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PRE-HEARING
GROUND-WATER DISCHARGE PLAN ANALYSIS
for
HOMESTAKE'S URANIUM MILL NEAR MILAN, NEW MEXICO
HOMESTAKE MINING COMPANY

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TABLE OF CONTENTS

FIGURES

TABLES

1.0 SUMMARY AND CONCLUSIONS

Homestake Mining Company (Homestake or HMC) has operated, or been a partner in the operation, of an alkaline-leach uranium mill and tailings facilities located 5 miles north of Milan, in Cibola County, New Mexico, since 1958. Uranium mills at this site have been operated by Homestake-Sapin partners, Homestake-New Mexico Partners, United Nuclear-Homestake Partners and presently Homestake Mining Company. The site contains two above-grade, unlined, tailings reservoirs, one of which is presently used. Operation of both tailings reservoirs has impacted water quality in the San Mateo alluvium and the upper Chinle aquifer.

Ground waters to be protected at the site are in the alluvial aquifer, the upper and middle Chinle aquifers and the San Andres aquifer. In 1976, Homestake entered into a ground-water protection plan with the New Mexico Environmental Improvement Division (EID) to contain contaminants seeping from the tailings reservoirs and reduce concentrations of contaminants in ground water in subdivisions south of Homestake's property. In 1981, Homestake submitted a discharge plan for activities at the mill and tailings facilities that might impact ground water. The EID has determined that a public hearing will be held to provide the public an opportunity to present their concerns on the adequacy of the discharge plan to protect ground water and compliance with New Mexico water-quality regulations.

This technical analysis of Homestake Mining Company's proposed ground-water discharge plan (DP-200) for its alkaline-leach uranium mill and tailings facilities has been conducted by the staff of the EID Ground Water Quality and Hazardous Waste Bureau. During the analysis, an attempt was made to determine whether the discharge plan for the mill and tailings facilities satisfies the requirements of the New Mexico Water Quality Act and the New Mexico Water Quality Control Commission (NMWQCC) Regulations.

Specifically, Homestake's plan was analyzed from the perspective of whether Homestake has sufficiently demonstrated that discharges (planned or accidental releases) will not result in ground-water contamination beyond NMWQCC standards at a place of withdrawal of water for present or reasonably foreseeable future use. The EID has sampled wells on and adjacent to Homestake's property and analyzed the samples at the NM Scientific Laboratory Division (SLD). These analyses agree closely with analyses of samples collected and analyzed by Homestake. As a result of the agreement in analyses, the EID believes that Homestake has accurately defined the levels and areal extent of contamination resulting from the operation of their mill and tailings facilities.

The staff of the EID has determined that Homestake's activities described in the discharge plan will not result in ground-water contamination beyond the NMWQCC standards. However, this analysis was made without the benefit of additional information which may be presented at the public hearing. Therefore, this document must be viewed as a preliminary assessment, subject to change as a result of new evidence presented at the hearing.

1.1 Hydrologic Impacts

The Homestake Discharge Plan presents the existing and potential impacts to ground-water quality which may result from 1) the active-tailings reservoir facility; 2) the mill; 3) the tailings-slurry pipeline; 4) structural stability of the active-tailings reservoir; 5) the inactive-tailings reservoir facility; and 6) flooding.

1. Water quality in the alluvial aquifer has been impacted by seepage from the active-tailings reservoir facility. Concentrations of total dissolved solids (TDS), nitrate, sulfate, chloride, molybdenum, selenium and uranium exceed the NMWQCC numerical ground-water standards in ground water on Homestake's property. Concentrations of TDS, sulfate, and selenium exceed the numerical standards in ground water in subdivisions south and west of Homestake's property boundary. Nitrate and molybdenum only exceed the numerical standards in small isolated areas in the subdivisions. Uranium is projected to exceed the numerical standard in the northeast corner of Murray Acres although no wells currently exceed the uranium standard.

   Approximately 75 gpm of tailings fluids with a TDS of 10,000 mg/l seep to ground water in the San Mateo alluvium. Contaminated ground water has moved down-hydraulic gradient to the south and southwest of the active-tailings reservoir in the alluvium.

   Homestake has undertaken a ground-water protection program to reduce contaminant concentrations in the alluvium to the NMWQCC numerical ground-water standard as defined in Section 3-103 of the Regulations or mean-background concentrations, whichever are higher. The program involves the use of collection/injection wells to collect seepage as it enters the alluvium near the active-tailings reservoir, reduce hydraulic gradients to the north and south of the tailings reservoir and inject good quality water to dilute and disperse contaminated water to the south of Homestake's property boundary.

To determine the effectiveness of the ground-water protection program for the alluvium, both Homestake and the EID have performed numerical and analytical modeling. Modeling indicates that elevated concentrations of sulfate and selenium, that currently violate NMWQCC numerical ground-water standards, will be lowered in most of areas in the subdivisions to NMWQCC numerical ground-water standards or mean-background concentrations, whichever are higher, by 1984. Other water-quality parameters that currently exceed the NMWQCC numerical ground-water standards, including TDS, nitrate, and molybdenum, will approach the standards by 1984, in the subdivisions, because the modeling of sulfate and selenium represents the most conservative cases. However, due to some stagnation points in the alluvial aquifer, total reclamation of water quality beyond Homestake's property may not take place until 1988. In the interim, Homestake will continue to supply water to residents of subdivisions. Ground-water quality monitoring by Homestake and the EID has verified that the ground-water protection program is improving water quality in the subdivisions. Homestake has committed to operating the collection system after closure of the mill and tailings facilities to assure that seepage from the active-tailings reservoir will not violate NMWQCC ground-water standards in a place of foreseeable future use. After closure of the mill and tailings facilities, water pumped from the collection wells will be disposed of by a method approved by the EID so that the active-tailings reservoir can drain to specific retention.

Water quality in the upper Chinle aquifer exceeds NMWQCC numerical ground-water standards for TDS, sulfate, chloride, molybdenum, selenium and uranium on Homestake's property and in the vicinity of Broadview Acres. A downward-hydraulic gradient exists between the alluvium and the upper Chinle aquifer, creating a potential for downward movement of tailings fluids into the upper Chinle aquifer.

Homestake has proposed to mitigate contamination in the upper Chinle aquifer by injecting water obtained from the San Andres aquifer into the upper Chinle aquifer north of Broadview Acres. This will drive contaminated ground water back toward the active-tailings reservoir, where an upward hydraulic gradient created by the collection wells in the alluvium should cause the contamination to migrate upward into the alluvial collection wells. The EID believes the proposed contaminant mitigation plan for the upper Chinle aquifer may be of limited

effect because of the relatively small area of upward hydraulic gradient in the upper Chinle aquifer and the low hydraulic conductivity of the shale that separates the alluvial aquifer from the upper Chinle aquifer. However, if the upper Chinle aquifer injection program north of Broadview Acres does not reduce elevated concentrations in the aquifer by the time the alluvial collection system can be stopped (after 1992), then an alternate program will be initiated. The alternate program will consist of pumping the upper Chinle aquifer in the elevated concentration zone. Homestake has also committed to installing a monitoring well in the upper Chinle aquifer in Broadview Acres to further define the areal extent of contamination beyond their property.

Water quality in the middle Chinle aquifer has not been impacted by the migration of tailings seepage. However, a downward-hydraulic gradient from the alluvium into the middle Chinle aquifer indicates a potential for contamination over time. Travel time of tailings seepage to the middle Chinle is more than 5000 years. In the most conservative analysis, sulfate concentrations are estimated to increase from 530 to 730 mg/l by that time on Homestake's property. However, sulfate concentrations should not exceed the NMWQCC numerical ground-water standards beyond Homestake's property.

Water quality in the San Andres aquifer has not been, and will not be impacted by tailings seepage as it is separated from the middle Chinle aquifer by a large thickness of shale of low-hydraulic conductivity.

2. The processing mill is currently operating at 800 to 1000 tons per operating day. During operation, small spills resulting from ruptures of the mill circuit will be contained by curbing within the buildings. A major spill in the mill that would flow outside the immediate mill area would be contained by the same facilities which would contain a spill from a tailings-slurry pipeline break. The collected spills will be discharged to the tailings reservoir. The EID's analysis of the site's geology, hydrology and mill's engineering design supports Homestake's conclusion that minimal impacts to ground water should result from a spill within from the mill facility.

3. A slurry pipeline transports tailings from the mill to the tailings-disposal reservoir. Safety features

included in the design are: 1) a flow alarm with automatic shutdown at the mill; 2) collection channels, berms and beaches to contain a possible spill; and 3) frequent inspection by operators.

The EID's analysis of the engineering design and maintenance of the tailings-slurry pipeline supports Homestake's conclusion that minimal impacts to ground water should result from the failure of the tailings-slurry pipeline.

4. The structural stability of the tailings reservoir is sufficient to prevent a failure of the tailings-reservoir embankment. A release of tailings that occurred on February 5, 1977, resulted from erosion of freeboard by a break in the tailings slurry line, rather than a structural failure. Monthly monitoring of phreatic levels in the tailings embankment and analysis of the stability of buildout, assure structural stability for the next few years. Frequent inspections by cyclone-truck operators will detect structural instability and should a failure occur, the resulting spill would be collected by a berm located 1/4 mile south of the tailings reservoir. Mechanical clean-up of the spill would assure that minimal contamination would reach ground water. The staff of the EID concludes that the structural stability of the tailings reservoir design-safety features, frequent monitoring and inspection will prevent a structural failure. In the unlikely event that a failure should occur, the resulting spill will have negligible impact on ground-water quality.

5. Tailings were discharged from the mill to the inactive-tailings reservoir from 1958 to 1962. Seepage from the inactive-tailings reservoir has contributed to elevated levels of contaminants in subdivisions south of Homestake's property. Evaluation of potentiometric data and ground-water modeling of the inactive reservoir indicate that present seepage is minimal. In 1982, the top of the reservoir was contoured to enhance the evaporation of collected runoff, and a sump pump was installed to prevent ponding in a depression on the southeast end of the reservoir. Homestake has committed to maintaining the top of the reservoir in a dry condition using these engineering methods, until final stabilization of the inactive-tailings reservoir is complete. Stabilization of the inactive-tailings reservoir is being delayed by Homestake pending funding by Congress under the Federal Commingled Tailings Act. According to the Homestake Discharge Plan:

> "If HMC receives Discharge Plan approval, they will submit a plan to stabilize the inactive-tailings reservoir, along with a time schedule, either within six (6) months of Congress' decision to not take responsibility for stabilization of these tailings or within one (1) year prior to the expiration of the 5-year term of the approved Discharge Plan, whichever occurs first. These plans will comply with present New Mexico Radiation Protection Regulations and Water Quality Control Commission Regulations. HMC will undertake stabilization activities in accordance with present New Mexico regulations within one (1) year after approval of the stabilization plan. If HMC believes there are valid circumstances indicating that stabilization should not be undertaken at such a time, then this information will be submitted with the plan for final stabilization of the inactive tailings reservoir to the EID by the date stipulated above. HMC must receive written approval from the EID to postpone final stabilization beyond the dates set forth above."

6. The Homestake uranium mill and tailings facilities are adequately protected from floods resulting from the 100-year storm. The present 100-year storm (flood) protection berm will be extended eastward upon inactivation of the facility to ensure 200-year storm protection of the tailings embankments. Homestake's long-term stabilization procedures will provide adequate protection against the flood resulting from a Probable Maximum Precipitation (PMP) event. Ground-water quality impacts from the PMP would be negligible.

1.2 Monitoring Commitments

Homestake's monitoring program will be sufficient to ascertain when contaminated portions of the alluvial and upper Chinle aquifers have been reclaimed to NMWQCC numerical ground-water standards or mean-background concentrations, whichever are higher, and to detect further possible degradation of ground-water quality. The proposed monitoring system includes 87 alluvial wells plus active-collection wells, 5 wells in the upper Chinle aquifer, 10 wells in the middle Chinle aquifer and one well in the San Andres aquifer. Wells will be sampled quarterly or semi-annually for key chemical parameters and annually for a detailed list of parameters. The lists of monitoring wells, parameters tested, and frequency of sampling are given in Table 6. Monitoring data will be submitted to the EID quarterly for the first two years following discharge plan approval and semi-annually thereafter

2.0 INTRODUCTION

2.1 Discharge Plan Submittal and Review

On April 21, 1981, Homestake Mining Company (Homestake or HMC) was notified by the New Mexico Environmental Improvement Division (EID) that a ground-water discharge plan was required for its uranium mill and tailings facilities located 5 miles north of Milan in Cibola County, New Mexico. The discharge plan (DP-200) was submitted on December 2, 1981, pursuant to requirements set forth in the amended New Mexico Water Quality Control Commission (NMWQCC) Regulations, adopted January 11, 1977. The plan describes the potential impacts to ground water which may result from the operation of the mill and tailings facilities.

This document presents an analysis of Homestake's discharge plan conducted by the technical staff of the EID Ground Water Quality and Hazardous Waste Bureau. Quotes contained in this analysis are from the discharge plan. The analysis included herein is based on review of the discharge plan, quarterly updates to the discharge plan and additional information supplied by Homestake to the EID upon request. The following list of documents are appurtenant to this discharge plan analysis:

D'Appolonia Consulting Engineers, Inc. (D'Appolonia), 1980a, Letter report - preliminary stability assessment prepared for United Nuclear-Homestake Partners, Grants, New Mexico.

D'Appolonia, 1980b, Engineers report - stability assessment prepared for United Nuclear-Homestake Partners, Grants, New Mexico.

D'Appolonia, 1982, Uranium mill license renewal application, environmental report, Homestake Mining Company, Grants, N.M.

Hoffman, G.L., 1976, Groundwater hydrology of the alluvium, consulting report to Homestake Mining Company.

Hoffman, G.L., 1977, Modeling, design and specifications of the collection and injection systems, consulting report to Homestake Mining Company.

Homestake Mining Company (HMC), 1981, Meteorological data for the year 1980 at Homestake's Partners Mill, HMC, Grants, New Mexico.

As part of the review, the EID technical staff performed on-site investigations and ground-water modeling to provide an independent analysis of the site conditions. The analysis assesses whether Homestake's discharge plan satisfies the technical requirements of the NMWQCC Regulations. Major provisions of the NMWQCC Regulations require that ground water having an existing total dissolved solids concentration of less than 10,000 milligrams per liter (mg/l) is to be protected from contamination resulting from discharges onto or below the surface of the ground. NMWQCC numerical ground-water standards are established at the point of present or foreseeable future use for arsenic, barium, cadmium, chromium, cyanide, fluoride, lead, total mercury, nitrate, selenium, silver, uranium, combined radium-226 and radium-228 radioactivity and eight other parameters, based on human health criteria. There are 14 additional standards based on secondary domestic use criteria and criteria for irrigation use and a provision that the discharge must not cause a toxic pollutant as defined in Section 1-101.UU of the Regulations to be present at a place of foreseeable future use.

A proposed discharge plan shall set forth, in detail, the methods or techniques the discharger proposes to use or processes expected to naturally occur which will ensure ground-water protection. The discharger must demonstrate that approval of the discharge plan will not result in concentrations in excess of the NMWQCC ground-water standards or the presence of a toxic pollutant at any place of withdrawal of water for present or reasonably foreseeable future use. The Regulations state: "if the existing concentration of any water contaminant in ground water is in conformance with the standard of Section 3-103 of these regulations, degradation of the ground water up to the limit of the standard will be allowed." In the case where the existing concentrations in the aquifer exceed the NMWQCC numerical ground-water standards: "When an existing pH or concentration of any water contaminant exceeds the standard specified in Subsection A, B, or C, the existing pH or concentration shall be the allowable limit."

Provided that the other requirements of these Regulations are met, the EID director shall approve a proposed discharge plan if the discharge will not result in NMWQCC ground-water standards being violated or a toxic pollutant being present at the place of use in the present or reasonably foreseeable future.

Members of the EID Bureau technical staff responsible for the review are Kent Bostick (ground-water hydrologist), Joel Hubbell (ground-water hydrologist) and Devon Jercinovic (geomorphologist). Ken Stollenwerk of the U.S. Geological Survey performed laboratory column tests to determine distribution coefficients for selenium.

It must be emphasized that this evaluation was developed without the benefit of the discussions and testimony to be presented during the forthcoming public hearing on the plan. Therefore, this document should be viewed as a preliminary assessment, subject to change as a result of new evidence presented at the hearing.

2.2 General Description of Mill and Tailings Facilities

Homestake's mill and tailings facilities are located in Section 26, Township 12N, Range 10W, New Mexico Principal Meridian (Figure 1). The mill uses a alkaline-leach circuit to process uranium ore. The milling rate is approximately 800-1000 tons per operating day (December 1983), with an operating schedule of 10 days on 4 days off. The mill has a nominal capacity to process 3500 tons of uranium ore per day.

Make-up water for the mill comes from a mixture of water from two wells in the San Andres aquifer and water recycled from the active-tailings reservoir. As much as 350 gallons per minute (gpm) may be required for operation of the mill. Approximately 120 gpm make-up water is derived from the San Andres aquifer. The remaining make-up water will be derived from seepage collection wells around the active-tailings reservoir, collection systems in the alluvium north of the tailings reservoir, and collection wells in Murray Acres.

Most of the uranium is removed from the ore in the alkaline-leach milling process. However, the weight of the uranium in the ore is less than one-fifth of one percent. The waste from the ore, called tailings, is transported from the mill to the active-tailings reservoir in a slurry form by pipeline.

The slurry is approximately one-half liquid by weight. The slurry is deposited in the active-tailings reservoir, which contains an east cell and west cell. Separation of liquid and solids occurs in the tailings reservoir. Decant towers collect part of the clarified liquid, which is piped to an ion-exchange facility. This facility removes additional uranium from the tailings liquid. The liquid is then recycled into the mill circuit.

The tailings embankment is made of coarse tailings, and "marginal" weeping is intended to occur. Liquids weeping from the tailings and water pumped from the collection wells are received in a collection channel around the tailings facility. Liquids in the collection channel are routed to two unlined sumps located on the south side of the collection channel. From the sumps, the liquids are generally pumped to the ion-exchange facility, and thus returned to the mill circuit. If calcium carbonate precipitation in the collection channel is not sufficient to prevent interference of calcium carbonate with the ion-exchange facility, liquids in the collection channel are pumped directly from the sumps into the active-tailings reservoir.

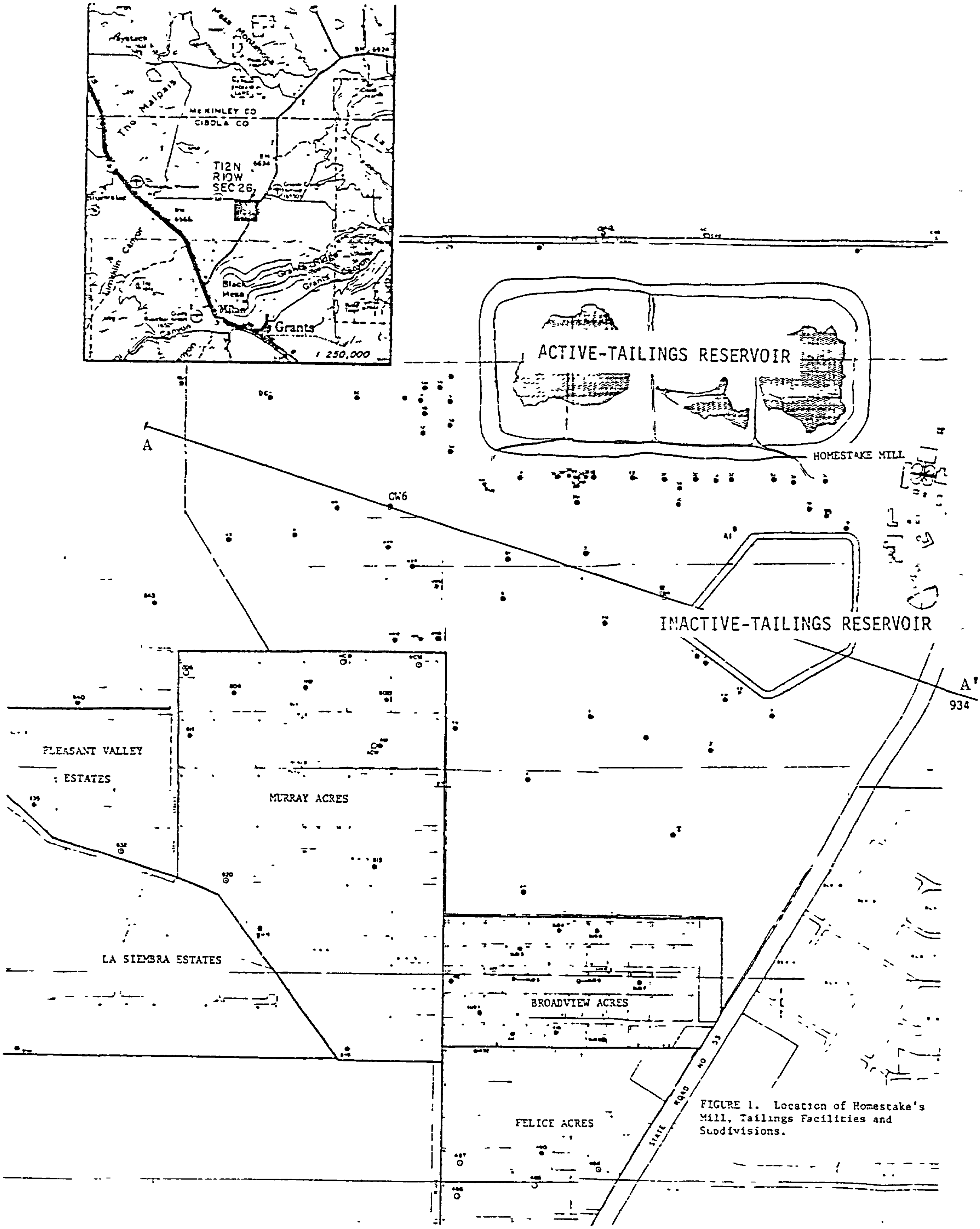


FIGURE 1. Location of Homestake's Mill, Tailings Facilities and Subdivisions.

2.3 Potential Points of Discharge and Impacts on Ground Water

The operation of the mill and tailings facilities produces several possible points of discharge of effluents. This analysis addresses each of the following possible points of discharge and their potential impact on ground-water quality.

1. Ground-water quality impacts from active-tailings facility
2. Ground-water quality impacts from the mill facility
3. Ground-water quality impacts from the tailings slurry pipeline
4. Ground-water quality impacts from the structural stability of the active-tailings reservoir facility
5. Ground-water quality impacts from the inactive-tailings reservoir facility
6. Ground-water quality impacts from flooding

2.4 Summary of Hydrogeologic Setting

Homestake's mill and tailings facilities are located within the Zuni uplift portion of the San Juan Structural Basin. The basin is characterized by broad areas of relatively flat-lying sedimentary rocks, dipping to the northwest, with portions of the basin covered with alluvium and basalt flows. The site is within the broad, San Mateo alluvial valley that extends from the Mount Taylor and Ambrosia Lake mining areas in the north to the Rio San Jose alluvial system in the south.

The stratigraphic sequence of hydrologic significance at the site consists, in descending order, of the San Mateo alluvium, the Chinle Formation, the San Andres Limestone and the Glorieta Sandstone. A geologic cross section is presented on Figure 2. The San Mateo alluvium (alluvial aquifer) rests on an erosional surface of the Chinle Formation and has saturated thickness of as much as 60 feet in depressions in the Chinle surface. Depth to water in the alluvium is 40 to 60 feet. The Chinle Formation is composed primarily of shale, but two, thin, interbedded sandstones, hereafter referred to as the upper and middle Chinle aquifers, are of hydrologic importance at the site. The Chinle Formation is approximately 850 feet thick near the tailings facilities. Vertical migration of tailings seepage through the alluvium into the upper Chinle aquifer is restricted by a thin sequence of shale of low hydraulic conductivity. The potentiometric surface is 40 to 60 feet below land surface in the upper Chinle aquifer and 110 to 120 feet below land surface in the middle Chinle aquifer, thereby inducing a downward hydraulic gradient from the alluvium into the Chinle aquifers. The San Andres Limestone and Glorieta Sandstone are hydraulically connected and constitute the San Andres aquifer, which has the capability to be a high-volume water producer at the site.

