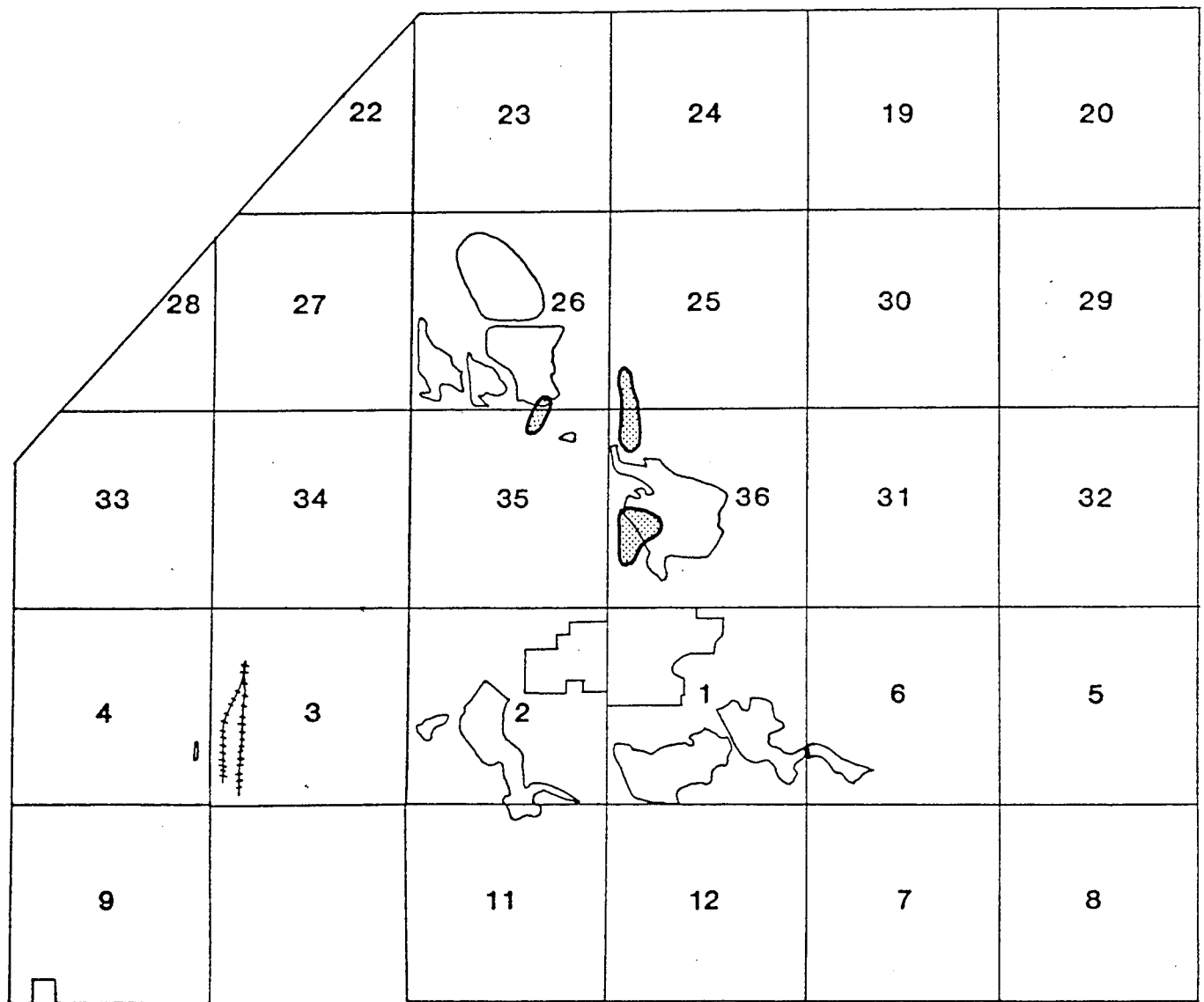
3.2.10.3 Comparison of Alluvial to Denver Water Quality

The comparison of the relatively well documented alluvial distribution of arsenic in the vicinities of Basins A, B, C, and F to the arsenic distribution in the Denver aquifer shows a previously undocumented component in the Denver ground water.

The presence of arsenic in both aquifers within the southern portion of Section 35 should also be noted. Isolated detections of arsenic in Denver ground water in Sections 2, 19, and 24 do not correspond with alluvial ground water data. However, numerous detections in single wells located in Sections 1, 9, and 32 report measureable concentrations of arsenic in both the alluvium and Denver aquifers.

3.2.10.4 Comparison of ISP to Historical Water Quality Data

The historical distribution maps identifying arsenic in alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-17.



DENVER WELLS

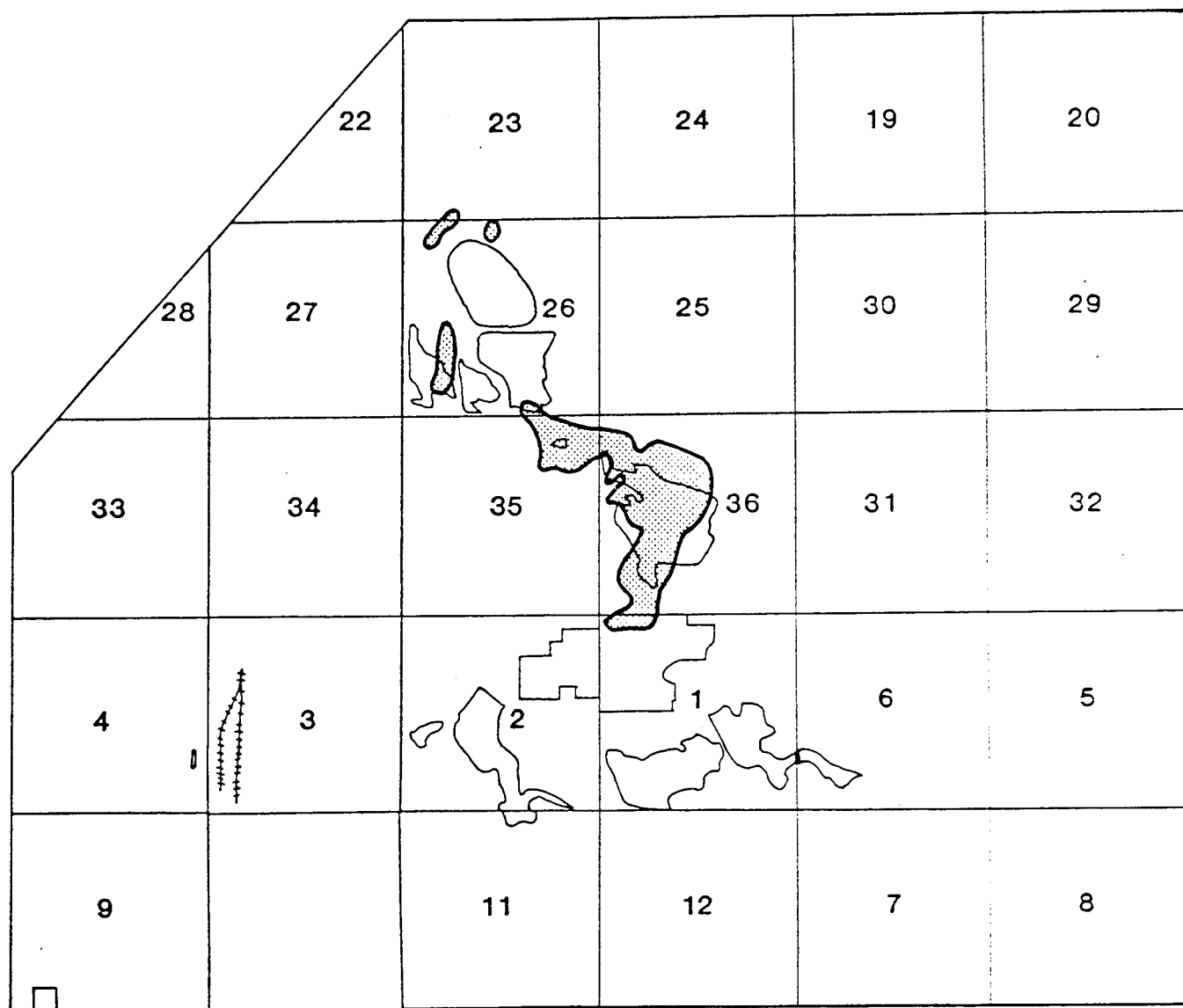
EXPLANATION



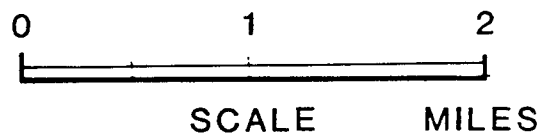
AREAS WHERE DETECTED



Figure 3.2-17
HISTORICAL ARSENIC DISTRIBUTION IN THE DENVER AND ALLUVIAL AQUIFER



ALLUVIAL WELLS



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A comparison of the ISP alluvial ground water data with the historical alluvial ground water data confirms general plume trends for arsenic. Both data sets report that concentrations are associated with known sources, particularly Basin A, the Acid Lime Pits (Section 36), and the Basin A-Neck area (Sections 35 and 36). ISP chemical data identify potential plumes in the southern portion of Section 35, and in Sections 26 and 27, west of Basin F. A potential plume extending toward the northern boundary of RMA has also been identified in Section 23. These plumes had not been previously identified in the historical data base. Isolated, single point anomalies have been identified in the current chemical data base in Sections 1, 2, 4, 9, 22, 24, and 32. These data are not confirmed by the historical chemical data.

A comparison of ISP Denver ground water chemical data with historic Denver data shows major discrepancies in the distribution of arsenic. ISP chemical distribution maps show that concentrations of arsenic are associated with known sources, particularly Basin A, Basin F, and the South Plants area. A plume has also been identified exiting north of the Basin F area towards the northern boundary of RMA in Section 23. These plumes were not previously identified in the historical data. Two isolated plumes have also been identified in Sections 2, 34, and 35 and Sections 2, 3, 4, and 33. These plumes are not consistent with the historical data.

3.2.11 FLUORIDE

A total of 296 ground water samples were analyzed for fluoride during the ISP. Of these samples, fluoride was detected in 181 at concentrations ranging from 1.2 mg/l to over 300 mg/l. The distribution of fluoride in both alluvial and Denver aquifers has been plotted and the data summarized in the following subsections of this report.

3.2.11.1 Alluvial Distribution

Fluoride was identified in 95 of 153 alluvial ground water samples analyzed. Twenty-three samples were not analyzed for fluoride. Concentrations ranged from 1.2 mg/l (in several wells) to 307 mg/l in well 26041. Highest concentrations of fluoride were identified northeast of Basin F and throughout the central areas of Sections 1 and 36.

The distribution of fluoride in the alluvial aquifer is shown in Figure 3.2-18. Concentrations of fluoride above background levels are generally confined to areas where concentrations of target organic analytes were found to be present. Moderate concentrations of fluoride are present in the alluvial ground waters in the South Plants area of both Sections 1 and 2. Fluoride was also detected in the Basin A area and through the Basin A-Neck. Moderate and continuously observed concentrations of fluoride are also present in the vicinity of the Basins (C, D, E, and F) and onward to both the north and northwest boundary of RMA.

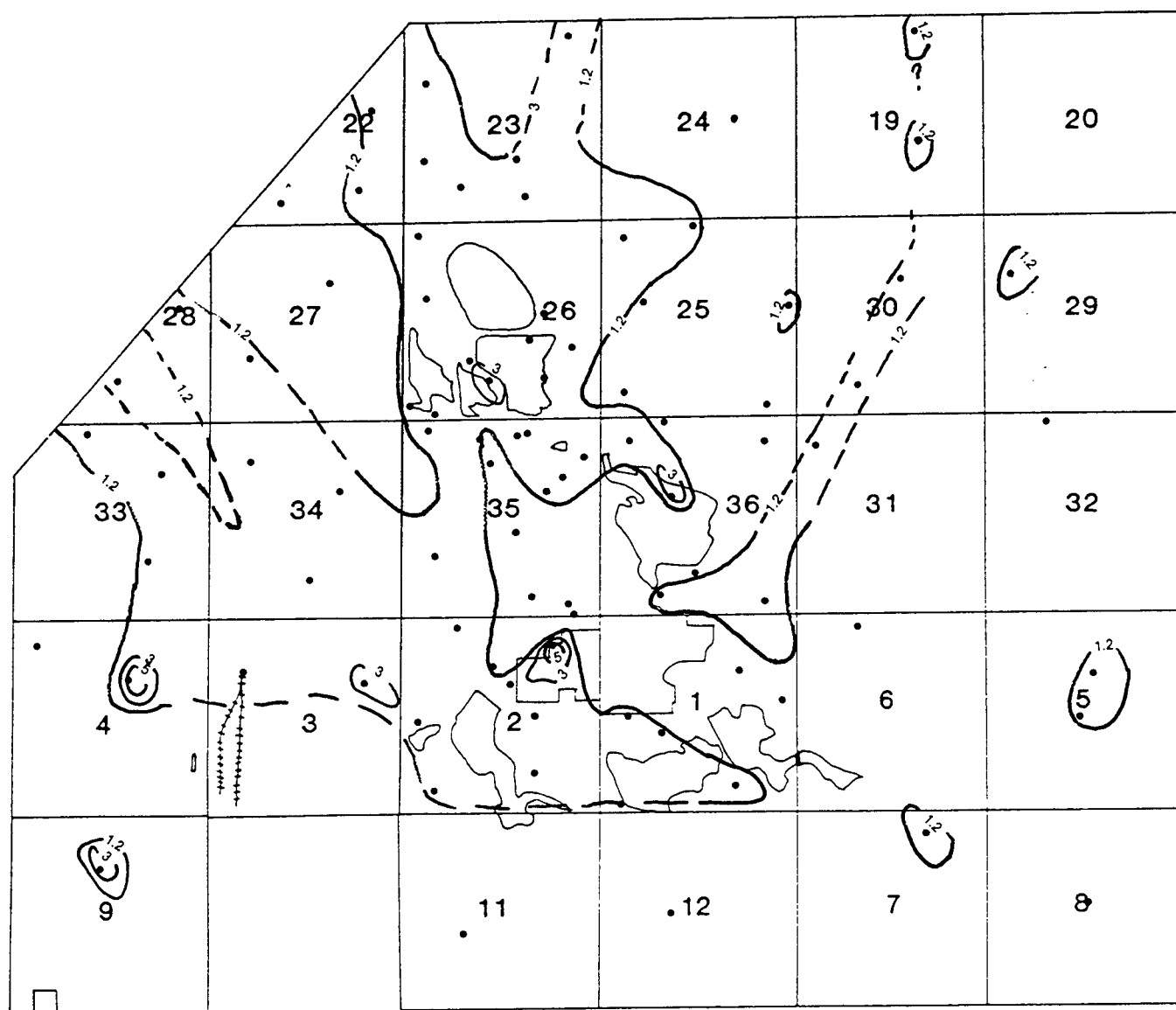
3.2.11.2 Denver Distribution

Fluoride was identified in 86 of the 143 Denver ground water samples analyzed. Concentrations ranged from 1.2 mg/l to a maximum of 9.5 mg/l in well 03007. Detectable fluoride concentrations were observed throughout large areas of the Denver aquifer (Figure 3.2-18). Highest concentrations were observed in Sections 36, 26, and 3. With the exception of a few anomalously high values, concentrations of fluoride are evenly distributed throughout the areas immediately downgradient of the primary contaminant sources.