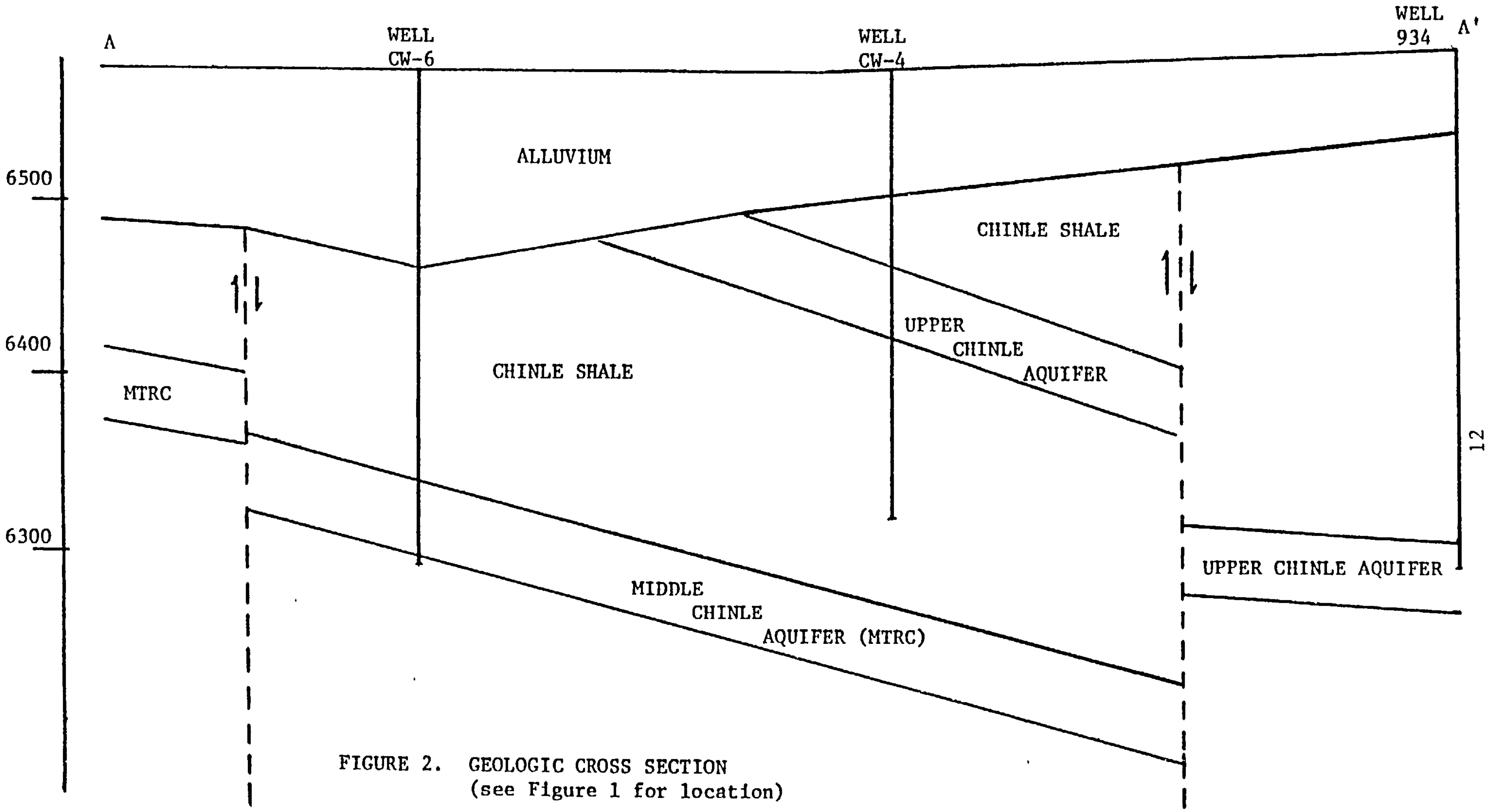


FIGURE 2. GEOLOGIC CROSS SECTION
(see Figure 1 for location)

Two concealed faults are located near Homestake's tailings-disposal area. Their approximate location has been delineated by analysis of drilling and pumping test data. Faulting occurred prior to deposition of the alluvium and hydraulically affects the flow systems in the pre-alluvial bedrock. Faults structurally restrict the areal extent of the upper and middle Chinle aquifers near Homestake's mill and tailings-disposal area by offsetting geologic units east and west of the faults.

Water quality in the alluvial aquifer is variable, depending on the extent of influence of tailings seepage. Mean-background water quality, up-hydraulic gradient of the tailings reservoirs averages 1770 mg/l total dissolved solids (TDS), but may be influenced by ground-water underflow and flooding events from mining and milling activities at Ambrosia Lake to the north of the site as well as natural variation. Ground-water affected by tailings seepage may have a TDS content as high as 28,000 mg/l.

The upper Chinle aquifer has also been affected by seepage from the tailings reservoir. Background-water quality is similar to the alluvial ground water. Total dissolved solids are as high as 5,000 mg/l in wells influenced by tailings seepage.

The middle Chinle aquifer water quality has not been influenced by tailings seepage and has a TDS ranging from 1000 to 2000 mg/l.

Background-water quality for the San Andres aquifer, which has not been influenced by tailings seepage, is as high as 2,200 mg/l in TDS.

2.5 Ground Waters to be Protected

The ground water most likely to be affected by a discharge of effluents is the San Mateo alluvium. Ground water in the alluvium that has been affected is down-hydraulic gradient to the south and west of the active and inactive-tailings reservoirs. The alluvium has supplied water for domestic, livestock and minor irrigation uses from individual wells in the Broadview, Felice, Murray Acres and Pleasant Valley subdivisions. The locations of these subdivisions are shown on Figure 1. Seepage from the active-tailings reservoir, collection channel and sumps will, if not collected, enter the alluvium and move downgradient beyond Homestake's property. Contamination of the Chinle aquifers must also be considered. The Chinle aquifers have provided water for domestic, livestock and minor irrigation uses from individual wells at Murray Acres, Felice Acres and, to a lesser extent at Broadview Acres. Tailings-reservoir seepage has moved down-hydraulic gradient to the southwest in the upper Chinle aquifer.

The discharge plan is designed to protect the quality of ground water in the San Mateo alluvium and Chinle Formation. The nearest places of present or reasonable foreseeable future use are the wells in Broadview and Murray Acres. Homestake's property line adjoins Broadview Acres on the south, and Murray Acres on the west. Homestake will covenant with the EID not to allow drilling of wells for use as a domestic or agricultural water supply, on the Homestake property without the consent of the EID.

Ground water in the San Andres aquifer should not be impacted by seepage from the tailings facility as the San Andres aquifer is overlain by several hundred feet of Chinle Formation with a relatively low, vertical-hydraulic conductivity. This has been verified by Homestake's monitoring data.

2.6 Ground-Water Protection Program

Seepage from the active-tailings reservoir and inactive-tailings reservoir was detected in 1975, in two subdivisions, south and west of the Homestake Mill (then known as the United Nuclear-Homestake Partners Mill), during a joint-sampling program conducted by the EID and the Environmental Protection Agency. As a result of the sampling program, several residents of two subdivisions were notified of the elevated selenium concentrations and advised to refrain from using their well water for domestic purposes.

Subdivision residents visited Homestake to discuss the ground-water situation. Homestake voluntarily established a program to distribute bottled water for drinking and cooking purposes. Homestake also designed and implemented a complex hydrological assessment to identify the water movement in the alluvial aquifer and determine whether Homestake's operations could be a source of the elevated concentrations of selenium observed in the subdivisions. The hydrological assessment "Ground Water Hydrology of the Alluvium at UN-HP (now Homestake) Mill near Milan, New Mexico" was prepared and submitted to the EID after extensive sampling of subdivision wells, existing Homestake wells and over 40 new wells drilled specifically for the study.

Thereafter, a Ground-Water Protection Plan Agreement, referred to as the Agreement, was entered with the EID on August 18, 1976. The Agreement provides that Homestake would design and construct a system to contain seepage from Homestake's tailings reservoirs to shallow ground water in the area, and at the same time, provide a method to reduce selenium levels in the alluvium in the Broadview and Murray Acres subdivisions to background levels, regardless of the source or sources of selenium. The Agreement also provides for a cooperative EID/Homestake ground-water monitoring program to verify the results of the Agreement.

As a result of the Agreement, Homestake installed a system of collection wells south and west of the active-tailings reservoir to prevent tailings seepage from migrating beyond the collection wells and to subsequently pump back seepage that had already migrated down-hydraulic gradient. In addition, a line of recharge wells (Broadview Acres Injection System) was installed on Homestake's property, immediately north of Broadview Acres, to inject good quality water from the San Andres aquifer into the alluvial aquifer. The purpose of the recharge-well system is to obtain a quality of ground water, through dilution and dispersion, equivalent to that of mean-background levels or the NMWQCC numerical standards, whichever are higher as described in Section 3.2.1.3. The basic document for this system was a report entitled "Modelling, Design and Specifications of the Collection and Injection Systems at United Nuclear-Homestake Partners Mill" dated January 1977, which was submitted to the EID. An extensive ground-water monitoring program was also implemented. The Broadview Acres injection system was expanded in 1981, within the stipulations of the 1976 agreement, and a similar injection system was installed in Murray Acres in 1983. EID approval was obtained prior to each phase of this program.

Homestake has been operating its ground-water protection program under the Agreement since 1976. In September 1980, a report evaluating the performance of the corrective system was submitted to the EID entitled "Review of Broadview Acres Injection System at United Nuclear-Homestake Partners Mill Near Milan, New Mexico." Ground-water monitoring reports submitted quarterly since the submission of the discharge plan have also been used in evaluating the performance of the protection program. In addition to the Agreement, Homestake has been operating under an approved discharge plan (DP-102) for the protection and clean-up of the alluvial aquifer in Murray Acres.

Also, as part of the ground-water protection program proposed in the discharge plan, a separate injection/collection system, with collection wells up-hydraulic gradient of the active-tailings reservoir has been proposed to intercept the natural underflow in the alluvium and prevent its contamination. The collected underflow, which is of ambient background quality (approximately 1,800 mg/l TDS), will be used as make-up water at the mill. Water pumped from the San Andres aquifer will be injected into a well completed in the upper Chinle aquifer near Broadview Acres to reduce contaminant concentrations through dilution and dispersion.

To determine whether Homestake has accurately assessed the levels and areal extent of contamination resulting from the operation of the mill and tailings facilities and to define the effectiveness of the ground-water protection program, the EID has split samples collected by Homestake and had the samples analyzed at the NM Scientific Laboratory Division

(SLD) since 1978. Split samples for all monitoring wells in the Homestake Discharge Plan have been analyzed by the SLD on an annual basis since July 1981. In June through September, 1983, the EID independently collected split samples in wells on and adjacent to Homestake's property and analyzed the samples at the SLD. There is a close agreement between analyses by the SLD and analyses by Homestake's Laboratory.

The EID collected water samples from a pumping well at logarithmically spaced time intervals to determine if the chemical quality changed with the volume of water pumped from the well. The results showed minor fluctuations in the concentrations of bicarbonate, chloride and total dissolved solids, while other elements tested, including heavy metals, showed only small variations attributable to measurement error.

3.0 GROUND WATER QUALITY IMPACTS FROM ACTIVE TAILINGS RESERVOIR FACILITY

3.1 Active-Tailings Reservoir Facility Description

Homestake's active-tailings reservoir facility is located on the northern half of Section 26, Township 12N, Range 10W, N.M.P.M. The active-tailings reservoir facility consists of the tailings reservoir, a seepage collection channel, and two collection channel return sumps. The facility covers 170 acres of land, stands about 90 feet high and contains about 19,700,000 tons of tailings material (April 1982). Tailings have been discharged to the active reservoir since 1958.

The active-tailings reservoir collection channels and return sumps are unlined and the depth to ground water below the tailings reservoir in the alluvium is approximately 50 feet. Piezometers in the tailings embankment indicate a different phreatic surface than the water table in the alluvium, suggesting unsaturated flow occurs beneath the active-tailings reservoir facility.

3.1.1 Chemical Analyses of Tailings Liquid

Chemical analyses of tailings liquid for five dates, 11/16/78, 11/06/79, 9/23/81, 10/28/82 and 8/18/83 are presented in Table 1. The analyses show that the liquid has a pH of approximately 10 with high concentrations of sodium, sulfate, bicarbonate, potassium and chloride. Concentrations of sulfate, chloride, TDS, selenium, arsenic, uranium, molybdenum and radium-226 are present in quantities that greatly exceed the NMWQCC numerical ground-water standards. A sulfate concentration in the range of 10,000 mg/l is probably representative of the seepage water for the last few years. Uranium, selenium and molybdenum concentrations of 43, 25, and 90 mg/l, respectively, are representative in tailings liquid. In October, 1982, a sample of tailings liquid collected from the east decant was analyzed for organic constituents at the SLD. While no purgeable organic constituents exceeded the NMWQCC numerical ground-water standards, the sample contained a total organic carbon (TOC) of 1590 mg/l. High concentrations of TOC may be related to the discharge of mill sewage into the east decant and high organic concentrations in the uranium ore.

3.1.2 Seepage Rate by Water Balance Method

Seepage from the active-tailings reservoir to ground water in the alluvium is 153 gpm as calculated by the following water balance.

TABLE 1. CHEMICAL ANALYSES OF TAILINGS LIQUID

Date Collected Laboratory	11/16/78 HMC	11/06/79 HMC	9/23/81 HMC	10/28/82 HMC	8/18/83 EID
Constituent					
Ca	.01	.01	135	35	0.01
Mg	--	.1	30.0	--	175
Na	10,000	10,000	9,800	9,080	17,181
K	0.58	--	--	450	56.6
HCO_3	3,280	--	1,850	2,480	3,750
CO_3	--	--	6,450	--	3,605
SO_4	8,100	8,420	15,700	12,800	23,024
Cl	624	1,070	2,340	1,870	3,602
TDS	--	--	43,300	31,400	49,295
pH (units)	--	10.1	10.3	9.9	9.90
NO_3	13.8	11.0	8.2	--	3.30
NH_3	1.0	--	--	--	0.78
Kjeldahl Nitrogen	--	--	--	--	7.87
Al	--	--	1.0	--	0.365
As	0.18	--	0.07	0.08	2.29
Ba	1.0	--	1.0	1.0	0.1
Cd	.01	--	.01	.01	0.008
Pb	.01	--	.01	0.01	0.026
Mo	80.5	74.8	105	94.0	160
Se	26.4	14.7	35.5	24.8	34.0
U_3O_8	64.1	55.8	24.8	29.2	53.8
V	16.9	--	9.23	4.23	3.46
Zn	14.8	--	6.62	1.0	0.05
Ra-226 (pCi/l)	31.9	23.5	88.4	80.3	--
Th-230 (pCi/l)	--	0.036	0.151	--	--

NOTE: All Concentrations in mg/l, except as noted.

WATER BALANCE FOR ACTIVE-TAILINGS RESERVOIR, FALL 1981
WATER INPUT TO THE TAILINGS RESERVOIR

SOURCE		RATE (gpm)
Process Make-up Water - Plant Evaporation		255 - 48 = 207
Collection Wells		175
Ore @ 6.5% H_2O		40
NaOH @ 50%, 20#/Ton		6
Precipitation and Drainage		113
	TOTAL	541

WATER LOST FROM THE TAILINGS RESERVOIR

SOURCE		RATE (gpm)
Tailings Reservoir Evaporation		285
Retained in Solids		103
Total		388
Seepage by Difference	541-388 =	153

3.2.0 Hydrologic Investigations

3.2.1 Alluvial Aquifer

Water quality in the alluvium has been impacted by seepage from the active-tailings reservoir facility. Tailings seepage has moved down-hydraulic gradient to the south and southwest of Homestake's property. Portions of the alluvial aquifer beyond Homestake's property boundaries have concentrations of TDS, sulfate, nitrate, molybdenum, selenium and uranium that exceed NMWQCC numerical ground-water standards.

Homestake has agreed to a ground-water protection program that will restore ground water to the mean-background concentration or the NMWQCC numerical ground-water standards, whichever is higher, to mitigate the water-quality impacts of seepage from the tailings reservoirs. The scenario for this program, including the methods and dates of implementation, is presented in Section 3.2.1.6 of this report. Over 125 wells have been completed in the San Mateo alluvium by Homestake to define the hydraulic characteristics and water quality of the alluvial aquifer and to implement the collection and injection system described in the ground-water protection program.

Numerical and analytical modeling indicate that the ground-water protection program should prevent NMWQCC ground-water standards from being violated in the foreseeable future and will also reduce elevated concentrations of TDS, sulfate, nitrate, molybdenum, selenium and uranium in subdivisions south and west of Homestake's property to mean-background levels or the NMWQCC numerical ground-water standards, whichever is higher. The EID's analysis of the modeling has determined that hydraulic gradients to the south and southwest of the tailings reservoirs will be reversed by the collection/injection system implemented under the ground-water protection program. Thus an effective hydraulic barrier will be created to prevent the migration of tailings seepage in the alluvium beyond Homestake's property. By 1984, concentrations of sulfate and selenium in subdivisions south of Homestake's property are predicted to approach mean-background concentrations of 976 mg/l and 0.12 mg/l, respectively. By 1988, concentrations of sulfate and selenium in the subdivisions are predicted to be below mean-background concentrations and approach NMWQCC numerical ground-water standards of 600 mg/l and 0.05 mg/l, respectively. Uranium, molybdenum and nitrate concentrations should decrease before selenium, as they have higher distribution coefficients (adsorbed more) and lower concentrations relative to the NMWQCC numerical ground-water standards than selenium. TDS will eventually approach the 1400 mg/l concentration of the San Andres aquifer injection water.

Since actual field conditions may be somewhat different than those modeled, particularly the discontinuity of the alluvial aquifer, stagnation points in the flow field may occur and concentrations may remain unchanged at some locations. However, Homestake has committed to maintaining ground-water reversals in the alluvial aquifer while in operation and preventing the NMWQCC ground-water standards from being violated beyond Homestake's property in the foreseeable future after cessation of operations. Eventually, all the water in the subdivisions will approach the quality of the San Andres aquifer injection water.

3.2.1.1 Hydrogeologic description

The San Mateo alluvium consists of unconsolidated, intertonguing, fluvial sediments ranging in grain size from clay to coarse gravel, but is predominantly composed of medium to very fine-grained sand. The alluvium is 50 to 120 feet thick and rests on an erosional surface of the Chinle Formation. Saturated thickness of the alluvium varies from zero feet on the northwestern and southeastern edges of Homestake's property to 60 feet southwest of the active-tailings reservoir. Depth to water, measured from ground surface, is 40 to 60 feet in the alluvium. A geologic cross section is shown on Figure 2.

3.2.1.2 Water levels

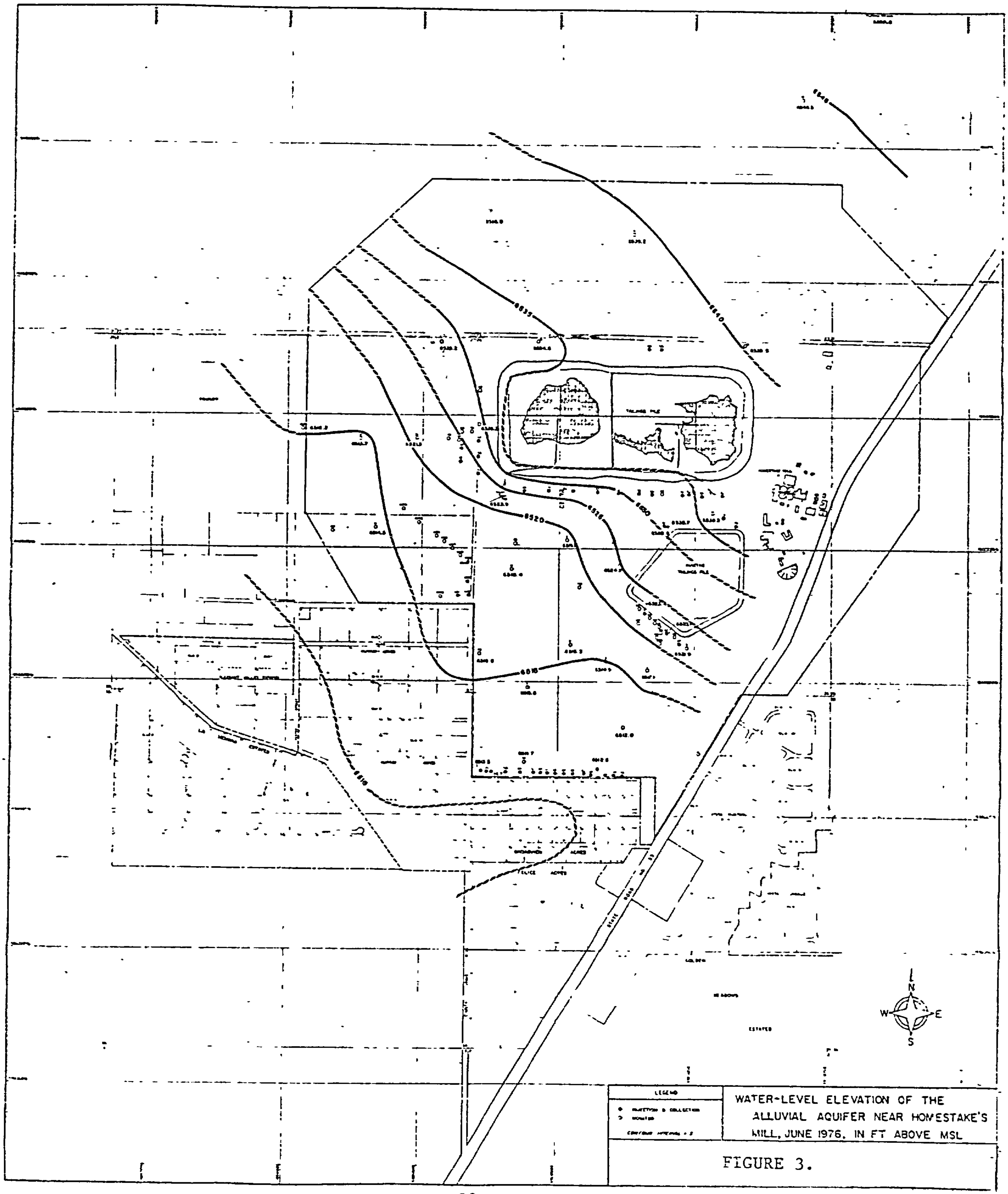
June 1976, water-level elevations for the alluvial aquifer are presented on Figure 3. Tailings seepage from the active-tailings reservoir prior to the installation of the injection and collection wells has influenced the configuration of the water table contours. The general ground-water flow direction in 1976 was toward the southwest. Recharge from the active-tailings reservoir was indicated by the down-gradient bending of water-level contours. Ground water from the vicinity of the active-tailings reservoir flowed toward Murray Acres, while water from the vicinity of the inactive-tailings reservoir flowed toward Broadview Acres.

The influence of the collection and injection wells on the water-level elevations in July 1983, can be seen on Figure 4. To the south and west of the active-tailings reservoir, the collection wells are forming overlapping cones of depression, capturing ground-water underflow moving beneath the active-tailings reservoir and, consequently, seepage from the active-tailings reservoir. Homestake plans to install new collection wells or increase pumping rates in areas around the active-tailings reservoir where water is moving past the collection wells to obtain a condition of contiguous drawdown. Several collection wells are operated within and northeast of Murray Acres. These wells are being used to collect poor-quality water in these areas.

North of Broadview Acres, discharge from the Broadview Acres injection wells has formed a ground-water mound, reversing the natural ground-water gradient between Broadview Acres and the active-tailings reservoir and preventing seepage from the tailings reservoirs from moving into this subdivision. Injection of San Andres aquifer water into the Broadview Acres wells dilutes and disperses poor-quality water in the Broadview Acres subdivision, causing it to migrate faster toward the southwest of the area. In some portions of the alluvial aquifer, ground water was moving slowly prior to the development of the injection system. However, stagnant water is being dispersed and diluted with better-quality water.

3.2.1.3 Water quality

Water quality in the San Mateo alluvium has possibly been influenced by natural variations in aquifer permeability, geochemical reactions of aquifer recharge with native and disturbed materials, ground-water underflow from Poison Canyon, Lobo Canyon and the Ambrosia Lake mining district, flood flows from the Ambrosia Lake mining district which recharge the alluvium, and seepage from the active and inactive-tailings reservoirs.



WATER-LEVEL ELEVATION OF THE ALLUVIAL AQUIFER NEAR HOMESTAKE'S MILL, JUNE 1976, IN FT ABOVE MSL

FIGURE 3.