3.2.11.3 Comparison of Alluvial to Denver Water Quality

The distribution of fluoride in the alluvial and Denver aquifers (Figure 3.2-18) is generally very similar. However, higher concentrations are almost always observed in the alluvial aquifer. With respect to the Basins area, fluoride concentrations in both aquifers are distributed throughout the Basins A, B, C, and F areas with moderate concentrations trending towards the north and northwest boundaries. Subtle differences in the distribution pattern could be the result of a lesser number of Denver aquifer wells and the locations of wells in both aquifers.

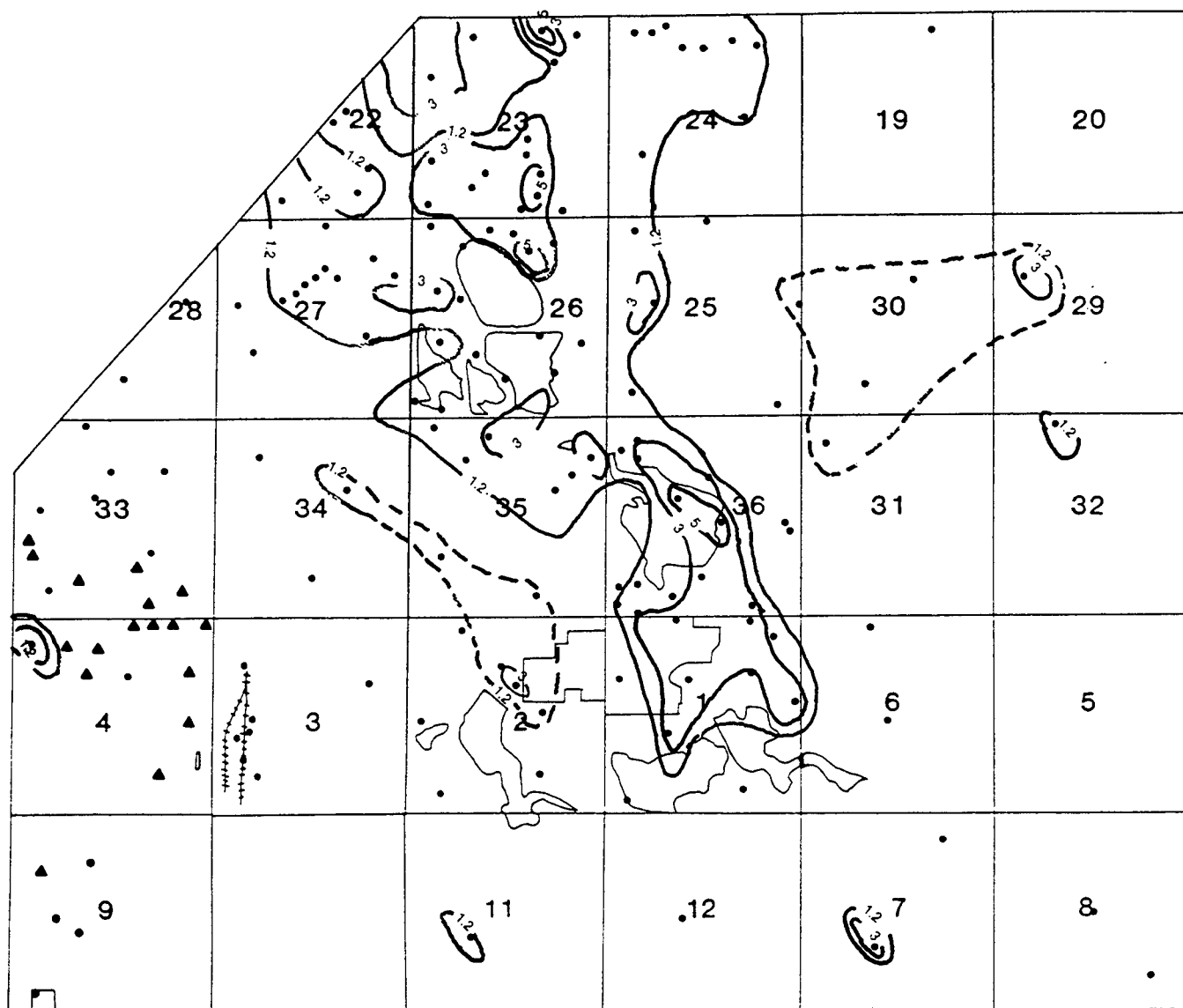
One major difference in the distribution of fluoride in the alluvium and Denver aquifers is the moderate concentrations trending from Section 2 through Sections 3, 35, 27, and 33 for the Denver aquifer. This distribution was not observed in the alluvial aquifer.



DENVER WELLS

0 1/2 1 MILE

Figure 3.2-18
INITIAL SCREENING PROGRAM FLUORIDE DISTRIBUTION IN THE DENVER AREA



ALLUVIAL WELLS

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3.2.11.4 Comparison of ISP to Historical Water Quality Data

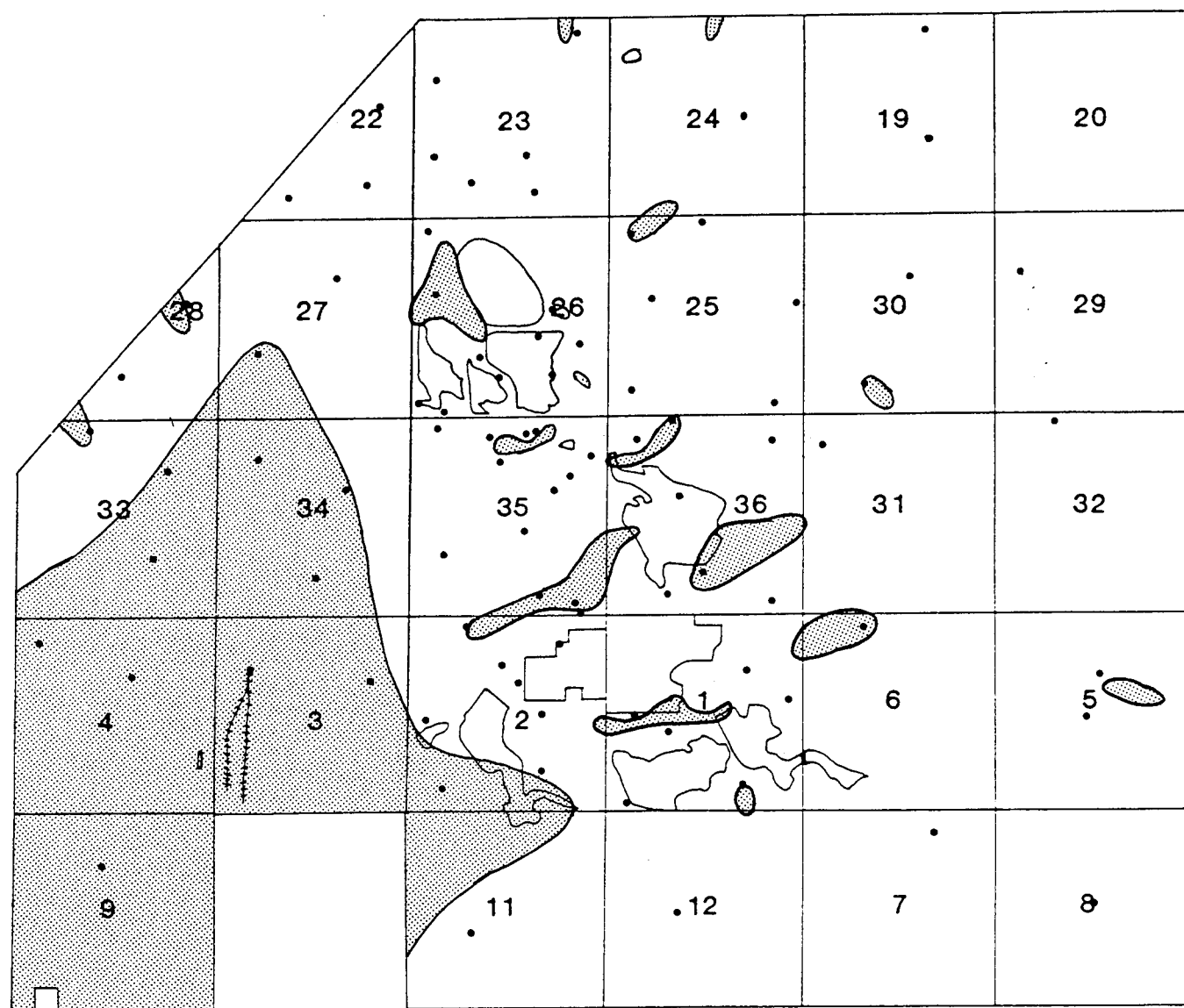
The historical distribution maps identifying fluoride in alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-19. Historical data presented in Spaine et al. (1984) report that fluoride concentrations in ground water parallel plume trends observed in the ISP data base. Concentrations of fluoride in alluvial ground water were also similar on a RMA wide basis.

A comparison of the ISP alluvial ground water distribution map with the alluvial historical data confirms general plume trends. Both sets of chemical data report findings of widespread fluoride distribution throughout RMA. The highest concentrations in both aquifers are coincident and are identified in areas associated with known sources, particularly Basins A (Section 36) and F (Sections 23 and 26) and the South Plants area (Section 1). ISP chemical data identify an extended plume in Sections 2, 35, and 36 which was not identified in the historical data base. Single point anomalies which were identified in the current data base in Sections 4 and 7, are not coincident with historical detections.

A comparison of the ISP Denver ground water chemical data confirms general plume trends identified in the historical data for fluoride. Both data sets identify fluoride concentrations associated with known sources, particularly Basin F (Sections 23 and 26) and the South Plants area (Section 1). The current chemical data base reports a generalized plume extending from Sections 1 and 2 through Sections 13, 22, 23, 33, and 34 which was not previously identified in the historical data base. Another potential plume which has been identified from data reported in the ISP data base extends from the southeast corner of Section 36 in a northeasterly direction through Sections 31 and 30. This fluoride distribution was not previously identified in the historical data base.