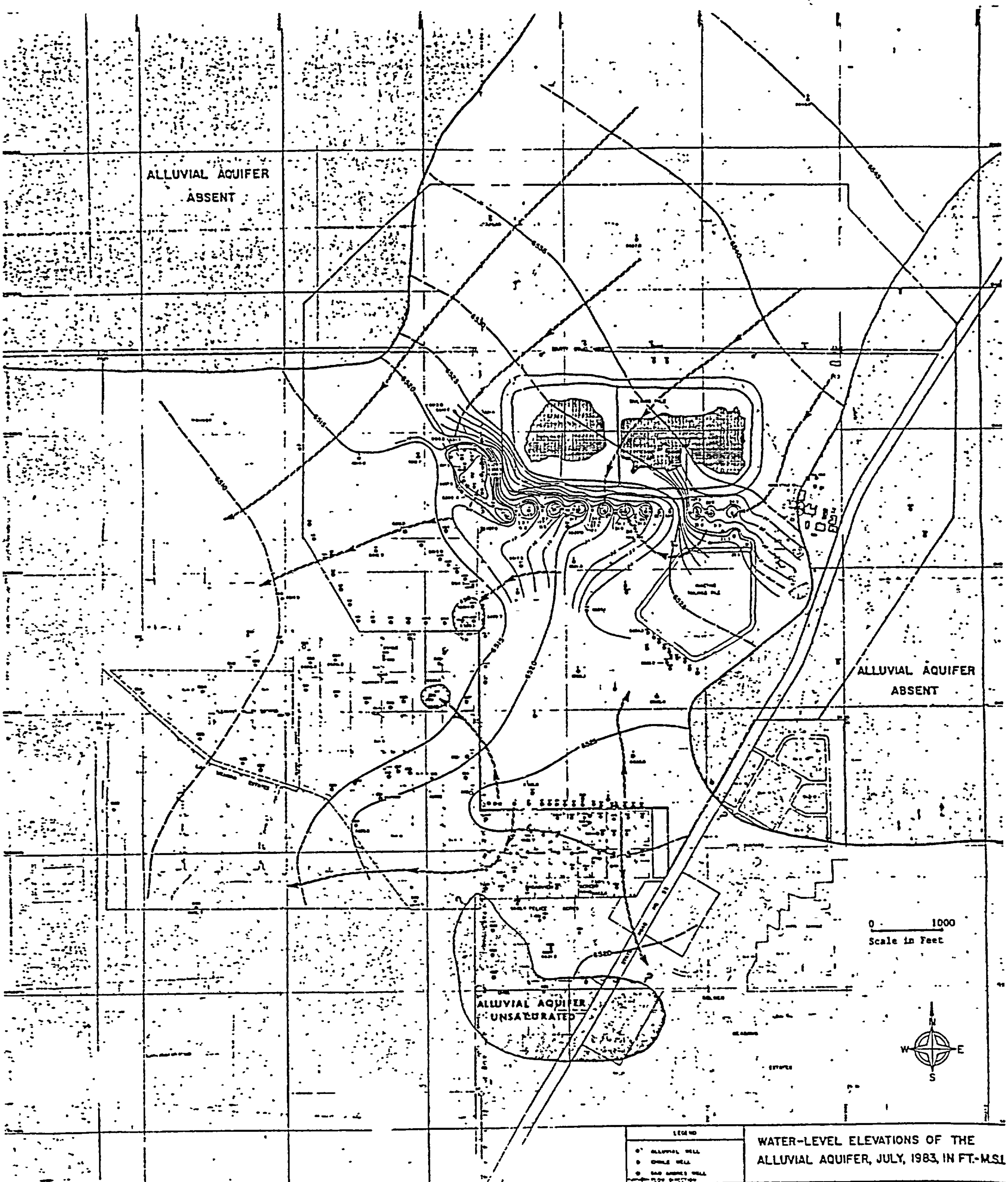

ALLUVIAL AQUIFER ABSENT
ALLUVIAL AQUIFER ABSENT
ALLUVIAL AQUIFER UNSATURATED
0 1000
Scale in Feet
N
W
E
S
LEGEND
WATER-LEVEL ELEVATIONS OF THE ALLUVIAL AQUIFER, JULY, 1983, IN FT.-MSL

FIGURE 4

Wells P, Q and R were drilled up-hydraulic gradient from Homestake's tailings reservoirs to define the mean-background water quality (up-hydraulic gradient) (Table 2). The locations of these wells are shown on Figure 26, page 82. Background-water quality was variable with TDS ranging from 1200 to 3000 mg/l, sulfate ranging from 650 to 1900 mg/l, and selenium ranging from 0.01 to 0.30 mg/l. Ground-water underflow moving beneath Homestake's property would eventually cause all concentrations beneath and downgradient of Homestake's property to return to the mean-background concentrations of the underflow in the foreseeable future, if Homestake's activities ceased. Homestake has committed to restore alluvial aquifer water quality to mean-background concentrations or the NMWQCC numerical ground-water standard, whichever is higher. The EID believes this commitment fulfills the requirements of the NMWQCC Regulations.

The quality of the alluvial ground water immediately down-hydraulic gradient from Homestake's tailings reservoirs is extremely poor with the TDS as high as 28,000 mg/l. Seepage from the tailings reservoirs has reached ground water and has migrated down-hydraulic gradient toward the southwest. Dilution, dispersion, chemical reactions and adsorption alter the quality of this water as it moves from the tailings reservoir. Around the active and inactive-tailings reservoir areas, the NMWQCC numerical ground-water standards are exceeded by pH, TDS, sulfate, chloride, nitrate, molybdenum, selenium and uranium.

Further down-hydraulic gradient from the tailings reservoirs the water quality improves, but areas in the subdivisions still have ground-water quality that exceeds the NMWQCC numerical ground-water standards. Murray Acres has a small area where concentrations of TDS, sulfate, nitrate, molybdenum, selenium and uranium exceed NMWQCC numerical ground-water standards. Broadview Acres has concentrations of TDS, sulfate and selenium which exceed standards, while Felice Acres has concentrations of TDS, sulfate, molybdenum and selenium, exceeding the standards.

The water quality in the alluvial aquifer can be generally represented by the concentrations of sulfate, selenium and uranium. These three parameters are used because: 1) they are all found in high concentrations in the tailings fluid; 2) they have previously migrated beyond Homestake's property in concentrations that exceed the NMWQCC numerical ground-water standards; 3) sulfate acts as a conservative ion, that is, it is not strongly affected by chemical reactions or adsorption which could alter its concentration in ground water. Because sulfate is the dominant ion in the tailings fluid, it is representative of TDS concentration in the ground water; 4) selenium is only slightly adsorbed and represents the worst case of contaminant transport for heavy metals; and 5) uranium, in the hexavalent state, is conservatively representative of the migration of radionuclides species as it is adsorbed less

TABLE 2. MEAN-BACKGROUND CONCENTRATIONS FOR THE ALLUVIAL AND SAN ANDRES AQUIFERS

CONSTITUENT	MEAN-BACKGROUND CONCENTRATION ALLUVIAL[2]	SAN ANDRES[3]
SO_4	976	646
TDS	1,770	1,438
Cl	52	156
Na	272	249
HCO_3	301	561
NO_3 as N	12.4	-----
U_3O_8	0.05	<.044
Se	0.12	<.016
Mo	0.03	<.046
Ra-226	1.6	1.6

NOTES:

1. Concentrations in mg/l, except Ra-226, in pCi/l.
2. Alluvial aquifer mean-background concentrations are from wells P, Q and R.
3. San Andres mean-background concentrations are from Deep Well #2, the source of injection water. Where concentrations are below the detection limits, the detection limit was used in determining the mean. The mean-background concentration is therefore actually less than (<) those concentrations reported for U_3O_8, Se and Mo.

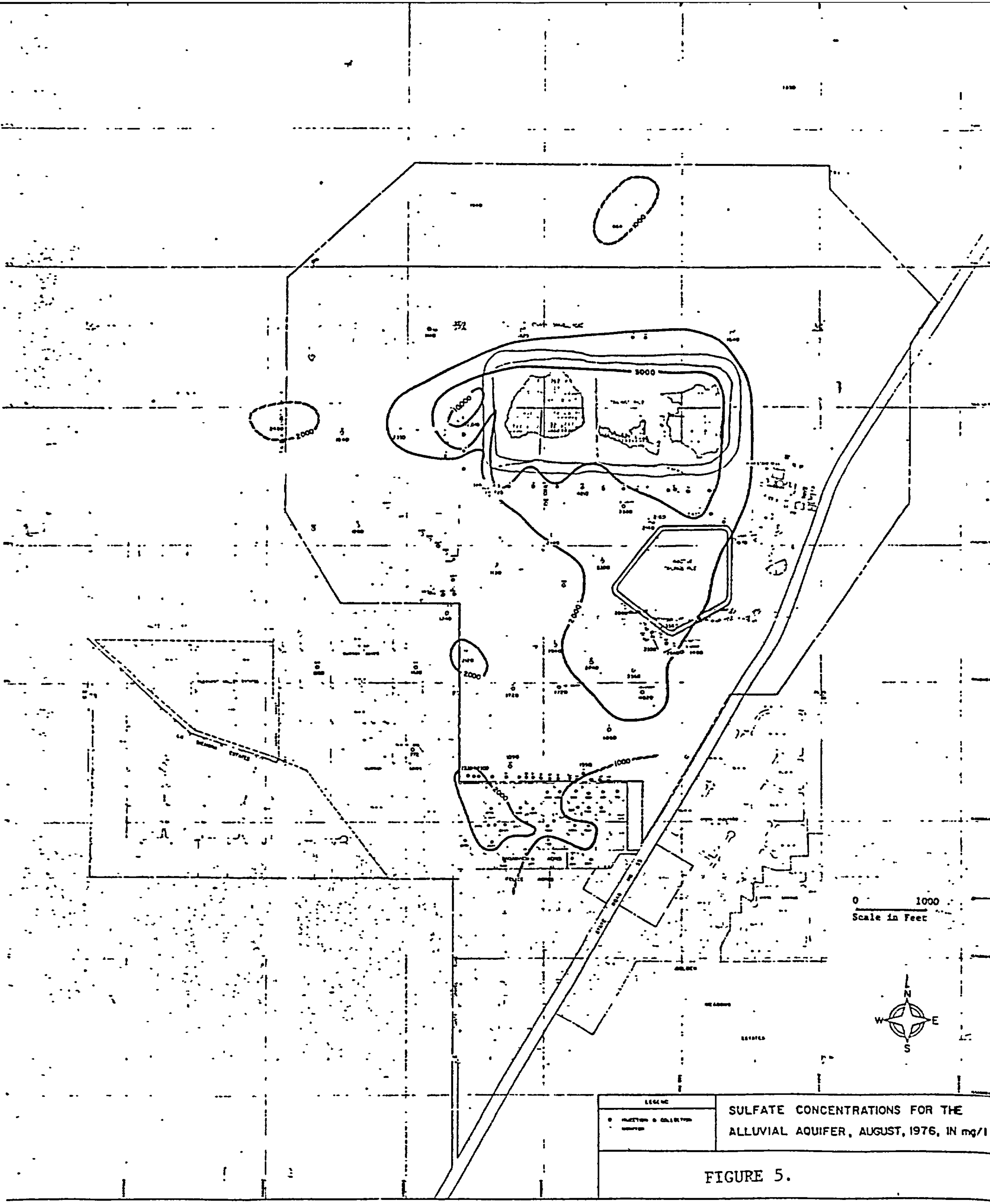
than other radionuclides present in significant concentrations in the tailings fluid. Other contaminants found in concentrations exceeding NMWQCC ground-water standards in the alluvial aquifer beyond Homestake's property are TDS, nitrate and molybdenum. As concentrations of uranium, selenium and sulfate are reduced to NMWQCC ground-water standards, the other contaminants are expected to be reduced to concentrations below standards at either the same or a faster rate.

The mean-background concentration for sulfate at this site is 976 mg/l. Sulfate concentrations for the alluvial aquifer for August 1976, are presented on Figure 5. Sulfate concentrations near the active and inactive-tailings reservoirs in August 1976, were significantly greater than 2000 mg/l and are indicative of tailings seepage. Concentrations of sulfate slightly greater than 2000 mg/l were found in Broadview Acres, Murray Acres and west of the active-tailings reservoir. Most of the wells tested in the subdivisions south of Homestake's property exceeded the mean-background concentration for sulfate.

Figure 6 presents the July 1983 sulfate concentrations for the alluvial aquifer. A large reduction in the areal extent of high sulfate contours has occurred in and north of Broadview Acres after injection of San Andres aquifer water north of Broadview Acres. The operation of the collection well system has reduced sulfate concentrations to the west of the active-tailings reservoir. Much of the alluvial aquifer south of the active-tailings reservoir within Homestake's property boundary shows little reduction in sulfate concentrations. Ground water in a portion of Felice Acres and the southern part of Broadview Acres contains concentrations of sulfate that exceed the mean-background concentration.

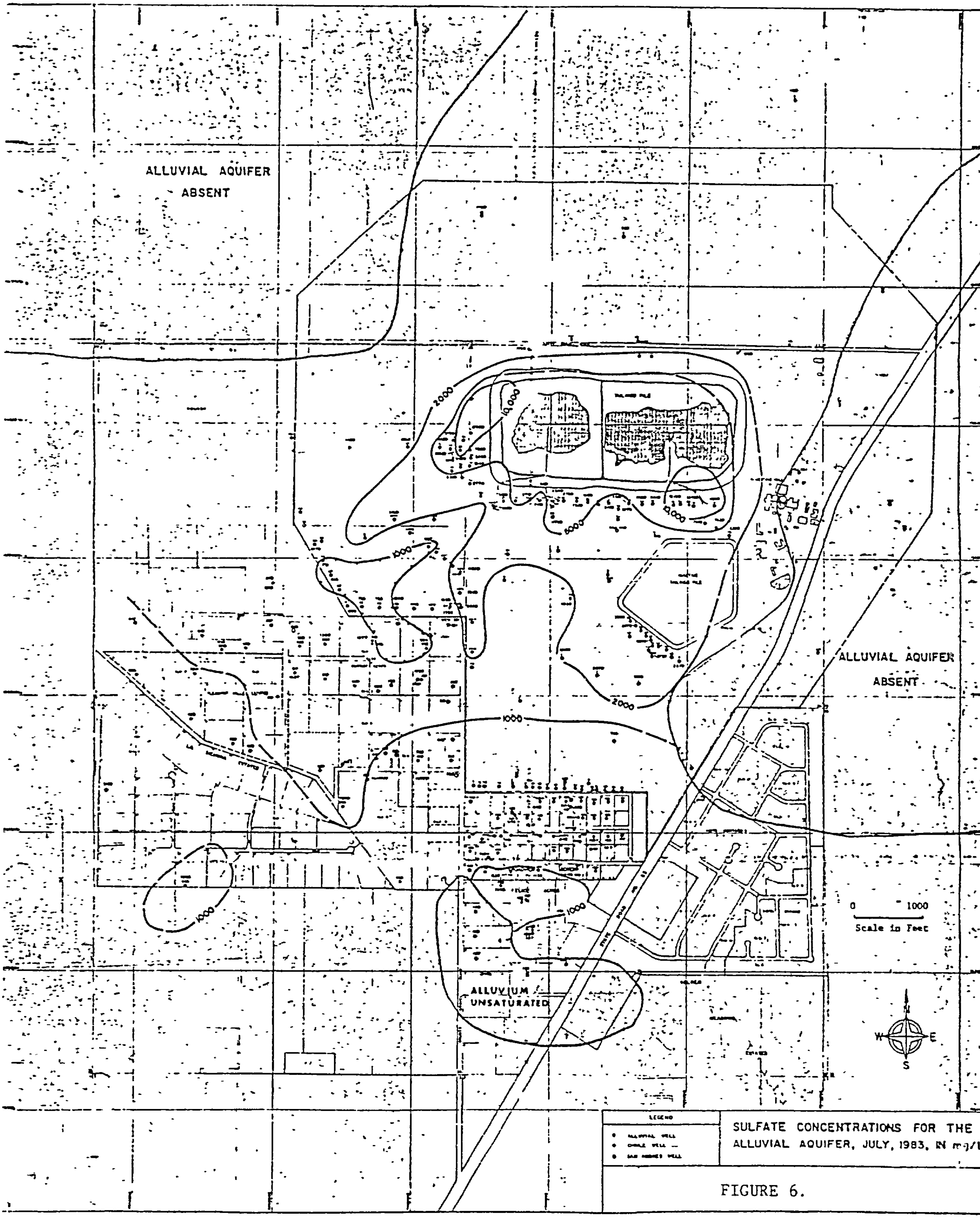
The selenium mean-background concentration is 0.12 mg/l at the site. August 1976 selenium concentrations, (Figure 7) exceeded the 0.12 mean-background concentrations over a large area in the subdivisions south of Homestake's property. Portions of Broadview Acres and the northwest corner of Murray Acres had selenium concentrations exceeding 1.0 mg/l. July 1983, selenium concentrations are presented on Figure 8. Concentrations have been reduced in the northern portion of Broadview Acres and immediately west of the active-tailings reservoir. Selenium concentrations are decreasing in the southern portion of Broadview Acres and the northern portion of Felice Acres; however, wells in this area still exceed mean-background concentrations.

The NMWQCC numerical ground-water standard for uranium is 5.0 mg/l. In August 1976, uranium concentrations in the alluvial aquifer exceeding the 5.0 mg/l standard covered a large area in Broadview Acres south of Homestake's property (Figure 9). July 1983, uranium concentrations indicate only a small area in the northeast corner of Murray Acres where the numerical standards are projected to be exceeded (Figure 10).



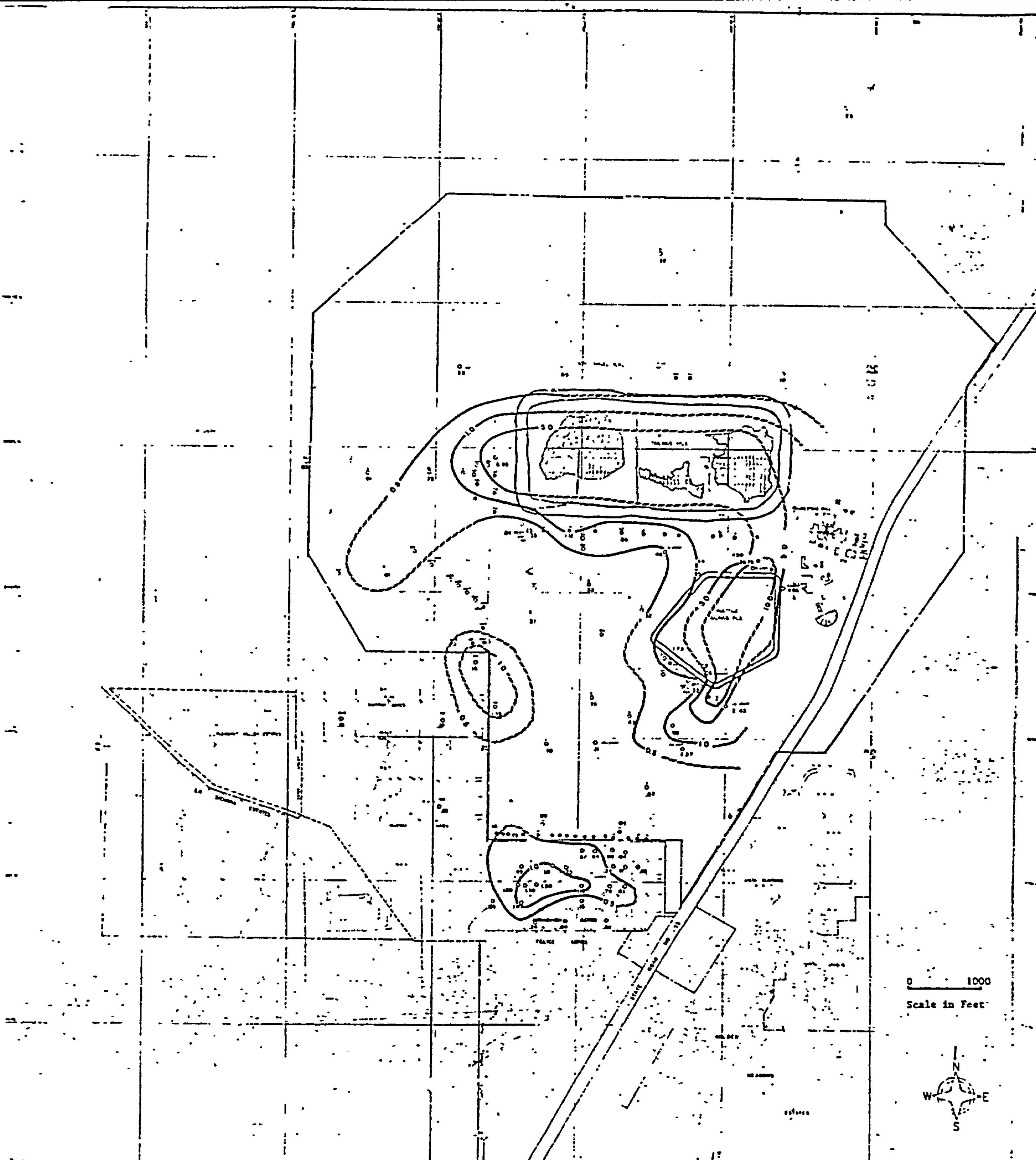
SULFATE CONCENTRATIONS FOR THE ALLUVIAL AQUIFER, AUGUST, 1976, IN mg/l

FIGURE 5.



SULFATE CONCENTRATIONS FOR THE ALLUVIAL AQUIFER, JULY, 1983, IN mg/l

FIGURE 6.



SELENIUM CONCENTRATIONS FOR THE ALLUVIAL AQUIFER, AUGUST, 1976, IN mg/l

FIGURE 7.

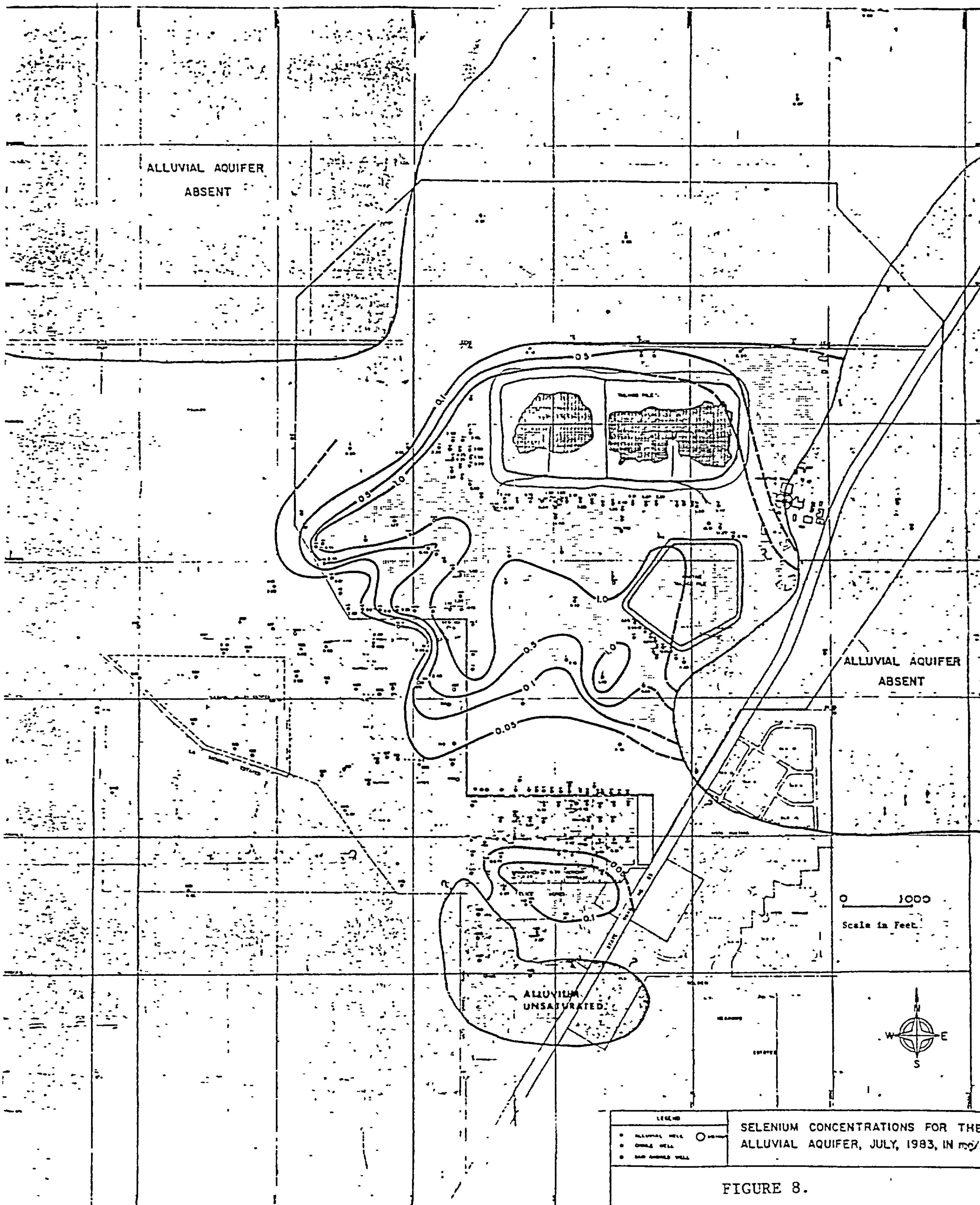
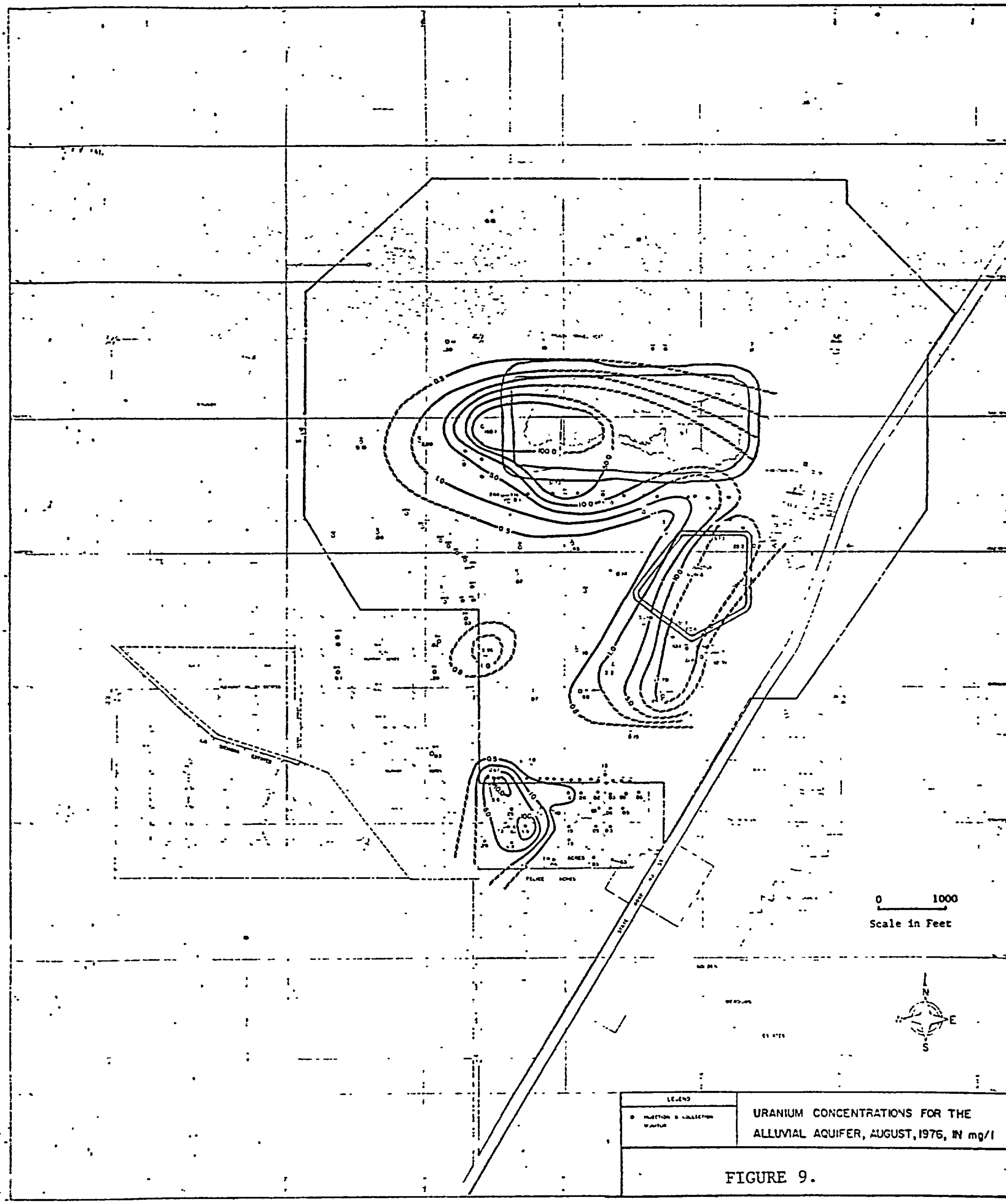
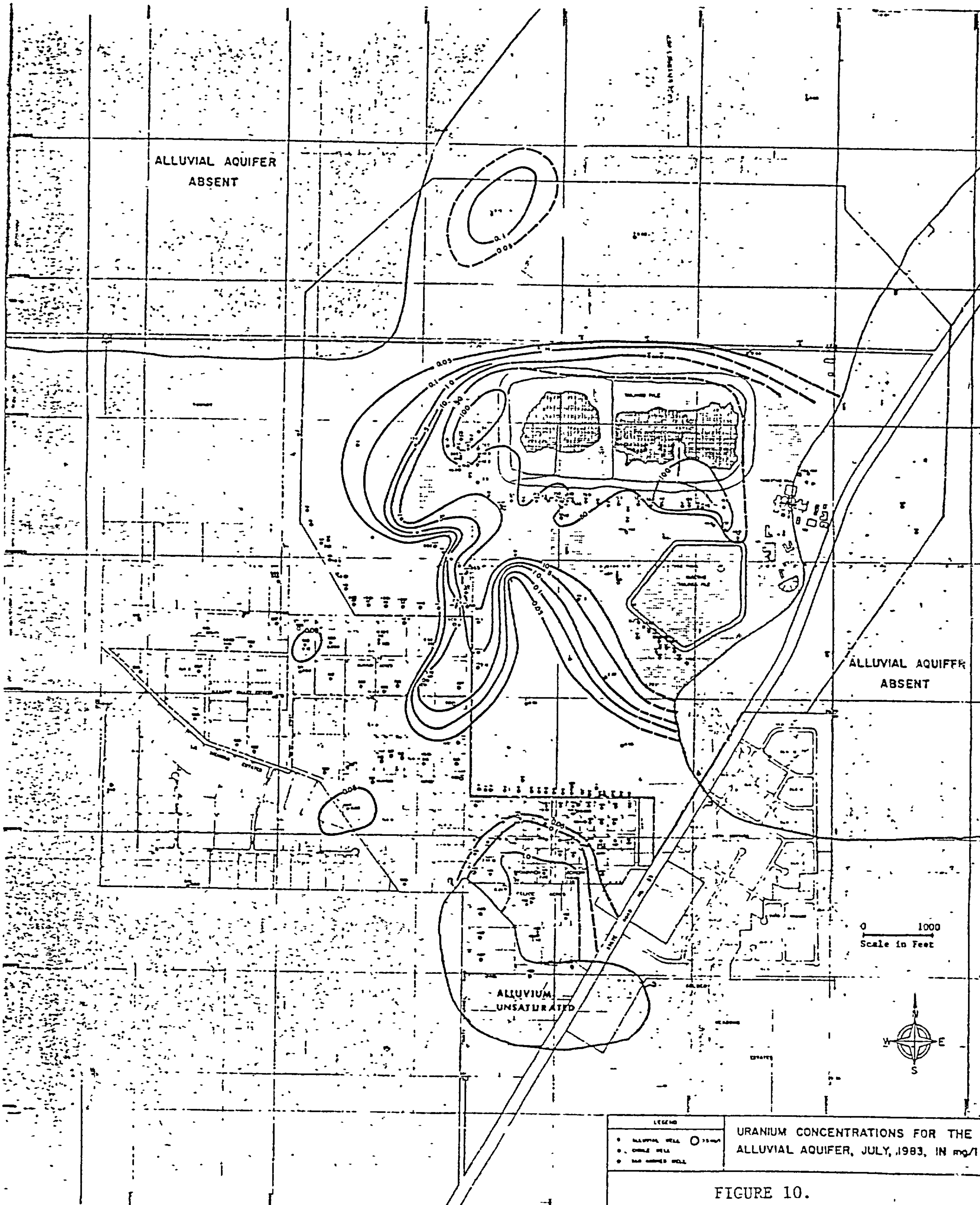

ALLUVIAL AQUIFER
ABSENT
ALLUVIAL AQUIFER
ABSENT
ALLUVIUM
UNSATURATED
0.5
0.1
1.0
0.05
0
1000
Scale in Feet
N
W
E
S
LEGEND
SELENIUM CONCENTRATIONS FOR THE
ALLUVIAL AQUIFER, JULY, 1983, IN mg/l

FIGURE 8.



URANIUM CONCENTRATIONS FOR THE ALLUVIAL AQUIFER, AUGUST, 1976, IN mg/l

FIGURE 9.


ALLUVIAL AQUIFER
ABSENT
ALLUVIAL AQUIFER
ABSENT
ALLUVIUM
UNSATURATED
0 1000
Scale in Feet
N
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S
LEGEND
URANIUM CONCENTRATIONS FOR THE ALLUVIAL AQUIFER, JULY, 1983, IN mg/l

FIGURE 10.

However, uranium concentrations in all subdivision wells have been reduced below the NMWQCC numerical ground-water standards.

3.2.1.4 Aquifer Parameters

Distribution coefficients were determined for different soil and aquifer materials at the site. Homestake performed batch tests to measure the extent of selenium, uranium, molybdenum and nitrate adsorption of site materials at different concentrations of the species in solution. The batch tests were performed by equilibration with ambient ground water. Homestake determined that selenium had the lowest distribution coefficient of the above species, averaging 0.7 milliliters per gram (ml/g).

The U.S. Geological Survey (U.S.G.S.) performed column leach tests on site samples using tailings solution and found the distribution coefficient to be 0.09 ml/g. Adsorption of the SeO_4^{--} anion is decreased by the higher pH of the tailings solution used in the U.S.G.S. tests. At a lower pH, ferric and ferrous hydroxides have a net positive charge and thereby increase anion adsorption. The distribution coefficient for selenium calibrated from Homestake's numerical ground-water model, 0.1 ml/g, closely agrees with the work performed by the U.S.G.S.

Adsorption of other ions will not be further discussed as selenium is absorbed the least amount of the ions tested. The analysis of selenium migration and adsorption represents the most conservative case for heavy metals and radionuclides.

Homestake conducted two pumping tests with observation wells and numerous single-well pumping tests to define the hydraulic conductivity of the alluvial aquifer. The hydraulic conductivity of the alluvium ranges from 35 to 1300 gallons per day/per square-foot (gpd/ft^2). The transmissivity of the alluvial aquifer ranges from 750 to 29,000 gallons per day per foot (gpd/ft). Some of Homestake's pumping tests were conducted under less than ideal conditions. The aquifer parameters obtained were influenced in some cases by interference from other pumping wells, changes in the small saturated thickness, lack of observation wells and the short length of some of the tests. However, the EID believes the transmissivities input to the model, presented in Section 6.4-1 of the discharge plan, are representative of site conditions. Storage coefficients proposed by Homestake for the unconfined alluvial aquifer range from 0.01 to 0.20.

3.2.1.5 Ground-Water Velocity and Underflow

Average seepage velocities in the vicinity of Homestake's mill and tailings facilities range from 0.14 to 0.7 ft/day. The average seepage velocity of alluvial ground water up-hydraulic gradient from the tailings disposal area is 0.7 feet

per day (ft/day) using a hydraulic gradient of 0.0023 foot per foot (ft/ft), a hydraulic conductivity of 225 gpd/ft^2 and an effective porosity of 0.1. The quantity of ground-water underflow through a cross-sectional area in the San Mateo alluvium north of the tailings reservoir is estimated to be 53 gpm.

3.2.1.6 Contaminant Mitigation Measures and Implementation Schedule

Homestake has undertaken a ground-water protection program to reduce elevated concentrations of TDS, sulfate, nitrate, molybdenum, selenium and uranium in the alluvial aquifer in subdivisions located to the south and west of the tailings reservoirs. The plan consists of an injection and collection system designed so that seepage from the tailings reservoirs can be collected and that concentrations in the subdivisions can be diluted and dispersed to the NMWQCC numerical ground-water standards or mean-background concentrations, whichever are higher. Ground-water monitoring by Homestake and the EID to date indicates that the plan has been moderately successful. Computer modeling was used to determine the time scale for the NMWQCC ground-water standards to be achieved. The time scale and development schedule for the ground-water protection program, described by Homestake in the discharge plan, is as follows:

> An injection rate of 300 gpm into the Murray Acres injection system will continue until elevated concentrations currently located between the active-tailings reservoir and Murray Acres are pushed back into close proximity to the collection wells, such that they can continue to pull the constituents to the collection wells. Reduction of slightly elevated sulfate concentrations in Murray Acres and Pleasant Valley Estates will also be used as one of the criteria to determine when the Murray Acres injection can be stopped. However, elevated sulfate concentrations are expected to be reduced before the contaminated water located between the active-tailings reservoir and Murray Acres is pushed back toward the tailings collection wells. Modeling indicated that the Murray Acres injection will be needed until 1992. The Murray Acres collection wells were simulated to operate until November 1984 in the model. These wells will be pumped until concentrations in the collection wells reach NMWQCC ground-water standards.

The Broadview Acres injection rate is proposed to be reduced to 200 gpm after the start of the Murray Acres injection. This reduction in injection rate was simulated as occurring in November 1982, in the model, but will probably not take place until after February 1983.

An additional change in the Broadview Acres injection system was simulated in the modeling effort, beginning November 1988. The injection rate was reduced to 100 gpm, and the area of injection was moved to just south of the inactive-tailings reservoir to increase the rate of ground-water movement north of this area to the collection wells. Concentrations south of the November 1988 injection wells will be reduced before injection starts in order to prevent ground-water constituent concentrations at Homestake's property boundary from exceeding NMWQCC ground-water standards. Beginning in November 1988, an injection rate of 50 gpm was simulated to be continued at the present injection system site just north of Broadview Acres. The Broadview Acres injection will be stopped when high concentrations between the active-tailings reservoir and Broadview Acres are pushed northward to the zone of reversed hydraulic gradient that is maintained by operation of the collection wells. Concentrations in Broadview and Felice Acres should be reduced long before the concentrations north of Broadview Acres are pushed back to the collection wells.

The total pumping rate of the collection wells near the active-tailings reservoir is proposed to be reduced to 200 gpm after the start of the Murray Acres injection program. This reduction was simulated as beginning in November 1982, but probably will not occur until after February 1983. The collection wells were simulated as continuing operation until November 1992, but will have to be maintained until seepage will not cause concentrations at Homestake's property boundary to exceed the NMWQCC standards. This will require that

pumping continue several years after this mill ceases operation. The collection rate may be increased to 300 gpm after cessation of the Murray Acres injection system in order to maintain the hydraulic gradient reversal near the active-tailings reservoir.

Pumping up-gradient of the active tailings reservoir in the San Mateo alluvium near well P, to reduce the base flow under the tailings, is proposed to start after collection in Murray Acres stops. This pumping of 80 gpm is scheduled to begin in November 1984.

The above discussion presents simulated changes in the numerical model for the Homestake remedial program. Homestake will roughly follow the model time schedule but will use the above discussed criteria to determine the actual timing of changes in injection and collection rates and locations.

3.2.1.7 Homestake's Numerical Ground-Water Model

Homestake, upon request from the EID, used the U.S. Geological Survey Finite Difference Solute Transport Model developed by Konikow and Bredehoft (U.S.G.S., 1978, Computer model of two-dimensional solute transport and dispersion in ground water: Technique of Water Resource Investigations, Book 7, Chapter 2) and modified by the U.S. Nuclear Regulatory Commission (Tracy, J., 1982, Users guide and documentation for adsorption and decay modification to the USGS solute transportation model:NUREG/CR-2502) for adsorption to predict the performance of the ground-water protection program. Predicted concentration changes caused by the proposed injection of water from the San Andres limestone near Broadview and Murray Acres and the collection of high-concentration water near the tailings facilities are of salient interest in this simulation.

3.2.1.7.1 Model Calibration

A 24 by 32 grid system was selected to simulate the alluvial aquifer near Homestake's tailings reservoir with a grid spacing of 500 ft. by 500 ft. (Figure 11)

Discretized input to the model included transmissivity, aquifer thickness, potentiometric levels, hydrologic sources and sinks and boundary conditions. Additional model input parameters are shown on Table 3.

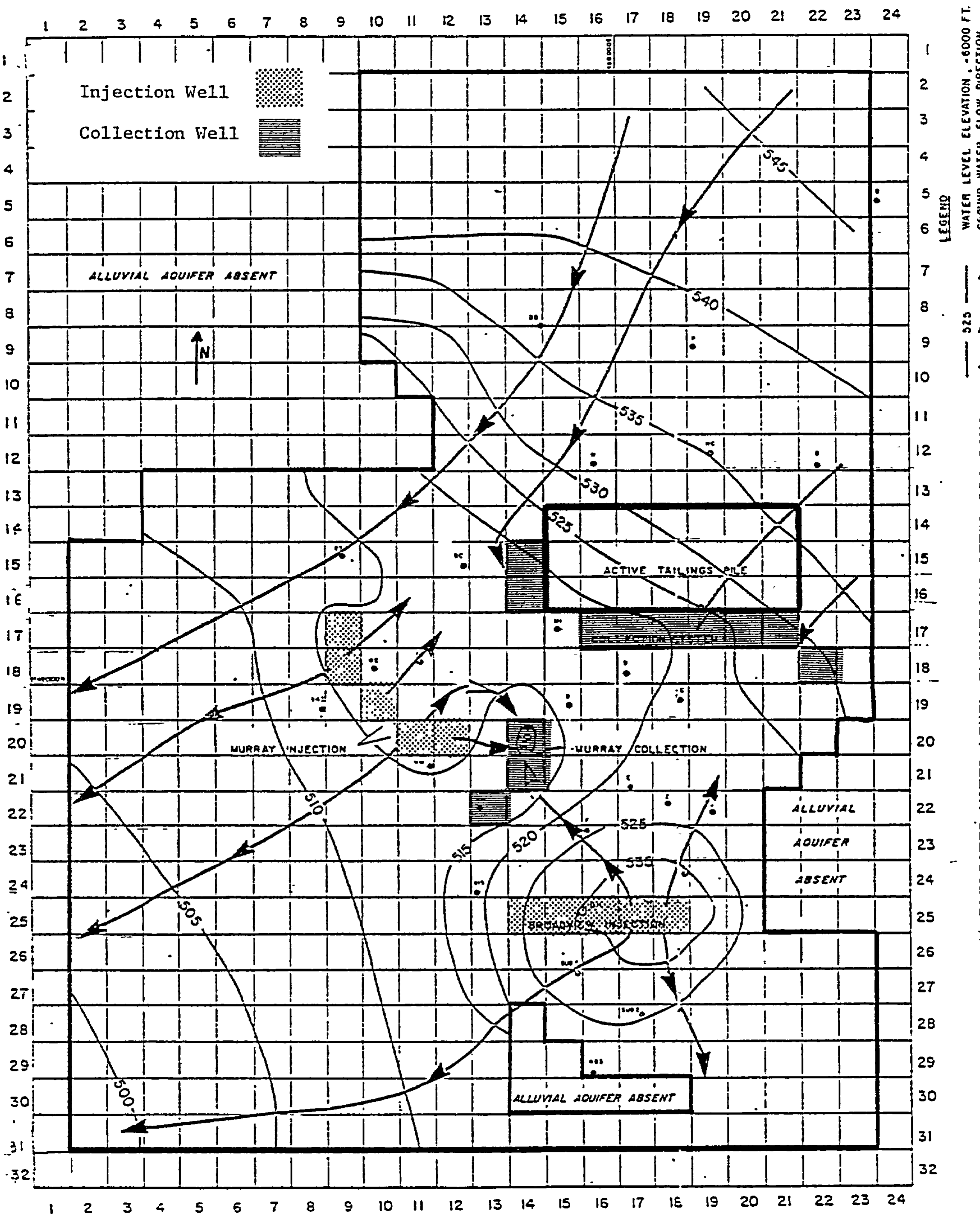


FIGURE 11. PREDICTED WATER-LEVEL ELEVATIONS AFTER 110 DAYS OF MURRAY ACRES INJECTION

TABLE 3. MODEL INPUT PARAMETERS

GRID SIZE	= 500 ft x 500 ft
NUMBER OF COLUMNS	= 24
NUMBER OF ROWS	= 32
INITIAL TIME STEP	= 86400 Sec
EFFECTIVE POROSITY	= 0.2
STORAGE COEFFICIENT	= 0.2
LONGITUDINAL DISPERSIVITY	= 65.5 ft
RATIO OF TRANSVERSE TO LONGITUDINAL DISPERSIVITY	= 0.33
HORIZONTAL ANISOTROPIC RATIO	= 1.0
ROCK DENSITY	= 2.12 gm/cm
DISTRIBUTION COEFFICIENT	= 0.1 ml/g for Selenium 0.0 for Sulfate
NO. OF ITERATION PARAMETERS	= 7
CONVERGENCE TOLERANCE	= 0.01
MAXIMUM CELL DISTANCE PER MOVE OF PARTICLES	= 0.5
MAXIMUM NO. OF PARTICLES	= 5715
NO. PARTICLES PER NODE	= 8

The numerical model of the alluvial aquifer was calibrated by using June 1976, alluvial-aquifer data as inputs and attempting to simulate observed data from May 1982. Comparison of simulated and observed water-level elevations, sulfate concentrations and selenium concentrations were used in calibration. After calibrating water-level elevations, transport of the conservative ion, sulfate was used to calibrate dispersivities. Transport of the slightly adsorptive ion, selenium, was subsequently used to calibrate the distribution coefficient. Injection and collection rates used in calibration are shown on Table 4.

Model calibration indicated that effectively only 75 gpm is seeping from the active-tailings reservoir to ground water rather than the 153 gpm determined from the water balance. The EID believes that one possible source of this discrepancy may be the application of a 2-dimensional model to a 3-dimensional flow system that implies tailings seepage may be entering the Chinle Formation in the vicinity of the active-tailings reservoir (see Section 3.2.2). From model calibration, the selenium distribution coefficient was found to be 0.1 ml/g. This agrees closely with the distribution coefficient obtained from U.S.G.S. column tests, 0.09 ml/g. Distribution coefficients obtained from Homestake Laboratory batch tests, 0.7 ml/g, were too high to match the observed distribution of selenium in the aquifer as the migration was severely retarded.

In general, the calibration of the model produced an acceptable agreement between observed and predicted conditions.

3.2.1.7.2 Model results

After calibration of the model, the potentiometric surface and the transport of the sulfate and selenium ions were simulated during four consecutive time intervals; 6 months, 2 years, 4 years and 4 years. The dates, shown on Table 4, corresponding to these time intervals in the following text, are 8 months antecedent of the actual dates of implementation due to the delay of the start up of the Murray Acres injection system.

Figure 11 shows predicted water-level elevations at 110 days after beginning operation of the Murray Acres injection system (Nov. 1982). Injection of water at a rate of 300 gpm quickly reverses the ground-water flow direction northeast of the Murray Acres injection line to a distance mid-way to the tailings collection wells. Actual reversal of the ground-water gradient is expected to be significantly quicker than suggested by the simulation, because the water-level elevation calibration lagged the observed water-level increases in Broadview Acres. Figure 11 also shows that the San Mateo alluvial ground-water flow down-gradient of the active-tailings reservoir is completely reversed except for the flow lines which converge on

TABLE 4. INJECTION AND COLLECTION RATES FOR PERIODS OF AQUIFER SIMULATION.

Date	Region of Activity	Flow Rate (gpm)
BASE-LINE DATA FOR CALIBRATION		
6/76 - 6/77	No injection or collection	
6/77 - 9/80	Broadview injection	49
7/78 - 9/80	Tailings collection	100
9/80 - 10/81	Murray collection	42
10/81 - 5/82	Tailings collection	266
2/82 - 5/82	Broadview injection	290
SIMULATION PERIODS		
1st		
5/82 - 11/82	Murray collection	67
	Tailings collection	266
	Broadview injection	290
2nd		
11/82 - 11/84	Murray collection	67
	Tailings collection	200
	Broadview injection	200
	Murray injection	300
3rd		
11/84 - 11/88	Murray collection	off
	Tailings collection	200
	Broadview injection	200
	Murray injection	300
	Injection to well AW	20
	Collection at well P	80
4th		
11/88 - 11/92	Murray injection	300
	Tailings collection	200
	Broadview injection	50
	Injection to well AW	20
	Collection at well P	80
	Injection at K wells	100

NOTE: Actual dates of implementation of injection and collection will be 8 months later than shown in this table.

the Murray Acres collection wells and a flow path northeast of the active-tailings reservoir.

Predicted water-level elevations for November 1984 (Figure 12) 2 years after operation of the Murray Acres injection system at 300 gpm, indicate a significant increase in the water-level elevations of the alluvial aquifer near Murray Acres. The potentiometric surface has been reversed completely between Murray Acres and the tailings collection wells. Flow direction in the vicinity of the injection wells and the area between Broadview Acres and the tailings collection wells has been reversed except for a small area immediately south of the east end of the tailings-collection wells. The low hydraulic conductivity of the alluvial aquifer in this area delays the potentiometric response.

Predicted water-level elevations for November 1988 (Figure 13), show a continuous mound of ground water between the Broadview and Murray Acres injection systems. The ground-water gradient immediately south of the east end tailings-collection wells, in a low-hydraulic conductivity area, has been reversed during this simulation period. Pumping up-hydraulic gradient near well P is intercepting a large percentage of the up-hydraulic gradient ground water flowing in the San Mateo alluvium. The hydraulic gradient north of the tailings has not been reversed but is very flat.

The final predicted water-level elevations are for November 1992 (Figure 14). One-hundred gpm of the Broadview Acres injection was moved north to increase potentiometric heads just south of the inactive-tailings reservoir. This increase in potentiometric head will increase the hydraulic gradient and cause the remainder of the high-concentration water to travel faster toward the collection wells. However, water-quality data would be used to determine when this movement of the Broadview Acres injection could take place. All high-concentration areas would need to be north of any proposed injection wells. The pumping wells located up-hydraulic gradient of the active-tailings reservoir have caused a flat potentiometric surface to develop between them and the active-tailings reservoir.