3.2.12 CHLORIDE

A total of 295 ground water samples were analyzed for chloride during the ISP. Chloride was detected in 290 ground water samples and ranged in concentration from 4.8 mg/l to over 25 g/l. The distribution of chloride concentrations in



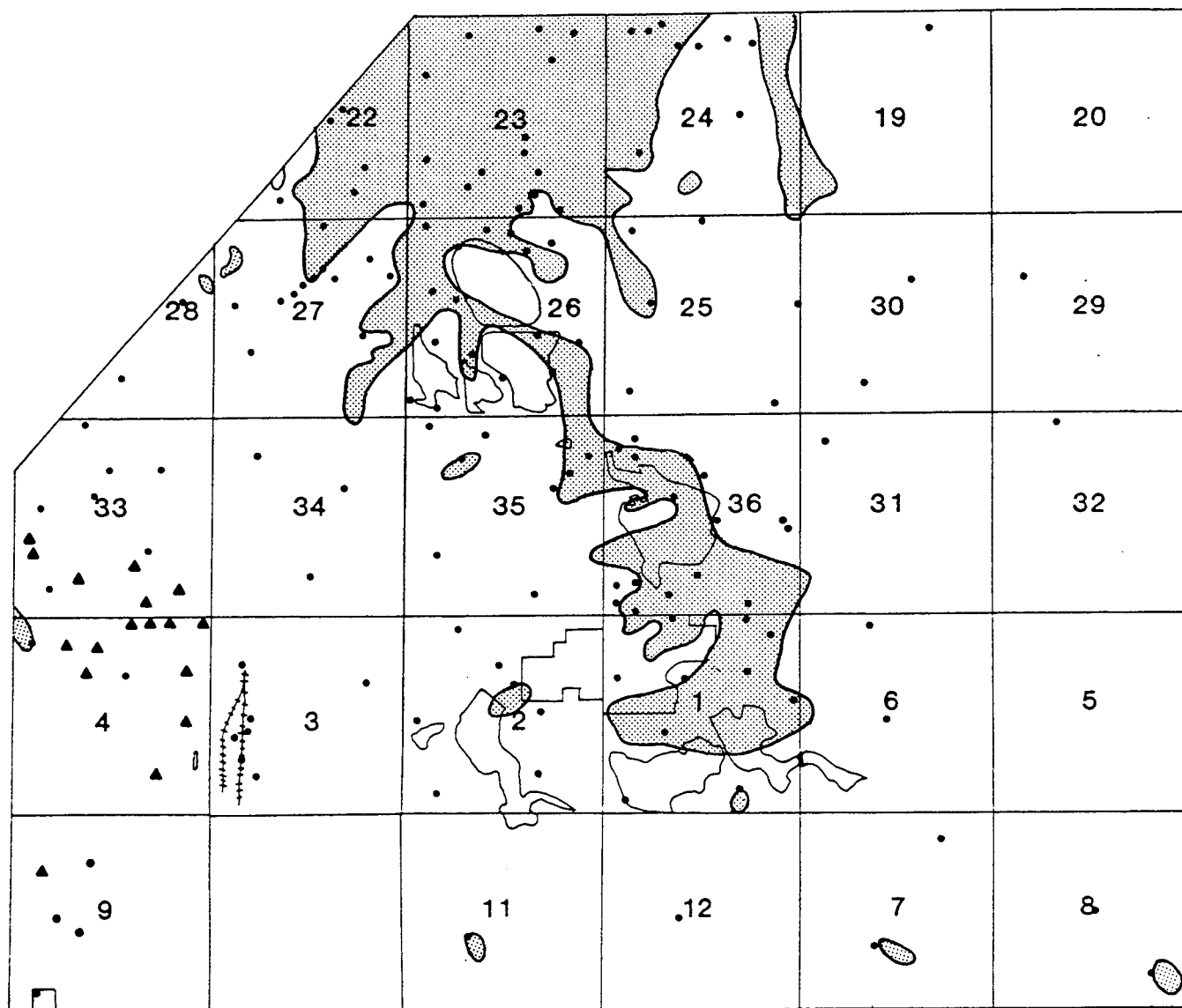
DENVER WELLS

EXPLANATION

 AREAS WHERE DETECTED

0  1/2 1 MILE

Figure 3.2-19
HISTORICAL FLUORIDE DISTRIBUTION IN THE DENVER AND ALLUVIAL AQU



ALLUVIAL WELLS

both the alluvial and Denver aquifers have been plotted and the data presented in these maps are summarized in the following subsections.

3.2.12.1 Alluvial Distribution

Chloride was reported in 149 of the 152 ground water samples analyzed from alluvial monitoring wells. Concentrations ranged from 4.9 mg/l (several wells) to 25.9 g/l in well 26041.

Concentrations of chloride were observed throughout large portions of the Denver aquifer. The highest concentrations were observed in areas associated with known sources in Sections 1, 23, 26, and 36 (Figure 3.2-20). Moderate concentrations of chloride are present in alluvial ground waters in the vicinity of Basins C, D, and E and extend in a north and northwesterly direction toward the RMA boundaries.

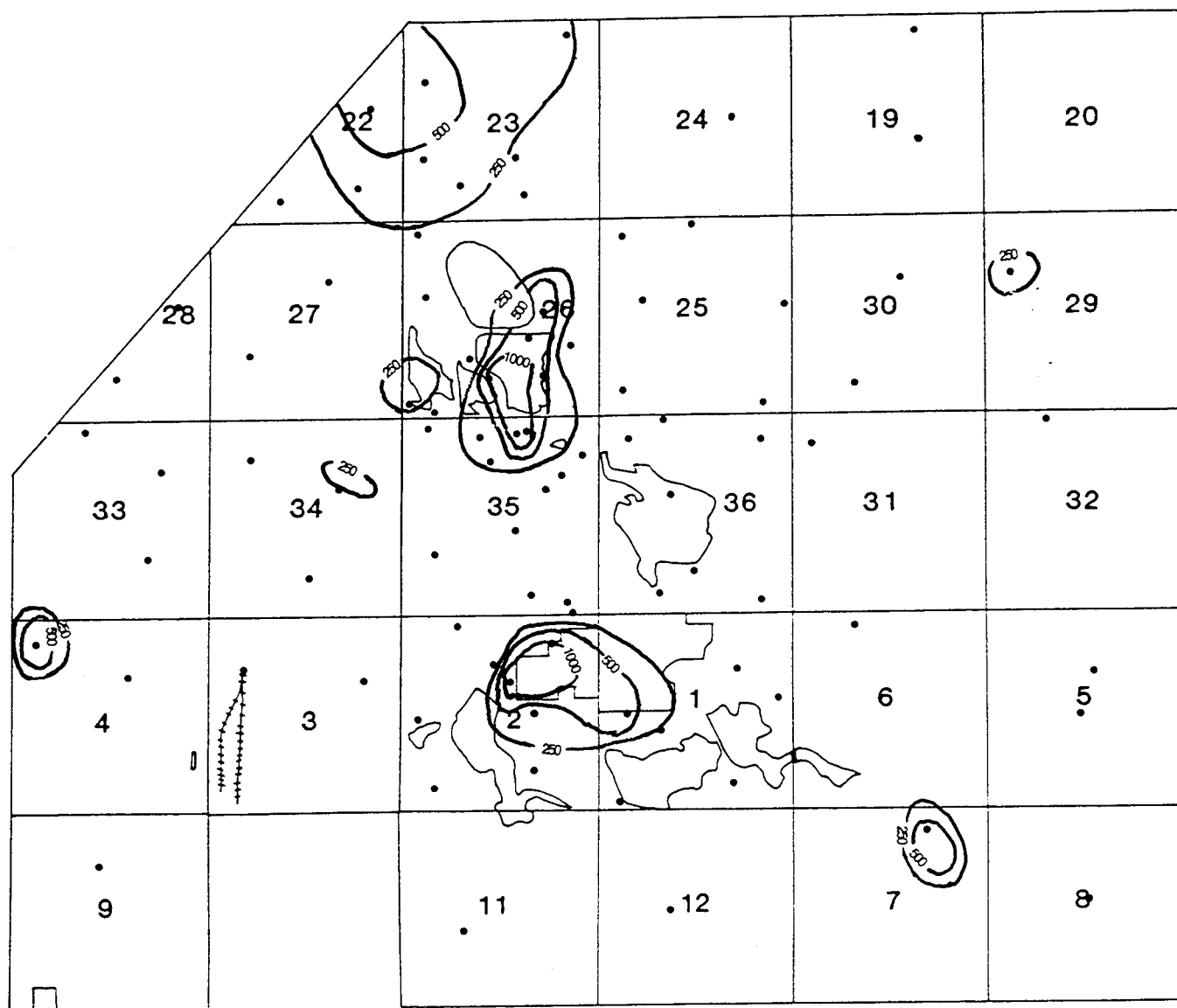
3.2.12.2 Denver Distribution

Chloride was reported in 141 of the 143 Denver ground water samples analyzed. Concentrations ranged from 4.8 mg/l to 4.8 g/l.

The highest concentration of chloride was observed at well 04008. Highest concentrations of chloride were identified in the Denver aquifer south and southeast of Basin F in Section 26 (Figure 3.2-20). High concentrations were also identified in the northeast quadrant of Section 1 and the northeast quadrant of Section 2. Moderate concentrations are reported extending from Sections 1 and 36, through the Basin A-Neck area and northwesterly to Basin F. These concentrations extend in a northerly and northwesterly direction toward the northern boundary of RMA. Upgradient concentrations are also observed in Sections 5, 7, and 29.

3.2.12.3 Comparison of Alluvial to Denver Water Quality

The distribution of chloride in the alluvial and Denver aquifers (Figure 3.2-20) is generally similar and follows observed ground water trends identified by other target analytes. High chloride concentrations in both aquifers are distributed throughout the Basin B, C, and F areas. Moderate concentrations are reported north of Basin F and extend towards the north and northwest boundaries of RMA. Observed differences in chloride distribution between the

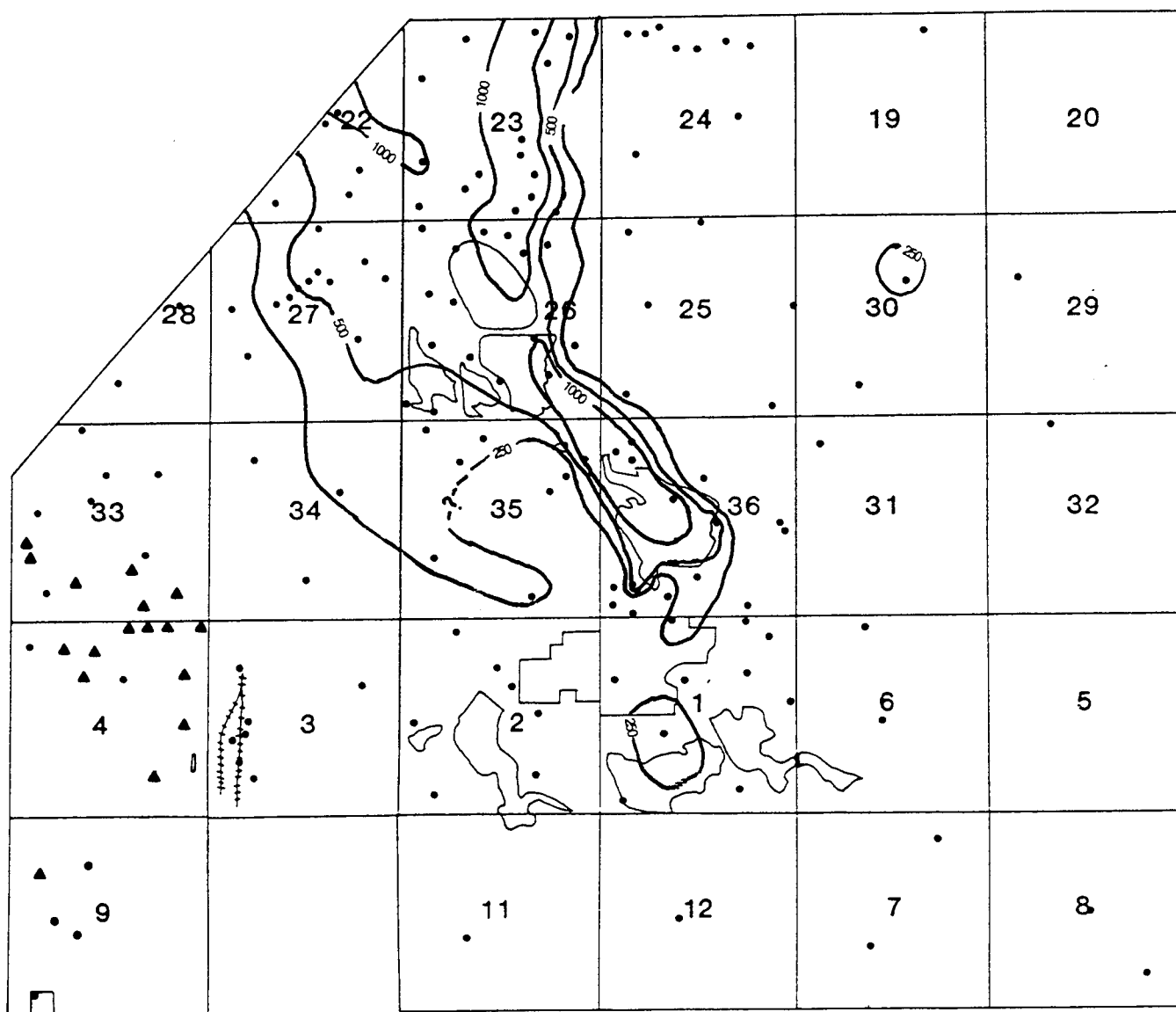


DENVER WELLS

0 1/2 1 MILE

Figure 3.2-20

INITIAL SCREENING PROGRAM CHLORIDE DISTRIBUTION IN THE DENVER AN



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alluvial and Denver aquifers are noted in Sections 1, 2, 36, and in the northwestern quadrant of Section 26. Discrepancies in Sections 2 and 26 are most likely the result of differing well sampling densities between aquifers. High concentrations of chloride in alluvial ground water were reported in Section 26, but were not observed in the underlying Denver aquifer. Single point anomalies were observed in several upgradient Denver wells and in Section 4. These anomalies were not observed in the overlying alluvial aquifer.