Figure 15 presents predicted sulfate concentrations for November 1984. These contours show a large improvement in concentrations in southern Broadview Acres. Sulfate concentration in the grid in which well Sub 2 is located is predicted to be 672 mg/l. Some concentrations in Felice Acres south of Sub 2 are still slightly above 1000 mg/l, but these concentrations exist in grids in which flow is nearly stagnant. All sulfate concentrations in the alluvial aquifer in Felice Acres should be below 1000 mg/l unless the geometry of the aquifer is such that the ground water is stagnant. The highest sulfate concentration (1390 mg/l) in Murray Acres and Pleasant Valley Estates is predicted to be along the western edge of

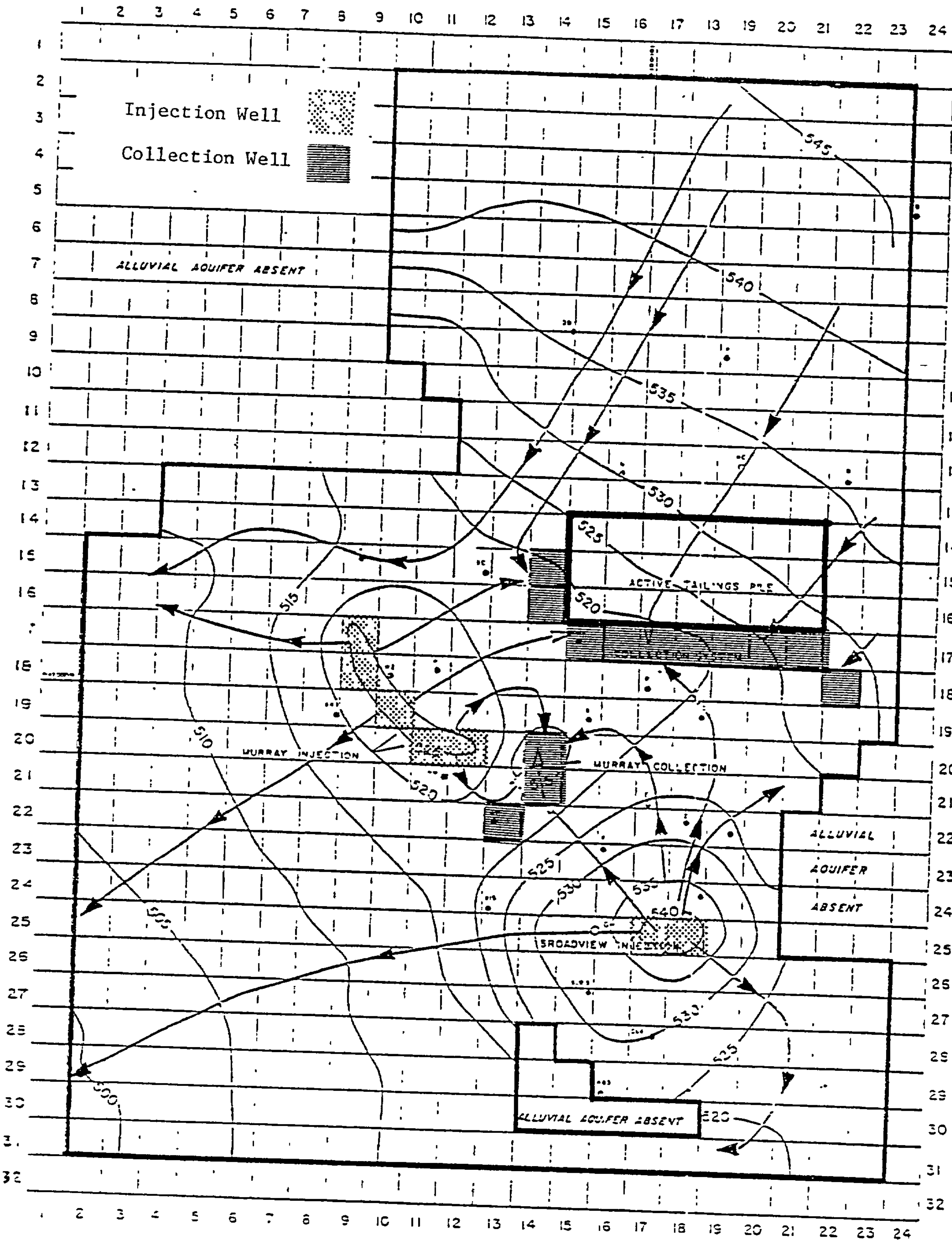


FIGURE 12. PREDICTED WATER-LEVEL ELEVATIONS FOR NOVEMBER, 1984

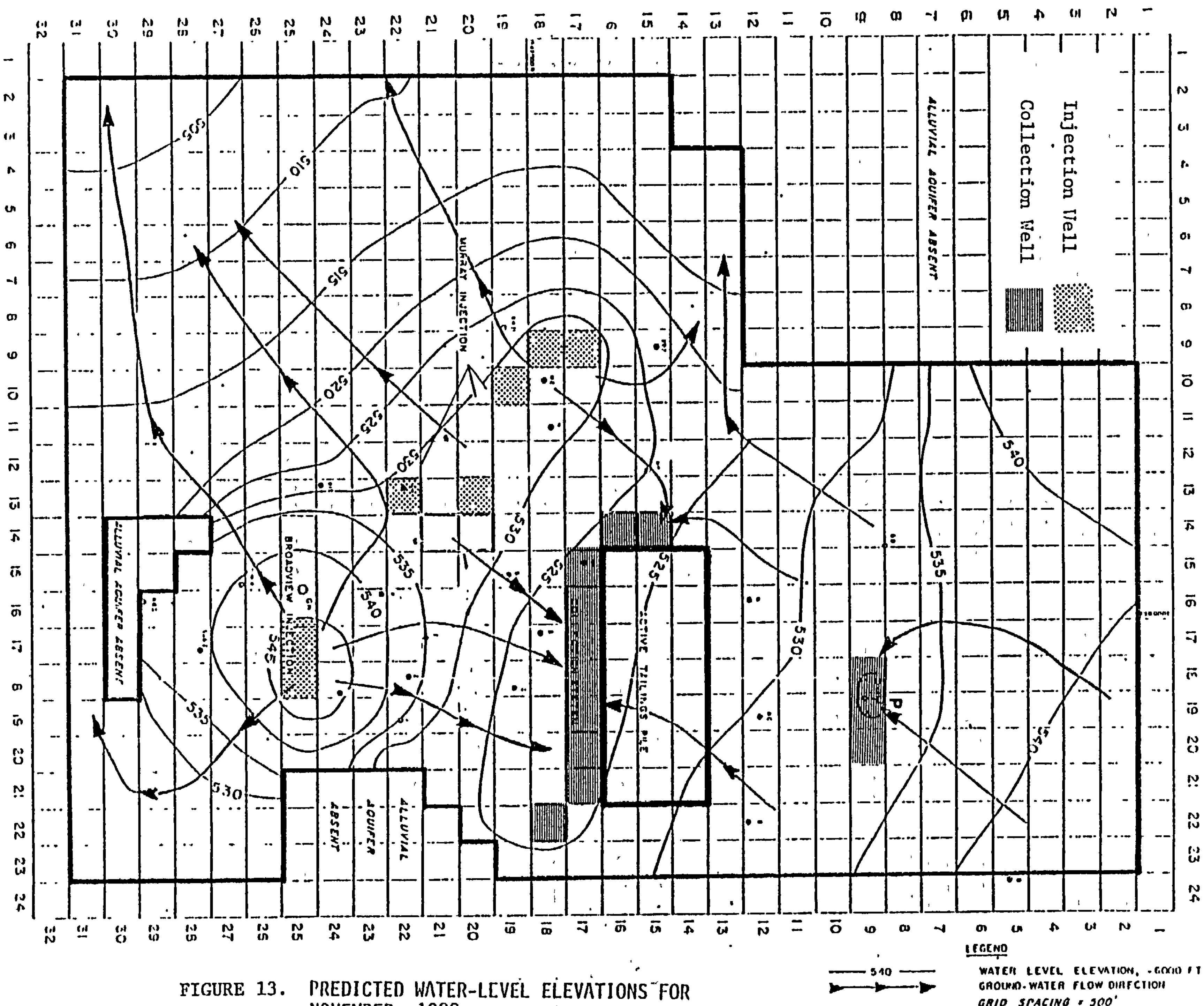


FIGURE 13. PREDICTED WATER-LEVEL ELEVATIONS FOR NOVEMBER, 1988

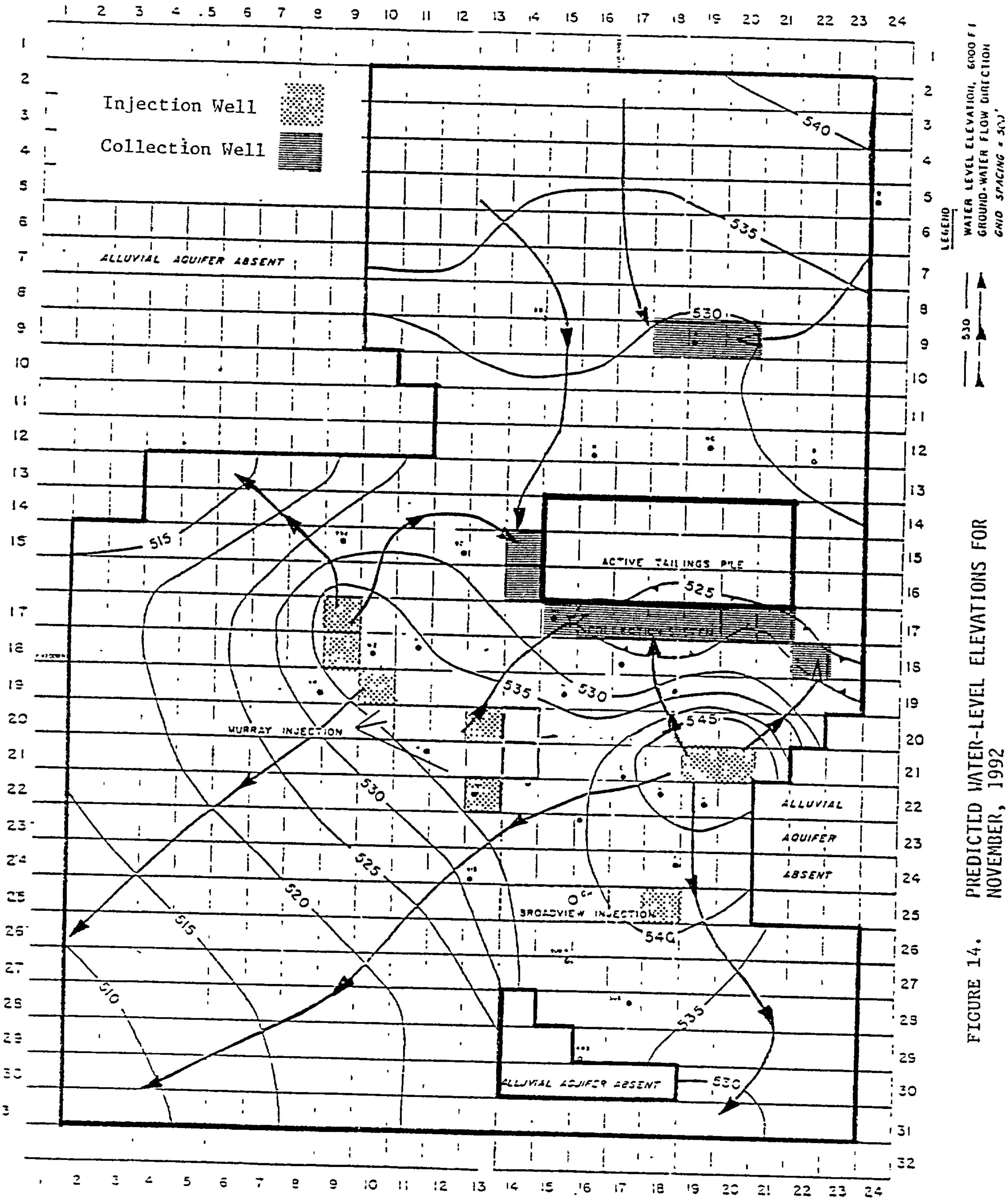


FIGURE 14. PREDICTED WATER-LEVEL ELEVATIONS FOR NOVEMBER, 1992

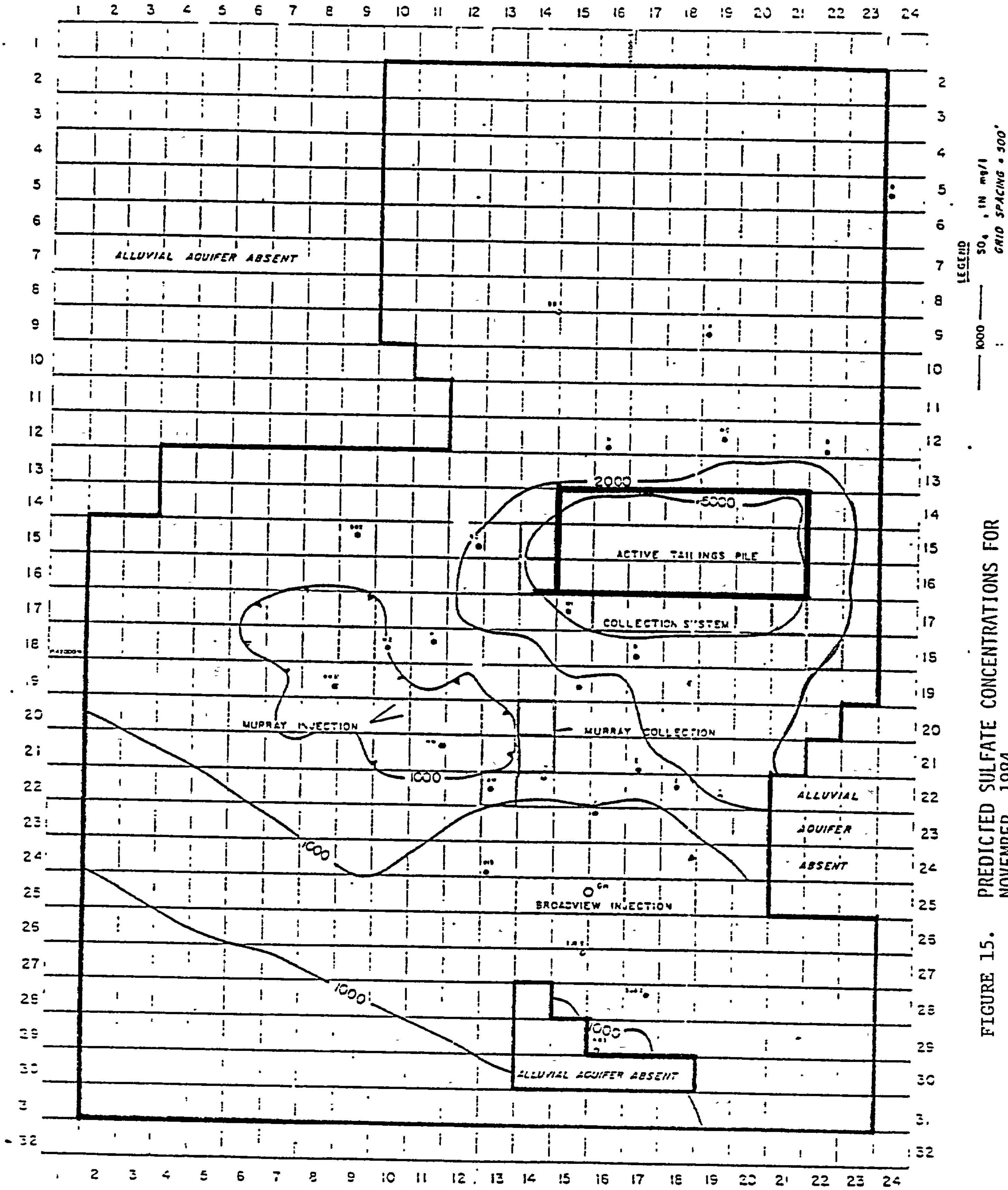


FIGURE 15. PREDICTED SULFATE CONCENTRATIONS FOR NOVEMBER, 1984

Pleasant Valley Estates, where the present concentration is 1750 mg/l. High concentrations in the northeast corner of Murray Acres should be decreased to the range of 1200 mg/l by this time (Nov. 1984). High concentrations between the sub-divisions and the active-tailings reservoir have been pushed closer to the active-tailings reservoir.

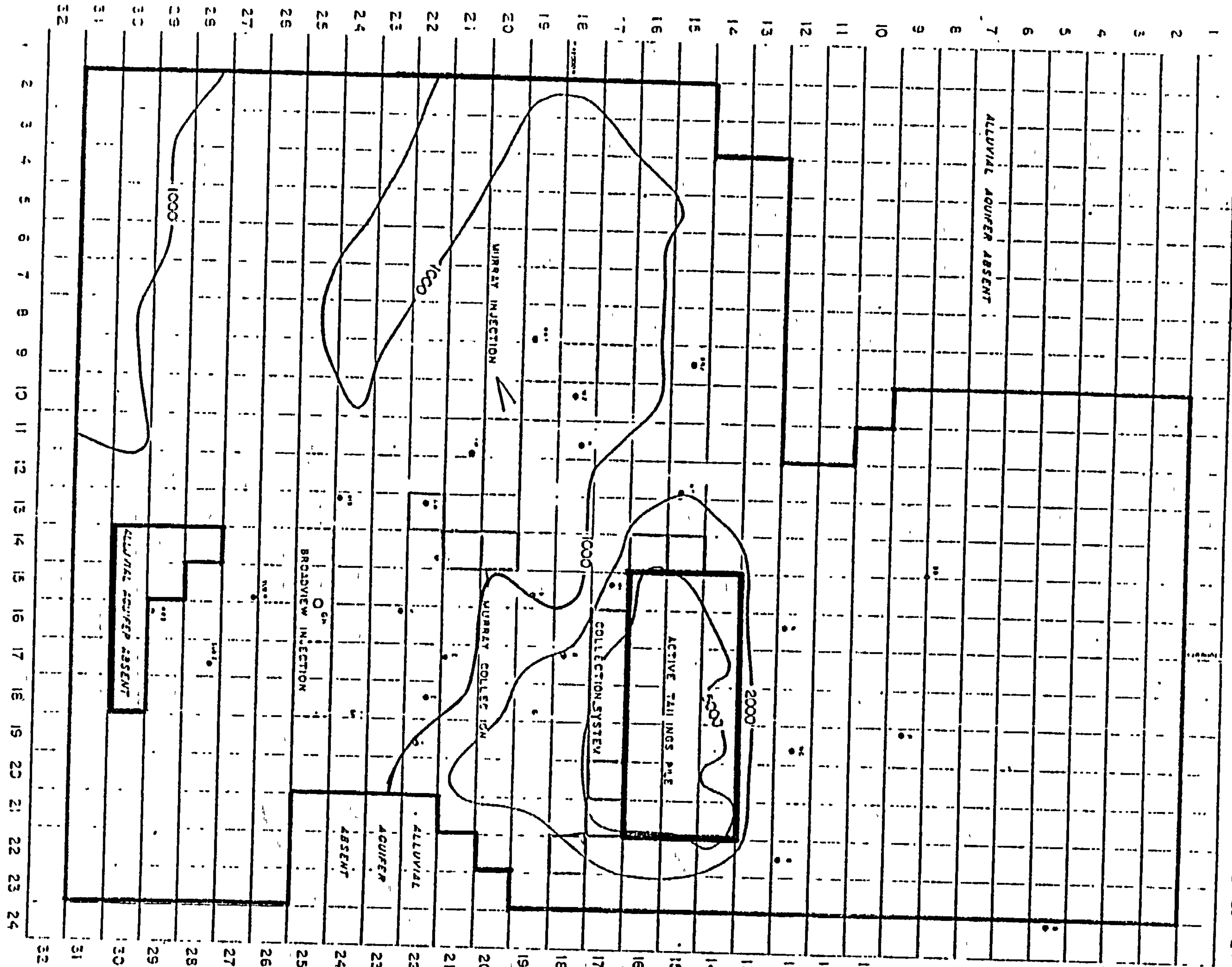
Predicted sulfate concentrations for November 1988 are presented on Figure 16. The highest sulfate concentration in Murray Acres is 782 mg/l. Most of the alluvium in Pleasant Valley Estates should contain similar sulfate concentrations, but the simulations indicated that the southern portion of this subdivision will have concentrations in the range of 1100 mg/l. All of the alluvial water in Broadview Acres should contain sulfate concentrations approximately equal to that of the injected water. Some areas of Felice Acres could still have a sulfate concentration in the range of 750 mg/l.

The predicted sulfate concentrations in the subdivisions should approach those of the injected water by November 1992 (Figure 17). The high sulfate concentrations are pulled very close to the tailings-collection wells. After all high concentrations are pulled within the potentiometric influence of the collection wells, the injection systems could then be discontinued. Simulation with the injection systems discontinued was not conducted, because actual monitoring will determine when that is appropriate.

Predicted selenium concentrations for November 1984 (Figure 18), indicate a few values greater than the mean-background concentration (0.12 mg/l) in Felice Acres. The highest predicted value in Felice Acres at this time is 0.27 mg/l. This compares favorably with 0.29 mg/l of selenium in Felice Acres measured during sampling on September 15, 1983, by Homestake. These elevated values are in areas where water, according to the simulation, becomes fairly stagnant. If the water in the alluvial aquifer in Felice Acres does not have areas of stagnation, then all selenium concentrations are expected to be below the mean-background concentration by this time. All selenium concentrations in Murray Acres and Pleasant Valley Estates are predicted to be at or below the mean-background concentration by 1984. Selenium will exceed the NMWQCC numerical ground-water standard of 0.05 mg/l in only a few areas, at this time.

Figure 19 presents predicted selenium concentrations for November 1988. All selenium concentrations in Murray Acres and Pleasant Valley Estates are predicted to be below the mean-background concentration (0.12 mg/l). However, a small area of concentrations at or above 0.1 mg/l is shown to still exist in Felice Acres.

Figure 20 presents November 1992, predicted selenium concentrations. All concentrations in Broadview Acres, Felice



LEGEND

2000 SULFATE, IN mg/l

GRID SPACING = 500'

FIGURE 16. PREDICTED SULFATE CONCENTRATIONS FOR NOVEMBER, 1988

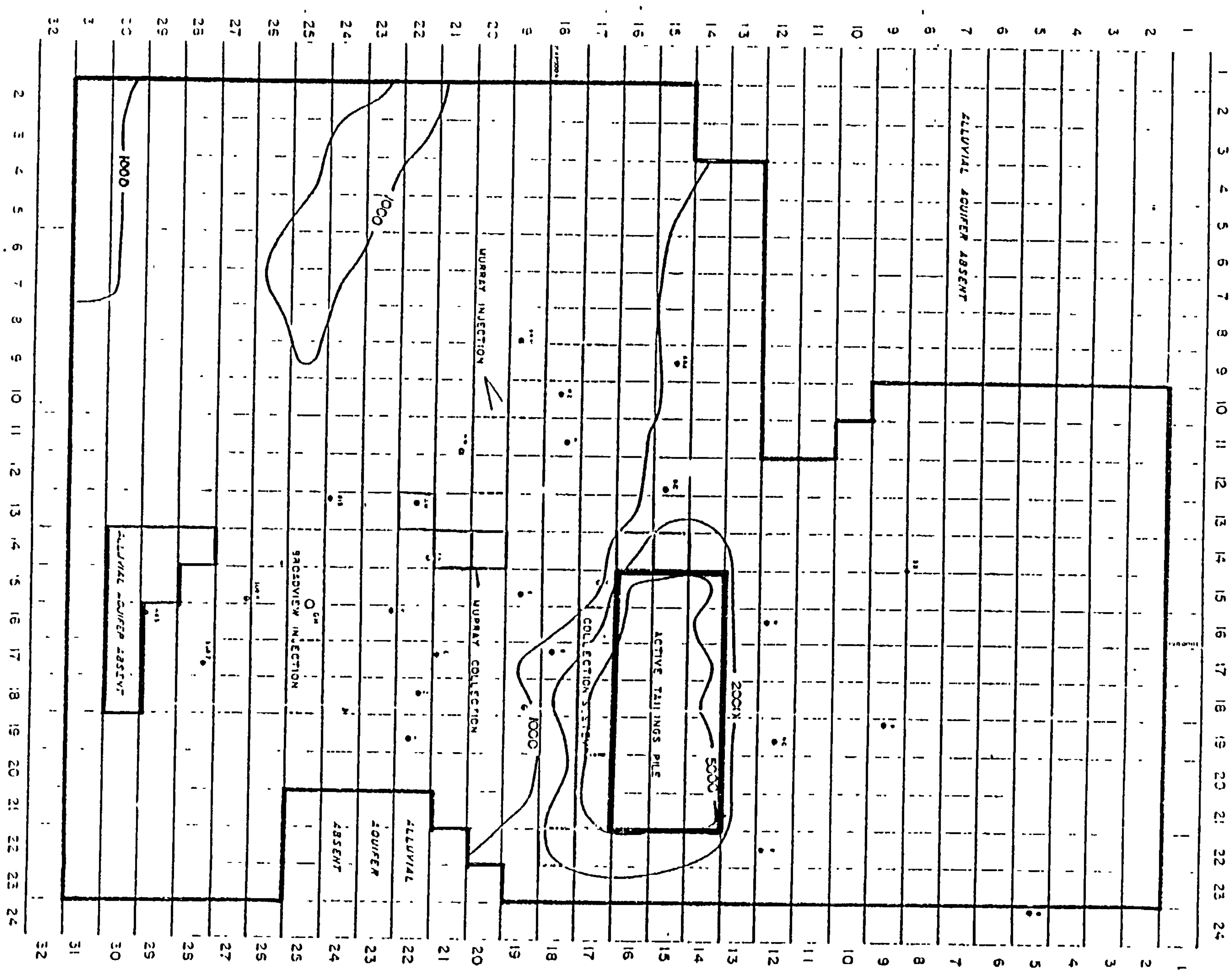


FIGURE 17. PREDICTED SULFATE CONCENTRATIONS FOR NOVEMBER, 1992

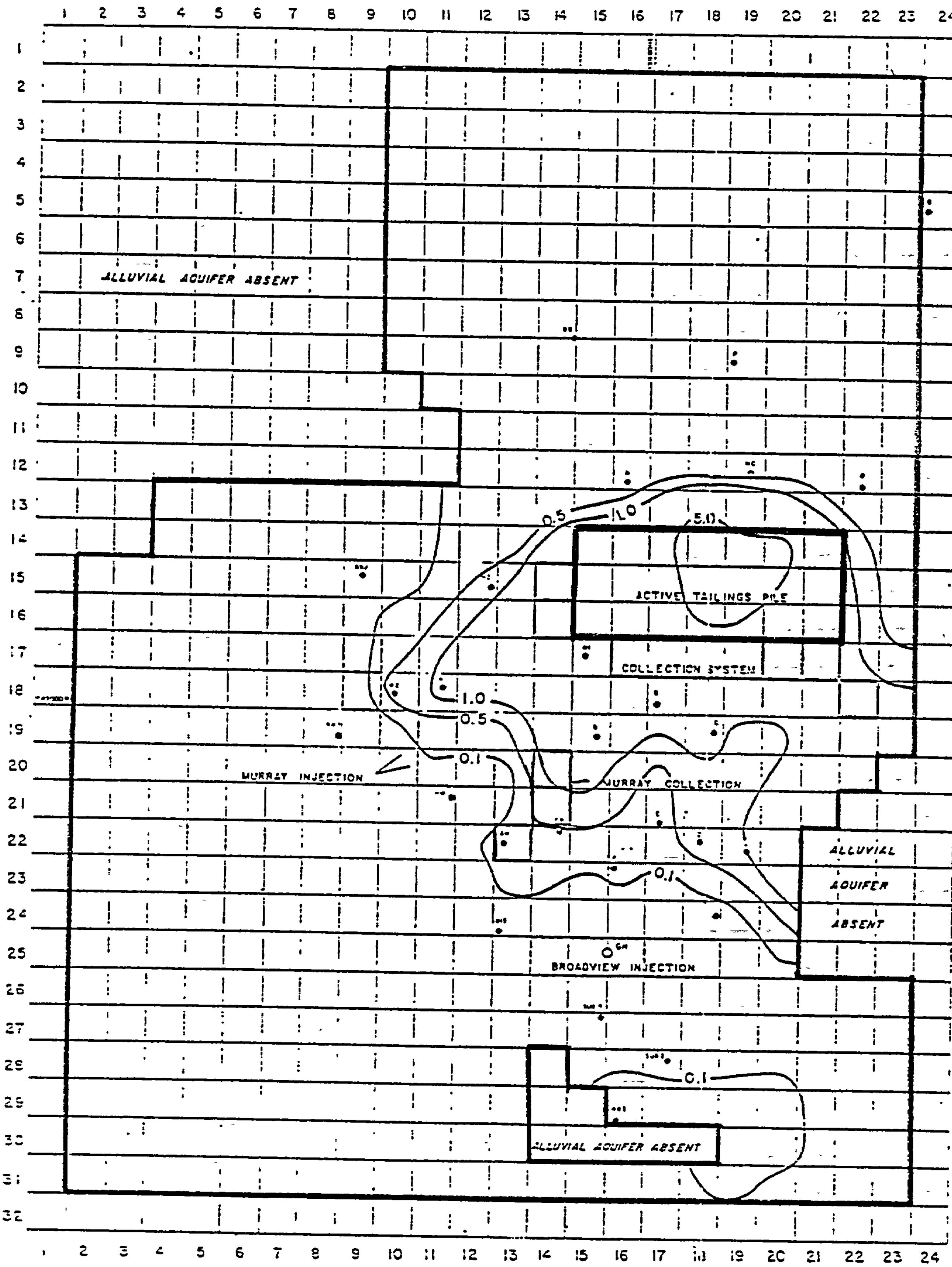
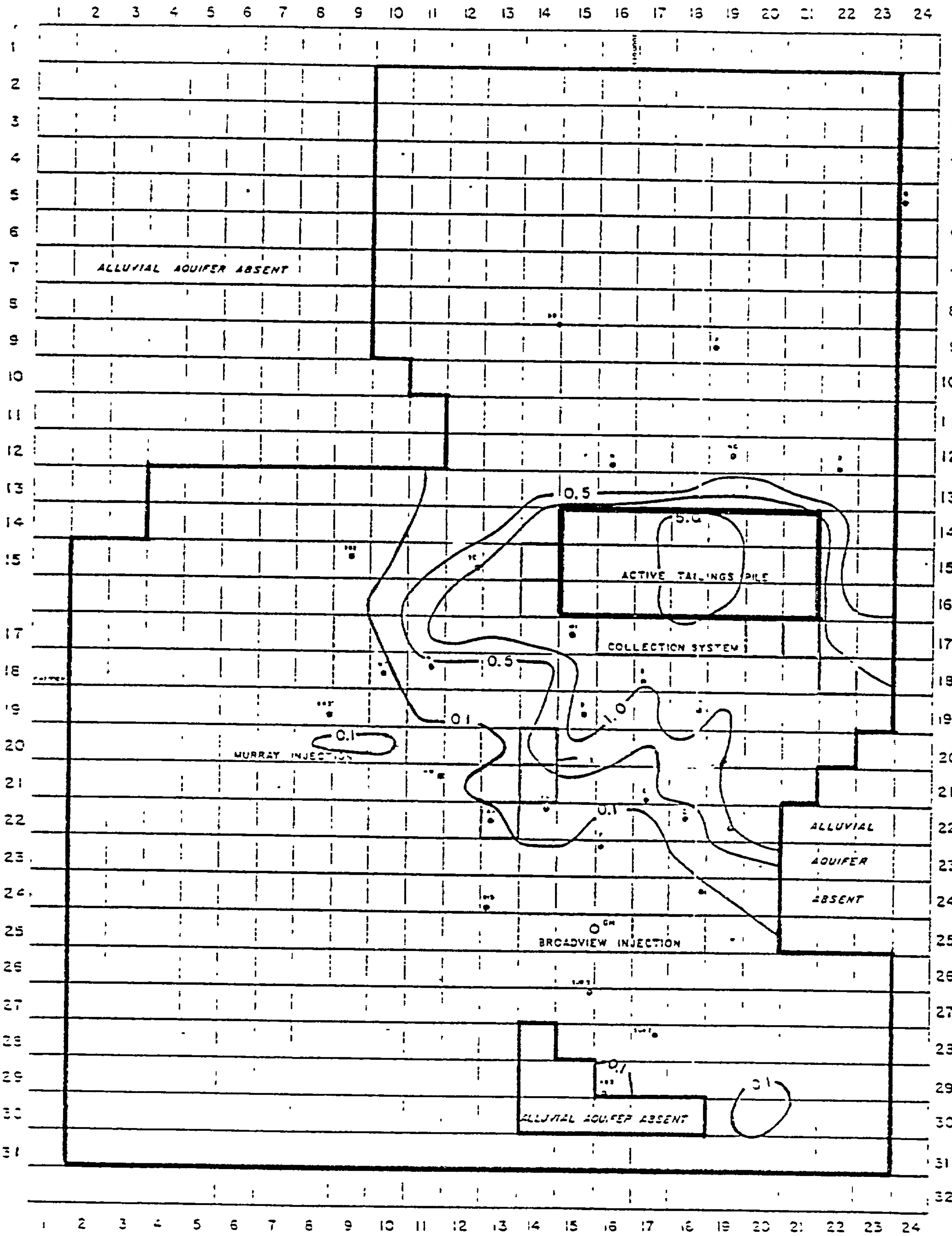


FIGURE 18. PREDICTED SELENIUM CONCENTRATIONS FOR NOVEMBER, 1984



LEGEND

— 0.5 — SELENIUM, IN mg/l

GRID SPACING = 300'

FIGURE 19. PREDICTED SELENIUM CONCENTRATIONS FOR NOVEMBER, 1988

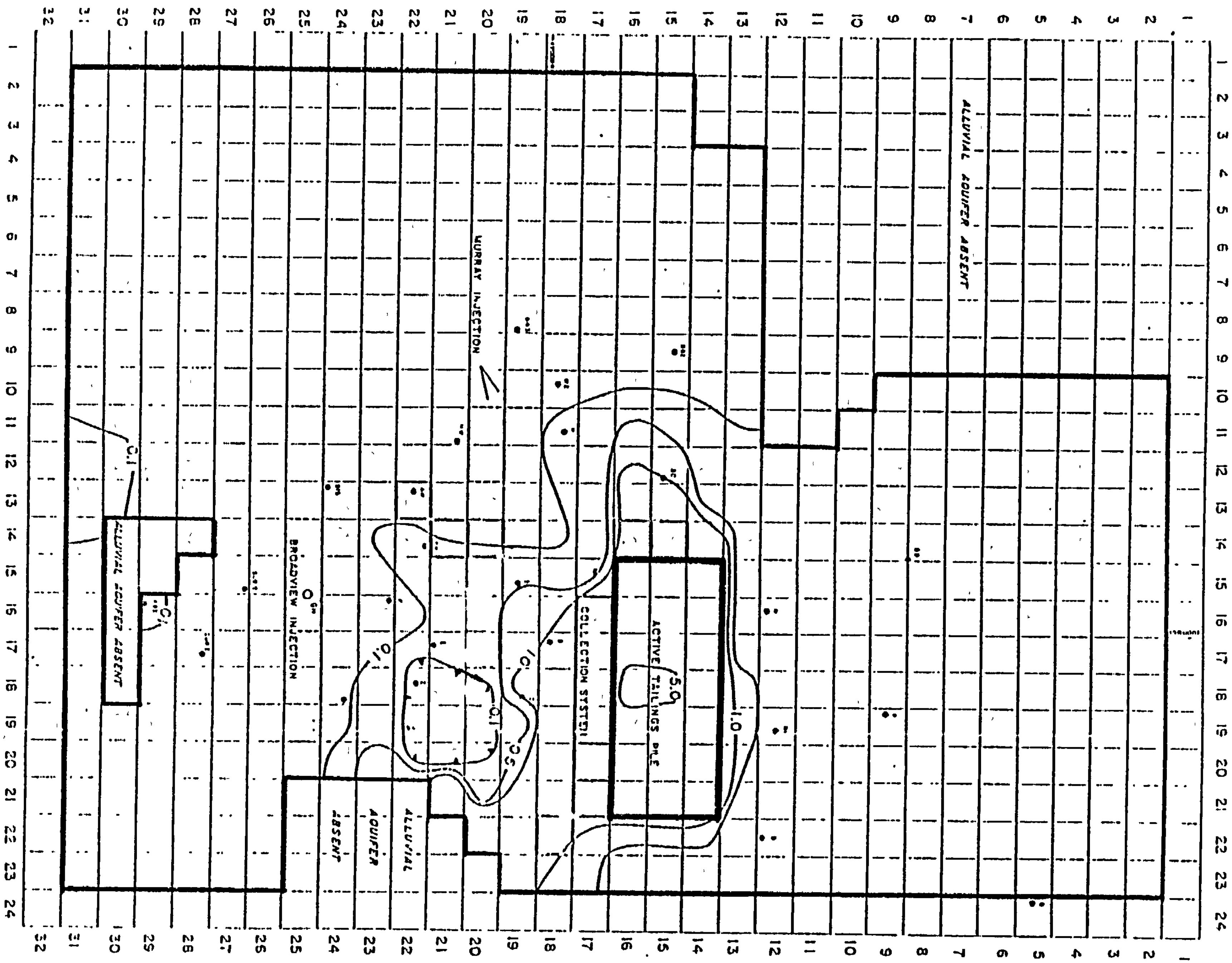


FIGURE 20. PREDICTED SELENIUM CONCENTRATIONS FOR NOVEMBER, 1992

LEGEND
— 10 — SELENIUM, mg/l
GRID SPACING = 500'

Acres, Murray Acres, and Pleasant Valley Estates are below the mean-background concentration.

3.2.1.8 Homestake's analytical ground water model

A one-dimensional solution to the dispersion equation for a pulse of selenium contamination of 0.5 mg/l for a period of 2,000 days was used to predict concentrations at both 1,000 and 5,000 feet down-gradient of Felice Acres. Figures 21 and 22 present selenium concentrations versus time for a range of selenium distribution coefficients (0.1 to 0.7 ml/g). If the distribution coefficient is conservatively assumed to be 0.1 ml/g, concentrations are shown to exceed the selenium mean-background standard of 0.12 mg/l by a factor of three at a distance of 1,000 feet from Felice Acres. However, actual concentrations down-hydraulic gradient will not greatly exceed the mean-background standards, because the initial concentration of the contaminant pulse would be a maximum of 0.3 mg/l, the selenium concentration presently found in Felice Acres, rather than the 0.5 mg/l used as input to the one-dimensional solution. Therefore maximum concentrations down-hydraulic gradient of Felice Acres will be substantially less than 0.3 mg/l (reduced by approximately 40 percent). Concentrations down-hydraulic gradient of the injection wells will eventually decrease to concentrations much lower than those found presently in Felice Acres as the injection system has removed the source of selenium by creating a hydraulic barrier to the movement of tailings fluids. Neither the rate nor direction of migration of selenium down-hydraulic gradient will be substantially altered from the natural state by the operation of the injection system. Potentiometric influences of the injection system on the hydraulic gradient are near-field because the major influences on the hydraulic gradient are hydraulic conductivity and topographic control. Furthermore, the distribution coefficient, rather than the hydraulic gradient exerts the major influence on the rate of selenium migration. Predicted concentrations of selenium, 5000 feet down-hydraulic gradient of Felice Acres, will be at or below the standards. Actual concentrations, however, will be 40 percent lower than those predicted by the analytical model in view of the previous explanation.

3.2.1.9 Independent ground water modeling by the New Mexico EID

3.2.1.9.1 Numerical ground-water model

The U.S.G.S. solute transport numerical model was also used by the EID to determine the accuracy of parameters used in the Homestake model. Simulation involved the use of the same grid spacing and aquifer parameters. However, discharge was added for the inactive-tailings reservoir and the water table was calibrated using a constant head rather than constant flux boundary. Results of the EID simulation indicate that

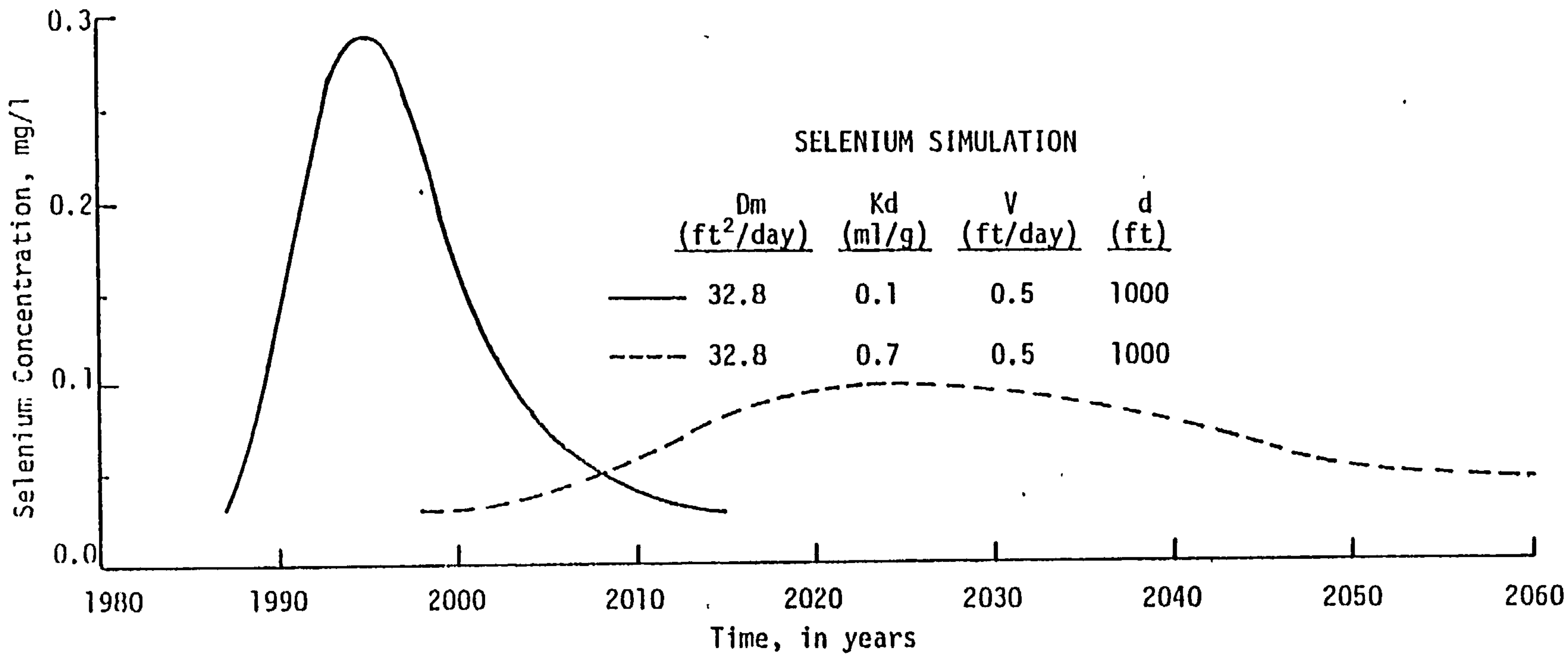


FIGURE 21. PREDICTED SELENIUM CONCENTRATIONS 1000 FEET DOWNGRADIENT OF FELICE ACRES

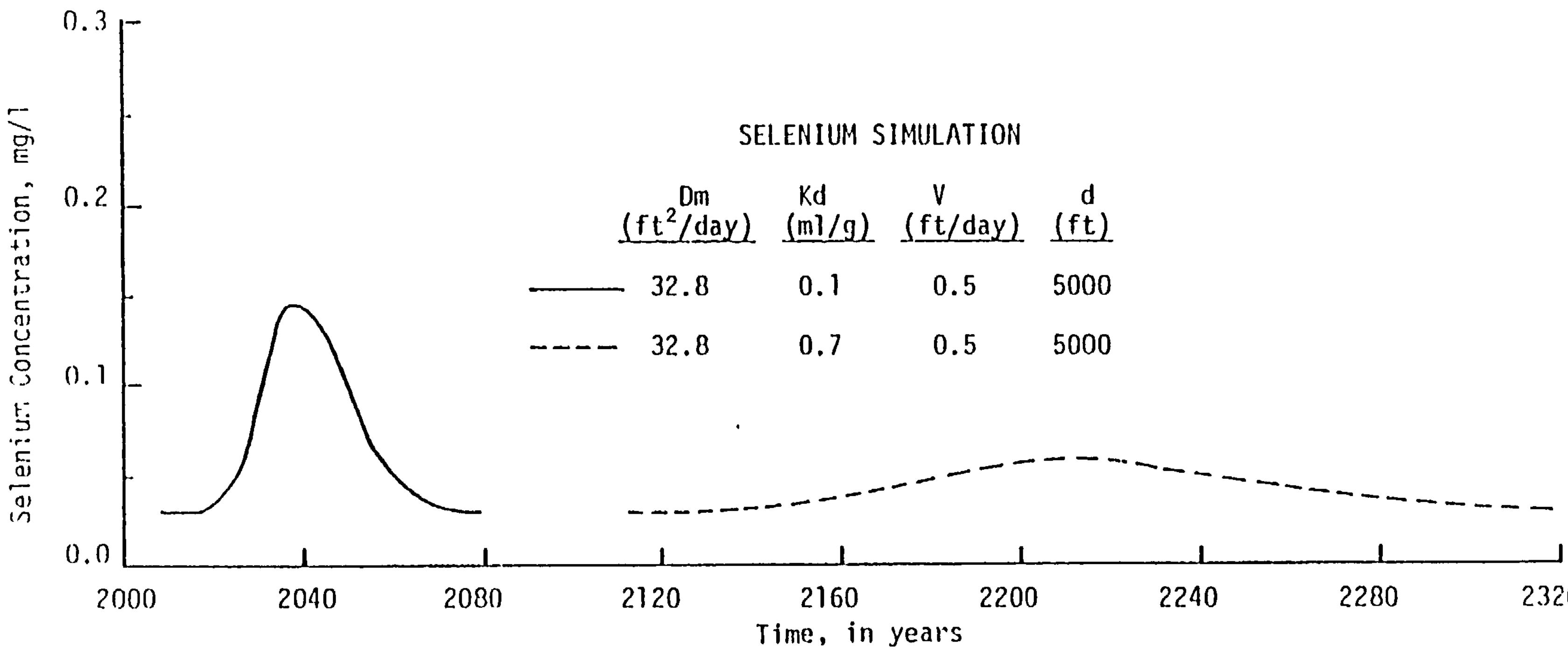


FIGURE 22. PREDICTED SELENIUM CONCENTRATIONS 5000 FEET DOWNGRADIENT OF FELICE ACRES

the observed sulfate distribution cannot be calibrated if the active-tailings reservoir seepage is 150 gpm and the inactive-tailings reservoir is assumed to discharge at 75 gpm. The reason for this is that high concentrations move farther down-gradient than actually observed. Therefore, Homestake's use of 75 gpm, discharging from the active-tailings reservoir and no discharge from the inactive-tailings reservoir, appears to be valid. However, the EID calibration was not able to match the extent of sulfate attenuation down-gradient in Broadview, Murray and Felice acres with the dispersivities and concentrations in the discharge used by Homestake in their ground-water model. This implies that the two-dimensional model may be influenced by movement in the 3rd or vertical-dimension. The fact that tailings seepage has reached ground water in the upper Chinle substantiates that this is occurring.

Because Homestake accounted for this discrepancy by changing discharge rates and concentrations until the model was calibrated, the flow system and concentration distribution projections are probably correct. However, the modeled seepage rates and concentrations are probably lower than actual rates and concentrations because of flow in the 3rd-dimension which was not accounted for in the Homestake model.

3.2.1.9.2 Sensitivity analysis

To test the validity of the ground-water model, the EID performed a sensitivity analysis to determine whether discretization errors were causing numerical dispersion. The EID determined that discretization errors did not affect the accuracy of the model.

Most numerical dispersion in numerical solutions to the dispersion equation results when the advective component of the dispersion equation dominates as follows:

$$\frac{\partial c}{\partial t} = D_l \frac{\partial^2 c}{\partial x^2} + D_t \frac{\partial^2 c}{\partial y^2} - V \frac{\partial c}{\partial x}$$

($-V \frac{\partial c}{\partial x}$ is the advective term)

This results in numerical oscillations or artificial smearing. The oscillations could produce negative concentrations. However, these are not evident in the Homestake model. The artificial smearing is harder to detect as it appears as a larger dispersion coefficient. An indication of numerical smearing is that concentrations tend to appear up-gradient. This is not the case with the Homestake model.

In one-dimensional problems, numerical dispersion can be controlled by satisfying the constraints of the Courant number (C) and the Peclet number (P). For a centered-in-time scheme

with uniform node spacing Δx, time step Δt, dispersivity α, seepage velocity V and dispersion coefficient D, these criteria are:

$$C = \frac{V\Delta t}{\Delta X} \leq 1$$

$$P = \frac{V\Delta x}{D} \leq 2$$

$$P = \frac{\Delta X}{\alpha} \leq 2$$

If we consider the seepage velocity to average 0.5 feet per day (ft/day), the time step to be one day, the dispersity to be 65 ft, and the grid spacing 500 ft, we satisfy the Courant criteria but slightly exceed the Peclet criteria by a factor of 4.

As these numerical instabilities pertain primarily to the advective component of the equation, they do not apply to transverse dispersivities. The Peclet criteria can only be applied to longitudinal dispersivities because advection in the y-direction, $V\,\partial C/\partial Y$, is zero. The lack of influence of transverse dispersivities on the stability criteria is also evident in an equation presented by Konikow & Bredehoft (1978) for their model.

$$t = \min \left[\frac{0.5}{\frac{D_{xx}}{\Delta_x^2} + \frac{D_{yy}}{\Delta_y^2}} \right]$$

where $D_{yy}/\Delta y^2$ is much less than $D_{xx}/\Delta x^2$. Nevertheless, for parameters previously specified, the Homestake model sufficiently meets the above criteria.

In finite-element models, discretization errors arise out of the element-wise interpolation in finite elements. In a method of characteristics or particle-tracking model, such as that used by Homestake, the equivalent error is due to having an insufficient number of particles per node. Should this occur, in the Konikow and Bredehoft model, the program has the parameter NZCRIT, the critical number of void cells which influence numerical stability. If NZCRIT is exceeded, a warning message is printed, and the program returns to subroutine GENPT which generates new particles per node. However, no warning messages are listed in the printout for the Homestake Model.

Numerical dispersion in the Method of Characteristics solution to the solute transport equation in the model is minimized by the fact that only the dispersion term dominates in the numerical solution as the advective term is solved by the movement of particles.

To further evaluate the potential for discretization errors in the model, several computer runs were made by the EID with the Homestake grid spacing of 500 ft by 500 ft and varying the mesh Peclet ratios ($\Delta X/\alpha_L$) from 1 to 10 to 25. The time-step increment multiplier was also varied from 1 to 10.

It was determined that numerical oscilations develop at $\Delta X/\alpha_L \leq 10$ and large time steps. However, it is felt by the EID that the Homestake model falls within the acceptable limits of this criteria.

3.2.2 Chinle Formation Aquifers

Water quality in the upper Chinle aquifer has been impacted by percolation of seepage from the tailings reservoirs. Contamination has reached the upper Chinle aquifer either by way of tailings seepage in the alluvium moving downward through fractures in the confining shale layer, leakage by improperly constructed wells or by recharge along the possible subcrop of the upper Chinle along an erosional surface beneath or south of the active-tailings reservoir. It is improbable that tailings seepage has penetrated to the upper Chinle in the vicinity of the active-tailings reservoir because there is good quality water in the upper Chinle aquifer in this area. Ground-water quality in the upper Chinle aquifer is primarily impacted to the south of the active-tailings reservoir in the vicinity of Broadview Acres where concentrations of sulfate (2600 mg/l) and selenium (1.38 mg/l) exceed NMWQCC numerical ground-water standards. Homestake proposes to mitigate contamination in the upper Chinle aquifer by injecting 100 gpm of water from the San Andres Limestone into the upper Chinle aquifer immediately north of Broadview Acres until concentrations are reduced to alluvial mean-background concentrations or NMWQCC numerical ground-water standards, whichever is higher. The EID believes that the proposed contaminant mitigation plan for the upper Chinle aquifer may be of limited effect because of the relatively small area of upward hydraulic gradient in the upper Chinle aquifer and the low hydraulic conductivity of the shale that separates the alluvial aquifer from the upper Chinle aquifer. If it appears concentrations in the upper Chinle aquifer are not being reduced in a timely fashion, Homestake proposes an alternative plan; to pump the areas of high concentration to reduce the overall volume of contaminants in the aquifer. The combination of withdrawal of contaminants and dilution and dispersion by injection of better-quality water should result in ground water in the upper Chinle aquifer meeting NMWQCC ground-water standards.