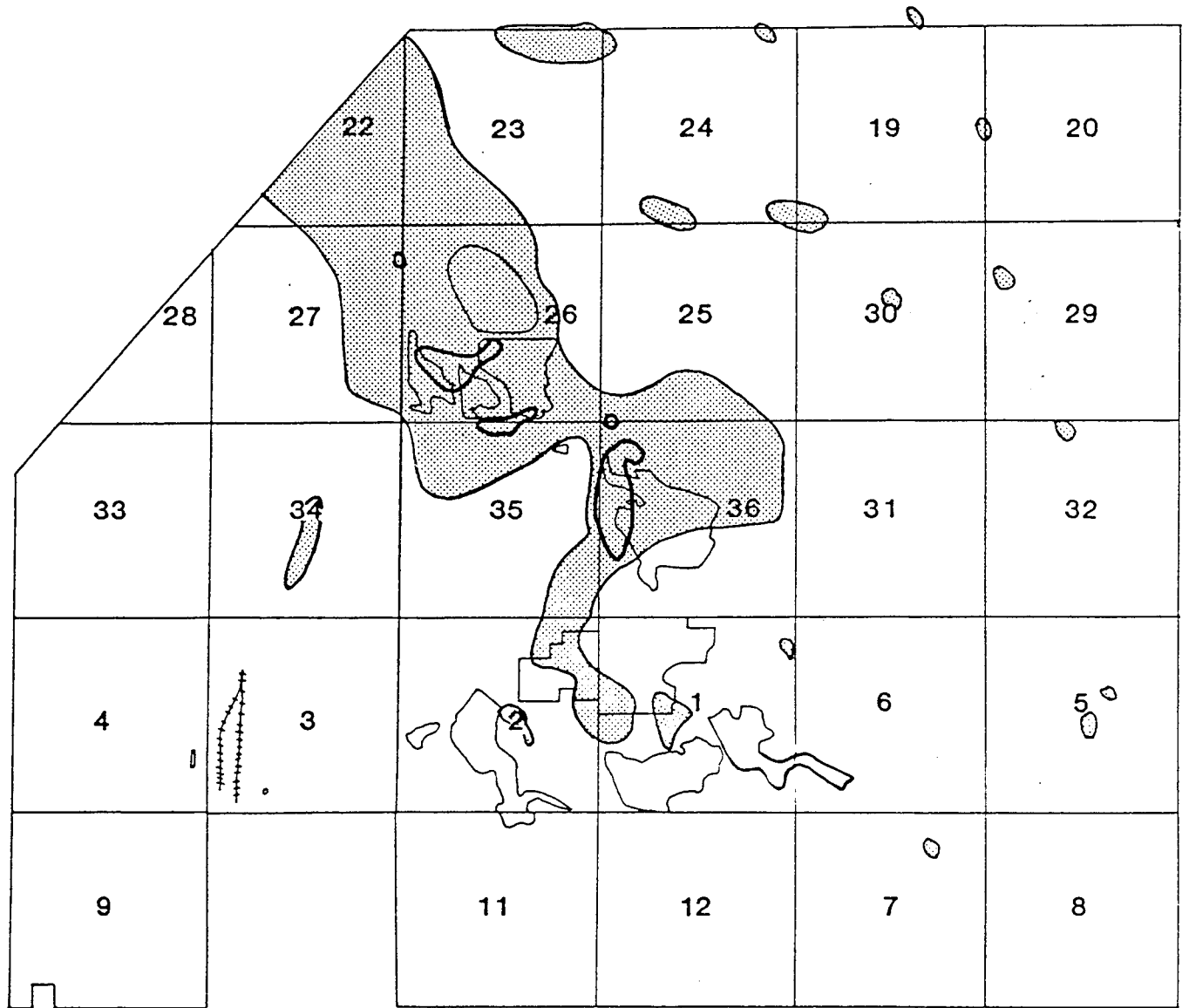
In general, the chloride distribution was more widespread and higher concentrations were observed in the alluvial aquifer. These generalities most likely reflect the overall differences in the location and sampling density of monitoring wells between the alluvial and Denver aquifer.

3.2.12.4 Comparison of ISP to Historical Water Quality Data

The historical distribution maps identifying chloride in alluvial and Denver ground waters have been prepared and are presented in Figure 3.2-21. A comparison of the ISP alluvial ground water distribution maps with alluvial historical maps confirms general plume trends. Both data sets report findings of widespread chloride distribution throughout RMA. Highest identified concentrations are reported for both data sets in areas associated with known sources, particularly Basins A and F and the South Plants. Historical data shows an extended distribution of chloride in Sections 1, 2, 6, 12, 28, and 33. These data are not confirmed in the current chemical data base for reported chloride concentrations.

Historical data presented in Spaine et al. (1984) report that chloride concentrations in ground water parallel the plume trends observed in the ISP data base. Concentrations of chloride on a RMA wide bases were also similar.

A comparison of the ISP Denver ground water chemical data with the historical data confirms general plume trends for chloride. Both data sets report that concentrations of chloride are associated with known sources, particularly Basin F and the South Plants area. The current chemical data show an extended chloride distribution in Section 23 and a single point anomaly in Section 4 which had not been previously identified in the historical data base.



DENVER WELLS

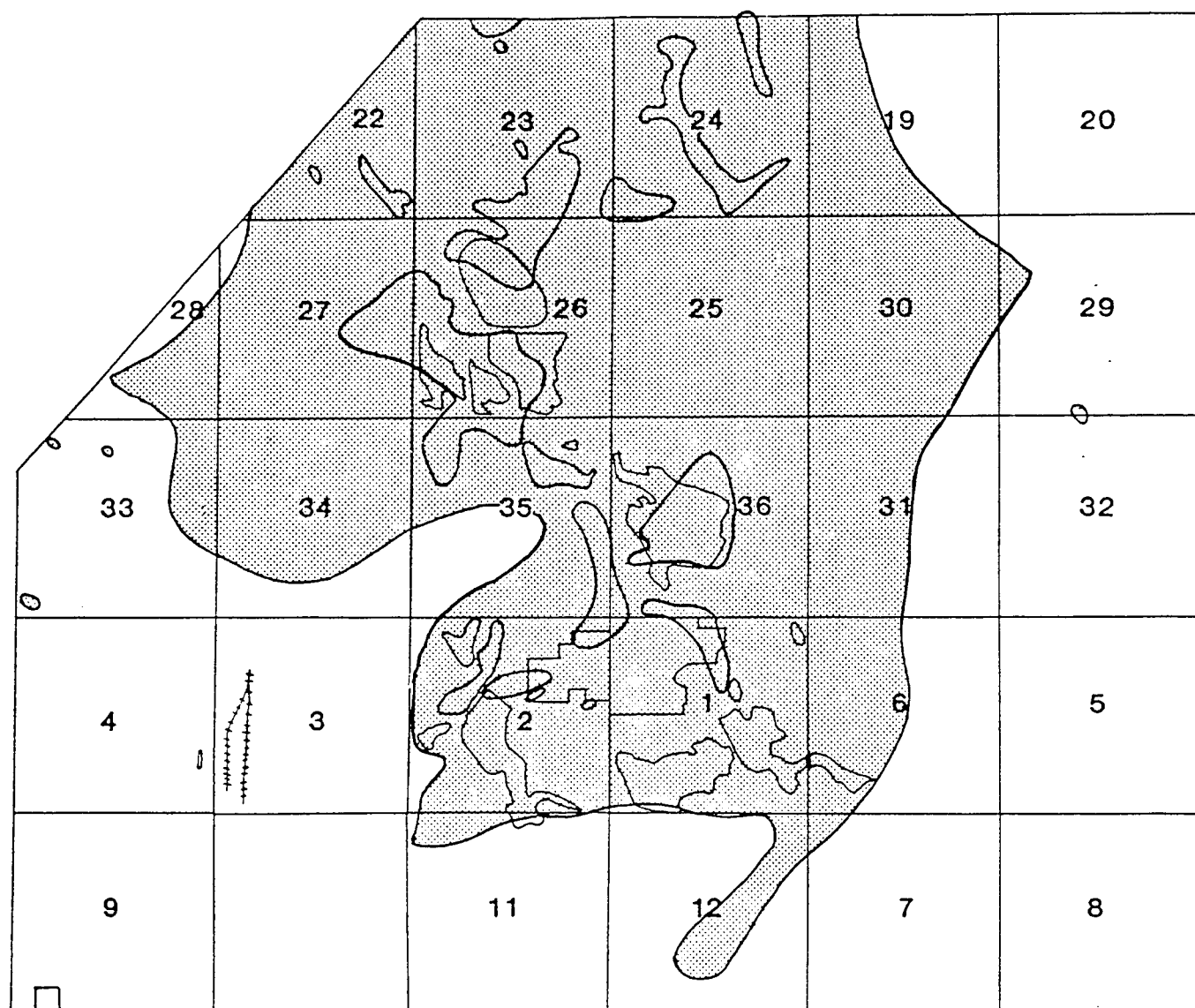
EXPLANATION



AREAS WHERE DETECTED

Figure 3.2-21

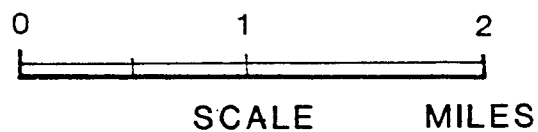
HISTORICAL CHLORIDE DISTRIBUTION IN THE DENVER AND ALLUVIAL AQUIFERS



ALLUVIAL WELLS

CONTOUR INTERVAL

10 mg/l
1000 mg/l



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3.2.13 SUMMARY COMPARISON OF ALLUVIAL/DENVER WATER QUALITY

As described in Section 2.0 of this report, most Task 4 ground water samples were analyzed for a suite of 50 target analytes. Upon review of the resultant analytical data and taking into account frequency of detection, several of these target analytes were grouped into categories based on compound origin and chemical similarities. Five groups were assembled and chemical data were presented in the form of composite distribution maps for organochlorine pesticides, organosulfur compounds, purgeable aromatics, purgeable halocarbons, and dithiane/oxathiane. In addition to analytes which were assembled into groups, the frequency of occurrence and concentrations of several individual analytes were plotted on individual chemical distribution maps. Included in this group were arsenic, DBCP, DCPD, DIMP, chloride, and fluoride.

Each of the resulting chemical distribution maps was examined to determine the distribution of analytes or groups of analytes in the alluvial and Denver aquifers and to assess intra-aquifer chemical interaction. In general, concentrations of target analytes are higher and occur more frequently over a wider area in the alluvial aquifer than in the Denver aquifer. This may be a result of the fact that the primary sources of these organic and inorganic analytes were introduced to the alluvial aquifer in contact with these sources. Natural processes such as molecular diffusion will tend to reduce concentrations of these analytes prior to introduction to the Denver aquifer. The distribution of most analytes in the Denver aquifer is confined to areas beneath or immediately downgradient of primary source areas.

With respect to the organochlorine pesticides, the organosulfur compounds, and dithiane/oxathiane, distributions in the alluvial aquifer are generally confined to the South Plants area of Section 1, Basins A, B, C, and F, and areas between Basin F and the north and northwest boundaries. The distribution of these three classes of compounds in the Denver aquifer appears to be confined to areas in the immediate vicinity of Basin F including the northern portion of Sections 35 and 26. Concentrations of these compounds are significantly lower than concentrations observed in the alluvial ground water.

For the volatile aromatic compounds, the distribution in alluvial ground waters is generally confined to the Basin A area and immediately downgradient of Basin F. The distribution of these compounds in the Denver aquifer is more erratic. Detections in Denver ground water were areally located between the two alluvial anomalies and in several locations downgradient (north or northwest) of the Basins area.

Detections of volatile halocarbons in the alluvial aquifer occurred in the South Plants area of Section 1, throughout the Basins area including Basins A and F, and in ground waters between the Basins and the north/northwest boundaries. These compounds were also present in the Western Tier of Sections 4 and 33. The associated distribution of these compounds in the Denver aquifer shows erratic or sporadic detections in areas where alluvial concentrations had been measured. Concentrations of volatile halocarbons in the Denver are significantly lower and detections less frequent than those observed in alluvial ground water.

Detections of DCPD in both aquifers were generally infrequent and confined to the area downgradient of Basin F in alluvial ground water and in the South Plants area for the Denver aquifer.

The distribution of DIMP in the alluvial aquifer occurs in the Basins area, including Basins A and F, and areas between the Basins and the north boundary. Detections of DIMP in the Denver aquifer were lower in concentration and confined to the area of Basins B, C, and F.

Arsenic concentrations in the alluvium are significantly higher than previous detections observed in the Denver aquifer. The distribution of this element in both aquifers is very similar in the Basins area and areas between the Basins and the north boundary. Continuous, detectable concentrations are reported in these areas. Two potential plumes have been identified in the Denver aquifer in Sections 34 and 35, and Sections 3, 4, and 33. Corresponding plumes do not exist in alluvial ground water.

Chloride and fluoride were detected in measureable concentrations throughout the primary source areas in both alluvial and Denver aquifers. Although high concentrations of chloride are present throughout the alluvial aquifer, high

concentrations of chloride in the Denver are confined to Sections 2 and 26. Fluoride concentrations in the Denver are generally lower than those observed in the alluvium, but this variation in concentrations is slight and the distribution of this element in both aquifers is similar.

In summary, concentrations of the primary organic analytes are significantly lower in the Denver aquifer than in the alluvial aquifer. The distribution of these compounds in the Denver is confined to primary source areas while the distribution in the alluvium is more extensive.

3.2.14 SUMMARY COMPARISON OF HISTORICAL DATA TO ISP DATA

An overview of the historical and ISP data and the resultant chemical distribution maps confirm typically observed plume trends in ground water at RMA. In general, the distribution of historical target analytes was more widespread than those reported in the ISP. This is likely the result of the more comprehensive historical data base which encompassed a greater number of analyzed ground water samples from a greater number of well sampling locations.

Historical data observed over time show that inorganic chemical compounds exhibit consistent trends with respect to most wells. Organic chemical trends are more erratic. Variations in concentrations of these chemical compounds are most likely the result of several factors.