Homestake has also committed to installing a monitor well in the upper Chinle in Felice Acres to further define the extent of contamination beyond their property.

Water quality in the middle Chinle aquifer has not been affected by seepage from the tailings reservoirs. However, a potential for water quality in the middle Chinle aquifer to be impacted by tailings reservoir seepage exists because of a downward-hydraulic gradient in the alluvium and the upper Chinle toward the middle Chinle. Homestake has calculated the travel time of tailings seepage to the middle Chinle to be more than 5,000 years. Sulfate concentrations should not exceed the NMWQCC numerical ground-water standards beyond Homestake's property. However, should indications appear in the near future that this might occur, Homestake has committed to a contingency plan which would adequately protect ground water in the middle Chinle aquifer from being contaminated beyond the NMWQCC numerical standards.

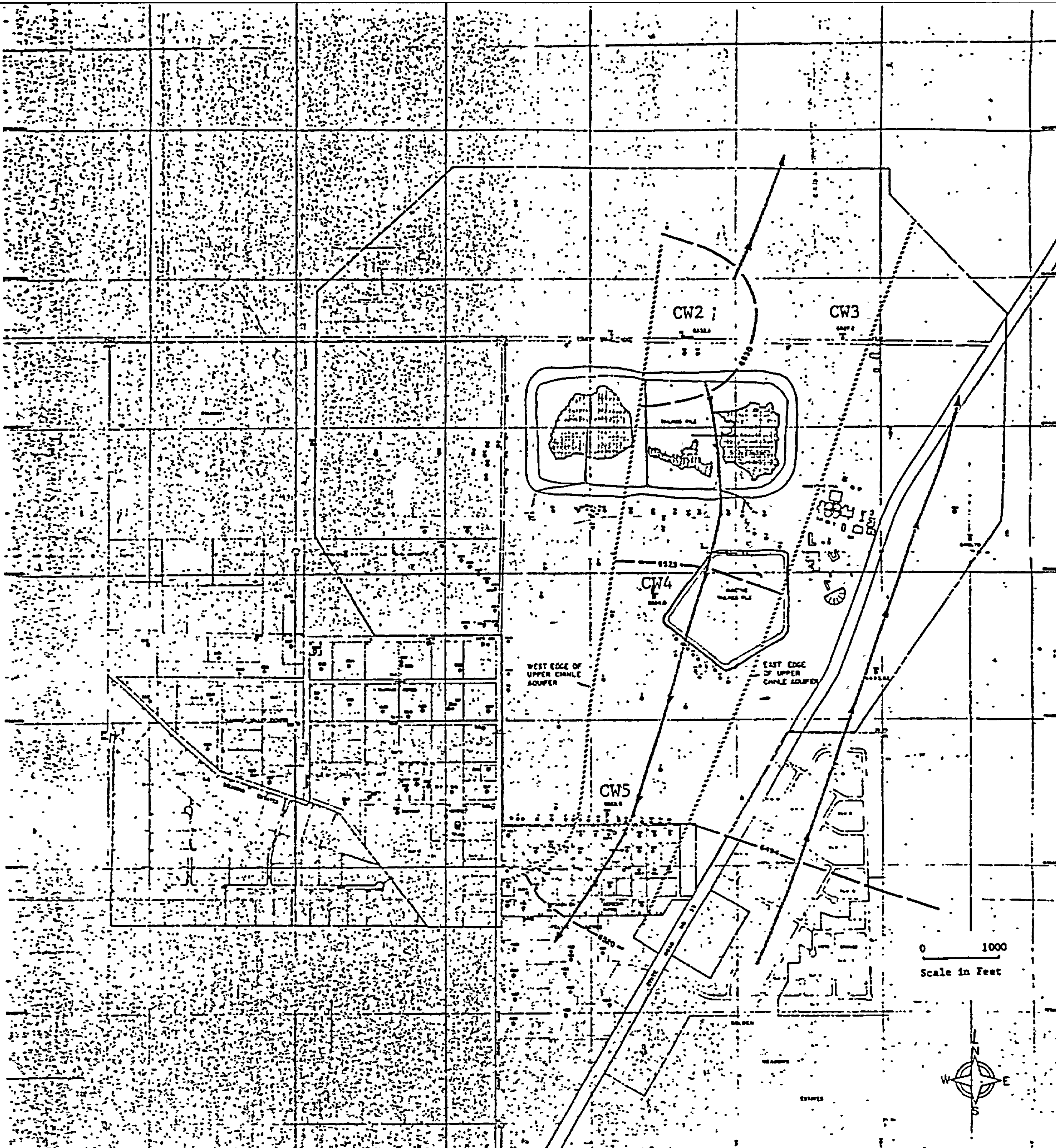
3.2.2.1 Hydrogeologic description

The uppermost portion of the Chinle Formation at the site is shale, which varies in thickness from zero to 100 feet, depending on the dip and extent of erosion (Figure 2). The shale is underlain by the upper Chinle aquifer, a sandstone varying in thickness from zero to 30 feet. Below the upper Chinle aquifer lies 110 to 140 feet of shale and which is underlain by the middle Chinle aquifer, a 30 to 50 foot-thick sandstone layer. The lower-most portion of the Chinle Formation consists of 550 feet of shale with some wells showing a discontinuous sandstone layer up to 35 feet thick within the sequence.

3.2.2.1.1 Upper Chinle Aquifer

3.2.2.1.2.1 Water levels

The upper Chinle aquifer dips toward the east and is stratigraphically confined above and below by a thick sequence of shale. Figure 23 presents the approximate areal extent of this aquifer along with the water-level elevations recorded in August of 1983. The upper Chinle sandstone is bounded on the west by either an erosional contact between the upper Chinle sandstone and the overlying alluvium, or by a pinch out in the upper Chinle sandstone. The upper Chinle aquifer is bounded on the east by an eastward-dipping normal fault (Figure 23). Analyses of pumping tests suggest that the upper Chinle aquifer is not in hydraulic connection with the same stratigraphic unit on the other side of the fault. Water-quality data support the evidence for the lack of hydraulic connection as no impacts to water quality from tailings seepage are evident on the eastern side of the fault. Ground-water flow is toward the southwest in the western section of upper Chinle aquifer, sub-parallel to flow in the alluvial aquifer, indicating some hydraulic connection. The depth to the potentiometric surface



WATER-LEVEL ELEVATION OF THE UPPER CHINLE AQUIFER NEAR HOMESTAKE'S MILL, AUGUST, 1983 IN FT. ABOVE MSL

FLOW DIRECTION

FIGURE 23.

in the upper Chinle aquifer is 40 to 60 feet below land surface, several feet below the water table in the alluvial aquifer.

3.2.2.1.1.2 Water quality

Four wells have been completed in the upper Chinle aquifer to define aquifer parameters and water quality; 2 wells are located 500 feet north of the active-tailings reservoir, one west of the inactive-tailings reservoir, and one several hundred feet north of Broadview Acres. Total dissolved solids in the upper Chinle aquifer in 1982, ranged from 1200 to 4900 mg/l. High TDS ground water in the upper Chinle aquifer is indicative of the influence of tailings fluid seepage. NMWQCC numerical ground-water standards are exceeded for TDS, sulfate, chloride, molybdenum, selenium and uranium in the upper Chinle aquifer.

Sulfate concentrations for 1982, were 860 and 800 mg/l north of the active-tailings reservoir, 800 mg/l near the inactive-tailings reservoir, and 2600 mg/l north of Broadview Acres. Similar trends are seen with selenium and uranium concentrations. Selenium concentrations north of the active-tailings reservoir were 0.09 to 0.01 mg/l, and 0.28 mg/l near the inactive-tailings reservoir, and 1.38 mg/l north of Broadview Acres. Uranium concentrations were 0.01 mg/l north of the active-tailings reservoir, 5.34 mg/l near the inactive-tailings reservoir, and 6.36 mg/l north of Broadview Acres. The area near Broadview Acres is the only area of the upper Chinle south of Homestake's property that appears to be impacted by tailings seepage. Homestake has committed to reclaim ground-water in the upper Chinle aquifer to the mean-background concentrations of the alluvial aquifer.

3.2.2.1.1.3 Aquifer parameters

Hydraulic characteristics of the upper Chinle aquifer were determined by conducting 3 multiple-well and one single-well pumping test. Hydraulic conductivities ranged between 50 and 1300 gpd/ft^2 with a representative value of 700 gpd/ft^2. The storage coefficient was calculated to be 4×10^{-6}.

3.2.2.1.1.4 Ground water velocity and underflow

The ground-water velocity is estimated to be 0.1 ft/day between the inactive-tailings reservoir and Broadview Acres. The quantity of underflow through the upper Chinle aquifer in the cross section bounded by the fault and the depositional/ erosional edge is approximately 3 gpm or 4000 gpd.

3.2.2.1.1.5 Contaminant mitigation measures

Homestake plans to inject 100 gpm of water from the San Andres Limestone into the upper Chinle aquifer at well CW5 immediately north of Broadview Acres (shown on Figure 23).

This will dilute and disperse contaminated quality in the vicinity of Broadview Acres and increase the potentiometric head to ultimately reverse the hydraulic gradient between Broadview Acres and the tailings reservoirs. The remaining contaminated water will be driven back toward the active-tailings reservoir. At the collection wells, immediately south of the active-tailings reservoir, the potentiometric surface will be lowered in the alluvium. There will be a hydraulic potential for upward movement of water from the upper Chinle aquifer into the collection wells in the alluvial aquifer near the active-tailings reservoir. Two upper Chinle aquifer wells located north of the active-tailings reservoir will be monitored to insure that contamination will not migrate north of these wells. Homestake has proposed a contingency plan to pump contaminated water out of the upper Chinle aquifer if the injection program does not reduce elevated concentrations in the aquifer by the time the alluvial aquifer collection system ceases operation (Nov. 1992).

3.2.2.1.2 Middle Chinle Aquifer

3.2.2.2.1.1 Water levels

Depth to water in the middle Chinle aquifer is approximately 80 feet below land surface. Water-level elevations for the middle Chinle aquifer in March 1982, as shown on Figure 24. Water-level elevations (potentiometric contours) indicate that flow is to the northeast. Two normal faults limit the areal extent of the aquifer on both the western and eastern sides by vertically displacing the aquifer. Analyses of pumping tests indicate that these faults behave as hydraulic barriers. A downward-hydraulic gradient exists between the upper Chinle aquifer and the middle Chinle aquifer indicating a potential impact of water quality by tailings seepage.

3.2.2.2.1.2 Water quality

Water quality in the middle Chinle aquifer has not been affected by tailings fluids. Background water quality ranges from 1200 to 1600 mg/l for TDS, 800 to 900 mg/l for sulfate; 0.09 to 0.01 mg/l for selenium, and 0.03 to 0.01 mg/l for uranium.

3.2.2.2.1.3 Aquifer parameters

The transmissivity for the middle Chinle aquifer, determined from pumping tests ranges from 4270 to 7640 gal/day/ft. The average hydraulic conductivity is 25 ft/day at this site. A storage coefficient of 3×10^{-5} was determined from analysis of Homestake's pumping tests.

An average horizontal hydraulic conductivity of 8×10^{-3} ft/day for the Chinle shale was measured in two constant head tests performed on well CW7. Vertical hydraulic conductivities

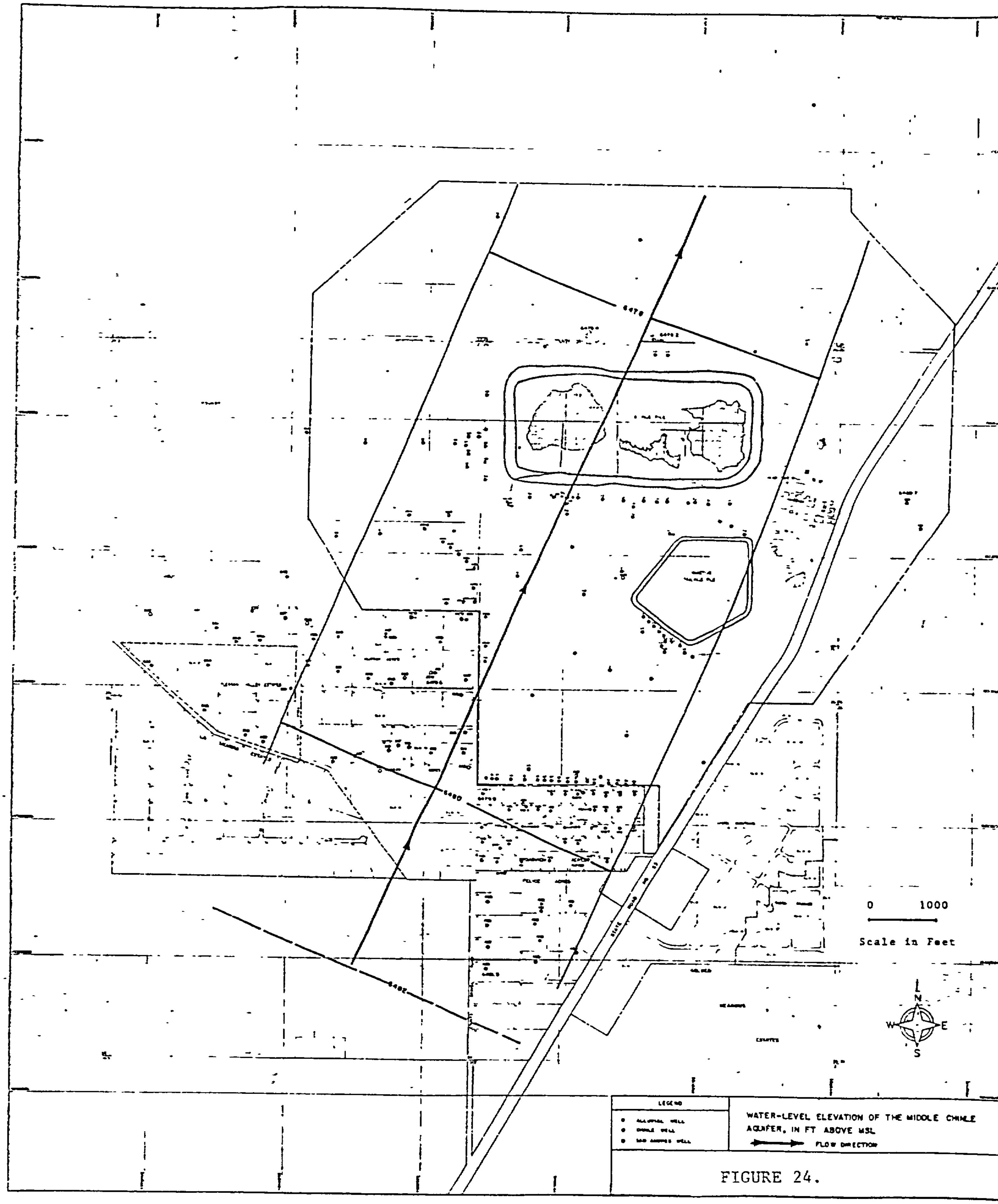

0 1000
Scale in Feet
N
W
E
S
LEGEND
WATER-LEVEL ELEVATION OF THE MIDDLE CHINLE AQUIFER, IN FT ABOVE MSL
FLOW DIRECTION

FIGURE 24.

1 x 10^-5 ft/day

for the Chinle shale averaged 1×10^{-3} ft/day for three different core samples from depths of 105, 220 and 280 ft in well CW8. A Neuman and Witherspoon (October 1972, Field determination of hydraulic properties of leaky multiple aquifer systems; Water Resources Research, Vol. 8, No. 5) ratio method field test was conducted to determine the vertical hydraulic conductivity of the Chinle shale by pumping middle Chinle well CW2 and observing the drawdown in well CW8, which is completed in the Chinle shale 22 feet above the middle Chinle. The EID believes the method described in Appendix B of the Discharge Plan is sufficiently conservative. A vertical hydraulic conductivity of 3×10^{-5} ft/day for the Chinle shale was obtained from this test.

3.2.2.2.1.4 Ground water velocity and quantity of underflow

The ground-water velocity in the middle Chinle aquifer is calculated to be 30 ft/yr using an average hydraulic gradient of .0003 ft/ft, a hydraulic conductivity of 25 ft/day and a porosity of 0.1. Underflow in the middle Chinle aquifer was estimated to be 12 gpm for the cross sectional area bounded by the east and west faults. The travel time of seepage from the upper Chinle aquifer to the middle Chinle aquifer was calculated to be more than 5,000 years using Darcy's Law, an hydraulic gradient of 0.26 ft/ft, a hydraulic conductivity of 3×10^{-5} ft/day, and an effective porosity of 0.1. Approximately 0.3 gpm of vertical seepage has been estimated by Homestake to be flowing from the alluvium to the middle Chinle aquifer over the area of the active-tailings reservoir. If the areal extent of contamination in the upper Chinle aquifer extends to 3 times the area of the tailings pile, seepage of contaminated water will increase threefold to 0.9 gpm. However, underflow in the middle Chinle is 12 gpm, or more than an order of magnitude larger than the vertical seepage of contaminated water through the Chinle shale.

3.2.2.2.1.5 Contaminant mitigation measures

Concentrations of sulfate in tailings seepage reaching the middle Chinle should be sufficiently diluted by underflow resulting in minimal water quality impacts. Homestake has predicted that sulfate concentrations will, in a worst case analysis for all contaminants, increase from the present concentration of 550 mg/l to 730 mg/l in the next 5,000 years. However, in the next few years of operation, Homestake will employ contaminant mitigation measures that will reduce concentrations and the areal extent of waters impacted by tailings seepage. Thus, the source of contamination will be largely removed and the impact of seepage to the middle Chinle will be negligible.

Homestake has committed to the following contingency plan in the discharge plan:

Homestake will conduct a ground-water study of the middle Chinle aquifer if this aquifer becomes significantly contaminated above the NMWQCC numerical ground-water standards in Murray Acres, Broadview Acres, Felice Acres, or Pleasant Valley Estates. The purpose of this study would be to determine if Homestake's activities are the cause of the elevated concentrations. Homestake will propose a mitigation program to reduce concentrations to NMWQCC numerical ground-water standards if Homestake's activities are proved to be the cause.

3.2.3 San Andres Limestone Aquifer

The San Andres Limestone and Glorieta Sandstone comprise the San Andres aquifer which is the major aquifer in the region. It lies beneath the Chinle Formation which is more than 650 feet thick at Homestake's Mill. The San Andres aquifer has not been affected by seepage of tailings fluid on Homestake's property. The potentiometric surface in the San Andres aquifer is 60 to 80 feet below that in the alluvial aquifer and 25 feet below the potentiometric surface in the middle Chinle aquifer, resulting in a downward-hydraulic gradient toward the San Andres aquifer. However, ground water within the San Andres aquifer is hydraulically isolated from the vertical migration of tailings fluid by a thick sequence of shale and clay within the Chinle Formation. Two San Andres aquifer wells are used for make-up water at the mill. Deep well number 2, used for the injection well water, is sampled and analyzed semi-annually. A description of the quality of the water used for injection is presented in Table 2. The EID does not anticipate that this aquifer will be affected by seepage from the active-tailings reservoir.

4.0 GROUND-WATER QUALITY IMPACTS FROM THE MILL FACILITY.

The processing mill is currently operating at one-fourth its normal operating capacity. During operation, small spills resulting from ruptures of the mill circuit will be contained by building floors with curbing. A major spill in the mill that would flow outside the immediate mill area would be contained by the same facilities which would contain a spill from a tailings-slurry pipeline break. The collected spills will be discharged to the active-tailings reservoir. The EID's analysis of the site's geology and hydrology and the engineering designs incorporated into the mill supports Homestake's conclusion that minimal impacts to ground water should result from a spill from within the mill facility.

5.0 GROUND-WATER QUALITY IMPACTS FROM THE TAILINGS-SLURRY PIPE LINE

Tailings are transported in a slurry form to the tailings facility by pipeline. The liquid portion of the slurry is similar in chemical characteristics to the free liquid in the tailings reservoir after settling. If the pipeline breaks or de-couples, spillage of the slurry will occur. Because of the operational procedures described below, the spillage itself would be insignificant in terms of impact on ground water. However, a more significant impact on ground water would occur if the spillage from the pipeline eroded away the tailings embankment, allowing the tailings liquid to escape with associated solids. This type of event occurred on February 5, 1977, at the Homestake Mill. The liquid did not escape beyond Homestake's property line. The accompanying solids were cleaned up and placed on top of the inactive-tailings reservoir, and radiation surveys were conducted. The survey and ground-water monitoring did not indicate any contamination of ground water occurred from the February 5, 1977, accident. As a result of this accident, a number of operating procedures and physical changes have been instituted to prevent the re-occurrence of such an event.

A break in the slurry line will not cause a violation of the NMWQCC Regulations under the present system for the following reasons:

1. Spillage from the pipeline at the tailings facility would be collected in the collection ditches on the down-gradient side of the active-tailings reservoir. An automatic flow alarm system has been installed which will allow mill shutdown within a few minutes. Thus, the volume of spill would be small.

2. The pipeline, except for the crossing between the mill and the active-tailings reservoir, is maintained on the inside edge of the berm of the tailings reservoir so a spill will not erode away the freeboard.

3. A five-foot vertical freeboard is maintained above the elevation of liquid in the tailings reservoir.

4. A fifty-foot wide beach is maintained from the top of the inside embankment crest to the reservoir's edge.

5. Two tailings reservoir operators are stationed at the tailings facility during all operations. One operates the cyclone truck, while the other inspects the tailings embankment. They are provided with radio communication.

6. A berm has been constructed approximately one-quarter mile south of the tailings reservoir to contain on Homestake property, liquids and solids that might escape.

If spillage from the pipeline does reach the collection channel, seepage of the liquid fraction would be held within the hydraulic influence of the tailings reservoir collection wells. If liquids from an erosional tailings breach escaped beyond the perimeter of the collection wells, some adsorption during infiltration through the unsaturated zone would take place. Considerable contaminant retardation could occur before spillage could seep to ground water. The adsorptive properties of soils are discussed in Section 3.2.1.4 of this report.

6.0 GROUND WATER QUALITY IMPACTS FROM STRUCTURAL STABILITY OF ACTIVE-TAILINGS RESERVOIR FACILITY

If the active-tailings reservoir embankment failed from a lack of structural stability, liquids and solids could be released. A release that occurred on February 5, 1977, resulted from erosion of the freeboard by a break in the slurry line, rather than a structural failure. However, a release from a structural failure would generally resemble the release of February 5, 1977, and have little or no effect on ground-water quality. Structural-stability assessments indicate that a structural failure of the tailings facility is unlikely.

A stability assessment was prepared by D'Appolonia Consulting Engineers in November, 1980, and submitted to the EID. All portions of the tailing facility were brought up to a static slope stability factor of safety of 1.5 or greater. Other stability criteria including pseudo-static slope stability under earthquake loading, potential for seepage forces causing piping and sloughing, liquifaction potential under earthquake loading, and performance during severe hydrologic events were concluded to be satisfactory.

Stability assessments involve calculations based on phreatic levels in the tailings reservoir embankment. Homestake has installed piezometers in the embankment to provide actual measurements of the phreatic levels. These measurements are made at least monthly, and submitted to the State Engineer's Office for evaluation on a monthly basis. D'Appolonia is currently preparing an assessment of the stability criteria for the tailings facility during the next years of buildout. The tailings facility is inspected each shift during operations. Two people are assigned to the tailings, an inspector and the cyclone truck operator. Signs of a potential structural failure should be detected during these frequent inspections.

If a release does occur, protection is provided by the berm located approximately one-quarter mile south of the active-tailings reservoir. Mechanical clean-up of tailings would be necessary in event of release.

7.0 GROUND WATER QUALITY IMPACTS FROM INACTIVE-TAILINGS RESERVOIR SEEPAGE

Tailings were discharged to the inactive-tailings reservoir from 1958 to 1962. The milling of uranium and the tailings produced were authorized under Atomic Energy Commission contracts. During the period of active use, approximately 1.9 million tons of tailings were discharged to the reservoir that now covers 40 acres on a site southwest of the mill (see Figure 1).

Seepage from the inactive-tailings reservoir has contributed to the elevated levels of TDS, sulfate, chloride, molybdenum, nitrate, selenium and uranium in ground-water in the subdivisions south of Homestake's property. Although no tailings have been discharged to the reservoir for the last 20 years, the moisture contained in the finely ground portions of the tailings (slimes) may have continued to seep during this period. The inactive-tailings reservoir was constructed directly on the alluvium with no liner. Thus, percolating moisture moves to the water table in the alluvium. However, migration of tailings seepage down-hydraulic gradient in the alluvium is somewhat slower than in the vicinity of the active-tailings reservoir, because of a lower hydraulic conductivity in the vicinity of the inactive-tailings reservoir.

Inspection of the water-level elevations for 1976 and 1983, shown on Figures 3 and 4 respectively, indicates no down-gradient bending of water-level contours in the vicinity of the inactive reservoir, which suggests little or no seepage recharge. Ground-water modeling supports the conclusion that no appreciable seepage from the inactive reservoir is reaching ground water in the alluvium.