Factors affecting such trends in the historical data include variations in method detection limits achieved by various laboratories (RMA, CDH, and SCC) performing analyses for organic compounds. Secondly, measured concentrations for semi-volatile compounds present at or near the method detection level are commonly variable. Thirdly, erratic results for semi-volatile substances can be affected by incomplete or inconsistent well purging techniques, poor sampling techniques or sample handling, and poor preservation techniques. The final factor affecting the comparison of current and historical data for the distribution of chemical compounds is the variation in parameters analyzed and reported in historical analytical programs. Of particular importance is the lack of historical data for volatile aromatic and volatile organohalogen compounds which were included for analysis in the ISP.

Historical data summarized from the USATHAMA data base did not contain documentation of sampling and purging techniques and hence the impact of the true potential inadequacies cannot be evaluated. However, method detection limits are available from previous analytical programs and are presented in Table 3.2-3 for comparison to the ISP.

As a result of these factors, the historical chemical distribution maps may not be truly representative of the historical chemical distribution in ground waters at RMA. Therefore, a summary comparison of the historical chemical distribution with the current chemical data should not be strictly interpreted.

Table 3.2-3. Detection Limits for Historical Analytical Data
(Page 1 of 2)

Compound	Laboratory	Test*	Detection Limits (µg/l)
Aldrin	RMA	R1	1.0, 0.2, 0.3
	Shell	T1	0.3
	CDH		0.131
PCPMS	RMA	R1	5.0, 10
		4P	5.0, 10, 20
	Shell	T1	10
PCPMSO	RMA	R1	5.0, 10
		4P	1.0, 5.0, 20
	Shell	T1	10
PCPMSO ₂	RMA	R1	5.0, 10
		4P	5.0, 10
	Shell	T1	10
DBCP	RMA	4Q	0.2
		R1	0.2, 0.4
		T1	0.2
	Shell	99	10
DCPD	RMA	T1	1.0, 20
		R1	30
		T2	10
	Shell	T2	10
	CDH		20
DIMP	RMA	R1	2.0, 10, 50
		4S	10
		T1	0.2, 0.5, 5.0
	Shell	T1	10
	CDH	T1	5.0
Dieldrin	RMA	R1	0.2, 0.5, 1.0
	Shell	T1	0.3
		99	10
	CDH	T1	1.0, 20
Endrin	RMA	R1	0.3, 0.5, 1.0
	Shell	T1	1.0
	CDH	T1	0.1
Carbon Tetrachloride	RMA	99	1.0
	Shell	99	10

Table 3.2-3. Detection Limits for Historical Analytical Data
 (Page 2 of 2)

Compound	Laboratory	Test*	Detection Limits (µg/l)
Toluene	RMA	99	1.0
MIBK	RMA	99	5.0
	Shell	99	10
Trichloroethylene	RMA	99	1.0
	Shell	99	10
Tetrachloroethylene	RMA	99	1.0
	Shell	99	10
Benzene	RMA	99	1.0
	Shell	99	10
Chloroform	RMA	99	1.0
	Shell	99	10
Chlorobenzene	RMA	99	1.0
Xylene	RMA	99	10
Dimethyl Disulfide	Shell	99	10
Arsenic (Total)	RMA	R1	50
		99	5.0, 20, 50
	Shell	99	1,000
Chloride	RMA	6H	20,000
		R1	20,000
	Shell	99	20,000
	CDH		900
Fluoride	RMA	4V	100
		R1	0.02
		99	0.02
		T1	0.02
	Shell		None
		CDH	600

* Test codes refer to specific analytical procedures. A code 99 refers to a procedure not approved by USATHAMA.

Source: Rocky Mountain Chemical Ground Water Merge File Listing.
 Dated 7 April 1986.

4.0 SURFACE WATER MONITORING RESULTS

4.1 WATER QUANTITY

The water quantity portion of the ISP required the measurement, reduction, and compilation of hydrologic data.

4.1.1 STAGE AND DISCHARGE

The surface water monitoring program currently in operation at RMA utilizes 12 Stevens Type F water-level recorders. Data recorded by the Stevens recorders represent stage as a continuous function of time. All RMA recorders are equipped with 8-day clocks.

Initial data reduction required estimating the stage to the nearest 0.05 foot for each hour of each day. Once recorded, the hourly stages were then converted into hourly discharges through the utilization of rating curves developed for the monitoring sites at RMA (Appendix D). Following the conversion, hourly discharge values for each day were averaged and converted from cubic feet per second to acre-feet per day. The daily flow values were summed to obtain weekly and monthly values. Daily discharges for all gages are presented in Appendix D.

Five lakes were monitored as part of the water monitoring program during the ISP. Monthly volume changes were calculated by first determining the stage corresponding to the first hour of the first day for the month in question and for the following month. These values were then converted to volumes using the stage volume curve. Finally, the volume from the first of the following month was subtracted from the volume of the month in question to obtain the change in storage (Appendix D).

For Upper Derby, Lower Derby, and Ladora Lakes, existing staff gages were read on a weekly basis. The volumetric changes were then determined from these weekly staff gage readings as described above. Havana Pond is equipped with a Stevens-Type F water level recorder for a continuous surface elevation record and was recently surveyed (Figure 4.1-1) in order to provide accurate stage volume and stage-area curves.

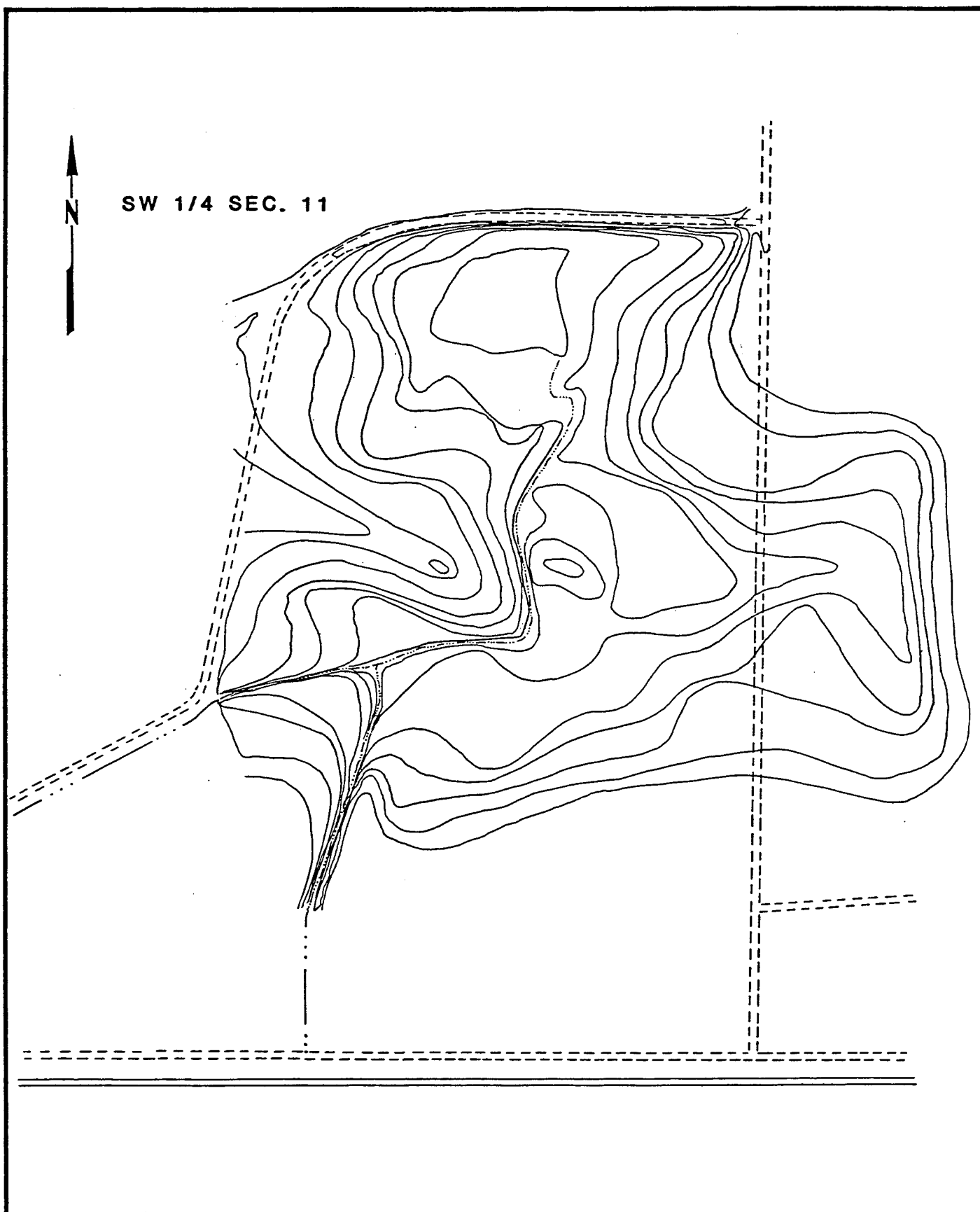


Figure 4.1-1
BATHYMETRIC CONTOURS
HAVANA POND

SOURCE: RCI, 1986

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Lake Mary also has a staff gage which was read weekly. Necessary survey data were not available to construct stage-volume curves. In order to monitor volume changes, the surface area was determined for the lake by planimetering an aerial photo. Assuming the surface area is constant with stage over the range of fluctuations, the volume changes were determined by subtracting stage values representing the beginning of a month from those representing the end of the month and multiplying by the area in acres.

Appendix D lists the weekly lake stages as well as the sewage treatment plant and Ladora pumphouse meter readings. Pump discharge volumes were calculated by subtracting the gallon reading representing the first of the month from that representing the last and converting to acre-feet.

4.1.2 WATER BALANCE

A generalized water balance has been computed on a monthly basis for the requested areas of hydrologic interest at RMA. These areas are Havana Pond (which includes the Havana Pond itself and the gages on the Havana and Peoria interceptors), the Lakes area (which includes the lower lakes, namely Upper and Lower Derby and Ladora, and the gages at the Highline Lateral, North and South Uvalda, the South Plants Ditch, and the Ladora Weir), First Creek (which includes South and North First Creek gages), Basin A, and Lake Mary. The last two areas are treated separately due to their isolation from other surface water areas. Finally, a calculation of the difference in flows between the North and South Uvalda gages was prepared.

The form which is utilized for the water balance is that which was used in the previous RMA analyses. This form represents the requested water balance analysis. However, in some instances, adequate data are not available. In these cases the form will show either a blank or an estimated value. In either case, the letter "a" will appear to indicate that the data were estimated.

4.1.2.1 Precipitation

Precipitation data used in the water balance were obtained by averaging the daily data obtained from the two gages installed at RMA and the daily data from the National Weather Service station at Stapleton Airport. Data from the three precipitation stations are shown in Table 4.1-1.

4.1.2.2 Transpiration

Transpiration is neglected in this analysis because of the lack of reliable information, which is a result of variable vegetation density and mixed consumptive use patterns by plants. Errors caused by omitting transpiration data from the analysis of fall and winter months (when transpiration values are at a minimum) appear to be negligible.

4.1.2.3 Evaporation

Values utilized for evaporation were taken from Corps of Engineers data obtained at Cherry Creek Reservoir, approximately 12 miles south of RMA. These values are shown on a monthly basis in Table 4.1-2.

4.1.2.4 Overland Flow

The current water balance format does not include surface water runoff. It is suspected that in some cases it should be considered, since during the summer months intense thunderstorm activity may cause significant overland flows. This point will be investigated further during the analysis of data from the summer months.

4.1.2.5 Monthly Water Balance Computations

Appendix D presents the monthly water balance computations for the months of October 1985 through May 1986. The methods of computation, the hourly stage summaries, and the weekly water level and rain gage charts are also included.

4.2 WATER QUALITY

Of the 30 sites selected for water quality analysis, only 16 could be sampled during the ISP. Low flows resulting from the advent of the winter season caused the remaining sample locations to be dry.

Table 4.1-1. Monthly Precipitation

Month	Down time North RMA raingage	Down time South RMA raingage	Precip. average	Precip. Stapleton	Precip. average
10/85	10/1-10/9 ^{1/}	—	0.74	0.77	0.76
11/85	11/9-11/30 ^{2/}	11/9-11/30 ^{2/}	—	1.20	1.20
12/85	12/1-12/16 ^{2/}	12/1-12/31 ^{2/}	—	0.66	0.66
1/86	—	1/1-1/31 ^{2/}	0.10	0.22	0.16
2/86	—	2/1-2/28 ^{2/}	0.48	0.65	0.57
3/86	—	3/1-3/31 ^{2/}	0.48	0.43	0.46
4/86	—	3/1-3/16 ^{2/}	2.25	2.59	2.42
5/86	—	—	1.42	1.30	1.36

^{1/} Gage activated October 9, 1985.

^{2/} Gage not winterized.

Source: RCI, 1986.

Table 4.1-2. Cherry Creek Reservoir Monthly
Evaporation (inches)

October	2.85
November	1.75
December	0.66
January	0.51
February	0.66
March	1.17
April	2.34
May	5.11

Ref: Colorado Climate Center, Colorado State
University, Fort Collins, CO

4.2.1 COMPOUND DISTRIBUTION

Due to dry conditions, limited results were obtained during the ISP. It appears, however, organochlorine pesticides are present in surface waters over much of RMA. Other than the widespread compound distribution seen in samples analyzed in the South Plants-Basin A area, volatile organohalogens are the only other compound group detected. Both surface water quality sites in Section 2.4 recorded purgeable detections. Specifically, location 24-1 had indications of chloroform, while 24-2 contained trichloroethylene and 1,1,2-trichloroethane. Results are plotted in Figure 4.2-1 and are tabulated in Appendix D.