In 1982, Homestake contoured the top of the tailings reservoir to enhance evaporation of runoff and installed a sump pump in a depression in the southeastern corner of the reservoir where runoff had been collecting in a pool. The implementation of these engineering features has kept the surface of the reservoir in a dry condition. Homestake has committed to continue these engineering methods until reclamation of the tailings reservoir is completed. Removal of the collected runoff at the southern edge of the inactive-tailings reservoir will prevent leaching of concentrated tailings salts to ground water in the alluvium.

Homestake has provided the following stabilization commitment in the discharge plan:

> Tailings deposited into this tailing pile were generated entirely to produce uranium concentrates for the national defense program, and the entire phase of

stabilization cost, etc. for these tailings would be federal under the format of the Commingled Tailings Act. Congress has not, as yet, funded the program. It is understood that Homestake's inactive-tailing pile will fall under the auspices of this Act. If stabilization activities are undertaken by Homestake for this pile at this time, an unnecessary question might be created as to whether this activity would prejudice funding under the Commingled Tailings Act.

If HMC receives Discharge Plan approval, they will submit a plan to stabilize the inactive-tailings reservoir, along with a time schedule, either within six (6) months of Congress' decision to not take responsibility for stabilization of these tailings or within one (1) year prior to the expiration of the 5-year term of the approved Discharge Plan, whichever occurs first. These plans will comply with present New Mexico Radiation Protection Regulations and Water Quality Control Commission Regulations. HMC will undertake stabilization activities in accordance with present New Mexico regulations within one (1) year after approval of the stabilization plan. If HMC believes there are valid circumstances indicating that stabilization should not be undertaken at such a time, then this information will be submitted with the plan for final stabilization of the inactive tailing reservoir to the EID by the date stipulated above. HMC must receive written approval from the EID to postpone final stabilization beyond the dates set forth above.

8.0 GROUND WATER QUALITY IMPACTS FROM FLOODING

8.1 Surface Hydrology and Hydrometeorology

8.1.1 Climate

The Homestake uranium mill site is located on the eastern side of the continental divide and has an arid to semiarid climate. The annual, mean-monthly temperature is 39° F (4°C) (Homestake, 1981). Average precipitation is estimated to be approximately 10.37 inches per year with 39 percent of the annual moisture falling during summer convective (thunder) storms. The streams, therefore, are ephemeral and flow only in response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice. Short-duration, high-intensity thunderstorms often result in local flash flooding in the typically dry arroyos because of the sparseness of vegetation. The prevailing winds are from the southwest (SW) averaging five miles per hour (D'Appolonia, 1982).

8.1.2 Regional Surface Hydrology

The Homestake uranium mill site is located in the Rio Grande drainage system of west-central New Mexico. The mill site lies within the San Mateo watershed. The San Mateo watershed is perennial upstream from the village of San Mateo, but is ephemeral (flows only in direct response to precipitation or snowmelt) at the mill site. The San Mateo arroyo drains into the ephemeral Rio San Jose which discharges to the Rio Puerco, a tributary to the Rio Grande.

8.1.3 San Mateo Watershed

The San Mateo watershed has a drainage area of approximately 291 square miles and has an oval shape (Figure 25). The overall drainage pattern is dendritic, although local headwaters develop parallel drainage in the steeply-sloping valley fill. Maximum relief in the watershed is 4724 feet with elevations ranging from 6576 feet in the south to 11,300 feet at Mount Taylor in the northeast. Channel gradients in the watershed range from nearly zero in the valley floor to 50 percent in the headwaters. The headwaters are characterized by deeply-incised (between ten and thirty feet) arroyos, while the valley floor contains shallow, poorly-defined, braided channels.

8.2 Design Storms and Flood Flows

Homestake submitted peak discharge tabulations for the San Mateo watershed for 100-year, 200-year and PMP (Probable Maximum Precipitation) recurrence interval storms (D'Appolonia, 1980a; D'Appolonia 1980b; D'Appolonia, 1982). Homestake

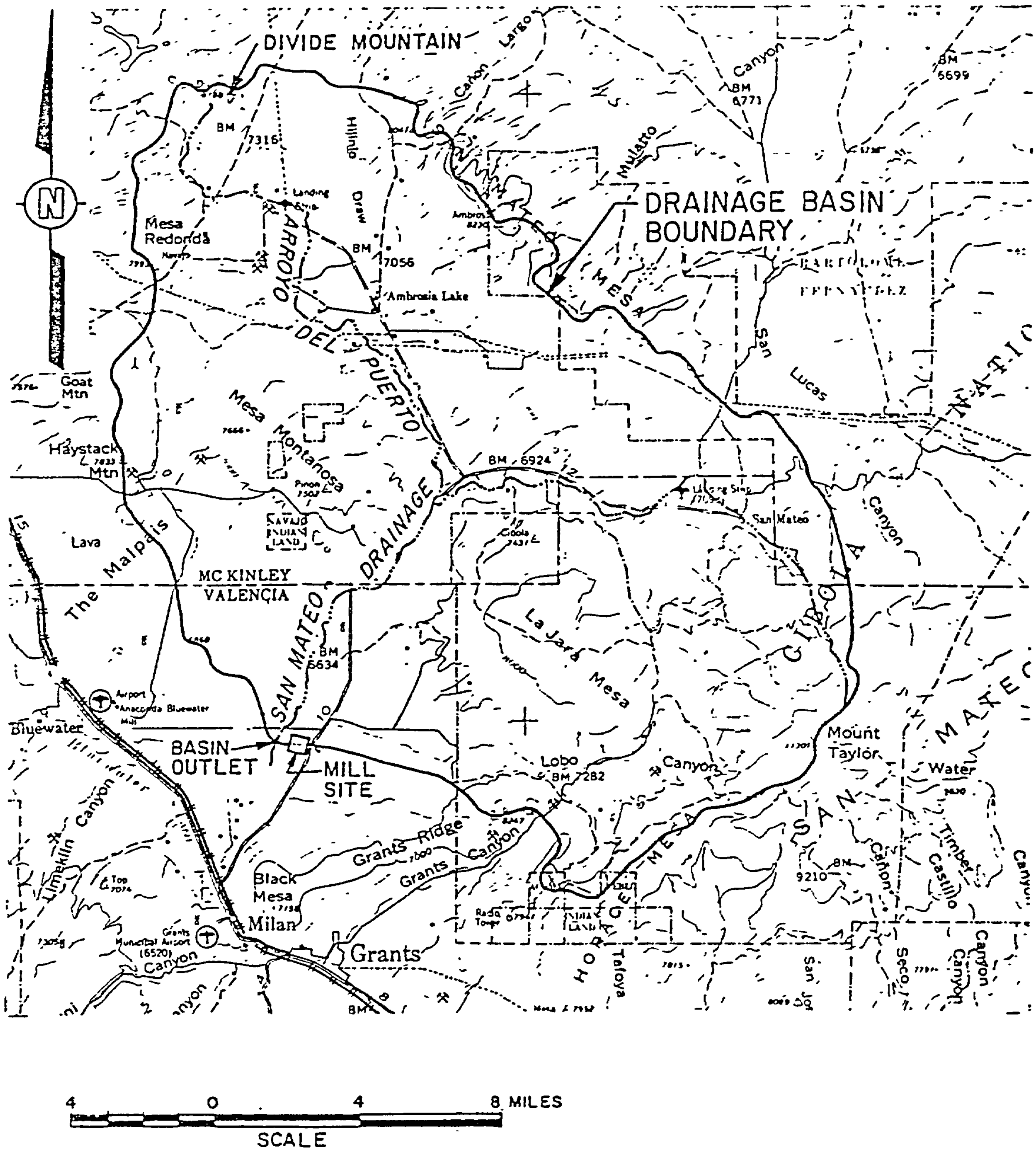


FIGURE 25. San Mateo Watershed and HMC Uranium Mill Site.

concluded from the tabulations that the current flood protection berm that protects the west end of the active-tailings reservoir embankment provides adequate protection from the one-hour, six-hour, and the twenty-four hour, 100-year storm. The berm will be extended around the north side of the active-tailings reservoir embankment for protection from a 200-year recurrence interval storm. The mill site and inactive-tailings reservoir are above the elevation of the flood resulting from a 100-year recurrence storm. Protection against PMP flood flows for both the active and inactive-tailings reservoirs both before and after reclamation, was concluded by Homestake to be unwarranted, due to the low probability of the PMP and the small potential for damaging erosion.

The EID staff concurs with Homestake that both the active and inactive-tailings reservoir embankments are adequately protected from the 100-year recurrence interval storm and the subsequent flood flows. Upon inactivation of the facility, the proposed 200-year flood protection berm will be extended another 1000 feet eastward along the northern side of the tailings embankment to provide adequate protection of the active and inactive-tailings reservoirs from the projected 200-year recurrence storm floodplain. Although the EID staff concurs that protection from the PMP is unwarranted during mill operation, long-term PMP protection of the tailings embankment is a justifiable concern. Long-term stabilization procedures outlined by Homestake in their uranium mill license (D'Appolonia, 1982) entail covering the top of the recontoured tailings with 18 inches of earth and rip rapping the entire tailings embankment with 6 inches of rock. Construction of the 200-year recurrence storm flood protection berm and implementation of the long-term stabilization measures proposed in the uranium mill license, should adequately protect the tailings from severe erosion during a PMP occurrence. The EID staff also concurs with Homestake that even if the maximum amount of tailings material were eroded from the embankment during a PMP occurrence, the concentration of the tailings in the flood waters would be extremely low. In 1977, approximately 150,000 tons of tailings were accidentally released from the tailings embankment onto the valley floor. Since that time, there have been no measureable affects on ground-water quality. By comparison, there should be no significant impacts to ground-water quality from infiltrating PMP flood waters containing low concentrations of tailings material.

Homestake's proposed design for stabilization of the active-tailings reservoir is currently under review by the EID Radiation Protection Bureau and may be changed to meet more stringent reclamation and radiation protection criteria.

9.0 HOMESTAKE'S MONITORING COMMITMENTS

Homestake's ground-water monitoring program should be adequate to ascertain when portions of the alluvial aquifer and upper Chinle aquifer have been reclaimed to NMWQCC ground-water standards and also detect degradation of ground-water quality. If seepage from the active or inactive-tailings reservoirs impact ground water, specific commitments have been made by Homestake to restore ground-water quality to NMWQCC standards. A list of major commitments is presented in Table 5.

9.1 Monitoring Commitments

A monitoring well system has been designed to assess the performance of the ground-water protection program and to prevent degradation of ground-water quality resulting from Homestake's activities. Monitor-well locations, parameters analyzed, sampling frequency and reporting interval are presented in Table 6. The locations of monitor wells are shown on Figures 1 and 26. The proposed monitoring system will require monitoring 83 alluvial wells, all active-collection wells, 5 wells in the upper Chinle aquifer, 10 wells in the middle Chinle aquifer and one well in the San Andres aquifer. In addition, four regional, alluvial wells will be monitored annually. Wells will be sampled quarterly or semi-annually for key parameters and annually for a detailed list of parameters. Monitoring data will be reported to the EID each quarter for the first two years after discharge plan approval and semi-annually thereafter. This monitoring program will be continued until Homestake can demonstrate to the EID that monitoring is no longer necessary to ensure protection of the ground water.

TABLE 5. LIST OF HOMESTAKE'S MAJOR COMMITMENTS.

Murray Acres collection wells will be operated until their concentrations are reduced to mean-background or NMWQCC numerical ground-water standards, whichever is higher.

An injection rate of 300 gpm into the Murray Acres injection system will continue until elevated concentrations currently located between the active-tailings reservoir and Murray Acres are pushed back into close proximity to the collection wells, such that they can continue to pull the constituents to the collection wells.

Additional collection and/or injection wells will be added to the Murray Acres system if the present collection-injection system is unsuccessful.

The Broadview Acres injection system will be operated until the elevated concentrations between Broadview Acres and the tailings collection wells are reduced so that their movement off Homestake property would not exceed the average alluvial background or NMWQCC numerical ground-water standards, whichever is higher.

The Broadview Acres injection will be stopped when high concentrations between the active-tailings reservoir and Broadview Acres are pushed northward to the zone of reversed hydraulic gradient that is maintained by operation of the collection wells.

Concentrations south of the injection wells located immediately south of the inactive-tailings reservoir will be reduced before injection starts in order to prevent ground-water constituent concentrations at Homestake's property boundary from exceeding NMWQCC standards.

The contingency plan for the Broadview Acres injection system is to add more injection wells to increase the rate of injection. This plan would be implemented if the current injection rate of over 250 gpm does not reduce objectionable chemical-constituent concentrations in Broadview and Felice Acres to background levels. However, if the extension injection wells (GE, GF, GI, GJ, GK, GL, GM and GN) cause chemical-constituent concentrations to demonstrate a significantly increasing trend at the subdivision boundaries after 6 months of operation, the extension wells will probably be shut-off and a collection system designed. Operation of the injection and collection systems simultaneously will depend on data and interpretations made at that time.

Homestake will operate the collection system (around the active-tailings reservoir) until concentrations are reduced

TABLE 5 (cont'd)

to a level which can be demonstrated that contaminants will not exceed NMWQCC ground-water standards at Homestake's property boundary.

If the present collection system around the active-tailings reservoir does not intercept all of the seepage, additional wells will be added to maintain the necessary continuous pumping.

The collection wells (around the active-tailings reservoir) will be maintained until it can be demonstrated that the seepage will not cause ground-water chemical constituent concentrations at Homestake's property boundary to exceed the state standards.

The collection water (around the active-tailings reservoir) will not be discharged to the tailings reservoir during the final stage of tailing drainage. An alternate discharge storage area or treatment system will have to be designed for containment or release of the collection water toward the end of the collection program.

The upper Chinle aquifer injection program will start as soon as the discharge plan is approved.

The upper Chinle aquifer injection system will be operated until concentrations in the upper Chinle aquifer between Broadview Acres and the tailings pile are decreased to the extent that their movement off Homestake's property will not exceed the average alluvial background concentrations or the NMWQCC numerical ground-water standards, whichever is higher.

If the upper Chinle injection program north of Broadview Acres does not decrease concentrations at a rate which will reduce elevated concentrations in the aquifer by the time the alluvial collection system can be stopped, then an alternate program will be added. The alternate program will consist of pumping the upper Chinle aquifer in the high concentration zone to increase the rate of removal of elevated constituents.

A new upper Chinle aquifer well will be drilled in Felice Acres to replace well CW5 as a monitoring well prior to injection into well CW5.

Homestake will conduct a ground-water study of the middle Chinle aquifer if this aquifer becomes significantly contaminated above the NMWQCC ground-water standards in Murray Acres, Broadview Acres, Felice Acres, or Pleasant Valley Estates. The purpose of this study would be to determine if Homestake's activities are the cause of the elevated concen-

TABLE 5 (cont'd)

trations. Homestake will propose a mitigation program to reduce concentrations to NMWQCC ground-water standards if Homestake's activities are proved to be the cause.

The monitoring program will probably be adjusted somewhat for post-operation conditions. A program similar to that given in Table 5 (of this report) will be used until Homestake can demonstrate to the EID that monitoring is no longer necessary to ensure protection of the ground waters.

Monitoring data will be reported to the EID each quarter for the first two years after discharge plan approval and semi-annually thereafter. A charge balance will be computed as a part of the monitoring program for these samples.

Samples from the main mill monitoring wells will be split and labeled differently once a year to demonstrate measurement repeatability for the routine monitoring constituents.

The EID will be notified within 24-hours of unusual conditions which would lead to failure of the (tailings management) system and result in a release of tailings or waste into unrestricted areas.

Stabilization (of the active-tailings facility) will be accomplished "by a cover that provides protection of the tailings against erosion for a period of 200 years". (EIB Radiation Protection Regulations, 12-300B.) Section 12-300C of the EIB Radiation Protection Regulations provide:

> "C. Stabilized waste-retention systems shall be protected against run-off from surrounding drainage areas by provision of other appropriate controls. If the edges of stabilized waste-retention systems are near a water course which might affect the system during flood stages and if diversion channels are impracticable, potentially exposed sections of such systems shall be additionally diked, riprapped, or otherwise protected in a configuration as shown by detailed engineering analysis to resist erosion."

The surface of the inactive-tailings reservoir has been contoured to prevent runoff from ponding at the southern end. These contours will enhance the removal of water from the top of the reservoir by evaporation. Homestake commits to maintain the reservoir in this contoured condition until final reclamation. A pump located at the southern end of

TABLE 5 (cont'd)

the inactive-tailings reservoir will be used to distribute runoff water to the contours if water should accumulate in this area.

If HMC receives Discharge Plan approval, they will submit a plan to stabilize the inactive-tailings reservoir, along with a stabilization time schedule, either within six (6) months of Congress' decision to not take responsibility for stabilization of these tailings or within one (1) year prior to the expiration of the 5-year term of the approved Discharge Plan, whichever occurs first. These plans will comply with present New Mexico Radiation Protection Regulations and Water Quality Control Commission Regulations. HMC will undertake stabilization activities in accordance with present New Mexico regulations within one (1) year after approval of the stabilization plan. If HMC believes there are valid circumstances indicating that stabilization should not be undertaken at such a time, then this information will be submitted with the plan for final stabilization of the inactive-tailings reservoir to the EID by the date stipulated above. HMC must receive written approval from the EID to postpone final stabilization beyond the dates set forth above.

The flood protection (for the active-tailing reservoir) will be increased to a 200-year flood basis upon inactivization of the facility.

Sulfate and selenium concentration maps will be developed semi-annually. If major changes occur in the Chinle aquifers, then updated maps for these aquifers will also be prepared. These contour maps will be submitted to the EID along with the periodic progress reports.

TABLE 6. MONITORING COMMITMENTS

Well Locations	Parameters Analyzed	Sampling Frequency
ALLUVIAL AQUIFER		
Collection Wells		
All Active Collection Wells	Discharge and Discharge Totalizer	Weekly
DM, DN, D, DP, DQ, DZ, SO, SP, S, BC	W.L.	Weekly
All Active Collection Wells	W.L., SO_4, U	Monthly
Murray Acre Wells		
802, 804, 805, HW	W.L., SO_4, U, Se	Monthly
Background and Mill Monitoring Wells		
P, Q, R, DD, BB2, BC, W2 NC, B, FB, F, I	W.L., pH, TDS, SO_4, Cl, U, Se, Mo, NO_3	Quarterly
Broadview Wells		
SUB2, SUB3, SUB5, SUB6, SUB1, SUB8, 410, 411, 412	pH, TDS, SO_4, Cl, U, Se, Mo (W.L. in Wells GH, SUB2 and SUB3)	Quarterly
Murray Acres Wells		
WR1, WR2, AW, HW, 802, 811 815, 844, 845	pH, TDS, SO_4, Cl, U, Se, Mo, NO_3, (W.L. in Wells WR1, AW, HW, 802, 815, 844)	Quarterly
Felice and Pleasant Valley Wells		
490, 492, 832, 835, 840, 843 846	pH, TDS, SO_4, Cl, U, Se, Mo, NO_3 (W.L. in 490, 492 and 846)	Quarterly
Secondary Mill Monitoring Wells		
A1, B1, C, D, DC, DM, DP, DZ, E, J, K2, KM, KZ, M1, M4, N, O, PM, S, SM, SO, T, W, WR11, WR9, WR7, WR5, X, Y, Z	W.L., pH, TDS, SO_4, Cl, U, Se, Mo, NO_3	Semi-annually
All Active Collection Wells	W.L., TDS, pH, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Semi-annually
Mill Monitoring Wells		
P, Q, R, DD, BB2, BC, W2, NC, B, FB, F, I	W.L., pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Annually

TABLE 6 (cont'd)

Well Locations	Parameters Analyzed	Sampling Frequency
Broadview and Felice Acres Wells		
SUB1, SUB2, SUB3, SUB4, SUB5, SUB6, SUB7, SUB8, 410, 411, 412, GH, 490, 492	pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Annually
Murray and Pleasant Valley Wells		
WR2, AW, HW, 802, 804, 811, 815, 844, 835, 840, 843, 846	pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Annually
Secondary Mill Monitoring Wells		
A1, B1, C, D, DC, DM, DP, DZ, E, J, K2, KM, KZ, M1, M4, N, O, PM, S, SM, SO, T, W, WR11, WR9, WR7, WR5, X, Y, Z	W.L., pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Annually
Regional Wells		
920, 942, 905, 910	pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Annually
UPPER CHINLE AQUIFER		
CW3, CW4, CW5, CW2-1	W.L., pH, TDS, SO_4, Cl, U, Se, Mo, NO_3 (only W.L. for CW2-1)	Quarterly
931	W.L., pH, TDS, SO_4, Cl, U, Se, Mo, NO_3	Semi-annually
CW3, CW4, CW5, 931	W.L., pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Annually
MIDDLE CHINLE AQUIFER		
CW2, 484, 486, 487, WCW, HCS, ACW, 820, 832	pH, TDS, SO_4, Cl, U, Se, Mo, NO_3 (W.L. in CW2) (only W.L. in 486)	Quarterly
CW2, 484, 487, WCW, HCW ACW, 820, 832, 844	pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226	Annually
SAN ANDRES AQUIFER		
Deep Well No. 2	Ground water Reg. List (except organics) plus HCO_3, CO_3, Na, Ca, Mg, K	Semi-annually

TABLE 6 (cont'd)

ACTIVE-TAILINGS SOLUTION		
	pH, TDS, SO_4, Cl, HCO_3, CO_3 Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226, (monthly average volume of tailings discharge)	Annually

Note: Reporting interval: Quarterly for 2 years after discharge plan approval, semi-annually thereafter with reports due in January and July.

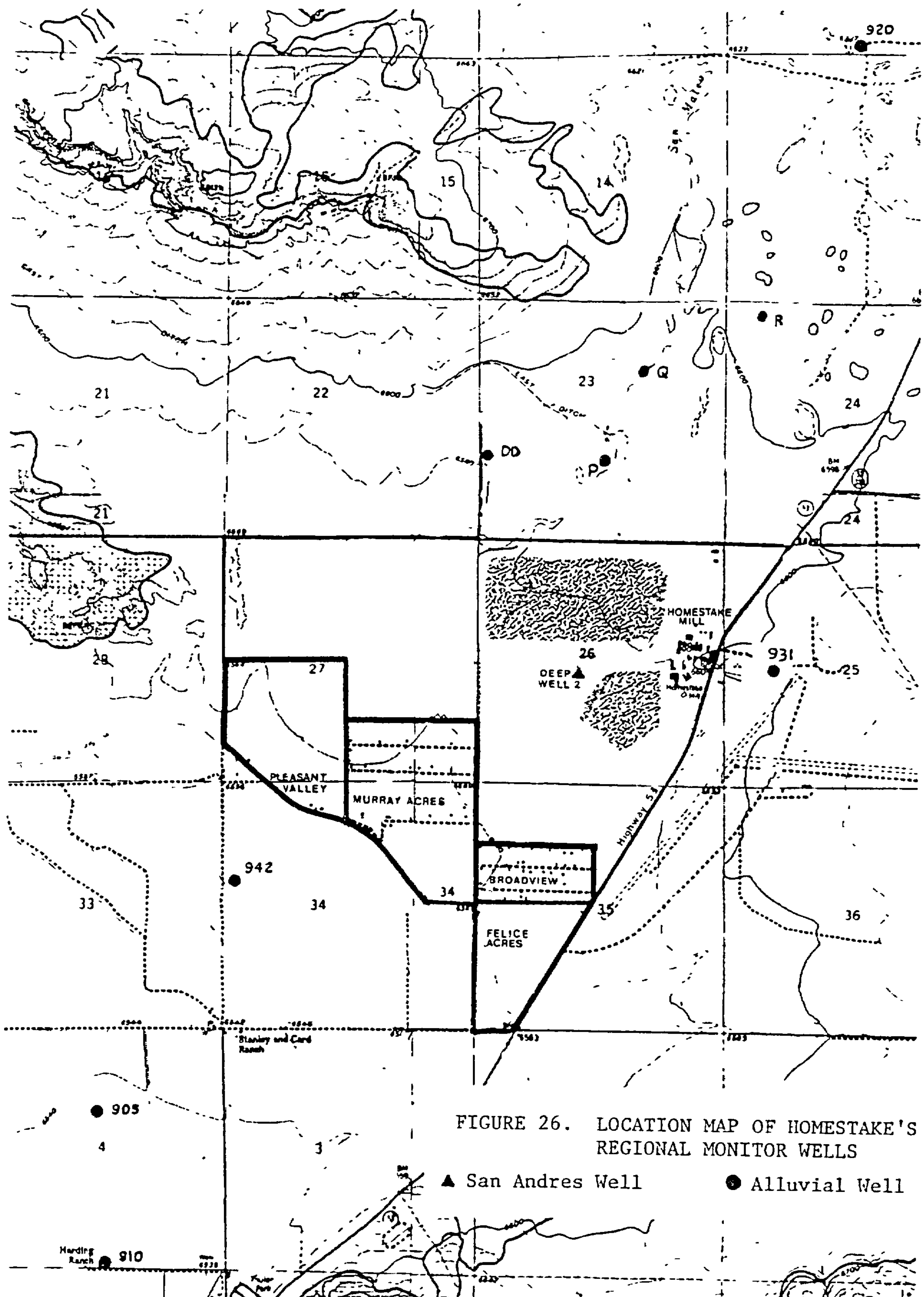


FIGURE 26. LOCATION MAP OF HOMESTAKE'S REGIONAL MONITOR WELLS

▲ San Andres Well ● Alluvial Well