4.3 SUMMARY COMPARISON WITH HISTORICAL SURFACE WATER DATA

Occurrences of compounds detected in surface water samples during past analytical programs are plotted in Figure 4.3-1. There do not appear to be any patterns or trends of compound distribution. This is further illustrated through a comparison of the ISP results with the historical data. Based on one sampling period, no conclusions can be made.

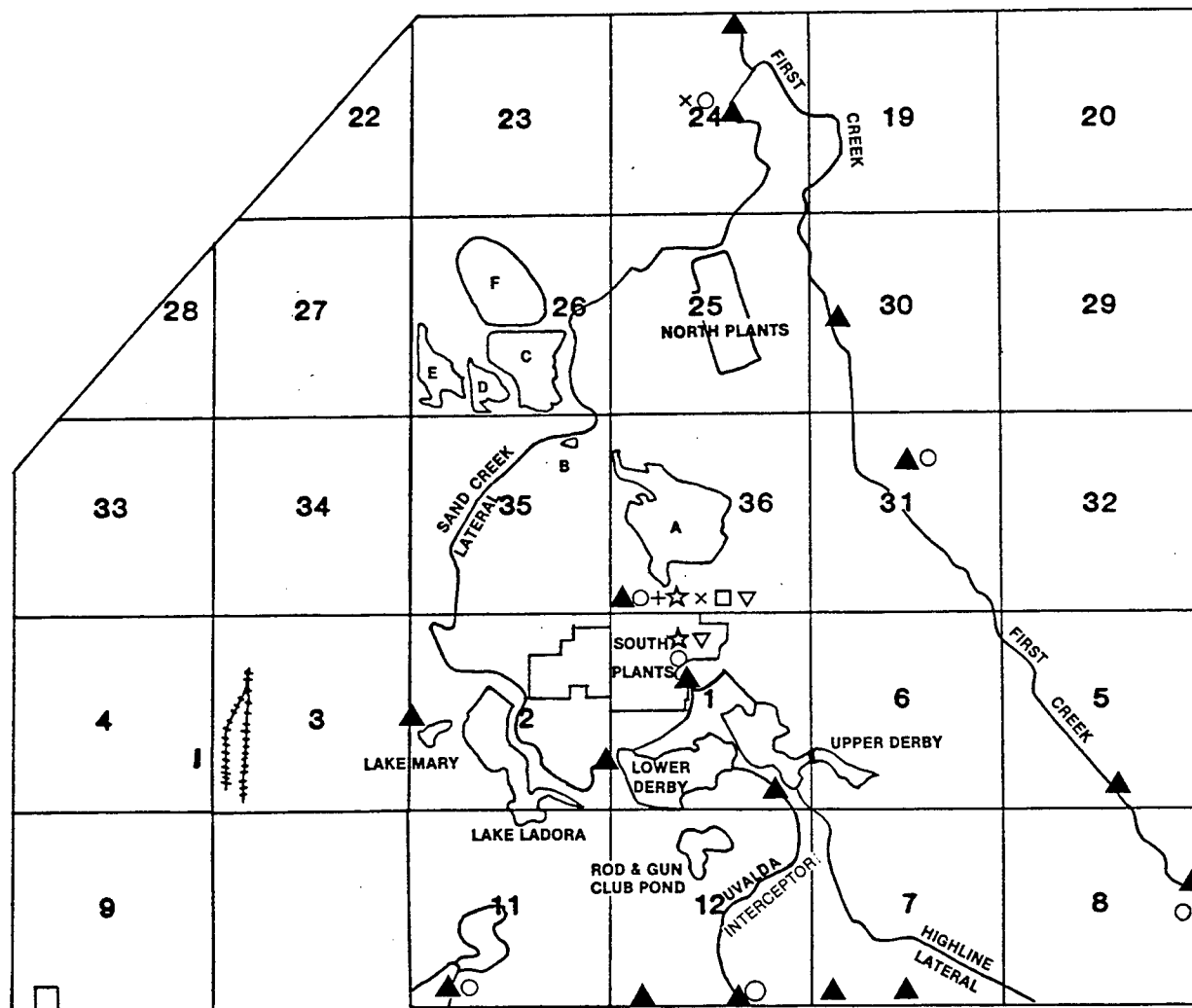
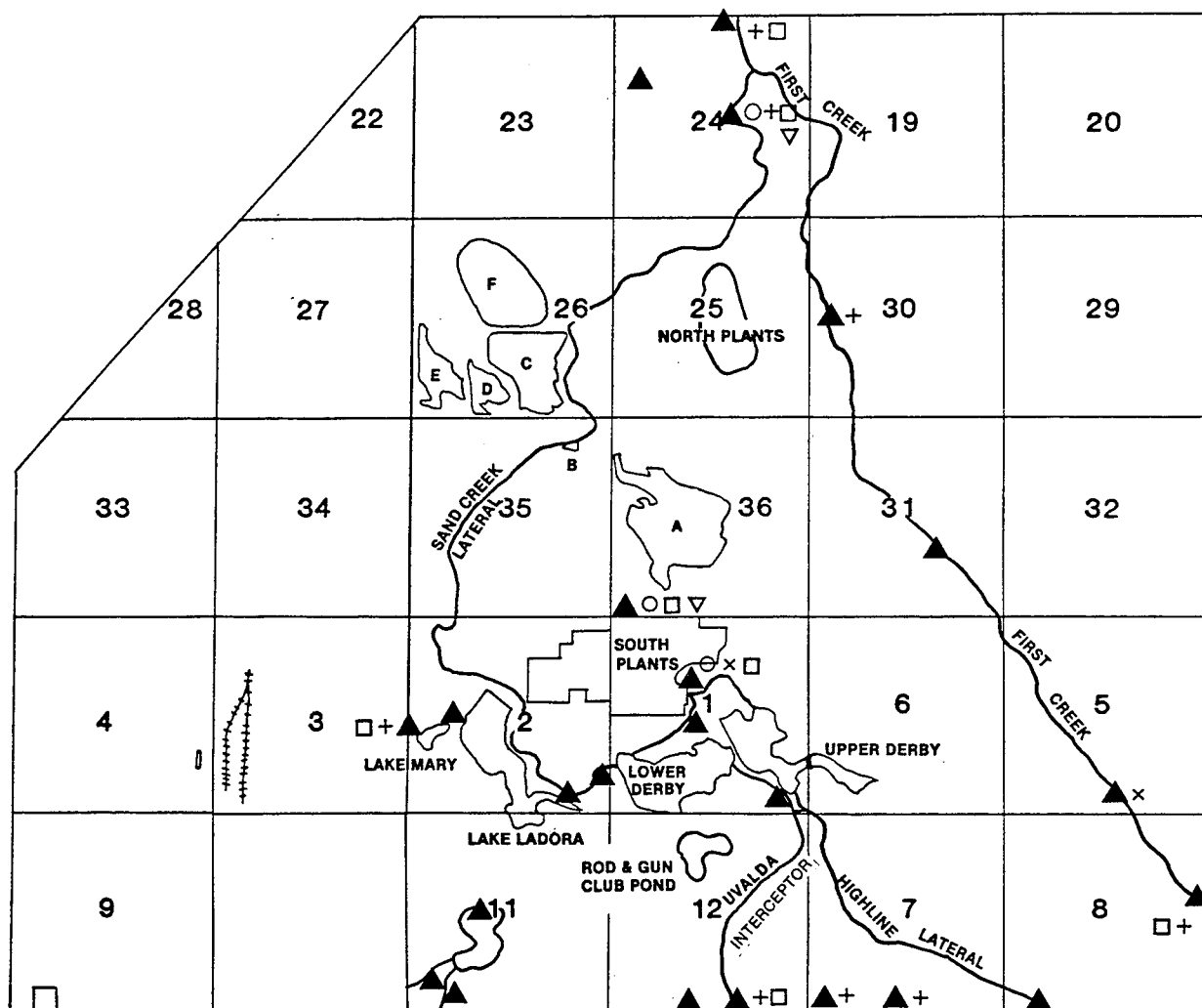


Figure 4.2-1
SCREENING EFFORT COMPOUND
DISTRIBUTION IN SURFACE WATER

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland



- ▲ Sample Sites
- Organochloride Pesticides
- + DIMP
- ☆ DCPD
- × Purgeables
- DBCP
- ▽ Organosulfur Compounds



0 1 2
SCALE MILES

Figure 4.3-1
HISTORICAL DISTRIBUTION OF SELECTED
COMPOUNDS IN SURFACE WATER

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

5.0 RECOMMENDATIONS FOR FUTURE SAMPLING

Further investigations of water quantity and quality on RMA will include the Third and Fourth Quarter sampling programs and a long-term monitoring effort. These studies will include the continued measurement of ground and surface water levels and the collection and analysis of ground and surface water samples. The objectives and design of future sampling projects are described below.

5.1 OBJECTIVES OF THIRD QUARTER SAMPLING

5.1.1 DOCUMENTATION OF SEASONAL VARIATIONS

The principal and original objective of the Third Quarter Program is to document variations in water quantity and quality which may result from seasonal influences.

5.1.2 CONFIRMATION OF INITIAL SCREENING PROGRAM RESULTS

Data obtained during the Third Quarter should allow resolution of the discrepancies observed between screening quarter results and the historical chemical data. A comparison of these data should also allow identification of any spurious results.

5.1.3 IMPROVED RESOLUTION OF CONTAMINANT DISTRIBUTIONS

The areal dimensions of contaminant plumes need to be defined more precisely. By sampling wells previously unsampled situated on either side of plume boundaries and in vertical clusters in different aquifers, the lateral and vertical extent of contaminant distributions can be identified. Continued sampling will enable detection of changes in lateral or vertical limits of contaminant plumes.

5.1.4 IMPROVED DESCRIPTION OF HYDROGEOLOGIC CONDITION

Geologic cross sections can be used to identify the stratum represented by each well; this will allow the correlation of particular contaminant suites with specific strata. Thus individual contaminant plumes associated with different hydrogeologic units can be defined. The location, extent, and behavior of these various plumes will provide additional information of hydrogeologic characteristics of the aquifers at RMA.

5.2 THIRD QUARTER SELECTION PROCESS

The surface water monitoring and sampling sites selected for the ISP will all be included in the Third Quarter Program. The water level measurement network will also remain the same. However, the ground water sampling network will be modified.

Information obtained during the ISP indicated that the number of wells for ground water sampling could be reduced without diminishing the effectiveness of the monitoring program. A more efficient well network is proposed for the Third Quarter based on Initial Screening Program results. The rationale for well selection and rejection is discussed below.

5.2.1 WELL SELECTION CRITERIA

The primary criteria for selection of wells were location with respect to contaminant plumes and the occurrence of discrepancies between historical and screening program chemical data. As secondary criteria for well selection, vertical clusters of wells, adequate documentation of construction, wells that did not dewater, and wells which could be pumped were preferred over other wells in approximately the same locations. Basin F Monitoring Program wells were automatically selected despite the presence of more suitable wells in the area. Wells that could not be sampled during the ISP were automatically rejected.

5.2.1.1 Water Quality

Wells which represent areas of background water quality conditions, high concentrations of contaminants, and transitional water quality will be included in the Third Quarter Program. Background wells will be sampled to ensure that contaminants are not migrating to these areas from offpost.

5.2.1.2 Proximity to Contaminant Plumes

The definition of plume boundaries is perhaps the most important criterion for well selection. Wells were chosen so that both lateral and vertical extents of contaminant plumes can be defined and any continued migration of contaminants can be monitored. Wells located in central areas of plumes will also be sampled to monitor changes in contaminant concentrations.

5.2.1.3 Historical Data Discrepancies

Some discrepancies between the historical chemical data and ISP results have been identified as described in Section 3.2.1.3. Those wells displaying significant discrepancies will be included in the Third Quarter Sampling Program to verify results. Once the problem is resolved, a well may be dropped from subsequent sampling programs.

5.2.1.4 Well Construction Factors

Construction evaluations were reexamined for all of the wells included in the ISP. Additional information on well conditions was supplied by field observations (summarized in Table 5.2-1), which include physical conditions (constricted, destroyed, etc.) and sampling technique (pump vs bail). This information was used to reject wells which could not be sampled and to aid in identifying wells with preferred characteristics.

5.2.1.5 Ongoing Programs

Wells sampled by ongoing regulatory programs were automatically included in the Third Quarter Sampling Program. These include the 12 Monitoring Program wells near Basin F. The 12 wells in the current Basin F program include several which are considered to be of unacceptable construction and two which were dry during the ISP. An alternative group of wells is proposed, which should provide better coverage of Basin F than the current network. The proposed network also includes 3 vertical clusters of wells for better definition of vertical contaminant migration. Both sets of wells - current and proposed - are included in the Third Quarter Program so that results can be compared. These wells are identified in Table 5.2-2.

5.2.2 ANALYTICAL PARAMETER SELECTION

Determination of all previously monitored analytical parameters in all areas of RMA is not considered necessary based on the ISP and historical results. Because each area had distinct differences in contaminant groups being detected, it is proposed that the area be divided into regions with different analytical requirements (Figure 5.2-1). Chloride and fluoride will be monitored in every well as indicators of general water quality. This information is summarized in Table 5.2-3.

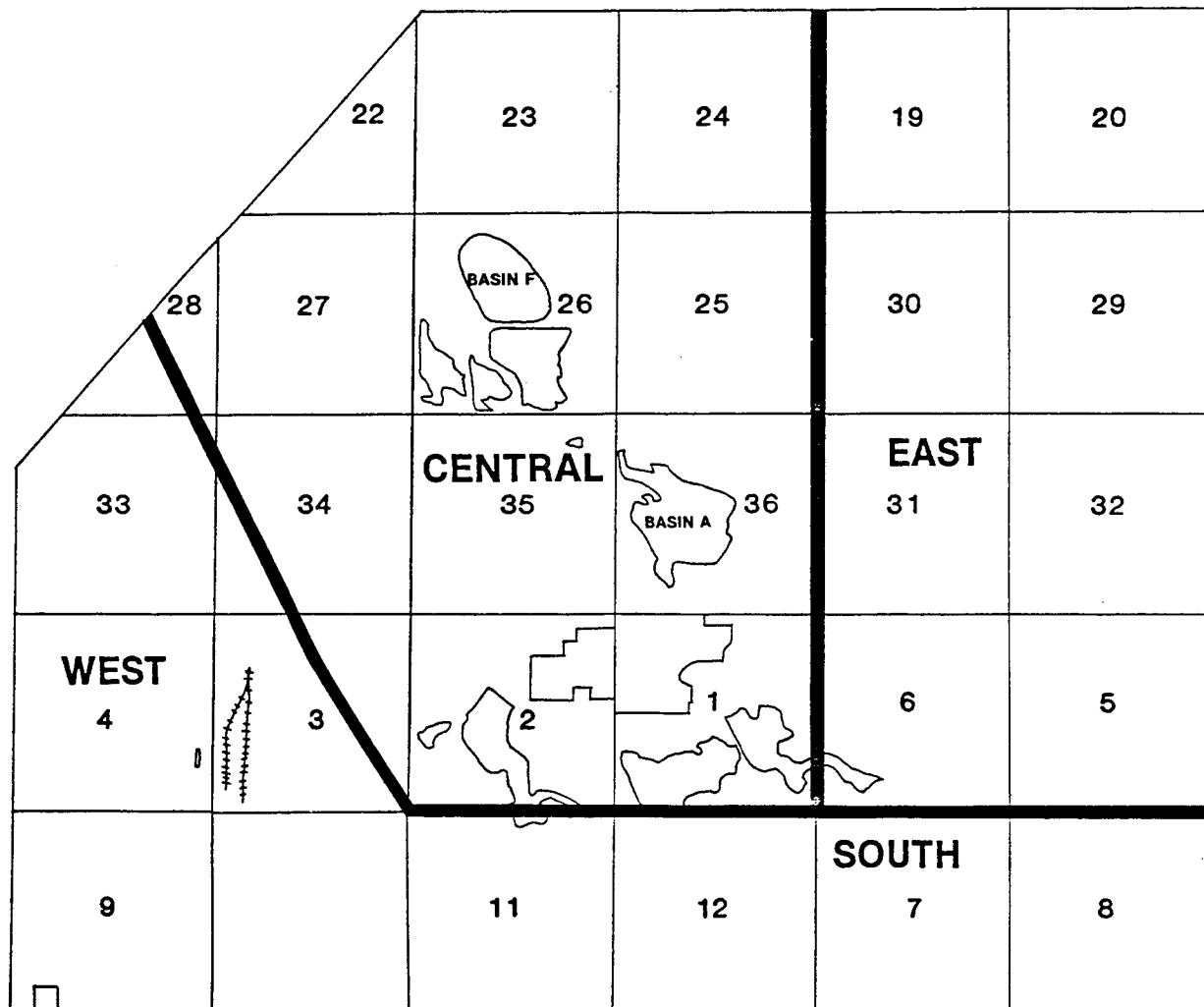


Figure 5.2-1
REGIONS OF RMA REQUIRING DIFFERENT
ANALYTICAL SUITES FOR THIRD QUARTER
(FY86) SAMPLING

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Table 5.2-1. Screening Program Well Summary (Page 1 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
01008	2	36" Bailer	22'	
01012	2	22" Bailer	14.5'	
01014	2	28" Bailer	20'	
01017	2	22" Bailer	13.6'	
01019	2	28" Bailer	25'	
01020	2	22" Bailer	16.1'	
01021	4	28" Bailer	18.3'	
01022	4	48" Bailer	26'	
01023	4	28" Bailer	56.2'	
01024	4	28" Bailer	9'	
01025	4	28" Bailer	62'	
01026	4	--	--	Well Destroyed
01027	4	28" Bailer	15'	
01028	4	Pumped	72'	Dewatered at 2.5 Vol
01029	4	Pumped	115'	Dewatered at 1.5 Vol
01030	3	28" Bailer	15'	
01031	4	Pumped	32.7'	
01032	4	Pumped	25'	
01033	3	Bailed	10'	
01034	4	Bailed	90'	
01035	4	Pumped	10'	Casing broken 2" from ground
02008	2	48" Bailer	117'	
02009	4	48" Bailer	47'	
02010	4	24" Bailer	46'	Only one that fits
02011	4	24" Bailer	45'	
02012	4	48" Bailer	56'	
02013	4	--	--	Constriction at 27'-30'
02017	3	--	--	Well is dry
02018	4	28" Bailer	60'	
02019	4	28" Bailer	60'	
02020	4	28" Bailer	11'	
02021	4	--	--	Constricted 36" and 25" won't fit
02022	4	28" Bailer	45'	
02023	4	22" Bailer	15'	
02024	4	28" Bailer	31.8'	
02025	4	28" Bailer	54'	48" and 36" got stuck
02030	4	36" Bailer	90'	--
02031	4	48" Bailer	68'	
02034	3	22" Bailer	15'	
02035	3	Pumped	41.2'	Dewatered at 1.5 Vol
02036	3	48" Bailer	28'	
02037	2	28" Bailer	16"	
02038	3	Pumped	17'	
02039	3	Pumped	38'	

Table 5.2-1. Screening Program Well Summary (Continued, Page 2 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
03001	2	Pumped	--	
03002	3	Bailed	70'	
03003	4	48' Bailed	117'	
03004	4	20" Bailed	179'	
03005	4	Pumped		
03006	4	36" Bailer	128'	Dewatered at 1.3 Vol
03007	4	Pumped	196'	Dewatered at 1 Vol
03008	--	Bailed	65'	Dewatered at 3 Vol
03009		Pump Rig		
03010		Bailed	72'	
03523	1	Pumped		
04001		Pumped		
04002				
04004		Pumped		
04007	4	Pumped		
04008	4	22" Bailer		
04009	4	Bailed		
04010	4	36" Bailer		
04011	4	36" Bailer		
04012	4			28" Bailer, Well casing constricted
04013		Bailed		
04014		Bailed	73'	
04019		Pumped		
04020		Pumped	66'	
04021		36" Bailer	73'	
04022		36" Bailer	73'	
04023		36" Bailer	73'	
04024		Pumped	73'	
04025		Pumped	74'	
04026		Pumped	67.5'	
04027		Pumped	67'	
04028		Pumped	67.5'	
04029		Pumped		
04030		36" Bailer	68'	
04031		Bailed	68.5'	
04032		Pumped	80'	
04033		Pumped	75'	
04524	1	Bailed	64'	
05001	1	Pumped Rig		Dewatered at 1 Vol
05002	4	Bailed	63'	Dewatered at 1 Vol
05003	4	Bailed	77'	Dewatered at 1 Vol
06002	2	Pumped Rig		
06003	4	Bailed 28'	17'	
06004	4	Bailed	65'	
06005	4	36" Bailer	19'	
07001	2		25'	Dewatered at 1 Vol

Table 5.2-1. Screening Program Well Summary (Continued, Page 3 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
07003	3	--	--	Well Dry
07004	4	Bailed	65'	Dewatered at 2 Vol
07005	4	Bailed	139'	Dewatered at 1 Vol
08002	2	Pumped Rig	21'	
08003	4	28" Bailer	9'	
08004	4	Pumped	38'	
08005	4	48" Bailer	50'	
09001		Pumped	58'	Dewatered at 1 Vol
09002	4	Pumped	70'	
09003	4	28" Bailer	73'	
09004	4	28" Bailer	170'	Well bailed until end of day-3 Vol
09005		Pumped	65'	
09006		Pumped	53'	
09007		Pumped	61'	
11002	4	Pumped	19'	
11003	3	28" Bailer	55.8'	
11004	4	46" Bailer	48.4'	
12002	4	22" Bailer	20'	
12003	4	Pumped	20'	
12004	4	Bailed		Dewatered at 3 Vol
19014	4	--	--	Well Dry
19015	4	36" Bailer	43'	
19016	4	28" Bailer	133'	Dewatered at 1 Vol
19017	4	28" Bailer	30'	
19018	4	28" Bailer	56.8'	Dewatered at 1 Vol
19019	4	28" Bailer	116'	
22020	3	Pumped	33'	Dewatered at 1 Vol
22021	3	22" Bailer	33.3'	
22022	3	28" Bailer	34'	
22023	4	Bailed	36'	
22024	4	Pumped	106.7'	Dewatered at 1 Vol
22025	3	--	--	Well Dry
22027	4	28" Bailer	77'	
22028	4	36" & 28" Bailer	115'	
22029	3	Tried to bail	--	Well Dry
22030	4	Pumped	90'	
22031	4	Pumped	60	
22049	4	28" Bailer		Dewatered at 0.5 Vol Not enough to sample
22059	3	28" Bailer	51'	
22060	4	28" Bailer	39'	Dewatered at 3 Vol
23007	3	Bailed	42'	
23029	2	Bailed	22"	
23039	2	--	--	Well Dry
23049	1	--	--	Dry
23142	2	Pumped	51.4'	With well wizard
23166	3	22" Bailer	16'	Dewatered at 1 Vol

Table 5.2-1. Screening Program Well Summary (Continued, Page 4 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
23176	3	Pumped Rig	40'	
23177	4	Pumped	18'	
23178	3	28" Bailer	14.5'	
23179	4	Bailed	51.5'	Dewatered at 2 Vol
23180	4	Bailed	72'	Dewatered at 1 Vol
23181	4	Bailed	102'	Dewatered at 2 Vol
23182	4	Bailed	35'	
23183	4	Bailed	39'	
23184	4	28" Bailer	122'	
23185	4	Bailed	46'	
23186	4	Pumped	57'	
23187	4	48" Bailer	103'	
23188	4	22" Bailer	26.5'	
23189	4	Bailed	45'	
23190	4	22" & 28" Bailer	87.5'	
23191	4	28" Bailer	55'	
23192	4	Pumped		Dewatered at 1 Vol
23193	4	Pumped	175'	Dewatered at 1.3 Vol
24001	3	Bailed	32'	
24150	3	Bailed	10'	
24158	3	Bailed	9'	
24159	4	24" Bailer	13'	
24170	3	--	--	Casing broken off below ground
24178	3	Bailed	11'	
24179	3	Pumped	8.6'	
24184	3	Bailed	9'	
24185	3	Bailed	9'	
24188	3	--	--	Well destroyed
25008	4	Bailed	60'	
25009	4	28" Bailer	66'	
25010	4	28" Bailer/Pump	139'	Well dewatered at 1 Vol
25011	4	28" Bailer	13'	
25012	4	28" Bailer	61.5'	Dewatered at 1.75 Vol
25013	4	28" Bailer	92.0'	Dewatered at 1 Vol
25014	4	36" Bailer	76'	
25015	4	22" Bailer	40'	
25016	4	Bailed	67'	Dewatered at 1 Vol
25017	4	28" Bailer	68'	Dewatered at 2 Vol
25018	4	--	--	Well constricted
25019	4	36" Bailer	85'	Dewatered at 1 Vol
25020	4	36" Bailer	42.1'	
25022	3	28" Bailer	57.8'	Dewatered at 1 Vol
25023	3	28" Bailer	57.7'	
25024	3	Bailed	94'	
25038	3	28" Bailer	27'	
25039	3	Bailed	30.5'	

Table 5.2-1. Screening Program Well Summary (Continued, Page 5 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
25040	3	28" Bailer	84.2'	Dewatered at 2.5 Vol
26011	2	Bailed	47'	
26041	2	Bailed	49.2	
26065	2	--	--	Dry
26066	2	48" Bailer	41'	
26067	2	Pumped	52'	
26070	2	--	--	Water below screened interval, Dry
26071	2	Pumped	45.6'	
26072	2	Pumped	53.2'	
26073	2	Bailed	51'	
26074	2	Bailed	58'	
26075	2	Pumped	60'	
26076	2	Bailed	--	Dry, Dewatered at 1 Vol
26083	2	48" Bailer	30'	Dewatered at 2 Vol
26084	2	Pumped	86'	Dewatered at 2 Vol
26085	2	36" Bailer	34'	
26086	2	Pumped	41'	
26091	1	36" Bailer	32'	
26092	2	Pumped	30'	
26093	2	Bailed	28'	Dewatered at 3 Vol
26094	2	Pumped	40'	
26127	2	28" Bailer	45'	
26128	2	Pumped	43'	
26129	2	Pumped	55'	
26132	2	--	--	Well stickup gone, well could not be located
26133	2	Bailed	44.2'	
26140	3	48" Bailer	63'	
26141	3	36" Bailer	72.5'	
26142	3	Pumped	149'	Dewatered at 1.9 Vol
26145	4	Bailed	--	Dewatered, never recharged
26146	4	--	--	Well constricted
26147	4	Pumped	52'	
27003	2	Bailed	51'	
27040	2	22" Bailer	41'	Dewatered at 1.5 Vol
27053	4	28" Bailer	57'	
27054	4	Pumped	105'	Dewatered at 1 Vol
27055	4	Pumped	137'	Dewatered at 1 Vol
27056	4	22" Bailer	47'	
27057	4	22" Bailer	66.7'	Dewatered at 2 Vol
27058	4	28" Bailer	101'	Dewatered at 1 Vol
27059	4	--	--	Well constricted
27060	4	--	--	Well obstructed
27061	4	--	--	Well obstructed

Table 5.2-1. Screening Program Well Summary (Continued, Page 6 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
27062	4	28" Bailer	45'	
27074	4	Bailed	44.2'	
27075	2	22" Bailer	55.6'	
27076	4	28" Bailer	58'	
27077	4	28" Bailer	55.6'	
27078	4	28" Bailer	62'	
28023	2	28" Bailer	38'	
28025	4	28" Bailer	95'	Dewatered at 1 Vol
28026	3	Pump & 28" Bailer	114'	Dewatered at 1 Vol
28027	2	28" Bailer	43'	
28028	4	22" Bailer	41.7'	
28029	4	--	--	Obstructed
29002	4	22" Bailer	40'	
29003	4	28" Bailer	113.2'	
30003	4	--	--	Well Dry
30004	4	Bailed	47'	Dewatered at 3 Vol
30005	4	Pumped	50'	
30009	4	28" Bailer	12'	
30010	4	Pumped	18'	
30011	4	Pumped	137'	Dewatered at 1 Vol
31005	4	Pumped	30'	
31006	4	Pumped	28'	
31007	4	Pumped	80'	Dewatered at 1 Vol
31008	4	48" Bailer	33'	
32001	1	36" & 28" Bailer	31'	
32002	4	Pumped	101.9	
32003	4	Pumped	76	
33002	2	Pumped	50'	
33015		Pumped	69.5	
33016	2	Bailed	68'	Nearly Dewatered
33017		Pumped	60.5'	
33018	2	24" Bailer	73'	Dewatered at 3 Vol
33019	2	28" Bailer	69'	
33020	2	Bailed	69'	
33021	2	24" Bailer	70'	
33022	2	24" Bailer	70'	
33023	2	24" Bailer	65'	
33024	2	Bailed	67.6'	
33025	2	Bailed	63'	Dewatered at 4 Vol
33026	4	Bailed	60'	
33027	4	Pumped	58.3'	
33028	4	--	--	Well Dry
33029	4	--	--	Bailer would not fit down hole
33030	4	24" Bailer	64'	
33031	4	--	--	Well constricted

Table 5.2-1. Screening Program Well Summary (Continued, Page 7 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
33032	4	36" Bailer	201'	Dewatered at 1 Vol
33033	4	24" Bailer	51'	
33034	4	28" Bailer	54'	
33035	4	36" Bailer	109'	Dewatered at 1 Vol
33046		Bailed		
33047		Bailed		Dewatered at 3+ Vol
33060	4	36" Bailer	63.5'	
33061	4	28" Bailer	82'	
33062	4	--	--	Water below screened interval, Dry
33063	3	28" Bailer	72'	
33514	2	Bailed	59'	Dewatered at 2 Vol
34002	4	Bailed	80'	
34003	4	28" Bailer	83.5'	
34004	4	--	--	Constricted
34005	4	Bailed	74'	
34006	4	Bailed	70'	
34007	4	Bailed	134'	Dewatered at 1.5 Vol
34008	4	22" Bailer	65'	
34009	4	28" Bailer	100'	Dewatered at 2 Vol
34010	4	22" Bailer	75'	
35005	2	Bailed	33'	
35012	2	Pumped	26.5'	Dewatered at 4 Vol
35013	2	28" Bailer	20'	
35016	2	28" Bailer	26'	
35017	2	Pumped	70'	Dewatered at 2 Vol
35034	2	Bailed	16'	Dewatered at 1 Vol
35035	3	--	--	Well destroyed
35036	3	Bailed	32'	
35037	2	22" Bailer	37.4'	
35038	3	Pumped	41.5'	
35039	3	Pumped	63.1'	
35052	4	28" Bailer	15'	
35053	4	22" Bailer	58'	Dewatered at 1 Vol
35054	4	Bailed	80'	Dewatered at 1 Vol
35055	4	--	--	Well obstructed
35056	4	Pumped	78'	
35058	4	28" Bailer	30.8'	
35059	4	Pumped	60'	Dewatered at 2 Vol
35060	4	--	--	Obstructed, something stuck
35061	4	28" Bailer	28'	
35062	4	22" Bailer	80'	Dewatered at 1.5 Vol
35063	4	36" Bailer	55'	
36065	4	22" Bailer	21.6'	
35066	4	28" Bailer	20'	

Table 5.2-1. Screening Program Well Summary (Continued, Page 8 of 8)

Well Number	Ranking (1-4)	Pump/Bailer	Sample Depth	Comments
35067	4	36" Bailer	85'	Dewatered at 1+ Vol
35068	4	Pumped	47.9	
35069	4	28" Bailer	20'	
35070	4	Pumped	75'	
35071	3	Pumped	26'	
35072	3	--	--	Obstructed
36001	2	Bailed	17'	
36048		36" Bailer	22'	Dewatered at 1 Vol
36065	2	36" Bailer	20'	Dewatered at 1.5 Vol
36066	2	Pumped	60'	Dewatered at 2 Vol
36069	2	Bailed	21'	
36075	2	28" Bailer	13.5'	
36076	2	22" Bailer	22'	
36082	2	36" Bailer	9'	
36083	2	Pumped	28'	
36084	2	36" Bailer	11.8'	
36090	2	Bailed	28'	
36091	2	--	--	Well Dry
36109	2	48" Bailer	17'	
36110	2	36" Bailer	43'	
36112	4	28" Bailer	35'	
36113	3	36" Bailer	83'	Dewatered at 1+ Vol
36114	3	36" Bailer	65'	
36116	4	--	--	Water below screened interval, Dry
36117	3	28" Bailer	82'	Dewatered at 1 Vol
36118	4	Pumped	75'	Dewatered at 1 Vol
36119	3	36" Bailer	86'	Dewatered at 1 Vol
36121	4	28" Bailer	43'	
36122	3	36" Bailer	64'	
36136	3	36" Bailer	18'	
36137	3	28" Bailer	19'	
36138	3	48" Bailer	21'	
36139	3	48" Bailer	20'	
36140	3	36" Bailer	18'	
36141	3	46" Bailer	38.7'	
36142	3	36" Bailer		

Table 5.2-2. Proposed Replacement RCRA Monitoring Network

Old	Proposed	Reason
23049	no	Well dry in Initial Screening Program
23095	no	Unacceptable construction
23108	no	Unacceptable construction
23142	yes	Ok
	23185	Cluster
	23186	Cluster
	23187	Cluster
	23191	Cluster
	23192	Cluster
	26011	Better construction, replace 26015,17
26015	no	Unacceptable construction
26017	no	Unacceptable construction
26020	no	Unacceptable construction
26041	yes	Ok
26073	yes	Ok
26076	no	Well dry
	26083	Cluster - replace 26020
	26084	Cluster - replace 26020
26085	yes	Ok
26127	yes	Ok
27016	no	Unacceptable construction

Table 5.2-3. Analytical Parameters Proposed for Third Quarter
(FY86) Sampling

Analyte	Region*			
	East	South	Central	West
Organosulfur Compounds	Yes	Yes	Yes	No
Organochlorine Pesticides	Yes	Yes	Yes	Yes
DIMP	Yes	Yes	Yes	No
DCPD	Yes	Yes	Yes	No
DBCP	Yes	Yes	Yes	Yes
Volatile Organohalogens	Yes	Yes	Yes	Yes
Volatile Aromatics	Yes	Yes	Yes	Yes
Purgeable Organics	Yes	Yes	Yes	Yes
Chloride/Fluoride/Sulfate	Yes	Yes	Yes	Yes
ICP Metals	No	No	Yes	Yes
Arsenic	No	No	Yes	Yes
Mercury	No	No	Yes	No

* Regions are outlined on Figure 5.2-1.

The eastern region will be analyzed for organosulfur compounds, organochlorine pesticides, DIMP, DCPD, DBCP, and purgeable organics. This region should display background water quality levels.

The southern region will be sampled for similar parameters as the east region. This area is also considered to represent background water quality. Organochlorine pesticides, DBCP, and purgeable organic compounds as well as the ICAP suite (see Table 2.3-1) and arsenic will be monitored in the western region of RMA. The major problems in this area are the DBCP and TCE contamination originating in the Rail Classification Yard.

All of the Task 4 analytical parameters should be monitored in the central region. This area contains the source for the major ground water contamination plumes. All of the analytes have been detected and need to be monitored in this region.

Based on continued sampling and further chemical data, the analytical scheme may be modified on a quarterly basis. However, every fifth quarter all wells to be sampled will be analyzed for a complete list of chemical parameters.

5.2.3 THIRD QUARTER MONITORING PROGRAM

The well network selected for the Third Quarter includes 188 wells. Choices were based on the criteria discussed above, as summarized in Table 5.2-1. The locations of the proposed alluvial, intermediate Denver, and lower Denver wells are shown in Plates 7,8, and 9, respectively.

Wells deleted from the sampling program fell into three categories:

- o Wells that could not be sampled;
- o Wells in close proximity to chosen wells with preferred characteristics; or
- o Wells located such that samples would yield no significant additional information.

The wells rejected and reason for deletion from the program are listed in Table 5.2-4.

Table 5.2-4. Wells Deleted From Sampling Program (Page 1 of 4)

<u>Region</u>	Well Number	Unable to Sample	Proximity to Preferential Wells	No Additional Information
<u>South</u>				
	07003	x		
	08002		x	
	08004			x
	08005			x
	11003		x	
<u>East</u>				
	05001			x
	05002			x
	05003			x
	19014	x		
	19017			x
	19018		x	
	29002			x
	29003			x
	30003	x		
	30004		x	
	31005		x	
	31007		x	
	32002			x
	32003			x
<u>West</u>				
	03001		x	
	03009		x	
	03010		x	
	04001		x	
	04002	x		
	04004		x	
	04008		x	
	04012	x		
	04013		x	
	04015		x	
	04019			x
	04020			x
	04022		x	
	04023		x	
	04025		x	
	04026		x	
	04028		x	
	09004		x	
	09006		x	
	09007		x	
	28028		x	
	28029	x		
	33015		x	

Table 5.2-4 Wells Deleted From Sampling Program (Page 2 of 4)

<u>Region</u>	Well Number	Unable to Sample	Proximity to Preferential Wells	No Additional Information
<u>West</u>				
	33017		x	
	33018		x	
	33019		x	
	33020		x	
	33021		x	
	33022		x	
	33024		x	
	33028	x		
	33029	x		
	33031	x		
	33035		x	
	33046		x	
	33047		x	
	33062	x		
	33063		x	
	33514		x	
<u>Central</u>				
	01008		x	
	01017		x	
	01019			x
	01026	x		
	01027		x	
	01028			x
	01029			x
	01033		x	
	01034			x
	01035			x
	02013	x		
	02017	x		
	02018		x	
	02021	x		
	02022		x	
	02023		x	
	02024		x	
	02025		x	
	03006		x	
	03007		x	
	22020		x	
	22022		x	
	22023		x	
	22025	x		
	22027		x	
	22028		x	
	22029	x		
	22030		x	

Table 5.2-4. Wells Deleted From Sampling Program (Page 3 of 4)

<u>Region</u>	Well Number	Unable to Sample	Proximity to Preferential Wells	No Additional Information
<u>Central</u>				
	22031		x	
	22049		x	
	23007		x	
	23029		x	
	23039	x		
	23176		x	
	23178		x	
	23181		x	
	23184		x	
	23189		x	
	23193		x	
	24001		x	
	24170	x		
	24179		x	
	24184		x	
	24188	x		
	25014		x	
	25017		x	
	25018	x		
	25019			x
	25020			x
	25024		x	
	25038			x
	25039			x
	25040			x
	26065	x		
	26067		x	
	26070	x		
	26071		x	
	26072		x	
	26074		x	
	26075		x	
	26091		x	
	26092		x	
	26093		x	
	26094		x	
	26129		x	
	26132	x		
	26141		x	
	26145		x	
	26146	x		
	27003		x	
	27016		x	
	27059	x		
	27060	x		
	27061	x		

Table 5.2-4. Wells Deleted From Sampling Program (Page 4 of 4)

<u>Region</u>	Well Number	Unable to Sample	Proximity to Preferential Wells	No Additional Information
<u>Central</u>	27074		x	
	27075		x	
	27076		x	
	27077		x	
	27078		x	
	34003		x	
	34004	x		
	34005		x	
	34006		x	
	34007		x	
	34010		x	
	35005		x	
	35016		x	
	35017		x	
	35035	x		
	35036		x	
	35053		x	
	35054		x	
	35055	x		
	35056		x	
	35060	x		
	35066		x	
	35069		x	
	35070		x	
	35071		x	
	35072	x		
	36048		x	
	36069		x	
	36084		x	
	36090		x	
	36091	x		
	36109		x	
	36116	x		
	36117		x	
	36118		x	
	36119		x	
	36122		x	
	36136		x	
	36137		x	
	36138		x	
	36140		x	
	36141		x	
	36142		x	

Five wells not sampled during the screening program were added to the Third Quarter network where gaps in information were observed. These are identified in Table 5.2-2.

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